

UNCLASSIFIED

AD NUMBER
AD071277
NEW LIMITATION CHANGE
TO Approved for public release, distribution unlimited
FROM Distribution: Further dissemination only as directed by Commander, USA Ballistic Research Lab., Aberdeen Proving Ground, MD; 17 Sep 99 or higher DoD authority
AUTHORITY
Army Research Laboratory, Security/CI Office ltr., dtd July 28, 2000.

THIS PAGE IS UNCLASSIFIED

UNCLASSIFIED



AD NUMBER

AD-071 277

CLASSIFICATION CHANGES

TO UNCLASSIFIED

FROM CONFIDENTIAL

AUTHORITY

Cmdr, USABRL via ASTIA Tab No U69-9-5; Sep 1, 1963

19990923051

THIS PAGE IS UNCLASSIFIED

UNCLASSIFIED



AD NUMBER

AD-071 277

NEW LIMITATION CHANGE

TO DISTRIBUTION STATEMENT - F

Distribution: Further dissemination only as directed by Cmdr, USA
Ballistic Research Lab, Aberdeen Proving Ground, MD; 17 Sep 99
or higher DoD authority

LIMITATION CODE: 5

FROM No Previous DoD Distr Scty Cntrl St'mt Assgn'd

AUTHORITY

DoDD 5230.24, Para f.3.b.; Sep 17, 1999

THIS PAGE IS UNCLASSIFIED

UNCLASSIFIED

AD 71 277

DEFENSE DOCUMENTATION CENTER

FOR

SCIENTIFIC AND TECHNICAL INFORMATION

CAMERON STATION, ALEXANDRIA, VIRGINIA

CLASSIFICATION CHANGED

TO UNCLASSIFIED

FROM CONFIDENTIAL

PER AUTHORITY LISTED IN

ASTIA TAB NO. 79-9-3

DATE 1 SEP. 69



UNCLASSIFIED

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

UNCLASSIFIED

71277

BRL

FC

MEMORANDUM REPORT No. 800

**Air Blast Measurements
Around Moving Explosive Charges,
Part II (U)**

BRADSHAW F. ARMENOT, JR.

Reproduced From
Best Available Copy

DEPARTMENT OF THE ARMY PROJECT No. DDAG-04-002
GIVENANCE RESEARCH AND DEVELOPMENT PROJECT No. TDS-0121

BALLISTIC RESEARCH LABORATORIES



ABERDEEN PROVING GROUND, MARYLAND

OCT 4 1955

55AA

42669

UNCLASSIFIED

Retain or destroy per AR 380-5 and SR 345-215-5 or comparable AF or Navy Regulations. Contractors should consult their government contracting officers regarding procedures to be followed. DO NOT RETURN

Information has been made of this report to no other
person or organization. Additional distribution
is limited to those persons or organizations who are
authorized to receive it. It is to be kept in the
files of the contracting officer and to be used only
for the purpose for which it was prepared.

This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18 U. S. C. Sections 793 and 794. The transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

UNCLASSIFIED

BALLISTIC RESEARCH LABORATORIES

MEMORANDUM REPORT NO. 900

MAY 1953

AIR BLAST MEASUREMENTS AROUND MOVING EXPLOSIVE CHARGES, PART II (U)

Bradley F. Aronoff, Jr.

Department of the Army Project No. SD3-04-002
Ordinance Research and Development Project No. TR3-0112J

ABERDEEN PROVING GROUND, MARYLAND

55AA 4266

UNCLASSIFIED

UNCLASSIFIED

BALLISTIC RESEARCH LABORATORIES

MEMORANDUM REPORT NO. 900

**Warrant/plg
Aberdeen Proving Ground, Md.
May 1955**

AIR BLAST MEASUREMENTS AROUND MOVING EXPLOSIVE CHARGES, PART II (V)

ABSTRACT

Additional blast measurements are taken around 1/8 pound, spherical explosive charges of Composition B, detonated while moving about 1750 feet per second, and compared to measurements obtained from similar charges detonated while at rest. The data obtained indicate that the side-on peak pressure and positive impulse are both increased in the direction of charge motion and decreased in the opposite direction. In the particular case shown, the peak pressure was increased by about 10% and the positive impulse was increased by about 30% in the forward direction.

A qualitative interpretation of the velocity effect, based partly on the data obtained, is suggested.

UNCLASSIFIED

CONFIDENTIAL

The work of Patterson and Menig, as described in MIL Memorandum Report No. 767¹, was continued in an effort to collect more data regarding the effect of charge motion on the blast wave. The results of these additional experiments, together with a proposed explanation of the velocity effect are contained in this report.

