TM 9-731B

RESTRICTED

WAR DEPARTMENT

TECHNICAL MANUAL

MEDIUM TANK M4A2

JANUARY 13, 1943

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TECHNICAL MANUAL
No. 9-731B

WAR DEPARTMENT,
Washington, January 13, 1943

MEDIUM TANK M4A2

Prepared under the direction of the
Chief of Ordnance

(with the cooperation of Fisher Body Division, General Motors Corporation)

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PART I—OPERATING INSTRUCTIONS

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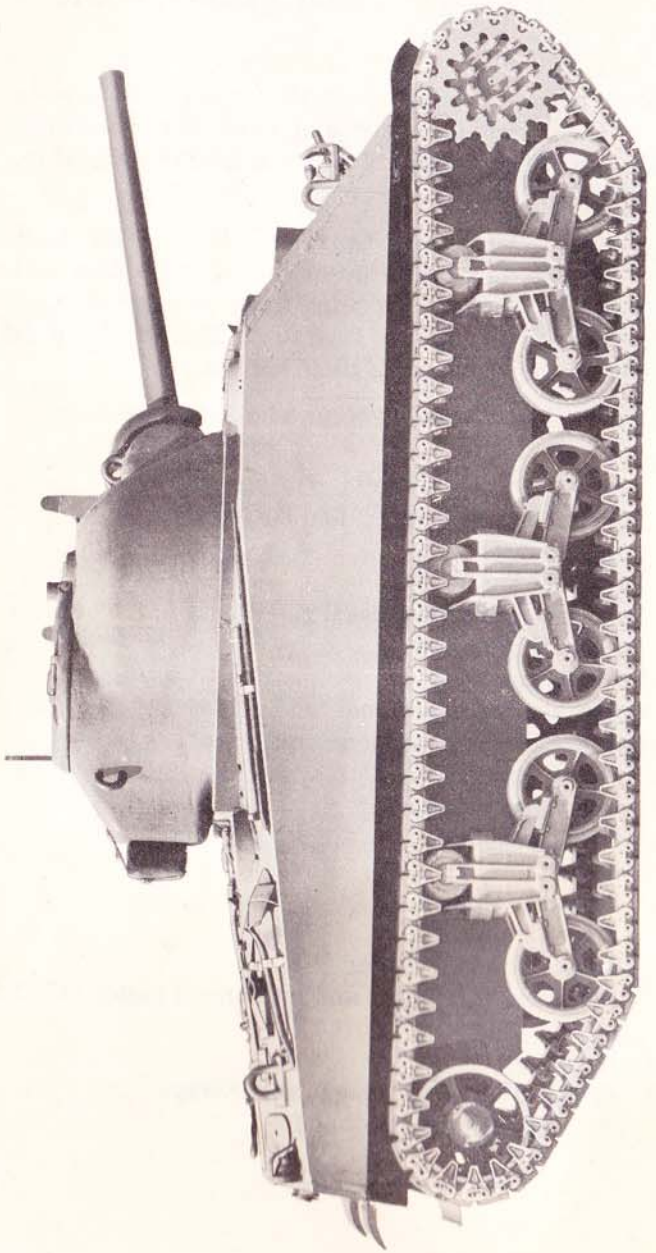
NOTE

3-INCH GUN MOTOR CARRIAGE M10

The power plant, propeller shaft, transmission, differential and final drives, controls, instrument panel and many other units and accessories on the Medium Tank M4A2 are identical with those used in the 3-Inch Gun Motor Carriage M10.

Therefore, this Temporary Operator's Manual for Medium Tank M4A2, which contains later information may be used as a reference and guide in operating and servicing those units which are common to both vehicles until Temporary Operator's Manual TM 9-752A for the 3-Inch Gun Motor Carriage, M10, is revised.

The following Sections will apply to both vehicles in main or in part.



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Frontispiece—Medium Tank M4A2, with Rubber Tracks and First Type Suspensions

PART I—OPERATING INSTRUCTIONS

Section I

INTRODUCTION

1. SCOPE.

This technical manual is intended to serve temporarily (pending the publication of a more complete revision) to give information and guidance to personnel of the using arms charged with the operation, maintenance and minor repair of this materiel.

2. CONTENT AND ARRANGEMENT.

a. Part I (Sections 1 through X) contains information chiefly for the guidance of operating personnel.

b. Part II (Sections XI through XXVI) contains information intended chiefly for the guidance of the using arms personnel doing maintenance work.

3. REFERENCES.

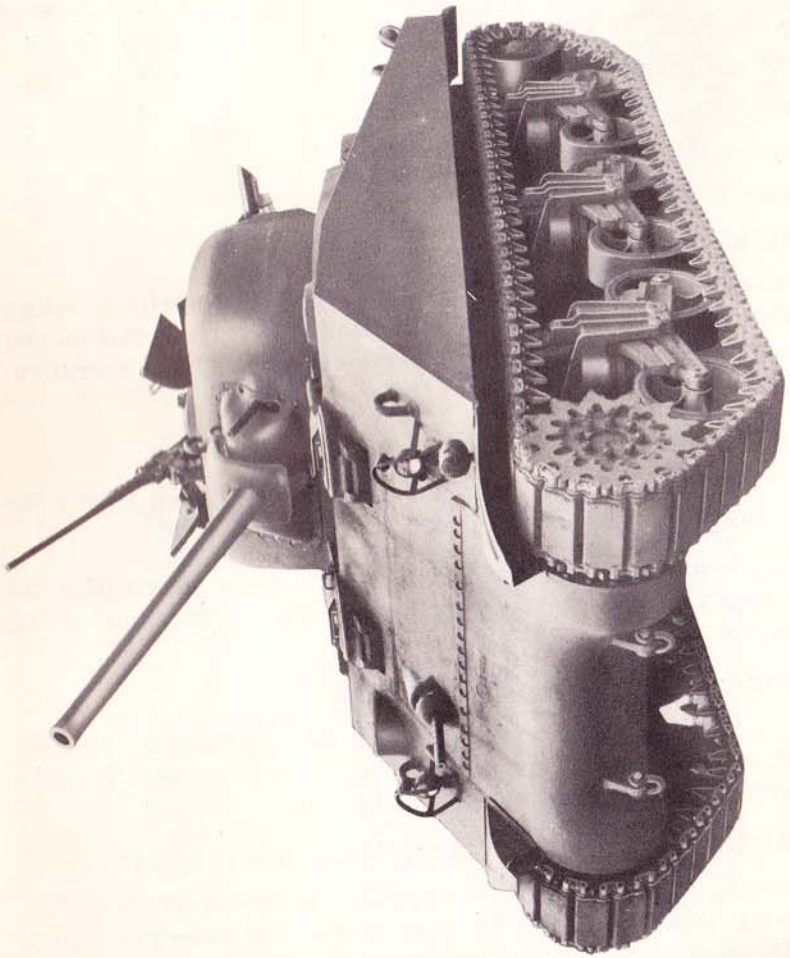
Sections XXVII, at the end of Part II, lists all Standard Nomenclature Lists, Technical Manuals, and other publications, also Training Films, applying to the materiel described herein.

4. DESCRIPTION, MEDIUM TANK M4A2 (figs. 1, 2, 3, and 4).

a. General. The Medium Tank M4A2 is a heavily armored full-track-laying vehicle powered by twin six-cylinder two-cycle liquid-cooled Diesel engines. Its chief armament is a 75-mm. gun in a cast armor steel turret, which is mounted on an all-welded hull of armor plate.

b. Turret and hull. The turret carries a combination mount for a 75-mm. gun and a cal. .30 machine gun. The turret platform, or basket,

MEDIUM TANK, M4A2



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INTRODUCTION

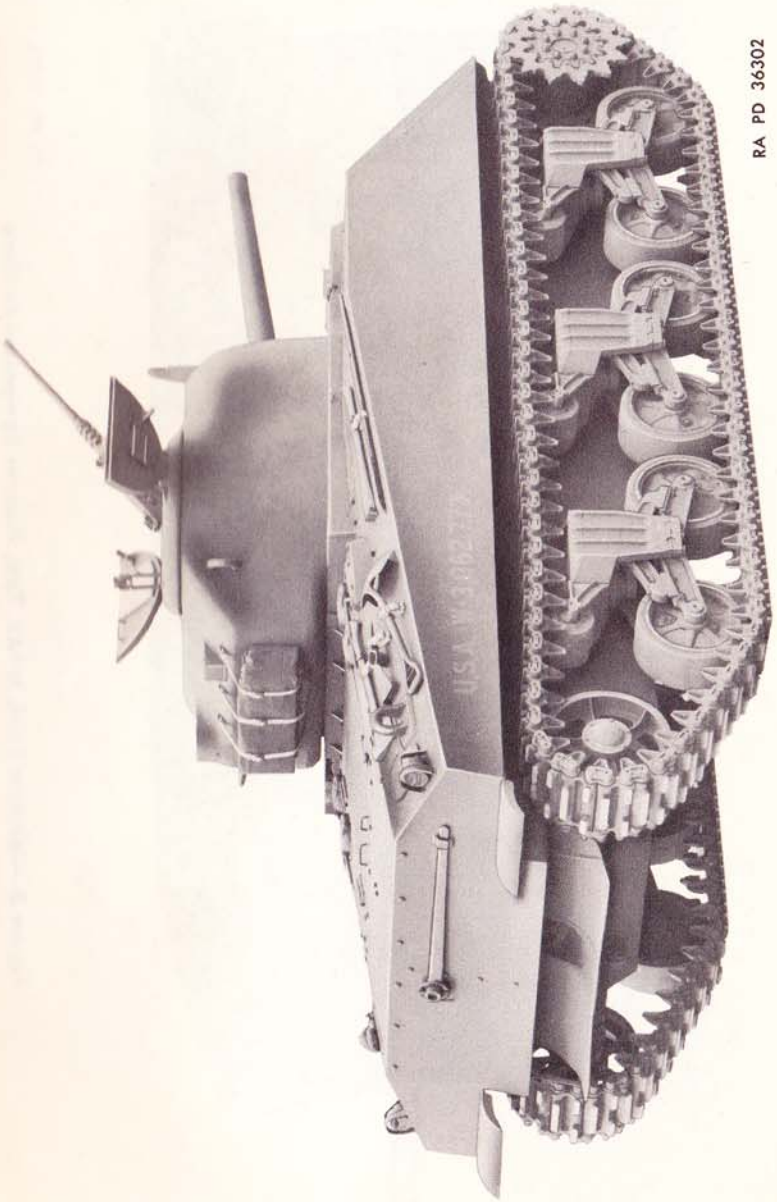

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Figure 2—Medium Tank M4A2, with Steel Tracks and Second Type Suspensions

MEDIUM TANK, M4A2

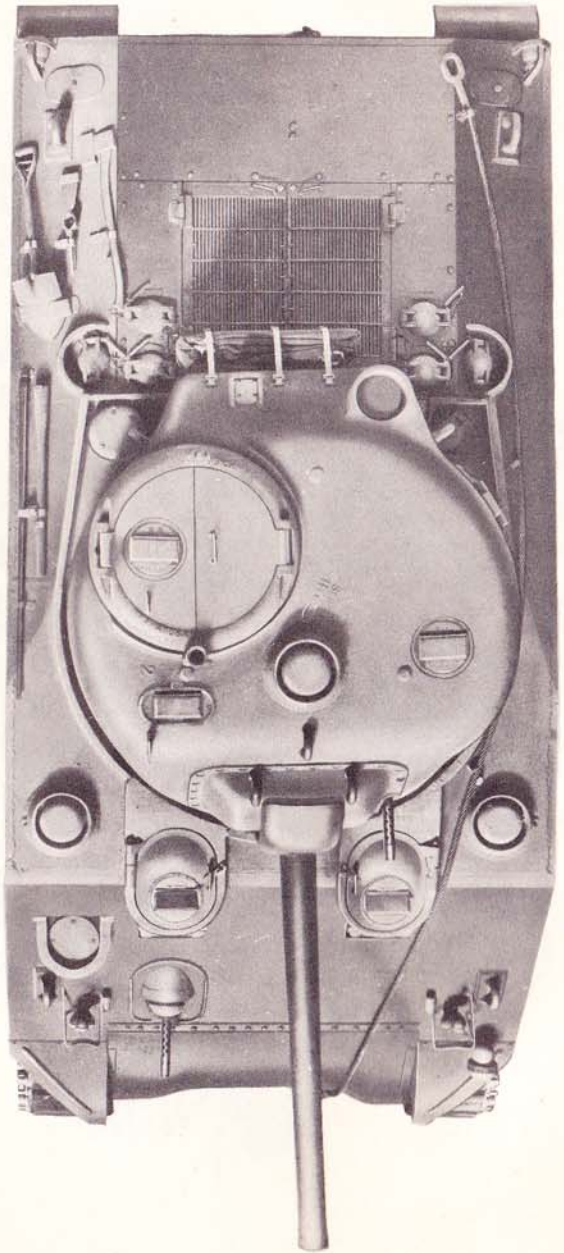

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Figure 3—Medium Tank M4A2, Top, Pioneer Equipment in Place

INTRODUCTION

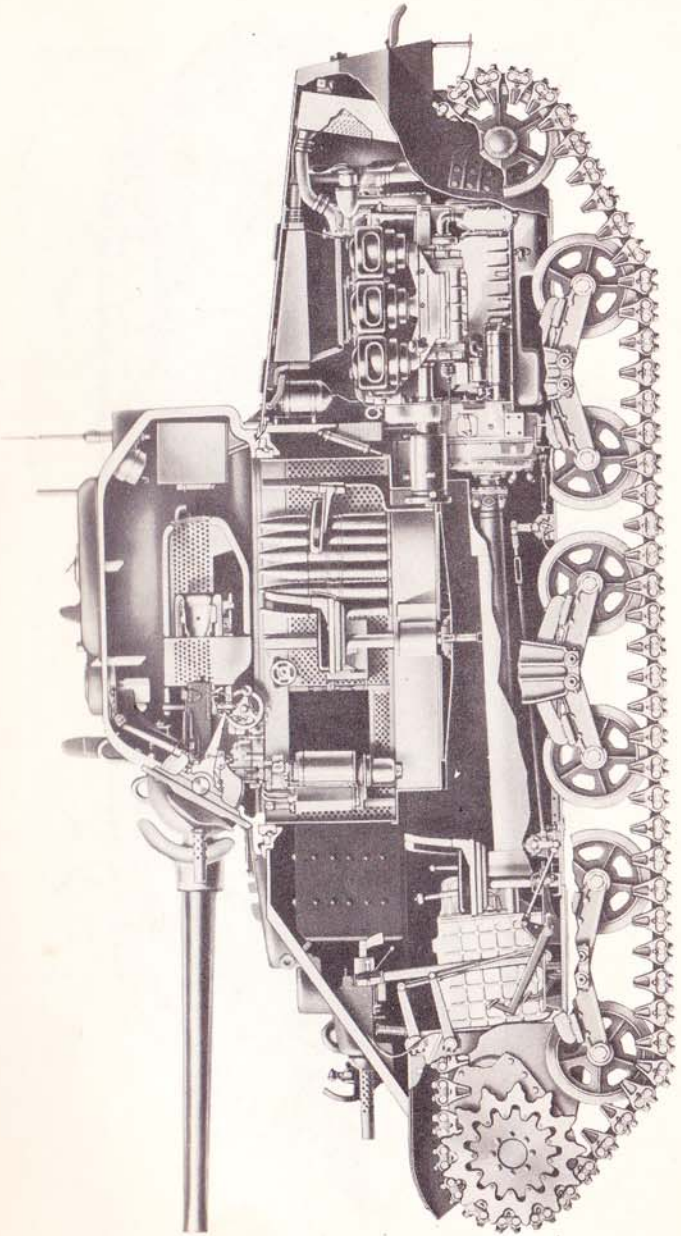

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Figure 4—Medium Tank M4A2, Cutaway

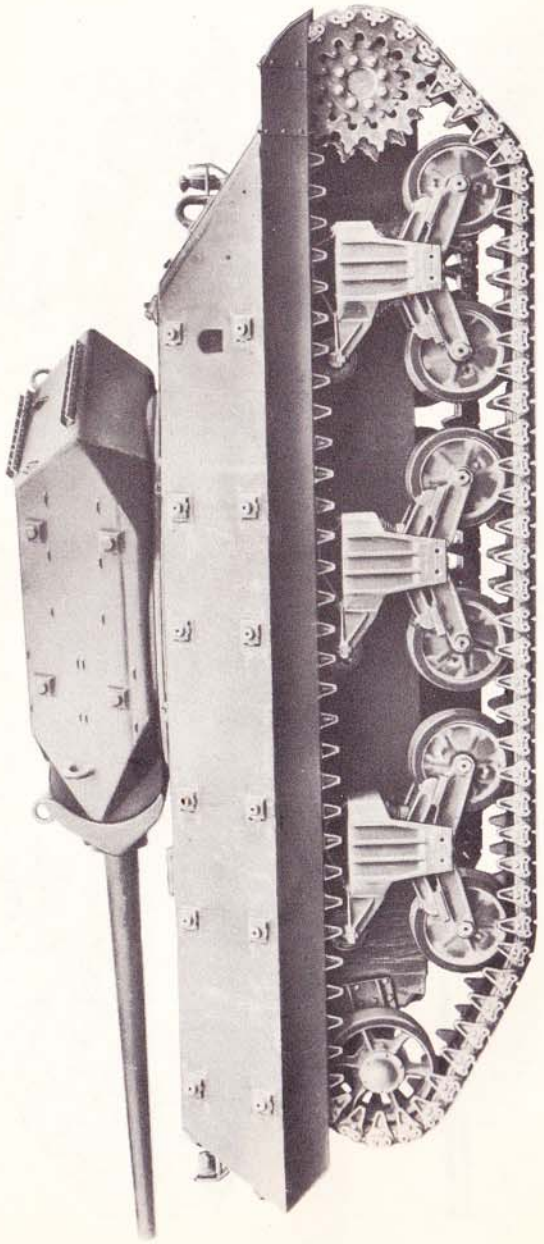

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Figure 4A—3-Inch Gun Motor Carriage M10, Right Side, Gun in Traveling Position

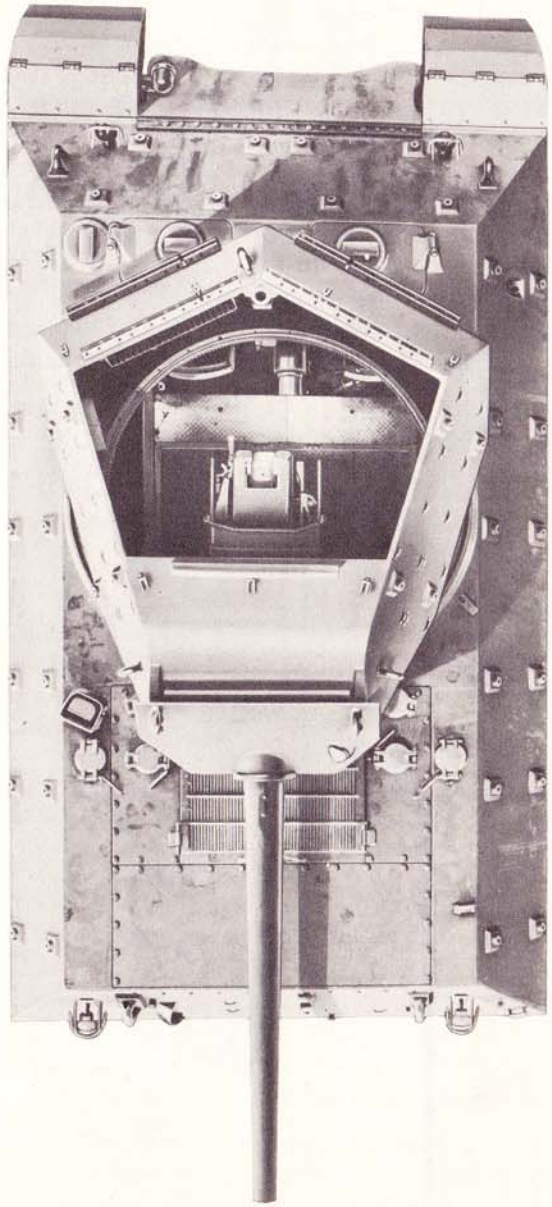

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Figure 4B—3-Inch Gun Motor Carriage M10, Top

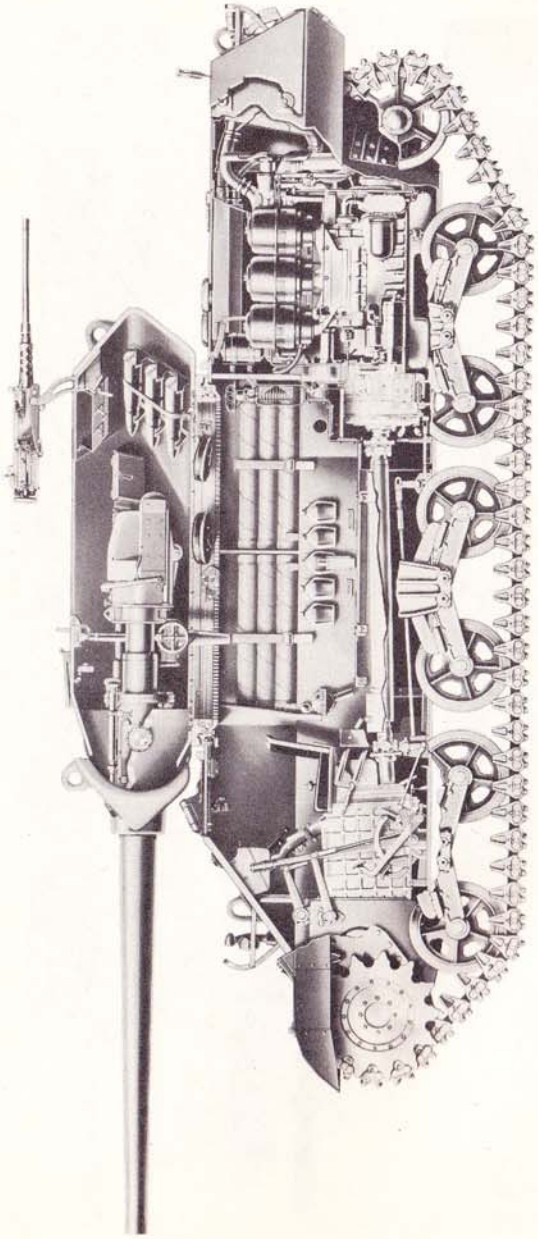

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Figure 4C—3-Inch Gun Motor Carriage M10, Cutaway

rotates with the turret, which may be traversed through 360 degrees either by hand crank or by electric-hydraulic drive. The combination gun mount permits the gun to be elevated 25 degrees above the horizontal, and depressed 10 degrees below the horizontal. The turret guns may be manually elevated or depressed by operating the elevating handwheel. When the gyro-stabilizer is in operation, the gun is elevated by hydraulic power, controlled by the elevating handwheel, and the gyro-stabilizer automatically holds the gun steady, at any quadrant angle of elevation at which it has been laid, while the tank is in motion. The one-piece cast armor steel turret has a thickness of 3 inches at the front, 2 inches at the sides and rear, and 1 inch on top. The all-welded hull is of armor plate, 2 inches thick at the front, 1½ inches at the sides and rear, and ¾ inch on top.

c. Power unit.

(1) The twin Diesel engines are mounted in a compartment at the rear of the hull. Each engine is a complete unit, with its own fuel system, lubricating system, cooling system, and radiator.

(2) The twin engines are joined by means of a heavy junction plate at their fan ends and a double clutch housing and power transfer unit at the flywheel ends. The engine drive shafts carry gears meshed with a smaller gear on the engine driven shaft, which is connected to a single propeller shaft. Each engine has its own clutch, between its flywheel and the step-up gear unit. In normal operation, the two clutches are controlled by the single clutch pedal, but either clutch may be locked out by a control on the hand throttle panel. The tank, therefore, can be operated with only one engine should the other engine be disabled.

(3) The normal rated output of the power unit is 375 horsepower. The engine governors control the fuel feed, to limit maximum engine speed to 2100 rpm at full load. With this governor setting, the tank maximum speed is 30 mph with both engines running at 2100 rpm. With only one engine operating, a tank speed of 20 mph may be attained—an indication of the generous margin of power in reserve when both engines are operating at full governed speed.

d. Controls. The tank is steered by means of levers, which operate steering brakes in the one-piece differential housing. Braking is effected by pulling back both steering brake levers at once. A hand-operated parking brake operates on a drum on the transmission output shaft.

On later model tanks, the transmission parking brake is eliminated and both steering brake levers may be locked in applied position by tripping a pedal. The transmission has five forward speeds and one reverse speed.

e. Auxiliary generator. In addition to the two generators of the twin Diesel engines, an auxiliary generator unit, consisting of a generator and a one-cylinder air-cooled gasoline engine, is provided for use in charging the batteries when the Diesel engines are not running, and to provide current when the turret-traversing mechanism, gyro-stabilizer, radio, etc., impose a heavy load on the electrical system.

f. Armament. Besides the 75-mm. gun and cal. .30 machine gun on the combination mount in the turret, the tank carries a cal. .30 machine gun on a flexible ball mount in the front plate of the hull. A cal. .50 machine gun for anti-aircraft fire is carried inside the turret, to be mounted for action in a bracket on the turret hatch ring, which permits a 360 degrees traverse. A cal. .45 Thompson submachine gun, carried inside the turret, may be fired through the pistol port in the left side of the turret.

g. Crew stations. The tank crew consists of five men. The driver sits at the left bow of the tank, to the left of the transmission. The assistant driver's position is in the right bow, to the right of the transmission and directly behind the bow machine gun. The tank commander is stationed at the rear of the turret, just to the right of the 75-mm. gun guard. The gunner's station is almost directly in front of the commander. The loader's station is to the left of the 75-mm. gun.

h. Access. Access to the tank is provided by two hatches in the bow and a revolving hatch in the turret. For use in an emergency, a quick-opening escape hatch is provided, in the tank floor directly back of the assistant driver.

i. Vision. For each of the five crew stations there is a periscope, all except the gunner's mounted so that they may be rotated for observation in any direction and tilted to raise or lower the line of vision. The gunner's periscope is connected to the gun mount by linkage that keeps the line of vision in constant alinement with the gun as the gun is elevated or depressed. The gunner's periscope is fitted with a telescopic sight so mounted that it may be moved, independent of the periscope and the gun for gun laying. For the driver and assistant driver, direct vision is provided by horizontal slots in the hull front plate. The slots are fitted with heavy protective covers.

j. Supply tanks. The cooling system, Diesel fuel oil tanks, and lubricating oil tanks of the power unit, and the gasoline tank of the auxiliary generator engine, are filled from the top of the hull on right and left sides at the rear of the turret. Each filler opening (see fig. 26) is marked with a metal plate having raised letters, so that they may be readily identified.

k. Communication. The tank is equipped with two-way radio for outside communication, and with a telephone system (interphone) serving all five of the crew.

l. Hatch hood and windshield. A removable folding hood, with safety glass windshield, is provided for the protection of the driver. It may be attached, by means of special fittings, to cover the opened hatch over the driver's seat. The windshield has an electric wiper and an electric defroster, which receive their current through a flexible cable that can be plugged into an outlet socket on the instrument panel.

m. Distinguishing features. All M4 medium tanks (M4A1, M4A2, M4A3, M4A4) are of the same general design and size, and carry the same armament. All have identical transmissions, volute spring suspensions, rear idlers, and shoe tracks (steel or rubber). Other identical units are the turret and turret platform, gyro-stabilizer, combination turret gun mount, and bow gun (cal. .30) mount. All M4A2's, produced by five manufacturers, have the same twin Diesel power unit, and all have both upper and lower hulls of welded construction. M4A2's are built with either one-piece or three-piece differential housings. The M4A1, M4A3, and M4A4 all differ from the M4A2 in their power units (gasoline engines of three different types).

n. Identification plate. Each M4A2 Medium Tank has a serial number plate mounted in the crew compartment to the left of the driver. This plate carries the tank serial number and manufacturer's name, as well as operating data. Refer to the plate before ordering parts for repairs to avoid confusion of models and manufacturers.

5. TABULATED DATA.

a. General.

Weight fully equipped	65,476 lbs.
Ground pressure, per square inch (with rubber tracks)	13.2 lbs.
Over-all width	8 ft. 7 in.

Ground clearance	18 in.
Tread (center to center of tracks)	83 in.
Height (to top of turret)	8 ft. 11¾ in.
Over-all length	19 ft. 5 7/16 in.

b. Power unit.

Make	General Motors Diesel
Type	Direct injection twin two-cycle engine (6 cylinders each)
Model and series	Model 6046, Series 71
Recommended Diesel fuel	U. S. Army Spec. No. 2-102B, Oct. 2, 1941
Number of cylinders (each engine)	6
Bore and stroke	4¼ x 5 in.
Displacement (each engine)	425 cu. in.
Compression ratio	16 to 1
Normal compression pressure at 1000 rpm	500 lbs. per sq. in.
Location of No. 1 cylinder	Nearest to fan
Firing order of cylinders	1-4-2-6-3-5
Number of driveshaft revolutions for 100 crankshaft revolutions	137
Rated horsepower (two engines combined)	375
Maximum torque at propeller shaft	880 lbs.-ft. at 1500 rpm
Idling speed	400 rpm
Recommended idling speed during halts	600 rpm
Maximum full-load engine speed	2100 rpm
Maximum no-load engine speed	2250 rpm
Total weight of power unit	4490 lbs.
Total weight of power unit and cooling system, with coolant	5120 lbs.
Cooling system capacity, each engine, including tanks and radiators	15 gal.
Over-all length (front of fan to rear of generator)	65⅝ in.
Over-all width (installed—including air cleaners)	59 5/32 in.
Over-all height (tip of fan blade to bottom of oil pan drain plug)	45 21/32 in.

c. Weights.

Turret, with 75-mm. gun	9090 lbs.
Power train unit (transmission, differential, and final drives, with sprocket and hug assemblies)	8035 lbs.

d. Armament. NOTE: A few early model M4A2 Medium Tanks were equipped with two cal. .30 machine guns in a fixed mount in the bow, in addition to the armament listed here.

1 gun, 75-mm., M3 (mounted in combination gun mount M-34).
1 gun, machine, cal. .30, M1919A4 (combination turret mount).
1 gun, machine, cal. .30, M1919A4 (flexible—ball mount in front plate).
1 gun, machine, cal. .50, M2HB (flexible—race mount on turret hatch ring).
1 gun, submachine, cal. .45 Thompson, M1928A1 (carried on brackets within tank).
1 mount, tripod, machine gun, M1928A1, cal. .30, M2.

e. Ammunition carried.

75-mm. ammunition, 50 per cent H. E., 40 per cent A. P., 10 per cent W. P.	97 rounds
Cal. .50 ammunition, 80 per cent A. P., 20 per cent Tracer	300 rounds
Cal. .30 ammunition, 80 per cent A. P., 20 per cent Tracer	6,750 rounds
Cal. .45 ammunition, Ball	660 rounds
Hand grenades, 4 Fragmentation M2, 2 Offensive M3 w/ Fuze M6, 4 Smoke, 2 Thermite	12 rounds

f. Armor thickness.

Hull: Front	2 in.	Turret: Front	3 in.
Rear	1½ in.	Sides	2 in.
Sides	1½ in.	Top	1 in.
Top	¾ in.	Rear	2 in.

g. Turret. Cast armor steel, 360 degrees traverse.

h. Communication.

Radio set, either SCR-508, SCR-528 or SCR-538	1
Commander's tank, SCR-506	1
Voice	15-25 miles
Code	30-45 miles
Intratank	Telephone
Spare radio antenna, with cover	1
Signal flags—M238—red, orange, green	3
Flag staff—M-270	3

i. Crew. Five men.

j. Tracks (rubber block or all-steel).

Track shoe width (tread)	12 1/16 in.

Track pitch ..... 6 in.
Ground contact (with rubber tracks) ..... 4832 sq. in.

k. Capacities.

Diesel fuel oil, total for vehicle ..... 148 gal.
- Upper tank ..... each 59½ gal.
- Lower reserve tank ..... each 14½ gal.

Gasoline (auxiliary generator fuel tank) ..... 17.3 qt.

Lubricating oil—
- Engine lubricating system complete with tank ..... each 32 qt.
  - Engine lubricating oil tank ..... each 24 qt.
  - Engine lubricating system ..... each 8 qt.
- Engine transfer gear unit ..... 2½ qt.
- First type AC air cleaner ..... each 1 qt.
- Second type AC air cleaner ..... each 2½ qt.
- Donaldson air cleaner ..... each 2½ qt.
- Power train unit (transmission, one-piece differential, and final drives) ..... 152 qt.
- Power train unit (transmission, three-piece differential, and final drives) ..... 136 qt.

Oil, hydraulic, Univis 47 (U. S. Army 2-97A)—
- Gyro-stabilizer, complete system ..... 2½ qt.
- Gyro-stabilizer oil reservoir ..... 1 qt.
- Hydraulic traversing mechanism (Oilgear), complete system ..... 4 qt.

Oil, recoil, heavy (U. S. Army 2-96A)—
- 75-mm. gun, recoil cylinders ..... 16 pt.

Water—
- Engine cooling system ..... each 15 gal.

l. Performance.

Maximum recommended sustained speed on hard road ..... 25 mph
Maximum speed, short periods ..... 30 mph
Maximum grade ascending ability ..... 60 per cent
Maximum grade descending ability ..... 60 per cent
Maximum width of ditch tank will cross ..... 100 in.

Maximum vertical obstacle, such as wall, that tank will climb over:
- Rubber track without grousers ..... 24 in.
- Steel tracks, or rubber with grousers ..... 36 in.

Maximum fording depth (at slowest speed) ..... 40 in.
Allowable list ..... 25 degrees

Section II

OPERATING INSTRUCTIONS AND CONTROLS

6. GENERAL INFORMATION ON CONTROLS (fig. 5).

a. Accelerator and hand throttle. The foot throttle, or accelerator, controlling both engines, is at the left of the transmission housing, convenient to the driver's right foot. Hand-operated throttle levers, one for each engine, are mounted within easy reach of the driver's right hand. In normal operation the engines are stopped by closing the hand throttles.

b. Steering lever. Two steering levers (see fig. 5) are mounted on the floor in front of the driver's seat. To steer the vehicle, pull back on the lever on the side toward which it is desired to turn. Pulling back either lever slows down the track on that side and causes the speed of the other track to be correspondingly increased.

c. Brakes.

(1) **Service brakes.** Pulling back with equal force on both steering brake levers slows down or stops the tank, depending on the effort applied.

(2) **Parking brake.** The parking brake lever is located on the upper rear end of the transmission housing, to the right of the driver. The brake shoe operates on a conical brake drum attached to the transmission output shaft. On later model tanks, the transmission parking brake is eliminated and both steering brakes may be locked in applied position by tripping a pedal. CAUTION: Always check to see that the parking brake(s) are released before starting the tank. The transmission parking brake is never to be used while the tank is in motion.

d. Clutch. The clutch pedal, located along the hull left side convenient to the driver's left foot, disengages the clutches of both engines at once. Either one or both of the clutches may be locked out (in the disengaged position) by depressing the pedal all the way and pulling out the lockout controls on the hand throttle panel (see par. 10 **d**). CAUTION: Do not **ride the clutch** at any time, as serious damage to the clutch will result. The driver must keep his foot off the pedal except when actually operating the clutch.

e. Gear shifting. Shifting of transmission gears for speed changes is effected by means of the gearshift lever, mounted on the transmission to the right of the driver. (See fig. 5.) The positions of the gearshift lever for the various speeds are shown in the diagram (fig. 6). The operation is the same as in automobile gear shifting, except that the gearshift lever is equipped with a latch to prevent accidental shifting into first speed or reverse. The latch must be released, by pressing down the button on the lever, to engage first or reverse.

7. PRESTARTING INSPECTION.

Before the engine is started, the following prestarting inspection must be carried out:

a. Driver's compartment.

(1) Check oil level in power train unit, fill if necessary.

(2) Check fuel level, both sets of tanks, fill if necessary.

(3) Check engine oil supply, both engines. Refill as necessary.

(4) Test engine shut-down valves (emergency stop buttons and switches).

(5) Check presence and condition of portable fire extinguisher.

(6) See that voltmeter reads **zero** with battery switch open and that other instruments indicate normal shut-off readings.

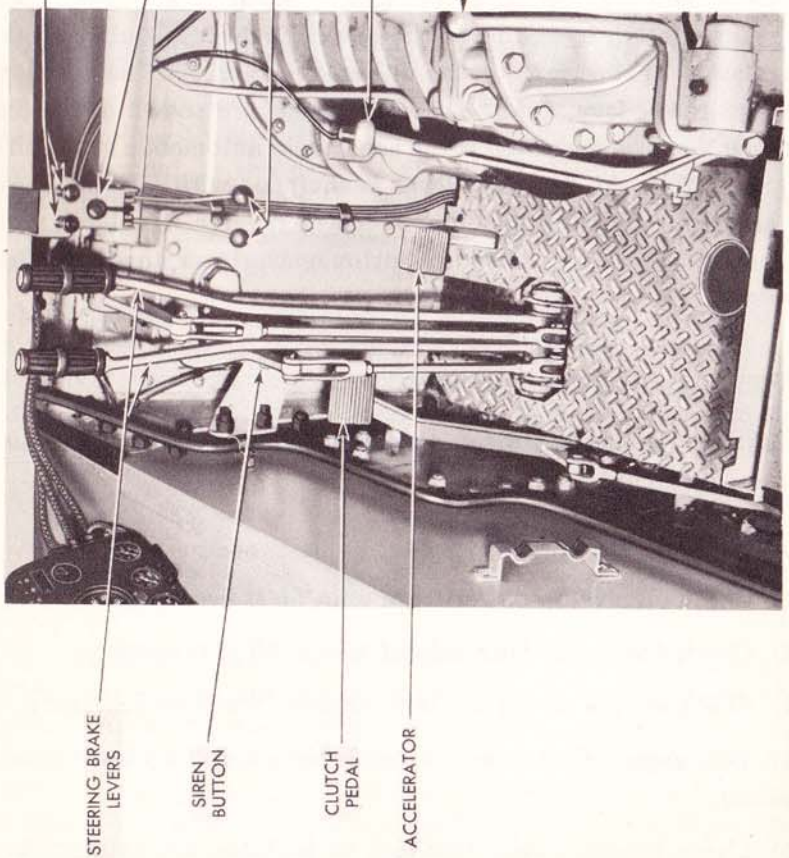

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Figure 5—Driver's Controls (Driver's Seat Removed)

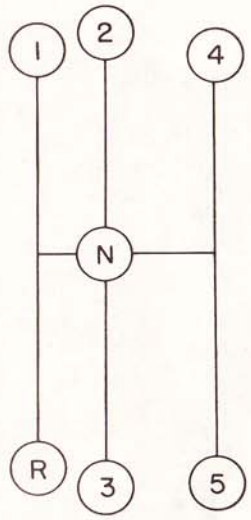

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Figure 6—Gearshift Positions

(7) Be sure air heater fuel inlet line shut-off valve on top of instrument panel is closed, unless air heaters are to be used. Close valve after engines start if air heaters are used.

(8) Check that steering levers, clutch pedal, accelerator pedal, gearshift lever, clutch lockouts and hand throttles operate freely and over full range.

(9) Check lights and siren.

(10) Close battery switch and watch ammeter and voltmeter. If ammeter shows excessive discharge, open battery switch immediately and seek cause. The voltmeter should normally read 25½ to 28 volts.

(11) Check operation of bow gun.

b. **Turret.**

(1) Check radio and telephones.

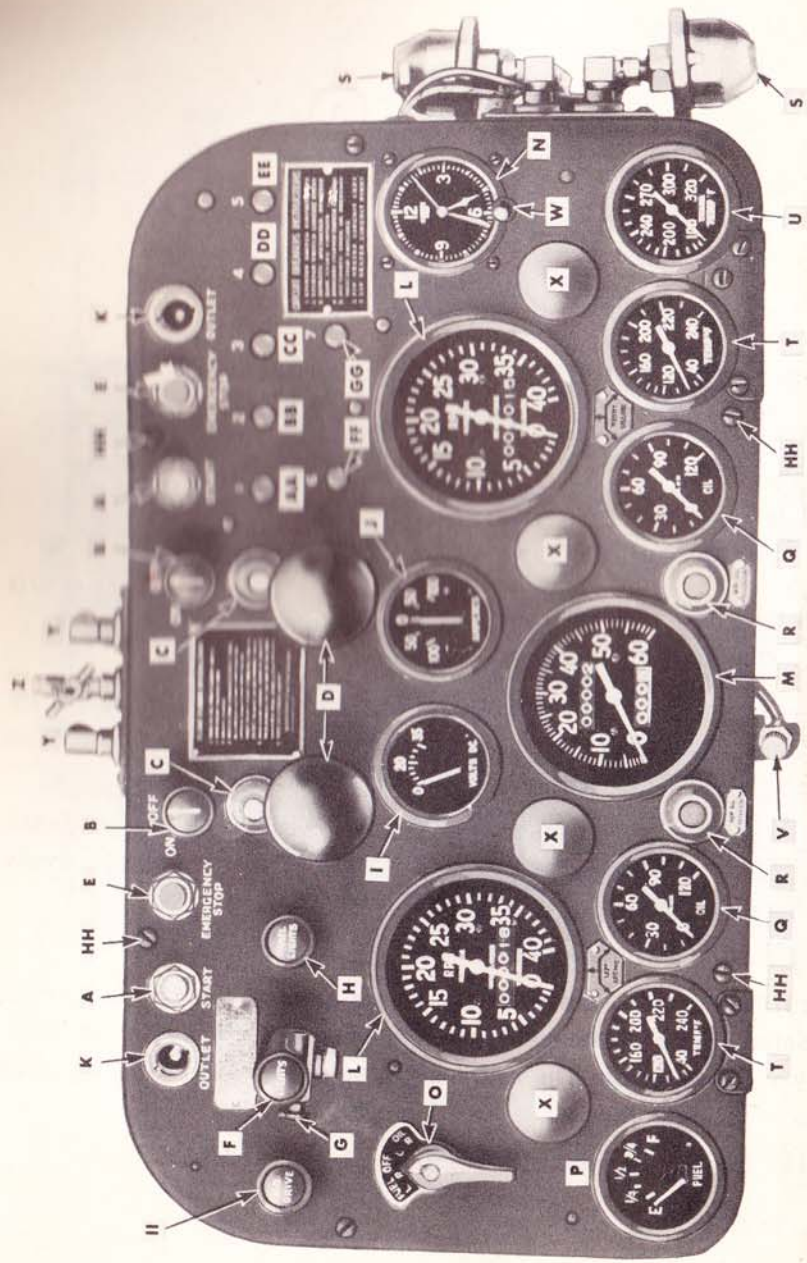


Figure 7—Instrument Panel

OPERATING INSTRUCTIONS AND CONTROLS

A—STARTER SWITCH

B—AIR HEATER SWITCH

C—AIR HEATER INDICATOR LIGHT

D—AIR HEATER FUEL PUMP

E—EMERGENCY STOP SWITCH

F—DRIVING LIGHT SWITCH

G—BLACKOUT LIGHT BUTTON

H—PANEL LIGHT SWITCH

I—VOLTMETER

J—AMMETER

K—ACCESSORY OUTLET

L—ENGINE TACHOMETER

M—SPEEDOMETER

N—CLOCK

O—TANK GAGE CONTROL SWITCH

P—FUEL AND LUBE TANK GAGE

Q—ENGINE OIL PRESSURE GAGE

R—LOW OIL PRESSURE INDICATOR

S—LOW OIL PRESSURE INDICATOR LIGHT SWITCH

T—ENGINE TEMPERATURE GAGE

U—TRANSMISSION OIL TEMPERATURE GAGE

V—SPEEDOMETER TRIP MILEAGE RESET

W—CLOCK WIND AND SET

X—INSTRUMENT LIGHT BULB COVER

Y—AIR HEATER FUEL PUMP OUTLET LINE

Z—AIR HEATER FUEL PUMP INLET LINE, WITH SHUT-OFF

AA—CIRCUIT BREAKER (LC ENGINE STARTER CIRCUIT)

BB—CIRCUIT BREAKER (LA ENGINE STARTER CIRCUIT)

CC—CIRCUIT BREAKER (OUTLET SOCKET, VOLTMETER, RESISTOR, TANK GAGE SWITCH AND TANK UNIT CIRCUITS)

DD—CIRCUIT BREAKER (AUXILIARY STARTER SWITCH CIRCUITS)

EE—CIRCUIT BREAKER (HULL, STOP, LOW OIL, BLACKOUT, AND DRIVING LAMPS, AND SIREN, CIRCUITS)

FF—CIRCUIT BREAKER (LC ENGINE AIR HEATER CIRCUIT)

GG—CIRCUIT BREAKER (LA ENGINE AIR HEATER CIRCUIT)

HH—PANEL FACE PLATE ATTACHING SCREW

II—BLACKOUT DRIVING LIGHT SWITCH

RA PD 36307A

Figure 7A—Instrument Panel—Legend

(2) Check transfer case oil level, fill if necessary.

(3) Check presence and condition of fixed and portable fire extinguishers.

(4) Check battery solution, add water if necessary.

(5) Check for oil leaks on floor of fighting compartment.

(6) Open fuel tank selector valve.

(7) Check operation of turret locking mechanism.

(8) Check traverse and operation of turret weapons and turret.

(9) Check gyro-stabilizer mechanism.

(10) Check stowage of ammunition, flags, field equipment and rations, if carried.

(11) Check water cans, fill if necessary.

(12) Inspect sighting and vision devices for breakage.

(13) With a clean cloth clean all vision and fire control devices.

(14) Inspect guns and mounts for defective performance.

(15) See that covers for guns, sighting equipment and accessories are properly installed.

c. Outside tank.

(1) Check general condition of sprockets, bogies, springs, guides, gudgeons, track supporting rollers, and idlers. Tighten sprocket bolts if necessary.

(2) Check tracks for wear, tightness, and tension.

(3) Check track connectors for wear.

(4) Check tightness and wear of track connector wedges and wedge nuts.

(5) Check grousers, if in use. If not in use, check to see that a full set is stowed in vehicle.

(6) Be sure radiators are clean and cores completely open.

d. Beneath tank.

(1) Check to see that engine inspection plates are in place and bolted securely.

(2) Check to see that all drain covers and plugs are in place and tight.

(3) Look at ground under tank for oil, water, and fuel leaks.

c. On top of tank.

(1) Check to be sure turret race is clear of any foreign matter which would obstruct rotation of turret.

(2) Check radio antenna for breaks.

(3) Check for oil, water, and fuel leaks in engine compartment, then bolt engine compartment doors securely.

(4) Check that all accessories (pioneer tools) are present.

(5) Check level of engine coolant and refill as needed. Be sure drain valves are closed. Open bleeder valves when filling and close when system is full.

(6) Check auxiliary generator fuel, fill if necessary. Test auxiliary generator.

8. STARTING INSTRUCTIONS.

a. General.

(1) Each engine has its own starting motor (see fig. 23) and its own starting controls on the instrument panel (fig. 7).

(2) Open fuel tank selector valve.

(3) Always hold the clutch pedal all the way down, or lock out the clutches, while the starter is cranking its engine.

(4) Move both hand throttles forward until they are felt to seat in the **idle** position. NOTE: Low pressure oil indicator lights on instrument panel will come on when hand throttles are moved into **idle** position.

(5) Start the engines **one at a time** by pressing first one starter button and then the other. Do not press both starter buttons at once, to avoid too great a load on the battery. Starting both engines at

once (with clutch engaged) by means of a single starter must not be attempted, because of the overload on the starter motor. If engine does not start within 30 seconds, release starter button and check engine (see par. 45 **b** and **c**).

(6) After one engine is started, it may be run independently of the second engine, provided that the clutch of the second engine be locked out.

(7) One engine may be started and used to start the second engine (see par. 8 **d**), but this method is to be used only when one of the engines cannot be started in the normal way.

(8) CAUTION: Only trained personnel should attempt to start this Diesel power unit by towing. (See par. 8 **e**.)

(9) When both engines have been started, set the hand throttle levers to equalize engine speeds at 800 to 1000 rpm for the warm-up period—until engine temperature gages read 160 F (71 C)—and release the clutch lockouts and/or the clutch pedal.

b. Cold weather starting. When the temperature is below 40 F (5 C), the following procedure, which utilizes the air heater built into each engine, is to be used to start first one engine and then the other:

(1) Be sure gearshift lever is in neutral.

(2) Lock out **both** clutches (see par. 10 **d**).

(3) Fully open the air heater fuel inlet line shut-off valve (see fig. 7) above the instrument panel.

(4) Open the engine throttle wide.

(5) Turn on the air heater ignition switch (see fig. 7) on the instrument panel.

(6) Release the air heater pump plunger on the instrument panel by turning the knob counterclockwise.

(7) Press the starter button and hold it in firmly, while operating the air heater pump with smooth, even strokes, using a firm pressure of ten pounds or more on the pumping stroke. (If the weather is extremely cold, a few additional strokes of the air heater pump after the engine starts, with a pause after each stroke, will help warm up the engine and keep it from stalling.)

(8) When the engine starts, release the starter button and quickly regulate the throttle to avoid racing the engine.

(9) Turn off the air heater ignition switch promptly. CAUTION: The coil may be seriously damaged if the switch be left on too long.

(10) Push the air heater pump plunger all the way in and turn it clockwise until its spring catch engages.

(11) Follow steps (4) through (10) to start the second engine.

(12) Close air heater fuel shut-off valve.

(13) When both engines have been started, adjust hand throttle levers to equalize engine speeds at 800 to 1000 revolutions per minute (watch tachometers) for the warm-up period, and lock the throttle levers by pulling down the locking lever (between the throttle levers).

(14) Depress clutch pedal fully, release both clutch lockouts, then release clutch pedal slowly.

(15) When engines have reached normal operating temperature (160 F, 71 C), and **always** before starting the tank, release hand throttle lock and move both hand levers to the idling position.

c. Warm weather starting. At temperatures above 40 F (5 C), the air heaters need not be used. Start one engine and then the other, as follows:

(1) Be sure gearshift lever is in neutral.

(2) Push both hand throttles all the way down, then move them up to the idling position.

(3) Hold down clutch pedal, or lock out the clutches.

(4) Push in one starter button and hold it firmly until its engine starts.

(5) Repeat step (4) to start second engine.

(6) Look at tachometers on instrument panel to make sure both engines are running, adjust hand throttle levers to equalize engine warm-up speeds at 800 to 1000 revolutions per minute, and lock the levers.

(7) Engage clutches slowly.

(8) When engines have warmed up, and always before starting the vehicle, move both hand levers to idling position.

d. Emergency starting. In case only one engine can be started by the normal methods outlined in **b** and **c**, preceding, the second engine often can be started by cranking it with the running engine, as follows:

(1) With both clutches still locked out, or clutch pedal fully depressed, adjust the throttle lever of the running engine to 800 to 1000 revolutions per minute on its tachometer.

(2) With both clutch lockouts released, slowly release the clutch pedal while opening the foot throttle gradually to maintain the speed of the running engine.

(3) When the second engine starts, again depress the clutch pedal fully, set the hand throttle levers to equalize the warm-up speeds at 800 to 1000 revolutions per minute, then gradually release the clutch pedal.

(4) When engines have warmed up, and **always** before starting the tank, move both hand levers to idling position.

e. Starting by towing. Starting by towing should be done only in cases of emergency. In such instances, the steps outlined below should be followed:

(1) Check engine and fuel, oil, and cooling system to determine if in condition to start.

(2) The towing vehicle should be placed in the lowest gear.

(3) The vehicle to be towed should be placed in the highest gear.

(4) Lock out one of the engine clutches, then, after the towed vehicle starts to move, the other clutch should be smoothly engaged with the throttle in the **no fuel** position.

(5) When the engine is turning over, move the throttle to the **full fuel** position, until the engine fires. If the engine does not start after a few revolutions, stop the vehicle and recheck to determine if engine is in condition to start. **Do not continue to tow a Diesel powered vehicle if it does not start readily.**

(6) Do not tow the vehicle with the throttle in the **idle** position,

since the governor action will move the injector rack position to **no fuel** when the engine is turned over faster than idling speed.

(7) When atmospheric temperature is 40 F or lower, operate the air heater when the clutch is engaged to turn over the engine.

(8) After starting one engine by towing, start the other engine by means of the running engine, observing the rules listed in **d**, preceding.

9. ENGINE TEST.

a. As soon as the engine has started, the oil gage should be watched. If the gage does not indicate oil pressure within one-half minute, the engine should be shut down and an investigation made. Low oil pressure warning lights (see fig. 7) should come on when hand throttles are moved out of the **no fuel** position, and continue to burn with engines idling. They are automatically turned off when proper oil pressure is reached as engine speed is increased. If lights do not go out as engine speed increases, stop engines and correct cause of low oil pressure (see par. 45 **j**).

b. Warm up the engine by idling at speed of 800 to 1000 revolutions per minute for at least five minutes.

10. OPERATING THE TANK.

a. The driver should be thoroughly familiar with the function and operation of all the controls (fig. 5) and instruments (fig. 7) before attempting to drive the tank.

b. When the engine has warmed up, and all instruments showing normal readings, the tank is ready to start.

(1) Release the parking brake.

(2) Disengage the clutch by pressing clutch pedal down to the floor and holding it down. (Disengage lockouts.)

(3) Engage first or second gear (see fig. 6). NOTE: Normal starts, on level, hard ground, are made in second gear. First gear is a **creeper** gear, for use in maneuvering the tank inch by inch, or in close quarters, and for starting the tank up a grade or in deep mud or sand.

(4) Gradually release the clutch pedal, at the same time depressing the foot throttle. CAUTION: Do not attempt to move the tank in close quarters without the aid of personnel outside the tank serving as a guide.

(5) When the tank has started and picked up speed, release the foot throttle and depress the clutch again, then move the gearshift lever into the next higher gear position. Release the clutch and depress the accelerator to pick up the load.

(6) The same sequence of operations is repeated for each shift. The tank should be driven in the highest gear that will permit the engine to be run at its full governed speed (2100 revolutions per minute). NOTE: Never make the Diesel engine labor or lug; shift to a lower gear, and keep the engine speed up. CAUTION: **Do not ride the clutch.** The driver must keep his foot off the clutch pedal while driving, to avoid serious damage to the clutch.

(7) To engage reverse gear, the tank must be at a dead standstill. With the throttle closed to idling speed, hold down the clutch pedal, depress safety lock button on the gearshift lever, and move lever to the reverse position (see fig. 6). CAUTION: Backing the tank should never be attempted without an observer out front to direct the driver.

(8) To steer, pull back the right-hand steering lever to make a right turn, or the left-hand lever for a left turn. This action slows down the track on the inside of the turn and speeds up the other track. On turns, more power is needed. As the driver anticipates making a turn he must be ready to open the foot throttle to a greater extent, depending on the sharpness of the turn.

(9) To stop the tank, depress the clutch pedal, release the throttle, and pull back equally on both steering levers at the same time.

(10) The parking brake, located on the transmission housing, should be used only for parking—never while the tank is in motion.

(11) The tachometer, the water temperature gage, and the oil pressure gage give the most satisfactory indications of engine performance. Should the indications of any of these instruments appear to be irregular, the engine should be throttled down and the cause investigated. Water temperature should not exceed 190 F (88 C) under normal climatic conditions (see par. 83 b).

c. Use of hand throttles.

(1) On the inside front slope, in line with the driver's right arm and at eye level, is the hand throttle bracket. There are two hand throttle levers, one for each engine. Pushing down on the hand throttle moves the governor link, which in turn moves the injector control racks toward the full injection position. Pulling up on the hand throttles moves the injector control racks toward the **no fuel** position. When hand throttles have been pulled up as far as they will go, they are in the **no fuel** position and the engines will stop.

(2) To set the hand throttle levers for idling speed, first push them down beyond the idling position, then move them upward until the governor control levers are felt to seat in the idling notches of the governor control cams.

(3) Between the two hand throttles is a third lever, the throttle lock. By pushing down this lever, hand throttles can be locked in any position.

d. Use of clutch lockouts. On the hand throttle bracket, directly above the hand throttle levers, are two nickel buttons (see fig. 5) of the pull-out type. These buttons control the clutch lockouts, one for each engine. Light wires in flexible housings lead from the pull buttons back to the lockout levers (see fig. 92) in the clutch selector lever bracket. Although the two clutches operate simultaneously when the clutch pedal is operated, the clutch lockouts can be used to lock out either engine. Their purpose is to permit the continued operation of the tank on one engine if the other engine fails. CAUTION: Care must be used in operating the clutch lockouts. The lockout levers cannot be moved unless the clutch pedal is fully depressed. To pull out or push in the lockout cable buttons, hold the clutch pedal down as far as it will go.

e. Idling. Prolonged periods of idling, especially during cold weather, produce conditions that can adversely affect operation or even result in serious damage to engine parts. Idling time should be held to a minimum and should never exceed five minutes. Whenever possible stop the engine to avoid a long idling period. During necessary idling periods, engine speeds should be above 600 revolutions per minute in order to maintain engine operating temperatures above 160 F (71 C) minimum.

11. STOPPING THE ENGINE.

To stop the engine, release the foot throttle, and let engine slow to idling speed. With quick motions, push the hand throttles down and immediately snap them all the way up to the **off** position.

12. COLD WEATHER OPERATION.

a. Cold weather starting difficulties are largely eliminated by the engine air heaters (see par. 53 **a**), provided that the lubricating oil in the engine is of proper grade for the existing temperature.

b. Under extremely cold conditions it may be necessary, in order to avoid malfunctions, to exercise special precautions in lubricating machine guns and other armament. TM 9-850 gives information covering the proper treatment of such equipment during extremely cold weather.

c. For instructions for operation in extreme cold, see Section VIII.

13. AUXILIARY GENERATOR UNIT (figs. 143 and 144).

a. Description. The auxiliary generator is used to keep the tank batteries charged when the Diesel engine generators are not operating, and to supplement the output of the Diesel engine generators when the gyro-stabilizer unit, turret-traversing motor, gun-firing solenoids, radio, and other electrical installations, impose a heavy load on the batteries. The unit, which is mounted in the hull compartment on the sponson floor to the left rear of the turret platform, or basket, consists of a 30-volt 1500-watt generator directly driven by a one-cylinder air-cooled gasoline engine. A governor controls the speed of the engine at all loads. On the control box, in front of the unit, is the ammeter, which indicates the charging rate of the generator. The panel also has the starter button, and a charging circuit reset button used to reset the circuit breaker. The normal charging rate with a discharged battery is 50 amperes. With a fully charged battery, the auxiliary generator ammeter reading should be 3 to 5 amperes. The unit has its own fuel (gasoline) tank, holding 17.3 quarts, which is filled through the filler port (see fig. 26) marked GASOLINE, in the hull just to the left rear of the turret.

b. Lubrication and fuel. For proper lubrication of the unit, ⅜ pint of OIL (ENGINE, SAE 30) must be thoroughly mixed with each gallon of gasoline **before the fuel is put into the tank.** Thorough

mixing is essential, both to lubricate the unit properly and to prevent fouling of the spark plug and the intake and exhaust ports. (If SAE 30 oil is not obtainable, use SAE 50.)

c. Starting, electric.

(1) Open the shut-off cock on the fuel filter at the bottom of the fuel tank.

(2) In cold weather, below 32 F (0 C), close the carburetor choke by moving the choke lever on top of the carburetor, directly behind the engine. (The choke is open when the lever is against the stop pin.) In warm weather, or when the engine is warm, the choke should **not** be used.

(3) Hold the starting button in, and release it as soon as the engine starts. Immediately, open the choke part way, then gradually open it to the full open position as the engine warms up. CAUTION: The choke must not be used as a throttle. The automatic governor keeps the engine at the proper speed, at all loads.

d. Starting, hand. The auxiliary generator unit may be started by hand.

(1) Pry open the three clips on the magneto shield.

(2) Remove the front half of the shield.

(3) Wind the starting rope counterclockwise on the exposed starting pulley.

(4) Use the choke as for electric starting (par. 13 **c.** (2).

(5) Give the rope a sharp pull to spin the engine quickly.

e. Battery charging. The auxiliary generator should be in operation during use of the gyro-stabilizer unit, turret power-traversing mechanism, radio or interphones, and when any of the solenoid-operated guns are being fired, if the Diesel engine generators are not operating, and also if they are running and the ammeter on the main instrument panel indicates that the battery is discharging.

f. Air duct. With the unit in operation, the heat from the gasoline engine is normally carried into the Diesel engine compartment by air from the auxiliary generator engine blower, on which the engine depends for cooling. The warm air can be directed into the crew compartment by opening the door at the end of the air duct.

g. Stopping the generator engine.

(1) Press the red stop button on the back of the magneto and hold it down firmly until the engine stops.

(2) Turn the fuel shut-off cock clockwise until it is fully closed.

Section III

ARMAMENT

14. ARMAMENT.

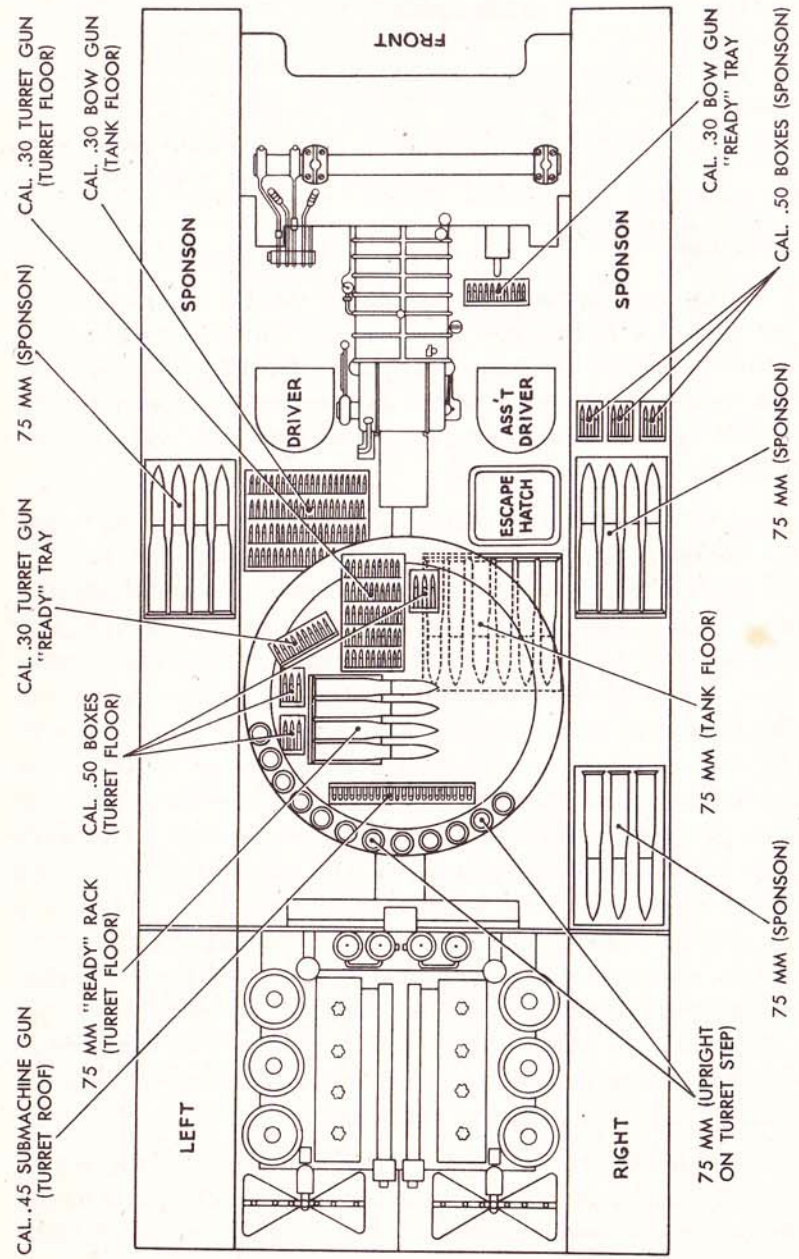
a. Description.

(1) The standard armament installation in the Medium Tank M4A2 consists of a 75 mm gun and a caliber .30 machine gun on a combination mount in the turret; a flexible-mount caliber .30 machine gun, in the right bow; a caliber .50 machine gun for mounting on the revolving turret hatch ring for antiaircraft fire; and a caliber .45 submachine gun, carried inside.

(2) The 75 mm gun and the caliber .30 machine gun in the turret have a 360-degree traverse (effected by traversing the turret), and may be elevated 25 degrees above the horizontal and depressed 10 degrees below the horizontal. Elevation of these guns is controlled either manually or by a gyro-stabilizer, which automatically maintains their angle of elevation **with reference to the horizontal** when the tank is in motion. The gunner sits to the right of the 75 mm gun and operates the elevating and traversing controls, the stabilizer controls, and the firing switches for both turret guns (or the 75 mm gun firing pedal). The gunner sights through a telescopic sight built into his periscope (par. 15 **e**). The mount for the gunner's periscope is connected to the gun by an arm and link, so that the line of aim is automatically changed with any change in gun elevation, and is automatically maintained (vertically) on the target when the gyro-stabilizer is controlling the gun. Calibrated controls enable the gunner to adjust the reflecting prism of the telescope to bring the line of aim on the target when the gun is elevated to the angle called for by the range to the target.

(3) The loader is stationed to the left of the 75 mm gun. A periscope for the loader is located in the top of the turret, in a mount that can be tilted or revolved to change the angle of vision. A pistol port is provided in the left side of the turret.

MEDIUM TANK, M4A2



RA PD 36308

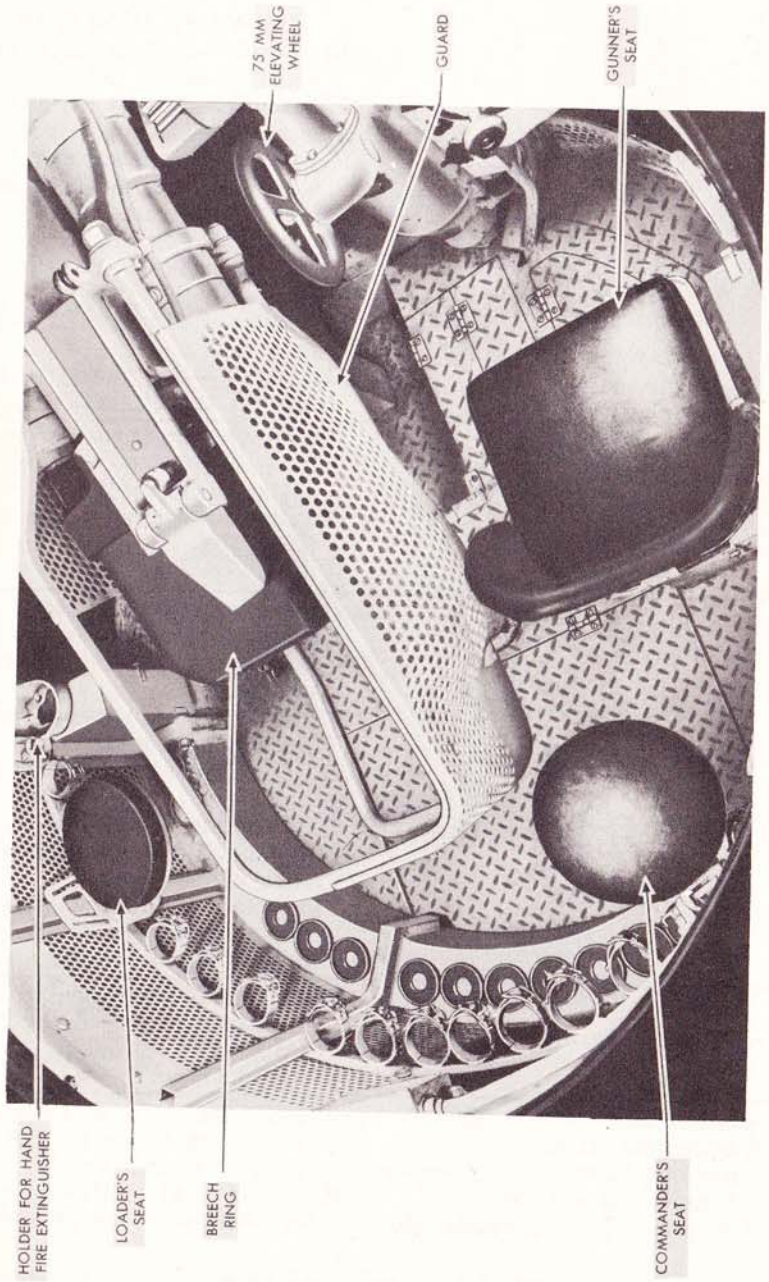
Figure 8—Ammunition Stowage Diagram

ARMAMENT

AMMUNITION	STOWAGE POSITION
97 rounds 75 mm 50% HE 40% AP 10% WP (smoke)	**15 rounds**—Left sponson forward of water can rack. **17 rounds**—Right sponson next to assistant driver. **15 rounds**—Right sponson forward of engine compartment bulkhead. **30 rounds**—On floor under turret basket to rear of escape door. **8 rounds**—On turret "ready" rack floor. **12 rounds**—In ready clips around turret basket step.
300 rounds caliber .50 80% AP 20% tracer	**150 rounds**—In three 50-round boxes right sponson next to assistant driver. **150 rounds**—In three 50-round boxes strapped to turret floor.
6750 rounds caliber .30 80% AP 20% tracer	**4500 rounds**—In eighteen 250-round expendable boxes under turret basket to rear of driver. **1750 rounds**—In seven 250-round expendable boxes, on turret floor under 75 mm gun. **250 rounds**—One 250-round expendable box on "ready" rack of bow gun. **250 rounds**—In one 250-round expendable box on "ready" rack of turret machine gun.
660 rounds caliber .45	**660 rounds**—In twenty-two 30-round clips in submachine gun bracket above turret radio.
12 grenades, hand 4 fragmentation M2. 2 thermite, incendiary. 4 smoke. 2 offensive M3 w/fuze, detonation, hand grenade, M6.	4 fragmentation, 2 offensive and 2 smoke in box under 75 mm gunner's seat. 2 smoke and 2 thermite in box, left side turret wall.

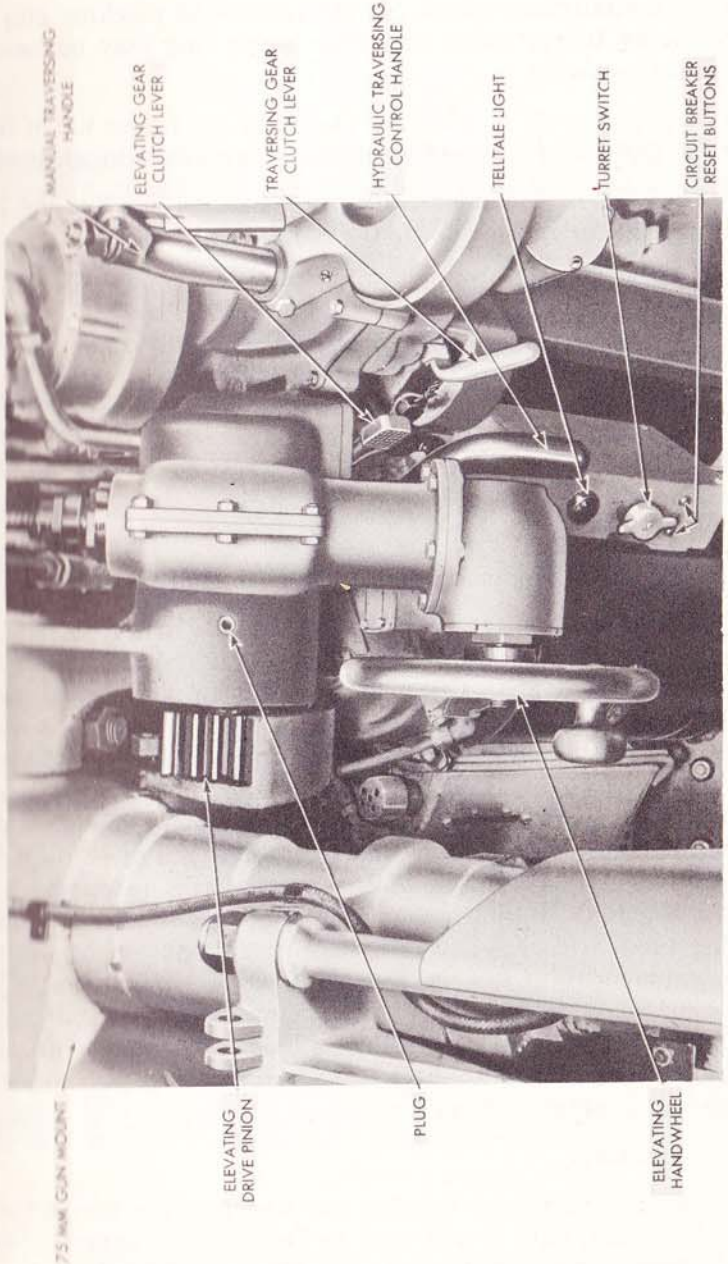
Figure 8A—Ammunition Stowage

RA PD 36308A



RA PD 36309

Figure 9—Interior of Turret, Showing Crew Stations



RA PD 36310

Figure 10—Controls for Turret Operation and Gun Firing

(4) An antiaircraft mount for the caliber .50 machine gun is on the revolving turret hatch ring. The hatch ring may be locked to prevent its revolving.

(5) A periscope in a revolving mount in the turret hatch is provided for the use of the tank commander when the hatch is closed.

(6) The caliber .45 submachine gun is carried in a bracket in the top rear of the turret, just above the radio.

b. Stowage of ammunition.

75 mm	97 rounds
.30 caliber	6750 rounds
.50 caliber	300 rounds
.45 caliber	660 rounds
Hand grenades	12 rounds

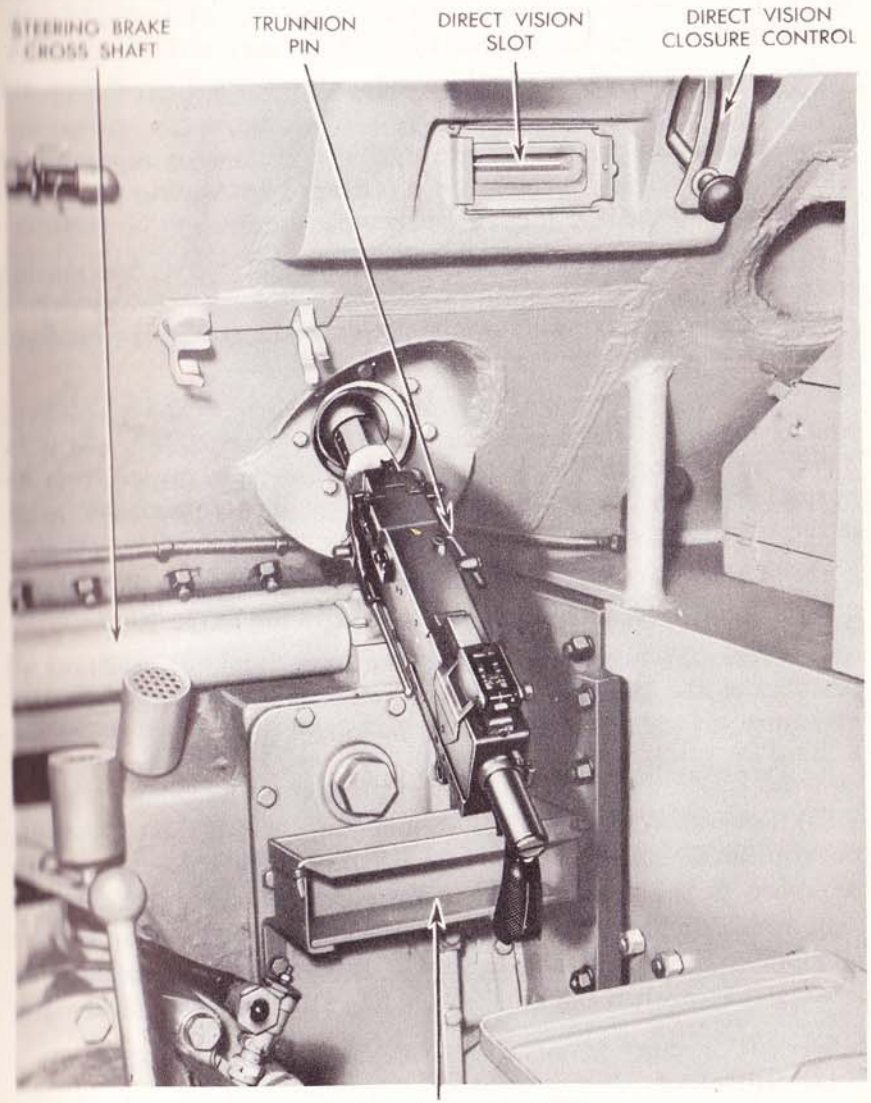
15. OPERATION (figs. 11-14).

a. Turret traversing mechanisms (figs. 10 and 148).

(1) **Description.** The turret can be traversed manually by means of a handwheel, or mechanically by means of a hydraulic mechanism with electric drive. Power traversing of the turret may be done at varying speeds and in either direction, depending on the degree and direction of rotation of the pistol-grip control. A disengaging shift lever keeps the power traversing mechanism inoperative as long as the handwheel is engaged for manual traversing. The power traversing mechanism and the traversing handwheel are directly in front of the gunner. The position of the turret, with reference to the front of the tank, is indicated by a telltale arrow (on top of the slip ring box), which always points to the front end of the tank. At the gunner's right is a locking clamp which, when engaged, prevents rotation of the turret. It is important that this locking clamp be completely disengaged (with the handwheel turned as far as possible to the **left,** or **counterclockwise**) before power or manual traversing of the turret is attempted.

(2) **Traversing.**

(a) Free the turret by turning the wheel of the turret locking clamp to the left until it will turn no farther, to completely disengage the locking lug from the turret ring gear.



RA PD 36311

Figure 11—Assistant Driver's Station in Right Bow

(b) Before using the power traversing mechanism, always check to see that the turret traverses freely without binding. Push down on the shift lever below the hand traversing grip while slowly turning the traversing handle to engage the hand traversing gears. Rotate the turret 360 degrees by hand, to make certain it does not bind.

(c) The power traversing mechanism may now be engaged and the hand traversing mechanism disengaged by pulling up on the shift lever while slowly turning the handle.

(d) Turn the turret switch, on the face of the turret master switch box, to **on.** Closing the switch starts the motor, which drives the oil pumps supplying hydraulic power to the traversing mechanism and to the gyro-stabilizer.

(e) The turret can now be rotated by turning the pistol-grip control handle in the desired direction. The traversing speed is in direct relation to the angle to which the handle is turned from its normal position; that is, the farther the handle is turned, the faster is the traversing speed.

(f) When the stabilizer and the power traversing mechanism are not to be used, turn the motor switch to the **off** position.

(g) Lock the turret by turning the turret clamp handwheel all the way to the right, or clockwise, rotating the turret slightly, if necessary, to engage the clamp in the turret gear.

b. Gyro-stabilizer unit (figs. 138; 148-150).

(1) **General.** When firing the 75 mm gun with the tank in motion, the gun can be aimed and held at a constant angle of elevation, **with reference to the true horizontal,** by means of the gyro-stabilizer unit, which operates the hydraulic elevating cylinder to offset the pitching or rolling of the tank. CAUTION: Do not operate the gyro-stabilizer when the tank is standing still, to avoid drain on the batteries.

(2) **Operation.**

(a) Check the oil level in the stabilizer oil gage (fig. 149). The glass gage at the front of the reservoir should show at least two-thirds full (Univis 47). Add oil if needed.

(b) Take the hand elevating gears out of mesh by pushing in on the trigger on the bottom of the elevating gear clutch lever (fig. 10) and then moving the knurled lever to the left and releasing the trigger. Do not operate lever with gyro-stabilizer power switch **on.**

(c) By hand, move gyro-stabilizer control box (fig. 150) mounted on turret caliber .30 machine gun bracket to left of 75 mm gun, to the **true** vertical. CAUTION: Do not turn on current or attempt to operate gyro-stabilizer until control box has been placed in correct position. If the box is not vertical, the gun will move and may seriously injure personnel in turret.

(d) Be sure the multi-prong plug (fig. 150) is connected to the gyro-control unit.

(e) Set the stiffness adjustment knob on the recoil and stabilizer control box (fig. 149) at zero.

(f) To start the gyro unit, turn the turret switch to the **on** position. Then snap the stabilizer toggle switch to the left or **on** position. (NOTE: Allow at least 60 seconds for the gyros to reach top speed. In sub-zero (F) weather, allow one-half minute running time for each degree below zero.)

(g) Turn the stiffness adjustment knob slowly to the right as far as possible. If the gun vibrates, indicating too stiff an adjustment, decrease the setting slowly until movement stops. Failure of the gun to remain in its set position indicates insufficient stiffness. If the gun starts to vibrate as the stiffness rheostat knob is adjusted, turn the knob in the opposite direction until the vibration is eliminated. During operation, it may be necessary to make slight changes in the stiffness adjustment knob from time to time as conditions vary.

(h) Bring the gun to the desired elevation by turning the elevating handwheel.

(i) Before firing, set the recoil adjustment knob on the control box to the **No. 5** position.

(j) If the breech drops after firing the first round, change the recoil setting, by turning the knob to the right, or clockwise. If the breech rises, turn the knob to the left. Check the recoil setting after

each of the first few shots, and adjust until the correct setting is reached.

(3) **Cautions.** In operating the stabilizer, certain cautions are to be observed:

(a) Never force the gun up and down rapidly by hand, to avoid drawing air into the system around the piston rod.

(b) When controlling gun elevation, avoid turning the handwheel after the gun has reached its limit of elevation or depression. Continued turning of the handwheel will cause the motor to labor, and overload the tank battery.

(c) Keep all stabilizer parts tight, and moving parts properly lubricated.

(d) Watch oil level in gage when turning on the stabilizer. There should be no drop in level. Change in oil level when stabilizer is turned on indicates presence of air in the system. (For remedy, see par. 143).

(e) Sudden changes in the speed of the tank will cause the gun to bob. For consistent firing, it is essential that the speed of the tank be kept as constant as possible, with the engine running **at full governed speed.** (To run the tank at reduced speed, shift to a lower gear and maintain full engine speed, rather than run on part throttle in a higher gear.)

(f) To protect the battery, the auxiliary generator should always be in operation while the stabilizer or the power traversing mechanism is in use.

(g) While the tank is standing still, the gun should be controlled manually. Do not use the stabilizer except when the tank is in motion.

c. 75 mm gun and caliber .30 machine gun.

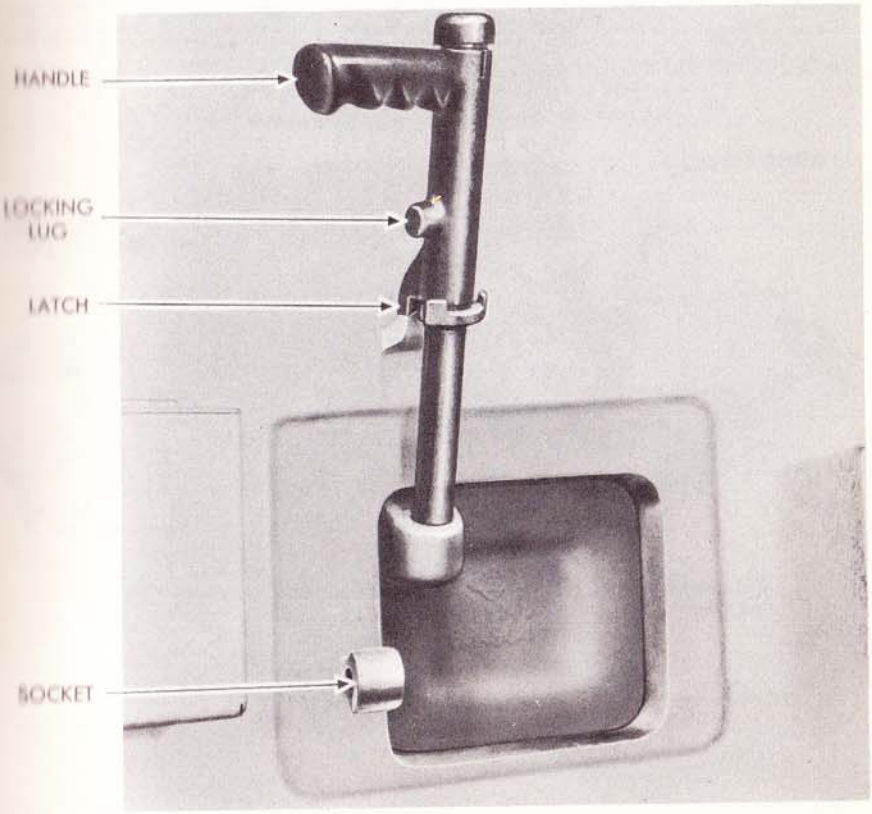
(1) **Firing controls** (fig. 138). The two turret guns are fired electrically by means of the firing buttons (foot-operated switches) to the left of the gunner. The foot switches operate only when the firing switch on the turret switch box is to the left or **on** position. A red telltale light warns when the firing switch is on. The right

switch fires the 75 mm gun, the left switch the caliber .30 machine gun. The 75 mm gun can be fired mechanically by a pedal mounted to the left of the foot switches.

(2) **Precautions.** The care and operation of the 75 mm gun are covered in detail in TM 9-307. Certain precautions should be noted:

(a) Make sure that the telescope is perfectly calibrated with the gun by bore sighting.

(b) Check the alinement of the machine gun by firing on a target



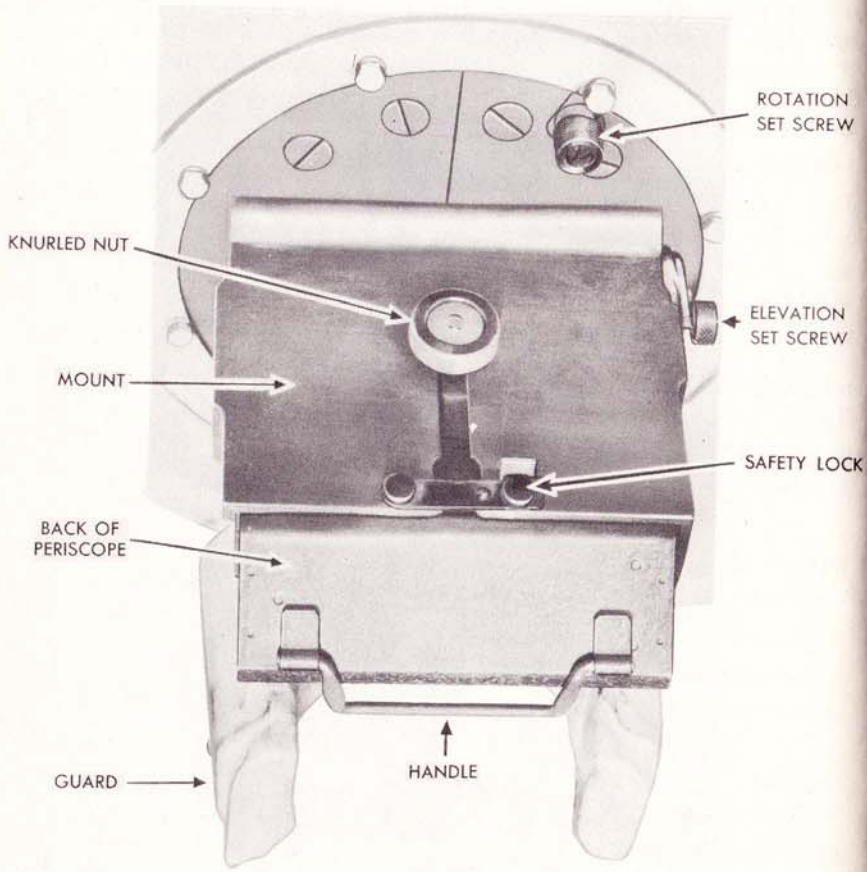
RA PD 36312

Figure 12—Pistol Port, Closed and Locked

at a known range, and make any necessary adjustment at the rear of the gun mount.

(c) Before firing the 75 mm gun with the gyro-stabilizer in operation be sure the stiffness and recoil adjustments are properly set. The recoil should be set at 5 at the start, and adjusted as necessary after each of the first few shots.

d. Firing of other guns.



RA PD 36313

Figure 13—M5 Periscope and Housing Details

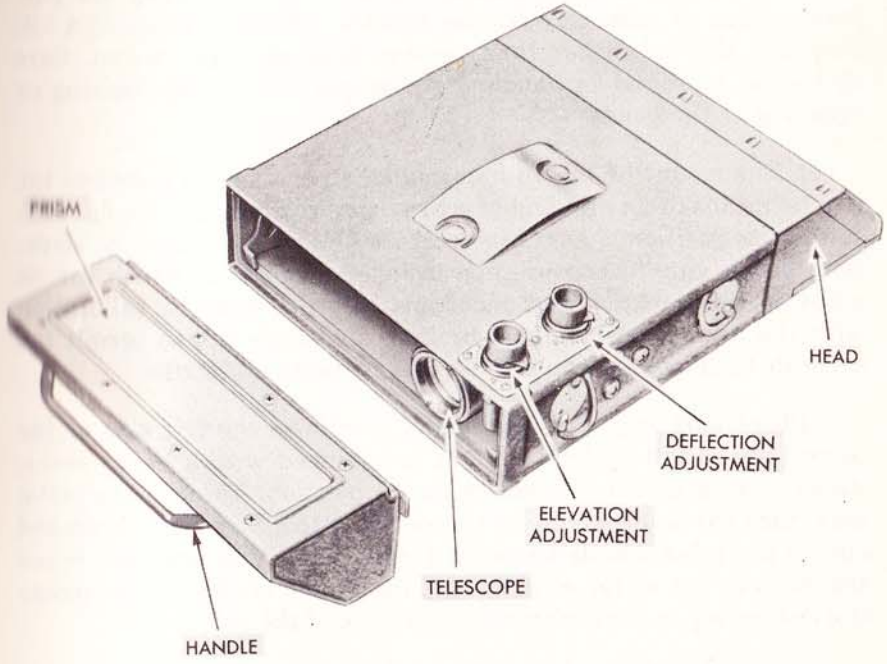
(1) The assistant driver observes the strike of his caliber .30 flexible-mount bow machine gun by means of his periscope.

(2) The caliber .45 submachine gun can be fired through the pistol port, and its fire observed also through the periscope of the loader or the tank commander. The caliber .45 gun can be used also to supplement the caliber .50 gun for antiaircraft fire.

(3) The caliber .50 machine gun is fired from a special mount on the revolving turret hatch ring (fig. 145), which permits an all-round traverse, and almost verticle fire for antiaircraft use.

e. Periscopes and telescopic sight (figs. 13 and 14).

(1) An indirect vision device, or periscope, is provided for each crew member at his station (see fig. 4). Each periscope, except that



RA PD 36314

Figure 14—M3 Periscope, with Telescope, for 75 MM Gunner

of the 75 mm gunner, is mounted in a revolving plate which permits vision in any direction, and the mount can be tilted to raise or lower the line of vision. Lock screws are provided to hold the mount stationary when desired. The periscope is held in place in its mount by a knurled nut on the back. A safety lock on the periscope housing prevents the periscope from falling out if the nut becomes loosened.

(2) To install the periscope, push it upward into place until the retaining bolt is against the mount. (If the periscope does not enter freely, check to see whether the head guard bolts have been tightened down too far, so that they protrude inside the periscope mount.) Tighten the knurled nut at the back of the periscope and move the safety lock into place. To remove the periscope, unlatch the safety lock, loosen the retaining nut, and pull the periscope down by the handle.

(3) The heads of the periscopes are replaceable. They are purposely made of relatively fragile material so that, in case of a hit, they will shatter rather than become wedged in the mount. Care should be exercised in handling periscopes to prevent cracking or breaking of the heads.

(4) The mount of the 75 mm gunner's periscope is linked to the gun by means of an arm and synchronizing rod linkage (see fig. 149) so that its position changes in accord with any change in the elevation of the gun. This periscope includes a telescope which can be adjusted for elevation and deflection, to provide for its calibration with the gun (as determined by bore sighting) and to permit the accurate laying of the gun and the observation of its strike.

f. Pistol port (fig. 12). The pistol port is in the left side of the turret, above the loader's seat. It is equipped with a heavy cover, which can be locked in open or closed position. To open the pistol port, turn the lever handle to release the latch, then push down and out on the lever handle to swing the port cover up and out. When the cover is out as far as it will go, turn the lever handle to engage the locking lug in the socket at the left side of the port.

g. Turret hatch (fig. 145). When the turret hatch is open, a safety check, just below the hinge of each hatch cover, keeps the cover locked in the open position. To close, pull out the check release ring

while pulling the cover. The half cover equipped with the locking lever should be closed last. When both covers are closed, they should be locked by moving the latch handle to engage the latch with the rim of the hatch. To keep the hatch cover ring from revolving, turn it so that the slot in the lower edge of the turret hatch ring is in line with the finger release ring, then push the locking bar up into the slot in the hatch ring.

Section IV

INSPECTIONS

16. PURPOSE.

To maintain mechanical efficiency, tanks must be systematically inspected at regular intervals in order that possible defects may be discovered and corrected before they cause serious damage.

17. PRESTARTING INSPECTION.

It is essential that all five members of the crew be utilized in the inspection of the tank, under the direction of the tank commander. The inspection will cover the entire tank as well as the engine, as outlined in paragraph 7.

18. INSPECTION DURING OPERATION.

a. During operation, the driver should be alert to detect abnormal functioning of the engine. He should be trained to detect unusual engine sounds or noises. Each engine should be listened to individually, to isolate trouble when it is detected. The driver should glance frequently at the instrument panel gages to see whether the engine is functioning properly. An unsteady oil gage pointer may indicate low oil supply in tank or air leak in the suction side of the oil pressure pump, provided that engine speed is fairly constant. The driver should frequently check the free travel of the clutch pedal (par. 90). The steering and braking levers must be checked to make sure that their operation is positive.

b. Only under exceptional circumstances should a vehicle be operated after indications of trouble have been observed. When in doubt, stop the engine.

c. Inspection during operation applies to the entire vehicle, and should never be neglected.

INSPECTIONS

19. INSPECTION AT THE HALT.

a. At each halt the operator should make a careful inspection of the vehicle to determine its general mechanical condition. Minor defects detected during operation, and defects discovered at the halt, should be corrected before resuming the march. If the defects cannot be corrected during the halt, report to the proper authority.

b. A suitable general routine is as follows:

(1) Allow the engine to run a short time at idling speed. Listen for unusual noises. Then speed up the engine several times, again listening carefully. Check oil pressures and engine temperatures.

(2) Inspect for water, fuel, or oil leaks, inside and outside the tank.

(3) Examine tracks for adjustment and for worn, loose, broken, or missing parts. Remove dirt from rollers and from between bogie arms and levers.

(4) Inspect hull and fittings for missing, worn, or loose parts.

(5) Check the transmission oil temperature gage.

(6) Inspect the lights.

(7) Check steering brake adjustment.

(8) Check fuel supply.

(9) Check engines for loose parts, connections, and leaks.

(10) Wipe all vision devices. (Do not use an oily or dirty rag.)

20. INSPECTION AFTER OPERATION.

a. At the end of each day's operation, the commander should require an inspection similar to that made at halts, but more thorough and detailed. The inspection should be followed by preventive maintenance. If defects cannot be corrected, they should be reported promptly to the person in charge. Oil checks should be made on level ground after the vehicle has been allowed to stand until the oil has settled. NOTE: The fuel tank selector valve should be closed whenever stops of any length are to be made.

b. Cracks that develop in castings or other metal parts may often

be revealed upon the completion of a run by the presence of oil and dust deposits.

c. The following points shall be covered in the inspection:

(1) Examine the tracks and bogies.

(2) Check track tension.

(3) Inspect idler and bogie.

(4) Examine the drive sprockets for worn or broken teeth and loose bolts.

(5) Examine track shoe units for unserviceable units.

(6) Check transmission and differential oil level.

(7) Check and clean air cleaners.

(8) Inspect lights and siren.

(9) Check for loss or damage of exhaust mufflers and accessories.

(10) Inspect sighting and vision devices for breakage.

(11) Inspect guns and mounts for defective performance.

