ENGINE MAINTENANCE MANUAL

NO. 252B

for

MODEL 567B ENGINES

4th Edition

March, 1953

This manual is designed to cover all 6, 8, 12, and 16 cylinder Model 567B railroad engines and attached accessories. Minor differences between engines and the manual, due to slight refinements in specifications after the manual was sent to press may be encountered.

Model 567A engines are similar to Model 567B engines and this manual may be used as a general guide on these engines.

Refinements in specifications of production engines generally are not reflected in engines already in service. Therefore, we feel it inadvisable to make revisions of manuals already distributed, except when major changes are recommended for engines already in service.

PRICE $5.00

SECTION INDEX

ELECTRO-MOTIVE DIVISION

General Motors Corporation

LA GRANGE, ILLINOIS, USA

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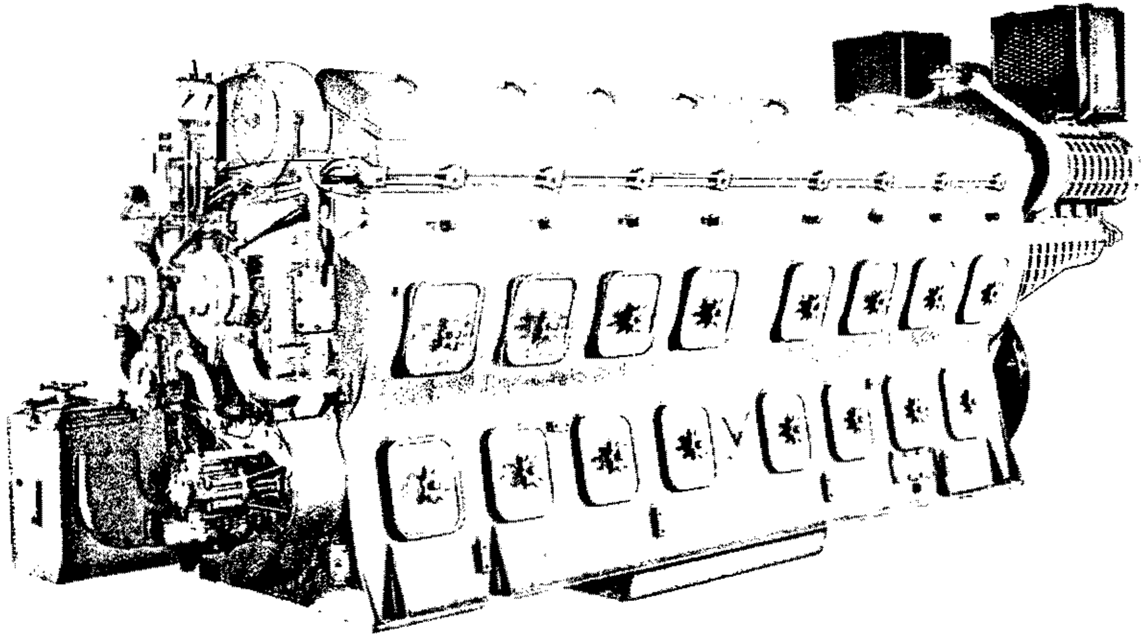
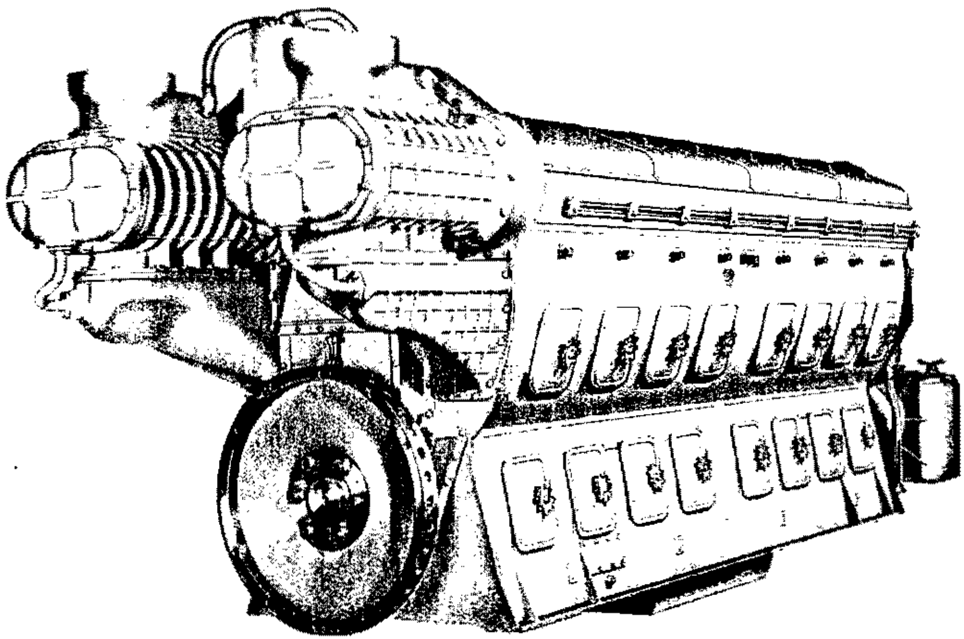


Front Three-Quarter View Model 16-567B Engine
Fig. 0-1



Rear Three-Quarter View Model 16-567B Engine
Fig. 0-2

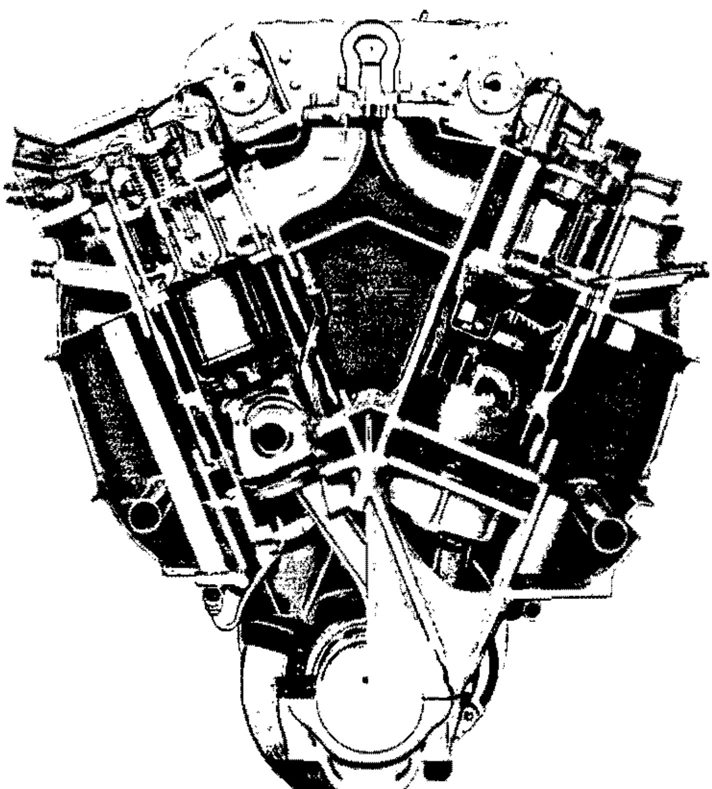
FOREWORD

This manual covers the 567B Diesel engine applied to railway use. Each section consists of the description, operation and maintenance of the component parts of the engine; followed by specifications on wear and clearance limits of the various parts contained in the section.

Wear limits are often given as diametric clearance. This means the total clearance on the diameter. Most diametric clearances can be measured by placing a feeler gauge on only one side of the object being checked. Other items may have to be checked by measuring the outside diameter of the shaft, using a micrometer, and subtracting this figure from the inside diameter of the bearing in which the shaft turns. A ball micrometer for measuring wall thickness of bearings, and a dial indicator for measuring diametric and longitudinal clearances will be found necessary. For measuring clearances such as piston to cylinder head, or oil pump gears to housing, the use of lead ribbon will be desirable. The lead ribbon is inserted between the parts, removed and measured to obtain the clearance.

Where radial clearance is specified it is because the nature of the part is such that diametric clearance cannot be measured. The radial clearance is always one-half of the diametric clearance.

Longitudinal or thrust clearances are listed throughout the manual with all of the clearances removed at one end of the part being measured. Where it is not convenient to take out all of the thrust at one end, the thrust at each end should be measured and added, to give the total longitudinal clearance.



Engine Cross-Section - Cutaway

567 SERIES ENGINES

	Foot Pounds
Cylinder Head Nuts	
Liners #1 and #2	290-300
Liner #3	200
Fork Rod Basket Capscrews	190-200
Fork Rod Basket Capscrews (checking ONLY, see Section 3)	175-185
Main Bearing Nuts	500-800
Main Bearing Studs	250
Crab Stud Nuts	1800
Engine Flywheel Mounting Bolts	1200
Injector Crab Nuts	50
Blower Timing Gear Cover Nuts	35-40
Oil Pan to Crankcase Mounting Bolts	450
Front and Rear 1/2" Mounting Capscrews	
Hardened (with mark on head)	85
Not Hardened (without any mark on head)	65
Aux. Gen. Drive Assby. 3/4" Mounting Bolts	175
Cylinder Head Frame Capscrews	30
Rocker Arm Shaft Nuts	300
Injector Fuel Lines	40
Camshaft and Injector Shaft Capscrews	20-25
Fuel Manifold Blocks	25
Exhaust Manifold Stud Nuts	90-100
Harmonic Balancer Capscrews (Mounting)	400
Accessory Drive Gear Capscrews (Mounting)	250
Liner Stud Application (Min.)	50
Water Pump Impeller	80
Water Pump Gear	265
"Pee" Tubes	20
Exhaust Manifold Connecting Clamp Bolt	70 in. lbs.
Bolted Crankshaft Counterweights	200
Engine Hold Down Bolts	450

NOTE: All single values given may vary plus or minus five percent of the value.

TORQUE WRENCHES		PART NO.
Crab Nut Powerwrench	(ratio 6.7-1)	8133312
Main Bearing Powerwrench	(ratio 5-1)	8155363
Cylinder Head Powerwrench	(ratio 3.1-1)	8166975
Torque Wrench (25 ft. lbs.) 1/2" Drive		8157122
Torque Wrench (100 ft. lbs.) 1/2" Drive		8157120
Torque Wrench (300 ft. lbs.) 3/4" Drive		8157121

0

OPERATING DESCRIPTION

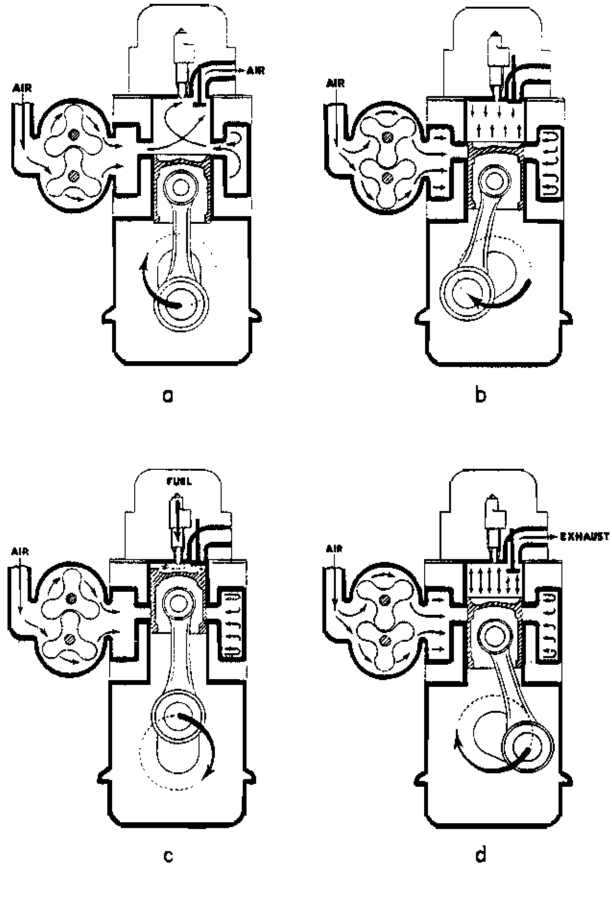
In a four-cycle engine, four strokes of the piston are required to complete one cycle of events: the intake stroke, compression stroke, power stroke and exhaust stroke. The crankshaft will make two revolutions per cylinder for each power stroke. During the intake and exhaust strokes the piston functions as an air compressor, which operation consumes power.

In a two-cycle engine, such as the model 567B, only two strokes of the piston are required to complete the cycle of events. Intake and exhaust takes place during part of the power and compression strokes. Each downward (power) stroke of the piston delivers a power impulse to the crankshaft. Therefore, a two-cycle engine has twice as many power impulses as a four-cycle engine, with the same number of cylinders and operating at the same speed.

As the piston in a two-cycle engine is not required to function as an air pump, an external means of supplying air must be provided. A specially designed blower, handling a large volume of air at low pressure, is used for this purpose. The blower forces air into the cylinder through ports in the cylinder liner wall, thus expelling the exhaust gases and filling the cylinder with a fresh charge of air for combustion.

The cycle of events of the two-cycle engine and operation of the blower are graphically described on Fig. 0-4 and explained in the following paragraphs.

Fig. 0-4a. At the lower end of its downward stroke the piston uncovers a row of ports in the cylinder liner admitting the scavenging air to the cylinder. This flow of air through the ports and exhaust valves produces complete scavenging, leaving the cylinder full of clean air when the piston covers the ports on its upward stroke.



FOUR-CYCLE

INTAKE STROKE	COMPRESSION STROKE	POWER STROKE	EXHAUST STROKE

TWO REVOLUTIONS OF THE CRANK SHAFT

INTAKE	COMPRESSION STROKE	POWER STROKE	EXHAUST	INTAKE	COMPRESSION STROKE	POWER STROKE	EXHAUST

TWO-CYCLE

Cycle Of Events Of Engine
Fig. 0-4

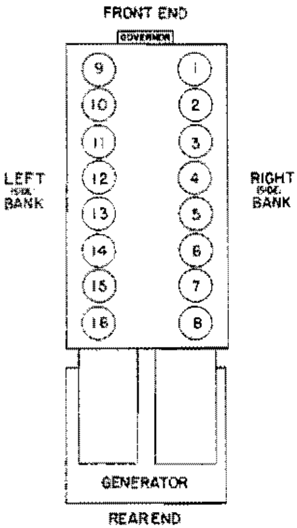
Fig. 0-4b. As the piston continues on the upward stroke the exhaust valves close and the charge of air is compressed to about one-sixteenth of its initial volume, or about 600 pounds per square inch. Air, when compressed to this extent, increases in temperature to approximately 1000° F. This high compression ratio is maintained at all loads and speeds.

Fig. 0-4c. Shortly before the piston reaches the top dead center of its stroke, the fuel, atomized by high pressure is injected into the combustion chamber. The fuel is ignited by the high temperature of the air and continues to burn until the charge is consumed. The burning charge rapidly builds up a high pressure which acts upon the piston, forcing it downward on the power stroke.

Fig. 0-4d. Just before the piston reaches the end of the power stroke, the exhaust valves open, releasing the gases to the atmosphere. The piston then uncovers the air inlet ports. By this time the exhaust gases have expanded to the point where the pressure is lower in the cylinder than in the air-box. The cycle is then repeated.

GENERAL DESCRIPTION AND DATA

The Model 567B Diesel engine is a "V" type, two-cycle engine, incorporating the advantages of low weight per horsepower, fully scavenging air system, solid unit injection, and high compression.



The accompanying sketch serves to identify the cylinder locations, ends and side of the engine, as they are referred to in this manual. The governor, water pumps and lubricating oil pumps are mounted on the "FRONT END." The blowers, oil seperator and generator are at the "REAR END."

GENERAL DATA

Bore		8-1/2"
Stroke		10"
Compression Ratio		16:1
Maximum Governed Speed		800 RPM
Idling Speed		275 RPM
Starting Speed		75 to 100 RPM
Rotation (Facing Rear End)		Counter-Clockwise
Weight (Approx.)	6-567B	15,000 lbs.
	8-567B	17,500 lbs.
	12-567B	23,500 lbs.
	16-567B	30,000 lbs.

Rated Horsepower
(at 800 RPM)

Engine	Model	HP
6-567B		600
8-567B	SW8-TR6	800-1600
12-567B	NW5	1000
12-567B	E8	1125 (2250)
12-567B	SW9-TR5	1200-2400
16-567B	F2	1350
16-567B	F3, F7, FP7, BL1, BL2, GP7, SD7	1500

Displacement per Cylinder 567 cubic inches

Firing Order		
	6-567B	1-4-3-6-2-5
	8-567B	1-5-3-7-2-6-4-8
	12-567B	1-12-7-4-3-10 9-5-2-11-8-6
	16-567B	1-8-9-16-3-6-11-14 4-5-12-13-2-7-10-15

Number of Exhaust Valves per Cylinder	4
Crankpin Diameter	6-1/2"
Crankshaft Diameter	7-1/2"
Number of Main Bearings	6-567B 4
	8-567B 5
	12-567B 7
	16-567B 10

ENGINE CONVERSION POSSIBILITIES

To further promote a desired service to our customers, enabling them to obtain greater spare unit utility through interchangeability, our Parts Department has developed a means whereby a 16-567B crankcase may be assembled with special parts from the proper one of four (4) Bills of Material to produce a modified "B" engine which is suitable for replacing individual 16 cylinder 567 engines in the field, of the same designated type.

Information covering complete modified "B" replacement engines, engine and locomotive alteration parts and numbers for application of a modified 16-567B in FT locomotives and other replacement engines may be obtained from our Parts Department.

In addition, there are other engine conversions available to enable customers to improve existing engines in the field. If desired 12-567A and 16-567A engines which are conditionally and dimensionally satisfactory may be converted to 567B model engines. This conversion, at present, must be done at the La Grange Branch shop. Also, 567 Cast Top Deck and Fabricated Top Deck engines may be converted to 567AC or 567AF engines, providing decided advantages over the original engine.

Information concerning these conversion procedures can be obtained from the La Grange Office upon request.

SECTION I

CRANKCASE AND OIL PAN

A. DESCRIPTION

1. Crankcase

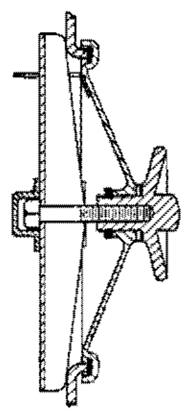
The crankcase is the main structural part of the engine, Fig. 0-3, Section 0. It is fabricated of steel stress plates and forgings which are combined to form a rigid and self-supporting assembly. The crankcase supports the power assemblies and engine mounted auxiliaries. Manifolds for engine cooling water and lube oil are built into the crankcase.

Inlet cooling water manifolds are formed for each bank of cylinders by two parallel plates running the entire length of each bank at the bottom of the crankcase. These plates are bored to receive the cylinder liners. A silicone rubber seal ring is used between each plate and the liner, connecting the liner water passage to this manifold and preventing water leaks to oil pan and air box. A water line connects the manifold to the water pump at the front of the engine. The engine cooling water outlet manifold is located in the "V" formed by the angle of the cylinder banks at the upper end. Enclosed in this discharge water manifold are the exhaust elbows from the cylinder head retainer exhaust passage as shown in Fig. 0-3, Section 0. Two water drain pipes, one for each bank, connect the lowest points of the water discharge manifold with the water inlet manifold. These pipes drain the water discharge manifold when the engine is drained.

The main lube oil manifold is formed by the "V" junction of the inner stress plates and a cover plate. The main lube oil manifold runs the entire length of the crankcase. Oil pipes, pressed into drilled passages through the main bearing "A" frames at their center carry the oil to each main bearing. These pipes extend above the bottom of the manifold to insure a clean supply of oil to the main bearings. The lube oil to the rear gear train oil passages and camshafts is supplied from the rear end of this main lube oil manifold.

The air box is the space surrounding the cylinder liners. This space is a reservoir for scavenging air to the cylinder liner ports, supplied by the volume air blowers. Accumulations of oil or moisture drain from the air box through an opening in the crankcase and oil pan mounting flange into air box drain tanks located in each side of the engine oil pan. Beginning September 1951, the external air box drain bosses and elbows on the crankcase have been eliminated since they are not necessary. Hand holes in the air box side sheets opposite each cylinder liner, permit inspection, servicing and cleaning the air box. Hand holes are closed by cork gasketed covers, Fig. 1-1, which are easily applied or removed.

The end plate machining of the "B" engine is dimensionally different than previous engines, and blind tapping bosses are used to prevent oil or air leakage. These changes will not allow other than "B" engine fittings to be mounted on end plates.



Hand Hole Cover
Fig. 1-1

The "B" engine top deck cover frame is built to include the lube oil pressure line mounted in the outward side of the left bank cover frame.

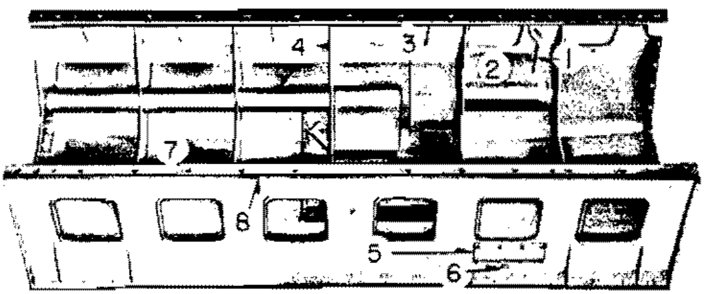
Metal back-up strips are applied to cylinder head cover frame flange mounting for support. They are available for engines not originally equipped. Cylinder frame capscrews torque value is 30 ft. pounds.

Redesigned cover frame breather shields are applied which are not perforated, to reduce or eliminate oil splash at the corners of the cylinder head cover frame. For part numbers, refer to Catalog 90.

2. Oil Pan

The oil pan, Fig. 1-2, is a fabricated structure of steel plates, and serves as the support for the crankcase and as a lube oil reservoir. It is enclosed by side sheets and end plates, and is braced internally by transverse plates. The bottom is constructed so the sides slope downward at an angle toward a channel sloping from each end toward a central oil reservoir of the oil pan. Where the sloping channels empty into this reservoir, a hinged door is provided at the end of each channel. These hinged doors help hold the oil in the reservoir as they only swing inward to oil reservoir.

Incorporated in the oil pan construction are two air box drain tanks, one on each side of the oil pan



1. Air box drain
2. Air box drain tank
3. Oil reservoir and drain
4. Scavenging oil suction line
5. Air box drain tank cover
6. Air box tank drain
7. Oil pan drain channel
8. Seal groove

Oil Pan
Fig. 1-2

shown in Fig. 1-2 on the 12 cylinder pan. These are connected by a drain line running from each tank to the oil pan mounting flange, and line up with a drain hole through the mounting flange into the air box. A cover plate on the outside of the oil pan adjacent to the tanks gives access to the inside of the air box drain tanks. There is one pipe extending from the air box drain tank to the outside of the oil pan for draining. These tanks should be drained while locomotive is standing, before leaving the maintenance point.

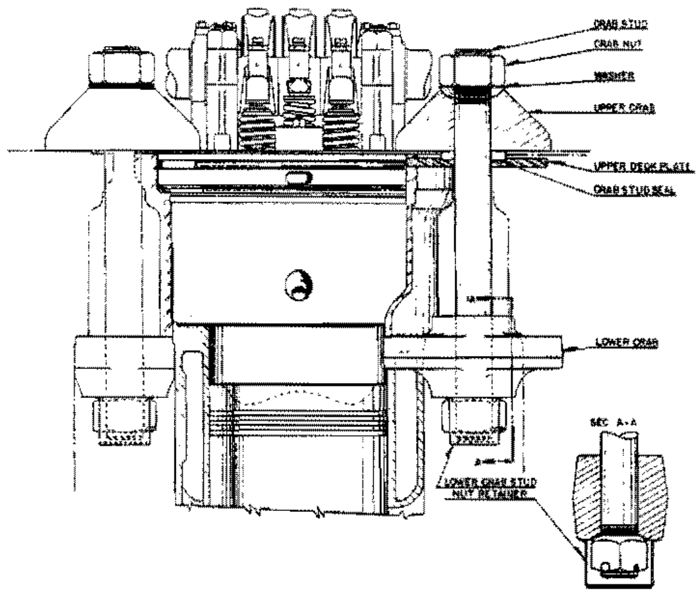
The scavenging pump suction line, Fig. 1-2, is located in the oil pan, extending from the oil reservoir along the right side of the oil pan. The opening of this line is close to the bottom of the oil sump, to insure a submerged suction even with minimum oil level. This scavenging pump oil line extends to the front end plate of the oil pan where it mates with the opening in the accessory drive housing to the scavenging pump suction screen housing.

An opening is provided in the front oil pan end plate to the accessory gear drive housing to allow oil from the gear train to drain into the oil pan.

A bayonet type oil gauge or "dip-stick" is located on the left side of the oil pan at its center (one on either side on later 567B oil pans), to indicate allowable levels in the lube oil reservoir. An oil pan drain line extends to the outside, under the locomotive carbody, and is located just back of the engine fuel tank. This line is provided with valve and plug.

Hand holes are also on both sides of the oil pan, directly under the air box hand holes and are provided with the same gaskets and covers. The inside lower parts of the engine are inspected and serviced through these hand holes.

The crankcase is mounted and held rigidly on the oil pan by the crankcase to oil pan mounting bolts, the relative position held by four tapered dowels. The

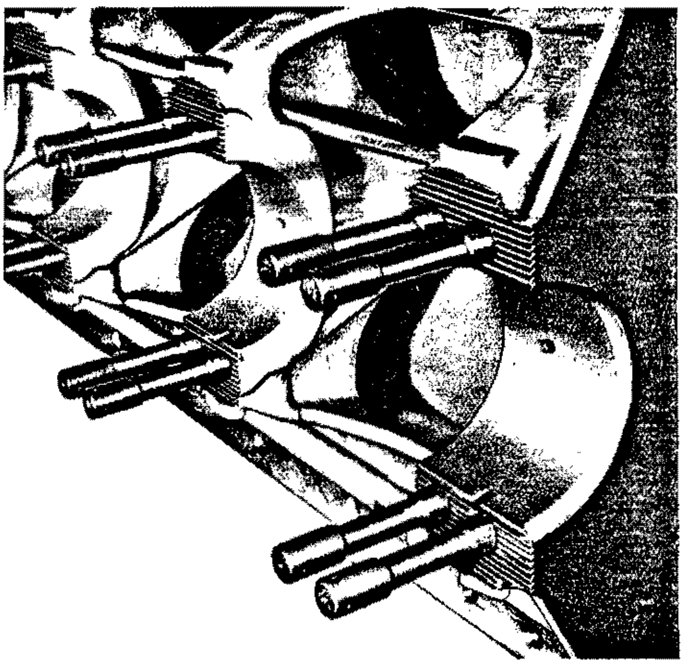


Crab Stud Assembly
Fig. 1-3

sealing arrangement on all new production engines beginning with engine serial number A-52-116 consists of a round silicone rubber cord .225" in diameter placed in a proper groove running the length of the oil pan just outside the mounting bolt holes. A slight amount of #3 Tite Seal gasket compound is applied between the outside edge of pan and seal cord. This seal arrangement replaces the previously used shim and gasket arrangement. For installation see Maintenance item #1. UTEX and RANR engines and crankcase and oil pan assemblies will be modified to use this new sealing arrangement when the Branch Shops are equipped to do this work on assemblies originally built using a gasket between oil pan and crankcase. For engine ramp alteration to reworked oil pans see Modification Inst. 5063.