With minor modifications, the experimental procedure of Patterson and Menig was followed. A bare, spherical charge of Composition B,² weighing about 1/8 pound, was projected at a velocity of approximately 1750 feet per second and exploded in flight by means of magnetic induction. Blast gauges placed around the point of detonation, at a distance of 2.71 feet, measured the side-on peak pressure and impulse of the shock wave. Stationary charges were fired also for the purpose of comparison.

Modifications of the original procedure include:

1. Use of side-on blast gauges having 1/8-inch diameter piezoelectric crystals rather than the one-inch crystals employed previously. This results in much less distortion of the recorded pulse due to the finite size of the gauge.
2. Direct calibration of the blast waveform gauges by comparison with the peak pressures obtained from shock velocity measurements. This provides better estimates of the peak pressure and positive impulse from both moving and stationary explosive charges.
3. Removal of the experimental setup from clayey soil to a concrete strip, thereby providing a more stable mounting for the gauges and speeding the work during periods of inclement weather.
4. Use of an improved reference system for locating the point of detonation of the moving charges, resulting in increased accuracy of this measurement.

Many other less important changes were made in the experimental setup, resulting in increased convenience, safety, and reliability.

Side-on blast pressures were detected by piezoelectric-type transducer crystal gauges. The gauge output was amplified, displayed on an oscilloscope, and recorded by General Radio streak camera using 16mm film moving about two inches per millisecond. All records were read on a type 121 Televiewer. Peak pressures and positive impulses were calculated from these readings.

¹ MIL Memorandum Report No. 767, "Air Blast Measurements Around Moving Explosive Charges," (U) J. B. Patterson and J. Menig, March 1974. Report classified Confidential.

² Composition B - 60/40, HX/TN.

CONFIDENTIAL

Each gage was calibrated by firing stationary 1/8 pound pentolite charges and comparing its peak output with the peak pressure inferred from shock velocity measurements. Gage size error was calculated by the method of Arens and Cole,³ utilizing values for the initial slope of the shock wave as shown by Thelheimer.⁴ The average correction for gage size error was about 6% for the stationary rounds and varied between 6% and 11% for the moving rounds, depending on the position of the gage. This correction was subtracted from the peak pressure inferred from velocity gage measurements, and the result was compared to the uniform gage output for the purpose of calibration. Thus the gage constant was obtained independent of size effect. When experimental records were obtained, the gage peak pressure was calculated first, then gage size correction was calculated and added to obtain the true peak pressure. This procedure was necessary since gage size error is a large and variable factor in the measurements.

The position of the burst of the moving charge was located by triangulation, using cameras equipped with one-microsecond electronic shutters.

A summary of the data is made in Table I, and the results of the individual firings are shown in Tables II and III. For the stationary charges, the average peak pressure was 67.3 pounds per square inch with a standard deviation of the individual of 7.5% and the average positive impulse was 8.1 pound-milliseconds per square inch with a standard deviation of the individual of 10%.

Since the moving charges did not detonate exactly at the reference point because of the variations in the time of initiation, average values of the peak pressure and positive impulse could not be calculated as simply as for the stationary rounds. The following method was used to estimate the peak pressure and positive impulse at a distance of 2.71 feet from the moving charge as a function of angular position from the line of fire. It was noticed that although the deviations in absolute distance from the intended burst were significant, the deviations in angular position were not. Therefore it was assumed that the nominal angles were obtained. Over the small interval of distance involved, the dependence of peak pressure and impulse on distance was assumed to be linear and linear least square fits were made to the observed values. The values of the peak pressure and positive impulse at the distance 2.71 feet and angles of 15°, 45°, and 105° from the line of fire were obtained from these fits. The tabulated values of Table I are plotted on polar graph paper in Figures I and II.

³ Journal of the Acoustical Society of America, Vol. 21, No. 1, January 1950, A. B. Arens and R. E. Cole, "Design and Use of Piezoelectric Gages for the Measurement of Large Transient Pressures."

⁴ NVOB Report 1734, "The Determination of the Time Constant of a Blast Wave from the Pressure-Distance Relation," F. Thelheimer, December 1950.

