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OSRD NO. 6360

DIVISION 11  
NATIONAL DEFENSE RESEARCH COMMITTEE  
of the  
OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT

M5-4 (F12-7R1) MECHANIZED FLAME THROWER  
INSTALLED IN M4A1 OR M4A3 MEDIUM TANKS

Service Directive: CWS-10

Endorsement (1) from Dr. H.C. Hottel, Chief, Section 11.3  
to Dr. H.M. Chadwell, Chief, Division 11.

Forwarding report and noting:

"This report describes a mechanized flame thrower installed in the M4A1 or M4A3 medium tanks. This development was begun in August, 1944, due to the obsolescence of the M5A1 light tank in which an earlier mechanized flame thrower had been installed. This mechanized flame thrower was placed in production, and 620 units were on order at the end of the war. Following V-J day, this order was reduced to 150 units. Seventeen of these units, accompanied by one of the engineers from the Standard Oil Development Co., were sent to the Pacific in June, 1945, but they arrived too late for action."

Endorsement (2) from Dr. H.M. Chadwell, Chief, Division 11  
to Dr. Irvin Stewart, Executive Secretary of the National  
Defense Research Committee.

Forwarding report and concurring.

This is a progress report under Contract OFMSr-390  
(11-270) with the Standard Oil Development Co.

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M5-4(E12-7R1) MECHANIZED FLAME THROWER  
INSTALLED IN M4A1 OR M4A3 MEDIUM TANKS

by

Standard Oil Development Co.

Report OSRD No. 6350

Copy No. 22

Date: October 31, 1945

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STANDARD OIL DEVELOPMENT COMPANY  
Elizabeth, N. J.

M5-4 (E12-7R1) MECHANIZED FLAME THROWER  
INSTALLED IN M4A1 OR M4A3  
MEDIUM TANKS

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S.O.D. Projects 31472 and 31720  
O.S.R.D. Contract OEMsr-390  
Final Report PDN 4025  
October 31, 1945

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TABLE OF CONTENTS

	<u>Page</u>
I. SUMMARY	1
II. INTRODUCTION	4
III. DESCRIPTIVE DATA	7
IV. DESCRIPTION	13
A. Modifications to M4A1 or M4A3 Tank	13
1) Gun	13
2) Turret	13
3) Hull	13
B. Flame Gun and Controls	15
C. Main Fuel System	15
D. Main Air System	17
E. Secondary and Atomizer Fuel Systems	17
F. Auxiliary Air System	19
G. Ignition System	19
V. PERFORMANCE	21
VI. SERVICING	23
VII. COMPARISON OF M4A1 AND M4A3 INSTALLATIONS	25
VIII. SPECIAL DEVELOPMENTS	27
A. E7R1 Extended Nozzle	27
B. Rotary Joint	27
C. Dummy Gun Tube	29
D. Igniter Spark Plugs	32
E. Fire-Resistant Ignition Cable	33
F. Flame Gun Sighting Equipment	36
G. Elevating Gear Adapter	36
H. Commander's Seat	37

TABLE OF CONTENTS (CONT.)

	<u>Page</u>
IX. SAFETY FEATURES	38
A. Gun Controls	38
B. Pressure Reliefs	38
C. Emergency Shut-Off Cocks	39
D. Fire Extinguishers	39
E. Flexible Hoses	39
X. PRODUCTION IMPROVEMENTS	40
XI. INSPECTION AND TESTING DURING MANUFACTURE	41
XII. SERVICE TESTS	42
A. Shakedown and Operation	42
B. Radio Interference	42
XIII. MISCELLANEOUS TESTS	43
XIV. PERSONNEL TRAINING	45
XV. ACKNOWLEDGMENTS	46
XVI. APPENDIX	47
A. Bibliography	48
B. Military Training Classes	52
C. List of Drawings	54
1) E7R1 Flame Gun	54
2) M5-4 (E12-7R1 Flame Thrower Installation)	56
D. Drawings	
1) E7R1 Flame Thrower Gun - Figure A	69
2) M5-4 (E12-7R1) Flow Plan - Figure B	70

C O N F I D E N T I A L

INDEX OF ILLUSTRATIONS

	<u>Page</u>
Figure 1 - M5-4 (E12-7R1) Flame Thrower in M4A1 Tank (Side View)	-
Figure 2 - M5-4 (E12-7R1) Flame Thrower in M4A1 Tank (Top View)	3
Figure 3 - Simplified Flow Plan - M5-4 Flame Thrower System	6
Figure 4 - Schematic Layout - M5-4 Flame Thrower in M4A1 or M4A3 Tank	12
Figure 5 - E7R1 Flame Gun	14
Figure 6 - Schematic Flow Diagram - Main Fuel System	16
Figure 7 - Auxiliary Air-Pressure Regulating System	18
Figure 8 - Ignition System in Dummy 75 mm. Tube	18
Figure 9 - M5-4 Firing 8% Napalm-thickened Fuel - 65 Yards to Target	20
Figure 10 - Servicing M5-4 Flame Thrower with Main Fuel and Air (using E8R1 Mobile Service Unit)	22
Figure 11 - E7R1 Interchangeable Nozzle Extension	26
Figure 12 - Rotary Joint	28
Figure 13 - 75 mm. Dummy Gun Tube Installation	30
Figure 14 - I-10 and I-11 Igniter Spark Plugs	31
Figure 15 - Flame Gun Sighting	35
Appendix Figure A - E7R1 Flame Thrower Gun	69
Appendix Figure B - Flow Plan - M5-4 (E12-7R1) Flame Thrower in M4A1 or M4A3 Medium Tank	70