3. Crab Studs

The crab studs hold the cylinder liner and head assembly down in place on the head seat shoulder of the head retainer, Fig. 1-3. The crab studs extend through the top deck plate of the crankcase, and through a lower crab and plate. (This plate is not used on end studs or center studs of 16-567B engine.) The plate is welded to the lower crab and to the head retainer. (Some "B" engines were made without this plate.) When the cylinder head and liner assembly is in position, the crab studs, upper and lower crabs, spherical washer and crab nuts clamp the head solidly in the retainer. Upper crab nuts and sperical washers are lubrized to alleviate galling when tightening.



Main Bearing Studs
Fig. 1-4

The lower crab stud nut is held by a 1/4"-20 x 3-1/4" bolt and elastic stop nut on later engines, and on earlier engines they are cotter keyed to the bottom of the stud. This assembly is held in place by a bracket welded to the lower crab. A synthetic rubber seal ring around the stud prevents air leaking from the air box between the top deck plate and the stud. The seal ring is compressed against the top deck plate by the upper crab.

Whenever crab stud nuts and crabs are removed, place a crab stud protector (part #8034600) over the end of the stud to prevent damage to the threads.

4. Main Bearing Studs

The main bearing studs, Fig. 1-4, are installed in the bottom of the "A" frame with a stud driver. There are four studs for each main bearing cap, except the two center caps on the 16-567B engine, which have only two studs. To facilitate stud application, each main bearing stud hole is vented by a drilled passage extending through the "A" frame to the bottom of the stud hole.

Two different types of main bearing studs have been used in "B" engines. A long stud, 9-3/16" long, previously used, has been replaced by a shortened stud 8-3/8" long. The difference in length of the stud was the threaded end for the "A" frame. The long stud having 13/16" longer thread on the "A" frame end.

The holes in the "A" frames were drilled to a depth conforming to the increased thread on the long stud, and either stud could be applied. In later engines, the "A" frame tapped hole is drilled to a depth to conform to the shorter thread of the short stud, voiding the use of the long stud in these engines.

The main bearing stud dimension to be maintained is the length from the serrations on the "A" frame to the top of the stud. This dimension is 6-1/2" $\pm$ 1/16". The main bearing studs are lubrized to prevent galling when applied to the "A" frame.

The main bearing caps are serrated to fit the "A" frame to which they are applied and are not interchangeable, but must be installed in the same location from which they were removed. The "A" frame and the bearing cap are also stamped with the bearing number to assure proper location.

5. Engine and Crankcase Serial Numbering System

The method of designating serial numbers of engines and crankcases was revised January 1950 and on engines again in February 1951 and again on crankcases January 1952. Prior to January 1950 engine and crankcase serial numbers run consecutively, regardless of cylinders or model.

Serial numbers of engines as of January 1950, begin with number 10,001 and identifying letters and figures are combined with this number to designate the month and year of manufacture. Letters as "A", "B", "C", etc., except "I", which is not used in the engine serial number, identify the month of manufacture: "A" for January, "B" for February and so on. Following this letter is the last two figures of the year of manufacture. As for example, engine serial number M50-12334, indicates by "M50" that the engine was built in December, 1950, and according to number 12334 it was the 2334th engine built since January 1, 1950. Engines are numbered in production sequence regardless of cylinder or model.

Beginning February 1951, engine serial numbers will retain the month and year as "51-B", "51-C" etc., but the number will correspond to the monthly manufacturing sequence beginning with #1 each month. An example, 51-B-1 indicates first engine built in February

1951, 51-B-225 the 225th engine built in February, or 51-F-4, indicates the fourth engine built in the month of June 1951, and so forth.

The engine serial number is located in two places on the engine (1) at the left front of the crankcase just below the base of the cylinder head cover frame support and (2) on the engine name plate attached to the air box side sheet about 6 inches from the cylinder cover base between the two center cylinders. The name plate also gives the model of the engine, as 16-567B or other.

Since January 1950 through December 1951 the crankcase serial numbers have been consecutive, beginning with number 1, and included the year and month of manufacture, and number of cylinders. For example, crankcase serial 16M50-2295, identifies a 16 cylinder case, built in (M) December (50) 1950 and was the 2295th crankcase built since January 1950. The letter "I" is not used in serial numbers. This system continued through December 1951 when a slight revision was made to have the crankcase serial numbers correspond generally to that on the engine and other engine parts.

Crankcase serial numbers starting January 1952 are as follows: example, 16-52J-32, identifies a 16 cylinder, built (J) September (52) 1952 and was the 32nd crankcase built that month. The 16 is replaced by 6, 8 or 12 if the crankcase consists of that number of cylinders. The month letter as "A", "B" etc will correspond to January, February and so forth; the year designation the last two numbers of the current year and the monthly manufacturing sequence used in place of the prior used yearly sequence.

Crankcase serial numbers are located in four different areas; on each main bearing cap, on the first and last main bearing "A" frame on the right hand side, and under each camshaft at the center of the engine.

Oil pan serial numbers are located on the left side of the pan near the crankcase support base at the front or rear.

NOTE: When referring to any serial numbered part, it is important that part name be included as well as part serial number to aid in identification.

6. Crankcase and Oil Pan Assemblies Sold by Parts Department

Serial numbers will also be applied to all crankcases and oil pan assemblies sold through the Parts Department for railroads to build into new engines. The serial number will be stamped on the name plate that is mounted on the right side of the air box about six inches below the cylinder head cover frame base between the two center cylinders. Numbering will start with S-9001 and run consecutively regardless of the number of cylinders. When the crankcase and oil pan is finally assembled into a complete power unit, the crankcase and oil pan serial number then becomes the engine serial number. Under no circumstances should a name plate be removed from one assembly and attached to another similar assembly. The serial number of the crankcase and oil pan assemblies will not indicate the month, year or manufacturing sequence. It will only indicate a partial engine assembly that will be completed by the customer.

7. Engine Data Plate for Rebuilt Engines

As an assistance to the railroads in engine repair and record keeping, all 567 series engines and crankcases rebuilt at La Grange will carry a "data plate", Fig. 1-5, mounted below the original engine serial name plate. This new data plate has eight item spaces to be filled in and used to identify either engine dimensions or part sizes.

We recommend that railroads rebuilding 567 engines apply this data plate, which may be purchased through our Parts Department under 8163005, and stamp on it the appropriate data.

B. MAINTENANCE

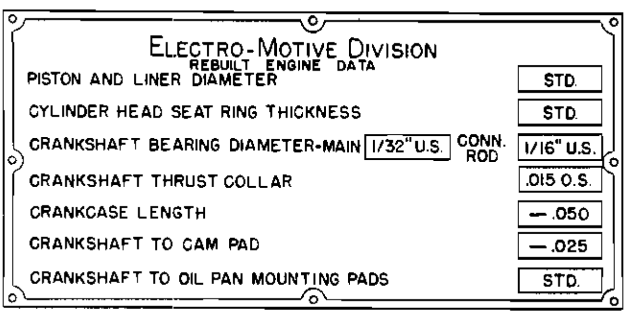
1. Silicone Seal Application and Tightening Crankcase To Oil Pan Bolts

Before seal application inspect oil pan rails for nicks, burrs, oil and foreign material of any kind in seal grooves or top of rails, and remove to provide a clean smooth surface. Any indentation in the seal grooves that would allow oil seepage must be filled with solder and finished flush with adjacent area. Check crankcase rails also, and similarly treat any indentation in the rails that would position over seals.

Along outside edge of oil pan rail surface, apply one coat of Tite Seal #3 approximately 1/2" width and about .015" thick, or thickness of ordinary playing card.

Install seals in grooves without twisting or stretching and without lubricant. The individual seals for each model engine are longer than required. At this time, do not cut off seal ends.

Place crankcase over oil pan, and using line up pin guides in the four corner holes, lower crankcase on oil pan. Apply taper dowel bolts and tighten. Check crankcase to oil pan alignment.



Rebuilt Engine Data Plate
Fig. 1-5

Assemble all crankcases to oil pan bolts plus washers and snug four corner bolts to about 100 ft. lbs. torque. Then torque all bolts to approximately 100 ft. lbs., in sequence as shown in table 1 starting with #1 bolt to higher numbers. Beginning 16B engine 52-P-111 washer GM 131019 is used under the nuts.

After initial 100 ft. lbs. sequence tightening, bring each bolt to the recommended torque of 450 ft. lbs. following the diagram sequence of table 1.

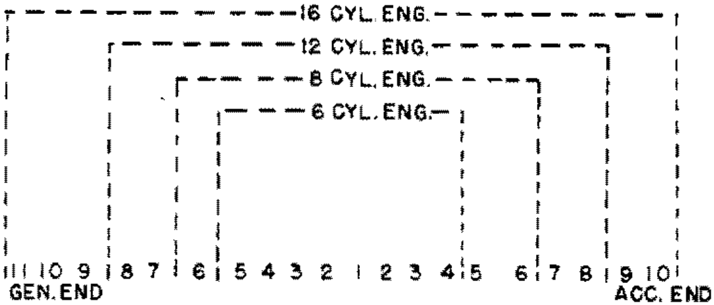


Table 1 - Crankcase To Oil Pan Bolt Tightening Diagram

After all bolts have been tightened to 450 ft. lbs. cut seal cord ends to provide a protrusion from face of end plate of 3/32" $\pm$ 1/64". This seal protrusion will seal 3 way joint of oil pan, crankcase and gear train housing.

All crankcase to oil pan bolts must be tightened at regular intervals, in accordance with mileages indicated on the Scheduled Maintenance Program.

If these bolts are allowed to become loose, the relative movement of crankcase to oil pan will cause gasket or seal wear, resulting in an oil leak. It will also cause the dowels to elongate the holes.

2. Cleaning Crankcase

The crankcase should be cleaned after any work has been done on the interior of the engine to remove particles of metal or dirt. This can be done by using a spray gun #8072902 and solvent. The equipment near the engine should be protected against the spray. After spraying the top deck (cylinder heads, rocker arms, etc.), wipe with towels saturated with solvent. Wipe up all solvent trapped in corners and pockets. Use only lintless bound edge towels.

Cleaning of the air box with a spray gun while liners are in place is not recommended practice, due to possible foreign particles finding their way into cylinders. If the air box requires cleaning, only bound edge towels with petroleum solvent should be used.

3. Engine Painting Instructions

If an engine is to be removed from the locomotive and completely overhauled and the interior repainted, the parts to be painted must be cleaned in a vat of caustic solution to remove old paint, grease and oil from the pores of the metal. The caustic solution must be removed by thoroughly washing in clean hot water. Then the part should be air dried with air hose (aluminum parts must not be washed in caustic solution). If caustic cleaning is not done before painting, the paint will peel off the interior of the engine and restrict the lubricating oil lines and strainers. Mask off parts not to be painted.

Use crankcase paint (interior or exterior) buff (Du Pont) 8173025, yellow (Rinshed Mason) 8141496 on the following: interior of crankcase, air box, oil pan, blower support housing, top deck, cylinder head cover support frames (except where cover spring contacts), inside cylinder head covers, hand hole covers, accessory and camshaft drive housings and covers. Do not paint any machined surfaces, cylinder liners or gasket and seal surfaces.

To refinish the exterior of the engine, remove all grease and oil with an alkaline cleaner. Mask the water, oil and fuel connections and apply either of the paints listed in the preceding paragraph.

After primer coat has dried and engine is installed in locomotive, apply a finish coat of Du Pont Dulux Suede Gray (5 gal. - #8133054, 1 gal. - #8122047).

4. Crab Studs

Before removing a crab stud, the 1/4"-20 x 3-1/4" bolt and elastic stop nut or the cotter key must be removed from the slotted nut on the lower end of the stud.

Damaged crab stud threads can be cleaned with a 1-3/4"-12 thread die (part #8067409). Damaged threads in crab stud nuts can be cleaned with 1-3/4"-12 thread tap (part #8050688).

Torque values for tightening the cylinder head crab nuts are 1700-1900 foot-pounds. If torque wrenches are not used the crab nuts should be tightened by three men using a five foot extension on the crab nut socket and wrench. A power wrench (part #8133312) for tightening crab nuts is available through our Parts Department. This is a mechanical advantage wrench employing a standard torque wrench.

Before application or reassembly of the crab nut, spherical washer and crab, these parts should be examined for nicks, roughness and galling which would give a false torque value indication or improper tightening. The threads of the nut and stud should also be in good condition.

To aid in proper assembly, the friction surfaces, threads, crab and spherical washer surfaces should be lubricated, either using engine lube oil or a stud lubricant having specifications similar to Texaco Stud Lube 921.

Crab stud nuts should be tightened in two passes, half total torque at each pass tightening the diagonally opposite nuts alternately to form a letter "X.". This method applies whether tightening the whole bank or the crabs on one cylinder. After final cylinder assembly, if possible, the engine should be put on load test for one hour; or if load test is not possible, run the engine for about one hour in the sixth or seventh throttle position with the engine water temperature 150° - 180° F. and retighten crab stud nuts in conjunction with tightening of the rest of the cylinder assembly using proper torque values. If load test cannot be made, the crab stud nuts and head assembly should again be checked for tightness at 1000 miles (or less if possible). Thereafter retighten according to the Scheduled Maintenance Program.

For tools applicable to cylinder head crab stud, for various model engines, refer to tool catalog 91A.

5. Main Bearing Studs

Damaged main bearing stud threads can be cleaned with a 1-1/4"-12 thread die (part #8060349). Damaged main bearing stud threads in the "A" frame can be cleaned with a 1-1/4"-12 thread tap (part #8060387). Oversize taps are available. For sizes refer to tool catalog 91A.

To remove a broken stud, drill stud with a 13/16" drill and remove with a stud extractor (part #8044587). If a main bearing stud is broken during operation, all the studs in that particular bearing cap must be replaced with new studs. Oversize main bearing studs are available if required.

Broken main bearing studs are usually the result of insufficient tightening of bearing cap nuts or foreign particles between serrations. Whenever bearing caps are removed, serrations of cap and "A" frame should be throughly cleaned by wire brushing before reassembly. Also, use care in handling caps to avoid nicking serrations. Either of these conditions will prevent caps from being pulled up in place, resulting in poor bearing alignment and possible broken studs or other damage.

Main bearing caps are originally installed on the "A" frame and are all line bored; hence, NOT INTERCHANGEABLE or available for replacement. They must be installed in same location and position as removed. The main bearing caps and "A" frame are marked to aid in correct assembly. The "A" frame is stamped with the bearing number on the right side and a corresponding number is stamped on cap belonging to that particular "A" frame. The caps are also stamped with the crankcase serial number.

Torque values of the main bearing stud nuts are 500-800 foot pounds. For correct assembly the stud nuts should be torqued to 500 foot pounds; then tightened further until line up with first lockwire hole is reached, to assure tightening within 500-800 foot pounds. A main bearing nut Powerench 8155363 and speed ratchet offset wrench 8191591 are available which facilitate nut application.

Main bearing "A" frame bore diameter is: Minimum 8.249"; Maximum 8.252" and out-of-round limit .003". The specified diameter limits are the average of six (6) measurements, three (3) taken at each end of bore, 60° apart, with main bearing nuts torqued to 650 foot pounds. Main bearing bore alignment, vertical and horizontal, can be determined using precision telescope fixtures 8190176 (complete information on request).

On a repaired crankcase which has had the main bearing bore reconditioned, there may be uncleaned areas about .001" to .002" deep in the unloaded area next to the serrations. Cleaning this area up 100% would add to the repair cost and shorten crankcase life. Therefore, care must be taken when measuring the "A" frame bore, not to include this portion of greater dimension.

To facilitate measurement of crankcase "A" frame or cap distortion, a serration measuring gauge #8177167 is available. This gauge is semi-circular to fit around the crankcase and has serration prongs that fit "A" frame serrations, one actuating a dial micrometer. Distortion is read directly from the dial micrometer. The maximum limit from the nominal "A" frame serration center line dimension is plus or minus .003". A separate master gauge is provided for checking prong distance. Any crankcase having dimensions exceeding the maximum limits should be returned for rebuild, see Factory Rebuild Service bulletin #109.

6. Crankcase Inspection

Serious and dangerous crankcase failures can be avoided and longer crankcase life obtained by careful and periodic crankcase inspection. Careful inspection may disclose small discrepancies which if they were allowed by neglect to progress would result in a possible major failure, loss of service or loss of the crankcase. (See Section 4, Fig. 4-7, for crankcase liner bore dimensions and condemning limits).

Inspection and early repairs are most important since major repairs generally cannot be done in the field. In most cases extensive welding, stress relieving and remachining are required for suitable repair and this tends to shorten crankcase life, as there is a limit to the number of times this can be done on a crankcase.

When inspecting crankcases, particular attention should be given to all weld zones of high stress and corners or edges where cracks usually originate.

It is important that cracks be repaired before they progress too far. Generally crankcases having cracks over six inches long will have to be returned to the factory for major repairs.

In addition when an engine failure occurs due to a breakdown of parts, a careful inspection is essential at locations other than the immediate damaged area. (For example, an engine failure in which a connecting rod damages the lower deck or liner support plate). A rod may also strike and nick the stress plates. It is most important in this event, that the stress plate be inspected for nicks in the circumference of the 10" holes (in the plate opposite the liner ports) and if any nicks are found they be blended out. The stress plates are subject to shock loading and any nicks in the circumference of the 10" holes may serve as a possible point for stress concentration and lead to cracking.

NOTE: Maintenance Instruction 2114 outlines procedure for the operation of the "Lower Deck Boring Bar" used to rebore the liner support plates after welding. It should be noted that this repair in the field should only cover emergency cases where the liner support plates have been damaged due to part failure in the engine, such as damage from connecting rod or piston failure, or when the liner support plates have worn to exceed the condeming limit.

In cases of field welding repair and reboring, this repair is limited to only two cylinder bores per engine bank; four cylinder bores per engine, consisting of an upper and lower liner support plate per cylinder.

If it is necessary to weld more than two cylinder bores per engine bank, it is mandatory that the crankcase be given stress relief after repair. In this event crankcase should be returned for rebuild.

7. Lower Liner Support Reinforcing Pilot Rings

There may be cases in the field where application of pilot rings to the lower cylinder liner support plate is considered. Application of these pilot rings in the field is NOT recommended, as excessive heat from welding shortens the crankcase and severe stresses are set up, even when precautions are taken during weld procedure. Indiscriminate welding on the crankcase often leads to main bearing "A" frames being pulled out of line; and even with reboring, failure is likely to occur if the crankcase has not been stress relieved.

However, all crankcases sent in for repair to be rebuilt and stress relieved and which have not previously been rebuilt will be modified to include the ring. This affects 567, 567A, 567B, 567AF and 567AC model engines.

8. Return of Engine Crankcases

Crankcases returned to the factory for rebuild have certain work performed which involves welding on the upper and lower liner support plates. This welding tends to shorten the crankcase a small amount which necessitates machining both ends of the crankcase to make sure they are square with the center line of the crankshaft. In such cases considerable difficulty will be experienced in assembling the end housing to the crankcase unless the oil pan and cover frames are also machined to the same length dimension as the crankcase. Therefore, it is recommended that whenever a crankcase is returned for repair or unit exchange these parts should also be returned at the same time. Unit exchange crankcases will be furnished oil pans and cover frames in all cases.

9. Field Repair Procedures

In addition to the preceding instructions covering the crankcases, other specific field repair procedures concerning the crankcase may be found in the following Maintenance Instructions:

General Welding Procedure	M.I. 1800
Repairing Engine Crankcases in the Field	M.I. 1801
Water Inlet Pipe Repair and Replacement	M.I. 1802
Water Drain Pipe Repair and Replacement	M.I. 1803
Reinforcing Bar Application Junction Rear End Plate and Stress Plate	M.I. 1804
Cylinder Head Retainer Crack Repair	M.I. 1810
Upper Deck Boring Bar - (Retainer Bore)	M.I. 2101
Lower Deck Boring Bar (Liner Plate Bores)	M.I. 2114
12-567A Oil Pan - Scavenging Line and Gusset Strengthening	M.I. 2119
Repair of Oil Pan Gusset Cracks	M.I. 2120
Engine Ramp Alteration and Application to Reworked Oil Pans	M.I. 5063

Repair procedures not yet in instruction form are also available covering crankcase gusset modification. This and other information concerning engine questions may be obtained from the Service Department.

C. EQUIPMENT LIST

Name	Part No.
Spray gun	8072902
Bound edge towels	8050752
Engine paint (interior or exterior)	
Buff (Du Pont)	8173025
Yellow (Rinshed Mason)	8141496
Suede gray paint (5 gal.)	8133054
Crab stud protector	8034600
Crab stud thread die - 1-3/4" - 12	8067909
Crab stud tap - 1-3/4" - 12	8050688
Powerench (main bearing nut)	8155363
Ratchet offset set (main bearing nut)	8191591

Main bearing stud thread die - 1-1/4" - 12	8060349
Main bearing tap - 1/4" - 12	8060387
Stud extractor	8044587
Powerench (crab nut)	8133312
"A" frame serration gauge	8177167
Alignment fixtures (Crankcase "A" frame bores)	8190176
(an expensive item — precision telescope check)	

D. SPECIFICATIONS

Main bearing studs (length from serrations)	6-1/2" ± 1/16"	
Main bearing bores	Min.	Max.
diameter*	8.249"	8.252"
out-of-round		.003"

*Average of 6 readings, 3 each end bore, 60° apart with main bearing nuts torqued to 650 ft. lbs.

Main bearing bore alignment	
Vertical step bottom of one bore to adjacent bore	.0015"
Vertical step between center bore 16 cyl.	.001"
Vertical bow of main bearing bores	
16 cyl.	.004"
12 cyl.	.003"
8 cyl.	.002"
6 cyl.	.001"
Horizontal misalignment between bores	.002"
Horizontal bow of main bearing bores	
16 cyl.	.006"
12 cyl.	.0045"
8 cyl.	.003"
6 cyl.	.0015"
Cylinder liner bores	
Upper head seal (13.687" bore)	13.698"
Upper liner pilot (12.061" bore)	12.079"
Upper liner seal (11.140" bore)	11.158"
Lower liner pilot (10.250" bore)	10.267"
Allowable variation in length between mated case and pan	.010"

	Min.	Max.
Main bearing bore center line to base rail	7.365"	7.390"
Main bearing bore center line to cam pads		
567V, 567A and 567B	43.480"	43.502"
567U adjust by shimming cam bearings		
*Main bearing bore center line to head seat	40.667"	40.692"
*Head seat to lower liner seat	23.932"	23.947"
*Head seat to upper liner seat	20.932"	20.947"
Lower to upper liner seat	2.995"	3.005"
Thrust width 6, 8, and 12 cyl.	4.369"	4.375"
16 cyl.	10.743"	10.752"
*With standard seat ring machining; compensate .038" for oversize seat ring machining.		
Minimum cylinder head retainer thickness at top of 13.687" bore	5/16"	
Cam bearing keyway spacing (except 567U)	17.470"	17.474"
Vertical misalignment between adjacent cam pads		.002"
Overall camshaft pad sag or bow		
16 cyl.		.005"
6, 8, 12 cyl.		.003"
Crankcase or oil pan gasket rail		
16 cyl.		.015"
6, 8, 12 cyl.		.010"
Main bearing bore center line to piston cooling manifold pads	5.235"	5.265"
Grommet seats to top of cylinder head retainer 567V, 567A and 567B	7/32"	5/16"

SECTION II

CYLINDER HEAD ASSEMBLY

II

A. DESCRIPTION

1. Cylinder Heads

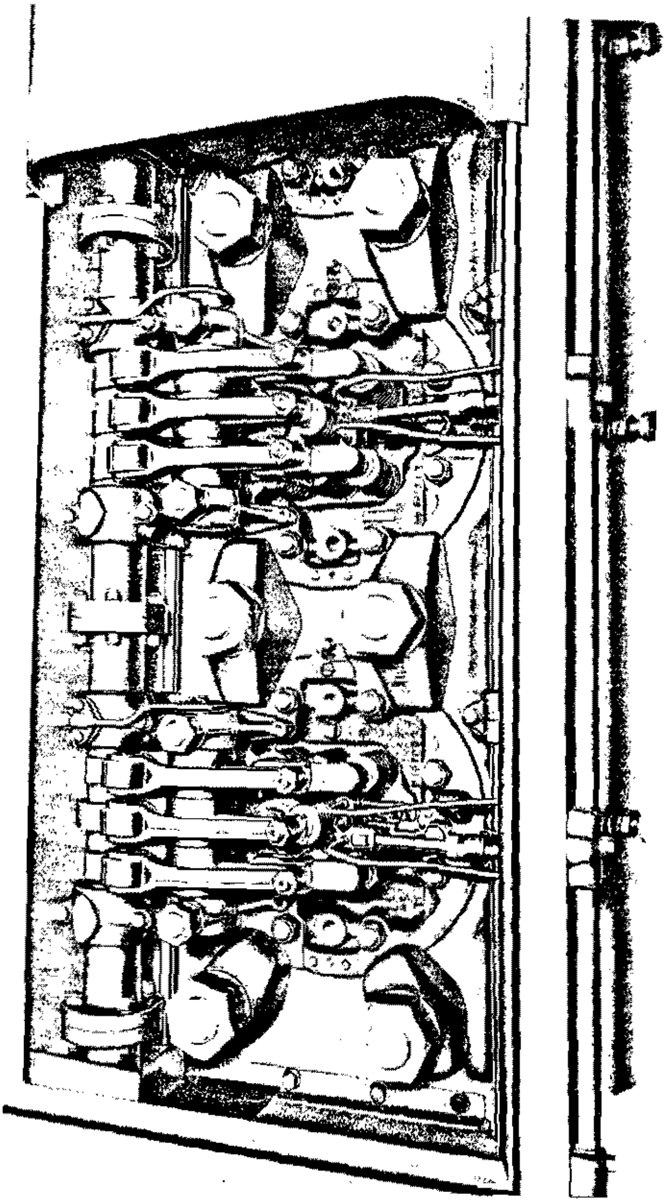
Cylinder heads are made of alloy cast iron and are clamped in place in the counter-bored, steel head retainers in the top deck of the crankcase. An indexing plate on the head fits over a dowel in the top deck to correctly locate the head, Fig. 2-1.