CONFIDENTIAL

Thornhill and Hetherington⁵ predict that close to the surface of a moving charge, the shock velocity, and thus inference of the peak pressure, can be approximated by vectorial addition of the shock velocity for the stationary charge and the terminal velocity. However, at large distances from the charge, the terminal velocity increment to be added vectorially must approach zero, since the shock velocity approaches the velocity of sound. Thus the terminal velocity increment should decay in some manner between these two points, as illustrated in Figure III. For the particular case investigated (i.e., 2.71 feet from a charge moving about 1750 ft/sec) it would be expected that the increase in peak pressure in the forward direction could be inferred from a vectorial addition to the static shock velocity of a velocity increment somewhat smaller than 1750 ft/sec. Therefore, the peak pressures from Table I were used to infer the shock velocities by means of the Rankine-Hugoniot equation,⁶ and the results plotted in Figure IV. It was observed that the values obtained for the moving rounds fall approximately on a circle of the same radius as for the static rounds, but with the center shifted about Mach 0.3 in the direction of motion, corresponding to a vectorial addition of 200 ft/sec to the shock velocity of the stationary rounds.

In order to be able to predict the peak pressure about a moving charge it is planned to obtain more data to investigate the possibility of establishing a decay curve of the type shown in Figure III.

The data for the positive impulse (Figure II) show an enhancement in the direction of motion of the charge, but no simple scheme for prediction of the enhancement has been suggested.

Bradley F. Aronson, Jr.

BRADLEY F. ARONSON, JR.

⁵ AEE Memo 6153, "Some Notes on Explosions of Moving Charges," G. K. Thornhill and R. Hetherington, April 1952.

$$^6 \quad \frac{P_2}{P_0} = \frac{2\gamma}{\gamma+1} \left[\frac{v^2}{c^2} + 1 \right]$$

Where: P_2 = peak excess pressure
 P_0 = ambient pressure
 v = shock velocity
 c = sound velocity
 γ = ratio of specific heats for air

CONFIDENTIAL

TABLE I
SUMMARY OF EXPERIMENTAL RESULTS

Charge Velocity	0 ft/sec	1753 ft/sec		
		Angle from line of flight		
		15°	45°	105°
Peak Pressure (psi)	67.3	71.0	82.0	52.5
Positive Impulse (psi-sec)	8.1	10.2	9.8	7.9

TABLE II
EXPERIMENTAL DATA FROM STATIONARY CHARGES

Round Number	Angle from Line of Flight (degrees)	Distance from Charge (feet)	Charge Velocity (feet/sec)	Peak Pressure (lb/in ²)	Positive Impulse (lb-sec/in ²)
405	15°	2.71	0.0	53.9	7.96
	45	2.71	0.0	64.7	7.44
412	105	2.71	0.0	62.2	6.96
	15	2.71	0.0	63.5	6.75
	45	2.71	0.0	71.1	7.29
414	105	2.71	0.0	73.0	6.80
	45	2.71	0.0	70.8	7.87
	15	2.71	0.0	63.8	7.90
	15	2.71	0.0	71.0	7.89
	45	2.71	0.0	67.3	7.93
426	15	2.71	0.0	64.9	6.78
429	105	2.71	0.0	72.2	8.25
	15	2.71	0.0	62.8	6.72
	45	2.71	0.0	64.7	8.25
441	15	2.71	0.0	64.2	8.32
	15	2.71	0.0	71.0	8.96

CONFIDENTIAL

TABLE II (CONT)

Round Number	Angle from Line of Flight (degrees)	Distance from Charge (feet)	Charge Velocity (feet/sec)	Peak Pressure (lb/in ²)	Positive Impulse (lb-sec/in ²)
451	105	2.71	0.0	70.0	8.00
	45	2.71	0.0	77.6	7.11
455	105	2.71	0.0	75.2	9.66
	45	2.71	0.0	68.6	8.75
460	15	2.71	0.0	59.4	7.09
472	105	2.71	0.0	71.0	8.37
479	105	2.71	0.0	49.1	7.67
	45	2.71	0.0	70.4	9.86
	45	2.71	0.0	66.2	8.17
493	105	2.71	0.0	64.8	8.62
	15	2.71	0.0	66.3	8.67
	45	2.71	0.0	65.7	8.38
Average				67.3	8.08
Standard Deviation				7.98	9.98

