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SHAPED CHARGES

AN ANNOTATED BIBLIOGRAPHY

FC

by

Mauree W. Ayton
Jack R. Gibson
C. Grace Gurtowski
Barton Bledsoe

Compiled for the Ballistic Research Laboratories, Aberdeen Proving Ground and the Office of Naval Research under Government Order NAonr 185-54

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PREFACE

The bibliography on shaped charges comprises an earlier bibliography of 1008 references on the same subject issued in card form in February 1951, and supplementary references compiled since that time. It has been prepared at the request of the Ballistic Research Laboratories, Aberdeen Proving Ground and the Armament Branch, Office of Naval Research, as a task under Government Orders NAonr 13-47 and NAonr 185-54.

Scope

The bibliography contains references, with informative abstracts, to all pertinent literature found in books, periodicals, and unclassified and classified reports on the subject of shaped charges, particularly their military applications. Detonation phenomena, explosives for military purposes, and high-speed photography have also been included when related to shaped charge research and development. While some Aberdeen Proving Ground firing records relating to shaped charges have been included, no attempt has been made to cover all of them in this compilation. A complete list of these records is contained in Shaped charges and related subjects; a bibliography of Aberdeen Proving Ground firing records, (Secret), by K. M. Crawford, [Oct. 1952]. In general, the time period covered extends from 1930 through 1953, although some earlier background material and a few 1954 references have been included.

Sources searched

The principal sources searched for published literature were:

Applied Mechanics Reviews, 1948-1952
Engineering Index, 1930-1952
Industrial Arts Index, 1930-1948
Library of Congress catalogs, 1930-1953
Royal Engineers' Journal, 1930-1947

Some of the above sources were not searched for supplementary entries because of a paucity of references.

References to reports were found by searching card catalogs, files, indexes, and inventories of the following:

Aberdeen Proving Ground
Air Materiel Command, Wright-Patterson Air Force Base
Army Ordnance
Army War College
British Intelligence Objectives Subcommittee
British Joint Services Mission, Washington, D. C.
Bureau of Aeronautics, Navy Dept.
Bureau of Mines
Bureau of Ordnance, Navy Dept.
Combined Intelligence Objectives Subcommittee
Engineer Research and Development Laboratories, Fort Belvoir
Field Information Agency Technical
Joint Intelligence Objectives Agency
Library of Congress, Technical Information Division. Includes the Technical information pilot (TIP) collection of the former Navy Research Section, the Astia document (AD) collection, and the Office of Scientific Research and Development (OSRD) collection.

Ministry of Supply (Gt. Brit.)
National Archives
National Bureau of Standards
National Defense Review (Confidential), v. 1 (1)-v. 4 (4)
Naval Ordnance Laboratory
Naval Research Laboratory
Office of Naval Intelligence
Office of Technical Services, Department of Commerce
Office of the Chief of Ordnance, Executive Branch, Technical and Foreign Reports (ORDTK-AB)
Research and Development Board

Form of entry and arrangement

The form of entry for published literature references is author, title, and journal, giving volume, date, and pagination; or author, title, place of publication, publisher, year, and pagination, in the case of books or pamphlets. For report references, the form of entry is, in general, that used in Technical information pilot; that is, source of the document, contract number, title, author, date, pagination, report number, and accession or other control number. Information on translations of foreign documents is also given in the citation. The principal accession or control numbers, which indicate the location of the report in loan collections, are:

AD — Astia document; available at the Astia Document Service Center, Dayton 2, Ohio, or Astia Reference Center, Library of Congress, Washington 25, D. C.

OSRD — Office of Scientific Research and Development document; available at the Technical Information Division, Library of Congress.

TIP — Technical information pilot; available at the Astia Reference Center, Library of Congress.

The entries in the bibliography are arranged in a single alphabetical listing by name of the first author for published literature, or by name of the source (corporate author) for reports. Where there is more than one entry for a source of reports, the arrangement is by contract number, and then by date. Reports which have a common title, however, such as Fundamentals of shaped charges, are treated as entities, being arranged by date within each such series. Item numbers for the entries have been prefixed with the letter "L" (i.e., L168) in order to distinguish them from item numbers in the original bibliography and other current listings.

Abstracts

The abstracts are of the informative type, giving a concise statement of the work accomplished and the results obtained. Test data, experimental results, and operational experience have been summarized, but no attempt has been made to analyze the data critically. In many instances, tabular penetration data for various weapons and liners have been included. When available, target characteristics, including material, physical properties, and thickness, have also been given. Unless otherwise indicated, abstracts have been made from the original documents.

Indexes

A detailed subject index, arranged alphabetically, has been provided. In preparing this index, an attempt has been made to indicate the significant subject matter of each reference. Cross references to synonymous and related subjects have been used where necessary.

In addition, an author index has been included, and a report number index has been provided which correlates all significant identification numbers, e.g., AC (Advisory Council on Scientific Research and Development (Gt. Brit.)); HEC (Halstead Exploiting Centre (Gt. Brit.)); OSRD; etc.

Additional Sources

Further sources of shaped charge information may be found in:

(1) The Ordnance shaped charge research report, (Confidential), formerly known as The shaped charge journal (Confidential), published by the Ballistic Research Laboratories, Aberdeen Proving Ground. This periodical, issued on a quarterly basis beginning in late 1954, serves to disseminate new information in the field, some of which is of a preliminary nature.

(2) Factors influencing the effectiveness of shaped charges when used against military targets (Secret), published by Michigan State College in 1954. The 1047 abstracts issued to date are on IBM punch cards and may be sorted by machine methods. A great many of these references appeared in the earlier Library of Congress bibliography and these, as well as most of the others listed, have been included herein.

Acknowledgements

The compilers wish to acknowledge the valuable assistance of Dr. Louis Zernow and Mr. J. E. Shaw of the Ballistic Research Laboratories in initiating and guiding the present work. Mr. Charles E. Burns of the Armament Branch, ONR, and Col. C. H. M. Roberts, then of the Office of the Chief of Ordnance, are to be thanked for their aid in technical matters and for their support of the original work which was issued in 1951. Acknowledgements are also due the staffs of the libraries listed above for their assistance in obtaining material for the bibliography, to fellow staff members of the Technical Information Division, particularly Mr. Thomas J. Derby for assistance in indexing, and to the staff of the Publications Section for aid in preparing the material for publication.

Washington, D. C.
May 1955

L1

ARD/ADD Interdepartmental Panel on Hollow Charge Projectiles (Gt. Brit.).
DAMAGE EFFECT BEHIND PLATES ATTACKED BY HOLLOW CHARGE PROJECTILES. Oct. 1943, 27p. incl. illus. (HCP rept. no. 13; OSRD Liaison Office I-A-335; Inclosure I to MA London rept. no. 69886) Secret

Test results are listed for the following projectiles: 2-in. mortar bomb, no. 68 grenade, 4-in. HEAT, 3-in. OSP, 28-mm. spigot HEAT, 10-in. mortar AT/HC, PIAT, 95-mm. and 3.7-in. howitzer HE/AT/HC, Burney 3.45-in. HE/AT/HC, 3-in. tank howitzer HE/AT/HC, American shaped charge shells, and German shaped charge shells.

L2

[ARD/ADD Interdepartmental Panel on Hollow Charge Projectiles (Gt. Brit.).]
GERMAN HOLLOW CHARGE BOMBS, by A. D. Merriman. Jan. 4, 1944, 2p. (HCP rept. no. 32; OSRD Liaison Office WA-2541-15) Secret

The general arrangement is shown of the charge used in shaped charge bombs SD250. Unsatisfactory performance in the SD250 led to the development of the 250SL. Performance tests showed that the 250SL penetrated 35 cm. of armor. A special nose fuze containing a shaped charge is described which was used to obtain greater penetrating power of the bomb when dropped from low altitudes.

L3

ARD/ADD Interdepartmental Panel on Hollow Charge Projectiles (Gt. Brit.).
JOINT REPORT ON RESEARCH AND DEVELOPMENT WORK ON HOLLOW CHARGES. Oct. 1944, 89p. incl. illus. tables, diagrs. (HCP rept. no. 89; ARD Explosives rept. no. 690/44; ADD/IB no. 1337/44, OSRD Liaison Office WA-5051-3A and WA-3651-4) Secret

Summaries are presented on methods of investigating Munroe jets, effect of charge characteristics on jet formation, cutting tube and similar charges, the hydrodynamic theory of jet formation and structure, methods of investigating damage in metal and special targets, theories of target damage in steel and other metals, scaling laws, and miscellaneous applications of shaped charge effects (such as follow-through projectiles). A large number of British, German, Japanese, Italian, and American shaped charge weapons and demolition charges are described. These are summarized in 5 pages of tables. A bibliography of 120 references (the same as that in item no. L172) is listed.

L4

Aberdeen Proving Ground.
TO DEVELOP A SATISFACTORY SHAPED CHARGE FOR CONCRETE DEMOLITION, by J. W. Cave, A. B. Jenny, and C. E. Hawk. Dates of test: Oct. 23, 1942-Mar. 1, 1943. 14p. incl. tables, diagrs. (Firing record no. M-20768) Confidential

M1, M1A1, M2, and M1A2 charges were tested to determine their effectiveness, functioning, and safety.

L5

Aberdeen Proving Ground.
TO DEVELOP A SATISFACTORY SHAPED CHARGE FOR CONCRETE DEMOLITION, by J. N. Weber and L. A. Watson. Dates of test: Mar. 14-June 24, 1943. 1p. illus. tables, diagrs. (Firing record no. M-27293) Confidential

Data are presented for charges fired against concrete slabs and pillboxes. No conclusions are stated. Charge designs are diagramed and firing results tabulated.

L6

Aberdeen Proving Ground.
DEVELOPMENT OF SHAPED CHARGES, by J. W. Cave and L. O. Oates. Date of test: July 6, 1943. 2p. incl. table. (Firing record no. M-24417) Confidential

Ten shaped charges were detonated against a slab 61 in. thick to determine the effect of charge length on penetration. The charges were 8 in. in diameter, had 60° steel liners, and were loaded with 50/50 pentolite. Charge lengths were 8, 12, 16, 20, and 24 in. The charges were detonated by means of electric blasting caps. It was found that an increase in the length of the charge did not increase the penetration depth.

L7

Aberdeen Proving Ground.
DEVELOPMENT OF SHAPED CHARGES, by J. W. Cave and L. O. Oates. Date of test: July 23, 1943. 4p. incl. tables. (Firing record no. M-24971) Confidential

Five cylindrical shaped charges, 6 in. in diameter were detonated statically against concrete slab, 61 in. thick, to determine if an increase in charge length would yield an increase in the size of the penetration. Three 5-lb. linear charges were detonated statically against steel.

L8

Aberdeen Proving Ground.
DEVELOPMENT OF SHAPED CHARGES, by J. W. Cave and L. O. Oates. Dates of test: July 28-30, 1943. 7p. incl. tables. (Firing record no. M-25118) Confidential

The investigation was made to determine optimum standoff distance. Sixty-six cylindrical shaped charges were detonated statically against concrete slabs. A charge length of 2 diameters yielded maximum penetration when tested at 1 diameter standoff. Charges with linear angles of 60° and standoffs of 2 diameters yielded the deepest average penetrations. Penetration increased with standoff distance from 0 to 2 diameters.

L9

Aberdeen Proving Ground.
DEVELOPMENT OF SHAPED CHARGES, by J. W. Cave and L. O. Oates. Dates of test: Aug. 5-7, 1943. 4p. incl. tables. (Firing record no. M-25373) Confidential

Optimum standoff was investigated. Thirty-eight cylindrical shaped charges (8 in. in diameter and 12 in. long) were detonated statically against a 60-in. concrete slab. Charges with liner angles of 60° yielded the deepest average penetrations. Penetration depth increased with standoff distance from 0 to 2 diameters.

L10

Aberdeen Proving Ground.
TO DETERMINE THE EFFECT OF TORPEDO WARHEAD SHAPED CHARGES, MK XIII ON STEEL PLATE, by J. H. Weber and F. X. Hartman. Dates of test: Sept. 15, 16, and 17, 1943. 1p. incl. tables. (Firing record no. M-26337) Confidential

Three MK XIII charges, 2 with 60° metal liners and 1 loaded in the conventional manner with no conical liner, were tested against homogeneous steel plates.

L11

Aberdeen Proving Ground.
TO DETERMINE EFFECT OF CONE WALL THICKNESS, CONE ANGLE, AND DIFFERENT TYPES OF EXPLOSIVE FILLER ON RESULTS OBTAINED WITH SHAPED CHARGE ACTION AGAINST CONCRETE, by J. H. Weber and J. Meszaros. Dates of test: Oct. 27-29, 1943. 2p. incl. tables. (Firing record no. M-27355) Confidential

L12

Aberdeen Proving Ground.
INVESTIGATION OF EFFECT PRODUCED BY CHANGING CONE ANGLE AND LINER THICKNESS OF 8-IN. CHARGES, MANUFACTURED BY DU PONT COMPANY, by J. W. Cave and J. Meszaros. Dates of test: Nov. 17 and 18, 1943. 2p. incl. tables. (Firing record no. M-27817) Confidential

L13

Aberdeen Proving Ground.
COLD WEATHER TESTS OF SHAPED CHARGE IN HEAD OF 2.36-IN. ROCKET, HEAT, M6A3C AS USED FOR MAKING HOLES IN FROZEN GROUND (1950-1951 WINTER TRIALS), by W. D. Woodford. June 18, 1951, 9p. illus. (Proj. no. TQ3-0106, rept. no. 4) TIP C6711 Confidential

Shaped charges in heads of 2.36-in. rockets were detonated at 8-in. standoffs over various types of frozen ground. A 1-in. steel ground shield plate with a 1-in. or 3-in. diameter hole was used with about half the charges. Some of the holes made were enlarged by extrudible explosive or dynamite. Holes about 30 in. deep were made in ground frozen to 18 in. The depth of penetration was reduced in certain types of ground containing rock, gravel, or sand.

Aberdeen Proving Ground see also
Ballistic Research Laboratories
Development and Proof Services
Foreign Matériel Branch
Ordnance Bomb Disposal School
Ordnance Research and Development Center
Ordnance Research Center
The Proving Center

L14

Admiralty Undex Works (Gt. Brit.).
REPORT ON TRIALS WITH SHAPED CHARGES REPRESENTING 18-IN. AND 21-IN. TORPEDO WARHEADS AGAINST BULGE MODEL. Aug. 1944, 6p. illus. tables, diagrs. (Rept. no. AUW/TRI.1/RF.15; OSRD Liaison Office WA-3454-1) Confidential

One-fifth scale model trials were made to compare the relative damaging effect of a normal charge and a shaped charge constructed in the form of a torpedo warhead. It was concluded that: (1) a shaped charge warhead is more effective than a solid charge head; (2) the 18-in. "Snapdragon" head will defeat a bulge structure at angles of attack up to 45° with some margin, but the effectiveness falls off rapidly as the angle of obliquity is increased above 45°; and (3) a cutting tube warhead behaved in all respects like a solid charge and failed to penetrate the protective bulkhead. Particulars of each trial in the series are tabulated.

L15

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
REPORT ON THE EFFECT OF THE SHAPE OF A CHARGE, by W. Payman. Aug. 23, 1940, 4p. illus. diagrs. (AC 313; Phys/Ex. 48; OSRD Liaison Office W-12-108) Confidential

A translation of a paper by E. Neumann, "Neuartige Hohlkörper aus Brisanzstoffen"

(Novel hollow charges from explosive materials), published in Zeitschrift fur gesamte Schiess- und Sprengstoffwesen, v. 9, May 15, 1914: 183-187, (item no. L1352) is given. An extract from an article by Payman and Woodhead published in the Proceedings of the Royal Society of London, v. 163A, Dec. 22, 1937: 575-592, is appended.

L16

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
EXTRACT FROM AN ARTICLE BY MUNROE. Sept. 23, 1940, 2p. illus. (AC 349; Phys/Ex. 55; OSRD Liaison Office W-12-119) Confidential

This rept. is an extract from an article by C. E. Munroe which appeared in Popular Science Monthly, v. [illegible], Feb. 1900: 444-455 (item no. L1214).

L17

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
NOTE ON THE MUNROE EFFECT, by A. R. Ubbelohde. Oct. 21, 1940, 2p. (AC 405; Phys/Ex. 61; OSRD Liaison Office W-12-121) Secret

It is suggested that the following factors be investigated: (1) distance to "pick up" of complete detonation; (2) change of "aspect" of the charge with respect to the action point; and (3) enhanced decay of intense shock waves.

L18

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES (I AND II), by W. Payman. Oct. 25, 1940, 13p. incl. illus. diagrs. (AC 413; Phys/Ex. 63; OSRD Liaison Office W-12-123) Confidential

An investigation was carried out to determine the effect on penetration of shaping a charge. However, the term "shaped charge" refers to the geometrical form of the entire explosive charge. No suggestion is made that the charge contained a cavity. A brief mention is made of the Munroe effect.

L19

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES III. Feb. 7, 1941, 5p. (AC 607; Phys/Ex. 84; OSRD Liaison Office W-12-143) Confidential

An investigation was carried out to determine the effect on penetration of shaping a charge. However, the term "shaped charge" refers to the geometrical form of the entire explosive charge. No suggestion is made that the charge contained a cavity. A brief mention is made of the Munroe effect.

L20

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES IV, by W. Payman. Sept. 15, 1941, 3p. (AC 1199; Phys/Ex. 154; OSRD Liaison Office WA-62-10 and WA-[illegible]) Confidential

The effect of different explosives on targets of varying thicknesses was reported. However, the term "shaped charge" refers to the geometrical form of the entire explosive charge. No suggestion is made that the charge contained a cavity.

L21

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES V, by W. Payman. May 23, 1941, 2p. (AC 871; Phys/Ex. 117; OSRD Liaison Office WA-2-8 and W-49-21) Confidential

A summary of general conclusions drawn from experimental work on shaped charges conducted at the Safety in Mines Research Station, Buxton (Gt. Brit.) is given.

L22

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES VI. THE EFFECT OF HE ON STEEL PLATES, by R. Jeffrey. Aug. 13, 1941, 3p. (AC 1097; Phys/Ex. 137; OSRD Liaison Office W-49-16, W-50-46, and W-49-31) Confidential

The influence of variations in the physical and chemical characteristics of the steel plates used as targets made necessary the instituting of control by means of a microscopic metallurgical examination of these plates. A discussion of such an examination is reported and photographs are included.

L23

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES VII. SPEED OF PROJECTION OF METAL PLUGS FROM STEEL PLATES PERFORATED BY CONED CHARGES, by H. Titman. Aug. 20, 1941, 1p. (AC 1129; Phys/Ex. 143; OSRD Liaison Office W-49-15) Confidential

Results of photographic determinations of the velocity of projection of the metal plug and the velocity of the shock wave are tabulated.

L23

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES VIII. EXPERIMENTS TO ELUCIDATE THE EFFECT OF SPECIALLY SHAPED CHARGES, by D. W. Woodhead and H. Titman. Aug. 21, 1941, 4p. incl. illus. (AC 1130; Phys/Ex. 144; OSRD Liaison Office W-49-14) Confidential

Investigations were made of setting-up detonations, and the flame projected by the explosive.

L25

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
A NOTE ON THE AXIAL EFFECTS PRODUCED BY HE "CAVITY PELLETS" [SHAPED CHARGES], by R. Mines. May 29, 1941, 4p. illus. diagrs. (AC 884; Phys/Ex. 119; OSRD Liaison Office WA-2-9 and W-49-20) Confidential

A geometrical analysis of the explosive effects observed along the axis of the explosive is presented. The analysis was based on the following assumptions: (1) the effect of the explosive is due to the projection normal to the surface of particles of constant surface density and velocity; and (2) where the radial momenta are mutually destructive, the associated energy appears as heat. An appendix containing a translation of a paper on the "Behavior of a Cavity Pellet" by D. Lodati which appeared in the Giornale de Chimica Industriale ed Applicata, v. 14, Mar. 1932: 130-132, is included. (See also item nos. L676 and L1149.)

L26

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
DEMONSTRATION OF VARIOUS SHAPES OF PLASTIC EXPLOSIVES [ON] 22ND JULY 1941, by A. B. Connelly. Aug. 8, 1941, 2p. diagr. (AC 1066; Phys/Ex. 132; OSRD Liaison Office W-49-19, W-50-59, and W-49-26) Confidential

The following shapes of molded plastic explosive were tested to compare their efficiency against concrete targets: (1) cylinder with hollow cone base; (2) hollow hemisphere; and (3) solid cylinder. A discussion and diagrams of the test results are presented.

L27

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
A NOTE ON THE EFFECTS PRODUCED ON THE AXIS OF DETONATORS NO. 8 AND OF PLASTIC EXPLOSIVE CHARGES WITH FLAT AND RECESSED BASES, by W. M. Evans. Aug. 20, 1941, 2p. diagrs. (AC 1127; Phys/Ex. 142; OSRD Liaison Office W-49-17) Secret

The detonators used in these experiments were no. 8 ASA and no. 8 Briska; the shape of the base and the density of the explosive filling were varied. Results of these experiments are presented graphically to show depth and volume of penetration in relationship to standoff.

L28

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
EXPERIMENTS AND OBSERVATIONS ON THE MUNROE EFFECT, by Lord Cherwell and J. L. Tuck. Sept. 24, 1941, 6p. (AC 1221; Phys/Ex. 158; OSRD Liaison Office WA-66-42) Confidential

Experiments on charges with various liners and standoffs are reported. Conclusions are given concerning the jet and penetration.

L29

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
THE EROSION OF METAL BY GAS JETS FROM EXPLOSIVES, by G. I. Taylor and J. E. Lennard-Jones. Oct. 25, 1941, 3p. (AC 1309; Phys/Ex. 166; OSRD Liaison Office W-58-11) Confidential

The theory that metal under a shaped charge is swept away by a hot jet and that this is the main cause of the penetration of steel plates by such charges was discussed. Calculations were made of the rate at which metal might be swept away.

L30

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
"CAVITY EFFECT" OF EXPLOSIVES. A SUMMARY OF ITS HISTORY AND SERVICE USES. Oct. 27, 1941, 12p. (AC 1312; Phys/Ex. 167; OSRD Liaison Office W-56-12) Confidential

A historical summary is presented; discussions are included on the application of the cavity effect to the design of service munitions, and the use of shaped charges in mining operations. Thirteen references published from 1811 to 1937 are listed.

L31

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
THE MECHANISM OF DAMAGE IN THE MUNROE EFFECT, by W. M. Evans and A. R. Ubbelohde. Nov. 24, 1941, 10p. incl. tables. (AC 1416; Phys/Ex. 191; OSRD Liaison Office W-125-60) Confidential

Experiments are described which show that normally any loss of weight in steel targets due to some mechanism of erosion is practically negligible. The experiments include weight and volume changes accompanying target damage, erosion with Al and Cd targets, detrusion of a Pb target with detonators as charges, and damage from charges with heavier lateral confinement. A discussion is appended on the metallographic examination of steel target blocks.

L32

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
[EXPLOSIVES RESEARCH COMMITTEE (PHYSICS AND PHYSICAL CHEMISTRY); MEETING HELD DEC. 1ST, 1941]. Rept. no. 19. Dec. 15, 1941, 2p. (AC 1499; Phys/Ex. 201) Secret

Various explanations are mentioned for the mechanism of erosion. Results from experiments in which steel block targets were weighed, before and after firing, showed that there was practically no loss in weight; however, the metal was distorted, showing plastic deformation in a radial direction from the crater. The experiments also showed that an Fe liner produced a broad crater of a certain depth, while a Cd liner produced a narrow but much deeper crater; in neither case was there loss of weight or of volume of the target. Additional tests showed that deeper penetration was obtained when the liner material was of low boiling point. Photographic evidence supported the views that Fe bombarded as solid or semi-molten particles, while Cd bombarded as a vapor jet.

L33

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
EXPLOSIVES RESEARCH COMMITTEE (PHYSICS AND PHYSICAL CHEMISTRY); MEETING HELD IN LONDON ON WEDNESDAY MAR. 4TH, 1942. Rept. no. 21. Mar. 13, 1942, 2p. (AC 1815; Phys/Ex. 237) Secret

It was reported that the usual effect from a shaped charge was reduced greatly when it was immersed in water. By using an air space at the base long enough to allow convergence of the jet before it strikes the water, a plate immersed some distance away could easily be penetrated and considerable damage caused on the far side. Ease of penetration and amount of damage also depended on the length of air column and on the depth of water to be traversed.

L34

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
EXPLOSIVES RESEARCH COMMITTEE (PHYSICS AND PHYSICAL CHEMISTRY); MEETING HELD ON WEDNESDAY, DEC. 16TH, 1942. Rept. no. 28. Dec. 30, 1942, 3p. (AC 3283; Phys/Ex. 370) Secret

Work on the effect of shaped charges with steel liners against massive steel targets was reported. It was noted that: there was a loss in penetration as the air gap in the target increased; the cosine law for the angle of attack was followed; the penetration in armor plate was 0.8 times that in mild steel; and hemispherical liners gave the best penetration. A metallurgical examination made of a 5-in. mild steel plate perforated by a shaped charge was also reported. Melting was observed on the surface of the hole and heating had penetrated beyond the surface; the metal was displaced and cold-worked and its method of hardening was considered to be connected with vibrations along the plate. Nitride was observed near the hole.

L35

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
INFLUENCE OF SHAPE IN EXPLOSIVE CHARGES. THE MUNROE-EFFECT SITUATION, JAN. 1942. Jan. 8, 1942, 4p. (AC 1580; Phys/Ex. 214; OSRD Liaison Office WA-87-12) Confidential

General discussions at the meeting of the Explosives Research Committee included focusing, erosive effect, and the influence of liners on penetration.

L36

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
THE MECHANISM OF JET FORMATION IN THE MUNROE EFFECT, by W. M. Evans and A. R. Ubbelohde. Jan. 12, 1942, 22p. incl. illus. tables, diagrs. (AC 1591; Phys/Ex. 216; OSRD Liaison Office WA-87-13) Confidential

Measurements were recorded on damage from shaped charges lined with various metals over a range of thicknesses. Characteristic differences were observed between fragment jets from high boiling metals such as Fe, and fluid jets from low boiling metals such as Cd, Zn, Sn, Pb, and alloys. A new penetration law was observed for fluid jets (mild steel targets), whereas the penetration law previously formulated from fragment gun data seemed to apply to fragment jets.

L37

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
ON THE SUBMARINE USE OF THE MUNROE EFFECT, by W. M. Evans and A. R. Ubbelohde. Feb. 21, 1942, 4p. incl. diagrs. (AC 1733; Phys/Ex. 229; OSRD Liaison Office W-156-19) Confidential

A method is described for increasing the Munroe effect under water by maintaining an air gap between the base of the liner and the water, allowing the convergence of the jet to take place in air.

L38

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SUPPLEMENTARY EXPERIMENTS ON MUNROE JETS IN AIR, by W. M. Evans and A. R. Ubbelohde. Feb. 25, 1942, 7p. incl. tables. (AC 1749; Phys/Ex. 234; OSRD Liaison Office W-156-26) Confidential

Brief descriptions of the following investigations on Munroe jets in air are reported: residual damage on the far side of armor plate, pin effects with Munroe jets, explosive fillings other than PE, use of alloy liners, experiments with liners made of Fe filings bonded into a plastic mass, the effect of confinement lateral to the jet, and jet penetration into telephone directories.

L39

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
VELOCITIES OF JETS FROM HOLLOWED CHARGES, by P. Bessent and W. M. Evans. Feb. 26, 1942, 4p. diagrs. (AC 1755; Phys/Ex. 235; OSRD Liaison Office W-187-2) Confidential

A study was made of the velocities of jets from low and high melting point materials at various distances from the base of the charge.

L40

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
PENETRATION OF FLUIDS BY MUNROE JETS, by W. M. Evans and A. R. Ubbelohde. Mar. 31, 1942, 4p. incl. diagr. (AC 1911; Phys/Ex. 245; OSRD Liaison Office W-252-53) Confidential

Experiments were carried out on an underwater target in order to compare the damage produced by shaped charges lined with low-melting, low-boiling metals with that reported by other workers. Experiments with targets of water, beeswax, and sand gave preliminary information on the apparent stopping power of various materials.

L41

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
THE DISPERSION OF MUNROE JETS OF METALS OF LOW MELTING POINT IN WATER, by G. I. Taylor. Apr. 4, 1942, 3p. (AC 1928; Phys/Ex. 247; OSRD Liaison Office W-212-14) Confidential

Mention is made of the studies of Oehler concerning the manner in which a high speed water jet disintegrates when projected in air, and of Kuthe on the way a liquid jet disintegrates when projected into a large volume of the same liquid. A theoretical study was made of the effect which variation in the ratio of density of the jet to density of the surrounding fluid might be expected to have on the distance to which the jet will penetrate before disintegrating.

L42

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
THE USE OF SHAPED CHARGES AGAINST COMPOSITE TARGETS. May 2, 1942, 6p. incl. diagr. (AC 2026; SC.4.1; OSRD Liaison Office II-5-1523) Confidential

Shaped charges with 80° liners, deeply dished disc, shallow disc, disc and ring, and plastic charges were tested against composite targets consisting of a series of steel plates of varying thicknesses. The performance of shaped charges used as a means of projecting a mass of steel conformed to a linear scale rule, i.e., the pressures remained constant regardless of the scale. A shaped charge with an 80° liner and with the HE placed behind the metal liner gave best results. When performance factors were investigated, it was noted that the jet velocity attained 15,000 ft./sec. The penetration was greatly reduced when the target was nearer than 1 diameter to the liner base. The deeply dished disc charge liner was not fragmented. It was found that when this charge was fired against the composite target, the slug penetrated successive plates on a diameter of about 0.5 that of the original. After successive penetrations, the target broke up into several pieces. There was a critical liner thickness which gave optimum results; when the thickness was too great, the slug was not sufficiently collapsed and too little thickness produced overfragmentation. A thickness of about 1/12 the diameter appeared correct. With plain disc charges, it was found that a slight dishing of the disc of about 1/12 the diameter reduced the amount of break-up. When the amount of explosive was increased, the plain disc did not hold together. By using a ring equal in weight to the weight of the disc, it was possible to use twice as much explosive as with the plain disc, and consequently to give it high velocities. The disc-ring combination gave a performance approximately equal to a plain disc charge of 30% greater diameter. The plastic charge did not have the advantage of dishing; there was a tendency for the first plate to fragment and disperse, thus reducing its capacity to penetrate successive plates.

L43

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
CONTROLLED AND DIRECTIONAL FRAGMENTATION. I. PRELIMINARY REPORT, by H. Titman. July 7, 1942, 8p. incl. illus. diagrs. (AC 2362; SC4.13; SD/FP. 16; OSRD Liaison Office WA-188-15) Confidential

A method for the controlled fragmentation of a disc of steel and the projection of the fragments in a liner of small angle are described. Topics discussed include an experimental bomb, targets and means of collection, natural fragmentation, controlled projection of a single disc, and large and small fragments induced by the use of a grooved charge.

L44

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES FOR THE DEMOLITION OF CONCRETE STRUCTURES. (SUMMARIES OF RRL REPORTS NOS. MOS/112/FNS AND MOS/113/FNS: FIRST INTERIM REPORT ON THE DEMOLITION OF CONCRETE BRIDGES; MODEL TESTS ON THE DEMOLITION OF ANTITANK OBSTACLES.) July 7, 1942, 2p. (AC 2318; Phys/Ex. 290; OSRD Liaison Office WA-163-32) Confidential

A shaped charge was developed to cut a slot in reinforced concrete surfaces to destroy the continuity of the steel reinforcement. Test results are summarized. Full-scale tests which should be made on reinforced concrete antitank obstacles are outlined.

L45

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
NOTE ON ACOUSTIC EFFECTS IN FRAGMENTATION, by A. R. Ubbelohde. July 15, 1942, 2p. (AC 2347; SC4. 12; OSRD Liaison Office II-5-2108) Secret

It is pointed out that the efficiency of jet formation by the liners of Munroe charges depends on intimate contact between the explosive and the metal. This suggests that initial fragmentation, or the absence of it, may in part depend on acoustic effects in the metal set up as the result of the detonation wave.

L46

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
THE COMPARATIVE PROPERTIES OF MUNROE JETS FORMED BY VARIOUS LINED HOLLOW CHARGES, by W. M. Evans and A. R. Ubbelohde. Aug. 4, 1942, 13p. illus. diagrs. (AC 2461; Phys/Ex. 303; SC4. 25; OSRD Liaison Office WA-556-20B) Confidential

Jets were compared for Cd and steel liners of spherical contour, from shallow dishes to hemispheres, perfect and truncated. A range of thicknesses was investigated for each shape to determine the optimum value.

L47

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
FIRST AND SECOND INTERIM REPORTS ON THE HOLLOW CHARGE. Aug. 6, 1942, 4p. illus. diagrs. (AC 2468; Phys/Ex. 304; OSRD Liaison Office WA-260-45) Confidential

Tests were made to determine the effect on maximum penetration of standoff, explosive filling, point of initiation, liner thickness, and brass liners.

L48

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SUGGESTIONS FOR IMPROVEMENT OF CS BOMBS OF THE DISC TYPE, by M. J. Poole. Sept. 2, 1942, 2p. diagr. (AC 2644; SC4. 24; SD. 126; OSRD Liaison Office WA-348-24) Confidential

Composite charges were used in which explosives of high and low velocities of detonation were arranged in contact and the geometry required is discussed with a view to providing a bomb in which the disc may be molded into a compact high velocity projectile.

L49

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
EXPERIMENTAL WORK ON THE MUNROE EFFECT AND ITS BEARING ON PRACTICE, by R. Robertson. Sept. 22, 1942, 3p. (AC 2734; Phys/Ex. 318; OSRD Liaison Office WA-279-5) Confidential

Brief general remarks are reported on British investigation of: attack on steel, crater formed by deformation of steel, effect of various liner materials, formation of Munroe jets and laws of their penetration into steel, standoff, underwater attack, and attack on concrete.

L50

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SOME NOTES ON THE THEORY OF LINED HOLLOW CHARGES, by J. E. Lennard-Jones and A. F. Devonshire. Oct. 27, 1942, 10p. incl. diagrs. (AC 2934; Phys/Ex. 328; OSRD Liaison Office WA-358-8 and W-328-34) Confidential

This note considers possible processes by which a metal liner may be melted, and attempts to determine the properties of explosive and liner which may be important in determining the effect. The time interval involved in melting is of the order of 10^{-5} sec. which limits the possible melting methods. Three possible methods are discussed: (1) erosion of the fragments by the hot gases; (2) collision of the fragments in the center of the jet with consequent transformation of kinetic energy into heat; and (3) heating of the fragments by the passage of shock waves through them.

L51

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
DEMOLITION OF GERMAN SD BOMBS BY MEANS OF HOLLOW CHARGES, by A. D. Merriman and R. Hurst. Nov. 19, 1942, 3p. (AC 3050; BMB. 213; OSRD Liaison Office WA-304-22) Confidential

Tests results showed that for demolition of the SD 500 bomb, a 12-oz. charge with 90° liner would give complete detonation if placed along the bomb axis and directed through the base plate. Partial detonation was achieved when the fuze pocket was clear, or when the shaped charge was directed through the bomb wall at any point in its side.

L52

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SOME EXPERIMENTS ON THE PROPAGATION OF DETONATIONS ACROSS GAPS, by J. Taylor and J. E. L. Thomas. Nov. 26, 1942, 7p. diagr. (AC 3086; Phys/Ex. 345; SC4.30; OSRD Liaison Office WA-592-10) Confidential

Tests showed that a convex-ended primer gave a much lower gap sensitivity than a plane-ended primer. Curves are drawn that show the momentum communicated at various distances from the ends of exploding cartridges of various shapes.

L53

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SOME FURTHER NOTES ON THE THEORY OF LINED HOLLOW CHARGES, by A. F. Devonshire. Dec. 10, 1942, 3p. diagr. (AC 3187; Phys/Ex. 348; OSRD Liaison Office WA-384-19) Confidential

The effect of the initial size of the fragments on the melting rate is considered, and also the effect of having a distribution of particles of different sizes. Tests showed that Cd fragments would melt to a very large extent while travelling over a short distance (67% after 10^{-5} sec., and 80% after 2×10^{-5} sec.), while steel fragments would be melted slightly (13% after 10^{-5} sec., and 19% after 2×10^{-5} sec.).

L54

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
A NOTE ON THE THEORY OF THE MUNROE EFFECT, by J. L. Tuck. Feb. 27, 1943, 10p. (AC 3596; Phys/Ex. 393; SC. 3; OSRD Liaison Office WA-638-24) Confidential

A theory of the Munroe effect based on a hydrodynamic mechanism is proposed in which the jet is generated by the convergence of a fluid shell. Liner and jet velocities are considered. The influence of the proposed mechanism on design and possible improvements in performance are discussed. The sensitivity of the jet to asymmetry is noted. Road Research Laboratory Note no. MD/14/DJM on "The photography of the spurt of material from a hollow coned charge," Mar. 1943, (2p. illus. diagrs.) is appended. The jet velocities of 80° lined charges 0.25 in. and 2 in. in diameter backed by 1 g. and 1 oz. of PE respectively, were found to be about 14,000 ft./sec.

L55

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
STUDIES OF SHAPED CHARGES BY FLASH RADIOGRAPHY. I. PRELIMINARY, by J. L. Tuck. Mar. 15, 1943, 8p. incl. illus. diagrs. (AC 3654; Phys/Ex. 399; SC. 6; OSRD Liaison Office WA-693-11 or II-5-4944) (In cooperation with Armament Research Department) Confidential

A description of the equipment and procedure for photographing the detonation of explosives by X-ray technique (flash radiography) is given. Some of the first radiographs obtained during the detonation of various shaped charges are appended.

L56

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
STUDIES OF SHAPED CHARGES BY FLASH RADIOGRAPHY. II. THE MUNROE EFFECT, by J. L. Tuck. Aug. 10, 1943, 12p. incl. illus. diagrs. (AC 4130; Phys/Ex. 423; SC. 34; OSRD Liaison Office WA-917-10) (In cooperation with Armament Research Department) Confidential

Flash radiographs are presented showing stages in the development of the Munroe effect in an 80° brass liner and a spherical Cd cap, and the projection of some brass plane discs. Velocities of the jet and slug from the 80° liner and of the projected material from the plane discs were obtained from the radiographs. Evidence of the degree of fragmentation in both curved and flat linings and the information yielded by these radiographs concerning the nature and formation of Munroe jets are discussed.

L57

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
STUDIES OF SHAPED CHARGES BY FLASH PHOTOGRAPHY. III. SOME MISCELLANEOUS CHARGES, by R. J. Branthwaite. Apr. 1944, 11p. incl. illus. diagrs. (AC 6127; Phys/Ex. 543; SC. 82; OSRD Liaison Office WA-2539-9) Secret

Radiographs are shown of the penetration of an

Al target by 80° shaped charges, and of the detonation of charges with hemispherical brass and 80° steel liners.

L58

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD ON WEDNESDAY, MAR. 3RD, 1943. Rept. no. 1. Mar. 17, 1943, 2p. (AC 3673; Phys/Ex. 401; SC. 7; OSRD Liaison Office WA-528-15) Confidential

The applications of shaped charges to the attack of concrete were examined. It was found that a 78-lb. charge perforated 5 ft. of reinforced concrete used in the construction of pill-boxes and gave lethal pressures on the other side. A comparison between strip and conical shaped charges showed that a square-sectioned strip charge gave only 1/3 of the penetration of a coned charge of the same weight. An investigation of the possibility of directing the jet was made using a 5-oz. charge with an 80° liner. The dispersion of the fragments was found to be about 5°. It was also reported that the 35-lb. AS bomb, 7 in. in diameter and having a conical liner 0.25 in. thick, penetrated 2 plates, 0.5 and 7/8 in. thick, at a stand distance through water of 51 in.

L59

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD IN LONDON ON TUESDAY, APR. 6TH, 1943. Rept. no. 2. Apr. 14, 1943, 2p. (AC 3824; Phys/Ex. 406; SC. 16; OSRD Liaison Office WA-601-13) Confidential

The meeting was concerned with: development of a follow-through projectile; work being performed in the United States on high pressure shock waves; firing trials on a 5-in. follow-through bomb; concrete demolition; and the effect of lateral charge confinement on Munroe jets. These topics are summarized briefly in general terms; no technical information is reported.

L60

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD ON WEDNESDAY, MAY 12TH, 1943. Rept. no. 3. [May 1943], 1p. (AC 4084; Phys/Ex. 423; SC. 32; OSRD Liaison Office WA-706-8) Secret

The meeting is briefly reported. The design of the CS bomb is discussed, and it is suggested that the slug can replace the jet in penetrating spaced targets.

L61

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD ON WEDNESDAY, JUNE 23RD, 1943. Rept. no. 4. [June 1943], 1p. (AC 4376; Phys/Ex. 453; SC. 39; OSRD Liaison Office WA-791-10) Confidential

Brief summaries are reported on the use of shaped charges for clearance of mine fields, and on a theory of the Munroe effect based on collisions of shock waves.

L62

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD ON TUESDAY, AUG. 17TH, 1943. Rept. no. 5. [Aug. 1943], 1p. (AC 4673; Phys/Ex. 472; SC. 47; OSRD Liaison Office WA-940-12) Secret

The meeting was devoted to United States repts. on Munroe jet phenomena. Theories to account for the phenomena are briefly mentioned.

L63

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD ON WEDNESDAY, OCT. 13TH, 1943. Rept. no. 6. Nov. 4, 1943, 1p. (AC 5063; Phys/Ex. 492; SC. 57; OSRD Liaison Office WA-1235-11) Secret

Brief and general summaries of topics discussed at the meeting are given. Included are the mechanism of the jet, multiple jet aircraft bomb, and attack of spaced (multiple) plate targets.

L64

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD ON FEB. 9TH, 1944. Rept. no. 7. Feb. 23, 1944, 1p. (AC 5806; Phys/Ex. 524; SC. 75; OSRD Liaison Office WA-1711-35) Secret

Brief summaries are given of the topics discussed at the meeting: the effect of confinement of charges, and the cutting tube charge head.

L65

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD ON WEDNESDAY, MAR. 8TH, 1944. Rept. no. 8. Apr. 1, 1944, 1p. (AC 6031; Phys/Ex. 537; SC. 78) Secret

A theoretical paper on the penetration by jets of various types is summarized. By taking moving axes through the end of the jet and equating pressures at the stagnation point at the bottom of the hole, the velocity of penetration was obtained. An equation for the depth of penetration is given in terms of the densities of the materials of the jet and the target. The result, which holds only if the target material is of low compressibility compared with pressure, indicated that the penetration was independent of the jet velocity and of the strength of the target material. The volume of the hole made in the target depends on the amount of the energy of the jet which is communicated to the target. It is suggested that the crater produced by a jet of given velocity, density, and linear dimensions is independent of the material of the jet.

L66

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD ON TUESDAY, APR. 18TH, 1944. Rept. no. 9. May 5, 1944, 2p. (AC 6279; Phys/Ex. 559; SC. 90; OSRD Liaison Office WA-2146-14)
Secret

A series of experiments was reported in which the fragments, down to dust in size, from the shaped charge liner were collected in ice. Spherical particles were found up to a size of 1.2 x 10^{-2} cm. and a large proportion of the fragments were hardened. The presence of Fe_2N was confirmed. Results indicated that dish-shaped liners were subject to greater interaction with the gases than were conical liners. All shapes of liners, except a flat disc, gave a proportion of fragments with dimensions greater than the thickness of the original liner, so that some measure of collapse of the liner must have occurred. There were indications of 3 different mechanisms of fragment formation. It is pointed out that the distribution formulas which were suggested for fragments from bombs and shells were not intended to apply to the smallest fragments which might result from gas erosion.

L67

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD ON WEDNESDAY, JUNE 7TH, 1944. Rept. no. 10. June 15, 1944, 2p. (AC 6511; Phys/Ex. 563; SC. 100; OSRD Liaison Office WA-2351-19)
Secret

A brief summary is given of the follow-through projectiles which were being tested at that date. A paragraph suggests more evidence to show the interaction between fragments and explosion products.

L68

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD ON JULY 12TH, 1944. Rept. no. 11. July 31, 1944, 2p. (AC 6709; Phys/Ex. 574; SC. 107; OSRD Liaison Office WA-2609-11)
Secret

Brief summaries are given on the investigation of particle damage behind armor plate, Mach effects, follow-through projectiles, jet penetration, and the mechanism of the break-up of hemispherical liners.

L69

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD ON WEDNESDAY, AUG. 30TH, 1944. Rept. no. 12. [Aug. 1944], 1p. (AC 6964; Phys/Ex. 586; SC. 114; OSRD Liaison Office WA-2923-10)
Secret

A brief statement of the subjects covered at this meeting is made.

L70

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD ON NOV. 8TH, 1944. Rept. no. 13. Nov. 23, 1944, 2p. (AC 7389; Phys/Ex. 603; SC. 124; OSRD Liaison Office WA-3425-13)
Secret

Brief summaries report on protection against shaped charges, effects of very large shaped charges, and cored charges.

L71

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD IN [ON] JAN. 30TH, 1945. Rept. no. 14. Jan. 30, 1945, 2p. (AC 7812; Phys/Ex. 626; SC. 138; OSRD Liaison Office WA-4016-15)
Secret

Brief mention is made of the effects of very large shaped charges, protection against shaped charges by chemical action, various uses for shaped charges, and the effect of shaped charges on different materials.

L72

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; MEETING HELD ON MAR. 22ND, 1945. Rept. no. 15. Apr. 4, 1945, 1p. (AC 8033; Phys/Ex. 635; SC. 141; OSRD Liaison Office WA-4287-7)
Secret

It is mentioned briefly that the Hill-Mott-Pack theory of penetration was extended by Birkhoff to allow for the extension of the jet with standoff of the charge and for rotation. It was shown in the original theory that the volume of the crater in steel is proportional to the energy given up by a jet or a shot; a further analysis indicates that the same may be true for penetration into concrete. It is still not clear where the material displaced by the jets goes, and experiments are designed to determine this. The difference in the shape of crater obtained in such materials as gypsum and concrete may give a clue and suggests that the presence or absence of air spaces in the material attacked is connected with the shape of crater formed. Other work reported shows that, if allowance is made for the difference in density of the metals, the properties of Al and steel jets are closely similar. (AC abstract)

L73

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
A SIMPLE SHAPED DEMOLITION CHARGE - THE "GENERAL WADE", by J. Taylor. Mar. 29, 1943, 4p. incl. diagr. (AC 3740; SC. 16; OSRD Liaison Office WA-638-35)
Confidential

The General Wade is an arched charge, the inside arch being of 1/8-in. mild steel and the flat bases, top and side, being of thin tinned plate. The charge is initiated at the top of the arch by a 1-oz. CE field primer. When the charge was fired on an 8-in. thick mild steel plate, a gash 3.5 in. deep, about 15-in. long, and 5-in. wide at the surface was produced. Placed directly on 2-in. armor plate, the charge cut through, produced a large scab, and shattered or cracked the plate.

L74

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
EXTRA-MURAL WORK IN PROGRESS ON SHAPED CHARGES. Apr. 6, 1943, 8p. (AC 3779; SC. 17; OSRD Liaison Office WA-571-5)
Confidential

A chart outline of the research on shaped charges on this date is presented. Fundamental aspects, present state of work, and estimated time for completion are noted.

L75

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES: A REVIEW COVERING THE PERIOD AUG. 26TH, 1942 TO FEB. 28TH. 1943, by E. A. Monro. Apr. 14, 1943, 23p. (AC 3827; SC. 19; OSRD Liaison Office WA-638-34)
Confidential

Discussions are included on antitank weapons, HC fuze no. 233, controlled fragmentation, attack of capital ships, attack of submarines, perforation of reinforced concrete structures, follow-through projectiles, and German and Italian shaped charge shells.

L76

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
A SIMPLE SHAPED DEMOLITION CHARGE THE "GENERAL WADE". A FURTHER NOTE, by J. Taylor. Apr. 21, 1943, 2p. (AC 3877; SC. 24; OSRD Liaison Office WA-620-16) Confidential

The General Wade was modified by increasing the base pressure charge area by 50% over the original design without sacrificing the line cutting power or increasing the weight of the explosive charge or container. No tests were made on this charge.

L77

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
HOLLOW CHARGE ROTATED PROJECTILES. May 7, 1943, 9p. incl. illus. diagrs. (AC 3987; SC. 27; OSRD Liaison Office WA-645-31)
Confidential

During the development of a shaped charge shell for the 25-pounder field gun, the penetration decreased as the velocity of the shell increased because of shell rotation. Tests showed that deterioration could be shifted to higher velocities by using a liner of small apex angle at a short length. A shaped charge design for the 3.7-in. howitzer shell proved satisfactory up to the maximum muzzle velocity of the gun (1450 ft./sec.).

L78

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
EXTRA-MURAL WORK IN PROGRESS. May 25, 1943, 7p. (AC 3933; Phys/Ex. 417; OSRD Liaison Office WA-708-4) Confidential

Proposed investigations and the status of shaped charge projects are outlined in chart form.

L79

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
A FORMULATION OF MR. TUCK'S CONCEPTION OF MUNROE JETS, by G. I. Taylor. May 27, 1943, 6p. incl. diagr. (AC 3724; Phys/Ex. 427; OSRD Liaison Office WA-638-32)
Confidential

Tuck's paper (item no. L54) suggests that the high velocity in the jet is due to purely hydrodynamical causes and can be explained by regarding the liner as a fluid conical shell which is given a velocity normal to the generators of the liner, and it

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concludes that the minimum velocity of escape of the jet forward is equal to the rate of passage of the disturbance along the axis of the bomb. Taylor points out that a complete hydrodynamical picture of the motions which may be expected on the collapse of a conical shell of fluid is not easy to give if the shell is of uniform thickness, because the ring shaped elements of it increase inversely as the radius diminishes. If the shell is regarded as of infinite extent, the scale of the whole configuration increases with time. This difficulty does not occur if consideration is given to the 2-dimensional case when the conical shell is replaced by 2 sheets, each of uniform thickness or the case where the original shell thickness decreases inversely as the distance from the vertex. In either of these cases the whole configuration can be reduced to steady motion by impressing a velocity backwards. Taylor concluded that the treatment given here seems to be a correct formulation of the ideas of Tuck, although it does not agree in all respects with what Tuck deduced from his premises.

L80

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
REPORT ON HANKLEY COMMON TRIALS.
June 18, 1943, 1v. incl. illus. tables, diagrs.
(AC 4242; C. 5) Secret

A program was carried out to explore and develop the most practical use of explosives in assault blasting. The shaped charges tried out against 3-ft. thick walls were: 6-in. Beehives; 6-in. Beehives with shaped fillings (Queen Bee) between the liner and the surface attacked; composite charges consisting of Beehives, Queen Bee, and circumscribing annular charge; solid right cylindrical conical charges; charges of plain rectangular section; German demolition "Headlight" charge, and a variant of this called a "Cheese" charge; and an arched linear charge called the "General Wade". Results with 6-in. Beehives showed that the standard filling gave the best results. An average penetration of 36 in. was obtained with the standard Beehive. In tests with the Queen Bee, it was found that in concrete which was too thick to be penetrated, the charge did not materially improve on the results obtained with the 6-in. Beehives alone. Tests with composite charges were designed to determine whether the Beehive shaped charge could be incorporated in a composite charge which would combine disruption with penetration, the penetration taking place ahead of the disruption and so adding to the general effect. It was concluded that the composite charges required complicated initiation, were difficult to position on the target, and that their effect was not sufficiently superior to other simpler charges to compensate for the difficulties of application and manufacture. Tests with the 8-lb. solid right cylindrical conical shaped charge showed that the charge did not cut reinforcing bars embedded 4 in. beneath the surface of the concrete attacked, and its cutting effect on armor plate was inferior to the General Wade charge. This charge was also difficult to position. Tests were carried out with 8-lb. charges of rectangular section 8 x 6 x 3 in. The charge, which had a large area of contact/lb. of explosive gave good results; however, it failed to cut the reinforcing bars embedded 4 in. beneath the surface of the concrete, and its cutting effect on steel and armor plate was inferior to the General Wade charge. German demolition "Headlight" charges tested against 3-in. thick reinforced concrete gave the best penetration values when the charges were set about 1.5 diameters away from the target. The area of contact which these charges had with the surface attacked was small, and consequently their general disruptive effect was comparatively poor. Tests with various fillings in General Wade charges showed that 25/75 Pentolite was a suitable filling. Cu liners showed no apparent advantage over steel liners. Fired on 8-in. thick mild steel plate, placed on the floor of a whinstone quarry, 1 26-lb. General Wade charge produced a gash in the target plate 3.5 in. deep, 15 in. long, and 5 in. broad at the surface. A scab, 22 in. in diameter and 5 in. deep at the deepest point, was knocked off the back of the plate. Against 2-in. armor plate, the charge cut through, cracking and shattering the plate. The General Wade also penetrated 2 2-in. thick armor plates, 1 on top of the other. It was concluded that the General Wade charge was suitable for assault blasting when a made-up charge of high efficiency, easily positioned, and quickly connected in multiple was desired. One 26-lb. "Flying Dustbin", fired against a 3-ft. reinforced concrete wall, bared the reinforcement and removed the top of the wall. Against a 4-ft. wall, 4 26-lb. "Flying Dustbins" stripped the concrete over a 6.6-ft. gap and knocked some of the bars out. Against a 6-ft. wall, 9 26-lb. "Flying Dustbins" produced a 12-in. wide gap and broke most of the bars. One 30-lb. Hayrick charge fired at a 4-ft. wall produced surface damage, knocking out the first reinforcement bars. Tabular data follow for comparative tests against a 3-ft. thick concrete wall:

BEEHIVE	GENERAL WADE	FLYING DUSTBIN
6-lb. explosive charge. Hole 3 in. diam. Some cratering in front and little spalling in rear.	26-lb. explosive charge. Surface damage 4 ft. x 4 ft. x 12 in. deep. Two bars out.	26-lb. explosive charge. Reinforcement bared over semicircle 4-ft. diam. Top of wall removed.

L81

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
GENERAL WADE CHARGES. June 24, 1943, 2p.
(AC 4283; SC.38; C. 12, OSRD Liaison Office WA-750-12) Confidential

Two tests were carried out on reinforced concrete "T" beams, 3 ft. deep and 1.4 ft. thick. Both charges were tamped with 2 layers of sand bags around the sides and top. The 13-in. and 17-in. base General Wade charges used produced gaps in the roadway, cut the tension bars, and demolished the beams; the 17-in. charge bent the tension bars more. An addendum is included on the detonation of a 30-lb. Ammonal charge which produced a gap in the roadway, and pressed down the tension bars at a steeper angle than the General Wade charges.

L82

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
ANTI-CONCRETE MEETING. NOTES ON CONFERENCE HELD AUG. 4, 1943. Aug. 10, 1943, 3p. (AC 4561; C.29; OSRD Liaison Office WA-1091-1s) Confidential

The meeting was concerned with the most suitable design of a rocket projectile which would effect disruption of a 10-ft. thick wall when fired from a projector on the ground or mounted in some kind of craft. Consideration was given to the size and weight of explosive head required to clear a tank breach in reinforced concrete walls which would be encountered, and to the size and weight of explosive head required to neutralize enemy pillboxes.

L83

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
A STUDY OF THE MECHANISM OF HOLLOW CONED CHARGES, by H. Kolsky and others. Aug. 24, 1943, 11p. illus. diagrs. (AC 4633; SC.50; OSRD Liaison Office WA-1201-29) Confidential

Penetration of shaped charges (6 mm. and 1 cm.) into various targets (mild steel, polythene, polymethyl methacrylate, paraffin wax, etc.) was investigated, and the mode of deformation of the Cu and steel liners was studied. Bimetallic liners 1 cm. in diameter, consisting of a Cu and steel layer bonded together, were fired into polythene and into water. A pointed fragment was found at the bottom of the hole in the polythene, and a slug and secondary fragment were also found. A method of photographing jets is described. The jet of explosive products obtained from these shaped charges was formed by a hydrodynamic compression of the liner by the explosion, and the penetration was due initially to certain fragments, the weights of which were less than 0.1 that of the liner. The liner thickness-slug weight relationship was investigated. (Also published as Part I of item no. L1144.)

L84

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
PLASTER SHOTS ON WALLS. Nov. 17, 1943, 2p. (AC 5184; C.59; OSRD Liaison Office WA-1441-9) Secret

General Wade charges were considered for breaching a maximum wall thickness. (A breach was defined as a gap of 12-ft. effective width leaving little or no step or crater.) Using these charges, the maximum thickness should be taken at 12, 9, and 6 ft. for lightly, medium, and heavily reinforced concrete walls, respectively. Tests indicated that these figures were satisfactory for light and medium reinforced walls, but uncertain for heavily reinforced walls.

L85

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
EXPERIMENTS ON THE REFLECTION OF INCLINED SHOCK WAVES, by G. H. Lean. Dec. 14, 1943, 12p. illus. diagrs. (AC 5348; Phys/Ex. 501; OSRD Liaison Office WA-1682-15) Secret

An investigation was made of an abnormal type of reflection of inclined shock waves in a supersonic air stream to provide quantitative experimental evidence on the occurrence of phenomena predicted by von Neumann on theoretical grounds. In this abnormal type of reflection a third shock wave was formed at the wall near the point of reflection. The theoretical results were verified experimentally at $M = 2.6$, where Mach reflection occurred at an inclination of the incident shock wave of 41° at a wedge angle of 19°. At greater inclinations of the incident shock wave, the motion became more complex, the Mach shock became curved, and the inclination angle of the reflected shock wave decreased. Also, the vortex sheet behind the Mach shock became inclined to the airflow direction.

L86

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
TEST REPORT ON THE EFFECT OF PLASTER AND GENERAL WADE CHARGES. Dec. 29, 1943, 3p. table, diagr. (AC 5441; C.70; OSRD Liaison Office WA-1569-5) Secret

A comparison was made of the effect of correctly and badly placed plaster and General Wade charges. It was recommended that whenever possible the General Wade charge be used in preference to plaster charges because weight for weight they give better results with better cutting and the loss in effect due to bad placing is not so pronounced.

L87

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
DEMOLITION OF 1:10 SCALE MODEL REINFORCED CONCRETE SOLID VAULT ARCH BRIDGES WITH MODEL GENERAL WADE CHARGES. REPORT OF EXPERIMENTS CARRIED OUT AT BOVINGTON ON JAN. 4TH, 1944. Jan. 29, 1944, 3p. (AC 5633; C.83; OSRD Liaison Office WA-1948-5) Secret

Model General Wade charges, 15.5-in. long filled with 25/75 PETN-TNT with 4 CE pellets in each charge, were fired against a 1:10 scale model bridge to determine the effect of untamped charges in the demolition of the crown of reinforced concrete solid vault arch bridges. With these charges, a gap 10 to 12 in. wide was produced in the bridge, and all the reinforcement was cut. Results of full scale tests showed that an untamped charge of 5500 lb. of Pentolite in twin General Wade containers holding, together, 105 lb. of Pentolite/ft. and stretched across the full width of the bridge would cut through 25 in. of filling and 16 in. of reinforced concrete to make a gap from 8 to 10 ft. wide. The abutments and cantilever ends of the arch were undamaged.

L88

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
HOLLOW CHARGE FOLLOW THROUGH PROJECTILE. Apr. 26, 1944, 6p. incl. illus. diagrs. (AC 6208; SC. 84; OSRD Liaison Office WA-2174-18)
Secret

Experiments were performed using a mild steel rod or a central tube as a follow-through projectile which was embedded in the explosive charge. The embedded portion acted as a guide or brake for the follow-through projectile.

L89

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
A STUDY OF THE MECHANISM OF SHAPED CHARGES WITH HEMISPHERICAL LINERS, by H. Koisky. May 26, 1944, 12p. incl. illus. (AC 6399; SC. 97; OSRD Liaison Office WA-2539-16)
Secret

Small cylindrical charges with hemispherical liners of Cu or mild steel were fired into targets of polythene and of mild steel to investigate the jet characteristics. Although penetration of the jets into targets was very similar to that obtained with comparable shaped charges, the mode of deformation of the liner, and the distribution of the particles in the jet, differed considerably in the 2 cases. (Also published as Part II of item no. L1144.)

L90

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
TESTS ON REINFORCED WALLS AT FOULNESS - SUPPLEMENTARY TRIALS. COMPARISON OF PERFORMANCE OF GENERAL WADE CHARGES (CHARGE DEMOLITION NO. 2. 25-LB. MK. I) WITH VARIOUS FILLINGS - 23rd JUNE 1944. June 23, 1944, 5p. incl. illus. (AC 6716; C. 162; OSRD Liaison Office WA-2666-3)
Secret

Results are given for a comparison of General Wade charges containing 25/75 Pentolite, Explosive 851, 50/50 RDX-TNT with 17% dibutylphthalate-nitrocotton gum as desensitizer, and 50/50 RDX-TNT with 8.5% dibutylphthalate-nitrocotton gum.

L91

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
THE PROTECTION OF STEEL TARGETS FROM ATTACK BY SHAPED CHARGES. I. REPORT BY THE EXPLOSIVES MANUFACTURING PRACTICES LABORATORY, AUSTRALIA (REPORT NO. MEM (A) 13). III. PROTECTION OF STEEL TARGETS BY NON-METALLIC SUBSTANCES, WITH SPECIAL REFERENCE TO OXIDIZING AGENTS (ARD EXPLOSIVES REPORT NO. 638/44). Sept. 25, 1944, 10p. (AC 7015; SC. 112; OSRD Liaison Office WA-3251-14)
Secret

I. Three methods of defeating the penetrative power of shaped charges were considered: (a) explosives; (b) oxidizing agents; and (c) plastic compounds. Type a was not thought to be applicable to tank defense, but types b and c were practical. Type b was found superior to type c. Both of these were superior to armor plate, giving adequate protection at small increase in weight. III. Experiments were made with jets from 1.38-in. diameter scale 45° liners passing through various layers of oxidizing substances. Standard shaped charges were used at 1 diameter away from layers of barium nitrate, barium chlorate, etc. Results showed that nonmetallic substances protected the main target by reducing the depth of penetration and the crater volume. On a weight basis, sodium carbonate dehydrate was the most favorable protecting material. Barium perchlorate, dry sand, barium chlorate, and possibly barium nitrate and potassium perchlorate were more efficient in arresting jets than metallic materials capable of plastic flow.

L92

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
REPORT ON DAMAGE BY SHAPED CHARGE BOMB. Oct. 13, 1944, 5p. incl. illus. (AC 7107; SC. 118; OSRD Liaison Office WA-3251-15; Inclosure 1 to MA London rept. no. 2315-44)
Secret

A summary is given of the damage caused by a German shaped charge bomb of the composite aircraft type. The crater was approximately circular, 45 ft. in diameter and 11 ft. deep. From the crater there was a trench about 9? ft. long. The area of total destruction o[illegible] es was about 250 ft. long. Details of the damage are described and photographs are included.

L93

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
SHAPED CHARGES SUBCOMMITTEE; REPORT OF A MEETING HELD ON NOV. 14TH, 1944. THE PROTECTION OF AFV'S AGAINST ATTACK BY HOLLOW CHARGES. Nov. 28, 1944, 2p. (AC 7413; SC. 122; OSRD Liaison Office WA-3606-17)
Secret

Brief discussions are reported on oxidizing salts to destroy Munroe jets and various protection methods such as spaced assembly on existing tanks, wire mattress (flexibly mounted to cause the projectile to rebound), spikes, and use of natural aggregates with and without bitumen.

L94

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
THE COLLAPSE OF LININGS IN SHAPED CHARGES, by M. R. Jefferis. July 24, 1945, 5p. diagrs. (AC 8434; SC. 154; OSRD Liaison Office WA-5206-5) Secret

A mathematical treatment of the collapse of a hemispherical liner postulated on the hydrodynamic theory of jet formation is presented.

L95

Advisory Council on Scientific Research and Technical Development (Gt. Brit.).
VELOCITY GRADIENT IN SHAPED CHARGES WITH CONICAL LININGS, by M. R. Jefferis. July 24, 1945, 4p. illus. diagr. (AC 8435; SC. 155; OSRD Liaison Office WA-5206-6) Secret

A "complete and perfect" slug from a conical liner was compared as to weight, length, and shape with the predictions of the hydrodynamic theory for this liner. The considerable variations are explained by a velocity gradient modification of the theory. It is assumed that the initial velocity imparted to the liner is not uniform but falls off toward the skirt. A simple assumption of velocity distribution is made and its implications analyzed geometrically.

L96

Aerojet Engineering Corporation (N7onr-462, Task Order 2).
RESEARCH ON ROCKETS AND OTHER VEHICLES AS CARRIERS OF SCIENTIFIC INSTRUMENTATION, by F. Zwicky and others. Semi-annual rept. Dec. 1, 1947-July 8, 1948. Aug. 26, 1948, 73p. incl. illus. diagrs. (Rept. no. 326) TIP C1156 Confidential

Investigations are being made of generating jets of particles whose velocities are well into the hypersonic range, and should at the same time be as massive as possible in order to be seen at great distances. The generation of luminous particles and the luminosity originating at the time the particles are fired were studied. Preliminary investigations are reported of the factors affecting the trajectory of shaped charges under ordinary atmospheric conditions.

L97

Aerojet Engineering Corporation (N7onr-462, Task Order 2).
RESEARCH ON ROCKETS AND OTHER VEHICLES AS CARRIERS OF SCIENTIFIC INSTRUMENTATION, by F. Zwicky and others. Quarterly summary rept. July 9-Oct. 9, 1948. Dec. 23, 1948, 44p. incl. illus. diagrs. (Rept. no. 346) TIP C1932 Confidential

Tests seemed to indicate that in order to produce observable shaped charge jets for extreme altitude work, it is necessary to form liners of metallic powder mixtures which will react exothermically at the temperature of the collapsing liner. Shaped charge firings are reported.

L98

Aerojet Engineering Corporation (N7onr-462, Task Order 2).
RESEARCH ON ROCKETS AND OTHER VEHICLES AS CARRIERS OF SCIENTIFIC INSTRUMENTATION, by F. Zwicky and others. Final rept. Dec. 1, 1947-Jan. 31, 1949. [1949], 15p. illus. diagrs. (Rept. no. 362) TIP C1962 Confidential

Shaped charges, fitted with metallic or other solid conical liners, were investigated for use as tertiary rockets in experiments to reach the remote regions of shape. The slow slug and extruded jet of very fast small particles which may attain velocities of the order of the detonation velocity are intended to play the role of test particles whose speeds and spectra may be observed to determine the laws of hypersonic aerodynamics and the composition of the media traversed. Firing results are indicated.

L99

Aerophysics Development Corporation (DA-04-495-ORD-284).
FEASIBILITY STUDY OF THE DART ANTITANK MISSILE, by W. Bollay and others. Aug. 15, 1952, 64p. illus. diagrs. (Rept. no. 106-5) AD-15 224 Confidential

The proposed shaped charge warhead for the DART missile is discussed. The warhead is described as a 20-lb., 8-in. diameter shaped charge fitted with an Al liner having an apex angle of 90°. This charge will penetrate 14-16 in. of armor plate and produce maximum damage beyond defeatable armor. Al is chosen as the liner material since it is particularly effective in igniting heavy fuel oil similar to that used in Russian tanks, and because this material is less sensitive to deviations at optimum standoff distance than is Cu.

L100

Aerophysics Development Corporation (DA-04-495-ORD-404).
DEVELOPMENT STUDY OF THE DART ANTITANK MISSILE, by W. Bollay and others. Apr. 2, 1953 [120]p. illus. tables, diagrs. (Rept. no. 1003-1-R2) Confidential

Two experimental warheads containing 8-in. shaped charges with a cone angle of 60° and an Al liner 3/8-in. thick were tested for use in the DART missile. The first firing was made against an 8-in. armor plate at 0° obliquity and a 16-in. standoff. The charge easily penetrated the target plate, the hole diameter being 2 in. Calculations indicated that the luminous part of the jet rose to a height of about 80 ft. This test indicated that the charge penetration was considerable, approximately 25 in. in mild steel or 20 in. in armor plate. It was concluded that by either decreasing the standoff distance or changing the liner angle, a larger hole and increased damage would result. In the second firing, the shaped charge was tested against a 5-in. armor plate at 55° and an 8-in. standoff. A larger hole resulted than in the first firing and the height of the jet obtained was approximately 30 ft. Considerable fragmentation and spalling occurred at the exit hole. It was concluded that the effectiveness of the charge was not decreased at 55° obliquity.

L101

Aerophysics Development Corporation (DA-04-495-ORD-404).
DART ANTITANK MISSILE, by F. K. Feldman. Progress rept. June 1, 1953, 10p. tables, diagrs. (Rept. no. 1003-2-R1) Confidential

Tests were conducted on the shaped charge warheads for the DART missile, a ground-launched, rocket propelled antitank weapon. Static penetration tests of the assemblies were made against 6-in. armor plates stacked to a thickness of 18-in. The pertinent data follow:

Standoff (charge diam.)	Apex angle of Al liner (°)	Liner weight
1	60	4.03
1	60	4.03
2	60	4.03
2	45	5.15

Comp. C3 (lb.)	Hole vol. (cu. in.)	Hole depth (in.)
10.6	42	9-3/8
10.7	101	11-5/8
10.6	43	13.0
14.2	5[illegible]	14.25

L102

[Aircraft Armament Experimental Establishment (Gt. Brit.).]
AIR FIRING TRIALS WITH 60-LB. HE/GP (HOLLOW CHARGE) ROCKET SHELL AGAINST TANKS. Mar. 11, 1946, 3p. (Inclosure 1 to MA London rept. no. R2731-46) Confidential

Tests are described which compare the 60-lb. shaped charge rocket head containing 16 lb. of 50/50 RDX/TNT with the 60-lb. semi-armor-piercing rocket head containing about 13 lb. of HE when fired from aircraft against Churchill and Panther tanks and a Jagdpanther gun motor carriage.

L103

Allegany Ballistics Laboratory, George Washington University (OEMsr-273).
T59 HIGH-VELOCITY ROCKET GRENADE (SUPER BAZOCKA), by S. Golden and others. Final rept. Dec. 1945, 142p incl. illus. tables, diagrs. (Series W, no. 6) (NDRC Div. 3) OSRD 5779 Confidential

A detailed account is given of this shaped charge 2.36-in. rocket grenade. The rept. is chiefly concerned with rockets - internal ballistics, propellants, etc. A number of progress repts. on the T59 are listed in a bibliography.

L104

Allied Force Headquarters (Gt. Brit.).
TECHNICAL INTELLIGENCE SUMMARY NO. 16. Jan. 4, 1944, Part IV, p. 2-3, Annex H. Secret

Brief comments are made on the German 300-g. shaped demolition charge. These charges were not effective against volcanic rock; however, they were very effective on 7/16-in. hardened steel plate. With 3-in. armored steel plate, a cavity only 0.25 in. deep was produced.

L105

Alsos Mission, USFET.
MISZNAY (SCHARDIN) EFFECT, by G. H. Wannier. Sept. 10, 1945, [7]p. incl. diagrs. (Rept. no. GHW/297) Confidential

An English summary is given of a German rept. on a modification of the shaped charge effect which was discovered by Misznay, and on German efforts to apply it to the development of new arms. The information is drawn from the Osenberg files at "Dustbin". A short historical reference is given by General Schneider, Head of Wa Prüf. The experiment is described in its primitive form. It was found that the destructive effect of the shaped charge detonation could be checked under certain circumstances. The directed explosion could be made to accelerate a solid object. In the experiment of Schardin, the shaped charge accelerated a disc of about its own weight. The resultant motion was remarkable for its high velocity (8000 ft./sec.) and its small angle of scattering (20' of arc at a distance of 400 ft.). The work done in the Planungsamt is also summarized.

L106

American Machine and Foundry Co. (DA-30-069-ORD-1168).
FEASIBILITY STUDY OF BOOSTED-ROCKET TANK WEAPON, by [K. H. Jacobs]. Final rept. Feb. 3, 1954, 87p. tables, diagrs. (Ordnance proj. no. TU2-1035) Confidential

This study showed that development of HEAT ammunition having the following characteristics was feasible:

Caliber	105 mm.
Warhead	shaped charge
Explosive charge	2.79 lb. HE
Penetration	6-in. armor (60° obliquity)
Standoff	7.5 in.
Muzzle velocity	1200 ft./sec.
Velocity at 2000 yds.	1800 ft./sec.
Fin-stabilized	

It was pointed out that many of the details and characteristics of the proposed ammunition were patterned after the 105-mm. T119 BAT round. In an appendix, the shaped charge warhead was briefly discussed and the problem of spin compensation was considered from the standpoint of the boosted rocket.

L107

Ammunition Development Division, Research and Development Service, War Department.
ROCK PENETRATION TESTS OF M3, 40-LB. SHAPED CHARGES. July 1945 (?) 2p. illus. TIP C59434 Confidential

Data are given for static tests of M3, 40-lb. shaped charges against lava, sandstone, limestone, and concrete surfaces. Photographs show the craters made by these charges.

L108

ANALYSIS OF CHINESE 3.5-IN. (87-MM.) ROCKET. Ordnance Intelligence Summary, v. 2, serial no. 15, Dec. 15, 1951: 3-4. Secret

A brief description of the Chinese 87-mm. HEAT rocket is given. The 55° shaped charge liner is made of hot-rolled steel and appears similar in configuration to the shaped charge liner of some American HEAT weapons. The liner was crudely made.

L109

Antiaircraft Artillery Board, Fort Bliss.
SERVICE TEST OF EXPLOSIVE SHAPED CHARGE T3, by F. E. Gross. Jan. 27, 1945, 4p. illus. appendixes A-C. Restricted

Tests were made to determine the suitability of the T3 shaped charge as a means of defense against low-flying aircraft. The T3 charge weighs 40 lb. (includes 20 lb. of HE), is 9.5 in. in diameter, 15 3/8 in. high, and has a steel liner. Tests made to determine the side blast effect of the charges, fired both singly and in groups of 5 showed only a few small holes in the targets from a single charge, while the group of 5 charges ripped all the target cloths from the frame. An inspection of the damage sustained by the CQ3 target plane indicated that the T3 charges were capable of damaging or destroying low-flying aircraft, but accurate fire control was absolutely necessary.

L110

Applied Physics Laboratory, Johns Hopkins University.
ANALYSIS OF THREE NEW MEXICO PHOTOGRAPHS OF HOLLOW PROJECTILES IN SUPERSONIC FLIGHT, by E. M. Eichelberger. Jan. 8, 1946, 1p. memo. (JHU-APL/CM-186) Confidential

Three photographs were analyzed by the method of CM60 to find drag coefficient C_D and shock wave θ_W. Values obtained are compared with Taylor-MacCall values for cones. [This abstract assumes that hollow projectiles might possibly refer to shaped charge projectiles.]

L111

Applied Physics Laboratory, Johns Hopkins University.
TASK H (BUMBLEBEE CANNONBALL). Quarterly progress rept. July 1-Sept. 30, 1952. Nov. 15, 1952, p. 6-7 incl. illus. (Rept. no. APL/JHU TG-156-1) Secret

A shaped charge warhead was designed for the 150-lb. Cannonball spherical service missile. No tests of this warhead have been made; however, it is estimated that penetrations of armor ranging from about 12 in. at 7-in. standoff to about 21 in. at 20-in. standoff will be obtained.

L112

Applied Physics Laboratory, Johns Hopkins University.
TASK H. Quarterly progress rept. Oct. 1. - Dec. 31, 1952. Mar. 5, 1953, p. 15. (Rept. no. APL/JHU TG-156-2) Secret

Shaped charge warheads for the 150-lb. Cannonball spherical missile were fired against armor plate at the Aberdeen Proving Ground. Confirming extrapolation of existing data (item no. L111), these tests gave penetrations of 12 in. and approximately 18 in. at standoffs of 7 in. and 10 in., respectively. The jet penetrations were accompanied by considerable blast effects.

L113

Arctic Test Branch, Army Field Forces.
GRENADE, RIFLE, M1, HEAT, ENERGA (ARCTIC PHASE II). Mar. 27, 1953, [17]p. incl. illus. (Proj. no. 2355(ATB)) AD-8089 Secret

This grenade is a fin-stabilized, point-initiated, base-detonated, shaped charge projectile. It is effective against armor at any range at which a hit can be obtained and does not depend on muzzle velocity to obtain penetration. At 70°F, the grenade has a muzzle velocity of 174 ft./sec., a maximum range at 45° elevation of 328 yd., and a usable range of approximately 100 yd. The grenade was stable in flight but did not function satisfactorily on graze impact on snow-covered frozen terrain. The fuze functioning of the grenade was not satisfactory against ice-crete-covered, sloped armor plate at -5° to -11°F. The functioning of cold-soaked grenades against bare armor plate and of the flash barrier assembly was satisfactory at -15° to -22°F. Moisture accumulated in and froze the tops of the fiber grenade containers, making the tops difficult to remove. An arctic trigger for the M1 rifle was considered essential to allow a rifleman to handle the grenade effectively in sub-zero temperatures. The fuze of the grenade was not sufficiently sensitive to ensure detonation on all surfaces other than bare armor. Details of tests are included in the appendixes. (TIP abstract)

L114

Armament Design Establishment (Gt. Brit.).
A THEORETICAL TREATMENT OF THE MISZNAY-SCHARDIN EFFECT, by F. Chorlton. Sept. 1950, [24]p. incl. tables, diagrs. (ADE Technical rept. no. 10/50; [Inclosure 1 to ORD-TRART-314]) TIP S51273 Secret

The Misznay-Schardin or end effect is the phenomenon in which metal at 1 end of a cylindrical or shaped HE charge is projected at very high velocity in a forward direction by a detonation wave initiated from the other end. A new theoretical treatment is presented for predicting fragmentation velocities obtained from suitably designed liners when TNT is used as detonator. The method used is based on Lagrange's problem in interior ballistics.

L115

Armament Design Establishment (Gt. Brit.).
DEVELOPMENT OF A 2.62-IN. DIAMETER PRESSED LINER FOR SHAPED CHARGES, by A. V. Feist. Progress rept. Sept. 1952, [15]p. incl. tables, diagrs. (ADE Technical rept. no. 15/52) Secret

Cu and 70/30 cartridge-brass liners, filled with RDX/TNT 60/40, were tested against homogeneous armor plate targets 147.7 mm. to 258 mm. thick at standoffs ranging from 4.1 in. to 8.2 in. From the test firings it was concluded that: (1) the cartridge-brass liners' performance compared favorably with the standard Cu liners; (2) the addition of spit-tubes was not worthwhile; and (3) no advantages were obtained with peripheral initiation of RDX/TNT 60/40 because of the pourability problem of cavitation. Tabular data are given for all firings in an appendix.

L116

Armament Research Department (Gt. Brit.).
THE PERSISTENCE OF MUNROE JETS. ATTACK ON MULTIPLE PLATE TARGETS. PART I, by W. M. Evans and A. R. Ubbelohde. Nov. 1942, 17p. incl. tables, diagrs. (ARD Explosives rept. no. 355/42; AC 3095, Nov. 23, 1942, Phys/Ex. 347; OSRD Liaison Office WA-498-20) Confidential

The investigation was undertaken to obtain information on the effect of spacing the stopping material at various intervals to compare it with the limiting case of a massive slab. Results are given for charges of 1-3/8 in. diameter used in an attack of multiple steel plates with jets from various shaped charges with mild steel liners. It was noted that as the air gap between the layers was increased from light contact to several charge diameters the penetration loss became roughly constant for each gap. A comparison of mild steel and armor plate targets showed that penetration through armor plate was approximately 0.8 times that through mild steel plates. The most persistent jets of approximately equal penetration were obtained from perfectly machined 80° liners, from pressed steel hemispheres, from pressed 80° liners, and from pressed welded 45° liners.

L117

Armament Research Department (Gt. Brit.).
CAVITY EFFECT OF HIGH EXPLOSIVES. A SUMMARY OF RECENT WORK ON HOLLOW CHARGES AND THEIR SERVICE APPLICATIONS. Jan. 1943, 55p. illus. diagrs. (ARD Explosives rept. no. 28/43; AC 4026, May 14, 1943; SC. 29; OSRD Liaison Office WA-746-29) Secret

The summary is concerned primarily with the work of the Armament Research Department from the middle of 1941 to the end of 1942. Lines of research in other departments are indicated. An outline of the present theoretical aspect of the subject is given. Thirty-six pages of pertinent diagrams, graphs, and photographs are included.

L118

Armament Research Department (Gt. Brit.).
5-IN. DIAMETER FOLLOW-THROUGH BOMB (EXPERIMENTAL DESIGN). FIRING TRIALS AGAINST 1.25-IN. MS PLATE. Jan. 1943, 7p. incl. illus. diagrs. (ARD Explosives rept. no. 19/43; AC 3694, Mar. 13, 1943; SC-12; OSRD Liaison Office WA-591-9) Confidential

Tests were carried out with a 5-in. diameter bomb to determine the effect of increasing the linear scale of the bomb approximately 3 times. Results indicated that the follow-through mechanism will operate on a scale as large as that of the 5-in. diameter bomb which was capable of making a 5-in. diameter perforation in a 1.25-in. mild steel plate and propelling a 3-in. diameter projectile through the hole.

L119

Armament Research Department (Gt. Brit.). GERMAN 105-MM. HOLLOW CHARGE SHELL (GUN HOWITZER) IFN. 18. Jan. 1943, 4p. incl. diagrs. (ARD Metallurgical rept. no. 17/43) Confidential

Results are reported of a metallurgical examination made of this shell.

L120

Armament Research Department (Gt. Brit.). ITALIAN 75/27 HOLLOW-CHARGE SHELL. Jan. 1943, 4p. incl. diagrs. (ARD Metallurgical rept. no. 3/43) Confidential

Results of a metallurgical examination of the emptied shell are presented.

L121

Armament Research Department (Gt. Brit.). REPORT ON 7.5-CM. GERMAN 75/27 ITALIAN HOLLOW-CHARGE AMMUNITION. Jan. 1943, 8p. incl. diagrs. (ARD Explosives rept. no. 15/43) Confidential

Results of examinations on these German and Italian shells are reported.

L122

Armament Research Department (Gt. Brit.). REPORT ON GERMAN 10.5-CM. GUN HOWITZER HOLLOW CHARGE SHELL. Jan. 1943, 3p. incl. diagr. (ARD Explosives rept. no. 16/43) Confidential

Results of an examination of this shell and the method of filling it are reported.

L123

Armament Research Department (Gt. Brit.). THE EFFECT OF LATERAL CHARGE CONFINEMENT ON MUNROE JETS (PART 1), by W. M. Evans. Feb. 1943, 24p. incl. tables, diagrs. (ARD Explosives rept. no. 60/43; AC 3518, Feb. 22, 1943; SC. 5; OSRD Liaison Office WA-526-14) Confidential

Shaped charges 1 in., 1 3/8 in., and 2 in. in diameter having 80° liners, hemispherical liners, and disc liners of Cd or steel were fired under varying degrees of lateral confinement against massive steel targets. This investigation was to determine how target damage varied with the amount of confinement and to confirm the scaling laws between the charge and target damage and to determine how confinement fits into the laws of scaling. Results are tabulated and also presented graphically.

L124

Armament Research Department (Gt. Brit.). GERMAN DEMOLITION CHARGE (HOLLOW CHARGE TYPE). Feb. 1943, 2p. illus. (ARD Metallurgical rept. no. 38/43; OSRD Liaison Office II-5-3572) Secret

Results of a metallurgical examination of the emptied demolition charge are reported.

L125

Armament Research Department (Gt. Brit.). THE CUTTING ACTION OF DIRECTED FRAGMENTS, by T. Nash and A. R. Ubbelohde. Mar. 1943, 9p. diagrs. (ARD Explosives rept. no. 67/43; AC 3602, Mar. 27, 1943; SC. 4; OSRD Liaison Office WA-542-35) Secret

Experiments are described on the direction of fragments by detonation waves when these fragments meet surfaces of steel and of fluid metals. Results from these experiments had some bearing on the possibility of jet formation by the collision of fragments and on the mechanism of fragmentation by detonation waves. From the study of charge design, it was concluded that a cusp of revolution of suitable shape and material gave rise to a cutting tube of fragments whose properties were of value in attacking certain targets.

L126

Armament Research Department (Gt. Brit.). MUNROE JETS WITH PERTURBED SYMMETRY. (THE MECHANISM OF JET FORMATION), by T. Nash and A. R. Ubbelohde. Mar. 1943, 6p. diagrs. (ARD Explosives rept. no. 85/43; AC 3849, Apr. 16, 1943; SC. 21; OSRD Liaison Office WA-601-14) Confidential

Charges of 1 3/8-in. diameter were modified by using paper in place of thick steel confinement to avoid complications from particles from the casing. Perturbations were introduced by tilting the charge axis at various angles to the axis of the detonation wave. As the angle between the charge axis and the detonation wave was progressively increased up to 60°, the angle between the charge axis and the direction in which the jet was found to travel likewise increased. Results are diagramed for steel and Cd liners. Observations and other experiments supported the view that jet formation results from inelastic collisions between liner particles, and possibly between particles and shock waves leading to a compensation of momenta in all directions except that of the propulsion of the jet.

L127

Armament Research Department (Gt. Brit.).
THE COMPARATIVE PERFORMANCE OF DISCS AND HEMISPHERES IN CS BOMBS, by A. R. Ubbelohde. Apr. 1943, 4p. (ARD Explosives rept. no. 86/43; AC 3848, Apr. 16, 1943; SC.20; OSRD Liaison Office WA-620-15)
Confidential

Experiments were made to compare the performance of the CS disc [liner] with a steel hemisphere of suitable thickness, and to compare the effect on penetrating power of solid steel and laminated steel confining the explosive. Previously it was shown that, for attack on multiple plate targets, the most persistent jets were obtained from steel liners of suitable thickness and of conical or hemispherical shape. Experiments were performed to confirm this information using larger liners, and laminated steel spirals for confining the disc.

L128

Armament Research Department (Gt. Brit.).
THE FOLLOW-THROUGH BOMB. Apr. 1943, 8p. diagrs. (ARD Explosives rept. no. 126/43; AC 4062, May 18, 1943; SC.31; OSRD Liaison Office WA-668-13)
Confidential

Experiments were designed to reduce to a minimum the back axial pressure from the high explosive. Some of the results from these experiments were applied to a follow-through bomb where the end of the HE charge farthest from the target was in the form of an 80° cone. With a charge 1.75 in. in diameter, a hole 0.95 in. in diameter was made in a 0.5-in. mild steel plate, and bullets 0.75 in. in diameter were projected through it at normal and at 30° angle of incidence. The follow-through mechanism was a bullet with a hole drilled through it mounted between the shaped charge and an explosive; when the charge was detonated, gas passed through the hole in the bullet, ignited the explosive, and the bullet was driven through the hole made by the shaped charge.

L129

Armament Research Department (Gt. Brit.).
GERMAN 7.5-CM. HOLLOW CHARGE SHELL. Apr. 1943, 2p. illus. diagr. (ARD Metallurgical rept. no. 90/43; OSRD Liaison Office II-5-3780)
Secret

Results of a metallurgical examination of the emptied shell are reported.

L130

Armament Research Department (Gt. Brit.).
GERMAN 7.5-CM. HOLLOW CHARGE SHELL. Apr. 1943, 2p. illus. diagr. (ARD Metallurgical rept. no. 105/43)
Confidential

Results are reported of a metallurgical examination made of this shell.

L131

Armament Research Department (Gt. Brit.).
DAMAGING PROPERTIES IN MASSIVE STEEL TARGETS OF JETS FROM MUNROE CHARGES LINED WITH ALUMINUM, by W. M. Evans. May 1943, 5p. tables, diagrs. (ARD Explosives rept. no. 158/43; AC 4173, June 6, 1943; OSRD Liaison Office WA-722-12)
Confidential

An investigation was made of the damage in mild steel targets caused by charges lined with low density Al. The results were compared with charges lined with steel and Cd. At firing distances up to about 6 charge diameters from the target, the craters due to shaped charges with Al liners were much wider but much shallower than those due to corresponding charges with steel or Cd liners. At 7 charge diameters, the hole diameter and penetration were greater for Al than for steel or Cd. Results of logarithmic plots of entry diameter vs. penetration showed that the shallower liners obeyed the fragment law while the deeper liners tended towards a law intermediate between fragment and fluid. Test results showed that charges with Al hemispherical liners when linearly scaled in dimensions and fired at 1 diameter or 4 diameters from the target face produced corresponding linear scaling of damage. Tests also revealed that the percentage increase in volume of crater with lateral confinement (cardboard) was less for Al hemispheres than for steel or Cd; the percentage increase in penetration with confinement was less at 4 diameters for Al than for steel or Cd, but the increase in entry diameter was greater.

L132

Armament Research Department (Gt. Brit.).
FOLLOW-THROUGH BOMB FOR PENETRATION OF CONCRETE, by H. L. Porter and others. May 1943, 4p. table, diagrs. (ARD Explosives rept. no. 114/43; AC 4036, May 18, 1943; SC.30; OSRD Liaison Office WA-668-12)
Confidential

Trials were carried out on a 1:9 scale in collaboration with Road Research Laboratory in an attempt to produce a follow-through bomb that, on a 30-in. diameter scale, could project an explosive shell through 15 ft. of reinforced concrete. A 1.25-lb. shaped charge 3.75 in. in diameter having an 80° brass liner was used to penetrate a 20-in. reinforced concrete block and attempts were made to project solid steel bullets of various diameters and lengths through the resulting holes. The effects of reducing the propellant charge and of firing at an angle 30° to normal were included in the investigation. Diagrams of the follow-through bomb and test arrangement are included. Firing results are tabulated and discussed.

L133

Armament Research Department (Gt. Brit.).
GERMAN HOLLOW-CHARGE AMMUNITION FOR 7.5-CM. LG 40. (RECOILLESS EQUIPMENT.) May 1943, 6p. illus. diagrs. (ARD Explosives rept. no. 101/43; OSRD Liaison Office II-5-4102) Unclassified

The examination of this shell is reported. The essential differences from German shaped charge shells previously examined are: (1) a thicker 30° steel liner; (2) the flash tube leading from the gaine stopped at the apex of the liner instead of continuing to the nose fuze; and (3) a steel washer was fitted across the cavity, probably to prevent fuze fragments from reaching the liner. It is estimated that the shell will penetrate 70 mm. of homo armor plate (IT 80) at normal and 60 mm. at 30°.

L134

Armament Research Department (Gt. Brit.).
THE PERSISTENCE OF MUNROE JETS IN AIR. ATTACK ON MASSIVE TARGETS AT A DISTANCE, by W. M. Evans and A. R. Ubbelohde. May 1943, 10p. incl. tables, diagrs. (ARD Explosives rept. no. 172/43; AC 4221, June 15, 1943; SC.37; OSRD Liaison Office WA-722-13) Confidential

The investigation was concerned with geometrical factors affecting persistence of jets from 80° liners, the comparative persistence of jets from liners of different shapes and materials (steel, hardened Pb, Cd, brass, Al) damage caused by steel and Al jets at large distances (up to 68 diameters) and retardation of jets in air. Axial asymmetry in the liner decreased the stability of the jet from an 80° liner. Progressive decrease in thickness from base to apex of liners which were axially symmetrical led to less persistent jets than those from liners of uniform thickness. Comparison of various metal liners and shapes of charges indicated that the greatest penetration was obtained from jets from fluid metals and from deep hollows. Up to 68 diameters, steel and Al dishes gave effective jets. Calculated results agreed with observation that beyond a certain distance, fragment jets might show better persistence than fluid jets from the same liner shape.

L135

Armament Research Department (Gt. Brit.).
ENEMY MUNITIONS. GERMAN MAGNETIC ANTITANK GRENADE. June 1943, 2p. diagr. (ARD Explosives rept. no. 136/43; OSRD Liaison Office II-5-4696) Unclassified

A general examination and an analysis of the explosive components of this grenade are reported. The 60° mild steel liner was 2 mm. thick. It is estimated that the weapon will penetrate 110 mm. of homoplate (IT 80) and have considerable effect behind the target.

L136

Armament Research Department (Gt. Brit.).
GERMAN MAGNETIC HAND [ANTITANK] GRENADE (HOLLOW CHARGE). July 1943, 2p. illus. (ARD Metallurgical rept. no. 188/43; OSRD Liaison Office II-5-5013) Unclassified

Results of a metallurgical examination of this weapon are reported.

L137

Armament Research Department (Gt. Brit.).
THE PERSISTENCE OF MUNROE JETS. ATTACK ON SPACED (MULTIPLE) PLATE TARGETS, PART II, by A. R. Ubbelohde. July 1943, 17p. incl. tables, diagrs. (ARD Explosives rept. no. 191/43; AC 4491, July 30, 1943; Phys/Ex.461; OSRD Liaison Office WA-996-41) Confidential

The investigation was carried out to obtain more accurate comparisons of performance against spaced plate targets of jets from steel hemispheres and 45° and 80° steel liners. For normal attack in the absence of disturbing factors such as air spaces, the narrower jets from charges of the same weight penetrated a greater thickness of steel than the wider jets. Comparison of the total amounts of steel penetrated when the thickness of the plates was progressively decreased indicated that there was a loss of energy at the discontinuities, other than that associated with the punching out of fragments from the targets. In the case of attack at 45°, the energy losses at the discontinuities were greater than the normal attack with the jet from the 80° liner, and still greater with the 45° liner, while the jet from the hemisphere was not appreciably affected. It was noted also that the distribution of fragments appeared to be about the same with the 3 jet types investigated. The angle of scatter decreased as the energy of the jet became spent. Bright metallic deposits were formed on both the upper and lower sides of the plates; when these deposits formed on a layer of asbestos, they seemed to be composed of metal (steel) spheres ranging from 2×10^{-4} to 2×10^{-5} cm.

L138

Armament Research Department (Gt. Brit.).
COMPARATIVE FRAGMENT DAMAGE BEHIND ARMOR PENETRATED BY JETS FROM HOLLOW CHARGES CONFINED IN VARIOUS WAYS, by W. M. Evans. Oct. 1943, 4p. tables, diagrs. (ARD Explosives rept. no. 337/43; AC 5260, Dec. 1, 1943; SC.60, OSRD Liaison Office WA-1331-7) Secret

The investigation was to determine whether the mass and strength of the confining tube influenced the damage to the plate when it was easily penetrated, and the fragment damage behind the penetrated plate. Charges with 80° mild steel liners, confined in various ways, were fired at 30° normal and at a standoff of 2.5 in. from the main target plate. Results showed, for damage in main armor plate, that the hole diameter increased up to a limiting value with increase in lateral confinement of the explosive and depended not only on the mass but on the strength of the confining wall. Approximately the same hole diameter was produced by a thick-walled mild steel charge, as by a similar but thin-walled charge of the same external diameter but with explosive diameter increased by about 20%. For fragment damage behind the main armor plate, the damage tended to increase with increase in confinement of the explosive. Damage was somewhat less when produced by a thick-walled mild steel charge than for a similar but thin-walled charge with explosive diameter increased about 20%.

L139

Armament Research Department (Gt. Brit.).
C[UTTING] T[UBE] DAMAGE ON ARMOR PLATE, by T. Nash and A. R. Ubbelohde. Oct. 1943, 3p. diagrs. (ARD Explosives rept. no. 368/43; AC 5398, Dec. 20, 1943; SC. 68; OSRD Liaison Office WA-1388-12B) Secret

An investigation was made of the damage to armor plate by simple contact action of HE when a circular cut was first made in the armor. Simplified cutting tube charge heads were used. Damage was observed in experiments using 40- and 50-mm. homo armor plate, and at standoffs of 0.5 and 3 in. from the target. Fluid liners of 93:7 Pb-Sb were compared with conical steel liners, steel dishes, and with Mark E charge heads. Damage from a blow transmitted to armor from a flat ended charge was enhanced, if the edge of the charge was shaped so as to provide a cutting tube. This formed a circular crack, and allowed the following blast to push the central plug forward against less resistance than in the absence of the crack. The armor thickness penetrated under comparable conditions depended on the radius of this cutting tube. When penetration occurred, the central plug was pushed forward as a projectile. A rept. is appended on the use of simplified 3-in. cutting tube charge heads.

L140

Armament Research Department (Gt. Brit.).
THE INITIATION OF NOSE FUZED HOLLOW CHARGE SHELL. A NEW PRINCIPLE EXEMPLIFIED BY MODIFICATIONS TO THE NO. 243 FUZE MAGAZINE, by W. E. Soper and R. M. Laidler. Oct. 1943, 4p. diagrs. (ARD Explosives rept. no. 328/43) Secret

The investigation was concerned with a method by which a concentrated mass of fragments could be ejected from the base of the no. 243 fuze. The method was to weaken the end confinement of the magazine pellet at the center by drilling a hole through the magazine cap. The hole was then backed by a disc of thin brass immediately in contact with the magazine pellet. This modification had the effect of canalizing the energy emitted from the base of the fuze.

L141

Armament Research Department (Gt. Brit.).
MECHANISM OF JET FORMATION. THE ROLE OF FRAGMENTS IN MUNROE JETS. PART I, by G. E. Roberts and A. R. Ubbelohde. Dec. 1943, 24p. incl. illus. tables, diagrs. (ARD Explosives rept. no. 412/43; AC 6025, Mar. 30, 1944; SC. 77; OSRD Liaison Office WA-1918-9a) Secret

Fragments in jets formed from mild steel liners were investigated; the distribution of fragment sizes as a function of thickness and shape of the liner, and the extent of thermal and chemical interaction between the fragments and explosion products were determined. Various methods were examined for collecting the complete range of fragments from liners. Appendixes are included on the role of fragments in jets, current theories of jet formation, and a metallurgical examination of fragments.

L142

Armament Research Department (Gt. Brit.).
PERFORMANCE OF THE 3-IN. C[UTTING] T[UBE] CHARGE HEAD, by T. Nash and A. R. Ubbelohde. Dec. 1943, 5p. diagrs. (ARD Explosives rept. no. 271/43; AC 5572, Jan. 17, 1944; SC. 69; OSRD Liaison Office WA-1569-17) Secret

Experiments were performed to measure the limits of performance of a selected design of cutting tube charge head on the 3-in. diameter scale: The 3-in. Mark E design backed by 2.25-lb. PE penetrated 40 mm. at normal, 40 mm. at 15°, 35 mm. at 22.5°, and 27 mm. at 30°. The target hole aperture was 3.4 in. Compared with an ordinary shaped charge, the cutting tube head operated close in to the target, cooperated with the blast from the sides of the charge, and occupied considerably less explosive space in the charge than deep shaped charges. Shaped charges designed to give greater penetration gave holes of smaller aperture and pushed the target metal aside instead of punching it forward. Fuze systems were less likely to interfere with cutting tube performance than with shaped charges. Underwater penetration tests showed cutting tube charges superior to regular shaped charges. It was concluded that these charges might be useful in this respect, and particularly in enhancing the effect of ordinary charge heads.

L143

Armament Research Department (Gt. Brit.).
PROPOSAL FOR A "CUTTING TUBE" WARHEAD, by T. Nash and A. R. Ubbelohde. Dec. 1943, 3p. diagrs. (ARD Explosives rept. no. 421/43; OSRD Liaison Office WA-1628-11) Secret

A proposal is made that cutting tube charges be fitted into torpedo warheads. The cutting tube head is compared with the Munroe head, and the comparison is decidedly favorable to the cutting tube charge. The advantages are reported as: (1) able to act in contact with the target; (2) loss of explosive space not more than about 5%; (3) functioning not disturbed by an exploder system along the axis of the charge; (4) metal from target punched forward as large fragments capable of useful damage and the hole is equal to the diameter of the charge head; and (5) the penetrating power against armor plate is up to 0.55 diameters of the charge head.

L144

Armament Research Department (Gt. Brit.).
PENETRATION BY MUNROE JETS, by R. Hill and others. Jan. 1944, 8p. (ARD Theoretical research rept. no. 2/44; AC 5756, Feb. 18, 1944; SC.72; OSRD Liaison Office WA-1620-8)
Secret

Theoretical considerations of penetration in steel and other materials by jets are reviewed. A formula for depth of penetration was derived from which it was concluded that the penetration depth was independent of jet velocity and dependent only on the jet length and density. The cross-sectional area of the crater depended essentially on the flow stress, and experiments with materials of different yield strengths but similar densities were suggested to determine the relation between these quantities. For fluid and fragment jets, it was suggested that the crater produced by a jet of given velocity, density and linear dimensions would, for high velocities, be independent of jet material; the effect of different liners must be solely on the dimensions and velocity of the jet formed.

L145

Armament Research Department (Gt. Brit.).
THE ACTION OF FLUID MUNROE JETS AGAINST SPACED TARGETS. MULTIPLE PLATE TARGETS. PART III, by A. R. Ubbelohde. Feb. 1944, 18p. incl. tables, diagrs. (ARD Explosives rept. no. 518/44; AC 6362, May 22, 1944; Phys/Ex. 557; SC.93; OSRD Liaison Office WA-2216-14)
Secret

The investigation was made to determine the action of fluid jets on spaced targets composed of multiple plates of mild steel, armor plate, or in some cases, Pb plate. A comparison was made of the penetration power of fluid jets against spaced targets with that of persistent jets from steel liners. The scatter of particles behind the plates was compared with that of steel liner jets. Information is presented on the mechanism of jet target penetration, and on the effect of standoff on penetrative power.

L146

Armament Research Department (Gt. Brit.).
COMPARATIVE FRAGMENT DAMAGE BEHIND ARMOR PENETRATED BY JETS FROM VARIOUS HOLLOW CHARGES, by W. M. Evans. Feb. 1944, 16p. incl. tables, diagrs. (ARD Explosives rept. no. 529/44; AC 6196, Apr. 25, 1944; SC.83; OSRD Liaison Office WA-2096-26)
Secret

An investigation, using 45° and 80° brass, Al, and Cd liners, was made to gain information on the comparative fragment damage behind armor defeated by shaped charges with bases of various shapes and with various metal liners. Results showed that the number of fragments/unit cone angle of scatter of fragments diminished rapidly with increase in angle, the majority lying within 80°. Charges with steel liners gave better performance than those with Cd liners. The damage by deep strikes was greater for particle than for fluid jets. The residual particle jet was more persistent than the residual fluid jet.

L147

Armament Research Department (Gt. Brit.).
COMPARATIVE PERFORMANCE OF DEEP MUNROE CONES, by A. R. Ubbelohde. Mar. 1944, 8p. incl. tables, diagrs. (ARD Explosives rept. no. 551/44; AC 6304, May 10, 1944; SC.91; OSRD Liaison Office WA-2174-19)
Secret

The investigation was made to obtain experimental information on the performance of liners surrounded by a belt of explosive and meeting the end of the steel charge casing at a flat edge, compared with liners meeting the charge casing at a sharp angle; the performance of 19° liners of uniform thickness compared with 19° liners tapering in thickness towards the apex; and the comparative performance of uniform 19° and 45° liners. It was concluded that whenever design permitted, the Munroe hollow should extend to the edge of the charge casing to give it the maximum effective diameter. With targets at 1 diameter standoff, tapered liners appeared to give better performance than liners of uniform thickness. Test results showed that although fair performance could be obtained from the tapered 19° liners, more regular and more effective damage was obtained with 45° liners, which should, if practicable, extend to the edge of the charge.

L148

Armament Research Department (Gt. Brit.).
COMPARATIVE TERMINAL DAMAGE FROM MUNROE JETS, by A. R. Ubbelohde. Mar. 1944, 13p. incl. table, diagr. (ARD Explosives rept. no. 536/44; AC 6839; SC.111; OSRD Liaison Office WA-2748-14)
Confidential

Data were formulated from a statistical range of experiments on the attack of targets by jets so as to: (1) permit ready comparison of damage by specific designs incorporating shaped charges, thus measuring the efficiency of the design; and (2) compare the penetration from a given weight of charge with the damage by AP shot of the same weight. Comparisons were based on penetration and entry diameter of the holes produced.

L149

Armament Research Department (Gt. Brit.).
GERMAN 3.7-CM. PAK MUZZLE-STICK BOMB. Mar. 1944, 3p. incl. illus. diagr. (ARD Metallurgical rept. no. 69/44; OSRD Liaison Office WA-1992-11) Unclassified

Results of a metallurgical examination of an emptied, unfired muzzle-stick bomb are reported.

L150

Armament Research Department (Gt. Brit.).
PENETRATION OF ARMOR BY HIGH VELOCITY PROJECTILES AND MUNROE JETS, by R. Hill and others. Mar. 1944, 20p. (ARD Theoretical research rept. no. 13/44; AC 6024, Mar. 30, 1944; SC. 76; OSRD Liaison Office WA-1769-11) Secret

Jet penetration is discussed, consideration being given to a jet of liquid or solid metal with negligible flow stress for the latter case, and to a fragment jet which breaks up on impact. A study was made of the jet density as compared with the liner density. Calculations are included for loss of energy to target material and hole volume. It is shown that penetration depth is proportional to the jet length and depends on the density of the metal in it and on the target density. This penetration depth was found to be almost independent of jet velocity and yield strength of the target, which are factors determining the hole volume.

L151

Armament Research Department (Gt. Brit.).
PENETRATION OF PRE-HOLED TARGETS WITH APPLICATION TO AP SHOT AND BOMB, by H. L. Porter and W. M. Evans. Mar. 1944, 10p. incl. tables, diagrs. (ARD Explosives rept. no. 531/44; AC 6254, May 3, 1944; OSRD Liaison Office WA-2123-4) Secret

The investigation was undertaken to find how the work done by a bullet forced slowly through a pre-holed plate varied with the hole diameter, and to apply the knowledge to increase the penetrative power of solid shot and AP bombs by placing a shaped charge in front to pre-hole the target. It was concluded that when the diameter of the preformed hole is half that of the bullet, the reduction in work done compared with that for plain discs is 27%.

L152

Armament Research Department (Gt. Brit.).
A ROCKET FOLLOW-THROUGH PROJECTILE, by H. L. Porter and W. M. Evans. Mar. 1944, 3p. incl. diagrs. (ARD Explosives rept. no. 540/44; AC 6210, Apr. 27, 1944; SC. 85; OSRD Liaison Office WA-2086-11) Secret

A description is given of a small-scale model shaped charge bomb which had a follow-through projectile propelled as a rocket. Trials indicated that this type of follow-through projectile would work successfully.

L153

Armament Research Department (Gt. Brit.).
APPLICATION OF THE FOLLOW-THROUGH PRINCIPLE TO SHELL, by H. L. Porter and W. M. Evans. Apr. 1944, 10p. incl. illus. diagr. (ARD Explosives rept. no. 567/44; AC 6393, May 26, 1944; SC. 96) Secret

Trials were carried out with modified 25-pounder shells fired statically against 1.25-in. mild steel plates. Trials were made also with modified 95-mm. shells on targets of 60-mm. homo steel. The shell front consisted of a shaped charge in the form of a 3-in. mild steel smooth bore cone for the 25-pounder shell, and a 45° mild steel liner as used in the 3.7 shaped charge shell for the 75-mm. shell. In both cases the rear of the charge was in the form of an 80° liner. Results for the 25-pounder shell showed that with central ignition of the propellant, a hole 1.45 in. in diameter was made in the 1.25-in. target by the shaped charge; the shot passed through the hole and penetrated 12 in. of sand, 2 Sn plate sheets and 8 in. of earth. Detonation gases from the rear of the shaped charge swept down the inner walls of the shell cases, violently squeezing in the walls of the lower part of the gun tube, and severing it. For the 95-mm. shell, with central ignition of propellant, the hole produced in the 60-mm. homo steel target was less than the diameter of the shot. It was concluded that the follow-through principle could be applied successfully to the shell provided the rear of the HE charge was in the form of an 80° liner to exert the minimum detonative action on the nose of the shot and muzzle of the gun; the initiation should be from the rear of the high explosive.

L154

Armament Research Department (Gt. Brit.).
COMPARISON OF FUNCTIONING OF HOLLOW CHARGE AND FRAGMENT TYPE FUZES BY FLASH RADIOGRAPHY. I. STATIC TRIALS IN FREE AIR. Apr. 1944, 10p. incl. illus. diagrs. (ARD Metallurgical rept. no. 94/44; AC 6620; SC. 105; OSRD Liaison Office WA-2505-19) Secret

Flash radiographs were made to study the shaped charge and fragment types of fuzes. The shaped charge type projected a thin jet (about 0.06-in.

diameter) along its axis, the front of the jet having a velocity of the order of 4 x 105 cm./sec. In the fragment type, the fragments of the magazine wall were projected radially with a velocity of about 1.2×10^5 cm./sec. which was less than half the velocity of the head and about 3 times the radial velocity from the corresponding fragments of the shaped charge type. It was thought that the difference was due to the metals of the 2 fuzes (Al alloy for the fragment type and brass for the hollow charge type), and to the difference in charge weight.

L155

Armament Research Department (Gt. Brit.). EXPERIMENTS ON EMERGENT CONED CHARGES DETONATED IN STEEL TUBES, by H. L. Porter and W. M. Evans. Apr. 1944, 12p. incl. diagrs. (ARD Explosives rept. no. 558/44; AC 6107, Apr. 30, 1944; Phys/Ex. 542; SC.87; OSRD Liaison Office WA-2056-17) Secret

A study was made of the fragmentation and confinement of charges in steel tubes. The charges were initiated at the liner apex (apex initiation) or at the end remote from the apex (base initiation), so that the influence of the direction of propagation of detonation could be studied. It was concluded that, for shaped charges where the influence of the rear of the charge is to be reduced to a minimum, initiation should be from the rear.

L156

Armament Research Department (Gt. Brit.). THE MECHANISM OF JET FORMATION; ON SCALE LAWS FOR LININGS TO MUNROE CHARGES PART I. FLUID LININGS, by T. Nash and A. R. Ubbelohde. Apr. 1944, 6p. incl. table, diagrs. (ARD Explosives rept. no. 572/44; 1 to MA London rept. no. 69885; AC 6366, May 23, 1944; SC.94) Secret

Theoretical and experimental evidence is reviewed which suggests that the thickness of the liner for shaped charges should scale with the diameter of the hollow at any zone perpendicular to the axis of the hollow. Measurements of target damage (mild steel) from charges containing 3-in. diameter 80° PL-Sb and uniform liners heavily confined showed that tapered liners gave increased penetration but approximately the same crater volume. Test results are tabulated and diagrams illustrating the tapering scale are included.

L157

Armament Research Department (Gt. Brit.). MECHANISM OF JET FORMATION. THE ROLE OF FRAGMENTS IN MUNROE JETS. PART II. THE INTERACTION BETWEEN FRAGMENTS AND EXPLOSION PRODUCTS, by G. E. Roberts and A. R. Ubbelohde. Apr. 1944, 7p. incl. illus. (ARD Explosives rept. no. 568/44; AC 6305, May 10, 1944; Phys/Ex. 553; SC.92; OSRD Liaison Office WA-2146-12) Secret

A study was made of the interaction between metal fragments and explosion products in jets in order to throw light on the mechanism of jet formation. Test results showed very extensive dust formation from particulate liners, much more than from mild steel liners of the same shape. The surface of recovered particles showed marked erosion with pits and projections. The introduction of a damping material between the particulate liner and the explosive charge lessened dust formation. Nitridation, although affected little by the liner shape, was reduced when a damping material was used between the explosive and the particulate liner.

L158

Armament Research Department (Gt. Brit.). ALUMINIZED FILLINGS IN HOLLOW CHARGES. PART I. 1 3/8-IN. DIAMETER CHARGES WITH HEAVY CONFINEMENT (CHARGE/WEIGHT RATIO 0.2), by W. M. Evans and A. R. Ubbelohde. May 1944, 2p. tables, diagrs. (ARD Explosives rept. no. 586/44; AC 6146; Phys/Ex. 561; SC.98; OSRD Liaison Office WA-2272-2) Secret

Mild steel liners in the shape of 80° cones, hemispheres, and spherical dishes were backed by 50/50 RDX/TNT, Torpex II, Minol, and PE, and the damage in massive mild steel targets was compared at standoffs of 1 diameter, 1.5 diameters, and 2 diameters. Al particles of the size range present in Torpex II and Minol II did not appear to react in time to impart energy to jets from 1 3/8-in. diameter charges with 60 g. of explosive. The time of energy release from such particles was estimated as greater than about 10 µsec.

L159

Armament Research Department (Gt. Brit.). THE EFFECT OF CONFINEMENT ON JET FORMATION FROM HOLLOW CHARGES, by W. M. Evans. May 1944, 9p. tables, diagrs. (ARD Explosives rept. no. 583/44; AC 6484; Phys/Ex. 560; SC.90; OSRD Liaison Office WA-2315-17) Secret

The investigation was to determine why damage should increase with increased confinement, and how damage was related to the physical properties of the confining walls. PE charges, 1 3/8 in. in diameter were fired normal to the target. The damage (volume) increased with mass/unit area of metal confinement of the charges. Confinement by mild steel, Pb cast Fe, and duralumin of the same weight was equally effective. Penetrations from charges with conical liners did not change appreciably with mass of confining tube, while charges with hemispherical liners showed a definite increase with such confinement. Damage was less when produced by a thick-walled 80° charge than by a similar thin-walled charge with the diameter of explosive increased by approximately 20%; this was not true of comparable 45° charges. It was concluded that the increase in damage with confinement of lined charges was due to the greater pressure exerted on the liner which collapsed more rapidly, thus producing a primary jet of increased mass and velocity; and the increased pressures applied to the walls of the collapsed liner which, having a liquid core, was squirted out as a secondary jet with an increased mass and velocity.

L160

Armament Research Department (Gt. Brit.). A REVIEW OF CERTAIN ASPECTS OF RESEARCH ON MUNROE JETS, by D. C. Pack. May 1944, 11p. (ARD Theoretical research survey no. 1/44; AC 6554; Phys/Ex. 567; SC. 103; OSRD Liaison Office WA-2320-24) Secret

This rept. summarizes work carried out in Great Britain and in the United States on fundamental aspects of Munroe jets, 3 theories of jet formation (shock wave, hydrodynamic, and spalling theories), damage by jets, and the action of cutting tube charges.

L161

Armament Research Department (Gt. Brit.). CONVERGENCE PHENOMENA IN MUNROE JET PENETRATION, by D. C Pack. June 1944, 7p. (ARD Theoretical research rept. no. 25/44; AC 6608; SC. 104; OSRD Liaison Office WA-2615-9) Secret

When a shaped charge is given diminishing standoff below that required for proper convergence of the jet, it is characteristic of attack on massive targets that the penetration falls away from the optimum, and at the same time a bulge is observed inside the hole made in the target. This rept. shows how the different results may be correlated, on the assumption of a physical model in which the jet contracts until it reaches a cylindrical converged state.

L162

Armament Research Department (Gt. Brit.). GERMAN HOLLOW CHARGE ANTITANK HAND GRENADE, PANZERWURFMINE (L). June 1944, 8p. incl. illus. (ARD Explosives rept. no. 8/44: OSRD Liaison Office WA-2514-4) Restricted

An outline is given of the construction and results of an examination of 2 incomplete specimens of the Panzerwurfmine.

L163

Armament Research Department (Gt. Brit.). UNDERWATER PENETRATION BY MUNROE JETS, by D. C. Pack. June 1944, 3p. (ARD Theoretical research rept. no. 20/44; Inclosure 1 to MA London rept. no. 938-44; AC 6553; Phys/Ex. 566; SC. 102; OSRD Liaison Office WA-2320-25) Secret

A formula was obtained for penetration of a jet into a composite target, i.e., for a target consisting of steel with a given depth of water covering it.

L164

Armament Research Department (Gt. Brit.). FOLLOW-THROUGH AP BOMB, by H. L. Porter and W. M. Evans. July 1944, 2p. tables, diagrs. (ARD Explosives rept. no. 86/44; AC 7110, Oct. 9, 1944; SC. 119; OSRD Liaison Office WA-2985-7) Secret

Scale models were tested of a design of a follow-through AP bomb. In this design, there was the problem of keeping the c. g. of the composite bomb within 0.4 of the over-all length from the nose to maintain flight stability. Tests were made to determine how the rear liner thickness affected the velocity of projection of the AP bomb and how the thickness influenced the damage on the nose of the AP bomb. Test results are tabulated.

L165

Armament Research Department (Gt. Brit.). VELOCITIES OF JETS FROM MUNROE CHARGES. PRELIMINARY REPORT, by W. M. Evans. July 1944, 2p. (ARD Explosives rept. no. 618/44; AC 5807; SC. 110; OSRD Liaison Office WA-2684-8) Secret

The investigation was undertaken to determine the jet velocities from shaped charges with 80°, 130°, 180° (flat), and spherical liners of steel and Cd; the test results are tabulated. For Cd liners, the velocity of the dished cap was about 400 m./sec. greater than that for the flat disc. For steel liners, the velocity of the dished cap was 600 m./sec. greater than that for the flat disc.

L166

Armament Research Department (Gt. Brit.). CAVITATION PHENOMENA IN DUCTILE MATERIALS AND THE DYNAMIC TERM IN THE RESISTANCE TO PENETRATION, by R. Hill. Aug. 1944, 11p. incl. diagrs. (ARD Theoretical research rept. no. 34/44) Restricted

By cavitation in ductile materials during penetration by a projectile is meant the occurrence of a hole of width greater than the projectile caliber. The critical velocity was worked out for an ogive of certain c. r. h. [caliber radius head]. The onset of cavitation was associated with the appearance of a true dynamic term which represented the energy used in making the hole wider than the projectile. The term was calculated for various head shapes, and was found to be sensitive with increasing caliber radius head.

L167

Armament Research Department (Gt. Brit.).
A COMPARISON OF THE PERFORMANCE OF THE 88-MM. RAKETEN PANZERBUCHSE 43, THE BRITISH 95-MM. HEAT SHELL AND THE PIAT UNDER STATIC FIRING CONDITIONS, by W. E. Soper. Aug. 1944, 8p. incl. tables, (ARD Explosives rept. no. 628/44) Secret

A comparison of performance was made of the PIAT filled with 50/50 RDX/TNT and fuzed with a no. 426, the 95-mm. HEAT shell filled with Pen. D.1 and fuzed with a no. 233, and mock-up charges representing the Raketen Panzerbuchse 43 using liners turned from mild steel bar and liners shaped by spinning. Results showed that the German projectile was superior in performance to the 2 British weapons for attack of armor protected by skirting plates. It was concluded that the German pear shaped liner was not as superior as at first supposed, and that under comparable conditions the conventional liner would give only slightly inferior performance. It was recommended that the pear shaped liner should be tried out in the 95-mm. HEAT shell with or without modification to the cap to determine the effect of rotation upon performance.

L168

Armament Research Department (Gt. Brit.).
NOTE ON THE MECHANISM OF PLATE PENETRATION BY MUNROE JETS, by W. M. Evans. Aug. 1944, 3p. incl. table. (ARD Explosives rept. no. 636/44; AC 6970; Phys/Ex. 567; SC. 115; OSRD Liaison Office WA-2905-5h) Secret

Tests were made to determine the relative contribution of jet and plate to the fragment damage behind the penetrated plate and the manner in which this contribution varies with standoff. The charges (hemispherical and 80°) were of 60 g. PE, 1 3/8-in. inside diameter confined in steel tubes. A Pb plate was placed 18 in. from the target. The plate was divided into 12 sectors radiating from the approximate center of damage; and with the same center, circles were drawn of diameters such that they subtended cone angles of 10°, 30°, 50°, 70°, and 90° at the point in the target where the jet emerged. Test results showed that the volume of fragment damage outside the cone angle of 10° was of the same order for both high and low residual penetrations. In this region the fragments came mainly from the target, and as the standoff was increased the area (particularly the scab area) tended to be reduced. Rough measurements of the ratio of volume of scab for 30% and 5% residual penetrations gave respectively 14:1 for the 80° charge and 2:1 for the hemispherical charge. It is stated that a shaped charge weapon could function within fairly wide limits of standoff without appreciably affecting the damage by fragments outside the cone angle of 10°. The damage within this angle would be considerably affected.

L169

Armament Research Department (Gt. Brit.).
TARGET DAMAGE BY MUNROE JETS. PROTECTION OF STEEL TARGETS BY NON-METALLIC SUBSTANCES, WITH SPECIAL REFERENCE TO OXIDIZING AGENTS, INTERIM REPORT, by C. E. Roberts and A. R. Ubbelohde. Sept. 1944, 6p. incl. tables. (ARD Explosives rept. no. 638/44; OSRD Liaison Office WA-2985-16) Secret

See item no. L91 in which this rept. is reproduced as Part III.

L170

Armament Research Department (Gt. Brit.).
NOTE ON BAKELITE CHARGE CASES FOR HOLLOW CHARGES, by A. R. Ubbelohde. Oct. 1944, 4p. incl. table, diagr. (ARD Explosives rept. no. 653/44; AC 7250; SC. 120; OSRD Liaison Office WA-3234-8) Secret

Tests were made to determine how the change from a steel to a bakelite case of equal weight affected shaped charge performance. Results showed that with a shaped charge (80° liner), the replacement by bakelite led to a decrease in crater volume of about 13%, but did not reduce the penetrative power by more than 4%.

L171

Armament Research Department (Gt. Brit.).
TARGET DAMAGE BY MUNROE JETS. COMPARATIVE DAMAGE IN FACE-HARDENED ARMOR PLATE, HOMOPLATE, AND MILD STEEL, by G. E. Roberts and A. R. Ubbelohde. Oct. 1944, 11p. incl. diagrs. (ARD Explosives rept. no. 651/44; AC 7404; SC. 126; OSRD Liaison Office WA-3284-6) Secret

The study was made to determine how far the damage produced by various jets in steel targets was effected by the strength of the target material. Jets from steel liners showed some penetration loss in changing from mild steel to homo or face hardened armor targets. Fluid liner jets showed a similar penetration loss in changing from mild steel to homo armor, and a greater loss with face hardened armor. Considerable spalling occurred when face hardened armor was attacked by Munroe jets. The spalling was more marked with cutting tube charges. The diameter and volume of the craters were least in face hardened armor, and greatest in mild steel.

L172

Armament Research Department (Gt. Brit.).
THE MAIN LINES OF BASIC RESEARCH ON HOLLOW CHARGES. Nov. 1944, 41p. incl. diagrs. (ARD Explosives rept. no. 669/44; AC 7367, Nov. 21, 1944; SC. 123; OSRD Liaison Office WA-3649-11) Secret

Experimental and theoretical research is reviewed on: methods of investigating Munroe jets; effect of the explosive charge on jet formation; theories of jet formation and structure; general methods of investigating damage in metal targets; target damage in special targets; theories of target damage in steel and other metals; damage behind targets; cutting tube and similar charges, and miscellaneous applications of shaped charge effects. A bibliography of 120 references (the same as that in item no. L3) is appended.

L173

Armament Research Department (Gt. Brit.).
MECHANISM OF DAMAGE IN STEEL TARGETS. THE CRITICAL CHANGE IN C[UTTING] T[UBE] DAMAGE TO ARMOR PLATE WITH CHANGE IN AREA OF ATTACK, by T. Nash and A. R. Ubbelohde. Nov. 1944, 15p. incl. illus. tables, diagrs. (ARD Explosives rept. no. 679/44; AC 8240; SC. 148; OSRD Liaison Office WA-4475-9)
Secret

The discussion is concerned with differences in damage produced by cutting tube and 130° shaped charges acting against steel targets. Metallurgical tests were made on sectioned mild steel blocks after attack by both types of charges to investigate the flow of metal in the target due to crater formation. These tests showed that a Munroe charge pushes the target material aside from the crater and a cutting tube charge pushes a plug of metal forward.

L174

Armament Research Department (Gt. Brit.).
TARGET DAMAGE BY MUNROE JETS: EFFECT OF TARGET STRENGTH ON CRATER VOLUMES, by G. E. Roberts and A. R. Ubbelohde. Nov. 1944, 13p. incl. diagrs. (ARD Explosives rept. no. 666/44; AC 7434; Phys/Ex. 606; SC. 126; OSRD Liaison Office WA-3425-16) Secret

Jets were obtained from standard Swansea charges with PE using 45° mild steel liners and steel and Pb dishes. The targets were mild steel, homo-armor, face hardened armor, and Pb. Crater shapes were measured in detail by pouring in known volumes of Hg and measuring the increment of the level in the crater. By comparing the volumes of equal fractions of crater depth, it was found that the volume of crater times yield strength of target material was equal to a constant. The constant varied for jets from different liners.

L175

Armament Research Department (Gt. Brit.).
THE ENERGY REQUIRED FOR PENETRATION OF CONCRETE, by D. C. Pack. Jan. 1945, 2p. (ARD Theoretical research memo. no. 2/45; AC 7672; SC. 134; OSRD Liaison Office WA-3833-7)
Secret

A comparison was made of the relationship between energy and hole volume in the attack of concrete by Munroe jets and AP projectiles. The calculations showed that the ratio of the energy of the projectile used up, to the volume of the crater made in concrete, was of the same order of magnitude whether the attack was made by an armor piercing projectile or a Munroe jet.

L176

Armament Research Department (Gt. Brit.).
NOTE ON THE PROTECTIVE POWER OF INDASCO PLASTIC AGAINST MUNROE JETS, by G. E. Roberts and A. R. Ubbelohde. Jan. 1945, 3p. (ARD Explosives rept. no. 403/45; AC 7734; SC. 138; OSRD Liaison Office WA-3830-21)
Secret

Tests were made of the protective power of INDASCO plastic, used to give an antimagnetic layer on tanks, against Munroe jets. Results showed that the material was considerably less efficient in stopping Munroe jets than other non-metallic materials.

L177

Armament Research Department (Gt. Brit.).
THE STRUCTURE OF MUNROE JETS. PART I. EFFECT OF STANDOFF ON DEPTH OF PENETRATION, by G. E. Roberts and A. R. Ubbelohde. Jan. 1945, 9p. incl. diagrs. (ARD Explosives rept. no. 401/45; AC 7840; Phys/Ex. 628; SC. 139; OSRD Liaison Office WA-4016-17)
Secret

The investigation was undertaken to explain the velocity distribution along Munroe jets from detailed measurements of the effect of standoff on target damage. An explanation is given of the effect of increasing standoff on the penetration of targets by shaped charges. The tests were made with 80° liners of steel and of Al; test results for both are diagramed.

L178

Armament Research Department (Gt. Brit.).
GERMAN A/C, A/T BOMB SD 4. Feb. 1945, 3p. incl. diagr. (ARD Explosives rept. no. 11/45)
Restricted

A description is given of the German SD 4, a shaped charge aircraft bomb of approximately 4 kg. fitted with an electromagnetic nose fuze. The HE filling consisted of 12 oz. of cast 45/55 RDX/TNT initiated by a standard no. 34 gaine (booster). The estimated penetration of IT 80 homo plate was 160 mm. at normal and 140 mm. at 30° incidence.

L179

Armament Research Department (Gt. Brit.).
HOLLOW CHARGE FOLLOW-THROUGH SHELL, by H. L. Porter and W. M. Evans. Feb. 1945, 6p. incl. diagrs. (ARD Explosives rept. no. 27/45; AC 8079; SC. 144; OSRD Liaison Office WA-4301-15)
Secret

An investigation was made to determine whether the follow-through principle could be successfully incorporated in a 95-mm. shell. One charge was used which would make a hole in the armor of a tank target large enough to permit the clear passage of a solid follow-through shot 1 in. in diameter; the other was a follow-through shot, 2-pounder AP, 1.57 in. in diameter which was greater than the estimated diameter of the hole so that it would have to force its way through.

L180

Armament Research Department (Gt. Brit.). ENEMY MUNITIONS. GERMAN HOLLOW CHARGE STICKY A/T GRENADE. Mar. 1945, 2p. diagr. (ARD Explosives rept. no. 35/45; OSRD Liaison Office WA-4244-1W) Restricted

The examination of this shaped charge grenade (32° tapered liner) is reported. The mouth was closed by a thin metal cap to which was riveted a felt pad impregnated with an adhesive of mineral oil-polyisobutene composition. This was covered by a thin steel pull-off lid. The penetration at normal against homoplate is estimated at 125 mm.

L181

Armament Research Department (Gt. Brit.). GERMAN HOLLOW CHARGE SHELL. 10-CM. GR. 39 ROT Hl/A, Hl/B, Hl/C. MAR. 1945, 3p. diagrs. (ARD Explosives rept. no. 12/45; OSRD Liaison Office WA-4104-5) Restricted

The examinations of these shells are reported. The 3 types were apparently modifications of the 10-cm. Gr. 39.

L182

Armament Research Department (Gt. Brit.). PENETRATION OF STEEL TARGETS BY MUNROE JETS, by W. M. Evans. Mar. 1945, 7p. illus. diagrs. (ARD Explosives rept. no. 98/45; AC 8683; Phys/Ex. 685; OSRD Liaison Office WA-5511-9) Unclassified

The rate of penetration of mild steel by shaped charge jets and the structure of the jets were studied. The jets of fragment and fluid types were produced by 80° charges lined with steel and Sn, respectively. Tabulated results of experiments show: interval of penetration, time of penetration, average emergent velocity, average penetration velocity, length of jet used up, average density of jet used up, and energy of jet used up.

L183

Armament Research Department (Gt. Brit.). THE INITIATION OF AN EXPLODER BY A MUNROE JET (FLASH RADIOGRAPHY). Apr. 1945, 5p. incl. illus. diagrs. (ARD Metallurgical rept. no. 45/45; AC 8356; OSRD Liaison Office WA-4618-8) Confidential

This investigation was undertaken to obtain radiographs of the jet striking Tetryl pellets to determine at what stage initiation occurred. The radiographs showed that detonation was initiated by the front portion of the jet and that complete detonation took place before the slug reached the pellet.

L184

Armament Research Department (Gt. Brit.). PENETRATION BY MUNROE JETS; SECONDARY PENETRATION AND THE EFFECT OF TARGET STRENGTH. PART I, by D. C. Pack and W. M. Evans. Apr. 1945, 13p. diagr. (ARD Theoretical research rept. no. 11/45 and ARD Explosives rept. no. 51/45; Inclosure 1 to MA London rept. no. R3212-45; AC 8355; Phys/Ex. 656; SC. 151; OSRD Liaison Office WA-4586-11) Confidential

Results of experiments on penetration of massive targets of mild steel, homo armor Pb, and various combinations of these materials confirmed the theory that the total observed penetration could be separated into 2 parts. The first part was derived from the elementary theory of jet penetration and modified to allow for target strength, while the second part was due to flow taking place in a target after penetration by the jet had ceased. The theory accounted for the shape of the penetration curves observed experimentally when a given plate of armor was inserted at varying depths in a stack of Pb plates. It was demonstrated that the "equivalent plastic effect" was dependent on the properties of the jet, as well as target characteristics.

L185

Armament Research Department (Gt. Brit.). THE EFFECT OF SPIN ON THE PERFORMANCE OF HOLLOW CHARGE AND DISC FUZES, by R. M. Laidler and others. May 1945, 18p. incl. diagrs. (ARD Explosives rept. no. 414/45; AC 8327; Phys/Ex. 655; SC. 150; OSRD Liaison Office WA-4575-7) Secret

The effect of rotation at high angular velocity on the no. 233 and no. 243 fuzes with modified magazines was investigated across air gaps up to 44 in. The fuzes were rotated by means of a spinning machine and the fragment patterns recorded on mild steel sheet at various distances. The no. 233 provided a cluster of useful fragments, while the no. 243 furnished only a single fragment. In neither fuze was the performance materially affected by rotation up to speeds of 16,000 r.p.m. over air gaps up to 44 in. It was concluded that, with reasonably controlled machining, the fragments could be expected to lie within a cone, the 0.5 angle of which would be 1.5° for all distances between 10 and 44 in.

L186

Armament Research Department (Gt. Brit.).
FLASH RADIOGRAPHY OF SHAPED CHARGES. THE COLLAPSE OF HEMISPHERICAL AND DISH-SHAPED LINERS. May 1945, 11p. incl. illus. diagrs. (ARD Metallurgical rept. no. 62/45; Inclosure 2 to MA London rept. no. R1252-49) TIP S50198 Secret

Flash radiographs of hemispherical and dish shaped liners (Zn, steel, and brass) taken at various stages of collapse were obtained for study. The charge container was cardboard, exerting a very slight degree of confinement. The early stages of collapse for all types of liners appear to be almost uniform. A discussion of the formation of the jet based on examination of the radiographs is given.

L187

Armament Research Department (Gt. Brit.).
NOTE ON THE EFFECT OF STANDOFF ON THE PENETRATION BY MUNROE JETS, by D. C. Pack. May 1945, 4p. incl. diagrs. (ARD Theoretical research memo. no. 17/45; AC 8311; SC. 149; OSRD Liaison Office WA-5101-20) Confidential

The effect of standoff on penetration by a jet was calculated on the assumption that the jet retained a constant cross-section during its passage through the air, but elongated with uniform velocity gradient from head to tail. The result was compared with experimental observations made by Roberts and Ubbelohde (item no. L177).

L188

Armament Research Department (Gt. Brit.).
THE MECHANISM OF JET FORMATION - PERFORMANCE OF TAPERED CONES IN HOLLOW CHARGES. ON SCALING LAWS FOR LININGS TO MUNROE CHARGES - PART II, by T. Nash and A. R. Ubbelohde. July 1945, 7p. incl. diagrs. (ARD Explosives rept. no. 416/45; AC 8701; Phys/Ex. 689; OSRD Liaison Office WA-5563-12) Restricted

The possible advantages of tapering for increasing target damage from 80° liners of brass and steel compared with Pb-Sb alloy (heavily confined) liners were investigated. Three degrees of confinement (heavy, light, PIAT) were used. A limited number of tests were also made with uniform and tapered 45° liners of steel and Al. Experimental results are summarized and tabulated.

L189

Armament Research Department (Gt. Brit.).
METALLURGICAL EXAMINATION OF THREE GERMAN 10-CM. 1 F.H. 18 (HOLLOW CHARGE) SHELLS, TYPES A, B, AND C. July 1945, 3p. illus. (ARD Metallurgical rept. no. 83/45; OSRD Liaison Office WA-5190-5) Confidential

The metallurgical examination of this German shell is reported. Photographs of the microstructures are appended.

L190

Armament Research Department (Gt. Brit.).
ENEMY MUNITIONS. GERMAN 8.8-CM. KW.K. 43 CARTRIDGE QF, HE/TRACER WITH HOLLOW-CHARGE SHELL (GR. 39 HL.). Aug. 1945, 4p. diagr. (ARD Explosives rept. no. 68/45; OSRD Liaison Office WA-5192-2) Unclassified

An examination of 1 round of this shell is reported. The design was found to be similar to that of the 10.5-cm. shell, but the funnel shaped washer fitted in front of the cavity was longer and sharper and the steel liner was thicker.

L191

Armament Research Department (Gt. Brit.).
METALLURGICAL EXAMINATION OF TWO GERMAN HOLLOW CHARGE ANTITANK BOMBS (FAUSTPATRONE I AND II) AND PROJECTORS. Sept. 1945, 5p. illus. diagrs. (ARD Metallurgical rept. no. 110/45; OSRD Liaison Office WA-5450-3) Unclassified

Metallurgical examinations of 2 models of this weapon are reported. Photographs of microstructures are appended.

L192

Armament Research Department (Gt. Brit.).
GERMAN 7.5-CM. GR. 38 HL/C HOLLOW CHARGE SHELL. Oct. 1945, 2p. illus. (ARD Metallurgical rept. no. 120/45) Unclassified

Results are reported of a metallurgical examination of an emptied unfired German shell.

L193

Armament Research Department (Gt. Brit.).
GERMAN HOLLOW CHARGE STICKY GRENADE (ANTITANK). Oct. 1945, 2p. illus. (ARD Metallurgical rept. no. 119/45) Unclassified

The results are reported of a metallurgical examination of an emptied unfired German sticky grenade.

L194

Armament Research Department (Gt. Brit.).
FLASH RADIOGRAPHY OF 60° CONICAL CHARGES WITH ALUMINUM LINERS. Dec. 1945, 5p. incl. diagrs. (ARD Metallurgical rept. no. 141/45; AC 8902; Phys/Ex. 700; OSRD Liaison Office BC-922) Unclassified

A study was made of the collapse of Al liners and the subsequent formation of a jet, and to compare the results with those previously obtained by flash radiography of brass liners. The flash radiographs showed that except for an increased jet velocity, the results were similar to those obtained with brass 80° liners. For these Al liners the jet head traveled at a velocity of 6.3 x 10^5 cm./sec. and continued to form for about 25 μsec., by which time it was about 15 cm. long. The jet and slug then separated, with the slug traveling behind the jet with a velocity of the order of 3 x 10^5 cm./sec. For the brass liners, the jet velocity was 4.25 x 10^5 cm./sec. and the slug velocity 0.715 x 10^5 cm./sec.

L195

Armament Research Department (Gt. Brit.). GERMAN 7.5-CM. CARTRIDGE QF, HE (HOLLOW CHARGE). GR. 38 Hl/C (C.I.A. SK.E.A. NO. 429). Feb. 1946, 6p. incl. diagr. (ARD Explosives rept. no. 6/46; Inclosure 1 to MA London rept. no. R827-46) Unclassified

Results of an examination of the explosive components of a round of this ammunition are reported. The liner was die-cast Zn alloy made in 1 piece with central flash tube. The metallurgical examination of this shell is discussed in ARD/Metallurgical rept. no. 120/45 (item no. L192).

L196

Armament Research Department (Gt. Brit.). GERMAN NOSE FUZE. A.Z. 38 ST. (C.I.A. SK. NO. 411). Feb. 1946, 3p. incl. diagr. (ARD Explosives rept. no. 7/46; Inclosure 1 to MA London rept. no. R828-46) Unclassified

A specimen of this fuze, which is used on the hollow charge shell 7.5-cm. Gr. 38 Hl/C, was examined and a drawing prepared.

L197

Armament Research Department (Gt. Brit.). PENETRATION OF MUNROE JETS FROM 80° CONED CHARGES AS A FUNCTION OF CHARGE-LENGTH AND STANDOFF, by J. H. Hopkins and W. M. Evans. Feb. 1946, 9p. incl. charts, diagrs. (ARD Explosives rept. no. 403/46; Inclosure 1 to MA London rept. no. R1679-46; AC 8995; Phys/Ex. 705; OSRD Liaison Office BC 954) Confidential

The investigation was to determine the effect of charge length and standoff on the performance of Munroe jets against homogeneous armor plate. Charges (3/16-in. diameter, PE3) having deep stamping steel liners (80°, 2-in. diameter) were used, each fired normal to the target (2 armor plates, 100 mm. thick). Test results and graphical analysis are included.

L198

Armament Research Department (Gt. Brit.). ENEMY MUNITIONS. GERMAN 7.5-CM LE J.G. 18 CTGE. WITH H/C SHELL (JGR 38 HL/A). (C.I.A. SK. NO. 394.) Mar. 1946; 4p. diagr. (ARD Explosives rept. no. 18/46; Inclosure to MA London rept. no. R1345-46) Unclassified

The results of an examination of this German shaped charge shell are reported.

L199

Armament Research Department (Gt. Brit.). A COMPARISON BETWEEN STEEL, PURE COPPER, AND COPPER/SILVER ALLOY CONICAL LINERS FOR HOLLOW CHARGES, by T. Nash and W. M. Evans. Apr. 1946, 3p. (ARD Explosives rept. no. 406/46; Inclosure 1 to MA London rept. no. R1943-46) Confidential

Test firings of charges (light steel confinement, L/D = 1.3) bearing 80° liners against 100-mm. armor plate indicated that the penetration obtained using a 0.1% Cu-Ag alloy liner is about the same as that obtained using a pure Cu liner. Both of these liners will give 27% better penetration than a steel liner. These tests were prompted by United States investigations with the 2.36-in. HEAT rocket from which it was concluded that the Cu-AG alloy liner gave a better performance than the Cu liner. Thickness of the Cu and Cu-Ag liners in the above British tests was approximately 0.082 in.; steel liners used were standard PIAT type. The opinion is expressed that use of a different type of charge and confinement might change the effectiveness of the above liners.

L200

Armament Research Department (Gt. Brit.). GERMAN 8.8-CM. KWK 43 (GR. 39 Hl) HOLLOW CHARGE SHELL. July 1946, 6p. incl. diagrs. (ARD Metallurgical rept. no. 39/46; Inclosure 1 to MA London rept. no. R3773-46) Confidential

A German 88-mm. HEAT shell was examined metallurgically. The shell body was formed from medium C steel by punching and drawing, and received no heat treatment after forging. The nose cap was forged and machined from a low C steel. The liner was cold-pressed from mild steel strip. The frustrum was made of 2 pieces, each stamped from hot-rolled mild steel strip. The flash tube was made of commercially pure Al seamless tubing. Results of physical tests on the shell are given.

L201

Armament Research Department (Gt. Brit.). PENETRATION OF CEMENT-MORTAR TARGETS BY MUNROE JETS, by W. W. Rees and W. M. Evans. July 1946, 12p. incl. diagrs. (ARD Explosives rept. no. 412/46; Inclosure 1 to MA London rept. no. R3939-46) Confidential

This investigation was to gain information on the mechanism of penetration of jets of the fragment and fluid type in concrete targets. Comparisons were made of the penetration of the above types of jets against steel and concrete and the rate of penetration against concrete. The insufficient data available from these experiments, however, make it impossible to determine to what extent the mechanism of penetration in metallic targets can be applied to concrete targets.

L202

Armament Research Department (Gt. Brit.). PENETRATION BY MUNROE JETS. SECONDARY PENETRATION AND THE EFFECT OF TARGET STRENGTH. PART II. THE EFFECT OF STAND-OFF; LIGHT JETS, by W. M. Evans and D. C. Pack. Dec. 1945, 15p. incl. diagrs. (ARD Theoretical research rept. no. 12/45 and ARD Explosives rept. no. 415/45) Confidential

Previously it had been shown how an analysis of the results of experiments with Munroe jets fired into targets from a fixed standoff could be made using the simple theory of jet penetration. An examination was made of the standoff effect using the penetration formula with a uniform velocity gradient. An analysis of the expansion rate of the hole caused by the passage of a jet supported the explanation on the basis of secondary penetration of the hemispherical shape of the bottom of the holes observed in the Pb blocks attacked by jets from Sn caps. Experiments using light jets from Al hemispheres satisfied the same analysis previously employed for the jets of steel, Sn, etc.

L203

Armament Research Establishment (Gt. Brit.). HOLLOW CHARGE AND PLASTER SHOT WEAPONS. Rept. for 3-month period to July 1948, 2p. (Extract from ARE rept. no. 3/48) TIP S50149 Secret

Plans for a spinning machine with which to study rotating charges are reported briefly. No details of the machine are given. It is suggested that a liner shape other than the conventional cone might produce a jet stable enough to penetrate both the skirting plate and the main tank armor.

L204

Armament Research Establishment (Gt. Brit.). THE HOLLOW CHARGE EFFECT AND THE PENETRATION OF ARMOR, by W. E. Soper. Sept. 1948, 25p. incl. tables, diagrs. (Inclosure 3 to ORD-TRART-LR-77) TIP S50199 Secret

Part I gives the principle factors affecting shaped charge performance: cavity shape, standoff, liner thickness, charge confinement, charge length, liner material, choice of explosive, and aberrations in shaped charge performance. Part II treats the application of the shaped charge to weapons for armor attack, and considers fuzing and stability. Test results are indicated for the effect of rotation and standoff on performance of different liner shapes in standard 95-mm. HEAT shells fitted with 45°, 60°, and 80° liners. Results are shown also for the effect of a 4 sector offset liner on performance with rotation. Part III discusses refinements to shape and liner material. Results are given for the effect of shaping the detonation wave by insertion of a core of cast TNT into a Pentolite charge (30°, 45°, 60°, 80°, and 120° steel liners and 45° Cu liners), and for the effect of shaping the detonation wave by inserting an inert material (air, paraffin, or wood) into Pentolite charges.

L205

Armament Research Establishment (Gt. Brit.). MECHANISM OF THE HOLLOW CHARGE EFFECT, by W. M. Evans. Sept. 1948, 14p. illus. diagrs. (Inclosure 5 to ORD-TRART-LR-77) TIP S50197 Secret

A discussion is given of the hydrodynamic theory of jet formation. The penetration theory is considered as applied to metals and to metallic and nonmetallic materials of low density. Brief mention is made of techniques for the measurement of jet characteristics and factors affecting shaped charge performance: explosive, charge length, charge confinement, liner and cavity shape, standoff, asymmetry, rotation, and scaling. The scaling law that a linear change in the dimensions of a shaped charge leads to corresponding changes in linear dimensions of the craters produced was found to hold within experimental limits, with the exception of very small charges which were difficult to scale from a larger model.

L206

Armament Research Establishment (Gt. Brit.). SHAPED CHARGES XXX. THE PRESSURE DISTRIBUTION ROUND CYLINDRICAL CHARGES OF 30/70-CE/TNT HAVING PLANE OR EMERGENT-CONE ENDS, by H. ?.tman. Sept. 1950, 11p. diagrs (ARE rept. no. 26/50; Buxton rept. no. E. 189; [Inclosure 1 to ORD-TRART-288]) TIP S1805 Secret

A piezoelectric gage and cathode ray oscillograph were used to examine the pressure distribution in the shock wave system generated by freely suspended uncased charges of 30/70-CE/TNT. The charges were cylinders 3.17 cm. in diameter and weighed 143 g., the end remote from initiation being either plane or shaped like an emergent cone. The observed values of pressure were correlated with the values of wave speeds and the shape of the wave as determined earlier by photographic methods. (ARE abstract)

L207

Armament Research Establishment (Gt. Brit.).
SHAPED CHARGES XXXI. THE DETONATION OF CYLINDRICAL CHARGES WITH AXIAL CAVITIES, by H. Titman and M. J. W. Billings. Oct. 1950, 11p. illus. (ARE rept. no. 36/50; Buxton rept. no. E. 190; [Inclosure 1 ORD-TRART-287]) TIP C5902 Confidential

The establishment of the high velocity of detonation set up in charges with axial cylindrical cavities was further investigated with charges of crystaline CE. It is shown that the high velocity arises from a compression of the wall of explosive by the high-speed cavity effect which is ahead of the detonation wave. External confinement of a hollow charge may not further increase the velocity of detonation. (ARE abstract)

L208

Armament Research Establishment (Gt. Brit.).
SHAPED CHARGES XXXII. THE SPREAD OF THE DETONATION WAVE IN ANNULAR CHARGES WITH ASYMMETRICAL INITIATION, by M. J. W. Billings. May 1954, 11p. illus. diagrs. (ARE rept. no. 11/54) AD-36 700 Confidential

A study was made of the spread of detonation in annular charges of cast RDX/TNT 50/50, asymmetrically initiated, using a rotating mirror camera. Three-in. diameter charges having axial cavities 2-in. in diameter were used.

L209

Armament Research Establishment (Gt. Brit.).
SURVEY OF PUBLISHED INFORMATION ON THE EFFECT OF ROTATION ON TARGET-PENETRATION BY HOLLOW CHARGES, by A. Schofield. Mar. 1951, 9p. diagrs. 15 refs. (Survey no. 1/49; Physics of Explosives Survey no. 1/49; [Inclosure 1 to AA London rept. no. R1010-51]) TIP S1883 Secret

Information on the effect of rotation on hollow charge performances was obtained from German, American, and British repts. Topics discussed include the effect of spin on the performance of simple conical, hemispherical and trumpet-shaped liners; possible reasons why spin has an effect; and methods of counteracting it. (TIP abstract)

L210

Armament Research Establishment (Gt. Brit.).
CONTROLLED FRAGMENTATION XXIX. CONTROLLED FRAGMENTATION OF MILD STEEL CASINGS BY MEANS OF GROOVED CHARGES, by J. W. Gibson and T. W. Taylor. Apr. 1951, 11p. illus tables, diagrs. (ARE rept. no. 4/51; Inclosure 1 to AA London rept. no. R1385-51) Confidential

The method of controlling the fragment mass distribution by means of grooved charges was studied fundamentally and applied to mild steel, parallel-walled canisters with internal diameter of 2.9 in. and with several wall thicknesses. Fluted paper liners of different pattern sizes were used. It was shown that parallel-walled casings of mild steel with a length/diameter ratio of 4/1, filled with RDX/TNT 55/45 and initiated from 1 end, were effectively controlled by means of V-shaped grooves cut into the HE charge, of apex angle 75° and depth 0.4t, where t is the wall thickness of the casing. The largest fragments obtainable were bar-formed fragments as long as the casing, and as wide as natural fragmentation permitted. For each wall thickness, determinations were made of the range of sizes (and in particular, the minimum) to which the fragmentation of the casing may be controlled.

L211

Armament Research Establishment (Gt. Brit.).
CONTROLLED FRAGMENTATION XXX. THE APPLICATION OF THE GROOVED CHARGE PRINCIPLE TO SPIN-STABILIZED SHELL, II, by H. Titman and T. W. Taylor. Jan. 1952, [12]p. incl. illus. tables. (ARE rept. no. 1/52; Buxton rept. no. E. 193; Inclosure 1 to AA London rept. no. R723-52) TIP C8522 Confidential

Shells fitted with fluted paper liners and filled with cast 55/45 RDX/TNT were examined after having been fired from a gun in order to determine whether fragmentation control by the fluted-liner method was impaired by the stresses set up during discharge. No appreciable differences were found between the fired and unused shells. Fragmentation control was not affected by a difference in steels or the amount of setback. A 0.007-in.-thick paper liner with 75° flutes withstood the stresses caused by setback and spin; thicker paper and liner strengthening were unnecessary. (TIP abstract)

L212

Armament Research Establishment (Gt. Brit.).
CONTROLLED FRAGMENTATION XXXI. THE DEVELOPMENT OF RUBBER LINERS FOR THE GROOVED-CHARGE METHOD, by W. C. F. Shepherd and J. W. Gibson. Jan. 1952, [13]p. incl. illus. tables. (ARE rept. no. 18/51; Inclosure 1 to AA London rept. no. R427-52) TIP C8521 Confidential

In the application of the grooved-charge method of controlling the fragmentation of a casing, there are manufacturing problems associated with the production of a charge of the required shape and with the required pattern of grooves. A method of fabricating fluted rubber liners which meets this requirement is described. A metal former carrying the chosen fluted pattern and shaped to the cavity of the casing is sprayed with rubber latex under specified conditions. The liner, in the form of a bag is peeled off the former and inserted into the casing. The process of filling with molten explosive helps in achieving a good fit of the liner to the cavity. Fragmentation results with cylindrical and barrel-shaped casings are described.

L213

Armament Research Establishment (Gt. Brit.).
CONTROLLED FRAGMENTATION XXXIII. FURTHER DEVELOPMENT OF RUBBER LINERS FOR THE GROOVED CHARGE METHOD OF CONTROLLING FRAGMENTATION, by J. W. Gibson, T. W. Taylor, and N. L. Heathcote. Nov. 1952, 7p. illus. (ARE rept. no. 5/53; Buxton rept. no. E. 201) AD-8774 Confidential

Further developments in the design of flexible rubber liners for the grooved-charge method of controlling fragmentation are described. The thickness of rubber is an important factor and emphasis is laid on the need for the thinnest possible liner of adequate strength. Attempts were made to stiffen thin liners; however, little success was achieved and this only with some loss of efficiency. (ARE abstract)

L214

Armament Research Establishment (Gt. Brit.).
A BIBLIOGRAPHY AND REVIEW OF THE HOLLOW CHARGE EFFECT, by R. M. Fricker and S. J. Tupper. Oct. 1951, [47]p. incl. diagrs. (Survey no. 3/51) TIP S2347 Secret

A review of the progress made in the last 10 years in understanding the principal phenomena associated with unrotated charges and a reasonably complete bibliography of the shaped charge effect are given. Subjects reviewed include: (1) Shaped charge variables; (2) Liner collapse and jet formation; (3) External ballistics; (4) Terminal ballistics; (5) The explosive charge; (6) Charge reproducibility; (7) The Taylor-Birkhoff quantitative theory of jet formation; and (8) The Mott-Pack quantitative penetration theory. The bibliography of [306] items covers shaped charge research and development in the United States, Great Britain, and Germany during the years from about 1941 through 1951. A list of 17 repts. on basic shaped charge research is also included.

L215

Armament Research Establishment (Gt. Brit.).
A STUDY OF SHAPED CHARGES LINED WITH COPPER CYLINDERS, by H. J. James and M. E. Miller. May 1953, 11p. illus. tables. (ARE rept. no. 15/53) AD-14 667 Secret

Shaped charges lined with Cu cylinders 0.927 in. in external diameter and having tapered wall thicknesses gave good penetrations when fired into mild steel targets. The penetration depths equaled those obtained with the 45° steel liners 1.625 in. in diameter. The Cu liners were designed on the basis of the "free flow" theory which stipulates the necessity of a velocity gradient in the collapse process for good jet formation. On rotation the cylindrical Cu liners performed like the 45° steel liners, indicating that these liners do not provide an immediate solution to the problem of degradation in penetration caused by spin. However, it is suggested that conical liners with tapered thicknesses would produce jets having high velocity gradients at very short standoffs which would minimize the effect of spin.

L216

Armament Research Establishment (Gt. Brit.).
A STUDY OF THE INFLUENCE OF THE CONDITIONS AT THE BASE OF THE CONICAL LINER ON SHAPED CHARGE PERFORMANCE, by H. J. James and others. Sept. 1953, 9p. illus. tables. (ARE rept. no. 21/53) AD-19 416 Secret

Studies were made in which the explosive at the base of the conical liner in a shaped charge was replaced by inert fillings of various heights to determine the effect on shaped charge performance. The experimental results indicated that the asymmetric inert fillings at the base of the liner completely upset shaped charge performance. It was concluded that the spread in shaped charge performance was caused primarily by quality differences, the presence of air occlusions, in the explosive filling. These results did not agree completely with the Taylor-Birkhoff hypothesis which postulates that steady state conditions exist at the stagnation zone and that the metal acts as a perfect fluid, each element being unaffected by its neighbor. It was postulated that the collapsing liner does transmit stress waves and that the velocity gradient of the jet is largely determined by the inertia drag of the liner base.

L217

Armament Research Establishment (Gt. Brit.).
3.5-IN. HEAT ROCKET HEAD FILLING DEVELOPMENT, by D. McKenzie and R. W. Nicholson. Dec. 1953, 4p. illus. table, diagrs. (ARE rept. no. 26/53) AD-27 162 Confidential

A rapid-stirring method for increasing the pourability of RDX/TNT 60/40 was applied to the filling of 3.5-in. HEAT rocket heads. A summary of trials of the RDX/TNT fillings, including penetration data are given.

L218

Armament Research Establishment (Gt. Brit.).
EXPLORATORY TRIALS WITH PRE-PRESSED FILLINGS FOR HOLLOW CHARGES, by D. McKenzie and J. Trower. Apr. 1954, 9p. illus. (ARE rept. no. 8/54) Secret

The penetration in mild steel of hollow charges with pre-pressed fillings has been examined. At

5-in. stand-off 80/20 RDX/TNT was found to give much the same performance as 60/40 RDX/TNT. The performance of composite charges was also explored. It was noted that charge performance was greatly enhanced when a TNT, air or wood center section was used.

L219

Armament Research Establishment (Gt. Brit.).
A NEW ASPECT OF THE COLLAPSE PROCESS AND JET FORMATION IN THE HOLLOW CHARGE, by E. de L. Costello, H. J. James, and others. June 1954, 5p. diagrs. (ARE Memo. rept. no. 6/54) Secret

Flash radiography was used to study the stages in collapse of a conical liner. Completely filled charges and charges filled at the base with both symmetric and asymmetric inert loadings were fired. Radiographic data obtained give a clearer view of the mechanism of liner collapse and jet formation.

L220

[Armaments Design Department (Gt. Brit.).]
SHAPED CHARGES. Mar. 1945, 18p. incl. tables, diagrs. (Design Data Sheets, DF 4, Issue no. 1; Inclosure 1 to MA London rept. no. R3671-45) Secret

The method of operation of shaped charges and the principles and basic experimental data on which the design of shaped charges is based are summarized briefly. These factors include: charge diameter, charge length, confinement, liner materials, liner thickness, liner collapse, and the hydrodynamic theory of jet formation.

L221

[Armaments Design Department (Gt. Brit.).]
TARGET EFFECTS. APPLICATION OF SHAPED CHARGES. Mar. 1945, 7p. incl. tables, diagrs. (Design Data Sheets, DO 5, Issue no. 1; Inclosure 1 to MA London rept. no. R3671-45) Secret

A summary is given of the applications of shaped charges and of their effects against steel, homogeneous armor, and concrete. Scales are constructed to indicate the minimum weight of explosive for penetration into a massive target, for perforation of plate targets, and for effective damage behind targets. A definition is given of the follow-through and follow-up projectiles.

L222

Armaments Design Department (Gt. Brit.).
GERMAN AMMUNITION: A SURVEY OF WAR-TIME DEVELOPMENT; ANTITANK MINES, IGNITERS AND ANTI-LIFTING DEVICES, by R. W. Martyn. Feb. 1946, 10p. diagrs. (ADD Technical rept. no. 2/46, Part Q) Secret

A number of German land mines are described and illustrated. The Panzermine (Hohl Sprung Mine) and the Panzerstabmine employ the shaped charge principle.

L223

Armaments Design Department (Gt. Brit.).
GERMAN AMMUNITION: A SURVEY OF WAR-TIME DEVELOPMENT; DEMOLITION STORES AND ACCESSORIES, by R. W. Martyn. Feb. 1946, 8p. illus. diagrs. (ADD Technical rept. no. 2/46, Part R) Secret

A survey of German demolition charges is reported. Trends of design and late developments are discussed and illustrated. The electromagnetic charge is considered particularly interesting for its method of adhesion. The electrolyte is introduced into a cell when the igniter is operated; the cell is in effect short circuited through the coils of an electromagnet, and produces 100 w. for 30 sec., by which time the charge should have functioned.

L224

Armaments Design Department (Gt. Brit.).
GERMAN AMMUNITION: A SURVEY OF WAR-TIME DEVELOPMENT; RECOILLESS GUN AND SPECIAL GUN AMMUNITION, by J. U. Woolcock. Feb. 1946, 10p. diagrs. (ADD Technical rept. no. 2/46, Part K) Secret

The development of the German recoilless gun from the standpoint of its ammunition is summarized. The peculiarities of the shaped charge rounds used in the Puppchen and the Hammer are reported and a description of these 2 weapons is given.

L225

Armaments Design Department (Gt. Brit.).
GERMAN AMMUNITION: A SURVEY OF WAR-TIME DEVELOPMENT; MORTAR BOMBS AND CARTRIDGES, by R. G. Holton and E. R. S. Pearce. Apr. 1946, 16p. diagrs. (ADD Technical rept. no. 2/46, Part M) Secret

Several types of German mortar ammunition are described. The shaped charge grenades included are the 8-cm. Granate Patrone 44621 and the 10.5-cm. Panzerwurfgranate. Armor penetration of 200 mm. at 30° to normal is claimed for the latter but has not been proved.

L226

Armaments Design Department (Gt. Brit.).
GERMAN AMMUNITION: A SURVEY OF WAR-TIME DEVELOPMENT; GRENADES, by W. J. Ashby. Nov. 1946, [104]p. incl. diagrs. (ADD Technical rept. no. 2/46, Part N; Inclosure 1 to MA London rept. no. R6093-47) Restricted

Brief discussions and drawings are presented on rifle grenades (rotated), Panzerfaust, shaped charge stick grenades (hand), method of explosive filling and types of HE used in grenades, magnetic antitank grenades, Panzerhandmine, Panzerwurfmine, gross grenade Panzergranate, 46-mm. Gewehr Panzergranate, 61-mm. S.S. Gewehr Panzergranate, Panzer Gewehr Granate P.40, and 30-, 60-, 100-, 150-, and 250-mm. Faustpatrone, and Faustpatrone fuzes. A summary is given of interviews with Dr. Langweiler on spaced targets, liners, and proof of Panzerfausts.

L227

Armored Board, Fort Knox (Proj. no. 743).
TEST OF SHELL, 105-MM., HEAT, M67E1 (COPPER CONE AND COMPOSITION "B" FILLER). Sept. 25, 1945, [12]p. incl. illus. diagrs. Confidential

Tests were made to determine the armor penetration ability of the ammunition (M67E1) muzzle velocities (m.v.) 1250 and 1625 ft./sec. in comparison with standard HEAT ammunition (M67). The shells were fired against a 6-1/8 in. thick plate of rolled homogeneous armor at a range of 500 yd. Results showed that all of the M67E1 (m.v. =1250 ft./sec.) shells penetrated the target completely. Fifty percent of the M67E1, charge 7 rounds (m.v. =1625 ft./sec.) produced complete penetrations, while the standard shell, M67 (m.v. =1250 ft./sec.) did not produce any complete penetrations. Firing tests were also made to compare the ballistics of the M67E1, charge 7, and the HE, M1, charge 7.

L228

Armored School, Fort Knox.
ARMOR VS. ARMAMENT, by J. R. Burton, G. J. Grout, and others. Research rept. 1951-1952. Apr. 1952, 153p. incl. illus. Secret

In this discussion of tank development from the standpoint of armor and armament, shaped charge projectiles and protection against them are considered. Comparative performance charts for armor-defeating rounds for various calibers (76 mm. to 120 mm.) fired at targets ranging in obliquities from 0° to 60° are given. Spaced armor, sloping armor, laminated armor, plastics, and spikes are offered as a means of protection against enemy armament including HEAT projectiles. The vulnerability of the Soviet JS III tank to attack by the 90-mm. HEAT projectile (muzzle velocity 2,800 ft./sec.) is evaluated in an appendix.

L229

Armor Research Foundation (NOrd-11142).
DESIGN AND DEVELOPMENT OF HEAT BOMB AND CLUSTER, by F. Brown and K. H. Jacobs. Memo. rept. for Dec. 1, 1950-June 1, 1951. June 20, 1951, 1v. incl. diagrs. (Rept. no. 6) TIP C6614 Confidential

A cluster bomb with few moving parts for low-level aircraft attack against armored vehicles and surrounding personnel was designed. The cluster body contains 55 heat bombs having shaped charge heads able to penetrate 7-in. armor and to produce antipersonnel fragmentation. Inclined vanes on the cluster body cause rotation which disperses the heat bombs when the 2-section shell is opened at a suitable distance from the target. An optimum pattern size and spacing of the bombs, about 42-ft. wide and from 42- to 250-ft. long (depending upon the dive angle of the airplane at the moment of release) is produced if the cluster opens at 300 ft. from the ground. In this case a 10- x 20-ft. target within the pattern will be hit by at least 1 bomb.

