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PROGRESS REPORT

ON

FLAME WARFARE

Prepared for the Tenth Tripartite Conference

Chemical Center, Army, Attn: CMLRD-CW-PC

1955

CHEMICAL CORPS

RESEARCH AND ENGINEERING COMMAND

Army Chemical Center

Maryland

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PROGRESS REPORT FOR THE
TENTH TRIPARTITE CONFERENCE

Part I. Action Taken on Pertinent Recommendations of the Ninth Tripartite Conference

1. Recommendation: Each country should devote as much effort as may be reasonably possible to the study of the fundamental physical, chemical, and burning properties of thickeners and fuels.

Actions: The U. S. effected three research contracts with scientific institutions and commercial research laboratories to study the basic physical and chemical structures of thickened fuels and to correlate their findings to the performance of the gel under various firing conditions. Reported on in Part II of this report.

2. Recommendation: In view of the importance of liquid thickeners the work in U.S. and Canada on latex thickeners should be extended as far as staff and facilities can be made available.

Action: Work on liquid latex thickeners was continued and is reported on in Part II of this report.

3. Recommendation: In view of the apparent advantages of compressed soaps for continuous mixing processes now under development in UK, the method should be exploited by the UK.

Action: None required by US.

4. Recommendation: U.S. and Canada to be supplied with full details of the UK plastic fire bomb design and development.

Action: None required by U.S. Details of UK design have been received by U.S.

5. Recommendation: A considered policy statement on the tactical employment of flame weapons ground and air should be prepared in order to facilitate the development of standard equipment and munitions.

Action: A flame policy statement is being prepared and should be available for discussion at the Service Aspects meetings of the Tenth Tripartite Conference.

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Part II. Thickening Agents

1. Introduction - In consonance with the first and second objectives established by the Ninth Tripartite Conference, the fields of basic physical, chemical, and burning properties of both aluminum soaps and rubber thickeners and fuels have been examined through work conducted by private contractors and by the Department of Defense as follows.

2. Progress - Progress has been made through two fields, namely through research contracts let to private enterprises and through government owned research laboratories.

a. Three research contracts were let to investigate the fundamental chemistry of the thickeners and fuels.

(1) Franklin Institute, under the direction of Dr. Philippoff, is conducting studies on the rheological properties of the Thickeners M1, M2, M3, E4, E5, E7, E9, and E10. Viscosity was determined at rates of shear from 10^{-5} to 10^{6} reciprocal seconds on gels formed using the optimum concentration of thickeners. The viscometers used were capillary viscometers of the Philippoff and McKee types and the Rotational viscometer; the data generated from all types overlapped precisely, thus indicating true values. At the lowest rates of shear the curves showed wide variation in slope, however, at shear rates normally encountered in the flame throwers the curves formed a sheaf. The slope at higher rates of shear becomes parallel to the slope of the solvents. Work has not yet progressed to the point where conclusion can be formed concerning the relationship of visco-elastic properties to performance of the thickeners during firing.

(2) Cornell University, under the direction of Prof. Debye, has conducted studies on measurement of the size of the ultimate soap particle in dilute solutions. This work has now been extended to more concentrated solutions and the results will be coordinated into the work of other agencies conducting rheological studies.

(3) Rennsalaer Polytechnic Institute, under the direction of Dr. Bauer, is conducting studies on the preparation of aluminum soaps of various branched chain acids and oxo process acids with a view of determining structural differences and the effect of these differences on the rheological properties. In addition, they are to investigate the mechanism of surfactants and peptizers and their effect on the gelation rate by means of infrared absorption or other techniques devised by the contractor. It is anticipated this work will be completed by the end of this year.

(4) Esso Research and Engineering Co. has continued their work under contract to study the variables encountered in the manufacture of M3 thickener with a view of producing a process which will

yield a soap of uniform quality. They have developed a continuous 2-stream laboratory process which yields a soap having superior gelation characteristics and which is relatively free of aluminum hydroxide and free fatty acid. CRL is now scaling up to pilot plant size the laboratory process developed by the Esso Laboratories with the intent to produce a uniform product with equivalent gelation characteristics to the laboratory material.

b. Department of Defense effort on the fundamental chemistry and performance of thickened fuels has been confined to technical supervision of the contracts and evaluation of the fuels and information generated by them. The status of these thickeners is as follows:

(1) Thickener E4R1 (based on isooctoic acid) has completed development tests and is awaiting user test procurement.

(2) Thickener E5R2 (based on oleic and dimerized linoloic acid) has completed development tests. This thickener was developed as a replacement for thickener M2 and uses domestically available acids. Additional work was conducted to develop a cold temperature peptizer. Results indicated peptizers strong enough to peptize the soap below 0°F also destroy all gel characteristics.

(3) Liquid latex thickeners, E7 and E7R1. Several varieties of synthetic latices have been tested as fuel thickeners using a large variety of all types of wetting agents as additives. Encouraging results were received when GRS 2104, formerly known as X711, a poly butadiene, was blended with gasoline containing 1 percent by formula weight "Tween 85" a polyoxyethylene sorbitan trioleate. Difficulty is being encountered in procuring a latex which is flowable at -40°F and stable in storage at -80°F. Under a research contract the US Rubber Co. is concentrating latex CRS 2104 in a medium of water and formamide in film evaporators. By adding a surfactant, ("Antarox G100", alkyl polyoxyethylene glycol amide) the modified GRS 2104 has a pour point at -40°F and a thaw-freeze resistance at -66°F for periods of at least two months in cycles of 24 hours at room temperature and 48 hours at below freezing temperature. Field tests conducted during June 1955 in a portable flame thrower were satisfactory.

(4) Liquid latex thickeners, E8. As the primary efforts on the liquid thickeners has been directed to the synthetic latices, no significant progress has been made in the field of natural latices.

(5) E9 (M3 plus wetting agent blend) - This thickener, under development by the Chemical Corps, has performed satisfactorily when fired in the portable and mechanized flame thrower. It is the diacid aluminum soap of 2-ethylhexoic acid.

(6) Solid rubber thickeners (E10). The solid rubber GRS XP268 (polybutadiene) constituent of fortified fuel mixture PT5 has proved to be very promising as a gasoline thickener for fire bomb and flame thrower use. Laboratory tests showed that thickener E10, which is 94 parts XP268 containing 3 parts talc by weight and 3 parts "Span 40" a sorbitan monopalmitate, absorbed any type of fuel down to -40°F. The particles knitted to a cohesive gel in a few minutes at room temperature and within a hour at -40°F.

Preliminary tests with Thickener E10 as a flame thrower fuel show considerable promise. Optimum concentrations and methods of effecting mixture have not as yet been determined.

Stability tests at 160°F have indicated poor storage characteristics for the thickener. Work is being done to determine the cause of the apparent instability at high temperature and means to stabilize it.

The outstanding features of the E10 Thickener is the similarity of its density to that of gasoline. As a result the thickener when rapidly dispersed in gasoline absorbs the gasoline without settling out as the aluminum soaps do. A further advantage is the ability to form a gel in unheated gasoline without special mixing equipment.

(7) Fortified fuel mixture, PT5. A fortified incendiary mixture utilizing polybutadiene XP268 as the thickening agent has passed the final development tests. User test procurement is scheduled for the 2d quarter of FY 1956.

Part III. Flame Throwers and Service Equipment

1. Portable Flame Thrower - Current requirements for portable flame throwers are essentially the same as previously presented at the Ninth Tripartite conference, namely for a lightweight multishot portable flame thrower with minimum weight components, and a one-shot portable weapon that could be reused or discarded if the need arose. However, comparison tests have indicated that the M2A1 has an excessive holdup of fuel in the tanks as compared to the experimental models. Therefore, it has been recommended that the military characteristics be modified to read "4 gallons of effective fuel, where effective fuel is defined as that quantity of fuel which can be ejected from the gun in one continuous rod." The present characteristics simply state that the fuel tank be capable of holding 4½ U.S. gallons.

a. E30 One-Shot Portable Flame Thrower (see Figure 1). The Aerojet General Corporation designed the E30 one-shot portable flame thrower and furnished 17 units for evaluation performance tests. Of these units, 16 were tested at the Army Chemical Center to establish a confidence level and to determine design deficiencies. The units were hand fired in July and they were considered satisfactory from the point of view of operability, reliability and accuracy. The 17th unit was retained by the contractor to run tests which will determine the safe life of the unit, i.e., the number of times the unit can be safely fired. Based on facts determined by these tests 40 additional units are being purchased for final development tests.

The E30 one-shot flame thrower is of the "U" type design. The weapon consists of two 3.5-inch diameter tubes, connected by a 180° bend of the same diameter, with a minimum radius. Gas-liquid separation is accomplished by the use of a flexible rubber spherical piston with an interference fit. Gas from a burning propellant is introduced into the fuel tank through a pressure metering nozzle in the top of one tube at a point above the location of the ball. The flame portion of the propellent is shunted to the ignition nozzle in the opposite tube. When sufficient pressure is built up from the gas the ball acts as a piston and forces the fuel down the tube, around the bend, and up the other tube to the ¼-inch nozzle and the pyrotechnic ignition system.