The head is cast with drilled water passages, with openings matching those in the cylinder liner. The engine cooling water is circulated through the liner, up through the head, and is discharged from side wall ports in the head to outlet ports in the crankcase. Synthetic rubber seal rings, above and below the circumferential outlet passage in the cylinder head, seal the water passages. See Fig. 0-3, Section O. The exhaust ports in the head line up with a water-jacketed exhaust port in the crankcase. Fig. 2-2 shows the component parts of the cylinder head.

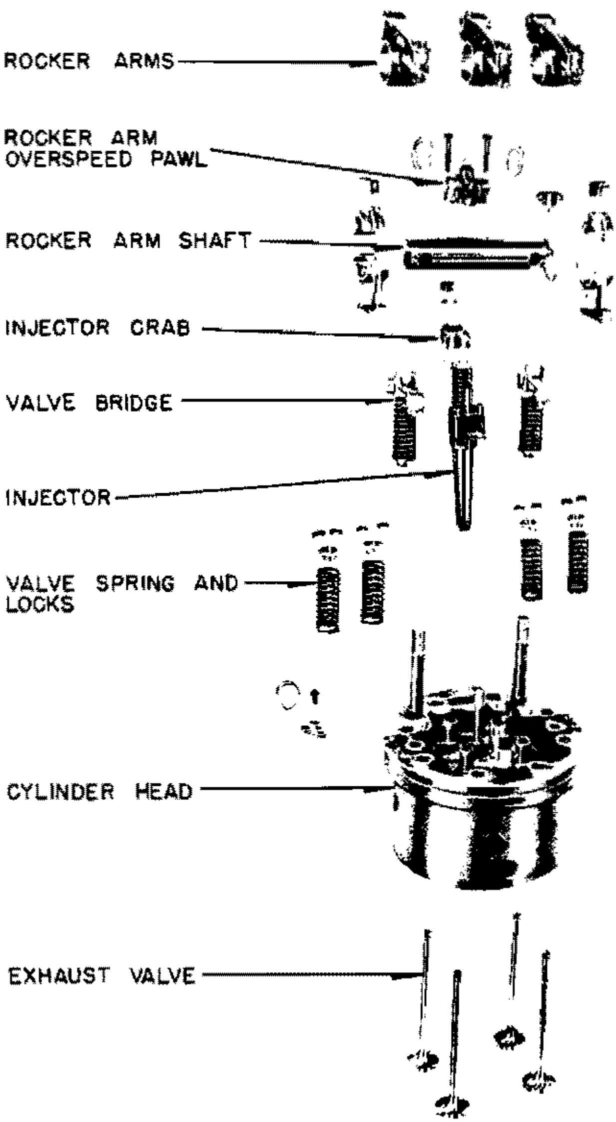
Cylinder heads are designated design #2 and design #1 to differentiate in their application and water inlet arrangement. Design #2 having drilled water inlet holes replaces design #1 previously manufactured having cored water inlet holes. Particular instructions governing application are given under installation of cylinder head, since all cylinder heads and liners are not interchangeable.

2. Exhaust Valves

Each cylinder head is equipped with four exhaust valves, valve guides and valve springs. The precision valve guides are pressed into the head. The valve



Top View Of Cylinder Heads
Fig. 2-1



Cylinder Head Assembly
Fig. 2-2

and spring assembly is held in place by a tapered spring retainer and two conical locks. The valves are long type eliminating the use of valve caps and shims used with short valves on previous model 567 series engines. Either long valves or short valves with caps and shims may be used provided each valve under the same bridge are the same type.

3. Valve Bridges and Hydraulic Lash Adjuster

The valve bridge operates two exhaust valves from one rocker arm. A return spring and ball seat are held on the stem of the bridge by retaining ring. The ball seat rests in a socket bore in the cylinder head, and the spring applies a pressure against the rocker arm so that the valve bridge seat will stay in contact with the rocker arm.

The hydraulic lash adjuster on the 567B engine is similar to lash adjusters on previous 567 engines, except for its greater length to give longer plunger travel. It may be identified by a thicker body shoulder than previous lash adjusters. The short lash adjuster may be used with the long lash adjuster, provided the lash adjusters in the same bridge are the same.

The hydraulic lash adjuster maintains constant zero clearance between the valve stem and the valve bridge. The assembly consists of a body, plunger, spring, ball check and a ball check guide. A snap ring retains parts within the lash adjuster body, Fig. 2-3. The lash adjusters are pressed into the ends of the valve bridge.

Oil flows through a drilled passage in the valve bridge to the top of the lash adjuster, past the ball check and into the body. When the rocker arm depresses the valve bridge, a slight movement of the plunger in the lash adjuster seats the ball check, trapping the oil.

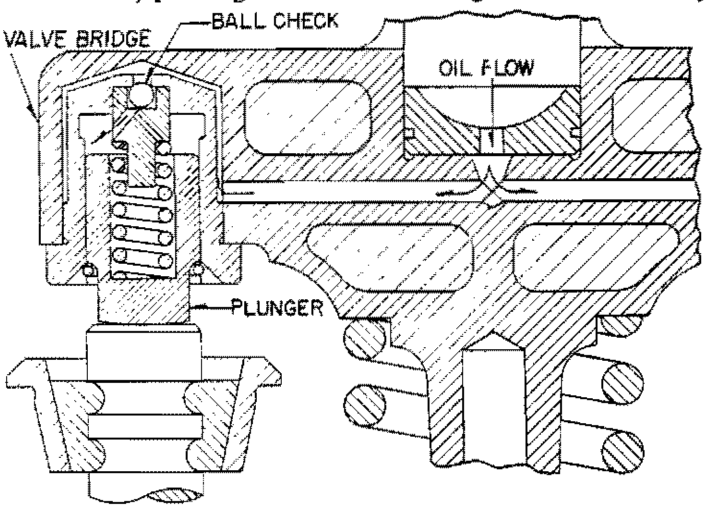
4. Rocker Arms

Three rocker arms are mounted on the cylinder head. Two rocker arms actuate the four exhaust valves, the third arm operates the injector. The rocker arms are operated directly by the camshaft through a cam follower roller mounted at the fork end of each rocker arm. The opposite end of each rocker arm has an adjusting screw and locknut for setting the injector timing and adjusting the hydraulic lash adjuster.

An oil jumper line from the camshaft bearing carries oil to the rocker arm through drilled passages in the rocker arm shaft, Fig. 2-1. The rocker arm is drilled to supply oil to the valve bridge and lash adjuster, and to the cam followers.

5. Cylinder Test Valves

The cylinder test valve consists of a valve body, valve stem, packing nut and seal ring. This assembly



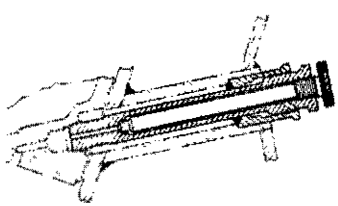
Hydraulic Lash Adjuster
Fig. 2-3

is inserted in a housing which extends from the side plate of the crankcase through the head retainer and seats in the cylinder head, Fig. 2-4.

The purpose of the cylinder test valves is to relieve compression in the cylinders and to permit detection of water or oil in the combustion chamber before the engine is started. To make this test, open cylinder test valves and turn engine over with starter, with fuel pump off, holding governor power piston in shut down position with layshaft manual control lever. If the engine has been dead a considerable length of time the engine should be barred over by hand with the test valves open before starting. If liquid is discharged from one or more test valves, do not attempt to start engine until cause has been corrected. Water may enter cylinder through open exhaust valves from exhaust stack when locomotive is standing dead in heavy rain. It is advisable to cover exhaust stacks if conditions warrant it.

When servicing engine, or making inspections, the engine should be barred over by hand. Starter must not be used to "inch" the engine over. This will cause serious damage to the electrical equipment. Test valves must be opened when barring engine to relieve compression; fuel pump should be off and engine starting fuse removed.

CAUTION: When opening test valves, two or three turns is sufficient. If test valve is opened too far, the cylinder pressure may force the valve out with enough force to damage equipment or injure someone standing nearby.



Cylinder Test Valve
Fig. 2-4

In an emergency, several test valves can be opened to enable starting an engine when the battery is weak. If this is done, the test valves should be closed as soon as engine starts, to prevent burning the test valve seats. Do not open test valves while engine is running.

Test valve wrench #8032587 is used to open and close the valves. Care should be taken not to tighten the valves too tight, as this may cause damage to the valve seat or valve stem threads. Fig. 2-5 shows the wrench in use.

B. MAINTENANCE

The maintenance procedures which follow consist of removing, cleaning, reconditioning, and installing the cylinder head and its component parts. For cylinder head Magnaflux Inspection limits see Maintenance Instruction 2127.

Cylinder Test Valve Wrench
Fig. 2-5

The engine cooling system must be drained before removing a cylinder head. If the cylinder liner is not to be removed it should be held in place with liner anchor tool #8058880 before head removal to prevent disturbing the liner seals. If this is not done, liner will move when the crabs are loosened, resulting in water leaks or possible bending of the piston cooling oil "Pee" pipe. It is good policy to apply liner anchor tools to cylinder liners adjacent the cylinder worked on since the crabs contact two cylinder heads. See Fig. 2-6 for application of liner anchor tool.

1. Removing Cylinder Head

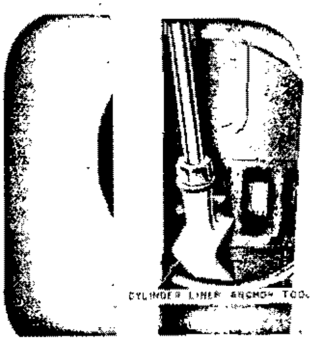
NOTE: For complete cylinder assembly shop removal see article under that heading.

The cylinder test valve must be removed before attempting to remove cylinder head. If the cylinder liner is to be removed, be sure to remove the piston cooling oil pipe assembly before starting to remove cylinder head. If this is not done, the piston cooling oil pipe may be bent when crab nuts are loosened, allowing liner to move.

When removing cylinder heads from the engine, the cylinder head retainer should be examined for cracks. Cracks in the head retainer may occur at the lower part of the retainer, originating at the outside diameter of the retainer wall near the lower crab weld. Cracks in the retainer do not seriously weaken the retainer or affect engine operation provided they are not allowed to progress too far. Maintenance Instruction 1810 outlines procedure for repair of retainer cracks.

a. Remove rocker arms, rocker arm shaft, and valve bridges.
   (1) Disconnect oil line from camshaft bearing cap.
   (2) Remove two nuts and caps holding rocker arm shaft in place.
   (3) Remove rocker arms and shaft assembly. Use care when handling, so that shaft will not fall out of rocker arms.
   (4) Remove valve bridges.

b. Remove injector.
   (1) Disconnect fuel oil lines between injector and fuel manifold.
   (2) Remove adjustable injector link.
   (3) Remove injector crab.
   (4) Remove injector using prybar #8041183, Fig. 2-7. Protect injector from dirt and damage by using holding rack #8045418 or #8159228, or shipping container.



Cylinder Liner Anchor Tool
Fig. 2-6

(5) Install liner anchor tool if liner is not to be removed. Anchor the adjacent liner in either case.

c. Remove cylinder liner stud nuts.

d. Remove crab nuts and crabs. Fig. 2-8.

(1) Place crab stud protector tubes #8034600 over studs to protect threads.

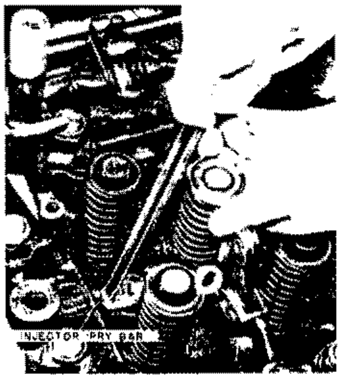
e. Remove cylinder head with use of head removing tool #8075894. Place head into cylinder head carrying basket #8060247 to protect machined gasket seat surfaces of head from damage.

f. Remove cylinder head seat ring. Clean ring and seat and check for wear. See specification at end of this section.

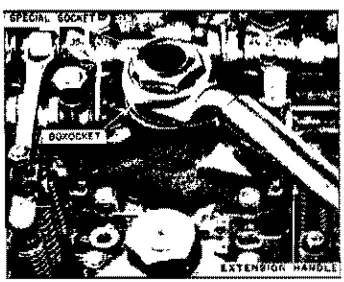
Complete Cylinder Assembly Removal

To facilitate engine disassembly in the repair shop, a cylinder assembly pulling tool may be used which permits removal of the head, liner, piston and connecting rod at one time. The tool assembly, Fig. 2-9, consists of three components, pulling tool #8158650, the piston stop #8160626, and two special piston stop bolts #8160627 which must be used together.

The pulling tool is used in place of the conventional head removal tool, and the piston stop with lip inward is secured to the liner by special bolts after removal of the piston cooling "Pee" pipe.



Removing Injector
Fig. 2-7



Removing Crab Nut
Fig. 2-8

a. Cylinder Assembly Removal Procedure

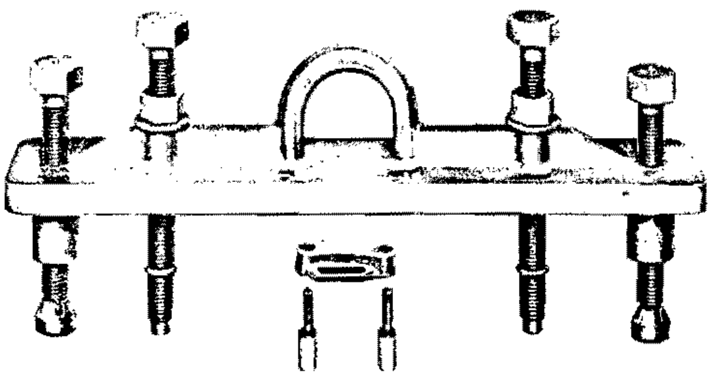
(1) Rotate crankshaft to place piston at bottom dead center. Remove fork rod basket and lower bearing completely. If fork rod assemblies are not to be removed support fork rod with holding tool #8052958. When all assemblies are to be removed, left bank is removed first.

(2) Remove the piston cooling oil "Pee" pipe and apply the piston stop #8160626 in its place on the liner, using special bolts #8160627. Piston stop holds piston in the liner during assembly removal.

(3) Follow items a, b and d under "Removing Cylinder head." Disregard item 5 under b, when all assemblies are to be removed. Remove complete cylinder test valve assembly.

(4) Apply pulling tool #8158650 to cylinder head. Back off on outer jack bolts and screw lifting bolts into head up to stop rings. Loosen head to liner nuts 2 turns.

(5) Screw down evenly on outer jack bolts against engine top deck to loosen cylinder head from liner and loosen entire assembly.



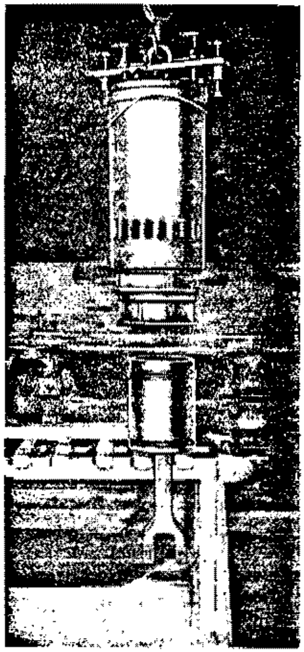
Cylinder Assembly Pulling Tool
Fig. 2-9

(6) Apply hoist hook to pulling tool and raise assembly carefully to prevent binding or cocking in crankcase bore. Guide assembly during lifting.

(7) Place the cylinder assembly so that piston and rod are supported in piston and rod carrying wagon, Fig. 2-10, and remove piston stop from liner. EMD drawing #8042754 outlines details and construction of the piston and rod carrying wagon.

(8) Lift cylinder head and liner assembly from the piston and place on wooden platform, where loosened head nuts may be removed and head and liner separated.

(9) Follow Item "f" under "Removing Cylinder Head"



Removing Cylinder Assembly
Fig. 2-10

2. Rocker Arms and Shafts

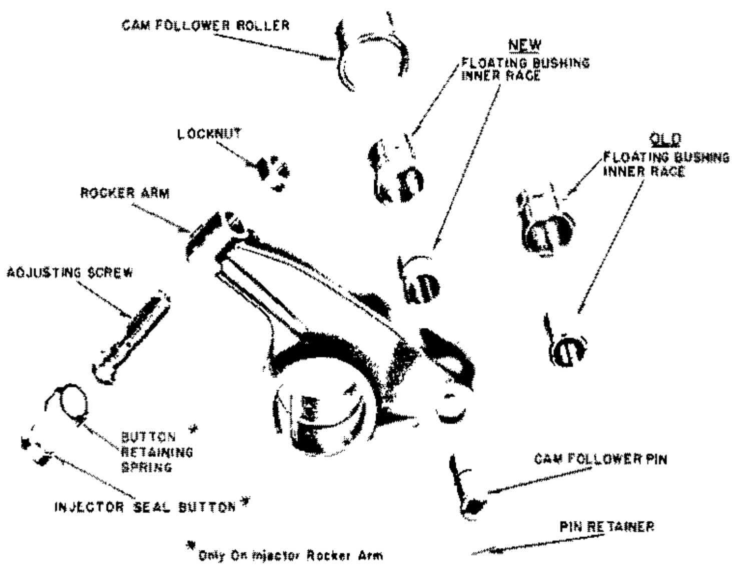
Inspect the rocker arm bushings, cam followers, and rocker arm shaft for wear or damage.

Subsequent to the use of the new fuel injector having a .421" diameter plunger, the rocker arm cam follower floating bushing and inner race was redesigned to provide better lubrication of the parts and increased wear life.

It is important to distinguish between the new cam follower floating bushing and inner race and the old assembly, due to the restrictions governing the use of the old assembly.

Only the new floating bushing and inner race assembly should be used with injector rocker arm assemblies. Either old or new floating bushing and inner race assemblies can be used in the exhaust valve rocker arms.

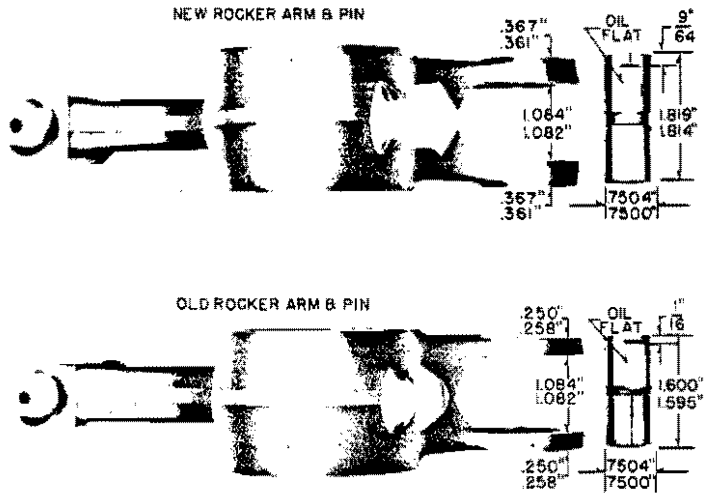
The difference in the assemblies is shown in Fig. 2-11. The old floating bushing #8051001 has a grooved surface and the old inner race #8050977 has a smooth surface. The new floating bushing #8135971 is not grooved but retains the six oil holes around the circumference at the center. The new inner race #8135970 is drilled and grooved around the circumference at the middle. The new inner race and bushing are not interchangeable



Exploded View Of Old And New Rocker Arm Bushings
Fig. 2-11

with the old inner race and bushing. That is, an old and a new part should not be used together. The bushing diameter is such to insure proper assembly. Improper assembly will be evidenced by excessive clearance.

In addition to the preceeding improvements, a new rocker arm has been developed to provide additional strength at the fork end. The fork end of the new rocker arm, Fig. 2-12, has each side of the fork increased in thickness. The inside dimension between the forks is the same in both rocker arms, but the new rocker arm has a greater outside dimension at the fork. The increased outer dimension necessitates the use of a new cam follower roller pin having a length greater than the pin used with the old rocker arm. The distance from end of pin to oil flat on new pins is 9/64" (on a few 1/16"). Only new pins having the 9/64" dimension may be used in either old or new rocker arms. In the event that old and new rocker



Old And New Type Rocker Arms And Pins
Fig. 2-12

arms are to be assembled on an engine, the new one should be used for the injector rocker arm.

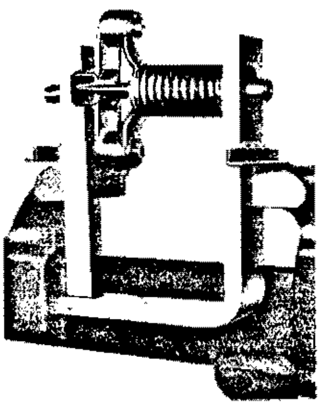
When the new style rocker arm is installed on older engines, there may be slight interference with the camshaft bearing caps. When new rocker arms are installed the clearance between rocker arm and camshaft bearing cap should be checked in all positions by barring crankshaft around. If the clearance is not 1/64", then the camshaft bearing cap should be removed and ground off until sufficient clearance is obtained.

Engines in locomotives delivered after March 16, 1950, incorporate the new design rocker arms with bearing caps machined to insure sufficient clearance.

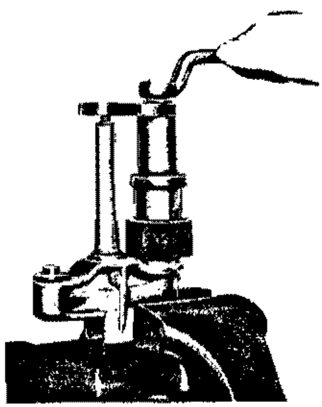
3. Valve Bridges and Lash Adjusters

Clean valve bridges using a solvent, inspect for wear or damage. Rework as in following paragraphs.

a. Removing and installing valve bridge springs or spring seats, Fig. 2-13.



Compressing Valve Bridge Spring
Fig. 2-13



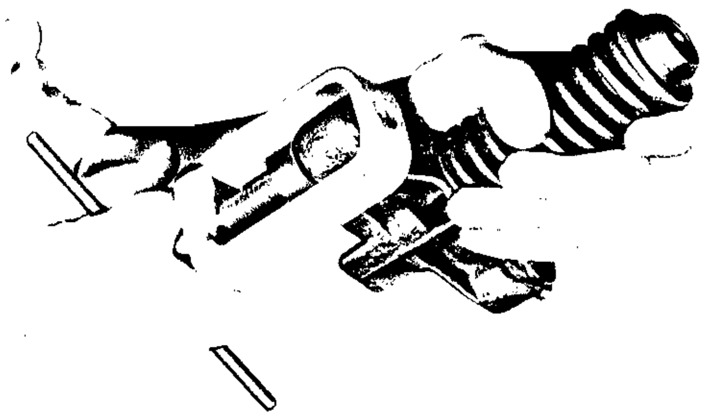
Removing Hydraulic Lash Adjuster
Fig. 2-14

(1) Mount valve bridge spring compressing tool #8070883 in vise.
(2) Install valve bridge in compressing tool, compress spring, remove snap ring and remove spring.
(3) Install new spring or valve spring spherical seat as required, and replace snap ring using snap ring tool #8070903.

b. Removing and installing hydraulic lash adjuster.

NOTE: Inoperative lash adjusters are noisy and can be located while engine is running at idle by their sharp tapping. (This may be noticed at times with good adjusters when first starting an engine, caused by cold oil). To correct this condition, remove lash adjuster and clean or replace parts, as necessary.

(1) To remove lash adjuster, clamp valve bridge in vise and remove lash adjuster, as shown in Fig. 2-14, using lash adjuster removing tool #8070866. Two puller arms are available for this tool,



Installing Lash Adjuster
Fig. 2-15

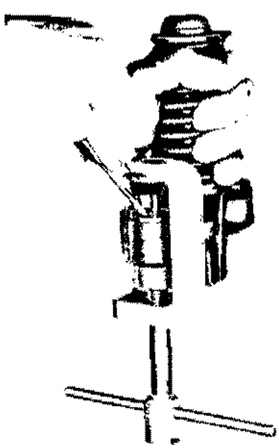
#8154408 for long travel lash adjusters, #8106862 for short travel.

(2) To install lash adjuster, use installing tool #8072927 shown on Fig. 2-15. Use this tool, with plug, to compress the lash adjuster plunger for removing the snap ring as shown on Fig. 2-16 using snap ring removing tool #8080632. Internal parts of the lash adjuster can then be removed for cleaning or replacement. This can be done without removing lash adjuster body from valve bridge.

c. Cleaning lash adjuster

Lash adjuster may be cleaned without removing body from valve bridge, as outlined above. Dirt in the lash adjuster will cause the lube oil to leak past the ball check. This can be tested by depressing plunger by hand. If the plunger can be rapidly depressed with the lash adjuster full of oil, the ball check is leaking.

To correct this condition, disassemble the lash adjuster as outlined above and clean all parts thoroughly. A gummy deposit on the plunger can be cleaned by using alcohol or lacquer thinner. The lash adjuster should then be reassembled, the valve bridge filled with lube oil, tested as above, and replaced if defective.



Removing Lash Adjuster
Snap Ring
Fig. 2-16

4. Exhaust Valves and Guides

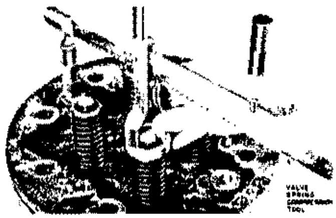
a. Removing valve springs.