L230

Armor Research Foundation (NOrd-11142).
DESIGN AND DEVELOPMENT OF HEAT BOMB AND CLUSTER, by F. Brown and K. H. Jacobs. Rept. no. 7, June 1-30, 1951. Aug. 31, 1951, 19p. tables, diagrs. TIP C6970 Confidential

Results of the penetration tests on the AT-AP bomb containing shaped charge heads were satisfactory. Armor penetrations of 9-11 in. were obtained.

L231

Armor Research Foundation (OEMsr-673).
THE ANTISUBMARINE SCATTER BOMB, by T. C. Poulter. Final rept. 29p. illus. diagrs. (NDRC Div. 6) OSRD 5494 Confidential

A detailed description is reported of the development and final models (only 1 of which made use of the shaped charge principle) of this bomb. The rept. is primarily concerned with the separation of the cluster and achieving a satisfactory bomb pattern.

L232

Army Attache, London.
DEVELOPMENT OF ANTITANK WEAPONS FOR FIGHTER/GROUND ATTACK, by W. Levin. Oct. 20, 1950, 6p. (Inclosure 1 to AA London rept. no. R-3302-50) Secret

A condensed picture of past and present British effort in development of antitank aircraft rockets is given. Trials of the 6-in. shaped charge rocket head and fuze no. 893 are briefly discussed. This rocket head, composed of a steel liner 0.150 in. thick, PETN boosters, and 16 lb. of 50/50 RDX/TNT, easily defeated 254 mm. of homogeneous plate at 50° obliquity. Of 17 rounds fired, 11 penetrations were obtained; at 55° obliquity, fuze no. 893 failed. In addition, a proposed antitank rocket battery was considered. Though it is uncertain whether the 3.5-in. shaped charge rocket could defeat the Russian JS3 heavy tank, it was concluded that better kill probabilities could be obtained with the 3.5-in. shaped charge rockets than with the 6.5-in. shaped charge rockets because of the increased accuracy (greater maximum velocity) of the former.

L233

Army Attache, Spain.
LECEA PYROTECHNICS COMPANY (PIROTECNIA LECEA), by C. S. Askins. June 27, 1951, 5p. illus. (AA Spain rept. no. R-226-51) Confidential

The firm has done development work on a bazooka-type rocket and rocket launcher. This rocket is 57 mm. in caliber, has a weight of 3.25 lb., and a length of 15.75 in. It is filled with a shaped charge of explosive, uses a conventional percussion fuze..., and has the usual finned tail assembly. The launcher ... is not of the stovepipe-type but more closely resembles a rifle. The barrel is 14 in. in length and 0.45 in. in outside diameter. The rocket slips over this slim tubing and the projectile is fired by pulling the trigger which activates a mechanical firing pin located inside the barrel. This firing pin strikes a fulminate of mercury primer in the base of the rocket which sets off the rocket charge. The advantage of this system over the present 3.5-in. rocket used by the US Army is that no electrical current is generated. The back blast from this rocket weapon is diverted from the firer's face by a 17-in. diameter circular plate affixed to the weapon just ahead of the receiver. A small opening at the base of the huge shield contains the rear sight. Because of this protective shield, the launcher is ungainly and very heavy. The rocket and launcher were offered to the Spanish Army but the probability of acceptance seems small. (AA abstract)

L234

Army Attache, Sweden (formerly Military Attache).
FINNISH, SWEDISH, AND RUSSIAN PROGRESS IN HOLLOW CHARGE PENETRATION, by R. W. Cole, Jr. Nov. 21, 1949, 1p. (AA Sweden rept. no. R857-49) Confidential

A conversation is reported with Hands O. Donner of the Finnish "Tampella" works in which he stated that the Russians are "considerably behind in the development of their hollow charge ammunition". The Russians were impressed by the Finnish shaped charge ammunition, but the Swedes stated that their own was much superior. It was revealed that the Finns are using this type of ammunition in the 120-mm. mortar.

L235

Army Field Forces Board Number 1, Fort Bragg (Proj. no. FA5051).
SHELL, HEAT, FS, 105-MM., T131E31. June 4, 1952, [25]p. incl. illus. tables. Secret

The 105-mm. HEAT shell, a shaped charge, fin-stabilized projectile with a muzzle velocity of 1750 ft./sec., was tested. Rounds were fired at ranges of 400 to 1500 yd. in accuracy determinations. Testing was terminated because of the inaccuracy of the rounds. It was concluded that this shell is not suitable for field artillery use.

L236

Army Field Forces Board Number 3, Fort Benning. (Proj. no. 2334).
CARTRIDGE, HEP, 105-MM, T139E2 AND CARTRIDGE, HEAT, 105-MM, T43. May 15, 1951, 1v. incl. illus. tables, diagrs. Secret

Tests were made to determine the amount of armor that could be defeated, and the accuracy of the HEP and the HEAT shells when fired from the 105-mm. rifle, M27. Results showed that a concrete wall 18 in. thick was defeated with 1 round of 105-mm. HEP and with 1 round of the 105-mm. HEAT. The 36-in. thick concrete wall was defeated with 2 rounds of 105-mm. HEP, but 4 rounds of 105-mm. HEAT were required to accomplish comparable damage. When firing against log emplacements, 2 rounds of HEP destroyed the emplacement, but 4 rounds of HEAT were required for comparable damage. Against sand bag emplacements, 2 rounds of HEP destroyed the emplacement, and 5 rounds of HEAT accomplished comparable damage. Accuracy, reliability and functioning data are also given. Temperature extremes (-40° and +120°F) did not affect the functioning of the HEP or HEAT shells. The HEAT shells defeated spaced armor in a vertical position. The 105-mm., HEAT projectile did not defeat a 4-in. plate of vertical armor on which a layer of sand bags had been placed. When the plate was sloped to 45°, all sand bags were destroyed by the first round, and the armor plate was defeated. The HEAT projectile also defeated a 4-in. armor plate sloped to 45° and covered with linoleum. The same results were obtained when the plate was covered with a wooden frame, and when the frame was covered with a 0.75-in. layer of heavy axle grease.

L237

Army Field Forces Board Number 3, Fort Benning.
PROPOSED REVISION OF MILITARY CHARACTERISTICS FOR BATTALION ANTITANK WEAPONS. APPENDIX E. US AND UK MILITARY CHARACTERISTICS FOR THE BATTALION ANTITANK WEAPONS. Feb. 25, 1952, 11p. (Proj. no. 2301-A, rept. no. 4) Secret

The United States and United Kingdom military characteristics of battalion antitank (BAT) ammunition and fuzes are briefly stated. US: At all usuable ranges beyond 30 ft., 90% of the HEAT rounds fired must defeat an average of 14 in. of Class B homogeneous armor plate at normal impact. The HEAT fuze must function reliably to insure armor penetration at angles of obliquity up to 64°; the minimum arming range is 30 ft. with a maximum arming range of 75 ft. UK: 90% of the HEAT rounds used at ranges beyond 20 ft. must penetrate 6 in. of homogeneous armor or its equivalent by weight of sandwiched and spaced armor at an angle of obliquity of 64°. The HEAT fuze employed must arm within a range of 20-60 ft.

L239

Army Field Forces Board Number 3, Fort Benning.
REPORT OF TEST OF PROJECT NO. 2501 ROCKET, ANTITANK, 73-MM., FRENCH, AND LAUNCHER, ROCKET, 73-MM., FRENCH. Oct. 31, 1952, 69p. incl. illus. Secret

Tests were made to determine and compare the armor penetration effectiveness of the French 73-mm. antitank rocket and the US 3.5-in. HEAT rocket. Characteristics of these rockets follow:

	French	US
Model	73AC	M28A2
Diameter	2.875 in.	3.5 in.
Fuze	base-detonating	base-detonating
Warhead	shaped charge	shaped charge
Liner material	Cu cone	Cu cone
Type filler	Comp. B	Comp. B
Muzzle velocity	525 ft./sec.	320 ft./sec.

The rockets were fired against 6-in., 9-in., and 12-in. homogeneous armor plate at obliquities of 0°, 45°, 55°-61°, and 64°. Maximum penetration (12.21 in.) of the French 73-mm. was obtained at 61° against a 6-in. target, while the US 3.5-in. achieved maximum penetration (11.04 in.) on a 6-in. target at an obliquity of 57°. Of 5 French rockets fired at 0° obliquity against 12-in. homogeneous armor plate, 1 penetrated completely; no complete penetrations were obtained under these conditions for the 5 US rockets tested, the maximum penetration being 10.25 in. Entry holes varied from 0.75 to 1.12 in. (French) and 1.75 to 2.65 in. (US); exit holes varied from 0.30 to 0.54 in. (French) and 0.70 to 1.12 in. (US). The 3.5 in. rocket had greater effect on witness plates and produced a greater destructive effect on the front of target armor plate than did the French 73-mm. rocket. However, it was concluded that at all the obliquities considered the French 73-mm. rocket was superior to the US 3.5-in. rocket, being capable of penetrating approximately 1 in. more armor. Additional tests were made to determine and compare the destructive effect of the French and US rockets when fired against reinforced concrete walls, log emplacements, and earthworks. From these tests it was concluded that the French rocket was superior in penetrating ability against all 3 target types, while the US rocket was superior in blast, concussion, and destructive effect.

L230

Army Ground Forces, Board Number 2, Fort Knox (Proj. no. 1257).
STUDY OF 1946-47 WINTER TEST OF SHAPED CHARGES, M2A3, AND M3, BY ARMY GROUND FORCES TASK FORCES FRIGID, FROST, AND WILLIWAW. Nov. 12, 1947, 1v. incl. illus. Confidential

Test results are reported for M2A3 and M3 shaped charges fired against ice, frozen ground, and other materials. Exposure for 60 days in temperatures ranging from + 60°F to - 28°F had no deteriorating effect and did not interfere with the functioning of the M3 shaped charge. Exposure tests resulted in partial deterioration, due to moisture, of the fiber standoff support for the M2A3 shaped charge. Modifications of the charges are suggested on the basis of these trials.

L240

Army Ground Forces Board Number 2, Fort Knox (Proj. no. P-1201).
TEST OF SHELL, 105-MM., HEAT, M67E1, COPPER CONE AND COMPOSITION "B" FILLER. June 18, 1948, 1v. incl. illus. tables, diagrs. Restricted

Two groups (2 rounds/group) of semi-fixed, M67E1 HEAT shells were fired against 7 in. of laminated armor at a range of 500 yd. and a muzzle velocity of 1566 ft./sec. At 35° obliquity penetrations of 4.25 and 5 in. were obtained, while at 41° the penetrations were 3.5 and 5 in.

L241

Army Services of Supply, Southwest Pacific Area, 5250th Technical Intelligence Composite Co.
ORDNANCE INTELLIGENCE TEAM MEMORANDUM NO. 6. Jan. 27, 1945, p. 2-3. Confidential

The Japanese Lunge Mine, a shaped charge weapon with handle attached, is described. The mine weighed 11 lb. and was equipped with 3 legs at the bottom to give proper standoff distance. The mine was reported to be capable of penetrating armor up to 6 in. thick. The mine was struck against the tank side by a lunge; this lunge forced the striker into the detonator, causing a blast which penetrated the armor.

L242

Army Technical Intelligence Center, Ordnance Section, 5250th Technical Intelligence Co.
TYPE 4 70-CM. "HOLLOW CHARGE" ROCKET (JAPANESE ORDNANCE EQUIPMENT). by K. L. Warden, Jr. Jan. 3, 1946, 3p. incl. illus. (Ordnance Section rept. no. 136) Unclassified

The rocket, which employs a shaped charge, is described.

L243

Australian Army Staff, London.
WEAPONS AND EQUIPMENT. [1947], p. 1, 2, 5, 7 incl. illus. (Extracts from AMGO Technical rept. no. 10/47) Secret

A German "Hammer" shaped charge projectile with stabilizing tail is discussed. The "Cam-Al" projectile is described which consists of a heavy cylindrical head carrying the fuze and filling, and a tubular brass tail extension of slightly less diameter than the head. The Schulmann projectile achieves stability by means of the forward displacement of the center of mass and the flat head. A projectile is illustrated which can be fired at supersonic velocities.

L244

Baader, F.
INVESTIGATION OF A THEORY OF BLASTING (Versuch einer Theorie der Sprengarbeit). Berjmannisches Journal von Kohler und Hoffman, v. 1, Mar. 1792: 193-212.

This is the earliest known reference to the "hollow charge principle". For a discussion of this reference see item no. L416 appendix A.

L245

Ballistic Research Laboratory, Aberdeen Proving Ground.
WORK ON HOLLOW CHARGES, by R. H. Kent and others. Preliminary rept. May 6, 1943, 1v. incl. illus. diagrs. (BRL Memo. rept. no. 159) Confidential

A discussion is presented on the region of the Mach reflection and the condition for the stationary existence of 3 plane shock waves. X-ray photographs were made on the fragmentation from several cylindrical and conical charges.

L246

Ballistic Research Laboratory, Aberdeen Proving Ground.
DESIGN DATA FOR 10-IN. AND 16-IN. HOWITZERS FOR PROPELLING HOLLOW CHARGE PROJECTILES, by J. N. Sarmousakis. June 12, 1943, 26p. incl. tables, diagrs. (BRL rept. no. 366) Confidential

Design data of 10-in. and 16-in. shaped charge projectiles are given. Probable errors in horizontal range and altitude of impact for these projectiles were estimated. Interior ballistic design data for howitzers to propel these shells were computed. Calculations were made of the weights of the howitzers and their carriages. These howitzers were compared with the 155-mm. gun M1918 firing an AP projectile. An addendum is included which gives estimates of the thickness of vertical concrete walls which would be penetrated by the projectiles at various ranges taking into consideration obliquity of impact.

L247

Ballistic Research Laboratory, Aberdeen Proving Ground.
HIGH SPEED RADIOGRAPHIC STUDIES OF CONTROLLED FRAGMENTATION. I. THE COLLAPSE OF STEEL CAVITY CHARGE LINERS, by L. B. Seely and J. C. Clark. June 16, 1943, 50p. incl. illus. (BRL rept. no. 368) Confidential

Ultra high speed radiographs were made of small steel lined shaped charges during liner collapse and immediately thereafter. Liners of 0.010, 0.020, 0.037 in. thickness and 45° apex angle and 0.020 in. thick liners with 80° apex angle were used. These radiographs show a complete deformation and the jet formation. They indicate that the liner is deformed as soon as the detonation wave strikes it; that the collapse is quite rapid; and that the jet continues to emerge after collapse is complete.

L248

Ballistic Research Laboratory, Aberdeen Proving Ground.
HIGH SPEED RADIOGRAPHIC STUDIES OF CONTROLLED FRAGMENTATION. II. MOTION OF EXPLOSION GASES IN LINED AND UNLINED CAVITY CHARGES, by J. C. Clark and L. B. Seely. July 26, 1943, 13p. incl. illus. (BRL rept. no. 392) (In cooperation with du Pont de Nemours, E. I., & Co. (W670-ORD-4331)) Confidential

Flash radiographs were made of lined and unlined shaped charges during and immediately after the detonation wave had passed through the cavity region. The explosive charges were $Pb(NO_3)_2$ and 50/50 Pentolite, suitably mixed to give reasonable X-ray absorptions, and thus record the position and relative density of the explosion gases.

L249

Ballistic Research Laboratory, Aberdeen Proving Ground.
HIGH SPEED RADIOGRAPHIC STUDIES OF CONTROLLED FRAGMENTATION. III. COLLAPSE OF HEMISPHERICAL AND HEMICYLINDRICAL STEEL CAVITY CHARGE LINERS, by J. C. Clark and L. B. Seely. Oct. 14, 1943, 25p. incl. illus. diagr. (BRL rept. no. 415) (In cooperation with du Pont de Nemours, E. I., & Co. (W670-ORD-4331)) Confidential

Radiographs were made of hemispherical and hemicylindrical steel shaped charge liners during and after liner collapse. The technique used in obtaining these radiographs is described briefly. The radiographs revealed that the liner turned inside out and collapsed toward the charge axis forming a broad jet of fast moving fragments.

L250

Ballistic Research Laboratory, Aberdeen Proving Ground.
HIGH SPEED RADIOGRAPHIC STUDIES OF CONTROLLED FRAGMENTATION. IV. GAS MOTION IN UNLINED WEDGE CHARGES, by L. B. Seely and J. C. Clark. Oct. 28, 1943, 18p. incl. illus. diagrs. (BRL rept. no. 420) (In cooperation with du Pont de Nemours, E. I., & Co. (W670-ORD-4331)) Confidential

Radiographs were made of 60° and 100° unlined wedge charges. Two waves of explosion gases from the inner edges of the charge were observed to interact at the center of the wedge producing a well-defined jet which was very narrow and dense in the early stages.

L251

Ballistic Research Laboratory, Aberdeen Proving Ground.
HIGH SPEED RADIOGRAPHIC STUDIES OF CONTROLLED FRAGMENTATION. V. TARGET PERFORATION BY STEEL JETS, by J. C. Clark and L. B. Seely. Sept. 25, 1944, 22p. incl. illus. diagrs. (BRL rept. no. 489) (In cooperation with du Pont de Nemours, E. I., & Co. (W670-ORD-4331)) Confidential

Radiographs are shown of jets from conical steel liners perforating steel, Al, duraluminum and water targets which were at normal and at 45° inclination to the jet.

L252

Ballistic Research Laboratory, Aberdeen Proving Ground.
HIGH SPEED RADIOGRAPHIC STUDIES OF CONTROLLED FRAGMENTATION. VII. THE EFFECT OF THE BASE FLANGE ON CONICALLY LINED HOLLOW CHARGES, by J. C. Clark and W. M. Podas. Nov. 13, 1945, 30p. incl. illus. diagrs. (BRL rept. no. 585) Confidential

Conically lined charges in which the base flange of the liner was unbacked, partially backed, and completely backed by explosive were statically detonated and studied by flash radiography and by jet penetration into steel targets.

L253

Ballistic Research Laboratory, Aberdeen Proving Ground.
MATHEMATICAL JET THEORY OF LINED HOLLOW CHARGES, by G. Birkhoff. June 18, 1943, 11p. incl. diagr. (BRL rept. no. 370) Confidential

High speed X-ray shadowgraphs by Clark and Seely gave rise to the view that the lining collapses with a normal velocity, and when the sides of the wall collide along the lining axis, the momentum forces the lining out in a forward slender, high speed jet, and a backward thick, low speed jet or slug. Discussions are included on the heat generated by plastic deformation, and on scale experiments with models.

L254

Ballistic Research Laboratory, Aberdeen Proving Ground.
HIGH SPEED MOTION PICTURES OF SHAPED CHARGES (PROBLEM NO. I-34), by [J. C. Clark]. Part B of progress rept. on Terminal Ballistics for June 1943. June 30, 1943, 2p Confidential

A series of 10-lb., 6-in. diameter cavity charges were fired and high speed motion pictures were obtained with a pinhole camera. Constants of the camera are given. Preliminary results obtained from the pinhole camera showed that the fast moving fragments from a 90° steel liner had an average velocity of 19,600 ft./sec. during the first 250 μsec. of travel, 15,600 ft./sec. during the second 250 μsec., and a slight decrease in speed thereafter.

L255

Ballistic Research Laboratory, Aberdeen Proving Ground.
MEASUREMENTS ON SHAPED CHARGES WITH THE BALLISTIC PENDULUM, by J. H. Frazer and C. P. Fenimore. Aug. 17, 1943, 10p. incl. illus. diagrs. (BRL rept. no. 391) Confidential

Calculations of the momentum imparted to a target by the jet from conical shaped charges are reported. Measuring the mass of the pendulum bob, length of pendulum, and length of chord of the stylus trace allowed the calculation of the momentum given the bob by the jet of the charge.

L256

Ballistic Research Laboratory, Aberdeen Proving Ground.
FLASH RADIOGRAPHIC STUDY OF THE CONTROLLED FRAGMENTATION FROM A CABLE CUTTER TYPE CHARGE, by J. C. Clark. Dec. 2, 1943, 5p. incl. illus. (BRL Memo. rept. no. 253) Confidential

A cylindrical trough charge was investigated for use as a cable cutting charge. Radiographs of the charge at various stages after firing are shown.

L257

Ballistic Research Laboratory, Aberdeen Proving Ground.
DETONATION TIME MEASUREMENTS OF M6A1 ROCKETS EQUIPPED WITH A POINT DETONATING FUZE, by J. C. Clark. Dec. 22, 1943, 5p. incl. illus. (BRL Memo. rept. no. 260) Confidential

M6A1 rockets, modified with a M46 fuze in the nose end, were fired to determine the detonation time. High speed photographs were made to determine the condition of the ogive at detonation.

L258

Ballistic Research Laboratories, Aberdeen Proving Ground.
MEASUREMENT OF DETONATION TIME FOR 2.36-IN. ROCKET, by J. C. Clark. Dec. 23, 1943, 37p. incl. illus. diagrs. (BRL rept. no. 440) Confidential

Measurements were made of the time interval between the rocket ogive contact with target and the instant of detonation of the explosive charge. Photographs made with a pinhole drum camera are shown of the rocket approaching the target and detonating after impact.

L259

Ballistic Research Laboratory, Aberdeen Proving Ground.
VISIT TO SAFETY IN MINES LABORATORY, BUXTON; EXPLOSIVE PHENOMENA AND FRAGMENTATION, by R. H. Kent. Dec. 28, 1943, 2p. Confidential

Brief summaries of the topics are discussed on the visit to the Safety in Mines Laboratory are reported. It is mentioned that paper liners were used successfully in the 3-in. rocket to obtain fragments of any desired size. A mass distribution law for fragmentation is stated briefly.

L260

Ballistic Research Laboratory, Aberdeen Proving Ground.
FLASH RADIOGRAPHS OF COMMERCIAL ELECTRIC DETONATORS DURING DETONATION, by J. C. Clark. Mar. 28, 1944, 14p. incl. illus. (BRL rept. no. 451) Confidential

Flash radiographs are shown of commercial detonators of no. 6, no. 8, no. 12, and "Engineers Special" sizes during detonation.

L261

Ballistic Research Laboratory, Aberdeen Proving Ground.
FLASH RADIOGRAPHS OF THE BRITISH 233 FUZE DURING DETONATION, by J. C. Clark. Apr. 24, 1944, 7p. incl. illus. (BRL Memo. rept. no. 288) Confidential

Radiographs are shown of the jet formed by the British 233 fuze which employs a lined shaped charge.

L262

Ballistic Research Laboratory, Aberdeen Proving Ground.
STABILITY OF THE 57-MM. HEAT SHELL T20 AND HE SHELL T22, by H. P. Hitchcock. June 7, 1944, 17p. incl. tables. (Ordnance Research Center proj. no. 2804, BRL Memo. rept. no. 300) Confidential

Stability firings were made of the HEAT shell, T20, with either the blunt-nosed or long-pointed windshield. These tests showed that the T20 rounds of both types were not stable enough to trail properly when fired from the 57-mm. gun T15E2 having a 1/30 twist, i.e., 1 turn in 30 calibers; however, satisfactory flight stability was obtained when both types of rounds were used with the 57-mm. gun T15E3 having a 1/20 twist. It was concluded that when fired from a 1/25-twist gun, the long-pointed type would tumble but the blunt-nosed type would trail properly.

L263

Ballistic Research Laboratory, Aberdeen Proving Ground.
DESIGN OF A 60-MM. HOLLOW CHARGE FINNED SHELL, by S. Zaroodny. Sept. 27, 1944, 5p. diagrs. (Ordnance Research and Development Center proj. no. 2221-I, BRL Memo rept. no. 332) Confidential

The design of a 60-mm. shaped charge, fin-stabilized shell for use with the M1 and T18E6 mortars is discussed. It is proposed that: (1) fins be used to overcome the overturning moment of the shell body, thus maintaining stability; (2) the ogive be short and narrow, i.e., like those used by the Germans in the faustpatrone and puppchen shells, to keep the c.p. as far aft as possible; (3) the electro-magnetic fuze be heavy in order to displace the c.g. of the shell as far forward as possible; (4) the fuze be similar to the German point-detonating fuze AZ-5095; (5) the fuze not obstruct the jet; (6) the conical liner be similar to the Bazooka liner, but of smaller diameter so as to withstand the high external pressure. It is believed that a shell of substantially the same design can be used in a 57-mm. recoilless gun or its equivalent. Sketches of a 60-mm. shaped charge shell are included.

L264

Ballistic Research Laboratory, Aberdeen Proving Ground.
REMARK ON THE HILL-MOTT-PACK THEORY OF PENETRATION BY MUNROE JETS, by G. Birkhoff. Oct. 31, 1944, 4p. incl. diagr. (BRL rept. no. 497) Confidential

A study of the Hill-Mott-Pack theory revealed why standoff does not increase the volume of the hole from a jet, and why the penetration depth is not increased by standoff in the case of rotated conical liners.

L265

Ballistic Research Laboratory, Aberdeen Proving Ground.
PANEL FRAGMENTATION TESTS OF 105-MM H.E. SHELL, M1. AND 105 MM. HEAT SHELL, M67, by A. V. Bashkovitch. Mar. 3, 1945, 28p. incl. diagrs. illus. (BRL Memo rept. no. 358)
Confidential

Panel fragmentation tests of the M67 showed 1321 performations on a 20-ft. sphere surrounding the shell. Between 100 and 200 of these were caused by very small fragments associated with the shaped charge "spit" in the nose spray and would not contribute to the fragmentation efficiency of the shell. The M1 shell gave 1507 perforations on the 20-ft. sphere. The directional distributions of the fragments of the M67 and M1 shells were those of typical artillery shells. The M67 shell had a very intense nose spray that exceeded that of the M1. The fragment velocity in the side spray of the M67 shell was 3410 ft./sec. and 3780 ft./sec. for the M1. Fragment velocity in the tail spray of the M67 was 2730 ft./sec. against 2790 ft./sec. for the M1.

L266

Ballistic Research Laboratory, Aberdeen Proving Ground.
FLASH RADIOGRAPHS OF ROTATING CHARGES, by [J. C. Clark]. Progress rept. Feb. 15-Mar. 15, 1945. 3p.
Confidential

Flash radiographs made of the jets from steel hemispherically lined charges during rotation showed no effect of rotation in the early stages, but in the later stages the jet spread at rotational speeds above 150 r.p.s. for the charges used.

L267

Ballistic Research Laboratory, Aberdeen Proving Ground.
FLASH RADIOGRAPHS OF ROTATING CAVITY CHARGES, by [J. C. Clark]. Progress rept. Apr. 15-May 15, 1945. May 22, 1945, 3p. incl. illus. diagr.
Confidential

Flash radiographs were made of jet formation from rotating charges bearing 45° Cu and steel liners. The radiographs show that the jets from rotated charges experience spreading and that the amount of spreading increases with the rotational speed.

L268

Ballistic Research Laboratory, Aberdeen Proving Ground.
FLASH RADIOGRAPHIC STUDY OF CONTROLLED FRAGMENTATION, by [J. C. Clark]. Progress rept. May 15-June 15, 1945. [May 20, 1945], 7p. incl. illus.
Confidential

Flash radiographs were made of the jets from flanged and unflanged liners to correlate the nature of the jet and target penetration data, and to determine the effect of the base flange upon the process of jet formation. Flash radiographs are shown also for ring charges.

L269

Ballistic Research Laboratory, Aberdeen Proving Ground.
PROPOSALS TO COMPENSATE EFFECTS OF PROJECTILE SPIN ON SHAPED CHARGE JETS BY MAGNETIC FIELDS, by G. Breit. May 25, 1945, 11p. incl. diagrs. (BRL Memo. rept. no. 372)
Confidential

Attempts were made to compensate for the disturbing effects of projectile rotation on the formation of shaped charge jets by a magnetic field directed along the spin axis. Compensation of rotation effects by magnetic fields was reported to be impractical; weaknesses in the proposals are enumerated.

L270

Ballistic Research Laboratories, Aberdeen Proving Ground.
HOLLOW CHARGE ANTITANK PROJECTILES, by G. Birkhoff. Feb. 10, 1947, 25p. incl. table, diagrs. (BRL rept. no. 623)
Confidential

The hydrodynamic theories of jet formation and penetration by lined charges are discussed with emphasis on change of scale, compressibility, hydrodynamics of rotation, and shear lines in the slug. Practical questions relating to the use of shaped charge projectiles are treated. A number of useful bibliographical references are given in the footnotes.

L271

Ballistic Research Laboratories, Aberdeen Proving Ground.
A NOTE ON THE INITIAL VELOCITIES OF FRAGMENTS FROM WARHEADS, by T. E. Sterne. Sept. 2, 1947, 20p. (Rept. no. 648) TIP C59018
Confidential

Theoretical analyses are presented for the velocities of fragments from cased explosive cylinders with metal cores, from "sandwiches" consisting of slabs of metal separated by slabs of explosive, and from single slabs of metal in contact with slabs of explosive. Satisfactory agreement is found with experiment, and limits are obtained which bound the velocities of fragments from hollow cylindrical warheads. (TIP abstract)

L272

Ballistic Research Laboratories, Aberdeen Proving Ground.
EXPERIMENTS WITH 105-MM. (HOWITZER) FIN-STABILIZED HOLLOW CHARGE SHELL, by S. J. Zaroodny. Sept. 15, 1947, 1v. incl. illus. diagrs. (BRL Memo. rept. no. 457)
Confidential

To regain the loss of penetration of the 105-mm. HEAT shell M67 caused by spin, attempts were made to stabilize this shell by means of fins. A detailed sketch and discussion of the design as last tried are given. Experimentation was limited to rigid shapes, i.e., without any moving parts. A brief summary of the firing records is presented.

L273

Ballistic Research Laboratories, Aberdeen Proving Ground.
VULNERABILITY OF SIMULATED MISSILE WARHEADS, by K. S. Jones. Dec. 12, 1947, 59p. incl. illus. tables, diagrs. (BRL Memo. rept. no. 472)
Confidential

A series of tests to determine the vulnerability of guided missile warheads to fragments, blast, shaped charges, and bullets are described. Warheads were simulated by 500-lb. GP bombs and 4000-lb. LC bombs. In the shaped charge portion of the experiments, 40-lb. shaped charges and 2.36-in. M6A5 rockets were tested. Diagrams and results of firing tests are appended.

L274

Ballistic Research Laboratories, Aberdeen Proving Ground.
HIGH SPEED RADIOGRAPHIC STUDIES OF CONTROLLED FRAGMENTATION – COLLAPSE OF HEMISPHERICAL AND SEGMENTAL CAVITY CHARGE LINERS, by R. O. Fleming, Jr. Mar. 25, 1948, 12p. illus. (BRL rept. no. 667)
Confidential

Data are given on the collapse of hemispherical liners, and the possibilities were investigated of using lined explosive charges as high velocity fragment projectors. Investigations made of the charges showed that under certain conditions, an opposite collinear jet is formed in addition to the forward moving component.

L275

Ballistic Research Laboratories, Aberdeen Proving Ground.
SPECIAL PROBLEM IN SHAPED CHARGES. Progress rept. June 1948. 1p. incl. diagr.
TIP C1662
Confidential

The purpose of the investigation was to obtain a jet having a large mass which is suitable for incorporation in a guided missile warhead. Axially bisected convex charges were detonated resting flush upon 0.5-in. steel plates. The location and depth of a deep gouge, made in the steel plate at the point of shock wave interaction, was controlled by the base angle of a Pb nozzle.

L276

Ballistic Research Laboratories, Aberdeen Proving Ground.
SPECIAL PROBLEM IN SHAPED CHARGES. Progress rept. July 1948. 1p. incl. table.
TIP C1703
Confidential

The purpose of the investigation was to obtain a jet having a large mass which is suitable for incorporation in a guided missile warhead. Four large 6-in. diameter charges (90° and 120° Cu liners) were detonated at ranges of 100 and 200 ft. against 3-in. armor plate. The 1/8 in. thick, 90° spherical segment liner gave the best penetration and least spread of fragments.

L277

Ballistic Research Laboratories, Aberdeen Proving Ground.
THE EFFECT OF ROTATION UPON THE EXPLOSIVE COLLAPSE OF THIN METAL SURFACES OF REVOLUTION, by J. C. Clark and R. O. Fleming, Jr. July 8, 1948, 22p. incl. illus. diagrs. (BRL rept. no. 671)
Confidential

Flash radiographs of the collapse of thin metal surfaces of revolution surrounded by explosive were taken during the rotation process. The radiographs showed that jets from hemispherical liners did not undergo the marked changes that occurred in the case of jets from conical liners. Jets from hemispherical liners broadened at high rotational speeds. The spreading or fanning of jets from collapsing right circular liners was greater at higher rotational speeds. Flash radiographic experiments are discussed and comments are made on X-ray apparatus, rotator, X-ray triggering and timing, explosive charges, and thin metal liners.

L278

Ballistic Research Laboratories, Aberdeen Proving Ground.
JET EFFECTS FROM PLANE-ENDED CHARGES, by H. L. Breidenbach and R. O. Fleming, Jr. Dec. 14, 1948, 12p. incl. illus. diagrs. (BRL Memo. rept. no. 485) TIP R1727
Restricted

Experiments are described in which the detonation products from a plane-ended explosive charge are directed through conical nozzles having various cone angles. A thin disc of either wood or metal placed in the orifice of the nozzle is accelerated to a high velocity. The interaction of the shock waves that are reflected from the wall of the conical nozzle produces a resultant shock wave which appears in the form of a narrow jet, which strikes the disc at its center. By varying the cone angle of the nozzle, it is possible to produce resultant jets either along or opposite to the direction of the detonation. It is not at present a means of obtaining a jet at all comparable to that obtained from cavity charges. This is true because of the nonplanar shape of the emergent shock wave which strikes the nozzle walls at different angles causing various interaction angles and times of interaction, which may have a subtractive as well as an additive effect. (BRL abstract)

L279

Ballistic Research Laboratories, Aberdeen Proving Ground.
LONG RANGE LOW VELOCITY JETS FROM SHAPED CHARGES, by R. O. Fleming, Jr. and H. F. Breidenbach. Oct. 1949, 12p. incl. illus. diagrs. (BRL Memo. rept. no. 493) TIP C2837
Confidential

Four experimental shaped charges (cast 50/50 Pentolite) in the form of paraboloids (20-cm. diameter) with a stem, designed to produce jets of low velocity and high mass, were detonated at 30 and 60 m. from the back surface of a 7.5-cm. face-hardened armor plate. Two charges had 90° and 2 employed 120° spherical shell segments as liners. One charge having a 90° spherical segment liner (15-cm. diameter, 3 mm. thick) detonated at a distance of 30 m. produced a pattern in which 90% of the fragments were located in a circular area 18 cm. in diameter. The large slugs from this charge which weighed 3.49 kg. penetrated to a depth of 3.75 cm. Although only 1 of this type of charge was detonated, it appears that such a design may be useful where a linear stream of high velocity (2,200 m./sec.) fragments is required at large standoff distances. For velocity comparison, 6 Navy Mark 3 demolition charges (7.5-cm. diameter, 80° steel liners) were detonated and velocities taken at various distances up to 40 m. Test results are tabulated.

L280

Ballistic Research Laboratories, Aberdeen Proving Ground.
OUR ANTITANK PROJECTILE PREDICAMENT, by T. C. Compton. Mar. 20, 1950, p. 27-34 incl. tables. (Proj. no. TB3-1224B, BRL rept. no. 739) (In its Rept. of First Tank Conference held at Aberdeen, Mar. 20-22, 1950, [compiled by] F. I. Hill, Secret, TIP S1651) Secret

In the discussion on ways to defeat tanks, it was pointed out that the fin-stabilized shaped charge projectile, both the rocket and non-rocket type, may be able to defeat 4.7-in. plate at 55° obliquity (the front glacis plate of the Russian JS III tank is 4.7 in. at 55° obliquity). Tests showed that at point-blank range, the 90-mm. non-rocket type defeated 5 in. at 60°. The fins presented a weakness because of their susceptibility to cross winds, and they limited the velocity at which the projectile could be fired.

L281

Ballistic Research Laboratories, Aberdeen Proving Ground.
PROGRESS IN DEVELOPING EMPIRICAL WEAPONS LAWS FOR TANK PERFORMANCE: THE PERFORATION OF THE JS III FRONTAL ARMOR, by F. I. Hill. Mar. 21, 1950, p. 85-113 incl. tables, diagrs. (Proj. no. TB3-1224B, BRL rept. no. 739) (In its Rept. of First Tank Conference held at Aberdeen, Mar. 20-22, 1950, [compiled by] F. I. Hill, Secret, TIP S1651)
Secret

An investigation of penetration, gun weight, and tank gross weight showed that the 90-mm. HEAT round appeared to be a promising solution to the gun-round combination to defeat the JS III frontal armor. Examination of the first round hit probability of the guns showed that some type of range finder was desirable with all guns, and that with the best of contemplated range finders for tanks, the present accuracy of the 90-mm. HEAT round was such that an 80% probability of a first round hit could be attained at only 1000 yd.

L282

Ballistic Research Laboratories, Aberdeen Proving Ground.
PROOF FIRINGS OF 105-MM. T138 PROJECTILE, by A. C. Charters. July 6, 1950, [4]p. incl. diagrs. Confidential

Data obtained from firing various configurations of slow-spin HEAT projectiles at full-scale are given. It is pointed out that the data are scanty, but there was some indication that light based configurations with separation fixing devices were promising.

L283

Ballistic Research Laboratories, Aberdeen Proving Ground.
PROBABILITIES OF HITTING FOR FIN-STABILIZED PROJECTILES FOR THE 90-MM. T108 HEAT TYPE. Aug. 1950, 4p. diagrs. (Proj. no. TB3-0230A, BRL Technical note no. 282)
Confidential

Probabilities of hitting a vertical target 7.5 ft. x 7.5 ft. at 1000- and 2000-yd. range are graphed against various errors in estimating range for muzzle velocities of 1800, 2440, and 3000 ft./sec., and various assumptions of interior and exterior ballistic variations for the 90-mm. T108 fin-stabilized HEAT round. (BRL abstract)

L284

Ballistic Research Laboratories, Aberdeen Proving Ground.
PROPOSED PROGRAM FOR DEVELOPMENT OF ARMOR TO DEFEAT HEAT AND SQUASH-HEAD PROJECTILES, by [F. I. Hill]. Aug. 1950, 11p. incl. tables, diagrs. (Proj. no. TB3-1224B, BRL Technical note no. 281) Confidential

The following proposed experimental program to develop suitable tank armor capable of giving some protection against probable types of shaped charge and squash head projectiles is discussed: (1) the design of a glass armor material for application to steel, capable of providing protection against the 3.5-in rocket and the 90-mm. T108 round; (2) the development of spike designs for defeat of the 3.5-in. rocket and the 90-mm. T108; (3) the determination of practicable methods of using plastic explosives defensively against shaped charges. Each practicable armor type which defeats the shaped charge projectiles fired will be tested against the 105-mm. T81 projectile.

L285

Ballistic Research Laboratories, Aberdeen Proving Ground.
WIND TUNNEL TESTS OF THE T84 75-MM. HEAT PROJECTILE, by R. H. Krieger. Sept. 1950, 41p. incl. illus. tables, diagrs. (Proj. no. TB3-0230A, BRL Memo. rept. no. 518)
Confidential

Models of the T84 75-mm. HEAT fin-stabilized round were tested at M = 1.72 to determine their lift, drag, normal force, pitching moment, and c.p. Three different fin assemblies and 2 different body nose shapes, 1 sharp and the other blunt, were used. All the fins were of approximately the same plan form, but with sweepback angles of 50°, 65°, and 75°, respectively. The projectile was stable for all body-fin combinations tested, the greatest stability being possessed by the blunt-nosed body with the 50-degree sweptback fins. It was observed that with increasing fin sweepback angle, the c.p. moved forward decidedly. An increase in the tail sweepback reduced the fore drag; all the sharp-nose body-tail configurations showed lower fore drag than the blunt-nose body-tail combinations. The test results appear as aerodynamic coefficients on graphs and tables. (BRL abstract)

L286

Ballistic Research Laboratories, Aberdeen Proving Ground.
COMPARISON OF SINGLE AND RIPPLE FIRING OF ROCKETS, by W. L. Deemer, Jr. Nov. 1950, p. 200-206. (Proj. no. TB3-1224B, BRL rept. no. 779) (In its Rept. of Second Tank Conference held at Aberdeen, Nov. 27-29, 1950, compiled by J. R. Williams, Secret, TIP S2268)
Secret

Brief mention was made of the first 200 6.8-in. shaped charge rockets used in Korea against tanks. Of 180 rounds fired from F51 aircraft, 12 hits were kills.

L287

Ballistic Research Laboratories, Aberdeen Proving Ground.
ON THE DEVELOPMENT OF A LOW SPIN ANTITANK PROJECTILE, by J. D. Nicolaides. Nov. 1950, 17p. illus. tables, diagrs. (Proj. no. TB3-2030A, BRL Memo. rept. no. 527)
Confidential

This phase of the T138 project is concerned with the development of an aerodynamic carrier for the shaped charge which is capable of cheap, quick, and easy construction and may be launched by employing conventional ballistic techniques. Estimates of the aerodynamic coefficients from the supersonic wind tunnel and the transonic range are given. Estimates are also given for the performance of the standard E20 model and various c.g. modifications. It was shown both theoretically and experimentally that the E20 shell performance could be improved by locating the c.g. in a particular rear position. A change of the c.g. by 0.24 calibers toward the base resulted in a reduction of the horizontal and vertical probable errors by 4 and 3, respectively.

L288

Ballistic Research Laboratories, Aberdeen Proving Ground.
PRELIMINARY RESULTS OF FIRST VULNERABILITY STUDIES ON TANKS, by F. I. Hill. Nov. 1950, p. 18-38 incl. tables, diagrs. (Proj. no. TB3-1224B, BRL rept. no. 779) (In its Rept. of Second Tank Conference held at Aberdeen, Nov. 27-29, 1950, compiled by J. R. Williams, Secret, TIP S2268)
Secret

Various projectile types, including the HEAT 3.5-in. (M28A2) rocket, were fired in the vulnerability study of T26E4 tank targets. Preliminary results of the 3.5-in. rocket firings indicated that:

(1) the K kill success of the HEAT round depends on its striking the tank's fuel or ammunition.
(2) the HEAT jet must hit the ammunition to detonate a round.
(3) the major damage occurs in a small cylinder aft of the jet.
(4) the damage outside this area is caused primarily by small armor fragments which can be stopped with body armor.

L289

Ballistic Research Laboratories, Aberdeen Proving Ground.
SPACED ARMOR, by A. Hurlich. Nov. 1950, p. 207-231. (Proj. no. TB3-1224B, BRL rept. no. 779) (In its Rept. of Second Tank Conference held at Aberdeen, Nov. 27-29, 1950, compiled by J. R. Williams, Secret, TIP S2268)
Secret

The use and limitations of spaced armor against various ordnance, including shaped charges, are discussed. Very brief mention is made of shaped charge attack against spaced armor during and after World War II. It is believed that an arrangement having the main armor sloped at about 30° obliquity with the skirting plate tilted in the opposite direction as a single plate or as a series of plates in a Venetian-blind configuration will be equally effective against shaped charge and "squash-head" rounds as well as against all types of kinetic-energy projectiles.

L290

[Ballistic Research Laboratories, Aberdeen Proving Ground].
INTERIM REPORT OF AD HOC COMMITTEE TO STUDY SHAPED CHARGE PROGRAM, by G. Birkhoff and others. Jan. 26, 1951, [21]p. incl. diagrs. Secret

A summary is presented of the status of work on shaped charges and related questions. Mention is made of the work being conducted at the Carnegie Institute of Technology including the study of detonation waves, liner collapse and jet formation, Kerr cell technique, jet penetration and armor, and spin compensation. A 3 page progress rept. on Basic Research and Development of Shaped Charges by W. Blum of the National Bureau of Standards is appended. In it, the preparation on smooth and fluted liners is discussed.

L291

Ballistic Research Laboratories, Aberdeen Proving Ground.
THE ACCURACY AND PENETRATION CHARACTERISTICS OF THE 2.36-AND 3.5-IN. HEAT ROCKETS, by [A. R. Vincent]. Revised, May 1951, 20p. incl. diagrs. (Proj. no. TB3-1224B, BRL Technical note no. 363) Confidential

The penetration and accuracy data for the 2.36- and 3.5-in. HEAT rockets are compiled, and the probability of penetrating a 6 ft. x 6 ft. target at 60° obliquity from normal is given as a function of range and plate thickness.

L292

Ballistic Research Laboratories, Aberdeen Proving Ground.
ESTIMATES CONCERNING THE VULNERABILITY OF THE RUSSIAN T34/85 TANK TO THE 3.5-IN. AND 2.36-IN. HOLLOW CHARGE WEAPONS. Aug. 1951, 38p. incl. tables, diagrs. (Proj. no. TB3-1224B, BRL Technical note no. 472) TIP C6775 Confidential

Estimates of the vulnerable areas of the T34/85 Russian tank to the 2.36-in. and 3.5-in. HEAT rockets are given for various angles of attack from both air and ground. The method for calculating tank vulnerable areas is appended. The probability of a hit being a kill as a function of azimuth angle of attack is given also. Results indicated that the vulnerable areas of the T34/85 to the 2.36-in. HEAT rocket were only slightly less than the areas vulnerable to the 3.5-in. HEAT projectile. Vulnerable area to mobility damage was larger than vulnerable area to fire power damage. The vulnerable area to damage resulting in a kill was considerably smaller than that of either of the above categories of damage. Tabular data summarizing the results follow:

Round	Elevation angle	Mobility damage	Fire power damage	Probability of a "kill"
2.36-in.	0°	.32	.14	.12
rocket	30°	.29	.12	.11
3.5-in.	0°	.35	.17	.14
rocket	30°	.33	.16	.13

L293

Ballistic Research Laboratories, Aberdeen Proving Ground.
PERFORMANCE OF NAVAL SHAPED CHARGE ROCKETS, by A. N. Beardslee. Aug. 27, 1951, p. 56-66. (Proj. no. TB3-1224B, BRL rept. no. 780) (In its Rept. of Third Tank Conference held at Aberdeen, Aug. 27-29, 1951, compiled by A. E. Roden, Secret, TIP S2284) Secret

Penetration test results are reported from the 5-in. Mk 25 Mod 1 shaped charge head. The head employs a Cu conical liner, 4.5-in. in diameter and 1/8 in. thick. Rounds fired from the 1050-ft. launcher at 0°, 45°, 60° and 63° obliquity, penetrated completely 9.5 in. of armor. At the extreme obliquity an actual penetration of 20 in. was obtained. It was concluded that with the Mk 25 head: (1) the expected consistent penetration of class B armor plate was about 16.5 to 17.5 in.; (2) sandbags with or without trigger plates were ineffective as protection in conjunction with any known tanks; and (3) the fuze will operate at a maximum obliquity of about 65°. Penetration tests of the 6.5-in. ATAR using the 1500 ft. launcher showed that the rockets penetrated from 10.5 to 13.5 in. of armor at 60° obliquity. It was concluded that shaped charge rockets can defeat the armor of any tank that can be foreseen, and that any defense against these rockets must be obtained by means other than by increased armor thickness. Fragmentation test results showed that at 30 ft., the shaped charge rockets produced 3 times as many perforations of 1/8-in. plate and twice as many perforations of 3/8-in. plate as did the standard GP head.

L294

Ballistic Research Laboratories, Aberdeen Proving Ground.
ACCURACY AND PENETRATION OF THE 2.36-IN. AND 3.5-IN. HEAT ROCKET, by A. R. Vincent. Aug. 28, 1951, p. 174-186 incl. tables, diagrs. (Proj. no. TB3-1224B, BRL rept. no. 780) (In its Rept. of Third Tank Conference held at Aberdeen, Aug. 27-29, 1951, compiled by A. E. Roden, Secret, TIP S2284) Secret

The results are reported of a study made to evaluate the 2.36-in. and 3.5-in. HEAT rockets as effective antitank weapons. Dispersion data are shown for the 2 rockets. With this dispersion data, the probability of a hit as a function of range was calculated. Penetration data from dynamically and statically fired rockets are given. A comparison of this data showed that static firing results gave a penetration depth 1.5 to 2 in. greater than the dynamically fired rockets. It was concluded that these weapons are short range weapons, and they are very sensitive to range error.

L295

Ballistic Research Laboratories, Aberdeen Proving Ground.
THE CHARACTERISTICS AND PERFORMANCE OF THE HELLER ROCKET AND LAUNCHER, by E. S. Guy. Aug. 28, 1951, p. 85-112 incl. illus. diagrs. (Proj. no. TB3-1224B, BRL rept. no. 780) (In its Rept. of Third Tank Conference held at Aberdeen, Aug. 27-29, 1951, compiled by A. E. Roden, Secret, TIP S2284) Secret

The Heller rocket and launcher is being developed by the Canadians as an infantry platoon antitank weapon. The weapon is fin-stabilized and has a shaped charge shell. Shaped charge shells with 42° Cu conical liners fired statically against homo armor plate produced an average penetration of 13 in. In firings against mild steel, the average penetration was increased to 14.5 in. The HE used in both cases was RDX/TNT 60/40, and the liner was 0.09 in. thick. Tests also showed that when the shaped charge was initiated by the spit-back booster, the average depth of penetration was only 80 to 85% of that obtained when the charge was initiated at the rear with an electrical detonator.

L296

Ballistic Research Laboratories, Aberdeen Proving Ground.
PERFORMANCE OF? [AND] CHARACTERISTICS OF BAT WEAPON, by W. J. Kroeger, C. W. Fleischer, and H. P. Manning. Aug. 28, 1951, p. 113-155 incl. illus. diagrs. (Proj. no. TB3-1224B, BRL rept. no. 780) (In its Rept. of Third Tank Conference held at Aberdeen, Aug. 27-29, 1951, compiled by A. E. Roden, Secret, TIP S2284) Secret

A review is presented of the requirements for a recoilless battalion antitank rifle. Data from Firestone Tire and Rubber Co. show that the T138 shaped charge projectile with smooth Cu conical liner, 1/10-in. wall thickness, spinning at approximately 35 r.p.s. and fired at 7.5-in. standoff, penetrated 14 in. of armor. Estimated penetration values for T118E11 (Al body) and E13 (steel body) are given.

L297

Ballistic Research Laboratories, Aberdeen Proving Ground.
RECENT DEVELOPMENTS IN DESIGN OF ANTITANK ROCKETS AND GRENADES, by C. L. Beaudry. Aug. 28, 1951, p. 77-84. (Proj. no. TB3-1224B, BRL rept. no. 780) (In its Rept. of Third Tank Conference held at Aberdeen, Aug. 27-29, 1951, compiled by A. E. Roden, Secret, TIP S2284) Secret

The developments in the design of antitank rockets and grenades, 2.36-in. and 3.5-in. rockets (bazooka and super-bazooka rockets) and .30 caliber rifle grenades are reviewed.

L298

Ballistic Research Laboratories, Aberdeen Proving Ground.
UTILIZATION OF HAND ANTITANK WEAPONS BY THE INFANTRY, by C. A. Mette, Jr. Aug. 28, 1951, p. 156-173 incl. tables. (Proj. no. TB3-1224B, BRL rept. no. 780) (In its Rept. of Third Tank Conference held at Aberdeen, Aug. 27-29, 1951, compiled by A. E. Roden, Secret, TIP S2284) Secret

The employment of antitank weapons is discussed. A rept. is appended from the Army Field Forces Board Number 3, Fort Benning, Ga. on Characteristics and Data on Standard and Test Infantry Antitank Weapons which gives tabular data on: (1) rifle grenade launchers and ammunition (HEAT-M9A1, HEAT Energa (T41), and T37); (2) rocket launchers and ammunition (2.36-in. HEAT and 3.5-in. HEAT M28); and (3) recoilless rifles and ammunition (57-mm. HEAT, 75-mm. HEAT, and 105-mm. HEAT and HEP). The defeat of armor results for the ammunition at various angles of obliquity are given.

L299

Ballistic Research Laboratories, Aberdeen Proving Ground.
ANALYSIS OF THE PERFORMANCE OF THE MOCK-UP BOOSTER ASSEMBLY FOR THE MULTI-JET, SHAPED CHARGE, ANTITANK MINE, by R. A. Bailey, D. Born, and M. Sultanoff. Oct. 1951, 13p. incl. illus. table, diagrs. (Proj. no. TB3-1224B, BRL Memo. rept. no. 584) TIP C7923 Confidential

An analysis of the performance of a booster designed for use in a multi-jet shaped charge antitank mine was made. The profile of the shock on emergence from the booster, photographed with the ultra high speed camera, was fitted with a circular arc. The location of the center of curvature of this arc is reported for several lots of modified boosters. It was concluded that the reproducibility of the initiation produced by the boosters furnished by Picatinny Arsenal (PA-E-6774-6797, 6798, 6799) is not sufficient to give a spherical initiation of the mine. A brief estimate of the over-all effectiveness of the multi-jet mine is also presented. (BRL abstract)

L300

Ballistic Research Laboratories, Aberdeen Proving Ground.
THE APPLICATION OF THE FARADAY MAGNETO-OPTIC EFFECT TO THE OPTICAL STUDY OF EXPLOSIVE AND SHAPED CHARGE MECHANISMS, by M. Sultanoff and R. A. Bailey. Nov. 1951, 21p. incl. illus. diagrs. (Proj. no. TB3-0112K, BRL rept. no. 791) Unclassified

The employment of the "Rapatronic" Faraday type magneto-optic shutters of 4 and 1 μsec. exposure times as developed by Edgerton, Gemeshausen, and Grier in the study of various mechanisms of explosive reactions is described. A succession of shaped charge (conical and hemispherical liners) records taken with the 4 and 1 μsec shutters are shown.

L301

Ballistic Research Laboratories, Aberdeen Proving Ground.
APPLICATION OF THEORY TO DESIGN, by N. Rostoker. Nov. 1951, p. 291-298 incl. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

The scope of the discussion was limited to the design of shaped charges with metal cone liners. Design parameters considered were material, geometry, and confinement of the explosive, and material and geometry of the liner. Performance was assessed on the basis of penetration depth, hole volume, and hole shape. Several specific charge designs and their observed performance are described. On the basis of these examples an attempt was made to evaluate the guidance afforded by theory, in its present status to the design of shaped charges.

L302

Ballistic Research Laboratories, Aberdeen Proving Ground.
COMPARATIVE EFFECTIVENESS OF ARMOR-DEFEATING AMMUNITION, by A. Hurlich. Nov. 1951, p. 197-216 incl. tables, diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

The performance of chemical energy projectiles against simple armor targets showed that: (1) Depth of penetration by HEAT shell was inversely proportional to the square root of the density of the material under attack; therefore, the thickness of material required to defeat the attack was also proportional to the square root of its density. (2) The jet generated by HEAT charge continued in a relatively straight line along the line of flight of the shell, consequently the armor penetration performance of this type of ammunition closely followed the cosine law. (3) The performance of the 90 mm. HEAT T108E20 varied greatly against a simple armor target consisting of 4-in. plate at 40° obliquity. Of 10 rounds fired, all perforated the target, but the residual penetration varied from 2 to 5 3/8 in. When tested against spaced armor with 8-in. spacing, 2 rounds of 3 90 mm. T108E20's fired failed to defeat the target.

L303

Ballistic Research Laboratories, Aberdeen Proving Ground.
CURRENT PROGRAM ON HEAT AND HEP ARTILLERY PROJECTILES, by R. E. Rayle. Nov. 1951, p. 235-246 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

The current program for fin-stabilized HEAT artillery projectiles is discussed. Status of development is given in each of the various calibers. Principal development has been in 90-mm. and 105-mm. sizes, and developments in these calibers are being extended to other sizes. Highlights of these developments are discussed, including the electric fuze, the effect of standoff and slow spin, and the effect of cone variables on penetration. The K factor as employed in a recent tripartite conference was defined as that depth into homogeneous armor measured in cone diameters to which 90% of the rounds will penetrate. A K factor of 4 appears descriptive of current HEAT rounds. Accuracy of fin-stabilized HEAT rounds is discussed. The accuracy appears to be about .35 mil horizontal or vertical probable error, compared to about .15 mil for spin-stabilized projectiles.

L304

Ballistic Research Laboratories, Aberdeen Proving Ground.
THE DAMAGE EFFECTIVENESS OF SHAPED CHARGES AGAINST TANKS, by F. I. Hill. Nov. 1951, p. 363-367 incl. tables. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

A summary of the damage from firing over 100 3.5-in. rockets and limited numbers of 90-mm. T108 projectiles vs. the T26E4 tank is made. From these data, it is tentatively concluded that interior damage after a perforation by both these projectiles is comparable. However, the conditions to achieve a perforation with the better fuzed projectile are not so rigorous. A comparison of terminal ballistic data for the 90-mm. HEAT and kinetic energy projectiles is made indicating the general damage from perforating kinetic energy projectiles is considerably greater than that from HEAT rounds. A further analysis is made in which the vulnerable areas of these rounds are compared. This analysis indicates that the vulnerable areas to mobility, firepower and total destruction are not considerably greater for the kinetic energy projectiles. An explanation of this apparent anomaly lies in the fact that the principal targets inside a tank are ammunition, fuel and the engine, and that the personnel are not the most important targets. A brief estimate is made of the relative over-all effectiveness of 90-mm: HVAP and HEAT rounds to show their expected relative probabilities of a hit being a kill for these projectiles against the M26 tank.

L305

Ballistic Research Laboratories, Aberdeen Proving Ground.
DEFENSES AGAINST HOLLOW CHARGES, by R. J. Eichelberger. Nov. 1951, p. 373-383 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531)
Confidential

A résumé of the principles set forth in recent reports on this subject are given, together with some more recent results on the use of glass as a protective device. Glass blocks or plates fastened on the outside of homoplate and protected on the outside surface by a relatively thin homoplate are believed to provide the most practical protection. Al armor fastened to the outside of basic homoplate provides several advantages over glass but would add more weight for the same protection. Under certain circumstances patterns of spikes or layers of explosives between steel plates may provide very low weight protection. In principle any low density material can be used for protection, since the weight that must be added for a given protection is proportional to the square root of the density of the protecting material. The protective qualities of Al are due to this relation but the protective qualities of glass are much greater than this relation predicts. Glass is the 1 known exception.

L306

Ballistic Research Laboratories, Aberdeen Proving Ground.
DESIGN VARIABLES AFFECTING THE PERFORMANCE OF THE BAT HEAT ROUND, by E. W. Ford. Nov. 1951, p. 279-290 incl. tables, diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

Some of the factors investigated in the development of a HEAT round for the BAT project were: cone angle, standoff flange effect, target material, effect of interference, cone shape, wires through cone, base element location, temperature effect, spit-back tube length, cone wall thickness, cone material, constant head versus constant volume, and confinement. Firestone has adopted a 42° cone, pressed from sheet Cu having no flange and a short spit-back tube, with a wall thickness of 0.100 in. for use in the T138 HEAT rounds. This round is to be fired at 25 r.p.s. The design of this round is explained in detail.

L307

Ballistic Research Laboratories, Aberdeen Proving Ground.
DEVELOPMENT OF SHOULDER-FIRED SHAPED CHARGE ROCKET HEADS, by H. S. Weintraub, S. Fleischnick, and I. B. Gluckman. Nov. 1951, p. 247-268 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531)
Confidential

In order to evaluate the design features to be incorporated into a lightweight T205 head, a shaped charge investigation was conducted by varying different parameters in the standard 3.5-in. M28A2 head. Results obtained through this investigation and pertinent to designing the prototype T205 head were as follows: (1) the optimum cone thickness for the 3.5-in. M28A2 rocket is .075 in. + .003 in.; (2) the HE charge can be reduced to 1.5 lb. without affecting penetration; (3) the optimum standoff distance for the 3.5-in. M28A2 rocket is 9 in.; (4) the booster pellet may be placed as close to or atop the apex of the Cu cone without any significant difference in penetration being noted. Preliminary tests with a modified 3.5-in. M28 type rocket head which eliminated the flat at the base of the cone (the M28A2 head has a flat of approximately 0.1 in. at the cone base) indicated that an increase in penetration of approximately 2 in. might be expected. Studies to improve the performance of the 2.36-in. T59E3 rocket head (1) by the use of explosives having higher rate of detonation than Comp. B, such as 70/30 Cyclotol and 75/25 Cyclotol, (2) by shaping the detonation wave front traveling through the charge, and (3) by use of a tandem cone arrangement, have resulted in no marked improvement in penetration. Investigations are being conducted with the T2016 and T2017 rocket heads to determine whether increased standoff and correspondingly decreased explosive charge (over-all length of head being constant) would result in increased penetration.

L308

Ballistic Research Laboratories, Aberdeen Proving Ground.
EXPENDABLE FLASH X-RAY TUBE, by G. Hauver and G. Brian. Nov. 1951, p. 151-155 incl. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md. Nov. 13-16, 1951, Confidential, AD-1531)
Restricted

For the flash radiography of explosive phenomena, an expendable X-ray tube may be used without protective shielding, facilitating flexible instrumentation. Experimental expendable tubes of the field emission type are described, along with preliminary performance data.

L309

Ballistic Research Laboratories, Aberdeen Proving Ground.
FLASH RADIOGRAPHIC STUDY OF JETS FROM ROTATED 105-MM. SHAPED CHARGES, by L. Zernow, S. Kronman, F. Rayfield, J. Paszek, and B. Taylor. Nov. 1951, p. 133-150 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Also published as BRL rept. no. 856, Apr. 1953, AD-14 932
Confidential

Jets from rotated 105-mm. shaped charge projectiles were studied using new low voltage flash radiographic techniques. The first radiographs showed in considerable detail the deleterious effects of rotation-axial breakup and radial dispersion. A tentative hypothesis characterizing these 2 effects was proposed. The use of the shaped charge as an experimental device for studying otherwise inaccessible properties of liner materials under conditions of unusual stress combinations and very high strain rates was also considered. The advantages of a cylindrical liner were discussed including its expected resistance to spin deterioration. It was pointed out that the penetration of such a liner depended more upon liner length than upon the caliber of the projectile.

L310

Ballistic Research Laboratories, Aberdeen Proving Ground.
FLASH RADIOGRAPHIC STUDY OF JETS FROM UNROTATED 105-MM. SHAPED CHARGES, by L. Zernow and others. Nov. 1951, p. 119-132 incl. illus. diagr. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Also published as BRL rept. no. 857, Apr. 1953, AD-13 608
Restricted

Flash radiographs were used to compare jets from Fe-lined and conical Cu shaped charges of 105-mm. caliber at various jet lengths. The early breakup of Fe into a particle jet and the taffy-like stretching of the Cu jet due to the velocity gradient were quite evident. Cu-trumpet and hemispherical-liner jets which gave poor penetration were shown to be badly formed and associated with an unfavorable velocity distribution along the jet.

L311

Ballistic Research Laboratories, Aberdeen Proving Ground.
FOREIGN DEVELOPMENTS IN SHAPED CHARGES, by H. Bechtol. Nov. 1951, p. 299-303. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground Md., Nov. 13-16, 1951, Confidential, AD-1531
Confidential

Shaped charge developments from the following sources were discussed: Europe - Representative of recent European advancements in shaped charge technology, the Belgian Energa rifle grenade and the French 73-mm. rocket possess such features as lighteness of over-all weight, improved mechanical-type fuzes, and shaped charges using RDX-type filler and Cu liners. The Energa, employing a 2.7-in. diameter, 45° Cu cone similar to late model US shaped charge rounds, gives penetrations up to 10 in. at a full standoff of 1.3 calibers. The French 73 mm. rocket utilizes a unique trumpet shaped or double angle cone of 2.75-in. diameter with an angle of approximately 22° at the apex and approximately 58° at the base. The cone thickness increases from apex to base (approximately .055 in. to .084 in.). Penetrations of 12.0 in. (4.4 cone calibers) were recorded at a full standoff of 1.5 calibers. Russia and China - By current standards the Russian and Chinese designed shaped charges are generally considered to be crude. Tests of Russian 76-mm. and 122-mm. shaped charge artillery projectiles show penetrations of about 1 caliber for either round. Both, except for spit-back fuzes, resemble early US designs which used steel cones. Of very recent make is the Chinese 87-mm. spinning rocket with a launcher closely copied from that of the US 3.5-in. Rocket. The shaped charge for this cone has TNT filler and a wrapped and seamed fabricated cone. No performance data are available.

L312

Ballistic Research Laboratories, Aberdeen Proving Ground.
GENERALIZATIONS CONCERNING THE MOTION OF A THIN SHAPED CHARGE LINER WITH AN ARBITRARY INITIAL CONTOUR, by G. E. Hudson and C. Gardner. Nov. 1951, p. 61-74 incl. diagr. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

Upon assuming a thin liner whose particles do not exert any forces on one another, and upon treating it as an incompressible fluid during its motion, general equations of motion and continuity are derived. It is shown that these are equivalent to a Schrodinger time-dependent type of equation with space and time variables interchanged. The impingement and subsequent extrusion of this liner at an arbitrary moving and oriented surface element are investigated. This formulation suggests several new problems, experimental, theoretical, and mathematical, as well as the importance of further investigation of some already considered. In the latter class are the problems of the interaction of simple waves of finite amplitude, and the effects of compressibility in the liner. Friedrichs, Keller and A. Lax, and then Touart have considered the possibility of rarefaction and compression shocks in the liner, and thus justified the assumption by G. I. Taylor that the liner acts as a continuously turning stream of non-interacting incompressible fluid particles. Touart and Friedrichs have also shown that the observed mass distribution in the jet can be accounted for by the continuing pressure exerted by the burnt explosive on the liner as it collapses. In addition, Touart has shown that the probable effect of the rarefaction wave in the burnt explosive as it expands into the atmosphere is the observed decrease in velocity from head to tail of the jet. Thus the external shaping of the explosive is important in standoff effects. (BRL abstract)

L313

Ballistic Research Laboratories, Aberdeen Proving Ground.
HELLER WARHEAD DEVELOPMENT, by R. W. Foster. Nov. 1951, p. 225-233 incl. illus. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-15, 1951, Confidential, AD-1531) Confidential

The discussion is concerned with warhead design, Cu liner, warhead casing, filling, standoff, fuzing, and shaped charge liner for spit-back fuze. The 3.2-in. caliber Heller warhead in static penetration tests penetrated 13 in. of homo armor plate. In flight tests against 280 mm. of armor at normal angle of attack, 80% of the rounds fired defeated the armor. In flight tests against 120 mm. of armor at 60° to normal, 80% of the rounds fired were successful.

L314

Ballistic Research Laboratories, Aberdeen Proving Ground.
HIGH SPEED HIGH RESOLUTION STREAK PHOTOGRAPHY, by C. T. Linder. Nov. 1951, p. 169-194 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential AD-1531) Confidential

A simple rotating mirror camera with high space and time resolution, and great versatility in the photographing of various explosive phenomena is described. The camera features a thin single surface plane mirror so that the locus of the image is circular to a high degree of accuracy, and employs film strips which are 6 in. in width. The selection of the appropriate mirror width, speed of rotation, and radius of film track permit the choice of a variety of fields of view and of writing speeds up to 3 mm./μsec. The design employs a single lens and an expendable external slit placed at the location of the phenomena to be photographed. An effective lens aperture of f/3.5 can be retained and a 1/1 magnification ratio is possible. Various applications to which the camera is particularly suited are discussed.

L315

Ballistic Research Laboratories, Aberdeen Proving Ground.
HIGH SPEED PHOTOGRAPHY WITH AN IMAGE CONVERTER TUBE, by R. D. Drosd, T. P. Liddiard, and E. N. Singleton, Jr. Nov. 1951, p. 181-188 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

The results of an investigation in the use of an image converter tube as a high speed camera shutter and an image brightness intensifier are given. With the 1P25A (sniperscope) image converter tube it was found that exposure times of 30 mμsec. with a gain in image brightness of 2 are easily attainable. The relative merits of the image converter and the Kerr cell cameras are discussed. The construction of the 1P25A camera is shown.

L316

Ballistic Research Laboratories, Aberdeen Proving Ground.
INITIAL STUDY OF THE EFFECTS OF ANNEALING ON THE PENETRATION PERFORMANCE OF COPPER SHAPED CHARGE LINERS, by R. L. Phebus and W. O. Rassenfoss. Nov. 1951, p. 43-60 incl. tables, diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

Previous studies of various metals as shaped charge liners are summarized. The need for additional study of metallurgical aspects of liner performance is indicated. Cu liners of various hardness were fired to study the effect of the variable upon standoff penetration curves. These tests indicate that annealing within this recovery region or grain growth region will improve the penetration performance of Cu liners. No improvement will be observed when Cu liners are annealed within the recrystallization region. A proposed investigation is outlined to study the effect of second phases and their distribution upon liner performance. (BRL abstract)

L317

Ballistic Research Laboratories, Aberdeen Proving Ground.
THE KERR CELL CAMERA AND ITS APPLICATIONS, by E. C. Mutschler. Nov. 1951, p. 157-174 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

The Kerr cell method of high speed photography was used to photograph both luminous and non-luminous transient phenomena at exposure times down to 0.5 µsec. In the case of non-luminous phenomena, the opening of the Kerr cell is synchronized electronically with the light flash obtained from an electrically exploded wire having a peak intensity of about 5 x 10^8 candle power. The Kerr cell is of sufficient size to allow the use of a 7-in., f/2.5 lens at an effective aperture of f/4. To operate such a large Kerr cell requires a voltage pulse of amplitude 25 kv. This method is ideally suited to the photography of detonating explosives, metal jets in shaped charges, shock waves in transparent liquids and solids, and other phenomena having propagation velocities up to 10,000 m./sec.

L318

Ballistic Research Laboratories, Aberdeen Proving Ground.
LOW VOLTAGE FLASH RADIOGRAPHY, by J. J. Paszek, B. C. Taylor, and J. L. Squier. Nov. 1951, p. 107-118 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Also published as BRL rept. no. 845. Restricted

A system is described for taking sub-µsec. duration flash radiographs of shaped charge phenomena using low-voltage (34 kv.) X-rays.

L319

Ballistic Research Laboratories, Aberdeen Proving Ground.
MINIMIZING THE EFFECT OF ROTATION UPON THE PERFORMANCE OF LINED CAVITY CHARGES, by H. Winn. Nov. 1951, p. 339-351 incl. table, diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

The effect of rotation on the penetration of shaped charges is described. An empirical correlation, useful for design purposes, is presented, which permits the estimation of the spin rate penetration curve for shaped charges with reasonable reliability. In an effort to overcome the deleterious effect of rotation both fluted liners and double body projectiles were studied. It is shown that a degree of spin compensation was obtained by each method and that the prospect for an ultimate solution to the problem is good.

L320

Ballistic Research Laboratories, Aberdeen Proving Ground.
MULTIPLE-FRAGMENT-IMPACT EFFECTS IN SHAPED CHARGE PENETRATION, by J. S. Rinehart. Nov. 1951, p. 33-42 incl. table, diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Restricted

It is assumed that a shaped charge jet contains a relatively small group of discrete hypervelocity solid fragments. The probable cumulative effect of the successive impacts of the several fragments are predicted from known facts concerning the impacts of very high velocity fragments. The predictions are compared with experimental observations on the interactions between targets and shaped charge jets. The conclusion reached is that the cumulative effects of multiple impacts appear, in some cases, to play an important part in the mechanics of shaped charge penetrations.

L321

Ballistic Research Laboratories, Aberdeen Proving Ground.
PERFORMANCE OF PERIPHERALLY INITIATED SHAPED CHARGES, by A. D. Solem and W. T. August. Nov. 1951, p. 83-95 incl. tables, diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

The performance of experimental cone-lined shaped charges is being investigated under the condition of peripheral initiation of the charges. Peripheral initiation is simultaneous initiation of the entire top pheriphery of the charge in contrast to point or plane wave initiation. It is obtained by use of a cup-shaped inert-filled initiator placed over the top of the charge such that initiation is transmitted to the periphery of the charge but is delayed in passage through the inert material in contact with the top surface of the charge. The behavior of penetrations from peripherally initiated charges into mild steel targets for variation of charge height, standoff, cone material, cone wall thickness, and cone apex angle are being studied and compared for like conditions. The results are described and reasons for the observed behavior discussed. Experimental evidence showing why peripherally initiated charges produce greater penetrations are presented. (BRL abstract)

L322

Ballistic Research Laboratories, Aberdeen Proving Ground.
THE PERFORMANCE OF PRECISION-MADE CONICAL LINERS, by J. Dewey, H. L Breidenbach, Jr., J. Panzarella, and J. Longobardi. Nov. 1951, p. 97-106 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

Small drawn, cast, and machined cones in bare Pentolite charges were investigated for a determination of fabrication control necessary for good reproducibility of performance. Explosive casting was carefully controlled. Deliberately introduced flaws in cones produced effects which were usually predictable from consideration of time at which each portion of the cone reaches the axis. Flash radiography of the jets supplemented observation of target blocks. Precision cast cones gave about the same reproducibility as drawn cones. Three fabricators made electroformed and machined Cu cones of widely differing precision and performance. Warping and metallurgical non-uniformity were sources of large spread in the performance of the products of 2 fabricators. The third manufacturer produced 0.75-in. Cu cones to 0.1 mil tolerances from which straight jets of uniform penetration were obtained. A 3% cone gave 6.8 cone diameters penetration.

L323

Ballistic Research Laboratories, Aberdeen Proving Ground.
THE PIN TECHNIQUE FOR VELOCITY MEASUREMENTS, by H. D. Mallory. Nov. 1951, p. 175-180 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

This is an electronic method for determining arrival times of an event at various positions during its motion. The method takes its name from the electrical switches which are charged pointed pins. The moving metal target or ionized shock wave is electrically grounded so that on contact with a pin, a pip is generated on an oscilloscope screen. Pips from a sequence of pins are photographed by a still camera as they appear on the screen. Time is determined from a crystal controlled sine wave superimposed over the pips. It is believed that with this method, time can be resolved better than can reasonably be expected of a photographic method alone. Also, it is possible with the pin technique to investigate the initial motion of a moving object over the interval from 0 to 1 mm. with good reproducibility. It is over this close-in range that photographic methods are at their worst and the pin technique is at its best.

L324

Ballistic Research Laboratories, Aberdeen Proving Ground.
THE PRESENT PERFORMANCE AND PROBLEMS OF THE 105-MM. BAT RIFLE, by H. P. Manning, C. W. Musser, and H. W. Euker. Nov. 1951, p. 269-278 incl. illus. tables, diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

As candidates for "The BAT Rifle" there are 3 105-mm. recoilless rifles, 4 mounts, 4 spotting rifles, 1 set of fire control, 4 types of HEAT rounds and 5 types of spotting ammunition including tracer. These will be assembled into 4 "weapon systems". The T136 Rifle, T118 Ammunition and T149 Mount have given accuracy at 1,000 yd. with a HPE of 0.29 mils, and a VPE of 0.44 mils. Static penetration tests have given 16.9-in. penetration against homogeneous armor. These data represent ammunition already superseded by improved designs. Caliber .50 tracer and spotting ammunition have shown reasonable good functioning and matching performance. The major problems currently being encountered with the T135 Rifle, T118 Ammunition, T149 Mount, T43 spotting rifle combination are: recoil balance seems to be unduly sensitive to loading density; the method of spinning the long boom, fixed-fin T118 type projectile; the amount of spin to meet accuracy and penetration requirements; variations in measured jump under different conditions have been encountered; questions of over-all evaluation of the spotting device and techniques for its use are yet unanswered.

L325

Ballistic Research Laboratories, Aberdeen Proving Ground.
REMARKS ON SOME FUNDAMENTAL FEATURES OF DETONATION, by S. J. Jacobs. Nov. 1951, p. 5-13 incl. table, diagr. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

Computations for the shaped charge effect require a knowledge of the state of detonation product gases and the isentropic relation for expansion to a reasonable degree of precision. These functions can be derived from basic data for a number of compounds and mixtures using more or less approximate equations of state. Experimental checks indicate that the important parameters for calculations of boundary motions are capable of being predicted with reasonable precision (5 or 10%). The discussion presents some useful approximations to aid in computations.

L326

Ballistic Research Laboratories, Aberdeen Proving Ground.
REVIEW OF THE PRESENT POSITION OF HOLLOW CHARGE AND SQUASH HEAD RESEARCH AND DEVELOPMENT IN UNITED KINGDOM, by W. E. Soper. Nov. 1951, p. 217-224. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

The following subjects concerning shaped charge development are discussed:

(a) liner production
(b) lethality
(c) regularity and symmetry of liner
(d) filling of shaped charge
(e) rotation
(f) weapon design for high level performance at large angles of incidence
(g) future investigations to: (1) increase mass of jet without decreasing velocity gradient; (2) study shock waves involved in shaped charge phenomena; (3) study penetration phenomena by hollow jet.

L327

Ballistic Research Laboratories, Aberdeen Proving Ground.
ROTATED-NON-ROTATED REPORT ON 120-MM. SPIN STABILIZED PROJECTILE WITH NON-ROTATING SHAPED CHARGE, by S. Dubroff. Nov. 1951, p. 305-318 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

In order to secure an armor penetrating round in the 120-mm. caliber which will have greater penetration than the AP shot, this shaped charge carrying round is being developed. Considerations leading to this design are: compactness of round, due to its spin stabilization; improvement of armor penetration of the shaped charge by reduction of spin to approximately 0. The proposed round has an exterior member which is rotated at the full spin rate for this weapon. Because of the large moment of inertia provided by the cylindrical section, stability is secured. The inner member carrying the shaped charge cone is carried on ball bearings. Load pressure distribution on the inner and outer member reduces the load on the ball bearings to a very small value during "setback".

L328

Ballistic Research Laboratories, Aberdeen Proving Ground.
SHAPED CHARGE DAMAGE BEYOND ARMOR, by D. R. Kennedy. Nov. 1951, p. 359-361. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 195 Confidential, AD-1531) Confidential

The development of shaped charge weapons has been concentrated primarily on achieving maximum penetration capabilities of the charge, and little attention has been given to the effects of the jets beyond the defeated armor, or, more specifically, within the enemy tank. Realizing the need for such information, a program was initiated at the Naval Ordnance Test Station early this year to determine the comparative effects of various shaped charge liner materials and cone angles in producing damage beyond defeated armor. The charges investigated were identical to the 6.5-in. ATAR in size and load. Cu, Al, and steel were utilized as cone materials, with cone angles of 42.5°, 60°, 90°, and 120°. Three series of tests were conducted to determine: (1) the mass, size, number, and spatial distribution of fragments ejected beyond armor; (2) the distribution of jet fragments impinging on angle plates beyond the primary armor; and (3) the pressures and temperatures generated within confined steel targets by the various shaped charge jets. Al liners were discovered to have unique damaging properties when fired at extremely close standoff distances against defeatable armor. Indications are that Cu liners, although superior in depth of penetration capability, are inferior to steel and Al liners as damaging agents.

L329

Ballistic Research Laboratories, Aberdeen Proving Ground.
SHAPED CHARGE DAMAGE TO AIRCRAFT STRUCTURES, by G. C. Throner. Nov. 1951, p. 369-371. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

The search for an ideal warhead for ground-to-air guided missiles was centered upon 4 different types of heads, the most promising of which, according to some investigators, is 1 using the shaped charge principle. Since 1950, the Naval Ordnance Test Station has been engaged in studies of the effects of shaped charges fired at aircraft structures from long standoff distances. Tests have shown that the hypervelocity shaped charge jet fragments can be directed against aircraft targets 100 to 150 ft. from the point of detonation and produce K-kill damage. The type of damage incurred is referred to as "vaporific" damage, and is characterized by a brilliant flash which envelopes the target and produces severe structural and skin damage to the aircraft. Present investigations lead to the hypothesis that "vaporific" damage is the result of target material combining explosively with its surrounding atmosphere because of the high energy imparted to the material by impacting jet fragments. Single hypervelocity (8,000 to 15,000 ft./sec.) pellets have been fired from "Pugh charges" against enclosed, multiple-plate Al targets containing both inert and reactive atmospheres such as He, N, O, and engine exhaust gas. It was shown that "vaporific" flashing and the accompanying damage can occur only in an atmosphere which will react with the target material when the latter is produced in finely divided form by high velocity impact. The possibility of protection by purging the interior of aircraft wings with engine exhaust gas is cited.

L330

Ballistic Research Laboratories, Aberdeen Proving Ground.
SOURCES OF DISPERSION IN SHAPED CHARGE PERFORMANCE, by R. von Heine-Geldern. Nov. 1951, p. 75-81 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

Dispersion in the performance of shaped charges can be assigned to 3 distinct causes: (a) lack of homogeneity of the explosive; (b) geometric liner imperfections; (c) improper alignment between charge and liner. Of these 3 causes, only the last 2 have been evaluated quantitatively. The importance of perfect axial symmetry in zones perpendicular to the axis can hardly be stressed enough. Very little is known about the effect of (a). Further attempts at reducing charge variability should be directed at improving the homogeneity of the explosive. (BRL abstract)

L331

Ballistic Research Laboratories, Aberdeen Proving Ground.
SPIN COMPENSATION, by E. L. Litchfield. Nov. 1951, p. 331-338 incl. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

Techniques and methods for the manufacture of fluted cones as developed in cooperation with the NBS are discussed. Techniques used in producing CIT laboratory size samples are essentially those required for large scale production of liners for weapons use. It is shown that the problem of obtaining good fluted liners is of the same magnitude as that of obtaining good smooth liners. The results obtained from tests with various fluted liner designs are presented. Several fluted liner designs have produced 100% compensation (i.e. static smooth liner performance) at spin rates as high as 150 to 180 r.p.s.; other liner designs have produced as much as 75% compensation at spin rates as high as 300 to 330 r.p.s. Additional fluted liner groups which may be of importance in future weapons design are also discussed.

L332

Ballistic Research Laboratories, Aberdeen Proving Ground.
STUDY OF THE EFFECTS OF ROTATION UPON THE PENETRATION OF JETS FROM 105-MM. SHAPED CHARGES, by L. Zernow, J. Regan, J. Simon, and I. Lieberman. Nov. 1951, p. 319-330 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

An analysis of the targets into which rotated shaped charges were fired was carried out prior to flash radiographic studies previously reported. Clear evidence was found for the bifurcation and subsequent apparent polyfurcation of the jet at increasingly higher rotational frequencies. Photographs of sample targets illustrating this effect are shown. A rotational standoff effect is established, which shows that the depth of penetration of a rapidly rotated shaped charge decreases sharply with increasing standoff. Additional evidence for the importance of shocks and compressibility in the penetration process is found in peculiar holes of essentially square cross section associated with the jets from the rotated projectiles. It is noted that these effects may be important in lethality studies. A hydrodynamic model of a rotating hollow liquid cylinder which is unstable under rotation is proposed as a basis for understanding the bifurcation process.

L333

Ballistic Research Laboratories, Aberdeen Proving Ground.
THEORY OF LINED HOLLOW CHARGES, by E. M. Pugh. Nov. 1951, p. 11-31 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Confidential

An extension of the theory of cone collapse and jet formation published in the Journal of Applied Physics is presented (item no. L353). By assuming a time gradient in the velocity of collapse of the cone walls, the long rear end of the jet is explained without recourse to a slug extrusion theory. Experiments verifying this theory are discussed. The theory of penetration is reviewed to see how well it explains the experimental results obtained with liners of different materials and with targets of different materials. A release wave hypothesis, based upon characteristic surfaces of Courant and Friedrichs, is briefly mentioned. Though manifestly inadequate, it provides a very rough correlation between the performance of explosives of quite different shape. (BRL abstract)

L334

Ballistic Research Laboratories, Aberdeen Proving Ground.
A ZERO ORDER THEORY OF THE INITIAL MOTION OF FLUTED HOLLOW CHARGE LINERS, by L. H. Thomas. Nov. 1951, p. 353-358 incl. diagrs. (Proj. no. TB3-0134, BRL rept. no. 837) (In its Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951, Confidential, AD-1531) Also published as BRL rept. no. 765, TIP C59201 Confidential

When a cased charge detonates, the early motion of the casing may be divided into 3 parts: the initial state of rest or steady motion, a confused regime of shock waves and reflected rarefactions, and a more or less steady motion under the continuing pressure of the explosion gases. For a light casing a plausible 0 order theory treats the whole intermediate stage as the motion of a single shock wave forming a refracted extension of the detonation wave into the casing, which sets the casing impulsively into motion. The momentum impulsively given in this approximation to a certain area of the casing is proportional to its thickness; the physical reason for this being the longer time that the material is confined by that adjoining it when it is thicker. This picture makes it possible to estimate the angular momentum of a zone of a shaped charge liner immediately after the passage of the detonation wave, and the angular momentum is not likely to change much later as equal pressure on the outer surface of the liner would produce no change. The assumption that nearly 0 angular momentum is a necessary condition for the formation of a good jet now leads to a prediction of the effect of any given fluting in counteracting initial rotation which is in qualitative, and perhaps rough quantitative agreement with observation. If this 0 order theory is borne out by further comparison with observation, it may assist the design of efficient liners for rotating projectiles.

L335

Ballistic Research Laboratories, Aberdeen Proving Ground.
AN OPTICAL STUDY OF SHAPED CHARGE JETS, by R. A. Bailey, D. R. Born, and [M.] Sultanoff. Dec. 1951, 38p. incl. illus. diagrs. (BRL rept. no. 788) TIP R6426 Restricted

Standards are to be established for comparison with the results to be obtained from tests of shaped charges prepared with carefully controlled parameters. Data were established for the performance of the steel cone from the M9A1 rifle grenade cut down to a 1-in. diameter base. The luminous phenomena recorded in the short-duration optical studies of shaped charges were investigated, and the velocity of penetration of various materials by the M9A1 jet was determined. By application of the wipe-off theory (Journal of Applied Physics, v. 19, 1948: 563-582), the penetration records were further analyzed to determine the velocity gradient for the jet. Three separate air shocks associated with cone collapse and jet formation were identified. The optical studies confirmed the linear dependence of penetration velocity on the square root of target density, and the velocity gradient was linear. The association of each jet particle (by its velocity) to an origin along the cone axis was indicated. The results are in good agreement with existing theories and previous observations. Comparison of short-duration recording methods employed in shaped charge studies and modifications of the Bowen RC-3 rotating-mirror camera are discussed in appendixes. (TIP abstract)

L336

Ballistic Research Laboratories, Aberdeen Proving Ground.
WIND TUNNEL TESTS OF THE T131 105-MM. HEAT PROJECTILE. Dec. 1951, 68p. incl. illus. diagrs. (Proj. no. TB3-0230A, BRL Technical note no. 565) Confidential

Budd Company models of the 105-mm. T131 HEAT round were tested to determine the pitching moment, c.p., drag and normal force for configurations using 2 body nose types, 2 folding 4-fin tail assemblies, 5 fixed 6-fin tail designs, and 3 different boom lengths. The projectile was stable for all fin-body combinations tested with the greatest stability being obtained with the 30° leading-edge, sweepback, end-plated, fixed fin, short nose, long boom body design. The test results indicated that by using the low-drag folding fin tail, the over-all length of the projectile could be reduced and stability still maintained. The aerodynamic coefficients are given for all models.

L337

Ballistic Research Laboratories, Aberdeen Proving Ground.
BODY NOSE SHAPES FOR OBTAINING HIGH STATIC STABILITY, by A. S. Platou. Feb. 1952. 54p. incl. illus. diagrs. (Proj. no. TB3-0230A, BRL Memo. rept. no. 592) TIP C8092
Confidential

In an attempt to develop a short length 105-mm. spin-stabilized shaped charge projectile, wind tunnel tests were made on various projectile nose shapes. A c.p. much further aft than that required on conventional projectiles was required because of the rearward c.g. position of the shaped charge and because of the fact that excessive spin causes penetration degradation in the shaped charge. The tests results showed that the necessary rearward c.p. positions could be obtained by replacing the conventional ogive by a spike which produces a region of separated flow between the tip of the spike and the front of the main body. By this means c.p.'s up to 76% of the length aft of the nose were obtained as compared to 48% for a cone cylinder of the same length.

L338

Ballistic Research Laboratories, Aberdeen Proving Ground.
SPIN AND AERODYNAMIC CHARACTERISTICS OF THE 105-MM. SHELL T131, HEAT. Feb. 27, 1952, 14p. incl. table, diagrs. (Proj. no. TB3-0230A, BRL Technical note no. 593)
Confidential

Aerodynamic tests were made on the 105-mm., T131 HEAT round with plain and with end-plated fins to determine its moment, spin, and damping characteristics. A limited series of launchings of full-scale rounds provided the basic data. The results indicate that the spin initially gained damps slowly, and that the round having end-plated fins launches more uniformly.

L339

Ballistic Research Laboratories, Aberdeen Proving Ground.
INVESTIGATION OF THE SPIN OF THE 120-MM. T230 PROJECTILE WHICH INCORPORATES A SHAPED CHARGE. Mar. 1952, 14p. incl. table, diagrs. (Proj. no. TB3-0230A, BRL Technical note no. 588)
Confidential

Since it was found experimentally that shaped charge penetration decreased rapidly at spin rates above 25 r.p.s., a spin-stabilized type of projectile was investigated. Four T230 rounds, consisting of a spinning part and a nonspinning part, were fired. Data indicated that the initial spin of the centerbody was slightly less than that imparted by the rifling of the gun. The spin rate increased slightly as the projectile traveled down range having a mid-range value of 317 r.p.s. A modification of the original T230 rounds tested gave similar results. Therefore it was concluded that the T230 configuration was not suitable for shaped charge adaptation.

L340

Ballistic Research Laboratories, Aberdeen Proving Ground.
A WIRE-DRIVEN PROJECTILE ROTATING DEVICE FOR HOLLOW CHARGE INVESTIGATIONS, by S. Kronman and L. Zernow. Mar. 21, 1952, 19p. incl. illus. diagrs. (BRL rept. no. 789) TIP C8100
Confidential

A description is given of a wire-driven device for rotating and detonating large caliber (105-mm.) hollow charge projectiles at rotational frequencies in excess of 350 r.p.s. The only element of the system expended is the 0.052-in. piano wire. Methods of monitoring the rotational frequency and electrically initiating the charge are discussed. The system is also suited for studies of spin compensation systems. Data are given showing the effect of rotation on penetration of 105-mm., 45° Cu liners with spitback fuzes fired at a stand-off of 7 in. Losses in penetration of about 50% for spin rates as low as 45 r.p.s. are indicated.

L341

Ballistic Research Laboratories, Aberdeen Proving Ground.
THE EVOLUTION OF JETS FROM CAVITY CHARGES AS SHOWN BY FLASH RADIOGRAPHS, by H. I. Breidenbach. Apr. 1952, 34p. incl. illus. tables, diagrs. (Proj. no. TB3-0134, BRL rept. no. 808) TIP C8558
Confidential

Flash radiographs of past and present types of acute angle, model cavity charges were analyzed. From this analysis it was determined that: (1) liner apex angle, liner thickness, ratio of charge to liner diameter, and liner symmetry all affect the collapse angle β+, and consequently the mass distribution between the slug and jet; (2) after complete collapse of the liner, considerable dimensional changes take place in the slug; (3) sufficient pressure is exerted on the target by portions of the slug to contribute to the penetration of a steel target; (4) hardness of the liner material is a determining factor in the final form of the slug and the jet; (5) jet mass, although a different percentage of the liner for different designs of liner and charge, is a constant percentage for each liner type after total collapse; and (6) electroformed liners made to close tolerances produce longer, straighter jets and symmetrical slugs, and give target penetrations having standard deviations of not over 5%.

L342

Ballistic Research Laboratories, Aberdeen Proving Ground.
PENETRATION OF SHAPED CHARGE JETS INTO MASSIVE MILD STEEL TARGETS; A LITERATURE SURVEY, by J. E. Shaw. Apr. 1952. 36p. incl. diagrs. (Proj. no. TB3-0134, BRL Memo. rept. no. 607) TIP C8314
Confidential

Curves are presented for the penetration of shaped charge jets into massive mild steel targets as a function of liner angle, liner thickness, and standoff. Liners were of steel, Cu, Al, Zn, and Pb. The curves were plotted from data published by NDRC Div. 8 and du Pont during the period from 1943-1945.

L343

Ballistic Research Laboratories, Aberdeen Proving Ground.
THE DESIGN AND SELECTION OF ARMOR MATERIALS, by A. Hurlich. May 1952, p. 70. (Proj. no. TB3-1224B, BRL rept. no. 815) (In its Rept. of Fourth Tank Conference held at Aberdeen, Feb. 25-27, 1952, compiled by A. E. Roden, Secret, TIP S2561)
Secret

Chemical energy armor-defeating ammunition of the HEAT and HEP types is very briefly discussed concerning the design and selection of armor materials.

L344

Ballistic Research Laboratories, Aberdeen Proving Ground.
EXPLODING WIRE BACKLIGHTING FOR THE STUDY OF DETONATION, SHOCK AND SHAPED CHARGES, by R. S. Holtzworth and D. J. Hinz. May 1952, 26p. incl. illus. diagrs. (BRL rept. no. 818) TIP U24621
Unclassified

An exploding wire backlighting source was developed to investigate fast transient shock phenomena. A 3 mil, 1-in. W (tungsten) wire, exploded electrically by the energy from a bank of capacitators, provided an excellent light source of high intensity and long duration. This light source was designed for use with the Bowen RC-3 rotating-mirror camera and the 1 μsec. magneto-optic shuttered camera. Good definition of the shock phenomena was obtained by placing a plano-convex condensing lens between the detonation phenomenon and the exploding wire. Backlighted photographs of shaped charge phenomena are included.

L345

Ballistic Research Laboratories, Aberdeen Proving Ground.
FRENCH ANTITANK GUIDED MISSILE, by Newton. May 1952, p. 136. (Proj. no. TB3-1224B, BRL rept. no. 815) (In its Rept. of Fourth Tank Conference held at Aberdeen, Feb. 25-27, 1952, compiled by A. E. Roden, Secret, TIP S2561)
Secret

The 35-lb. French SS10 antitank guided missile containing an 8.8-lb. shaped charge warhead is briefly described. Of 14 rounds fired at a 6-ft. square target, range 1100 yd., 8 were hits and 3 near-misses. The 3 failures occurred during the test of a new type guidance control. No penetration data were given.

L346

Ballistic Research Laboratories, Aberdeen Proving Ground.
PROTECTION OF ARMORED FIGHTING VEHICLES AGAINST MINES, by C. Dunbar. May 1952, p. 239-256. (Proj. no. TB3-1224B, BRL rept. no. 815) (In its Rept. of Fourth Tank Conference held at Aberdeen, Feb. 25-27, 1952, compiled by A. E. Roden, Secret, TIP S2561)
Secret

The hollow charge mine as an antitank weapon was discussed. Tests showed that: (1) a 6.25-lb. hollow charge mine buried at a depth of 30 in. would penetrate armor 20 mm. thick; (2) penetration of the jet into the tank proper would probably cause a fire because of the necessity of stowing large amounts of ammunition on the tank floor; (3) the hollow charge mine was ineffective against tank tracks, penetrating but not severing the tracks.

L347

Ballistic Research Laboratories, Aberdeen Proving Ground.
SOVIET ARMOR DISTRIBUTION, by A. E. Roden. May 1952, p. 150-167 incl. diagrs. (Proj. no. TB3-1224B, BRL rept. no. 815) (In its Rept. of Fourth Tank Conference held at Aberdeen, Feb. 25-27, 1952, compiled by A. E. Roden, Secret, TIP S2561)
Secret

A mathematical analysis was made to evaluate the ballistic performance of HEAT, AP, HVAP and HEP projectiles and guns ranging from the 76-mm. T91 to the 120-mm. T123 against the JS III and T34/85 tanks and the JSU152 and SU100 self-propelled guns of the Soviet Mechanized Army and Rifle Corps. The calculated data are given on curves which provide a means of comparing the probable penetration capabilities of the various antitank projectiles considered. It was concluded that the 90-mm. HEAT round is adequate for combatting all Soviet armored vehicles with the possible exception of the JS III.

L348

Ballistic Research Laboratories, Aberdeen Proving Ground.
SOVIET TANK COMBAT METHODS, by H. H. Howze. May 1952, p. 216-227. (Proj. no. TB3-1224B, BRL rept. no. 815) (In its Rept. of Fourth Tank Conference held at Aberdeen, Feb. 25-27, 1952, compiled by A. E. Roden, Secret, TIP S2561) Secret

The following were briefly considered in regard to tank warfare:
(1) the German Panzerfaust
(2) the fin-stabilized 90-mm. HEAT round as compared with the 105-mm. AP round.

L349

Ballistic Research Laboratories, Aberdeen Proving Ground.
STUDIES OF ARMOR TO DEFEAT HEAT AND HEP PROJECTILES, by E. L. Kirkpatrick. May 1952, p. 73-120 incl. illus. tables. (Proj. no. TB3-1224B, BRL rept. no. 815) (In its Rept. of Fourth Tank Conference held at Aberdeen, Feb. 25-27, 1952, compiled by A. E. Roden, Secret, TIP S2561) Secret

The following studies are discussed:
(1) Natural aggregates (sand, gravel and crushed stone) vs. the 2.36-in. rocket M6A3C.
(2) Heavy Al armor vs. 3.5-in. HEAT rocket.
(3) Al and the density law.
(4) Tests with small shaped charges and AP projectiles.
(5) Spaced armor.
(6) The Flintkote contract.
(7) Kalo plastics.
(8) The Nelson Stud Welding contract.

L350

Ballistic Research Laboratories, Aberdeen Proving Ground.
SUMMARY OF BRL MINE STUDIES, by A. R. Vincent. May 1952, p. 264-281. (Proj. no. TB3-1224B, BRL rept. no. 815) (In its Rept. of Fourth Tank Conference held at Aberdeen, Feb. 25-27, 1952, compiled by A. E. Roden, Secret, TIP S2561) Secret

The performance possibilities of the single and the proposed multijet hollow charge mines when used against tracks of the US T26E4 and the Soviet T34/85 tanks were considered. In a test 3.5-in. HEAT rockets were fired through the tank tracks; no damage resulted. The single hollow charge mine, with explosive and cone similar to the 3.5-in. HEAT rocket, caused no track damage, being effective only on penetrating the tanks floor plate to fire ammunition and fuel. It is believed that the proposed multijet mine, containing 6 cones set at 45° elevation in a 12-lb. hemisphere of explosive, will cause track damage and also provide the possibility of a complete tank kill. It is assumed that the multijet mine will require lower densities per unit area to achieve the same level of target immobilization caused by the M6 HE (12-lb.) mine or the single hollow charge mine. A more complete evaluation will be made when the multijet mine is tested and additional information is obtained on the JS III track.

L351

Ballistic Research Laboratories, Aberdeen Proving Ground.
TANK VULNERABILITY TESTING, by A. Pillersdorf. May 1952, p. 137-146. (Proj. no. TB3-1224B, BRL rept. no. 815) (In its Rept. of Fourth Tank Conference held at Aberdeen, Feb. 25-27, 1952, compiled by A. E. Roden, Secret, TIP S2561) Secret

The 3.5-in. and 6.5-in. HEAT aircraft rockets are briefly discussed.

L352

Ballistic Research Laboratories, Aberdeen Proving Ground.
THE VULNERABILITY OF THE JS III TO ATTACK BY TWO TYPES OF PROJECTILES, by G. A. Zeller. May 1952, p. 168-183 incl. tables, diagrs. (Proj. no. TB3-1224B, BRL rept. no. 815) (In its Rept. of Fourth Tank Conference held at Aberdeen, Feb. 25-27, 1952, compiled by A. E. Roden, Secret, TIP S2561) Secret

A study was made of the practicability of replacing the 90-mm. gun (HEAT round) on the medium tank with the 105-mm. gun (AP round). The HEAT round was used since it offered, on the basis of penetration, the only possibility of consistently defeating the JS III with the 90-mm. gun. Target kill probability, rate of fire, number of attack tanks in action, and effectiveness in mass action against a group of JS III target tanks were considered. This analysis suggested that the 90-mm. gun was more desirable for the medium tank than was the 105 mm. However, it was concluded that guns larger than the 90 mm. were needed for complete success against the JS III. Graphs are given for kill probability as functions of azimuth angle of attack and range for both rounds.

L353

Ballistic Research Laboratories, Aberdeen Proving Ground.
EXAMINATION OF SMALL CAST IRON LINERS FOR USE IN SHAPED CHARGES. June 1952, 10p. incl. illus. (BRL Technical note no. 709) Confidential

Three samples of cast Fe shaped charge liners from a lot tested at the Naval Ordnance Laboratory were examined metallurgically to ascertain why their performance did not confirm penetration data for liners of this type. The liners were simple cones with a 45° apex angle and a 1-in. base diameter, machined from small rough castings or cast billets. The specimens were examined at magnifications of 100 x and 500 x. Material in these liners was comparable to Cu on the basis of hardness only. The reason for the favorable performance of the cast Fe liners was not determined.

L354

Ballistic Research Laboratories, Aberdeen Proving Ground.
DETONATION AND SHOCK IN A HOLLOW EXPLOSIVE CYLINDER, by M. Sultanoff. July 1, 1952, 17p. incl. illus. diagrs. (Proj. no. TB3-0112K, BRL rept. no. 824) TIP U24718
Unclassified

The detonation and shock associated with hollow 50/50 pentolite cylinders 6 in. long (effective length 5 in.), having inside and outside diameters of 1 in. and 1.5 in., respectively, and boostered by truncated cones of Comp. C-3, were analyzed. A Mach shock velocity of 15 mm./µsec., approximately twice the detonation velocity, was measured. The mechanism of the connection between the detonation front and the shock wave, in the cavity, which outruns it is not understood. The detonation velocity remained normal (7.6 mm./µsec.) until the detonation front reached a point 75 mm. from the charge's open end at which point the velocity increased to 8.1 mm./µsec. It is postulated that the increase in detonation velocity is caused by a change in the density of the explosive brought about by the pressure in the internal shock wave. A graphical configuration of the detonation and shock front in the cylinder at 1 µsec. intervals is given.

L355

Ballistic Research Laboratories, Aberdeen Proving Ground.
WIND TUNNEL TESTS OF THE T153 120-MM. HEAT PROJECTILE, by R. H. Krieger. Aug. 1952, 86 p. incl. illus. tables, diagrs. (Proj. no. TB3-1838AF, BRL Technical note no. 724) TIP C8898
Confidential

Budd Company models of the T153 120-mm. HEAT round were tested to determine pitching moment, c.p., and normal force for configurations employing 4 body nose shapes, 5 fixed 6-fin tail designs, 2 folding 4-fin tail units, and 4 boom lengths. Projectile stability was obtained with all fin-body configurations, with the greatest stability being possessed by the 30° leading-edge, sweepback, end-plated fixed fin model. The test results showed that the use of the folding fin tail offers the possibility of reduced over-all projectile length at M = 4.0. It was also indicated that a more stable folding-fin round of the same length as the best fixed round can be designed. The aerodynamic coefficients are given for all models.

L356

Ballistic Research Laboratories, Aberdeen Proving Ground.
VELOCITY AND PENETRATION MEASUREMENTS OF CAVITY CHARGE JETS IN RAREFIED ATMOSPHERES, by H. I. Breidenbach and J. W. Gehring. Sept. 1952, 33p. incl. illus. tables, diagrs. (Proj. no. TB3-0134, BRL rept. no. 833) TIP C8956
Confidential

Jet particle velocities in rarefied (60-120 µ) and sea level (760 mm.) atmospheres measured both electronically and optically show similar average apparent decelerations in both atmospheres at distances of 300 to 750 mm. from the base of the shaped charge liners. The particles in the rarefied atmosphere show evidence of flashing, yawing, and possible tumbling, thus complicating the interpretation of both electrically and optically recorded data. A discussion of this problem is included. The apparent deceleration of the jets is of the same order of magnitude as that observed for meteors at altitudes of 70-75 km. Penetration measurements made on steel targets struck by jets fired at optimum standoffs in 60 to 120 µ atmospheres show no significant difference from the usual penetration obtained from similar charges fired at sea level. Flash radiographs of jets fired simultaneously in normal air pressure and at reduced pressure, at both close and long standoffs, show no apparent differences in formation or in flight which could be attributed to the reduced pressure. (BRL abstract)

L357

Ballistic Research Laboratories, Aberdeen Proving Ground.
ANALYSIS OF SOME EXPERIMENTAL DATA ON GLASS AS A TANK ARMOR TO DEFEAT SHAPED CHARGES, by J. P. Shanley. Feb. 1953, 16p. incl. tables, diagrs. (Proj. no. TB3-1224B, BRL Memo. rept. no. 643) AD-7993
Confidential

Experiments were performed to examine the possibility of using glass, backed by steel, as an armor for tanks. Rocket heads (3.5 in.) were statically fired into various thicknesses of glass backed by mild steel. It is shown that glass varies in relative effectiveness in stopping the penetration dependent on the thickness used. At its best, 6 in. of glass is equivalent to 6.5 in. of steel. At other thicknesses, glass is not so effective on a thickness basis, although on a weight basis it is superior to steel at all the thicknesses tested. It is concluded that an armor partly composed of glass still shows promise for defeating shaped charges.

L358

Ballistic Research Laboratories, Aberdeen Proving Ground.
FLASH RADIOGRAPHY OF COLLAPSING 105-MM. SHAPED CHARGE LINERS, by L. Zernow, S. Kronman, F. Rayfield, and J. Simon. Feb. 1953, 12p. incl. illus. diagr. (Proj. no. TB3-0134, BRL rept. no. 846) AD-9401
Unclassified

Flash radiography of large collapsing shaped charge liners was accomplished with a low voltage (50 kv) field type flash radiography system. The expected increase in visible detail was found. A highly efficient film protection system which depends in part on large deformations of the protective elements is a crucial part of this technique for radiographing liner collapse. The first radiographs of collapsing liners show that the break-up of a steel jet must occur at an even earlier stage than was deduced from jet studies. Cu is found to behave in its usual fashion, and dural in the early stages appears to be collapsing as expected.

L359

Ballistic Research Laboratories, Aberdeen Proving Ground.
A METHOD FOR INCREASING THE DESTRUCTIVENESS AND LETHALITY OF LINED CAVITY CHARGES, by H. I. Breidenbach. Feb. 1953, 44p. incl. illus. tables, diagrs. (Proj. no. TB3-0134, BRL rept. no. 848) AD-10 002
Confidential

A truncated conical Al or Mg alloy sleeve of tapering wall thickness fitted snugly over a standard, Cu cavity charge liner improves the incendiary effect, doubles the total weight of material penetrating the target and at least doubles both the area of effectiveness and the number of large lethal particles striking objects placed remotely from the exit side of an intervening steel wall. No change in optimum standoff nor loss in the usual penetration of the Cu liner is experienced. This rept. includes diagrams and data of the evolutionary stages leading up to the final design and a series of illustrations of unusual liner shapes developed by German scientists during World War II.

L360

Ballistic Research Laboratories, Aberdeen Proving Ground.
STATUS OF EXPLOSIVE ARMOR STUDIES, FEB. 1953, by J. P. Shanley. Feb. 1953, 26p. incl. illus. tables, diagrs. (Proj. no. TB3-1224B, BRL Memo. rept. no. 648) AD-9475
Confidential

Experiments were performed to examine the possibility of using explosives as a protective device for armor against shaped charges. Explosives have proved very effective in reducing jet penetrations. A fixture was designed for static tests which, with modifications, can be used to mount explosives on tanks. At this time it appears that confinement of explosives adds to the explosive's effectiveness in stopping shaped charge penetrations. The results of the experiments indicate that the reduction in jet penetration by the explosive is a function of the weight of the explosive used.

L361

Ballistic Research Laboratories, Aberdeen Proving Ground.
A TRIPLE-FLASH RADIOGRAPHY SYSTEM FOR STUDYING JETS FROM LARGE SHAPED CHARGES, by S. Kronman, J. Simon, F. Rayfield, and L. Zernow. Mar. 1953, 25p. incl. illus. diagrs. (Proj. no. TB3-0134, BRL Memo. rept. no. 659) TIP C1383
Confidential

A triple-flash field radiography system is described. It is highly flexible and has been applied to the study of jets from both rotated and unrotated 105-mm. shaped charges as well as to the study of the collapse of 105-mm. liners and to the study of penetration of targets. Sample triple-flash radiographs are shown.

L362

Ballistic Research Laboratories, Aberdeen Proving Ground.
ON THE STABILITY OF AN ELONGATING METAL JET, by G. F. Carrier. Apr. 1953, 11p. (Proj. no. TB3-0134, BRL rept. no. 862) AD-20 700
Restricted

The jet produced when a lined shaped charge is detonated frequently breaks up into discrete pellets distributed along the length of the jet. Because of the limitations imposed by a lack of knowledge concerning the physical properties of this material at high rates of deformation, a theory was formulated. The theory is consistent with the laws of mechanics but is of a quasi 1-dimensional nature and allows the postulation of a simple, qualitatively acceptable, stress-deformation law for the metal. The law, which is essentially that of a perfectly plastic material, leads to a prediction of instability of the elongating configuration but the viscous law does not. Possible interpretations of the results are discussed.

L363

Ballistic Research Laboratories, Aberdeen Proving Ground.
PENETRATION OF SHAPED CHARGES INTO TITANIUM AND OTHER METALS, by E. L. Kirkpatrick. Apr. 1953, 19p. incl. illus. tables, diagrs. (Proj. no. TB3-1224B, BRL Memo. rept. no. 670) AD-18 328
Confidential

Test results are given for the penetration of small shaped charges into steel, Al, Ti, and Mg. Ti provided protection equal to the same thickness of steel with a weight saving of 35%. The penetration into 3S Al is almost 50% more than into 24ST Al. The penetration into 24ST Al was 92% of the distance predicted by the density law. Mg provided 15% better protection than that which was predicted but showed a tendency to crack and shatter. (BRL abstract)

L364

Ballistic Research Laboratories, Aberdeen Proving Ground.
AN ANALYSIS OF RESULTS OF SOME DYNAMIC FIRINGS OF SHAPED CHARGES AGAINST SPIKED ARMOR, by J. P. Shanley and E. L. Kirkpatrick. June 1953, 22p. illus. diagrs. (Proj. no. TB3-1224B, BRL Memo. rept. no. 684) AD-18 400
Confidential

Tests were made to determine the effectiveness of spiked armor in defeating shaped charges. Ten 105-mm. HEAT, T184E3 rounds, having a 45° conical liner, a 3.47-in. base diameter, and a PI, BD, T208E7 piezo-electric nose fuze, were fired at 0° and 60° obliquities at spiked targets. Eight rounds defeated the spikes; the 2 remaining rounds suffered from fuze malfunctioning. It was concluded that spiked armor is ineffective against shaped charge ammunition of the fast-fuzed type tested.

L365

Ballistic Research Laboratories, Aberdeen Proving Ground.
AERODYNAMIC AND FLIGHT CHARACTERISTICS OF THE 90-MM. FIN STABILIZED SHELL, HEAT, T108, by B. G. Karpov. July 1953, 37p. incl. illus. tables, diagrs. (Proj. no. TB3-0230, BRL Memo. rept. no. 696) AD-18 412
Confidential

The shrouded tail of the 90-mm. T108 shell was replaced by unshrouded 6 fin bladed tail. Firing trials showed that the new configuration performed satisfactorily when fired from a rifled gun tube. Firings from the smooth bore gun tube gave poor accuracy on a target at 1000 yd. Investigation of this phenomenon in the large Spark Range showed conclusively that in order to maintain accuracy the shell must have an axial spin. The spin for the 90-mm. T108 shell need not be high, of the order of 10 r.p.s., but it is essential for neutralizing unavoidable aerodynamic asymmetries built into the shell in the process of manufacture. Aerodynamic characteristics of the 90-mm. T108 shell were determined over a wide range of Mach numbers, over which the shell is statically stable. The stability margin, i.e., c.p. - c.g. separation in units of over-all length varies from about 21% at M = 0.9 to 7% at M= 2.4. A systematic decrease in the stability margin with increasing Mach number is due to a loss of lift on the fins. This rate of loss appears to be less than theoretically predicted for wings of very low aspect ratio. The difference is probably due to body wake and interference effects.

L366

Ballistic Research Laboratories, Aberdeen Proving Ground.
AN EVALUATION OF THE TERMINAL EFFECTIVENESS OF THE 2.75-IN. FFAR AND 8-CM. OERLIKON HEAT ROCKETS AGAINST A US MEDIUM TANK, by W. Gholston, D. D. O'Neill, and J. R. Williams. Aug. 1953, 51p. incl. illus. tables, diagrs. (BRL Memo. rept. no. 716) AD-22 789
Confidential

Four-hundred-eight rounds were fired at T26E4 tanks from an F84E fighter to obtain terminal effectiveness data for the 2 types of HEAT rockets. Of the 219 2.75-in. FFAR's fired, 32 were hits, with 18 perforating the target; of the 189 8-cm. Oerlikon rounds expended, 39 were hits, with 15 perforating the target. Analysis of data from these firings and from tests against armor plate indicated no significant difference in the armor penetrating ability of the 2 rockets. The probability of perforation, given a random hit on the target, averaged 0.38 for each rocket which was considered to be adequate penetration-wise. Analysis of the damage after perforation again failed to show any significant differences between the 2.75-in. and 8-cm. rockets. Summarized assessments of the hits scored, including total penetration data, are included for each round.

L367

Ballistic Research Laboratories, Aberdeen Proving Ground.
SOME EXPERIMENTS ON COMPOSITE ARMOR USING GLASS TO DEFEAT SHAPED CHARGES, by J. P. Shanley and E. L. Kirkpatrick. Aug. 1953, 20p. incl. tables, diagrs. (Proj. no. TB3-1224B, BRL Memo. rept. no. 712) AD-20 626
Confidential

Experiments were performed which indicate that glass can be used in a composite armor to protect tanks against shaped charges. Composite armor consisting of steel plate, insulating material and glass were very effective against statically fired 3.5-in. rocket heads at 0° and 60° obliquities. It is shown that the addition of a steel plate in front of the glass improved the performance of the glass. The effectiveness of glass with a faceplate is doubled when the faceplate is insulated from the glass by as little as 0.25 in. of felt or 0.5 in. of air. Results of 0° obliquity tests are described in which the glass in the targets reduced jet penetrations into steel by 1.5 times the thickness of glass used. Weight savings as high as 54% over the weight of mild steel to defeat 3.5-in. rockets were achieved. A design of composite armor is proposed which would protect the frontal areas of present day medium tanks against 3.5-in. rockets or equivalent shaped charges with approximately a 4% increase in weight of the tank.

L368

Ballistic Research Laboratories, Aberdeen Proving Ground.
WIND TUNNEL TESTS ON THE BUDD COMPANY T153 120-MM. HEAT SPIKE NOSE, FOLDING-FIN PROJECTILE, by R. H. Krieger and J. M. Hughes. Oct. 1953, 83p. incl. illus. tables, diagrs. (Proj. no. TB3-1838 AP, BRL Memo. rept. no. 733) AD-28 488
Confidential

Wind tunnel tests were performed on a 34.0% scale model of the Budd Co. T153 120-mm. HEAT folding fin, spike nose projectile at M = 1.72, 3.20, and 3.78 at the Aberdeen Proving Ground. The design of the model allowed the sweep angle of the folding fin to be varied during the tests. Measurements of pitching moment were made; from these normal force and c.p. positions were calculated. Drag forces were also determined. The test results appear as aerodynamic coefficients. (BRL abstract)

L369

Ballistic Research Laboratories, Aberdeen Proving Ground.
PROGRAM FOR THE SYMPOSIA ON SHAPED CHARGES AND IMPROVED SHOULDER-FIRED ANTITANK WEAPONS HELD 7-11 DEC. 1953 AT THE BALLISTIC RESEARCH LABORATORIES, ABERDEEN PROVING GROUND, MD. [Dec. 1953, 56p.]
Confidential

Forty-one abstracts of papers presented at the symposia are given. At the Shaped Charge Symposium, sessions were held on weapons (non-shoulder fired), defense against shaped charges, fundamentals, rotation, and lethality. Presentations given at the Improved Shoulder-Fired Antitank Weapons Symposium included foreign shaped charge weapons development (e.g. Heller, 3.5-in. Chinese Bazooka, and the Belgian 83-mm. HEAT Enegra grenade) and current studies in shaped charge research with implications for shoulder-fired weapons.

L370

Ballistic Research Laboratories, Aberdeen Proving Ground.
A GATING CIRCUIT FOR SYNCHRONIZING THE INITIATION OF EXPLOSIVES WITH A PREDETERMINED WRITING SPEED OF A ROTATING MIRROR CAMERA, by J. B. Feldman, Jr. Apr. 1954, 14p. incl. diagrs. (Proj. no. TB3-0112K, BRL Memo. rept. no. 786)
Unclassified

The circuit described was designed to synchronize the initiation of high explosives with a predetermined angular frequency of the rotating mirror of a streak camera. The circuit input uses 3-v. pulses with a short rise time. In this application the width of the pulses need not be specified since the angular frequency begins with zero and gradually increases to the desired frequency. However, for random pulses the accuracy of definition of the time interval depends on the pulse width. The streak camera produces electrical pulses which are synchronized with a given position of the mirror by means of a magnetic pick-up at the rate of 1 pulse/revolution. Four of these pulses are used to initiate the event, and measure the period of revolution. The first pulse is delayed by means of 2 uni-vibrators. The delayed pulse and the second pulse are fed to a coincidence circuit. At coincidence a keying circuit is closed to allow the remaining pulses, after being suitably shaped, to pass through the circuit. The third pulse initiates the event and also starts the chronograph. The fourth pulse stops the chronograph. The circuit was designed to operate in the range of time intervals from 1000 to 3000 μsec. For a given dial setting, the time interval will vary, on the average, by approximately ± 0.2%. (BRL abstract)

L370a

Ballistic Research Laboratories, Aberdeen Proving Ground.
CHAPTER I. INTRODUCTION, by E. M. Pugh. [May 1954], p. 1-17 22 refs. (Proj. no. TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311)
Confidential

The history of shaped charge research is briefly described. Unlined charges, early use of liners, coordination and expansion of US research, influence of foreign developments, emergence of shaped charge theories in 1943, jet formation, and non-steady jet formation are considered.

L370b

Ballistic Research Laboratories, Aberdeen Proving Ground.
CHAPTER II. STATUS OF THEORY, by G. Birkhoff and L. H. Thomas. [May 1954], p. 18-44 incl. illus. diagrs. 90 refs. (Proj. no. TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311)
Confidential

In discussing shaped charge mathematical theory, the following subjects were considered: (1) detonation wave; (2) jet formation: "zero-order" theory; (3) jet-formation: "first-order" theory; (4) applicability of "first-order" theory; (5) ultra-fast jets; (6) jet breakup; (7) similarity: behavior of similar shaped charge rounds; (8) penetration: "zero-order" theory; (9) penetration: "first-order" theory; (10) effect of rotation; (11) spin compensation; (12) perturbation methods; (13) numerical methods; and (14) some possible problems.

L370c

Ballistic Research Laboratories, Aberdeen Proving Ground.
CHAPTER III. LINER PERFORMANCE, by J. E. Shaw. [May 1954], p. 45-102 incl. illus. tables, diagrs. 29 refs. (Proj. no. TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311) Confidential

The following subjects are discussed: (1) measures of liner performance; (2) factors affecting liner performance; (3) methods of manufacture (e.g., spinning, drawing, casting, etc.); (4) desirable properties of a liner; (5) experimental results of inaccuracies in the liner (e.g., warping, wall thickness variations, shallow grooves etc.); (6) tolerances; (7) the effect of design parameters on penetration; (8) the effect of liner details on penetration (e.g., tapered walls, wires and other obstructions within the cavity, flanges, etc.); and (9) jet velocities.

L370d

Ballistic Research Laboratories, Aberdeen Proving Ground.
CHAPTER IV. THE UNFUZED WARHEAD, by H. Winn. [May 1954], p. 103-118 incl. tables, diagrs. 66 refs. (Proj. no. TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311) Confidential

In tracing the development of a typical shaped charge warhead, the following subjects were discussed: (1) selection of weapon type and size; (2) consideration of liner parameters; (3) assembly of the liner; (4) boostering of the charge; (5) confinement; and (6) internal ogive shape.

L370e

Ballistic Research Laboratories, Aberdeen Proving Ground.
CHAPTER V. THE EXPLOSIVE COMPONENT OF SHAPED CHARGES, by A. D. Solem and W. T. August. [May 1954], p. 119-138 incl. table, diagr. 27 refs. (Proj. no. TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311) Confidential

Since the shaped charge effect depends upon the pressure impulse of a detonated explosive to accelerate the liner walls in the collapse process, the following subjects are discussed: (1) detonation theory; (2) effect of different type of explosives; (3) explosive distribution and initiation; (4) charge preparation; and (5) charge imperfections.

L370f

Ballistic Research Laboratories, Aberdeen Proving Ground.
CHAPTER VI. FUZES FOR SHAPED CHARGE MISSILES, by J. Rabinow and W. Piper. [May 1954], p. 139-176 incl. illus. diagrs. (Proj. no. TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311) Confidential

Contact fuzes for shaped charge projectiles are considered. The following subjects are discussed: (1) general requirements: (2) electrical fuzing; (3) arming systems; (4) specific fuzes (e.g. fuze T208, fuze M404, etc.); (5) $BaTiO_3$ piezoelectric fuze; (6) fields for future work (e.g., fuzes with long standoffs, detonation research, production engineering of fuzes, etc.; and (7) Energa rifle grenade fuzing.

L370g

Ballistic Research Laboratories, Aberdeen Proving Ground.
CHAPTER VII. THE EFFECT OF ROTATION UPON SHAPED JETS, by L. Zernow. [May 1954] p. 177-209 incl. illus. diagrs. 26 refs. (Proj. no. TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311) Confidential

In this study on the effect of rotation, the following subjects were considered: (1) rotation theory; (2) scaling under rotation; (3) effect of liner angle upon penetration under rotation; (4) effect of liner thickness on penetration under rotation; (5) effect of standoff upon penetration under rotation; (6) effect of liner material upon penetration under rotation; and (7) effect of liner shape upon penetration under rotation.

L370h

Ballistic Research Laboratories, Aberdeen Proving Ground.
APPENDIX [TO CHAPTER VII]. DERIVATION OF THE EXPRESSION FOR ω_0 IN TERMS OF CHARGE PARAMETERS, by F. P. Beitel. [May 1954], p. 210-213 (Proj. no. TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311) Confidential

An expression for the effect of rotation upon penetration of a conical liner is derived. Only elemental rings on the liner are considered since a non-steady collapse theory is required; in addition, the liner wall is assumed to be thin. This gives

$$\frac{P}{P_0} = \frac{1}{\sqrt{1+\omega^2/\omega_0^2}}$$

where $\omega_0 = \dfrac{V_j\, d \sin^2 \beta/2}{RS}$; P = element of penetration due to the ring element spun at angular velocity ω; Po = penetration for $\omega = o$; ω = angular velocity of uncollapsed cone; V_j = jet velocity of jet element arising from ring under consideration; β = collapse angle of cone; R = radius of uncollapsed ring; and S = standoff for the ring element.

L370i

Ballistic Research Laboratories, Aberdeen Proving Ground.
CHAPTER VIII. SPIN COMPENSATION, by R. J. Eichelberger. [May 1954], p. 215-253 incl. illus. diagrs. 29 refs. (TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311) Confidential

The use of fluted liners as a means of compensating for the initial spin of a shaped charge and its liner is presented. The following subjects are discussed: (1) mechanism of spin compensation by fluted liners; (2) experimental results with fluted liners; (3) variability in performance of fluted liners and tolerances required; (4) methods of fluted liner manufacture; and (5) miscellaneous observations pertinent to fluted liners. In addition, other means of eliminating the spin of projectiles, i. e., using vanes or peripheral jet engines, mounting the charge in bearings, or employing fin-stabilization, are briefly considered.

L370j

Ballistic Research Laboratories, Aberdeen Proving Ground.
CHAPTER IX. DEFEAT OF SHAPED CHARGE WEAPONS, by R. von Heine-Geldern. [May 1954], p. 255-268 incl. illus. diagrs. 25 refs. (TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311) Confidential

Of all possible means of defeating shaped charges, the most promising consists of a combination of glass and steel armor. Glass, in the form of plates, blocks, or large balls, may be used with a suitable shock-absorbing material. This means of protection has the advantage of low density and hence over-all weight; in addition, the abnormal stopping power of glass, which is not approached by any other method of passive defense, is utilized. Ti displays this abnormal stopping power to a much smaller extent. Recent results suggest that explosive pellets or linear shaped charges provide a very high degree of protection under certain circumstances; however, these last 2 methods are not developed to the point of practicability. (BRL abstract)

L370k

Ballistic Research Laboratories, Aberdeen Proving Ground.
CHAPTER X. TERMINAL BALLISTICS EFFECTIVENESS OF SHAPED CHARGES AGAINST TANKS, by F. I. Hill. [May 1954], p. 269-278 incl. tables, diagrs. 28 refs. (Proj. no. TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311) Confidential

Tabular data are given for: (1) a summary of shaped charge firings on T26E4 and T26E5 tanks; (2) 3.5-in. (M28) vs. M26 tank; (3) HEAT 2.36-in. and 3.5-in. firings against 80 octane gasoline; (4) 2.36-in. (M6A6), 3.5-in., and 90-mm. (T108E15) rounds against diesel fuel; (5) 90-mm. (T108E1) vs. ammunition; (6) performance of Energa grenade; (7) Engera grenade vs. 17 pdr. APCBC ammunition; (8) witness plate firings of statically detonated 3.5-in. rockets and 95-mm. HEAT shells; (9) effectiveness of several HEAT projectiles in penetrating tank armor; (10) hit probability and vulnerability studies of Soviet JS III and T34/85 tanks; (11) vulnerable area of US M26 tank to 3.5-in. rocket; (12) hit probability on Soviet armored vehicles JSU152 and SU100. An evaluation of the present methods of hit probability and tank vulnerability is briefly given.

L370l

Ballistic Research Laboratories, Aberdeen Proving Ground.
APPENDIX I. AMERICAN HEAT AMMUNITION. [May 1954], p. 299-310 incl. illus. (Proj. no. TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311) Confidential

Rept. and firing record references available at Aberdeen Proving Ground and round characteristics are given for the following American HEAT ammunition: (1) cartridge, HEAT, T108, 90-mm.; (2) grenade, rifle, HEAT, M31(T37E4); (3) rocket, HEAT, T230, 3.5-in.; (4) grenade, rifle, HEAT, M28 (Energa)T41; (5) shell, HEAT, M307A1, 57-mm.; (6) shell, HEAT, M310A1, 75-mm.; (7) rocket, HEAT, M28(T80E2); (8) rocket, HEAT, T205, 3.5-in.; (9) rocket, FFAR, T2016, 2.75-in.; (10) shell, HEAT, M67, 105-mm.; (11) shell, HEAT, M324(T43), 105-mm.; (12) shell, HEAT, M344(T119E11), 106-mm.; and (13) shell, HEAT, M66, 75-mm. Specific penetration data are not given for the ammunition described.

L370m

Ballistic Research Laboratories, Aberdeen Proving Ground.
APPENDIX II. FOREIGN TYPES OF AMMUNITION (SOVIET). [May 1954], p. 311-317 incl. diagrs. (Proj. no. TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311) Confidential

Brief descriptions and rept. no. references available at Aberdeen Proving Ground on the following Soviet shaped charge ammunition are given: (1) Soviet HEAT projectile for 12-mm. howitzer, Mod. 38; (2) Soviet HEAT projectile for 76.2-mm. regimental gun, Mod. 27; (3) hollow charge shell, 7.5-cm, GR 38; (4) Soviet grenade, hand, HEAT, Mod. RPG6; and (5) Soviet grenade, hand, AT, Mod. 1943. RPG 43. In addition, 4 intelligence repts. on Soviet HEAT ammunition are included.

L370n

Ballistic Research Laboratories, Aberdeen Proving Ground.
APPENDIX III. FOREIGN (MISCELLANEOUS). [May 1954], p. 319-323 incl. diagrs. (Proj. no. TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311) Confidential

Brief descriptions and rept. no. and firing record references available at Aberdeen Proving Ground are given for the following shaped charge weapons: (1) Heller; (2) 8-cm. Oerlikon (Swiss) aircraft rocket; (3) Panzerschreck; and (4) Panzerfaust.

L370o

Ballistic Research Laboratories, Aberdeen Proving Ground.
APPENDIX IV. SOVIET ARMOR. [May 1954], p. 325-328 incl. diagrs. (Proj. no. TB3-0134, BRL rept. no. 905) (In its Critical Review of Shaped Charge Information, May 1954, Confidential, AD-48 311) Confidential

Diagrams of the Soviet tanks JS III and T34/85 and the self-propelled Soviet gun, the SU100 are given.

L371

Ballistic Research Laboratories, Aberdeen Proving Ground.
STATUS OF EXPLOSIVE ARMOR STUDIES, by J. P. Shanley and A. C. Doskocil, Jr. June 1954, 23p. incl. tables, diagrs. (Proj. no. TB3-1224B, BRL Memo. rept. no. 807) Confidential

Explosive armor was evaluated as a defense mechanism against du Pont jet tappers and 3.5-in. rocket heads. The reduction in jet penetration by unconfined explosives was primarily dependent on the height and diameter of the explosives rather than on their weight. In the case of confined explosives, the reduction in jet penetration was almost constant, being independent of explosive weight. Results indicated that preinitiation of the explosive armor gave less protection against shaped charges than when the explosive armor was initiated by the shaped charge jet itself.

L372

[Ballistics and Munitions Development, Army Ordnance Office, Wa A]
7.5-CM. GR. 38 HL/C. Oct. 23, 1942, 1p. diagr. (Rept. no. 1745/42 g. Kdos. Wa Prüf 1 IV/2b; OTIB rept. no. 1249, AOO-8 - In German) Unclassified

The grenade penetrated 95 to 100 mm. of armor at 60° and 75 to 80 mm. of armor at 45°. Its conical liner was made of a Zn alloy and its explosive charge of 60/40 H5/Fp was activated by an AZ 38 fuze.

L373

Ballistisches Institut der Luftkriegsakademie, Berlin-Gatow.
REPORT ON THE INVESTIGATION OF THE PENETRATION EFFECT OF HOLLOW CHARGE EXPLOSIVES ON ARMOR PLATES (Bericht über die Untersuchung der Durchschlagswirkung von Sprengstoffhohlkörpern auf Panzerplatten), by G. Hensel. June 1940, 35p. illus. (Rept. no. ZWB/LKA/6/40 - In German; AMC Desk Catalog no. 962 13048 6) Unclassified

Basic investigations to develop the highest possible penetration of steel with shaped charges are described. Apex angle and the "U" shape are emphasized. Experiments with halved liners of various shapes are reported and illustrated with excellent photographs.

L374

[Ballistisches Institut der Luftkriegsakademie, Berlin-Gatow].
RESULTS OF BLASTING TESTS WITH HOLLOW CHARGES WITH AND WITHOUT LINERS. 1941. (Trans. as OTIB rept. no. 1476, 4p. illus. diagrs.) Restricted

Results are reported of tests with unlined charges, charges with Fe liners at 0 standoff, and charges with Fe liners at 2/3D - 3/2D standoff.

L375

Ballistisches Institut der Luftskriegsakademie, Berlin-Gatow.
THE APPLICATION OF THE X-RAY FLASH RADIOGRAPHY METHOD IN THE INVESTIGATION OF THE HOLLOW CHARGE PROBLEM (Die Verwendung der Röntgenblitzmethode bei der Untersuchung des Hohlkörperproblems), by G. Thomer. July 3, 1941, 8p. incl. illus. (Rept. no. 5/41; OTIB rept. no. 1627 - In German) Restricted

A flash radiographic technique employing a discharge duration of 10^{-7} sec. is reported. The apparatus is described and radiographs of a collapsing hemispherical liner are reproduced.

L376

Ballistisches Institut der Luftkriegsakademie, Berlin-Gatow.
INVESTIGATION OF THE HOLLOW CHARGE PROBLEM BY MEANS OF THE X-RAY FLASH RADIOGRAPHY METHOD (Untersuchung des Hohlkörperproblems mit Hilfe der Röntgenblitzmethode), by G. Thomer. Nov. 20, 1941, 16p. incl. illus. (Rept. no. 9/41; OTIB rept. no. 1628 - In German). Restricted

Flash radiographic apparatus and radiographic technique for studying shaped charges are reported. Radiographs of the collapse of hemispherical liners are included.

L377

Ballistisches Institut der Luftkriegsakademie, Berlin-Gatow.
INCANDESCENCE AND TEMPERATURE DURING THE DETONATION OF IRON LINED HOLLOW CHARGES (Über Leuchterscheinung und Temperatur der bei der Sprengung eines H-Körpers mit eiseneinlage herausfliegenden Einlage), by L. Holtgreven. June 1, 1942, 37p. incl. illus. diagrs. (Rept. no. 16/42; Trans. as OTIB rept. no. 1472, 15p.). Restricted

Discussions are reported on the type and cause of the luminous trace by: (1) a comparison of photographs of detonations in air and N; (2) spectroscopic examination; (3) temperature measurements; and (4) evaluation of spectral photographs. An appendix is included on incandescence of gas clouds and the possibility of determining their temperature.

L378

Ballistisches Institut der Luftskriegsakademie, Berlin-Gatow.
BLASTING EXPERIMENTS WITH VARIED HOLLOW CHARGES (Sprengversuche mit variierten Hl-Körpern), by Weigel. June 12, 1943, [14]p. incl. diagrs. (Rept. no. 792/43, g.Kdos. Wa Prüf 1 IV/2b; OTIB rept. no. 1249, AOO-2 - In German) Unclassified

The charge is formally divided into 2 portions: the solid "base" and the hollow "crown". The shape of each is varied independently of the other. The depth of penetration is first investigated as a function of standoff of the crown and of the shape of its outer surface (the inner surface is kept conical with a body angle of 37°). The first function shows several maxima and minima, the second proves that maximum efficiency requires cylindrical outer surface. The bases are investigated at various shapes (truncated cones of different heights and slants) with different crowns, with and without tamping. It is shown that tamping increases the penetration and lowers the dependence upon the height of the base. The optimum height is obtained empirically for nonspinning projectiles by multiplying the maximum diameter of the explosive charge by 2.17 to 2.50. (APG abstract)

L379

Ballistisches Institut der Technischen Akademie der Luftwaffe, Berlin-Gatow.
SPECTROSCOPIC INVESTIGATIONS AND TEMPERATURE MEASUREMENTS ON DETONATING CONE SHAPED HOLLOW CHARGES (Spektroskopische Untersuchungen und Temperaturmessungen an detonierenden, kegelförmigen H-Körpern), by Burkhardt and others. Feb. 23, 1943, 9p. incl. illus. (Rept. no. 4/43; OTIB rept. no. 2788, 9p. incl. illus. - In German; Trans. as OTIB rept. no. 1486, 5p. illus.) Translated cover sheet incorrectly dated 2/2/43. Restricted

By a study of microflash photographs of the spectra of jets from lined and unlined charges, conclusions are drawn as to their compositions and the part played by the liner in the luminescence of the jet. The temperature prevailing in the jet was determined from the spectra to be approximately 3000° K for an unlined charge and somewhat higher for a lined charge. The temperature is lower for conical than for hemispherical units. (Abstract taken from OTIB rept. 1486)

L380

[Ballistisches Institut der Technischen Akademie der Luftwaffe, Berlin-Gatow].
TEST OF THE HOLLOW CHARGE EFFECT. RESULTS OF BLASTING WITH A NEW HOLLOW SPACE SHAPE ("HELMUT SHAPE"). Mar. 1943. ([Rept. no. 5/43]; Trans. as OTIB rept. no. 1479, 5p. diagrs.) Unclassified

Tests were made with a shaped charge consisting of a cone placed on top of a hemisphere. The intended effect (combining large depth effect with the production of open cylindrical holes) was achieved when proper dimensions were selected. The most favorable thicknesses of the liners were much thinner than for the separate cone or hemisphere.

L381

Ballistisches Institut der Technischen Akademie der Luftwaffe, Berlin-Gatow.
RECENT STUDIES MADE IN THE FIELD OF HOLLOW CHARGES, by H. Schardin. June 1943. (Rept. no. 6/43; Lecture given by Prof. Schardin at the meeting for the exchange of information on "hollow charges" on Feb. 9, 1943) (Trans. as OTIB rept. no. 1480, 15p. illus. diagrs.; Also trans. in OTIB rept. no. 1146A, 1945; And also trans. in rept. no. BIOS/Gp.2/HEC 2576, p. 6-31, illus. diagrs.) Restricted

Experiments carried out at the Ballistic Institute are reported and discussed. The topics are: liners of miscellaneous shapes, jets studied by means of flash, Kerr-cell, and spectroscopic photography, the effects of rotation, experiments with conical liners, and jet formation. It was concluded that a helmet-shaped liner would combine the advantages of the conical and hemispherical liner; tests proved this.

L382

[Ballistisches Institut der Technischen Akademie der Luftwaffe, Berlin-Gatow].
MULTIPLE SPARK PHOTOGRAPHS OF HOLLOW CHARGE PROJECTILES UNDER [STATIC] AND ACTUAL FIRING CONDITIONS, by Funfer. June 26, 1943. (Rept. no. 12/43; Trans. as OTIB rept. no. 1481, 33p. incl. illus. diagrs.)
Restricted

A 6.6-cm. shaped charge armor-piercing shell was used to investigate Kerr cell pictures of static detonations and detonations under actual firing conditions, and to measure the period of the fuze delay.

L383

[Ballistisches Institut der Technischen Akademie der Luftwaffe, Berlin-Gatow].
EFFECT OF SPIN ON PENETRATION OF HOLLOW CHARGE PROJECTILES. Nov. 2, 1943. ([Rept. no. 11/43]; Trans. as OTIB rept. no. 1475, 7p. illus. diagrs.)
Restricted

Results of static and dynamic firing tests to demonstrate the effect of rotation are shown. Ellipsoidal, conical, and hemispherical liners were used; the first 2 were dependent on rotation; the last was less affected.

L384

[Ballistisches Institut der Technischen Akademie der Luftwaffe, Berlin-Gatow].
X-RAY FLASH PHOTOGRAPHS OF HOLLOW CHARGES. 1944. ([Rept. no. 13/44]; Trans. as OTIB rept. no. 1478, 7p. illus. diagrs.)
Restricted

A method of measuring detonation velocity is described which must satisfy these conditions: any desired phase of the detonation process must be caught, and the path of the shaped charge liner and the time elapsed must be capable of being measured with the greatest possible accuracy.

L385

Ballistisches Institut der Technischen Akademie der Luftwaffe, Berlin-Gatow.
AN EXAMINATION OF THE INFLUENCE OF EXPLOSIVES ON HOLLOW CHARGE EFFECT (Beitrag zur Untersuchung sprengstoffseitiger Einflüsse auf die Hohlraumwirkung), by H. Freiwald. Jan. 10, 1944, 16p. incl. diagrs. (Rept. no. 1/44; Trans. as OTIB rept. no. 1473, 6p. diagrs.; Also trans. as OTIB rept. no. 2793)
Restricted

The performance uniformity of explosives is investigated in an effort to explain the differences in hole volume from the same size of charge. Artificial cracks and cavities were made in various areas of explosive charges and the test results are illustrated by graphs. The technique and apparatus for extraction analysis of explosive compositions are described.

L386

Ballistisches Institut der Technischen Akademie der Luftwaffe, Berlin-Gatow.
EXPERIMENTS WITH LONG RANGE MINES (Versuche mit Fernwirkungsminen). Jan. 10, 1945, 3p. illus. tables, diagrs. (Rept. no. 19/44; OTIB rept. no. 1249, AOO-1- In German)
Unclassified

The mine is based on the idea of accelerating uniformily every point of the liner during the explosion and to project in in 1 piece. The function of the mine depends upon: (a) the curvature of the concave face; (b) the outside profile of the charge; (c) the composition and thickness of the liner; (d) the type of explosive. Three types of mines may be distinguished: (1) hyperbolic steel liner (1 piece); (2) steel liner with embedded explosive charge designed to detonate on impact; (3) shrapnel liner, consisting of smaller parts. The experiments measured the armor piercing effect, the velocity of the liner, the effect of the explosive composition. The thickness of the liner was of little, in any, influence. Photographs of the trajectory indicate wobbling of the liner. Type 2 detonated only by impact on very solid substances. Type 3 is not discussed. (APG abstract)

L387

Basset, James and Jacques Basset.
INFLUENCE OF SURROUNDING PRESSURE ON THE EFFECT OF HOLLOW CHARGES AND THE COMBUSTION OF POWDERS (Influence de la pression ambiante sur les effets des charges creuses et la combustion des poudres). Comptes rendus hebdomadaire des séances de l'académie des sciences, v. 231, Dec. 18, 1950: 1440-1442.

The disappearance of the effect of a hollow charge rotating about its axis is attributed to the pressure produced by centrifugal force. Acceleration of the charge has the same effect. The action of pressure on the velocity of combustion of powders is also discussed. The velocity of combustion as a function of pressure is represented by a linear function of the type $V = a + bP$.

L388

Battelle Memorial Institute (OEMsr-722).
EXAMINATION OF ENEMY MATERIEL (OD-113) AC-77): METALLURGICAL EXAMINATION OF A GERMAN 75-MM. HE HOLLOW CHARGE SHELL, by R. M. Evans and others. Apr. 8, 1944, 10p. incl. illus. tables. (NDRC research proj. NRC-32, progress rept. no. 46; Serial no. M-246) (NDRC Div. 18) OSRD 3538
Unclassified

The metallurgical examination did not uncover any radical differences in material or method of manufacture from shells of the same type previously examined.

L389

Beauftragter des Reichsministers für Bewaffnung und Munition, Berlin.
REPORT ON THE FIRST PLENARY SESSION OF THE STUDY GROUP ON HOLLOW CHARGES ON JAN. 17, 1941 IN THE ARMY ORDNANCE OFFICE (Bericht über die erste Vollsitzung der Erfahrungsgemeinschaft H.-Ladung am 17. 1. 1941 im Heereswaffenamt), by Becker. Feb. 4, 1941, [4]p. (OTIB rept. no. 1249, Misc.-3 - In German) Unclassified

Lectures on the following subjects are summarized: factors which affect the performance of a shaped charge; effect of liner; linearity; and utilization of shaped charges by the Navy and Air Forces.

L390

Beauftragter des Reichsministers für Bewaffnung und Munition, Berlin.
REPORT OF THE MEETING OF THE STUDY GROUP ON HOLLOW CHARGES ON FEB. 27, 1941 IN THE AIR WARFARE ACADEMY, GATOW (Niederschrift über die Sitzung der Erfahrungsgemeinschaft H - Ladung am 27. II. 1941 in der Luftkriegsakademie Gatow), by Becker. Mar. 18, 1941, [20]p. (OTIB rept. no. 1249, Misc.-3 - In German) Unclassified

Lectures on the following subjects are summarized: the utilization of the shaped charge by the Air Force (airborne troops, bombs against warships and tanks, etc.); the theory of the shaped charge effect (multiple reflection of the detonation wave at armor plate and gas cloud front); the history of the shaped charge; increasing the break-off effect [spalling] on the reverse side of an armor plate by filling the air space of the shaped charge with Fe cores; and the performance of some shaped charge bombs. (APG abstract)

L391

Beauftragter des Reichministers für Bewaffnung und Munition, Berlin.
CONVENTION OF STUDY GROUP ON HOLLOW CHARGES IN THE NAVY INSTITUTE OF CHEMICAL AND PHYSICAL RESEARCH OF MAY 29, 1941 IN KIEL (Tagung der Erfahrungsgemeinschaft H-Ladungen in der CPVA [Chemisch Physikalische Versuchsanstalt der Marine] vom 29. 5. 1941 in Kiel), by Döring. July 9, 1941, 4p. (Rept. in [file] no. G. 1059-242; Trans. as OTIB rept. no. 1961 A, 2p.) Restricted

Research at the CPVA on the measurement of underwater detonations by means of the "pressure box" (Druckdose) and the "box model" is described briefly and the results are noted. The possibility of fitting an AP shell with a shaped charge is commented upon. Prof. Schardin reported on 3 effects of large hollow charges (size and type not stated). His remarks are summarized.

L392

Beauftragter des Reichsministers für Bewaffnung und Munition, Berlin.
REPORT ON THE MEETING OF THE STUDY GROUP ON HOLLOW CHARGES ON JAN. 31, 1942 (Protokoll über die Sitzung der Erfahrungsgemeinschaft H-Ladungen am 31. 1. 1942), by Döring. Feb. 19, 1942, [8]p. (OTIB rept. no. 1249, Misc.-3 - In German) Unclassified

Lectures on the following subjects are summarized: the design of the 7.5- and 10-cm. armor piercing shells (liner, fuze design, and arrangement within the shell); tests with slow super caliber shells (stick grenades, rifle grenades, Polte grenades); problems arising in the production of small armor piercing shells; experiments with electric fuzes; X-ray flash photography; and the difficulties encountered in the fuze design for fast Navy shells. (APG abstract)

L393

Beauftragter des Reichministers für Bewaffnung und Munition, Berlin.
THE CONFERENCE ON MAGNETIC FUZES IN HOLLOW CHARGES HELD MAR. 9, 1942 (Die Sitzung betreffend Magnetzünder bei H-Geschossen vom 9. März 1942). Mar. 11, 1942, [2]p. (Nr. g. Kdos. 115 - 242; OTIB rept. no. 1249, Misc.-4 - In German) Unclassified

Two magnetic fuze designs are discussed. One type initiates within 10^{-4} sec. (excluding primer). The other type comes in 2 forms, the H-shaped which ignites by tearing and the ring-shaped which ignites by breaking.

L394

BELGIAN AT WEAPONS. Ordnance Intelligence Summary, v. 2, serial no. 6, Mar. 15, 1951: 2-3. Secret

Test firings of various Belgian antitank weapons were made in Nov. 1950 at Brasschaat-Polygone artillery range in Belgium to obtain armor penetration data. "Below is a table showing armor penetration for the different weapons as fired [at a range of 27.3 yd] in the tests mentioned above":

	I		II		III		IV	
Weapon	Obliq.	Equiv. thick.	Obliq.	Equiv. thick.	Obliq.	Equiv. thick.	Obliq.	Equiv. thick.
Blindicide	60°	7.8 in.	17°	10.6 in.	10°	7.5 in.		
(83 mm.)	65°	9.3 in.			13°	8.8 in.		
Grenade "50"					0°	6.25 in.	60°	6.9 in.
(73 mm.)							65°	7.4 in.
Grenade "51"			0°	10.1 in.			60°	6.3 in.
(73mm.)			13°	10.3 in.			65°	7.4 in.
Grenade (400 g.								
shaped charge)	60°	7.8 in.	14°	10.4 in.				
(80 mm.)	65°	9.3 in.	31°	11.8 in.				

Plate characteristics:

I Homogeneous steel, 3.9 in. thick
II Homogeneous steel, 10.1 in. thick
III Trapezoidal X-section, top 3.9 in., base 9.85 in. (material not specified)

IV Plate 3.14 in. thick (material not specified)

Evidently the data presented here represent equivalent thicknesses only and not actual penetration values, unless complete penetrations were obtained in all cases.

L395

Birkhoff, G., D. P. Macdougall, E. M. Pugh, and G. Taylor.
EXPLOSIVES WITH LINED CAVITIES. Journal of Applied Physics, v. 19, June 1948: 563-582.

After a brief historical introduction and a general review of the basic principles of lined shaped charges, a mathematical discussion of jet formation based on the hydrodynamic theory is presented. The theoretical predictions are compared with observation. Penetration by constant (idealized) jets is compared with penetration by variable (real) jets, and a theory of penetration is discussed.

L396

BLASTING IN QUARRIES. Mine and Quarry Engineering, v. 15, Mar. 1949: 69-78.

One modern development of the use of plaster or "lay on" charges for stone breaking is the application of the shaped charge. It consists essentially of a molded charge of high explosive having a central hemispherical, conical or cylindrc conical shaped cavity. The penetration produced was found to be greater than when orthodox "lay on" charges were used. Many factors have to be taken into account, including the distance of the charge from the surface of the boulder, or standoff distance, and the shape of the cavity to be used, before success is obtained. The need for specially shaped metal containers to retain the correctly shaped cavity makes the method very expensive.

L397

Bomborn, B.
THE NEW GERMAN DETONATOR OF SCHULZE (Die neue deutsche Sprengkapsel von Schulze). Zeitschrift für das gesamte Schiess- und Sprengstoffwessen, v. 16, Dec. 1, 1921: 177-179.

The effectiveness of a detonator is greater when its charge is denser at the bottom than at its top. In the Schulze detonator this is accomplished by pressing the detonator over a cone shaped die.

L398

Boone, A. R.
AERIAL EXPLOSIONS HELP TO FINE HIDDEN OIL. The Explosives Engineer, v. 27, Jan.-Feb. 1949: 7-10, 27-28.

An account of seismic exploration is given in which shaped charges were fired above ground to produce a flat wave front over a large area. The charge was modified so that, instead of producing a long narrow jet, it produced a symmetrical umbrella shaped jet by which it was possible to obtain an essentially flat wave front 80 ft. in diameter.

L399

British Intelligence Objectives Subcommittee.
DEVELOPMENT OF PANZERFAUST, by A. R. F. Martin and S. A. B. Hitchins. [1945], 22p. incl. diagrs. (BIOS Final rept. no. 100) Restricted

Interviews with Dr. Heinrich Langweiler and Gen. Maj. Friedrich Kittel are reported. The development of the Panzerfaust from the earliest to the latest models is described in detail. The Panzerfaust 150 (last model) employed a new shaped charge principle: a hemispherical liner was used, and a paper wad inserted in the HE charge just forward of the point of initiation. This was thought to shape the detonation wave so that it struck the liner simultaneously on both sides, thus enhancing the performance of the jet. Greater standoff (1.6 diameters) was achieved by a new nose cap of conical shape. A fragmentation sleeve was produced to slip over the head of the projectile when antipersonnel effects were desired. By firing at a high angle of elevation with the fragmentation sleeve fixed, effective air-bursts against infantry were thought possible. It was also planned to use the weapon in the same way against low-flying aircraft. Langweiler attached great importance to enhancing the incendiary effect behind the target as the best way to increase the jet efficiency. The effect could be greatly increased by incorporating up to 30% of powdered Al into the HE charge without impairing performance. [Following sentence not clear]. "The most effective liner material apart from steel being tungsten carbide, wc, which Langweiler claimed gave 20 in. better penetration than steel." The Panzerfaust 150 projectile and fuze are illustrated.

L400

British Intelligence Objectives Subcommittee.
DEVELOPMENT OF GERMAN PANZERFAUST AND OTHER HOLLOW CHARGE WEAPONS, by A. R. F. Martin. Aug. 23, 1945, 18p. incl. diagr. (BIOS Final rept. no. 99) Restricted

Interviews are reported with several German scientists and industrial engineers who were connected with the development and production of the Panzerfaust and Panzerschreck. Details of performance and manufacture of these weapons are noted.

L401

British Intelligence Objectives Subcommittee.
DEVELOPMENT OF HOLLOW CHARGE WORK BY RHEINMETALL, BORSIG, BERLIN; INTERROGATION OF DR. OSCAR HERRMANN AT CEAD, THE GRANGE, KNOCKHOLT, NOV. 16TH, 1945, by H. L. Porter. [Nov. 1945], 16p. incl. diagrs. (BIOS Final rept. no. 570) Secret

The Würfpanzer grenade, the follow-through shell, and the follow-through bomb are described. An interview with Dr. Herrmann on the influence of the shape, size and material of the liner, aluminized explosives, and jet formation theory is reported.

L402

British Intelligence Objectives Subcommittee. INTERROGATION OF DR. HEINRICH LANGWEILER, by J. U. Woolcock. Jan. 1946, 2p. (BIOS Interrogation rept. no. 607) Secret

Henrich Langweiler, head of the Ammunition Research and Development Section of Hugo Schneider A. G., was questioned concerning the Panzerfaust, the 3-cm. combined HE and incendiary high capacity shell, and the Jägerfaust--an unusual recoilless weapon firing a 5-cm. high capacity shell. The information collected was published as Armament Design Department Technical rept. no. 2/46, Sections J, L, N, and Q.

L403

British Intelligence Objectives Subcommittee. EXPLOSIVES WORK AND ASSOCIATED PHOTOGRAPHIC TECHNIQUE, by C. A. Adams and H. L. Porter. Mar. 5, 1946, 15p. incl. illus. (BIOS Final rept. no. 492) Confidential

Interviews with German scientists (chiefly Dr. H. Schardin) are reported; topics discussed include high explosive damage curves, the disc bomb (Misznay-Schardin effect), reduction of mass of bullet in gun, shock wave behind bullet, Schlieren photography, Kerr-cell shutter, interferometer for photographing shock waves, and theory of penetration by AP shot.

L404

British Intelligence Objectives Subcommittee. INTERROGATION OF DIPL. ING. E.A. MARQUARD BY ADD, D.4.P. - 27TH MAR. 1946. Sept. 5, 1946, 3p. (BIOS Interrogation rept. no. 128; Inclosure 2 to MA London rept. no. R5132-46) Confidential

E. A. Marquard, Chief of the Technische Luft Rustung, Dept. E7, during the period 1933-1944, was questioned concerning fabrication of AP bombs, securing of base bungs, nose-hardening methods, general-bomb development, development of the SD2, transverse fuze pockets, water roll-bombs, and bombs with hemispherical liners made of hexagonal bars.

L405

British Intelligence Objectives Subcommittee. EXPLOSIVE WORK AND DISC PRODUCTION. SECOND VISIT TO LABORATORY OF THE PHYSICS AND BALLISTICS INSTITUTE AIR MINISTRY, BERLIN, GATOW, by H. L. Porter. Sept. 19, 1946, 10p. (BIOS Final rept. no. 1062) Secret

The discussion with Dr. Schardin [sic] and his staff covers blast measurements from explosive charges, effect of reduced air pressure (at heights) on shock wave from explosive charges, X-ray photographs of detonation in solid explosive material, the Misznay-Schardin effect, application of the dish as a mine and for attack of low-flying airplanes, and in rockets, and a description of a water model of shaped charge jet formation.

L406

British Intelligence Objectives Subcommittee. INTERROGATION OF DR. GUNTHER SACHSE ON 19TH AUG. 1947, by W. M. Evans. [Aug. 1947], 2p. (BIOS Interrogation rept. no. 672) Confidential

Dr. Gunther Sachse was questioned concerning his work on shaped charges from 1937 to 1945. He spoke of shapes, liners, and penetration in brief, general terms.

L407

British Intelligence Objectives Subcommittee. INTERROGATION OF DR. GUNTHER SACHSE ON 21ST AUG. 1947. [Aug. 1947], 2p. (BIOS Interrogation rept. no. 609; Inclosure 1 to MA London rept. no. R5833-47) Confidential

Through questioning, it was found that Dr. Sachse was connected with work carried out to determine the optimum liner angle, charge shape, and liner construction related to jet characteristics and armor penetration. Sachse described the principles of 2 high speed cameras.

L408

British Intelligence Objectives Subcommittee. INTERROGATION OF DR. GUNTHER SACHSE ON 26TH AUG. 1947, by J. U. Woolcock. Aug. 27, 1947, 2p. (BIOS Interrogation rept. no. 606; Inclosure 1 to MA London rept. no. R5834-47) Secret

Dr. Sachse was questioned concerning his work with shaped charges. Brief general remarks by him are reported under the headings of pear shaped liners, follow-through and incendiary effect, rotation, and shaping of the detonation wave by means of "lenses" (barriers).

L409

British Intelligence Objectives Subcommittee. INTERROGATION OF DR. GUNTHER BRAUNSFURTH ON 1ST AND 7TH SEPT., 1948. Oct. 22, 1948, 3p. incl. diagrs. (BIOS Interrogation rept. no. 631; Inclosure 1 to MA London rept. no. R7276-48) TIP S50124 Secret

Dr. Gunther Braunsfurth was interrogated concerning shaped charges and the investigation of detonation waves by X-ray photography. He mentioned investigations that were carried out on the variation of the material and thickness of liners. Steel, Cu, W, and Al were tried; steel was found to be the best material. Development was undertaken to shape the detonation wave by inserting slabs of inert material into the explosive charge, or by using a lens of a different explosive.

British Intelligence Objectives Subcommittee.
see also Combined Intelligence Objectives Subcommittee

L410

Budd Co. (DA36-034-ORD-42).
105-MM. CARTRIDGE T131 FIN-STABILIZED HEAT FOR 105-MM. M2A1 AND T79 HOWITZER, by E. A. Zettlemoyer and G. D. Pagon. Final rept. June 1952, 133p. incl. illus. tables, diagrs. (Proj. no. TA1-1526) Confidential

Work was undertaken to provide ammunition of maximum armor penetration and probability of hitting the target, for use in the 105-mm. howitzer M2A1 and T79. As developed, the T131E3 design has the following performance characteristics: characteristics:

shell weight:	24 lb.
velocity:	1750 ft./sec. at ambient temp.
pressure:	20,000 lb./sq. in. at ambient temp.
average probable error (horizontal) at 1000 yd:	0.37 mil
average probable error (vertical) at 1000 yd:	0.40 mil
maxim. penetration:	complete penetration of 7-in. armor plate inclined 60° to the vertical
maxim. obliquity:	complete penetration of 5-in. armor plate inclined 75° to the vertical

Discussions are included on the body, conical liner, boom, tail, cartridge case, fuze, rotating ring, etc. Tests showed that conical liner tolerances of longitudinal and transverse variations could be relieved considerably on 105-mm. conical liners without an appreciable reduction in penetration. At first the T209 spit-back fuze was specified for the T131 HEAT projectile, but the front end of the round was redesigned to accommodate the faster acting T208 electric fuze.

L411

Budd Co. (DA36-034-ORD-1362-RD).
75-MM, 90-MM, 110-MM. [HEAT] SHELLS. Engineering progress rept. Aug. 1-31, 1955. 108p. incl. tables, diagrs. (Proj. nos. TA1-1451; TA1-1464; TA1-1281) Confidential

Detail and assembly drawings are given for the 75-mm. HEAT round T221E12 and for the 90-mm. HEAT rounds T316E10 and T316E11. Drawings of the conical liner assembly and the tube liner extension are included for the 90-mm. T316 projectile. Computations are presented for the 90-mm. T316 HEAT round including the weight of HE charge, weight and c. g. of the liner, and stress analysis of the liner and its components.

L412

Bureau of Mines.
SHAPED CHARGES APPLIED TO MINING. PART I. DRILLING HOLES FOR BLASTING, by H. C. Draper and others. Nov. 1946, 12p. illus. (Rept. of investigations RI 4371) TIP U3321 Unclassified

Extensive tests were made to determine the effectiveness and limitations of M3 (steel liner) and M2A3 (glass liner) charges for drilling blasting holes in rock for underground mining operations. It was concluded that the method was impractical, since the cost of $8.00/ft. of hole and spalling was 20 times that of producing a better hole with a rock drill. The concussion would prohibit use of this method in many mines, and the excess produced by the Pentolite explosive would be an additional hazard underground.

L413

Bureau of Ordnance, Navy Department.
[CAPTURED ENEMY EQUIPMENT]. n.d., 2 diagrs. (No. CEE 8693 from Ordnance Investigation Laboratory, Naval Powder Factory; Covering letter from Bureau of Ordnance) Confidential

Two identical diagrams are presented of a 70-mm. Japanese army HE shaped charge shell.

L414

Bureau of Ordnance, Navy Department.
COMPARISON BETWEEN SHAPED CHARGE AND STANDARD FULL-SCALE TORPEDO WARHEADS MK 13 MOD 1 AND MK 13 MOD 2, by J. F. Moulton. May 23, 1944, [12]p. incl. illus. tables, diagrs. (Explosives Research memo. no. 15) Confidential

This memo. shows the effects of a hollow steel cone in a full-scale shaped charge torpedo warhead, Mark 13 Mod 1, on the underwater explosion pressure and momentum fields, and compares these effects with those produced by the full-scale standard torpedo warhead Mark 13 Mod 2. Tabular data showed that the momenta for both types of warheads were essentially independent of angle. There was no significant difference between the momenta for the shaped charge and standard Torpex-2 loaded warheads at angles from the charge axis other than 0° even though there was a charge weight difference of about 15%. Tabular data also showed that although the jet produced by the shaped charge warheads loaded with Comp. B was equivalent to the similar Torpex-2 loaded warheads, the momenta produced by the Comp. B warheads fell below those produced by the Torpex-2 loaded ones. A comparison of results for full-scale shaped charge warheads Mark 13 Mod 1 and standard warheads Mark 13 Mod 2 is given in tabular form.

L415

Bureau of Ordnance, Navy Department.
US NAVY CAVITY CHARGES. June 26, 1944, 11p. incl. illus. (Ordnance Pamphlet 1203)
Restricted

General remarks are made on the shaped charge effect and descriptions are given of the Mark 1, Mark 2, and Mark 3 charges and the disposal of bombs by them. (This rept. is superseded by Ordnance Pamphlet 1720, item no. L426.)

L416

Bureau of Ordnance, Navy Department.
APPLICATIONS OF THE CAVITY EFFECT, by L. F. Porter. Feb. 1945, 45p. incl. illus. tables. (Foreign Ordnance rept. no. 2) Confidential

This rept. includes a description of the shaped charge and its principles, major technical design considerations, and examples of foreign ordnance employing the cavity effect. Appendix A is a brief history of the shaped charge; appendix B lists 36 references.

L417

Bureau of Ordnance, Navy Department.
DEVELOPMENT OF FUZING FOR SHAPED CHARGE GENERAL PURPOSE BOMB, by W. C. Chewning. Sept. 15, 1945, 8p. (NAVORD rept. no. 56-45) Confidential

The various methods of fuzing general purpose bombs investigated are: (1) electrical fuzing systems; (2) mechanical fuzing systems; (3) screw-out extension rod device which carried the fuze with it; (4) VT fuzing; and (5) water discriminating fuze. No tests were made of any of the above methods; brief descriptions are given of each.