The military requirements call for a weapon which has a maximum weight of 25 pounds when filled, and which is capable of discharging two U.S. gallons of fuel in a continuous rod. The one-shot flame gun is designed to perform in three ways: (1) It can be a manually triggered weapon; (2) it can be used as a booby trap by means of lanyard firing; and (3) it can be used as an emplaced weapon and electrically fired in banks by the use of remote control apparatus. The E30 meets all of these requirements except that the weight of the unit is approximately 26-1/2 pounds. However, it is predicted that by use of mass production techniques not feasible in such limited quantities this weight can be reduced to within one-half pound of the required 25 pounds.

b. <u>E32 Flame Gun and E37 Hose Assembly (see Figure 2)</u>. The Stewart Warner Coporation, under contract, developed the E32 flame gun which weighs 4.77 pounds. It is 8 inches shorter, 33 percent lighter and easier to operate than the standard M2A1 flame gun. In conjunction with this a lightweight hose assembly designated as the E37 has been developed. It is 25 percent lighter and more flexible under Arctic conditions than the standard M1 hose assembly. Orders have been placed for 300 of these flame guns and hose assemblies in order to study manufacturing problems. Permanent tooling will be provided under this procurement order.

c. <u>Fuel Group Assemblies</u>. Progress during the past year has been satisfactory considering the problems involved in reducing the weight of the empty fuel group assembly to 15 pounds.

(1) The Englander Company, through a subcontractor, has produced fiber glass reinforced epoxy resin pressure vessels which were satisfactory. The contractor is fabricating a fuel group assembly designated E29R1 which is similar in construction to the M2A1. It is still problematical if the 15-pound weight can be achieved due to the fact that the metal parts must be increased in size to overcome the handicaps of current plastic construction techniques. Four units are being made to determine this fact and to evaluate the plastic construction in actual usage.

(2) Gray and Huleguard were not able to produce a satisfactory plastic toroidal fuel tank or a spherical pressure vessel within the allotted amount of funds and time, therefore their contract was not renewed. It is still believed that the design is feasible although no further work is being done on a plastic torus at this time.

(3) A contract was awarded to the Walter Kidde Company to develop a fuel group assembly designated the E32 (see Figure 3). This unit consists of two aluminum cylindrical tanks of equal diameters but of unequal lengths and a steel spherical pressure vessel, of the same diameter as the tanks, located below the shorter fuel tank. A prototype of this unit was delivered early in May 1955. Evaluation showed it to be essentially satisfactory but it will require minor modification. The unit weighed 49.2 pounds filled with fuel. The unit is equipped with a quick opening harness developed by the Davis Aircraft Corporation, which test showed to be superior in all respects to the harness presently used, both from a comfort point of view and ease and rapidity of detachment.

(4) A contract has been awarded to the Chrysler Corporation to develop a fuel group assembly. This unit differs from all other units in that the fuel tank and the pressure vessel form an integral unit. The fuel group assembly will consist of a spirally wound tube formed into the shape of a torus. The spirals of the tube are then brazed to form a continuous unit with the interior void forming the fuel tank and the interior of the tube being the pressure unit.

(5) CRL has developed a new design for two fuel group assemblies which differed only in the arrangement of the air flasks. They both were fabricated of aluminum and weigh approximately 48.5 pounds loaded. They present a more compact silhouette (see Figures 4 and 5), have relocated safety valves, and a newly designed pressure regulator. Comparative test will be undertaken with the Kidde model and Englander model when they are received late this summer.

(6) A continuing problem in connection with the development of a lighter fuel group is that of producing an air-pressure reducing regulator smaller and lighter in weight than that of the standard Grove model 93, used on the M2A1 flame thrower and an additional problem is malfunctioning of the rubber components at low temperature. Work is being done on various types of rubber in attempting to eliminate this deficiency. Several promising candidate regulators are being considered including one designed by the Chemical Corps. The Walter Kidde Co. designed a regulator which they are adapting to work with their E32 fuel group assembly. Chrysler's fuel group assembly design calls for a combined regulator and valve inclosed in the torus. This will require a completely new design of a regulator.

2. Mechanized Flame Throwers

a. E24-29 Nonintegral Flame Thrower (see Figure 6). A major failure occurred in the trailer engine and pump due to a deficiency in the oiling system. Design corrections have been made and the equipment is again undergoing final development tests. At the completion of these tests, the item will be sent to CONARC for evaluation tests and concept studies as to the need for continued development of this type of flame thrower.

b. T67, Integral Flame Thrower (see Figure 7). This item has been standardized as the M7-6 Flame Thrower, Mechanized Main Armament. Ordnance Corps will standardize the tank as the M67 Flame Thrower Tank.

c. T68 Flame Thrower, Mechanized Main Armament. This is the deturreted T33 flame tank equipped with the Iroquois hand-operated gun. Previously reported deficiencies in elevation and traverse have been corrected and the units are now undergoing final development tests. If the evaluation is favorable, three hundred and fifty M4 tanks will be converted in accordance with this design for use as an interim item.

d. Universal Vehicular Mounted Flame Thrower for Armored Utility Vehicle/Armored Personnel Carrier, AUV/APC, Type Vehicles, E31-36 (see Figure 8).

The development contract for study and design of flame equipment for AUV/APC type vehicles has been completed. Under this contract two flame gun designs and a universal type of fuel unit were investigated. It was decided the major effort will be on development of the design which consists of a manually-actuated cupola, containing a 30-caliber machine gun, a flame gun and a sighting device. It has been designated E36 gun. The other flame gun design which is based on a small externally mounted gun that may be placed on either the glacis plate or top plate of a vehicle, will be made for comparison purposes. This gun would be remotely controlled by an amplidyne rate system and equipped with panoramic sight. No E number has been assigned to this unit.

The universal fuel unit will consist of a number of identical spherical fuel and air units which can be easily joined in any numbers appropriate for a given vehicle has been designated the E31. The fuel capacity of the sub-units will be approximately 50 U.S. gallons and the air capacity 1.24 cu.ft. each. All components of the pressure regulating and control system are incorporated into a single container. It is expected to make a prototype model prior to July 1957.

3. Fuel Mixers - Additional work has been conducted on the E3R3 Mixing and Transfer Unit which has been standardized as the AN-M3A1. The principle effort has been directed at the development of kits for conversion of existing M3 and E3R2 models into AN-M3A1, converting the AN-M3A1 for use with JP-4 fuels, and development of a mixer suitable for all types of ground operations. Essentially the work was as follows:

a. Kit, Conversion Incendiary Mixing and Transfer Unit, E7. This unit was developed at the request of the Air Force to convert the M3 Mixing and Transfer Unit into the AN-M3A1. It consists of a mechanical proportioner identical with the one used on the AN-M3A1, three substitute pipe nipples, four mounting bolts and a set of conversion instructions. Final development tests were completed this summer. No user tests for this kit are contemplated as identical components are in use on the M3A1 Unit.

b. Kit Conversion, PT-4 System Incendiary Mixing and Transfer Unit, E8. This unit was developed at the request of the Air Force for the purpose of adapting the AN-M3A1 unit to prepare fire bomb gel using JP-4 fuel in lieu of gasoline. The kit consists of an electrically driven pump to increase the fuel pressure, a heater nozzle with a smaller orifice than that used with the gasoline to assure complete atomization of the fuel and more efficient combustion, an adjustable pressure regulator to vary the fuel pressure, a solenoid valve to control the flow of fuel to the nozzle and a pressure gage and stainless steel tubing for feed and a pump recycle lines. Using this equipment and JP-4 fuel, satisfactory gels have been prepared in the temperature range of -40°F to 120°F using thickeners E4R1 and M2 which has a vortex time below 60 seconds. M2 Thickener having a vortex time greater than 60 seconds required the use of a peptizer to form satisfactory gels.

c. Mixing and Transfer Unit, E3R4. This unit (see Figure 9) was developed to service Marine Corps and Army mechanized flame throwers. Essentially the unit is the same as the AN-M3A1, the only difference being the addition of a water separator. However, as it was required to dimensionally fit into a landing craft (LVTP-5) a rearragement of the components was necessary and a skid mounting was used instead of the wheel mount of the AN-M3A1. This unit has successfully produced gels using thickeners M2, E4R1, and E5R2, however, in view of the shorter contact time compared to the batch mixing M4 Unit, a higher concentration of thickener was required to produce gels comparable to those produced in the M4 Unit. The optimum concentrations for firing have been found to be 4.3% for E4R1 and 6% for E5R2, and M2.

d. The Army and Marine Corps have requested a continuous mixer capable of servicing both mechanized and portable flame throwers and field flame expedients. Preliminary work indicates that the E3R4 unit can be redesigned to incorporate a system of various sized venturi's which may be interchanged to yield different flow rates, i.e., 25 gpm for the mechanized flame thrower and 5 gpm for the portable. Work on this item is being continued.