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FIG. 1 M5-4 (E12-7R1) FLAME THROWER IN M4A1 MEDIUM TANK

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I. SUMMARY

Under contract OEMsr-390 and at the request of Chemical Warfare Service, the Standard Oil Development Company undertook the development and design of the Mechanized Flame Thrower E12-7R1 which was later standardized as the M5-4. Much of the development work had been completed in the design of the earlier Model Q prototype, the Navy Mark 1, the E7-7 (M5A1 light tank), and the E7-LVT-A1 (amphibious tank) units, but additional improvements were developed and tested under the M5-4 assignment. Acting as engineering consultants for Chemical Warfare Service, and with the guidance and cooperation of Chemical Warfare Service-Technical Division, Headquarters A.S.F., and the New Developments Division, the assignment was carried out in close cooperation with the C.W.S. prime contractor, the M. W. Kellogg Company, and their subcontractor, the Lecourtenay Company. Initiated in August, 1944, this assignment also included the inspection and testing of the first twenty units, which were completed in May, 1945, establishing inspection procedures for large scale production, training of two U. S. Army instructor teams, issuing operating and maintenance manuals, and providing a field consultant under O.F.S. in the theater of operations.

The M5-4 design included the E7R1 flame gun (improved "Model Q" with interchangeable 1/2" and 3/4" bore nozzles) replacing the 75 mm. cannon in M4A1 or M4A3 medium tanks, with pressure containers in turret and hull providing for 270 gallons effective capacity of thickened fuel and storage of 2000 p.s.i.g. propellant air or inert gas. In silhouette the M5-4 appears as a standard medium tank equipped with a 75 mm. gun and normal auxiliary armament.

Cessation of hostilities reduced production to a total of approximately 150 units and precluded combat testing of M5-4 flame thrower tanks, although several units had been shipped to the Pacific Theater for training and combat operations.

Characteristics of the M5-4 are summarized as follows:

Vehicle	M4A1 or M4A3 Medium Tank*
Silhouette	Unchanged
Flame Gun (E7R1)	Replaces 75 mm. cannon in turret
Nozzles	1/2" or 3/4" bore - interchangeable

---

\* Restricted to those models providing dry 75 mm. ammunition stowage.



C O N F I D E N T I A L

2.

Rate of Fire 2.2 gals./sec. (1/2" nozzle)  
4.4 gals./sec. (3/4" nozzle)

Elevation -12° to +25° (double original  
75 mm. elevation speed)

Traverse 360°+ (Power or Manual)

Effective Fuel Capacity 270 gals.  
Operating Pressure 375-400 p.s.i.g.  
Total Firing Time 125 secs. (1/2" nozzle)  
63 secs. (3/4" nozzle)

Fuel Propellant Compressed air or nitrogen (11.5  
cu.ft. at 2000 p.s.i.g.)

Ignition Gasoline-Electric

Crew 2 - Turret  
2 - Hull

Typical Range Data\* (8% Napalm Thickened Gasoline)

<u>Nil Wind</u>	<u>10° Elevation</u>	<u>20° Elevation</u>
1/2" nozzle	95 yards	105 yards
3/4" nozzle	105 yards	125 yards
<u>10 MPH Tail Wind</u>		
1/2" nozzle	110 yards	125 yards
3/4" nozzle	125 yards	150 yards

\* Measured from flame gun to center of ground deposit.

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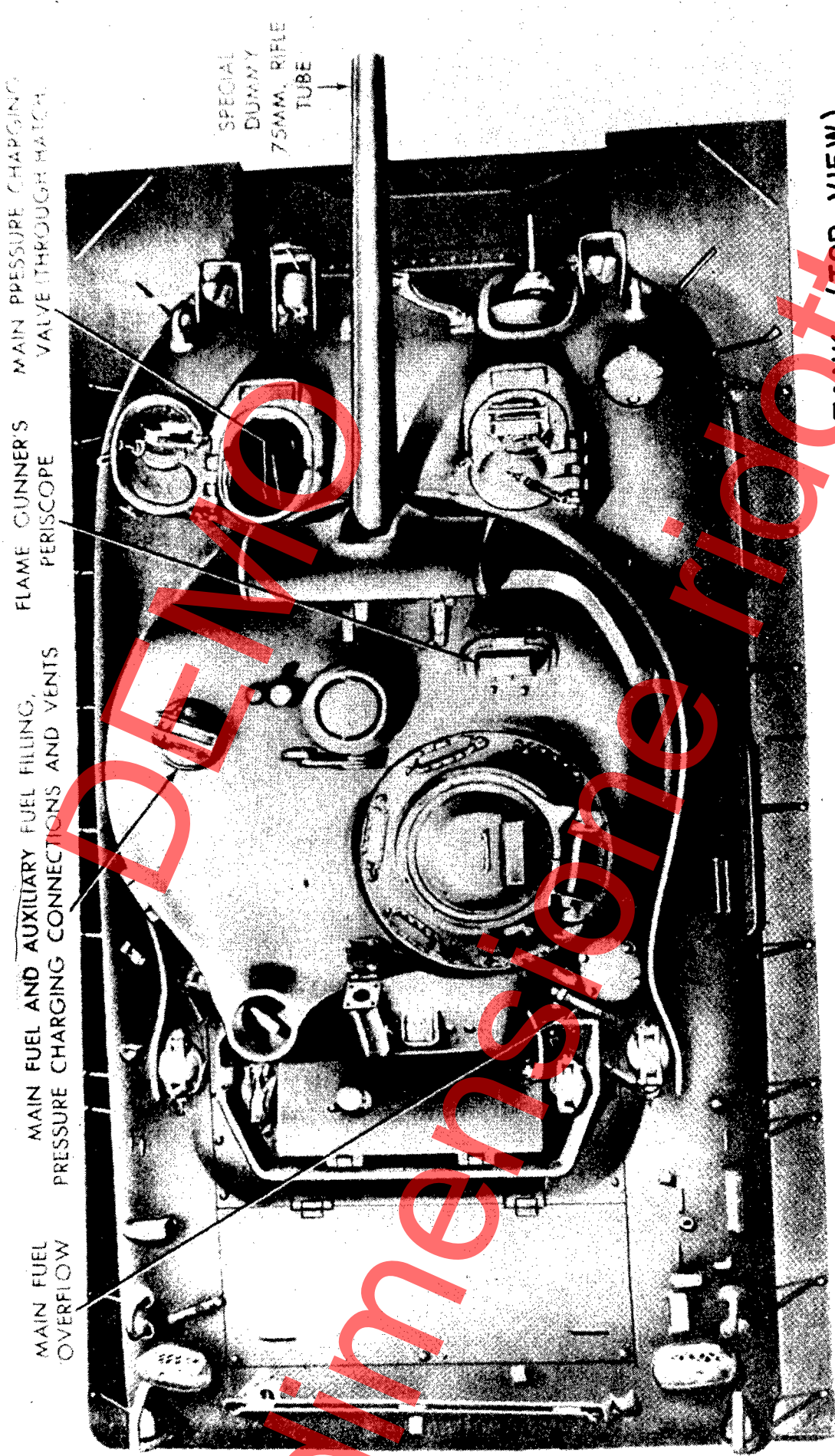