L418

Bureau of Ordnance, Navy Department.
DEVELOPMENT OF THE CABLE AND CHAIN CUTTER MK I MOD I, by G. L. Ericson. Oct. 11, 1945, 7p. incl. diagrs. (NAVORD rept. no. 64-45)
Restricted

A cutter (Mark 1 Mod. 0) having the following characteristics was developed: (1) shaped charge frame in the shape of a "U" with loaded clamping handle; (2) loaded with plastic explosive protected by hinged covers; (3) standoff is a water-tight compartment, permitting underwater use; and (4) electrically fired. The design was revised to allow for all types of firing and the handle made smaller (cutter Mark 1 Mod. 1). The production difficulties and means of overcoming them are discussed. Illustrations of the above charges are included.

L419

Bureau of Ordnance, Navy Department.
PERFORMANCE OF SHAPED CHARGE WAR HEADS, by S. H. Wollman. Nov. 28, 1945, 20p. incl. illus. (NAVORD rept. no. 208-45)
Confidential

Tests were made of underwater penetration of jets from full-scale shaped charge warheads. The target was a series of spaced steel plates immersed in water representing a completely flooded torpedo protection system of the CVB41 class aircraft carrier. It was found that Mark 16 warheads fitted with 15-in. 45° liners gave unsatisfactory performance as did the Mark 13 warheads fitted with 18 in. 60° liners. However, Mark 13 warheads fitted with 19.75-in. 45° steel liners succeeded in defeating the target with some energy to spare. Torpex gave better performance than Comp. B.

L420

Bureau of Ordnance, Navy Department.
BULLETIN OF ORDNANCE INFORMATION NO. 4-45. Dec. 31, 1945, paragraphs 35-99, p. 29-34 incl. illus. diagrs. Confidential

Tests carried out with scaled (1:10, 1:6, 6:21) models of warheads showed that the jet from a modified warhead could defeat systems consisting of spaced steel plates with some of the intervening space containing water which the conventional warhead could not defeat. In a series of 3:8 scale tests, a scale model caisson target of the torpedo protection system of a CVB41 class aircraft carrier was used. Brief summaries are given of: (1) tests with full-scale warheads fired against a submerged system of spaced plates representing a completely flooded full-scale torpedo protection system of a CVB41 class carrier; (2) modification of 1000-lb. bombs AN M65 (with a 45° liner); (3) modification of Mark 13 warhead; (4) tests with 2000-lb. bombs AN M66 fired against a target simulating an enemy battleship with superstructure; and (5) drop tests of 500- and 1000-lb. shaped charge bombs from an airplane to determine fuze action and over-all functioning of the bombs. The problem of scaling of water penetration was also investigated; it was found that the performance of large scale charges could be roughly predicted from small scale charges.

L421

Bureau of Ordnance, Navy Department.
APPLICATIONS OF LINED CAVITY CHARGES. June 1, 1946, 44p. incl. illus. (Ordnance Pamphlet 1647) Confidential

A summary is given of the factors determining the effectiveness of shaped charges: (1) composition and properties of the explosive; (2) quantity of explosive; (3) base dimension of the charge and liner; (4) confinement of the explosive; (5) standoff;

(6) cavity shape; (7) material and thickness of liner; and (8) other factors (point of initiation, symmetry and uniformity of charge, symmetry of liner, effects of rotation). The section on applications of shaped charges describes demolition charges, applications in weapons, and disposal of explosive filled ordnance by shaped charges. (This rept. is superseded by Ordnance Pamphlet 1720, item no. L426.)

L422

Bureau of Ordnance, Navy Department.
BRITISH EXPLOSIVE ORDNANCE. June 10, 1946, 456p. incl. illus. diagrs. (Ordnance Pamphlet 1665) Confidential

The AS 35-lb. Mk. I bomb, antitank grenades including the AT rifle grenade no. 68, and other weapons using the shaped charge effect are described very briefly.

L423

Bureau of Ordnance, Navy Department.
GERMAN EXPLOSIVE ORDNANCE. June 11, 1946, 2v. [v. 1, p. 1-346, v. 2, p. 347-624] incl. illus. diagrs. (Ordnance Pamphlet 1666) Restricted

Data on German shaped charge weapons are given along with data for other German ordnance in sections on bombs, fuzes, rockets, land mines, grenades, igniters, projectiles, and projectile fuzes.

L424

Bureau of Ordnance, Navy Department.
ITALIAN AND FRENCH EXPLOSIVE ORDNANCE. June 14, 1946, 215p. incl. illus. diagrs. (Ordnance Pamphlet 1668) Unclassified

Data are given on Italian shaped charge weapons such as 3.5-kg., 5-kg., 25-kg., and 100-kg. shaped charge bombs; 47/32-mm. EP (shaped charge) projectile, 47/32-mm. EPS (shaped charge) projectile; 65/17-mm. EPS (shaped charge) projectile; and on the base fuze for 100/17 shaped charge.

L425

Bureau of Ordnance, Navy Department.
JAPANESE EXPLOSIVE ORDNANCE. June 14, 1946. 2v. [v. 1, p. 1-263, v. 2, p. 265-547] incl. illus. diagrs. (Ordnance Pamphlet 1667) Restricted

Japanese shaped charge rifle grenades and projectiles are described in addition to other Japanese ordnance weapons.

L426

Bureau of Ordnance, Navy Department.
SHAPED CHARGE AMMUNITION AND APPLICATIONS OF SHAPED CHARGES TO EXPLOSIVE FILLED ORDNANCE. June 9, 1947, 31p. incl. illus. diagrs. (Ordnance Pamphlet 1720) Restricted

Brief descriptions are included on the rifle grenade AT, M9A1, rocket HEAT, M6A5, shells 75-mm. M66, 105-mm. M67, 57-mm. M307, 75-mm. M310, M2A3, M3, cable cutter M1, shaped charge containers Mark 1 Mod 0, Mark 2 Mod 0, Mark 3 Mod 0, Mark 4 Mod 0, demolition charge Mark 22 Mod 0, and cable and chain cutter Mark 1 Mod 1. Instructions are given on the use of: (1) cylindrical charges; (2) linear and curvilinear charges for sectioning thin-skinned and thick-cased ordnance; (3) curvilinear charges for cutting steel pipe and welded steel tubing; and (4) linked linear charges for sectioning explosive filled ordnance. The linear cavity charge calculator is described and its use illustrated by problems. (This publication supersedes Ordnance Pamphlet 1203, item no. L415 and Ordnance Pamphlet 1647, item no. L421.)

L427

Bureau of Ordnance, Navy Department.
THE EXPLOSIVES RESEARCH AND DEVELOPMENT PROGRAM OF THE BUREAU OF ORDNANCE, by S. Brunauer. Aug. 3, 1948, Section B5, p. 33-40. (NAVORD rept. no. 422)
TIP S684 Secret

A general, non-technical rept. on the development of the shaped charge warhead and bomb is presented. An outgrowth of the use of the shaped charge effect led to the development of antisubmarine follow-through bombs. Advantages of a shaped charge guided missile over a fragmentation warhead include higher jet velocity and deeper penetration. It is believed that a single shaped charge may be supported by a gimbal arrangement so that the axis of the liner, with the help of a homing device, can align itself in the target direction. The shaped charge has a drawback in that the jet aims in one direction, whereas the fragments fly in many directions. It may be possible to overcome this drawback by the use of multiple jets. Mention is made of the Misznay-Schardin effect in which an explosive of a definite shape can be used to propel a steel disc forward with very high velocity. Because of the poor ballistic qualities of such a disc, prefragmented discs made up of fragments fitted together in "honeycomb" fashion were fired with good results. A brief discussion is given in the section on fragmentation of the use of shaped charges for controlling fragment size.

L428

Bureau of Ordnance, Navy Department (Proj. no. Re2c-46).
SHAPED CHARGE MUNITIONS. [Extract]. Quarterly progress rept. for period ending Sept. 30, 1948. p. 2-101, 2-102. Confidential

Experiments were performed to study jet formation and longevity in a rarefied atmosphere. Data were obtained by firing shaped charges at an altitude of over 10,000 ft. Spectrograms and colored stills were obtained together with motion picture films of the jets. The average height of the jets in the rarefied atmosphere was found to exceed the normal by 85%. A study of the jet itself, by spectrographic techniques, is in progress. Attempts are being made to measure the temperature of a given point within the jet as a function of time and also to obtain velocity-time plots of discreet luminous particles of a jet. Tests of shaped charge bombs were conducted against the Nevada, Ex-BB36, off Pearl Harbor. In the first phase of the test, 2 1000-lb. and 2 2000-lb. bombs were statically detonated in locations selected to provide data comparable to previous full-scale tests against simulated battleship and cruiser targets. The locations selected also gave direct information on the ability of the bombs to penetrate the armored deck and intervening decks to the magazine spaces. After the simultaneous explosion of the 4 bombs, the damage was inspected. The static detonations were followed by dropping 100-lb. and 500-lb. shaped charge bombs from altitudes of approximately 2500 ft. The principal objective of this phase of the tests was to observe fuze performance. Hits were obtained with 9 100-lb. bombs with instantaneous fuzes, 3 500-lb. bombs with instantaneous fuzes, and 3 500-lb. bombs with VT fuzes. Damage was again evaluated after this phase of the tests. The third phase consisted of dropping 1000-lb. and 2000-lb. shaped charge bombs. Drops of 2 1000-lb. bombs with VT fuze and 1 2000-lb. bomb with instantaneous fuze resulted in hits. Damage from the static tests showed that the results were essentially the same as indicated by full-scale tests against armor plate conducted at Dahlgren in 1945 and 1946. Evidently the many obstructions to the jet path caused by miscellaneous equipment and materials located in the compartments traversed by the jets do not weaken its effectiveness to any great extent. One 2000-lb. bomb located on the 5th armor overhead of turret no. 3 penetrated to the lower handling room and ignited some coiled cotton fire hose. It penetrated 9 in. of armor plate and set a fire at a distance of 48 ft. from the point of detonation. The drop tests indicated that the VT fuzes were giving detonations reliably at the standoff distances for which they were set. Jet penetration of the drop tests were comparable to those of the full-scale static tests conducted at NPG, Dahlgren.

L429

Bureau of Ordnance, Navy Department.
UNDERWATER DEMOLITION TEAM DEMOLITION MATERIALS AND THEIR USES. Sept. 9, 1953, p. 9-12, 39 incl. illus. diagrs. (Ordnance Pamphlet 1839) Confidential

Brief descriptions were given of: (1) the 15-lb. shaped charge M2A3; (2) the 40-lb. shaped charge M3 (formerly the T3); (3) linear channel charges; and (4) the cable and chain cutter Mk 1 Mod 1 (linear shaped charge). It was noted that shaped charge performance was determined by liner angle, standoff distance, charge height, charge width, and liner material.

L430

Byers, L. S.
MULTIPLE-JET SHAPED BLASTING CHARGE — WHY IT FUNCTIONS. Pit and Quarry, v. 42, Nov. 1949: 99-102.

The multiple-jet shaped blasting charge, which is placed on the outside of the boulder, has the advantages of both block-holing and mud-capping techniques. It eliminates the necessity of drilling holes in boulders and accomplishes the results of mud-capping without mud or artificial covering of any kind. It produces disruptive action far in excess of the effect to be expected by the amount of explosive used. The action of this shaped charge produces a multiple jet. The top apex, being closest to the "business" end of the blasting cap, collapses first, starting its downward jet in the direction of the object to be blasted, such as rock boulder. This is followed by the collapse of the side apexes with their own directional flow of concentrated energy, which upset or dephase the initial jet which has already started its boring effect into the boulder. The direction of this boring effect is interrupted by the meeting of the dephasing or secondary jets having a different direction of flow, and at this common meeting point a violent disturbance occurs. The firing rate or velocity of the explosive has been correlated with the collapsing of the apexes. The concentrated blast effect not only continues downward, but sidewise as well, to rip the boulder apart. These shaped blasting charges are used for clearing congested or clogged finger raises in underground mining, dismemberment of steel bridges, blasting of abutments, quick reduction of metal for scrap, etc.

L431

Byers, L. S.
NEW "PLURAJET" SHAPED BLASTING CHARGE READY FOR INDUSTRY. Pit and Quarry, v. 43, Nov. 1950: 79-81.

A new type of "split-jet-shaped" blasting charge is described which is known as the "Plurajet". The charge is simply placed on a boulder and a conventional blasting cap is inserted. Practically no wastage of explosive force occurs because of the deflection of the shock waves towards the object to be blasted. In a demonstration, 16 boulders from 0.5 to 12 tons each, weighing a total of approximately 80 tons, were broken to crusher size by the work of 1 man in 30 min.

L432

Cairns, R. W.
STUDY OF HIGH EXPLOSIVES BY HIGH-SPEED PHOTOGRAPHY. Industrial and Engineering Chemistry (Ind. ed.), v. 36, Jan. 1944: 79-85.

The method of photographing high explosives using rotating drum and rotating mirror cameras is described.

L433

Canadian Armament Research and Development Establishment.
INTERIM REPORT ON THE DEVELOPMENT OF AN INFANTRY ANTITANK ROCKET (THE HELLER), by E. S. Guy. Aug. 5, 1948, [28]p. incl. illus. tables. (CARDE Technical memo. no. 28/48) Confidential

The preliminary development work on an antitank weapon called the Heller is reviewed. The shaped charge warhead weighs about 4.0 lb. and contains a 45° soft Cu conical liner. Penetration achieved in trials varied to a large extent even when all factors were held constant. Penetrations as high as 200 mm. of homo armor plate were achieved. The degree of variation in penetration was partly attributed to the method of manufacturing the conical liners.

L434

Canadian Armament Research and Development Establishment (Proj. no. HQS 7616-3).
[HELLER WEAPON], by E. S. Guy. [Progress rept. Nov. 1, 1950-Apr. 30, 1951. 17p. incl. tables.] Secret

Static penetration test results with the Heller weapon are shown. The targets were homo armor plates and the weight of RDX/TNT 60/40 was about 1.4 lb. The conical liner base diameter was 2.9 in.

Conical liner thickness in in.	Average penetration of 90% of rounds fired in in.
0.05	11.3
0.06	11.3
0.07	12.1
0.09	13.0

Standoff in cone diameters	Average penetration of 90% of rounds fired in in.
1.75	11.8
2.0	11.5
2.25	11.3

It was noted that as the liner thickness increased, the penetration depth also increased.

L435

Canadian Armament Research and Development Establishment.
HELLER ENGINEERING TRIALS. PART II. PENETRATION TRIALS. Aug. 3, 1951, [2]p. (CARDE/N-17-1) Secret

Tests were conducted to determine the effect of Rocket, 3.2-in., HEAT, Cdn. Ex.1 (HELLER), against homogeneous armor plate 260 mm. thick (Series A) at normal and against armor plate 120 mm. thick (Series B) at 60° from normal. The projectile was filled with 60/40 RDS/TNT and had a Cu conical liner 0.1 in. thick with a spitback type fuze, PD M-52. In Series A test firings, 6 of 10 rounds defeated the main target, while in Series B test firings, 7 of 10 penetrated completely. No fuzes malfunctioned.

L436

*Canadian Armament Research and Development Establishment.
HELLER WARHEAD DEVELOPMENT, by R. W. Foster. Nov. 9, 1951. (CARDE Technical letter no. N17-1-5) (In Transactions of Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., Nov. 13-16, 1951) Confidential

The warhead design of the Heller, a platoon antitank weapon of 3.2-in. caliber is described. The shaped charge warhead is initiated by a spitback fuze. Tests were made to determine the optimum standoff and the optimum thickness of the Cu conical liner wall. Manufacturing tolerances which were set for the conical liner, design of the warhead casing, and methods of filling are discussed. A brief summary of results obtained in armor penetration tests is included.

L437

[Carnegie Institute of Technology].
STAHLER'S THEORY OF JET FORMATION AND PENETRATION, by K. Staller [Stahler] [1951], [3]p. incl. diagr. (Presented at the Symposium on Shaped Charges held at the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., [Nov. 13-16, 1951] Confidential

A theory of shaped charges, formulated by a group of Czechoslovakian scientists in 1943-1944, is presented in a drawing prepared by K. Staller [Stahler?], former Technical Director, Small Arms Factory, Czechoslovakia. The differences between this theory and the commonly accepted theory of shaped charge effect are discussed. It is postulated that the Munroe effect is more than just a mechanical one, since heat may play an important role.

L438

Carnegie Institute of Technology (DA36-061-ORD-7).
FUNDAMENTALS OF SHAPED CHARGES. Bimonthly rept. no. 1. Aug. 31, 1950, 72p. incl. illus. diagrs. (Rept. no. CIT-ORD-28) (Formerly contract W36-061-ORD-2910) TIP C4631 Confidential

Standard experimental techniques for the study of the geometry of detonation waves were applied to a variety of detonation wave types in solid explosives. The geometry of detonation waves could be predicted by the application of Huygen's

*Reference not verified in the original.

principle and Fermat's principle of least time to as high a degree of accuracy as is attained in measurements. The detonation wave shape and control thereof were discussed in relation to the design of shaped charges. By controlling the detonation wave shape, the effective detonation rate along the lining which is 1 of the factors that determine jet mass and velocity, could be varied over a wide range. One of the aberrations in shaped-charge performance was traced to asymmetry of the detonation wave. Calculations are made which indicate the permissible tolerances in detonator placement for a variety of charge designs. (Contractor's abstract)

L439

Carnegie Institute of Technology (DA36-061-ORD-7). FUNDAMENTALS OF SHAPED CHARGES. Bimonthly rept. no. 2. Oct. 31, 1950, 49p. incl. illus. diagrs. (Rept. no. CIT-ORD-29) TIP C4900 Confidential

A new rotating mirror camera increases greatly the accuracy of measurements on jet formation and penetration into targets. A thin 1-sided plane mirror is rotated at speeds up to 420 r. p. s., corresponding to an image velocity of 2020 m./sec. Detonators are fired at about 10 kv. by a system synchronized to the mirror shaft so that the lens aperture can be F/3.5, the locus of the image is practically circular, and the position of the photograph can be predetermined accurately. Kerr cell camera photographs show some dissimilarities in the jets from Cu, Al, and steel liners having apex angles of 22°, 44°, 66°, and 88°. Methods for eliminating the shroud accompanying the jet from flat-topped conical liners were unsuccessful. In a thick glass target, cracking of the glass ahead of the jet reduced the stopping power of the unpenetrated target to that predicted by the density law. (TIP abstract)

L440

Carnegie Institute of Technology (DA36-061-ORD-7). FUNDAMENTALS OF SHAPED CHARGES. Bimonthly rept. no. 3. Dec. 31, 1950, 31p. incl. illus. diagrs. (Rept. no. CIT-ORD-30) TIP C5759 Confidential

Experimental data from mass distribution measurements are given for 4 charge designs (2 steel liners of different wall thicknesses, a Cu liner, and an Al liner). Two approximations to the problem of liner propulsion were considered in the interpretation of the data by means of the generalized theory of cone collapse. In 1 approximation the liner elements were assumed to collapse normal to the original liner surface; in the other case Taylor's theorem was assumed to be applicable to the nonsteady process. The 2 approximations give the same results in the case of thick liners. For thin liners the differences between the results are so great that the best approximation may possibly be determined experimentally. Small deviations from Taylor's theorem when applied to the nonsteady theory of jet formation are considered to have a negligible effect on the end results. Performance tests of Ti targets indicated some improvement over mild steel in stopping power on a weight basis, but data were inconclusive. (TIP abstract)

L441

Carnegie Institute of Technology (DA36-061-ORD-7). FUNDAMENTALS OF SHAPED CHARGES, PART I. Bimonthly rept. no. 4. Feb. 28, 1951, 45p. incl. illus. diagrs. (Rept. no. CIT-ORD-31) TIP C5964 Confidential

A theory of jet formation is presented in which the collapse velocity of the walls of a conical liner is assumed to decrease with increased distance from the apex. On the basis of this assumption jets are longer than predicted by hydrodynamic theories of jet formation (Birkhoff, MacDougall, Pugh, and Taylor, Journal of Applied Physics, v. 19, June 1948: 563-582) in which a constant collapse velocity is assumed. The new theory was experimentally verified. A graphical method is presented for predicting the shapes of the jet and slug. (TIP abstract)

L442

Carnegie Institute of Technology (DA36-061-ORD-7). FUNDAMENTALS OF SHAPED CHARGES, PART II. Bimonthly rept. no. 4. Feb. 28, 1951, 41p. incl. illus. diagrs. (Rept. no. CIT-ORD-31) TIP C6144 Confidential

Investigations of jet and target characteristics are summarized. The scatter of experimental data was reduced to verify the generalized theory of jet formation; further reduction is necessary. Different liner designs are being studied on the basis of results obtained for the S1 standard charge lined with an M9A1 cone. Methods are being developed for measuring variables to provide a test of the theory for a variety of liner designs. Subjects discussed include the relation between the design and collapse velocity, detonation waves, transport pressure, penetration and standoff, target strength effects, jet material, and the penetration efficiency of cone elements. The large spread in penetration of apparently identical shaped charges was attributed to charge imperfections. The use of statistical techniques to obtain a quantitative interpretation of penetration values proved difficult due to the extremely skewed frequency distribution of the penetrations. The order of importance of imperfections which affect charge performance was concluded to be as follows: (1) lack of alignment between liner and charge axis; (2) geometric liner imperfections, especially those which destroy cone symmetry; and (3) inhomogeneity of explosive. (TIP abstract)

L443

Carnegie Institute of Technology (DA36-061-ORD-7). FUNDAMENTALS OF SHAPED CHARGES, PART III. Bimonthly rept no. 4. Feb. 28, 1951, 100p. incl. illus. diagrs. (Rept. no. CIT-ORD-31) TIP C6167 Confidential

The Kerr cell photographic technique is described. Results obtained with Kerr cell photographs of jets are presented. Photographs are included of jets traveling in air; jets penetrating steel, H_2O, Plexiglas, and glass; and detonation and shock waves from explosives and jets. A double Kerr cell camera was developed with which 2 consecutive pictures can be taken of the same phenomenon, each exposure lasting 0.5 µsec. and the time between exposures being adjustable from 0 to several hundred µsec. A photoelectric method is being developed for triggering the Kerr cell and light source. The lowest weight of protection against jets was found to consist of glass blocks surrounded by a shock-absorbing material backed up by hard homogeneous armor of steel or alloy. (TIP abstract)

L444

Carnegie Institute of Technology (DA36-061-ORD-7). FUNDAMENTALS OF SHAPED CHARGES. Bimonthly rept. no. 1. Apr. 30, 1951, 39p. incl. illus. diagrs. (Rept. no. CIT-ORD-32) TIP C6558 Confidential

Penetration and hole volume for shots into mild-steel targets were measured; charge design and liner thickness were constant, and the liners were of different materials with cone angles between 22° and 88°. The results indicated that for large hole volume and shallow penetration a small cone angle low-density liner, and short standoff are best, but for deep penetration a 44° Cu cone at 4 in. is desirable. Al liners are most effective at much greater standoff than Cu or steel; their relative penetration is less, but the relative hole volume is greater. The data indicate that (1) penetration performance can be improved by reducing the imperfections in the lined shaped charges and (2) liner materials which are ductile under high-speed loading will increase the penetration at shorter standoffs. High-speed photographs of the fracture of glass were supplemented by photographs which used photoelastic methods to show the shock waves set up in the glass. The velocity of the shock waves increased with increasing shock intensity to 6150 m./sec. The secondary fracture of glass is initiated at the velocity of propagation of the disturbance for sufficiently intense disturbances. The time delay between passage of the disturbance and the first appearance of cracks decreases with increasing shock intensity. (TIP abstract)

L445

Carnegie Institute of Technology (DA36-061-ORD-7). MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 1. Aug. 31, 1950, 22p. incl. illus. diagrs. (Rept. no. CIT-ORD-M15) (Formerly contract W36-061-ORD-3910) TIP C59289 Confidential

Tests were made with model charges lined with mosaic arrays of hexagonal prisms of both steel and Al. Results showed that the hexagonal prisms had a slight advantage over grooved plates if the critical characteristics were number of fragments or penetration depth; however, there was a slight disadvantage in that the fragment velocity for a given value of c/m (c = mass/unit area of explosive, m = mass/unit area of liner) was somewhat lower. The over-all relative advantages of mosaic and integral liners seemed to depend upon the specific conditions of charge use.

L446

Carnegie Institute of Technology (DA36-061-ORD-7). MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 2. Oct. 31, 1950, 37p. incl. tables, diagrs. (Rept. no. CIT-ORD-M16) TIP C59290 Confidential

A physical picture of conditions within the product gases of a detonating explosive charge is developed on the basis of simple assumptions and the known qualitative behavior of shock waves. The present purpose is simply to establish a rather detailed hypothesis, without attacking the extremely difficult mathematics, for a 3-dimensional situation, the result being intended to serve as a starting point for simultaneous theoretical and experimental investigation. The forces at a given point on the liner are pictured as due to the momentum of the exploded gases combined with a static type of pressure whose duration depends upon the time taken by the release wave to arrive from the nearest free surface. Reflections from the liner are neglected. It is shown that the picture developed is in qualitative agreement with the few pertinent experimental data that are available. Some predictions that are easily obtained from the picture and that are pertinent to the Wizard warhead problem are described, and experiments designed to test the predictions are discussed. Some exploratory experimental results have been obtained that appear to substantiate the qualitative aspects of the picture and provide data that can be used to form a quantitative basis for further work. The solution of this problem should be of considerable use for determining the collapse velocities for conical liners. (Contractor's abstract)

L447

Carnegie Institute of Technology (DA36-061-ORD-7). MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 3. Dec. 31, 1950, 27p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-M17) TIP C59291 Confidential

Six tests with model charges lined with grooved steel discs have been completed. These tests combined with 6 similar tests described previously permit a statistical analysis of the performance of model charges independent of any fundamental assumptions as to penetration laws or velocity laws. The most significant result of the experiments is the discovery of a strong linear correlation between fragment penetration and the ratio of explosive weight to liner weight. The correlation indicates that the depth of penetration produced by similar charges decreases with increasing c/m over the entire range of c/m included in the experiment. Performance characteristics other than fragment velocity and penetrating power appear to be independent of c/m.

L448

Carnegie Institute of Tecnnology (DA36-061-ORD-7). MISZNAY-SCHARDIN EFFECT, by E. M. Pugh, R. J. Eichelberger, and W. F. Donaldson. Bimonthly rept. no. 4. Feb. 28, 1951, 51p. incl. illus. diagrs. (Rept. no. CIT-ORD-M18) TIP C59292 Confidential

A summary (item no. L634) is included of work done on the application of end-fragmentation to warheads for guided interceptor missiles. The use of high explosives in projecting a mass of metal at high velocities is very important. The necessary conditions that must be satisfied if the mass is to be projected in one piece are discussed. These conditions are based upon the necessity for satisfying both the laws of energy conservation and momentum conservation. An empirical determination was made of the usable range of ratios of charge mass to liner mass (c/m). A theory is being developed for the behavior of rarefactions in an exploding charge and their probable effect on the performance of a warhead.

L449

Carnegie Institute of Technology (DA36-061-ORD-7). ROTATED CHARGES, by E. M. Pugh, R. J. Eichelberger, and E. Litchfield. Bimonthly rept. no. 1. Aug. 31, 1950, 25p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-R13) TIP C59293 Confidential

Dynamic performance tests were completed on 2 lots of cones [conical liners] having 36 flutes manufactured by a new technique that leaves partially flat flute surfaces. The results show that such a liner performs quite well in both depth of penetration and uniformity of performance. This indicates that the very difficult problem of fabricating uniform conical liners with accurately reproducible flutes is nearly solved. Both lots of liners gave optimum velocities of -60 r.p.s., however. Purely empirical considerations indicate that the new low negative optimum velocity should be expected, since earlier tests with intermediate numbers of flutes showed 0 optimum velocities. Flute profile measurements for fluted liners tested earlier are described. It is evident that recent alterations in manufacturing procedure have greatly reduced the variability of the flutes. This is very hopeful, since uniformity in the manufactured liners is absolutely essential, if the problem is to be solved either by an empirical or a theoretical approach. The available data conclusively demonstrate the fact that the optimum velocity ν_0 is not proportional to the product na (number of flutes x flute depth) as predicted by all of the early theories. ν_0 is not even a single-valued function of na. However, the ratio ν_0/na does appear to be a single-valued function of n. The plot of ν_0/na vs n suggests that ν_0 can be positive between n=0 and n=32 and negative for n larger than 32. Both larger and smaller numbers of flutes than 32 are to be investigated. The complete theory of compensation involves several phenomena whose detailed characteristics are practically unknown, since they are of so little interest for other problems that they have not been investigated previously. Under these circumstances an empirical approach offers the greatest hope for an early solution. (Contractor's abstract)

L450

Carnegie Institute of Technology (DA36-061-ORD-7). ROTATED CHARGES, by E. M. Pugh, R. J. Eichelberger, and E. Litchfield. Bimonthly rept. no. 2. Oct. 31, 1950, 33p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-R14) TIP C59294 Confidential

Liners (NBS Lot 17) having 16 flutes, a nominal linear variation of flute depth with liner radius, and a nominal maximum flute depth of 0.025 in. at the liner base, were cast into the standard CIT charge of Comp. B and fired at 6.0-in. standoff. Best penetrations obtained were 4.9 and 5.1 in. at 210 and 270 r.p.s., respectively. The maximum penetration obtained represented 34% compensation in terms of best static performance of a smooth liner. NBS Lot 16 liners having 16 flutes, a linear variation of flute depth with liner radius and a nominal maximum flute depth of 0.030 in. at the base gave erratic performance. The best penetration achieved was 4.8 in. at 300 r.p.s., which represented 50% compensation compared with the best performance of smooth liners. Two additional liner groups having the same general features as Lots 15 and 16 yielded optimum velocities of -60 r.p.s. and showed that certain changes in the number of flutes and the liner wall thickness did not affect the optimum velocity of this liner type. A charge design proposed by BRL for a 105-mm. shell to be stabilized at 45 r.p.s. was scaled and tested in the rotator. The scaled models showed about 6% degradation of static performance at 45 r.p.s. and 1 diameter standoff. The models showed little difference between 44° and 66° apex angle liners at this standoff and frequency. Birkhoff's equations, relating penetration depth and rotational frequency, which afforded scaling relations were investigated to identify the constants. A mathematical analysis of the collapse process of rotated smooth liners substantiated previous experimental results that, within wide limits, rotation had no effect upon the gross picture of liner collapse. Tests for penetration performance of a group of thin wall 57-mm. Cu liners machined from heavier parent liners by NBS indicated that the liner performance was not degraded in any way by the machining process.

L451

Carnegie Institute of Technology (DA36-061-ORD-7). ROTATED CHARGES, by E. M. Pugh, R. J. Eichelberger, and E. Litchfield. Bimonthly rept. no. 3. Dec. 31, 1950, 30p. incl. tables, diagrs. (Rept. no. CIT-ORD-R15) TIP C59295 Confidential

Test results are described for several groups of fluted liners having many (36 to 90) flutes. With 2 lots of NBS liners having 36 flutes of nominal maximum depth of 0.008 in. at the base, the optimum rotational velocity for the groups was between 30 and 50 r.p.s., the compensation at optimum being essentially complete. NBS liners having 60 flutes of nominal maximum depth of 0.008 in. with plain flat surfaces on all flutes had optimum rotational velocity at about 90 r.p.s., compensation at optimum being essentially complete. Poor over-all performance gave a relatively low average penetration figure. NBS liners with 90 flutes of nominal maximum depth of 0.008 in. had an optimum rotational velocity at about 90 r.p.s., and compensation appeared to be potentially complete although only 1 penetration greater than 8 in. was observed. NBS liners having 16 flutes of nominal maximum depth of 0.016 in., the flutes being sharp on the internal surfaces and relatively smooth on the external surface of the liner, yielded an optimum velocity of about 90 r.p.s., the compensation being essentially complete. Another group of NBS liners formed with 16 flutes having a nominal depth of 0.025 in. yielded an optimum rotational velocity of about 150 r.p.s. with essentially complete compensation. The liners described above were 42° Cu liners manufactured for use in a 57-mm. shell. The liner wall thickness was about 0.045 in. and the internal diameter at the base was 1.69 in. All laboratory tests were made at 6-in. standoff against mild steel targets with charges 5 in. long and 1-5/8 in. in diameter confined in Al tubing of 0.25 in. wall thickness. The results obtained with the above liners were believed to be good enough to justify copying the design on a larger scale to provide compensation for an 105-mm. slow-spin projectile. It is expected that liners of the appropriate size should provide compensation in a 105-mm. shell at some rate between 20 and 75 r.p.s., depending upon the design used.

L452

Carnegie Institute of Technology (DA36-061-ORD-7). ROTATED CHARGES, by E. M. Pugh, R. J. Eichelberger, and E. Litchfield. Bimonthly rept. no. 4. Feb. 28, 1951, 41p. incl. tables, diagrs. (Rept. no. CIT-ORD-R16) TIP C59296 Confidential

A general summary of progress to date is given in the study of the effects of rotation on performance of shaped charges and the counteraction of detrimental effects of rotation by fluting of the liners. The effects of such design parameters of fluted liners as flute depth, flute number, and flute profile are discussed. The goal is to design a fluted liner to provide complete compensation at rotational velocities as high as 220 r.p.s. Complete compensation was obtained with liners designed for the 57-mm. HEAT shell at rotational velocities as high as 180 r.p.s. At compensation velocities as high as 150 r.p.s., performance equal to that of smooth liners fired statically in both depth of penetration and consistency was obtained. Partial compensation (as high as 75%) was achieved at much higher (320 r.p.s.) velocities. The most profitable lines of attack for further investigation are described and specific liner designs that were ordered for testing in the immediate future are enumerated. (Contractor's abstract)

L453

Carnegie Institute of Technology (DA36-061-ORD-28). FUNDAMENTALS OF SHAPED CHARGES. Bimonthly rept. no. 2. June 30, 1951, 37p. incl. illus. diagrs. (Rept. no. CIT-ORD-33) TIP C6703 Confidential

Kerr-cell method photographs of the collapse of a wedge-shaped liner were satisfactory when the wedge was long and its apex angle was sharp. A method of tracing liner particles was used in which the charge is scored on the bottom surface at right angles to the direction of propagation of the detonation, and parallel to the optic axis of the camera; qualitative preliminary results suggest that the areal density of the liner is the only variable of major importance, the role of the liner strength being secondary. A 1- x 1-in. pentolite cylinder was detonated from the top end on a 0.25-in. mild steel plate placed above another similar plate; spalling of the bottom plate, when in contact with the upper plate, was about as extensive as that produced in a single 0.5-in. plate. Spalling was reduced by an air space but was still visible with 0.5 in. separation of the plates. A 0.125-in. layer of gasket rubber reduced this type of damage the same amount as 0.5 in. of air; with a 0.25-in. layer neither spalling nor cracking occurred.

L454

Carnegie Institute of Technology (DA36-061-ORD-28). FUNDAMENTALS OF SHAPED CHARGES. Bimonthly rept. no. 3. Aug. 31, 1951, 19p. incl. illus. diagrs. (Rept. no. CIT-ORD-34) TIP C6977 Confidential

An approach to a steady-state jet was achieved with a charge design having a uniform thickness of explosive around the liner. With this design the velocity gradient within the jet was reduced by a factor of 2. The amount of metal going into the jet was decreased in accordance with non-steady-state hydrodynamic theory. The extrusion of additional jet from the slug was of little significance. A proper velocity gradient was necessary for good penetration performance.

L455

Carnegie Institute of Technology (DA36-061-ORD-28). FUNDAMENTALS OF SHAPED CHARGES. Bimonthly rept. no. 4. Oct. 31, 1951, 37p. incl. illus. diagrs. (Rept. no. CIT-ORD-35) TIP C7122 Confidential

The penetration performance of liners manufactured by an electrodepositing process showed an improvement of approximately 10% over the standard M9A1 Cu liner. The concept of a release wave and its action on the expanding gases of an explosive charge is presented. It is shown how the release wave leads to a zone of high pressure and density behind the detonation wave and how the shape of this zone influences the collapse velocity of the liner. These concepts are applied to the CIT standard charge as an example. Comparison with the results computed from slug recovery data indicated that more refinement of the release wave theory is needed. A shaped charge antitank mine was shot to test the basic soundness of a proposed design. The results indicate the feasibility of employing shaped charges in land mines.

L456

Carnegie Institute of Technology (DA36-061-ORD-28). MISZNAY-SCHARDIN EFFECT, by E. M. Pugh, R. J. Eichelberger, and W. F. Donaldson. Bimonthly rept. no. 1. Apr. 30, 1951, 13p. incl. tables, diagrs. (Rept. no. CIT-ORD-M19) TIP C59297 Confidential

A fragment gun using small steel cylinders surrounded by Woods metal was satisfactory for producing fragments of known shape and mass with velocities greater than 3000 m./sec. Fragment guns tested were limited by a large ratio of explosive mass to fragment mass, and a discrepancy between fragment velocities from the gun and those from model charges. Tests designed to increase the efficiency of the gun, to produce larger fragments, and to determine the source of velocity differences are planned.

L457

Carnegie Institute of Technology (DA36-061-ORD-28). MISZNAY-SCHARDIN EFFECT, by E. M. Pugh, R. J. Eichelberger, W. F. Donaldson, and N. Rostoker. Bimonthly rept. no. 2. June 30, 1951, 30p. incl. diagrs. (Rept. no. CIT-ORD-M20) TIP C59297 Confidential

A detailed analysis of the theory developed by T. E. Sterne for the velocity of a fragment propelled from the end of an explosive charge is described, with special attention to the physical picture implied by the mathematical assumptions. The results indicate that the method used by Sterne, while leading very simply to accurate predictions of the final velocities achieved by such fragments, cannot be modified in any manner to provide a satisfactory picture of liner acceleration; therefore it cannot be used in the development of a theory of fragment direction. (Contractor's abstract)

L458

Carnegie Institute of Technology (DA36-061-ORD-28). MISZNAY-SCHARDIN EFFECT, by E. M. Pugh, R. J. Eichelberger, and W. F. Donaldson. Bimonthly rept. no. 3. Aug. 31, 1951, 15p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-M21) TIP C59297 Confidential

The release wave theory was tested with Comp. B charges lined with discs of varying thickness. The critical value of D/l (D=charge diameter, l=charge length) was about 1.3, as compared with the value 0.75 for Pentolite. The relatively large critical value of D/l observed for Comp. B was in agreement with known characteristics of that explosive and Pentolite. Tests were completed with charge designs of Comp. B having high c/m values. The liners consisted of Woods metal discs with 3/20-in. holes drilled in the centers to accommodate small steel fragments of various thicknesses. No fragment break-up was observed for values of c/m less than about 39, at which a fragment velocity of approximately 0.43 cm./sec. was obtained. The probability of fragment break-up remained small for c/m less than 50, but above c/m=50, the fragments might break up or shatter. Charges were fired into armor plate targets to determine the feasibility of applying end-fragmentation principles to the design of antitank land mines. Two charges of cast TNT were fired at 18- and 24-in. standoffs. At 18-in. standoff, 2.75 in. of armor plate was penetrated, and at 24 in., a 2-in. perforation was observed. A third charge of cast Comp. B fired at 20-in. standoff perforated 6 1-in. armor plates and indented 0.75 in. in the 7th plate. The velocities measured for the TNT charge were 3880 and 3460 m./sec. for the 18- and 24-in. standoffs, respectively. The Comp. B charge produced fragments traveling at 3060 m./sec. at 20-in. standoff. It was concluded that the general design used would be satisfactory for use as an antitank mine.

L459

Carnegie Institute of Technology (DA36-061-ORD-28). MISZNAY-SCHARDIN EFFECT, by E. M. Pugh, R. J. Eichelberger, and W. F. Donaldson. Bimonthly rept. no. 4. Oct. 31, 1951, 13p. incl. illus. diagrs. (Rept. no. CIT-ORD-M22) TIP C59297 Confidential

Tests on a proposed design for an antitank mine showed that improper burial of mines could make them completely inefficient, although earlier tests showed their potential penetrating power to be over 6 in. End-fragmentation warhead tests were continued to determine the applicability of the principle under different conditions. It was desired to change the warhead design to decrease the c/m ratio and the number of fragments. Thus, much larger fragments with greater terminal destructive power would be produced and the energy lost because of air drag would be reduced. The tests showed that the fragmentation principle was easily adapted to the design of warheads for antiaircraft missiles. The principle was very flexible with regard to fragment velocity, fragment mass, number of fragments, and penetrating power.

L460

Carnegie Institute of Technology (DA36-061-ORD-28). ROTATED CHARGES, by E. M. Pugh, R. J. Eichelberger, and E. Litchfield. Bimonthly rept. no. 1. Apr. 30, 1951, 33p. incl. illus. diagrs. (Rept. no. CIT-ORD-R17) (Formerly contract DA36-061-ORD-7) TIP C59298 Confidential

Results described indicate a limit of about 150 r. p. s. for complete compensation of the detrimental effects of rotation by use of linear flutes on the standard 57-mm. liner of 0.045-in. wall thickness. In order to achieve performance equivalent to the static performance of the smooth liners at spin rates above 150 r. p. s., it will evidently be necessary to use a nonlinear relation between flute depth and position on the liner, or to modify the design of the blank liner. Results of an exploratory test using blanks with walls thicker than the standard 0.045 in. show promise of increasing the spin rates and the consistency in performance by simply increasing the thickness of the blanks. Fortunately the curve of penetration liner thickness is very flat for smooth liners fired statically. Consequently, much thicker blank liners can be used without much reduction in penetration. Thick liners also are affected less by rotation. Attempts to simplify the manufacture of fluted liners by using flute profiles that can be formed by a milling process yielded negative results. An exploratory investigation of smaller numbers of flutes than have been ordinarily used also unsuccessful. Graphical data are appended showing slug mass peak penetration for all lots of fluted 57-mm. liners fired to date. Appendix II gives brief descriptions of standardized procedures for recovering slugs and partially collapsed fluted liners. (Contractor's abstract)

L461

Carnegie Institute of Technology (DA36-061-ORD-28). ROTATED CHARGES, by E. M. Pugh, R. J. Eichelberger, and E. Litchfield. Bimonthly rept. no. 2. June 30, 1951, 29p. incl. tables, diagrs. (Rept. no. CIT-ORD-R18) TIP C59298 Confidential

Results of tests with smooth liners fired both statically and rotated are described. The penetration depth vs. rotational frequency curve is in excellent agreement with a previous determination using a different explosive; this control curve is now quite well defined. Penetration depth vs. penetration time data, obtained in this experiment for the first time, support the hypotheses advanced previously that the jet from near the base is strongly affected. Preliminary results have been obtained with M6 liners modified to be similar to standard 57-mm. liners except for their considerably thicker wall. The peak penetration with the modified M6 is somewhat less than that produced by the standard 57-mm. liner with the standard laboratory confinement; it is likely, however, that the M6 performance may be raised to the level of the standard 57-mm. liner by using heavier confinement. NBS lot no. 1M6-34 fluted liners have been tested and the results of these tests are included in this report. The combined data from lots 1M6-25 and 1M6-34 show 85% to 100% compensation at 120 to 130 r. p. s. Thus, a flute design which was entirely unsatisfactory on the standard 57-mm. blank gave excellent results on the thicker walled blank. (Contractor's abstract)

L462

Carnegie Institute of Technology (DA36-061-ORD-28). ROTATED CHARGES, by E. M. Pugh, R. J. Eichelberger, and E. Litchfield. Bimonthly rept. no. 3. Aug. 31, 1951, 44p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-R19) TIP C59298 Confidential

A 0 order theory for the behavior of fluted liners, based on shock wave concepts, was received from L. H. Thomas, and analyzed in a first attempt to determine its possible usefulness in treating fluted liners. Thomas's paper (item. no. L334) is included in this rept. together with a description of the analysis carried out, and a comparison of computations with experimental observation. At present, it appears that the theory is either incomplete or that the approximations are too poor to yield agreement with experiment. The physical concepts are very satisfying, however, and the theory seems to afford a guide of use in the design of special fluted liners and the modification of past designs. Recent experimental results of a considerable variety are described. The first successful pictures with the newly installed Kerr cell camera are shown. Experiments in which increased confinement has caused liners having wall thickness much greater than the ordinary to perform better than the standard liners are described. Preliminary tests were conducted in which peripheral initiation was used in an attempt to improve performance with steel liners and the results are discussed. Exploratory tests on effects of certain liner and charge imperfections including the effects of fluting the explosive charge instead of the metal liner; and preliminary results with a non-destructive system of gauging, intended to be the fore-runner of a system by which every fluted liner tested could be gauged prior to testing, are also described. (Contractor's abstract)

L463

Carnegie Institute of Technology (DA36-061-ORD-28). ROTATED CHARGES, by E. M. Pugh, R. J. Eichelberger, and E. Litchfield. Bimonthly rept. no. 4. Oct. 31, 1951, 37p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-R20) TIP C59298
Confidential

Tests were conducted with a series of 57-mm. fluted liners formed on 0.063-in. wall blanks instead of the previously tested 0.045-in. blanks. These tests showed that flutings formed on heavy blanks may prove quite useful. The heavier liners produced smaller penetrations under test conditions, but the performance level of the heavier liner may be improved by heavier confinement. The relatively flat penetration frequency curves indicated that fluted liners formed on these blanks may have some advantage for field use. Additional preliminary tests of fluted charges with smooth liners indicated that variations in flute depth in the master produced little change in the exhibited compensation frequency curve, and the peak penetration obtained, were closely related to those of the parent fluted liner group. The fluted liners that were tested are not suitable for checking the 0 order theory proposed by L. H. Thomas. Fluted liners manufactured according to the design proposed by L. H. Thomas will be procured to test this theory. It is believed that a higher order of approximation will be required before the theory will agree with experiments.

L464

Carnegie Institute of Technology (DA36-061-ORD-122). FUNDAMENTALS OF SHAPED CHARGES. Bimonthly rept. no. 1. Dec. 31, 1951, 30p. incl. diagrs. (Rept. no. CIT-ORD-36) (Formerly contract DA-36-061-ORD-28) TIP C7303
Confidential

The formation of the high pressure-high density (HPHD) zone behind the detonation wave in an exploding charge is described in terms of the release wave theory; a release wave is the characteristic surface (density and particle velocity constant) on which the pressure has diminished to such a value as to have a negligible effect on propulsion of the liner. In order to apply the theory, the time Δt between the arrival of detonation and release wave at each point of the liner must be known. An indirect method of determination used measured fragment velocities. The results of this method did not agree with observations made by the flash radiographic technique. This discrepancy was eliminated by taking into account the relative motion of liner and product gases. A justification is given for the normalizing procedure employed in the transition from an ideal semi-infinite charge to the charge used in practice.

L465

Carnegie Institute of Technology (DA36-061-ORD-122). FUNDAMENTALS OF SHAPED CHARGES. Bimonthly rept. no. 2. Feb. 2, 1952, 68p. incl. diagrs. (Rept. no. CIT-ORD-37) TIP C7518
Confidential

A detailed analysis is given for a 1-dimensional semi-infinite explosive which propels a liner from 1 end of the charge. The wave motion in the explosive and in the liner are considered, and the analysis for a rigid liner is obtained by a limiting process in which the shock velocity in the liner approaches infinity. The solution for a rigid liner is also obtained directly by the method of Riemann characteristics. An analysis of a finite 1-dimensional charge is also given; the solution is restricted to the case of a polytropic gas with $\gamma = 3$. Results indicate that calculations for a semi-infinite charge are capable of describing the early stages of motion of the liner to good approximation. With this approximation, the wave propagation can be described with relative ease. By studying experimentally the early stages of liner motion, it should be possible to obtain fundamental information about equations of state for explosive products and metals at high pressures. The calculations for 1-dimensional charges indicate that the shock-wave propagation in the liner may be neglected and the liner treated as a rigid body to good approximation, except in the early stages of liner motion. The initial conditions for the detonation products were found to significantly affect the asymptotic motion of the liner.

L466

Carnegie Institute of Technology (DA36-061-ORD-122). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and R. von Heine-Geldern. Bimonthly rept. no. 4. June 30, 1952, 45p. incl. illus. diagrs. (Rept. no. CIT-ORD-39) TIP C8093
Confidential

A partial summary is given of the work done on Kerr cell photography and the results obtained with this technique. By means of the methods discussed, which utilize the largest Kerr cell used so far, it is possible to obtain exposure times of 3×10^{-7} sec. triggered by the phenomenon and synchronized with an external light source of 3 to 5×10^{8} candle power. The methods which were developed for the photography of jets from shaped charges were found to be applicable to a large variety of high-speed phenomena, such as the detonation of explosive charges, propagation of shock waves through transparent solids and liquids, and the problem of crack propagation in brittle solids such as glass.

L467

Carnegie Institute of Technology (DA36-061-ORD-122). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh, R. J. Eichelberger, C. T. Linder, and F. E. Allison. Bimonthly rept. no. 5. Aug. 31, 1952, 53p. incl. illus. diagrs. (Rept. no. CIT-ORD-40) TIP C8481 Confidential

A theoretical and experimental investigation of the peripherally initiated charge is reported. The release wave theory has been applied to 1 charge design which uses the M9A1 steel liner, and a semi-quantitative explanation of the beneficial effect on the penetration performance of this design is obtained. The experimental results indicate that an improvement in penetration occurs when the detonation wave is shaped by peripherally initiating it. However, the increased performance appears to be quite sensitive to charge conditions and to small differences between liners. The release wave theory has now been applied to the standard charge with a number of different 44° liners. These calculations are compared with experiment and certain trends are noted. The preliminary results of the experimental technique of inhibiting the collapse of the liner at predetermined locations are reported. The method of inserting steel dies, called liner collapse inhibitors, inside the liner to isolate different lengths of jet by interrupting the collapse process is described.

L468

Carnegie Institute of Technology (DA36-061-ORD-122). FUNDAMENTALS OF SHAPED CHARGES. Bimonthly rept. no. 6. Sept. 30, 1952, 26p. incl. illus. diagrs. (Rept. no. CIT-ORD-41) TIP C8757 Confidential

Experiments with du Pont jet tappers: The jet tapper consisted of 2 oz. of RDX in which was embedded an 80° Cu liner of 1.75 in. base diameter and 0.025-in. wall thickness. The charge was confined in a Durez plastic case. An initial rept. by the Flintkote Co. indicated that the charges were less variable in performance than most jet charges; a subsequent rept. showed that the jet tappers had deteriorated and gave only average results. By using inverted Dixie cups as supports for the charges, the target-penetrating effect of the blast was reduced. The average penetration of charges fired while mounted on open-ended tubes was 6.77 in., with a standard deviation of $\pm$ 0.62 in. With the Dixie cups the average penetration was 6.08 in., and the standard deviation was $\pm$ 0.39 in. The average penetration was reduced about 17% when the disc was placed at the base of the 80° liner in the jet tappers. Increased penetration of the target was observed when the spherical disc, which formed the bottom of the base of the liner. Similar tests with 45° CIT liners did not result in change in penetrating effect. The effect of magnetization on the stopping power of steel was also studied without conclusive results. Glass as a target material: The apparent rebound effect of glass was investigated by which a steel blast plate, set on top of a plate of glass, was not perforated by a metallic jet but was deformed away from the glass surface. Indirect evidence indicates that the metal jet acquires particle nature when penetrating glass.

L469

Carnegie Institute of Technology (DA36-061-ORD-122). MOTION OF A LINER PROPELLED BY A ONE-DIMENSIONAL CHARGE, by N. Rostoker and T. P. Murray. Dec. 31, 1951, p. 4-29 incl. diagrs. (Part A of its Bimonthly rept. no. 1 on the Misznay-Schardin Effect; Rept. no. CIT-ORD-M23) (Formerly contract DA36-061-ORD-28) TIP C59297 Confidential

Results are given for the analysis of a 1-dimensional semi-infinite explosive which propels a liner from 1 end of the charge. The wave motions in the liner and explosive products have been considered in detail. The analysis for a rigid liner has been obtained by a limiting process in which the shock velocity in the liner approaches infinity. The results of the analysis of a finite 1-dimensional charge of length l are also given. The asymptotic motion of a liner propelled from 1 end of the finite charge differs little from the asymptotic motion predicted by Sterne's theory. However, the present analysis, provides a quantitative description of the early stages of motion of the liner and detonation products that is based on initial conditions that are physically more realistic. (Contractor's abstract)

L470

Carnegie Institute of Technology (DA36-061-ORD-122). RELEASE WAVE CONCEPTS IN THREE-DIMENSIONAL CHARGES, by R. J. Eichelberger, C. T. Linder, and J. A. Dreesen. Dec. 31, 1951, p. 30-55 incl. diagrs. (Part B of its Bimonthly rept. no. 1 on the Misznay-Schardin Effect; Rept. no. CIT-ORD-M23) (Formerly contract DA36-061-ORD-28) TIP C59297 Confidential

The physical reasoning behind the formation of a high pressure, high density (HPHD) zone in the product gases of an exploding finite 3-dimensional charge is described. An explanation of the formation of this zone is accomplished through the concept of a release wave. An experimental method by which the velocity of the release wave may be determined is discussed. The results of this method lead to an apparent discrepancy with observations made by the flash radiographic technique. However, it is shown that this discrepancy can be partly resolved by considering the motion of the liner relative to the product gases. In addition, a justification is given for the normalizing procedure employed in the transition from the semi-infinite charge of the previous part of the rept. to the 3-dimensional charge used in practice. (Contractor's abstract)

L471

Carnegie Institute of Technology (DA36-061-ORD-122). MISZNAY-SCHARDIN EFFECT, by E. M. Pugh, R. J. Eichelberger, W. F. Donaldson, and J. A. Dreesen. Bimonthly rept. no. 2. Feb. 29, 1952, 13p. incl. illus. diagrs. (Rept. no. CIT-ORD-M24) TIP C59299 Confidential

Four binary charges (charges consisting of more than 1 type of explosive in appropriate shapes) were tested in an attempt to gain fundamental information on the control of fragment direction. The charges were shaped like right circular cylinders, 4 in. in diameter by 2 in. in height. The core, a solid cone with a 90° apex angle and a base diameter of 4 in., consisted of 1 type of explosive, with a complimentary component of appropriate shape made from a second type of explosive. The explosives used in the tests were 50/50 pentolite and a mixture of TNT and litharge. Two general designs were tested; in 1, the base of the cone was in contact with the liner, and in the other, the apex of the cone was in contact with the liner. In all cases, the liners used were grooved steel discs 1/16 in. thick and 4 in. in diameter, the grooves being spaced in such a manner as to produce fragments 1/8-in. square. Results showed that the binary charges afforded control over fragment direction, but the changes in fragment direction were much greater than would be desired in practice. It was also observed that the penetrations seemed to be sensitive only to the type of explosive in contact with the liner and not particularly to the depth of that explosive behind the liner.

L472

Carnegie Institute of Technology (DA36-061-ORD-122). MISZNAY-SCHARDIN EFFECT, by W. F. Donaldson, J. A. Dreesen, R. J. Eichelberger, and E. M. Pugh. Bimonthly rept. no. 3. Apr. 30, 1952, 28p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-M25) TIP C59299 Confidential

A series of exploratory experiments leading to the design of more efficient fragments to improve the performance of warheads are reported. The reasons underlying the expectation of improved performance characteristics by self-forging fragments are given, and a simple fragment design which should fulfill these expectations is described. The general design chosen to be tested was a small tapered cone of 0.5-in. base diameter and varying combinations of internal and external angles. A number of variables were investigated to determine their effect on the performance of the self-forging fragments. These variables included explosive material, cone surround, cone material, and cone geometry. Within the range of the variables tested the best performance was achieved by unsurrounded cones of low C steel with internal/external angle combinations in the neighborhood of 140/120°, shot from Comp. B charges. A direct comparison between the self-forging fragment-type liner and 2 flat-ended cylinders, each of which had 1 of the advantages of the former, was made. It was found that the penetration achieved by the self-forging fragment was 2-1/3 times that of the better penetrating of the 2 cylinders, while its velocity was equal to that of the faster. (Contractor's abstract)

L473

Carnegie Institute of Technology (DA36-061-ORD-122). MISZNAY-SCHARDIN EFFECT, by J. A. Dreesen, R. J. Eichelberger, and W. F. Donaldson. Bimonthly rept. no. 4. June 30, 1952, 20p. incl. illus. diagrs. (Rept. no. CIT-ORD-M26) TIP C59297 Confidential

Experimental work performed with peripherally initiated warheads is discussed. The peripheral initiators used with the standard model warhead were litharge cores surrounded on all sides, except at the point of contact with the charge, by a 0.25-in. layer of 50/50 pentolite. All charges were equipped with 1/16-in. thick grooved steel liners, and were fired from 48 in. standoff at 24- x 24- x 0.25-in. steel target plates. It was concluded that fragment distribution when compared with that of point-initiated charges, was improved by using the peripheral initiators. For cylindrical charges with a length to diameter ratio of 0.246, the optimum initiator diameter was between 0.2 and 0.3 charge diameters. Tests with binary charges showed that fragment velocities were increased by using these charges made with a core of slow explosive surrounded by a layer of a second explosive with a higher detonation rate. A possible explanation for the observed effect was advanced, based upon the formation of a Mach bridge at the intersection of the converging detonation wave in the slow core.

L474

Carnegie Institute of Technology (DA36-061-ORD-122). MISZNAY-SCHARDIN EFFECT, by R. J. Eichelberger, W. F. Donaldson, and J. A. Dreesen. Bimonthly rept. no. 5. Aug. 31, 1952, 22p. incl. illus. tables. diagrs. (Rept. no. CIT-ORD-M27) TIP C59299 Confidential

The results of a number of experiments with 3 types of fragment guns, confined, binary (fast and slow core), and peripherally initiated are given. Control data obtained from unconfined point-initiated charges are also presented. It is shown that all 3 of these fragment gun types are capable of producing axial fragment velocities in excess of those obtained with the control charges. For this purpose the wave shaping charges (slow core binary and peripherally initiated) are the most successful. The confined fragment gun gives axial fragment velocities only slightly greater than the unconfined point-initiated charge. The maximum fragment velocities obtained in the experiments were:

Point-initiated (unconfined)	0.415 cm./usec.
Point-initiated (confined)	0.435 " "
Slow core binary (unconfined)	0.534 " "
Peripherally initiated (unconfined)	0.487 " "

(Contractor's abstract)

L475

Carnegie Institute of Technology (DA36-061-ORD-122). MISZNAY-SCHARDIN EFFECT, by W. R. Donaldson and others. Bimonthly rept. no. 6. Oct. 31, 1952, 20p. incl. illus. tables. (Rept. no. CIT-ORD-M28) AD-12 382 Confidential

Further tests were conducted on model warheads lined with mosaic arrays of individual cells (item no. L445). For a given charge weight, mosaic liners were inferior to integral discs from the standpoint of depth of penetration and fragment velocity. This was apparently caused by the leakage of the explosive gases between the cells. However, with respect to the number of cells within the lethal area, the mosaic liner was superior to the integral disc. The release wave theory predicts an increase in velocity given to individual cells of the mosaic arrays as their distance from the center increases; this was observed. Though the theory further predicts that this velocity passes through a maximum before the periphery is reached, this was not observed. Attempts to use tracers in the liners for justifying the statistical procedure used in the test evaluations were not completely successful.

L476

Carnegie Institute of Technology (DA36-061-ORD-122). ROTATED CHARGES, by E. M. Pugh, R. J. Eichelberger, and E. L. Litchfield. Bimonthly rept. no. 1. Dec. 31, 1951, 34p. incl. illus. diagrs. (Rept. no. CIT-ORD-R21) (Formerly contract DA36-061-ORD-28) TIP C59298 Confidential

Experimental data on fluted liners contained in this rept. make possible a comparison of (nominally) identical fluted liner designs formed on smooth blanks of 3 different wall thicknesses. The results show that, for the linear flute design tested, the thicker walled liner produces the higher percentage compensation for the effects of rotation, but at a lower spin frequency. The same experimental data also make possible a comparison of different flute depths for flutes formed sharp on the exterior of the standard 57-mm. liner. The results show the anticipated linear relationship between flute depth and compensation frequency. Preliminary gauging data from a few liners of this group are discussed relative to other gauging data and to dynamic performance. Additional data concerning the effects of rotation on smooth liners are described and a comparison of 2 blank liners differing only in wall thickness is discussed. It is shown that (percentage-wise) the heavier blank does not degrade as much as the lighter blank at a given spin frequency. Control data on penetration depth as a function of standoff distances are discussed. It is indicated that the penetration performance of the Cu liners being used for compensation tests at present is reasonably independent of standoff in the 2.0-in. to 8.0-in. standoff range. (Contractor's abstract)

L477

Carnegie Institute of Technology (DA36-061-ORD-122). ROTATED CHARGES, by R. J. Eichelberger, E. L. Litchfield, and F. P. Beitel. Bimonthly rept. no. 2. Feb. 29, 1952, 50p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-R22) AD-11 189 Confidential

A gauging installation using an electro-mechanical transducer of the type known as a "linear differential transformer" and an electrical recorder is described. As the apparatus has been used, the equipment has a precision of approximately 0.00013 in. and the entire gauging system has a precision of approximately 0.00018 in. For the fluted liner groups discussed, the variability in a given ring may be characterized by a standard deviation of 0.0002 in. to 0.0006 in. and the variability, in the pressing process, from liner to liner in a given group can usually be characterized by a standard deviation of 0.0002 in. The results discussed indicate that there is considerable variation from flute to flute in the dies used to flute the liners. Also, the "statistical" flute characterizing these liners is nonlinear. Kerr cell photographs of confined and unconfined charges (42° Al and steel liners, 1.69-in. base diameter, 0.045-in wall thickness) are shown. Unconfined charges gave satisfactory photographs, but when they were confined the jets were always enclosed by an opaque cloud. Liner wall thickness was considered to be an important factor because tests with heavy Al liners yielded better pictures than tests with thinner liners. (Contractor's abstract)

L478

Carnegie Institute of Technology (DA36-061-ORD-122). ROTATED CHARGES, by F. P. Beitel, R. J. Eichelberger, E. L. Litchfield, and E. M. Pugh. Bimonthly rept. no. 3. Apr. 30, 1952, 62p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-R23) AD-11 180 Confidential

Results from 6 lots of fluted liners are reported. The liners were all formed under large pressures between matched metal dies. Comparisons of results from 2 fluted liner lots show that dies formed by the "hobbing" process can be reproduced quite well. [In making the die, a "hob" having the dimensions of the die cavity is machined in the same manner as the punch. The "hob" is then hardened and pressed into the die block to form the die cavity. Comparison of results of 3 fluted liner lots indicates that the relative indexing of interior and exterior fluted dies could be an important factor in determining the optimum frequency of a fluted liner design. Preliminary results from 2 other fluted liner groups designed to investigate some fundamental aspects of compensation are also discussed. In particular, liners fluted internally but perfectly smooth on the exterior have demonstrated very good performance at an optimum spin frequency of ~100 r.p.s. Control tests designed to investigate the effects of charge length upon penetration depth for charge configurations of interest in ammunition are discussed. Results with the standard 42° apex, 0.045-in. wall, 1.69-in. base diameter Cu liner in a 1-5/8 in. diameter Comp. B charge showed that charge length could be varied over fairly wide limits with very little effect on the penetration, but the hole volume depended quite markedly upon the charge length.

L479

Carnegie Institute of Technology (DA36-061-ORD-122). ROTATED CHARGES, by N. Rostoker and R. J. Eichelberger. Bimonthly rept. no. 4. June 30, 1952, 79p. incl. diagrs. (Rept. no. CIT-ORD-R24) AD-11 037 Confidential

A unified picture of the current status of understanding of the spin compensation achieved by fluted conical liners is presented. The experimental observations described were taken from the detailed accounts written by this and other groups since World War II, with the objective of presenting only the salient features which may possibly be explained by theoretical treatment based on simplified representations. Explanations proposed so far for spin compensation achieved by fluted liners were collected and studied to determine the practical significance of each explanation in terms of the available experimental evidence. The following subjects were considered:

I. Experimental observations
   a. Qualitative features of spin-compensation
   b. Quality of compensating liners
II. Liner and charge design
   a. Liner design
   b. Charge design
III. Mechanisms for compensation of incompressible liners
   a. ERL theory
   b. Physical basis for compensation
   c. Approximate calculations of the compensation frequencies produced by thick-thin and transport effects
IV. Approximate treatment of compensation for compressible liners
   a. Rotational impulse due to the first refracted shock in the liner
   b. Rotational impulse due to the first reflected wave in the liner
   c. Discussion of cumulative effects for compressible liners
   d. Comparison with L. H. Thomas' theory

L480

Carnegie Institute of Technology (DA36-061-ORD-122). ROTATED CHARGES, by R. J. Eichelberger, E. L. Litchfield, and F. P. Beitel. Bimonthly rept. no. 5. Aug. 31, 1952, 27p. incl. tables, diagrs. (Rept. no. CIT-ORD-R25) AD-11 190 Confidential

Four lots of fluted liners were tested in which only the number of flutes was intentionally varied. Only qualitative conclusions were drawn because of accidental variation in other parameters. It was pointed out that there is an optimum number of flutes between 12 and 20 which gives the maximum frequency of compensation for a given flute depth. A series of tests with smooth liners showed that the relative degradation in penetration due to spin was independent of the liner thickness, at least over the range of thicknesses between 15 and 40% of the liner diameter. Another set of tests of a purely practical nature demonstrated a method of casting charges by base alignment of the liners that appeared to be as good as the standard procedure of liner alignment used previously. Performance data are shown for 3 groups of M9A1 steel liners fired unconfined at 4-in. standoff. One group which was cast in the standard CIT mold, gave an average penetration of 5.46 in. and produced an average hold volume of 13.1 cu. in. The second group cast "as is" in molds which used the liner flange to align the liner in the charge produced an average penetration of 5.73 in. and an average hole volume of 12.94 cu. in. The third group was also cast in a base-aligning mold, but the liner flanges were machined before casting. The average penetration for this group was 5.74 in. and the average hole volume was 13.9 cu. in. It was concluded that liners having flanges properly oriented with respect to the liner axis and cast by base alignment techniques yielded penetrations and variabilities comparable to those obtained with liners cast in the standard CIT molds.

L481

Carnegie Institute of Technology (DA36-061-ORD-122). ROTATED CHARGES, by E. L. Litchfield and others. Bimonthly rept. no. 6. Oct. 31, 1952, 29p. incl. tables, diagrs. (Rept. no. CIT-ORD-R26) AD-12 309 Confidential

Six lots of fluted Cu liners were tested to determine the effect of varying only the relative indexing of inside and outside flutes. The liners were cast into the standard CIT charge (1-5/8 in. diameter x 5 in. long) of Comp. B or 50/50 Pentolite and fired at 6-in. standoff into mild steel target plates at the desired spin rates. A difference of indexing of about 0.25 of a flute resulted in a compensation-frequency change of 200 r.p.s. Comparison of fluted Cu and steel liners of the same design indicated that there were no significant differences in their compensation frequencies. Tests with smooth liners showed that penetration degradation owing to rotation was the same for both Cu and steel liners and was independent of wall thickness over a range of 1.5 - 4.0% of the liner diameter. Data are given showing rotational frequency (r.p.s.) and penetration in inches.

L482

Carnegie Institute of Technology (DA36-061-ORD-122). HIGH SPEED PHOTOGRAPHY, by R. von Heine-Geldern, M. A. Holmes, and T. P. Murray. Apr. 30, 1952, p. 35-55 incl. tables, diagrs. (Part D of its Bimonthly rept. no. 3 on the Fundamentals of Shaped Charges; Rept. no. CIT-ORD-33) TIP C7842 Confidential

The spectral distribution of radiant energy from an electrically exploded wire [selected as a light source for Kerr cell photographs] is considered and some unsuccessful attempts at increasing its luminous efficiency by converting the UV energy to visible light with fluorescence are described. It is shown that contrary to estimates of others, the percentage of UV light from this source is small.

L483

Carnegie Institute of Technology (DA36-061-ORD-122). JET AND TARGET CHARACTERISTICS, by F. E. Allison, R. J. Eichelberger, C. T. Linder, and E. M. Pugh. Apr. 30, 1952, p. 4-32 incl. tables, diagrs. (Part B of its Bimonthly rept. no. 3 on the Fundamentals of Shaped Charges; Rept. no. CIT-ORD-38) TIP C7842 Confidential

The results of slug recovery experiments and release wave studies on 22° angle Cu liners are reported, and their performance characteristics are compared with those of 44° Cu liners. These 2 techniques provide independent methods for determining $V_0(x)$ [collapse velocity], $V_j(x)$ [jet velocity], and $\beta(x)$ [collapse angle]. With the 22° liners the agreement between the 2 is better than should be expected from the known uncertainties in the techniques. With the 44° liners the disagreements are less than the uncertainties. It is shown that small angle liners should be useful in weapons because of their small optimum standoff and large jet energy. It is also shown that explosive-compensated charges reduce the velocity gradients in the jets to such a point as to cause steel and Cu jets to obey the jet density relation of the simple penetration theory.

L484

Carnegie Institute of Technology (DA36-061-ORD-291). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh, C. T. Linder, F. E. Allison, and R. J. Eichelberger. Bimonthly rept. no. 1. Dec. 31, 1952, 36p. incl. diagrs. (Rept. no. CIT-ORD-42) (Formerly contract DA36-061-ORD-122) TIP C9036 Confidential

The sensitivity of certain charge designs to small alterations in the shape of the explosive and in the kind of confinement near the base of the liner is described. Calculations were made of the asymmetry that follows a spiral from apex to base of the conical liner. The results for a typical case indicated that the penetration at a standoff of 4 diameters would be reduced to 50% of the normal penetration if a spiral exists in which the variation in thickness or density is as much as 2.2%. The study suggested that spiral asymmetry may be 1 of the most detrimental types of asymmetry, particularly in the case of Cu liners. The presence or absence of a liner flange was shown to be inconsequential with respect to the performance of the jet when there is no explosive shoulder. Charges with explosive shoulders and containing liners with and without flanges were studied under various conditions of lateral and base confinement. The study demonstrated how confinement can alter the shock conditions in an exploding charge so as to effect the performance of the jet. The resulting penetrations and hole profiles were analyzed through the qualitative application of the basic principles of the release wave theory combined with the nonsteady theory of jet formation. The action of the flange was shown to be inconsequential except under special conditions when it has the effect of light base confinement in causing a change in the shock conditions in the charge. The possible usefulness is pointed out of the application of the basic ideas of the release wave theory when modifications in weapon design are contemplated. An investigation of 22° and 44° electrodeposited liners indicated that: (1) the 44° liners were nearly comparable in penetration performance to the 22° liners and exhibited less variability of penetration, and (2) better quality 44° drawn liners can be obtained than the 44° electrodeposited liners studied.

L485

Carnegie Institute of Technology (DA36-061-ORD-291). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh, R. von Heine-Geldern, F. E. Allison, R. J. Eichelberger, and C. T. Linder. Bimonthly rept. no. 2. Feb. 28, 1953, 27p. incl. tables, diagrs. (Rept. no. CIT-ORD-43) Confidential

Tests made at Aberdeen and CIT were compared. It was concluded that when tests are made under the same conditions, similar results are obtained. Three different laboratories, including the Flintkote Co., were in agreement on the essential features of glass as an effective protective device against weapons with lined cavity charges. In order to achieve practical protection with glass, the glass blocks were mounted in a panel with the proper thicknesses of face plate and backing plate. The individual blocks were separated from each other by a light cushioning material like foam rubber. A similar construction using gravel high in quartzite was found to be successful, but glass blocks were superior to gravel since they were more compact. The face plate provided increased protection against HEAT weapons, especially those that function at inferior standoff. It also protected the glass from small arms fire, fragments from exploding shells, and from accidental blows. It was shown that the standard unconfined charge performed more reliably when the diameter of the charge was increased; however, the increase in charge diameter did not produce a corresponding increase in average penetration.

L486

Carnegie Institute of Technology (DA36-061-ORD-291). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh. Bimonthly rept. no. 3. Apr. 30, 1953, 20p. incl. diagrs. (Rept. no. CIT-ORD-44) AD-10 337 Confidential

Experiments reported by Firestone indicate that the liner elements originating near the liner base collapse in such a manner that they follow a curved path rather than the straight line path predicted by existing theories. Such a curved path can be predicted if the current theory is modified to take into account the loss of kinetic energy of these liner elements due to plastic work. Although the exact path of collapse cannot be predicted from basic principles, a semi-quantitative description is presented which is in agreement with the observations reported by Firestone.

L487

Carnegie Institute of Technology (DA36-061-ORD-291). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and R. von Heine-Geldern. Bimonthly rept. no. 4. June 30, 1953, 23p. incl. tables, diagrs. (Rept. no. CIT-ORD-45) AD-17 418 Confidential

Data are presented on glass as a target material against shaped charges. An attempt was made to present a unified picture of the results obtained at various laboratories. Specific variables discussed were geometry of the glass target, effect of face plate, and effect of charge type. Performance of glass against the 3.5-in. Bazooka is also discussed.

L488

Carnegie Institute of Technology (DA36-061-ORD-291). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh, R. J. Eichelberger, C. T. Linder, and F. E. Allison. Bimonthly rept. no. 5. Aug. 31, 1953, 27p. incl. tables, diagrs. (Rept. no. CIT-ORD-46) AD-25 719 Confidential

The preliminary results of a systematic investigation of the effect on the penetration and on the jet characteristics when a taper is introduced in the wall thickness of conical liners for shaped charges are reported. No significant change was observed in the penetration depth when small amounts of taper were present. A small change in the initial jet velocities was observed and is compared with that which is predicted by the release wave theory in conjunction with the generalized theory of jet formation. It is pointed out that this phenomenon is peculiar to the generalized theory and is not predicted by the steady-state theory. An appendix presents in mathematical detail an approximation to the release wave theory that can be used to simplify many calculations involving shaped charges.

L489

Carnegie Institute of Technology (DA36-061-ORD-291). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh. Bimonthly rept. no. 6. Oct. 31, 1953, 22p. incl. tables, diagrs. (Rept. no. CIT-ORD-47) AD-28 191 Confidential

Comp. B charges of 1-5/8 in. diameter were investigated statistically. This analysis indicated that the decreased variability previously associated with the increase in diameter to 2 in. was partly attributed to more careful manufacture of the explosive. Two-in. diameter charges were also tested at standoffs other than 4 in. Though the penetrations for the larger charges were more reproducible, more nearly following a normal distribution at any given standoff, the variability exceeded 5% at the optimum standoffs, which were considerably larger than the 4-in. standoff of the earlier study. Therefore 2-in. diameter charges cannot be classified as reliable in the strictest sense since the definition requires that performance be measured at optimum standoff. However, because of the increased reproducibility at a standoff of 4 in., it was possible to verify an earlier conclusion on the validity of release wave calculations.

L490

Carnegie Institute of Technology (DA36-061-ORD-291). MISZNAY-SCHARDIN EFFECT, by J. A. Dreesen and others. Bimonthly rept. no. 1. Dec. 31, 1952, 16p. incl. table, diagrs. (Rept. no. CIT-ORD-M29) AD-12 381 Confidential

An experimental method, based on plate indentation by exploding charges, is given for measuring the release wave velocity as observed from a stationary frame of reference. Nine charges, all 1-in. long cylinders of Comp. B with diameters varying in 0.5-in. intervals from 1 in. to 5 in., were point-initiated at the center of their upper surface while in contact with a thick steel target. The crater depths produced by these charges were measured from an arbitrary reference plane as a function of the radial distance from the center of the crater along a line lying in the reference plane. The results indicated that a relatively sharp break occurred in the crater slope at a radial distance that varies with charge size as predicted by the release wave theory. There was relatively close agreement between the value of K, the ratio of release wave velocity to the detonation rate, determined in this experiment and in that obtained by Schall's flash radiographs of exploding charges.

L491

Carnegie Institute of Technology (DA36-061-ORD-291). MISZNAY-SCHARDIN EFFECT, by R. J. Eichelberger and others. Bimonthly rept. no. 2. Feb. 28, 1953, 17p. incl. table, diagrs. (Rept. no. CIT-ORD-M30) AD-3560 Confidential

Charges of cylindrical, square, or rectangular shape were fired from 100-cm. standoff, and their fragment flight times were recorded in an attempt to evaluate the effect of the interactions of rarefaction waves on fragment velocity. The charges were lined at 1 end with a steel plate the same shape as the charge end, each containing a 0.5-in. diameter Wood's metal disc. A fragment, one, 1/8-in. diameter steel cylinder/charge, was located in the Wood's metal disc directly below the point of initiation. From the incomplete data available, it is concluded that interactions may be neglected for practical purposes.

L492

Carnegie Institute of Technology (DA36-061-ORD-291). MISZNAY-SCHARDIN EFFECT, by N. Rostoker and J. A. Dreesen. Bimonthly rept. no. 3. Apr. 30, 1953, 35p. incl. diagrs. (Rept. CIT-ORD-M31) AD-10 089 Confidential

A description is given of an experiment in which a small charge was detonated in a large, thick-walled cylinder. Since the test closely approximated the ideal 1-dimensional experiment, it was analyzed by 1-dimensional shock-wave theory. Three distinct cases were treated: (1) both ends of charge free; (2) confinement at the plane of initiation; and (3) confinement at the end opposite initiation. By using the method of Riemann characteristics, expressions were derived for the pressure acting on the wall of the cylinder as a function of time and position, and for the impulse per unit area (the time-integrated pressure) delivered to the cylinder wall by the exploding charge as a function of position. The deformation of the cylinder wall, an easily measured experimental quantity, was related to 1 of the derived expressions by assuming that the deformation is a monotonely increasing function of the impulse delivered. Thus, the derived impulse curves should show the essential features of the expected deformation. No experimental results are given.

L493

Carnegie Institute of Technology (DA36-061-ORD-291). MISZNAY-SCHARDIN EFFECT, by W. F. Donaldson and others. Bimonthly rept. no. 4. June 30, 1953, 17p. incl. illus. diagrs. (Rept. no. CIT-ORD-M32) AD-18 281 Confidential

Four charges of Comp. B, 2 with both ends free and 2 confined at the end remote from initiation, were fired to investigate the deformation of thick-walled steel cylinders under internal explosive loading, and to obtain experimental results for comparison with the theoretical predictions (item no. L492). The 2 charges, free at both ends, having a length of 2 in. (including 0.25-in. tetryl booster) and a diameter of 1/2 in., were placed centrally in steel cylinders of 5.75-in. outside diameter and lengths of 5 in. and 6 in., respectively. In the other 2 charges, confinement was provided in 1 case by a 1/8-in. thick steel disc covering the entire charge end, and in the other (the case of infinite end confinement) by placing the charge in intimate contact with the bottom of a 4-in. hole drilled along the cylinder axis. Comparison of the measured deformation with the impulse curves calculated earlier (item no. L492) gave very good agreement. These calculated impulse curves not only located the point of maximum deformation, but also accurately reproduced the shape of the measured deformation curves. It was concluded that the shock theory based on a polytropic gas with $\gamma=3$ was capable of describing accurately the experimental results designed to approximate as closely as possible the 1-dimensional character of the models used in theoretical treatment. This experimental technique also offers the possibility of a much closer correlation between rigorous (but only 1-dimensional) shock theory and the release wave theory.

L494

Carnegie Institute of Technology (DA36-061-ORD-291). MISZNAY-SCHARDIN EFFECT, by J. A. Dreesen and others. Bimonthly rept. no. 5. Aug. 31, 1953, 29p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-M33) Confidential

Eight tests were made on model warheads having liners composed of mosaic arrays of hexagonal steel prisms which substantiated completely all earlier conclusions (item no. L475). The charges used were 7.5-in. diameter, 1.77-in. long cylinders of Comp. B, fitted with tetryl boosters inserted in the rear, and point-initiated at the center of this surface. The hexagonal prisms, 5/32 in. between parallel sides and ranging in length from 1/32 in. to 5/32 in., were cemented in close-packed array to the charge's face. Standoff for all charges was 48-in., with the cell flight times being measured with Potter chronographs for 4 different positions on the target. The attempt to resolve the variation in fragment velocity with position on the charge was inconclusive. However, these tests revealed that: (1) the fragment direction was dependent only on the charge's geometrical shape, being independent of fragment size and shape; (2) penetration depth at the velocities covered (0.25 to 0.35) cm./μsec. was apparently independent of velocity, depending instead on fragment mass; (3) fragment distributions generally exceeded Wizard specifications within a 20° cone of damage, but fell below at greater angles; and (4) fragment velocities were barely adequate except for high c/m ratios. It was concluded that the mosaic liners were inferior in all respects to the integral plate liners tested previously. Two exploratory tests with tapered cones (self-forging fragments) showed that tapered cones offered no advantages in a warhead designed to Wizard specifications. However, these cones would be useful in warheads where high penetration and high fragment velocities outweigh the loss in fragment numbers.

L495

Carnegie Institute of Technology (DA36-061-ORD-291). MISZNAY-SCHARDIN EFFECT, by F. E. Allison and others. Bimonthly rept. no. 6. Oct. 31, 1953, 28p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-M34) AD-28 192 Confidential

The vulnerability of cased explosive charges to high velocity fragments was investigated. The tests substantiated an earlier conclusion that, provided a fragment perforates the casing, the kinetic energy of the material entering the explosive is not the critical factor in determining whether detonation results. It is postulated that the high temperatures of these perforating fragments may be primarily responsible for the detonations. In the tests, single fragments propelled from fragment guns were used. These fragments, 5/8 in. in diameter, with thicknesses from 0.036 in. to 0.122 in., provided fragment kinetic energies ranging from 10.2×10^{10} to 16.4×10^{10} ergs. The fragments were fired individually from 4 in. in diameter by 2 in. long Comp. B. charges at the target charges at 75-cm. standoff. The target charges, identical with the charges used to propel the fragments, were inserted in 0.25-in. steel confinement rings with 6-in. by 6-in. steel cover plates of 1/8-in., 3/16-in., and 0.25-in. thicknesses, respectively, welded on 1 end. Test data revealed that: (a) for any given fragment thickness, fewer detonations were obtained when the protecting cover plate was thicker; (b) there was evidence that the optimum fragment thickness increased as cover-plate thickness increased; (c) the curves showing number of detonations vs. fragment thickness for the 3/16-in. and 0.25-in. cover plates exhibited a maximum indicating that an optimum fragment thickness existed for these cover-plate thicknesses; (d) apparently there was no correlation between the number of detonations and the initial kinetic energy of the fragment. A single test in which the end-fragmentation effect was applied to the design of antipersonnel warheads was also described. The mine tested contained 5.3 lb. of Comp. B., completely unconfined and initiated by a tetryl booster 1-5/8 in. in diameter by 0.5 in. thick. Its cylindrical surface, a 25-in. radius of curvature, contained closely-packed arrays of hexagonal steel prisms of mass 0.07 oz. each. The test indicated that warheads of this type would operate effectively.

L496

Carnegie Institute of Technology (DA36-061-ORD-291). ROTATED CHARGES, by R. J. Eichelberger and others. Bimonthly rept. no. 2. Feb. 28, 1953, 25p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-R28) AD-5381 Confidential

Tests were made on 5 lots of (s, r) fluted Cu liners produced by the fluted die and rubber pad technique of the NBS. Although the highest compensation frequency was obtained with an early group of these NBS liners, the method did not give reproducible results, being inferior to the matching dies technique for practical liner production. Observations revealed that the optimum rotational frequency was a linear function of the flute depth a_0 range from 8 to 16 mils and was nonlinear outside that region. These limits of a_0 corresponded to v_0's of 100 and 188 r.p.s., respectively. At a_0's above 16 mils, severe and rapid degradation of penetration resulted. It was concluded that flute depth and not spin-rate was the chief cause of penetration decrease. The nonlinearities are not expected to characterize other flute designs, especially the (s, s) flutes. In an appendix, experimental techniques and data are given for the individual liner groups.

L497

Carnegie Institute of Technology (DA36-061-ORD-291). ROTATED CHARGES, by E. L. Litchfield and others. Bimonthly rept. no. 3. Apr. 30, 1953, 27p. incl. tables, diagrs. (Rept. no. CIT-ORD-R29) AD-11 185 Confidential

Five new groups of fluted liners provided additional data on the compensation processes of fluted liners, and permitted estimation of the effects of wall thickness upon optimum frequency, v_0, and the effects of scaling linear dimensions. The v_0 for the .063-in. (s, s) liners usually was less than for the .045-in. (s, s) liners. However, at small positive indexings, ϕ, the v_0 for the heavy liners was greater than for the light liners. For the other 2 liner types (b, s) and (s, b) which did not contain the indexing variable, ϕ, quantitative estimates of wall thickness were obtained directly. The v_0 for the .063-in. (s, s) liner, $\phi = 4°31'$, was -100 r.p.s. After adjustment for discrepancy in flute depth, the ratios of the v_0's for the (b, s) and (s, b) liners were 0.43 and 0.59, respectively. Though the data available are not sufficient to establish the laws for scaling, it is now known that compensation is caused by small second order dynamic effects whose scaling relations are not certain.

L498

Carnegie Institute of Technology (DA36-061-ORD-291). ROTATED CHARGES, by R. J. Eichelberger and others. Bimonthly rept. no. 5. Aug. 31, 1953, 17p. incl. tables, diagrs. (Rept. no. CIT-ORD-R31) AD-16 935 Confidential

Five lots of (s, r) type liners, ostensibly reproductions of an earlier group of 5 lots in which only the number of flutes was varied intentionally, were tested. Since the earlier group (I) had an offset angle which was a systematic function of flute number, the repeat group (II) was fluted with new dies to obtain a more constant offset angle. Comparison between I and II indicated that: (a) the earlier conclusion that for a given flute depth the maximum optimum frequency was obtained at flute numbers between 12 and 20 was substantiated; (b) small variations in the offset angle were unimportant when the offset angle itself was small; (c) the correction of the original offset angle error gave no significant change in the optimum frequency obtained for (s, r) type flutes. While the improvement in consistency of the offset angle produced little effect in the (s, r) type liners, it is essential to the success of the proposed tests with the (s, s) type liners which are formed between matching metal dies. Variations in the performance level of the I and II liners may result from the interplay of flute depth, flute number, and minimum wall thickness; however, the details of such interplay are not known.

L499

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. I. PREDICTIONS OF SHAPED CHARGE PERFORMANCE FROM THE RELEASE WAVE THEORY, by R. J. Eichelberger. [Dec. 1953], p. 3-41 incl. diagrs. (In its Quarterly status rept. no. 1, Jan 31, 1954, Confidential)
Confidential

An approximate method of extending 1-dimensional shock theory to describe the interaction between explosive products and a shaped charge liner in 3-dimensional cases is described. The basis of the method (referred to briefly as the release wave theory) involves use of certain postulates concerning the product gases and the propagation of rarefactions in 3 dimensions. The procedure for applying the release wave theory to shaped charges is described and the results of computations are used to predict the effects on jet characteristics of variations in charge diameter, liner thickness, cone angle, cone material, and explosive; changes to be expected from cones with tapered walls, liner shapes other than conical, peripheral initiation, and unusual shaped charges are also described. The predictions are compared with experimental data for all cases in which observations are made. In general, the release wave theory affords accurate qualitative comparison and qualitative predictions of the effects to be expected from a wide variety of alterations in shaped charge design. The refinements required to obtain greater quantitative precision are also discussed. (Contractor's abstract)

L500

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. II. APPLICATION OF PENETRATION THEORY TO THE PROBLEMS OF DEFENSE, by R. von Heine-Geldern and C. T. Linder. [Dec. 1953], p. 42-56 incl. diagrs. (In its Quarterly status rept. no. 1, Jan. 31, 1954, Confidential)
Confidential

The well-known "density law" is re-stated in precise terms, and its different versions are examined critically. Only 2 materials were found to date which deviate from this law: glass (including fuzed quartz and Si containing rocks) and Ti. The behavior of these 2 materials is examined in some detail, and a tentative explanation of the mechanism involved is presented.
(Contractor's abstract)

L501

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. III. A SURVEY OF DATA REQUIREMENTS IN LINERS, by R. von Heine-Geldern. [Dec. 1953], p. 57-63 incl. diagrs. (In its Quarterly status rept. no. 1, Jan. 31, 1954, Confidential)
Confidential

Firings of shaped charges showed that very stringent manufacturing tolerances on conical liners are necessary to insure consistent charge performance. It was concluded that rigid tolerances should be maintained for the lower half of the liner, with relaxed tolerances acceptable for the apex or upper half, especially if this relaxation provides greater accuracy for the base half.

L502

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. IV. ROTATED CHARGES: RECENT DEVELOPMENT IN FLUTED LINERS, by R. J. Eichelberger and E. L. Litchfield. [Dec. 1953], p. 64-81 incl. diagrs. (In its Quarterly status rept. no. 1, Jan. 31, 1954, Confidential) Confidential

Detailed experimental observations on fluted liners formed between matching metal dies are described. The experiments completed to date include studies on the effects of: (1) variations in index angle; (2) variations in wall thickness; and (3) variations in flute depth. The practical potentialities of this type of fluted liner are discussed and compared with those of other designs that were tested. (Contractor's abstract)

L503

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. I. EXPERIMENTAL INVESTIGATION OF TITANIUM AGAINST SHAPED CHARGE JETS, by C. T. Linder, G. M. Bryan and R. J. Eichelberger. [Apr. 1954], p. 1-23 incl. illus. tables, diagrs. (In its Quarterly status rept. no. 2, Apr. 30, 1954, Confidential) Confidential

The results of the experimental investigation of Ti as a target material against jets from shaped charges are given. These results are compared with those from similar experiments on glass as a target material, and possible mechanisms of the action of these materials on jets are considered.
(Contractor's abstract)

L504

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. II. THE EFFECT OF CHARGE DIAMETER UPON THE PERFORMANCE OF M9A1 LINERS, by W. F. Donaldson, R. F. Eichelberger, and F. E. Allison. [Apr. 1954], p. 24-44 incl. tables. (In its Quarterly status rept. no. 2, Apr. 30, 1954, Confidential) Confidential

The effect of charge diameter upon the penetration produced by confined and unconfined charges containing M9A1 liners was investigated. For unconfined charges not more than 2.5-in. in diameter, the results are essentially the same as those previously reported in the literature. For Cu liners, it is shown that increasing the charge diameter beyond 3 in. decreases the penetration about 30%. Confined charges exhibit the same behavior but at smaller charge diameters, thus lending support to the idea that inert confinement is equivalent to explosive confinement in some respects. This general behavior of penetration as a function of charge diameter for large diameters is made plausible by reducing the results to a more familiar experiment. (Contractor's abstract)

L505

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. III. SPIN COMPENSATION, by K. R. Becker, R. J. Eichelberger, and E. L. Litchfield. [Apr. 1954], p. 45-79 incl. tables, diagrs. (In its Quarterly status rept. no. 2, Apr. 30, 1954, Confidential) Confidential

Final evaluation was completed for the (s, s) liner series designated $\{.046\ (16 \times .015)\ (s, s)\ (\phi)\}$ and $\{.060\ (16 \times .015)\ (s, s)\ (\phi)\}$ and the results are presented here. The effects of indexing angle, ϕ, are discussed for each of the wall thicknesses above. The effects of wall thickness at constant indexing are also discussed. It is shown that the effects of wall thickness are a function of ϕ in both the optimum frequency obtained and in the penetration observed at this optimum frequency. Preliminary results from a fluted liner scaling experiment are also discussed briefly. (Contractor's abstract)

L506

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. IV. APPLICATION OF SELF-FORGING FRAGMENTS TO ANTIPERSONNEL WEAPONS, by W. F. Donaldson, R. J. Eichelberger, and F. E. Allison. [Apr. 1954], p. 80-83 incl. illus. table. (In its Quarterly status rept. no. 2, Apr. 30, 1954, Confidential) Confidential

Several designs of small self-forging fragments were tested to ascertain their usefulness in antipersonnel applications. It was found possible to propel such fragments with initial velocities up to 3000 ft./sec. with only 0.30 in. of military explosive. Several fragment designs were capable of perforating 2.25 in. of yellow pine placed 25 ft. from the charge. (Contractor's abstract)

L507

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. V. THE INTRODUCTION OF CURVED CONE ELEMENT TRAJECTORIES INTO THE THEORY OF CONE COLLAPSE AND JET FORMATION, by F. P. Beitel. [Apr. 1954], p. 84-104 incl. diagrs. (In its Quarterly status rept. no. 2, Apr. 30, 1954, Confidential) Confidential

The description of non-steady cone collapse is modified through introduction of an arbitrary method of providing for curved element trajectories. The results of calculations indicate that the collapse parameters on the whole are changed very little. However, the modification provides a possible explanation for the failure of the entire liner to contribute to the jet and slug. (Contractor's abstract)

L508

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. VI. X-RAY PHOTOGRAPHY, by E. L. Litchfield and R. W. Watson. [Apr. 1954], p. 105-123, incl. illus. (In its Quarterly status rept. no. 2, Apr. 30, 1954, Confidential) Confidential

Pictures of the jet elements of F3 57-mm. smooth and fluted Cu conical liners and M9A1 Cu and steel conical liners were obtained with a low-voltage (30-35 kv.) X-ray installation. Comparisons are made with a set of Kerr cell photographs.

L509

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. I. CRATERS FORMED BY HIGH VELOCITY FRAGMENTS, by R. J. Eichelberger, F. E. Allison and W. F. Donaldson. [July 1954], p. 1-24, incl. illus. table, diagrs. (In its Quarterly status rept. no. 3, July 31, 1954, Confidential) Confidential

The craters formed by high velocity fragments in target materials of different strengths and densities (e.g. Cu, Ti, steel, bronze) were investigated. The crater depths for a large number of target materials are in agreement with a hydrodynamic theory based on Bernoulli's equation, provided strength terms are included. The limitations of the theory are discussed in detail. The crater volumes do not correlate with any of the known parameters except for Pb targets, where good correlations were obtained between volume and depth of penetration. (Contractor's abstract)

L510

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. II. FINITE ACCELERATION TIMES IN THE THEORY OF JET FORMATION, by R. J. Eichelberger [July 1954], p. 25-40 incl. diagrs. (In its Quarterly status rept. no. 3, July 31, 1954, Confidential) Confidential

The effect of a finite and variable time of acceleration of a shaped charge liner upon the theory of jet formation is considered in a qualitative fashion. It is demonstrated that, within the range of values of acceleration time permitted by experimental observations, neither a constant nor a variable acceleration time appreciably affects the analysis of liner collapse and of jet formation. (Contractor's abstract)

L511

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. III. AN ATTEMPT TO TEST THE L. H. THOMAS FORMULATION OF THE THEORY OF SPIN COMPENSATION, by R. J. Eichelberger, E. L. Litchfield, and K. R. Becker. [July 1954], p. 41-48 incl. illus. diagr. (In its Quarterly status rept. no. 3, July 31, 1954, Confidential) Confidential

An attempt was made to compute the compensation frequencies of fluted liners based on shock wave phenomena. Tests were conducted using a liner design consistent with the mathematical formulation given in L. H. Thomas' monograph, "A Zero Order Theory of the Initial Motion of Fluted Hollow Charge liners" (item no. L334). Since no penetration was obtained, the results of these tests are not conclusive.

L512

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. IV. SCALING TESTS WITH FLUTED LINERS, by K. L. Litchfield, K. R. Becker, and R. J. Eichelberger. [July 1954], p. 49-74 incl. illus. tables, diagrs. (In its Quarterly status rept. no. 3, July 31, 1954, Confidential) Confidential

The results of a (s, s type) fluted liner scaling experiment are given and discussed. It is concluded that the simple model scaling laws are not applicable to liners of this type.

L513

Carnegie Institute of Technology (DA36-061-ORD-394). FUNDAMENTALS OF SHAPED CHARGES. V. A TECHNIQUE FOR X-RAY MEASUREMENT OF INDEXING OF FLUTED LINERS, by E. L. Litchfield and K. R. Becker. [July 1954], p. 75-77 incl. illus. (In its Quarterly status rept. no. 3, July 31, 1954, Confidential) Confidential

A simple non-destructive technique for measuring index angles of fluted liners by use of X-rays is described. For reasonable ratios of flute depth to wall thickness, there is sufficient difference between the "thick" and "thin" portions of a cone fluted between matching dies to show up well on an X-ray photograph. Such a photograph can be made by loading the film into the interior of the cone and taking a picture with X-rays normal to the cone axis. A sufficient amount of high density backing material is required behind the film to assure that only X-rays traversing the desired cone surface activate the film. (Contractor's abstract)

L514

Carnegie Institute of Technology (OEMsr-202). A ROTATING DRUM CAMERA FOR THE OPTICAL STUDY OF DETONATIONS, by G. H. Messerly. Progress rept. July 8, 1942, 19p. incl. diagrs. (NDRC Div. 8) OSRD 682 Confidential

The apparatus, which records photographically the detonation of a column of explosive, works on the principle that the image of the explosive column is focused along a cylindrical element of the drum surface. When the drum is covered with a strip of film and rotated, the luminous detonation wave front moving from top to bottom of the explosive stick will be recorded on the film as a straight line slanted across the film. The actual detonation velocity may be obtained from the angle which this line makes with the film edge, if the film linear speed and optical magnification of the system are known.

L515

Carnegie Institute of Technology (OEMsr-202). MICROWAVE TUBE DESTRUCTION (SC-41), by D. P. MacDougall. Progress rept. to Dec. 1, 1942. Dec. 9, 1942, 9p. illus. diagr. (NDRC Div. 8) OSRD 1122 Confidential

Experiments were performed to determine the design of a shaped charge capable of demolishing a special microwave tube. The tube was made in the form of a short Cu cylinder with external cooling fins and with an inner structure consisting of a central hole and 8 peripheral "perforations."

L516

Carnegie Institute of Technology (OEMsr-202). MICROWAVE TUBE DESTRUCTION, by M. A. Paul. Progress rept. to Mar. 10, 1943. Mar. 23, 1943, 8p. diagr. (NDRC Div. 8) OSRD 1287 Confidential

Space restrictions made it necessary to reinvestigate the charge design for certain installations. A 100° sand conical liner with 3-in. base diameter at 2-in. target distance was considered adequate for the purpose. Danger from fragments was investigated.

L517

Carnegie Institute of Technology (OEMsr-202). MICROWAVE TUBE DESTRUCTION, by M. A. Paul. Final rept. Aug. 20, 1943, 1p. (NDRC Div. 8) OSRD 1723 Confidential

A test of the modified destructor charge was made on a microwave tube mounted on a standard installation within a mock-up plane fuselage.

L518

Carnegie Institute of Technology (OEMsr-202). THE MECHANISM OF ACTION OF CAVITY CHARGES, by G. B. Kistiakowsky and others. Progress rept. to Mar. 15, 1943. Apr. 12, 1943, 22p. illus. diagr. (NDRC Div. 8) OSRD 1338 Confidential

An attempt is made to formulate a general working hypothesis of the action of lined and unlined shaped charges on various targets but chiefly steel. The J. von Neumann theory (unlined charges) for laws of reflection of shock waves (Mach wave) from solid obstacles is presented. Optical evidence (slug, liner fragments, photographs of jet) was studied to determine the mechanism of liner collapse and jet formation. The penetration of the jet against steel targets is discussed under the following points: relation between luminous jet and penetration agent, penetration agent, penetration times, and effect of standoff. An appendix concerning the acceleration of a solid particle in a gas stream is included.

L519

Carnegie Institute of Technology (OEMsr-202). PENETRATION OF STEEL TARGETS BY LINEAR CHARGES, by M. A. Paul. Progress rept. to Apr. 1, 1943. May 4, 1943, 6p. illus. diagr. (NDRC Div. 8) OSRD 1393 Confidential

An investigation of steel target penetration by linear charges was made. Wedge, triangular, and cowbell cross sectioned charges with Pb, steel, and Cu liners in various thicknesses were tested.

L520

Carnegie Institute of Technology (OEMsr-202). THE FLASH PHOTOGRAPHY OF DETONATING EXPLOSIVES, by G. H. Messerly. Progress rept. to May 1, 1943. June 3, 1943, 11p. incl. illus. (NDRC Div. 8) OSRD 1488 Confidential

The intense luminosity produced by a shock wave in A (gas) was utilized as flash light to photograph the jet from an exploded shaped charge. The luminosity of the jet was quenched by exploding the shaped charge in an atmosphere of a C_3H_8-C_4H_{10} mixture.

L521

Carnegie Institute of Technology (OEMsr-202). THE EFFECT OF UNSYMMETRICAL CONE ALIGNMENT ON THE JET FROM A CAVITY CHARGE, by M. A. Paul. Progress rept. Aug. 5, 1943, 5p. illus. (NDRC Div. 8) OSRD 1681 Confidential

Charges bearing M9A1 liners were fired with their axes deliberately offset from the charge axes either by tilting the liner at a small angle or by displacing the liner laterally.

L522

Carnegie Institute of Technology (OEMsr-202). THE EFFECTIVE DIAMETER OF THE JET FROM A CAVITY CHARGE, by M. A. Paul. Progress rept. Aug. 5, 1943, 9p. illus. tables. (NDRC Div. 8) OSRD 1679 Confidential

The effective jet diameter was estimated for several small-scale charges, such as charges carrying an M9A1 conical liner, cast Pentolite charges, steel lined 45° cavity charge, and 45° sand lined charges. The smallest hole through which the jet could pass without enlarging it or scoring the walls was taken as an upper limit to the jet diameter.

L523

Carnegie Institute of Technology (OEMsr-202). TARGET PENETRATION BY THE JET FROM A ROTATING CONE CHARGE, by M. A. Paul. Progress rept. Aug. 5, 1943, 7p. illus. diagr. (NDRC Div. 8) OSRD 1680 Confidential

Charges with 30° and 40° steel liners were fired into steel targets while rotating at speeds up to 10,000 r.p.m.

L524

Carnegie Institute of Technology (OEMsr-202). TARGET PENETRATION BY THE JET FROM A ROTATING CONE CHARGE, by M. A. Paul. Progress rept. no. 2. July 10, 1944, 27p. illus. diagr. (NDRC Div. 8) OSRD 3874 Confidential

Experiments with rotating shells and small rotating shaped charges are reported. The effect of rotation on penetration, apex angle, standoff, and jet velocity is discussed. It appeared that for conical liners, with spins such as are required for adequate flight stability, the depth of penetration is practically independent of standoff and is about 50% of the depth attained in static trials at optimum standoff. The adverse effect of rotation leveled off when sufficient high speed was attained. No advantage was found with apex angles of less than 45°. Evidence was found that hemispherical liners are relatively much less affected by rotation than conical liners, but they require excessively large standoff. The modification of liners to compensate for the effects of rotation was investigated. The jet velocity of a miniature shaped charge (for use in a point-detonating fuze) was found to be unaffected by a moderate speed of rotation, as was its ability to initiate a pressed Tetryl booster pellet 6 to 8 in. distant.

L525

Carnegie Institute of Technology (OEMsr-202). PENETRATION OF STEEL TARGETS IN AIR BY SMALL-SCALE CAVITY CHARGES, by M. A. Paul. Progress rept. Sept. 29, 1943, 17p. illus. diagr. (NDRC Div. 8) OSRD 1881 Confidential

The effects of standoff, liner weight, and cavity shape on steel target penetrations in air by small-scale steel lined cavity charges were investigated. Liners with apex angles from 30° to 120° were tested, as were other special shapes. For each angle, liners covering a broad range of weights bracketing the optimum were included.

L526

Carnegie Institute of Technology (OEMsr-202). EXPERIMENTAL STUDIES OF CONE COLLAPSE AND JET FORMATION: PART I. RECOVERY OF CONES FROM LOW-POWERED CHARGES, by H. Linschitz and M. A. Paul. Progress rept. Nov. 29, 1943, 15p. incl. illus. (NDRC Div. 8) OSRD 2070 Confidential

The progressive stages of liner collapse were studied on M9A1 and other liners using charges with a graded degree of power and recovering the liner residue in water. The graded power was generated by nitroguanidine hand tamped to various densities of 0.25-0.69.

L527

Carnegie Institute of Technology (OEMsr-202). EXPERIMENTAL STUDIES OF CONE COLLAPSE AND JET FORMATION: PART II. THE MASS CONTRIBUTED TO THE JET, by M. A. Paul and H. Linschitz. Progress rept. Nov. 29, 1943, 24p. illus. diagr. (NDRC Div. 8) OSRD 2072 Confidential

Weights of sections of recovered and of original conical liners were compared. The original liner surface was marked with light circular scratches which were retained on the slug, or the original liner was presectioned before firing with the slug being recovered in separate sections. Results are compared with the Tuck-Taylor-Birkhoff theory.

L528

Carnegie Institute of Technology (OEMsr-202). EXPERIMENTAL STUDIES OF CONE COLLAPSE AND JET FORMATION. PART III. FURTHER STUDIES OF JET MASS ORIGIN AND SLUG STRUCTURE, by M. A. Paul. Progress rept. Dec. 20, 1945, 22p. illus. diagr. (NDRC Div. 8) OSRD 5602 Confidential

The experimental investigation of firing presectioned liners and recovering the slug residues was carried out for 1-5/8 in. diameter 45° steel liners. The behavior of presectioned and composite liners of larger diameter consisting of alternate segments of steel and Cu was studied.

L529

Carnegie Institute of Technology (OEMsr-202). IMPROVEMENTS IN THE PERFORMANCE OF CAVITY CHARGES, by M. A. Paul and J. F. Lemons. Progress rept. Apr. 3, 1944, 23p. incl. tables, diagrs. (NDRC Div. 8) OSRD 3443 Confidential

Experiments to determine the possibility of improving the performance of shaped charges by shaping the detonation wave and by observing the effect of various degrees of confinement were conducted. Small-scale charges consisting of concentric cylindrical cast TNT cores and some inert cores inside a cast Pentolite shell were fired against mild steel targets. M9A1, M66, M6, and other steel and Cu liners having various apex angles (45°-120°) were used in these charges.

L530

Carnegie Institute of Technology (OEMsr-202). MOMENTUM AND KINETIC ENERGY OF THE SHAPED CHARGE JET, by M. A. Paul and J. F. Lemons. Progress rept. Oct. 23, 1945, 27p. illus. diagr. (NDRC Div. 8) OSRD 5570 Confidential

The momentum of the jet was measured for small cavity charges using a compound pendulum as the target. The kinetic energy of the jet was obtained by determining the temperature rise produced in the target.

L531

Carnegie Institute of Technology (OEMsr-202). UNDERWATER PENETRATION BY SMALL-SCALE SHAPED CHARGES, by E. P. Meibohm and M. A. Paul. First and final rept. Oct 24, 1945, 15p. tables, diagrs. (NDRC Div. 8) OSRD 5569 Confidential

Underwater penetration data for small scale, Pentolite-filled shaped charges (4 in. long, 1.58-in. diameter) fired against 0.5-in. mild steel targets are presented in tabular form. Among the chief variables studied were the following: (1) liner shape (20°-120° cones, trumpets, domes and hemispheres); (2) liner material (steel, Cu, Al, Pb, Zn alloy, brass and plastic bonded steel filings); (3) explosive content (Pentolite, Torpex II and Comp. B); (4) liner weight; and (5) standoff. Results from tests to determine effect of: (1) confinement (steel, cardboard); and (2) double targets (0.25-in. steel plus 0.5-in. steel on underwater penetration are included. A statistical analysis of the above penetration data is made.

L532

Carnegie Institute of Technology (OEMsr-202). RADIOGRAPHY OF EXPLOSIVE MATERIALS, by O. E. A. Bolduan. Progress rept. Nov. 5, 1945, 10p. illus. diagrs. (NDRC Div. 8) OSRD 5575 Confidential

A description of the techniques, apparatus, and procedures developed at Explosives Research Laboratory, Bruceton for the radiographic examination of explosive charges and charge liners is given. Photographs resulting from application of these techniques are included.

L533

Carnegie Institute of Technology (OEMsr-202). TARGET PENETRATION BY ROTATING CAVITY CHARGES, by M. A. Paul. Progress rept. Nov. 5, 1945, 34p. illus. diagr. (NDRC Div. 8) OSRD 5598 Confidential

Hemispherical liners were tested at short standoffs to determine their effectiveness in a rotating shell. A set of trumpet shaped liners with a fixed degree of offset and a number of grooved liners were tested at various rotational speeds.

L534

Carnegie Institute of Technology (OEMsr-202). THE EFFECTS OF VARIOUS ABERRATIONS ON THE PERFORMANCES OF CAVITY CHARGES, by M. A. Paul and others. Progress rept. Dec. 3, 1945, 61p. illus. (NDRC Div. 8) OSRD 5590 Confidential

Results of a series of investigations into the effects on shaped charge performance of various types of controlled distortions and aberrations of the liner, explosive content, or entire charge assembly are presented. Following is an outline of these investigations: (1) liner construction (methods of manufacture, variations among lots, liner hardness and heat treatment, wall taper); (2) controlled distortion (fabrication of large liners, effects of elliptical and triangular departure from concentricity); (3) liner alignment and off-axial initiation; (4) flaws in the castings (casting technique, effect of holes, effect of liner-charge separation); and (5) holes and wires through the liners (application to electromagnetic fuzing).

L535

Carnegie Institute of Technology (OEMsr-202). SHAPED CHARGE BOMBS, by J. F. Lemons and others. Progress rept. Dec. 20, 1945, 77p. illus. diagr. (NDRC Div. 8) OSRD 5600 Confidential

Shaped charge bombs were tested against battleship targets with and without superstructure, large and small aircraft carrier targets, and heavy cruiser targets. Discussions on bomb construction, loading and initiation, and effect of large air spaces on shaped charge performance are included. Shots were fired to determine the effect of charge shape. Incendiary effects of shaped charge jets were investigated.

L536

Carnegie Institute of Technology (OEMsr-202). SHAPED CHARGE BOOSTERS, by L. Goodman. Progress rept. Dec. 26, 1945, 14p. incl. tables. (NDRC Div. 8) OSRD 5629 Confidential

The possibility of improving the initiating power of the Mark 17 and other auxiliary detonators and boosters by means of a cavity in the base was investigated. The shaped charge boosters proved to be of value where it is necessary to initiate a second booster at a distance, but did not appear to have any particular merit where the main charge is close to or in contact with the booster. It was concluded that failure of 5-in. 38 AA shells was due to some cause other than weakness of the booster in the auxiliary detonator.

L537

Carnegie Institute of Technology (OEMsr-202). CONSTRUCTION AND OPERATION OF THE ROTATING MIRROR CAMERA, by S. J. Jacobs. Progress rept. Jan. 2, 1946, 20p. diagrs. (NDRC Div. 8) OSRD 5614 Confidential

Construction details of a single lens rotating mirror camera which will produce an image velocity of at least 1,000 m./sec. are discussed. External slits, destroyed by each detonation, are described. A discussion on the combination of lenses for 2 lens system which will give the maximum uniform image brightness on the film, for given condition and image size, is appended.

L538

Carnegie Institute of Technology (OEMsr-202). POINT-INITIATING FUZES FOR SHAPED CHARGE WEAPONS, by J. F. Lemons and M. A. Paul. Progress rept. Jan. 3, 1946, illus. tables. (NDRC Div. 8) OSRD 5601 Confidential

Tests with the electromagnetic fuze, point-initiating, T2003 are described. The fuzing requirements of shaped charge projectiles are discussed. A point-initiating fuze of the spit-back type is described. It has a miniature shaped charge in the nose that spits with a velocity of the order of 20,000 ft./sec. down an axial flash tube through the main charge to a Tetryl booster pellet at the base.

L539

Carnegie Institute of Technology (OEMsr-202). STEEL TARGET PENETRATION IN AIR BY SMALL-SCALE CAVITY CHARGES, by E. J. Huber and others. Progress rept. no. 2. Jan. 15, 1946, 45p. diagrs. (NDRC Div. 8) OSRD 5604 Confidential

Comparative penetrations in armor, and mild steel and Al targets from M6 Cu and M6 steel conical lined charges are recorded. Information is included on the effect of base flange on performance of confined and unconfined charges and on charges having a diameter greater than diameter of base liner; relation between optimum liner weight and degree of confinement; and effect of flash tubes on performance of charges bearing hemispherical steel liners.

L540

Carnegie Institute of Technology (OEMsr-202). STUDIES OF SHAPED CHARGES WITH THE ROTATING DRUM CAMERA, by M. D. Hurwitz and H. A. Strecker. Progress rept. Jan. 15, 1946, 22p. diagrs. (NDRC Div. 8) OSRD 5615 Confidential

Initial jet velocity of cast Pentolite (50/50) charges (1-5/8 in. diameter, 6 in. long) with steel liners

(45°-120°) of various weights was studied as a function of liner thickness and liner weight. Penetration time and emergent jet velocity of uncased charges (60/40 Cyclotol or 50/50 Pentolite, 1.63-in. diameter, 6-in. long) bearing M9A1 and other steel liners (45°-120° apex angles) were measured as a function of target material (water, glass, concrete, Al, steel, brass, Cu and Pb), target thickness, and standoff. All measurements were made using the rotating drum camera with and without multiple slit technique. Four flash photographs of M9A1 liners are included.

L541

Carnegie Institute of Technology (OEMsr-202).
STUDIES OF A SHAPED CHARGE ASSISTED SAP BOMB, by L. P. Saxer. Progress rept. Jan. 18, 1946, 33p. illus. diagr. (NDRC Div. 8)
OSRD 5605 Confidential

A brief and incomplete study on a 1:5 model scale was made of the possibility of developing a shaped charge assisted bomb for attack of armored targets. The bomb consists of a shaped charge head attached to the 500-lb. SAP bomb. It was concluded that the addition of such a head would add 12 in. in length and 250 lb. in weight to the full-scale bomb which might then be expected to perforate 6 in. of homogeneous armor at 750 ft./sec. striking velocity. An appendix contains tabulated information concerning hole diameter measurements for steel, Cu, and Al liners having the following shapes: cone, trumpet, inverted trumpet, cutting tube type, hemisphere, and hemitorus. Targets were armor plate or mild steel.

L542

Carnegie Institute of Technology (OEMsr-202).
THE APPLICATION OF FLASH PHOTOGRAPHY TO THE STUDY OF EXPLOSION PHENOMENA, by E. M. Boggs and others. Progress rept. Jan. 28, 1946, 20p. illus. diagrs. (NDRC Div. 8)
OSRD 5616 Confidential

The flash photography technique discussed is concerned with the development of a relatively long duration light source for use with the drum or mirror camera to obtain rate pictures of rapidly moving non-luminous phenomena. A transparent tube filled with A (gas), with an explosive pellet at 1 end of the tube, was used to produce the intense light of duration (40-50 μsec.). The action of lined and unlined charges was studied. Cased charges and measurements of initial fragment velocity were investigated. Some of the shadowgraphs obtained were studied to secure an estimate of the pressure of the detonation products within the expanding case.

L543

Carnegie Institute of Technology (OEMsr-202).
SHAPED DETONATION WAVES, by S. J. Jacobs and R. J. Grabenstetter. Progress rept. Jan. 28, 1946, 31p. illus. diagrs. (NDRC Div. 8)
OSRD 5603 Confidential

The possibility of improving the cavity effect by shaping the detonation wave was investigated using cored (TNT or Barotol) charges (Pentolite or Comp. B) and plane wave or peripheral initiation. Optical and brisance studies were made of the production and performance of these resulting types of shaped detonation waves: wedge shaped (cored block charge), conical (cylindrical charge), toroidal (cylindrical charge), and cylindrical (tapered charge). The addition of a PbO barrier (equal to peripheral initiation) or a wafer (thin layer of explosive) was also tested to determine its usefulness in shaping the detonation wave. Diagrams of the test charges, brisance depressions and means of initiation, and rotating mirror camera records of the shots fired are included.

Carnegie Institute of Technology (OEMsr-202)
see also Explosives Research Laboratory, Bruceton

L544

Carnegie Institute of Technology (OEMsr-950).
DEFENSE AGAINST HOLLOW CHARGES. I, by E. M. Pugh. Jan. 27, 1944, 32p. incl. illus. diagrs. (Armor and Ordnance rept. no. A-242, NDRC Div. 2) OSRD 3199 Confidential

Experiments were made to find materials or combinations of materials that might be effective in defense against shaped charges, and to study the mechanism by which the jets from shaped charges were able to penetrate deeply into armor plate, plastic armor, and other materials.

L545

Carnegie Institute of Technology (OEMsr-950).
COMPARISON OF HEADED AND NONHEADED NO. 8 DETONATORS USED IN INITIATING M9A1 SHAPED CHARGES, by R. J. Lew and R. J. Eichelberger. June 1, 1944, 4p. diagr. (Armor and Ordnance memo. no. A-92M, NDRC Div. 2) OSRD 3715 Confidential

A number of tests using similar M9A1 shaped charges shows that charges initiated with headed detonators gave a larger average penetration and a smaller standard deviation than charges initiated with nonheaded detonators.

L546

Carnegie Institute of Technology (OEMsr-950).
A THEORY OF TARGET PENETRATION OF JETS, by E. M. Pugh. June 5, 1944, 42p. incl. illus. diagrs. (Armor and Ordnance rept. no. A-274, NDRC Div. 2) OSRD 3752 Confidential

Experimental facts which must be considered in setting up a theory that could explain the penetration of jets from lined shaped charges are listed. A section which treats body penetrations and neglects surface affects is included. The effects of the back surfaces of target plates upon the residual penetrations of jets were investigated.

L547

Carnegie Institute of Technology (OEMsr-950).
TESTS OF PLASTIC MATERIALS, by E. M. Pugh and others. Aug. 18, 1944, 9p. diagr. (Armor and Ordnance rept. no. A-288, NDRC Div. 2) OSRD 4046 Confidential

Tests have been completed to determine the relative effectiveness of different types of plastic armor as protection against attack by shaped charges. Comparative tests of the effectiveness of various types and concentrations of particles, which were mixed with bitumen, were made by means of a "merit" ratio.

L548

Carnegie Institute of Technology [OEMsr-950].
DEFENSE OF CONCRETE FORTIFICATIONS AGAINST SHAPED CHARGES, by E. M. Pugh and G. H. Winslow. Sept. 15, 1944, 3p. incl. table. (Monthly rept. OTB-2f, NDRC Div. 2) OSRD 4148f Confidential

Preliminary tests on 15-in. slabs were made to investigate possible target sizes and problems involved. These tests indicated that in thick concrete, penetration does not depend on target size, concrete strength, or type of reinforcing.

L549

Carnegie Institute of Technology [OEMsr-950].
DEFENSE OF CONCRETE FORTIFICATIONS AGAINST SHAPED CHARGES, by E. M. Pugh and G. H. Winslow. Nov. 15, 1944, 5p. incl. tables, diagrs. (Monthly rept. OTB-4d, NDRC Div. 2) OSRD 4357d Confidential

Woven wire mesh was used to reinforce a 7-ft. wall prototype. The dimensions of the prototype and of the scaled prototype are compared.

L550

Carnegie Institute of Technology [OEMsr-950].
DEFENSE OF CONCRETE FORTIFICATIONS AGAINST SHAPED CHARGES, by E. M. Pugh and G. H. Winslow. Apr. 15, 1945, 5p. incl. tables, diagr. (Monthly rept. OTB-9g, NDRC Div. 2) OSRD 4948g Confidential

Work was started on a series of shots to determine the minimum thickness of solid concrete and of spaced concrete for complete protection against shaped charges.

L551

Carnegie Institute of Technology [OEMsr-950].
DEFENSE OF CONCRETE FORTIFICATIONS AGAINST SHAPED CHARGES, by E. M. Pugh and G. H. Winslow. May 15, 1945, 6p. incl. tables, diagrs. (Monthly rept. OTB-10b, NDRC Div. 2) OSRD 5094b Confidential

An investigation was made to obtain targets that will defeat shaped charges. Measurements of residual penetrations into mild steel placed behind reinforced concrete slabs protected by 0.25-in. mild steel front plates showed that concrete behaved like a homogeneous material when attacked by a shaped charge.

L552

Carnegie Institute of Technology [OEMsr-950].
DEFENSE OF CONCRETE FORTIFICATIONS AGAINST SHAPED CHARGES, by E. M. Pugh and G. H. Winslow. July 15, 1945, 14p. incl. illus. diagrs. (Monthly rept. OTB-12d, NDRC Div. 2) OSRD 5350d Confidential

Data obtained on the attack of a scale-model concrete fortification wall by the CIT standard charge are presented.

L553

Carnegie Institute of Technology [OEMsr-950].
FUNDAMENTAL PRINCIPLES OF JET PENETRATION; SECONDARY PENETRATION IN HOLLOW CHARGE TARGETS, by R. J. Eichelberger. Sept. 15, 1944, 5p. incl. table, diagrs. (Monthly rept. OTB-2g, NDRC Div. 2) OSRD 4148g Confidential

An experimental investigation of penetration by shaped charges in targets was made. Additional penetration was accounted for by the Pugh theory, but not by the Hill-Mott-Pack theory.

L554

Carnegie Institute of Technology [OEMsr-950].
FUNDAMENTAL PRINCIPLES OF JET PENETRATION; SECONDARY PENETRATION IN HOLLOW-CHARGE TARGETS, by E. M. Pugh and R. J. Eichelberger. Nov. 15, 1944, 4p. incl. table, diagr. (Monthly rept. OTB-4e, NDRC Div. 2) OSRD 4357e Confidential

Tests on targets of combined mild steel and armor are reported. Data are shown for primary and secondary jet penetration produced by varying position of armor plate in a pile of mild steel plates.

L555

Carnegie Institute of Technology [OEMsr-950].
PROTECTION OF ARMORED VEHICLES AGAINST SHAPED CHARGES. DYNAMIC TESTS OF PLASTIC AND STEEL ARMOR COMBINATIONS, by E. M. Pugh. Sept. 15, 1944, 4p. incl. tables. (Monthly rept. OTB-2e, NDRC Div. 2) OSRD 4148e Confidential

Dynamic tests against HCR1 and HCR2 with the M6A3 (Bazooka) and an experimental shaped charge projectile were carried out.

L556

Carnegie Institute of Technology [OEMsr-950]. PROTECTION OF ARMORED VEHICLES AGAINST SHAPED CHARGES. STATIC TESTS OF PLASTIC AND STEEL ARMOR COMBINATIONS, by E. M. Pugh and R. J. Eichelberger. Sept. 15, 1944, 4p. incl. table, diagrs. (Monthly rept. OTB-2d, NDRC Div. 2) OSRD 4148d. Confidential

Two plastic materials, HCR1 composed of 50% atomized Al, 40% asphalt and 10% wood flour, and HCR2 composed of 80% Lilesville gravel (0.75 in. to 2.25 in.), 15% asphalt, and 5% wood flour, were developed to protect armored vehicles against shaped charges.

L557

Carnegie Institute of Technology [OEMsr-950]. CORRELATION BETWEEN RESIDUAL PENETRATION OF SHAPED CHARGES IN MILD STEEL AND PERCENTAGE OF PERFORATIONS IN HOMOPLATE, by E. M. Pugh and R. J. Eichelberger. Oct. 15, 1944, 6p. incl. table, diagrs. (Monthly rept. OTB-3b, NDRC Div. 2) OSRD 4258b Confidential

The method of obtaining correlation of residual penetration in mild steel and percentage of perforation in homoplate is described. Better judgment as to which combinations of plastic armor and homoplate are effective against the standard charge will be obtained from this correlation.

L558

Carnegie Institute of Technology [OEMsr-950]. PROTECTION AGAINST SHAPED CHARGES AFFORDED BY SPACED ARMOR, by E. M. Pugh and R. J. Eichelberger. Oct. 15, 1944, 4p. incl. tables, diagr. (Monthly rept. OTB-3c, NDRC Div. 2) OSRD 4258c Confidential

Preliminary experiments are reported in which spaced armor was used to decrease the weight of protection needed for armored vehicles. An attempt was made to gain some advantage by spacing the front plate, which is used to protect plactic armor, from the front surface of the plastic.

L559

Carnegie Institute of Technology [OEMsr-950]. SCALING LAWS FOR CONCRETE TARGETS ATTACKED BY SHAPED CHARGES, by E. M. Pugh and G. H. Winslow. Oct. 15, 1944, 3p. incl. diagr. (Monthly rept. OTB-3d, NDRC Div. 2) OSRD 4258d Confidential

The importance of perforation of slabs necessitated more rigid control of the concrete than if penetrations alone into massive concrete were to be measured. Princeton and British scaling laws for penetration by lined charges are presented.

L560

Carnegie Institute of Technology [OEMsr-950]. FUNDAMENTALS OF JET PENETRATION; THEORY OF JET PENETRATION, by E. M. Pugh and E. L. Fireman. Nov. 15, 1944, 10p. incl. diagrs. (Monthly rept. OTB-4f, NDRC Div. 2) OSRD 4357f Confidential

The differential equation for jet penetration was solved without any approximations. This new expression for primary penetrations vs. standoff agrees with experimentation at large but not at small standoff. A numerical example is shown which relates the theoretical and experimental penetration-standoff results for mild steel targets.

L561

Carnegie Institute of Technology [OEMsr-950]. PROTECTION OF ARMORED VEHICLES AGAINST SHAPED CHARGES, EFFECT OF PARTICLE SIZE, GRADING, AND COMPOSITION UPON STOPPING POWER OF LILESVILLE GRAVEL PLASTICS, by E. M. Pugh and R. J. Eichelberger. Nov. 15, 1944. 4p. incl. tables. (Monthly rept. OTB-4c, NDRC Div. 2) OSRD 4357c Confidential

Tests were made in an attempt to find some method of improving the HCR2. The gravel size and grading were varied. Experiments showed that HCR2 composition (80% gravel, 20% type-B mastic) could not be improved to any appreciable extent.

L562

Carnegie Institute of Technology [OEMsr-950]. DYNAMIC TESTS ON HCR2 AT ABERDEEN, by E. M. Pugh and R. J. Eichelberger. Dec. 15, 1944, 10p. incl. tables. (Monthly rept. OTB-5c, NDRC Div. 2) OSRD 4477c Confidential

Tests were made to find some combination of plastic armor and front plate that would stand up under attack by HE and AP ammunition, and afford protection for an M4 tank against shaped charge ammunition. Tests were made with 105-mm. HEAT and Panzerfausts.

L563

Carnegie Institute of Technology [OEMsr-950]. FUNDAMENTAL PRINCIPLES OF JET PENETRATION. STUDIES OF CONTROL SHOTS, by W. H. Bessey and others. Dec. 15, 1944, 9p. incl. illus. diagrs. (Monthly rept. OTB-5d, NDRC Div. 2) OSRD 4477d Confidential

An investigation was made to improve the uniformity of charges, and to reduce or eliminate the variability in their performance. Frequency distributions for penetrations produced by CIT charges in massive mild steel at 2-, 4-, and 6-in. standoffs are shown.

L564

Carnegie Institute of Technology [OEMsr-950]. DEFENSE OF ARMORED VEHICLES AGAINST SHAPED CHARGES. WEIGHTS AND THICKNESSES OF PROTECTIVE SLABS, by E. M. Pugh and E. Fireman. Mar. 15, 1945, 3p. incl. diagr. (Monthly rept. OTB-8g, NDRC Div. 2) OSRD 4829g Confidential

Calculations were made for weights and thicknesses of slabs filled with protective materials of different densities that must be added to protect an M4 tank against a large shaped charge.

L565

Carnegie Institute of Technology [OEMsr-950]. FUNDAMENTALS OF PENETRATION BY JETS, by E. Fireman and E. M. Pugh. Mar. 15, 1945, 16p. incl. diagrs. (Monthly rept. OTB-8h, NDRC Div. 2) OSRD 4829h Confidential

The method of calculating residual penetration is described which makes use of the penetration-standoff curve. Experiments to check the curves using water, Pb, and 24ST Al are reported.

L566

Carnegie Institute of Technology [OEMsr-950]. FUNDAMENTALS OF PENETRATION BY JETS, by E. M. Pugh and E. Fireman. Apr. 15, 1945, 9p. incl. diagrs. (Monthly rept. OTB-9h, NDRC Div. 2) OSRD 4948h Confidential

An investigation was made to determine whether a series of slabs containing materials of different densities could be arranged to afford better protection than that of a single homogeneous material having the same total weight and thickness. Residual penetration equations are presented.

L567

Carnegie Institute of Technology [OEMsr-950]. PROTECTION OF ARMORED VEHICLES AGAINST SHAPED CHARGES. USE OF CHEMICAL COMPOUNDS, by E. M. Pugh and R. J. Eichelberger. Mar. 15, 1945, 7p. incl. table, diagr. (Monthly rept. OTB-8f, NDRC Div. 2) OSRD 4829f Confidential

Tests on oxidizing agents and inert materials to defeat shaped charges were made. Substances included were NH_4NO_3, Na_2CO_3, $KClO_4$, MgO_2, sand (dry), air, steel, etc.

L568

Carnegie Institute of Technology [OEMsr-950]. COMPARISON OF HCR2 WITH METALS OF COMPARABLE DENSITY AS DEFENSE AGAINST SHAPED CHARGES, by E. M. Pugh and R. J. Eichelberger. Apr. 15, 1945, 3p. incl. table. (Monthly rept. OTB-9f, NDRC Div. 2) OSRD 4948f Confidential

HCR2 was compared with homogeneous materials of comparable density (Dowmetal, 24ST Al alloy) to find under what conditions HCR2 afforded superior protection against shaped charges.

L569

Carnegie Institute of Technology [OEMsr-950]. NEW TYPES OF PLASTIC ARMOR FOR DEFENSE AGAINST SHAPED CHARGES, by E. M. Pugh and R. J. Eichelberger. Apr. 15, 1945, 5p. incl. table. (Monthly rept. OTB-9e, NDRC Div. 2) OSRD 4948e Confidential

Plastics ranging in density from 0.62 to 2.16 g./cc. were tested. Plastics containing hard steel balls, glass marbles, etc., were also tested.

L570

Carnegie Institute of Technology [OEMsr-950]. SPIKE DEFENSE AGAINST SHAPED CHARGES. [I], by E. M. Pugh and R. J. Eichelberger. Apr. 15, 1945, 12p. incl. table, diagrs. (Monthly rept. OTB-9d, NDRC Div. 2) OSRD 4948d Confidential

Long spikes were developed to destroy the jet action instead of absorbing the penetrating energy of shaped charges. Test results showed that these spike targets completely defeated the M6A3 bazooka at normal incidence and at all angles up to at least 45°.

L571

Carnegie Institute of Technology [OEMsr-950]. SPIKE DEFENSE AGAINST SHAPED CHARGES. II, by E. M. Pugh and R. J. Eichelberger. June 15, 1945, 7p. incl. table, illus. (Monthly rept. OTB-11a, NDRC Div. 2) OSRD 5220a Confidential

Work continued on spikes for defeating the M6A3 bazooka in an attempt to reduce the length and weight of the spikes, and to make them less vulnerable to damage by blast and fragments. Tests were made on 5/8-in. diameter drill rod spikes fired at a range of approximately 20 ft., and at 0°, 20°, and 40° angles of incidence.

L572

Carnegie Institute of Technology [OEMsr-950]. SPIKE DEFENSE AGAINST SHAPED CHARGES. III, by E. M. Pugh and R. J. Eichelberger. July 15, 1945, 6p. incl. illus. diagr. (Monthly rept. OTB-12c, NDRC Div. 2) OSRD 5350c Confidential

Tests were made with the M6A3 bazooka on targets with greater spacing of spikes to determine how much spacing is possible and other conditions that must be met with increased spacing. The spikes were made of drill rod, hardened to approximately 430 Brinell, and were press-fitted into 0.75-in. mild steel plates.

L573

Carnegie Institute of Technology [OEMsr-950]. COMPOSITE TARGETS OF HCR2, STEEL, AND 24ST ALUMINUM. [I], by E. M. Pugh and others. May 15, 1945, 8p. incl. table, diagrs. (Monthly rept. OTB-10c, NDRC Div. 2) OSRD 5094c
Confidential

Test results are given for composite targets of HCR2, steel, and 24ST Al. The experimental data are given with the equivalent thicknesses, equivalent weights, and ratios of experimental to theoretical values of residual penetration.

L574

Carnegie Institute of Technology [OEMsr-950]. COMPOSITE TARGETS OF HCR2, STEEL, AND 24ST ALUMINUM. II, by E. M. Pugh and others. June 15, 1945, 8p. incl. table, diagrs. (Monthly rept. OTB-11c, NDRC Div. 2) OSRD 5220c
Confidential

Work was continued to find some combination of HCR2, steel, and 24ST Al that would provide better protection against shaped charges. Changes of areal density and thickness were kept at a minimum.

L575

Carnegie Institute of Technology [OEMsr-950]. PENETRATION-STANDOFF CURVE FOR GERMAN PANZERFAUST AND VARIOUS TARGETS TESTED WITH PANZERFAUST, by E. M. Pugh and R. J. Eichelberger. May 15, 1945, 9p. incl. table, diagrs. (Monthly rept. OTB-10a, NDRC Div. 2) OSRD 5094a
Confidential

Combinations of homoplate and HCR2 designed to give increased AP protection were tested against statically and dynamically fired Panzerfausts. The penetration-standoff curve is shown which was obtained when the Panzerfausts were fired statically into stacks of the homoplate combinations.

L576

Carnegie Institute of Technology [OEMsr-950]. SPACED ARMOR, by E. M. Pugh and others. May 15, 1945, 6p. incl. tables, diagr. (Monthly rept. OTB-10d, NDRC Div. 2) OSRD 5094d
Confidential

Experimental results from spaced armor as a protection against shaped charges are presented. The spaced armor targets were chosen to be comparable with a standard target of 4 in. of HCR2 and 0.25-in. mild steel face plate.

L577

Carnegie Institute of Technology [OEMsr-950]. SPACED STEEL TARGETS, by E. M. Pugh and others. June 15, 1945, 4p. incl. table. (Monthly rept. OTB-11b, NDRC Div. 2) OSRD 5220b
Confidential

Homoplate and mild steel targets were compared in order to determine the difference in surface effect in spaced metal targets. Data are presented for a homoplate target tested previously, and for a mild steel target tested at 0.5-and 2-in. standoffs with the statically fired CIT standard charge.

L578

Carnegie Institute of Technology [OEMsr-950]. PENETRATION-STANDOFF CURVES FOR CIT STANDARD CHARGE AND M6A3 BAZOOKA; SECONDARY PENETRATION CURVES FOR STANDARD CHARGE, by E. M. Pugh and R. J. Eichelberger. July 15, 1945, 12p. incl. tables, diagrs. (Monthly rept. OTB-12b, NDRC Div. 2) OSRD 5350b
Confidential

Penetration-standoff curves are shown for CIT standard charges fired into mild steel and homoplate, and for the M6A3 bazooka fired into mild steel. From these curves, an approximate curve of secondary penetration in mild steel as a function of standoff was deduced for the standard charge.

L579

Carnegie Institute of Technology [OEMsr-950]. PERFORMANCE OF HOLLOW-CHARGE WEAPONS, by W. H. Bessey and others. July 15, 1945, 17p. incl. tables, diagrs. (Monthly rept. OTB-12f, NDRC Div. 2) OSRD 5350f
Confidential

Factors investigated which affect the performance of hollow charge weapons include over-all shape and size of the projectile, type and amount of explosive, and the construction and shape of the liner. Various German, Japanese, and US weapons and shells are discussed.

L580

Carnegie Institute of Technology [OEMsr-950]. SPACED 24ST ALUMINUM-TARGETS, by E. M. Pugh and others. July 15, 1945, 7p. incl. tables, diagrs. (Monthly rept. OTB-12e, NDRC Div. 2) OSRD 5350e
Confidential

Targets made up of spaced plates of 24ST Al were tested against statically fired charges. Results are included of variation of number of plates, variation of air space, effect of steel face plate, and effect of light material in place of air.

L581

Carnegie Institute of Technology [OEMsr-950]. FUNDAMENTALS OF JET PENETRATION, by E. M. Pugh and E. L. Fireman. Aug. 15, 1945, 17p. incl. tables, diagrs. (Monthly rept. OTB-13e, NDRC Div. 2) OSRD 5462e
Confidential

A penetration-standoff relation was developed which converged so rapidly that the first approximation fitted the available experimental curves satisfactorily. Penetration-standoff curves fitted for the bazooka M6A3, German Panzerfaust, and several CIT charges give the magnitude of various jet properties which in turn can be correlated with the charge design and the care used in manufacture.

L582

Carnegie Institute of Technology [OEMsr-950]. GLASS TARGETS, by E. M. Pugh and others. Aug. 15, 1945, 6p. incl. tables, diagrs. (Monthly rept. OTB-13c, NDRC Div. 2) OSRD 5462c Confidential

Glass targets (plastic armor composed of 80% Akrolith glass marbles 0.75-in. in diameter and 20% type B wood-flour mastic, and glass plates of heavy and hammered glass) were tested as protection against shaped charges, and compared with other target types.

L583

Carnegie Institute of Technology [OEMsr-950]. STATISTICAL ANALYSIS OF SHAPED-CHARGE EXPERIMENTS, by E. M. Pugh and others. Aug. 15, 1945, 13p. incl. table, diagrs. (Monthly rept. OTB-13d, NDRC Div. 2) OSRD 5462d Confidential

A method for analyzing the penetrations obtained with shaped charges fired into identical targets is proposed. The analysis indicated that the frequency distribution of measurements depended upon the charges, standoff, target composition, and target thickness.

L584

Carnegie Institute of Technology (OEMsr-950). PROTECTION AGAINST SHAPED CHARGES, by E. M. Pugh and others. Final rept. Aug. 1, 1943-Nov. 10, 1945. Feb. 1946, 302p. incl. illus. diagrs. (NDRC rept. no. A-384, Div. 2) OSRD 6384 Confidential

This final rept. covers jet penetration fundamentals, protection of armored vehicles against shaped charge weapons, and defense of concrete fortifications against shaped charges. Appendixes are included on performance of shaped charge weapons, radiographic studies of shaped charges, method of curve fitting, derivation of a consistent residual penetration theory, specifications for charges used in testing protection for armored vehicles, statistical analysis of shaped charge experiments, and correlation between residual penetrations and percentage protection afforded by various protective armors.

L585

Carnegie Institute of Technology (W36-061-ORD-2773). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh. Bimonthly rept. no. 1. Feb. 1, 1946, 5p. Confidential

(Not indexed; material covered in final rept., this contract, item no. L588.)

L586

Carnegie Institute of Technology (W36-061-ORD-2773). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh. Bimonthly rept. no. 2. Apr. 1, 1946, 22p. illus. diagrs. Confidential

(Not indexed; material covered in final rept., this contract, item no. L588.)

L587

Carnegie Institute of Technology (W36-061-ORD-2773). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh. Bimonthly rept. no. 3. June 1, 1946, 55p. incl. tables, diagrs. (Rept. no. CIT-ORD-3) Confidential

(Not indexed; material covered in final rept., this contract, item no. L588.)

L588

Carnegie Institute of Technology (W36-061-ORD-2773). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh. Final rept. June 30, 1946, 92p. incl. illus. diagrs. TIP C51798 Confidential

The primary purpose of the investigation of the fundamentals of shaped charges is discussed. Results of measurements of jet velocity and penetration velocity for standard shaped charges fired into steel and glass targets are given and compared and are used to calculate jet characteristics which may be inferred from the completed experiments. A study was made to try to determine the kind of asymmetry of charge construction which is chiefly responsible for poor performance of seemingly well made charges. Various types and thicknesses of glass targets were investigated and definite conclusions were drawn regarding the effect of different variables on the stopping powers of the targets. An attempt at a theoretical explanation of the phenomena encountered is included. An attempt is made to adapt Bethe's theory for the penetration of armor by projectiles to shaped charge jets. Curves are given for the hole volume in mild steel and armor plate as a function of standoff. Bethe's dynamic theory is also discussed and applied to shaped charges.

L589

Carnegie Institute of Technology (W36-061-ORD-2773) [W36-061-ORD-2879]. FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh. Bimonthly rept. no. 4. [Bimonthly rept. no. 1]. Aug. 1, 1946, 29p. incl. illus. diagrs. (Rept. no. CIT-ORD-4) Confidential

A description of 2 electronic methods (method I, "break" system and method II, "make" system) of measuring jet velocity and penetration velocity of shaped charge jets against various target materials (steel and glass) is presented. A mathematical method for calculating hole contours from a theory developed for the penetration of armor by projectiles and from measurements of jet and penetration velocities is described. Results are given for application of this theory to hole contours in mild steel and armor plate at a standoff of 2 in. A formal calculation which leads to a bulge in the hole contour is included.

L590

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 2. Oct. 31, 1946, 49p. incl. illus. diagrs. (Rept. no. CIT-ORD-5) Confidential

Detailed experiments on velocity of target penetration (using the electronic method of measurement) and on jet collection are described. The effects on charge performance of scrap Pentolite, and pouring temperature of molten Pentolite, were investigated. Work was continued on the stopping power of glass targets against jets from Cu and steel liners.

L591

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 3. Dec. 31, 1946, 25p. incl. tables, diagrs. (Rept. no. CIT-ORD-6) Confidential

An investigation was made, using the rotating mirror camera, of the penetrating characteristics and the velocity gradient of the jet formed by an M9A1 Cu liner.

L592

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 4. Feb. 28, 1947, 106p. incl. tables, diagrs. (Rept. no. CIT-ORD-7) Confidential

The effects of variations in standoff upon the penetration phenomenon were studied. Comparisons of penetration in various target materials were made. Charges of various types of explosives, confined and unconfined, were tested. A mathematical analysis of standoff experiments is appended.

L593

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 5. Apr. 30, 1947, 46p. incl. tables, diagrs. (Rept. no. CIT-ORD-8) TIP C393 Confidential

A study of the characteristics of the jet formed by the Cu lined S2 charge was completed. A new chemical method for separating collected jet particles from waste material is described. Revised mass measurements are given for a set of jet collection experiments.

L594

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 6, annual summary. June 30, 1947, 205p. incl. illus. diagrs. (Rept. no. CIT-ORD-9) TIP C50209 Confidential

A reprint of the paper "Explosives with Lined Cavities" by Birkhoff, MacDougall, Pugh, and Taylor is included. Techniques are described for measuring penetration depth, hole volume, jet velocities, penetration times, jet masses, and momentum and energy. Experimental results are given for velocity distribution measurements in jets. A comparison was made of velocity distributions for P2, S2, and CA4 charges. Two mechanisms were proposed which may explain the presence of a velocity gradient. Pugh's model of the jet and the penetration process were shown to substantiate experiments with mild steel targets at various standoffs. A casting technique is described which gives more consistent charges than have been obtainable. A performance specification for the manufacture of shaped charges is discussed. An experiment was proposed which may help to decide which of 2 mechanisms (1 based on penetration data, and the other based on velocity data) is of primary importance in explaining the abnormal stopping power of glass. A method is given for calculating hole profiles based on an adaptation theory for armor penetration by projectiles and on measurements of jet and penetration velocities.

L595

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 7. Aug. 31, 1947, 40p. incl. illus. diagrs. (Rept. no. CIT-ORD-10) TIP C394 Confidential

Experiments concerning the effect of gas pressure inside the liner on the formation of a shaped charge jet are reported, and it was concluded that no measurable effect on the characteristics of the jet is made by Mach waves. Test results from cylindrical liners are compared with standard lined charge results. Curves of penetration depth vs. standoff, and of hole volume vs. standoff, are presented. Experiments were carried out to determine the conditions under which the velocity distributions in jets from similar charges remain constant.

L596

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 8. Oct. 31, 1947, 20p. incl. diagrs. (Rept. no. CIT-ORD-11) TIP C957 Confidential

The procedure used in correlating charge performance with liner imperfections is described.

A special mechanism postulated to explain the weakening of glass with increasing depth of penetration is discussed.

L597

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 9. Dec. 31, 1947, 57p. incl. graphs, diagrs. (Rept. no. CIT-ORD-12) TIP C957 Confidential

Experiments on the use of explosives as protection against shaped charges are reported. Experimental results of an investigation of liner imperfections made with specially measured steel liners are given. A discussion of basic statistical concepts and quantities and of distributions encountered in shaped charge work is presented.

L598

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 10. Feb. 29, 1948, 54p. incl. tables, diagrs. (Rept. no. CIT-ORD-13) TIP C957 Confidential

Experiments to determine whether an after-jet could be formed by extrusion from the slug were performed. Jet recovery tests with M9A1 steel conical liners were made. Slug recovery results were correlated with jet collection data. An attempt to correlate geometric liner imperfections and charge performance was made.

L599

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and R. von Heine-Geldern. Bimonthly rept. no. 11. Apr. 30, 1948, 65p. incl. tables, diagrs. (Rept. no. CIT-ORD-14) TIP C958 Confidential

Investigations to eliminate the causes of excessive variability in shaped charge performance were undertaken. Experiments dealing with the effects of steel confinement and booster thickness on charge performance are reported. The distribution of average penetrations and standard deviations from samples of various sizes are described.

L600

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 12, annual summary. June 30, 1948, 63p. incl. tables, diagrs. (Rept. no. CIT-ORD-15) TIP C959 Confidential

A theory of jet formation is discussed. A description of the jet from an M9A1 steel conical liner from formation to target penetration is given. The investigation of charge imperfections and their effects was continued. The use of smaller samples for statistical predictions and tests with accuracy comparable to that obtainable only with large samples is being investigated.

L601

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 13. Aug. 31, 1948, 57p. incl. tables, diagrs. (Rept. no. CIT-ORD-16) TIP C1464 Confidential

Experiments are described in which the mechanisms of jet formation and target penetration for charges with hemispherical liners are compared with conical lined charges. A correlation experiment using 100 specially measured M9A1 steel liners was repeated at the place of manufacturing, so that the charges were not shipped to another point. A small but significant negative correlation between wall thickness variations and charge performance was found. The theory underlying the electro-optic (Kerr cell) shutter and the high-intensity light flash is discussed. A short bibliography on the Kerr cell is included.

L602

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 14. Oct. 31, 1948, 28p. incl. illus. diagrs. (Rept. no. CIT-ORD-17) TIP C1465 Confidential

Attempts were made to describe hole volumes at different standoffs, and hole diameters at various depths for a given standoff by using Bethe's equation together with known jet characteristics. Measurements were made of the penetration for a P2 charge fired into a mild steel target at 4-in. standoff and of cumulative hole volumes in mild steel targets.

L603

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and R. von Heine-Geldern. Bimonthly rept. no. 15. Dec. 31, 1948, 13p. incl. illus. diagrs. (Rept. no. CIT-ORD-18) TIP C1580 Confidential

A method of photographing shaped charge phenomena is described in which the shaped charge jet triggers both the light source and the shutter at the required instant. The Kerr cell used is too small to allow use of the camera at full aperture (f/1.5); all pictures taken showed some blurring due to the motion of the jet and of target particles. The experimental method was undesirable also because the triggering that takes place inside the box in which the jet is photographed produces clouding of the picture due to a spray of target material on either side of the trigger plates.

L604

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 16. Feb. 28, 1949, 84p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-19) TIP C2155 Confidential

A new theory of jet formation from metal liners, which is consistent with known experimental evidence and with the theories of detonation rates and of scaling laws for explosive phenomena, considers the whole process to be continuous instead of comprising primary and after jets. It assumes that the liner collapse velocity decreases toward the liner base. This slowing down as the detonation wave proceeds toward the base is sufficient to account for the slow portion of the jet because it decreases the speed with which the elements approach the axis to be divided into jet and slug, curves the collapsing liner into such a shape that a larger percentage of it enters the jet, and introduces a gradient into the jet that causes it to lengthen during its formation as well as after the formation is completed. A convenient method for determining the velocity distribution in a jet is presented and illustrated by comparison of the jets from M9A1 Cu and steel liners. Experimental evidence on the penetration of jets into various target materials indicates that the hydrodynamic theory seems to give a correct picture of the process except in the case of glass targets. This behavior might be attributed to their extremely high strength on rapid loading and their ability to spread the jet. Experiments arising from the Shaped Charge Symposium of Oct. 1948 on: (1) simultaneous firing of neighboring shaped charges, and (2) protection by destruction of the jet by explosive steel and explosive glass laminated targets are reported. Experimental distributions of a number of sample parameters were investigated, using 6000 "artificial" penetrations. New conclusions from this study are listed.

L605

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 17. Apr. 30, 1949, 40p. incl. table, diagrs. (Rept. no. CIT-ORD-20) TIP C2659 Confidential

Since the new theory of jet penetration is dependent upon a single mechanism of jet formation, a modified mathematical background for the theory is presented. The discussion considers the initial reaction of the liner to the impact of the detonation wave, the behavior of the collapsing liner, and the formation of the jet and slug. Mathematical details of the theory are appended.

L606

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 18, annual summary, Part I. June 30, 1949, 64p. incl. illus. diagrs. (Rept. no. CIT-ORD-21) TIP C3310 Confidential

The hydrodynamic theory of jet formation is reviewed, and its failure to explain the velocity gradient and the effect of the after-jet is noted. A modification of this theory is presented which takes into account the non-steady state existing in the phenomenon and describes the jet in its entirety. Experimental verification by velocity measurements, slug recovery, and a study of liner collapse is reported. The theory of target penetration based on Bethe's theory (including hole volume and hole profile) was reexamined. Penetration depths and times were measured at various standoffs and the results are shown graphically. It was concluded that the theory in its present form is not adequate for consideration of penetration by high speed jets, although it seems to agree very well with observations on the low speed portion of the jet.

L607

Carnegie Institute of Technology (W36-061-ORD-2879). FUNDAMENTALS OF SHAPED CHARGES, by R. von Heine-Geldern and others. Bimonthly rept. no. 18, annual summary, Part II. June 30, 1949, p. 65-102 incl. illus. diagrs. (Rept. no. CIT-ORD-21) TIP C3310 Confidential

An unexpected result was obtained when the second half of a group of charges was tested 1 year after the first half; the second half showed an increase of 14% in average penetration. No explanation of this effect was suggested. The CIT casting procedure in which a special device aligns the liner axis with the charge axis was compared with the conventional casting procedure in which the flange is used for alignment; charges made by the latter method gave a standard deviation almost 3 times greater than the former and less average penetration. Work on high speed photography is also reported. An improved Kerr cell shutter, circuit developments, and the development of the Kerr cell unit are discussed. The following experimental techniques are described: triggering, exposure by light of the jet only, photography of a shaped charge fired into a vacuum, and photography of shock waves from charges detonated under various conditions.

L608

Carnegie Institute of Technology (W36-061-ORD-2879). INVESTIGATION OF THE MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 1. Apr. 30, 1948, 16p. incl. tables, diagrs. (Rept. no. CIT-ORD-M1) TIP C59300 Confidential

Preliminary investigations have produced fragment velocities comparable to those claimed by German physicists using the Misznay-Schardin effect. The phenomenon is to be used in the design of warheads for "Wizard" guided missiles.

L609

Carnegie Institute of Technology (W36-061-ORD-2879). INVESTIGATION OF THE MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 2. June 30, 1948, 10p. incl. illus. tables. (Rept. no. CIT-ORD-M2) TIP C59301 Confidential

Experiments were performed using a new velocity measuring technique with charges supplied with flat steel discs. Additional experiments showed that increasing the length of a charge beyond 1 in. increased the energy imparted to a disc very slowly. A charge 4 in. long gave about 20% more energy to the disc than a charge 1 in. long. A number of shots were made using improved measuring techniques and improved charges to check previous results. Tests on the effect of charge length were carried out to determine the minimum length of charge required to give the desired penetrating power.

L610

Carnegie Institute of Technology (W36-061-ORD-2879). INVESTIGATION OF THE MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 3. Aug. 31, 1948, 13p. incl. illus. diagrs. (Rept. no. CIT-ORD-M3) TIP C59302 Confidential

Target damage caused by fragments from flat steel discs was investigated. The simple flat liner did not give a satisfactory pattern. Preliminary experiments on spherical shaped liners showed that such liners yielded a very satisfactory dispersion of fragments and velocities high enough to be useful in the Wizard warhead. Results of an experiment with flat plates set at an angle to the charge axis showed that regardless of obliquity, an element of a shaped liner can be expected to travel in a direction slightly toward the axis from the normal to its surface.

L611

Carnegie Institute of Technology (W36-061-ORD-2879). INVESTIGATION OF THE MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and others. Bimonthly rept. no. 4. Oct. 31, 1948, 17p. incl. illus. diagrs. (Rept. no. CIT-ORD-M4) TIP C59303 Confidential

A preliminary study of scaling effects in Misznay-Schardin charges indicated that for geometrically similar charges the velocity of fragments was independent of charge dimensions and that the depth of penetration by the fragments increased linearly with charge dimensions. Tests were carried out in an attempt to control the fragment size.

L612

Carnegie Institute of Technology (W36-061-ORD-2879). INVESTIGATION OF THE MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and others. Bimonthly rept. no. 5. Dec. 31, 1948, 27p. incl. illus. diagrs. (Rept. no. CIT-ORD-M5) TIP C59304 Confidential

Experimental results on the effect of charge design upon penetrating power of the Misznay-Schardin fragments showed that for every charge design there is an optimum liner thickness that gives the most penetrating fragments, but this optimum thickness depends upon the charge dimensions. Tests with simulated warheads showed that fragments that are barely capable of perforating the casing can detonate the charge if their initial velocity is sufficiently high; the fragment capable of the greatest depth of penetration is not necessarily the most effective for detonating target charges. An exploratory liner design intended to produce the uniform distribution of fragments desired for the Wizard warhead was tested.

L613

Carnegie Institute of Technology (W36-061-ORD-2879). INVESTIGATION OF THE MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and others. Bimonthly rept. no. 6. Feb. 28, 1949, 31p. tables, diagrs. (Rept. no. CIT-ORD-M6) TIP C59305 Confidential

Tests on controlled fragmentation showed that the size of fragments projected from the end of a high explosive charge can be controlled, within limits, by cutting grooves in the liner. An investigation of the vulnerability of cased high explosive charges to initiation by high velocity fragments substantiated earlier conclusions that provided a fragment has sufficient kinetic energy to perforate the casing, its velocity after perforation is the critical factor in determining whether or not it will cause initiation. One test was made with 1:5 scale prototype charge in connection with the Wizard warhead. The charge was cylindrical in shape and had a flat disc steel liner. Results showed that: (1) control over fragment size was not complete; (2) penetrating power of the fragments was satisfactory since nearly all fragments that hit within the critical area perforated the target; (3) the distribution of fragments was fairly satisfactory; and (4) there were visible on the target only a few pits due to fragments that lay outside the desired cone of dispersion. Tests were carried out on charges with half or totally imbedded steel balls in the development of the fragment gun. The only tests that were even partially successful were those in which steel bearing balls were completely imbedded in Pentolite charges.

L614

Carnegie Institute of Technology (W36-061-ORD-2879). INVESTIGATION OF THE MISZNAY-SCHARDIN EFFECT, by E. M. Pugh. Bimonthly rept. no. 7. Apr. 30, 1949, 14p. incl. tables, diagrs. (Rept. no. CIT-ORD-M7) TIP C59306 Confidential

The experimental data obtained so far on the Misznay-Schardin effect are recapitulated. The charges used in the experiments were 50/50 Pentolite covered at 1 end with an integral steel disc, plain or grooved, or a single layer of steel balls. These data were used to design prototype charges and to predict their performance. Controlled fragmentation, fragment velocity, and fragment penetration (according to the de Marre formula) are discussed. It was concluded that very probably the Misznay-Schardin effect can be used as the basis of a satisfactory warhead for the Wizard missile.

L615

Carnegie Institute of Technology (W36-061-ORD-2879). INVESTIGATION OF THE MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 8. June 30, 1949, 21p. incl. illus. diagrs. (Rept. no. CIT-ORD-M8) TIP C59307 Confidential

Results of controlled fragmentation tests with grooved steel discs showed that a ratio of charge diameter to liner thickness of at least 20 $\left(\frac{D}{t}\right)$ was necessary for satisfactory control of fragment size. Neglecting small diameter charges, results showed that groove depth was unimportant; liners having ratios of groove depth to liner thickness of 0.32, 0.50, and 0.64 gave essentially uniform results over a wide variety of conditions. The minimum value of groove spacing to disc thickness for complete control was judged to be between 1.0 and 2.0 $\left(\frac{S}{t}\right)$. Charges fired to study the characteristics of fragment charges based on the end effect indicated that a simple flat or spherical charge end would not yield an efficient distribution of fragments. The most efficient shape for the charge end depended upon the aspect ratio (ratio of length to diameter) of the charge and possibly upon the liner used.

L616

Carnegie Institute of Technology (W36-061-ORD-2879). ROTATED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 1. Aug. 31, 1948, 43p. incl. illus. diagrs. (Rept. no. CIT-ORD-R1) TIP C59308 Confidential

Experiments are described in which the principle of fluting liners to minimize the effect of rotation was investigated. Calculations made from the theory with fluted trumpet and conical liners disagreed with experimental results; reasons for the disagreement are discussed. A discussion is appended on the design of a fluted liner to produce optimum penetration when rotated at 320 r.p.s.

L617

Carnegie Institute of Technology (W36-061-ORD-2879). ROTATED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 2. Oct. 31, 1948, 18p. incl. illus. diagrs. (Rept. no. CIT-ORD-R2) TIP C59309 Confidential

Tests on fluted liners added further evidence in favor of the use of these liners for the counteraction of the detrimental effects of rotation. Slug recovery experiments substantiated indications from volume measurements that rotation causes the energy of a jet to be spread over a larger area but does not affect the fundamental process of liner collapse and jet formation.

L618

Carnegie Institute of Technology (W36-061-ORD-2879). ROTATED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 3. Dec. 31, 1948, 23p. incl. illus. diagrs. (Rept. no. CIT-ORD-R3) TIP C59310 Confidential

Tests with trumpet shaped liners indicated that in all respects they are equal in effectiveness to conical liners. Tests with deeply fluted conical liners showed that it is possible to compensate for high rotational velocities and that the optimum velocity was at least roughly proportional to the flute depth. Extensive slug recovery experiments with conical liners substantiated earlier evidence that the basic processes of liner collapse and jet formation were not affected by rotation of the charge.

L619

Carnegie Institute of Technology (W36-061-ORD-2879). ROTATED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 4. Feb. 28, 1949, 10p. incl. tables. (Rept. no. CIT-ORD-R4) TIP C59311 Confidential

Five groups of Cu liners made by drawing and electro-deposition were fired; all had the same basic design (42° angle 1.69-in. base diameter, 0.045-in. wall thickness) each with 16 flutes of varying depths. Test results showed the change in flute shape by milling was sufficient to change completely the liner performance characteristics. Results obtained with the apex sections of liners and observations of twisted flute liners on recovered slugs showed that when the flute depth is a linear function of the radius, each small ring element of the liner is compensated at a different rotational velocity. When the flute depth is large, the variation in the compensation velocity along the liner for the various elements is so rapid that there is no single velocity at which an appreciable part of the liner is compensated.

L620

Carnegie Institute of Technology (W36-061-ORD-2879). ROTATED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 5. Apr. 30, 1949, 13p. incl. illus. diagrs. (Rept. no. CIT-ORD-R5) TIP C59312 Confidential

Data on fluted liners for rotated charges obtained so far are summarized. Data are given also for 2 new fluted liners, 1 having a maximum flute depth at the base of 0.016 in. (group X), and the other having a maximum depth of 0.025 in. (group XI). Both groups were made of standard basic Cu liners. For group X, maximum penetration of about 8.4 in. occurred at about 90 ft./sec.; while for group XI, maximum penetration of about 8.8 in. occurred at about 150 ft./sec.

L621

Carnegie Institute of Technology (W36-061-ORD-2879). ROTATED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 6, annual summary. June 30, 1949, 26p. incl. illus. diagrs. (Rept. no. CIT-ORD-R6) TIP C59313 Confidential

All data obtained during the first year of experimental investigation with fluted liners are discussed. New fluted Cu liners (16 flutes, maximum depth 0.035 in.) were fired from a 6-in. standoff into mild steel targets. Maximum penetration depths were 6.8 in. and 6.7 in. at ±330 and ±360 r.p.s.; the hole volumes for these shots were 12.3 and 14.6 cm. These values, compared with those obtained from the same basic type of liner without fluting and fired statically, indicated that 73% compensation had been achieved. It was concluded that fluted liners could be manufactured to counteract the detrimental effects of rotation to such an extent that, at some rotational velocity, they would perform as well as similar smooth liners fired statically, and that good compensation could be achieved with rounded flutes.

L622

Carnegie Institute of Technology (W36-061-ORD-2879). SURVEY OF DEVICES FOR PROTECTING ARMORED VEHICLES AGAINST SHAPED CHARGES. CHARGES WITH LINED CONICAL CAVITIES, by E. M. Pugh. Special rept. June 30, 1949, 16p. TIP C3306 Confidential

Devices for protecting tanks from shaped charge weapons are discussed in considerable detail; an estimation of the value of each is given after the advantages and disadvantages are commented upon. The devices are: spikes, small shaped charges, wire screens, HE between metal or glass sheets, chemical compositions, low-density materials, Al alloy plate, Mg alloy, glass blocks and glass plates, plastic armor, spaced armor, and skirting plates. The 3 devices considered practical are: fastening steel spikes to the armor plate, combining hard Al armor plate on the outside with homogeneous steel armor on the inside, and combining glass blocks or spaced glass plates in a steel panel on the outside with homogeneous steel armor on the inside.

L623

Carnegie Institute of Technology (W36-061-ORD-2910). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 19. Aug. 31, 1949, 43p. incl. illus. tables. (Rept. no. CIT-ORD-22) (Formerly contract W36-061-ORD-2879) TIP C3366 Confidential

Experiments on the effect of the order of manufacture of explosive charges and the influence of different molds are reported. It was concluded that the order of manufacture had no effect on average penetration, and that penetrations contributed by the different molds could be assumed to have parent distributions with equal standard deviations but not with equal means. In the study of shaped charge jets by high speed photography, it was found that the shroud surrounding the jet was eliminated by using perfectly conical liners of the common type having flat apexes. A series of photographs show the progressive stages of perforation of a steel target; another illustrates a jet broken up into particles at relatively long standoff. The phenomena resulting from the interference of shock waves are discussed.