4. Air Compressors

a. E32R2 - This is a lightweight compressor capable of delivering 3½ cfm (see Figure 10). Since the last report certain defects were noted during user test. These will be corrected and the item resubmitted for additional tests.

b. E35 - This is a high pressure high capacity compressor designed for the Marine Corps to be used with the mechanized flame throwers. It has a capacity of 100 cfm at 3,000 psi (see Figure 11). It has successfully passed User Tests and is now in the process of being standardized.

c. E39 - This unit was designed for the US Army. It is a large capacity, lightweight unit, weighing only 1500 pounds compared to the 4000 pounds of the E35 (see Figure 12). It has a capacity of 50 cfm at 3,000 psi. Final development tests have not been completed but tests to date indicate this is a superior compressor and all ground services have indicated their interest.

d. A feasibility study has been initiated on a free-piston type compressor (see Figure 13). No definite conclusions have been reached as yet, however, in view of the advantages, i.e., low cost, lightweight, compactness, simplicity of design and operation, and low maintenance, it seems this compressor will be a useful addition to the Mixing and Transfer Equipment.

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FIGURE 1

E30 One-Shot Portable Flame Thrower

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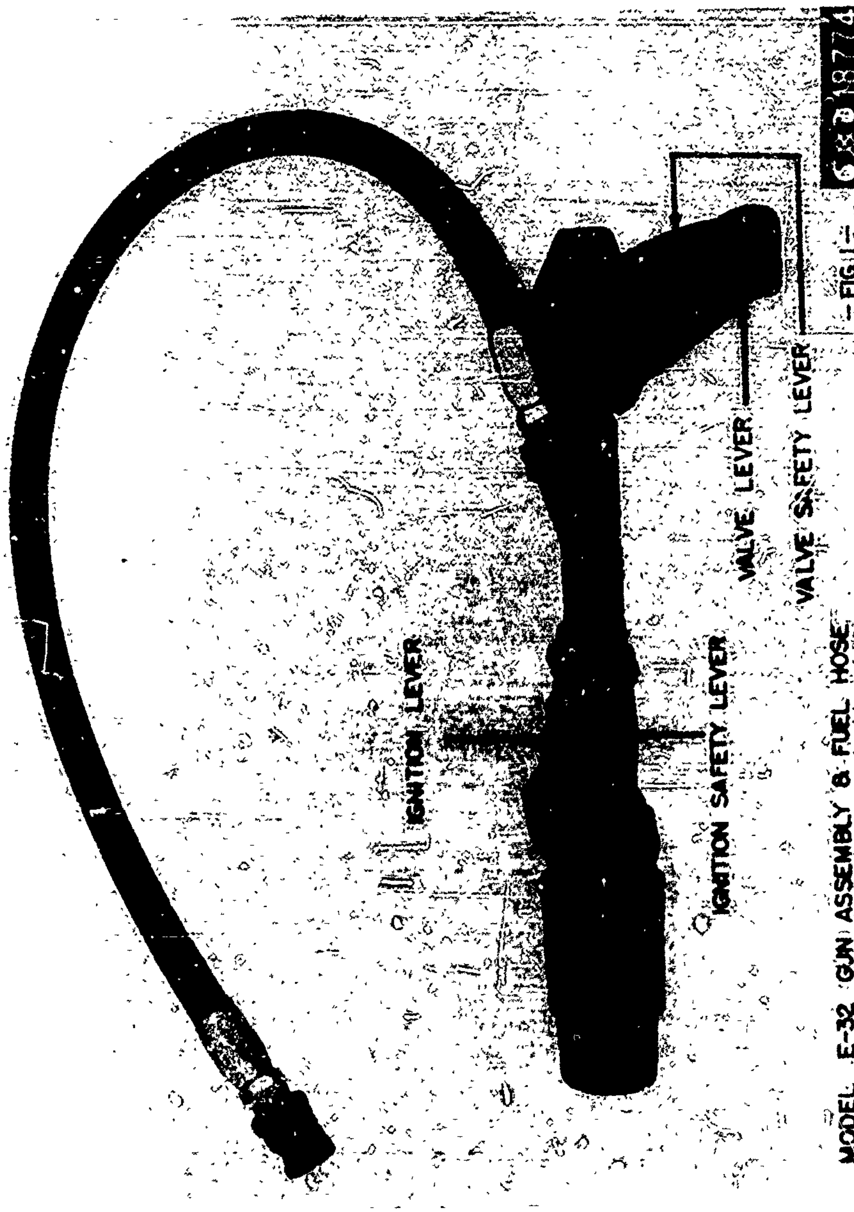

FIGURE 2

E32 Flame Gun and Hose Assembly

FIGURE 3
E32 Fuel and Pressure Unit

FIGURE 4
Front View Comparison of the E32 and Alternate Chemical Corps Designs for Fuel and Pressure Units

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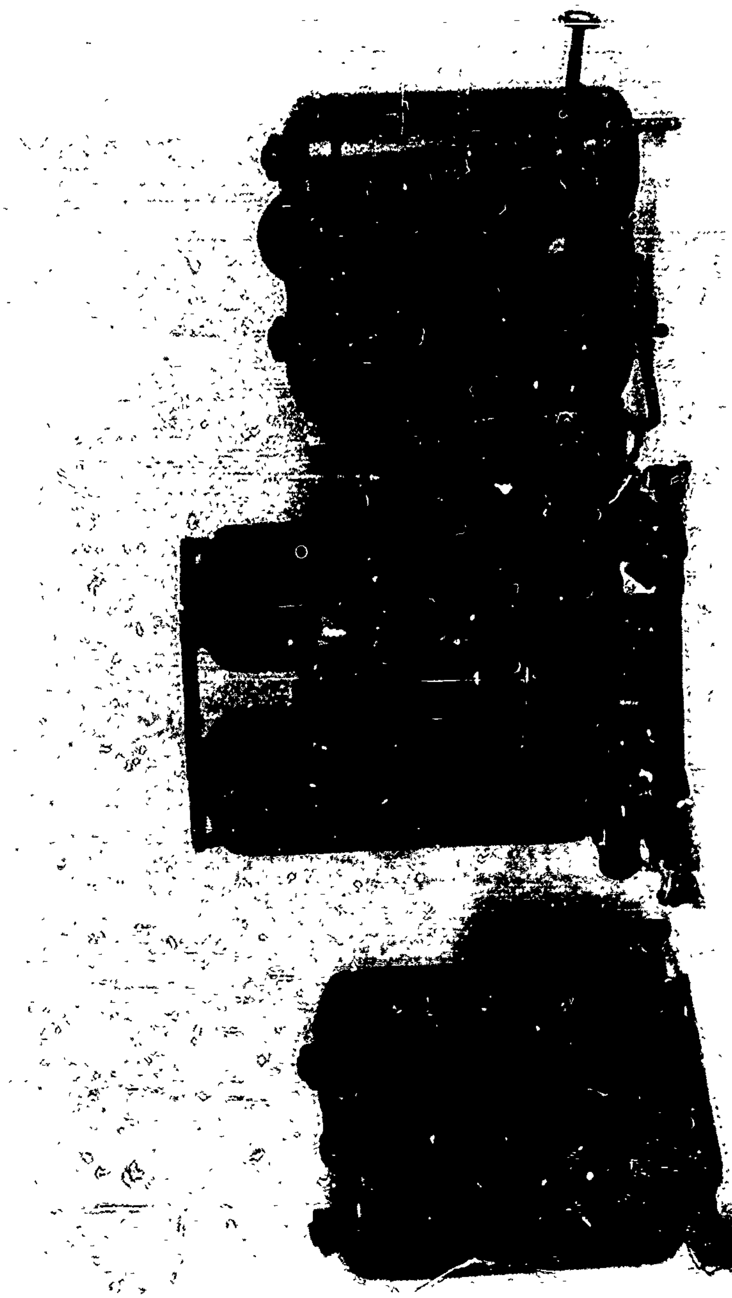

FIGURE 5

Side View Comparison of the E32 and Alternate Chemical Corps Designs for Fuel and Pressure Units