Compress spring using the compressor tool

#8033783 and adapter #8034054 screwed to head, as shown on Fig. 2-17, or use type of compressor tool that compresses all four springs #8072932, Fig. 2-18. (Remove cap retainer ring before compressing valves with caps). Valve springs can be removed and replaced without removing cylinder head from the engine, by using special short adapter with tool #8033783. If this is done, piston must be at top center to prevent valves from falling into cylinder when the valve locks are removed.

b. Mating Locks and Valve Stems.

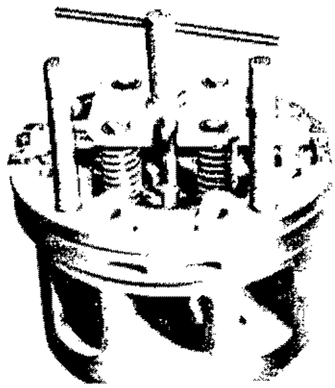
Before installing valves in head, check conical lock fit to valve stem. If lock fits loosely, try new lock. If new lock is loose, it will indicate that the valve stem grooves are worn. Discard valves or locks if either is worn or appreciably scuffed. Check locks and spring seats together. Match to obtain rigid assembly, so no spring seat wobble is felt. Minimum dimension top of lock to top of long valve is 9/32".



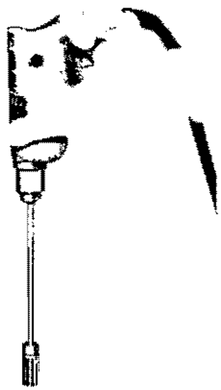
Removing Exhaust Valve
Fig. 2-17

c. Reconditioning Valves.

Visually inspect all exhaust valves after removal from heads to determine whether or not they are sufficiently good condition to merit reworking. Depending on extent, light pitting on valve face is acceptable provided it can be cleaned up within the 11/32" maximum allowable width.



Compressing Valve Springs
Fig. 2-18



Stud Hole Cleaning Tool
Fig. 2-19

Minimum distance valve face edge to top of valve is 7/64". Lightly scuffed valve stems may be buffed after zyglo inspection. Valves are not re-usable if valve faces are burned, deeply pitted, cracked or warped. There should not be any appreciable wear or scarring in the keeper grooves. Long stem valves should have ends buffed smooth free from nicks or scratches. Valves should be given a zyglo inspection to determine other defects as outlined in Maintenance Instruction 2124. After zyglo, make close inspection of the valves using the magnifying glass.

For refacing valves follow instructions supplied with valve refacing machine #8117779-110 volt or #8117780-220 volt. See tool catalog for complete valve tools.

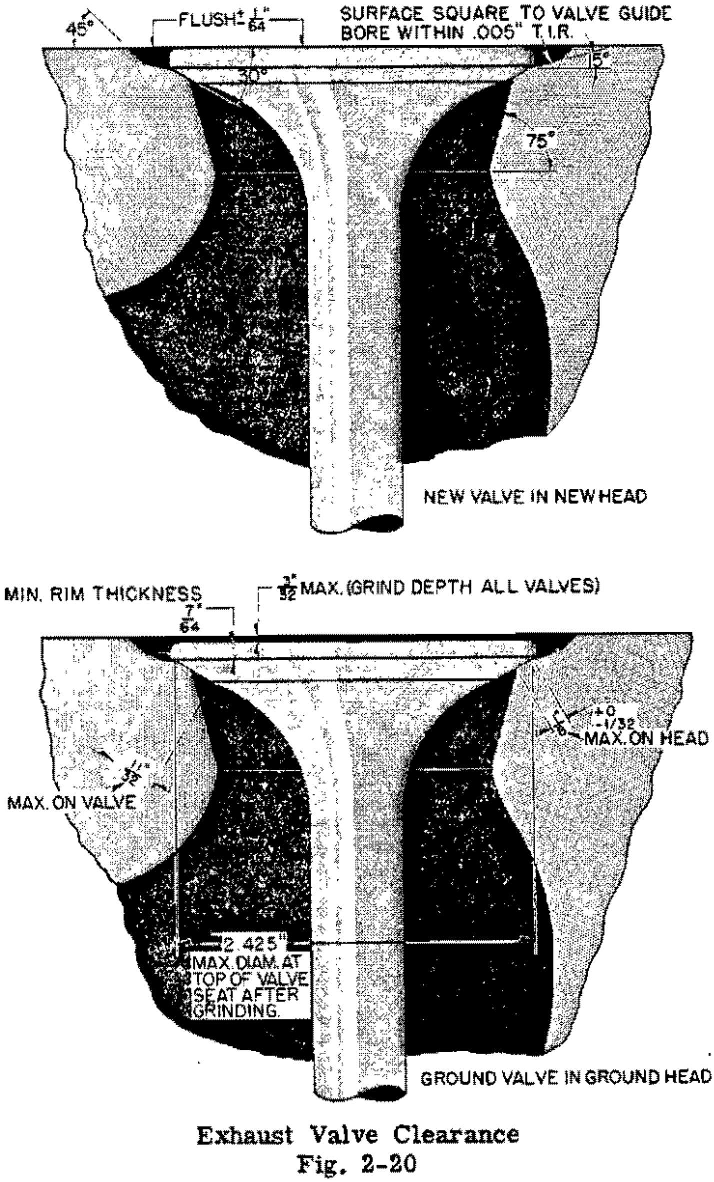
d. Valve guides.

The precision valve guides are a press fit in the cylinder head and can be pressed in or out, using a brass pin with shoulder, to prevent damage to guide. Although the valve guides are precision guides and do not require reaming after assembly, it is recommended a .626" reamer or plug gauge be inserted after guide installation to assure a .626" minimum diameter. For precision valve guide limits refer to Specifications under Valve Guides at the end of this section.

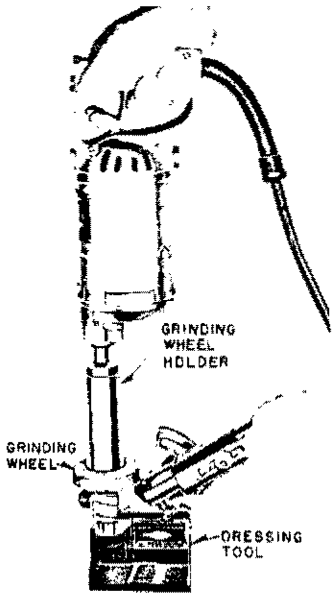
5. Cylinder Heads

a. Cleaning and inspection.

Cylinder heads should be thoroughly cleaned after



Exhaust Valve Clearance
Fig. 2-20



Dressing Valve Seat Grinder
Fig. 2-21

disassembling, as outlined in Maintenance Instruction 1706. When head is removed from cleaning tank, stud holes should be cleaned. A stud hole cleaning tool #8148439, Fig. 2-19, is available for this purpose. Clean cylinder test valve threads in head with 1/2" standard pipe tap. When head is clean, inspect for cracks and damaged seal surfaces, then proceed with following service operation. Magnaflux inspect per M.I. 2127.

b. Grinding valve seats. Use valve seat reconditioning set #8035775-110 volt or #8041445-220 volt. Do not use grinding compound. See Fig. 2-20 for valve and valve seat dimensions. Proceed as follows:

(1) Dress grinding wheel before using on each cylinder head. Mount as in Fig. 2-21. Wipe pilot with oil-soaked cloth for lubrication. Do not get oil on the grinding wheel. Adjust the spiral sleeve on the dressing tool until the wheel touches the diamond. Make final adjustment with diamond adjusting screw. Holder and grinding wheel are then revolved with the high speed drive. Hold the driver as straight as possible. Move the diamond steadily across the wheel taking light cuts. Keep grinding wheel properly dressed to obtain the best results for fast grinding, accuracy and a smooth finish.

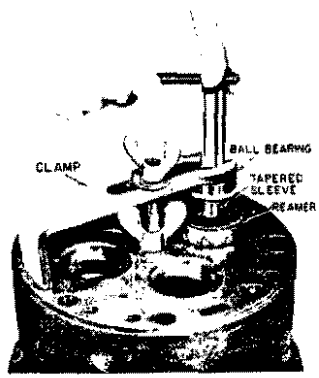
(2) Clean valve guides with cleaning tool #8035427, driver #8062140 - 220 volt, #8045450 - 110 volt shown in Fig. 2-22. Any evidence of galling inside of guide must be entirely removed by reaming or the guide replaced. See specifications for condemning limits.

(3) Select a tapered pilot which will bring the shoulder on the pilot above the valve guide. Press pilot firmly into guide, using pin. Wipe pilot with an oily cloth.

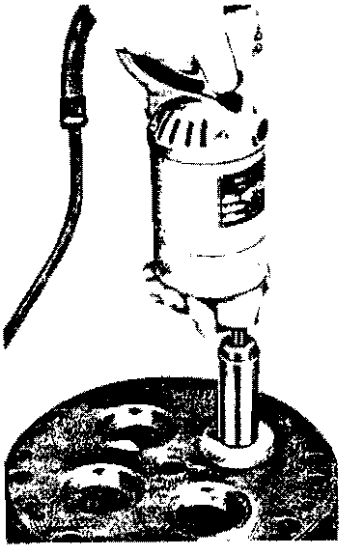
(4) Ream inside and outside of seat to make it conform to dimensions on Fig. 2-20. First use reamer #8064867 to ream clearance inside of seat. Then use reamer #8061039 to ream outside of seat to narrow seat to proper width of 1/8". Use reamer clamp #8068115 (plus foothold adapter 8168115 on #2 heads) to apply an even adjustable pressure to reamers, Fig. 2-23.

(5) Place holder with wheel over pilot. Insert abrasive cloth between grinding wheel and valve seat,

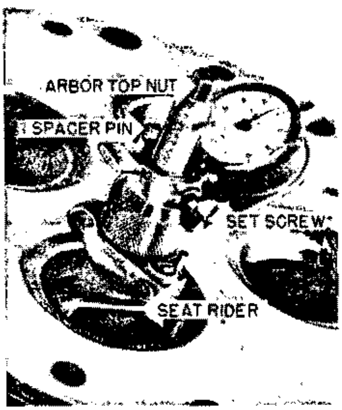
Cleaning Valve
Guide
Fig. 2-22



Reaming Valve
Seat
Fig. 2-23



Grinding Valve Seat
Fig. 2-24



Checking Valve
Seat Roundness
Fig. 2-25

and clean seat by turning holder by hand. Remove abrasive cloth and proceed to grind with driving motor, as shown in Fig. 2-24. No pressure is required when grinding. Permit the driving motor to run at top speed. Hold driving motor as straight as possible. Grind until valve seat is true. Raise grinding wheel off seat before stopping motor.

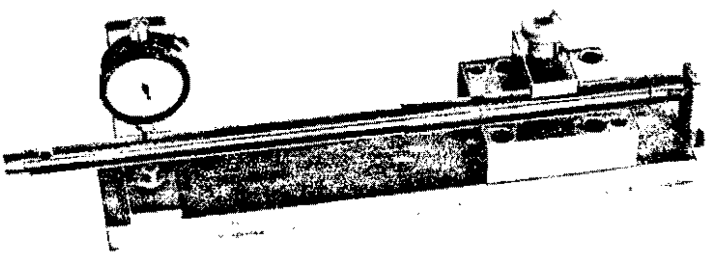
(6) Use new indicator and expanding arbor assembly #8173945 shown in Fig. 2-25, to measure trueness of valve seat. The expanding arbor of this assembly can only be used for gauging valve seat with the indicator assembly, not as a grinding pilot as in the old seat indicator.

To apply assembly, loosen expanding sleeve at bottom of arbor and insert arbor in valve guide until it rests on upper arbor taper. Then screwing arbor top nut which will expand bottom sleeve, secure arbor in valve guide. Loosen indicator base set screw and place indicator assembly over arbor until valve seat rider contacts valve seat. Press spring loaded indicator spacer pin down against indicator base. Before releasing spacer pin, tighten set screw. The spacer pin gauges indicator button to its bevel seat and the set screw holds indicator base on arbor at this position. The indicator base set screw should not enter arbor top holes, as these are only to aid in arbor removal with wrench supplied.

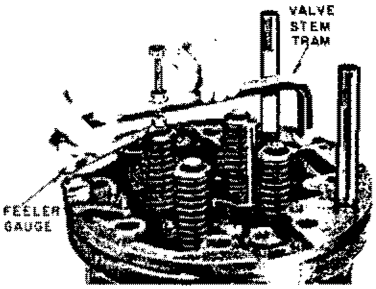
To indicate valve seat after procedure above, set indicator pointer at zero and rotate seat rider by turning at provided knurl. Valve seat out-of-round will be shown on the dial indicator. Indicator reading must not show more than .002" out-of-round. An attempt should be made to obtain a perfect valve seat, it is an important factor in valve life.

A pilot checking fixture #8173996, Fig. 2-26, is available to check tapered pilot run-out or bent pilots. Any pilot having a run-out exceeding .0005" should not be used or valve seat grinding will be eccentric to valve guide centerline.

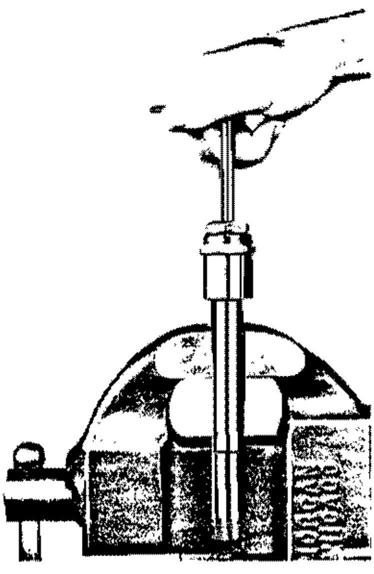
(7) Check valve seat width. If over 1/8", ream with outside reamer, then grind lightly to remove any raised edge caused by reamer.



Pilot Checking Fixture
Fig. 2-26



Checking Height Of
Valve Stems
Fig. 2-27



Reaming Test Valve Seat
Fig. 2-28

c. Testing valve seat. To check seal of valve seat, assemble valves and springs to head and place head in level position with no weight on valves and valve seat up. Pour kerosene or fuel around each valve seat and blow air, not exceeding 25 pounds, against the valves through the exhaust ports. If air bubbles appear, the valve face or valve seat is defective.

d. Checking the height of valve stems.
After reconditioning valves and valve seats, the height of the valve stem above cylinder head must be checked. This is done with the use of the valve stem tram #8041773 shown in Fig. 2-27. Clean off bottom feet of tram, and portion of cylinder head on which tram rests. Hold the tram down firmly on cylinder head and with use of the feeler gauge and screw, as shown in Fig. 2-27, determine the difference of valve stem height. The difference of this height between valve stems (or caps with short valves) under the same bridge should not vary more than 1/16". Should this occur, when the dif-

ference did vary more than 1/16", the high valve would have to be replaced or the low valve ground in, provided this did not exceed the limits given on Fig. 2-20. End of valve should not be ground off as tip is hardened. On short valves, shims may be added or removed, providing the minimum of .030" is used and maximum shims of .090" is not exceeded.

6. Cylinder Test Valves

a. If the cylinder test valve leaks with normal tightening, valve seat in test valve body should be reamed using tool #8064804, Fig. 2-28. If valve stem seat surface is scored or damaged, stem should be replaced.

b. Installing cylinder test valve.
When installing a cylinder test valve apply a small amount of white lead or pipe thread compound to the threads. This will prevent rusting or binding of threads and permit easier removal of the valve body. Valve stem should be tightened with cylinder test valve wrench #8032587. Do not over-tighten. Over-tightening will score valve stem or seat.

7. Installing Cylinder Head

Two cylinder head designs are in use in the field, Fig. 2-29 and 2-30. Design #1 is no longer manufactured, being replaced in production and replacement parts by design #2. Design #2 may be distinguished from design #1 by its 12 drilled water inlet holes as compared to the cored water inlet holes in design #1.

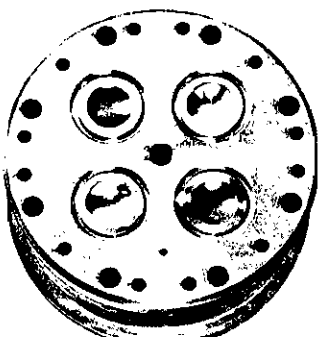
Cylinder head design #2 can be used with any liner design #3, #2, or #1. Cylinder head design #1 must be used only with liner design #1, or #2. Liner #3 has 12 drilled water discharge holes with counterbore for grommet seal and water tube and is 1/16" longer than liner #2 or #1 above air inlet ports to head seat. Liner #2 has 12 drilled holes without counterbore; dimensionally the same as liner #1, long used, having cast water discharge holes.

It is important that the proper cylinder head to liner gasket be used according to the liner used. Liner

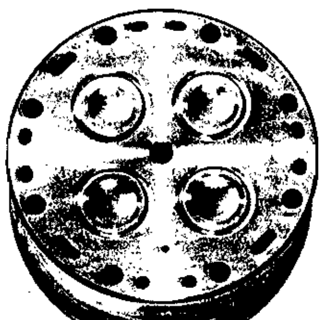
#3 must use copper coated, steel shim gasket #8194009. Liners #1 and #2 must use copper, asbestos, steel gasket #8142549. Gasket #8194009 has two notched liner stud holes which go over the pilot stud and left adjacent stud. Gasket #8142549 is stamped "This Side Down" and should be so installed. (See Section 4).

Torque values of the liner stud nuts on the #3 liner are less than used on #1 or #2 liners. Liner #3 torque value is 200 ft. lbs. but a torque value of 290-300 ft. lbs. is used on liners #1 and #2. To identify the #3 liner installed, each liner stud has a 1/8" off center drilled hole on top. Liner #3 studs are straight shank of weaker material than the necked down liner studs that must be used with liner #1 and #2.

Before installing a cylinder head the exhaust area of the head retainer in the crankcase should be throughly cleaned. The retainer seat area and above must be smooth, free from nicks, scratches or corrosion. A power driven wire brush or emery cloth may be used to clean this area. Care should be taken to remove dirt and grit after cleaning to prevent interference with gasket seals or head seat ring.



New Cylinder Head
Design 2 (Bottom View)
Fig. 2-29



Old Cylinder Head
Design 1 (Bottom View)
Fig. 2-30

Check cylinder head for cleanness, especially the inside of the liner stud holes. The stud holes should be cleaned using tool #8141439, Fig. 2-19, or by using a wire brush to remove scale, rust or dirt from these holes. Otherwise, when head is applied these foreign particles may be dislodged falling on the gasket or seal surfaces. Application of a small amount of green soap around the bottom edges of the holes before head application will tend to prevent dirt falling from these holes.

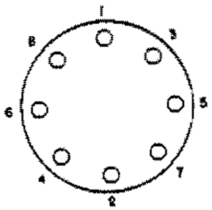
Liner stud nuts should be examined and discarded when pressure side of nut or threads are galled or fibre area cracked torn or frayed.

Inspect cylinder head nut seating surface for good condition. If damaged to a depth of .015" or more, apply washer as given under item 11 "Repair of Cylinder Head Nut Seating Surfaces" in this section. A washer #8140912 has been used under the liner nuts since January 1950 and liner studs are 1/8" longer than previously to accommodate this washer.

Examine counterbores in liner #3 for cleanness and check water tubes for tightness or bending, replace any damaged or loose tubes. Tube applying and removing tools and counterbore cleaning tool are available, see Section 4. Use new grommets in the counterbores. Inspect liner gasket surfaces before application of new gaskets.

Check cylinder head seat ring before application for wear and bending. See specifications for limits. Apply seat ring with inside bore bevel up. Lubricate head seal rings using green soap or other water soluble lubricant. (Vastaline, a water soluble lubricant may be obtained from our Parts Department, #8149962 one gallon.) Apply upper seal to head and put lower seal in place on seat ring. Lubricate head retainer for upper head seal.

When this preliminary work is completed, proceed with cylinder head application as follows:



a. Lower head into position slowly to avoid twisting of seals. (Use cylinder head removing tool). Line up indexing plate on head with dowel in top deck.

b. Apply cylinder liner stud nuts and tighten snug. Use lube oil or a lubricant having specifications similar to Texaco Stud Lube #921 on threads and bottom nut. At this initial tightening apply only 75 foot-pounds torque.

c. Crab stud seals should be replaced if cracked. To install seals, use tool #8069934.

d. Apply crabs, washers and crab nuts. Pull crab nuts down lightly, to locate indexing plate over dowel. (Remove anchor liner tool if used).

e. Tighten liner stud nuts progressively as illustrated in the sketch. Torque values are: liner #3, head #2 and the shim type gasket 200 ft. lbs.; #1 or #2 liner, head #1 or #2 and sandwich copper asbestos steel gasket 290-300 ft. lbs. Powerwrench #8166975, having a ratio of 3.1-1 is available for tightening cylinder head to liner nuts. Special offset wrenches used with this provide access to head nuts under rocker arms.

f. Tighten crab nuts using socket #8065580, box socket #8034085, and 60" extension handle #8084091. Crab nuts should be tightened alternately forming the letter "X" and in two passes, fifty percent of full torque for each tightening pass. It is necessary to use three men on the handle to properly tighten the crab nuts. Torque values for crab nuts are 1700-1900 foot-pounds. A Powerwrench #8133312 for tightening crab nuts is available through our Parts Department. This is a mechanical wrench employing a standard torque wrench.

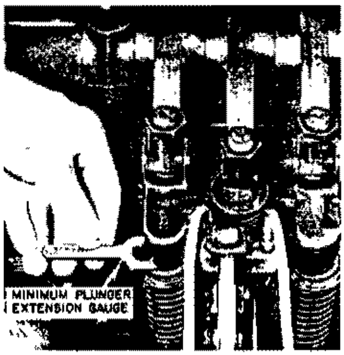
g. Install injector (torque values for injector crab nut are 40 to 50 foot-pounds). Connect fuel oil lines and adjustable link.

h. Install valve bridges (with bosses toward camshaft), rocker arms and shaft. Connect lube oil line.
i. Install cylinder test valve.
j. Install piston cooling oil pipe assembly and check alignment. Before applying "Pee" pipe check pipe with cleaning tool #8087086.
k. Load testing.
Load testing of new #2 head and #3 liner assembly is not required. After installing and tightening this assembly, bring engine water temperature to 170° and retorque cylinder head nuts to 200 foot-pounds. Recheck torque at approximately three month intervals. For conventional sandwich type gasket assemblies, the following procedure is recommended:
   (1) After assemblies are tightened and the engine prepared for running, run engine on load test for one hour. Then remove rocker arms and retighten the assemblies to proper torque of 290-300 foot-pounds on the liner stud nuts and 1700-1900 foot-pounds on the crab nuts. A drop of 40 to 50 foot-pounds will usually be found at this time on the liner stud nuts being retorqued.
   (2) If load test facilities are not available, run engine for one hour in sixth or seventh throttle position with 150-180° water temperature and retighten the nuts with rocker arms removed (or use Powerwrench and offset tool #8166975) to 290-300 foot-pounds torque as given under Item "e".
   (3) If the load test was not run (as when following Step 1), it will be necessary to recheck the cylinder head nut tightness at 1000 miles (or less, if possible).
   (4) If load test was performed, it will be necessary to retighten at the next maintenance period of the locomotive.
   (5) All head tightening will be done thereafter at mileages specified in Scheduled Maintenance Program.

NOTE: When liner and crab nuts are being retightened, those which move at LESS than the specified torque valves should be tightened to the proper values. Those nuts which DO NOT move below or up to the proper values, should be checked by pulling up to a value not exceeding 10% more than the recommended torque values.

8. Adjusting Hydraulic Lash Adjusters

After complete cylinder head assembly has been installed the lash adjusters must be reset.



Minimum Plunger Check
Fig. 2-31

a. Rotate crankshaft so that piston is at or near top center.
b. Loosen rocker arm adjusting screw locknut.
c. Turn adjusting screw until lash adjuster just contacts lowest valve stem (or cap); then turn screw one and one half (1-1/2) turns more with long travel lash adjuster or with short travel lash adjuster turn screw one half (1/2) turn further.
d. Check valve bridge spherical seat for looseness. If loose, turn adjusting screw down until no looseness is felt, so seat is spring loaded, then turn adjusting screw 1/4 turn further down.
e. Tighten rocker arm adjusting screw locknut.
f. Time the injector as outlined in Section X.
g. After running the engine to circulate warm oil through lash adjusters and to allow excess oil in the lash adjuster to leak off, check the extension of the lash adjuster plunger out of the lash adjuster body to top of valve stem (or valve cap) with piston near top dead center. Use minimum extension gauge #8107788 as shown in Fig. 2-31. This gauge is 1/16" thick. If this plunger extension is less than 1/16" and

preceeding steps (a) to (e) have been correctly made, the cylinder head should be removed for reconditioning or rejection.

NOTE: Do not confuse this 1/16" gauge with the .150" valve feeler gauge #8058298 formerly used in setting hydraulic lash adjuster.

9. Tracing A Defective or Noisy Cylinder

A cylinder that is not firing properly will have a cooler exhaust stack, compared to one that is firing properly (engine at idle). This may be caused by:

a. Badly leaking exhaust valves.
b. Defective injector.
c. Improper injector timing or control rack setting.
d. Dirty injector filter.
e. Air bound injector.
f. Excessive ring blow-by.
g. Cracked piston.

To determine if injector is at fault, disconnect injector adjustment link on the suspected cylinder and, with engine running at idle, push control rack open slowly. If injector is operating properly, a pronounced laboring of the cylinder will be detected.

An exhaust valve leak can be detected when standing outside of locomotive by a pronounced blow at the exhaust stack, with engine idling. To locate the leaking cylinder (engine shutdown) install cylinder test adapter #8070872 in place of cylinder test valve, connect air hose to adapter, rotate crankshaft until piston of cylinder to be tested is at top center and turn on air pressure. If valves are leaking, blow will be heard at exhaust stack. This method can also be used for checking excessive piston ring blow-by. In this case, blow will be heard in air box. If piston is cracked, blow will be detected at oil pan.