FIG. 2 M5-4 (E12-7R1) FLAME THROWER IN M4A1 TANK (TOP VIEW)

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II. INTRODUCTION

Prior to 1944, application of flame throwers in combat by the U. S. Armed Forces was generally confined to the use of short-range, low-capacity portable units employed directly by ground troops or by improvised installation in available armored vehicles.

Following experimental and development work on large capacity, long-range flame throwers carried out under Contract OEMsr-390 in 1942, the Standard Oil Development Company by early 1943 had completed and demonstrated\* to the military the "Model Q" (E7) flame gun designed for use with thickened fuels in mechanized vehicular installations. The first production model of this gun was completed in July, installed in an M5A1 light tank, and demonstrated in November, 1943. Three additional M5A1 installations were completed by late 1944 and successfully combat tested in Luzon, Philippine Islands in April, 1945\*\*. Further work on this installation was abandoned because of obsolescence of the vehicle.

In early 1944, thirty-one large flame thrower units, designated U.S.N. Mark 1, were built for the U. S. Navy using this basic design\*\*\*. These flame throwers were equipped with the "Model Q" guns and designed for use in small landing boats. The units were successfully employed in amphibious tanks in land combat on Peleliu Island (September-October, 1944).

Experience gained with the above units and combat operations with improvised flame throwers built and operated in the Pacific emphasized the important need for long-range, large capacity, heavily armored vehicular flame throwers in both mop-up and offensive operations. Use of the British "Crocodile" in the European Theater also proved the value of the large mechanized flame thrower in combat.

- 
- \* PDN 1158, "Mobile Flame Thrower Model Q," April 6, 1943
  - \*\* PDN 3925, "Development and Field Use of E7-7 Mechanized Flame Thrower Installed in M5A1 Light Tank," September 12, 1945
  - \*\*\* PDN 2290, "Demonstration of U. S. Navy Mark 1 Flame Thrower," March 24, 1944.

Hence, in August, 1944, the Army Ground Forces and C.W.S. requested construction of twenty medium tank flame throwers to be used for service and combat testing as a basis for extended production. This limited procurement comprised the M5-4 (E12-7R1) mechanized flame thrower installed in M4A1 medium tanks\*. Successful service testing (March, 1945) of the first completed unit by the military in this country led to an extended order\*\* for 600 M5-4 installations in M4A1 or M4A3 medium tanks, curtailed to approximately 150 units for training purposes following V-J Day. Cessation of hostilities precluded combat testing in either the European or Pacific Theaters.