(12) See that covers are properly installed on guns, sighting equipment, and accessories.

(13) Inspect ammunition and fighting compartments for cleanliness and orderly arrangement.

(14) Replenish oil, fuel, water, and ammunition.

(15) For continuous operation in hot weather, battery water must be replenished about twice a week.

(16) Check operation of turret traverse.

(17) Check operation of auxiliary generator.

(18) Check all items listed on commander's report.

21. PERIODIC INSPECTION.

The following periodic inspections are prescribed:

a. After 50 hours or 500 miles of operation (whichever occurs first).

Point of Inspection	Remarks	Paragraph Reference
Engine assembly	Check for loose parts, lines, and connections	
Air cleaner	Clean and refill	26; 64
Battery	Replenish water and clean terminals	117 b
Clutch and controls	Check and adjust	90
Propeller shaft	Test for vibration and backlash	97
Lubricating oil system	Drain and refill	25 b
	Check lines and connections for leaks	
	Replace filter elements	60 b (1)
	Clean strainer	60 b (2) (b)
Fuel oil system	Check lines and valves for leaks	
Power traversing mechanism, turret	Lubricate at two grease fittings on traversing gear	
	Use general purpose grease in grease fittings on traversing gears and on turret race	
Auxiliary generator	Check spark plug	136 a
	Check magneto contact points	136 b
Repeat **Inspection After Operation** Steps		20
Make out driver's report		

b. **After 100 hours or 1,000 miles of operation** (whichever occurs first).

MEDIUM TANK, M4A2

Point of Inspection	Remarks	Paragraph Reference
Repeat **Inspection After Operation** Steps		20
Repeat 50-hour inspection		21 a
Engine	Clean thoroughly	
Fighting and engine compartments	Clean out; correct cause of excess oil	
Auxiliary generator	Inspect for dirty condition, loose or faulty contacts	136
Generator regulators	Inspect	119 b
Generator	Check functioning and lubricate	26; 54 b
Clutch and controls	Check and adjust	90
Propeller shaft	Inspect and lubricate	97, 98
Cooling system	Clean radiators and fan shrouds	
Fuel system	Inspect lines for leaks at connections	
Primary fuel filter	Check, clean if necessary	75 d
Secondary fuel filter	Check, and replace filter element if necessary	75 e
Valve and injector operating mechanism	Check, and adjust if necessary	48, 49

Section V

LUBRICATION

22. LUBRICATION.

The War Department Lubrication Guide (figs. 16 and 17) for Medium Tank M4A2 shows the points to be lubricated, the periods of lubrication, and the lubricants to be used. Besides the items listed in the guide, moving parts such as door and shield hinges, pistol port covers, and door latches, must be kept lubricated. (Oil holes and lubrication fittings are painted red for easy identification.)

23. POWER UNIT (fig. 15).

a. Lubricating oil is drawn from the oil supply tank by the pressure oil pump (par. 59) and is pumped through the engine oil cooler (par. 61), which is mounted on the outer side of each engine. The cooled oil is then pumped through the engine lubricating oil circuit, and returns to the two sumps (front and rear) in the engine oil pan, from which the two scavenger pumps return it to the supply tank. A spring-loaded by-pass valve in the oil cooler adapter by-passes oil directly from the pump to the engine lubricating system, whenever the pressure at the oil cooler inlet becomes approximately 40 pounds greater than the pressure at the oil cooler outlet.

b. A pressure relief valve is housed in the oil pump, and an oil pressure regulator valve is attached to the rear of the cylinder block, on the oil pan bolt flange.

c. Two lubricating oil filters (see par. 60) for each engine are mounted on the filter panel (fig. 30) on the engine compartment bulkhead. Oil entering the filter is bled off one of the oil passages in the cylinder block, forced through the filter element, and returned directly to the engine oil pan.

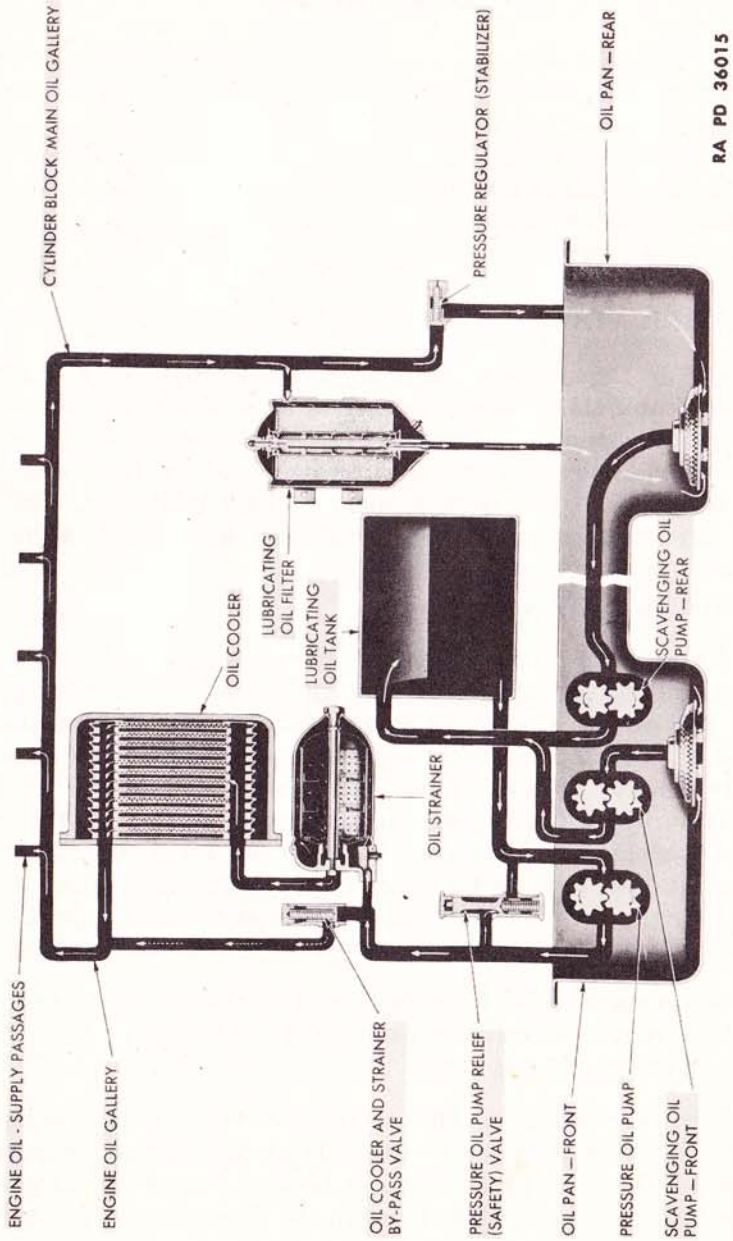


Figure 15—Diagram of Engine Lubrication System

d. A breather vent at the top rear of each engine leads from the flywheel housing into the cylinder head. A breather outlet at the governor housing leads to the air cleaner inlets.

24. TRANSMISSION OIL COOLER.

The transmission oil cooler (par. 104 **f**) is mounted in the crew compartment, at the top center of the engine bulkhead (see fig. 74). Oil from the transmission circulates through the cooler and back to the transmission through two tubes, which are located to the right of the propeller shaft housing, on the hull floor.

25. LUBRICATING OIL TANKS AND LINES (figs. 18 and 19).

a. **Tanks** (fig. 18). A separate lubricating oil tank is provided for each engine. Each tank is filled through its own filler hole on the top of the tank back of the turret. Oil level is shown by the combination lubricating oil and fuel gage (par. 122 e (10)) on the instrument panel (fig. 7).

b. **To drain tanks and engines.**

(1) Remove the lubricating oil tank drain plug cover plate, below the hull floor plate (¾-inch box or open-end wrench).

(2) Remove the drain plugs (square ½-inch Allen wrench).

(3) Remove the two engine oil pan drain plug cover plates beneath each engine (⅞-inch open-end wrench).

(4) Remove the engine oil pan drain plugs, one in the front and one in the rear, from each engine.

c. **External lubricating oil lines** (fig. 19). Engine overheating and other symptoms of faulty lubrication (as outlined in par. 45, **Trouble Shooting**) may indicate the need for removal and cleaning of external lubricating oil lines, and possible replacement of faulty tubes, hose, or fittings. To remove oil lines:

(1) Drain the lubricating oil systems (par. 25 **b**).

(2) Remove the inlet and outlet hoses to lubricating oil filters, disconnecting them at the filters (fig. 30) and at the junction plates immediately below.

(3) Remove the vent hose (see fig. 19) between each lubricating oil tank and the engine breather connector.

(4) Remove the lubricating oil inlet and outlet tubes, from beneath the engines, with inspection plates removed (see par. 71 (2)).

(5) Remove the inlet tube connections from the lower rear outer sides of the two engines, and disconnect tubes from lubricating oil tanks.

(6) Blow out all lines and fittings that have been removed, and flush out with gasoline.

(7) Install lines by reversing the removal procedure.

26. LUBRICATION INSTRUCTIONS.

a. General.

(1) The following lubrication instructions for Medium Tank M4A2 are published for the information and guidance of all concerned, and supersede all previous instructions.

(2) **References.** Materiel must be lubricated in accordance with the latest instructions contained in Technical Manuals and/or Ordnance Field Service Bulletins. Reference is made to the General Instruction section (OFSB 6-10) for additional lubrication information, and to the Product Guide section (OFSB 6-2) for latest approved lubricants.

b. Lubrication Guide (figs. 16 and 17). Lubrication instructions for all points to be serviced by the using arm are shown in **Lubrication Guide** No. 119, which specifies the types of lubricants required and the intervals at which they are to be applied. The detailed lubrication instructions that follow contain the same information as the guide. Guides from which data are reproduced are 10 x 15 inch laminated charts, which are a part of the accessory equipment of each piece of materiel. Data contained in the lubrication guides are taken from Technical Manuals and are binding on using troops.

c. Notes. Reference numbers in the Lubrication Guide (figs. 16 and 17) refer to the following notes giving additional lubrication and service instructions on individual units and parts. (**Cold weath-**

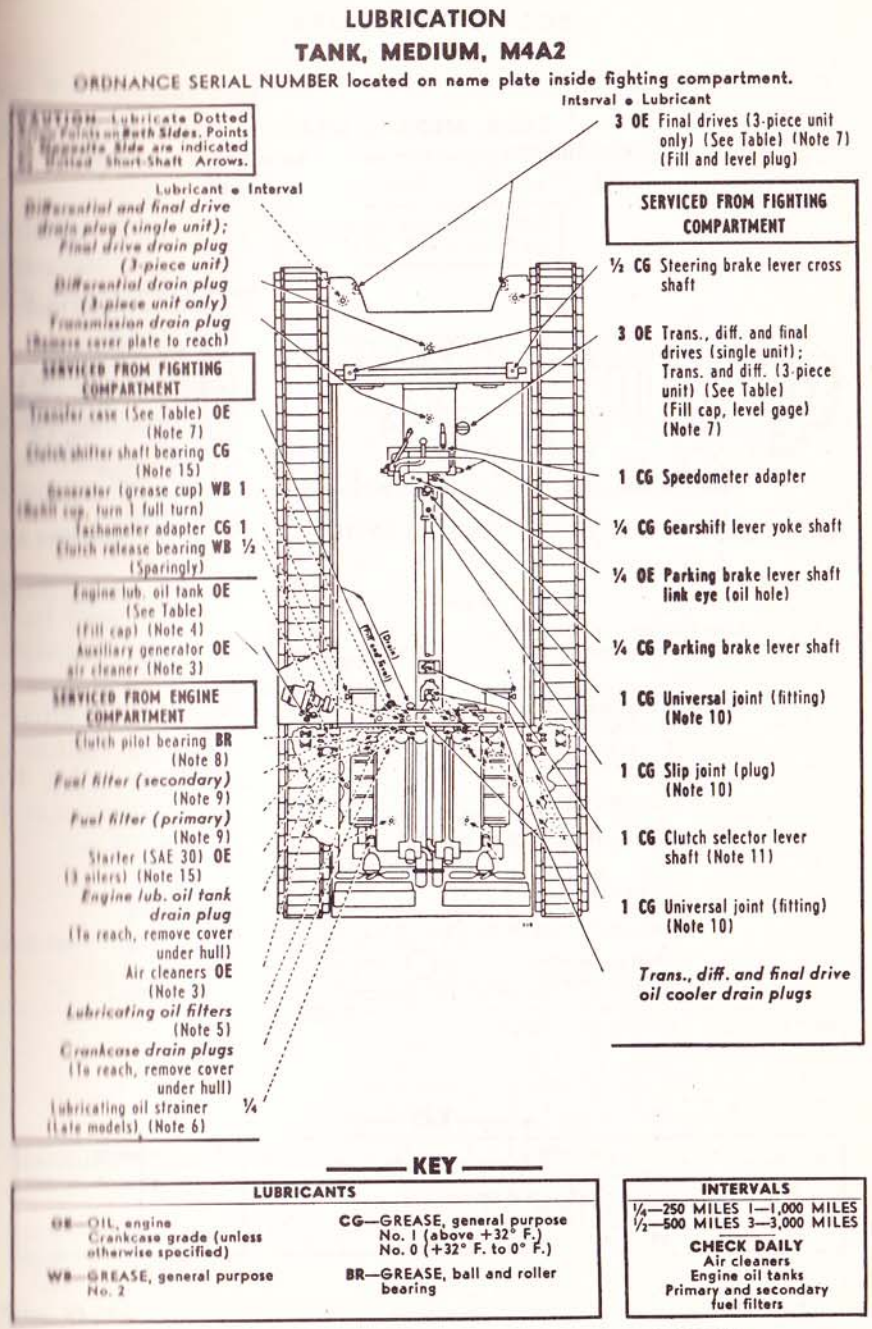
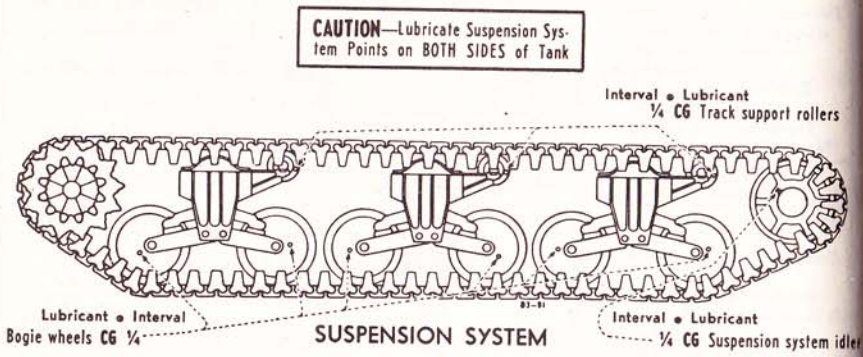


Figure 16—Lubrication Guide, Medium Tank M4A2

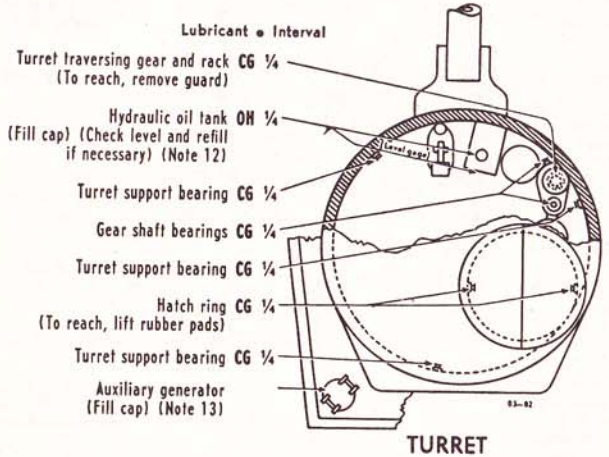
MEDIUM TANK, M4A2

TANK, MEDIUM, M4A2

ORDNANCE SERIAL NUMBER located on name plate inside fighting compartment.



SUSPENSION SYSTEM



TURRET

KEY

LUBRICANTS	INTERVAL
OE—OIL, engine CG—GREASE, general purpose No. 1 (above +32° F.) No. 0 (+32° F. to 0° F.) OH—OIL, hydraulic	¼—250 MILES

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Figure 17—Lubrication Guide, Medium Tank M4A2

LUBRICATION

For lubrication and service at temperatures below zero F (-18 C), refer to Section VIII).

NOTES—LUBRICATION GUIDE

TABLE OF CAPACITIES AND LUBRICANTS TO BE USED

UNIT	Capacity (approximate)	Lowest Expected Air Temperature: +32° F. and above (0° C. and above)	Lowest Expected Air Temperature: +32° F. to 0° F. (0° C. to −18° C.)	Lowest Expected Air Temperature: Below 0° F. (Below −18° C.)
Engine Lubricating Oil System (each)	32 qt. (refill)	OE SAE 30	OE SAE 10	Refer
Transfer Case	2½ qt.	OE SAE 30	OE SAE 30	to
Trans., Diff., and Final Drives (single unit)	152 qt.	OE SAE 50	OE SAE 30	Section
Final Drives (each) (3-piece unit)	36 qt.			VIII
Trans. and Diff. (3-piece unit)	64 qt.			

NOTE 1.

Fittings. Clean before applying lubricant. Lubricate universal joints, bogie wheels, idler and track support rollers, and tachometer and speedometer adapters, until lubricant overflows at relief valve; lubricate other points until new lubricant is forced from the bearing, unless otherwise specified. CAUTION: Lubricate suspension points after washing tank.

NOTE 2.

Intervals. Intervals indicated are for normal service. For extreme conditions of speed, heat, water, sand, mud, snow, dust, etc., reduce interval by one-third or one-half, or more if conditions warrant.

NOTE 3.

Air cleaners and filters.

a. Engine air cleaners (fig. 61). The power unit has six oil bath air cleaners, three on each blower inlet housing. Three types of cleaners are in use. The **first** type (AC) cleaner has a single oval opening. The **second** type (AC) cleaner has horizontal slots. The **third** type (Donaldson) cleaner has vertical oval slots. All six air cleaners on any one power unit must be of the same type. Always clean filter elements before servicing other parts of tank, to permit ample time for them to drain dry. The frequency of servicing air cleaners depends on the dust and sand conditions encountered. Under extreme dust and sand conditions, service air cleaners every eight hours to prevent premature engine wear. All six cleaners must be serviced at the same time.

(1) Clean and fill oil reservoir every 25 hours or oftener, as required by operating conditions.

(a) Wipe off loose dirt from outside of air cleaners.

(b) Starting at center, loosen wing bolt and remove air cleaner as an assembly.

(c) Carefully cover intake housing ports. (Do not stuff loose rags into housing).

(d) Remove upper portion of air cleaner with element and pour out old oil. Scrape out sediment and wipe clean with rag soaked in Diesel fuel oil. (On Donaldson cleaner, remove snap ring and baffle to clean reservoir, and then install baffle and snap ring.)

(e) Inspect all grommets, seals, and gaskets for wear, and replace worn parts. Inspect condition of air filter element for clogging and caking.

(f) Fill air cleaner oil reservoir with used crankcase oil or OIL, engine, crankcase grade. (CAUTION: Do not overfill oil reservoir.)

	Capacity
First type AC (with oval opening)	1 qt.
Second type AC (with horizontal slots)	3½ qt.
Donaldson (with vertical oval slots)	2½ qt.

(g) Assemble air cleaner, remove cover from intake housing, and install air cleaner, being careful not to spill oil into housing. Tighten wing bolts and connections securely.

(2) Clean air cleaner filter element every 100 to 500 miles, or whenever inspection shows accumulation of dust, dirt, or foreign matter.

(a) With air cleaner disassembled, brush off or blow off dirt and then thoroughly flush the filter element or upper section in clean Diesel fuel oil.

(b) Shake out element or upper section, and blow off or drain thoroughly dry before assembling the cleaner, filling the reservoir, and installing on engine. If element is not dried, fuel oil drawn into the housing will cause serious detonation.

b. Auxiliary generator air filter. Clean the air filter monthly, as follows:

(1) Remove screws attaching air filter (see fig. 144) to carburetor.

(2) Disassemble filter and wash parts in SOLVENT, dry cleaning.

(3) Shake parts dry and assemble filter.

(4) Dip upper end of air filter screen in OIL, engine, SAE 30.

(5) Install air filter on carburetor.

NOTE 4.

Engine lubricating oil tanks (fig. 18). Each engine has its individual lubricating oil tank mounted on the floor in the forward corner of the engine compartment.

MEDIUM TANK, M4A2

a. Check oil level in each tank daily.

(1) With engines running, turn tank gage selector switch (see fig. 7) on instrument panel to either lubricating oil tank position.

(2) Read level and add OIL, engine, grade specified in **Table of Capacities,** until gage reads **full.** Do not overfill.

(3) Repeat operations for other tank.

b. Drain and refill engine lubricating system every 250 miles or 25 hours.

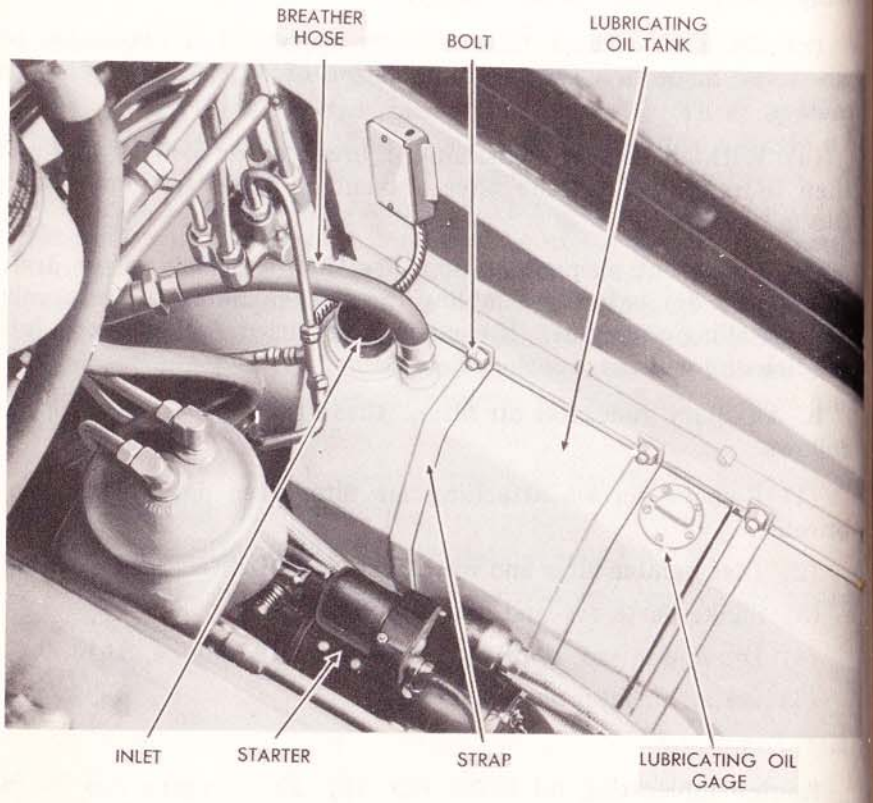

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Figure 18—Lubricating Oil Tank

LUBRICATION

(1) Remove drain hole cover plates under hull floor and remove drain plug from each lubricating oil tank and two drain plugs from each engine oil pan.

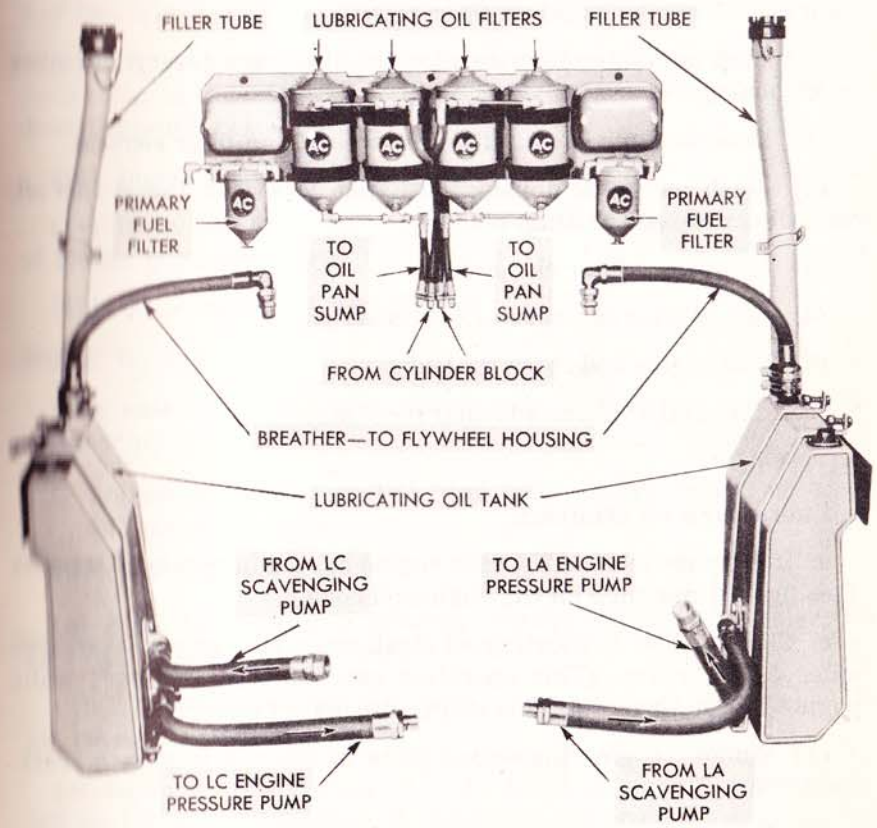

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Figure 19—Lubricating Oil Lines and Tanks

(2) Wipe off drain plugs and install after units have drained dry. Replace drain hole covers.

(3) Refill each lubricating oil tank with 32 quarts of OIL, engine, grade specified in **Table of Capacities.**

(4) Run engines and recheck oil level in both tanks. Add oil if necessary to bring level up to **full** mark.

NOTE 5.

Lubricating oil filters. Two lubricating oil filters (see fig. 27) for each engine are mounted on filter panel.

a. Install new filter element at each oil change (every 250 miles or 25 hours).

(1) Remove filter cover, filter drain plug, and filter element.

(2) Wash out filter housing with rag soaked in Diesel fuel oil, wipe dry, and replace drain plug.

(3) Install new filter element.

(4) Install filter cover, using new cover gasket.

(5) Run engine and check for leaks.

(6) Check oil level and add oil if necessary.

NOTE 6.

Lubricating oil strainers.

a. In later model M4A2's, each engine has a lubrication oil strainer (see fig. 23) mounted on the engine oil cooler.

b. Clean engine lubricating oil strainer on each engine every 250 miles or 25 hours. (This operation can best be performed while engine lubricating system is empty during oil change.)

(1) Remove engine inspection plate in floor of engine compartment (par. 71 **b**).

(2) Remove drain plug from oil strainer housing and loosen center bolt to drain strainer.

(3) Remove engine oil outlet hose elbow from engine oil pan by removing attaching bolts.

(4) Remove strainer center bolt with gasket, strainer, housing, and element.

(5) Thoroughly wash inner and outer surfaces of element by rinsing in clean Diesel fuel oil. **Do not scrape, or use wire brush.**

(6) Remove dirt deposit from inside of housing and face of oil cooler adapter. Wipe clean with rag soaked in Diesel fuel oil.

(7) Examine strainer housing gasket, and replace if necessary.

(8) Place new gasket over center bolt. Insert center bolt part way into housing and carefully slide element into housing.

(9) With element and housing held in place, firmly seat the element collar in the oil cooler adapter. Center the housing and tighten down the center bolt.

(10) Install drain plug and tighten.

(11) Install outlet elbow, using new gasket. Make sure flat side of gasket is against elbow.

(12) Install engine inspection plate.

NOTE 7.

Gear cases (transmission, differential, final drives, and engine transfer unit).

a. Transmission, differential, and final drives, with one-piece differential housing.

(1) Check oil level weekly.

(a) With tank on level ground, remove transmission filler cap (see fig. 99) and wipe off indicator rod.

(b) Insert rod in filler neck with cap resting on filler neck. **(Do not engage threads.)**

(c) Remove cap and read oil level. Add OIL, engine, grade specified in **Table of Capacities,** if necessary, to bring level up to **full** mark.

(d) Replace cap and screw on tight.

(2) Drain oil at end of first 250 miles and every 3,000 miles thereafter. (Drain immediately after tank has been operated.)

(a) Remove transmission drain hole cover under hull floor.

(b) Remove transmission drain plug and drain plug from each final drive housing.

(c) Wipe off magnetic drain plugs and install after units have been drained dry.

(3) Flush out gear cases.

(a) Remove transmission filler neck strainer.

(b) Thoroughly clean strainer in Diesel fuel oil and re-install.

(c) Fill to one-half normal capacity with OIL, engine, SAE 10 and install filler cap.

(d) Drive tank **slowly** three to five minutes.

(e) Drain out flushing oil.

(f) Wipe off drain plugs and install plugs and drain hole covers.

(4) Refill transmission differential and final drives with OIL, engine, grade specified in **Table of Capacities.**

(a) Fill through transmission filler neck with quantity specified in the **Table of Capacities.**

(b) Operate tank three minutes and recheck oil level in transmission.

(c) Add oil, if necessary, to bring level up to **full** mark.

b. Transmission, differential, and final drives, with three-piece differential housing and final drives in separate housings.

(1) Check oil level weekly (see a (1), preceding).

(2) Drain oil at end of first 250 miles and every 3000 miles thereafter. Drain immediately after tank has been operated.)

(a) Remove transmission drain hole cover under hull floor.

(b) Remove transmission drain plug and differential housing drain plug.

(c) Remove drain plug from each final drive housing.

(d) Wipe off all magnetic drain plugs and install after units have drained dry.

(3) Flush out gear cases (see a (3), preceding).

(4) Refill transmission, differential, and final drive housing, with OIL, engine, grade specified in **Table of Capacities.**

(a) Fill transmission and differential through transmission filler neck with quantity specified in **Table of Capacities.**

(b) Remove level plug from each final drive housing, fill to within one inch of hole, and install plugs.

(c) Operate tank three minutes and recheck oil level in transmission.

(d) Add oil if necessary to bring level up to **full** mark.

c. Engine transfer gear case.

(1) Check level every 500 miles or 50 hours.

(a) Remove filler plug (see fig. 21) and add OIL, engine, SAE 30, to overflowing.

(2) Drain and refill every six months, or at clutch overhaul.

(a) Provide suitable container under drain plugs, both sides, and remove plugs.

(b) After unit has drained dry, install drain plugs.

(c) Remove filler plug and fill with OIL, engine, SAE 30, to overflowing.

NOTE 8.

Clutch pilot bearings. At time of disassembly of clutch for inspection, replacement, or overhaul, clean and repack clutch pilot bearing with GREASE, ball and roller bearing.

a. Removal.

(1) Back out center stud of clutch pilot bearing puller tool J-1914 (see fig. 22). Insert fingers of tool through bearing. Expand fingers behind inner race by turning center stud.

(2) Position frame of puller against flywheel. Turn down nut while holding center stud from turning, to pull bearing.

b. Clean and pack.

(1) Wash bearing thoroughly in clean fuel oil and blow dry. Inspect bearing for corrosion or rough spots on balls or races. Replace with new bearing if in doubt.

(2) Thoroughly pack balls with GREASE, ball and roller bearing.

Also pack bore in crankshaft approximately half full of GREASE, ball and roller bearing.

e. Install pilot bearings.

(1) Start bearing square into bore of flywheel by hand.

(2) Place clutch pilot bearing driver, J-1910, or other suitable tool, so it contacts **only the outer race** of the bearing, and drive bearing in flush with the outer face of flywheel.

NOTE 9.

Fuel filters. (Primary fuel filters at extreme ends of filter panel (fig. 30), secondary fuel filters on side of engine at flywheel end).

a. Drain primary and secondary fuel filters (see fig. 27) daily.

(1) Open drain cocks on filters for one engine only.

(2) After units have drained dry, close drain cocks.

(3) Start engines and run until even fuel flow has been restored.

(4) Stop engines and repeat operations (1), (2) and (3) for filters for other engine.

b. Clean primary fuel filter element every 1000 miles or 100 hours.

(1) Turn fuel tank selector valve (fig. 83) to **off** position.

(2) Back out retainer bolt at top of filter and remove bowl and element.

(3) Thoroughly wash disks in Diesel fuel. **Do not scrape, or use stiff brush.**

(4) Wash out bowl and fill with clean Diesel fuel.

(5) Reassemble, using new element gasket and bowl gasket.

(6) Turn fuel selector valve to **on** position, start engine, and check for leaks.

(7) Repeat operations (1) through (6) for other primary fuel filter.

c. Replace secondary fuel filter element every 5000 miles or 500 hours.

(1) Turn fuel selector valve to **off** position.

(2) Unscrew nut at bottom of bowl. Drop bowl.

(3) Discard filter element and clean inside of bowl.

(4) Install new filter element and reassemble, using new gaskets at top of collector tube and at top and bottom of filter element.

(5) Loosen filter outlet connection, turn fuel tank selector valve to **on** position, lock out clutch, and run other engine to fill filter bowl until fuel is forced out at loose connection.

(6) Tighten connection, start engine, and check for leaks.

(7) When engine runs smoothly, replace filter element on other engine.

NOTE 10.

Universal joints and slip joint (figs. 97 and 98). Every 1000 miles, lubricate propeller shaft universal joints and slip joint.

(1) Remove propeller shaft housing front cover.

(2) With pressure gun, apply GREASE, general purpose, seasonal grade, to universal joint fitting (see fig. 97) until it overflows the relief valve.

(3) Remove propeller shaft slip joint plug (see fig. 97) and replace with lubrication fitting.

(4) Apply GREASE, general purpose, seasonal grade, until it shows at spline end.

(5) Remove lubrication fitting and install plug.

(6) Install propeller shaft housing cover.

(7) Traverse turret so that rear propeller shaft housing cover can be removed through turret platform hatch door.

(8) Release catches, remove bolts, and remove cover.

(9) Apply GREASE, general purpose, seasonal grade, to propeller shaft rear universal joint (see fig. 97) until grease overflows relief valve.

(10) See Note 11 for lubrication of clutch selector lever shaft, which can best be performed at this time.

(11) Install propeller shaft housing rear cover.

NOTE 11.

Clutch selector lever shaft (see fig. 92). Every 1000 miles, lubricate clutch selector lever shaft. (This operation can best be performed at the same time the rear propeller shaft universal joint is lubricated.)

(1) Raise turret platform hatch door.

(2) Rotate turret to reach fitting through hole in left side of propeller shaft housing, at rear of battery box.

(3) With pressure gun, apply GREASE, general purpose, seasonal grade, three or four shots.

NOTE 12.

Hydraulic oil tank (see fig. 138). The hydraulic oil tank for the Oilgear traversing mechanism is mounted at the side of the turret electric motor. It has a capacity of four quarts.

a. Check oil level every 250 miles.

(1) Oil tank should be kept two-thirds full, as indicated on glass level gage.

b. Fill oil tank.

(1) Remove filler cap at top of oil reservoir.

(2) Add OIL, hydraulic, Univis 47, until two-thirds full, and install cap.

c. Remove air from system.

(1) Fill oil tank to proper level.

(2) Run motor slowly by snapping switch on and off until system is filled.

(3) With motor running, slowly turn operating handle first in one direction, then the other.

(4) Further operate traversing mechanism until movement is steady and all air is out of the system.

(5) Add OIL, hydraulic, if necessary, to maintain level.

NOTE 13.

Auxiliary generator (figs. 143 and 144). The two-cycle air-cooled

gasoline engine which drives the auxiliary generator, mounted on the left sponson floor at the rear, is lubricated by OIL, engine, mixed with the gasoline.

a. To fill fuel tank.

(1) Raise tank filler cap cover on outside of tank upper deck at left rear side of turret and remove filler cap.

(2) Mix thoroughly ⅜ pint OIL, engine, SAE 30, with each gallon of gasoline **before** pouring mixture into fuel tank, which holds 17.3 quarts.

b. Clean fuel strainer.

(1) Close fuel shut-off valve.

(2) Remove strainer bowl (see fig. 144) and strainer.

(3) Wash out and blow off strainer.

(4) Clean out bowl, install strainer and bowl, then open fuel valve.

c. Lubricate magneto cam follower felt every 200 hours.

(1) Raise clips and remove magneto shield.

(2) With oil can, apply one or two drops of OIL, engine, seasonal grade, to cam follower oil wick. Do not over-lubricate.

(3) Install magneto shield.

NOTE 14.

Oil can points. Every 250 miles, lubricate door and shield hinges, direct vision slot doors, pistol port covers, escape hatch lever and bolts, door latches, lever bushings, control rod pins, clevises, clutch and throttle pedals, and control shaft bearings gearshift lever links and pins; hull drain valves and controls; steering brake levers, shafts, and links; seat supports, control levers, and pins; machine gun mount ball sockets, periscope holder pivots, races, and cover hinges, and other working parts not specifically covered in the **Lubrication Guide,** with OIL, engine, SAE 30.

NOTE 15.

Points to be lubricated when engine is removed for inspection or overhaul.

a. Starter motor.

(1) Remove oiler plug from flywheel housing and fill hinged-cap oiler with OIL, engine, SAE 30. Replace plug.

(2) Lubricate at each end of starter motor housing at oiler cap with OIL, engine, SAE 30.

(3) CAUTION: Never oil commutator or brushes.

b. Clutch shifter shaft bearings.

(1) At overhaul, remove bearings and clean in Diesel fuel.

(2) Pack bearings with GREASE, general purpose, No. 1, and install bearings and seals.

(3) Install shifter shaft, and pack grease channels full before installing grease channel pipe plug, which will force additional grease into bearings.

NOTE 16.

Points requiring no lubrication service. Water pumps, clutch pilot bearings, fan drives, bogie wheel suspension linkage and slides (rubbing plates, fig. 113), final drive sprocket hub bearings, hydraulic traversing pump, and turret electrical motor bearings.

27. REPORTS AND RECORDS.

a. Reports. If lubrication instructions are closely followed, proper lubricants are used, and satisfactory results are not obtained, a report will be made to the ordnance officer responsible for the maintenance of the materiel.

b. Records. A complete record of lubrication servicing will be kept in the **Motor Book** for the materiel.

Section VI

CARE AND PRESERVATION

28. RECORDS.

a. Use. An accurate record of each motor vehicle issued by the Ordnance Department must be kept in the Ordnance Motor Book (O.O. Form No. 7255), generally called Log Book, which is issued with, and must always accompany, the vehicle. The Motor Book, kept up to date, forms a complete record that provides valuable information on operation and maintenance costs, replacements, etc., and organization commanders must require that entries be made correctly and promptly. The Motor Book is to be kept in a canvas cover to prevent its being damaged or soiled.

b. **Combat zone precautions.** Before a vehicle enters the combat zone, the Motor Book page bearing a record of assignment must be destroyed, and all other posted references to the identity of the organization must be erased or removed.

29. CLEANING.

a. Grit, dirt, and mud are the chief sources of wear to a motor vehicle. If deposits of dirt and grit are allowed to accumulate, particles will find their way to bearing surfaces, causing abnormal wear and, if the condition is not promptly remedied, resulting in serious damage.

b. Whenever parts or units are to be removed in making repairs or replacements, and whenever working joints or bearing surfaces are to be exposed for inspection, painstaking care must be used to protect exposed surfaces. Grit and dirt that might find its way to the exposed surfaces must first be removed. Tools must be clean. The possibility of brushing dirt or grit into the opening with the sleeve or other part of the clothing must be eliminated.

c. To cut oil-soaked dirt and grit, hardened grit, or road oil, use SOLVENT, dry cleaning, applied with cloths (not waste) or brushes. Water should be kept from power plants and electrical installations, because it is likely to interfere with their operation. Clogged oil holes

should be opened with wire (never with wood, which might break or splinter and permanently clog the passages).

d. Detailed information on cleaning is included in TM 9-850.

30. CARE AFTER EXPOSURE TO GAS.

Vehicles that have been exposed to gas require special cleaning and decontaminating treatment, described in Section IX, Decontamination.

Section VII

TOOLS AND EQUIPMENT FOR USING ARMS

31. TOOL, EQUIPMENT AND SPARE PARTS LISTS.

a. The M4A2 Medium Tank carries a set of pioneer tools, most of which are secured to the outside of the hull by brackets and straps; a special set of tank repair tools, carried inside the tank; and special equipment, also carried inside the tank, for gas decontamination and fire fighting; also special sighting and fire control equipment for use with the 75 mm. and sub-caliber guns.

b. These lists are prepared from data available at time of publication. For current list, see On Vehicle Materiel List issued by Office of Deputy Chief of Ordnance and furnished with each vehicle. Lists of the several classes of tools and equipment, with number per tank, are as follows:

(1) Tools and accessories carried outside the tank.	Quantity
ANTENNA, radio, for regular use	1
AXE (chopping, single bits, 5 lb.)	1
CABLE, towing	1
CROWBAR, 5 ft. long	1
GROUSER (when track D48076 or D48067 is used)	26
HANDLE, mattock	1
MATTOCK, pick M1 (without handle)	1
NET, camouflage, 45 ft. x 45 ft.	1
PADLOCK, 1½ in., 2 keys	1
SHOVEL, short handled	1
SLEDGE, blacksmith, double face, 10-lb.	1
TARPAULIN, 12 ft. x 12 ft.	1
WRENCH, track adjusting	1

(2) Special repair tools, tank set.	Quantity
ADAPTER, button head to bayonet type	1
ADAPTER, button head to hydraulic type, fitting	1
EXTENSION, handy grip, ½ in. sq. drive, 5 in. long	1
EXTENSION, ½ in. sq. drive, 10 in. long	1

Special repair tools, tank set (continued)	Quantity
FIXTURE, track connecting	1
GUN, grease, hand, type 1 (pressure)	1
HAMMER, machinist, ball peen, 2 lb	1
HANDLE, flexible, ½ in. sq. drive, 12 in. long (with cross bar)	1
HOSE, lubricating, heavy duty, 15 in. (button head fitting)	1
PLIERS, combination, slip joint, 8 in.	1
PLIERS, side cutting, 8 in.	1
RATCHET, reversible, ½ in. sq. drive, 9 in.	1
SCREWDRIVER, machinist, 5 in. blade	1
SCREWDRIVER, special purpose, 1¾ in. blade	1
SCREWDRIVER, special purpose, 1½ in. blade	1
SOCKET HEAD, ½ in. sq. drive, ⅜ in. sq.	1
SOCKET HEAD, ½ in. sq. drive, 7/16 in. hex.	1
SOCKET HEAD, ½ in. sq. drive, ½ in. hex.	1
SOCKET HEAD, ½ in. sq. drive, 9/16 in. hex.	1
SOCKET HEAD, ½ in. sq. drive, ⅝ in. hex.	1
SOCKET HEAD, ½ in. sq. drive, ¾ in. hex.	1
SOCKET HEAD, ½ in. sq. drive, ⅞ in. hex.	2
SOCKET HEAD, ½ in. sq. drive, 15/16 in. hex.	2
SOCKET HEAD, ½ in. sq. drive, 1 in. hex.	1
SOCKET HEAD, ½ in. sq. drive, 1 1/16 in. hex.	1
SOCKET HEAD, ½ in. sq. drive, 1⅛ in. hex.	1
SOCKET HEAD, ¾ in. sq. drive, 1½ in. hex.	1
SPEEDER, ½ in. sq. drive, 17 in. long	1
TAPE, adhesive, 4 in. wide x 3¼ O.D., 15 yards long	1
TAPE, friction ¾ in. wide, 30 ft. roll	1
TEE, combination, ½ in. sq. drive, 11 in. long	1
TEE, combination, ¾ in. sq. drive, 17 in. long	1
UNIVERSAL JOINT, ½ in. sq. drive	1
WRENCH, adjustable, single end, 8 in. long	1
WRENCH, adjustable, single end, 12 in. long	1
WRENCH, engineers, double head, alloy steel, 5/16 in. x ⅜ in.	1
WRENCH, engineers, double head, alloy steel, 7/16 in. x ½ in.	1
WRENCH, engineers, double head, alloy steel, 9/16 in. x 11/16 in.	1

Special repair tools, tank set (continued)	Quantity
WRENCH, engineers, double head, alloy steel, ⅝ in. x ¾ in.	1
WRENCH, engineers, double head, alloy steel, 15/16 in. x ⅞ in.	1
WRENCH, engineers, double head, alloy steel, 15/16 in. x 1 in.	1
WRENCH, plug, 9/16 in. hex. (for transmission and oil drain plug)	1
WRENCH, plug, ¾ in. hex. (differential filler and drain plug)	1
WRENCH, safety screw, 3/32 in. hex.	1
WRENCH, safety screw, ⅛ in. hex.	1
WRENCH, safety screw, 3/16 in. hex.	1
WRENCH, safety screw, ¼ in. hex.	1
WRENCH, safety screw, 5/16 in. hex.	1
WRENCH, safety screw, ⅜ in. hex.	1
WRENCH, safety screw, ⅝ in. hex.	1

(5) Special armament repair tools carried in tank.	Quantity
Special repair tools for cal. .30 machine gun.	
ROLL, tool (without contents)	1
SCREWDRIVER, combination, M1	2
WRENCH, combination, M6	2
WRENCH, socket, front barrel bearing plug	1
Special repair tools for cal. .50 machine gun.	
WRENCH, combination, M2	1

Special repair tools for 75 mm. gun.	Quantity
CHISEL, cold, ¾ in.	1
DRIFT, brass, taper, 5/16 in. point, 4 in. long	1
DRIFT, brass, taper, ½ in. point, 6 in. long	1
EXTENSION, oil gun	1
EYEBOLT, breechblock removing	1
FILE, hand, smooth, 8 in.	1
FILE, 3 in. sq., smooth, 6 in.	1
GUN, recoil oil	1
HAMMER, machinists, ball peen, 20 oz.	1
PUNCH, drive pin, ⅛ in. point, 4 in. long	1

MEDIUM TANK, M4A2

Special repair tools for 75 mm gun. (continued)

	Quantity
PUNCH, drift, ¼ in. point, 10 in. long	1
ROD, push (for shaft B163351)	1
ROLL, tool, M4 (w/o contents)	1
TOOL, assembling, firing pin retainer	1
TOOL, breechblock removing	1
WRENCH, adj. screw, knife handle, 12 in. long	1
WRENCH, engineers, double head, 1¼ in. x 1½ in. (for closing spring piston rod nut)	1
WRENCH, firing plunger retainer	1

(4) Equipment and accessories.

	Quantity
ANTENNA, radio, with cover, for spare use	1
APPARATUS, decontaminating, 1½ qt., M11	2
BAG, canvas, field, O. D., M1936	5
BAG (for arm spotlight C100212)	1
BELT, safety	5
BOOK, O. O. Form 7255	1
BUCKET, canvas, folding, w/spout, 8 qt.	1
CAN, ¼ gal. ("OIL, traverse and stabilizer," in black letters on can)	1
CANTEEN, M1910, with cup and cover M1910	5
COMPASS (in turret or hull)	1
CONTAINER, water, 5 gal. (QMC Standard A-353)	2
EXTINGUISHER, fire, 10 lb., CO_2 (fixed)	2
EXTINGUISHER, fire, 4 lb., CO_2 (portable)	2
FLAG SET, M238	1
1 CASE, CS-90, 1 FLAG, MC-273 (red)	
1 FLAG, MC-274 (orange), 1 FLAG, MC-275 (green)	
3 FLAGSTAFFS, MC-270	
FLASHLIGHT	3
GOGGLES, aviation type, Model C	5
GUIDE, lubrication (check-chart)	1
HELMET, tank, sizes 7, 7⅛, 7⅛, 7⅜, 7⅜	5
HOOD, hatch, driver's	1
KIT, first-aid (24 unit)	1
LAMP BULB, inspection	1
LAMP, inspection	1
LIGHT, blackout driving (for left front only)	1
LIGHT, recognition, signal	1

TOOLS AND EQUIPMENT FOR USING ARMS

Equipment and accessories (continued)

	Quantity
MANUAL, field, for cal. .30, M. G. M1919A4 FM23-50	1
MANUAL, field, for cal. .45, S.M.G. M1928A1 FM23-40	1
MANUAL, field, for cal. .50, M. G. M2 FM23-65	1
MANUAL, field, for hand grenades FM23-30	1
MANUAL, technical, for 75 mm. gun, M3TM9-307	1
MANUAL, technical, for operator, TM 9-758	1
MITTENS, asbestos, prs.	2
OIL, 1 qt. Univis No. 47 (in can B101420)	1
OILER (trigger type, 1 pt.)	1
RADIO SET, SCR-506, for command tanks only	1
RADIO SET, either SCR-508, SCR-528, or SCR-538	1
RATIONS	
Type C—2 day rations for 5 men, cans	60
Type D—1 day rations for 5 men, cans	2
RESPIRATOR, dust, M3	5
ROLL, blanket	5
STOVE, cooking, gasoline M1941	1
COLEMAN MILITARY BURNER	
No. 520 w/accessory cups 8½ in. high, 4 7/16 in. diam.	
TUBE, flexible, nozzle	2

(5) Sighting and vision equipment.

	Quantity
HEAD, periscope, M4 and M6, for spare use	15
PERISCOPE, M4 (w/TELESCOPE, M38)	1
PERISCOPE, M4 (w/TELESCOPE, M38) for spare use	1
PERISCOPE, M6	6
PERISCOPE, M6, for spare use	4
SIGHT, bore, for 75 mm. gun, M3	1
TARGET, testing	6

(6) Fire control equipment.

BINOCULAR, M3 complete	1
1 BINOCULAR, M3	
1 CASE, carrying	
1 STRAP, neck	
CASE, carrying, gunner's quadrant, M1	1
QUADRANT, gunner's, M1	1
WATCH, wrist, commander's, complete	1
1 WATCH, wrist, 6 or more jewels	
1 WRISTLET, watch	

(7) **Spare tank parts carried in tank.** **Quantity**

BLOCK, track, shoelink (furnish block in accordance with track being used)	6
CONNECTION, track, shoe-end	12
LAMP, bulb, 3 CP 24-28V	4
NUT, safety, 5/8-18NF-3	16
PIN, locking (for tow shackle pin)	2
PIN, cotter, 1/4 x 2 1/4 (for tow shackle pin)	2
WEDGE, track shoe-end connection	12

32. USE OF SPECIAL EQUIPMENT.

a. Fixed fire extinguisher system.

(1) To extinguish fires in and around the engines, a fixed type fire extinguisher system is provided for the engine compartment. The system consists of two ten-pound carbon dioxide cylinders companion mounted in special brackets on the left side of the tank hull to the rear of the battery box, and connected directly to discharge nozzles in the upper and lower parts of the engine compartment. When turned on carbon dioxide gas is forced into the engine compartment in clouds smothering the fire. CAUTION: If possible, stop engines in case of fire.

(2) The fire extinguisher cylinders are operated by either outside or inside handles, or pulls. The outside handles (fig. 26) are underneath the rear overhang of the turret on the left side of the tank, forward of the water and lubricating oil filler pipe covers. The inside handles are mounted on a bracket attached to the hull roof, to the left rear of the driver. Cylinders are accessible for servicing through the hatch in the turret platform.

(3) To operate, pull handles all the way out and let go. After use replace discharged cylinders with fully charged extinguishers.

(4) CAUTION: Great care must be exercised in handling cylinders containing carbon dioxide under high pressure. Do not drop, strike or handle roughly. Keep cylinders away from excess heat.

(5) Every four months, or oftener, weigh each fire extinguisher cylinder. If extinguisher (fixed type) weighs less than 9 1/2 pounds replace it with a fully charged cylinder.

b. Removal of fixed fire extinguishers.

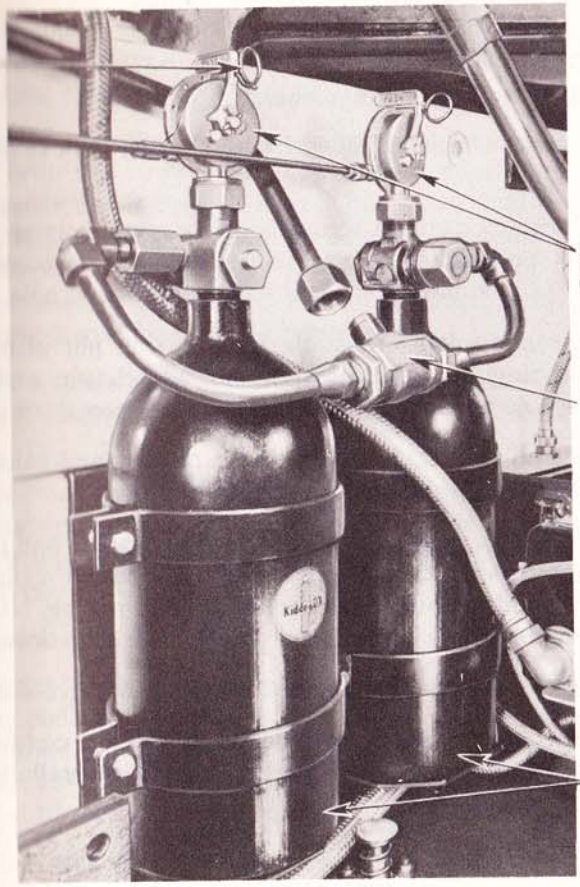


Figure 20—Fixed Fire Extinguisher and Controls

(1) Disconnect control heads from cylinder valve by backing off flared nuts.

(2) Raise control heads clear of cylinder valves, supporting the heads and cable tubing in approximately normal position by wiring them to auxiliary generator support.

(3) Disconnect cylinder connecting tube from each extinguisher valve outlet. CAUTION: Never remove cylinders with connecting tube attached to cylinder outlet valves.

(4) Loosen bolts and remove cylinder clamps.

(5) Lift cylinders out carefully.

c. Installing fixed fire extinguishers.

(1) With control head removed from cylinder, remove cover, exp ing cam.

(2) Check cable clamp set screws to make certain clamp is tight cable will not pull out of clamp. To tighten set screws, use a slen screwdriver (⅛ inch nose) that will follow screw into hole.

(3) Reset remote control handle by inserting pin in control h shaft and turning counterclockwise until clutch pin and arrow lined up. Replace pull-out pin and seal wire, if necessary.

(4) Inspect all tubing, lines, discharge nozzles and other openin to be sure they are clear of foreign matter.

(5) Install cylinders by setting cylinders on bracket and partly tigh ening clamps, leaving them loose enough to permit cylinders to turned as required to connect control heads and tubing. NOTE: Wh installed, cylinder valve outlets face in opposite directions.

(6) Connect discharge (or connecting) tube to valve outlet.

(7) Install control heads in cylinder valves. Make certain heads a in correct position (pin lined up with arrow) before installation. Tighte flare nut securely.

(8) Tighten cylinder clamps.

d. Portable fire extinguishers.

(1) Two portable four-pound carbon dioxide fire extinguishers a provided, one in the left sponson beside the driver, one in the turr basket at the loader's station.

(2) To operate: Carry the extinguisher in the left hand, grasp co in right hand, holding it at the base of the cone at the hose connectio and press the trigger. Rate of discharge is determined by the positio of the trigger. Direct the discharge at base of flame, with the cone close as possible to the flame. Increase the rate of discharge from th extinguisher as the flame diminishes. After use, replace cylinder wit one fully charged.

(3) Every four months, or oftener, weigh each cylinder. If the ex- tinguisher (portable type) weighs less than 3½ pounds, replace it with a fully charged extinguisher.

e. Periodic inspections. The fire extinguishing system requires no more than ordinary care to insure its proper operation. As the system is for emergency use, it must be kept in operating condition at all times; therefore, frequent inspection should be made to insure that apparatus is intact. Check red cap on safety outlet of valve. If not intact, cylinder has been prematurely discharged and must be recharged immediately. The following inspections will be performed:

(1) **Inspection after 250 miles.** Inspect entire system for any mechan- ical damage. Make certain that shielded nozzles are free of foreign matter.

(2) **Inspection every 30 days.** Weigh cylinders to determine the carbon dioxide content. Do not attempt to determine content by means of a pressure gage. Empty weight and carbon dioxide charge are stamped on cylinder valve body. Proceed as follows:

(a) Remove cylinders.

(b) Weigh cylinders and subtract from this weight the empty weight that is stamped on the valve body. Empty weight includes cylinder valve and cylinder, but does not include the control head. If the result- ing net weight of either cylinder is less than nine pounds, cylinder must be recharged to its full rated capacity of ten pounds.

(c) While both control heads are disassembled from cylinders, remove the cover exposing the cam. Check cable clamp set screws to make certain that cable does not pull out of clamp. After replacing cover, pull remote control handle to make certain that cable does not bind. The cam inside control head should rotate, and the pin should advance.

(d) Install cylinders.

Section VIII

OPERATION UNDER UNUSUAL CONDITIONS

33. UNUSUAL CONDITIONS.

a. Cold weather operation.

(1) NOTE: For Centigrade equivalents of the Fahrenheit temperatures given in this section, see table paragraph **f** (2), following.

(2) The operation and maintenance of automotive vehicles at low temperatures involve factors which do not exist at normal temperatures, and operators and maintenance personnel must spend more time in protective maintenance. Failure to give this extra service will result in actual damage, unnecessary and unwarranted expense, and failure to start.

(3) Low temperatures have been divided into two ranges, minus 10 F. to minus 20 F., and below minus 30 F. Engines and lubricants undergo changes in their physical properties below minus 30 F. In many cases, accessory equipment for supplying heat to batteries, engines, fuel, oil, and intake air will be required.

b. Diesel fuel.

(1) Diesel fuel procured under U. S. Army Specification 2-102B shall be used.

(2) In an emergency, if it is necessary to procure a commercial fuel oil, care must be taken to verify that the pour point is 10 degrees **lower** than the lowest temperature anticipated; otherwise the fuel will not flow at this temperature.

(3) At temperatures below zero, if fuel does not flow freely, dilute with kerosene as necessary.

(4) Water in the fuel will form ice crystals, which will interfere with the flow. Take every precaution to prevent water from getting into the fuel.

(5) Insofar as possible, always keep the fuel tank **full.** This will reduce condensation of water from the free air space above the fuel.

c. Engine lubrication.

(1) Engine lubrication at temperatures above minus 10 F. is covered in paragraph 26, **Lubrication Instructions.** The following instructions are intended to supplement this information and apply only to instances where the temperature falls below minus 10 F. for long periods.

(2) Several methods of keeping engine oil sufficiently fluid for proper lubrication at temperatures below minus 10 F. are listed below. Preference should be given to the different methods in the order listed, according to the facilities available.

(a) When engine is stopped, drain engine lubricating oil from tanks and oil pan while it is hot and store in a warm place until vehicle is to be operated again. **Tag the vehicle in a conspicuous place in the driving compartment to warn personnel that crankcases are empty.** If warm storage is not available, heat the oil before refilling lubrication system. (Avoid overheating the oil; heat only to the point where the bare hand can be inserted without burning.)

(b) If the vehicle is to be kept outdoors and if the oil cannot be drained, cover the engines with a tarpaulin. About three hours before engines are to be started, place fire pots under the tarpaulin. The Van Preg, Primus type, or other type blowtorch may be used.

(c) Dilute the engine lubricating oil. (Oil may be diluted with Diesel fuel only.)

(d) The following table shows the quantities of diluent to be added to the engine oils prescribed in the **Lubrication Guide** (see par. 26) for use at minus 10 F. These quantities of diluent will form mixtures for satisfactory starting at the temperatures indicated.

	−10 F. to −30 F.	Below −30 F.
Diesel Fuel	½ qt. to each 3½ qt. of engine oil	1 qt. to each 4 qt. of engine oil

(e) When engine oils are first diluted turn the engine over several times to mix lubricating oil and diluent thoroughly. Diluent should be added when engine is hot or mixed with oil before filling.

(f) The presence of a large percentage of light diluent will increase oil consumption, and for this reason, the oil level should be checked frequently.

d. Transmission, differential, and final drives.

Below minus 15 F. dilute the lubricants prescribed for use at minus 10 F. with 10 percent kerosene or gasoline, or 15 percent Diesel fuel. If circumstances preclude dilution of the lubricants, heat the gear cases with a blowtorch. Play the torch lightly over the entire gear case; do not concentrate the heat in one spot.

e. Chassis lubricants.

(1) Chassis lubricants prescribed for use at minus 10 F. will furnish satisfactory lubrication at temperatures as low as minus 30 F. for sustained temperatures below minus 30 F., greases comparable to GREASE, special, low temperature, or GREASE, O. D. No. 00, should be used.

(2) Greases normally used cannot be applied at temperatures below zero F. except in heated buildings. In an emergency, when heated buildings are not available, use oil, and inspect and lubricate frequently.

f. Protection of cooling systems.

(1) High boiling point permanent antifreeze solutions should be used, since each engine is equipped with a high-point thermostat that begins to open at 158 F. (70 C.) and is fully open at 185 F. (85 C.). **Alcohol cannot be used successfully with this thermostat,** because alcohol boils at 173 F. (75 C.).

(2) GLYCOL, ethylene (Prestone), is prescribed for use as an antifreeze solution. If GLYCOL, ethylene, is not obtainable, other materials may be used. The following table lists the quantity of Prestone or G.P.A. radiator glycerine to be added to prevent freezing at the indicated temperatures:

Freezing Point	Pints Ethylene Glycol (Prestone) Per Gallon of System Capacity	Pints, *G.P.A. Radiator Glycerine Per Gallon of System Capacity
10 F. (−12 C.)	2	3
0 F. (−18 C.)	2½	3
−10 F. (−24 C.)	3	3½
−20 F. (−30 C.)	3½	4
−30 F. (−35 C.)	4	5
−40 F. (−41 C.)	4½	–
−50 F. (−47 C.)	4½	–
−60 F. (−53 C.)	5	–
−70 F. (−59 C.)	5	–

*Glycerine Products Association

(3) CAUTION: Do not mix antifreeze solutions.

(4) The following precautions should be taken before putting in the antifreeze solution:

(a) Flush cooling system thoroughly. The radiators and cylinder blocks should be flushed separately in order not to transfer any residue from one to the other.

(b) Check the systems for leaks; tighten the hose connections and replace if necessary.

(c) CAUTION: It is important that water and the antifreeze solution be thoroughly mixed **before** they are poured into the cooling system. If they are poured in separately, the water may freeze before the thermostat opens and the solution becomes thoroughly mixed.

(d) Be sure that the water thermostats are functioning properly.

g. Electrical systems.

(1) **Generator and starter.** Check the brushes, commutators, and bearings. See that the commutators are clean. The large surges of current which occur in starting the cold engines require good contact between brushes and commutators.

(2) **Wiring.** Check and clean all connections, especially battery terminals. Care should be taken that there are no short circuits.

(3) **Batteries.** The efficiency of batteries decreases sharply with decreasing temperatures, and becomes practically zero at minus 40 F. Do not try to start engine with the battery when it has been exposed to temperatures below minus 30 F. without first warming up battery by running the auxiliary generator. Keep auxiliary generator in operation until both engines are running smoothly. See that the battery is always fully charged, with hydrometer reading between 1.275 and 1.300. A fully-charged battery will not freeze at temperatures likely to be encountered even in Arctic climates, but a fully-discharged battery will freeze at 5 F.

(4) **Starting.** Before every start, remove any ice from wiring or other electrical equipment.

h. Starting and operation.

(1) In temperatures below 40 F. it is necessary to preheat the ingoing air charge of the Diesel engines in the M4A2 tank (see par. 8 **b, Cold Weather Starting**) to facilitate starting.

(2) An additional heating measure for Diesel engines is to direct a blowtorch against the air intake manifold. Heated air is one of the greatest aids in starting Diesel engines. Air heaters (see par. 8 **b**) should be used, and pumping action **continued for a short period after engines start** to make sure all cylinders are firing.

(3) **Temperatures from −10 F. to −30 F.**

(a) Prior to attempting to start, see that everything is in readiness so that the engine will start on the first cranking. Have one engine running smoothly before attempting to start the other engine.

(b) When cranking, the engine must be turned over as rapidly as possible. All engines have a critical cranking speed; they must be turned over at a certain speed before any firing is possible. For General Motors Diesel engines in good mechanical condition, this critical speed may vary from 80 to 120 revolutions per minute. Below this speed too much heat is lost through the cylinder walls and engines will not fire.

(c) After the engines have started, run at 800-1000 revolutions per minute until they have warmed up to 160-180 F.

(4) **Temperatures below −30 F.**

(a) Cover engines with tarpaulin, tent, or portable shed. Place oil stoves or fire pots under the covering about three hours prior to time a start is to be made.

(b) Keep the vehicles in sheltered areas shielded from wind. Cold winds increase starting difficulties.

(c) It is possible for ice to collect in the fuel lines. If the engine does not appear to be getting enough fuel, heat the fuel lines and filters lightly, but be very careful of fire.

(5) Keep engines in the best mechanical condition.

(a) Water pump should be serviced prior to the advent of cold weather.

(b) Dilute oil in air cleaners, if necessary, so it will pour freely.

(6) **Stopping.** Increase engine speed momentarily before moving hand throttles into **no fuel** position. As the engine coasts to a stop, it will blow out all the residual products of combustion, including water vapor, and leave only air in the engine.

i. Cold weather accessories.

The use of the following materiel is at the discretion of officers in charge.

(1) Tarpaulins, tents, or collapsible sheds are useful as covers.

(2) Fire pots, Primus type, or Van Prag blowtorches, ordinary blowtorches, or oil stoves, can be used for heating vehicles.

(3) Extra batteries and facilities for changing batteries quickly are aids in starting.

(4) Steel drums and suitable metal stands are useful for heating crankcase oil.

(5) Radiator covers or engine compartment door covers can be improvised locally, and help to keep the engine running at normal temperatures.

j. Other unusual conditions.

(1) NOTE: Medium Tank M4A2 is built and equipped for operation under varied extremes of temperature, and over varied terrain. There are, however, important precautions which the operating crew and maintenance personnel should observe, with respect to lubrication and care of the engine, power train, and other components of the vehicle.

(2) **Operation under warm temperatures.**

(a) Make sure that the cooling system is functioning efficiently.

(b) Watch temperature gages.

(c) See Section XVI, **Cooling System.**

(3) **High altitude.** The power plant is adequate to meet performance requirements for high altitudes. However, the same precautions as for warm temperature operation should be observed.

(4) **Sand.** Desert operation and operation under other extremely sandy road conditions may necessitate cleaning the air cleaners as often as every four to eight hours (par. 64).

(5) **Slippery terrain.**

(a) When operating the tank (with rubber tracks) in mountainous terrain, in mud, or over ice and snow, where sufficient traction is not normally possible, grousers are provided, which should be installed as described in paragraph 115. NOTE: Grousers are not necessary with steel tracks.

(b) Tracks and bogies should be periodically cleaned of mud, snow, or ice.

Section IX

DECONTAMINATION

34. PROTECTION AND DECONTAMINATION.

a. Protective measures.

(1) When materiel is in constant danger of gas attack, unpainted taken that the oil does not touch the optical parts of instruments are included among the items to be protected by oil from chemical clouds or chemical shells, but ammunition is excluded. Care will be taken that the oil does not touch the optical parts of instruments or leather or canvas fittings. Materiel not in use will be protected with covers as far as possible. Ammunition will be kept in sealed containers.

(2) Ordinary fabrics offer practically no protection against mustard gas or lewisite. Rubber and oilcloth, for example, will be penetrated within a short time. The longer articles of clothing are exposed, the greater the danger in wearing them. Rubber boots worn in an area contaminated with mustard gas may offer a grave danger to men who put them on even several days later. Impermeable clothing will resist penetration for an hour, but should not be worn longer.

b. Decontamination of materiel.

(1) **Cleaning.**

(a) All unpainted metal parts of materiel that have been exposed to any gas except mustard and lewisite must be cleaned as soon as possible with SOLVENT, dry cleaning, or ALCOHOL, denatured, and wiped dry. All parts should then be coated with engine oil. The using arm will decontaminate the exterior surfaces, the bore, the breechblock assembly, and all porous attachments such as straps, covers, etc., of artillery pieces exposed to gas.

(b) Ammunition which has been exposed to gas must be thoroughly cleaned before it can be used. To clean ammunition use AGENT, decontaminating, noncorrosive; if this agent is not obtainable, use strong soap and cool water. After cleaning, wipe all ammu-

nition dry with clean rags. CAUTION: dry powered AGENT, decontaminating (chloride of lime), used for decontaminating certain other types of materiel, must not be used on or near ammunition supplies, because it causes flaming when it is brought into contact with liquid mustard.

(2) **Decontaminating.** For the removal of liquid chemicals (mustard, lewisite, etc.) from materiel, the following steps should be taken.

(a) **Protective measures.**

1 For all these operations a complete suit of impermeable clothing and a service gas mask will be worn. Immediately after removal of the suit, a thorough bath with soap and water (preferably hot) must be taken. If mustard comes in contact with any skin areas, if even a small particle of mustard gets into the eye, or if the vapor of mustard is inhaled, it is imperative that complete first-aid treatment be given within twenty or thirty minutes after exposure. (First-aid instructions are given in TM-91850 and FM-21-40.)

2 Garments exposed to mustard will be decontaminated. If impermeable clothing has been exposed to **vapor only**, it may be decontaminated by hanging in the open air, preferably in sunlight, for several days. It may also be cleaned by steaming for two hours. If the impermeable clothing has been contaminated with **liquid** mustard, steaming for six to eight hours will be required. Various steaming devices can be improvised from materials available in the field.

(b) **Procedure.**

1 Commence by freeing materiel of dirt through the use of sticks, rags, etc., which must be burned or buried immediately after this operation.

2 Grease or heavy oil should be removed from materiel before decontamination is begun, by means of SOLVENT, dry cleaning, or other available solvents for oil, applied with rags attached to sticks.

3 Decontaminate the painted surfaces of the materiel with bleaching solution made by mixing one part AGENT, decontaminating (chloride of lime), with one part water. This solution should be swabbed over all surfaces. Wash off thoroughly with water, then dry and oil all surfaces.

4 All unpainted metal parts and instruments exposed to mustard or lewisite must be decontaminated with AGENT, decontaminating, noncorrosive, mixed one part solid to 15 parts solvent (ACETYLENE TETRACHLORIDE). If this mixture is not obtainable, use warm water and soap. Bleaching solution must not be used, because of its corrosive action. Instrument lenses may be cleaned only with PAPER, lens, tissue, using a small quantity of ALCOHOL, ethyl. Coat all metal surfaces lightly with engine oil.

5 In the event AGENT, decontaminating (chloride of lime), is not available, materiel may be temporarily cleaned with large volumes of hot water. However, mustard lying in joints or in leather or canvas webbing is not removed by this procedure, and will remain a constant source of danger until the materiel can be properly decontaminated. All mustard washed from materiel in this manner lies unchanged on the ground, necessitating that the contaminated area be plainly marked with warning signs before abandonment.

6 The cleaning or decontaminating of materiel contaminated with lewisite will wash arsenic compounds into the soil, poisoning any water supplies in the locality for both men and animals.

7 Leather or canvas webbing that has been contaminated should be scrubbed thoroughly with bleaching solution. In the event that this treatment is insufficient, it may be necessary to burn or bury such materiel.

8 Detailed information on decontamination is contained in FM 21-40, TM 9-850, and TC 38, 1941, Decontamination.

(3) **Special precautions for automotive materiel.**

(a) When vehicles have been subjected to gas attack with the engine running, the air cleaners should be serviced by removing the oil, flushing the cleaners and elements with SOLVENT, dry cleaning, and refilling with the proper grade of oil.

(b) Instrument panels should be cleaned in the same manner as outlined for instruments.

(c) Contaminated seat cushions will be discarded.

(d) Washing the compartments thoroughly with bleaching solution is the most that can be done in the field. Operators should con-

[illegible] be on the alert, when running under conditions of high temperatures, for slow vaporization of the mustard or lewisite.

[illegible] Exterior surfaces of vehicles will be decontaminated with bleaching solution. Repainting may be necessary after this operation.

Section X

DESTRUCTION OF MATERIEL

. DEMOLITION.

a. When to destroy tank. When the loss of a tank to the enemy unavoidable (as when a crippled tank must be abandoned during withdrawal, or when a tank is disabled on the battlefield and its pture is imminent), the tank will be destroyed by its crew.)TE: If time and circumstances permit, machine guns and tri-ds, the submachine gun, and the antiaircraft gun, together with possible ammunition for these guns, should be removed from the nk and carried to a safe distance before demolition of the tank.

b. Destruction of other materiel. The tank crew, besides being arged with the destruction of its own tank, may be called upon to in the destruction of other vehicles and materiel—either that onging to friendly troops, or abandoned or captured enemy mate-l that cannot be recovered. In general, enemy materiel should destroyed before our own equipment.

. Large materiel, particularly vehicles that are being set afire, uld (if possible) be destroyed on a bridge, in a defile, or at least a road, so as to hinder the enemy, unless such action would also der the movements of friendly troops.

. Destruction of armored vehicles.

1) Method No. 1—Using antitank weapons.

a) Materials needed.

Antitank rocket launcher and rocket, or

Antitank rifle grenade, grenade launcher and rifle, or

Any other tank or antitank gun.

Fuel in the tank of the abandoned vehicle.

) Action. Fire the weapon into the vehicle, aiming at the fuel and/or ammunition load. If a good fire is started, the vehicle be considered destroyed. If not, the engine, suspension, and ament should be damaged by antitank fire, in the order named.

Method No. 2—(for M3 Light Tanks) using TNT.

Materials needed.

Half pound blocks of TNT. (CAUTION: Do not use nitro- any other explosive than TNT.)

detonating cap.

safety fuze (one to two minutes' length).

lighter or matches.

in the tanks of the vehicle.

improvised bracket welded or bolted in place inside the en- compartment against the bulkhead and near the gas tank. should be drilled to connect the engine compartment with compartment, so as to permit insertion of the cap and the right time. This hole should be as small as possible, and practicable, have a removable plug. This modification made by ordnance personnel under the supervision of an officer.)

Action. Carry two blocks of TNT in the improvised bracket engine compartment. Carry the fuze and crimped cap in the compartment. To destroy tank, insert cap and fuze in the fire. The ensuing blast will set the vehicle on fire and it.

Destruction of rubber-tired vehicles.

Materials needed.

Sledge or axe.

AN-M14 grenade. (One for each rubber tire desirable, but mandatory.)

Fuel in the tank. (Desirable, but not mandatory.)

Action.

Place an incendiary grenade under each tire.

Smash engine and engine accessories with axe or sledge.

Open crankcase drain plug.

Pull safety pins from the incendiary grenades. The ensuing destroy the tires and most of the vehicle.

NOTE: In extreme emergencies, action (a) and (b) will

f. Destruction of artillery weapons of 75 mm caliber or larger.

(1) **Method No. 1.**

(a) **Materials needed.**

1 M9A1 antitank grenade.

2 Round of HE shell.

3 Improvised wooden adapter (for calibers of 155 mm or larger which will hold the grenade approximately centered in the tube.

4 Lanyard long enough to reach a slit trench or other protection.

5 AN-M14 grenade (one per tire).

(b) **Action.** Level the barrel. Place the armed M9A1 grenade in the tube ahead of (but not touching) the nose of the shell which is loaded. The nose of the grenade must point toward the breech. Insert an unfuzed HE shell. Take cover. Fire. (This will destroy tube, breech, and recoil mechanism, and do some damage to the carriage.) Now place one incendiary grenade against each tire and ignite. (NOTE: Difficulty has been experienced in unfuzing the 105 mm shell. This operation should be performed in advance.)

(2) **Method No. 2.**

(a) **Materials needed.**

1 Five or more grenades AN-M14 per gun tube, plus one per tire.

(b) **Action.** Level the tube. Place five AN-M14 grenades in the tube beyond the nose of a round when inserted. Ignite. (The thermit will fuze with the tube. If the enemy attempts to fire this gun without inspecting the bore, the gun will be destroyed.) Place an AN-M14 grenade against each tire and ignite.

(3) **Method No. 3.**

(a) **Materials needed.**

1 Sledge hammer and axe.

2 Small arms, AP ammunition.

3 One AN-M14 grenade per rubber tire.

(b) **Action.** Smash fire control equipment and small parts. Fire AP small arms ammunition into recoil system and other critical parts. Take precautions against ricochets. Set fire to each tire by means of the incendiary grenades.

g. Destruction of artillery and aircraft cannon less than 75 mm caliber.

(1) **Method No. 1.**

(a) **Materials needed.**

1 One AN-M14 grenade per rubber tire.

2 One round HE shell.

3 Long lanyard.

(b) **Action.** Pack muzzle with mud and stones for a length of at least 1 1-2 feet. Load one round HE shell. Fire from slit trench or other protection. Set grenade against each rubber tire and ignite.

(2) **Method No. 2.** Same as paragraph f (3).

h. Machine guns.

(1) **Materials needed.**

(a) A round of ammunition.

(b) Long lanyard.

(2) **Action.** Load round. Plug muzzle with mud and rock. Take cover in slit trench or other shelter. Fire.

i. Shoulder weapons. Smash against rocks, trees, etc.

PART II—ORGANIZATION INSTRUCTIONS

Section XI

ORGANIZATION MAINTENANCE

36. SCOPE.

a. The scope of maintenance and repairs by the crew and of the using arm is determined by the ease with which the be accomplished, how much time is available, the nature of temperatures, weather conditions, concealment, shelter, hostile fire, the equipment available, and the skill of the all these are variable, no exact system of procedure can be or followed.

b. The following definitions are included in order that the name may be correctly interpreted by those doing the work

(1) **Service.** Consists of cleaning, lubricating, tightening nuts, and making external adjustments of subassemblies or and controls.

(2) **Repair.** Consists of making repairs to, or replacement subassembly, or assembly, that can be accomplished without disassembling the subassembly or assembly, and does not re welding or riveting, machining, fitting, and/or alining.

(3) **Replace.** Consists of removing the part, subassembly, bly, from the vehicle and replacing it with a new or recon rebuilt part, subassembly, or assembly.

(4) **Rebuild.** Consists of completely reconditioning and serviceable condition any unserviceable part, subassembly, o of the motor vehicle (including welding, riveting, machini alining, assembling, and testing).

c. NOTE: The using arm personnel is authorized to re reinstall an engine or a power train unit assembly; however, t ment of an engine with **another** engine, or the replacement train unit with **another** transmission assembly, **must not b the using arm unless authorization is received from ordnance**

d. The following are the maintenance duties which may be pe formed by the using arm personnel. All other replacements and repai will be performed by the ordnance maintenance personnel.

G. M. DIESEL POWER UNIT, SERIES 71, MODEL 6046

Unit	Operation	Paragra Referen
Cylinder head	Replace gasket	46
Cylinder head assembly	Replace	46c and
Hand hole cover gaskets	Replace	
Exhaust valves	Adjust lash	48
	Replace springs	48
	Grind	48
	Replace	4
Rocker arm	Replace	48
Cam followers	Replace	48 h an
Push rods	Replace	4
Power unit	Replace	
	Remove	7
Transfer gear unit	Replace	72
Lubrication System		
Oil pan	Replace	58
	Replace gasket	58
Oil pump	Replace	58
	Clean intake screens	5
Oil pressure regulator valve	Replace	5
	Service	
Oil filter	Replace element	60 b (1)
Oil strainer	Clean	60 b (2)
Oil cooler	Replace	6
Oil by-pass valve	Replace	6
	Service	6
Oil lines, external	Clean	2
	Replace	2
Oil tank	Replace	6

MEDIUM TANK, M4A2

Unit	Operation	Paragraph Reference
Fuel and Air Intake System and Air Heater		
Injectors	Replace	49 c and
	Timing	
	Positioning control racks	49 h and
Governor	Adjust	
	Replace control housing assembly	
	Replace weight and housing assembly	
Air heater	Replace	
	Replace pump	
Fuel pump	Replace	
Fuel oil manifolds	Replace	
Air housing assembly	Replace	
	Replace gaskets	
	Replace solenoid	
	Service air shut-down valve	
Air cleaners	Replace	
	Service	
Blower assembly	Replace	
	Replace gasket	
	Replace drive shaft	
Mufflers	Replace	
Fuel oil filter, primary	Service	
Fuel oil filter, secondary	Replace element	
Fuel tanks, lower	Replace	
External fuel lines	Replace	
Cooling System		
Fan assembly	Replace	
Water pump	Replace	
Water outlet manifold	Replace	
	Replace gasket	
Thermostat	Replace	70 b (7
	Service	
Radiator	Replace	
Hose and fittings	Replace	
Water expansion tank	Replace	

ORGANIZATION MAINTENANCE

Unit	Operation	Paragraph Reference
Clutch		
Clutch	Service	89 and 90
	Replace plates	91
	Replace housing and clutch assembly	91 f and 94
Propeller Shaft		
Propeller shaft	Replace	98 a
Power Train Unit		
Steering brakes	Service	102 b and c
Brake shoes	Replace	102 c
Parking brakes	Adjust	103
Power train unit	Replace	105 and 106
Final drive unit	Replace	109
Suspensions and Tracks		
Sprocket and hub assembly	Replace	111 b
Bogie wheel	Replace	112 c and e
	Replace grease seals and bearings	112 d
Volute springs	Replace	112 e and f
Tracks	Service	113
	Replace	113 f
Idlers	Replace	114 d and f
	Replace bearings and grease seals	114 e
Electrical System		
Starter assembly	Replace	52 b
	Replace solenoid	52 c
Generator assembly	Replace	54 c
Battery	Charge	116 b
	Service	117 b
	Replace	117 c and d
Battery switch	Replace	117 f

Unit	Operation	
Generator regulator	Replace	
Voltage regulator	Replace	
Instrument panel	Replace face plate	
	Replace bulbs	
	Replace instruments	
Siren	Replace	
Collector ring assembly	Service	(M4A2 only)
Generator radio filter	Replace	

Auxiliary Generator Unit (M4A2 Only)

Spark plug	Replace	
Magneto	Adjust	
Fuel strainer	Clean	
Air filter	Clean	
Commutator	Clean	
Assembly	Replace	

Turret and Hull (M4A2 Only)

Hydraulic traversing unit	Replace	
Turret hatch ring	Replace	

Gun Firing Mechanism and Controls (M4A2 Only)

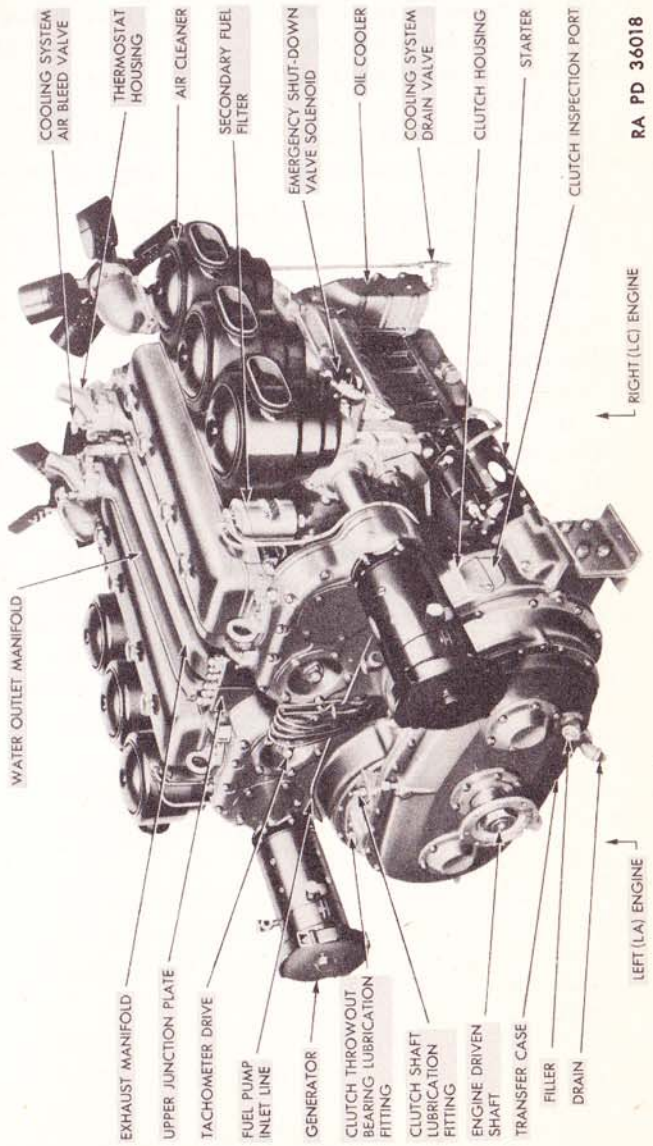
Gyro-stabilizer system	Service	
Machine gun	Replace	

37. DIFFERENCES BETWEEN LA AND LC ENGINE PA

a. The two engines of the power plant are identical exc relatively few parts and assemblies. Care must be exercised in parts or assemblies to be sure that they are correct for the which they are to be used.

b. The following parts and assemblies are different on the and the right (LC) engines, and in procuring replacement necessary to specify for which engine they are required:

Adapter assembly, oil cooler	Body assembly, water pu
Blower assembly	Cam, governor control



Cover, balance weight
Cover, flywheel small hole
Cover assembly, governor
Cover and lever assembly, governor
Cover, water pump body
Elbow, exhaust manifold
Fan assembly
Gear, blower drive
Generator assembly
Governor assembly
Housing assembly, air inlet
Housing assembly, flywheel
Housing assembly, governor control
Housing, oil cooler
Housing, starting motor drive
Manifold, exhaust
Pipe, pressure oil pump outlet
Plate assembly, lower junction
Plate assembly, upper junction
Pump assembly, fuel
Pump assembly, water
Radiator assembly
Shaft, blower drive
Shaft assembly, governor operating
Shaft assembly, governor throttle
Shield, fuel pump drip
Spring, air shut-down valve
Starting motor assembly
Tube, air heater pump inlet, upper to lower junction plate
Tube, fuel pump inlet, upper junction plate to fuel pump
Tube, fuel pump to secondary filter
Tube and bracket assembly, injector and governor control
Tube assembly, injector and governor control
Tube, lubricating oil pressure gage
Tube, secondary fuel filter to manifold
Tube, water by-pass
Vent, cylinder head

ORGANIZATIONAL TOOLS AND EQUIPMENT

38. ENGINE TOOLS (fig. 22).

Organizational special repair tools for the twin Diesel power unit are allotted in sets to maintenance organizations as shown in the following tabulation.

MFG. NO.	SPECIAL ENGINE TOOLS	TANK MECH. SET	TANK CO. SET	BAT'L CREW SET	REG'T MAINT PLAT SET
J-1227	REMOVER, injector; also COMPRESSOR, valve spring: also REMOVER, fan shaft bearing retainer oil seal	..	X	X	X
J-1244	REMOVER, broken push rod, and cam follower	..	X	X	X
J-1245	REMOVER, push rod (set of three)	..	X	X	X
J-1261	JAWS, vise, for injector body, with popping tools	..	X	X	X
J-1819A	GAGE, cylinder compression	..	X	..	X
J-1914	REMOVER, flywheel pilot bearing	..	..	..	X
J-1915	PILOT, clutch aligning	..	..	..	X
J-1928	WRENCH, cylinder head stud nut (under control shaft), 15/16 in.	..	X	X	X
KMO-320	GAGE, fuel pressure	..	X	X	X
J-1924	FRAME, twin motor assembly, and carriage	..	..	..	X
J-1925	HOOKS, engine lifting, twin and single	..	X	..	X
J-1922	WRENCH, push rod lock nut	..	X	X	X

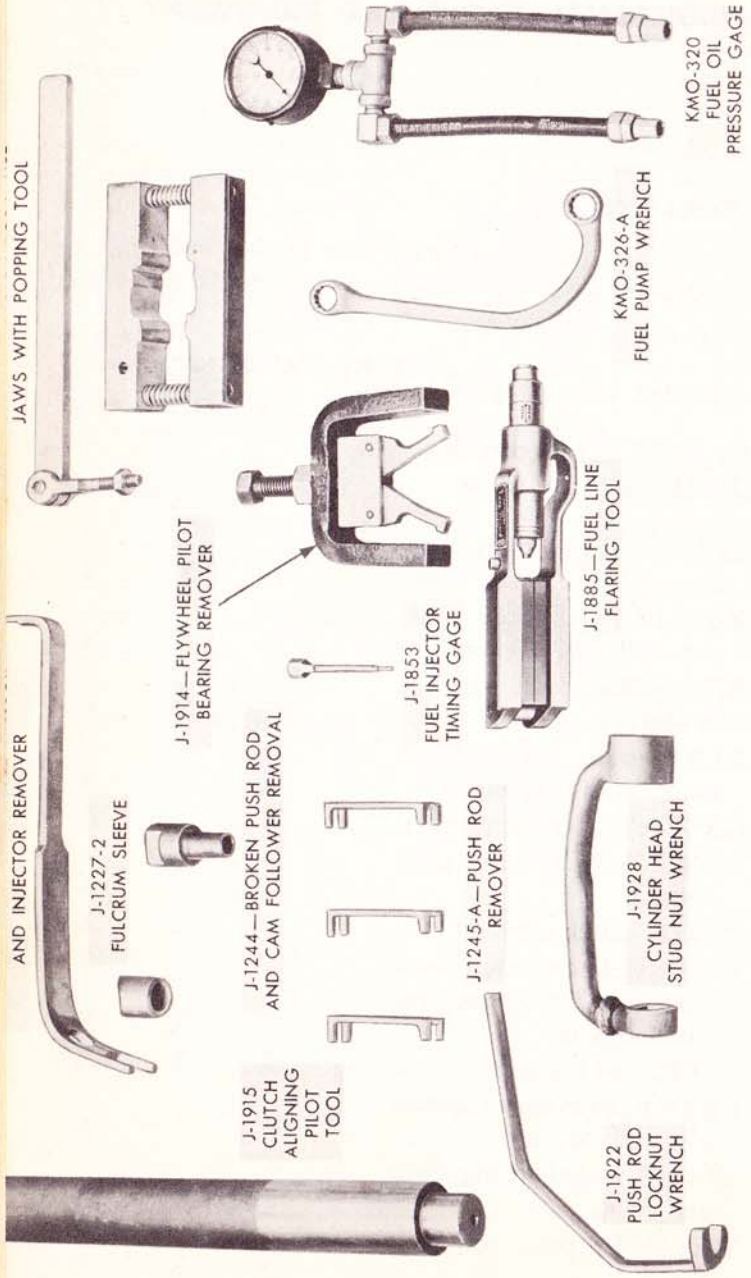


Figure 22—Special Engine Tools

SPECIAL ENGINE TOOLS	TANK MECH. SET	TANK CO. SET	BAT'L CREW SET	REG'T MAINT. PLAT SET
GAGE, fuel injection timing	..	X	X	X
TOOL, fuel line double flare seat	..	X	X	X
INDICATOR, piston top dead center, with feeler	..	..	..	X
WRENCH, clutch throw-out bearing lock nut	..	..	..	X
WRENCH, fuel pump	..	X	X	X

TOOLS.

distribution of organizational special repair tools for the main- of Medium Tank M4A2 is as follows:

SPECIAL TANK TOOLS	TANK MECH. SET	TANK CO. SET	BAT'L CREW SET	REG'T MAINT. PLAT SET
button head to bayonet type	..	X	..	X
tow	..	X	..	..
GREASER, grease, portable, 25 lb., type, high pressure, w/HOSE and FITTING	..	X	..	X
GREASER, volute spring	..	X	X	X
bogie wheel oil retainer, assem-	..	X	X	X
rear idler oil retainer, assembling,	..	..	..	X
track support roller oil retainer, bling, inner	..	..	..	X
track end connector, removing	..	X	..	X
BOLT, lifting, engine compartment plate	..	X	X	X
BOLT, ¾-16NF-2, turret front 75 mm rotor and shield (M4A2	..	..	..	X

MEDIUM TANK, M4A2

MFG. NO.	SPECIAL TANK TOOLS	TANK MECH. SET	TANK CO. SET	BAT'L CREW SET	REG'T MAINT. PLAT SET
	EYE-BOLT, 1-14 NC-2, turret (M4A2 only)	..	..	..	X
	FIXTURE, track connecting, w/SIMPLEX JACK and HANDLE, adjustable	..	X	X	X
	FITTING, lubricating, button head type, 1/8-27NPT, male	..	X	..	X
	GUIDE, bogie wheel gudgeon, assembling	..	X	X	X
	HAMMER, slide, bogie wheel gudgeon	..	X	X	X
	LIFT, bogie	..	X	X	X
	PROTECTOR, bogie wheel gudgeon, driving	..	X	X	X
	PULLER, gudgeon, screw type	..	..	..	X
	PULLER, idler wheel	..	..	..	X
	SLING, power train, complete	..	..	..	X
	WRENCH, socket, 13/16 hex. 1/2 sq. extra deep	..	..	..	X
	SPREADER, suspension gudgeon clamping slot	..	X	X	X
	TOOL, idler wheel, installing	..	..	..	X
	TOOL, companion flange, installing	..	..	..	X
	WRENCH, plug, 3/4 hex., final drive, differential filler, and drain plug	..	X	X	X
	WRENCH, special box, 3 in. hex.	..	X	X	..
	WRENCH, plug, 9/16 hex., transmission and oil tank drain plugs	..	X	X	..
	BIT, screwdriver, 1/2 in. sq. drive	..	X	X	X
	WRENCH, set, ferret, 3/8 in. sq. drive, consisting of:				
	(1) BAR, sliding	X	..	..	..
	(1) EXTENSION, bar, 3 in.	X	..	..	..
	(1) EXTENSION, bar, 6 in.	X	..	..	..
	(1) EXTENSION, bar, 12 in.	X	..	..	..
	(1) JOINT, universal	X	..	..	..

ORGANIZATIONAL TOOLS AND EQUIPMENT

SPECIAL TANK TOOLS	TANK MECH. SET	TANK CO. SET	BAT'L CREW SET	REG'T MAINT. PLAT SET
(1) RATCHET, reversible	X	..	..	..
(1) SPEEDER, 17 in.	X	..	..	..
(1) SOCKET, wrench, ferret, 3/8 in.	X	..	..	..
(1) SOCKET, wrench, ferret, 7/16 in.	X	..	..	..
(1) SOCKET, wrench, ferret, 1/2 in.	X	..	..	..
(1) SOCKET, wrench, ferret, 9/16 in.	X	..	..	..
(1) SOCKET, wrench, ferret, 5/8 in.	X	..	..	..
(1) SOCKET, wrench, ferret, 11/16 in.	X	..	..	..
(1) SOCKET, wrench, ferret, 3/4 in.	X	..	..	..
WRENCH, set, socket, special, 1 in. sq. drive, extra heavy duty, consisting of:				
(1) EXTENSION, 9 in., 1 in. square	..	X	X	X
(1) HANDLE, tubular, 36 in. long, 1 1/8 I.D., 1 7/16 O.D.	..	X	X	X
(1) HEAD, square, 1 in. female	..	X	X	X
(1) HEAD, square, 1 in. male	..	X	X	X
(1) SOCKET, 2 1/4 in., brake inspection cap nut	..	X	X	X
(1) SOCKET, 1 7/16 in.	..	X	X	X
(1) SOCKET, 2 3/8 in., bogie wheel gudgeon nut	..	X	X	X
(1) SOCKET, 1 1/2 in., idler bracket spreader	..	X	X	X
(1) SOCKET, 2 5/8 in., idler hub nut	..	X	X	X
(1) BAR, sliding, 22 in.	..	X	X	X
(1) HEAD, ratchet, 1 in.	..	X	X	X
(1) SOCKET, 1 13/16 in., clutch retainer nut	..	X	X	X
WRENCH, spanner, track support roller retainer	..	X	X	X
WRENCH, spanner, track support roller lock ring	..	X	X	X
WRENCH, socket, 2 3/8 in. hex., bogie wheel gudgeon head, holding, special	..	X	X	X

NO.	SPECIAL TANK TOOLS	TANK MECH. SET	TANK CO. SET	BAT'L CREW SET	REG'T MAINT. PLAT SET
	ENCH, socket, 1½ in. hex., extra spension spring compressor	..	X	X	X
	ENCH, ⅝ in. hex., volute spring ıg, male	..	X	X	X

Section XIII

ANIZATION SPARE PARTS AND ACCESSORIES

ANIZATION SPARE PARTS AND ACCESSORIES.

parts.

organization spare parts is supplied to the using arm for ement of those parts most likely to become broken, worn, unserviceable. The set is kept complete by requisitioning for those used. Organization spare parts are listed in pertinent

of organization spare parts is covered in Section VI, **Care ration.**

ories. Accessories include tools and equipment required for ssembling and assembling as the using arm is authorized to and for the cleaning and preservation of the armament, sight- fire control equipment, ammunition, etc. They also include overs, tool rolls, and other items necessary to protect the when it is not in use or when it is traveling. Accessories should for purposes other than as prescribed, and when not in use properly stored.

nisation spare parts, armament. A separate set of spare parts to the using arm for each subcaliber gun. After the initial set will be kept complete by requisitioning new parts to those used. Allowances are prescribed in the SNL's for the ment.

ories, armament. The accessories are tools and equipment the using arm for cleaning and preserving the subcaliber gun and for keeping a complete record of their use.

ment parts and accessories per tank. The issue per tank of accessories for the armament carried by Medium Tank M4A2

machine guns (2), cal. .30, Browning M1919A4.

parts carried in tank. (For complete list of repair parts, SNL A-6.)