L624

Carnegie Institute of Technology (W36-061-ORD-2910). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 20. Oct. 31, 1949, 42p. incl. illus. diagrs. (Rept. no. CIT-ORD-23) TIP C3757 Confidential

Experiments are described in which charges lined with apex sections of various heights from M9A1 steel liners were fired into S2 Al targets. The holes produced in these targets were found to increase in depth and diameter as the height of the liner was increased, the details of which were not understandable in terms of the simple theories of jet formation, target penetration, and cavitation. Various hypotheses were considered in an attempt to explain the qualitative details of hole growth. Two classes of mechanisms are distinguished, those which involve the jet formation process, and those which involve the process of target penetration. Further experiments were carried out to evaluate the relative importance of the proposed mechanisms. Of the mechanisms that involve the jet formation process, the interaction of shock waves reflected from charge boundaries and the process of ductile drawing between the slug and jet were significant, and capable of explaining most of the details of target damage produced by sectioned liners. The "skinning" of the large diameter elements at the rear of the jet may significantly affect the process of target penetration.

L625

Carnegie Institute of Technology (W36-061-ORD-2910). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 21. Dec. 31, 1949, 40p. illus. (Rept. no. CIT-ORD-24) TIP C3758 Confidential

The first section describes an improved Kerr cell using 3 rather than the conventional 2 electrodes. It also discusses recent improvements in triggering and pulsing circuits which make synchronization, light source, and shutter opening more dependable. The second section on experimental results includes recent photographs of explosive phenomena, and shows that truly conical liners are completely free of the shroud that accompanies liners with flat apexes. The part entitled "Shaped charge jets in air" deals with the factors influencing jet diameter. "Target materials" describes the effect of shock waves from jets on glass and Plexiglass targets. The illustrations of these shock waves are considered unique, and indicate that the penetration of glass requires enough energy to melt it whereas the penetration of metal needs only enough energy to make it flow plastically. "Interactios of jets and targets" deals with the spalling that results when Cu liners are fired against steel targets, and the effects of Cu liners against glass and Plexiglass targets.

L626

Carnegie Institute of Technology (W36-061-ORD-2910). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 22. Feb. 28, 1950, 79p. incl. illus. diagrs. (Rept. no. CIT-ORD-25) TIP C52005 Confidential

The differential equation for the collapse of a shaped charge liner is transformed and an analytical solution obtained in terms of the mass division parameter β. Previous experimental techniques (slug recovery and jet collection from grooved and presectioned (multiple division) liners) for obtaining β are discussed and an improved method of slug recovery (single division liners) is described by means of which more accurate values of β are obtained. Application of the mathematical analysis to slug recovery data for 3 different liner designs (S1-Id$_2$ steel, S2-Id copper, and M9A1 steel liners) yields results that disagree with observations. An initial condition applied in the treatment, which assumes that the process is steady-state, is evidently the cause of the discrepancies. Inspection of the results indicate that, even initially the collapse process varies rapidly enough to make such a condition inapplicable.

L627

Carnegie Institute of Technology (W36-061-ORD-2910). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 23. Apr. 30, 1950, 62p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-26) TIP C52298 Confidential

A double Kerr cell camera for taking 2 pictures slightly displaced in time is described. Photographs show the manner in which detonation progresses around a corner. To determine the effect confinement had on detonation velocity, an 8-in. pentolite charge of rectangular cross section (1 in. x 0.5 in. thick) was detonated in contact with a 1-in. steel plate. The results showed that the detonation front was perpendicular to the axis of the charge; there appeared to be no change in detonation velocity due to the confinement, for if there were, the detonation front would be slanted in the direction of travel of the detonation wave or away from it, thus indicating an increase or decrease in detonation velocity. Photographs show that the tubular charge and the conical cavity charge caused more target damage than the flat-ended charge. Several methods for obtaining better pictures of shock waves are presented. Photographs are shown of jets traveling through water, producing shock waves and cavitation. Results showed that there was interference when 2 adjacent shaped charges were detonated nonsimultaneously. Additional experiments are described which were designed to detect any changes in the optical properties of the glass of the envelope seen in pictures of jets penetrating glass targets. The shape of the area in which the optical changes took place and its location with respect to the jet seemed to indicate that it was bounded by the shock wave, and that a residual strain was present inside it. The statistical analysis is continuing in which the artificial population of 6000 penetration values was used to obtain information on the sampling distribution of certain parameters (sample range, 3rd and 4th central moments, and variance ratio), in order to determine if these parameters are useful in shaped charge work.

L628

Carnegie Institute of Technology (W36-061-ORD-2910). FUNDAMENTALS OF SHAPED CHARGES, by E. M. Pugh. Bimonthly rept. no. 24. Annual summary. June 30, 1950, 66p. incl. illus. diagrs. (Rept. no. CIT-ORD-27) TIP C4781 Confidential

A system of calculation was developed based on the generalized theory of cone collapse and jet formation. The significant physical quantities associated with cone collapse and jet formation can be predicted from measurements of slug mass distribution and the velocity of the jet front. The statistical level of significance of the predicted values can be estimated. Four charge designs were analyzed. A comparison of the predicted and observed velocities of the front of a jet demonstrated that a steady-state initial condition was not obtained. The statistical level of significance of slug recovery data was improved with single-division cones. Calculations from slug recovery data of the significant quantities in cone-collapse theory are given. Results indicate that charge and cone axes should coincide within 5 min. of arc for optimum charge performance. Photographs of jets in the process of perforating steel plates

show that the amount of spall produced by the jet decreases with increased plate thickness. The simultaneous detonation of 2 shaped charges placed near each other did not interfere with the process of jet formation. When the charges were detonated at different times, poor performance was obtained from the last detonation.
(TIP abstract)

L629

Carnegie Institute of Technology (W36-061-ORD-2910). INVESTIGATION OF THE MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 9. Aug. 31, 1949, 25p. incl. diagrs. (Rept. no. CIT-ORD-M9) TIP C59314
Confidential

Experiments with 3 types of 1:4 scale charges are described. The fragment dispersions and velocities and the penetration depths are compared to specification requirements for the Wizard warhead. Two types of liner were used: 1 grooved in a "waffle" pattern and 1 composed of matrices of small, individual hexagonal pieces. The latter type gave more accurate control of fragment size. It was concluded that the Misznay-Schardin effect can be used to produce an effective warhead.

L630

Carnegie Institute of Technology (W36-061-ORD-2910). INVESTIGATION OF THE MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 10. Oct. 31, 1949, 32p. incl. illus. diagrs. (Rept. no. CIT-ORD-M10) TIP C59315
Confidential

Results of recent tests with model warhead charges show that control of fragment size by grooving liners is not as effective as had been hoped but seems to be adequate; liners composed of discrete particles will undoubtedly give better performance. Tests with numerous charge shapes have been made in an attempt to determine the principles governing the direction in which fragments are propelled by the Misznay-Schardin effect and to correct defects in the patterns of target damage obtained in earlier tests. Evidently it will be possible to calculate the modifications in charge design needed to correct an observed distribution of target damage, but the underlying principles governing fragment directions are obscure. Tests with various explosives show that Comp B and Pentolite produce essentially the same results; TNT tends to scatter the fragments more and yields lower fragment velocities. Fragment recovery tests are described and the results are tabulated.

L631

Carnegie Institute of Technology (W36-061-ORD-2910). INVESTIGATION OF THE MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 11. Dec. 31, 1949, 18p. incl. illus. diagrs. (Rept. no. CIT-ORD-M11) TIP C59316
Confidential

The usefulness of shaped charges (in the strict sense of the word) for the Wizard warhead is discussed and experimental evidence is described. It is concluded that the Misznay-Schardin effect would be superior to ordinary hollow charges at the ranges required for operation of the Wizard. The conclusion is based on the unsatisfactory performance of shaped charges at large standoffs and the difficulties that would be encountered in initiating the warhead in a manner that would produce coherent jets.

L632

Carnegie Institute of Technology (W36-061-ORD-2910). INVESTIGATION OF THE MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 12. Feb. 28, 1950, 18p. (Rept. no. CIT-ORD-M12) TIP C59317
Confidential

Basic principles derived for designing a warhead from the best available theories of fragmentation by the Misznay-Schardin effect and of penetration by fragments show that the optimum ratio of charge mass to liner mass is independent of the intrinsic energy of the explosive, the desired penetration, the total weight of the warhead, and the material and shape of the fragments. The information available yields predictions that do not agree well with those obtained by scaling laws from CIT model experiments; the experiments are considered the more reliable.

L633

Carnegie Institute of Technology (W36-061-ORD-2910). MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 13. Apr. 30, 1950, [41]p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-M13) TIP C59318
Confidential

A series of tests is described in which the charges used were scale-model warheads in all respects except that the metal liner on the end was flat instead of being curved to direct the fragments in the desired direction. The primary purpose of the experiments was to test fundamental data previously published and the distribution of the fragments at the target was considered to be of only secondary interest. The results show that charges having a shape adapted for use as Wizard warheads will yield somewhat higher fragment velocities than are predicted using the results from earlier fundamental experiments. The theory of fragment velocity does describe very well the variation with changes in charge design, if the constants are suitably adjusted. The measured depths of penetration agree reasonably well with predictions from the statistically derived equations published previously; but because of the highly questionable form of these equations, a different formula that fits the model data and which is in agreement with scaling relations is derived and used. Interpretations of the data directed from 2 different points of view lead to contradictory conclusions as to the best

charge design to meet the requirements for the Wizard warhead. Although the differences in expected performance are only slight, they are sufficiently large to make the difference between a charge being able to meet all specifications and not being able to do so. The ultimate conclusion from the model tests is that some 1 of several charge designs will be able to meet all specifications for the Wizard warhead and will probably appreciably exceed the specified minimum fragment velocity. The best charge design for the purpose, however, is not yet determined.
(Contractor's abstract)

L634

Carnegie Institute of Technology (W36-061-ORD-2910). MISZNAY-SCHARDIN EFFECT, by E. M. Pugh and R. J. Eichelberger. Bimonthly rept. no. 14. June 30, 1950, 22p. incl. illus. diagrs. (Rept. no. CIT-ORD-M14) TIP C59319 Confidential

Fundamental tests with model warheads showed that an end-fragmentation warhead can be designed to meet present specifications with only slight modification of the models tested; it seemed unlikely that a more effective warhead for the purpose could be designed on the basis of any other known explosive principle. Sterne's equations were very useful in the exploratory phases of the investigation; however, a new theory is needed that will not be limited to charges of special designs or to calculation of fragment velocities for only a small portion of the fragments produced. A treatment of shock wave interaction within a charge, which appears to provide the needed extension to the existing theory of fragment velocity, is in the final stages of formulation.

L635

Carnegie Institute of Technology (W36-061-ORD-2910). ROTATED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 7. Aug. 31, 1949, 12p. incl. illus. diagrs. (Rept. no. CIT-ORD-R7) TIP C59320 Confidential

Tests of liners having 32 flutes are described. A very low optimum rotational velocity was observed due to the nearly symmetrical profiles of the flutes. The theory of compensation by fluted liners is discussed and a method of analysis of data is presented.

L636

Carnegie Institute of Technology (W36-061-ORD-2910). ROTATED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 8. Oct. 31, 1949, 27p. incl. illus. (Rept. no. CIT-ORD-R8) TIP C59321 Confidential

Exploratory slug recovery experiments were performed using several types of fluted liners. The results of these tests indicate that the slug recovery technique is extremely useful as a quick and convenient method for determining whether or not a given fluted liner is properly designed.

Though this method of testing gives no indication of the optimum velocity for design, it does show whether or not all parts of the liner are compensated for the same frequency.

L637

Carnegie Institute of Technology (W36-061-ORD-2910). ROTATED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 9. Dec. 31, 1949, 18p. incl. illus. diagrs. (Rept. no. CIT-ORD-R9) TIP C59322 Confidential

Experimental results are described that give a direct comparison of the effectiveness of flutes, round on the exterior of the liner, with the effectiveness of flutes sharp on the exterior. The optimum rotational velocity for flutes sharp on the exterior was observed to be 150% higher than for rounded flutes. Experiments are also described that demonstrate the difference between the performance under laboratory testing conditions at large standoff and under field conditions at low standoff. Under field conditions the maximum penetration may be somewhat lower but the rotational frequency for good performance should be less critical.

L638

Carnegie Institute of Technology (W36-061-ORD-2910). ROTATED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 10. Feb. 28, 1950, 37p. incl. illus. diagrs. (Rept. no. CIT-ORD-R10) TIP C59323 Confidential

Observations on the shapes and depths of fluted liners used in rotated shaped charge firings previously reported showed wide variations that account for inconsistencies in the results. The flute depths on mandrels used for forming the flutes varied as much as 15% in critical zones. Peculiarities in the flow of Cu in pressing flutes into liners indicate that the effective flute depths in critical zones varied at least 30%. The accuracy of dies and mandrels and the method of pressing flutes into liners are being improved and the design is being simplified so that these improvements can be more easily effected.

L639

Carnegie Institute of Technology (W36-061-ORD-2910). ROTATED CHARGES, by E. M. Pugh and others. Bimonthly rept. no. 11. Apr. 30, 1950, 23p. incl. illus. tables, diagrs. (Rept. no. CIT-ORD-R11) TIP C59324 Confidential

Two groups of fluted liners (NBS Lots 13 and 14), cast into cylindrical charges of 50/50 pentolite, 1.625 in. in diameter, 5 in. long, were fired at 6-in. standoff in the confinement of the Al charge head or its equivalent. Lot 13 liners having 16 flutes formed to a nominal maximum depth of 0.016 in. at the liner base and having a linear variation of flute depth with linear radius were fluted between matched metal dies to give sharp flutes on both the exterior and interior of the liner. The best penetration obtained was 8.2 in. at -60 r.p.s. Apparently the failure to produce a suitable optimum velocity was due to faulty liner design. Comparison with smooth liners fired statically indicated that 85% compensation was obtained for these liners. Lot 14 liners, made with a fluted female die and a rubber pressure pad, had 32 flutes formed to a nominal maximum depth of 0.015 in. at the liner base and a linear variation of flute depth with linear radius. These liners gave a peak penetration of 5.8 in. at an optimum velocity of 0 r.p.s. which represented 61% compensation. This disappointing performance may be in accordance with the theory of fluted liners which is further complicated by the "transport" effect and "thick-thin" effect. Comparisons of both lots were made with previously tested liner groups of similar characteristics. Investigations with smooth liners, including calculation of the collapse parameters were described briefly, and experiments to determine fundamental laws for fluted liner design were presented. In addition, another possible method of compensation for the detrimental effects of rotation by "counter-rotating" the detonation wave instead of the liner was given. This technique, variously called "wind effect" and "rotating detonation" effect, involves the production of a tangential component of the detonation velocity in planes normal to the charge axis.

L640

Carnegie Institute of Technology (W36-061-ORD-2910).
ROTATED CHARGES, by E. M. Pugh, R. J. Eichelberger, and E. Litchfield. Bimonthly rept. no. 12, annual summary. June 30, 1950, 30p. incl. diagrs. (Rept. no. CIT-ORD-R12)
TIP C59325 Confidential

A satisfactory design for a liner for use in spin-stabilized projectiles has not been achieved. A method of manufacturing was perfected by the National Bureau of Standards for reproducing any desired external flute contour on a mass production basis. The required optimum velocity of 230 r.p.s. for a 57-mm. HEAT shell was bracketed by 2 groups of fluted liners, 1 of which produced 85% compensation at 180 r.p.s., while the other gave 85% compensation at 330 r.p.s.

L641

Chamberlain Corporation (DA11-022-ORD-662).
DESIGN AND DEVELOPMENT OF HEP, HEAT, HE, AND CHEMICAL SHELL, by I. Herman. Progress rept. Aug. 1, 1952-June 30, 1953. v.1, p. 52-87 incl. illus. diagrs. AD-20 533
Confidential

The design and development of the HEAT shells, 76-mm., T180 and T319 for the 76-mm. guns M1A2 and T91 are discussed. The cartridge cases, shell bodies, cone assemblies, nose sections and fins of these projectiles are described. Data are given on the various lots of these shells tested by Picatinny Arsenal and Aberdeen Proving Ground.

L642

[Chemical Defence Experimental Station (Chemical Warfare) (Gt. Brit.)].
THE CAVITY EFFECT AND ITS APPLICATION TO ATTACK OF AFV's BY CW AGENTS, by E. W. Voice and F. G. Hasler. July 22, 1942, 15p. incl. diagrs. (Porton rept. no. 2305; Serial no. 41; OSRD Liaison Office WA-280-159)
Secret

In considering the addition of CW agents to shaped charges in order to defeat tanks, an investigation was made with shaped charges alone to determine their lethal effects on animals placed inside a tank. It was concluded, after firing 3-in. diameter charges with 80° steel and spherical Cd liners, that the lethal effect from these jets was confined to a limited zone. Consequently, it was considered worth while to add a CW agent in order to increase the effectiveness of the charges. Simple modifications to charges having the cavity lined with a CW agent or placed within the explosive above the cavity proved ineffective, since simultaneous projection of the substance with the jet caused the destruction of the CW agent. It was concluded that the logical solution would be a composite weapon to pierce a hole in the armor and subsequently project the CW agent through the opening.

L643

[Chemical Defence Experimental Station (Chemical Warfare) (Gt. Brit.)].
INTERIM REPORT ON THE HOLLOW CHARGE EFFECT AND ITS APPLICATION TO ATTACK OF AFV's BY CW AGENTS, by E. W. Voice and F. G. Hasler. Mar 30, 1943, 15p. incl. illus. diagrs. (Porton rept. no. 2498; Serial no. 55; Inclosure 1 to MA London rept. no. 55817; OSRD Liaison Office WA-565-10) Confidential

Further experiments to obtain lethal effects from CW agents by simple modifications of standard shaped charges and shaped charge shells are reported. It was concluded that there was little hope of producing satisfactory penetration of CW agents where such agents formed an integral part of the shaped charge. Experiments with composite weapons indicated the feasibility of producing a shaped charge projectile having a rear container which would lodge in the hole and eject its contents. The rear container is reported to follow the explosive without damage provided the back of the charge is suitably shaped and the weapon has a striking velocity of more than 200 ft./sec. A lethal concentration of HCN was established in a tank by a single round, and it was estimated that serious damage to the tank and crew could be caused by a single round containing liquid P. Diagrams and photographs illustrate the follow-through type of projectile.

L644

[Chemical Defence Experimental Station (Chemical Warfare) (Gt. Brit.)].
HOLLOW CHARGE FOLLOW-THROUGH PROJECTILES. SHELL DESIGNED FOR THE 25 PDR. GUN, by E. W. Voice and F. G. Hasler. May 16, 1944, 8p. incl. illus. diagr. (Porton rept. no. 2618; AC 6384, May 24, 1944; SC.95; OSRD Liaison Office WA-2194-8a) Secret

The modifications of the 25-pounder shell were: a light ballistic cap filled with a nose fuze, the body of the shell forward of the shaped charge liner weakened by axial sawcuts, an 80° liner fitted inside the shell body, and a follow-through tube carried by an adapter at the back of the shell. A Mark I tank with 2.5-in. thick walls was used as the target. In most cases a hole was formed in the target wall at 35° obliquity in spite of using an 80° liner in a rotated shell at 1000 ft./sec.

L645

Chemisch-Physikalische Versuchsanstalt der Marine, Kiel.
PATENT APPLICATION. DEFENSE AGAINST THE EFFECT OF HOLLOW CHARGES (Patentanmeldung. Abwehr der Wirkung von Hohlraum-Ladungen). [Aug. 1941], 3p. (OTIB rept. no. 1249, Misc.-8- In German) Unclassified

The patent covers the employment of 2 or more layers of armor separated by layers of air or of any material other than the armor. It also includes the substitution of light metal alloys for the customary armor materials on the basis of experiments showing that the loss of resistance is made up by the smaller weight. (APG abstract)

L646

Chemisch-Physikalische Versuchsanstalt der Marine, Kiel.
RECENT EXPERIENCES OF THE GERMAN NAVY IN THE FIELD OF HOLLOW CHARGES (Neuere Erfahrungen der Marine auf dem H-Ladungsgebiet). BRIEF SUMMARY OF THE LECTURE BY DR. KEIL (CPVA) ON FEB. 9, 1943 TO THE SOCIETY FOR THE EXCHANGE OF HOLLOW CHARGE INFORMATION (Kurze Darstellung des Vortrages Dr. Keil (CPVA) am 9.2.43 vor der Erfahrungsgemeinschaft H-Ladungen), by Keil. Mar. 8, 1943, 5p. illus. diagrs. (Attachment to B. Nr. G. Kdos. 157/43 p Id. -) (Trans. as OTIB rept. no. 1961B, 3p. illus. diagrs.; Also trans. in rept. no. BIOS/Gp. 2/HEC 2577, 6p. illus. diagrs.; Also trans. in OTIB rept. no. 1146B) Restricted

Results of experiments carried out by the German navy to determine the value of shaped charges underwater are discussed. The following problems were investigated: (1) braking of the shaped charge projectiles by water, (2) effect of shaped charges on ammunition; (3) pressure measurement of underwater detonation of shaped charges; and (4) the development of shaped charges for special purposes, such as destroying steel ropes and tubes, heavy Fe plate, and books. Illustrations of these special charges are included.

L647

Chemisch-Physikalische Versuchsanstalt der Marine, Kiel.
INTRODUCTION TO UNDERWATER EXPLOSIONS (Einführung in das Unterwasser-sprengwesen). 1945. (DTMB trans. no. 208, July 1948, p. 146-159 incl. illus. diagrs.) TIP C1967 Confidential

German development of hemispherical, conical, and bell shaped charges is included. Conical charges with a 30° apex angle were most effective. Measured data are shown for the effect of the thickness of the lining on the penetrative efficiency. Basic distinction was made between partial penetration and complete penetration of the target. The German army charge, type H15, with a hemispherical liner is described. A study of the penetrative efficiency of the shaped charges showed that charge type H15 produced impressions 15 to 20 mm. deep in a steel plate after traversing a stratum of water 2.5 m. thick. Consideration was given to using numerous small depth cavity charges to combat submarines, and to equipping a torpedo warhead with a shaped charge. A number of German uses for shaped charges is described.

L648

Chief Inspector of Armaments, Ministry of Supply (Gt. Brit.).
AMMUNITION BULLETIN NO. 48. Oct. 1945, 56p. incl. diagrs. (Item nos. 1347-1396; Inclosure 1 to MA London rept. no. R5731-45) Restricted

Descriptions and diagrams of various foreign and domestic ammunition are given. Only 3 items pertain to shaped charge ammunition: Item 1389, 8.8-cm. Kw. K. 43 cartridge QF hollow charge with tracer (8.8-cm. Gr. Patr. 39 Hl. Kw. K. 43); Item 1390, Tracer for 8.8-cm. hollow charge shell; and Item 1391, hollow charge antitank bomb with projector (Panzerfaust 60mm.).

L649

Church, J. H. and others. PETARD MISSILE. United States patent no. 2,412,967, Dec. 24, 1946.

The invention concerns explosive missiles, particularly a petard to be applied from a distance. One of the claims is for a shaped charge missile with an annular shock deadening unit and 1 of several types of base detonating fuzes activated by inertia.

L650

Clark, G. B. and W. H. Bruckner.
BEHAVIOR OF METAL CAVITY LINERS IN SHAPED EXPLOSIVE CHARGES. Mining Technology, v. 11, May 1947: 12p. (American Institute of Mining and Metallurgical Engineers, Technical Publication no. 2158)

The behavior of liner metal under the impact of the advancing explosion wave is discussed. The conclusions are drawn on the basis of metallographic examination of a slug salvaged from a cast Fe liner.

L651

Clark, G. B.
STUDIES OF THE DESIGN OF SHAPED EXPLOSIVE CHARGES AND THEIR EFFECT IN BREAKING CONCRETE BLOCKS. Mining Technology, v. 11, May 1947: 16p. (American Institute of Mining and Metallurgical Engineers, Technical Publication no. 2157)

Results of experiments on the use of shaped charges in mining are reported. The effects of thickness and taper of liner wall, confinement, liner metals, and strength of explosive were studied.

L652

Clark, G. B.
SECRETS OF THE SHAPED CHARGE. Ordnance, v. 33, July-Aug. 1948: 49-51.

The discussion presents a brief history of the Munroe effect, the use of shaped charges in the bazooka, and factors which affect the performance of shaped charges: standoff, explosives, liner metal, apex angle, liner thickness, and confinement of the charge.

L653

Clark, J. C.
FLASH RADIOGRAPHY APPLIED TO ORDNANCE PROBLEMS. Journal of Applied Physics, v. 20, Apr. 1949: 363-370.

The feasibility of using µsec. X-ray bursts in the study of internal ballistics and explosive phenomena is discussed and the apparatus is described. The study of jets from metal lined shaped charges is reported briefly; the mechanisms of jet formation and liner collapse are illustrated by flash radiographs.

L654

Coles Signal Laboratory, Signal Corps Engineering Laboratories (DA3-91-02-803).
COLD WEATHER TESTS ON SHAPED CHARGES FOR HOLE DRIVING AT FT. CHURCHILL, MANITOBA, WINTER 1948-49, by A. G. Storrar. Apr. 12, 1949, 7p. illus. tables. (Signal Corps no. 2008-19, Test rept. no. T-1198) TIP U69025 Confidential

The tests on various shaped charges were conducted at temperatures ranging from -18°F to -32°F in various types of Arctic terrain. The 2-lb. M9A1 shaped charge, 2.25 in. in diameter and having a Cu liner, blasted holes in the frozen muskeg and the frozen sand and gravel a depth of from 6 in. to 25 in. at standoffs from 2 in. to 12 in. At the best average standoff of 8 in., the average hole in frozen muskeg was 19 in. deep, 2 in. in diameter at the top and 1.5 in. in diameter at the bottom. In frozen sand and gravel the hole was 12 in. deep with a diameter at the top of 1.5 in. and 0.75 in. at the bottom. The 3-lb. M6A3 with steel liner and a diameter of 2.75 in. blasted holes in frozen muskeg and frozen gravel and sand a depth of 3 in. to 20 in. at standoffs varying from 4 in. to 12 in. At the best average standoff of 6 in., the average hole in frozen muskeg was 14 in. deep, with a top diameter of 3 in. and a bottom diameter of 2 in. In frozen sand and gravel the hole was 14 in. deep with a top diameter of 1.5 in. and a bottom diameter of 0.75 in. The 15-lb. M2A3 shaped charge of 7-in. diameter blasted holes in the frozen muskeg 53 in. deep, having a 5 in. top diameter and a 3 in. bottom diameter. In frozen gravel and sand the depth was 36 in. with a top diameter of 7 in. and a bottom diameter of 3-in. The standoff was 5 in. The 40-lb. M3, with a charge diameter of 9 in., blasted holes in the frozen muskeg 60 in. deep with top and bottom diameters of 11 in. and 6 in., respectively at a standoff of 15 in. In frozen gravel and sand the depth was 69 in. with a top diameter of 10 in. and a bottom diameter of 6 in. Dark smudges ranging from about 6 ft. in diameter for the small charges to about 10 ft. in diameter for the large charges ringed each hole after firing. Many of the smaller holes were covered with a bridge of debris near the top while in the larger holes the bridge formed about 1/3 from the top. All of the holes were tapered from top to bottom; some of the holes were blasted in at an angle because the shaped charge assembly was slightly tilted. The following personnel safety-factor distances were determined for the various shaped charge detonations: (a) M9A1, 300 ft.; (b) M6A3, 300 ft.; (c) M2A3, 400 ft.; (d) M3, 600 ft.

L655

Combined Intelligence Objectives Subcommittee.
EXPLOSIVES, HOLLOW CHARGE, AND SHOCK WAVES, by H. L. Porter. n.d. 50p. diagrs. (Items no. 2 and 13, File no. XXXIII-27; BIOS target nos. C2/793, C13/37, C2/794, C13/38, C2/795, C13/39, C2/796, C13/40, C2/797, C13/41, C2/798, C13/42, C2/799, C13/43) TIP C52071 Confidential

These interrogation repts. cover the experimental and theoretical scientific work accomplished in Germany, particularly in the field of explosives, to about 1944. Areas covered include measurement, damage, and lethal effect of shock waves, detonation under water, detonation theory, temperature of explosions, and shaped charges. Dr. H. Schardin, Director of the Physics and

Ballistics Institute for German Air Ministry, Berlin, gave information on the following subjects: (1) hollow charges, earlier work; (2) use of high explosives for shaped charge effect; (3) lined shaped charges; (4) X-ray photographs [for the study of shaped charge phenomena]; (5) coned charges; (6) theories of shaped charges; (7) experiments with water jets; (8) fountain effects [using a glass cone at the water surface]; (9) stereoscopic photographs [of the functioning of a conical lined charge]; (10) the hemispherical shaped charge, physical theory; (11) service applications [of German shaped charges], (12) effect of rotation of shaped charge projectile; and (13) magnetic induction fuze SD4HL [for shaped charges]. A list of repts., books and pamphlets obtained from the Physics and Ballistics Institute, Berlin is also included.

L656

Combined Intelligence Objectives Subcommittee. CAVITY CHARGE AND DETONATION PHENOMENA, by R. O. Fleming, Jr. [1945]. (CIOS FILE no. XXX-71) (In its Special Mission on Captured German Scientific Establishments, June 1, 1945, p. 156-163) Restricted

Basic research on the cavity effect was begun by TAL in 1939. The most popular German theory of jet penetration was the "plastic" or "mud" theory which acknowledged a change in the physical state of the steel in the immediate vicinity of penetration although the theory of jet formation was identical to that advanced by G. Birkhoff in the United States. Schardin believed that there was considerable difference between the end results of detonations of charges with conical and hemispherical liners. For a shaped charge having a hemispherical liner, there is no actual formation of jet, as is produced by a conical liner. Design formulas for lined charges, tapered liners for small angled charges and helmet liners, and measurement techniques for detonation velocities and pressures are discussed.

L657

Combined Intelligence Objectives Subcommittee. CAVITY CHARGE EXPERIMENTS, by R. O. Fleming, Jr. [1945]. (CIOS File no. XXX-71) (In its Special Mission on Captured German Scientific Establishments, June 1, 1945, p. 202-204) Restricted

Dr. Hans Tomanck was questioned regarding his experiments on shaped charge phenomena; his conclusions were that: (1) conical liners were superior for spin-stabilized shaped charge projectiles with diameters of less than 10 cm., while for diameters of more than 10 cm., hemispherical liners produced better results; (2) the optimum liner form for all types of charges or projectiles (provided that size and shape would permit) was the bottle shaped; and (3) for projectiles, a conical liner was superior, since it was not as dependent upon standoff as a hemispherical liner. A unique rifle launched spin-stabilized rocket is described, the propellant for which was contained in the cavity of the HE charge.

L658

Combined Intelligence Objectives Subcommittee. CAVITY EFFECT AND ALUMINIZED EXPLOSIVES, by R. O. Fleming, Jr. [1945]. (CIOS File no. XXX-71) (In its Special Mission on Captured German Scientific Establishments, June 1, 1945, p. 66-69) Restricted

At the DWM research establishment, Lubeck, work was done on shaped charges for the 7.5-cm. HL 43 projectile for use in the recoilless gun, and for a 5.5-cm. R4M (Panzerblitz III) air to ground aircraft rocket. An unusual feature of the first projectile was that it contained a venturi baffle plate which rested on the rim of the liner. This baffle was supposed to reconverge wide jets caused by rotation, but unsatisfactory results were obtained with it. An attempt was made to use sintered Fe liners, because the jets and slugs from these sintered liners were supposed to have better ignition properties on inflammable material than mild steel or cast Zn liners. Two aluminized explosives that were developed are described.

L659

Combined Intelligence Objectives Subcommittee. CAVITY EFFECT AND DETONATION PHENOMENA. by R. O. Fleming, Jr. [1945]. (CIOS File no. XXX-71) (In its Special Mission on Captured German Scientific Establishments, June 1, 1945, p. 98-105) Restricted

At TAL, Berlin-Gatow, the high speed flash radiograph technique used by Schardin for investigating detonation phenomena was essentially the same as that used by J. C. Clark at Ballistics Research Laboratories. The single flash model consisted of 4 30 kv. condensers which were charged in parallel and discharged in series, giving a total output of about 120 kv. The tube was constructed of metal (presumably Mg) and porcelain, rather than of glass. The target within the tube was of W. The duration of the X-ray was 10^{-7}, 10 x as fast as that produced by the corresponding US technique. The pictures were very clear. At the time of writing, the most recent development of this technique was the use of 6 sets of surge generators, with a variable timing circuit with which it was possible to obtain 6 successive pictures of the same charge or projectile during detonation or flight. Rept. titles on detonation phenomena are given.

L660

[Combined Intelligence Objectives Subcommittee.] GERMAN ORDNANCE RESEARCH AND DEVELOPMENT - INTERVIEWS WITH [LIEUTENANT] GENERAL RICHARD JOHN, by H. B. Allen. 1945, 1p. (Extract from Ordnance Target rept. no. 30) Secret

A brief summary of German research on shaped charge shells is reported. Because 30 to 40% of the effectiveness of the shells was lost through rotation, experiments were made with shells equipped with revolving driving bands consisting of a loosely fitting ring which took up most of the rotation. This permitted a standard gun to fire rotating HE shells as well as the non-rotating type. The smooth bore 8-cm. Panzerwurfkanone ("Paw 600") and its fin-stabilized shell are described; the effective range was 700 m. and the muzzle velocity just below 1700 ft./sec. It is noted that the Panzerfaust superseded the Panzerschreck because it could be handled by 1 man instead of 2; the model 150 issued in Mar., 1945 increased the range to 150 m. and flattened out the trajectory. Brief mention is made of the "Puppchen", a 3.5-in. bazooka mounted on a light carriage; the effective range was 200 m.

L661

Combined Intelligence Objectives Subcommittee. [INTERROGATION OF] KARL BADSTEIN, D. ING., by D. Carmichael. June 27, 1945, 3p. (CIOS Evaluation rept. no. 147) PB 133 Unclassified

The results of an interview with this German scientist are reported. One of the weapons described by him is a 7.5-cm. shaped charge shell that was fitted with a special base fuze (no further description) and stabilized by fins which open as the shell leaves the barrel. The muzzle velocity of the shell was 550 to 600 m./sec.

L662

[Combined Intelligence Objectives Subcommittee.] FUZE AND BOOSTER FUNCTIONING ON GERMAN SHAPED CHARGE AT PROJECTILES EMPLOYING POINT-INITIATED FUZES, by K. R. Cooney. Progress rept. no. 86. July 1945. 4p. incl. illus. (CIOS Ref. no. 508) Restricted

The functioning of the point-detonating fuze, gaine (booster), and spitback fuze used in German shaped charge rockets is discussed.

L663

Combined Intelligence Objectives Subcommittee. INTERROGATION OF SAUR, HEAD OF TECHNICAL DEPT. IN THE SPEER MINISTRY. July 4, 1945, 4p. (CIOS Evaluation rept. no. 163b) Secret

Brief mention is made of the protection of tanks against shaped charge projectiles. Wire netting was at first provided because the smallest resistance was sufficient to detonate the projectile. The nets were fitted at a distance in front of the tank (about 10 cm.), but they were broken up by antitank gunfire and hindered the free movement of the gun and view of the crew. It was noted that the effect of shaped charge ammunition was greatest when the charge was laid on the armor and detonated; the next greatest effect was achieved by shooting at the armor with a non-rotating projectile; the smallest effect occurred with rotated projectiles.

L664

Combined Intelligence Objectives Subcommittee. OBSERVATIONS ON SHAPED CHARGE DEVELOPMENT IN GERMANY, by C. H. Brooks. Aug. 1945, 4p. incl. diagrs. [CIOS File no. XXX-62] Restricted

German development included many weapons with hemispherical liners; the magnetically attached antitank weapon and the Panzerschreck are well known. Later models indicated the use of conical liners similar to those used in the United States.

Combined Intelligence Objectives Subcommittee
see also British Intelligence Objectives Subcommittee

L665

[Combined Services Detailed Interrogation Centre (United Kingdom)]. REPORT ON INFORMATION OBTAINED FROM PWCS/283 [ILLEGIBLE] SCHMENINGER OKH. HEERESWAFFENAMT CAPTURED IN PARIS 25 AUG. 1944. [Aug., 1944]. p. 3-4. (Rept. no. SIR 998) Secret

A study of shaped charge liners led to the composite shaped liner of cone plus sphere. This design, as found in the Panzerschreck, had the advantage of the conical liner in rotation combined with the long standoff of the hemisphere. The tapered liner found in the small German A Tk rifle grenade was caused by manufacturing differences and was not so designed. Only Zn and steel were tried for liners; Zn liners had to be thicker than steel liners to give the same effect. The penetration depth was always independent of the impact angle. It was concluded that the shaped charge was useful as a bridge between low and high velocities, but at higher velocities it was preferable to use normal piercing shells because damage behind the plate was greater.

L666

Cornell Aeronautical Laboratory, Inc. PROJECT LACROSSE. PRELIMINARY REPORT OF FIRST STATIC FIRING OF LACROSSE WARHEAD TYPE T34, 500-LB. SHAPED CHARGE. Feb. 24, 1953, 3p. diagrs. (Bulletin no. 3) Confidential

The Lacrosse warhead, T34, was statically fired at the Aberdeen Proving Ground against a pillbox target having 7-ft. thick walls of reinforced concrete. In this test, the jet penetrated the 7-ft. wall, traversed 13 ft. of airspace, penetrated a 1-ft. thick interior wall, travelled through another airspace of 8 ft., and splattered against the far wall and 0.5-in. steel plate. Inside of the 7 ft. wall, approximately 1 cu. yd. of concrete was spalled, the pieces ranging from dust to basketball size. Witness plates were twisted and bent. An extensive amount of choking dust was present. The Bikini pressure gages gave readings from 6.1 p.s.i. to 20.0 p.s.i. It was concluded that this T34 firing against a pillbox would have defeated the enemy target. A medical report will be issued later on the effects of this test on animals placed within the pillbox.

L667

Cornell Aeronautical Laboratory, Inc.
PROJECT LACROSSE. PRELIMINARY REPORT OF SECOND STATIC FIRING OF LACROSSE WARHEAD TYPE T34, 500-LB. SHAPED CHARGE. Feb. 26, 1953, 2p. diagrs. (Bulletin no. 4) Confidential

In this test, the T34 shaped charge warhead was fired statically at an obliquity of 55° against a 7 ft. thick wall of the reinforced concrete pillbox target used in an earlier test (item no. L666). The jet completely penetrated the wall, the total penetration being approximately 12 ft. There was extensive spalling at both entrance and exit and a considerable amount of choking dust within the pillbox. The witness plates were crumpled. Pressures recorded by the Bikini gages ranged from 6.15 p.s.i. to 16.9 p.s.i. No damage was evident opposite the exit hole of the jet. It was concluded that the warhead could successfully defeat 12 ft. of reinforced concrete.

L668

Cornell Aeronautical Laboratory, Inc.
LACROSSE PRESENTATION. PART 2B. WARHEAD STUDIES. Oct. 22, 1953, p. 44-47 diagrs. Confidential

The Lacrosse warhead investigations are briefly summarized. Two test firings of the T34, 500-lb. shaped charge Lacrosse warhead were made against a 7-ft. reinforced concrete pillbox target. At 0° obliquity, the T34 completely penetrated the pillbox and a 1-ft. interior wall, spalling out a cu. yd. of concrete inside the target; at 55° obliquity the warhead defeated the target, producing a large hole with extensive spalling at both the entrance and exit. In addition, a graph is given showing the penetration of concrete by shaped charges of various sizes.

L669

Cornell Aeronautical Laboratory, Inc. (DA30-115-ORD-47).
PROJECT LACROSSE. SECTION IX. LACROSSE WARHEAD STUDIES, by A. Ahlin. Quarterly progress rept. Jan.-Mar. 1952. Apr. 15, 1952, p. 80-82. (Rept. no. BE-745-T-5) Secret

The proposed Lacrosse warhead is described. This high explosive warhead, incorporating a shaped charge at the forward end, will serve as the missile nose cone. It was decided to make the warhead contour that of 2 conical frustrums rather than a tangent ogive to avoid the forming of compound curves in the warhead skin. Preliminary specifications for the warhead follow:

Total HE warhead weight	500 lb.
Explosive charge	382 lb. Comp. B
Liner shape	conical
material	Cu
base diameter (outside)	about 15 in.
apex angle	40°
Fuze	contact
Fuze arming	radio command
Warhead length (over-all)	about 80 in.

L670

Cornell Aeronautical Laboratory, Inc. (DA30-115-ORD-47).
PROJECT LACROSSE. SECTION IX. LACROSSE WARHEAD STUDIES, by A. Ahlin. Quarterly progress rept. Apr.-June 1952. July 15, 1952, p. 73-74. (Rept. no. BE-745-T-6) Secret

Various means of fabricating a shaped charge conical liner of Cu 0.29-in. thick for use in the 500-lb. Lacrosse warhead T34 were investigated. The following methods were considered: (1) deep-drawing; (2) spinning; (3) metallizing; (4) plating; and (5) hand-forming 2 half-cones and brazing or Ag-soldering them together. No decision was made concerning the method of liner fabrication.

L671

Cornell Aeronautical Laboratory, Inc. (DA30-115-ORD-47).
PROJECT LACROSSE. SECTION IX. LACROSSE WARHEAD, by A. Ahlin. Quarterly progress rept. July - Sept. 1952. Oct. 15, 1952, p. 59. (Rept. no. BE-745-T-7) Secret

Cu liners for the T34 warhead were fabricated by brazing 2 half-cones together. Other procedures for making the shaped charge liners are being investigated (item no. L670). It is concluded that the most preferable method is by deep-drawing the complete cone; however, the die costs are prohibitive.

L672

Cornell Aeronautical Laboratory, Inc. (DA30-115-ORD-47).
LACROSSE I. SECTION III. LACROSSE EQUIPMENT DESCRIPTION, by D. A. Kahn. Nov. 1953, p. 35-36. Confidential

The design objectives and recommended equipment for LACROSSE I, a guided missile system incorporating a shaped charge warhead, are described. One of the warhead types, the T34, contains a conical Cu liner with an apex angle of 40°

and an explosive charge of 381 lb. of Comp. B. It is capable of penetrating 13 ft. of concrete. The second warhead design, basically incendiary, has 2 variations; in 1, part of the incendiary material is replaced by a shaped charge.

L673

Cornell Aeronautical Laboratory, Inc. (NOrd-10629). LACROSSE SUMMARY REPORT. TASK E June 1949-Mar. 1950. Mar. 22, 1950, p. 6, 7, 22 diagr. (Rept. no. BE-635-S-2) Secret

In the Lacrosse warhead investigation, data were gathered on the blast effectiveness and plastic and shaped charge type warheads. The pertinent shaped charge data are presented graphically for penetration vs. warhead weight. Curves are drawn for the effect of jets on homogeneous armor and on concrete and for the effect of blast on concrete. It was concluded from these data that a 100-lb. shaped charge warhead would defeat 5 ft. of concrete only if "fortunately oriented", that is, if its impact angle were such that the full effect of the jet resulted. Therefore a 500-lb. Lacrosse warhead was proposed to obtain a safe margin of penetration performance.

L674

Cornell Aeronautical Laboratory, Inc. (NOrd-10629). LACROSSE FINAL REPORT. TASK I. June 1949-Mar. 1950. Aug. 1, 1950, p. 12-13, 48-55 diagrs. (Rept. no. BE-635-S-3) Secret

In the Lacrosse warhead investigation, a 500-lb. modified blast shaped charge warhead was considered for penetration of pillbox and bunker targets. Performance data for this weapon type are given as functions of warhead weight and target thickness penetrated. A graph showing the weight of a shaped charge plotted against charge diameter is also presented. It was concluded that the blast effect for a given weight shaped charge is diminished by only 10% to 20% because of the fact that 1 end of the explosive is shaped. Therefore, it was proposed that a 500-lb. modified blast type warhead with a shaped charge incorporated be used in the Lacrosse missile.

L675

Curtiss-Wright Corporation. ON THE HOLLOW CHARGE EFFECT (Über den Hohlraumeffekt), by G. Hensel. Nov. 19, 1946, 52p. incl. illus. diagrs. (Rept. no. U-46-29; CGD-749) Restricted

A brief survey of the history of the shaped charge effect is reported. Experiments by the Aerial Warfare Academy with unlined charges of miscellaneous shapes are summarized; it was concluded that the "U" or dome shaped (hemisphere plus cylinder) cavity was the most favorable for piercing armor. It is stated that the diameter of the hollow space should be as large as possible but a sufficient wall thickness of explosive must be retained. Experiments with Fe lined charges indicated that the best liner shape was again the "U" or dome shaped. Formulas are given for depth of penetration, and hole diameter was found to be in the order of magnitude of the diameter of the charge cavity.

L676

Curtiss-Wright Corporation. DISCUSSION ON THE SUBJECT OF THE HOLLOW CHARGE EFFECT. (SUPPLEMENT TO THE REPORT "ON THE HOLLOW CHARGE EFFECT" BY GERHARD HENSEL, U-46-29), by V. Schmidt and others. Dec. 4, 1946, 42p. incl. diagrs. (Rept. no. U-46-30; CGD-750) Restricted

Comments on and additions to Hensel's "On the hollow charge effect" are reported. Klein stated that optimum dimensions for the cavity and total height and diameter for charges of various explosive weights had been determined. He considered the experiments of Lodati (item nos. L164 and L1149), which emphasized the thermal effects of the shaped charge, to be of great importance. V. Schmidt reported the Schlieren photography and measurement of pressure waves from a shaped charge detonated under water. Schweninger stated that fragmentation behind armor plate was more important than penetration, and that a hemispherical shape was more effective than a conical shape for this purpose. He also stated that experiments had shown the best relation between the height of cavities and the diameter to be 1.5, i.e., the height of the cavity should be 1.5 x the diameter.

L677

Davidson, S. H. and R. Westwater. THE SHAPED OR HOLLOW CHARGE. Mine and Quarry Engineering, v. 15, May 1949: 140-145.

Discussions on the Munroe or Neumann effect, the mechanism of the shaped charge, suitability of explosive filling, material and shape of lining for shaped charge, type of container, standoff distance, and application of the shaped charge are presented. "A review of the work done on shaped charges leads definitely to the conclusion that these devices have only a very limited application in the commercial field. The main reasons for this are: (1) the shaped charge uses only a small part of the explosive energy available, and this means that the cost of the explosive is greater than with normal charges; (2) to achieve the shaped charge effect, high velocity of detonation is essential, and this can only be achieved by using the more expensive explosives with special priming; (3) metal liners are costly and this, together with the high cost of the explosive, makes a shaped charge a relatively expensive article; there does not appear to be any possibility of appreciably reducing its cost, even if large quantities were to be produced."

L678

Defence Research Board (Canada).
ARMAMENT AND EXPLOSIVES, by J. J. Green. Dec. 8-10, 1952, [12]p. incl. illus. (Fourth Symposium, Review Paper 1) (In cooperation with Canadian Armament Research and Development Establishment) AD-16 413 Secret

In this review of the accomplishments of the Canadian Armament Research and Development Establishment (CARDE), the shaped charge Heller antitank rocket is briefly described. The rocket, stabilized by a tail ring and fins, is fired at a high subsonic velocity from a smooth bore launcher of 3.2-in. inside diameter. Specifications require that it defeat 8 in. of homo armor plate at 64° obliquity and 13.5-in. at 0° obliquity. In penetration tests, the round defeated 11-12 in. of homo armor plate at 0° obliquity. Equipped with a proper sight, the Heller approaches the accuracy of a gun.

L679

Defence Research Board (Canada).
RECENT INVESTIGATION OF SHAPED CHARGES, by T. S. Sterling. Nov. 30, Dec. 1-2, 1953, 9p. incl. illus. table. (Fifth Symposium, Armament and Explosives Paper 2) (In cooperation with Canadian Armament Research and Development Establishment) Secret

An analysis is made of the performance of the 2.3-in. Heller shaped charge warhead. It is concluded that the mean penetration and regularity can both be increased by increasing the thickness of the booster pellet, by improving the method of liner support, and also by improving the initiation. The performance of the present spitback fuze limits the performance of the warhead seriously. There is some evidence to suggest that the shape of the warhead housing is not optimum. (CARDE abstract)

L680

Demolition Research Unit, Naval Amphibious Training Base, Fort Pierce.
REPORT ON CRUIM NO. 4, DEMOLITION CHARGES MARK 16 AND MARK 17, by E. R. Pedersen. Feb. 27, 1945, 17p. incl. illus. tables. Confidential

Tests were conducted to determine the effectiveness of Demolition Charges Mk 16 and Mk 17 as demolition munitions. The Mk 16 is a conical shaped charge having a waterproof standoff sleeve to permit its use underwater. The charge is composed of:

Metallic charge (container and liner)	8.5 lb.
Explosive charge (50/50 pentolite)	10 lb. (approx.)
Waterproof standoff sleeve	10.5 lb.
Standoff base (1-in. thick metal ring)	11.0 lb.

When attacking above water targets, a tripod base is used in place of the sleeve to obtain the proper standoff distance. Demolition Charge Mk 17 differs from the smaller Mk 16 in that the charge case is not a truncated cone, having instead a heavier body of rounded contour. This charge consists of:

Metallic charge (container and liner)	19.5 lb.
Explosive charge (50/50 pentolite)	29 lb. (approx.)
Waterproof standoff sleeve	31.75 lb.
Standoff base	6.00 lb.

The charges were employed against reinforced concrete and sandstone targets of various contours above and below water. In these tests the Mk 16 penetrated solid reinforced concrete to a depth of 36 in., giving a hole-bottom diameter of about 3 in.; the Mk 17 penetrated calciferous sandstone to a depth of 70 in., producing a hole-bottom diameter of 4 in. It was observed in several instances that the jet of the Mk 16 charge was deflected by the reinforcing rods; however, the change of direction was not more than 2 in. The jet of the Mk 17 was not affected in this way. From the tests, it was concluded that neither the Mk 16 nor the Mk 17 demolition charge is efficient as the sole demolition agent for small reinforced concrete obstacles above or below water.

L681

Department of Controller General of Research and Development, Ministry of Supply (Gt. Brit.).
CONFERENCE ON "SHAPED CHARGES" HELD AT SHELL MEX HOUSE, ROOM NO. 297, WEDNESDAY, 26TH AUG., 1942 [WITH] GENERAL BARNES' U. S. MILITARY MISSION METALLURGY AND GUN AMMUNITION GROUP. [1942?]. 12p. (OSRD Liaison Office WA-249-9a) Confidential

Brief summaries of topics discussed at the conference include experimental work on the Munroe effect and its bearing in practice, and the following applications: antitank and HE shells, demolition of reinforced concrete structures, controlled fragmentation, the capital ship bomb, underwater penetration, and the utilization of shaped charge heads in rockets.

L682

Department of Tank Design (Gt. Brit.).
TRIAL OF SKIRTING PLATES AS A DEFENSE AGAINST HOLLOW CHARGE ATTACK, by A. R. F. Martin. May 30, 1944, 15p. incl. illus. tables. (DTD rept. no. M7000A/17, no. 1) Secret

The investigation was made to determine the degree of protection against shaped charge attack which could be given to side armor of British tanks by the fitting of thin skirting plates. The charges used in the tests were the PIAT, 95-mm. HEAT shell, and a copy of the German 3-kg. magnetic shaped demolition charge. Results showed that the 95-mm. HEAT shell (rotated) was defeated by a target of 6-mm. I.T. 100 spaced 15 in. in front of a 32-mm. plate. The PIAT (unrotated) filled with RDX/TNT 50/50 was capable of penetrating a target of 6-mm. I.T. 100 spaced in front of a 32-mm. I.T. 80 plate when fired at point blank range from a projector. It failed when detonated statically in contact with the skirting plate. The copy of the 3-kg. shaped magnetic demolition charge defeated a 6-mm. I.T. 100 plate placed 15 in. in front of a 100-mm. I.T. 80 plate. It is stated that this charge appeared to be approaching the limit of its performance from a consideration of damage. The charge failed against a target of 25-mm. I.T. 80 placed 30 in. in front of a 100-mm. I.T. 80 plate.

L683

Department of Tank Design (Gt. Brit.).
THE PROTECTION WITH SKIRTING PLATES OF CHURCHILL, SHERMAN, AND CROMWELL TANKS, AGAINST ENEMY HOLLOW CHARGE ATTACK, by A. R. F. Martin. Aug. 30, 1944, 7p. incl. tables. (DTD rept. no. M7000A/17, no. 2) Secret

Faustpatrone 1 and 2, 8.8-cm. Raketen Panzerbüchse, 3-kg. magnetic shaped demolition charge, and 3.7-cm. Stielgranate (muzzle-stick bomb) were tested against tanks fitted with skirting plates. It was concluded that the fitting of skirting plates was of no advantage where the Faustpatrone 2 or the 3.7-cm. Pak Stielgranate were concerned. Against all the other charges tried, the skirting plate gave marked additional protection to the hull side armor by reducing the vulnerable arc and the damage inside. The skirting plates were found to be of greatest value to the Churchill VII and of least value to the Sherman.

L684

Department of Tank Design (Gt. Brit.).
PLASTIC ARMOR AND GRAVEL AS A DEFENSE AGAINST HOLLOW CHARGE ATTACK. TRIAL WITH GERMAN 8.8-CM. RAKETEN PANZERBUCHSE, by A. R. F. Martin. 1945, 9p. incl. illus. table. (DTD rept. no. M6406A/3, no. 1) Secret

Tests were made to determine whether a 6-in. layer of dry gravel or plastic armor would protect the 2.5-in. thick turret wall of the Comet tank against the Faustpatrone 2 and Raketen Panzerbüchse. A comparison was made to determine whether the relationship between the resistance of plastic armor and M.Q. steel armor was the same when the shaped charges were the actual German projectiles fired from their service projectors as that from small-scale experiments with charges detonated statically. Results showed that this 6-in. layer of gravel would be of no value to the Comet turret since this would be vulnerable to attack at 40° by the 8.8-cm. Raketen Panzerbüchse, a less powerful weapon than the Faustpatrone 2. It was found that 2.4 mm. of plastic armor had the same resistance to this charge as had the 1 mm. of homo M.Q. steel armor or that 0.66 lb./sq.ft. of plastic armor was equivalent to 1 lb./sq.ft. of steel armor. This figure compared with results obtained by Road Research Laboratory and United States sources, of 0.4 lb./sq. ft. and 0.5 lb./sq.ft. of plastic armor respectively from experiments with small-scale charges detonated statically.

L685

Department of Tank Design (Gt. Brit.).
LIABILITY TO PREMATURE DETONATION OF FUZES IN PANZERFAUST 60, by A. R. F. Martin. Mar. 21, 1945, 4p. (DTD rept. no. M7000A/44, no. 1; Inclosure 1 to MA London rept. no. R2056-45) Secret

Fuzes captured for the Panzerfaust 60 with W.C. or W.A. markings were, according to information obtained from foreign documents, liable to cause prematures when fired. Forty-two rounds with fuzes marked W.C. were fired; all functioned satisfactorily.

L686

Department of Tank Design (Gt. Brit.).
SPIKED SKIRTING PLATES AS A DEFENSE AGAINST HOLLOW CHARGE ATTACK, by A. R. F. Martin. Mar. 29, 1945, 18p. incl. tables, diagrs. (DTD rept. no. M6342A/2, no. 1; Inclosure 1 to MA London rept. no. R2294-45) Secret

Tests were made with a spiked skirting plate consisting of 0.25-in. mild steel plate to which was welded a series of steel spikes 10-in. long, 3/8-in. in diameter, set 4.5-in. apart. The shaped charge projectiles used for these tests were the 3.7-cm. Pak Stielgranates. Trials were carried out with Panzerfaust 60 against: (1) a lattice framework of steel strips 1-in. wide, 3/8-in. thick through the intersections of which spikes 8-in. long, 0.5 in. in diameter were screwed and bolted at the back; and (2) a mild steel plate 0.5-in. thick with welded spikes 8-in. long, 0.5 in. in diameter. The appendixes give data and diagrams of target arrangements.

Department of Tank Design (Gt. Brit.). see also Fighting Vehicles Design (Gt. Brit.)

L687

Deutsche Akademie der Luftfahrtforschung, Berlin.
ON THE HISTORY OF THE HOLLOW SPACE EFFECT ON EXPLOSIVE CHARGES (Zur Geschichte der Hohlraumwirkung bei Sprengladungen), by H. Freiwald. Schriften, 1941, 58p. illus. (Rept. no. ZWB/DAL-1046-41; AMC Desk Catalog no. 926 10074 2) (Trans. as rept. no. BIOS/Gp. 2/HEC 591, "Unclassified", 53p. incl. illus.; Inclosure 1 to MA London rept. no. R3007-46; Also trans. as OTIB rept. no. 1148, 1v. incl. illus. diagrs., photographs referred to throughout this rept. are missing) Restricted

A summary and discussion on available literature covering the shaped charge effect is given. Extracts from German and other publications up to the year 1937 are included. Among these are repts. by Munroe, Marshall, Payman, and Woodhead. It was pointed out that the shaped charge effect was described by the German Max von Foerster as early as 1883, 5 years before Munroe. Photographs and sketches covering many of these early experiments are included in the rept. A bibliography of 29 refs. is included. (Abstract taken from HEC translation 591)

L688

Deutsche Akademie der Luftfahrtforschung, Berlin.
EXPERIMENTAL WORK IN THE FIELD OF DETONATION (Experimentelle Arbeiten zum Problem der Detonation), by H. Schardin. Schriften, 1941, p. 21-49, illus. (Rept. no. ZWB/DAL/1033-41 - In German; AMC Desk Catalog no. 962 10179 4) Unclassified

The subject is primarily the detonation of various explosives, but the "hollow charge effect" is commented upon generally and the investigation of various conical and U-shaped charges is described.

L689

Deutsche Waffen- und Munitionsfabriken A. G., Berlin.
PROCESS OF MANUFACTURING PRESSINGS FROM METAL POWDER (Verfahren zur Herstellung von Presskoerpern aus Metallpulver); APPENDIX TO PATENT. DEVICE FOR PRESSING METAL POWDER TO MAKE HOLLOW PRESSINGS; APPLICATION FOR PATENT. n. d. (Application for patent: D 90 564 XI/72d; Trans. as rept. no. BIOS/Gp/HEC 5861, 6p. diagrs.) Restricted

A method using 2 complementary dies is described for the manufacture of pressings from metal powder to produce liners for shaped charges. This pressing not only increases the explosive effect, but also keeps it uniform. A device for pressure molding of nozzle shaped liners is also described.

L690

Deutsche Waffen- und Munitionsfabriken A. G., Berlin.
[PATENT NOTIFICATION]. ARMOR-PIERCING SHELLS. Nov. 11, 1943. (No patent number; Trans. as rept. no. BIOS/Gp. 2/HEC 10030, 20p. incl. diagrs.; Inclosure 1 to MA London rept. no. R3662-46) Unclassified

Armor-piercing, shaped charge [follow-through] projectiles are described. Ignition of the second shell is brought about by detonation of the first on target impact.

L691

Deutsche Waffen- und Munitionsfabriken A. G., Berlin.
PATENT NOTIFICATION. HOLLOW CHARGE WITH DOUBLE SIDED INITIATION. Apr. 12, 1944. (No patent number; Trans. as rept. no. BIOS/Gp. 2/HEC 5588, 7p. incl. diagrs.) Secret

The invention, intended to increase the efficiency of shaped charges, provides for increasing to a certain extent the length of the wall of explosive beyond the greatest diameter of the liner, a cylindrical form being preferred, and for igniting it simultaneously with the explosive round the liner by means of a detonator with a primer charge-annular, if possible. Both the detonator and the primer charge simultaneously ignite the explosive from either end. With the hollow cylinder of explosive given the proper length and a simultaneous ignition occurring from above and beneath, the detonation waves will meet in the liner at a point which is almost farthest from the center, and a stronger acceleration will be given to the particles distant from the center which are comparatively unaffected by the ordinary type of initiation.

L692

Deutsche Waffen- und Munitionsfabriken A. G., Berlin.
[PATENT NOTIFICATION]. HOLLOW STED CHARGES WITH IMPROVED PERFORMANCE. Nov. 17, 1944. (8/TP 732 D 94252 IVb/78e v. 17. 11. 44; Trans. as BIOS/Gp. 2/HEC 5832, 7p. incl. diagrs.; Inclosure 1 to MA London rept. no. 2721-46) Unclassified

A uniform acceleration of detonation in shaped charges, and thus an improvement in their performance, is produced by an igniting charge fixed so that the pressure waves emanating therefrom strike approximately vertically on the external surface of the liner. By this arrangement, the detonation waves from the igniting charge are guided so that they strike the liner at normal, and detonation follows with absolute uniformity and maximum force.

L693

Development and Proof Services, Aberdeen Proving Ground.
DEVELOPMENT OF LAUNCHER AND ROCKET, SHAPED CHARGE (DEVICE K), 10 IN., WITH SINGLE 4.5-IN. MOTOR, by W. M. Podas. Apr. 26, 1945, 43p. illus. tables, diagrs. (Rept. no. 1; Rept. no. 41 on Ordnance program no. 5191) Confidential

Tests were made: to investigate the feasibility of propelling a 10-in. caliber shaped charge (device K) round with a single 4.5-in. rocket motor, utilizing existing components if possible; to determine the range and dispersion of the round; to develop or select a suitable fuze for the round; and to design a crate-type launcher for the round. Device K, developed by the du Pont Co., used the same drawn steel liner as in the M3 charge, and is capable of propulsion by spigot mortar or other methods. Results of firings with dummy heads to compare 2 methods of propulsion (spigot mortar and rocket) showed that the flight of the rocket round was erratic and its dispersion poor as compared with the spigot mortar round. Static firings of device K indicated that the extended nose tube designed to give the necessary standoff adversely affected charge penetration. Device K was redesigned with a false hemispherical ogive. It was concluded that the rocket now met the tentative requirements of an assault weapon for use against pillboxes, concrete fortifications and armor. Rounds fired from a rigidly mounted crate launcher were placed in a 10-ft. vertical square at 100 yd. range or in a 25-ft. vertical square at 220 yd. range; however, these tests were not adequate to determine the dispersion under service conditions. The velocity of the rocket can be increased from about 235 ft./sec. to about 325 ft./sec. by increasing the propellant load from 3.1 lb. of thin web ballistite to 4.65 lb. of standard ballistite; however, this change will increase the dispersion since more of the rocket burning occurs outside the launcher. On the basis of eccentricity measurements on 20 rounds, there was no correlation between eccentricity and dispersion. Tests indicated that the crate type launcher is satisfactory for the rocket, being definitely superior to an open angle Fe launching rail. Neither the Mk 147 rocket fuze nor the AIR 6 rocket fuze functioned with the round.

L694

Development and Proof Services, Aberdeen Proving Ground.
SHAPED CHARGE BOMB TEST AGAINST LAMINATED ARMOR PLATE, TO DETERMINE THE PENETRATION AND HOLE DIAMETER, by E. H. Harrison and E. F. Barr. Dates of test: Oct. 11, 1946-Feb. 3, 1947. 10p. incl. tables. (Firing record no. B-9427) Confidential

L695

Development and Proof Services, Aberdeen Proving Ground.
BOMB, SHAPED CHARGE, 2000-LB., T6E2, WITH FUZE, AN M103, TESTED AGAINST THICK ARMOR PLATE, by E. H. Harrison and E. F. Barr. Dates of test: Mar. 10-Apr. 25, 1947. 3p. incl. table. (Firing record no. B-9435) Confidential

L696

Development and Proof Services, Aberdeen Proving Ground.
VULNERABILITY OF WARHEADS TO FRAGMENTS - TESTS 3 AND 4. Dates of test: July 22, 1947-Apr. 22, 1948. 8p. incl. tables. (Firing record no. B-9440-H) Restricted

This record covers 2 tests against 500-lb. Comp. B loaded bombs employing shaped charges. Test 3 deals with the shaped charge M3 detonated at distances of 40 to 140 ft. from the bombs; test 4 covers the rocket M6A3, HEAT, from distances of 14 to 40 ft. inclusive.

L697

Development and Proof Services, Aberdeen Proving Ground.
TO INVESTIGATE THE ARMOR PENETRATION EFFECTIVENESS OF VARIOUS HE LOADINGS IN SHELL, HEAT, 105-MM., M67E1. Date of test: Dec. 12, 1947. [40]p. incl. illus. tables. (OCO proj. no. TM1-1526; Firing record no. P-42875) Confidential

Five lots of experimental, M67E1, shells and 1 lot of standard, M67, shells were tested for armor penetration. The experimental shell varied from the standard shell in that the standard steel liner was replaced with a Cu liner and the standard pentolite explosive was replaced with Comp. B explosive (in 1 lot) or Comp. B explosive plus a cast TNT core (in 4 lots). It was concluded from the static firing tests that the experimental loadings gave results superior to those obtained with the standard loading. The Comp. B loading was as effective as the cast-core type loading. Dynamic firing results are also included.

L698

Development and Proof Services, Aberdeen Proving Ground.
DEVELOPMENT OF FIN-STABILIZED PROJECTILE FOR 90-MM. GUN, M3. Dates of test: Nov. 12, 1948-Apr. 10, 1949. 59p. illus. tables. (Firing record no. P-44797) Confidential

L699

Development and Proof Services, Aberdeen Proving Ground.
TEST OF SHAPED CHARGES, M2A1, M3, M6A3, AND M9A1 ON ARCTIC TERRAIN, by H. B. Gibson. Aug. 10, 1949, 24p. incl. illus. tables, diagr. (Proj. no. TM3-5201, rept. no. 1; Proj. no. TX4-0100, Partial rept. no. 8) Confidential

Shaped charges M2A1, M3, M6A3, and M9A1 were tested to determine their utility in preparing holes in frozen Arctic terrain. The charges were detonated on frozen sand, frozen muskeg, and lake ice at standoffs ranging from 0 to 14 in. The firing data follow:

Charge	Number tested	Target	Hole size (in.) Ave. width (top)	Ave. width (bottom)	Ave. depth
M3	2	Lake ice	5.0	3.75	60.0
	3	Frozen muskeg	10.5	5.5	62.0
	1	Frozen sand	10.0	6.0	69.6
M2A1	2	Frozen muskeg	6	3.75	51.5
	3	Frozen sand	7	3.5	53.5
M6A3	11	Frozen muskeg	2.25	1.25	12.0
	12	Frozen sand	1.5	1.0	10.0
M9A1	12	Lake ice	1.0	0.75	7.5
	18	Frozen muskeg	2.0	0.75	12.5
	16	Frozen sand	1.5	1.0	[illegible]
M2 (AP 30-cal. cartridge)	2	Frozen sand	0.5	0.5	2.0

From these tests, it was concluded that shaped charges M3 and M2A3 were unsatisfactory because of the large holes and cratering produced while shaped charges M5A3 and M9A1 were considered to be generally satisfactory for installing Signal Corps equipment in Arctic terrain.

L700

Development and Proof Services, Aberdeen Proving Ground.
TEST OF RUSSIAN SHAPED CHARGE AMMUNITION: PROJECTILE, 122-MM., AND GRENADE, STICK, HAND, by H. S. Cassell. Jan. 5, 1950, 5p. illus. tables, diagrs. (Proj. no. TM1-5002, rept. no. 1; Firing record no. P-46020) Confidential

The 122-mm. Russian shaped charge projectile, and the Russian stick hand grenade, RPG M1943 were statically detonated against 8- and 10-in. homogeneous armor plate. Maximum penetration for the 122-mm. projectile was 5.5 in. and 2.75 in. for the hand grenade. It was concluded that for a round of its caliber, the 122-mm. projectile had extremely small penetration depth. The standard US 105-mm., HEAT, M67 round penetrated 11.5 in. of armor plate when fired statically.

L701

Development and Proof Services, Aberdeen Proving Ground.
FUNCTIONING AND ACCURACY TESTS OF 2.36-IN. ROCKETS, T59E3 AND T60E3, by M. T. Smith. Mar. 15, 1950, 36p. illus. tables, diagr. (Proj. no. TU2-1001, rept. no. 1) Confidential

The 2.36-in. fin-stabilized HEAT rocket, T59E3, with an 0.97 lb. explosive charge, was fired against 8-in. thick homogeneous armor plate at various obliquities and a range of 100 ft. A summary of the firing results follows:

No. of rounds	Plate obliquity	Penetration Character	Penetration Average depth (in.)
4	45°	Partial	5.37
5	0°	Partial*	5.87
5	60°	Partial	6.24
2	75°	"	2.50
2	70°	"	4.06
4	65°	"	5.08
1	65°	"	5.62
1	65°	"	7.37
5	0°	"	5.26
5	65°	"	5.02

* 1 of 5 rockets in this group completely penetrated the target

These results indicate that the penetration performance of the rocket, only 1 complete penetration being obtained, was very erratic and unsatisfactory at every target obliquity. It is believed that the PD fuze, T2000E1, Mod A, contributed to these erratic penetrations, failing to function or functioning late in 10% of the rounds fired. However, all the failure occurred at plate obliquities of 65°, 70°, and 75°. In addition, tests were conducted to compare the accuracy of the 2.36-in. practice rocket, T60E3, fitted with machined bar stock and die cast cones. The firing of 30 rounds of the practice rockets against a vertically mounted painted steel target (0° obliquity) indicated that there is no significant difference in the functioning of these 2 cone types.

L702

Development and Proof Services, Aberdeen Proving Ground.
HOLLOW CHARGES, A BIBLIOGRAPHY, by D. K. Parker. June 1950, 42p. [442 refs.] Secret

This is a list of documents available at the Aberdeen Proving Ground, on the general subject of shaped charges. It is arranged alphabetically according to the issuing agency, and then chronologically.

L703

Development and Proof Services, Aberdeen Proving Ground.
SPECIAL COMPARISON TEST OF 57-MM. AND 75-MM. RECOILLESS, HEAT ROUNDS AGAINST 2-IN. HOMOGENEOUS PLATE AT 60° OBLIQUITY. Date of test: Aug. 12, 1950. 4p. incl. tables. (Firing record no. P-47379) Restricted

L704

Development and Proof Services, Aberdeen Proving Ground.
THE VULNERABILITY OF ARMORED VEHICLES TO BALLISTIC ATTACK. CHAPTER II. SECTION VI. JET PENETRATION. Sept. 1950, p. 75-80 incl. illus. diagrs. (Proj. no. TT1-709) Confidential

In this vulnerability study of armored vehicles, the shaped charge was briefly considered. The following subjects were discussed: (1) the factors affecting shaped charge performance; (2) the materials for protection against shaped charges; and (3) the future of shaped charge attack and protective measures.

L705

Development and Proof Services, Aberdeen Proving Ground.
TO OBTAIN DATA ON THE VULNERABILITY OF A T26E4 TANK TO ATTACK BY A 3.5-IN. HEAT ROCKET, M28 AT 100 YD. RANGE. Dates of test: Sept. 19-Dec. 3, 1950. 1v. incl. illus. tables. (Proj. no. TB3-1224B; Firing record no. Ar-17193) Restricted

Seventy 3.5-in. HEAT rockets of the M28 type were fired against a fully equipped T26E4 tank.

Of 69 hits on the tank, 39 penetrated the interior and 30 failed to penetrate. The large percentage of failure to achieve penetration was attributed to slow fuze functioning. An additional source of inconsistency in performance, hence reduced effectiveness, was the unknown variation in behavior of the explosive charge and liner which was attributable to conditions of manufacture.

L706

Development and Proof Services, Aberdeen Proving Ground.
TO DETERMINE FUNCTIONING AND ARMOR PENETRATION OF 90-MM. SHELL, HEAT, T108E1. Dates of test: Oct. 12-Dec. 4, 1950. 3p. tables. (Proj. no. TMI-1451; Firing record no. P-47250) Confidential

L707

Development and Proof Services, Aberdeen Proving Ground.
TO DETERMINE TRACER FUNCTIONING OF CARTRIDGE HEAT-T, M307A1, WITH FUZE, PI, M90 FOR 57-MM. RIFLE, AMMUNITION LOT NO. PA-E-3957. Date of test: Nov. 21, 1950. [10]p. incl. tables, diagrs. (Firing record no. P-47360) Restricted

L708

Development and Proof Services, Aberdeen Proving Ground.
STATIC PENETRATION TESTS OF THE SHAPED CHARGE HEAD OF ROCKET, HEAT, 3.5-IN., M28, by M. T. Smith. Nov. 27, 1950, 26p. illus. tables, diagrs. (Proj. no. TU2-1015, rept. no. 1) Confidential

The rocket heads, containing a 1.93 lb. bursting charge of Grade I Comp. B, were fired statically against 12-in. thick Class B homogeneous armor plate at angles of obliquity ranging from 30° to 70° to determine the penetration characteristics of the M28. A summary of the plate penetration data follows:

Rounds considered	Standoff (in.)	Obliquity (°)	Penetration mean (in.)
5	4.2	30	13.55
5	4.2	45	12.52
5	4.2	55	12.55
5	4.2	60	11.48
3	4.2	65	10.98
5	4.2	70	11.20

At 65° obliquity the penetration was 0.2 in. less than that obtained at 70° obliquity; however, these data are based on limited firings. In most cases, it was observed that the jets penetrated the plate along the predetermined line of obliquity. It was concluded that the efficiency of the 3.5-in. HEAT rocket, M28, was greatly decreased by the slow functioning (60 msec.) BD fuze, M404. Penetration profiles are included for the various angles of obliquity.

L709

Development and Proof Services, Aberdeen Proving Ground.
TO DETERMINE CHARACTERISTICS OF FUZE, BD, T165E3, ASSEMBLED TO SHELL, HEAT, M66, FOR 75-MM. HOWITZER, M1. Dates of test: Nov. 30 and Dec. 3, 1950. [14]p. incl. tables. (Proj. no. TM1-2537B; Firing record no. P-47396) Restricted

L710

Development and Proof Services, Aberdeen Proving Ground.
DEVELOPMENT TEST OF SHELL, HEAT, T131 SERIES FOR 105-MM. HOWITZER, M2 AND M4. Dates of test: Dec. 6, 7, and 18, 1950, 10, 11, 12, and 16, Jan. 1951. 16p. illus. tables, diagrs. (Firing record no. P47450) Confidential

L711

Development and Proof Services, Aberdeen Proving Ground.
TO DETERMINE EFFECT OF ALTITUDE ON JET PENETRATION OF SHAPED CHARGES. Dates of test: Dec. 8, 1950-Jan. 30, 1951. 1p. illus. (Proj. no. TB3-5238; Firing record no. P-47298) Restricted

L712

Development and Proof Services, Aberdeen Proving Ground.
FIRST REPORT ON TEST OF SHAPED CHARGE, MODIFIED 2.36-IN. ROCKET HEAD M6A3C, ON FIRM GROUND, by S. C. Noble. Dec. 21, 1950, 22p. illus. table. (Proj. no. TM3-5201, rept. no. 2) Confidential

Test firings were made using 5 shaped charges with ground shields and 5 shaped charges alone. The results of these firings at a standoff of 8 in. follow:

With ground shield: Round no.	Depth of Hole (in.)	Without ground shield: Round no.	Depth of hole (in.)
1	34.75	2	32.25
3	29.50	4	38.75
5	31.50	6	29.75
7	28.50	8	32.25
9	34.75	10	33.00
Average	31.80	Average	33.20

The diameter of all holes was very uniform, being approximately 5 in. for a depth of about 1.5 ft. The target ground was moist and packed well; however, the ground was not waterlogged, the holes remaining water free.

L713

Development and Proof Services, Aberdeen Proving Ground.
STATIC DETONATION OF SHELL, 90-MM. T108 AGAINST ARMOR PLATE, by J. D. Armitage. [1951], 2p. (In Engineering progress rept. for June 15-July 15, 1951 of the Budd Co. (DA33-034-ORD-62), p. 5-6) (Proj. no. TA1-1451, Memo. rept. no. 1) Confidential

Two hundred fifteen shells, HEAT, 90-mm. T108E11 were fired statically against armor plate to determine the effect of various manufacturing irregularities upon the depth of penetration. The armor plate consisted of plates 8 in. x 8 in. with a thickness of 3 in. and 1.25 in. The 3 top plates were 3 in. thick and the remaining 7 plates were 1.25 in. thick. The Brinell Hardness of the 3-in. plate was 248 and of the 1.25-in. plate was 175. The standoff was 6 in. for all the shells tested. It was concluded that the shells with the internally machined bodies did not yield significant increase in the depth of penetration as compared with those shells having "as forged" bodies. A longitudinal variation up to 0.011 in. and a spit-back eccentricity of 0.010 in. did not affect the depth of penetration. The depth of penetration was decreased by a tube eccentricity of 0.020 in., by a transverse liner variation from 0 to 0.003 - 0.006 in., and by wavy liners with a transverse variation up to 0.010 in. Rounds with variations such as: (1) Frankford Arsenal machined bodies and (2) forged bodies; (3) Budd Co. RS1 and (4) RS2 rounds with 0.010-and 0.020-in. controlled tube eccentricities respectively; (5) Budd Co. RS3 round with 0.020-in. random tube eccentricity; (6) Budd Co. RS4 liner longitudinal variation up to 0.008 - 0.011 in.; (7) RS5 liner transverse variation up to 0.003 - 0.006 in.; (8) wavy liners - maximum 0.010-in. transverse variation; (9) RS6 "as forged" control; and (10) RS7 "as forged" were tested. Penetrations in in. of: (1) 13.37; (2) 13.06; (3) 13.42; (4) 12.57; (5) 12.98; (6) 13.14; (7) 10.80; (8) 10.11; (9) 13.21; and (10) 13.14, respectively, were obtained.

L714

Development and Proof Services, Aberdeen Proving Ground.
TEST OF ROCKET, HEAT, 3.5-IN., M28 (T80E2), by S. J. Nicolosi. [1951], 21p. incl. tables, (Proj. no. TU2-1002A, rept. no. 2) Restricted

Test firings were made to determine the plate penetration characteristics of the 3.5-in. HEAT rocket, M28 (T80E2) at obliquities of 45° and 60° against various thicknesses of armor plate. A summary of these firings follows:

Armor plate thickness (in.)	obliquity (°)	Ave. penetration depth (in.)
7	45	9.9+
7	60	8.5
10	45	9.7
5	60	10.0+

It was concluded that 70% of these rockets will completely penetrate 5 in. of armor plate at 60° obliquity and at range of 600 ft.

L715

Development and Proof Services, Aberdeen Proving Ground.
VULNERABILITY OF T26E4 TANKS: 3.5-IN. HEAT ROCKET HEADS VS. FUEL TANKS (GASOLINE FILLED). Dates of test: Jan. 5-Apr. 11, 1951. [30]p. incl. illus. tables, diagrs. (Proj. no. TB3-1224B; Firing record no. AR-17341) Restricted

Results are reported of tests against 5-gal., light gauge, stock issue tinned cans, and 2 pieces of 3-in. thick rolled homogeneous armor plate simulating a tank hull. The rocket heads were also fired against T26E4 fuel tanks mounted in engine compartments. The observation rept. states that although fires resulted in all cases, damage to containers with less gasoline and when jets were aimed above the fuel level was less than when jets were aimed below the fuel level.

L716

Development and Proof Services, Aberdeen Proving Ground.
TO DETERMINE ACCURACY OF SHELL, HE, M309A1, AND HEAT, M310A1 (T39), 75-MM. RIFLE. Dates of test: Jan. 12 and 17, 1951. [10]p. incl. tables, diagrs. (Firing record no. P-47594) Unclassified

L717

Development and Proof Services, Aberdeen Proving Ground.
REPORT OF TRIP TO UNITED KINGDOM, FRANCE, AND BELGIUM, 30 JAN. 1951 TO 24 FEB. 1951, by T. F. Colleran. Mar. 5, 1951, 25p. illus. tables, diagrs. Secret

It is reported that the British linear shaped charge device "Hayrick", having a 9-lb. explosive charge, is effective. These charges are placed in necklace form to cut large bridge girders. The flat charge metallic mine being developed by the French was very effective when fired against thick belly armor (80 mm.). A plastic shaped charge mine is also being developed by the French. This mine contains a 90° glass liner 14 cm. in diameter x 6 cm. deep. No tests were made on the mine.

L718

Development and Proof Services, Aberdeen Proving Ground.
VULNERABILITY OF T26E4 TANKS: 3.5-IN. HEAT ROCKET M28A1 VS. TEST TANK NO. 3 (SIMULATING ATTACK BY AIRCRAFT). Dates of test: Mar. 6-Apr. 12, 1951. [4]p. incl. illus. tables, diagrs. (Proj. no. TB3-1224B; Firing record no. Ar-17340) Restricted

A summary of rounds fired at the target tank is appended. It was concluded that the crew, under combat conditions with the tank in motion, would have been unable to extinguish fuel fires caused by the 3.5-in. rocket rounds. Of 16 hits, 6 would have destroyed the tank by fire and 4 others would have put the tank out of action.

L719

Development and Proof Services, Aberdeen Proving Ground.
TEST OF SHELL, HEAT, 75-MM., T84, FIN-STABILIZED. Dates of test: July 28-Sept. 24, 1950. Mar. 13, 1951, 4p. illus. tables, diagrs. (Proj. no. TM1-1282, rept. no. 1; Firing record no. P-47000) Confidential

Shells were fired from a smooth bore tube for operation of the fin assembly, accuracy at ranges of 1000 and 1500 yd., and time of flight over approximately 1000 yd. The fins began to open while the shell was traveling down the tube, but the gouging of the tube wall was not considered serious in this test. The fin opened on all shells fired. Accuracy of the shell at ranges of 1000 and 1500 yd. was considered unsatisfactory.

L720

Development and Proof Services, Aberdeen Proving Ground.
COLD WEATHER TESTS OF SHAPED CHARGE IN HEAD OF 2.36-IN. ROCKET, HEAT, M6A3C AS USED FOR MAKING HOLES IN FROZEN GROUND (1950-1951 WINTER TRIALS), by W. D. Woodford. June 18, 1951, 9p. illus. (Proj. TQ3-9106, rept. no. 4) Confidential

Shaped charges in the heads of 2.36-in. rockets (HEAT, M6A3C) were detonated at a standoff of 8-in. over various types of frozen ground in the Devils Lake, North Dakota area. A 1-in. steel ground shield plate with a 1-in. or 3-in. diameter hole was used with about half the charges. Some of the holes made by the shaped charges were enlarged by extrudible explosive or dynamite. Holes averaging about 30 in. deep were made in ground frozen to 18 in. Penetration was reduced to a minimum of 6 in. in certain types of ground containing sand, gravel and rock. A maximum penetration depth of 41 in. was obtained in sandy clay. Round-by-round assessments of the firings are included in appendixes.

L721

Development and Proof Services, Aberdeen Proving Ground.
BALLISTIC TEST OF A PROPOSED MEANS OF DEFEATING SHAPED CHARGE AND PLASTIC EXPLOSIVE SHELL ATTACK. Dates of test: Mar. 12-July 11, 1951. Aug. 8, 1951, 9p. illus. tables, diagrs. (Proj. no. TT1-5, rept. no. 2; Armor test rept. no. AD-1139) Confidential

Results are presented for the ballistic testing of the proposed arrangement. The angle arrangement as tested against the 3.5-in. HEAT, M28A2 rocket afforded protection against 100% of the impacts at 60° obliquity, 43% of the impacts at 45° obliquity, and 0% of the impacts at 0° obliquity.

L722

Development and Proof Services, Aberdeen Proving Ground.
TO OBTAIN DATA ON THE PENETRATION OF 3.5-IN. HEAT ROCKET HEADS VS. CAST ALUMINUM AND ROLLED STEEL PLATES. Dates of test: Aug. 8-23, 1951. [27]p. incl. illus. diagrs. tables. (Proj. no. TB3-1224B; Firing record no. Ar-17648) Restricted

Seventy-one rocket heads were detonated for the following conditions: (1) normal to edge of Al (average penetration = 28.2 in.); (2) Al at 60° obliquity backed by steel (average penetration = 11.2-in. Al, 7.2-in. steel); (3) normal to Al backed by steel (average penetration = 5.6-in. Al, 16-in. steel); (4) normal to steel, Al and steel (average penetration = 5.6-in. Al, 9.7-in. steel); (5) normal to 1-11/16-in. steel plate, 5.6-in. air space, more steel plate (average penetration = 13.0-in. steel); (6) 5.6-in. additional standoff from 1-11/16 in. steel plate (average penetration = 12.2-in. steel); (7) rocket touching and normal to steel 1-11/16 in. plate (average penetration = 11.9-in. steel). Radiographs of the penetrations obtained for condition 1 are appended.

L723

Development and Proof Services, Aberdeen Proving Ground.
TO DETERMINE THE VULNERABILITY OF DIESEL FUEL CONTAINERS TO 3.5-IN. HEAT ROCKET HEADS, M28A2, STATICALLY DETONATED. Dates of tests: Aug. 28-Sept. 20, 1951. 10p. incl. tables. (Proj. no. TB3-1224B; Firing record no. Ar-17650) Restricted

Eighty-one rocket heads for 3.5-in. HEAT, M28A2, were statically detonated against containers of no. 2 diesel fuel, and 4 rounds against gasoline containers. Tabular data are appended.

L724

Development and Proof Services, Aberdeen Proving Ground.
DEVELOPMENT OF FUZE PI, T150 SERIES, FOR 75-MM. AND LARGER HEAT AMMUNITION. Date of test: Oct. 15, 1951. 13p. incl. tables. (Proj. no. TA1-2537C (TA1-2702); Firing record no. P-49398) Confidential

Firings were made against homogeneous steel armor plate targets at various obliquities to test the functioning of the T150E and M91 fuzes. A summary of these firings using the 75-mm. M310A HEAT round follows:

Rounds	Fuze	I	II	III	IV
8	T150E3	0°	4.5 in.	1	7 (ave. 3.4 in.)
6	M91	0°	4.5 in.	0	6 (ave. 3.6 in.)
5	T150E3	60°	2.0 in.	0	0
3	T150E3	60°	2.0 in.	0	0
2	M91	60°	2.0 in.	2	0

I = plate obliquity; II = target thickness; III = complete penetration; IV = partial penetration.

All rounds appeared to function with high order; however, it was apparent in the firings against plate at 60° obliquity, that this high order detonation was not the result of fuze action with the possible exception of 2 rounds. It was concluded that the test fuzes performed unsatisfactorily against steel armor plate.

L725

Development and Proof Services, Aberdeen Proving Ground.
VULNERABILITY OF 26E4 TANKS: 105-MM. HEAT-T M67 VS. TEST TANK NO. 10 AT 500-YD. SIMULATED RANGE. Dates of test: Oct. 16-30, 1951. [44]p. incl. illus. tables. (Proj. no. TB3-1224B; Firing record no. Ar-17726) Restricted

Test results showed that all rounds functioned properly and formed proper jets except for 1 round which was upset when it hit the edge of the gun mantlet before hitting the turret. Of the 20 rounds fired, 7 penetrated the tank. Two rounds were defeated by armor and obliquity, and 4 rounds did not cause any damage. Other data are included.

L726

Development and Proof Services, Aberdeen Proving Ground.
TEST OF ROCKET, ANTITANK, 73-MM, FRENCH AND LAUNCHER, ROCKET, 73-MM, FRENCH. Nov. 15, 1951, 14p. illus. tables. (Proj. no. TU2-8B, rept. no. 1; Proj. no. TS4-4019, rept. no. 6) Secret

Rockets, 73-mm., both practice and HEAT, were fired to obtain data relative to the accuracy, velocity, plate penetrating ability, fuze time, and fuze arming distance of these rockets as well as characteristics of the launcher when subjected to pendulum, dust, mud and rain tests. It was concluded that the rocket, antitank, 73-mm., French, was superior to the rocket, HEAT, 3.5-in., M28A2, with respect to armor penetrating ability, probability of obtaining a first round hit on a moving target, and its light weight. The launcher, rocket, 73-mm., French, was satisfactory except for several deficiencies with respect to handling and aiming ease.

L727

Development and Proof Services, Aberdeen Proving Ground.
TO DETERMINE THE ACCURACY AND FUNCTIONING OF SHELL, HEAT, T138E57, 105-MM. RIFLE, T137E1. Dates of test: Nov. 26 and 28, 1951. 8p. tables, diagrs. (Proj. no. TA1-1540; Firing record no. P-51033) Confidential

The HEAT shell, T138E57 was fired against homogeneous armor plate targets at obliquities of 0° and 60° to obtain penetration data. A summary of the firings at 1007-yd. range follows:

Target	Horizontal penetration (in.) Mean	Max.	Min.
6-in. +6-in. +4-in. homo. armor plates	14	15.25	12.0-
6-in. +4-in. homo. armor plates	13.375	15.0	12.0-

L728

Development and Proof Services, Aberdeen Proving Ground.
VULNERABILITY OF T26E4 TANK: 90-MM. HEAT-FS, T108E15 W/FUZE, PI, T209, VS. TEST TANK NO. 11 AT 540-YD. RANGE. Dates of test: Dec. 13, 1951-Jan. 23, 1952. 1v. incl. illus. tables, diagrs. (Proj. no. TB3-1224B; Firing record no. Ar-18098) Confidential

Tabular results from tests with 34 rounds of HEAT-FS fired against the tank target are given. Thirty-one of the rounds hit the tank. The depth of damage produced by a penetration was seldom great.

L729

Development and Proof Services, Aberdeen Proving Ground.
TEST OF CARTRIDGE, 90-MM., T108E11 IN GUN, 90-MM., T133E1, by F. M. Mahan. Dec. 18, 1951, 15p. tables, diagr. (Proj. no. TA1-1462, rept. no. 1) Confidential

Tests were conducted to determine the performance of the 90-mm. HEAT, T108E11 round when fired at 2800 ft./sec. muzzle velocity from the 90-mm. T133E1 gun. Fifteen rounds were fired against a 5-in. homogeneous armor plate target at a range of 1000 yd. and an angle of obliquity of 55°. Twelve complete penetrations were obtained giving average entry and exit hole diameters of 1.25 and 1.0 in., respectively. One partial penetration of 9 in. was also recorded. From these data, it was concluded that the performance of the T108E11 round when fired from the T133E1 gun is comparable to that obtained when the 90-mm. M3 gun is used.

L730

Development and Proof Services, Aberdeen Proving Ground.
TEST OF FUZE, PIBD, T209, ASSEMBLED TO CARTRIDGE, HEAT, 90-MM., T108 SERIES, by F. M. Mahan. Dec. 27, 1951, 27p. tables. (Proj. no. TA1-2608A, rept. no. 1) Confidential

90-mm. HEAT rounds, fitted with modifications of the fuze PIBD, T209, were tested against armor plate at obliquities of 0°, 55°, and 60° to determine the functioning characteristics of the spit-back-type fuze. Round-by-round assessments of the firings, including target type, obliquity, range, and number of complete and partial penetrations, are given. From these data, it was concluded that the T209 fuze is a satisfactory interim fuze for use with nonrotated, fin-stabilized HEAT rounds.

L731

Development and Proof Services, Aberdeen Proving Ground.
STATIC TEST OF SHELL, HEAT, FS, T188E2, 57-MM. RIFLE, TPR FA-RE-162, by L. E. Wills. [1952], 16p. tables. (Proj. no. TA1-1152, Memo. rept. no. 1) Confidential

Three types of 57-mm. T188E2 static firing devices, loaded with Comp. B, were fired against target stacks of 1.5-in. thick homogeneous steel plates piled 13.5 in. high to obtain penetration data. A summary of the test firings follows:

Lot and type of round	Rounds	Penetration (in.) Max.	Min.	Ave.	Mean deviation (in.)	Ave. hole vol. (cu. in.)
PA-E-9827 (simple liner, conduit with wire through side of liner)	10	10.1	6.8	9.3	0.4	1.35
PA-E-9828 (spitback type liner, conduit with wire through side of liner)	10	10.0	8.5	9.0	0.5	1.34
PA-E-9829 (spitback type liner, conduit with wire through spitback tube in apex of liner)	9	11.0	8.6	9.9	0.5	1.34

L732

Development and Proof Services, Aberdeen Proving Ground.
PRELIMINARY SERVICE BOARD TEST OF CARTRIDGE, HEAT, T184E3, 105-MM. RIFLE, M27. Dates of test: Jan. 24-Feb. 26, 1952. 20p. illus. tables, diagrs. (Proj. no. TA1-1540; Firing record no. P-52591) Confidential

The 105-mm. HEAT shell, T184E3, was fired against various combinations of laminated homogeneous armor plate at different obliquities, ranges, and temperatures to obtain penetration data. A summary of the firing data follow:

I	II	III	IV	V	VI
6	16 in.	0°	5	0	——
1	10 in.	60°	0	1	17 in.
13	10 in.	60°	0	12	15 in.

I = rounds considered; II = target (armor plate); III = obliquity; IV = complete penetration; V = partial penetration; VI = ave. penetration.

In extreme temperature tests, rounds were fired against a lamination of 6 1.5-in. armor target plates at 60° obliquity and at a range of 133.3 yd. At +125°F, the 2 rounds considered gave an average penetration of 14 in., while the 2 rounds fired at -65°F gave an average penetration of 14.5 in. It is concluded that the large number of deflagrations was caused by damage to the fuze during assembly.

L733

Development and Proof Services, Aberdeen Proving Ground.
DEVELOPMENT OF SHELL, HEAT, T84, FIN-STABILIZED FOR 75-MM. GUNS. Dates of test: Aug.-Sept. 1951. Jan. 29, 1952, 7p. illus. tables, diagrs. (Proj. no. TA1-1232, rept. no. 1; Firing record no. P-49071) Confidential

A powder charge (31.25 oz. of propellant, lot 19843) was developed that produced a maximum velocity (2200 ft./sec.) within the desired pressure range. The projectile was accurate at a range of 1000 yd. when fired from a rifled tube and when the fin-operating mechanism functioned normally.

L734

Development and Proof Services, Aberdeen Proving Ground.
DETERMINATION OF EFFECTIVENESS AND FUNCTIONING CHARACTERISTICS OF GRENADE, RIFLE, HEAT, T37 SERIES, WITH FUZE GRENADE, T1014, by A. B. Jenny. Feb. 13, 1952, 70p. incl. illus. tables, diagrs. (Proj. no. TQ3-5911, rept. no. 1) Confidential

Forty-nine grenades of the types T37, T37E2, and T42 (Energa) with the T1014 fuze were fired from an M1 rifle in penetration tests against varying thicknesses of homogeneous armor plate. The armor penetration data follow:

Type and no. fired	Target thickness (in.)	Impact	Penetration (in.) max.	min.	ave.
T37 (2)	6	Normal	One	complete	penet.
T37 (1)	8	60°	No	"	"
T37 (1)	4	55°	One	"	"
T37 (1)	5	55°	One	"	"
T37 (10)	10	Normal	8.6	3.6	6.0
T37E2 (12)	11*	Normal	11.0	8.4	10.25
T37E2 (5)	6.75	60°	10+	4.5	6.7
Energa (2)	11*	Normal	10.0	10.0	10.0

*10 in. of steel in target

It was concluded that: (1) the T37 grenade was unsatisfactory from the standpoint of armor penetration; (2) the T37E2 performed satisfactorily in armor penetration tests; (3) insufficient Energa grenades were fired to obtain adequate armor penetration data; (4) the T1014 fuze was unsatisfactory with respect to functioning, graze impact, and arming.

L735

Development and Proof Services, Aberdeen Proving Ground.
REAR BLAST EFFECT OF 3.5-INCH ROCKET. Dates of test: Oct. 18-31, 1951. Feb. 27, 1952, 6p. illus. tables, diagrs. (Proj. no. TU2-7C, rept. no. 1; Firing record no. R-2814)
Restricted

Tests were made to determine the danger area for personnel and inflammable materials to the rear of 3.5-in. rocket launchers. It was concluded that high velocity gases, particles, and flame from the rear of the launcher would injure personnel and ignite inflammable materials up to a distance of at least 25 ft. directly to the rear of the launcher.

L736

Development and Proof Services, Aberdeen Proving Ground.
TO DETERMINE THE FUNCTIONING AND PENETRATING ABILITY OF THE ROCKET, HEAT, 3.5 IN., T205, WITH FUZE, ROCKET, PIBD, T2030E2. Dates of test: Mar. 26 and Apr. 2, 1952. 10p. table. (Firing record no. R-2848)
Confidential

The 3.5-in. HEAT rocket, T205, fitted with PIBD fuze T2030E2 was fired against 12-in. thick homogeneous armor plate to determine the rocket's penetrating ability. Penetration data obtained at 0° obliquity follow:

Rounds	Penetration Partial	Penetration Complete	Duds
1-5	2	0	3
6-10	4	1	0

After firing the first 5 rounds with poor results, the remaining 5 rounds were disassembled in an attempt to determine the causes for the 3 duds. Examination of the fuzes revealed that the insulating tape between the rocket body and the electrical contact was defective or improperly installed, or had moved out of place during handling. New tape was installed and though the PIBD T2030E2 fuzes appeared to function properly the penetrations were poor for the second lot of 5 rounds tested. The flight characteristics of all rockets fired were good.

L737

Development and Proof Services, Aberdeen Proving Ground.
TO DETERMINE FUNCTIONING AND SAFETY OF AMMUNITION FOR 105-MM. RIFLE, T137E1. Dates of test: Apr. 2-July 16, 1952. 62p. illus. tables. (Proj. no. TA1-1540; Firing record no. P-52705)
Confidential

Firings were conducted to determine the cause of the consistent plate failures of the T138E57 HEAT round. Laminated steel plate targets 9 and 12 in. thick, placed at obliquities of 0° and 60° and a range of 400 ft., were used to test the various lots of ammunition. X-rays of various rounds failed to indicate that the filler loading was at fault. Shells were disassembled and defects corrected, but poor penetrations still resulted. No better results were obtained when new base elements were installed. On modifying the wall thickness of the T-cap from 0.10 to 0.050 in., improvement in performance was evident. However, it was concluded that the plate action of the T138E57 round is not equal to that of the T184E6 or T119E11 rounds. The results of 1 series of firings at homogeneous armor plate (60° obliquity) at a range of 400 ft. follow:

Round type	Rounds considered	Horizontal penetration (in.) Mean	Max.	Min.
T119	5	15.0	15.0	14.50
T138E57	5	12.0	13.25	10.75
T138E57	5	11.75	12.50	10.50
T138E57	4	12.75	15.0	10.50

L738

Development and Proof Services, Aberdeen Proving Ground.
TO DETERMINE THE EFFECT ON PENETRATION OF A CHANGE IN THE THICKNESS OF THE COPPER LINER IN THE 105-MM. T118 STATIC FIRING DEVICE. Date of test: Apr. 15, 1952. 26p. incl. tables, diagrs. (Proj. no. TA1-1540; Firing record no. P-51104)
Confidential

Thirty 105-mm. T118 HEAT shells with 3 different liner thicknesses (0.120, 0.110, and 0.100 in.) were fired statically to obtain penetration data. Ten rounds of each liner thickness were detonated on a stack of 1.5-in. target plates. Measurements were made of the depth of penetration, the hole volume, and entrance and exit diameters. The following results were obtained:

Liner thickness (in.)	Average penetration (in.)	Average hole volume (cu. in.)
0.120	17.89	5.92
0.110	17.78	5.97
0.100	17.83	6.28

These results indicate that there is a statistical correlation between liner thickness and volume, the smaller the liner thickness, the greater the hole volume. However, the effect of liner thickness on penetration depth is not evident from the data.

L739

Development and Proof Services, Aberdeen Proving Ground.
FUNCTIONING AND SAFETY OF CARTRIDGE, HEAT, T118E18, 105-MM. RIFLE, T136E2. Dates of test: May 5 and 6, 1952. 72p. incl. illus. tables. (Proj. no. TA1-1540; Firing record no. P-53397)
Confidential

The 105-mm. HEAT rounds, fitted with the PIBD, T208E7 fuze were fired against a target (60° obliquity) composed of 6 1.5-in. homogeneous armor plates to obtain penetration data. The firing data follow:

Number of rounds	Penetration (in.) Mean	Max.	Min.
10	13.9	15.5	12.0
10	12.5	15.0	12.0
8	12.7	15.0	12.0*

*Fuze failed on 1 round

L740

Development and Proof Services, Aberdeen Proving Ground.
TEST OF FUZE, PIBD, (T208 SERIES), ASSEMBLED TO CARTRIDGE, HEAT, FS, 90-MM., (T108 SERIES), by F. Mahan. May 27, 1952, 125p. illus. tables. (Proj. no. TA1-2702, rept. no. 2) Confidential

90-mm. HEAT-FS, T108 series rounds, assembled with PIBD T208 series fuzes, were fired against various armor plate, wood, and ground targets. In penetration tests, approximately 76% and 50% of the rounds fired completely penetrated 5-in. and 6-in. armor targets, respectively, at angles of obliquity up to 60°. The remaining rounds either partially penetrated the targets or deflagrated on the face of the plate. A summary of the round-by-round firings, including target type, range, angle of obliquity, and depth of partial penetration in in., is given.

L741

Development and Proof Services, Aberdeen Proving Ground.
COMBINED ENGINEERING AND ARMY FIELD FORCES TESTS OF SHELL, HEP, T81E28 AND CARTRIDGE, HEAT-FS, T131E31 FOR 105-MM. HOWITZERS M2A1 AND M4. June 16, 1952, 62p. incl. illus. tables. (Proj. no. TA1-1526, rept. no. 2) Secret

Tests were conducted to determine the effectiveness of the HEAT-FS, T131E31 round with 0.100-in. thick liner against armor plate 5 and 7 in. thick and against 4- x 5- x 7-ft. concrete slab targets. The penetration data follow:

I	II	III	IV
5	7	60	5 of 5
5	7	0	3 of 5
5	7	60	5 of 5
5	7	60	3 of 4*
5	7	60	4 of 5
5	5	70	4 of 5
4	5	75	2 of 3*
8	7	60	4 of 5*

*Fuze failure, target misses, etc.
I = No. of rounds fired; II = Armor thickness (in.); III = Armor obliquity (°); IV = Complete penetrations

The 48-in. thick concrete target was destroyed by the 5 HEAT-FS, T313E31 rounds fired.

L742

Development and Proof Services, Aberdeen Proving Ground.
TO COMPARE THE ARMOR PENETRATION PERFORMANCE OF FOUR GROUPS OF COPPER CONES ASSEMBLED IN 75-MM. STATIC TEST DEVICES IN CONNECTION WITH DESIGN OF SHELL, HEAT, 75-MM. T221. Date of test: June 20, 1952. 25p. illus. tables. (Proj. no. TA1-1281; Firing record no. P-52747) Confidential

Tests were conducted on 4 groups of conical Cu liners which differed as follows: (A) machined liner, modified from a 90-mm. liner with a sharp 45° apex angle; (B) stamped liner of good quality with a sharp 45° apex angle; (C) stamped liner of fair quality (i.e., scratches and die marks present) and a 45° apex angle; (D) machined liner, modified from a 90-mm. liner with a spitback tube. Each group was detonated statically on a stack of 10 pieces of 1.5-in. thick homogeneous armor plate. Penetration depth and hole volume data for the 4 groups showed that:

Liner Group	Ave. penetration (in.) (10 rounds)	Ave. hole vol. (cu. in.) (10 rounds)
A	13.228	3.390
B	12.778	3.166
C	12.906	3.267
D	*13.428	2.953

*1 round penetrated all plates completely

These results indicated that the machined liners, both the 45° apex and spitback tube types, gave slightly better penetration than stamped liners having a 45° apex. However, the small differences in average penetration of the 4 liner groups are not considered to be significant because of the limited number tested and the variations within groups.

L743

Development and Proof Services, Aberdeen Proving Ground.
DEVELOPMENT TESTS OF ROCKET, HEAT, 2.36-IN. T59E3 AND ROCKET, PRACTICE 2.36-IN., T60E3, by M. T. Smith. Aug. 5, 1952, 70p. illus., tables, diagrs. (Proj. no. TU2-1001A, rept. no. 1) Confidential

The 2.36-in. HEAT rocket, T59E3, was fired against homogeneous armor plate of various thicknesses to determine its penetration characteristics. A summary of these firings follows:

Rounds fired	Rocket temp. (°F)	Target thickness (in.)	Target obliquity (°)	Rounds considered	Penetration ave. (in.)	Penetration complete	Penetration partial
10	70	4	70	—	—	0	10
20	120	3	70	—	—	6	13
10	-20	3	70	—	—	1	9
9	70	2	60	—	—	0	3
8	70	1.25	60	—	—	3	1
10	70	4	60	—	—	2	0
10	-20	4	60	—	—	3	7
12	120	4	60	—	—	4	0
10	70	6	45	9	6.70	3	7
20	70	4.2	60	10	5.30	0	10
20	70	9.2	0	9	7.45	5	15
10	-20	8.2	0	6	6.97	2	6
10	70	8.3	0	7	7.54	3	6

It was concluded that the plate penetration characteristics of this rocket can be improved by rigid fabrication control of the rocket head metal parts.

L744

Development and Proof Services, Aberdeen Proving Ground.
TO DETERMINE THE EFFECT ON PENETRATION BY VARYING THE WALL THICKNESS OF THE CONFINING BODY OF STATIC FIRING DEVICE TO SIMULATE SHELL, HEAT, 105-MM., T184. Date of test: Aug. 5, 1952. 29p. incl. tables. (Proj. no. TA1-1536; Firing record no. P-52455) Confidential

This study was undertaken to determine the effect on shaped charge penetration of varying the properties of the confining body, all other factors remaining constant. Each static firing device for the 105-mm. HEAT shell, T184, was placed upon a stack of 17 homogeneous steel target plates, 1.5- x 8-in. square, and detonated in groups of 10 using Engineers' Special blasting caps wired in series. After the firings, the total amount of penetration was obtained and the plate in which jet terminated was determined. In some cases the plates were sectioned to verify the exact penetration depth. A summary of these firings at 8-3/8 in. standoff follows:

Confining body material	Confining body thickness (in.)	Ave. hole vol. (cu. in.)	Ave. penetration depth (in.)
steel	.062	3.51	13.76
"	.125	4.42	15.65
"	.250	5.40	17.80*
"	.375	5.94	17.91**
aluminum	.250	3.60	15.82

* Omitting 1 low value (14.4 in.), the average penetration is 18.18 in.
** Omitting 1 low value (12.7), the average penetration is 18.48 in.

All of the devices functioned satisfactorily. A round-by-round tabulation of the firing data is given.

L745

Development and Proof Services, Aberdeen Proving Ground.
EFFECTIVENESS OF 5-IN. HEAT ROCKET HEADS WITH ALUMINUM AND COPPER LINERS AGAINST T26E4 AND T26E5 TANKS, by R. L. Huddleston. Aug. 25, 1952, 123p. illus. tables, diagrs. (Proj. no. TB3-1224B, rept. no. 4; Armor test rept. no. AD-1151) Confidential

In these tests, 40 HEAT charges were statically detonated against medium tanks and against special targets such as containers of diesel fuel and live 90-mm. AP ammunition. Sixteen of the charges fired possessed the following characteristics:

Charge length: 12 in.
Outside diameter of liner: 4.75 in.
Explosive charge: 10 lb. Comp. B.
Liner material: Al (9% Si)
Liner weight: 590 g.
Liner thickness: 0.285 in.
Liner apex angle: 42.5°
Standoff: 5 in.

The remaining 24 charges were Mk 25 Mod 1, 5-in. ATAR rocket heads containing conical Cu liners and explosive charges of approximately 16 lb. of Comp. B. The standoff for the Cu liner charges was 5 in. plus that distance already built into the rocket head for the nose fuze. Results of the test firings indicated that: (1) 8 of 9 Al liner charges and 11 of 15 Cu liner charges put the target tanks out of action; (2) in most cases, there was enough blast generated to cause rupture of the eardrums of tank personnel, (3) against diesel fuel containers behind plate; Al and Cu liners were equally effective, producing violent fires if detonated below the fuel level and less violent fires if detonated above the fuel level; (4) detonation of Al and Cu charges against live ammunition caused explosions in all cases. It was concluded that the damage resulting from the Al liner charges was not appreciably different from that produced by charges with Cu liners. However, it was noted that the Cu liner charge possessed more penetrating power than the Al liner charge at the standoffs used in these firings. The Al liner gave a larger entrance hole in armor up to a 5- or 6-in. thickness; above this thickness, the hole size decreased rapidly and the performance of the Al liner jet inside the tank resembled that of a much smaller charge, e.g. the 3.5-in. HEAT rocket.

L746

Development and Proof Services, Aberdeen Proving Ground.
COMBINED ENGINEERING AND SERVICE BOARD TESTS OF AMMUNITION FOR THE 105-MM. BAT RIFLES. Dates of test: Sept. 19, 1952-May 14, 1953. 29p. incl. tables. (Proj. no. TA1-1540; Firing record no. P-56003) Confidential

Firings of the T119E8 and T138E57 HEAT shells from the T137E3 rifle and of the T184E HEAT shell from the T170 rifle were made to determine their armor penetrating ability. The tests were conducted against various target combinations of homogeneous steel plates at different temperatures and ranges. In the firings at 400 ft., the average penetration of the T119E8 round for all temperatures was 17-1/8 in. for the T184E6, 15.0 in., and for the T138E57, 12.5 in. As indicated in the firing summary below, the T119E8 round gave the deepest average penetration in every phase except that fired at 0° plate obliquity:

Phase	Penetration (in.)		
	T184E6	T119E8	T138E57
All ranges & obliquities	15-1/2	16-1/10	12-2/5
All 1000-yd. firings	15-1/4	15-2/5	11-1/5
All 500-yd. firings	15-1/10	16-3/8	13-5/8
All 60° plate obliquities	15-3/4	16	12-3/4
All 30° plate obliquities	14-1/5	15-7/8	11-3/8
All 0° plate obliquities	16-2/5	16-3/8	13-1/8

These data indicate that the penetrating ability of the T119E8 and the T184E6 rounds are comparable, with the T119E8 giving a slightly better performance; the T138E57 round consistently gave the least penetration. A round-by-round assessment of the firings is included.

L747

Development and Proof Services, Aberdeen Proving Ground.
ENGINEERING TESTS OF CHINESE 87-MM., HEAT ROCKET, by G. D. Sanford. Dec. 12, 1952, 21p. illus. tables. (Proj. no. TB3-0035, rept. no. 8) AD-5666 Confidential

Tests were made to determine the penetration and performance characteristics of the spin-stabilized 87-mm. HEAT rocket (Chinese). The head assembly of this shoulder-fired weapon contains 1.70 lb. of TNT and 2 hot-rolled steel cones positioned with the apex of each cone pointing toward the rear of the head. The cone in front of the explosive charge has a hole in the apex and a small diameter sheet metal tube is welded to the cone at this point; in the rear of the explosive charge is a truncated cone which probably serves to conserve the explosive material. A fuze of the point-initiated, spit-back type is used. In static firings against 12-in. homogeneous armor plate, 3 rounds penetrated an average of 4.33 in. At a range of 150 ft., the penetration of 2 rockets fired at 5.75-in. homogeneous plate at 0° obliquity averaged 3.8 in. Further test firings at 150-ft. range gave the following results:

No. of rounds considered	Target (homogeneous armor plate)	Obliquity	Ave. penetration
8	5.75 in.	0°	3.75 in.
3	3.0 in.	45°	3.75 in.
1	3.0 in.	60°	3.75 in.

The spin rate for 5 rockets observed was 131 r.p.s. In graze impact tests, 3 of 5 rockets functioned in high order. From these tests, it was concluded that the Chinese 87-mm. HEAT shaped charge rocket is inferior to all US rockets of comparable caliber and type in accuracy and armor plate penetrating characteristics.

L748

Development and Proof Services, Aberdeen Proving Ground.
TEST OF CARTRIDGE, HEAT, 105-MM. T131E31, TO ESTABLISH RELIABILITY OF FUNCTIONING AND TO DETERMINE THE PENETRATION OF THE ROUND WHEN FIRING AGAINST HOMOGENEOUS ARMOR PLATE. Date of test: Dec. 29, 1952. 5p. illus. table. (Proj. no. TA1-1523; Firing record no. P-54521) Confidential

The T131E31 HEAT test rounds were fired from an M2A1 105-mm. howitzer at a range of 400 ft. against a 7-in. homogeneous armor plate (Brinell Hardness no. 270) set at 60° obliquity. A summary of the firings follows:

Rounds considered	Complete penetrations	Partial penetrations
17	12	5 (ave. 10.25 in.)

Photographs of the impacts of all rounds against the target indicated that detonation occurred when the nose was crushed only 1 or 2 in.

L749

Development and Proof Services, Aberdeen Proving Ground.
SHAPED CHARGES AND RELATED SUBJECTS: A BIBLIOGRAPHY OF ABERDEEN PROVING GROUND FIRING RECORDS, by K. M. Crawford. [1953, 77p.] Secret

Approximately 750 Aberdeen Proving Ground firing records, ranging in time from about 1942 to 1952, are included in this bibliography. The references are arranged by firing record number and cover the following subjects: Ammunition, foreign; Bombs, shaped charge; Cartridges, HEAT; Charges, shaped; Grenades, HEAT; Projectiles, HEAT; Rockets, HEAT; and Shells, HEAT.

L750

Development and Proof Services, Aberdeen Proving Ground.
DEVELOPMENT OF FUZE, BD, T165E3 AND T165E5, by S. S. Sine. Jan. 9, 1953, 86p. tables. (Proj. no. TA1-2702, rept. no. 3; Proj. no. TA1-2537B, rept. no. 1) AD-8750 Confidential

75-mm. HEAT M66 rounds, assembled with BD, T165E3 and T165E5 fuzes, were fired against homogeneous armor plate targets. The results of these firings using the M1A1 howitzer against 3-in. armor plate follow:

No. of rounds	Obliquity	Penetration Complete	Partial
10	0°	10	
2	0°	2	
2	55°	—	—
8	45°	2	6
2	45°		2

L751

Development and Proof Services, Aberdeen Proving Ground.
PLATE FUNCTIONING OF FUZE, PIBD, T224, ASSEMBLED TO SHELL, HEAT-FS, T188E2, 57-MM. RIFLE, M18, AMMUNITION LOT PA-E-11544. Dates of test: Jan. 12-15, 1953. 9p. incl. tables. (Proj. no. TA1-2702; Firing record no. P-54731) Confidential

HEAT-FS, T188E2 rounds were fired against laminated homogeneous armor plate targets at obliquities of 0° and 65° (i.e., 25° from the horizontal). A summary of these firings follows:

Rounds	Plate thickness	Plate obliquity	Penetration complete
3	7 in.	0°	3
	effect. thick.	obliquity	average
6	16.5 in.	65°	8.25 in.

No plates were sectioned to determine the exact penetration.

L752

Development and Proof Services, Aberdeen Proving Ground.
FIRINGS TO DETERMINE THE FUNCTIONING CHARACTERISTICS OF FUZE, PIBD, T277, ASSEMBLED TO CARTRIDGE, HEAT, 90-MM., T108E4. Date of test: Jan. 29, 1953. 10p. incl. tables. (Proj. no. TA1-2702; Firing record no. P-55331) Confidential

Test firings of the HEAT round, T108E40 were conducted against 5-in. and 12-in. homogeneous armor plate targets. The firing data follow:

Rounds considered	Target obliquity	Target thickness	Penetration complete	Penetration partial
4	0°	12 in.	3	1 (ave. 7.5in.)
3	61°	5 in.	2	1 (ave. 7.5in.)

The remaining 5 rounds, modified by installing plastic inner ogives, gave 4 complete penetrations when used against a 5-in. armor target at 61° obliquity. One round deflagrated on the target plate.

L753

Development and Proof Services, Aberdeen Proving Ground.
TEST OF FUZE PIBD, T199 AND FUZE PIBD, T208E7, ASSEMBLED TO CARTRIDGE HEAT-FS, (COMP. B) T184E6, FOR 105-MM. RIFLE, T170, AMMUNITION LOTS PA-E-11748 (T199) AND PA-E-11749 (T208E7). Dates of test: Feb. 12 and Apr. 15, 1953. 9p. illus. tables. (Proj. no. TA1-2702; Firing record no. P-55320) Confidential

In plate penetration tests using 2 different fuzes with the HEAT-FS, T184E6 round, firings were made at a range of 300 ft. and 60° obliquity against homogeneous armor plate targets composed of a 6-in. and a 1.5-in. plate. A summary of the firings follows:

Rounds considered	Penetration complete	Penetration partial	ave.
T199 Fuze			
8	5	3	10.7 in.
T208E7 Fuze			
5	5	—	—

The fuze function times of both groups of shells, measured by smear camera techniques, were almost the same.

L754

Development and Proof Services, Aberdeen Proving Ground.
DEVELOPMENT OF SHELL, HEAT, 120-MM., T153 SERIES, FIRINGS TO CONFIRM PREVIOUS ACCURACY RESULTS OF SHELL, T153E8A AND TO DETERMINE FUZE FUNCTIONING AND PENETRATION CHARACTERISTICS. Dates of test: Mar. 12-Aug. 18, 1953. 24p. incl. illus. tables. (Proj. no. TA1-1602; Firing record no. P-57038) Confidential

In the plate penetration phase of the tests, the 120-mm. HEAT shell, T153E8, was fired against a homogeneous armor target composed of a 6-in. plate (Brinell Hardness no. 261) and a 2-in. plate (Brinell Hardness no. 285) at 60° obliquity and a range of 400 ft. All 5 rounds completely penetrated the 6-in. plate, 1 round completely penetrating both plates. The target plates were not clamped together. Examination revealed that the flaring made by the exit of the jet from the 6-in. plate was considerably flattened out, indicating that the plate jumped upon impact of each round. This may account for the fact that all of the rounds did not completely penetrate both plates. Fastax photographs of the projectile striking the target and Smear camera functioning times were obtained.

L755

Development and Proof Services, Aberdeen Proving Ground.
DEVELOPMENT OF FUZE PI, T209E3 FOR SHELL, HEAT-FS, T108E45, LOT PA-E-11973. Date of test: Mar. 13, 1953. [3]p. (Proj. no. TA1-2702; Firing record no. P-55812) Confidential

HEAT-FS rounds, T108E45, fitted with PI fuze T209E3, were fired against rolled homogeneous armor targets at obliquities of 0° and 55°, range 300 yd. A summary of the firing data follows:

Rounds considered	Target obliquity	Target thickness	Penetration complete	Penetration partial
14	55°	5 in.	13	1
14	0°	10 in.	11	2

L756

Development and Proof Services, Aberdeen Proving Ground.
FUZE TEST OF CARTRIDGE, HEAT, T119E11 AND T138E57, 105-MM. RIFLE, T137E3 AGAINST PLATE AND FOR PREMATURE FUNCTIONING. Dates of test: Mar. 30-Apr. 2, 1953. 6p. tables, diagrs. (Proj. no. TA1-2702; Firing record no. P-55741) Confidential

Included in the tests were firings conducted at various angles of obliquity against 6-in. homogeneous steel plate targets located 400 ft. from the T137E3 rifle. A summary of these firings follows:

Shell type	Rounds	Obliquity	Penetration complete	Penetration partial
T138E47	5	0°	5	—
T138E47	20	60.5°	8	10
T119E11	8	64.5°	7	—

L757

Development and Proof Services, Aberdeen Proving Ground.
VULNERABILITY OF T26E4 TANKS TO ATTACK BY 2.75 IN. AND 8-CM. HEAT AIRCRAFT ROCKETS, by T. K. Brace and A. Pillersdorf. Apr. 29, 1953, 107p. illus. diagrs. (Proj. no. TB3-0226, rept. no. 1; Armor test rept. no. AD-1166) Confidential

The 2.75-in. folding-fin aircraft rocket (FFAR) and the Swiss (Oerlikon) 8-cm. aircraft rocket (fin-and spin-stabilized, weight of explosive .92 lb., maximum velocity at 70° F 2130 ft./sec.) were fired from a F84 fighter to determine their terminal ballistic performance against stationary T26E4 tanks. Both of these HEAT rockets contained impact, point-initiating, base-detonation, spit-back fuzes. Of the 225 FFAR rounds fired, 32 were hits, 14 put the tank out of action and 2 of these were fire kills. Of the 192 Oerlikon rounds fired, 39 were hits, 14 put the tank out of action and 2 resulted in fire kills. From analysis of the data it was concluded that: (1) there was no significant difference between the 2 types of rounds; (2) specific components on the turret top and engine compartment were vulnerable to attack by these rockets; and (3) a high degree of protection was offered by fenders, stowage boxes, and suspension components on the tank targets. It was recommended that the rockets should be equipped with fuzes similar to the 90-mm. HEAT T108 round to insure faster jet formation than was evidenced in these tests. Round-by-round assessments of the firings are included in an appendix.

L758

Development and Proof Services, Aberdeen Proving Ground.
PLATE FUNCTIONING OF FUZE, PIBD, T224, ASSEMBLED TO SHELL, HEAT-FS, T188E10, 57-MM. RIFLE, M18, AMMUNITION LOT PA-E-12385. Date of test: May 1953. 14p. incl. tables, diagrs. (Proj. no. TA1-2702; Firing record no. P-56207) Confidential

Penetration tests were made against homogeneous steel targets composed of a 4-in. and 3 1.5-in. plates at obliquities of 0° and 64°, range 400 ft. The results of these tests follow:

Rounds fired	Target obliquity	Penetrations complete	Penetrations partial	Penetrations ave.
5	0°	3	2	8.4 in.
19	64°	5	5	8.5 in.

All rounds fired at the normal plate (0° obliquity) functioned high order to produce satisfactory penetrations. However, only 10 out of 19 fired at the inclined target plate gave satisfactory penetrations. It is believed that the "lucky" was not compressed properly on plate impact at 64° obliquity.

L759

Development and Proof Services, Aberdeen Proving Ground.
TO COMPARE THE EFFECTS OF MODIFIED AND STANDARD 3.5-IN. HEAT ROCKET HEADS AGAINST EXISTING ARMOR. Dates of test: May 25-June 5, 1953. 9p. incl. table. (Firing record no. Ar-19301) Confidential

Thirty 3.5-in. HEAT rockets, M28A2, were fired against 2 T26E5 target tanks having 6 in. of armor at 45° on the upper front slope of the hull. Witness plates of 20 gauge steel were positioned within the hull at distances from 3 to 18 in. behind the frontal armor. Fifteen of the rounds fired were modified by adding a machined Al sleeve over the Cu liner. The firing data follow:

Type	I	II	III
1st modified	3	2	*
2nd modified	12	8	8
Standard (Lot no. M-A-26)	15	10	7

*Plates were not used in this firing
I=number fired; II=number penetrating tank; III number penetrating witness plates.

It was concluded that there was no appreciable difference in the damage caused by the standard or modified rounds within the target hull. A round-by-round assessment of the firing data is included.

L760

Development and Proof Services, Aberdeen Proving Ground.
TEST OF ROCKET, ANTITANK, 73-MM., FRENCH, MODIFIED. June 1, 1953, 27p. illus. tables. (Proj. no. TU2-8B, rept. no. 2)
Secret

Tests were conducted to determine the over-all characteristics of the modified French 73-mm. antitank rocket including penetration ability, fuze arming distance, and burnout distance. Eighteen HEAT rockets of this type when fired against homogeneous plate to determine their penetration characteristics at 300-ft. range gave the following results:

No. of rounds	Plate obliquity	Plate thickness (in.)	No. of complete penetrations
5	0°	12	4
3	0°	12	2
3	0°	12	1
3	45°	6	3
4	60°	6	4

It was concluded that the fuze of the modified French 73-mm. rocket does not arm below 10-ft. range, that the modified rocket burns out visually between 2.5 and 3 ft. from the muzzle at 70°F, and that this rocket is not otherwise appreciably different from the original rocket tested (item no. L726).

L761

Development and Proof Services, Aberdeen Proving Ground.
STATIC PENETRATION TEST OF SHELL, HEAT, 120-MM. T153 TO DETERMINE DEPTH OF PENETRATION AND RELATIVE EFFECTIVENESS OF TWO TYPES OF CONES. Dates of test: June 9 and 10, 1953. 12p. incl. tables. (Proj. no. TA1-1602; Firing record no. P-56510)
Confidential

Static firing tests were made using steel and Cu liners against homogeneous armor plates of Brinell Hardness nos. 248 to 311, 1.0 to 1.5 in. thick, stacked to a height of approximately 28 in. A summary of the 7 rounds fired at 8-in. standoff follows:

Type shell	Liner material	Ave. penetration
T153ST-1	steel	14.152 in.
T153ST-2	Cu	22.598 in.

The steel liner shells produced metal splashing about 14 in. in diameter around the holes between each pair of plates penetrated; approximately 50% less metal splashing was obtained from the Cu liner shells. In every instance, the metal slugs followed the jet through the target, joining from 3 to 5 plates together. Cu liner slugs measured 6.25 in. to 8.5 in. in length; the steel liner slugs were approximately 3 to 5 in. in length.

L762

Development and Proof Services, Aberdeen Proving Ground.
BALLISTIC CHECK OF CARTRIDGE HEAT, T184E12, 106-MM. RIFLE, T170E1, LOT PA-E-12657. Date of test: June 10, 1953. 4p. incl. table. (Proj. no. TA1-1510; Firing record no. P-56883)
Confidential

Eight rounds of the T184E12 projectile were fired against a target composed of 4 1.5-in. armor plates, at 65° obliquity and a range of 300 ft. In all cases, complete penetration of 3 plates was obtained (10.7 in.) with partial penetration of the fourth plate. All rounds functioned satisfactorily.

L763

Development and Proof Services, Aberdeen Proving Ground.
VULNERABILITY OF TANKS: 3.5-IN. HEAT, 90-MM. AP, 105-MM. HEP PROJECTILES VS. HCR2 COATING ON T26 TANKS, by T. K. Bruce. June 23, 1953, 46p. incl. illus. diagrs. (Proj. no. TB3-1224B, rept. no. 6; Armor test rept. no. AD-1179)
Confidential

Ten-in. and 14-in. thick protective coatings of HCR2 (86% Lilesville gravel, 10.5% asphalt, and 3.5% wood flour) were mounted on the upper and lower glacis plates of 2 tanks for tests against HEAT, AP, and HEP projectiles. Twelve of the 13 3.5-in. HEAT rockets fired defeated the HCR2. The deepest penetration of the tank armor by the jet from the HEAT rounds was 6.75 in. after passing through the 10-in. thick HCR2 coating. Similar results were obtained with the AP and HEP rounds. It was concluded that the use of HCR2 as a protective means for tanks was not feasible. Round-by-round assessments of the firings are given in appendixes.

L764

Development and Proof Services, Aberdeen Proving Ground.
FIRST AND FINAL REPORT ON FRAGMENTATION OF BOMB HEAT, FRAGMENTATION, T57E1, by S. P. Willan. July 20, 1953, [138]p. incl. illus. tables. (Proj. no. TA2-2051, rept. no. 1)
Confidential

The HEAT bombs, Types A and B, were composed of a shaped charge of 1.35 lb. of Comp. B contained in a bomb section 5.80 in. in length to which was attached an ogive (standoff) about 2.5 in. long. Type A bombs differed from Type B bombs in that .093 wire (the same size as that used on the M26 hand grenade) was wrapped around the explosive charge for a distance of about 3.75 in. Fragmentation tests were conducted on 5 of the bomb heads, 4 of Type A and 1 of Type B, in a wood panel setup consisting of 2 semicircular, horizontal arcs of 1-in. dressed ponderosa pine boards 9 ft. in length. From these panels, size and effectiveness of the fragments and their distribution or spatial pattern were determined. Perforation and penetration data for the pine-panel target follow:

Type of round	Perforations	Penetrations	Total hits
(20-ft. radius)			
A	242	277	*519
B	90	315	405
(40-ft. radius)			
A	141	219	*360
B	25	173	198

*Type A data (average of 4 rounds)

The Type A shaped charge bomb gave an average perforation density of 2.12/sq. ft. at 20 ft. and 0.39/sq. ft. at 40 ft. It was concluded that this bomb would cause personnel casualties within 38.7 ft. of the point of detonation. From the Type B shaped charge bomb, an average perforation density of 0.55/sq. ft. at 20-ft. and 0.03/sq. ft. at 40 ft. was obtained. Results of these limited tests indicate that the Type B bomb is 57% as effective as the Type A bomb as an antipersonnel weapon.

L765

Development and Proof Services, Aberdeen Proving Ground.
TEST OF FUZE, PIBD, T224, ASSEMBLED TO SHELL, HEAT-FS, T188E10, 57-MM. RIFLE, M18, LOT PA-E-1377 AGAINST NORMAL PLATE. Dates of test: Aug. 17-26, 1953. 10p. incl. tables. (Proj. no. TA1-2702; Firing record no. P-57073) Confidential

The tests were made against a homogeneous steel target composed of a 6-in. and 2 1.5-in. plates at 0° obliquity and a range of 400 ft. A summary of these results follows:

Rounds	Penetrations complete	Penetrations partial	Failed
16	8 (9.1 in.)	3 (8.36 in.)	5

Recovered shaped charge liners and parts of the fuze base elements from the 5 rounds which gave no penetration indicated that these shells received no fuze initiation.

L766

Development and Proof Services, Aberdeen Proving Ground.
BALLISTIC TEST TO DETERMINE THE EFFECTIVENESS OF STEEL SPIKES IN DEFEATING THE SHAPED CHARGE ATTACK OF THE CARTRIDGE, HEAT, T184E3, WITH FUZE PIBD, T208E7 FOR 105-MM. RIFLE M27, by W. B. Frye and W. C. Pless. Aug. 25, 1953, 30p. illus. diagrs. (Proj. no. TB3-1224B, rept. no. 7; Armor test rept. no. AD-1182) AD-24 146 Confidential

Tests were made using fin-stabilized 105 mm. HEAT cartridges to determine the effectiveness of steel spikes mounted on 2-in. homogeneous armor plate in defeating shaped charges. The 7.5-in., 8-in., and 8.5-in. spikes, arranged so that no 2 spikes of equal length were adjacent, were spaced 2.5 in. from center to center. Of the 20 rounds fired against spiked and unspiked armor at 0° and 60° obliquity, only 3 malfunctioned. In addition, it was observed that: (1) projectile detonation at the target caused many of the spikes to become secondary projectiles and thus a source of danger to supporting infantry; (2) the spikes, themselves, would be a hazard to the vehicle crews; (3) mounting of spikes on an armored vehicle would be difficult because of the welding of the studs to which the spikes are attached; and (4) the weight of spikes, 48.6 lb./sq. ft., would be prohibitive for a complete vehicle. Therefore it was concluded that this means of defeating shaped charges was ineffective. A round-by-round assessment of the firing data is given in an appendix.

L767

Development and Proof Services, Aberdeen Proving Ground.
DEVELOPMENT OF CARTRIDGE, HEAT, 90-MM., T108E40. FIRINGS TO ESTABLISH ACCURACY AND PLATE PERFORMANCE OF ROUNDS MANUFACTURED TO THE FINAL ORDNANCE DRAWINGS. Dates of test: Sept. 1-3, 8, and 17, 1953. 22p. illus. tables. (Proj. no. TA1-1451; Firing record no. P-57206) Confidential

Since very poor flight characteristics were obtained during the accuracy firings, only 10 rounds of the 90-mm., T108E40 projectile were tested for plate performance. The rounds were fired at a range of 373 ft. against a 6-in. homogeneous armor plate (Brinell Hardness no. 285-293) set at an angle of obliquity of 60°. Ten complete penetrations were obtained.

L768

Development and Proof Services, Aberdeen Proving Ground.
FIRST REPORT ON GRENADE, RIFLE, HEAT, T37E4 WITH FUZE, GRENADE, T1014E1, by R. A. Clark. Oct. 19, 1953, 46p. incl. tables, diagrs. (Proj. no. TA3-5911, rept. no. 1) Confidential

Tests were conducted to obtain penetration performance data and flight characteristics of the T37E4 HEAT rifle grenade for comparison with the HEAT rifle grenade T41 and the practice grenade T42. Two-hundred six-four rounds of the T37E4, a fin-stabilized grenade having a 2.5-in. conical Cu liner, a shaped charge of 0.78 lb., and a diameter of 2.62 in. at the ogive, were fired against laminated armor plate at a range of 50 ft. Penetration data follow:

Grenade	Rounds	Target	Obliquity	Ave. penetration
T37E4	12	12-in.	0°	9.5-in.
T41	15	12-in.	0°	7.9-in.
T37E4	5	7-in.	55°	8.7-in.*
T41	4	7-in.	55°	8.9-in.
T37E4	6	7-in.	50°	8.9-in.
T41	8	7-in.	50°	8.0-in.

*Excludes 1 round with a 3.1-in. penetration

From the tests it was concluded that: (a) the T37E4 grenade was more stable in flight than the T42 grenade; (b) the penetration effectiveness of the T37E4 and the T41 offered no significant differences, the T37E4 being superior at 50° obliquity and inferior at 55° obliquity; (c) the performance of the T1014E1 fuze was not dependable.

L769

Development and Proof Services, Aberdeen Proving Ground.
DEVELOPMENT TESTS OF ROCKET, HEAT, 3.5-IN., T205E1, AND ROCKET, PRACTICE, 3.5-IN., T206 AND T206E1, by B. B. McGlothlin. Dec. 3, 1953, 129p. illus. tables, diagrs. (Proj. no. TU2-1015A, rept. no. 1; Army project no. 517-17-015) AD-28 989 Confidential

3.5-in. HEAT rockets, T205E1, fitted with PIBD rocket fuze, T2030E2, were fired into homogeneous armor plate to obtain plate penetration data. This solid propellant, fin-stabilized, armor-piercing rocket contains 1.5 lb. of Comp. B and utilizes the shaped charge principle. A summary of the firings follows:

I	II	III	IV	V	VI
28	0°	12 in.	15	13	10.8 in.
9	0°	12 in.	7	2	11.9 in.
10	0°	12 in.	8	2	9.0 in.
19	60.3°	6 in.	8	9	9.3 in.
10	60.3°	6 in.	5	5	8.7 in.
9	60.3°	6 in.	3	6	9.4 in.
10	59.7°	5 in.	10	0	———
9	69.8°	5 in.	4	5	9.9 in.
10	29.7°	10 in.	8	2	9.7 in.

I = rounds fired; II = target obliquity; III = target thickness; IV = complete penetration; V = partial penetration; VI = average penetration

It was observed that the 3.5-in. HEAT rocket, T205E1, with PIBD fuze T2030E2 completely penetrated a 12-in. homogeneous armor plate target at 0° obliquity 65% of the time, a 6-in. armor plate target at 60° obliquity 45% of the time, and a 5-in. armor plate target at 60° obliquity 100% of the time.

L770

Development and Proof Services, Aberdeen Proving Ground.
[FRENCH ANTITANK MISSILE, SS10], by M. E. Bonnett. Feb. 10, 1954, 8p. illus. tables, diagrs. (Proj. no. TU1-2050, Memo. rept. no. 8) Secret;not releasable to foreign nationals

The French SS10 antitank missile with high explosive, shaped charge warhead was tested against homogeneous steel armor plate targets at 0° and 59° obliquity. Eleven of the rounds were fired using the APG signal generator and 6 with the French generator no. 7. A summary of the firings follows:

I	II	III	IV	V
		APG Signal Generator		
4	11	0°	3	1
4	3	0°	4	0
		French Generator no. 7		
1	11	0°	0	1
2	3	59°	2	0

I = rounds fired; II = target thickness (in.); III = obliquity; IV = complete penetration; V = partial penetration.

It was concluded that the SS10 missile failed to penetrate satisfactorily 11 in. of laminated armor at normal obliquity.

L771

[Director of Miscellaneous Weapons Development (Gt. Brit.)].
REPORT BY DMWD ON UNDERWATER TRIALS AT WHITECHURCH (MD1) WITH HOLLOW CHARGES AGAINST TARGETS REPRESENTATIVE OF A SECTION OF A SUBMARINE, by E. A. Guggenheim. July 11, 1942, 3p. incl. table, diagr. (DMWD rept. no. 44/1) Secret

Data are listed for full-scale underwater trials of shaped charges against targets representing a section of a submarine. During previous 1:2 scale trials, it was found that the meth. of filling with PE was very important and that steel liners were more reliable than bronze liners. Results are indicated for trials with 6-in. charges fitted with Beehives, with charges of 7-in. diameter, and with charges with improved priming.

L772

[Director of Miscellaneous Weapons Development (Gt. Brit.)].
2ND REPORT BY DMWD ON UNDERWATER TRIALS AT WHITECHURCH (MD1) WITH HOLLOW CHARGES AGAINST TARGETS REPRESENTATIVE OF A SECTION OF A SUBMARINE. Aug. 6, 1942, 3p. incl. table, diagr. (DMWD rept. no. 44/2) Confidential

Tests were made with 80° steel liners, 5.75 in. in diameter. With a 0.25-in. thick liner and with 4-in. standoff, penetration of 0.75-in. plate at 45° through a slant distance of 42 in. of water was achieved whether the charge was submerged or in air. At 48-in. slant distance, there was no penetration; at 42-in. slant distance of water 7/8-in. plate was penetrated with the charge submerged. Two shots with 3/8-in. thick liners were unsuccessful, which led to the conclusion that liner thickness was a critical factor.

L773

[Director of Miscellaneous Weapons Development (Gt. Brit.)].
WRECK DISPERSAL. [1944-1945], 1v. incl. illus. diagrs. (DMWD Technical History no. 30, ACSIL/ADM/48/363) Confidential

Tests were made underwater with shaped charges against concrete filled-scale-model blockship targets. The charges were used also against fullscale blockships filled with concrete. Beehives (charge, demolition no. 10) were adapted for underwater use by fitting a suitable cylinder in front of the charge to provide the necessary standoff. Throughout both the model and full-scale tests it was found impossible to detonate a number of charges simultaneously because of some failure in the electrical method of firing. A countermining pistol was devised to fire a large number of closely spaced charges. Diagrams and work done on the countermining pistol are included.

L774

Directorate of Weapon Research (Defence) (Gt. Brit.).
CORRECTION FOR SPIN IN HOLLOW CHARGES, by D. A. Richards. Feb. 1951, p. 7-8. (In its Progress rept., 4th quarter, 1950; Inclosure I to MA London rept. no. R1156-51) Secret

A method of spin compensation was discussed based on the use of 2 explosives having different rates of detonation. By casting them in suitable geometric shapes it was shown how spin of sufficient magnitude could be induced at the inner surface of the charge to compensate for the spin of the shell. While the method was thought to be possible a strongly supported opinion was expressed that the fundamental cause of the variable behavior of shaped charge and the spread in performance of the explosive itself, and it was considered of urgent importance to discover the reason for this. A charge based on 2 different explosives, it was thought, might therefore prove to be a complicated problem. Reference was made to the use of "ring bombs" during the war and it was thought that the system had not been taken to the limit in design. Other suggestions made were that it might be possible to stop the shell spinning at a later stage in flight — it was noted that the fraction of the total shell energy in the spin was quite small, about 2%, — and to mount the charge so that it did not pick up the spin of the body. This was thought to be a major engineering problem. (DWR(D) abstract)

L775

Division of Naval Intelligence, [Office of Naval Operations].
AUSTRALIAN COMMONWEALTH MILITARY FORCES, WEEKLY INTELLIGENCE REVIEW NO. 118, NOV. 11, 1944. Nov. 25, 1944, 3p. (OP-16-PT Technical intelligence extract) Secret

Shaped charge ammunition was developed for use with Japanese standard infantry rifles, type 92 70-mm. battalion gun, type 41 75-mm. regimental gun, type 94 75-mm. mountain gun, and type 91 105-mm. howitzer. Armor penetration data for these rifle grenades and shells are listed.

L776

[du Pont de Nemours, E. I., & Co.].
EXPERIMENTAL EVIDENCE FOR DU PONT SPALL THEORY OF MECHANISM OF CONE COLLAPSE, by C. O. Davis. n.d., 4p. Restricted

Presented in outline form are the theoretical reasons for the belief that the primary process of conical liner collapse must involve spalling from the inner walls of the liner. Some experimental results which support the spall hypothesis and theory of liner collapse are also discussed.

L777

[du Pont de Nemours, E. I., & Co.].
THEORY OF CAVITY EFFECT, by M. A. Cook. n.d., 10p. incl. diagr. Confidential

An explanation of the cavity effect by considering the conditions existing in the detonation head is presented. These conditions include: hydrodynamic theory and detonation head concept, edge effect, size and shape of detonation head, microscopic properties of detonation head, collision of the wave with a flat steel plate and with a liner, mechanism of focusing, cavity effect vs. detonation pressure, confinement, and liner thickness. Objections to the simple procedure for estimating the amount of spall and the validity of ideas underlying the theory of spall are outlined. Investigation of a number of explosives showed that cavity effect correlated closely with calculated detonation pressures but failed to do so with other quantities.

L778

[du Pont de Nemours, E. I., & Co.].
DEVICES A, B, C, D, E, AND M9A1. DISCUSSION OF CONE COLLAPSE. Mar. 30, 1942, 16p. Confidential

A study, largely mathematical, of the collapse of liners is reported. Recovered liners weighed approximately half as much as before firing. The kinetic energy of the jet was 40-60% of the total heat of explosion of the filler. Details of the calculation of liner weight, dimensions, and kinetic energy are presented.

L779

du Pont de Nemours, E. I., & Co.
"CAVITY EFFECT". REVIEW OF 26 SECRET BRITISH REPORTS. June 11, 1942, 14p. Confidential

Twenty-six British repts. on shaped charges are listed and abstracted. The material is grouped as: (1) history of the shaped charge; (2) investigation of liner materials and shapes; (3) fundamental studies of detonation affecting shaped charges; and (4) demolition charges. The following conclusions were reached concerning the use of shaped charges in armor-piercing munitions after a study of these repts: rear initiation must be used; the deeper the cavity the better; the longer the explosive charge the greater the effect up to a critical maximum length; an ogive 3 to 9 times as long as the charge diameter must be used; and the higher the brisance of the explosive the greater the effect.

L780

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Sect. B-1 Interim rept. on Controlled Fragmentation and Shaped Charges, Aug. 15-Sept. 15, 1942, 7p.; Rept. no. CF-1) Confidential

A cavity and liner are being developed for use in a small scatter bomb. Preliminary tests to aid in the selection of a preferred cavity shape and liner were made against homogeneous armor plate, not in water. Liners of approximately 45° were used to investigate the effect of charge diameter or liner base diameter on penetration.

L781

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Sect. B-1 Interim rept. on Controlled Fragmentation and Shaped Charges, Sept. 15-Oct. 15, 1942, 6p.; Rept. no. CF-2) Confidential

Tests on cold rolled steel liners and cast steel liners are reported. Results are presented for full-scale shots with machined cold rolled steel liners, 60/40 Cyclotol (RDX/TNT), 50 in. of water between target plates. The effect was studied of the weight of 60/40 Cyclotol on penetration of 2 0.75-in. mild steel plates separated by water and of the ogive design on penetration.

L782

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Sect. B-1 Interim rept. on Controlled Fragmentation and Shaped Charges, Oct. 15-Nov. 15, 1942, 10p.; Rept. no. CF-3) Confidential

Welded steel conical liners (45°) previously reported (Sept., 1942 rept.) as having produced erratic results were evaluated again in full-scale tests and found to be satisfactory for use in the antisubmarine scatter bomb. Full-scale tests with cast steel conical liners (45°) proved them unsatisfactory for the scatter bomb. Approximately half scale tests were carried out using E cones (4-in. high, 3.5-in. outside diameter, 45° apex angle) to determine: (1) the relationship of penetration to ogive length; (2) the effect of a uniform layer of water between the ogive and the top target plate; and (3) penetration depth resulting from firings at a 45° angle to target using the Straub nose design. Results from these tests are tabulated and discussed.

L783

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, Nov. 15-Dec. 15, 1942, 9p.; Rept. no. CF-4) Confidential

Maximum penetration for a 6-in. bomb was measured. Pentolite, Torpex, Macarite, and TNT were investigated for use in the bomb.

L784

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, Dec. 15, 1942-Jan. 15, 1943, p. 9-11; Rept. no. CF-5) Confidential

An ogive was designed for the 6-in. bomb which meets these requirements: (1) sufficient weight in a small volume; (2) large hole for free passage of the penetrating agent; (3) inner walls of approximately a 66° slope; (4) Pb jacket to give weight and cushion a blow; (5) ogive firmly screwed to liner to give strength and insure alignment; and (6) no welding to the liner.

L785

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, Jan. 15-Feb. 15, 1943, p. 20-24; Rept. no. CF-6) Confidential

A preliminary static test was made of the complete 6-in. antisubmarine bomb. Loading and assembling details of the bombs are given.

L786

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, Feb. 15-Mar. 15, 1943, p. 17-22; Rept. no. CF-7) Confidential

Static tests, simulating attack on a large German submarine while surfaced, diving or surfacing, and submerged, were made with the 6-in. antisubmarine bombs.

L787

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, Mar. 15-Apr. 15, 1943, p. 13-20; Rept. no. CF-8) Confidential

Investigation of the following aided in further development of the scatter bomb: (1) determination of the optimum liner thickness for the 6-in. bomb; (2) effect of a 60° liner on the penetration power of a 5-in. bomb; (3) penetration obtained with a 1:2 scale model of the 6-in. bomb; and (4) underwater scaling. A brief discussion is given of each of the above topics. One-sixth scale models of a ship's torpedo defense system were constructed and 3.5-in. diameter bombs bearing 45° steel liners were fired against them to obtain information concerning target construction, handling, damage, inflammability and ease of recovery after a shot. Results and photographs of the tests and a diagram of the target are included.

L788

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, Apr. 15-May 15, 1943, p. 27-28; Rept. no. CF-9) Confidential

A comparison of 60/40 Cyclotol and Comp. B for use in the scatter-bomb was made. The results of pouring tests of each of these explosives are discussed.

L789

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, June 15-July 15, 1943, p. 23-24; Rept. no. CF-11) Confidential

Two model antisubmarine scatter bombs were fired in air against an underwater target of mild steel. The test was to observe and record the trajectories of the tail fragments by means of still and movie cameras. The results of the firings are discussed briefly. A description and diagram of the plan for converting the Mark 4A Mousetrap into a shaped charge antisubmarine projector are included.

L790

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, July 15-Aug. 15, 1943, p. 36-40; Rept. no. CF-12) Confidential

A special test made with a modified scatter bomb is described. A discussion is included of the manufacture of liners by the following methods: (1) progressive drawing (female and male methods); (2) flattened liner; and (3) spinning. Loading data for an antisubmarine projector (Mousetrap) and diagrams of the above mentioned bombs and liner manufacturing methods are given.

L791

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Aug. 15-Sept. 15, 1943, p. 21-27; Rept. no. SC-1) Confidential

Loading data for 32 antisubmarine bomb cases are given. Modified Mark 4 AS Projector (Mousetrap) bombs (standard and lined, 45° steel) filled with various explosives were tested underwater to obtain comparative pressure and momentum measurements. Gage readings and test design data are included.

L792

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Oct. 15-Nov. 15, 1943, p. 37-45; Rept. no. SC-3) Confidential

Full-scale damage tests against submarine models were made to obtain blast pressure information. Types of bombs tested were: (1) the modified Mark IV-A projector (modified Mousetrap); (2) the modified British AS bomb; and (3) the Navy scatter-bomb. Tests were made to determine whether the Tetryl train was the cause of the failure of several Straub fuse mechanisms (electrical condenser horn fuse) used in the Navy scatter bomb. Design data and test results are included for both of the above investigations.

L793

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Dec. 15, 1943-Jan. 15, 1944, p. 19-21; Rept. no. SC-5) Confidential

Fuze failures which occurred in field tests of the Navy scatter-bomb seemed to be due to 2 probable causes: (1) separation of the SSS cap from the Tetryl train; and (2) failure of the Tetryl train to propagate due to small diameter or low density or both. An attempt is made to determine means of overcoming these failures.

L794

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Jan. 15-Feb. 15, 1944, p. 23; Rept. no. SC-6) Confidential

No additional information is given.

L795

du Pont de Nemours, E. I. & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, May 15-June 15, 1944, p. 22-24; Rept. no. SC-10) Confidential

Drawn steel liners for the scatter-bomb were tested.

L796

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, June 15-July 15, 1944, p. 26-27; Rept. no. SC-11) Confidential

Data from underwater penetration tests to compare the range of 50% perforation of hand-formed and drawn steel (45°) and Cu (60°) liners are tabulated.

L797

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Aug. 15-Sept. 15, 1944, p. 24; Rept. no. SC-13) Confidential

The loading of 225 clusters (2700 bombs) with Comp. B thinned with TNT is discussed.

L798

du Pont de Nemours, E. I., & Co.
THEORY OF DETONATION, by M. A. Cook. Mar. 19, 1943, 1v. incl. tables, diagrs. Confidential

Theoretical developments of the Eastern Laboratory regarding the process of detonation and its application to the study of military explosives are presented in 5 sections. I. Equations of the hydrodynamic theory are developed and the method of application outlined. Appendixes containing outlines of the fundamental basis of the theory and detailed derivations contributing to an understanding of the theory are included. II. Equations are developed to make use of the adiabatic expansion law and the equation of state derived from the hydrodynamic theory in evaluating the available energy of an explosive. III. Methods of calculating explosive equilibrium, composition of gases and temperature (detonation products at various stages in the detonation process are given). IV. The hydrodynamic theory treats only the macroscopic conditions existing in detonation. However, the concepts of this theory are taken into account in a discussion of the kinetics of detonation. An appendix of definitions of terms used in this discussion and a bibliography of pertinent literature are included. V. Thermodynamic properties of a number of military explosives are calculated and tabulated. A brief discussion of these calculations and of the errors involved is given. The strength of explosives as measured by the du Pont ballistic mortar and some considerations of underwater blasting are discussed briefly.

L799

du Pont de Nemours, E. I., & Co.
SCALING-UP OF UNDERWATER PENETRATION BY SHAPED CHARGES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, Apr. 15-May 15, 1943, p. 33-34; Rept. no. CF-9) Confidential

Investigation to find the laws governing underwater penetration was continued with 6-in. (45° steel liner) and 3-in. (42°, M67 liner) charges. Results are discussed briefly.

L800

du Pont de Nemours, E. I., & Co.
SCALING-UP OF UNDERWATER PENETRATION BY SHAPED CHARGES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, May 15-June 15, 1943, p. 32-35; Rept. no. CF-10) Confidential

Results of underwater scaling tests are given for 3-in. diameter steel liners (45°, 60° apex angles).

L801

du Pont de Nemours, E. I., & Co.
SCALING-UP OF [UNDER] WATER PENETRATION BY SHAPED CHARGES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, June 15-July 15, 1943, p. 25-26; Rept. no. CF-11) Confidential

A table summarizes briefly the 50% perforation point of a 0.25-in. mild steel plate when charges with steel liners (45°, 60°, and 90° apex angles) of varying wall thicknesses were fired against it.

L802

du Pont de Nemours, E. I., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, Apr. 15-May 15, 1943, p. 29-32; Rept. no. CF-9) Confidential

One-sixth scale torpedoes, 3.5-in. diameter, containing 42° steel liners were used in experiments to determine: (1) the possibility of starting fires in a ships hull with the penetrating agent from a steel liner in the nose of the warhead; and (2) the degree of inflammability of cargo material required for easy ignition. Tests were made using a 6:21 scale torpedo bearing a 6-in. diameter 45° steel liner to discover the possibility of such a torpedo penetrating a 6:21 scale multiplate defense system. Test results are tabulated and photographed and diagrams of the test equipment are included.

L803

du Pont de Nemours, E. L., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges. July 15-Aug. 15, 1943, p. 41; Rept. no. CF-12) Confidential

No additional information is given.

L804

du Pont de Nemours, E. I., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Aug. 15-Sept. 15, 1943, p. 28-32; Rept. no. SC-1) Confidential

A modified Mark 13 warhead was designed and its characteristics compared with the standard Mark 13. Penetration test and loading data for full-scale and 1:6 scale models are given.

L805

du Pont de Nemours, E. I., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Sept. 15-Oct. 15, 1943, p. 23-30; Rept. no. SC-2) Confidential

Full-scale tests of 3 modified Mark 13 warheads (2 lined and 1 unlined) were made to evaluate large diameter (18 in.) segmented liners (1 steel, 1 Fe). Results of target damage tests, jet velocity measurements, and blast pressure measurements are given. Design data for experimental warheads, boostering plan, and target and test assembly are included.

L806

du Pont de Nemours, E. I., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Oct. 15-Nov. 15, 1943, p. 34-35; Rept. no. SC-3) Confidential

Various preliminary phases of the research program on warheads are discussed briefly.

L807

du Pont de Nemours, E. L., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Part A, Nov. 15-Dec. 15, 1943, p. 27-35; Rept. no. SC-4) Confidential

Information is presented concerning the following investigations: (1) evaluation of DBX by comparison with Cyclotol and Torpex as a filler for warheads; (2) comparison of target damage from 1:6 scale conventional and modified Mark 13 Mod. 1 warhead models; and (3) use of a shaped charge (7-in., 10-in., and 15-in. liner diameter) to improve the performance of the Mark 17. Design data for the above mentioned warheads and targets are included.

L808

du Pont de Nemours, E. I., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Dec. 15, 1943-Jan. 15, 1944, p. 22-24; Rept. no. SC-5) Confidential

Loading data for 3:8 scale Mark 13 Mod. 1 warheads (conventional and modified) are given. Sketches showing charge and method of boostering for loaded warheads are included. Construction of multiplate targets and preparation of charges for 1:6 to 1:10 scale Mark 13 Mod. 1 warheads are discussed. Design of the charge for the Mark 17 is commented upon briefly.

L809

du Pont de Nemours, E. I., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Jan. 15-Feb. 15, 1944, p. 16-22; Rept. no. SC-6) Confidential

The loading of full-scale Mark 13 Mod. 1 warheads with Torpex and Comp. B is discussed. The effect of a pickup knob (on ogive) on penetration of the Mark 13 Mod. 1 was studied. Loading and penetration test data on 1:5 scale Mark 17 warheads is tabulated. A comparison of the experimental models of the Navy scatter-bomb and the Mark 17 warhead is made.

L810

du Pont de Nemours, E. I., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Feb. 15-Mar. 15, 1944, p. 28-34; Rept. no. SC-7) Confidential

Loading data and blast damage comparison for 1 Mark 13 Mod. 1 and 2 modified Mark 13 warheads, and penetration test results for small scale Mark 17 warheads are tabulated. Wall thickness, shape of ogive, and the HE charge shape of the Mark 17 were also investigated. A comparison of the design of Mark 18 Mod. 1 and Mark 17 warheads is made.

L811

du Pont de Nemours, E. I., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Mar. 15-Apr. 15, 1944, p. 19-26; Rept. no. SC-8) Confidential

One-tenth scale conventional (2) and shaped charge (4) Mark 13 Mod. 1 warheads were fired against a multiplate target. Results of target damage tests, target design, warhead design, and loading data are included. Loading and test data for penetration tests using 1:5 scale Mark 17 and Mark 16 Mod. 1 warheads are given. A design for the Mark 16 Mod. 1 was prepared and target damage comparison photographs are presented.

L812

du Pont de Nemours, E. I., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Apr. 15-May 15, 1944, p. 17-19; Rept. no. SC-9) Confidential

Blast damage tests of 0.34-scale model Mark 13 Mod. 1 warhead are reported.

L813

du Pont de Nemours, E. I., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, May 15-June 15, 1944, p. 19-21; Rept. no. SC-10) Confidential

Comparative tests were made against 0.37-scale caissons using 0.34-scale charges.

L814

du Pont de Nemours, E. I., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, June 15-July 15, 1944, p. 24-25; Rept. no. SC-11) Confidential

Results of a caisson target damage test using a 0.34-scale Mark 13 Mod. 1 warhead loaded with Torpex II are discussed. The test was conducted at Norfolk Navy Yard.

L815

du Pont de Nemours, E. I., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, July 15-Aug. 15, 1944, p. 40-45; Rept. no. SC-12) Confidential

Underwater pressure and momentum measurements made on shaped charge warheads containing an 18-in. diameter, 60° angle, 0.5-in. thick steel liner were compared with measurements from warheads of standard design.

L816

du Pont de Nemours, E. I., & Co.
SHAPED WARHEADS FOR TORPEDOES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Aug. 15-Sept. 15, 1944, p. 21; Rept. no. SC-13) Confidential

Design data for 4 modified Mark 13 Mod. 1 and 8 Mark 16 Mod. 1 warheads are given.

L817

du Pont de Nemours, E. I., & Co.
EXPERIMENTAL EVIDENCE CONCERNING CAVITY EFFECT, by C. O. Davis. June 22, 1943, 6p. illus. table, diagr. (Paper prepared for the June 30, 1943, Technical Meeting of the Joint Committee on Shaped Charges) Confidential

An experiment is outlined in which cavity effect can be obtained without conical liner rupture. The Kistiakowsky experiment is described in which the target plate was placed some distance beyond the conical liner base to see if the penetrating stream remained focused.

L818

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH [ASFT] BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, July 15-Aug. 15, 1943, p. 42-44; Rept. no. CF-12) Confidential

A general description for an ASFT bomb was tentatively agreed upon and a program for its development is outlined. A brief discussion of the work already begun on the follow-through projectile is presented.

L819

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH [ASFT] BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Aug. 15-Sept. 15, 1943, p. 30-41; Rept. no. SC-1) Confidential

Design and test data for HE forward charges of arbitrarily chosen size and shape are given. Conical (45° and 120° apex angles), hemispherical, and spherical section steel liners were used in these experiments. Performance and design of a follow-through projectile (ogival nose) are discussed. Description of a high inertia target for testing the above projectiles is included.

L820

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH [ASFT] BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Sept. 15-Oct. 15, 1943, p. 31-40; Rept. no. SC-2) Confidential

The most satisfactory size, shape and weight of HE charge for the follow-through projectile were determined through various target damage tests. Attention is also given to the development of a mode of propulsion and initiation for the follow-through projectile including: (1) the design of a test mortar; and (2) velocity measurements with and without the forward charge in place.

L821

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH [ASFT] BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Oct. 15-Nov. 15, 1943, p. 46-58; Rept. no. SC-3) Confidential

Development work on components for an ASFT bomb are described. Tentative design, loading data, and firing results against a modified high inertia target are given for the HE charge. Follow-through projectile velocity measurement tests against a high inertia target are described and recorded. A description of the equipment for velocity measurement tests is given. Exploratory design data and results of a mortar damage test on a fuse initiation system involving the use of shaped charge detonators are included. Side initiation with Primacord is discussed. Apparent required characteristics of the bomb are outlined.

L822

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH [ASFT] BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Part B, Nov. 15-Dec. 15, 1943, p. 47-51; Rept. no. SC-4) Confidential

Further study was made of: (1) velocity attained by a follow-through projectile (square projectile and mortar) containing a given weight of MX2 propellant; and (2) the charge weight which will cause rupture of the mortar. Preliminary fuse tests in connection with the bomb and the fuse design (TAM603) are discussed.

L823

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH [ASFT] BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Dec. 15, 1943-Jan. 15, 1944, p. 25-26; Rept. no. SC-5) Confidential

Full-scale tests of 1 possible design for a follow-through bomb were made against a mild steel plate (0.5 in.) target. The bomb design plan and test results are included.

L824

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH [ASFT] BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Jan. 15-Feb. 15, 1944, p. 24-25; Rept. no. SC-6) Confidential

Target damage tests were made using 3 full-scale ASFT bombs of a revised design. Two bombs were fired at a 45° angle of attack and 1 at a 90° angle of attack.

L825

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH [ASFT] BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Mar. 15-Apr. 15, 1944, p. 27-28; Rept. no. SC-8) Confidential

Initiation failures led to design revisions of the ASFT bomb to: (1) improve contact of the leather gas check; (2) increase area for contact of projectile nose with detonator stab; and (3) obtain more positive alignment of travel direction of detonator stab with axis of detonator. Diagrams of the revised bomb and underwater test target are included.

L826

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH [ASFT] BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Apr. 15-May 15, 1944, p. 21-23; Rept. no. SC-9) Confidential

A 6-in. projectile (1.25-in. outside diameter) containing a 5.25-in. HE charge (1-in. diameter) was tested against a 1-in. mild steel target.

L827

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH [ASFT] BOMB. (In NDRC Div. 8 Interim rept. on Shaped Charges, May 15-June 15, 1944, p. 25-30; Rept. no. SC-10) Confidential

Static tests of the ASFT bomb were made. Experiments were made to determine the depth of water required to obtain the same performance of the forward charge with partially submerged target as had been obtained with the target completely submerged.

L828

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH [ASFT] BOMB. (In NDRC Div. 8 Interim rept. on Shaped Charges, June 15-July 15, 1944, p. 36-40; Rept. no. SC-11) Confidential

Experimental work to determine the velocity required for driving an antisubmarine follow-through projectile through the blast of the forward charge is described and test equipment used for these velocity tests is illustrated.

L829

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH [ASFT] BOMB, by J. L. VerBryck and others. (In NDRC Div. 8 Interim rept. on Shaped Charges, July 15-Aug. 15, 1944, p. 49-54; Rept. no. SC-12) Confidential

Tests were made to determine the propellant weight required for a forward charge under water and for a submerged charge and water-backed target plate.

L830

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH [ASFT] BOMB, by J. L. VerBryck and G. C. Jacquot. (In NDRC Div. 8 Interim rept. on Shaped Charges, Aug. 15-Sept. 15, 1944, p. 25; Rept. no. SC-13) Confidential

No additional information is given.

L831

du Pont de Nemours, E. I., & Co.
DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH [ASFT] BOMB, by J. L. VerBryck and G. C. Jacquot. (In NDRC Div. 8 Interim rept. on Shaped Charges, Sept. 15-Oct. 15, 1944, p. 11-15; Rept. no. SC-14) Confidential

Preliminary tests with a heavy mortar and projectile assembly demonstrated adequate strength and projectile velocity for follow-through. Six complete bomb assemblies (3 with inert and 3 with explosive loaded projectiles, unfused) were fired. Follow-through was achieved with the inert and 1 TNT loaded projectile; 3 shots failed because of difficulties with the forward charge; the TNT loaded projectile failed to defeat 1-in. mild steel target plate. A proposed rear assembly of the complete ASFT bomb is diagramed.

L832

du Pont de Nemours, E. I., & Co.
UNDERWATER SCALING AND CONE FABRICATION, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Aug. 15-Sept. 15, 1943, p. 33-35; Rept. no. SC-1) Confidential

Investigation was started to determine whether suitable segmented liners could be made from Armco Fe plate by cold binding. The Armco Fe liners were compared to steel liners (3-in. diameter, 60° apex angle). Penetration test results are discussed.

