DIESEL ENGINE-MECHANICAL

SERVICE MANUAL

●

GENERAL ELECTRIC

MODEL U25B

DIESEL-ELECTRIC

LOCOMOTIVE

GENERAL ELECTRIC

3-62 (1000)

INTRODUCTION

This manual is intended to aid the maintainer in getting acquainted with the locomotive in general and with the various aspects of the locomotive as related to performing running maintenance. Running maintenance constitutes such work as terminal servicing, minor repair and adjustments, interchanging small components or any other work operation which will restore the locomotive to service within an eight hour period.

The manual includes service information pertaining to major equipments and systems as applied to a production model locomotive. Therefore instructions on specific customer modifications will not be included here-in but will be covered in the backshop manual which includes all instructions dealing with heavy and running maintenance work.

Main subjects within this instruction are arranged consecutively under separate section numbers. (Example: Section 4 Lubricating Oil System)

Illustrations identified by figure numbers, within each section show the section number and figure number (Example: Fig. 4-1).

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LOCOMOTIVE DATA

MAJOR EQUIPMENT

Diesel Engine	7FDL16
Main Generator	GT-598
Traction Motors	GE-752
Auxiliary Generator	GY-27
Exciter	GY-50
Air Compressor (Gardner-Denver)	W130
(WABCO)	3CWDL
Fan &Blower Unit	GDY-40
Air Brake System	26L
Wheel Diameter (New)	40 inch
Permissible Variations in Size (40 Inch Diameter Wheel)	
Wheels on Same Axle	None
Wheels on a Locomotive Unit	25 Tapes

SYSTEM CAPACITIES

Fuel Oil - Large Tank	2900 gal.
Small Tank (Optional)	1700 gal.
Water Tank (Optional)	1200 gal.
Lubricating Oil	330 gal.
Cooling Water	220 gal.
Engine Governor	2 quarts
Fan & Blower Unit	10 1/2 gal.
Compressor - Small Crankcase	10 quarts
Sand	32 cu. ft.

BRAKE SYSTEM ADJUSTMENTS

Brake Cylinder Piston Travel -	Min.	2 1/2 in.-
	Max.	6 in.
Compressor Governor Switch	- Cut In	130 psi
	- Cut Out.	140 psi
Compressor Intercooler Safety Valve		65 psi
Main Reservoir Safety Valve		150 psi
Regulating Valve		Variable
Independent Brake Valve, Full Service		45 psi
Control Air Reducing Valve		70 psi
Power Cutout Switch (PCS)	- Open	30 ± 1 psi
	- Close	42 ± 1 psi

LOCOMOTIVE DATA

OPERATING SETTINGS

Diesel Engine, Idle	400 ± 15 RPM
Diesel Engine, Full Speed.	1000 ± 4 RPM
Overspeed Shutdown Trips	1100 ± 10 RPM
Diesel Engine Operating Temperature . . .	160-180 F
Hot Engine Alarm (ETS) - Close	200 ± 2 F
- Open	193 ± 2 F
Engine Lubricating Oil Header	
Pressure - Idle	Approx. 15 psi
- Full Throttle	Approx. 45 psi
Oil Pressure Shutdown (OPS)	
- Engine at Idle (40 Second delay) . .	10-14 psi
- Engine above 1st Notch (No delay) . . .	25-30 psi

ENGINE SYSTEMS PRESSURE VALVES

Fuel Oil Pump Pressure, Relief Valve . . .	75 psi
Fuel Header Pressure Regulating Valve. . .	35 psi
Lubricating Oil Pump Pressure Relief	
Valve (Begins to Open)	90 psi
Lubricating Oil Pressure Regulating Valve .	50 psi
Lubricating Oil Filter By Pass Valve. . . .	20 psi

WEIGHTS (Approximate Weights for Lifting Purposes Only)

Complete Locomotive (Fully Serviced) . .	250, 000 lbs.
One Truck (Complete) . . .	43, 000 lbs.
One Truck Frame .	6, 050 lbs.
One Swing Bolster . .	1, 475 lbs.
One Spring Plank	390 lbs.
One Motor, Wheel and Axle Assembly . .	11, 600 lbs.
Traction Motor (Less Gear Case) . .	7, 000 lbs.
Air Compressor (Dry) . . .	1, 370 lbs.
One Battery Tray	300 lbs.
Engine Hood Assembly (Not Including	
Radiator Hood) . .	4, 000 lbs.
Fan & Blower Unit (Complete with Fans) .	4, 500 lbs.
Each Radiator Fan	370 lbs

LOCOMOTIVE DATA

Fan & Blower Unit Drive Shaft and	
Couplings	200 lbs.
Radiator and Frame Assembly	1, 750 lbs.
Each Radiator Section	280 lbs.
Equipment Blower Rotor	200 lbs. En-
gine and Generator (Complete)	57, 000 lbs.
Main Generator with Auxiliaries	17, 500 lbs.
Auxiliary Generator	690 lbs.
Exciter	625 lbs. En-
gine (Less Generator)	37, 500 lbs.
Engine Component Parts	
Main Frame (Bare).	10, 670 lbs.
Crankshaft	3, 955 lbs.
Turbocharger.	1, 330 lbs.
Intercooler (Dry)	480 lbs.
Cylinder Complete	540 lbs.
Piston and Master Rod Assembly	207 lbs.
Piston and Articulating Rod Assembly. . .	94 lbs.
Oil Pump	250 lbs.
Water Pump	248 lbs.
Control Governor	112 lbs.
Governor Drive Assembly	159 lbs.
Oil Pan	995 lbs.
Free-End Cover	1, 330 lbs.
End Cover (Generator End)	89 lbs.
Lube Oil Cooler (Dry)	570 lbs.
Lube Oil Filter Tank (Dry-including	
8 elements)	600 lbs.

LOCOMOTIVE DESCRIPTION

GENERAL

The General Electric Model U25B diesel-electric locomotive is especially designed and built to meet the requirements of modern high-speed freight traffic. The design provides for high horsepower per axle with a minimum of equipment and weight. With available modifications, the locomotive can be used in passenger service.

POWER PLANT

DIESEL ENGINE

The locomotive is powered by a 16-cylinder four stroke cycle, turbo-charged diesel engine with 9 inch by 10 1/2 inch cylinders in a 45 degree Vee arrangement. The engine has an integral head and cylinder arrangement which can be removed in a minimum of time. It is equipped with cast-iron pistons, valve seat inserts and the Bendix fuel system. The cylinder liner is chrome plated and 3/16 inches thick.

GOVERNOR

The engine governor is of the self-contained, electro-hydraulic type. It automatically regulates the horsepower output at each throttle setting.

OVERSPEED PROTECTION

The engine is automatically shut down if the speed exceeds maximum rated r.p.m. by 10 per cent.

COOLING SYSTEM

Water is circulated through the engine, turbo-supercharger, radiator, and lubricating-oil cooler by a gear-driven centrifugal pump integral with the diesel engine. An expansion tank is provided with a sight gage to indicate water level; fill pipes are located on each side and at the roof of the locomotive.

ENGINE TEMPERATURE CONTROL

A flow control valve, thermostatically operated, automatically maintains temperature by regulating the flow of cooling water through the radiator sections.

LOCOMOTIVE DESCRIPTION

FUEL SYSTEM

A motor-driven pump transfers fuel from the tank through filters to the injection pumps.

Each cylinder is equipped with high pressure fuel injection pump and injector.

LUBRICATING SYSTEM

A full-pressure system is supplied by a gear-type pump integral with the diesel engine.

A lubricating-oil reservoir is located in the engine subbase. Lubricating oil filters, strainer, and water cooled oil cooler are provided. Abnormally low lubricating oil pressure automatically shuts down the engine.

ENGINE STARTING

The diesel engine is cranked by the traction generator from storage battery power.

ELECTRIC TRANSMISSION

TRACTION GENERATOR

One General Electric, GT-598 traction generator is mounted directly on the engine. It is a direct-current, single anti-friction bearing, separately-excited machine and is equipped with windings to permit starting the engine by storage battery power.

TRACTION MOTORS

Four, General Electric GE-752 traction motors are furnished. The traction motor is direct current, series wound, separately ventilated by the cleaned-air system. The armature is mounted in anti-friction bearings.

Motors drive through single-reduction spur gearing. They are supported by the axles to which they are geared and by resilient nose suspensions on truck transoms.

LOCOMOTIVE DESCRIPTION

CONTROL

The locomotive is equipped with General Electric railway-type single end-single unit control and basic equipment. Control devices are grouped in a pressurized steel compartment, fitted with access doors. The reverser and line contactors are electro-pneumatically operated. Other contactors are magnetically operated. Circuit breaker type switches are used in control circuits where over current protection is required.

Transition is automatic.

EXCITER

One General Electric, Type GY-50 is provided. It is gear-driven from the traction generator and provides controlled excitation of the traction generator field.

BATTERY-CHARGING GENERATOR

One General Electric, Type GY-27 battery-charging generator is provided. It is gear-driven from the traction generator and furnishes power at regulated potential for battery charging, lighting and control.

STORAGE BATTERY

A 32-cell lead acid type storage battery is furnished for starting the engine and to furnish power for lights and other auxiliaries when the engine is shut down.

WHEEL SLIP CORRECTION

Wheel slip is automatically detected by comparison of output signals from an alternator mounted on each axle. Slip is corrected by an automatic light application of locomotive brake.

GROUND RELAY PROTECTION

If a ground occurs, engine speed returns to idle, power is removed and visual indication is given to the operator.

LOCOMOTIVE DESCRIPTION

OPERATING CONTROLS

Controls and instruments for operating the locomotive are grouped at the operator's station and at auxiliary panels in the operator's cab.

Operating Controls:

Controller with throttle reverser, and selector levers .
Engine start push buttons.
Engine stop push button.
Brake valves.
Sander valve.
Bell ringer valve.
Air horn valve.
Window wiper.
Circuit breakers and switches.
Emergency engine stop button.
Emergency fuel shutoff.

Instruments:

Brake gages.
Load meter.

Warning Indicators:

Low engine lubricating oil pressure -- alarm bell and warning light.
High engine water temperature -- alarm bell and warning light.
Wheel slip -- buzzer and warning light
Ground relay -- red indicator
Engine shutdown -- alarm bell
No battery charge -- alarm bell and warning light

A number of accessories and modifications are available to suit customer needs.

LOCOMOTIVE BRAKES

AIR BRAKES

Schedule 26L with D control valve combined independent and automatic is furnished as basic equipment.

Locomotive brakes may be operated either independently or with train brakes. Connections for furnishing compressed air to the train brakes are provided at each end of the locomotive.

LOCOMOTIVE DESCRIPTION

COMPRESSOR

One, 3 cylinder, 2 stage, water-cooled engine-driven air compressor furnishes air for the locomotive and train braking systems.

Compressed air displacement:

Idle engine speed . . . . 112 cfm
Full engine speed . . . . 282 cfm

RESERVOIRS

Reservoir capacity of 56, 000 cu. In is furnished for storing and cooling air for the brake system.

BRAKE EQUIPMENT

Brake cylinders are mounted on the truck frames and operate fully equalized brake rigging, which applies brake shoes to each wheel.

Brake rigging is furnished with hardened steel bushings, and adjustment is provided to compensate for wheel and shoe wear. Two Type A30 brake shoes are provided per wheel.

HAND BRAKE

A hand brake located in the front compartment is provided for holding the locomotive at standstill.

RUNNING GEAR

The running gear of the locomotive consists of two four-wheel, two-axle, side-equalized, swing motion swivel trucks.

The truck frame, bolster, and spring plank are of cast steel. The frame is supported by two equalizers on each side with coil springs between the equalizer and the frame. Elliptic springs are applied between the bolster and spring plank. The spring plank is supported by forged steel swing links pinned to the truck frame.

LOCOMOTIVE DESCRIPTION

WHEELS

Solid multiple wear, rim-treated rolled steel of 40 inch diameter. The wheels have standard AAR tread and flange contour.

AXLES

Axles are of forged open hearth steel, conforming to AAR material specifications.

JOURNAL BOX

Journal boxes are equipped with roller bearings, grease lubricated. Journal box guides, housings, pedestal openings and equalizer seats are lined with renewable steel wear resistant plates.

CENTER.BEARINGS

Center bearings are equipped with hardened steel liners, arranged for lubrication and protected by dust guards.

SIDE BEARINGS

Side bearings with renewable wear-resistant steel plates are provided.

SAFETY HOOKS

Body and truck safety hooks are provided to prevent slewing and to permit the trucks to be lifted with superstructure.

SUPERSTRUCTURE

The superstructure, of welded steel construction, consists of a front hood, and operator's cab, an engine hood and a radiator compartment. The hoods are bolted to the underframe and are removable.

FRONT HOOD

The front (short) hood contains sandboxes and a dry type sanitary fixture. Doors and a roof hatch provide access. Headlights, marker lights and number boxes are arranged for maximum accessibility.

LOCOMOTIVE DESCRIPTION

OPERATING CAB

The sides and roof of the operating cab are insulated and steel lined. The floor, raised above the platform, is insulated and covered with heavy duty vinyl tile.

The cab has safety glass windows in the front, rear and each side, providing visibility in all directions. Two-pane center windows on each side of the cab have sliding sash equipped with latches. All other windows are fixed and mounted in rubber self-sealing sash.

One door on each side of the operating cab provides access to walkways along the hoods. The doors have windows, weather stripping and provision for locking.

WALKWAYS

Platform walkways with handrails and non-skid treads are provided at each end of the locomotive and along the hoods.

ENGINE HOOD

The engine hood encloses the diesel engine, the traction generator and the air compressor.

Full height side access doors extend the length of the engine and generator on both sides of the hood. Doors in the roof provide access to engine cylinders. Detachable roof sections permit removal of equipment.

RADIATOR COMPARTMENT

The radiators are roof-mounted. A reinforced screen over the air outlet opening is removable to allow access to the radiators, fans and gearbox, and the equipment air cleaner. Dynamic braking grids, when provided, are mounted along each side of the radiator compartment.

An end section holds two sandboxes, serviced from the outside walkway, rear headlights, marker lights and number boxes.

LOCOMOTIVE DESCRIPTION

EQUIPMENT COMPARTMENTS

Main propulsion control equipment is located on the left side of the locomotive beneath the operating cab. This compartment, maintained under positive air pressure to keep out dirt and water, contains contactors, reverser, braking switch, resistors and auxiliary electrical devices.

All air brake devices and air operated equipment, battery trays, and air filter assemblies for the engine are located in easily accessible compartments along the sides of the locomotive.

VENTILATION

Mechanically filtered air is provided through a large self-cleaning air cleaner in the bottom of the radiator compartment and is delivered under pressure for the engine, for equipment cooling, and cab ventilation. Engine air is additionally cleaned by oil bath filters.

UNDERFRAME

The underframe is fabricated by welding, using low alloy steel sections and plate, with cast steel centerplate bolster, bolster side members and draft gear housing.

Hoods, cab, equipment and tanks are supported by the main frame members. Space between these members is enclosed with plate, top and bottom, to form an air duct.

WEARPLATES

Renewable, wear-resistant hardened steel plates are applied to the center bearing side bearing pads and draft gear housing.

COUPLERS

AAR Type E top-operated couplers with rubber-cushioned draft gear are provided at each end of the locomotive.

PILOTS AND SIDE STEPS

A pilot is provided at each end. Side steps providing access to the platform are integral in each side of each pilot.

LOCOMOTIVE DESCRIPTION

LIFTING AND JACKING

Four jacking pads in combination with lugs for cable slings are integrally cast in the side bolsters.

FUEL TANKS

A heavy gage welded steel fuel tank is bolted to the underframe between the trucks. Filler connections and fuel level gages are furnished on each side of the locomotive, and a full depth sight gauge on one side. An emergency fuel trip valve, baffle plates, clean-out plugs and water drains are provided.

DIESEL ENGINE
DESCRIPTION & SPECIFICATIONS

COMPONENT LOCATION TERMS

The following terms will be used throughout this book in locating various components on the engine. (See FIG. 3-1.) Their designation or explanation is as follows:

FREE END - The end of the engine where the turbocharger and intercoolers are mounted.

GENERATOR END - The end of the engine where the generator is mounted.

RIGHT AND LEFT SIDE - The right or left side of the engine is determined by viewing the engine while facing the generator end.

CYLINDER LOCATION - The cylinders are numbered from the FREE END to the GENERATOR END. (Number 1 Right and 1 Left cylinders are nearest the turbocharger. Number 8 Right and 8 Left cylinders are nearest the generator.)

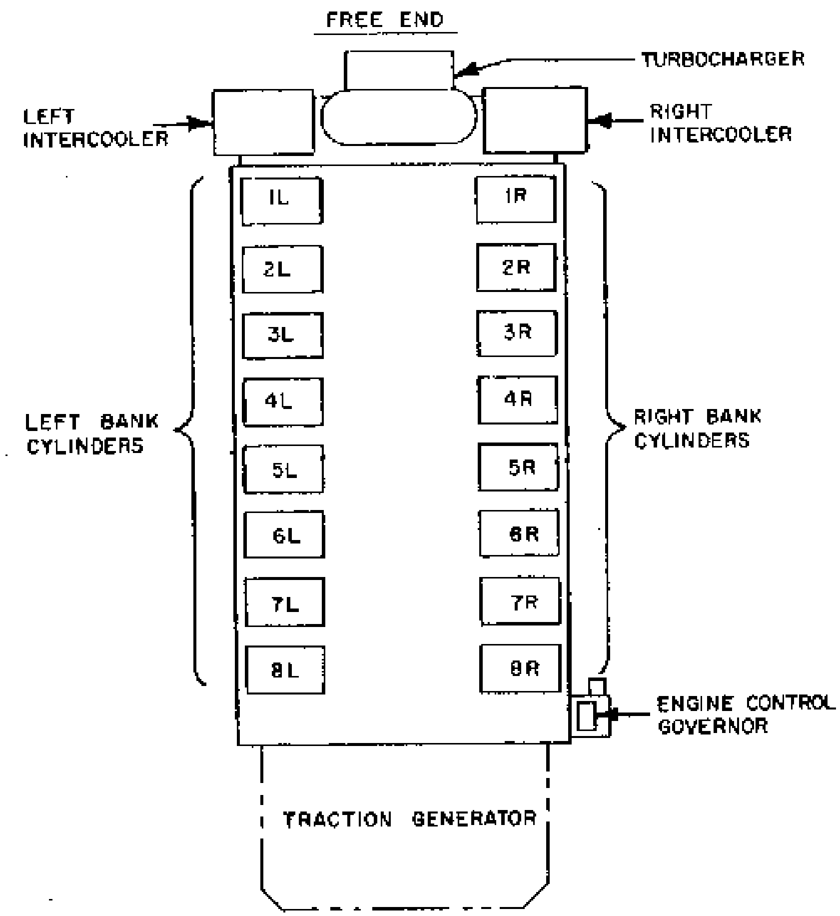
CRANKSHAFT ROTATION - During engine operation the crankshaft rotates clockwise when viewed from the FREE END or counterclockwise when viewed from the GENERATOR END.

ENGINE SPECIFICATIONS

Model	7FDL16
Gross Horsepower	2750
Number of Cylinders.	16
Stroke Cycle	4
Cylinder Arrangement	450V
Bore	9-In.
Stroke	101/2-In.
Compression Ratio	12.7-1
Idle Speed	400 RPM
Maximum Governed Speed	1000 RPM
Firing Order . . . 1R - 11, - 3R - 3L - 7R - 7L - 4R - 4L* 8R-8L-6R-6L-2R-2L-5R-5L	
Turbocharger	Single
Engine Dimensions	
Height (Overall Including Stack) .	8 Ft. 10 3/4 In.
Length (Overall Including Generator).	21 Ft. 8 7/16 In.
Width (Overall)	5 Ft. 8 1/4 In.
Weight (Including Generator)	57,000 Lbs.

*Revised 8-62

DIESEL ENGINE
DESCRIPTION & SPECIFICATIONS



GENERATOR END

SCHEMATIC OVERHEAD VIEW OF ENGINE

FIG. 3-1

DIESEL ENGINE
DESCRIPTION & SPECIFICATIONS

ENGINE DESCRIPTION

General Electric had developed the FDL16 engine for use in diesel-electric railroad locomotives. Its design and rating is based on extensive laboratory tests backed up by thousands of hours of field experience.

A cross section view of the engine is shown in FIG. 3-2. External views of the engine are shown in FIG. 3-3 and FIG. 3-4.

The following brief description merely highlights the principal features of the engine. Each component is more fully described in other sections of the book.

MAIN FRAME

The engine main frame is a single piece casting of special ductile cast iron reinforced by ribs and gussets. Further strength and rigidity are added to the frame by bolting main bearing caps horizontally as well as vertically. Four machined surfaces are used for mounting the main frame on the locomotive platform. Corrosion problems created by coolents common in other types of engines are completely eliminated. The cooling water does not contact any part of the frame. The crankcase inspection covers are light-weight with a quick-acting single handle release.

CRANKSHAFT

The crankshaft is forged of high quality steel and nitride hardened for long life. The journal surfaces are precision ground and all bearing surfaces are force fed with lubricating oil. A removable, split drive gear, mounted on the generator end of the shaft, drives the camshafts, and through gears, the control and overspeed governor.

The traction generator armature is directly bolted to the crankshaft flange.

BEARINGS

Replaceable, precision-fit main and connecting rod bearings are used. They have steel backs and are lined with a copper-lead alloy. The crankshaft thrust bearings are located in No. 8 main bearing. The camshafts rotate in replaceable, split-sleeve type, aluminum bearings.

DIESEL ENGINE
DESCRIPTION & SPECIFICATIONS

VIBRATION DAMPERS

One round, sealed, viscous type, damper is mounted on the free end of the crankshaft. This unit dampens and controls crankshaft torsional vibration.

CAMSHAFT

Two camshafts of forged high alloy steel are used to operate the engine valves, and fuel pumps. These shafts are mounted in the frame on each side of the engine and are directly gear driven from the crankshaft at one-half crankshaft speed. The fuel and valve cams on these shafts are individually replaceable.

CONNECTING ROD ASSEMBLY

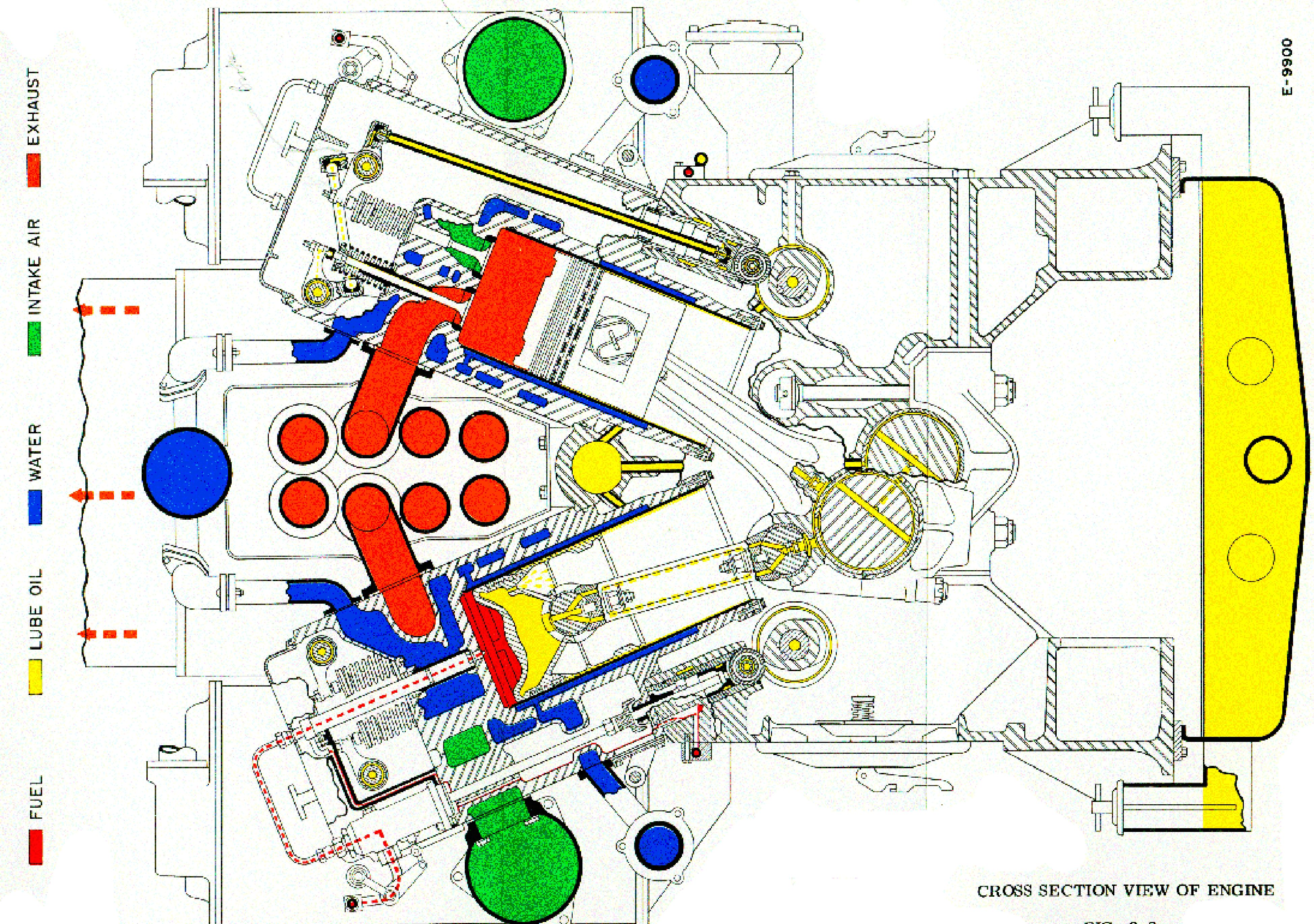
Each connecting rod assembly consists of a master connecting rod and an articulated connecting rod. These rods are made of forged alloy steel. The articulated-rod bolts to a pin fitted in the master connecting rod and the master connecting rod is bolted to the crankshaft. This design provides for a maximum of bearing surface area.

PISTONS

The pistons are of a special cast iron giving them the ductility needed for long piston life. Each piston is equipped with four compression rings and two oil rings. The piston rings may be inspected and replaced without disconnecting the piston by removing the cylinder. The lower piston area is tin-plated to aid rapid piston break-in and to prevent scuffing which would cause cylinder damage. The pistons are lubricated and cooled by oil. Oil is forced through holes drilled in the connecting and articulated rods to the piston pins and the cavity under the piston crown.

CYLINDERS

Cylinder castings are of a special ductile cast iron with the cylinder head an integral part of the casting. Hardened replaceable intake and exhaust valve seats are in stalled in the cylinder head. The valves are arranged with the two intake



CROSS SECTION VIEW OF ENGINE

FIG. 3-2

DIESEL ENGINE
DESCRIPTION & SPECIFICATIONS

valves outboard and the exhaust valves toward the center of the engine "vee". This design allows for uni-directional gas flow and provides the optimum of engine "breathing" which results in lower exhaust temperature and longer engine life. The fuel pump injection nozzle, valve rocker arms, and allied valve equipment is located within the upper portion of the cylinder casting. The cylinder casting is bolted to the main frame. The bolting lugs are located at the bottom of the cylinder to keep hold-down stresses away from the maximum pressure area in the cylinder head.

CYLINDER LINERS

Replaceable, water cooled, centrifugal cast iron cylinder liners are provided. The liner wear-surfaces are chrome plated to give longer liner life. The upper end of
the liner is seated on a soft, embedded, copper gasket. The lower end is sealed with a rubber "O" ring, held in place by a packing ring. The liners are installed in the cylinders with an interference fit and secured in place with a bolted clamping ring.

FUEL INJECTION PUMP

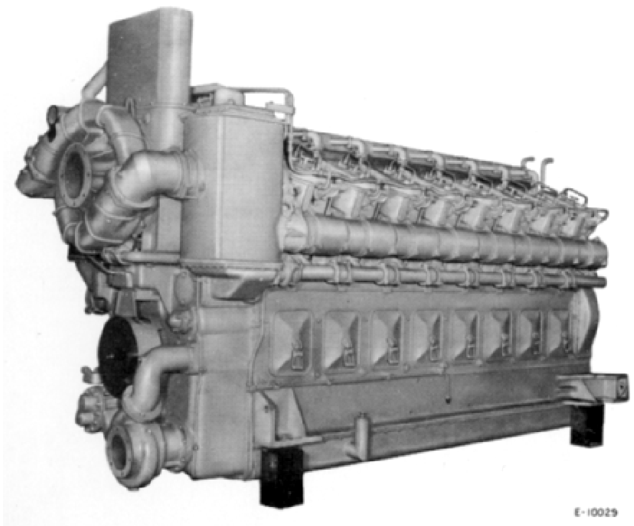
An impulse or "jerk" type fuel injection pump is mounted in the top of each cylinder head and operates through a pushrod from the camshaft. An adjustable tappet located below the pump pushrod provides adjustment for pump timing. The pump increases fuel pressure for injection, accurately measures the quantity to be injected, and delivers the fuel at the proper time to the fuel nozzle. The pumps are controlled by the governor to measure and deliver the fuel at the proper time and in the amount required for a given horsepower load.

FUEL NOZZLES

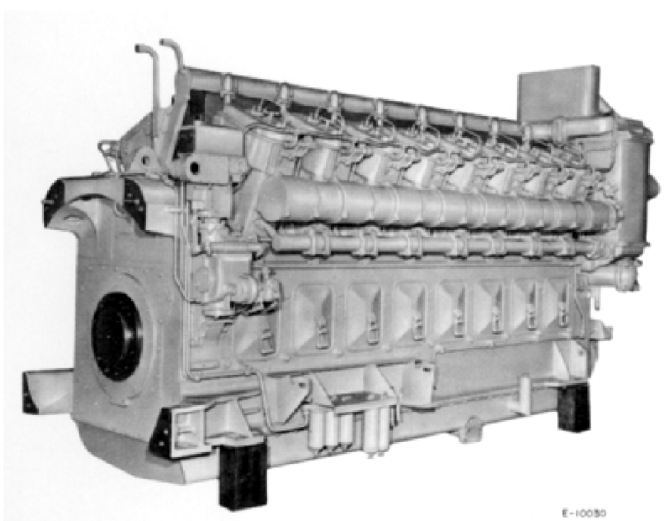
An injection nozzle is mounted in the center of each cylinder and is connected to the fuel injection pump by a short high pressure line.

Fuel is forced through tiny holes in the nozzle tip which atomize the fuel into a very fine mist in a symmetrical pattern for proper combustion. The injection nozzles are made up of several easily replaceable components.

DIESEL ENGINE
DESCRIPTION & SPECIFICATIONS



OBLIQUE VIEW OF ENGINE - FREE END
FIG. 3-3



OBLIQUE VIEW OF ENGINE - GENERATOR END
FIG. 3-4

DIESEL ENGINE
DESCRIPTION & SPECIFICATIONS

ENGINE CONTROL GOVERNOR

The engine is equipped with a electro-hydraulic, speed regulating governor which is equipped with a small, internally-mounted load controlling rheostat. The governor is mounted on top of the engine main frame at the generator end and is gear driven from the right camshaft gear. The governor maintains desired engine speeds at all loads by regulating fuel rack travel to the fuel pumps. The governor has its own oil supply and its own oil pump which supplies the pressure needed to regulate the governor's operation.

TURBOCHARGER

A single turbocharger, mounted on top of the main frame at the free end is driven by the engine exhaust gases and provides air at approximately twice atmospheric pressure to the cylinders. The turbocharger is water cooled and lubricated with oil from the engine's pressurized system.

INTERCOOLERS

The engine is equipped with two inter-coolers, which are small enclosed radiators mounted on each side of the engine. They are connected between the turbocharger and each air intake manifold. Part of the cooling system water flows through the inter-coolers and compressed air from the turbocharger blows across the radiator cores. The water absorbs heat from the air which allows cooler air to be delivered to the cylinders. Supplying cooler air for combustion enables a greater amount of fuel to be burned with a given amount of air which greatly increases engine power.

MANIFOLDS

The air intake manifolds are mounted to the outside of each bank of cylinders. They are sectional in construction for ease in alignment and quick engine maintenance. The exhaust manifolds, mounted in the "vee" of the engine, are stainless steel with gasketed flange connection to each cylinder and the turbocharger. The individual exhaust pipes have bellows sections at appropriate intervals to compensate for thermal expansion with varying engine loads.

DIESEL ENGINE
DESCRIPTION & SPECIFICATIONS

AIR SYSTEM

Incoming engine air first passes through the locomotive primary air cleaner. This cleaner contains a multitude of specially constructed tubes which act as minature cyclonic dirt separators. Better than 95 per cent of the air borne dirt is removed by the cleaner and is discharged beneath the locomotive. This cleaned air passes through panel type oil bath air filters for additional filtration before it enters the turbocharger.

COOLING SYSTEM

Cooling water is circulated through the system by an engine mounted water pump. The pump is mounted on the free end cover and is gear driven from the crankshaft. Cooling water is forced through the engine, turbocharger, oil cooler and intercoolers to carry engine heat away. Hot water flow is controlled by a flow control valve which directs water to the roof mounted radiators where the water is cooled by forced air from the gear driven radiator fan.

FUEL SYSTEM

Fuel is pumped through the system by an externally mounted, electric-motor driven fuel booster pump. The pump transfers fuel from the locomotive fuel tank through filters to each fuel injection pump. Excess fuel returns to the tank through a sight glass and regulating valve. A relief valve is installed near the pump to protect the system against excessive pressure.

LUBRICATION SYSTEM

Lubricating oil is circulated through the engine by the gear driven lube pump mounted on the free end cover. The entire engine is automatically lubricated with oil pressure controlled by a regulating valve. A relief valve is installed to protect the system against excessive pressure. An externally mounted, water cooled, oil cooler, cools the oil which picks up heat in lubricating and cooling the pistons and allied parts.

DIESEL ENGINE
DESCRIPTION & SPECIFICATIONS

LUBRICATING OIL FILTERS

A full-flow strainer and externally mounted filters are installed in the lubricating oil system to filter out abrasives or foreign matter.

SAFETY DEVICES

The engine is equipped with a overspeed governor which shuts the engine down if the engine speed exceeds a predetermined safe value. The governor is mounted on the governor drive gear box which is located at the generator end and is gear driven from the camshaft gear. When the governor trips, it closes butterfly valves located in the air intake manifolds, which shut off air to the engine. A manual reset button is provided to reset the governor after an overspeed trip. This overspeed governor is <u>failsafe</u>. Any failure of the overspeed mechanism itself will automatically shut the engine down.

A safety device to detect low engine lube oil pressure is built into the speed-regulating governor and is connected to the engine lube oil header. It provides low lube oil pressure protection throughout the entire engine speed range. Should the lube oil pressure drop below a safe value the device shuts down the engine. A manual reset button is provided to reset the pressure device after a low oil pressure shut down. A YELLOW indicating lamp is provided to inform the operator when an engine shut-down is caused by low oil pressure.

An alarm bell and a RED indicating light are provided to inform the operator if the engine water temperature exceeds a safe value.