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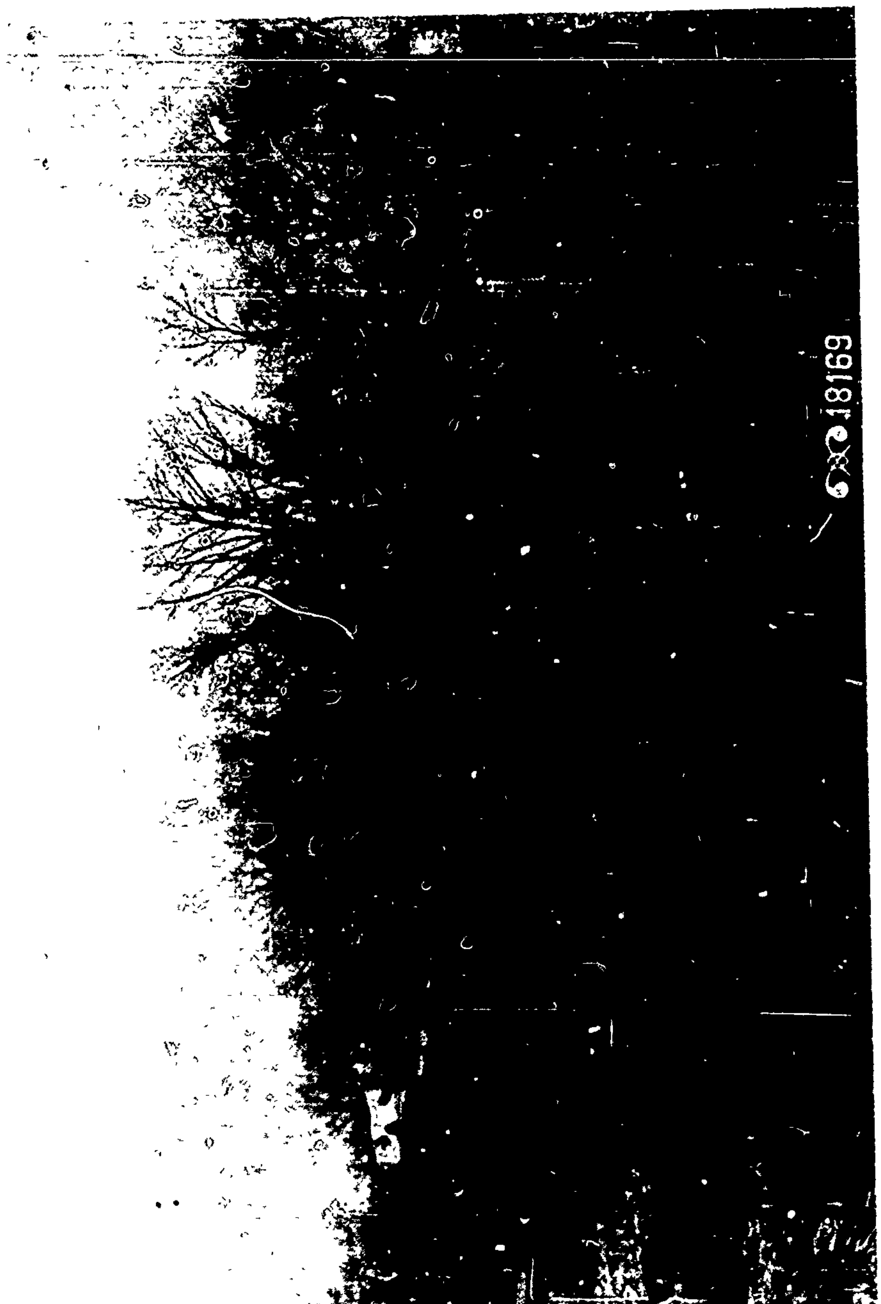

FIGURE 6
E24-29 Non-Integral Flame Thrower

FIGURE 7
T67 Integral Flame Thrower

FIGURE 8
E31-36 Universal Vehicular Mounted Flame Thrower for AUV/APC Type Vehicles