Part	No. per tank
ACCELERATOR	2
BARREL, spare	2
BOLT, assembly	2
BUSHING, belt feed lever pivot	1
CAN, tubular (w/o contents)	1
CASE, spare bolt M2 (w/o contents)	2
COVER, assembly	1
ENVELOPE, spare parts, M1 (w/o contents)	2
EXTENSION, barrel, assembly	1
EXTRACTOR, assembly	2
LEVER, cocking	1
LEVER, feed belt	1
LOCK, breech	1
NUT, belt feed lever pivot bushing	1
PAWL, feed belt	2
PIN, accelerator, assembly	2
PIN, belt feed pawl, assembly	2
PIN, belt holding pawl, split	2
PIN, cocking lever	1
PIN, driving spring rod	1
PIN, firing, assembly	2
PIN, trigger	1
PIVOT, belt feed lever	1
ROD, driving spring, assembly	1
ROLL, spare parts, M13 (w/o contents)	1
SEAR	2
SLIDE, feed belt, assembly	1
SPRING, belt feed pawl	1
SPRING, belt holding pawl	1
SPRING, cover extractor	2
SPRING, driving	1
SPRING, locking barrel	1
TRIGGER	1

(b) **Accessories carried in tank.** (For complete list of repair parts see SNL A-6.)

Part	No. per tank
BAG, empty cartridge, cal. .30 (flex. bow gun)	1
BAG, empty cartridge, cal. .30 (turret)	1

Part	No. per tank
BRUSH, chamber cleaning, M6	1
BRUSH, cleaning, cal. .30, M2	6
CHEST, ammunition, cal. .30	27
COVER, muzzle, cal. .30 (flex. bow gun)	1
COVER, muzzle, cal. .30 (turret)	1
COVER, receiver, cal. .30 (flex. bow gun)	1
COVER, receiver, cal. .30 (turret)	1
EXTRACTOR, ruptured cartridge, Mk. IV	2
OILER, rectangular, 12 oz	1
REFLECTOR barrel, cal. .30	1
ROD, cleaning, jointed, cal. .30, M1	2

(3) **For submachine gun, cal. .45, Thompson, M1919A1**—when authorized by TBA as personal weapon of member of tank crew.

(4) **Spare parts carried in tank.** (For complete list of repair parts, see SNL A-32.)

Part	No. per tank
DISCONNECTOR, 6D	1
EJECTOR, 4B	1
EXTRACTOR, 15A	1
PIN, firing, 14A	1
ROCKER, 16D	1
SPRING, disconnector, 9A	1
SPRING, firing pin, 14C	1
SPRING, magazine catch, 9D	1
SPRING, recoil, 17C	1
SPRING, sear, 9B	1

(5) **Accessories carried in tank.** (For complete list of repair parts, see SNL A-32.)

Part	No. per tank
BRUSH, chamber cleaning, M6	1
BRUSH, cleaning, cal. .45, M5	1
CASE, accessories and spare parts M1918 (w/o contents)	1
COVER, Thompson submachine gun	1

Part	No. p
ENVELOPE, fabric, one button, 3 x 3⅛ in.	
MAGAZINE, 30 rounds (clip)	
SLING, gun, M1923 (webbing)	
THONG	

(3) **For machine gun, cal. .50, Browning, M2Hb.**

(a) **Spare parts carried in tank.** (For complete list of re see SNL A-39.)

Part	No. p
EXTRACTOR, assembly	

(b) **Accessories carried in tank.** (For complete list of re see SNL A-39.)

Part	No. p
BOX, ammunition (50 rounds cal. .50)	
BRUSH, cleaning, cal. .50, M4	
ROD, jointed, cleaning, M1	

(4) **For 75 mm. gun, M3.**

(a) **Spare parts carried in tank.** (For complete list of re see SNL C-34.)

Part	No. p
FORK, cocking	
MECHANISM, firing	
Composed of:	
1 GUIDE	
1 PIN	
1 PIN	
1 SPRING	
1 STOP	
PIN, cotter, ⅛ x 1¾ in.	
PIN, firing	
PLUG, recoil cylinder	
PLUNGER	
PLUNGER, firing	
POUCH, spare parts roll (w/o contents)	

Part	No. per tank
RETAINER, sear	1
RETAINER, firing	1
SPRING	1
STOP, firing spring	3

(b) **Accessories carried in tank.** (For complete list of repair pa see SNL C-34.)

Part	No. per tank
BOOK, artillery, gun, O.O. Form 5825 (blank)	1
BRUSH, bore, M10 w/staff (112 3/16 in. long)	1
Composed of:	
1 BRUSH, bore, M10	
1 STAFF, end	
1 STAFF, middle	
CAN, ¼ gal. (OIL, recoil)	1
COVER, bore brush, M516	1
COVER, muzzle	1
OIL, recoil, heavy, 1 qt. (in can)	1
SETTER, fuse, M14	1
WRENCH, fuse	1

(5) **For tripod mount, cal. .30 machine gun, M3.**

(a) **Spare parts and accessories carried in tank.** (For complete of repair parts, see SNL A-6.)

Part	No. per tank
COVER, tripod mount, M2	1

f. **Tank spare parts.** Spare parts for the tank, except in a few m instances, are not carried in the tank. When replacements are necess the new parts are procured by exchanging the worn or damaged p for new ones at the Service of Supply.

Section XIV

POWER UNIT

41. POWER UNIT (figs. 21, 23, and 24)

a. General description.

(1) The Medium Tank M4A2 power unit, Model 6046, consists of two General Motors six cylinder, 2-cycle Diesel engines of 4¼ inch

POWER UNIT

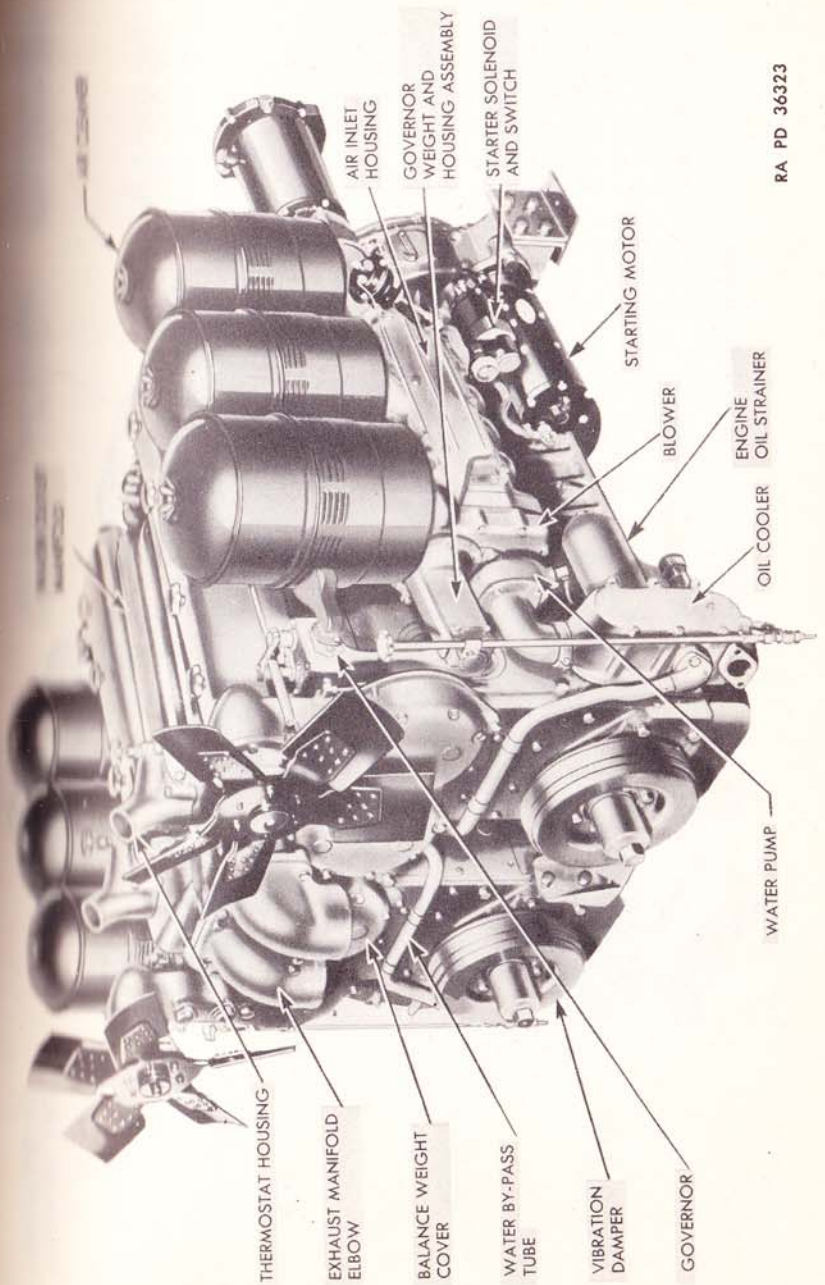
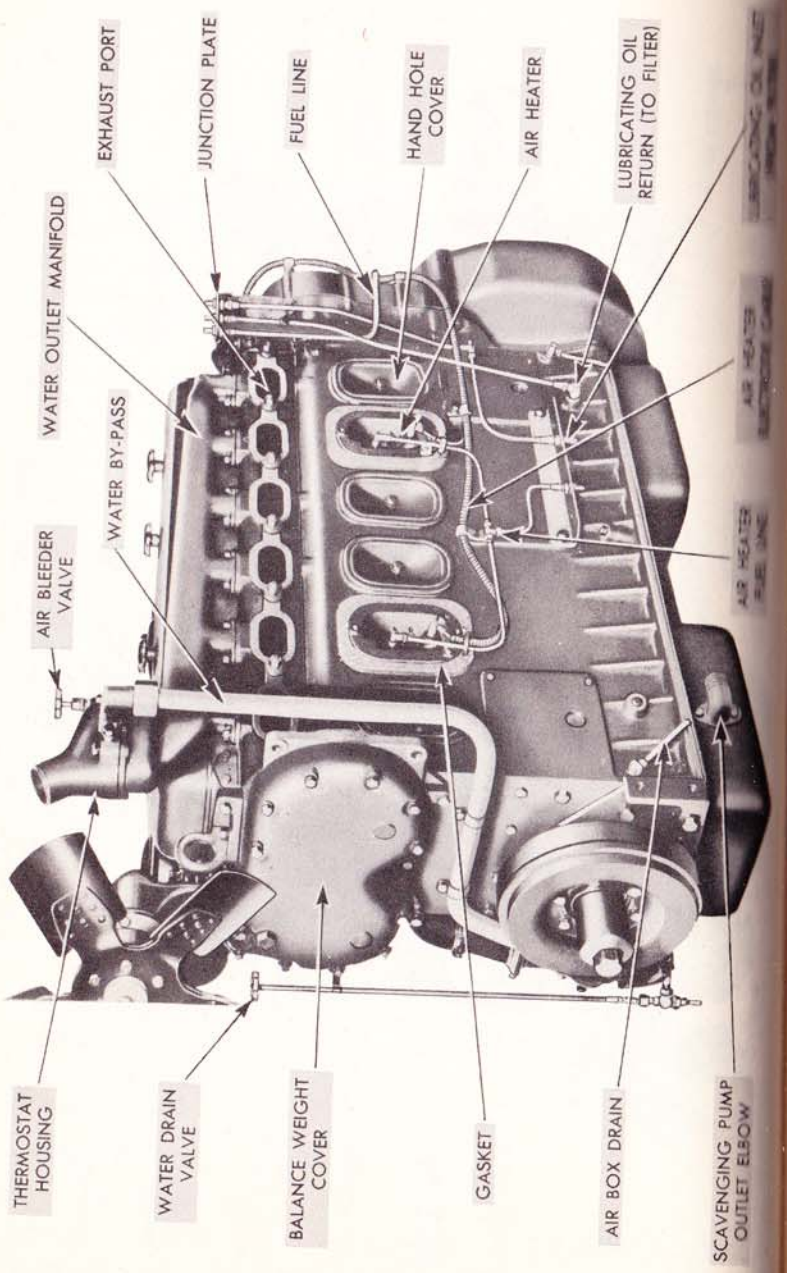


Figure 23—Power Unit, Intake Side and Fan End



bore by 5 inch stroke (425 cubic inch displacement, each eng
The two engines, each of which is a complete functioning un
itself, are mounted alongside each other, and are arranged for
operation as a single unit through the medium of a transfer ca
which both crankshafts are geared to a single power output s
which turns at 1.37 times crankshaft speed.

(2) Each of the two engines is equipped with its own sta
motor, generator, fuel pump, oil cooler, clutch, and other acc
ries necessary to permit either engine to be operated independ
of the other.

b. Diesel principles. The Diesel engine, like the gasoline en
is an internal combustion engine; that is, an engine whose en
is produced by the burning of a mixture of air and fuel insid
cylinders. The Diesel differs from the gasoline engine princi
in the means used to introduce and to ignite the fuel. In the gas
engine, fuel and air are mixed in a carburetor and drawn int
cylinder, where the mixture is compressed by the piston and
ignited by an electric spark. In the Diesel engine, air alone is
pressed in the cylinder; then a charge of fuel is sprayed int
cylinder, and ignited by the heat of compression. (The Diesel
pression ratio is about 16 to 1, that of a gasoline engine about
1. When air is compressed, its temperature rises. The Diesel
compression raises the temperature of the air to about 1000 F
C), more than high enough to ignite the fuel as it is injected
the cylinder.)

c. Two-cycle Diesel operation.

(1) Most automotive gasoline engines, and some Diesel eng
operate on a cycle of four strokes—intake (suction), compres
expansion (power), exhaust; that is, each cylinder has only
power stroke for each **two** revolutions of the crankshaft. The D
engines of this power unit, however, operate on the two-cycle
ciple, each cylinder having one power stroke for each crank
revolution.

(2) In the two-cycle Diesel, every upward stroke of the pist
a compression stroke, and every downward stroke is a power st
Because there is no intake (suction) stroke, nor any exhaust st
mechanical means are provided for filling the cylinder with ai

for clearing out the burnt gases. In this unit, each engine has a blower to supply air to the cylinders. As the piston nears the bottom of its stroke, the exhaust valves (two per cylinder) open, permitting the burnt gases to escape to the exhaust manifold. Further downward movement of the piston uncovers ports through which the blower forces air into the cylinder, expelling the remnants of the burnt gases through the still-open exhaust valves, and filling the cylinder with fresh air. As the piston begins its up-stroke, it covers the air inlet ports, and the exhaust valves close. During the rest of the stroke, the trapped air is compressed to one-sixteenth of its former volume, reaching a pressure of approximately 500 pounds per square inch. Just before the piston reaches the top of its stroke, fuel is sprayed into the cylinder, to be ignited by the 1000 F temperature of the compressed air. The intense heat of combustion causes a rapid expansion of the air, greatly increasing the pressure on the piston. This pressure continues during the downward (power) stroke of the piston until the exhaust valves again open. Since the complete cycle of operations requires but two strokes, the term "two cycle" is used to distinguish this type of engine from a four-stroke (or "four cycle") engine.

d. Special nomenclature.

(1) **Left and right engines.** In most automotive vehicles, and in boats, the twin Diesel engine used in the M4A2 tank is mounted with its fan end to the front and its flywheel end to the rear of the vehicle or vessel. In that position, the engine bearing the manufacturer's model designation "LA" is on the left-hand side of the vehicle or vessel, and is referred to as the left engine. Model "LC" engine is on the right-hand side, and is known as the right engine. In this manual, the designations and terms for the two engines remain the same, and using personnel should always speak of the **right** and the **left** engine as if the engines were mounted forward in the tank with their fans to the front. (See fig. 25.) This system of nomenclature is essential to the avoidance of confusion and error in procuring service parts, some of which fit only the right or the left engine and bear manufacturer's parts numbers or symbols that identify them as right or left. Using personnel should familiarize themselves with the proper nomenclature. A thorough study of the diagram (fig. 25) is recommended. An easy way to remember which is the LA model and which is the LC model is to fix in the mind the

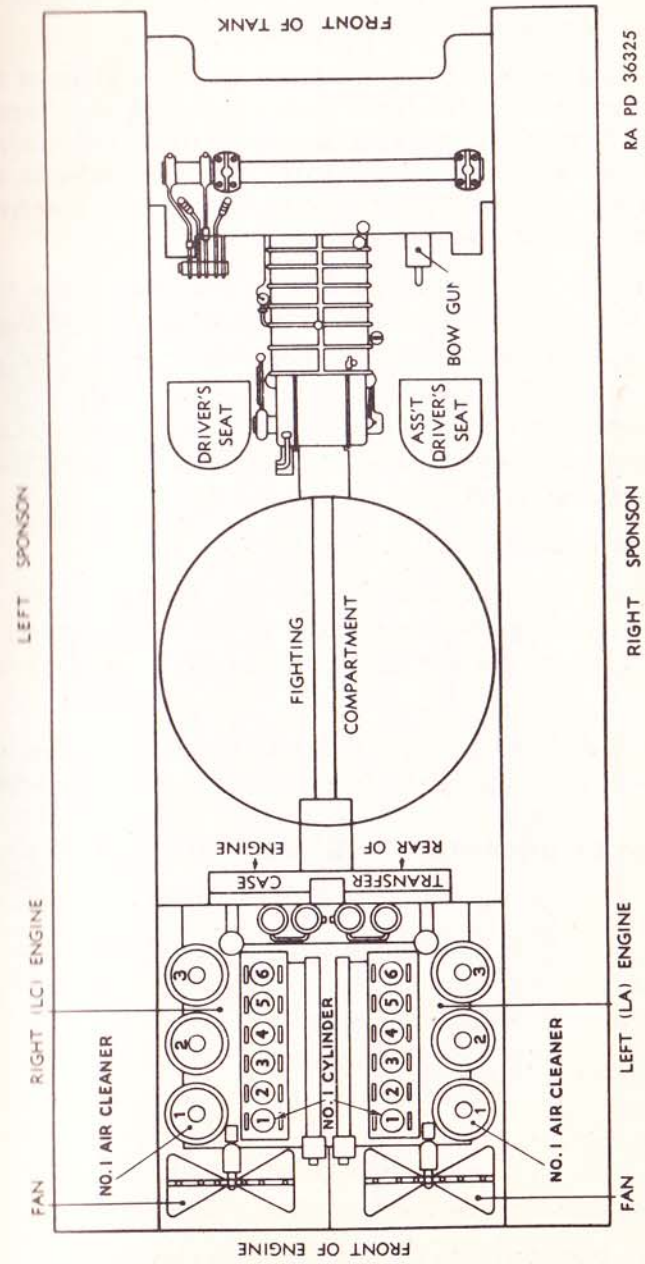


Figure 25—Designation of Engines and Engine Units

:d "LAFT" (for left), the LA model being the left engine, as wed from the flywheel end of the power unit.

2) **"Front" and "rear" of engine.** Although the engines of the ver unit are reversed in the tank, having their fan ends turned he rear, the terms **front** and **rear,** as applied to the engines, are be used as they are when applied to an engine mounted in the nt end of a car or truck. The fan end of the engine is the **front** ; the flywheel end is the **rear** end.

3) **Fuel and oil.** In general automotive practice, the phrase el and oil" always means **gasoline** and **lubricating** oil. The Diesel ine, however, uses **fuel oil** instead of gasoline. In order to avoid fusion between fuel oil and lubricating oil, the word **oil** by itself uld never be used in referring to the fuel, which should be called ıer **fuel oil** or just **fuel.** In this manual, the word **oil** by itself ays means **lubricating** oil.

. **Direction of rotation.**

1) In referring to the direction of rotation, the right-hand di- tion (the direction in which one turns an ordinary wood screw screw it **in**) is clockwise, and left-hand direction is counterclock- e.

2) Rotational directions of engine parts should always be de- ibed as viewed when facing the front, or fan end, of the engine.

DIRECTION OF ROTATION—VIEWED FROM FAN END

	Left engine (LA)	Right engine (LC)
ınkshaft	counterclockwise	counterclockwise
nshaft	clockwise	counterclockwise
:hometer drive	counterclockwise	clockwise
ı	counterclockwise	clockwise
el pump	counterclockwise	clockwise
rting motor	clockwise	clockwise
ıerator	counterclockwise	clockwise
wer (drive shaft)	counterclockwise	clockwise

output shaft, geared to both crankshafts, turns clockwise.

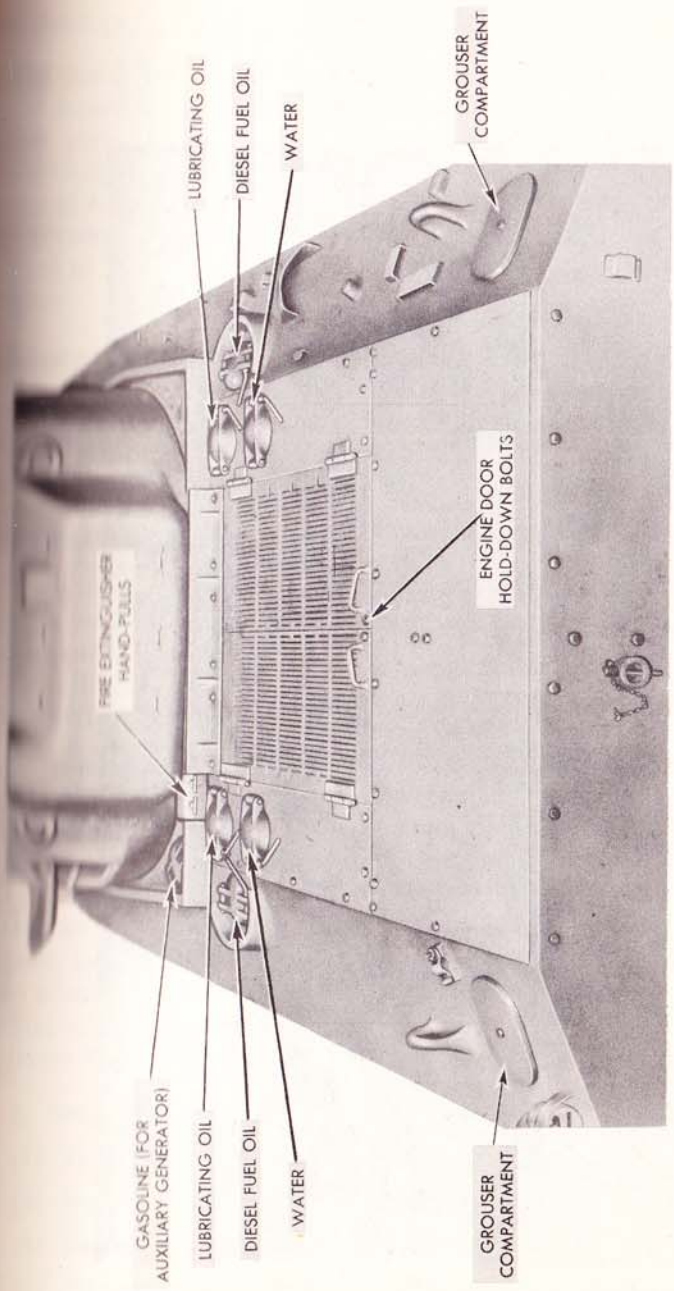


Figure 26—Rear Deck and Engine Compartment Doors

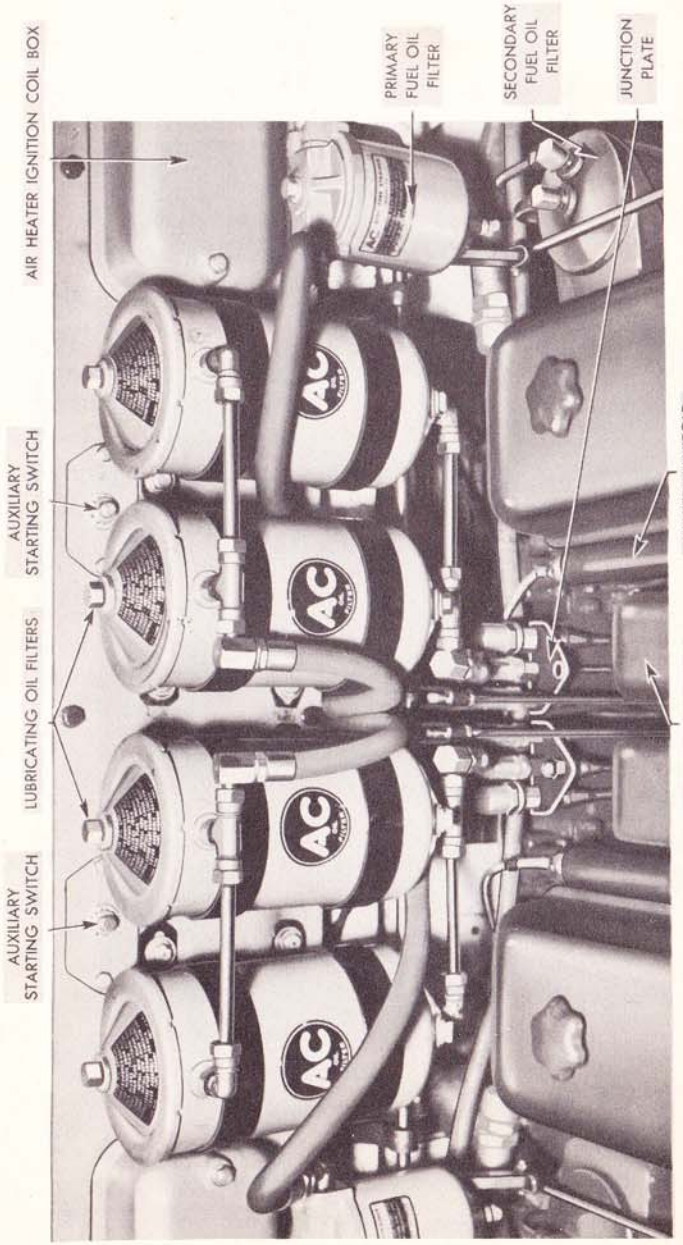


Figure 27—Power Unit Installation, Looking Toward Filter Panel

42. INSTALLATION.

The power unit is mounted at the rear of the tank, in a compartment separated from the fighting compartment by a bulkhead of armor plate. Access to the engine compartment is by way of the engine hatch in the rear deck. The hatch closure is two heavy steel louvered doors that lie flush with the deck. Between the engines and the louvered doors is a splash panel of ¼-inch heat treated steel, hinged at the front so that it may be raised to give access to the engine.

43. DETAILED DATA.

Specifications covering the main features of the power unit, and detailed information on its characteristics, are tabulated in paragraph 5 b.

44. DRIVE MECHANISM.

The propeller shaft is attached to the engine driven shaft flange at the power transfer, or transfer gear unit, at the rear of the power unit (fig. 21).

45. TROUBLE SHOOTING.

a. **General.** Satisfactory performance of the Diesel engine depends chiefly on two factors—first, sufficiently high compression, and second, the injection of the right quantity of fuel at the right time. Compression depends almost entirely on the pistons, piston rings, valves, and valve operating mechanism. Fuel injection depends on the fuel feed, the injectors, and their operating mechanism. Lack of engine power, uneven running, excessive vibration, and a tendency to stall when idling, may be caused by loss of compression, faulty injector action, poor adjustment of the throttle and injector control linkage, or improper adjustment of the governor.

b. **Engine fails to start.**

(1) **Throttle not in correct starting position.** (See par. 8.)

(2) **Fuel tank selector valve closed.**

(3) **Fuel tank empty.**

(4) **Engine shut-down valve closed.**

(5) **Blower rotors not revolving** (indicated by smoke coming out of the air intakes). (Notify ordnance maintenance personnel.)

(6) **Leaking cylinder head gasket.** Check compression (par. 45 **e**).

(7) **Fuel supply insufficient.** Examine fuel supply tank selector valve, filters, and line connections. (See pars. 74, 75, 76, and 78.)

(8) **Air in fuel system.** Check for air leaks in fuel suction line. Check for faulty injector (par. 49 **d**).

c. Engine fails to start at freezing temperature.

(1) Check air heater pump.

(2) If pump is operating properly, inspect air heater units and replace if necessary (par. 53 **c**).

d. Uneven running and excessive vibration.

(1) **Faulty injector timing or rack setting.** (See par. 49 **f, h, i**.)

(2) **Throttles of engines not equalized.** (See par. 50 **c** (2).)

(3) **Fuel supply insufficient.** Examine the fuel supply tanks, valves, filters, and line connections. (See pars. 74, 75, 76, and 78.)

(4) **Hunting governor.** Check for injector mechanism bound by any of the following causes—(a) through (f).

(a) **Injector clamp too tight or not properly positioned.** A binding injector rack oftentimes can be freed by tapping the foot of the clamp lightly with a small hammer and a long drift or screwdriver.

(b) **Gummy injector.** In long service, an injector may stick because of accumulated gum and sludge. Remove the injector (par. 49 **c**) and wash it in clean gasoline.

(c) **Injector rack control lever out of position or cocked.** Loosen the two screws in the rack control lever, and move the lever along the control tube to aline it properly with the injector rack. Cocking of the rack control lever may be due to damage to the ends of the adjusting screws or to the surfaces against which they bear. Correct by filing the damaged parts; then adjust the rack control lever for proper position. (See fig. 46.)

(d) **Injector control tube sticking or binding.** The small ball bear

[illegible] on which the rack control tube turns must be free from chips, dirt, or sludge, and must be lubricated. Binding due to poor alinement of the bearing supports can be corrected by loosening the bearing support cap screws and realining the bearing supports. When the control tube is free of bind, its return spring alone should move the tube and the injector racks when governor link is disconnected. Whenever the control tube bearing supports have been loosened, the adjustment of rack control levers should be checked (par. 49 **h** and **i**). CAUTION: **Never stretch or tamper with the rack control spring to change its tension.**

(e) **Control tube spring bent.** Replace.

(f) **Governor linkage binding.** Check for bind in the pin connecting governor control link to control tube lever. (See fig. 48.)

(g) After all the foregoing checks—(a) through (f)—have been made, if the governor still fails to control the engine speed properly, the governor may be worn or otherwise unfit for further use, and should be removed and inspected (par. 50 **b** and **d**). If overhaul of the governor is necessary, notify ordnance maintenance personnel, and replace the governor with one in good condition.

(5) **Cooling water temperature too low.** Remove thermostats from water manifold and inspect for failure to close (par. 70 **c**).

(6) **Valves in bad condition.** Check compression (par. 45 **e**).

(7) **Valve clearance not set correctly.** (See par. 48 **c**.)

(8) **Cylinder(s) cutting out.**

(a) A cylinder may be failing to fire because of faulty injector or valve operation, or the engine may fire irregularly because of some fault with the fuel feed to the injectors. Two methods of testing the operation of the injectors are used:

(b) To determine quickly which cylinder is not firing, run engine at idling speed and cut out each injector, one after another, by pressing down firmly on the injector spring guide with a screwdriver held vertically alongside the rocker arm. If a cylinder is firing properly, cutting out its injector will cause a noticeable difference in engine sound and a decrease of engine speed. If a cylinder is not firing, cutting out its injector will not affect the operation of the engine in any way.

(c) A more positive test for locating a misfiring cylinder is to increase the fuel feed to each cylinder in turn:

1 With engine idling, loosen (one full turn) upper adjusting screw on the control tube lever of No. 1 injector (fig. 46).

2 Move the control rack of the injector inward, causing No. 1 cylinder to receive an increased charge of fuel. There will be a noticeable increase in engine sound and speed if the cylinder is firing properly, no change in sound or speed if the cylinder is not firing.

3 If No. 1 cylinder is found to be firing correctly, reset its injector control rack (pars. 49 **h** and **i**); then make the same test on each cylinder in turn until the misfiring cylinders are located.

(d) Check injector timing of misfiring cylinder (par. 49 **f**).

(e) Check for correct exhaust valve lash (par. 48 **c**) of misfiring cylinder, and inspect valve springs.

(f) If the valve springs and valve lash are correct, remove the fuel injector (par. 49 **c**) and install a new one.

(g) If the cylinder with its new injector still fails to fire regularly, check the compression of that cylinder (par. 45 **e**).

(9) **Engine firing irregularly.** If the quick test (see (8) above) of injectors does not indicate that particular cylinders are at fault, check the engine as a whole:

(a) Check all injectors for correct timing (par. 49 **f**).

(b) Check for air in fuel system. Inspect for leaks at fuel connections from the fuel tank to the fuel pump, at the bowl gasket of the primary fuel filter, and at fittings in air heater lines.

(c) Check exhaust valve lash at each cylinder (par. 48 **c**).

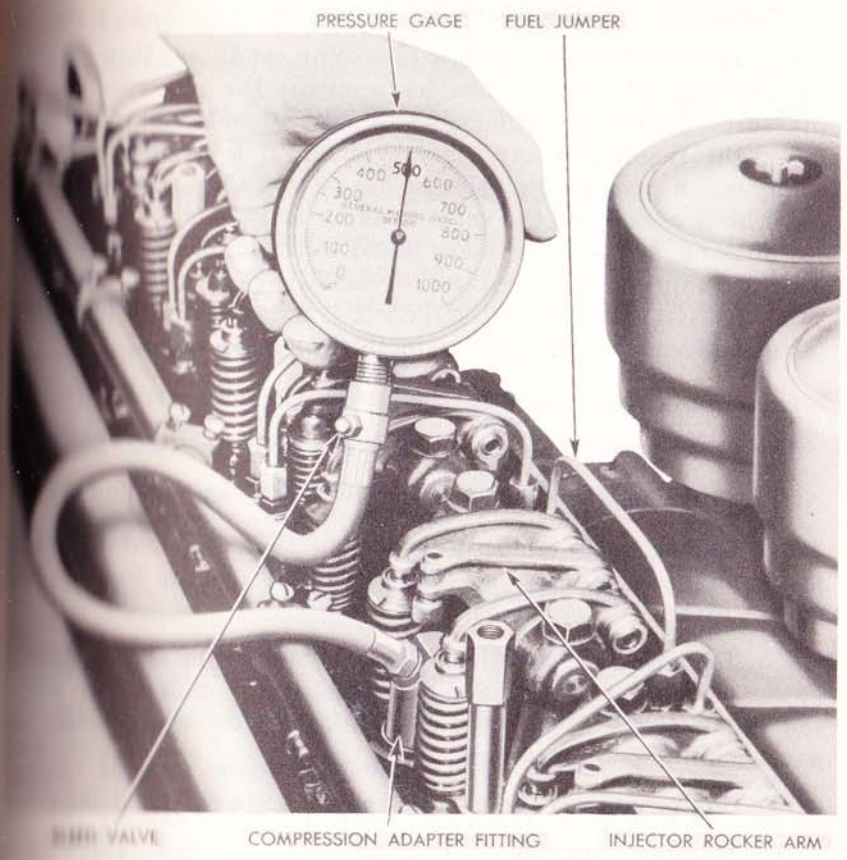
(d) Inspect exhaust valve springs.

(e) Check compression, all cylinders. (See following text.)

e. Checking compression (fig. 28).

(1) Remove the rocker cover.

(2) Start with No. 1 cylinder and remove fuel lines from both the injector and the fuel connectors.



RA PD 36328

Figure 28—Checking Compression

(3) Remove the injector (par. 49 **c**) from No. 1 cylinder and install the pressure gage in its place in the same way as the injector was installed, and restore the rocker arm to operating position.

(4) Use one of the two fuel lines as a jumper connecting the fuel supply manifold and the return manifold fittings, to permit fuel from the supply manifold to flow directly to the return manifold.

(5) Start the engine, run it at about 1,000 revolutions per minute,

and take readings on the gage. (Do not test compression by cranking the engine with the starter.)

(6) Restore No. 1 cylinder to operating condition; then test each of the other cylinders in turn, and compare the gage readings. The pressure of any one cylinder should not be more than 25 pounds below the reading of any other cylinder. If a cylinder shows low compression, remove the cylinder head (par. 46 **c**). Inspect the cylinder head gasket and the valve seats for leaks, and check the valves for sticking. If these parts are found to be in good order, then the loss of compression must result from leakage past the piston, due to ineffective piston rings. NOTE: If it is necessary to inspect the piston rings, notify ordnance maintenance personnel.

f. Engine stalls frequently.

(1) **Idling speed too low.** Adjust for 400 rpm (par. 50 **c** (2)).

NOTE: Both engines must be adjusted to the same idling speed.

(2) **Cooling water temperature too low.** Remove thermostat from water manifold (par. 70 **c**) and inspect for failure to close. Also make sure air bleeder valve is closed.

(3) **Too sudden application of load at low engine speed.** If clutch grabs, check adjustment of clutch pedal and of clutch (par. 90). If the clutch grabs when these adjustments are correct, notify ordnance maintenance personnel.

(4) **One or more cylinders cutting out.** (See par. 45 **d** (8).)

(5) **Hunting governor.** Remove all bind (par. 45 **d** (4)) from injector control rack operating shaft mechanism.

(6) **Fuel filters clogged.** (See pars. 75 **c, d, e.**)

(7) **Injector operation faulty.** (See par. 49 **d.**)

(8) **Governor or linkage incorrectly set.** (See par. 50 **c.**)

(9) **Air in fuel system.** Inspect for leaks at all fuel connections from fuel tank to fuel pump, at the bowl gasket of the primary fuel filter (par. 75 **d**) on the bulkhead, and at fittings for air heater lines.

g. Loss of power.

(1) **Injector racks not properly positioned.** (See pars. 49 **h** and **i**)

(2) **Faulty injector timing.** (See par. 49 **f.**)

(3) **Cylinder(s) cutting out.** (See par. 45 **d** (8).)

(4) **Air cleaners clogged.** (See par. 64 **d.**)

(5) **Insufficient fuel supply.** Examine fuel supply tanks, selector valve, filters, and line connections.

(6) **Clogged fuel oil filters.** (See par. 75 **d** and **c.**)

(7) **Air in fuel system.** Inspect for leaks at fuel connections from the fuel tank to the fuel pump, at bowl gasket of the primary fuel filter on the engine bulkhead, and at fittings on air heater lines.

(8) **Injector operation faulty.** (See par. 49 **d.**)

(9) **Governor out of adjustment.** (See par. 50 **c.**)

(10) **Loss of compression.** Check cylinder pressure (par. 45 **e**).

(11) **Throttle linkage out of adjustment.** (See par. 89 **e.**)

h. Smoky exhaust.

(1) Excessive **black smoke** indicates one or more of the following:

(a) **Poor grade of fuel.** (See par. 77, **Fuel Oil Specifications.**)

(b) **Injector timing late.** (See par. 49 **f.**)

(c) **Injector operation faulty.** (See par. 49 **d.**)

(d) **Gasket leaking at hand hole cover or air heater cover plate.** Replace gasket (pars. 47 and 53 **c**).

(e) **Air ports in cylinder liner clogged.** Remove cylinder head (par. 46 **c**) and clean sludge from air box and ports into air box.

(f) **Blower intake obstructed.** Remove air intake housing (par. 88 **b**) and inspect and clean screen between housing and blower.

(g) **Air shut-down valve out of adjustment.** If valve is drawn shut by the blower, adjust valve (par. 66).

(2) **Blue smoke** is an indication of one or more of the following:

(a) **Injectors not equalized.** (See pars. 49 **f** and **g.**)

(b) **Cylinder (s) cutting out.** (See par. 45 **d** (8.)

(3) **Lubricating oil enters combustion chambers:**

(a) **Piston rings pass oil.** The rings may be worn or stuck; oil rings incorrectly assembled. (Notify ordnance maintenance personnel.)

(b) **Oil leaks at blower.** Oil leaks into air box or blower housing because blower housing gasket is leaky (replace gasket—par. 65 e) or the blower rotor shaft seals are leaky (notify ordnance maintenance personnel).

(c) **Oil level too high in air cleaner.** (See par. 64 b.)

i. Engine detonates. If a hard, metallic knock indicates detonation in one or more cylinders, the engine should be stopped immediately as serious damage may be caused by the excessive pressures accompanying detonation. Detonation is caused by the presence of fuel or lubricating oil in the air charge of the cylinders during the compression stroke. To correct, the engine should be checked as follows:

(1) **Leaky injectors.** Replace (par. 49 **c** and **e**).

(2) **Lubricating oil dilution due to fuel leaks.**

(a) Drain and refill the lubricating oil system with specified oil. Then inspect the air box and clean it out with compressed air.

(b) If air box drains are clogged, remove obstructions.

(c) Tighten all fuel connections.

(d) If piston rings are suspected, notify ordnance maintenance personnel.

(3) **Oil pullover from air cleaners.** See that oil in air cleaners is not above prescribed level and that oil is of the proper viscosity. (See par. 64 b.)

(4) **Leaky blower housing gasket.** Replace the gasket (par. 65 e).

(5) **Leaky blower oil seals.** (Notify ordnance maintenance personnel).

(6) **Fuel feeding into air box through air heater.** Check for leaky check valves at the air heater pump on instrument panel. Make sure shut-off valve is kept closed.

(7) **Plugged air box drains.** Remove obstruction (par. 63 **c**).

j. Lack of lubricating oil pressure.

(1) **Oil outlet pipe from pump to cylinder block loose or broken.**

(2) **Oil supply low.**

(3) **Oil supply diluted by fuel oil.** Check odor of oil in crankcase for traces of fuel. Check for fuel leaks (par. 45 **i**).

(4) **Use of improper lubricant.** (See par. 26.)

(5) **Worn crankshaft or connecting rod bearings.** (Notify ordnance maintenance personnel.)

(6) **Lubricating oil pump relief valve sticking open.** (Notify ordnance maintenance personnel.)

(7) **Oil pressure regulator valve sticking.** (Notify ordnance maintenance personnel.)

(8) **Oil cooler clogged.** (Notify ordnance maintenance personnel.)

(9) **Oil scavenging pump screens clogged.** Remove oil pan (par. 58 **b**) and clean screen (par. 59 **c**).

(10) **Oil pump drive inoperative.** Remove oil pan (par. 58 **b**). Inspect oil pump drive and check for a broken oil pump drive shaft. If drive is inoperative, notify ordnance maintenance personnel.

(11) **Air leak in pressure pump supply.** Inspect hose and connections for leaks or loose joints.

(12) **Oil lines clogged or leaking.** Remove oil pan (par. 58 **b**), inspect gaskets, tighten connections. If the oil lines are clogged as a result of dirty and sludging oil, the lubricating system should be thoroughly cleaned. (See par. 25.)

(13) **Oil outlet pipe from pump to cylinder block loose or broken.** (See par. 25 d.)

k. Engine overheats.

(1) **Not enough water in cooling system.**

(2) **Radiator core air passages clogged.** Clean out obstructions and accumulated oil and dirt.

(3) **Clogged water hose and connections.** (See par. 82.)

(4) **Water pump inoperative.** Replace (par. 69 **b**).

46. **CYLINDER HEAD ASSEMBLY** (figs. 29, 37 and 39).

a. Description. The cylinder head assembly, which can be removed (fig. 29) from the engine as a unit, consists of the cylinder head casting and the cam followers, guides, push rods, rocker arms, exhaust valves, fuel injectors, fuel manifold, exhaust manifold and water outlet manifold. The exhaust valve seats (see fig. 37) are hardened inserts shrunk into the cylinder head casting. From each cylinder, two exhaust passages lead to a single port opening into the exhaust manifold. Water passages, for cooling, surround the exhaust valve seats, exhaust passages, and the thin walled copper tubes into which are inserted the injectors (see fig. 37). Between the cylinder block and the head, a laminated steel gasket is used as a compression seal, and a cork gasket as an oil seal. A pressed steel valve rocker cover encloses the top of the cylinder head.

b. To replace cylinder head gasket.

(1) Remove cylinder head as outlined in paragraph 46 **c**, omitting steps 18 and 19. (Injectors should be left in place.)

(2) Remove cylinder head gasket and clean cylinder head and cylinder block surfaces.

(3) Install new gasket (par. 46 **d** (1) and (2)).

(4) Replace cylinder head (par. 46 **d**).

c. To remove cylinder head assembly (fig. 29).

(1) Drain the cooling system (par. 80 **d**).

(2) Remove rear deck and engine splash shield (par. 71 **b** (10)).

(3) Remove the filter panel par. 71 **b** (22)).

(4) Remove water outlet tubes (figs. 87 and 88).

(5) Remove the by-pass elbow from each engine.

(a) Take out the two bolts holding the by-pass elbow to the thermostat housing (9/16-inch wrench).

(b) Back off the hexagon packing gland nut that holds the elbow to the by-pass tube (1⅝-inch open end wrench) and remove the elbow.

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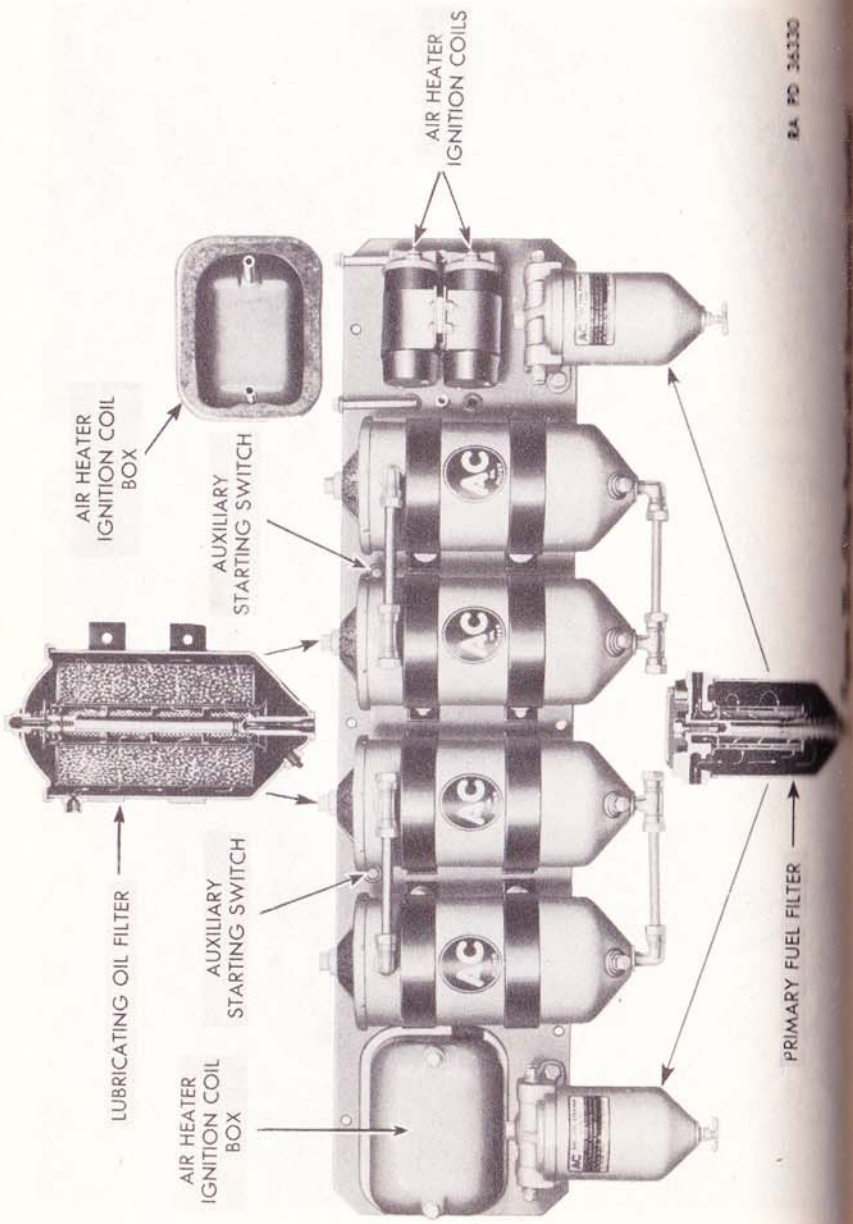
Figure 29—Cylinder Head Being Removed from Engine Compartment



(6) Withdraw the cotter and clevis pins from each end of the throttle rod at the side of each engine and remove the rod.

(7) Remove the three air cleaners. Cover the air intake housing holes with wood plugs, boards, or tape. (Do not use small rags or material that might drop or be drawn into the air intake housing.)

(8) Remove the water temperature gage capillary tube from the rear end of the water manifold and cover the manifold opening to keep out dirt. Protect bulb with wrappings.

(9) Remove the rocker arm cover.

(10) Disconnect the lubricating oil tank breather hose at the rear of the engine and move it out of the way. NOTE: Also remove governor breather hose if first type air cleaners (fig. 61) are in use.

(11) Remove the lifter bracket from the rear of the engine (5/8-inch socket, ratchet handle, and short extension wrench, and 5/8-inch open-end wrench).

(12) Remove the governor control housing (par. 50 b).

(13) Remove the secondary fuel filter:

(a) Remove the inlet and outlet fuel pipes from the filter (5/8-inch open-end wrench).

(b) Back off the hex nut at the bottom of the filter housing, and withdraw the assembly from the mounting bracket.

(c) Take out the bolts holding the mounting bracket to the engine (9/16-inch open-end or socket wrench) and remove the bracket.

(14) Remove the four bolts and lock washers which hold the engine lifter bracket to the balance weight cover (5/8-inch socket, ratchet handle, and long extension wrench) and remove the bracket.

(15) Remove the four bolts (5/8-inch socket and ratchet handle wrench) and lock washers which hold the exhaust pipe elbow to the exhaust manifold.

(16) Remove the four bolts (7/16-inch wrench) and lock washers which hold the breather pipe at the rear of the water manifold.

(17) Remove the cross shafts on the bulkhead. Pull out the cotter and clevis pins holding the vertical throttle rods to the cross shaft levers. Remove the four bolts (1/2-inch open-end wrench) holding each cross shaft bracket to the bulkhead.

(18) Remove injectors (par. 49 **c**). NOTE: Removal of injectors is unnecessary if no work is to be done on the cylinder head. If injectors are left in place, exercise care in handling the head so that spray tips will not be damaged. In laying down the head, place wooden blocks beneath it to prevent spray tips and valve followers from being injured.

(19) Disconnect governor control link and remove capscrews holding injector control tube assembly. Remove assembly by pulling straight up away from cylinder head. (These capscrews are conveniently removed by using a $\frac{7}{16}$-inch universal socket wrench, as shown in fig. 31.)

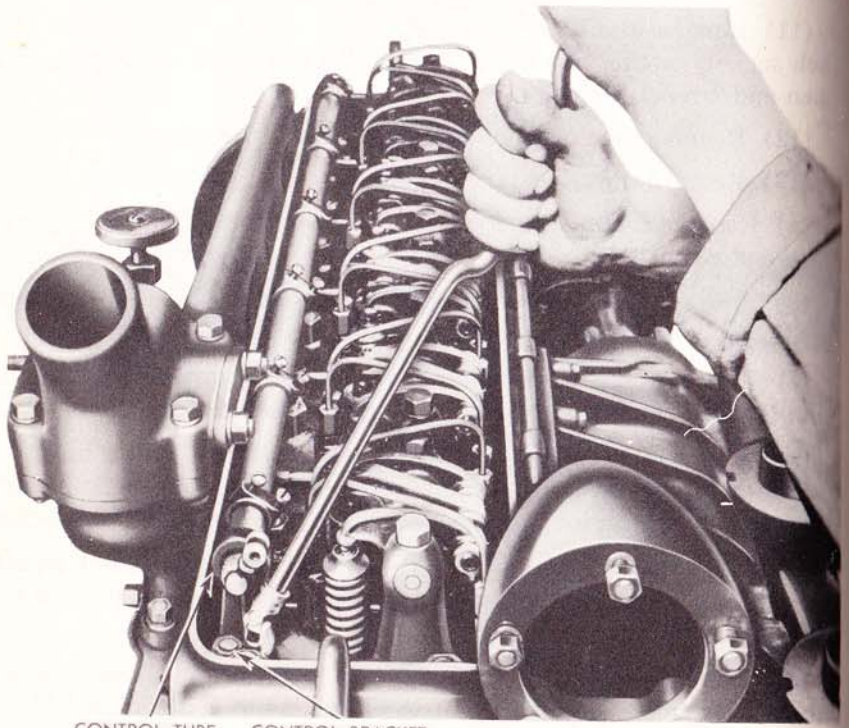


Figure 31—Removing Injector Control Tube

(20) Remove the cylinder head hold-down stud nuts ($1\frac{5}{16}$-inch thin-wall socket wrench).

(21) Attach hoist hooks to the holes in each end of the cylinder head and lift the assembly from the cylinder block (fig. 29). CAUTION: Lift the assembly slowly, making sure that it clears the fan tower, by-pass pipes, and bulkhead.

d. Install cylinder head assembly. Install the cylinder head by reversing the preceding steps, using new gaskets throughout, and observing the following precautions and directions:

(1) Cover camshaft and balancer shaft pockets with rags. Remove the old cork gasket (oil seal) from the cylinder block, clean the surface well, and install a new gasket, using shellac between the gasket and the block. Do not put on the shellac until all operations necessary on the block have been completed. Shellac the top surface of the gasket just before installing the head.

(2) Wipe upper surface of the cylinder block clean, and install a new laminated steel (compression seal) gasket with the surface marked **top**, and the head around the cylinder openings, turned upward. Do not use shellac or any other sealing compound on this gasket.

(3) Wipe the under side of the cylinder head clean before lowering it into place on the block.

(4) With the governor control housing installed, pour about one-half pint of lubricating oil into the housing.

(5) With throttle in **off** position, declutch, and turn engine over to see that all parts function properly.

(6) Check to see that the throttle can be moved to a fully open position in the governor control cam.

(7) Adjust valve lash (par. 48 **c**).

(8) Time injectors (par. 49 **f**).

(9) Adjust rack control levers (par. 49 **h** and **i**).

(10) Pour about one quart of lubricating oil over the valve springs and rocker arms.

(11) Before replacing rocker cover, open engine throttle to idling

position. Start the engine, and at about 1500 revolutions per minute check to see that all fuel line connections are tight. (If fuel oil leaks into the cylinder head, diluting the lubricating oil, engine bearings may be seriously damaged.)

(12) Install new rocker cover gasket, if necessary. Use shellac.

47. HAND HOLE COVER GASKET REPLACEMENT.

To replace hand hole cover gaskets (see fig. 24), it is necessary to remove the inspection plates in the hull beneath the engines.

a. Remove the inspection plate from beneath the engine opposite the one on which the gasket is to be replaced. (See par. 71 **b** (2)).

b. Remove the bolts, with flat washer and copper washer, from the hand hole cover (9/16-inch socket and ratchet handle wrench).

c. Remove the cover and take off the old gasket.

d. Install a new gasket, shellacking it to the cover (not to the engine block).

e. Replace the cover by reversing steps **a** and **b**.

48. VALVE AND INJECTOR OPERATING MECHANISM (fig. 32).

a. Description.

(1) For each cylinder, there are three rocker arms—the middle one to operate the injector, the others to operate the exhaust valves. The rocker arms operate on the rocker shaft, which is supported by two brackets. Two rocker shaft bolts hold each shaft in place and fasten its brackets to the top of the cylinder head. The rocker arms are lubricated by oil that flows from a passage in the cylinder head through the drilled lower ends of the rocker shaft bolts into the rocker shaft brackets and thence through the shaft to the rocker arms. The removal of the two bolts and the shaft permits turning the rocker arm assemblies back on their push-rod clevis pins, giving easy access to the fuel injector and the valve springs (fig. 33).

(2) The injector end of each injector rocker arm is fitted with a hardened ball stud and a ball seat. The valve end of each valve rocker arm is hardened and ground to a cylindrical surface which

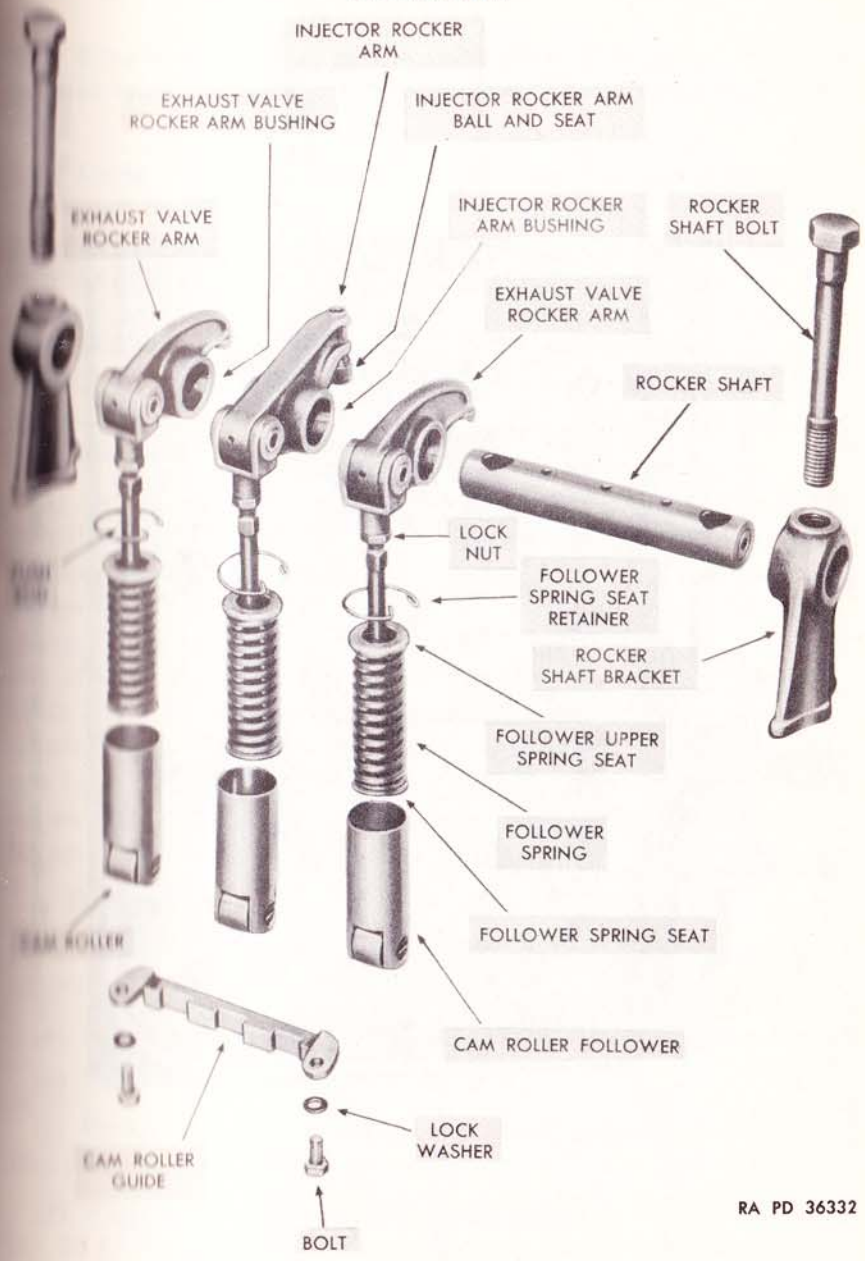


Figure 32—Valve and Injector Operating Mechanism, Disassembled

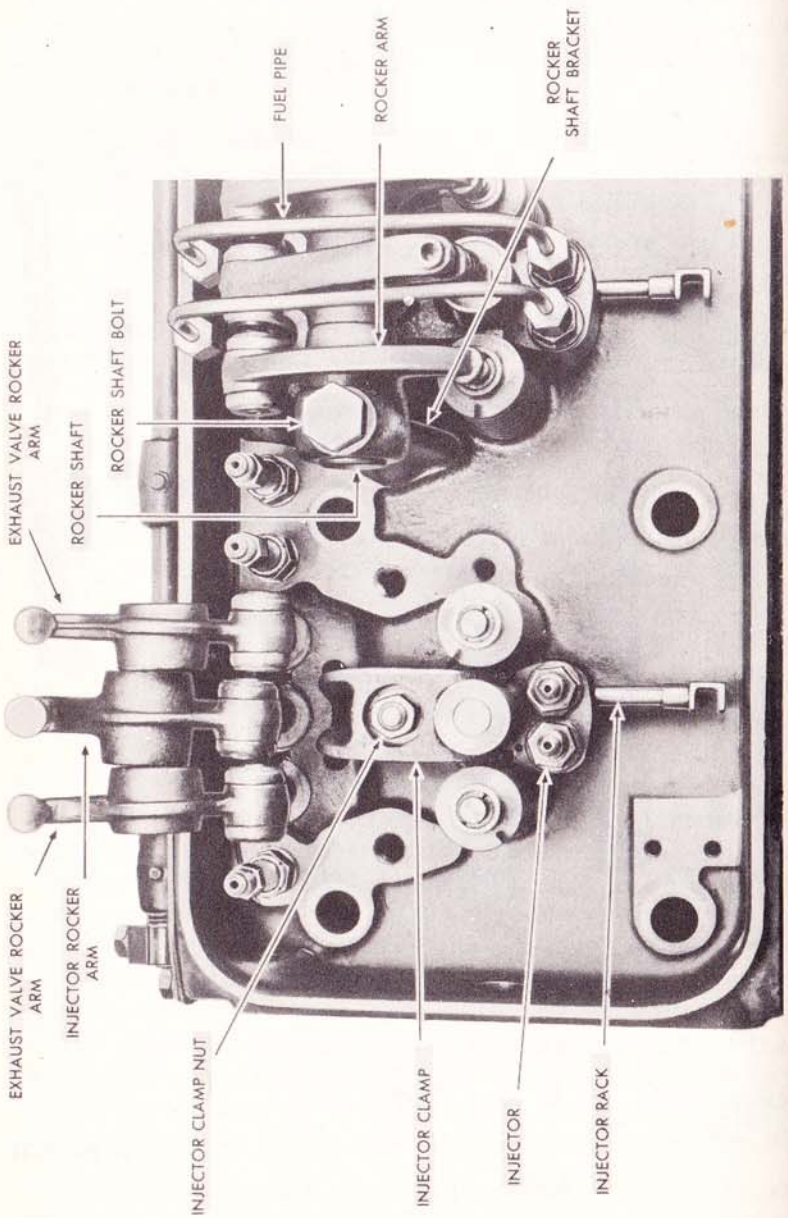


Figure 33—Rocker Arms, with Brackets and Shaft Removed

bears directly on the end of the valve stem. The rocker arms are operated from the camshaft through cam followers and short push rods.

(3) Contact between the cam follower and the cam is by means of a roller, on needle bearings. Each set of three cam followers is provided with a guide, bolted to the bottom of the cylinder head, to keep the follower rollers in line with the cams and to serve as a retainer during assembly and disassembly. The push rod spring fits down inside the hollow cam follower, and is held in place at its upper end in the cylinder head follower hole by a retainer and a wire locking ring. The valve springs are held in place by retainers and two-piece tapered seat locks.

(4) Late model engines have a valve spring (interchangeable with the old spring) of new design, a new valve spring cap, and a new spring seat. The new cap may be used with the old-style spring, but care must be taken that the cap rests flat on the end coil of the spring. If the cap rocks on the spring, the projecting lug on the bottom of the cap should be ground off. The new valve spring seat, which has a pin through its flange, can be used only on engines with cylinder heads having ⅛-inch drilled holes for seating the pin, but may be adapted to other engines by grinding off the pin underneath the seat. If the old-style valve spring does not rest flat on the seat, the pin on top of the flange must be ground off.

b. Maintenance.

(1) Operations on the valve mechanism that may be performed without removing the cylinder head are:

(a) Adjustment of lash (valve clearance). (See par. 48 **c.**)

(b) Replace valve spring. (See par. 48 **d.**)

(c) Replace rocker arm, rocker arm shaft, or rocker arm bracket. (See par. 48 **a.**)

(d) Replace cam follower spring, cam follower, or push rod. (See par. 48 **j.**) These parts, however, are more easily changed from the lower side of the cylinder head when the head is off the engine. (See par. 48 **h** and **i.**)

(2) The cylinder head must be removed for the following valve operations:

(a) Replace valve. (See par. 48 **f**.)

(b) Replace valve guide. (Notify ordnance maintenance personnel.)

(c) Replace valve seat. (Notify ordnance maintenance personnel.)

(d) Grind or reseat valves. (See par. 48 **e**.)

(e) Replace injector tubes. (Notify ordnance maintenance personnel.)

c. Valve lash adjustment (fig. 34).

(1) Correct valve lash is extremely important because of the

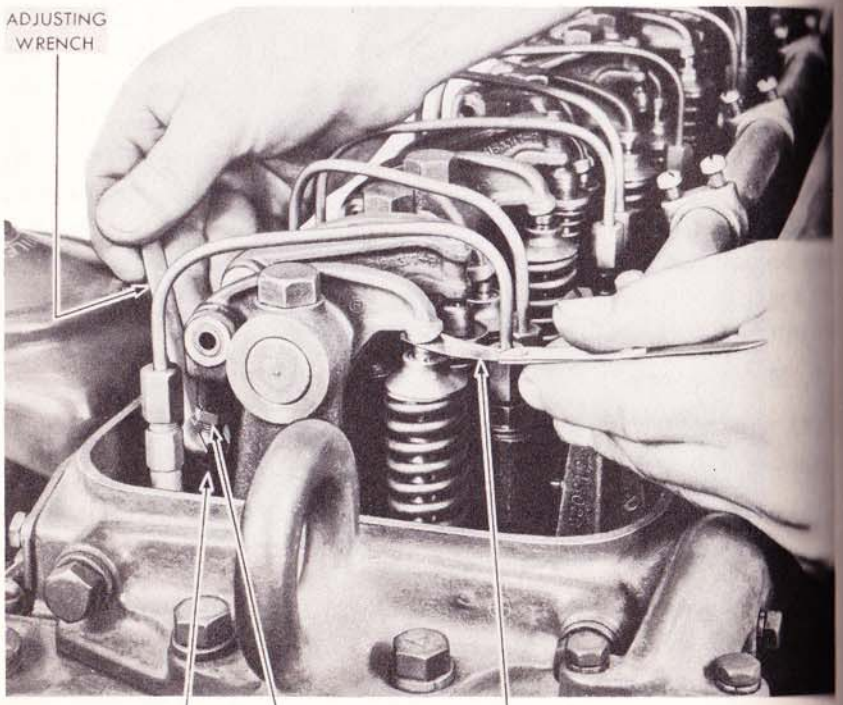


Figure 34—Valve Lash Adjustment

high compression (500 lb. per sq. in.). Too little clearance causes a loss of compression, misfiring, and eventual burning of valves and valve seats. Too much clearance causes noisy operation, especially in the idling range. The correct lash between the valve stem and the rocker arm is .011 inch **go** and .013 inch **no go**, with the engine hot; that is, with the water temperature between 165 and 185 F (71 and 85 C).

(2) Adjustment of valve lash can be changed by means of the threaded upper part of the push rod, which is screwed into the push rod clevis and locked by a lock nut. The adjustment is checked by feeling with the proper gages, between the valve stem and the rocker arms, at the moment when the injector arm is depressing the injector plunger. The clearance must be enough to let the thin gage pass but not enough to pass the thick gage.

(3) CAUTION: Whenever a push rod has been disconnected from the push rod clevis, or partly unscrewed, the rod **must** be screwed back into the clevis until the end strikes the rocker arm. Unless this adjustment is correct, the piston may hit the head of the valve.

d. Replace exhaust valve spring (fig. 35). To replace an exhaust valve spring with the cylinder head on the engine:

(1) Remove rocker cover.

(2) Turn over engine until piston is at top of stroke (when the injector plunger has traveled approximately $\frac{3}{16}$-inch on the downward stroke), in order that the valve spring shall be fully extended.

(3) Disconnect and remove fuel feed lines from injector and loosen them at the fuel oil connectors (½-inch open end wrench), then swing them aside. Use extreme caution to protect injector fittings from dirt. (Cover with shipping caps if they are obtainable.)

(4) Remove the two rocker shaft bolts holding the rocker shaft brackets to cylinder head (¾-inch socket wrench), remove the brackets and shaft, and turn rocker arms back out of the way (fig. 38).

(5) Slip one of the rocker shaft bolts through the valve spring compressor fulcrum sleeve and through the valve spring compressor (tools J-1227, 1 and 2, fig. 22) and install the bolt firmly in the tapped hole of the cylinder head adjacent to the valve spring to be removed, having the jaw of the tool astride the valve stem.

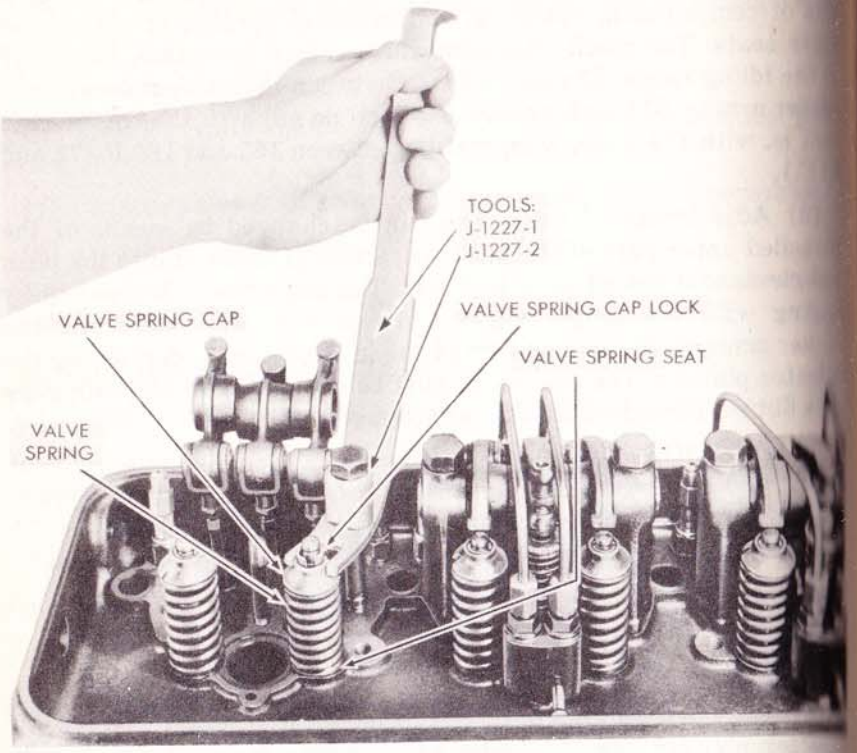


Figure 35—Removal of Valve Spring

(6) By moving the free end of the tool, the valve spring cap can be depressed and the valve spring cap lock removed. The spring may now be lifted out.

(7) A valve spring may be installed by reversing the operations for removal, and observing these additional directions:

(a) Adjust valves for .015 inch lash with engine cold, then run engine and relash to .011 inch **go** and .013 **no go** with the engine hot (par. 48 **c**).

(b) Before installing the rocker cover, run the engine and inspect all fuel connections for leaks. (Should fuel oil leak into the cylinder

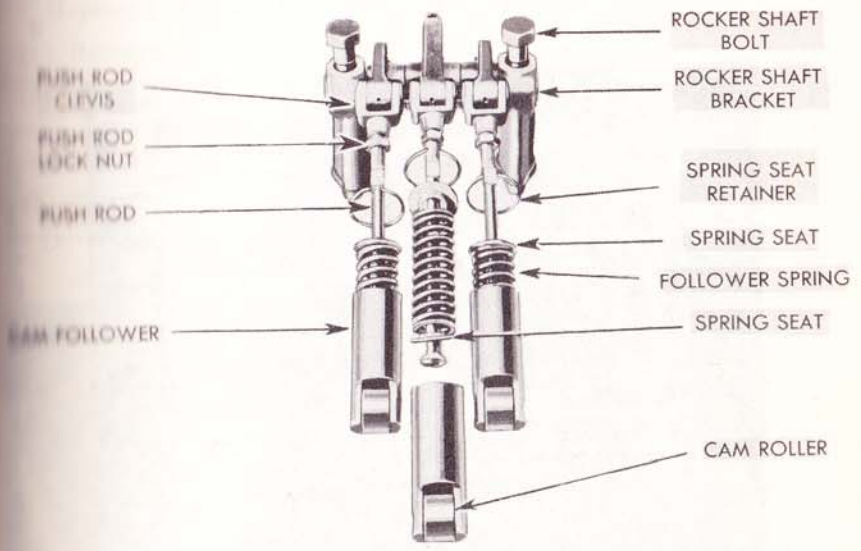


Figure 36—Details of Valve and Injector Operating Mechanism

head and dilute the lubricating oil, the engine bearings might be seriously damaged.)

e. **Recondition valves and valve seats.**

(1) When either a new or a used valve is installed, the valve seat in the cylinder head should be examined for proper valve seating. If a used valve is to be installed again, the valve stem should be cleaned and the valve seat reground to the correct angle of 45 degrees. The valve guide should be thoroughly cleaned with the valve guide reamer. If the bore of the valve guide is worn out of round or if valve heads are warped, the parts should be replaced.

(2) The contact between valve and seat after a valve has been

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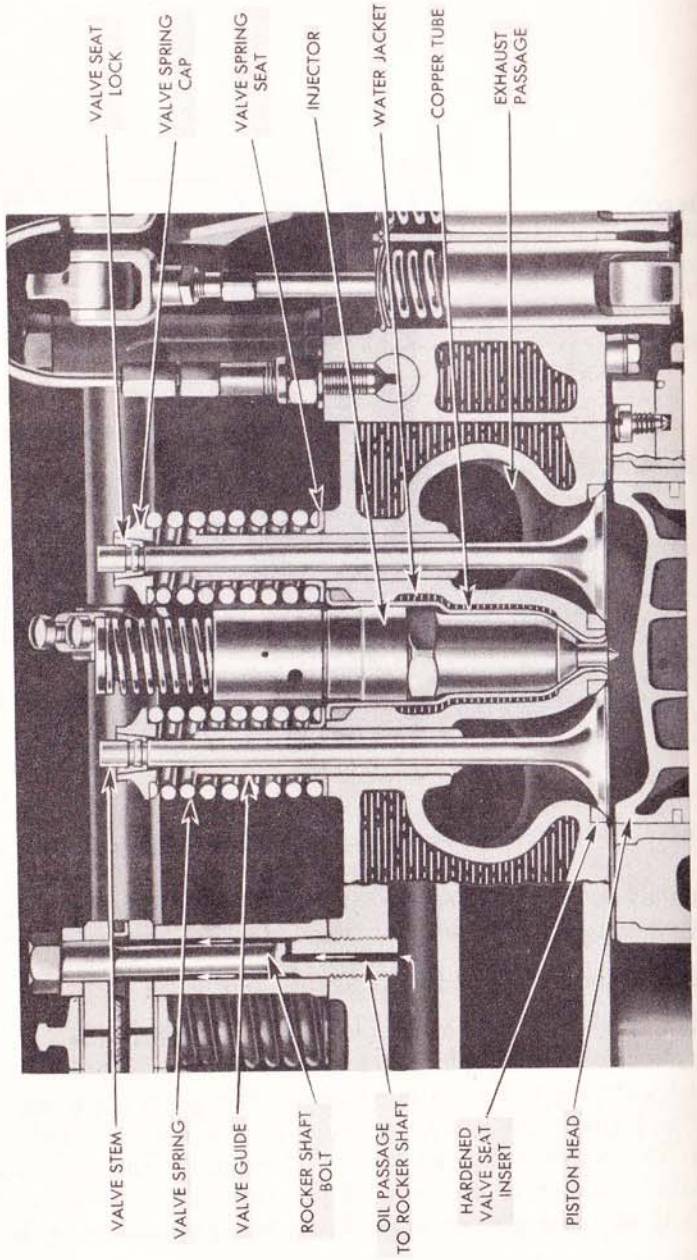


Figure 37—Valve and Seats in Cylinder Head

lapped in, may be checked by wiping a thin film of Prussian blue on the valve seat, setting valve in place, and bouncing valve on seat. If the valve is seating properly, an unbroken band of blue will be visible on the face of the valve.

f. **Replace exhaust valves.**

(1) Remove cylinder head (par. 46 **c**).

(2) Place the cylinder head right side up, resting on two-inch blocks of wood (to protect the valve followers and injector spray tips from damage) and release the valve springs (par. 48 **d**).

(3) Turn the cylinder head on its side (see fig. 39) and withdraw the valves from the bottom.

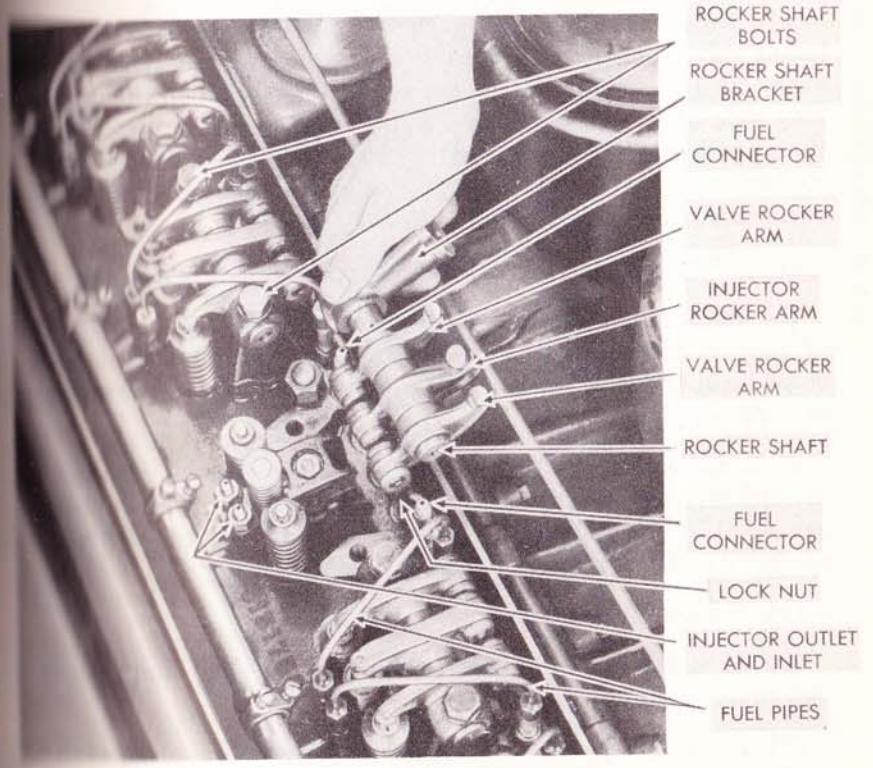


Figure 38—Removal of Rocker Bracket and Shaft

(4) Install valves by reversing the preceding steps. (See e, preceding.)

g. Replace rocker arm or shaft (fig. 38).

(1) Remove the rocker arm shaft brackets and shaft (par. 48 d).

(2) Loosen the lock nut (½-inch open-end wrench) at the upper end of the push rod, next to the clevis, and unscrew the clevis and rocker arm from the push rod.

3) Before replacing rocker arms or parts, inspect the rocker arm bushings for excessive wear, and clean out the oil holes in the rocker arms, rocker shaft bolt, and rocker shaft, with gasoline, small wire, and dry compressed air.

(4) Note that the injector rocker arm is different from the exhaust valve rocker arms; also, that the boss for the rocker shaft in each valve rocker arm is longer on one side than on the other. The long side of the boss must face the injector rocker arm. Lubricate the outside of the rocker shafts with clean engine oil and install the rocker arms and shafts by reversing the operations for removal, observing these additional directions:

(a) After replacing the rocker arms, adjust valve lash (par. 38 e).

(b) Before installing the valve cover, run the engine and check all fuel oil connections for leaks. (Should fuel oil leak into the cylinder head and dilute the lubricating oil, the engine bearings might be seriousy damaged.)

h. Remove cam followers. Cam followers may be removed from the cylinder head from the top, with the cylinder head in place (see par. 48 j). If the cylinder head is already removed, the cam followers are more easily removed from the bottom.

(1) Remove the rocker arms (par. 48 g).

(2) Turn the cylinder head on its side (fig. 39) and remove the cam roller guide bolts and the guides.

(3) Pull out the cam follower, follower spring, spring seats, and push rod as an assembly. The cam follower spring seat retainer will remain in the cylinder head, and may be left in place unless the parts are to be installed in another head.

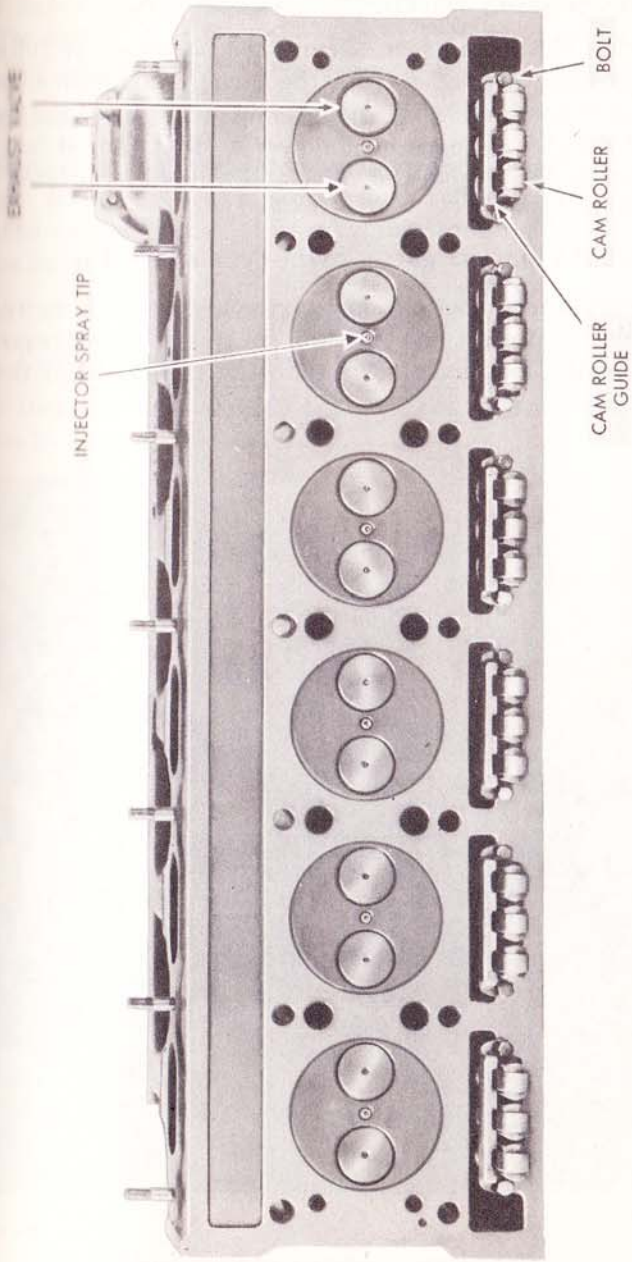


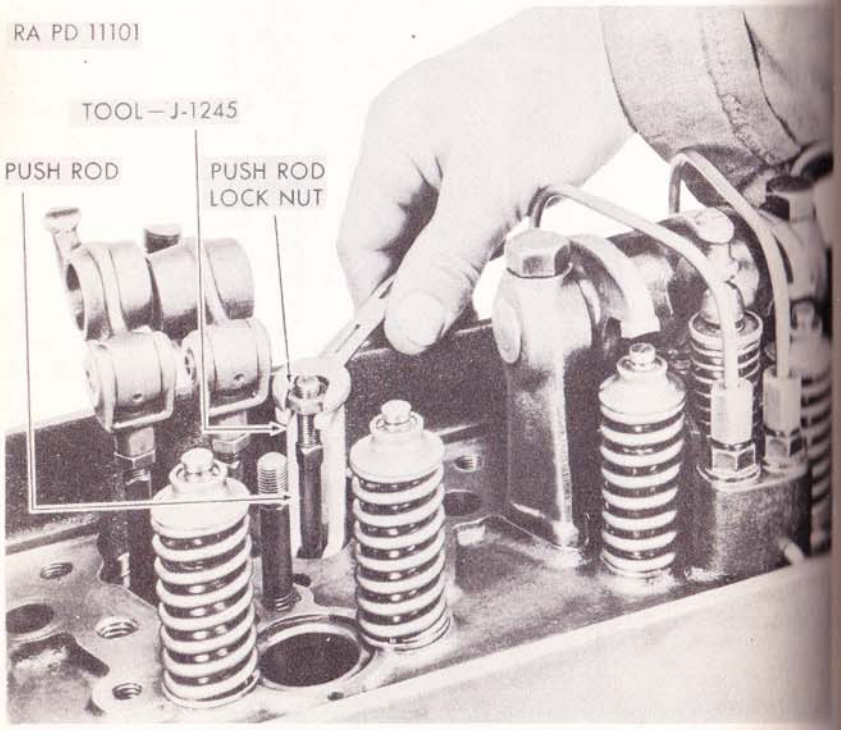
Figure 39—Bottom of Cylinder Head

i. Replace cam followers (cylinder head removed).

(1) See that the spring seat, spring, and push rod are fully down in the hollow followers. Then, with the spring seat retainer in place in the cylinder head, slide the follower assembly into the cylinder head, being careful to turn the follower so that the oil hole in its lower end points away from the valve and will not be covered by the follower guides.

(2) Attach the follower guides to the cylinder head.

(3) Provide wood blocks 2 inches thick on which to rest the cylinder head, to protect the injector spray tips; then reverse the head and run the lock nuts down onto the upper end of the push rods.



RA PD 11101

Figure 40—Removal of Push Rod

(4) Screw the end of each push rod into the rocker arm clevis so that the end of the rod strikes the rocker arm. Leave the lock nuts loose, for adjusting clearance after cylinder head is installed.

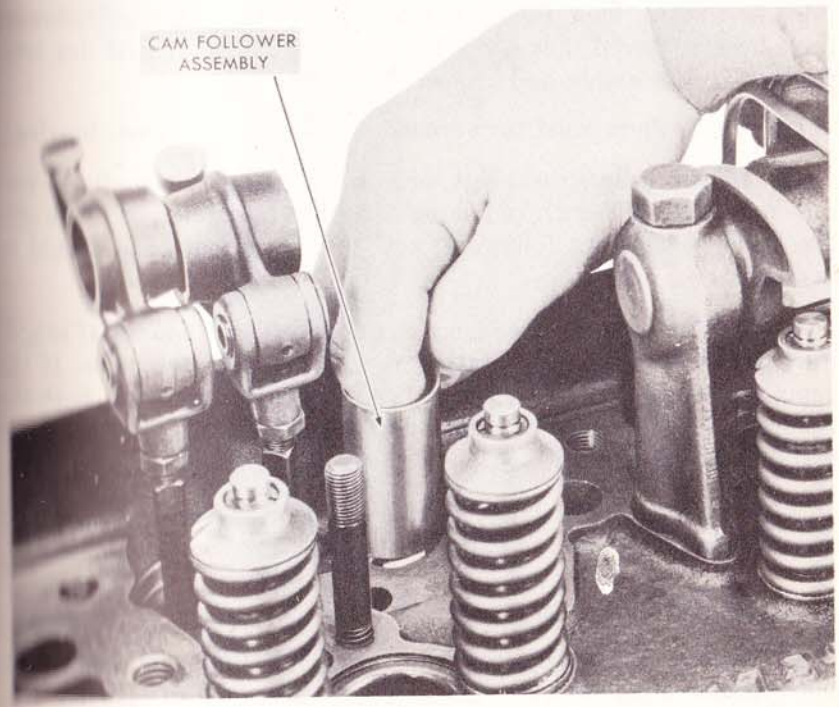
(5) Install the cylinder head (par. 46 **d**).

j. Replacing push rod from top of cylinder head (fig. 40). A push rod may be changed, or a broken push rod removed, with the cylinder head on the engine. (Fig. 40 shows the injector removed, but it may be left in place.)

(1) Remove valve rocker cover.

(2) Remove rocker arm (par. 48 g).

(3) Insert tool No J-1245 between the cam follower spring seat and the lock nut on the push rod.



RA PD 11102

Figure 41—Removal of Cam Follower

(4) Screw the lock nut down to compress the spring until spring retainer is relieved.

(5) Dislodge the spring seat retainer from the groove in the cylinder head with a screwdriver.

(6) Back off push rod nut and remove compressing tool.

(7) Withdraw the push rod, spring, and cam follower (fig. 41).

(8) Replace cam follower and push rod by reversing the preceding steps, making certain that cam follower oil holes are turned away from the valve.

(9) After installing the push rod and replacing the rocker arms and fuel lines, adjust the valves to .015 inch lash with engine cold, then run engine and relash to .011 inch go and .013 inch **no go**, engine hot.

k. To inspect cam follower assembly. After the cam followers have been removed they should be cleaned, blown off with dry compressed air if possible, and inspected as follows:

(1) Cam rollers must turn smoothly and freely on their bearings.

(2) If cam rollers, bearings, or pins are worn sufficiently to permit more than .005 inch radial movement of the roller, or if the pins are loose in the cam followers, new follower assemblies should be installed.

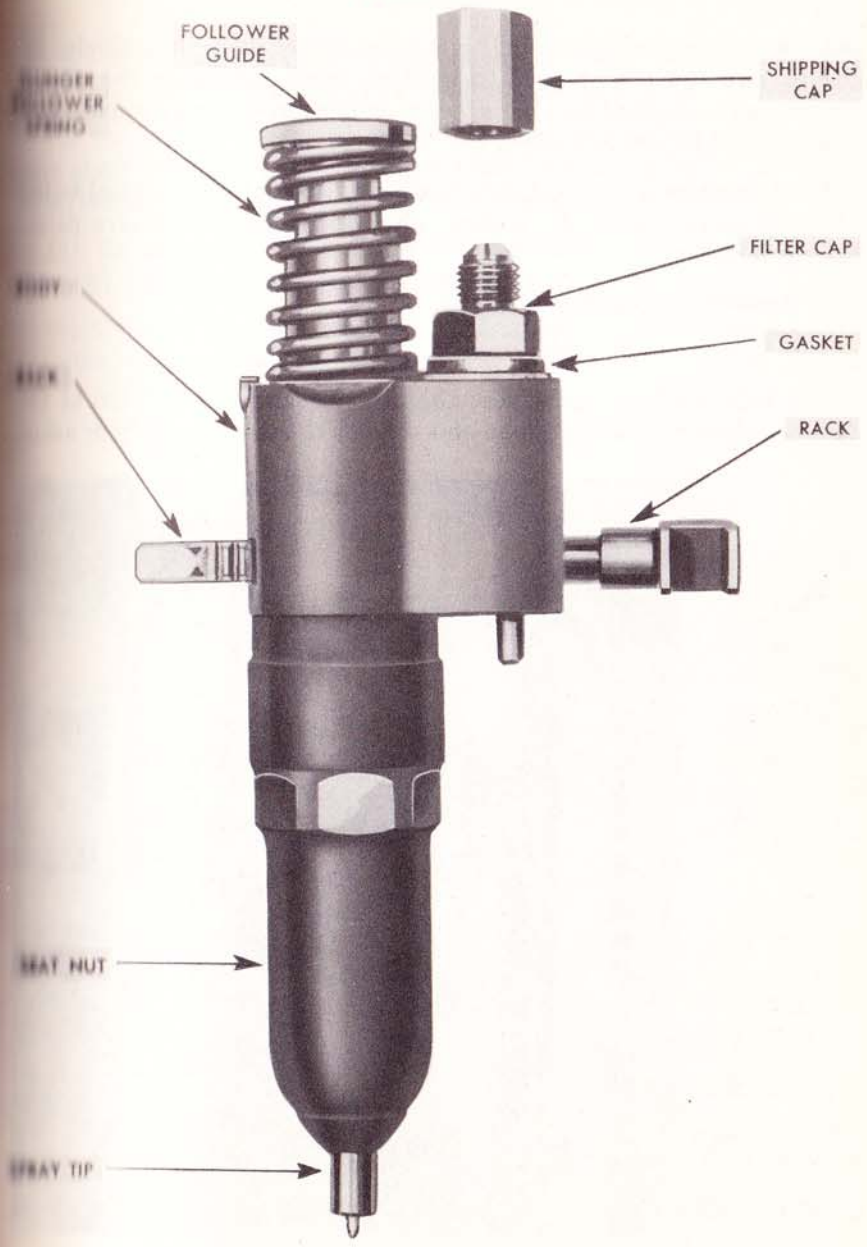
(3) Rollers must be free from flat spots or scuff marks. If not, or if rollers have not been rotating freely, examine the cams. If the cams are scuffed, or the noses of the cams are worn down, both the rollers and the camshaft should be replaced. (Notify ordnance maintenance personnel.)

(4) NOTE: Rapid change in valve lash may be due to the conditions listed in (2) and (3) above.

49. INJECTOR (fig. 42).

a. Purpose. A fuel injector, one for each cylinder, is mounted in the cylinder head between the exhaust valves of its cylinder (fig. 33). To obtain combustion an accurately metered quantity of finely atomized fuel must be mixed, at the end of the compression stroke,

POWER UNIT



RA PD 36342

Figure 42—Fuel Injector, as Removed from Cylinder Head

with the charge of air which has been forced into the cylinder by the blower and compressed to ignition temperature by the piston. This is accomplished by the injector, which provides a complete and independent injection system for each cylinder.

b. Maintenance. Correct functioning of the injector is vital to the efficient operation of the engine. Therefore, it must receive painstaking servicing.

c. Removal of injector (fig. 43).

(1) Remove rocker arm cover.

(2) Remove fuel pipes from the injector and loosen them at the fuel connectors (½-inch open-end wrench), then swing them aside.

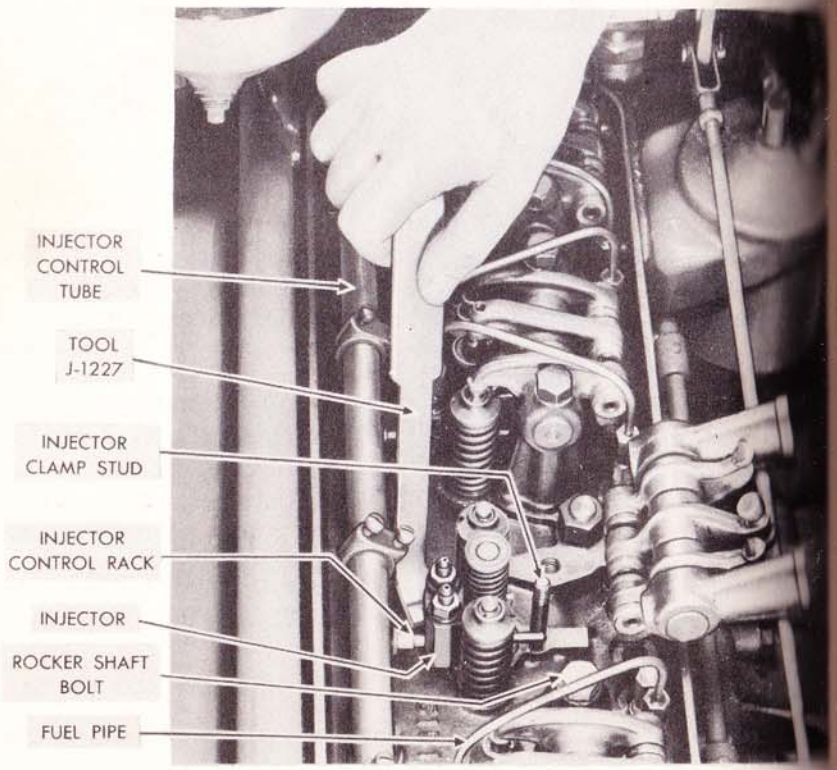


Figure 43—Removal of Fuel Injector

(Exercise extreme caution to protect injector and connector fittings from dirt. Install shipping caps on injectors if they are obtainable.)

(3) Remove the two bolts (¾-inch wrench) holding the rocker arm shaft brackets to the cylinder head, and swing entire assembly clear, being careful not to bend the push rods.