CRANKING

The engine crankshaft is directly connected to the traction generator armature. When the generator is electrically energized (from batteries) through its start field, the generator acts as a motor to rotate the crankshaft to start the engine.

LUBRICATING OIL SYSTEM

DESCRIPTION

The engine lubricating oil system provides pressure lubrication to bearings within the engine and carries away heat produced by friction and combustion.

The lubricating oil system consists of the following components in their order of oil flow.See FIG. 4-7.

1. Engine crankcase
2. Pump
3. Relief valve
4. Filter
5. By-pass valve
6. Cooler
7. Regulating valve
8. Strainer
9. Engine supply system

An oil pan is bolted to the main frame to enclose the bottom of the crankcase and hold the oil supply. Two oil fill openings, one on each side of the crankcase, are sealed by removable-type plugs to which dip-sticks are attached. Oil from the crankcase is drawn over an inverted trap and into the suction side of the gear-type lube oil pump.

OIL FLOW OUTSIDE THE ENGINE

Oil discharged from the pump is piped to the lube oil filter. A relief valve protects the system against excessive pressure.

Oil is forced through the oil filter which contains eight identical, clamped-in elements. A by-pass valve is externally connected between the filter inlet and discharge pipe. This valve insures continuing engine lubrication if filters become clogged.

Oil discharged from the filter is conducted to the lower end of the oil cooler. Water flowing through tubes inside the cooler removes heat from the oil.

Oil discharged from the cooler is piped to the engine free-end cover and through the strainer mounted in the cover.

LUBRICATING OIL SYSTEM

An oil pressure regulating valve, also mounted in the cover at the strainer inlet, controls engine oil header pressure and discharges excess oil to the crankcase.

OIL FLOW INSIDE THE ENGINE

The main engine supply header and branch passages within the main frame conduct oil to all main bearings and the two free-end camshaft bearings. Oil enters the crankshaft from the main bearings and flows through angularly drilled passages in the shaft to the connecting rod bearings. Oil passes upward from the connecting rod bearings through drilled passages in the rods to lubricate the articulated rod bearings and piston pins and to cool the pistons. It then flows through openings inside the pistons to return to the crankcase.

Oil entering the two free-end camshaft bearings is conducted lengthwise through the drilled camshafts. Holes drilled radially into the shafts supply oil to each of the other shaft bearings.

The camshaft bearings contain annular grooves connecting to drilled passages in the engine main frame. Oil flows through these passages to the valve and fuel push rod cross-heads.

Oil also flows upward through the valve push rods to supply lubrication to the working valve parts at the top of the cylinder. Oil return is through the valve push rod cavities to lubricate the cams and cam rollers, then to the crankcase.

The free-end cover bearing and the idler gear bushings are lubricated through a passage from the oil header to an annular groove around the cover bearing. Another drilled passage connects the annular bearing groove to a drilled passage in the idler gear shaft. Oil from these bearings returns by gravity to the crankcase.

The turbocharger bearings receive lubrication through an external line flange-connected to the oil header at the free-end cover. From the turbocharger

LUBRICATING OIL SYSTEM

oil is returned to the crankcase through a pipe, also flange-connected to the cover.

Lubricating oil is piped to the governor drive assembly and to the low oil pressure shut-down device, located on the engine control governor. This pipe is flange-connected to the engine oil header at the generator end. Oil from the governor drive gear case returns to the crankcase internally.

Oil supply for the overspeed governor is maintained in a small reservoir built into the governor drive gear case. The reservoir is kept filled by an oil passage in the drive gear bearings.

The camshaft gears are splash-lubricated through an orifice and pipe from the engine oil header.

The auxiliary drive gear, located on the crankshaft, is lubricated internally by oil flowing through a passage within the shaft and through the gear hub.

Bearings and drive gears of the oil and water pumps are lubricated by running partially submerged in lube oil contained within the free-end cover reservoir.

LUBRICATING OIL

Heavy duty lubricating oil must be used. It is a neutral mineral oil compounded with suitable additives to provide a stable lubricant that is resistant to oxidation, is not corrosive, is resistant to the formation of acid and sludge, and upon removal will leave an engine that requires no further cleaning. The additives will also control foaming, pourpoint, and viscosity index.

LUBRICATING OIL PRESSURE

Oil pressure must be maintained at all times during engine operation. Insufficient or no oil pressure will cause extensive damage to bearings, pistons, cylinders and other moving parts within the engine.

The low Tube oil pressure device will stop the engine and turn on a yellow indicating light in the operator's cab if a condition of insufficient oil pressure exists.

LUBRICATING OIL SYSTEM

When the engine is operating within its normal temperature range, the oil header pressure will be approximately as noted on the DATA sheet.

During engine starting, a time delay built into the low oil pressure shut-down device allows time for engine oil pressure to build up. If pressure fails to build up within the time allowed, the low oil pressure device will trip and prevent the engine from starting.

LUBE OIL SERVICING
(See FIG. 4-7)

FILLING

To service the lubricating oil system, proceed as follows:

1. Check that valves A, B, C and D are closed.

2. Fill crankcase, either through the crankcase cover doors or through the dip-stick openings, with the correct quantity of new lubricating oil. The oil must conform to the required specifications. Fill to the FULL level mark on the dip-stick.

3. WITH THE ENGINE IDLING THE OIL LEVEL MUST BE BETWEEN THE "FULL" AND "LOW" MARKS ON THE DIP-STICK. (Distance between the marks represents approximately 60 gallons.) See FIG. 4-1.

DRAINING

Four drain valves are in the lubricating oil system. All must be closed before the engine is started.

1. Crankcase Drain Valve (A) is located on the right side of the engine near the dip-stick opening. It is used to drain the main oil supply from the engine crankcase.

2. End Cover Drain Valve (B) is located on the right side of the engine below the lube oil strainer. It is used to drain the free-end cover to permit pump removal.

LUBRICATING OIL SYSTEM

LUBE OIL FILL PIPE AND OIL LEVEL DIP-STICK
FIG. 4-1

3. Filter Drain-back Valve (C) is located next in line near Valve (B). It is used to drain oil contained in the cooler, filter, and piping back to the engine crankcase. When Valve (B) and (C) are both open, oil will drain from the filter and the free-end cover out through the main oil drain pipe.

4. Strainer Drain Valve (D) is located on the under side of the strainer next to the free-end cover. It is used to drain the oil from the strainer shell to the free-end cover when its plunger is pushed UP. This valve will close itself automatically from oil pressure if left open. It may also be closed manually by pulling the plunger DOWN.

5. With Valves (C) and (D) open, the oil level in the filter will drop by gravity to the level in the crankcase. This will take less time if the vent plug in the filter cover is removed. To lower the oil level in the filter still further,

LUBRICATING OIL SYSTEM

air pressure may be introduced through the vent opening. After the oil from the bottom of the filter has been driven into the crankcase, close Valve (C) so that the oil will not run back and then cut off air pressure. The filter and free-end cover may also be drained overboard into a barrel by opening Valves (B) and (C).

CHANGING OIL

1. With the engine stopped, remove the pipe cap from the drain pipe which extends below the platform over the main air reservoir on the engine right side.

2. Arrange barrels or drain hose system to catch used oil.

3. Open Crankcase Drain Valve (A), End Cover Drain Valve (B) and Filter Drain Valve (C).

4. Remove the vent plug on the filter cover.

5. Push up Strainer Drain Valve (D).

6. Cleaning Strainer

   a. Remove strainer cover and basket.

   b. Remove basket end covers and clean basket using suitable cleaner or low pressure steam. Blast with compressed air to dry.

   c. Inspect all gaskets and renew if damaged.

   d. Reassemble strainer and tighten cover nuts evenly. UNEVEN OR EXCESSIVE TIGHTENING OF COVER NUTS MAY CAUSE THE COVER TO BREAK.

7. Renewing Filter Elements

   a. After oil has been drained from filter shell, loosen filter cover clamps and open hinged cover.

LUBRICATING OIL SYSTEM

   b. Remove wing screws and the element hold down plates.

   c. Remove the used elements and place in a suitable container to catch drippings.

   d. Clean any sludge deposits from filter shell.

   e. Install new filter elements. (See Renewal Parts Catalog for correct replacement.)

   f. Install element hold-down plates and wing nuts. Tighten nuts evenly. HAND TIGHTEN ONLY.

   g. Inspect the filter cover gasket for possible damage and replace if necessary. Close filter cover and tighten clamping bolts EVENLY.

   h. Replace vent plug and tighten. See previous system FILL instructions.

RELIEF AND REGULATING VALVES

Pressure and flow within the lube oil system is automatically controlled by three pressure-operated valves.

1. Pressure Relief Valve

2. Filter By-pass Valve

3. Pressure Regulating Valve

These valves are held closed by spring pressure which is adjustable. When sufficient oil pressure develops, it will overcome the spring pressure causing the valve to open and pass oil.

The function of each of the three valves within the system should be thoroughly understood before any attempt is made to change their settings. Normally these valves do not get out of adjustment; however, they may fail to function properly due to leakage caused by dirt holding the valve off its seat, or dirt wedged around the valve stem causing erratic valve operation. When disassembling a valve for

LUBRICATING OIL SYSTEM

cleaning, always mark the adjustment so that is may be returned to its correct setting without removal from the system.

If the valve has been maladjusted or requires additional work, it must be removed from the system and bench tested.

PRESSURE RELIEF VALVE

The Pressure Relief Valve, located near the outlet of the lube oil pump, protects the system against excessive oil pressure which may develop should the system become restricted. If the pump discharge pressure exceeds the valve operating pressure, the valve will be forced open permitting oil to flow to the free-end cover, thus limiting pressure.

Testing

The Pressure Relief Valve must be removed from the system and bench tested if repairs or adjustments are required. FIG. 4-2 shows a suitable air test stand set-up which may be constructed for testing purposes. An air supply pressure of at least 100 psi is required to operate the test stand.

When testing and adjusting the Pressure Relief Valve, use the following procedure:

1. Install the valve in test stand as shown in FIG. 4-2.

2. With the Discharge Valve closed, open the Inlet Valve fully.

3. Open the Discharge Valve slowly to prevent chattering until the pressure gage reads the prescribed valve opening pressure.

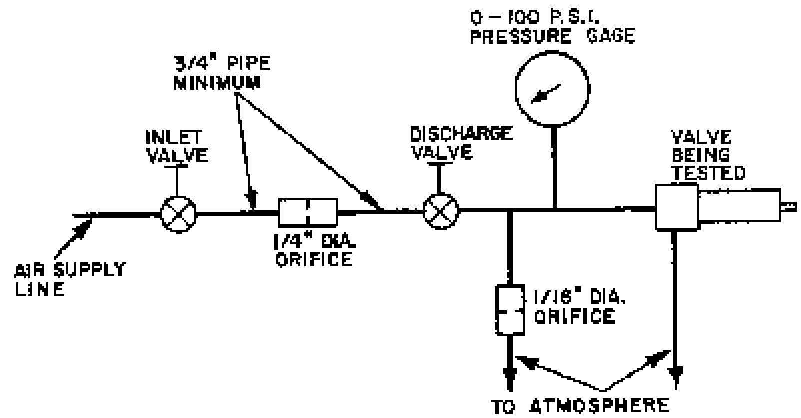
4. Inspect the piston through the discharge port to see that is just uncovers the valve passage and begins to pass air at its correct pressure setting.

5. If the valve opens at a pressure lower or greater than that prescribed, remove the cap, unlock the adjusting screw and turn the screw until the piston just uncovers the valve passage at its prescribed pressure.

LUBRICATING OIL SYSTEM

6. Lock the adjusting screw and replace the cap. Recheck pressure setting.

7. To check valve leakage, adjust the discharge valve to set the pressure 15 per cent below the opening pressure. Repair the valve if leakage is excessive.



TEST ARRANGEMENT FOR ADJUSTING VALVES
FIG. 4-2

FILTER BY-PASS VALVE

The Filter By-pass Valve is located beside the oil filter and is connected in parallel across the filter. It operates on differential pressure drop across the filter and serves two functions:

1. To insure maximum lube oil filtration when the filter elements are clean. (Low filter pressure drop.)

2. To insure continuing engine lubrication when filter elements become clogged. (High filter pressure drop.)

The valve remains closed with clean filter elements installed. It will open, allowing oil to by-pass the filter, when the pressure drop, due to clogged filters, reaches the operating pressure of the valve. The action of the Bypass Valve differs

LUBRICATING OIL SYSTEM

from the Pressure Relief Valve in that maximum flow through the By-pass Valve occurs at only slightly higher pressure than that required to start the valve opening.

Testing

The Filter By-pass Valve must be removed from the system and tested in the following manner:

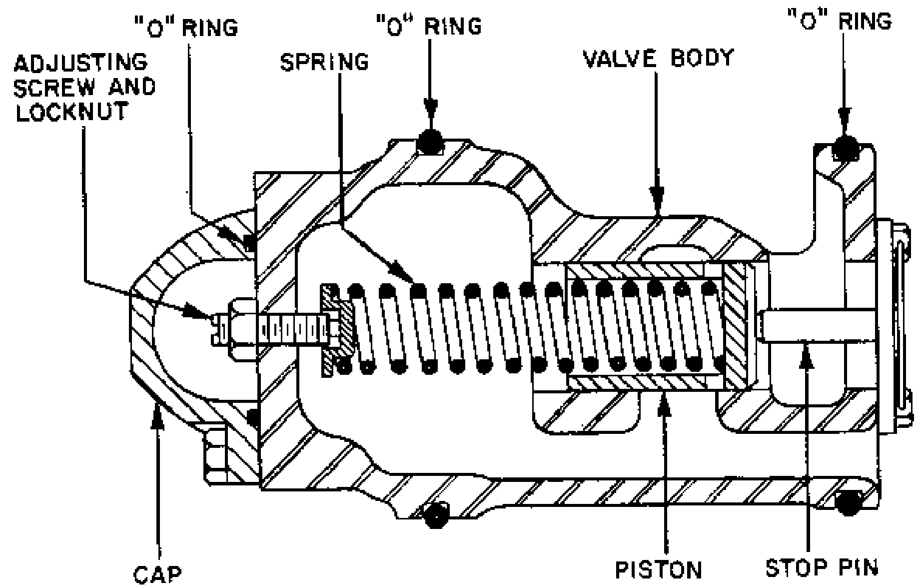
1. Install the valve in the test stand as shown in FIG. 4-2.
2. With the Discharge Valve closed, open the Inlet Valve.
3. Open the Discharge Valve slowly to prevent chattering until it is fully open.
4. The gage should now read the prescribed valve opening pressure (see DATA) and air should be flowing from the valve outlet.
5. If the pressure does not read as prescribed, remove the cap, loosen the adjusting screw lock-nut and turn the screw until correct pressure is indicated.
6. Lock the adjustment and replace the cap. Recheck pressure setting.

NOTE: Leak test the valve, using the same method as described for the Pressure Relief Valve. Repair of leakage is excessive.

PRESSURE REGULATING VALVE

The main lube oil header pressure regulating valve is a self-contained device located inside the left-bank camshaft access opening in the free-end cover. The valve body is sealed to the end cover oil passages by "O" rings and held in place by bolts. Access to the pressure adjustment screw is obtained by removing the cap. See FIG. 4-3.

LUBRICATING OIL SYSTEM



PRESSURE REGULATING VALVE (LUBE OIL HEADER)
FIG. 4-3

This valve maintains a relatively constant engine oil header pressure, although the volume of oil flowing through the system continues to change as a result of engine speed change.

Adjustment

If it becomes necessary to adjust this valve, it can be done most easily in place on the engine as follows:

1. With the engine stopped, install a calibrated 0 to 60 psi test gage in the test boss in the lube oil line which runs from the cooler to the free end cover. Make sure strainer is clean.
2. Warm up the engine to bring the lube oil within its normal operating temperature range. Run the engine at full speed, no load and adjust as given on DATA sheet. Turn screw in to raise or out to lower pressure.

LUBRICATING OIL SYSTEM

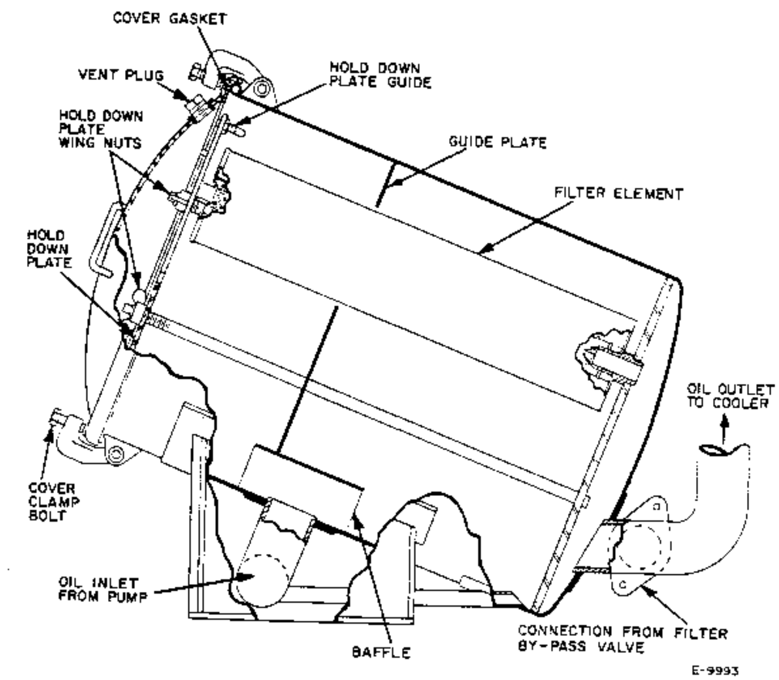
3. Secure the adjustment lock nut and install the cap. Recheck pressure setting.

4. Stop the engine. Remove the test gage and apply the pipe plug.

LUBE OIL FILTER
(See FIG. 4-4)

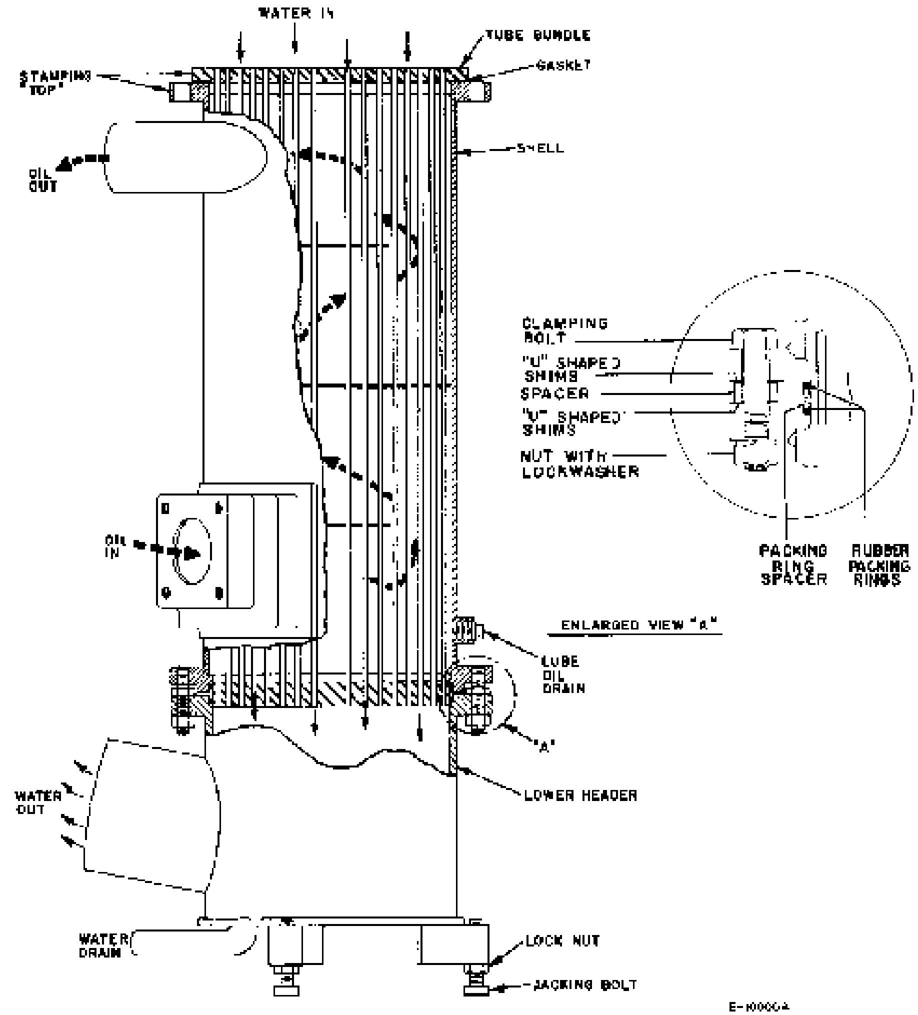
The lube oil filter is a fabricated cylindrical steel shell. It has a hinged and gasketed cover which is clamped to hold maximum system pressure. The filter shell is supported by a fabricated steel frame which is part of the filter assembly.

Internally, the filter is arranged with two separate cavities. Oil flowing into the filter shell passes inward through the eight elements located in the upper cavity, downward through the element centers into the lower cavity, and out through the outlet pipe.



LUBE OIL FILTER
FIG. 4-4

LUBRICATING OIL SYSTEM



LUBE OIL COOLER
FIG. 4-5

LUBRICATING OIL SYSTEM

LUBE OIL COOLER

The lube oil cooler is a fabricated steel shell containing vertical water tubes. See FIG. 4-5.

The cooler is mounted in a vertical position with its top flange bolted directly to the underside of the water storage tank. Water from the tank flows downward through the tubes to the bottom header which is connected to the suction side of the water pump.

Oil from the filter enters at the bottom of the cooler and flows upward around the tubes to the oil outlet which is connected to the engine free-end cover. Internal baffles direct oil flow across the tubes to produce maximum cooling.

The tubes are secured to their end sheets by expansion rolling. The upper tube sheet is clamped and sealed between the upper cooler flange and the water tank. The lower tube sheet is free to move vertically in the shell to compensate for thermal expansion. A seal, consisting of two packing rings and a packing ring spacer, located at the lower header flange, prevents leakage between oil and water sections but allows movement of the tube sheet at its lower end.

The packing ring spacer has several weep holes drilled through it. Failure of either packing ring will be indicated by oil or water leakage at the flange. (See Fig. 4-5, enlarged view A.)

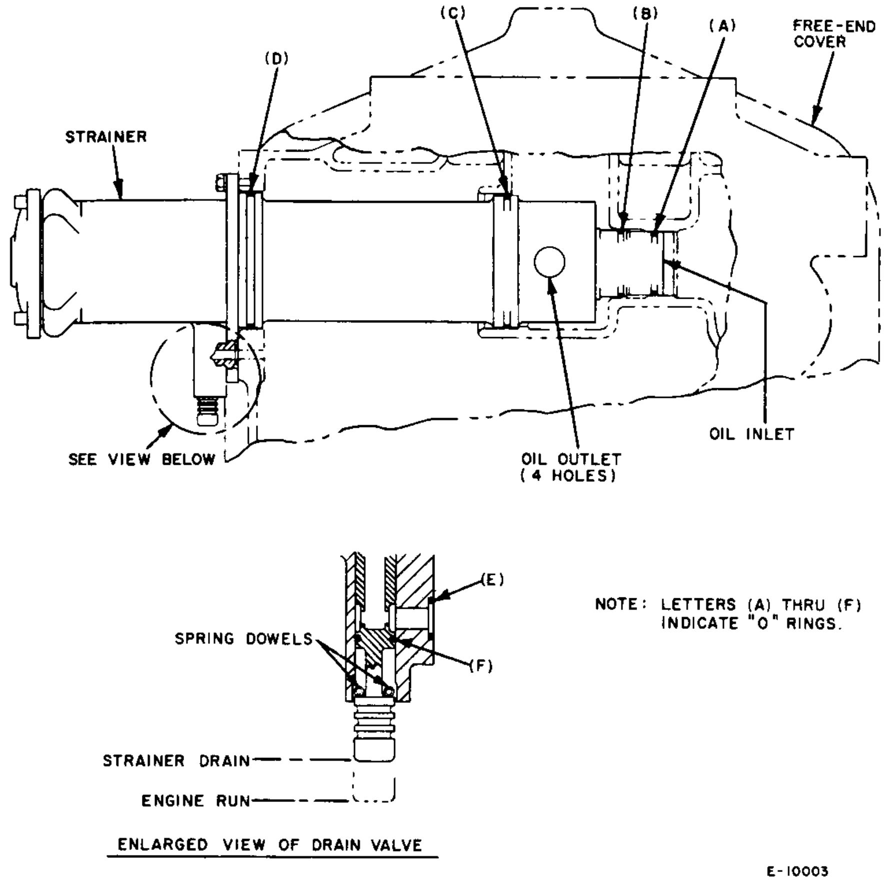
Horse shoe shaped spacers and adjusting shims are located around each bolt between the flanges. The spacer and shims limit the force applied to the packing rings and also maintain alignment of the flange faces.

LUBE OIL STRAINER

The lube oil strainer is built into the free-end cover of the engine as shown in FIG. 4-6. Five "O" rings seal between the strainer housing and the free-end cover are labeled (A) through (F) in FIG. 4-6.

Leakage past "O" rings (A) or (B) may be determined by oil seepage from the 1/4 inch tell-tale hole in the free end cover located just to the right of the engine timing pointer. (Viewed when facing the free-end cover.)

LUBRICATING OIL SYSTEM



LUBE OIL STRAINER ARRANGEMENT
FIG. 4-6

Leakage past "O" ring (C) gives no external indication, but may be suspected if lube oil pressure drops below normal and other parts of the system are in good condition.

Leakage past "O" rings (D) or (E) will be noticed by oil on the outside of the free-end cover below the strainer.

The strainer is equipped with a drain valve. Pushing up on the valve handle will drain oil from the strainer housing back to the crankcase.

LUBRICATING OIL SYSTEM

Oil running down the drain valve handle indicates that the "O" ring labeled (F) is defective. To renew this "O" ring, knock out the two 1/4 inch roll pins at the bottom of the valve housing and pull down the plug to remove. Replace the "O" ring. Push the valve in, and replace the roll pins.

HOUSING REMOVAL

To remove the strainer housing, take out the three bolts around the strainer flange. The strainer may then be jacked out by inserting three 5/8-11 by 2 bolts in the tapped jacking holes in the mounting flange and pulling up on the bolts EVENLY until the strainer comes free.

HOUSING INSTALLATION

Before reinstalling the strainer "O" ring, grooves on the exterior should be cleaned and new "O" rings installed. Inspect and clean sealing surfaces in the free-end cover. Lubricate the "O" rings. When inserting the strainer into the free-end cover, make sure that the small "O" ring (E) is in the round groove in the strainer flange back of the drain valve. If necessary, extra long 5/8-11 bolts may be used temporarily in the mounting flange to assist in pulling the strainer into its seat.

LUBRICATING OIL SYSTEM

LUBRICATING OIL SYSTEM DATA

Oil Capacity. . . . . 330 Gal.

Pump
Speed Ratio . . . . 1.104 to 1

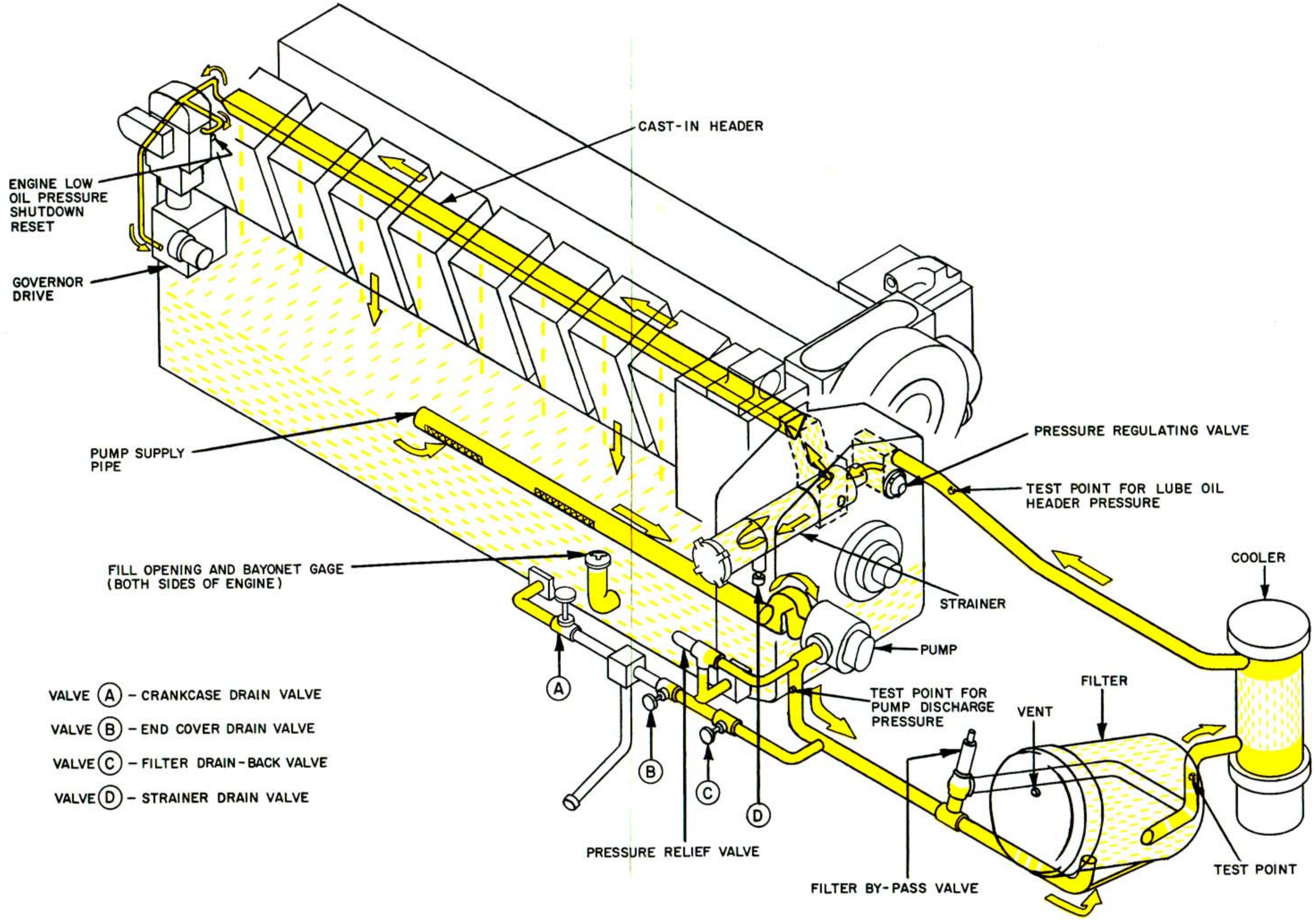
Pressure Relief Valve (begins to open) . . . . . . 90 psi

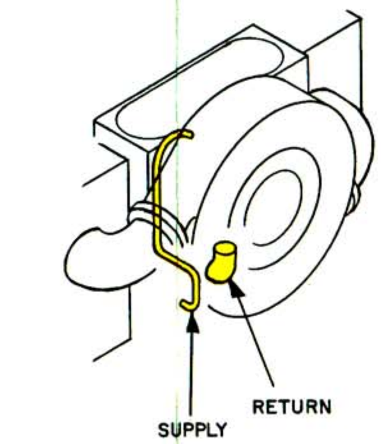
Filter By-Pass Valve . . . . 20 psi

Header Pressure Regulating Valve . . . . 50 psi

Engine Header Pressure (Normal operating temperature
at strainer inlet)
Engine Idle (Approximately) . . . . 20 psi
Engine Full Speed . . . . 50 Psi

Low Oil Pressure Shutdown Device (In governor)
Idle Speed Shutdown . . . . 10 to 14 psi
Full Speed Shutdown . . . . 25 to 30 psi





TURBOCHARGER LUBE OIL PIPING

LUBRICATING OIL SYSTEM

FIG. 4-7

FUEL OIL SYSTEM

DESCRIPTION

The engine fuel supply is contained in two fuel tanks located below the locomotive platform. Fuel is drawn from the forward tank by the electric-driven fuel-booster pump and circulated through the system. See FIG. 5-9.

The fuel system consists of the following components, listed according to fuel flow from the fuel tank and through the system:

1. Fuel Tank(s)
2. Emergency fuel cut-off valve
3. Primary filter
4. Fuel booster pump
5. Relief valve
6. Secondary filter
7. Engine fuel header
8. Injection equipment
9. Regulating valve
10. Sight glass

The suction side of the system is between the tank and the booster pump. Fuel is drawn through the emergency fuel cut-off valve and a two-element primary fuel filter before reaching the pump.

The pressure side of the system is between the booster pump and the pressure regulating valve which discharges excess fuel back to the tank. Fuel discharged by the booster pump flows to a three-element secondary fuel filter. A relief valve is connected to the pump discharge and protects the booster pump from overloads caused by flow restrictions in the pressure side of the system.

The three-element secondary fuel filter serves to more completely filter foreign particles from the fuel. Fuel is conducted from the secondary fuel filter through a pipe to the engine fuel header.

FUEL OIL SYSTEM

Individual flexible hoses connected between the injection pump inlet fittings make up the engine fuel header. The fuel header first supplies fuel to the injection pumps on the right bank, then crosses over near the turbocharger arid supplies the injection pumps on the left bank.

Excess fuel returns to the tank through a sight glass and a regulating valve. The regulating valve is adjusted to maintain pressure in the engine fuel header. Visual inspection of fuel flow can be made through the sight glass when priming or trouble shooting the fuel system.

FUEL SUPPLY TANKS

The locomotive is equipped with two fuel supply tanks (main and auxiliary). The forward or main supply tank is fitted with two fill openings, one on each side of the locomotive. Two clean-out drain openings are located in the bottom of each tank and are sealed by pipe plugs. Each tank also contains two bleed-off drain plugs one at each end of each tank sump. Two fuel level sight gages, an upper and lower, are located on either side of the main fuel tank. Each tank is also fitted with two vent-pipes to maintain the fuel supply at atmospheric pressure.

EMERGENCY FUEL CUT-OFF VALVE

The emergency fuel cut-off valve furnishes a means of shutting off the flow of fuel from the supply tank to the engine in case of emergency. The valve is located in the booster pump suction line and is mounted on a bracket between the two fuel tanks. It is a manual-trip, manual-reset type valve and when tripped is held closed by a spring.

The valve may be tripped by pulling the triangular shaped handles at any one of the following three locations on the locomotive.

1. Within the operator's cab near the engineman's position.
2. On the left side of the locomotive near the fuel fill opening below the platform.
3. On the right side of the locomotive near the fuel fill opening below the platform.

FUEL OIL SYSTEM

When the valve is tripped (closed) the fuel sight glass should indicate no fuel flow.

To reset the valve, pull the reset handle located on the left side of the locomotive between the fuel tanks. This lifts the valve stem against spring pressure and opens the valve.

NOTE: The emergency shut-off valve should be used only in case of emergency. Unnecessary use of this valve while the booster pump is running may cause failure of fuel system parts due to insufficient lubrication.