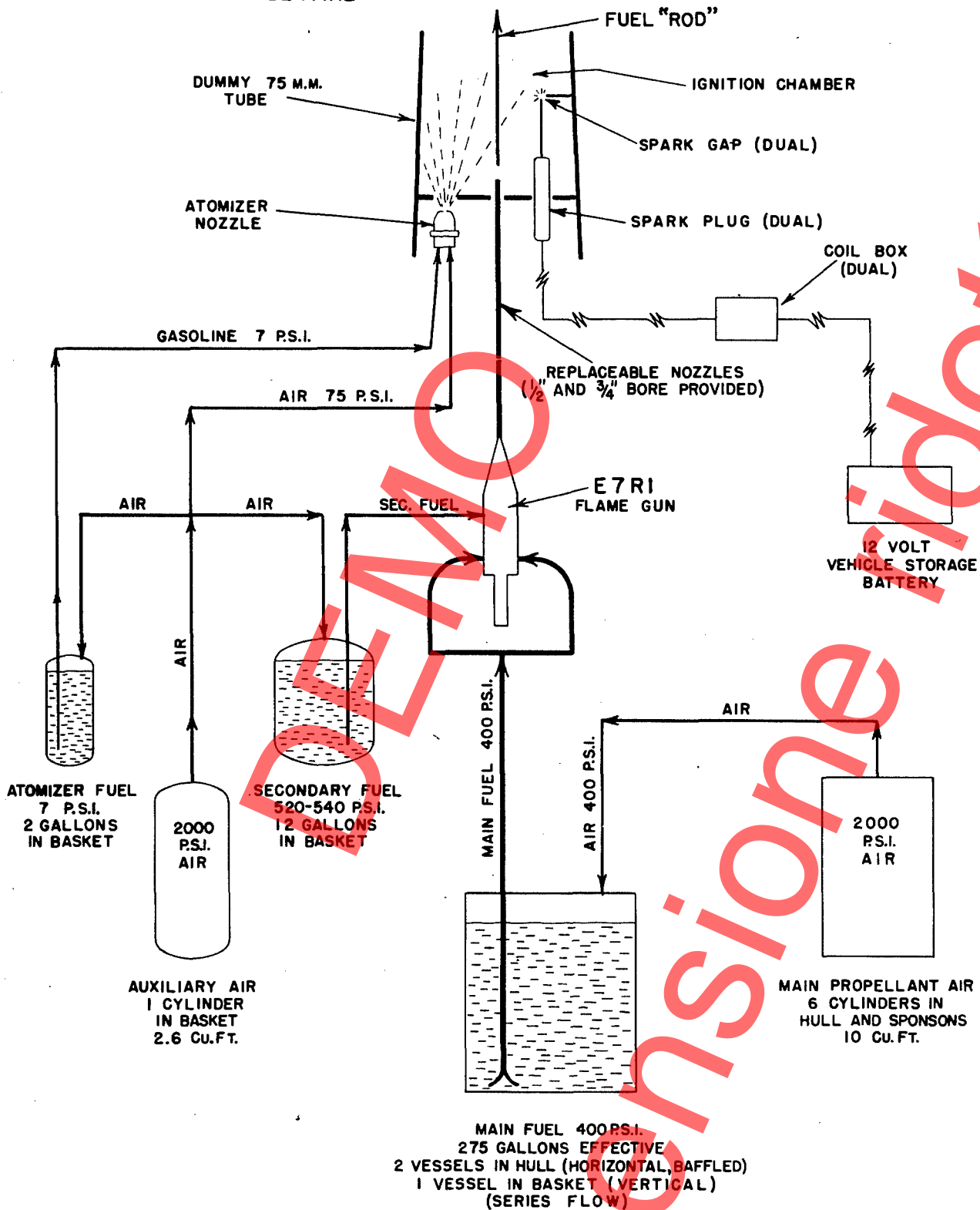
Under Contract OEMsr-390, the Standard Oil Development Company acted as engineering consultants for the Chemical Warfare Service in the design and development of the M5-4 mechanized flame thrower through limited and extended procurement. The assignment was carried out over the period August, 1944 - October, 1945, with the guidance and cooperation of Chemical Warfare Service-Technical Division, Headquarters A.S.F., and the New Developments Division. Extended in close cooperation with the C.W.S. prime contractor, the M. W. Kellogg Company, and their subcontractor, the Lecourtenay Company, the assignment included design and development, the inspection and testing of the first twenty units, establishing inspection and test procedures for large scale production, training of two U. S. Army instructor teams, issuing operating and maintenance manuals\*\*\*, and providing a field consultant under O.F.S. in the theater of operations.

The M5-4 medium tank flame thrower system included an E7R1 (improved Model Q) flame gun replacing the 75 mm. turret cannon, with pressure vessels in hull and turret basket sufficient to fire 270 gallons of fuel with the necessary 2000 p.s.i.g. compressed air, nitrogen, or inert gas propellant. Externally, the M5-4 flame thrower is identical in appearance with a standard M4A1 or M4A3 medium tank equipped with a 75 mm. gun.

- 
- \* PDN 2936, "Flame Thrower, Mechanized, E12-7R1," September 28, 1944.
  - \*\* PDN 3265, "Mechanized Flame Throwers-E12-7R1, Servicing Units-E8, Suggested Responsibilities for Extended Orders," January 11, 1945.
  - \*\*\* PDN 3450, "Flame Thrower, Mechanized, E12-7R1, April 16, 1945. Assistance rendered C.W.S. in preparation of War Department TM 3-360, "Flame Thrower, Mechanized, E12-7R1," July 20, 1945.

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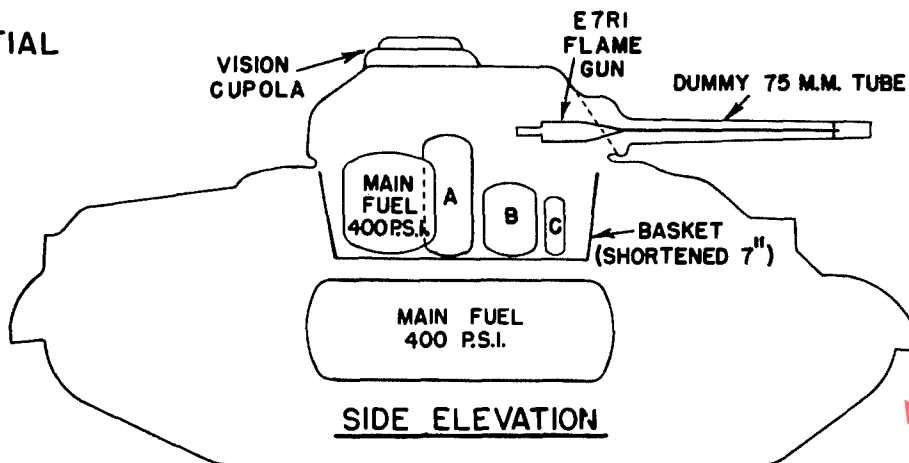
## NOTES :-

- (1) PRESSURE TO FUEL VESSELS AND ATOMIZER NOZZLE CONTROLLED AUTOMATICALLY BY AIR REGULATORS.
- (2) IGNITION CONTROLLED BY FLAME GUNNER'S LEFT FOOT PEDAL.
- (3) FUEL FIRING INCLUDING SECONDARY FUEL CONTROLLED BY FLAME GUNNER'S RIGHT FOOT BUTTON (ELEC.).
- (4) FLAME GUN ACTUATED BY AIR FROM AUXILIARY AIR CYLINDER IN BASKET.