(4) Remove the injector hold-down stud nut (⅜-inch socket wrench), also the special washer and clamp.

(5) Pry the injector straight up from its seat by means of the injector removing tool (fig. 43).

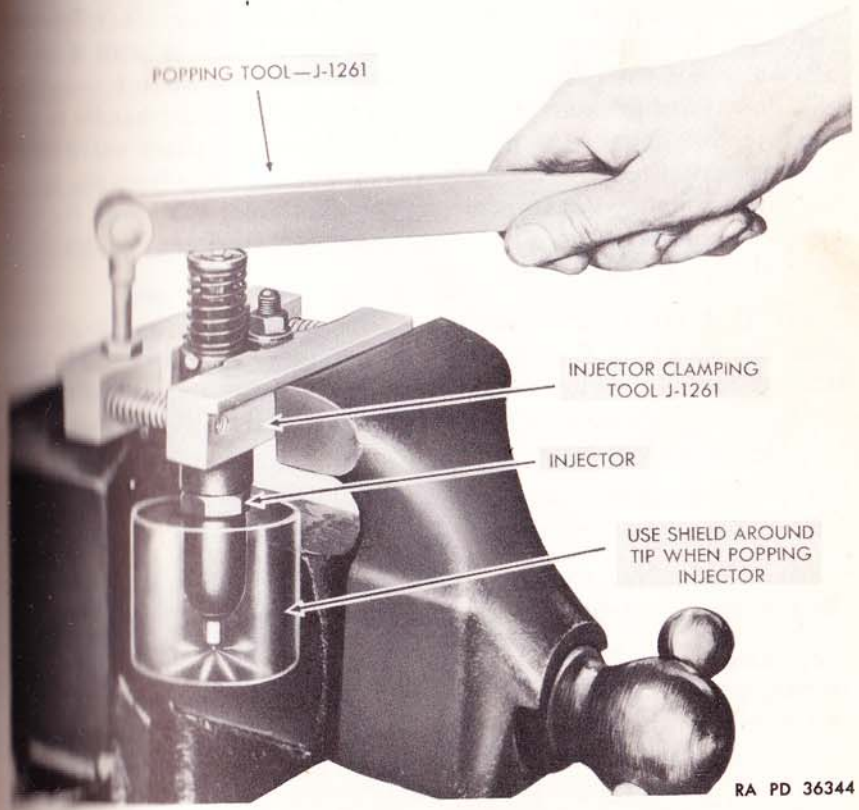


Figure 44—Testing (Popping) an Injector

(6) Lift the injector from seat, at the same time disengaging the injector rack from the rack control lever.

d. Testing fuel injectors (fig. 44). An injector should always be tested before it is installed in the engine. This test, known as "popping the injector," is accomplished with tool No. J-1261, as follows:

(1) Place injector in test fixture.

(2) Using a clean oil can filled with clean fuel oil, introduce fuel into one of the injector openings until fuel flows from the other opening.

(3) To determine whether all seven holes in the spray tip are open, move the injector rack into the **full fuel** position; then forcibly press the test handle down on the plunger follower with a quick motion. When the check valve opening pressure is correct, considerable downward pressure will be required on the fixture handle to pop the injector; if but little pressure is required, the check valve opening pressure is too low. CAUTION: Keep hands away from the spray tip when popping the injector, as the fuel from the spray tip will penetrate the skin and may cause blood poisoning. It is advisable to use a shield around the spray tip.

(4) Test for a leaky check valve by wiping or blowing all fuel from the spray tip, then pressing down on the fixture handle firmly, but not forcibly enough to open the check valve. Maintain a steady pressure while watching the spray tip. If oil appears, the check valve is not seating properly.

(5) If the injector fails to pass these tests, notify ordnance maintenance personnel.

(6) NOTE: Never remove the filter from the injector, because of the risk of getting dirt into the oil passages.

e. Installation. The injector is installed in the cylinder head by reversing the sequence of operations for removal (par. 49 c). A dowel on the injector body registers with a hole in the cylinder head so that the injector can be located in only one position. When inserting the injector into its tube be sure to engage the injector rack with the rack control lever. After installing the injector, tighten with the hold-down clamp and nut. Avoid over-tightening; a firm pull of 40 pounds on a 6-inch ratchet handle (equivalent to 20 to 25 pounds

foot on a torque wrench) is enough. Check for free movement of the injector rack. Then attach fuel pipes to injector and tighten them at fuel connectors.

f. Fuel injector timing (fig. 45). For proper engine operation, it is essential that all six injectors be properly timed, so that the cylinders shall fire at exactly even intervals. In addition, all the injector racks must be positioned; that is, so adjusted that, at any throttle opening, each one will deliver exactly the same quantity of fuel as the others. Therefore, before the engine is run, each newly-installed injector must be timed, and if more than one injector has been installed, all six racks must be positioned (par. 49 g). To time an injector, proceed as follows:

(1) Remove valve rocker cover.

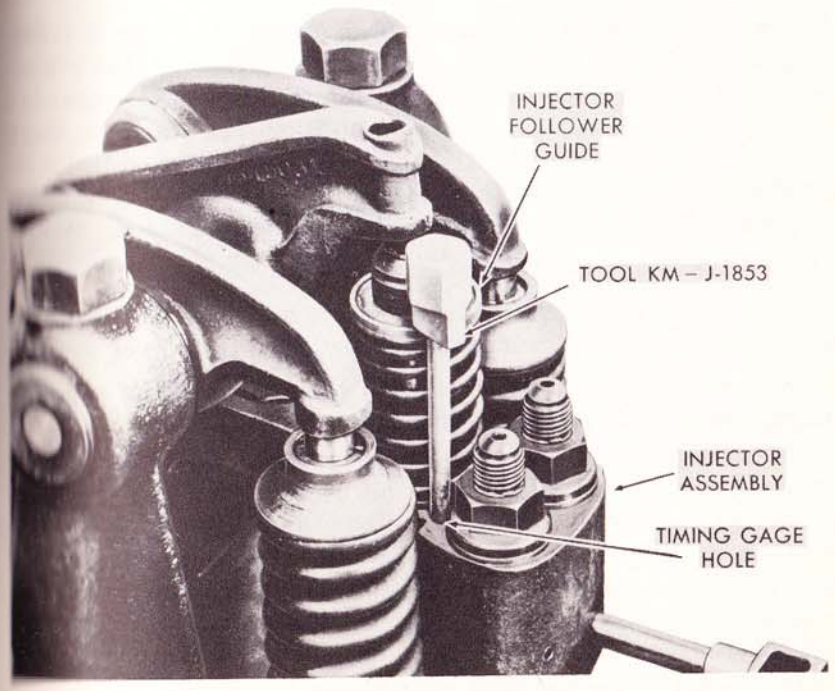


Figure 45—Timing Fuel Injectors RA PD 11112

(2) Turn throttle control to **off** position.

(3) Crank engine, by means of the starting motor, until the exhaust valves of the cylinder to be timed are fully open (all the way down).

(4) Place injector timing gage (tool J-1853, fig. 22) in timing gage hole on the top face of the injector body (fig. 45).

(5) Rotate timing gage until the lower edge of either of the two flats on the hexagon knob is over or against the plunger follower guide. (Timing gage height is 1.460 inch.)

(6) Adjust the injector rocker arm, by means of the screw adjustment on the upper end of the push rod, until the lower face of the timing gage just passes over the top of the plunger follower guide. Tighten lock nut on push rod and check adjustment again. If more than one injector has been newly installed and timed, do not run the engine until racks on all six injectors have been positioned (see following).

g. Positioning injector rack. After an injector has been installed, its rack position must be adjusted to correspond with the others, because the quantity of fuel injected into the combustion chamber at each stroke is governed by the rack position. The maximum quantity of fuel is injected when the rack is all the way **in**; no fuel is injected when the rack is all the way **out**. The rack movement, either in or out, is limited by the length of the toothed part of the rack.

h. Positioning of control racks (engine not running) (fig. 46).

(1) Loosen lock nut on buffer spring screw and turn screw **out** until approximately $\frac{5}{8}$-inch projects from side of governor housing.

(2) Turn out several turns on both the inner and the outer adjusting screws on **all** rack control levers.

(3) Hold governor control lever securely in **full open** position (as shown in fig. 46). Slowly turn down the inner adjusting screw on the rack control lever of No. 1 cylinder until a definite step-up in resistance is felt. When this step-up is felt, the governor idle adjusting screw will be seen to move slightly outward. After this movement is seen to start, back off inner screw about one-third turn, then turn down outer adjusting screw to lock.

(4) **Check rack control lever adjustment.**

(a) It should be possible to move the governor control lever

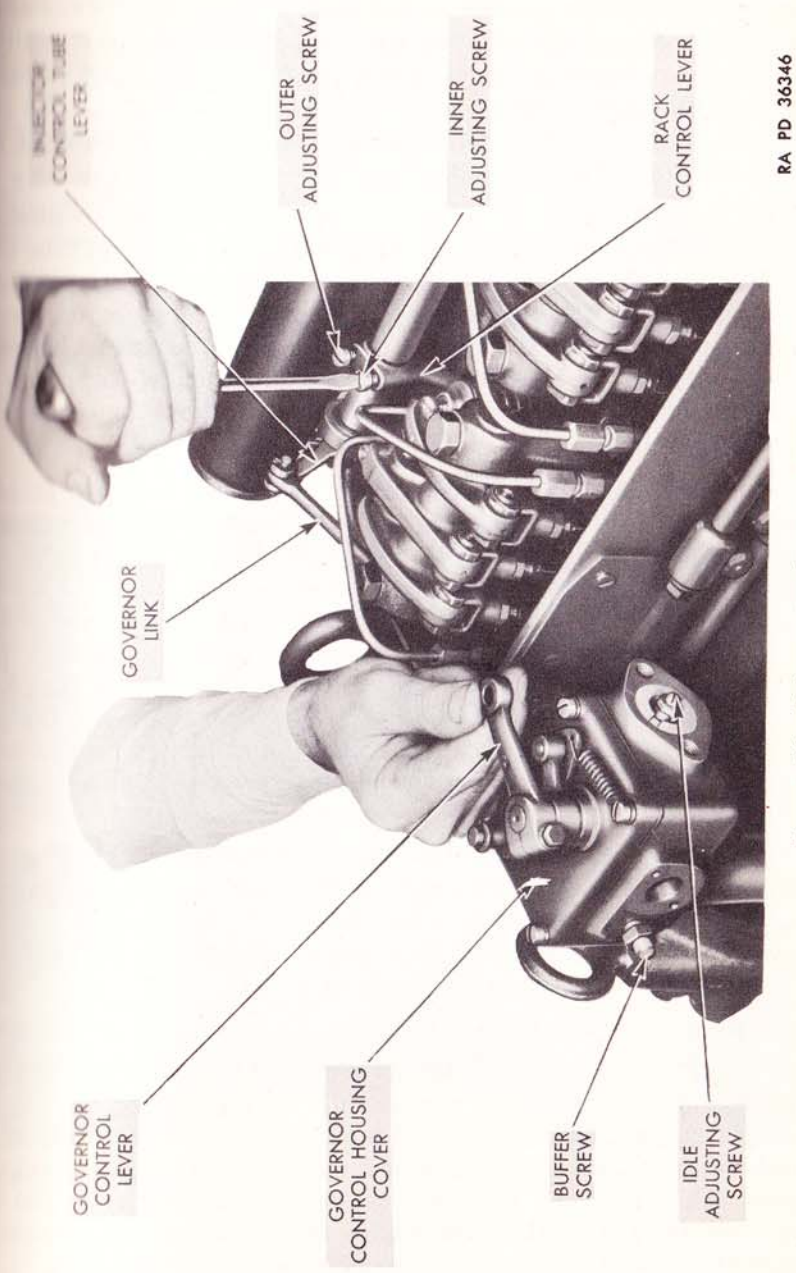


Figure 46—Injector Rack Positioning

smoothly from **idle** position to **full open** position (at the end of the slot) without any definite step-up in effort near the open position. If a sudden increase in resistance is felt near the end of travel toward **full open** position, the inner adjusting screw on the rack control lever is in too far. Back off the inner screw slightly and tighten the outer adjusting screw to lock.

(b) Hold the governor control lever in the **full open** position, as shown in figure 46. Firmly pushing the injector control tube lever by hand should move the injector racks outward slightly (from ⅛ to $\frac{1}{32}$ inch, about the thickness of a thumb nail) before an increase in resistance is felt and before the idle adjusting screw begins to move outward. If this free travel is more than $\frac{1}{32}$-inch, back off slightly on the outer adjusting screw, turn down inner screw to lock, and recheck.

(5) After the injector rack of No. 1 cylinder has been properly positioned, hold rack all the way in and adjust each of the remaining rack control levers to the full **in** position. Adjust each lever in turn by slowly turning down the inner adjusting screw until the injector rack can be felt striking bottom, and No. 1 rack can be seen to begin movement **outward.** Then tighten down outer screw and lock inner screw. Each time a rack lever is positioned, check to see that No. 1 rack has not been moved outward. If No. 1 has moved out, the lever last positioned has been set too far in, and should be readjusted by slightly backing off its inner adjusting screw, then tightening outer adjusting screw.

(6) **Check for stop position.** Hold the governor control lever in the **stop** position. The injector racks should not have more than $\frac{3}{16}$-inch **outward** movement when the injector control tube lever is moved with the hand. NOTE: Visual inspection should show that **all** injector **racks** extend approximately ⅞-inch.

(7) Set idle speed (par. 50 **c** (2)).

i. NOTE: No attempt should be made to balance the injectors to obtain smoother no-load performance by adjusting individual rack control levers after all have been positioned as in **h** preceding. If one rack be adjusted farther in than the others, only that one cylinder gives full output; all the other racks are held back from full load position, thus preventing the engine from developing its maximum power.

50. GOVERNOR.

a. An engine speed governor is attached to the blower front end cover and to the cylinder head of each engine. It is driven by means of a splined shaft, which fits into the upper blower rotor shaft, and is lubricated by oil from the blower and from the cylinder head. The governor regulates the idling speed and limits the top speed of the engine, to prevent dangerous overspeeding. Once set for the proper speed limit, the governor should not be tampered with.

b. Replacement of governor control housing (figs. 47, 48, and 49).

(1) Disconnect governor air breather hose (on engines with early type air cleaners only) (see fig. 47).

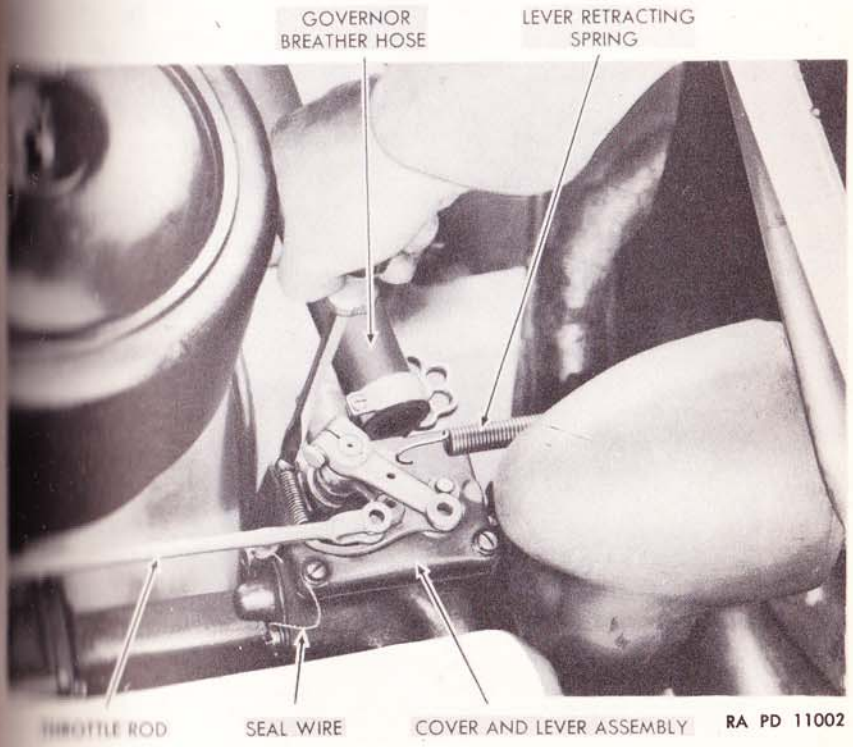


*Figure 47—**Removal of Governor Control Housing Cover***

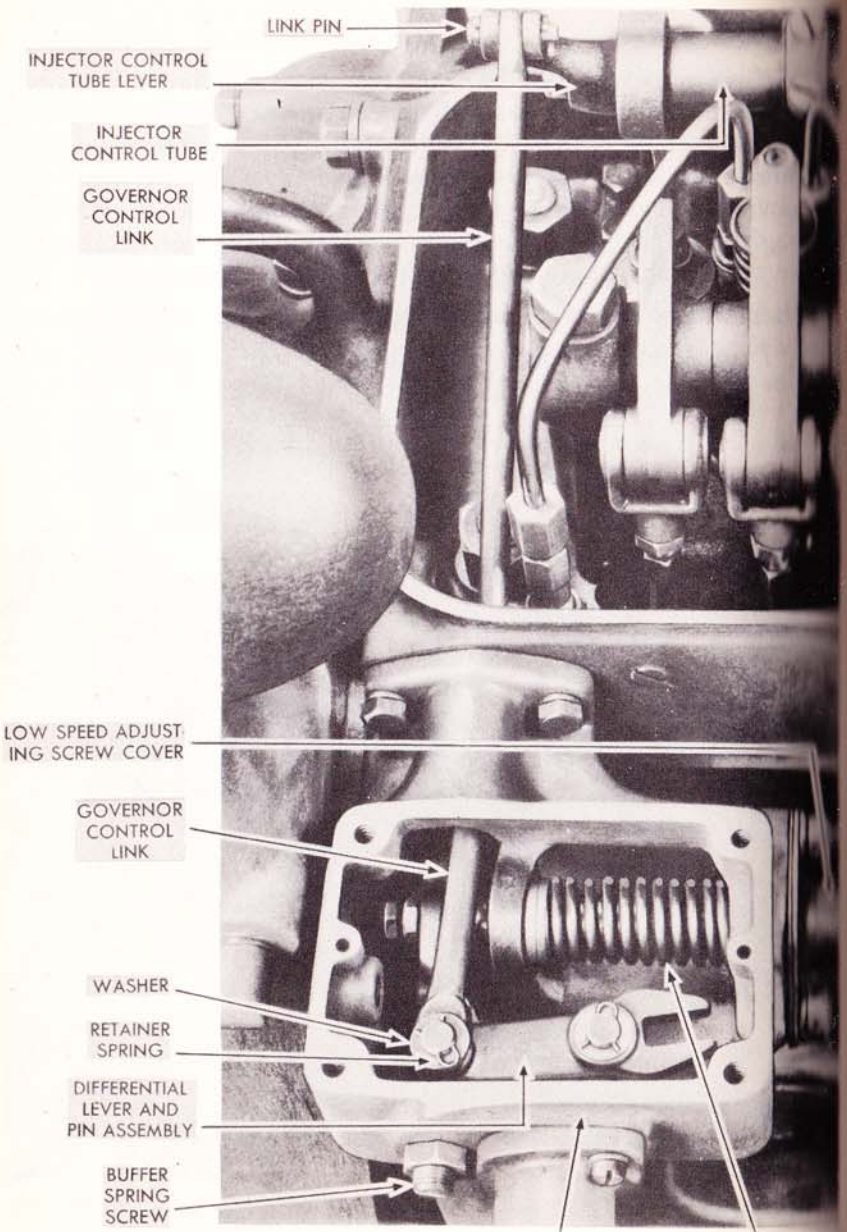


Figure 48—Governor Control Housing, Cover Removed

(2) Disconnect throttle control rod from the governor control lever.

(3) Remove the control lever retracting spring.

(4) Remove the four screws and lockwashers from the cover.

(5) Lift off the cover and gasket.

(6) Remove rocker cover from cylinder head.

(7) Remove the retainer spring and flat washer holding the governor control link to the governor differential lever (fig. 48).

(8) Remove the four bolts and lockwashers from the weight carrier cover plate.

(9) Lift off the plate and gasket.

(10) Remove the clevis pin from the governor control link and injector control tube lever (fig. 49).

(11) Remove the governor link by pulling it out toward the control tube lever.

(12) Replace the flat washer and retainer spring on the differential lever.

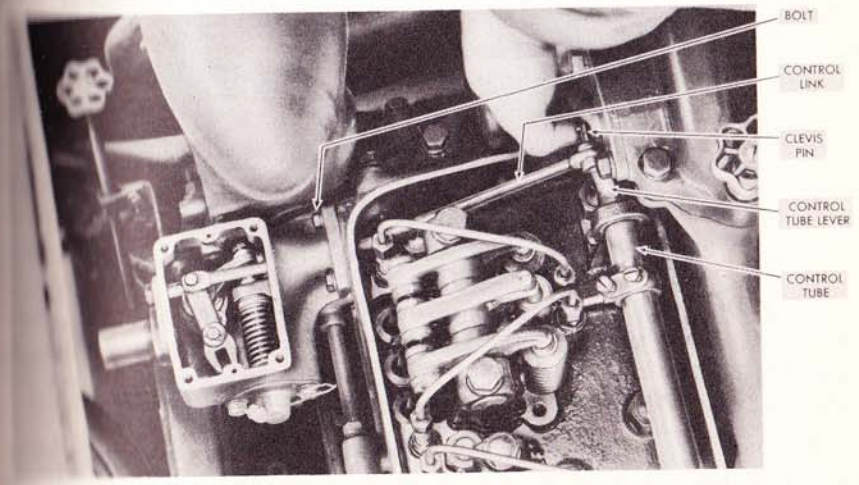


Figure 49—Removal of Governor Control Link

(13) Remove the two bolts holding the governor assembly to the cylinder head ($\frac{7}{16}$-inch open-end wrench).

(14) Lift off the governor control housing assembly from the governor weight housing dowel pins.

(15) Reverse these steps to install the governor. Be sure to install good gaskets at the governor weight cover and at the cylinder head. CAUTION: In assembling the governor control housing to the weight housing, make sure that both the ball thrust bearing and the thrust washer are between the fork of the vertical operating shaft and the sliding sleeve, or riser, on the horizontal weight carrier shaft (fig. 50).

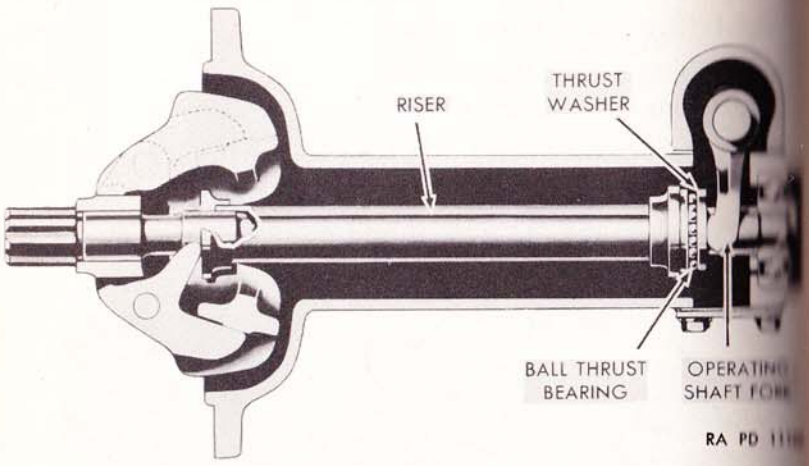


Figure 50—Governor Weight and Housing Assembly

(16) Before replacing the governor control housing cover, pour at least a half pint of engine oil into the top of the governor. In putting on the cover, be sure that the governor fulcrum lever pin goes between the jaws of the differential lever.

(17) After installing the governor, time the injectors (par. 49 f) and position the injector control racks (par. 49 **h**). Also make low speed plunger, idling speed, and buffer screw adjustments (see next paragraph).

g. Governor adjustments. The governor spring plunger gap must be correctly set to obtain full engine power. If the gap is too wide, a flat spot will occur, near 1200 revolutions per minute, where the governor control lever can be moved without a corresponding change in engine power. If the gap is too narrow, a flat spot will occur at about 800 revolutions per minute. After the governor plunger gap or the injector racks have been adjusted, the idle speed of the engine must be reset.

(1) **Spring plunger gap setting** (figs. 46 and 51).

(a) Remove the spring cover at the rear of the governor control housing and set the idle-adjusting screw so that it projects $\frac{1}{8}$ to $\frac{3}{16}$ inch from the locknut.

(b) Remove the governor cover and the link between the governor and the injector control shaft.

(c) Start the engine with the aid of a helper, and regulate its speed by hand operation (see fig. 46) of the injector control tube lever. CAUTION: **The governor is now disconnected, and care must be taken not to overspeed the engine.**

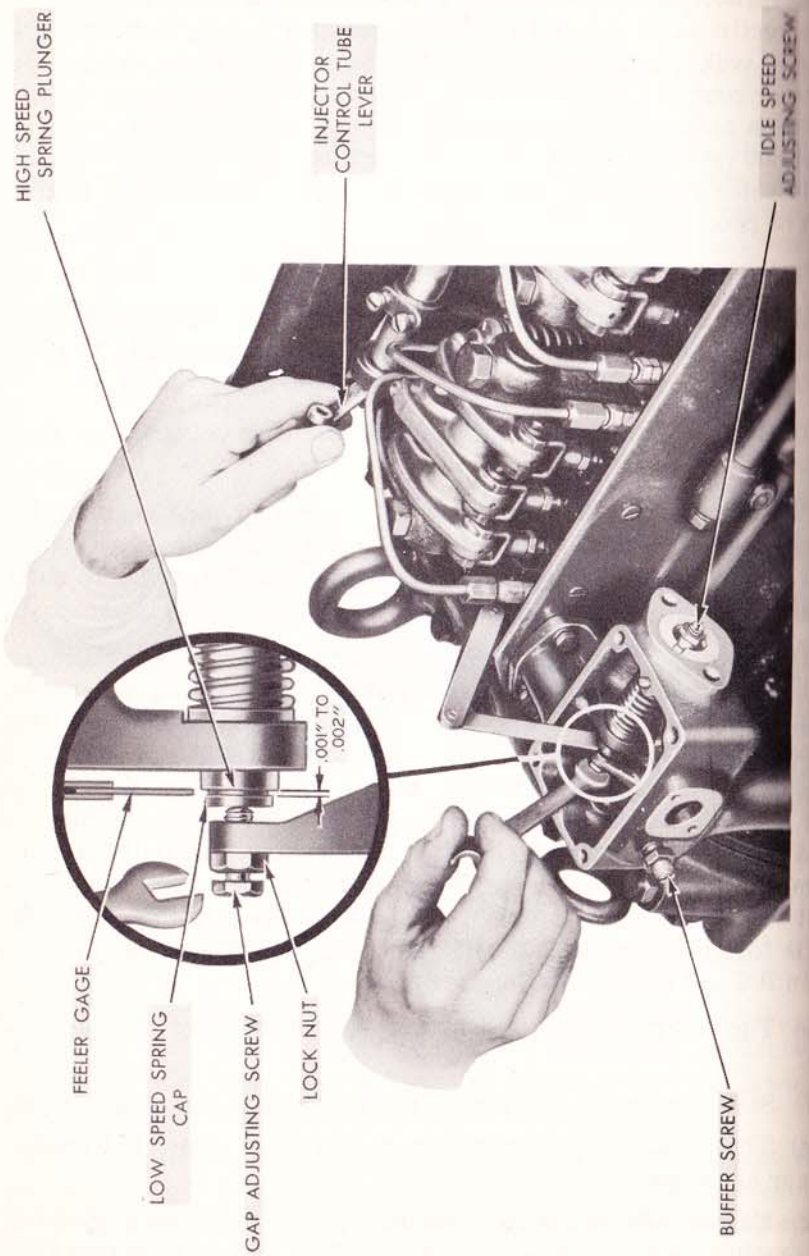
(d) Keep the engine running between 700 and 1000 revolutions per minute and set the gap adjusting screw so that the gap between the low speed spring cap and the high speed spring plunger is .001 to .002 inch. The gap may be measured with a .0015 or .002 inch feeler gage inserted between cap and plunger. NOTE: If no feeler gage is available, the gap setting may be roughly checked by inserting a screwdriver between the governor housing and gap adjusting screw, and using it as a lever. When gap is properly set, the movement between cap and plunger will be barely perceptible when the gap is forced closed with the screwdriver, with engine running between 700 and 1000 revolutions per minute.

(e) Tighten the locknut each time before checking the gap setting.

(f) Stop the engine and install the link and the governor cover.

(g) The injector racks must be re-positioned (par. 49 **h**) after the gap has been set.

(2) **Engine idle speed adjustment.** The correct idling speed is 500 revolutions per minute (minimum). It is highly important that



the idling speeds for the two engines be equalized. To equalize engines, follow the procedure for throttle linkage adjustment and synchronizing engines given in paragraph 89. When the throttle linkage is correctly adjusted, changes in the idling speed of the engine are effected by means of governor adjustments as follows:

(a) Remove the spring cover at the rear of the governor control housing, exposing the idle-adjusting screw.

(b) Loosen locknut and back out the buffer screw until it projects about 5/8-inch from the governor housing.

(c) Start engine and warm up to operating temperature.

(d) Move governor control lever to set against the idling stop in the control cam, and let engine run at idle. If engine gallops, after it has become thoroughly warmed up, gradually turn the buffer screw until the engine roll disappears, or nearly disappears.

(e) Turn the idle-adjusting screw in or out to set the idling speed of the engine at 400 revolutions per minute. (Neither engine should be set to idle at less than 400 revolutions per minute. Since engine cannot be **exactly** synchronized, the speed of the slower engine must be at least 400, while the other engine may be slightly faster.)

(f) Adjust buffer screw (see following).

(g) **Buffer screw adjustment** (fig. 46). The purpose of the buffer screw adjustment is to prevent low speed engine roll and stalling. To adjust (after the screw has been backed out as directed for low speed adjustment in the preceding paragraph), turn the buffer screw in to bring the idle roll to a minimum. CAUTION: Do not raise the idling speed of the engine by more than 20 revolutions per minute with the buffer screw adjustment, or it may be impossible to shut down the engine.

(h) When the adjustments are completed, install the spring cover over idle-adjusting screw.

d. **Governor weight and housing assembly removal and inspection** (figs. 52 and 53). To remove the governor weight and housing assembly, first remove the governor control housing assembly (par. 50 b), and proceed as follows:

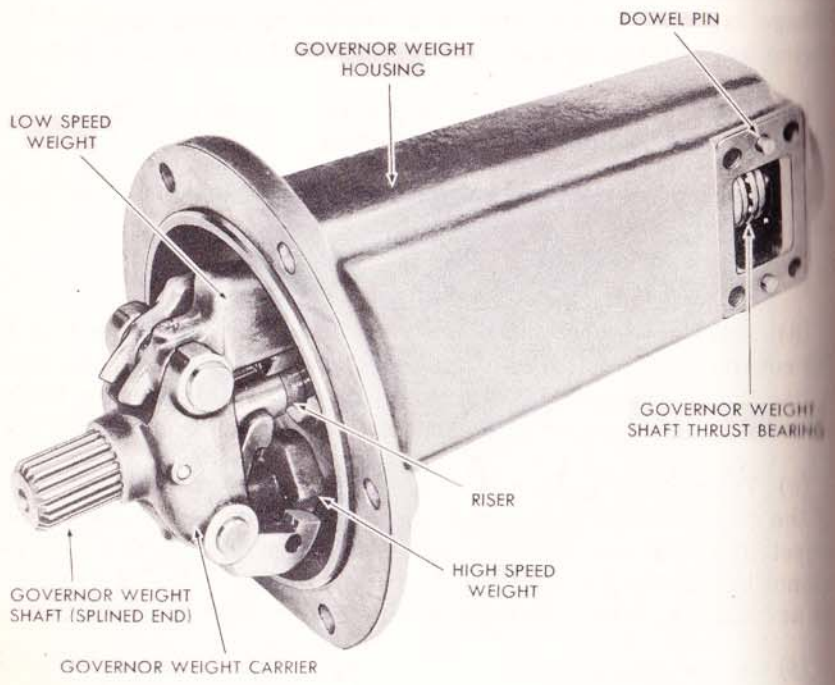


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Figure 52—Governor Weight and Housing Assembly

(1) Remove the middle air cleaner and the one nearest the governor.

(2) Remove the six bolts which attach the weight housing to the blower (½-inch box wrench).

(3) Separate the governor weight shaft from the front blower shaft by pulling the assembly straight out (fig. 53).

(4) Check condition of bearings.

(5) Check operation of weights to see that they move freely.

(6) Check the riser to see that it moves freely on the shaft.

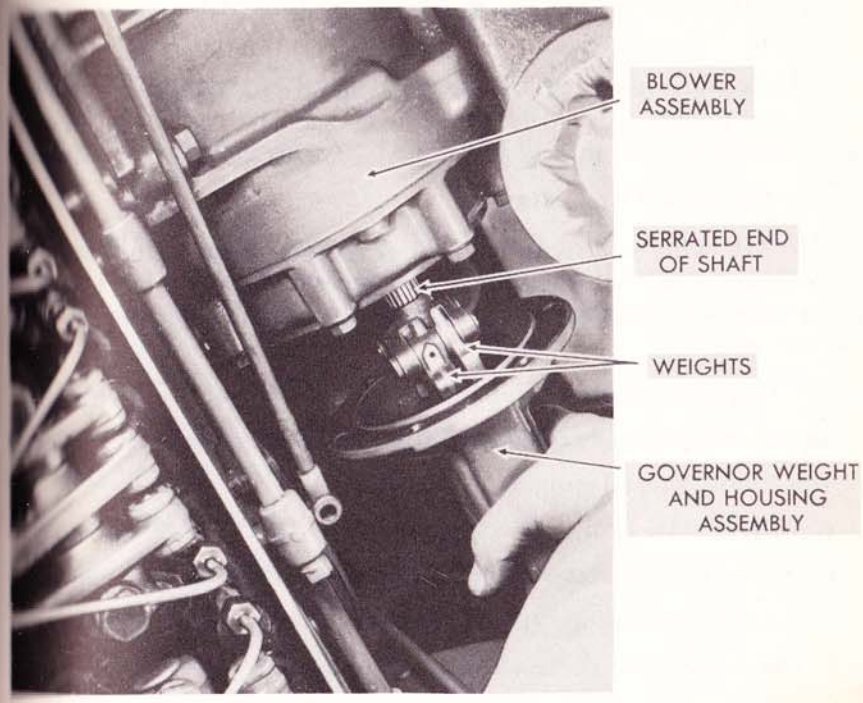

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Figure 53—Removal of Governor Weight and Housing Assembly

(7) NOTE: Should parts need replacement or service, notify ordnance maintenance personnel.

(8) Replace by reversing steps (1), (2), and (3). CAUTION: The ball thrust bearing and the thrust washer must be between the yoke of the vertical operating arm lever and the sliding sleeve (riser) on the weight carrier shaft. (See fig. 50).

51. ENGINE TUNE-UP.

Should engine performance indicate the need for a general engine tune-up, the following operations should be performed:

a. Clean **fuel filters** (par. 75 **d** and **e**).

b. **Check fuel pressure.**

(1) Remove pipe plug from front end of upper fuel manifold.

(2) Attach pressure gage to pipe connection with a short length of tubing.

(3) Measure fuel pressure at engine speed of 2000 to 2100 revolutions per minute. A fuel pressure of at least 25 pound per square inch should be maintained. If the fuel pressure is low, check for:

(a) **Insufficient fuel in tanks.**

(b) **Air being drawn into the fuel system.** Inspect for leaks at fuel connections from the tank to the fuel pump, at the bowl gasket of the primary fuel filter (par. 75 **d**) on the bulkhead, and at fittings for air heater lines.

(c) **Clogged fuel filter elements.**

(d) **Partly plugged fuel lines** (ice or dirt).

(e) **Faulty fuel oil pumps.** (See par. 55 **d**.)

c. Adjust valve lash (par. 48 **c**).

d. Time injectors and adjust injector racks (par 49 **f** and **h**).

e. Adjust buffer screw (par. 50 **c** (3)).

f. Check governor control of injector racks.

(1) Start the engine and idle at 1000 revolutions per minute for a few minutes.

(2) Drop speed to normal idling speed and then quickly throw the throttle to **full throttle** position, pushing on the control tube lever with the finger to move the injector racks farther toward full throttle position. (This operation must be executed quickly, before the engine comes up to the governed speed.) If the governor low speed plunger gap adjustment and rack setting are correct, pushing on the control tube will not move the injector racks. Next, test as in **g**, following.

g. Test the governor for no fuel position during engine deceleration. With the engine running at maximum speed, quickly move the throttle lever to the idling position. The injector racks should move all the way in to the **no fuel** position, if the buffer screw adjustment is correct. Check to make sure that the fuel is cut off by watching the exhaust while the engine is slowing down from full speed. There should be no visible exhaust, and no sound of engine firing. If the

cylinders continue firing, and if the exhaust is blue, the buffer screw adjustment should be corrected (par. 50 **c** (3)).

h. Check lubricating oil pressure. The oil pressure gage on the instrument panel should register 30 pounds (minimum) at 2100 revolutions per minute. Low oil pressure indicates one or more of the following conditions:

(1) **Oil supply low.**

(2) **Crankcase oil diluted by fuel.** Check odor of oil in crankcase for traces of fuel. If fuel is present in crankcase, check for fuel leaks (par. 45 **i** (2)).

(3) **Improper lubricant.** (See **Lubrication Guide,** par. 26.)

(4) **Crankshaft or connecting rod bearings worn.** (Notify ordnance maintenance personnel.)

(5) **Oil pressure regulator valve sticking.** (See par. 59 **d**.)

(6) **Oil scavenger pump intake screens clogged.** Remove and clean screens (par. 59 **c**).

(7) **Oil cooler clogged.** Replace. (See par. 61 **b**.)

(8) **Oil pump drive inoperative.** Remove oil pan (par. 58 **b**) and inspect oil pump drive. (If service is needed, notify ordnance maintenance personnel.)

(9) **Oil lines clogged or improperly tightened, or broken gaskets at pipes. Remove oil pan** (par. 58 **b**), inspect gaskets, tighten connections. If oil lines are clogged because of dirty and sludging oil, the lubricating system should be thoroughly purged (par. 25 **b**).

i. Replace oil filter element (par. 60 **b**).

j. Check thermostat. If water temperature remains below 165 F (74 C), the thermostats should be inspected.

(1) Drain the cooling system (par. 80 **d**).

(2) Remove the thermostat housing (par. 70 **c**) and lift thermostats out of seats for inspection (see fig. 68).

(a) Thermostat valves should be fully closed and seated at temperatures below 158 F (70 C).

(b) Thermostat valve should be wide open (⅜-inch) at 185 F (85 C).

(3) Thermostats that do not close or open fully at the given temperature should be replaced.

52. STARTING MOTORS.

a. Description. Each engine has its separate starting motor, a Delco-Remy 24-volt heavy-duty unit mounted on the outer side of the engine at the rear (fig. 23). The starters are controlled by means of starting buttons, one for each engine, on the instrument panel (fig. 7). To facilitate engine trouble-shooting and tune-up, auxiliary starting switches (see fig. 30) are provided in the engine compartment on the filter panel.

b. Starter replacement. If the starter fails to function, first check the battery and its connections. If the starter requires replacement, proceed as follows:

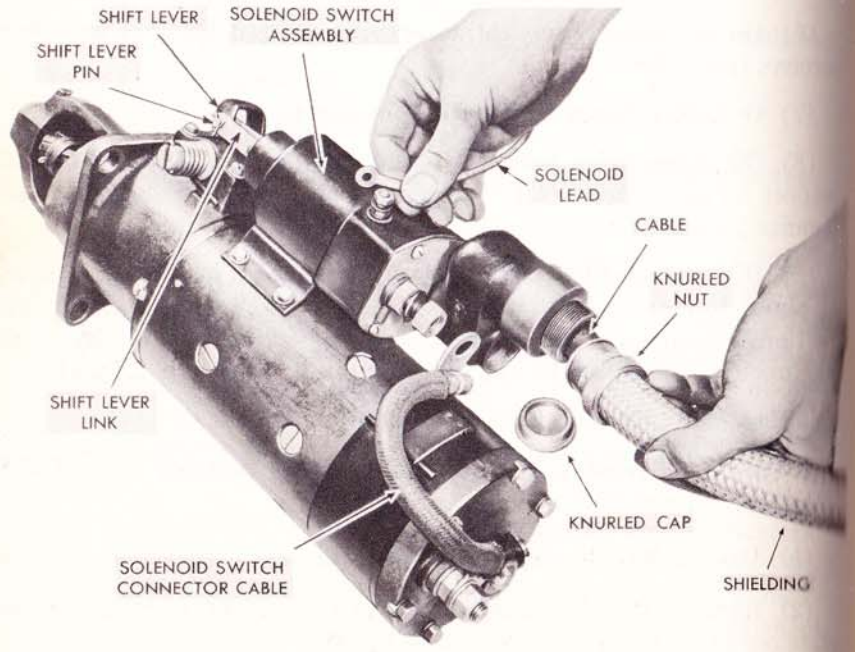


Figure 54—Removal of Engine Starting Motor

(1) Disconnect cables from battery.

(2) Disconnect yellow wire with black tracer from the starter solenoid (fig. 54).

(3) Remove the inspection plate (par. 71 **b** (2)) beneath the engine from which the starter is to be removed.

(4) Drain oil from the engine oil pan and from the lubricating oil tank (par. 25 **b**).

(5) Remove the two flexible oil sump lines underneath engine from the oil tank and the oil pan.

(6) Remove the three mounting bolts at the rear of the starter assembly (⅞-inch open-end or box wrench). The top bolt can be removed from the top of the engine by removing the middle and the front air cleaners. Cover open air intake. The lower two bolts are reached from beneath the engine.

(7) Remove clip holding shielded battery cable to bottom of engine (½-inch socket wrench).

(8) Lift the starter toward the fan end of the engine until it is clear, then lower it through the inspection plate opening, without removing shielding and cable.

(9) Remove, by hand, the knurled terminal shield from cap at the front end of the solenoid assembly, beneath the starter cable shielding.

(10) Remove the nut (¾-inch socket and ratchet-handle wrench) and lock washer recessed into the opening from which the knurled terminal shield cap has just been removed. (This nut holds the battery cable clip to the solenoid terminal stud.)

(11) Loosen, by hand, the knurled nut which holds the cable shielding to the solenoid assembly. Retract the shielding, then pull out the battery cable, being careful not to cut through insulation. The starter assembly is now completely detached.

(12) To install the starter assembly, reverse the order of the foregoing.

c. To replace starter solenoid and switch assembly (fig. 54).

(1) Remove starter assembly (par. 52 b).

(2) Remove cotter pin and disconnect shift lever links from starter shift lever.

(3) Remove the four mounting screws (⅜-inch wrench) holding the solenoid to the starter assembly, and remove the solenoid and switch assembly.

(4) Reassemble by reversing the foregoing.

d. Lubrication. The starting motor should be lubricated by ordnance maintenance personnel whenever the engine or starter is removed from the engine compartment. There are three oiling points—one at each end of the starter, and one inside the engine flywheel housing, reached by removing a plug. CAUTION: Do not over-oil the starter. Never put oil on the commutator or brushes.

53. AIR HEATERS.

a. Description.

(1) Auxiliary starting equipment is not necessary for starting at temperatures above 40 F (5 C). For starting at lower temperatures, two air heaters (see fig. 24) are provided for each engine. The heaters are operated while the engine is cranked with the starter to provide immediate engine response. The air heater is essentially a small pressure oil burner with electric ignition, mounted in the engine air box. Air for combustion is obtained from the engine blower, and the flame-heated air is forced directly into the cylinders.

(2) Each air heater consists of three units. One comprises the hand-pressure pump and ignition switch, mounted on the instrument panel (fig. 7). The second contains the burner nozzle, filter, and ignition electrode. (There are two of these heaters per engine, one mounted on the second hand hole cover plate and the other on the fifth.) The third unit is a high tension ignition coil, mounted on the filter panel (fig. 71) in the engine compartment.

(3) The hand pump supplies fuel under pressure to the burner unit. A firm hand pressure of ten pounds or over on the pump plunger knob will deliver finely atomized fuel, which is ignited by the spark at the electrodes of the burner. The engine usually starts

firing during the first or second pumping stroke in combination with the starter. At low temperatures, the engine may require continued help from the air heater until the engine develops sufficient power to run unassisted. Under these conditions, it is advisable to pause briefly at the end of each pumping stroke, to allow the engine time to absorb the heat generated. At temperatures of 10 F (-12 C) or lower, the heaters should be kept in operation until all engine cylinders are firing.

b. Maintenance. Should an air heater fail to function, remove the assembly, containing the burner nozzle, filter, and ignition plug, for inspection and service or replacement. If the nozzle is plugged or parts are damaged, the assembly should be replaced.

c. Replace air heater.

(1) **Remove air heater coil** (see fig. 71).

(a) Remove the two bolts that hold the cover to the coil.

(b) Remove the leads and the coil.

(2) **Remove air heater unit** (see fig. 24). (The following steps apply to either air heater of either engine, as installed in the second and fifth hand holes.)

(a) Remove the inspection plate beneath the engine **opposite** the engine from which air heater is to be removed.

(b) Remove the two bolts holding the air heater cover to the air heater body (½-inch socket wrench).

(c) Remove the bolt, slotted or hex head (screwdriver or $\frac{7}{16}$-inch open-end wrench) and the clip holding the fuel inlet tubes to the air heater body.

(d) Disconnect the couplings at both ends of the tubes ($\frac{7}{16}$-inch open-end wrench) and remove the tubes.

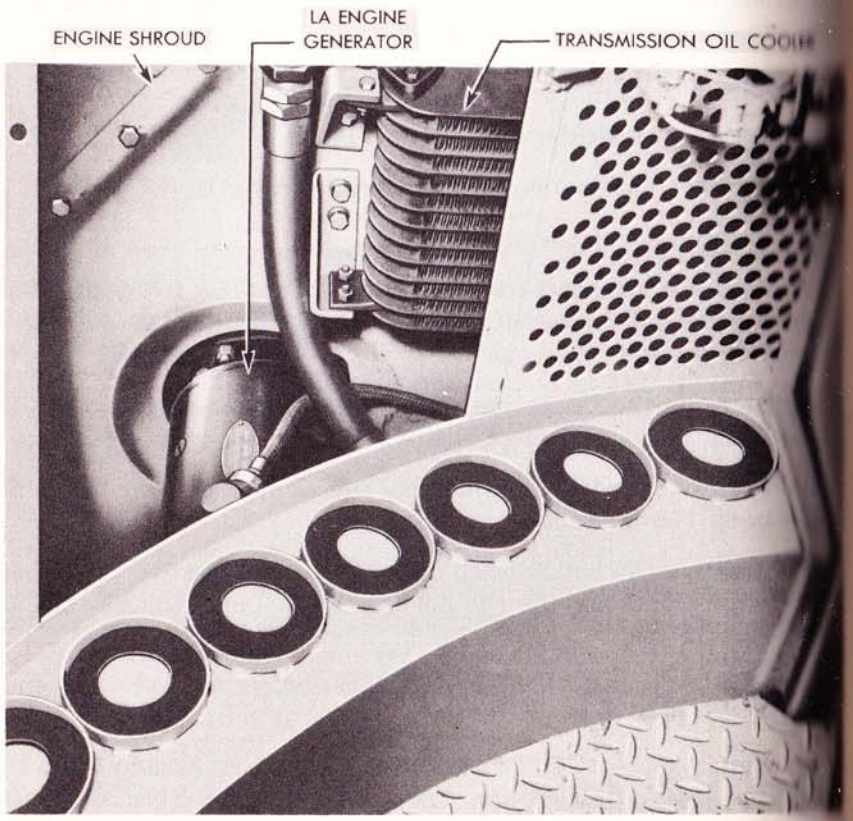
(e) Remove the bolts, lock washers, and copper gaskets from the air heater body (9/16-inch socket wrench). Remove the air heater bodies from the engine block.

(f) Install by reversing the preceding steps, using a new copper gasket.

54. GENERATOR.

a. Description. One 24-volt 1200-watt generator is provided [illegible] each engine. It is mounted on the flywheel housing (see fig. 21) [illegible] driven from the blower drive shaft at 1.95 times engine speed.

b. Lubrication. One grease cup, reached from the fighting [illegible] partment, is provided for generator lubrication. The cup should [illegible] turned down one full turn every 1000 miles or 100 hours of [illegible] operation, and refilled with grease (general purpose, No. 2). **Never oil the commutator.**



RA PD [illegible]

Figure 55—LA Engine Generator as Seen from Turret Platform

[illegible] generator replacement. The procedure for generator replacement is the same for both engines, except that to remove the LC generator it is necessary to remove the auxiliary generator first (see par. 71 b (28)).

(1) **Removal.**

(a) Disconnect cables from battery.

(b) Working through opening in turret basket (see fig. 55), remove the knurled cap nut and the knurled nut on the shielding [illegible] and the terminal nut (9/16-inch socket wrench) on top of the generator.

(c) Remove shielded cable from terminal on side of generator [illegible] cable up out of the way.

(d) Remove the nuts and lock washers from the four through [illegible] and two studs (two 9/16-inch open-end wrenches) which hold generator to the engine. (Bolt heads must be held from the [illegible] compartment side.)

(e) Remove the generator through opening in turret basket.

(f) Cover opening into engine with suitable covering.

(g) Remove coupling ring.

(h) Remove gasket.

(2) **Installation of generator.** To install generator, use a new gasket, and reverse the steps for removal.

[illegible] Polarizing generator. The generator field coils must be polarized whenever the field coil lead has been disconnected, to be sure that the generator has the correct polarity in relation to direction of armature rotation. **Polarizing must be done before engine is started.** Failure to do this will result in serious damage.

(1) Traverse turret to obtain access to radio filter at top of battery box.

(2) Remove radio filter face plate (three screws).

(3) Connect jumper wire (long enough to reach field terminal on [illegible] of the generator) to battery terminal at bottom of radio filter.

(4) Disconnect generator wire from generator field terminal.

(5) Momentarily touch jumper wire to generator field terminal [illegible] establish contact. (CAUTION: Do not maintain the contact.)

This operation allows a surge (or flash) of current to flow to the generator field windings, which correctly polarizes the generator.

(6) Connect generator wire.

(7) Remove jumper wire from radio filter battery terminal.

(8) Replace face plate on radio filter.

55. FUEL PUMP.

a. A vane type rotary fuel pump is bolted to the rear end of the blower housing of each engine. It has a capacity of about 40 gallons per hour.

b. At the 50-hour inspection, check for leakage at the joints and fittings.

c. Before the fuel pump is adjudged the cause of insufficient fuel, intake lines should be checked for leaks, and the fuel pressure should be checked (par. 51 **b**). If the fuel pressure is less than 25 pounds, at 2100 revolutions per minute, inspect primary and secondary fuel filters, and service them if necessary (par. 75 **d** and **e**).

d. To replace the fuel pump. Should the fuel pump fail to supply a sufficient quantity of fuel, the pump should be replaced with a unit in good operating condition. The procedure is as follows:

(1) Remove the three air cleaners from the engine.

(2) Disconnect the fuel pump lines (¾-inch and ⅝-inch open-end wrench) and move them out of the way.

(3) Remove the three bolts and lock washers which hold the fuel pump to the blower (½-inch open-end wrench, and special fuel pump wrench KMO 326-A (see fig. 22)).

(4) Remove the fuel pump and the fuel pump coupling fork by pulling the assembly toward the rear of the engine and lifting it upward and out. Exercise caution not to drop the coupling fork.

(5) Remove the gasket.

(6) Replace by reversing the preceding steps, installing a new gasket.

56. FUEL OIL MANIFOLDS.

a. Description. The fuel pump supplies fuel to the injector fuel

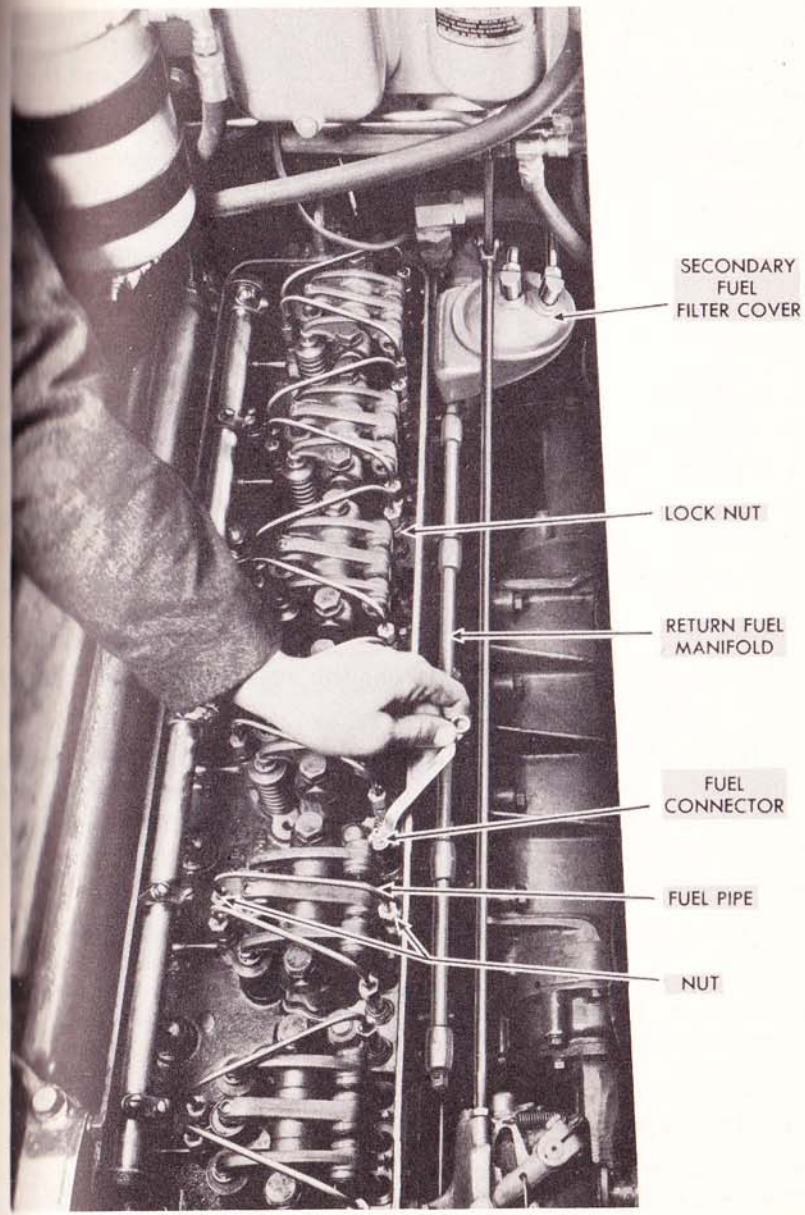


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Figure 56—Removal of Fuel Oil Manifold

pipes through the lower of two fuel manifolds, which are located on the side of the cylinder head (fig. 56). The upper manifold leads the excess fuel from the injectors to the return fuel line and thence to the fuel tank.

b. Maintenance. Fuel connectors, which fit into tapered seats in the manifold fittings, lock the fuel oil manifolds in position. The connectors must be removed whenever it is necessary to change a fuel manifold. Any leakage from the tapered seats would be noticeable on the outside of the cylinder head, since lock nuts and copper washers on the connectors prevent leakage inside the cylinder head.

c. Replacement of fuel oil manifolds (fig. 56). The following steps apply to the replacement of the return (upper) fuel manifold. (See (9) below for replacement of the supply (lower) manifold.)

(1) Close fuel tank selector valve and remove the secondary filter assembly by backing out the hexagon nut (1⅛-inch open-end wrench) beneath the assembly.

(2) Remove the rocker arm cover.

(3) Disconnect the fuel line from the rear end of the manifold (½-inch open-end wrench).

(4) Loosen the hexagon nuts holding the six outlet fuel pipes at the injector and disconnect the nuts holding the pipes to the fuel connectors (½-inch open-end wrench). Swing pipes away from connectors. NOTE: The outlet fuel pipe for each injector is the one toward the flywheel end of the engine.

(5) Loosen the lock nuts on the fuel connectors (⅝-inch deep socket wrench).

(6) Remove the fuel connectors (7/16-inch box wrench) and the copper washers. Always use new washers when connectors are replaced.

(7) Slide the manifold outward until it can be readily lifted out of the engine compartment.

(8) Install the return fuel manifold by reversing the preceding steps. NOTE: When installing fuel connectors for either manifold, first put them in place finger-tight only, making sure that the connectors seat firmly in the manifold. When all are in place, tighten them securely,

working from both ends of the manifold toward the middle, and tighten the lock nuts against the copper washers.

(9) The supply (lower) manifold is replaced in the same manner as the return (upper) manifold, except that at each injector the fuel pipe and the fuel connector toward the front of the engine are to be disconnected and removed, respectively. NOTE: it may be necessary to remove the governor control housing (see par. 50 **b**).

(10) CAUTION: Before replacing rocker arm cover, start engine and operate at about 2000 rpm. See that all fuel line connections are tight, so that no fuel oil can leak into the cylinder head and dilute the lubricating oil. If the lubricating oil is diluted with fuel oil, engine bearings may be seriously damaged. Check for fuel leaks at injector fuel pipe connections, at connector lock nut, copper washer, and at the fuel manifold holes on the outside of the cylinder head.

57. ENGINE LUBRICATION AND LUBRICANTS.

a. Specifications. See paragraph 26, **Lubrication Instructions.**

b. Engine lubrication system (see fig. 15).

(1) Positive lubrication of each engine is provided by a system consisting of an oil pump, an oil cooler, and two oil filters. (An oil strainer (see par. 60) is incorporated in late models.) A relief valve, housed in the oil pump, safeguards the system against excessive pressure, and an oil pressure regulator valve, attached to the rear of the cylinder block on the oil pan bolting flange, maintains a constant pressure in the oil lines.

(2) A by-pass valve in the oil cooler adapter, between the oil pump and the oil cooler, by-passes oil directly into the engine lubrication passages whenever the pressure at the oil cooler inlet becomes 40 pounds greater than the pressure at the cooler outlet.

(3) The oil pump assembly consists of one pressure pump and two scavenging pumps. The pressure pump draws oil from the external supply tank and forces it through the oil cooler and strainer to the main oil gallery in the cylinder block. The two scavenging pumps draw oil through intake screens from the two sumps in the oil pan and return it to the external supply tank.

(4) Vapors are removed from the crankcase, gear train housing, and

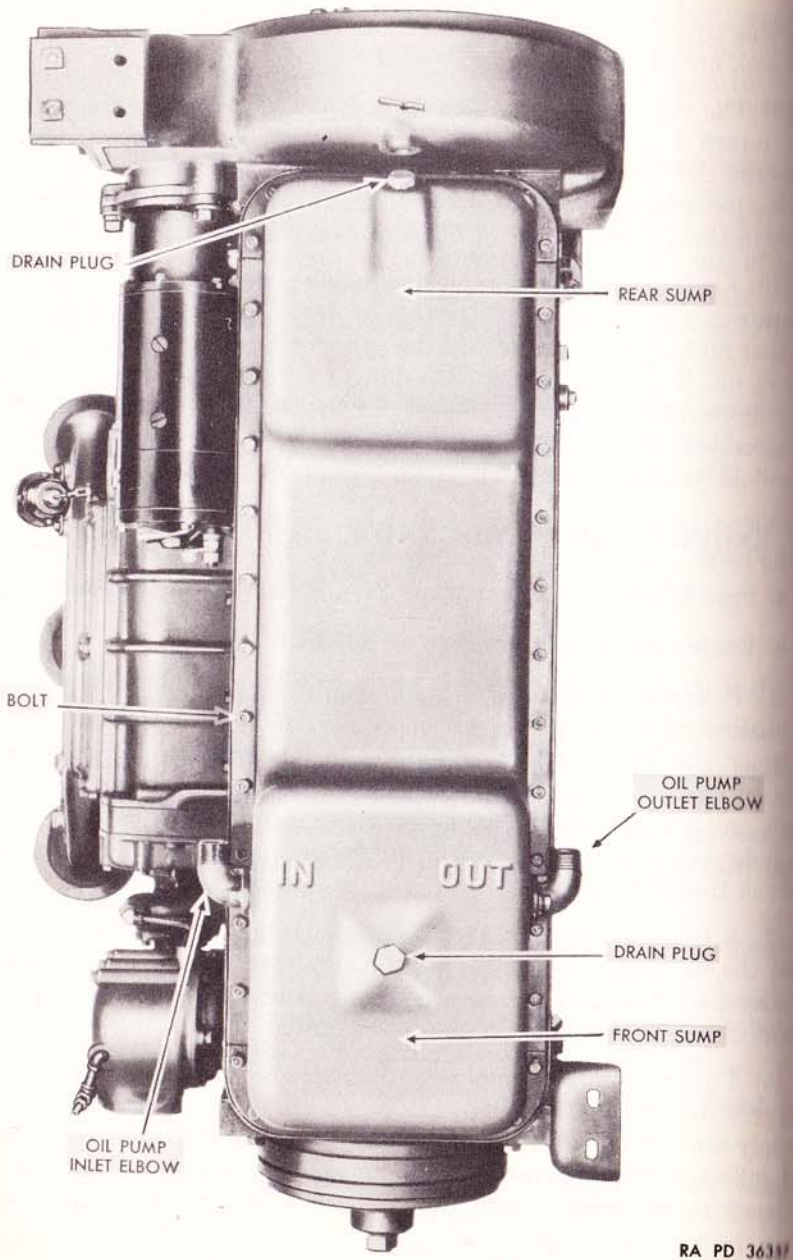

Figure 57—Engine Oil Pan

valve compartments, by a continuous ventilation system. A slight pressure is maintained in the crankcase by the seepage past the pistons of a small volume of fresh air from the air box. This air passes through the crankcase and gear train housing, and then into the valve compartment by way of a small hollow casting connecting the top of the flywheel housing to the rear corner of the cylinder head. Ventilating air is discharged from the cylinder head valve compartment through a vent leading from the governor control housing. With the first type air cleaners, the vent is a hose leading through the sponson plate; with the second type air cleaners, the vent is a casting, leading to the louvers of the No. 1 air cleaner.

58. **OIL PAN** (fig. 57).

a. **Access.**

(1) The oil pan at the bottom of each engine can be reached through an opening in the bottom of the tank hull, upon removing a bolted-on inspection plate.

b. **Removal of oil pan.**

(1) Remove the bottom inspection plate (par. 71**b** (2)), underneath the oil pan to be removed.

(2) Remove drain plug covers and drain oil tank.

(3) Drain the oil pan sumps by removing plugs.

(4) Remove oil inlet and outlet elbows from oil pan.

(5) Remove bolts, with their lock washers, which hold the oil pan to the crankcase (½-inch socket wrench).

(6) Drop the pan. (If the pan sticks in place, tap smartly on the sides with a soft hammer.)

(7) Remove the gasket from the pan or cylinder block flange.

(8) Install oil pan by reversing the preceding steps, first shellacking a new gasket to the oil pan and cleaning the cylinder block flange.

(9) CAUTION: When installing oil pan elbow gaskets, make sure that raised side is against oil pan, rings in holes and flat side against elbow.

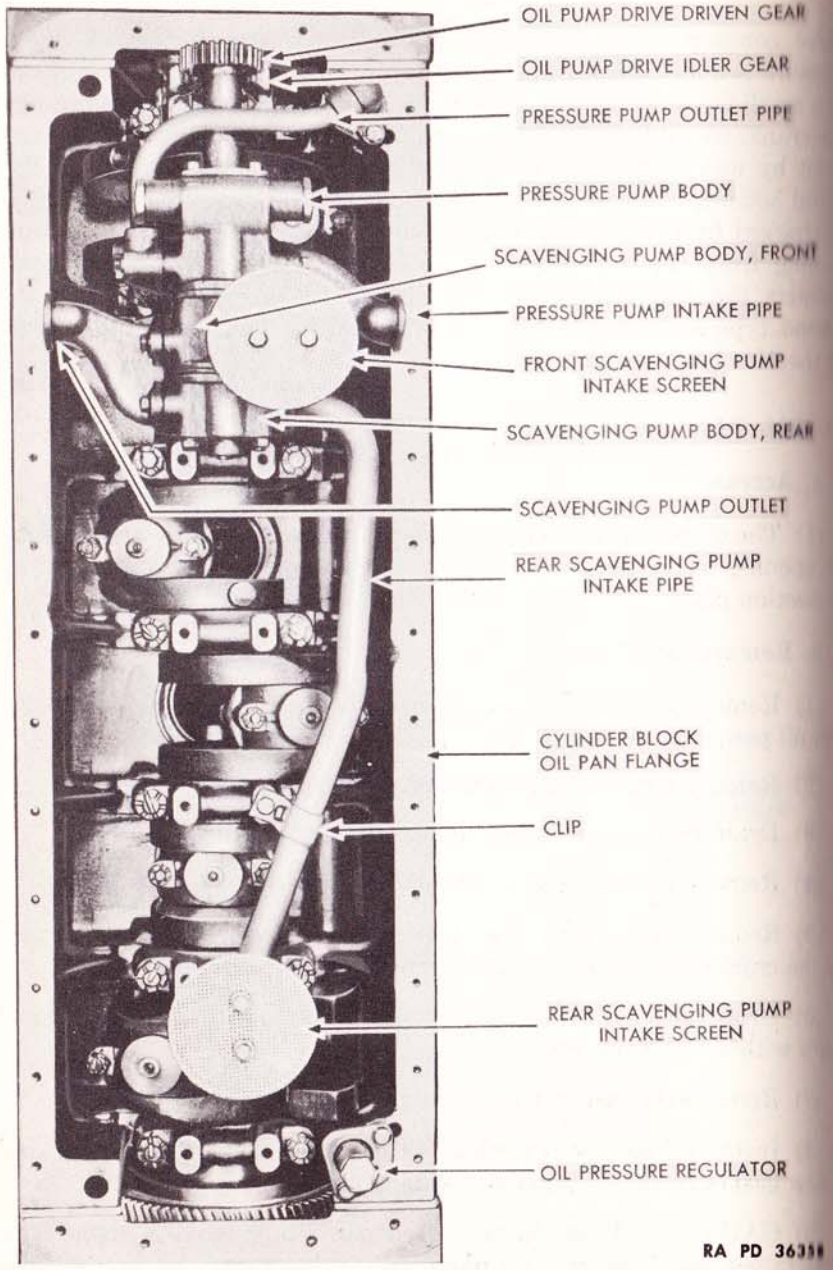

Figure 58—Oil Pump (Engine Oil Pan Removed)

59. **LUBRICATING OIL PUMP** (fig. 58).

a. **Description.** The gear-type oil pump is mounted inside the front sump of the oil pan, supported on the front two main bearing caps. The unit combines three gear-type pump units. The center (scavenger) pump draws oil from the front sump of the oil pan and the rear (scavenger) pump draws oil from the rear sump; both scavenger pumps return the oil to the supply tank outside the engine. The front (pressure) oil pump draws oil directly from the supply tank. It incorporates a plunger type relief valve, which by-passes oil to the intake side of the pump in case of excessive back pressure. The oil pump is driven from crankshaft by a train of three spur gears. This combination scavenger and pressure system permits operation of the engine on a slope up to 35 degrees in any direction.

b. **Replacement** (fig. 58).

(1) Remove the oil pan (par. 58 **b**).

(2) Remove the two capscrews holding the rear scavenger pump intake pipe bolting flange to the pump body.

(3) Remove the rear scavenger intake pipe clip capscrew at No. 5 main bearing cap, and remove the intake pipe and screen.

(4) Remove bolts (lock washers) which attach the pressure pump outlet pipe to the cylinder block and oil pump.

(5) Remove the four bolts (9/16-inch wrench) holding the oil pump assembly to the No. 1 and No. 2 main bearing caps. (Support the pump while removing the bolts.)

(6) Remove the oil pump assembly, with the outlet pipe.

(7) Install the oil pump by reversing these steps. NOTE: See that driving gears have backlash, that is, a very slight play between the teeth on the oil pump rear and idler gear. If necessary, shift pump on supports to obtain this play.

(8) With pump properly located and both gaskets affixed to flanges, assemble outlet pipe, tightening screws into cylinder block and pump body alternately so that pipe is free from strain.

c. **To clean scavenger oil pump intake screens** (fig. 58). After the oil pan has been removed (par. 58 **b**), each intake screen may be cleaned.

(1) Remove the two bolts (lockwashers) which hold the screen to the oil pump or to the rear scavenger pump intake pipe, and remove screen.

(2) Clean the screen with a brush and fuel oil or kerosene.

(3) Install screen, lockwashers, and bolts.

d. To inspect oil pressure regulator valve (fig. 58). The oil pressure regulator valve should be inspected whenever the oil pan is removed. Remove the two bolts (lockwashers) and valve from the cylinder block and test valve plunger for free action. Remove the old gasket, and use a new one when installing the valve.

60. FILTERS AND STRAINER.

a. Purpose. To protect bearings and bearing surfaces from damage due to foreign particles in the lubricating oil, and to prevent clogging of oil passages, the lubricating oil circulating system for each engine incorporates two oil filters. In later models, an oil strainer is included, in addition to the filters.

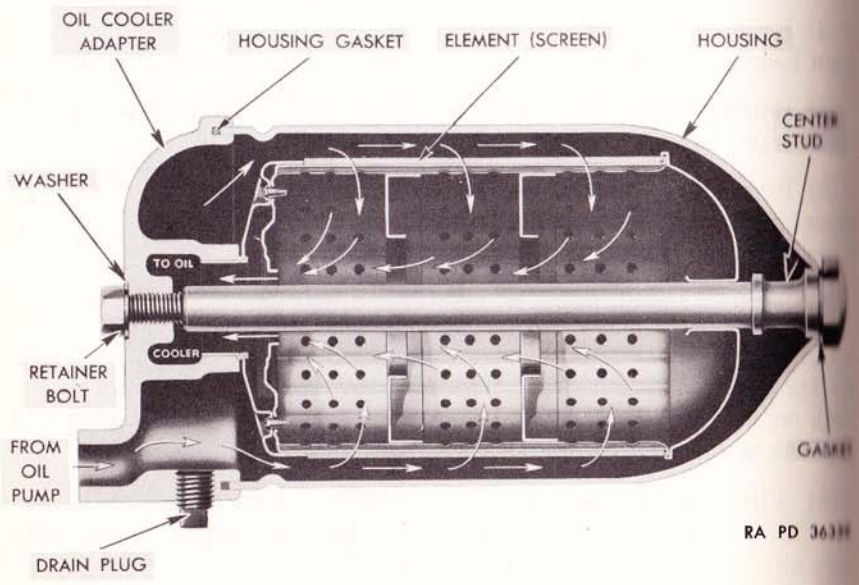

Figure 59—Lubricating Oil Strainer

b. Maintenance. Both the strainer and the filters should be maintained in efficient operating condition by frequent attention.

(1) **Lubricating oil filters** (fig. 30).

(a) **Description.** Two AC senior military (replaceable element type) lubricating oil filters are provided for each engine. The four filters are mounted on the accessory panel in the engine compartment. Oil is piped (see fig. 15) to each filter from one of the oil passages in the cylinder block, and returns via the filter clean-oil discharge pipe to the rear sump of the engine oil pan.

(b) **To change filter element.** The filter element in each oil filter must be changed at oil change periods; it cannot be cleaned. To change filter element:

1. Stop engine. (It is desirable that the engine be hot, to prevent excessive loss of oil when the element is withdrawn from the filter housing.)

2. Remove the housing cover by loosening the retainer nut at the top.

3. Withdraw the filter element, with the element seating spring.

4. If the housing contains appreciable sludge, flush it out with fuel oil after removing the drain plug near the bottom of the housing.

5. Install a new filter element on the center stud in the housing, with the small end of the seating spring turned up.

6. Install the housing cover gasket.

7. Put on the housing cover. (Be sure the seating spring is in place, so that the filter element will be properly positioned.)

8. Draw the retainer nut snug against the nut gasket, but not tight enough to bend the cover.

9. Run engine at 1000 rpm and examine cover for oil leaks.

(2) **Lubricating oil strainer** (fig. 59).

(a) **Description.** All the oil drawn from the supply tank by the pressure pump is forced through the oil strainer, between the pump and the engine oil cooler (see fig. 15), except when the strainer and cooler relief valve opens (because of clogged strainer or oil cooler) and permits the oil to flow directly into the engine oil gallery. The strainer consists of a housing enclosing a strainer element. The housing and strainer are

held by a retaining bolt, which runs through both, and screws onto a shorter retaining bolt which passes through the oil cooler adapter housing. Oil discharged from the pressure pump is led into the housing and is forced through the .005-inch openings in the strainer, which retains any larger particles on its outer surface. Whenever the strainer coats up rapidly with carbon and sludge deposits, it is an indication that the lubricating oil in use is unsuitable.

(b) **Cleaning oil strainer.** The lubricating oil strainer should be cleaned after the first 50 hours or 500 miles of operation, and thereafter as its condition indicates. To clean the strainer, proceed as follows:

1. Remove plug and drain oil from oil cooler adapter.

2. Loosen retainer at the samll end of the strainer housing by turning the bolt head counterclockwise.

3. Pull housing, strainer, retainer, and retainer gasket away from oil cooler adapter.

4. Remove strainer element from retainer and thoroughly wash inner and outer surfaces by rinsing in clean fuel oil. **Do not use stiff wire brush for cleaning.** A fine wire or a bristle brush will be satisfactory. **Be sure strainer is clean before re-installing it.**

5. Remove all sludge from inside of housing.

6. Examine large circular composition gasket—embedded in oil cooler adapter—against which the strainer housing seats. If gasket is damaged so that tight seal cannot be maintained, replace gasket.

7. Position strainer collar into oil cooler adapter.

8. Install housing over strainer.

9. Install new gasket under head of retainer, insert retainer through small end of housing, and tighten it securely.

10. Replace oil drain plug.

11. After starting engine, check for oil leaks.

61. LUBRICATING OIL COOLER.

a. Description. Each engine is equipped with an oil cooler (see fig. 23). The pressure pump forces oil through the passages of the oil cooler unit, which resembles in construction the radiator core of an

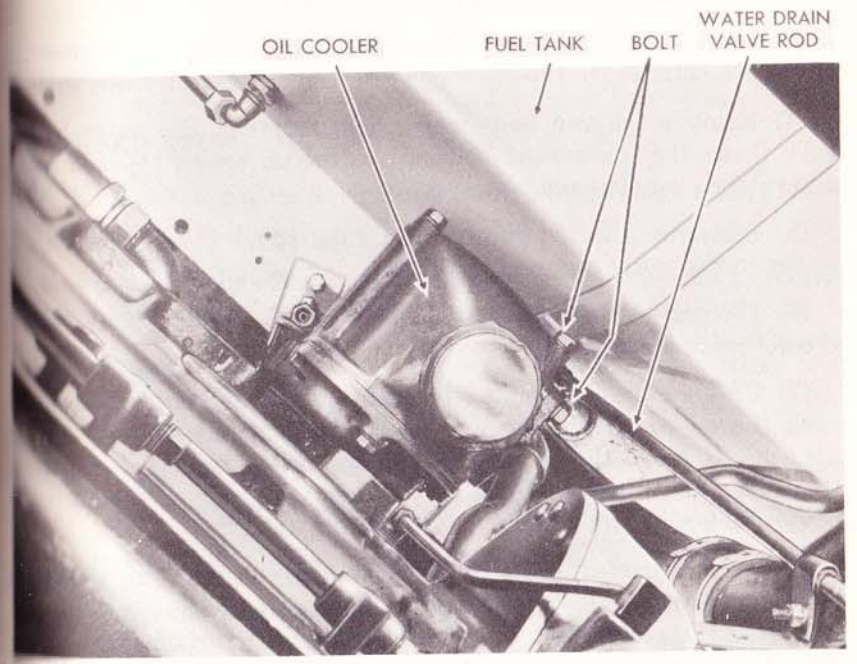

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Figure 60—Removal of Engine Oil Cooler

automobile. At the same time, water from the cooling system circulates between the thin-walled oil passages. When the oil is hotter than the water, some of its heat is transferred to the water. During the engine warm-up period, the water trapped in the cylinder block by the thermostats warms up rapidly, and since it circulates through the oil cooler by way of the water by-pass tube, it serves to raise the engine oil temperature quickly, thus promoting engine efficiency. An oil cooler by-pass valve (par. 58 **b** (2)) is provided to let the oil by-pass the cooler, should the cooler become clogged.

b. Replace the oil cooler (fig. 60). The oil cooler may be removed with the engine in place in the tank, provided certain other units are first removed. To remove cooler:

(1) Drain cooling system (par. 80 **d**).

(2) Remove the fuel tank (par. 76 **c**) adjacent to the oil cooler. (NOTE: In some models, it is not necessary to remove tank.)

(3) Remove the two bolts holding the flange of the water connection (from the radiator) to the lower end of the cooler (⅝-inch box wrench).

(4) Remove the two bolts which hold flange of the water by-pass tube (from the thermostat housing) to the oil cooler (½-inch socket and ratchet handle wrench).

(5) Disconnect water pump drain tube running from back of oil cooler to the water pump housing.

(6) Disconnect the clip holding the water drain valve control rod to the governor housing.

(7) Unscrew the eight bolts (six on the outside and two on the inside) from the oil cooler adapter and cooler housing respectively (½-inch wrench). Remove the cooler by sliding it away from the adapter on the engine and lift out. CAUTION: When withdrawing the oil cooler, be careful not to drop or damage the cooling unit.

(8) When removed, the oil cooler should be cleaned out, preferably by a jet of steam mixed with a soapy solution. If steam cannot be used, submerge the cooler unit in a vessel containing carbon tetrachloride (or other solvent), and force the liquid back and forth through the plates. (Use carbon tetrachloride only in the open air or in well ventilated space; its fumes should not be breathed.)

(9) Install the oil cooler by reversing the preceding steps. Use new gaskets at all points. (Shellac gaskets on the oil cooler side, and install cooler before the shellac dries.)

c. Removal of oil cooler by-pass valve. The engine lubricating oil cooler by-pass valve is mounted in the engine oil cooler adapter. On early models, not equipped with the lubricating oil strainer, the by-pass valve is on the side of the adapter. On later models, the valve is on top of the adapter. Upon removing the oil cooler (and/or adapter), check to be sure by-pass oil passages are clear and that the by-pass plunger operates freely. To remove by-pass valve from adapter:

(1) Remove hexagonal head plug.

(2) Remove special gasket.

(3) Lift out oil pressure relief valve spring.

(4) Remove valve plunger.

(5) Clean parts and install by reversing procedure. NOTE: Be sure that all parts are seating properly and that by-pass valve is closed, so that oil will circulate through oil cooler.

62. LUBRICATING OIL TANK (fig. 18).

a. Each engine has its separate oil tank, filled through a filler hole on its own side of the tank in back of the turret (see fig. 26).

b. Oil tank replacement. Either lubricating oil tank can be replaced without removing the engine. Proceed as follows:

(1) **Removal.**

(a) Remove governor control housing (par. 50 **b**).

(b) Remove the air intake housing (par. 63 **b**).

(c) Drain the cooling system (par. 80 **d**).

(d) Remove the blower assembly (par. 65 **b**).

(e) Drain the lubricating oil tank (par. 25 **b** (1) and (2)).

(f) Detach the two oil sump lines from the oil tank (9/16-inch box or open-end wrench).

(g) Remove the breather hose which leads from the top of the flywheel housing and gear train cover of the engine to the oil tank.

(h) Disconnect and remove the oil filler pipe. Loosen the clamp at the oil tank with a screwdriver and remove the two bolts (¾-inch open-end or box wrench) which hold the upper end of the pipe to the hull. Cover the filler pipe opening in the oil tank to keep out dirt.

(i) Disconnect the green lead from the oil level gage at the oil tank. Remove the clamp immediately above, which holds wire shielding, and move shielding and lead to one side. (See fig. 18.)

(j) Remove the strap which holds the tank in place by removing the top and bottom strap bolts (¾-inch open-end wrench).

(k) In addition to the bolts removed from the cover plate beneath the lubricating oil tank, two bolts which hold the tank at the bottom must be removed (¾-inch open-end wrench).

(l) Close the fuel tank selector valve and remove the fuel pump to secondary fuel filter tube, together with clip that attaches it to blower drive bearing support (5/8-inch and 9/16-inch wrenches).

(m) Remove the fire extinguisher tube by backing off the hex nuts (1-inch open-end wrench) at each end. This tube is attached at the top to a fitting near the bulkhead and at the bottom near the lower side of the engine.

(n) Remove the three mounting bolts (7/8-inch open-end and box wrenches) at the rear of the starter assembly. The top bolt can be reached from the top of the engine, the lower two through the inspection plate beneath the engine.

(o) Slide the starter assembly back, lower it, and rest it on a block beneath the engine. Do not disconnect starter cable and shielding.

(p) Turn the oil tank toward the space formerly occupied by the starter (see fig. 18) and lift it out.

(q) Install the tank by reversing the preceding steps.

63. AIR INTAKE SYSTEM.

a. Description (fig. 23). Three air cleaners on each engine remove dust and dirt from the air before the air enters the blower. These air cleaners are mounted on the air intake housing, which is attached to the blower housing. As each engine piston nears the end of its down stroke, a charge of air, forced into the cylinder by the blower, sweeps the burnt gases out through the exhaust valve ports. At the beginning of the compression stroke, the cylinder is filled with fresh clean air.

b. To replace air intake housing gaskets.

(1) Remove the air cleaners (par. 64 **c**).

(2) Disconnect wire from the emergency air shut-down valve solenoid.

(3) Remove the two bolts which hold the fuel tank and lubricating oil tank center strap in place (3/4-inch wrench). (The lower bolt must be reached from below the tank; therefore, the inspection plate beneath the engine must first be removed.) Move the strap toward the rear of the tank a few inches.

(4) Unscrew the six bolts and lockwashers which hold the intake

housing to the blower housing (9/16-inch open-end wrench). (Bolts can not be removed from the intake housing until it has been removed from the tank.) The three upper and the front and rear lower bolts are accessible from the top of the engine. The center lower bolt is accessible from beneath the engine.

(5) Remove the air intake housing with the gasket, striker plate, and the air intake combination screen and gasket.

(6) Install new gaskets as needed and reassemble, reversing the foregoing.

c. Air box drains (see fig. 24).

(1) **Description.** In normal operation, a small volume of vapor from the air charge condenses and settles to the floor of the air box, which is the hollow part of the cylinder block surrounding the cylinders. To drain off this condensation, and oil that enters through the cylinder ports, passages drilled in the ends of the cylinder block lead from the air box floor to vents or openings below the floor on the outside of the block, on the exhaust side of each engine. Each opening is fitted with a connection and a short length of tubing. CAUTION: Air box drains must be kept open to discharge freely at all times. If oil accumulates in the air box, the engine may run away, damaging the injector tips and cylinder head.

(2) **Clearing drains.** Whenever engine inspection plates are removed, check engine drains to be sure passages are clean.

(a) With engines running, place finger close to drain tube. If a steady stream of air can be felt, drains are open. If a slight flow of air is felt, or no air at all, drains are partly or wholly plugged.

(b) Put compressed air line on end of tube and blow out tube and passage. Repeat until line is cleared. (Engines can be left running or stopped during this operation.)

(3) **Servicing.** The air boxes, drains, fittings, and tubes should be serviced whenever the power unit is removed from the tank.

(a) Remove hand hole cover plates on side of engine block, and inspect air box for accumulation of liquid or sludge. Clean out air box with lint-free rags, then blow out air box with compressed air.

(b) Remove drain connector and drain tube from vent, or opening, in lower part of cylinder block.

(c) With hand hole cover plates removed, blow out passages with compressed air.

(d) Disconnect connectors and tubes, clean thoroughly, and blow out with compressed air.

(e) Reassemble connectors and tubing. Install assemblies in air box vents or openings in cylinder block.

(f) Install hand hole cover plates.

64. AIR CLEANERS (fig. 61).

a. Description.

(1) Three oil-bath air cleaners are used on each engine, mounted on the air intake housing. They are serviced through the engine compartment doors. Three types of air cleaners are in use. The first has a single large, oval-shaped air intake port on its side. The second is larger and has horizontal slots, or louvers, running completely around the lower housing, instead of an air intake port. The third type is similar in appearance to the second, except that it has small vertical oval ports, a spring clip on each side of the upper body, and heavier wings on the wing bolt.

(2) NOTE: All six air cleaners on the power unit must be of identical type and size.

(3) Each type cleaner consists of a metal wool or screen filter element supported inside a sheet metal housing which contains a reservoir for oil. Air drawn into the cleaner by the blower passes through the oil bath, where most of the dirt is trapped, then up through the filter element, which removes the remaining (finer) particles of dirt, and finally down the central duct to the blower.

b. Maintenance. Air cleaners should be supplied with oil of the same viscosity as is properly used in the engines at prevailing temperatures. In extremely cold weather, lighter oil may be necessary. The oil reservoir should be cleaned and refilled daily when operating on dusty roads, cross country, or in sandy regions, and at least 250 miles when operating on paved roads or during wet weather. Desert operation and operation under other extremely sandy or dusty conditions will necessitate cleaning the air cleaners every eight hours, or more frequently as required, to maintain proper efficiency. NOTE: Under these conditions third type air cleaners must be cleaned every four hours or oftener.

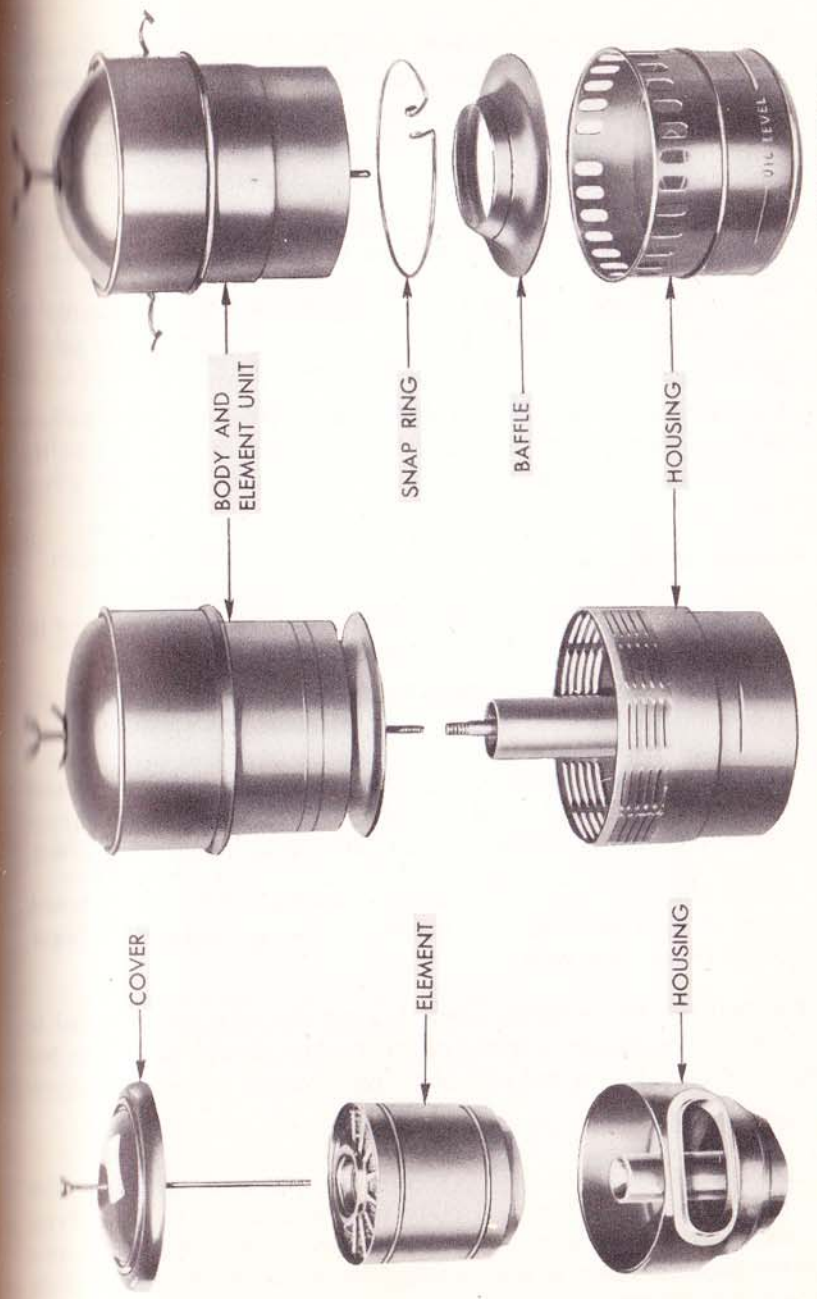


Figure 61—Air Cleaners, Disassembled

(1) The first type air cleaner, with large, oval-shaped intake opening on the side, should not have more than one quart of oil in its reservoir. CAUTION: **Disregard the oil level mark** on the housing, and fill the reservoir with just enough oil to cover the top of the bottom step in the reservoir, about ⅜-inch **below** the oil level mark.

(2) The second, or slotted, type air cleaner requires 3½ quarts of oil for each cleaner. Fill to oil level mark on the reservoir.

(3) The third type (identified by small oval air inlet ports and a spring clip on each side of the cleaner) requires 2½ quarts of oil for each cleaner. Fill to oil level mark on the reservoir.

(4) CAUTION: Filling any one of these air cleaners higher than here prescribed will cause oil to be drawn through the air cleaner into the engine, resulting in detonation or smoky exhaust, and possibly a run-away engine.

c. Remove air cleaners.

(1) Thoroughly wipe off outside of air cleaners, particularly at air intake housing, to avoid danger of dropping dirt into air intake.

(2) Loosen the wing bolts holding the air cleaners to the air intake housing.

(3) Lift out the air cleaners one at a time, beginning with air cleaner No. 2 (see fig. 25). CAUTION: Do not remove air cleaners with engines running, and use care in removing so as not to spill oil out of reservoir.

(4) Cover the openings in the intake housing with a clean board, plugs, tape, or other suitable cover to prevent dirt from entering blower. CAUTION: **Do not use rags.**

d. Recondition air cleaners. Since the air cleaners are designed to protect the engine against premature wear, they should be maintained at peak efficiency by careful and thorough reconditioning, as follows:

(1) Remove air cleaners (par. **c** preceding).

(2) Disassemble air cleaner. (On second type, unscrew wing nut after center bolt is removed, and pull body from reservoir. On third type, after center stud is removed, release clips and pull off top of cleaner assembly.) NOTE: Filter element cannot be removed from upper body of second or third type cleaner.

(3) With first type air cleaners, wash the filter element in clean Diesel fuel oil or gasoline, shake out, and drain dry.

(4) To service the second and third type air cleaners, lift the upper body assembly from the oil cup. On third type, remove snap ring and baffle from oil cup. Scrape out dirt and replace baffle and snap ring after washing oil cup, baffle, and snap ring in clean Diesel fuel oil or gasoline. CAUTION: On third type cleaner, it is absolutely necessary to change oil and thoroughly clean oil cup whenever (or before) the deposited dirt in the bottom of the cup reaches a maximum depth of one-half inch, or when the oil appears to be too thick or heavy to spray or circulate properly. Inspect and wash screen in upper body at least once a week. Replace gasket, if necessary. NOTE: It is not possible to replace the rubber gasket on the bottom of the oil cup. If gasket is damaged, install a new oil cup.

(5) On all air cleaners drain oil reservoir, remove sludge, and wipe clean.

(6) Refill oil reservoir of all type air cleaners with proper quantity of oil as prescribed in paragraph 64 **b**. CAUTION: Do not overfill.

(7) Assemble air cleaner, making sure that all sections are seated, and that gaskets and seals are in place. In type three air cleaners, be sure oil level is balanced on both sides of the baffle within the oil cup.

e. Install air cleaners. Starting at either end, place air cleaners in position, using care not to spill oil out of reservoirs. Make sure cleaners are properly seated on intake housing. Tighten wing bolts.

65. BLOWER (fig. 24).

a. Description. The blower of each engine forces air into the cylinders, to sweep out burned gases through the exhaust valve ports, and supply fresh air for combustion. Air enters the blower from the air-cleaners and air intake housing, and is picked up by the rotors and forced to the discharge side of the blower. Rotors may be seriously damaged if dirt, dust, or other foreign matter enters the intake housing. Wipe off exterior of parts and cover the openings when servicing.

b. Replace blower assembly (fig. 62). To replace the blower without removing the engine from the tank, it is necessary first to remove other units from the engine, as outlined in the following procedures:

MEDIUM TANK, M4A2

(1) Drain the cooling system (par. 80 **d** (1) and (2)) and close fuel tank selector valve.

(2) Remove air cleaners (par. 64 **c**).

(3) Remove governor control housing assembly (par. 50 **b**).

(4) Remove governor weight and housing assembly (par. 50 **d**).

(5) Remove two bolts (lockwashers) which hold the water pump discharge flange (see fig. 66) to the engine block (½-inch open-end wrench on the upper bolt; ½-inch socket wrench with a 6-inch extension ratchet handle on the lower bolt). Leave the water pump seal on the pump assembly.

(6) Disconnect the water by-pass tube at the water pump (7/16-inch wrench).

(7) Remove the air intake housing (par. 63 **b**).

(8) Cover the blower intake opening with a metal plate or other protective covering to keep out foreign material.

(9) Remove fuel lines from the fuel pump (¾-inch and ⅝-inch wrenches).

(10) Remove the nut (lockwasher) from the bolt which holds the fuel pump drip shield (9/16-inch, ⅜-inch drive socket and ratchet handle wrench).

(11) Remove the eight bolts (flat washers) which hold blower to the engine block (⅝-inch box wrench). NOTE: The four lower bolts can be reached only from the bottom of the engine compartment, which requires the removal of the inspection plate beneath the engine.

(12) Pull the blower toward the rear of the tank so that the serrated end of the blower driveshaft is pulled completely out of the blower timing gear (fig. 62), then tilt the driveshaft end of the blower upward until the assembly can be lifted from the engine compartment.

(13) Install the blower with a new gasket (par. 65 **c**) by reversing the preceding steps. When installing the serrated end of the blower driveshaft into the blower rotor gear, rotate blower rotors until the shaft slides freely into the gear.

(14) CAUTION: Do not permit weight of the blower to rest on the driveshaft, to avoid damaging the shaft. Rest the blower housing flange on the upper edge of the cylinder block.

POWER UNIT

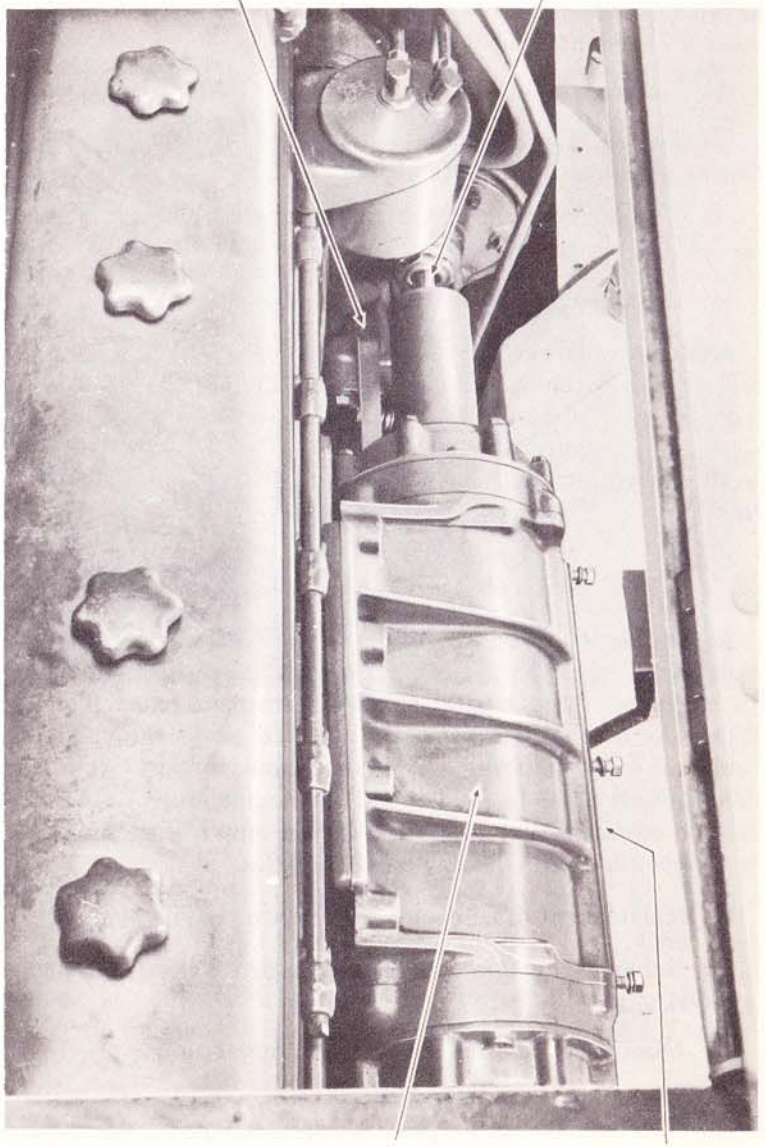


Figure 62—Removal of Blower RA PD 36362

c. Replace blower gasket. The blower-to-engine-block gasket should be replaced whenever the blower housing is removed or whenever gasket leaks are evident. Follow these steps:

(1) Remove the blower (par. 65 **b**).