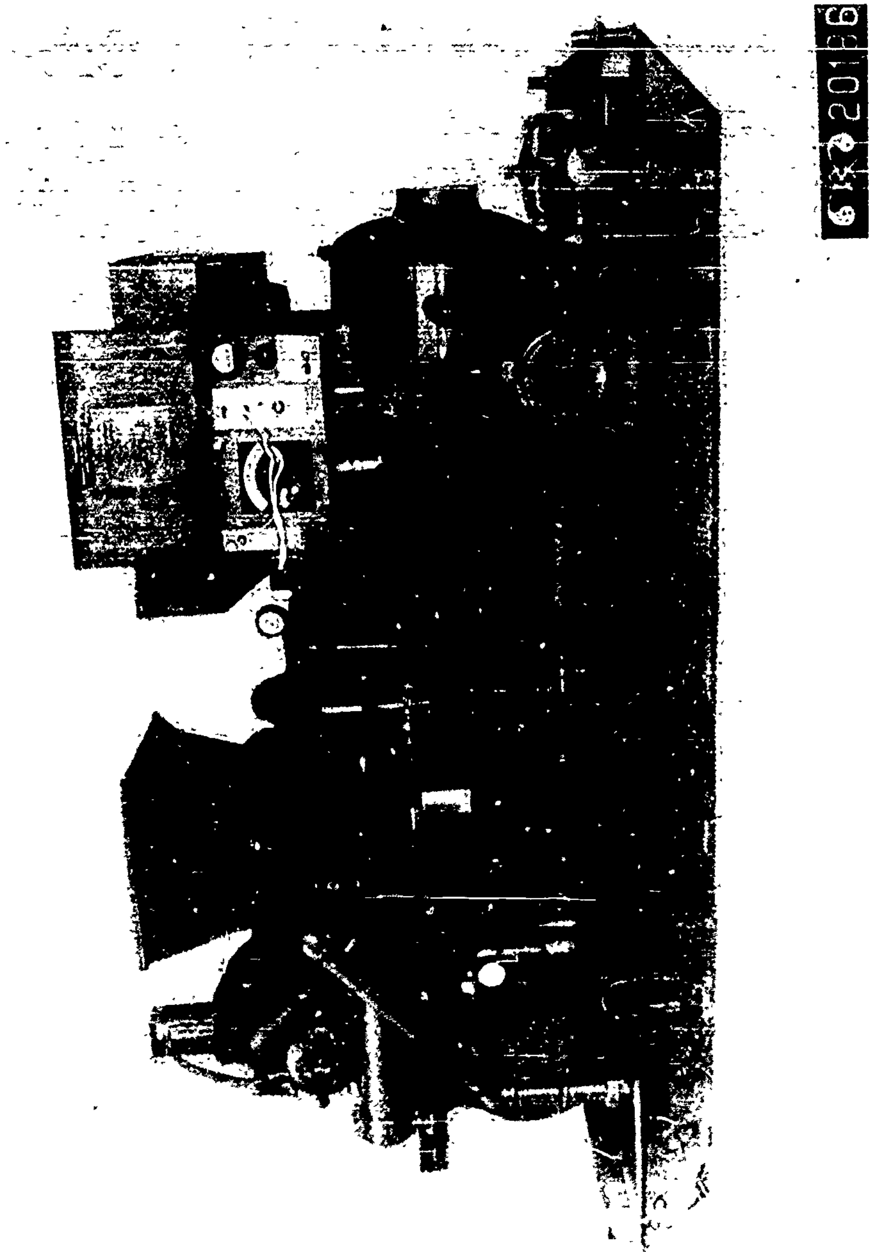

FIGURE 9
E3R4 Mixing and Transfer Unit

FIGURE 10

E32 Lightweight Air Compressor

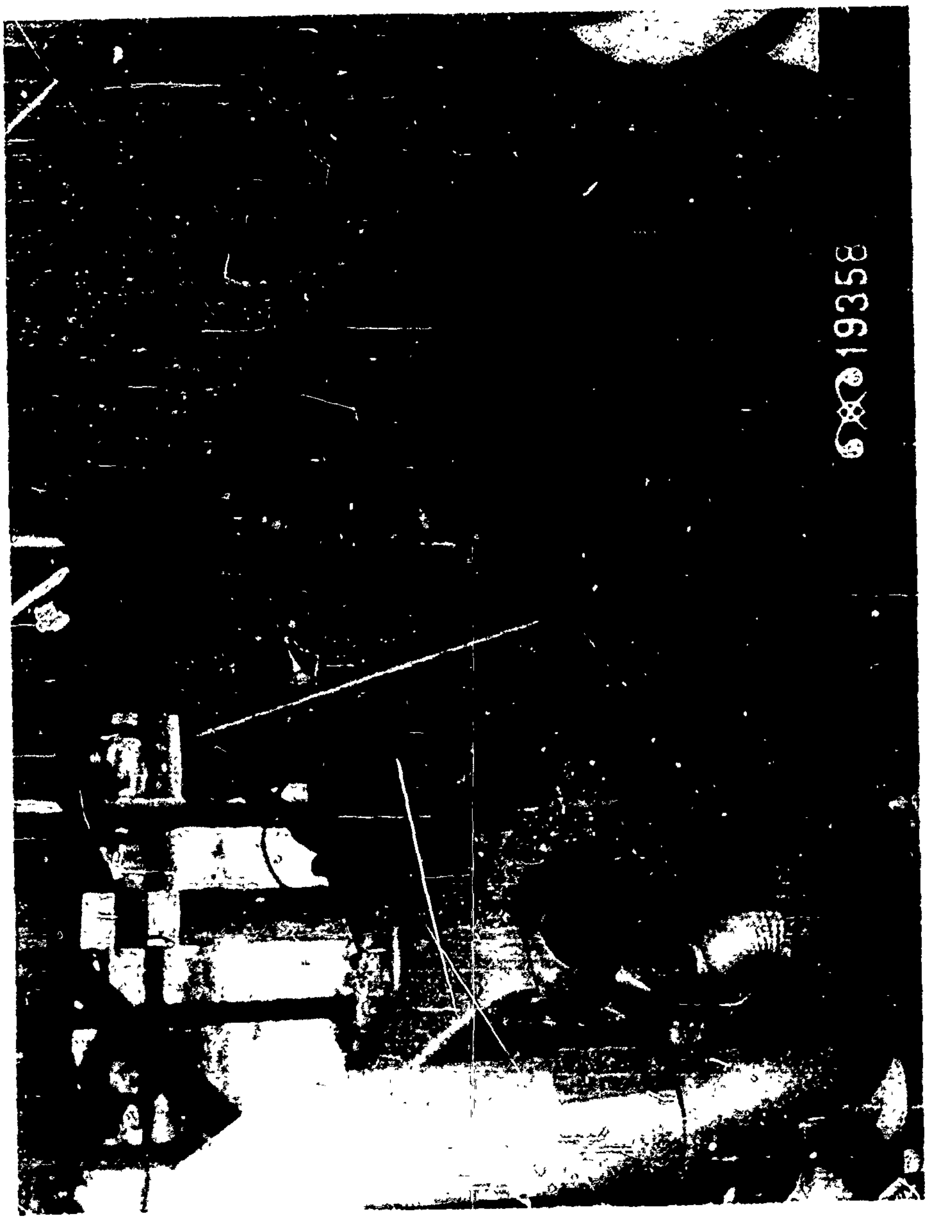

FIGURE 11
E35 Compressor, Reciprocating, GED, 100 CFM

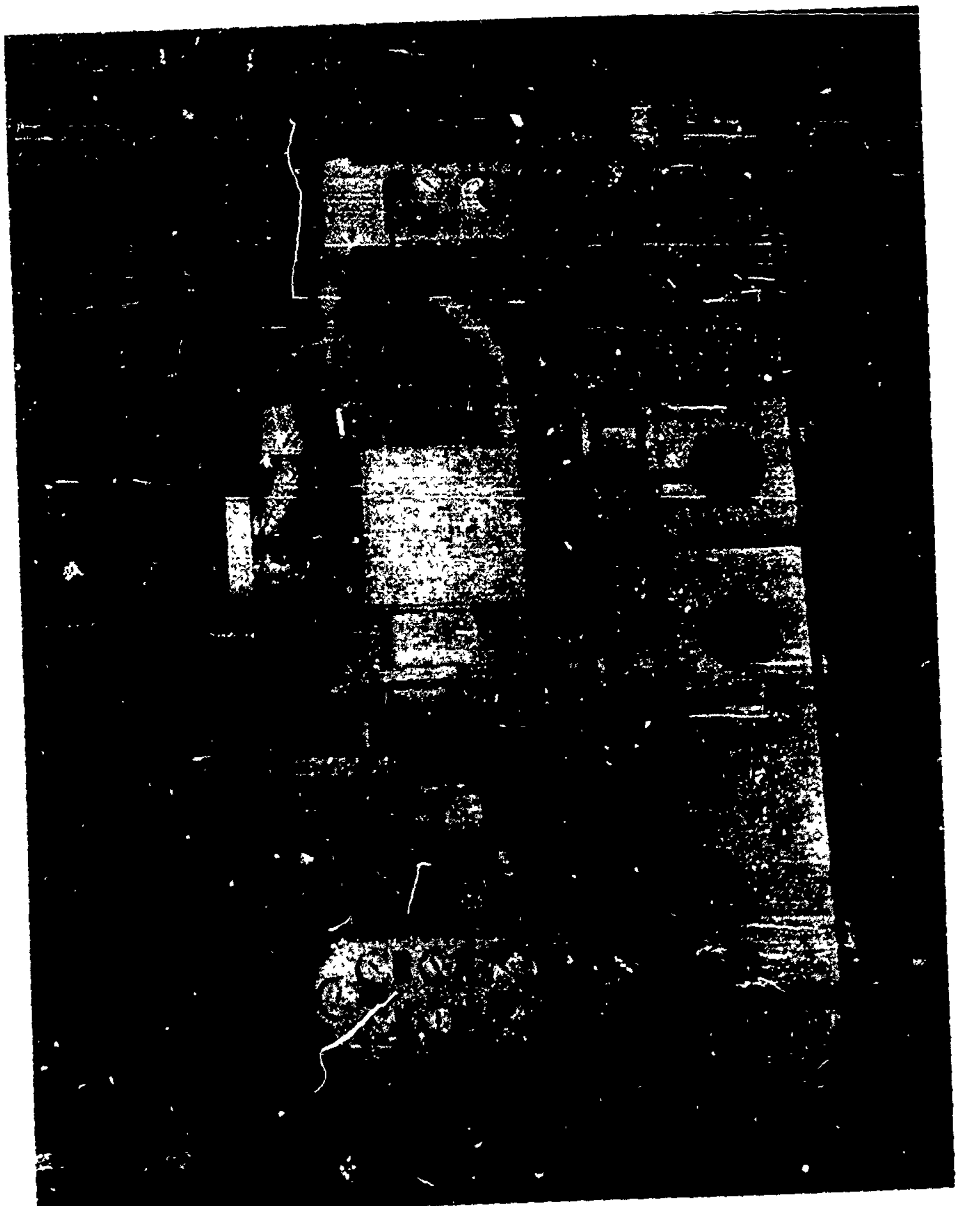

FIGURE 12
E39 Compressor, Reciprocating, GED, 50 CFM

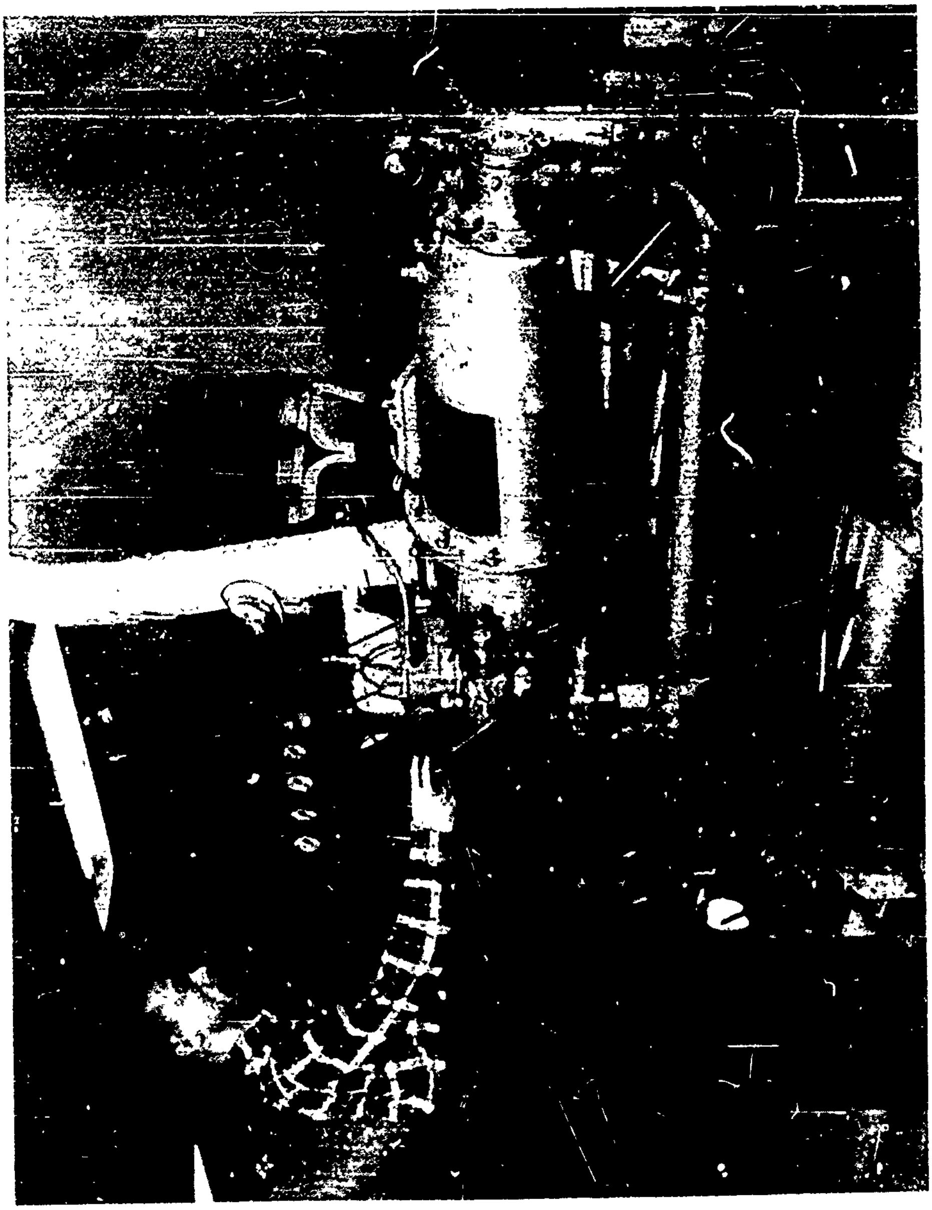

FIGURE 13
Compressor, Free Piston Type

Part IV. Aerial Flame Munitions

1. Fire Bombs.

a. E114 Plastic Fire Bomb - The Air Force originated a requirement for a plastic fire bomb in 1952. Work progressed slowly and in May 1954 their interest in the project for development was cancelled, however, they permitted the use of allocated funds to complete the development contract. However, the Navy was sufficiently interested to agree to support the test phase of the development. In April 1955 four E114 fire bombs were delivered to the Naval Proving Ground for tests. The E114 bomb is similar in shape to the M116 (aluminum) bomb. It is fabricated from fiber glass reinforced epoxy plastic resin, weighs 146 pounds empty and 833 pounds filled with fuel. The bomb satisfactorily withstood a 10.7g's fore and aft load when tested on a catapult. However, on the side test at 6.2g's the sway brace pads punctured the skin. Two of the bombs were air dropped and gave a similar fuel dispersion pattern as the M116 bomb. Minor design changes were incorporated and more bombs are being procured for further development tests.