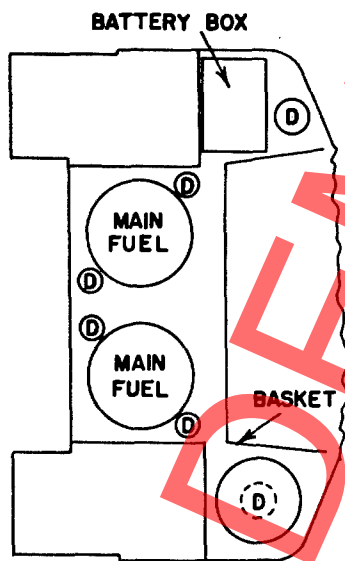
FIG. 3 SIMPLIFIED FLOW PLAN M5-4 FLAME THROWER SYSTEM

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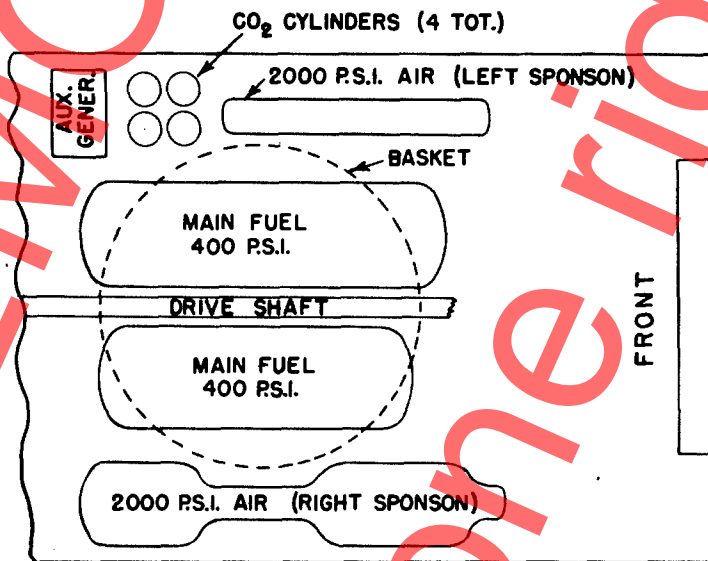
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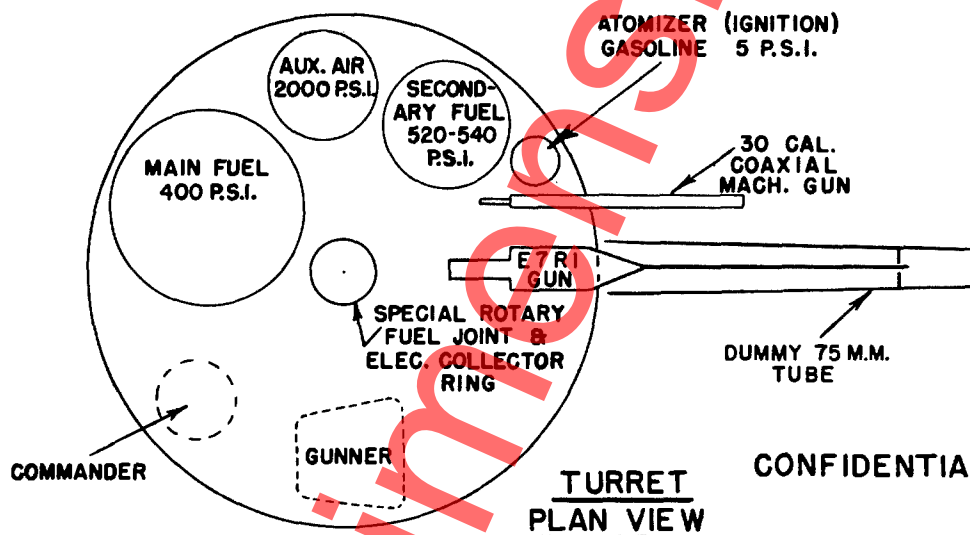
(A = 2000 P.S.I. AIR FOR FLAME GUN AUXILIARIES IN BASKET  
 (B = SECONDARY FUEL FOR FLAME GUN  
 (C = ATOMIZER GASOLINE FOR IGNITER  
 (D = 2000 P.S.I. AIR CYLINDERS IN HULL OR SPONSONS



REAR ELEVATION



PLAN VIEW



TURRET PLAN VIEW

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FIG. 4. SCHEMATIC LAYOUT  
 M5-4 FLAME THROWER IN M4A1 OR M4A3 TANK

IV. DESCRIPTION

The M5-4 flame thrower unit consists of an E7R1 flame gun (improved Model Q) installed in an armored dummy tube replacing the 75 mm. gun in the turret, and the E12 fuel and pressure unit mounted in the hull and turret basket of an M4A1 or M4A3 medium tank as shown in Figure 4. Flame thrower fuel is ejected by compressed air, inert gas, or nitrogen. A simplified flow plan of the flame thrower system, Figure 3, is detailed in Appendix Figure B.