DISASSEMBLY

1. With the valve in a closed position, drive out stem nut lock-pin.
2. Unscrew stem-nut and remove washer. Be careful not to exert any twist on stem.
3. Lift trip mechanism off stem.
4. Unscrew stem assembly out of valve body.
5. Lift stem assembly out of valve body.
6. Take stem assembly apart by holding one side of disc in vise at vise jaw ends with assembly in the horizontal position. File off peened end of brass pin that locks disc assembly. Drive pin down and out.
7. Hold stem assembly in vise by flats on stem and unscrew disc. Assembly will come apart.

REASSEMBLY

1. Replace worn or damaged parts within the valve. NEVER ATTEMPT TO REASSEMBLE A VALVE WITH USED RUBBER PARTS.
2. Screw disc on stem. DO NOT TIGHTEN EXCESSIVELY. Tightening is sufficient when a small amount of disc facing rubber extends beyond the disc sleeve.

FUEL OIL SYSTEM

3. Trim the small amount of disc facing rubber with a razor blade.

4. Using the hole in the disc sleeve as a guide, drill through the stem and apply a new brass disc pin. Peen ends of disc pin to secure.

5. Insert valve stem assembly into valve body and assemble in reverse order to disassembly instructions, Steps 1 through 4.

TESTING

The valve must be tested for leakage in the following manner:

1. With the valve in the closed position, apply 10 psi air pressure to the inlet side of the valve.

2. Immerse valve outlet in water and inspect for air bubbles.

3. With the valve closed, apply 10 psi air pressure to the outlet opening.

4. Immerse valve completely in water and inspect for air bubbles around the valve stem.

Leakage through valve will indicate a defective valve face or valve seat. Leakage around the valve stem will indicate a porous or cracked bellows within the valve.

If any leakage appears during the above tests, the valve should be replaced with a new or approved pre-tested valve.

FUEL SERVICING

FUEL OIL SPECIFICATION

The fuel oil recommended for the engine must be distilled fuel and should conform to the American Society for Testing Materials (ASTM) Specification D-975 No. 2-D. For extreme low temperatures or for engines at high altitudes, number ID fuel with a minimum cetane value of 45 may be desired.

FUEL OIL SYSTEM

FILLING

Fuel filling may be done from either side of the locomotive. Apply the fuel hose to the fill opening located near the upper fuel level sight gage. Observe the upper sight gage periodically during filling to determine when tank is full.

Fuel supply may be determined at any time by observing the upper and lower sight gages for the indicated fuel level.

The two fuel tank levels are self-equalizing due to their interconnecting pipe arrangement.

DRAINING

The main and auxiliary fuel tanks each contain two hex head drain plugs located at the outer ends of each tank sump. These drain plugs permit draining of condensate or small quantities of fuel. They contain a drilled passage and when partially screwed out will allow a small stream to flow.

NOTE: Do not attempt to completely remove the drain plugs. A cross-pin at the inner end of the plug prevents its removal. To gain access to the sump, after draining the tank, remove the flange assembly containing the drain plug.

The fuel tank sump should be drained periodically to remove any accumulated water and sediment.

If water should be found in the fuel, a check of the engine fuel filters, system and supply should be made immediately.

Water can cause excessive damage to the system parts.

Large quantities of fuel may be quickly drained from either tank by removal of the large drain plug located at the bottom of each tank. These plugs along with the sump end covers can be removed to permit access to the tank if internal cleaning becomes necessary.

FUEL OIL SYSTEM FUEL

OIL FILTERS

DESCRIPTION (See FIG. 5-1)

The fuel injection equipment is protected from foreign material by a primary and a secondary filter assembly. Both are attached to a supporting bracket mounted on the engine near the fuel booster pump.

The primary filter assembly consists of a cast-manifold and two filter shells, each containing a honey-comb cotton filter element.

The shells are arranged for parallel flow and the assembly is pipe-connected to the suction side of the booster pump.

FUEL FILTERS
FIG. 5-1

FUEL OIL SYSTEM

The primary filter removes comparatively large particles of foreign matter from the fuel before it reaches the pump .

The secondary filter assembly is similar to the primary assembly except that it contains three shorter filter shells, each containing a honey-comb cotton filter. The secondary filter is pipe-connected between the booster pump discharge opening and the engine fuel header. It completes the filtering process by removing the remaining small foreign particles to protect the engine fuel injection equipment.

ELEMENT CHANGING

A gradual drop in fuel flow and header pressure indicates that fuel filters have become restricted and should be renewed.

****
CAUTION
****

NEVER INTERCHANGE FILTER ELEMENTS BETWEEN THE PRIMARY AND SECONDARY FUEL FILTERS. THE ELEMENTS APPLIED TO EACH FILTER MANIFOLD HAVE DIFFERENT FILTERING RANGES TO INTERCHANGE ELEMENTS WILL CAUSE SERIOUS DAMAGE TO THE INJECTION EQUIPMENT.

To change elements proceed in the following manner: Refer to FIG. 5-1.

1. Open the drain cock and drain the filter shells.

2. Loosen cover nut until the center bolt is free, than lower the shell assemblies.

3. Remove and discard used filter elements. Wipe inside of shells clean.

4. Remove protective wrapper from new elements, place element in shell and press down firmly. Fill primary filter shells with clean fuel oil.

5. Use new cover gaskets and place shells against filter heads. Engage center bolts and tighten cover nut securely.

FUEL OIL SYSTEM

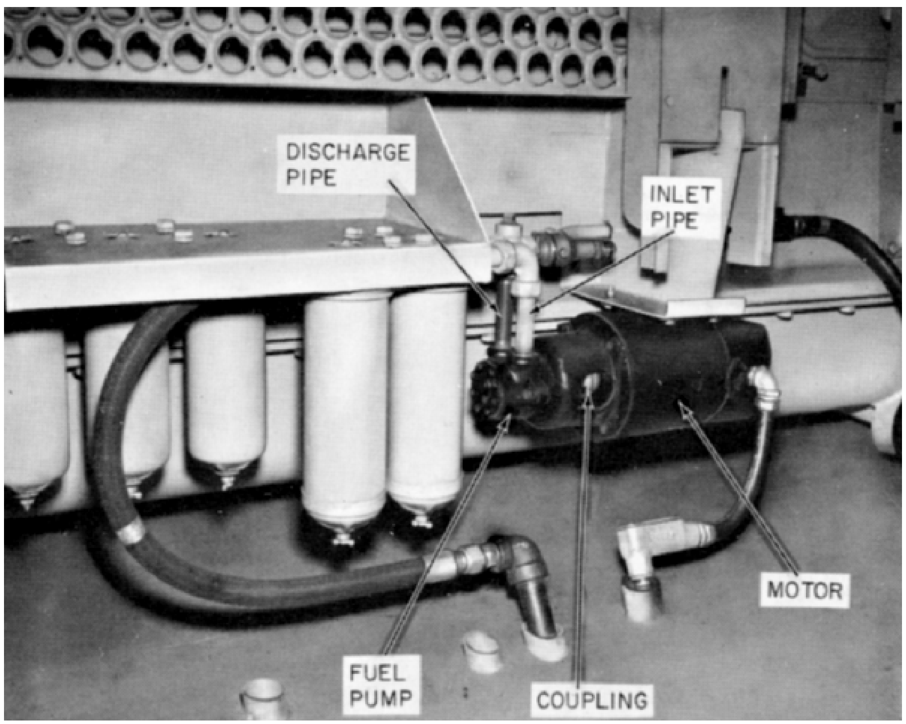
6. Close drain cocks. Start fuel booster pump. Loosen air vent screws on secondary filter. When the fuel stream is free of air bubbles, close vent screws.

7. Check shell gaskets and vent screws for leakage after a short period of operation.

BOOSTER PUMP AND MOTOR

DESCRIPTION

The fuel-booster pump is a gear-type pump driven directly by an electric motor through a flexible coupling. It maintains a constant supply of fuel to each cylinder injection-pump.



FUEL BOOSTER PUMP
FIG. 5- 2

FUEL OIL SYSTEM

The pump housing is constructed as part of the motor end cover which eliminates shaft alignment problems. The motor base is fastened to its supporting bracket which is bolted to the side of the engine frame on the left side of the locomotive.

Pump rotation is indicated by an arrow on the pump housing and is CCW when looking at the pump drive-shaft end.

INSPECTION AND MAINTENANCE

Check coupling parts, pump housing, rotors and idler gear for wear and chipped or worn pump parts caused by the abrasive action of foreign particles in the fuel oil.

Care must be taken, when connecting pump piping, that pump housing is not distorted by misaligned pipes. Also, when applying pipe compound apply to the male fittings only to prevent compound from entering pump and system. Pipe compounds contain abrasive material which will damage pump parts if allowed to enter the system.

PUMP MOTOR

The 75-volt d-c motor is compound-wound and totally enclosed. The armature shaft rotates on sealed ball bearings. The motor commutator brushes can be removed by removing gasketed covers over the brush openings.

The fuel pump motor assists in regulating fuel header pressure. The motor is constructed to have a variable speed range from 1, 800 rpm to 2, 200 rpm when pumping against 40 psi and 0 psi respectively.

NOTE: Do not run the pump without fuel for longer than two minutes. Pump gear damage will result from lack of fuel oil which lubricates pump parts.

ENGINE DRAIN SYSTEM

A slight leakage of fuel from the injection pump and the injection nozzle on each power cylinder is normal. This leakage of fuel is required to lubricate pump and injection nozzle parts and must be drained to the fuel tank.

FUEL OIL SYSTEM

A system of passages within each cylinder assembly conducts leakage fuel through the upper portion of the cylinder, around the base of the injection pump and downward through the pump push rod cavity.

Passages in each cylinder base are aligned with drilled passages within the engine main frame. A fuel drain header pipe is attached to each side of the engine main frame with a connector to each of these passages to collect drainage fuel. Each header pipe is constructed with an open stand pipe at one end. The other end is connected to return drainage fuel to the auxiliary fuel tank.

The fuel drain system must remain free of obstructions to permit gravity flow of fuel to the tank. If the system should become clogged, fuel dilution of the lubricating oil may occur.

SYSTEM PRIMING

Normally it is not necessary to prime the fuel system as the regulating valve will vent the system when the booster pump is started. However, it is good practice when replacing a primary filter element, to fill the filter shell with clean fuel before installing. This will insure against pump damage due to insufficient lubrication during initial start and allow quicker priming of the system.

RELIEF VALVE

DESCRIPTION (See FIG. 5-8)

A relief valve (A), is located in the fuel system between the booster pump discharge and the secondary filters. The valve protects both the booster pump motor against electrical overloading and the system against excessive pressure caused by clogged secondary filters or fuel flow stoppage in the pressure side of the system.

ADJUSTMENT

1. Remove 1/2 inch pipe plug and install a calibrated 100 psi test gage at the test point (1).

2. Remove secondary filter discharge pipe and install a 3/4 inch pipe plug in opening. Do not tighten plug-excessively or filter head may be cracked.

FUEL OIL SYSTEM

3. Start booster pump and observe test pressure gage. See DATA for correct valve setting.

4. To correct valve setting remove valve cap, loosen adjustment locknut and adjust slotted screw to set desired pressure. Turn screw in to raise pressure. Turn screw out to lower pressure.

5. Tighten locknut and replace valve cap. Check gage reading and stop booster pump.

6. Remove test gage and restore piping to normal.

REGULATING VALVE

DESCRIPTION (See FIG. 5- 9)

A pressure regulating valve (B), is mounted near the secondary fuel filter and is located in the system between the fuel tank and the engine header. It is set to maintain the fuel header pressure when measured at test point (2). See DATA for correct valve setting. When setting the fuel header pressure, the engine must be stopped, the primary and secondary filters must be clean, and the fuel in the system must be free of air bubbles.

When fuel header pressure drops slowly over a period of time, it is usually a condition of clogged fuel filters rather than incorrect setting of the pressure regulating valve. Filter elements should be renewed first, then if necessary adjust the pressure regulating valve as follows:

ADJUSTMENT

1. Install a 100-psi test gage at test point (2).

   NOTE: Be sure clean filter elements have been installed.

2. Start the fuel booster pump and observe fuel pressure on test gage. Do not start engine.

3. Remove valve cap and loosen adjustment lock-nut. Adjust slotted screw to set desired pressure. See DATA for valve setting. Turn screw in to raise pressure or out to lower pressure.

4. Tighten adjustment lock-nut and replace valve cap. Check gage reading.

5. Stop booster pump, remove test gage and replace pipe plug.

FUEL INJECTION EQUIPMENT

PUMP REMOVAL (See FIG. 5-3)

1. Remove high-pressure fuel line between pump and injector. Cover openings in pump and fittings with threaded caps or tape.

2. Remove fuel branch line between the fuel header line and pump. Cover header pipe connection after fuel has drained from header.

3. Remove spring clip and the adjustable link that connects the pump rack to the fuel control linkage.

4. Remove mounting bolts at base of pump and lift pump from engine. Cover area where pump was removed to prevent foreign matter from entering engine. Seal pump inlet opening.

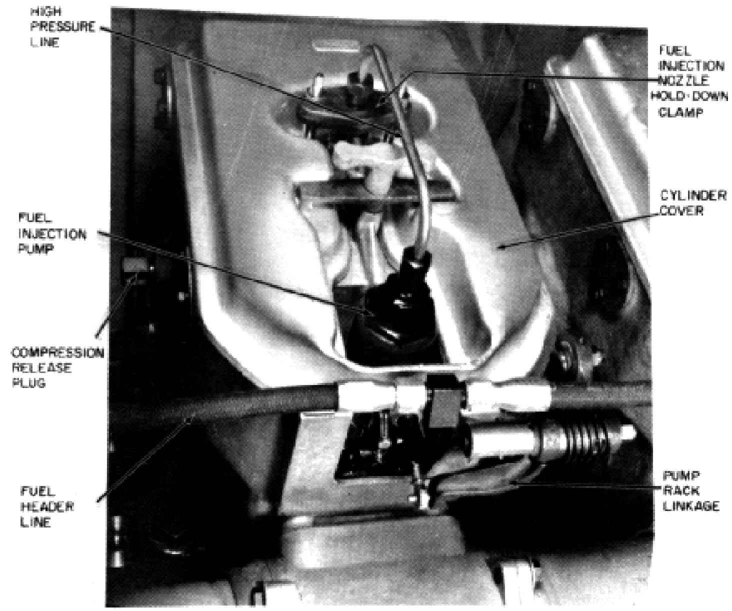
INSTALLATION (See FIG. 5-3)

****
CAUTION
****

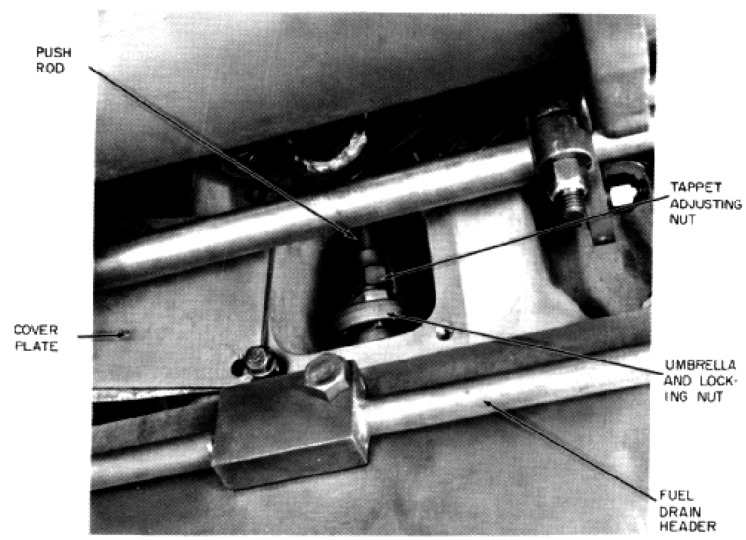
BEFORE INSTALLING PUMPS ON ENGINE, SHORTEN PUSHROD TRAVEL. REMOVE COVER AT BOTTOM OF CYLINDER. SEE FIG. 5-4. LOOSEN LOCK NUT AND TURN TAPPET ADJUSTING NUT 4 OR 5 FULL TURNS TO SHORTEN TRAVEL. EXCESSIVE PUSHROD TRAVEL CAN DAMAGE PUMP AND PUSHROD ASSEMBLY.

NOTE: When installing a pump, be careful that no dirt or foreign matter enters fuel-oil lines, connections, or the engine. Keep plugs or seals in place until connections are to be made.

1. Install pump on cylinder and secure mounting bolts. See DATA for bolt torque.



CONNECTIONS TO FUEL INJECTION PUMP
FIG. 5-3



FUEL INJECTION PUMP PUSH ROD ADJUSTMENT
FIG. 5-4

FUEL OIL SYSTEM

2. Connect fuel header and high-pressure fuel lines.

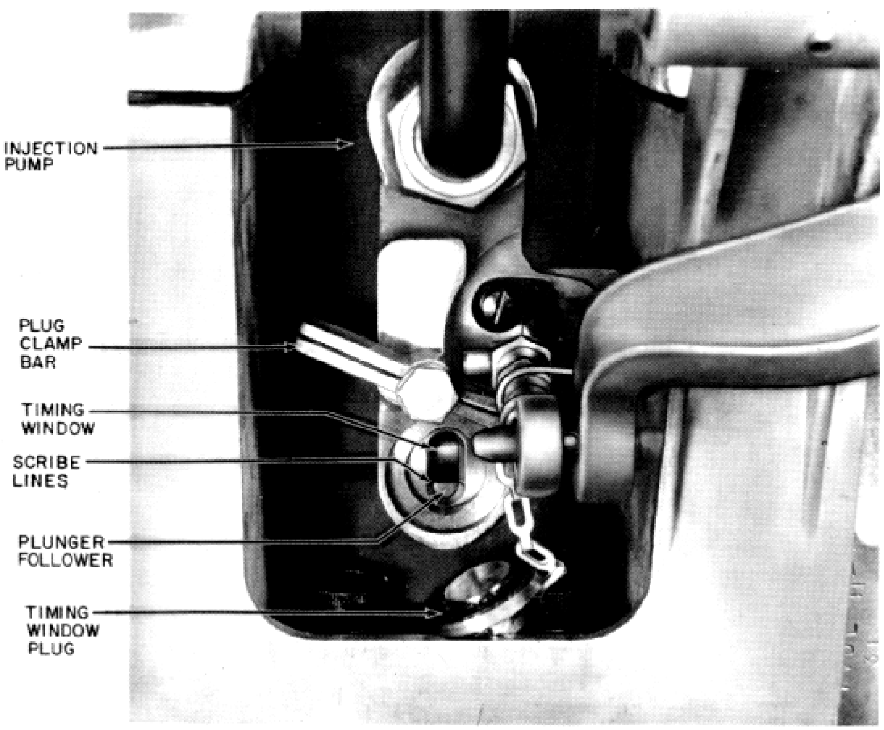
3. Install adjustable link between pump rack and fuel control linkage. Secure the link with the spring clip.

PUMPING TIMING ADJUSTMENT (See FIG. 5-5 and FIG. 5-6)

When timing fuel injection pumps, the following indicating marks must be referred to:

1. Scribed lines at pump timing window.

2. "Set marks" on the timing ring of the barring over hub.



INJECTION PUMP TIMING WINDOW
FIG. 5-5

FUEL OIL SYSTEM

A timing window, covered with a plug, is located on the lower outside of the pump housing. Each side of the window is scribed with a timing line. The plunger follower in the pump appears behind the timing window and its upper edge is used to set pump timing. See FIG. 5-5. When the pump is properly timed, the upper edge of the plunger follower will exactly line up with the scribed timing marks at the edge of the pump window.

The engine timing ring is located on the outer face of the barring-over hub at the free end of the engine. The ring contains four pump "set" marks and each mark contains two numbers. The numbers identify the eight pairs of opposite cylinders. For example: (1-8) (2-7).

There are two indicating points mounted above the timing ring. One pointer indicates right bank timing and the other left bank timing. When viewing the timing ring from the free end of the engine as in FIG. 5-6, note the right bank indicating pointer appears on the left hand side. The left bank pointer appears on the right hand side.

****
CAUTION
****

INCORRECT INJECTOR PUMP TIMING CAN CAUSE EXCESSIVE PUMP PLUNGER TRAVEL WHICH MAY RESULT IN DAMAGE TO THE PUMP.

Number 1 right cylinder pump is used as an example and is a good starting point to use when all engine pumps are to be timed.

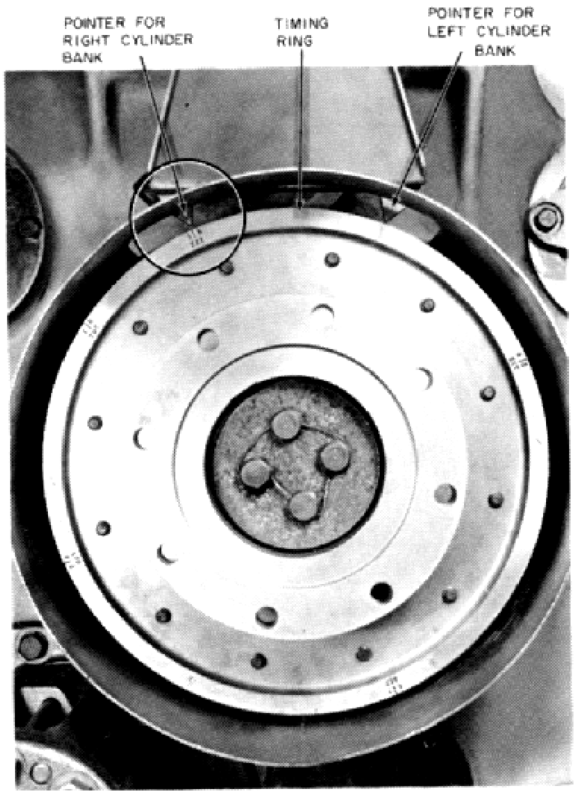
1. Back off compression release plugs one full turn on all cylinders.

2. Slowly, barr the crankshaft over in its direction of rotation until timing mark "1-8 SET" exactly lines up with the right bank pointer. See FIG. 5-6.

3. Remove cylinder head covers.

4. Check that all valves are closed on 1-R cylinder. (If valves are closed a small amount of free movement will be noted by manually moving both rocker arms.)

FUEL OIL SYSTEM



FUEL PUMP SET MARKS ON TIMING RING
FIG. 5-6

5. If all valves are not closed, rotate the crankshaft one more revolution in direction of rotation. Stop on "1-8 SET" mark and recheck valves.
6. Remove the plug from the fuel pump timing window.
7. Remove the cover over the pushrod adjusting nut. See FIG. 5-4.
8. Adjust the fuel pump pushrod adjusting nut until the top edge of the plunger follower is exactly aligned with the scribed marks at the sides of the fuel pump timing window. See FIG. 5-5.
9. Lock the pushrod adjusting nut and recheck alignment of pump timing marks.
10. Replace pushrod adjusting covers and the fuel pump timing window plug.

FUEL OIL SYSTEM

FUEL NOZZLE

FUNCTION

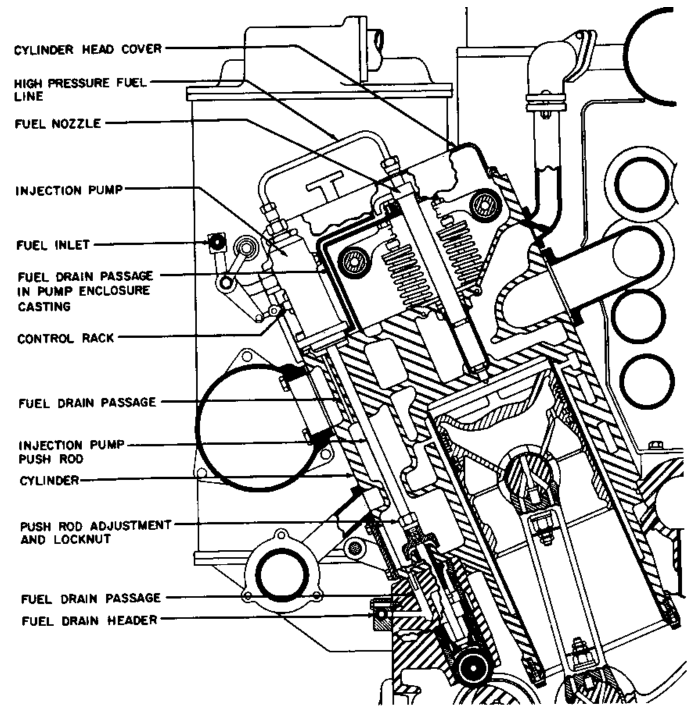
The nozzle is the device used to inject metered amounts of fuel into the cylinder clearance at the exact required instant during the compression stroke.

The valve in the nozzle seals the fuel passage into the nozzle tip and prevents leakage of fuel.

The spray holes atomize the fuel into a very fine mist in a symmetrical pattern, to mix with the compressed air to start ignition and maintain combustion.

DESCRIPTION

The fuel-injection nozzle, see FIG. 5-7, is located in the cylinder head and injects fuel oil directly into the



CUT AWAY VIEW SHOWING FUEL INJECTION
SYSTEM IN CYLINDER
FIG. 5-7

FUEL OIL SYSTEM

cylinder. It consists of a holder body with a fuel inlet duct and drain duct, a valve and valve body, nozzle tip, valve loading spring, stop plate, spring pressure adjusting shims, and assembly nut to hold the assembly together.

Fuel enters the nozzle holder through the connection at the top and passes down through the holder to the valve. The loading spring keeps the valve closed.

When the hydraulic pressure of the fuel (3, 500 to 3, 800 psi) in the chamber between the valve seat and valve, exceeds the valve-spring pressure, the valve is forced open.

When the valve is open, fuel oil at high pressure flows from the chamber between the valve and valve seat, down to the nozzle tip and is sprayed into the cylinder through the spray holes in the nozzle tip. As the holes are only a few thousandths of an inch in diameter, the oil sprayed through them forms a fine mist which mixes with the compressed air in the cylinder to form a combustible mixture. This mixture is then ignited by the heat created by compressing the air trapped in the cylinder. It burns rapidly and produces the increased pressure needed to drive the piston on the power stroke.

A small quantity of fuel leaks upwards between the valve stem and valve bore to lubricate these parts. It then goes through a drain line from the nozzle holder body into a drain passage in the pump enclosure casting. From here it combines with leakage fuel from the injection pump in the cavity under the pump. From the pump cavity, leakage fuel drains downward through a drilled passage into the pushrod cavity.

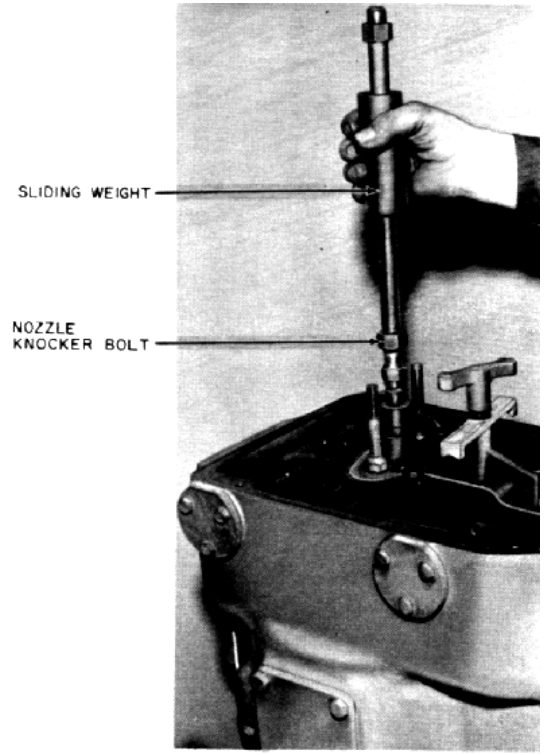
REMOVAL

The nozzle holder must be handled with care and it is extremely important to maintain cleanliness in the handling of the complete unit or parts. DO NOT BUMP THE TIP. Place threaded caps over connections to prevent dirt from entering. Place a cover over the cylinder opening to prevent foreign matter from entering the engine.

To remove an injection nozzle from the engine for servicing or renewal, proceed as follows:

1. Clean the area around the high pressure fuel line units with fuel oil and a stiff bristle brush.

FUEL OIL SYSTEM



NOZZLE KNOCKER TOOL
FIG. 5-8

2. Remove the high pressure fuel line and seal off the line and nozzle openings using caps or tape.

3. Remove the nozzle mounting nuts and using the nozzle knocker tool shown in FIG. 5-8, remove the nozzle with its copper sealing gasket.

INSTALLATION

Before installing the fuel nozzle, tighten the packing gland around the nozzle bushing in the top deck of the cylinder head to guard against possible water leaks.

1. Clean out all carbon in the nozzle holder recessed port on the cylinder head and make sure lower end of nozzle holder is clean.

FUEL OIL SYSTEM

2. Place a NEW copper gasket on the lower end of the nozzle.

3. Insert lower end of nozzle holder into the recessed port, orient fuel drain, and place clamp plate over nozzle holder and holder studs.

4. Apply washers and nuts, and tighten evenly to torque value listed in DATA. Do not over tighten.

Leakage past the nozzle holder will cause an accumulation of carbon by leakage of fuel mixture and exhaust gases that eventually will form a solid mass of carbon between fuel nozzle port and fuel nozzle making removal of the nozzle holder difficult.

STORING SPARE NOZZLES

If the fuel nozzle assembly is not immediately installed on the engine, pour clean lubricating oil, SAE-10, into fuel inlet and drain holes and close with a threaded protector cap.

Protect nozzle tip by covering the spray holes with grease; then dip the nozzle in a hot plastic dip of ethyl cellulose. Cover the inlet port of the nozzle with hot plastic dip.

Handle carefully to avoid damage to nozzle tip or external threads.

Never take a chance with injection equipment. If it needs renewing -- renew it, rather than try to extend its life.

FUEL OIL SYSTEM

DATA

TANK CAPACITY

Large Tank	2,900 Gal.
Small Tank	1, 700 Gal.
Water or Aux. Fuel Tank	1, 200 Gal.

FUEL BOOSTER PUMP

RPM.	1, 800
Pressure	40 psi
Fuel	3 GPM

VALVE SETTINGS

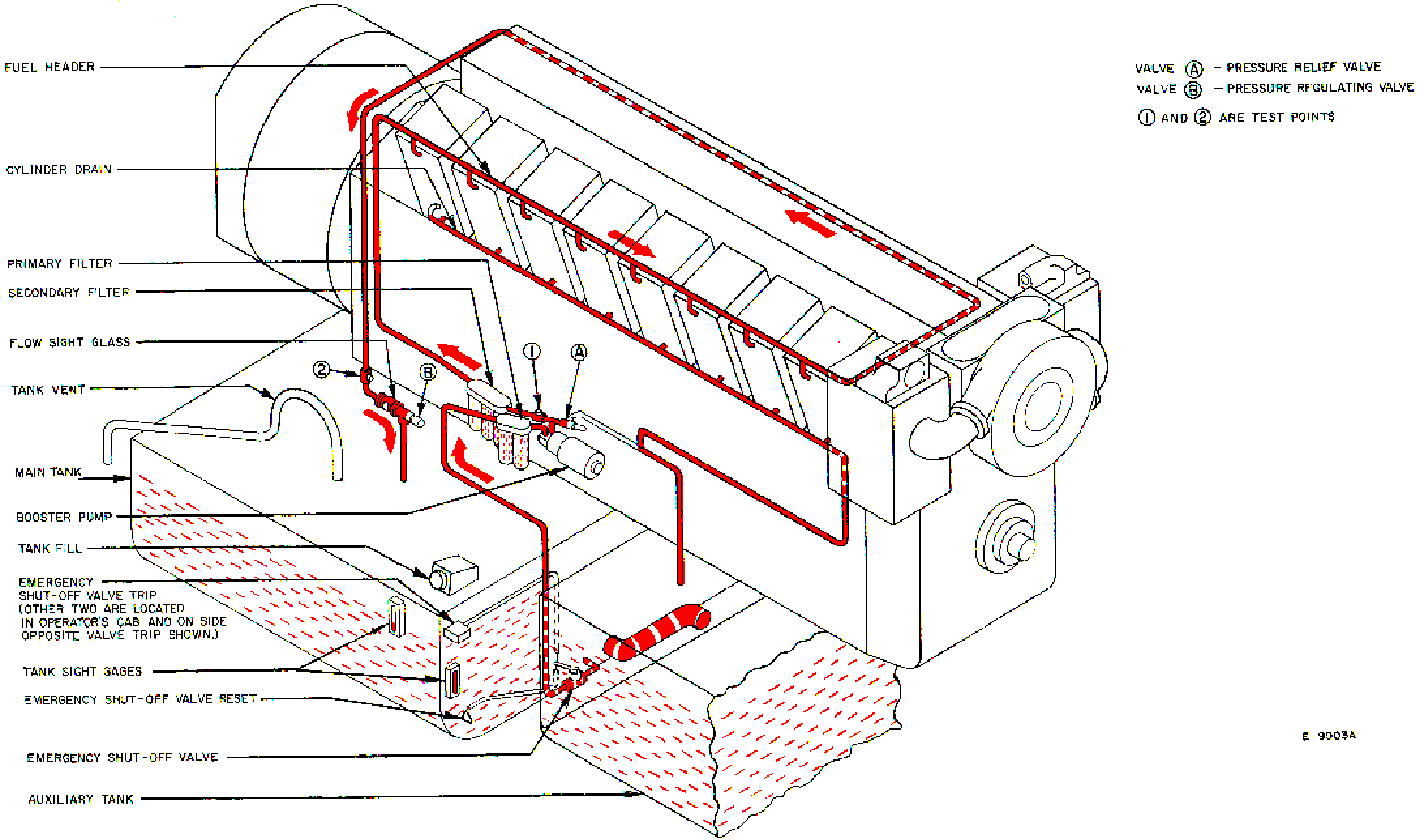
Pump Relief	75 psi
Pressure Regulating	35 psi

INJECTION PUMP

Timing	33 BT DC

TORQUE VALUES

	LB. FT.
Injection Pump Adapter Sleeve	320 - 340
Delivery Valve Holder	300 - 320
Fuel Nozzle Mounting Nuts	30 - 35
Nozzle Assembly Nut	130 - 150
Injection Pump Mounting Bolts	45 - 50



SECTION 5 - 523

ENGINE FUEL OIL SYSTEM - FIG. 5-9

COOLING WATER SYSTEM

DESCRIPTION

COMPONENTS

The cooling system consists of the following principal components:

1. Water Storage Tank
2. Water Pump
3. Water Inlet Headers
4. Water Discharge Header
5. Flow Control Valve
6. Radiator Panels
7. Cab Heaters

SYSTEM OPERATION

The water storage tank is in an elevated location on the engine side of the bulkhead between the engine compartment and the radiator compartment. A water level sight glass is mounted on the side of the tank. Water and water treatment may be added through the fill pipe on top. On each side an additional pipe extends from beneath the underframe to the inside of the tank near its top. These pipes are for pressure filling, vent and overflow purposes. See FIG. 6-5.

The lubricating oil cooler is bolted to the bottom of the water storage tank. Water flows down through vertical tubes inside the cooler to cool lubricating oil circulating around the tubes. From the lube oil cooler water enters the gear-driven centrifugal water pump.

Water discharged from the pump enters a lateral passage in the free end cover of the engine which distributes it to the inlet water header pipes, the turbo-charger and the intercoolers.