(2) Remove the old gasket and clean the mounting surfaces of the blower housing and the engine block.

(3) Shellac the new gasket to the engine block. (Allow shellac to become tacky, but not dry, before installing the blower assembly.)

(4) Install the blower assembly (par. 65 **b**).

d. Replace blower driveshaft. The blower driveshaft may be readily replaced upon removing either the blower (par. 65 **b**) or the generator (par. 54 **c**). The easier method is to remove the generator. When the blower or the generator is removed, the splined blower driveshaft may readily be withdrawn from the blower rotor gear hub and the generator coupling.

66. ENGINE SHUT-DOWN VALVE (fig. 24).

a. Description. The air intake of each engine is equipped with an emergency engine shut-down valve, controlled by a solenoid. There is an emergency stop button on the instrument panel for each engine. When the button is pressed, the solenoid closes the valve, which prevents air from entering the blower, and thereby stops the engine. (The button must be held in till the engine stops.) CAUTION: This method of stopping the engine is for use only in case the engine cannot be stopped by means of the hand throttles.

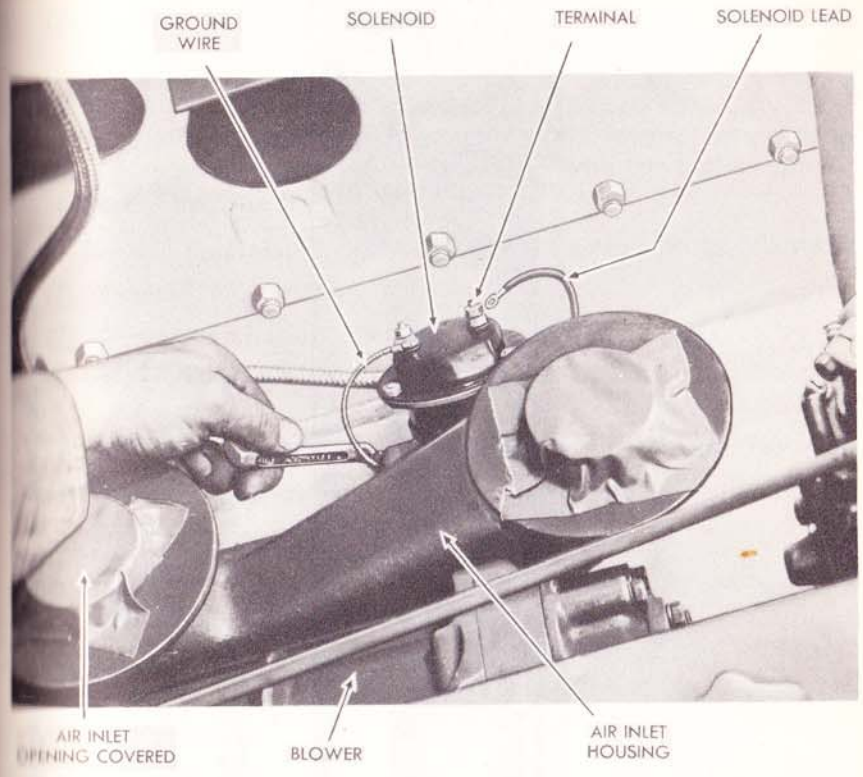
b. Replacement of solenoid. To replace the solenoid:

(1) Remove the two air cleaners nearest the front of the engine (par. 64 **c**).

(2) Disconnect the blue wire from the terminal on the top of the solenoid.

(3) Remove the cotter pin and clevis pin from the solenoid clevis.

(4) Remove the two mounting bolts (7/16-inch open-end wrench) and lift out the unit (see fig. 63). Note that one of the mounting bolts also holds the ground wire.



RA PD 36363

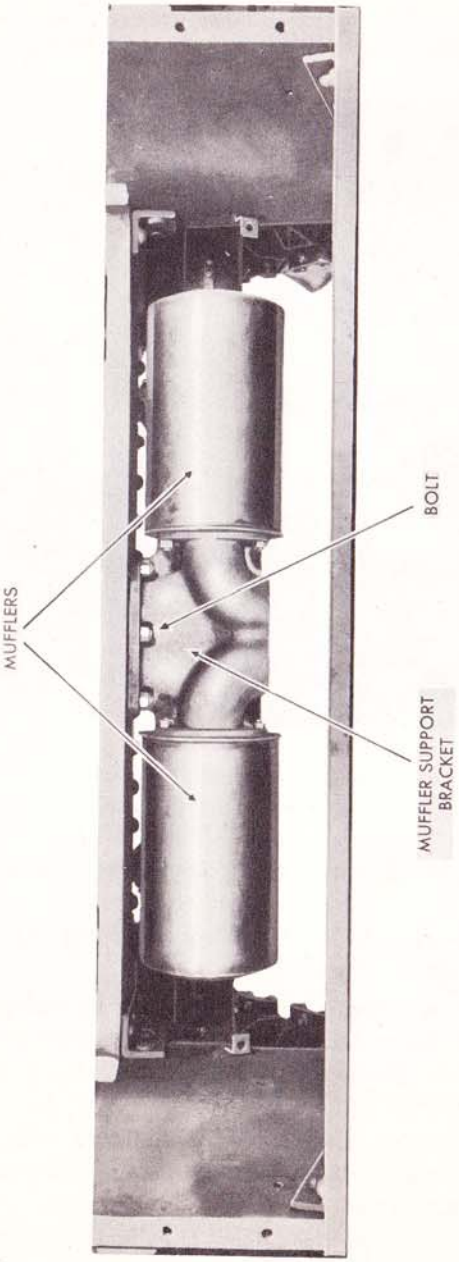
Figure 63—Removal of Air Shut-Down Valve Solenoid

(5) Install the solenoid by reversing the foregoing stops, adjusting the unit as outlined in **c**, next.

c. Adjustment of solenoid. It is important, when adjusting the solenoid plunger, to make sure that the air shut-down valve closes before the solenoid plunger reaches the bottom of its stroke. Make adjustment as follows:

(1) Close the air shut-down valve by hand and, with solenoid plunger bottomed in the housing, turn the clevis so that the holes line up with the hole in the valve lever.

(2) When holes are in line, turn the clevis one-half to one turn clockwise, toward the solenoid.



RA PD 36364

Figure 64—Exhaust Mufflers, as Seen from Above

(3) Insert the clevis end pin and cotter pin.

(4) Tighten the lock nut on the clevis.

67. **MUFFLERS** (fig. 64).

a. **Description.** A muffler is provided for each engine. An elbow and exhaust pipe connect each exhaust manifold with the muffler support, to which the mufflers are bolted.

b. **Replace mufflers.** Either muffler may be replaced as follows:

(1) Remove radiator (par. 81 **b**).

(2) Remove the muffler guard and deflector plate as a unit.

(a) Remove the two long brackets holding the deflector plate to the hull.

(b) Remove the four short brackets supporting the muffler guard.

(c) Remove the bolts holding the muffler guard to the hull.

(d) Remove muffler guard and deflector plate.

(3) Remove the four nuts (lockwashers) which hold the muffler to the muffler support (⅞-inch box wrench).

(4) Lift off the muffler.

(5) Install by reversing the preceding steps.

68. **FANS** (figs. 23 and 65).

a. **Description.** Each engine is equipped with a gear driven pusher-type five-bladed built-up steel fan. The fans operate at 2.21 times engine speed, forcing air from the engine compartment **out** through the radiator cores, to lower the temperature of the coolant as it moves through the cross-flow radiator. The fans revolve in opposite directions. Fan shaft housings are marked with arrows showing direction of rotation. CAUTION: Use great care to mount fans on proper engines, because fans mounted on wrong engines will draw air **into** the engine compartment, causing serious overheating. Fan assemblies are lubricated by an oil line leading from the engine oil gallery in the cylinder block to a fitting at the side of the balance weight cover. Pressure lubrication forces oil through the hollow idler gear shafts, idler gear bushings, and drilled gears, to the gear teeth. Splash off the gear teeth lubricates the fan shaft bearings.

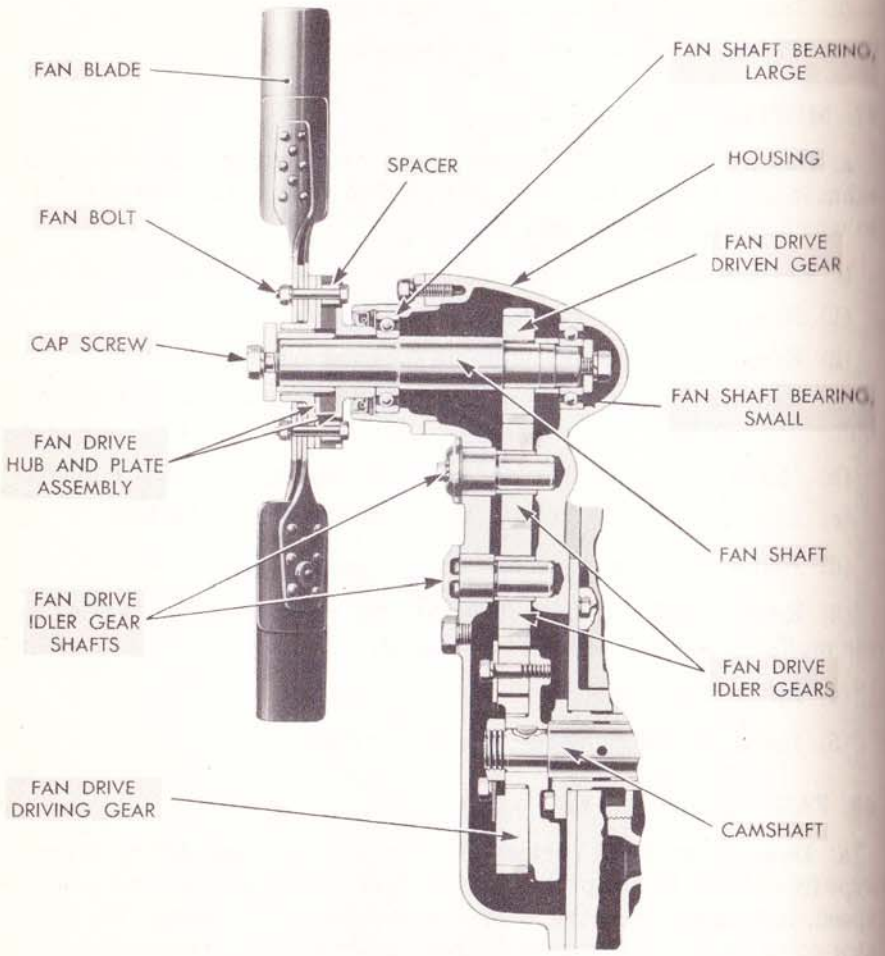


Figure 65—Removal of Fan Assembly

b. Fan assembly replacement (fig. 65).

(1) **Removal.** The fan assembly may be removed through the engine compartment doors without removing the top rear hull plates. To remove fan:

(a) Open engine compartment doors and raise splash guard.

(b) From the top of the engines, reach between fan blades and remove capscrew (¾-inch open-end wrench) that holds the fan drive plate and drive plate spacer to the fan shaft. NOTE: Remove lockwasher and plain washer with capscrew.

(c) Remove the six nuts (½-inch open-end wrench) and lockwashers from the bolts which hold the fan to the drive hub and plate assembly. Lift off fan and remove by maneuvering as necessary to clear through fan shroud. CAUTION: Be careful that fan blades do not damage radiator cores.

(d) Remove the six spacers from counterbore at rear face of drive hub and plate assembly.

(e) Remove fan drive plate and fan drive plate spacer from shaft.

(2) **Installation of fan.**

(a) Install fan by reversing preceding steps. **Be sure fan is installed on its proper engine.** (**See** CAUTION, par. 68 **a.**)

(b) Lower splash guard and close and bolt engine compartment doors.

69. WATER PUMP.

a. Description. A centrifugal water pump (see fig. 23) circulates water through the cylinder block, cylinder head, and radiator. The water pump ball bearing is filled with lubricant and requires no lubrication.

b. To replace water pump with engine in place (fig. 66).

(1) Remove the governor control housing (par. 50 **b**).

(2) Remove the governor weight and housing assembly (par. 50 **d**).

(3) Replace the rocker cover to protect valve and injector operating mechanisms.

(4) Drain cooling system (par. 80 **d**).

(5) Remove the two bolts (lockwashers) that hold the water pump outlet packing flange to the engine block (½-inch open-end wrench on the upper bolt; ½-inch socket wrench with a 6-inch extension ratchet handle on the lower bolts).

(6) Loosen the clamp on the inlet elbow (short screwdriver).

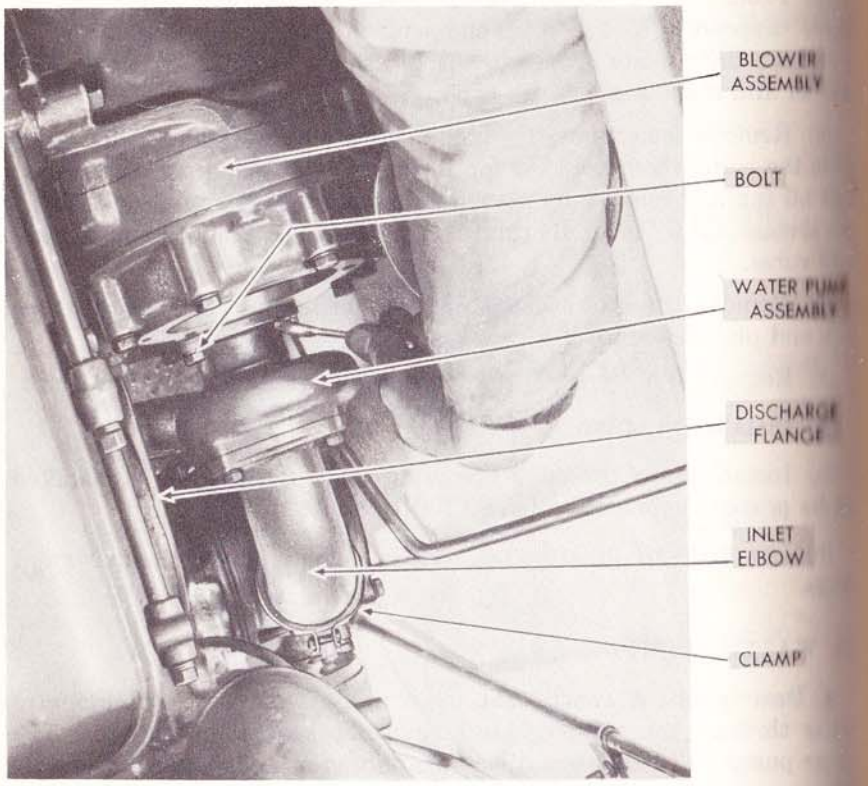


Figure 66—Removal of Water Pump

(7) Remove the three bolts that hold the water pump to the blow (½-inch open-end wrench and tool KMO-326A). (See fig. 66.)

(8) Pull the water pump toward the front of the engine and lift it ou

(9) Remove the gasket from the mounting flange and the rubb seal ring from the outlet flange.

(10) Install the water pump by reversing the foregoing steps. (Us new gasket or rubber seal ring if it is not in good condition.)

70. WATER MANIFOLD (fig. 67).

a. Description. A water outlet manifold is bolted to each cylind

Figure 67—Removal of Water Outlet Manifold

head. A thermostat housing containing two thermostats (par. 79) is attached to the front end of each manifold.

b. To replace water manifold (fig. 67).

(1) Drain the cooling system (par. 80 **d**).

(2) Remove thermostat housing and thermostats (see **c**, following).

(3) Remove the rocker arm cover. (Exercise caution in subsequent operations so that rocker arm assemblies and control tube will not be damaged.)

(4) Remove the water temperature capillary tube connection from the rear of the manifold (5/8-inch open-end wrench), and wrap it to prevent damage.

(5) Remove the twelve nuts (lockwashers) which hold the manifold to the cylinder head. (See fig. 67.)

(6) Lift off the manifold and remove the six gaskets (one for each attaching flange).

(7) Replace the water manifold by reversing the foregoing steps, installing new gaskets. Gaskets should be shellacked on the cylinder head side, and the manifold installed when the shellac becomes tacky.

c. To replace thermostats (fig. 68).

(1) Drain the cooling system (par. 80 **d**).

(2) Loosen the two hose clamps and force the hose upward on the radiator water inlet pipe.

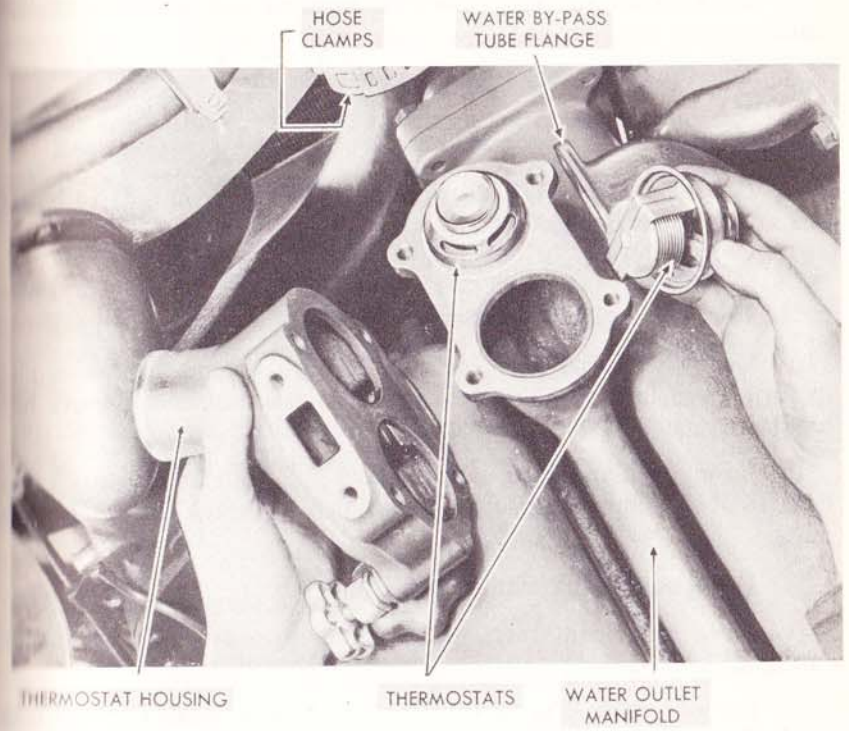
(3) Remove the four bolts (lockwashers) from the top of the thermostat housing and the two bolts (lockwashers) which secure the housing to the water by-pass flange (9/16-inch box wrench).

(4) Lift off the housing.

(5) Lift out thermostats.

(6) Install new gaskets, shellacking them to the housing and to the by-pass pipe flange when shellac is almost, but not completely, dry.

(7) Install thermostats and the housing by reversing the first five steps. (Make sure thermostats are in correct position, with supports crosswise. Inspect thermostats; replace if necessary.)



RA PD 11016

Figure 68—Removal of Thermostats

71. POWER UNIT REPLACEMENT.

a. To replace engines, facilities must include an engine stand, clean containers for drained lubricating oil and coolant, lengths of wire cable or chain equipped with hooks, and heavy-duty hoisting equipment (preferably an A-frame equipped with two heavy-duty chain falls). CAUTION: **Be sure ends of all wires are taped and all openings taped or covered.** For ease, speed, and accuracy in reinstalling fittings, tag or identify all parts removed. **Be sure that fuel tank selector valve is shut off.**

b. **Removal of power unit.**

(1) **Disconnect battery cables.**

(a) Turn off both battery switches and remove battery box cover.

(b) Remove slide covering electrical terminals on side wall of battery box.

(c) Disconnect battery ground cable from battery.

(d) Disconnect both starting motor flexible conduits from terminals in battery box.

(e) Loosen nuts holding starting motor flexible conduits to battery box and pull out cables.

(f) Replace slide and battery box cover for safekeeping.

(2) **Remove engine inspection plates.**

(a) Center rollaway-type jack under each engine inspection plate in turn, raise jack to hold plate firmly in position, and remove bolts holding plate.

(b) Lower jack and plate carefully and pull both from beneath tank. CAUTION: Remove personnel from beneath tank before lowering plate.

(3) **Drain engine lubricating oil system.**

(a) Place clean containers of 10-gallon capacity under each lubricating oil tank drain.

(b) Remove drain plugs and drain both engine lubricating oil tanks (par. 25 **b**).

(c) Drain engine lubricating oil sumps into clean 5-gallon containers.

(d) Remove and cover containers. NOTE: After engine lubricating oil has been drained, check to see whether it is in condition to be used again. If necessary, the engine lubricating oil systems will be refilled with fresh lubricating oil in the quantity and of the viscosity as prescribed in the Lubrication Guide (par. 26).

(e) Replace all drain plugs and tighten securely.

(4) **Disconnect lubricating oil pressure gage hoses.** Disconnect hoses from junction plates mounted on the inside of each cylinder block. NOTE: Connections are accessible only from beneath tank.

(5) **Disconnect air heater fuel hoses.** While engine lubricating oil is draining, disconnect air heater fuel hoses from junction plates mounted on the inside of each engine cylinder block. NOTE: Connections are accessible only from beneath tank.

(6) **Disconnect engine lubricating oil inlet and outlet hoses.** Disconnect hoses from both engines and lay hoses on tank floor close to lower fuel tanks. CAUTION: Be sure engine oil pan sumps are thoroughly drained before removing hoses.

(7) **Remove engine mounting bolts, fan end.** Through engine inspection openings, remove bolts from center engine mounting bracket at rear of engine compartment.

(8) **Drain cooling systems.** Drain coolant (par. 80 **d** (2)) into containers. NOTE: If antifreeze solution is being used, attach hoses to cooling system drain cocks and drain coolant into **clean** 10-gallon containers. Cover containers. (Capacity of each cooling system is 15 gallons.)

(9) Remove clips holding starting motor cables to engines. Attach wires to cables and pass wires up between sides of engines and lower fuel tanks, so that cables can be pulled up and wired to cooling system bleeder valve handles when lower sections of engine shroud are removed.

(10) **Remove engine compartment deck plates and splash guard** (fig. 26).

(a) Traverse turret manually to right or left until 75-mm. gun is at right angle to center line of tank. CAUTION: If traversed to left, be sure pistol port is closed.

(b) Remove all bolts around outside edges of deck plates where plates are bolted to hull, and the row of bolts across the top of the rear hull plate which hold the rear edge of the rear deck plate.

(c) Remove the two bolts directly in line with the division between the doors, and halfway between the lower edges of the doors and the rear of the tank. CAUTION: **Do not** remove the row of bolts running across the rear deck directly below the bottom edges of the doors, which fasten the door plates and the rear deck plate to the deck cross-brace.

(d) Unbolt and open engine compartment doors.

(e) Unhook splash guard and allow guard to rest on top of engines.

(f) Open lubricating oil filler pipe covers.

(g) Pass wire cable or chain down through right lubricating oil filler pipe opening, under deck plate and above splash guard, and up through left filler pipe opening, and hook to hoisting tackle.

(h) Close and bolt engine compartment doors.

(i) Hook hoisting tackle to engine compartment door handles, one hook to each handle. NOTE: The rear line(s) must be long enough so that when strain is put on hoisting tackle, the turret edge of the deck plate unit will break away first and the unit will assume an angle of about 20 degrees as it is lifted clear of the tank, filler pipe opening highest.

(j) Lift off deck plate unit slowly and carefully.

(k) Lift out splash guard.

(11) **Disconnect engine compartment throttle rods** (fig. 91).

(a) Remove cotter and clevis pins from yokes on both ends of horizontal throttle rods, and disconnect rods from governor control levers and from the outer cross-shaft levers mounted on the engine compartment bulkhead. Remove throttle rods.

(b) Remove cotter and clevis pins from yokes at upper ends of both vertical throttle rods (between engines at flywheel end) and disconnect rods from inner cross-shaft levers on engine compartment bulkhead.

(c) Lower vertical throttle rods between engines until they rest on tank floor. NOTE: In installing, drop wire between engines, fasten to yokes on vertical throttle rods, and pull up on wire.

(12) Remove air cleaners (par. 64 **c**). CAUTION: Cover air intakes tightly.

(13) Remove radiators (par. 81 **b**).

(14) Remove fan shrouds. Remove bolts, pull fan shrouds toward rear of tank, and lift out. (See fig. 70.) CAUTION: When installing fan shrouds, be careful to center shroud opening around fan in order to obtain full uniform clearance.

(15) Remove center radiator mounting plate.

(16) **Remove exhaust pipes.**

(a) Remove the four bolts (⅝-inch socket, extension, and ratchet handle) which hold exhaust elbows to engines, and lift elbows off exhaust pipes.

(b) Lift out exhaust pipes, and put exhaust elbows back on engines.

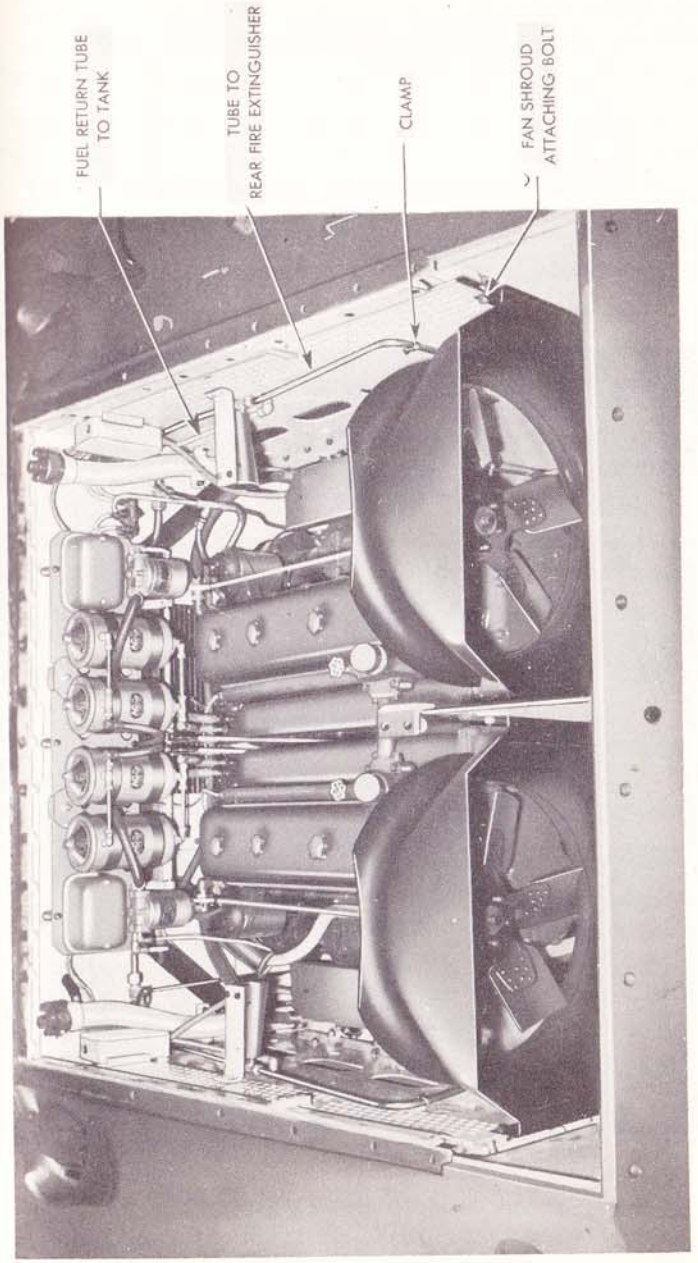
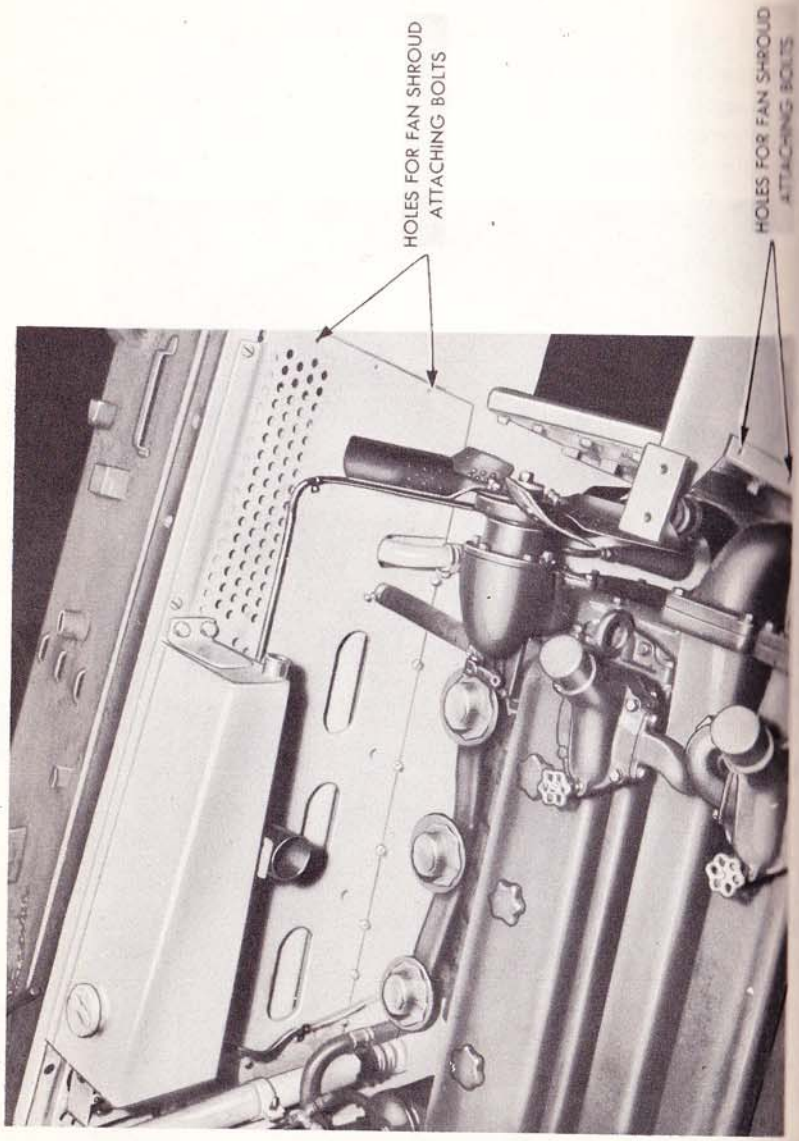


Figure 69—Power Unit Removal—Radiators and Water Tanks Removed



(17) Disconnect wires from both air shut-down valve solenoids, engine lubricating oil tank gages, and the starting switch wires from both starting motors.

(18) Loosen clamps and remove both governor breather hoses. NOTE: The second-type governor breather, a casting, used with the larger air cleaners, remains bolted to the governor.

(19) Remove both upper fire extinguisher discharge nozzles and brackets, rear vertical tubing, and lower rear discharge nozzles and brackets.

(20) Close engine cooling system drains.

(21) Remove all cooling system piping, hose connections, clamps, and both water expansion tanks (par. 83 **c**).

(22) **Remove filter panel** (figs. 71 and 72).

(a) Disconnect the four short engine lubricating oil hoses and the two long fuel inlet hoses from the junction plates on the top rear of the engines, beneath the filter panel. Leave fuel inlet hoses connected to primary fuel filters and threaded behind engine lubricating oil filters.

(b) Remove air heater coil covers from filter panel.

(c) Remove the two high tension wires from each set of air heater coils and pull wiring clear of panel, and coil wires on top of engine. Install core covers for safekeeping.

(d) Remove covers from each engine compartment terminal box.

(e) Disconnect the two wires in the left filter panel flexible conduit from their terminals in the left engine compartment terminal box.

(f) Remove nut holding flexible conduit to terminal box and pull wiring clear. Replace nut on flexible conduit.

(g) Repeat steps (e) and (f) on right filter panel flexible conduit. NOTE: There are **three** wires in this conduit.

(h) Replace covers of engine compartment terminal boxes.

(i) Disconnect lubricating oil tank breather hoses from both engines. Tape hose ends and engine fittings. Wire engine ends of hoses to lubricating oil tank filler pipe caps to keep hoses upright, out of the way.

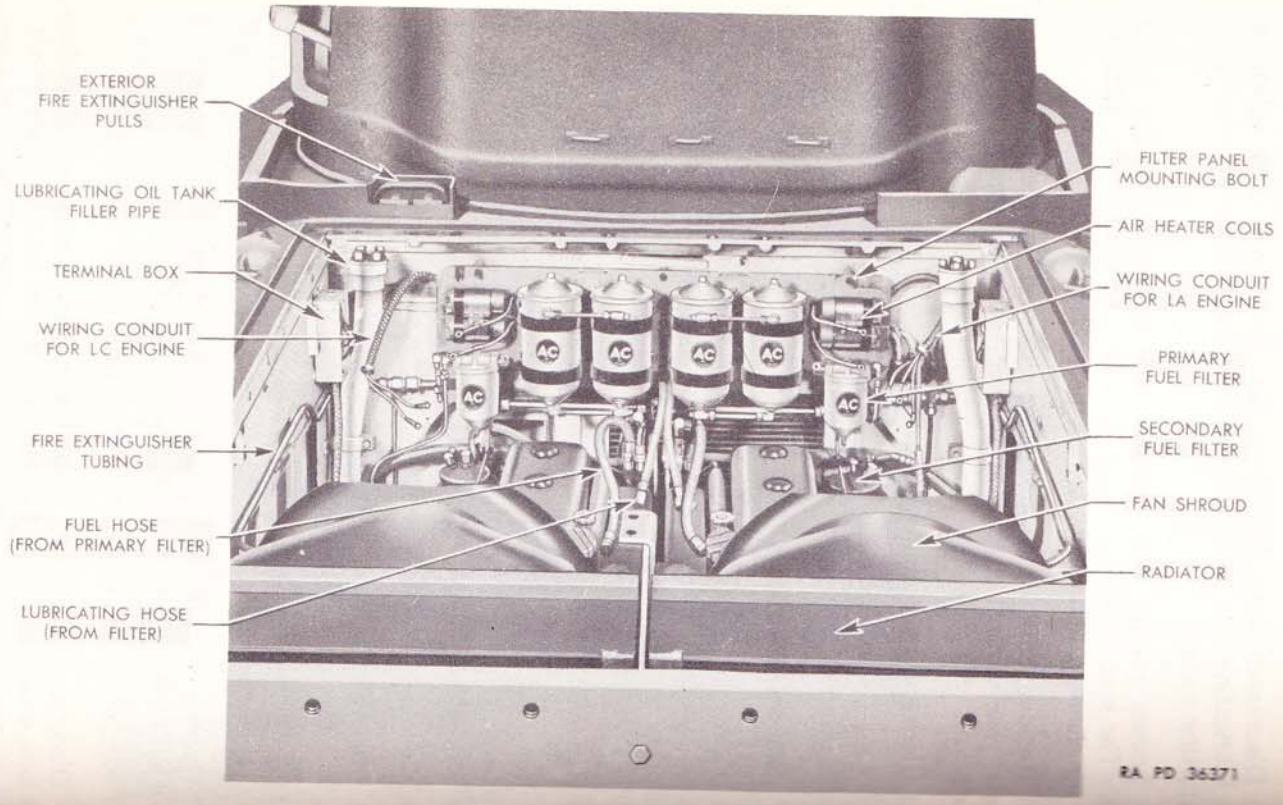


Figure 71—Removal of Filter Panel—Fuel and Lubricating Oil Lines Disconnected

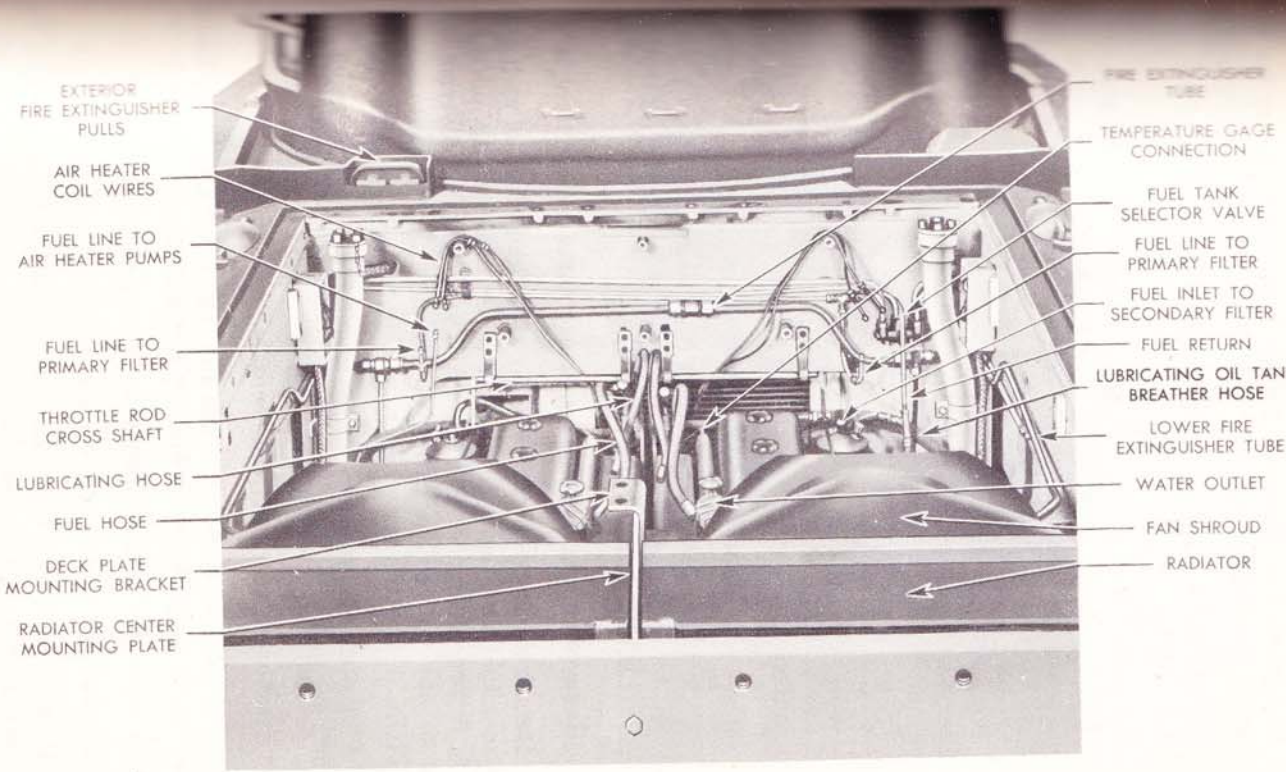


Figure 72—Power Unit Removal—Filter Panel Removed

(j) Disconnect fuel lines (see fig. 86) from both primary fuel filters mounted on the filter panel.

(k) Disconnect air heater pump fuel feed line (see fig. 86) from left primary fuel filter.

(l) Disconnect the two fuel return hoses from both engines and from the tee fitting (see fig. 86) on the end of the metal tubing leading to the fuel tank selector valve, and remove. Pull long hose clear of engine lifting brackets.

(m) Support filter panel with wood blocking, remove six bolts which hold filter panel to bulkhead (9/16-inch socket, extension, and ratchet handle), and lift out filter panel. (See fig. 72.)

(23) **Remove auxiliary generator muffler flexible outlet tubing.**

(a) Loosen clamp on outside of rear hull plate which holds auxiliary generator flexible outlet tubing.

(b) Loosen clip holding tubing to blower housing.

(c) Pull flexible tubing clear of rear hull plate and coil up on top of engine, so it can be pulled through opening in engine compartment bulkhead. (Leave asbestos covering attached.)

(24) **Remove engine water temperature gages.**

(a) Detach water temperature gages at bulkhead end of each engine water manifold and tag each water temperature bulb to aid in reinstalling in proper engine. Protect bulbs with suitable covering. Wire cables to any convenient fitting on engine compartment bulkhead. CAUTION: Use extreme care in removing bulbs.

(b) Plug openings in engine water manifolds. (Steps in engine compartment are now completed; see fig. 73.)

(25) **Disconnect rear universal joint.**

(a) Open hatch in turret platform and release spring catches holding rear section of propeller shaft housing to tank floor.

(b) Remove two bolts holding cover to engine shroud.

(c) Lift out rear section of propeller shaft housing.

(d) Remove bolts from universal joint companion flanges (see fig. 74). (Hold bolts as nuts are turned off.)

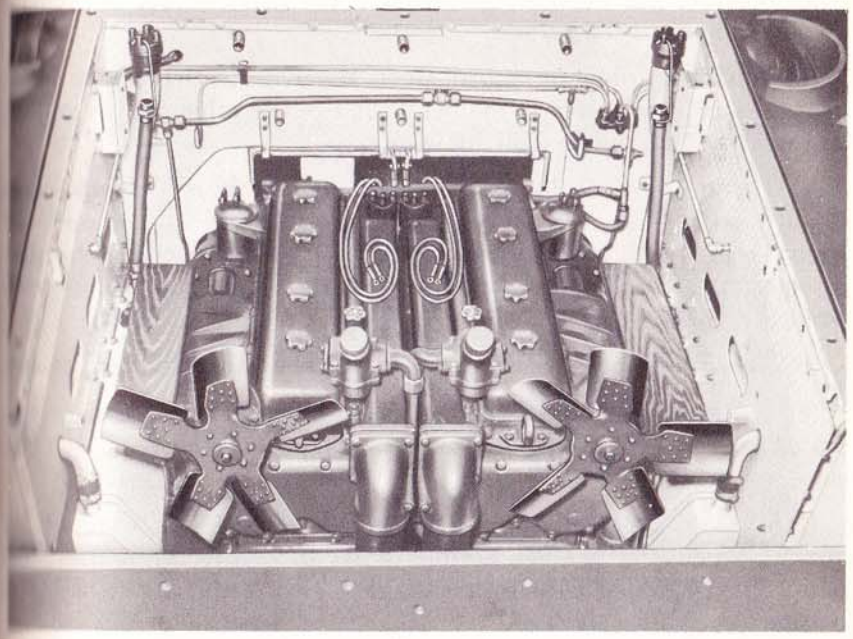


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Figure 73—Power Unit Removal—Steps in Engine Compartment Completed

(26) **Disconnect clutch shifter levers.** Back off lock nuts on clutch selector links (see fig. 92) and unscrew and remove links.

(27) **Remove transmission oil cooler** (see fig. 74).

(a) Disconnect transmission lubricating oil inlet and outlet hoses from the lubricating oil lines, and from the fittings on the transmission lubricating oil cooler.

(b) Remove the bolts which hold the transmission lubricating oil cooler to the mounting brackets on the engine shroud.

(c) Lift out unit, taking care not to damage felt gasket or cooler fins.

(d) Remove clips holding transmission lubricating oil lines to engine shroud and bend tubes as far away as possible from shroud.

(28) **Remove auxiliary generator air duct** (see figs. 74, 143, 144).

(a) Traverse turret to bring opening in turret basket opposite engine shroud end of auxiliary duct.

(b) Push open door in end of duct, remove the two screws which hold the auxiliary generator muffler flexible outlet tubing to the muffler, and remove flange end of tubing from duct.

(c) Remove bolts which hold duct to engine shroud and to sponson (7/16-inch socket, short extension, ratchet handle and 7/16-inch open-end wrench) (fig. 140). NOTE: Lower corner bolt behind duct, holding duct to shroud, is reached from underneath duct with 7/16-inch open-end wrench.

(d) Remove inspection cover from duct at auxiliary generator end.

(e) Remove the four socket head screws which hold auxiliary generator muffler flexible coupling to the auxiliary generator (5/32-inch hex stock wrench).

(f) Lift out the duct. NOTE: When installing the duct, attach the auxiliary generator muffler flexible outlet tubing to the muffler, and pass tubing through shroud opening into engine compartment before bolting duct to shroud.

(g) Pull auxiliary generator muffler flexible outlet tubing through opening in shroud and remove.

(29) Disconnect and remove fixed fire extinguisher cylinders and brackets. (See fig. 20.)

(30) **Remove LC engine generator** (par. 54 c).

(31) **Disconnect LC engine tachometer drive cable.**

(a) Loosen knurled nut and remove tachometer drive.

(b) Tape fitting on end of cable and engine connection.

(c) Wire cable to auxiliary generator to keep it out of way.

(32) **Remove LA engine generator** (par. 54 c).

(33) **Remove LA engine tachometer drive cable.**

(a) Repeat steps outlined in (31) (a) and (b).

(b) Wire cable to fuel tank selector valve control handle to keep cable out of way. (Be sure selector valve is closed.)

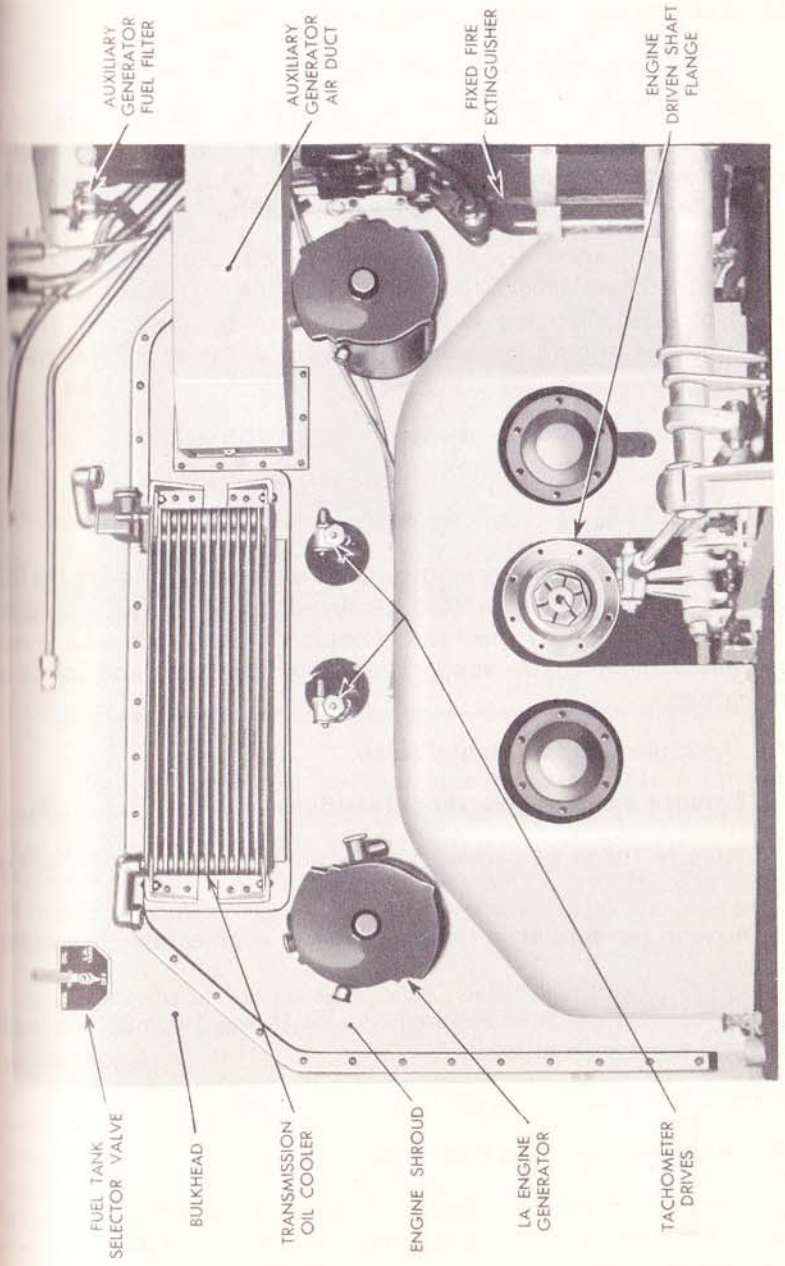


Figure 74—Engine Shroud

(34) **Remove lower engine shroud sections** (fig. 74).

(a) Remove bolts from both lower sections of engine shrouds.

(b) Move left lower section of shroud as close to battery box and as far toward the outside of the tank as possible. NOTE: Pass starting motor cables into engine compartment so that they can be pulled up and wired to cooling system bleeder valve handles.

(c) Move right lower section of shroud as close to stowage box and as far toward the outside of the tank as possible. NOTE: If additional space is required, remove bolts holding stowage box and 75-mm ammunition box to tank floor and move both as far as possible toward front of tank.

(d) Maneuver shrouds as necessary to lift through hatch in turret floor, and then remove from tank.

(35) **Remove engine mounting bolts, flywheel end.**

(a) Before removing upper sections of engine shroud, remove the four bolts (⅞-inch socket and ratchet handle) from each engine support bracket (see fig. 75) at flywheel end of engine. (After engines have been hoisted out, remove engine support brackets from tank and install on engine carrier.)

(36) Disconnect engine ground strap.

(37) **Remove upper engine shroud sections** (see figs. 74 and 75).

(a) Traverse turret as necessary to remove bolts in upper sections of engine shrouds.

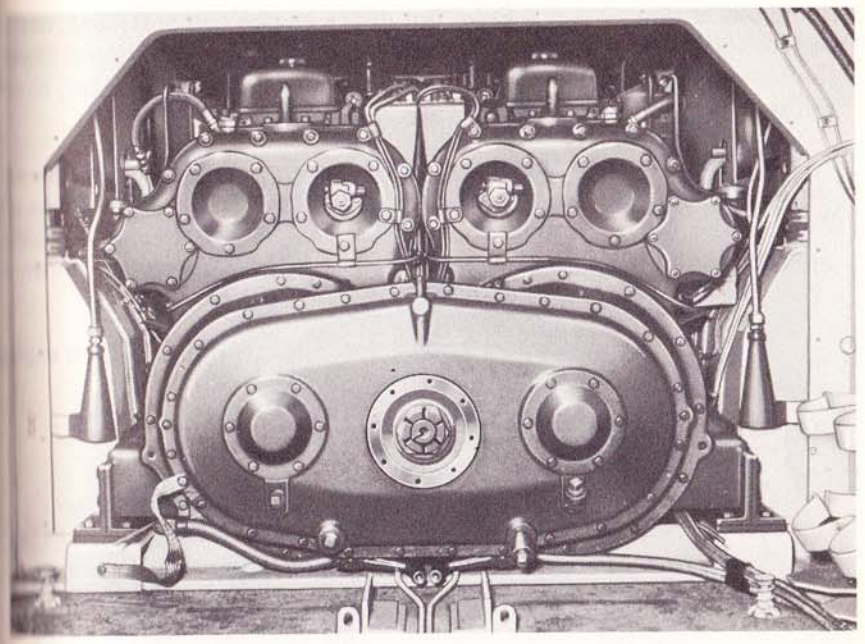
(b) Move upper shroud sections away from engines and close to turret basket.

(c) Maneuver shrouds as necessary to lift through opening in turret basket, and remove from tank.

(d) Close or replace hatch cover in turret floor.

(38) **Lifting engines from tank** (figs. 76 and 77).

(a) By means of the wires attached to the starting motor cables, pull cables up between sides of engines and the lower fuel tanks, and wire them to cooling system bleeder valve handles.



RA PD 36375

Figure 75—Power Unit Removal—Engine Shroud Removed

(b) Hook lifting chain hooks or hoisting tackle into front and rear engine lifter brackets. NOTE: Chains at flywheel end must be longer than fan-end chains so that when strain is placed on the hoisting tackle, engines will assume a slope of about 25 degrees, fan end highest (fig. 76). If two chain falls are used, control the individual chain falls to get the correct angle.

(c) Place spacer bar between front chains about one-third of the way above front (fan end) lifter brackets, to keep chain pressure off the thermostat housings. NOTE: The spacer bar can be made of a length of three-quarter-inch pipe, 20 inches long, and half-inch bar stock, 28 inches long and threaded on both ends, with four large washers and two nuts (see fig. 76). Place pipe over bar, install washers on each end of bar, place ends of bar through chain links, install washers, and screw on nuts.

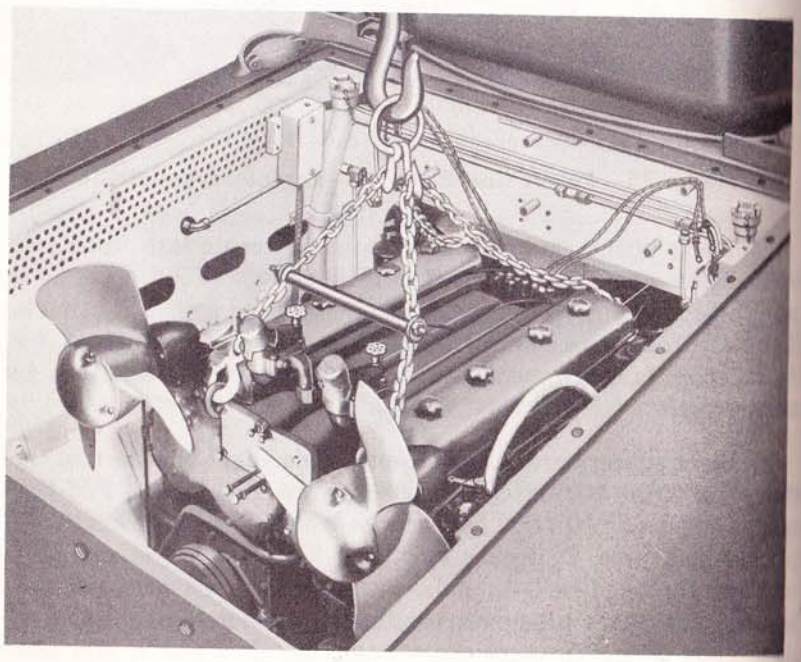
(d) Station sufficient personnel around engine compartment to hand-

guide power unit as it is hoisted out of the engine compartment, and to see that all fittings and connections clear. CAUTION: Watch closely the air shut-down solenoids, vibration dampers, junction plates, clutch shifter levers, and water drain valves.

(e) With engines at the proper angle (see fig. 77), hoist them **slowly, alternately upward and toward the rear of the tank,** until engines are clear of the engine compartment bulkhead. When engines are clear, hoist straight up. (Engine compartment will now appear as shown in fig. 78.)

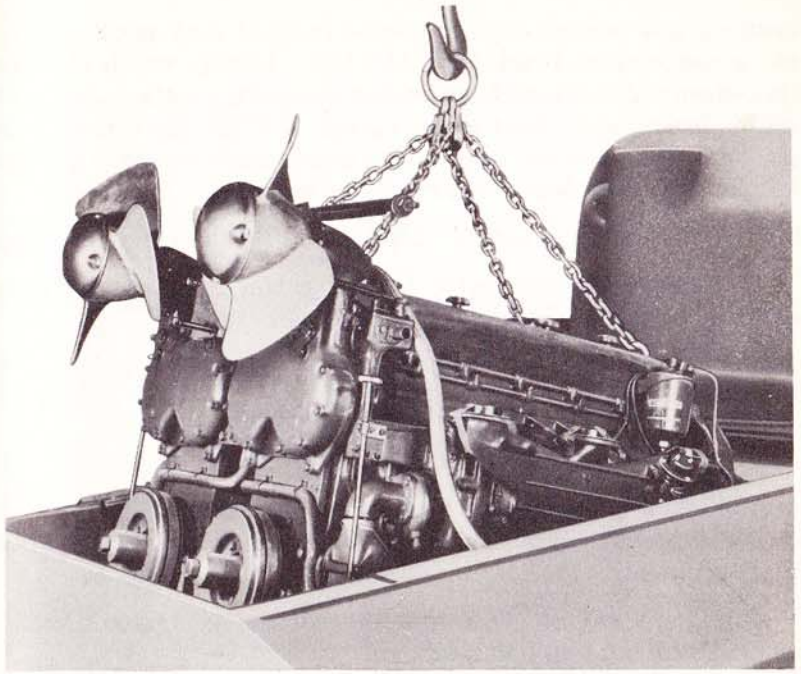
(f) Remove engine support brackets from tank and install on engine carrier.

(g) Place engines on engine carrier (tool J-1924).



RA PD 36376

Figure 76—Power Unit Removal—Lifting Fixture in Place



RA PD 36377

Figure 77—Lifting Power Unit from Engine Compartment

c. Installation of engines.

(1) Check engine compartment to see that all wiring, tubing, and hoses are out of the way.

(2) Open or remove hatch cover in turret floor. NOTE: Traverse turret as required to perform engine installation operations in turret.

(3) Station sufficient personnel around engine compartment and in turret to hand-guide engines into position, and to see that all fittings clear.

(4) Hook hoisting tackle to engines and lift them from engine carrier. NOTE: Engines must be installed in the same manner and at the same angle as in their removal (par. 71 **b** (38)).

(5) Remove engine support brackets from engine carrier and install in tank.

(6) Lower engines slowly into engine compartment, alternately

lowering and moving engines toward front of tank until engines seat on engine support brackets. CAUTION: Closely watch clearance of shut-down valve solenoids, vibration dampers, junction plates, clutch shifter levers, and water drain valves. NOTE: Have man in turret place crow-bar under transfer case to steady engines as they are lowered, keeping crow-bar clear of clutch shifter levers.

(7) Bolt engines to support brackets (at flywheel end of engines).

(8) Remove starting motor battery cables from engine fastenings and pass through bulkhead to battery box.

(9) Connect engine ground strap.

(10) Install upper sections of engine shrouds.

(11) Install lower sections of engine shrouds.

(12) Install transmission lubricating oil cooler and connect lubricating oil hoses to cooler and to transmission oil tubing. Install tubing clips to shrouds.

(13) Install engine generators and connect generator flexible conduits. Install clips on bulkhead.

(14) Install engine tachometer drives.

(15) Lead starting motor battery cables into battery box, tighten lock nuts, and connect cables to terminals.

(16) Move stowage and 75-mm. boxes on tank floor into position and bolt securely.

(17) Install and connect fixed fire extinguisher cylinders.

(18) Connect auxiliary generator muffler outlet tubing to muffler and pass tubing through opening in engine compartment bulkhead.

(19) Replace auxiliary generator duct, flexible coupling and inspection plate cover.

(20) Install and adjust clutch selector links.

(21) Connect rear universal joint companion flanges.

(22) Replace rear universal joint cover and bolt to engine shrouds. Install hold-down clamps.

(23) Replace filter panel.

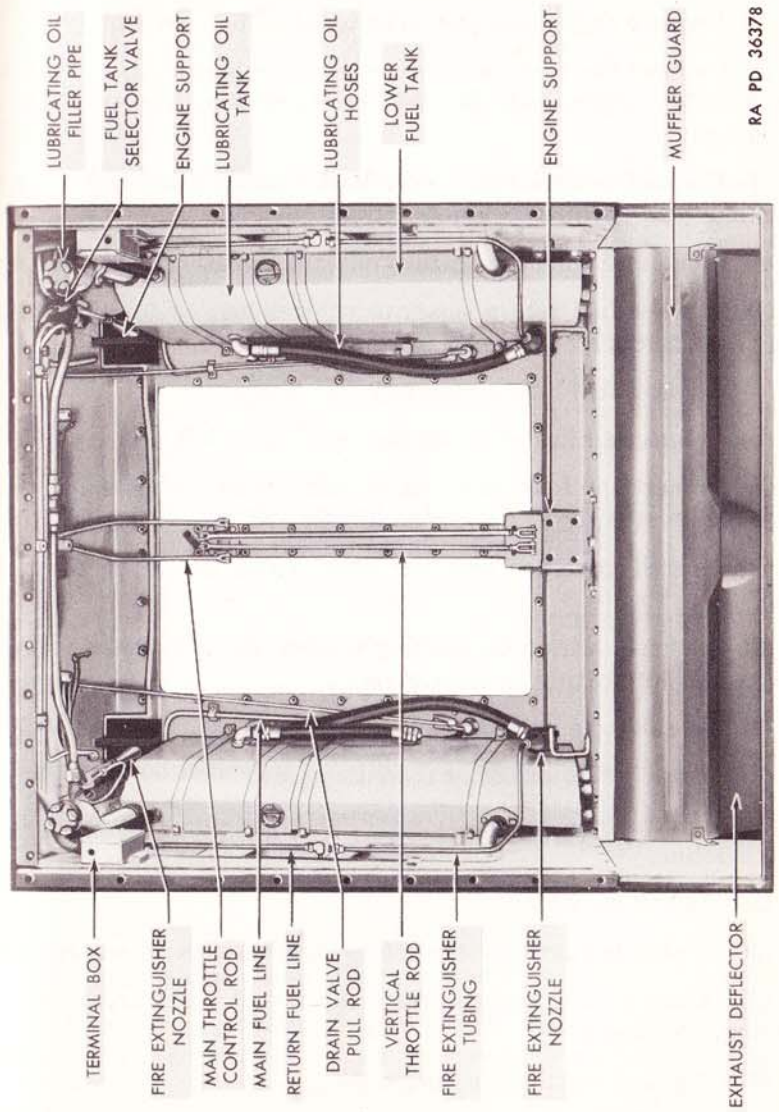


Figure 78—Engine Compartment after Removal of Power Unit

(a) Remove covers on high tension coils, lead wires through panel to terminals, and replace covers.

(b) Remove engine compartment terminal box covers.

(c) Connect the two wires in the left flexible conduit to their terminals in left engine compartment terminal box. Tighten lock nuts, attach cover.

(d) Connect three wires in right flexible conduit to terminals in right terminal box. Tighten lock nuts, attach cover.

(e) Connect engine lubricating oil tank breather noses to engines.

(f) Connect fuel return hoses to engines and to tee fitting. (Lead long hose through engine rear lifter brackets.)

(g) Connect fuel lines to primary fuel filters.

(h) Connect air heater pump fuel feed line to left primary fuel filter.

(i) Connect the four short engine lubrication oil hoses and the two long fuel inlet hoses to the engine junction plates.

(24) Install governor breather hoses (with first type air cleaners only).

(25) Connect wiring to starting motors, air shut-down valve solenoids, and lubricating oil tank gages.

(26) Install exhaust pipes.

(27) Install radiator center mounting plate.

(28) Install fan shrouds. CAUTION: Be sure they are centered around fans.

(29) Install radiators.

(30) Install fire extinguisher tubing, brackets, and discharge nozzles.

(31) Close cooling system drains and install water expansion tanks, tubing, and hoses.

(32) Fill and install air cleaners.

(33) Install auxiliary generator muffler flexible outlet tubing. (Fasten clamp on rear hull plate and clip on blower housing.)

(34) Install engine temperature gages.

(35) Install engine splash guard.

(36) Install deck plate unit.

(37) Connect air heater fuel hoses at junction plates between engines.

(38) Connect lubricating oil pressure gage hoses at junction plates between engines.

(39) Connect engine lubricating oil inlet and outlet hoses.

(40) Install engine mounting bolts (fan end).

(41) Install starting motor cable clips on engines.

(42) Install engine inspection plates.

(43) Fill engine lubricating oil tanks.

(44) Fill cooling systems.

(45) Fill fuel tanks.

(46) Connect battery ground cable to battery and turn on battery switches. (Test turret lights to make sure current is on.)

(47) Install or close turret platform hatch cover.

(48) Open fuel tank selector valve.

(49) Check instrument panel lights.

(50) Move hand throttles to **idle** position and check low pressure lubricating oil indicator lights on instrument panel.

(51) Check air heater indicator lights, open shut-off valve on air heater fuel oil intake line, and operate pumps on instrument panel until Diesel fuel oil is felt in pump cylinders. Close valve.

(52) Check level of fuel and lubricating oil.

(53) Start engines, one at a time (par. 8).

d. Check engine timing (figs. 79 and 80). After a power unit has been removed and overhauled, its timing should be checked. This operation can be performed more readily before the engine is installed. To check timing with the engine in the tank, proceed as follows:

(1) No. 5 injectors of each engine must be correctly timed.

(2) Remove No. 1 injector and install the engine timing fixture, tool

J-1929, in its place. Use the injector clamp to hold the fixture in place (See fig. 79.)

(3) Push the timing rod down against the piston head.

(4) Prepare to crank the engine by hand, by removing the rear universal joint cover and inserting a long bar in a universal joint yoke to use as a lever for turning over the engine. CAUTION: Be sure gearshift lever is in **neutral.**

(5) Hand-crank the engine in the direction of normal rotation until timing rod no longer moves upward, then at least one-quarter revolution more to make sure the cylinder has passed top dead center. **Do not touch the timing rod.** It must stay in the timing dead center position until next step is completed.

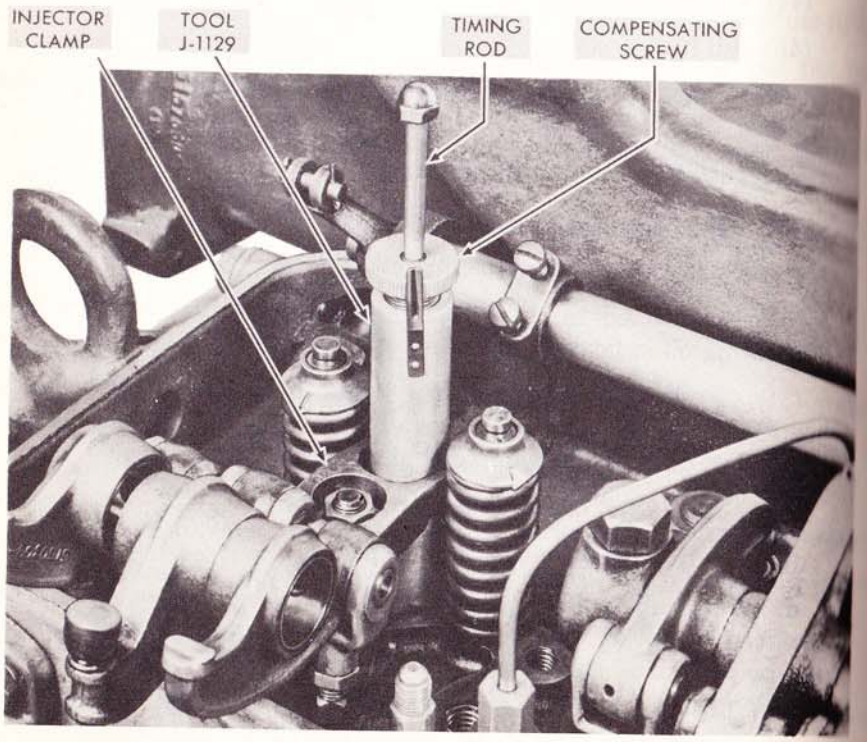


Figure 79—Checking Engine Timing RA PD 11117

(6) Adjust the compensation screw to correspond with the timing mark on the timing rod. This adjustment is made to compensate for any variation in head thickness, gasket thickness, carbon on piston head, etc.

(7) Hand-crank the engine in the direction of rotation until the timing rod can be pushed all the way down against the stop nut on the upper end of the rod.

(8) Hand-crank in direction of rotation until the upper mark on the timing rod is flush with the face of the compensating screw.

(9) Try the **go** and **no go** gages between the injector timing pin and the face of the follower guide (see fig. 73). This operation is performed at No. 5 injector for both engines.

(a) If **go** gage will pass through and **no go** will not, engine timing is correct.

(b) If both **go** and **no go** gages will pass through, engine is timed fast.

(c) If neither gage will pass, engine is timed late, or slow.

(d) NOTE: If engine timing is either fast or slow, it is an indication that the gears of the engine gear train are incorrectly meshed. Notify ordnance maintenance personnel.

72. POWER TRANSFER UNIT (fig. 81).

a. Description. Power from the two engines is transferred from the engine drive gear of each engine to the engine driven gear, through which the combined power of the two engines is transmitted, by means of the engine driven shaft and flange. The two engine drive gears and the one engine driven gear operate in the transfer gear housing.

b. Replacement. The power transfer unit cannot readily be replaced unless the turret and turret basket have been removed from the tank, or the engine has been removed. To replace the unit after the engine has been removed (par. 71 **b**), proceed as follows:

(1) **Removal.**

(a) Remove the bolts (9/16-inch socket and ratchet handle wrench with a short extension) and lockwashers which hold the transfer gear housing to the clutch housing.

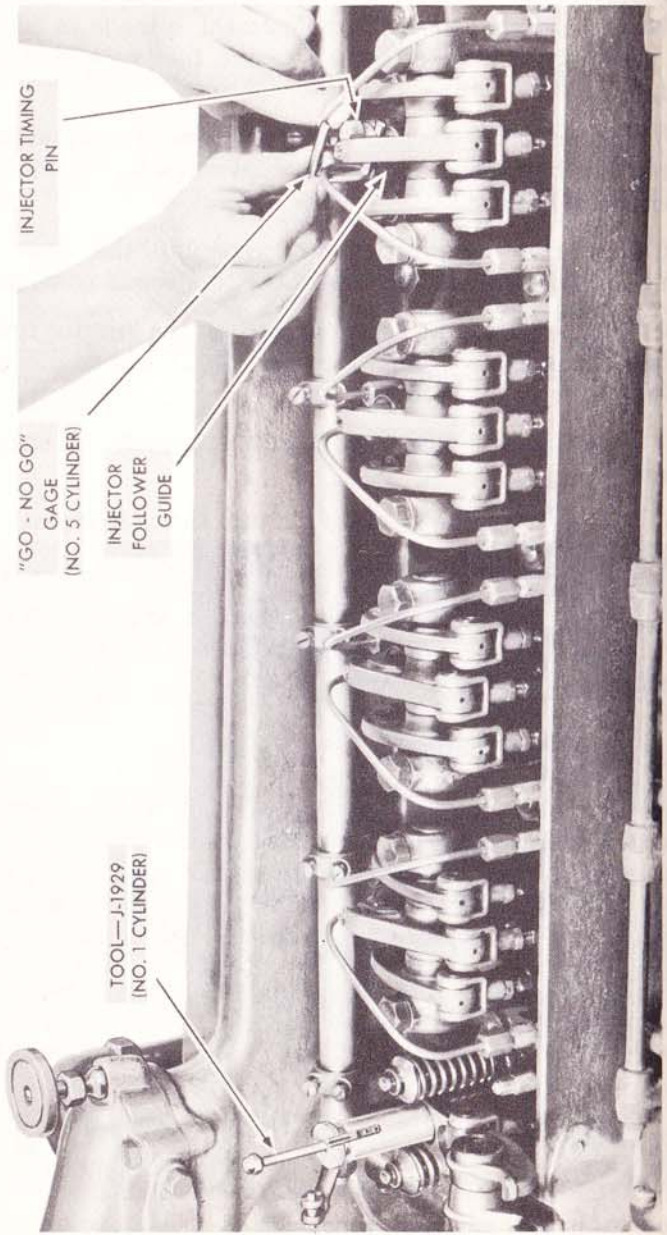
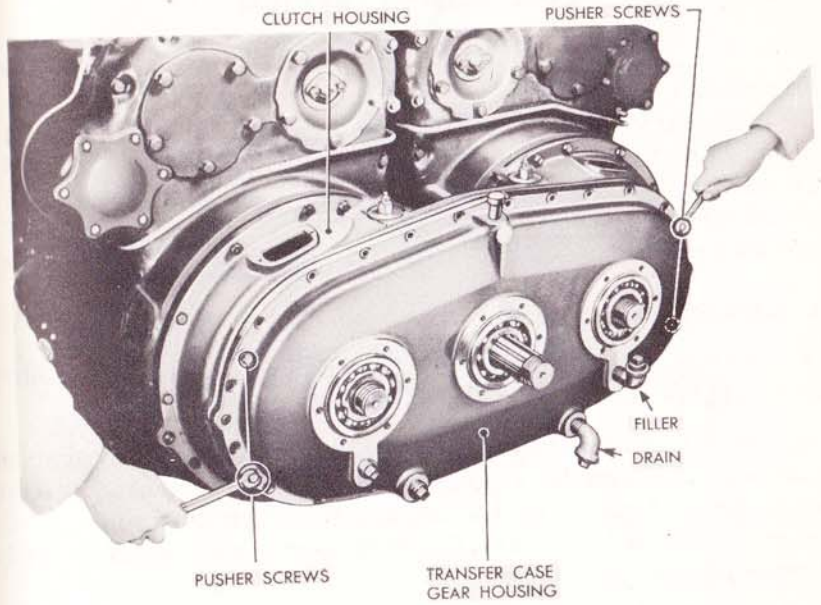


Figure 80—Checking Engine Timing



RA PD 36381

Figure 81—Removal of Transfer Gear Housing

(b) Place one of these bolts in each of the four tapped holes in the housing, to serve as pusher screws (see fig. 81), and by screwing them in evenly, free the housing from the dowel pins. The housing can now be lifted out. CAUTION: Exercise care not to allow splined shafts in the transfer gear housing to touch oil seals in the clutch housing, or to bump any part.

(2) **Install transfer gear housing.** The assembly is installed by reversing the preceding steps. Note the following points:

(a) It may be necessary to rotate gears and one flywheel in order to line up the splines of the shafts with those of the clutch assemblies.

(b) Install a new gasket. It should be shellacked and set in place in the clutch housing when the shellac is almost dry.

(c) When installed, the transfer gear housing should be refilled with lubricating oil. (See Lubrication Instructions, par. 26.)

Section XV

FUEL SUPPLY SYSTEM

73. DESCRIPTION (fig. 82).

a. The fuel system comprises the fuel oil tanks, fuel lines, fuel filters, fuel pump, fuel manifolds, and fuel injectors.

b. Diesel fuel oil is constantly circulated through the system, the maximum rate being 40 gallons per hour. This constant flow serves two purposes. First, it washes out any air which may collect in the system, preventing the fuel system from becoming airbound. Secondly, it serves to cool the injectors.

c. Fuel pressure should be maintained at a minimum of 25 pounds at 2100 revolutions per minute. If the pressure falls below that mark, it indicates that filters are clogged, or the fuel pump is defective, or there is ice in the fuel system, or a fuel line is plugged. When there is a lack of power, fuel pressure should be checked with a pressure gage.

d. The piping system is arranged so that either or both of the engines may be run on the right or the left set of two fuel supply tanks, but not on both sets at once. By suitable valving, the spill is returned to the set of tanks from which it is withdrawn. Each set of tanks has 74-gallons capacity, a total of 148 gallons for both engines.

74. FUEL TANK SELECTOR VALVE (fig. 83).

a. Valve. The fuel tank selector valve, mounted on the bulkhead in the engine compartment, is controlled by a hand lever on the bulkhead in the crew compartment.

b. Operation. The selector valve lever may be placed in any one of three positions—**off**, or **right-hand fuel oil tank**, or **left-hand fuel oil tank**. Fuel for both engines is drawn from only one set of tanks (upper and lower) at a time. When the upper (59½-gallon) tank on one side

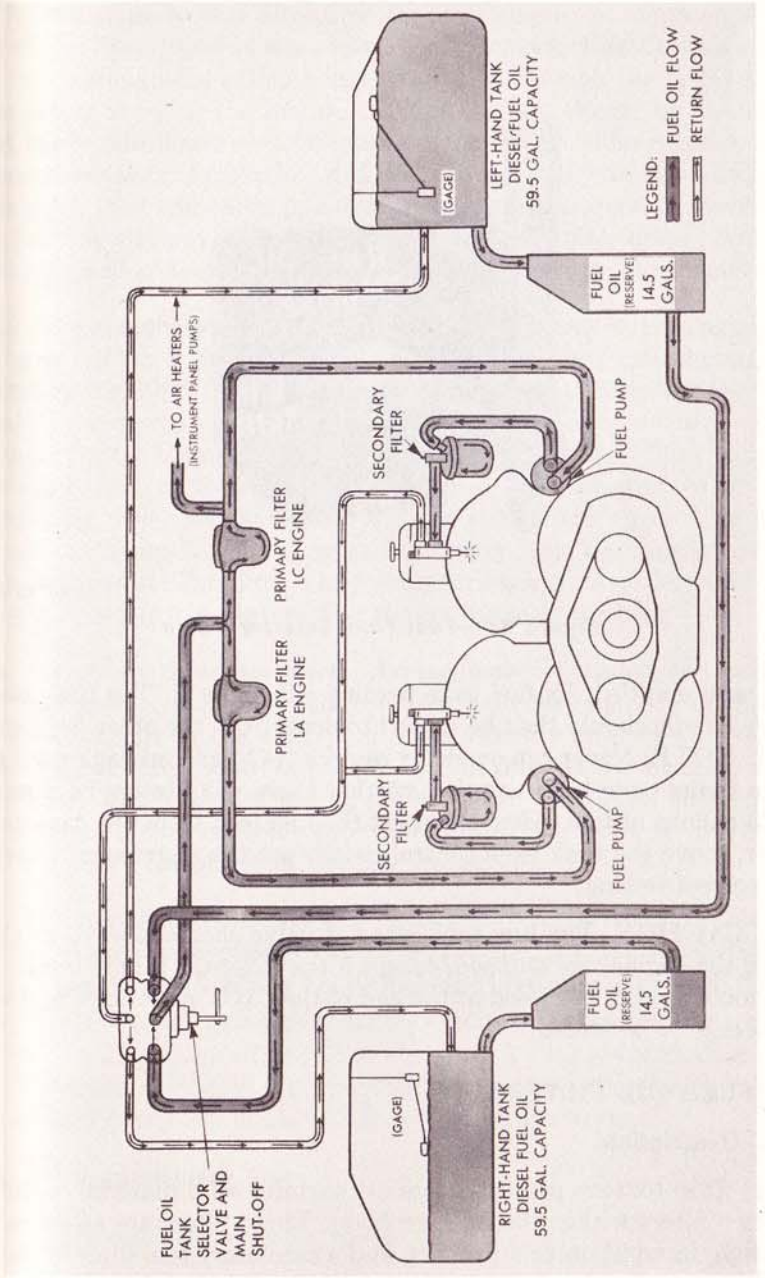


Figure 82—Fuel System Diagram

RA PD 36381

Figure 83—Fuel Tank Selector Valve

has been emptied, its fuel gage reading will show **E.** The fuel selector valve handle should then be moved to draw from the other 59½-gallon tank. NOTE: Never run on either reserve (14½-gallon) tank until **both main tanks** have been emptied, so that there will always be a reserve of 29 gallons of fuel. After changing the fuel feed from one tank to the other, move the tank gage control switch (on the instrument panel) to the correct setting.

c. CAUTION. The fuel tank selector valve should always be closed when the engines are stopped, except if the stoppage is only temporary. It should always be closed at the end of the day's operations, and when vehicle is to be stored.

75. FUEL OIL FILTERS.

a. Description.

(1) Injectors are protected against harmful solid material in the fuel by two filters within the injector body. These filters are an extra precaution, in addition to a primary and a secondary fuel filter in the fuel supply line of each engine.

(2) **The primary fuel filter,** one for each engine, is mounted at the end of the filter panel in the engine compartment. Fuel is drawn from the tank through the selector valve and then through the primary fuel filter before entering the fuel pump. The element should be cleaned at least every 500 hours or 5,000 miles of operation. The primary filter assembly consists of a stacked-disk element assembly and a sheet metal filter bowl. Inlet and outlet passages are marked **in** and **out,** respectively. The filtering element consists of a large number of filter disks (.002 inch thick) stacked and squeezed together by a spring on the filter bowl stud.

(3) **The secondary fuel filter** is mounted on the side of the engine just to the rear of No. 3 air cleaner. Fuel is forced from the pump through the secondary fuel filter to the fuel manifold. The replaceable filter element should be renewed every 500 hours or 5,000 miles of operation. The secondary filter consists of a steel shell and an enclosed filter element. The steel shell, or filter bowl, is assembled to a stamped cover by a center tube which screws onto a retainer stud in the cover. The cover contains openings for incoming and outgoing fuel. The center opening is marked **outlet.** The filter element comprises a shell of dense filtering material molded to a perforated cylinder, or collector tube.

b. Secondary filter operation. Having passed through the primary fuel filter and the fuel pump, the fuel enters the secondary filter through the inlet passage in the cover and flows into the filter bowl. Pressure created by the fuel pump forces the fuel oil through the filtering material, where dirt particles are removed. Clean fuel flows through the perforations of the collector tube, through drilled holes in the hollow rod, and up to the outlet in the filter cover.

c. Maintenance. The mileage or time before replacement or cleaning of filter element is necessary cannot be arbitrarily established, because each depends on operating conditions and cleanliness of fuel. Therefore, the operator must determine a service schedule from observation and inspection of the filter element. A fuel pressure check is a reliable indicator of fuel filter condition. However, the element should be replaced every 500 hours or 5,000 miles of operation.

d. To clean primary filter.

(1) Turn fuel tank selector valve to **off.**

(2) Back out retainer bolt at top and remove bowl and element.

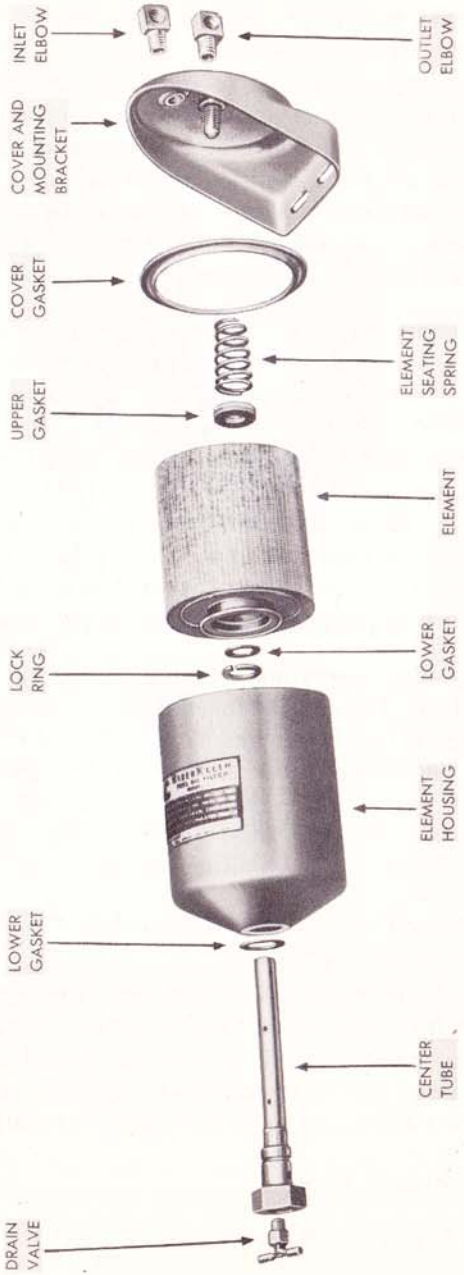


Figure 84—Secondary Fuel Filter, Disassembled

(3) Carefully wash disks in fuel oil. **Do not scrape, or use stiff brush.** Be careful not to bend disks.

(4) Wash out bowl and fill with clean fuel oil.

(5) Reassemble, using new element gasket and bowl gasket.

(6) Turn fuel selector valve to **on** position, start engine, and check for leaks.

c. To replace secondary filter element (fig. 84).

(1) Turn fuel selector valve to **off** position and drain bowl.

(2) Unscrew nut at bottom of bowl. Drop bowl.

(3) Discard filter element and clean inside of bowl.

(4) Install new filter element and reassemble, using new gaskets at top of collector tube and top and bottom of filter element.

(5) Loosen filter outlet connection, turn fuel tank selector valve to **on** position, lock out clutch, and run **other** engine until fuel is forced out of connection.

(6) Tighten connection, start engine, and check for leaks.

(7) When engine runs smoothly, clean filter on other engine.

76. FUEL OIL TANKS (figs. 85 and 86).

a. Description. There are two sets of fuel tanks; capacity, 74 gallons, each set. The upper tanks hold 59½ gallons each. They feed into the lower (reserve) tanks, which hold 14½ gallons each.

b. To drain fuel oil tanks.

(1) Remove the two bolts which hold the small cover plate in the hull floor plate directly under the lower fuel oil tank.

(2) Remove the drain plugs.

(3) NOTE: To drain upper tanks only, remove plate in sponson floor, then remove drain plugs.

c. Removal of lower fuel oil tank (fig. 85). To remove the lower fuel oil tank (with engine already removed), proceed as follows:

(1) Remove drain plug cover plate from underneath tank, by taking out the holding bolts (¾-inch open-end or socket wrench).

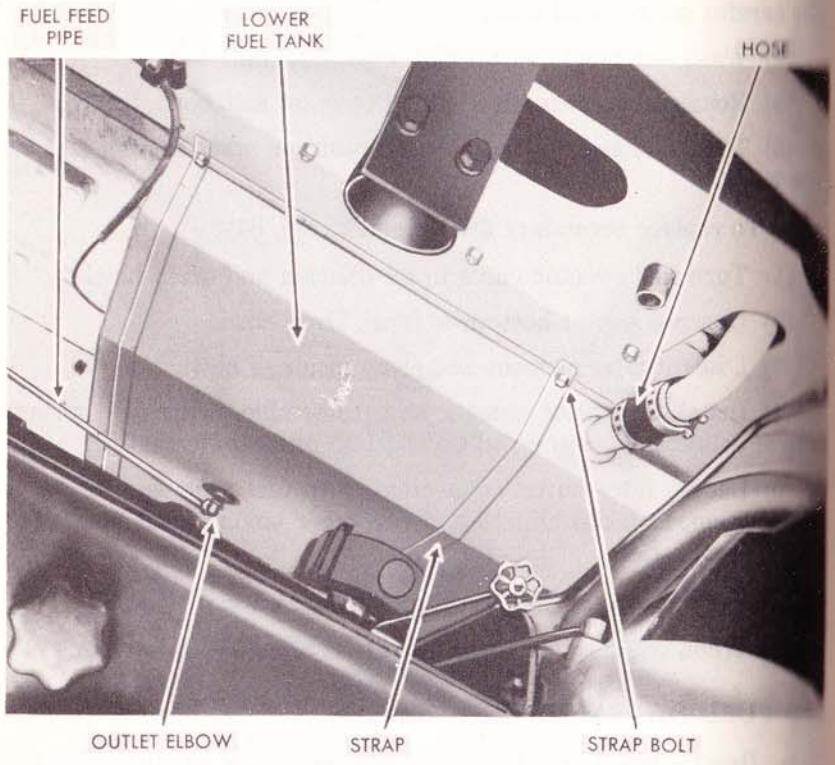


Figure 85—Lower (Reserve) Fuel Oil Tank

(2) Place receptacle under drain plug and remove plug (⅝-inch Allen wrench).

(3) From same position, remove the two bolts which hold the fuel tank to the bottom hull plate (¾-inch open-end or socket wrench).

(4) Inside engine compartment, uncouple the fuel feed from outlet elbow on the lower side of the fuel tank (⅞-inch open-end wrench).

(5) Loosen screws on the clamps which hold the connecting hose between the outlet elbow of the upper fuel tank and the inlet pipe of the lower fuel tank, and push the hose down on the lower inlet pipe.

(6) Remove the front and rear fuel tank holding straps (¾-inch open-end wrench).

(7) Lift the tank out, being careful not to jam it or dent it against the elbow projecting from the lower part of the upper tank.

(8) Install fuel oil tank by reversing the preceding steps.

77. FUEL OIL SPECIFICATIONS.

a. Fuel oils for General Motors two-cycle Diesel engines, Series 71, must be completely distilled petroleum products.

b. Suitable fuels must comply with the classification limits established by the American Society for Testing Materials for the No. 1-D or No. 2-D grades of Diesel fuel oil.

c. Fuel properties of foremost importance for satisfactory engine operation are ignition quality and volatility.

(1) High cetane number shortens the ignition delay period, thereby facilitating starting, improving combustion smoothness, and minimizing deposit formation.

(2) High volatility causes more complete vaporization of the fuel, cleaner combustion, and less residue formation.

(3) Since both these fuel properties influence the combustion process simultaneously, a low value of one can be counteracted by a high value of the other. Best results will be obtained from a fuel with low final boiling point and reasonably high cetane rating.

d. The suitability of a fuel oil depends greatly on engine operating conditions. If speed and load changes are frequent, the fuel should be cleaner burning than fuels satisfactory for constant speed operation.

e. The above specifications are in conformity with U. S. Army Specifications No. 2—102B of October 2, 1941, for "Diesel Fuel Oil for High-Speed Automotive-Type Diesel Engines."

78. EXTERNAL FUEL LINES (fig. 86).

a. Low fuel pressure, inadequate fuel supply, and other symptoms outlined in paragraph 45, **Trouble Shooting**, may indicate the need to remove external fuel lines, clean them, and make necessary replacements. Proceed as follows:

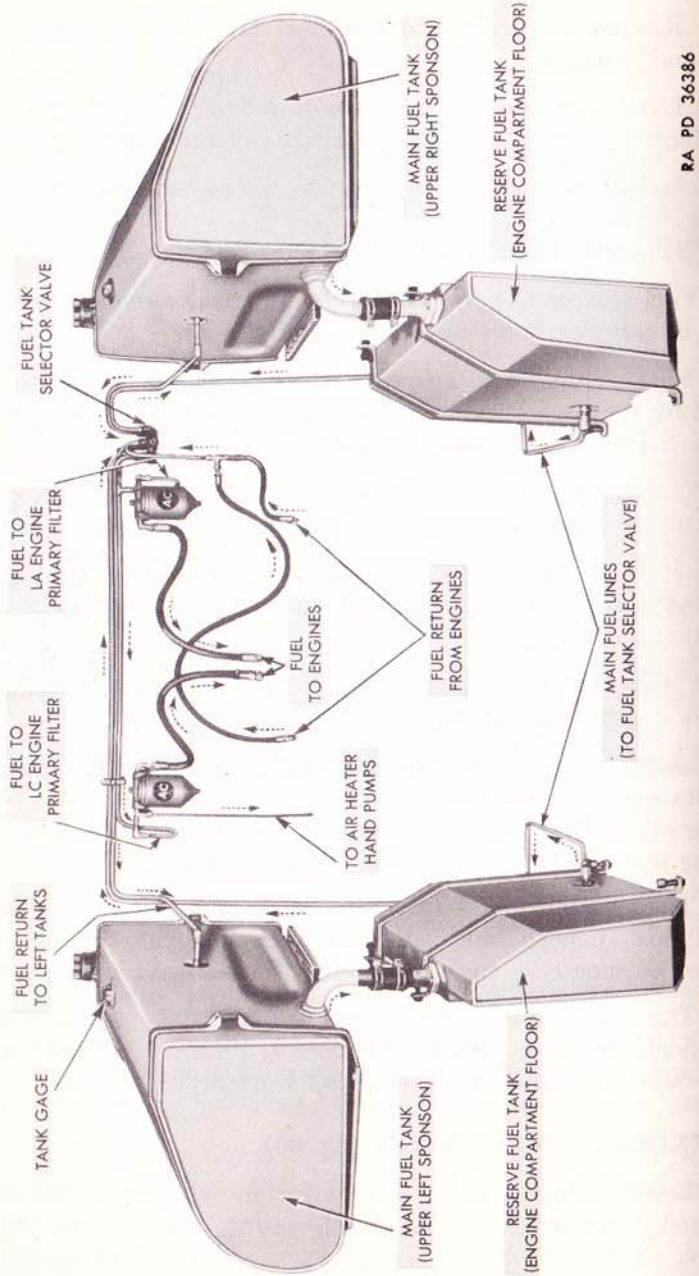


Figure 86—Fuel Oil Tanks, Lines, and Connections

(1) Drain the fuel system (par. 76 **b**).

(2) Remove primary fuel filter inlet and outlet lines, disconnecting them at the filters and at the junction plates between the engines.

(3) Remove the fuel tubes and fittings between fuel tanks, filters, fuel tank selector valve, and engines.

(4) Wash out all tubes, hose, and fittings in gasoline, and blow out with compressed air.

(5) Install new fittings, hose, and tubes as required.

(6) Prime system with fuel oil before attempting to start engine, by filling the fuel filter, lines, and hoses, with clean fuel oil. Lock out the clutch of the engine worked on, and run the **other** engine to force fuel through the system to the idle engine (see par. 75 **e** (5)).

Section XVI

COOLING SYSTEM

79. DESCRIPTION.

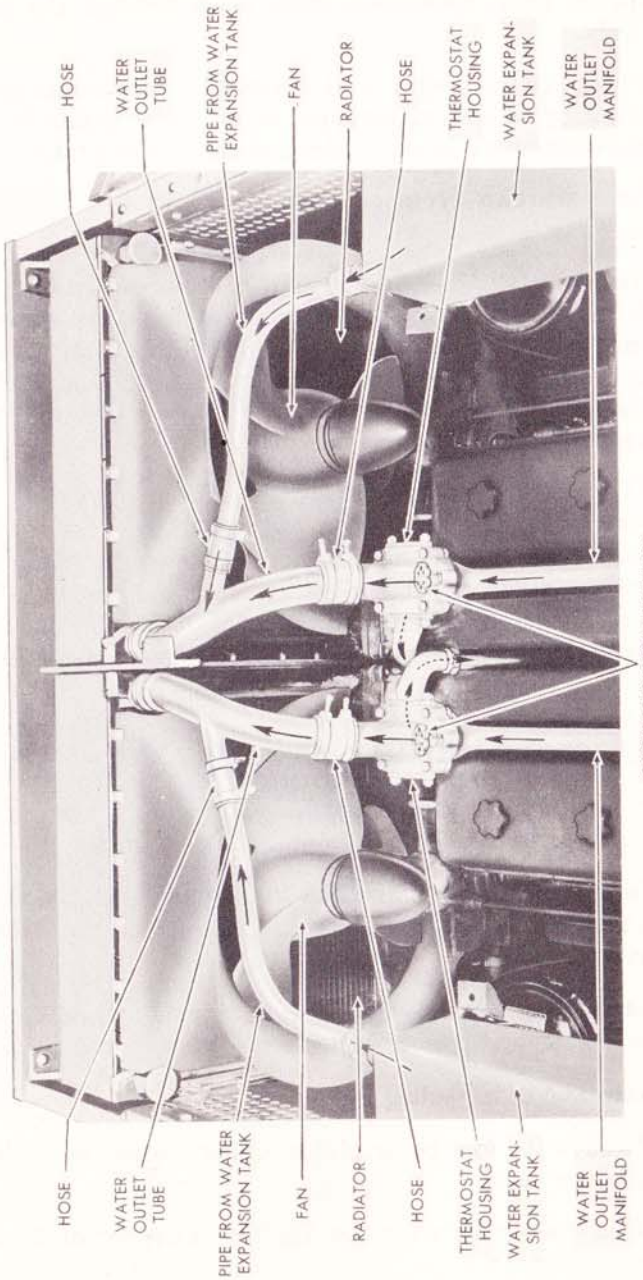
a. A centrifugal pump, mounted on the front end of the blower and driven by the lower blower rotor shaft through a coupling, provides circulation of water through the cylinder block, cylinder head, and radiator of each engine.

b. The water pump works in conjunction with a radiator through which the water passes in the process of cooling. A cooling fan on each engine forces air through the radiator core and lowers the water temperature. The water pump draws the cooled water from the bottom of the radiator and through the oil cooler, and discharges it into the lower part of the cylinder block. Openings in the water jacket around the cylinder bores connect with corresponding openings in the cylinder head, where the water circulates around the valve seats and fuel injectors. Cylinder bores are water-jacketed for their full length. A water manifold and thermostat housing, bolted to the cylinder head, discharges the cooling water back into the radiator.

c. Water temperature in the engine is controlled by two thermostats mounted in the outlet end of the water manifold of each engine. The vent valve, on the top of the thermostat housing, should be closed except when the cooling system is being filled or drained.

d. When the engine is started cold, the thermostats prevent water circulation, except through the by-pass tube, which allows water to recirculate through the oil cooler, cylinder block, cylinder head, and water outlet manifold. The thermostats start to open at 158 F. (70 C.) and are fully open at 185 F. (85 C.). After the thermostats start to open, and until they are fully opened, water circulation takes place through both the by-pass tube and the radiator. After the thermostats

COOLING SYSTEM



RA PD 36387

Figure 87—Cooling System, First Type, Showing Direction of Flow

have opened fully, circulation takes place through the radiator and engine only.

e. During the warm-up period, before the thermostats start opening, the lubricating oil passing through the oil cooler is rapidly warmed by the circulation of warm water through the by-pass tube.

f. There are two types of cooling systems in use on the M4A2 Medium Tank.