b. M116 Fire Bomb (see Figure 14) - This bomb prior to standardization was designated as the E74. Since being standardized the Air Force has requested several modifications to simplify assembly. The standardized model requires internal assembly of components through hand holes. The modified version designated E74R2 provides for external assembly of the components and also provides for the use of a modified M23 Igniter which has a bayonet type fitting instead of the rolled threads. Twenty five of this type were procured, tested and found satisfactory. However, in view of the experimental status of the modified M23 igniter, the E74R2 was modified to accept the standardized version of the M23 i.e., rolled threads, and designated as the E74R3. This design was then standardized as the M116A1 (see Figure 15).

c. Mk 77 Mod 0, Fire Bomb - This bomb is being developed to fulfill the Navy's requirement for a fire bomb suitable for release from fighter aircraft in high altitude dive bombing attacks. Development tests have been conducted at the Army Chemical Center using various type fuzes for aerial bursts or ignition at ground impact. To date, low altitudes release with ignition at ground impact yields the better dispersion pattern; however, the aerial burst seem promising enough to warrant continued tests with improved fuzes.

2. Cluster Adapters - The program to develop a lightweight, multi-purpose adapter for clustering bomblets developed under various Chemical Corps projects was continued. The development has progressed on three designs to the point where for economical reason two of them were dropped and effort concentrated on completing the development of the most satisfactory design.

a. E53 Cluster Adapter (see Figure 16) - This adapter has proved to be the most satisfactory of the three developed and development tests are being completed. It is fabricated of steel and is of the side-opening type. Failures were encountered in effecting hermetic seals. The sealing edges and the gasket material have been modified and provisions for electrical fuzing has been incorporated. A total of one thousand and three hundred E53R2 cluster adapters were procured for the various cluster programs. During the period additional tests pertaining to the 750-lb. cluster program in general have been undertaken at the request of WADC. These tasks include assembly of 750-lb. clusters of various inert weights for aircraft compatibility and release studies, also the design and fabrication of a test jig for the field assembly of clusters. An additional task is the monitoring of the electrical fuze program to insure compatibility of the electrical fuzing with the E53R3 cluster adapter. The cluster adapter E53R3 was standardized as Cluster Adapter, M30.

b. E50 Cluster Adapter - This adapter is the plastic version of the E53 adapter. Five units were fabricated and subjected to preliminary rough handling and flight tests, the results of which were satisfactory. However, on further tests deficiencies were noted which were objectionable and due to funding limitations the work necessary to complete development of this item has been suspended.

c. E52 Cluster Adapter - This adapter fabricated of steel is of the nose-ejection type. It was considered possible to improve the bomblet dispersion pattern by this type of ejection. Tests conducted indicated no significant improvement and as the Air Force accepted the E53R3, as meeting their requirements, this project has been dropped.

3. Incendiary Clusters - Essentially the work performed during the report period consisted of completing work necessary to standardization of the clusters previously reported.

a. E115 Cluster - This cluster consists of the E53R3 Cluster Adapter and the PT-1 filled M74A1 bomblet which is equipped with the all-ways, delay type fuze M197. (See Figure 17.) The final development and user type tests were telescoped to expedite standardization. Twenty clusters were dropped from 40,000 feet with the cluster fuze set to function at 11,000 feet to prove functionability. This resulted in 94 percent over-all bomblet functioning. Design changes were made and an additional 36 clusters were dropped with a 97.7 percent functioning. Static drop tests were conducted which proved the cluster capable of withstanding a 20-foot drop onto concrete with the bomblets remaining unarmed. The E115R5 cluster having successfully passed the User Test has been standardized as the M35 cluster. The following data concerning the penetration ability of the M74 bomblet was generated during simulated air drop tests. The M74 bomblet could penetrate the minimum resistance of the incendiary target when impacting at 90° from the horizontal, providing the velocity was not less than 217 feet per second. At greater velocities (approximately 350 feet per second) the bomblet could penetrate any section of the target. A rafter impact usually results in some type of ricochet and eventual bomblet penetration. It appeared that the M74 bomblet could not penetrate the minimum resistance when impacting at approximately 181 feet per second. An additional 30 inert clusters were subjected to flight tests to determine penetration of Russian prototype targets. Results of this test indicate the M74 bomblet is not satisfactory for use on Russian type targets.

b. E116 Cluster - This cluster consists of the E53R3 cluster adapter and the high penetration 35-pound PT-1 filled E71 bomblet (see Figure 18). The major effort during this report period was directed toward the preparation of data required for conducting a comparative evaluation of the penetration characteristics of the E71 bomblet with those of the E89 (4-lb. Mg Incendiary Bomblet) and the M74 (PT-1 10-lb. Bomblet). Further work on this cluster is being held in abeyance pending results of the high altitude penetration tests being conducted on the E115 and E117 Cluster.

c. E117R2 Cluster - This cluster consists of the E53R3 cluster adapter and the E89 bomblet (see Figure 19). The E89 bomblet is the M50A3 Incendiary Bomblet modified by a redesigned tail assembly to permit clustering the 4-lb. Mg bomblet in the E53R3 adapter. It consists of a shorter tail body with spring-actuated retractable fin blades which on release from the cluster extends into position. Seven clusters were flight tested and showed need for increase of the structural strength of the fin. This was accomplished and seven more clusters were dropped from 40,000 feet at 500 mph. Only 92 percent of the bomblets functioned with fin damage the major cause of the duds. The fin assembley has been redesigned and 33 clusters of the latest revision were shipped to the Edwards Air Force Base for range bombing and functioning tests. The 33 clusters were dopped from altitudes varying from 25,000 to 40,000 feet with opening altitudes from 8,000 to 10,000 feet. The over-all functioning of the bomblets was 95 percent. However, when the cluster was dropped from altitudes of 25,000 feet or more and were fuzed to open at 10,000 feet the cluster successfully met the 95 percent functioning requirement. Having successfully passed the User Test, the cluster has been standardized with the restriction that it was for use only under these conditions as the Cluster, Incendiary Bomb, M36. The E89 bomblet was standardized as the Bomb Incendiary 4-lb. M126. An additional 30 inert clusters will be dropped on Russian prototype target at Eglin Air Base for penetration data.