Each of the two inlet water headers is made up of eight individually re-movable sections, with each section including a flanged jumper pipe bolted to the cylinder. The sections are connected by Dresser couplings. The assembly is sup-ported by the connections to the cylinders.

COOLING WATER SYSTEM

The cylinder contains a wet-type liner surrounded by vertical fluted passages. The incoming water enters half of these passages and flows downward to the bottom of the liner where it crosses over to the alternate passages and flows upward into passages in the cylinder head to cool the upper head area. It then flows to the outlet header.

A portion of the system water flows through two intercoolers which cool the engine air supply. They are fabricated steel cases containing tube and fin- type radiator cores. Water enters the intercooler bases from a passage in the free-end cover of the engine. From the intercooler bases, water flows to the inlet water headers and also upward through the intercooler tubes. The two top covers conduct water to the discharge water header.

The turbocharger, located at the free end of the engine, is water cooled. Water enters the turbocharger casing through a jumper pipe flange connected to the free end cover water passage. Water is discharged through three openings located on the exhaust inlet side near the top of the turbocharger casing and connected to the left intercooler discharge pipe.

Water is supplied to the cab heater and air compressor from the engine inlet water header and is returned to the engine outlet water header.

The outlet water header is a single pipe centrally located lengthwise over the engine. Welded-in branch pipes are connected to individual cylinders by Dresser fittings. The water discharge header pipe is connected to a junction box mounted on top of the right intercooler. Water discharged from the turbocharger and intercoolers combines with cylinder discharge water and flows through a single pipe from the top of the right intercooler to the flow control valve.

The flow control valve regulates water temperature by routing the water as follows:

1. Directly to the water storage tank - when minimum engine cooling is required.

2. To the forward two radiator sections - when partial engine cooling is required.

3. To all radiator sections - when full engine cooling is required.

COOLING WATER SYSTEM

Water is cooled in the radiators and returned to the storage tank. When only minimum cooling is required, or when the engine is stopped, the flow of water to the radiators is cut off and they drain by gravity into the storage tank. Thus, there is no possibility that they will freeze in cold weather .

COOLING WATER TREATMENT

The water used in the engine cooling system should not contain an excessive amount of minerals which can cause scale formation when the water becomes heated. Such scale, if permitted to form on the inner surfaces of the cylinder-jackets, radiator-cores and other areas, will reduce heat transfer and cause restriction of water flow. Only clean, treated water should be used in the cooling system. Untreated distilled water is not recommended for use in the system because of its high content of free oxygen which will cause corrosion and rusting.

Water is said to be either acid or alkaline, depending on its chemical makeup. Proper alkaline condition of water is important in order to prevent corrosion of internal system parts.

The water should be tested for alkalinity once a month, or more often if necessary. This test must indicate that the cooling water has a ph value of 8.5 or greater. If the ph is less than 8.5, further treatment is necessary to protect against corrosion.

A number of suitable commercial chemical water softeners are available. One widely used in locomotive cooling systems is sodium chromate. To maintain a ph value of 8.5 minimum and a chromate concentration of 2000 parts per million minimum, chromate compound should be used in the proportion of 1/2 ounce by weight per gallon of cooling water.

Treatment chemicals should not be added to the system in a dry form. They should first be dissolved in a small quantity of water, then added to the system. If applied dry, directly to the system, the compound may not dissolve completely. Undissolved compound may cause restrictions within the system passages.

COOLING WATER SYSTEM

If it is desirable to use a type of water treatment other than that mentioned, the manufacturer's recommendations must be closely followed.

FILLING

The locomotive cooling water system can be pressure filled through either fill pipe. To avoid damage do not apply over 25 psi water pressure to the system when filling. Filling may also be accomplished through the pipe on top of the water storage tank.

The pressure fill pipes are so arranged in the water storage tank that system venting and filling to proper level is automatic. When filling from one pipe the other functions as a vent and overflow. If excessive overflow is permitted when adding water to the system, a weakening of the water treatment will occur.

When filling the system from a completely drained condition, adjust the water to proper level after starting the engine. Correct system water level is indicated by marks on the side of the storage tank.

Large fluctuations in sight gage water level will occur during engine operation. When cooling is required, a portion of the water leaves the tank and is diverted to the radiators. This will lower the water level in the sight gage and is a normal condition which does not indicate that water should be added.

Normal operating temperature of the engine discharge water is thermostatically-controlled to maintain a temperature between 170 F and 175 F. This temperature can be measured at the flow control valve test opening. No manual adjustments are provided.

The high temperature alarm switch is adjusted to close its electrical contacts when the engine discharge water temperature is excessively hot. Closing and opening temperatures are listed on the DATA sheet at the end of this section.

COOLING WATER SYSTEM

DRAINING

Three manually-operated shut-off valves are used in the cooling system. See FIG. 6-5.

1. MAIN SYSTEM DRAIN VALVE (A). This valve, located near the base of the lubricating oil cooler, drains water from the engine, storage tank, and lubricating oil cooler.

2. SECONDARY DRAIN VALVE (B). This valve, located near the compressor, drains water from the air compressor, cab heater, and associated piping. Valve (C) must be open when draining through valve (B).

3. SHUT-OFF VALVE (C). This valve is located in the operator's cab at the cab heater inlet pipe. It regulates or stops water flow to the cab heater.

The system may be completely drained by opening valves (A), (B), and (C). In freezing weather, also remove the 1/4 inch drain plug located in the bottom of the water pump impeller casing.

FLOW CONTROL VALVE

Cooling water temperature is regulated by the flow control valve, an assembly made up of the six thermostats, two piston-type valves and a filter screen, all housed in a fabricated steel case.

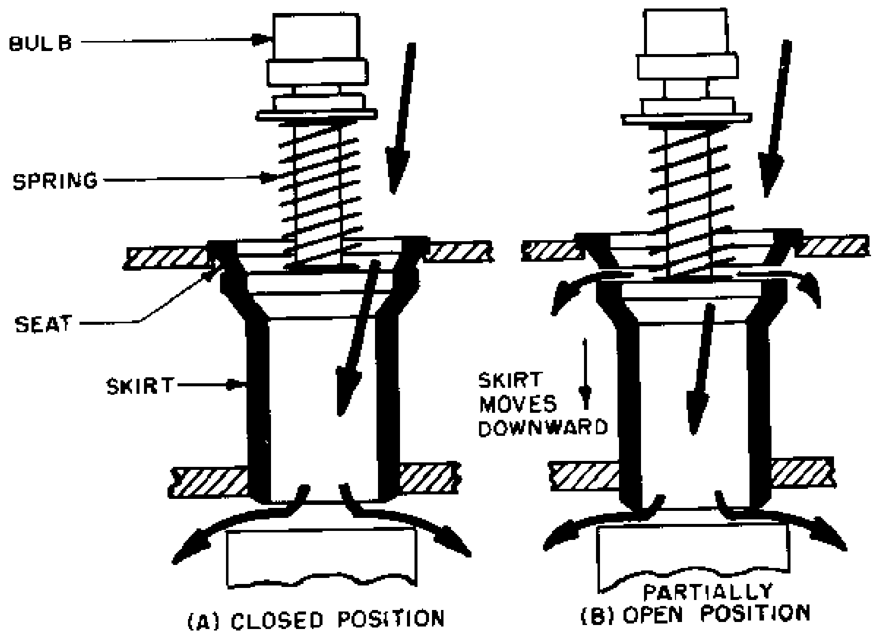
Located on top of the water tank, the flow control valve case has a removable top cover to permit access to the internal parts. A temperature or pressure gage can be installed in the pipe boss on the side of the case for test.

VALVES WITHIN THE CASE

The thermostats function as two-way valves. When water temperature is below their operating point, as in FIG. 6-1 (A), they pass the water directly through their cylindrical bodies to the water tank below.

When the water temperature increases, the temperature-sensitive compound in the bulb (located on top) expands, overcoming spring pressure and forcing the skirt downward. (See FIG. 6-1 (B).) As this skirt moves, the opening at the

COOLING WATER SYSTEM



OPERATION OF THERMOSTATS
FIG. 6-1

bottom becomes more and more restricted, while the previously closed opening at the top of the skirt - increasing in size - permits water pressure to start building up in the adjacent chamber.

The thermostats are identical and are individually renewable. The cooling system will operate satisfactorily with as few as four of the six thermostats functioning, except during extreme conditions of ambient temperature.

Successful operation of the system during freezing weather depends upon water flow through the radiator sections being either at a high rate or completely off. If trickles of water were permitted to pass through the radiators, ice would form in the tubes.

These conditions of flow are controlled by the two "snap action" piston-type valves, V1 and V2. (See FIG. 6-2.) Vertically-mounted within the case, they each consist of an upper and a lower piston connected by a stem. These valves are identical and interchangeable. The center portion is hollow to permit water which leaks past the upper pistons to return through the valves to the storage tank. Thus leakage has no effect on operation. To assure accurate operation, the weight of each valve is held within close limits during manufacture.

COOLING WATER SYSTEM

COMBINED OPERATION

The flow control valve regulates the temperature of the cooling system by directing water flow in the following manner:

1. When minimum engine cooling is required (FIG. 6-2):

   Water discharged from the engine enters Chamber A to flow downward through the filter screen and thermostats. Since the thermostats are below operating temperature, water passes through their lower openings to the tank.

2. When partial engine cooling is required (FIG. 6-3):

As the engine discharge water temperature rises, the thermostats begin to operate. Downward movement of the skirts partially restricts water flow to the tank. At the same time, openings at the top of the lower skirts allow water to enter Chamber B.

Pressure now begins to develop in Chamber B. When the thermostats have moved their skirts enough to cause this pressure to reach approximately 4 psi, valve V1 "snaps" upward to the limit of its travel.

Chamber B is now open to Chamber C, and Chamber C is closed to the storage tank by the lower piston of valve Vi. Water flows from Chamber C through the pipe connection to radiator sections 1 and 2.

At the moment valve V1 opens, water pressure in Chambers B and C falls somewhat below 4 psi, thus valve V2 does not open. Valve V1 remains up, however, because the area of the bottom of its upper piston that is exposed to pressure is still large enough to hold V1 up, even with reduced pressure.

COOLING WATER SYSTEM

If cooling demands are now satisfied, and water temperature remains approximately constant, no changes in valve position take place. Small variations in cooling requirements are satisfied by slight opening or closing of the thermostats to modulate the flow.

If cooling requirements should fall off, the thermostats will close the opening at the top of the skirt (and open the exit to the tank) sufficiently to lower the pressure in Chambers B and C to the point that gravity will pull valve VI down to closed position, resulting again in the situation depicted in FIG. 6-2. Air from the storage tank enters Chamber C to vent the radiator, permitting it to drain.

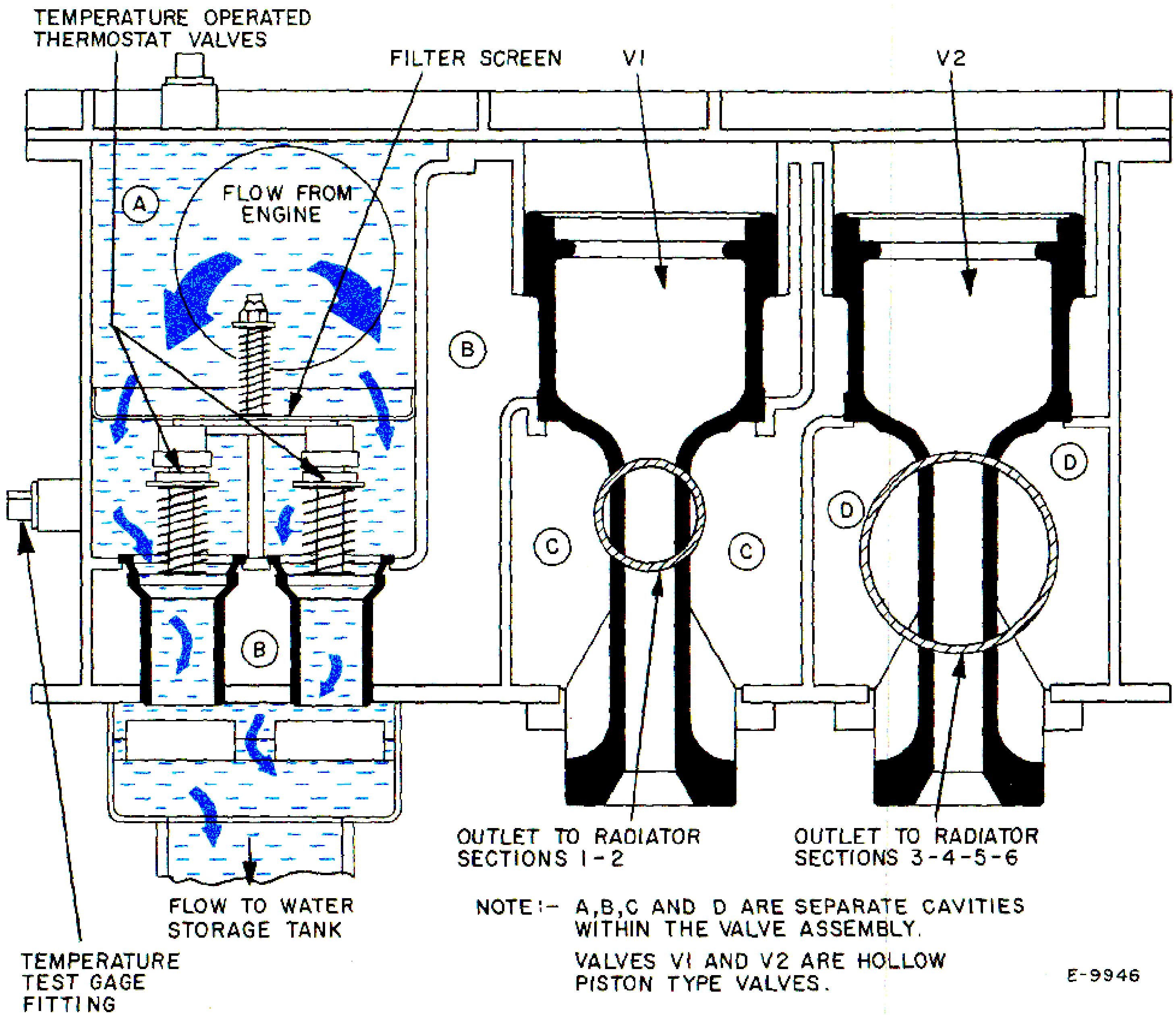
3. When full engine cooling is required (FIG. 6-4):

   If, with valve VI open, engine discharge water temperature continues to rise, the thermostats will still further restrict water flow to the storage tank, and at the same time allow increased flow to Chambers B and C. Pressure in these chambers again begins to increase. When it reaches approximately 4 psi for the second time, valve V2 will "snap" upward to the limit of its travel.

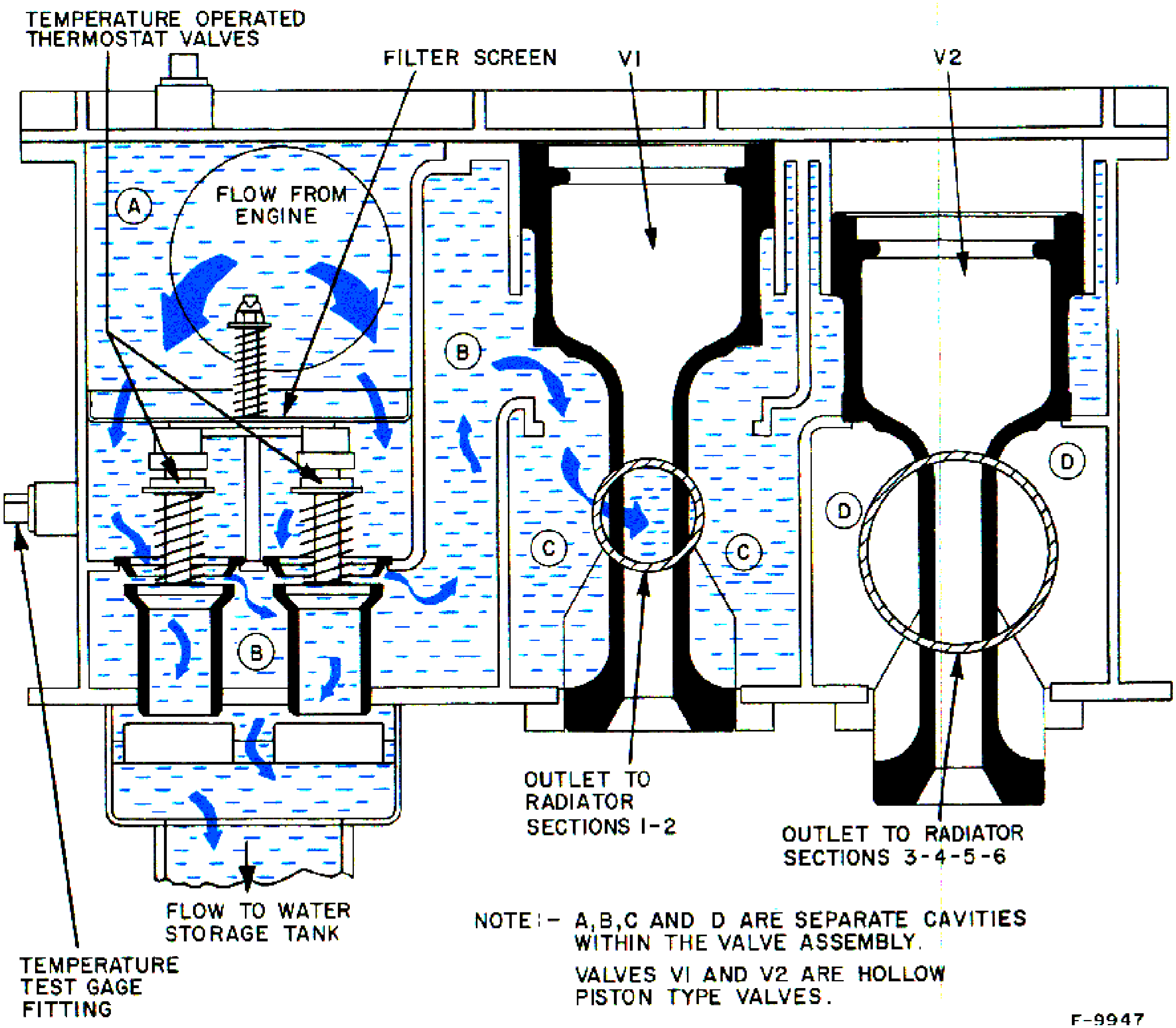
   Chamber C is now open to Chamber D, and Chamber D is closed to the storage tank by the lower piston of valve V2. Water flows from Chamber D through the pipe connection to radiator sections 3, 4, 5 and 6.

   Water is now flowing to all radiator sections, resulting in maximum cooling by the system. As before, small variations in cooling requirements are satisfied by slight opening or closing of the thermostats to modulate the flow.

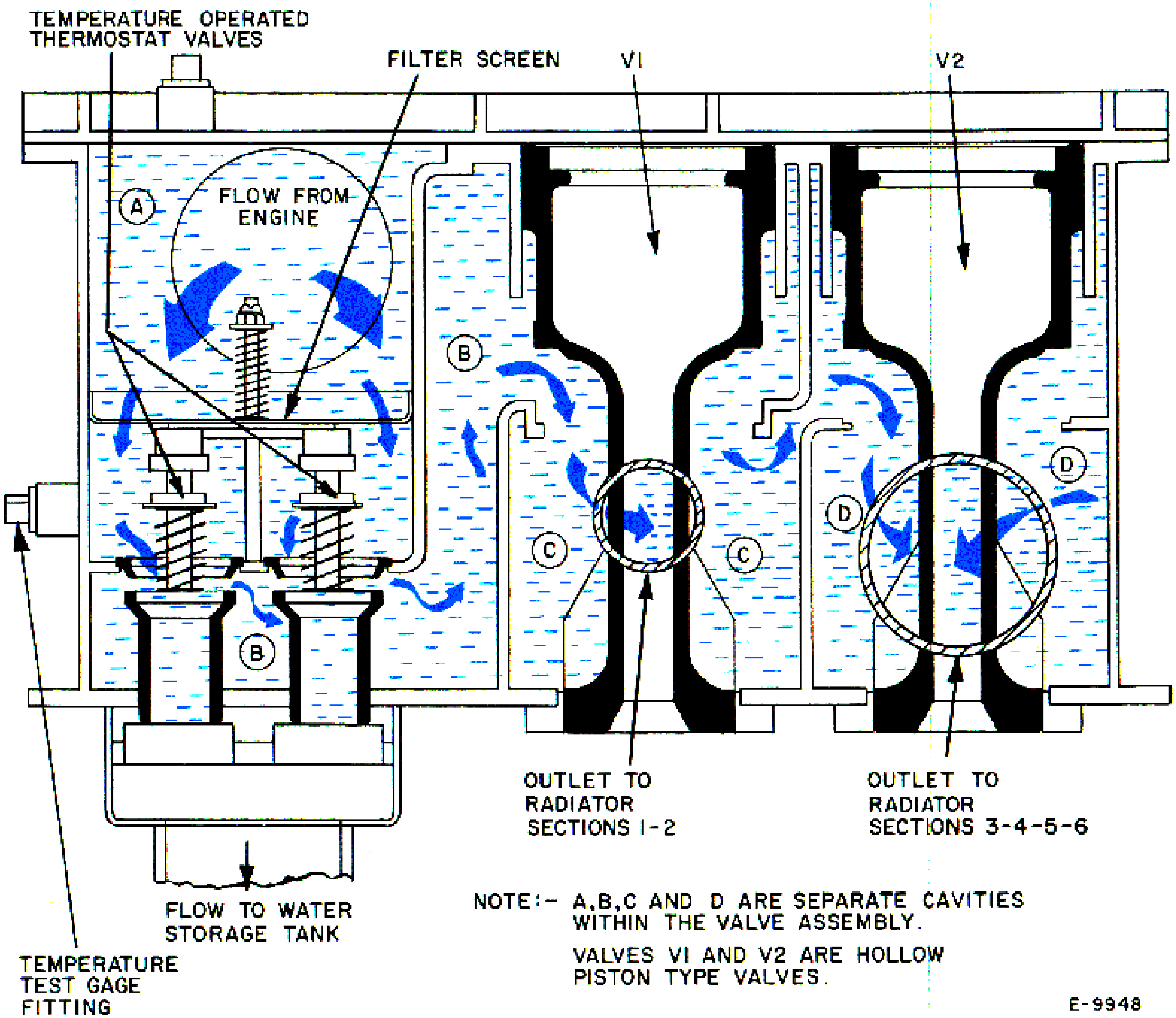
4. When engine cooling requirements decrease: When cooling requirements decrease sufficiently, the thermostats will operate to gradually shut off



FLOW CONTROL VALVE OPERATION
CONDITION: MINIMUM ENGINE
COOLING REQUIRED
FIG. 6-2



FLOW CONTROL VALVE OPERATION
CONDITION: PARTIAL ENGINE COOLING REQUIRED
FIG. 6-47



FLOW CONTROL VALVE OPERATION
CONDITION: FULL ENGINE COOLING REQUIRED
FIG. 6-48

COOLING WATER SYSTEM

water flow to Chambers B, C and D. When the pressure in these chambers falls off to the point that it can no longer hold valves V1 and V2 open, gravity will pull both valves to their lower position, completely stopping flow to all radiator sections. All water will drain out of the sections back to the tank, due to air from the tank venting the radiators through Chambers C and D.

As determined by load and ambient conditions, the flow control valve will now repeat its cycle of operation, starting in Step 1.

INSPECTION AND REPAIRS

It is not necessary to drain the water system to inspect or replace parts in the flow control valve. Proceed as follows:

1. Remove the top cover.

2. Check the piston type valves for free vertical movement by lifting and releasing.

3. Remove the filter screen and clean.

4. Remove the six thermostats and test in agitated hot water for proper operation. See DATA for temperature values. Replace defective units.

5. Reassemble parts and replace the top cover. Renew the cover gasket, if damaged.

ENGINE HIGH TEMPERATURE SWITCH

The engine high temperature switch, mounted on the flow control valve case, should be tested in agitated hot water for correct pick-up and drop-out temperatures. See DATA for the proper values.

RADIATORS

The radiator is made up of six individual sections, three on each side of the locomotive, mounted so as to slope downward from the locomotive center line to the outer sides. Wire screening is mounted over the upper side of the radiators to protect them from damage.

COOLING WATER SYSTEM

Radiator sections are alternately numbered, odd numbers on the right, even numbers on the left starting from the water storage tank.

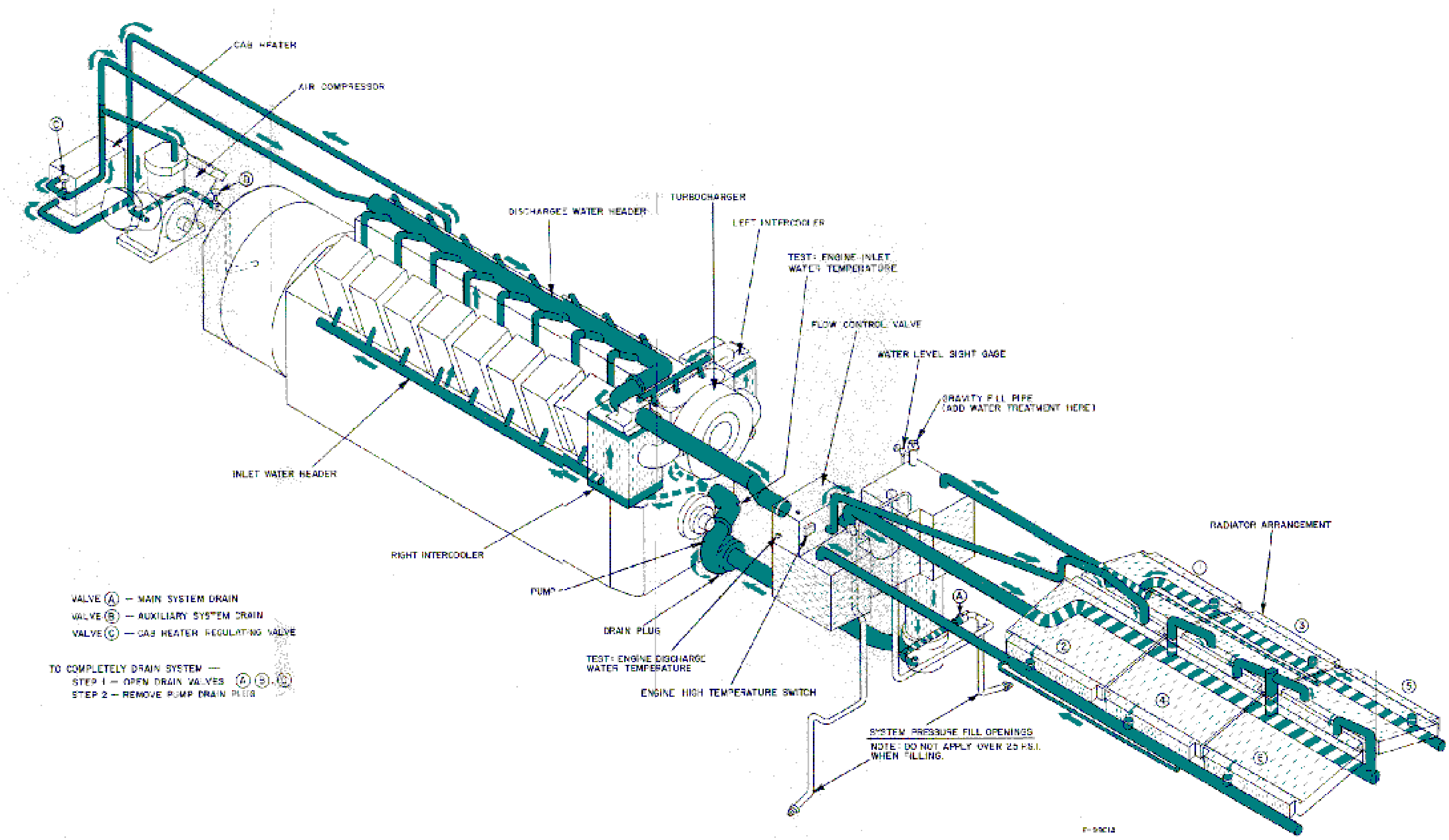
A pipe connects Chamber C of the flow control valve to the inlets of sections 1 and 2 of the radiator. Pipes connect Chamber D of the flow control valve to the inlets of radiator sections 3, 4, 5 and 6. Radiator pipe connections are made by various forms of Dresser fittings to permit easy removal.

Cooled water flows from the radiator panels through their respective drain header pipes to the water storage tank. A small pipe, connected parallel to the large drain header pipe, assures complete draining even if the locomotive is on track that is not level.

COOLING WATER SYSTEM

DATA

Water Capacity			220 Gals.
Flow Control Valve			
	Thermostats	- Start to Open	165 F
		- Fully Open	180 F
	Engine Temperature Switch		
		Contacts Close	200 F ± 2
		Contacts Open	193 F ± 2



LOCOMOTIVE COOLING WATER SYSTEM - FIG. 6-5

AIR SYSTEMS

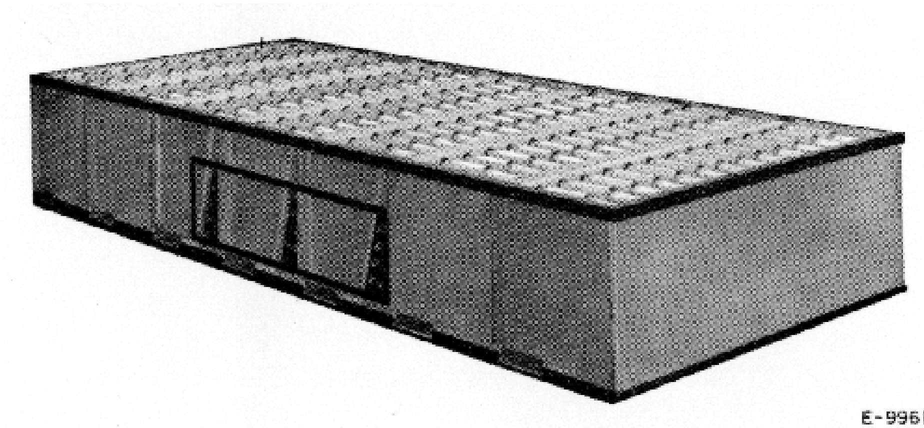
DESCRIPTION

LOCOMOTIVE AIR SYSTEM

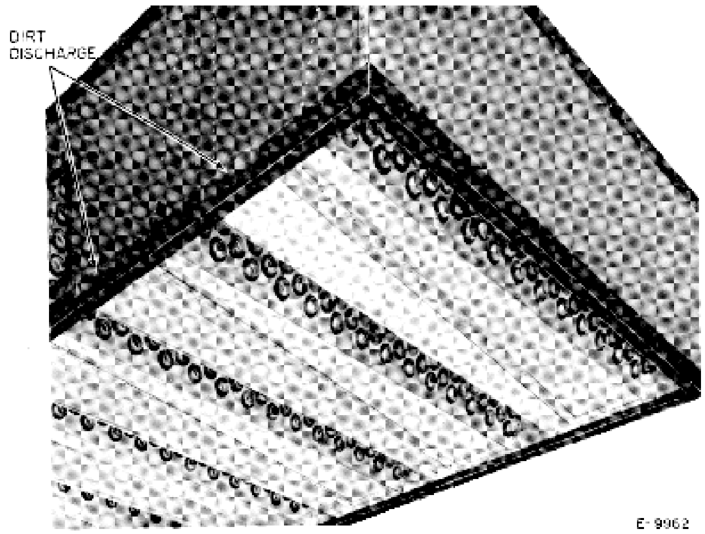
All air used by the locomotive enters horizontally through both sides of the radiator compartment at the opposite end from the operator's cab. The incoming air passes first through the dynamic braking grids, if the locomotive is so equipped, and then divides its flow, with part of it being driven upward, through the radiators by the two radiator fans, and the remainder being driven downward by the equipment blower into the primary air cleaner. See FIG. 7-12. This is the air supplied to the engine, used for equipment cooling, and for ventilating the operator's cab.

As shown in FIG. 7-1 and 7-2, the primary cleaner is made up of 1470 individual cleaning tubes, arranged in seven banks of 210 tubes each, with suitable ducts to direct the air flow.

Each tube acts as a miniature cyclonic dirt separator. Referring to FIG. 7-3, incoming air enters the outer tube around the periphery of the inner tube. Turning vanes cause the air to swirl. Dirt particles, being heavier, go to the outside, and eventually leave the far end of the outer tube. The clean air swirling in the central portion makes a 180 degree turn, coming out of the inner tube in the opposite direction to which it entered the outer tube.



PRIMARY AIR CLEANER - TOP VIEW
FIG. 7-1



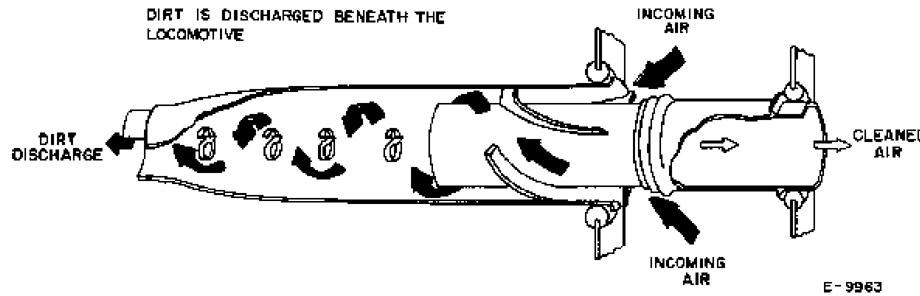
PRIMARY AIR. CLEANER - BOTTOM VIEW
FIG. 7-2

As shown in FIG. 7-2, a small opening at the bottom of each bank of tubes permits the separated dirt to escape. It is discharged from the locomotive continuously, through an outlet beneath the underframe. Approximately 5 per cent of the total air entering the cleaner is discharged with the dirt.

Test results show that all dirt particles 8 microns or larger are removed by this cleaner. Although some of the incoming dirt particles smaller than this will pass through with the cleaned air, the over-all efficiency of the cleaner is better than 95 per cent.

The greater portion of the cleaned air passes from the open bottom of the cleaner into the main air duct of the locomotive, which has been formed by enclosing the space between the center sills, top and bottom, with metal plates welded air tight.