(1) The **first type** (see fig. 87), installed on early tanks, is particularly identified by having only one connection on the water expansion tank, and a small-diameter tube leading directly from it to the engine water outlet pipe, between the engine and the radiator. The water outlet on the radiator is at the bottom and connects directly to the engine lubricating oil cooler housing.

(2) The **second type** (see fig. 89) has a deeper expansion tank with two connections. The small-diameter outlet is for the equalizer tube, which leads from the water expansion tank down to the radiator outlet tube (engine intake or suction), which runs to the engine lubricating oil cooler. The large-diameter outlet is for the air venting tube, which connects the water expansion tank to the upper outside fitting of the radiator.

80. INSPECTION AND MAINTENANCE.

a. At the 100-hour inspection, all surfaces of the radiators and shrouds should be cleaned of accumulated oil and dirt.

b. Water pump lubrication. The water pump ball bearing, shielded type, is filled with lubricant when assembled, and no further lubrication is necessary.

c. Fan lubrication. The fan of each engine is pressure-lubricated from the engine, and no lubrication service is required.

d. Drain and refill cooling system.

(1) Remove the four cover plates (under crankcase oil drain plugs) from hull floor plate.

(2) Open the bleeder valve (see fig. 23) on the top of the thermostat housing.

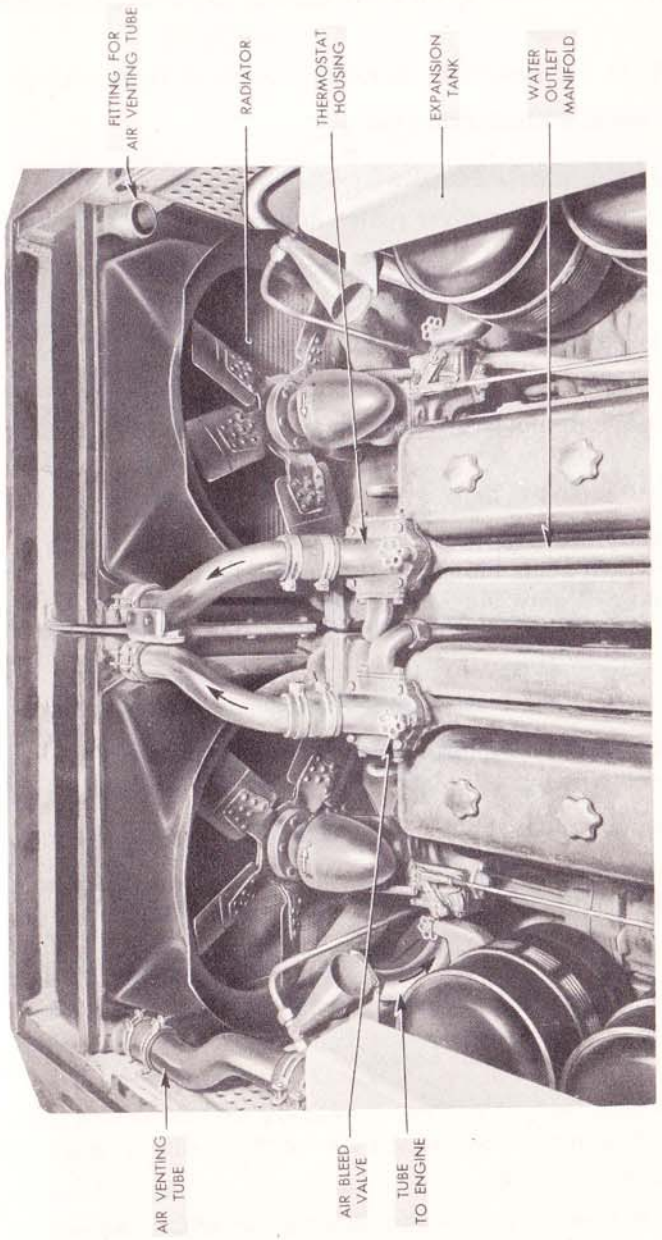


Figure 88—Cooling System, Second Type, Right Air Venting Tube Removed RA PD 36388

(3) Open the water drain valve control at the front outer side of the engine.

(4) When the system is thoroughly drained, flush with clean water.

(5) Close the water drain valve.

(6) Fill the cooling system.

(7) Install the four cover plates in hull floor.

(8) Run engines for a few minutes and add any water necessary to fill the cooling system to capacity.

(9) Close the bleeder valve on top of the thermostat housing.

(10) NOTE: If system is being drained to prevent freezing, the pipe plugs must be removed from the rear outer corners of the radiators.

81. RADIATOR.

a. Description (fig. 89). Each engine is equipped with a radiator, through which air is **blown** by the engine fan, at the rear of the tank.

b. To replace radiators (figs. 88 and 89). Either radiator can be replaced as follows:

(1) Remove the top rear hull plate, back of the engine compartment.

(a) Remove the 16 hexagon bolts (lockwashers) (15/16-inch box or socket wrench) from the plate.

(b) Remove the two bolts in the center of the plate (7/8-inch wrench).

(c) Remove six bolts from rear outer hull plate which hold the rear edge of deck plate.

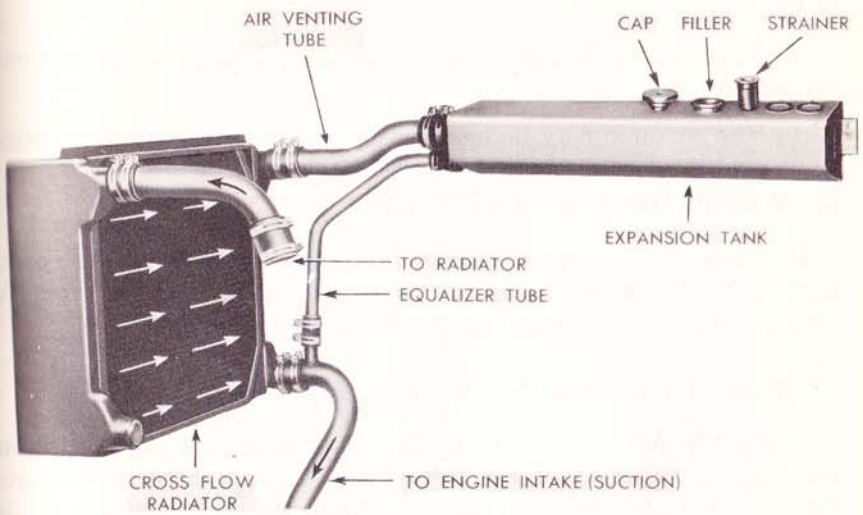
(d) Lift off the top rear hull plate, using a hoist if available.

(2) Drain the cooling system (par. 80 **d**).

(3) **Disconnect radiator hoses.**

(a) On the **first type** cooling system (fig. 87), loosen the hose clamps on the engine outlet hose at the top of the radiator. Slip clamps and hose down over tubing.

(b) On the **second type** cooling system (fig. 88), disconnect the engine water outlet tube and the water expansion tank air venting tube from



RA PD 36389

Figure 89—Cooling System, Second Type, Showing Connections

the inside and outside upper fittings on the radiator. Loosen hose clamps and slide clamps and hoses down over tubing.

(4) Reach down along sponson plate at the radiator (see fig. 89) and loosen hose clamps at radiator outlet tube (long screwdriver). Pull radiator outlet tube (engine intake or suction) away from radiator. Leave clamps and hose on tubing.

(5) The radiator is mounted on four brackets, two at the top and two at the bottom. Each bracket is bolted to a rubber mounting, which in turn is bolted to the hull. Detach each bracket (5/8-inch socket and ratchet handle wrench) by removing the bolt holding the bracket to the mounting, and remove the bolt which holds the mounting to the hull. Remove the mounting. CAUTION: At this point, remove only the two top mountings, so that the radiator will be supported by the lower mountings.

(6) Attach a hoist to the upper radiator brackets. Take up the weight of the radiator on the hoist, and then remove the two lower mountings.

(7) Work the radiator free, pulling it at the bottom toward the rear of the tank.

(8) Hoist out the radiator, exercising care not to damage fan shroud or radiator core.

(9) The radiator may be installed by reversing the foregoing steps.

82. WATER HOSE AND FITTINGS.

Description. The water tubing, hoses, and fittings of the cooling system are shown in fig. 87 (first type) and fig. 89 (second type). All hose connections are attached with a clamp at each end.

83. WATER EXPANSION TANK (fig. 90).

a. Description. A water expansion tank (first type, fig. 90; second type, fig. 89) is provided for each engine. It is mounted in the engine compartment above the air cleaners. The engine cooling system is filled through a filler opening in the hull above the tank. The cooling system for each engine should be filled to overflowing. The water level will not rise above the bottom of the filler neck, and therefore will leave space for expansion of the water during engine operation. The filler cap has a pressure-regulating valve, which maintains an even operating pressure in the cooling system. CAUTION: Do not use any other type of cap.

b. Pressure filler cap. The cooling system normally operates with its water 105 F. (41 C.) hotter than the atmosphere. In hot weather, therefore, the water frequently exceeds 212 F. (100 C.), the boiling point of water. Under these conditions, steam pressure will be built up in the system. The filler cap of the water expansion tank therefore is provided with a pressure-regulating valve, which relieves the pressure in the cooling system when the steam pressure reaches 12 pounds per square inch, when the water temperature is about 225 F. (107 C.).

CAUTION: Extreme caution must be exercised in removing the filler cap, because if the tank is under pressure, a blast of steam will endanger the mechanic. Before removing the cap under such circumstances, the engine should be allowed to run at idling speed until the water temperature drops to a safe point.

c. Replace water expansion tank. Either water expansion tank can be removed as follows:

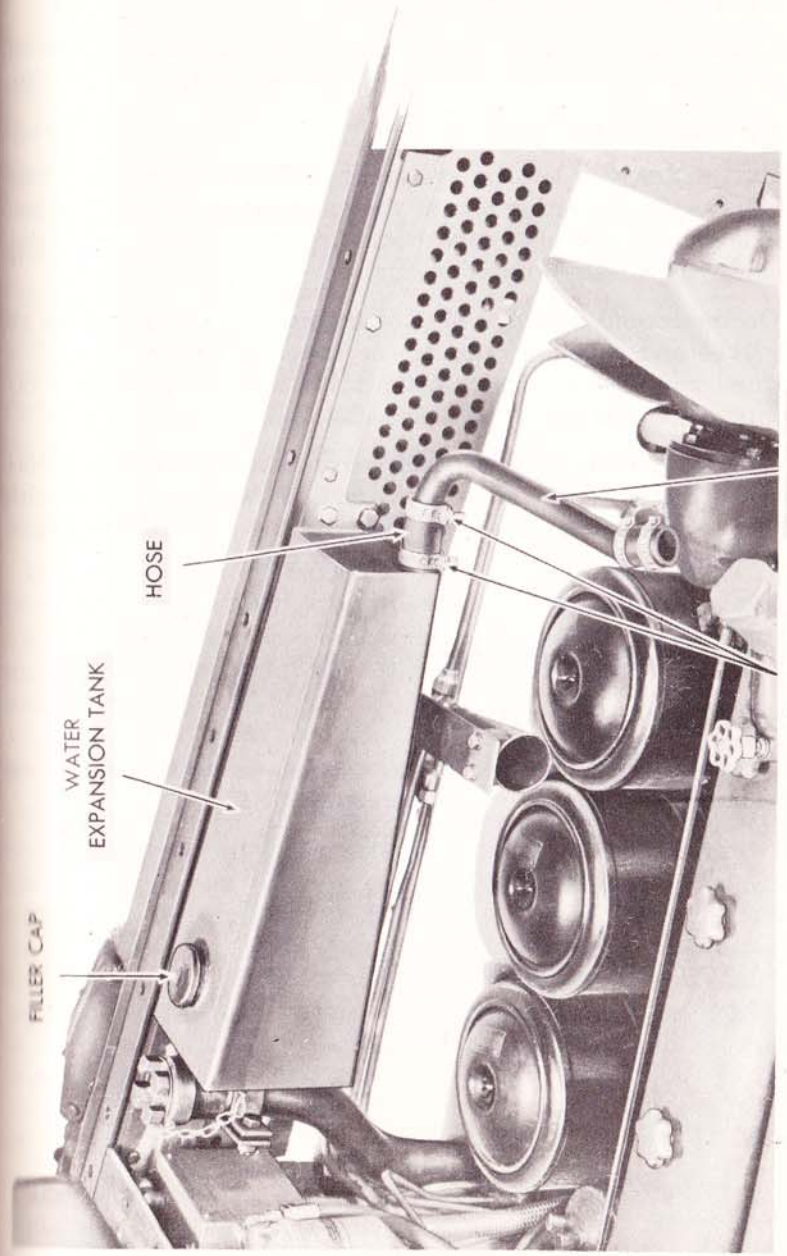


Figure 90—Removal of Water Expansion Tank, First Type

(1) Drain the cooling system (par. 80 **d**).

(2) Remove the rear deck plates to which the engine compartment doors are fastened, the doors, and the splash guard (par. 71 **b** (10)).

(3) **Disconnect hoses.**

(a) On the **first type** cooling system (fig. 87), loosen the two hose clamps on the small breather pipe at the water expansion tank connection. Slide clamps and hose connections onto the tubing, and move tubing away from water expansion tank.

(b) On the **second type** (fig. 89), loosen the hose clamps on the air venting tube and equalizer tube at the water expansion tank. Slide clamps and hose connections onto the tubes and move tubing away from water expansion tank.

(4) Remove the four bolts (¾-inch socket, short extension, ratchet handle, and ¾-inch open-end wrench) and lockwashers, two at each end, holding the water expansion tank to the wall of the engine compartment.

(5) Lift out the tank.

(6) Install by reversing the preceding steps.

84. ANTIFREEZE SOLUTIONS.

For detailed instructions for the protection of the cooling system during cold weather operation, see paragraph 33 **f**.

Section XVII

CLUTCH

85. CLUTCH.

Each engine has its individual clutch, which serves as a coupling between the engine and the motive-power train, consisting of the power transfer unit, propeller shaft, transmission, differential, final drives, and sprockets. The clutch is between the engine flywheel and the power transfer unit.

86. OPERATION.

Depressing the clutch pedal moves the clutch pressure plate away from the flywheel, mounted on the crankshaft, thus permitting the flywheel and pressure plate to turn independently of the clutch disk, mounted on the engine drive shaft. When the clutch pedal is released, the clutch pressure plate spring forces the pressure plate toward the flywheel, securely clamping the clutch disk between the pressure plate and the flywheel, causing the disk to turn and to transmit engine power to the drive shaft. Clutch engagement should be carefully controlled, to prevent excessive slipping.

87. CARE.

The release bearing for each clutch is lubricated through a special fitting, reached through the engine shroud from within the crew compartment. (See par. 26, **Lubrication Instructions.**)

88. INSPECTION WHILE OPERATING.

Faulty operation, such as slipping, grabbing, or rattling, as noted by the driver, should be reported to ordnance maintenance personnel.

89. SYNCHRONIZING ENGINE SPEEDS.

a. Allowable variation. When the clutch pedal is depressed, the separate clutches of the two engines are released, permitting each engine to run free. Ideally, both engines should run at the same speed, as indicated by their tachometers; but some variation in their speeds is unavoidable, and a slight variation is permissible. At 1200 to 2100 revolutions per minute (top governed speed), the difference in speed should be not greater than 200 revolutions per minute. With engines idling, the speed of each engine should be not less than 400 or more than 450 revolutions per minute, and engine speeds should be adjusted so that each engine runs within that range.

b. Importance of synchronizing. When one engine lags greatly behind the other engine, full power from the twin unit cannot be obtained at full throttle. Also, uneven wear on the clutch facings will result, since in starting and gear shifting the clutch on the faster engine will be subject to more slippage than will the clutch on the slower engine.

c. When fault is throttle linkage (fig. 91). The following instructions are for correcting unbalanced engine speeds only when the fault is in the linkage between the foot throttle (or the hand throttles) and the governor control levers. Therefore, before undertaking to equalize speeds by adjusting the throttle linkage, first disconnect the horizontal throttle rods from the governor control levers and check engine speeds with both clutches locked out.

(1) If the engine speeds are not nearly equal, the fault lies in one or both engines. To correct, carry out the indicated procedure outlined in **Engine Tune-up** (par 51).

(2) If the engines, with their throttle linkage disconnected, run at (nearly) equal speeds, but become unsynchronized when the throttle linkage is reconnected, the linkage must be adjusted.

d. Free-up throttle linkage. A common cause of unequal engine speeds is binding or stiffness in the throttle linkage. To correct, thoroughly oil all clevis pins, bell cranks, cross shafts, levers, and other

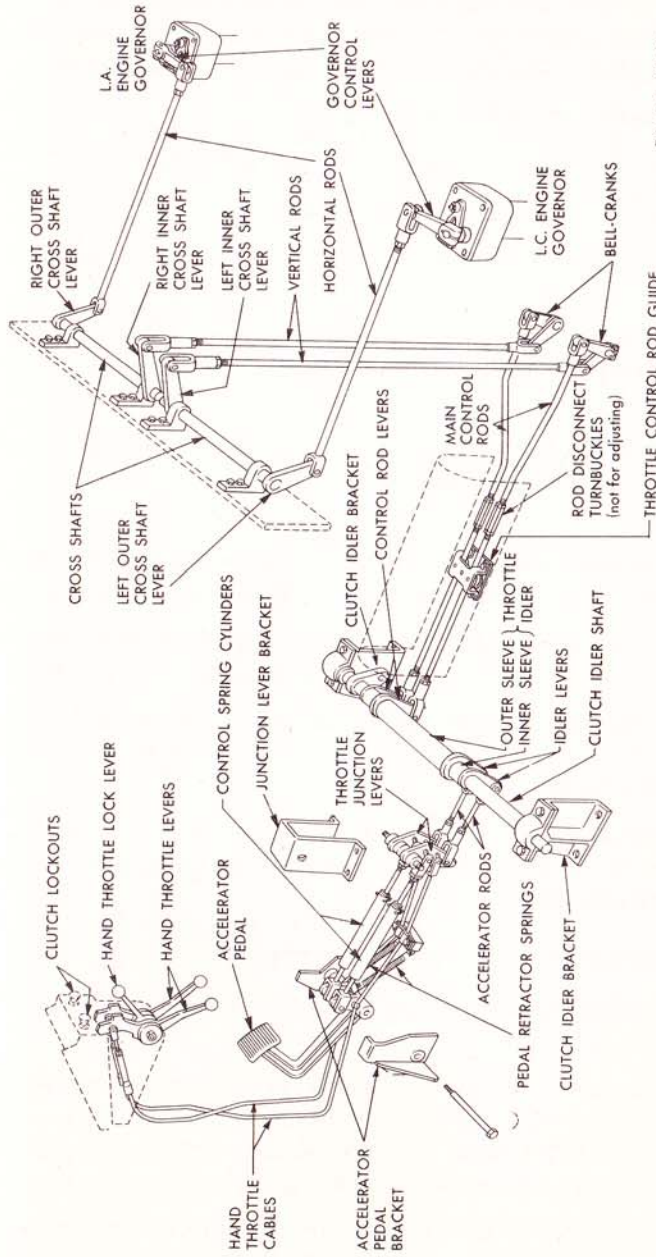


Figure 91—Throttle Linkage Diagram

points of friction, and make sure the linkage operates freely and smoothly. If engine speeds are still unbalanced at speeds above 1200 revolutions per minute, adjustments in the throttle linkage must be made.

e. Adjusting throttle linkage (fig. 91).

(1) Depress clutch pedal and lock out both clutches.

(2) Start and warm up both engines.

(3) With hand throttles in **idle** position, note idling speed of each engine.

(4) While a man inside the tank slowly operates the foot throttle, closely observe movement of the governor control lever on each engine governor:

(a) Interrupted, or jerky, travel of the governor control lever indicates binding or cramped throttle linkage. Check linkage (see d, preceding).

(b) Unequal travel, with one throttle lever reaching **full fuel** position before the other, indicates linkage unequalized. Correct as follows:

1. With engines idling, remove clevis pin from throttle rod at governor control lever on the engine that requires speed adjustment.

2. To increase engine speed, screw clevis toward end of rod. CAUTION: This is a sensitive adjustment. From ½ to 3 turns will usually be enough.

3. Connect throttle rod to governor control lever and check engine tachometers. (If necessary, further adjust the clevis until correct engine speeds are attained.)

90. COMPLETE CLUTCH ADJUSTMENT (fig. 92).

a. Complete clutch linkage adjustment consists of two separate operations, as follows:

(1) Adjustment of the turnbuckle on the single long rod to obtain proper relationship between clutch pedal and clutch lockouts. This **pedal linkage adjustment** does not require further attention after factory adjustment, unless the linkage is badly worn or has been damaged.

(2) Adjustment of the two synchronizing links for free pedal travel and proper dual clutch engagement. This **synchronizing adjustment**

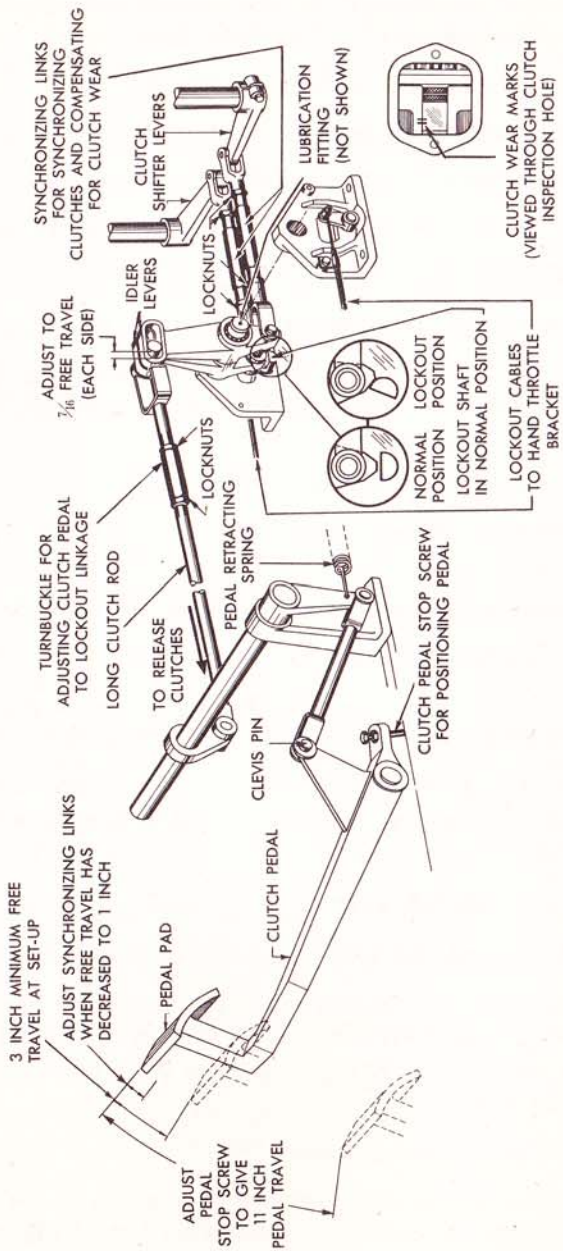


Figure 92—Clutch Linkage Diagram

will be required occasionally to compensate for clutch wear and to equalize the engagement of the two clutches.

b. Clutch pedal linkage adjustment (fig. 92).

(1) **Adjust clutch pedal position.**

(a) Remove clevis pin from pedal link.

(b) Adjust stop screw so that pedal foot pad has 11 inches travel.

(c) Install clevis pin.

(2) **Adjust linkage between clutch pedal and lockouts.**

(a) Place the two idler levers in lockout position by shortening the synchronizing links until lockout shafts can be revolved. Then lengthen synchronizing links about three turns.

(b) Hold clutch pedal all the way down.

(c) Adjust turnbuckle on long rod until both idler levers just move from the lockout shafts.

(d) Continue to shorten rod one-half turn of turnbuckle.

(e) Tighten two lock nuts.

(f) CAUTION: Do not use turnbuckle to renew free pedal travel lost through clutch wear, or lockouts will not operate.

c. Synchronizing adjustment (fig. 92). This adjustment is required when free pedal travel has decreased to one inch, and for synchronizing clutches. The procedure is as follows:

(1) **Check clutch disk wear.**

(a) Remove inspection hole covers from flywheel housings.

(b) When clutch wear marks (see inset diagram at lower right in fig. 92) on driving lugs and clutch cover appear staggered, remove the shims from under the twelve clutch cover plate bolts before adjusting synchronizing links.

(2) **Adjust synchronizing links.**

(a) Release both clutches from lockout position by depressing clutch pedal all the way and pushing in lockout buttons. Release clutch pedal to uppermost position.

(b) Adjust the two synchronizing links to give 7/16-inch free travel in the elongated slots in each of the idler levers, and tighten four lock nuts. (This adjustment will give a free pedal travel of three to four inches.)

(c) Hold down the clutch pedal and run both engines at about equal speed **above** 1000 revolutions per minute. Synchronize the hand throttles if necessary.

(d) Place the transmission in fifth gear, let the clutch pedal up slowly, and observe the speed changes on the two tachometers.

(e) If both engines drop off in speed together, the clutches are synchronized. If one engine does not drop off in speed as soon as the second engine, shorten the synchronizing link **slightly** on the first engine.

(f) Check lockout operation. (See next paragraph.)

(3) **Check lockout operation.**

(a) Hold clutch pedal all the way down.

(b) Pull out two clutch lockout buttons, and release clutch pedal.

(c) It must now be possible to revolve the propeller shaft by hand with the transmission in neutral.

(d) If this is not possible, lengthen each of the two synchronizing links one-third turn and recheck operations from (2) (c), above.

91. TO REMOVE THE CLUTCH HOUSING AND CLUTCH ASSEMBLIES.

With the power unit removed from the tank, proceed as follows to remove the clutches for inspection and replacement of plates, bearings, or other parts:

a. Remove the transfer gear housing assembly (par. 72 **b**; see fig. 81).

b. Disconnect the clutch turnbuckles from the clutch shifter levers. Loosen the jam nuts (3/4-inch open-end wrench) at each end of the clutch turnbuckles. Unscrew the rods from the clutch shifter arm clevises (5/8-inch open-end wrench).

c. Remove the bolts (lockwashers) holding the clutch housing to the flywheel housing (fig. 93).

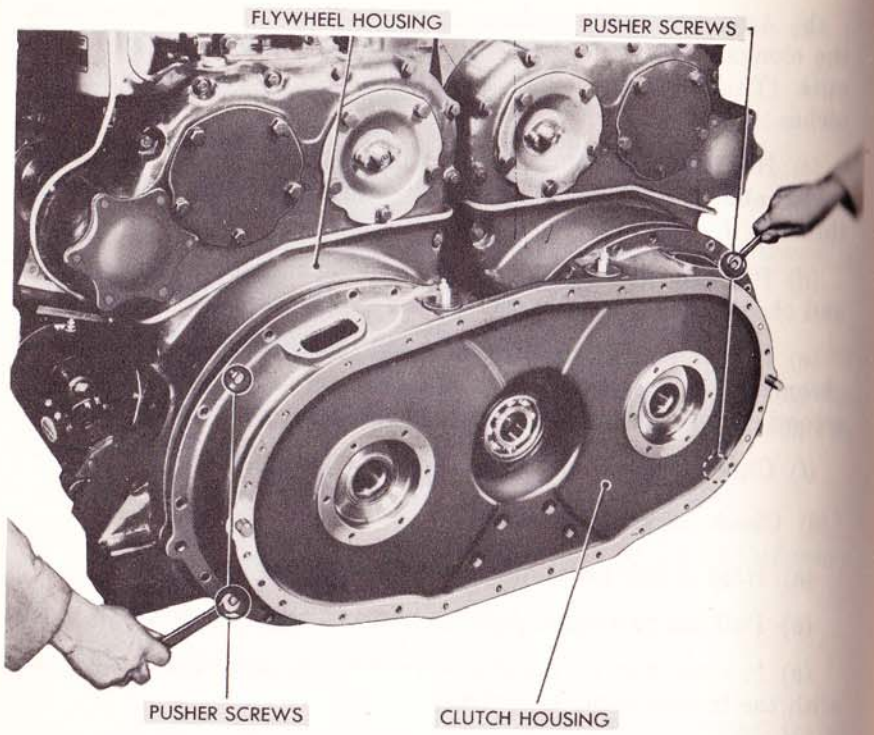


Figure 93—Removal of Clutch Housing Assembly

(1) Use a 9/16-inch socket, short extension, and ratchet handle wrench.

(2) In order to remove the four lower center bolts, first remove the four pipe plugs which cover them (1/2-inch drive socket handle).

d. Remove the clutch housing inspection hole covers (fig. 93).

(1) Remove the two bolts and lockwashers which hold each cover to the clutch housing.

(2) Unscrew the clutch release lubrication fitting (7/16-inch open-end wrench) and remove the fitting and plate.

e. Remove the clutch housing assembly (fig. 93).

(1) Take four of the bolts (just removed) that held the clutch hous-

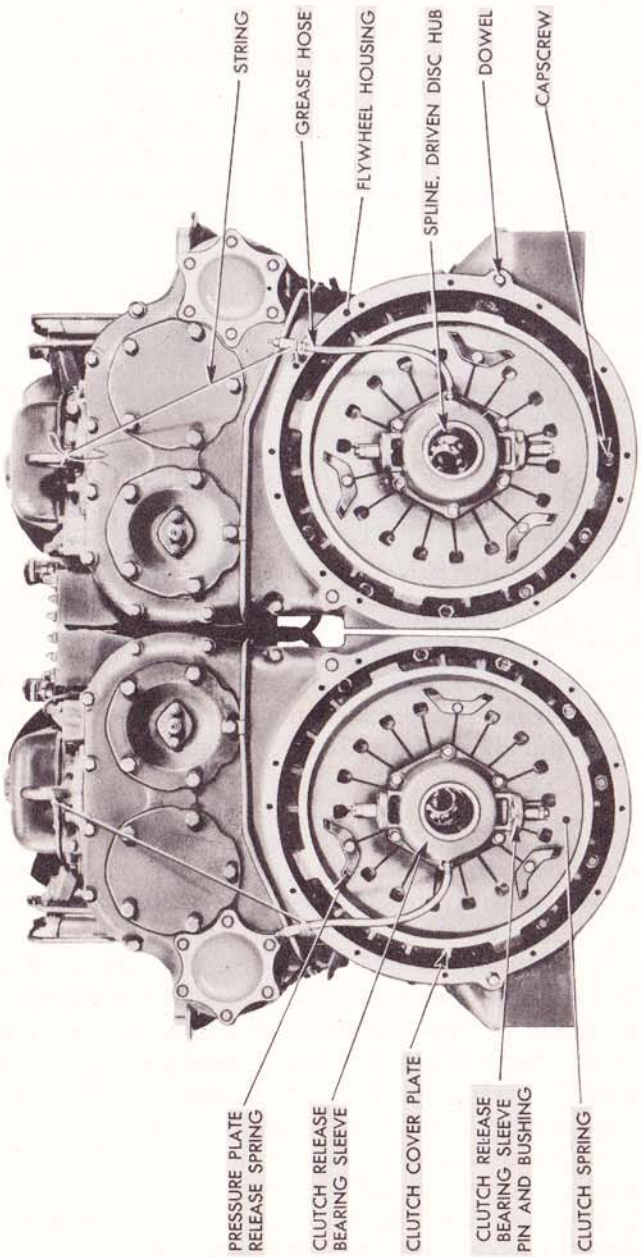


Figure 94—Removal of Clutch Assembly

ing to the flywheel housing and screw them evenly into the four tapped holes in the clutch housing, thus drawing the housing off the dowel pins. Exercise care to draw housing off the dowel pins evenly, to avoid distorting the housing.

(2) Lift off the assembly, carefully disengaging the clutch shifter shaft yokes. CAUTION: When lifting off, be careful not to damage tachometer cables, temperature gage tubes, and leather oil seals for clutch drive shafts.

f. Remove the clutch assembly (fig. 94).

(1) Loosen evenly the twelve clutch assembly bolts (½-inch socket wrench) which hold the clutch assembly to the flywheel, until all tension on the bolts is relieved. (This prevents bolts from binding.) Then remove all bolts and lockwashers.

(2) Pull out and lift off the clutch assembly, including the clutch release bearing assembly. (Note shims between the clutch assembly and the flywheel.)

(3) Lift out the clutch driven disk assembly (fig. 95).

92. INSPECTION AFTER REMOVAL.

After the clutch housing assembly and the clutch assembly have been removed, all possible parts should be inspected. (If further disassembly is required, notify ordnance maintenance personnel.) To inspect:

a. Wash all parts except the disk.

b. Inspect clutch driven plate and splines for wear. Check clutch facings for wear, loose rivets, evidence of overheating, and glazing. If condition of facings appears satisfactory, measure total thickness of driven plate at three different locations on the facings. If minimum reading is less than .370 inch, the shims between the clutch cover and the flywheel should be removed before reinstalling the clutch assembly. If the minimum thickness is less than .340 inch, the clutch driven plate assembly should be replaced. (Do not attempt to replace the clutch facings, as the clutch driven plate is serviced only as assembly.) Also inspect the clutch driven plate hub splines for improper fit due to excessive wear or burred edges. The engine drive shaft should have a free sliding fit in the hub, without excessive play. Remove burrs by honing damaged part, or make necessary replacement.

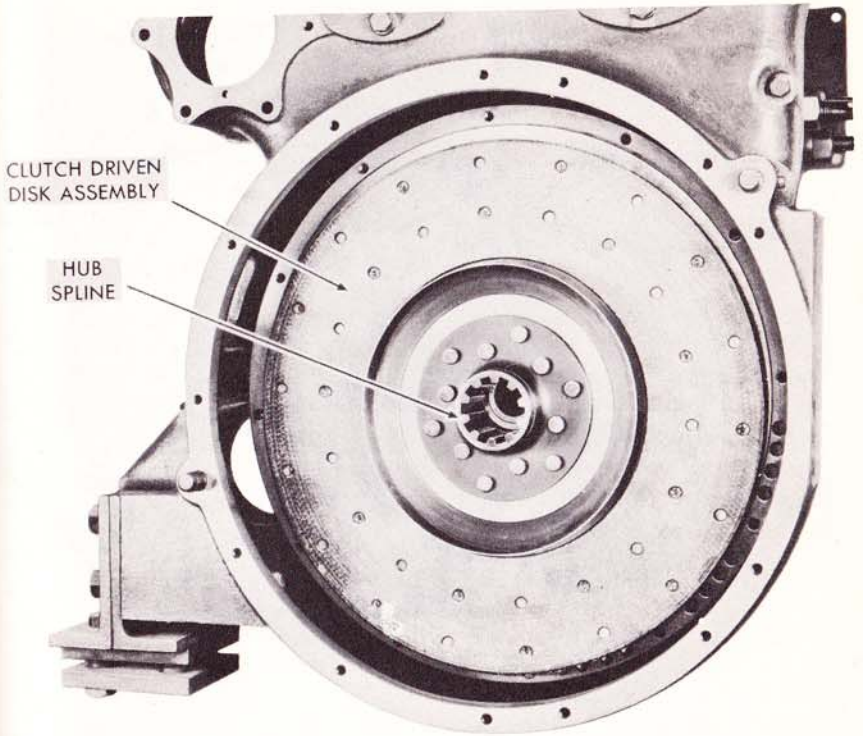


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Figure 95—Clutch Driven Disk Assembly

93. CLUTCH PLATES.

Clutch plates provide for gradual and smooth application of power, and for positive non-slipping drive when fully engaged. Worn or damaged clutch plates should be replaced with new or rebuilt plates (notify ordnance maintenance personnel).

94. TO INSTALL CLUTCH HOUSING AND CLUTCH ASSEMBLIES.

To replace the clutch, follow in reverse the steps for removing the clutch housing assembly and the clutch assembly (par. 91), except that the following precautions must be observed:

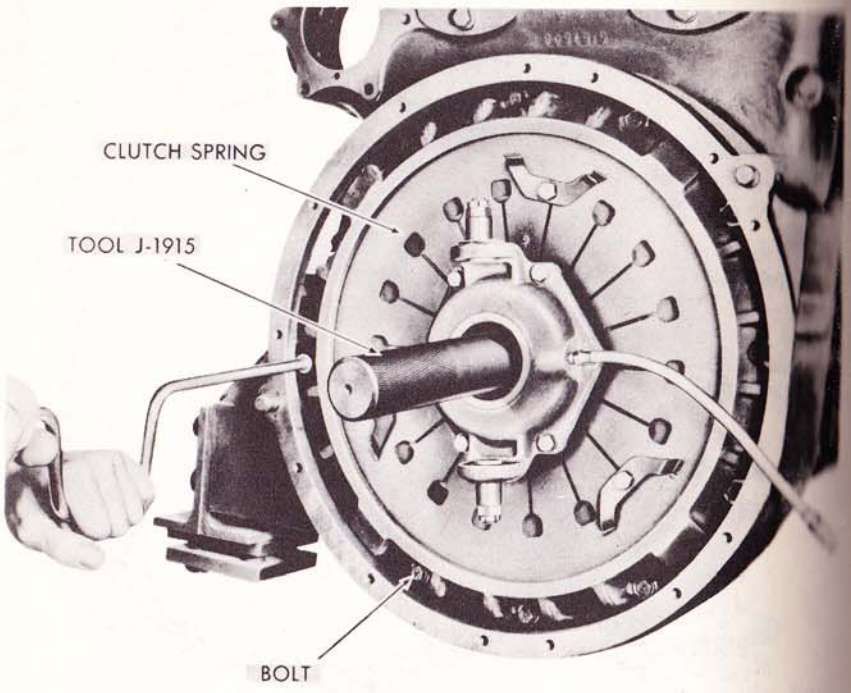

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Figure 96—Installation of Clutch Driven Disk Assembly

a. Installing clutch driven disk assembly (fig. 96).

Insert pilot tool J-1915 through the disk assembly into the flywheel clutch shaft pilot bearing to hold the disk in position while the clutch assembly is being installed.

b. Installing the clutch housing assembly.

Before installing the housing over the dowel pins on the flywheel housings, tie a cord to the grease fitting on each clutch release bearing hose and draw the ends up through the clutch housing inspection holes.

c. Install new gaskets on clutch housing inspection holes.

d. Installing clutch shifter levers.

Use a soft hammer to pound the levers on to the shifter shafts.

Section XVIII

PROPELLER SHAFT

95. DESCRIPTION (fig. 97).

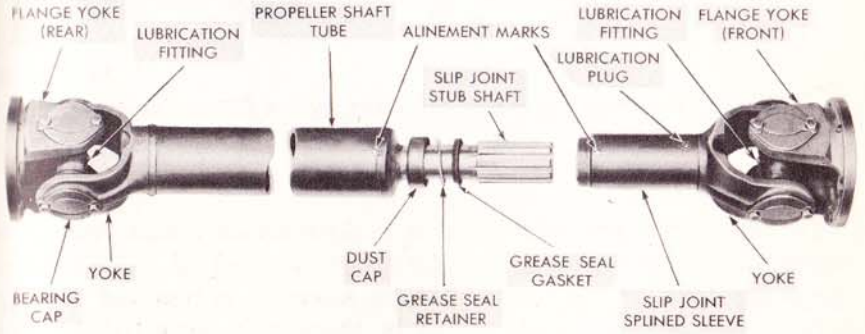
The propeller shaft, which transmits power from the engine driven shaft to the transmission, is equipped with a universal joint at each end. Back of the front universal joint is a splined slip joint to allow for variations in the length of the shaft while it is in operation. The propeller shaft is enclosed in a housing, or tunnel, on the crew compartment floor under the turret platform.

96. LUBRICATION.

Both the universal joints and the slip joint require lubrication. (See par. 26, **Lubrication Instructions.**)

97. INSPECTIONS.

a. The universal joints should be inspected during the 50-hour and the 100-hour inspection to determine whether the bearings and cups



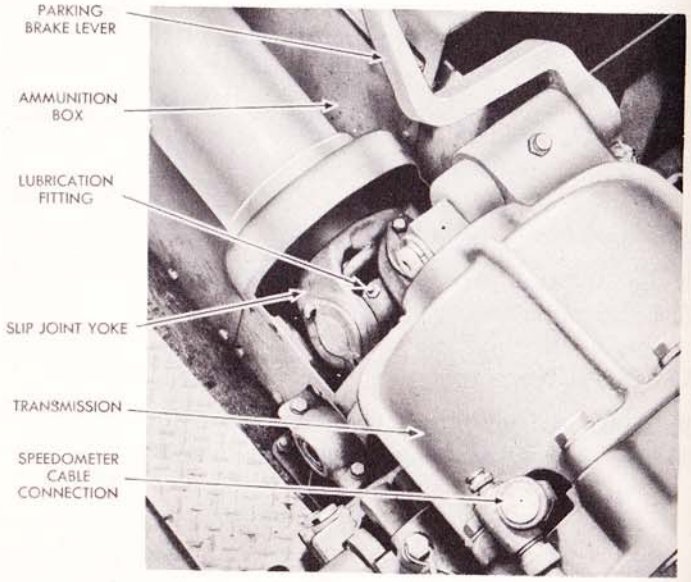
RA PD 36397

Figure 97—Propeller Shaft, Separated at Slip Joint

are worn. (Symptoms of wear on these parts are excess vibration and noise while the shaft is in motion.) Worn bearings will necessitate the replacement of the shaft.

b. Inspection should be made for leaking grease seals, indicated by streaks of lubricant inside the universal joint covers of the housing. Leaky seals should be replaced.

c. With the engine stopped, the shaft should be tested for looseness, and the bolts on the front and rear flanges tightened if necessary.



RA PD 36398

Figure 98—Front Universal Joint, Inspection Cover Removed

98. REPLACEMENT.

To remove the propeller shaft, it is not necessary that either the power train or the turret and turret platform be removed, but whenever the power train or the turret-platform assembly is removed for any purpose, the propeller shaft should be thoroughly inspected in order that any necessary work on it may be done readily.

a. Remove propeller shaft.

(1) **Remove assistant driver's seat.**

(a) Lift off the seat back.

(b) Pull out knob at seat post base and lift out seat post and seat.

(c) Remove parts from tank through assistant driver's door.

(2) Remove two bolts holding front universal joint housing cover (⅜-inch open-end wrench) and remove cover.

(3) Remove nine bolts (7/16-inch open-end wrench) holding front section of propeller shaft housing, and remove the section.

(4) **Remove 75-mm. ammunition box.**

(a) Remove one screw each from the two clips holding electrical conduit to top front edge of ammunition box.

(b) Remove the two lock nuts (⅝-inch open-end wrench) from the front bottom edge of the ammunition box.

(c) From underneath the tank, remove two slotted bolts (large screwdriver) which hold rear of ammunition box to floor of tank. (These two bolts are just behind the hull floor front cross braces.)

(d) Slide ammunition box out through power train opening.

(5) Remove stowage box behind 75-mm. storage rack on tank floor.

(6) Remove U-shaped slip ring support from top of propeller shaft housing by backing out two bolts (7/16-inch open-end wrench).

(7) Remove rear section of the propeller shaft housing (½-inch, ⅝-inch, 7/16-inch wrenches) and take out through turret hatch opening.

(8) Remove propeller shaft housing center cover (⅜-inch open-end wrench).

(9) Remove front and rear propeller shaft housing cross braces from inside housing.

(10) Uncouple companion flanges of rear universal joint by removing eight bolts and lock nuts (two 9/16-inch open-end wrenches).

(11) Separate the two sections of the propeller shaft by unscrewing dust cap at the slip joint, sliding splined end of shaft out of the universal joint yoke.

(12) Remove propeller shaft through escape hatch or assistant driver's hatch.

Section XIX

POWER TRAIN UNIT

99. POWER TRAIN COMPONENTS.

The power train unit (fig. 99) comprises the transmission, differential, and the two final drives, all of which are lubricated by a single oil circulating system, including a pump and an oil cooler. The entire power train unit may be removed from the tank as a single assembly. Only the final drives may be removed from the tank as separate units. The differential and the transmission are always removed together.

100. TRANSMISSION (figs. 99 and 104).

The transmission, synchronized type, has five forward speeds and one reverse. Synchronizers, to facilitate gear shifting, are provided for all speeds except first and reverse. The gears for all speeds are in constant mesh. A parking brake, built into the transmission, is operated by a lever to the right of the driver. This brake is to be applied only when the tank is at a standstill. (In later models, the steering brakes may be locked in applied position, and there is no parking brake on the transmission.)

101. DIFFERENTIAL.

a. **Operation.** The differential is called a **controlled** differential because it not only serves to permit one track to move slower or faster than the other to compensate for irregular ground or turns (as does the ordinary automobile differential), but also may be con-

POWER TRAIN UNIT

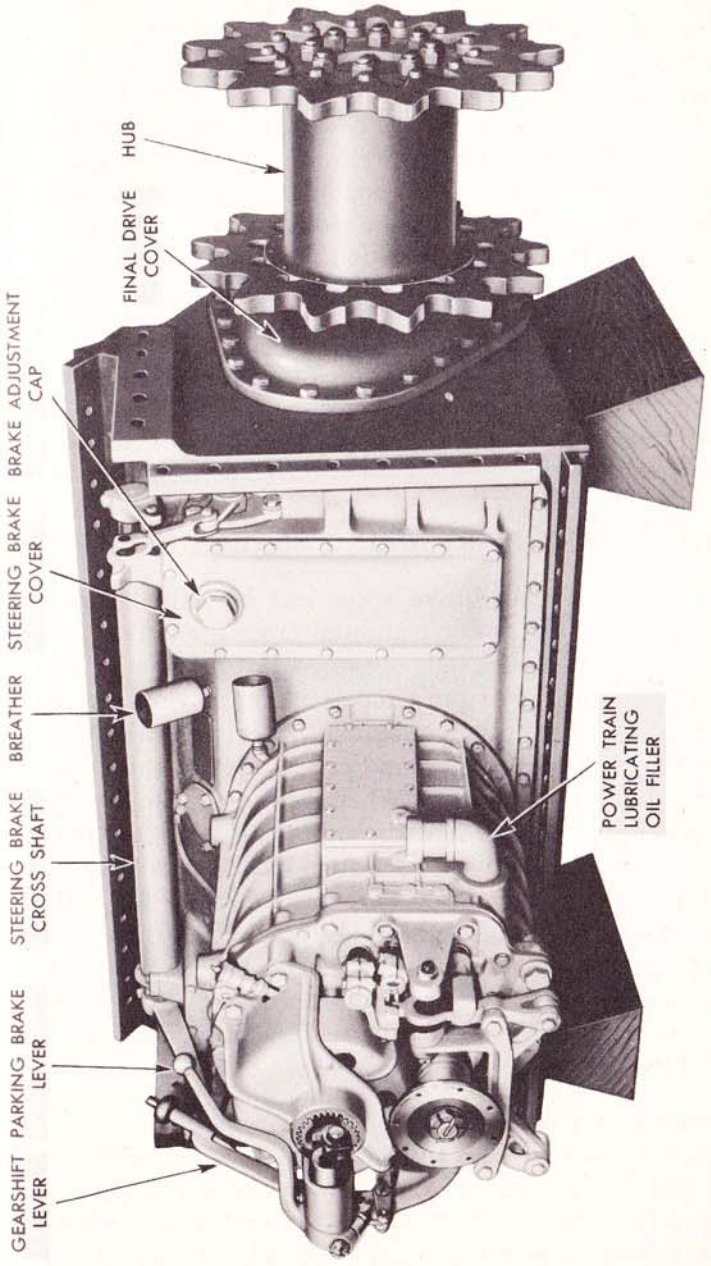


Figure 99—Power Train Unit on Blocks

trolled by the operator to cause either track to run slower than the other, for steering the tank. When a steering brake lever is pulled back, it tightens the brake band and slows or stops the brake drum on its particular side. This slowing or stopping of the brake drum and its compensating shaft slows down (but cannot stop) the track on the side on which the steering brake is operated, and causes a corresponding increase in the speed of the other track, so that the tank turns toward the side of the slower track. Sharpness of the turn depends on the force with which the steering lever is pulled. If the two steering levers are operated equally, the tank will slow or stop without turning to either side.

b. Housings. Most M4A2 Medium Tanks have one-piece differential housings. A few models have three-piece differential housings. The operations covered in this manual apply only to differentials with one-piece housings, except where the operations are similar.

102. ADJUSTMENT OF STEERING BRAKES (figs. 100-103).

a. General. Steering brake shoes can be adjusted or replaced without removing the power train unit from the tank. The work is done inside the tank through openings in the differential housing directly in front of the driver's and assistant driver's stations. The openings are covered by rectangular steering brake drum cover plates, each of which has a round access port in the upper section for minor brake adjustments. When steering brake levers have too much over-travel, check for worn brake linings; when brake application is not fully effective, check for glazed brake linings; when a screeching is heard when brakes are applied, check for brake linings worn down to rivet heads, or foreign matter between brake lining and brake drum. Adjust brakes or replace brake shoes as required. Brake shoes with badly worn or glazed linings, and linings worn down to the rivet heads, should be replaced immediately to prevent scoring of brake drums.

b. Steering brake adjustment (minor). When the tank is equipped with new brake linings, and the steering brake levers, linkage, and steering brakes are in correct adjustment, the steering lever has a free travel of four inches. As new brake linings wear in, it will be necessary to make minor brake adjustments, from time to

time, so as to hold steering lever free travel to a maximum of eight inches. (Steering lever free travel is the distance the **tops** of the steering levers move from the fully released full forward position, against the stops, to an almost vertical position where the brake shoes are felt to make contact with the brake drums.) These adjustments are made as follows:

(1) Remove the brake adjustment port caps and gaskets (2¼-inch wrench).

(2) Insert wrench (1⅛-inch socket, extension, and ratchet handle) into port (see fig. 101) and back off or take up brake adjust-

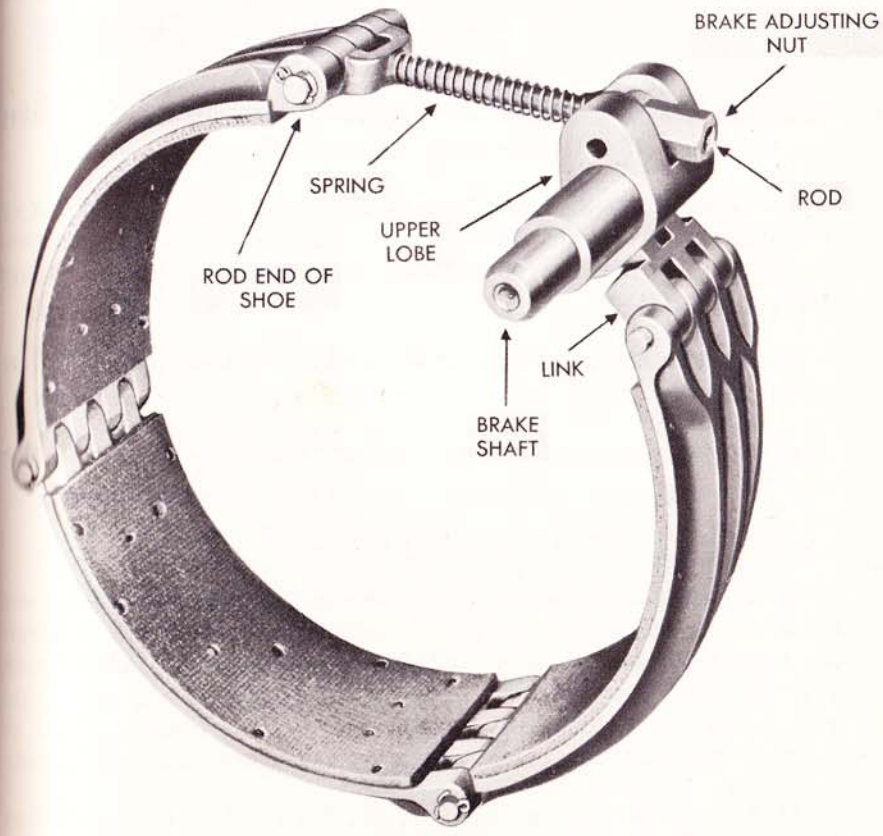


Figure 100—Details of Brake Shoes and Brake Shaft

ing nut (see fig. 100) the necessary number of notches to adjust steering levers to free travel of eight inches. NOTE: Backing off adjusting nut lengthens free travel; taking up on the nut shortens the travel. The following table indicates the number of notches needed to correct travel:

If free travel of steering lever is	Number of notches on brake adjusting nut
4 inches	Back off 4 or 5
6 inches	Back off 2 or 3
8 inches	0
10 inches	Take up 2 or 3
12 inches	Take up 4 or 5
14 inches	Take up 6 or 7

(3) Remove socket wrench. CAUTION: Be careful that socket does not come off extension and drop into differential housing.

(4) Check steering brake levers for equal travel. A notch or two on either or both of the brake adjusting nuts, in either direction, is permissible to effect equalization. CAUTION: Do not change steering lever stops.

(5) Measure steering lever free travel at the tops of the steering levers.

(6) Replace brake adjustment port gaskets and caps and tighten securely.

c. Steering brake adjustment (major).

Major brake adjustments are necessary when brake linings are worn out, brake drums are worn or scored, or unsatisfactory steering operation cannot be corrected by a minor brake adjustment. The following instructions will be observed also when new brake linings have been installed, the power train has been removed, or the steering brake lever linkage has been disconnected or changed.

(1) **Drain power train** (par. 104 **d**). Oil must be drained before the steering brake cover plates are removed. Drain oil into clean containers, sufficient to hold 152 quarts. NOTE: If lubricating oil

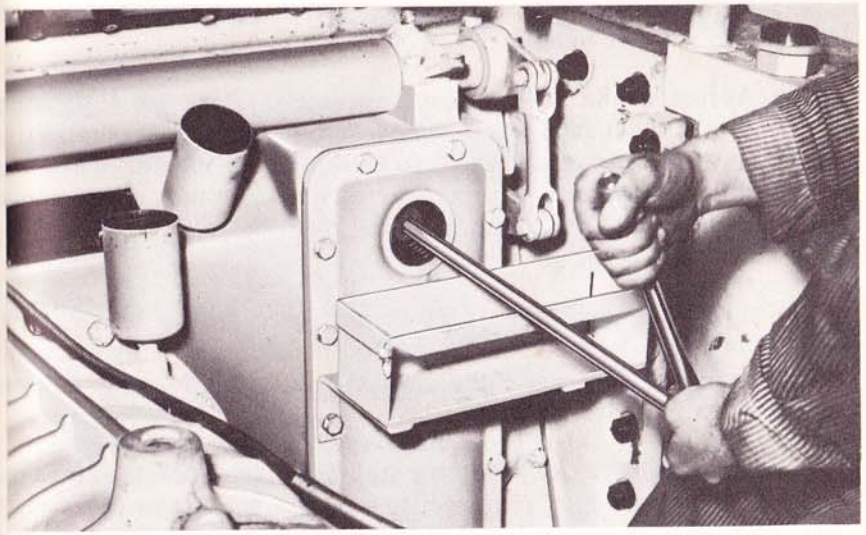


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Figure 101—Adjusting Steering Brake Shoes

is to be used again, it must be filtered through clean cloth before it is poured back.

(2) **Check index marks.** Make certain that levers are correctly indexed. The brake cross-shaft lever, right, and the actuating lever for the right brake, should be installed with marks on ends of shafts and hubs of levers in line. Connect the lever rod to the actuating lever by installing the pin and securing it with cotter pin. The brake cross-shaft lever, left, and the actuating lever for the left brake, are correctly positioned on shafts when the marks on hubs of lever are two serrations **ahead** of marks on ends of shaft. If index marks are absent or indistinct, mark shaft ends and lever hubs (before disassembling) with prick punch marks **in line**, to assure correct reassembling.

(3) **Disconnect steering lever linkage.** Remove cotter and clevis pins from steering lever connecting rod upper yokes and disconnect rods from left brake actuating lever and from brake cross-shaft right lever, both on the left side of the differential housing.

(4) Remove steering brake cover plates and gaskets (¾-inch socket and ratchet handle).

(5) **Adjust brake shoe supporting screw.** Back off supporting screw jam nut (1-inch open-end wrench) and adjust supporting screw (⅞-inch open-end wrench) to give .005-inch clearance between brake drum and brake lining directly over supporting screw. Tighten supporting screw jam nut, and recheck. NOTE: Use feeler gage to get correct measurement.

(6) Apply an approximate 50-pound force to the brake cross-shaft left lever (left side of differential housing), to fully compress the right brake shoe assembly against the brake drum. Maintain this force while adjusting right brake.

(7) Turn right brake adjusting nut (1⅛-inch socket, extension, and ratchet handle) as required, to position the brake cross-shaft left lever, so that the center of the clevis hole in the end of the lever measures exactly two inches **above** the top horizontal machined surface of the left side rail of the differential housing (see fig. 99). NOTE: Taking up on the adjusting nut raises the lever; backing off the nut lowers the lever.

(8) Remove 50-pound force or load from brake cross-shaft left lever.

(9) Remove socket, extension, and ratchet handle from right brake adjusting nut.

(10) Apply an approximate 50-pound force to the left brake actuating lever (left side of differential housing), to compress the left brake shoe assembly against the brake drum. Maintain this force while adjusting left brake.

(11) Turn left brake adjusting nut (1⅛-inch socket, extension, and ratchet handle) as required, to position the left brake actuating lever so that the center of the clevis hole in the end of the lever measures exactly 3¾ inches **below** the top horizontal machined surface of the left side rail of the differential housing (see fig. 99).

(12) Remove force or heavy pressure from left brake actuating lever.

(13) Remove socket, extension, and ratchet handle from left brake adjusting nut.

(14) **Adjust steering levers.**

(a) Loosen lock nuts on steering lever stop screws.

(b) Adjust steering lever stop screws to position both steering levers even with each other and with their rear edges two inches ahead (toward front of tank) of the center of the clevis pin hole in the brake cross-shaft left lever (the lever between the two steering levers), when that lever is in the down position.

(c) Tighten both stop screw lock nuts.

(15) **Adjust steering lever connecting rods.** Apply an approximate 50-pound force first to the brake cross-shaft left lever, and then to the left brake actuating lever, both on the left side of the housing. While this force is applied, perform the following operation, first on the right steering lever connecting rod and then on the left rod.

(a) With steering lever forward against its stop, adjust yoke on steering lever connecting rod so that the clevis pin hole in the yoke is in line with the clevis pin hole in the brake shaft lever. Further adjust yoke approximately ¼-inch, or five full turns, to increase length of rod. Remove load from lever, line up lever clevis pin hole and yoke clevis pin hole, and install clevis pins and cotter pins. NOTE: This additional length on each steering lever connecting rod will provide the necessary clearance between brake lining and brake drum and give the correct four inches of steering lever free travel, measured at the top of the steering lever handle. Each ⅛-inch added to length of the connecting rod adds 2 inches of free travel to the steering lever. CAUTION: Be sure clevis pins are properly locked with cotter pins, and that lock nuts on stop screws are tight.

(16) **Test steering levers for equal travel.** A notch or two on either or both of the steering brake adjusting nuts, in either direction, is permissible to effect equalization.

(17) NOTE: A nominally correct adjustment will have been obtained when the brake shoes just engage the brake drums when the steering levers are pulled back to a nearly vertical position.

(18) Install both steering brake drum cover plates and gaskets. (Make sure gaskets are in good condition.)

(19) Refill power train with lubricating oil, following instructions in Lubrication Guide (par. 26, Note 6 **a**).

d. Removal of brake shoes.

(1) Drain power train unit (par. 104 **d**).

(2) Remove driver's and assistant driver's seat.

(3) Disconnect steering lever connecting rod clevises at the left side of the differential housing.

(4) Take off steering brake cover plates and gaskets (¾-inch socket, extension, and ratchet handle), and wipe out the housing.

(5) Loosen lock nut and turn down supporting screw (1-inch and ⅞-inch open-end wrenches) below brake shoes as far as possible, to provide clearance when removing shoes.

(6) **Disconnect brake shoes** (fig. 102).

(a) Remove brake adjusting nut (1⅛-inch socket and ratchet handle).

(b) Remove spring clip from brake adjusting rod.

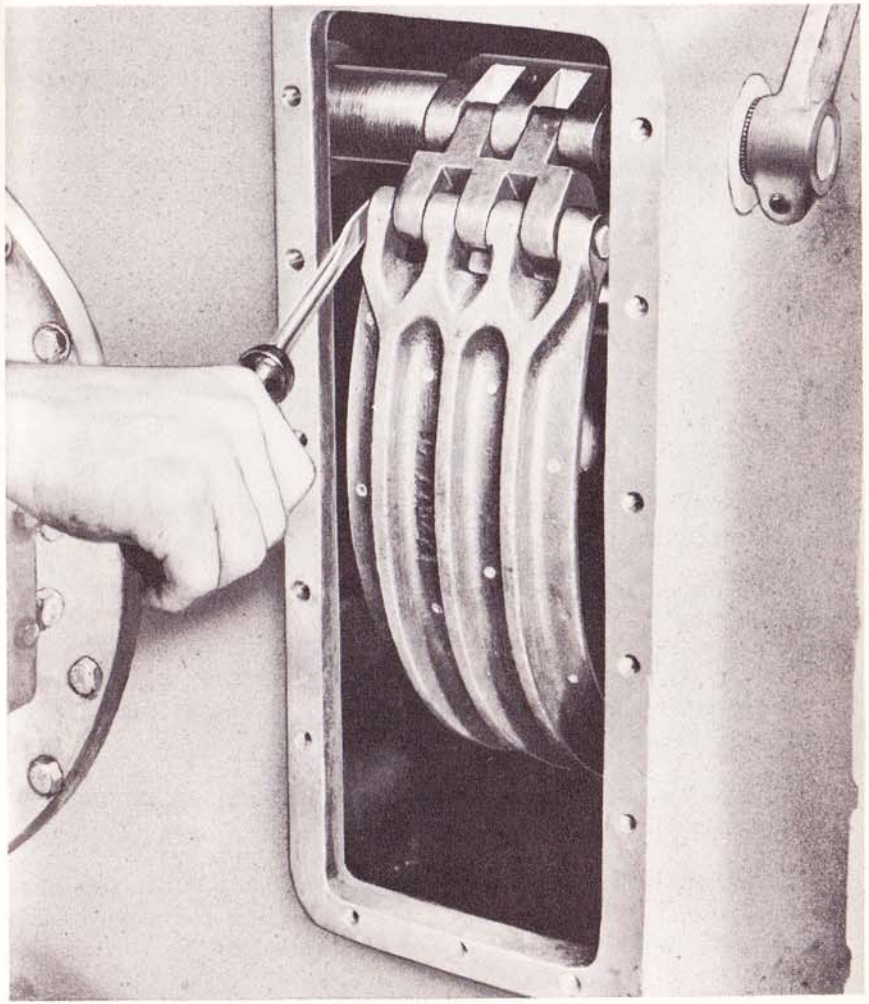
(c) Push end of brake adjusting rod through brake shaft pin and remove washer and spring. (CAUTION: Take care not to drop washer inside housing.) The end of brake shoe assembly toward front of tank is now free, and the assembly will slide part way off the top of the brake drum to rest against the differential housing.

(d) Remove cotter pin from center lobe of brake shaft cam and shoe link.

(e) Remove the three bolts holding the brake shaft trunnion to the differential housing. To provide clearance to push the pin connecting the brake shaft cam and shoe link toward the center of the differential housing, pull trunnion out at least one inch, moving the brake shoe and brake shaft linkage far enough toward the outside of the housing to give the required clearance.

(f) (Right brake only.) Before removing the trunnion bolts remove cotter and clevis pin from the lower yoke of the brake shaft lever rod, on right side of differential housing, which connects the brake cross-shaft right lever to the right brake actuating lever.

(g) Insert screwdriver in groove around end of pin. Pry pin



RA PD 36402

Figure 102—Disconnecting Brake Shoe from Link

toward center of differential housing until brake link is free and can be removed from brake cam. Brake shoe assembly is now free. NOTE: As pin cannot be freed entirely from brake cam because end of pin strikes against the differential carrier, it will be necessary to manipulate the trunnion until pin can be moved far enough to allow link to drop out of cam.

(7) **Withdraw brake shoes** (fig. 103). Pull brake shoe assembly around and from under brake drum toward inside of tank. Use a pinch bar to aid in working it out. CAUTION: Use care in working hinged section of brake shoe assembly over supporting screw.

(8) Inspect all brake parts for wear, breakage, or drum scoring. Replace, if necessary. Wipe out housing and remove any foreign matter.

(9) Disassemble brake shoes by removing cotter pins and link pins.

(10) Inspect pins and holes for wear. Inspect lining for wear and loose rivets. Replace shoes having worn linings.

e. Installation of brake shoes.

(1) Check to see that brake shoe supporting screw is screwed all the way down.

(2) Fasten wire to brake adjusting rod and second wire to adjusting rod yoke.

(3) Pass wires under drum, up between drum and differential housing, and over top of drum. Use pinch bar to ease assembly over supporting screw.

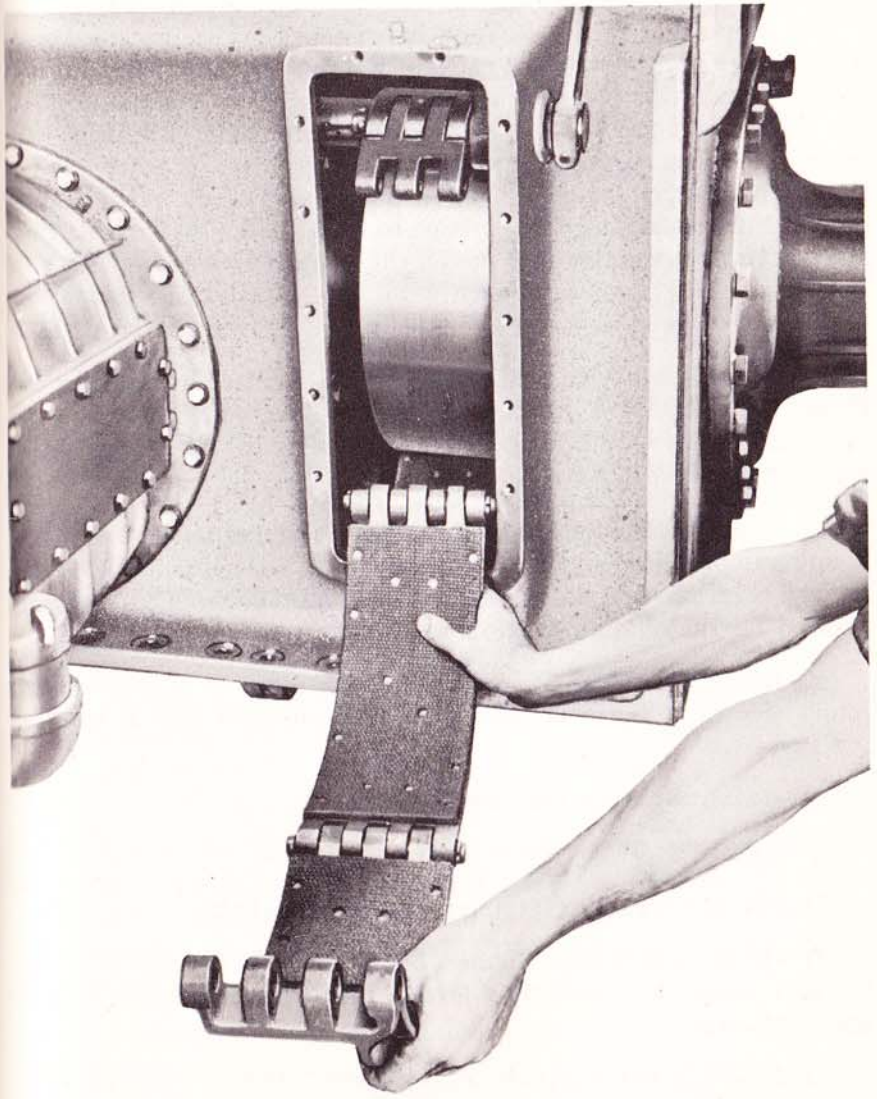
(4) Feed brake shoe assembly, beneath and up around drum, pulling from the top with the wires.

(5) When brake shoe assembly comes around the top of the brake drum, fasten wire attached to adjusting rod yoke to brake cross-shaft support bracket to hold section in place.

(6) **Connect brake shoe assembly.**

(a) Move trunnion toward outside of differential housing.

(b) Lift link end of brake shoe assembly into place in brake shaft cam.



RA PD 36403

Figure 103—Removing Brake Shoes from Below Drum

(c) Slide pin connecting link and cam into place. Manipulate trunnion as necessary. NOTE: Be sure slotted end of pin is toward center of differential.

(d) Aline cotter pin holes, and insert pin. NOTE: Pin has a slot in the outer end, in which a screwdriver may be inserted to rotate pin. To reach this slot with a screwdriver, it is necessary to remove the brake actuating lever from the brake cam shaft. Remove cap screw (9/16-inch wrench) and drive lever off shaft. Remove brake shaft trunnion by removing three cap screws (1-inch wrench) and lock washers attaching the trunnion to the carrier. After installing and splitting the cotter pin, install the trunnion and the three cap screws and lock washers (1-inch wrench). Install brake actuating lever and secure with the cap screw (9/16-inch wrench).

(e) Remove wire from brake adjusting rod and install spring. Install the washer. Hold washer against spring with left hand and, by means of the second wire, pull the adjusting rod yoke toward the steering brake opening with the right hand.

(f) Position adjusting rod in brake shaft cam pin, flat side of pin facing adjusting rod spring, washer against flat of pin. Pull adjusting rod through cam pin by means of the wire and hold spring compressed for installation of clip and adjusting nut.

(g) Instill clip. NOTE: Install clip with flat side of clip against round side of brake shaft cam pin, clips outward and in vertical position.

(h) Install adjusting nut, bevel side in.

(i) Remove wire.

(7) Position brake shaft trunnion and tighten bolts.

(8) (Right side only.) Connect brake cross-shaft right lever rod to right brake shaft actuating lever. Line up index marks on hub and shaft end.

(9) Adjust brake supporting screw until .005-inch clearance is obtained with a feeler gage between brake drum and brake lining, directly above the supporting screw. Tighten supporting screw jam nut, and recheck.

(10) Check brake shaft ends and brake actuating lever hubs for correct relation of punch marks. Adjust, if necessary.

(11) Adjust brake shoes, steering levers, and steering lever connecting rods (par. 102 **b**).

(12) Install steering brake cover plates and gaskets. Be sure only good gaskets are used.

(13) Install driver's and assistant driver's seat.

(14) Refill power train unit with lubricating oil, following instructions in **Lubrication Guide** (par. 26).

103. PARKING BRAKE (fig. 104).

a. **Linkage.** The parking brake lever transmits motion to the conical brake shoe through a single toggle link, pivoted to the shoe and to the brake lever shaft. When the lever is pushed all the way forward, past the dead-center position of the toggle linkage, the lever remains locked in position, with the brake lining under compression against the brake drum. As the brake lining wears away, the linkage must be adjusted (lengthened) to restore full brake pressure when the brake lever is in the locked position.

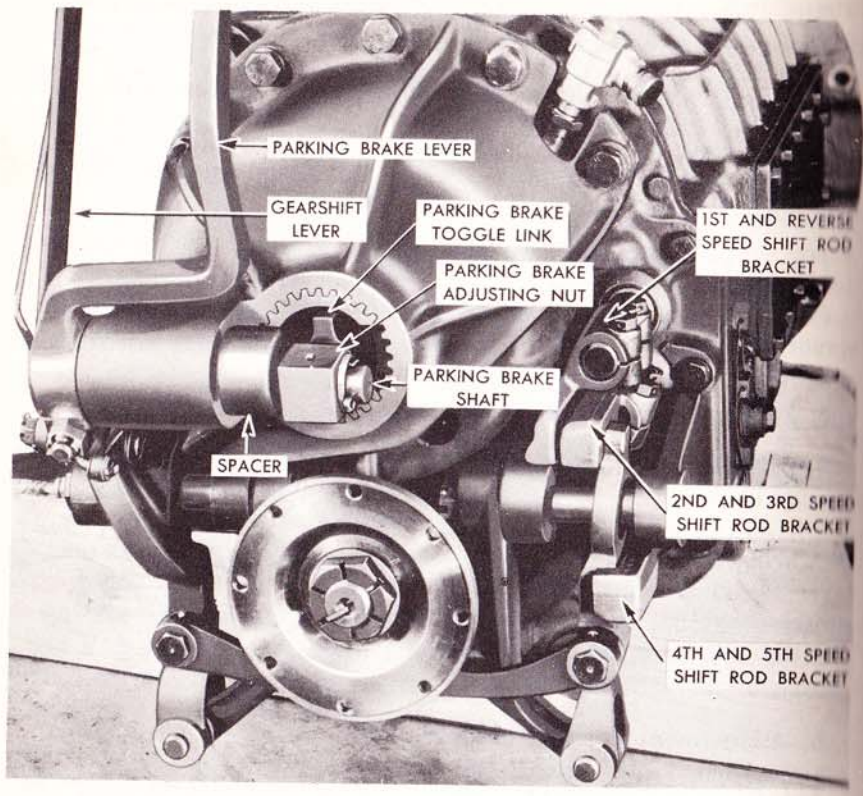
b. **Adjustment (see fig. 104).**

(1) Remove parking brake lever with brake shaft lever attached, by withdrawing cotter pin from the shaft and sliding shaft out of the adjusting nut of the toggle link, removing the washer and spacer.

(2) Screw the adjusting nut outward (counterclockwise), to lengthen the link and decrease the clearance between the brake lining and the drum. NOTE: The adjusting nut must be given a complete turn, or several complete turns, in order to bring the oil hole on top.

(3) Reinstall brake shaft, spacer, washer, and cotter pin, and test adjustment. Readjust as necessary to effect complete contact between shoe and drum when lever is in the locked position.

(4) When the proper adjustment has been attained, lock the brake by pushing the lever all the way forward, then loosen the



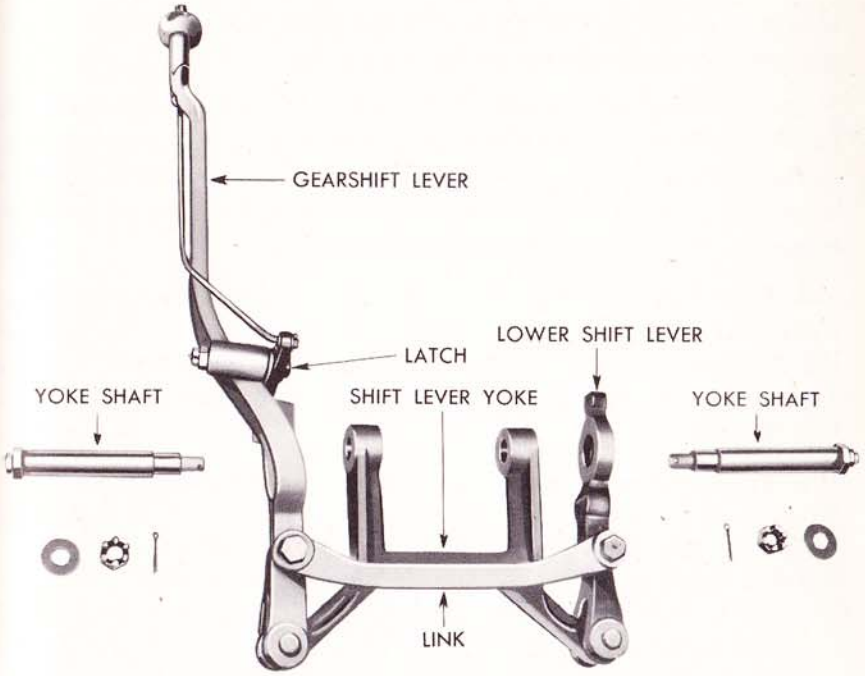
RA PD 36404

Figure 104—Transmission, Rear View

clamping bolt at the bottom of the brake lever, move the lever to vertical or slightly forward position, and tighten clamping bolt. Secure nut on bolt with cotter pin.

104. LUBRICATION OF POWER TRAIN.

a. Oiling system. The entire power train unit, which comprises the transmission, differential, and two final drives, is lubricated by a single oiling system. An oil pump, inside the transmission case, draws oil from a sump in the bottom of the differential housing and forces it through an outlet on the left side of the transmission case. From this outlet the oil is forced through hose lines and tubes to the oil cooler, through which it circulates, and then is returned to the



RA PD 36405

Figure 105—Shift Lever, Link, and Yoke, Removed

oil gallery of the transmission. From the transmission, the oil passes (through openings in the front wall of the transmission case) to the differential housing and two final drive housings, from which it is again drawn out by the pump to begin another cycle. An oil line from the tee connection in the return line from the cooler loads to the differential carrier, where it delivers a constant stream of cooled oil to the ring gear and pinion.

b. Filling. The power train is filled with lubricating oil at the filler (see fig. 99) on the right side of the transmission case.

c. Checking oil level.

(1) A bayonet-type measuring gage, or dip stick, for measuring the oil level, is attached to the filler cap. To measure the oil level, remove the cap, wipe off the gage, then insert it into the transmis-

sion case as far as it will go, with the cap merely resting on top of the filler opening. **Do not screw the cap in.**

(2) To determine accurately the level of oil in the power train, place the vehicle on level ground. The tank must have been operated enough to warm up the oil, and must have stood still for at least five minutes to allow the oil to settle. The **full** oil level should be maintained by frequent checking and adding oil as required.

d. Draining. To drain the power train requires the removal of three drain plugs—two underneath (one at each side) the differential housing, and one on the bottom of the transmission housing (accessible only through a cover plate on the underneath side of the hull floor).

e. Filling drained unit. If the power train has been drained, refilling requires special procedure. After putting in oil to raise level to the **full** mark on the dip stick, operate the tank until the oil is warmed up, then stop the tank and allow five minutes for the oil to drain back to the transmission. Again check oil level and add oil up to the **full** mark on dip stick. If, after the correct total measured quantity of oil has been put into a drained power train, the level does not come up to the **full** mark, it is because the oil has not yet fully drained back from the system after the warming-up run.

f. Oil cooler. Because the oil in the power train absorbs not only the heat generated by the gears, but also that generated by the brakes in steering and stopping the vehicle, an oil cooler is provided. It is mounted on the top center of the engine bulkhead, inside the crew compartment. The oil pump forces the oil through the passages here in the cooler, and air is drawn through the cooler core by the engine fans. CAUTION: Do not permit anything to block the flow of air to the oil cooler. It must be kept clear at all times.

105. REMOVAL OF POWER TRAIN UNIT (figs. 106-108).

a. Equipment. Besides the necessary tools, this operation requires three 10-ton jacks and a second vehicle or wrecker for towing. The tank being repaired must be on a firm and level surface.

b. Procedure.

(1) **Drain transmission and differential** (par. 104 **d**).

(2) **Break the tracks.** Break each track (par. 113 **c** (4)) **just below the sprocket.** Carry upper section to rear of tank and lay it flat on ground, to permit tank to be backed up without running off tracks.

(3) Detach towing cable.

(4) **Remove siren.** Unbolt siren from fender, and wire or tie to headlight guard.

(5) **Remove front fenders.**

(a) Remove the three bolts (9/16-inch socket wrench) holding fender to the hull, using a short-handled screwdriver beneath the fender to hold the bolts from turning.

(b) Remove the three bolts (1⅛-inch socket with 20-inch extension and heavy-duty ratchet handle) and lock washers that hold the side plate of the fender to the final drive housing. (Using a bar, turn sprocket, to gain access to the bolts.)

(c) Remove two bolts (¾-inch socket wrench and 20-inch extension) underneath fender where it attaches to front slope and lift off fender.

c. Break interior connections.

(1) **Disconnect universal joint** (figs. 97 and 98). Remove the front section of the propeller shaft housing (par. 98 **a** (3), (4)) and disconnect universal joint by removing the eight bolts (two 9/16-inch wrenches) and lock nuts from the companion flanges.

(2) **Disconnect steering rods.** Remove the cotter pins and clevis pins at the top ends of both steering lever connecting rods to disconnect them from brake shaft levers.

(3) Remove two bolts (¾-inch open-end wrench) from right side of left brake drum cover plate on differential housing and remove clips holding hand throttle and clutch lockout cables. Free cables and then replace bolts, screwing in by hand only enough to hold bolts in place. Leave clips attached to cables.

(4) Disconnect transmission oil temperature gage capillary tube from fitting at oil outlet on left side of transmission (¾-inch open-end wrench). Pass gage line under steering lever cross shaft to clear, and tie up out of the way, being careful not to kink the cable or injure the end fitting. Tape end of gage line and the opening in fitting on transmission housing.

(5) Disconnect both stoplight switches by removing the nuts (⅜-inch open-end wrench) on the adjustable switch rods which connect the stoplight switches to the brake shaft arms. Replace nuts on rods for safekeeping.

(6) Remove siren switch bracket from side of power train.

(7) Remove both stoplight switch brackets by removing two bolts (¾-inch open-end wrench) from left side of left brake drum cover plate on differential housing. Replace bolts, screwing in only enough to hold in place.

(8) Wire siren switch bracket, siren switch, and stoplight switches up out of the way.

(9) Disconnect transmission oil cooler lines (1⅜-inch open-end wrench) at fittings on transmission housing. Cover fittings and oil line couplings with cloth or tape.

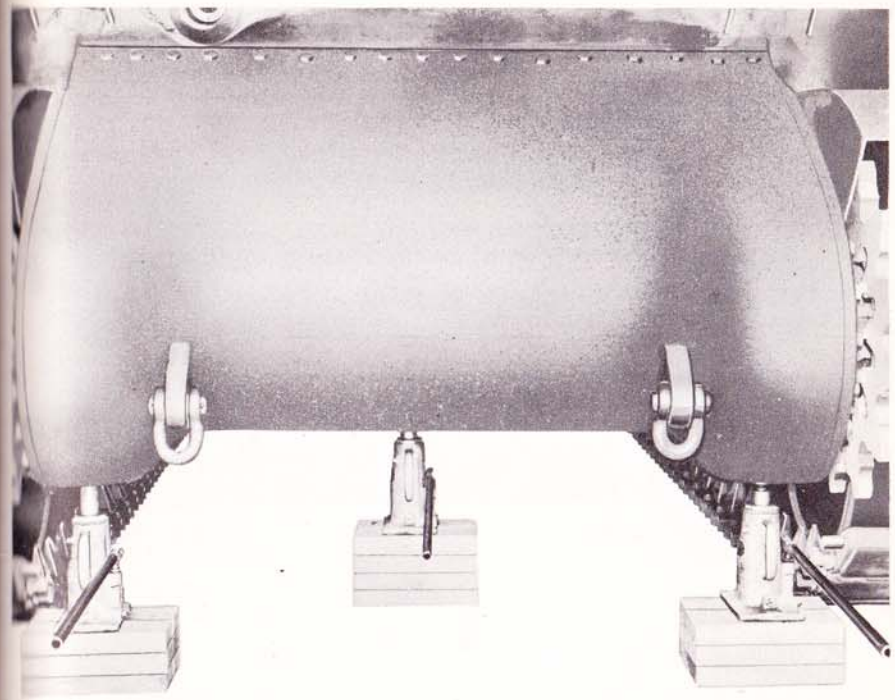
(10) Remove machine gun trunnion pin (see fig. 11) and lift gun out of mount. Remove coil spring.

(11) Disconnect speedometer cable from fitting at top right rear of transmission housing by loosening knurled nut. Pass cable under steering lever cross haft to clear and then tie up out of the way. Tape end of cable and opening in fitting.

d. Free power train housing.

(1) Use a power train carrier (figs. 107 and 108), or three hydraulic jacks, under the power train—one jack under the rear center of the differential housing, and one under each final drive housing (see fig. 106). Pull up the jacks until they are solidly loaded, making certain that each is squarely in contact with a flat surface of the housing.

(2) Remove the 20 bolts and lock nuts (1⅛-inch socket wrench



RA PD 36406

Figure 106—Power Train Unit on Jacks, Ready to Be Detached from Hull

with heavy-duty ratchet handle) which hold the lower edge of power train housing to tank floor. Lock nuts must be held from inside.

(3) With a man inside the tank holding the nuts (1⅛-inch open-end wrench), remove all the bolts (39) from the sides and the top where the power train is joined to the tank hull. The upper corner bolts on each side holding the power train to the hull are the only bolts with lock washers.

(4) If necessary, loosen side plate shims from inside tank by hitting smartly with a hammer and ¼-inch punch or drift.

e. **Block up power train.** For the security of the power train, and

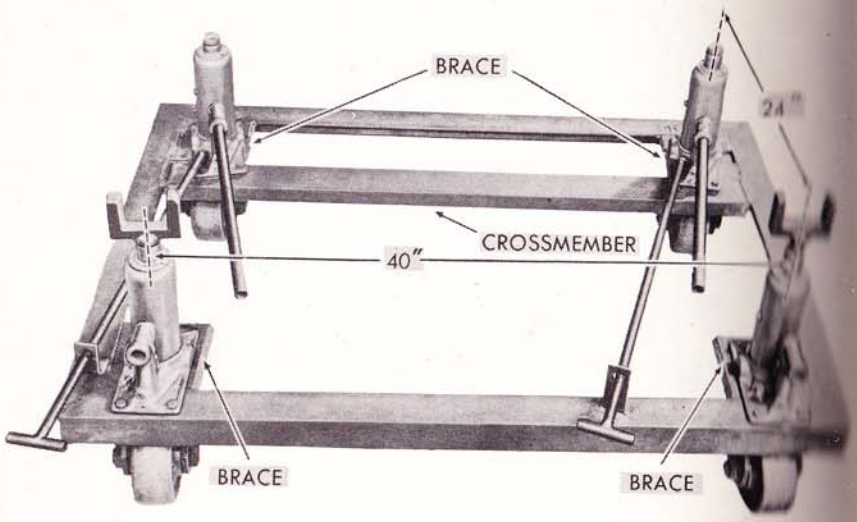


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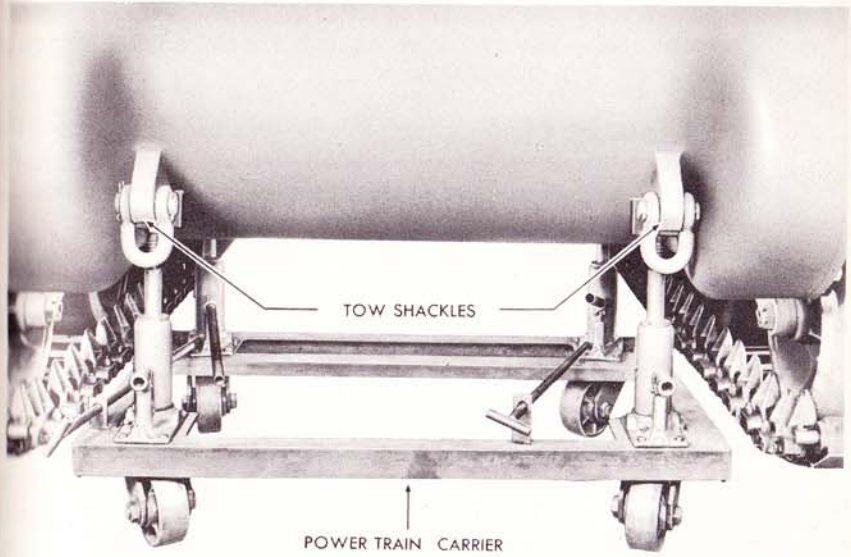
Figure 107—Power Train Carrier

to permit the release of the three jacks, install heavy blocking under the final drive housing and the differential, leaving some clearance to permit lowering the power train enough for it to clear the hull. The blocking under the final drives should be not smaller than twelve-by-twelves, about four feet long.

f. Separate power train from the tank. Slowly raise each jack in rotation, until the housing breaks free from the hull. As a safety measure, anchor the housing with chains from the towing clevises to some solid anchorage ahead of the tank. Attach a towing cable to each rear towing shackle and then, with wrecker or other vehicle, pull tank slowly and with extreme caution, on a straight line, and on its own tracks, away from power train. CAUTION: Station a man inside the tank to see that the transmission and the gearshift and parking brake levers clear. Additional clearance for the levers may be gained by lowering the jack under the differential.



RA PD 36408

Figure 108—Power Train Carrier in Place

g. **Remove jacks.** As soon as the tank is clear of the power train, lower the jacks evenly to let power train unit rest on blocking, and remove jacks.

106. INSTALLING POWER TRAIN UNIT.

a. **Equipment.** Besides the necessary tools, a second vehicle or wrecker, and three ten-ton jacks, are required.

b. **Procedure.**

(1) **Line up tank and power train.**

(a) The power train unit must be centered on blocking so placed as to allow room for the installation of jacks. It must also be accurately lined up with the tank.

(b) Apply soft-drying mineral putty to all attaching edges of power train.

(c) Install jacks under the differential and power train housings (par. 105 **d**) and raise the unit high enough for the bottom flange to clear the top of the hull floor.

(d) With blocking still in place, slowly and carefully push the tank up to the power train housing with a wrecker or other vehicle. (Station a man inside tank to see that control levers and transmission clear.)

(2) **Install housing.**

(a) Install and line up the side shims, holding them in place with a soft-drying mineral putty.

(b) Line up the bolt holes in the power train with those in the tank hull side plates. (This operation may require moving the tank slightly forward or backward, or raising or lowering one or more of the jacks.) Use drift to keep holes lined up. Place four equally spaced bolts in each side and four equally spaced across the top of housing to hold power train in line.

(c) Lower jacks gradually, in rotation, until the top of the housing seats on the tank hull front slope.

(3) **Attach housing to tank.**

(a) Install and tighten the top-slope bolts and lock nuts, and side bolts and lock nuts (1⅛-inch socket wrench and heavy-duty ratchet handle).

(b) Install the bottom bolts and lock nuts. Have man inside hold nuts (1⅛-inch open-end wrench).

(c) Remove blocking.

(4) **Connect propeller shaft.**

(a) Line up the holes in the propeller shaft and transmission companion flanges. Install connecting bolts and lock nuts (two 9/16-inch wrenches).

(b) Replace propeller shaft housing front cover section.

(5) **Connect steering levers.** Install the clevis pins connecting the brake shaft arms to the steering lever linkage. CAUTION: Clevis

pins must be secured with cotter pins. Adjust position of steering levers (par. 102 **c** (14), (15)).

(6) **Connect oil cooler lines.** Install and tighten the flexible inlet and outlet oil cooler lines to the fittings on the transmission housing (1⅜-inch open-end wrench). The long (outlet) line is connected to the forward fitting, the short (inlet) line to the rear fitting.

(7) Attach clips holding hand throttle and cluch lockout cables to right side of left brake drum cover plate (¾-inch open-end or socket wrench) where cover plate bolts were left in place.

(8) Connect oil temperature gage capillary tube to fitting on transmission lubricating oil outlet.

(9) Attach stoplight switches and brackets to left side of brake drum cover plate where two bolts were left in place.

(10) Attach the adjustable stoplight switch rods to the brake shaft arms. Test switches, by moving steering brake levers, and adjust rods if necessary.

(11) Attach siren switch bracket.

(12) Connect speedometer cable at top right side of transmission.

(13) **Install cal. .30 machine gun.** Slide barrel of gun through swivel mount, and install trunnion pin. Install gun mount spring and spring seat.

(14) **Install front fenders.**

(15) **Install siren.**

(16) Fill power train unit with oil (see par. 104 **e**).

(17) Connect tracks (see fig. 121).

107. FINAL DRIVE UNITS.

The final drives transmit power from the differential to the driving sprocket hubs. Each final drive unit has a pair of herringbone reduction gears, through which power from the compensating drive shaft of the differential is transmitted to the final drive shaft, which

is flanged at its outer end and attached to the sprocket hubs by studs and nuts. The larger of the two herringbone gears is mounted on the final drive shaft, which is supported on two heavy-duty roller bearings in the final drive cover. The smaller gear, or pinion, is supported at its outer end on a roller bearing in the final drive cover, and at its inner end on a roller bearing in the differential housing. The final drive cover is attached to the differential housing by bolts. The two driving sprockets for each track are bolted to a hollow hub which fits over the outer end of the final drive cover.

108. LUBRICATION OF FINAL DRIVES.

The gears and bearings of the final drives are lubricated by the oil within the differential housing.

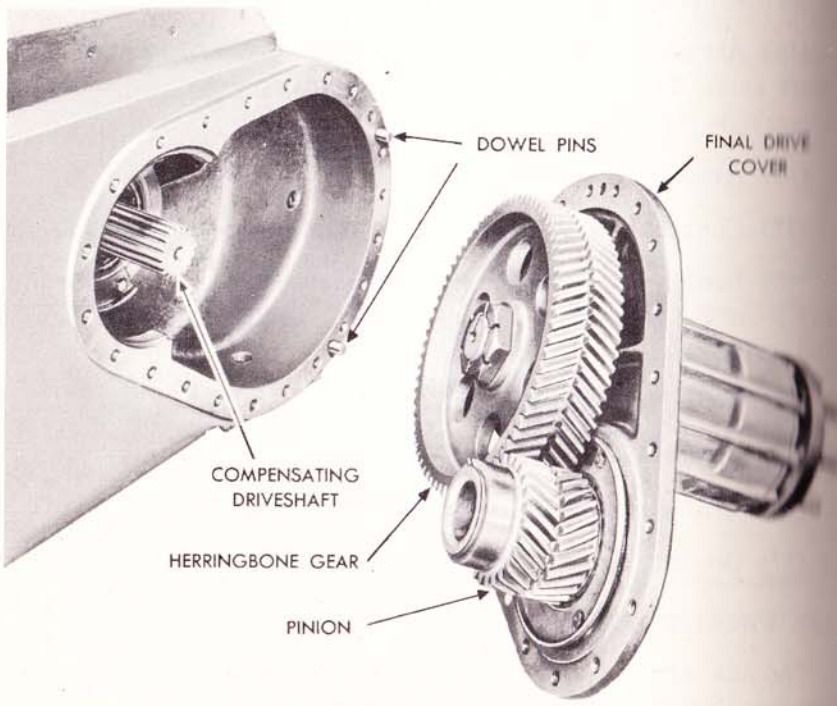


Figure 109—Final Drive Unit Removed from Power Train Unit

109. REPLACEMENT OF FINAL DRIVES (fig. 109).

a. Removal.

(1) Drain the oil from transmission, differential, and final drives.

(2) Remove the sprockets and hub assembly (par. 111 b).

(3) Arrange a hoist to support the final drive while it is being removed, exerting just enough lift to take the weight off the attaching bolts and the dowel pins.

(4) Remove 22 bolts (1⅛-inch wrench) that attach the final drive unit to the tank.

(5) Pry the final drive unit away from the differential housing with a pinch bar. The unit must be carefully manipulated to withdraw it in a straight line away from the tank, in order that the herringbone pinion gear may slide straight off the splined end of the compensating drive shaft of the differential.

(6) Remove dowel pin, used to aline the final drive unit.

b. Installation of final drives.

(1) Reverse the preceding steps, using new gasket.

(2) Refill the power train unit with oil (see par. 104 e).