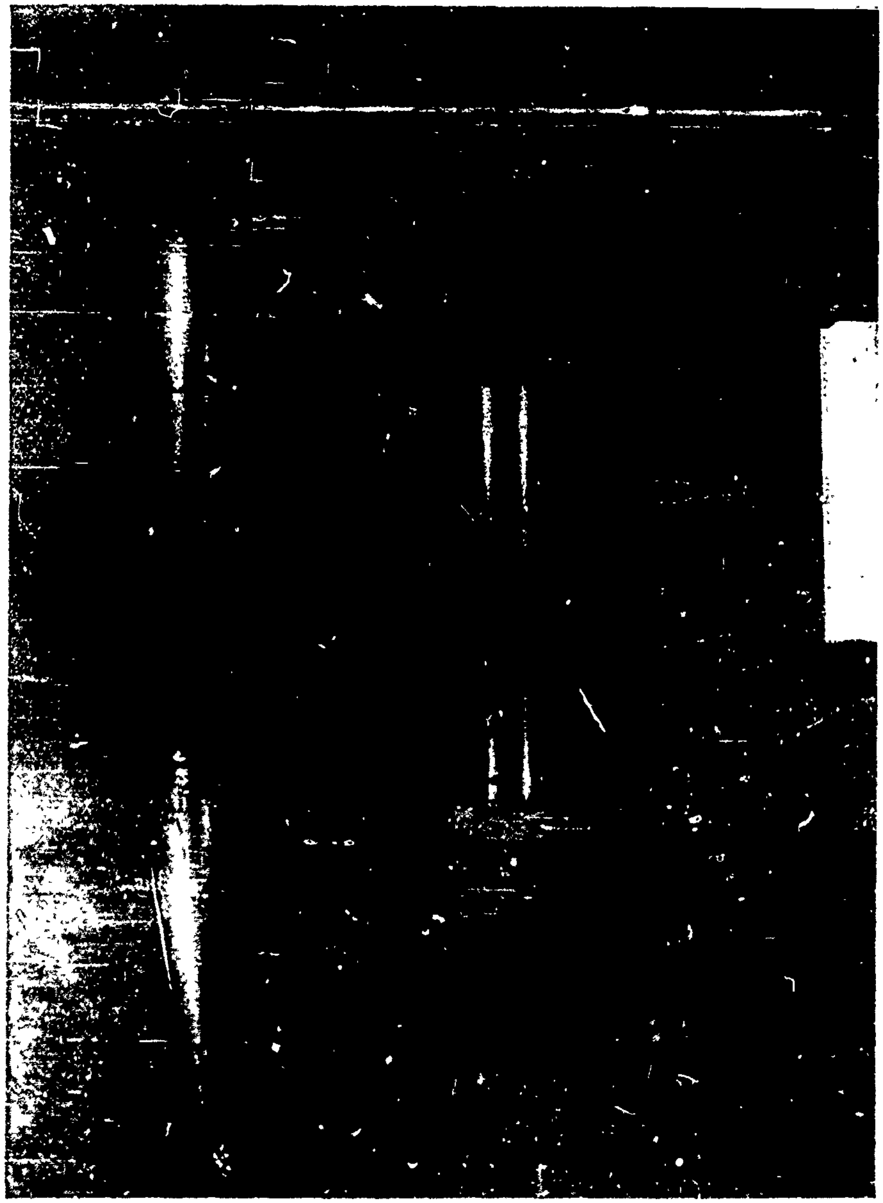

FIGURE 14
M116 Fire Bomb

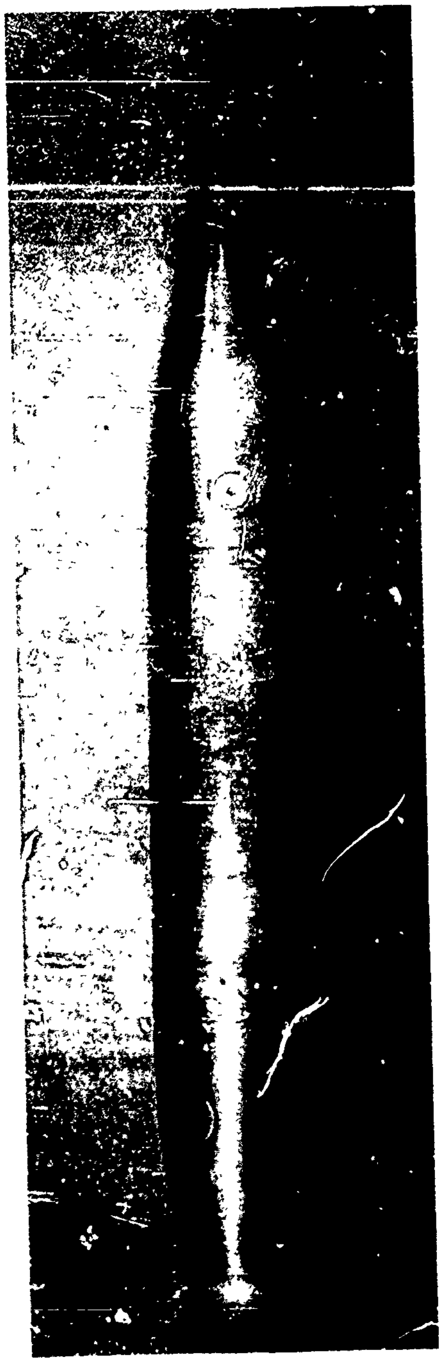

FIGURE 15
M116A1 Fire Bomb

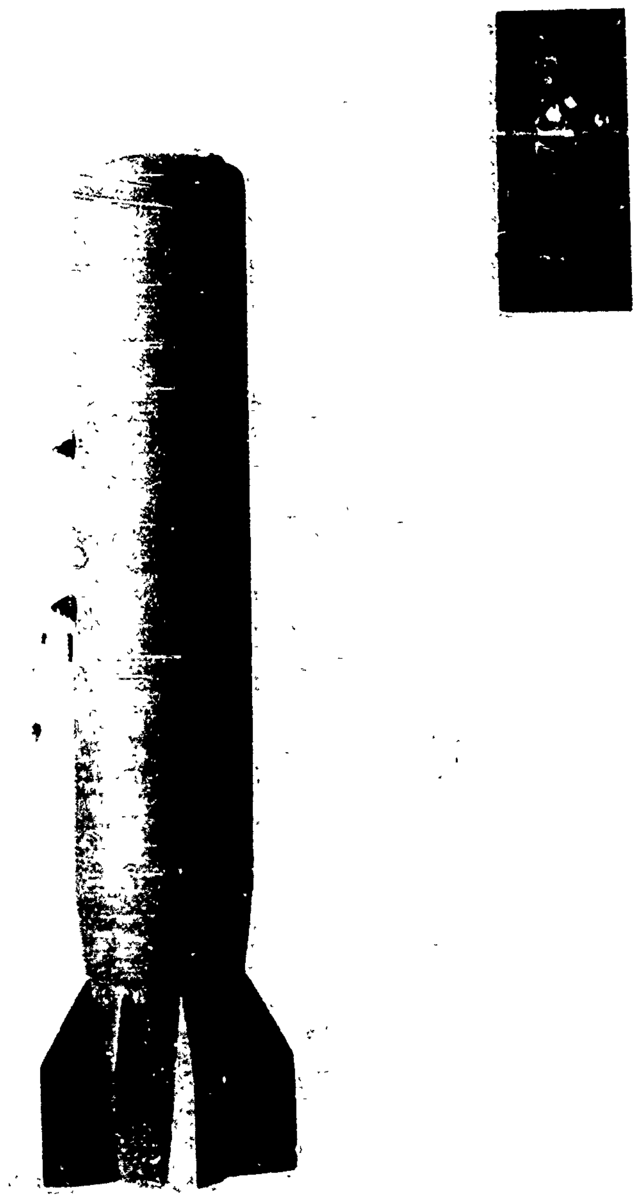

FIGURE 16
M30 Cluster Adapter

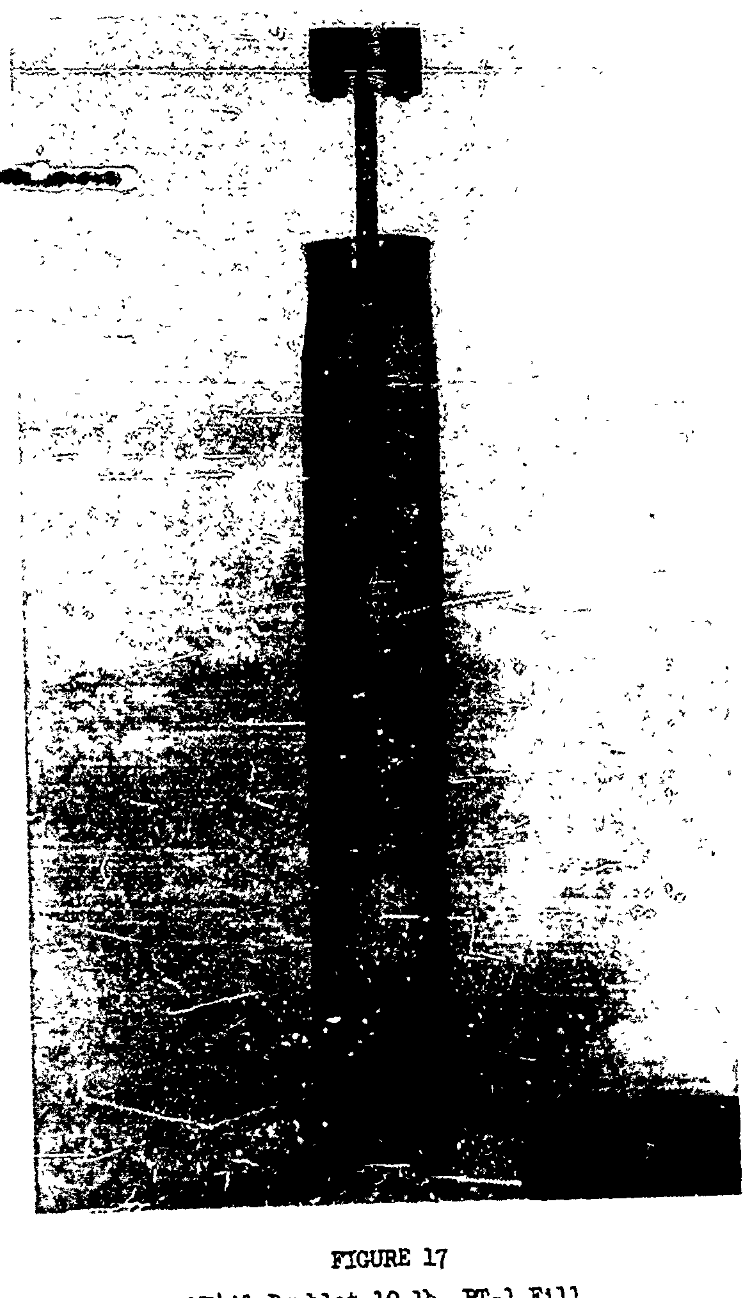

FIGURE 17

M74A1 Bomblet 10-lb. PT-1 Fill

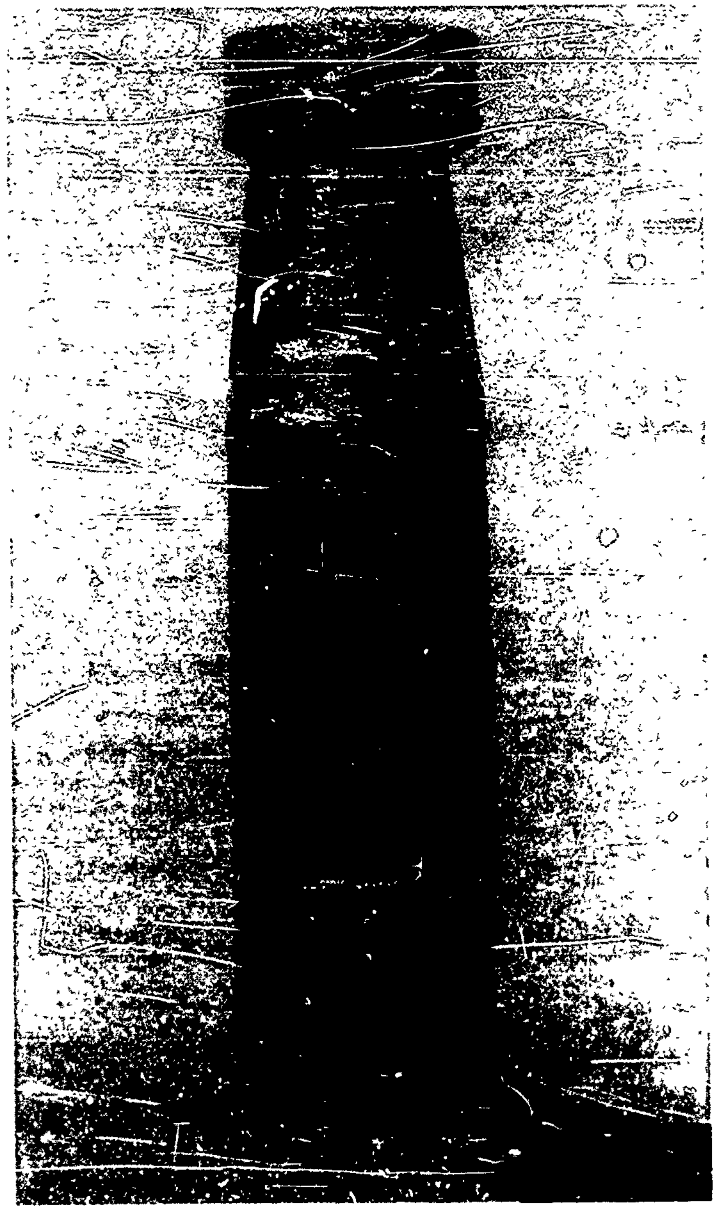

FIGURE 18

E71 Bomblet 35-lb. PT-1 Fill

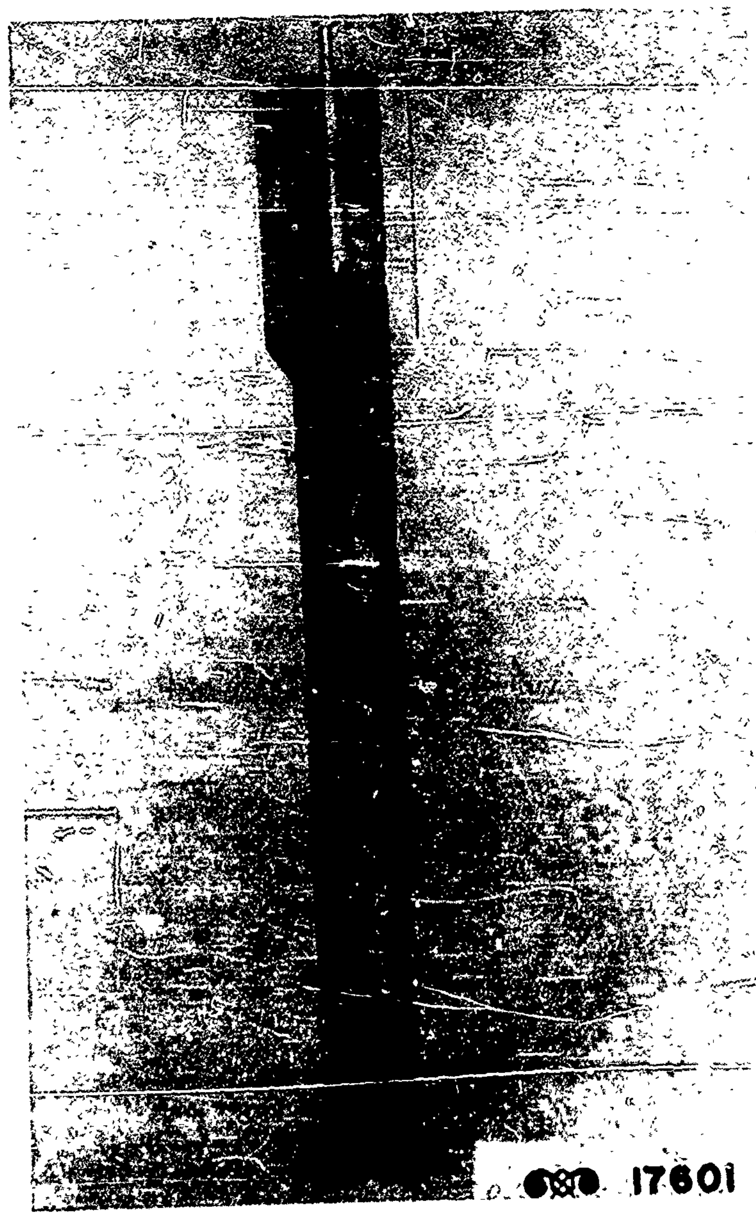

FIGURE 19

E89 Bomblet 4-lb. Magnesium Body, Thermate 64-C Fill

Part V. Miscellaneous Flame Projects

1. Bouncing Betty Land Mine - The feasibility of a "Bouncing Betty" type land mine is being investigated. It is intended to project a 10-gallon size land mine approximately 5 feet above the ground prior to detonation to achieve optimum dissemination.

2. Bunker Bomb - A "bunker bomb" is being developed which is based on the field expedient utilized in the Korean conflict. The field expedient consisted of a .30 or .50 cal. ammunition container filled with thickened gasoline using a WP grenade as the igniter. The improved version will incorporate safety features which the expedient lacked.

3. Fire Rocket - Work on the development of the fire rocket continued until the responsibility for the development was transferred to the Ordnance Corps. Up until that time performance of the rocket was improved considerably through the use of the 2.75 FFAR motor and a redesign of the fins. Ranges of 1,450 to 1,500 yards were achieved. Further modifications to include the use of front and rear fairings and the use of tie rods within the warhead container increased the range to an average of 2,650 yards. A single 2.75 motor was used in all test firings. A series of tests were conducted to evaluate the physiological effect of this weapon. Clothed animals in open and dug in positions were placed in the target area and the following results were obtained:

	On Surface	In foxholes
Immediately disabled	17	8
No. of Animals in target area	24	44

No further work is being done by the Chemical Corps and any future work on this item will be presented by the Ordnance Corps.