10. Repair of Damaged Sealing Surfaces 567 Cylinder Head

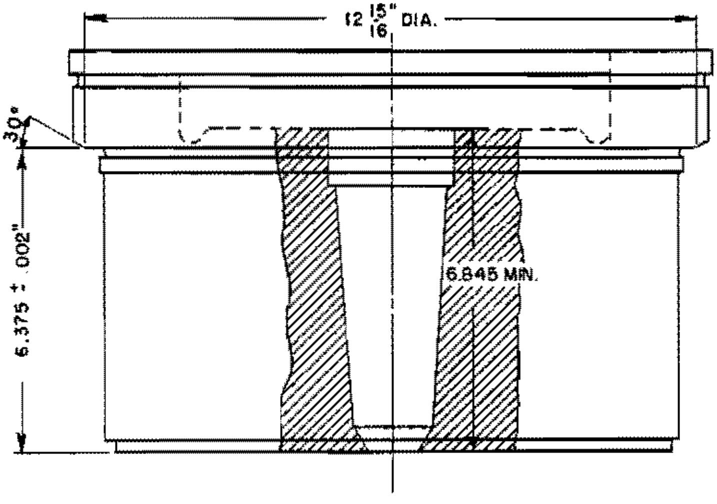
It is permissible to rework cylinder heads which have damaged sealing surfaces within certain limits as follows: For dimensions on the following procedure, see Fig. 2-32. (Refacing fixture 8193622 aids this).

a. If the bottom of the gasket face is damaged, cut off up to .010" of the face. This will allow the 6.375" ± .002" dimension to become a minimum of 6.363".

b. If bottom gasket face does not clean up when reworked as in (a):

(1) Cut .010" off the cylinder head retainer seating surface. This .010" cut off is the absolute limit. Do not recut the 30° chamfer to the 12-15/16" dimension unless this surface is also damaged.

(2) The operation in (1) has restored the minimum 6.363" measurement to a minimum of 6.373". Now the bottom gasket face can be recut up to



Cylinder Head Dimensions
Fig. 2-32

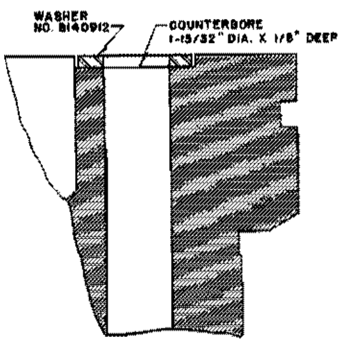
.010" to clean up and the 6.363" minimum will not be exceeded.

c. In order to repair damage to the 30° chamfer surface which bears against the lower cylinder head seal:
   (1) Recut the 6.375 ± .002" dimension to a maximum of 6.382". This limit is not to be exceeded.
   (2) The 30° chamfer should then be recut to re-establish the 12-15/16" diameter.

d. If either the lower cylinder head seal surface or bottom gasket face does not clean up by following a, b, and c, or if the dimension from valve spring seat surface to bottom head gasket surface is less than 6.845" minimum, Fig. 2-32, the cylinder head must be scrapped. There is no more tolerance.

11. Repair of Cylinder Head Nut Seating Surfaces

All new liners since December 1949 are equipped with studs of such length to accomodate the use of hardened washer #8140912 which is used under each cylinder head to liner nut. Prior to the use of this washer, cylinder head nut seating surfaces were damaged by the use of rough bottom cylinder head to liner nuts. Nut seating surfaces on these cylinder heads if damaged to a depth of .015" or more should be repaired and the hardened washer used.



Repair Section
Cylinder Head
Fig. 2-33

To repair the damaged area around the liner stud holes in the cylinder head, the rough surface is removed by counterboring as shown in Fig. 2-33. The special hardened washer

#8140912 is then added to compensate for the metal removed. The counterbores should be 1/8" deep x 1-13/32" in diameter and concentric with the liner stud holes. To facilitate this operation a special counterbore tool #8190311 is available from our Parts Department. Supplies of #8140912 may also be obtained. This washer is also used on the accessory drive gear mounting bolts.

Damaged nut seating surfaces affect torque value adversely with subsequent trouble resulting.

C. SPECIFICATIONS

Exhaust Valves

Diameter of stem	.6220" - .6225" (New)
Diameter of head	2-1/2"
Valve seat angle	30°
Lift	.686"
Number per cylinder	4

Valve Springs

Free length	(approx.)	4-1/8" (New)
Length - valve open		2-11/16"
Length - valve closed		3-3/8"

Pressure with valve open 213 lbs. to 225 lbs. (New)
(2-11/16" length) 175 lbs. Low limit
Valve bridge spring - same as valve spring.
Spring must not show any set after being compressed with coil touching.

Valve Shims

Long valves	8082254, 8178121,	None
Short valves	8060418, 8054464,	Min. .030"
	8069526, 8080503,	Max. .090"
Short valves	*8054464, 8035522,	Min. .060"
	(*Used prior to August, 1944.)	Max. .090"

Rocker Arm

Clearance - bushing to shaft	New .002" - .004"
	Limit .008"
Rocker arm shaft dia.	Min. 2.246"
Rocker arm lever bushing I.D.	Max. 2.254"
Press - bushing to rocker arm	.002" - .004"
Inner race (8135970) O.D.	Min. 1.048"
Floating bushing (8135971) I.D.	Max. 1.055"
O.D.	Min. 1.4435"
Inner race (old) O.D.	Min. 1.057"
Floating bushing (old) I.D.	Max. 1.064"
Floating bushing (old) O.D.	Min. 1.4425"
Outer race I.D.	Max. 1.4505"

(Parts at these limits, if not exceeded, should give satisfactory service to next overhaul).

Clearance - cam follower to floating bushing when new	
Floating bushing 8135971 (new)	.002" - .004"
Floating bushing 8051001 (old)	.004" - .006"
Clearance - floating bushing to inner race when new	
Bushing 8135971 and inner race 8135970	.003" - .005"
Bushing 8051001 and inner race 8050977	.003" - .005"
Cam follower assembly overall clearance (diametral)	Limit .015"

Valve Guide

Inside diameter (not installed)	New .6270" - .6290"
(installed in head)	New .626" - .6285"
Limit (at bottom)	.632"
Limit (1/2" from bottom and top)	.630"
Valve stem to guide clearance	.0040" - .0065"
	Limit .010"
Press fit in head	.0005" - .0020"

Cylinder Head Seat Ring

Thickness (New) Standard	.192" $\pm$ .002"
Minimum thickness	.184"
Uniform thickness within	.002"
Oversize	.230" $\pm$ .002"
Minimum	.222"

D. EQUIPMENT LIST

	Part No.
Test Valve Wrench	8032587
Liner Anchor Tool	8058880
Injector Holding Rack For 12 Injectors	8045418
Injector Holding Rack For 16 Injectors	8159228
Snap Ring Removing Tool	8080632
Crab Stud Protector Tubes	8034600
Cylinder Head Removing Tool	8075894
Cylinder Head Carrying Basket	8060244
Valve Bridge Spring Compressing Tool	8070883
Valve Bridge Snap Ring Tool	8070903
Lash Adjuster Removing Tool	8070866
Lash Adjuster Installing Tool	8072927
Exhaust Valve Spring Compressing Tool	8033783
Adapter (for above)	8034054
4-Spring Compressing Tool	8072932
Short Adapter (for valve compressing tool)	8033783
Valve Refacing Machine 110 Volt	8137779
Valve Refacing Machine 220 Volt	8137780
Valve Seat Reconditioning Set 110 Volt	8035775
Valve Seat Reconditioning Set 220 Volt	8041445
Valve Guide Cleaning Tool	8035427
Driver (for above) 110 Volt	8045450
Driver (for above) 220 Volt	8062140
Valve Seat Reamer (inside)	8064867
Valve Seat Reamer (outside)	8061039
Reamer Clamp	8068115
Reamer Clamp Adapter (foot holder for #2 cylinder heads)	8168115
Valve Seat Out-of-Round Indicator Assembly	8173945

Valve Stem Tram	8042773
Crab Stud Seal Applying Tool	8069934
Crab Nut Socket	8065580
Box Socket Wrench	8034085
60" Extension Wrench	8084091
Lash Adjuster Minimum Extension Gauge	8107788
Cylinder Test Valve Adapter	8070872
Vastoline (Water soluble lubricant)	8149962
Crab Nut Powerwrench	8133312
Cylinder Head Powerwrench	8166975
"Pee" Pipe Cleaning Tool	8087086
Cylinder Assembly Pulling Tool	8158650
Piston Stop (used with #8158650)	8160626
Piston Stop Bolts (used with #8160626	8160627
Cylinder Head Stud Hole Cleaning Tool	8141439
Cylinder Head Counterbore Tool	8190311
Injector Prybar	8041183
Taper Pilot Arbor Checking Tool	8173996
Cylinder Test Valve Reamer	8064804
Refacing Fixture (Cylinder head holding)	8193622

NOTES

SECTION III

CONNECTING RODS, CONNECTING ROD BEARINGS, PISTONS AND PISTON PINS

A. DESCRIPTION

1. Connecting Rods

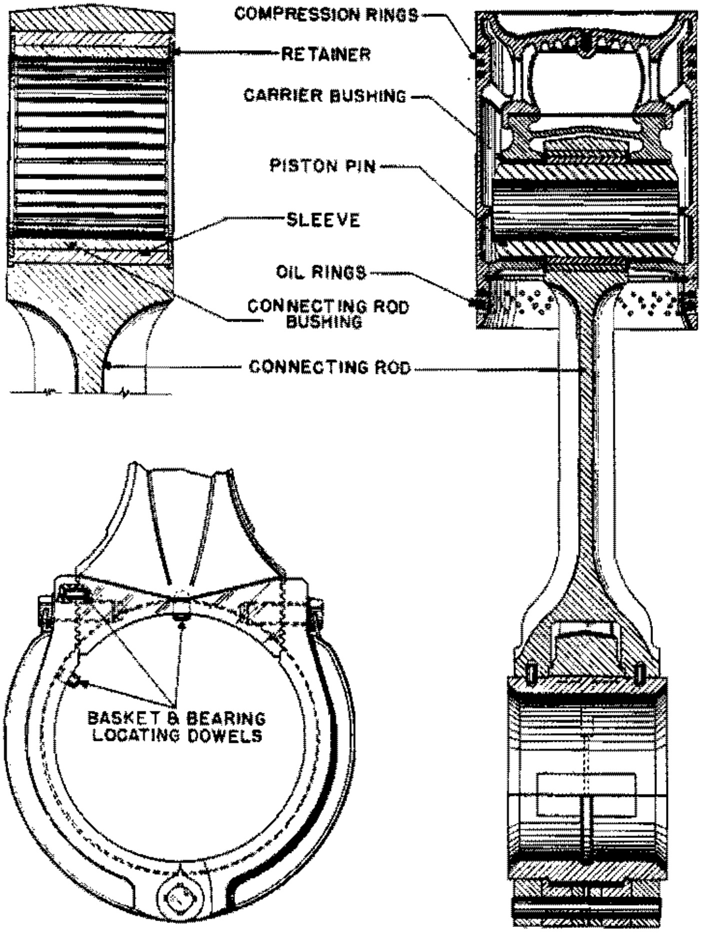
The connecting rods are of the interlocking, blade and fork rod construction. The blade rod oscillates on the back of the upper bearing shell and is held in place by a counter-bore in the fork rod. See Figs. 3-1 and 3-2.

One side of the blade rod bearing surface is longer than the other and is known as the "long toe." The blade rods are installed in the right bank of the engine, with the long toe toward the center of the engine.

The fork rods are installed in the left bank of the engine. Serrations on the sides of the rod at the bottom match the serrations on the two piece hinged bearing basket. Rods and bearing baskets are machine fitted in sets and are numbered to match. If either basket or rod is defective, both parts must be replaced as a unit, or reconditioned by remanufacture, see item 5.

2. Connecting Rod Bearings

Connecting rod bearings consist of upper and lower shells both of which are steelbacked, bronze, lead-tin overlay on shaft side, with no overlay on blade rod side of upper bearing. The upper shell is held in position by dowels in the fork rod. The lower shell is doweled to the bearing basket for locating purposes to insure correct assembly and the right basket serration is doweled to the outboard engine side of the fork rod. The outside of the upper shell provides the bearing surface for the blade rod. The inside surface of the



Piston And Connecting Rod (Cross-Section)
Fig. 3-1

bearing shell is overlaid to permit rapid seating on a worn crankpin. After bearing shells are once used, they must be used on same crankpin, and not changed to other crankpins.

No adjustment of the connecting rod bearings is provided. When bearing clearances exceed the limit, or at intervals specified in the Scheduled Maintenance Program, replace with new bearings.

The connecting rod bearing is lubricated by oil from the adjacent main bearing, fed through a drilled passage in the crankshaft. A hole drilled through the upper bearing shell conducts oil to the blade rod bearing surface.

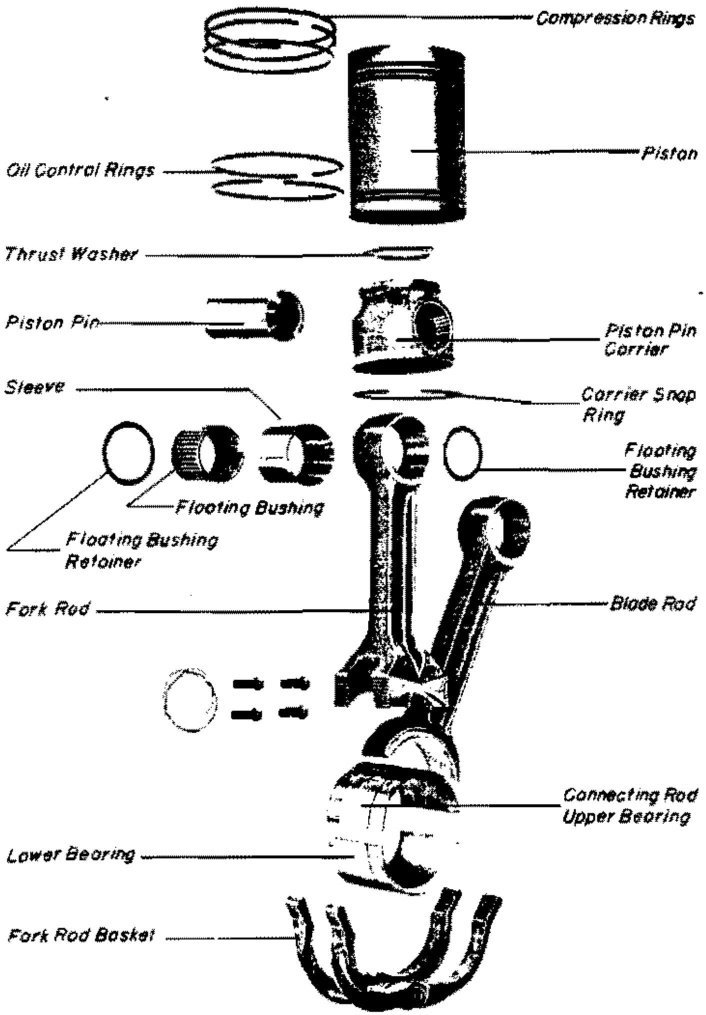
3. Pistons

The alloy cast iron pistons used in the Model 567B engine are of the two piece or "floating" type. The body of the piston is supported by a piston pin carrier which is held in position within the piston by a 3/16" snap ring. A thrust washer is inserted between the piston carrier and the piston platform. See Fig. 3-10.

This type of construction permits more efficient cooling of the piston crown eliminating "hot spots," better lubrication of the piston pin and bushing, and more evenly distributed piston wear and load.

The piston cooling oil is directed through a drilled passage in the piston pin carrier, and discharged through another drilled passage diametrically opposite. The piston pin and bushing are lubricated by the constant flow of piston cooling oil.

The pistons are treated by a process which etches the surface giving it a dark gray color. This treatment, known as the Parco Lubrize process, helps to retain the lubricating oil on the surface of the piston.



Piston And Connecting Rod Assembly
Fig. 3-2

NOTE: Information on relubrizing of pistons in the field may be obtained by requesting Maintenance Instruction 2175.

4. Piston Pins and Piston Pin Bushings

The piston pin is made of alloy steel, carburized and hardened, inside and out. It is polished to a mirror finish and can be used (except when overheated) according to limits given under specifications.

When reusing a piston pin, polish well with crocus cloth or buff. NEVER reuse a piston pin that shows discoloration from excessive heat.

The piston pin bushing is lubricated by the piston cooling oil.

For piston pin Magnaflux inspection see Maintenance Instruction 2130.

5. Remanufacture of Connecting Rods and Pistons

a. Connecting Rods

Blade and fork connecting rods may be returned to the Factory Branch for remanufacture on a Rebuild and Return basis. Conditions requiring connecting rod rework and those which are cause for scrapping are outlined under Maintenance, Item 5. However, precise measurement and inspection before remanufacture will determine if the connecting rod can be reworked.

b. Piston

Only those pistons which pass Magnaflux and dimensional inspection will be processed. The following rework may be given pistons.

(1) Lubrize piston.

(2) Machine wear step from top ring groove.

(3) If top ring groove is worn beyond the .260" limit, the groove is machined to accommodate an oversize ring.

Piston carriers may also be returned for rebushing if satisfactory dimensionally and also pass the Magnaflux inspection given in Maintenance Instruction 2125.

Parts found not suitable for remanufacture will be scrapped at the factory. Complete details concerning prices and remanufacture procedures may be obtained from your field representative or by inquiry direct to your closest Factory Branch.

B. MAINTENANCE

Maintenance of the piston and connecting rod assembly with engine dead, consists of the following: Inspection (in engine), removal, disassembly, cleaning, inspection of parts, reworking, reassembly and installation. For Magnaflux Inspection see following Maintenance Instructions: piston carrier - M.I. 2125, piston - M.I. 2129, piston pin - M.I. 2130, and connecting rods and basket - M.I. 2128.

1. Inspection

Inspection of the piston and connecting rod assembly may be made after removing the hand-hole covers from the air box and oil pan. Then proceed as follows:

a. Block open starting contactors in low voltage cabinet.

b. Open cylinder test valves and rotate crankshaft so that piston to be inspected is at bottom center.

NOTE: Crankshaft must be barred over, bringing piston to correct position for each of the following items.

(1) Air Box Inspection:

(a) Inspect cylinder wall and top of piston. Check for scoring of cylinder walls and water leaks.

(b) Inspect rings for blow-by (through the liner ports). Rings in good condition will be bright and free from vertical brown streaks. Ferrox grooves should still be visible. Smooth rings without the ferrox grooves should be replaced. Do not use a bar or piece of wood to see if rings are free as there is a possibility of damaging the ring face or breaking the ring. A stuck ring will show blow-by.

(c) Inspect piston skirt for scuffing.

(d) Inspect air box for foreign matter and water leaks.

(2) Oil Pan Inspection

(a) Inspect the back of upper half connecting rod bearing for cutting or discoloration.

(b) With piston at top center, inspect lower liner walls for scoring.

(c) Inspect oil pan for foreign matter, and water leaks from liner seals.

To check for thrust washer wear, measure clearance between piston and snap ring, as given under specifications at the end of this section. Excessive clearance indicates worn parts.

2. Pulling Piston and Rod Assembly

NOTE: For complete cylinder assembly removal at one time, see Maintenance Section 2 under that subject.

a. Remove piston cooling pipe.

b. Remove cylinder head (see Section II) and clean carbon from cylinder wall above piston travel.

c. Remove fork rod basket and lower bearing shell.

d. Insert piston pulling eye bolt, 8040413, in tapped hole in center of piston crown.

e. Fork rod removal.

(1) Pull piston and rod assembly. Hold rod as it clears crankshaft so that it will not fall and strike inside of piston skirt or liner. Failure to observe this will result in damaged parts.

(2) After rod is clear of crankshaft, apply rod boot (8062034 for fork rod) to protect cylinder liner walls while pulling piston and rod.

f. Blade rod removal.

When pulling piston and blade rod assembly, it is necessary that fork rod and piston be held up in liner so that blade rod will clear the fork rod. Fork rod holding tool, 8052958, is used for this purpose. Proceed as follows:

(1) Remove fork rod basket and lower bearing shell.

(2) Rotate crankshaft so that fork rod piston is at (or near) top center. Cylinder test valves must be open.

(3) Apply fork rod holding tool. This tool is secured to fork rod by using two fork rod basket cap screws.

(4) Rotate crankshaft slowly in opposite direction. See that connecting rod and upper bearing shell follow crankpin, and holding tool seats in corner of oil pan. Continue rotating crankshaft until blade rod piston is at top center.

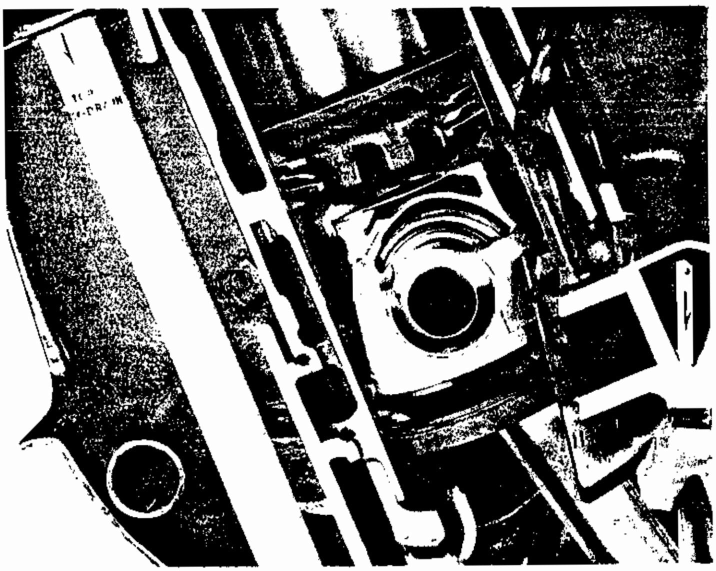
(5) Pull piston and rod. Do not allow upper bearing shell to fall or rod to strike inside of piston skirt.

(6) After rod is clear of crankshaft, apply rod boot (8062033 for blade rod).

3. Disassembly of Piston and Rod

a. Place piston and rod assembly on stand (drawing 8071694 - Fig. 3-12) and remove snap ring using snap ring pliers 8171633.

b. Lift out rod and piston pin carrier and place on a clean surface, with carrier down.



567B Engine Piston Cutaway

c. Remove piston pin and lift out rod.

4. Cleaning Pistons

To clean piston and rod assembly and to remove carbon, follow procedure outlined in Maintenance Instruction 1706.

5. Checking Connecting Rods

After all parts are put through cleaning process, check basket cap-screws and tapped holes in fork rod. It is not necessary to replace basket cap-screws on a mileage or time basis. They should be inspected for damage when removed at any time. If they appear bent, battered or nicked, or the threads appear worn or cannot be run into the rod with the fingers, they should be replaced by new cap-screws.

Clean fork rod and basket serrations and inspect for nicks and burrs. Also, inspect rods and baskets visually for cracks. (See M.I. 2128 for Connecting Rod and Basket Magnaflux Inspection). The tapped holes in fork rod may be cleaned with a 5/8"-18 tap. The flame hardening process is used on blade connecting rods in place of the previous method which included copper plating above the blade end. Common to the flame hardening is a slight discoloration or blue-black color at the blade end of the rod. This discoloration should not be interpreted as an overheated rod. No discoloration is on the machined surfaces.

A new type basket cap-screw is used in later engines, that has a large washer face (integral on earlier, loose nonremovable on late cap-screws), which extends outside the head of the cap-screw. This washer aids in better seating of the cap-screw and eliminates mutilation of the basket face. These cap-screws have also been improved by increasing head thickness from 3/8" to 1/2" to give better socket fit. It is recommended when old cap-screws, 8028953, are removed they be replaced with the new washer face type cap-screw.

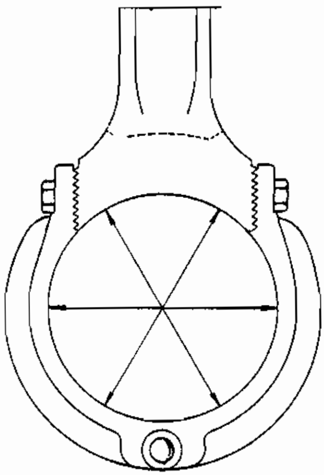
Before installation of the new cap-screw, the basket face must be made smooth and square and cleaned to remove any roughness caused by the old cap-screw. This may be done with a spot facing tool 1-1/4" in diameter with at least a 1/16" radius at the cutting tooth end. The maximum cutting depth for cleaning operation of the basket face is 1/32" deep.

The greatest roughness caused by the old cap-screw will be around the cap-screw hole in the basket. The basket will provide sufficient bearing area even though the area adjacent cap-screw hole is not entirely clean, providing the rest of the spot facing area is smooth and flat. This permissible rough area around the cap-screw hole must be limited to the area within a circle whose circumference is 1/16" outside the cap-screw hole in the basket.

In the event the basket face cannot be cleaned up within these limits, it will be necessary to scrap the basket and fork rod and replace with a new fork and basket assembly, or return rod for new basket application.

Check the bore of the fork rod by bolting basket securely in place (175 foot-pounds torque for this check on engine application basket cap-screw torque should be 190-200 foot-pounds) and measuring across the bore at points 60° apart, as indicated on Fig. 3-3. The average of these dimensions must not exceed 7.626". If bore is beyond this dimension, the rod and basket must be replaced or reworked.

The blade rod is checked on a mandrell, 7.692" in diameter. If it is found that the ends of the blade rod bearing surface are "closed in," the rod must not



Checking Fork Rod
Fig. 3-3

be used, see the following. Blade rod slipper surface should be bright and shiny. If pitted, polish with buffing wheel. If darkened from heat, scrap.

Any of the following conditions will necessitate rework of the connecting rod.

a. Blade rod

(1) Scarred, pitted or deeply rust etched slipper surface.

(2) Ends of slipper surface closed in.

(3) Ends of slipper surface opened out. Open slipper surface may be accepted for use providing a .003" feeler gauge cannot be inserted further than 2" from each end of slipper when mounted on a 7.692" arbor. (See item 6 following).

(4) Twist exceeding .0045" for length of eye sleeve bore.

(5) Bores exceeding maximum out-of-parallel limit of .003" for length of eye bore.

(6) Piston pin bearing sleeve worn in excess of 3.983" and/or scoring, excessive etching or damage to staking shoulder.

(7) Length between bore centers below the minimum allowable dimension 21.994".

b. Fork Rod

(1) Average of 60° measurements across fork and basket bore exceeding 7.626".