The main duct supplies air to each traction motor directly, through a bellows-type connection. Other outlets supply air to the main generator, exciter, auxiliary generator and control compartment. Air is also circulated through the cab heater core



PRIMARY AIR CLEANER TUBE
FIG. 7-3

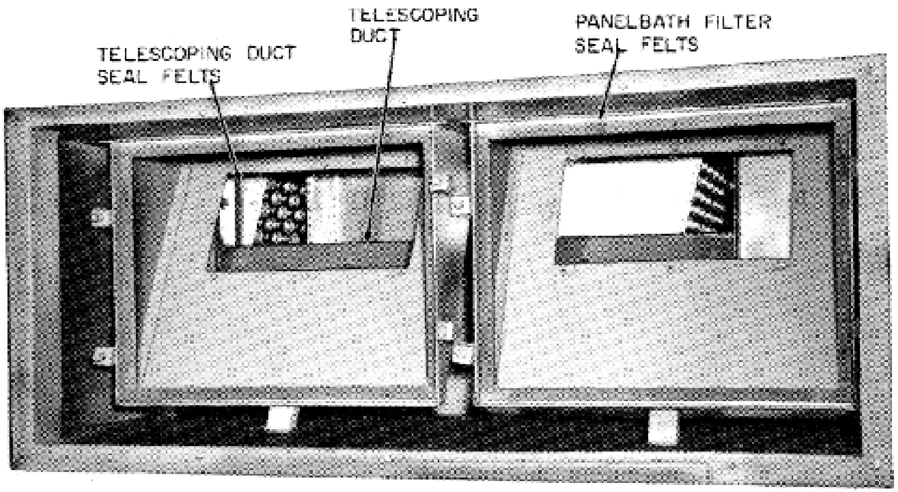
section to supply the operator's cab and defrosters. Cab temperature may be controlled by adjusting shutters and a damper, and by adjusting a valve in the hot water line supplying the heater.

The portion of the cleaned air used for engine combustion is discharged from the triangular openings on each side of the primary cleaner through telescoping ducts slanting downward and outward into the Panel bath filter chambers. As shown in FIG. 7-4 and 7-13, the air flows around the bottom and sides of the Panel bath filters, enters the filters - where it is cleaned further - then flows into the top portion of these compartments and through ducting into the turbocharger.

ENGINE AIR SYSTEM

The turbocharger, driven by engine exhaust, compresses the air for delivery through intercoolers -- where part of the heat of compression is removed -- to the sectional air intake manifolds on each side of the engine. See FIG. 7-13.

The overspeed shutdown butterfly valves and their actuators are located between the outlets of the intercoolers and the first sections of the intake manifolds. In normal engine operation, the engine overspeed governor takes engine lube oil, increases its pressure, and delivers this oil to the butterfly valve actuators. Each actuator is constructed very much like an air brake cylinder. Pressure on the head causes the piston to advance, opening the butterfly valve.



FILTER COMPARTMENT WITH PANELBATH
FILTERS AND ACCESS COVERS REMOVED
FIG. 7- 4

When engine overspeed is detected by the overspeed governor it cuts off oil pressure supply to the butterfly valve actuators. Both actuator springs then return the pistons, closing the butterfly valves and cutting off air supply to both sides of the engine.

To prevent overheating of the oil being pumped to the butterfly valve actuators by the overspeed governor, as would result if no flow were permitted, the actuators are built so that a small amount of oil circulates through them to the crankcase. At the same time, this feature also hastens "dumping" the oil which is in the actuators and closing the butterfly valves when an overspeed is detected. The sectional intake air manifold is made up of lightweight castings bolted to each cylinder with connecting sheet metal tubes sealed by "O" rings under clamping flanges.

This allows easy application to the cylinder and eliminates the need for precise line-up of cylinder assemblies, intercoolers and manifolds.

The diesel engine exhaust system consists of eight stainless steel exhaust pipes - surrounded by a metal shroud - which conduct the hot exhaust gases to the turbocharger inlet. Each individual exhaust pipe serves two cylinders. Each pipe for the first four cylinders on both banks is made in one section, with bellows providing flexibility and permitting thermal expansion. Each pipe serving the four rear cylinders in both banks is made in two sections. These sections are joined together by a bolted flange with gasket. The exhaust manifold is shown in FIG. 7-5 with the top portion of the shroud removed.

Each exhaust pipe is flange connected, with a gasket, to the turbocharger inlet.

MAINTENANCE

PRIMARY AIR CLEANER

The primary air cleaner, having no moving parts, ordinarily requires no maintenance. At a convenient time, when the fan gear unit is removed, the primary air cleaner should be inspected to insure that all tubes are in place and that none of the rubber grommets holding these tubes has been dislodged.

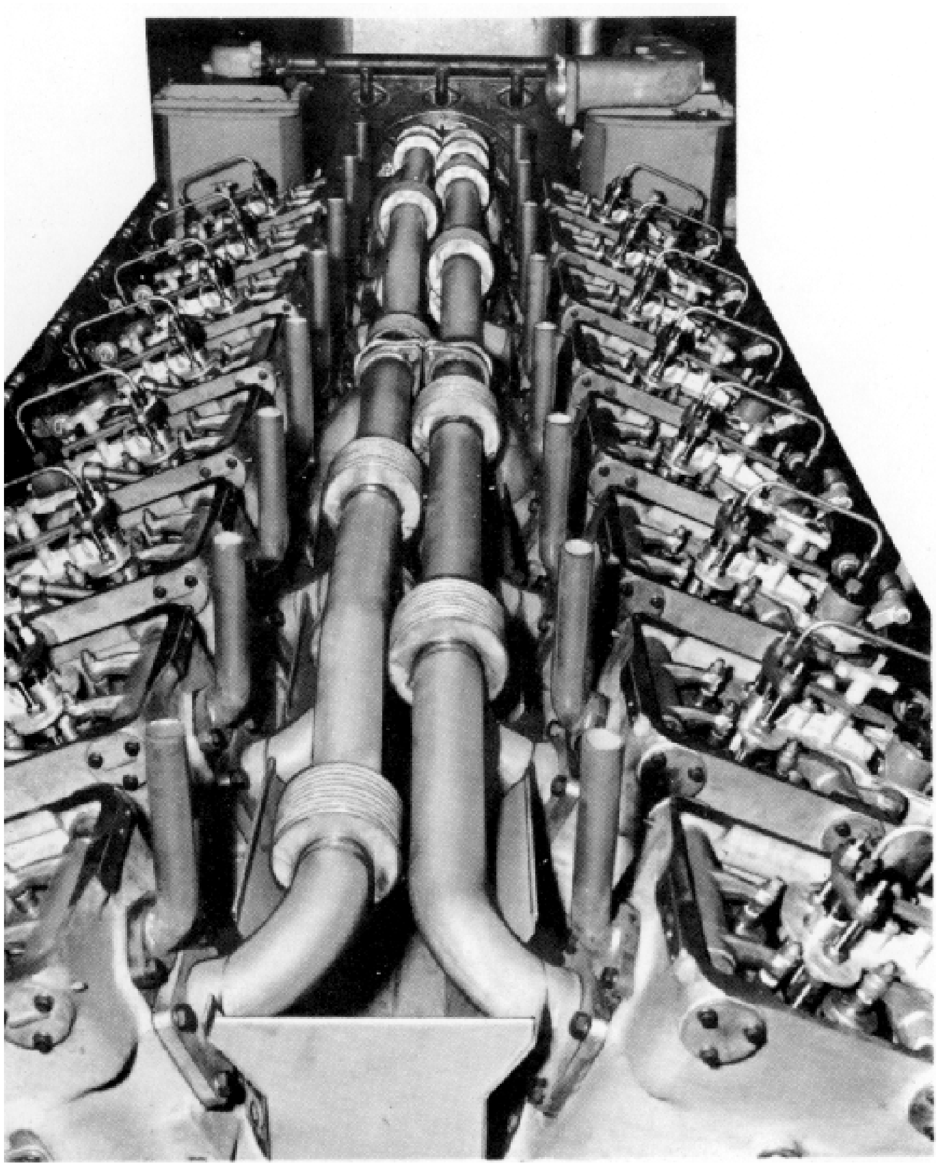
Present experience indicates that periodic cleaning of the primary air cleaner is not needed. Normal scouring by dirt particles borne in the incoming air, together with rain and snow particles, will provide all the cleaning necessary.

If, due to extremely unusual operating conditions, it is felt that additional cleaning is desirable, a light spray of an appropriate detergent into the entrance of the equipment blower, with the engine at idling speed, is suggested. The primary air cleaner is constructed of aluminum, nylon base plastic, rubber, and steel. The detergent used should be chosen carefully, taking care that it will not injure any of these materials. See DATA for approved cleaners. Follow the use of detergent with a light spray of clear water.

MAIN AIR DUCT

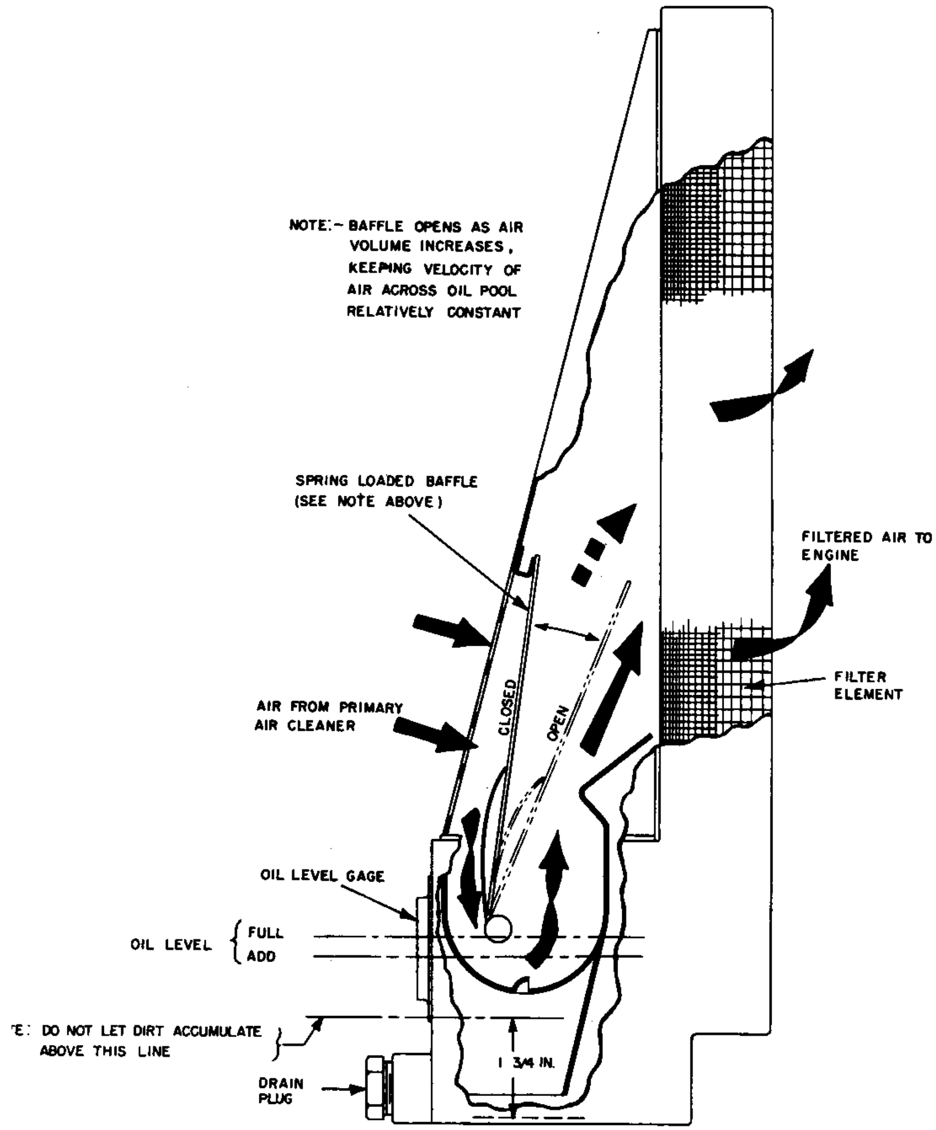
An access hole is provided beneath the locomotive platform through which the main air duct may be entered for inspection. The cover on this hole should be kept tight to prevent leakage of ventilating air.

AIR SYSTEMS



EXHAUST MANIFOLD ARRANGEMENT
FIG. 7-5

AIR SYSTEMS



PANELBATH FILTER - CROSS SECTION
FIG. 7-6

AIR SYSTEMS

Felt seals and flexible ducts at points where air from the main duct goes to various pieces of equipment should be kept tight. Poor maintenance of these seals and ducts will result in dirt gaining entry to the various devices and can result in enough air leakage to cause overheating.

PANELBATH FILTERS

The oil level in Panelbath filter tanks should be checked periodically through the small hinged doors on the filter compartments. Check after the engine has been shut down for 20 minutes or longer. However, the oil level is satisfactory if it remains at or above the "add oil" mark with the engine idling. DO NOT OVERFILL.

Over a long period of time the oil level may increase due to accumulation of dirt in the bottom of the filter tanks. When necessary, remove the filters and clean the tanks thoroughly. If the oil level has been maintained properly, no further cleaning of the filter screens will be required. If the oil level has been allowed to become excessively low or go dry, the filter screens will require cleaning.

When the diesel engine is running at low speed, all air entering the Panelbath filter assembly through the front screen is deflected downward. Due to the high velocity of the air as it passes across the surface of the oil pool, droplets of oil are picked up and carried upward to wet the screen of the filter panel. It is this oil, running back down into the reservoir at the bottom, that carries away dirt particles trapped by the filter screen. The quantity of this dirt is comparatively small due to cleaning action of the primary air cleaner.

As the engine speed increases, the spring loaded panel in the front, as shown in FIG. 7-6, will be deflected by the pressure of the air stream and permit most of the air to go directly to the filter panel. However, a portion of the air is deflected downward and across the oil pool to maintain the self-cleaning action of the filter.

Access to the telescoping ducts shown in FIG. 7-4 may be gained by removing the bolted-on covers behind the Panelbath filters.

AIR SYSTEMS

NOTE: In order to remove the primary air cleaner from the locomotive, the bolts holding the telescoping ducts in place (reached through these access holes) should be loosened and the ducts pulled down to give adequate side clearance.

Felt on the end of the telescoping duct where it bears against the sides of the primary air cleaner prevents loss of air to the engine.

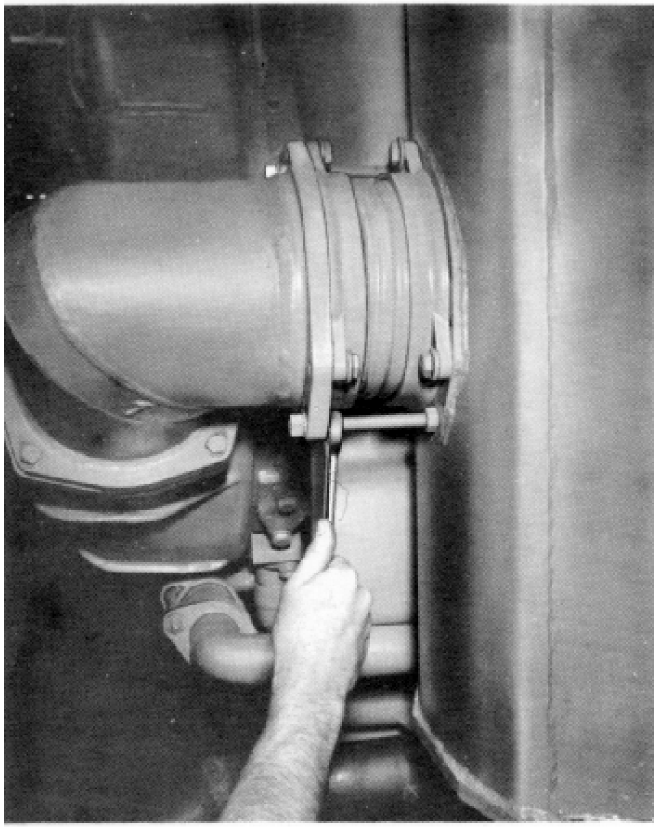
****
CAUTION
****

FELT SEALS IMMEDIATELY BEHIND THE PANELBATH FILTER ASSEMBLIES MUST BE KEPT IN GOOD CONDITION. FAILURE TO DO THIS WILL RESULT IN FINE PARTICLES OF DIRT, NOT REMOVED BY THE PRIMARY AIR CLEANER, BYPASSING THE FILTER AND ENTERING THE ENGINE DIRECTLY. THIS WILL RESULT IN HIGHER RATES OF WEAR IN THE ENGINE. RENEW THESE FELTS AS NECESSARY.

The entire air duct system between the Panelbath filters and the turbocharger entrance must be kept air tight. Any leakage in this duct will admit dust.

AIR PIPE ELBOWS

Connecting elbows between the turbocharger and the intercoolers are constructed with adjustable flanges at the intercoolers. This permits slight variations in alignment between flange connections. When assembling the elbows, the hex nuts on the studs at the intercooler should be loosened several turns to allow for adjustment. Make sure the sealing "O" rings are in place. Install and tighten bolts in all the flanges. Now the hex nuts on each side of the adjustable flange may be drawn up evenly, taking care not to distort the flexible elbow in the process. These components are shown in FIG. 7-7.



ASSEMBLING ADJUSTABLE ELBOW
FIG. 7-7

INTERCOOLERS

The intercoolers are similar in construction to radiator cores. They act as heat exchangers to transfer heat from the air flowing around the tubes to cooling water passing through the tubes. Oily dirt can build up in the air passages, restricting air flow to the intake manifold and resulting in high cylinder temperatures, exhaust smoke, and loss of horsepower. Improper maintenance of the Panelbath filters will hasten dirt build-up.

Intercoolers should be inspected periodically for dirt build-up by looking through the air inlet connections after removing the adjustable elbows. A light coating of oily dust is normal. The intercoolers must be removed, disassembled, and cleaned thoroughly if dirt build-up is excessive.

The preferred method of cleaning is by complete immersion in an agitated tank containing appropriate cleaning solution, followed by thorough flushing with clear water.

NOTE: THE INTERCOOLER CONTAINS BOTH STEEL AND ALUMINUM PARTS. DO NOT USE A CLEANER HARMFUL TO ALUMINUM. Use one of the cleaners listed under DATA at the end of this section, or equivalent. If scale within the water tubes must be removed, follow special instructions given in SECTION 6, COOLING WATER SYSTEM.

Following cleaning, the cooler may be reassembled using new gaskets. It should then be tested for leaks by applying gasketed blanking plates over the air flanges, with one plate adapted for an air hose connection. Apply maximum 30 psi air pressure while the entire intercooler is submerged in clear water. Inspect for leaks, as indicated by air bubbles.

Leaks in tubes may be eliminated by soldering closed both ends of such tubes. Replace the intercooler if more than 10 per cent of the tubes require blocking.

OVERSPEED SHUTDOWN VALVES

The overspeed shutdown system is "fail safe". In case of a broken line or a damaged governor, oil pressure will not build up; thus the engine cannot run since the butterfly valves are spring-loaded shut. Refer to FIG. 7-11 for schematic oil flow in the overspeed shutdown system.

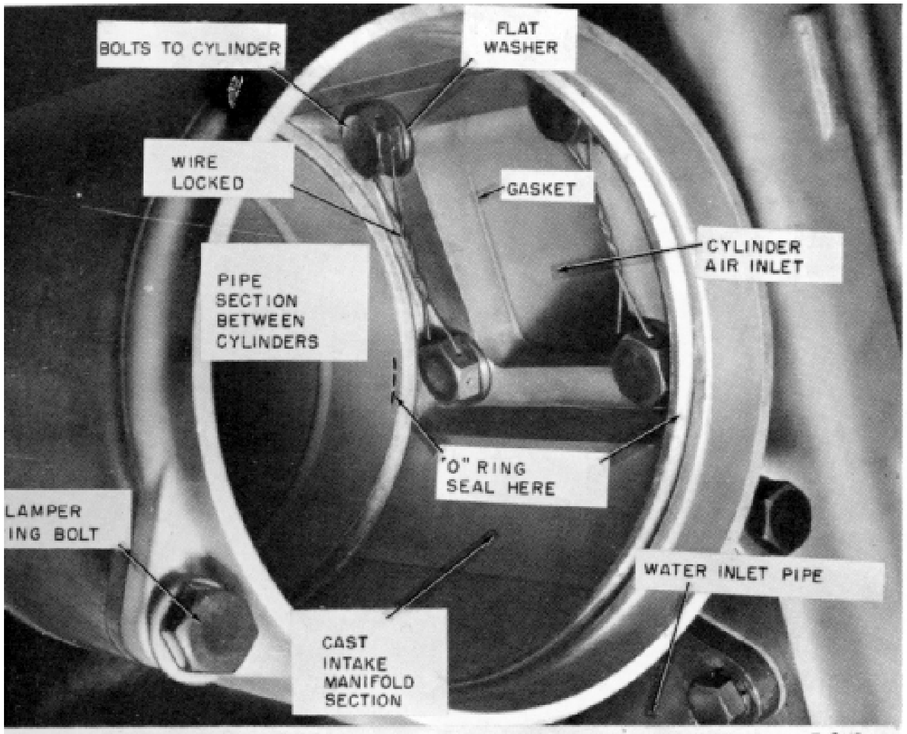
INTAKE MANIFOLDS

Air intake manifold bolts must be kept tight to avoid air leaks. See FIG. 7-8. When assembling sections of the manifold, such as after a cylinder change out, care should be taken that the sealing "O" rings are in place and that the beads in the interconnecting tubes are visible, as shown in FIG. 7-9.

EXHAUST MANIFOLD

Exhaust manifold flange connections to the cylinders, to the turbocharger, and between sections should be checked periodically for tightness. Where a leak is found, a new gasket should be installed and the bolts tightened evenly. It is good practice to retighten a new gasket after a few hours' operation.

AIR SYSTEMS

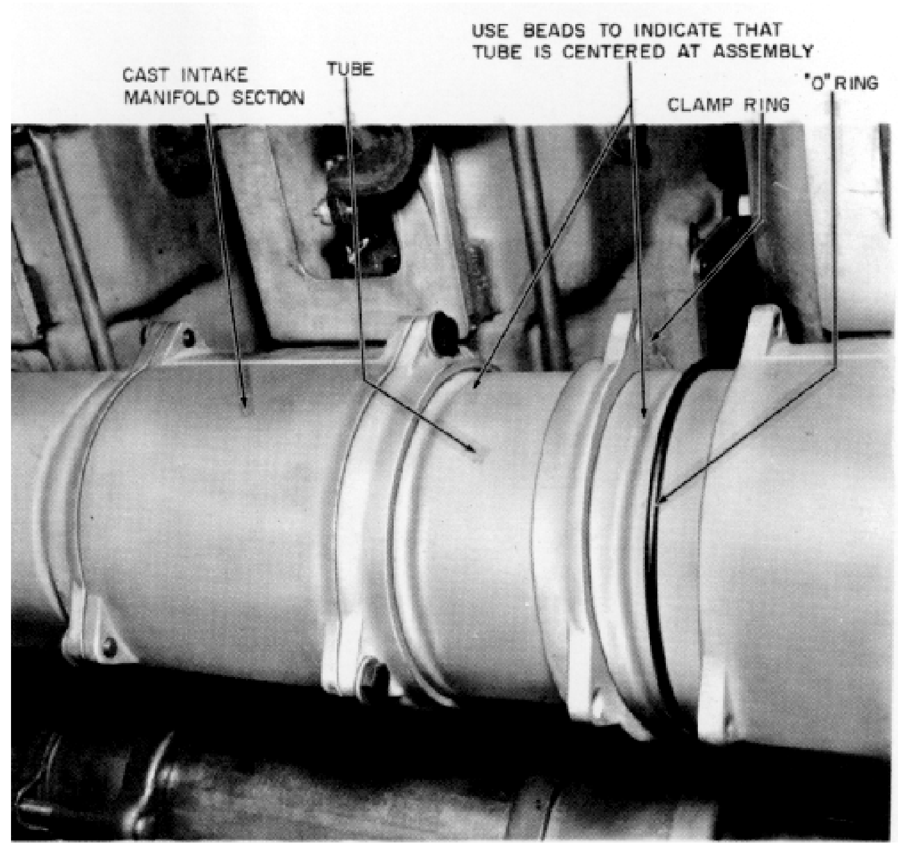


SECTION OF AIR MANIFOLD INSTALLED ON CYLINDER
FIG. 7-8

Due to the tightly nested construction, upper exhaust pipes must be removed to gain access to the lower pipes. When assembling exhaust pipes, the following sequence is suggested for the easiest operation: (1) pipes to cylinders Nos. 6 & 7, right and left with extensions; (2) pipes to cylinders 5 & 8, right and left with extensions; (3) pipes to cylinders 2 & 3, right and left; (4) pipes to cylinders 1 & 4, right and left. FIG. 7-10 shows typical pipes.

Flanges should be bolted and clamped at the turbocharger connections as the pipes are installed. New gaskets must be used at all joints.

AIR SYSTEMS

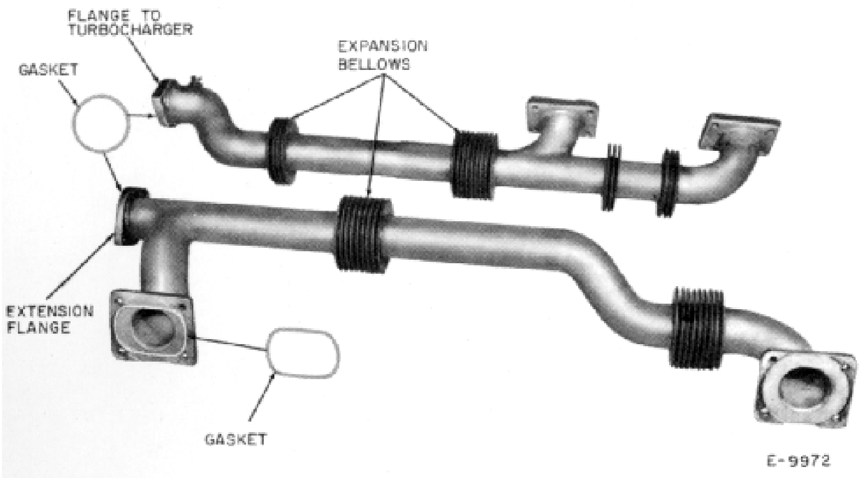


AIR INTAKE MANIFOLD
FIG. 7-9

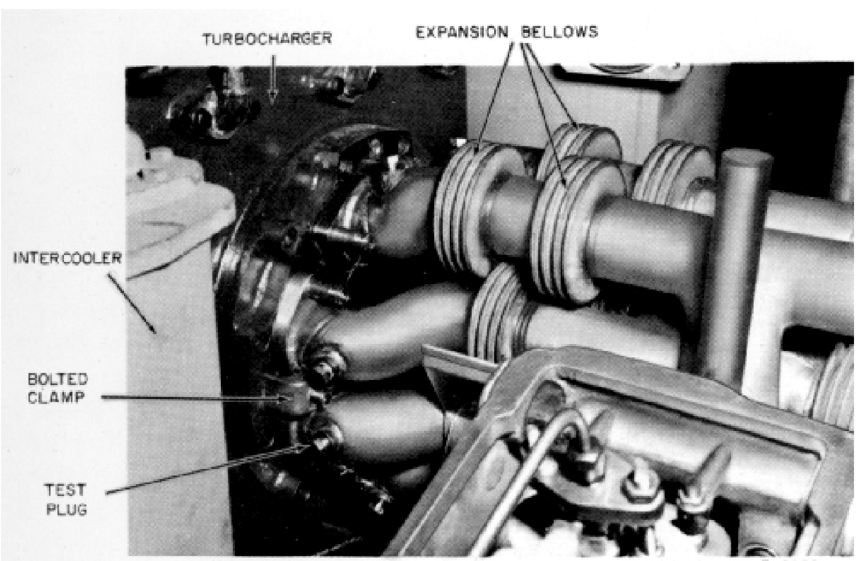
All bolts in exhaust pipe connections to the cylinders, to the turbocharger, and between sections, as well as bolts holding the upper parts of the exhaust shroud in place, should be coated with a high temperature thread compound to prevent seizing and galling due to exposure to high temperature and to make later disassembly easier. Use the compound listed under data at the end of this section, or equivalent.

If a crack is found in a pipe section, repair as follows:

1. Prepare a cleaning solution made up of 2.25 parts hydrochloric acid, 24 parts nitric acid, and 100 parts water by volume. Heat to 145 F.



EXHAUST PIPES
FIG. 7-10



CLAMPING ARRANGEMENT (EXHAUST PIPES TO TURBOCHARGER INLET CASING)
FIG. 7-11

2. While the solution is hot, apply it to the area to be repaired by dipping or swabbing. Continue cleaning for three to five minutes, or until all oxide and scale is removed.

3. Flush the cleaned area with water.

4. Adjust a tungsten inert gas (TIG) welder or a direct current welder, using straight polarity, for approximately 80 amperes current with argon or helium gas flow of about 15 cu. ft. per hour. Electrodes should be 1/16 inch diameter tungsten, 1 to 2 per cent thoriated.

5. If necessary, tack-weld first, using the engine as an alignment fixture. After removal from the engine, complete the weld using 3/32 inch diameter No. 347 stainless steel filler rod as needed.

6. If extensive welding is to be done, back-up of the weld with 6 to 8 psi argon or helium gas pressure will be helpful in obtaining 100 per cent weld penetration. Seal off the pipe openings with gasketed blanking plates. Adapt a blanking plate at one end for the gas supply fitting. Provide a small orifice in the blanking plate at the opposite end. Let the gas flow for enough time to purge all air from the pipe before welding.

AIR SYSTEMS

DATA

PRIMARY AIR CLEANER

CLEANING COMPOUNDS

Name of Manufacturer	Name of Product
Oakite Products, Inc.	Oakite Composition No. 61A Oakite Composition No. 20
Turco Products, Inc.	Turco No. 4215
Lix Corporation	Lix Diesel Clean Heavy Lix Engine Cleaner
Pennsalt Chemicals Corp.	Pennsalt 62
Wyandotte Chemical Company	Altrex or Rillor

Use the above cleaners according to directions supplied by the cleaner manufacturer. Equivalent cleaners made by other manufacturers may also be used.

INTERCOOLER

CLEANING COMPOUND

Name of Manufacturer	Name of Product
Oakite Products, Inc.	Oakite Composition No. 111
Pennsalt Chemicals Corp.	Pennsalt Delchem Super CR Pennsalt Cleaner 44
Turco Products, Inc.	Turco Mulsirex
Magnus Chemical Co. Inc.	Magnusol

Use the above cleaners according to directions supplied by the cleaner manufacturer. Equivalent cleaners made by other manufacturers may also be used.

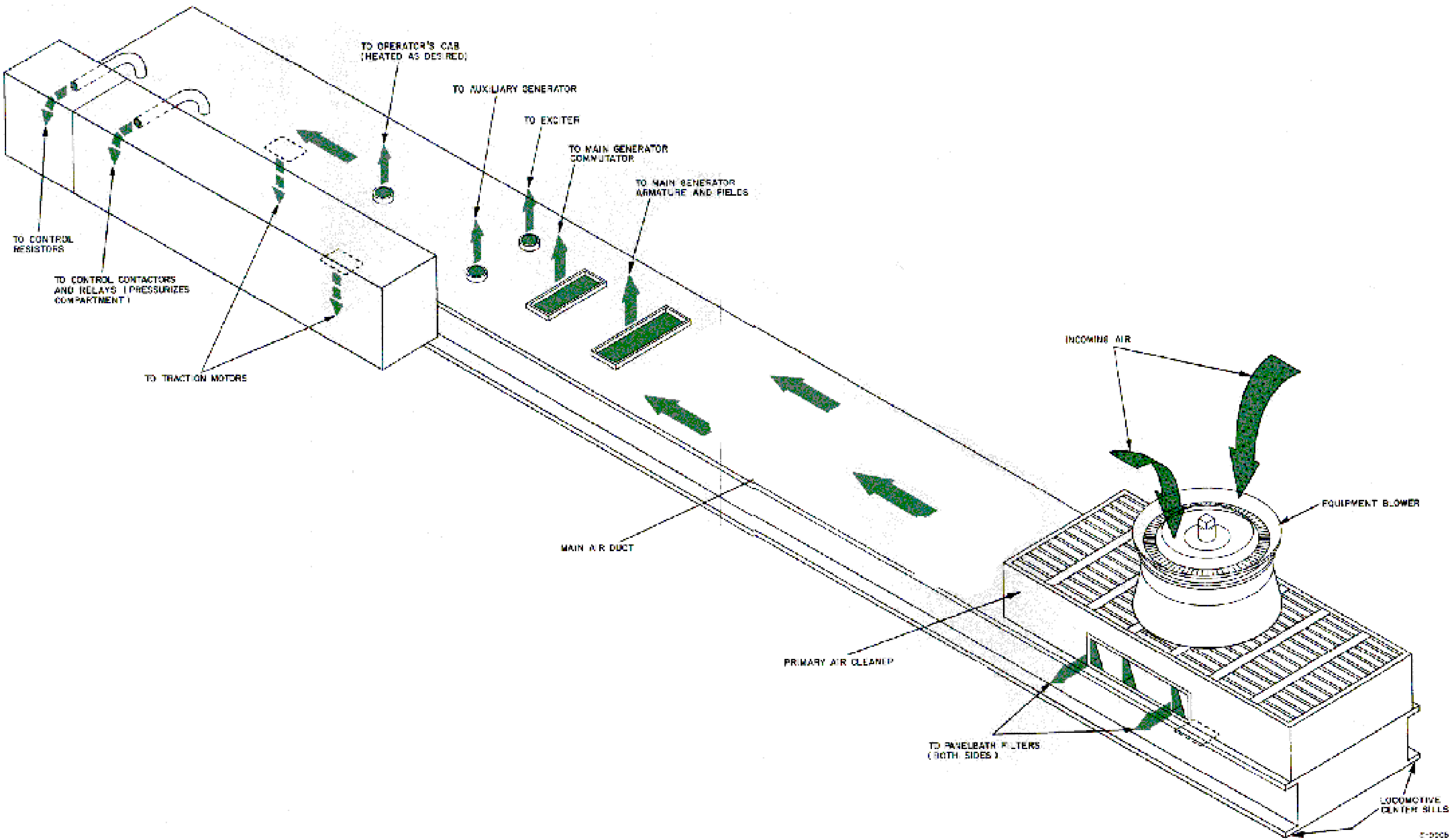
AIR SYSTEMS

EXHAUST MANIFOLD

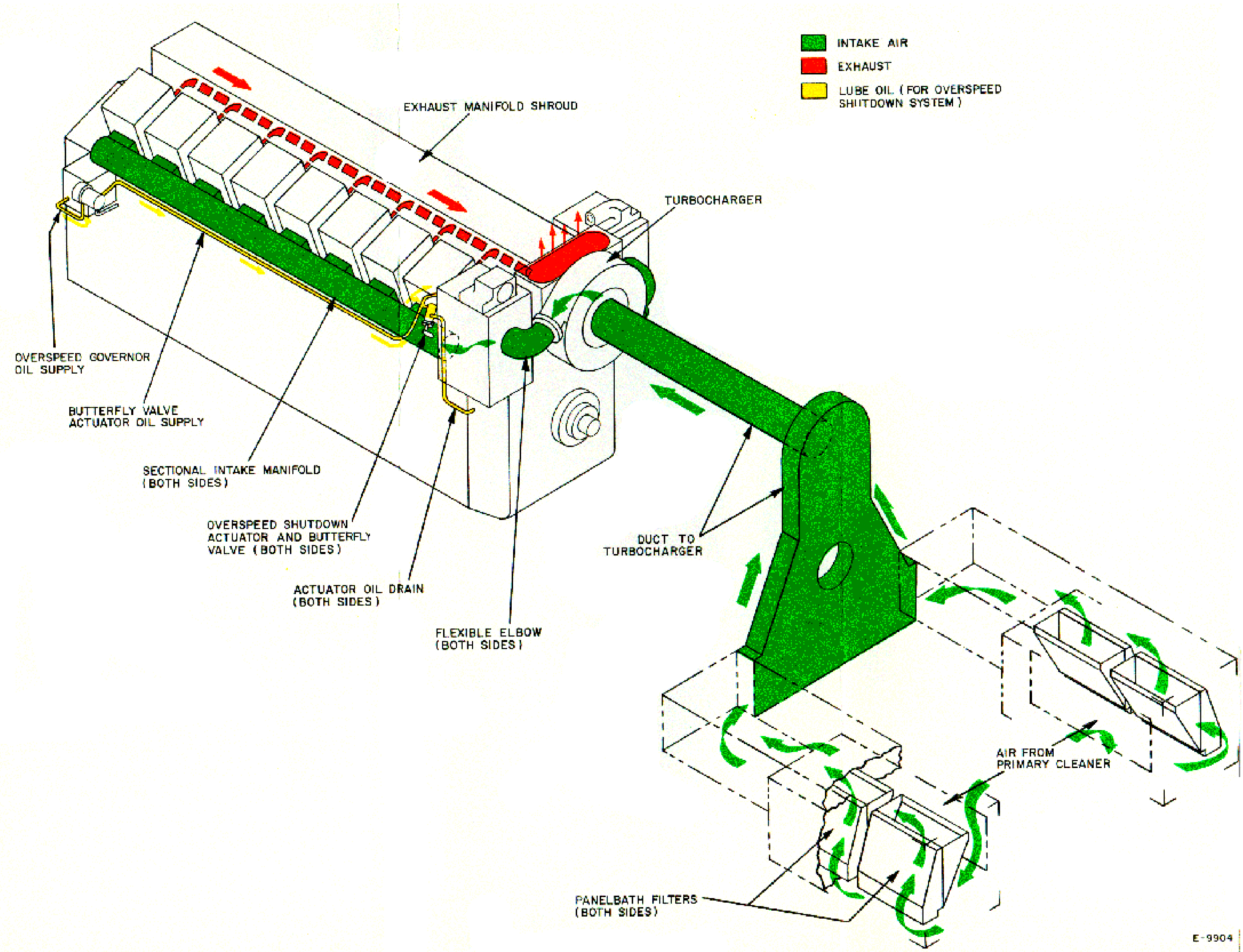
HIGH TEMPERATURE THREAD COMPOUND

Name of Manufacturer	Name of Product
Surveyor's Inc. 302 So. Olden Ave., Trenton, New Jersey	FEL-PRO-C-5 COMPOUND

Equivalent compounds made by other manufacturers may also be used.