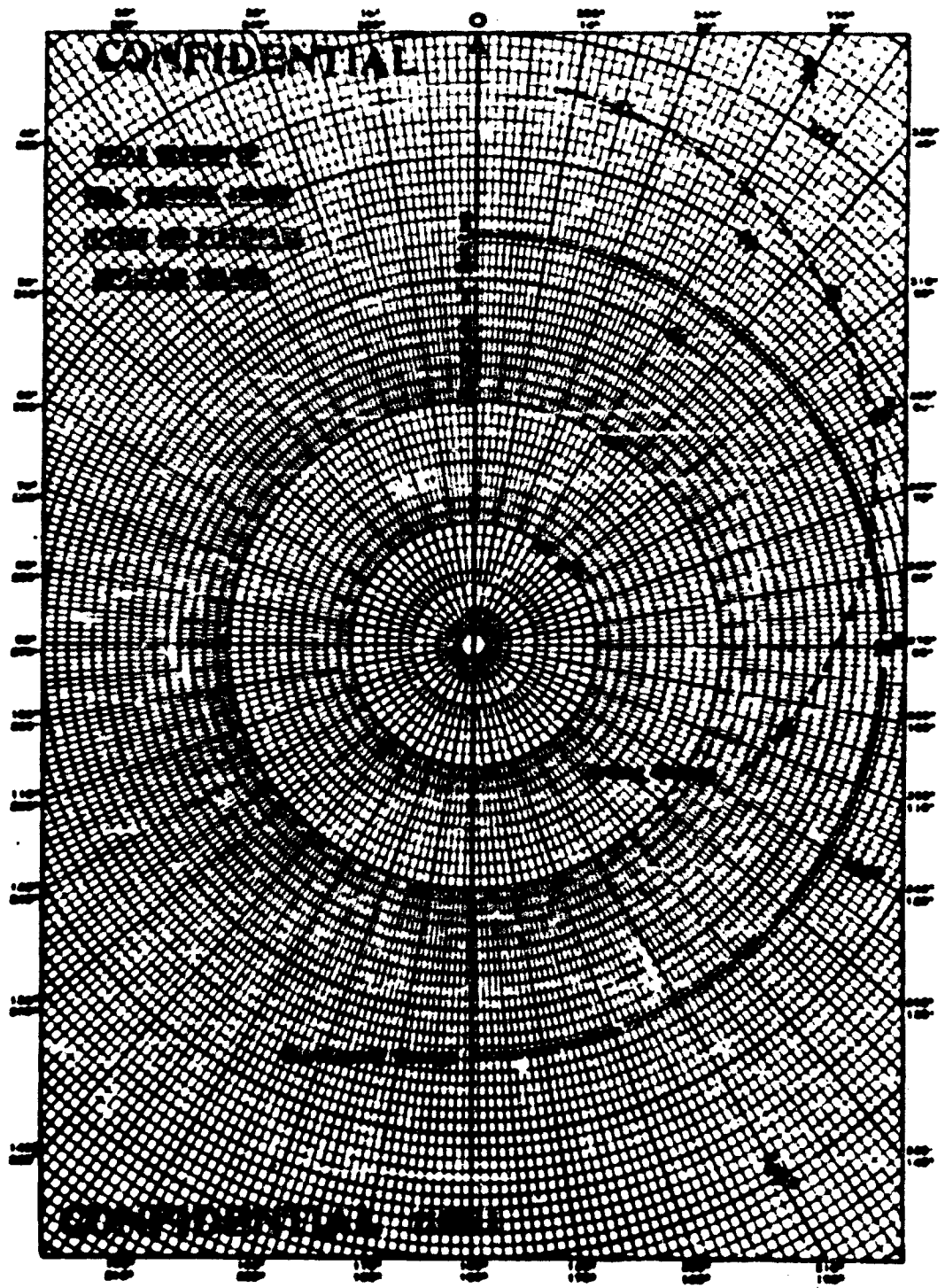
CONFIDENTIAL

TABLE III

EXPERIMENTAL DATA FROM MOVING CHARGES

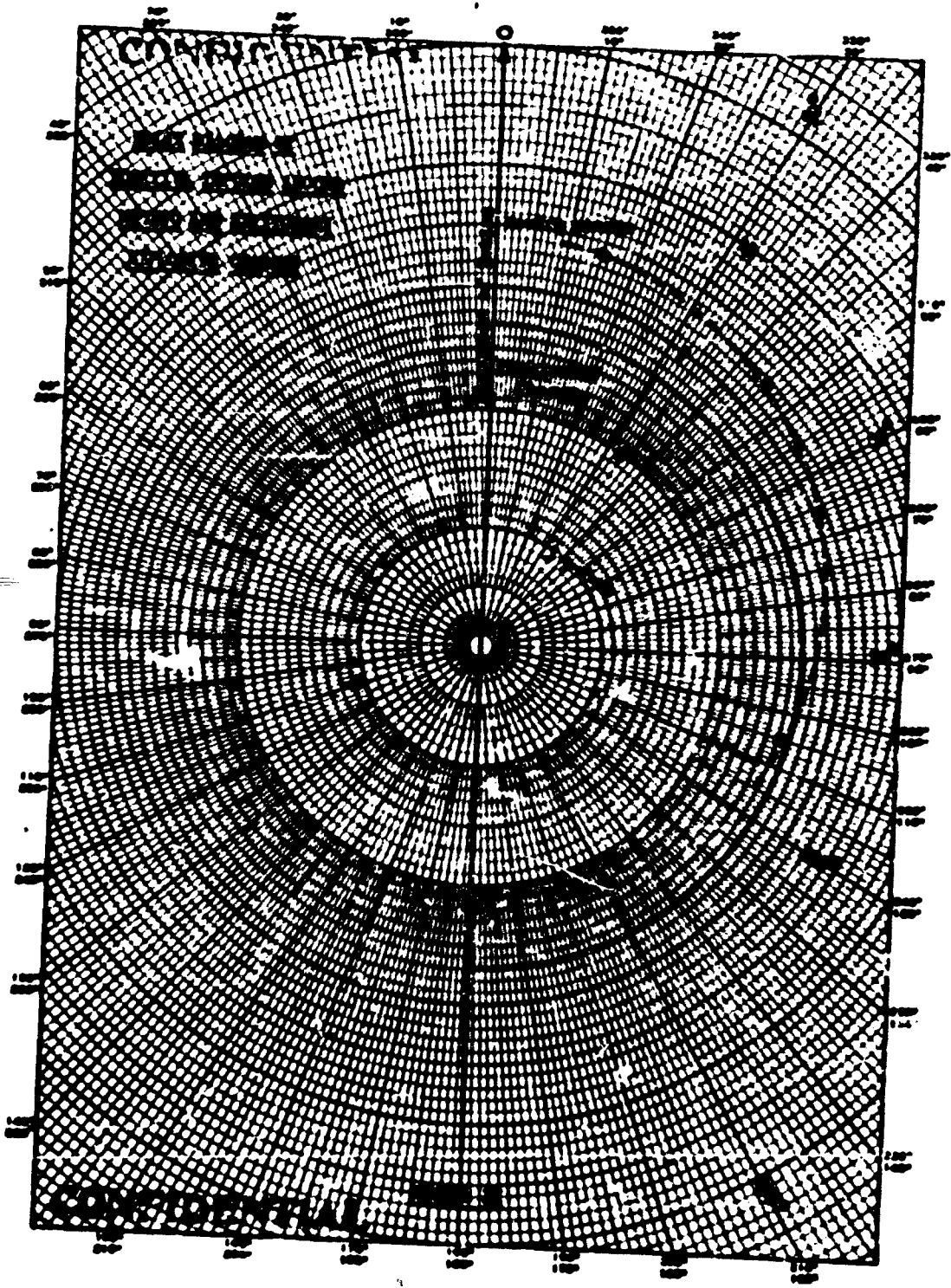
Round Number	Angle from Line of Flight (degrees)	Distance from Charge (feet)	Charge Velocity (ft/sec)	Peak Pressure (lb/in ²)	Positive Impulse (lb-sec/in ²)
404	103.9	2.58	1713	61.2	8.27
	45.5	2.85	1711	73.5	5.91
411	100.6	2.85	1651	66.4	7.73
	38.4	2.60	1661	102.9	8.66
	44.9	2.45	1661	80.6	9.07
413	113.5	2.97	1677	41.5	7.36
	52.6	2.48	1677	102.4	9.67
	20.6	2.28	1677	95.9	11.08
	15.7	2.22	1677	99.1	8.33
	51.7	2.31	1677	77.7	8.49
425	12.1	2.96	1644	91.0	9.91
440	12.9	2.53	1802	91.4	11.91
	18.8	2.60	1802	103.2	9.96
450	107.9	2.79	1811	48.3	7.55
	46.8	2.57	1811	86.2	9.74
454	102.0	2.76	1872	53.7	8.29
	46.8	2.75	1872	77.7	11.24
459	14.8	2.70	1752	82.6	11.43
472	117.9	3.09	1750	35.4	6.27
478	111.9	2.83	1793	51.3	6.79
	50.8	2.48	1793	59.0	8.82
	50.8	2.47	1793	53.7	9.41
492	107.5	2.60	1808	90.1	—
	12.5	2.60	1808	77.6	—
	48.2	2.76	1808	80.9	—
Average			1753		
Standard Deviation			4.15		