L833

du Pont de Nemours, E. I., & Co.
UNDERWATER SCALING, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Oct. 15-Nov. 15, 1943, p. 30; Rept. no. SC-3) Confidential

Scaling-up of underwater penetration with 6-in. (60° apex angle) and 3-in. (90° and 120° apex angles) diameter charges was continued and results tabulated.

L834

du Pont de Nemours, E. I., & Co.
UNDERWATER SCALING, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Part B, Nov. 15-Dec. 15, 1943, p. 36-46; Rept. no. SC-4) Confidential

Complete test results and test conditions are tabulated for underwater scaling of 3-in. diameter steel (welded and annealed) liners (45°-120°) fired in 6-in. charges at 0.6 charge diameter standoff against 0.25-in. submerged mild steel plate.

L835

du Pont de Nemours, E. I., & Co.
UNDERWATER SCALING, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Jan. 15-Feb. 15, 1944, p. 14-15; Rept. no. SC-6) Confidential

Underwater scaling tests were made to determine the effect of annealing on hand-formed welded steel liners of the type used in the Navy scatter-bomb.

L836

du Pont de Nemours, E. I., & Co.
UNDERWATER SCALING, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Apr. 15-May 15, 1944, p. 20; Rept. no. SC-9) Confidential

Investigation of water penetration with 6-in. diameter charges containing 45°, 90°, and 120° liners at 3.5-in. standoff against 0.25-in. mild steel target plate was continued.

L837

du Pont de Nemours, E. I., & Co.
UNDERWATER SCALING, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, June 15-July 15, 1944, p. 28-35; Rept. no. SC-11) Confidential

A summary of the data obtained from an investigation of the underwater performance of charges bearing 6-in. diameter steel liners (45°-120°) is tabulated. Graphs illustrating the following relationships are included: range vs. liner (45°-120°) thickness, optimum liner thickness vs. sine of half liner apex angle, and maximum range vs. apex angle.

L838

du Pont de Nemours, E. I., & Co.
UNDERWATER SCALING, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, July 15-Aug. 15, 1944, p. 46-48; Rept. no. SC-12) Confidential

Water penetration results obtained at the Explosives Research Laboratory, Bruceton, were compared with those obtained at Eastern Laboratory, du Pont.

L839

du Pont de Nemours, E. I., & Co.
UNDERWATER SCALING, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Aug. 15-Sept. 15, 1944, p. 22-23; Rept. no. SC-13) Confidential

Further tests against the standard scale-up target (0.25-in. mild steel target plates) were made with drawn Cu liners (6-in. diameter, 45° and 60° apex angles). Comparison of results with performance of similar steel liners is made.

L840

du Pont de Nemours, E. I., & Co.
SHAPED CHARGES FOR UNDERWATER USE. I. DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH BOMB. II. SHAPED WARHEADS FOR TORPEDOES. III. DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB. IV. UNDERWATER SCALING, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Oct. 15-Nov. 15, 1944, p. 17-22; Rept. no. SC-15) Confidential

I. Five complete assemblies of the antisubmarine follow-through bomb were tested; 2 to evaluate projectile explosive fillers, and 3 to evaluate design simplifications. Loading data and diagrams of the rear assembly and complete experimental bomb are included. II, III, and IV. No additional information is given.

L841

du Pont de Nemours, E. I., & Co.
SHAPED CHARGES FOR UNDERWATER USE. I. DEVELOPMENT OF ANTISUBMARINE SCATTER-BOMB (FT MODIFICATION). II. SHAPED CHARGE TORPEDO WARHEADS. III. AS FOLLOW-THROUGH BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Nov. 15-Dec. 15, 1944, p. 19-22; Rept. no. SC-16) Confidential

I. A follow-through modification of the Navy scatter-bomb designed to increase the damage to outer and inner pressure hulls of a submarine is described. A diagram of the proposed modification is included. II. Loading data for 6 Mark 16 Mod. 1 and 4 Mark 13 Mod. 1 full-scale warheads are given. III. No additional information is given.

L842

du Pont de Nemours, E. I., & Co.
SHAPED CHARGES FOR UNDERWATER USE. I. SHAPED TORPEDO WARHEADS. II. DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Dec. 15, 1944-Jan. 15, 1945, p. 28-31, Rept. no. SC-17) Confidential

I. Mark 13 Mod. 1 and Mark 16 Mod. 1 experimental warheads were tested against a target consisting of a sequence of plates interspaced with water. II. Tentative designs of a base fuze and an interrupted detonator system are shown.

L843

du Pont de Nemours, E. I., & Co.
SHAPED CHARGES FOR UNDERWATER USE. I. SHAPED CHARGE TORPEDO WARHEADS. II. DEVELOPMENT OF ANTISUBMARINE FOLLOW-THROUGH BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Jan. 15-Feb. 15, 1945, p. 10-14; Rept. no. SC-18) Confidential

I. One-sixth scale Mark 13 Mod. 1 warhead models were fired against a similarly scaled model target. II. Two bomb assemblies, 1 with an inert loaded follow-through projectile and 1 with a live loaded follow-through projectile, were tested.

L844

du Pont de Nemours, E. I., & Co. (OEMsr-764).
ANTISUBMARINE SCATTER BOMB; A BRIEF DISCUSSION OF THE BOMB AND ITS PERFORMANCE IN STATIC TESTS, by C. O. Davis and others. Mar. 31, 1943, 14p. illus. tables, diagrs. (NDRC Div. 8) Confidential

Specifications and descriptions of the various components for an antisubmarine shaped charge scatter bomb are presented. Results of static performance tests of such a bomb and its effect on a submarine are discussed.

L845

du Pont de Nemours, E. I., & Co. (OEMsr-764).
TESTS OF SHAPED CHARGE MARK 13 MOD. 1 WARHEADS AT ABERDEEN PROVING GROUND, by C. O. Davis and others. Dec. 23, 1943, 12p. illus. diagrs. (NDRC Div. 8) Confidential

Tests on this model of warhead, some of which have steel and others Fe liners, are described. The primary purpose was to obtain assurance that satisfactory liners could be fabricated by hand from sheet metal. The magnitude and pattern of air blast pressures were also investigated. (These tests are also discussed in item nos. L805 and L806.)

L846

du Pont de Nemours, E. I., & Co. (OEMsr-764). SHAPED CHARGES FOR UNDERWATER USE. I. SHAPED CHARGE TORPEDO WARHEADS. II. AS FOLLOW-THROUGH BOMB. III. INFLAMMABILITY AND BALLISTIC MORTAR STRENGTH OF ALUMINIZED EXPLOSIVES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Feb. 15-Mar. 15, 1945, p. 21-26; Rept. no. SC-19) Confidential

I. Measures to be taken to insure the production of charges free from defects are listed. Results of tests of 1:6 scale Mark 13 Mod. 1 models are given. II. Modifications to eliminate damage to the follow-through projectile were tested. III. Inflammability and mortar tests were made on Torpex II, Minol II, HBX, Comp. B, TNT, and 80/20 TNT/Al.

L847

du Pont de Nemours, E. I., & Co. (OEMsr-764). SHAPED CHARGES FOR UNDERWATER USE. I. SHAPED CHARGE TORPEDO WARHEADS. II. ANTISUBMARINE FOLLOW-THROUGH BOMB. III. UNDERWATER SCALING. IV. UNDERWATER PENETRATION WITH CAST LEAD CONES, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Mar. 15-Apr. 15, 1945, p. 28-36; Rept. no. SC-20) Confidential

I. Descriptions of 45°, 19.75-in. diameter steel liners, and tests to be made with these liners are presented. II. Tests made with antisubmarine follow-through bombs are reported. III. Tests were made with 3-in. diameter 45°, 60°, and 90° liners of optimum wall thickness. IV. Underwater penetration with 3-in. diameter 90° angle, 0.134-in. wall, welded and annealed Pb liners is described.

L848

du Pont de Nemours, E. I., & Co. (OEMsr-764). SHAPED CHARGES FOR UNDERWATER USE. I. SHAPED CHARGE TORPEDO WARHEADS. II. AS FOLLOW-THROUGH BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, Apr. 15-May 15, 1945, p. 26-32; Rept. no. SC-21) Confidential

I. Six full-scale Mark 13 Mod. I warheads (19.75-in. diameter, 45° steel liners) were fired against multiplate and caisson targets. Three of these warheads were loaded with Torpex II and 3 with Comp. B. Results of firing tests, loading data, and a revised design of this warhead are included. II. Loading data and results of firing tests to evaluate use of 5-sec. delay fuze in 3 follow-through projectiles are tabulated. An experimental design of the antisubmarine follow-through bomb is included.

L849

du Pont de Nemours, E. I., & Co. (OEMsr-764). SHAPED CHARGES FOR UNDERWATER USE. I. SHAPED CHARGE TORPEDO WARHEADS. II. UNDERWATER SCALING. III. AS FOLLOW-THROUGH BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, May 15-June 15, 1945, p. 28-34; Rept. no. SC-22) Confidential

I. A Mark 17 conventional warhead, containing 1000 lb. of TNT, fired against a full-scale caisson did less damage than the Mark 13 shaped charge warhead containing 428 lb. of Torpex II. II. The determination of underwater penetrations for 6-in. 45°, 60°, and 90° steel liners against 0.25-in. and 0.5-in. targets was completed. III. Tests were described previously in which follow-through was obtained, but the projectile was always recovered in 2 or 3 large fragments. Additional tests with complete bombs showed that the primer detonator 5 sec. delay fuze was at fault.

L850

du Pont de Nemours, E. I., & Co. (OEMsr-764). SHAPED CHARGES FOR UNDERWATER USE. I. SHAPED CHARGE TORPEDO WARHEADS. II. AS FOLLOW-THROUGH BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, June 15-July 15, 1945, p. 21-24; Rept. no. SC-23) Confidential

I. Existing facilities for the manufacture of 19.75-in. diameter 45° angle steel liners were investigated. II. Set-back and set-forward forces connected with the repeated failure of the 5 sec. primer-detonator delay, used in the follow-through projectile, were determined.

L851

du Pont de Nemours, E. I., & Co. (OEMsr-764). SHAPED CHARGES FOR UNDERWATER USE. I. SHAPED CHARGE TORPEDO WARHEADS. II. ANTISUBMARINE FOLLOW-THROUGH BOMB, by W. E. Lawson. (In NDRC Div. 8 Interim rept. on Shaped Charges, July 15-Aug. 15, 1945, p. 6-8; Rept. no. SC-24) Confidential

I. Results of shots fired at normal incidence revealed that with 0.304-scale Mark 13 Mod. 1 warheads and a scale model of the Solomons multiplate target (all water-loaded), Cu liners were equivalent to steel, HBX3 was inferior to Torpex II, 60° liners were inferior to 45° liners, and a partially filled ogive interferred with jet penetration. II. No additional information is given.

L852

du Pont de Nemours, E. I., & Co. (OEMsr-764). SCALING LAWS FOR UNDERWATER PENETRATION WITH CAVITY CHARGES, by J. K. Detrick and others. Final rept. Aug. 1, 1945, 4p. tables, diagrs. (NDRC Div. 8) OSRD 5392 Confidential

Underwater penetration of shaped charges containing steel, Cu, and Pb liners (45°-120° apex angles) was measured at 0.6-liner diameter standoff by determining the range for 50% perforations of 0.25-in. and 0.5-in. mild steel plate. Equations were derived from these data for 3-in. and 6-in. diameter liners and from Explosive Research Laboratory's data for 1.63-in. diameter liner relating optimum liner thickness and maximum penetration with liner diameter and apex angle.

L853

du Pont de Nemours, E. I., & Co. (OEMsr-764). DEVELOPMENT OF THE ANTISUBMARINE SHAPED CHARGE SCATTER BOMB, by W. E. Kirst and others. Final rept. Oct. 1, 1945, 11p. illus. diagrs. (NDRC Div. 8) OSRD 5760 Confidential

The development of a shaped high explosive charge for use in the antisubmarine scatter bomb was completed by investigation of the following components of the charge: liner material, liner shape, type of explosive, standoff, liner thickness, apex angle, and effect of liner mutilations. Results of underwater performance tests and bomb design data are included.

L854

du Pont de Nemours, E. I., & Co. (OEMsr-764). SHAPED CHARGE TORPEDO WARHEADS, by J. K. Detrick. Final rept. Oct. 9, 1945, 15p. illus. diagrs. (NDRC Div. 8) OSRD 5752 Confidential

In the development of a shaped charge torpedo warhead, emphasis was placed on the adaption of the Mark 13 Mod. 1. Tests at both reduced and full-scale led to the recommendation of a 19.75-in. diameter, 45° angle, 0.5-in. wall Cu liner for this warhead. A standoff of 0.44-liner diameter permitted a retention of 75% of weight of explosive used in the standard Mark 13 Mod. 1. Comparisons of penetrations obtained with Torpex II (used in standard warhead), HBX $1\frac{1}{2}$, HBX 3, and Comp. B filled rounds led to the recommendation that Torpex II or HBX $1\frac{1}{2}$ be used. In full-scale tests, the preferred design exhibited penetrating power in excess of that specified and was definitely superior to a standard warhead in a target damage comparison against a compartmented caisson. Tentative designs are also presented for the Mark 17 and Mark 16 Mod. 1 warheads, but little work was done with these. Test data are tabulated; charge designs and target damage photographs are included.

L855

du Pont de Nemours, E. I., & Co. (OEMsr-764). ANTISUBMARINE SHAPED CHARGE FOLLOW-THROUGH BOMB. Final rept. Oct. 22, 1945, 16p. tables, diagrs. illus. (NDRC Div. 8) OSRD 5753 Confidential

An experimental bomb, 3.5 in. in diameter and 21 in. long without tail fins was developed which, in static tests under water at a 45° angle of attack, consistently perforated a reinforced 0.5-in. mild steel target plate (simulating outer hull of a submarine) and propelled through this hole from a self-contained mortar a delay fuzed HE projectile capable of rupturing a 1-in. mild steel plate (simulating the pressure hull of a submarine). Chief details of the bomb covered in this investigation were: (1) development of the forward charge and follow-through projectile, and (2) the evolution of the complete experimental bomb design.

L856

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). THEORY AND APPLICATION OF THE CAVITY EFFECT, by L. B. Seely and others. Rept. for Feb. 1943. Mar. 11, 1943, 1v. incl. illus. diagrs. Confidential

Experiments are reported on direction of flight of particles thrown from metal plates, the effect of varying amounts of explosive on slug formation, the origin of effective particles inside the liner, and the recovery of particles from liners. Tests on TNT and 50/50 Pentolite pressed to various densities are discussed. The shaped demolition charge M2 containing 10 lb. of cast 50/50 Pentolite and no critical materials of construction is discussed.

L857

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). THEORY AND APPLICATION OF THE CAVITY EFFECT, by W. R. Burke and others. Rept. for Mar. 1943. Apr. 20, 1943, 1v. incl. tables, diagrs. Confidential

Results from tests made on charges with varying base diameters (9, 10, 11 in.) and liner angles of 60° and 80° are reported. The final design of the M2 charge is shown. The effect of confinement on penetration was reinvestigated using a target of mild steel plates and liners of various wall thicknesses. During the development of the M2, various steel conical cavity liners were compared. Tests were made on liners constructed from segments and sections to determine the effect on the depth of penetrations and the volume of the hole produced, and the feasibility of constructing larger liners from a number of segments. A graph of hole volume vs. detonation pressure is shown which makes it possible to predict the relative effectiveness of any untried explosive in shaped charges knowing only its composition, density, and velocity. Test results from conical liners made of Cu, Pb, Al, Zn and steel are given.

L858

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). THEORY AND APPLICATION OF THE CAVITY EFFECT, by E. R. Griffith and others. Rept. for Apr. 1943. May 19, 1943, 1v. incl. illus. diagrs. Confidential

Changes in cavity effect caused by holes, thin spots, etc.. in the liner walls or by tubes or rods within the liner were studied. Tests to determine the effect of standoff on cavity effect or on hole depth, diameter, and shape were made using the M6 liner (0.062-in. wall thickness). Photographs, using the high speed X-ray technique, are shown of cavity liners in various stages of collapse. An experiment was performed to show that the spall knocked from the inside of a steel liner by the detonation of a thin layer of explosive proceeds in a narrow jet or stream and is focused. The relationship between detonation pressure and depth of penetration was investigated. Steel liners lined with Cu and Al were tested. The effect of 85% Pb, 15% Sn, Pb, and Al foil liners placed inside steel liners was studied. Test data on 45-lb. charges are presented. The manufacture of welded steel liners is described.

L859

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). THEORY AND APPLICATION OF THE CAVITY EFFECT, by L. B. Seely and others. Rept. for May 1943. June 17, 1943, 40p. incl. illus. tables, diagrs. Confidential

The study of fragment velocity from flat plates was continued. Several 30-lb. charges were tested against a pillbox; they breached the 5-ft. walls completely with holes of 1.5-in. to 2-in. minimum diameter. It was found that the mere formation of a hole through the wall of the pillbox with the accompanying blast wave was not sufficient in itself to injure seriously the occupants of the pillbox. The edge effect and the effect of variation in size and shape of the detonation head were studied by determining the target penetration from M6 and M9A1 liners with different charge diameters. In a further attempt to tag the liner debris so that it could be identified in the target, M9A1 liners were modified in various ways and shot into Armco Fe targets. Ball bearings were suspended at various heights along the liner axis inside M9A1 steel liners to determine the effect of a small, hard obstruction on the cavity effect and liner collapse. The radiographic study of shaped charges continued with the investigation of the collapsing liner and the fragment stream. Technique improvements were: (1) greatly increased definition obtained by decreasing the distance from charge to film and increasing the distance from X-ray tube to charge; (2) use of a strip of relative opaque explosive (high $Pb(NO_3)_2$ content) along 1 side of the explosive charge to indicate the progress of detonation; and (3) development of a method of timing the events in the various processes involved based on the use of Primacord.

L860

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). THEORY AND APPLICATION OF THE CAVITY EFFECT, by J. L. VerBryck and others. Rept. for June 1943. July 16, 1943, 1v. incl. illus. diagrs. Confidential

Preliminary experiments were made on 35-lb. linear trough charges to determine the magnitude of cutting action from these charges. M67 liners containing axial tubes of 1/8-in., 3/8-in., and 5/8-in. outside diameter extending from the apex of the liner to a point 3.5 in. below the base were tested. Developmental progress is reported on a 35-lb. shaped charge. Ceramic materials as cavity liners for shaped charges were investigated. A series of charges was studied having an explosive column of constant diameter and varying liner base diameter. The effect of heavy confinement on the column length required for maximum cavity length was investigated. High speed photographic studies of cavity effect are reported. Liners with rods projecting into the explosive charge, M9A1 liners sliced in half, liners with windows, liners containing petrolatum, and half liners were studied. The Kistiakowsky experiment is discussed in which the target plate was placed some distance beyond the liner base to determine if the penetrating stream remained focused.

L861

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). THEORY AND APPLICATION OF THE CAVITY EFFECT, by J. C. Clark and others. Rept. for July 1943. Aug. 21, 1943, 1v. incl. illus. diagrs. Confidential

High speed radiographic studies of controlled fragmentation were continued. A linear 5-lb. charge for cutting structural beams is described. Tests were made with 3-, 4-, and 5-in. heavily confined charges to determine at what point the penetration dropped. Results for shaped charges fired 7° from the plane of the target at 1.5-, 2-, 3-, 5-, and 7-in. standoff are reported. In the investigation of large-scale liners a 10-in., 60° cone was manufactured in segments joined together by dowel pins. Performance of the segmented liner was not as satisfactory as that of the regular liner.

L862

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). THEORY AND APPLICATION OF THE CAVITY EFFECT, by J. C. Clark and others. Rept. for Aug.-Sept. 1943. Oct. 20, 1943, 1v. incl. illus. diagrs. Confidential

The alignment of liners of wedge shaped cavities with the charge axis is discussed. Tests are reported in which the confining wall thickness was varied in the range 0.5 to 0 in. corresponding to an explosive weight equal to approximately 10 to 90% of the total weight of the charge. Standard 1.83 x 6 in. explosive charges with unlined M9A1 shaped cavities in 1 end were fired against a 3-in. thick mild steel plate from 0 standoff. Measurements of depth, entry diameter, and volume of the crater formed in the target were made. Bimetallic liners were investigated with special attention to steel liners lined with various metals. The possibility was investigated of removing some of the explosive from the lower liner section in order to increase the depth of penetration and at the same time retain a charge of large diameter at the top. In the investigation of scale-up laws for steel liners against concrete targets, the properties of M9A1 shaped charges (1.64-in. diameter) were studied. Ease of initiation tests of cast 50/50 Pentolite led to an investigation of the Engineers Special Caps and Primacord to determine their degree of dependable initiation.

L863

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). THEORY AND APPLICATION OF THE CAVITY EFFECT, by J. C. Clark and others. Rept. for Oct. 1943. Nov. 30, 1943, 1v. incl. illus. diagrs. Confidential

An investigation of small charges with strips of thin Pb foil placed along an element of the cylindrical surface revealed that the width of the image of the moving foil was an index of the duration of the discharge, and that the nature of the image of the moving foil indicated the nature of the discharge. An investigation of linear cavity charges was concerned with determination of optimum standoff as a function of liner angle, and determination of the relation of liner thickness to liner angle with standoff fixed at optimum. M2 (6-in. diameter) charges with 60/40 Cyclotol, 50/50 Pentolite, 75/25 Tetratol, 55/45 Ednatol, 60/40 Amatol, and TNT were fired against a 5-ft. reinforced concrete target from a standoff of 6 in. A study was made of the position of the initiation point along the charge axis for best performance. A fast method of cutting nylon rope using Primacord is described.

L864

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). THEORY AND APPLICATION OF THE CAVITY EFFECT, by J. C. Clark and others. Rept. for Nov. 1943. Dec. 30, 1943, 1v. incl. illus. diagrs. Confidential

Radiographs are shown of jets from 0.75-in. diameter mild steel M9A1 liners sliced into halves from base to apex. Tests against steel targets with M2 charges containing various explosives are reported. A study of collapse, jet formation, and fragment recovery of steel cones with 80°-180° apex angles was made. Optimum liner thickness with 45°, 60°, 80°, and 100° cones of 4- and 8-in. diameter was investigated. The variation of cavity effect with charge length and liner thickness was also studied. Shaped charges for cutting steel cables were tested.

L865

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). THEORY AND APPLICATION OF THE CAVITY EFFECT, by E. R. Griffith, Jr. and others. Rept. for Dec. 1943. Jan. 31, 1944, 1v. incl. illus. diagrs. Confidential

The investigation of variation of cavity effect with liner thickness continued with tests of 1.63- and 1.88-in. diameter charges. The study of effect of target temperature on shaped charge performance continued with the firing of 2 x 6 in. Pentolite charges bearing 60° glass liners into mild steel blocks at -10°C and at +96°C. Tests were made to determine the effectiveness of the lower portion of the liner for unconfined charges. A fountain charge is being designed which will defeat a 1-in. mild steel target.

L866

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). SHAPED CHARGES FOR PERFORATION OF CONCRETE, by C. O. Davis and others. May 24, 1943, 1v. incl. illus. diagrs. (In cooperation with W145-Eng-467) Confidential

Experiments and tests leading to the development of the M1 and M2 shaped charges for concrete perforation are described. Results indicated the need for increased liner thickness for the M1 charge. Design data for the M2 are given.

L867

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). INVESTIGATION OF 30-LB., 35-LB., AND 45-LB. SHAPED CHARGES FOR CONCRETE DEMOLITION, by C. O. Davis and others. July 31, 1943, 11p. illus. diagrs. Confidential

In the development of the 45-lb. charge which would perforate 5 ft. of reinforced concrete, 60°, 70°, and 80° conical liners and 9-, 10-, 10.5-, and 11-in. diameter charges were investigated. The 30-lb. charge was sufficient to breach a 5-ft. concrete wall, but the hole produced was not large enough to accommodate a Bangalore torpedo. Tests on a 35-lb. charge (60° conical liner) showed that the hole produced when a 4-ft. wall was perforated was large enough to accommodate the Bangalore torpedo.

L868

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). LINEAR CHARGES FOR CONCRETE BEAM AND PILLAR CUTTING, by W. R. Burke and others. Jan. 13, 1944, 3p. illus. diagrs. Confidential

Tests were made with linear shaped charges, 4.25 and 6 in. wide, wedge shaped, with 70° internal angle, and of cast 50/50 Pentolite against reinforced concrete beams and pillars. Each end of the wedge liner was enclosed with half of a conical liner in an attempt to increase the effectiveness of the charge.

L869

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). MECHANISM OF CONE COLLAPSE, by M. B. Cook. Apr. 15, 1944, 1v. incl. tables, diagrs. Confidential

Observed facts including continuous decrease in the particle velocity from the head to the rear of the jet and the variation in the mass of the jet, secondary jet, liquid and particle jets, motion of slug, and effect of mass of liner on cavity effect were explained quantitatively by considering the finite conical liner thickness, and assuming that the wall was divided into independently moving layers. The original spall theory was abandoned, but the theory that the impulse action of the detonation wave is responsible for the effect was retained. Additional considerations of the theory of the interaction of the detonation head with normal and oblique liners are presented.

L870

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). DEVELOPMENT OF SHAPED CHARGES FOR CUTTING 5-IN. STEEL SHAFTING, by C. P. Spaeth and others. Final rept. July 1, 1944, 3p. tables, diagrs. Confidential

A 6.5-lb. linear charge of 50/50 Pentolite containing a thick steel wedge liner, and a 3.75-lb. cylindrical charge of 50/50 Pentolite containing a thick steel conical liner were tested against 5-in. mild steel shafting.

L871

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). MISCELLANEOUS PROJECTS, by E. R. Griffith, Jr. and others. Final rept. July 24, 1944, 1v. incl. illus. Confidential

Large angle liners (80°-180°) having a wall thickness of 0.043-0.056 in. were tested at standoffs of 2-7 diameters. The target was 7 spaced mild steel plates. The effect of liner wall thickness (0.038-0.062 in.) on the slug size and penetration was studied on M6 liners of 42° apex angles and 2.07-in. base. Formation of a concave detonation wave was attempted by: (a) inserting truncated steel liners filled with Pb, and (b) tapering the charge upward and downward from a line just above the apex of the liner and inserting a solid steel liner at this line. The results of the tests on the penetration effect were inconclusive. Collapse of glass liners and the behavior of the slug were studied on 45° Pb glass and 60° Pyrex liners by tank shot method and on 60° Pb glass liners radiographically. The effectiveness of a mixture of PETN 28.5, TNT 28.5, and RDX 43% in shaped charges was compared to that of 60/40 Cyclotol and 50/50 Pentolite. Comparative tests were made on the penetration of hemispherical liners, whole and with top removed. The effect of pouring temperature (80°-100° C) of 50/50 Pentolite on its detonation through a gilding metal cap well was studied.

L872

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-15). DEVELOPMENT OF THE FOUNTAIN CHARGE, by L. A. Burrows and others. Final rept. Oct. 2, 1944, 25p. incl. tables, diagrs. Secret

Experimental work is described on the Fountain charge, a shaped charge device for use as a sabotage weapon. The objective was a shaped charge which would perforate a 1-in. thick mild steel plate from a distance of 10 ft. (representing a locomotive boiler) and 2 1-in. mild steel plates at distances of 2 ft. and 3 ft. from the charge (representing a locomotive cylinder). Best results were obtained with drawn steel 80° liners and heavier (0.130 in.) drawn Al liners. Annealing the drawn steel liners did not affect their performance. In static tests made with 3 scrap locomotives as targets, both steel and Al lined charges made holes through the bottom and top of the cylinders, stopping in the steam chest; both types also perforated the bottom of a boiler and bent or broke several of the lower tubes. Essentially the same results were obtained with the locomotive running at 20 m.p.h. Since Al did not show any advantage over steel as a liner material, steel was adopted for the final design.

L873

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). SHAPED CHARGES FOR CUTTING 2-IN. STEEL CABLE AND 1-IN. AND 1.5-IN. ANCHOR CHAINS, by L. H. Wilson and others. Final rept. Nov. 8, 1944, 6p. illus. diagrs. Confidential

Cavity charges tested for cutting 2-in. stranded steel cable and 1, 1.5-in. diameter anchor chains comprised 55/45 Pentolite cast over a 1/3-cylindrical hard brass linear cavity liner in a galvanized Fe container. The charge was boostered with a 4.5-g. pressed Pentolite pellet and initiated with a no. 6 electric detonator.

L874

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-1). EVALUATION OF DEEP-DRAWING STEELS FOR MANUFACTURE OF CAVITY CHARGE CONES, by W. R. Burke and others. Final rept. Dec. 6, 1944, 1v. incl. illus. diagrs. Confidential

Ten representative types of deep drawn steel were tested and evaluated for use in conical liners for shaped charges.

L875

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). SHAPED CHARGES IN PROCESS OF DEVELOPMENT AT EASTERN LABORATORY. Summary rept. Dec. 15, 1944, 19p. incl. diagrs. Confidential

Descriptions, performance, and materials of construction are given for the following grenades: 10-in. T24; 10-in. KFT (follow-through grenade); Spigot, HEAT T21 for guns 37-mm. M3 and M3A1 device M; rifle, AT, M9A1; and for the shaped charge bomb, 2000-lb., AN M66A1 modified.

Several grenades are included that are not shaped charge weapons. Data are given on a 2800-lb. lot of 70/30 Cyclotol.

L876

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-157). DEVELOPMENT OF AN IMPROVED HEAD FOR 2.36-IN. ROCKET HEAT, by L. B. Seely and others. Summary rept. Jan. 13, 1945, 4p. tables, diagrs. Confidential

An improved head for this rocket was developed by using a Cu liner. Cyclotol rather than Pentolite, and increasing the length of the body and the ogive.

L877

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-167). PERFORMANCE OF PORCELAIN ENAMELED * STEEL CONES IN CAVITY CHARGES [* title should read "IRON CONES"], by E. R. Griffith and others. Final rept. Jan. 19, 1945, 4p. incl. tables. Confidential

Tests on Armco Fe liners coated with porcelain enamel are described. Comparison is made with unenameled Armco Fe liners and steel liners having approximately the same total thickness as the enameled liners.

L878

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-136). FUNDAMENTAL INVESTIGATION OF GLASS CONES FOR USE IN CAVITY CHARGES, by W. R. Burke and others. Progress rept. Jan. 25, 1945, 6p. tables, diagrs. Confidential

Results of tests using glass liners are described. Only standoff and apex angle were evaluated before the program was postponed.

L879

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-129). PERFORMANCE OF COPPER CLAD STEEL CONES IN CAVITY CHARGES, by E. R. Griffith and C. P. Spaeth. Progress rept. Feb. 5, 1945, 4p. tables, diagr. Confidential

Experimental work to evaluate Cu-clad steel cones as liners is described. Tests indicated that steel liners clad on the inner surface with 0.018 in. of Cu gave an average depth of penetration midway between those given by all-steel and all-Cu liners, and that the Cu-clad liner required a greater standoff than the steel liner.

L880

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-9). DEVELOPMENT OF SHAPED CHARGE M2A3, by W. R. Burke and others. Final rept. Feb. 23, 1945, 10p. tables, diagrs. Confidential

Experiments on and development of shaped demolition charges M2, M2A1, M2A2, and M2A3 are described. Lining the detonator cavity with gilding metal shell gave improved initiation. Six explosive compositions were tested for effectiveness. Bullet sensitivity, the effect of submersion of charges in water, and malalignment were investigated.

L881

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). CAVITY CHARGES FOR CONCRETE BEAM AND PILLAR DEMOLITION, by P. H. Wornom and C. P. Spaeth. Final rept. Mar. 15, 1945, 5p. illus. diagrs. Confidential

Linear and cylindrical charges were tested against reinforced concrete beams and pillars. Since 2 35-lb. semicircular charges fired simultaneously failed to cut any of the reinforcing bars in the column, they were not tested on other targets.

L882

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-137). FUNDAMENTAL INVESTIGATION OF LINEAR CAVITY CHARGES, by P. H. Wornom and others. Final rept. Mar. 15, 1945, 5p. tables, diagrs. Confidential

The results of an investigation of the effect of apex angle (60°-120°) liner thickness (.025-.092 in.), charge weight and shape, liner material (steel), and standoff (0-4 in.) on the penetration of linear shaped charges are presented. No conclusions are drawn.

L883

du Pont de Nemours, E. I., & Co. (W670-ORD-4331). EVALUATION OF EXPLOSIVES FOR USE IN CAVITY CHARGES - 70/30 CYCLOTOL AND PTX2, by P. H. Wornom and others. Progress rept. Apr. 11, 1945, 7p. tables, diagrs. Confidential

The explosives 50/50 Pentolite, PTX2, 70/30 Cyclotol, and 65/35 Cyclotol were investigated for pourability, density, sensitivity, segregation, and performance in cavity charges. Boosters required to produce maximum cavity effect for 70/30 Cyclotol and PTX2 were investigated.

L884

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-26).
EVALUATION OF THINNER STEEL CONES IN ROCKET, HEAT, 2.36-IN. M6A3, by L. B. Seely and others. Final rept. May 7, 1945, 8p. illus. diagr. Confidential

Tests on steel liners of various thicknesses for this rocket are reported. Three factors were investigated: distortion or displacement of the liner on target impact, standoff, and confinement.

L885

du Pont de Nemours, E. I., & Co. (W670-ORD-4331).
EVALUATION OF EXPLOSIVES FOR USE IN CAVITY CHARGES - 70/30 CYCLOTOL, 65/35 CYCLOTOL AND PTX2, by P. H. Wornom and others. Final rept. May 16, 1945, 10p. tables, diagrs. Confidential

PTX, 65/35 Cyclotol, and 70/30 RDX-TNT were investigated as possible replacements for the Pentolite filler used in shaped charges.

L886

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-193).
GRENADE, SPIGOT, HEAT, T30 FOR 57-MM. GUN M1, by W. R. Burke and others. Final rept. July 21, 1945, 10p. tables, diagrs. Confidential

Work on a shaped charge spigot grenade for the 57-mm. gun M1 up to the time of cancellation of the project is described. A design is proposed for an Al grenade weighing 29 lb. with a 45° Cu liner and an 8-lb. HE charge. A spitback shaped charge element was suggested as part of the fuze.

L887

du Pont de Nemours, E. I., & Co. (W670-ORD-4331).
EFFECT OF SEPARATION OF CONE FROM EXPLOSIVE CHARGE, by C. P. Spaeth and P. H. Wornom. Final rept. Aug. 12, 1945, 4p. tables, diagrs. Confidential

The effect of separation of the liner and explosive on charge performance was investigated for the M9A1 grenade and the 2.36-in. rocket charges at 1-5/8 and 1.5-in. standoff.

L888

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-2).
40-LB. SHAPED DEMOLITION CHARGE M3, by P. A. Coombs and others. Final rept. Aug. 28, 1945, 1v. incl. illus. diagrs. Confidential

Experiments leading to the development of the M3 (40-lb.) shaped charge for concrete perforation are described. Drawn steel liners gave better performance than welded annealed liners. An improvement was made in the explosive loadings, and a more satisfactory standoff pedestal was developed.

L889

du Pont de Nemours, E. I., & Co. (W670-ORD-4331).
EVALUATION OF THINNER STEEL CONES IN GRENADE, RIFLE, HEAT, M9A1. Final rept. Aug. 29, 1945, 4p. incl. table. (Proj. no. TTS-25) Confidential

This investigation was undertaken to compare the performance of M9A1 rifle grenade steel liners 0.025 in. and 0.037 in. thick under conditions of actual operation. Static tests made at a standoff of 2 7/16 in. against 3-in. homogeneous armor plate confirmed the superiority of the thinner liners as indicated below:

I	II	III	IV	V	VI	VII	VIII
0.037	8	100	25	0.75	0.32	0.25	1.1
0.025	8	100	100	0.80	0.37	0.27	0.9

In dynamic tests the thinner liner was somewhat more effective against 3-in. homoplate armor as shown by the following firing data:

I	II	III	IV	V	VI	VII	VIII
0.037	6	100	50	0.78	0.38	0.26	1.0
0.025	6	100	100	0.79	0.38	0.31	1.1

I = liner wall thickness (in.); II = no. of rounds; III = % perforation; IV = % slugs; V = ave. entrance diam. (in.); VI = ave. exit diam. (in.); VII = ave. min. diam. (in.); VIII = ave. depth to 0.6-in. diam. (in.)

However, the standard 0.037-in. liners were superior against 4-in. homoplate armor, perforating 3 out of 3 times, while the 0.025-in. liners perforated the plate only 1 out of 3 times.

L890

du Pont de Nemours, E. I., & Co. (W670-ORD-4331).
ROCKET, HEAT, 2.36-IN., M6A3 MALFUNCTIONING OF ROUNDS MANUFACTURED BY THE PHILCO CORPORATION, by L. B. Seely and others. Final rept. Sept. 10, 1945, 12p. illus. diagrs. Confidential

An investigation of the unsatisfactory performance of rounds manufactured by the Philco Corporation is reported.

L891

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-129).
PERFORMANCE OF COPPER-CLAD STEEL CONES IN CAVITY CHARGES, by E. R. Griffith and C. P. Spaeth. Final rept. Oct. 1, 1945, 4p. tables. Confidential

Tests of Cu, steel, and Cu-clad steel liners in M9A1 rifle grenade and M6A3 Bazooka rocket bodies showed the order of effectiveness to be Cu, Cu-clad steel, and steel. Cu-clad steel liners in M6A3 bodies gave penetrations very close to those of Cu, which were probably due to a more nearly optimum ratio of Cu: steel: total wall thickness in the M6A3 cones.

L892

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-151).
BOMB, SHAPED CHARGE, 23 IN., by J. K. Detrick and others. Final rept. Oct. 5, 1945, 5p. tables, diagrs. Confidential

The design for and tests made on the 23-in. bomb are described. A 60° steel liner 18 in. in diameter was used. Recommendations for design improvements are presented.

L893

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-157).
IMPROVEMENT OF HEAD OF ROCKET, HEAT, 2.36 IN., by L. B. Seely and others. Final rept. Oct. 5, 1945, 21p. tables, diagrs. Confidential

Two improved heads for the 2.36-in. Rocket HEAT are described. Improvement is chiefly in greater penetrating power, which was achieved by substituting Cu for steel liners, and increasing the standoff and charge length. A comparison of explosive compositions indicated that 65/35 RDX/TNT was a better explosive for small caliber shaped charges than 70/30 RDX/TNT or PTX2.

L894

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-116).
PERFORMANCE UNIFORMITY OF THE CARNEGIE INSTITUTE OF TECHNOLOGY STANDARD CAVITY CHARGE, by P. H. Wornom and C. P. Spaeth. Final rept. Oct. 9, 1945, 1v. incl. tables, diagrs. Confidential

The results of an investigation of factors affecting the performance of the shaped charge noted in the title are presented. The factors were: liner alignment, liner symmetry and thickness, liner material, and explosive charge compositions.

L895

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-29).
DEVELOPMENT OF 10-IN. SHAPED CHARGE GRENADES. GRENADE, SHAPED CHARGE, 10-IN., T24. GRENADE SHAPED FOLLOW-THROUGH, 10-IN. (DEVICE KFT) GRENADE, DEMOLITION, 10-IN., T27, by P. A. Coombs and others. Final rept. Oct. 16, 1945, 10p. illus. diagrs. Confidential

Experiments leading to the development of the 3 charges named in the title are described; the last-named is not a shaped charge. The first contained a 47-lb. cavity charge and a 60° steel liner; a modified M52R1 point-detonating fuse was used with a Primacord train to carry the initiation to the rear of the charge. In the second, substantially the same head was used, with a follow-through projectile that depended on its own momentum to carry it through the blast of the forward charge.

L896

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-168).
IMPACT SENSITIVITY OF MILITARY EXPLOSIVES, by J. E. Lufkin and others. Final rept. Oct. 30, 1945, 6p. illus. diagrs. Confidential

The results of an investigation of the impact sensitivity of 17 military explosives manufactured in Great Britain, Canada, and the United States are presented.

L897

du Pont de Nemours, E. I., Co. (W670-ORD-4331, Proj. no. TTS-20).
SHAPED CHARGE FOR CUTTING 3/8-IN. STEEL CABLE, by J. L. VerBryck and others. Final rept. Oct. 31, 1945, 6p. illus. diagrs. Confidential

An explosive cutter charge for emergency cutting of 3/8-in. steel tow cable is described. An appendix giving directions for installing the cutter charge is included.

L898

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-23).
SHAPED CHARGE FOR CUTTING 9/16-IN. STEEL CABLE, by J. L. VerBryck and others. Final rept. Nov. 5, 1945, 4p. tables, diagrs. Confidential

An explosive cutter charge for emergency cutting of 9/16-in. steel tow cable for gliders is described. An appendix giving directions for installing the cutter charge is also included.

L899

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-158).
IMPROVEMENT OF THE HEAD OF GRENADE, RIFLE, HEAT M9A1, by P. A. Coombs and others. Final rept. Nov. 8, 1945, 12p. illus. diagrs. Confidential

Tests leading to an improved head for the M9A1 rifle grenade are described. The improvement was accomplished chiefly by substituting a thin Cu liner for a steel liner, increasing the charge length and standoff, and improving the liner alignment with the charge.

L900

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-141).
GRENADE, SPIGOT, HEAT, T21 FOR 37-MM. GUNS M3 AND M3A1 (DEVICE M), by J. K. Detrick and others. Final rept. Nov. 12, 1945, 9p. illus. diagrs. Confidential

The development of a shaped charge spigot for the 37-mm. gun M3 is described. A drawn Cu liner of 42° angle with a flash tube through the apex was used. Performance test data and recommendations for changes in design are given.

L901

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-131).
BOOSTER REQUIREMENTS FOR CAST MILITARY EXPLOSIVES, by E. R. Griffith, Jr. and others. Final rept. Nov. 20, 1945, 5p. illus. diagr. Confidential

The determination of minimum booster requirements of 13 explosives for effective penetration in unconfined cylindrical charges is described.

L902

du Pont de Nemours, E. I., & Co. (W670-ORD-4331, Proj. no. TTS-189).
DEVELOPMENT OF FOLLOW-THROUGH, T1 FOR SHAPED CHARGE M3, by W. R. Burke and others. Final rept. Dec. 11, 1945, 5p. diagrs. Confidential

A device was developed which, when attached to the 45-lb. shaped demolition charge M3, would throw a 37-mm. HE projectile into the hole made by the M3. The device consists of a short-barreled mortar and a 37-mm. HE shell with sufficient auxiliary equipment to attach them to and align them with the forward (M3) charge. Since it was known that the 37-mm. HE shells M63 used as follow-through projectiles in these units had very unstable flight when fired from unrifled mortars, it is thought that a more stable projectile will have to be developed before the device will give 100% performance.

L903

du Pont de Nemours, E. I., & Co. (W670-ORD-4331).
DEVELOPMENT OF DESTRUCTOR T15, by J. L. VerBryck and others. Final rept. Dec. 14, 1945, 17p. incl. tables, diagrs. Confidential

Development was undertaken on an explosive charge that would be capable of jettisoning the wings from the jet propelled JB2 bomb. Since the wings on the JB2 were mounted on a single spar comprising essentially a 4.5-in. outside diameter x 0.25-in. wall pipe, it was thought that the problem could be solved by cutting this pipe with a shaped charge. The final design employed a 1/3-cylindrical liner of brass. Optimum liner dimensions were 2-in. diameter and 0.63-in. width at the curved section, and a wall thickness of 0.046 in. A 48-g. charge of 65/35 RDX-TNT was satisfactory. Since it was necessary that there be no damage to the gas tanks, tests indicated that the spar could be cut 1.25 in. from the tank with little damage to the tank. The charge was retained in a fixed position by the single 5/8-in. cap screw used to hold each wing on to the spar.

L904

du Pont de Nemours, E. I., & Co. (W672-ORD-5723).
HIGH SPEED PHOTOGRAPHS OF CONE-END PENTOLITE CHARGES. Rept. no. 1 on the Investigation of Cavity Effect. Oct. 14, 1942, 10p. illus. diagrs. (Rept. no. RE-3-10, no. 1) Confidential

High speed drum camera photographs were taken of the detonation of shaped charges with M9A1 drawn steel and pyrex liners. The photographs suggested several general conclusions on slug formation, glass liners, jet particles, mechanism of perforation, and kinetic energy contained in the jet.

L905

du Pont de Nemours, E. I., & Co. (W672-ORD-5723).
PRELIMINARY EVALUATION OF VARIOUS FACTORS WHICH INFLUENCE THE DEPTH AND DIAMETER OF THE PENETRATION IN ARMOR PLATE. Rept. no. 2 on the Investigation of Cavity Effect. Nov. 9, 1942, 9p. table, illus. (Rept. no. RE-3-10, no. 2) Confidential

Cast TNT, 50/50 Pentolite and 60/40 Cyclotol are evaluated as explosive charges, using M9A1 liners at various standoffs and from both normal and oblique angles. The effects of confinement by means of steel tubing and the addition of an explosive belt around the liner base were also investigated.

L906

du Pont de Nemours, E. I., & Co. (W672-ORD-5723).
VARIATION OF CAVITY EFFECT WITH EXPLOSIVE COMPOSITION, by W. R. Burke. Rept. no. 3 on the Investigation of Cavity Effect. Feb. 3, 1943, 1v. incl. tables, diagrs. (Rept. no. RE-3-10, no. 3) Confidential

Thirteen explosives were compared by measuring the hole volumes resulting when each was used in a shaped charge with a 60° Pyrex liner. The effects of charge length, charge diameter, and standoff were studied in an attempt to find a relationship between the effectiveness of an explosive and its thermochemical or hydrodynamic properties. An appendix outlines the hydrodynamic theory.

L907

du Pont de Nemours, E. I., & Co. (W672-ORD-5723). METALLURGICAL OBSERVATIONS ON THE CAVITY EFFECT, by W. B. De Long. Rept. no. 4 on the Investigation of Cavity Effect. Feb. 17, 1943, 11p. illus. (Rept. no. RE-3-10, no. 4) Confidential

The mechanisms of liner disintegration and target penetration were investigated by metallographic examination of holes produced by test shots and the available remnants of liners. No conclusions could be drawn, but observations are made on penetration, slug formation, target reaction, and the effect of particles from the liner.

L908

du Pont de Nemours, E. I., & Co. (W672-ORD-5723). THEORY OF THE CAVETY EFFECT, by M. A. Cook and L. B. Seely. Rept. no. 5 on the Investigation of Cavity Effect. Mar. 5, 1943. 19p. tables, diagrs. (Rept. no. RE-3-10, no. 5) Confidential

A theory of the shaped charge effect postulated on the spalling process is presented. The theory was formulated from the hydrodynamic concept of the detonation wave, the edge effect, the laws of conservation of energy and momentum, and observations on the effect of charge length and diameter.

L909

du Pont de Nemours, E. I., & Co. (W672-ORD-5723). INVESTIGATION OF CAVITY EFFECT, by C. O. Davis and others. Final rept. Sept. 18, 1943, 21p. illus. diagrs. (Rept. no. RE-3-10, no. 6) Confidential

This final rept. lists conclusions drawn from the research program under the contract. Data are given on the effect of various physical conditions on penetration. The relative effectiveness of 8 explosives is calculated from their detonation pressures, and hole volumes and hole depths made in stacks of mild steel plates. The efficiency of non-ferrous metals, glass, and pottery as liner materials was tested at various standoffs. The effect of non-conical and miscellaneous liner designs was tested. The collection of particles amounting to 95% of the weight of the liner by shooting into a specially constructed tank of water is described. The variation of penetration with charge diameter was investigated.

L910

Engineer Board, Fort Belvoir. INVESTIGATION AND DEVELOPMENT OF EXPLOSIVE SHAPED CHARGES, M1 AND M2 EMPLOYING THE CAVITY EFFECT, by W. A. Ford, Jr. Engineering rept. May 12, 1943, [32]p. incl. illus. tables. (Proj. no. DM 377A, Demolitions rept. no. 30) Restricted

Test results showed that the M1 and M2 shaped charges penetrated completely a 30-in. reinforced concrete wall, making a hole approximately 2 in. in diameter, throwing fragments of concrete from the rear of the wall for about 50 ft. The M1 charge drilled a borehole 1.5 in. in diameter and 20 to 24 in. deep into reinforced concrete of 4500 to 6000 lbs. strength and of over 30 in. in thickness. The M2 charge drilled a borehole 2 to 3 in. in diameter and 25 to 35 in. deep in reinforced concrete of 4500 to 6000 lb. strength and of over 36 in. in thickness. The liner angles most satisfactory for steel and glass were 50° and 60°, respectively. Cast Fe, pottery, ceramic, sand carborundum were unsuitable for use as liners. Drawn steel annealed, welded steel annealed with a thickness of 0.125 to 0.150 in. and high density soft Pb glass similar to Corning G12 with a thickness of 0.360 0.03 in. were suitable for use as liners. Explosives in order of decreasing effect were Pentolite (50/50), Tetrylol (65/35), and TNT. The charge should be separated from the target a distance equal to the diameter of the liner. This distance may be increased up to 3 times the diameter, but the diameter of the borehole will be decreased. The space between the charge and target must be free of any obstacles as they interfere with the cavity effect. The material of the container did not contribute to the action of the shaped charge and it may be made of plastic or some other non-critical material. The strength of the concrete affected the size of the hole produced.

L911

Engineer Board, Fort Belvoir. PROPOSED INFORMATION BULLETIN ON EXPLOSIVE SHAPED CHARGE, M2. May 20, 1943, 4p. illus. diagr. (Demolitions rept. no. 32) Restricted

The M2 charge is a demolition charge designed principally for use in drilling boreholes in reinforced concrete for demolition purposes and as an assault weapon on fortifications of concrete and steel. The charge can be detonated with a US Engineer Special Electric Blasting Cap, a US Engineer Special Non-Electric Blasting Cap, or Primacord. The charge may be also used as a mine or for directional firing. Special precautions are pointed out, i.e.; care in handling, no obstructions should be placed in liner, holes drilled by the charges should be allowed to cool, number of adjacent charges fired together should not be closer than 3 ft. when primed with electric blasting caps; this distance may be decreased when charges are primed with primacord, etc.

L912

Engineer Board, Fort Belvoir. INVESTIGATION AND DEVELOPMENT OF EXPLOSIVE, SHAPED CHARGE, T3, by W. A. Ford, Jr. Engineering rept. July 1, 1943, [32]p. incl. illus. tables, diagrs. (Proj. no. DM 377B, Demolitions rept. no. 37) Confidential

Large shaped charges capable of penetrating a 60-in. thickness of reinforced concrete with the largest diameter hole attainable were developed. Experimental charges were prepared by casting explosives into sheet metal and plastic containers with liners of cast G12 glass, welded steel, and a combination of G12 glass apex and welded steel apron. The apex angles of the liners were 60°, 70° and 80°, and the liner thickness varied from 0.138 to 0.375 in. Results showed that a shaped charge of 45 lb. gross weight with a 10-in. diameter and 60° welded steel liner and containing 33.5 lb. of 50/50 pentolite explosive completely penetrated a 5-ft. reinforced concrete wall. The hole had a minimum diameter of 2.5 in. and permitted a standard bangalore torpedo to be pushed through it. The T3 charge weighing 33 lb. gross, with a 9-in. diameter and 60° welded steel liner containing 26 lb. of 50/50 pentolite explosive completely penetrated a 5-ft. reinforced concrete wall. The hole had a minimum diameter of 1.75 in. and permitted a standard bangalore torpedo to be inserted to a depth of 27 to 40 in.

L913

Engineer Board, Fort Belvoir.
USE OF THE EXPLOSIVE, SHAPED CHARGE, M1 AND M2, FOR THE PRODUCTION OF BORE HOLES IN THE DEMOLITION OF REINFORCED CONCRETE STRUCTURES, by W. A. Ford, Jr. Engineering rept. July 22, 1943, [28]p. incl. illus. tables. (Proj. no. DM 377a, Demolitions rept. no. 39) Confidential

The investigation was made to determine whether shaped charges M1 and M2 could be used for the production of bore holes in the demolition of reinforced concrete structures. The M1 shaped charge produced a bore hole which was approximately 24 in. deep and had an average diameter of 2 in. The M2 charge produced a bore hole approximately 30 in. deep and with an average of 2.5 in. The bore holes produced by shaped charges had a very high temperature and should be allowed to cool for 20 min. or be cooled with water before they are filled with explosives. Fragments and slugs from the glass and steel liners were occassionally lodged in the hole. The glass fragments from the M2 shaped charge were less objectionable than the steel slug from the M1 shaped charge because the glass fragments cooled more rapidly. Bore holes were successfully produced at angles from 90° to 45° to the face of the target; however, the most satisfactory bore holes were produced at 90° to the face, when the thickness of the concrete structure was greater than 3 ft. Results showed that bore holes could be drilled in reinforced concrete with the shaped charges without seriously weakening the structure. Plastic Comp. C or C2 was the most suitable explosive available for loading bore holes by shaped charges. Reinforced concrete slabs from 3 ft. to 6 ft. thick and concrete trestle bridge bents were collapsed by drilling bore holes with shaped charges, and loading the holes with explosive.

L914

Engineer Board, Fort Belvoir.
INVESTIGATION OF 5-LB. AND 35-LB. LINEAR SHAPED CHARGES, by W. A. Ford, Jr. Nov. 20, 1943, 28p. incl. illus. tables, diagrs.
Confidential

Five-lb. and 35-lb. linear shaped charges were tested against an 18-in. steel I-beam and steel plates, and they were compared with Comp. C and the standard 0.5-lb. TNT demolition blocks. Results showed that the linear shaped charge cut linear holes in steel targets to a depth approximately equal to the charge width. 5-lb. linear charges penetrated steel to a greater depth than an equivalent weight of Comp. C or TNT blocks; they were not as effective for demolishing structural steel members of bridges as standard charges of military explosives. Linear shaped charges were less flexible in their utility than Comp. C where the quantity/linear in. could be varied to suit individual requirements.

L915

Engineer Board, Fort Belvoir.
SHAPED CHARGES IN CONSTRUCTION OF FIELD FORTIFICATIONS AND IN QUARRYING OPERATIONS, by W. A. Ford, Jr. Nov. 20, 1943, 27p. incl. illus. Confidential

An investigation was made to determine the suitability and practicability as a rapid means of rock excavation of shaped charges M1 and M2. The charges were tested in sandy clay, hard clay, limestone rock, granite rock, sandstone, trap rock, hard schist rock, and gneiss. Results showed that the M1 and M2 shaped charges were unsuitable for use in the construction of either hasty or deliberate types of field fortifications with the exception of prone shelter and open shallow type machine gun emplacements in weathered seamy rock or sandstone. The charges were impracticable as a rapid means of rock excavation, and they did not produce boreholes with sufficient depth for use in quarrying operations.

L916

Engineer Board, Fort Belvoir.
HOLLOW DEMOLITION CHARGE, 5 KG. [ITALIAN]. Feb. 14, 1945, 3p. incl. illus. (File no. 400.1 (GN3 408)) PD 15429
Unclassified

A brief description and 2 photographs of the above named Italian charge are presented. It is roughly equivalent to the US shaped charge, M1.

L917

Engineer Board, Fort Belvoir.
EXPERIMENTAL USES OF THE CHARGE, SHAPED, 40-LB., M3, by J. W. Barnes. Mar. 5, 1947, 34p. incl. illus. tables, diagrs. (Proj. no. DMS 416, rept. no. 994) Restricted

The 40-lb. M3 shaped charge was investigated to obtain data on. (1) the optimum standoff for boreholes in soil; (2) clearance of fields of fire through underbrush; (3) usefulness as a satchel charge against minefields and tanks. From tests carried out at A. P. Hill Military Reservation and at Fort Belvoir, Virginia, it was concluded that: (a) the standoff for making boreholes in earth with M3 shaped charges is not critical between 3 ft. and 6 ft.; (b) in clay and clay-loam soils, boreholes 5 ft. deep and 7 in. in diameter are produced by M3's; (c) successive M3's fired into a borehole in earth deepen the hole if no loose soil is present in the hole; (d) fields of fire through underbrush are not cleared efficiently by use of M3's; (e) the M3 shaped charge is not effective in cleaning mine fields; (f) the M3 shaped charge is effective against tanks since 10 out of 11 charges fired against an M4 medium tank penetrated its armor at distances ranging from 12 ft. to 100 ft. Data are presented in tabular form.

L918

Engineer in Chief Branch, GHQ, MEF (Gt. Brit.).
HOLLOW CHARGES; A BRIEF EXPLANATION. May 1943, 12p. Confidential

A general discussion is presented on the first use of shaped charges, the focusing, the jet, form of cavity, type of explosive, charge lining, penetration, improving the crater, and penetration data for 30° liners of various diameters and thicknesses.

L919

Engineer in Chief Branch, GHQ, MEF (Gt. Brit.).
SHAPED CHARGES; A BRIEF EXPLANATION. July 1943, 4p. Confidential

Basic ideas of the shaped charge are presented. Brief discussions are included on the form of the charge, concentration effect, and explosives used in the charge.

L920

Engineer Liaison Officer, SD5, Canadian Military Headquarters.
HOLLOW CONE CHARGES, by J. T. Wilson. June 15, 1942, 6p. incl. diagrs. (SD5 (ELO) rept. no. 103; Demolition Series no. 13; OSRD Liaison Office WA-276-18) Secret

Brief summaries are reported on: (1) the theory of shaped charges (explosive forces and factors affecting performance); (2) results obtained with shaped charges against tanks, pillboxes, concrete antitank walls, and for cratering; (3) development of wedge and bell charges; and (4) use of models and scaling of linear dimensions in experiments.

L921

Engineer Liaison Officer, SD9, [Canadian Military Headquarters].
SHAPED CHARGES AND THE HOPKINSON BAR EFFECT. Oct. 19, 1942, 3p. incl. illus. (SD9 (ELO) rept. no. 141; Demolition Series no. 23) Confidential

The Hopkinson bar effect is defined. A discussion is given on the conservation of momentum when a shaped charge explodes forming a jet in 1 direction. The follow-through projectile described is a hollow dish shaped charge lined with metal in front of the projectile that blows a hole through the target. The projectile ignites a Briska detonator which fires a charge of black powder in the rear of the projectile. This propels a smaller steel projectile filled with HE into the tank. A 3-in. (rocket AA) shell is shown in which the TNT pellets were separated by brass discs and grooved round the bases and longitudinally to cut the casing by Munroe effect into fragments about 3 in. long.

L922

Engineer Research and Development Laboratories, Fort Belvoir.
[CHARGE, SHAPED, 15-LB., M2A3; CHARGE, SHAPED, 40 LB., M3, APPENDIX R], by W. T. Field. [1947], p. 159-169 incl. diagrs. (Proj. no. MES 434, rept. no. 1006) (In its Cold Weather Testing of Demolition Equipment, Aug. 22, 1947) Restricted

Tests were made with M2A3 charges to determine their effectiveness against lake ice, permafrost, and granite found in the vicinity of Fort Churchill, Manitoba, Canada, during the winter of 1946-47. Results showed that both charges penetrated 66 in. of lake ice. The M2A3 charge with a 30-in. standoff produced a hole 6 ft. deep with a diameter tapering from 6 in. at the top to 1.5 in. at the bottom in the permafrost. The M3 charge at normal standoff produced an average hole in the permafrost, 6.5-ft. deep with a 7-in. top diameter tapering to 4 in. at the bottom. Poor results were obtained with both charges against the particular granite formation encountered.

L923

Engineer Research and Development Laboratories, Fort Belvior.
MISZNAY-SCHARDIN EFFECT PERTAINING TO SHAPED CHARGES; MEMORANDUM TO OBSTACLES AND DEMOLITIONS BRANCH, by E. W. Sarven. Aug. 15, 1947, 4p. Secret

The Misznay-Schardin effect is defined and a summary of the information known to the writer is presented. The uses of this effect as a distant operating charge and as shrapnel against infantry, with performance data, are briefly reported.

L924

*Engineer Research and Development Laboratories, Fort Belvoir.
COLD WEATHER TESTING OF DEMOLITION EQUIPMENT. Aug. 22, 1947, 182p. incl. illus. tables, diagrs. (Proj. no. MES 435, rept. no. 1006) SIP R52 Unclassified

The effectiveness of demolition equipment used under subarctic conditions is determined. The difficulties of the use and ease of handling standard demolition items, the strength of military explosives upon detonation after long storage at subzero temperatures, and the effect of explosive mine clearing devices upon snow-covered minefields were studied. Equipment tested included demolition snake M2, blasting machine, antipersonnel mine M3, and incendiary grenade M14. It is concluded that shaped charges are the most useful of the standard prepared demolition charges for utility work in determining ice thickness and preparing holes in permafrost and frozen muskeg. The recommendations include the development of an adjustable tripod for use with shaped charges, and the determination of the ultimate penetration of each type of charge against winter fresh water ice and the optimum-standoff distance for winter ice. (SIPRE abstract)

L925

Engineer Research and Development Laboratories, Fort Belvoir.
PLASTIC EXPLOSIVES FOR CUTTING STEEL, by W. T. Field. Nov. 16, 1948, 33p. incl. illus. (Proj. no. 8-67-01-001, rept. no. 1095) Confidential

Cylindrical shaped charges (1, 1.25, 2.44, 3.68, 4.90, and 6.14 in. in diameter) using plastic explosive Comp. C-3 as a filler were tested. Steel and paper liners were used. All the charges were confined with 2 wraps of paper and detonated in air with no external tamping. All liners were straight sided troughs with an 80° apex angle. Steel liners were made of 24-gage annealed sheet metal, and paper liners were of stiff manila folders. Results indicated that linear shaped charges with a paper trough liner completely penetrated the same thickness of homogeneous steel plate as did charges with steel liners of the same diameter. When fired under the same conditions against more massive targets where only partial penetration resulted, charges with paper liners were only 80% as effective as the charges with steel liners. Comp. C3 compared favorably with Comp. X (developed by the Germans which contained 50% Hexogen, 47.5% Nitroglycol, and 2.5% Nitrocellulose). Cylindrical linear shaped charges have potential application for cutting homogeneous sections in a steel structure of a thickness approximately 60% of the charge diameter.

*Reference not verified in the original.

L926

Engineer School, Fort Belvoir.
INTERIM REPORT ON SHAPED CHARGES, by H. M. Roth and others. July 2, 1943, 27p. incl. illus. diagrs. Secret

Tests were carried out to determine: (1) the blast effects produced inside of pillboxes by external shaped charges, and (2) means of exploiting these perforations once produced. M1 and 35-lb. charges were used against concrete pillboxes with 5 ft. of protective thickness. Goats were used to simulate personnel. Results showed that complete casualties could not be expected. Gases, smoke and concrete debris persisted in the pillbox for several minutes after the explosion which could limit the actions of personnel within the pillbox. The hole produced by the 35-lb. charge was suitable for exploitation by the flame thrower, a Bangalore torpedo, or an AT rocket. The 10-lb. charge perforated 2 ft. of concrete and blew off an embrasure door. Tests of the Beehives against concrete pillboxes, with goats simulating personnel, showed that a 30-lb. Beehive charge produced a hole 2 to 3 in. in diameter completely through a 5-ft. concrete wall. A Beehive larger than 35 lb. was too hard to handle for use in assault operations. The hole produced by a 30- or 45-lb. Beehive charge could also be exploited.

L927

Entwicklungskommission Munition, Berlin.
HUNGARIAN ARMOR PIERCING AMMUNITION (Panzerbrechende Munition Ungarn), by Wagner. Nov. 9, 1944, 2p. (Nr. 1125/44 g. Rs.; OTIB rept. no. 1249, Misc.-1 - In German) Unclassified

This Hungarian shell, weighing 32 kg., should penetrate a target 170 mm. thick when fired at 300 m. The weapon is inferior to the German "Panzertod" because of small penetration and large launching device. Because of the heavy weight of the shell and low initial velocity, the weapon has limited application.

L928

Evans, W. M.
HOLLOW CHARGE EFFECT. Bulletin of the Institution of Mining and Metallurgy, no. 520, Mar. 1950: 9-25; no. 522, May 1950: 23-33.

A concise account of the shaped charge phenomena is presented. On the assumption that the strength of metals can be neglected in comparison with the pressures of detonation, the theory of hydrodynamics of perfect fluids has been applied: (1) to the formation of jets from conical liners, which when acted upon by the detonation wave collapse inward, collide, and squirt out along the axis a long, thin jet traveling with a very high velocity (of the order of 8,000 m./sec.), and (2) to the remarkable properties of penetration of such jets in various metals. Many experimental techniques have borne out the essential validity of the hydrodynamic theory. The following factors affecting the performance of shaped charges are discussed: explosive composition, length of charge, confinement, initiation, liner shape and material, standoff, asymmetry, and scaling. Diagrams and calculations are included.

L929

Evans, W. M. and A. R. Ubbelohde.
FORMATION OF MUNROE JETS AND THEIR ACTION ON MASSIVE TARGETS. Research (Supplement), v. 3, July 1950: 331-336.

The following topics are discussed: (1) the concept of Munroe jets (bare hollow charges and hollow charges lined with metals); (2) the mode of action of jets on massive targets (metal targets and stopping powers of different materials); and (3) the mechanism of formation of Munroe jets (change of shape of jets in space and the effect of the shape of the cavity on the formation of jets).

L930

Evans, W. M. and A. R. Ubbelohde.
SOME KINEMATIC PROPERTIES OF MUNROE JETS. Research (Supplement), v. 3, Aug. 1950: 376-378.

For the detection of the passage of the head of the jet with time, gaps were formed by fine strips of metal about 1 mm. apart and placed at intervals of from 1 to 2 in. (2.5 to 5.0 cm.) in the direction of travel of the jet. The closures were recorded on an A (gas) lamp chronograph reading to 1 μsec. From the space/time plots, the space/velocity curves could be constructed. Target calorimetry involved setting up steel targets on strong supports with small areas of contact, so as to minimize loss of heat by conduction. A thermocouple was inserted axially upwards from the bottom of the target, to a depth determined by previous experiments, so that the disturbance of the target metal at the bottom of the crater, when this was formed by the jet, just failed to break the couple. It was important to have the couple as near to the crater as possible to secure temperature/time curves which required the minimum extrapolation. After the shot had been fired, the temperature first rose to a peak, then the temperature/time curve flattened as the heat was redistributed in the steel, and finally it fell uniformly due to heat losses from the steel to the ambient air. Rather rough methods of approximation were used to allow for these losses, but order of magnitude of the heat liberated in the target could be estimated with fair accuracy. Simple calibration methods were used to measure the depth and entry diameter of the craters formed for various distances between the charges and the target. In studying the effect of charge dimensions, it was assumed that the unit length was the diameter of the explosive filling. So far as supplies of metal tubing and metal linings permitted, all the other dimensions were increased pro rata to the diameter of the explosive charge. Theoretically it need not follow, for explosive phenomena, that all the dimensions scale linearly but so far as the penetration data over the range of diameters 1 to 1.25 to 2 in. (2.5 to 5.0 cm.) were concerned linear scaling of results was observed within experimental error. (Research abstract)

L931

Evans, W. M. and D. C. Pack.
PENETRATION BY HIGH-VELOCITY ("MUNROE") JETS: II. Proceedings of the Physical Society, v. 64B, part 4, Apr. 1, 1951: 303-310.

Work is described in which the 2 stages of penetration by a high-velocity ("Munroe") jet were separated experimentally. The large penetrations measured in Pb targets are shown to result from the flow which takes place in the metal after the jet itself has been consumed. For a given jet at a given standoff it is possible to predict the penetration into a combination of targets from the results of a very small number of standard experiments. The method depends upon the calculation of a certain quantity which is constant for a given jet at a given standoff, and examples are given of the determination of this quantity from experimental data. (Physical Society abstract)

L932

Explosive Experimental Co., Inc., Berlin-Dahlem.
EXAMINATION OF A NEW WIRE HOLLOW CHARGE TO IMPROVE HOLLOW CHARGE EFFECT. Oct. 13, 1944. (Rept. no. 149; Trans. as OTIB rept. no. 1249, 6p. diagrs.) Restricted

An investigation was made to determine where in a longitudinal section firing wires could be introduced in the cavity to keep the shaped charge effect with firing wires as little as possible under that of the conventional shaped charge. It was concluded that the shaped charge effect was improved 20-50% through the addition of properly dimensioned and spaced wires, but wires or metal pieces placed in the cavity reduced the effect if the wires were not correctly installed.

L933

Explosives Investigation Laboratory, Naval Powder Factory, Indian Head.
CUTTING OF STEEL CABLE AND ANCHOR CHAIN BY MEANS OF SHAPED CHARGES, by H. W. Kline. Mar. 2, 1944, 16p. incl. diagrs. (EIL rept. on OIM, no. 116) Confidential

A shaped charge was developed which will effectively cut, in air and under water, plow steel cable 2 in. in diameter and anchor chain 1.5 in. in diameter. The device is fitted with a handle and spring-loaded clamp for attachment by hand to the cable or chain to be cut. When filled with Comp. C1 or C2, the effective cutting charge is approximately 2 lb. of explosive.

L934

Explosives Investigation Laboratory, Naval Powder Factory, Indian Head.
USE OF MK.2 CONE ON 100-, 250- AND 500-LB. BOMBS, by G. H. Taylor. May 5, 1944, 27p. incl. illus. (EIL rept. on OIM no. 174, Part I) Confidential

Mark 2 charges were used at various standoffs (2 to 18 in.) and in various positions in order to gain access to the bomb filling. Satisfactory results were obtained with these charges. No 1 standoff or position could be given as a standard because no 2 shots gave the same results. Tests were carried out with 2 linked linear charges (0.4 in. wide with 0.021 in. thick 80° apex angle liner). Standoffs varied from 1/8 to 3/8 in. A linked charge with 9 3-in. links made a clean cut through bomb cases and explosives with no detonation. Tail and nose sections were blown about 20 ft. Similar results were obtained with 5 6-in. links.

L935

Explosives Investigation Laboratory, Naval Powder Factory, Indian Head.
THE DEVELOPMENT OF A CAVITY CHARGE SUITABLE FOR CUTTING 3-IN. DIAMETER WIRE ROPE BOTH IN AIR AND UNDER WATER, by J. F. Nachman. June 10, 1944, 7p. incl. diagrs. (EIL rept. on OIM no. 157) Confidential

Shaped charges of Comp. C-1 fitted with liners of steel angle Fe were used to cut steel wire rope of 1.5-, 2-, and 2.75-in. diameter both in air and under water. Results indicated that a charge of approximately 3 lb. of explosive formed on a steel angle Fe liner with legs would successfully cut 3-in. steel wire rope under both conditions. Specifications for charges required to cut various sizes of wire rope are tabulated.

L936

Explosives Investigation Laboratory, Naval Powder Factory, Indian Head.
USE OF MK.2 CONE AND LINEAR CHARGES ON 5 IN./38 AA, 5 IN./38 AA COMMON, 6 IN. AA COMMON, AND 8 IN. AA COMMON PROJECTILES, by G. H. Taylor. June 15, 1944, 19p. incl. tables, diagrs. (EIL rept. on OIM no. 174, Part II) Confidential

The Mark 2 charge was used at standoffs varying from 0 to 8 in. to acquire a partial detonation of the projectiles used. Tabular results are shown.

L937

Explosives Investigation Laboratory, Naval Powder Factory, Indian Head.
SECTIONING OF DEPTH BOMB, AN MARK 49 TO DETERMINE THE EXTENT OF CAVITATION AND SEGREGATION, by H. W. Kline. June 23, 1944, 9p. incl. illus. (Part II of [EIL] rept. on EIM no. 34) Confidential

Torpex-loaded depth bombs, AN Mark 49, were sectioned using linear charges of Comp. C-1. Samples from the bombs were analyzed for segregation, and impact and friction sensitivities.

L938

Explosives Investigation Laboratory, Naval Powder Factory, Indian Head.
USE OF MK.2 CAVITY CHARGE ON GERMAN AND JAPANESE GENERAL PURPOSE BOMBS AND GERMAN SEMIARMOR PIERCING BOMBS, by T. F. Darrah. July 6, 1944, 7p. incl. illus. (EIL rept. on OIM no. 182) Confidential

The Mark 2 charge was used at 4- to 8-in. standoff on the 63-kg. GP Japanese bomb, and at 6- to 14-in. standoff on the German 50-kg. semiarmor-piercing bomb to find the best positioning of the charge which would give the least violent partial detonation. In most cases for the Japanese bombs, the optimum standoff was 8 in. Photographs show that the tail of the bomb was sheared off. With the German 250-kg. bomb, most successful results were obtained at 8-in. standoff; with the German 50-kg. SAP bombs, 14-in. standoff gave the desired results in all but 1 case.

L939

Explosives Investigation Laboratory, Naval Powder Factory, Indian Head.
ENTERING THE UNIT COMPARTMENTS OF MINE CASES BY MEANS OF CAVITY CHARGES, by T. F. Darrah. July 25, 1944, 13p. incl. diagrs. ([EIL] rept. on OIM no. 78) Confidential

Cutting of Al plate by means of linear shaped charges at incident angles of 30°, 45°, and 60° was investigated. From these experiments, circular shaped charges were designed so that the jets from the charges would strike the target plate at an incident angle of 45°; and it seemed that these charges might cut a circular disc from the target plate and lift the cut portion away. On the failure of the circular forms to accomplish the desired result, experiments were conducted with linear cavity charges formed into rectangular shapes. Experimentation was discontinued in favor of a linear charge circumscribing the mine case.

L940

Explosives Investigation Laboratory, Naval Powder Factory, Indian Head.
USE OF MK.2 CAVITY CHARGE ON 20-LB. FRAGMENTATION BOMBS, by G. H. Taylor. Aug. 7, 1944, 6p. incl. illus. (EIL rept. on OIM no. 174, Part III) Confidential

Tests were made to develop a standard technique, employing Mark 2 charges, for opening the cases of 20-lb. fragmentation bombs. The Mark 2 charges opened by a low order detonation the 20-lb. bombs which contained unarmed and safe fuzes. The bombs containing armed fuzes were opened by high order detonations when shot into by the Mark 2 charge.

L941

Explosives Investigation Laboratory, Naval Powder Factory, Indian Head.
A REPORT ON THE APPLICATION OF SHAPED CHARGES, by H. W. Kline. [Apr. 1945], 50p. incl. illus. (EIL rept. on [OIM no. 2]) Confidential

The investigation was concerned with developing suitable techniques for the disposal, without detonation, of various types of HE filled ordnance under field conditions. A shaped charge was developed for the disposal of mines and bombs through such intervening media as sand, mud, and considerable air gaps. Mines and bombs filled with HE ranging in impact sensitivities from TNT to Torpex were opened with very little detonation of the filling when subjected to the shaped charge metallic jet. Mines filled with German Hexanite were cut into transverse sections by means of linear charges circumscribing the explosive-filled compartment of the mine. A shaped charge was developed that was believed to be capable of detonating a [illegible]6-in. heavy AP shell when detonated 3.[illegible] in. above the forward edge of the rotating band of the projectile. The shaped charge effect is described briefly in an appendix.

L942

Explosives Manufacturing Practices Laboratory, Explosives Factory Maribyrnong (Australia).
THE PROTECTION OF STEEL TARGETS FROM ATTACK BY SHAPED CHARGES, by W. H. Coulson. June [illegible]9, 1944, 3p. incl. diagr. (Rept. no. ME 4(a) 13; OSRD Liaison Office II-5-6468 (S)) Confidential

(See item no. L91 in which this rept. is reproduced as Part I.)

L943

Explosives Manufacturing Practices Laboratory, Explosives Factory Maribyrnong (Australia).
INTERIM REPORT ON "CHEMICAL ARMOR" METHODS OF DEFEATING SHAPED CHARGES, by W. H. Coulson. Sept. 1944, 2p. tables, diagr. (Rept. no. ME 4(a) 16; OSRD Liaison Office II-5-[illegible]430 (S)) Confidential

Tests were carried out with shaped charges 1 1/2 in. in diameter having Al liners and filled with 30/70 CE/TNT. These charges were capable of penetrating 2 in. of mild steel plate, and were readily defeated by being made to act through a layer of explosive (Baratol, RDX, Cordite, etc.) or a vigorous oxidizing medium $(BaNO_3)_2$, $KClO_3$ etc.) Results showed that Al was more easily stopped than steel. The liner shape had no marked effect; the narrow liner of the M9A1 grenade and the wider liner of the British no. 68 grenade were equally difficult to defeat. The most effective stopper was a cast mixture of Na and K nitrates.

L944

Explosives Research Laboratory, Bruceton.
FRAGMENT VELOCITY CAMERA, by D. P. MacDougall. (In NDRC Sect. B-1 Interim rept. on Controlled Fragmentation and Shaped Charges, Aug. 15-Sept. 15, 1942, 3p.; Rept. no. CF-1) Confidential

The method is described for measuring accurately the velocity of a projectile or of a single fragment whose trajectory is defined within the limits of a known solid angle.

L945

Explosives Research Laboratory, Bruceton.
OPTICAL STUDIES OF CONED CHARGES, by D. P. MacDougall. (In NDRC Sect. B-1 Interim rept. on Controlled Fragmentation and Shaped Charges, Aug. 15-Sept. 15, 1942, 3p.; Rept. no. CF-1) Confidential

The blast wave which emerges from the end of a charge was studied. The velocity of the blast wave as a function of distance from the end of the charge was measured for lined and unlined charges.

L946

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall. (In NDRC Sect. B-1 Interim rept. on Controlled Fragmentation and Shaped Charges, Sept. 15-Oct. 15, 1942, 7p.; Rept. no. CF-2) Confidential

Photographs were taken in which the slit plane of the camera was perpendicular to the axis of the charge. Shots were also fired with the slit parallel to the axis of the charge in order to study the velocity of the blast as a function of the shape and material of the liner, and of the distance from the charge. The fragment velocity camera was used in an attempt to determine the velocity of the slug of steel which is usually formed from a 45° steel liner. Preliminary experiments on penetration of steel targets through a layer of water by lined charges are reported.

L947

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall. (In NDRC Sect. B-1 Interim rept. on Controlled Fragmentation and Shaped Charges, Oct. 15-Nov. 15, 1942, 11p.; Rept. no. CF-3) Confidential

Penetration times through various thicknesses of steel plate were measured for: (1) charges of varying diameters containing porcelain, steel, and glass liners (45° and 60°); and (2) cast Pentolite and cast Cyclotol charges with M9A1 steel liners. Results are tabulated for the tests and also for brief studies on the effect of the liner (45° Pb and steel of various thicknesses) on blast velocity. Experiments to determine the velocity of the slug were made using M9A1 (1 5/8-in. diameter) and spun steel (45°, 1.5-in. diameter) liners in 6-in. Cyclotol charges fired against steel plate and through heavy pipe targets. Underwater penetration of Pb (45°-180°) and steel (45°-120°) liners was studied by determining the relationship of the weight of the liner to the distance of 50% penetration of 0.25-in. steel plate. Tests to determine the effect of all possible variables on the penetration of steel targets by small-scale charges were continued with special concentration upon the effect of standoff and shape and material of the liner (Pb and steel, 30°-120° apex angles). Results from the latter 3 series of tests are presented graphically.

L948

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, Nov. 15-Dec. 15, 1942, 11p.; Rept. no. CF-4)
Confidential

Penetration times were measured for 1 5/8-in. diameter charges of cast Pentolite, 5 in. long, containing M9A1 liners fired from a fixed distance of 6 in. through hot-rolled steel plates of different thicknesses. Blast velocities as a function of distance from the charge were measured for several 45° lined charges with liners of different weights. Shots were made with steel lined charges fired through a layer of water. Results are presented for penetration through steel targets in air.

L949

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, Dec. 15, 1942-Jan. 15, 1943, p. 2-9; Rept. no. CF-5)
Confidential

Truncated cone charges were fired from a distance of 8 in. through a 1 3/8-in. steel plate for penetration time measurement. Shaped charges with 80° spun steel liners of various wall thicknesses were fired through armor plate. Measurements were made of detonation and blast wave velocities, and of blast wave profile of charges with cylindrical cavities. Pictures are shown of the luminous blast from unlined charges at successive intervals of time. Measurements of penetration of steel targets through a layer of water were made for 1.5-in. diameter charges.

L950

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, Jan. 15-Feb. 15, 1943, p. 3-13; Rept. no. CF-6)
Confidential

Measurements were made of penetration times for shaped charges with steel liners. Tests were made with the slit removed from the camera in an attempt to follow the blast farther through the series of target plates when it tended to leave the slit plane. Without the slit, it was difficult to distinguish the instant at which the blast hits the target. A study was made of the effect of confinement of the blast wave from a flat-ended cylindrical charge. Results of underwater penetration measurements are given for cast Pentolite charges contained in lengths of cardboard mailing tube. The effects on steel plates of wedge or linear charges were investigated.

L951

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, Feb. 15-Mar. 15, 1943, p. 3-16; Rept. no. CF-7)
Confidential

Results are shown of the blast wave leaving a flat surface cut obliquely to the charge axis. A study of the effect of optical filters on the quality of the pictures obtained with the rate camera gave disappointing results, i.e., the jet as a whole remained unresolved. An attempt was made to study the structure of the jet by photographing the self-luminous parts of it. Various experiments were tried to get the outline of the jet by taking shadow pictures of it, using detonation in an A (gas) atmosphere as a light source. Blast velocity was obtained for an 80° cone charge of cast Pentolite. Underwater penetration measurements were made on 1 5/8-in. Pentolite cavity charges. Measurements of penetration of steel target plates by wedge or linear cavity charges are given. Velocity and penetration data are shown for AA shells loaded with ammonium picrate, TNT, Cyclotol, and Torpex.

L952

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, Mar. 15-Apr. 15, 1943, p. 3-12; Rept. no. CF-8)
Confidential

Penetration times for charges bearing M9A1 liners were measured through Pb, water, and Al targets. Cast Pentolite charges (2-in. diameter) with a metal disc (1 5/8 in.) embedded in the flat end surface were fired to obtain velocity of the metal fragments. Thickness and material (Cu, steel) of the liners were varied. The improvements made in the technique of flash photography are discussed. Results of underwater penetration tests (range vs. standoff) using charges with steel liners (60°, 100°) are presented graphically. Data from penetration tests against steel target plates using sand lined (45°-120°) charges are presented and discussed.

L953

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, Apr. 15-May 15, 1943, p. 3-22; Rept. no. CF-9) Confidential

Penetration times and jet velocities before and after penetration for M9A1 liners were measured against various target materials. Flash photography and penetration depth in Pb targets are discussed briefly. Results of underwater penetration tests using charges with steel liners (45°, 60°) of varying weights and thicknesses are given. Data obtained from steel target penetration tests using steel lined (45-120°) charges are presented graphically. The relationship of initial hole diameter to final hole diameter for M9A1 liners fired through previously drilled holes in 1-in. steel targets was investigated. Penetration depth and hole volume of sand lined (45°-120°) charges were measured in relation to liner thickness, standoff, charge length and liner weight.

L954

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, May 15-June 15, 1943, p. 3-25; Rept. no. CF-10) Confidential

Penetration times and jet velocities before and after penetration for M9A1 liners and 120° apex angle liners were measured against various target materials. Results of underwater penetration tests using steel liners (45°) are given. A comparison of Torpex, Pentolite, and Comp. B for underwater performance was made. Data for the penetration of steel targets by steel (45°, 120°) and Cu (45°) liners, and the relationship of penetration depth to liner (45°, 120° steel) weight and charge diameter (45°, 120° steel liners) are presented graphically. The effect of varying charge length, the penetration of steel through water, the effect of confinement (explosive belt), the relationship of target temperature to penetration, and the effect of liner weight on jet diameter were all studied briefly.

L955

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and others. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, June 15-July 15, 1943, p. 3-19; Rept. no. CF-11) Confidential

The results of: (1) jet velocity tests of charges having glass and steel liners (30°-60° and 100°-180° apex angles) of varying diameters; and (2) target (water, Al, steel, Cu, Wood's metal) penetration studies (time, depth, and velocities) using charges containing M9A1 liners and 45° and 120° steel liners of various weights are tabulated and discussed. The relationship of penetration time and final velocity to target thickness are graphed. The charges were cast Pentolite having M9A1 liners fired against both Cu and Al targets. The doubt concerning the interpretation of the opaque zone which appears in flash photographs of the jet is commented upon. Underwater penetration was studied with respect to: (a) effect of charge length on the range of charges having 45° spun steel liners; and (b) the range for charges bearing 30° spun steel and 60° drawn steel liners and 80° composite liners (steel particles bonded with resin). The relationship of liner weight to apex angle is shown graphically for these underwater tests. Small-scale charges bearing 30° spun steel and 60° drawn steel liners were fired against steel targets in air. The variables were charge weight and standoff. A table is included which summarizes the performance of the best liners (30°-120° apex angles) tested to date. The alignment of the liner with the charge axis is discussed. The performance of 80° composite liners (steel fragments, resin binder), the possibility of using steel-backed concrete or Al as target materials, and the development of a charge for making a linear cut in Al were also investigated.

L956

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and others. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, July 15-Aug. 15, 1943, p. 3-29; Rept. no. CF-12) Confidential

Penetration times and jet velocities before and after target penetration for M9A1 liners fired against various target materials were measured by the multiple slit method. The opaque zone of the jet was studied by flash photography. The following phases of underwater penetration were studied: (1) range of 80° steel liners of varying weights; (2) effect of charge diameter on range of M9A1 steel liners; (3) penetration through water into heavy steel targets; and (4) effectiveness of steel dome liners. Penetration studies were also made of the following: (a) small-scale charges bearing 80° (varying weights) and hemispherical liners (steel); (b) relationship of liner hardness to behavior of liner (45° apex angle); (c) effect of rotation; (d) M9A1 liners with apex filled (solder); (e) cored charges; and (f) modified confinement. Charges filled with explosives of varying degrees of power were fired for the purposes of studying the mechanism of liner collapse and observing recovered liner fragments. An investigation was begun into the possibility of increasing the effectiveness of boosters by making use of the cavity effect or inserting flat discs in the base.

L957

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and others. (In NDRC Div. 8 Interim rept. on Shaped Charges, Aug. 15-Sept. 15, 1943, p. 3-20; Rept. no. SC-1) Confidential

Preliminary optical studies of the detonation wave from a composite cylindrical charge (cast Pentolite with TNT or Amatol core) are discussed. Results of underwater performance tests using small scale charges are reviewed with respect to liner material, confinement (steel, cardboard), use of composite charges (TNT or wood cores) and penetration of 2-in. diameter charges into heavy steel. Penetration depths from steel and Pb liners, and the effect of charge diameter on penetration depth, were measured. Effect of rotation on penetration depth and hole contour of charges bearing trumpet and 45° and 100° liners was studied. TNT core and confinement effects were tested using M9A1 steel and Cu liners. M9A1 lined charges were fired into ice blocks and liner fragments recovered for study of jet distribution.

L958

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and others. (In NDRC Div. 8 Interim rept. on Shaped Charges, Sept. 15-Oct. 15, 1943, p. 3-22; Rept. no. SC-2) Confidential

Jet velocities of small scale charges bearing steel liners (45°-120°) were measured within a range of 11 in. to 17 in. from base of charge (rotating drum camera). Further work was done on shaping of the detonation wave from a composite charge consisting of a Pentolite shell and a core of TNT, Amatol or nitroguanidine. Underwater performance of standard small scale charges having non-Fe liners (45° spun Al, 45° Zn alloy and 80°, 120° Pb) was tested against 0.5-in. target plate. Variables were liner weight and standoff. Scaling experiments were started using small-scale charges with steel liners (1-in., 1 5/8-in. and 2-in. diameter). Test results are given for firings against steel target plate; targets were scaled in thickness proportionally to the charge and liner diameter. Information received from studies of the following is included: (1) penetration of Al and Zn alloy liners (45°), (2) slug penetration (M9A1 liner), (3) effect of explosive belt on penetration of charge (M9A1 liner); (4) effect of various speeds of rotation of M66 liners (45° steel) on penetration; (5) effect of large standoff (steel liners; 45°-80°) on penetration; (6) comparison of penetration of M9A1 liners into steel and Al targets; and (7) effect of composite (cored) charges on penetration of M66 liners (42°).

L959

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and others. (In NDRC Div. 8 Interim rept. on Shaped Charges, Oct. 15-Nov. 15, 1943, p. 3-33; Rept. no. SC-3) Confidential

Jet velocity and penetration time measurements are tabulated for investigations of the following: standard small-scale charges with steel liners (30°-120° apex angles); comparison of cast TNT and cast Pentolite charges (M9A1 liners); effect of liner diameter and charge diameter; non-Fe liners (45° Cu and Al and 60° glass); composite (sugar cored) charges; and hard steel (Ketos) and Al targets. Photographs (rotating drum camera) of composite charges with inert cores (sugar or air) and low-density cores (ammonium nitrate, nitroguanidine and TNT) are evaluated. A flash photograph taken in a vacuum of an M9A1 jet penetrating a steel target is discussed. Underwater penetration of 120° Pb liners (confined) and Al liners (30°-80° apex angles, varying standoff) was measured. Scaling experiments for 1-in. diameter charges (45° steel liners) against scaled targets were completed. Small scale tests against a "double hull" (2 thicknesses of steel separated by a varying depth of water) were made with 45° steel liners. Slug penetration of 45° Al liners at varying standoff and target thickness was measured. Penetration results are given for M9A1 lined charges fired into spaced steel targets and comparison is made with depth of penetration into a solid (laminated) target. Preliminary data are reported on the effect of a flash tube extending from a truncated liner apex through the main charge. Fragment analyses of 2 charges (M9A1 liners without flanges) fired into ice blocks are made. Results of firings of 15-in./38 cal. Mk. 35-6 AA shells using small shaped charges as boosters are discussed.

L960

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and others. (In NDRC Div. 8 Interim rept. on Shaped Charges, Part A, Nov. 15-Dec. 15, 1943, p. 3-26; Rept. no. SC-4) Confidential

The measurement of jet velocity and penetration time as functions of standoff for 45° Al liners was made against steel and water targets. Underwater performance of steel (20°) and Al (20°, 30°, 80°) liners, lightly and heavily confined charges with Pb liners, and steel confined charges with M9A1 steel liners is discussed. The effect of standoff on penetration of steel targets by standard small-scale unconfined charges bearing steel (20°), Al (45°, 80°) and heavy Pb liners (120°) and liners with uniformly tapering walls was studied. Tests were made to determine the effect of liner diameter base flange and confinement of small-scale (45°, 80°) steel liners on penetration depth. Scaling of 45° steel liners and the effect of target spacing (steel plates) on penetration were investigated briefly. A regulation M66 75-mm. hollow charge shell was fired, rotating at various speeds (1-in. standoff) and results evaluated. Depth of penetration was measured for composite (TNT core) charges and for charges having a central tube extending from a truncated liner apex. A linear charge initiated from 1 end was fired. Heavy-walled 45° steel liners were segmented horizontally and fired to determine loss in mass of various sections (liner fragment recovery). Al 80° liners were used to determine the relationship between jet momentum and standoff.

L961

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and others. (In NDRC Div. 8 Interim rept. on Shaped Charges, Dec. 15, 1943-Jan. 15, 1944, p. 3-18; Rept. no. SC-5) Confidential

Blast velocity and penetration time were measured for charges bearing 60°-120° steel and 45° Al liners using a water target. Underwater performance of heavy 120° Pb liners at a standoff of 2 charge diameters, and M9A1 lined charges (2-in. diameter) with and without base flange is discussed. Comparative penetration results are given for standard small scale M9A1 lined charges, confined and unconfined, fired against a homogeneous armor plate target at 2-in. standoff. The adverse effect of the M9A1 base flange in a heavily confined charge with a small explosive belt was confirmed. The effect of confinement was also observed in 45° Al lined charges. M9A1 steel liners (2-in. standoff) and Al liners (45°, 2-in. and 6-in. standoff) were compared for effect against spaced mild steel targets and tentative conclusions are drawn. The effect of rotation on charges bearing conical (20°) and hemispherical steel liners was studied briefly. Penetration depth and width of cut from 80° Al lined linear charges fired against mild steel target plates were measured at varying standoffs (0-6 in.). The effect of confinement on charges initiated (nose) by detonator or Primacord through a central tube in the main charge was studied. The depth of penetration of a composite liner (45° Al liner inside a 45° steel liner) into a mild steel target was measured at 2-in. and 12-in. standoff.

L962

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and others. (In NDRC Div. 8 Interim rept. on Shaped Charges, Jan. 15-Feb. 15, 1944, p. 3-13; Rept. no. SC-6) Confidential

Jet velocities of 4 1 5/8-in. diameter cast. Pentolite charges containing 60° steel liners of varying weights were measured. Four cast Pentolite charges containing spun Al liners were fired through steel and water targets at varying standoffs to determine penetration times and jet velocities before, after, and during penetration. Comparative depths of penetration, hole diameters, and hole volume in homogeneous armor plate and mild steel targets of various thicknesses resulting from firings of small-scale charges are compiled. The effect of confinement on charges containing a central tube allowing nose initiation was compared to the effect of confinement on charges having no central tube and using standard initiation (rear). Types of liners used were M9A1 (steel) and M6 (brass).

L963

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and others. (In NDRC Div. 8 Interim rept. on Shaped Charges, Feb. 15-Mar. 15, 1944, p. 3-27; Rept. no. SC-7) Confidential

Partially completed results of jet velocity measurements (rotating drum camera) of 3/8-in. diameter charges cased (1/32-in. steel tubing) and uncased bearing 80° Cu or Al liners were used in an effort to determine the time interval between detonation of a small shaped charge and a Tetryl pellet at which the charge was aimed. Underwater performance of charges with drawn (45°, 80°) and pressed (120°) Al liners, and drawn Cu liners (45°) is recorded and a study made on the use of small-scale linear charges for cutting obstacles through an intervening layer of water. The target was 1-in. mild steel plates; liners were steel or Al (80°, 120°). Further penetration tests were carried out with drawn (45°, 80°) and spun (120°) Al liners in small-scale confined and unconfined charges. The study of steel confinement on charges bearing 45° steel liners was continued. The effect of nose initiation (Primacord, shaped charge, and axial rod) on charges, confined and unconfined, having M9A1 and M6 liners was studied. The relationship of standoff to penetration for small-scale linear charges (120° steel liners) and the possible use of linear charges for cutting heavy metal bars were also investigated.

L964

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and others. (In NDRC Div. 8 Interim rept. on Shaped Charges, Mar. 15-Apr. 15, 1944, p. 3-18; Rept. no. SC-8) Confidential

Maximum, minimum, and average jet velocities for 92 charges (3/8-in. diameter) with Cu or Al liners (60 and 80°) are reported. One charge (80° Al liner) was fired while rotating. The purpose of these tests was to determine the time interval between detonation of a shaped charge and detonation of a Tetryl pellet at which the charge was aimed. Underwater penetration studies of charges containing 45° Al liners (1-in. and 2-in. diameter) were made to determine if standoff scales linearly with liner diameter. Application of scaling laws with respect to target thickness was investigated using small-scale charges (45°-120° steel liners) fired against a steel plate target. Several shots to determine the effect of rotation on penetration of hemispherical and 45° steel liners were fired. Several results with 3/8-in. diameter miniature rotating charges (80° Al liners) are described. Further work was done on the initiation of shaped charges by means of a miniature 3/8-in. diameter shaped charge fuze.

L965

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and others. (In NDRC Div. 8 Interim rept. on Shaped Charges, Apr. 15-May 15, 1944, p. 3-16; Rept. no. SC-9) Confidential

Jet velocity data from 3/8-in. base diameter 60° and 80° apex angle charges are given. Results obtained from tests to check on the relative effectiveness of small angle (45°) and wide angle (80°) steel liners against thin steel plates through water are presented. Measurements were made using a 1 5/8-in. diameter 45° steel liner having no base flange to determine the behavior of the liner in large water depths. Test results are shown for charges having steel hemispherical liners fired at 240 r.p.m. at 4- and 6-in. standoff. Results are given from cutting tube charges, made by sectioning M9A1 liners and piecing them together again with the apex segment inverted.

L966

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and others. (In NDRC Div. 8 Interim rept. on Shaped Charges, May 15-June 15, 1944, p. 3-16; Rept. no. SC-10) Confidential

Three charges (0.5-, 0.75-, 1.0-in. charge length) with 0.375- to 0.012-in. wall thickness were fired at 4-in. standoff to study the effect of charge length on jet velocities, and the initiation of Tetryl pellets by such lined charges. T20 HEAT rounds with steel liners for the 57-mm. recoilless gun were fired to test the effect of rotation on performance. Tests are reported with 45° liners with tapered wall thickness. Static tests of 3.25- and 4.5-in. caliber charges against homogeneous armor plate were made using 80° steel liners. A fuze train was developed to initiate the HE follow-through projectile with controlled delay to permit the projectile to pass through the hole in the target before detonating.

L967

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and others. (In NDRC Div. 8 Interim rept. on Shaped Charges, June 15-July 15, 1944, p. 3-23; Rept. no. SC-11) Confidential

The jet velocities of charges with 80° liners were obtained. Modified hemispherical liners were tested in an attempt to find some shape that would be affected little by rotation, and be more effective at shorter standoffs. Cu liners, 2.25-in. base diameter spun from 16 gage sheet metal were tested to try to improve the performance of the point-initiated 2.34-in. shaped charge projectile. Cast TNT and wood cored charges were tested on 2.25-in. base diameter liners having 7/16-in. outside diameter steel tubes attached. The incendiary action of the jet after it had penetrated through a steel target using gasoline and cordite as materials was investigated. Tests were made on 4 3/8 in. diameter 45° steel liners having uniform walls and walls with tapering thickness.

L968

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and M. A. Paul. (In NDRC Div. 8 Interim rept. on Shaped Charges, July 15-Aug. 15, 1944, p. 3-39; Rept. no. SC-12) Confidential

A series of charges was fired at 2 ft. to determine the effect of water depth on scaling laws. Results of tests on 2 3/8-in. diameter brass hemispherical liners without axial tubes are shown. Test results are given for annealed Cu liners fired at 2- and 6-in. standoff in standard small-scale charges against laminated mild steel targets. Penetration tests with Cd and amalgam liners were made. The dispersion of lethal fragments behind the target was studied for several types of small-scale cavity charges.

L969

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and M. A. Paul. (In NDRC Div. 8 Interim rept. on Shaped Charges, Aug. 15-Sept. 15, 1944, p. 3-20; Rept. no. SC-13) Confidential

Results are tabulated for penetration tests using offset M6 steel liners (2 sector and 4 sector, soldered) fired against steel targets in an attempt to introduce compensation for the adverse effect of rotation. A mathematical theory to account for the influence of the direction of rotation on offset liners is presented. Penetration results for 1 45° Cd liner fired rotating at 230 r.p.s. are included. Modifications of the M52B1 point-detonating mortar fuze to provide safety features for point initiation for non-rotating shaped charge projectiles are described. Penetration data and high speed photographs of the jets from firings of several 2.34-in. mortar-propelled projectiles containing modified M52B1 point-detonating fuzes are given. Investigations to determine the best type of liner for producing the largest possible hole through thin armor plate were continued with tests using a cutting-tube type of charge and 2-in. and 2.25-in. diameter conical lined (45° and 80°) charges for comparison. Test results are evaluated.

L970

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and M. A. Paul. (In NDRC Div. 8 Interim rept. on Shaped Charges, Sept. 15-Oct. 15, 1944, p. 3-10; Rept. no. SC-14) Confidential

M6 steel liners having grooves milled in the outer surfaces were tested to determine the effect of rotation on penetration. Three M66 75-mm. HEAT shells bearing steel hemispherical liners were fired while rotating and results are tabulated. Two 2.34-in. mortar-propelled shaped charge projectiles (45° steel liners) were fired, initiated by means of M52B1 base-detonating fuzes (modified) and high speed photographs of the penetration included. Further investigation with the cutting tube type of charge for defeating thin armor plate was carried out and results evaluated. Modifications of delays for a fuze train for the follow-through projectile are described.

L971

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and M. A. Paul. (In NDRC Div. 8 Interim rept. on Shaped Charges, Oct. 15-Nov. 15, 1944, p. 3-16; Rept. no. SC-15)
Confidential

A number of spinning charges (confined) bearing hemispherical liners of steel and Cu were fired at varying standoffs and speeds to determine the effect of rotation on penetration. Illustration and description of the spinning device are included. A study was made of hole size from penetration of 1 5/6-in. diameter charges (spinning) with steel (45°, 80°) and Al (80°) liners against 2-in. homogeneous armor to determine possibility of stabilizing follow-through projectiles by spin. Further attempts were made to develop a fuze with safety arming features for the forward component of the follow-through projectile by observing results from firings of several shells containing the modified point-detonating fuze (M52B1). In order to establish the feasibility of point-initiation in large shaped charge bombs by means of a shaped charge fuze, 1-in. diameter small-scale conical lined charges were tested for accuracy of alignment and ability to initiate a pressed Tetryl booster some distance away.

L972

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and M. A. Paul. (In NDRC Div. 8 Interim rept. on Shaped Charges, Nov. 15-Dec. 15, 1944, p. 3-18; Rept. no. SC-16)
Confidential

A spinning Cu hemisphere was fired at 6-in. standoff and 260 r.p.s. Results are tabulated. Rotating shots of T20E2 57-mm. HEAT rounds, bearing 1.88-in. Cu hemispheres with axial flash tubes, were fired and the results evaluated in relation to stabilization of their performance. Further unsuccessful attempts to apply the M5B1 fuze to the forward component of the Gulf follow-through projectile are discussed. Tests with the proposed T59 2.36-in. rocket head led to the discovery that the performance was improved by using a heavier walled liner (M6 steel) with wider flash tube (3/8 in.) attached. Penetration test results for these rocket heads with and without the above modifications are tabulated. Ten 1-in. diameter charges bearing 80° Al liners were fired down 2-in. inside diameter flash tubes at Tetryl pellets 48 in. away to determine possible application to point initiation of 1,000-lb. shaped charge bombs. A diagram indicating how the AN-M103 nose fuze may be modified as a shaped charge fuze is given. High speed photographs showing the impact of M6A3 rockets against steel targets protected by spikes are included.

L973

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and M. A. Paul. (In NDRC Div. 8 Interim rept. on Shaped Charges, Dec. 15, 1944-Jan. 15, 1945, p. 3-27; Rept. no. SC-17)
Confidential

The effect of confinement on the performance of 45° steel liners (1 5/8-in. diameter) was studied. A plastic firing pin in the M52B1 PD fuze, modified for spitback shaped charge initiation, was tested in dynamic rounds of 2.34-in. caliber. The relative effectiveness of 70/30 Cyclotol, PTX-2, Comp. B and Pentolite in small cavity charges was investigated. The separation of explosive from liner was studied to determine the effect of such a gap on the performance of small cavity charges. Small charges bearing 1 5/8-in. diameter 45° and 60° steel liners were fired against targets representing scaled-down ship deck systems in connection with the development of the AN M65 GP 1000-lb. bomb.

L974

Explosives Research Laboratory, Bruceton.
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and M. A. Paul. (In NDRC Div. 8 Interim rept. on Shaped Charges, Jan. 15-Feb. 15, 1945, p. 3-9; Rept. no. SC-18)
Confidential

Scaled-down shaped charge bombs were fired against targets representing ship deck systems. The charges fired had casings corresponding closely in shape to that of the 1000-lb. GP AN M65 bomb.

L975

[Explosives Research Laboratory, Bruceton].
RATE OF DETONATION CAMERA, USED FOR STUDY OF SHAPED CHARGES, by F. J. Martin and others. Jan. 4, 1943, 5p. incl. illus. tables. (Research rept. no. 38-A) Confidential

Data are presented from 3 charge types (solid cylindrical rod, cylindrical rod having a cylindrical cavity bored into 1 end, and a cylindrical rod having a cylindrical cavity in the middle section of the charge). Detonation velocity and blast velocity were measured, and profiles of the blast from some of the charges are graphed.

L976

[Explosives Research Laboratory, Bruceton].
RATE OF DETONATION CAMERA, USED TO DETERMINE BLAST OUTLINES FOR CONE CHARGES, by F. J. Martin and others. Jan. 4, 1943, 14p. incl. illus. diagrs. (Research rept. no. 39A) Confidential

The theory used and the experimental work done to obtain the outline of a luminous blast from unlined charges at successive intervals of time are given. Profile curves are shown for 45°, 80°, and 120° liners.

L977

Explosives Research Laboratory, Bruceton.
BEHAVIOR OF THE JET FROM A CAVITY CHARGE, by D. P. MacDougall and others. June 21, 1943, 26p. (Rept. prepared for the Technical Meeting of the Joint Committee on Shaped Charges to be held in Washington, D. C., June 30, 1943) Confidential

A fundamental study of the jet after it emerges from the cavity was conducted. Jet velocity and penetration velocity were measured against various target materials by means of the rotating drum camera. Luminous profiles of the jet (rotating drum camera photographs) were studied to determine its effective diameter. Tests were carried out to determine the kinetic energy of the jet. A discussion of flash photography and some flash photographs of jets from various types of liners are included.

L978

Explosives Research Laboratory, Bruceton.
INDEX TO NDRC INTERIM REPORTS AND PROGRESS REPORTS ON SHAPED CHARGES (SERVICE DIRECTIVE AN-1), by M. A. Paul. (In NDRC Div. 8 Interim rept. on Shaped Charges, July 15-Aug. 15, 1944, p. 59-87; Rept. no. SC-12) Confidential

An index to NDRC interim and progress repts. on shaped charges is included in this rept.

L979

Explosives Research Laboratory, Bruceton (OEMsr-202).
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and M. A. Paul. (In NDRC Div. 8 Interim rept. on Shaped Charges, Feb. 15-Mar. 15, 1945, p. 3-30; Rept. no. SC-19) Confidential

Cu and Al liners (1 5/8-in. diameter) fitted in the noses of bomb casings were fired against targets representing battleships with and without superstructure. Tests to study the effect of off-center initiation were made with the T2003 electromagnetic nose fuze. Modified T2003 nose fuzes consisting of plastic M52B1 fuze bodies were tested. The effect of separation of the liner and charge was studied on 1 5/8-in. diameter charges fired through 12 in. of water backed by steel. Tests were made with Al and steel liners vs. steel targets protected by 1-in. layers of 50/50 Amatol and NH_4NO_3 in an attempt to discover whether the destructive action of explosives on jets was peculiar to Al and whether Al or steel jets could be destroyed by a simple oxidation without explosion.

L980

Explosives Research Laboratory, Bruceton. (OEMsr-202).
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and M. A. Paul. (In NDRC Div. 8 interim rept. on Shaped Charges, Mar. 15-Apr. 15, 1945, p. 3-27; Rept. no. SC-20) Confidential

Offset trumpet liners were tested in an attempt to counteract rotation. Three full-scale shaped charge bombs were fired against a target representing a battleship without superstructure. The instantaneous functioning time of the AN M103 bomb nose fuze and the functioning times of the M400 and M400E1 base fuzes were estimated by high speed photography. Tests were made on a new lot of fluid 70/30 Cyclotol to obtain good castings for small cavity charges. Preliminary data are presented for liner eccentricity tests.

L981

Explosives Research Laboratory, Bruceton (OEMsr-202).
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and M. A. Paul. (In NDRC Div. 8 Interim rept. on Shaped Charges, Apr. 15-May 15, 1945, p. 3-25; Rept. no. SC-21) Confidential

Since difficulty was encountered when applying spitback initiation to the Gulf follow-through projectile, the effect of an axial tube on the penetration was reinvestigated. Tests were conducted on the T59 2.36-in. HEAT rocket. Poor performance by M6A3 rockets equipped with M400 and M400E1 base fuzes was investigated. Comparative tests on Simmons and Budd Cu M8 liners were made. Several 1:10 scale bombs were fired to determine whether or not an extra quantity of explosive beyond the diameter of the liner had any significant effect on the performance.

L982

Explosives Research Laboratory, Bruceton (OEMsr-202).
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and M. A. Paul. (In NDRC Div. 8 Interim rept. on Shaped Charges, May 15-June 15, 1945, p. 3-27; Rept. no. SC-22) Confidential

The results of a shaped charge bomb against a target representing a large aircraft carrier are shown. The effect of symmetrical liner distortions on shaped charge performance was investigated. Alignment tests on 3/8-in. diameter shaped charge auxiliary detonator units were conducted. Data on the effect of an axial flash tube on the performance of a small cavity charge are presented. A projectile, propelled by the T59 rocket motor was designed to defeat 12-in. armor. Tests on the T59 rocket head containing the electromagnetic point-initiating fuze T2003 are reported.

L983

Explosives Research Laboratory, Bruceton (OEMsr-202).
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and M. A. Paul. (In NDRC Div. 8 Interim rept. on Shaped Charges, June 15-July 15, 1945, p. 3-20; Rept. no. SC-23) Confidential

Offset trumpet liners, modified to counter the effect of spin, were fired at rotational speeds in the positive direction ranging from 0 to 290 r.p.s. The effect of standoff on the penetration of steel-cased charges bearing M6 steel and M8 Cu 45° liners of 0.062-in. wall thickness was determined. Tests on rocket heads with T2000 fuzes are reported. Scale tests of the shaped charge bomb were continued with a 60° steel liner of 2-in. base diameter and 0.041-in. wall thickness.

L984

Explosives Research Laboratory, Bruceton (OEMsr-202).
STUDIES OF SHAPED CHARGES, by D. P. MacDougall and M. A. Paul. (In NDRC Div. 8 Interim rept. on Shaped Charges, July 15-Aug. 15, 1945, p. 3-6; Rept. no. SC-24) Confidential

Disappointing results in connection with the T2000 fuze were investigated. A steel pin 1 3/16 in. long was set vertically on a steel target and a charge 2 1/16 in. in diameter bearing a steel liner with axial flash tube was fired at 4-in. standoff from the target, the pin being aligned on the charge axis.

Explosives Research Laboratory, Bruceton see also Carnegie Institute of Technology OEMsr-202

L985

Fabrik Krümmel Der Dynamit-Aktien-Gesellschaft, vormals Alfred Nobel & Co.
REPORT ON THE MEETING AT OFFICES OF WEAPONS PROOF AND DEVELOPMENT ON DEC. 14, 1942 ON HOLLOW CHARGES (Referat auf der Sitzung bei Wa Prüf am 14.12.1942 über Hohlladungen) [sic], by [Meyer]. Jan. 19, 1943, [17]p. incl. tables, diagrs. (OTIB rept. no. 1249, Misc.-6 - In German) Unclassified

A rept. is made on experiments comparing firing and blasting with 2 types of armor piercing shells (with and without nozzle) and with various explosive mixtures including: ((a) 50% TNT and 50% Cyclonite; (b) 70% TNT and 30% Cyclonite; (c) 40% TNT, 30% Cyclonite, and 30% ammonium nitrate). Best firing results were obtained with explosive c and best blasting results with explosive b. Nozzles often improve the effect. Contrary to expectation, impact fuzes worked satisfactorily. Spin has a reducing effect on the penetration. It may, however, be partly compensated for by drilling a suitable hole into the shell nose. The partial vacuum which results in the air space improves the performance. (APG abstract)

L986

Fagerberg, G. and C. H. Johansson.
BLASTING EFFECT OF EXTERNAL CHARGES UPON BLOCKS AND BOULDERS (Sprängverkan av utanpå liggande laddningar på block och skut. Jernkontorets Annaler, v. 133(6), 1949: 199-232).

The term "directed blasting" is discussed with special emphasis on the effect of concentration obtained with a charge having a conical cavity (Munroe effect). In Swedish, shaped charges are called "blasterladdningar" (blowing charges); solid charges are termed "massivladdningar"; and if the shaped charges are lined, they are known as projektilladdningar" (projectile charges). The theory of the projectile charge and results of its use for blasting drill holes and boulders are discussed. It is concluded that they are not satisfactory for civilian use because of excessive costs. Experiments with solid and blowing charges, referred to collectively as "slagladdningar" (shock charges) proved to be more satisfactory, especially when clay is packed around the charge so that it adheres to the target. The following factors affecting the use of shock charges were investigated: cost, confinement, and required amount of explosive. Numerous illustrations, calculations, and diagrams are included.

L987

[Far East Command].
HIGH EXPLOSIVE ANTITANK (HEAT) AMMUNITION FOR THE SOVIET M1927 76-MM. HOWITZER, by [Ordnance Intelligence Team in Korea]. [1950], 2p. incl. diagrs. (Ordnance Technical Intelligence rept. no. 21; Rept. no. TB-971-50) Secret

Three HEAT rounds for the M1927 76-mm. Soviet Howitzer were examined. The unfuzed projectile had a 0.5-in. threaded cavity in the nose, protected by a black plastic threaded plug. No explosive was visible due to the cavity in front of the shaped charge. Dimensions are given for the carrying and cartridge cases.

L988

[Far East Command].
RPG-43 HEAT HAND GRENADE, by [Ordnance Intelligence Team in Korea]. [1950], 1p. diagr. (Ordnance Technical Intelligence rept. no. 11; Rept. no. TB-797-50) Secret

Eleven hand grenades, which appeared to be similar to the "RPG-43 HEAT hand grenade", were captured north of Hamchang. The grenade contained the explosive (presumably a shaped charge), and the firing pin. No performance data are given.

L989

Federal Telephone and Radio Corporation (OEMsr-1215). A SUMMARIZING REPORT ON PROJECT CASEY JONES, by W. H. Crew and S. P. Shackleton. Sept. 1, 1945, 1v. incl. illus. (Appendix to final rept. on Contract OEMsr-1349; Final rept. on Contract OEMsr-1215) (In cooperation with Riggs and Jeffries, Inc., Contract OEMsr-1349) (See item no. L1509.) Confidential

L990

Ferguson, R. H. SAFETY PRECAUTIONS IN JET TAPPING. Journal of Metals, v. 3, May 1951: 377-378.

The jet tapper accomplishes the opening of a tap hole without any individual being near the runner and reduces the skulling in the stopper well. It was pointed out that a case of 24 jet tappers was completely burned in a bonfire of kerosene-soaked wood without any sign of a violent reaction. In another test, 6 tappers were laid side by side between steel plates, and a 150-lb. weight was dropped 9 ft. onto the upper plate. Although the charges were completely crushed, there was no evidence of detonation. Precautions are discussed for the cases where the tapper cannot be fired by the operator, and where the heat breaks out and the gush of molten steel washes the assembly down the runner into the ladle.

L991

Fighting Vehicles Design Department (Gt. Brit.). WIRE SKIRTING SCREEN DEFENSE AGAINST HOLLOW CHARGE ATTACK, by C. G. Phillips. Feb. 22, 1946, 13p. incl. illus. (Armor Branch rept. no. AT 271, Part I; Inclosure 1 to MA London rept. no. R1017-46) Secret

The protection afforded by wire skirting screens against attack by Panzerfaust 100 was investigated in firing trials held at Shoeburyness on Jan. 9, 1943. An unsprung wire screen of 10-gauge wire, 1-in. square mesh, was spaced 30 in. ahead of a 4-in. thick homogeneous armor plate. This target was attacked at normal and at 30° from a range of 20 yd. The use of the spaced screen gave increased protection, but not sufficient to give complete immunity to the target. Two appendixes contain tabulated detailed firing results and a photographic record of the tests.

L992

Fighting Vehicles Design Department (Gt. Brit.). PROTECTION ON CHURCHILL TANKS AGAINST PANZERFAUST, by R. C. Ballam. Feb. 23, 1946, 14p. incl. illus. (Armor Branch rept. no. AT 271, Part II; Inclosure 1 to MA London rept. no. R1929-46) Secret

The investigation was made to determine the degree of protection against Panzerfaust afforded by expanded metal screens devised by the Fighting Vehicles Design Department. Panzerfaust 60 and 100 were directed against the target from a fixed mounting at a 9-yd. range. Both types were used at normal angles, and Panzerfaust 60 was used at angles varying from 30° to 60° obliquity from a range of 10 yd. Tests showed that the layout of screens provided limited protection against Panzerfaust 60. Perforation of the side armor occurred under attack at angles up to 60° obliquity. The extent of damage decreased as the attack angles increased. It was concluded that this type of screen did not afford effective protection.

L993

Fighting Vehicles Design Department (Gt. Brit.). DEFENSE OF A[RMORED] F[IGHTING] V[EHICLES] AGAINST ATTACK BY HOLLOW CHARGE WEAPONS, by A. R. F. Martin. Dec. 1948, 31p. incl. illus. tables, diagrs. (Permanent Records of Research and Development, MOS Monograph no. 5.035) Restricted

A summary is presented of the defense of AFV's against attack by shaped charge weapons. A certain degree of protection was obtained by making the charge detonate away from the main armor plate by means of a thin skirting plate. Plastic armor, consisting of stone or gravel in a bituminous matrix, had better resistance to shaped charge attack than an equal weight of steel. Trials were made also with oxidizing agents and explosives, spikes attached to armor, and resilient screens. The most promising means of defense was with the thin skirting plate mounted as far from the main armor as possible.

Fighting Vehicles Design Department (Gt. Brit.). see also Department of Tank Design (Gt. Brit.)

L994

Fighting Vehicles Design Establishment (Gt. Brit.). THE EFFECT OF ENERGA GRENADES AGAINST LIVE AMMUNITION, PETROL, AND DIESEL FUEL, by A. Harvey and A. E. Masters. Jan. 11, 1951, [13]p. incl. illus. tables. (Rept. no. AT 320/1) Secret

Tests were made to determine whether the propellant in live ammunition or petrol and diesel fuels could be ignited when the armor plate behind which they were stowed was defeated with Energa grenades, and to determine the extent of fragmentation of the Energa grenades. Mock-up targets were arranged so that Energa grenades were aimed at petrol tanks, diesel oil tanks and 6 pr. live rounds of ammunition through 100-mm. armor at normal obliquity from a range of 10 m. Results showed that after penetrating armor 100 mm. thick at normal obliquity, the jets from the Energa grenades caused propellant fires in 6 pr. ammunition in 2 attacks, and a burst cartridge case in a third attack. Attacks with this weapon also ignited tanks containing petrol but did not ignite diesel oil under the same conditions of attack. The most lethal fragment thrown back from the target consisted of a light alloy disc 0.8 in. in diameter x 0.4 in. thick.

L995

Fighting Vehicles Proving Establishment (Gt. Brit.) [with Fighting Vehicles Design Establishment cover sheet].
EFFECT OF BEEHIVE MINES, by J. Baker. Aug. 8, 1949, [7]p. incl. illus. (Rept. no. AT 309) Secret

Tests were made to determine the effect of 30-lb. Beehive demolition charges detonated below the track and hull of a heavy AFV, armored fighting vehicle, with the charges buried at various depths down to 5 ft. below ground level. Results showed that to allow the hollow charge jet to develop, it was essential that sufficient air space be provided above the mine, measured from the apex of the liner. At a depth of 32 in., measured from the base of the liner, and with an earth cover of 20 in., the jet, if properly developed, could hole the floor plate of the AFV target and cause extensive damage to the stowage and fittings; perforation of live ammunition would cause a cordite fire. A mine laid at a depth of 32 in. below the center of a track failed to sever it, the jet breaking the inner spuds of 3 track links. It was pointed out that possibly the mine was not absolutely level, thus projecting the jet at an angle away from the center of the track.

L996

Fighting Vehicles Proving Establishment (Gt. Brit.) [with Fighting Vehicles Design Establishment cover sheet].
EFFECT OF BEEHIVE MINES, by A. Harvey and A. E. Masters. Aug. 22, 1950, [8]p. incl. illus. tables. (Rept. no. AT 309/1) Secret

Tests were made to determine the effect of 6.25-lb. Beehive demolition charges detonated below the track and hull floor plate of a heavy AFV, armored fighting vehicle, when the charges were buried at various depths below ground level, and to compare the results with those obtained from the 20-lb. Beehive demolition charge. The tests showed that the jet from this type of mine, buried to give 18 in. of earth covering and detonated under the belly of an AFV, perforated the floor plate and ignited cartridge cases within the vehicle. When the mine was detonated below the track, the damage to track and suspension was approximately confined to a small area around the jet. Laid under the track, the effect of the Beehive was very much less destructive than the normal service A/T disc type mine. Detonated under the belly the A/T mine containing 20 lb. of explosive immobilized the vehicle by permanently bulging the floor plate and displacing the internal gear, whereas the 6.25-lb. Beehive mine was not so certain to stop the tank. The effect of the jet on the crew is not known. The tests indicated that the limiting depth of earth cover for the 6.25-lb. Beehive mine, to effect floor plate perforation, was around 29 in.

L997

Fighting Vehicles Proving Establishment (Gt. Brit.) [with Fighting Vehicles Design Establishment cover sheet].
ENERGA GRENADE VS. GERMAN PANTHER TANK, by J. Baker and D. M. Rycroft. Nov. 15, 1950, 16p. incl. illus. (Rept. no. AT 320) Secret
TIP S1822

The Energa rifle grenade, weighing 1.5 lb. and having an effective range of 150 yd., was tested against a tank target. Of the 34 rounds fired at the German Panther V, model G tank, 30 were effective. From these firings, it was concluded that: (a) armor 100 mm. thick could be defeated at 50° obliquity and 45 mm. of armor at 75°; beyond 75° the fuze failed to function; (b) the shaped charge jet, after penetrating the tank armor, was capable of killing or maiming personnel, causing fuel fires, and damaging equipment; however, the damage was very local, occurring only in the direct path of the jet; (c) plastic protective plating (PPP) and Churchill track links failed as defensive mechanisms against the grenade; (d) a skirting plate 5 mm. thick, placed 29 in. from the tank armor, defeated the grenade in the first attack; in the second attempt, the jet just defeated the armor. Round-by-round assessments of the firings are given.

L998

Fighting Vehicles Proving Establishment (Gt. Brit.) [with Fighting Vehicles Design Establishment cover sheet].
INFANTRY HEAT PROJECTILES VS. MODIFIED CHURCHILL TANK, by A. Harvey and A. E. Masters. May 10, 1951, [31]p. incl. illus. (Rept. no. AT 324) Secret

Comparative tests were made to determine the lethality of 3 types of shaped charge weapons against a tank incorporating spaced plate armor. The attacks were made with 3.5-in. US Bazooka shaped charge rockets, and 4.5- and 5-in. caliber shaped charge heads. The target was a Churchill Mark 4 tank with glacis plate up-armored to 6 3/8 in. thick at 64° from normal. A 14-mm. plate was available as a glacis burster plate spaced 4 in. from the main armor. Results showed that shaped charge jets from each caliber succeeded in perforating the armor, caused casualties among the crew, damaged the equipment, and initiated ammunition fires. Penetration results showed that the 5-in. shaped charge head was superior to the other heads.

L999

Fighting Vehicles Proving Establishment (Gt. Brit.) [with Fighting Vehicles Design Establishment cover sheet].
THE EFFECT OF HOLLOW-CHARGE MINES, by A. Harvey and A. E. Masters. Nov. 26, 1951, 3p. illus. tables, diagrs. (Rept. no. AT 309/2) Secret

Tests were made to determine the effect of shaped demolition charges (American M2A3 charges and British 16-lb. demolition charges no. 6) employed in the role of antitank mines. The charges were detonated beneath the track and belly of a heavy AFV. The American demolition charges, M2A3, were effective in making a hole in the belly plate when buried up to 18 in. deep, but at 24 in. deep, the belly suffered only slight local bulging without perforation. The British 16-lb. HC demolition charge no. 6 produced a hole in the floor plate when buried 22 in. below ground level. Neither of the charges directed against the vehicle tracks caused sufficient damage to immobilize the vehicle. It was noted that adequate space free of earth must be provided above the liner to allow the jet to form; otherwise, the performance is greatly degraded.

L1000

Firestone Tire and Rubber Co. (DA33-019-ORD-33).
105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 1. Aug. 1950, 29p. incl. tables, diagrs. Confidential

Work was undertaken to design, develop, and manufacture a 105-mm. Battalion Antitank rifle (BAT), with accessories and ammunition, capable of defeating the heaviest armor of any known tank at ranges up to 1000 yd. Two T138E20 projectiles without tee, fired at 6 7/8-in. standoff, penetrated 15 and 15.75 in. of armor plate. Five projectiles fired at a spin rate of 45 r.p.s. penetrated 9.5, 10, 10.75, 10.5, and 10-in. at a standoff of 6 7/8 in. In each of the firings, 60° Cu liners, a M36 detonator, and a tetryl booster were used. No fuze was used.

L1001

Firestone Tire and Rubber Co. (DA33-019-ORD-33).
105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 2. Sept. 1950, 37p. incl. tables, diagrs. Confidential

The standard T138E20 projectile assembly with c.g. at 1.04 calibers from the base, consists of an Al plug, steel body, Cu liner assembly, steel ring, and Al tee. A group of these projectiles was modified by moving the c.g. rearward 0.24 calibers by means of an extra heavy steel plug, Al ring, and Al tee. Projectiles were also designed with a heavy steel plug, Al ring, and Al tee so that the c.g. was moved rearward 0.13 calibers. Other projectiles, designed without rotating bands and with brass tee, had the c.g. moved forward 0.06 calibers. Another projectile with Al body and a brass tee had its c.g. 0.19 calibers in front of the c.g. of the standard T138E20 projectile. Results of accuracy firings (velocity from 1800 to 2000 ft./sec.) of the modified T138E20 projectiles showed that there probably is a position for the c.g. in the region around 0.85 calibers from the rear which is optimum for the projectiles having the c.g. toward the rear. Increase of the muzzle velocity resulted in an improvement in accuracy. It is pointed out that the possibility exists for firing the projectile with 0 spin and c.g. well forward. Accuracy might be improved by increasing the projectile weight and/or increasing the muzzle velocity without affecting the gun weight. The Armor T84 75-mm. projectile and the Naval Ordnance Test Station (NOTS) fin rocket are being studied in connection with the development of the BAT weapon. A few "Moby Dick" type drag-stabilized projectiles were constructed in the 37-mm. size. Several of the projectiles had smooth body and nose, while others had a "pine-cone" type nose. The theory of spin compensation is discussed. The data show that the values of the variable consistent with practical liners of the 105-mm. size can be determined. Tabular data are included which review results obtained in the penetration study program. Improvement in performance of the 45° liner over the 60° liner led to the study of the liner angle variation. With 60° liners fired at 7.5-in. standoff and 0 r.p.s. rotation, rounds (old lot), containing Comp. B. initiated by spitback fuze, with Frankford Arsenal liners, Primacord, penetrated from 9 1/16 to 14.5 in.; rounds (old lot), containing Comp. B, no fuze, standard ring, base-initiated with Frankford liners penetrated from 13 3/8 to 15.75 in.; rounds (new lot) (Holston no. 3-6) with Comp. B penetrated from 13 5/8 to 16 in.; with 45° liners fired at 7.5-in. standoff with 0 r.p.s. rotation, rounds (new lot) with Comp. B (Holston no. 3-6), no fuze, standard ring, with Firestone and Frankford liners, base-initiated, penetrated from 19.75 to 21.75 in.

[illegible]

Firestone Tire and Rubber Co. (DA33-019-ORD-33).
105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 3. Oct. 1950, 42p. incl. illus. tables, diagrs. Confidential

Penetration test results with 45° and 60° conical liners are shown. There was considerable variation in the depth of penetration for a given liner angle because of the type of detonation used. It is pointed out that cutting away the ring is not beneficial to penetrations. Best results were obtained with no tee. Tabular data show the effect of standoff on penetratic Graphical results show that the penetration due to the 45° liner is reduced much more rapidly than the penetration of the 60° liner as the rotational speed is increased. A survey of the literature on shaped charges is appended.

L1003

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Supplement to progress rept. no. 3. Oct. 1950, 9p. incl. illus. tables, diagrs. Secret

Data relating the depth, angle of cant, and the center included angle defined by 2 radii and the canted and offset surfaces are given. A theoretical discussion is given on the effect of spin. It is pointed out that properly designed flutes on the outer liner surface will partially compensate for rotation. The data show that liners split into either 2 or 4 segments and then revolved about their apices and reassembled so as to give offset on the liner showed better penetration at about 150 r.p.s. than at 0 r.p.s. These liners also showed about 25% greater penetration at 150 r.p.s. than a smooth liner at the same spin rate. Firing results showed that the offset liners were 35% better than the smooth liners at 155 r.p.s. while the offset trumpet liners showed only 15% improvement under the same conditions.

L1004

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 4. Nov. 1950, 31p. incl. tables, diagrs. Confidential

Various static and dynamic aerodynamic coefficients (drag, moment, and normal force) were determined for the T138 projectile. A theoretical discussion is given on the T171 projectile. A model of the T171 projectile body and tail, equipped with 2 interchangeable nose sections (1 of Al and the other of bronze), was constructed. Physical measurements are tabulated for the T171 60° liner inert-loaded projectile. Tabular results for the various penetration firings in connection with the BAT project are given. Rounds, using 35°, 40°, 45° Firestone liners with Comp. B, lot 3-6, explosive charge, base initiated, no fuze, standard ring, were fired at a standoff of 7.5 in. and 0 r.p.s. to give average penetrations of 20.6, 20.0, and 16.6 in., respectively. A second group, equipped with 50°, 55°, and 60° Firestone liners, was fired against high quality armor plate superior to the regular target material employed with the other rounds. Penetrations of 19.2, 17.1, and 14.1 in., respectively, were obtained. For rounds with a 60° sintered liner, the average penetration was 12.7 in. Rounds with Comp. B, lot 3-6, DRL 45° Al liners, base initiated, no fuze, and standard ring at 0 r.p.s. and 7.5-in. standoff gave an average penetration of 6.1 in.

L1005

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Supplement to progress rept. no. 4. Nov. 1950, 5p. incl. illus. tables, diagr. Secret

Twenty-five charges with 45° smooth Cu (type 1) or 45°, 16 flute, Cu (type 2) liners were fired against 22, 1-in. mild steel plates. With type (1) charges, 0 r.p.s., the average penetration was 18.3 in.; with the same type charges spinning at 22 and 45 r.p.s., the average penetrations were 15.2 and 10.0 in., respectively. One charge of type (1) and 2 charges of type (2) were fired for slug recovery. To accomplish the recovery the charges at 0 r.p.s. were fired into rock wool or similar material which stopped the slugs with minimum distortion. The charges were fired at a standoff of 2.5 ft. Slugs from the type (2) charges were recovered, but the slug from the type (1) charges penetrated 20 ft. of rock wool, a 0.75-in. thick steel plate, and became embedded in a 0.5-in. thick steel plate. It was noted that the slugs from the fluted liners showed quite clearly the ridges which were the flutes in the original liners. These were substantially straight and parallel with the axis of the slug. The slugs from the 2 fluted liners were much smaller than the slug from the smooth liner. This was taken as an indication that only a portion of the fluted liner collapsed in a normal manner. It was also pointed out that unusual stress concentrations resulting from the sharp flute contour or unequal wall thicknesses might cause premature fracture with resultant disintegration of the last half of the liner. On the basis of these possibilities, liners of different flute designs are being manufactured for test.

L1006

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 5. Dec. 1950, 46p. incl. illus. tables, diagrs. Confidential

Graphical results, which show velocity plotted against range, indicate that the velocity of the T138 projectile approaches or passes the velocity of sound at ranges of 3000 ft. unless the initial velocity is higher than specified. Graphical results for spin rate range show that the spin rate in radians/caliber increases with range. Mathematical expressions are given for the static or gyroscopic stability factor and for the dynamic stability factor. Graphical results of these 2 stability factors for T138 E32 and E33 projectiles showed that these projectiles, at any muzzle energy condition considered, passed through regions in which dynamic instability was apparent. A list is given which shows possible variations in the exterior shape of the T171 projectile. Twelve rounds of the 105-mm. folding-fin projectile, T119, were fired from a smooth-tube, recoilless gun. Photographic data showed that the fin-opening mechanism opened rapidly; the fins were fully open within 6 ft. of the muzzle. Though the fin-opening was symmetrical for any given round, there was no uniformity in the extent of opening from round to round. The fins, which were the most fragile components, withstood the gun blast and opening stresses with no apparent damage. A comparison test was made of cylindrical test bodies with T138 bodies to study the effect of small changes in body shape and thickness. The variations in penetration were of the order of 6% except for 1 group. This variation was acceptable. Standoff studies showed that for a given spin rate and liner angle, penetration increased with increased standoff. A comparison of target materials (regular armor plate, Brinell 220-230 and high quality armor plate, Brinell 310-320) at 0 spin and at 45 r.p.s. showed that penetration decreased 14% for 0 spin and 12% for 45 r.p.s. Data show a wide spread in the average penetrations obtained as successive groups were fired. The list of possible causes for the variation included effect of temperature, variations in quality of plate used, variations in loading technique, and variation in liners. The test program on barium titanate crystals as generating elements for electric fuzing of the HEAT round is continuing.

L1007

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Supplement to progress rept. no. 5. Dec. 1950, 5p. incl. table, diagrs. Secret

The following methods are being considered for achieving spin compensation: anti-rotation jet motor; projectile with internal anti-rotation rifling; double-body projectile with rotating outer shell and non-rotating charge and liner; and helical-charge separators for rotating detonation wave. Diagrams are shown for test rounds incorporating the above features.

L1008

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 6. Jan. 1951, 29p. incl. illus. tables, diagrs. Confidential

Modified T138 projectiles, the E32A, E32B, E42B, E42C, and E42E, were fired on the 1000-yd. range in accuracy tests. Better accuracy was obtained for the E32B projectiles having the smaller bourrelet diameter than for the E32A projectiles. The data show that the use of bourrelet improved the accuracy. Also, moving the c.g. from 1.106 diameters from the base (E20) to 0.88 diameters from the base improved the accuracy, but this is still not adequate to meet specification requirements. The E42 projectiles, fired at a muzzle velocity of 2090 ft./sec. from a 1-120 twist tube to give a spin-rate of 53 r.p.s., were all accurate within the specification requirements. The group E42C, having the largest bourrelet diameters of the projectiles tested, displayed the best accuracy. Considering the E42B, E42C, and E42E projectiles as 1 group, the probable error for the 18 projectiles which hit the target was HPE 0.53 mils and VPE 0.45 mils. Although these projectiles were fired at the same muzzle energy as a 17.5-lb. projectile (muzzle velocity of 1700 ft./sec.), the higher spin-rate of 53 r.p.s. contributed to the projectiles' stability. The E41 group, which was identical with the E42 group except that no rotating bands were used, flew very inaccurately from the smooth bore tube. The use of the sleeve in the rear of the E44 projectile did not improve conditions nor did the use of fins (E45 group). T119 projectiles which had been fired previously, were examined to determine the cause for the variability in the degree of fin opening. It was found that mechanical interference existed between the fins and the piston in some of the assemblies; this interference contributed to the variability of the degree of fin opening. Results from a series of boosters tested at temperatures ranging from 70° to 0°F and from detonators tested at 70°F showed that temperature had little effect upon them. The preliminary design of a base element in the fuzing chain is also discussed.

L1009

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 7. Feb. 1951, 23p. incl. tables, diagrs. Confidential

Accuracy firings were conducted using the modified T138 projectiles, T138E46 to T138E49. None of these rounds hit the target when fired from a smooth bore gun at the same muzzle energies. The projectiles were statically stable, but dynamically unstable. It was concluded that these T138-type projectiles cannot be fired accurately from a smooth bore gun. In further tests T138E60 projectiles were fired, giving a horizontal probable error of 0.84± 0.27 mils and a vertical probable error of 0.69± 0.22 mils. The T138E61 projectiles also hit the target; however, their flight characteristics were not as promising as the E60's. Tests indicated that temperature variations in Comp. B and in armor plate were not a major cause of the variation in penetration. In addition, the design for the base element of a HEAT round was completed.

L1010

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 8. Mar. 1951, 47p. incl. illus. tables, diagrs. Confidential

Four rounds of the T138E55A type (weight 17.62 lb., c.g. 4.96 in. from the base, square cut front face) were fired from a 105-mm. howitzer equipped with a 1-120 rifled tube which gave a projectile spin of 41 r.p.s. at a muzzle velocity of 1700 ft./sec. All of the projectiles hit the target at a range of 900 yd. Calculations gave a vertical probable error (VPE) of 0.435 mils and a horizontal probable error (HPE) of 0.425 mils for the 4 rounds fired. Under better wind conditions the VPE was 0.324 mils and the HPE was 0.352 mils for the 7 rounds fired. From the data given concerning the effect of temperature on penetration, the effect of plate material, and liner uniformity, it was concluded that these causes were insignificant. A metallographic examination was made of a target consisting of 7 3-in. thick steel plates cut into 7-in. squares, which had been penetrated by a jet from a 45° conical Cu cavity liner mounted in a T138E20 type body. Analysis of the steel within 1/16th of an in. of the cavity, at several points along the cavity, failed to disclose any increase in the Cu or Al content, indicating that there was no significant diffusion of the jet material into the steel. Analysis of the deposit left on the inside of the cavity showed 10 to 20% Fe. The data showed that the Cu jet in passing through the Al tee picked up about 2 to 5% Al and about 10 to 20% of Fe from the target. Pieces of the Al tee were hurled forward by the force of the explosion and entered the cavity, splattered against the sides, and alloyed with the residual jet material. The slug then entered the cavity, lodging at a point where the cavity diameter became less than that of the slug.

L1011

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Supplement to progress rept. no. 8. Mar. 1951, 8p. incl. illus. tables, diagrs. Secret

A series of 16- and 36-flute liners were fired at Bruceton into used target plate of mild steel (Brinell Hardness no. 140) and at Aberdeen into used target plate of an alloy steel similar to armor plate (Brinell Hardness no. 220-230). Results showed that the 16-flute liners (0.001-in. thick wall) performed unsatisfactorily. The best performance of these liners was obtained at 0 spin, the average penetration being 18.3 in. at 7.5-in. standoff. There was only slight evidence to indicate any tendency to compensate. The data obtained from Aberdeen indicated a slight asymmetry in the direction of positive spin rates (9.3 in. vs. 7.2 in. at +30 and -30 r.p.s., respectively). The slug from the liner was found to be only 1/3 as large as was expected, indicating that these fluted liners were breaking up before collapsing completely. The 36-flute liners showed a tendency to compensate at about 10 r.p.s. and performed better at +30 r.p.s. than any smooth liner that had been fired. These liners also demonstrated a maximum penetration as good as that normally expected of 45° smooth liners.

L1012

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 9. Apr. 1951, 42p. incl. illus. tables, diagrs. Confidential

Ten T119 projectiles were fired at a target placed 900 yd. away. On the basis of the 9 projectiles which hit the target, the HPE was calculated to be 0.56 mils and the VPE was 0.92 mils. Tests were continued to determine the variation in penetration with loading technique as the variable. The data indicated that this was not the cause.

L1013

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Supplement to progress rept. no. 9. Apr. 1951, 11p. incl. illus. tables, diagrs. Secret

Tests were carried out with 45° conical Cu liners (P16 series) for the T120 projectiles having 16 machined flutes with a nominal flute depth of 0.070 in. at the base datum plane, and a wall thickness of 0.150 in. The flute profile was flat. The liners, fired at 7.5-in. standoff against a mild steel target, produced average penetrations of 3.96, 6.69, 8.87, 9.60, 9.42, 8.48, and 5.19 in. with spin rates of 0, +30, +45, +52.5, +60, +70 and +90 r.p.s., respectively. These penetration data were compared with the best data obtained at Aberdeen with the T138E20 (plug, body and nose ring, no tee); it was pointed out that these P16 liners performed best at about 55 r.p.s., however, the best penetration was only 65% of that of a smooth, non-rotated liner having a 0.150-in. wall and only 47% of that of the best non-rotated liner with a 0.100-in. wall. Over the range 50 to 60 r.p.s., the actual penetration (9.5 in.) was approximately 1 to 2 in. greater than that of the best 0.100-in. wall smooth liner over the same range of spins. It was pointed out that the relatively low efficiency of these liners at their optimum spin rate was the result of incomplete collapse. The slugs recovered from the penetrated targets were only about 2 in. long, compared with a normal expected slug length of 5 to 6 in. Forty-five degree conical Cu liners having 16 machined flutes with a nominal flute depth of 0.028 in. at the base datum plane, and a wall thickness of 0.100 in. were tested. The flute profile was circular and at each transverse section had a radius of the unfluted liner at the same section. At a standoff of 7.5 in. against a mild steel target, average penetrations of [7.62?] 5.40, 6.29, 7.04, 8.36, 7.36, 7.47, and 4.44 in. were obtained for spin rates of 0, -30, 0, +15, +30, +45, +60 and +90 r.p.s. respectively. Reproducibility of the data was good, but the performance of the liners was poor. It was pointed out that optimum performance is in the vicinity of 30 r.p.s. but even at this spin rate, the penetration is 4 to 5 in. less than that of a smooth 45° liner spun at the same rate. The slug was quite short (about 2 in. long) which suggested again that the liner ruptured before the normal collapse had been completed.

L1014

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 10. May 1951, 40p. incl. illus. tables, diagrs. Confidential

In accuracy firings T138E57A projectiles with the c.g. located 5.25 in. from the base and fired from a howitzer with a 1-120 tube gave the best results. Satisfactory results were also obtained when this projectile was fired from a howitzer with a 1-160 tube. In order to facilitate the penetration of the shaped charge, the diameter in the hole in the tee was enlarged, and a conical section in the base of the tee was removed. A group of T138E57A projectiles were loaded with Comp. B and fired for penetration studies with a dummy nose element, tee and dummy base element in place. When fired with the original tee having only 0.5-in. hole, the penetration obtained was only 6 in. With a tee having a conical cut-out and 0.75-in. hole in the base, the penetration was 15 in. while a tee having a cut-out and a 1-in. hole in the base gave a penetration of 18.0 in. It was concluded that a tee could be designed which would meet the requirements for aerodynamic performance and penetration. Twelve T119 test projectiles were fired for accuracy on a 1000-yd. range from a modified T19 recoilless rifle (with 85-in. tube, rifled 1 turn in 120 calibers). The rifled tube was used in an attempt to impart a small stabilizing rotation to the unbanded projectiles. One round missed the target; the probable errors for the remaining 6 rounds were 1.28 mils VPE and 1.08 mils HPE. Preliminary attempts to measure the spin of rounds indicated that rotation was approximately 6 r.p.s. at a distance of 50 ft. from the muzzle. Tests were continued to determine the variation in penetration. Rounds fired with no fuze, standard ring retainer, 45° Cu liner, Comp. B, Holston Lot 3-6, base-initiated, non-rotated, at 7.5-in. standoff gave an average penetration of 19.4, 18.8, 19.6, and 19.1 for the 4 groups. Rounds with Comp. B Lot 3-21, Al-bronze 45° liner, cylindrical body, no fuze, base initiated, non-rotated, fired at 7.5-in. standoff gave an average penetration of 7.5 in. An average penetration of 19.5 in. was obtained with a round containing no fuze, standard ring retainer, 45° Cu liner, Comp. B, Lot 3-21. cylindrical body, non-rotated, base initiated, fired at 7.5-in. standoff. It was pointed out that results from rounds with Al bronze alloy liners indicated that considerable development and experimentation would be required before alloy liners would be as satisfactory as Cu liners. Results from rounds fired to study target material (Aberdeen target plate and boiler plate) led to the conclusion that there was no significant difference in penetration resistance of the 2 types of plate. It is pointed out that this conclusion does not imply that hardened armor plate or other target materials will not differ from the boiler plate in resistance to penetration.

L1015

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Supplement to progress rept. no. 10. May 1951, 12p. incl. tables, diagrs. Secret

Three series of serrated liners and a control series of smooth liners were tested. DRD33-3 liners have a circular flute profile so that at each transverse section, the radius of curvature is approximately equal to the original outside radius of the unfluted liner at the same section. DRD35-3 liners have a flat flute profile corresponding to the chords of the arcs of the DRD33-3 liners and they are identical in all other respects to the DRD35-3. Both series have 36 flutes with a nominal depth of 0.020 in. at the base datum plane and a wall thickness of 0.150 in. DRD17-6 liners have 16 flat flutes with a nominal depth of 0.028 in. at the base datum plane and a wall thickness of 0.150 in. The axes of symmetry for the 2 series were 15 r.p.s. for the DRD33-3 liners and 10 r.p.s. for the DRD35-3 liners. In each case, the maximum expected penetration into mild steel was 15 to 15.5 in. The slug length for these liners was normal. The DRD17-6 liners performed satisfactorily. The axis of symmetry was at 15 r.p.s. and the maximum penetration in mild steel was 16.1 in. As with the DRD33-3 and DRD35-3 series, the DRD17-6 liners were superior to a smooth liner with a 0.100-in. wall at spin rates greater than 35 r.p.s. but inferior below this rate. It was noted that there is a striking difference between the performance of a smooth liner with a wall thickness of 0.100 in. (static penetration of 19 to 20 in.) and 1 of 0.150 in. (static penetration of 14 to 15 in.). At 45 r.p.s., the penetrations are 10.5 and 10.0 in., respectively. Each of the 3 series of serrated liners had a maximum penetration greater than that of the non-rotated smooth 0.150-in. wall control. It is suggested that the machining of the flutes reduces the effective wall thickness so as to improve the overall efficiency. Therefore an optimum wall thickness exists for each type of serrated liner and it may not coincide with the optimum for a smooth liner. It is pointed out that although all 3 series of serrated liners appeared to have a maximum penetration into mild steel at 15 r.p.s., the DRD33-3 and DRD35-3 liners differ from the DRD17-6 liners in flute depth, number of flutes and orientation of flutes. Earlier data obtained by the Carnegie Institute of Technology indicated that similarly oriented 16 and 36 flute liners compensated in opposite directions. When these series of liners were designed, the orientation of the 16-flute liners was reversed relative to that of the 36-flute series. "Since all 3 of these series compensate in the same direction, the observations by the CIT group would seem to be confirmed."

L1016

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 11. June 1951, 52p. incl. tables, diagrs. Confidential

Liners, without spit-back tubes, with 1.25-in. tubes, and with 2.4-in. full length tubes were tested to determine the effect of tube length on penetration. Although there was some slight indication that the longer spitback tubes resulted in greater penetration. the difference was small (0.5 in.) and within the experimental accuracy of the measurements. The following series of rounds were tested: (1) the booster was buried in the Comp. B, and the booster cavity in the base plug was filled with a maple plug; (2) a solid steel base was used, and the tetryl pellet was embedded in the Comp. B; and (3) the standard control series had a steel base plug with a centrally located hole in which the tetryl booster was placed. All 3 rounds demonstrated about the same penetration in mild steel, although a number of Al protector plugs were damaged when the booster was buried in the Comp. B. Tests with 45° liners with and without spitback tubes showed that the average penetration for the group with the booster embedded in the high explosive was lower by approximately 2 in. than the best values ordinarily obtained with the 45° Cu liner having a spitback tube. Liners having cylindrical sections (1.00-, 1.75- and 2.50-in. outer diameter, and wall thickness of 0.100 in. for the first 2 liners and 0.50 in. for the second) were tested. The large diameter liners produced an average penetration of 7.25 in., the 1.75-in. outer diameter liner produced an average penetration of 12 in., and the 1.00-in. outer diameter liner produced an average penetration of 9.5 in. Penetration firing tests for hemisphere and trumpet-type liners showed that the penetration values were low in comparison with 45° Cu liners. Removal of the pilot ring on the liner did not affect penetration results. A group of projectiles fired at a spin rate of 240 r.p.s. produced an average penetration of 4.15 in. With the 105-mm. round, this fast spin caused a reduction in penetration of about 78%. A tee configuration which did not interfere with jet action is shown. Tests to determine the effect of radius at the interior base of the liner showed that the average penetration for liners without radius was slightly better than for those with the radius. Data were correlated in the study of the effect of rotation on penetration. It was observed that the lined cavity charge having the greatest non-rotated penetration produced the greatest penetration at any specified spin rate. Hemispheres and wide angle liners suffered less degradation of penetration during rotation than small angle liners, but the latter still penetrated the greater distance at any finite spin rate. With liners larger than 105 mm., the increased penetration obtained was almost completely lost when the liner was rotated faster than 40 r.p.s.

L1017

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 12. July 1951, 34p. incl. illus. tables, diagrs. Confidential

Rounds were fired at various spin rates to determine the effect of tee configuration on penetration. Greater penetrations were obtained at all spin rates with the DRC224 tee than with the DRC230 tee. Studies with hemispherical liners showed that the liners with and without tubes gave better penetration at 11.5-in. standoff than at 7.5-in. standoff (with the same spin rate). The average penetration with trumpet liners at 0 spin was about 1-in. less at the 11.5- standoff than at 7.5-in. standoff. Rounds with conical Cu liners without spitback tubes fired at 7.5-in. standoff gave an average penetration about 2 in. less than the best results obtained with standard Cu conical liners with spitback tubes. Tests with Al liners having the same mass as the Cu liners gave inferior results compared with results obtained from Cu liners under similar conditions. Rounds with 60° Cu liners fired at 0 spin and at 30 r.p.s. penetrated 12 in. and 13-15/32 in. respectively.

Rounds with 45° Cu liners fired at standoffs varying from 1.5 to 40-3/16 in. and at 238-240 r.p.s. gave penetrations from 2.75 to 0.75 in.

L1018

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 13. Aug. 1951, 49p. incl. illus. tables, diagrs. Confidential

Data were compared for T138E20 rounds fired into regular target plate and into homogeneous armor plate at 0 and 45 r.p.s. At each spin rate, penetration into the homogeneous armor was 10 to 15% less than into the regular mild steel. Comparative tests with the T138 projectile fired at 25 r.p.s. and at 7.5-in. standoff showed an average penetration of 14.9 in. in mild steel, and 14.1 in. in homogeneous armor. It was established that the DRC224-1 tee does not reduce penetration into mild steel at spin rates up to 45 r.p.s. The DRC263 tee has the same internal configuration as the DRC224 tee and is also presumed to be satisfactory. Comparative tests with steel and Cu liners showed that 45° steel liners behave very much like 45° Cu liners. The actual penetration of these steel liners is only about 70% that of a similar Cu liner. The performances of the DRB268 Cu liner 45° was determined at 0 and 25 r.p.s. and 7.5-in. standoff. Non-rotated penetration into mild steel was 19.0 in., which was 1 to 2 in. better than was normally obtained with the DRB2-5 liners. The behavior of simple sharp apex liners was compared with the DRB2-5 liner having a full spitback tube. The optimum standoff for the tubeless liner appeared to be at about 15 in., that of the spit-back tube liner at about 18 in. It appeared that a liner with spit-back tube should be used regardless of the type of fuzing employed.

L1019

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Supplement to progress rept. no. 13. Aug. 1951, 17p. incl. tables, diagrs. Secret

The summary of tests with serrated liners pointed out that spin rates at which a given series of serrated liners showed maximum penetration increased with increased number and depth of flutes, but decreased as the residual wall thickness was increased. In order for any significant shift of the spin rate to occur there must be a variation in wall thickness across the flute. With 36 flutes, it made little difference whether the flute contour was curved or flat. With a larger number of flutes the difference should become less, but with a smaller number of flutes, it may become important. The 16-flute liners have a reverse orientation from the 36- and 60-flute liners, but the shift of optimum spin rate is always in a positive direction. It is pointed out that there must be some flute number between 16 and 36 where orientation would make no difference, i.e., where there is no shift of the optimum spin rate.

A preliminary design is shown for a double-body round of the T138 type projectile as a means of achieving higher than normal penetrations with rotating rounds.

L1020

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 14. Sept. 1951. 43p. incl. illus. tables, diagrs. Confidential

Liners having various wall thicknesses (0.050, 0.100, 0.200 in.) were tested at standoffs of 4.5, 7.5, 9.5 in. The data show that the optimum wall thickness is very close to 0.100 in. For this wall thickness, the penetration increased with standoff. Tests were made on standard conical liners with internal spitback tubes. The penetration achieved by the internal tube liner was very poor. The loss of penetration caused by rotation at 45 r.p.s. was greater than expected for a round whose initial penetration was 5.96 in. Further tests to determine the degradation in penetration showed that annealing reduced hardness and increased elongation, but had little effect upon penetration. It is pointed out that the various factors studied did not individually have a significant effect upon penetration. It is thought that either an accumulation of small effects caused the degradation, or some effect not yet isolated.

L1021

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Supplement to progress rept. no. 14. Sept. 1951, 7p. incl. illus. tables, diagrs. Secret

Two types of charge separators were tested for penetration at 7.5-in. standoff and at various spin rates. One separator has a spiral which advances 0.25 of a revolution/caliber length (DRC24) and the other 1/3 of a revolution/caliber (DRC25). If the spiral separators perform their intended function, the detonating front on 1 surface of a separator will lag behind the front on the other surface. Under these conditions a shock wave might arrive at the opposite surface prior to the arrival of the lagging detonation wave front causing premature ignition of the Comp. B and nullifying at least a portion of the separator. To guard against the possibility of such an occurrence all of the DRC24 separators and 10 of the DRC25 separators were covered with a 1/16-in. thickness of soft cardboard. The uncovered DRC24 separators showed low penetration without any indication of compensation. When covered with cardboard, the maximum penetration obtained was at about 45 r.p.s. The covered DRC25 separators did not show any real compensation, but the penetration curve appeared to be asymmetric in the direction of positive spin. In all cases, the maximum average penetration was below the non-rotated penetration of the smooth control liners. Only the covered DRC24 separators showed a superiority, to smooth liners, and then only over the range 30 to 80 r.p.s.

L1022

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 15. Oct. 1951, 36p. incl. illus. tables, diagrs. Confidential

The T138 HEAT projectiles fired against homogeneous armor gave an average penetration of 13.6 in. at 0° obliquity. Rounds fired at 60° obliquity functioned normally and gave an average penetration of 13 in. Comparative tests were made with Cu and steel liners. The tests were made at a spin rate of 180 r.p.s. and at various standoff distances. Penetration figures were lower for these spin stabilized projectiles than for slow spin or static projectiles.

L1023

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 16. Nov. 1951, 29p. incl. illus. tables, diagrs. Confidential

T138 HEAT projectiles were fired against homogeneous armor at 60° obliquity at 1000 yd. Of the 10 rounds which penetrated the target, 8 went through 12 in. of armor, 1 bulged the plate at 12 in., and 1 penetrated less than 12 in. To determine the effectiveness of skirting armor as protection against shaped charges, T138 projectiles with standard Cu liners were fired at a 7.5-in. standoff. Spacing of the skirting armor, measured from the bottom surface of the skirting plate to the top surface of the target plates, varied from 0 to 24 in. Rotational velocities of 0, 10, and 25 r.p.s. were used. Penetrations were measured at normal impact and at 45° obliquity. The target material was 3-in. thick 1020 hot-rolled plate cut into 8-in. squares. The data indicated that spaced armor did not materially degrade the penetration produced by shaped charges, and that under certain conditions the penetrating power of the round was improved by the presence of the skirting plate. Total penetration was not materially reduced by inclining the skirting plate and armor at 45°. In the single instance tested, a 3-in. skirting plate seemed to be slightly more effective in reducing penetration than the lighter 0.75-in. plate, but the supporting structure required for the 3-in. thick skirting plate would be too heavy. From the standpoint of assembly, it was desirable to run a wire which would connect the nose element to the base element in HEAT rounds. The data indicated that with the rounds tested, the wire was not detrimental.

L1024

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Supplement to progress rept. no. 16. Nov. 1951, 8p. incl. diagrs. Secret

Methods were found for correlating the optimum spin rate and the maximum average penetration of the serrated liners tested. As a result, several tentative conclusions were suggested. Data from tests with various series of serrated liners are discussed. Further work on double body projectiles is reported.

L1025

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 17. Dec. 1951, 21p. incl. tables, diagrs. Confidential

Rounds with hemispherical liners with and without spitback tubes, and rounds with trumpet liners were sent to Ballistic Research Laboratories for testing. Accuracy results obtained with T138 projectiles are discussed.

L1026

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 18. Jan. 1952, 28p. incl. illus. tables, diagrs. Confidential

Two series of 105-mm. 42° drawn Cu liners were tested in a preliminary evaluation of drawn liners. The only significant difference between the 2 types of liners was in the flange detail, and the lower penetration of 1 of the liners was attributed to this difference. A study made to determine the effect of body wall thickness upon penetration showed that variations in interior body contour had no significant effect upon the penetration.

L1027

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Supplement to progress rept. no. 18. Jan. 1952, 11p. incl. tables, diagrs. Secret

Two series of serrated liners and 1 control series of smooth liners were tested for penetration into mild steel at various spin rates and at a standoff of 7.5 in. The DRD161-1 liners had 36 flat flutes machined on the exterior surface. The average penetration at the peak in the penetration curve was 16.9 in. of mild steel and occurred at 35 r.p.s. This penetration represents 91% of the non-rotated penetration of the unfluted 0.100-in. wall control liners. At all spin rates above 20 r.p.s., the fluted liners penetrated a greater depth of mild steel than did the controls. At the optimum spin rate for the fluted liners (35 r.p.s.) the penetration was 5 in. greater than for the controls. The DRC162-2 liners had 45 flat flutes machined on the exterior surface. The average penetration at the peak in the penetration curve was 16 in. and occurred at 40 r.p.s. This penetration represented 86% of the non-rotated penetration of the unfluted controls. These fluted liners penetrated to a greater depth than the controls at all spin rates above 23 r.p.s., and at their optimum spin rate of 40 r.p.s. penetrated 5 in. deeper than the controls.

L1028

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 19. Feb. 1952, 24p. incl. tables, diagrs. Confidential

Tests on liners to study the effect of a wire through the apex of the liner and approximately along the axis of the tee showed that this wiring method should be avoided.

L1029

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 20. Mar. 1952, 30p. incl. illus. tables, diagrs. Confidential

Two series of penetration rounds were fired into Aberdeen target plate to study the penetration vs. liner angle relationship for constant length of projectile body, for constant weight of high explosive, and for constant head of high explosive. Graphical results show that the constant length and constant weight of high explosive curves fall into essentially parallel curves, with the constant weight data (armor plate) being about 1.5 in. lower than that using the constant length of projectile. In each case there was peaking at a liner angle of about 42°. The data for the constant head series showed no such maximum and penetration increased linearly with decreasing liner angle. Further tests with a band of explosive behind the flange of the liner showed that the explosive-backed flange should be avoided. Improvement in performance was noted when the explosive-backed flange was eliminated. Progress is reported monthly on the rifle, the T138, T171, and T119 projectiles, and fuzes for HEAT rounds.

L1030

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Supplement to progress rept. no. 20. Mar. 1952, 16p. incl. tables, diagrs. Secret

Three series of rounds with serrated liners and 2 series with smooth control liners were tested for penetration into mild steel at various spin rates and at a standoff of 7.5 in. Penetration results with DRD117-3 spiral serrated liners (16 flat spiral flutes machined on exterior surface) showed that the average penetration was 15.4 in. in mild steel at 7.5 r.p.s. This penetration represented 90% of the non-rotated penetration of the 0.150-in. wall of the unfluted control liners, but it was only 85% of the unfluted 0.100-in. wall control liners. It is pointed out that such a spiral does not offer any advantage over straight unspiraled flutes. Based upon the performance of DRD78-2 liners (16 flutes interior and exterior surface), DRD213-1 liners (16 exterior flutes, pressed from DRB2-8 smooth liners), and DRD223 liners (16 interior flutes, pressed from DRB2-8 smooth liners), the following tentative conclusions were made: (1) external fluting of a given geometry shifts the spin rate for best average penetration further from 0 r.p.s. than does the corresponding internal fluting; (2) internal fluting of a given geometry does not reduce the penetration at the best spin rate as much as does the corresponding external fluting; (3) matching internal and external flutes result in a net performance which seems to be a balance between the effect of the external and internal flutes. If different mechanisms of compensation result from the use of external and internal flutes it may be possible to cause the 2 mechanisms to reinforce 1 another rather than to oppose 1 another as they seem to in the single instance of the DRD78-2 liners.

L1031

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 21. Apr. 1952, 25p. incl. illus. tables, diagrs. AD-16 455 Confidential

Penetration tests were made with semi-cylindrical liners against mild steel target plates (7 in. square and 3 in. thick). The average penetration of 11.0 in. was much less than that obtained with Cu liners of similar base diameter (3.61 in.). Experiments with tapered wall steel liners (1.63- and 4.35-in. diameter) failed to show that liners thinner toward the apex were superior to liners with uniform walls. Further tests are planned.

L1032

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 22. May 1952, 38p. incl. tables, diagrs. AD-15 364 Confidential

Penetration studies were made to determine the comparative resistances of targets of Pb, mild steel, gray cast Fe, 302 stainless steel plate, and 302 cast stainless steel to shaped charges. For the 21 rounds fired at a standoff of 7.5 in. and a spin rate of 0, penetrations ranged from an average of 23.26 in. in Pb to 16.62 in. in 302 stainless steel. The Pb and gray cast Fe plates were fragmented as well as penetrated. In addition a comparison was made of the penetrations produced by 81 rounds having 45° machined liners (DRB2, 0.100-in. wall thickness) with spitback tubes of different lengths and diameters. With an increase in the length of the spitback tube from .25 in. to 2.80 in., the penetration increased from 17.36 in. to 18.18 in.; increasing the tube diameter from .25 in. to 1.0 in. caused the average penetration to increase from 16.7 in. to 19.1 in. Penetration data are presented in tables.

L1033

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 23. June 1952, 32p. incl. illus. tables, diagrs. AD-15 365 Confidential

Penetration studies were made with the T171 HEAT type projectile (DRC193 body), substituting the DRB91 nose ring for the DRB83 nose ring employed in earlier tests (item no. L1023). Cu liners (45°, DRB2, 0.100-in. wall thickness) were used. The change in the nose ring doubled the round's penetration. For the 5 rounds fired at a standoff of 7.5 in., the average penetration in mild steel was 20.20 in.; at a standoff of 18.0 in., the average penetration for the 5 rounds fired into mild steel was 20.75 in. Comparison of drawn liners with machined liners indicated that both liners penetrate equally well. In addition, rotation tests showed that at 25 r.p.s., the penetration is independent of the type of assembly but 0 r.p.s., the penetration is nearly 5 in. greater with the DRC376 test assembly than with the T138E57. This suggests that the tee of the T138E57 interferes with charge penetration.