Section XX

SUSPENSIONS AND TRACKS

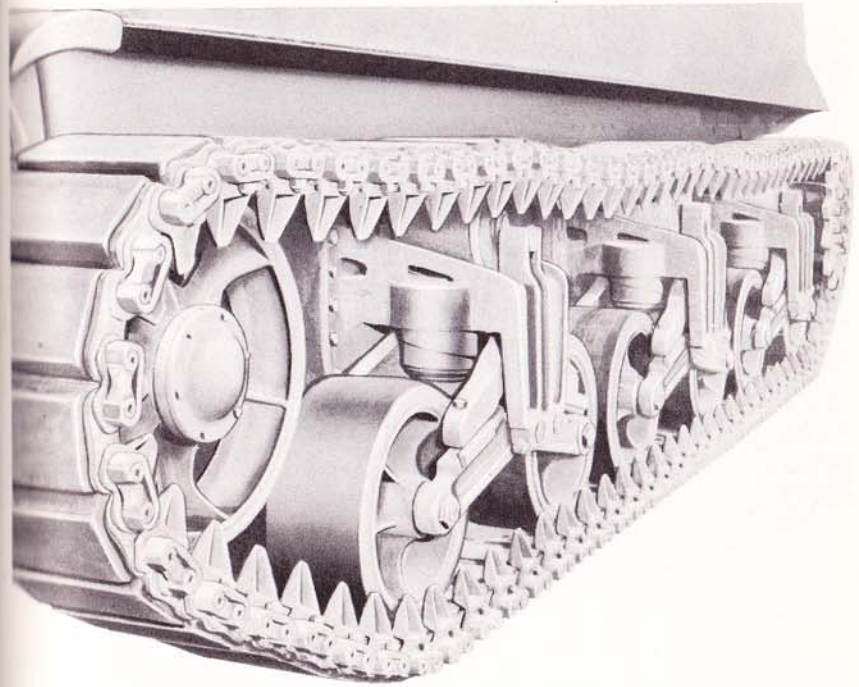
110. SUSPENSIONS AND TRACKS (figs. 110-125).

a. Description and operation. Six suspensions, or bogies, each having two volute springs and two rubber-tired bogie wheels, support the tank. The tracks are driven by sprockets on the front of the tank. Two idlers, mounted on eccentric shafts at the rear, provide for the adjustment of track tension. The upper reach of the track, between the idler and the sprocket, is supported and guided by three steel rollers mounted on brackets attached to the bogie brackets. The first-type bogie (fig. 114) has its track support roller directly over the bracket. The second type (fig. 115) has its roller offset to the rear of the bracket, and is fitted with a track skid on top of the bracket.

b. Inspection. Tracks should be inspected at every opportunity, in order to detect in the early stages any fault that, if not corrected, would lead to serious impairment of the efficiency of the tank. The best preventive maintenance is to keep the entire track and suspension system as clean as possible, free from stones, sticks, and other debris. At every inspection, the following routine should be carried out:

(1) **Inspect track tension** (figs. 110 and 111). If the track shows noticeable sag, the track should be tightened (par. 113 **b**).

(2) **Inspect track condition.** Check end connectors for wear and for bent or broken guide lugs. Inspect for presence and tightness of wedges and wedge nuts. Check for bottomed wedges; if clearance between wedge and connector is less than $\frac{1}{32}$-inch, install new wedge. If grousers are being used, inspect their condition and tightness. Inspect for dead track blocks (fig. 112) and replace them. (To be detected, a dead track block must be in the top reach of the track, unsupported by a roller; therefore, the tank must be moved several times to make a complete inspection). During this check, the inside wedges and connectors also can be inspected.



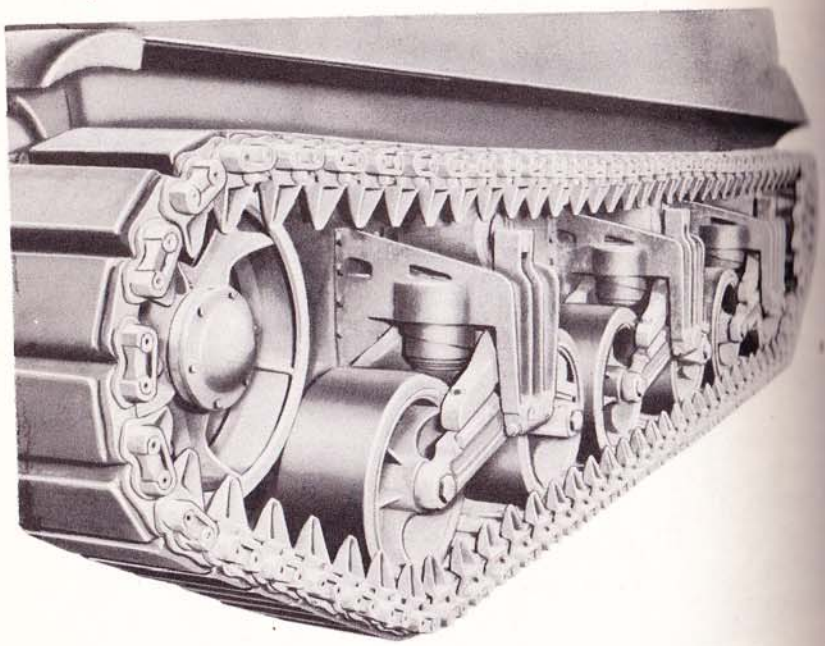
RA PD 36410

Figure 110—Track with Insufficient Tension

(3) **Inspect sprockets.** Check for sprung or worn teeth. Check cap screws and hub nuts for tightness.

(4) **Inspect bogie wheels** (fig. 113). Check condition of tires on all wheels. Look for evidence of outer spacer turning (tighten gudgeon nut). Check for presence of gudgeon nuts and cotter pins. Check grease fittings and relief valves (replace if damaged or missing).

(5) **Inspect bogie assemblies.** Inspect for worn wheel arm and lever wear plates (replace). Inspect bogie bracket for presence of bolts, nuts, and lock wire. NOTE: Volute springs are not considered unserviceable, and should not be replaced, unless they are broken or have taken a permanent set. When three or more inner coils of **both** springs, in any one suspension, rest upon the lower spring seat, and this condition is found to exist **at more than one stop,** it is reasonable to assume



RA PD 38411

Figure 111—Track with Proper Tension

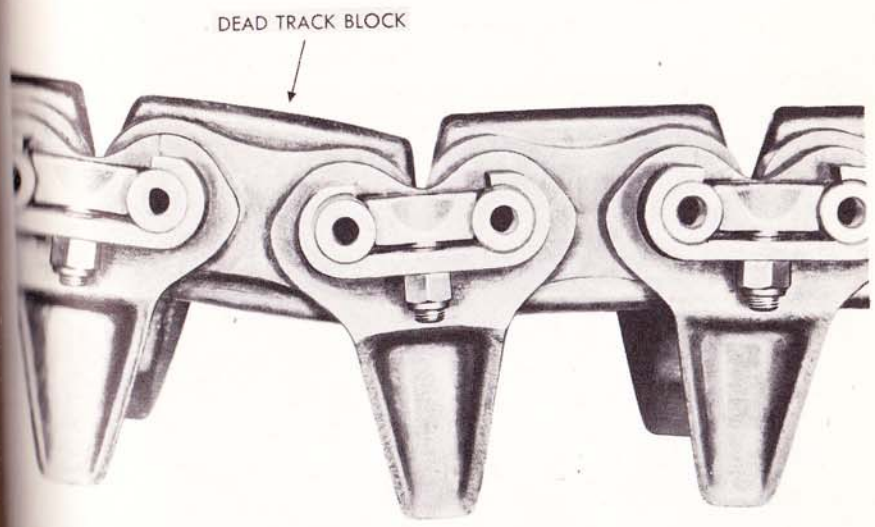
that one or both of these springs have taken a permanent set and should be replaced.

(6) **Inspect support rollers** (figs. 114 and 115). Look for evidence of roller not turning. Free all rollers by cleaning out mud, rocks, etc. Check grease fittings. (It is essential that all rollers turn freely, since inoperative rollers will develop flats.)

(7) **Inspect idlers.** Check for presence of idler cap and grease fitting.

111. DRIVE SPROCKETS (fig. 123).

a. Description. The sprocket and hub assembly is formed of two sprockets bolted to a hub, which is attached by studs and nuts to the drive flange of the final driveshaft. Sprocket and hub assemblies, interchangeable as units, should be transposed between the right and left final driveshafts when the sprocket teeth have become appreciably worn by contact with the track end connectors after long use in one direction.



RA PD 12481

Figure 112—Dead Track Block Dropped Out of Line

b. Replace sprocket and hub assembly.

(1) Slacken and disconnect the track below the sprocket, and move the upper section of track back off the sprocket.

(2) Remove the eight hub retaining nuts.

(3) Remove the hub assembly.

(4) To install, proceed in reverse order.

(5) Connect the track (fig. 122) and adjust tension (see par. 113 b).

112. BOGIES.

a. Description and operation. The six suspensions, or bogies, are the tank supporting units. Road shocks are transmitted by the wheel arms and spring levers to the volute springs, two in each bogie. Wear between the wheel arms and the spring levers is taken by upper and lower rubbing plates (fig. 113), which can be replaced when worn. On top of each bogie bracket (first type) is mounted a steel roller (fig. 114) to support and guide the track as it runs between the idler and the

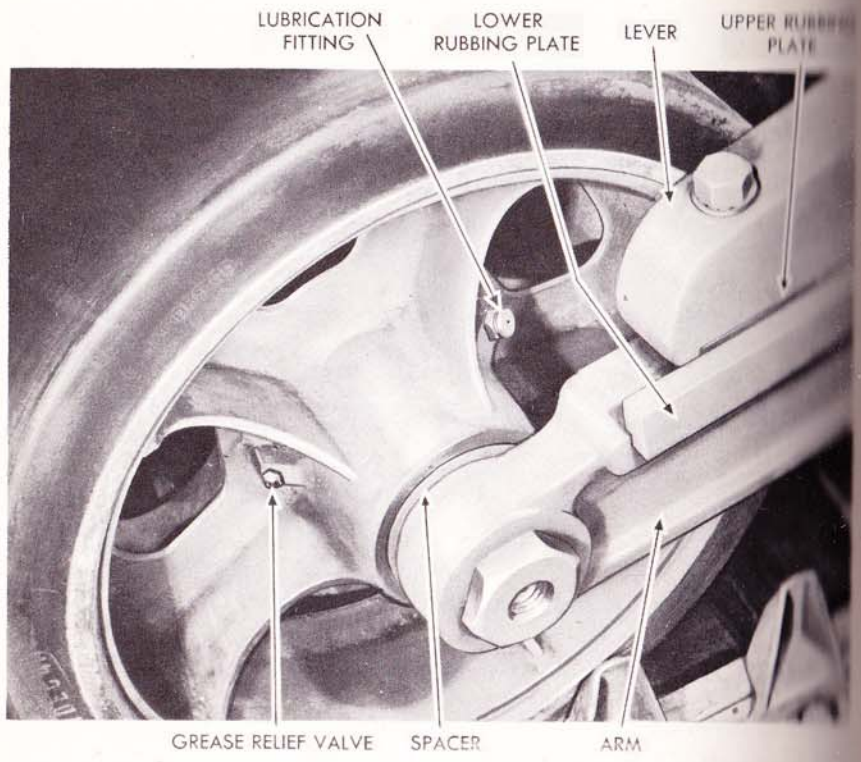


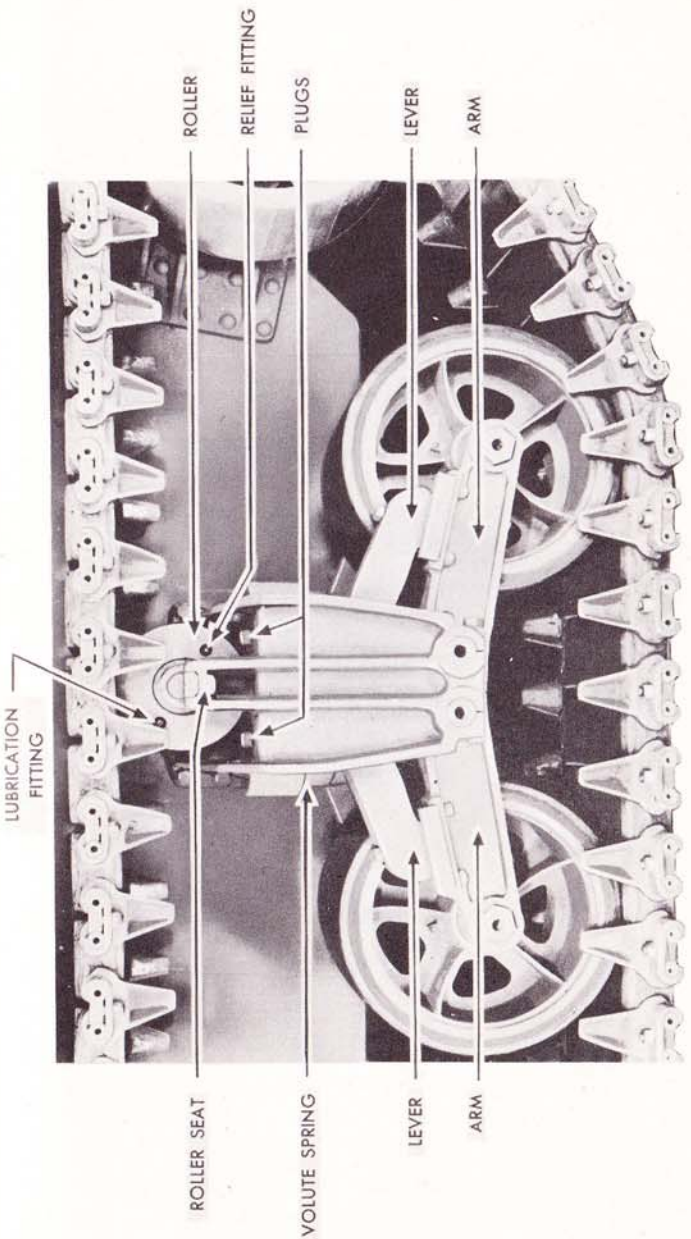
Figure 113—Detail of Bogie Wheel

sprocket. The second-type bogie (fig. 115) has its roller mounted on a separate bracket to the rear of the bogie bracket, and is fitted with a track skid.

b. Lubrication. Lubrication of the wheels (see fig. 113) and the track-supporting rollers (see fig. 114) is through pressure fittings. Relief valves are provided to prevent injury to the grease retainers.

c. Bogie wheel (fig. 116).

(1) Bogie wheels will be **removed** when the rubber has worn down even with the height of the rim flanges. Bogie wheel tires which have rubber along one or both sides scooped out, due to cutting action of the track end connectors or track guides, need not be changed unless



RA PD 36414

Figure 114—M4A2 Suspension (First Type, with Overhead Roller)

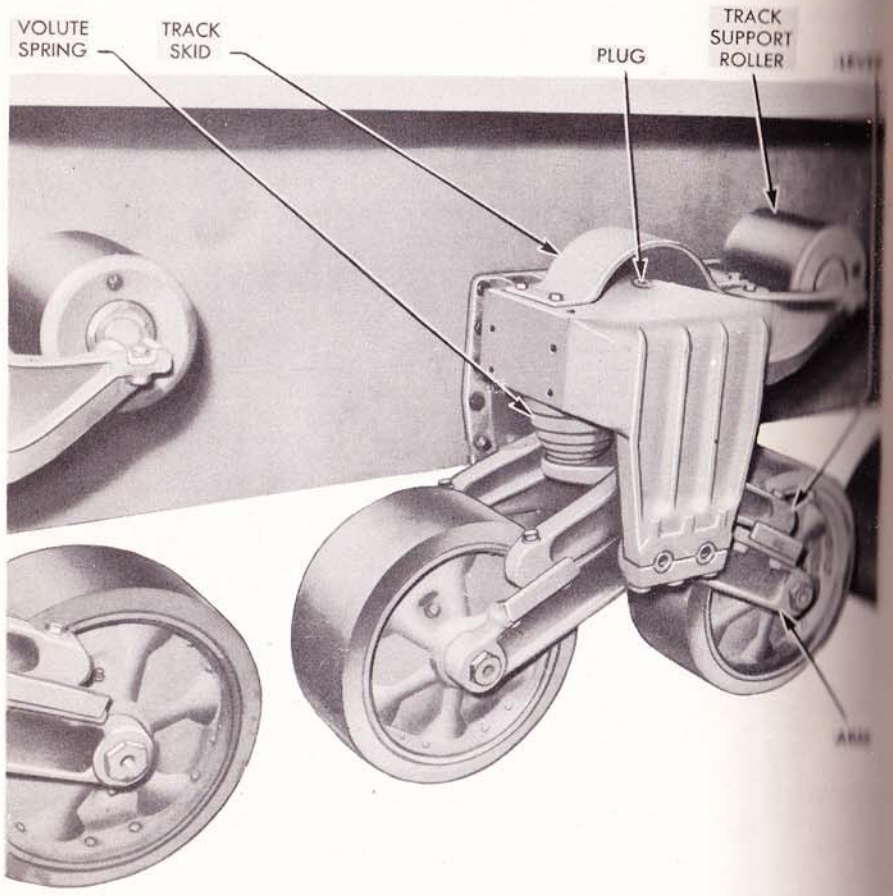


Figure 115—M4A2 Suspension (Second Type, with Offset Roller)

there is not a continuous band of rubber all the way around the center portion of the wheel.

(2) Bogie wheels are removed for replacement of grease seals or spacers, and for any other necessary repairs.

(a) Place a heavy-duty hydraulic jack on the track directly under the center of the suspension assembly, and jack up the bottom spring seat until all load is removed from the wheel arm.

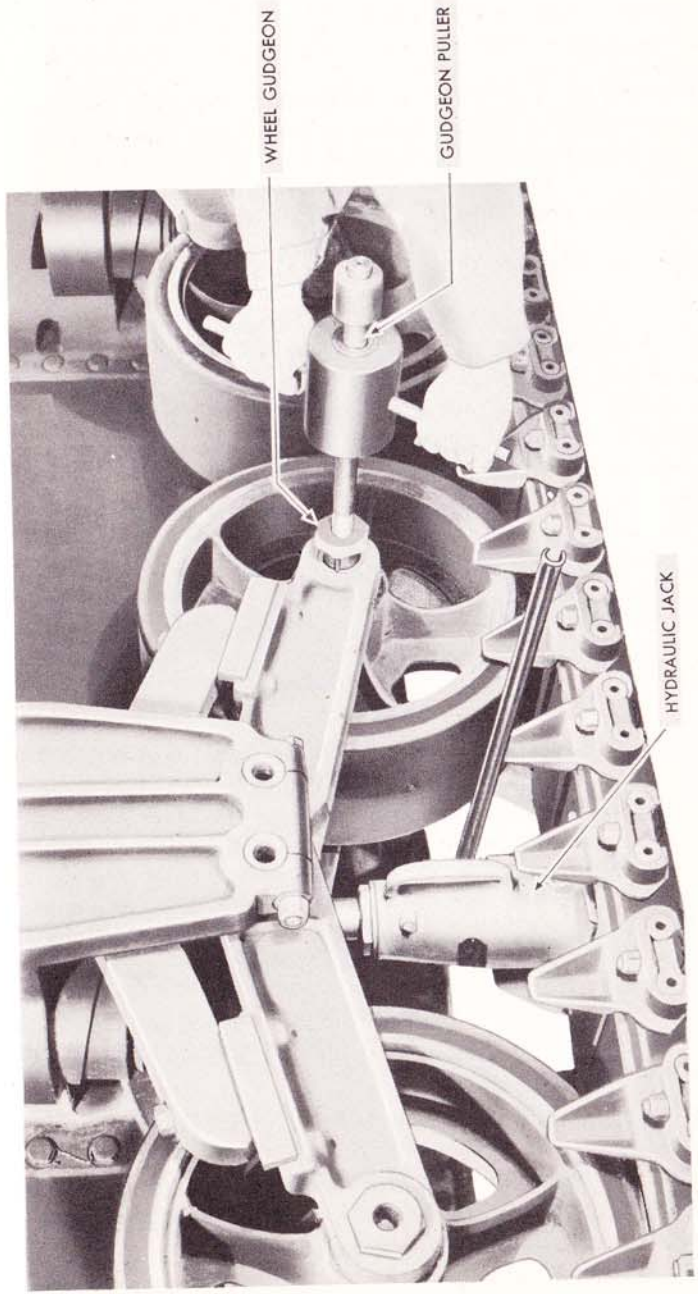


Figure 116—Pulling Wheel Gudgeon to Remove Bogie Wheel

(b) Remove the cotter pin from the nut on the inner end of the wheel gudgeon and remove the gudgeon nut (2⅜ inch gudgeon wrench).

(c) Screw the slide hammer gudgeon puller into the threaded hole in the outer end of the gudgeon and pull the gudgeon, then remove the wheel from between the arms.

d. Replacing bogie wheel grease seals and bearings.

(1) Pull out the two outer spacers.

(2) Turn the wheel on its side on two blocks and, with a brass drift through the upper side of the wheel, drive the bearing and grease seals down and out between the blocks. (It is necessary to move the inner spacer upward, away from the bearing, in order to seat the drift on the outer race of the bearing. Keep moving the drift around the entire circumference of the bearing outer race, in order to drive it out evenly and avoid damage to the bearing). The spacer will drop out when the bearing is removed.

(3) Turn the wheel over and remove the remaining bearing and grease seals by the same method.

(4) Clean bearings and inspect for wear, cracked rollers, or flat spots.

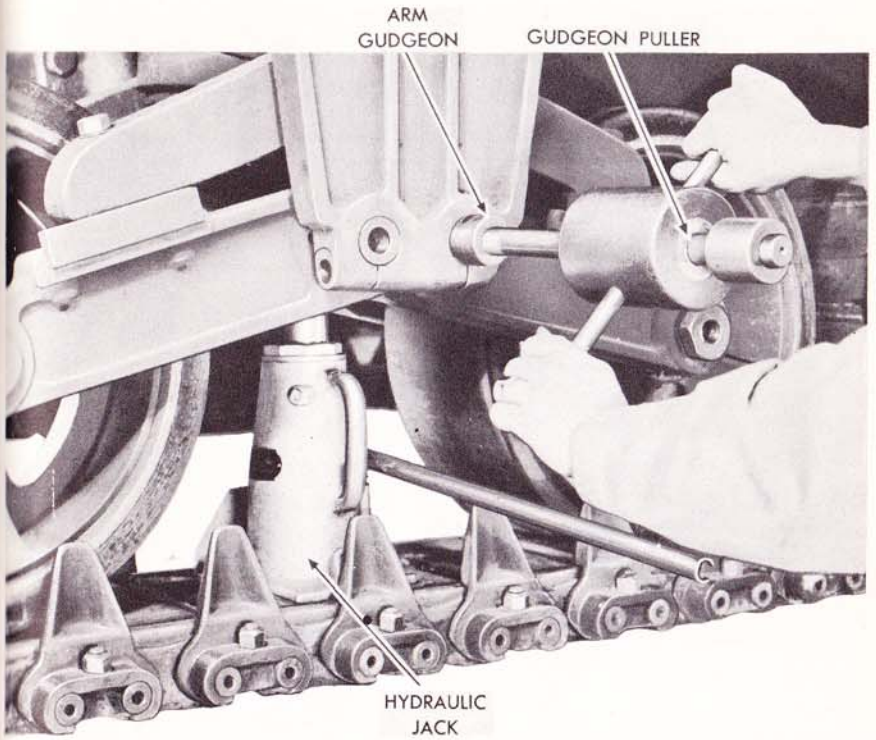
(5) Install the bearing by starting it by hand and tapping it lightly into place, using a brass drift and working around the outer race. Be sure the bearing is seated squarely against the shoulder in the wheel, to allow room for the grease seals.

(6) Slide two new grease seals into place on an outer spacer, being sure that the seals are installed with their lips toward the flange of the spacer. Start the lower seal into the wheel and tap seals and spacer (rawhide mallet) into place.

(7) Turn the wheel over, insert the center spacer, and install bearing, oil seals, and outer spacer.

e. Installing bogie wheel.

(1) With the wheel in place between the two arms, raise the arms and aline their holes with the hole in the wheel. Start the wheel gudgeon through the outer arm and into the outer spacer, grease seals, and outer bearing of the wheel. Line up the center spacer by means of bar inserted



RA PD 36417

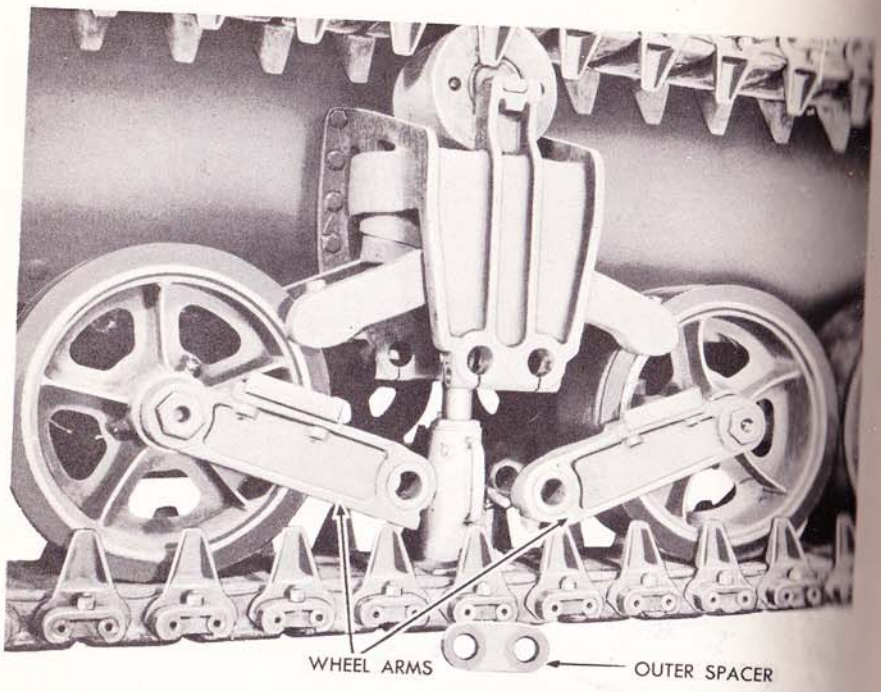
Figure 117—Pulling Arm Gudgeon, for Removal of Volute Springs

from the inner side of the wheel, and tap gudgeon into spacer. Then drive gudgeon through far enough to allow the key slot in the gudgeon to be lined up with the slot in the arm. Install the key, and drive the gudgeon in the rest of the way. Install and tighten the gudgeon nut on the inner end of the gudgeon and secure with a cotter pin.

f. Removal of volute springs (figs. 117-119).

(1) Position the jack on the track (fig. 117) so that the head of the jack is in the center of the spring seat plate. (In placing the jack, arrange blocking, if necessary, in order that the jack plunger will be nearly at the upper limit of its travel when the thrust of the springs is taken up, to permit a greater lowering travel later).

(2) Raise the jack until the thrust of the springs has been taken up.



RA PD 36418

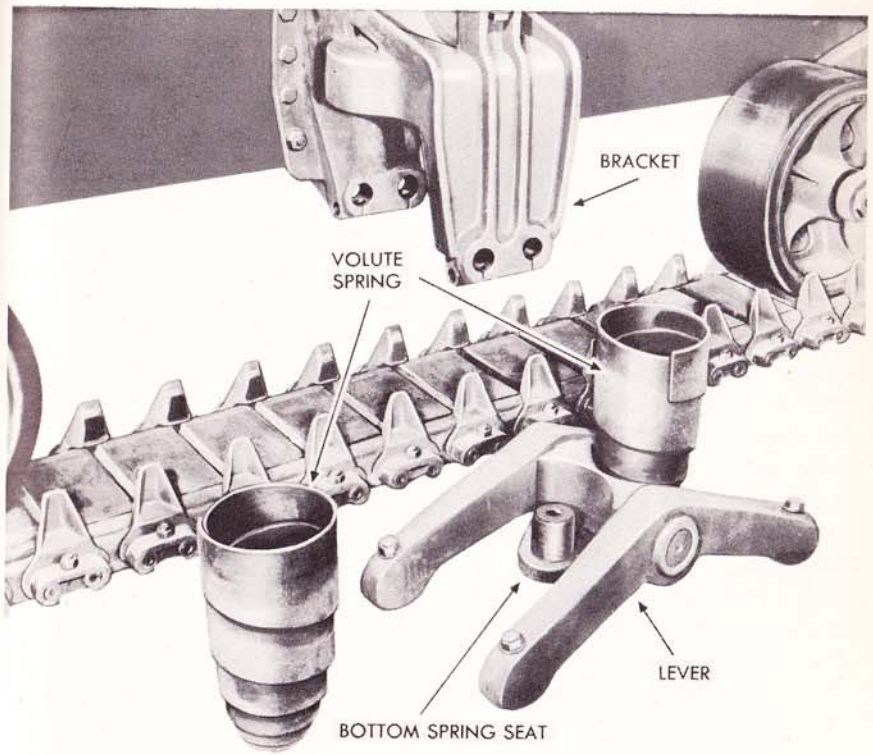
Figure 118—Wheels and Arms Ready for Removal

(3) Loosen and remove the nuts (1 1/16-inch and 1 1/8-inch open-end wrenches) on the locking bolts that secure the gudgeon in the bogie bracket, then drive out the bolts with a large drift and a hammer.

(4) Screw a gudgeon puller into the outer end of a gudgeon pin and puli the pin out. When both pins are out, the bogie arms and spacer plates will drop (fig. 118).

(5) Lower the jack, with the spring seat plate and springs. If the jack has not sufficient travel to decompress the springs, push two bars through the gudgeon pin holes and lower the spring seat plate until it rests on the bars. Then remove the blocking, or readjust the jack, and raise the plate off the bars. Remove bars, and continue to lower the jack.

(6) If the spring seat plate and springs (fig. 119) do not drop out on removal of the jack, free them with a hammer or block of wood.



RA PD 36419

Figure 119—Volute Springs, Levers, and Bottom Seat, Removed

g. Installation of volute spring.

(1) Place the springs and spring seat plate in position and raise with a heavy-duty jack until the springs are compressed sufficiently.

(2) Aline the bogie arms and spacer plates and, using the gudgeon-puller slide hammer, install the gudgeon pins, making sure that their locking grooves are underneath, to permit installation of the locking bolts.

(3) Drive in the gudgeon locking bolts, and install the nuts (1 1/16-inch and 1 1/8-inch open-end wrenches).

(4) Lower and remove the jack.

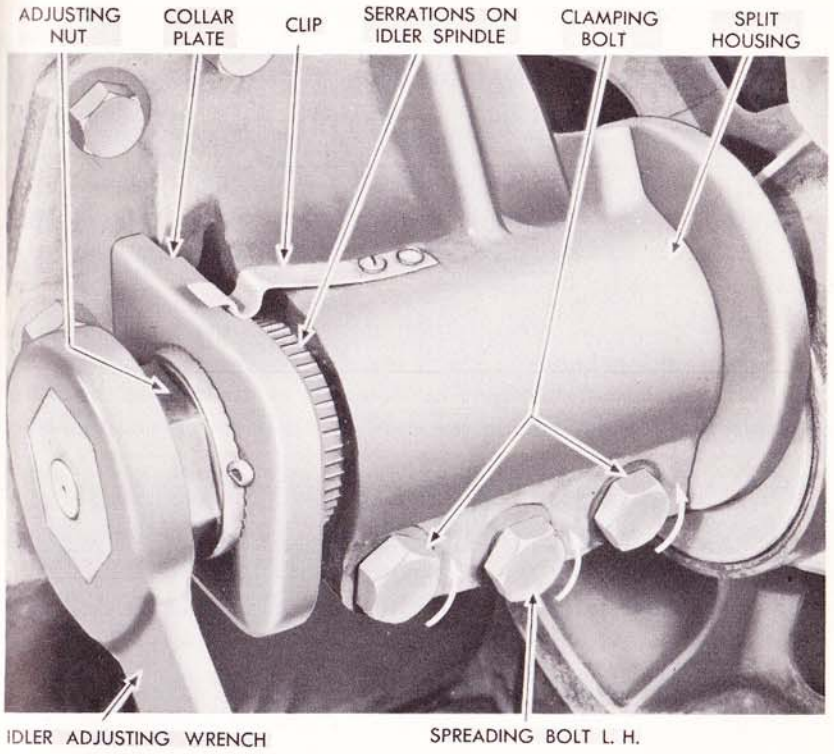
113. TRACKS.

a. Description.

(1) **General.** Each track has 79 separate shoes, or blocks, which may be either of two types—rubber covered, or all-steel. Two parallel pins run through each block, and project at both ends. Steel connectors fit over the ends of the adjacent pins of adjoining blocks, linking the blocks to form a continuous track. Each track pin has doughnut-shaped rubber spacers vulcanized to it; these spacers, when the pin is pressed into the steel frame of the track block, form a flexible cushioning bond between the pin and the block. The track connectors are held to the pins by bolt-type wedges, the faces of the wedges fitting against milled flats on the pins. When the wedges are pulled up between the two pins by the bolt, an integral part of the wedge, they cause an angle between adjacent blocks. This angularity tends to make the track bend closely around the rear bogie, the idler, and the sprocket. Flared perpendicular projections on the connectors serve as guides to keep the track in alinement and to hold it on the bogie wheels, idlers, track support rollers, and drive sprockets. The sprocket teeth engage the track between adjacent connectors. NOTE: Since the condition and adjustment of the track definitely affect the performance of the tank, it is essential that it be maintained in the best possible condition and at the correct tension.

(2) **Rubber block type.** Two designs of rubber track shoes, or track blocks, are in use, the **first type** having the same thickness of rubber on both sides, the **second type** having a greater thickness of rubber on the tread (ground contact side) than on the inside or bogie wheel contact side. Shoes of either type must be replaced when further wearing away of the tread would expose the tubular sections of the inner steel frame of the block to the risk of being dented or damaged. Shoes that are damaged must be replaced immediately. Undamaged shoes of the **first type** may be reversed (par 113 **d.**). The **second type** is not reversible.

(3) **All-steel type.** Steel shoes, or track blocks, are formed with one long lug at the toe of the block (the forward edge when the block is on the ground) and two short lugs at the heel (rear edge). Steel tracks are normally installed, when new, with the long lugs forward when the shoes are on the ground; but the entire track may be turned end-for-end when it is necessary (see par. 113 **g**). Replace a steel shoe when the lugs are so worn that the distance from the surface of the lug to the



RA PD 36420

Figure 120—Tightening Track with Idler Adjustment

edge of the end connector flange is less than (?) inch. (To measure, lay a straightedge lengthwise on the tread surfaces of the two short lugs, and measure from the straightedge to the edge of the connector flange.)

b. Adjusting track tension (fig. 120). Tracks should be **checked daily** for correct tension. If a pronounced sag is present, tension should be restored to eliminate the possibility of the track's being damaged or thrown off. (Figure 110 shows a track with too little tension; figure 111 shown a track with correct tension). Track tension is adjusted by means of the eccentric idler shaft. The spindle of the eccentric shaft is clamped between the halves of a massive split housing, which are drawn together by means of two clamping bolts. Between the clamping bolts is a spreader bolt. When the clamping bolts have been backed part way out,

turning the spreader bolt **in the same direction** forces apart the halves of the split housing, freeing the spindle. The split housing is chiefly for supporting the idler shaft in alinement, not to lock it against turning. A collar plate that fits over the serrated end of the spindle and bears against flats on the body of the housing locks the idler shaft against turning. To adjust track tension, proceed as follows:

(1) Back out part way (do not remove) the two end (clamping) bolts (1½-inch socket wrench) on the rear of the split housing (see fig. 120).

(2) Turn down the spreader bolt to open up the housing. Because this bolt has a **left-hand** thread, it is turned **counter**clockwise to move it **in.** NOTE: Remember that in loosening or tightening the spindle, the spreader bolt is turned **in the same direction** as the clamping bolts.

(3) Loosen the screws holding the spring clip at the end of the housing and raise the spring clip. Tap the collar plate all the way off the serrations on the spindle to the position shown in figure 120, leaving the large cotter pin in place in the spindle. NOTE: It may be necessary to take the load off the collar by using the idler adjusting wrench on the hex end of the spindle, as in **tightening** the track.

(4) Tighten or loosen the track by using the idler adjusting wrench on the hex at the end of the spindle.

(a) To tighten, **raise** the handle of the wrench (using a pipe for leverage, or a jack under the end of the handle) until the track shows a sag of not more than ¾-inch midway between the idler and the rear support roller. Sag can be measured from a straightedge laid on the track over the idler and the roller. CAUTION: Tracks that are too tight will seriously impair the performance of the tank.

(b) To loosen the track, push the handle of the wrench **down.**

(5) When correct tension has been attained, drive the collar plate back on the serrations of the spindle and lock it in place with the spring clip. It may be necessary to turn the spindle slightly to permit the collar to position itself.

(6) Back out the center spreader bolt by turning it **clockwise** until it does not project into the split of the housing.

(7) Pull both outside clamping bolts up tight, and tighten down the spreader bolt until it binds sufficiently to prevent it from working loose.

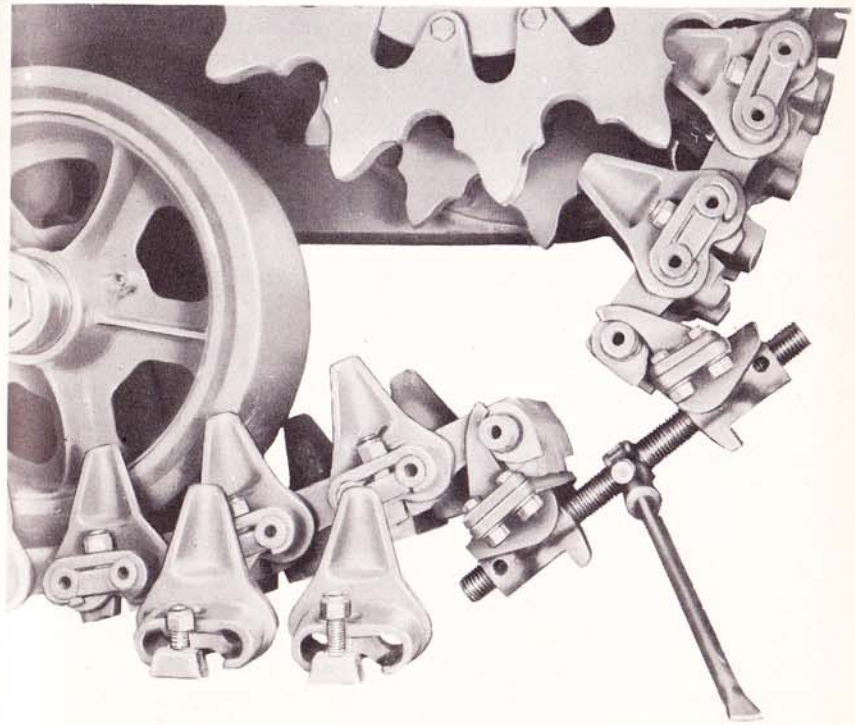
c. **Replacing dead track block** (fig. 122). A dead track block is one in which the rubber bond between the pin and the metal frame of the block has failed, leaving the pin free to turn. Dead blocks are easily recognizable (fig. 112), and should be replaced immediately, as they may result in a broken track.

(1) Move tank so that the dead track block is midway between the idler and the rear bogie wheel, then set the parking brake on the tank.

(2) Release the track tension (par. 113 **b**).

(3) Remove the wedge nuts (⅞-inch open-end wrench) on the two inside and the two outside connectors attached to the track block to be replaced. Tap out wedges, being careful not to injure threads.

(4) Remove dead track block.



RA PD 36421

Figure 121—Joining Ends of Track, Using Track Assembling Fixture

(a) With bar and hammer, drive the two inside and two outside track connectors **halfway** off the pins of the track block to be removed.

(b) Between the track connectors and the blocks, insert the curved fingers of the Simplex jack track connecting fixture over the exposed pins in the two track blocks immediately adjacent to the dead track block. (See fig. 122). The upper surfaces of the track connecting fixture plates must fit snugly against the tread surfaces of the track blocks.

(c) Insert handle in jack ratchet fitting, pull up track until the jack and fixtures are securely solid, then knock off the four loosened connectors. (Fig. 122 shows dead steel track block with outside track connectors removed, and inside connectors still in place and holding block). CAUTION: In pulling up track to knock off connectors, care must be exercised not to draw it up too tight, or track connectors will bind on pins and cannot be removed. The preferred method is to have one man operate jack while second man tests freeness of connectors by hitting smartly with a heavy hammer. When connectors move freely, stop operating jack and drive off the two inside and the two outside track connectors, freeing the dead track block.

(5) **Install new track block.**

(a) Place new track block in position.

(b) Install track connectors and drive halfway on to pins, operating jack, if necessary, to position the pins.

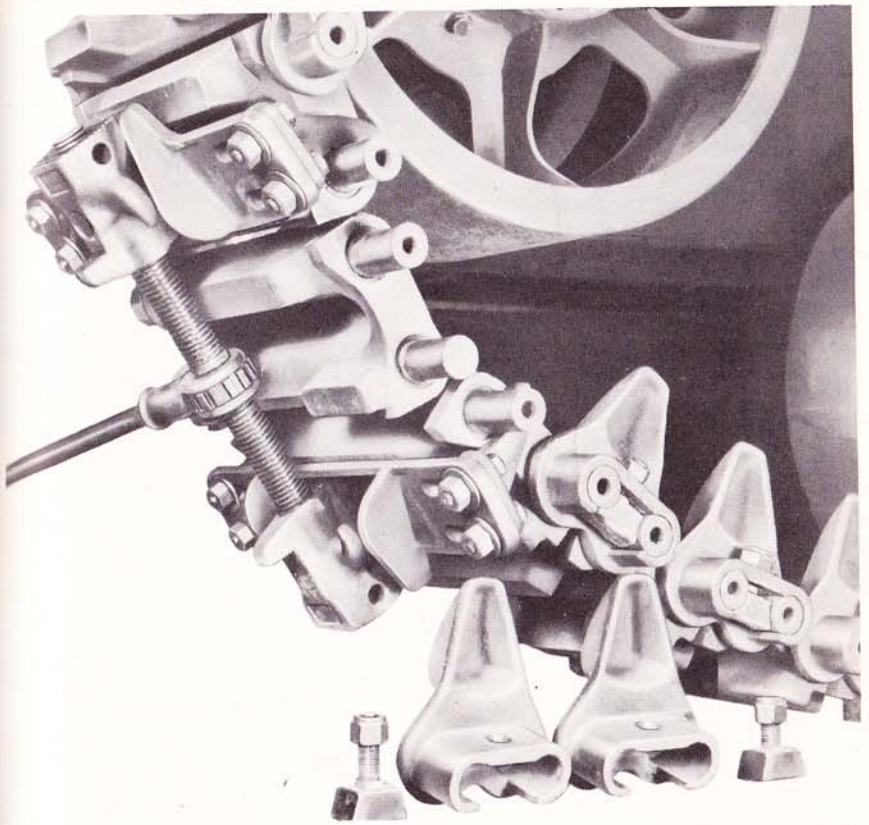
(c) Back off jack and remove track connecting fixture.

(d) Drive connectors home.

(e) Install wedges in connectors and draw them tight (7/8-inch wrench). NOTE: Before installing, inspect wedges and nuts, and replace if worn or damaged.

d. Turning the track blocks. When rubber track blocks (first type) are to be reversed (turned over), or several blocks in different parts of the track must be replaced, the track should be removed from the tank. Note that for this operation, the track should be broken and joined **at the front** of the tank (see fig. 121), between the sprocket and the front bogie wheel, instead of at the rear, as for the replacement of a single block.

(1) Break the track (par. 113 **c** (2), (3), (4)) just below the sprocket.



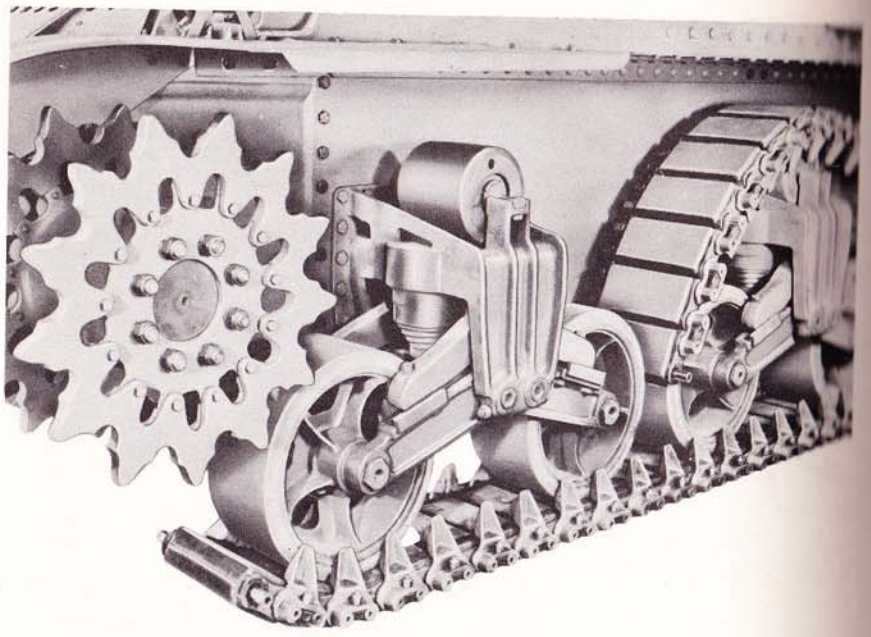
RA PD 36422

Figure 122—Replacing Dead Track Block

(2) Move the upper part of the track to the rear over the drive sprocket by turning the sprocket with a bar, and pull the track back off rollers (see fig. 123).

(3) Break the track back of the rear bogie.

(4) Reverse the blocks of the part of the track rolled off by removing the connectors and turning each block over. To equalize the wear on the sprocket-contact surfaces of the connectors, transfer the connectors from the side of the track on which they were previously used to the other side.



RA PD 36423

Figure 123—Track Rolled Back Off Drive Sprocket

(5) Connect the section of track with reversed blocks to the section underneath the bogie wheels, and tow the tank back onto the section already reversed.

(6) Disconnect the un-reversed section of the track and reverse blocks and connectors.

(7) Connect the two sections of the track, tow the tank onto the front section, and roll the rear section over the idler, support rollers, and sprocket, using a bar to turn the sprocket.

(8) Connect the track (see fig. 121).

e. Replacing thrown track. Because conditions under which a track may be thrown vary greatly, no single procedure can be set down as the best possible method for its replacement. Sometimes the track may be thrown in such a manner that proper manipulation of the tank, and the use of blocks, make it possible to work the track on again. The

following procedure, which can be used under the worst conditions, can be modified for different situations:

(1) Break the track underneath either the idler or the sprocket, at whichever end the track has the least twist. NOTE: If the track is completely thrown, break at any point.

(2) Tow the tank completely off the track.

(3) Roll up track and move it to the front or to the rear of the tank, whichever has the best ground for towing the tank back on the track.

(4) Lay the track out with one end at the nearest bogie. Before laying it out, dig a trench ahead of the bogie long enough to hold the first several blocks and deep enough to let the bogie roll onto the track without having to climb up on it.

(5) Tow the tank onto the track until the leading bogie wheel is about sixteen inches from the end of the track.

(6) Roll the track up over the idler, the track support rollers, and around the sprocket, using a bar to turn the sprocket.

(7) Join ends of track (fig. 121) with track connecting fixture.

f. Installing new track.

(1) To install a new track when the old track is still on the tank:

(a) Break the old track under the sprocket and roll the track back off the sprocket and rollers, using a bar to turn the sprocket.

(b) Lay out the new track in front of the old one, and connect the two.

(c) Tow the tank onto the new track until the front bogie wheel is about sixteen inches from the end of the track.

(d) Disconnect the old track, and roll the new one up over the idler and the track support rollers, and around the sprocket. Connect the ends (fig. 121).

(2) To install a new track when the old track is off the tank, proceed as in **e** (3), (4), (5), (6), and (7), preceding.

g. Reversing track direction. To equalize the driving wear on the track connectors, and thus lengthen the operating life of the track, the entire track can be turned end-for-end, shifting the driving wear to

the other sprocket-contact surfaces of the connectors. With good ground conditions, the shift can best be done by breaking the tracks at the front, just below the sprocket, working the tracks up and off the sprockets, and pulling the tank completely off both tracks. The following method can be used when, because of mud, soft ground, or other conditions, it is advantageous to keep the tank on part of the track.

(1) Break the right track at the rear of the tank, just below the idler, and, using the left track for traction, drive the tank ahead slowly until the end of the right track comes off the sprocket.

(2) Break the right track at its middle, turn the free section around end-for-end, and drive on the connectors far enough to hold the ends together.

(3) Move the tank back until all bogie wheels are on the turned section of track; then turn the other half of the track and reconnect the ends, this time driving the connectors completely on and pulling down the wedges.

(4) Move the tank forward until the front bogie wheel is on the fourth track block from the end.

(5) Roll the track up over the idler, support rollers, and sprocket, and connect the track (fig. 122).

(6) Repeat the operations on the left track.

h. Care and maintenance of tracks.

(1) **Reversible.**

(a) **To be turned.** The standard reversible type rubber block tank track will be **turned** when the rubber on the first side has worn to the extent that wear on the steel end links is imminent, or when the rubber has cracked over the cross tubes to such an extent that separation of the rubber from, and exposure of, the cross tubes is imminent, whichever condition shall first occur.

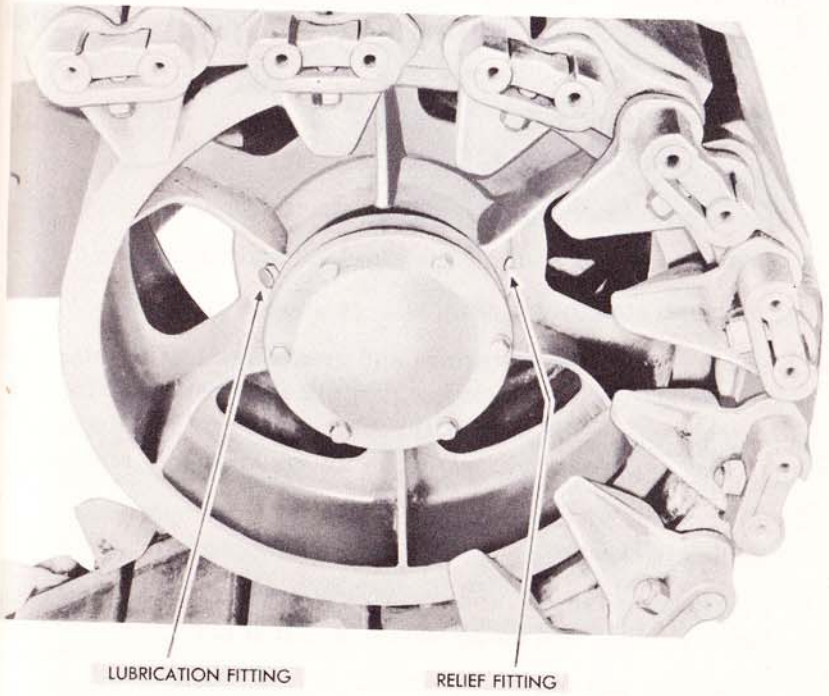
(b) **To be removed.** The standard reversible type rubber block tank track will be removed when the rubber on the second side has worn to the extent that wear in the steel end links is imminent.

(2) **Non-reversible.**

(a) **To be removed.** The non-reversible type rubber block tank track will be **removed** when the rubber on the ground side has worn to the extent that wear on the steel end links is imminent.

(3) The rubber block tank track with steel Burgess Norton adapter will be removed when the steel shoe has worn to the extent that it no longer provides traction or when wear on the end links is imminent.

(4) **Single track blocks.** In replacing single blocks which have worn out or become damaged, replacement should be made with a block that has about the same degree of wear as the remaining blocks in track.



RA PD 36424

Figure 124—Details of Idler

(5) **Equalizing wear on tracks.** Tank tracks operated on roads have a tendency to wear faster on the right hand side of the vehicle. Left hand tracks should be combined with other tracks of equal wear, or tracks should be switched from one side of the vehicle to the other, in order to obtain maximum wear from all tracks.

114. IDLERS (fig. 124).

a. Description. Two large steel idler wheels are mounted at the rear of the tank to guide and support the tracks. They are provided with an eccentric adjustment for the purpose of adjusting the tension of the tracks.

b. Adjustment. See paragraph 113 **b.**

c. Lubrication. A lubrication fitting adaptable to the grease gun is installed in the hub of the idler, which is also equipped with a relief fitting.

d. Removing idler wheel.

(1) Break track, below idler, and roll it clear.

(2) Remove the idler cap by removing six cap screws.

(3) Take out split pin securing the wheel nut and remove the nut.

(4) Pull wheel straight out off shaft.

e. Replacing idler wheel bearings and grease seals. The procedure is the same as with bogie wheels (see par. 112 **d**), except that the idler wheel has only one grease seal (at the inner bearing), the outer end of the hub being capped. Pack bearings with grease before reinstalling them.

f. Installing idler wheel.

(1) With bearings, spacer, and grease retainers installed in the wheel, place idler on its shaft, and install wheel nut in split pin.

(2) Install idler cap and six cap screws.

(3) Fill hub with grease, using pressure gun.

(4) Connect track.

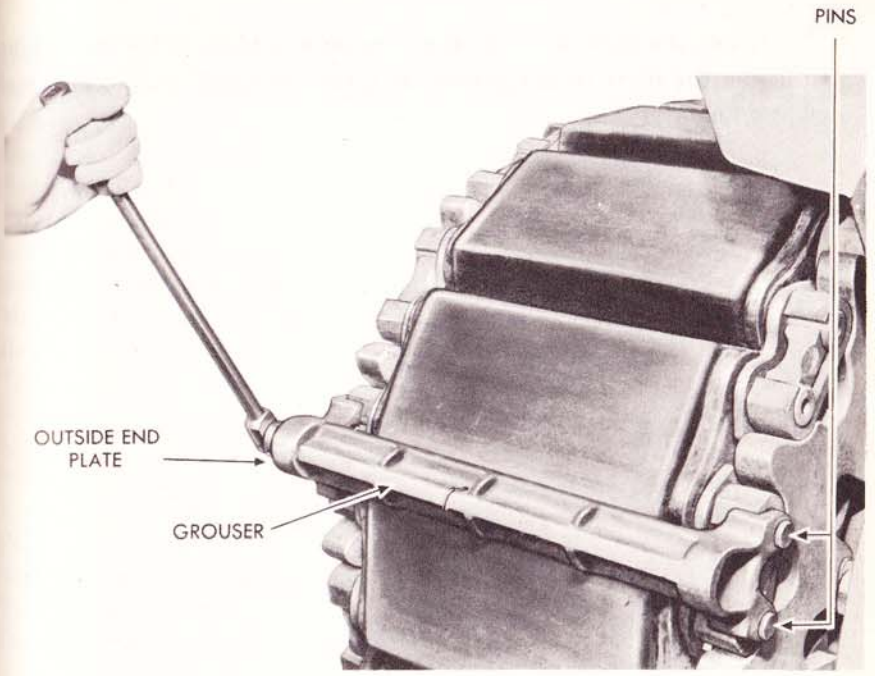


Figure 125—Installing a Grouser

115. GROUSERS (fig. 125).

a. General. Grousers are for use only with rubber block tracks, to give traction on wet mud, ice, snow, and other slippery surfaces. There are ten grousers (and three spares) for each track. In use, one grouser is installed at every eighth block of each track. Under special conditions, as when tank is in a mud hole, a series of grousers may be grouped close together at the front or rear of one or both of the tracks.

b. Installation.

(1) Remove bolt, washer, and end plate on grouser and place the grouser across the track, over the opening between two track blocks.

Slide the two pins on the inside end of the grouser into the holes in the pins of the two blocks.

(2) Insert the pins of the outside grouser end plate in the block pins, and fasten the plate to the grouser with bolt and lock washer ($^{15}/_{16}$-inch socket wrench).

Section XXI

ELECTRICAL EQUIPMENT AND INSTRUMENT PANEL

116. DESCRIPTION.

To provide for the many electrically operated accessories, the 24-volt electrical system comprises not only the two Diesel engine generators, but also an auxiliary generator plant (see Section XXII), composed of a small gasoline engine and a generator, to supply extra power at times of peak load and to aid in charging the batteries. The wiring and installation diagrams (figs. 126-130) show the location of the electrical units and the wiring.

117. BATTERY and BATTERY SWITCHES (figs. 131 and 132).

a. Description. Two twelve-volt storage batteries are connected in series to maintain the voltage of the system at 24. The battery compartment is located in the left side of the tank on the hull floor half way between the driver's seat and the engine bulkhead. A direct or separate 12-volt radio circuit is supplied by one of the batteries and controlled by the radio switch. The battery is made

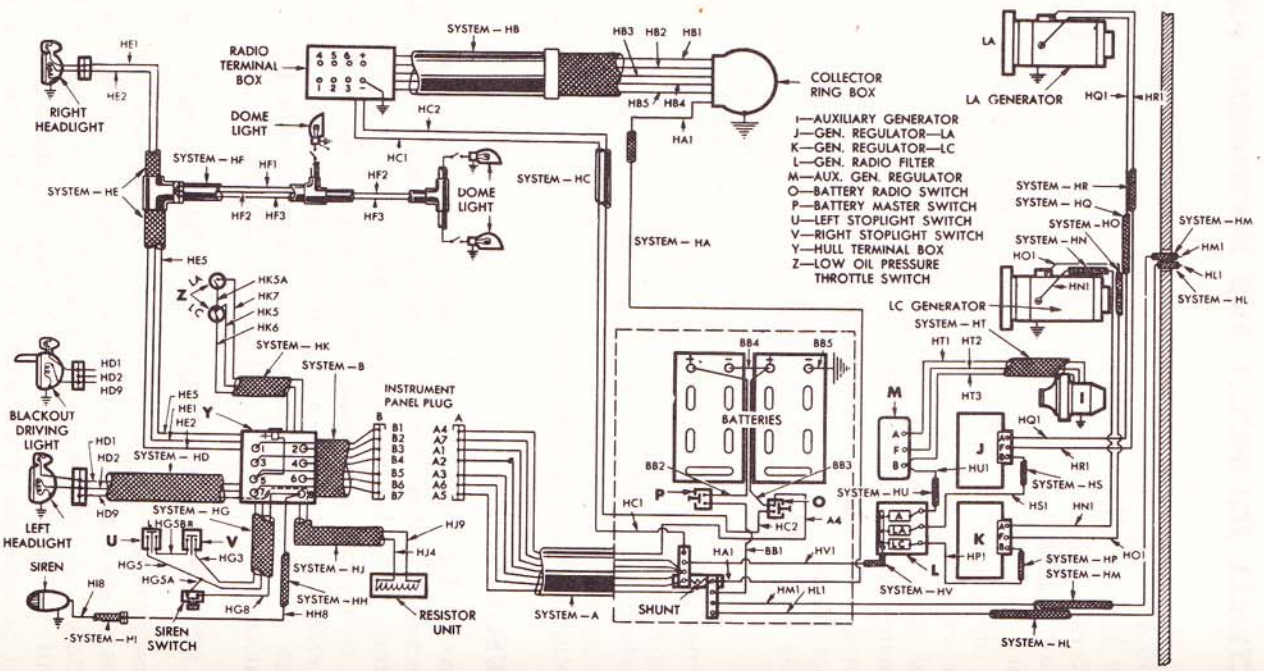


Figure 126—Hull Wiring Diagram—Schematic

RA PD 364084

System A—Battery Box to Instrument Panel
- Wire A1—No. 12 black
- Wire A2—No. 12 black
- Wire A3—No. 12 black
- Wire A4—No. 14 natural, tracer
- Wire A5—No. 16 natural, red and black tracer
- Wire A6—No. 16 natural, green tracer
- Wire A7—No. 12 black

System B—Terminal Box to Instrument Panel
- Wire B1—No. 14 orange
- Wire B2—No. 14 orange, tracer
- Wire B3—No. 14 green
- Wire B4—No. 14 black, tracer
- Wire B5—No. 14 black
- Wire B6—No. 16 gray, tracer
- Wire B7—No. 18 gray

System HA—Battery Box to Collector Ring Box
- Wire HA1—No. 2 natural, black and yellow tracer

System HB—Radio Terminal Box to Collector Ring Box
- Wire HB1—No. 18 red
- Wire HB2—No. 18 yellow
- Wire HB3—No. 18 shielded
- Wire HB4—No. 18 shielded
- Wire HB5—No. 12 black, red tracer

System HC—Battery Box to Radio Terminal Box
- Wire HC1—No. 6 black
- Wire HC2—No. 12 black, red tracer

System HD—Terminal Box to Left Headlight
- Wire HD1—No. 14 orange
- Wire HD2—No. 14 orange, tracer
- Wire HD9—No. 16 black, tracer

System HE—Terminal Box to Right Headlight
- Wire HE1—No. 14 orange
- Wire HE2—No. 14 orange, tracer
- Wire HE5—No. 14 black

System HE—Connector to Dome Lights
- Wire HF1—No. 18 black
- Wire HF2—No. 18 red
- Wire HF3—No. 18 black

System HG—Terminal Box to Stoplight and Siren Switches
- Wire HG3—No. 14 green
- Wire HG5—No. 14 black
- Wire HG5A—No. 14 black
- Wire HG5B—No 14 black
- Wire HG8—No. 14 yellow

System HH—Terminal Box to Siren Connector
- Wire HH8—No. 14 yellow

System HI—Siren Connector to Siren
- Wire HI8—No. 14 yellow

System HJ—Terminal Box to Resistor Unit
- Wire HJ4—No. 14 black, tracer
- Wire HJ9—No. 16 natural, tracer

System HK—Terminal Box to Throttle Low Oil Switches
- Wire HK5—No. 14 black
- Wire HK5A—No. 14 black
- Wire HK6—No. 18 gray, tracer
- Wire HK7—No. 18 gray

System HL—Battery Box to LC Starter
- Wire HL1—No. 00 black

System HM—Battery Box to LA Starter
- Wire HM1—No. 00 black

System HN—LC Generator Armature to Regulator
- Wire HN1—No. 6 black, tracer

System HO—LC Generator Field to Regulator
- Wire HO1—No. 14 yellow

System HP—LC Generator to Radio Filter
- Wire HP1—No. 8 black, tracer

System—HQ—LA Generator Armature to Regulator
- Wire HQ1—No. 6 black

System HR—LA Generator Field to Regulator
- Wire HR1—No. 14 yellow

System HS—LA Generator Regulator to Radio Filter
- Wire HS1—No. 8 black, tracer

System HT—Auxiliary Generator to Regulator
- Wire HT1—No. 8 black
- Wire HT2—No. 14 yellow
- Wire HT3—No. 8 red

System HU—Auxiliary Generator Regulator to Radio Filter
- Wire HU1—No. 8 red

System HV—Radio Filter to Battery Box
- Wire HV1—No. 2 natural, black and yellow tracer

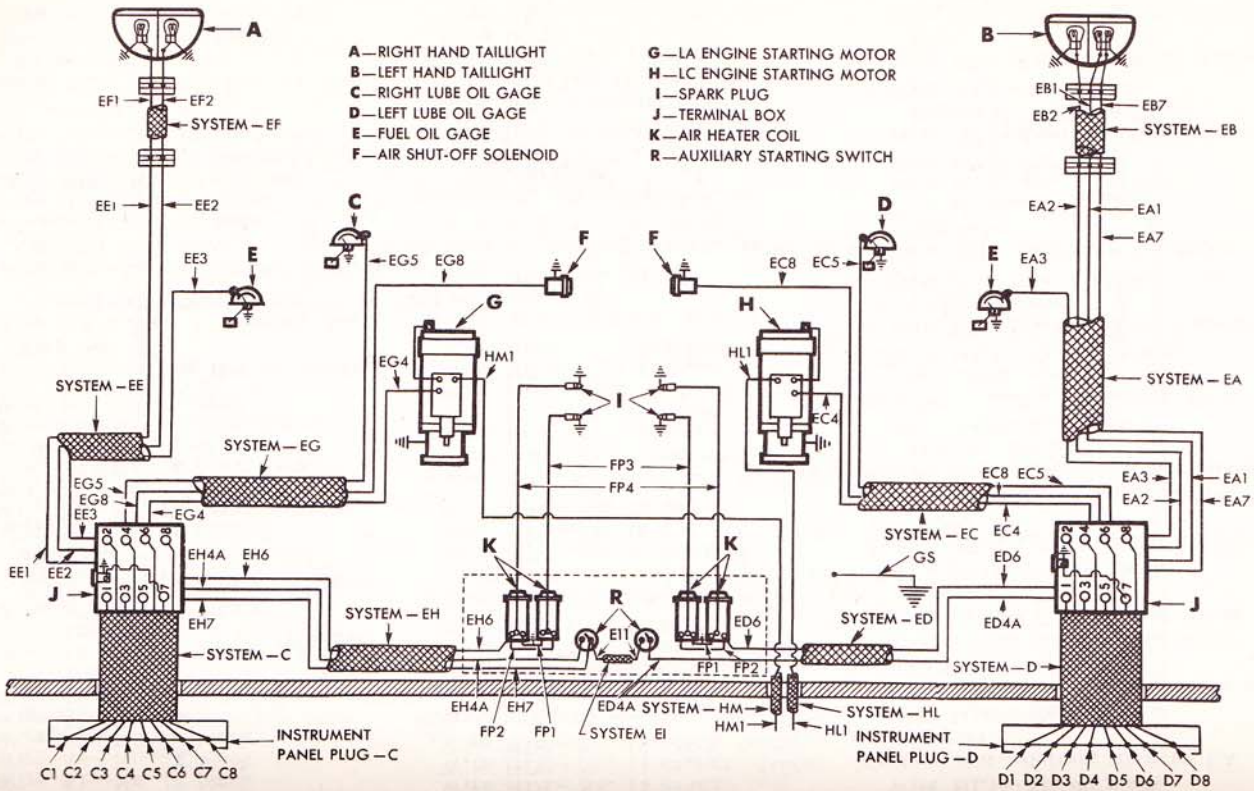


Figure 127—Engine Compartment Wiring Diagram—Schematic

System EA—Left Terminal Box to Taillight Connector

Wire EA1—No. 14 black, tracer
Wire EA2—No. 14 orange
Wire EA3—No. 14 yellow, tracer
Wire EA7—No. 14 orange, tracer

System EB—Left Taillight Connector to Taillight

Wire EB1—No. 14 black, tracer
Wire EB2—No. 14 orange
Wire EB7—No. 14 orange, tracer

System EC—Left Terminal Box to LC Engine

Wire EC4—No. 12 natural, tracer
Wire EC5—No. 14 natural, tracer
Wire EC8—No. 14 blue, tracer

System ED—Left Terminal Box to Filter Panel

Wire ED4A—No. 12 natural, tracer
Wire ED6—No. 14 green, tracer

System EE—Right Terminal Box to Taillight Connector

Wire EE1—No. 14 red
Wire EE2—No. 14 orange
Wire EE3—No. 14 yellow

System EF—Right Taillight Connector to taillight

Wire EF1—No. 14 red
Wire EF2—No. 14 orange

System EG—Right Terminal Box to LA Engine

Wire EG4—No. 12 natural
Wire EG5—No. 14 tan
Wire EG8—No. 14 blue

System EH—Right Terminal Box to Filter Panel

Wire EH4A—No. 12 natural
Wire EH6—No. 14 green
Wire EH7—No. 12 maroon

System EI—Auxiliary Starter Switch Jumper

Wire EI1—No. 12 maroon

System HL—Battery Box to LC Starter

Wire HL1—No. 00 black

System HM — Battery Box to LA Starter

Wire HM1—No. 00 black

Air Heater Coil Wires

Wire FP1—Air heater coil ground wire
Wire FP2—Air heater coil jumper
Wire FP3—Air heater coil to plug short
Wire FP4—Air heater coil to plug long

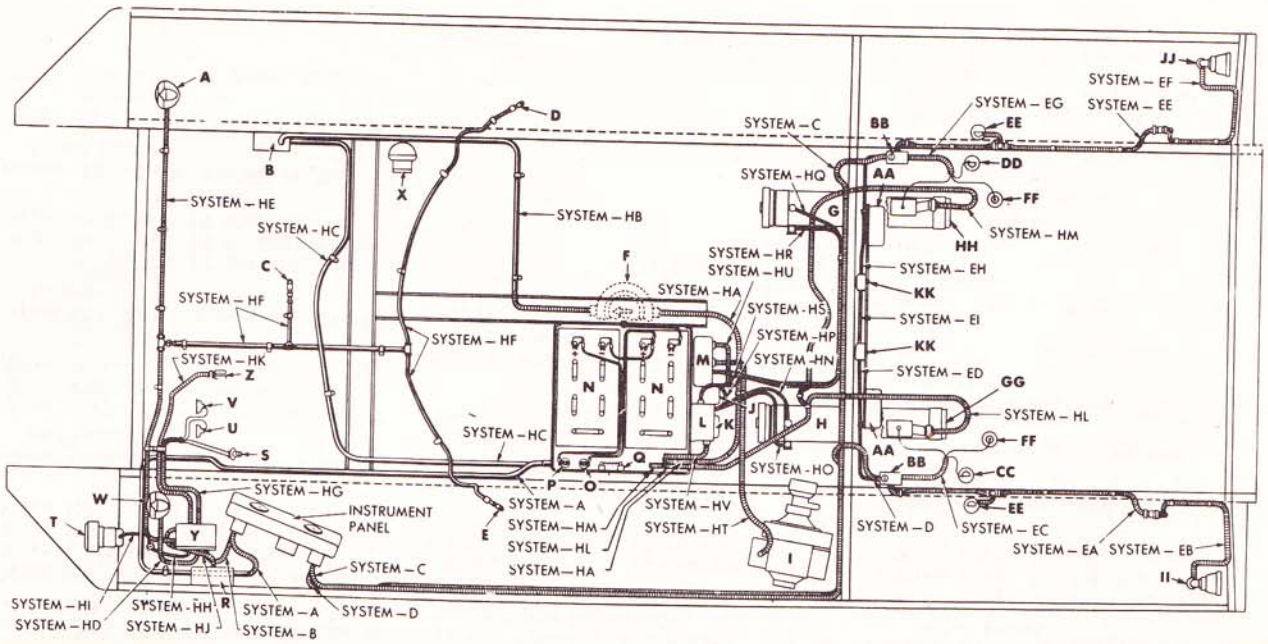


Figure 128—Hull Electrical Installation, Plan View

RA PD 36428

A—Right headlight
B—Radio terminal box
C—Dome light, center
D—Dome light, right
E—Dome light, left
F—Collector ring box
G—LA Engine generator
H—LC Engine generator
I—Auxiliary generator
J—LA Engine generator regulator
K—LC Engine generator regulator
L—Radio filter box
M—Auxiliary generator regulator
N—Battery
O—Radio master switch
P—Battery master switch
Q—Shunt
R—Resistor box
S—Siren switch
T—Siren
U—Left stop switch
V—Right stop switch
W—Left headlight
Y—Terminal box
Z—Low oil pressure cut-off micro-switch

AA—Air heater coil
BB—Terminal box
CC—Left lube oil gage
DD—Right lube oil gage
EE—Fuel oil gage
FF—Air shut-down solenoid
GG—LC Engine starting motor
HH—LA Engine starting motor
II—Left-hand taillight
JJ—Right-hand taillight
KK—Auxiliary starting switch

System A—Battery box to instrument panel
System B—Terminal box to instrument panel
System C—Terminal box to instrument panel
System D—Terminal box to instrument panel
System HA—Battery box to collector ring box
System HB—Radio terminal box to collector ring box
System HC—Battery box to radio terminal box
System HD—Terminal box to left headlight
System HE—Terminal box to right headlight
System HF—Dome light connector to dome lights
System HG—Terminal box to stoplight and siren switches

System HH—Terminal box to siren connector
System HI—Siren connector to siren
System HJ—Terminal box to resistor unit
System HK—Terminal box to throttle low oil switches
System HL—Battery box to LC starter
System HM—Battery box to LA starter
System HN—LC generator armature to regulator
System HO—LC generator field to regulator
System HP—LC generator regulator to radio filter
System HQ—LA generator armature to regulator
System HR—LA generator field to regulator
System HS—LA generator regulator to radio filter

System HT—Auxiliary generator to generator
System HU—Auxiliary generator regulator to radio filter
System HV—Radio filter to battery box
System EA—Left terminal box to taillight connector
System EB—Left taillight connector to taillight
System EC—Left terminal box to LC engine
System ED—Left terminal box to filter panel
System EE—Right terminal box to taillight connector
System EF—Right taillight connector to taillight
System EG—Right terminal box to LA engine
System EH—Right terminal box to filter panel
System EI—Auxiliary starter switch jumper

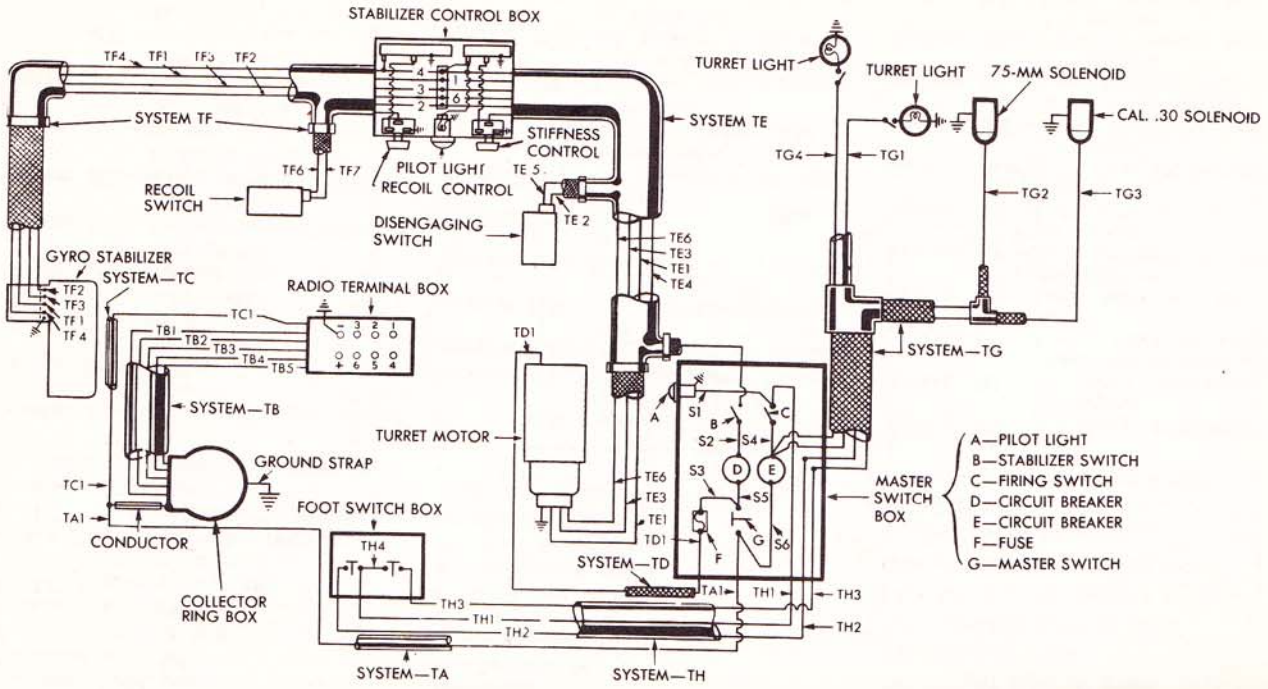


Figure 129—Turret Wiring Diagram—Schematic

RA PD 36429

System TA—Collector Ring Box to Master Switch Box

Wire TA1—No. 2 natural, yellow and black tracer

System TB—Collector Ring Box to Radio Terminal Box

Wire TB1—No. 18 red
Wire TB2—No. 18 yellow
Wire TB3—No. 18 shielded
Wire TB4—No. 18 shielded
Wire TB5—No. 12 black, red tracer

System TC—Collector Ring Box to Radio Terminal Box Power Lead

Wire TC1—No. 6 black

System TD—Master Switch Box to Motor

Wire TD1—No. 2 natural, yellow and black tracer

System TE—Master Switch Box and Motor to Control Box

Wire TE1—No. 18 green
Wire TE2—No. 18 red
Wire TE3—No. 18 yellow
Wire TE4—No. 18 black
Wire TE5—No. 18 red
Wire TE6—No. 18 white

System TF—Control Box to Gyro-Stabilizer

Wire TF1—No. 18 green
Wire TF2—No. 18 red
Wire TF3—No. 18 yellow
Wire TF4—No. 18 black
Wire TF6—No. 18 white
Wire TF7—No. 18 white

System TG—Master Switch Box to Dome Lights and Solenoids

Wire TG1—No. 18 green
Wire TG2—No. 14 chrome
Wire TG3—No. 14 blue
Wire TG4—No. 14 green

System TH—Master Switch Box to Foot Switch Box

Wire TH1—No. 18 red
Wire TH2—No. 14 chrome
Wire TH3—No. 14 blue
Wire TH4—No. 14 red

Turret Switch Box Wires

Wire S1—No. 14 red
Wire S2—No. 14 black
Wire S3—Strap
Wire S4—No. 14 red
Wire S5—No. 14 black
Wire S6—No. 14 tan

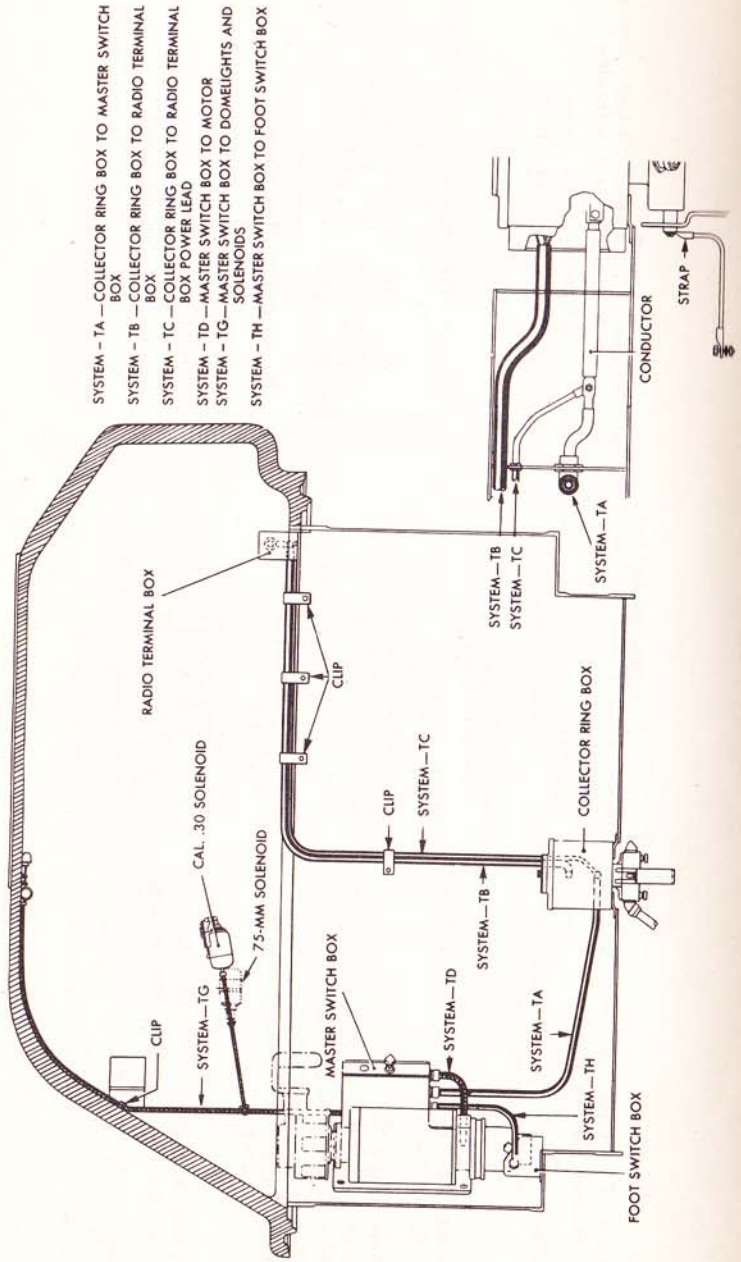
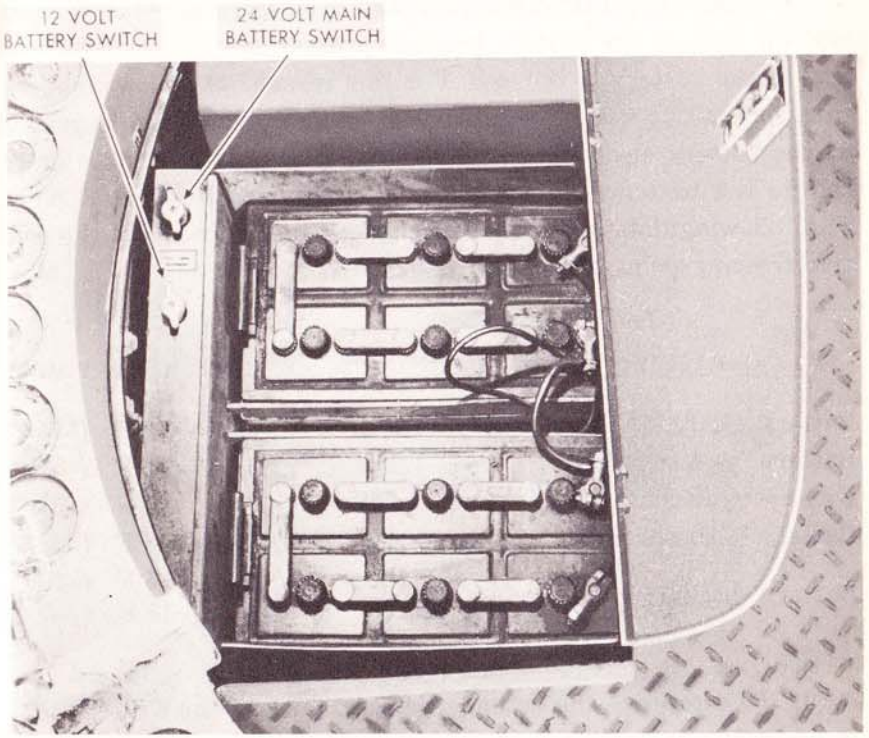


Figure 130—Turret Electrical Installation, Elevation



RA PD 36431

Figure 131—Location of Batteries and Battery Switches

accessible by traversing the turret manually to the right until the hatch or opening in the turret floor is directly over the battery box.

b. Maintenance.

(1) **Care.** Battery terminals and terminal posts will be frequently checked, cleaned, and coated with petrolatum. Check the battery fluid level once a week and after every long run. Maintain the level at ¼-inch above the plate assemblies by adding distilled water. Take a specific gravity reading every twenty-four hours, and exchange any battery having a specific gravity of 1.225 or less at 80 F (26 C) for a fully charged battery, or bring battery up to charge with auxiliary generator.

(2) **Capacity and temperature data.** At temperatures below freezing, the load on the battery becomes greater and the relative capacity of the battery is reduced. For this reason, when low temperatures prevail, it will be necessary to maintain the specific gravity of the battery electrolyte at 1.250 or higher and to replace or recharge the battery when its gravity reading is below that point. The following data show the capacity of the batteries and the relative freezing point of the electrolyte:

CAPACITY	ACTUAL SPECIFIC GRAVITY	FREEZING POINT
Battery charged	1.285	... –96 F (–71 C)
Battery ⅓ discharged..	1.255	... –60 F (–51 C)
Battery ½ discharged...	1.220	... –31 F (–35 C)
Battery ¾ discharged ..	1.185	... – 8 F (–22 C)
Battery discharged	1.150	... +5 F (–15 C)
	1.100	... +18 F (–7 C)

(3) To determine the actual specific gravity of the electrolyte, it is necessary to check the temperature of the solution with a thermometer. At 80 F (26 C) the specific gravity reading will be correct. However, if the temperature is above or below 80 F it will be necessary to make an allowance to determine the actual specific gravity, because the liquid expands when warm and the same volume weighs less than at normal temperature. When the temperature is below 80 F the liquid has contracted and the same volume weighs more. The following correction table shows the figures to be used to make these corrections. For example, when the specific gravity **as shown by the hydrometer reading** is 1.290, and the temperature of the electrolyte is 60 F, it will be necessary to subtract 8 points (.008) from 1.290, which gives 1.282 as the **actual** specific gravity. If the hydrometer reading is 1.270, at a temperature of 110 F, it will be necessary to add 12 points (.012) to the reading, which gives 1.282 as the **actual** specific gravity.

HYDROMETER CORRECTION TABLE

Temperature of Electrolyte		Correction in Hydrometer Reading	
Centigrade	Fahrenheit		
49	120	Add	.016
43	110	Add	.012
37	100	Add	.008
32	90	Add	.004
26	80	Add	0.000
21	70	Subtract	.004
15	60	Subtract	.008
10	50	Subtract	.012
4	40	Subtract	.016
– 1	30	Subtract	.020
– 7	20	Subtract	.024
–12	10	Subtract	.028
–18	0	Subtract	.032
–24	–10	Subtract	.036
–29	–20	Subtract	.040

c. Removal of battery.

(1) Open both battery switches (fig. 132).

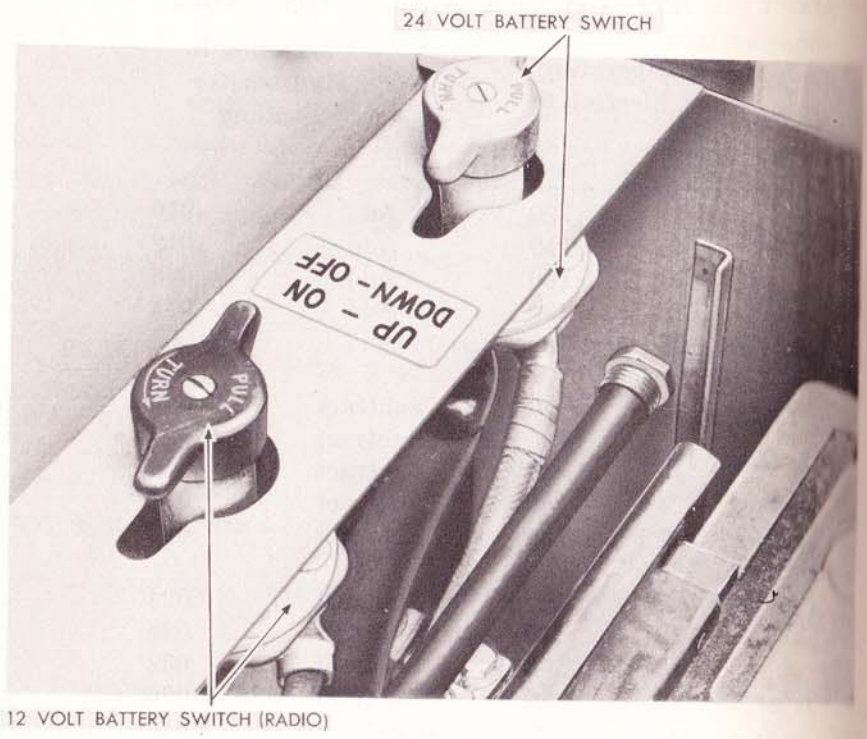
(2) Disconnect the battery cables (check legibility of markings).

(3) Remove the bracket hold-down bolts.

(4) Remove the battery through the opening in the turret platform.

d. Installation. See that the terminals are toward the propeller shaft; that the posts and the terminals have been cleaned, and (after the clamps have been installed) coated with petrolatum; and that the terminals are tight.

e. Battery switches (fig. 132). Two battery switches are mounted at the top on the left side of the battery box. The current from both 12-volt batteries goes through the 24-volt switch, and current from



RA PD 36432

Figure 132—Battery Switches

only one of the batteries goes through the 12-volt switch controlling the radio and telephone circuits. To open either circuit, raise and turn the switch handles. CAUTION: The 24-volt switch, when open, does not cut off the radio circuit. Both switches must be opened to cut off the battery completely (except for the lead to the air-heater switches and engine shut-down solenoids, which remain **hot**).

f. Replacement of battery switch. If a battery switch is damaged, or no longer makes a good contact, it must be repaired or replaced. Burning or pitting, due to arcing while the switch is being opened or closed, may cause a bad contact. To replace a switch:

(1) Remove partition separating battery and switch compartments.

(2) Remove the switch handle retaining screw and the handle.

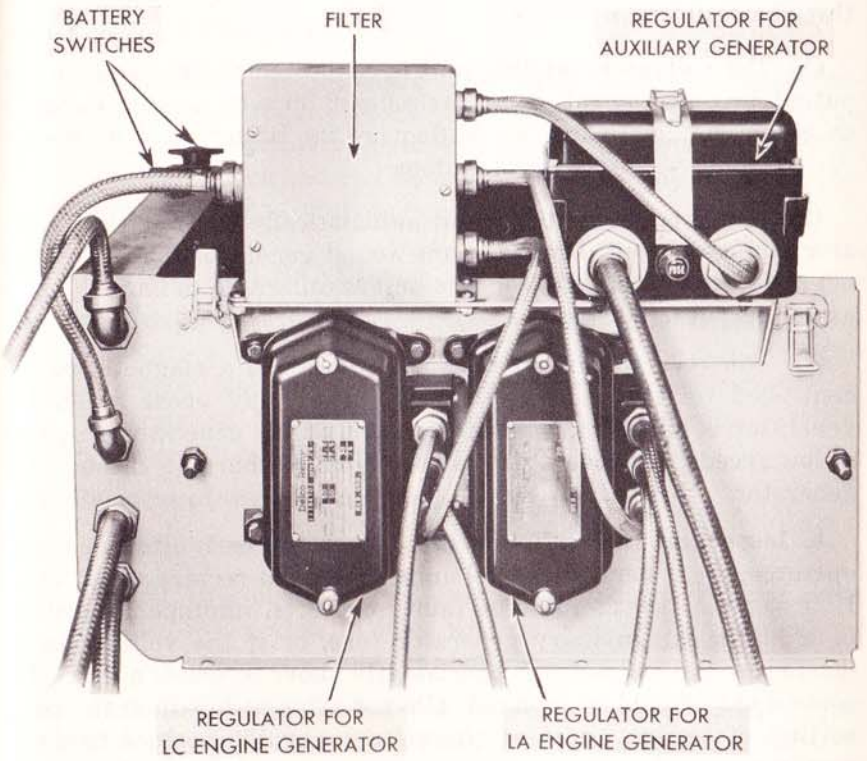
(3) Remove the terminal nuts and detach the leads.

(4) Remove the two retaining bolts.

(5) Position a new switch and install retaining bolts, terminal nuts, terminal leads, switch handle, and handle retaining screw, in the order named.

118. GENERATORS (figs. 21 and 55).

There are two shunt-wound 24-volt generators (one on each of the twin Diesel engines). (For details of their operation, and instructions for their replacement, see par. 54.) The generator regula-



RA PD 36433

Figure 133—Voltage and Current Regulators on Wall of Battery Box

tor (par. 119) controls the current output of the generators. Three radio filters (one for each Diesel engine generator and one for the auxiliary generator) are mounted in a box behind the battery box.

119. GENERATOR REGULATORS (fig. 133).

a. Description. The voltage automatically controls generator output in proportion to the amount of current being used and the condition of charge in the battery. Each engine generator has its own individual voltage regulator mounted on the rear face of the battery box. The auxiliary generator regulator is mounted alongside the generator radio filter on the bracket at the rear of the battery box. The auxiliary generator is equipped with either an Eclipse or a Delco-Remy regulator. All three voltage regulators are made up of three basic units, as follows:

(1) The **voltage regulating unit** is calibrated to limit the voltage output, or charging rate, to a maximum of 30 volts, to guard against excessive voltage, which would damage the battery and injure the various units of the electrical system.

(2) The **current limitator unit** automatically controls the generator ampere output. On the shunt-wound generator it replaces the old style third brush control. The unit is calibrated to limit the generator output to 50 amperes.

(3) The **reverse current relay,** or cut-out, is a magnetic switch controlled by the generator output. The relay opens when the generator is at rest or when the output of the generator drops off at low speeds, to prevent the battery from discharging through the generator.

b. Inspection and adjustments. When properly installed and operated, the generator control units should not require adjustment. If inspection reveals loose or faulty contacts, improper operation, or a blown-out auxiliary generator fuse, or if the voltage as indicated by the voltmeter is consistently above or below normal, the control unit should be replaced. (Do not attempt to adjust the point setting of various units of the voltage regulator, since to do so requires special tools, electrical equipment, and knowledge of the circuits.) To replace the Delco-Remy type regulators, remove the junction box cover, disconnect wires and conduits, remove four

mounting bolts. The Eclipse type regulator may be replaced without removing the base by releasing the spring catch on the cover and pulling out the upper element. The Eclipse type also has a replaceable fuse in the base, which should be inspected before replacing the unit. CAUTION: Before attempting to inspect or replace voltage regulators, make sure both battery switches are open.

120. BUS BARS.

Two bus bars, low resistance connections for common circuits, are in the rear of the battery compartment. Current is led from the battery and the generator to the bus bars and on to the circuit breakers and switches.

121. CIRCUIT BREAKERS.

Circuit breakers (see par. 122 **e** (14)), mounted behind the instrument panel face plate, are used (instead of fuses) to protect the circuits. In the event of an overload, the circuit breaker operates automatically. The circuit can be restored by pushing in the proper reset button on the instrument panel.

122. INSTRUMENT PANEL (fig. 7).

a. Mounting. The instrument panel assembly is supported by shock insulating rubber brackets which attach the panel to the sponson bottom plate, to the left of the driver. To facilitate servicing, the front of the panel, with all the instruments, may be removed without removing the back plate.

b. Removal of instrument panel face plate.

(1) Turn battery switch **off.**

(2) Detach two lubricating oil lines at pressure switches at right end of panel. Wrap ends of lines with rags to prevent oil leaking out. Mark lines and connectors for identification.

(3) Detach three air heater fuel oil pump lines (**Y, Z,** fig. 7) at top center of panel. Mark lines and fittings for identification.

(4) Detach both the tachometer drive cables by unscrewing ferrule at rear of instrument panel.

(5) Detach speedometer cable.

(6) Unscrew locking rings on four master cable connectors and pull cables off the panel.

(7) Remove six large round-head screws (**HH**, fig. 7) on face of instrument panel.

(8) Pull top of panel out and down. Rest panel on a padded thin board slipped under instrument panel back plate.

c. Install instrument panel face plate. Reverse foregoing procedure, making certain oil line connections are tight. Do not force assembly. Turn battery switch **on** and check operation of all instruments and controls.

d. Instrument panel bulb replacement.

(1) **Indirect lighting bulbs.**

(a) Turn panel light switch knob (**H**, fig. 7) left (counterclockwise) to **full on** (bright) position. Check all four bulbs by sighting through edges of instrument face.

(b) Remove bulb cover snap-in plugs (**X**, fig. 7) using thin screwdriver blade to raise edge of plug.

(c) Push in slightly and turn bulb one quarter turn to left to release bayonet connection.

(d) Install bulb, then press in the plug, using care to avoid excessive jar.

(2) **Low lubricating oil pressure and engine air heater indicator bulb replacement.** When an indicator bulb fails to light, the bulb may be burned out. Check by transferring a good bulb to the socket of the bulb that does not light.

(a) Red signal retainer may be pried out by using thin blade screwdriver under rounded edge of retainer.

(b) Turn bulb one quarter to left to disengage bayonet connection. Lift out bulb and replace. Press red signal retainer back into place.

e. Operation and functioning of instruments and controls.

(1) The instruments and controls for the engine (LC) on the left side **of the tank** are grouped on the left side of the instrument panel;

those for the engine (LA) on the right side **of the tank** are on the right side of the panel. Other instruments, such as the speedometer, clock, voltmeter, ammeter, fuel and oil level gage, which do not pertain to separate engines, are mounted in the center or on either side of the panel.

(2) **Starter switch button** (**A**, fig. 7). Separate starter buttons are provided for each engine. The starter button controls a solenoid-operated switch and shift mechanism on the starter motor. With clutch disengaged or locked out, start engines one at a time by depressing starter button and holding it down until engine starts, then immediately release. NOTE: Do not hold starter button down more than 30 seconds; if engine doesn't start, check engine. (Auxiliary starter buttons are mounted near the top of the filter panel in the engine compartment for convenience when working on the engine.)

(3) **Emergency stop control buttons** (**E**, fig. 7). In case of emergency, when the throttle or governor fails to control engine speed, the engines may be stopped by depressing the emergency stop buttons holding them down until the engines stop. A solenoid actuated shut-down valve closes off the air intake at the engine blower and starves out the engine. CAUTION: Do not use the emergency stop to shut down the engine in normal operation. (Stop the engines by snapping the hand throttle levers down, then up as far as they will go, shutting off the fuel feed.)