CONFIDENTIAL



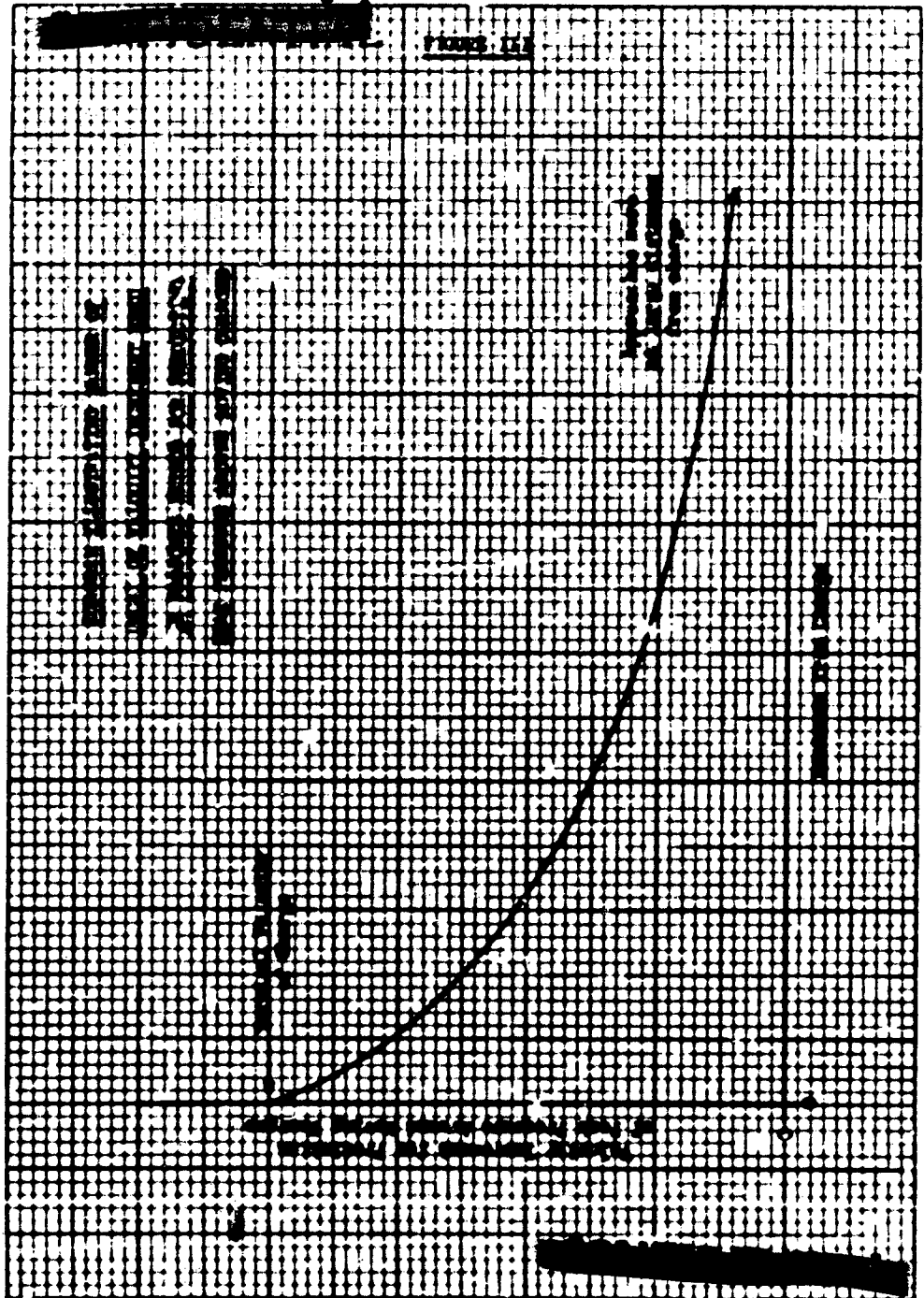
CONFIDENTIAL

CONFIDENTIAL



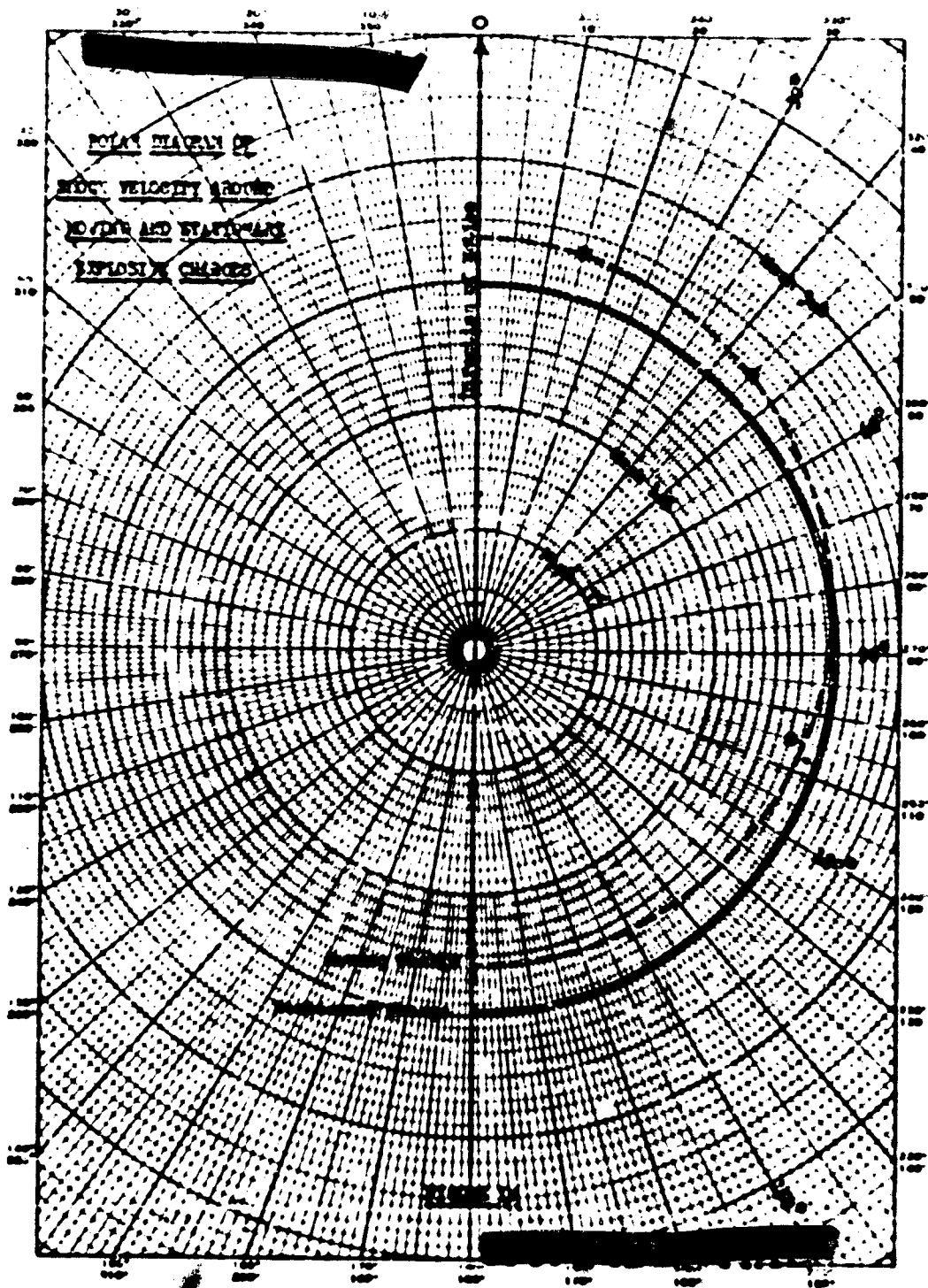
CONFIDENTIAL

UNCLASSIFIED



UNCLASSIFIED

UNCLASSIFIED



UNCLASSIFIED

DISTRIBUTION LIST

<u>No. of Copies</u>	<u>Organization</u>	<u>No. of Copies</u>	<u>Organization</u>
	Chief of Ordnance Department of the Army Washington 25, D. C. Attn: ODDTB - Bul Sec	1	Commander Naval Ordnance Laboratory Corona, California Attn: Dr. H. A. Thomas
		5	Commander Wright Air Development Center Wright-Patterson Air Force Base, Ohio Attn: WCLDB-4 (2 cpy) WCLDB-4 (1 cpy) WCLDB (1 cpy) WCLDB-1 (1 cpy)
10	British Joint Services Mission 1800 K Street, N.W. Washington 6, D. C. Attn: Mr. John Isard, Reports Officer Of Interest To: Mr. G. Sims, R.A.S. Dr. E. E. Hall	1	Commander Air Proving Ground Eglin Air Force Base, Florida Attn: Director of Armament
4	Canadian Army Staff 2450 Massachusetts Ave., N.W. Washington 6, D. C.	1	Commander Air Force Armament Center Eglin Air Force Base, Florida Attn: ACIR
3	Chief, Bureau of Ordnance Department of the Navy Washington 25, D. C. Attn: BuJ	1	Director, Project RAND Department of the Air Force 170C Main Street Santa Monica, California
2	Commander Naval Proving Ground Bahlgren, Virginia	1	Commander Air Research & Development Command P. O. Box 1395 Baltimore 3, Maryland Attn: NTHRO
2	Commander Naval Ordnance Laboratory White Oak Silver Spring 19, Maryland	5	Director Armed Services Technical Information Agency Documents Service Center Knett Building Dayton 2, Ohio Attn: DSC - SA
1	Commander Naval Ordnance Test Station China Lake, California Attn: Technical Library	4	ASSTIA Reference Center Technical Information Div. Library of Congress Washington 25, D. C.
1	Commander Naval Air Development Center Johnsville, Pennsylvania		
2	Chief, Bureau of Aeronautics Department of the Navy Washington 25, D. C. Attn: Armament Division		