(2) Nicks, burrs and fretting on fork and basket serrations.

(3) Damaged threads in cap-screw holes, loose dowels.

(4) Damaged or distorted basket.

(5) Twist exceeding maximum limit of .0045" for length of eye sleeve bore.

(6) Bores exceeding maximum out-of-parallel limit of .003" for length of eye sleeve bore.

(7) Piston pin bearing sleeve worn in excess of 3.983" and/or scoring, excessive etching or damage to staking shoulder.

(8) Length between bore centers below the minimum allowable dimension of 21.994".

(9) Basket faces mutilated at the cap-screw holes.

(10) Fork counter-bore exceeding .400" maximum depth.

If any one or more of the following conditions exist, part should be scrapped.

a. Blade Rod

(1) Rejectable Magnaflux indications as outlined in Maintenance Instruction 2128.

(2) Heat discoloration on slipper surface.

(3) Below minimum flange thickness or slipper shoulder of .335".

(4) Damaged oversize bore after previous rework to oversize.

(5) Twist, out-of-parrallel or damage, beyond repair.

(6) Length between bore centers below 21.979".

b. Fork Rod

(1) Fatigue cracks through basket serrations and rejectable Magnaflux indication as given in Maintenence Instruction 2128.

(2) Heat discoloration in basket or fork.

(3) Damage to oversize bore after previous rework to oversize.

(4) Fork rod bent or damaged beyond repair.

(5) Length between bore centers below 21.979".

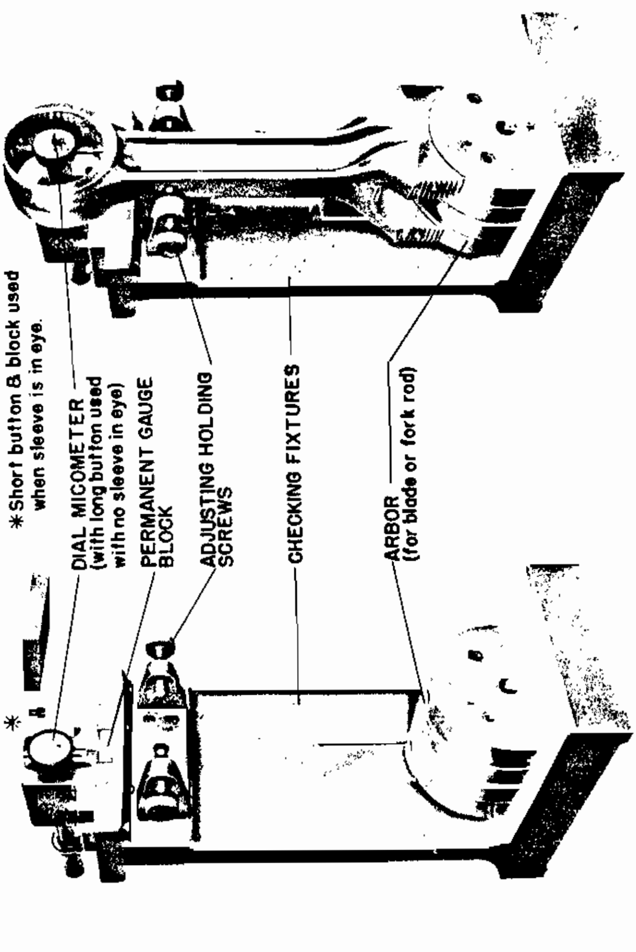
6. Checking Rod Length, Twist and Bore Parallel

When cylinder assemblies are removed, the connecting rods should be inspected for twist, length and piston pin bore parallel. A fixture shown in Fig. 3-4 for making these checks can be constructed according to blueprint M248 (Maintenance Section) or possibly purchased complete.

Two conditions of the rod are considered. A rod with sleeve and without rod eye sleeve. The fixture is permanently constructed to check standard rods without sleeves. Therefore, a gauge block as thick as a new sleeve (.260" thick) is required when checking rods having sleeves. The separate gauge block is placed on top of the permanent gauge block. In conjunction with the use of the separate gauge block a short indicator button is used, since the indicator travel is not sufficient to allow use of long button with the block.

Position indicator on fixture permanent gauge block or separate gauge block, and set indicator to zero. Place rod on fixture and place indicator button at bottom of bore. Adjusting holding screws, place rod to vertical position.

Check for slipper surface open ends by trying a .003" feeler at each toe end, between slipper surface



Checking Connecting Rods
Fig. 3-4

and arbor. Blade rods with opened end slipper surfaces may be used providing a .003" feeler gauge cannot be inserted further than 2" from each end of slipper when mounted on the 7.692" arbor. Close in of the slipper surface is evidenced by ends having no clearance and top of slipper surface open. Do not use rods having "closed in" slipper surface.

After positioning indicator and placing rod in vertical position, turn indicator 90° and run indicator along bore length noting deflection. Indicator deflection shows rod twist. Twist should not exceed .0045" for length of sleeve bore.

Place indicator at bottom of bore, note indicator reading. Check along length of bore for out-of-parallel. Bore should not exceed out-of-parallel limit of .003" for length of sleeve bore.

Replace indicator on tool gauge block and check setting, being sure dial is set to zero. Then insert indicator in eye bore from the edge, and note reading. Reading should not exceed .006" for re-use to give a rod bore centerline dimension not less than 21.994". If sleeve is in rod, compensation must be made for radial sleeve wear. A .021" indicator reading, showing a 21.979" bore center, scrap the rod.

NOTE: When checking oversize rod eye without sleeve, compensation must be made according to radial oversize and added to .006" (reuse) or .021" (scrap) limits.

7. Checking Piston Pin Bushings

Inspect piston pin and bushing for scoring or indications of overheating. A piston pin showing discoloration from overheating must not be used. The sleeve is press fit into rod eye, and is staked to hold the floating bushing retainers in position. The piston carrier bushing is also press fit in the carrier. See Fig. 3-1.

Piston pin and bushing clearances are listed under Specifications at the end of this section. If limits are exceeded, parts must be replaced. Floating bushings should be retired on condition as well as wear. Particular attention should be paid to groove condition, and any parts showing sharp edges due to wear or smearing of the silver should not be re-used. Corrosion does not impair bushing serviceability, unless there has been considerable loss in surface area.

8. Checking Connecting Rod Bearings

The connecting rod bearings should be checked for "out-of-round" whenever the piston and rod assembly is removed from the engine. To make this check, apply bearings to fork rod and basket in which they are to be used, tighten basket cap-screws to 175 foot-pounds torque, and measure across the bearing bore at points 60° apart. This is the same procedure as when checking fork connecting rod bore, Fig. 3-3. The average of these three readings must not be less than is necessary to insure a clearance between crankpin and bearings of at least .006", or a maximum of .015". A maximum out-of-round of .006" must not be exceeded. It is permissible to tap the basket with a soft mallet in order to maintain the out-of-round limit.

NOTE: After operation, rod bearings may give indication of being tight across the split line when loose on the crankpin. However, rod bearings intended for use should be mounted in the fork and rod basket and then checked.

Check upper bearing shell step thickness as indicated on Fig. 3-5. This will indicate blade rod bearing surface wear. Step thickness should not be less than .027"

Bearing shells showing indication of scoring must be replaced.

NOTE: After bearings are once used they should not be used on different crankpin or crankshaft, but should be re-installed on the same crankpin from which they were removed.

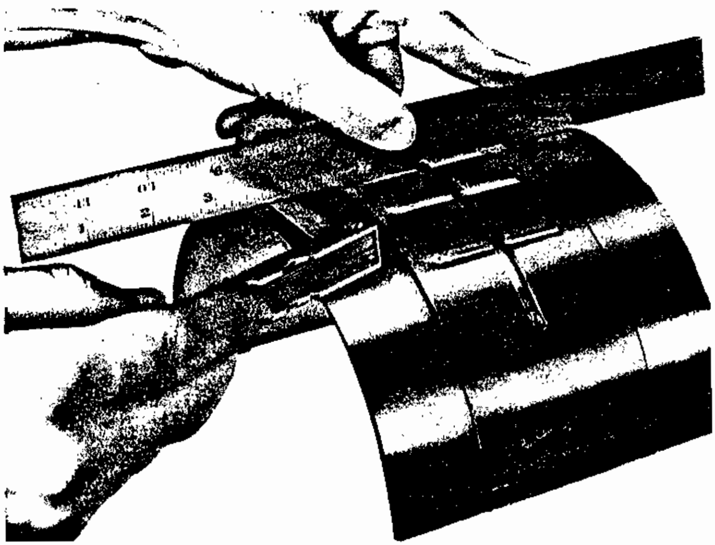
9. Removing and Installing Piston Rings

Use piston ring expander, 8042062, when removing or installing rings. See Fig. 3-6. This tool prevents twisting or over-expanding which distorts the ring.

New rings should be used at each installation of the piston, to insure quick seating, and avoid difficulties caused by damaged rings. Used rings, once disturbed, may not seat-in.

10. Inspecting Piston and Carrier

Limits are listed under Specifications at end of this section. See Fig. 3-11 for Piston and Ring Clearances.



Checking Upper Connecting Rod Bearing Shell
Fig. 3-5

a. Check the piston and carrier for cracks or damage.

b. Measure the piston diameter.

c. Measure thickness of thrust washer.

d. Check the carrier to the piston snap ring clearance.

e. Measure clearance rings to lands.

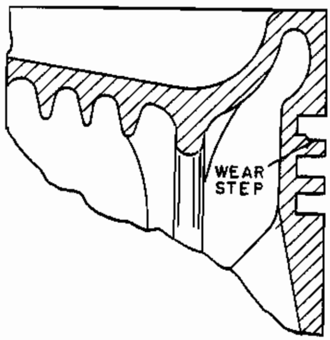
f. Check ring groove wear step.

Removing Piston Rings
Fig. 3-6

Check the wear step on the ring grooves lower face. See Fig. 3-7. The maximum wear step allowable is: #1 compression ring groove .006"; #2, and #3 compression and both oil ring grooves .005". Top ring breakage is usually the result of excessive step wear.

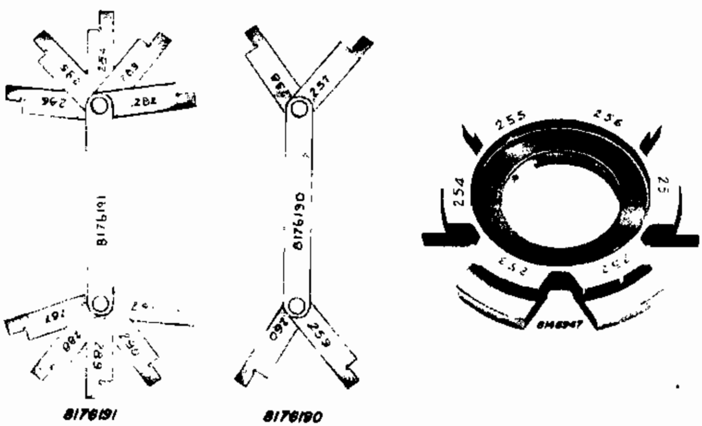
Wear step gauges 8146947, 8176190, and 8176191, Fig. 3-8, have been made to facilitate this measment. Each gauge consists of a number of separate width indicators precise to .001". Gauge 8146947 originally issued, is circular having six integral indicators from .251" through .256". Gauge 8176190 having individual indicators from .257" through .260", supplements gauge 8146947 to provide measurement since the wear step limit at time of issue of 8146947 has been increased. Gauge 8176191 is similar to 8176190 but has 1/32" oversize indicators for use on oversize ring grooves.

To measure the wear step, it is first necessary to determine the original ring groove width since it may vary originally from .251" to .254". By trial, insert gauge blocks in ring groove to determine which one enters its full depth. This will show the original width to be the dimension of that particular block. Then insert largest



NOTE: Reworked ring grooves should have 1/32" top and bottom radii and 45° x .015" chamfer on land edges.

Piston Ring Groove Wear Step
Fig. 3-7



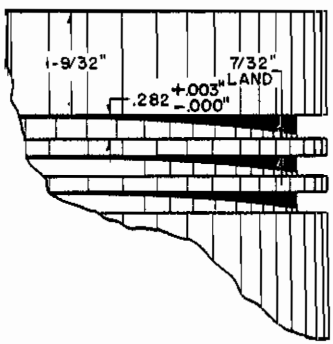
Wear Step Measure Gauges
Fig. 3-8

block that will enter groove up to the wear step. By subtracting the smaller block dimension from the larger one to enter, the wear step is determined. No piston should be placed back in service having a top ring groove wear step exceeding .006".

When step wear greater than .006" is found on the lower face of the TOP compression ring groove, the groove may be recut to remove the wear step, provided the finished groove width does not exceed .260" when finished for use with standard ring.

In the event that the ring groove is worn beyond a width of .260", it is possible to machine the top ring groove to accommodate a 1/32" oversize width ring, using the dimensions shown in Fig. 3-9.

When performing either of the above operations, care must be taken to keep the ring groove faces parallel to each other and at right angles to center line of piston. In addition, the surface finishes must be smooth to avoid excessive initial wear.



Ring Groove Oversize Dimension
Fig. 3-9

Piston and ring oversizes may be obtained. For details see parts catalog.

11. Assembling Piston and Rod

To assemble piston and rod, reverse procedure outlined under Subject 3. Oil all bearing surfaces during assembly.

When assembling rod and carrier, the tapered piston cooling oil hole in the carrier must be on the same side as the dowel hole in the serrations of the fork rod, and on the opposite side to the "long toe" of the blade rod. This will insure proper position of the hole when assembly is installed in the engine.

After the snap ring has been installed, check clearance between the bottom of the carrier and snap ring (dimension "A", Fig. 3-10). As a final test, revolve carrier inside of piston and oscillate rod in carrier to check for binding or obstruction.

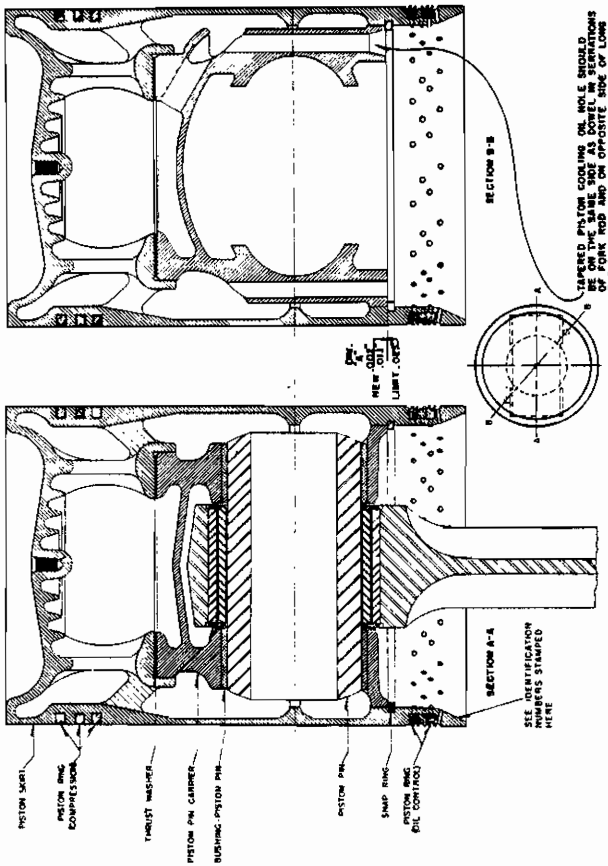
12. Installing Piston and Rod

NOTE: Cylinder liner should be serviced as in Section 4, before re-installing piston and rod.

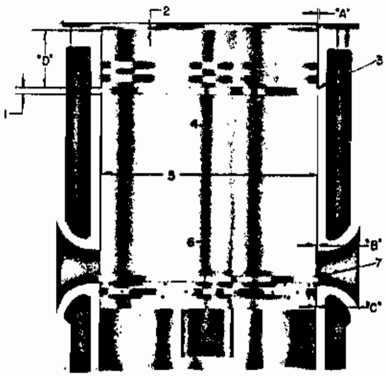
a. Set piston ring compressor and guide, 8034087, in place on cylinder liner and oil cylinder wall, ring compressor and piston. Rod and basket serrations must be thoroughly cleaned before assembly to insure proper seating of rod bearing.

b. Apply connecting rod boot then lower piston assembly into liner through ring compressor, using eye bolt. Be sure piston carrier is located so that the tapered hole is toward the outside of the engine.

c. Oil inside and outside of bearing shells and install upper bearing shell in position on crankpin.



Floating Piston Assembly
Fig. 3-10



1. Compression and oil ring groove width	New	.251" - .254"
Wear step on ring groove lower face not to exceed:		
#1 compression ring		.006"
#2, #3 compression and oil rings		.005"
Compression ring groove may be recut to Maximum #1 ring		
Standard		Max. .260"
1/32" Overwidth ring		Max. .282" + .003" - .000"
*2. Piston to head clearance	Minimum	.026"
	Maximum	.066"
3. Compression ring to land clearance	New	.004" - .008"
	Limit - #1 ring	.014"
	#2 and #3 ring	.010"
4. Compression ring gap (new ring in 8.500" liner)	New	Min. .025"
	Condemn ring when worn to bottom of Ferrox groove at any point.	
5. Piston diameter	New	8.488" - 8.490"
	Limit (interchangeable)	8.485"
	(.005" out-of-round) permissible)	
6. Oil ring gap (new ring in 8.500" liner)	New	.015" - .025"
	Limit	.070"
7. Oil ring to land clearance	New	.002" - .006"
	Limit	.010"
Piston to liner clearance of "A"	New	.0485" - .0525"
Piston to liner clearance of "B" and "C"	New	.0095" - .0135"
Piston taper "D"	Limit	.020"

*NOTE: An increase in compression clearance of .025" from the assembly value at the time of installation condemns the assembly. Any sudden increase should be immediately investigated.

Piston And Ring Clearance
Fig. 3-11

Lower blade rod to rest on upper bearing, then install fork rod. Be certain that dowels in fork rod enter dowel holes in shell without binding.

d. Open basket wide enough to clear crankpin and bottom of fork rod and insert lower bearing shell in basket, being certain that dowels in basket enter dowel hole in shell without binding.

e. Lift basket in place and see that dowels in basket enter dowel holes in fork rod.

f. Start cap-screws in doweled side of basket, pull up snug and back out one turn. Then swing opposite side of basket into position and apply cap-screws.

g. Tighten all cap-screws and install lock wire. If a torque wrench is used, tighten to 190 to 200 foot-pounds. If cap-screws are not properly tightened, the basket will work on the serrations, and a broken basket or broken cap-screw will result, with possible damage to engine.

NOTE: Retighten all cap-screws at assigned maintenance point according to mileage in Scheduled Maintenance Program.

h. Install cylinder head as in Section 2.

i. Install piston cooling oil pipe and check alignment as follows:

Use piston cooling oil pipe gauge, 8071720, shown on Fig. 3-12. Insert small end of gauge in nozzle of piston cooling oil pipe. Rotate crankshaft over slowly to bring piston to its lowest position, at the same time, rotate the gauge by hand to make certain that it does not bind in tapered hole. Gauge must enter hole above the tapered opening. If gauge indicates misalignment, replace pipe assembly. Do not use gauge to align pipe. Piston cooling "Pee" pipe should be checked before application by using "Pee" pipe cleaning tool 8087086.

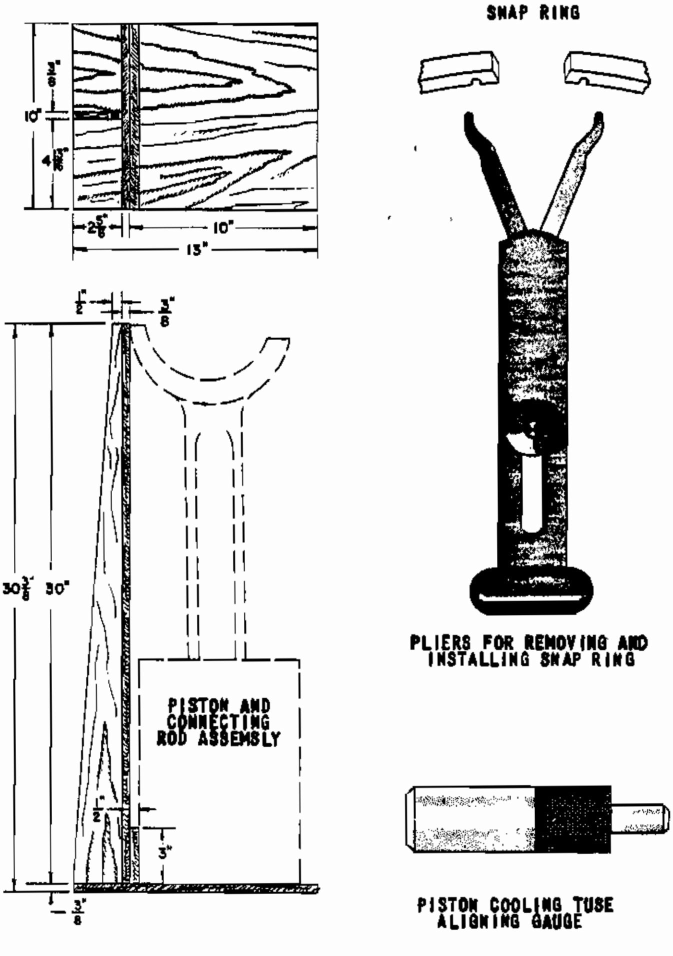
13. Piston to Cylinder Head Clearance

The piston to cylinder head clearance governs to a great extent the efficiency of the engine and should be maintained within specified limits for best operation. In addition, if regular inspections are made, piston to head clearance may be used as an indication of wear in the parts of the piston and connecting rod assembly. Recorded or charted clearance readings will aid in the prevention of serious trouble from excessive wear of parts, as their condition will be indicated by comparing the successive piston to head clearances. This procedure is doubly beneficial since it also indicates the required intervals of piston assembly removal and thereby eliminates mileage or set periodic removal of these parts which is considered undesirable.

Engine records supplied the railroad on new locomotive deliveries include the original readings of piston to cylinder head clearance of each cylinder of the engine. By recording the original and each successive reading in its proper place on a chart, a definite condition of the parts will be shown. Readings of the piston to head clearance may also be started on re-installed piston and rod assemblies by taking the clearance of the newly installed assembly. Also, with engines in the field delivered before the piston to head clearance was included in the engine record sheet, the average lead reading may be used. These readings, which are the average of most engines, are .040" to .055".

It is recommended that compression lead readings be taken on all cylinders at intervals specified in the Scheduled Maintenance Program. More frequent inspection should be made on assemblies which show excessive or dangerous rates of increase in the clearance.

The following method is recommended to obtain the piston to head clearance. Rotate the crankshaft to



Tools For Servicing Floating Piston
Fig. 3-12

place the piston to be checked at bottom dead center. Place a 1/8" soft lead or solder wire shaped to the contour of the piston crown, with the ends of the wire not over 8-1/4" apart on top of the piston, through the liner ports. Position the lead wire directly above the piston pin parallel to the engine crankshaft. The engine is then barred over one revolution and the wire removed and both ends measured with micrometer. The clearance reading will be the average of the two measurements taken. If the difference is excessive between the two ends of the wire, the clearance should be rechecked as the wire may have rotated on the piston to be at right angles to the piston pin.

The time necessary for taking the readings on an engine may be lessened considerably by forming enough lead wire needed, to the proper contour of the piston by using a spare piston. Also, observing the location of the various pistons as the crankshaft is rotated will enable all readings to be taken in two revolutions of crankshaft.

The limits of piston to head clearance on a new engine are .026" minimum and .068" maximum; with the readings on the average engine about .040" to .055". The condemning limit of piston to head clearance is .025" over the original assembly piston to head clearance. This limit also applies to cylinder assemblies applied in the field and leaded as outlined. When a gain of .025" is reached the parts of the assembly should be removed and checked, replacing the worn parts. The condemning limits of the various individual parts of the assembly govern their respective replacement. These limits may be found under Specifications of this Section.

In conjunction with the piston to head clearance, the snap ring clearance should also be checked. If it is found that the piston to head clearance is within the .025" limit but the snap ring clearance is at, or sufficiently near, the condemning limit, the piston assembly should be removed and the piston thrust washer checked.

C. SPECIFICATIONS

Connecting Rod:

Fork rod and basket bore	New - 7.624" - 7.625" Max. - See Text
Bearing seat diameter blade rod	7.692" - 7.693"
Clearance between shoulder on blade rod and counterbore in fork rod	New .008" - .012" Max. - .025"

(This is measured by placing a feeler gauge between the blade rod and the outside of the bearing.)

Depth of counterbore from bearing bore to counterbore	New .385" - .3865" Limit .400" provided the above .025" max. clearance is held.
Thickness of shoulder on blade rod	New .3445" - .346" Limit .335" provided .025" max. clearance is held.

Connecting Rod Bearings:

Bearing inside diameter (Average of three 60° measurements)	New 6.5066" - 6.510"
Bearing shell thickness	New .5587" - .5595"
Minimum wall thickness	Standard - .553" 1/32" U.S. - .5686" 1/16" U.S. - .5843" 3/32" U.S. - .5999" 1/8" U.S. - .6155"
Bearing shell step height	New .030" - .031" Limit .027"

Bearing to crankpin clearance	Min. .007" - .011" Limit .015"

Piston:

Number of compression rings	3
Number of oil control rings	2
Piston and ring wear	See Fig. 3-11
Clearance - - top (piston to carrier)	New .003" - .007" Limit .010"
Clearance - - bottom (piston to carrier)	New .002" - .007" Limit .012"
Thrust washer thickness	New .060" - .063" Limit .055" Max. variation in thickness .003"
Clearance - snap ring to piston carrier	New .002" - .013" Limit .025"

To detect uneven wear of carrier bushings, there should not be more than .003" difference in measurement from the top of bushing bore to the piston platform surface.

Carrier bushing I.D. (not to exceed)	Max. 3.486"
Center line of bushing bore to platform face (not less than)	Min. 3.551"

For interchangeable assembly the following limits should be observed:

Piston skirt (.005" out-of-round permissible)	Min. Dia. 8.485"
Carrier - top pilot	Min. Dia. 5.992"
Carrier - bottom pilot	Min. Dia. 7.481"
Piston platform shoulder	Max. Dia. 6.004"
Piston skirt pilot	Max. Dia. 7.493"

For interchangeable assembly, the following limits should be observed when new thrust washers are used:

Carrier height	Min. 5.993"
Piston platform to snap ring groove	Max. 6.258"

NOTE: Parts over the interchangeable limits may be re-used by selective assembly observing the limiting clearance.