A. Modifications to M4A1 or M4A3 Medium Tank

1. Gun

The 75 mm. cannon, gun mount, and counterweight were replaced by the E7R1 flame gun, dummy gun tube, and special rotor mount and counterweight. The gyro stabilizer was eliminated. The standard turret shield (for M34A1 gun mount) and accommodations for mounting the coaxial .30 cal. machine gun and telescope were retained.

2. Turret

A special basket, shortened 7 inches to accommodate the flame thrower system in the hull, was installed to support four pressure vessels and other essential flame thrower equipment and personnel in the turret. The turret gun loader was eliminated, but original space for turret gunner and tank commander in the right basket area was retained. Turret stowage and wiring were altered to accommodate the flame thrower system. The gun elevation handwheel was provided with a special gear adapter to double elevating speed. A special periscope link, spring, and peepsight were installed on the gunner's periscope to facilitate sighting and aiming the flame gun. External charging connections for main fuel and auxiliary fuel and air were installed under the left turret roof periscope plate and cover.

Each turret was equipped with a standard vision cupola for improved vision and an AN-VRC-3 radio for communication with ground troops.

3. Hull

Stowage and wiring were rearranged in the hull to accommodate the flame thrower system. Only vehicles originally equipped for dry stowage of 75 mm. ammunition were employed. Batteries were moved from the hull floor to a special box in the left sponson. Remaining hull stowage under the basket was removed. Floor mounted main generators were relocated over the forward drive shaft, and voltage regulators shifted to the left

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INTERCHANGEABLE  
LONG NOZZLE  
EXTENSION  
(1/2" OR 3/4" BORE)

SHORT NOZZLE  
EXTENSION

TAPERED NOZZLE

MAIN CONTROL  
VALVE

MAIN VALVE  
SPRING HOUSING

VERTICAL TRUNNION

TRUNNION ELBOW

AIR CHAMBER

TRUNNION BEARING CAP

SPRING HOUSING NUT

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FIG. 5 E7RI FLAME GUN

DEMO Ridotta





sponson as necessary. The CO<sub>2</sub> fire extinguisher cylinders were moved to the left sponson and extra cylinders and discharge horns provided for either engine or fighting compartment fires. Right sponson stowage was reduced and rearranged to accommodate a large propellant air cylinder. An external overflow and vent pipe from the main flame thrower fuel system was installed through the right hull roof adjacent to the rear ventilator. Pressure relief valve discharge tubes and main fuel safety relief vent were piped respectively through the right sponson and hull floors. The external rear hull blanket rack was relocated in a higher position. A ground stake and cable for static electric discharge during servicing operations was installed on the left rear of the vehicle. An external interphone (RC-298) was installed on the right rear hull for direct infantry communication.

B. Flame Gun and Controls\*

The E7R1 flame gun is remote-controlled, equipped with a fast-acting internal valve which is opened by air pressure and closed by spring action (Figure 5 and Appendix Figure B). The gun is designed primarily for use with thickened fuels, although liquid fuels can be employed. An internal perforated cylinder feeds a coating of secondary fuel (unthickened, motor gasoline) around the main fuel prior to ejection of the fuel rod from the gun nozzle, improving ignition and range of thickened fuels fired under adverse wind and cold weather conditions. Both 1/2" and 3/4" bore extended, interchangeable gun nozzles are provided to permit variation in flame thrower range, firing time, and firepower.

The flame gun is fired by depression of a right foot button switch in front of the turret gunner, which actuates a solenoid-operated air valve opening the internal fuel valve in the weapon. Secondary fuel is simultaneously released around the main fuel flowing through the gun. An emergency foot pedal can also be used to actuate the gun in case of solenoid or local electrical failure. The standard elevation handwheel with special gear adapter permits elevation or depression of the flame gun at twice the normal elevation speed of the medium tank main armament. Traverse of the flame gun is accomplished through the normal power or emergency manual hand traverse control in front of the gunner, the flame gun traversing 360° with the turret.