(4) **Engine air heater controls.**

(a) The engine air heaters (par. 53), installed in the engine air box, provide pre-heated air to the cylinders to overcome cold-weather starting difficulties. Instructions for the use of the air heaters, given on a plate attached to the instrument panel, must be followed exactly. The air heaters should be used only at temperatures below 40 F (4 C).

(b) Air heater controls on the instrument panel (for each engine) are as follows:

1 **Air heater ignition switch** (**B**, fig. 7). Turning the knob to the **on** position causes a continuous spark between electrodes in the air heaters, for igniting the fuel oil.

2 **Air heater ignition switch indicator lights** (**C**, fig. 7). The light

glows when the switch is **on**, as a warning to the driver to turn off the current when the engine starts.

3 **Air heater hand pump** (**D**, fig. 7). Operating the plunger sprays fuel oil into the air heaters, where it is ignited by the spark at the electrodes.

4 **Air heater fuel shut-off valve** (**Z**, fig. 7). Valve must be opened before operating pumps. Always close valve tight after using air heaters, to prevent air being drawn into fuel system.

(5) **Panel light switch** (**H**, fig. 7). Four bulbs in sockets behind snap-in plugs (**X**, fig. 7) provide indirect illumination for the instruments. To turn lights **on**, rotate panel light switch knob as far as it will turn, to definite stop. Rheostat-type switch enables driver to dim panel lights by turning knob.

(6) **Tachometer** (**L**, fig. 7). The tachometer indicates engine crankshaft speed. It also records total engine revolutions in **thousands.** Engine speed is important during warm-up and must be held within reasonable limits for maximum efficiency and performance. Total revolutions are used to determine length of service and inspection intervals.

(7) **Speedometer** (**M**, fig. 7). The automotive type speedometer, driven from the transmission output shaft, indicates speed in miles per hour. The odometer records total miles tank has traveled. The trip odometer may be reset by pushing in on the small plastic knob directly below the speedometer (**V**, fig. 7) and turning it clockwise. It is used to determine miles traveled between start and destination.

(8) **Voltmeter** (**I**, fig. 7). The voltmeter indicates the pressure of the current flowing in the electrical circuits. The reading should not exceed 28.5 volts. High amperage output with high voltage indicates generator regulator out of adjustment. (Replace regulator unit.) Low voltage with high amperage output indicates battery is in a discharged condition.

(9) **Ammeter** (**J**, fig. 7). The ammeter shows the quantity of current flowing in the battery circuit. A positive reading shows current flowing into the battery in excess of what is being consumed by the electrical equipment. The generator voltage regulator automatically guards against overcharging the battery. A discharge or negative

ammeter reading indicates current consumption in excess of generator output. The ammeter may be used to check the functioning of the various circuits by turning them on one at a time with the engines stopped, and noting whether the ammeter shows discharge, which indicates that the current is flowing.

(19) **Fuel and lubricating oil gage** (**P**, fig. 7).

(a) The fuel gage may be used to show the level of fluid in either the upper left or the upper right Diesel fuel oil tank, and in either the left-hand or the right-hand engine lubricating oil tank, by setting the control switch (**O**, fig. 7) at the proper position. Always check both fuel and both lubricating oil tanks when starting a run. Then set control switch at proper position for the fuel tank that is being used. When change is made to other tank, move control switch to corresponding setting. Each lower fuel tank acts as a 14.5 gallon reserve. Never run on either reserve supply until both main tanks show "E" (empty) on the gage.

(b) When filling lubricating oil tanks, do not fill beyond the point where gage shows **full**, approximately 24 quarts, leaving space for expansion of the oil. Keep lubricating oil tanks full when possible. Gage shows empty when there is approximately 2¾ gallons of oil remaining.

(11) **Engine oil pressure gage** (**Q**, fig. 7). The oil pressure gage shows the pressure of the engine lubricating oil in pounds per square inch. It provides a constant check on the functioning of the engine lubrication system, and should be observed regularly and frequently while the engines are running.

(12) **Low oil pressure warning light** (**R**, fig. 7). The low oil pressure warning light is controlled by the electric pressure switch (**S** fig. 7). The switch closes the circuit when the oil pressure is less than 11 pounds per square inch, and turns on the red tell-tale light, which burns until the pressure increases to more than 11 pounds per square inch. At idling speed, with engine warm, pressure may drop to four pounds. Normal pressure is 45 pounds. To prevent the warning light from burning when the engine is not running, a microswitch (see par. 133 **l**) is opened when the hand throttle lever is in the **no fuel** position.

(13) **Clock** (**N**, fig. 7). An eight-day stem-wind clock with sweep

second-hand is mounted at the extreme right of the instrument panel. The clock is wound by turning the stem (**W**, fig. 7). (CAUTION: Do not over-wind.) To set hands, pull out stem and turn.

(14) **Circuit breakers (AA to GG, fig. 7).** Automatic circuit breakers are grouped at the upper right-hand side of the instrument panel. These circuit breakers take the place of fuses formerly used, and protect the circuits against excessive overload, or short circuits which might cause serious damage to the various units or result in fire from overheated wiring. When the electrical load reaches a predetermined level, a bimetal strip flexes, opening the circuit and causing the button to snap out with a click. If the overload is a temporary one, the circuit breaker may be reset by pushing in the button. However, if there is a short or ground in the circuit, the circuit breaker will continue to cut out until the trouble has been corrected. CAUTION: Do not hold button depressed. Investigate cause of overloading and correct. The buttons control various circuit breakers, as follows:

BUTTON (see fig. 7)	CIRCUITS
AA	LC engine starter switch circuit
BB	LA engine starter switch circuit
CC	Accessory outlets, voltmeter, resistor, tank gage control switch, and tank gage tank unit circuits
DD	Auxiliary engine starter switch circuits
EE	Interior hull lights; service head, tail, and stoplights; driving light and stoplight switch; low oil pressure indicator and switch; and siren and switch circuits
FF	LC engine air heater switch and spark coil circuits
GG	LA engine air heater switch and spark coil circuits

(15) **Light switch (F, fig. 7).** The knob on the instrument panel marked LIGHTS controls the service lights and the blackout marker lights. A spring-operated safety button (**G**, fig. 7) prevents the knob from being accidentally pulled out beyond the blackout position. To release, push button in with thumb, at the same time continuing outward pull on knob. The switch has three positions (besides OFF, or all the way in), controlling lights as follows.

Light Switch Position	Lights Operating	Location
Blackout—		
1st position	Blackout marker	Top of R & L headlights
	Blackout taillights	Lower section R & L taillights
	Blackout stoplight	Upper section R H taillight
Service—		
2nd position	Service headlights	R & L headlights
	Service taillight	Upper section L H taillight
	Service stoplight	Upper section L H taillight
Stoplight—		
3rd position	Service stoplight	Upper section L H taillight

(16) **Transmission oil temperature gage (U, fig. 7).** A capillary-type oil temperature gage records the temperature of the transmission lubricating oil. Excessive heat tends to thin out the oil and rob it of its lubricating quality. The transmission oil cooler should be kept clean and free of any material that might restrict radiation. Normal operating temperature ranges from 200 to 250 F (93 to 121 C). When temperature of transmission oil exceeds the maximum figure, check for cause of overheating.

(17) **Engine water temperature gage (T, fig. 7).** Each engine is provided with a gage which shows the water temperature at the cylinder head water outlet manifold. These gages should be noted frequently while the engines are running, so that proper precautions may be taken to prevent overheating. The engines should be warmed up to 160 F (71 C) before the tank is driven. The engines operate most efficiently between 175 and 180 F (79 and 82 C). In hot weather, engine temperatures up to 225 F (107 C) are permissible, since the engines normally run 105 F (41 C) hotter than the atmosphere. (See par. 83 **b.**)

(18) **Accessory outlets (K, fig. 7).** Two bayonet-type accessory outlets are provided at the upper corners of the instrumnet panel. These outlets may be used to supply current for trouble lights, windshield wiper, defroster, ventilating fans, and other accessories.

(19) **Blackout driving light switch (II, fig. 7).** The blackout driving light may be used to supply illumination for driving when the service driving lights might reveal the position of the tank. First remove both service headlights from their sockets at the front of

the tank. Then insert the blackout driving light in the socket of the left front lamp. With the master light switch (**F**, fig. 7) pulled out to first position, pull out on blackout driving light switch button to turn on blackout driving light. The blackout headlight, taillights, and stoplight also will be on with the switches in this position. CAUTION: Under combat conditions, the blackout driving light should be used intermittently, and only when absolutely necessary for safe vision. Remove all headlights and stow them inside tank when not needed under combat conditions. Protect headlight sockets by inserting protection plugs attached to headlight guards.

123. SOLENOID STARTER SWITCH.

A solenoid starter switch is located on each starter motor. By eliminating the necessity of running heavy cables up to the instrument panel, it reduces voltage drop. These solenoids are actuated by the push button starter switches on the instrument panel and filter panel.

124. MAINTENANCE OF INSTRUMENTS (fig. 134).

a. All instruments and switches that become inoperative should be exchanged for serviceable ones.

b. Compass.

(1) **Compensation.** Corrections for the attraction of the metal components surrounding the compass are made by means of compensating screws.

(a) Using a small brass (non-magnetic) screwdriver, turn each screw until the white dot on the screw alines with the white dot on the compass body.

(b) With all tank equipment of a magnetic nature in place, head the tank due magnetic north, which usually is different from the true north. (Note: All directions are to be determined by an instrument placed at some distance from the tank. A surveyor's transit may be used.) Turn the N-S screw until the compass reads N. Head the tank due east and set the compass at E by turning the screw marked E-W. Head the tank due south of magnetic north and remove **one-half** the existing error by turning the N-S adjusting

screw. Head the tank due west and remove **one-half** the remaining existing error by turning the E-W adjusting screw.

(c) Recheck by heading the vehicle in each of the true directions shown on the correction card, furnished with each instrument, and record the corresponding compass readings in the spaces provided.

(d) If satisfactory compensation is not obtainable by the foregoing procedure, notify ordnance maintenance personnel.

(2) **Maintenance.** At frequent intervals, inspect the compass for the presence of air in the bowl and, if necessary, remove the filler plug and refill with ethyl alcohol. Compensation for error due to local magnetic variation should be made as required by change of station.

125. REPLACEMENT OF INSTRUMENTS (fig. 134).

To replace any electrical instrument in the instrument panel:

a. Open both battery switches.

b. Remove the nuts holding the wires to the back of the instrument.

c. Remove wires from connections, marking each for identification.

d. Loosen the nut on the clamp holding the instrument and remove instrument.

e. Insert new instrument.

f. Tighten the nut on the holding clamp.

g. Install wires on connections.

h. Install nuts.

i. Close battery switches.

126. TERMINAL BOX.

Terminal boxes are mounted as follows:

a. One on each engine compartment side panel for circuits supplying the air shut-down valves, fuel and lubricating oil tank (gage)

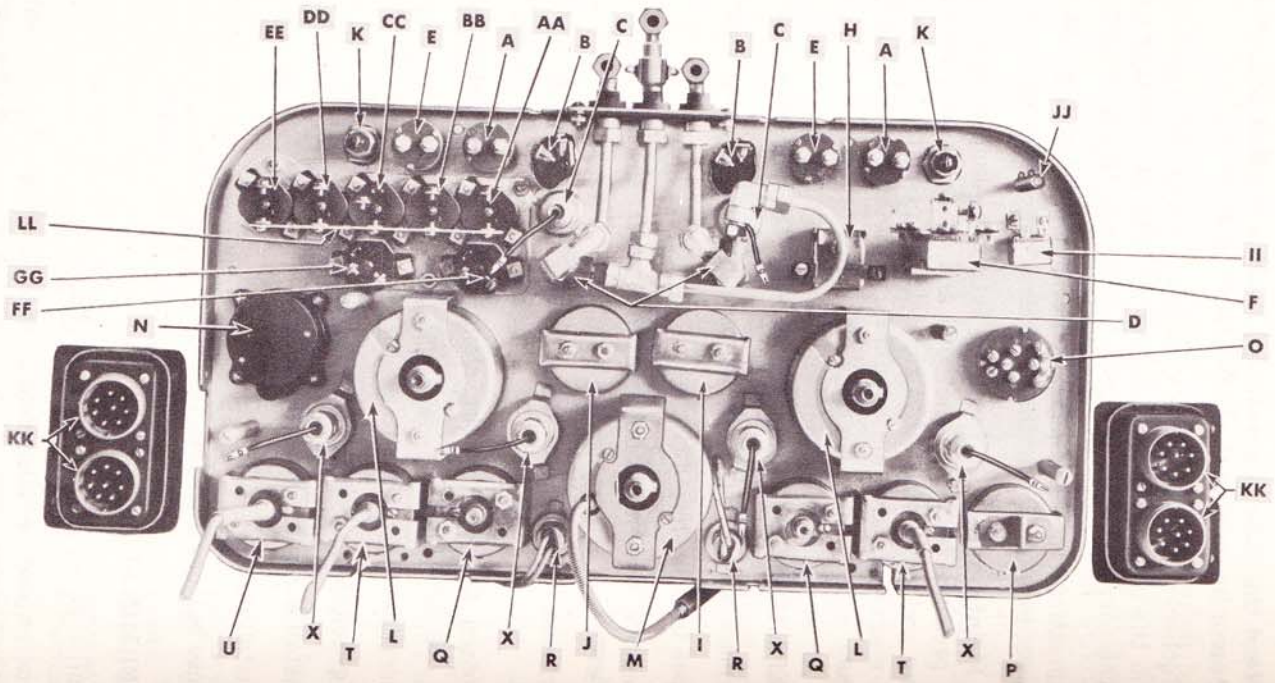


Figure 134—Rear of Instrument Panel Face Plate

A—Starter switch
B—Air heater switch
C—Air heater indicator light
D—Air heater fuel pump
E—Emergency stop switch
F—Driving light switch
H—Panel light switch
I—Voltmeter
J—Ammeter
K—Accessory outlet
L—Engine tachometer
M—Speedometer
N—Clock
O—Tank gage control switch
P—Fuel and lube tank gage
Q—Engine oil pressure gage
R—Low oil pressure indicator light
T—Engine temperature gage
U—Transmission oil temperature gage
X—Instrument panel lights
AA—Circuit breaker (LC Engine starter circuit)
BB—Circuit breaker (LA Engine starter circuit)
CC—Circuit breaker (outlet socket, voltmeter, resistor, tank gage switch, and tank unit circuits)
DD—Circuit breaker (auxiliary starter switch circuits)
EE—Circuit breaker (bow gun, solenoid; hull, stop, low oil, blackout, and driving lamps; and siren, circuits)
FF—Circuit breaker (LC Engine air heater circuit)
GG—Circuit breaker (LA Engine air heater circuit)
II—Blackout driving light switch
JJ—Resistor
KK—Multi-prong socket
LL—Bus bar

units, air heater, ignition coils, auxiliary starter buttons, and taillights.

b. One terminal box on the left sponson, forward, for circuits supplying all lights on the front of the tank, hull dome lights, low-oil cut-off switch system, siren and stoplight system, siren system, and resistor wire system.

c. In addition, there are two terminal boxes for the radio and intratank telephone system, one in the turret and one on the right hull side plate.

127. SOLENOIDS.

a. The air shut-down valves of the Diesel engines are operated by means of solenoids, controlled by two buttons on the instrument panel.

b. When properly installed, these solenoids should not require any attention. If trouble is experienced, a heavy jumper placed across the contact terminals with switch button depressed will indicate whether the solenoid switch is inoperative or the trouble lies in some other part of the circuit. Replace inoperative solenoid.

128. LIGHTS.

a. Headlamps. A socket is provided above each front fender for installation of the combination driving and position lights. The lights should be kept inside the tank except when specific orders are given for their use. A plug (see fig. 135) provided to weather-seal the socket should be kept in the socket when the lights are not installed. The plug is chained to a protective housing in which the plug is stored when not in use.

b. Focusing. The driving lights are focused by means of a focusing screw back of the lights.

c. Blackout driving light (fig. 135). A special blackout driving light is provided for mounting in the left front light socket.

d. Taillamps. The taillamps are combination lamps. In the left lamp, the upper lens is the service light and service stoplight, the lower lens is the blackout light. In the right lamp, the lower lens is the blackout light, the upper lens is the blackout stoplight. Both

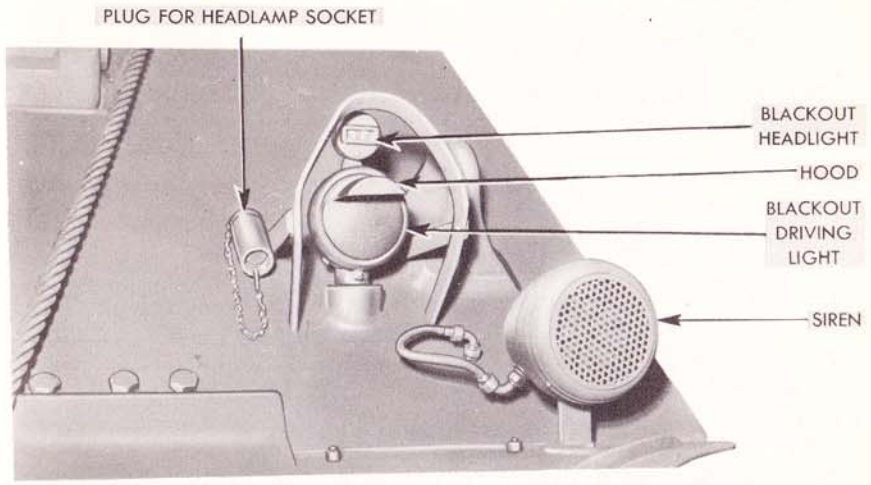


Figure 135—Blackout Driving Light with Hood Attached

stoplights are controlled by stoplight switches, connected in series, operated by the steering brake levers. Stop signals show only when both hand levers are pulled, indicating a slowing down or a stop.

129. SIREN.

The siren, mounted on the front left fender of the tank (see fig. 135), is operated by a button at the driver's left foot. To remove siren:

a. Open both battery switches.

b. Disconnect the electric cable at fender connector.

c. Remove the nuts and bolts, freeing the siren.

130. RADIO INTERFERENCE ELIMINATION.

a. Shielding.

(1) **Description.** The wiring system is shielded to prevent radio interference. The shielding is constructed so that if any part is

damaged it may be readily replaced without discarding the entire shielding structure.

(2) **Maintenance and inspection.**

(a) The electrical wiring, the shielding, and conduits, require frequent inspection and checking.

(b) Crushed conduit and shielding should be replaced. Clean oily or dirty shields or shielding fittings and tighten all coupling nuts. Replace wires or conduits that have become oil-soaked.

(c) In cleaning couplings or shields, use carbon tetrachloride. (If none is at hand, dry-cleaning solvent may be used. CAUTION: Be sure both battery switches are open.) The threads should be cleaned with a small wire brush to remove high-resistance oxidation, which sometimes forms on the inside of brass couplings.

b. Generator radio filter. The generator radio filter, mounted on the rear of the battery box, dampens or filters out the radio interference caused by arcing of the brushes and the generator regulator contact points. The filter is made up of three separate interchangeable filtering units, one for each of the engine generators and one for the auxiliary generator. (For replacement of radio filter, see par. 133 j (3).)

131. STARTING MOTOR.

A 24-volt electric starter is used on each engine. For details of its operation and replacement, see paragraph 52.

132. TURRET ELECTRICAL INSTALLATIONS.

a. General. Current for all electrical units in the turret is brought in through the collector ring (slip ring) assembly (fig. 136) located at the center of the turret basket floor. The upper rings carry the 12-volt current for the radio and intratank telephone system. The lower rings carry the 24-volt current for the traversing and stabilizer mechanisms and the firing switches. All leads from the 24-volt circuits go through the turret switch box (fig. 137).

b. Inspecting slip rings (fig. 136). The slip ring assembly will seldom require attention. It should be kept tightly covered. Slip

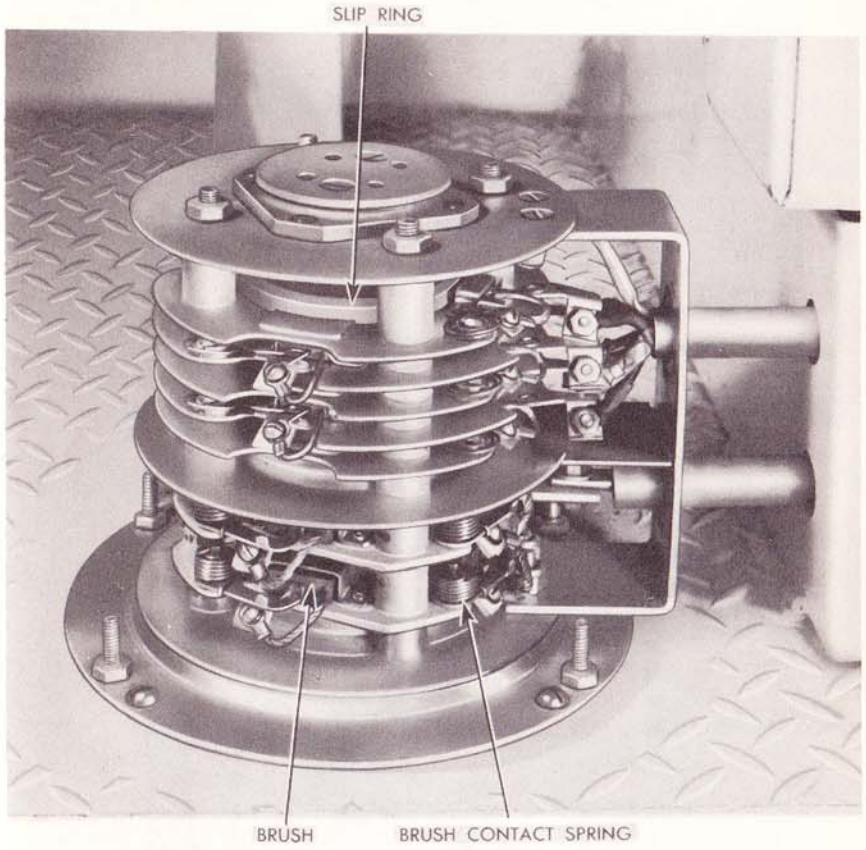


Figure 136—Collector Ring Assembly, Cover Removed

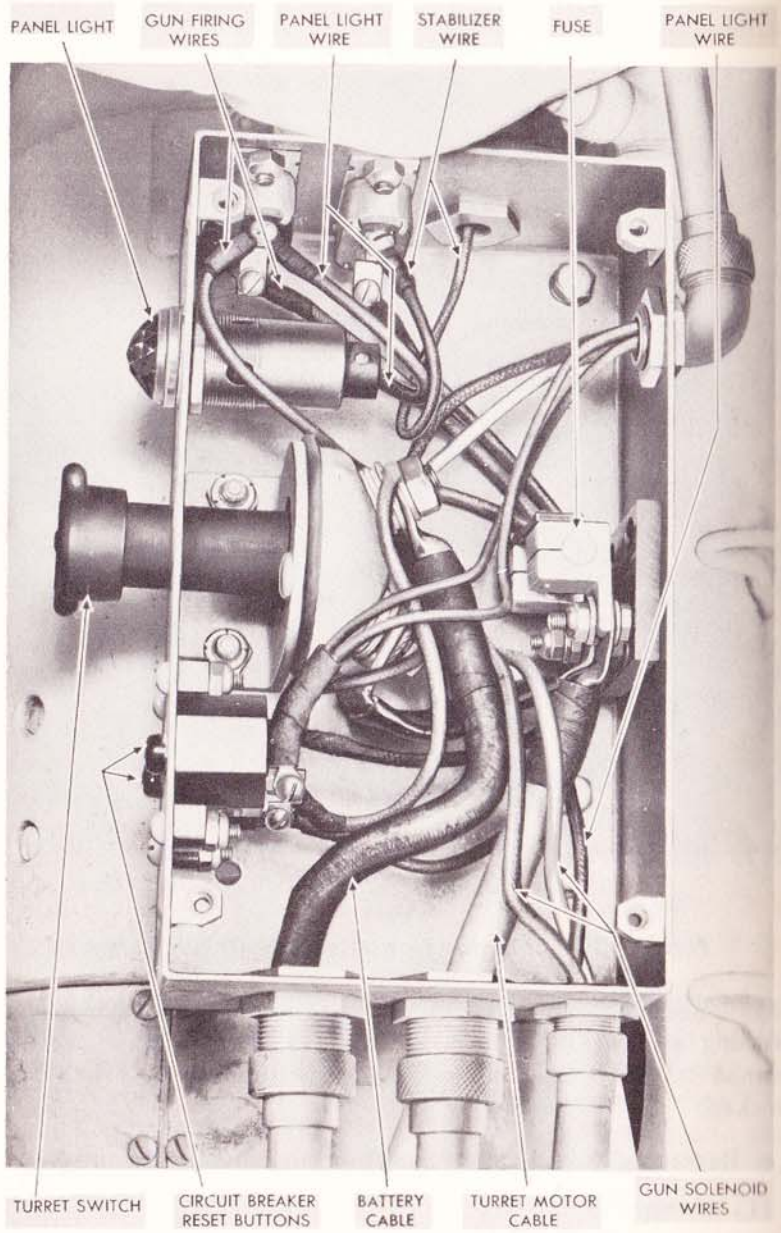
rings should be inspected for presence of dirt, and wiped off with cleaning solvent if necessary. Brushes should be inspected and cleaned in the same manner, and the tension of brush springs checked.

c. Replacing fuse in turret switch box (fig. 137).

(1) Remove switch box cover (4 screws).

(2) Loosen two self-locking nuts that hold prongs of fuse assembly and lift out the fuse.

MEDIUM TANK, M4A2



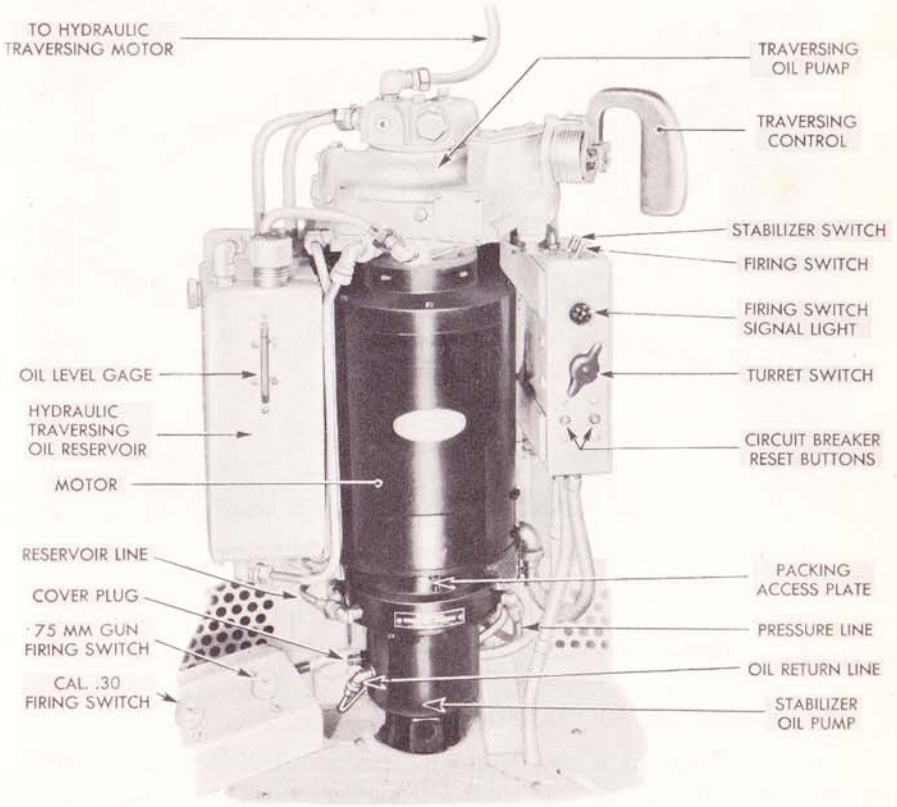
RA PD 12550

Figure 137—Turret Switch Box with Cover Removed

(3) Slip new 100-ampere fuse into place on the studs and tighten the nuts.

(4) Replace switch box cover.

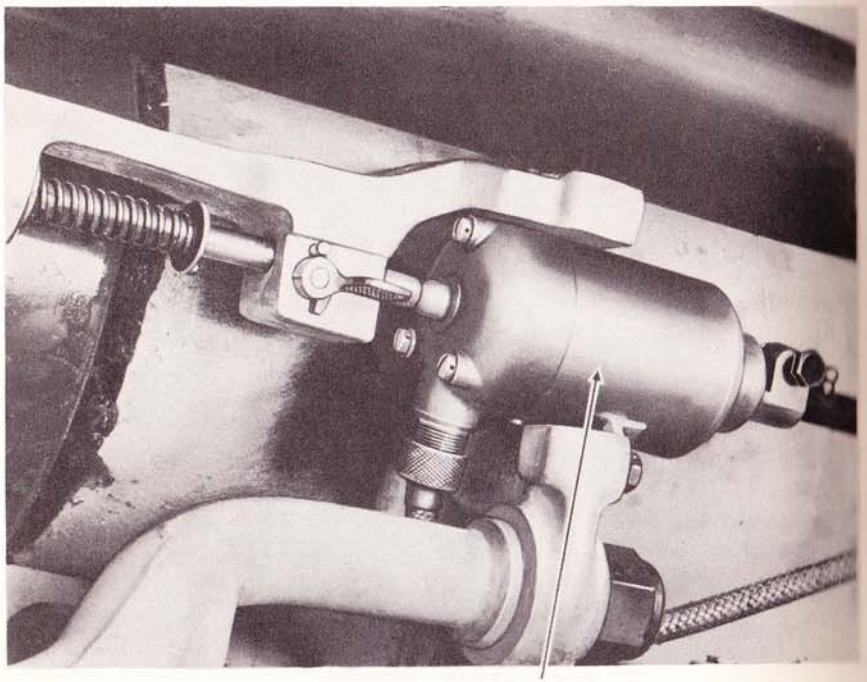
d. Stabilizer and traversing mechanisms. No repairs, and no adjustments other than those called for in the use of these mechanisms, will be made on any units of the traversing and stabilizer mechanisms. Faulty operation traced to any unit should be reported immediately to ordnance maintenance personnel, and the unit replaced.



RA PD 36438

Figure 138—Stabilizer and Traversing Oil Pumps and Motor

e. Inspecting firing solenoids. The 75 mm gun and the cal. .30 machine gun firing solenoids should be inspected regularly for security, adjustment, and correct operation. If a solenoid fails to operate, check all lines with a light; and if circuit is undamaged, replace the solenoid.

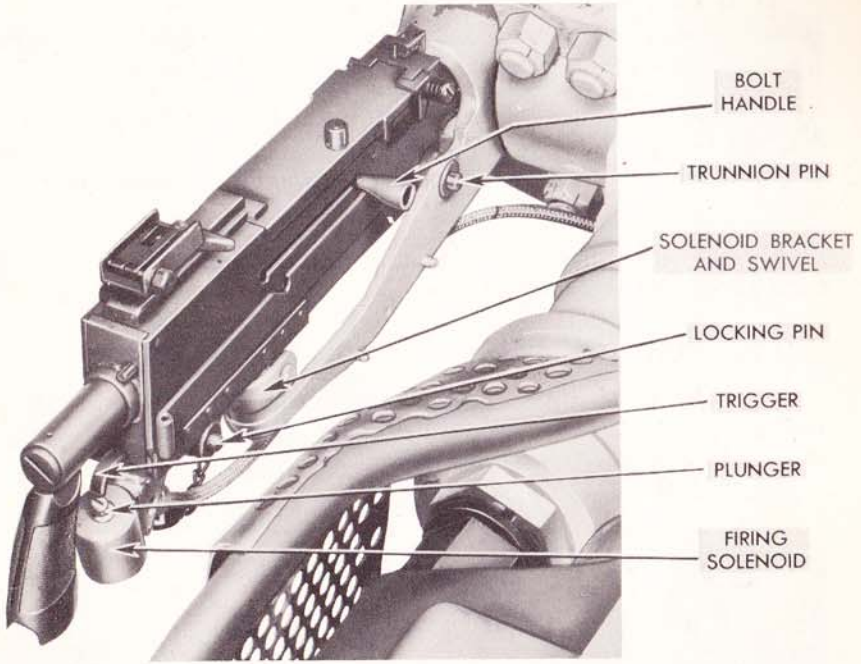


RA PD 12518

Figure 139—Firing Solenoid Installed on 75 MM Gun

133. TROUBLE SHOOTING.

a. Checking main circuits to localize trouble. With both battery switches **on** and all electrical units turned **off**, a negative or discharge ammeter reading indicates either a grounded or a shorted wire in one of the electrical circuits. To determine in which system the faulty circuit is, perform the following preliminary check:



RA PD 36440

Figure 140—Firing Solenoid on Turret Cal. .30 Machine Gun

(1) Remove the bottom instrument panel plug **B** (see fig. 126) on the right-hand side of the instrument panel. If the ammeter reading returns to zero, the trouble is in one of the circuits fed by the driver's compartment terminal box. If the ammeter still reads discharge, the trouble is in one of the other systems and can be located by removing the remaining instrument panel plugs, one after the other, as follows:

(2) Remove the top instrument panel plug C (see fig. 127) on the left-hand side of instrument panel. If the ammeter still reads discharge, the trouble is not in the circuits fed by the engine compartment right terminal box.

(3) Remove the bottom connector plug **D** (see fig. 127) on the left-hand side of instrument panel. If the ammeter still reads discharge, the trouble is not in the circuits fed by the engine compartment left terminal box.

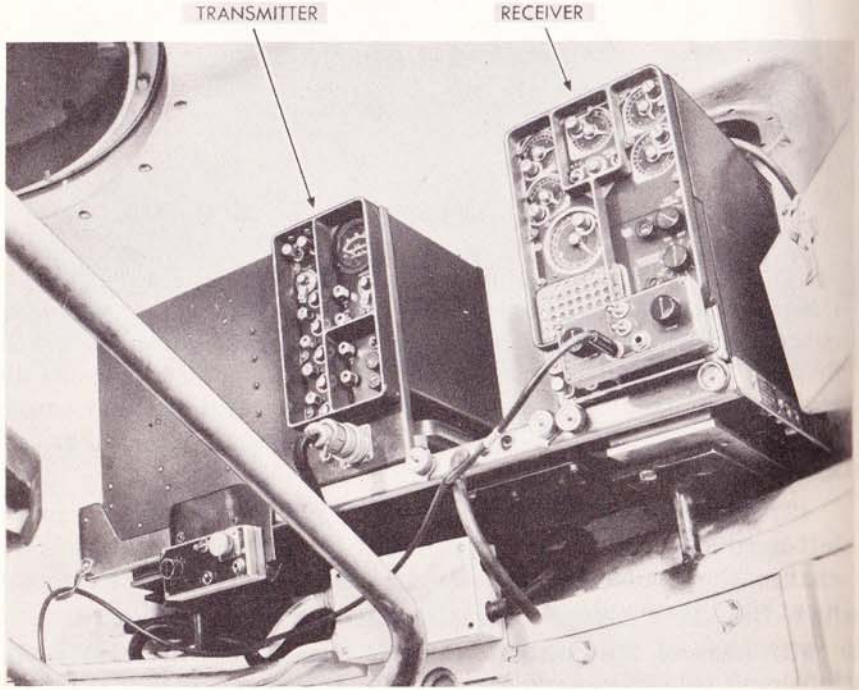
(4) If after removing plugs **B, C, D,** the ammeter still shows discharge, the trouble is localized in System A (see fig. 126), which is the main circuit from the battery to instrument panel.

(5) After making preliminary check and determining which circuit the trouble is in, refer to the complete wiring diagrams (figs. 126-130) in order to determine which individual wire may be at fault.

(6) All wires that are accidentally grounded or have open circuits should be replaced with wires of the same size and color.

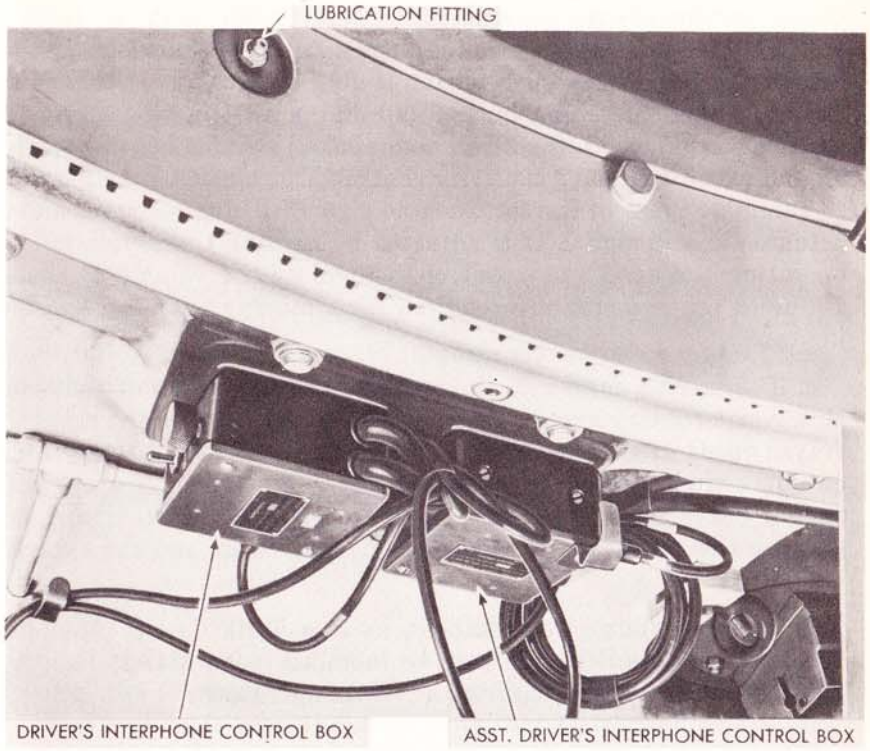
134. DESCRIPTION AND USE OF RADIO SETS.

a. The M4A2 Medium Tank may have the SCR-508, the SCR-528 (fig. 142), or the SCR-538, radio set. These are all high-frequency voice-operated sets with simple controls, and do not require a



RA PD 12438

Figure 141—Typical Radio and Interphone Installation (SCR-528)



RA PD 36442

Figure 142—Interphone Control Boxes for Driver and Assistant

technically trained operator. The SCR-508 consists of a transmitter and two receivers, which may operate at the same time on different channels; the SCR-528 has a transmitter and one receiver; the SCR-538 has one receiver and no transmitter. The SCR-538 has a special phone amplifier. There is a phone for each man in the crew, with which he may talk to the others. The radio sets will operate reliably from 10 to 15 miles, but are considerably affected by the terrain and the directional effect of the antenna.

b. The SCR-508 radio has 10 pre-set channels, any one of which may be selected by depressing a push button. The only controls on the transmitter for the operator, other than the push buttons, are the **on** and **off** switch and the radio-interphone switch. The transmitter should be left **on** whenever the set is manned, but the micro-

phone button should be held closed only while actually talking, which should not be for more than one minute continuously. The receiver has, besides its push button tuning controls, a set **on** and **off** switch, a manual tuning button and dial, a switch for turning the loudspeaker on or off, the interphone control switch, and the **squelch on** and **off** switch and sensitivity control. The squelch circuit is used to eliminate noise in the set when no signal is being received, and to actuate the call signal. It is adjusted by turning the switch **on** and operating the sensitivity control to regulate the volume of sound. Different adjustments are required for a moving tank and a standing tank.

c. There is no danger to the operator in these types of radio set. However, ordinary precautions must be taken, such as the repair of frayed cords or battery leads. Turn off the set at the battery radio circuit switch whenever changing fuses or tubes. The operator should not attempt anything but first echelon maintenance; i.e., keeping the set, headsets, and microphones clean, and the external wires tight.

d. Under certain circumstances, as in a Tank Group (Medium) Headquarters, an SCR-506 may be installed in an M4A2. This is a medium power CW set requiring a trained operator.

Section XXII

AUXILIARY GENERATING UNIT

135. INSPECTIONS.

The auxiliary generator requires regular attention to keep it at full operating efficiency. The inspections of the unit covered in Section IV should be supplemented with frequent checks on operations, and with preventive maintenance.

136. MAINTENANCE (figs. 143 and 144).

a. Spark plug. The spark plug should be replaced during every regular 50-hour inspection of the tank, or after every 25 hours of operation of the auxiliary generator.

(1) **Removal.**

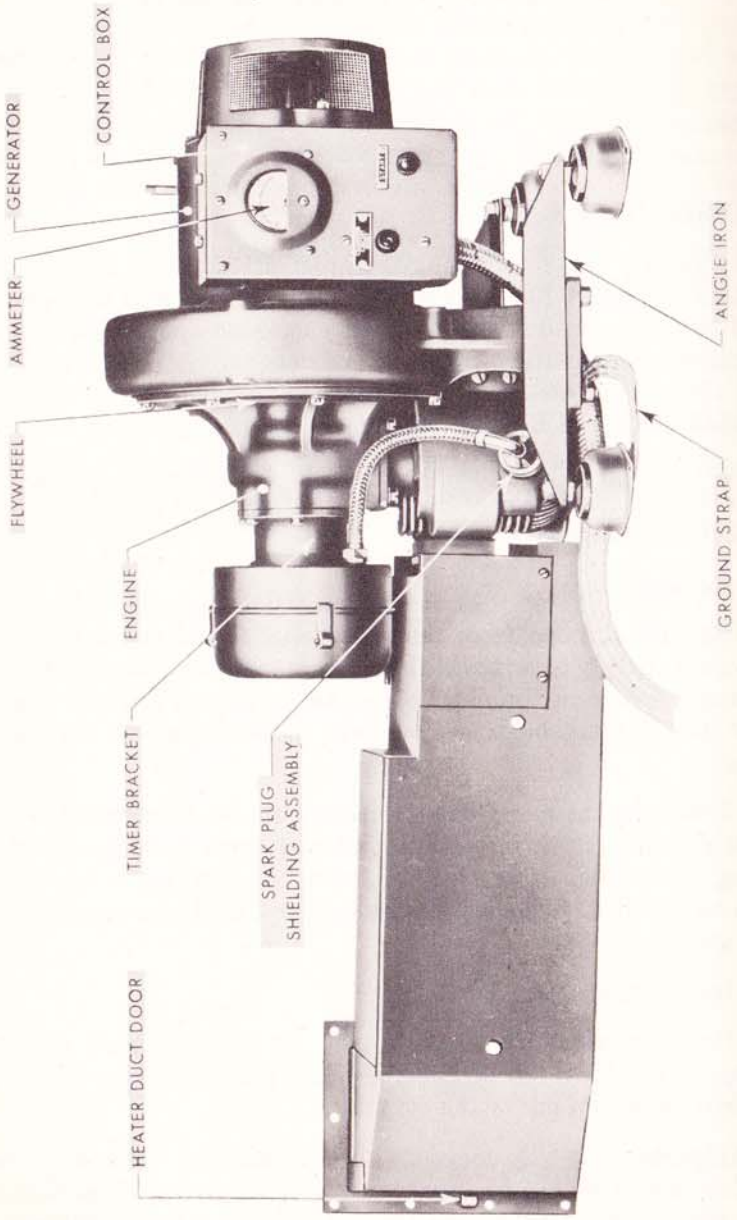
(a) Remove the cap from the spark plug shield and take out the plug with a spark plug wrench. If the adapter comes out with the spark plug, remove it from the plug. Note that in reinstalling the plug, the copper gasket must be placed **outside** the metal shield surrounding the plug.

(b) Whenever the spark plug is removed, the adapter should be taken out for cleaning. Both sides of the adapter must be scraped out and thoroughly cleaned. After every 75 hours of operation, a new adapter should be installed. When installing a new or a used adapter, always use a new gasket.

(2) **Installing spark plug.**

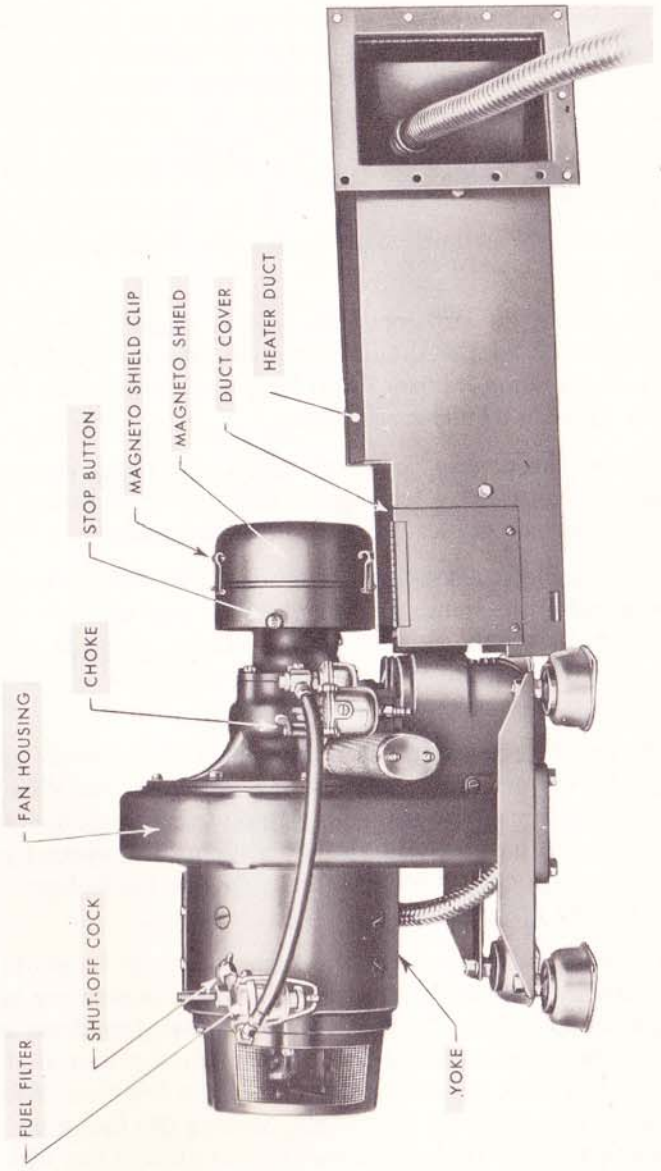
(a) Before reinstalling a spark plug or adapter, hold down the starting button for a few seconds, in order that any loose carbon particles may be blown out of the cylinder.

b. Magneto. The only magneto adjustment is at the contact point assembly, which should be inspected every 100 hours of operation (of the auxiliary generator) to see that the gap is exactly .020 inch. To adjust, proceed as follows:



RA PD 49715

Figure 143—Auxiliary Generator Unit, Front



RA PD 49716

Figure 144—Auxiliary Generator Unit, Rear

(1) Pry open the three clips on the shield over the magneto, and take off the front half of the shield.

(2) Remove the magneto rotor by loosening the rotor puller nut, to expose the contact points. NOTE: Do not remove the three screws holding the starting plate to the rotor. The contact points are now exposed.

(3) Remove the spark plug, to relieve compression and permit turning the flywheel.

(4) Rotate flywheel until gap reaches its maximum. (Check with feeler gage.)

(5) Gap should be .020 inch. To adjust, **slightly** loosen the screw which fastens the contact point assembly to the stator plate. Move the entire breaker mechanism **toward** the cam to increase the gap, or **away from** the cam to decrease the gap.

(6) Tighten the contact point assembly, fastening screw securely, and recheck the gap with a feeler gage. Readjust if necessary. (Tightening the set screw sometimes changes the adjustment.)

(7) The entire contact point assembly pivots on the breaker lever bearing pin, which permits adjustment of the gap without altering the relationship between the contact point surfaces. If the breaker cam is removed from the intake valve shaft, reinstall with the arrow (indicating direction of rotation) on the outside.

(8) Uneven or pitted contact points may be restored by using a smooth carborundum stone, after which all dust particles must be removed with a dry cloth. However, if points are in bad condition, it is best to install a new set. **Do not use a file on the contact point surfaces.** Stiff paper or cardboard will remove the oxide formation that results from long idleness.

c. Carburetor. Adjustment of the carburetor will be made only by trained ordnance maintenance personnel. Keep the strainer in the fuel inlet connection, on top of the carburetor bowl, free from sediment. When this strainer is being inspected, open the fuel line shut-off cock beneath the fuel tank to make certain there is a free flow of fuel to the carburetor. If fuel does not flow freely, remove the fuel filter sediment bowl beneath the fuel tank and clean the strainer in top of bowl.

d. Air filter. Clean the air filter intake on the carburetor monthly.

Take apart and rinse with SOLVENT, dry cleaning, then dip the upper end of the screen in OIL, engine, SAE 30, and reassemble. (See par. 26, Note 11.)

e. Generator commutator. To inspect the commutator, remove the accessible brush head cover plate with an offset screwdriver. The commutator should require no cleaning for several hundred hours of operation. It need be cleaned only when excessively carbonized. To clean the commutator, start the engine and use a strip of very fine (00 to 8/0) sandpaper, **not emery,** on the commutator, holding the sandpaper down with a stick of wood until the commutator is bright.

137. REPLACEMENT OF UNIT.

a. Removal. For complete overhaul, or for major repairs, remove the unit from the tank.

(1) Open both battery switches.

(2) Remove the air duct cover.

(3) Remove exhaust coupling.

(4) Close the shut-off cock and disconnect the fuel line at the carburetor.

(5) **Remove control box.**

(a) Take off cover by removing two screws at top.

(b) Disconnect, at terminals in control box, the three wires that come through back of the box from the generator yoke.

(c) Remove the two screws holding the box to the generator yoke (just above the fiber panel in box.) (Use care not to drop these screws and washers in back of the panel board. If any are accidentally dropped, be certain to remove them before assembling, as they may cause a short circuit.)

(d) Push the three wires, disconnected in (b) preceding, through the hole in the box and take off the control box. (Any repair work on the control box can be accomplished in the tank, so that further removal is unnecessary.)

(6) Disconnect angle iron supports from fan housing or foot mountings, or detach foot mountings from sponson, whichever is most expedient.

(7) If necessary, to facilitate removal of unit from tank, disconnect shielding assembly at spark plug, remove screws holding timer bracket to crankcase, and take off entire magneto and timer bracket assembly.

(8) Lift out the unit.

b. Installing unit. The unit may be installed by reversing the foregoing steps for removal. The following precautions are to be taken:

(1) Make sure that good gaskets are on both ends of the flexible exhaust coupling. CAUTION: All exhaust connections, and the exhaust pipe itself, should be inspected frequently. The escape of exhaust gasses into the tank will subject members of the crew to the dangers of carbon monoxide poisoning.

(2) In attaching magneto and timer bracket assembly, see that the intake valve spring on governor assembly fits in the center of crankpin screw (hex screw holding connecting rod in place) and that the hole in the head of the magneto shaft fits over the crankpin screw.

Section XXIII

TURRET AND HULL

138. TURRET

The turret is a one-piece armor steel casting, rotating on a ball bearing race, which is recessed and protected against direct hits and lead splash. The turret platform, or basket, is suspended from the turret by a ring of bolts around its top circumference. On top of the turret is the turret hatch ring, also on a ball-bearing race, which carries the turret hatches. The hatch ring mounts the cal. .50 gun.

139. TURRET TRAVERSE (figs. 10 and 138).

a. Mechanisms. The turret may be traversed 360 degrees by either a power (hydraulic) or a manual traversing mechanism.

b. Hydraulic traversing. Close the motor switch by pulling out on the knob and turning it to the right. Pressure in the hydraulic system will build up almost instantly. For hydraulic operation, the clutch lever or traversing selector should be in the **up** position. (CAUTION: Be sure that the turret hand lock is disengaged before attempting to traverse the turret.) To traverse the turret, grasp the pistol grip control, and turn in the desired direction of traverse—right or left. The farther the handle is turned, the faster the turret moves.

c. Hydraulic mechanism.

(1) The hydraulic traversing system consists essentially of three units (fig. 138)—the pump, the control valve mechanism, and the hydraulic motor.

(a) The **pump** is directly connected to, and mounted on the top of, an electric motor in front of and slightly to the left of the gunner's seat.

(b) The **control valve mechanism** is mounted on the side of the pump, which is at the same height as the turret race ring. It has a pistol-grip control handle.

(c) The **hydraulic motor** is mounted on the top of the manual traversing mechanism housing (see fig. 10). The hydraulic motor, which is reversible, is directly connected to a gear train whose final drive pinion engages the traversing rack of the turret.

(2) The reservoir, mounted to the left of the electric motor, holds one gallon of a special oil (see par. 26, **Lubrication Instructions,** Note 10). The oil should be maintained at the ⅔ level. The mechanism should not be operated without oil, which serves not only to transmit power but also to lubricate the mechanism. (In an emergency, SAE 20 lubricating oil may be used, but it must be replaced with the proper oil at the earliest opportunity.)

(3) Incorporated in the hydraulic control valve is a relief valve which determines the system pressure. A breather cap allows for expansion of the oil.

d. Manual traversing. The turret may be traversed manually by turning off the power, pushing the clutch lever to the **down** position, and cranking the vertical brass handle.

e. Replace hydraulic traversing units.

(1) **Removal.**

(a) **Drain mechanism.** Place a clean one-gallon container under oil reservoir. Disconnect tube from bottom of reservoir and allow reservoir to drain completely. NOTE: Before disconnecting any tubing in the turret traversing system, mark both the tubes and the ports, to aid in installing. Tags with wires for attaching are satisfactory. Number each tube and corresponding fitting, or port. Cover all openings.

(b) **Remove hydraulic motor, gear box, and adapter** (fig. 10).

1. Disconnect and remove the three tubes from the top and side of the hydraulic motor.

2. Remove the two pinion-guard screws on bottom of the hand traversing mechanism housing.

3. Lift off guard.

4. Remove the two bolts which hold the hand traversing mechanism housing to the turret edge, and lift off unit. CAUTION: Support unit while removing bolts.

5. Remove the hydraulic motor and adapter from the gear box by removing the four safety nuts which hold the hydraulic motor and adapter to the gear box housing.

6. To remove the hydraulic motor from the adapter, cut the lock wire from the four screws which hold the hydraulic motor to the adapter, remove screws, and lift off hydraulic motor and pinion.

(c) **Remove oil pump** (fig. 138).

1. Remove all tubes from the oil pump, mounted on the top of the electric motor.

2. Cut lock wire from four screws holding pump to electric motor, remove screws and lock washers, and lift pump **upward.** CAUTION: Do not lose coupling connecting pump and electric motor shaft.

(d) **Remove oil reservoir.**

1. Disconnect and remove tubes attached to oil reservoir.

2. Remove filler cap.

3. Remove four mounting bolts and lock washers which hold reservoir to turret basket, and lift oil reservoir from brackets. CAUTION: Support oil reservoir while removing bolts.

(2) **Install hydraulic traversing units.** Units are installed by performing the removal steps in reverse order. CAUTION: Use extreme care to connect all tubes to the proper fitting or port.

140. TURRET HATCH RING (figs. 145 and 146).

a. Because the turret hatch ring acts as a 360-degree antiaircraft mount for the cal. .50 machine gun, it must rotate freely and easily. If its movement is restricted, and no external cause can be discovered, the ring and cover assembly should be removed and inspected, and, if necessary, replaced.

b. Replacement.

(1) **Removal.**

(a) Remove all but three equally spaced cap screws (9/16-inch socket wrench) that hold the retaining ring and the lower half of the inside race to the upper half of the inside race.

MEDIUM TANK, M4A2

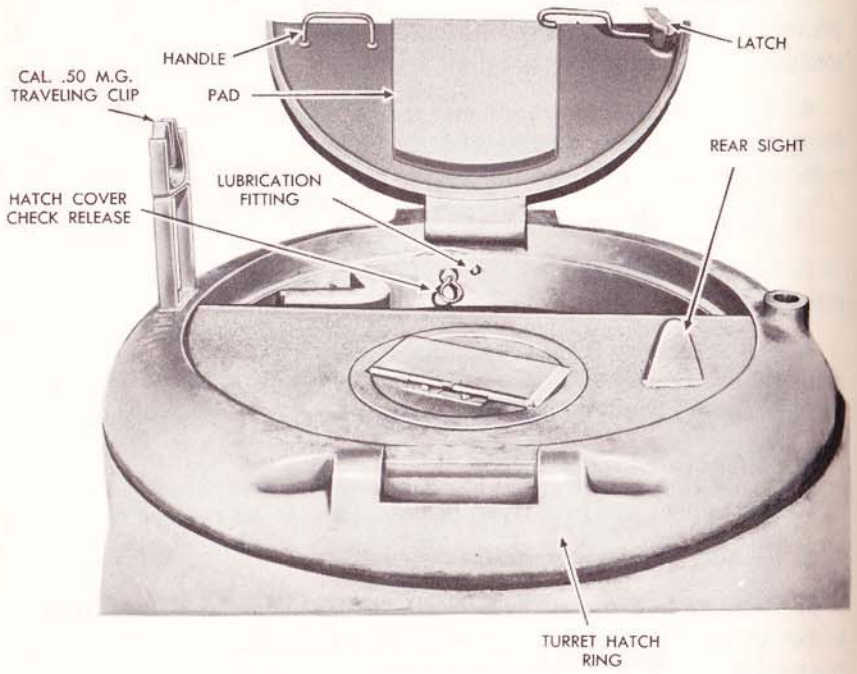


Figure 145—Details of Turret Hatch

(b) Before removing the last three cap screws from the retaining ring, provide means of supporting the ring so that it will not drop and release the bearing balls from the race. Wooden supports can be bolted into place under the ring (see fig. 146) with bolts screwed upward into the tapped holes for the outer race retaining bolts.

(c) Remove the remaining cap screws and lift off the ring and cover assembly (two men).

(d) If lower half of inner race has been damaged, remove ball bearings and lift out race.

(e) If outer race has been damaged, remove the 18 screws (heavy-duty socket screwdriver, or a drag link tool and handle) and remove the race.

TURRET AND HULL

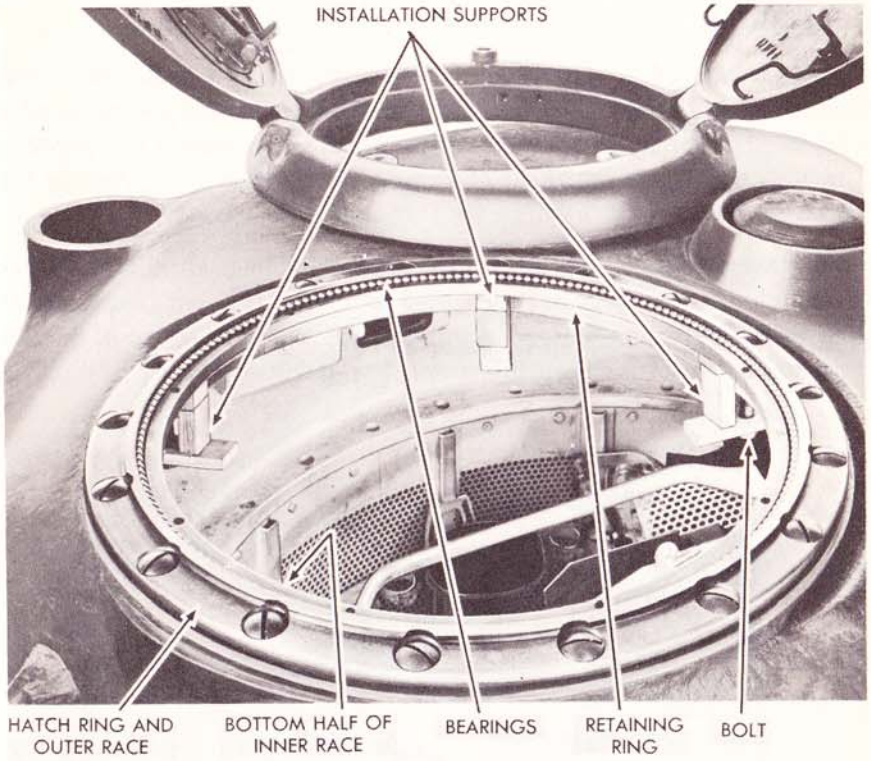


Figure 146—Method of Supporting Inner Race While Removing Hatch Ring

(2) **Installation of turret hatch ring.**

(a) If outer race has been removed, put it in place and turn down the 18 screws a little at a time, each one in turn, to seat the ring evenly (heavy-duty socket screwdriver or drag link tool and handle).

(b) Set retaining ring and lower half of inner race in place on supports, and install and pack the bearing balls.

(c) Set the turret hatch ring and covers in place (two men). Line up bolt holes in retaining ring, race, and turret hatch ring, and install and tighten the cap screws ($\frac{9}{16}$-inch socket wrench).

(d) Remove the supports.

141. HULL.

a. Hatch and port covers. All hatch covers and port covers must close tight and latch easily. Damaged covers should be repaired or replaced immediately. To remove a cover, first remove the periscope mount, then drive out the hinge pin. Always replace any worn or torn gaskets, so that covers will be weather-tight when closed.

b. Escape hatch (fig. 147). The escape hatch is an important provision for the safety of the crew, and should be checked frequently for easy and correct operation. It will be removed and cleaned of dirt and rust, and its working parts lubricated, at regular intervals.

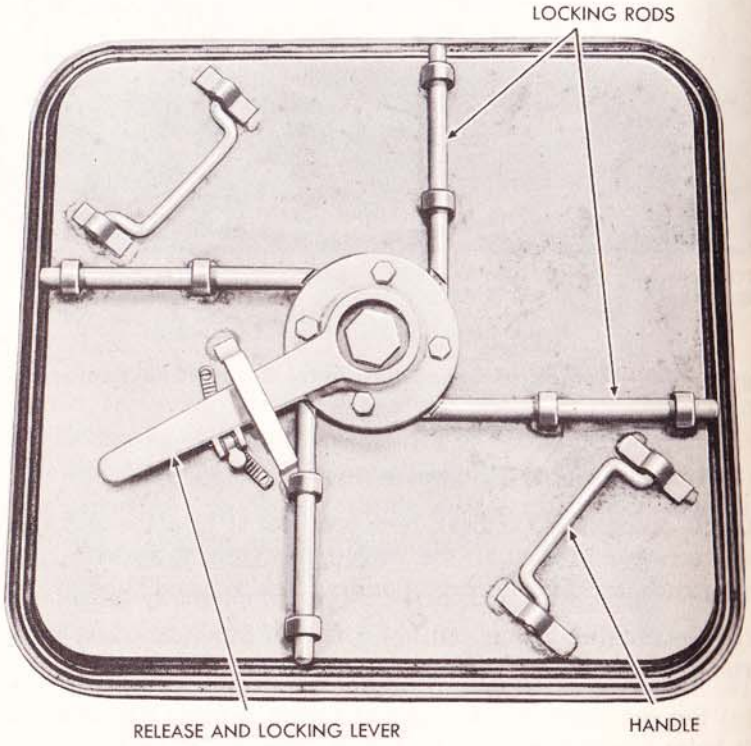


Figure 147—Escape Hatch

142. INSPECTIONS AFTER COMBAT.

a. Ordinarily, the turret and hull will require little attention other than careful checking to see that all parts are tight and that hinges and other moving parts are properly lubricated.

b. After the tank has been in combat, special inspections are important.

(1) Check hull and turret, inside and out, for evidences of cracks or damage.

(2) Remove debris or bullet splash from turret race, from under turret hatch ring, and from behind gun shields.

(3) Check complete 360-degree traverse of turret, using hand-traversing wheel.

(4) Check complete 360-degree traverse of turret hatch ring. (To replace, see par. 140 **b**).

(5) Inspect all periscope mounts for presence and condition of covers, and for free action of elevation and rotation.

(6) Elevate and depress the 75 mm. gun to its full travel, using the manual control.

(7) Inspect direction vision slots and covers.

Section XXIV

GUN FIRING MECHANISMS AND CONTROLS

143. GYRO-STABILIZER SYSTEM (figs. 148-150).

a. Repairs.

(1) The interior parts of the sealed gyro-stabilizer control mechanism are classified as **confidential**, and the seals are not to be broken except by fifth echelon personnel. The disassembly and overhaul of gun stabilizers, stabilizer control mechanisms, and oil pumps, will be performed only by the fifth echelon or authorized arsenals, to which component assemblies not reparable in the field are to be returned for repair. (See Ordnance Field Service TB 1798A-1.)

(2) In case of failure of the motor or the gyro-stabilizer control unit, check all leads and switches. If the trouble is found to be in the unit itself, it should be replaced.

b. Testing for presence of air. It is essential to the correct operation of the gyro-stabilizer system that oil leaks be prevented and that air be kept out of the system. The presence of air in the hydraulic system of the gyro-stabilizer system is ordinarily evidenced by loss of sensitivity of the system, rapid **hunting**, or oscillation of the gun mount, bobbing of the gun when the elevating wheel is turned, and failure of the gun to return quickly to the correct position. A simple check for air in the system is made by the following procedure:

(1) Lock the gun in fixed position with the locking bar.

(2) While watching the oil level in the stabilizer oil gage (see fig. 149), turn the turret switch on, starting the gyro-stabilizer motor. If the oil level drops, there is air in the system.

(3) Turn the turret switch to the **off** position, release the locking bar, disengage the hand elevating mechanism, and work the gun **slowly** up and down by hand for five to ten minutes, then repeat the check as in (1) and (2). If the system still shows presence of air, the system should be charged with oil.

c. Charging with oil (figs. 138, 148, 149). In charging the stabilizer

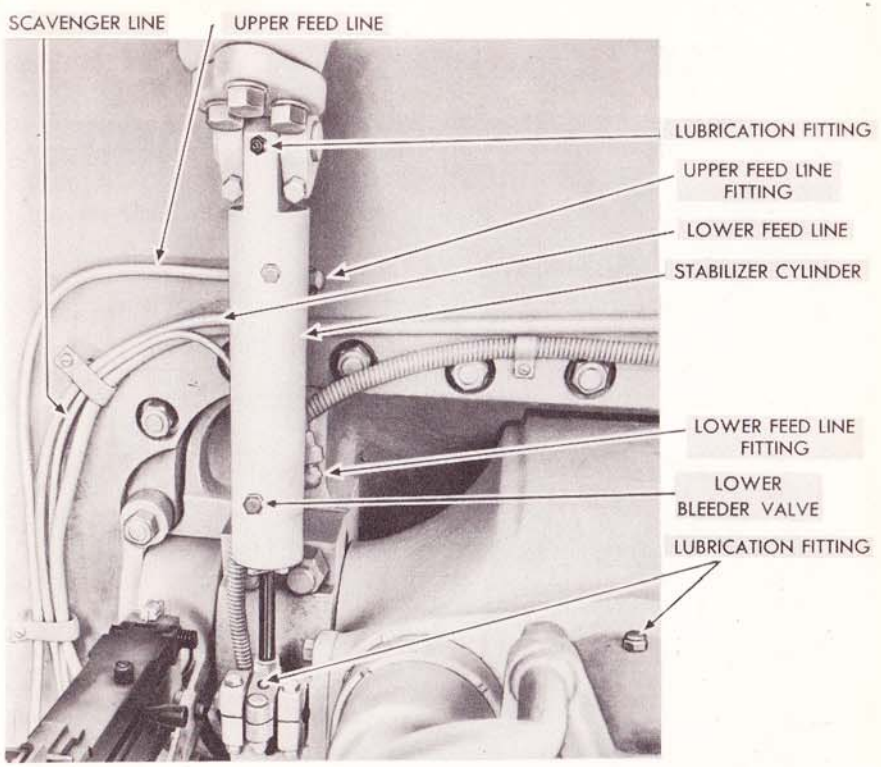


Figure 148—Stabilizer Cylinder and Connections

system with oil, it is important that every bit of air trapped in the system be removed. The following procedure should be adhered to:

(1) Use Univis 47 oil (Government Specifications 2-79-A).

(2) Heat oil to 150-200 F (65-93 C) if possible.

(3) Remove filler plug (see fig. 149). Oil may be poured directly into the reservoir, pumped in with a plunger-type oil can, or added under low pressure. A pressure feed can be arranged as follows:

(a) Fit a filler can with a three-foot feed line and pressure source, such as compressed air. Install a shut-off valve at the reservoir con-

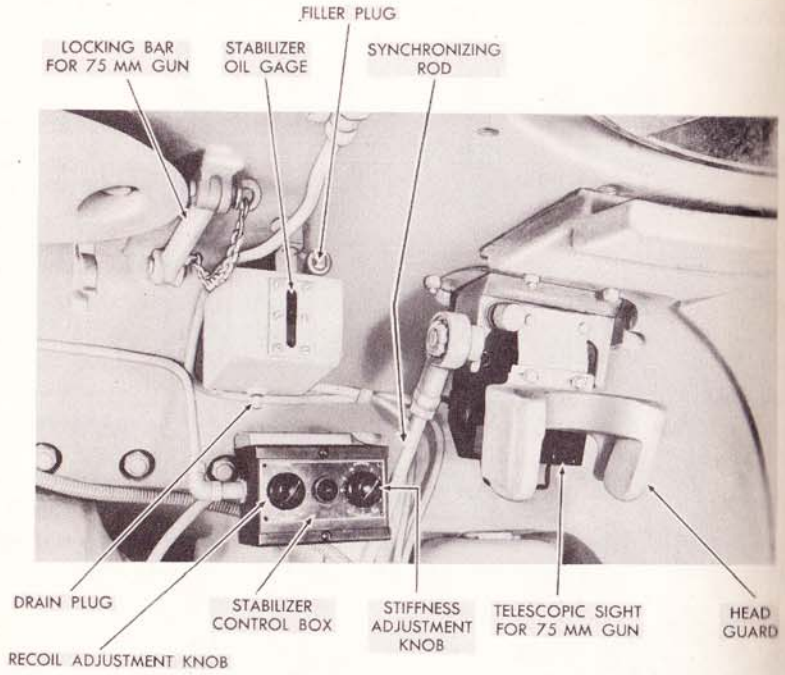


Figure 149—Upper Controls at Gunner's Station

nection end of the feed line, and a ⅜-inch union below the shut-off valve.

(b) Remove oil supply line from reservoir.

(c) Connect filler can feed line to oil reservoir.

(4) Make certain that the turret switch is in the **off** position.

(5) Loosen the oil return line at cylinder hex plugs, and loosen two bleeder valves on cylinder (fig. 148).

(6) Add oil to the system until a flow free from bubbles is obtained from the return line, then tighten this connection permanently.

(7) After a solid flow of oil is obtained from bleeder valves, screw them up finger-tight.

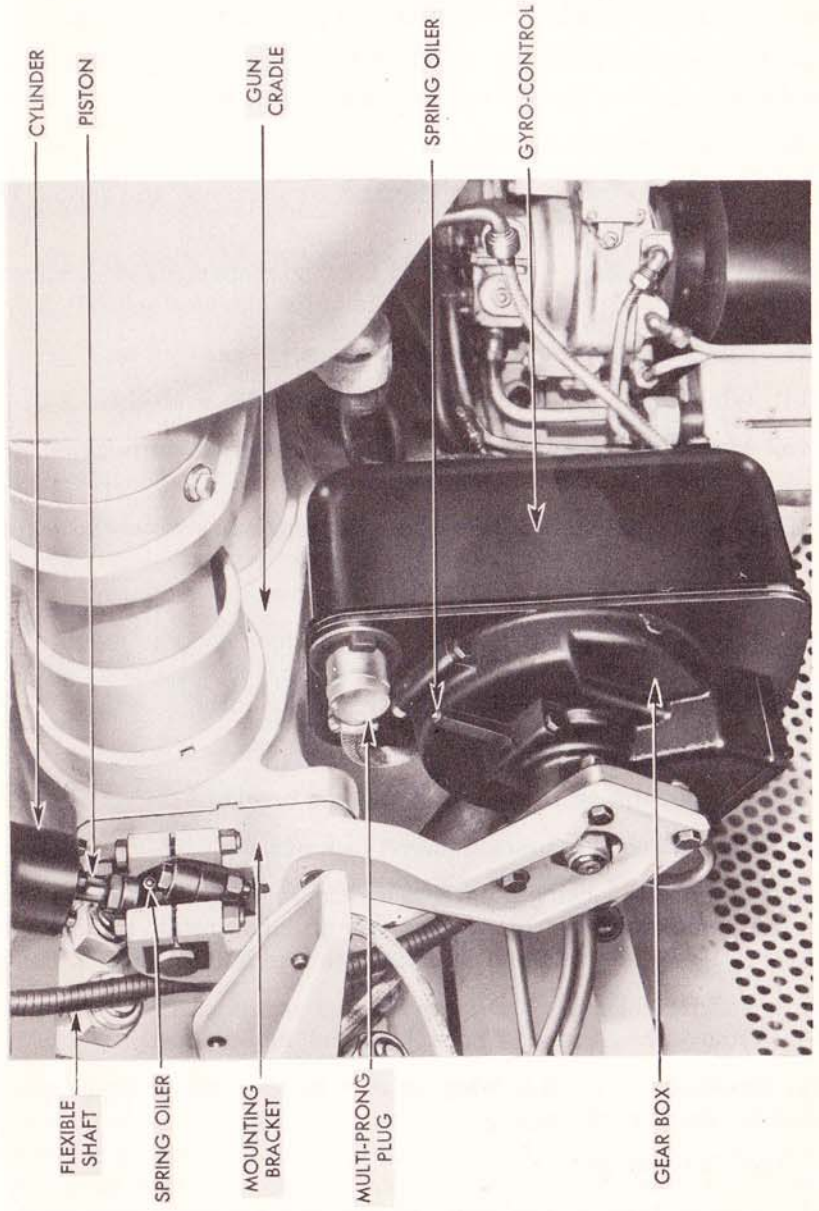


Figure 150—Gyro Control and Gear Box Installed on Gun Mount

(8) Loosen top bleeder valve. Push breech **slowly** to extreme **up** position and tighten bleeder valve after a solid flow of oil is obtained.

(9) Loosen lower bleeder valve. Push breech **slowly** to extreme **down** position and tighten bleeder valve after a solid flow of oil is obtained.

(10) Repeat steps (8) and (9).

(11) Remove pressure supply line and connections, and union, reconnect oil reservoir supply line.

(12) Work gun up and down **slowly** until no more signs of air appear in oil reservoir.

(13) Run the pump for about ten minutes.

(14) While pump is running, loosen both bleeder valves.

(15) After a solid flow of oil is obtained, tighten valves permanently and stop the motor.

(16) Recheck oil level and fill reservoir approximately two-thirds full.

144. TURRET MACHINE GUN (fig. 140).

a. General. Since the firing of the cal. .30 machine gun mounted in the turret is controlled electrically, by means of a solenoid, special procedure must be used in dismounting and mounting the gun.

b. Dismounting the gun.

(1) Back out the set screw in the solenoid bracket.

(2) Back off solenoid bracket swivel lock nut slightly.

(3) Pull out the locking pin, releasing the solenoid bracket from the gun. Let bracket swing below gun mount, and install locking pin. (CAUTION: Steady solenoid bracket with one hand as pin is pulled clear.)

(4) Remove the trunnion pin, pull out gun, and replace pin.

(5) Swing the solenoid bracket up over the gun mount and tape or wire it in place for safekeeping.

c. Mounting the gun.

(1) Remove tape or wire from solenoid bracket and swing bracket below gun mount.

(2) Remove trunnion pin and locking pin from mount.

(3) Set the gun in place and insert trunnion pin.

(4) Lift solenoid bracket into position beneath gun and insert locking pin.

(5) Screw in the solenoid bracket set screw until bracket is tight against floor plate of gun.

(6) Set check nut on solenoid bracket swivel and tighten lock nut.

d. Testing solenoid firing of gun.

(1) **Test for runaway gun.**

(a) Cock the machine gun.

(b) Squeeze machine gun trigger. The firing pin should snap forward, if the solenoid adjustment is correct to prevent a runaway gun.

(c) If the firing pin does not snap forward when the trigger is operated (having gone forward when bolt handle was released in cocking the gun), the adjustment would cause a runaway gun. To correct, unscrew the lock nut on the plunger arm (fig. 140) and turn the plunger clockwise. (This adjustment will lengthen the plunger arm, pushing the lower arm of the link to the rear and pulling the upper arm and finger farther from the machine gun trigger.) Test action again, by cocking gun and squeezing trigger. If firing pin snaps forward, tighten the lock nut on the plunger.

(2) **Test action.**

(a) Cock the machine gun and close the firing switch, operating the solenoid.

(b) Check by pulling the trigger. Then:

1. If the firing pin has been released by the solenoid, the adjustment is correct.

2. If pulling the trigger releases the firing pin, the solenoid adjustment must be changed. Unscrew the lock nut on the plunger arm and turn the plunger counterclockwise. Test adjustment as in (a) and (b), preceding, and check for runaway gun as in paragraph 144 **d** (1). When adjustment is correct, tighten lock nut.

Section XXV

PAINTING

145. PAINTING.

a. Ordnance materiel is painted before issue to the using arms. One maintenance coat per year will ordinarily be ample for protection. With but few exceptions, this materiel will be painted with ENAMEL, synthetic, olive drab, lusterless. The enamel may be applied over old coats of long oil enamel and oil paint previously issued by the Ordnance Department if the old coat is in satisfactory condition for repainting.

b. Paints and enamels, usually issued ready for use, are applied by brush or spray. They may be brushed on satisfactorily when used unthinned in the original package consistency or when thinned no more than 5 per cent by volume with THINNER. The enamel will spray satisfactorily when thinned with 15 per cent by volume of THINNER. (Linseed oil must not be used as a thinner in this enamel, since it will impart an undesirable luster.) If sprayed, enamel dries rapidly enough to permit repainting after one-half hour, and dries hard in 16 hours.

c. Certain exceptions to the regulations concerning painting exist. Fire-control instruments, sighting equipment, and other associated items will not be painted.

d. Complete information on painting is contained in TM 9-850.

146. PREPARING FOR PAINTING.

a. If the base coat on the materiel is in poor condition, it is more desirable to strip the old paint from the surface than to use sanding and touchup methods. After stripping, it will be necessary to apply a primer coat.

b. PRIMER, ground, synthetic, should be used on wood as a base coat for synthetic enamel. It may be applied by either brushing or

spraying. Primer will brush satisfactorily as received or after the addition of not more than 5 per cent by volume of THINNER. It will be dry enough to touch in 30 minutes, and hard in 5 to 7 hours. For spraying, primer may be thinned with not more than 15 per cent by volume of THINNER. Lacquers must not be applied to PRIMER, ground, synthetic, within 48 hours.

c. PRIMER, synthetic, rust inhibiting, for bare metal, should be used on metal as a base coat. Its use and application are similar to those outlined in the preceding paragraph.

d. The success of a job of painting depends partly on the selection of a suitable paint, and largely on the care used in preparing the surface. All parts to be painted should be free from rust, dirt, grease, kerosene, oil, and alkali, and must be dry.

147. PAINTING METAL.

If metal parts to be painted are in need of cleaning, they should be washed in a solution of SODA ASH in warm water, in the ratio of one-half pound to 8 quarts, then rinsed in clear water and wiped thoroughly dry. Wood parts in need of cleaning should be treated in the same manner, but the alkaline solution must not be left on for more than a few minutes, and the surfaces should be wiped dry as soon as they are washed clean. When artillery or automotive equipment is in fair condition and marred only in spots, the bad places should be touched up with ENAMEL, synthetic, olive drab, lusterless, and permitted to dry. The whole surface will then be sandpapered with PAPER, flint, No. 1, and a finish coat of ENAMEL, synthetic, olive drab, lusterless, applied and allowed to dry thoroughly before the materiel is used. If the equipment is in bad condition, all parts should be thoroughly sanded with PAPER, flint, No. 2, or equivalent, given a coat of PRIMER, ground, synthetic, and permitted to dry for at least 16 hours. They will then be sandpapered with PAPER, flint, No. 00, and wiped free from dust and dirt. A final coat of ENAMEL, synthetic, olive drab, lusterless, will be applied and allowed to dry thoroughly before the materiel is used.

148. PAINT AS A CAMOUFLAGE.

a. Camouflage is now a major consideration in painting ordnance vehicles, with rust prevention secondary. The camouflage plan at present employed utilizes three factors—color, gloss, and stenciling.

(1) **Color.** Vehicles are painted with ENAMEL, synthetic, olive drab, lusterless, which blends in reasonably well with the average landscape.

(2) **Gloss.** Lusterless enamel makes a vehicle difficult to see from the air or from relatively great distances over land. A vehicle painted with ordinary glossy paint can be detected more easily and at greater distances.

(3) **Stenciling.** A blue-drab stencil enamel, which cannot be photographed from the air, is used. Blue-drab markings are illegible at distances exceeding 75 feet.

b. Preserving camouflage.

(1) Continued friction or rubbing must be avoided, as it will smooth the surface and produce a gloss. The vehicle should not be washed more than once a week. Care should be taken to see that the washing is done entirely with a sponge or a soft rag. The surface should never be rubbed or wiped except while wet, or a gloss will develop.

(2) It is not desirable that vehicles painted with lusterless enamel be kept as clean as vehicles were kept when glossy paint was used. A small accumulation of dust increases the camouflage value. Grease spots should be removed with SOLVENT, dry cleaning. Whatever portion of the spot cannot be so removed should be allowed to remain.

(3) Continued friction of wax-treated tarpaulins on the sides of a vehicle will produce a gloss, which should be removed with SOLVENT, dry cleaning.

(4) Tests indicate that repainting with olive drab paint will be necessary once yearly, with blue-drab paint twice yearly.

149. REMOVING PAINT.

After repeated paintings, the paint may become so thick as to crack and scale off in places. Before repainting, remove the old paint by use of a lime-and-lye solution (see TM 9-850 for details) or REMOVER, paint and varnish. It is important that every trace of lye or other paint remover be completely rinsed off and that the equipment be perfectly dry before repainting is attempted. It is preferable that the use of lye solutions be limited to iron or steel parts. If used on wood, the lye solution must not be allowed to remain on the surface for more than

a minute before it is thoroughly rinsed off and the surface wiped dry with rags. Crevices or cracks in wood should be filled with putty, and the wood sandpapered, before refinishing.

150. PAINTING LUBRICATING DEVICES.

Oil cups, grease fittings, and similar lubricating devices, and a circle about three-fourths inch in diameter at each oil hole and at each device, will be painted with ENAMEL, red, water resisting, in order that they may be readily seen.

Section XXVI

PREPARATION FOR SHIPMENT AND STORAGE

151. SHIPMENT.

a. When shipping Medium Tank M4A2 on flat cars, every precaution must be taken to have the tank properly blocked and fastened. Material used for blocking must be hardwood, fir, spruce, or long leaf yellow pine, straight grain, and free from strength-impairing knots.

(1) Cars must be inspected to see whether they are in suitable condition to carry the load to its destination. The weight of the tank, 30 tons, makes it most necessary that the cars have sound floors. All loose nails or other projections not belonging to the car must be removed; but loose nails, bolts, and other parts used in the construction of the car should be made tight, not removed.

(2) The load must be so distributed that there will not be more weight on one side of the car than on the other. If a single tank is placed on a car it must be so located that each truck of the car carries approximately one-half of the load.

(3) All doors and other openings of the tank must be closed and secured as a protection against weather and pilfering of equipment. Drain valves should be blocked open to drain out seepage and condensation.

(4) If the tank is to be used immediately upon reaching its destination, it may be desirable to keep the fuel tanks filled. If transportation of the tank is by rail express, in which case civilian passengers may be carried in coaches of the same train, the fuel tanks must be drained. The draining of the fuel tanks is not required if only military personnel is carried in accompanying coaches.

(5) The handbrake of the car must be set securely during the loading operation. At least six inches clearance must be left around and above the handbrake wheel or lever.

(6) Equipment moving from manufacturer to arsenal or proving ground, or from arsenal or proving ground to army post, or individual

units moving from one army post to another, **must** be placarded **DO NOT HUMP.**

(7) Further details on loading are to be found in "Special Supplement Containing Rules Governing the Loading of Mechanized and Motorizing Army Equipment, also Major Caliber Guns for the United States Army and Navy, on Open Top Equipment," published by the Association of American Railroads, Operations and Maintenance Department, April 1, 1941. F.M. 101-10 also gives information on shipping instructions.

(8) Before fastening the tank to the car it will be necessary to take certain measures to prevent corrosion during transit. If the vehicle is to be put in dead storage after it reaches its destination, corrosion-preventive treatment should be applied to the engine immediately before shipment and shortly after it reaches its destination. (The following paragraph outlines the methods of applying corrosion-preventive compounds.)

152. STORAGE.

a. General instructions. The storage of motor vehicles and equipment, and inspection in connection therewith, are covered in AR 850-18. With a few exceptions, the information given in this manual will apply directly to storage and the preparation for storage of Medium Tank M4A2. Insofar as possible, methods outlined in AR 850-18 must be followed in order that engines and other units of the materiel be properly protected from damage by corrosion.

b. Storage conditions. Tanks that are not in actual use will be stored in closed buildings or covered sheds, if available. In lieu of this preferred storage space, they may be stored in the open and covered with tarpaulins. In each case, the floor must be solid and free from crushed rock, deep dust, and oil. It is desirable that the rubber tracks rest on planks. Every precaution must be taken to afford proper drainage of water from the floor, and to locate the place of storage so that the materiel will be properly protected from flood or fire.

c. Technical inspections. The tanks and equipment will be inspected at the time they are placed in storage, and at frequent periods as designated in AR 850-18. A tag or tags tied to the unit or vehicle will be kept up to date by the inspector, to indicate the condition of the tank and the work to be done before the unit is again placed in service.

Minor work of surface preservation and application of corrosion-preventives will be accomplished at the time of inspection. Work involving the use of shop facilities will be accomplished at the earliest practicable date. When a tank is placed in dead storage, the batteries must be removed, and placed in active stock if practicable.

d. Limited storage. Tanks in limited storage are those that are to be out of service for less than thirty days. They will be kept ready for immediate service, with fuel tanks and lubricating oil tanks filled and with cooling systems filled according to seasonal requirements. The battery will be maintained in a fully charged condition, and should remain in the tank. The battery switches will be open during storage periods. The tank must be thoroughly cleaned and lubricated before being placed in limited storage, and proper precautions should be taken to protect the rubber elements from extreme light or heat. Brakes will not be left applied, and the tank will not be left in gear.

e. Dead storage. Tanks in dead storage are those that will not be required for service for an indefinite period. (Tanks should not be in **limited** storage status for over thirty days; however, it will be impossible to adhere to this ruling under certain combat conditions.) When the Medium Tank M4A2 is placed in dead storage, the engine will be removed, inspected, repaired at once if practicable, and treated with COMPOUNDS, corrosion-preventive. Cylinder walls should be coated with SAE 50 or 60 viscosity lubricating oil or an approved corrosion-preventive compound. In any event, it is most essential that the treatment with corrosion-preventive compound be given immediately after the engine is placed in dead storage.

(1) **Engine.**

(a) After the final shut-down, the engine should be allowed to cool off. (A thicker film of corrosion-preventive compound will cling to cold cylinder walls than to hot walls.)

(b) **Rocker arm assemblies.** With rocker arm cover removed, spray the valve mechanism with Diesel engine corrosion-preventive compound. Special spraying outfits are available for applying this compound. The engine crankshaft will be rotated while the corrosion-preventive is applied so as to cover thoroughly the entire surface of protruding ends of valve stems.

(c) **Cylinders.**

1 Remove the inspection covers and air heaters from the air box to gain access to the cylinder air ports. Move the piston in each cylinder in turn to the bottom of its stroke so that the cylinder air ports are uncovered. Force the viscous protective oil through any convenient tube that can be inserted in the ports. Forcing the oil through several small holes in the end of the tube will help to spray the cylinder walls with a protective film. Heating the viscous oil beforehand facilitates pumping or forcing it through the tube. Rotate the crankshaft two or more revolutions by hand (see par. 71 **d** (4) and (5)) to distribute the protective oil uniformly on the cylinder walls. (Turning the crankshaft by hand is preferred to power cranking because it avoids damage which might result if an excess of oil were trapped between the piston and the cylinder head.) Remove any excess oil puddled in the combustion chambers in the piston crown. Reinstall hand-hole cover plates and air heaters.

2 NOTE: The quantity of compound to be sprayed into each cylinder will be metered, if possible; if meters are not available, measurement will be accomplished by accurately determining the time required to spray the specific quantities and timing subsequent spraying of the individual cylinders to obtain the proper quantity in each. Personnel first performing the spraying operation shall determine by experiment the proper technique for completely coating cylinder wall, piston head and valves with corrosion-preventive. Two ounces (⅛ pint) of compound will be sprayed into each cylinder, after which the engine crankshaft will be turned at least two complete revolutions. The cylinder space above each piston will then be resprayed with 1/16 pint of compound, without revolving the crankshaft farther, since this space is particularly susceptible to corrosion. This procedure permits treatment of the maximum surface of the cylinder wall and the piston head. After thus treating the interior of all cylinders, a small quantity of the corrosion-preventive compound will be sprayed into each exhaust port, with each exhaust valve opened so that it will be coated.

(d) **Openings.** All fuel and lubricating oil lines or open connections, cylinder ports, and other openings, shall be closed with suitable plugs, covers, etc. Threaded openings shall be closed with threaded plugs whenever practical. If wooden or similar tapered plugs are used, they shall be so constructed that they cannot be accidentally pushed or driven completely into the openings.

(e) **Exterior of engine.** The exterior of the engine will be thoroughly cleaned with SOLVENT, dry-cleaning. A coating of COMPOUND, rust-preventive, will be applied on all unpainted steel parts. Rust appearing on any part before storage will be removed with sandpaper or a wire brush and the metal coated with corrosion-preventive compound, unless the surface was originally painted. Painted surfaces will be repainted. If possible, the entire engine should be enclosed in a suitable weatherproof fabric.

(2) **Fuel oil.** Drain fuel oil and return it to proper storage.

(3) **Battery.** Remove the battery. After plugging the vents in the cells, clean the case with a solution of soda ash and water (8 ounces to the gallon) to neutralize the acid. Care should be taken to prevent shorting out while the vents are plugged. After this treatment, flush the case with cold water; do not use hot water or steam. Remove plugs from the vents after cleaning. Terminals and cable ends should be thoroughly cleaned with soda ash solution, scraped clean with suitable tool or wire brush, and then greased with petrolatum or light grease. Hydrometer readings of cells should be taken, and the battery charged if readings are 1.275 or less. Add distilled water to cover the plates, but not in excess of ¼ inch above the plates. Place the battery in active stock. Never allow batteries in stock to become discharged below a hydrometer reading of 1.275, as a precaution against freezing.

(4) **Tank, general.** Rust appearing on any part before storage will be removed with sand paper. Painted surfaces will be repainted, and unpainted surfaces will be lightly coated with rust-preventive compound.

(5) **Inspection tag.** Attach a tag to the dash board. The dates of inspections will be entered on this tag and each initialed by the inspector.

f. Periodic treatment in dead storage.

(1) At the expiration of each three-month period, corrosion-preventive treatment will be repeated, with particular attention to the cylinders, valve compartments, and other internal parts. Under unfavorable climatic conditions, such as might exist in tropical climates or near salt water, it will be necessary to perform more frequent inspections and corrosion-preventive treatments in order to prevent damage to the equipment.

(2) Tanks will be inspected frequently to see that equipment or parts are not removed without proper authority.

g. Removing tanks from dead storage.

(1) **Cylinders.** When taking the engine assembly out of storage, care must be taken to flush out the cylinder and combustion chamber thoroughly. Fuel oil or kerosene may be used. It may be sprayed into a cylinder, then the dome of the piston blown out with compressed air. Always check air box drains after flushing.

(2) **Valves.** Rotate the crankshaft through three or four revolutions by hand and observe for proper operation of valve mechanism. Any valve found to be sticking should have the stem generously lubricated with penetrating oil or with a 50-50 mixture of kerosene and light lubricating oil. Continue to turn the engine over by hand until all evidence of sticking valves has been eliminated. If this treatment does not free the valves, mechanical repairs to free them must be made before the engine is placed in service.

(3) **Fuel oil tank.** Tank shall be filled.

(4) **Battery.** Install a fully charged battery.

(5) **Cooling system.** Fill with coolant as required by seasonal conditions.

(6) **Transmission, differential, final drives.** Drain old lubricant from these units and other enclosed gears, flush thoroughly with lubricating oil SAE 10, and fill them to proper levels with the correct lubricant (see par. 26).

(7) **Lubricating oil.** Install the engine in the tank, fill each oil tank about half-full. Since the material used as a corrosion-preventive on the interior surfaces of the engine mixes freely with engine oil, it will not be necessary to remove it before adding lubricating oil. Run the engine two or three hours, then drain the oil tank and fill with new oil.

(8) **Lubrication.** The tank shall be thoroughly lubricated before being placed in service.

(9) **Inspection.** A thorough inspection of the tank will be made upon removal from dead storage. Any repairs that have been ordered on the inspection tag attached when the vehicle entered storage and which have not been previously made must be taken care of at this time.

(10) **Starting engine.** Engine will be started according to the instructions given in Section II, **Operating Instructions.** Particular attention

should be given to watching for overheating of the engine, excessive vibration, or any unusual noises.

153. STORAGE OF COMPONENTS AND EQUIPMENT.

Components removed from tanks prior to storage must be thoroughly inspected and overhauled if necessary before being stored for reissue. These components, including engines, need not be retained in storage for any particular vehicle, but should be considered as stock when issue becomes necessary.

Section XXVII

REFERENCES

154. STANDARD NOMENCLATURE LISTS.

Current Standard Nomenclature Lists are as tabulated here. An up-to-date list of SNL's is maintained in the Ordnance Publications for Supply Index (OPSI).

a. Armament.

Gun, machine, cal. .30, Browning, M1919A4, fixed and flexible bow mounts	SNL A-6
Gun, machine, cal. .50, Browning, M2 heavy barrel, fixed and flexible and ground mounts	SNL A-39
Gun, submachine, cal. .45, Thompson, M1928A	SNL A-32
Materiel, 75-mm., Tank Gun M2, M3	SNL C-34

b. Cleaning, preserving, and lubricating materials — SNL K-1

c. Tanks.

Tank, Medium, M4A2 (in preparation)	SNL G-104 (Vol. VII)

155. EXPLANATORY PUBLICATIONS.

a. Armament.

Browning machine gun, cal. .50, all types	TM 9-1225
Gun, Machine, cal. .30, Browning, M1919A4	FM 23-50
Gun, submachine, cal. .45, Thompson, M1919A5	FM 23-40
Gun, 37-mm., M6, and cal. .30, M1919A5	FM 23-81
75-mm. Tank Gun Materiel	TM 9-307
Stabilizer, all types	TM 9-1799

b. Cleaning, preserving, and lubricating materials — TM 9-850

c. Engine.

Ordnance Maintenance, General Motors Diesel Model 6046 Power Plant for Medium Tanks M3A3, M3A5, and M4A2	TM 9-1759

d. Maintenance and inspection.

Echelon system of maintenance ..... TM 10-525
Fire prevention, safety precautions, accidents ..... TM 10-360
Motor transport inspection ..... TM 10-545
Sheet metal work, body, fender and radiator repairs. TM 10-450

e. Miscellaneous.

Automotive electricity ..... TM 10-580
Automotive lubrication ..... TM 10-540
Defense against chemical attack ..... FM 21-40
Electrical fundamentals ..... TM 1-455
Fuels and carburetion ..... TM 10-550
Ordnance Maintenance, Auxiliary Generator for Medium Tank M3 ..... TM 9-1752
Tank units ..... FM 7-10

f. Storage and shipment.

Loading of mechanized and motorized army equipment on open top railroad equipment—Association of American Railroads Storage of Military Motor Vehicles ..... AR 850-10

156. TRAINING FILMS AND FILM STRIPS.

a. Hand, measuring, and power tools ..... FS 10-40

b. Lubrication ..... FS 10-39

c. Maintenance and inspection.

First echelon of maintenance ..... FS 10-53
Inspection of motor vehicles ..... FS 10-58
Second echelon of maintenance ..... FS 10-54
The motor vehicle driver, first echelon maintenance. TF 11-558

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BY ORDER OF THE SECRETARY OF WAR:

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DISTRIBUTION:

D 17(10); IR 17(6); R 9(2); Bn 9(1); IBn 17(4); C 9(4); IC 17(17).

(For explanation of symbols, see FM 21-6)

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