Piston Pin:

Pin to floating bushing clearance	New .005" - .007" Limit (with new pin) .010"

NOTE: Piston pins may be used, if in good condition to a minimum diameter of 3.475". With pins of this diameter (3.475") the maximum clearance (pin to floating bushing) is increased to .015".

Pin to carrier bushing clearance	New .003" - .005" Limit .010"
Out-of-round and taper of piston pin (check pins at six positions along length and repeat at 90°)	Max. .002"

Piston Pin Floating Bushings:

Sleeve to floating bushing clearance	New .005" - .007" Limit .010" (with new sleeve)

NOTE: Connecting rod eye sleeves may be re-used until the vertical dimension (bore dimension) of the sleeve exceeds the horizontal (bore dimension) by .005". The difference between the vertical and horizontal dimension may be added to the .010" maximum clearance up to a maximum of .015" total clearance.

D. EQUIPMENT LIST

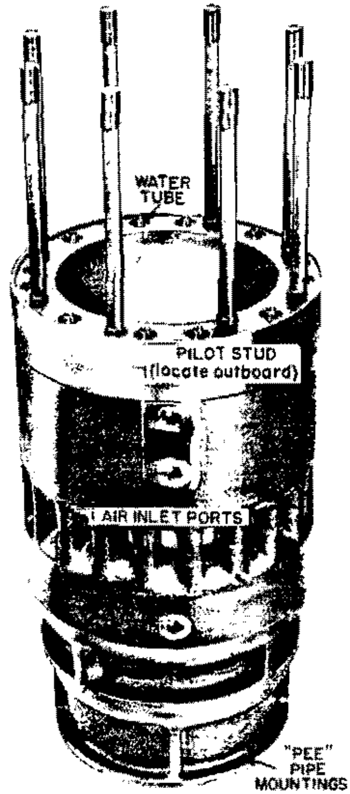
NAME	PART NO.
Piston pulling eye bolt	8040413
Fork rod boot	8062034
Fork rod holding tool	8052958
Blade rod boot	8062033
Drawing (piston assembly stand)	8071694
Snap ring pliers	8171633
Motor driven flexible shaft buffer 110 V.	8084282
Motor driven flexible shaft buffer 220 V.	8084283
Piston ring expander	8042062
Piston ring guide	8034087
Piston cooling "Pee" pipe alignment gauge	8071720
Piston "Pee" pipe cleaning tool	8087086
Connecting Rod checking fixture (Print)	M248
Piston wear step gauge (original .251" - .256")	8146947
Piston wear step gauge (8146947 Supl. .257" - .256")	8176190
Piston wear step gauge (for 1/32" oversize rings)	8176191

SECTION IV

CYLINDER LINERS

A. DESCRIPTION

The cylinder liner, Fig. 1, is made of cast iron with an integral water jacket formed by a cored annular space between the inner and the outer walls. The liner is secured to the cylinder head by eight studs and nuts and the assembly is held in place in the engine by the cylinder head crabs. A "pilot" stud locates the cylinder liner in proper angular relation to the cylinder head, and insures alignment with the piston cooling pipe assembly.



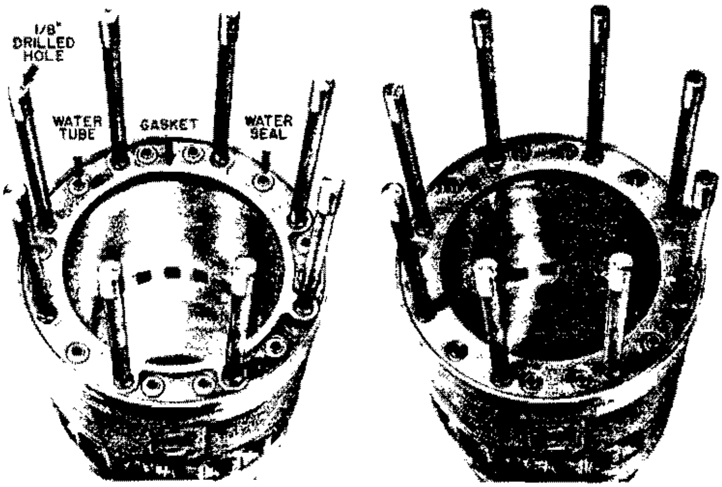
Cylinder Liner
Design No. 3
Fig. 4-1

The scavenging air inlet ports are located in the wall of the liner just above the top of the piston when it is at bottom center. The liner water jacket is open at the bottom to admit cooling water from the cooling water inlet manifold. Upper and lower seal rings are used between the liner and water manifold plates. The water flows through the liner water jacket and enters the cylinder head water passages. See Fig. 4-6 for cross-section view of cylinder liner.

IV

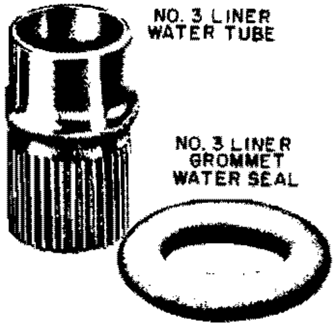
Three liner designs are currently used in the field, liner #1, #2 and #3. Two cylinder head designs are used (see section 2) designated cylinder head #1 and #2. Cylinder head #1 has been replaced by #2. All liners and cylinder heads cannot be used together. Cylinder head #2 can be used with all liners, but cylinder head #1 can be used only with liners #1 and #2.

Liner #3 Fig. 4-2 is used on all production engines and can be identified by its 12 drilled and counterbored water discharge holes in the head to liner gasket surface. The water tubes and grommet seals, Fig. 4-3, are used in this liner. A 1/8" hole is drilled in the top, of all #3 liner studs. Since February 1951 liner studs and May 1951 pilot studs of #3 liner are straight shank of less strong material than necked down studs used in liner #1 and #2. Straight shank studs must only be used in the #3 liner. Also, #3 liner is 1/16" longer than liner #1 or #2 since it uses the thin copper coated, steel shim, head to liner gasket #8194009.



Liner Design No. 3
Fig. 4-2

Liner #2, Fig. 4-4A, is identical to liner #1 except for the 12 drilled water discharge holes same as liner #3 but without counterbore. Necked down liner studs as used on liner #1 are used on liner #2 provide strength for the additional torque used on these liners. Liner #2 replaces liner #1.



Water Tube
And Grommet
Fig. 4-3

Liner #1, Fig. 4-4B, is similar to liner #2 except as noted in the water discharge holes, which are cored in the #1 liner.

Gaskets used with the liner designs are shown in Fig. 4-5. The copper coated steel shim type must only be used with liner #3; the conventional sandwich type copper asbestos steel gasket is used on liners #1 and #2.

Liner seal rings on all production engines are silicone rubber, upper seal #8173669, lower #8142104. Synthetic rubber liner seals used prior to the silicone are available as replacement, if desired.

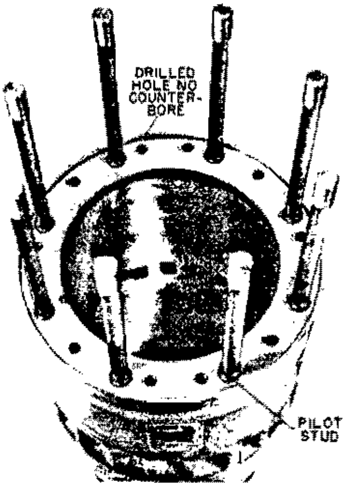
B. MAINTENANCE

1. Inspection

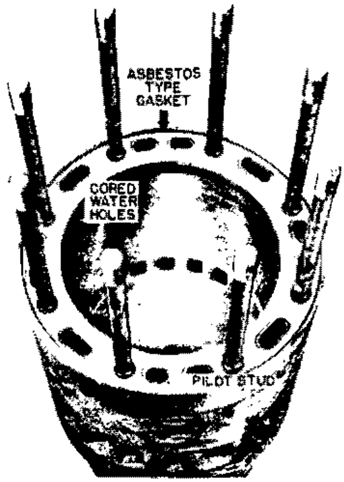
Cylinder liners are inspected (with engine dead) by removing air box and oil pan hand hole covers. Inspect for damage, cracks or water leaks at seals. Also check for scored liner walls through inlet ports or from oil pan.

2. Removing Cylinder Liner

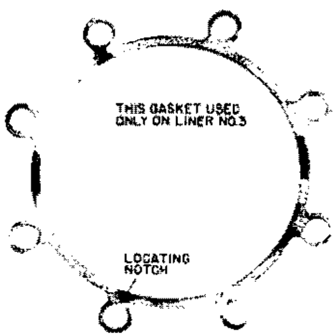
Removal of cylinder head or complete cylinder



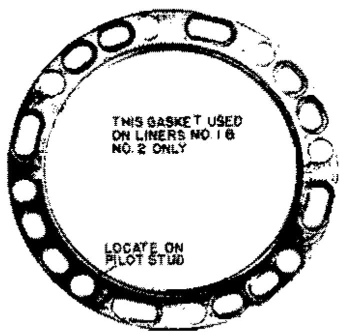
Liner Design No. 2
Fig. 4-4a



Liner Design No. 1
Fig. 4-4b



Thin Shim Type



Conventional Type

Fig. 4-5

assembly removal is covered in Section II and piston and rod assembly in Section III. After head, piston and rod have been removed, apply cylinder liner lifter #8116358 to liner studs and remove the liner. Use care when handling the liners to avoid damaging the studs. A hard side blow on the studs will damage the threads or crack the liner.

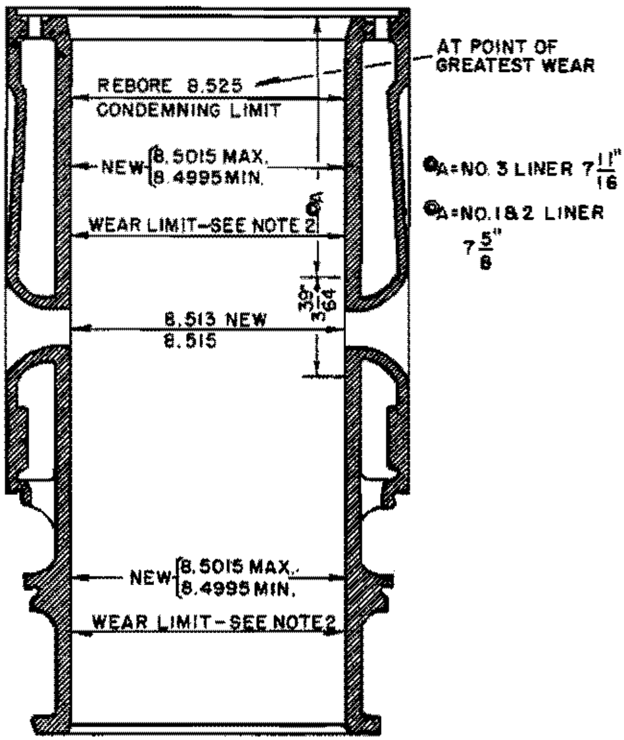
3. Cleaning Cylinder Liners

Complete cylinder liner cleaning information is contained in Maintenance Instruction 1706. After liners are cleaned, proceed with the following service operations.

4. Measuring Cylinder Liners for Wear

Before cylinder liners are measured for wear, the bore should be checked for scoring or other defects. The bore should be free from all lint, grease or oil. Micrometers should be checked for initial error and micrometer buttons should be checked to be sure they are tight. See Figs. 4-6 and 4-7. Liner bore gauge #8187645 has been designed to accurately determine liner bore measurement. When the three pronged end of the tool is placed in the liner bore, measurement is instantly read on a dial indicator at the top of an upright extending above the liner bore. Master setting gauge ring #8187647 - 8.500" is used with this tool; and oversize liner gauge rings may be obtained.

New cylinder liners are finished to a diameter of 8.4995" - 8.5015" except through the port relief zone, Fig. 4-6. Accumulated cylinder liner and piston wear will increase the clearance between cylinder liner and piston. It must be remembered at all times when checking cylinder liner wear

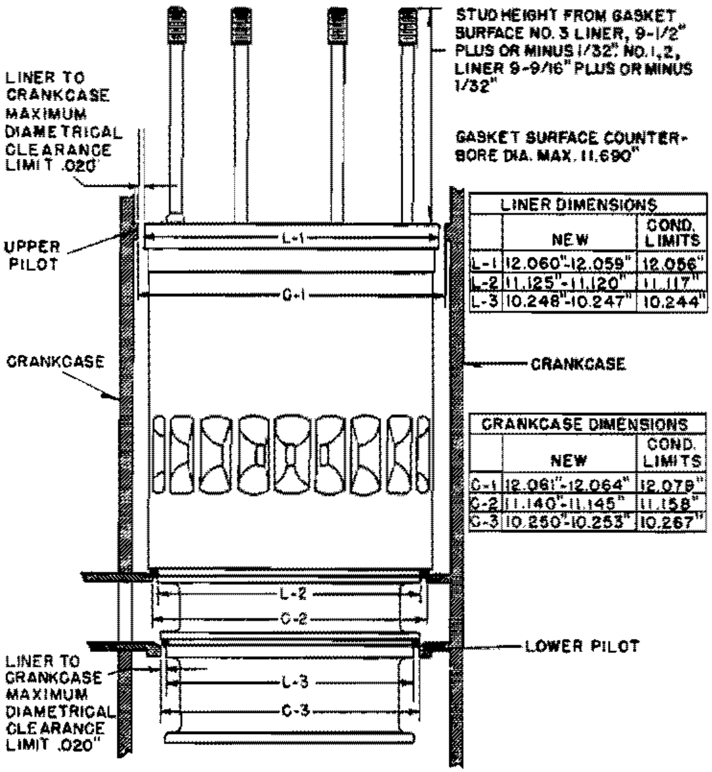


NOTES:

1. Piston to liner clearance — New .0095" - .0135"; Limit .020"

2. For <u>service applications,</u> used pistons and liners should be matched within maximum clearance of .020" (from bottom to 6" from top of liner, except at ports). For example, with a liner worn to 8.510" diameter a high limit piston of 8.490" diameter must be used. With a piston worn to 8.485" diameter, the liner diameter must not exceed 8.505".

Wear Limits Of Cylinder Liner
Fig. 4-6



LINER DIMENSIONS		
	NEW	COND. LIMITS
L-1	12.060"-12.059"	12.056"
L-2	11.125"-11.120"	11.117"
L-3	10.248"-10.247"	10.244"

CRANKCASE DIMENSIONS		
	NEW	COND. LIMITS
C-1	12.061"-12.064"	12.079"
C-2	11.140"-11.145"	11.158"
C-3	10.250"-10.253"	10.267"

Condemning diametrical limits as listed pertain to crankcase bore and liner diameters as separate dimensional limits. The maximum diametrical clearance at upper and lower pilot bores on any crankcase to liner should not exceed the following limits. Upper pilot bore, liner to crankcase not to exceed .020" diametrical clearance. Lower pilot bore liner to crankcase not to exceed .020" diametrical clearance.

Crankcase To Liner Dimensions And Condemning Limits
Fig. 4-7

that the specified wear limits are given only as a means of determining whether the liner has worn to a point where it can no longer be matched with a new or worn piston to give a piston to liner clearance not to exceed .020" at the time of a service installation.

Cylinder liners will wear tapered, with maximum wear normally occuring at the top limit of piston ring travel. Maximum wear should be checked at the point of greatest wear, taking two readings 90° apart. The wear limit is 8.525" at this point. A liner worn to this dimension leaves only .005" stock to allow for cleaning up the bore when it is rebored to 1/32" oversize. If this limit is exceeded it may not be possible to rebore the liner to 1/32" oversize and it would then have to be rebored to 1/16" oversize, thus losing an appreciable amount of its wear life. Therefore, it is suggested no liner be re-installed if the maximum bore diameter exceeds 8.520".

The liner should also be checked at the two points 6" and 16" below the top, taking two readings 90° apart, to determine liner wear and "out-of-round" condition. Should the "out-of-round" be .005" or more, the liner must be rebored to the next oversize, regardless of other wear measurements which may still be within limits.

Using the maximum piston to liner clearance of .020" at the time of a service installation as a guide, liners which have worn to a dimension of 8.510" at a point 6" from the top of the liner may again be used, providing they have not worn to limit of .005" out-of-round and that they are matched with a NEW piston of top limit diameter of 8.490", which would assure the maximum .020" piston to liner clearance would not be exceeded. If a piston worn to the minimum diameter of 8.485" were to be used, the diameter of the liner must not exceed 8.505" which would assure the maximum .020" piston to liner clearance would not be exceeded.

Cylinder liners for interchangeable service assembly should not exceed 8.505" diameter, when measured six inches below the top of liner, except at the liner ports. Pistons as small as 8.480" may be selectively assembled to new liners by observing the .020" maximum clearance.

5. Marking Used Liners and Pistons In Stock

It is suggested that used pistons and liners, which are not going back into an engine immediately, but are to be placed in stock, be thoroughly cleaned, inspected and checked for size. The dimensions as checked should be marked on the outside of the liners and on the crown of the pistons which will allow liner and piston combinations to be selected with a minimum of delay.

6. Oversize Liners

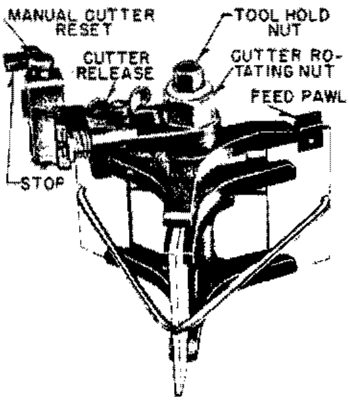
Liners can be rebored in either 1/32" or 1/16" oversize. The dimensions of oversize liners are the same as shown on Fig. 4-6 except that the figures showing diameter are increased by 1/32" or 1/16" as the case may be. Standard or 1/32" oversize liners worn beyond the limits can be returned to Electro-Motive for refinishing to the next oversize.

7. Removing Cylinder Liner Ridge

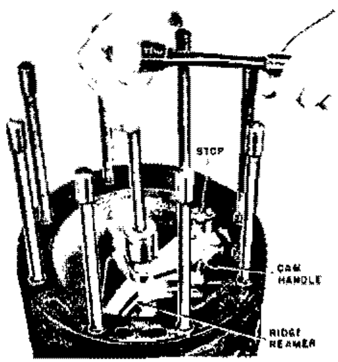
The ridge will appear at the top of ring travel on the liner wall caused by wear of the piston rings.

After the liner has been removed from the engine, this ridge is removed by using cylinder liner ridge reamer #8157279, Fig. 4-8.

There are two models of liner ridge reamers. The reamer used prior to December 20, 1949, Fig. 4-9, #8035738 has been improved by a new cutter head having a vertical automatic feed. The improved cutter head is shown in Fig. 4-10 and new reamer in place in the liner, Fig. 4-11. In place of the cam handle cutter blade release on the old reamer, an eccentric operated by a wing nut is employed on the improved reamer. Also, the automatic feed shown at the bottom of the cutter on the new reamer contacts the pawl on the liner tool support each revolution of the cutter, causing the cutter to be raised slightly each revolution. Other features are common to both of the liner ridge reamers. Before using the liner ridge reamer oil the liner wall just under the ridge. Then proceed as follows:



Improved Ridge Reamer
Fig. 4-8

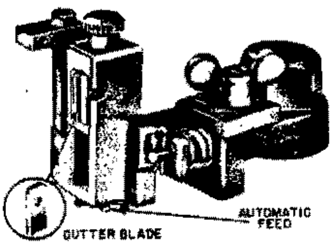


Old Reamer
In Liner
Fig. 4-9

a. Turn wing nut or cam handle, depending on the reamer used, so cutter blade is drawn away from liner. On new improved reamer, position cutting blade at bottom of guide by turning knurled nut on top of cutter.

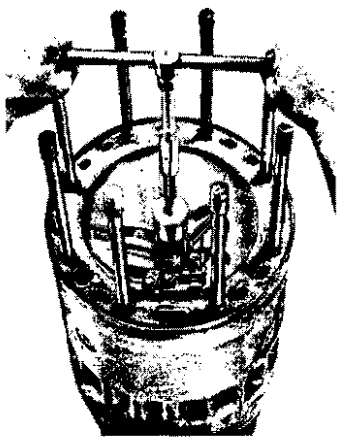
b. Swing out stop on cutter and lower reamer into liner until stop rests on top of liner.

c. Tighten center chuck nut. Rotate the cutting head and check clearance between stop and top of liner. If reamer is not centered, loosen chuck nut and rechuck until reamer is properly located.



Improved Reamer Arm
Fig. 4-10

d. Swing stop nut out of the way and turn wing nut or cam handle to release position, permitting the cutter blade to move outward against ridge on liner wall.



Application Of Ridge Reamer
Fig. 4-11

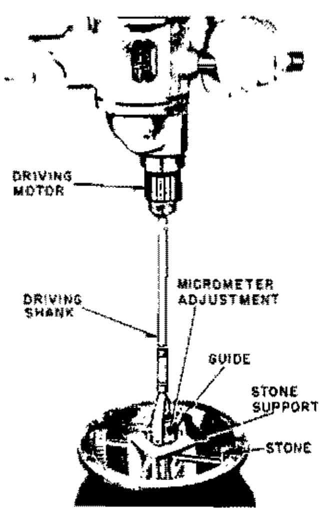
e. Turn the reamer with socket and wrench. It is recommended that a solid bar "T" handle and extension be used for turning the cutter to eliminate upward or downward pressure while turning. Turning should be steady, therefore reversal or turning backward should be avoided so as to protect the cutting blade edge. Continue turning until cutter is at uppermost travel and no more metal is removed. Or reset, if necessary, the old model reamer for additional cuts.

f. After reaming is finished, release cutting blade by turning wing nut or cam handle, loosen fixture and remove from liner.

NOTE: Old reamers 8035738 may be converted to new reamer by adding the cutter arm 8157326 and the trip pawl 8159305. Also, a new ridge grinder 8190134 is available, which is electric operated, having blending wheel and adjustable diameter fitting.

8. Honing Cylinder Liners

After ridge reaming, the cylinder liners should be honed. The purpose of honing cylinder liners is to remove the glaze on the liner wall in order that new piston rings will seat quickly. When honing liners, remove glaze only. Do not attempt to remove scoring or deep scratches. If the liner is scored, it should be returned to Electro-Motive for reboring oversize.



Honing Cylinder Liner
Fig. 4-12

Equipment for honing consists of the following: hone kit less the motor #8039177; 1/2" electric drill with 300 to 500 RPM motor #8104770-110 volt, #8104771-220 volt. Copies of drawing #8062024 showing fixtures for holding the liner and drill motor will be sent on request.

To hone cylinder liner proceed as follows:

Chuck driving shank in drill motor as shown in Fig. 4-12. Place stone support on hone body. Note that one end is marked "top". Mount the stones and guides in the hone. This is done by removing the center splined shaft and inserting the stone and guides in the holes marked "X". The two stones are applied on opposite sides. Place the stones and guides completely into the holder and insert the splined center shaft. Keep this shaft out 1/4" to prevent the adjustment gears at the top from meshing, and lower the hone into the cylinder. Turn the adjustment to expand the hone to fit the cylinder. Push splined shaft all the way in and turn the micrometer adjustment for a snug fit.

Keep stones and liner walls flooded with kerosene. While honing, raise and lower the hone in the liner so that stones pass completely from top to bottom. Do not let hone extend outside liner as this may cause binding. Keep the hone moving and snug in liner to prevent chattering.

Use finishing stones only to produce an even, dull gray finish. Do not remove any more metal than is necessary to obtain the desired finish. In no case should liner be brought to a polished or mirror finish.

The driving shank is made with a weak section so that if the hone is improperly used, causing it to bind, the shank will break, preventing damage to the stone assembly.

9. Installing Cylinder Liners

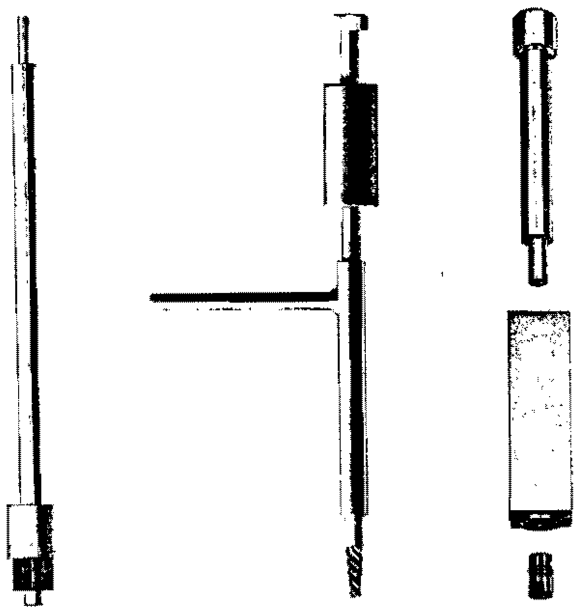
Before installing liner, be sure that all gasket and seal surfaces (both on the liner and crankcase) are clean. Check water tubes of design No. 3 liners for damage or looseness, replace if necessary, and be sure counterbore for water tube seals are clean.

Special tools are available to improve and facilitate maintenance of the #3 liner as shown in

Fig. 4-13. Also, a crankcase liner seal seat cleaning tool, Fig. 4-14 is available. The liner seal seats must be clean, free from nicks, rust, sharp edges and corrosion.

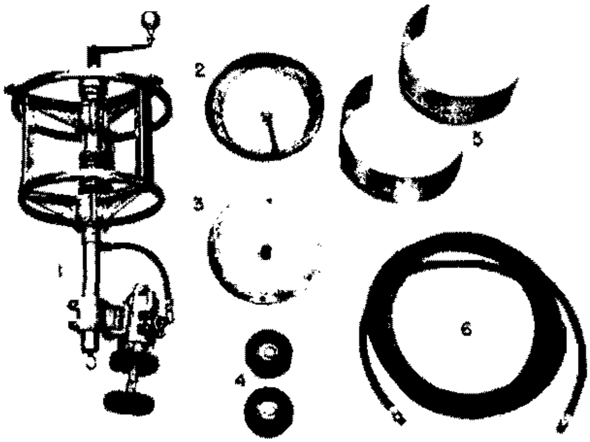
Apply new liner seals. Two liner seal applying guides, #8164914 lower, Fig. 4-15, and upper #8176923 similiar to that shown provide for easy and proper application of the liner seals.