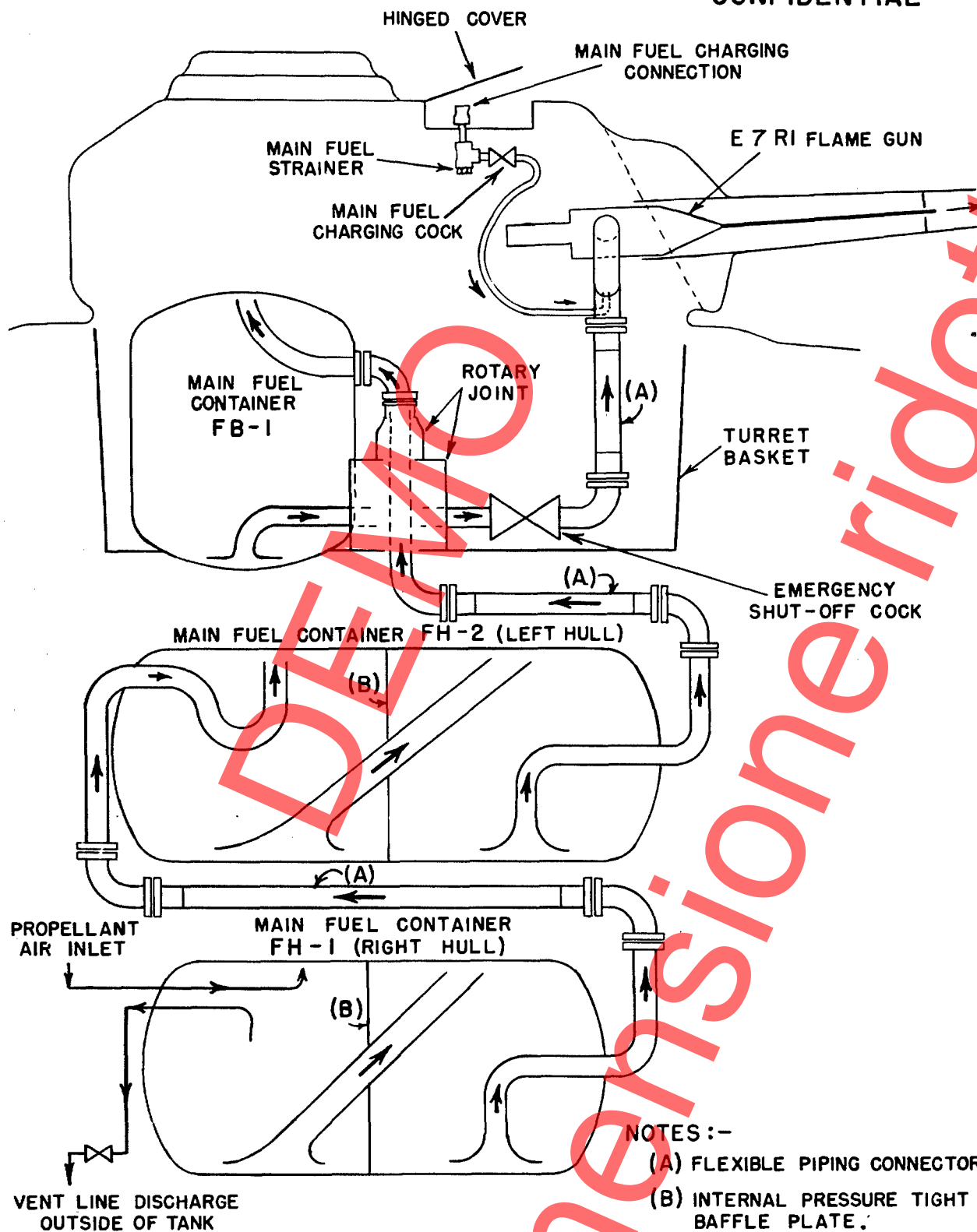
C. Main Fuel System

Main fuel for the flame gun is carried in three pressure vessels connected in series as shown in Figure 6. Two

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\* For operation, see War Department Technical Manual TM3-360, July 20, 1945, "Flame Thrower, Mechanized, E12-7R1."

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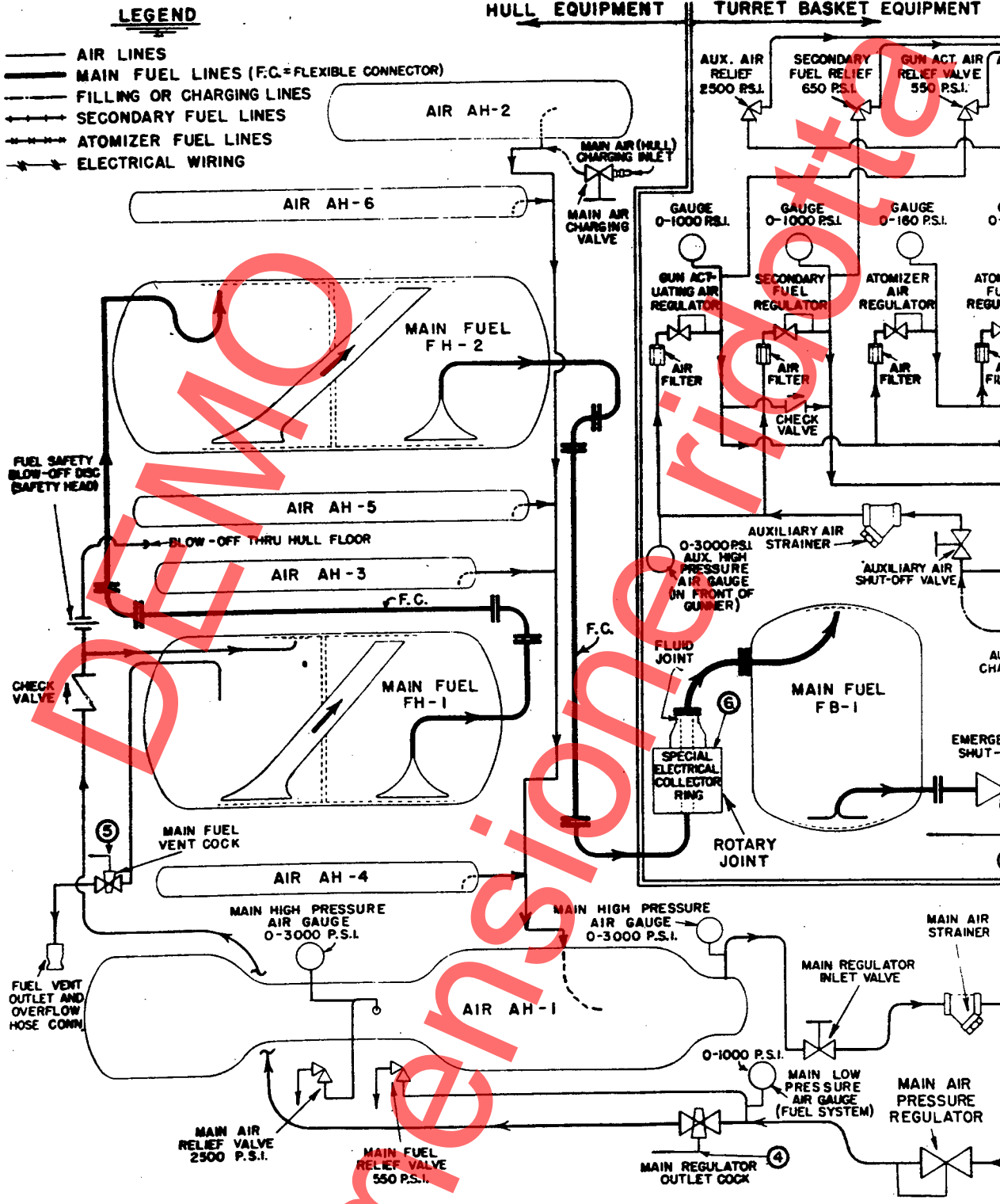


NOTES :-  
 (A) FLEXIBLE PIPING CONNECTOR.  
 (B) INTERNAL PRESSURE TIGHT Baffle PLATE.