4. Incendiary Burster for Improvised Munition - The Korean conflict revealed the need for an incendiary-burster in the use of improvised field munitions. Consequently a unit has been developed which consists of a steel tube, 10.5 inches long with a 1-inch inside diameter. The ends are a male and female interlocking type closure which also contains the initiating primer and fuze. A single unit will detonate and ignite a 5-gallon drum of thickened gasoline while 3 units joined together are used for the 55-gallon drum. Any number of units may be used to effect the desired ignition and detonation of an improvised device. The filling consists of a central column of 3/4-inch OD pellets of tetryl. This is surrounded by a loosely compacted charge of incendiary mixture of red iron oxide, titanium and zirconium. The item is now being procured for final development tests.

5. Chemical ignition for flame throwers - During the past year work has been pressed for a chemical igniter for the flame throwers. Chlorine trifluoride did seem to have some promise as an igniter, however, in view of the personnel hazard and its extremely corrosive action on material, an alternate material was sought. Chromyl chloride was tried with success in the portable flame thrower, the rate being 0.5 ml per gal of fuel expended. The chromyl chloride was ejected through a 0.025-inch nozzle under 20 psi of air. The ignition on the mechanized flame thrower fuel was not successful. The oxidizer was then changed to chromyl nitrate and ignition was effected in the mechanized flame thrower, the rate being 90 ml per 100 gal of fuel. The chromyl nitrate was ejected through an 0.082 inch nozzle under 5 psi of air. Development work is continuing on the chemical ignition system for flame throwers.

6. Evaluation Criteria for Incendiary Agents and Munitions - A project has been established to develop realistic criteria for the evaluation of Incendiary Agents and munitions. The object of this task is to conduct an over-all investigation involving the evaluation of flame and incendiary agents and munitions systems from the standpoint of anti-personnel and anti-material effects. It is intended to divide the criteria into the following categories, (a) Physiological, (b) Psychological, and (c) Destruction Capabilities. Preliminary tests have been conducted to correlate the effect of concentration of flame to the physiological incapacitation and the psychological effects on tests animals. Evaluation of this test data will permit a precise method of expressing, in mathematical terms, the effectiveness of a given incendiary munition or agents.

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