L1034

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 24. July 1952, 25p. incl. tables, diagrs. AD-16 754 Confidential

Three phases of shaped charge penetration phenomena were investigated. (1) Thirty rounds of the T138E57 projectile were fired to determine the effect of the DRC314 tee on penetration results. Two different penetration round assemblies were used. Firing data indicated that with the DRC376 the DRC314 tee reduced penetration by about 3 in. at 0 r.p.s., and caused little effect on penetration at 25 r.p.s. In the case of the DRC15-6 assemblies with DRB2 conical liners, the penetration results were not influenced by the presence of the tee at 0 r.p.s. (2) Test firings were made to study the effect of a T208 base element cavity on penetration. With the booster in a more rearward position results showed penetration was increased approximately 2 in. (3) Fifteen standard DRB398 conical liners and 9 recoined DRB398 liners were fired to determine the effect of recoining on penetration. The test data indicated that there was no substantial difference between the performance of the standard and recoined DRB398 liners.

L1035

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 25. Aug. 1952, 33p. incl. tables, diagrs. AD-16 753 Confidential

Three shaped charge penetration studies were conducted. (1) Fifteen liners drawn from Cu strip and 9 liners machined from hard drawn Cu bar were tested for penetration into mild steel at 0, 25, and 30 r.p.s. The drawn liners gave average penetrations of 20.80, 15.79, and 13.85 in. at 0, 25, and 30 r.p.s., respectively; average penetrations of 20.83 and 15.91 in. were obtained with the machined liners at 0 and 25 r.p.s., respectively. These data show that both drawn or machined liners penetrate equally well at spin rates of 0 and 25 r.p.s. As a result of the more rearward position of the booster (item no. L1034) penetrations were improved. (2) DRC314 tees were modified to determine the cause of the interference which reduced penetration of the DRB398 liner by about 1 in. at 25 r.p.s. and 4 in. at 0 r.p.s. Penetration tests revealed that the interference was not caused primarily by the 30° taper in the tee cavity. Further tests are planned to determine the effect of the boom and the boom entry hole contour. (3) Ten DRB398 Cu liners, modified to fit a 90-mm. projectile, were fired at standoffs of 4.0, 6.5, and 9.5 in. The highest average penetration obtained (16.40 in. at 6.5-in. standoff) was lower than that for an unmodified DRB398 liner in a ratio approximately equal to the reduction in the base diameter of the liner.

L1036

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Supplement to progress rept. no. 25. Aug. 1952, 7p. incl. illus. table, diagrs. AD-12 175 Secret

The use of a double body projectile, having a rotating stabilizing section and a slowly rotating charge section, to overcome the effect of spin on shaped charge penetration was briefly discussed. Further studies of spin compensation are planned with serrated Cu and Al liners of various flute number and flute depth.

L1037

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 27. Oct. 1952, 17p. incl. tables, diagrs. AD-16 452 Confidential

The effect of a number of variables upon the performance of the DRB398, 42° Cu liner was determined. The variables tested were: (1) the method of manufacture; (2) liner material; (3) type of body assembly (test body and tee); and (4) location of booster. It was concluded that: (a) the liner manufacture method had no effect upon penetration of test assemblies without tees when fired at 7.50-in. standoff; (b) Al liners were only 42% as efficient as Cu liners in penetration tests; (c) DRB321 and DRC376 bodies could be used interchangeably in static penetration tests; the DRC314 tee seriously reduced the penetration of non-rotated rounds; and (d) booster location was important to penetration; the round with the booster positioned in the base plug gave 1.0 in. more penetration than did the projectile having the booster and base element buried in the explosive. Penetration data are given for the Cu liners and spin rate curves are also presented.

L1038

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 28. Nov. 1952, 26p. incl. tables, diagrs. AD-16 453 Confidential

Tests were made to study the relationship of shaped charge penetration with liner angle and standoff, keeping the head of high explosive a constant 3.63 in. The 30° liner with 4.5 lb. of Comp. B produced average penetrations in mild steel of 18.22, 19.20, and 17.25 in. at standoffs of 7.5, 15.0, and 22.0 in., respectively; the 45° liner with 2.75 lb. of Comp. B gave average penetrations of 14.14, 21.20, and 22.21 in. at standoffs of 4.0, 13.0, and 22.0 in., respectively. Penetration data are also plotted for liner angles of 30°, 40°, 50°, and 60° at a standoff of 7.5 in.

L1039

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Supplement to progress rept. no. 28. Nov. 1952, 23p. incl. tables, diagrs. AD-33 332 Secret

Tests were made on 6 lots of serrated liners to determine the effect of flute number and flute depth upon spin rate-penetration behavior of internally fluted liners. The liners were pressed from DRB398 blanks to obtain flute numbers of 36, 45, 60, and 100 with nominal flute depths ranging from 0.010 in. to 0.038 in. at the lower datum. All series of liners gave satisfactory penetration performance. Test results indicated that there was no reversal in the direction of compensation as the number of flutes was increased which is contrary to the effect noted with liners having external flutes. It was concluded that internally fluted liners are much less effective than externally fluted liners in shifting the optimum frequency.

L1040

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 29. Dec. 1952, 25p. incl. illus. tables, diagrs. AD-16 454 Confidential

Four phases of penetration by shaped charges were investigated. (1) Tests were made to determine the effect of standoff upon penetration of 2 series, 1 machined, the other drawn, DRB398 Cu liners. The greatest average penetration for the machined liners was 21.50 in. in mild steel at a standoff of 15.0 in.; for the drawn liners, the greatest average penetration was 21.42 in. at 15.0-in. standoff. Thus, the standoff behavior of the 2 series was very similar although the machined liners gave better penetration at the longest standoff of 22.5 in. The greater uniformity of performance of the machined liners was attributed to their improved symmetry. (2) Studies of the effect of internal configuration of the tee upon penetration were conducted. Data showed that the average penetration of the DRB398 liner fired with the DRC314 tee was 16.01 in., with the DRC314 HW10, 16.2 in., and with the DRC314 HW14, 18.24 in. (3) Ten rounds were poured with 2 different types of pouring funnels or risers to determine the effect on penetration. The charges cast using the Al risers penetrated 1 in.

(5%) more than did those poured from risers made of glazed chemical porcelain. (4) A tee material study was conducted to ascertain the effect on penetration of using malleable Fe, malleable Fe and Mn, and mild steel tees. No differences in performance were observed. Test data are given and analyzed for each of the 4 phases discussed.

L1041

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 30. Jan. 1953, 23p. incl. illus. tables, diagrs. AD-16 658 Confidential

Tests were made to determine the effect of a wire located on the liner axis upon the penetration performance of a shaped charge. Ten rounds were without wires, 10 rounds had the wire drawn taut, 10 rounds had 0.5 in. of slack in the wire, and 10 rounds were assembled with 1 in. of slack in the wire. Some rounds were rotated at 15 r.p.s. The test results indicated that: (1) a taut wire on the axis of the liner greatly reduced charge penetration; (2) a slightly slack wire that may or may not have been on the axis showed interference in a portion of cases; (3) a quite slack wire caused little or no penetration reduction. It was concluded that the presence of a wire in the cavity was not detrimental unless it was located in the direct path of the jet. Further studies of the effect of internal tee configuration upon penetration of machined liners were completed. Results are compared with data obtained from tests of drawn liners. With the exception of the DRC314 HW10 tee, there was no significant difference between the performance of machined and drawn liners. Using this tee, the penetrations averaged 19.2 in. for the machined and 16.2 in. for the drawn liners. Evidently the degree of clearance provided by the DRC314 HW10 tee was sufficient for the machined but not for the drawn liner. In addition, tests were conducted to determine the applicability of a Se rectifier and a condenser in a setback-actuated electric fuze for a proposed HEAT shell arrangement. The test results are given.

L1042

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 31. Feb. 1953, 11p. incl. tables. AD-16 659 Confidential

A study was made to determine the effect of "holding time", the length of time a charge is held at the pouring temperature before casting, on shaped charge penetration performance. The charges of Comp. B were poured into warmed DRC376 test assemblies having DRB396 drawn liners when the melt first reached 85°C and again after a holding time of 1.5 hr. The average penetration of the charges cast as soon as the melt reached pouring temperature was only about 2% greater than those cast 1.5 hr. later.

L1043

Firestone Tire and Rubber Co. (DA33-019-ORD-33). 105-MM. BATTALION ANTITANK PROJECT. Progress rept. no. 32. Mar. 1953, 33p. incl. illus. tables, diagrs. AD-16 660 Confidential

The penetration-spin rate behavior of DRB398 Cu liners, modified by cutting off the base to fit in a 90-mm. projectile (item no. L1035), was observed. At a standoff of 6 in. and at spin-rates of 0, 15, 30, and 45 r.p.s., the penetration in mild steel was 16.39, 15.35, 11.48, and 8.35 in., respectively. In another study, 3 types of Cu liners were tested for penetration into mild steel at various standoff distances. The 3 types are as follows: (1) machined from hand drawn Cu bar, (2) drawn from Cu strip and recoined between matching steel dies, and (3) drawn from Cu strip. Penetration data showed striking differences in the 3 series at long standoff, but little difference at short or optimum standoff. At the optimum standoff of 15 in. (4.5 cone diameters) penetrations for all the liners averaged 21.5 in. At a standoff of 42 in., the average penetration of the machined liners was 20.5 in., the recoined liners 17.5 in., and the drawn liners 13.2 in. The third study was concerned with the performance of Cu liners, Cu liners with thin Al inserts, and both steel and Al liners with thin Cu inserts at 0 and 30 r.p.s. It was supposed that the steel and Al liners with Cu inserts would show penetrations approximating those of the Cu liners, and that Cu liners with Al inserts would be decidedly inferior. However, the latter liners were the best of the composite liners as indicated by the following data:

I	II	III
Cu	0	16.90
	30	13.94
Al insert (20% Al)/Cu shell	0	17.61
	30	11.57
Cu insert (20% Cu)/steel shell	0	15.40
	30	11.39
Cu insert (20% Cu)/steel shell	0	11.13
Cu insert (20% Cu)/Al shell	30	9.09

I = type liner; II = r.p.s.; III = average penetration (in. in mild steel)

L1044

Firestone Tire and Rubber Co. (DA33-019-ORD-33 and DA33-019-ORD-1202). BATTALION ANTITANK PROJECT. Progress rept. no. 35. June 1953, 22p. incl. tables, diagrs. AD-16 751 Confidential

Tests were made to extend the use of data for the 105-mm. liners and charges to other sizes. Therefore, studies were carried out to determine the effect of standoff and rotation on charges and liners scaled down in the ratio of 75/105. A generalized plot of the penetration standoff behavior of this type liner and charge gave a curve which fits the observed data for both 2.5-in. and 3.5-in. charges. A plot was also made showing the effect of rotation on liners of this type; the curve fits the observed data for both the 2.5-in and 3.5-in. liners and charges well within the experimental error.

L1045

Firestone Tire and Rubber Co. (DA33-019-ORD-33 and DA33-019-ORD-1202).
BATTALION ANTITANK PROJECT. Supplement to progress rept. no. 35. June 1953, 21p. incl. illus. tables. AD-20 555 Secret

In static and dynamic firings of smooth and fluted cones, the latter penetrated about 2.5 in. less than expected. In a bearing evaluation, double-body projectiles were fired at a 1700-ft./sec. muzzle velocity to impart a 240-r.p.s. spin to the rotating member. The cages apparently prevented the bearings from functioning properly. The Timken T127 appeared usable but not as satisfactory as the DRC389 assembly. Scaling studies were begun to determine the effect of size upon the penetration-cone and charge behavior. (ASTIA abstract)

L1046

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Aug. 26-Sept. 26, 1951. p. 1-9 illus. tables, diagrs. Confidential

Preliminary tests were started on armor to resist shaped charges. A standoff curve was plotted from test results of 1-in. mild steel plates at 1.25-, 2.25-, 3.25-, 4.25-, 6.25-, and 8.50-in. standoff. The tests were made by using a cardboard tube for the standoff and 0.25 in. was added for the distance back from the edge of the plastic case of the du Pont Jet Tapper to the edge of the conical Cu liner. It was noted that the points of the curve fell on a smooth curve, and the optimum standoff was around 4 in. with little difference in the penetrations obtained from 3- to 6-in. standoff. A preliminary test using plate glass showed that it was better than mild steel for resisting shaped charges on a thickness as well as weight basis.

L1047

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Sept. 26-Oct. 26, 1951. p. 10-49 incl. illus. tables, diagrs. Confidential

Various types of glasses tested (Pittsburgh polished plate glass, rough, rolled plate glass, Pittsburgh solid glass blocks, Mississippi polished wire glass, etc.) did not produce outstanding results. It was established that 5 in. of glass will stop a du Pont Jet Tapper as well as 7 in. of mild steel. A preliminary evaluation of HCR showed that while it was better than steel on a weight basis, it needed further refinement in order to be as effective as glass, particularly to reduce the effect of perforations due to the nonhomogeneous nature of the material.

L1048

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Oct. 26-Nov. 26, 1951, p. 50-89 incl. illus. tables, diagrs. Confidential

Tests were made on a borosilicate glass, and an equation was developed that shows the total penetration for any thickness of this glass. It is shown that a small thickness of glass is relatively more effective than greater thicknesses when a comparison is made with mild steel. Comparative results from a number of asphalt binders showed that harder materials are the most effective. Multiplate bullet-proof glass was found to be good but not much better than plate glass. It was noted that glass appeared to be more resistant perpendicular to the surface than parallel to the surface. Cushioning materials seemed to be of little or no stopping power when used between plates of glass.

L1049

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Nov. 26-Dec. 26, 1951. p. 90-130 incl. illus. tables, diagrs. Confidential

Tests showed that there was little difference in the effectiveness between plate glass and borosilicate glass. Further tests showed that when both plate glass and Herculite (a tempered glass) were tested parallel to the ordinary surfaces, the penetration was much greater than when tested perpendicular to the surfaces. This condition also appeared when shots were fired at 60° obliquity. The effect of using a thin face plate with glass armor was found to be relatively unimportant in regards to total penetration.

L1050

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Dec. 26, 1951-Jan. 26, 1952. p. 131-171 incl. illus. tables, diagrs. Confidential

A new lot of du Pont Jet Tappers gave a slightly higher penetration value against mild steel (7.30 in.) than the previous lot of Tappers (7.01 and 6.93 in.). Tests made on armor containing Lilesville gravel showed that the binder had only a minor effect on jet penetration; however, it was brought out that 1 in. of gravel was more effective than 1 in. of steel in stopping the jet, and consequently on a weight basis 13 lb. of gravel will have about the same stopping power as 48 lb. of mild steel. One test with ice showed that it was not very effective in stopping a jet. Formica FF55 made with Fiberglas cloth appeared to be very effective in stopping the jet, but the material was very expensive. Plain cellulose acetate appeared to have little or no effect in stopping the jet. Additional tests with glass materials showed that they were not as effective as plate glass, but further tests will be made.

L1051

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Jan. 26-Feb. 26, 1952. p. 172-204 incl. illus. tables, diagrs. Confidential

Tests showed that 2-in. glass balls were more efficient than 1-in. glass marbles for stopping a shaped charge. Carborundum and Emerycrete (hard natural carborundum) were of little value in stopping shaped charges. Preliminary tests were continued on magnetic fields. Several glass mat resin combinations from the Winner Manufacturing Co., glass cloth, and glass mat combinations with asphalt were tested. None of the samples shattered but there was a slight tendency to delaminate.

L1052

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Feb. 26-Mar. 26, 1952. p. 205-255, incl. illus. tables, diagrs.
AD-12 173 Confidential

Data are given for tests made with mixtures consisting of 86% by weight of 2-in. Lilesville Gravel, 3.5% by weight of wood flour, and 10.5% of 150° m.p. asphalt. It is pointed out that it made very little difference what binder was used because the gravel was the effective material in stopping the jet. Erratic results obtained from Lot 3 du Pont Jet Tappers are discussed.

L1053

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Mar. 26-Apr. 26, 1952. p. 226-258 incl. illus. tables, diagrs.
AD-15 320 Confidential

Additional tests made by firing shaped charges through magnets showed that penetration was less than when the charges were fired through unmagnetized material. The effect of the size of polished plate glass blocks on resistance to penetration was investigated. It was shown that 2-in. square pieces of glass were inferior to large pieces in stopping power. Tests with extra dense flint glass and plate glass showed that there was little difference in stopping power between the 2 glasses. A limited number of tests with white Carrara glass showed it to be slightly better than plate glass. An additional panel with 2-in. diameter glass balls was tested, and it proved to be better than 1 with 1-in. balls. Tests with single pieces of Lilesville gravel showed that the previous idea was correct, i.e., 1 in. of gravel is about equal to 1 in. of mild steel in ability to stop shaped charges. Tests with Lot 4 du Pont Jet Tappers against mild steel at 4.25-, 8.25-, and 12.25-in. standoffs showed that the standard derivation increased with increased standoff. Formica FF55 was found to be reasonably effective in stopping shaped charges; F55 did not appear to offer any advantages as compared with plate glass, but it was the best plastic material tested.

L1054

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Apr. 26-May 26, 1952. p. 259-289 incl. illus. tables, diagrs.
AD-12 174 Confidential

A review of data on polished plate glass showed that for stopping shaped charges the size of the du Pont Jet Tappers or CIT charges, about 3.6 in. of glass will give the minimum thickness of glass and mild steel, and 5.7 in. of glass will give the minimum weight of armor. Tests showed that the jet penetrated more glass at high obliquities (45° and 60°) than it did when tested at normal to the surface. It was pointed out also that there was some slight possibility that glass was more resistant to penetration when the jet entered the sheet with the direction of rolling than when it entered across the direction of rolling. Tests showed that it made no difference what arrangement of glass and steel was used up to 0.25-in. thick face plate. Tests showed that magnetized homogeneous armor plate was superior to unmagnetized material in stopping shaped charges.

L1055

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. June 26-July 26, 1952. p. 291-323 incl. illus. tables, diagrs.
AD-12 175 Confidential

The research group at Flintkote reported that: (1) results obtained at a standoff of 4.25 in. with du Pont Jet Tappers and 24ST Al conform to the simple residual penetration theory; (2) tests made using polished plate glass and 24ST Al showed that this combination gave the same stopping power as mild steel; (3) du Pont Jet Perforators, smaller charges than the Jet Tappers, were tested against plate glass, 24ST Al, and mild steel; results indicated that the usual scaling laws fail to apply for the Al or steel, though an apparent relationship was shown for glass; (4) hand-placed and vibrator-compacted Lilesville gravel performed equally well against jets; (5) tests on a Ciba casting resin (Araldite) and

2 in. of Lilesville gravel indicated that though the resin-gravel bond was strong, it offered no better performance than asphalt as a binder; (6) White Carrara glass equalled polished plate glass in resisting jets; (7) 2.25-in. diameter glass balls (density 146.4 lb./cu. ft.) performed better than 1-in. glass marbles in resisting jet penetration; (8) polished plate glass was tested to determine whether area of the glass or volume of the glass affects jet penetration; no conclusions were drawn; (9) resin-bonded Fiberglas cloth blocks (WR565) from the Winner Manufacturing Co. showed signs of delamination after test firings; (10) "Lazy Slurry," an extremely dilatant material composed of distilled H_2O, 5% $Zn(NO_3)_2$ solution, 5% Calgon solution, and precipitated $CaCO_3$, showed no merit when tested with Jet Tappers.

L1056

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. July 26-Aug. 26, 1952. p. 335-370 incl. illus. tables, diagrs.
AD-15 361 Confidential

The effect on penetration of varying the size of the glass targets was observed and a correction was made to the equation relating thickness of plate glass in the target to total penetration. Data indicated that on a weight basis, glass balls were superior to glass plate in resisting shaped charge jets. Penetration tests on Zr plates showed that this material evidently follows the simple residual penetration theory. This theory was compared with the empirical equation, developed at Flintkote, for penetration in glass targets and the resemblances and differences were discussed briefly. Penetration tests made in mild steel plates showed that Lot no. 5 du Pont Jet Tappers averaged 7.56 in. as compared with 6.89 in. for Lot no. 4. Erratic results were obtained when Jet Tappers were fired into steel plates magnetized by an electromagnet. Tests were made on cylinders of N to determine whether a shaped charge jet was slowed by passage through the highly compressed gas; no significant effects were observed. Further tests on "Lazy Slurry" showed that various formulations of this type of dilatant material were not effective in combatting jet effectiveness. Additional tests on Lilesville gravel (86%) wood flour (3.5%) asphalt (10.5%) mixes at 45° and 60° obliquity substantiated results obtained earlier at 0° obliquity. Preliminary tests were conducted on a sandwich armor of gravel mastic and glass blocks; no conclusions were drawn. In addition, the results of tests made at Aberdeen Proving Ground using 3.5-in. shaped charges against solid glass blocks are included.

L1057

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Aug. 26-Sept. 26, 1952. p. 371-399 incl. tables, diagrs.
Confidential

Data were collected from 269 shots fired into varying thicknesses of 2-in. Lilesville gravel in the original HCR2 formula at 4.25-in. standoff and obliquities of 0°, 45° and 60°. An empirical relationship was obtained correlating the gravel weight, and also the weight of HCR2, with the total weight to the mean depth of penetration. Comparisons were made with other materials and it was found that 1.0 lb. of mild steel, 0.25 lb. of plate glass, 0.34 lb. of Lilesville gravel, 0.40 lb. of HCR2, and 0.51 lb. of 24ST Al were equivalent in stopping shaped charge jets. In tests 3-in. to 6-in. size Lilesville gravel showed little performance advantage over the 2-in. size. The results of tests on 24ST Al plates were correlated using the empirical formula developed by Flintkote and Pugh's simple residual penetration theory. In further studies, Burundum, a tabular shaped, non-metallic, high density, ultra high-fired ceramic body, 2-in. porcelain grinding balls, and flint pebbles 1 5/8 in. to 2 in. in diameter were tested with the conventional asphalt binder against Lot no. 5 du Pont Jet Tappers. Comparison with Lilesville gravel indicated that Burundum offered no advantages on a weight basis, that the porcelain balls were slightly better than the gravel, and that the flint pebbles were equal to the gravel in performance. A cold-setting mastic (Thiokol LP2, plasticizers, and a catalyst) was also examined and found promising. The only test conducted against magnetized steel plates indicated that the penetration of the charge (Lot no. 5 Jet Tapper) was retarded.

L1058

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Sept. 26-Oct. 26, 1952. p. 400-423 incl. illus. tables, diagrs.
AD-15 362 Confidential

Further investigation of 3-in. to 6-in. size Lilesville gravel indicated that it was superior to the 2-in. size Lilesville gravel in resisting shaped charge jets. In test firings into magnetized and unmagnetized mild steel plates using du Pont lot no. 5 Jet Tappers and CIT charges, erratic and contradictory results were obtained. A few 3-in. Corning borosilicate glass balls imbedded in wood flour mastic were tested against du Pont Jet Tappers. It was concluded that balls of this diameter resisted shaped charges very well.

L1059

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Oct. 26-Nov. 26, 1952. p. 424-480 incl. illus. tables, diagrs.
Confidential

Tests were made to determine the effect of mild steel face plates on glass targets used against shaped charges. The results indicated that the effectiveness of glass, on a thickness basis, decreased as heavier steel face plates were employed. A graphical procedure was developed for predicting the effectiveness against jet penetration of various combinations of mild steel and glass. A test on 2-in. porcelain balls indicated that these balls were superior to 2-in. Lilesville gravel in stopping a shaped charge. Molded rubber press pads, 12 in. x 12 in. x 4 in. and weighing 26 lb., were tested against du Pont lot no. 5 Jet Tappers. The results showed that the rubber pads were not satisfactory on a thickness basis but were good on a weight basis at stopping shaped charges. Two-in. Lilesville gravel with water as a binder was tested using du Pont Jet Tappers. It was concluded that the gravel performed better with a wood flour mastic. Further studies on magnetized steel gave unreproducible results concerning the penetration of charges. A mockup of a section of tank armor containing Lilesville gravel wood-flour mastic gave satisfactory results when tested with Jet Tappers.

L1060

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Nov. 26-Dec. 26, 1952. p. 481-552 incl. illus. tables, diagrs.
Confidential

The equations developed for shaped charge penetration through glass targets were extended to include both a thickness and weight relationship for targets containing Lilesville gravel and glass. The new equations fit the experimental data with precision, their constants being determined from the density of the target material and the penetration of the shaped charge in mild steel. These expressions apply to targets that do not follow the residual penetration laws formulated by E. M. Pugh and others. At present, however, the equations apply only to targets tested at a single standoff with du Pont Jet Tappers and Carnegie Institute of Technology shaped charges. By their use, penetrations in composite targets of Al, mild steel, gravel, and glass can be predicted. Further tests on magnetized steel indicated that shaped charge penetration was occasionally retarded though the results were erratic. In addition a study was made of cold-setting mastic for use in gravel-type armor.

L1061

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Dec. 26, 1952-Jan. 26, 1953. p. 553-574 incl. illus. tables, diagrs.
Confidential

Tests indicated that HCR2 type armor, 10 and 14 in. thick, offered excellent protection against 3.5-in. shaped charge rockets fired at a range of 100 ft. The behavior of jets penetrating magnets was not resolved by photographs of the oscilloscope traces of a number of shots. Obsidian, a glass-like mineral of specific gravity 2.344, was tested and found satisfactory for defense against shaped charges, though slightly inferior to glass in performance. Further tests were made using cold-setting mastic as the binder for gravel or glass. Though not as good performance-wise as the hot asphalt—wood flour mastic, its convenience in use may counteract this.

L1062

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Progress rept. Jan. 26-Feb. 26, 1953. p. 575-596 incl. illus. tables, diagrs.
Confidential

Further tests of HCR armor at Aberdeen Proving Ground indicated that it provided satisfactory protection against shaped charges, AP projectiles, and HE shells. Si, density 2.35, was examined using du Pont Jet Tappers. Plots of the individual shots agree reasonably well with a curve calculated for the residual penetration. In addition, various plastics in sheets about 6-in. square and of different thicknesses were tested with du Pont jet tappers. In 1 series the Jet Tappers were placed on their sides, and a 1/16-in. steel plate was used to prevent the jet from perforating the plastic test material or the steel. Observations were made to determine if the steel plate bulged up, as in the case of glass and Formica FF55, or down, as in the case of 24ST Al, in an attempt to determine the usefulness of the test material in protecting against shaped charges. It was concluded that this method is not reliable.

L1063

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Supplementary rept. Jan. 26-Feb. 26, 1953. p. 597-608 incl. tables, diagrs.
Confidential

The Aberdeen Proving Ground data on the use of glass as tank armor for defeating 3.5-in. shaped charges (item no. L357) were studied and analyzed in an attempt to unify tests on tank armor. By the use of empirical relationships suggested by earlier Flintkote tests, the calculated values of the total penetration, P, were obtained and found to agree remarkably well with experimental values of P. It was concluded that a reasonably satisfactory method had been developed for explaining the penetration of 3.5-in. shaped charge rockets in glass targets and for correlating the results with earlier tests made using Jet Trappers (cone diameter 1.75-in.) and Jet Perforators (cone diameter 0.875 in.).

L1064

Flintkote Co. (DA30-069-ORD-245).
[ARMOR TO RESIST SHAPED CHARGES], by P. R. Smith. Final rept. July 1, 1953, p. 609-627 incl. diagrs.
Confidential

The most important aspects of the Flintkote contract on armor to protect tanks against shaped charges by static means were reviewed. From the investigations it was concluded that glass and gravel were superior to steel on both a weight and thickness basis, armor of these materials offering 20% less thickness and 50% less weight than steel. Estimation of the effectiveness of any combination of glass and gravel against shaped charges, AP projectiles, and HE shells was made by the use of correlation methods. In addition, a satisfactory method was developed for predicting the total penetration in armor composed of any number of layers of different materials, based on the individual performance of each of the materials. Tests were made on 24ST Al, gravel, and glass as target materials, and comparisons were made from the standpoint of residual penetration theories. Other tests showed that Si and Zr offered no particular advantages as armor, while certain ceramic materials held promise. A number of plastic materials were also investigated with none giving outstanding protection. Formica FF55, a fiber-glass cloth with a melamine resin binder, was 1 of the best of these; however, it was inferior to glass in performance. Results obtained in the jet firings through a magnet were not consistent. Indexes covering all of the subjects, tables, and plates presented in the repts. produced under this contract are also included.

L1065

[Foreign Matériel Branch], Aberdeen Proving Ground. TEST OF RIFLE-GRENADE, HOLLOW CHARGE, JAPANESE, by G. B. Jarrett. July 22, 1943, 2p. illus. diagr. (BRL Memo. rept.) Restricted

The general characteristics of the Japanese rifle grenade are listed. When the grenade was fired statically against a mild steel billet, the penetration depth was 3 7/8 in. with 0.5-in. diameter at the top of the penetration.

L1066

Forschungs Munition-Kommission, Lübeck. ON NEW STUDIES WITH HOLLOW CHARGES (LONG RANGE) (Über neue Untersuchungen mit H-Ladungen (Weitschuss)). Nov. 11, 1944, 2p. (OTIB rept. no. 1249, Misc.-1 - In German) Unclassified

Experiments with shaped charges showed that the relationships between the amount and type of explosive, shape, and liner thickness were poor. Very high initial velocities (ranging from 1600 to 2000 m./sec.) were reached. The shaped charge loading was approximately the same as in Tellerminen, 9 to 10 kg. of Trialin 106. At a standoff of 20 m.; the shells penetrated 100 mm. At 50 m., the penetration was approximately 80 mm. with a hole of 200 mm. diameter. The target plates had a tensile strength of 90 to 120 $kg./mm.^2$. Composite liners were used. At 100 m., these liners penetrated 35 mm. of wood, at 150 m., 20 mm. of wood, and at 50 m., 40 mm. of wood.

L1067

Forschungsabteilung des Heereswaffenamtes, Berlin. MATHEMATICAL EXAMINATIONS REGARDING THE DEPENDENCE OF THE EFFECT OF ENCASED HOLLOW CHARGES ON THEIR DETERMINANT QUANTITIES (Rechnerische Untersuchungen über die Abhaengigkeit der Wirkung verkleideter Hohlsprengkoerper von ihren Bestimmungsgroessen), by W. Trinks. Apr. 30, 1943. (Physics of Explosives rept. 43/6; Trans. as rept. no. BIOS/Gp.2/HEC 2592, 1v. incl. diagrs.; Inclosure 1 to MA London rept. no. R3654-46; Also trans. as rept. no. BIOS/Gp.2/HEC 5762, 73p. incl. diagrs.; Inclosure 1 to MA London rept. no. R2813-48; And also trans. as OTIB rept. no. 1484, 1v. incl. diagrs.). Restricted

The large number of factors affecting shaped charge performance are considered mathematically. The principal matters investigated were: apex angle, hole volume, standoff, penetration depth, cavity effect, detonation, and the effect of rotation. The validity of the equations that were derived was verified experimentally. It is stated that a bottle shape for explosive charges is the most "suitable" form.

L1068

Forschungsabteilung des Heereswaffenamtes, Berlin. PENETRATION OF HOLLOW CHARGES WITH LINERS. RESULTS OF MATHEMATICAL INVESTIGATIONS INTO THE EFFECT OF HOLLOW CHARGE SHAPES (Durchschlagsleistung verkleideter Hohlsprengladungen. Ergebnisse der rechnerischen Untersuchungen über den Einfluss der Ladungsform), by W. Trinks. Apr. 1, 1944, 49p. (Sprengstoffphysikbericht 44/10; Trans. as rept. no. BIOS/Gp.2/HEC 2594, 54p. incl. illus. diagrs.; Also trans. as OTIB rept. no. 1483, 13p.) Restricted

A method of calculation to determine the depth and shape of a crater obtainable by means of a shaped charge was used with a series of charge shapes. Topics discussed include the effect on penetration depth of charge shapes, limitation of penetration depth by disintegration of the jet, and consideration of high explosive energy when selecting a charge shape.

L1069

Forschungsanstalt Graf Zeppelin, Esslingen. REPORT ON THE MEETING OF THE STUDY GROUP ON HOLLOW CHARGES ON APR. 28, 1942 (Bericht über die Sitzung der Erfahrungsgemeinschaft H-Ladung von 28. Apr. 1942). Apr. 30, 1942, 2p. (OTIB rept. no. 1249, Misc.-3 - In German) Unclassified

A lecture on the improvement of the effect of shaped charges is summarized. The design of a quickly-responding impact fuze and rapid completion of detonation are considered.

L1070

Forster, M. von.
EXPERIMENTS WITH COMPRESSED GUN COTTON. Van Nostrand's Engineering Magazine, v. 31, Aug. 1884: 113-119. (Trans. from the German by Lt. J. P. Wisser, US Army)

In experimenting with guncotton, it was found that hollowed charges were more effective than solid charges.

Fort Belvoir see Engineer Board; Engineer Research and Development Laboratories; Engineer School; Mine Warfare Panel; Engineer Center

L1071

Frankford Arsenal.
EXPERIMENTS TO DETERMINE THE BEST FORM OF BOOSTER, by J. W. Taylor. Sept. 16, 1919, 11p. diagrs. Unclassified

An investigation was made to determine the most suitable form of booster when the bursting charge of a shell is in direct contact with the booster, and when there is a considerable gap between the 2. Results are given of fragmentation tests for various boosters. Photographs are shown of representative fragments. A test was made with boosters placed on an 0.08-in. C tool steel plate, and then exploded to compare the damage on the plate from deformation and from erosion.

L1072

Frankford Arsenal.
MECHANISM OF COLLAPSE OF CONICAL HOLLOW CHARGE LINERS, by H. P. George. Oct. 1945, 9p. illus. diagrs. (Rept. no. R-667) Confidential

A metallurgical examination of the slugs from M9A1 liners, selectively carburized, was made to obtain information on the mechanism of the collapse of shaped charge liners. Apparently the flattened apex of the M9A1 conical liner is inverted by the pressure wave, the liner collapsing inward from apex to base. Evidently the material near the inner liner surface is squeezed out along the symmetrical paths of escape as the metal meets along the axis. This explains the formation of the high-speed, slender jet which moves ahead of the relatively low-speed slug. Heating of the slug is brought about by the energy expended in liner deformation. Microstructural examination of the centers of the slugs indicates that maximum temperatures in the range of 1400°F to 2400°F were reached; at the surface of the slugs, where less deformation occurred, the temperatures probably ranged from 950°F to 1200°F. Data comparison with observations made of the slug obtained from the shaped charge liner of a 7.2-in. rocket shows that the larger liners' collapse process is similar to that of the liners tested. It is concluded that the test results are in substantial agreement with Birkhoff's jet theory.

L1073

Frankford Arsenal (Proj. no. TM3-5201D).
SPECIAL CONES. Quarterly progress rept. June 1-Aug. 31, 1950. 1p. TIP S50705 Secret

Five hundred liners are being manufactured for shipment to the National Bureau of Standards. Improved gaging methods are being investigated in an effort to insure liner uniformity.

L1074

Frankford Arsenal.
RNR REPORT ON 120-MM. SPIN-STABILIZED PROJECTILE WITH NONROTATING SHAPED CHARGE, by S. Dubroff. Aug. 1951, 11p. illus. Confidential

The historical and technical background of the 120-mm. HEAT, T230, spin-stabilized round with nonrotating charge is presented. For this projectile, a design was proposed in which the inner member, containing the shaped charge, is cradled in bearings to prevent this body from picking up full spin on the firing of the gun. The outer, heavy-walled member picks up full spin, thus providing the necessary projectile stability. It is desired to incorporate the largest possible diameter conical Cu liner in this projectile in order to improve performancewise on the best 120-mm. AP shot. The design and development of this projectile-type are continuing.

Frankford Arsenal see also Ordnance Laboratory

L1075

Gardiner, J. F.
USE OF SHAPED CHARGE PROCESS FOR OPEN HOLE SHOOTING. World Oil, v. 131, Aug. 1950: 99-103.

The application of the shaped charge to open hole completions is discussed, and the appearance and performance of the various types of gun equipment used are described. The type G gun equipment, containing an expendable carrier, is made of cast Fe and employs 7 charge assemblies located at 6-in. intervals and spaced 90° angularly. The charge assembly consists of a cylindrical cast Fe container closed on 1 end, a cartridge unit and a cast Fe cap. Cast Fe was chosen as the best for all structural parts of the type G gun. It was concluded that the explosives used in the type G gun were considerably less dangerous to handle than nitro. Any length of zone could be covered with open hole shaped charge equipment in a minimum of time. With the type G gun equipment, it was possible in many cases to cover the complete zone in 1 run. Shaped charges functioned satisfactorily at temperatures approximately twice as great as those at which nitro could be used. Open hole shaped charge shooting also proved useful in limestone areas which responded to acidizing.

L1076

[German document; original source unknown].
THE DEPENDENCE ON SPIN OF THE EFFICIENCY OF HL-PROJECTILES, by Gerche. n.d. (Trans. as rept. no. BIOS/Gp.2/HEC 192, 6p. incl. tables, diagrs. missing) Secret

A study was made on the effect of rotation on the mean efficiency of fin- or spin-stabilized shaped charges projectiles using existing firing data results.

L1077

[German document; original source unknown].
EXPERIMENTS AND DEVELOPMENTS TOWARD THE IMPROVEMENT OF THE EFFECT OF HOLLOW CHARGES BY MEANS OF NOZZLES (Versuche und Entwicklungen zur Leistungssteigerung der Hohlladungen durch Vorstaz von Düsen). n.d. [5]p. incl. diagrs. (Appendix no. 3 to rept. no. 544/42 g. Kdos. Wa Prüf 1 1V/2b; OTIB rept. no. 1249, AOO-3 - In German) Unclassified

The concentration of the shaped charge effect by nozzles in front of the air space depended upon the height and the angle of the nozzle. The height in turn was determined by the standoff and the shape of the charge. A graph of the penetration plotted as a function of the nozzle angle would show maxima at 50° and 75°. Performance was improved by 7%. The same effect was obtained by using metal discs fastened to the outlet of the air space. The detonation jet burst the disc open and bent it into the nozzle shape. In addition, the gas clouds were compressed before the burst. The application of nozzle discs resulted in improved penetration about 10 to 15%. Optimum thickness for the nozzle plate was 3.5 mm. for a 7.5-cm. Gr. 38 Hl/B shell. The thickness of the nozzle plate should be increased with the caliber. (APG abstract)

L1078

[German document; original source unknown].
[EXTRACTS FROM THE ILLUSTRATED RECORD OF GERMAN ARMY EQUIPMENT, 1939-1945, VOL. 5]. n.d. 18p. incl. diagrs. Unclassified

Descriptions and illustrations are given of the Panzerstabmine 43-, 300-, and 400-g. hollow charge S-mine, 12.5-, 15-, and 50-kg. hollow demolition charges, 3-, 3.6-, and 4-kg. antitank magnetic hollow charges, and 1.2- and 3.2-kg. hollow ring charges.

L1079

[German document; original source unknown].
5-CM. HOLLOW CHARGE SHELL FOR AUTOMATIC AAA 41 AND KWK (5-cm. Hohlladungsgranate für Flakautomat 41 und KWK), by Trinks. n.d., [2]p. (OTIB rept. no. 1249, AOO-10 - In German) Unclassified

A hemispherical-shaped space is suggested with a thick wall nozzle and circular ignition. This shape is chosen because of the standoff introduced by the long shell nose and because it is least affected by high speed and spin. The circular ignition is designed to match detonation front and air space surface. It is accomplished by a concrete disc embedded in the blast charge between detonator and tip of the cone. (APG abstract)

L1080

[German document; original source unknown].
GERMAN AMMUNITION DEVELOPMENT REPORT. n.d. (Trans. as rept. no. BIOS/Gp.2/HEC 10211, p. 21-22, 24-26, 41-42 50, 52-53, diagr.; Inclosure 1 to MA London rept. no. R4643-46) Unknown

Brief summaries are given of the development of the German shaped charge shell/C with folding tail unit, and the 8-cm. and 10-cm. shaped charge projectiles. Tests with Panzerfausts against spaced armor combinations are described briefly.

L1081

[German document; original source unknown].
[GERMAN SHAPED CHARGE WEAPONS]. n.d. (Appendixes 3, 7, 7a, 14, and 40 to rept. no. BIOS/Gp.2/HEC 5103, 17p. incl. diagrs.) Unclassified

The purpose, description, directions for use, packing, storage, and safety regulations are given for the magnetic antitank charge, Panzerfaust 30 and 60, circular shaped charge (10 and 17 cm.), antitank rocket gun 54, and a 15-kg. shaped charge (demolition charge).

L1082

[German document; original source unknown].
REPORT MADE BY ALBRECHT MAASS, DIPL. PHYSICS, AT HIS INTERROGATION. n.d. (Trans. as rept. no. BIOS/Gp.2/HEC 527, 12p. incl. diagr.) Unclassified

The brief part of this rept. dealing with shaped charges describes a late German development, the "encased" charge. The charge was sheathed with a light alloy which vaporized on detonation and greatly increased the efficiency of the charge. The flame jet is reported to have a temperature range of 4000°-5000°C, and to travel at a speed of 5,000 m./sec. It was suggested that this principle be employed to explode enemy bombs before they reach their target.

L1083

[German document; original source unknown]. REVIEW OF INVESTIGATIONS OF VARIOUS SHAPES OF HOLLOW CHARGES AND THICKNESSES OF DIE-CAST ZINC LINERS (Zusammenfassender Bericht über Untersuchungen verschiedener Hohlraumformen und verschieden starker Verkleidungen aus Zinkspritzguss), n.d. [20]p. incl. diagrs. (Appendixes to rept. no. 554/42, g. Kdos. Wa Prüf 1 IV/2b; OTIB rept. no. 1249, AOO-4 - In German) Unclassified

The hemispherical, bell, and cone-shaped hollow charges were compared. The cone was found to cause penetration 25%, the bell 15%, deeper than the hemispherical. The gain in depth was compared with a loss in cross section. Zn was found to be as effective as steel for liner material. It has the advantage of not tending to form plugs and perhaps of causing fatal Zn vapor in the interior of a tank. The best form for a liner is 1 with parallel interior and exterior curved surfaces. The best thickness of the liner depends upon the metal used. (APG abstract)

L1084

[German document; original source unknown]. THREE-KILO ADHESIVE HOLLOW CHARGE HALF-HI-3. MEMORANDUM ON USE AND MANIPULATION. n.d. 3p. incl. illus. (RTP/TIB trans. no. 2374 issued by the Ministry of Aircraft Production) (Reference obtained from Technical Intelligence Bureau, Ministry of Supply list of translations, 1935-1946, p. 291) Unclassified

A detailed description of this shaped charge and instructions for operation are reported. The cavity is lined with sheet Fe. Three magnets on a plastic base plate are provided for attachment of the charge to a tank or other metal target. Three prongs can be fitted over the magnets for use against wood.

L1085

[German document; original source unknown]. VIEWS ON... INVESTIGATION ON THE EFFECT OF HOLLOW CHARGES MADE OF SUBSTITUTE EXPLOSIVES. n.d. (Trans. as rept. no. BIOS/Gp.2/HEC 2586, 7p. tables, diagrs.) Secret

In a German Explosive-Physics rept. no. 43/8 by Möller and Wolk (item no. L1476), it was pointed out that explosives were found that could be substituted for TNT, hexogen, and PETN. Nipolit was mentioned, and tests were made with it by Reinsdorf, giving best results in the case of solid armor plate of 100 mm. thickness. Tabular results are shown for various explosives tested in conical charges.

L1086

[German document; original source unknown]. SUMMARY REPORT ON THE DEVELOPMENT AND APPLICATION OF HOLLOW CHARGE PROJECTILES (Zusammenfassende Darstellung der Entwicklung und Verwendung von Hohlladungen in Geschossen). Oct. 28, 1941, [9]p. incl. diagrs. (Nr. 1787/41 g. K. Wa Prüf 1; OTIB rept. no. 1249, AOO-5 - In German) Unclassified

A list of references, covering the years 1883 to 1935, is given on the development of the shaped charge principle. Brief summaries are given of 3 publications in the above list including: M. von Förester's "Test with Compressed Guncotton" ("Versuche mit comprimierter Schiessbaumwolle"); A. Stettbacher's "Blast and Explosive" ("Schiess-und Sprengstoff"), and a patent. Diagrams show various ways of initiating charges. A summary is given of a rept. (title not given) on the developmental experiment of Thomanek using TG 70 type 34. The front armor was dented about 10 mm.. and the back plate was cracked and partially splintered. The experiments with TG 70 in its present form were unsuccessful against 30-mm. thick plate having a tensile strength of 120 kg.

L1087

[German document; original source unknown]. DEVELOPMENT OF HOLLOW CHARGES. 1942. (Trans. as OTIB rept. no. 1468, 2p.) Restricted

A brief survey of shaped charge development in Germany is listed covering the years 1883-1940. The significant results are mentioned.

L1088

[German document; original source unknown]. MISZNAY (SCHARDIN) EFFECT. 1944, 7p. incl. diagrs. (Memorandum from Dr. Osenberg's file; Trans. as OTIB rept. no. 1984, classified "Restricted", 4p.; Also transmitted by ALSOS Mission, USFET, Ref: GHW/297, 2p.) Confidential

Experiments on and plans for weapons utilizing the Misznay effect - i. e., employing the detonation from a shaped charge to accelerate a solid object - are reported. An infantry weapon (known as "cannon without tube") for use against armor is described: discs having a weight ratio of 3:4 to the charge are stated to have an initial velocity of about 8,000 ft./sec. and an angle of scattering of 10 ft. of arc at a distance of 400 ft. The same weapon, with a segmented disc, was proposed to produce shrapnel. A rocket warhead for antiaircraft use was also developed on this principle. The covering letter from the ALSOS Mission summarizes the history of the Misznay effect; 2 detailed illustrations are reproduced.

L1089

[German document; original source unknown].
PENETRATION OF CERTAIN [GERMAN] AT WEAPONS. [1944?]; 2p. (Trans. as OTIB rept. no. 856) (Covering letter from office of the Chief of Ordnance, War Dept.) Unclassified

Penetration data are given for German rifle grenades, 5-cm. antitank guns (Pak 38), 7.5-cm. Gr. 38 HL/A antitank guns, 7.5-cm. light infantry howitzer, 10-cm. field howitzer, 15-cm. heavy self-propelled howitzer, 15-cm. heavy field howitzer, and magnetic antitank shaped charges.

L1090

[German document; original source unknown].
ON THE SUBJECT OF HOLLOW CHARGE EFFECTS AND EXPERIMENTAL RESULTS RESULTING FROM EXPERIMENTS CARRIED OUT WITH EXPLOSIONS HAVING HIGH SCATTERING POWER, by G. O. Erb. [Feb. 1944]. (Trans. as rept. no. BIOS/Gp. 2/HEC 323, 29p. incl. diagrs.) Secret

The initiation of shaped charge shells was investigated, and the author states that, by an added cap construction [standoff] of 10 cm., he obtained the same penetration results with high velocity projectiles as with stationary demolitions. Tests were made on the initiation at various points on the surface of the charge simultaneously with initiation at the end, and improvement in penetration depth is reported. The electrical phenomena that accompany HE shaped charge detonations were investigated, and evidences from Geiger tubes of radiation were noted to such an extent it was concluded that detonating HE shaped charges may serve successfully as firing elements for atom transformation.

L1091

[German document; original source unknown].
V_0 = 2000 M. PER SECOND WITHOUT USING A GUN BARREL (V_0 = 2000 m./sek. ohne Verwendung eines Rohres), by W. Badstein and W. Osenberg. Oct. 28, 1944, 14p. incl. illus. diagrs. (Inclosure 1 to MA Paris rept. no. R894-47) (Trans. as rept. no. BIOS/Gp. 2/HEC 11523, 14p. incl. illus. diagrs.; Inclosure 1 to MA London rept. no. R2831-47) Secret

Employment of the Misznay-Schardin effect to accelerate a disc at a velocity of 6400 ft./sec. without a gun barrel or projector is reported. Results of tests against tank targets and as an antipersonnel weapon (shrapnel) are described. Diagrams of the proposed application of this principle in antiaircraft rocket warheads are included.

L1092

[German document; original source unknown].
CALCULATIONS RELATIVE TO THE WEAPONS OR WARHEADS DEVELOPED FROM THE SCHARDIN EFFECT, by W. Badstein and W. Osenberg. Dec. 1, 1944. (Trans. as rept. no. BIOS/Gp. 2/HEC 11522, 30p. incl. illus. diagrs.; Inclosure 1 to MA London rept. no. R2875-47) Secret

Theoretical studies and tests of weapons employing the Misznay-Schardin effect are reported and photographs reproduced. The rocket warheads for antiaircraft use are said to give an additional forward acceleration to shrapnel of 6380 ft./sec. The data given for a small and a large trench mine include range, dispersion, and velocity of the shrapnel.

L1093

[German document; original source unknown].
ON THE DEVELOPMENT OF ARMOR-PIERCING AMMUNITION AND ITS CORRESPONDING ELECTRIC FUZES, by G. O. Erb. May 1945. (Trans. as rept. no. BIOS/Gp. 2/HEC 182, Part III, 14p. incl. diagrs.) Confidential

Mechanical fuzes showed ignition lags below 10^{-3} sec.; if shaped charges are to be used in a moving projectile, the ignition delays should not be longer than 10^{-5} sec. for speeds exceeding 500 m./sec. Short-time igniters are described; test results showed ignition times of at least 10^{-5} sec. with working voltages of 1.5 to 2 volts. The "thermal-element", discovered by Erb, is described and is the source of energy for the short-time igniter. A rocket projectile (the Panzerschreck) is discussed which employs this short-time igniter.

L1094

Globe American Corporation, Kokomo (DA33-008-ORD-391).
DESIGN AND DEVELOPMENT OF T57E1 HEAT, FRAGMENTATION BOMB, USING T48 ADAPTER, (T35 CLUSTER) AS A TEST VEHICLE, by W. F. Hagman. Final summary rept. Jan. 1953, 96p. illus. Confidential

The T57E1 HEAT, fin-stabilized fragmentation bomb, equipped with a piezoelectric fuze, is designed for use in the T35 bomb cluster. It contains a shaped charge similar to the 3.5-in. rocket and has a conical Cu liner and an explosive charge of Comp. B. Data indicated a minimum of 9.3 in. and an average penetration of 10.8 in. in homogeneous armor plate. When fitted with .093-in. fragmentation wire, the T57E1 produced an average of 4300 fragments of which 46% are lethal at a range of 20-40 ft. Twenty-four such bombs, when packed in a T48 adapter, make up the T35 cluster for employment against tanks and personnel.

L1095

Gray, J. C. and others.
PROJECTILE. United States patent no. 2,426,997, Sept. 9, 1947.

A coned or recessed face is employed to facilitate fabrication of a projectile and to insure its effective functioning. This is accomplished by using a blasting cap type of capsule and a nitroglycerin-absorbent base fuze.

L1096

Gulf Research and Development Co. [OEMsr-959].
DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges. May 15-June 15, 1943, p. 36-45; Rept. no. CF-10) Confidential

This investigation was made to determine the conditions under which a metal pellet (subsidiary projectile) inclosed within (embedded) or trailing behind a shaped charge can pass through a hole made in the target by this charge. The charges were 50/50 Pentolite, 1 5/8 in. diameter, 4 in. long; the liners were steel (conical); and the target was mild steel plates. A compilation of the experimental results is included.

L1097

Gulf Research and Development Co. [OEMsr-959].
DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, June 15-July 15, 1943, p. 27-39; Rept. no. CF-11) Confidential

The investigation was to determine the conditions under which a metal pellet enclosed within or trailing behind a shaped charge (fired statically) can pass through a hole made in a 1020 mild steel target by this charge. Test results are tabulated for the following determinations: (1) material (steel, Al, glass, sand) and dimensions (45°-180° apex angles, varying diameter and standoff) of liner which would produce a hole for passing the maximum size pellet; (2) the probability of penetration of the target (2-in. mild steel) by an attached pellet; and (3) necessary separation of pellet to prevent sympathetic detonation of HE filling. Photographs of sections of the slug formed from a brass and steel liner are included.

L1098

Gulf Research and Development Co. [OEMsr-959].
DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Controlled Fragmentation and Shaped Charges, July 15-Aug. 15, 1943, p. 45-52; Rept. no. CF-12) Confidential

The conditions under which a metal pellet enclosed within or trailing behind a shaped charge can pass through a hole made in a target by the shaped charge were determined. Results of the following investigations are tabulated: (1) survey of hole sizes made by 60° glass liners of varying thicknesses; (2) survey of hole sizes produced by reducing the base diameter of the liner (steel, 80°, 1/36 in. thick); (3) firing of shots with pellets of various shapes integrally attached at the liner (steel, 80°) apex; and (4) survey of hole sizes produced by liners (steel, 80°) having tapered wall thicknesses.

L1099

Gulf Research and Development Co. [OEMsr-959].
DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, Aug. 15-Sept. 15, 1943, p. 42-56; Rept. no. SC-1) Confidential

Experiments were conducted to determine conditions under which a metal pellet enclosed within or trailing behind a shaped charge (cast 50/50 Pentolite, 4 in. long, 1 5/8-in. diameter, 80° Al liner) can pass through a hole made in a 2-in. mild steel target. Factors studied in this investigation were: retarding of pellet by HE charge, design of follow-through shell; inclusion of steel axial rod; modification of liner apex; casing (steel) of HE charge; and modified (composite, segmented) liners. Results of tests involving these factors are tabulated.

L1100

Gulf Research and Development Co. [OEMsr-959].
DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, Sept. 15-Oct. 15, 1943, p. 41-46; Rept. no. SC-2) Confidential

Investigation was mainly directed toward development of a successful firing mechanism for the preliminary follow-through shell designs. Methods tried were: pellets (uniform, segmented and embedded), Pb-wrapped Primacord, small inverted shaped charges in the nose of the shell, and a firing pin placed diagonally inside liner.

L1101

Gulf Research and Development Co. [OEMsr-959].
DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, Oct. 15-Nov. 15, 1943, p. 59-69; Rept. no. SC-3) Confidential

Experiments were conducted with the follow-through shell design involving the use of a diagonally placed steel rod to facilitate detonation of the shaped charge. Discussions are presented of the penetration probability of long and short pellets; fuse requirements of the projectile; and various propagation speeds with respect to fusing by the following means: optical (radiation), electrical (impulse), acoustical (sound), chemical (high explosives), and ballistic (jets).

L1102

Gulf Research and Development Co. [OEMsr-959]. DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, Part B, Nov. 15-Dec. 15, 1943, p. 52-61; Rept. no. SC-4) Confidential

Six follow-through shells having diagonally placed steel rods and pellets of varying size were fired against 2-in. mild steel targets. Four tests were made to determine the effect of transmitting the detonation wave from a detonator in front of the shaped charge to the base of the charge (80° Al or steel liners) by means of a length of Primacord shielded by a steel tube. Data pertaining to these tests are tabulated.

L1103

Gulf Research and Development Co. [OEMsr-959]. DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, Dec. 15, 1943-Jan. 15, 1944, p. 27-36; Rept. no. SC-5) Confidential

Data obtained from hole diameters produced by cased steel lined (80°) small scale charges fired against 2-in. armor plate are revised. The time lag due to use of steel rods as firing pins to actuate detonators was established for rods of various lengths and gaps between detonator and rod. A study of the possibility of detonating a follow-through shell by means of a length of Primacord from the nose of the HE was continued. The probability of successfully penetrating 2-in. armor plate with a follow-through projectile, which incorporated a diagonally placed steel rod for striking the detonator enclosed in the rear of the HE, was established at 70%. Test results are tabulated.

L1104

Gulf Research and Development Co. [OEMsr-959]. DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, Jan. 15-Feb. 15, 1944, p. 26-39; Rept. no. SC-6) Confidential

Results are tabulated for the following experiments: (1) use of M20 detonators to initiate M18 detonators; (2) determination of hole diameter from charges containing 20° liners (steel, Al); (3) use of Primacord in an axial tube; and (4) effect of rod initiation on follow-through shells.

L1105

Gulf Research and Development Co. [OEMsr-959]. DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, Feb. 15-Mar. 15, 1944, p. 35-41; Rept. no. SC-7) Confidential

The following possibilities were investigated in an attempt to develop a satisfactory method of initiating a shaped charge follow-through projectile: axially placed nose fuzes; reduction of the charge length; and increased diameter of the charge. Penetration test results for charges utilizing the above possibilities are given.

L1106

Gulf Research and Development Co. [OEMsr-959]. DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, Mar. 15-Apr. 15, 1944, p. 29-34; Rept. no. SC-8) Confidential

Work was directed toward simplifying low velocity follow-through shaped charge shell designs to develop a shell easily adapted to methods of mass production. Descriptions, schematic diagrams, and test results for 4 possible revisions are presented.

L1107

Gulf Research and Development Co. [OEMsr-959]. DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, Apr. 15-May 15, 1944, p. 24-30; Rept. no. SC-9) Confidential

A conference and work, including tests, on a shell to defeat 4-in. armor are reported.

L1108

Gulf Research and Development Co. [OEMsr-959]. DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, May 15-June 15, 1944, p. 31-37; Rept. no. SC-10) Confidential

A follow-through shell with 3 long rods as firing pins spaced at 120° intervals around the periphery of the charge and 3 detonators correspondingly located at the base of the charge, and connected to the charge with Primacord, was tested against 4-in. armor plate at incident angles from 0° to 40° to determine the minimum standoff and charge length which could be used in shell design.

L1109

Gulf Research and Development Co. [OEMsr-959]. DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, June 15-July 15, 1944, p. 41-45; Rept. no. SC-11) Confidential

Shots were made with shells containing nose fuzes, inertia fuzes, and tubular guide. The casing wall thickness was investigated as a possibility of reducing the shell weight.

L1110

Gulf Research and Development Co. [OEMsr-959]. DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, July 15-Aug. 15, 1944, p. 55-58; Rept. no. SC-12) Confidential

Tests are reported on the determination of the optimum separation between the projectile and the forward charge at the time of initiation.

L1111

Gulf Research and Development Co. [OEMsr-959]. DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 3 Interim rept. on Shaped Charges, Aug. 15-Sept. 15, 1944, p. 26-29; Rept. SC-13) Confidential

Twenty-one shells were fired using point-detonating fuzes. Seventeen functioned properly. Three inert follow-through shells were fired with tubular tail fin and were observed to yaw; 9 fitted with folding fins were stable. Several live shells similar to the inert shells were fired from a mortar; the follow-through pellet generally failed to enter the hole. Five shells were fired with the follow-through pellet guided by a tube extending to the base of the HE. Three shots were made using rod-type fusing design to determine the effect of 300 ft./sec. striking speed on penetration. Design data and firing conditions for the above tests are given.

L1112

Gulf Research and Development Co. [OEMsr-959]. DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, Sept. 15-Oct. 15, 1944, p. 16-19; Rept. no. SC-14) Confidential

Pending production of suitable follow-through shells from available data, 100 unproved shells were fired against 4-in. armor plate. Results are discussed.

L1113

Gulf Research and Development Co. [OEMsr-959]. DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, Nov. 15-Dec. 15, 1944, p. 23-27; Rept. no. SC-16) Confidential

Firing trials of inert and live follow-through projectiles are described. A diagram of the type of projectile used is included.

L1114

Gulf Research and Development Co. (OEMsr-959). DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, submitted by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, Feb. 15-Mar. 15, 1945, p. 27-30; Rept. no. SC-19) Confidential

Investigations were undertaken to determine and eliminate poor holes made by the point-detonating fuze.

L1115

Gulf Research and Development Co. (OEMsr-959). DEVELOPMENT OF FOLLOW-THROUGH PROJECTILE, by M. Muskat. (In NDRC Div. 8 Interim rept. on Shaped Charges, July 15-Aug. 15, 1945, p. 9-13; Rept. no. SC-24) Confidential

Final tests are reported on firing of 10.7-lb follow-through rocket rounds shipped from the Gulf Laboratory.

L1116

Gulf Research and Development Co. (OEMsr-959). DEVELOPMENT OF A SHAPED CHARGE FOLLOW-THROUGH WEAPON, by M. Muskat. Final rept. Nov. 20, 1945, 10p. diagrs. (NDRC Div. 8) OSRD 6227 Confidential

The results of an investigation into the possibilities of improving the effectiveness of shaped charge projectiles by incorporating a follow-through missile in the weapon are presented in condensed form. References are given to Div. 8 interim repts. in which results are given in more detail. The objective of the final phase of this work was to produce a shaped charge follow-through rocket capable of defeating 4-in. armor plate. Thirty-two shots utilizing the final design of the above weapon were fired at 100-yd. range. Test results and final design data are included.

L1117

HQ Weapons Technical Staff, Field Forces (Med. Area), CMF (Gt. Brit.). PERFORMANCE OF PANZERFAUST (FAUSTPATRONE 2) AGAINST CHURCHILL AND SHERMAN TANKS FITTED WITH SKIRTING PLATE. June 26, 1944, 8p. incl. diagr. (Trial rept. no. SA/35/44) Confidential

Churchill and Sherman tanks fitted with 5-mm. mild steel skirting plates were defeated at normal, 25°, and 30° by the Panzerfaust. It was concluded that skirting plates of a weight which would not be too great to use on tanks, spaced at a maximum distance from the hull permitted by the width of Bailey and other bridges, would not prevent perforation of the main armor of the tanks by the Panzerfaust at angles at which detonation of the bomb was achieved. The German claim that the weapon would perforate 200 mm. of single armor plate appeared to be correct. Another rept. is included on further trials against Churchill and Sherman tanks. To counteract this weapon tests were made with: (1) sandbags between spaced plates and the turret; (2) spare Sherman tracks draped around the turret of the Churchill tank; (3) cans filled with water in close contact with the turret, (4) 3 thicknesses of blanket suspended 18 in. from the hull and heavily weighted at the bottom; and (5) plate at 45° to the line of fire to ascertain whether the large proportion of blinds were likely to occur at angles of 25°-30°

L1118

HQ Weapons Technical Staff, Field Forces (Med. Area), CMF (Gt. Brit.).
JOINT REPORT BY AFV(T) AND WTSFF ON FURTHER TRIALS WITH PANZERFAUST (FAUSTPATRONE 2). Aug. 26, 1944, 4p. (WTSFF/1105/ATK/2) Confidential

Tests were carried out with Panzerfausts against Churchill and Sherman tanks with 5-mm. skirting plates inclined at various angles to the vertical. Results indicated that the Panzerfaust could be relied upon to function at incident angles up to approximately 73°, the maximum angle tried.

L1119

HQ Weapons Technical Staff, Field Forces (Med. Area), CMF (Gt. Brit.).
PANZERFAUST V. [VS.] CHURCHILL AND SHERMAN TANKS, by R. E. W. Johnson. Oct. 28, 1944, 7p. (Trial rept. no. SA/35A/44; WTSFF/1105/ATK/2) Confidential

Trials were made on the protection of tanks from Panzerfausts by placing a wire screen netting across the sides of the tank. The first tests showed that the wire netting must be both taut and strong. It was concluded that screens made up from a double thickness of Sommerfield Track had possibilities of defeating the Panzerfaust. The results of the trials are tabulated.

L1120

Hesse-Eastern Corporation (DAI-19-020-501-ORD-(P)-24).
DESIGN AND DEVELOPMENT OF ROCKET, HEAT, 3.5 IN. T230 AND PRACTICE T-, by H. W. Aschaffenburg. Progress rept. no. 17-1153. Nov. 1953, 9p. illus. tables, diagrs. Confidential

Test rounds of the 3.5-in. HEAT Rocket, T230, were fired at +120° and -20°F. Results of the tests indicated that the effect of blast and particle discharge upon launching personnel at elevated temperatures must be determined, and the accuracy and velocity of the round improved at low temperatures by eliminating or reducing the propellant breakup near burnout.

L1121

THE "HOLLOW CHARGE": A DEADLY EXPLOSIVES PRINCIPLE WHICH USES BLAST TO BORE A HOLE THROUGH SOLID ARMOR. The Illustrated London News, v. 205, Nov. 25, 1944: 604-605.

Explanatory drawings show how the shaped charge principle controls the direction of the blast, concentrating it at the most effective point. (A translation of this article into German appears as part of item no. L1678.)

L1122

Hopkins, N. M.
BATTLESHIP WRECKING BOMB; AN ILLUSTRATED MONOGRAPH... [1940], 28p. incl. illus. diagrs. Unclassified

The use of shaped charge bombs (similar to the CS bomb) against battleships is proposed. After reviewing the work of Munroe and Egon Neumann and commenting on shaped charges at oblique angles of attack. It is argued that such bombs should be effective because of the: lighter casing required; heavier load of explosives permitted; and greater penetration achieved by the charge. Diagrams are presented of the proposed bomb.

L1123

Hutti, J. B.
SHAPED CHARGES FOR CHEAPER MINE BLASTING. Engineering and Mining Journal, v. 147, May 1946: 58-63.

Results of tests using shaped charges in underground blasting are presented. Secondary breakage, cavity shape and size, effect of standoff, and explosive content of charge were studied. Three tables containing results are given.

L1124

Hymans, J. C. S.
THE MUNROE JET. In Guns, Shells and Rockets: A simple guide to ballistics. Aldershot [Eng.], Hants, Gale, and Polden Ltd., 1950, p. 71-72.

A brief discussion is given of the work done by C. E. Munroe and E. Neumann.

L1125

I. T. E. Circuit Breaker Co. (DA36-034-ORD-145).
SHEAR FORMING OF COPPER CONES FOR LINED SHAPED CHARGES, by C. Server and F. J. Gardiner. May 30, 1951, 8p. illus. diagr. (Proj. no. TA1-1526) Unclassified

A technique is described for producing a liner having a 45° included apex angle and of a size suitable for a 105-mm. projectile having a transverse wall thickness uniformity of 0.001 in. and an axial uniformity of 0.003 in. between the datum planes.

L1126

Institute for Mathematics and Mechanics, New York University.
REMARKS ABOUT THE EFFECT OF THE DETONATION WAVE ON THE LINER OF A SHAPED CHARGE, by K. O. Friedrichs and others. Preliminary rept. Jan. 15, 1949, 64p. incl. diagrs. Confidential

Certain aspects of the detonation theory are examined in detail to prepare the way for a theoretical determination of the final motion of the liner. Well-known formulas for the speed and mass of jet and slug are re-derived, and the detonation process independent of the presence of a liner is studied. The consequences of assuming that the expansion of the burnt gas is not affected by the liner are investigated, and a general description of the motion of the liner is given. Shock wave processes in the liner material are discussed, and the train of the waves is determined in detail. Calculations and diagrams relevant to these studies are presented.

L1127

Institute for the Study of Rate Processes, University of Utah (N7onr-45107).
A NOVEL "GEOMETRICAL" APPROACH TO REACTION RATE DETERMINATIONS IN DETONATION, by M. A. Cook. Jan. 26, 1952, 25p. incl. diagrs. (Technical rept. no. 4) TIP C7454 Confidential

An empirical model of the detonation process was examined with respect to fundamental details and applications to military explosive problems, especially shaped charge studies. The examination was based on an analysis of experimental data and the relationships for the detonation and retonation heads of confined and unconfined cylindrical charges. The expression

$$N(t) = \left(1 - \frac{t}{\tau}\right)^3$$ was

derived for N(t), the fraction of the explosive which has reacted, the time (t), and the total reaction time (τ). Evaluation by comparison with the independent relationship $N = (D/D^*)^2$, based on the theory of the detonation head, was recommended; D and D* are the characteristic and ideal detonation velocities, respectively. (TIP abstract)

L1128

Institute for the Study of Rate Processes, University of Utah (N7onr-45107).
DETERMINATION OF REACTION RATES IN DETONATION BY MEANS OF SHAPED CHARGES STUDIES, by M. A. Cook. July 15, 1953, 10p. tables, diagrs. (Technical rept. no. 16) AD-16378 Confidential

The detonation head theory is extended to apply in the application of shaped charge measurements in the determination of reaction times in detonation. Using 45° Cu conical liners, shots were made with ideal explosives to establish calibration curves for the measurement of the effective detonation pressure. The influence of variations in conical liner wall thickness was studied quantitatively, and it was shown that accurate results will depend on the use of conical liners of less than .002-in. variation in wall thickness. Various non-ideal explosives were studied and quantitative evaluations carried out for coarse-grained TNT which proved to be in agreement with the theory within experimental error. Aluminized explosives appear to develop about the same detonation pressures that would be obtained if Al were considered to be entirely inert. Particle size effects were clearly evident in baratol and amatol, but not in aluminized explosive. Future studies will utilize more quantitative techniques.

L1129

Institute for the Study of Rate Processes, U. of Utah (N7onr-45107).
TIME LAG IN PROPAGATION OF DETONATION THROUGH AIR, STEEL, AND GLASS, by M. A. Cook. Mar. 15, 1954, 8p. illus. tables, diagrs. (Technical rept. no. 31) Confidential

Measurements of the average velocity $\bar{V}_g$ of propagation of detonation by influence through air, steel, and glass are reported. The results show that $\bar{V}_g$ was much lower than the detonation velocity D in all cases. Moreover, the $\bar{V}_g$ vs. distance curves observed for propagations over air gaps differed considerably both in shape and magnitude from the shock wave velocity (V*)-distance curves observed in this study. Detonation initiation time lag against gap distance curves are presented and the results discussed in connection with the hot product gas initiation mechanism. While further study is needed to elucidate completely the mechanism of propagation by influence, the experimental results obtained in this study should be useful in the design of detonation wave interrupters and wave shape control "lenses."

L1130

Institute of Industrial Research, Syracuse University (DA30-115-ORD-332).
THE INCENDIARY EFFECTS OF OXIDANTS WITH SHAPED CHARGES. Monthly progress rept. no. 1. Aug. 15, 1952, 12p. incl. illus. AD- 14 387 Confidential

Tests were conducted on 62.5°, 80-g. shaped charges of consolidated desensitized cyclonite with a PETN primer to which oxidizing agents were added. Liquid O, O gas, or Thermit provided little beneficial effect. Less penetration was observed when the jet was disturbed. Plates spaced 0.5 in. apart appeared to reduce penetration appreciably. (ASTIA abstract)

L1131

Institute of Industrial Research, Syracuse University (DA30-115-ORD-332).
THE INCENDIARY EFFECTS OF OXIDANTS WITH SHAPED CHARGES. Monthly progress rept. no. 2. Sept. 15, 1952, 8p. incl. illus. AD-14 388 Confidential

Thermit, 1/1 BaO_2/Mg, and 1/1/1 BaO_2/Mg/Thermit oxidants were evaluated with shaped charges. Arrangements were employed in which the jet passed through steel (B-B) shot and in which a 1-in. Fiberglas layer was placed between 2 steel plates as the target. Oxidant burning was obtained in 3 tests but the oxidant material did not appear to follow the jet into the hole. (ASTIA abstract)

L1132

Institute of Industrial Research, Syracuse University (DA30-115-ORD-332).
THE INCENDIARY EFFECTS OF OXIDANTS WITH SHAPED CHARGES. Monthly progress rept. no. 3. Oct. 15, 1952, 16p. incl. illus. AD-14 389 Confidential

Tests were conducted with shaped charges and oxidants positioned above 4-in. steel blocks with existing holes to determine if the oxidants could be forced through behind the jet. With a totally enclosed 90° shaped charge and oxidant, the hole made by the jet indicated possible oxidation. A mixture of red P-$KClO_3$-Thermit appeared to burn, the hole being thickly plated with a blistered coating of Cu color. The residue from a 62.5° shaped charge using Thermit as the oxidizing agent appeared to be a mixture of Cu and Thermit. However, the results of these tests were inconclusive.

L1133

Institute of Industrial Research, Syracuse University (DA30-115-ORD-332).
THE INCENDIARY EFFECTS OF OXIDANTS WITH SHAPED CHARGES. Monthly progress rept. no. 4, Oct. 15-Dec. 1, 1952. 8p. incl. diagrs. AD-14 390 Confidential

A test was conducted with a 62.5° shaped charge and Thermit to determine if the oxidant could be forced through the target hole behind the jet. No trace of Thermit passage through the hole was indicated. A special shaped charge design was proposed incorporating 2 connected explosives and 2 separate liners, 1 of Cu and 1 of incendiary mixture. It is presumed that the jet from the Cu cone will penetrate the target, and that the secondary jet of incendiary will follow the Cu jet through the target. No test has been made.

L1134

Institute of Industrial Research, Syracuse University (DA30-115-ORD-332).
THE INCENDIARY EFFECTS OF OXIDANTS WITH SHAPED CHARGES. Rept. no. 6, Jan. 1-Feb. 28, 1953. 13p. incl. diagrs. AD-14 391 Confidential

A projectile with propellant was placed over a shaped charge and both were fired by no. 6 detonators wired in parallel to the same 110-v. circuit. Preliminary tests using shotgun shells alone indicated that about half the shot passed through the hole. When the shotgun shells were fired with a 62.5° shaped charge into a solid steel target, only a few pellets went through. A 0.25-in.-diameter, 2.5-in. long projectile was fired into the top of a 90° shaped charge having a PETN primer but no detonator. The charge was not detonated and the Cu cone of the shaped charge was penetrated by the projectile. In another test firing, a 0.25-in.-diameter, 2.5-in. long dowel followed the jet through a 2.5-in. steel target. Pigment-filled steel capsules 0.25 in. in diameter, 1 in. long, also passed through the jet hole, splashing pigment over the collecting chamber beneath the target. Results indicated that projectiles 3/8 in. in diameter were too large to pass through the jet hole.

L1135

Institute of Industrial Research, Syracuse University (DA30-115-ORD-332).
THE INCENDIARY EFFECTS OF OXIDANTS WITH SHAPED CHARGES. [Monthly] progress rept. no. 7. Apr. 15, 1953, 13p. incl. table, diagrs. AD-14 392 Confidential

Determinations were made of projectile velocities from guns to be used with shaped charges. The velocities varied from about 500 ft./sec. for the smokeless powder-0.25-in. dowel projectile to about 2000 ft./sec. for a 0.25-in. diameter x 0.75 in. long Cu projectile. Several tests were also conducted using the projectile gun-62.5° shaped charge unit (item no. L1134). In 1 firing, a small amount of Therm 64C went through the hole in the target. In another firing, a steel dowel 0.5 in. x 0.25 in. and 2 of 100 kerosene-soaked cardboard discs followed the jet into the collecting chamber. Two other tests with Therm 64C cones were not successful.

L1136

Institute of Industrial Research, Syracuse University (DA30-115-ORD-332).
THE INCENDIARY EFFECTS OF OXIDANTS WITH SHAPED CHARGES. [Monthly] progress rept. no. 8. May 15, 1953, 9p. incl. diagr. AD-14 393 Confidential

A 0.443-g du Pont Pistol Powder no. 6 propellant packed inside a Remington stud-driver cartridge and a 62.5° shaped charge below the gun were fired simultaneously with 2 no. 6 electric detonators. The jet went through 4.13 in. of steel. The splash marks on top of the steel target and the dull appearance of the test hole indicated that the 6.5-mm. diameter, 0.75-in. long, rolled Pb projectile was melted. A 25-g. Therm 64C cone was pressed successfully with a cellulose nitrate binder. When a 62.5° cyclonite shaped charge without a cone was placed on top of the Therm cone, a jet was formed on firing which produced a 0.75-in. diameter hole 1 in. deep in the steel target; the steel was oxidized. A 25-g. Therm 64C cone was pressed on the top of a 26.5-g. Cu cone and a 62.5° shaped charge without a cone was placed on top; on firing the jet penetrated 3.63 in. of steel. Excessive oxidation occurred in and around the test hole. A 2-cone-in-series charge was constructed. This 2-cone shaped charge consists of a regular 62.5° cone, a 2-in. length of Cu tubing, an inverted 62.5° Cu cone with apex cut out to provide a 0.5-in. diameter hole, and another 62.5° cone, right side up, machined to match its neighboring cone. The volume available for explosive loading is 307 cc.

L1137

Intelligence Section, 1st Engineer Service Detachment, Headquarters.
STEEL CUTTING WITH EXPLOSIVES, by T. R. Fulton. June 30, 1947, 7p. incl. illus. diagrs. Confidential

A description is given of a German linear charge for cutting steel. The explosive used, designated as Comp. X for lack of a permanent name, was similar to C2 but apparently more effective; it cut so clearly that it was used in close places prohibiting ordinary explosives. The formula and characteristics of this explosive are reported.

L1138

Inter-Services Mines and Missiles Committee [Gt. Brit.].
HOLLOW DEMOLITION CHARGES (ITALIAN) 20 KG. AND 5 KG, by R. H. Rooksby. Sept. 24, 1944, 3p. incl. diagr. (Rept. no. 36; EI/211/3) Confidential

A description and construction details are given of the 20- and 5-kg. Italian shaped charges. Tests on a 4-ft. thick massive concrete roof gave poor results. The 20-kg. charge made a crater 4 ft. in diameter and 18 in. deep. Spalling on the underside made a crater up to 6 ft. in diameter and about 2 ft. deep. The roof was penetrated through the center of the crater by a hole approximately 1.5 in. in diameter. The 5-kg. charge made a crater 2 ft. in. diameter and 10 in. deep. There was no noticeable penetration in the center and only cracking on the underside.

L1139

Johns Hopkins University (OEMsr-773).
THE INTERACTION OF SHOCK WAVES, by R. W. Wood. Progress rept. Nov. 4, 1943, 21p. illus. diagrs. (NDRC Div. 8) OSRD 1996 Unclassified

Experiments were carried out to verify von Neumann's theory. Von Neumann's mathematical analysis led to the prediction of wave fronts of complicated form and properties similar to those described by Mach, who observed them on plates of smoked glass mounted close to powerful electric sparks. Photographs of interacting shock waves are shown. One of these photographs shows cusps, discontinuity lines, and the Mach wave bulging forward in the direction of its propagation as predicted by von Neumann. It was hypothesized that this effect might be partly responsible for the formation of the armor piercing jet in the case of shaped charges of explosive, the center of the "bridge" acquiring a gradually increasing velocity of propagation as the intensity of the shock waves was increased.

Johns Hopkins University see also Applied Physics Laboratory Operations Research Office

L1140

Joint Intelligence Center, Pacific Ocean Areas.
TRANSLATION OF CAPTURED JAPANESE DOCUMENT. EXPLANATION OF HOLLOW CHARGE AMMUNITION. Aug. 1943, 10p. (JICPOA Item no. 7651) Confidential

The discussion is concerned with: (1) origins of shaped charge ammunition; (2) basic principles of shaped charge ammunition; (3) practical application of these principles; (4) construction of shaped charge ammunition and its general qualities; (5) nature of its trajectory; (6) effectiveness of the projectile; (7) special characteristics of shaped charge ammunition; (8) contemporary use of shaped charge ammunition; (9) status of shaped charge ammunition in Japan today and its future; and (10) cautions concerning use of shaped charge ammunition.

L1141

Joint Intelligence Objectives Agency.
INTERROGATION OF DIPL. ING. E. A. MARQUARD. June 28, 1946, 3p. (File no. BIGS - 29)

(See item no. L404.)

L1142

Kast, H. and A. Haid.
INVESTIGATIONS ON THE FEASIBILITY OF PRACTICAL TESTING METHODS FOR DETONATORS (Untersuchungen über die Brauchbarkeit der Methoden zur praktischen Prüfung von Sprengkapseln). Zeitschrift für das gesamte Schiess- und Sprengstoffwesen, v. 19, Nov. 1924: 165-170.

Experiments with various detonators are reported. The greater effect of the Schulze detonator is attributable to the cavity rather than to the density gradient from top to bottom.

L1143

Kirkwood, J. G.
DIARY OF DR. J. G. Kirkwood. June 28-July 21, 1943, p. 1-32. (OSRD Liaison Office Reference no. WA-792-22a) [Part II; July 23-July 28, 1943; p. 33-42] (OSRD Liaison Office Reference no. WA-813-5a) Confidential

Discussions with British scientists are reported briefly. The subjects were explosion waves, underwater damage, bomb damage, and 2 repts. on shaped charges: (1) Visit to Mr. Tuck - Extrusion [Hydrodynamic] theory of the cavity effect and X-ray photographs of the jets from lined charges (1p.); and (2) Visit to Dr. Guggenheim - Utilization of the cavity effect in attack on underwater targets [shaped charge antisubmarine bomb] (2p.). Part II reports: (3) Visit to Sir Robert Robertson, Dr. Ubbelohde, and Dr. Porter - Shaped charges and follow-through projectile [bomb] (3p.); and (4) Notes on effect of rotation on the formation of the Munroe jet (3p.). [Summaries of AC 3987 and AC 4026.]

L1144

Kolsky, H. and others.
A STUDY OF THE MECHANISM OF MUNROE CHARGES. PART I. CHARGES WITH CONICAL LINERS. PART II. CHARGES WITH HEMISPHERICAL LINERS. Research, v. 2, Feb. 1949: 89-98.

Part I. The mechanism of penetration by conical steel and Cu lined charges 6 mm. and 1 cm. in diameter was studied by firing into steel, polythene, paraffin, and water. Collapse of the liners was studied by modifying the weight of explosive. Liners of various thicknesses were used to determine the relation between liner thickness and slug weight. The jets obtained from conical charges were formed by a hydrodynamic compression of the liner by the explosion, and the penetration was due initially to fragments, the weights of which were less than 0.1 that of the liner. Part II. The collapse of hemispherical liners was investigated. It was concluded that the mechanism of collapse differs considerably from that of conical liners, as does the distribution of the fragments in the jet.

L1145

Krasel'shchik, V. N.
CUMULATIVE CHARGES IN INDUSTRY (Kumulyativnye zaryady v promyshlennosti). Gornyi Zhurnal, v. 122 (1), 1948: 16-18.

The following factors relating to the use of shaped charges for blasting and drilling were investigated: (1) amount and type of explosive, and (2) dimensions and shape of charge and liner. Three basic forms of shaped charges were listed as conical, paraboloidal, and ellipsoidal.

L1146

Laboratoire d'Études Balistiques de Saint-Louis (France).
STATE OF RESEARCH WITH FLAT CHARGES (Etat de l'étude des charges plates), by Thomer. [1946], 50p. incl. illus. diagrs. (Rept. no. 6/46; Trans. by Service Branch, ID, 23p.) (Original and translation transmitted as Inclosure 1 to MA Paris rept. no. R737-47) TIP SE0123 Secret

The investigation of propelling flat charges by the detonation of shaped charges (the Misznay-Schardin effect) by the French with the assistance of Dr. Schardin is reported. Theory, dimensional design, powder studies, effect of asymmetry, and such applications as use in rocket warheads and as an antiaircraft weapon are described in detail. Velocity measurements and photography in the tests were improved by including a luminous composition in the cavity.

L1147

[Laboratoire d'Études Balistiques de Saint-Louis (France)].
[REPORTS ON BALLISTIC RESEARCH]. PART II. EFFECT OF SPINNING ON PENETRATION OF HOLLOW-CHARGE PROJECTILES, by H. Schardin. Feb. 10, 1946, p. 42-56 incl. diagrs. (Rept. no. 1/46; CIA 198045; Q-54-0) Restricted

Tests made with a 7.5-cm. shell fired dynamically are reported. The built-in liner was of Fe with an apex angle of 40°. Other tests with the FZ 65 projectile are reported. Descriptions are included of the test setup and method of measuring the r.p.m. R.p.m. measurements were made on shaped charges with liners in the shape of ellipsoids, hemispheres, and cones. A rough qualitative interpretation of the spin effect is given. From the test results, it was concluded that spinning causes a decrease in the penetration depth of shaped charges. A complete elimination of the spin with its damaging effect appeared impossible at present.

L1148

Lawrence, R. W.
A SCIENTIFIC APPROACH TO THE INDUSTRIAL APPLICATION OF SHAPED CHARGES. The Explosives Engineer, v. 25, Nov.-Dec. 1947: 171-173, 182-183.

The industrial application of shaped charges for such uses as hole drilling, boulder blasting, seismic prospecting, and oil-well shooting is discussed.

L1149

Lewis, R. S. and G. B. Clark.
APPLICATION OF SHAPED EXPLOSIVE CHARGES TO MINING OPERATIONS: TESTS ON STEEL AND ROCK. Bulletin of the University of Utah, v. 37, 1946: 48p. (Dept. of Mining Engineering Bulletin, no. 1)

Discussions are included on the history of the Munroe effect, mechanism of detonation in explosives, and theory of shaped charges. Tests were made with linear charges loaded with 60% NG dynamite fired against steel targets. Results were erratic because of the fact that the case and charge liner were made in 1 continuous piece of steel. Test results are shown for 1-in. charges with 45° and 30° liners fired against steel plates. Tests were made on 2 variations of 3-in. charges, with a liner screwed in the end of a pipe, and 1 with a bell or cast Fe cover screwed on top. The first type was used to determine optimum standoff distance for this charge size; the covered type was used to determine the relationship between the amount of powder in the charge and its penetrative power. Charges with hemispherical cast Fe liners were designed to test the effect of jets from hemispheres. Tests were made also with these charges to determine the most economical amount of explosive and optimum standoff against steel. Test results against rock are also reported. It was concluded that the application of shaped charges to mining is practical and economical.

L1150

Little, Arthur D., Inc. (DA-19-020-ORD-47 and DAI-19-020-501-ORD(P)33). EVALUATION OF METHYLENEDINITRAMINE (MEDINA) AS A HIGH EXPLOSIVE. Summary rept. Mar. 1, 1954, 108p. incl. illus. tables, diagrs. AD-29 631 Confidential

In the evaluation of MEDINA as a high explosive, its performance in shaped charges was tested. Penetration tests were conducted by Jet Guns, Inc. using 27-g. charges of MEDINA and Cyclonite (RDX(93.4)/Wax(4.9)/Graphite(1.7)). These charges were fired into targets of SAE 1020 hot-rolled steel bars, the best shot for each giving a penetration of 6.875 in. for MEDINA and 6.625 in. for Cyclonite. The best 3-shot average for MEDINA was 6.792 in. and for Cyclonite, 6.563 in. The standoff for all 24 Medina charges was 2 3/8 in. while the standoffs for the 22 Cyclonite charges varied from 1 in. to 2 5/8 in. It was concluded that the penetration performance of the MEDINA charges was about 4% better than that of the Cyclonite charges.

L1151

Little, Arthur D., Inc. (DA-19-020-ORD-338). 90-MM. HEAT SHELL. Progress rept. no. 20, Mar. 1953. Apr. 13, 1953, 2p. diagr. Confidential

The details of a new layout for the HEAT shell T249 are given. These include: (a) the attachment of the "Lucky" to the ogive and the wiring of the "Lucky" to the base element by a nylon covered wire that passes through a hole in the liner to a slot in the fuze cavity; (b) the Cu conical liner for the T108 round is to be modified for use in the T249 round by machining a small step on the backside of the lip and shortening the liner extension tube. Test models will be manufactured and fired to determine the best suitable nose construction for operating the "Lucky" at 60° obliquity. A drawing of the HEAT projectile assembly is presented.

L1152

Little, Arthur D., Inc. (DA-19-020-ORD-338). HEAT SHELL FOR 90-MM. RECOILLESS RIFLE. Monthly progress rept. no. 29, Dec. 1-31. 1953. Jan. 10, 1954, [9]p. incl. tables. Confidential

Thirty-five 90-mm. T249 HEAT rounds were tested at the Fort Dix range. From these firings, data were obtained for: (1) correlation of the piezo pressure gages on the chamber and the T1 Cu pressure gages inside the cartridge cases; (2) accuracy of the round; (3) interior ballistics of the round at elevated temperatures. Fifty test shells, with fuzes and steel plates, were sent to the Maynard Ordnance Area for static penetration tests.

L1153

Little, Arthur D., Inc. (DAI-19-020-501-ORD-(P)-19). RESEARCH ON MINES, ANTITANK AND/OR RELATED ITEMS, by G. Hess. Progress rept. no. 26, Mar. 1-31, 1954. Apr. 5, 1954, 5p. illus. diagr. (Ordnance proj. no. TQ3-5920; Army proj. no. RAD ORDTA-1-13115) Secret

Seven mines, 4 metallic and 3 nonmetallic, were fired down at targets of 3-in. armor plate in combination with 1-in. boiler plate placed on wood supports in penetration tests. Results of these firings follow:

Round number	material	Dish diam. (in.)	thickness (in.)	radius of curvature (in.)	Explosive	Standoff (in.)	Remarks (penetration)
[illegible]	steel	10	0.305	10	16.0-lb. Comp. B	18	complete
[illegible]	steel	10	0.305	10	16.0-lb. Comp. B	48	partial
[illegible]	steel	10	0.305	15	16.0-lb. Comp. B	18	partial
173	steel*	10	0.187	10	[illegible]-lb. C-6	18	partial

The Fiberglas dishes used in the nonmetallic mines were made of equal weights of Selectron 5003 polyester resin and Fiberglas cloth, the laminations being built up 1 ply at a time in a Castone (similar to plaster of paris) bowl of correct spherical radius. Results of these firings follow:

Round number	material	diam. (in.)	Dish thickness (in.)	radius of curvature (in.)	Explosive	Standoff (in.)	Remarks (penetration)
177	Fiberglas (46 ply)	14	0.5	14	13.0-lb. C4	10	complete
178	Fiberglas (48 ply)	12	0.5	12	14.0-lb. C4	18	partial
180	Fiberglas (59 ply)	12	0.50	12	C4, wgt. not given	18	partial

It was concluded that there is a dish diameter threshold above which penetration will occur; these data indicate that the threshold is between 12 and 14 in.

L1154

Little, Arthur D., Inc. (W19-020-ORD-6469). ABSTRACT REPORT ON MULTI-PURPOSE LIGHT WEIGHT ANTITANK WEAPON. Oct. 1, 1946, 12p. (Rept. no. C-57735) Confidential

Mention is made of the use of shaped charges as a means of defeating armor. For the required defeat of 11 in. of armor, a 75-mm. caliber HEAT warhead would be sufficient. Because shaped charges are sensitive to large rotational speeds, only slight spins are permissable for overcoming slight asymmetries. Fin stabilization was difficult at trans-sonic and supersonic speeds; subcaliber fins were inadequate above subsonic speeds.

L1155

Lodati, D.
AN EXPLANATION OF THE EXPLOSIVE BEHAVIOR OF A HOLLOWED BLOCK OF COMPRESSED TRINITROTOLUENE (Una spiegazione del comportamento esplosivo di blocchi cavi di tritolo compresso). Giornale di Chimica Industriale ed Applicata, v. 14, Mar. 1942: 130-132.

Experiments were made with explosive charges having triangular, square, octagonal, and circular cavities of various heights. The conical cavity produced the deepest penetration. It was concluded that this penetration was the result of interacting shock waves that produced a very high temperature. (See also item nos. L25 and L676.)

L1156

McLemore, R. H.
FORMATION PENETRATING WITH SHAPED EXPLOSIVE CHARGES. The Oil Weekly, v. 122, July 8, 1946: 56, 58.

Exhaustive tests proved that the shaped charge principle was very effective for opening oil well channels resulting in increased oil production.

L1157

McLemore, R. H.
CASING PERFORATING WITH SHAPED EXPLOSIVE CHARGES. Oil and Gas Journal, v. 45, Dec. 28, 1946: 268-271. (Also published in The Oil Weekly, v. 124, Dec. 30, 1946: 36-40.)

The normal casing perforating charge designed to give deep penetration under normal conditions, and the heavy-duty charge containing 2.5 times the amount of explosive in the normal charge were tested. Several open-hole charges were fired; entrance holes are shown. A double-ended charge was designed which when detonated from the mid-point, emitted jets from both ends. This article supplements the one which appeared in the July 8, 1946 issue of The Oil Weekly (item no. L1156).

L1158

McLemore, R. H.
PERFORATING CASING WITH SHAPED EXPLOSIVE CHARGES. The Oil Weekly, v. 124, Dec. 30, 1946: 36-40.

(See item no. L1157.)

L1159

McPherson, G.
POSSIBLE USE OF SHAPED EXPLOSIVE CHARGES IN MINING. Bulletin of the Institution of Mining and Metallurgy, no. 490, Sept. 1947: 1-11; no. 493, Dec. 1947: 29-41.

The design and function of the shaped explosive charges used in armor piercing weapons are discussed and the value of following certain experimental lines with the aim of using the same shaped charge principle in mining are pointed out to the mining industry.

L1160

Marine Corps.
INSTRUCTIONAL MATERIAL ON USE OF THE GRENADE, RIFLE, HEAT, T41 (ENERGA), FOR MARINE CORPS ORGANIZATIONS, by C. B. Cates. Nov. 24, 1950, 21p. illus. diagrs. (Inclosure 1 to Marine Corps Training Bulletin no. 4-50) Restricted

The antitank rifle grenade, Energa (HEAT) is a fin-stabilized, point initiated, base detonating, shaped charge projectile. The report gives details of the grenade, and its launcher, training instructions for personnel in the use of the grenade, instructions for transporting, handling and storing the grenade, and safety precautions.

L1161

Marine Corps Equipment Board.
REPORT OF TEST ANTITANK RIFLE GRENADE, "ENERGA". May 19, 1949, 45p. illus. Confidential

Tests were made to determine the capabilities and characteristics of the Energa antitank rifle grenade as compared with the US shaped charge shoulder weapons, the M9A1 rifle grenade and the 2.36-in. M6A3 HEAT rocket. The Energa grenade is a fin-stabilized, point-initiated, base-detonating, shaped charge projectile with an overall length of 15.75 in., a weight of 1.32 lb., an explosive charge of 11.65 oz., and a muzzle velocity of 174 ft./sec. Included in the comparative tests were: (1) destructive ability; (2) reliability of functioning at various angles of obliquity; (3) range and accuracy; (4) flight stability; (5) muzzle velocity; (6) performance at extreme high and low temperatures; and (7) fuze sensitivity. From these tests it was concluded that the Energa grenade, when modified, is a suitable replacement for the M9A1 grenade; however, because of its relatively short effective range, it is not a suitable replacement for the 2.36-in. HEAT rocket.

L1162

Marine Corps Equipment Board.
DEMONSTRATION OF THE ANTITANK RIFLE GRENADE (SPECIAL) 83-MM. BLINDICIDE ROCKET, AND THE 3.5-IN. ROCKET, by [H. C. Tschirgi]. May 23, 1952, [15]p. incl. illus. tables. (A7-5, Serial 07952) Confidential

Tests were conducted to determine the capabilities of the grenade and rockets against armor plate targets. Energa Rifle Grenade (Special): Against 12-in. armor plate, at 0° obliquity, the grenade penetrated approximately 10.5 in. Also at 0° obliquity the grenade penetrated 7.5 in. of armor plate after penetrating a 0.5-in. skirting plate placed 4 in. from the target. At 55° obliquity, complete penetration was achieved (approximately 13 in.) against 7.5-in. armor plate. Blindicide Rocket: At 0° obliquity against a target of 12-in. armor plate, the rocket penetrated 11.5 in., while at 55° obliquity against 7.5-in. armor plate complete penetration was made. 3.5-in. Rocket: When fired at 0° obliquity against 12-in. armor plate, the penetration was approximately 11 in. At 27°, 42°, and 63° obliquity, penetrations of about 10.5 in. were made; the rocket failed to penetrate completely at 55° obliquity against 7.5-in. armor plate. At 0° obliquity the rocket penetrated 7.5 in. of armor plate after passing through a 0.5-in. skirting plate 4 in. from the target. No malfunctions occurred during the tests. A comparison of their characteristics follows:

Round	83 mm.	3.5 in.	Energa
Length of projectile	23.75 in.	23.55 in.	15.87 in.
Weight of projectile	3.30 lb.	8.50 lb.	1.59 lb.
Muzzle velocity	660 ft./sec.	340 ft./sec.	150 ft./sec.
Max. effect. range	330 yd.	250 yd.	100 yd.

L1163

Marshall, A.
THE DETONATION OF HOLLOW CHARGES. Journal of the Society of Chemical Industry, v. 39, Feb. 16, 1920: 35T.

Historical material relating to the discovery of the shaped charge principle is given. The penetrative effect of the shaped charge is explained by the interaction of the "primary" and "secondary" detonation waves.

L1164

Michigan State College (DA20-018-ORD-13210).
DEFENSE AGAINST LINED SHAPED CHARGES. Quarterly progress rept. no. 1. Dec. 2, 1953, [32]p. incl. illus., tables, diagrs. Confidential

The research group working on defense against lined shaped charges reported that: (1) Hard laminated steel targets composed of 11 hacksaw blades or 15 to 20 razor blades set at an angle of 60° to the path of the jet showed promise as a defense mechanism. (2) Previous findings on hardened steel balls, which showed an effectiveness of 2.4 times (on a density basis) the resistance of mild steel to jet penetration, were substantiated. (3) Jet tapper shots were fired through various combinations of integrally cast fuzed silica plates in steel. (4) Studies of the mechanics of jet formation and penetration and the resulting pressure exerted by the jet were made. Data, including target description and residual penetration, are given for the various test firings. In addition, test data are presented for 3.5-in. shaped charges fired against various combinations of fuzed silica, glass, and steel at Aberdeen Proving Ground.

L1165

Michigan State College (DA20-089-ORD-35608).
DEFENSE AGAINST LINED SHAPED CHARGES. Quarterly progress rept. no. 1. Jan. 10, 1953, 78p. incl. tables. Confidential

The research group at Michigan State College reported that: (1) Abstracts of available Carnegie Institute of Technology and Flintkote Co. repts. on shaped charges were prepared. (2) A plan for entering data in a concordance on "Factors Which May Influence Defensive Measures [Against Shaped Charges]" was formulated and a tentative arrangement is given. (3) A study of the history of the piercing jet of shaped charges was made using metallographic studies of a jet-pierced bar of machinery. (4) Chamberlain shock-absorbing piles indicate some defensive merit when used with glass plate armor, but not when employed between steel plates alone. (5) Glass cloth and plastics combinations exhibited no exceptional resistance to the jet. However, the glass cloth phen-formaldehyde resin formica combination is being studied further. (6) Experiments and calculations were carried out in the investigation of the destruction of the jet by electrical condenser discharge. (7) Studies of chemical means of defense indicated that chemical reaction rates in the order of exploding dynamite (40-60%) were necessary.

L1166

Michigan State College (DA20-089-ORD-35608).
DEFENSE AGAINST LINED SHAPED CHARGES. Quarterly progress rept. no. 2. Apr. 10, 1953, [172]p. incl. tables. Confidential

The research group at Michigan State College working on shaped charge defense reported that: (1) The passage of a jet through hard steel balls showed considerable decrease in residual penetration (about 2.5 in. of steel balls equal 7 in. of solid steel). (2) Calculations and equipment assembly for defeating the jet by the discharge of electrical condensers were continued. In addition, electrical condensers were used to detonate ultra high speed arc firing electric caps in counter explosive defense. (3) A new, simplified concordance outline on shaped charge defense was prepared. (4) Shaped charge defense by means of jet-triggered counter explosives offers promise. However, such variables as amount of explosive, strength, distribution, triggering delay time, and detonation velocity must be evaluated first.

L1167

Michigan State College (DA20-089-ORD-35608).
DEFENSE AGAINST LINED SHAPED CHARGES.
Quarterly progress rept. no. 3. July 10, 1953, [50]p. incl. tables, diagrs. Confidential

The research group at Michigan State College working on the defense against lined shaped charges reported that: (1) Jet firings through blocks of hardened tool steel revealed that a combination of hardness and strength or size and hardness was needed to reduce jet effectiveness. Further study of the reduction of jet effectiveness caused by hard steel and hard alloy cast Fe balls 1.25 in. in diameter showed that the balls yielded an average effectiveness factor of 2 3/8 on a weight basis as compared with solid mild steel. It was concluded that jet effectiveness was decreased more when the jet encountered junctions of balls rather than when hitting the balls squarely. (2) Jet-triggered counter explosions were studied further using a dynamite-filled cell fired by an ultra-speed, arc-fired cap connected in series with a charged condenser-bank and a pair of triggering plates separated by sheet rubber. The circuit was closed and the cap fired by the passage of the jet through the triggering plates. Distances between the plates and dynamite were varied to determine the effect on the residual penetration of the jet. It was concluded from these limited tests that there was no valid correlation between blast formation time and residual penetration. (3) Evaluations were made on the protective value of sandwich-type assemblies composed of metallic and nonmetallic materials. Test firings showed that: (a) on the basis of weight, glass offered more protection than steel; (b) steel and glass blocks of cast lamellar construction offered more protection, even after repeated shots into the same area, than did glass blocks having steel cover plates. Equivalence ratio data and firing data including residual penetration are given in an appendix.

L1168

Michigan State College (DA20-089-ORD-35608).
DEFENSE AGAINST SHAPED CHARGES. Final rept. Aug. 10, 1953, [78]p. incl. tables, diagrs. Confidential

An evaluation of experimental and theoretical work on defense against shaped charges was made. It was concluded that: (1) steel balls 1 in. in diameter offered greater jet resistance than any other mechanical means tested, being equal to 2-3/8 times of mild steel on a weight basis, (2) it may be possible to store sufficient energy in an electrical condenser to interfere with the penetrating power of the jet by influencing the direction of the jet particles; (3) any defense mechanism using chemical reactions must have a reaction rate of explosive dimensions; (4) a detailed concordance on all shaped charge literature should be prepared; (5) sandwich-type assemblies of integral quartzite in steel offered the most promise against shaped charge jets. In addition, equivalence ratio data and firing table summaries including residual penetration data are given in an appendix.

L1169

Michigan University (W33-038-ac-14222).
APPLICATION OF THE SHAPED CHARGE PRINCIPLE AND THE MISZNAY-SCHARDIN EFFECT TO THE WIZARD ORDNANCE PROBLEM, by F. B. Cline. Nov. 6, 1947, 17p. incl. diagrs. (Proj. no. MX-794, External memo no. UMM-15) TIP S98 Secret

Shaped charges were studied in this investigation of methods for obtaining a directed and controlled cone of fire for an anti V2 guided missile. The first tentative design consists of using 7 separate shaped charges, each charge being similar to the US Army M3 demolition charge and weighing 40 lb. These charges are rigidly mounted in the nose of the final stage of the missile, 6 in an outer ring and 1 in the center. The center lines of the charges are so aligned with the axis of the missile that, when initiated, they will form a forward firing cone. A discussion is included on the Misznay-Schardin effect (regarded as a compromise between the Hopkinson-Bar effect and liner collapse) which offers the possibility of variation of fragment size, variation of density and cone angle or direction of fragment spray, high initial burst velocity, and any desirable compromise between density, range, and cone angle of fire. The fundamentals of jet formation and liner collapse are discussed.

L1170

Midwest Research Institute (DA23-072-ORD-264).
RESEARCH AND DEVELOPMENT OF MULTI-PURPOSE LIGHTWEIGHT ANTITANK WEAPON, by A. D. St. John and M. B. Thompson. Progress rept. no. 8, July 1-31, 1952. 23p. incl. illus. tables, diagr. (Proj. no. TS-4018; MRI proj. no. 687-E-65) AD-22 456 Confidential

Development studies of the T274 rocket-assisted HEAT projectile are continuing. The rocket motor of this round spins to provide stability, while the shaped charge warhead maintains little or no spin to offer the possibility of maximum penetration. The estimated weight and moments of inertia for the HEAT RA projectile are:

Weight
warhead section (nonrotating) = 6.07 lb.
rocket motor section (rotating) = 9.03 lb.

Moment of inertia
warhead section (nonrotating) = I_{ox} = 12.60 lb./sq. in.
rocket motor section (rotating = I_{ox} = 15.62 lb./sq. in.
transverse moment of inertia about c.g. I_{ox} (entire projectile) = 472.0 lb./sq. in.

L1171

Midwest Research Institute (DA23-072-ORD-264).
RESEARCH AND DEVELOPMENT OF MULTI-PURPOSE LIGHTWEIGHT ANTITANK WEAPON, by A. D. St. John and M. B. Thompson. Progress rept. no. 15, Feb. 1-28, 1953. 13p. incl. tables, diagrs. (Proj. no. TS4-4018; MRI proj. no. 687-E-65) AD-22 365 Confidential

The design and development studies of the HEAT RA (RNR) projectile, T274, are continued. The T274 consists of a warhead and rocket motor separated by a bearing section; the rocket motor section is rotated at a high speed by means of canted nozzles and rifling twist to provide accuracy and stability; the section containing the shaped charge warhead maintains a low spin rate to give maximum warhead effectiveness. In a test firing, round no. B2-17 showed a warhead muzzle spin rate of 2.94 r.p.s. as compared with a spin rate of 2.44 r.p.s. for round no. B2-11 tested earlier. It is proposed to use nylon bearings in the T274 projectile since these bearings offer a decrease in coefficient of friction for an increase in loading.

L1172

Midwest Research Institute (DA23-072-ORD-264).
RESEARCH AND DEVELOPMENT OF MULTI-PURPOSE LIGHTWEIGHT ANTITANK WEAPON, by A. D. St. John and F. W. Whitlock. Progress rept. no. 28, Mar. 1-31, 1954. 18p. incl. illus. tables. (Proj. no. TS4-4018; MRI proj. no. 687-E-65) Confidential

Two static spin tests were made on the RNR T274 HEAT projectile, a round designed with a bearing section to maintain a low spin rate for increased shaped charge effectiveness. In a preliminary analysis of the limited test data, it was estimated that the terminal spin rate of the 90-mm. warhead incorporating an ND Q30307 thrust bearing would be 125 to 150 r.p.s. at the end of a 2 sec. flight; the spin rate of a similar round using a nylon bearing would equal 250-300 r.p.s.

L1173

Military Attache, Argentina.
SMALL ARMS, MORTARS AND GRENADES OF ARGENTINE ARMY, by D. B. Weber. Apr. 10, 1948, 9p. (MA Argentina rept. no. R154-48) Confidential

Mention is made of an antitank grenade (fired from a rifle) similar in shape to a 60-mm. mortar shell. The grenade was fired against a 2-in. thick armor plate about 40 ft. from the rifle mounted on a tripod. Approximately 6 in. from the plate a heavy steel tank tread was interposed. After firing, a small hole about 0.5 in. in diameter was found in both the tank tread and the plate. It was pointed out that the penetration was not produced by a detonating wave, but by the production of extremely hot gases which melted their way through the plate and entered the interior at a temperature over 2000°C. There was no spalling noted at the time of penetration.

L1174

Military Attache, Cairo.
HOLLOW CHARGE AMMUNITION. May 22, 1942, 4p. incl. diagr. (MA Cairo rept. no. 2543) Confidential

Extracts are given from GHQ, MEF Intelligence Summaries no. 715 and 722 on German shaped charge ammunition but no technical information is presented. A diagram is shown of a German shaped charge rifle grenade.

L1175

Military Attache, Cairo.
HOLLOW CHARGE AMMUNITION FOR 75-MM KWK 38. Dec. 28, 1942, 3p. incl. diagr. (MA Cairo rept. no. 2961) Confidential

A description and drawing are presented of a shaped charge shell for the German 75-mm. KWK 38. The data are reproduced from Issue no. 75 of Middle East Technical Intelligence Summary.

L1176

Military Attache, Cairo.
RODDED BOMB FOR THE GERMAN 37-MM. AT GUN. Jan. 18, 1943, 4p. diagrs. (MA Cairo rept. no. 2996) Confidential

A description and detailed drawings of this bomb, which is similar to a spigot mortar bomb except that it has a perforated sleeve which fits over the barrel of the gun, are presented. The information was extracted from Issue no. 78 of the Technical Intelligence Summary published by MI 10, GHQ, MEF. No data on the performance of the bomb were available.

L1177

Military Attache, France.
BRANDT HEAVY AT ROCKET LAUNCHER, DEVELOPMENT OF, by W. W. Stromberg. Jan. 23, 1950, 4p. incl. diagrs. (MA France rept. no. R60-50) Secret

The Edgar J. Brandt Co. is developing a heavy 120-mm. AT rocket launcher called "SNEB" which will defeat 300 mm. (12 in. approximately) of armor at 700 m. The projectile, which is about 3.5 ft. long, is in 2 parts. The upper part contains the shaped charge and is separated from the lower part by a ring of ball bearings. The lower part contains the propellant which escapes through inclined vents at the rear of the projectile thus imparting spin. The spin provides gyroscopic stabilization in flight, and because of the ball bearings the spin is not imparted to the shaped charge portion of the projectile.

L1178

Military Attache, France.
NON-DETECTABLE ANTITANK MINE, by L. M. Riley. Dec. 7, 1950, 1p. (MA France rept. no. R769-50) Secret

The Edgar Brandt Co. is developing a shaped charge antitank mine which has a plastic cover approximately 10 in. long and 8 in. in diameter. It is devised to be used in pairs with an accompanying activating and firing device. In the opinion of the author its size and height are disadvantages because a fairly large hole is necessary in order to plant and hide this mine. It could be used in deliberate mine laying operations, but would be a considerable disadvantage for any hasty minefield operations.

L1179

Military Attache, France.
120-MM. HOLLOW CHARGE BAZOOKA, by L. M. Riley. Dec. 7, 1950, 1p. (MA France rept. no. R770-50) Secret

About 100 rounds were fired at panels 100, 300, and 500 m. from the firing point. Fairly uniform results were obtained. A ball-bearing rotational device was used to keep the shaped charge from excessive rotation. Experiments showed that while the shaped charge turned to a very small degree, it performed well within the effective limits. The rocket launcher will be carried on a jeep or small weapons carrier. The effective range can be increased up to about 1000 m.

L1180

Military Attache, London.
MUNROE EFFECT AND CHARGE FOR PENETRATING CONCRETE. (Abstract). [Jan. 6, 1942], 1p. (MA London rept. no. 46117) Confidential

A 5-lb. charge containing an 80° liner was fired at a standoff of 4.5 in. A 2.5-in. diameter hole, 2.5 ft. in depth was produced in the heavily reinforced concrete target. A second charge detonated over the hole increased its depth by 2 ft. It was concluded that to double the hole depth, all linear dimensions including the distance from the target must be doubled and the charge weight increased 8 times. Consequently, a 40-lb. charge produced a hole 4.5 in. in diameter, 3 ft. deep. It was decided that: (1) thickness and material of container are important; (2) for the 5-lb. charge, 1/8-in. malleable Fe casting was most suitable; (3) the liner angle must be 80°; (4) the standoff distance must be from 2/3 to 1-1/3 charge diameters; (5) the explosive should be TNT, Nobel 808, or plastic HE.

L1181

Military Attache, London.
TESTS TO ESTABLISH EFFECT ON MAXIMUM PENETRATION BY CHANGING (1) DISTANCE FROM CONE TO TARGET; (2) EXPLOSIVE FILLING; (3) CONE MATERIAL, (4) POINT OF INITIATION. Aug. 19, 1942, [5]p. incl. diagrs. (Interim rept. nos. 1 and 2 on the Hollow Charge; MA London rept. no. 49658) Confidential

Variation of distance showed maximum penetration at the [standoff] distances given below for 3 explosives:

PE (RD no. 1031)	7.5 in. = 2-1/8 diameters	
Nobel 808	9.5 in. = 2.75	"
TNT/PETN (75/25)	12 in. = 3.5	"

(distance measured from base of the liner to target)

PE showed a decided decrease in penetration past that point; with the other explosives the decrease was gradual. Steel liners showed a greater penetration (average 1 in.) than brass liners; the steel liners performed best at a 10-in. standoff, while the brass liners optimum standoff was 12 in. Both tests were made with 14 GA gauge and 808 filling. Tests made with charges using a central core showed that the optimum distance might vary and was less when the central core was used. Further tests with the same type charges and containers showed that with PE, brass, and Mn bronze were more effective than mild steel; the optimum thickness was 1/50 of the diameter; however, the reduction of penetration up to twice the optimum was only slight. With TNT, brass was more effective than steel with a thickness 1/50 of the diameter; preliminary results tended to show thicknesses below 1/50 of the diameter best. Steel was better than brass with Nobel 808 for a thickness approximately 1/50 of the diameter. It was concluded that TNT/PETN (75/25) may be a suitable substitute for Nobel 808 if brass liners are used and a plastic explosive is unnecessary.

L1182

Military Attache, London.
2000-LB. C[APITAL] S[HIP] BOMB. Dec. 26, 1942, 3p. (MA London rept. no. 52644) Secret

A brief summary is given of a CS bomb 27 in. in diameter, with a total weight of 2000 lb. and an over-all length of 72 in. The bomb, when released under normal conditions, would be capable of perforating the armored portion and bottom of a ship having "Tirpitz" construction. In case of near misses, the CS bomb would have a very effective side blast.

L1183

Military Attache, London.
GERMAN ANTITANK MAGNETIC HOLLOW CHARGE, by S. O. H. Dobbins. Mar. 11, 1943, 5p. incl. illus. (MA London rept. no. 54817) Unclassified

Photographs and a cross-sectional drawing of a German antitank magnetic shaped charge are shown.

L1184

Military Attache, London.
? -LB. ANTISUBMARINE BOMB (HOLLOW CHARGE) [BRITISH]. Mar. 15, 1943, 4p. incl. diagrs. (MA London rept. no. 54919) Secret

The 35-lb. antisubmarine Mark I bomb showed promising results against simulated submarine targets. The bomb contained 16 lb. of RDX/TNT which was held in place by a liner 7/32 in. thick and weighing 4 lb. A drag disc was welded to the fin assembly in order to facilitate entry of the bomb into the water. The disc decreased the bomb terminal velocity from approximately 550 ft./sec. to approximately 320 ft./sec. and made the bomb less stable.

L1185

Military Attache, London.
ROTATED HOLLOW CHARGE PROJECTILES. Apr. 20, 1943, 3p. (MA London rept. no. 56025) Confidential

British research indicated that the optimum apex angle for an unrotated lined shaped charge is 80°; American experience indicated an optimum angle of about 45°. The effect of rotation is discussed; it was concluded that an apex angle of 45° would not produce too wide a jet to be effective and that a nose fuze conserves standoff better than a base fuze. Neither type of fuze was found to be as effective as the spitback fuze employing a small lined shaped charge (Fuze no. 233).

L1186

Military Attache, London.
ROTATED HOLLOW CHARGE. June 27, 1944, 2p. (MA London rept. no. 69884) Secret

A brief rept. is made of a conference held at Fort Halstead to discuss the British status on the study of rotated shaped charges.

L1187

Military Attache, London.
60-LB. HOLLOW CHARGE HEAD FOR AIRCRAFT ROCKET [BRITISH]. Jan. 9, 1946, 1p. diagrs. (MA London rept. no. R95-46) Confidential

Detailed drawings are given for the 60-lb. shaped charge rocket shell.

L1188

Military Attache, London.
FOREIGN DEVELOPMENT OF SHAPED CHARGES, by F. F. Reed. Feb. 16, 1946, 9p. (MA London rept. no. R609-46) Restricted

The bibliography lists repts. on German gun ammunition, antitank rocket projectiles, antitank grenade, demolition stores; Italian gun ammunition; a Japanese grenade; War Office Technical Intelligence Summaries; repts. from Armament Research Department, Halstead Exploiting Centre, and from the Chief Engineer, Armament Division.

L1189

Military Attache, London.
TEST OF 60-LB. HOLLOW CHARGE ROCKET HEAD AGAINST GERMAN TANKS, by F. F. Reed. Mar. 20, 1946, 10p. incl. diagrs. (MA London rept. no. R1664-46) Confidential

The HE, 60-lb. GP shell was designed to produce a good fragmentation effect against vehicles and personnel, and sufficient AP performance to penetrate heavy tanks. The shell was tested against German Panther tanks to determine the resulting damage; live rabbits were placed in the driver's compartment to assess probable effect on tank occupants.

L1190

Military Attache, London.
CASUALTIES AMONGST ARMORED UNITS. (1) A SURVEY OF CASUALTIES AMONGST ARMORED UNITS AND (2) CASUALTIES IN ARMORED FIGHTING VEHICLES. July 9, 1946, 11p. (MA London rept. no. R2192-46) Secret

The rept. is concerned with casualties resulting from penetrations by shaped charges and AP shells. Over 30% of the casualties were caused by shaped charge weapons, the most prevalent of which was the Panzerfaust. The casualties are analyzed by type of tank, crew position, and place of penetration.

L1191

Military Attache, London.
CONFINEMENT OF EXPLOSIVE CONED CHARGES, by R. Farrent. Sept. 9, 1946, 3p. incl. diagrs. (MA London rept. no. R4321-46) Restricted

An investigation was made of the effect of liner thickness for confined and unconfined charges on maximum penetration.

L1192

Military Attache, London.
RESEARCH IN FRANCE BY GERMAN SCIENTISTS, by F. F. Reed and others. Oct. 11, 1946, 12p. (MA London rept. no. R4131-46) Confidential

A brief survey of the work of about 80 German scientists at Saint-Louis (France), who are under the direction of Prof. Schardin, is presented. Details of research and apparatus are given on spark photography technique, penetration of armor plate, theory of armor plate penetration, shaped charges, interferometer techniques and theory, high speed cathode ray oscillography, and ballistic aerodynamics.

L1193

Military Attache, London.
DISTANT OPERATING HOLLOW CHARGES. Nov. 13, 1946, [7]p. incl. tables. (MA London rept. no. R4849-46) Secret

During trials on the Munroe effect, it was shown that the large shaped charges (H. 15) showed considerable armor piercing capabilities even at distances of 10 to 20 m. Plates of 90 to 120 kg./mm^2 strength and captured Russian tanks were used. Three types of liners were used: a steel liner; a HE liner consisting of a steel liner fitted with a charge which detonates when the liner strikes a surface; and a shrapnel liner, made up of small pieces of metal. Four different explosives were employed, TNT, TH11, RDX/TNT, and Trialen. The charges tested weighed from 14.5 to 17.5 kg. and contained from 8.5 to 10.3 kg. of explosive. At 20 m. a 250-mm. diameter hole was made in 100 mm. plate; at 50 m. a 200-mm. hole was made in 80-mm. plate. Trialen was the most effective explosive.

L1194

Military Attache, Paris.
FRENCH EXPERIMENTAL WEAPONS; EXTRACT OF REPORT BY THE CO OF THE BRITISH RADAR TEAM PARTICIPATING IN THE MILITARY DEMONSTRATION AT BOURGES, 10 MAY 1946. June 13, 1946, 3p. (MA Paris rept. no. R312-46) Secret

Of the weapons demonstrated by the French Army, only 1 was a shaped charge weapon. This was the "plate" charge or "Assiette" being developed from a point reached by previous German researches, and based on the Misznay-Schardin principle. The bomb was about the size and shape of a dinner plate, being concave on 1 side and convex on the other. It was fired by an electric detonator at the axis. The convex side was thicker and the casing so designed that the explosion was evenly distributed across this side. Method of firing and the results are briefly described.

L1195

Military Attache, Paris.
FRENCH "FLAT" OR "DISH" CHARGE. Feb. 26, 1947, 4p. (MA Paris rept. no. R176-47) Secret

A weapon is described which consists of a slightly dished mild steel plate placed concave side up on top of a charge of TNT or other high explosive, formed to fit the bottom of the plate and to be in direct contact with it. Mention is made of 2 methods of firing this charge. Characteristics are listed for the flat charge, which is of German design, and at the time of this rept. was being developed by Schardin for the French. (See also item no. L1146.)

L1196

Military Attache, Switzerland.
EDGAR BRANDT ANTITANK RIFLE GRENADE, by A. T. Hamilton. Oct. 20, 1945, 3p. illus. (MA Switzerland rept. no. R260-45) Restricted

The antitank rifle grenade designed by Edgar Brandt is described. The grenade contains a shaped charge which is larger than that usually employed in rifle grenades, but the light weight of the metal components results in a grenade weight of 1.93 lb. The grenade was designed to be fired from the standard US Army rifle grenade launcher using a standard US grenade cartridge. The Swiss found that the grenade successfully perforated 150 mm. of steel armor plate. The best effective range was found to be from 30 to 50 m. for ordinary operations. The grenade functioned properly when fired against armor plate at angles up to 45°. The sensitivity of the fuze, after arming, was demonstrated by firing grenades from a rifle held parallel to the ground so that the grenade merely grazed the ground. The fuze fired successfully. Firing was also conducted against an empty burlap sack suspended in the air to prove the sensitivity of the fuze after arming. An inclosure to the rept. describes the antitank rifle grenade, Energa.

L1197

[Military Intelligence, Gt. Brit.].
[TECHNICAL INTELLIGENCE SUMMARY NO. 6]. [Aug. 14, 1943], Part V, p. 12-13, Annexes C-E. Confidential

The part of this rept. dealing with shaped charges describes the German magnetic antitank charge and the 400-g. demolition charge.

L1198

Military Intelligence Division, War Department.
THE HOLLOW-CHARGE PROJECTILE. Aug. 1943, 18p. incl. illus. tables. (PACMIRS document no. 2008) (Trans. as PACMIRS Technical Service trans. no. 15, Aug. 27, 1945) Confidential

This translation of a Japanese document covers shaped charge history, principles, function, characteristics, structure, and the use of shaped charge ammunition with specific attention to artillery shells and antitank projectiles.

L1199

Mine Warfare Panel, Engineer Center, Fort Belvoir.
[A DESCRIPTION OF NATO MINE WARFARE MATÉRIEL, by J. F. McCaslin]. n.d., p. 9-25 (Exhibit B in its Proceedings of the Panel on Tactical Land Mine Warfare convened at the Engineer Center, Fort Belvoir, Va., May 4, 1953, Secret, AD-27 408) Secret

The following shaped charge mines are briefly described: French—(1) Two types of AT Model 51 shaped charge mines, 1 using a steel liner and the other a glass liner, both 17 cm. in diameter, penetrated 100-150 cm. in armor plate. (2) The double shaped charge mine, made from 2 STRIM rifle grenades or rocket heads and connected by about 12 ft. of rubber hose, when buried under 2 in. of earth perforated a 4-in. armor plate 21.5 in. above the ground. Italian—The single-jet, Bombrini-Parodi-Delfino shaped charge with a nonmetallic liner gave the same penetration as those with metallic liners. This mine employs a cover directly over the base of the liner without the standoff covers conventionally found in US shaped charge devices. An igniter lights a pad of black powder on the inner side of this cover, which builds up pressure and flashes through a hole in the apex of the liner to ignite the booster and set off the main charge. In many cases, the black powder in blowing off the cover removes all the dirt from the top of the mine.

L1200

Mine Warfare Panel, Engineer Center, Fort Belvoir. STATUS OF ORDNANCE RESEARCH AND DEVELOPMENT OF MINE WARFARE MATERIEL, by J. R. Browder. n.d., [16]p. (Appendixes C and D-1 of its Annex no. 3 to Proceedings of the Panel on Tactical Land Mine Warfare. Rept. of the Committee on Research and Development convened at the Engineer Center, Fort Belvoir, Va., May 4, 1953, Secret, AD-27 444) Secret

The shaped charge land mines designated T23, T24, T25, T26, T28, T29, and T30 are briefly described. Data on their size, liner material, over-all weight, charge composition and weight, fuzing, and emplacement location are given in tabular form.

L1201

Mine Warfare Panel, Engineer Center, Fort Belvoir. THE STATUS OF RESEARCH AND DEVELOPMENT OF MINE WARFARE MATERIAL, by A. C. Wells, Jr. n.d., [13]p. (Appendixes C and D of its Annex no. 3 to Proceedings of the Mine Warfare Panel. Rept. of the Committee on Research and Development convened at the Engineer Center, Fort Belvoir, Va., Feb. 11, 1952, Secret, AD-12 469) Secret

In this study on the tactical aspects of land mine warfare, the following shaped charge land mines are briefly described: (1) the T23, single jet, 4.5-in. diameter, Al liner, 3.5-lb. Comp. B charge; (2) the T24, single jet, 6-in. diameter, Al liner charge; (3) the T28, single jet, 4.5-in. diameter, 3.5-lb. Comp. B charge; (4) the T25, multijet, 12-in. hemisphere, 7 steel-liner, 12-lb. Comp. B charge; (5) the T26, multijet, 22-in. diameter, 7 steel-liner, 14-lb. Comp. B charge; (6) the T29 (design stage), 9-in. diameter, 11-lb. Comp. B charge; and (7) the T30 (design stage), 9-in. diameter, 10-to 11-lb. Comp. B charge.

L1202

Mine Warfare Panel, Engineer Center, Fort Belvoir. DEVELOPMENT OF SHAPED CHARGES. Nov. 1951, [5]p. (Appendix F-4 of its Annex no. 3 to Proceedings of the Panel on Tactical Land Mine Warfare. Rept. of the Committee on Research and Development convened at the Engineer Center, Fort Belvoir, Va., May 4, 1953, Secret, AD-27 444) Secret

The operational and physical characteristics of a family of shaped charge mines, ranging from a single jet mine for deep burial to a multijet mine for shallow burial, are given. Preliminary designs have been prepared, based on the results of limited firings of shaped charge munitions through soil. Brief descriptions of the T23, T24, T25, T26, and T28E1 shaped charge mines under development at Picatinny Arsenal are also presented.

L1203

Mine Warfare Panel, Engineer Center, Fort Belvoir. THE PRESENT STATUS OF RESEARCH AND DEVELOPMENT IN ENGINEER MINE WARFARE MATÉRIEL. May 1953, [44]p. (Appendix D-2 of its Annex no. 3 to Proceedings of the Panel on Tactical Land Mine Warfare. Rept. of the Committee on Research and Development convened at the Engineer Center, Fort Belvoir, Va., May 4, 1953, Secret, AD-27 444) Secret

The linear shaped charge snake "Diamond Lil", which clears pressure actuated mines by means of a linear shaped charge jet and accompanying pressure, is briefly described. This device uses the "shaped charge" principle by emplacing 2 linear "V-shaped" hollow troughs along the length of the line charge (300 ft. or more). Tests are being conducted to determine optimum charge weight, trough angle, and trough orientation with respect to the ground. In addition, the method of operation and the physical characteristics of the shaped charge mine layers "Tom Cat", "Knotty Pine", "Lazy Tom", and "Black Cat" are given. Other mine warfare matériel, including mine detectors, are also mentioned.

L1204

Mine Warfare Panel, Engineer Center, Fort Belvoir. PRESENTATION ON BRITISH RESEARCH AND DEVELOPMENT IN LAND MINE WARFARE MATÉRIEL, by S. Lynn. May 1953, 9p. (Appendix E of its Annex no. 3 to Proceedings of the Panel on Tactical Land Mine Warfare. Rept. of the Committee on Research and Development convened at the Engineer Center, Fort Belvoir, Va., May 4, 1953, Secret, AD-27 444) Secret

In this survey, brief descriptions are given of British land mines using the Misznay-Schardin effect. A small shaped charge antipersonnel mine having a 60° liner pressed from polystyrene and capable of penetrating 0.25-in. plate is also mentioned.

L1205

Ministère de la Defense Nationale.
FRENCH AP RIFLE GRENADE. July, 1950, 4p. illus. (Inclosure 2 to ORD-TRART-LR-239, Rept. on French and Belgian Developments Antitank Rocket Launchers and Rifle Grenades from US User Representative for Infantry) Confidential

Base fuze priming in the 73-mm. grenade permits better functioning of the shaped charge and greater uniformity of target perforation. Against homogeneous steel armor plate, the grenade penetrates 240 to 250 mm. at normal obliquity and 90 to 100 mm. at 60° obliquity at ranges up to 250 m. This weapon is capable of defeating the newest armored tank.

L1206

Ministry of Supply (Gt. Brit.).
SHAPED CHARGES-SESSION 8A. July 1953, p. 11, 40-41. (In its Rept. on the Fifth Tripartite Conference on Armaments, Explosives, and Propellants held at London, Apr. 13-24, 1953, Secret, AD-19 520) Secret

In the discussion on shaped charges, it was recommended that: (1) emphasis be placed on the development of multiple-flash X-ray equipment; (2) triple-flash X-ray equipment be given wider use in the US, Canada, and Great Britain for the purpose of obtaining more uniform research techniques and data; (3) the problem of the lethality of the shaped charge jet be studied further.

L1207

Ministry of Supply, Shell Mex House, London.
THE DEVELOPMENT OF CONTINUOUS SHAPED CUTTING CHARGES, by L. A. Iles. n.d., 24p. incl. illus. diagrs. (Permanent Records of Research and Development, MOS Monograph no. 8.102, issued July, 1950) Restricted

Experiments with explosive charges having a hollow "tunnel-shaped" cavity in the form of an inverted "V" lined with metal were carried out, during 1942, by the Road Research Laboratory, DSIR, with the object of producing a charge which would cut the tension reinforcement in a reinforced concrete beam with a comparatively small quantity of explosive. The experiments were successful and led to the design and production of the "Charge, Demolition, no. 3, 15-lb. (Hayrick)". A line charge made of a single row of Hayricks (providing 30-lb. of explosive/ft. run) is adequate to deal with the heaviest tension reinforcement likely to be encountered in a reinforced concrete T-beam bridge. Later, 2 much smaller versions of the "tunnel charge", called the "Stooks", were designed and produced for the purpose of cutting steel in enemy beach obstacles. (MOS abstract)

L1208

Ministry of Supply, Shell Mex House, London.
INITIATION OF SHAPED CHARGES BY NOSE FUZES, by R. H. Farrant. Oct. 1945, 3p. diagrs. (Permanent Records of Research and Development, MOS Monograph no. 25.005, issued June, 1949) Secret

The problem of initiating shaped charge shells at the correct standoff is explained, and several nose fuzes designed to achieve this are described. The use of a shaped charge in the fuze itself is reported, and its employment in service fuzes is described.

L1209

Ministry of Supply, Shell Mex House, London.
THE USE OF THE SHAPED CHARGE IN PIAT AMMUNITION AND 3.7-IN., 95-MM. HEAT SHELL, by R. H. Farrant. Oct. 12, 1945, 14p. diagrs. (Permanent Records of Research and Development, MOS Monograph no. 25.000, issued Mar. 1949) Secret

The rept. is divided into 2 parts: Part I, "The use of the shaped charge in PIAT ammunition", and Part II, "The use of the shaped charge on 3.7-in. and 95-mm. HEAT SHELL". Part I. The steady increase in thickness of tank armor indicated that where lightness of the projector was important, the use of shaped charges rather than solid bullets to give penetration, would have advantages. An increased performance of 500% over the previous Infantry A/T Weapon (Boys Rifle) was shown to be possible by the use of a 3.5-in. diameter shaped charge initiated by a nose fuse. The modifications for production improvements in filling technique, and the use of cast fillings are described. Finally, a proposed redesign especially for cast filling is given. Part II. A requirement for an antitank round for field guns led to the design of a shaped charge round for use in the 3.7-in. and 95-mm. howitzers. This incorporated a 45° liner with a tubular extension from the apex, and a new nose fuse which detonated tetryl exploder pellets from a distance by means of a small Munroe jet. The trials being successful, production was started, but difficulties ... were experienced, and though production was completed the manufacturing defects have not yet been identified. (MOS abstract)

L1210

Mobile Explosives Investigation Unit Number 1 (U. S. Navy).
CONICAL ANTITANK HAND GRENADE, by J. S. Rath. n.d., 3p. incl. illus. Restricted

A Japanese antitank hand grenade was recovered on Leyete, consisting of the explosive charge, liner, and wooden base contained in a silk bag with a fuze and tail of hemp attached to the upper portion. Data, markings, and performance are included.

L1211

Morris, G.
IMPROVEMENTS IN OR RELATING TO EXPLOSIVE MISSILES SUITABLE FOR USE AGAINST ARMOR. British patent no. 578, 771, July 11, 1946.

The projectile described is an explosive charge with a co-axial core having a metal lining. The lateral parts of the projectile casing extend beyond the charge's foremost surface, terminating in a striking nose member having a circular knife edge to attack the target plate. On impact, the nose member transmits the shock to a fuze which initiates the detonation of the explosive charge from behind the apex of the conical surface at the proper standoff distance.

L1212

[Munitionskommission und Erfahrungsgemeinschaft "H-Ladung" des Reichministers für Bewaffnung und Munition].
REPORT ON THE DEVELOPMENT OF HOLLOW CHARGES. PART I, 1943. CONTRIBUTIONS ON THE STATUS OF DEVELOPMENTS IN THE REALM OF HOLLOW CHARGES. (LECTURES AT THE MEETING OF THE ARMY ORDNANCE OFFICE ON DEC. 20, 1942. AND THE SESSION OF THE ERFAHRUNGSGEMEINSCHAFT H-LADUNG ON FEB. 9, 1943). by H. Schardin and others. 1942-1943. (Trans. as OTIB rept. no. 1146A, 23p. illus. tables, diagrs.; Also trans. as rept. no. BIOS/Gp. 2/HEC 2576, 81p. incl. illus. diagrs.; Inclosure 1 to MA London rept. no. R3246-45) (Lecture by Dr. Schardin also trans. as rept. no. OTIB 1480, 15p. illus. diagrs. For abstract see item no. L581)
Restricted

Dr. Meyer discusses detonation tests using the 7.5-cm. shell 38 in which a nozzle with similarly tapered walls is placed in front of a tapered charge liner. Influencing factors investigated were: (1) best liner angle; (2) effect of nozzle and composition of explosive; (3) kind of ignition; and (4) use of a vacuum cap. Thomanek reported on the effect of conical liners having walls of parallel thickness as compared to those having walls of tapered thickness when tested in a charge with a diameter of 60 mm.. Test results are tabulated and graphed. Thomanek in his second lecture briefly discussed the jet, effect of rotation, and a scale-up law for conical liners.

L1213

[Munitionskommission und Erfahrungsgemeinschaft "H-Ladung" des Reichministers für Bewaffnung und Munition].
REPORTS ON THE DEVELOPMENT OF HOLLOW CHARGES. PART II, 1943. by Keil and others. 1942-1943. (Trans. as rept. no. OTIB 1146B, 20p. illus. diagrs.; Also trans. as rept. no. BIOS/Gp. 2/HEC 2577, classified "Secret", 54p. incl. illus. diagrs.) (Lecture by Dr. Keil also trans. as rept. no. OTIB 1961B, 3p. illus. diagrs. For abstract see item no. L646)
Restricted

Dr. von Holt discussed an investigation of shaped charge phenomena which was made using 7.5-, 8.8-, and 10.5-cm. caliber charges. Firing tests led to the following conclusions: (1) optimum range of apex angle is from 40° to 60°; (2) optimum liner thickness is 1.5 mm. and 2.0 mm., (3) optimum standoff with 1.5-mm. liner thickness is 80 mm. for angles from 40° to 60°; with 2.0-mm. liner thickness the optimum standoff varies according to the apex angle. Increased penetration was obtained by using a "Dusenhelm"—a funnel or jet shaped metal body placed in front of the cavity to concentrate the jet and thus increase its efficiency. The results of the complete series of tests are presented in tabular form. The question "Can the conditions of optimum efficiency of hollow charges be reduced to scientific laws?" was discussed by Geitmann. Bucklisch lectured concerning the further development of the 7.5-cm. shell 38 with emphasis on: (1) liner angle, material, and wall thickness; (2) use of effective explosives; (3) the possibility of directing the jet through a flash tube; and (4) the problem of ignition. Weigel reported on detonation tests to determine the function of particular parts of the shaped charge.

L1214

Munroe, C. E.
THE APPLICATIONS OF EXPLOSIVES. Popular Science Monthly, v. 56, Feb. 1900: 444-455.

Munroe was led by the following observations to construct a hollow cartridge (dynamite sticks tied around a can) for blowing up a safe: (a) the inscription on the face of a molded piece of guncotton fired resting on an Fe plate was reproduced on the plate; (b) holes of varying depth and width were bored in cylinders of guncotton and when these cylinders were fired, those having the widest, deepest holes completely perforated the Fe plate target. (See also item no. L16.)

L1215

Muraour, H. and J. Fauveau.
REMARKS ON A RECENT NOTE BY JAMES AND JACQUES BASSET ENTITLED, "THE INFLUENCE OF SURROUNDING PRESSURE ON THE EFFECTS OF HOLLOW CHARGES AND ON THE BURNING OF POWDERS" (Remarques sur une Note récente de MM. James et Jacques Basset intitulée "Influence de la pression ambiante sur les effets des charges creuses et la combustion des poudres"). Comptes rendus hebdomadaires des séances de l'académie des sciences, v. 232, Mar. 5, 1951: 942-944.

A critical analysis is presented by the authors of the hypothesis formulated by James and Jacques Basset in order to explain the inhibiting action of the centrifugal force on the perforating power of hollow charges. The authors point out that the true reason for the effect of rotation must be sought in the inhibiting action that the centrifugal force exerts on the formation of the metallic jet which, launched at a velocity of the order of 8000 to 10,000 m./sec., is the true perforating agent.

L1216

Murasour, H.
ON THE DECREASE OF BRISANCE OF SHAPED CHARGES UNDER THE INFLUENCE OF ROTATION (Sur la diminution des effets brisant des charges creuses sous l'influence de la rotation). Chimie et industrie, v. 66, Nov. 1951: 656.

The author points out that, contrary to a thesis supported by James and Jacques Basset, the fact that a rotating hollow charge has less perforating power than a nonrotating hollow charge cannot be attributed to a decrease of the brisance of the over-compressed explosive under the influence of the centrifugal force.

L1217

Muskat, M., F. W. Parker, and W. L. Keil (assignors to Gulf Research and Development Co.). APPARATUS FOR PERFORATING WELL CASINGS AND WELL WALLS. United States patent no. 2,494,256, Jan. 10, 1950.

The patent concerns an apparatus employing shaped charges for perforating pipe. Single, double, and multiple charges are used; the apparatus is particularly designed for perforating well casing in oil boreholes but may be used to perforate any pipe of which only the inside is accessible. Preferred relationships between charge length and diameter and standoff and diameter for Al and steel liners are specified, as are apex angles and liner thickness. It is stated that if a steel liner 1% to 3% of the caliber of the charge is used, the slug will be small enough to pass through the hole in the casing.

L1218

National Bureau of Standards (Proj. no. TM3-5201). PRODUCTION OF COPPER CONES, by W. Blum. Summary rept. Aug. 31, 1948, 3p. (Rept. no. 1) TIP S495
Secret

The investigation includes a study of the electroforming of smooth cones for liners, the precise engraving of flutes on steel mandrels by means of a pantograph engraving machine, and the forming of the flutes in the cones by means of a hydraulic press using rubber to transmit the pressure.

L1219

National Bureau of Standards (Proj. no. TM3-5201). [PRODUCTION OF COPPER CONES], by W. Blum. Progress rept. Dec. 31, 1948, 4p. TIP S776
Secret

A summary is presented of 2 activities: the electroforming of cones in Cu or other metals, and the production of metal dies to be used as mandrels for electroforming or as dies for producing flutes on cones. Details of electroforming processes are reported; periodic reverse current plating was found to give a much smoother and brighter deposit than that produced with continuous direct current. The production of fluted mandrels and the pressing of fluted cones is described.

L1220

National Bureau of Standards (Proj. no. TM3-5201). [PRODUCTION OF COPPER CONES], by W. Blum. Progress rept. Mar. 1, 1949, 3p. TIP S775
Secret

Progress on the electroforming of Cu, Ag, Au, and fluted Cu cones is reported. The production of mandrels and the pressing of flutes into cones are briefly described.

L1221

National Bureau of Standards (Proj. no. TM3-5201). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES. Research and development periodic technical progress rept., Mar. 1-June 30, 1949. 2p.
Confidential

Progress is reported on electroforming Cu, Ag, and Au liners.

L1222

National Bureau of Standards (Proj. no. TM3-5201-D). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES, by W. Blum. Research and development periodic technical progress rept., Mar. 1-June 30, 1949. June 30, 1949, 3p. TIP S997
Secret

Plain Cu liners (0.045-0.005-in. thick) were electroformed singly from an acid Cu bath; others were electroformed by periodic reverse current from a cyanide Cu bath. The method of fluting Cu liners is outlined. Three fluted liners were examined for cracks.

L1223

National Bureau of Standards (Proj. no. TM3-5201). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES, by W. Blum. Research and development periodic technical progress rept., July 1-Sept. 30, 1949. Sept. 30, 1949, 2p.
Confidential

Progress is reported on the production by electroforming of smooth Cu and Au liners.

L1224

National Bureau of Standards (Proj. no. TM3-5201-D). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES, by W. Blum. Research and development periodic technical progress rept., July 1-Sept. 30, 1949. Sept. 30, 1949, 3p.
Secret

Progress is reported on the production of fluted Cu liners by pressing with a fluted male steel die. Firing tests indicated that smooth Cu liners prepared by electroforming were somewhat inferior to drawn Cu liners. Firing tests also indicated that fluted Cu liners formed with a soft steel die were superior to those formed with a hardened steel die. The production of drawn fluted Cu liners by pressing on a female fluted die is also described.

L1225

National Bureau of Standards (Proj. no. TM3-5201). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES, by W. Blum. Research and development periodic technical progress rept., Oct. 1-Dec. 31, 1949. Jan. 30, 1950, 2p. Confidential

Progress is reported on the production by electroforming of smooth Au liners.

L1226

National Bureau of Standards (Proj. no. TM3-5201-D). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES, by W. Blum. Research and development periodic technical progress rept., Oct. 1-Dec. 31, 1949. Jan. 30, 1950, 3p. Secret

Progress is reported on the production of fluted Cu liners made by pressing fluted mandrels into Cu liners.

L1227

National Bureau of Standards (Proj. no. TM3-5201-D). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES, by W. Blum. Research and development periodic technical progress rept., Jan. 1-Mar. 31, 1950. Apr. 24, 1950, 4p. TIP S50558 Secret

An examination was made of the contours of the cross-sections of conical liners which were pressed in an electroformed Co-P alloy die with a rubber punch. Some deformation of the flute contour was caused by contraction of the electroformed die, the result of high internal stress. The blistering of the alloy deposit could be eliminated by changing the bath composition. Firing tests were made on Frankford Lot 3 blanks which were "ironed" with a smooth steel punch and smooth steel die. The performance of the lot was very poor, and thought to be due to the poor surface condition of the liners.

L1228

National Bureau of Standards (Proj. no. TM3-5201-D). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES, by W. Blum. Research and development periodic technical progress rept., Apr. 1-June 30, 1950. July 25, 1950, 3p. TIP S50558 Secret

Progress is reported on the production of fluted Cu liners.

L1229

National Bureau of Standards (Proj. no. TM3-5201-D). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES, by W. Blum. Research and development periodic technical progress rept., July 1-Sept. 30, 1950. Oct. 23, 1950, 5p. incl. tables. TIP S50776 Secret

Tabular data show the status of the fluted liners.

L1230

National Bureau of Standards (Proj. no. TM3-5201-D). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES, by W. Blum. Research and development periodic technical progress rept., Oct. 1, 1950-Jan. 31, 1951. 4p. TIP S50946 Secret

Two lots of liners with sharp inside flutes were pressed with tool steel punches and rubber dies. Preliminary tests with free-machining stainless steel as the mandrel material indicated that there was no improvement in machining accuracy. Promising results were obtained with Ag-plated brass mandrels.

L1231

National Bureau of Standards (Proj. no. TM3-5201-D). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES, by W. Blum. Research and development periodic technical progress rept., Feb. 1-Mar. 1, 1951. Apr. 30, 1951, 3p. TIP S50946 Secret

A Co-P die, with 60 flat-milled flutes, 0.016-in. maximum depth, was electroformed.

L1232

National Bureau of Standards (Proj. no. TM3-5201-D). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES, by W. Blum. Research and development periodic technical progress rept., Apr. 1-Sept. 30, 1951. [2 repts.] TIP S50946 Secret

Two shaped charge land mine components were completed. A smooth Cu conical liner with a black finish was examined. The liner appeared to be coated with a Cu compound, oxide or sulfide, but more material was required for positive identification.

L1233

National Bureau of Standards (Proj. no. TM3-5201-D). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES, by W. Blum. Progress rept. Oct. 1-Dec. 31, 1951. 2p. TIP S50946 Secret

A list is given of liners which were sectioned polished and mounted.

L1234

National Bureau of Standards (Proj. no. TA3-5201). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES, by V. A. Lamb. Periodic technical progress rept. Jan. 1-Mar. 31, 1953. 6p. Confidential

The following work was completed: (1) 138 plain Cu liners were electroformed; (2) section mounts and photographs of flute contours were made for the 16 flute, 0.020-in. and 0.005-in. maximum depth, and for the 20 flute, 0.020-in. maximum depth liners; (3) liners with 16 and 24 flutes of varying flute depth were sent to the Carnegie Institute of Technology; (4) 18 liners were plated inside with radioactive Ag 110 to varying distances from the base; (5) modification of the Co-P die by grinding a radius at the base of the thread permitted easier removal of the formed liner.

L1235

National Bureau of Standards (Proj. no. TA3-5201). BASIC RESEARCH AND DEVELOPMENT OF SHAPED CHARGES, by V. A. Lamb. Periodic technical progress rept. Apr. 1-June 30, 1953. 7p. Confidential

Work was started on 57-mm. Cu liners with 16 flutes, 0.017-in. maximum depth, sharp inside and outside with 4° rotation between inside and outside flutes. Preparation of these liners includes drawing of smooth blanks, forming of flute, and insertion into shell bodies. In addition, 30 plain Cu liners of the lot series BEC60 to 74 were electroformed. Section mounts and photographs of the flute contours of various lots were completed. Liners having 16 flutes with 0.015-in. maximum flute depth, pressed with a rubber pad on a smooth punch into an electroformed fluted Co-P die were sent to the Carnegie Institute of Technology.

L1236

National Bureau of Standards (Proj. no. TA1-2704). T2028 FUZE FOR HEAT ROCKETS. Quarterly progress rept. May 14-Aug. 31, 1952. Aug. 13, 1952, 11p. incl. illus. (NBS rept. no. 4A-129) Confidential

The development of a piezoelectric contact fuze for the 2.75-in. folding-fin aircraft HEAT round was undertaken to increase penetration performance of the rocket. The fuze proposed consists of an arming system and a detonator in the base element, electrically connected on arming with a hemispherical crystal of barium titanate in the nose; on impact, this crystal develops energy, firing the detonator. It is required that the fuze: (1) operate satisfactorily upon impact against armor at angles of obliquity from 0° to 65°; (2) function within 10 μsec; (3) mass in the path of the jet be kept to a minimum.

L1237

National Research Council of Canada. INTERIM REPORT ON CAVITY CHARGES, by A. Gillies and H. J. Poole. May 31, 1944, 7p. incl. illus. [15-C1(XT6)1] Secret

Preliminary tests were carried out using charges with 80° Cu and steel liners (1 5/8 in. base diameter) placed inside tubes which were attached below the base of the liners. A tapered tube (having the diameter at 1 end the same as the liner diameter, and at the other end a greater diameter) was used, and the charge liner was placed on a cardboard annulus on top of the tube. This arrangement brought more explosive in contact with the target, and also closer to the site at which the jet would penetrate. Results indicated that such a charge was very effective against a 2-in. target of boiler plate. These modified charges produced holes of increased volume and diameter.

L1238

National Research Council of Canada. REPORT ON SHAPED CHARGES, by H. G. V. Evans and M. C. Fletcher. Feb. 11, 1946, 37p. incl. tables, diagrs. [15-C1(XT-6-2)1] Secret

Canadian work on shaped charges during the war is summarized. Topics include the performance of various types of liners, the effect of varying the diameter of charge around the liner, the effect of frustum angle, the effect of inverted frustum angle, varying the length of cylindrical liners, comparison of 45° and 80° liners, mechanism of action of lined charges, weapon development, mechanism of action (hydrodynamic and shock wave theories), and the possibility of replacing conical liners with cylinders. The appendix discusses a charge containing 2 liners in series which has a follow-through effect, and charges with internal cavities above the liner apex. It is stated that the use of internal cavities permits optimum penetration at much shorter standoff.

L1239

Naval Attache, Cairo. ITALIAN 3.5-KG. HOLLOW CHARGE BOMB. Feb. 8, 1943, 2p. (NA Cairo, Serial 141-43) Confidential

A brief description is given of the shaped charge bomb, the forward end of which is fluted in 6 places to give added strength against crushing. This increased resistance to the collapse of the dome of the bomb held the unlined shaped charge off of the target and prevented breaking up until the fuze had time to function.

L1240

Naval Attache, London. GREAT BRITAIN - NAVY - EXPLOSIVES, BLAST MEASUREMENTS, MUNROE PRINCIPLE. Dec. 31, 1941, 5p. incl. diagrs. (NA London, Serial 3003) Secret

Two methods are described for obtaining photographically the shape and velocity of the blast wave from a shaped charge. One method employs photographic film placed upon the external periphery of a disc revolving at 3000 r. p. m. By a standard lens and slit system, a photographic record could be readily obtained of the trace of the flame front in a plane normal to the optical axis and along a line parallel to the axis of the spinning drum. For more accurate measurements, a lens system was used which directed the image rays on a mirror revolving at approximately 20, 000 r. p. m. which, in turn, reflected them on a stationary film attached to the inner side of a circular arc frame.

L1241

Naval Attache, London.
GREAT BRITAIN - NAVY - ASSET TRIALS - ANTISUBMARINE EXPERIMENTS AGAINST MODELS REPRESENTING THE GERMAN SUBMARINE "GRAPH" (EX-U570). Apr. 20, 1942, 1v. incl. illus. tables, diagrs. (NA London, Serial 962) Confidential

The minimum weight of explosive required for forward-thrown weapons used in submarine warfare was investigated using models of the German submarine U570 (now called "Graph") as targets. Full-scale asset trials completed to date are reviewed and a preliminary rept. of the 1:2 scale trials is given. Seventy-four photographs illustrating the results of most of the shots, and drawings of the 8 types of shaped charges used are included. Results of all the firings are tabulated and brief comments are made on the shaped charge portion of the trials.

L1242

Naval Attache, London.
GERMANY - ARMY - EXPLOSIVES (DEMOLITION). June 5, 1942, 4p. incl. diagrs. (NA London, Serial 1482) Confidential

Two demolition charges, 12. 5 kg. and 50 kg. in weight, with hemispherical hollow spaces were fired against armor plate. The 12. 5-kg. charge pierced armor up to 12-cm. thickness; the 50-kg. charge pierced armor up to 25-cm. thickness, while the 50-kg. charge followed by the 12. 5-kg. charge pierced armor up to 30-cm. thickness. Another rept. is appended on "German ring charges for gun demolition."

L1243

Naval Forces, Northwest African Waters.
SPECIFIC TYPES OF [ITALIAN] EXPLOSIVE CHARGES (CONCAVE CHARGES). June 19, 1945, 3p. (Serial 130-45) Restricted

Concave charges were used to perforate plates, as explosive charges of antitank mines and of regular attack mines, and as the detonating charges of missiles. To explain the effects of perforation of plates, Col. Tanferna submitted data concerning sizes and characteristics of the detonation of explosives. With the aid of Pulini, he carried out tests and obtained patents for the use of detonating explosives. Results of the study showed that with charges of 30 g. of explosive, the perforation of steel plates 3 cm. thick was obtained. Tanferna studied actual explosive lenses capable of concentrating the firing destructiveness of the explosive itself; he succeeded in combining these lenses with each other in more complex instruments, called "explosive field glasses", through which exceptional directional and perforation effects were obtained. Further experimentation showed exceptional projective effects from the concave charges as well as exceptional bursting effects in the projection of shrapnel shells. Tanferna derived many applications for the utilization of slow explosives using NH_4NO_3 and a coating of melted Tritolite or other high speed detonation explosives.

L1244

Naval Mine Depot, Yorktown.
XO-127, COMPOSITION B LOADING OF M3 SHAPED CHARGES, by W. F. Skinner and J. S. Harper. July 7, 1947, 1v. incl. illus. tables, diagrs. (Rept. no. 5, Research and Development Div.) Confidential

Work related to the loading (Comp. B) of 26 40-lb. M3 shaped charges in preparation for tests in the development of a special shaped charge warhead for antiaircraft missiles is described. Due to the nature of the container and the restrictions imposed for loading, 38 experimental main charges and 15 boosters were poured using varying techniques (discussed in the text) of control and then analyzed to determine the most satisfactory method. Tables listing the pouring data and results obtained from the above experiments are appended. Diagrams illustrating pouring methods are included.

L1245

Naval Ordnance Laboratory (Task NOL-37-Re2c-46-1). EFFECT OF LINER AND EXPLOSIVE UNIFORMITY ON PERFORMANCE UNIFORMITY OF SHAPED CHARGES, by B. E. Drimmer. June 24, 1948, 7p. (Memo. no. NOLM 9790) Confidential

The investigation was concerned with the lack of uniformity of performance displayed by apparently identical shaped charges. A charge of sensitized mononitromethane (liquid at normal temperatures) with a M6A3 steel liner machined from bar stock produced an average penetration depth of 5. 44 ± 0. 08 in. with a population standard deviation of 3. 6% of the average. With Pentolite instead of mononitromethane, the average penetration was 7. 50 or 5. 2% of the average. With nitromethane and standard drawn M6A3 steel liners, the average penetration was 5. 52 ± 0. 17 or 7. 2% of the average. Analysis of these data showed that increased symmetry of the liner and homogeneity of the explosive produced statistically significant improvements in reproducibility of results.

L1246

Naval Ordnance Laboratory [Task NOL-37-Re2c-46-1]. SHAPED CHARGES, by B. E. Drimmer. Progress rept. Apr. 16-July 15, 1948. Aug. 2, 1948, 5p. tables. (Memo. no. NOLM 9791) Confidential

Rotating trumpet-lined charges fired at speeds up to 180 r. p. s. showed the same decrease in jet efficiency as was found in conical-lined charges. The penetration depth dropped rapidly as the rotation speed was increased to about 140 r. p. s., then the decline was gradual. Small-scale experiments were made to determine the jet efficiency of a shaped charge bomb that would hit a ship in such a manner that the top of a relatively thin steel wall (0.012-in. cavity diameter) would be in the direct path of the jet, the direction of the jet being parallel to the wall. Of the 4 charges fired, 2 showed evidence of almost complete dispersion of the jet. The other 2 produced depths in the steel target below the wall of about 0.83 in., the average depth obtained under the same conditions without the wall.

L1247

Naval Ordnance Laboratory (Task NOL-37-Re2c-46-1). SHAPED CHARGES, by B. E. Drimmer. Progress rept. July 16, 1948-Oct. 15, 1948. Nov. 23, 1948, 10p. tables, diagrs. (Memo. no. NOLM 9916) Confidential

Results are given of tests to determine the effect of rotation on the penetration of the jet from plain trumpet liners collapsed by detonation of 50/50 Pentolite. The explosive and trumpets had a maximum diameter of 1.90 in. From 0 to 200 r. p. s. the penetration dropped from 8.2 to 3.3 in. Experiments were performed to determine the effect of rotation on the twist of the slug from charges with cylindrical liners. These liners were of steel, 1.00-in. outside diameter, 0.060 in. thick and 4.0 in. long. Shots were fired into water at speeds up to 155 r. p. s. Collapse by 50/50 Pentolite charges at 75 r. p. s. produced twists of 4° in the collapsed portion; higher rotation speeds produced only slight increase in twist. Experiments are described to measure the kinetic energy of the jet by a refinement of the calorimetric method.

L1248

Naval Ordnance Laboratory (Task NOL-37-Re2c-46-1). SHAPED CHARGES, by B. E. Drimmer. Progress rept. Oct. 16, 1948-Jan. 15, 1949. Feb. 16, 1949, 7p. tables, diagrs. (Memo. no. NOLM 10,000) Confidential

Experiments were continued to measure the kinetic energy of the jet by a refinement of the calorimetric method. Data were obtained for the total heat absorbed by a mild steel target from the jet, slug, and skirt fragments formed by a 1.63-in. diameter cylindrical charge of 50/50 Pentolite cast over an M9A1 steel liner. Partial data are given for the residual energy left in the jet after penetration of 1 and 2 in. of mild steel. An attempt was made to obtain information on the events occurring during the normal collapse of the shaped charge liner by studying liners partially collapsed by degraded shocks. Examination of the data and the contours of the recovered liners showed that the effects due to shocks from HE placed in contact with the entire liner might be continuous functions of the same variable (shock strength). Partially collapsing drawn liners appeared to make observable some of the geometric and material inhomogeneities in the gross structure of the liners. The appearance of the partially collapsed liners suggested that they collapsed incrementally rather than continuously.

L1249

Naval Ordnance Laboratory (Task NOL-37-Re2c-46-1). SHAPED CHARGES, by B. E. Drimmer. Progress rept. Jan. 16-Apr. 15, 1949. June 6, 1949, 7p. tables, diagrs. (Memo. no. NOLM 10,286) Confidential

Work was continued on the determination of the kinetic energy of the shaped charge jet absorbed by a steel target as a function of jet penetration depth. The data obtained indicated that more energy was absorbed in penetrating the third in. of steel target than the second in. This inconsistency was attributed to errors in measuring the temperature rise in the steel cylinder. The experimental method was investigated.

L1250

Naval Ordnance Laboratory (Task NOL-37-Re2c-46-1). SHAPED CHARGES, by B. E. Drimmer. Progress rept. Apr. 16-July 15, 1949. July 30, 1949, 6p. tables, diagrs. (Memo. no. NOLM 10466) Confidential

Further tests made to determine the kinetic energy of the shaped charge jet indicated that more energy was absorbed in penetrating the third in. of steel target than the second in. Cu jet absorbers will be used to check this result. In the controlled fragmentation program, hollow Cu hemicylinders were embedded in flat charges 12 in. long and detonated in contact with massive steel targets. Two groups of experiments were run: (1) the liner axis made an angle (from 30° to 90°) with the long dimension of the charge; and (2) with the above angle kept at 90°, a combination of explosives (a low velocity explosive such as Baratol or granular TNT plus a high velocity explosive such as Comp. B or Comp. C) was used to bend the detonation front in the slow explosive; thus, the detonation front hit the liners at a more favorable angle than occurred normally as the detonation proceeded down the charge. The depth of the cuts into the steel in both groups of experiments showed a marked dependence on the axial distance from the point of initiation. It was concluded that the actual depths obtained indicated that such liners and orientations would fail to affect control of the fragmentation of the shell.

L1251

Naval Ordnance Laboratory (Task NOL-37-Re2c-46-1). SHAPED CHARGES, by B. E. Drimmer. Progress rept. July 16-Oct. 15, 1949. 3p. table, diagr. (Memo. no. NOLM 10569) Confidential

Controlled fragmentation studies using Cu hemicylindrical liners with wall thicknesses of 0.015, 0.022, 0.030, and 0.040 in. showed that the thinner liners were superior. Tests are planned with unlined hollow spaces.

L1252

Naval Ordnance Laboratory (Task NOL-37-Re2c-46-2). SHAPED CHARGES, by B. E. Drimmer and W. August. Progress rept. Oct. 16, 1949-Jan. 15, 1950. Feb. 14, 1950, 5p. illus. tables, diagrs. (Memo. no. NOLM 10730) Confidential

An apparently new shock phenomenon was observed while experiments were being carried out with flat slabs of explosive. The effect, tentatively named the "ledge effect", manifested itself in making a "U" shaped cut in mild steel as much as 0.8 in. deep and 1.25 in. wide (maximum) at the top. The effect was tried as a means of improving shaped charges. Several unlined shaped charges were made in which the surface of the 4.4-in. conical cavity was machined so that it contained 6 right angle ledges. Duplicate charges with smooth inner conical liners were also produced, and the penetration determined at various standoffs from 0 to 2 in. Results showed that the effectiveness of the jet appeared to be almost equal to that from the smooth conical liner. It is hoped that more effective design of the ledges may result in an improvement.

L1253

Naval Ordnance Laboratory [Task NOL-37-Re2c-46-2]. SHAPED CHARGES, by B. E. Drimmer and W. T. August. Progress rept. Jan. 16-Apr. 15, 1950. May 1, 1950, 5p. diagr. (Memo. no. NOLM 10964) Confidential

Controlled fragmentation studies were continued with flat charges of Comp. B cast over hollow Cu hemicylinders of different thicknesses. Liners 0.015 in. thick made cuts 0.20 in. deep directly under the line of initiation and 0.13 in. deep 12 in. down the charge length. Thicker liners produced shallower cuts. Comparison with results obtained with similar charges of plastic Comp. C showed that the cuts made with cast explosive were approximately 10% deeper. Results obtained with pregrooved shells indicated that the insertion of liners of this shape into a 5-in. AA shell would fail to control the fragmentation of the shell.

L1254

Naval Ordnance Laboratory (Task NOL-37-Re2c-46-2). THE KINETIC ENERGY OF THE SHAPED CHARGE JET, by B. E. Drimmer and W. T. August. Jan. 12, 1950, 10p. tables, diagrs. (Memo. no. NOLM 10697) Confidential

The kinetic energy of the shaped charge jet resulting from the detonation of 50/50 Pentolite cast over a M9A1 steel liner was determined from calorimetric measurements to be 12,130 cal. The jet mass was calculated to be 5.49 g. or 24% of the original mass of the liner. It is pointed out that from an analysis of the use of the jet kinetic energy for increasing penetration depth, the jet is most efficiently used at a penetration depth of 1.64 in. It was believed that the over-all efficiency of the charge in making a hole in mild steel could be improved by designing a liner that would give a jet whose velocity (5330 m./sec.) and mass/unit length is the same as that of the jet of the experimental charge impinging on the target a depth of 1.64 in. The total momentum of the jet was calculated to be 2.12×10^6 g. cm./sec. When the calculated momentum of the course fragments and that of the slug were added, a total momentum of 3.67×10^6 g. cm./sec. was obtained which agreed with the value reported in the literature.

L1255

Naval Ordnance Laboratory. PENETRATION OF STEEL TARGETS AT LONG STANDOFFS BY STEEL-CONE-LINED SHAPED CHARGES, by B. E. Drimmer. Aug. 15, 1950, 35p. incl. illus. tables, diagrs. (Rept. no. NOLR 1145) Confidential

The effect on mild steel targets of 1.63-in. diameter shaped charges with steel conical liners was studied at standoffs up to 600 cavity diameters (c.d.). The study consisted of investigating the scaling factor and observing the effects of varying the following parameters: (a) standoff distance; (b) liner thickness; (c) apex angle of the conical liner; and (d) diameter of the charge. The data showed that with a 60° steel conical liner, penetration depth dropped sharply when the standoff was increased from 2.5 to 50 c.d. Beyond 50 c.d., the decline in depth was less rapid. As the standoff increased, the number of significant holes fell off sharply. Tests for effects of varying the liner thickness (range 0.027 to 0.137 in.) showed that 60° steel conical liners (0.045 in. thick) at 150 c.d. standoff produced the deepest hole (0.060 in. deep). The same liner produced 30 significant holes, more than any other liner. The apex angles of steel liners were varied from 30° to 180°. The charge containing a 100° apex angle liner produced a hole 84% deeper than the deepest hole produced by a flat-ended charge. This charge also produced 46 significant holes which was nearly 3 times as many as were formed by the flat-ended charge. Analysis of results obtained with 9 5-in. diameter charges showed that the linear scaling law was observed.