FIG. 6 SCHEMATIC FLOW DIAGRAM  
 MAIN FUEL SYSTEM

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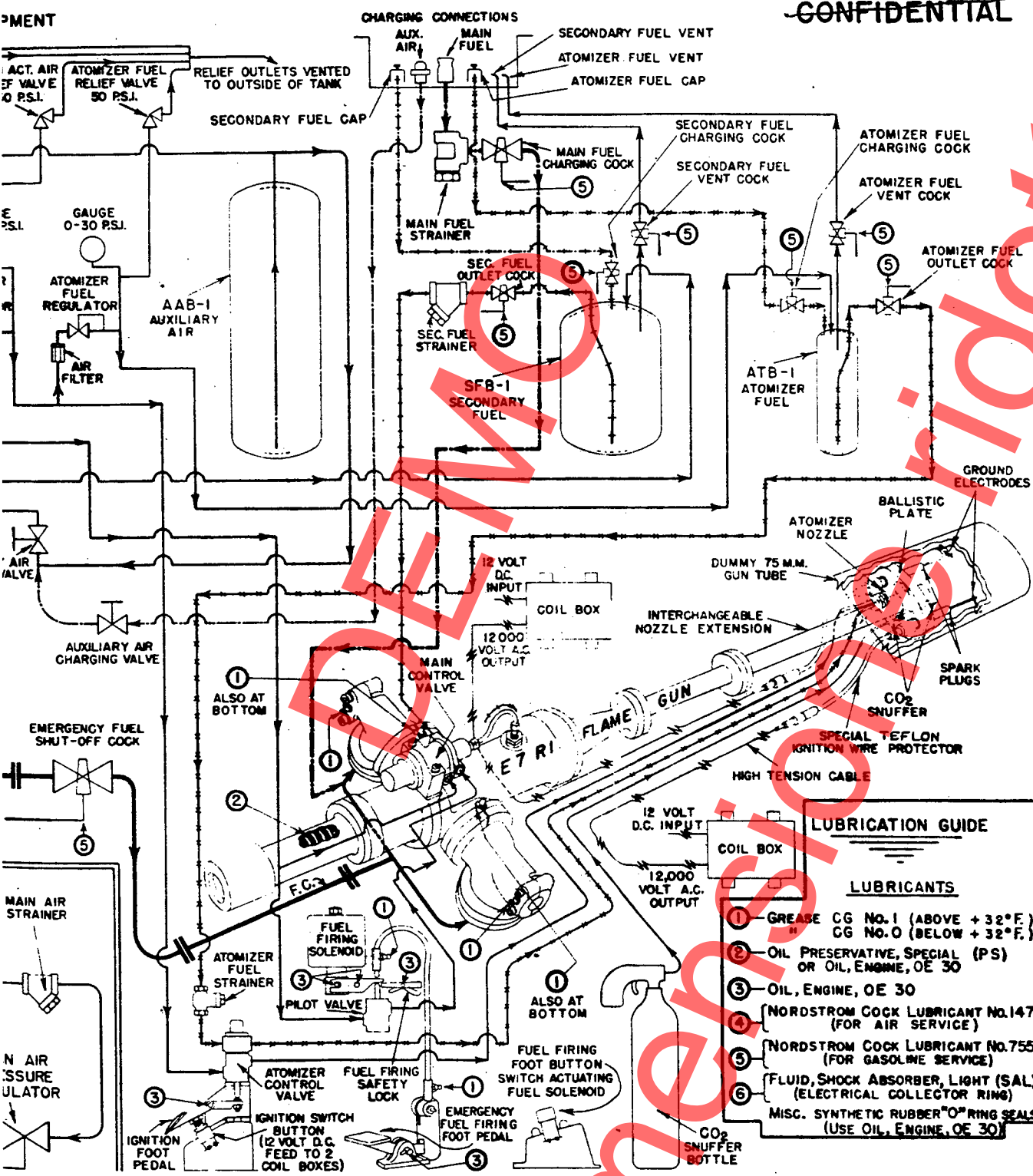
APPENDIX FIG: B FLOW PLAN M5 IN M4A1 OR M4A3

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LUBRICATION GUIDE	
LUBRICANTS	
①	GREASE CG No. 1 (ABOVE + 32°F.) CG No. 0 (BELOW + 32°F.)
②	OIL PRESERVATIVE, SPECIAL (PS) OR OIL, ENGINE, OE 30
③	OIL, ENGINE, OE 30
④	NORDSTROM COCK LUBRICANT No. 147 (FOR AIR SERVICE)
⑤	NORDSTROM COCK LUBRICANT No. 755 (FOR GASOLINE SERVICE)
⑥	FLUID, SHOCK ABSORBER, LIGHT (SAL) (ELECTRICAL COLLECTOR RING) MISC. SYNTHETIC RUBBER "O" RING SEALS (USE OIL, ENGINE, OE 30)

M5-4 (E12-7RI) FLAME THROWER  
14A3 MEDIUM TANK

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