IDENTIFICATION LIST

No. of Copies	Organization	No. of Copies	Organization
1	Commanding General Frankford Arsenal Philadelphia 37, Pa. Attn: Reports Group	1	Douglas Aircraft Company Calverley, California Attn: Mr. Thomas Johnson Sacramento 6, California
3	Commanding Officer Huntington Arsenal Bever, New Jersey Attn: Samuel Patton Ammunition Info.	THE: Air Force Plant No. Douglas Aircraft Company Florence 2, California Calver City, California	
1	Army Ordnance Representative HHS Annex 125 South Grand Avenue San Diego, California	1	Institute for Cooperative Research Project No. 1 1511 E. 12th Avenue Baltimore, Maryland
1	Applied Physics Laboratory 6011 Georgia Avenue Silver Spring, Maryland	THE: Security Matter National Office of the State, and District Main Post Office Baltimore 1, Maryland	
1	THE: Naval Inspector of Ordnance Applied Physics Laboratory 6011 Georgia Avenue Silver Spring, Maryland	Institute for Air Weapons Research University of Chicago Chicago 37, Illinois Attn: Mr. David Brown Mr. Herbert Brown	
1	Aircraft-General Corporation 6325 North Irwindale Road Anaheim, California	THE: General Corporation 6325 North Irwindale Road Anaheim, California	
1	THE: Bureau of Aeronautics Rep. Aircraft-General Corp. 6325 N. Irwindale Road Anaheim, California	1	THE: Aircraft, Inc. California Attn: Mr. E. L. Hale
1	Douglas Aircraft Company, Inc. Long Beach, California Attn: Mr. E. L. Hale	THE: Air Force Plant No. Douglas Aircraft Company, Inc. 125 Industrial Blvd. P. O. Box 220 Long Beach 1, California	
1	Brown Aircraft Corporation Babypage, Long Island, New York Attn: Assistant Group	1	THE: Aviation Corporation Babypage, Long Island, N.Y. Attn: Mr. E. L. Hale
1	THE: Bureau of Aeronautics Rep. Brown Aircraft Corporation Babypage, Long Island, N.Y.	THE: Air Force Office-In-Charge Babypage, Long Island, N.Y.	

AD-071277

Rec'd
8/3/2000



DEPARTMENT OF THE ARMY
UNITED STATES ARMY RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND 21005-5066

REPLY TO
THE ATTENTION OF

AMSRL-CS-IO-SC (380)

28 July 2000

MEMORANDUM FOR Defense Technical Information Center, ATTN:
DTIC-BCS, 8725 John J. Kingman Road Suite 0944,
Ft. Belvoir, VA 22060-6218

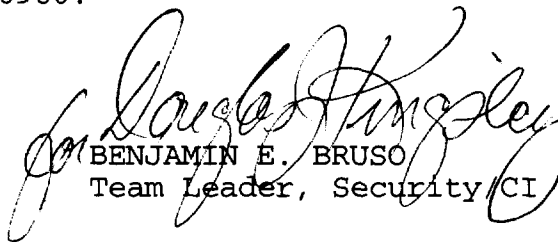
SUBJECT: Distribution Statement for BRL Memorandum Report No. 900

1. Reference: Ballistic Research Laboratories Memorandum Report No. 900, "Air Blast Measurements around Moving Explosive Charges, Part II", by B. F. Armendt, Jr., May 1955.

2. The correct distribution statement for the referenced report is:

Approved for public release; distribution is unlimited.

3. Request that you mark your copy of the report with this distribution statement. Our action officer is Mr. Douglas J. Kingsley, telephone 410-278-6960.


BENJAMIN E. BRUSO
Team Leader, Security/CI Office