ENGINE AIR SYSTEM - FIG. 7-13



ENGINE AIR SYSTEM - FIG. 7-13

OVERSPEED SYSTEM

DESCRIPTION AND OPERATION

The function of the overspeed system is to protect the locomotive power plant by preventing excessive rotational speed.

The overspeed system consists of the following principal components:

1. Overspeed governor.

2. Two overspeed shutdown butterfly valves, each with a hydraulic actuator connected by mechanical linkage.

3. Associated interconnecting lines.

The overspeed governor is located on the right side of the engine below the speed control governor. Like the speed control governor, it is driven from the right bank camshaft gear through the governor drive gearing. See FIG. 8-1.

During normal engine operation, the overspeed governor delivers engine lubricating oil at regulated pressure of 200 psi to the actuators of the two overspeed shutdown butterfly valves.

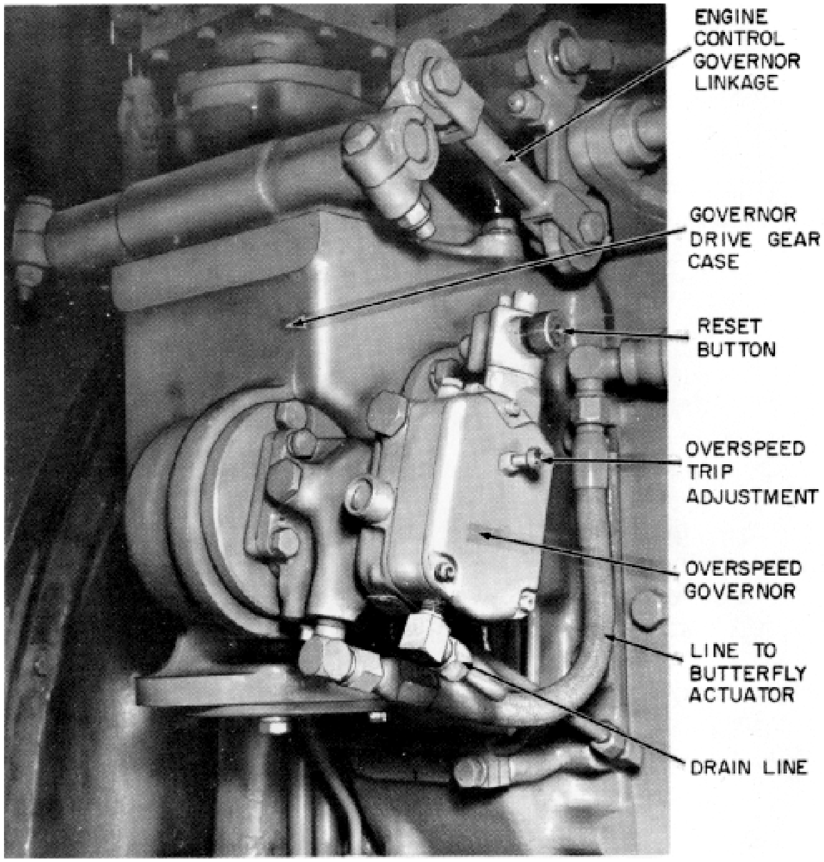
These valves are mounted, one on each side of the engine, between the air outlets of the intercoolers and the first sections of the intake manifolds. See FIG. 8-2.

The overspeed shutdown butterfly valves are shown in cross-section in FIG. 8-3. When open, they permit air to flow from the intercoolers into the intake manifolds. When closed, air supply to the engine is cut off.

The actuators of the butterfly valves are constructed very much like an air brake cylinder. Oil under pressure from the overspeed governor causes the actuator pistons to advance, opening the butterfly valves.

When engine overspeed is detected by the overspeed governor, it cuts off oil pressure to the butterfly valve actuators and permits the lines to drain. The actuator springs then return the pistons, closing the butterfly valves and cutting off air supply to both cylinder banks.

OVERSPEED SYSTEM

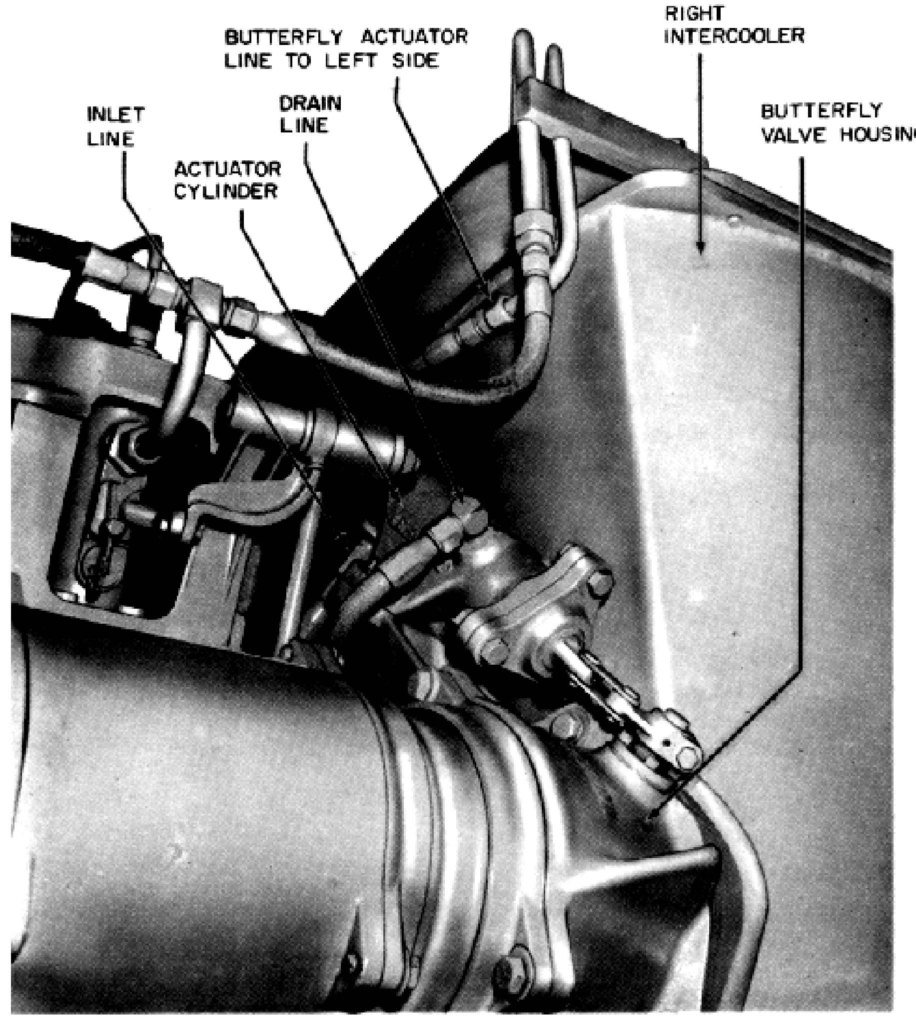


OVERSPEED GOVERNOR ARRANGEMENT
FIG. 8-1

The overspeed governor draws the lubricating oil, which it delivers to the actuators, from a small reservoir inside the governor drive gear housing. While the engine is running, oil in this reservoir is constantly replenished from the main lube oil header. The reservoir holds enough oil when the engine is shut down to permit the overspeed governor initially to open the butterfly valves when the engine is started.

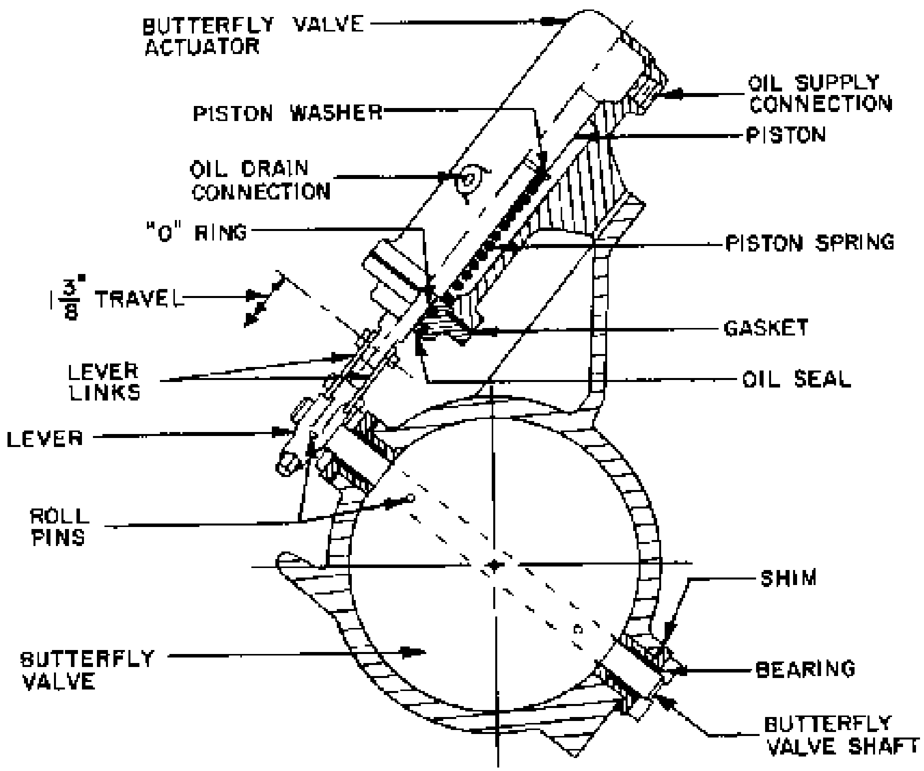
To prevent overheating of the oil being pumped to the butterfly actuators by the overspeed governor, and to cool components of the overspeed system, the actuators are built intentionally "leaky" so that a small amount of oil circulates

OVERSPEED SYSTEM



BUTTERFLY VALVE ARRANGEMENT - RIGHT SIDE
FIG. 8-2

OVERSPEED SYSTEM



OVERSPEED SHUTDOWN BUTTERFLY VALVE AND ACTUATOR (SHOWN IN CLOSED POSITION)
FIG. 8-3

through them to the crankcase. At the same time, this feature also hastens "dumping" of oil which is in the actuators and closing of the butterfly valves when overspeed is detected.

A schematic diagram of the oil flow in the overspeed system is included in FIG. 7-12 of SECTION 7, AIR SYSTEMS.

OVERSPEED SYSTEM

The overspeed system is " fail safe" in operation. A broken oil line, loss of engine oil or governor failure will stop the diesel engine.

NOTE: If an engine shutdown occurs due to overspeed investigate the cause and make necessary repairs. Reset the overspeed governor by depressing the reset button before cranking the diesel engine.

OVERSPEED GOVERNOR

DESCRIPTION

The governor main body contains the following components:

1. A pilot valve plunger with speeder spring and linkage.
2. A pair of flyweights mounted on the end of the drive shaft.
3. A power piston at the end of which is mounted the terminal lever.
4. An oil pressure relief valve mounted in the side of the governor case.

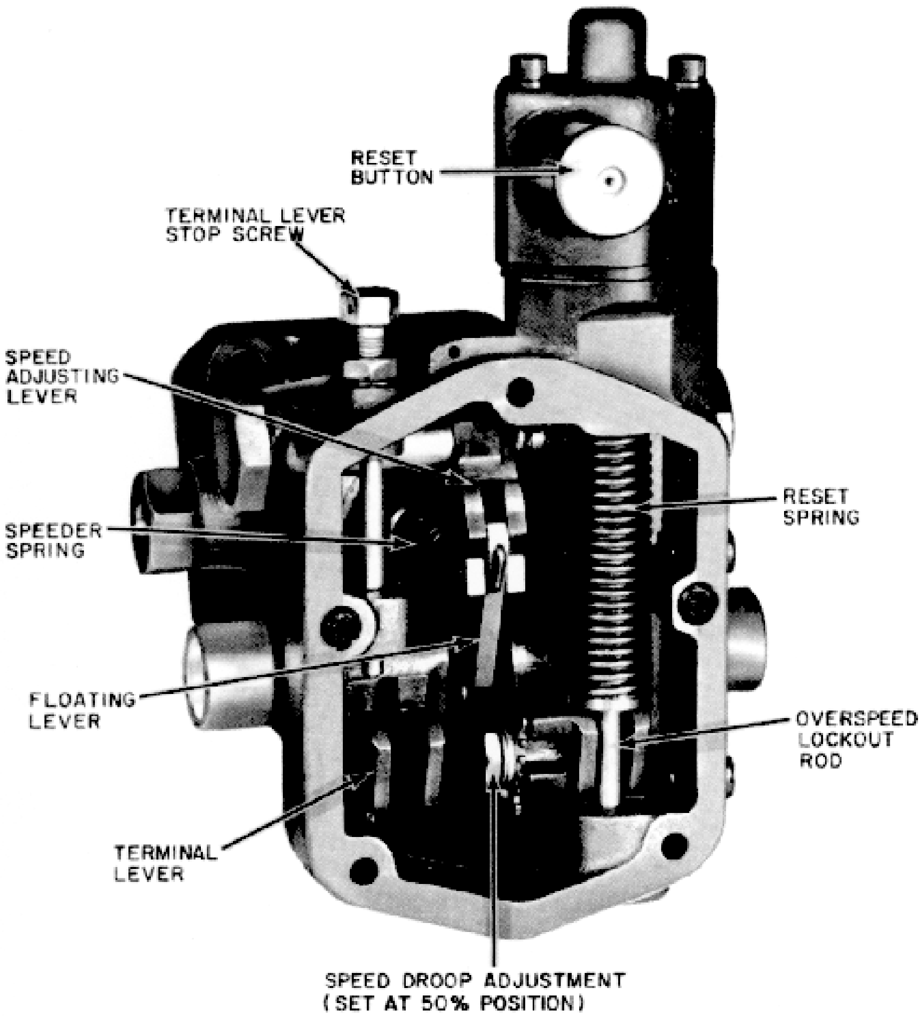
The base portion contains a positive displacement gear pump. The outer case portion contains the lock-out and latching mechanism. See FIG. 8-4.

OPERATION

Engine Running (Normal Speed Range) - See FIG. 8-5.

NOTE: On the engine the overspeed governor is mounted with its drive shaft horizontal. In FIG. 8-5 and FIG. 8-6 the governor is shown with the drive shaft vertical. The following text refers to the governor as it is shown in the FIGURES, NOT as it is mounted on the engine.

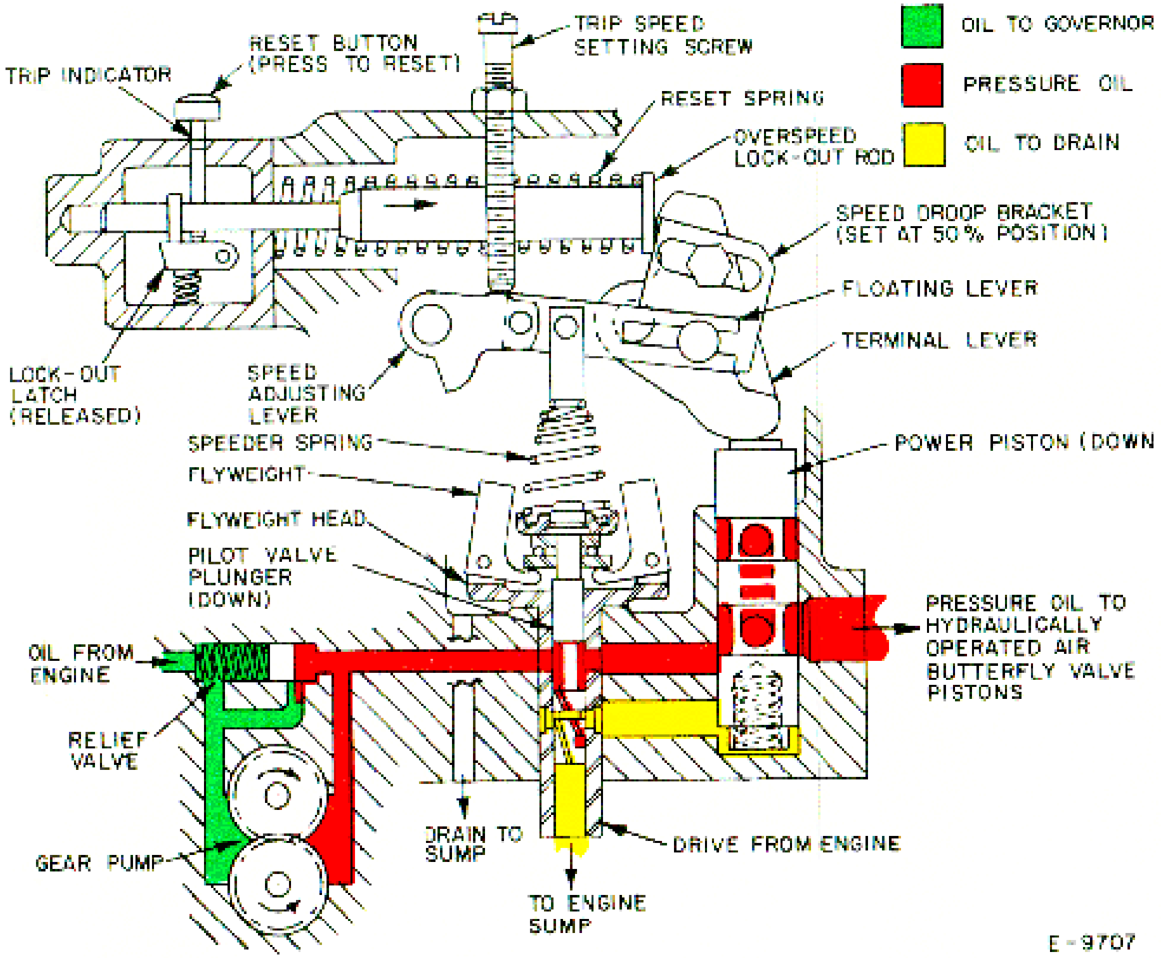
OVERSPEED SYSTEM



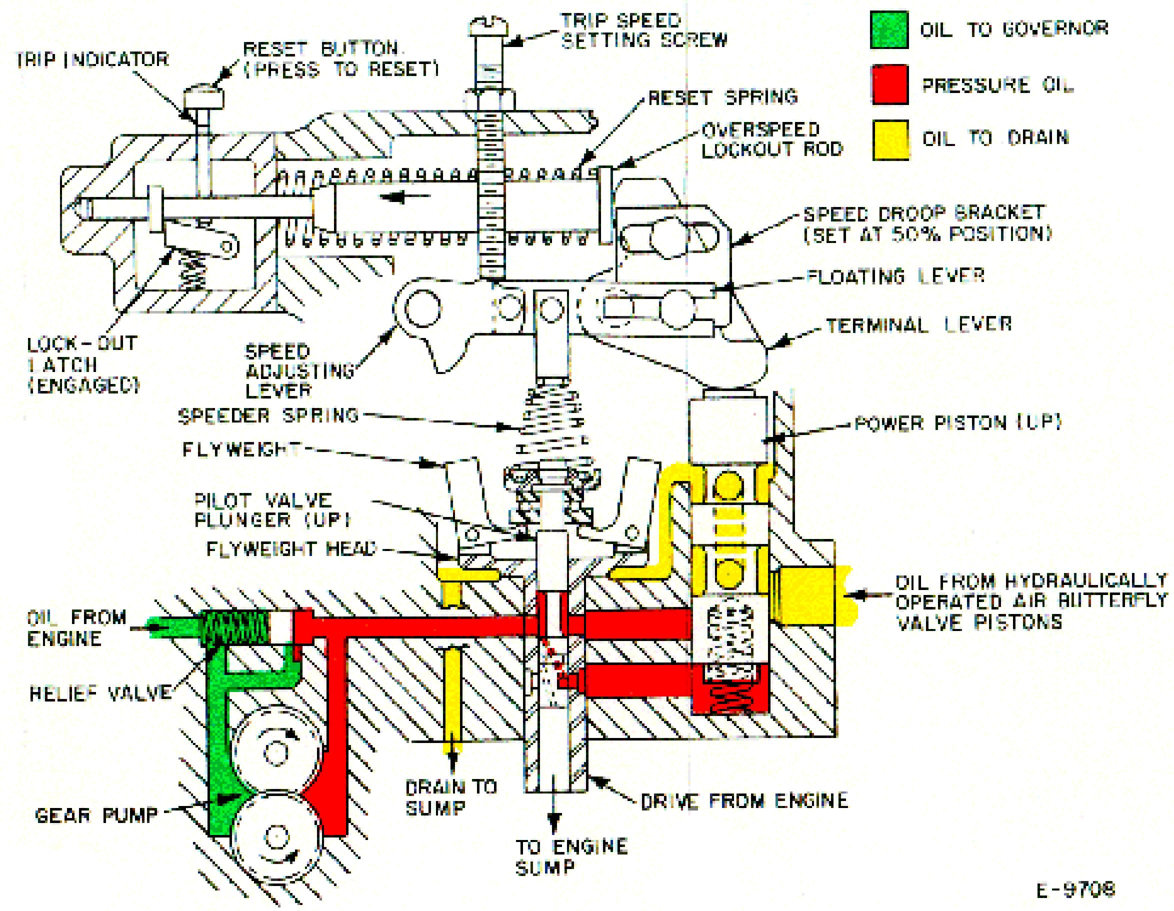
OVERSPEED GOVERNOR WITH COVER REMOVED
FIG. 8-4

1. The reset spring and overspeed lockout rod will position the terminal lever to hold the power piston down in its bore (lockout latch released).

2. Downward pressure of the speeder spring - as set by adjustment of the trip-speed setting screw - will hold the flyweights in and the pilot plunger down.



OPERATING CONDITION ENGINE RUNNING AT NORMAL SPEEDS
FIG. 8-5



TRIPPED CONDITION A s A RESULT OF ENGIDNE OVERSPEED
FIG. 8-6

OVERSPEED SYSTEM

3. In these positions the bottom of the power piston is connected to drain to the engine sump through ports in the pilot valve bushing to a groove in the pilot valve plunger, and through a slanting hole drilled from the groove to the lower end of the pilot valve plunger.

4. Oil under pressure (200 psi) from the pump is delivered through porting in the pilot valve bushing, around the pilot valve plunger and out to the power piston. With the piston down, the oil can flow around the lower groove and out of the governor case through connecting lines to the butterfly valve actuators.

   Note that the upper groove in the power piston will also contain oil under pressure by means of drilled holes connecting to the lower groove. Also, a slot in the pilot valve plunger - below the port connecting to the power piston - is connected to the pressurized oil in the pilot valve bushing through a second diagonally drilled hole.

Engine Overspeeding (Tripping Action) - See FIG. 8-6.

1. As engine speed increases to the overspeed setting, the flyweights will move outward and raise the pilot valve plunger, bringing the pressurized oil slot in line with the port connected to the power piston.

2. Pressurized oil flowing under the power piston will force the piston up to close off the supply of pressurized oil to the butterfly valve actuators, and will position the upper groove in the piston above the top of the power piston bore.

3. This allows oil from the butterfly valve actuators to flow back through the holes connecting the two grooves in the power piston, over into the flyweight head cavity in the governor case, and down through a drain hole to the engine sump.

4. This releases the spring-loaded butterfly valve pistons and the butterfly valves close, shutting off the engine air supply.

OVERSPEED SYSTEM

5. Upward movement of the power piston to the tripped position also rotates the terminal lever, raising the end of the floating lever at the speed droop bracket pin. This reduces the pressure of the speeder spring and allows flyweights to move out quickly. Rotation of the terminal lever also pushes the overspeed lockout rod back until the lockout latch engages and raises the reset button.

TRIP INDICATOR AND RESET

Visual indication that the unit is in tripped position is provided by a red band below the reset button, visible when the button is up. To reset the governor following an overspeed trip, push down on the reset button.

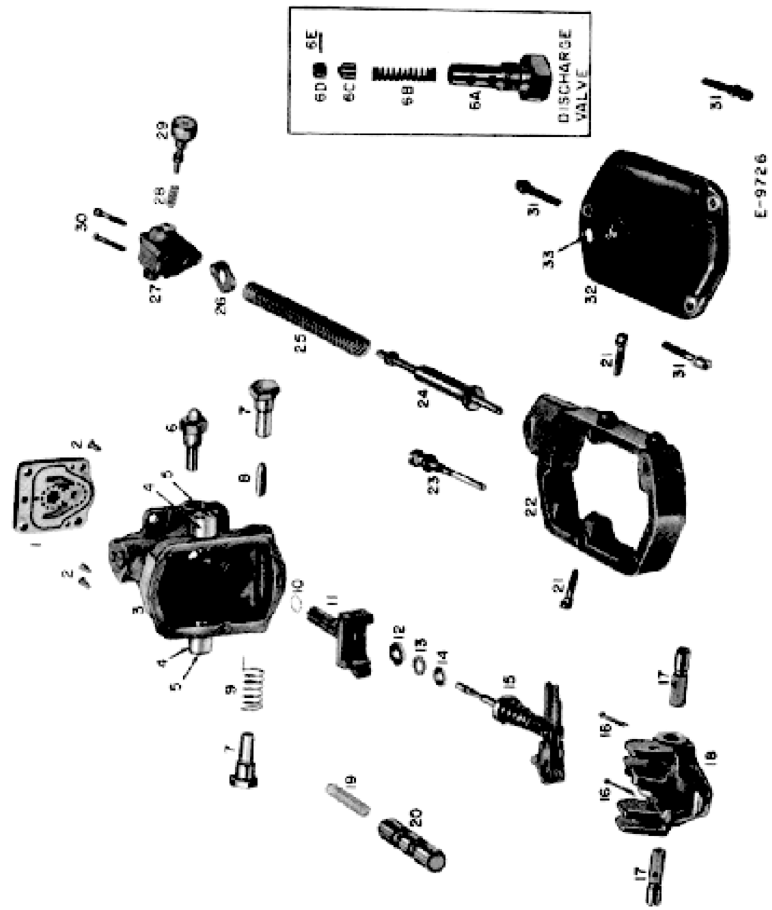
ADJUSTMENTS

The governor has 2 points for adjustment:

1. The speed droop bracket - located inside the governor on the terminal lever - must be set at mid-position.

2. The trip-speed setting screw in the governor cover must be adjusted to provide trip action at the specified overspeed for the engine.

OVERSPEED SYSTEM



EXPLODED VIEW OF GOVERNOR ASSEMBLY

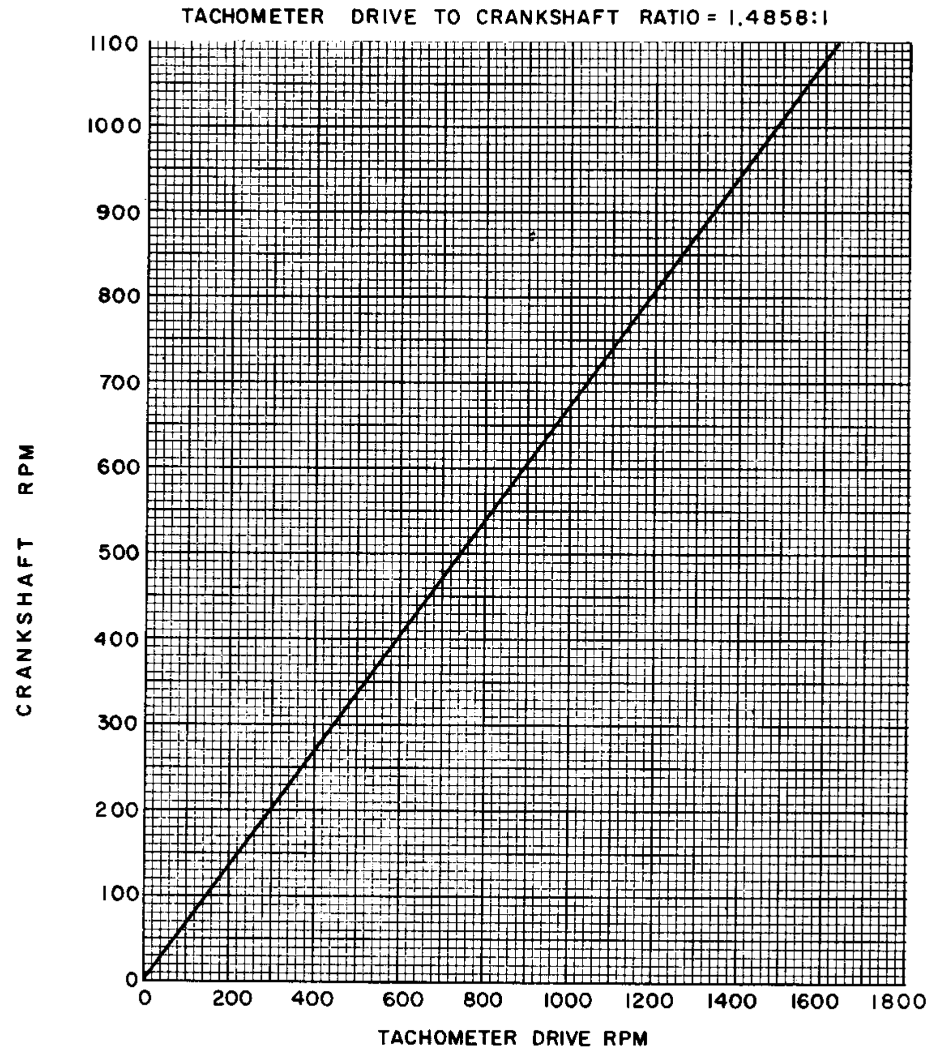
FIG. 8-7

OVERSPEED SYSTEM

1. Governor Base and Pump Gears
2. Slotted Screws (Base)
3. Governor Case
4. Terminal Sleeve
5. Welch Plug
6. Relief Valve (6A Sleeve
   (6B Spring
   (6C Plunger
   (6D Bushing
   (6E Pin
7. Spacer Cap
8. Pin
9. Torque Spring
10. Drive Shaft Snap Ring
11. Drive Shaft and Ball Head Assembly
12. Thrust Bearing Lower Race
13. Thrust Bearing Ball Cage
14. Thrust Bearing Upper Race
15. Pilot Valve, Speeder Spring
16. Cotter Pin
17. Terminal Shaft
18. Terminal Lever
19. Spring
20. Power Piston
21. Socket Head Screw
22. Outer Case
23. Stop Screw
24. Lockout Rod
25. Reset Spring
26. Spring Seat Spacer
27. Latch Housing
28. Spring and Floating Lever Assembly
29. Reset Plunger
30. Socket Head Screw
31. Socket Head Screw
32. Governor Cover
33. Screw (Trip Speed Adjusting)

<u>PARTS IDENTIFICATION FOR
FIG. 8-7</u>

OVERSPEED SYSTEM



TACHOMETER DRIVE SPPED VERSUS CRANKSHAFT SPEED CURVE

FIG. 8-8

OVERSPEED SYSTEM

TRIP ADJUSTMENT PROCEDURE

A direct-reading, accurately-calibrated tachometer is necessary to read engine crankshaft speed when adjusting the trip speed. The tachometer may be applied to the tachometer drive opening located on the governor drive gear case just behind the overspeed governor. The tachometer reading taken must be corrected to give crankshaft speed by using the graph shown in FIG. 8-8.

****
CAUTION
****

UNDER NO CIRCUMSTANCES CAUSE OR ALLOW THE DIESEL ENGINE CRANKSHAFT SPEED TO EXCEED 1110 RPM. IF THIS WARNING IS NOT HEEDED, EXTENSIVE DAMAGE COULD RESULT.

ONLY QUALIFIED PERSONNEL SHOULD BE PERMITTED TO CONDUCT AN OVERSPEED TEST AND MAKE NECESSARY ADJUSTMENTS TO THE OVERSPEED GOVERNOR MOUNTED ON THE DIESEL ENGINE.

1. Start the engine with the throttle at IDLE and allow the engine to reach operating temperature.

2. Run engine at Notch 8, no load.

3. Using a pry bar under governor power piston link, increase the engine speed to a maximum 1110 rpm.

4. Note speed at which overspeed governor trip action occurs. It must be 1100 plus or minus 10 rpm.

a. To lower trip speed, back out trip adjustment screw.

b. To raise trip speed, screw in on trip adjusting screw.

5. Recheck trip speed after final adjustment has been made.

If trip action is erratic or fails to occur, stop the engine and investigate the overspeed system for cause.