L1256

Naval Ordnance Laboratory.
PERIPHERALLY INITIATED SHAPED CHARGES, by B. E. Drimmer and W. T. August. Nov. 1, 1950, 19p. incl. illus. tables, diagrs. (NAVORD rept. no. 1722) TIP C6436 Confidential

When cylindrical shaped charges, with conical steel liners, were initiated along the entire periphery of the top of the charge, the penetrations into mild steel were significantly deeper than the holes formed by duplicate charges initiated along the charge axis. A disc of the proper dimensions of inert material inserted into the explosive column caused peripheral initiation. It is pointed out that the data indicated that if such a disc were incorporated into the present charge case of the M9A1 bazooka (conical steel liner), the average depth of penetration should be increased from 3.25 to 4.75 charge diameters. Possible explanations are listed for the superior performance of peripherally initiated shaped charges.

L1257

Naval Ordnance Laboratory.
SHAPED CHARGE PENETRATION IN MAGNESIUM ALLOY TARGETS, by B. E. Drimmer and W. T. August. Nov. 1, 1950, 12p. incl. tables, diagrs. (NAVORD rept. no. 1721) TIP C6292 Confidential

The depth of penetration of shaped charge jets into Mg and Mg-steel sandwiches has been observed under controlled firing conditions for the purpose of getting additional information on penetration laws. The depth of penetration into Mg of the jet from a 1-5/8 in. diameter charge of 50/50 Pentolite cast over a M9A1 steel cone was found to be 11.9 in., agreeing satisfactorily with the 11.7 in. predicted by the simple penetration theory. For targets made of sandwich layers of steel and Mg small differences in penetration not explainable by the simple theory were observed. (NOL abstract)

L1258

Naval Ordnance Laboratory.
A COMPARISON OF VARIOUS EXPLOSIVES WITH RESPECT TO SHAPED CHARGE EFFICIENCY, by A. Solem, W. T. August, and S. R. Walton. Aug. 1, 1951, 13p. incl. illus. tables. (NAVORD rept. no. 1853) TIP C6894 Confidential

Cast and pressed 50/50 Pentolite, Comp. B, HBX, PTX2, 70/30 Cyclotol, 75/25 Cyclotol, and Comp. A3 were compared for shaped charge effectiveness. Standardized, unconfined charges 4 in. high formed over M9A1 steel conical liners were used in the tests. Penetration depth results showed no significant difference between the 70/30 Cyclotol and Comp. B when compared by the statistical "t" test; the 75/25 Cyclotol, 50/50 Pentolite, and the HBX charges gave inferior results in that order. The order of efficiency of the explosives tested for either penetration depth or cavity volume was in general agreement with earlier reported experimental work, with the exception of the high efficiency of PTX2. This latter improvement was thought to be the result of more careful charge preparation.

L1259

Naval Ordnance Laboratory.
THE EFFECT OF SOIL BARRIERS ON SHAPED CHARGE PENETRATIONS, by W. T. August and A. D. Solem. June 27, 1952, 10p. incl. table, diagrs. (NAVORD rept. no. 2487) TIP C8370 Confidential

Data obtained for jet penetrations into mild-steel targets through loosely packed, sandy clay soil barriers indicated a rapid decrease in steel penetration with barrier thickness for the first few in. The 3.25- and 1.63-in.-diameter shaped charges were placed in loosely filled (1.0 to 1.6 sp. density) holes, and the steel targets were placed over the holes with varying air spaces between the top of the fill and the target. The rate of decrease diminished with the barrier thickness. The variation of penetration with standoff distance (between the charge and soil) occurred in a regular fashion, but was of secondary importance. (TIP abstract)

L1260

Naval Ordnance Laboratory (Task NOL-Re2c-1-1-53).
A CORRELATION OF EXPLOSIVE PROPERTIES WITH SHAPED CHARGE PERFORMANCE, by N. L. Coleburn. Jan. 19, 1953, 14p. incl. tables, diagrs. (NAVORD rept. no. 2721) AD-8286 Confidential

Jones' formulation of detonation theory was used to obtain functional relationships for predicting the performance of solid explosives in shaped charge penetration of mild steels by M9A1 steel liners. The quantities related to penetration are the detonation pressure, p, and functions of the detonation pressure, $\rho_0 D^2/k$ and p/k. The magnitude of k, the isentropic exponent, is determined by the Jones theory for each explosive. Using $\rho_0 D^2/k$ and p/k, the relationships are:

$$\text{Penetration (in.)} = \frac{\rho_0 D^2/k + 73.58}{73.99}$$

$$\text{Penetration (in.)} = \frac{p/k + 31.19}{21.31}$$

where D is the detonation velocity, ρ_0 is the explosive loading density and p is in kilobars. These relationships gave good agreement with the performance of the 13 explosives, including 1 aluminized, tested. The values of the various quantities for each explosive are presented in tables.

L1261

Naval Ordnance Laboratory.
PERIPHERAL INITIATION OF SHAPED CHARGES. III. PENETRATION PERFORMANCE WITH VARIOUS LINER MATERIALS; JET VELOCITY AND CHARGE CONFINEMENT TESTS, by W. T. August and A. D. Solem. Feb 11, 1953, 16p. incl. tables. (NAVORD rept. no. 2967)
Confidential

Jet penetration measurements from cylindrical, cone-lined charges using a shaped detonation wave obtained with peripheral initiation were extended to include Cu, brass, glass, Mg, Al, and cast Fe liners. Increased mean penetration over point initiation performance was observed for each material. Rotating mirror camera data are presented of emergent jet velocities from peripherally initiated charges with Cu and steel liners. The velocities are higher than those observed for point initiated charges. Experimental results of the effect of charge confinement are reported and compared with results from similar point charges. (NOL abstract)

L1262

Naval Ordnance Laboratory (Task NOL-Re2c-46-1-53).
SHAPED CHARGE PERFORMANCE WITH VARIOUS EXPLOSIVE LOADINGS, by W. T. August and A. D. Solem. Feb. 16, 1953, 9p. incl. tables. (NAVORD rept. no. 2767) AD-11 595
Confidential

In this comparison of various explosives for shaped charge performance, each M9A1 steel liner (1.626-in. base diameter, 44° apex angle, 0.037-in. wall thickness) was cast or pressed into an explosive cylinder 4 in. long x 1.625 in. in diameter. The charges were statically fired at 4.0-in. standoff into target stacks of 1-in. mild steel plates. The mean values of the depths and cavity volumes for the various explosive loadings follow:

Cast explosives

	Depth (in.)	Vol. (cc.)
(100/5) Comp. B/D2	5.82	—
(54.6/45.4) BTNEU/TNT	5.97	10.87
(77/23) HMX/TNT	7.45	15.57
(70/30) Tetryl/TNT	5.12	8.60
(60/40) HMX/TNETB	7.07	12.45

Pressed explosives

(90/10) BTNEU/Aristowax	5.64	9.97
(60/40/1) BTNEU/TNT/Calcium stearate	5.30	8.95
(90/10) BTNEN/Aristowax	5.65	11.36
(91/9) HMX/Stanolind wax	6.45	13.15

It was concluded from these data that the HMX mixtures are the most satisfactory for shaped charge application.

L1263

Naval Ordnance Laboratory.
CONTRIBUTIONS FROM THE NAVAL ORDNANCE LABORATORY, SYMPOSIUM ON SHAPED CHARGES, ABERDEEN PROVING GROUND, NOV. 1951. Aug. 1, 1953, 43p. incl. illus. tables, diagrs. (NAVORD rept. no. 2930)
Confidential

Four papers presented by Naval Ordnance Laboratory personnel at the Symposium (BRL rept. no. 837) are given. Abstracts preface each of the following papers:
(1) Remarks on Some Fundamental Features of Detonation, by S. J. Jacobs.
(2) Performance of Peripherally Initiated Shaped Charges, by A. D. Solem and W. T. August.
(3) The Pin Technique for Velocity Measurement, by H. D. Mallory.
(4) High Speed Photography with an Image Converter Tube, by R. D. Drosd, T. P. Liddiard, and B. N. Singleton, Jr.

L1264

[Naval Ordnance Test Station, Inyokern].
SHAPED CHARGE BIBLIOGRAPHY [OF REPORTS IN THE] TECHNICAL LIBRARY, BUREAU OF ORDNANCE. [1946?], 40p.
Confidential

Two hundred and eighty repts. on shaped charges and allied subjects dated between Aug., 1940 and Jan., 1946 are listed chronologically. Some foreign repts. are included.

L1265

Naval Ordnance Test Station, Inyokern.
STRUCTURAL DAMAGE LAUNCHING TESTS OF THE NOL EXPERIMENTAL SHAPED CHARGE WAR HEAD, by O. D. Terrell. Mar. 11, 1946, 12p. incl. illus. tables, diagrs. (Technical memo OUM 11.1)
Confidential

Launching velocities of 450, 525, and 675 ft./sec. were used to test water entry structural performance of the torpedo warhead. A detailed diagram of the experimental warhead is given. Launching conditions and damage notes for each entry velocity test are tabulated. Photographs of structural failures are included. Test results are discussed and evaluated.

L1266

Naval Ordnance Test Station, Inyokern.
BEHAVIOR STUDY TESTS OF THE NOL EXPERIMENTAL SHAPED CHARGE WAR HEAD, by O. D. Terrell. Aug. 19, 1946, 11p. incl. illus. charts, tables, diagrs. (Technical memo. OUM 11.2)
Confidential

Forty-six behavior study launchings of the NOL-RXD (modified) warhead fitted on Mark 13-6 torpedoes ("hot shot") were accomplished at a water entry velocity of 340 ft./sec. A detailed diagram of the modified warhead is given. Tables and charts include information on test conditions, projectile characteristics, entry velocities, entry orientations, tracings of typical launchings, and dive recovery. Test results are discussed and evaluated.

L1267

Naval Ordnance Test Station, Inyokern.
BIBLIOGRAPHY [OF] SHAPED CHARGE REPORTS. Oct. 1, 1948, 12p. (Rept. no. RRP-100148) TIP C50235 Confidential

This list of 152 shaped charge repts. arranged by rept. no. includes material from Aberdeen Proving Ground, OTIB (Ordnance Technical Intelligence Branch), OSRD (Office of Scientific Research and Development), and British sources covering the period from about 1940-1945. Some German repts. are included.

L1268

Naval Ordnance Test Station, Inyokern.
INVESTIGATION OF SHOCK WAVE PHENOMENA IN AIR. I. HIGH EXPLOSION [SHAPED CHARGE] RESEARCH: A. SPECTROSCOPIC... C. FLASHING IN SHAPED CHARGE JETS..., by M. D. Blatt and others. Quarterly rept. Dec. 1, 1948-Feb. 28, 1949. p. 1-2. TIP C2238 Confidential

Tentative conclusions are presented as a result of tests on several bimetallic liners. Liners prepared with Ag on the inner or axial surface and Cu outside showed only a Ag spectrum; the ratio of Ag to Cu thickness was 0.025:0.035 in. One liner tested with the Cu apex and Ag skirt (50% each) gave only a Cu spectrum. The liner material primarily responsible for great luminosity at the jet head and also for the damage at long standoff appeared to be that from the internal and apical region of the liner. A brillant and well-defined jet in which several Al spectrum lines and $Al-O_2$ bands were identified resulted from the firing of an Al lined charge. A transparent bag of A(gas) pierced by a jet, intensified and altered the spectrum of the jet. An atmosphere of He was not as effective. The flashing or periodic luminous pulsations observed in all shaped charge jets was attributed to the periodic melting of a surface layer of metal, its subsequent vaporization, and release from the particle surface.

L1269

Naval Ordnance Test Station, Inyokern.
INVESTIGATION OF SHOCK WAVE PHENOMENA IN AIR, by J. S. Stanton. Monthly progress repts. for the periods Apr. 1-30, 1949 through Oct. 1-31, 1949 and Dec. 1-31, 1949. Confidential

For abstracts of these repts. see the Shaped Charge Working Panel monthly repts. for the corresponding periods. The information in these 2 sets of repts. is identical, almost verbatim.

L1270

Naval Ordnance Test Station, Inyokern.
THE BEHAVIOR OF METAL UNDER HIGH AND RAPIDLY APPLIED STRESSES OF SHORT DURATION, by J. S. Rinehart. [1949], 19p. incl. illus. (SCWP Technical memo. no. 12) (Bound with its Shaped Charge Working Panel Monthly rept. [no. 9], Nov. 1-30, 1949) Confidential

Several interesting effects produced as the result of detonating explosive charges in intimate contact with metal plates, rods, and tubes are described. The principal effects are: (1) the fracturing of the metal due to a tensional stress produced as the result of the reflection of a high compressional stress wave at a free boundary; (2) the fracturing of the metal due to a high hydrostatic pressure resulting from extremely rapid compression of the metal; and (3) a simple low-order permanent strain similar to that observed in slow compression tests. The descriptions of the behavior of metals under high and rapidly applied stresses are still mostly qualitative, and further experimental investigation of these effects is contemplated. The need for a considerable amount of theoretical work along these lines is indicated.

L1271

Naval Ordnance Test Station, Inyokern.
DIFFERENTIAL SHADOWGRAPHY, by J. S. Stanton and C. R. Nisewanger. [1949], 9p. incl. illus. (SCWP Technical memo. no. 13) (Bound with its Shaped Charge Working Panel Monthly rept. [no. 9]. Nov. 1-30, 1949) Confidential

In the process of taking shadowgrams of luminous particles from shaped charge jets, it became apparent that conventional shadowgraph methods were unsatisfactory. A solution to the problem, obtained by optical means, is described and illustrated. Results are presented for rapidly moving particles, for electrical explosion of fine wires, and for sparks. Further investigation is indicated.

L1272

Naval Ordnance Test Station, Inyokern.
DRAG AND THE CONSERVATION PRINCIPLES IN DISCONTINUOUS SUPERSONIC FLOWS, by E. T. Benedikt. [1949], 5p. (SCWP Technical memo. no. 6) (Bound with its Shaped Charges Working Panel Monthly rept. no. 4, June 1-30, 1949) TIP C50810 Confidential

A study is made of the information regarding the drag on a body immersed in a fluid in motion and the nature of the processes responsible for the drag which are made available by the conservation principles as derived from the fundamental equations of aerodynamics. The equations derived from this examination are developed and discussed. Application of the theoretical results to the evaluation of drag will be presented in future repts.

L1273

Naval Ordnance Test Station, Inyokern.
THE DRAG OF SUPERSONIC WEDGES, by J. S. Stanton. [1949], 4p. diagrs. (SCWP Technical memo. no. 11) (Bound with its Shaped Charge Working Panel Monthly rept. [no. 8], Oct. 1-31, 1949) Confidential

The effect of shock dissociation of air upon the drag of supersonic wedge shaped projectiles with attached shock was calculated; a statement of the problem and the solution are included. The result is such as to produce a velocity dependence of drag which lies below that of square law under all conditions which were calculated.

L1274

Naval Ordnance Test Station, Inyokern.
EFFICIENCY OF FRAGMENTATION BOMBS, by J. P. McClellan. [1949], 6p. (SCWP Technical memo. no. 9) (Bound with its Shaped Charge Working Panel Monthly rept. [no. 7], Sept. 1-30, 1949) Confidential

As the first step in evaluating the comparative efficiencies of fragmentation bombs and shaped charge warheads, a mathematical analysis of a standard of efficiency is reported. The question: "Given the target and range, for what ratio of casing weight to charge weight will greatest efficiency be obtained, assuming the possibility of controlling fragment size?" is answered: "With steel casings and typical explosives constituting the bomb... the radius of the explosive would be about 0.9 that of the bomb and the thickness of the casing then about 0.1 the radius of the bomb."

L1275

Naval Ordnance Test Station, Inyokern.
THE MARLEY HIGH-SPEED CAMERA, by G. C. Throner. [1949], 16p. incl. illus. (SCWP Technical memo. no. 10) (Bound with its Shaped Charge Working Panel Monthly rept. [no. 7], Sept. 1-30, 1949) Confidential

A description with photographic illustrations is reported of the Marley High Speed Camera (exposure rate approximately 95,000 frames/sec.) used for studies of jet formation and related matters. Specifications, supplementary equipment, operation, synchronization, etc. are described.

L1276

Naval Ordnance Test Station, Inyokern.
NOTES ON MANGANESE STEEL, by N. A. MacLeod. [1949], 9p. incl. illus. tables, diagrs. (SCWP Technical memo. no. 8) (Bound with its Shaped Charge Working Panel Monthly rept. [no. 6], Aug. 1-31, 1949) TIP C3296 Confidential

Three Mn steel liners and 3 mild steel liners were tested and the performances compared. The Mn steel liners gave considerably less penetration than the mild steel, but they seemed to imply the possibility that shock wave effects may be involved in jet formation since hydrodynamic theories did not appear to explain the poor jet performance. Mn steel was also tested as a defense against shaped charges; since it was easily penetrated by standard charges, this type of steel was assumed to have no protective value.

L1277

Naval Ordnance Test Station, Inyokern.
SELECTION OF METALS FOR BIMETALLIC LINERS, by M. D. Blatt. [1949], 5p. illus. diagrs. (SCWP Technical memo. no. 7) (Bound with its Shaped Charge Working Panel Monthly rept. [no. 5], July 1-31, 1949) TIP C2561 Confidential

Tests were conducted on Fe, Mg, Al, and Ag conical liners as part of a program of selecting bimetallic liners for shaped charges. Cu liners produced the most satisfactory jets and strongest spectra. Both Ag and Al liners revealed informative spectra, the Ag spectra being somewhat sharper. Mild steel and Mg produced poor jets, and their spectra were weak. As density is an additional consideration in the selection of the 2 metals, Cu and Ag were selected as the best for the bimetallic liner; both fulfill the requirements for electroforming, reproducible jets, easily recognized spectra, and capability of producing narrow line spectra.

L1278

Naval Ordnance Test Station, Inyokern.
SOME OBSERVATIONS ON HIGH-SPEED IMPACT, by J. S. Rinehart. [1949], 11p. incl. illus. diagrs. (SCWP Technical memo. no. 14) (Bound with its Shaped Charge Working Panel Monthly rept. [no. 10], Dec. 1-31, 1949) Confidential

The physical nature of the phenomena associated with the impact of high velocity particles was studied for the purpose of developing more effective weapons. Some existing data on the subject and new data obtained from experiments on the impacts of high velocity shaped charge particles (20,000-30,000 ft./sec.) are presented and discussed under the following topics: (1) energetics of high velocity particles; (2) the nature of craters; (3) mechanics of crater formation; and (4) energetics of crater formation. It was concluded that only a few useful data were available; of principle significance was the close correlation existing between crater producing abilities of explosives and of high velocity particles.

L1279

Naval Ordnance Test Station, Inyokern.
A THEORY OF FLASHING OF HIGH-SPEED PARTICLES, by B. Cassen and J. S. Stanton. [1949], 9p. incl. graphs. (SCWP Technical memo. no. 5) (Bound with its Shaped Charges Working Panel Monthly rept. no. 4, June 1-30, 1949) TIP C50609 Confidential

A mechanism for the flashing phenomena observed in shaped charge jets is proposed. A model borrowed from certain high explosive experimentation was used to derive a theory (where the relative wind of the particle is definitely known) for predicting the period of flashing of high speed particles. The following conclusions were inferred: (1) the flashing period will increase with particle size; (2) the period of flashing is relatively independent of velocity in the range of M = 8 to 20; and (3) if the density of the atmosphere is varied while its local sound velocity is maintained, the period of flashing should remain relatively invariant. A crucial test of the theory depends upon the procurement of more reliable data specifically applying to the motion of fast particles.

L1280

Naval Ordnance Test Station, Inyokern.
THE SHAPED CHARGES WORKING PANEL MONTHLY REPORT NO. 1, MAR. 1-31, 1949, by G. C. Throner and others. [1949], 8p. TIP C50608 Confidential

The theory of the motion of fast particles (characteristics for the transient 2- and 3-dimensional aerodynamical problem) is considered for the possible determination of the shape, location, and stability of the shock front. Results of 25 tests (using Cu, Al, and Mg lined charges) made in an effort to obtain experimental evidence toward a theory of drag are discussed. Progress is also cited on: (a) interior ballistics (studies of the effect of magnetic field on fast moving particles); (b) exterior ballistics (particle erosion); (c) terminal ballistics (vaporifics); and (d) instrumentation (vacuum and pressure chamber, field shadowgraph, electronic mass measuring device).

L1281

Naval Ordnance Test Station, Inyokern.
THE SHAPED CHARGES WORKING PANEL MONTHLY REPORT NO. 2, APR. 1-30, 1949, by M. D. Blatt and others. [1949], 5p. TIP C50608 Confidential

Comp. C charges, detonators, and shaped charges all produced electrical effects when detonated on a metal platform connected to a high impedance voltmeter. The maximum potential was -250 v. for shaped charges; detonators left the plate positively charged to ground. Charges on a more highly insulated platform, measured by an electric microcoulometer, were + 0.65 μ coulomb for Comp. C, and -0.131, -0.256, and -0.131 μ coulomb for 3 du Pont shaped charges type 36c-21R. Analysis is made of a streak photograph of a jet particle shot to an unusual height of about 70 ft. Progress is also reported on: (a) interior ballistics (scaling studies); (b) exterior ballistics (motion of, flight of, and flashing of fast particles); (c) terminal ballistics (vaporifics, mechanical effects-Mn steel targets); and (d) instrumentation (vacuum pressure chamber, field shadowgraph).

L1282

Naval Ordnance Test Station, Inyokern.
THE SHAPED CHARGES WORKING PANEL MONTHLY REPORT NO. 3, MAY 1-31, 1949, by J. S. Stanton. May 15, 1949, 5p. TIP C50608 Confidential

Progress is cited on: (a) interior ballistics (scaling studies, electrical effects, Marley camera studies, production of single high speed particles); (b) exterior ballistics (motion of, flight of, and flashing of fast particles); (c) terminal ballistics (vaporifics); and (d) instrumentation (vacuum pressure chamber, field shadowgraph).

L1283

Naval Ordnance Test Station, Inyokern.
THE SHAPED CHARGES WORKING PANEL MONTHLY REPORT NO. 4, JUNE 1-30, 1949, by J. S. Stanton. July 15, 1949, 5p. TIP C50608 Confidential

A warhead section comprising 3 cavities (liners) made by pressing a 1-in. diameter steel ball nearly half its radius into a strip of 36 mil mild steel and bending the strip over spaced wooden forms gave 3 well defined jets of 100 ft. range, using about 1.5 lb. of HE. Another section of 5 liners (made by a 0.75-in. steel ball) gave a maximum particle range of 70 ft. and an average range of 40 ft. with 0.75 lb. of HE. Progress is also reported on: (a) interior ballistics (scaling studies, electrical effects); (b) exterior ballistics (motion of, flight of, and flashing of fast particles); and (c) instrumentation.

L1284

Naval Ordnance Test Station, Inyokern.
THE SHAPED CHARGE WORKING PANEL MONTHLY REPORT [NO. 5], JULY 1-31, 1949, by J. S. Stanton. Aug. 15, 1949, 5p. TIP C2560 Confidential

Preliminary to high altitude shaped charge tests, a series of Al liners of 0.020-, 0.040-, 0.060-, and 0.080-in. wall thickness were fired to determine initial jet velocities and range. Initial jet velocities varied regularly with liner thickness from 9,500 m./sec. (0.020 in.) to 7,500 m./sec. (0.080 in.). Corresponding jet heights were 2.5, 4.6, 3.5, and 3.9 m. Progress is also cited on: (a) interior ballistics (electrical effects); (b) exterior ballistics (motion of, flight of, and flashing of fast particles); and (c) instrumentation.

L1285

Naval Ordnance Test Station, Inyokern.
THE SHAPED CHARGE WORKING PANEL MONTHLY REPORT [NO. 6], AUG. 1-31, 1949, by J. S. Stanton. Sept. 15. 1949, 4p. TIP C3295
Confidential

Comparison was made of jets from 1-in. diameter hemispherical liners of steel (cold rolled and stainless), monel, Cu, Al, brass, phosphor bronze, Pb, and Zn. The steel, Cu, and monel liners produced jets of good range; the monel was remarkable in that discrete particles were sent to a range in excess of 1,000 ft. Pb and Zn liners produced no flashing; steel, Cu, and monel gave regular and sustained flashing. A single test to estimate over-drag at high particle speeds was made by firing a shaped charge through an envelope filled with A gas at atmospheric pressure. The principal jet particle entered the envelope at 7960 m./sec. and left it 10 m. down range at 4130 m./sec. The measured deceleration in the A gas was nearly constant at about $5.4 \times 10^{+8}$ cm./sec.^{2}. No evidence of over-drag appeared.

L1286

Naval Ordnance Test Station, Inyokern.
THE SHAPED CHARGE WORKING PANEL MONTHLY REPORT [NO. 7], SEPT. 1-31, 1949, by J. S. Stanton. Oct. 21, 1949, 4p. TIP C51443
Confidential

Brief repts. on a number of shaped charge research projects are presented. Scaling studies indicated a decreasing initial velocity with an increasing weight/unit area of liner and a decreasing jet length with a decreasing melting point of the liner material. One in. diameter Cu hemispherical charges fired at 11,000 ft. altitude were analyzed for initial velocity and luminosity. Off-center detonation of hemispherical liners indicated that off-centering as much as 30° did not prevent the formation of usable jets.

L1287

Naval Ordnance Test Station, Inyokern.
THE SHAPED CHARGE WORKING PANEL MONTHLY REPORT [NO. 8], OCT. 1-31, 1949, by J. S. Stanton. Nov. 18, 1949, 4p. Confidential

Several tarsex (target-synthesized explosive) experiments were conducted with negative results. Powdered FeO was used to line a Cu cone and also to make disc pellets which were used to cap HE cylinders. At a standoff of 30 in., the oxide lined cone produced no more vaporific effect than a plain Cu cone, and the oxide capped cylinders produced no vaporific effect. Progress is also reported on: (a) interior ballistics (collapse of conical liners); (b) exterior ballistics (luminous range and calculated total range, dissociation drag on supersonic wedge, shadowgraphy of fast particles); and (c) application of shaped charge studies (warhead efficiency).

L1288

Naval Ordnance Test Station, Inyokern.
THE SHAPED CHARGE WORKING PANEL MONTHLY REPORT [NO. 9], NOV. 1-30, 1949, by J. S. Stanton. Dec. 20, 1949, 5p.
Confidential

Brief summaries report progress on: (a) interior ballistics (collapse of transparent liners); (b) exterior ballistics (shadowgraph experiments, yaw-card range, erosion of fast particles, Kerr shutter photography), (c) terminal ballistics (hardening of metal, tarsex), and (d) instrumentation (controlled atmosphere range, field Kerr camera, focal plane Kerr shutter).

L1289

Naval Ordnance Test Station, Inyokern.
THE SHAPED CHARGE WORKING PANEL MONTHLY REPORT [NO. 10], DEC. 1-31, 1949, by J. S. Stanton. Jan. 16, 1950, 5p. TIP C4120
Confidential

Observation by a single streak camera of the collapse of Plexiglas liners (90° apex, 0.080-in. wall thickness, 1.81-in. diameter) indicates that the ratio of collapse to detonation velocity (for terminal skirt element) is .55 and the direction assumed by the collapsing element falls about 20° from the liner surface normal. Brief summaries report progress on: (a) exterior ballistics (erosion of fast particles); (b) application of shaped charge studies (vaporifics), and (c) shock wave phenomena (field shadowgraph, wide angle Kerr camera).

L1290

Naval Ordnance Test Station, Inyokern.
THE SHAPED CHARGE WORKING PANEL MONTHLY REPORT [NO. 11] JAN. 1-31, 1950, by J. S. Stanton and others. Feb. 19, 1950, 5p.
TIP C4120 Confidential

Attempts were made to obtain suitable tracers for studying the collapse process in plastic lined cones. Progress is also reported on (a) interior ballistics (imagery of conical transparent liners); (b) exterior ballistics (penetration-card range, differential shadowgraphy); (c) application of shaped charges (vaporifics); (d) shock-wave phenomena; (e) instrumentation; (f) terminal ballistics.

L1291

Naval Ordnance Test Station, Inyokern.
THE SHAPED CHARGE WORKING PANEL MONTHLY REPORT [NO. 12] FEB. 1-28, 1950, by J. S. Stanton and others. Mar. 20, 1950, 5p. (NOTS Technical memo. no. 759-032050)
TIP C4530 Confidential

The technique of observing the collapse process of shaped charges by adding suitable tracers to the liner was extended from plastic to metal liners without difficulty. Troughs cut in the liner to depths of 0.005 in. and filled with suitable tracer gave sufficient indication on the streak camera record to deduce collapse trajectories. Progress is also reported on (a) exterior ballistics (penetration-card range, thermodynamic properties of A (gas), drag on fast particles, (b) terminal ballistics, (c) application of shaped charges (vaporifics), (d) shock-wave phenomena (reinforcement of shock waves, high-intensity spark source), and (e) instrumentation (controlled-atmosphere range, wide-angle Kerr camera, project Helix).

L1292

Naval Ordnance Test Station, Inyokern.
THE SHAPED CHARGE WORKING PANEL QUARTERLY REPORT MAR. 1-MAY 31, 1950, by J. S. Rinehart. June 20, 1950, 5p. (NOTS Technical memo. no. 759-062050) TIP C4540 Confidential

The mechanism of erosion for fast particles in passage through 0.020-in. celluiose-acetate films was studied by a streak camera. A remarkable similarity to the flashing erosion in gases and to the skirt surrounding the base of shaped-charge jets was noted. The study reaffirmed that the majority of particles from a shaped charge did not luminesce while passing through air unless they struck a target. Progress is also reported on terminal ballistics, application of shaped charges, shock wave phenomena, and instrumentation.

L1293

Naval Ordnance Test Station, Inyokern.
NON-ERODING MATERIAL FOR MUNROE JETS, by N. A. MacLeod. Mar. 24, 1949, 6p. incl. table, diagrs. (SCWP Technical memo. no. 1) (Bound with its Shaped Charges Working Panel Monthly rept. no. 1, Mar. 1-31, 1949) Confidential

It had been suggested that liner materials be selected which would not exhibit the erodible characteristics shown in spectrographic studies of jets from various common metals (Fe, Cu, Al, and Pb). The study showed that: (1) the phenomenon of erosion was physical; (2) no significant chemical action was probable at the solid gas interface due to extremely high temperature involved; (3) the chemical reactions took place after sloughing off occurred and the metal lines in the spectrographic analysis were broadened by the continuous and intermittent sloughing off of metal.

L1294

Naval Ordnance Test Station, Inyokern.
HYPERSONIC FLIGHT, by N. A. MacLeod. Apr. 7, 1949, 2p. (SCWP Technical memo. no. 2) (Bound with its Shaped Charges Working Panel Monthly rept. no. 1, Mar. 1-31, 1949) TIP C2633 Confidential

In the flight of particles through atmospheres of various gases at velocities considerably above the mean velocity of the molecules of these gases, it was indicated that anomalous types of behavior compared to those usually encountered and visually identified by spark shadowgraphs of missile flight at 1,000 to 5,000 ft./sec. would be encountered. The periodicity of flashing observed in the flight of particles ejected by shaped charges is discussed.

L1295

Naval Ordnance Test Station, Inyokern.
JET INTERFERENCE, by N. A. MacLeod. Apr. 15, 1949, 15p. incl. illus. tables. (SCWP Technical memo. no. 4) (Bound with its Shaped Charges Working Panel Monthly rept. no. 3, May 1-31, 1949) TIP C2634 Confidential

The study was concerned with the degree of coincidence of initiation necessary to be maintained when 2 or more shaped charges are initiated at various degrees of propinquity. Test results showed that shaped charges could be fired successfully in close proximity without interference and that the degree of coincidence in initiation was within practical limits.

L1296

Naval Ordnance Test Station, Inyokern.
THE DECELERATION OF FAST PARTICLES BY ATMOSPHERIC DISSOCIATION, by J. S. Stanton. May 5, 1949, 10p. incl. illus. diagrs. (SCWP Technical memo. no. 3) (Bound with its Shaped Charges Working Panel Monthly rept. no. 2, Apr. 1-30, 1949) TIP C3007 Confidential

The mechanism of dissociation drag is discussed in which mass moving with velocity in excess of M = 10 may be subject to a drag, the origin of which lies in the dissociation of the air through which the particle passes. Consideration was given to a simple model of a cylindrical particle moving parallel to its axis and, preceding it, a plane shock of circular cross section similar to the shock which appears from the end of a bare cylindrical HE charge when detonated at the opposite end. Ionization effects occurring in the range M = 10 to 25 can be neglected, but not dissociation. A plot is shown of dissociation drag for a Cu cylindrical pellet from M = 5 to 25. An analysis is made of the motion of a Cu particle resulting from the firing of a shaped charge. Plots are shown of average acceleration vs. velocity, and of experimental drag results and calculated dissociation drag.

L1297

Naval Ordnance Test Station, Inyokern.
HIGH-INTENSITY TRANSIENT STRESS WAVES IN STEEL, by J. S. Rinehart. [1950], 11p. diagrs. (SCWP Technical memo. no. 15; RRB-60) (Bound with its TM no. 759-032050 Shaped Charge Working Panel Monthly Rept. Feb. 1-29, 1950) TIP C4531 Confidential

In a modification of the Hopkinson-bar experiment, a small cylinder of explosive was placed against the front of a heavy steel plate and a small steel pellet was affixed directly opposite on the back. The velocity of the pellet caused by the detonation of the charge was measured by multiflash photography. The intensities and duration of the transient stress waves in the metal as deduced for a typical wave were consistent with observed scabbing and plastic deformation of the metal.

L1298

Naval Ordnance Test Station, Inyokern.
INVESTIGATION OF SHOCK WAVE PHENOMENA IN AIR, by J. S. Stanton. Monthly progress rept. Jan. 1-31, 1950. 6p. TIP C51441
Confidential

Brief summaries report progress on: (a) interior ballistics (collapse and imagery of transparent conical liners); (b) exterior ballistics (penetration-card range, differential shadowgraphy); (c) shock wave phenomena (reinforcement effects, high-intensity sparks of brief duration); and (d) instrumentation (wide angle Kerr camera, project helix, streak camera timer).

L1299

Naval Ordnance Test Station, Inyokern.
RESEARCH IN ULTRA SPEED PARTICLES, by J. S. Stanton. Progress rept. Dec. 1, 1949-Feb. 28, 1950. May 1, 1950, 4p. TIP C4241
Confidential

The technique used for observing the functioning of shaped charges designed to produce high-speed particles involves direct forward stereoscopic observation by streak camera of the collapsing liner when suitable tracers are added to delineate the motion of individual elements. The following tracers were successfully used: Ce oxide, red P, and ThO_2(99%)-CeO_2(1%). The last of these gave tracers which were clearly visible to the point of jet coalition and was markedly superior to any of the others. By filling several circular troughs (0.032 in. wide by 0.005 in. deep) with the ThO_2-CeO_2 powder, complete information could be obtained as to the trajectories of the elements originating near this trough. Collapse velocities were measured as a function of position on the liner for conical Cu liners. The use of clear plastic cones confirmed the fact that the detonation front sweeps with uniform speed down the length of the conical liner. A method of producing high-speed particles being investigated involves taking a projectile (spherical steel ball) shot from a standard gun and attempting to accelerate it by passage down the axis of a detonating helix of explosive (Primacord). The pitch of the helix is graduated to keep pace with the projectile acceleration. Maximum velocities of about 20,000 ft./sec. may be available by this method. A single turn of the helix (doubly wound) in a heavy barrel was designed to match the entry speed (3720 ft./sec.) of the projectiles available. Synchronization of the helical detonation with the passage of the projectile was accomplished photoelectrically and by varying the length of the Primacord lead into the helix. By varying the synchronization, the projectile could be decelerated or accelerated as much as 25% in passing through a single turn of the helix. Numerous shaped charges were fired through penetration-card ranges composed of spaced sheets of X-ray film. By imparting a swiveling motion to the charge, it was shown that the periodicity of flashing of particles is not related to the rotation of the particle. (TIP abstract)

L1300

Naval Ordnance Test Station, Inyokern.
RESEARCH IN ULTRA SPEED PARTICLES, by J. S. Stanton. Quarterly rept. Mar. 1-May 31, 1950. June 21, 1950, [10]p. incl. illus. (NOTS Technical memo. no. 7594-062150) TIP C4559
Confidential

The mechanism of erosion for fast particles in passage through 0.020-in. cellulose acetate films was studied by the streak camera. The study revealed a similarity to the flashing erosion in gases and to the skirt surrounding the base of shaped charge jets. In addition, it showed that the majority of particles from a shaped charge did not luminesce in passage through the air unless they struck a target. Glass and gold shaped charges were fired to study the effect of chemical oxidation upon the drag of fast particles, but the particles produced were too small for trajectory analysis.

L1301

Naval Ordnance Test Station, Inyokern.
EVALUATION OF VAPORIFIC DAMAGE BY STREAK-CAMERA PHOTOGRAPHY, by M. D. Blatt. May 15, 1950, 8p. incl. illus. diagrs. (SCWP Technical memo. no. 16) (Bound with its Quarterly rept. Mar. 1-May 31, 1950 on the Shaped Charge Working Panel) TIP C4541 Confidential

Target-damage tests and exploratory rounds with shaped-charge warhead sections showed that individual particle velocities before and after striking the target can be determined by the streak camera, and that the extent of vaporific damage (the explosive effect produced when high-velocity particles strike Al) can be correlated with the intensity and duration of the recorded flash. When the desired level of damage is produced by 1 of a graduated series of charges, the average particle size of the effective charge may be obtained by water collection of particles from similar charges.

L1302

Naval Ordnance Test Station, Inyokern.
6.5-IN. ANTITANK AIRCRAFT ROCKET (ATAR) DESCRIPTION AND INSTRUCTIONS FOR USE. July 26, 1950, 18p. incl. illus. tables. (NOTS rept. no. 305; NAVORD rept. no. 1243)
TIP C4390 Confidential

The 6.50-in. antitank aircraft rocket (ATAR) described is a fin-stabilized rocket with shaped charge head and an electric contact fuze. The weapon is capable of penetrating 16-in. armor and functioning at obliquities up to 70°.

L1303

Naval Ordnance Test Station, Inyokern.
MANUAL FOR SHAPED-CHARGE DESIGN, by R. A. Brimmer. Aug. 17, 1950, 33p. illus. diagrs. 31 refs. (NOTS rept. no. 311; NAVORD rept. no. 1248) TIP C4380 Confidential

This manual is intended for the practical designer of shaped charges. It contains little theory, but is a compilation of the best available information on the penetration of various charges and the explosives used. Examples of present designs and proposals for further designs of shaped charges are listed. (NOTS abstract)

L1304

Naval Ordnance Test Station, Inyokern.
USE OF TRACERS TO STUDY THE COLLAPSE PROCESS IN SHAPED CHARGE LINERS, by J. S. Stanton and B. B. Dunne, Jr. Aug. 22, 1950, 13p. incl. illus. diagrs. (SCWP Technical memo. no. 23) (Bound with its Quarterly repts. Mar. 1-Aug. 31, 1950 on the Shaped Charge Working Panel) TIP C4544 Confidential

A Bowen rotating-mirror camera and 2 mirrors were arranged to photograph simultaneously the appearance of a collapsing liner from the axial and an abaxial position. Tracer material was packed into a shallow trough cut in the observed surface of the liner to label the elements of the liner. Cerium oxide and a ceria-thoria combination were successful. Tracer trajectories for 60° Plexiglas and 60° Cu liners started abruptly at the time the detonation front struck the coated element and persisted to the point of coalition. The Plexiglas cones formed a broad diffuse jet which was highly luminous immediately after coalition. The jet material from Cu was not luminous for several μsec. after collapse and the tracer elements could be followed into and along the jet, which was much narrower than for Plexiglas. Radial collapse velocities were generally quite constant after the initial acceleration. (TIP abstract)

L1305

Naval Ordnance Test Station, Inyokern.
FACTORS INFLUENCING SCABBING OF METAL PLATES, by J. S. Rinehart. Sept. 1, 1950, 19p. incl. tables, diagrs. (SCWP Technical memo. no. 22; RRB-88) (Bound with its Quarterly repts. Mar. 1-Aug. 31, 1950 on the Shaped Charge Working Panel) TIP C4546 Confidential

A modified Hopkinson-bar experiment was employed to determine the spatial distribution of particle velocities in the high-intensity stress wave induced in a metal plate by a charge exploded against 1 face. The resultant scabbing, or fracturing near the opposite face surface, of several metals was found to be governed principally by the spatial distribution of particle velocity within the wave and the critical impact velocity of the material.

L1306

Naval Ordnance Test Station, Inyokern.
A NEW APPROACH TO SHAPED-CHARGE PENETRATION, by J. S. Rinehart. Sept. 1, 1950, 10p. incl. diagrs. (SCWP Technical memo. no. 21; RRB-85) (Bound with its Quarterly repts. Mar. 1-Aug. 31, 1950 on the Shaped Charge Working Panel) TIP C4547 Confidential

The jet was treated as a small group of discrete particles rather than as a continuous jet of material. Agreement between theoretical predictions and experimental observations was excellent in a limited number of tests.

L1307

Naval Ordnance Test Station, Inyokern.
6.5-IN. ANTITANK AIRCRAFT ROCKET (ATAR) 6.5-IN. ROCKET HEAD MARK 2 MOD 0, DESCRIPTION AND INSTRUCTIONS FOR USE. Sept. 1, 1950, 15p. incl. illus. tables. (NOTS rept. no. 318; NAVORD rept. no. 1254) TIP C4483 Confidential

This rept. describes the 6.50-in. antitank aircraft rocket (ATAR) with the 6.50-in. rocket head Mk 2 Mod 0 and gives handling instructions for the complete round. This weapon employs the shaped charge principle and is designed for use by aircraft against heavily armored vehicles. It uses the 5.0-in. rocket motor Mk 2 all Mods and Mk 10 all Mods commonly known as the HVAR motor. The Mk 2 Mod 0 head is an improved version of the earlier production Mod 101 head. Only the differences between the ATAR and the HVAR are described in this rept. (NOTS abstract)

L1308

Naval Ordnance Test Station, Inyokern.
EXTERIOR BALLISTICS OF THE 6.5-IN. ANTITANK AIRCRAFT ROCKET (ATAR). PART I. EXPERIMENTAL, by L. Riggs. Oct. 1, 1950, 35p. incl. illus. tables. (NOTS Technical memo. no. 379) Confidential

The experimental procedure and analysis of data are outlined and comparisons between theoretical and experimental results are made for a rocket with a proposed 6.5-in. shaped charge head using the 5.0-in. HVAR motor and the standard HVAR rocket.

L1309

Naval Ordnance Test Station, Inyokern.
SHAPED CHARGE TESTS AGAINST SIMULATED AIRCRAFT SECTIONS, by G. C. Throner and others. [1951], 5p. illus. diagrs. (NOTS Technical memo. no. 400) Confidential

Shaped charges were fired against representative aircraft sections and other materials Mk 3 shaped charges were fired at standoff distances ranging from 5 to 80 ft. against targets consisting of 2 1/8-in. Al plates spaced 10 in. apart. Results showed that maximum damage was done at approximately 10- to 20-ft. standoff, which corresponded to an optimum standoff for aircraft damage of about 60 cone diameters. Design criteria for shaped charge warheads for use against air targets were investigated. Results of these experiments with larger shaped charge liners (60° and 80°) indicated that the maximum effective standoff for Cu liners, both cast and electroformed, was greater than 200 ft. Maximum effective standoff for steel liners was about 150 ft. for 6-in. diameter liners and between 150 and 200 ft. for 9-in. liners.

L1310

*Naval Ordnance Test Station, Inyokern.
EXPLORATION OF SHAPED CHARGE EFFECTS BEYOND ARMOR, by C. E. Weinland. Jan. 30, 1951, 5p. illus. table. (NOTS Technical rept. no. 4031-LP-608A TR-6) TIP C54321
Confidential

L1311

Naval Ordnance Test Station, Inyokern.
GROUND RANGE BALLISTIC TESTS OF 8-CM. OERLIKON ROCKET, INTERIM REPORT OF, by G. Leitmann. Feb. 22, 1951, 4p. illus. tables. (NOTS Technical note no. 5036-70)
Confidential

Tests were made to determine the basic ballistic parameters of the Swiss 8-cm. Oerlikon rocket including rounds fitted with simulated HEAT (shaped charge) heads. The weight, c.g., transverse moment of inertia, polar moment of inertia, velocity, acceleration, drag, and spin rate (r.p.s.) were determined for the 10 HEAT rounds fired. The values of spin rate obtained by spin sonde were in substantial agreement with those obtained by photographic means. These preliminary data are presented in tables and graphs.

L1312

Naval Ordnance Test Station, Inyokern.
EFFECT OF SINGLE HYPERVELOCITY PELLETS AGAINST SIMULATED AIRCRAFT SECTIONS, by R. D. Smith, D. R. Kennedy, and G. C. Throner. Apr. 19, 1951, 5p. illus. tables. (NOTS Technical memo. no. 411) TIP C6066
Confidential

Vaporific effects produced by single hypervelocity (8000 to 15,000 ft./sec.) pellets of known masses and by Mk 2 shaped charges, used for comparison, hitting simulated aircraft structures containing various atmospheres (air, N, He, O, or exhaust gases) were recorded photographically. Three charges fired against the O-filled target boxes produced heavy damage in the target due to internal fire and explosion. The target box was destroyed when hit by the Mk 2 shaped charge.

L1313

Naval Ordnance Test Station, Inyokern.
PRELIMINARY REPORT OF THE AIR-FIRING OF THE 8-CM. OERLIKON AIRCRAFT ROCKET, by L. Riggs. Apr. 21, 1951, 7p. incl. tables, diagrs. (NOTS Technical note no. 5036-78)
Confidential

The 8-cm. Oerlikon rocket was fired from an F51D aircraft to determine dispersion and trajectory drop data for the rocket fitted with HEAT-type and HE-type heads. The preliminary data are presented in tables and graphs. No penetration data are given.

L1314

Naval Ordnance Test Station, Inyokern.
EFFECTIVENESS OF SHAPED CHARGES AGAINST AIRCRAFT TARGETS AT LONG STANDOFFS, by R. D. Smith, D. R. Kennedy, and G. C. Throner. May 25, 1951, 13p. illus. tables, diagrs. (NOTS Technical memo. no. 433) TIP C6632
Confidential

A series of 3.750-in., 120° Cu, 6% standard shaped charges, was fired at long standoff to determine the limiting optimum standoff for vaporific damage to simulated aircraft sections. Test results indicated that about 125 ft. was the limiting standoff for effective vaporific damage. It was also found that the jet produced by the 120° standard charge was not luminous and that its average velocity (7500 ft./sec.) was much lower than that obtained from comparable charges with smaller liner apex angles.

L1315

Naval Ordnance Test Station, Inyokern.
EXAMINATION OF 8-CM. OERLIKON (SWISS) AIRCRAFT ROCKET, by D. H. Fairbanks. Aug. 16, 1951, 38p. incl. illus. tables, diagrs. (NOTS rept. no. 425; NAVORD rept. no. 1901) TIP C7327
Confidential

The 8-cm. Oerlikon aircraft rocket, a solid-fuel, fin-stabilized round with a burning time 0.93 sec. and a maximum velocity of 800 m./sec., was examined at NOTS. The details of construction, physical characteristics and dimensions of the motor, HE head, and fuze are presented. NOTS experimental data indicate that the shaped charge head weighs 3.9 lb. and the complete HEAT round 20.6 lb. Ballistic data provided by the Swiss manufacturer shows a shaped charge head weight of 4.2 lb., a burnt velocity of 2400 ft./sec. and penetrations into plate (type not specified) of 4.7 in. at 45° obliquity and 7.09 in. at 90° obliquity.

*Reference not verified in the original.

Appendixes contain verbatim copies of Oerlikon brochures no. 1119, " 'Oerlikon' 8 cm. Aircraft Rockets" and no. 1134, "The 'Oerlikon' Rocket-Projectile Fuze Type KVD."

L1316

Naval Ordnance Test Station, Inyokern.
STUDIES OF DAMAGE TO AIRCRAFT MATERIALS BY SHAPED CHARGES AT LONG STANDOFFS, by D. R. Kennedy, R. D. Smith, and others. Aug. 20, 1951, 63p. incl. illus. diagrs. (NOTS Technical memo. no. 443) TIP C7049 Confidential

Shaped charges were fired at long standoff against representative aircraft sections and materials and against actual aircraft. When several standard and modified Mk 3 shaped charges were fired against spaced Al-plate targets (5 to 80 ft.), maximum target damage occurred at about 10-ft. standoff (40 cavity diameters). Severe structural damage occurred when type-A charges loaded with Comp. C3 were fired against 5 different types of aircraft-wing construction. The extent of severity was proportional to the degree of confinement and the weight of the target-section bracing. The best approximation of jet striking velocity was obtained by placing a marker in the line of fire and measuring the average velocity over the last 20 ft. of flight. Dispersion patterns from a type-B charge at 125-ft. standoff were obtained with a 16- x 16-ft. Celotex target. Forward projected fragments were recovered by firing the charges into large masses of ice. The 6-in. diameter Al shaped charge liners produced greater damage to the FM2 aircraft than Cu liners. Conditions desired for inflicting K-kill damage to F6F aircraft include aiming the charge so that the center of the jet will strike the aircraft and employing an optimum liner angle between 80° and 120°. Standoff distances of 125 ft. or less and charge diameters of 6 in. or greater were indicated. Vaporific damage was decreased when the aircraft interior was filled with engine exhaust gas (1.4% O, 11.5% CO_2, and 3.3% CO).

L1317

Naval Ordnance Test Station, Inyokern.
6.5-IN. ROCKET HEAD MARK 2 MOD 0 DESIGN, MANUFACTURE, AND EVALUATION, by W. A. Swenson. Oct. 9, 1951, 33p. incl. illus. tables, diagrs. (NOTS rept. no. 445; NAVORD rept. no. 1913) TIP C7539 Confidential

A 6.5-in. rocket head has been designed for use with the 5.0-in. rocket motors Mk 2 and Mk 10, all Mods. The head has a windscreen 3 calibers long, a body containing a HE shaped charge, and an electric base fuze powered by dry batteries. A switch on the nose of the windscreen is closed on impact with the target to complete the electrical circuit of the base fuze. The fuze will function on 1/8-in. mild steel plate and at obliquities as high as 80°. The head weighs approximately 48 lb., including 20.5 lb. of Comp. B. It is 39 in. long, measured from the motor seating surface to the forward end of the nose fuze, and has a maximum outside diameter of 6.625 in. It is capable of consistently penetrating 17 in. of armor. Design, manufacture, test, and handling properties of this head, designated the 6.5-in. Rocket Head Mk Mod 0, are discussed. (NOTS abstract)

L1318

Naval Ordnance Test Station, Inyokern.
BALLISTIC EVALUATION OF THE 8-CM. OERLIKON AIRCRAFT ROCKET, by L. Riggs and H. L. Newkirk. Mar. 13, 1952, 29p. incl. illus. tables, diagrs. (NOTS rept. no. 502; NAVORD rept. no. 1848) TIP C7994 Confidential

The 8-cm. Oerlikon aircraft rocket with both HEAT and HE type heads was fired from a stationary launcher to determine velocity, acceleration, drag, and spin. Wind-tunnel tests were also made to obtain pitching-moment, axial drag, and normal-force coefficients for various yaw angles at M = 0.7 and 1.7. In addition, dispersion and trajectory drop estimates were made from over 200 air-to-ground firings. The data are given in appendixes.

L1319

Naval Ordnance Test Station, Inyokern.
INVESTIGATIONS OF THE EFFECTS OF SHAPED CHARGES BEYOND DEFEATABLE ARMOR, by D. R. Kennedy, G. C. Throner, and S. G. Wagenseller. June 27, 1952, 107p. incl. illus. tables, diagrs. (NOTS Technical memo. no. 462) TIP C8166 Confidential

This shaped charge study consists of 3 parts: Part I. Determination of masses, shapes, and spatial distribution of fragments ejected beyond armor. Results indicated that there was no strict relationship between hole dimensions in the main target and the amount of fragment damage as determined from fragment screens. Generally, however, those charges (Al liners) producing the greatest hole size were responsible for the greatest fragment damage, while those giving the smallest holes usually produced the least fragment damage. On the basis of fragment lethality (a mass over 3 g. and excluding the slug) the Al liners gave the greatest masses at greatest angles of dispersion. However, the steel liners produced more numbers of lethal fragments than either the Cu or Al liners. It was concluded that: (a) smaller liner apex angles (42.5° and 60°) gave more lethal fragments than did wider liner angles; (b) doubling the liner thickness of the 6-in. charge from 3 to 6% of the cavity diameter more than doubled the mass and number of lethal fragments; (c) the mass and number of lethal fragments beyond armor was increased multifold by increasing the liner dimensions only twofold. Part II. Comparative fragment dispersion on angle plates beyond armor. Observations made beyond defeated armor showed that: (a) the Cu jet spray consisted of small, nonluminous, high velocity fragments; because of their velocity and ductility, these fragments tended to plate out on the primary armor rather than to ricochet; (b) the steel jet was made up of larger, luminous, slightly lower velocity fragments which tended to ricochet on plates beyond the primary target; (c) the Al jet, composed primarily of large spall fragments at wide dispersion angles and at lower velocities than the other 2 jets, displayed an even greater tendency than the steel jet to ricochet on the secondary target plate. Part III. Determination of pressures and temperatures generated in confined targets defeated by shaped charges. On the basis of charge diameter, steel and Cu liners were inferior to Al in pressure and temperature tests. Correlations between maximum temperature and pressure rise and liner apex angle were not observed. Complete test data are given in appendixes.

L1320

Naval Ordnance Test Station, Inyokern.
DEMOLITION LINE CHARGE NOTS MODEL 301A PRELIMINARY DEVELOPMENT, by M. B. Gentry. July 31, 1952, 27p. incl. illus., table. (NOTS rept. no. 562; NAVORD rept. no. 1980)
TIP C8872 Confidential

This forward-thrown demolition charge is 300 ft. long having a Comp. C3 or C4 explosive charge of 6 lb./ft. It is capable of rocket-powered flight for a distance of 600 ft. and is detonated electrically. Tests with inert and live assemblies gave satisfactory results.

L1321

Naval Ordnance Test Station, Inyokern.
NONCRITICAL METALS SUITABLE FOR SHAPED CHARGE CONES, by [D. R. Kennedy]. [1953], p. 21-25, incl. illus. diagrs. (In its Rocket Quarterly, v. 1, Mar. 1953, NOTS rept. no. 649, Confidential) Confidential

In this brief review of pertinent shaped charge studies conducted at NOTS, shaped charge nomenclature is presented and the performance of Al, Cu, Zn, Mg, steel, and malleable Fe liners are considered. Photographs of the exit holes in 6.0-in. Class A armor plate produced by Cu, Al, and steel liners of identical geometry are also included.

L1322

Naval Ordnance Test Station, Inyokern.
SHAPED CHARGE LAND MINE TESTS, by D. R. Kennedy and E. G. Reby. Feb. 23, 1952, 12p. incl. illus. diagrs. (NOTS Technical memo. no. 1099) Secret

A limited series of tests was made to compare the effectiveness of Al liners with Cu liners in shaped charge antitank mines. The maximum barrier used in the tests was 3 ft. of loosely packed soil, with the targets (2-in. Class B homogeneous armor plate) being set 18 in. above the surface of the earth (item no. L1346). Standoff distance was 8 in. It was concluded that: (1) the liner material was the most important single variable in warhead design; (2) Cu liners were most effective at sizes smaller than 5-in. diameter; (3) Al liners of 6-in. diameter gave the highest kill probability; (4) shaped charges damaged armor when buried comparatively deep (2 ft.) in the soil; (5) an increase in the explosive charge beyond that needed for liner collapse did not increase the charge's penetration properties; and (6) the point of initiation, whether nose or base, had no discernible effect on the jet penetration through earth. A tabular summary of the test data is given in an appendix.

L1323

Naval Ordnance Test Station, Inyokern.
STUDIES OF DAMAGE TO AIRCRAFT STRUCTURES BY SHAPED CHARGES AT LONG STANDOFFS, by D. R. Kennedy, R. D. Smith, G. C. Throner, and S. G. Wagenseller. Mar. 17, 1953, 34p. incl. illus. tables, diagrs. (NOTS rept. no. 672; NAVORD rept. no. 2018) AD-14 162
Confidential

Experiments were conducted to study production of damage to aircraft structures from shaped charges fired at standoffs of 30 to 200 ft. in order to determine the feasibility of using such charges for guided-missile warheads. Results indicate that shaped-charge warheads are capable of producing K-kill damage to aircraft from 125-ft. standoff, if they have the following characteristics: (1) the axis of the charge aimed so that the center of its jet will strike the aircraft; (2) a liner angle between 80° and 120°; (3) a charge diameter of 6 in. or greater; (4) liner material of Al, steel, or Cu (in order of decreasing effectiveness); and (5) a liner thickness of at least 6% of the charge diameter.

L1324

Naval Ordnance Test Station, Inyokern.
EFFECTIVENESS OF 2.75-IN. SHAPED CHARGE HEAD AGAINST ARMOR, by F. H. Scheutt. Aug. 18, 1953, 7p. incl. tables, diagr. (NOTS rept. no. 743) Confidential

The terminal ballistics performance of the 2.75-in. HEAT head and T2023 fuze against armor, and its lethality against the Russian T34/85 tank are discussed. Test firings of 77 HEAT rounds (2.75 in.) into STS and Class B armor indicated average penetrations of more than 8 in. at 0° obliquity and between 6 and 7 in. at 45° and 60° obliquity. In considering damage beyond armor, it was believed that the fragments produced by the 2.75-in. HEAT head were too low in kinetic energy and too small to cause damage to components other than tankmen. Using data obtained at the Aberdeen Proving Ground (item no. L292), the following estimates of conventional kill probability for the 2.75-in. HEAT head against the Russian T34/85 tank were made:

Damage Criteria	Probability of Kill Given a Hit
Loss of mobility	.33
Damage beyond recovery	.13

A random azimuth orientation of the target tank, a 30° angle of dive, and an average target area of 124 sq. ft. were assumed.

L1325

Naval Ordnance Test Station, Inyokern.
SHAPED CHARGE LAND MINE TESTS. PART II, by T. H. Davis and D. E. Brink. Sept. 14, 1953, 16p. incl. illus. tables. (NOTS Technical memo. no. 1482) Secret

Comparison of the effectiveness of Al and Cu conical liners in a shaped charge land mine was made. The test data indicated that the Al liners were not successful within the limitations of size, shape and soil barriers to be defeated. The shaped charge having a 5-in. diameter, 45°, 0.15-in. Cu conical liner backed by 15.5 lb. of Comp. B. defeated 2-in. Class B armor plate through a 48-in. sand barrier and 18-in. airspace. However, the same charge failed to defeat the target plate under identical conditions when a 1-in. thick Al plate was placed at an 8-in. standoff from the liner to simulate the fuze mass. It was recommended that further tests be limited to shaped charges with Cu liners, varying only the soil barrier, explosive weight, and standoff.

L1326

Naval Ordnance Test Station, Inyokern.
TOWARD THE IMPROVEMENT OF SOLID PROPELLANT ROCKET AND LAUNCHER SYSTEMS: A PARTIALLY ANNOTATED BIBLIOGRAPHY, by D. J. Jacks, R. E. Boss, and O. L. Mitchell. Dec. 1, 1953, 59p. (NOTS Technical memo. no. 1509) Confidential

A section on shaped charges, containing 7 rept. references from American and British installations, is included. The references range in time from 1940 to 1952.

L1327

Naval Ordnance Test Station, Inyokern.
APPLIED RESEARCH ON WARHEADS. Jan. 1, 1954, p. 87-89 incl. illus. (In its Semiannual progress rept., June-Dec. 1953, NOTS STPR-7; NOTS rept. no. 790, Confidential) AD-25 192 Confidential

The following shaped charge investigations were reported: Penetration by shaped charge liners of various materials: Shaped charge cavity liners of identical geometry (apex angle 42°, 1.5-in. base diameter, 0.10-in. wall thickness) were manufactured from Al, Mg, Ti, Ni, Cu, Zn (Zamack-5 die-casting metal), Zr, Ag, Cd, and Ta. These conical liners were examined by X-ray diffraction, given microhardness tests, macrophotographed, and their weights accurately determined. Tests will be made to correlate penetration effectiveness of the liners with atomic weight, crystallographic classification, depth of work hardening, heat of oxide formation, and oxide density. In addition, tests will be conducted on spherical-segment or "dish" liners pressed from wafers of the same metals to determine their characteristics at standoffs of 240 caliber. Soil-barrier penetration: A combination of variables was found that allowed shaped charge jet penetration through 4 ft. of loose-packed soil and 2 in. of armor plate. Experimental difficulties caused by discrepancies in metal parts furnished by contractors were eliminated, and the test series was completed. Peripheral initiation: It was observed that the penetrating efficiency of a lined shaped charge can be increased by causing a detonation wave to advance through the explosive as if originating uniformly around the periphery at the rear of the charge. In practice this is achieved by 1-point axial detonation baffled by an inert circular barrier, of diameter smaller than the charge, just forward of the detonation. Five charges were tested using steel liners of 2-in. diameter and apex angle of 42.5°. Maplewood barriers were placed in 4 of the charges. The fifth charge, acting as the control, had no barrier. Firing data showed that: (1) the shallowest penetrations in the mild-steel plates were made by the control charge (8.6 in.) and 1 of the charges with barrier; (2) the 3 other charges exceeded the penetration of the control by an in. or more, the maximum penetration being 10.1 in.

L1328

Naval Ordnance Test Station, Inyokern.
GUIDED-MISSILE WARHEAD SYSTEMS. Jan. 1, 1954, p. 216-218 incl. illus. table. (In its Semiannual progress rept., June-Dec. 1953, NOTS STPR-7; NOTS rept. no. 790, Confidential) AD-25 192 Confidential

High-altitude tests: Charges 2.375, 5.0, and 7.5 in. long were fired at ground level (2,300-ft. elevation) to determine the effect on charge velocity of increasing the length of shaped charges. Firing data showed that with the 80° apex-angle, 0.150-in.-thick Al liners, the average velocity over a 240 caliber (30-ft.) standoff (1) increased 100% when the charge length was increased from 2.375 to 5.0 in., and (2) increased 130% with an increase in charge length from 2.375 to 7.0 in. Also tested were the 120° apex-angle, 0.150-in.-thick Al liners and Al dishes (spherical segments subtended by a 90° solid angle from a 1.874-in. diameter sphere). The dish liners gave the lowest velocity gradient over the 30-ft. standoff of the 3 geometries investigated. DART antitank warhead: The penetration of the DART shaped charge warhead was increased from 15 to 19 in. in a single field test, when the principle of peripheral initiation was employed. Aircraft-payload vulnerability to shaped charge attack: Tests were made to determine the distance at which shaped charges for guided missiles were effective against bombs carried by aircraft. Charges with steel and Al liners and dishes were fired at 0.75-in. mild-steel plates, simulating bomb casings, at standoffs ranging from 60 to 140 ft. The 120° steel liner was the most effective, giving 14 penetrations at 120-ft. and 4 at 140-ft. standoff. Least effective at long standoffs were the Al liners and dishes.

L1329

Naval Ordnance Test Station, Inyokern.
HYPERBALLISTICS. Jan. 1, 1954, p. 241-243 incl. illus. (In its Semiannual progress rept., June-Dec. 1953, NOTS STPR-7; NOTS rept. no. 790, Confidential) AD-25 192 Confidential

In the hyperballistics research program, an experimental technique was devised that simulates liner collapse in a shaped charge. The method is based on the impact of a cylindrical projectile having a 90° conical-cavity nose on a thin-plate target (0.020-in. Al). Photographic data indicate that material flows from the inner surface of the liner into the cavity. At this point the enhanced pressure creates a jet which cuts a hole in the liner with approximately twice the velocity of the projectile and flows along the projectile's axis. In addition, a procedure was evolved to measure the amount of steel eroded from a shaped charge fragment. It is estimated that aerodynamic heating causes a 70-mg. steel plate to lose about 0.1 mg./ft. of trajectory.

L1330

Naval Proving Ground, Dahlgren.
EXPERIMENTAL TEST OF 1000-LB. SC, T4E1, BOMBS VS. HEAVY CRUISER TARGET. [1946], 8p. incl. illus. (Communication F41-6/L5-2 (BPO 99129) to Chief of Bureau of Ordnance) Confidential

Two 1000-lb. shaped charge bombs T4E1, Comp. B cast around a central core of TNT, with modified AN M103 fuzes, were fired against a target simulating a heavy cruiser with superstructure. The target consisted of 4 3/8-in. mild steel plates separated by 7-ft. air spaces, 2 0.5-in. STS plates, 10-ft. air spaces and 3/8-in. mild steel plate. The bombs penetrated the target plates; it was concluded that the bombs would defeat the main armor of the heavy cruiser target with superstructure.

L1331

Naval Proving Ground, Dahlgren.
FRAGMENTATION OF 5-IN. (HC) EX26 PROJECTILES WITH CONTROL LINERS EX3, by V. Wilson. Final rept. Partial rept. no. 5 on Fragmentation of Projectiles and Warheads. June 12, 1950, 12p. incl. illus. table. (Proj. no. NPG-12-Re2c-35-12, NPG rept. no. 577) TIP C52386 Confidential

A test was conducted to obtain fragmentation (mass distribution data) for 5-in. HC Ex26 projectiles, Comp. B loaded with control liners Ex3. The Ex3's were Cu shaped charge liners 0.008 in. thick (75° apex angle) with continuous grooves 1/8 in. deep running parallel to the projectile axis for the whole length of the projectile's cylindrical portion. Upon detonation these grooves acted as shaped charges causing about 0.5 of the projectile mass to break into strip fragments of 40 to 320 g. in weight. Appendixes include photographs of the recovered fragments and a detailed table of the fragment mass and number.

L1332

*Naval Proving Ground, Dahlgren.
FRAGMENTATION TEST OF 5-IN. HC PROJECTILES WITH CONTROL LINER EX-4, by M. Berger. Final rept. Particle rept. no. 6 on Fragmentation of Projectiles and Warheads. Sept. 5, 1950, 6p. illus. tables. (NPG rept. no. 638) TIP C55078 Confidential

L1333

Naval Proving Ground, Dahlgren.
FRAGMENT VELOCITY LAW FOR CYLINDER, CONES, AND COMPOSITE SHAPES, by R. E. McConnell. Partial rept. no. 1. Partial rept. no. 10 on Warhead Characteristics. Jan. 21, 1951, 8p. illus. diagrs. TIP C7324 Confidential

Fragment velocities were determined over a range of charge-mass ratios on annularly loaded war heads. Three each of 3 types of Comp. C3 war heads 11.75 in. in diameter were employed which contained hollow axial cylinders that displaced 14.1%, 31.8%, and 56.6% of the explosive. Three fully-loaded cylinders were detonated for comparison. Under the test conditions employed, the removal of an axial core of explosive resulted in the reduction of fragment velocities from 6070 to 3700 ft./sec. for 0 to 55.6% of explosive removed and charge-mass ratios from 0.9218 to 0.3997. Graphs are appended which show the relationship between experimental and theoretical velocities for the % explosive removed. (TIP abstract)

L1334

Naval Proving Ground, Dahlgren.
FRAGMENTATION TEST OF ROD PRODUCING AAP TRIAL WARHEAD NO. 3, by M. Berger. Final rept. Partial rept. no. 15 on Fragmentation Testing of Warheads for Guided Missiles. Mar. 8, 1951, 6p. illus. tables. (Proj. no. NPG-5-Re3f-601-1, NPG rept. no. 736) TIP C5448 Confidential

Tests showed that the Angled Arrow projectile trial warhead no. 3 with 80° apex angle Cu fluted liner did not produce fragments of the desired rod length. Fragments having an average median velocity of 2610 ft./sec. were obtained.

*Reference not verified in the original.

L1335

Naval Proving Ground, Dahlgren.
5-IN. ROCKET HEADS EX12 (SHAPED CHARGE). DEVELOPMENT AND TEST, by F. W. Kasdorf. Final rept. Final rept. on Task Assignment no. NPG-37-Re2c-46-3. Partial rept. no. 1 on Task Assignment no. NPG-Re2c-46-1-51. Mar. 30, 1951, 15p. illus. diagrs. (NPG rept. no. 749) TIP C5887 Confidential

Empty 5-in. rocket heads Mk 4 Mod 0 with a 0.135- to 0.158-in. wall were used with approximately 4 in. cut off the closed base end. The remainder of the head, 29 in. long, was cut transversely 8 in. from the nose to permit insertion of the Cu cone. This empty 8-in. forward section of the finished head provided the essential standoff distance for fuze functioning. The c.g. of the loaded and fuzed round was 22 3/16 in. from the forward end. Cu cones 4.25-in. o.d. at the base, 5.345 in. high, and 0.125 in. in wall thickness were Ag-soldered to the steel locating ring and primacord casing tube. The explosive charge of 20 lb. originally specified can be reduced to 14.25 lb. without materially affecting the penetrating power of the head, the decrease permitting a decrease in the over-all length of the head. The 8-in. length section provides sufficient standoff for the Mk 149 fuze to detonate this head upon impact at 1700 ft./sec. and provides for a jet formation that will be giving maximum penetration of the target. The nose fuze, fired at aircraft striking velocities, functioned high order 100% of the time on targets as thin as 0.25-in. steel and at obliquities up to 63°. The head striking its target at 1700 ft./sec.: (1) consistently penetrated 9.5 in. of homogeneous armor plate at 0°, 45°, and 60° obliquity; (2) penetrated 3 ft. of high strength concrete, spalling a slab of concrete off the face of the block in the process; (3) penetrated 18.5 in. of homogeneous armor plate at 0° obliquity on 1 of 4 attempts; (4) penetrated 17.5 in. of homogeneous armor plate at 0° striking obliquity; (5) had its plate penetrating power reduced to approximately 42% of its normal value when triggered 15 in. in front of the plate target and penetrated 15 in. of sand before reaching the plate; and (6) penetrated the 2.5-in. armored front plate of a M4A3 medium tank at a 47° impact angle, its jet traveling the entire length of the tank into the engine compartment. (TIP abstract)

L1336

Naval Proving Ground, Dahlgren.
FRAGMENTATION OF PROJECTILES AND WARHEADS, by V. Philipchuk. Final rept. Final rept. on Fragmentation of Rocket Heads. Partial rept. no. 10 on Fragmentation of Projectiles and Warheads. Apr. 7, 1951, [67]p. incl. illus. tables. (Proj. no. NPG-Re2c-25-12-51, NPG rept. no. 784) TIP C6017 Confidential

Tests were conducted to obtain the fragmentation characteristics of 4 types of rocket heads including 2 containing shaped charges, the 5-in. Mk 25 Mod 0 (14.1-lb. Comp. B charge) and the 6.5-in. Mk 2 Mod 0 (20.5-lb. Comp. B charge). Six rounds of each rocket-head type were detonated in the space arena, an area of 30-ft. radius walled by 5-ft. high mild steel panels, to determine fragment space distribution and fragment velocities. Three of the 6.5-in. shaped charge rounds detonated produced metal slugs weighing up to 1.2 lb. These slugs were thrown in the jet path and penetrated 2 plates of 3/8-in. mild steel at 0° obliquity. No other slugs were recovered from the shaped charge firings. Three rounds of each type were placed in a horizontal position over the water pit and detonated to obtain mass distribution data for the beam spray 60° to 120° from the nose. Two night photographs of the shaped charge detonations showed that the 6.5-in. Mk 2 Mod 0 head gave a longer jet than the 5-in. Mk 25 Mod 0 head. Round-by-round assessments of the fragmentation characteristics of all the rocket heads tested are contained in appendixes.

L1337

Naval Proving Ground, Dahlgren.
DEVELOPMENT TESTS OF XR48 ELECTRIC BASE FUZE FOR 5-IN. SHAPED CHARGE ROCKET HEAD, by R. T. Ruble. Final rept. Partial rept. no. 14 on Aircraft Rocket Fuze Systems; Research, Development, and Test. June 23, 1951, 12p. illus. tables. (Proj. no. NPG-19-Re2b-11, NPG rept. no. 799) Confidential

Tests on a 0.350-in. diameter by 0.100-in. thick barium titanate crystal showed that it will produce sufficient electrical energy to fire a XR48 fuze when compressed by impact on a target at 1800 ft./sec. A 5-in. shaped charge rocket head employing a XR48 fuze penetrated the following targets: (1) 18.5 in. of homogeneous armor at 0° obliquity plus a 1/8-in. steel plate placed 2 ft. behind the target plate; (2) 4 ft. of heavily reinforced concrete; and (3) 14.5 in. through a 9.4-in. homogeneous armor plate set at 60° obliquity.

L1338

Naval Proving Ground, Dahlgren.
5-IN. ROCKET HEADS MARK 25 MOD. 1; SENSITIVITY AND PENETRATION TESTS, by F. W. Kasdorf. Final rept. Partial rept. no. 2. Sept. 1, 1951, 11p. illus. (NPG rept. no. 846) TIP C6781 Confidential

The 5-in. shaped charge rocket head is approximately 32.5 in. long, contains 15.5 lb. of Comp. B explosive, and weighs 50.5 lb. complete with Mk 149 nose fuze. For sensitivity tests, the heads were secured to 3.25-in. motors Mk 7 inserted in 5.0-in. diameter tubes by special adapters. Impact was made on a 2.5-in. STS target plate, simulating a ship's bulkhead. In penetration tests, the heads were fired from the 1050-ft. rocket launcher. Two 5.0-in. rocket motors Mk 2 Mod. 3 were used in tandem for propulsion of the heads to obtain striking velocities of 1600 to 1800 ft./sec.

The target was a 16.5-in. class B armor plate set at 0° obliquity. The heads did not deflagrate in 20 successive impacts with the 2.5 in. armor plate at 200 ft./sec. (Deflagration was defined as the addition of velocity to the fragments of the rocket head or motor after target impact by means of the explosive contained therein.) Complete penetration of 16.5 in. of homogeneous armor plate at 0° obliquity was accomplished 4 out of 5 times. The fifth round penetrated approximately 16 in. of armor. (TIP abstract)

L1339

Naval Proving Ground, Dahlgren.
AAP ROD-PRODUCING WARHEADS, FRAGMENTATION OF, by V. Philipchuk. Final rept. Partial rept. no. 30 on Fragmentation Testing of Warheads for Guided Missiles. Oct. 13, 1951, 6p. illus. tables. (NPG rept. no. 858) TIP C6867
Confidential

Tests were conducted to determine the fragment-mass distribution of Comp. C3 loaded rod-producing war heads, type no. 4, with and without a hemispherical shaped Cu liner. Both warheads were assembled with AAP rocket motors and were heat-treated to a hardness of Rockwell C47. Neither warhead produced design length rod-like fragments. The warhead without the shaped charge liner produced longer rod-like fragments. The rocket motor was fragmented approximately 50% more by the warhead without than the 1 with the shaped charge liner. (TIP abstract)

L1340

Naval Proving Ground, Dahlgren.
FRAGMENTATION OF 3-IN./50 AA PROJECTILES MK 27 FOR FRAGMENTATION CONTROL, by V. Philipchuk and A. N. Hughes. Final rept. Partial rept. no. 17 on Fragmentation of Projectiles and Warheads. Dec. 17, 1951, 6p. illus. table. (NPG rept. no. 898) TIP C7210
Confidential

Fragment-mass distributions were determined for Comp. B-loaded 3-in./50 cal. Mk 27 AA projectiles with electroformed Cu shaped charge liners having 12 longitudinal grooves traversing the length of the explosive cavity. The 12 strip fragments produced averaged 150 g. and 5 in. in length. Fragment-mass distribution photographs are appended. (TIP abstract)

L1341

Naval Proving Ground, Dahlgren.
FRAGMENTATION OF 5-IN. (HC) EX26 PROJECTILES WITH CONTROL LINERS B2 AND J1, by V. Philipchuk. Final rept. Partial rept. no. 16 on Fragmentation of Projectiles and Warheads. Jan. 16, 1952, 8p. illus. tables. (Proj. no. NPG-Re2c-25-1-52, NPG rept. no. 902)
Confidential

Tests were conducted to determine fragment mass distribution data for 5-in. HC Ex26 projectiles, loaded with Comp. B, with control liners B2 and J1. Comparative fragment velocity data were also obtained from these tests for projectiles with B2 liners and without liners. The B2 liners consisted of a 3.9-in. diameter, 12.5 in. long Cu cylinder. The cylinder was modified by 25 longitudinal rows of grooves with each row having 25 grooves. Each groove was 0.5 in. long, had a 75° apex angle, and was 0.25 in. deep. The grooves in each row were 0.5 in. apart separated by flat portions of the cylinder. The adjacent rows were staggered so that the grooves of 1 row were adjacent to the flat areas of the neighboring rows. The liner wall was 0.012 in. thick. The J1 liner differed from the B2 liner in that the grooves were held from the shell wall by a 1/8-in. standoff distance. Two of the 3 rounds which had the Be liner showed some degree of control of fragment size while the J1 liner was unsatisfactory in controlling fragment size. The B2 liner caused a 10% fragment velocity loss when compared with similar projectiles having no liner.

L1342

Naval Proving Ground, Dahlgren.
5.0-IN. ROCKET HEADS MK 25 MOD 1 WITH STEEL CONES. Final rept. Partial rept. no. 6 on Shaped Charges. May 22, 1952, [20]p. illus. tables. (NPG rept. no. 978) TIP C7942
Confidential

Tests were made to compare the penetration performance of the 5-in. Mk 25 Mod 1 rocket equipped with steel conical liners with that of similar heads having conical liners tested earlier (item no. L1335). The explosive charge was 15.5 lb. of Comp. B. Results of the tests obtained with impacts at approximately 1800 ft./sec. follow:

Rounds fired	Target Thickness	Target Obliquity	Penetration
Class B homogeneous armor plate			
2	10 in.	45°	2 complete
2	3 in.	54°	2 complete
2	10 in.	54°	1 complete 1 partial (5 in.)
3	10 in.	60°	3 no penetration
3	16-5/8 in.	0°	3 partial (14 to 15 in.)
Reinforced 12 ft. x 12 ft. concrete blocks			
1	4 ft.	0°	1 complete
1	6 ft.	0°	1 partial (4.2 ft.)
M4A3 Medium Tank			
1	2.5 in.	47°	1 complete

It was concluded that depths of penetration with the steel liner heads are slightly less than for those with Cu liners. No consistent difference in the size of target openings was noted on comparing steel with Cu liners. Round-by-round assessments of the firings are included.

L1343

Naval Proving Ground, Dahlgren.
CONTROLLED FRAGMENTATION OF 3 IN./50 AA PROJECTILES MK 27, BY RUBBER LINERS, by W. Wright, Jr. Final rept. Partial rept. no. 21 on Fragmentation of Projectiles and Warheads. June 12, 1952, 7p. illus. tables. (Proj. no. NPG-Re2c-35-1-52, NPG rept. no. 988) TIP C8087 Confidential

Tests were conducted to determine the fragment mass and fragment velocity data of 3 in./50 AA projectiles Mk 27-2, Comp. B loaded, having 75° rubber shaped charge liners with 12 longitudinal grooves running the length of the explosive cavity. The projectiles produced strip fragments varying from 3.75 to 6 in. long, fragments 4.75 in. long or greater averaging 141 g. each, and strip fragment velocities averaging 2250 ft./sec. Results showed that there were no appreciable differences between fragmentation characteristics of the projectiles equipped with either Cu or rubber shaped charge liners.

L1344

Naval Proving Ground, Dahlgren.
REDUCTION OF HAZARDS IN HANDLING AND STORAGE OF DEMOLITION CHARGES, by V. Philipchuck. Final rept. Partial rept. no. 7 on Shaped Charges. July 3, 1952, 9p. illus. (NPG rept. no. 998) Confidential

Tests were conducted to determine methods of preventing jet formation upon detonation of demolition shaped charges M2A3 (15 lb.) and T3(40 lb.). It was recommended that wood plugs for the M2A3 and concrete plugs for the T3 demolition charges be inserted into the cavities of the charges to prevent jet formation and retardation of conical liner fragments.

L1345

Naval Proving Ground, Dahlgren.
TESTS OF ENERGA ANTITANK RIFLE GRENADE, by W. Wright, Jr. Final rept. Final rept. on Tests of Energa Antitank Rifle Grenades. Partial rept. no. 24 on Projectiles and Warhead Fragmentation. Feb. 28, 1953, 5p. illus. tables. (Proj. no. NPG Re2c-35-1-53, NPG rept. no. 1094) AD-7366 Confidential

The lethal ranges of the nose, beam, and base fragments of the Energa antitank shaped charge grenade containing 0.73 lb. of RDX and TNT were determined in tests. The maximum range for penetration of 0.040-in. dural plates by a fragment from a statically detonated Energa grenade was between 275 and 300 ft. for the nose fragments, between 15 and 20 ft. for the beam spray fragments, and between 20 and 30 ft. for the base fragments. Fragment penetration data are given for the 28 rounds fired.

L1346

Naval Proving Ground, Dahlgren.
EFFECT OF SOIL BARRIERS ON SHAPED CHARGE PENETRATION, by V. Philipchuk. May 29, 1953, [12]p. incl. illus. tables, diagrs. (NPG rept. no. 1134) AD-12 951 Confidential

The 5-in. rocket head Mk 25, containing a 16-lb. charge of Comp. B and a Cu liner, was fired statically from beneath the soil surface to determine the effect of dry and wet soil barriers of sand, loam and clay on shaped charge jet penetration. On firing, the jet passed upward through the soil barrier and penetrated the 4.25-in. thick Class B armor plates set 12 in. above the surface of the earth. The test data showed that 2-ft. and 3-ft. loam soil barriers offered the least resistance to the jet. Wet soil conditions generally reduced the plate thickness penetrated. Four-ft. barrier depths did not result in any significant plate penetration differences. Plate penetrations ranged from 1 5/16 in. for 4 ft. of wet clay to 6.25 in. for 2-ft. of dry loam.

L1347

Naval Technical Mission in Europe.
OBSERVATIONS OF SHAPED CHARGE DEVELOPMENT IN GERMANY, by C. H. Brooks and others. Aug. 29, 1945, 4p. incl. diagrs. (Technical rept. no. 293-45) Restricted

Brief discussions are reported on the Panzerschreck (counterpart of the bazooka), German antitank devices fitted with magnets for attachment to the side of a tank, a rifle grenade containing a hemispherical liner, and shaped charge torpedo warheads.

L1348

Naval Technical Mission in Europe.
FUZE DEVELOPMENT FOR HOLLOW CHARGE BOMBS, by H. A. Chamberlin and R. C. Stoddard. Oct. 1945, 33p. incl. illus. diagrs. (Technical rept. no. 269-45) Confidential

Development by the Germans of a "discriminating" type of fuze for a shaped charge bomb which could classify a target upon impact and fire accordingly is reported. Descriptions are given of spring and oil damped fuzes, eddy current damped fuzes, use of soft Pb or other plastic material as a damping medium, Hg fuzes, use of vibration of a tuning fork, and fracture fuzes. It was concluded that 1 of the above mentioned speed-dependent fuzes should be used when the initial bomb velocity had been expended to the proper degree; a fracture fuze should be used when the physical security of the bomb construction was endangered; and time delay fuzes should be used after the termination of a certain delay period.

L1349

Naval Technical Mission to Japan.
JAPANESE DEMOLITION METHODS, by H. L. Blackwell. "Intelligence Targets Japan" (DNI) of Sept. 4, 1945. Fascile 0-1, Target 0-35. Oct. 5, 1946, 27p. incl. diagrs. (Index no. 0-35) Restricted

A brief description is given of the Sen Sūi Baku, a shaped charge antiboat mine. Inclosure A of this rept. presents a discussion of Japanese investigation of shaped charges and their theory of penetration. A number of weapons using the shaped charge principle are listed.

L1350

Navy Bomb Disposal School, American University, Washington, D. C.
USE OF MK2 CAVITY CHARGE IN BOMB DISPOSAL WORK, n. d., 4p. Restricted

Previous experiments demonstrated the feasibility of achieving partial detonation using the Mark 2 charge. To achieve low-order-detonations (using 100-lb. and 1,000-lb. CP bombs), the charges should be aimed as nearly as possible at the c. g. of the bomb. The optimum standoff was 8 in. Anticipated results were that the bomb case would be split open, occasionally flattened, and the explosive scattered in sizable pieces over a radius of 50 yd. For Navy, high capacity projectiles, the shell case would be broken. It was noted that 2 successive shots might be necessary to bring about the desired results. The second shot should be aimed directly at the hole in the shell case created by the first shot. It was emphasized that a high order detonation may result from the use of this charge and proper precautions for such an eventuality must always be taken.

L1351

Navy Bomb Disposal School, [American University], Washington, D. C.
PROJECTILE DISPOSAL HANDBOOK. July 15, 1944, p. 5-7 incl. illus. diagrs. Confidential

Instructions are given for blowing shells with shaped charges. Tests with Mark 1 cylindrical shaped charges filled with PE indicated that, when placed just forward of the rotating band of any projectile through 16 in., the charges detonated the projectiles with various degrees of fragmentation. If low order detonation of AP shells was desired, linear shaped charges were used.

L1352

Neumann, E.
NOVEL HOLLOW CHARGES FROM EXPLOSIVE MATERIALS (Neuartige Hohlkörper aus Brisanzstoffen). Zeitschrift für das gesamte Schiess- und Sprengstoffwesen, v. 9, May 15, 1914: 183-187.

Early comparative tests are reported with solid and shaped charges. The shaped charges required less explosive and were more effective. For translation of this article see item no. L15.

L1353

Neumann, M.
ON BRISANT EXPLOSIVES (Einiges über brisante Sprengstoffe). Zeitschrift für angewandte Chemie, v. 24, Nov. 24, 1911: 2233-2240.

Neumann calls attention to his discovery of the fact that in blasting with picric acid and other explosives on hard surfaces (Fe beams, rails, etc.) a 3-5 fold greater efficiency results if the explosive is not entirely in close contact with the surface, a hollow space being left in the explosive charge on the side adjacent to the surface to be acted upon.

L1354

New Mexico School of Mines (NOrd 9817, Task E).
EXPLOSIVES RESEARCH, by W. Hume, II. Quarterly rept. Mar. 31, 1948, 3p. (Rept. no. NMSM/RDD/T-536) TIP C1413 Confidential

Task E is concerned with explosive research and development including shaped charge study and fragmentation. The first phases to be investigated are shaped charge damage trials against aircraft or aircraft components and means of accelerating heavy masses to extremely high velocities.

L1355

[New Mexico School of Mines] [NOrd 9817, Task E].
EXPLOSIVES RESEARCH. Quarterly rept. June 30, 1948, 9p. illus. diagrs. TIP S646 Secret

M9A1 rifle grenades fired statically at 0.125-in. steel plate caused several separate perforations, rather than 1 large hole, at all standoffs from 6 to 40 ft. Firings down steel pipes indicated that the grenades can be fired into an elongated vacuum chamber without damaging it seriously. Attempts to accelerate ponderable masses of material to very high velocities were made by using a form of the 3-dimensional Valentine charge which is based on the focusing effect of "lenses" composed of 2 explosives having different detonation velocities. A complete description of this charge is given. The explosives used were TNT and Comp. C3; shots were fired into 0.75-in. Celotex sheets, 3 ft. distant; conditions of firing and depths of penetration are tabulated.

L1356

New Mexico School of Mines (NOrd 9817, Task E).
EXPLOSIVES RESEARCH, by M. E. Cieslicki and W. Hume, II. Quarterly rept. Oct. 1, 1948-Jan. 31, 1949. Apr. 6, 1949. 7p. diagrs. (Rept. no. NMSM/RDD/T-611-E) TIP S845 Secret

Task E is concerned with the acceleration to high velocities of a missile placed at the focus of a shaped charge so that the detonation wave will act uniformly on the entire contact area of the missile (Misznay-Schardin effect). More direct methods of studying the form of the detonation wave were desired, and attempts are reported to devise a system for measuring the relative times at which the detonation front reaches various points in the explosive body. The system proposed is a series of open electrical switches placed at the desired points in or on the explosive; the switches are closed by the arrival of the detonation front, thus producing a deflection of the beam on the screen of a cathode ray tube oscilloscope. The trace of the beam is recorded photographically. Attempts to develop suitable switches and a simple electrical circuit arrangement are described.

L1357

New Mexico School of Mines (NOrd 9817, Task E).
EXPLOSIVES RESEARCH, by M. E. Cieslicki and others. Quarterly rept. Feb. 1-Apr. 30, 1949. May 31, 1949, 10p. illus. diagrs. (Rept. no. NMSM/RDD/T-626-E) TIP S991 Secret

The investigation of detonation velocity measurements by electrical circuits is mentioned, but no details are reported since the process is still in the developmental stage. Work on a simulated 2.75-in. rocket head incorporating a shaped charge (100° steel liner) is described. The method of casting the Comp. B explosive by means of a "shake" table and IR heat is reported. No macroscopic defects were found in sectioned castings made in this manner; the density of the explosive was good; and test firings at 50 diameters standoff indicated that the explosive produced good jets. The results of firing statically 8 of the simulated 2.75-in. rocket heads in or near B17 aircraft are reported.

L1358

NEW OIL-WELL SHOOTING METHOD UTILIZES THE "SHAPED CHARGE" PRINCIPLE. Oil and Gas Journal, v. 45, Apr. 12, 1947: 86, 98.

The new method confines the explosion to the desired portion of the productive formation. Since an explosive acts perpendicular to its surface, a shell was designed using conical shaped shots. The new technique is applicable to star, pancake, and follow-up shots.

L1359

Northrup, H. H.
JET TAPPING OF OPEN HEARTH FURNACES. Iron and Steel Engineering, v. 28, July 1951: 83-86.

Experimental work carried out at the Republic Steel Corp. with jet tappers in blast furnace casting showed that this new method might have more possibilities in the open hearth, where tapping delays caused more trouble than in the blast furnaces. The jet tapper consists of a 2-oz. explosive charge enclosed in a plastic case. The blasting cap is in the back of the case, the thin Cu conical liner being embedded in the front of the case. The entire case is covered by a 0.5-in. thick bullet-shaped insulating shell. The charge is relatively less sensitive to impact or friction than most commercial explosives, and will not detonate, but only burn if heated to a sufficiently high temperature.

L1360

Oberkommando des Heeres, Berlin.
MEMORANDUM CONCERNING THE FIRST MEETING OF THE DEVELOPMENT UNIT 1 (HOLLOW CHARGES) OF THE EXPLOSIVE INDUSTRY ON DEC. 17, 1941 (Aktenvermerk über eine Sitzung des Entwicklungsringes 1 (Hohlladungen) der Sprengstoff-Industrie am 17.12.41 nachm.). Dec. 20, 1941, [2]p. (Bd. Nr. 2474/41 g. Kdos.-Wa Prüf 1/VIII; OTIB rept. no. 1249, Misc.-5 - In German) Unclassified

Lectures on the following subjects are summarized: the theory of the shaped charge effect; the performance of the 7.5-cm. armor piercing shell; the effect of standoff; and the shapes of charges and liners. (Aberdeen abstract)

L1361

Oberkommando des Heeres, Berlin.
MEMORANDUM CONCERNING THE SECOND MEETING OF THE DEVELOPMENT UNIT 1 (HOLLOW CHARGES) OF THE EXPLOSIVE INDUSTRY ON JAN. 6, 1942 (Aktenvermerk über die 2. Sitzung des Entwicklungsringes 1 (Hohlladungen) der Sprengstoffindustrie am 6.1.42). Jan. 12, 1942, [3]p. (Bd. Nr. 69/42 g. Kdos. -Wa Prüf 1/VIII; OTIB rept. no. 1249, Misc.-5 - In German) Unclassified

The following subjects were discussed: the material and shape of liners; the best solution of the fuze problem; the most effective explosive mixtures; and the resistance of spaced armor. (Aberdeen abstract)

L1362

Oberkommando des Heeres, Berlin.
MEMORANDUM CONCERNING THE THIRD MEETING OF THE DEVELOPMENT UNIT 1 (HOLLOW CHARGES) OF THE EXPLOSIVE INDUSTRY ON FEB. 3, 1942 (Aktenvermerk über die 3. Sitzung des Entwicklungsringes 1 (Hohlladungen) der Sprengstoffindustrie am 3.2.1942). Feb. 13, 1942, [5]p. (Bd. Nr. 69/42 g. Kdos.-Wa Prüf 1/VIII; OTIB rept. no. 1249, Misc.-5 - In German) Unclassified

The following subjects were discussed: initiators from nitro-guanidine; series connections of shaped charges; cast and pressed explosives mixtures; the effect of a hit on the interior of a tank; unsymmetrical shaped charges; temperature sensitivity; ignition delay; obstruction of the blast jet by the shell nose; and development of 3.7-, 5-, 7-cm. and extra long shells. (Aberdeen abstract)

L1363

Oberkommando des Heeres, Berlin.
NOMENCLATURE OF HOLLOW CHARGE PROJECTILES AND HOLLOW DEMOLITION CHARGES (Benennung von Hohlladungs-Geschossen und Sprengladungen). Feb. 9, 1942, 1p. (OTIB rept. no. 1249, Misc.-7 - In German)
Unclassified

Brief descriptions are given of a 7.5-cm. Gr. 38 shell using the old loading (cone with flash tube), and of a 7.5 cm. Gr. 38 Hl/A shell having a cone with varying wall thickness.

L1364

[Oberkommando des Heeres, Berlin].
EXPERIMENTS WITH IMPROVISED HOLLOW DEMOLITION CHARGES (Versuche mit behelfsmässig hergestellten Hohlsprengladungen), by [Trinks]. Nov. 11, 1943, [17]p. incl. illus. diagrs. (91 a 27 - Wa F/Ib, Bd. Nr. 397/43 g. Kdos.; OTIB rept. no. 1249, AOO-6 - In German)
Unclassified

This lecture gives empirical rules on the best dimensions of hollow charges and suggests some modifications. The diameter of the air space should be twice the thickness of the armor while the outer diameter and height of the charge should be 4/3 of the inner and outer diameter. The air space should be approximately a 60° cone with some standoff. Liners can be designed using such shapes as helmet, cup, and bottle neck.

L1365

[Oberkommando des Heeres, Berlin].
EXPERIMENTS WITH IMPROVISED HOLLOW DEMOLITION CHARGES (Versuche mit behelfsmässig hergestellten Hohlsprengladungen), by Trinks. Dec. 14 1943, [17]p. incl. illus. diagrs. (91 a 27 - Wa F/Ib, Bb. Nr. 397/43 g. Kdos.; OTIB rept. no. 1249, AOO-6 - In German)
Unclassified

Experiments were performed to determine the optimum penetration depth in armor, and to determine the optimum dimensions of shaped charges. Only uncoated charges were used. Optimum results were obtained using an air space about 4/3 that of the charge's outer diameter. The total height of the charge must be 4/2 of its outer diameter. The crater produced in the armor using TNT as the explosive had a semiconical shape and diameter approximately that of the air space. It was found that if the thickness of the armor plate was about 15 mm. smaller than the outer diameter of the charge, the back of the plate would be cracked and the cracks in the back would correspond to the cracks in the front of the plate. The optimum air space was a 60° cone. Data showed that the plate would be penetrated using the above dimensions. Optimum results were obtained with steel helmet liners encased in wood, the latter being surrounded by explosive. Tabular data also show results with plastic explosive.

L1366

Office of Scientific Research and Development.
COMMENTS ON THE TALKS BY DR. C. O. DAVIS AND DR. M. A. COOK AT THE TECHNICAL MEETING OF THE JOINT COMMITTEE ON SHAPED CHARGES, MAR. 29, 1943, by J. G. Kirkwood and others. n.d., 5p. (NDRC Div. 8)
Confidential

The main topics of the talks are: (1) experimental evidence for the spalling process as the mechanism of fragmentation of cavity liners; (2) a theory of the spalling process which attempts to correlate the velocity and mass of spalls with the thermodynamic properties of the explosive charge; and (3) a hypothesis on the nature of the processes which result in a focusing of the spalled fragments into a narrow jet. A recapitulation of the Hopkinson Bar effect is included, and its relation to spalling is discussed.

L1367

[Office of Scientific Research and Development].
MINUTES OF THE TECHNICAL MEETING OF THE JOINT COMMITTEE ON SHAPED CHARGES, MAR. 29, 1943. [1943], 8p. (NDRC Div. 8)
Confidential

Personnel attending and their projects are listed. The following presentations are briefly summarized: Dr. Seeger spoke on the interaction of shock waves; Prof. R. W. Wood demonstrated photographs showing the existence of the Mach wave under conditions predicted by theory; Dr. MacDougall outlined a theory of the action of shaped charges based on the supposition that fragments are entrapped in the gas stream which, coming from all sides of the cavity, form a Mach wave; Dr. Cook presented the theory of action developed at ERL (du Pont) based on spalling from the inside surface of the liner; and Dr. Kistiakowsky's comments on this theory.

L1368

Office of Scientific Research and Development.
BIMONTHLY SUMMARY REPORT FOR THE PERIOD JULY 15, 1943 TO SEPT. 15, 1943. Oct. 15, 1943, p. 25-51. (NDRC Div. 8)
Confidential

Abstracts of Div. 8 repts. from July 15, 1943 to Sept. 15, 1943 are presented. The subjects of the repts. on shaped charges are: antisubmarine scatter bomb, Mark 13 torpedo warhead, liner collapse, follow-through projectiles, and shaped charge boosters for artillery shells.

L1369

Office of Scientific Research and Development.
BIMONTHLY SUMMARY REPORT FOR THE PERIOD SEPT. 15, 1943 TO NOV. 15, 1943. Dec. 15, 1943, p. 25-35. (NDRC Div. 8)
Confidential

Abstracts of Div. 8 repts. from Sept. 15, 1943 to Nov. 15, 1943 are presented. The subjects of the reports on shaped charges are: antisubmarine scatter bomb, Mark 13 torpedo warheads, experiments with Al and Pb liners, follow-through projectiles, and shaped charge boosters for artillery shells.

L1370

Office of Scientific Research and Development. ANNOTATED BIBLIOGRAPHY OF NDRC TECHNICAL REPORTS, MEMORANDA, AND LETTERS PERTAINING TO ARMOR AND ORDNANCE AS OF MAY 1, 1945, AND SUPPLEMENT TO JULY 15, 1945. [1945]. 1v. (NDRC memo. no. A-104M) OSRD 4830 Secret

An annotated bibliography is presented containing titles of reports, memoranda, and letters pertinent to the work of Div. 1 through 4 of the National Defense Research Committee. The shaped charge material is listed in the section dealing with Div. 2.

L1371

Office of Scientific Research and Development. SYMPOSIUM ON SHAPED CHARGES, by C. H. M. Roberts and others. A compilation of papers presented at the Shaped-Charge Symposium sponsored jointly by the Joint Army-Navy-NDRC Committee on Shaped Charges and Div. 2 and 8, NDRC, May 9, 1945. (NDRC rept. no. A-346) OSRD 5754 Confidential

The symposium was concerned with the effects of shaped charges, development of shaped charge weapons, and the development of protection against such weapons. Topics included survey of United States and foreign shaped charge weapons, development and basic research on shaped charges, shaped charge torpedo warhead, improvements in hollow charge weapons as exemplified by the bazooka, shaped charge bombs, development of a follow-through shaped charge weapon, rocket HEAT, 7.2 in. T69, sectioning of explosive-filled ordnance by means of cavity charges, theories of target penetration by Munroe jets, protection of armored vehicles against shaped charge projectiles, flash radiographs of rotating charges, and point-initiating fuzes for shaped charge weapons.

L1372

Office of Scientific Research and Development. BIBLIOGRAPHY OF OSRD REPORTS ISSUED BY DIV. 8 OF THE NATIONAL DEFENSE RESEARCH COMMITTEE. Apr. 19, 1946, 290p. OSRD 6630 Confidential

A bibliography is presented of all OSRD reports issued by Div. 8, including those on shaped charges. Abstracts and full bibliographical information are given.

L1373

Office of Scientific Research and Development (OEMsr-1131). EFFECTS OF IMPACT AND EXPLOSION, by R. A. Beth and others. 1946, p. 12, 277-282, 349, 416-417, 498 incl. illus. diagrs. (Summary technical rept. of Div. 2, NDRC, v. 1) TIP C2315 Confidential

The work of Div. 2 is summarized in considerable detail. The chapter on "Defense Against Shaped Charges" deals chiefly with the hydrodynamic theory of jet penetration, plastic armor and spikes for tank protection, and the protection of concrete fortifications. The performance uniformity of charges is reported briefly; more consistent standard shaped charges are described which reduced the waver of the jet by an average of about 40%. Weapon data sheets give characteristics of demolition charges, penetration depths in concrete, and perforation of homogeneous armor by US, British, German, and Japanese shaped charge weapons.

L1374

Office of Scientific Research and Development (OEMsr-1131). PREPARATION AND TESTING OF EXPLOSIVES, by D. P. MacDougall and others. 1946, Sect. 3.1-3.6, p. 50-58. (Summary technical rept. of Div. 8, NDRC, v. 1) Confidential

A summary and review of the work done during the war on shaped charge bombs and similar weapons is presented. Problems of bomb construction, the chief of which was fuzing, are discussed. The last design of the antisubmarine shaped charge bomb and the antisubmarine follow-through bomb are illustrated and described, as are the follow-through projectile and the Mark 13 modified torpedo warhead. The follow-through rocket, charges for microwave tube destruction, and shaped charge boosters are briefly noted.

L1375

Office of Scientific Research and Development (OEMsr-1131). PREPARATION AND TESTING OF EXPLOSIVES, by M. A. Paul. 1946, Sect. 4.3-5.0, p. 67-88. (Summary technical rept. of Div. 8, NDRC v. 1) Confidential

A review of shaped charge theory and experimental investigations is presented. Fundamentals are discussed, such as standoff, apex angle, liner shape and materials, scaling laws, theories of jet formation and penetration, jet and penetration velocities, and the relative effectiveness of explosive compositions. A number of shaped charge weapons are noted, particularly bombs, torpedo warheads, and the follow-through rocket. Several linear charges are described. The effects of symmetry and of rotation, and work on underwater penetration and scaling are commented upon. Experiments on shaped detonation waves and Mach waves from cored charges are described. The problem of fuzing shaped charge weapons is analyzed and design data for a number of fuzes (chiefly the spitback and electromagnetic fuzes) are presented. The hydrodynamic theory of detonation is the subject of Sect. 5.

L1376

Office of the Chief of Ordnance, Army Service Forces.
REPORT ON GERMAN SCIENTIFIC ESTABLISHMENTS, by L. E. Simon. Sept. 1945, p. 67-68, 95-102, 140-143, 185-186. Restricted

A survey of scientific activities in central Germany associated with ordnance is reported. A number of late shaped charge weapons are described as well as developmental work, radiography, etc. Inspections of research establishments and interviews with German scientists are covered. A bibliography of German repts. on detonation phenomena and a brief description of their contents is listed. (See also item nos. L656-L659.)

L1377

Office of the Chief Ordnance Officer, GHQ, AFPAC, Tokyo.
RESEARCH, DEVELOPMENT, AND PRODUCTION [OF] JAPANESE ARMY AMMUNITION AND COMPONENTS, BOMBS, MINES, AND GRENADES, by P. L. Christensen and others. Jan. 28, 1946, p. 43, 47-49, 84-85. (Ordnance Technical Intelligence rept. no. 5) Unclassified

A shaped charge mine is described which consisted of a cast explosive charge, a metallic liner, and standoff assembly held together by a cloth sacking. It is stated that the mine will pierce steel armor plate up to 4.75-in. thickness. No change in effectiveness was noted when the mine was 12 in. from the steel armor plate. Handling instructions for the mine are appended. Mention is made of the "Ta" bomb which consisted of 30[-mm.] and 76[-mm.] shaped charge shells in a cluster.

L1378

Office of the Chief Ordnance Officer, GHQ, AFPAC, Tokyo.
JAPANESE HOLLOW CHARGE RESEARCH, by J. C. Clark. Feb. 14, 1946, 172p. incl. illus. (Ordnance Technical Intelligence rept. no. 11) Confidential

The research on and development of shaped charges by the Japanese is reported in detail, and a translation of Dr. Nobuji Nasu's "Theoretical and Experimental Investigations of the Hollow Charge" is reproduced in Appendix I. The theory of penetration developed by him regarded most of the penetration as achieved by a high density gas flow (10,000 m./sec. for a hemispherical charge with no liner and 8,000 m./sec. for a similar charge with liner) and liner fragments were considered of secondary importance. It was concluded that a hole at the apex of the liner was desirable and the hole size was thought to be critical. Experiments indicated that separation of the liner and the explosive decreased the effectiveness of the charge. Japanese weapons employing the shaped charge principle are described and illustrated, most of the attention being given to: artillery shells, grenades, land mines, the Sakura bomb, and warheads for torpedoes and guided missiles. Appendix II is a translation of a document comparing shaped charge to HE and AP ammunition.

L1379

Office of the Theater Chief Ordnance Officer, European Theater.
INTERVIEW WITH DR. RUDI SCHALL, GERMAN BALLISTIC EXPERT AT MARBURG, by C. H. Hahner and L. C. Gardner. Aug. 22, 1945, 2p. (ET Ordnance Intelligence Interrogation rept. no. 2) Confidential

Dr. Schall devised an offensive weapon for use against tanks consisting of a cylinder of explosive approximately 6 in. in diameter and 3 in. long. In 1 end of the weapon, there is a conical depression lined with metal approximately 1/8 or 0.25 in. thick. When correctly detonated, this metal is hurled as a missile, the initial velocity being approximately 6000 ft./sec. The missile is not streamlined and the velocity falls off rapidly, but it is effective against a tank at a distance of 120 ft. Methods of studying velocities and pressures by means of X-rays are also mentioned.

L1380

Old and Barnes, Inc. (NOrd-10719).
RESEARCH ON EXPLOSIVE ORDNANCE. PROJECT NO. 1. CONTROLLED FRAGMENTATION: SIMULTANEOUS AXIAL INITIATION OF PROJECTILES, by J. M. Carter. Progress rept. no. 3, Feb. 6-Mar. 20, 1950. Apr. 5, 1950, 22p. diagrs. TIP C4023 Confidential

The use of the shaped charge effect in the controlled fragmentation of projectile casings occasioned the review of the present methods of end initiation of projectiles. Current knowledge on shaped charges indicated that a radially expanding detonation front might be more efficiently employed in shaped charge fragmentation control of projectile casings than was possible where, in end initiation, the detonation wave front proceeded along the casing. Preliminary theoretical studies indicated that it may be possible to produce this condition by substantially simultaneous axial initiation of the main charge of a projectile without the use of initiating explosives within such axis. (Contractor's abstract)

L1381

Old and Barnes, Inc. (NOrd-10719).
RESEARCH ON EXPLOSIVE ORDNANCE. PROJECT NO. 1. CONTROLLED FRAGMENTATION: A. SIMULTANEOUS AXIAL INITIATION OF SHELL AND WARHEADS, by R. C. Fleming, Jr. and N. A. MacLeod. B. CLEAVAGE SPALL, by R. R. Van Devender, Jr., and N. A. MacLeod. Progress rept. no. 6. June 29, 1950, 1v. incl. illus. diagrs. (Memo. rept. nos. 4-5) TIP C5039 Confidential

Simultaneous axial initiation of shell and war heads: In order to determine the difference in fragmentation of a standard shell, 4 rings, 2 in. high were cut from a Navy Mk 48 5-in. shell, using the section located between the bourrelet and the rotating band. Because of the desirability of minimizing the amount of explosive, a solid mild steel insert from which a 90° segment was removed, was placed inside each ring. A 0.25-in.-diameter hole centered through the segment apex entended vertically through the ring. Both the hole and the 90° segment were filled with Comp. C3. A cardboard quarter section of a right circular cone filled with the same explosive was placed on top of the explosive surface. The quarter sections had a base whose cross sectional area was the same as that of the segment charge within the ring. The 4 charges were suspended 3 in. above the surface of water contained in a large steel tank thus making possible the recovery of fragments from that portion of the ring surface surrounding the explosive segment. Both axial and normal end initiation were simulated. The number of fragments was much greater in the case of simulated axial initiation. The mass of the average fragment was approximately 2.5 times greater in the case of normal end initiation. Cleavage spall: To study the significance of the orientation of the detonation wave front in an explosive attack on a liner, a semicylinder of explosive was mounted on a steel test block. In initiating the semicylinder, a triangular sheet of explosive was used extending back some distance from the curved surface. The semicylinder was detonated substantially simultaneously along a surface line parallel to its axis of curvature. Angles of attack relative to the metal surface of 0°, 30°, 60°, and 90° were possible. Before studying various types of grooved liners placed at the axis of curvature of the semicylinder, a test without liners established the basic reaction of the 0.5-in.-thick steel plate being attacked by this explosive system. Instead of the lacerated surfaces obtained where spalling has usually occurred, an extremely smooth surface of partition was developed on the 90° attack where the detonation wave front approached the metal surface normally; no spalling occurred at 0° attack. This phenomenon was called cleavage spall (the cleavage spall is 1 in which the surface of cleavage developed internally within the metal is a higher degree of smoothness than the normal milled surface obtained in metal in a machine shop). In duplicate tests, the spalls varied in weight and thickness by less than 1%. (TIP abstract)

L1382

Old and Barnes, Inc. (NOrd-10719).
RESEARCH ON EXPLOSIVE ORDNANCE. PROJECT NO. 1. INVESTIGATION OF CONTROLLED FRAGMENTATION, by N. A. MacLeod and R. R. Van Devender, Jr. Progress rept. no. 8, Feb. 1-June 30, 1950. Aug. 18, 1950, 17p. illus. diagrs. TIP C5750 Confidential

Photographs show the effects of discontinuities in metal surfaces and of the use of modifiers when metals are explosively attacked. The wiping action typical of the travel of the detonation wave along the wall of a shell in ordinary end initiation was used. The explosive was in a rather thin layer and the confinement effect concomitant with more massive explosive attack was largely absent. Fragmentation as a function of notching depended upon the interaction of shock waves reflected from the proximal and distal surfaces of the metal attacked and was influenced by the location and character of notches. Notches on the proximal surface should not contain explosive and should exceed a critical depth to produce complete transverse cleavage of metal subjected to a wiping explosive action. Modifiers which have low shock wave velocities had a pronounced effect. An optimum thickness of modifier on the proximal surface resulted in maximum spalling or shattering of the metal when a critical thickness of explosive was used with a wiping action. A modifier on the proximal surface inhibited a smooth cleavage spall by normal attack. (TIP abstract)

L1383

Old and Barnes, Inc. (NOrd-10719).
RESEARCH ON EXPLOSIVE ORDNANCE. PROJECT NO. 1. CONTROLLED FRAGMENTATION: THE USE OF SHAPED CHARGE LINERS IN CONTROLLING FRAGMENTATION OF PROJECTILES, by N. A. MacLeod and R. R. Van Devender, Jr. Rept. no. 7, May 1-Sept. 15, 1950. Dec. 4, 1950, 17p. illus. diagrs. (Progress rept. no. 10) TIP C5075 Confidential

A study was made of the various factors which may affect the efficiency of application of the shaped charge principle to controlled fragmentation of projectiles. In ordinary methods of initiating a projectile from one end, a shaped charge liner of semicircular cross section is more efficient than the usual V-shaped liner. It is further indicated that the shaped charge principle in controlled fragmentation is much more usefully applied when the conditions of initiation of the projectile filling would approximate to simultaneous axial initiation. (Contractor's abstract)

L1384

Old and Barnes, Inc. (NOrd-10719).
RESEARCH ON EXPLOSIVE ORDNANCE. PROJECT NO. 4 -SHAPED CHARGES. B. A SIMPLE ANALYSIS OF THE FIRST PHASE OF SHAPED CHARGE COLLAPSE, by K. J. Hammond. Progress rept. no. 13, Dec. 1950-Jan. 1951. Jan. 13, 1951, 9p. diagrs. (Memo. rept. no. 11) TIP C54311 Confidential

Some characteristics of rotating shaped charge liners during the collapse process were analyzed in a simple mathematical treatment. It was assumed that elements of a conical Cu liner 0.100 in. thick collapses, in a continuous process, into solid cylindrical discs which are then squeezed into a longer stream. The following quantities were calculated for various apex angles and base radii: (1) the mass of thin slices of the liner and of the surrounding C3 explosive; (2) the ratio of these masses; (3) the angular momentum of annular rings of the rotating liner; and (4) the angular velocity of these segments after collapse. Families of curves were plotted from these calculations. From the graphs it was concluded that base portions of the cone are less effective than apex portions in producing high speed jets because of the decreasing HELM, high explosive mass to liner mass, ratio from apex to base. In addition, the high rotational speed of the lower portion of the cone after collapse disperses the slug and jet, thus reducing target penetration by increasing the area under attack.

L1385

Old and Barnes, Inc. (NOrd-10719).
RESEARCH ON EXPLOSIVE ORDNANCE. PROJECT NO. 4 -SHAPED CHARGES. A. ROTATING SHAPED CHARGES, by N. A. MacLeod. Progress rept. no. 13. Jan. 15, 1951, 27p. incl. diagrs. (Memo. rept. no. 10) TIP C54311 Confidential

The general problems of the manner of conical shaped charge collapse and the rotation of shaped charges of this type are considered. Methods for testing the efficiency of the conical liner are also proposed. In addition, the following liner designs are discussed briefly: (1) multiple cone liner; (2) tapered cone liner; (3) tapered cylindrical liner; (4) secondary collapse liner; and (5) binary liner.

L1386

Old and Barnes, Inc. (NOrd-10719).
APPLICATIONS OF SOLID REACTIONS, by N. A. MacLeod. Rept. for Feb. 1951. Mar. 20, 1951, 16p. (Memo. rept. no. 14) (Part B of its Progress rept. no. 15 on Research on Explosive Ordnance proj. nos. 3 and 4, TIP C6101) TIP C6103 Confidential

A new type of bullet is proposed which has good internal and external properties and poor terminal ballistic strengths for attacking fuel areas of jet fighters and fast heavy bombers. Loading with a solid-reacting mixture which would be activated by conditions of propulsion within the barrel but which would retain a solid or semisolid form in flight with low compressive strength is recommended for shatter on impact and for release of aggregates sufficiently energized to burn through Al-alloy sheeting. A bullet with a high-density component is suggested for 50-cal. rounds against tanks. The addition of a combustible material (Al, Mg, Fe) is proposed to increase the persistence of ignition probability. A follow-through light shaped charge is considered for submarine warfare. The charge, designed on the principle of a binary lining, would have an extrudable slug to follow through the perforation. Solid reactants are suggested for the extrudable secondary liner; the addition of lung irritants (Li or Be alloys) would force the submarine to the surface. (TIP abstract)

L1387

Old and Barnes, Inc. (NOrd-10719).
NOTE ON ENERGY CONTENT OF SHAPED CHARGE JET PARTICLES, by N. A. MacLeod and J. M. Carter. Rept. for Feb. 1951. Mar. 20, 1951, 9p. tables, diagrs. (Memo. rept. no. 15) (Part C of its Progress rept. no. 15 on Research on Explosive Ordnance proj. nos. 3 and 4, TIP C6101) TIP C6104 Confidential

The phenomenal energy density of the individual jet particle, an energy density related to a mass aggregate which is equalled only by the energy of free flight astrospatial bodies, is considered. It was concluded that: (1) jet particles penetrate a target by means of a monatomic explosive if the particles are composed of a single element such as Cu, Al, or Fe; (2) target penetration by a train of jet particles presupposes that the first particle produces its own explosion and that the particle following is only minimally affected as it enters the cavity made by the first particle explosion. Tabular data are given of temperature-velocity relations for metal jets and for the available heat content of Al, Fe, Cu, Pb, and W on the sudden arrest of translational motion (10,000 m./sec.).

L1388

Old and Barnes, Inc. (NOrd-10719).
RESEARCH ON EXPLOSIVE ORDNANCE. PROJECT NO. 1. CONTROLLED FRAGMENTATION: THE USE OF SHAPED CHARGE LINERS IN CONTROLLING FRAGMENTATION OF PROJECTILES, by N. A. MacLeod and R. R. Van Devender, Jr. Progress rept. no. 18, Sept.-Oct. 1950, Jan.-Feb. 1951. Apr. 6, 1951, 11p. illus. diagrs. (Rept. no. 8) TIP C6227 Confidential

Firings against 0.5-in. steel plate supported on a Pb anvil, using half-round and V-shaped liners of steel or Al like those of Cu used previously, showed that Cu is likely to be better than steel for shaped-charge liners and that steel is decidedly better than Al; that a half-round liner is the best general all-purpose design for controlled fragmentation; and that investigation of axial initiation of projectiles is highly desirable. (TIP abstract)

L1389

OPEN HEARTH FURNACES "JET TAPPED" IN 30 SECONDS. Steel, v. 128, Apr. 30, 1951: 64 +.

Open-hearth furnaces are now being tapped with small high explosive charges which penetrate through more than 6 in. of steel. This new tool is a peacetime application of shaped charges, which were developed for penetrating armor plate and concrete fortifications. The tapper consists of a 2-oz. explosive charge enclosed in a plastic case which is surrounded by a hollow bullet-shaped insulating body with walls 0.5 in. thick. The penetrating power is derived from a Cu liner found in 1 end. The explosive used in jet tappers is relatively insensitive to impact, friction, and other causes of accidental explosion as compared to most commercial explosives. Tappers will penetrate more than 6 in. of cold steel. Although they would go somewhat farther through hot steel, target temperature has less effect on the depth of penetration than it has on the diameter of the hole produced.

L1390

Operations Research Office, Johns Hopkins University. PRELIMINARY REPORT ON THE D40 MISSILE, by J. F. McCloskey. May 27, 1952, 58p. incl. tables, diagrs. (Technical memo. ORO-T-189)
Secret

The possible use of a shaped charge warhead in the D40 weapon, a spherical, radio-controlled, jet-propelled and jet-supported missile, is discussed. In support of this, tabular data are presented for HEAT rounds of calibers ranging from 76 mm. to 120 mm. on their single-shot hit probability and penetration of homogeneous armor at various ranges and angles of obliquity. Using information obtained from theoretical studies on large HEAT rounds conducted at Ballistic Research Laboratories, the defeat probabilities for the D40 missile over the Russian JS III tank are extrapolated. In addition, brief tabular data are given on antitank guided missiles employing HEAT warheads, including 1 French, 1 Australian, and 2 American weapons.

L1391

Ordnance Board (Gt. Brit.). [INDEXES TO ORDNANCE BOARD PROCEEDINGS]
Secret

The Proceedings of the Ordnance Board are published in various parts. The standard "OB" Proceeding pertains to existing equipment and has a wide distribution throughout the British forces and research facilities. "Q" Proceedings are classified Secret and pertain to the new and experimental material not yet introduced into the services. The "U" Proceedings pertain to experimental rocket material. The "V" Proceedings pertain to the VT fuze program which is carried as a highly classified project. The "AG" Proceedings deal primarily with carriages and gun mountings and are of little interest except to carriage designers. Considerable investigation has not revealed a complete list of Ordnance Board indexes in the United States. A fairly reliable general summary might be: annual indexes to the Proceedings were made for the World War II years, and for some of the preceding years. A cumulated index of the Proceedings and "Q" Proceedings from Dec. 1, 1941 to Dec. 31, 1945 was published as "Report of the President of the Ordnance Board..." for the above period; a supplement was later published. Since 1945, annual indexes have been compiled of the Proceedings and of some of the lettered Proceedings, as "V" Proceedings, 1946 and 1947; "AG" Proceedings, 1946; "U" Proceedings, 1946, 1947, and 1948.

L1392

[Ordnance Board (Gt. Brit.)]. GERMAN 3-KG. MAGNETIC HOLLOW CHARGE. n.d., p. 25-26 of ? diagr. (OB Proceedings no. 884)
Secret

The German 3-kg. magnetic charge container was in the form of an inverted funnel mounted on a pentagonal plastic plate. The plate contained a large central hole corresponding to the liner, and had 3 magnets equally spaced on the underside. It was estimated that the charge would perforate a 110-mm. homogeneous plate and retain enough energy to be effective behind the plate. Tests proved the magnets to be unreliable in holding the charge on the tank suspensions when thrown from a distance of 16 ft.

L1393

[Ordnance Board (Gt. Brit.)]. GERMAN 13.5-KG. DEMOLITION CHARGE WITH HOLLOW CHARGE. n.d., p. 24-25 of ? diagr. [OB Proceedings no. 883]
Secret

The charge container consisted of the cavity liner, base ring (which carried the legs), the cover, and the cap. The liner was hemispherical with an internal radius of 4.92 in. and consisted of 4 superimposed close-fitting domes. With the legs fully extended and the charge fired normal to a 9-in. face-hardened plate, the perforation dimensions were 1.5 x 3.15 in. for the aperture at the plate surface, 3.5 x 2.75 in. for the aperture at the plate back, and the disintegrated area surrounding the aperture in the plate back was 15 x 15.5 in.

L1394

[Ordnance Board (Gt. Brit.)]. A NOTE ON THE ASSESSMENT OF THE PERFORMANCE OF ENEMY HOLLOW CHARGE MUNITIONS AGAINST ARMOR PLATE, by W. E. Soper. n.d., 2p. incl. table. (Appendix to OB Proceedings no. 30,768)
Confidential

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L1394

[Ordnance Board (Gt. Brit.)]. A NOTE ON THE ASSESSMENT OF THE PERFORMANCE OF ENEMY HOLLOW CHARGE MUNITIONS AGAINST ARMOR PLATE, by W. E. Soper. n.d., 2p. incl. table. (Appendix to OB Proceedings no. 30,758) Confidential

The performance of German shells and grenades was estimated on the static tests of various British experimental charges; the dynamic performance was based on that of 2 projected rounds, the PIAT and the 95-mm. QF HEAT. A formula for the estimation is stated, and examples are tabulated.

L1395

Ordnance Board (Gt. Brit.).
[PROJECTILES, HE]. n.d., 3p. incl. diagrs. (OB Proceedings no. Q 3,500) Secret

A summary of ARD Explosives rept. no. 579/44 on "Mechanism of Damage in Steel Targets; the Critical Change in Cutting Tube Damage to Armor Plate with Change in Area of Attack" is presented in this appendix. (See item no. L173.)

L1396

Ordnance Board (Gt. Brit.).
PROJECTILES, HE Sept. 30, 1942, 4p. incl. diagr. (OB Proceedings no. Q 740) Secret

This proceeding consists of a copy of PD Explosives rept. no. 234/42 entitled "Cavity Charge with Subsidiary Follow-through Solid or Explosive Projectile". (See item no. L1504.)

L1397

Ordnance Board (Gt. Brit.).
PROJECTILES, HE June 25, 1943, 3p. incl. diagr. (OB Proceedings no. Q 1,323) Secret

Minutes of a meeting of the Shaped Charges Subcommittee (first rept.) held on Mar. 3, 1943 concerning the development of shaped charges in various establishments are presented. Road Research Laboratory rept. no. MOS/195/JH, "Estimation of Blast Effect at Rear of Hollow-coned Charge" is reproduced as an appendix. (See item no. L1548.)

L1398

Ordnance Board (Gt. Brit.).
PROJECTILES, HE Sept. 15, 1943, 9p. incl. illus. (OB Proceedings no. Q 1,524) Secret

Radiological examinations and results of firing trials of the 95-mm. and 3.7-in. howitzer shells are reported.

L1399

Ordnance Board (Gt. Brit.).
PROJECTILES, HE Sept. 4, 1944, 1p. (OB Proceedings no. Q 2,558) Secret

The probable effects of using Al liners in shaped charge shells are discussed, and an NDRC, Div. 8 interim rept. on shaped charges (Oct.-Nov. 1943) is summarized briefly. (See item no. L959.)

L1400

Ordnance Board (Gt. Brit.).
PROJECTILES, HE Dec. 6, 1944, 2p. (OB Proceedings no. Q 2,852; CB Investigation no. 1,113) Secret

Tests are briefly described of a 95-mm. shell designed on the follow-through principle to eject P into a tank. The P containers were generally broken up by the HE outside of the target and the small quantity of P that entered the tank had little antipersonnel effect.

L1401

Ordnance Board (Gt. Brit.).
PROJECTILES, HE Dec. 11, 1944, 5p. (OB Proceedings no. Q 2,864) Secret

Rept. no. ME4(a)16, "Interim rept. on 'Chemical Armor' Methods of Defeating Shaped Charges", by the Explosive Manufacturing Practices Laboratory, Melbourne, Australia, is reproduced as an appendix. (See item no. L943.)

L1402

Ordnance Board (Gt. Brit.).
PROJECTILES, HE Feb. 5, 1945, 3p. incl. diagrs. (OB Proceedings no. 33,028) Confidential

The summary and conclusions of ARD Metallurgical rept. no. 141/45 on "Flash Radiography of 80° Conical charges with Aluminum Liners" are reproduced. (See item no. L194.)

L1403

Ordnance Board (Gt. Brit.).
PROJECTILES, HE Nov. 7, 1945, 3p. incl. appendix. (OB Proceedings no. Q 3,891) Secret

A rough sketch of a proposed follow-through shell 7.2 in. in diameter is reproduced and commented upon.

L1404

Ordnance Board (Gt. Brit.).
PROJECTILES, HE Nov. 12, 1945, 1p. (OB Proceedings no. 32,551) Confidential

The conclusions from ARD Explosives rept. no. 416/45 on "The Mechanism of Jet Formation—Performance of Tapered Cones in Hollow Charges" are listed. (See item no. L188.)

L1405

Ordnance Board (Gt. Brit.).
PROJECTILES, HE Nov. 18, 1947, 3p. incl. diagrs. (OB Proceedings no. Q 5,400; Inclosure 2 to MA London rept. no. R6698-47) Secret

A rept. by E.-in-C. (E.2) (W.O.) on "Trials of Large Shaped Charges at Dorverden (Germany)" is reviewed. (See item no. L1661.)

L1406

Ordnance Board (Gt. Brit.).
PROJECTILES, HE June 4, 1948, 1p. (OB Proceedings no. Q 5, 639) Secret

This proceeding reproduces an abstract of OSRD 5598 on "Target Penetration by Rotating Cavity Charges." (See item no. L533.)

L1407

Ordnance Board (Gt. Brit.).
ENEMY MUNITIONS. Apr. 2, 1943, 7p. incl. diagrs. (OB Proceedings no. 22, 499) Confidential

A summary of ARD Explosives rept. no. 15/43 on "7.5-cm. German and 75/27 mm. Italian Hollow Charge Ammunition" is presented. (See item no. L121.)

L1408

Ordnance Board (Gt. Brit.).
PROJECTILES AND FUZES. Apr. 7, 1943, 7p. (OB Proceedings no. Q 1, 126) Secret

An analysis is made of firings trials with rotated shaped charge shells. Penetration of these shells was unsatisfactory; therefore, it was concluded that the following points required investigation: (1) a ballistic cap to assist the fuze by providing a small delay for the fuze to function while keeping in the striking position of the plate; (2) the relation of the rate of spin to cone angle; and (3) the effect of the material and thickness of the liner. A number of firing trials are presented in tabular form.

L1409

Ordnance Board (Gt. Brit.).
BOMBS, AIRCRAFT. May 3, 1943, 3p. (OB Proceedings no. Q 1, 199) Confidential

ARD Explosives rept. no. 86/43 on "The Comparative Performance of Discs and Hemispheres in CS Bombs" is reproduced. (See item no. L127.)

L1410

Ordnance Board (Gt. Brit.).
ENEMY MUNITIONS. May 31, 1943, 2p. incl. diagrs. (OB Proceedings no. 23, 326) Confidential

An extract from ARD Explosives rept. no. 101/43 on "German 7.5-cm. Hollow Charge Ammunition" is given. (See item no. L133.)

L1411

Ordnance Board (Gt. Brit.).
PROJECTILES AND FUZES. July 9, 1943, 11p. incl. illus. diagr. (OB Proceedings no. Q 1, 375) Confidential

The following repts. are included as appendixes to this proceeding: (1) Appendixes I, II, and III are repts. of trials at Shoeburyness (1942) with shell QF HE hollow charge 25 pounder Mark I; (2) Appendix IV is a report on "Hollow Charge Rotated Projectiles by MD1" (May 7, 1943) (item no. L77); and (3) Appendix 5 is a reproduction of ARD Explosives rept. no. 28/43 (Jan. 1943) on "Cavity Effect of High Explosives" (item no. L117).

L1412

Ordnance Board (Gt. Brit.).
ENEMY MUNITIONS. GERMAN FAUSTPATRONE 1. TRIAL AGAINST SINGLE AND SPACED PLATES. Nov. 22, 1944, 2p. (OB Proceedings no. 29, 570) Secret

S. of E's (Shoeburyness) rept. dated Aug. 31, 1944 on a trial to ascertain the efficiency of the German Faustpatrone 1 against single and spaced plates is reproduced as an appendix.

L1413

Ordnance Board (Gt. Brit.).
ENEMY MUNITIONS. GERMAN FAUSTPATRONE 2 (PANZERFAUST) AGAINST SINGLE AND SPACED TARGETS. Nov. 22, 1944, 9p. (OB Proceedings no. 29, 574) Secret

S. of E.'s (Shoeburyness) repts. dated Aug. 31, 1944 and Sept. 16, 1944, on trials to determine the perforative performance of the German Faustpatrone 2 against single and spaced plates are reproduced as an appendix to this proceeding. WTSFF (Med. Area) reports on trials with various protective measures to defeat Faustpatrone 2 are also included as appendixes.

L1414

Ordnance Board (Gt. Brit.).
ENEMY MUNITIONS. GERMAN FAUSTPATRONE 1. TRIALS AGAINST SINGLE AND SPACED TARGETS. Dec. 28, 1944, 3p. (OB Proceedings no. 29, 873) Secret

S. of E.'s (Shoeburyness) rept. dated Dec. 9, 1944 of a trial to determine the perforation performance of the German Faustpatrone 1 against single and spaced plates is reproduced as an appendix.

L1415

Ordnance Board (Gt. Brit.).
ENEMY MUNITIONS. (GERMAN). 30-MM. RIFLED ANTITANK HOLLOW CHARGE GRENADE TRIAL TO DETERMINE CRITICAL THICKNESS OF PLATE PERFORATED. Dec. 28, 1944, 1p. (OB Proceedings no. 29, 881; OB Investigation no. 776) Secret

Comments are made on S. of E.'s (Shoeburyness) rept. XP No. 31/90, dated Nov. 20, 1944 concerning the trial to determine critical thickness of homoplate perforated by German 30-mm. rifled grenade at 30° to normal.

L1416

Ordnance Board (Gt. Brit.).
PROJECTILES, PIERCING. ASSISTED PENETRATION OF APCBC SHELL BY USE OF A HOLLOW CHARGE IN THE BALLISTIC CAP. Feb. 7, 1945, 1p. (OB Proceedings no. 30,245; OB Investigation no. 1,118) Secret

Comments are made on S. of E's (Shoeburyness) rept. dated Dec. 21, 1944 which gives the results of a trial carried out with 95-mm. HEAT shell fitted with cuspoid and with spherical shaped liners against a 6-in. "C" plate at 55° and 45° obliquity to ascertain the effect of the hollow charge on the cemented face.

L1417

Ordnance Board (Gt. Brit.).
ENEMY MUNITIONS; ARTILLERY, ANTITANK; MORTARS. May 17, 1946, 6p. incl. appendix, diagrs. (OB Proceedings no. Q 4,308) Secret

The 21st Army Technical Intelligence rept. no. 23 dated Aug. 18, 1945 on the development of a new German antitank equipment known as "Hammer" is reproduced as an appendix. The rocket was an 81-mm. shaped charge projectile with a forward discarding band and barrel-sized tail fins fired from a 10.5-cm. barrel.

L1418

Ordnance Board (Gt. Brit.).
PROJECTILES, ROCKET, AIRCRAFT. Sept. 27, 1946, 4p. illus. diagrs. (OB Proceedings no. Q 4,533; Inclosure 2 to MA London rept. no. R3896-46) Secret

Sixty-pound shaped charge rockets were fired from aircraft against Churchill tanks in ahead, astern, and flank attacks. Detailed results of each hit are reported and the damage is illustrated by photographs. It was concluded that a single hit on the front, rear, or sides is reasonably certain to immobilize this type of tank; casualties among the crew were thought certain to occur from perforations anywhere in the armor of the fighting and driving compartments.

L1419

Ordnance Board (Gt. Brit.).
PROJECTILES, ROCKET, AIRCRAFT. Nov. 8, 1946, 5p. (OB Proceedings no. Q 4,728) Secret

Damage inflicted by 60-lb. shaped charge rockets fired from aircraft against Jagd-Panther tanks is assessed. Dummies and live rabbits simulated the tank crew. It was concluded that this rocket will perforate 150 mm. of armor at 30° to normal and that the jet has sufficient energy after perforation to inflict damage on internal equipment and to injure the crew. Blast injuries to the rabbits were slight.

L1420

Ordnance Board (Gt. Brit.).
FOREIGN MUNITIONS (SWISS). Dec. 6, 1946, 4p. incl. appendix. (OB Proceedings no. Q 4,802) Secret

The Energa rifle grenade manufactured in Switzerland is discussed, but neither a diagram nor a complete description is presented. Apparently very superior performance was claimed for this grenade, including 140-mm. penetration at normal incidence and the defeat of skirting plates. The proceeding states that "there is no reason for supposing that the inventions listed in the patent have any advantages over anything which could be developed from present available knowledge and experience."

L1421

Ordnance Board (Gt. Brit.).
BOMBS, AIRCRAFT. Mar. 18, 1947, 3p. (OB Proceedings no. Q 5,600) Secret

The conclusions drawn in OSRD 5605 on "Studies of a Shaped Charge Assisted SAP Bomb" are presented and discussed. (See item no. L541.)

L1422

Ordnance Board (Gt. Brit.).
PROJECTILES, PIERCING, AND FUZES, GENERAL. June 10, 1947, 7p. incl. appendix. (OB Proceedings no. Q 5,138) Secret

Brief comments are reported on the performance of shaped charge shells.

L1423

Ordnance Board (Gt. Brit.).
PROJECTILES, PIERCING, AND FUZES, GENERAL. Nov. 7, 1947, 5p. (OB Proceedings no. Q 5,384 and appendix; OB Investigation nos. 1,503 and 1,901/1) Secret

Brief discussions are reported on: (1) fin-stabilized, unrotated, shaped charge shells; (2) performance degradation of a shaped charge shell by rotation; (3) static trials up to 70° with a shaped charge shell; (4) a rotated shaped charge shell; and (5) design of shaped charge and squash head shells and fuzes for the defeat of skirting plates.

L1424

Ordnance Board (Gt. Brit.).
BALLISTICS, EXTERNAL AND PROJECTILES, HE Feb. 13, 1948, 10p. incl. appendix, diagr. (OB Proceedings no. Q 5,501) Secret

The 4.5-in. Schulmann projectile and its lightweight smooth bore projector are described and commented upon. A demonstration of the shaped charge projectile was reported to be disappointing, but its potentialities were promising. The appendix lists the advantages and disadvantages of the projectile and the recommendations of an observer at 1 of the trials. It is stated that, in addition to its suitability for shaped charges because the projectile is unrotated, the robust head can assist in the formation of the jet by preventing the early breakup of the round at impact, thus, maintaining the correct standoff. One trial is reported to have penetrated armor plate equal to 3 diameters of the liner.

L1425

Ordnance Board (Gt. Brit.).
ENEMY MUNITIONS. May 28, 1948, 10p. incl. tables, diagrs. (OB Proceedings no. Q 5,618 and appendixes I (OB Proceedings no. Q 4,327), II, and III) Secret

The German 8-cm. P.A.W. 600 shaped charge shell (fin-stabilized) was fired against single armor plates and against armor protected by skirting plates. At 30°, perforation was good, but tended to fall off at larger angles. The jet persistance was poor against spaced armor.

L1426

Ordnance Board (Gt. Brit.).
PROJECTILES, PIERCING. Oct. 29, 1948, 4p. incl. appendix. (OB Proceedings no. Q 5,825; Inclosure 3 to MA London rept. no. R6515-48) Secret

Investigations to improve the performance of shaped charge shells are discussed. Large angles of attack and the defeat of skirting plates are emphasized.

L1427

Ordnance Board (Gt. Brit.).
FOREIGN MUNITIONS; GRENADES, SWISS, ENERGA ANTITANK RIFLE GRENADE. Jan. 19, 1951, [28]p. incl. illus. tables. (OB Proceedings no. 36,427 and appendixes I, II, III, IV, and V; OB Investigation no. 2,101; Inclosure 1 to AA London rept. no. R262-51) TIP C4939 Confidential

The 2.95-in. Al Swiss Energa antitank rifle grenade weighs 1.320 lb. and perforates 8-in. armor. It can be fired from any rifle to which a launcher has been fitted and functions at a high angle of incidence in order to defeat tanks of rounded outlines. The grenade contains 0.66 lb. of filling (principally RDX/wax, 80/20) which is pressed onto the exterior convex surface of a hollow metal liner. Tests showed that functioning was adequate at 120° and at -50°F; all grenades perforated 160-mm. plate at normal. In attacks against an up-armored German Panther tank, 1 or 2 of the dummy crew were usually killed or seriously wounded. Behind 100-mm. plate, 6-pr. ammunition was damaged and usually set on fire; gasoline was ignited, but diesel oil was not. On detonation, a slug about 22 mm. in diameter was projected towards the firer and might be fatal up to 50 yd. Small splinters were projected sideways about 15 yd. Results from rough usage and sealing and water-proofing tests showed that when dropped base down in the grenade, fuzes armed from 14 ft. upwards and shrouds from 16 ft. upwards. No fuze or shroud armed with vibration. Sealing was adequate at -30° and 120°F. After immersion under 4 in. of water for 1 week there was water in some grenades; however, all functioned adequately.

L1428

Ordnance Board (Gt. Brit.).
GRENADES, RIFLE, NO. 94 (ENERGA), TRIALS OF IMPROVED FUZE ARRANGED. Oct. 2, 1951, 2p. diagr. (OB Proceedings no. 36,640 and appendix; OB Investigation no. 2,101; Inclosure 1 to AA London rept. no. R2461-51) TIP C4939 Confidential

An improved fuze, M6059, for the Energa grenade is described. The fuze can be stripped completely, has improved performance against plate, has graze action in addition to direct action, and its safety dropping distance is 24 ft. as opposed to 6 ft. in the old type.

L1429

Ordnance Bomb Disposal School, Aberdeen Proving Ground.
JAPANESE 1-KG. HE BOMB AND FUZE. Aug. 1943, 3p. incl. diagr. Confidential

A brief description is given of the Japanese 1-kg. bomb which has a shaped charge in the nose and body. The bomb is similar to the 1/3-kg. Japanese HE bomb in construction and explosive effect.

L1430

Ordnance Investigation Laboratory, Naval Powder Factory, Indian Head.
SECTIONALIZING OF EXPLOSIVE-FILLED ORDNANCE BY MEANS OF CAVITY CHARGES, by H. W. Kline. n.d., 9p. incl. diagrs. Confidential

The successful sectionalizing of thin-cased ordnance depends upon cutting completely through the ordnance case and to a sufficient depth into the explosive filling to obtain sufficient shearing action to separate the explosive where sectioning is desired. Linear charges with liners of 120° were preferred, due to greater effectiveness at larger standoff distances and ease of manufacture. For sectionalizing steel cases thicker than 0.30 in., cavity liners of 80° were used. Sectioning of the German "George" type of mine is described. A slide rule calculator for determining thickness of liner, quantity of explosive, standoff, and width of charge for linear charges is illustrated.

L1431

Ordnance Investigation Laboratory, Naval Powder Factory, Indian Head.
USE OF LINEAR CAVITY CHARGE TO GAIN ACCESS TO 5 IN./38 AA PROJECTILES, by G. H. Taylor. Jan. 18, 1945, 5p. incl. illus. (Part I of [OIL] rept. on OIM no. 206)
Confidential

Linear charges (18 in. long, 1.75 in. wide, 80° apex angle) were used for disposal of 5 in./38 AA projectiles. The technique used depended on the cutting action of the linear charge and reduced the danger of fragmentation and high order detonations; 10 5 in./38 AA projectiles were opened successfully.

L1432

Ordnance Investigation Laboratory, Naval Powder Factory, Indian Head.
USE OF LINEAR CAVITY CHARGES TO GAIN ACCESS TO 8 IN./55 HC PROJECTILES, by G. H. Taylor and others. Feb. 15, 1945, 4p. incl. illus. (Part II of [OIL] rept. on OIM no. 206)
Confidential

Linear charges (27 in. long, 1.75 in. wide, 80° apex angle) were used for the disposal of 8 in./55 HC projectiles. The technique used depended on the cutting action of the linear charge and reduced the danger of fragmentation and high order detonations; 11 8 in./55 HC projectiles were opened successfully.

L1433

Ordnance Investigation Laboratory, Naval Powder Factory, Indian Head.
USE OF LINEAR CAVITY CHARGES TO GAIN ACCESS TO 6 IN./47 HC PROJECTILES, by G. H. Taylor and others. Mar. 9, 1945, 5p. incl. illus. (Part III of [OIL] rept. on OIM no. 206)
Confidential

A linear charge was placed over the longitudinal axis of a 6 in./47 HC projectile. On detonation of the charge, the projectile was split longitudinally, the steel nose plug dropped into the revetment which was made just forward of the projectile, and the base fuze was forced from the case. The method was recommended for disposal of these projectiles. It was concluded that this method of opening projectiles depended on the cutting action of linear charges and not upon any degree of partial detonation.

L1434

Ordnance Investigation Laboratory, Naval Powder Factory, Indian Head.
USE OF LINEAR CAVITY CHARGES TO GAIN ACCESS TO 100-LB. US GP BOMBS AN M30, by G. H. Taylor and others. Apr. 21, 1945, 4p. incl. illus. (Part IV of OIL rept. on OIM no. 206)
Confidential

Fourteen unfuzed 100-lb. US GP bombs were opened by means of linear charges. Two 100-lb. US GP bombs fuzed with armed AN M103 fuzes in the nose and armed AN M100A fuzes in the tail detonated (high order) when cut by linear charges. It was believed that the 2 high order detonations were caused by fuzes which were more sensitive than any similar fuze previously found in an unexploded bomb.

L1435

Ordnance Investigation Laboratory, Naval Powder Factory, Indian Head.
ROCKET, 8.8-CM. HE HOLLOW CHARGE (BAZOOKA) - GERMAN, by S. E. Wawroski. July 3, 1945, 2p. incl. illus. (Preliminary rept. no. Rocket - 1)
Confidential

The German shaped charge rocket is briefly described. The electric ignition is similar to the American launcher M1 and M6A1 rocket, HEAD, 2.36 in. Details concerning the liner, etc., are not given.

L1436

Ordnance Investigation Laboratory, Naval Powder Factory, Indian Head.
THE DEVELOPMENT OF A TECHNIQUE FOR THE DISPOSAL OF 6-IN. HC PROJECTILES BY MEANS OF LINEAR CAVITY CHARGES, by H. W. Kline and J. F. Nachman. Sept. 5, 1945, 7p. incl. illus. ([Part V of OIL] rept. on OIM no. 206)
Confidential

Tests on opening 6 in./47 HC projectiles by means of a linear charge resulted in several high order detonations from failure to split the projectile completely and subsequent burning of the explosive "D" filler. Further testing resulting in the development of a technique involving the use of 2 identical linear charges placed longitudinally on the projectile 180° apart. The simultaneous detonations of the 2 linear charges resulted in splitting the projectile in half longitudinally. The projectile fuzes were thrown a short distance from the projectile, suffering no perceptible damage. No high detonations resulted from the use of this modified technique.

L1437

Ordnance Investigation Laboratory, Naval Powder Factory, Indian Head.
USE OF LINEAR CAVITY CHARGE TO GAIN ACCESS TO 8 IN./55 HC PROJECTILES, by T. M. Reeves. Sept. 26, 1945, 5p. incl. illus. (Part II-A of OIL rept. on OIM no. 206)
Confidential

Tests with linear charges were unsatisfactory in that projectiles cut on 1 side often failed to split on the opposite side, and detonations resulted from ignition and burning of the projectile filler by the charge. Further tests to modify this technique employed identical linear charges placed longitudinally on opposite sides of the projectile. Simultaneous detonation of the charges resulted in longitudinal splitting of the projectile into 2 halves and removal of the base and nose fuzes.

L1438

Ordnance Investigation Laboratory, Naval Powder Factory, Indian Head.
EFFECT OF DIVERGENT MULTIPLE JETS FROM CAVITY CHARGES, by C. A. Quam. Nov. 21, 1945, 21p. incl. illus. ([OIL] rept. on OIM no. 253) Confidential

The following tests are described: (1) a Mark 2 charge fired horizontally at a sheet metal target 50 ft. away; (2) attempts to detonate a cluster of 3 Mark 2 charges simultaneously and a cluster of 3 Mark 2 liners in the same manner; and (3) clusters of 7 Mark 2 charges detonated from the center. Results showed that clustered charges greatly reduced the effectiveness of all the jets except the 1 formed directly under the point of detonation as the other jets are deflected at approximately a 45° angle. The particles of the jets are not concentrated at a single point, thus increasing the effectiveness of the target 40%. Numerous night photographs illustrating the above tests and conclusions are included.

L1439

Ordnance Investigation Laboratory, Naval Powder Factory, Indian Head.
RECOVERY OF FUZES FROM CERTAIN PROJECTILES AND ROCKET HEADS BY USE OF CAVITY CHARGES. PART II. Dec. 18, 1945, 45p. incl. illus. diagrs. ([OIL] final rept. on OIM nos. 273 and 275) Unclassified

Curvilinear shaped charges were used to cut base plugs away from shells and rockets as a means of fuze recovery. Specifications are given for the proper charge for each round disposed of as well as operating procedures and photographs of the assembly of the charge on the round and the results of detonating the charge.

L1440

Ordnance Investigation Laboratory, Naval Powder Factory, Indian Head.
PROJECTILE, HOLLOW CHARGE, 75-MM. SPIN-STABILIZED, HE, ARMY, JAPANESE, by J. Juse. May 27, 1946, 3p. incl. illus. (Preliminary rept. Projectile-30; 1095) Unclassified

This preliminary report describes the Japanese army 75-mm. (actually 72-mm.) spin-stabilized shaped charge projectile which contains a steel liner with an attached flash channel.

L1441

Ordnance Laboratory, Frankford Arsenal.
ATTEMPT OF A THEORY OF ARMOR PENETRATION, by H. A. Bethe. May 23, 1941, 91p. Unclassified

Bethe's theory, although primarily for projectiles, was used as a basis for the theoretical consideration of penetration by shaped charge jets. For a discussion of its application to this subject, see item no. L606.

L1442

Ordnance Laboratory, Frankford Arsenal.
EXAMINATION OF GERMAN 75-MM. HOLLOW CHARGE SEMIFIXED HOWITZER SHELL, by M. Wiater. July 1944, 8p. incl. tables, diagrs. (Proj. no. 2/70, rept. no. R-478) Restricted

A detailed drawing is shown of the assembled 75-mm. shaped charge semifixed Howitzer shell. Examination of the shell showed that the Cu banded body was forged from a WD1070-type steel, the nose was Zn base die casting, and an olive drab nitrocellulose lacquer coated the exterior of the entire shell. The liner was fabricated from a WD1010-type pearlitic steel, and the flash tube was of Al.

L1443

Ordnance Laboratory, Frankford Arsenal.
EXAMINATION OF GERMAN 90-MM. HOLLOW CHARGE ROCKET-BAZOOKA TYPE (FMAM 661), by M. Wiater. May 1945, 12p. incl. illus. tables, diagrs. (Proj. no. 2/70, rept. no. R-535) Confidential

Results are given of a physical, chemical, and metallurgical examination of a rocket identified as a German 90 (88?)-mm. shaped charge bazooka. Detailed drawings are included.

L1444

Ordnance Laboratory, Frankford Arsenal.
EXAMINATION OF JAPANESE 75-MM. HOLLOW CHARGE HE SHELL AND STEEL CARTRIDGE CASE FOR JAPANESE REGIMENTAL GUN (FMAM 665), by M. Wiater. June 1945, 13p. incl. illus. tables, diagrs. (Proj. no. 2/70, rept. no. R-561) Confidential

Results are given of a physical, chemical, and metallurgical examination of the Japanese 75-mm. shaped charge shell. Detailed drawings are included.

L1445

Ordnance Laboratory, Frankford Arsenal.
MECHANISM OF COLLAPSE OF CONICAL HOLLOW CHARGE LINERS, by H. P. George. Rept. no. 1. Oct. 1945, 1v. incl. illus. (Proj. no. 3/324, rept. no. R-667) Confidential

A metallurgical examination was made of the slugs recovered after firing selectively carburized liners for the M9A1 rifle grenade in order to obtain information on the nature of metal flow during deformation of the liners on firing, and the temperatures developed in the slugs. An appendix reports on the examination of the slug formed from the shaped charge liner of a 7.2-in. rocket.

L1446

Ordnance Laboratory, Frankford Arsenal.
POINT-INITIATING ELECTROMAGNETIC FUZE T16, by S. W. Kitchen and others. Rept. no. 3. Dec. 1945, 18p. diagrs. (Proj. no. 2/119, rept. no. R-683) Confidential

An attempt to develop an electromagnetic fuze for use in shaped charge shells is reported. The fuze was to function in less than 100 μsec. after the impact of the shell. Tests demonstrated that the functioning time of the fuze was satisfactory; but armor penetration of the M6A3 rocket assembled with this fuze was inferior to the penetration of the standard M6A3 rocket with the base detonating fuze. It was recommended that the fuze be redesigned to leave the center hollow so that the fuze would not interfere with the formation of the jet from the exploding shaped charge.

L1447

Ordnance Laboratory, Frankford Arsenal.
DEVELOPMENT OF A PIEZOELECTRIC FUZE, by J. R. Vigliante. Rept. no. 1. Dec. 1946, 11p. incl. diagrs. (Proj. no. 2/122, rept. no. R-750) Confidential

Preliminary attempts to apply piezoelectric crystals in connection with electric detonators to produce a fast acting fuze for use in shaped charges are described. Ammonium dihydrogen phosphate (anhydrous) was selected for the tests because of its excellent mechanical and electrical properties, availability in large amounts, and low cost of manufacture. The resistance, operating time, and energy required for detonation were measured for spark-gap primers, bridge-wire type detonators, and experimental spark-gap detonators. Sufficient work was done to indicate that this type of fuze is possible, but further work was suspended because of the success of the electromagnetic fuze.

L1448

Ordnance Missile Laboratories, Redstone Arsenal.
DELIBERATIONS CONCERNING PLATOON ANTITANK ROCKET PROBLEM, by C. M. Jaco, Jr. Jan. 1953, 53p. incl. diagrs. (Proj. no. TU2-10F, rept. no. 58-a) Secret

Shaped charge warheads and their role as antitank weapons are considered in a general study. From this viewpoint, recoilless rifles, antitank guided missiles including the French SS10 and the DART, and rockets are discussed. The requirements for protection of armored vehicles against shaped charge attack are presented in an appendix.

L1449

Ordnance Research and Development Center, Aberdeen Proving Ground.
THE DEVELOPMENT OF AN ARMOR ARRANGEMENT FOR MINIMIZING THE EFFECT OF THE GRENADES AT M9A1 AND AT M10. [June-Sept. 1943], [47]p. incl. tables, diagrs. (Armor test rept. no. AD-59) Confidential

Test results showed that the M9A1 grenade could be defeated by a number of armor arrangements, the most important consideration being the amount of space provided between the plates. Obliquities were effective in preventing complete penetration only when both plates of an arrangement were parallel. If the plates were set at an angle to each other, no advantage was gained over an arrangement in which the plates were parallel to each other and at 0° obliquity. The M9A1 grenade completely penetrated a 3-5/8 in. face hardened plate at an obliquity of 15°. The front plate of an armor arrangement must have physical properties which will enable it to withstand detonation of the M9A1 grenade. The method of fastening the front plate of an armor arrangement should not require any part of the fastening to protrude from the plate as it will be damaged by the detonation of high explosives. No tests were made with the AT M10 grenade because the grenade was considered obsolete.

L1450

Ordnance Research and Development Center, Aberdeen Proving Ground.
INVESTIGATION OF HCR2 PLASTIC ARMOR AS A METHOD OF DEFEATING SHAPED CHARGE AMMUNITION, by F. S. Wolff. Mar. 3, 1945, 59p. illus. (Armor test rept. no. AD-962) Confidential

An investigation of the effectiveness of HCR2 (silica rock and a mastic binder) in defeating the jet action of the Panzerfaust was made. Results showed that a minimum thickness of 12 in. of HCR2 with a 0.75-in. face plate was required (1) to prevent complete penetration of the sponson section of a medium tank (M4), and (2) to give absolute protection of the turret. Homogeneous armor (0.75 in.) spaced 12 in. in front of the turret or sponson of the medium tank did not give protection against the Panzerfaust. Armor plate of 0.5-in. thickness provided adequate protection as a front plate to retain the HCR2, when exposed to a direct hit from the 105-mm. HE, M1 shell. A minimum of 6 in. of HCR2 with a 0.75-in. face plate was required to give absolute protection of the sponson section of the medium tank against the 105-mm. HEAT, M67 shell. A minimum of 5 in. of HCR2 with a 0.75-in. face plate was required to give absolute protection of the turret section against the 105-mm. HEAT, M67 shell. The addition of a face plate and HCR2 provided an increase in protection against 75-mm. AP M72 and 75-mm. APC M61.

L1451

Ordnance Research and Development Center, Aberdeen Proving Ground.
TO DETERMINE THE CRATER MEASUREMENTS AND CHARACTERISTICS OF BOMB, SC, 2000-LB. T5 AND THE FLIGHT CHARACTERISTICS OF BOMB, SC, 2000-LB. T6, by J. W. Cave and F. J. Burke. Dates of test: Apr. 5 and 14, 1945. 3p. incl. diagr. (Firing record no. B-8646) Confidential

L1452

Ordnance Research and Development Center, Aberdeen Proving Ground.
TO DETERMINE EFFECTS ON THE BOMB, SC, 2000-LB., T6 (INERT LOADED) WHEN RELEASED FOR AN ANGLE OF IMPACT IN EXCESS OF 60° ON THE CONCRETE HARD SURFACE, by S. McLain and W. C. Olson. Date of test: May 2, 1945. 2p. diagr. (Firing record no. B-8709) Confidential

L1453

Ordnance Research and Development Center, Aberdeen Proving Ground.
TO DETERMINE: (1) THE PRACTICABILITY OF A NOSE FUZE EXTENSION FOR USE WITH THE SHAPED CHARGE BOMBS, AND (2) THE APPROXIMATE AIRSPEED AT WHICH THE EXTENSION WILL FUNCTION, by C. R. Carr and W. C. Olson. Dates of test: June 11-16, 1945. 2p. (Firing record no. B-8971) Confidential

L1454

Ordnance Research and Development Center, Aberdeen Proving Ground.
BALLISTIC TEST OF FRONT END CASTING FOR THE HEAVY TANK T28, by S. McLain and F. E. Mack. Date of test: June 16, 1945. 3p. (Firing record no. Ar-15590) Confidential

L1455

Ordnance Research and Development Center, Aberdeen Proving Ground.
RADIOGRAPHIC EXAMINATION OF 100-LB. SHAPED CHARGE BOMBS, T2, by S. McLain and A. S. Buchanan. Date of test: July 12, 1945. 3p. (Firing record no. Ar-16800) Confidential

L1456

Ordnance Research and Development Center, Aberdeen Proving Ground.
TO COMPARE THE PLATE PENETRATING CHARACTERISTICS OF SHELL, HEAT, 75-MM, M66E2 (30° CONE), WITH SHELL, HEAT, 75-MM, M66 (42° CONE). Dates of tests: Sept. 26, 28, and Oct. 1, 1945. 6p. incl. tables. (Proj. no. 3721(1221-P7-315); Firing record no. P-35562) Confidential

Shells loaded with 50/50 pentolite and fired against 5-in. homogeneous armor plate set a 0° obliquity at a range 100 yd. gave unsatisfactory results. The remaining rounds were fired against 4-in. homogeneous armor. One set of M66 shells (muzzle velocity, m. v. = 800 ft./sec.) completely penetrated the target while the similar shell with m. v. of 1400 ft./sec. produced an average penetration of 2.1 in. The M66E2 shells with m. v.'s of 1400 and 1600 ft./sec. produced average penetrations of 2.4 and 0.81 in., respectively.

L1457

Ordnance Research and Development Center, Aberdeen Proving Ground.
FIRST REPORT ON TEST TO DETERMINE THE MAXIMUM RANGE OF CHARGE, DEMOLITION, SHAPED, M2A3 AND M3. by C. E. Hawk. Oct. 2, 1945, [28]p. incl. illus. tables. (Ordnance program no. 5446, rept. no. 3) (Ordnance Research Center proj. no. 6119; Firing record no. P-37863) Confidential

Tests were made to determine the maximum range of the M2A3 and M3 shaped charges when placed with axis of the conical liner in a horizontal position. It was concluded that with the test technique used, the maximum range of the jet could not be determined. Portions of the slug from the M2A3 charge may travel as far as 600 ft., while portions of the slug from the M3 charge may travel as far as 1680 ft.

L1458

Ordnance Research and Development Center, Aberdeen Proving Ground.
INVESTIGATION OF GERMAN SHAPED CHARGE ANTITANK MINE (ILL. S MI. 4672), by J. E. Weber and J. Meszaros. Dates of test: Oct. 24, 1945 - Jan. 10, 1946. 3p. illus. diagrs. appendixes. (Firing record no. P-39954) Restricted

Physical measurement data and functioning characteristics are given for the German shaped charge antitank mine. Detailed drawings of component parts are appended. Chemical and physical analyses are also appended.

L1459

Ordnance Research and Development Center, Aberdeen Proving Ground.
THE USE OF STEEL SPIKES TO DEFEAT LINED, SHAPED CHARGE AMMUNITION, by F. S. Wolff. Oct. 30, 1945, 7p. and appendixes A-C. (Armor test rept. no. AD-1037) Confidential

L1460

Ordnance Research Center, Aberdeen Proving Ground.
TO INVESTIGATE THE CAVITY EFFECT OF THE M2 CHARGE AGAINST STEEL PLATE USING DIFFERENT TYPES OF FILLERS MANUFACTURED BY DU PONT COMPANY, by J. W. Cave and J. Meszaros. Date of test: Nov. 23, 1943. 1p. incl. tables. (Firing record no. M-27918) Confidential

Tabular results show the following:

		Penetration data		
I	II	III	IV	V
2	Amatol 60-40	220	4-7/8	2.30
3	Tetratol 75-25	407	7-9/16	2.64
3	Pentolite 50-50	477	7-5/8	2.96
3	Cyclotol-Holston 60-40	547	8-1/8	3.08
2	TNT	335	6-1/2	2.55
3	Ednatol 55-45	419	7-1/4	2.79

I = No. of charges; II = Type of filler; III = Ave. vol. (cc.); IV = Ave. depth (in.); V = Max. diameter at face (in.)

L1461

Ordnance Research Center, Aberdeen Proving Ground.
FIRST REPORT ON "THE FOUNTAIN" SHAPED CHARGE AND AUXILIARY EQUIPMENT WHEN TESTED AGAINST LOCOMOTIVES, by A. B. Jenny. Feb. 9, 1944, 16p. illus. (Ordnance program no. 5448, rept. no. 1) (Ordnance Research Center proj. no. 3186; Firing record no. M29438) Secret

The fountain charge was satisfactory against locomotives. The jet perforated the cylinders and boilers of the locomotives and yielded damage which required major repairs. The M1 shaped charge was effective against a boiler, but was unsatisfactory because of its increased size and weight which made handling and transit difficult.

L1462

Ordnance Technical Intelligence Detachment Number 510.
SOVIET, 76-MM. SHAPED CHARGE PROJECTILE WITH TRACER ELEMENT, by J. G. Ransier. July 10, 1951, 2p. diagrs. (Technical Intelligence rept. no. 510-14) Secret

Twenty rounds of Soviet 76-mm. shaped charge ammunition were received from the 5th Marine Regiment. All rounds were fuzed with the Soviet, point detonating BM fuze. The explosive charge in the projectile is a cast compound very similar to tetrytol and weighs 1 lb. The explosive is believed to be 50% TNT and 50% RDX.

L1463

Ordnance Technical Intelligence Detachment Number 528.
SOVIET HEAT HAND GRENADE, RPG6, by J. G. Ransier. June 7, 1951, 4p. incl. illus. diagr. Secret

Photographs are shown of the Soviet HEAT hand grenade, RPG6, which employs the shaped charge principle and will penetrate up to 3.94 in. of armor. It has an over-all length of 13.5 in. and weighs 2.4 lb. The grenade has an "all-ways-impact" fuze. The grenade may be thrown from 17 to 25 yd. with reasonable accuracy.

L1464

Ordnance Technical Intelligence Detachment Number 929.
CHINESE SHAPED CHARGE ANTITANK GRENADE, by T. P. Heselbarth. Apr. 18, 1951, 1p. diagr. (Technical rept. no. 920-1) Secret

The grenade is yellow in color, conical shaped, cloth covered, with a black metal igniter. The grenade contains a pull-type igniter, booster, main charge, wooden spacer, Al liner, 1.03 in. wide across apex, 3.90 in. wide across base, and a cloth cover. "It is believed that this grenade is designed to be placed by hand on armored surface, and then ignited by pulling the safety pin from the compressed-spring firing-pin device in the igniter. There is evidently a delay element in the detonator unit. Two of these grenades have been recovered in the 3rd US Div. area north of Uijongbu." No data are given. (OTID abstract)

L1465

Ordnance Technical Intelligence Detachment Number 920.
CHINESE SHAPED CHARGE AT GRENADE, by T. P. Heselbarth. May 5, 1951, 1p. diagr. (Amendment to Technical rept. no. 920-1) Secret

Upon additional investigation of the subject grenade, it has been determined that the striker works against anti-creep spring, rather than being activated by it. When the safety pin is pulled, prior to throwing the grenade, the striker is free to strike the primer, except for the resistance of the spring. Upon impact, the striker moves forward, overcoming the resistance of the spring, strikes the primer, and activates the explosive train. The grenade is thrown against, rather than placed upon, the armor of the tank. At this writing, no fins or other stabilizing equipment has been found, but it is believed that a fiber or cloth tail is attached. Tests have shown that this grenade will penetrate approximately 3 in. of turret-armor of the Soviet T34/85 tank. (OTID abstract)

L1466

Ordnance Technical Intelligence Detachment Number 920.
LAUNCHER, ROCKET, 87-MM; CHINESE - BAZOOKA TYPE, by J. G. Ransier. Sept. 18, 1951, 2p. illus. (Technical Intelligence rept. no. 507-20) Secret

A Chinese rocket launcher, type 135, for launching Chinese 87-mm. HEAT rocket was captured by the 1st Cavalry Div. The weapon is partially copied from the US rocket launcher, M20. No data are given.

L1467

Ordnance Technical Intelligence Detachment Number 920.
CHINESE COPY OF US 2.36-IN. ROCKET, HE/AT, M6A3, by T. P. Heselbarth. Oct. 30, 1951, 3p. illus. (Technical rept. no. 920-9)
Secret

The rocket is an exact copy of the US rocket, M6A3, except for slight differences in measurements, and explosive filler. In the Chinese copy, 2 collars, 0.028 in. in thickness, and 1.511 in. in height, are mounted circumferentially in the ogive, resting on the perimeter of the shaped charge liner, to increase the strength of the standoff. No data are given. (OTID abstract)

L1468

Ordnance Technical Intelligence Detachment Number 920.
CHINESE COPY OF JAPANESE 75-MM. HOLLOW CHARGE ROUND, MODEL 2, by T. P. Heselbarth. Jan. 6, 1952, 2p. (Technical rept. no. 920-12
Secret

Four Chinese copies of Japanese 75-mm. Model 2 shaped charge rounds were recovered by the 21st Infantry Regiment. Three of the projectiles were recovered minus the propellant case; 1 complete round was found packed in a metal container with 2 75-mm. HE rounds, and 3 Japanese type 88 instantaneous nose fuzes, 1 of which was painted black. Markings which appeared on the projectiles are given. No color bands or markings were found indicating use, filler, etc.

L1469

Pack, D. C. and W. M. Evans.
PENETRATION BY HIGH-VELOCITY ("MUNROE") JETS: I. Proceedings of the Physical Society, v. 64B, part 4, Apr. 1, 1951: 298-302.

By means of certain simplifying assumptions a formula is developed for the penetration into a ductile target by a high-velocity (Munroe) jet. The action of the jet is divided into 2 stages, each making its contribution to the total penetration. In the first stage a hole is formed by the lateral compression of the target as the jet penetrates it; the second stage begins when the last particle of the jet has ceased to act, the hole continuing to deepen until the residual energy in the target has been spent. At the high pressures set up by a Munroe jet the strength of the target plays only a subsidiary part in the phenomenon.
(Physical Society abstract)

L1470

PANSARNÄVEN. Flygning, v. 26B, July 15-28, 1948: 12p.

A brief description with a diagram is presented of this Swedish adaptation of the German Panzerfaust.

L1471

Physikalisches Institut der Universität Berlin.
X-RAY FLASH PHOTOGRAPHY INVESTIGATIONS OF HOLLOW CHARGES (Röntgenblitzuntersuchungen an Hohlsprengkörpern), by E. Schumann and others. Nov. 5, 1942, 28p. incl. illus. diagrs. (Sprengstoffphysikbericht 43/1; Trans. as rept. no. BIOS/Gp.2/HEC 2587, 43p. incl. illus. diagrs.; Also trans. as OTIB rept. no. 1470, 1v. incl. illus. diagrs.)
Restricted

The flash photography installation used to study the detonation wave is described and illustrated. Photographs of the formation of the jet, and explanations of them are given.

L1472

[Physikalisches Institut der Universität Berlin].
DEPENDENCE OF EXPLOSIVE EFFICIENCY UPON THE NATURE AND STRENGTH OF THE LINING MATERIAL IN HOLLOW EXPLOSIVE BODIES, by E. Schumann and others. Mar. 23, 1943. (Physics of Explosives rept. 43/4; Trans. as rept. no. BIOS/Gp.2/HEC 2596, 108p. incl. tables, diagrs.; Also trans. as OTIB rept. no. 1469, classified "Restricted", 2v. incl. 1v. of diagrs.) (In cooperation with [Forschungsabteilung des Heereswaffenamtes, Berlin])
Secret

Tests were made on armor plates of 90 to 120 kg./mm^2 tensile strength and 100-mm. thickness. Depth, width, and volume of the holes were measured. The liner metals could, with respect to their effectiveness, be divided into these groups: (numbers following metal groups indicate depth of hole with the optimum liner thickness) - Cu and Cu alloys (58 mm.); deep drawn sheet metal (55 mm.); Zn (51 mm.), sheet Fe (47 mm.); Al and Al alloys (39 mm.); Mg alloy (23 mm.); and Fe (55 mm.). Experiments were performed to devise a method for the production of the necessary liners with the maximum economy of material and in the simplest way. The results showed that, for all metals tested and liner thicknesses, a difference between metal liners in 1 piece and subdivided liners, apart from dispersions occurring, was not ascertainable. Small interstices between the various sectors, which may occur when the charge is lined with sectors, had no influence on explosive efficiency. It was found that greater efficiency was obtained when the liner material was placed as close as possible to the wall of the hollow space of the explosive body.

L1473

[Physikalisches Institut der Universität Berlin].
INCREASE OF HOLLOW CHARGE EFFECT THROUGH IGNITION CONTROL (LENSES), by E. Schumann and G. Heinrichs. Mar. 30, 1943. (Rept. no. 43/2; Trans. as OTIB rept. no. 1471, 3p. illus.; Also trans. as rept. no. BIOS/Gp.2/HEC 2590, "Unclassified", 12p. incl. illus. diagrs.)
Restricted

Experiments are reported on shaping detonation waves by inserting a barrier [German term: lens] of inert material (concrete in this case) in the explosive charge. The explosive is ignited in a circle around each end of the barrier and advances from both sides. Twenty-five % improvement in penetration depth is reported. The method is especially suitable for hemispherical charges. (Abstract taken from HEC translation 2590.)

L1474

[Physikalisches Institut der Universität Berlin]. THE SCIENTIFIC BASIS OF THE HOLLOW CHARGE EFFECT, by E. Schumann. Apr. 28, 1943. (HE Physics rept. 43/5; Trans. as rept. no. BIOS/Gp. 2/HEC 5919, 40p. incl. diagrs.; Also trans. as OTIB rept. no. 1485, classified "Restricted", 13p. illus. diagrs.) Confidential

The effect of a shaped charge on an armor plate was related in its origin to a vapor focusing process, where vapor was understood to be gas or metal vapor. Possibilities for controlling this process include cavity shape, shaping of the igniting detonation wave, and cavity liner. Sections are included on the development of a uniform conception of the process of detonation. It was stated that the effect on the armor plate originated from the vapor jet and could not be identified with a projectile effect. It was found that the data obtained led to new suggestions for the increase of and protection against the shaped charge effect. An increase was achieved by guided initiation and by employing echelon ignition with combined charges. As a protection, armor plates of a specific light metal of high sonic velocity and good plastic properties for molding were suggested.

L1475

[Physikalisches Institut der Universität Berlin]. CONTRIBUTION OF THE KNOWLEDGE OF THE MANNER OF ACTION OF HOLLOW EXPLOSIVE BODIES, by W. Holtz and others. Sept. 22, 1943. (HE Physics rept. 43/7; Trans. as rept. no. BIOS/Gp. 2/HEC 2595, 19p. incl. illus. tables; Also trans. as OTIB rept. no. 1482 entitled "Study of the effect of hollow charges", classified "Restricted", 11p. incl. illus.) (In cooperation with [Forschungsabteilung des Heereswaffenamtes Berlin]) Unclassified

The reaction of solid targets and targets consisting of stacked plates to shaped charge explosions is reported. Conclusions as to the processes taking place at the formation of the crater are drawn.

L1476

Physikalisches Institut der Universität Berlin. INVESTIGATION ON THE EFFECT OF HOLLOW CHARGES MADE OF SUBSTITUTE EXPLOSIVES (Untersuchungen über die Sprengwirkung von Hohlsprengkörpern aus Ersatzsprengstoffen), by H. Möller and K. Wolk. Oct. 25, 1943. 22p. diagrs. (Sprengstoffphysikbericht 43/8; Trans. as OTIB rept. no. 1477, 5p.; Also trans. as rept. no. BIOS/Gp. 2/HEC 2591, "Unclassified", 38p. incl. tables, diagrs.) (In cooperation with Forschungsabteilung des Heereswaffenamtes) Restricted

Twenty-one explosive compositions were tested and evaluated to ascertain which would be suitable for use in shaped charges. RDX was found to be the most effective for conical shaped charges. (Abstract taken from HEC translation 2591)

L1477

Picatinny Arsenal. EXAMINATION OF UNFIRED 90-MM. GERMAN ROCKET, "BAZOOKA"-TYPE (FMAM-861), by A. B. Schilling. First and final rept. Sept. 23, 1944, 6p. illus. diagrs. (Technical rept. no. 1427) Confidential

An examination was made of a German, 90-mm., bazooka-type rocket which consists of a point-fuzed, HE shaped-charge-loaded, thin walled, steel shell to which is attached a steel pipe with a venturi-type extension and a 8-vane fin, or stabilizer assembly.

L1478

Picatinny Arsenal. CARTRIDGE, HEAT, T108E11 FOR 90-MM. GUN, M3, by T. Clifford. Oct. 26, 1950, 5p. diagrs. (Proj. no. TM1-1451J, PA notes no. 24) Confidential

A description and diagrams are given for the fin-stabilized 90-mm. T108E11 HEAT cartridge. The shell was designed to penetrate approximately 5-in. homogeneous armor plate at 60° obliquity or 10-in. plate at normal impact.

L1479

Picatinny Arsenal. ROCKET, HEAT, 2.36-IN., T59E3, by L. B. Gluckman. Nov. 10, 1950, 7p. illus. diagrs. (Proj. no. TU2-1001A, PA notes no. 21) Confidential

The development of the T59E3 HEAT rocket which contains a shaped charge warhead is described. The ballistic data show its maximum range to be 1500 yd. and its penetration in armor to be a minimum of 7.5 in.

L1480

Picatinny Arsenal.
HEAD, ROCKET, HEAT, 2.75-IN., T2016 AND FUZE, ROCKET, PI, T2023, by S. H. Rush. June 15, 1951, 6p. illus. diagrs. (Proj. no. TU2-1020, PA notes no. 32) Confidential

The 2.75-in. HEAT rocket head, T2016, with point-initiated fuze, is briefly described including its construction, characteristics, and method of operation. The rocket head contains a conical Cu liner and HE charge of 0.92 lb. of Comp. B, Grade I. It is capable of penetrating 7 in. of Class B homogeneous armor plate at 0° obliquity, 6 in. at 30°, and 3 in. at 60°. On striking the target, the collapse of the nose of the windshield fires the primer to initiate the explosive train. The auxiliary detonator, designed with a hollow charge which "spits back" through the rocket head's fire tube, causes detonation of the booster pellet. This initiates the detonation of the HE charge and shaped charge penetration results.

L1481

Picatinny Arsenal.
CARTRIDGE, HEAT, 57-MM, FOR RECOILLESS RIFLE, FMAM-2039 (CHINESE). Oct. 5, 1951, 6p. illus. diagrs. (Proj. no. TA1-3500, Preliminary rept. no. 1835) Confidential

The loaded cartridge examined consisted of a point-fuzed HE-loaded shell, and a primed perforated Fe cartridge case. The HE shell is provided with a pre-engraved rotating band pressed into a seat in the shell. A base plug, over which is spit-welded a base plug cover, is threaded into the shell filler hole. A brass-clad Pb gasket is provided to seal the base plug to shell-base joint. Within the shell is a metal liner, having a flash tube in its hemispherical head. The base of the detonator is cavitated to form a conical shaped charge, the flash of which is transmitted through the flash tube directly against the upper surface of the solid booster pellet.

L1482

Picatinny Arsenal.
ANALYSIS OF FOREIGN ROCKETS (CHINESE 87 MM.), by T. Fruchtman. Nov. 19, 1951, 10p. illus. diagrs. (Proj. no. TU2-8A, Preliminary rept. no. 1857) AD-6275 Confidential

The examination and analysis of the Chinese 87-mm. rocket showed that the complete round consisted of 3 principal sub-assemblies: spin-type motor with 8 canted nozzles, shaped charge-type head with base detonating fuze, and nose fuze with spitback action. The shaped charge liner consisted of hot-rolled steel sheet rolled to shape and joined with a welded seam. It had an included angle of 55° and appeared generally similar in configuration to the shaped charge liner of some American HEAT weapons. "The head was tested against an armor barrier formed by 1 in. thick by 4 in. square mild steel plates, placed in a stack 18 plates thick. To detonate the head, a du Pont no. 6 blasting cap was inserted in a hole drilled in the wooden firing pin block of the fuze and taped in place. To simulate the designed charge confinement conditions, an inert motor body was assembled to the head. In order to accommodate the blasting cap it was necessary to support the head on the stacked plates by a cardboard tube, and by the same means maintain a distance of 1 in. between the fuze and the plate. The result was a shaped charge standoff of 4.5 in., 1 in. greater than would occur in impact against a target, assuming no nose crush. According to available information on shaped charges, this should result in an increase in penetration depth of a few % over that obtainable without the 1-in. standoff increase. The round detonated with high order and penetrated entirely through the top 3 plates and 0.75 in. through a fourth resulting in a total penetration of 3.75 in. The steel slug formed by the shaped charge liner was lodged in the third and fourth plates. The total penetration of 3.75 in. is extremely poor as compared to the performance of US shaped charge projectiles of similar caliber." It is believed that the poor performance is due to the explosive, TNT, which is not suitable for the shaped charge effect, and the liner material is steel (usually found inferior to Cu as a shaped charge material in static penetration test), and the workmanship was crude by US standards.
(PA abstract)

L1483

Picatinny Arsenal.
SHAPED CHARGE DESIGN NOTES, by G. L. Jackman. Dec. 13, 1951, 7p. incl. diagrs. TIP C7798 Confidential

Some of the many variables of design and manufacture which influence the effect of shaped charge jets directed against armor plate are briefly discussed. The following subjects are considered: (1) basic principles and general theory; (2) cone materials; (3) rotation of cone and charge; (4) design considerations including liner thickness, cone angle, charge shape; (5) loading techniques; and (6) end results including performance attainable, distribution curve of penetrations, and importance of reserve penetrating power. Much of the data presented are empirical.

L1484

Picatinny Arsenal.
MECHANICS OF ARMOR PERFORATION, A BIBLIOGRAPHY. [1952], 12p. (typewritten) Secret

Twenty-six references pertaining to shaped charges are included in this list of 42 abstracts covering the period from 1943-1951.

L1485

Picatinny Arsenal.
EXAMINATION OF UNFIRED 76-MM. HEAT-T COMPLETE ROUND OF SOVIET AMMUNITION MOD UBP 353M (FMAM 2268), by A. B. Schilling. Jan. 28, 1952, 10p. illus. tables, diagrs. (Proj. no. TA1-3590, rept. no. 1; Technical rept. no. 1824) Confidential

One loaded complete round of Soviet 76-mm. HEAT-T ammunition MOD UBP353M, with point fuze was examined. The shell which is loaded with a cast cyclotol charge cavitated to receive the metal liner, contains a paper flash tube between the apex of the liner and the forward end of a tetryl booster. The brass cartridge case, of conventional design, contains a fine-grained cord nitrocellulose-methyl centralite propellant powder. In the base is a short type percussion primer igniter containing a black powder pellet igniter charge. A tracer assembly is threaded into the base of the projectile.

L1486

Picatinny Arsenal.
NOTES ON DEVELOPMENT OF ROCKET, HEAT, 3.5-IN., T205, by H. E. DeFazio. Feb. 28, 1952, 5p. illus. (Proj. no. TU2-1015, PA notes no. 40). AD-11 774 Confidential

The T205 rocket is a HE, antitank, shoulder-fired weapon, quite similar in construction to the standard M28A2 rocket. The head assembly of the T205 contains a conical Cu liner weighing 0.53 lb. and a 1.35-lb. explosive charge of Comp. B, only 70% of that used in the M28A2. By use of a new explosive configuration, a thinner liner, and a greater standoff, the decreased weight of explosive gives greater penetration than the M28A2. Limited static firings of the T205 head at 7.3-in. standoff gave penetrations of about 16.2 in. in mild steel plate with a standard deviation of approximately 0.6 in. From these firings it is estimated that the T205 should give penetrations in homogeneous armor plate as follows:

Obliquity	Penetration
0°	12.9 in.
45°	9.2 in.
60°	6.5 in.

L1487

Picatinny Arsenal.
ROCKET, HEAT, 3.5-IN., T205, by H. E. DeFazio. Feb. 28, 1952, 5p. illus. diagrs. (Proj. no. TU2-1015, PA notes no. 40) Confidential

The T205 rocket is designed to have greater velocity, accuracy, range, and penetration than the standard M28A2 rocket. Static firing tests with the head of the T205 rocket which contains a conical Cu liner showed that the head will penetrate about 16.2 in. of mild steel plate with a standard deviation of about 0.6 in. when fired at full ogive standoff (7.3 in.) without the nose-fuze element.

L1488

Picatinny Arsenal.
GRENADE, HAND, AT MODEL (PHT-43) (SOVIET), by A. B. Schilling. Mar. 1952, 5p. illus. table, diagrs. (Proj. no. TB3-0035, rept. no. 1; Technical rept. no. 1834) Confidential

Two loaded complete assemblies of the grenade were examined. The grenade consists of a cylindrical light sheet steel body containing a high explosive shaped charge of cast TNT, and a steel liner, a detonator-booster assembly and a handle assembly. "Information is available indicating that the effective penetration of the grenade charge is through 75 mm. of normal plate."

L1489

Picatinny Arsenal.
ANALYSIS OF FOREIGN ROCKET, 73-MM. AT ROCKET (FRENCH), by T. Fruchtman. Apr. 18, 1952, 15p. illus. diagr. (Proj. no. TU2-8B, Preliminary rept. no. 1864) Secret

The rept. includes a chemical and physical analysis of all components of the rocket, an evaluation of propellant and HE performance, and the preparation of assembly and detail drawings. Two of the HEAT heads were fired to determine their static penetration values. Both heads, assembled with the normal ogive, were placed, nose down, on top of a stack of 20 5 in. x 5 in. x 1 in. mild steel plates. Head no. 2 penetrated 8.82 in. and head no. 3 penetrated 9.69 in. The head contains a trumpet shaped liner which appeared to have been drawn and then machined. The liner wall thickness tapered uniformly from about 0.107 in. at the base to 0.060 in. at the apex. The liner angle is about 55° near the base and 25° near the apex.

L1490

Picatinny Arsenal.
HEAD, ROCKET, HEAT, 2.75-IN., T2016E1 AND FUZE, ROCKET PI, T2023, by T. Fruchtman. May 2, 1952, 9p. incl. illus. diagrs. (Proj. no. TU2-1020, Addendum to PA notes no. 32) Confidential

A study was undertaken to determine if the seal in the base of the T2016 HEAT rocket head will block the passage of hot gases into the explosive cavity when rupture of the blowout disc occurs. Tests using motors with the disc removed indicated that gas leaked into the head at 130°F under static firing conditions. The head was modified by replacing the base plug and Cu gasket with a cup-shaped base adapter. It was concluded that the new design performs satisfactorily and offers protection against gas leakage from the motor into the head.

L1491

Picatinny Arsenal.
ROCKET, HEAT, 3.5-IN., T205E1, by T. Fruchtman. Oct. 5, 1953, 9p. incl. illus. (Proj. no. TU2-1015, Addendum no. 1 to PA notes no. 40) Confidential

The contour of the heat of the 3.5-in. HEAT rocket T205 was modified to improve its penetration performance, the modification being designated T205E1. By increasing the length of the cylindrical portion at the rear of the head and by reducing the length of the ogive, the same over-all length of 23.55 in. was maintained. This major design change resulted in an increase of the distance between the apex of the conical liner and the booster pellet from 0.25 in. to 1.3 in. Tests of the modified rocket against Class B armor plate gave satisfactory results. Drawings of the revisions are included.

L1492

POWER OF THE BAZOOKA. Army Ordnance, v. 29, July-Aug. 1945: 75-77.

The importance of the hollow-head charge in modern warfare is discussed. Schematic drawings show the hollow head projectile which the rocket carries.

L1493

[Princeton University Station, Princeton, N. J. ?]. SUGGESTIONS FOR CONSTRUCTION AND TRIALS OF CIRCULAR HOLLOW CHARGE ("PULLEY"), by [I. M. Freeman], n.d. 1p. diagrs. Secret

A rough sketch of the proposed "Pulley" charge apparently shows it to be circular in shape with a steel lined cavity (60° at apex) around the outer rim. The charge weight is stated as approximately 8 lb. A test is suggested in which land mines were to be placed 2 ft. apart along 3 radial lines drawn from a buried "Pulley" charge. The diameter of the resulting crater and the number of mines detonated in each line were to be noted.

L1494

Princeton University Station, [Princeton, N. J.].
SHAPED CHARGE PENETRATION INTO CONCRETE, by J. L. Lindstrom. May 31, 1944, 5p. incl. diagr. (Princeton Technical memo. no. 33) (NDRC Div. 2) Confidential

A mathematical examination of the penetration depth-charge weight relationship against concrete is reported. The equation $X_{in.} = 9.8W_{lb.}^{0.43}$ is found the most accurate to satisfy the existing data, but the equation is not considered infallible because of the lack of data and the variables which enter into the penetrating effect of a shaped charge. A bibliography is included.

L1495

Princeton University Station, [Princeton, N. J.].
FOLLOW-THROUGH AND SHAPED-CHARGE BOMBS, by F. G. Roth. June 1944, 7p. (Princeton Technical memo. no. 38) (NDRC Div. 2) · Confidential

The effectiveness of shaped charges against concrete is briefly summarized under the following topics: shape of cavity of charge, optimum apex angle, hole diameter, and optimum standoff. A German follow-through bomb is analyzed mathematically; it is concluded that this type of bomb is impractical against massive reinforced concrete targets because of the required disproportionate ratio of shaped charge to follow-through charge. Three German shaped charge bombs are also analyzed. A bibliography is included.

L1496

The Proving Center, Aberdeen Proving Ground.
TO DEVELOP A SATISFACTORY SHAPED CHARGE FOR CONCRETE DEMOLITION, by J. W. Cave and others. Dates of test: Oct. 23, 1942-Mar. 1, 1943. 1v. incl. illus. tables, diagr. (Firing record no. M-20798) Confidential

A majority of the charges fired are indicated by sample number only, but some are designated as standardized charges, i.e., M1 charge containing TNT encased in sheet metal with a Tetryl booster; M1A1 and M1A2 charges, similar except for the position of the blasting cap; and the M2 charge with a wooden adapter. These charges were tested for effectiveness, functioning, safety, and demolition characteristics.

L1497

Pugh, E. M., R. von Heine-Geldern, S. Foner, and E. C. Mutschler.
KERR CELL PHOTOGRAPHY OF HIGH SPEED PHENOMENA. Journal of Applied Physics, v. 22, Apr. 1951: 487-493.

The action of shaped charge metal jets on various target materials was photographed at exposure times of > 1 μsec by synchronizing an electrically exploded wire of peak intensity 3 to 5 x 10^8 candlepower and a Kerr cell shutter with the phenomenon. By using a large lens with a 7-in. focal length, and an effective aperture of $f/_4$ detail was obtained in the photographs. The technique was also employed to study the propagation of shock waves in solids and liquids. The following phenomena were photographed: (a) the jet from a Cu conical liner with a flat apex; (b) the jet from a machined brass conical liner with truly conical apex; (c) the jets obtained from the simultaneous detonation of 2 shaped charges; (d) the detonation wave traveling downward at 7510 m./sec. from a cylinder of pentolite; (e) the simultaneous detonation of 2 pentolite cylinders showing the region of Mach interaction between the 2 expanding cones of explosive products; (f) the simultaneous detonation of a cylindrical pentolite charge from both ends; (g) the underwater detonation of primacord; (h) the detonation of a small pentolite charge on the top face of a slab of Plexiglas 6 x 6 x 1.25 in.; (i) the detonation of a pentolite cylinder laid horizontally on the upper face of a piece of Plexiglas; (j) the perforation of a 0.5-in. steel plate by a metal jet; (k) a metal jet perforating water; (l) a metal jet penetrating Plexiglas; (m) a metal jet perforating a glass plate 1.25 in. thick after perforating a 1.25-in. slab of Plexiglas separated by a 0.5-in. air space from the glass; (n) a jet penetrating a glass plate at an angle of incidence of 20°.

Redstone Arsenal see Ordnance Missile Laboratories Technical and Engineering Division

L1498

Reichsminister für Rüstung und Kriegsproduktion, Berlin-Charlottenburg.
MEETING ON APR. 18, 1944 AT PROVING GROUNDS HEADQUARTERS (Besprechung am 18.4.1944 bei Wa Prüf Stab), by Heydenreich. Apr. 26, 1944, 11p. incl. diagrs. (OTIB rept. no. 1249, AOO-7 - In German) Unclassified

The meeting was held to discuss electric fuzes for shaped charge shells including current supply and electric primers. The following tactical requirements for hollow charges were also considered: (1) deep penetration; (2) safety; (3) no charging before firing; (4) not too sensitive impact fuze; (5) response at high angles of obliquity; (6) high muzzle velocity; and (7) maximum possible initial velocity. In addition, plans for future development were mentioned.

L1499

Reichsminister für Rüstung und Kriegsproduktion Munitionskommission, Berlin.
MEMORANDUM FOR H. D. L. SAUR (Aktenvermerk für H. D. L. Saur), by Wagner. Nov. 29, 1944, 2p. (Mk-Nr. 1178/44 g. Ks.; OTIB rept. no. 1249, Misc.-2 - In German) Unclassified

Extensive experiments were made with Beethoven and SHL 500 and SHL 1000 shaped charge bombs. Beethoven devices with shaped charges, 180 cm. in diameter and containing 5000 kg. of explosive, were used against ship targets and ground fortifications. Twelve Beethovens destroyed 2 battleships and 4 large transport ships by direct hits. The use of these bombs also proved successful against ground targets during the invasion in Holland. SHL 500 and SHL 1000 shaped charge bombs were used against light ship targets. The SHL 500, 65 cm. in diameter, successfully penetrated the hull of a ship. Mention is made of the development of new shaped charges, and of the improvement of penetration of existing devices (shaped charges with flanges [apparently with flanged liners]).

L1500

Research and Experiments Department, Ministry of Home Security (Gt. Brit.).
SPARK PHOTOGRAPHS OF THE MACH EFFECT BY COLONEL PAUL LIBESSART, WITH A COMMENTARY BY DR. J. BRONOWSKI, by P. Libessart. May, 1944, 23p. incl. illus. (Rept. no. R.C.417; AC 6569, June 23, 1944; Phys/Ex. 509; OSRD Liaison Office WA-2345-6) Confidential

Photographs are shown of Mach configurations from exploded detonators. All the photographs are positive prints taken with apparatus that fired 1 or more sparks (up to 4 in succession), the light from which fell directly on a photographic plate 15 in. x 12 in. The experiment was set up between the spark and the photographic plate, so that the objects in the experiment recorded their shadows on the plate. For the photographs taken in air, the distance between spark and plate was generally 6.5 m.; for water the distance was 1 m.

L1501

Research Department, Woolwich, Eng.
"CAVITY EFFECT" OF EXPLOSIVES. A SUMMARY OF ITS HISTORY AND SERVICE USES. Sept. 1941, 14p. (RD Woolwich, S.E. 18; (00.350.05/1305); OSRD Liaison Office WA-76-5) Confidential

(See item no. L30.)

L1502

Research Department, Woolwich, Eng.
EXPERIMENTAL STUDY OF THE MUNROE EFFECT. VELOCITY OF JETS PRODUCED BY CYLINDRICAL CHARGES WITH LINED AND UNLINED HOLLOW BASES, by P. Bessent and W. M. Evans. Mar. 1942, 11p. incl. graphs, diagrs. (RD Explosives rept. no. 67/42; OSRD Liaison Office II-5-3412) Secret

The study of the velocities of jets from lined and unlined shaped charges showed that the velocity of the jet front for the unlined charge, at 3 in. from the base, was nearly double that for the fastest lined charge. The velocity of the jet front was greater for a thin than for a thick liner. The velocity was smaller for a steel liner than for a Sn liner of similar dimensions. Curves are drawn to illustrate test results.

L1503

Research Department, Woolwich, Eng.
MUNROE EFFECT - APPLICATION TO UNDERWATER CHARGES, by A. R. Ubbelohde. Mar. 1942, 3p. diagrs. (RD Explosives rept. no. 73/42) Secret

Tests were made to determine suitable conditions for the application of the Munroe effect to the attack of underwater targets. The target consisted of an 0.75-in. mild steel plate soldered to a steel air chamber which was completely submerged in water. A Pb block inside the chamber served to catch scabs and to record any blast effects if the steel plate was punctured by the explosion. One in. and 2-in. diameter charges of PE contained in cylindrical steel tubing and having hollowed metal-lined bases were used. Initiation was effected by a no. 8 Briska detonator embedded in plasticine at the end remote from the cavity. It was found that charges with hollow bases lined with metals of low boiling point were capable of perforating steel target plates under water and producing appreciable blast damage after perforation. For the maximum effect to be obtained, an air gap must be provided between the water and the metal cavity liner. For a 2-in. diameter charge with Pb liner, satisfactory results through 6.5 in. of water were obtained with a 4.5-in. air gap. When the distance through the water was increased to 8 in., a marked reduction of effect was observed.

L1504

Research Department, Woolwich, Eng.
CAVITY CHARGE WITH SUBSIDIARY FOLLOW-THROUGH SOLID OR EXPLOSIVE PROJECTILE, by H. L. Porter and W. M. Evans. Aug. 1942, 4p. incl. diagr. (RD Explosives rept. no. 234/42; OSRD Liaison Office II-5-3454)
Secret

The investigation was concerned with the development of a shaped charge weapon of low intrinsic penetrating power which would produce a hole in armor or concrete, and then propel a subsidiary solid or explosive projectile through the hole made in the target. A layer of plasticine was interposed between the explosive charge and the follow-through projectile to prevent damage to the latter by reducing the effect of shock. Using a 1.75-in. charge with the cavity disc 3 in. from a 1-in. mild steel plate, a hole 1 in. in diameter was made in the plate and a subsidiary solid projectile 0.8 in. in diameter passed through the hole in the plate and penetrated about 8 in. into sand. Other test results are indicated.

L1505

Research Department, Woolwich, Eng.
CIRCUMFERENTIAL INITIATION OF LARGE HC BOMBS. Sept. 1942, 7p. incl. graphs, diagrs. (RD Explosives rept. no. 265/42; AC 2668, Sept. 7, 1942; SC. 4/27; SD. 119; OSRD Liaison Office WA-259-66)
Secret.

Large diameter bombs with certain fillings, such as 60/40 Amatol, were designed to ensure complete detonation of the outer layers. A proposed design is shown in which the initiation from a nose exploder is diverted by a layer of inert material so that detonation of the main filling commences at the outer layers.

L1506

Research Department, Woolwich, Eng.
GERMAN 7.5-CM. HOLLOW CHARGE SHELL FOR THE 7.5-CM. (KW.K) TANK GUN. Sept. 1942, 2p. illus. (RD Metallurgical rept. no. 584/42; OSRD Liaison Office II-5-3002E)
Confidential

Results are presented of a metallurgical examination made of the emptied shell body (without fuze).

L1507

Research Department, Woolwich, Eng.
METALLURGICAL EXAMINATION OF GERMAN HOLLOW CHARGE GRENADE. Oct. 1942, 3p. illus. (RD Metallurgical rept. no. 643/42)
Secret

Results of a metallurgical examination of the emptied grenade (recovered in the Middle East) are reported.

L1508

Rheinmetall-Borsig A.G., Werk Unterlüss.
SPARK KINEMATOGRAPHY AND ITS APPLICATION IN BALLISTIC MEASUREMENTS, by K. H. Schlüter. Aug. 14, 1945. (Trans. as rept. no. BIOS/Gp. 2/HEC 10780, 31p. incl. diagrs.; Inclosure 1 to MA London rept. no. 4339-47)
Unclassified

Topics discussed include the purpose of spark kinematography, historical development of spark kinematography, setup for kinematography on stationary film, various kinds of sources of illumination, Schlieren methods, front light photographs by means of the Kerr cell shutter, ballistic applications, and the limits of kinematography on stationary film. The application of this type of photography to shaped charges is mentioned briefly, and a number of possible uses are indicated.

L1509

Riggs and Jeffries, Inc. (OEMsr-1349).
A SUMMARIZING REPORT ON PROJECT CASEY JONES, by W. H. Crew and S. P. Shackleton. Sept. 1, 1945, 1v. incl. illus. (Appendix to final rept. on Contract OEMsr-1349; Final rept. on Contract OEMsr-1215) (In cooperation with Federal Telephone and Radio Corp., Contract OEMsr-1215)
Confidential

Parts IV and V deal with the Fountain Charge, a 2.5-lb. shaped charge with an 80°, 4-in. liner for concealed attack against rail transportation. Both electrical and mechanical initiation are described. The development and testing of the charge are reported in detail.

L1510

Rinehart, J. S.
SOME EXPERIMENTAL INDICATIONS OF THE STRESSES PRODUCED IN A BODY BY AN EXPLODING CHARGE. Journal of Applied Physics, v. 22, Sept. 1951: 1178-1181.

Small cylindrical charges of Comp. C3 were detonated on the surfaces of heavy steel plates 2 in. thick and 5 in. in diameter and the resulting craters were examined. The crater shape was substantially the same in all cases, being conical with nearly straight sides. This crater shape is not the type that a high velocity missile produces on striking a steel plate or the kind that a rock makes when thrown into mud. A summary of the measurements made on the craters and highly worked region follows:

I	II	III	IV	V	VI
0.5	0.059	152.0	0.157	0.002	0.032
1.0	0.138	156.0	0.258	0.073	0.231
1.5	0.216	159.0	0.334	0.162	0.781
2.0	0.276	161.5	0.394	0.510	1.67

I = Charge diam. (in.); II = Crater depth (in.); III = Crater cone angle (°); IV = Thickness of highly worked region (in.); V = Crater vol. (cu. in.); VI = Vol. of highly worked region (cu. in.)

The data show that with increasing charge diameter, the cone angle and crater depth both increase. Apparently the crater shape reflects the pressure distribution that existed at the surface of the target plate. In forming the craters, the target metal moved in the direction of the application of the pressure. Only near the crater edges did appreciable lateral motion occur. Scabbing or spalling took place in 2 cases.

L1511

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
SOME PRELIMINARY TESTS ON A METHOD OF OBTAINING DIRECTIONALLY CONTROLLED FRAGMENTATION. n.d., 4p. incl. table, diagr. ([Note no. MOS/54/GBT]; AC 1708, Feb. 17, 1942; Phys/Ex. 226; OSRD Liaison Office W-170-63 and W-156-13) Confidential

Tests were made to determine whether it would be possible to design a bomb giving fragmentation directed in a certain confined region. Shaped charges were used with 50 0.25-in. steel balls lightly pressed into the base of the charge.

L1512

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
RESISTANCE OF CONCRETE TO SHAPED CHARGES (MUNROE EFFECT). Nov. 1941, 4p. incl. illus. diagr. (Note no. ID/5/FNS; AC 1525, Dec. 26, 1941; Phys/Ex. 205; OSRD Liaison Office W-125-54) Confidential

Tests were made on reinforced concrete with shaped charges of various explosives.

L1513

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
1ST INTERIM REPORT ON DEMOLITION OF GERMAN PILLBOXES. PRELIMINARY EXPERIMENTS. Dec. 1941, 3p. illus. diagrs. (Note no. MOS/49/FNS; OSRD Liaison Office II-5-3196; AC 1704, Feb. 16, 1942; Phys/Ex. 323; OSRD Liaison Office W-202-2) Confidential

Contact explosives and shaped charges were used to determine the best method to attack massive reinforced concrete German pillboxes having a minimum wall thickness of 5 ft. Shaped charges were found to be more efficient.

L1514

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
2ND INTERIM REPORT ON DEMOLITION OF GERMAN PILLBOXES. THE EFFECT OF DIFFERENT KINDS OF EXPLOSIVES USING SHAPED CHARGES. [Feb. 1942], 2p. table, diagr. ([Note no. MOS/55/FNS]; AC 1705, Feb. 16, 1942; Phys/Ex. 224; OSRD Liaison Office W-156-10) Confidential

TNT, TNT-RDX, PE (primed), Lyddite, 808 Gelignite, 60/40 Amatol, and Polar Ammon Gelignite produced penetrations in that order of decreasing depth. The specimens were tested on the floor of an unlined pit in the ground, about 5 ft. deep and 4 ft. square.

L1515

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
3RD INTERIM REPORT ON DEMOLITION OF GERMAN PILLBOXES. THE EFFECT OF THE THICKNESS OF THE CONE LINING IN SHAPED CHARGES. [Feb. 1942], 2p. table, diagr. ([Note no. MOS/56/FNS]; AC 1706, Feb. 16, 1942; Phys/Ex. 225; OSRD Liaison Office W-156-11) Confidential

Tests were made with shaped charges of TNT to determine the effect of varying the thickness of the brass liner on the damage sustained by reinforced concrete.

L1516

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
4TH INTERIM REPORT ON DEMOLITION OF GERMAN PILLBOXES. FULL-SCALE TEST ON A PILLBOX AT BOVINGTON. Feb. 1942, 7p. incl. illus. diagrs. (Note no. MOS/63/FNS; AC 1740, Feb. 25, 1942; Phys/Ex. 230; OSRD Liaison Office W-187-1) Confidential

The test was made with a charge containing 74.5 lb.

of plastic HE supported horizontally at a fixed distance from the face of a reinforced concrete wall 5 ft. thick. The concrete was completely perforated by the explosion. Attempts to measure the blast at various points were unsuccessful due to the excess debris.

L1517

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
5TH INTERIM REPORT ON DEMOLITION OF GERMAN PILLBOXES. GENERAL CONSIDERATIONS OF DESIGN OF HOLLOW-CONED CHARGES. Mar. 1942, 3p. (Note no. MOS/71/FNS; AC 1877, Mar. 23, 1942; Phys/Ex. 244; OSRD Liaison Office W-319-43) Confidential

Available information on the use of shaped charges against reinforced concrete is summarized, and a table prepared giving the more important dimensions for various charge sizes.

L1518

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
6TH INTERIM REPORT ON DEMOLITION OF GERMAN PILLBOXES. FURTHER FULL-SCALE TESTS WITH HOLLOW-CONED CHARGES. Mar. 1942, 13p. incl. illus. tables, diagrs. (Note no. MOS/80/FNS.RJ; AC 1976, Apr. 20, 1942; Phys/Ex. 259; OSRD Liaison Office W-252-35) Confidential

Tests were made with shaped charges containing 20 lb. of explosive for attacking the armor plate, and 40 and 75 lb. of explosive for attacking the sides of the pillbox.

L1519

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
7TH INTERIM REPORT ON DEMOLITION OF GERMAN PILLBOXES. THE EFFECT OF THE VERTICAL ANGLE OF THE CONE ON HOLLOW-CONED CHARGES. Apr. 1942, 4p. incl. table, diagr. (Note no. MOS/83/FNS; AC 2010, Apr. 29, 1942; Phys/Ex. 264; OSRD Liaison Office W-252-29) Confidential

Tests were made with charges of TNT and PE to determine the effect on reinforced concrete of varying the vertical angle of the liner. The liners were 1/16 in. thick and 5 oz. of explosive were used.

L1520

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
8TH INTERIM REPORT ON DEMOLITION OF GERMAN PILLBOXES. INCIDENTAL TESTS. Apr. 1942, 3p. diagrs. (Note no. MOS/96/FNS; AC 2089, May 15, 1942; Phys/Ex. 270; OSRD Liaison Office WA-272-13) Confidential

An investigation was made of shaped charges against reinforced concrete to determine the effects of: placing the charge at an angle to the normal, varying the ratio of the length of the charge to its diameter, using composite explosive charges, and varying the quality of the concrete.

L1521

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
9TH INTERIM REPORT ON DEMOLITION OF GERMAN PILLBOXES. FURTHER TESTS WITH COMPOSITE CHARGES. July 1942, 4p. incl. diagrs. (Note no. MOS/116/JH; AC 2453, July 29, 1942; Phys/Ex. 301; OSRD Liaison Office WA-259-29) Confidential

Tests were made to examine the possibility of enhancing the performance of shaped charges by suitably arranging the relative dispositions and shapes of 2 or 3 explosives in the same case.

L1522

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
10TH INTERIM REPORT ON DEMOLITION OF GERMAN PILLBOXES. THE USE OF HOLLOW-CONED CHARGES ON THE CONCRETE APRON. July 1942, 4p. incl. diagrs. (Note no. MOS/120/FNS; AC 2541, Aug. 18, 1942; Phys/Ex. 293; OSRD Liaison Office WA-259-28) Confidential

A shaped charge containing 104 lb. of PE was detonated just above floor level on the outside of the concrete apron surrounding the bottom part of the pillbox. The charge demolished most of the 39 in. thick apron on the face attacked, bored a hole through the 5-ft. thick reinforced concrete wall behind the apron, and scattered a large quantity of debris over the pillbox floor.

L1523

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
11TH INTERIM REPORT ON DEMOLITION OF GERMAN PILLBOXES. THE EFFECT ON PERSONNEL OF ATTACK BY MEANS OF HOLLOW-CONED CHARGES. Sept. 1942, 4p. diagrs. (Note no. MOS/144/FNS; OSRD Liaison Office II-5-319E) Secret

A shaped charge containing 78.5 lb. of PE was detonated on the outside of a pillbox wall to test the effects on a dummy man and live rabbits. The displacements to which the dummy was subjected were recorded by an inertia based displacement meter attached to the back of the dummy and at its c. g.; the blast pressures were recorded by piezo-quartz blast gauges attached to the knees and chest. The main conclusion reached was that the effects of blast pressure, bodily displacement, and noxious fumes would not in themselves be lethal although they may be injurious.

L1524

Road Research Laboratory. Department of Scientific and Industrial Research (Gt. Brit.).
12TH INTERIM REPORT ON DEMOLITION OF GERMAN PILLBOXES. FURTHER INCIDENTAL TESTS. Oct. 1942, 3p. incl. diagrs. (Note no. MOS/160/FNS; AC 3067, Nov. 24, 1942; Phys/Ex. 340; OSRD Liaison Office WA-498-17)
Confidential

Tests were made to determine the effectiveness of different liner materials and to compare rough and machined castings as liners. The 5-lb. charges were applied to the walls of reinforced concrete pillboxes. Results showed that: (1) a machined liner was superior to an unmachined liner (tested in Mn bronze); (2) brass was superior to Mn bronze (tested with cast liners); and (3) malleable cast Fe was inferior to Mn bronze (tested with machined liners). It was noted that a combination of PE covering the liner backed by Ammonal gave a performance approximately equal to that of PE alone.

L1525

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
13TH INTERIM REPORT ON DEMOLITION OF GERMAN PILLBOXES. THE USE OF GLASS FOR CAVITY LININGS. Mar. 1943, 4p. incl. diagr. (Note no. MOS/207/JH; AC 3711, Mar. 23, 1943; SC. 14; OSRD Liaison Office WA-571-4)
Confidential

Experiments were made in which reinforced concrete blocks were attacked by shaped charges of PE with hemispherical, partially spherical, and conical liners of commercial Pb, Sb-Pb, or glass. The penetration produced in concrete by the commercial Pb liners and the Sb-Pb liners was about 70% of that produced by steel, brass, or Mn-bronze liners. Sb-Pb appeared to give deeper penetration than the Pb liner. Glass liners of 60° apex angle, and of double the normal thickness, gave about 75% penetration of corresponding hard metal liners of normal thickness.

L1526

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
14TH AND FINAL REPORT ON THE NEUTRALIZATION OF REINFORCED CONCRETE PILLBOXES. Apr. 1943, 8p. incl. diagrs. (Note no. MOS/221/FNS; Inclosure 1 to MA London no. rept. 59777; AC 3831, Apr. 29, 1943; Phys/Ex. 416; SC. 26; OSRD Liaison Office WA-693-12)
Confidential

Tests made to determine the amount and method of application of a single explosive charge to neutralize an occupied pillbox showed that a simple contact charge was too big to be practicable, but that a shaped charge containing 75 lb. of explosive applied to the outside of a wall would perforate the wall and probably kill or injure the inhabitants. Methods of making a 75-lb. charge included a nesting Beehive in which the parts could be nested together for packing and transport. Pb cavity liners gave about 30% lower penetration than steel, brass, or Mn-bronze liners.

L1527

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
1ST INTERIM REPORT ON THE DEMOLITION OF GERMAN PILLBOXES. DEMOLITION OF A CAPTURED PILLBOX. Aug. 1943, 11p. incl. illus. (Note no. MOS/251/JH; AC 4823, Sept. 27, 1943; C. 42; OSRD Liaison Office WA-1441-5)
Secret

Demolition of pillboxes was investigated by using shaped charges followed by borehole charges, mining charges, and concussion charges of Ammonal. Use of the shaped charge resulted in no saving of explosive and in more difficult firing conditions; they were not recommended.

L1528

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
1ST INTERIM REPORT ON DEMOLITION OF ROADS. EFFECT OF DETONATING SPECIALLY SHAPED CHARGES ON A CONCRETE ROAD. Dec. 1941, 1p. diagrs. (Note no. MOS/50/RFM; AC 1595, Jan. 14, 1942; Phys/Ex. 217; OSRD Liaison Office WA-580-17c and W-144-26)
Confidential

Tests conducted on a concrete road surface showed that by using shaped 5-lb. explosive charges of Nobel's 808 Gelignite, a hole could be made through both the concrete surfaces and into the gravel subsoil. When 3 charges were detonated successively at the same point in the road, the hole was increased from 1.5 ft. (from the first charge) to 6 ft.

L1529

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
2ND INTERIM REPORT ON DEMOLITION OF ROADS. MODEL (1:5 SCALE) TESTS WITH HOLLOW-CONED CHARGES ON TYPICAL ROAD SURFACES LAID ON VARIOUS SUBGRADES. Oct. 1942, 10p. incl. illus. diagrs. (Note no. MOS/158/FNS; OSRD Liaison Office II-5-4083)
Confidential

Shaped charges containing 1-oz. of PE were equivalent to full size charges of 7.8 lb. of explosive. These charges were fired against 1:5 scale surfaces of plain concrete, reinforced concrete, wood blocks and tar-macadam on pitch. These were laid on subgrades of loose sand, clay, brickearth, gravel and alluvial soil. Results showed satisfactory perforation of the surfaces in all cases except for tar-macadam on pitch. Satisfactory penetration into the subgrade was obtained in all cases except into gravel which was penetrated to a depth of about 70% of that into other subgrade types. The use of steel screening plates did not improve the performance on tar-macadam. After repeated charges at the same point, the diameter of the hole in the subgrade was generally greater than that in the surface. It was concluded that there would be no appreciable increase in depth when such charges were successively fired at the same point.

L1530

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
DEMOLITION TESTS ON MODEL CONCRETE BRIDGE PIERS. Feb. 1942, 3p. illus. diagrs. (Note no. MOS/69/RFM; AC 1876, Mar. 23, 1942; Phys/Ex. 243; OSRD Liaison Office W-212-6) Confidential

One-tenth scale models of a concrete bridge pier, 5 ft. in diameter, were tested with explosives to determine the best method of demolition. The 2 best demolition methods are: (1) by using a shaped charge to drill a hole, which is subsequently filled with explosive and detonated; and (2) by detonating 250 lb. of guncotton in the form of a sausage tied around the center of the pier and reaching approximately half its circumference.

L1531

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
2ND REPORT ON DEMOLITION TESTS ON CONCRETE BRIDGE PIERS. USE OF HOLLOW-CONED CHARGE. Apr. 1942, 5p. incl. illus. diagrs. (Note no. MOS/81/FNS; AC 1979, Apr. 20, 1942; Phys/Ex. 260; OSRD Liaison Office W-262-36) Confidential

A charge containing 40.25 lb. of PE was tested against a concrete bridge pier 5 ft. in diameter and encased in a shell of mild steel plate 0.25 in. thick.

L1532

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
3RD REPORT ON DEMOLITION TESTS ON CONCRETE BRIDGE PIERS - FURTHER MODEL TESTS. May 1942, 6p. incl. illus. diagrs. (Note no. MOS/108/RFM; AC 2508, Aug. 24, 1942; Phys/Ex. 308; OSRD Liaison Office WA-299-92) Confidential

Two methods were found to be satisfactory for demolishing a concrete bridge pier. One method employed 1 shaped charge containing 40 lb. of explosive followed by detonating approximately 60 lb. of explosive in the hole obtained; the other method used 2 shaped charges each containing 20 lb. of explosive at opposite ends of a diameter. The 2 holes produced would then be packed with explosive for the second stage of the demolition.

L1533

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
4TH AND FINAL REPORT ON DEMOLITION TESTS ON CONCRETE BRIDGE PIERS. FURTHER FULL-SCALE TESTS. Aug. 1942, 9p. incl. illus. diagrs. (Note no. MOS/134/FNS; AC 2622; Phys/Ex. 312; OSRD Liaison Office WA-300-17 and WA-271-27) Confidential

Shaped charges containing 20 lb. of PE were placed in holes bored on opposite sides of a full size bridge pier 5 ft. in diameter. The holes were inclined downwards at an angle of about 20°, 1 being near the bottom and the other near the top of the pier. The resulting holes were filled with 4-oz. cartridges of Nobel's 808 Gelignite. The pier was completely demolished. A shaped charge containing 40 lb. of PE was found to give too much general damage.

L1534

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
1ST INTERIM REPORT ON EFFECT OF CONED CHARGES ON SUNDRY MATERIALS. THE USE OF SUCCESSIVE CHARGES ON REINFORCED CONCRETE. Feb. 1942, 2p. (Note no. MOS/66/FNS; AC 1810, Mar. 12, 1942; Phys/Ex. 236; OSRD Liaison Office W-187-9) Confidential

Tests were made with charges containing 5 lb. of 75/25 TNT/PETN to determine the effect of detonating successive charges at the same point on the face of a reinforced concrete target. No material increase in depth was secured after detonation of the second charge.

L1535

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
2ND INTERIM REPORT ON EFFECT OF HOLLOW CONED CHARGES ON SUNDRY MATERIALS. TESTS ON BRICK WALLS. June 1942, 7p. incl. illus. (Note no. MOS/114/RFM) Confidential

Model tests were made on brick walls (modeled as regards general dimensions) to determine the possibility of using shaped charges to produce holes for subsequent filling with explosive for demolition purposes. Four walls were prepared using Staffordshire blue bricks and London stock bricks, 1 of each kind being built in cement mortar and 1 in lime mortar. It was concluded that the relationship between size of wall and size of charge was important. Penetration into hard bricks might be only half of that into soft bricks. While the type of mortar did not appear to influence the penetration depth, a weak mortar allowed greater general damage than a strong mortar especially with walls which were small in relation to the size of the charge. The use of successive charges at the same point enabled the hole caused by the first charge to be deepened, but it was not known how many such charges could be successfully applied.

L1536

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
3RD INTERIM REPORT ON EFFECT OF HOLLOW CONED CHARGES ON SUNDRY MATERIALS. FULL-SCALE TESTS ON BRICKWORK. Nov. 1942, 9p. incl. diagrs. (Note no. MOS/170/JH; AC 3220, Dec. 15, 1942; Phys/Ex. 364; OSRD Liaison Office WA-403-7)
Confidential

Full-scale tests were made on a massive brickwork bridge pier using 6.75-, 20-, and 30-lb. charges for producing holes which would be plugged with explosive for the final demolition.

L1537

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
MEASUREMENTS OF THE VELOCITY OF THE LUMINOUS AXIAL EXPANSION THROUGH TARGET PLATES FROM BOMB CS (DR) FIRED ON 8/5/42. May 1942, 2p. diagr. (Note no. MOS/102/WJOS; AC 2211, June 12, 1942; SC. 4.8; OSRD Liaison Office II-5-1948)
Secret

This bomb, 38 in. in diameter, was detonated statically against a series of 4 steel plates inclined at an angle of 55° to the axis of the bomb. The movement of the spurt through the plates was recorded photographically. The velocity immediately before reaching the second plate was 5,000 ft./sec., and after passing through this plate was 4,000 ft./sec; the time delay in passing through this plate was .55 msec. After passing through the third plate (3/8 in. thick) the velocity was 3,400 ft./sec. Immediately before reaching the fourth plate the velocity was 3,200 ft./sec. There was no evidence of fragments moving in advance of the luminous axial spurt.

L1538

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
1ST INTERIM REPORT ON THE DEMOLITION OF CONCRETE BRIDGES. PRELIMINARY TESTS. June 1942, 10p. incl. illus. diagrs. (Note no. MOS/112/FNS)
Confidential

Tests were made on thick reinforced concrete specimens using model charges having tunnel shaped brass liners on the inside in the form of a "V". This charge was developed to cut a slot in reinforced concrete surfaces so as to destroy the continuity of the steel reinforcement. Results showed that the penetration depth of the slot for a given weight of explosive was much less than that of the hole produced by a conical charge. Best results were obtained when: (1) the apex angle of the "V" was about 90°; (2) the liner thickness was 1/8 in. for an 8 oz. charge 2 in. in length; (3) depth/width ratio for a given length was about 0.53; and (4) the ratio of width of charge to its standoff was 6. In full-scale tests on a reinforced concrete "T" beam, the charge completely cut through 2 layers of reinforcing bars causing the beams to collapse.

L1539

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
2ND INTERIM REPORT ON DEMOLITION OF REINFORCED CONCRETE BRIDGES. FULL-SCALE TESTS ON T-BEAMS. Oct. 1942, 7p. incl. illus. diagrs. (Note no. MOS/161/FNS; AC 3068, Nov. 24, 1942; Phys/Ex. 341; OSRD Liaison Office WA-498-18)
Confidential

Tests were made to determine the minimum quantity of explosive required to deal with a "T" beam containing 2 layers of tension reinforcement, and to examine the possibility of using a tunnel charge to cut through 3 layers of tension reinforcement with bars 1.25 in. in diameter. Results showed that a tunnel charge containing 8.8 lb. of PE/ft. run and of the same length as the width of the beam completely severed all the bars in the bottom layer and 2 of the 5 bars in the top layer. A charge containing 25 lb. of PE/ft. run completely severed all the bars except 1 in the top which had necked badly.

L1540

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
3RD INTERIM REPORT ON DEMOLITION OF REINFORCED CONCRETE BRIDGES. TEST ON MODEL REINFORCED CONCRETE ARCH BRIDGE. Nov. 1942, 7p. incl. illus. diagrs. (Note no. MOS/166/FNS; AC 3069, Nov. 24, 1942; Phys/Ex. 342; OSRD Liaison Office WA-498-19)
Secret

A demolition test was made on a 1:10 scale model bridge using hollow V-strip or "tunnel" charges (linear charges). Schematic diagrams of the bridge model, charge, and test arrangement and photographs taken after demolition of the bridge are included.

L1541

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
5TH INTERIM REPORT ON DEMOLITION OF REINFORCED CONCRETE BRIDGES. FURTHER TESTS ON MODEL REINFORCED CONCRETE ARCH BRIDGES. Sept. 1943, 11p. incl. illus. diagrs. (Note no. MOS/262/FNS; AC 4822, Sept. 27, 1943; C.41; OSRD Liaison Office WA-1484-3)
Secret

Tests were made to examine the various methods of demolishing reinforced concrete arch bridges using Hayrick and /or abutment charges, or as a hasty demolition using pressure charges placed on the filling over the crown. Hayricks applied on the underside of the arch at the crown cut through the whole thickness of concrete. Hayricks applied on the underside just above each springing point was sufficient to cut through the intrados steel only. Hayricks were applied at the crown, and boreholes produced in the abutments by means of Beehives were plugged with plastic explosive. The fronts of the abutments were badly damaged and greater displacements occurred in the abutments. Results with pressure charges are also reported.

L1542

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
7TH INTERIM REPORT ON THE DEMOLITION OF CONCRETE BRIDGES. THE USE OF "HAY-RICKS" ON 1:10 AND 1:4 SCALE MODEL ARCH BRIDGES. Dec. 1943, 3p. illus. diagrs. (Note no. MOS/301/FNS; AC 5647, Feb. 1, 1944, C. 85; OSRD Liaison Office WA-1604-4) Secret

In demolition tests on model (1:10 and 1:4 scale) reinforced concrete fixed arch bridges; Hayricks were applied at the crown and springings of the arches. With the 1:10 scale model bridge, the 2 halves of the arch were thrown backwards, while with the 1:4 scale model bridge the 2 halves of the arch collapsed between the abutments. It was considered that a full-scale bridge would collapse similarly to the 1:4 scale model.

L1543

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
MODEL TESTS ON THE DEMOLITION OF ANTI-TANK OBSTACLES. June 1942, 4p. incl. illus. diagrs. (Note no. MOS/113/FNS) Confidential

The investigation was made to evolve a method for producing a gap 12 ft. wide in antitank obstacles consisting of concrete walls 6 ft. high, 6 ft. thick and up to 40 ft. long. The specimens were prepared to a scale ratio of 1 to 4.8. It was concluded that 6 60 lb. contact charges, suitably disposed, together with 2 shaped "V" strip charges would demolish the concrete and cut the reinforcement in the attack face. Three shaped charges, each containing 30 lb. of explosive, followed by plugging of the resulting holes with prepared tubes of explosive would demolish the concrete. Strip charges would be necessary to cut the reinforcing bars.

L1544

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
MEASUREMENT OF THE VELOCITY OF THE AXIAL SPURT THROUGH TARGET PLATES FROM THE CS BOMB, TYPE D, FIRED ON 14/7/42. July 1942, 2p. diagr. (Note no. MOS/119/WGM; AC 2592, Aug. 25, 1942; SC 4/20) Secret

The movement, through 4 steel plates, of the spurt from this 38-in. diameter bomb was recorded photographically. The spurt as far as plate 3 was much faster than that from the previous round fired in May, 1942. The velocity between plates 2 and 3 was 7,200 ft./sec. compared with 3,800 ft./sec. previously. Beyond plate 3 the spurt slowed down considerably; no luminous material reached the center of plate 4 until 11 msec. after initiation. Plate 4 was not penetrated centrally until 12 msec. after initiation, the emergent stream having a velocity of 1,800 ft./sec.

L1545

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
1ST INTERIM REPORT ON USE OF HOLLOW-CONED CHARGES AGAINST PROTECTED PILL-BOXES. METHODS OF PROTECTION. Dec. 1942, 6p. incl. illus. diagrs. (Note no. MOS/187/FNS; Inclosure A to NA London rept. no. 178-43) Confidential

Model tests were made to determine a suitable method of protecting reinforced concrete pillboxes against attack by a 75-lb. shaped charge. Complete protection against 1 charge was afforded by a layer of good quality gravel or broken stone 3 ft. thick held in position on the wall faces by wooden boards. If more than 1 shaped charge is likely to be detonated at or near the same position, it is necessary to reinforce the gravel.

L1546

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
2ND AND FINAL REPORT ON THE USE OF HOLLOW-CONED CHARGES AGAINST PILL-BOXES PROTECTED BY GRAVEL. SMALL-SCALE AND FULL-SCALE TESTS. Nov. 1943, 5p. incl. diagrs. (Note no. MOS/291/JH; AC 5415, Jan. 6, 1944; SC. 68; C. 72; OSRD Liaison Office WA-1682-5) Secret

A model slab of reinforced concrete 3 ft. square and 7.7 in. thick with a 1 in. cubical mesh reinforcement wire was covered with a layer 4.6 in. thick of flint gravel. Tests with models of shaped charges containing 75, 100, 125, and 150 lb. of explosive fired against the wall indicated that the 150-lb. charge would be required to perforate the wall. Full-scale tests against a German type of pillbox of reinforced concrete with walls 5 ft. thick and reinforced with 9-in. cubical mesh of mild steel bars showed that a 75-lb. Beehive perforated the 12-in. thick reinforced concrete retaining wall and the 3 ft. of gravel and penetrated 32 in. into the 5-ft. thick pillbox wall. Except for slight cracking on the side of the embrasure nearest the charge, there was no damage visible within the pillbox. The nesting-type Beehive filled with plastic 808 Gelignite perforated the 12-in. thick retaining wall and the 5-ft. thick pillbox wall. A small amount of debris was projected into the pillbox interior.

L1547

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
THE FRAGMENTATION OF A 5-OZ. HOLLOW-CONED CHARGE. Jan. 1943, 5p. incl. tables, diagrs. (Note no. MOS/197/GBT; AC 3379, Feb. 18, 1943; SC.1; OSRD Liaison Office WA-507-38) Confidential

Three 5-oz. brass-lined (80° apex angle) shaped charges were fired and the fragments collected in telephone directories at a distance of 24 ft. in order to determine the distribution, average velocity, and average weight of the fragments. The fragments passing through and from the rear of a 3/8-in. mild steel plate attacked by a similar 5-oz. charge were also collected in telephone directories. Results illustrating the behavior of the fragments are tabulated.

L1548

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
PRELIMINARY TRIALS WITH MODEL FOLLOW-UP BOMB. ESTIMATION OF BLAST EFFECT AT REAR OF HOLLOW-CONED CHARGE. Jan. 1943, 3p. (Note no. MOS/195/JH; AC 3675, Mar. 17, 1943; SC.8; OSRD Liaison Office WA-528-13) Secret

A target was attacked by a compound bomb consisting of a shaped charge of sufficient size to perforate a target and a thick-walled bomb supported at the rear of, and axially in line with the main shaped charge. It was found that the effective blast pressure was small and that better results might have been obtained if the follow-through bomb had been held in a tube behind the main charge and not merely supported by a wire frame.

L1549

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
1ST INTERIM REPORT ON THE MULTIPLE JET AIRCRAFT BOMB. ATTACK OF MS PLATES BY 1:5 SCALE HC CHARGES FIRED STATICALLY. Mar. 1943, 4p. incl. illus. diagrs. (Note no. MOS/208/JH; AC 4567, Aug. 13, 1943; SC.44) Confidential

Scale model shaped charges (5 oz.) with 1/16 in. thick turned brass liners were fired against 3/8-in. thick mild steel plates to examine the possibility of perforating a 20-mm. thickness of I. T. 80 armor plate at a range of 120 ft. The scaled charges produced a small number of perforations in the target plate.

L1550

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
2ND REPORT ON THE MULTIPLE JET AIRCRAFT BOMB. ATTACK OF ARMOR PLATE BY FULL-SCALE HOLLOW CONED CHARGES FIRED STATICALLY. SOME CONSIDERATIONS OF THE DESIGN OF THE MULTIPLE JET BOMB. July 1943, 22p. incl. illus. diagrs. (Note no. MOS/248/JH; AC 4568, Aug. 13, 1943; SC.45; OSRD Liaison Office WA-888-6) Confidential

The possibilities were examined of designing a bomb with several lined cavities on its underside, and fitted with a proximity fuse designed to operate when the bomb is 100 ft. above ground level. Experiments made on the attack of I. T. 80 armor plate 20 mm. thick, using single shaped charges containing 40 lb. of 25/75 PETN/TNT and fired statically at a range of 120 ft., showed that 2 such charges produced a large number of perforations in the target plates. Measured initial fragment velocities of the liners were of the order of 13,000 to 14,000 ft./sec.; the striking velocities at the target, 120 ft. distant from the charge, were of the order of 11,000 ft./sec. for the leading fragments. A model multiple jet bomb was fired statically, and it was found that each liner, independently of the others, caused approximately the same penetration into a reinforced concrete target at short range as would a single charge fitted with a similar liner. A statistical examination was made of the expectation of vehicles damaged by a bomb striking the target area.

L1551

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
COMPARISON OF CRATERS CAUSED IN MASSIVE REINFORCED CONCRETE BY "GENERAL WADE" AND PLASTER CHARGES OF EQUAL CONTACT AREA AND EQUAL WEIGHT. Feb. 1944, 5p. incl. illus. (Note no. MOS/312/JH.RK; AC 5714, Feb. 17, 1944; C.90; OSRD Liaison Office WA-1664-3) Secret

A comparison was made of the craters caused in massive reinforced concrete by General Wade and square plaster charges of uniform thickness, with the same weight and area of contact, and each filled with 25 lb. of 351 and 852 explosive. No significant difference was noted between the maximum depths of craters caused by the 2 types of charge though with each filling it appeared that the plaster charges caused craters of greater estimated volume than those of the General Wade charges.

L1552

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
DEMOLITION OF A VAULT ARCH, FILLED SPANDREL, REINFORCED CONCRETE BRIDGE. REVIEW OF WORK CARRIED OUT TO DEC., 1943 ON SCALE MODELS. Feb. 1944, 3p. (Note no. MOS/313/JH; AC 5718, Feb. 17, 1944; OSRD Liaison Office WA-1664-6) Secret

Four Road Research Laboratory notes (MOS/166/FNS, MOS/262/FNS, MOS/290/JH, and MOS/301/FNS) dealing with the demolition of concrete by Hayrick and General Wade charges are briefly summarized.

L1553

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
NOTE ON RELATIVE PERFORMANCE OF "GENERAL WADE" AND PLASTER CHARGES. SUMMARY OF US, OAC, AND RRL RESULTS. Feb. 1944, 1p. (Note no. MOS/316/MCF; AC 5742, Feb. 17, 1944; C.97; OSRD Liaison Office WA-1711-12) Secret

Brief summaries are given of: (1) US Engineer Board tests to determine the effectiveness of a General Wade charge as compared with a tetrytol pack; (2) OAC tests to compare the effect of General Wade and plaster charges; and (3) RRL tests to compare the craters caused in massive reinforced concrete by General Wade and plaster charges.

L1554

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
THE BREACHING OF AN EARTH-BACKED CONCRETE SEAWALL BY CONTACT CHARGES. TESTS ON A 1:6 SCALE MODEL. Apr. 1944, 2p. illus. diagrs. (Note no. MOS/327/RK.JH; AC 5966, Apr. 3, 1944; C. 114; OSRD Liaison Office WA-2096-4) Secret

Tests were made on model sea walls to determine the disposition of charges necessary to cause tank-negotiable breaches. General Wade, Dustbin, and plaster charges were used, only the first of which is a shaped charge. Test results are shown diagramatically. A charge of 1600 lb. of PE no. 2 formed in an inverted "U", and another of 2,000 lb. arranged in 2 rectangular charges were thought to have caused satisfactory breaches.

L1555

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
THE BREACHING OF AN EARTH-BACKED MASONRY SEAWALL BY CONTACT CHARGES. TESTS ON A 1:6 SCALE MODEL. Apr. 1944, 2p. illus. diagrs. (Note no. MOS/335/RK.JH; AC 5966, Apr. 3, 1944; C. 114; OSRD Liaison Office WA-2096-4a) Secret

Tests were made on model sea walls to determine the disposition of charges necessary to cause tank-negotiable breaches. General Wade, Dustbin, and plaster charges were used, only the first of which is a shaped charge. Good agreement was found between the 1:6 scale tests and full-scale tests, but the face shatter below the charge was appreciably less on the model scale. Test results are tabulated.

L1556

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
EXPERIMENTS WITH LARGE HOLLOW CONE CHARGES DETONATED AGAINST REINFORCED CONCRETE. PRELIMINARY TESTS AT HANKLEY COMMON. Apr. 1944, 4p. incl. diagrs. (Note no. MOS/338/FNS; AC 6251, May 3, 1944; C. 125; OSRD Liaison Office WA-2136-6) Secret

Tests were made with shaped charges containing 30, 35, and 70 lb. of 60/40 RDX/TNT detonated against the front face of a massive and lightly reinforced concrete wall. Liners of cold pressed steel and brass, and hot pressed steel were used. No significant difference was noted in penetration produced by charges with these liners.

L1557

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
REPORT BY MR. F. N. SPARKES ON HIS VISIT TO THE UNITED STATES OF AMERICA AND TO CANADA, JAN. 1944, by F. N. Sparkes. Apr. 1944, 20p. diagr. (Note no. MOS/332/FNS; AC 6296, May 18, 1944) Secret

Discussions were held at several US military and scientific institutions, at the Canadian National Research Council, and at Petawa Camp. It was concluded that the results of work by Americans and British on shaped charges agreed generally except that the American conical liner in Beehive charges was about 0.5 the thickness of British liners. The American and British formulas for the depth of penetration of shot into concrete gave about the same results.

L1558

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
COMPARISON OF CUTTING EFFECTS OF FLAT AND SHAPED CHARGES OF EXPLOSIVE. May 1944, 7p. incl. tables. (Note no. MOS/356/LGS; AC 6599, June 30, 1944; C. 156; OSRD Liaison Office WA-2539-1) Secret

Tests were made to compare the performance of flat, slightly dished, and grooved charges in cutting heavy mesh reinforcement of concrete slabs. The tests showed that there was no noticeable difference in the damage resulting from either flat or shaped charges in contact with the target. A slightly dished charge destroyed and cut the most steel but the improvement was not marked.

The shaped charge appeared to focus the effects of the explosive, and as a result formed deeper craters than did the flat charge.

L1559

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
EFFECT OF SHAPED CHARGES ON PILLBOXES. TRIALS WITH 50-LB. AND 100-LB. "BEEHIVE" CHARGES. May 1944, 8p. incl. tables, diagrs. (Note no. MOS/349/FNS. JH; AC 6297, May 15, 1944; C. 136; OSRD Liaison Office WA-2174-8) Secret

Tests were made with Beehive charges against reinforced concrete 5 ft. and 6 ft. thick to determine the effect on personnel behind the walls. Charges with a total weight of 50 lb. perforated the 5 ft. thick reinforced pillbox wall and scattered about 200 lb. of debris inside the pillbox. No significant difference was noted in the performance of the 30/50 lb. (30 lb. explosive and 50 lb. total weight) and of the 35/50 lb. charge. Results are shown for the 70/100 lb. charge.

L1560

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
THE USE OF PLASTIC PROTECTIVE PLATING TO REINFORCE EXISTING STEEL ARMOR ON LIGHTLY ARMORED AFV'S. May 1944, 5p. (Note no. MOS/351/DBW; OSRD Liaison Office WA-2205-1) Secret

Tests were made with a shaped charge copied after the German 3-cm. antitank grenade, and with AP shot, to compare the efficiency of PPP [Plastic Protective Plating] and machineable quality armor plate when used in front of an existing steel armor protection. The few tests carried out with shaped charges showed that the PPP gave better protection than an equal weight of steel armor.

L1561

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
PRELIMINARY TESTS ON THE BEHAVIOR OF CONCRETE IN PENETRATION TESTS. July 1944, 8p. incl. illus. (Note no. MOS/373/HLDP. ACJ; AC 6771. Aug. 10, 1944; C. 174; OSRD Liaison Office WA-2797-16) Secret

Shaped charges (0.75 in. diameter, 0.85 in. long with an 80° brass liner, 0.02 in. thick) were detonated at various distances from concrete blocks 6 in. square by 1.5 in. thick. With plain concrete at 2.25-in. standoff, the target was broken into several pieces, while with reinforced concrete at 5.2-in. standoff, 6 radial cracks were made, some reaching the edge of the specimen. Other results are indicated. Tests on glass targets showed more severe cracking and pulverization than with the concrete. A section is included on movement of concrete during penetration.

L1562

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
4TH INTERIM REPORT ON FULL-SCALE TESTS ON STANDARD WALLS FOR THE ANTI-CONCRETE COMMITTEE. THE USE OF GENERAL WADE CHARGES. Aug. 1944, 5p. incl. illus. (Note no. MOS/387/FNS. JH; AC 6765, Aug. 5, 1944; C. 172; OSRD Liaison Office WA-2797-14) Secret

Two tests were made using 64 General Wade charges on the face of a 10-ft. thick medium wall. In 1 test the charges were initiated by a Cordtex ring main and no. 27 detonators; in the other case special clips and detonators normally issued with these charges were used. In both cases the charges produced a gap which could not be negotiated by a Sherman tank.

L1563

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
7TH INTERIM REPORT ON FULL-SCALE TESTS ON STANDARD WALLS FOR THE ANTI-CONCRETE COMMITTEE. FURTHER TESTS WITH GENERAL WADE CHARGES. Dec. 1944, 6p. incl. illus. (Note no. MOS/417/JH; AC 7541; C. 211; OSRD Liaison Office WA-3730-12) Secret

Tests were made on a 10-ft. thick medium wall and on a 6-ft. thick heavy wall using 52 General Wade charges arranged in vertical rows on the face of the wall. The gap produced in the 10-ft. wall could not be negotiated by a Sherman tank; the gap in the 6-ft. wall was negotiated with difficulty by the tank. It was concluded that the General Wade charges were not suitable for breaching thick walls or walls containing very heavy reinforcement.

L1564

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
INVESTIGATION INTO THE USE OF PLASTIC PROTECTIVE PLATING TO REINFORCE TANK ARMOR AGAINST ATTACK BY SHAPED CHARGES. Aug. 1944, 2p. (Note no. MOS/389/DBW; OSRD Liaison Office WA-2684-3) Secret

A small number of tests are reported which were to determine: (1) how English plastic containing coal tar pitch compared with American plastic; (2) whether the use of a mild steel backing plate improved the plastic efficiency; and (3) how the plastic targets compared in efficiency with an equal weight of mild steel or armor steel.

L1565

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
DETERMINATION OF PERFORMANCE AGAINST REINFORCED CONCRETE OF HC DEMOLITION CHARGE NO. 6 MARK I (16/25 LB. "BEEHIVE"). Nov. 1944, 6p. incl. diagrs. (Note no. MOS/413/FNS. AHP; AC 7543; C. 213; OSRD Liaison Office WA-3305-15) Secret

Tests were made to determine the performance and penetration of the HC demolition charge no. 6 Mark I. The charges were fired against reinforced concrete targets 42, 54, and 72 in. thick. The 42- and 54-in. targets were both perforated, but the 72-in. targets resisted perforation and gave ultimate penetrations of 39 and 44 in.

L1566

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
A COMPARISON BETWEEN STEEL, PLASTIC PROTECTIVE PLATING, AND NATURAL AGGREGATES WHEN USED AS REINFORCEMENT FOR EXISTING STEEL ARMOR AGAINST HOLLOW CONE CHARGE ATTACK. Dec. 1944, 4p. tables, diagrs. (Note no. MOS/419/DBW. AHP; OSRD Liaison Office WA-3596-5) Secret

Tests were performed to compare the efficiencies of Plastic Protective Plating (PPP) and dry aggregate, e. g., sand with those of mild steel and steel armor when used to reinforce existing armor against shaped charge attack. PPP fixed in contact with armor gave more efficient protection than steel armor or mild steel of equal weight/unit area. Approximately 0.4 lb. of PPP gave a reduction in penetration equal to that given by 1 lb. of steel armor. On a thickness comparison, 1 in. of steel armor was equivalent to 1.5 in. of PPP. Dry aggregates were slightly less efficient than PPP when considered on a weight basis. Gravel made up of large particles appeared to be slightly more efficient than sand and smaller gravel. The use of a skirting plate reduced the chances of serious penetration. No significant difference in penetration could be detected between PPP, steel armor, or mild steel when used as the skirting plate.

L1567

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
THE PERFORMANCE OF NESTING BEEHIVES AGAINST CONCRETE TARGETS. TESTS WITH MODIFIED BEEHIVES. Dec. 1944, 6p. incl. diagrs. (Note no. MOS/418/JH. RK; AC 7542; C. 212; OSRD Liaison Office WA-3605-14) Secret

Experiments were made with pairs of no. 11 demolition charges nested together and fired against massive reinforced concrete to find if the formation of a double hole in the target could be eliminated by making simple modifications to the charges. Results showed that a 0.75-in. diameter hole in the liner apex prevented the formation of a double hole in the targets for amounts of malalignment within the limits expected between pairs of charges of this type if the 2 charges were firmly nested together. A provision for centering bands (to ensure good alignment) resulted in the formation of single holes in the target.

L1568

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
THE BREACHING OF EARTH-BACKED REINFORCED CONCRETE ANTITANK WALLS. MODEL TESTS ON STANDARD WALLS. Jan. 1945, 3p. illus. tables, diagrs. (Note no. MOS/426/LGS. RK; AC 7766; C. 223; OSRD Liaison Office WA-3926-2) Secret

Combinations of plaster charges and Beehives were used for model tests. It was concluded that the type of earth or clay backing affected the shape and quantity of explosive required.

L1569

Road Research Laboratory, Department of Scientific and Industrial Research (Gt. Brit.).
THE PERFORMANCE AGAINST REINFORCED CONCRETE OF MODIFIED HC DEMOLITION CHARGES NO. 6. (16/25 LB. "BEEHIVE"). July 1945, 4p. incl. table, diagr. (Note no. MOS/461/JH; AC 8441; C. 251; OSRD Liaison Office WA-5206-8) Secret

Tests were carried out on a reinforced concrete shelter to determine the penetration into concrete of the Beehive. A slight increase in penetration was obtained with charges fitted with an inert (wood) core in the filling. No such increase was obtained when an Ammonal core was used. It appeared that a slight reduction in penetration was caused by the use of a cast TNT core.

L1570

Roos, J. A.
SHAPED CHARGE HELPFUL IN PLACER DRILLING TESTS. Engineering and Mining Journal, v. 148, Jan. 1947: 73.

Experiments made with a small shaped charge formed in hand-shaped plaster of Paris and wet sawdust casts, and with a larger charge shaped around small tinned cans, are reported.

L1571

Royal Aircraft Establishment (Gt. Brit.).
ASSESSMENT OF AN ANTITANK GUIDED WEAPON, by D. G. King-Hele, C. L. Barham, and N. K. Walker. Jan. 1952, 27p. diagrs. (Technical note no. GW 157) TIP S2401 Secret

Designs and calculated performance are reported for a guided antitank weapon. A missile of about 200 lb. over-all weight, 4000-yd. range, 3-ft. wing span, and 7-ft. length is assumed capable of meeting requirements for destructive power, range, weight, and size. Initial simulator tests and theoretical approximations indicate target accuracies of 90%. The designs include missiles with moving wings and stabilizing fins, or fixed wings and tail-control surfaces. The possible use of a small missile with a shaped charge warhead similar to that of the French antitank weapon SS10 is also briefly discussed.

L1572

Royal Aircraft Establishment (Gt. Brit.).
A VISIT TO SOME FRENCH RESEARCH ORGANIZATIONS IN DECEMBER, 1951, WITH SPECIAL REFERENCE TO THE GUIDED ANTI-TANK WEAPON ENTAC, by C. L. Barham. Mar. 1952, 12p. diagrs. (Technical note no. GW 173) TIP S2685 Secret

ENTAC, Engin Télé-commandé Anti-Char, an antitank, wire-guided missile similar to the SS10 is described. ENTAC specifications call for:
(a) 1600-yd. range
(b) 12- to 14-in. penetration of armor plate
(c) target crossing speed of 45 m.p.h.
(d) accuracy better than ± 1 m. at 1500 m.
(e) 26-lb. weapon weight.
The 6-in. diameter warhead of the shaped charge type weighs 10 lb. and contains a trumpet shaped liner. Penetrations of 18 in. into armor plate (type or hardness not specified) are claimed. It is stated that the missile's double contact fuze will function at obliquities up to 70°, penetrating plate 6 in. thick. Since the missile is in the development stage, only a few rounds have been fired. In an appendix, mention is made that hollow charge and flash radiographic work are being carried out at Saint-Louis, France under the direction of Major DeFrance.

L1573

Safety in Mines Research Station, Buxton, Eng.
SHAPED CHARGES. IX. THE END EFFECT (MUNROE AND SOLID CONE), by W. Payman. Nov. 1941, 8p. incl. illus. diagrs. (Rept. no. E.16; AC 1429, Nov. 25, 1941; Phys/Ex. 194; OSRD Liaison Office W-92-32) Confidential

Tests on solid and shaped charges are reported. The topics discussed include the difference between axial and lateral effects, end effect, shape of the detonation wave, luminescence of the jet, and penetration of Pb plates.

L1574

Safety in Mines Research Station, Buxton, Eng.
SHAPED CHARGES. X. EXAMINATION OF A 5-IN. MILD STEEL PLATE PERFORATED BY HOLLOW-CONED CHARGE, by J. H. Andrew and others. July 1942, 17p. incl. illus. diagrs. (Rept. no. E.43; AC 2837, Sept. 1, 1942; Phys/Ex. 314; SC4/22; OSRD Liaison Office WA-259-22) (In cooperation with Department of Metallurgy, Sheffield University) Secret

When a 10- x 10- x 5-in. mild steel plate was examined after being perforated by a shaped charge of PE, the hole surface in the plate had been melted and the heating effects had penetrated the material beyond this surface. Measurements showed that 45% of the metal from the hole had been displaced to a position surrounding the hole causing deformation and bulging of the plate.

L1575

Safety in Mines Research Station, Buxton, Eng.
SHAPED CHARGES. XI. THE SHAPE OF THE DETONATION WAVE AND ITS CONTROL, by D. W. Woodhead. Aug. 1942, 5p. incl. illus. (Rept. no. E.47; AC 2743, Sept. 23, 1942; Phys/Ex. 320; SC4/28; OSRD Liaison Office WA-300-25 and WA-271-34) (Incomplete report.) Confidential

The effect of variations in dimensions of the charge on the shape of the wave reaching the end of the cartridge was examined photographically using Al Rounkol cartridges. Two methods of procedure are discussed in which the Buxton high speed revolving mirror camera was used in each case. Experiments were performed also to study the effect of position of the point of initiation.

L1576

Safety in Mines Research Station, Buxton, Eng.
SHAPED CHARGES. XIV. THE END EFFECT. II. SECOND INTERIM REPORT ON PHOTOGRAPHIC INVESTIGATION, by D. W. Woodhead and W. B. Cybulski. Aug. 1943, 8p. incl. illus. (Rept. no. E.89; AC 4762; Phys/Ex. 479; SC.52; S.E. 184; OSRD Liaison Office WA-1019-16) Confidential

A part of this rept. describes the photographic methods in use at Buxton for investigating the end effect from shaped charges. Results are presented which show how the shape of the end of cylindrical cartridges influences: (a) the velocity of the luminous effect and (b) the shape of the disturbance sent out from that end. A table shows velocities of the luminous effect.

L1577

Safety in Mines Research Station, Buxton, Eng.
SHAPED CHARGES. XV. THE END EFFECT. III. VELOCITY OF LUMINOUS EFFECT WHEN CONFINED IN A CYLINDRICAL TUBE, by W. B. Cybulski and D. W. Woodhead. Dec. 1943, 2p. incl. table. (Rept. no. E.100; AC 5479; Phys/Ex. 506; SC. 64; SE. 210) Secret

Tabular data from tests with cast cartridges of CE/TNT 40/60, 1.25 in. in diameter, 13 in. long, and having a density of 1.62, showed that there was no significant difference in the speed of the luminous effect in the open and along glass and cellophane tubes.

L1578

Safety in Mines Research Station, Buxton, Eng.
SHAPED CHARGES. XVIII. COMPOSITE CHARGES. II. CARTRIDGES WITH AXIAL CYLINDRICAL CAVITIES, by W. B. Cybulski and D. W. Woodhead. Jan. 1944, 10p. incl. illus. tables. (Rept. no. E.102; AC 5520; Phys/Ex. 508; SC. 66; OSRD Liaison Office WA-2146-11) Secret

A photographic study was made of the detonation traveling along the surface of a holed or annular charge, and also of the luminous effects which travel inside the cavity, and of those which are projected from its open end. The detonation wave traveled along a charge with an axial cavity at a rate greater than that at which it moves along the solid charge. Heated products of detonation traveled down the cavity at a rate which was much higher than that of detonation. The luminous effect eventually lost speed after a distance which was shorter for narrow than for wider cavities. The speed of the luminous effect from the open end of the cavity was usually greater than that from the solid cartridge, but was lower with deep cavities because of the progressive decay of the effect within.

L1579

Safety in Mines Research Station, Buxton, Eng.
SHAPED CHARGES. XVIII. COMPOSITE CHARGES. III. PRESSED CE WITH CLOSED CYLINDRICAL CAVITIES, by W. B. Cybulski and D. W. Woodhead. July 1944, 6p. incl. illus. (Rept. no. E.103; Inclosure 1 to MA London rept. no. 507-44; AC 6999; Phys/Ex. 589; SC. 67; OSRD Liaison Office WA-3005-15) Secret

A strong disturbance propagated along a hollow tube closed with an explosive pellet in a detonating HE cylindrical charge resulted in the setting up of detonation in the pellet provided the explosive was sufficiently sensitive and the tube not too long. Two new waves were initiated at the far end of the hollow and traveled in opposite directions through the remainder of the charge. A Dautriche effect occurred at the point where the wave which traveled backwards collided with the original detonation wave still advancing through the annular body of the cartridge. It was concluded that detonation time of a cartridge could be shortened by means of a succession of hollows.

L1580

Safety in Mines Research Station, Buxton, Eng.
SHAPED CHARGES. XIX. THE END EFFECT. IV. SPEED OF LUMINOUS EFFECT FROM A PLANE-ENDED CARTRIDGE OF PETN, by W. B. Cybulski. Dec. 1944, 4p. incl. tables, diagr. (Rept. no. E.133; AC 7550; Phys/Ex. 610; SC. 130; Inclosure 1 to MA London rept. no. R424-45) Secret

A method was developed by Dr. H. Jones by which the equation of state of the gaseous products of detonation could be partly determined for certain explosives rich in O. This method was applied to PETN, and the initial air shock-wave velocity from cartridges of 2 different densities was calculated. This calculation was confirmed experimentally.

L1581

Safety in Mines Research Station, Buxton, Eng.
SHAPED CHARGES. XXII. THE FORMATION OF MACH OR BRIDGE WAVES. III. SINGLE CONE-ENDED CYLINDERS, by D. W. Woodhead and R. Wilson. Mar. 1945, 7p. incl. illus. diagrs. (Rept. no. E.143; AC 8008, Mar. 30, 1945; Phys/Ex. 633; SC. 143; OSRD Liaison Office WA-4317-1c) Secret

The development of a Mach wave from a cylindrical charge of explosive with a cone end is described.

L1582

Safety in Mines Research Station, Buxton, Eng.
SHAPED CHARGES. XXIV. COMPOSITE CHARGES. IV. CAST TNT AND CE/TNT WITH CLOSED CYLINDRICAL CAVITIES, by W. B. Cybulski and D. W. Woodhead. Apr. 1945, 6p. incl. illus. diagrs. (Rept. no. E.151; AC 8408; Phys/Ex. 660; SC. 153; OSRD Liaison Office WA-5101-17) Secret

Immediate pre-ignition did not always occur with explosives which had a sensitivity lower than that of pressed CE when the intense disturbances propagated along a hollow tube in a detonating cylindrical charge arrived at the closed end. In a series of CE/TNT cast mixtures the tube gave rise to a range of results varying from immediate setting up of detonation to complete extinction. Immediate initiation could be ensured when desired in the less sensitive explosives by the insertion of a pellet of pressed CE at the bottom of the hollow tube.

L1583

Safety in Mines Research Station, Buxton, Eng.
SHAPED CHARGES. XXVI. THE FORMATION OF MACH OR BRIDGE WAVES. V. TWIN PLANE-ENDED CYLINDERS WITH PARALLEL AXES, by D. W. Woodhead and R. Wilson. Aug. 1945, 10p. incl. illus. diagrs. (Rept. no. E. 158; Inclosure 1 to MA London rept. no. R5329-45; AC 8596; Phys/Ex. 671; SC. 162; OSRD Liaison Office WA-5442-6) Confidential

A study was made of the mode of interaction of converging shock waves in twin plane ended cylinders as distinct from the diverging systems which arise from single cylinders. Charts were drawn of the complex Mach wave system which developed in the region between 2 unconfined cylinders of cast explosive when detonated. Instances of self-luminosity in a shock wave were observed.

L1584

Safety in Mines Research Station, Buxton, Eng.
SHAPED CHARGES. XXVII. THE FORMATION OF MACH OR BRIDGE WAVES. VI. OBLIQUE ARRANGEMENTS OF PAIRS OF CYLINDERS. VII. SUMMARY OF PARTS I-VI, by D. W. Woodhead and R. Wilson. Nov. 1945, 10p. incl. illus. diagrs. (Rept. no. E. 163; Inclosure 1 to MA London rept. no. 761/46; AC 8650; Phys/Ex. 683; OSRD Liaison Office BC-923) Confidential

Charts were drawn of the complex bridge (or Mach) wave system in the region between 2 cylinders of cast explosive, detonated simultaneously and unconfined, when the cylinders have oblique ends, and when they have plane ends arranged obliquely. A summary is given of the general photographic study of Mach or bridge waves occurring in the wave systems from single and from twin charges of explosive when detonated unconfined.

L1585

Safety in Mines Research Station, Buxton, Eng.
SHAPED CHARGES. XXVIII. THE END EFFECT. V. PLANE-ENDED CYLINDERS OF CAST 30/70 CE/TNT, by D. W. Woodhead. July 1948, 18p. incl. illus. tables, diagrs. (Rept. no. E. 181; Inclosure 1 to MA London rept. no. R7269-48) Confidential

Measurements were made by a photographic method of the initial velocities, and the velocities over 5-cm. intervals up to a distance of 75 cm., of the shock wave from the ends of plane ended cylinders in various diameters and lengths and detonated unconfined. Previously, it had been found that the magnitude of the pressure on the axis, as measured by a piezoelectric gage, was below the values calculated from the measured wave speed by means of the Rankine-Hugoniot relationship. It was concluded, from a further investigation of the end effect, that the use of a theoretical relationship to calculate the pressure in a shock wave of measured speed led to erroneous results when the shock wave was not freely expanding.

L1586

Safety in Mines Research Station, Buxton, Eng.
CONTROLLED AND DIRECTIONAL FRAGMENTATION. II. EFFECT ON (A) THICKNESS OF PLATE AND (B) DESIGN OF CHARGE, by H. Titman. June 1942, 2p. illus. (Rept. no. E. 38; AC 2363, July 17, 1942; Phys/Ex. 445; SD/FP. 17; SC4. 14; OSRD Liaison Office WA-188-16) Confidential

Experiments were carried out to increase the weight of fragments without decreasing their number. Previously, it was pointed out that the charge was designed to give a detonation wave as flat as possible in order to make the difference in time of arrival of the wave at the center and edge of the plate as short as possible. Experiments made to test the validity of this reasoning are reported.

L1587

Safety in Mines Research Station, Buxton, Eng.
CONTROLLED AND DIRECTIONAL FRAGMENTATION. III. TESTS OF COMPARATIVE DAMAGE CAUSED BY FRAGMENTS OF DIFFERENT SIZES, by H. Titman. July 1942, 2p. illus. (Rept. no. E. 41; AC 2364, July 17, 1942; SD/FP. 18; SC. 4. 15; OSRD Liaison Office WA-188-17) Secret

The number of fragments from a single shot could be varied from 1 disc weighing 575 g. to about 70 pieces of between 4. 0 to 7. 5 g. weight. Tests were made to determine the extent of the damage which these fragments could cause, and how the damage varied with particle size.

L1588

Safety in Mines Research and Testing Station, Buxton, Eng.
CONTROLLED FRAGMENTATION. XXVIII. APPLICATION OF GROOVED CHARGE PRINCIPLE TO SPIN-STABILIZED SHELLS. I, by H. Titman and T. W. Taylor. July 1949, [24]p. incl. illus. tables. (Rept. no. E. 185; Inclosure 1 to [MA London] rept. no. R3474-49) Confidential

The grooved-charge method of controlling fragmentation using fluted paper liners successfully developed with the 3-in. UP casing, was applied to gun shells. Results from 2 series of tests are discussed. A number of static firings were made to determine the efficiency of different types of liners with different pattern sizes. Gun tests were made for recovery and examination of shells filled with high-explosive substitute and fitted with liners of different materials and patterns. Static test results showed that the fragmentation of a gun shell having a cylindrical cavity could be successfully controlled within limits. The best control was obtained with grooves having a 75° apex angle. All the liners used caused fragmentation appreciably courser than natural fragmentation. Gun test results showed that all fluted Cu liners failed. The spin forces caused the flutes to be flattened, and together with set-back, caused considerable crumpling of the liner and charge. Results with fluted paper liners were encouraging. Of the 15 paper liners recovered, 1 was crumpled, 5 were only slightly or very slightly crumpled, and 9 were in good condition.

L1589

Sageb (Société Anonyme de Gestion et d'Exploitation de Brevet, Fribourg, Switzerland). EXPLOSIVE MISSILE. Bulgarian patent no. 4281; Category AI, class no. 4; Nov. 7, 1949.

The patent describes an explosive missile that can be used as a bomb, torpedo, grenade, or mine. The projectile contains several hollow bodies inside of its explosive charge which, under the action of pressure developing in the course of detonation, change in shape to become more and more condensed, striking the target with the accrued initial velocity of the shell. This increase of velocity is realized, according to the invention, by the distribution within the explosive charge of several detonators. The missile is actuated either by a nose fuze acting through a flash tube or by a rigid firing pin extending from the ogive to the base-detonating fuze.

L1590

*Saskatchewan U. (Canada).
OPTICAL INVESTIGATIONS OF INITIATION AND DETONATION, by G. Herzberg and G. R. Walker. (Proj. no. XR-84, in 5 parts dated Mar. 1945-Mar. 1949) Confidential

Measurements of detonation velocity have been made for several compositions with an accuracy of 0.1 to 0.2%. A Mach detonation wave is formed when 2 plane detonation waves intersect, providing that their directions of propagation differ by an angle which is less than some critical value. (Authors' abstract).

L1591

[School of Military Engineering (Gt. Brit.)].
ROAD CRATERING TRIALS CARRIED OUT AT USWORTH AERODROME. May 29, 1947, 16p. incl. illus. tables. (Rept. no. 2; Inclosure 1 to MA London rept. no. R3856-47) Restricted

Tests were made with 30-lb. nesting Beehives at standoffs up to 3 ft. for road cratering. The charges were unsatisfactory because the blast from the Beehive created a surface crater, and increased the work required to tamp the charge. Also, the loose debris blocked the main hole drilled by the Beehive. Tests were made with 6-in. Beehives at standoffs up to 3 ft. Holes up to 1.5 ft. in diameter were punched through the concrete and penetrated the ground to depths varying from 2.3 ft. to 4 ft. The bottoms of these holes were filled with loose rubble. The best penetration with least surface damage was obtained with a standoff of 1.5 to 1.75 ft.

*Reference not verified in the original

L1592

SHAPED CHARGE DEMONSTRATION A SUCCESS. Pit and Quarry, v. 42, Nov. 1949: 97-98+.

A new method of secondary blasting for reduction of boulders to crusher size was demonstrated by its inventor, L. S. Byers, at Logan quarry of the Granite Rock Co., Watsonville, Calif. The method consisted of placing a packaged charge of explosive upon boulders without mud-capping or artificial covering of any kind. The blasting effect was initiated within the package, or container, by use of apexes or planes so designed as to produce a plurality of explosive jets which created both a penetrating and ripping effect at their point of convergence. The majority of boulders, estimated to weigh from 1.5 tons to approximately 20 tons each, were broken to 100% crusher size at the first blow, with a noticeable absence of fines. Photographs show the results.

L1593

[Société Anonyme Belge de Méchanique et d'Armement].
ENERGA ANTITANK RIFLE GRENADE (MODEL 50). [1950], 15p. incl. illus. (Inclosure 3 to ORD-TRART-LR-239, Rept. on French and Belgian Developments Antitank Rocket Launchers and Rifle Grenades from US User Representative for Infantry) Secret

The Energa grenade weighs only 0.1 as much as a conventional 75-mm. projectile. This grenade is capable of perforating 200-mm. armor of Brinell Hardness no. 240 and easily defeats 100-mm. case hardened plates at 60° obliquity. In use against tank targets, the grenade usually causes fires. The Energa Model 50, fitted with a rigid monoblock tail unit, is very stable in flight even in wind gusts. At a range of 75 m., grenade groupings, 43 cm. x 40 cm., are common. Safety devices prevent premature detonation by drop or shock. In addition a hard rubber cap is used to protect the fuze against any deformation. New processes have provided improved grenade watertightness and protection of all its metal surfaces.

L1594

[Société Anonyme Belge de Méchanique et d'Armement].
THE ENERGA BLINDICIDE (MODEL 1950). [1950], 28p. incl. illus. diagrs. (Inclosure 4 to ORD-TRART-LR-239, Rept. on French and Belgian Development Antitank Rocket Launchers and Rifle Grenades from US User Representative for Infantry) Secret

The Energa Blindicide is an antitank weapon for use at ranges from 110 to 330 yd. The projectile perforates more than 200-mm. armor. Bursting on a skirting plate set in front of a thick armor plate, the projectile will perforate both of them. The Blindicide can be used for destroying not only tanks but trucks, armored trains, and various equipment. The projectile gives good results on masonery. A 600-mm. concrete wall is easily demolished or pierced.

L1595

Société Industrielle d'Entreprise et de Mécanique, France (Seine).
IMPROVEMENTS IN DEMOLITION CHARGES. (PATENT, GRADE 14-CLASS 3) (Perfectionnements aux charges de demolition. (Brevet d'invention, gr. 14-cl. 3)). French patent no. 921,405, May 7, 1947.

The invention claim states that demolition charges are improved by creating a cavity along the length of the explosive charge. It is also claimed that a liner of metal or some other substance increases the destructive effect. The claim is concerned only with linear charges.

L1596

[Source unknown].
MAKE-UP CHARGES. n.d., p. 5-11, Appendixes A, D, and E. (Inclosure 1 to MA London rept. no. 56711) Confidential

Brief descriptions are given of the 75-lb. Beehive, 6-in. Beehive, unit Hayrick, General Wade charge, and the pull igniter delay detonator,

L1597

[Source unknown].
EVIDENCE OF NUCLEAR TRANSMUTATION IN THE COURSE OF CERTAIN TYPES OF EXPLOSIONS OF NITRO COMPOUNDS, by Z. Fonberg. Nov. 14, 1949, 8p. incl. illus. diagrs. Unclassified

The explosion process was investigated. It is believed that "specially" shaped charges of certain nitro compounds exhibited evidence of nuclear transmutation due to the forces present in the course of an explosion. It is pointed out that "transmutation by means of explosion may create the possibility of producing comparatively large amounts of radioactive isotopes in a simple and inexpensive manner". Precautions to be taken in order to achieve the desired results are given.

L1598

[Source unknown].
SPECIFIC CONCENTRATION OF ENERGY AND ITS EFFECT IN THE COURSE OF EXPLOSION OF HOLLOW CHARGE, by Z. Fonberg. May 19, 1950, 3p. Unclassified

Consideration was given to a shaped charge in the form of a thick-skinned sphere in which initiation of the explosion took place simultaneously at all points of the outer surface. It is pointed out that the over-all increase of energy of large shaped charges seemed to be due to accentuated rearrangement of electronic structure of the atom rather than to the alteration of the nucleus. "The detonation of a large hollow charge will produce near the center of explosion a zone of low temperature which cannot be explained entirely by adiabatic expansion only, but rather infer the possibility of absorption of energy by residual atoms regaining their ground state after explosion. Action of radiant energy during explosion resulting in production of radioactive isotopes can be observed if appropriate elements will form the background for this action. Superficial observation of explosion of certain compounds arranged in hollow charges rather indicate large over-all increase of energy in comparison to detonation of the same amount of identical explosives as solid charges."

L1599

SOVIET ANTITANK CAPABILITIES. Intelligence Review, no. 187, Dec. 1951: 47-54. Secret

The Soviet Army employs a portable bazooka-type shaped charge weapon as the basic infantry antitank weapon. This weapon is believed to be a copy of the German Panzerfaust 250, although of greater range and accuracy. It is believed that this weapon should be capable of penetrating 8 in. of armor at 30° and 200 yd. The Soviets also are known to have a larger, wheeled, crew-served weapon which is believed to be a smooth bore, recoilless type that fires a fin-stabilized shaped charge round. No performance data are known. It is pointed out that Soviet shaped charge (HEAT) ammunition is all of the spinning type and is relatively inefficient.

L1600

SOVIET ANTITANK HAND GRENADES. Ordnance Intelligence Summary, v. 2, serial no. 8, May 15, 1951: 2-3. Confidential

Captured Soviet shaped charge hand grenades (Rpg 43 and Rpg 6) received by Aberdeen Proving Ground are described briefly. These grenades are used against tanks, armored cars, and armor plate shielding pill boxes.

L1601

Sprengstoff-Versuchs-Gesellschaft m.b.H., Berlin-Dahlem.
3.7-CM. SHAPED CHARGE GRENADE AND SHAPED CHARGE PROJECTILE DEVELOPMENT (3.7-cm. HL-Granate und HL-Geschossentwicklung). Mar. 31, 1943, 3p. (OTIB rept. no. 1249, Misc. 2 - In German) Unclassified

In an investigation to eliminate spin, tests were made with bottle-shaped liners to determine whether the penetration of the shell increased. Results were satisfactory, and an increase in penetration was noted for spin-free and spinning shells. Experiments were also conducted with egg-shaped grenades in which the charge was housed in a steel container, the latter floating in the outer shell of the grenade. Tests were made also with projectiles having rotating casing heads and bottle-shaped liners attached to the finned casing in such a manner that the air stream braked the finned casing, thus eliminating the spin.

L1602

Sprengstoff-Versuchs-Gesellschaft, m. b. H., Berlin-Dahlem.
INVESTIGATIONS CARRIED OUT ON THE 6.6 CUP-SHAPED ARMOR-PIERCING GRENADE FOR THE PURPOSE OF INCREASING THE ARMOR-PIERCING EFFECT (Untersuchungen an der 6.6 Schiessbecher Panzergranate zur Steigerung der Panzerbrechenden Wirkung). Oct. 16, 1944, 15p. tables, diagrs. (Rept. no. 146; Trans. as OTIB rept. no. 1149, 9p. incl. tables) Unclassified

The development and tests of bottle shaped liners for shaped charge armor-piercing shells for the 6.6 (cm.?) grenade launcher are reported. The effects of wall thickness and standoff were also studied.

L1603

Stanford Research Institute (DA-04-200-ORD-257).
STUDY OF LINER MATERIAL FOR SHAPED CHARGES, by T. C. Poulter. Progress rept. no. 1, July 1-Dec. 1, 1953. Dec. 18, 1953, 2p. (SRI proj. no. PU-863) Confidential

An X-ray diffraction technique was perfected for detecting crystal orientation segregation and mapping it with respect to the liner's surface in an attempt to account for the erratic performance of supposedly identical liners. Various liners were inspected by this method and striking differences were obtained. Firing tests will be conducted in an attempt to correlate the X-ray diffraction data with the actual shaped charge liner performance.

L1604

Stanford Research Institute (DA-04-200-ORD-257).
THE MECHANISM OF FLOW IN CONDENSED PHASES, by E. F. Poncelet. Feb. 15, 1954, 8p. illus. diagrs. (SRI proj. no. GU-863, Technical rept. no. 1) AD-29 642 Unclassified

Research was initiated to determine the effects of extreme pressure on the physical properties of shaped charge liner materials during jet formation. In support of this objective, a theoretical investigation was made of the mechanism of flow in condensed phases as developed by Dr. E. F. Poncelet. It is shown that the application of the theory of elasticity to the physical concept of the nature of condensed phases gives a complete understanding of the mechanism of flow and of the various phenomena associated with it (e. g. viscosity and rate of flow). No assumptions, such as the presence of "internal friction", are required. This study may eventually indicate the reasons for the erratic behavior of apparently identical shaped charge liners.

L1605

Stanford Research Institute (DA-04-200-ORD-257).
A STUDY OF LINER MATERIAL FOR SHAPED CHARGES; THE EFFECT OF CRYSTAL ORIENTATION ON JET FORMATION. Mar. 15, 1954, 12p. illus. diagrs. (SRI proj. no. GS-863, Technical rept. no. 2) AD-31 523 Confidential

A nondestructive X-ray diffraction method was developed for determining the crystal orientation pattern of a shaped charge liner. Correlation of this pattern with charge performance is being studied. This method was used to examine a 3 1/8-in. diameter, 42.5° liner drawn from a rolled sheet Cu blank and 3 3/8-in. diameter, 42.5° liner formed by deep drawing from a pellet instead of a rolled sheet. The liners were loaded into 846-g. C2 charges and fired into 5 3-in. steel blocks at 1.5 cone diameters standoff. The performance of these charges gave reasonably good agreement with the prediction based on X-ray diffraction orientation diagrams. In addition, 7 liners manufactured by various methods, were inspected and their performances predicted. These liners will be test fired at the Ballistic Research Laboratories and the correlations between prediction and performance obtained.

L1606

Stanford Research Institute (DAI-04-200-TC3-5204-ORD-(P)-1).
MISZNAY-SCHARDIN MINE. PART I. THEORY. PART II. EXPERIMENTAL. PART III. CALCULATIONS, by T. C. Poulter and E. F. Poncelet. Interim rept. no. 1, Jan. 15-May 15, 1953. June 1, 1953, 2v. incl. illus. tables. AD-13 748 Secret

The physics of the detonation process was studied to obtain design parameters and formulas for the construction of a land mine capable of penetrating any expected tank armor-plate thickness. Factors affecting the velocity imparted to a metal plate by an explosive were analyzed. Those appearing determinative were: (1) the impulse from the detonation zone of the over-all detonation process; (2) the impulse from the static-pressure portion of the deflagration zone between the detonation zone and the relief wave; (3) the impulse of the deflagration zone behind the relief wave due to self-confinement of the explosive; and (4) impulses resulting from external confinement of the explosive. An analysis of the effect of curvature of the detonation front on the detonation rate and a study of the theory of detonation showed that 3 conditions must be met to achieve a maximum plate velocity with a minimum of explosive: (1) the detonation must be concave and approach a curved metal plate normal to the convex surface; (2) the ratio (Q_v) of the volume of explosive to the volume of metal plate/unit area of explosive-to-metal interface must be a maximum at the edge of the liner to compensate for the lack of self-confinement at the charge periphery; and (3) the liner must be comparatively thin for a high Q_v ratio.

Charges of the theoretical design gave penetrations of up to 9 in. with a 1.5-lb. C3 charge and a 1/16-in., 4-in.-diameter steel liner with a 4-in. radius of curvature. (ASTIA abstract)

L1607

Stanford Research Institute (DAI-04-200-TQ3-5204-ORD-(P)-1).
MISZNAY-SCHARDIN MINE. PART IV. HOLE DIAMETER VS. PENETRATION, by T. C. Poulter and J. Burgess. Interim rept. no. 1. Dec. 31, 1953, 1v. incl. illus. diagrs. AD-35 058
Secret

Charges were fired using liners 0.125 and 0.062 in. thick in which the radius of curvature was varied in 8 steps from 3 in. to 8 in. An analysis of data from tests with these charges shows that it is possible to vary the hole diameter from 1 in. to more than 4 in. with corresponding penetrations into steel ranging from more than 10 in. to 1 in. An analysis of the relation of the volume of the hole to the curvature of the liners reveals that liners with small curvatures create holes by jet-type penetration, whereas liners with large curvatures cause high velocity slug-type penetration. (Contractor's abstract)

L1608

Sukharevskiĭ, M.
INVESTIGATION OF THE BRISANT ACTION OF EXPLOSIVES BY MEANS OF A CUMULATIVE WAVE (Issledovanie voprosa o vozmozhnosti uvelicheniía brizantnogo deistviía vzryvchatykh veshchestv metodom kumuliaťsionnoĭ volny). Tekhnika i Snabzhenie Krasnoĭ Armii (changed to Voina i Tekhnika), no. 170, Jan. 1925: 13-18; no. 177; Feb. 1925: 13-18.

Shaped charges and detonators are examined. The author disagrees with the Neumanns and explains the shaped charge effect as a result of heat formed by the colliding gas waves coming from opposite sides of the charge.

L1609

Sukharevskiĭ, M.
ABOUT THE PHENOMENA RESULTING FROM THE DETONATION OF HOLLOW CHARGES, AND THE PRACTICAL VALUE OF THE ADAPTATION OF THE PRINCIPLE OF THE HOLLOW BLASTING CHARGE IN BLASTING TECHNIQUES (O íavleniíakh, proiskhodíashchikh pri vzryve pustotelykh patronov, i o prakticheskom znachenii primeneniía prinťsipa pustotelykh patronov i zaríadov v podryvnoĭ tekhnike). Voina i Tekhnika, no. 253, Jan. 1926: 18-24.

Early work in the field of shaped charges is commented upon. The author's theory that heat is the primary cause of the shaped charge effect is repeated. Experiments with conical, square, and semicircular (hemispherical) cavities are reported, and it is concluded that hemispherical cavities give the deepest penetration. It is also concluded that the height of the cavity must not be greater than half the height of the charge.

L1610

Task Force 68, Atlantic Fleet.
APPENDIX FOURTEEN. REPORT ON DEMOLITION IN THE ICE FIELDS. 1947, [13]p. illus. tables, diagrs. (In Rept. of Operation Highjump, US Navy Antarctic Development Project 1947, v. 3, Confidential, TIP C95) Confidential

Demolition charges M2 and M3 and linear shaped charges were fired into bay ice in penetration tests conducted under Operation Highjump at the Bay of Whales in Feb. 1946. Tabular data, including weight of explosive, crater width and depth, standoff distance, liner material, etc., are given.

L1611

Technical and Engineering Division, Redstone Arsenal.
ENGINEERING ANALYSIS OF ANTITANK GUIDED MISSILE SS10, by A. H. Bryan and others. June 27, 1952, [78]p. incl. illus. tables, diagrs. TIP S2584 Secret

An engineering analysis was made of the French antitank guided missile SS10, a low-altitude, subsonic, rocket-propelled vehicle carrying a 6.5-in. shaped charge warhead weighing 6.6 lb.

L1612

Technical Division, Picatinny Arsenal.
EXAMINATION OF UNFIRED 75-MM. HOLLOW CHARGE HE SHELL, COMPLETE ROUND, OF GERMAN HOWITZER AMMUNITION (FMAM-330), by A. B. Schilling. First and final rept. Nov. 17, 1944 30p. incl. illus. tables, diagrs. (Technical rept. no. 1454) Confidential

An examination was made of a 75-mm. hollow charge HE shell for a German Howitzer. This semi-fixed round consisted of: (1) a point fuzed, thin-walled HE shell, loaded with a paper wrapped shaped charge, which contained a "U"-shaped liner; and (2) a short percussion primed brass-coated steel cartridge case containing a 5 zone propelling charge of discs of nitrocellulose-nitroglycerin sheet powder retained in the case by a pressed paper board closing cup.

L1613

Technical Division, Picatinny Arsenal.
LOADING CHARACTERISTICS OF 70/30 AND 65/35 CYCLOTOL, by P. B. Tweed. First and final rept. Jan. 3, 1945, 4p. incl. tables. (Technical rept. no. 1483) Confidential

An investigation was made to determine the effectiveness of the Cyclotols for shaped charges, using steel tubes containing M9A1 liners. Average depth of penetration data when these tubes were fired against 1-in. plates are given.

L1614

Technical Division, Picatinny Arsenal.
EXAMINATION OF UNFIRED AP RIFLE GRENADE, JAPANESE (FMAM-304), by A. B. Schilling. First and final rept. Jan. 10, 1945, 13p. incl. diagrs. (Technical rept. no. 1461) Confidential

An examination was made of the Japanese AP rifle grenade which consists of a forward cylindrical charge having attached, at the forward end, a hollow, blunt nose of sheet steel. Within the container is the shaped charge which has a steel liner 2.9 in. long with a 24° apex angle.

L1615

Technical Division, Picatinny Arsenal.
EXAMINATION OF UNFIRED 10.5-CM. (105-MM.) HOLLOW CHARGE HE SHELL, SHORT OGIVE, GERMAN (FMAM-467), by F. G. Haverlak. First and final rept. Jan. 13, 1945, 27p. incl. illus. diagrs. (Technical rept. no. 1481) Confidential

The complete assembly of the German 105-mm. hollow charge loaded HE shell consisted of a steel shell body having a bi-metal rotating band, a Zn die-cast nose threaded to the body, a superquick point fuze, a paper-wrapped hollow bursting charge of Cyclonite, and a conical liner and flash tube assembled in the charge. The flash tube was a 2 piece Al tube, approximately 3/8 in. in diameter and 11 13/16 in. long, extending in both directions from the liner apex. The apex angle was 30°. Between the forward surface of the liner flange and a shoulder in the shell nose were 2 paper charge liner washers and 2 fiber shell nose spacers used to hold the charge against longitudinal movement in the shell.

L1616

Technical Division, Picatinny Arsenal.
EXAMINATION OF UNFIRED 75-MM. HOLLOW CHARGE HE SHELL, COMPLETE ROUND, FOR GERMAN L.G. 40 (RECOILLESS) GUN (FMAM-411), by F. G. Haverlak. First and final rept. Jan. 18, 1945, 31p. incl. tables, diagrs. (Technical rept. no. 1487) Confidential

An examination is reported of a German hollow charge HE loaded shell which consisted of a point fuzed HE shell loaded with a charge of Cyclonite and wax having a steel liner, and a brass-coated steel cartridge case with plastic insert in the base. It contained a bagged propelling charge of nitrocellulose-DEGN propellant and igniter powders and a percussion primer.

L1617

Technical Division, Picatinny Arsenal.
EXAMINATION OF UNFIRED 15-CM. (150 MM.) HOLLOW CHARGE HE SHELL, GERMAN (FMAM-514), by A. B. Schilling. First and final rept. Jan. 19, 1945, 31p. incl. tables, diagrs. (Technical rept. no. 1480) Confidential

An examination was made of the complete assembly of the 15-cm. German hollow charge HE shell with a superquick point fuze. The liner used was fabricated from rimmed steel; an analysis of it, made at Watertown Arsenal, is reported.

L1618

Technical Division, Picatinny Arsenal.
EXAMINATION OF UNFIRED 75-MM. HOLLOW CHARGE HE SHELL COMPLETE ROUNDS FOR GERMAN PAK 40 GUN (FMAM-327 AND -458), by J. P. Wardlaw. First and final rept. Jan. 31, 1945, 38p. incl. tables, diagrs. (Technical rept. no. 1490) Confidential

An examination was made of the rounds which consisted of point fuzed HE shell loaded with lined shaped bursting charges. The shell bursting charge, consisting of Cyclonite and wax, was held in place laterally in the conical portion of the cavity by a black filler material; it was held against longitudinal movement by a plastic, a cork, and a steel washer assembled between the liner flange and a shoulder in the nose. The steel liner in the forward pellet of the charge had a rounded apex, and was 2.1 in. long with a 27° apex angle. The liner thickness varied from 0.09 in. at the flange to 0.06 in. at the apex. Crimped to the liner at the apex and extending to the rear was an Al flash tube.

L1619

Technical Division, Picatinny Arsenal.
EXAMINATION OF 10.5-CM. (105-MM.) HOLLOW CHARGE HE SHELL, TYPE C, (LONG OGIVE), GERMAN (FMAM-447), by F. G. Haverlak. First and final rept. Feb. 12, 1945, 22p. incl. tables, diagrs. (Technical rept. no. 1498) Confidential

Two German 105-mm. HE shells were examined. The complete assembly consisted of a steel shell body with a sintered iron rotating band, a Zn die-cast nose, a paper-wrapped hollow bursting charge of Cyclonite, a hemispherical liner, and a superquick point fuze. The hemispherical liner was in the body of the shell and surrounded by the forward portion of the bursting charge. An Al flash tube was secured to the liner at its apex and extended rearward through the bursting charge to a detonator-booster assembly in the base of the charge cavity. Assembled flange to flange with the liner was a steel liner protector, probably used to protect the liner from fragments of the fuze detonator assembly.

L1620

Technical Division, Picatinny Arsenal.
EXAMINATION OF 75-MM HOLLOW CHARGE HE SHELL COMPLETE ROUNDS FOR GERMAN KWK 40 GUN (FMAM-455), by F. G. Haverlak. First and final rept. Mar. 3, 1945, 7p. illus. tables, diagrs. (Technical rept. no. 1503)
Confidential

A chemical analysis of the explosives and a metallurgical examination of the shell and cartridge case were made. The complete round consisted of a point fuzed HE shell, loaded with a lined shaped bursting charge of Cyclonite and wax, a brass-coated steel cartridge case, an electric primer, and a bagged propelling charge.

L1621

Technical Division, Picatinny Arsenal.
EXAMINATION OF 61-MM. AP RIFLE GRENADES, GERMAN (FMAM-993), by F. G. Haverlak. First and final rept. Mar. 7, 1945, 18p. incl. tables, diagrs. (Technical rept. no. 1507)
Confidential

The 61-mm. AP rifle grenades examined consisted of a base fuzee, thin-walled steel body and charge container loaded with a shaped Cyclotol HE charge having a shaped charge liner, and a thin-walled steel nose. The liner, mounted on an internal ridge in the charge container, was of sheet steel, 2.81 in. long with a 33° apex angle. The wall thickness varied from 0.024 in. at the apex to 0.074 in. on the flange. The apex end was 0.4 in. in diameter, and the liner base was 2.035 in. in diameter.

L1622

Technical Division, Picatinny Arsenal.
EXAMINATION OF 46-MM. AP RIFLE GRENADES, GERMAN (FMAM-992), by F. G. Haverlak. First and final rept. Mar. 10, 1945, 7p. incl. illus. diagr. (Technical rept. no. 1509)
Confidential

An examination of German 46-mm. AP rifle grenades indicated that the steel body and charge container were apparently made in 1 piece. The conical charge liner, flanged with a cylindrical extension, was mounted on an internal ridge in the charge container with the extension engaging the base of the grenade nose. The liner was of sheet steel 2 1/16 in. long with a 36° apex angle. The wall thickness varied from 0.025 in. at the apex to 0.036 in. in the flange extension. The open apex end was 0.25 in. in diameter, and the conical portion base was 1.44 in. in diameter. The flange contained 6 equally spaced holes.

L1623

Technical Division, Picatinny Arsenal.
EXAMINATION OF JAPANESE AP (SHAPED CHARGE) RIFLE GRENADE WITH SPECIAL FIN ASSEMBLY (FMAM-552), by A. B. Schilling. First and final rept. Mar. 19, 1945, 20p. incl. tables, diagrs. (Technical rept. no. 1511)
Confidential

The Japanese AP rifle grenade (shaped charge type) examined was assembled with a 3-vane stabilizing fin, a fuze, and an anemometer-type arming vane. This design was evidently an adaptation of the Japanese AP Rifle Grenade (FMAM-304) for use as a light bomb.

L1624

Technical Division, Picatinny Arsenal.
EXAMINATION OF 75-MM. HOLLOW CHARGE HE SHELL COMPLETE ROUND FOR JAPANESE TYPE 41 MOUNTAIN GUN (FMAM-665), by A. B. Schilling. First and final rept. Apr. 27, 1945, 25p. incl. tables, diagrs. (Technical rept. no. 1521)
Confidential

A complete round of a Japanese 75-mm. hollow charge loaded HE shell was examined. It consisted of the shell loaded with Cyclonite TNT, a short steel brass-coated cartridge case, a percussion primer, and a bagged propelling charge. A comparison of Japanese and German ammunition is appended.

L1625

Technical Division, Picatinny Arsenal.
EXAMINATION OF 75-MM. HOLLOW CHARGE HE SHELL COMPLETE ROUNDS FOR GERMAN SHORT BARREL TANK GUN, KWK 38 (FMAM-260), by F. G. Haverlak. First and final rept. July 11, 1945, 20p. incl. tables, diagrs. (Technical rept. no. 1540)
Confidential

The complete rounds of German 75-mm. hollow charge HE shells examined consisted of a point fuzed HE shell, loaded with a shaped bursting charge of Cyclonite, TNT, and wax, a flanged "U" shaped liner, a brass-coated steel cartridge case, an electric primer, and a bagged propelling charge. An Al flash tube, extending in both directions from the apex of the liner, was roll-crimped to the liner at the apex. The forward end of the flash tube encompassed the fuze detonator and the base end surrounded the detonator-booster in the shell base.

L1626

Technical Division, Picatinny Arsenal.
STUDY OF RELATIVE INITIATING EFFICIENCY OF RDX IN DETONATORS, by S. Fleischnick. First and final rept. Aug. 1, 1946, 6p. tables, diagrs. (Technical rept. no. 1617)
Restricted

The investigation was centered primarily on the efficiency of RDX in detonators; experiments on indenting the base charge and the $Pb(N_3)_2$ charge of M16 detonators, thus giving a shaped charge effect, are also reported. The results of these tests did not show whether an indentation in the form of a cone having an apex angle of 120° produced a more efficient detonator than an indentation in the form of a cone with a 60° apex angle. Further experiments to determine the most satisfactory angle were considered desirable.

L1627

Technical Division, Picatinny Arsenal.
DEVELOPMENT OF IMPROVED BOOSTERS, by P. F. Schaeffer. Rept. no. 1. Feb. 4, 1948, 6p. incl. illus. tables. (Proj. no. TM3-5101A, technical rept. no. 1677) Confidential

To determine if variations in detonation rates exist and cause failures in penetration, the differences in detonation rates of small shaped charges of 10/90 Pentolite and cast TNT with M9A1 liners were investigated and the penetration depths measured. The Pentolite charges detonated at the maximum rate without measurable build-up in rate; the TNT charges had a low rate of detonation over the first in. of charge before attaining the maximum rate. The average detonation rate for the Pentolite charges was 7217 m./sec. and the average penetration value was 4.3 in. The average detonation rate for the TNT charges was somewhat slower, but the penetration value was also 4.3 in. Complete results of the tests are tabulated. It was concluded that variations in rates of detonation of such charges are not reflected by failures to penetrate steel, and the use of 10/90 Pentolite instead of cast TNT offers no advantage with respect to effectiveness.

L1628

Technical Division, Picatinny Arsenal.
INVESTIGATION OF FACTORS ENTERING INTO DESIGN OF SHAPED CHARGES. (LOADING AND TESTING OF HIGH EXPLOSIVES IN SHAPED CHARGES), by S. Fleischnick. Rept. no. 1. Oct. 14, 1948, 1v. incl. illus. tables, diagrs. (Proj. no. TM3-5201C, technical rept. no. 1668) TIP C3066 Confidential

The investigation was concerned with the causes of non-uniformity in performance of experimental shaped charges being manufactured for Carnegie Institute of Technology by Picatinny Arsenal and with methods of improving the performance of shaped charges.

L1629

Technical Division, Picatinny Arsenal.
MALFUNCTIONING INVESTIGATION OF 3.5-IN. ROCKET, HEAT, T80E2, by H. D. Rutkovsky. Jan. 1949, 73p. incl. illus. tables, diagrs. (Proj. no. TU2-1002, rept. no. 1; Technical rept. no. 1700) Confidential

A study was undertaken to determine the cause of malfunctionings of 3.5-in. HEAT rockets T80E2, Lots PA-E-1408 and -1456. Results of the investigation indicated that the motor closure threads of the HEAT rocket which failed (Lot PA-E-1456) were undersize; upon firing the closure separated from the motor, the rocket head being propelled forward and the motor being expelled to the rear of the launcher. Inspection of the remaining 62 rockets of Lot PA-E-1408 revealed no missing components or faulty assembly. However, metallurgical examination of the fractured motor of 1 rocket from this lot showed such minor defects as a lap, seams, and undersize wall thickness. It was concluded that the physical strength of the motor should be increased to withstand pressures of 145,000 p.s.i.

L1630

Technical Division, Picatinny Arsenal.
INVESTIGATION OF FACTORS ENTERING INTO THE DESIGN OF SHAPED CHARGES (EFFECTS OF TYPE OF BOOSTER, CHARGE LENGTH, CONFINEMENT, AND TYPE OF STANDOFF SUPPORT ON SHAPED CHARGE PERFORMANCE), by S. Fleischnick and D. E. Seeger. Rept. no. 2. Apr. 25, 1949, 9p. tables, graphs, diagrs. (Proj. no. TM3-5201C, technical rept. no. 1716) TIP C3935 Confidential

In comparative tests of bare and confined 50/50 Pentolite charges containing M9A1 steel liners, it was found that confinement, either total or at the booster end only, failed to have significant effect on the uniformity of penetration. Total confinement increased the mean penetration depth approximately 10%. Totally confined charges 3.5 in. long gave slightly more uniform and lower results than confined charges of greater length. There was no significant difference in either uniformity of penetration or penetration depth between charges tested with thick-walled standoff tubes and thin-walled standoff tubes. Charges with a hollow-type booster (type 3), in which the bottom of the detonator was in direct contact with the main explosive charge and surrounded by the booster explosive, gave penetration depths slightly less than charges with the solid type of booster (type 1), in which the detonator was set on top of the booster explosive, or with the half-solid, half-hollow type of booster in which the detonator was set half-way into the booster. In tests of totally confined charges, the type 3 booster yielded slightly more uniform results. An apparent correlation between dispersion and charge length was found which suggested the use of a short and uniform charge.

L1631

Technical Division, Picatinny Arsenal.
DEVELOPMENT OF IMPROVED DETONATORS, by S. Fleischnick. Rept. no. 2. Jan. 17, 1950, [28]p. illus. tables, diagrs. (Proj. no. TM-5101B, Technical rept. no. 1751) TIP C57293 Confidential

The standard M22 detonator and modified M22 detonators, indented at the base by solid angles of 60°, 90°, and 120° and by a hemisphere, were used to evaluate RDX as the base charge in military detonators. In the Pb Plate Test and in tests using the Explosive Train Efficiency Apparatus, the indented-base detonators were more efficient than the flat-base type as judged on the basis of metal disc perforation. However, in a new test which more closely approximates operating conditions, the indented types were less effective than the flat-type detonators in initiating high explosive detonations. It was concluded that RDX is superior to tetryl as a base charge in military detonators, and that the indented base detonators are no more effective than the flat-base type.

L1632

Technical Division, Picatinny Arsenal.
GRENADE, HAND, HEAT, MOD RPG6, FMAM-2288, by A. B. Schilling. July 1952, 4p. illus. (Proj. no. TB3-0035, Memo. rept. no. 11)
Confidential

The Soviet grenade is composed of a light steel body having a high explosive shaped charge of cast TNT, a detonator-booster assembly, and a handle assembly containing a cloth stabilizer. The following data are available:

Length of grenade assembly (closed	13.21 in.
Weight of grenade assembly	2.48 lb.
Maximum diameter of grenade body flange	3.604 [in.]
Weight of cast TNT charge	1.24 lb.
Weight of steel liner	0.31 lb.
Apex angle of liner	40.5°
Liner thickness (average)	0.055 in.
Contour of head	hemispherical

Photographs are included of the partially disassembled grenade and of the grenade body sectioned to show the loading characteristics, the shaped charge liner, and the hemispherical head.

L1633

Technical Division, Picatinny Arsenal.
EXAMINATION OF UNFIRED GRENADE, HAND, HEAT, (SOVIET) MOD RPG 6 FMAM-2288, by J. E. Capell. Feb. 13, 1953, 6p. illus. diagrs. (Proj. no. TB3-0035, rept. no. 1; Technical rept. no. 1879) AD-5215
Confidential

A technical examination of the grenade was made including the preparation of photographs, dimensioned drawings, and chemical analysis of the explosive charges. The round contains a conical steel liner having an apex angle of 40.5°, a weight of 0.31 lb., and an average liner thickness of 0.055 in. Cast TNT (1.24 lb.) comprises the explosive charge and the booster charge is 39.55 g. of tetryl. In a static firing test against 5 1-in. mild steel plates, the grenade penetrated 4.5 in. of the target material.

L1634

Technical Division, Picatinny Arsenal.
EFFECT OF PAINT ON THE LINERS OF SHAPED CHARGES ON THE PERFORMANCE OF THE CHARGES IN STATIC PENETRATION TESTS, by L. Jablansky. June 15, 1953, 5p. diagrs. (Proj. no. TA3-5201, Memo. rept. no. 32)
Restricted

Two series of tests were made at 4-in. standoff. In the first series, bare 50/50 pentolite-loaded shaped charges of the Carnegie Institute of Technology type, containing unpainted and painted M9A2 rifle grenade Cu liners of 0.023-in. wall thickness were fired into mild steel targets. The coatings of acid-proof black paint and olive drab enamel were 0.002 in. thick. In the second series of tests, 2.36-in. M6A5 rocket heads with unpainted and painted Cu liners were employed. Again, the coating thickness on the top and/or under surface of the liners was approximately 0.002 in. It was concluded that the paint coatings had no apparent effect on the dispersion of penetration values or on the average penetration depth of the shaped charges. However, it was noted that when protective coatings are used, their average thickness and variation in thickness relative to the liner thickness should be held to a minimum.

L1635

Technical Division, Picatinny Arsenal.
EVALUATION OF 70/30 CYCLOTOL AND 75/25 CYCLOTOL FOR USE IN HE AND HEAT PROJECTILES, by L. Jablansky. Aug. 25, 1953, 21p. tables. (Proj. no. EP-14, rept. no. 1; Technical rept. no. 1944) AD-17 262
Confidential

In static tests it was found that 3.5-in. HEAT rocket heads containing 75/25 Cyclotol bursting charges penetrated an average of 14.7 to 14.9 in. of mild steel. Similar heads using 70/30 Cyclotol charges penetrated 14.3 and 14.4 in. of mild steel in similar tests. Under the same conditions, 3.5-in. HEAT rocket heads filled with Comp. B penetrated 14.2, 14.4, and 14.6 in. of mild steel. When the 105-mm. M324 HEAT shell containing charges of 75/25 Cyclotol, 70/30 Cyclotol, and Comp. B, respectively, was tested statically, similar differences in penetrating ability were evident. It was concluded that the ability of nonrotated HEAT ammunition to penetrate steel is increased about 2 or 3% by substituting 75/25 Cyclotol for Comp. B. However, this advantage may be neutralized by the greater difficulty in meeting the 75/25 Cyclotol cavity and density standards. In addition, there is no apparent advantage in replacing Comp. B with 70/30 Cyclotol for HEAT rounds. Penetration and fragmentation data are included.

L1636

Technical Division, Picatinny Arsenal.
DETERMINATION OF THE EFFECT OF THE USE OF A HOMOGENEOUS EXPLOSIVE AND OF LINERS MADE IN VARIOUS WAYS TO CLOSE TOLERANCES ON THE PERFORMANCE OF EXPERIMENTAL SHAPED CHARGES, by G. D. Clift and C. E. Jacobson. Oct. 16, 1953, 9p. illus. tables, diagrs. (Proj. no. TA3-5201, rept. no. 3; Technical rept. no. 1975) AD-23 765 Confidential

Fifty-four deaerated nitroglycerine-loaded charges and 28 50/50 Pentolite-loaded charges, both using a variety of liners, were fired in order to determine whether lack of homogeneity in the explosive charge was a major factor in the wide dispersion frequently encountered in the depths of penetration of shaped charges. A summary of these firings at 4-in. standoff into mild steel plates follows:

Nitroglycerin-loaded charges

Type of Cu cone	I	II	III	IV
Machined	25	9.88	0.275	2.78
Drawn	9	9.89	0.326	3.30
Electroformed (Lot no. 1)	10	9.62	0.411	4.27
Electroformed (Lot no. 2)	10	10.03	0.302	3.01

50/50 Pentolite-loaded charges

Type of Cu cone	I	II	III	IV
Drawn	11	8.76	0.554	6.32
Electroformed (Lot no. 1)	3	8.40	0.529	6.30
Electroformed (Lot no. 2)	14	8.73	0.415	4.75

I = No. of charges; II = Ave. penetration (in.); III = Standard deviation (in.); IV = Standard deviation as % of penetration.

It was concluded that: (1) the use of a homogeneous liquid explosive (nitroglycerin) apparently produces greater uniformity of penetration than does the utilization of a heterogeneous solid explosive (50/50 Pentolite); (2) the uniformity of shaped charge penetration using a solid or liquid explosive evidently is not affected by the manufacture of the liners if reasonable tolerances are maintained; (3) no apparent correlation exists between the depths of penetration and the small variations in wall thickness and eccentricity of the liners fired.

L1637

Technical Division, Picatinny Arsenal (DA5-16-05-006Z).
ANALYSIS OF WARHEAD AND FUZE USED IN THE ANTITANK GUIDED MISSILE SS10, by T. Fruchtman. Dec. 18, 1953, 12p. illus. tables. (Proj. no. TU1-2050; Technical rept. no. 1982) AD-24 479 Confidential; not releasable to foreign nationals

Analysis of the French SS10 antitank warhead showed that the shaped charge liner is of a double-angle configuration with a 31° apex angle and a 51° base angle. The liner walls gradually increase in thickness from 0.076 in. at the apex to 0.126 in. at the base. This liner is formed apparently from sheet Cu, being similar to that liner used in the French 73-mm. antitank rocket. The HE charge is cast 50/50 cyclotol of charge density 1.67 g./ml. The fuze is a base-detonating, inertia-initiating type. One warhead was fired statically (45°F) at a standoff of 7.14 in. into a stack of 30 mild steel plates (Brinell Hardness no. 103) 1 in. x 6 in. x 6 in. Total penetration was 22.4 in. The slug, approximately 5 in. long, was lodged in the first 5 plates and tapered from a diameter of approximately 0.4 in. in plate no. 1 to an oval of 0.9 in. x 0.5 in. in plate no. 5.

L1638

Technical Division, Picatinny Arsenal.
DESIGN OF AN IMPROVED SHAPED CHARGE LINER FOR THE 105-MM. T43 HEAT SHELL, by C. E. Jacobson. Mar. 1954, 11p. tables, diagrs. (Proj. no. EPO-A1-6, Technical rept. no. 2004) AD-29 290 Confidential

Studies were undertaken to ascertain why the newly designed T34 HEAT shell (Pc Mk 75-14-619A3) gave less penetration of armor, in both static and ballistic tests, than the shell of previous design (Pc Mk 75-14-519A2), and to determine some of the design parameters affecting armor penetration by the 105-mm. T43 HEAT round. The new design employed a conical Cu liner and a Comp. B explosive charge while the previous design used a steel liner and 50/50 Pentolite. Tests showed that an annulus of explosive 0.12-0.13 in. wide at the base of the Cu liner caused the decrease in penetration performance. Concerning the effects of other important variables on the T43 HEAT shell, it was found that: (1) maximum penetration by unrotated shaped charges was obtained with a liner wall thickness of not less than 3% of the liner's base diameter; (2) liner thickness may vary 0.004 in. transversely in any plane and 0.020 in. over-all without causing much penetration degradation; (3) in static firings of unrotated T43 HEAT rounds, Comp. B was quite superior to 50/50 Pentolite, about equal to 70/30 Cyclotol, and slightly inferior to 75/25 Cyclotol in performance; however, 50/50 Pentolite produced the same penetrations as Comp. B in ballistic tests; (4) optimum standoff in static firings of the unrotated T43 HEAT shell was 6.5 in. for Cu and steel liners; for rotated T43 HEAT shells the standoffs were 3 in. with Cu liners and 2 in. with steel liners; (5) Cu liners gave appreciably greater penetrations than steel liners in unrotated T43 HEAT shells; for rotated rounds, there was little difference.

L1639

Technical Division, Picatinny Arsenal.
DEVELOPMENT OF IMPROVED METHODS FOR CAST-LOADING RDX/TNT COMPOSITIONS AND COMPARISON OF COMP. B AND 50/50 PENTOLITE AS HE FILLER FOR 2.36-IN. M6 ROCKET HEADS, by S. Fleischnick and C. E. Jacobson. Apr. 1954, 9p. tables, diagrs. (Proj. no. EPO-EP-12, Technical rept. no. 2008)
Unclassified

Approximately 400 Comp. B-loaded 2.36-in. HEAT rocket heads, M6A5 and M6A6, and 400 similar heads loaded with 50/50 Pentolite were fired statically at 2-in. standoff into mild steel targets. The average penetration depths for the Comp. B-loaded and 50/50 Pentolite-loaded heads were 9.20 in. and 8.54 in., respectively. A correlation was found between the extent to which the bursting charge fails to fill the forward end of the body cavity to the line of contact of the liner and body and the performance of the loaded head against a steel target. Poor penetration performance was obtained from those heads with larger voids at the forward end of the bursting charge. No correlation was evident between the projected area of the cavities in the remainder of the bursting charge and the depth of penetration in mild steel. From these tests, it was concluded that: (1) the penetrating power of the 2.36-in. HEAT M6-type rocket head was increased about 6% by the use of Comp. B rather than 50/50 Pentolite; (2) M6A5 and M6A6 rocket heads performed equally well in tests.

L1640

Toronto U. (Canada).
EXPERIMENTAL STUDY OF DEMOLITION CHARGES, by R. O. Braun and G. F. Wright. Aug. 15, 1943, 18p. incl. tables. ([15-Cl(XR-60)-2]; Inclosure 2 to MA Ottawa rept. no. R670-48)
Confidential

The investigation involved the casting of mixtures more powerful than present demolition types, and sensitive enough for complete detonation by a blasting cap or its equivalent but insensitive to shock such as rifle fire. Amatol, Tetryl, picric acid, NENO, and DINA were compared with TNT and plastic high explosive. Mark II Beehives, Mark I PIAT bombs, etc. were used. When conical charges, filled with NENO, were fired at 1 diameter standoff against a nonexplosive charge, the hole was poorly formed; when a mild steel baffle was placed at the surface of the p-dichlorobenzene, the jet made a clean, well-centered hole. The shaped charge initiated the CE/TNT and NENO/TNT/BWX satisfactorily, although occasional failures were noted. More detailed tabular results are indicated.

L1641

Toronto U. (Canada).
EXPERIMENTAL STUDY OF DEMOLITION CHARGES, by R. O. Braun and G. F. Wright. Dec. 1, 1943, 15p. incl. tables, diagrs. ([15-Cl (XR-60)-3]; Inclosure 3 to MA Ottawa rept. no. R670-48)
Secret

Triangular prismatic blocks ("delta charges") were metal encased for assembling into Hayrick shapes. The use of these assemblies as Hayricks was ineffective. Trials were carried out also with 6.5-lb. Beehives, filled with Nobel's 851, NENO/Lanolin, NENO/TNT/BWX, NENO/Al/BWX, and plastic explosive. All these explosives, except Nobel's 851, were approximately equal in effectiveness against steel or reinforced concrete. American M2 charges filled with 10 lb. of Pentolite and equipped with 60° glass liners were found to be less effective against either steel or concrete than the British Mark 11 Beehive. The sensitivity of these demolition charges to rifle fire was also tested.

L1642

Torrey, V.
THE BAZOOKA'S GRANDFATHER. Popular Science Monthly, v. 146, Feb. 1945: 65-69, 211-212, 216.

A popular account of the use of the Munroe effect in ammunition and demolition work in World War II is presented. This article was later published in The Explosive Engineer, v. 23, July-Aug. 1945: 160-163, under the title "The Shaped Charge".

L1643

Torrey, V.
THE SHAPED CHARGE. The Explosives Engineer, v. 23, July-Aug. 1945: 160-163.

(For abstract of this article see item no. L1642.)

L1644

Underwater Demolition Team 4, [Amphibious Forces, Atlantic Fleet].
THE EFFECTIVE AMOUNT OF EXPLOSIVE (C3) TO RUPTURE STEEL PLATING OF VARIOUS THICKNESSES UNDERWATER USING LINEAR CAVITY CHARGES, by T. J. Brady. Progress rept. no. 3. [1946?], 14p. incl. illus. diagrs.
Confidential

Through actual experimentation with linear charges a range of effective amounts of explosive for cutting 3/16-, 5/16-, 0.5-, 0.75- and 1-in. mild steel plates underwater was determined. Comparison of linear charge results with rope charge results showed the linear charges to be superior for cutting mild steel plates underwater. Test results are tabulated and a table of recommended values is included.

L1645

Underwater Demolition Team 4, [Amphibious Forces, Atlantic Fleet].
UNDERWATER ADAPTATION OF LINEAR CAVITY CHARGES, by T. J. Brady. Progress rept. no. 2. Oct. 1, 1946, 1v. incl. illus. diagrs.
Confidential

The investigation was undertaken to develop a shaped charge container, to correlate existing data on surface detonation vs. underwater effect, and to check container dimensions to determine the most effective ratio for maximum penetration. To further coordinate data for surface blasting with underwater penetration, tests were run in which charge characteristics were varied 1 at a time.

L1646

Underwater Demolition Team 4, Amphibious Forces, Atlantic Fleet.
UNDERWATER DEMOLITION TEAM FOUR. OPERATION HIGHJUMP. (A. NARRATIVE REPORT OF PARTICIPATION IN OPERATION HIGHJUMP. B. REPORT ON DEMOLITION IN THE ICE FIELDS. C....), by H. Iverson. Apr. 3, 1947, 40p. incl. illus. (Serial 0043)
Confidential

Linear charges, Bangalore torpedoes, and M2 and M3 charges were fired against bay ice. The craters formed by the charges in ice differed from the craters formed by similar charges when detonated on metal. It was doubtful that the 10-lb. M2 charge penetrated to the water. It was concluded that the ice could be broken by blasting an initial crater with an M2 or M3 shaped charge, enlarge the crater with plastic explosive, and detonate a 60-lb. charge submerged in the crater. Test results are tabulated.

L1647

Underwater Weapons Department, Admiralty (Gt. Brit.).
REPORTS ON TESTS WITH HOLLOW CHARGES. [1946]. (2640; PG 43147; ACSIL/ADM/46/118)
Unclassified

The results of research on various phases of torpedo warheads and underwater penetration [in 1942?] are reported. It was emphasized that a standoff distance 1. 5 times the length of the cavity diameter was necessary.

L1648

[User Representative for Infantry in the UK].
WESTERN UNION INFANTRY ANTITANK WEAPONS COMPARATIVE TRIALS. [Aug. 28, 1950], [12]p. incl. tables. (Rept. no. USERINF/ORD/34)
Secret

Comparative tests were made on the French 73-mm. rocket launcher and the Brandt Blindicide (75-mm. rocket launcher). Results showed that both weapons were highly accurate for a rocket launcher, due mainly to their relatively high velocity (French 500 ft./sec.; Blindicide 600 ft./sec.). The construction of the shaped charge of the French rocket appeared superior to the Blindicide. It was believed that the French were using RDX with a Cu liner while Brandt (Blindicide) seemed to be using a brass liner. The type of explosive in the Blindicide was unknown but it was assumed to be the same as that used in the Energa grenade. Tests were also made on the French rifle antitank grenades. Results showed that the French grenades were superior to the Energa grenades. The French 73-mm. grenade appeared to be the best of the French grenades.

L1649

User Representative for Infantry in the UK.
FRENCH 73-MM. ANTITANK GRENADE AND ROCKET LAUNCHER, by C. T. Horner. Dec. 6, 1950, 2p. (Rept. no. USERINF/ORD/46)
Secret

Tests were made on the French 73-mm rifle antitank grenade and rocket launcher. The grenade is capable of penetrating approximately 2-in. more homogeneous plate than the Brandt Energa 75-mm grenade. Major faults indicated by the tests were erratic penetration; unburnt propellant which forced to rear after rocket leaves the launcher will require either protective clothing, or redesign of launcher or rocket; back blast damages telescope front of the lens, necessitating changing this frequently; difficulty was experienced in loading the rocket in the launcher.

L1650

Volochkov, L. F.
USE OF HOLLOW CHARGES IN MINING (Primenenie pustoteiykh patronov pri shpurovoĭ otboĭke). Gornyi Zhurnal, v. 120(6), 1946: 19-20.

The efficacy of hollow charges was compared with that of solid charges in 2 different mines in actual mining operations. The hollow charges save approximately 25% of drilling as well as explosive. The blasting efficiency index (depth of penetration - average depth of blasthole) was consistently higher for the hollow charges.

L1651

Waffenamt Prüfwesen.
ARMOR PENETRATION CURVES (Panzerdurchschlags-Kurven). Apr. 17, 1942, 2p. incl. diagrs. (Gl - Wa Prüf 1/Stab Ia Nr. 741/42 g. Kdos.; OTIB rept. no. 1249, AOO-9 - In German)
Unclassified

Two graphs are shown of the penetration of 10-cm. Gr. 39 Hl/A and Hl/B, and 7.5-cm. Gr. 38 Hl/A and Hl/B shaped charge shells as a function of standoff.

L1652

Waffenamt Prüfwesen.
SHAPED CHARGE ANTITANK GRENADES WITH HIGH INITIAL VELOCITY (HL-PZ. Granaten mit Hoher Anfangsgeschwindigkeit), by Schneider. Oct. 9, 1944, 2p. (Nr. 1850/44 g. Kdos.; OTIB rept. no. 1249, Misc.-2 - In German)
Unclassified

Several projects were discussed briefly including: (1) construction of 8.8-cm. R Pz Gr. 43/12 grenades using the high pressure principle; (2) wing-stabilized projectiles; and (3) shells with folding fin assemblies.

L1653

Waffenamt Prüfwesen.
FLAT HOLLOW CHARGES (Flache Hohlladungen). Nov. 9, 1944, 1p. (Nr. 2065/44 g. Kdos.; OTIB rept. no. 1249, Misc.-2 - In German)
Unclassified

A mine with directed shrapnel is outlined. Several German scientists including Dr. Schardin collaborated on a new weapon using the shaped charge effect. The accelerative force of the flat shaped charge was utilized. From the shell casing, a rectangular hull was cut out and filled with shrapnel. It was anticipated that at a 6° angle, the shrapnel would scatter at a velocity of 1500 m./sec.

L1654

[Waffenamt Prüfwesen] Wa Prüf (BuM) 11, Berlin.
HUNGARIAN ROCKET GRENADE (Ungarische Raketen-Granate). Nov. 9, 1944, 2p. (Nr. 1047/44 g. Kdos.; OTIB rept. no. 1249, Misc.-1 - In German)
Unclassified

It was pointed out that this shell is not new to tank warfare. The construction of the antitank grenade differed from a standard shell in that it was spin stabilized in flight. Spin was prevented by serrations along the length of the liner.

L1655

Walker, H. and A. R. Almeida.
JET TAPPING. Journal of Metals, v. 3, May 1951: 374-376.

The jet tapper is being used to tap holes of furnaces. The jet tapper is a small, shaped explosive charge, designed specifically for the purpose of tapping the open hearth furnace. Two oz. of a relatively insensitive explosive are enclosed in a bakelite case, which is fixed in proper position in a hollow insulating body with walls 0.5 in. thick. This insulation is sufficient to prevent the charge from being destroyed by the heat of the tap hole, and sufficient to prevent the blasting cap from being detonated by the heat for a minimum of 3 min. when in the tap hole of the open hearth. The hollowed shape of the explosive and the Cu liner are responsible for the ability of the jet tapper to punch a hole through the frozen crust of the tap hole, with little sideward and rearward blast effect. This shaped charge will penetrate, under controlled test conditions, about 7 in. of cold, mild steel.

L1656

War Department, Washington, D. C.
WAR DEPARTMENT TECHNICAL BULLETIN; CHARGE, DEMOLITION, SHAPED, 40-LB., T3. Mar. 25, 1944. (TB 9-1940-6) Unclassified

The charge and its functioning are described, operational instructions are given, and safety precautions are noted.

L1657

War Department, Washington, D. C.
WAR DEPARTMENT TECHNICAL BULLETIN; CHARGE, SHAPED, 10-LB., M1, M2, M2A1, AND CHARGE, SHAPED, 15-LB., M2A3. Sept. 11, 1944. (TB 9-1940-9) Unclassified

The charges are described, and operational and safety instructions are given.

L1658

War Department, Washington, D. C.
WAR DEPARTMENT TECHNICAL BULLETIN; CUTTER, CABLE, M1. Dec. 18, 1944. (TB ORD 233) Unclassified

This cutting charge and its holder are described and illustrated. Instructions for operation and safety are given.

L1659

[War Office (Gt. Brit.)].
GERMAN HOLLOW CHARGE RIFLE GRENADES. n. d., 5p. incl. diagrs. (Annex J to Technical Intelligence Summary no 44) Secret

The S.S. Gewehr Panzergranate 46 and the S.S. Gewehr Panzergranate 61 contain steel liners of 36° apex angle for the smaller grenade and 32° for the larger grenade. The liner sides taper in thickness from mouth to apex. The 46-mm. grenade was found to perforate 70 mm. of I. T. 80 plate in direct attack at normal or short ranges. At longer ranges the thickness of plate perforated increased to approximately 90 mm. under static conditions. Under similar circumstances, the 61-mm. grenade perforated 100 mm. at short range, increasing to 125 mm. under static conditions. Interposition of a skirting plate of 0.25-in. mild steel spaced 11 in. in front of the armor completely defeated the 46-mm. grenade; penetration of I. T. 80 plate by the 61-mm. grenade was reduced to 25 mm. or less.

L1660

[War Office (Gt. Brit.)].
[GERMAN DEMOLITION CHARGES]. June 9, 1943, p. 7-9, diagrs. (Technical Intelligence Summary No. 106, Part II) Confidential

The German magnetic antitank hollow charges of 3 kg. and 3.6 kg. are described and illustrated; performance trials against rock and concrete are reported. The 400-g. German hollow demolition charge is described and illustrated.

L1661

[War Office (Gt. Brit.)].
[300-G. GERMAN DEMOLITION CHARGE]. Nov. 23, 1943. (Technical Intelligence Summary no. 117, Part II; Inclosure 1 to MA London rept. no. 63356) Secret

A drawing and brief data are given for the shaped German 300-g. demolition charge. Poor photostating; part of this rept. is illegible.

L1662

War Office (Gt. Brit.).
DEVELOPMENTS IN SMOOTH BORE EQUIPMENTS. June 13, 1945, 2p. diagr. (Appendix F to Technical Intelligence Summary no. 179; Inclosure 1 to MA London rept. no. R3530-45; OSRD Liaison Office WA-4503-12) Secret

The German policy of emphasizing smooth bore guns and shaped charge projectiles for use in them is reported. The 7.5-cm. shell is described, and a 15-cm. shaped charge projectile with fins is briefly mentioned.

L1663

War Office (Gt. Brit.).
DISTANT OPERATING HOLLOW CHARGES. [1946], 18p. incl. illus. tables. (Technical Intelligence rept. no. 2; Inclosure 1 to MA London rept. no. R4849-46) Secret

Tests showed that shaped charges had considerable armor piercing capabilities even at distances of 10 to 20 m. Liners used in the study include steel, HE (consisting of a steel liner fitted with a charge which detonates when the liner strikes a surface), and shrapnel. Charges tested weighed from 14.5 to 17.5 kg. and contained from 8.5 to 10.3 kg. of explosive. At 20 m., a 250-mm. diameter hole was made in a 100-mm. plate while at 50 m., a 200-mm. hole was made in 80-mm. plate.

L1664

War Office (Gt. Brit.).
REPORT ON TRIALS OF LARGE SHAPED CHARGES AT DORVERDEN ON JULY 11, 1947. Sept. 12, 1947, 11p. incl. illus. diagrs. (Inclosure 1 to MA London rept. no. R5890-47) Secret

The 3000-lb. demolition charge and the 45-in. CS/DR bomb were fired successfully at standoffs of approximately 70 ft. or 10 diameters from buildings consisting of a series of brick walls 10 in. thick. Both charges demolished large portions of the nearest brick wall and in both cases the damage to the final wall consisted of only 1 hole.

L1665

Warren, W. T.
DEVELOPMENTS IN UNDERGROUND DRILLING AND BLASTING PRACTICE. Mining Congress Journal, v. 32, Oct. 1946: 39-42.

Diamond drill blasthole methods used in underground drilling and blasting are reported. Conical and hemispherical shaped charges were successfully employed in reducing boulders on the grizzlies and in the scrams, and in breaking up finger hang-ups.

L1666

Watertown Arsenal Laboratory.
SHELL, HIGH EXPLOSIVE; EXAMINATION OF CONE FROM GERMAN 37-MM. HOLLOW CHARGE GRENADE, (FMAM 266), by S. V. Arnold. Nov. 11, 1943, 4p. incl. illus. (Experimental rept. no. WAL 763/539) Restricted

Results of a metallurgical examination on the liner from a German 37-mm. shaped charge grenade showed that the liner was cold drawn from 0.17% C-rimmed steel sheet. No intermediate or subsequent annealing operation was employed.

L1667

Watertown Arsenal Laboratory.
EXAMINATION OF CONE FROM 15-CM. HC HE SHELL, GERMAN, by S. V. Arnold. Feb. 11, 1944, 2p. illus. (Memo rept. no. WAL 763/579) Restricted

A metallographic examination of this liner is reported. Photomicrographs illustrate the microstructure.

L1668

Watertown Arsenal Laboratory.
SHELL, HIGH EXPLOSIVE, HOLLOW CHARGE; METALLURGICAL EXAMINATION OF TWO GERMAN 75-MM. HIGH EXPLOSIVE HOLLOW CHARGE SHELL, by H. G. Carter. Aug. 29, 1944, 33p. incl. illus. tables, diagrs. (Experimental rept. no. WAL 763/618) Restricted

Two German 75-mm. HEAT shells, proof-fired with inert loads, were examined metallurgically. Tests include chemical analysis, hardness surveys, tensile property determinations, macro-examinations, density determination, and micro-examinations.

L1669

Watertown Arsenal Laboratory.
HE SHELL, by H. G. Carter and C. M. Schwitter. Mar. 17, 1945, 1p. illus. (Memo. rept. no. WAL 763/718) Unclassified

Photomicrographs are shown of the liner portion of a shaped charge projectile after functioning of the shell against armor plate.

L1670

Watertown Arsenal Laboratory.
SHELL, HIGH EXPLOSIVE; METALLURGICAL EXAMINATION OF THREE GERMAN AMMUNITION COMPONENTS, by E. F. Hutchinson. Apr. 21, 1945, 8p. incl. illus. (Experimental rept. no. WAL 763/728) PB no. 55754 Restricted

The metallurgical examination of 1 of the German ammunition com- onents revealed that it was probably a shaped charge liner produced by deep drawing from a plain low C-rimmed steel sheet, and ground circumferentially on the exterior for 0.25 in. to an edge at the base. Since most of the liners had a flange at the liner base, it was thought that the ground surface constituted part of a new design for attachment.

L1671

Watertown Arsenal Laboratory.
METALLURGICAL EXAMINATION OF JAPANESE SHELL 7-CM. (75-MM.) MODEL 90 POINTED AA (FMAM-475), 7-CM. (75-MM.) MODEL 2 HOLLOW CHARGE (FMAM-1176), by H. G. Carter. Dec. 19, 1945. 21p. incl. illus. (Experimental rept. no. WAL 763/778) Restricted

The Japanese 7-cm. (75-mm.) Model 2 shaped charge shell (FMAM-1176) was composed of a thin-walled cylindrical body pierced and drawn from plain C steel billet stock. It appeared that the shaped charge liner had been spun from 0.45% C sheet stock. The apex angle was 26° as compared with the 42° angle of the US charge liners for shells of this caliber. This shell design differed slightly from similar German projectiles in that no gaine (booster) was used, and a greater stand-off distance was incorporated to the detriment of the explosive capacity. Complete details of these shells and their analyses are reported.

L1672

Watertown Arsenal Laboratory.
COMPARATIVE EFFECTIVENESS OF ARMOR-DEFEATING AMMUNITION, by A. Hurlich. Nov. 8, 1951, 12p. tables, diagrs. (WAL file no. WAL 710/930-2) Secret

The performance of kinetic energy and chemical energy projectiles against simple armor targets is discussed. It is pointed out that in the present stage of development, fin-stabilized HEAT shells do not match the accuracy of kinetic energy projectiles. The higher velocity and greater accuracy of kinetic energy projectiles make them more accurate than all present types of chemical energy armor-defeating ammunition. Methods of defeating the HEAT shell, which are discussed briefly, include the use of low density materials such as HCR2, spaced steel spikes, an arrangement of parallel angle irons made of armor steel placed on the surface of the main armor, and spaced armor.

L1673

Westfälisch-Anhaltische Sprengstoff-A. G.
METHOD OF MANUFACTURE OF EXPLOSIVE CHARGES (Verfahren zur Herstellung von Sprengkörpern). German patent no. 249,630, July 3, 1912.

This patent outlines a process for the manufacture of explosives charges characterized by the fact that the charge contains a cavity on the side facing the target for the purpose of increasing the explosive efficiency.

L1674

Westfälisch-Anhaltische Sprengstoff-A. G.
IMPROVEMENTS IN EXPLOSIVE CHARGES OR BODIES. British patent no. 28,030, Oct. 10, 1912.

This early patent (convention date, Germany, Dec. 14, 1910) states that the effect of an explosive body is enhanced if the side facing the target has a cavity so that actual contact is limited to an annular rim. The cavity may have a lining of sheet metal or other suitable material, or it may be filled with inert matter. It is suggested that the invention may be utilized for torpedoes and artillery shells.

L1675

[Westfälisch-Anhaltische Sprengstoff-A. G.].
PROPELLANT AS HIGH EXPLOSIVE. (BOOKLET ISSUED 11TH JUNE, 1942 BY WASAG). June 11, 1942. (Trans. as rept. no. DIOS/Gp. 2/HEC 5133, 69p. incl. illus.) Unclassified

Tests of a solventless propellant powder as the explosive charge for shaped charges are reported, and good results are said to have been obtained. The advantages of using this type of explosive in demolition charges and artillery shells are listed. A hand grenade employing the shaped charge principle is described, as are several other weapons not related to the subject.

L1676

Westfälisch-Anhaltische Sprengstoff-A. G. Chemische Fabriken, Berlin.
EXPLOSIVE TESTS WITH EXTENDED APPLICATION OF THE HOLLOW-CHARGE PRINCIPLE (Sprengversuche unter erweiterter Anwendung des H-Prinzips). Dec. 7, 1943, 9p. incl. diagrs. (Inclosure to letter no. B. Nr. 333/43, Dec. 14, 1943; Trans. in rept. no. BIOS/Gp. 2/HEC 67) Restricted

Experiments with bottle shaped charges were made to compare with the explosive effect of solid charges. The test results are diagramed. It was concluded that standoff was critical and that penetration increased with standoff. Tests were also made with shaped charges in which the standoff was occupied by flammable oil. Results were disappointing for the flame had a small spread. It was concluded that, to achieve a dispersal of the flame, there should be a ratio of oil to charge of 10 to 1. A German translation of an article in the London Illustrated News, Nov. 25, 1944, entitled "Hollow Charge" is appended (item no. L1121).

L1677

[Westfälisch-Anhaltische Sprengstoff-A. G., Reinsdorf Werke].
CONTRIBUTION TO THE SUBJECT OF THE EFFECT OF THE HOLLOW CHARGE (II AND III), by Gutmann. May 13, 1943 (Part II) and July 8, 1943 (Part III). (Trans. as rept. no. BIOS/Gp. 2/HEC 1260, 8p. illus.) Secret

(Part II). Asymmetry caused by eccentric initiation and the presence of spaces between charge and liner caused by imperfect manufacturing of the liners was investigated. The effect of the charge was found to be considerably decreased because concentration of the "lines of force" is disturbed by these 2 faults. Experiments on a shaped charge designed in the form of steps, in which the separate steps themselves also act as shaped charges, are briefly reported. It is indicated that a further concentration of "lines of force" can be achieved by this arrangement. (Part III). Tests were made of the effect on a jet of placing steel plates (20 x 5 mm.) in various positions within the cavity. It was found that suitable arrangements of the plates restrained the dispersion of the jet, thus adding to its concentration.

L1678

[Westfälische-Anhaltische Sprengstoff-A. G., Reinsdorf Werke].
BASIC EXPERIMENTS IN PHYSICS. PART I: GENERAL HE PHYSICS; HOLLOW CHARGE HE PHYSICS; HE DETONATION ABILITY PHYSICS, by von Holt and others. 1943-1944. (Trans. as rept. no. BIOS/Gp. 2/HEC 67, p. 1-27; Inclosure 1 to MA London rept. no. R2812-48) Secret

A number of letters, memoranda, and repts. concerning the physics of shaped charges and high explosives are reproduced. Experiments are described on the blast pressures from 2 shaped charges placed 0 to 400 mm. apart with the cavities facing each other and detonated simultaneously. A memorandum (p. 20) states that the incendiary effect was proved through experiments with liners of Ce or Th, and is increased by the "application" of sintered Fe. Another memorandum (p. 22) reports that the optimum thickness for bell shaped liners is 2.5 mm., and the optimum height and thickness for bottle shaped liners are 106 mm. and 2.5 mm., respectively.

L1679

Westwater, R.
SHAPED CHARGES. Colliery Engineering, v. 24, Jan. 1947: 5-9.

Non-military application of shaped charges is discussed for uses such as blasthole drilling, erection of pylons and poles in soft and hard ground and in rocks, pulverizing scrap metal, secondary breaking, and metal cutting.

L1680

Zwicky, F.
ARTIFICIAL METEORS. Ordnance, v. 32, July-Aug. 1947: 18-20.

It is stated that rockets can carry shaped charges to extreme heights and then eject small, fast particles from the earth's gravitational field. The escape velocity from the earth is 11.2 km./sec. and shaped charges are capable of generating energies of this order of magnitude. An experiment at White Sands with shaped charges in the V2 rocket is briefly described and future investigations are suggested.

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TIP S2685	L1572
TIP S5302	L207
TIP S50123	L1146
TIP S50124	L1109
TIP S50149	L1103
TIP S50197	L1105
TIP S50198	L1106
TIP S50199	L1104
TIP S50558	L1227
	L1228
TIP S50705	L1073
TIP S50776	L1229
TIP S50948	L1230-
	L1233
TIP S51273	L1114

END

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