OVERSPEED SYSTEM

DATA

SYSTEM

Hydraulic Oil . . . . Engine Lube Oil

Pressure During Normal Operation . . . . . 200 psi

GOVERNOR

Governor to Crankshaft Speed Ratio . . . . 3.465 to 1

Pressure Relief Valve Setting
(Non-Adjustable) . . . . .200 psi

Governor Trip Speed

Crankshaft RPM	Tachometer Drive RPM
1100 ± 10	1634 ± 15

ENGINE CONTROL GOVERNOR

DESCRIPTION

The engine control governor is an electro-hydraulic device which maintains specific engine speeds and limits engine load (see FIG. 9-1). The governor is self-contained, having its own oil supply, oil pressure pump and oil pressure-storing accumulators. Five electric solenoids control the governor hydraulic system to position the governor output shaft. This shaft is linked to the diesel engine fuel racks.

The governor is mounted on the governor drive gear case which is driven from the engine camshaft gearing. The rotating shaft operates the speed-sensing flyweights and governor oil pump. The primary function of the governor is to control the speed of the diesel engine by regulating the amount of fuel supplied to the engine cylinders. At any speed setting, speed control is isochronous; that is, the governor maintains constant engine speed with steady or changing conditions of load. The governor also has the following auxiliary functions:

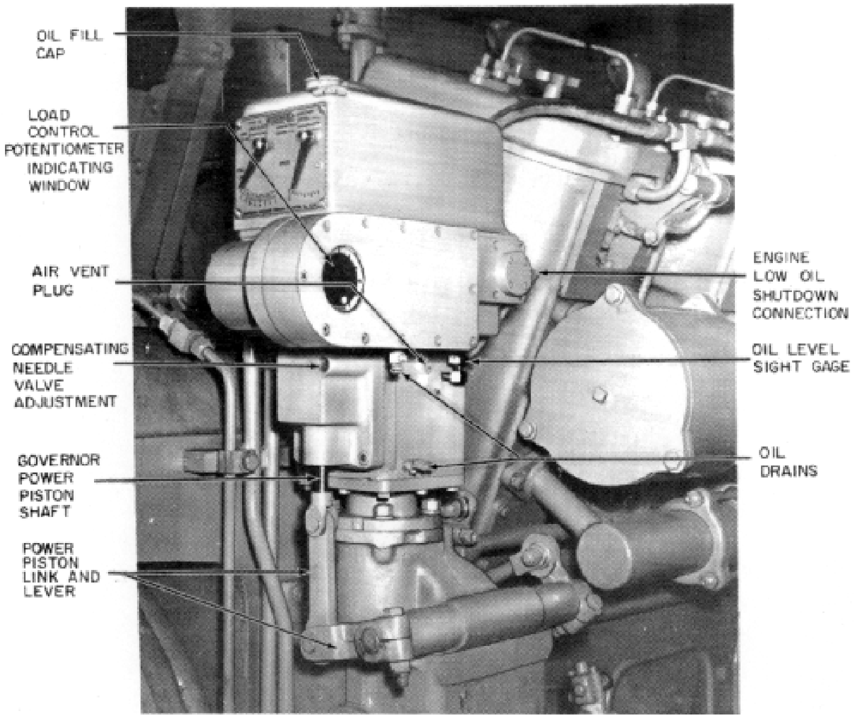
1. Remote electrical control for eight speeds from 400 to 1000 RPM, plus shutdown position.

2. Load control regulation which maintains a constant horsepower output of the engine for each speed setting.

3. Overriding of normal functioning of load control system to aid in control of wheel slip and dynamic braking functions.

4. Automatic shutdown of diesel engine in event of failure of engine lubricating oil pressure. A low oil pressure switch in the governor provides a light and bell warning in the operator's cab. The low oil pressure shutdown has a time delay at idle speed. This allows starting of engine without oil pressure (normal procedure) while still providing shutdown if engine lubricating oil pressure system fails to function normally within this time.

ENGINE CONTROL GOVERNOR



ENGINE CONTROL GOVERNOR ARRANGEMENTS
FIG. 9-1

<u>INSPECTION AND MAINTENANCE</u>

SOLENOID SEQUENCE TABLE

THROTTLE NOTCH	GOVERNOR SPEED CONTROL SOLENOIDS ENERGIZED			
Stop	-	-	-	D
Idle - 1	-	-	-	-
2	A	-	-	-
3	-	-	C	-
4	A	-	C	-
5	-	B	C	D
6	A	B	C	D
7	-	B	C	-
8	A	B	C	-

ENGINE CONTROL GOVERNOR

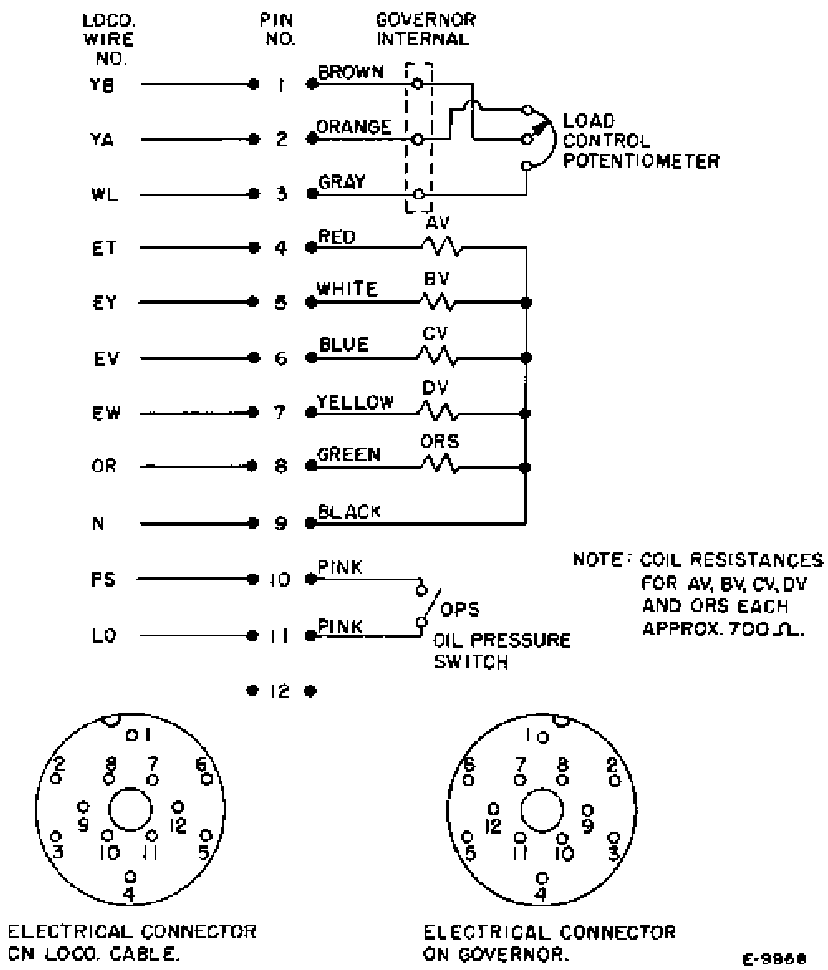
Energizing "D" solenoid alone controls governor to stop engine.

The overriding solenoid ^{11}0" is used during wheel slip. When "O" is energized, the brush arm of the load control potentiometer is forced toward the minimum excitation position. This action aids wheel slip recovery. The "O" solenoid is also used during dynamic braking to aid in control of braking current.

SOLENOID SEQUENCE TEST

1. With diesel engine shut down:
   a. Position reverse handle in OFF.
   b. Move selector handle to position 1.
   c. Move throttle handle to IDLE.
2. Have air system charged and locomotive brakes applied.
3. Remove electrical connector from the governor with a twist, pulling outward from the governor. Remove top cover, taking care to keep dirt and foreign matter from dropping into governor. Reinstall electrical connector.
4. Close battery switch, negative circuit breaker, fuel pump circuit breaker and control circuit breaker. Move EC switch to RUN. Make sure power limit switch is in NORMAL.
5. Depress safety control foot pedal (if used) and advance throttle handle from IDLE, checking governor solenoid pickup in each numbered notch. Solenoid operation may be checked either by feeling the solenoids as throttle is moved from notch to notch, or by observing the short visible length of the solenoid plunger which can be seen below the solenoid support. See SOLENOID SEQUENCE TABLE.
6. Move throttle handle back to IDLE. Move EC switch to START. Depress engine stop button. "D" solenoid should be energized.

ENGINE CONTROL GOVERNOR



PG GOVERNOR - WIRING CONNECTIONS
FIG. 9-2

7. If any solenoids fail to operate, check internal governor wiring and also connections to governor electrical connector.

8. After checking sequence, carefully remount governor cover and reinstall electrical connector.

ENGINE CONTROL GOVERNOR

GOVERNOR WIRING (See FIG. 9-2)

To check internal wiring of governor:

1. Disconnect electrical connector from governor.
2. Using an ohmmeter, check from pin 9 to pins 4, 5, 6, 7 and 8 in turn.See DATA for solenoid resistance value.
3. Connect the ohmmeter from pin 10 to 11. If the oil pressure shutdown button is "out", the ohmmeter should indicate a closed circuit (zero resistance). Push oil pressure shutdown button "in"; circuit should open (infinite resistance).
4. Using the ohmmeter, check load control potentiometer between pins 2 and 3. See DATA for resistance value. Check that brush arm is connected between pins 1 and 2 and 1 and 3.

GOVERNOR OIL

See FUEL AND LUBRICANT SPECIFICATIONS for LUBRICATING OIL to be used. In general, use same oil as applied to diesel engine crankcase.

****
CAUTION
****

ALWAYS USE CLEAN, NEW OIL: OTHERWISE DAMAGE TO GOVERNOR MAY OCCUR! CONTAINERS USED FOR ADDING OIL MUST BE PERFECTLY CLEAN. DO NOT MIX OILS THAT ARE INCOMPATIBLE.

CHANGING GOVERNOR OIL

When oil change period occurs, proceed as follows:

1. Have engine stopped.
2. Drain oil from drain cocks on lower side of governor case and underside of load control housing. See FIG. 9-1.

3. Close drain cocks and refill governor with CLEAN, NEW OIL through top filler cap.

4. After the engine is started, trapped air must be bled from the governor. See COMPENSATION ADJUSTMENT. Add oil as required to maintain correct governor oil level.

Flushing Governor

If it is desirable to periodically flush the governor, use only lubricating oil prescribed for use in the governor. Follow the steps described under CHANGING GOVERNOR OIL.

Operate the engine for 5 to 10 minutes after servicing the governor with new oil to circulate and warm the oil. Then repeat steps 1, 2, 3, and 4 while the governor oil is warm.

GOVERNOR ADJUSTMENTS

COMPENSATION ADJUSTMENTS

The compensation adjustment matches the governor operation to the operating behavior of each individual engine. Compensation adjustments may be needed when starting an engine the first time, when a governor has been changed, or after a governor oil change.

Adjust as follows:

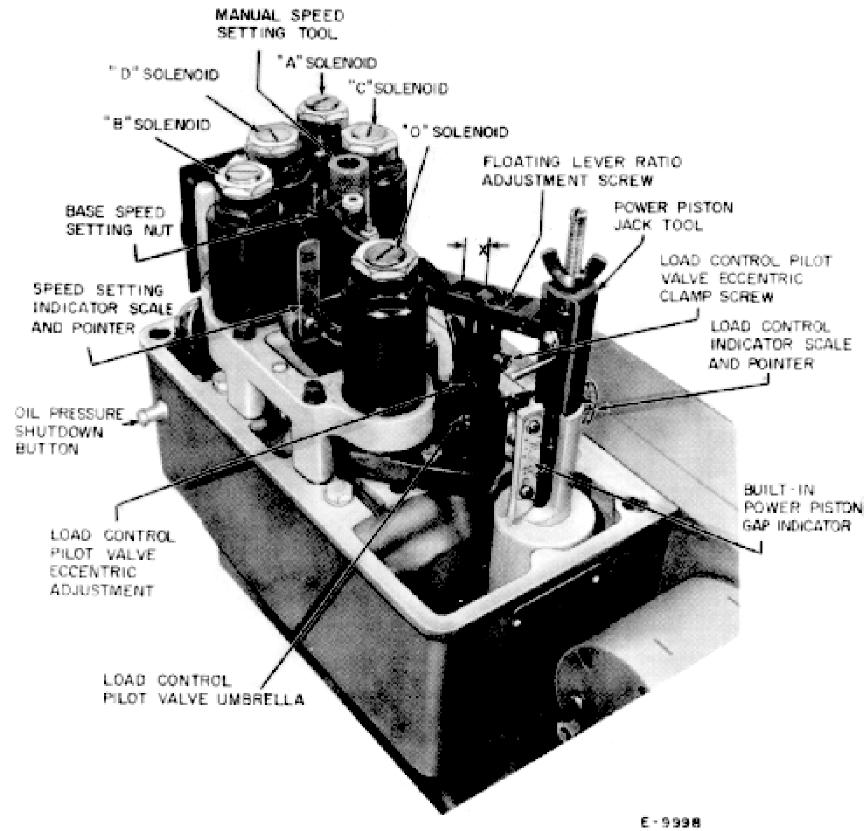
1. Start engine and allow to idle.

2. Loosen air vent plug several turns to allow oil to flow slowly. See FIG. 9-1.

3. Loosen the compensation needle valve several turns. See FIG. 9-1.

4. Allow engine speed to surge freely at idle speed
for 30 seconds to remove trapped air from governor oil passages.

5. After all air is removed, tighten the air vent plug and reset the governor compensating needle valve.



ENGINE CONTROL GOVERNOR WITH ADJUSTING TOOLS IN PLACE
FIG. 9-3

Close the needle valve slowly until all surging or hunting is eliminated. This usually occurs when the needle valve is between one-quarter and three full turns open.

6. Test stability by disturbing the engine speed. If the engine returns to steady speed, the adjustment is satisfactory. If hunting occurs, close needle valve slightly and test again. Keep the needle valve open as far as possible to prevent sluggishness and still obtain stability. Once the valve is properly set, further changes should not be necessary.

ENGINE CONTROL GOVERNOR

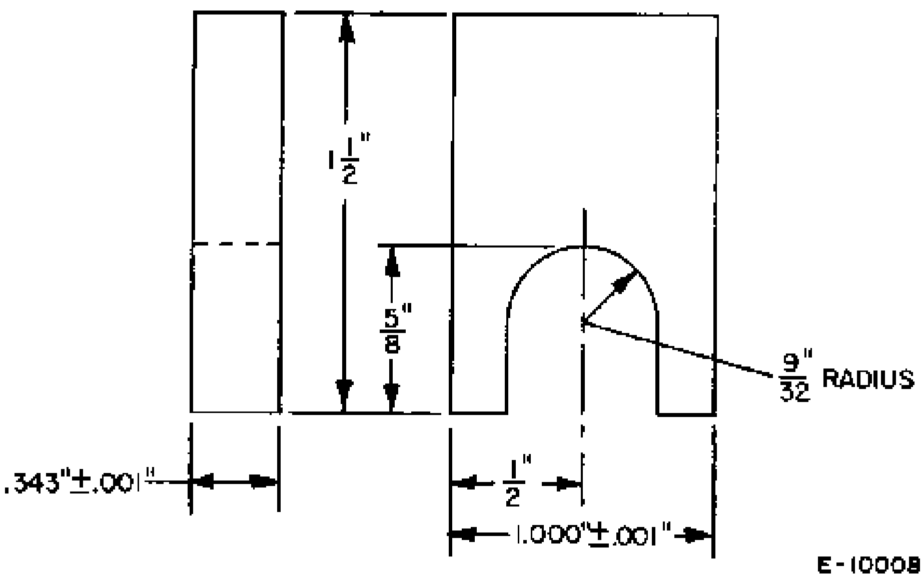
ENGINE CONTROL GOVERNOR

MATCHING FUEL INJECTION PUMPS TO GOVERNOR

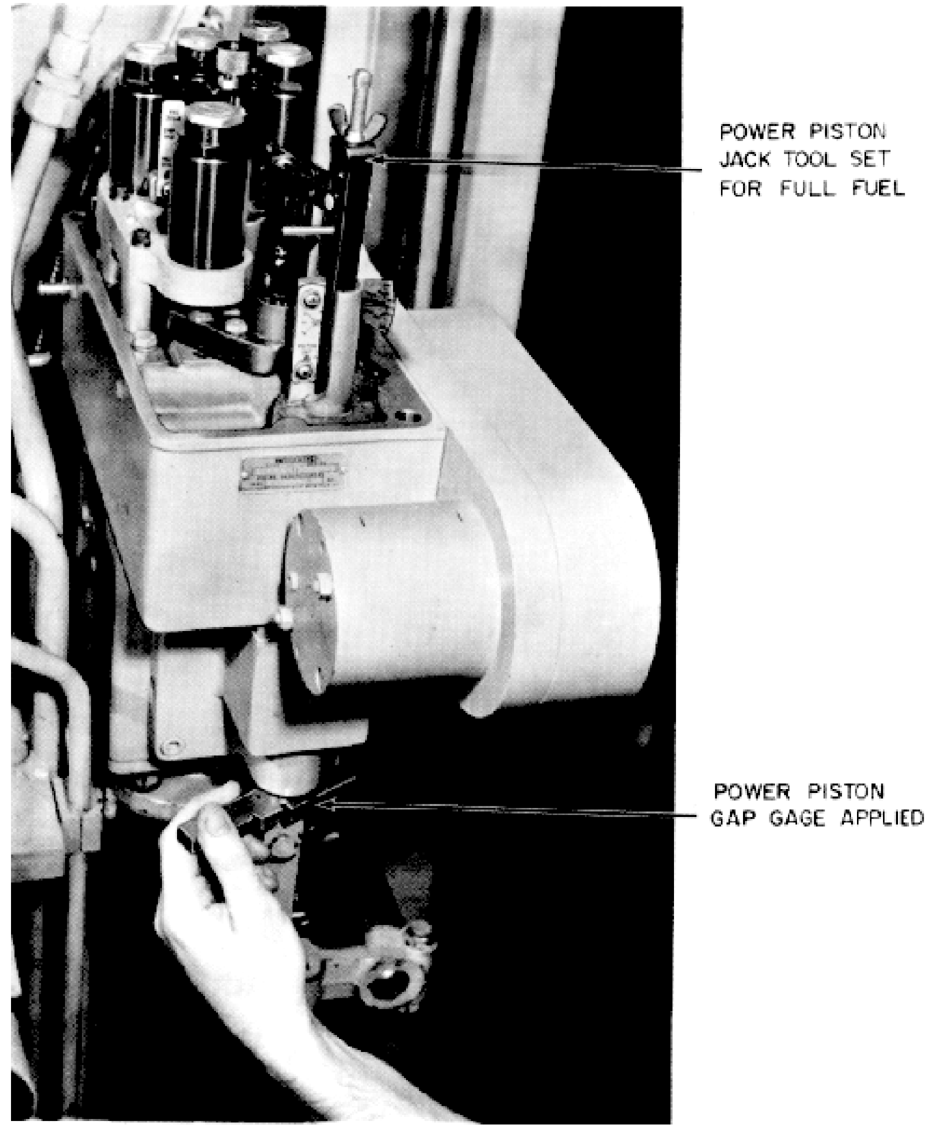
Use the power piston gap indicator if supplied on governor or, for more accurate adjustment, use gage shown on FIG. 9-4 to measure full fuel piston gap. Use portion of the gage block marked 0.344 inch. Gage block is placed against machined length of power piston rod, with lower side of block bearing on top rim of clevis. Power piston is at correct gap when gage is held lightly clamped between clevis and bottom of power cylinder.

With diesel engine shut down, adjust engine fuel-pump rack position to match governor piston gap as follows:

1. Remove governor top cover. Install power piston jack tool on top of power piston tail rod. See FIG. 9-3 and FIG. 9-5 (do not install manual speed setting tool). Use power piston jack tool to raise governor power piston to full load, full speed, piston gap of 0.344 inch. Each engine injection pump rack should read millimeters travel as given under DATA for full load setting.

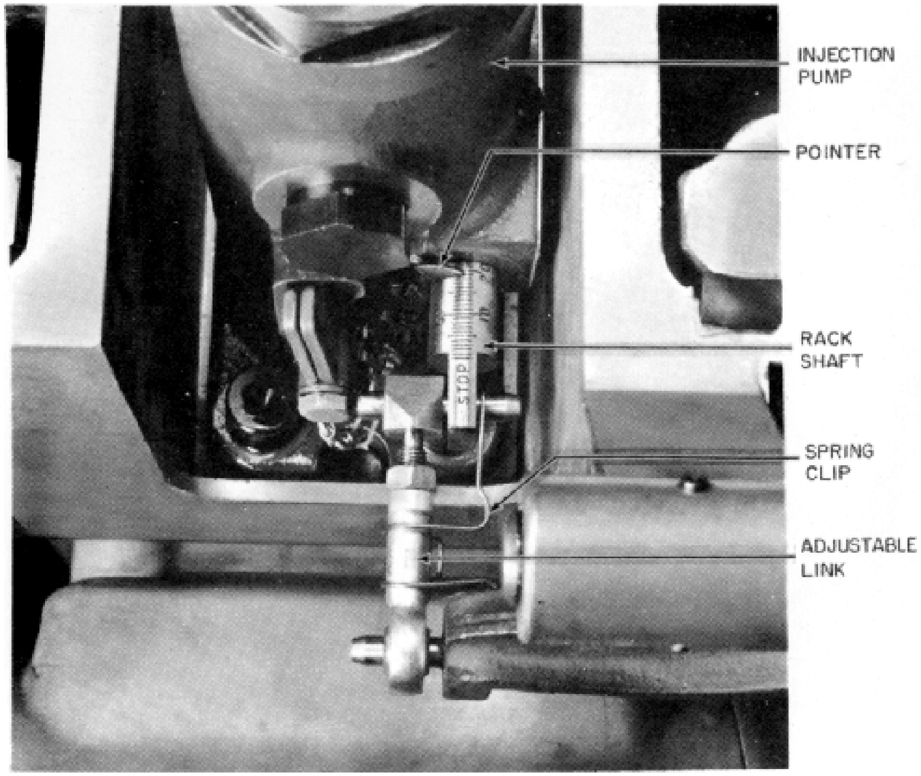


POWER PISTON GAP GAGE
FIG. 9-4



MEASURING PISTON GAP
FIG. 9-5

ENGINE CONTROL GOVERNOR



FUEL PUMP RACK SHAFT AND LINKAGE
FIG. 9-6

2. If any pump rack travel is not properly set, at the 0.344 inch piston gap, adjust individual rack links to obtain correct setting. See FIG. 9-6.

3. Back off the power piston jack tool, clamp the 1.000 inch portion of the power piston gap gage firmly as a measure of idle speed power piston gap.

   Pump racks should now read IDLE rack position as given under DATA.

4. Back power piston jack tool off completely. Racks should now read 0 to 3 millimeters which is the shutdown position.

5. Check that all nuts are tight and cotter pins are installed. Use new cotter pins where cotter pins were removed.

ENGINE CONTROL GOVERNOR

6. Remove power piston jack tool before attempting to start engine.

NOTE: DO NOT LEAVE GOVERNOR TOOLS IN GOVERNOR CASE AS THEY MAY CAUSE FLAKING OF CASE METAL, THUS CONTAMINATING GOVERNOR OIL.

****
CAUTION
****

DO NOT START ENGINE WITH POWER PISTON JACK TOOL INSTALLED. ENGINE DAMAGE MAY RESULT FROM OVERSPEED.

WHEN USING THE MANUAL SPEED-SETTING TOOL, THE LOW LUBRICATING OIL SHUTDOWN IS INOPERATIVE, AND THE ENGINE CANNOT BE STOPPED IN NORMAL MANNER. IF ENGINE OIL FAILURE OCCURS, ENGINE BEARING DAMAGE CAN RESULT.

ENGINE SPEED SETTINGS

Before attempting speed checks, governor piston gap and diesel-engine rack travel must be correctly matched. See MATCHING FUEL INJECTION PUMPS TO GOVERNOR.

Engine Speed Check

Engine speeds are determined using a recently calibrated direct reading hand tachometer as follows:

1. Remove 1/2 inch pipe plug on side of governor drive gear case. Hand tach will be applied through this hole. A short extension may be needed.

2. Start engine and allow to idle and warm up to normal operating temperature.

3. Have throttle handle in IDLE, reverse handle in OFF and selector handle in notch 1. Check idle speed of engine using hand tachometer.

4. Advance throttle handle, checking speeds at each numbered notch. Speeds should be within limits shown in DATA. See FIG. 9-9 for speed conversion.

ENGINE CONTROL GOVERNOR

5. If speed readings are out of limits, then engine speeds must be reset.

Engine Speed Adjustment

Adjust diesel-engine speeds for given throttle notches and IDLE in order shown:

1. Advance throttle handle to notch 6 and check diesel engine crankshaft speed. Notch 6 speed should be between 826 and 834 rpm. If necessary, adjust this speed using base speed setting nut. See FIG. 9-3.(Turn nut C.C.W. to increase speed.)

2. Advance throttle to notch 8. Engine speed should be 996-1004 rpm. To set this speed, loosen lock nut on top of solenoid D and rotate adjusting screw plug using screw driver. (Turning screw counterclockwise increases speed.) Tighten locknut.

3. Move throttle handle to notch 7. Using adjusting screw on top of solenoid A, set engine speed to 912-920 rpm.

4. Move throttle handle to notch 4. Using adjusting screw on top of solenoid B, set engine speed to 654-662 rpm.

5. Move throttle handle to IDLE. Using adjusting screw on top of solenoid C, set engine speed to 396-404 rpm.

6. Recheck speeds at each numbered throttle notch. All should be within limits given on SOLENOID SEQUENCE TABLE; otherwise, reset speeds.

LOAD CONTROL ADJUSTMENT

Changes to the load control linkage should be made only by experienced personnel, thoroughly trained in the operation of the governor.

If engine becomes overloaded, the load control potentiometer should start to rotate toward minimum field. White dot, seen through load control window, should move C. C. W. If load control operates incorrectly, check that fuel racks

ENGINE CONTROL GOVERNOR

are correctly matched to the governor. Also check that all cylinders are firing and that fuel control linkage is not binding.

Engine fuel control linkage must permit overtravel of the governor power piston past its full load piston gap, even though engine fuel injection pumps have reached their desired full-fuel rack settings. This overtravel is necessary to initiate proper load control action.

Use the following procedure when adjusting the load control of the governor on a locomotive. For correct information refer to DATA page.

1. Engine speeds must be correct. See Engine Speed Adjustments.

2. Governor speed setting indicator scale must be calibrated so that STOP, IDLE and FULL SPEED scribed lines on indicator plate coincide with indicator pointer for each of these speeds.

3. To calibrate the load-control indicator scale, with the engine running at IDLE, lift the load-control pilot valve plunger with a slight upward prying action, using a medium-sized screw driver blade under the pilot valve umbrella.. See FIG. 9-3. Shift plunger up or down until a condition of "balance" is reached on the servo motor. Balance is the point at which the load-control valve plunger laps the control ports, stopping oil flow to the vane servo motor. Under this condition the load-control rheostat brush arm indicator (white dot in window) should "float" with only slight movement when positioned near the mid point of its travel.

4. Loosen load-control indicator plate mounting screw. Adjust indicator plate so that pointer reads ZERO with white dot balanced.

5. Shut the Engine Down in a normal manner.

6. Set the FLOATING LEVER RATIO ADJUSTMENT to 5/8 inch gap between load-control pivot link and front of the rear spacer block on floating ratio lever. See FIG. 9-3 (dimension "X").

7. Install the MANUAL SPEED SETTING TOOL on stud provided. See FIG. 9-3. Turn tool down until speed indicator pointer coincides with FULL SPEED scribed line, previously calibrated to correct engine speed.

8. Install the POWER PISTON JACK TOOL on the POWER PISTON TAIL ROD.

9. Turn the wing nut until power piston gap is 0.344 inch.

10. Load-control indicator pointer should now read ZERO on indicator plate. If it does not, loosen the eccentric adjustment clamp screw, turn the eccentric to cause the pointer to read ZERO, and then tighten the clamp screw.

11. Back off manual speed setting tool until speed pointer coincides with IDLE line on speed indicator plate.

12. Adjust the governor power piston gap to 1.000 inch using power piston jack tool.

13. Load-control indicator pointer should now coincide with the MAX. FIELD START LINE on the indicator plate.

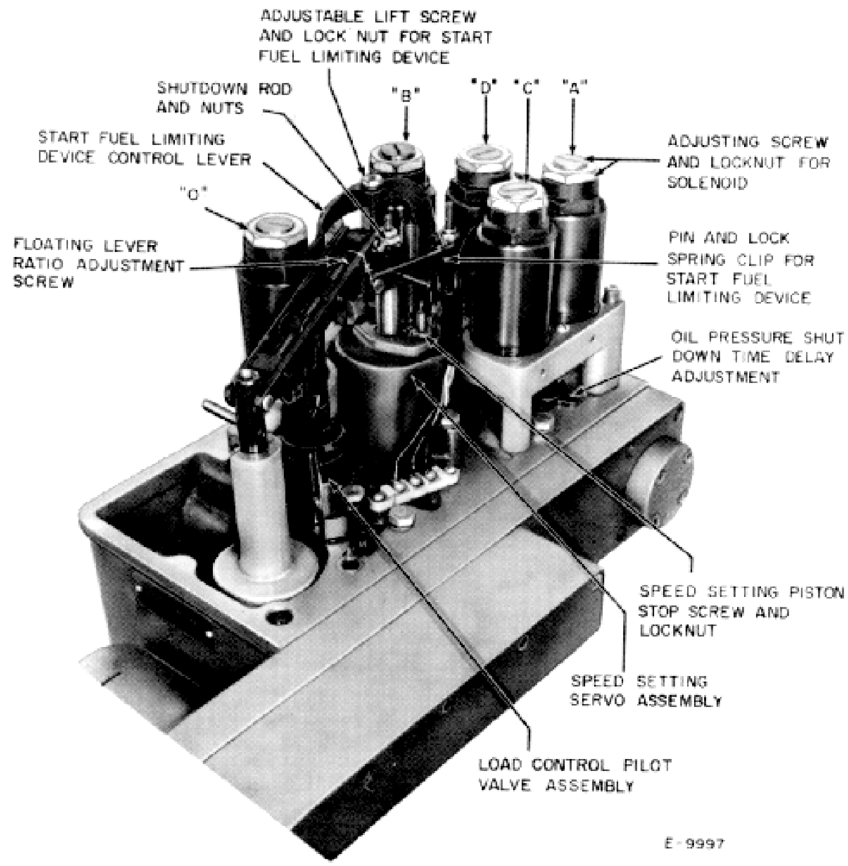
14. If the load-control pilot valve reads lower or higher than reading required, adjust floating ratio adjustment previously set at 5/8 inch until indicator pointer moves half the distance between the observed reading and the required reading.

15. Adjust pilot valve eccentric adjustment to lower or raise indicator pointer to required reading.

16. Repeat steps 7 through 15 until power piston gap and corresponding speed settings cause correct load control pilot valve position and movement.

START FUEL LIMITING DEVICE (See FIG. 9-7)

The start fuel limiting device consists of a control lever, pin and lock spring clip, and an adjustable lift screw and lock nut.



ENGINE CONTROL GOVERNOR - TOP RIGHT SIDE
WITH COVER REMOVED
FIG. 9-7

The rear of the control lever pivots at the restoring link pin while the forward end touches the adjustable floating lever link. The movement of the adjustable lift screw is a ratio relation between fuel and speed. With the adjustable lift screw and the governor shutdown nuts properly adjusted, the device will control the amount of fuel the engine cylinders can receive during starting. Control is affected by lifting the governor shutdown rod to regulate governor piston Gap.

ENGINE CONTROL GOVERNOR

When properly adjusted, the start fuel limiting device should have no effect on the engine in Notch 2 and higher.

Adjustments

1. Start the engine and run at IDLE.

2. Set the lift screw to lightly contact the speed setting piston fulcrum assembly over the speed setting piston.

3. Lock the lift screw lock nut.

4. Set the shutdown nut so that there is 1/32 inch gap between the governor shutdown nut and the adjustable lifting screw head when the slack is pulled out of the governor shutdown rod.

5. Lock the shutdown nuts.

CHANGING GOVERNORS ON ENGINE

****
CAUTION
****

TAKE PRECAUTIONS AGAINST DIESEL ENGINE BEING ACCIDENTALLY CRANKED WHEN CHANGING GOVERNORS. ENGINE DAMAGE CAN RESULT IF ENGINE IS STARTED WITH GOVERNOR REMOVED.

REMOVAL

Proceed with governor removal in the following manner:

1. Have diesel engine stopped and starting contactors blocked open.

2. Remove electrical connector plug from governor receptacle.

3. Disconnect oil pressure shutdown line at governor receptacle.

4. Remove cotter pin from power piston clevis pin and remove pin. This disconnects the power piston linkage.

ENGINE CONTROL GOVERNOR

5. Remove four nuts and lock washers from mounting studs.

6. Install eye-bolt in governor top cover.

7. Install a 3/4 inch steel pipe or equivalent between the two hood supporting cross members nearest overhead above governor.

8. Use a small chain hoist attached from pipe to eye bolt in governor. Hoist must be capable of handling governor weight.

9. Hoist straight up until governor spline shaft clears the governor drive gear case.

10. Lower governor, carefully easing it out through hood door to deck.

INSTALLATION

Proceed with governor installation in the following manner

1. Make sure governor spline shaft and mounting surfaces are clean. Have gasket in place.

2. Hoist governor into position over gear case.

3. Slowly lower governor into position on its adapter seat, matching spline to governor drive. No force should be required to locate governor and set it squarely on its seat with drive splines correctly aligned and mounting studs engaged.

4. Install nuts and lock washers to mounting studs.

5. Reconnect power piston linkage by installing pin through link and power piston clevis. Install cotter pin.

6. Attach oil pressure shutdown line to governor fitting.

7. Install electrical connector to governor receptacle.

8. Check governor oil level. Add oil as required. See GOVERNOR OIL.

9. Remove eye-bolt from governor and unblock starting contactors.

10. Match fuel control linkage to governor piston gap and make operational test of governor. Readjust as needed.

FUEL CONTROL LINKAGE

DESCRIPTION (See FIG. 9-8)

The fuel control linkage connects the engine control governor output shaft to each individual injection pump rack shaft.

The linkage consists of shafts, levers, links, bell cranks and push rods. The push rods operate on self-aligning oil bronze bushings. The horizontal shafts are supported in brackets fitted with oil bronze bushings.

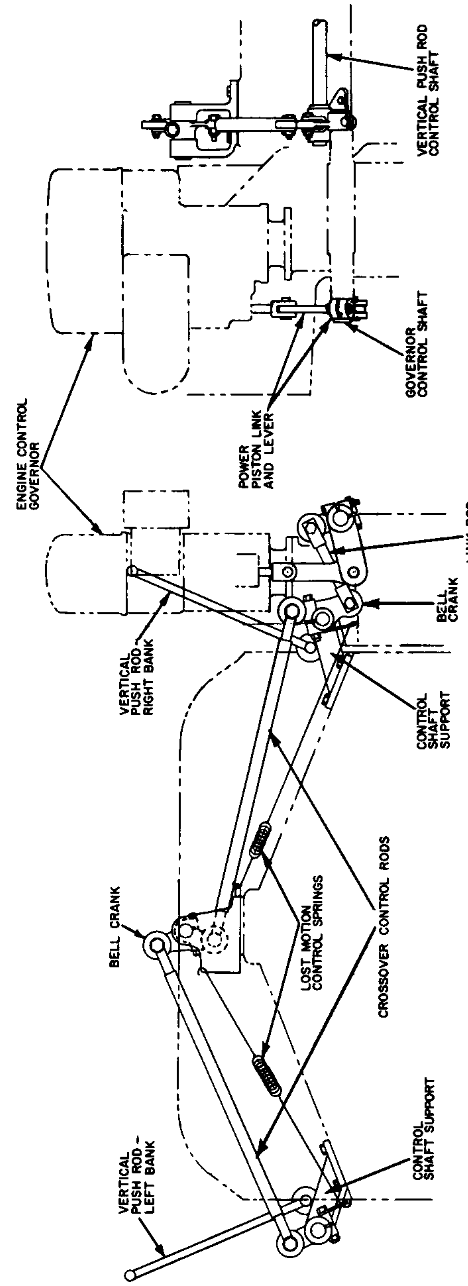
All linkage bearings can be lubricated through oiler buttons and oil must be applied periodically.

The linkage rods and levers are all of fixed lengths and the levers are keyed into position on the shaft.

Only one adjustment can be made to the linkage. This adjustment is made using the short adjustable link at each individual injection pump rack shaft. (See FIG. 9-6.)

INSPECTION

Inspect fuel control linkage periodically to insure that parts are free to move in their bearings and that bearings are receiving proper lubrication.



NOTE: ALL LINKS AND RODS ARE OF FIXED LENGTH.
ALL LEVERS, COLLARS AND BRACKETS ARE KEYED OR DOWELED IN POSITION.

FUEL CONTROL LINKAGE

FIG. 9-8

ENGINE CONTROL GOVERNOR

DATA

Woodward Model
No. 364714

SUPPLIES

Governor Oil - Use Heavy Duty Engine Lubricating Oil.

- Quantity . . . . 2 qt.

SPEED SCHEDULE

Control Position	Engine Crankshaft RPM	Tachometer Drive RPM	Governor RPM
Idle & Notch 1	400± 10	594 ± 15	443 ± 4
Notch 2	486 ± 20	722 ± 30	538 ± 15
Notch 3	572 ± 20	850 ± 30	633 ± 15
Notch 4	658 ± 10	978 ± 15	729 ± 4
Notch 5	744 ± 20	1105 ± 30	824 ± 15
Notch 6	830 ± 10	1233 ± 15	919 ± 4
Notch 7	916±10	1361±15	1014±4
Notch 8	1000 ± 5	1486 ± 7.5	1107 ± 4

ENGINE RPM

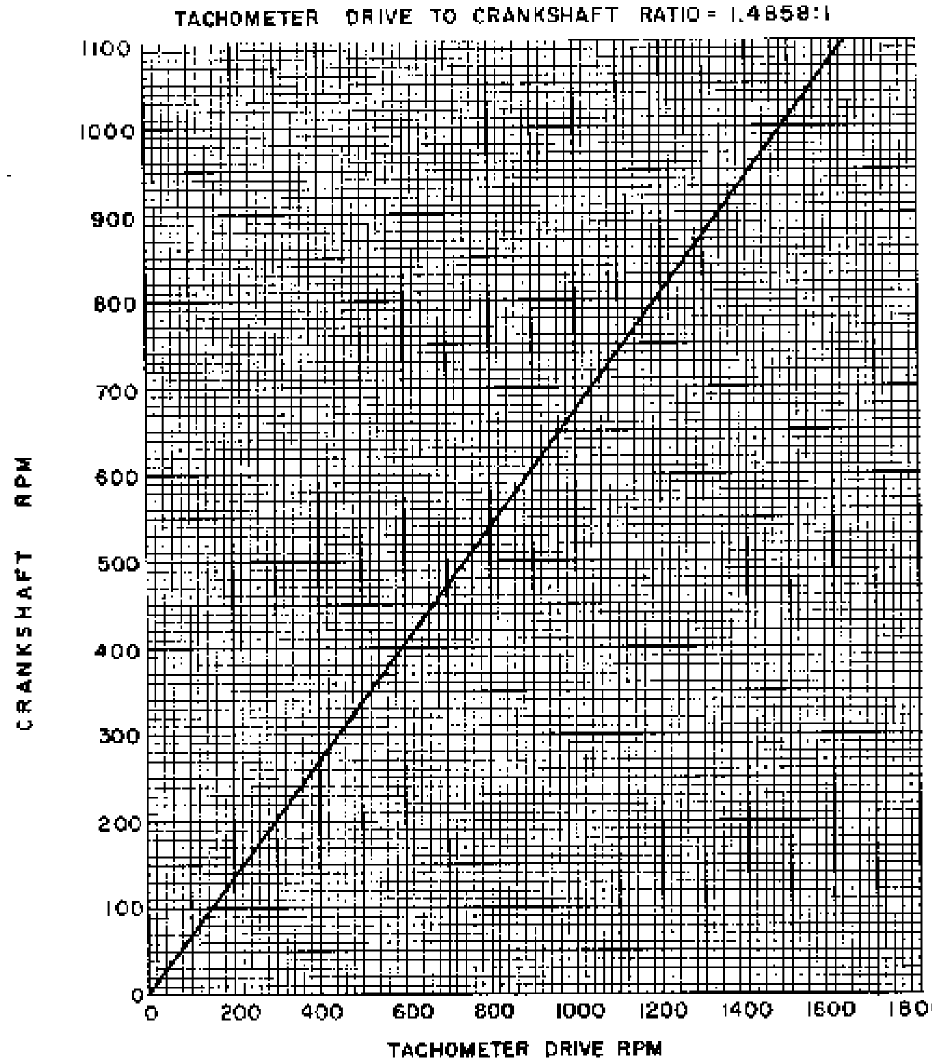
OVER-SHOOT	1075	1597

SETTINGS

Engine	Governor Piston Gap	Pump Rack Eng. Running	Pump Rack Eng. Stopped
Shutdown	Approx. 1.156 in.		0 - 3 MM
Idle	1.000 in.	Approx. 5 MM	
Full Load	0.344 in.	19 + 1/2* -0	19 MM

*Rack Travel Approached from Shutdown Position.

ENGINE CONTROL GOVERNOR



TACHOMETER DRIVE SPEED VERSUS
CRANKSHAFT SPEED CURVE
FIG. 9-9

ENGINE CONTROL GOVERNOR

LOAD CONTROL

Load Control Pilot Valve

a. Set for Maximum Field start @1.000 inch piston gap at Idle Speed.

b. Indicator pointer comes to zero (Servo Motor Balanced) at 0.344 inch piston gap and Full Speed.

c. Servo Motor timing Max. Field to Min. Field.

(Fixed). . . . . (Oil Temp. 180 F) . . . . 20 sec.

d. Servo Motor timing Min. Field to Max. Field

(Fixed). . . . . (Oil Temp. 180 F) . . . . 30 sec.

e. Servo Motor timing Max. Field to Min. Field, Solenoid "O" Energized . . . . . Less than 2 sec.

f. Vane Servo Motor pressure (Vane Stationary) . . . . 37 to 47 psi

g. Field rheostat Resistance (total) . . . 44 ohms

h. Solenoid resistance A, B, C, D & O . . . . 700 ohms @ 68 F

ENGINE LUBE FAILURE TRIP

Trip pressure at Idle and Notch 1 - Between .	10 to 14 psi
Trip pressure Full Speed - Between.	25 to 30 psi
Trip time delay Idle - Notch 1 (adjustable) . .	35 to 45 sec.
Trip time delay Notch 2 to Full Speed	0 sec.
Governor accelerating time from 443 to 1107 RPM.	16 sec.

LIGHT MAINTENANCE FEATURES

GAGES AND MEASURING DEVICES

During scheduled inspection periods and when performing light maintenance the following gages and measuring devices are used in specific work operations.

ENGINE LUBRICATING OIL DIP STICK - one located on each side of engine filler pipe. The stick is marked HIGH and LOW (FIG. 10-1). Proper level with engine idling is between HIGH and LOW.

FUEL OIL SIGHT GLASSES - mounted on both sides of the main fuel tank to indicate level of fuel in the tanks (FIG. 10-2).

COOLING WATER - a sight glass mounted on side of cooling water supply tank indicates level of cooling water in the system. Markings on tank indicate proper level for conditions. (Fig. 10-3)

COMPRESSOR LUBE OIL (Gardner-Denver Compressor) - a gage mounted on the compressor frame indicates oil level. The gage scale is marked ADD (lower red scale), RUN (green scale), EXCESSIVE (upper red scale). See FIG. 10-4. Take reading with engine shutdown. (Westinghouse Compressor) - dip stick marked HIGH and LOW indicator.

TRACTION GENERATOR GEAR BOX - has a dip stick marked EMPTY-ADD-FUEL. Proper level is between ADD and FULL. Proper level is between ADD and FULL with engine stopped. See FIG. 10-5.

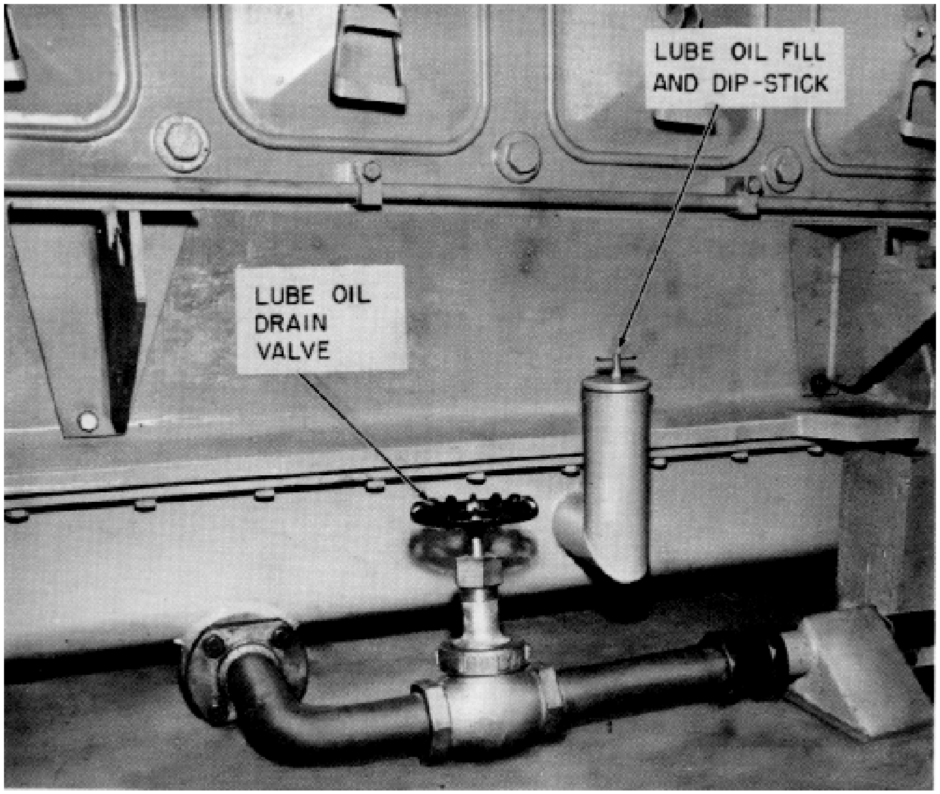
OIL BATH AIR FILTER SIGHT GLASS - there are four filters, two located on the right and two on the left side at rear of locomotive unit. A sight glass is mounted on each filter. Oil must be visible between lines on the sight glass, with engine idling. See FIG. 10-6.

FAN-GEAR UNIT OIL LEVEL PLUG - maintain oil level near spill over. See FIG. 10-7.

LIGHT MAINTENANCE FEATURES

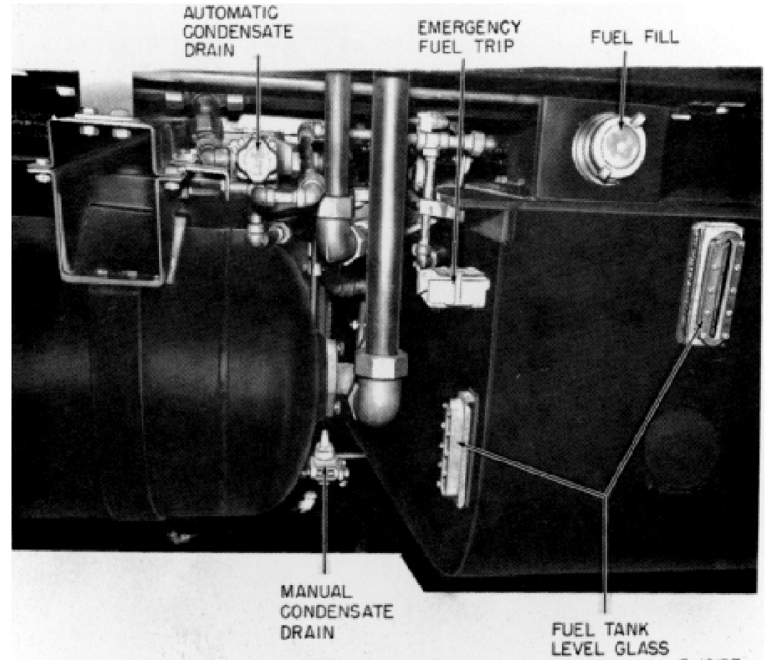
GOVERNOR OIL LEVEL SIGHT GLASS - located on left side of engine near traction generator. See FIG. 10-8. Oil level must be visible between marks on sight glass when engine is running.

NOTE: Refer to FIG. 10-11 and FIG. 10-12 for locations of locomotive equipments and all other lubrication and service points.

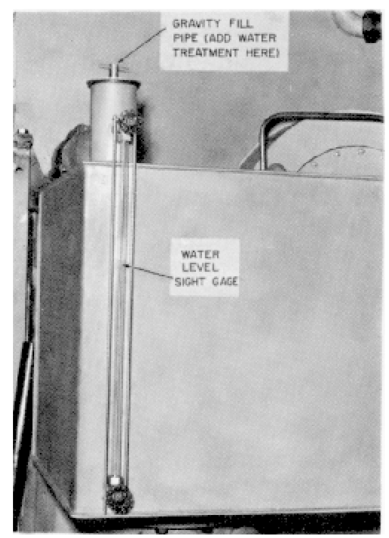


ENGINE CRANKCASE SERVICE POINTS
FIG. 10-1

LIGHT MAINTENANCE FEATURES

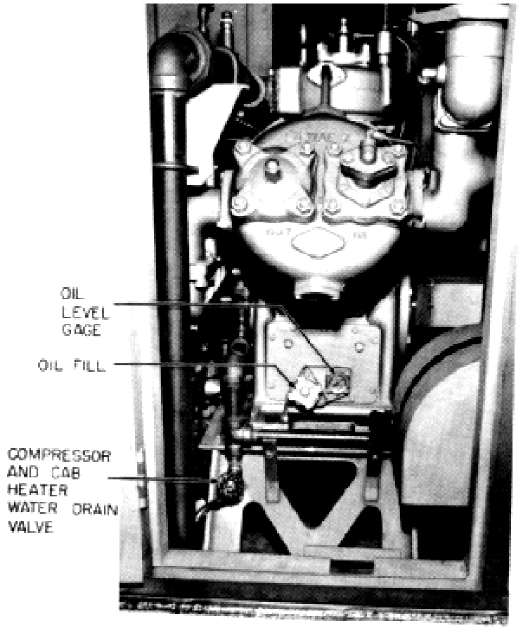


FUEL AND AIR PIPING DETAILS
FIG. 10-2

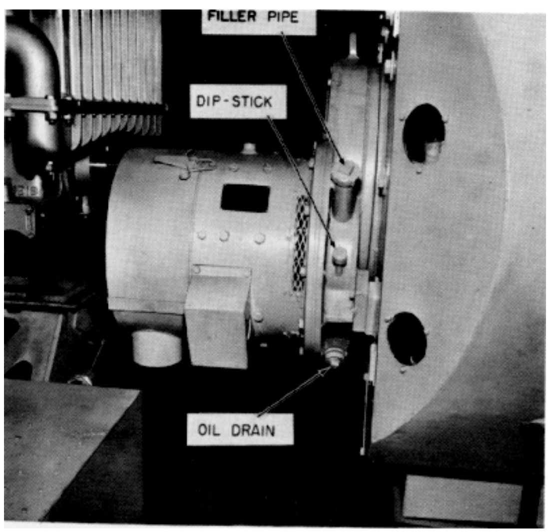


WATER STORAGE TANK (RIGHT SIDE)
FIG. 10-3

LIGHT MAINTENANCE FEATURES



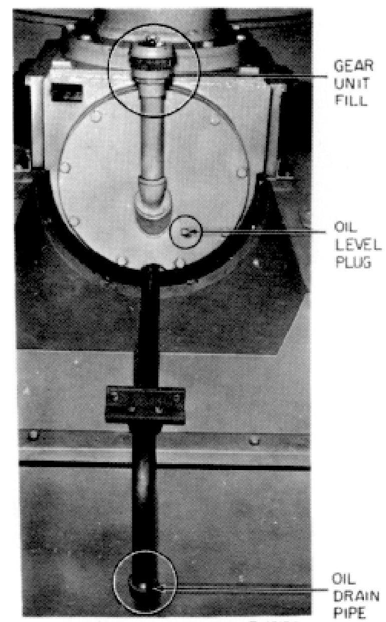
AIR COMPRESSOR (RIGHT SIDE)
FIG. 10-4



TRACTION GENERATOR GEAR UNIT
FIG. 10-5

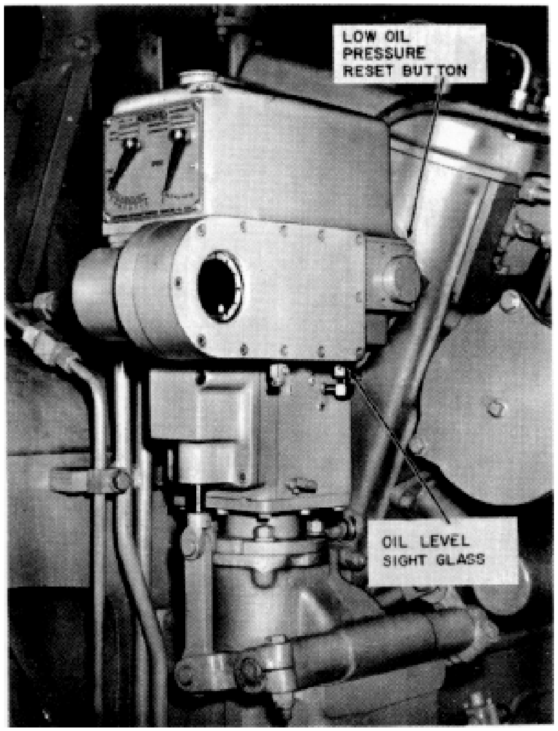
LIGHT MAINTENANCE FEATURES

ENGINE AIR FILTER
FIG. 10-6



FAN AND BLOWER UNIT SERVICE POINTS
FIG. 10-7

LIGHT MAINTENANCE FEATURES



ENGINE CONTROL GOVERNOR (LOCATED NEAR TRACTION GENERATOR - LEFT SIDE OF ENGINE)
FIG. 10-8

BRAKE RIGGING

The brake rigging is clasp type equipped with four brake cylinders per truck. Brake shoes are marked to indicate wear limit on outside of casting.

ADJUSTMENT (See FIG. 10-9)

1. Exhaust air from brake cylinders.

2. Lift nut retainer latch on manual slack adjuster and turn adjusting nut. To reduce piston travel, turn nut to move shoes closer to the wheel; to increase, move shoes away from wheels. Lower nut retaining latch.

3. Piston travel should be held as close as possible to low limit of 2 1/2 inches. Travel should not exceed 6 inches maximum.

LIGHT MAINTENANCE FEATURES

4. When piston travel cannot be adjusted with slack adjuster nuts alone, a coarse adjustment becomes necessary. To make a coarse adjustment, reconnect lower end of live lever to another set of coarse adjustment holes in pull rod. (See FIG. 10-10.) When reconnecting use NEW cotter pins.

BRAKE SHOE RENEWAL

1. Exhaust air from brake cylinder.

2. Move shoes as far as possible from wheel tread, by adjusting manual slack adjuster.

3. Hammer keys out of brake shoe header.

4. Knock shoes loose from brake head and remove. Lower ends of live levers may have to be disconnected from pull rods, to allow removal of shoes.

5. Insert new shoes in brake heads and line up keyways.

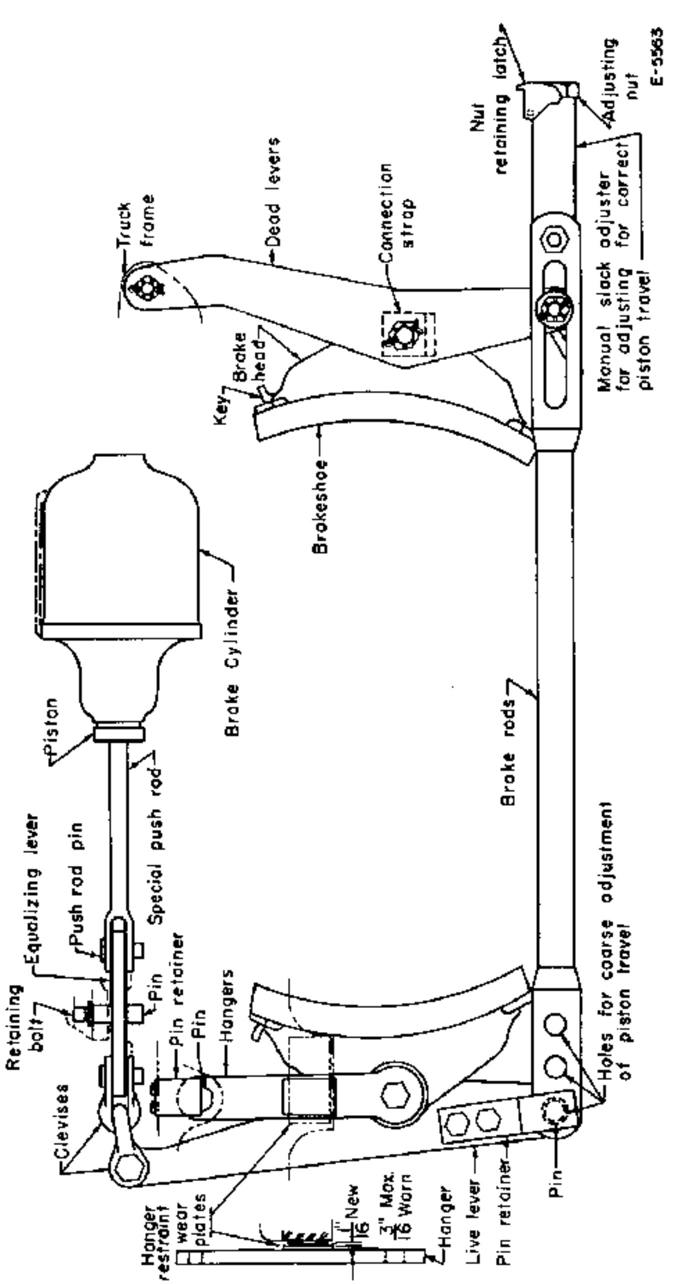
6. Drive keys in place and check shoes for tightness.

7. Reconnect live levers and pull rods, if removed, using NEW cotter pins.

8. Adjust manual slack adjuster nut to obtain 2 1/2 inch brake cylinder piston travel.

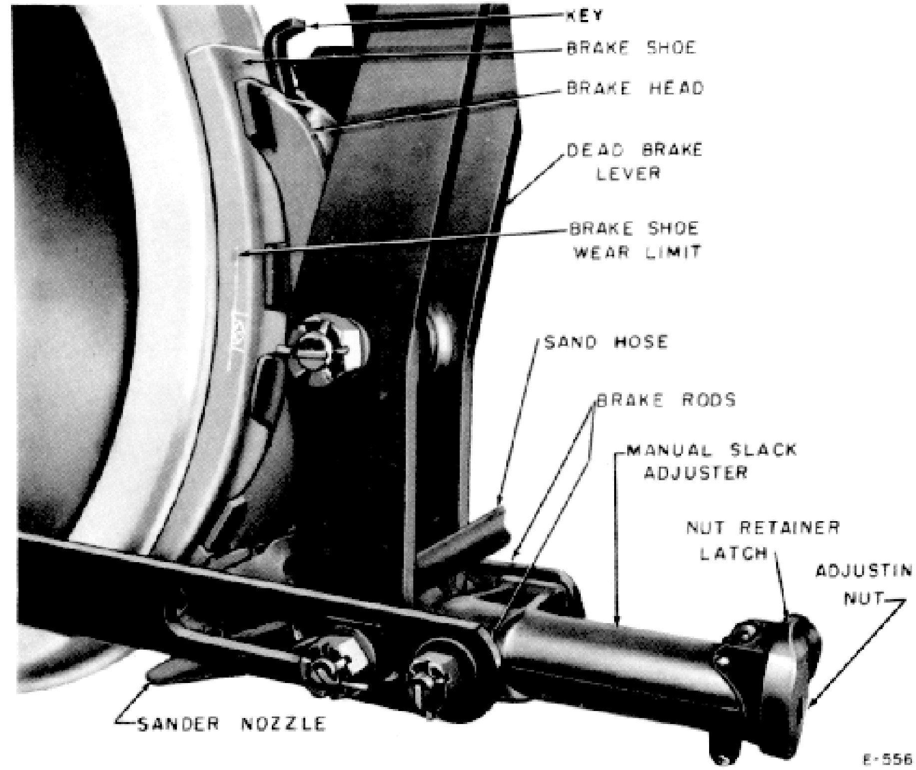
9. Be sure brake cylinder cut-out cocks are open when work is finished.

LIGHT MAINTENANCE FEATURES

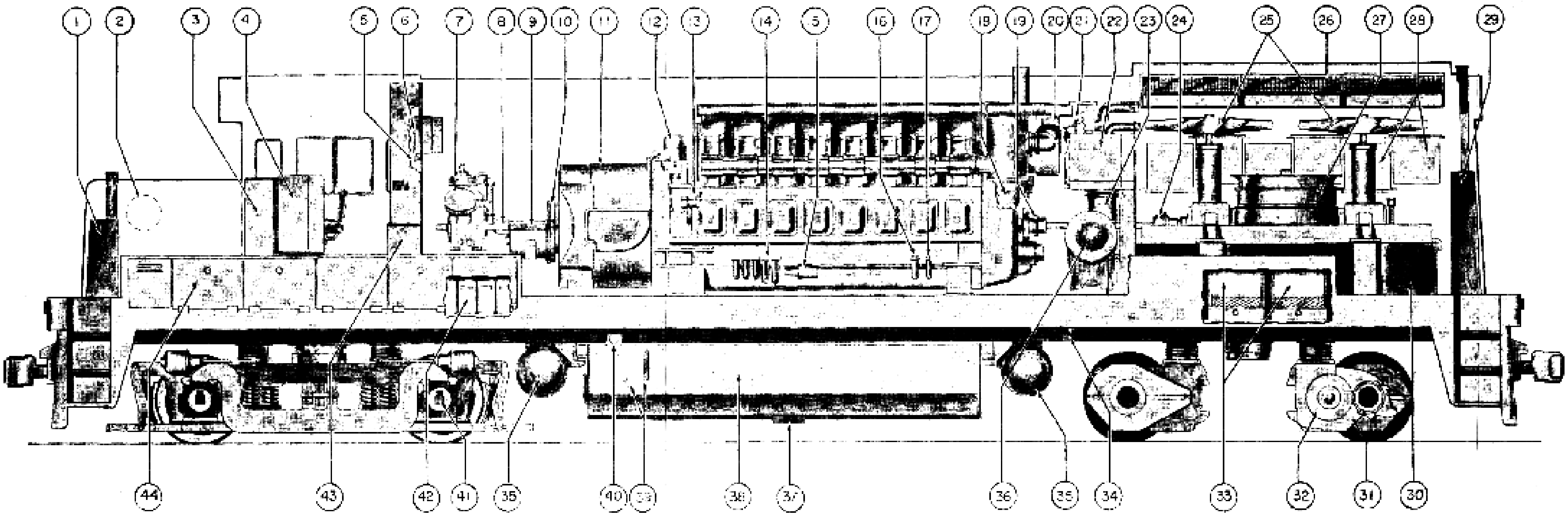


CLASP BRAKE RIGGING
FIG. 10-9

LIGHT MAINTENANCE FEATURES

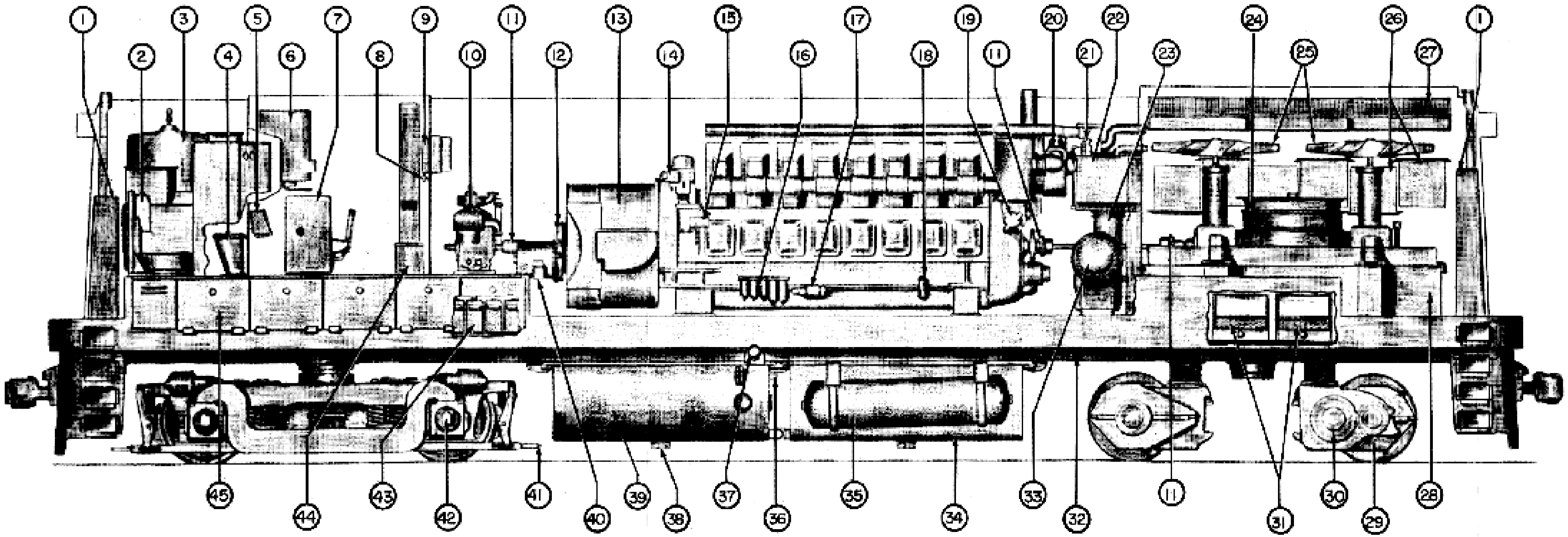


SLACK ADJUSTER AND BRAKE RIGGING DETAILS
FIG. 10-10



1. SAND BOX
2. HANDBRAKE
3. OPERATING CONTROLS AND GAGE PANEL
4. AIR BRAKE CONTROLS
5. EMERGENCY FUEL TRIP
6. ENGINE CONTROL PANEL
7. AIR COMPRESSOR
8. FLEXIBLE COUPLING
9. AUXILIARY GENERATOR (LEFT SIDE) EXCITER (RIGHT SIDE)
10. TRACTION GENERATOR GEAR CASE
11. TRACTION GENERATOR
12. ENGINE CONTROL GOVERNOR
13. OVERSPEED GOVERNOR
14. FUEL FILTERS
15. FUEL BOOSTER PUMP
16. LUBE OIL FILLER
17. LUBE OIL DIP-STICK (BOTH SIDES)
18. LUBE OIL STRAINER
19. FLEXIBLE COUPLING
20. TURBOCHARGER
21. WATER FILL (GRAVITY)
22. WATER STORAGE TANK
23. LUBE OIL COOLER
24. FLEXIBLE COUPLING
25. RADIATOR FANS
26. RADIATOR
27. EQUIPMENT BLOWER
28. BRAKING RESISTORS
29. SAND BOX
30. PRIMARY AIR CLEANER
31. TRACTION MOTOR GEAR CASE
32. TRACTION MOTOR
33. ENGINE AIR FILTERS
34. WATER FILL (PRESSURE) (BOTH SIDES)
35. MAIN AIR RESERVOIR
36. LUBE OIL FILTER
37. FUEL TANK SUMP
38. FUEL TANK
39. FUEL LEVEL GAGES
40. FUEL TANK FILL (BOTH SIDES)
41. AXLE ALTERNATOR (ALL AXLES)
42. BATTERIES (RIGHT SIDE)
43. CAB HEATER
44. CONTROL COMPARTMENT (LEFT SIDE) AIR BRAKE COMPARTMENT (RIGHT SIDE)

APPARATUS LOCATION (E-11662) (LOW NOSE LOCOMOTIVE)



1. SAND BOX
2. HAND BRAKE
3. STEAM GENERATOR (IF USED)
4. HOPPER
5. ENGINEMAN'S GAGE PANEL
6. MASTER CONTROLLER
7. AIR BRAKE STAND
8. EMERGENCY FUEL TRIP
9. ENGINE CONTROL PANEL
10. AIR COMPRESSOR
11. FLEXIBLE COUPLING
12. TRACTION GENERATOR GEAR CASE
13. TRACTION GENERATOR
14. ENGINE CONTROL GOVERNOR
15. OVERSPEED GOVERNOR
16. FUEL FILTERS
17. FUEL BOOSTER PUMP
18. LUBE OIL FILL AND DIP-STICK
19. LUBE OIL STRAINER
20. TURBOCHARGER
21. WATER FILL (GRAVITY)
22. WATER STORAGE TANK
23. LUBE OIL COOLER
24. EQUIPMENT BLOWER
25. RADIATOR FANS
26. BRAKING RESISTORS
27. RADIATOR
28. PRIMARY AIR CLEANER
29. TRACTION MOTOR GEAR CASE
30. TRACTION MOTOR
31. ENGINE AIR FILTERS
32. WATER FILL (PRESSURE)
33. LUBE OIL FILTER
34. AUXILIARY FUEL TANK
35. MAIN AIR RESERVOIR
36. EMERGENCY FUEL TRIP (BOTH SIDES)
37. FUEL TANK FILLER
38. FUEL TANK SUMP
39. MAIN FUEL TANK
40. AUXILIARY GENERATOR (LEF SIDE) EXCITER (RIGHT SIDE)
41. SLACK ADJUSTER
42. AXLE ALTERNATOR (ALL AXLES)
43. BATTERIES (RIGHT SIDE)
44. CAB HEATER
45. CONTROL COMPARTMENT (LEFT SIDE) AIR BRAKE COMPARTMENT (RIGHT SIDE)

APPARATUS LOCATION (E-10093) (HIGH NOSE LOCOMOTIVE)