Using liner lifter, lower liner into crankcase. When installing, line up liner with "Pee" pipe mounting holes to the right facing the liner, and the core plugs central with the hole in the stress plate, so the liner will not have to be moved any



Cleaning Tool — Water Tube Removing Tool — Water Tube Installing Tool

Fig. 4-13



1. Liner Seat Cleaner
2. Crankcase Dust Guard
3. Air Box Hole Dust Guard
4. Cleaning Brushes
5. Adjacent Liner Dust Guard
6. Air Hose

Cylinder Liner Seat Cleaning Tool Kit
Fig. 4-14

great amount with its weight resting on the seals. The indexing plate on the head will locate the liner when cylinder head is installed. Be sure liner pilot stud is in proper location above piston cooling line mounting holes at bottom of liner.

Lower Liner Seal Guide
Fig. 4-15

After liner is in position, install proper gasket for design liner installed (shim type on liner No. 3 and conventional sandwich type on liner No. 1 and No. 2). Install piston and rod assembly and proper cylinder head as outlined in Section II and III.

10. Engine Break-In

The finish and clearance of liners, pistons, bearings, and other parts of the engine are such that it is not necessary to subject the engine to a long "break-in" period.

See Section 2, item K of maintenance item 7 for cylinder assembly load test after installation. For engine pre-lubrication before service see Section 8.

C. SPECIFICATIONS

Cylinder Liners

Cylinder liner wear limits	See Fig. 4-6
Crankcase to liner limits	See Fig. 4-7
Liner stud application torque	50 ft. lbs. Min.
Bore	8-1/2"
Weight of liner with studs (approx.)	128 lbs.

D. EQUIPMENT LIST

Name	Part No.
Cylinder Liner Lifter	8116358
Cylinder Liner Ridge Reamer (New)	8157279
Cylinder Liner Ridge Reamer (Old)	8035738
Cylinder Liner Ridge Reamer Cutting Blade (New)	8157327
Cylinder Liner Ridge Reamer Cutting Blade (Old)	8069845
Ridge Reamer Cutting Arm (New)	8157326
Trip Rail For Cutting Feed (New)	8159305
Ridge Grinder (Electric)	8190134
Hone Kit (Less Motor)	8039177
1/2" Drill, 300 to 500 RPM, 110 Volt	8104770
1/2" Drill, 300 to 500 RPM, 220 Volt	8104771
Honing Tools Application Drawing	8062024

D. EQUIPMENT LIST (Cont'd)

Vastoline (Water Soluble Lubricant-1 Gal.)	8149962
#3 Liner Counter-Bore Cleaning Tool	8190175
#3 Liner Water Tube Removing Tool	8165803
#3 Liner Water Tube Applying Tool	8165802
Lower Liner Seal Guide	8164914
Upper Liner Seal Guide	8176923
Crankcase Liner Seal Seat Cleaning Tool	8165957
Liner Bore Gauge	8187645
Master Ring 8.500" (used with 8187645)	8187647

NOTES

SECTION V

CRANKSHAFT, MAIN BEARINGS, HARMONIC BALANCER, ACCESSORY DRIVE GEAR, CRANKSHAFT GEAR

A. DESCRIPTION

1. Crankshaft

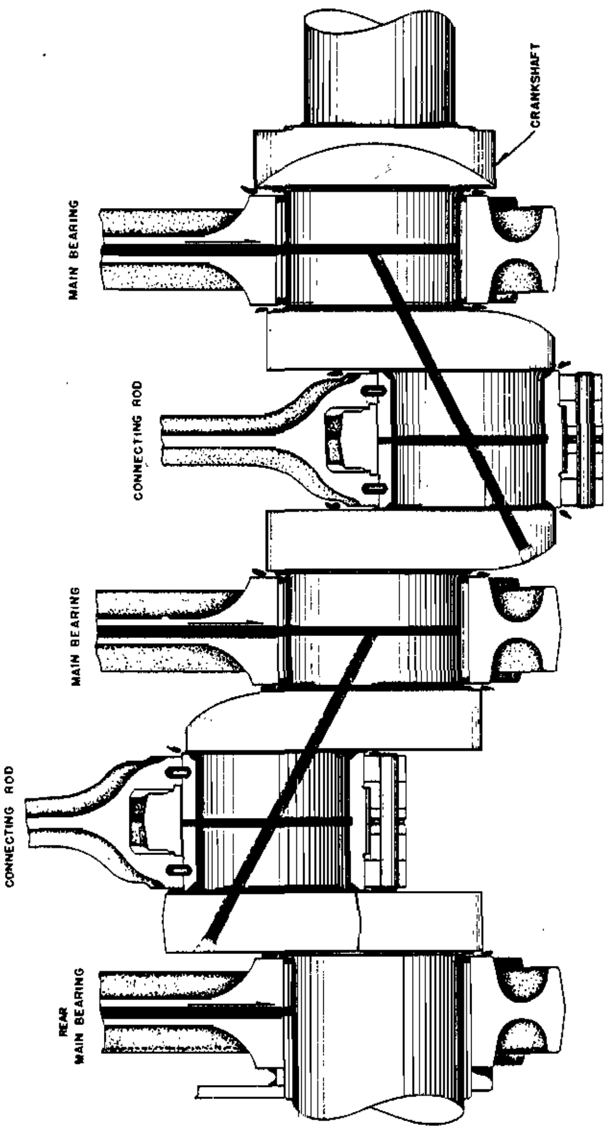
The crankshaft is drop forged carbon steel with induction-hardened main and crankpin journals. Drilled passages in the crankshaft provide means of carrying lubricating oil to the main and connecting rod bearings, Fig. 5-1.

V

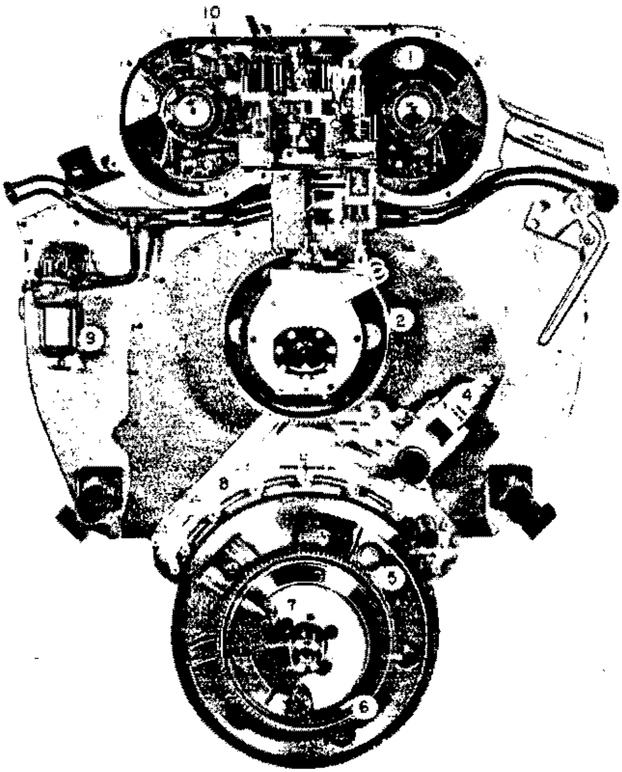
The 16-567B crankshaft is in two sections, and has two center main bearings. Either section can be replaced if damaged. Crankshaft must be returned for this service. All other 567B engines have one piece crankshafts.

2. Flywheel—Flexible Coupling

The main generator armature, is in effect the flywheel for the engine and is attached to the crankshaft by means of a flexible coupling, Fig. 5-2. There are two types of flexible couplings used on 567 series engines. The two piece (of which there are two designs) and a three piece coupling. All flexible couplings consist of two steel discs one of which is bolted at the center to the crankshaft flange, the other or generator disc is bolted at its center to the generator armature shaft flange. In addition, each coupling has a disc support or rim having degree markings around its circumference and holes provided for an engine jack or turning bar for rotating the crankshaft. The disc support or rim is an integral part of the engine disc of the two piece coupling; it is a separate part of the three piece coupling.

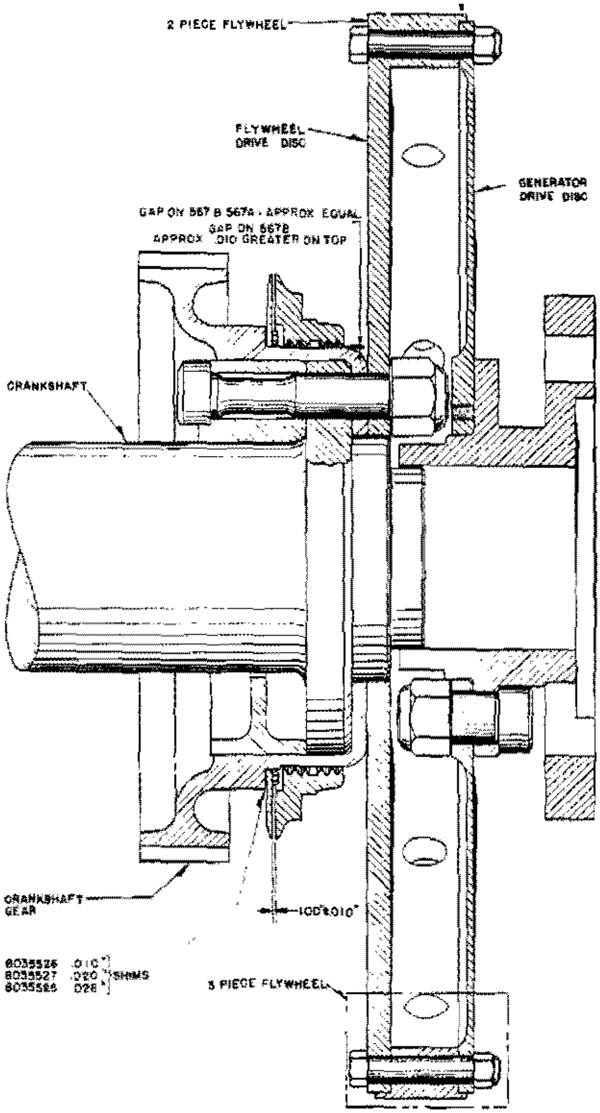


Crankshaft Oil Passages
Fig. 5-1



1. Camshaft Counterweight
2. Governor Drive Gear
3. Lube Oil Manifold
4. Lube Oil Relief Valve
5. Harmonic Balancer
6. Accessory Drive Gear
7. Oil Slinger
8. Piston Cooling Manifold
9. Fuel Filter Element
10. Overspeed Trip

Accessory End Cutaway



Crankshaft Rear End Details And Generator Coupling
Fig. 5-2

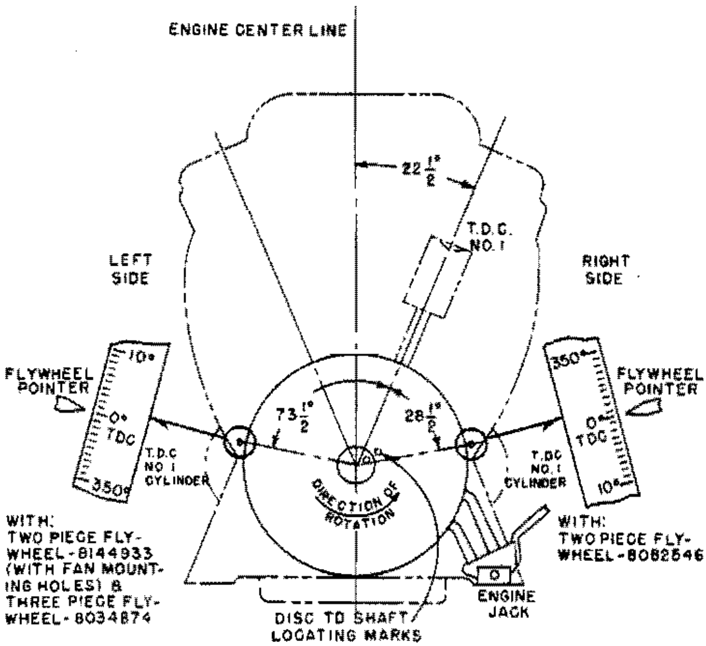
The coupling discs are joined at their outer circumference by twelve bolts passing through the discs and disc support. Eleven 3/4" - 16 bolts and one 3/4" - 16 x .8740" diameter bolt are used. The .8740" bolt is common to all couplings, but there is a difference between the smaller bolts used in the two and three piece couplings. The two piece coupling provides a loose bolt fit, whereas the three piece coupling bolts have a snug fit. A special tool #8068028 is used to remove the three piece coupling rim bolts. Line up of the "0" mark on the crankshaft flange and engine disc assures proper location of the engine disc. The oversize hole for the large diameter bolt assures proper relative position of disc support on installation.

Three piece coupling #8034874 has been used in the past on all 567 and 567A engines, while the two piece coupling #8082546 is used with "B" engines. Some "B" engines are equipped with the three piece coupling, particularly on NW-5 switcher locomotives. A two piece coupling #8144933 is also available for all 567 and 567A series railroad engines equipped with 1-3/4" coupling bolts and is used in conjunction with a new generator end disc #8144728. This new two piece coupling combination may be identified by the generator fan mounting holes compared with the other two piece coupling without holes #8082546 as well as by its part number.

The 567B engines are generally equipped with two piece coupling #8082546 which necessitates having the degree timing marker on the right side of the engine, see Fig. 5-3.

On 567, 567A or 567B engines equipped with three piece coupling #8034874 or two piece coupling #8144933, the timing marker must be on the left side of the engine because these two couplings have the 0° T.D.C. mark to the left of the vertical center line. The 0° T.D.C. mark on coupling #8082546 is on the right side of the vertical center line, when looking at rear of engine.

It is recommended that when an engine is returned for reconditioning, either on a Rebuild and Return or Unit Exchange basis, the engine coupling disc of the two piece coupling or the entire three piece coupling be included with the engine assembly. This will assure proper handling and installation of these parts on the returned engine.



Flywheel Pointer Location
Fig. 5-3

There will be instances when a weight will be observed attached to the engine disc on some locomotives. This additional weight has been placed at a specific location on the flywheel to aid in proper balance.

Any weighted flywheel should be kept for use with the engine on which it originally was a part. The weight should be maintained at the original position as applied to the coupling disc.

Torque values for engine disc coupling bolts are 1200 $\pm$ 5% foot-pounds.

3. Main Bearings

The main bearing shells are steel backed, lead-bronze having a lead tin overlay. They are precision type requiring no hand scraping or shims for fitting, having tangs which locate them in the correct axial position and also prevent them from turning.

Lower main bearings have two tangs on each side, upper main bearings one tang which fits a mating groove on the right side of the "A" frame bearing bore. Upper main bearings can be rotated out in a direction opposite to normal crankshaft rotation, when the lower bearing and cap are removed. Upper and lower bearing shells are not interchangeable.

Front and intermediate bearings, of each designation, upper or lower, are the same on all engines. Rear bearings on all engines are the same. Center bearings differ between 12 and 16 cylinder engines and with other bearings. Center bearings on 8 cylinder engines are intermediate bearings.

The upper and lower bearings are held in position in the "A" frame of the crankcase by a forged steel bearing cap. A serrated joint between the bearing cap and "A" frame holds the cap in the correct position.

The caps must not be interchanged or reversed. Marked side of the cap must match the marked side of the "A" frame. Caps are fitted to the "A" frame serrations after which they are line bored and therefore may not be supplied as interchangeable parts. See Section 1 for main bearing stud nut application and nut torque recommendation.

4. Crankshaft Thrust Collar

The thrust collars are solid bronze, of rectangular cross-section, and formed in a half-circle. They are rolled into a counterbored seat on each side of the center main bearing "A" frame on the 8, 12, and 16 cylinder engines and on each side of the #3 main bearing "A" frame on the 6 cylinder engine. They fit around the back of the upper main bearing shell and are held in position by the bearing cap.

Their purpose is to limit and absorb the thrust, or endwise movement of the crankshaft, by reason of the designed clearance between the face of the thrust washer and the machined surface of the shaft.

The thrust surfaces are lubricated from the main bearing leak-off oil and are installed with their "thumb print" oil depressions away from the "A" frame in which they are placed.

5. Harmonic Balancer

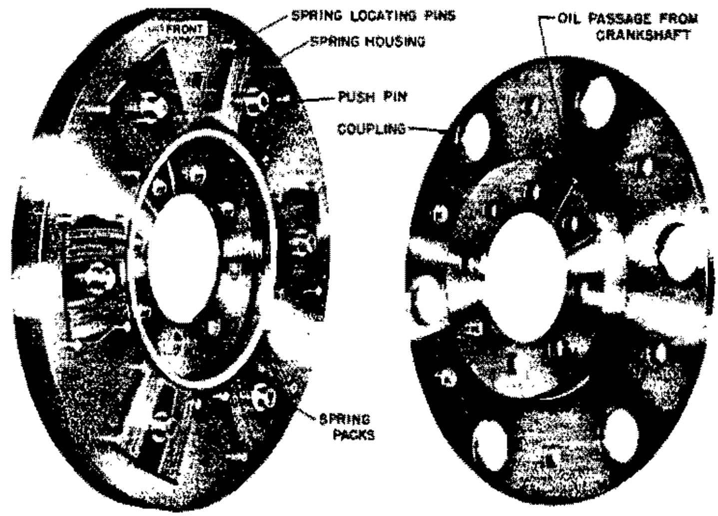
The harmonic balancer is used on the 12 and 16 cylinder engines and is located on the front end of the crankshaft. It consists of two couplings, laminated springs, pins, and a spring housing, Figs. 5-4 and 5-5. The function of the harmonic balancer is to dampen torsional vibration in the crankshaft. The springs receive lubricating oil from the engine through drilled passages in the harmonic balancer hub. See Fig. 5-4 and 5-6.

6. Accessory Drive Gear

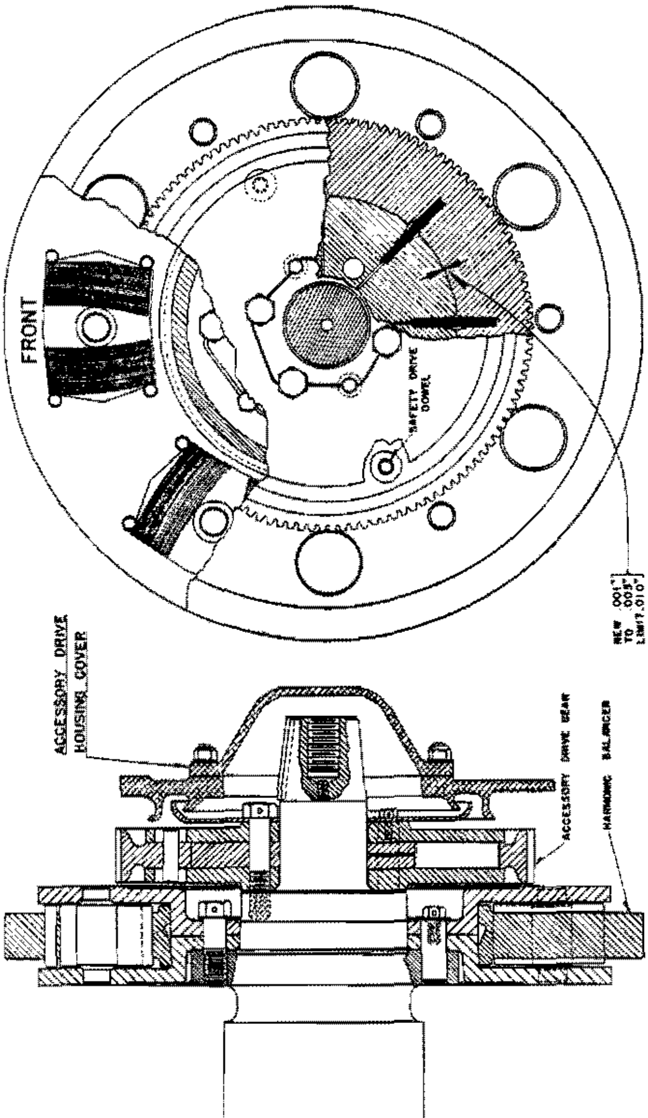
The accessory drive gear is mounted on the front end of the crankshaft, in front of and adjacent to the harmonic balancer, Fig. 5-5 and 5-6. This gear drives the water pumps, oil pumps and governor drive through spur gears.

The accessory drive gear assembly consists of a gear with safety dowels, hub, two discs and eight spring packs. See Fig. 5-6 and Fig. 5-7. The spring packs are fitted between the hub and gear and are held in position by the two discs. An oil slinger, attached to the outer side of the gear, prevents oil leakage between crankshaft and accessory drive housing cover.

A drilled passage in the crankshaft supplies oil to a circumferential groove in the hub, which is drilled to carry oil to the spring packs and the space between the gear and hub.

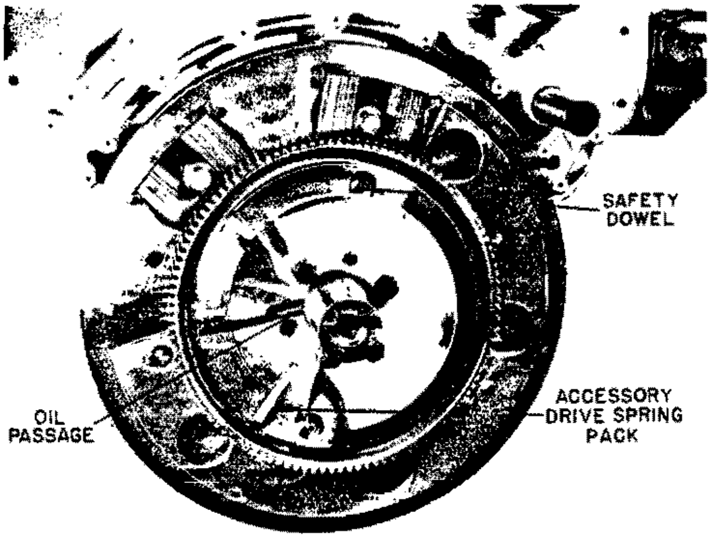


Exploded View - Harmonic Balancer
Fig. 5-4

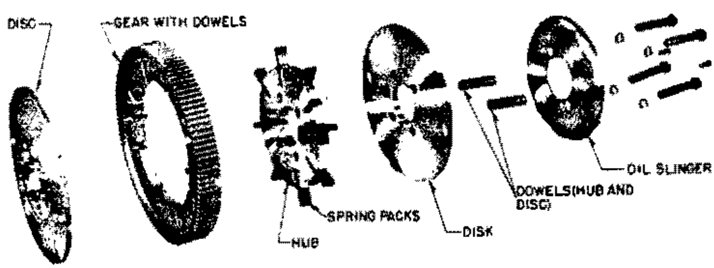


Harmonic Balancer And Accessory Drive Gear
Fig. 5-5

In the event a spring pack failure should occur, the safety dowels have been provided to keep the gear turning. This application is shown in Fig. 5-5 and Fig. 5-6. This dowel is a safety feature only. In the event of a spring pack failure, repairs should be made upon arrival of locomotive at the maintenance point.



Harmonic Balancer And Accessory Drive Spring Packs
Fig. 5-6



Exploded View - Accessory Drive Gear
Fig. 5-7

The accessory drive gear assemblies used on 567B engines differ only in the size of the oil slinger, compared to the accessory gear on 567 and 567A engines. The oil slinger on 567B engines is smaller.

B. MAINTENANCE

1. Crankshaft Inspection

When main and connecting rod bearings are removed, a visual inspection should be made of the crankshaft journals. Check for scoring or cracks. (See MI 2126 for Crankshaft Magnaflux Inspection).

The bearing surfaces of the 567 crankshaft are induction hardened. When a bearing fails, the resulting excessive heat tends to further harden the surface in some spots, and in most cases, thermal cracks result.

It is our recommendation that any such crankshafts be minutely examined and magnafluxed wherever possible. A crankshaft CANNOT be salvaged if there is a crack over one inch long and more than one-sixteenth of an inch deep in either the surface of a main bearing or crankpin journal, or any journal fillet. The depth of a crack may be determined by grinding with a high speed machine fitted with a fine conical-shaped stone. If, after this examination it appears that a shaft might be salvaged, it should be returned to locomotive manufacturer for machine grinding and balancing. For return of crankshaft see Factory Rebuild Bulletin #303.

Attempts to grind 567 crankshafts in the field have proven unsuccessful. The journals of all 567 engine crankshafts are induction hardened to a certain depth by a process requiring use of specialized induction hardening equipment. During the process of regrinding the induction hardened depth is checked and where necessary rehardened by the same method. Therefore, it is recommended they be returned when regrinding is necessary.

To aid in identification, used reground or reconditioned crankshaft are marked on the same cheek as the serial number to identify bearing journal and thrust bearing sizes.

2. Main Bearing Removal and Installation

All upper main bearings, except the rear bearings on the 6, 8, and 12-567B engines, and the two center bearings on the 16-567B engines, are removed by inserting the upper main bearing removing tool (part # 8055837) into the oil hole in the crankshaft, and rotating the crankshaft in a clockwise direction (opposite to normal rotation). The rear bearings on all engines, and center bearings on the 16-567B engine can be removed by using a small piece of brass to push out the bearing while rotating the crankshaft. Upper bearings are to be rotated into position by hand. This will insure proper alignment of bearing tang. Do not install with the removing tool.

3. Scheduled Main Bearing Renewal

Lower main bearings should be replaced at the intervals specified in the scheduled maintenance program for the particular type locomotive. This renewal should be made in complete engine sets at that time. Steel backed upper main bearings have a life expectancy of approximately 2 times the loaded lower half. Upper half main bearings should not be removed at scheduled maintenance intervals for this reason, unless a lower half being replaced shows signs of distress, in which case the upper half should be removed for inspection. However, these upper-half main bearings should be inspected at major engine overhaul periods and, if dimensionally satisfactory, should be cleaned up and reused.

If any new bronze bearings are in stock they should only be used in engines in yard switcher locomotives and replaced according to the scheduled maintenance program for main bearings.

4. Main Bearing Inspection

Interim inspection of main bearings should only be necessary when abnormal conditions are observed in the engine, such as contamination of lube oil due to dilution with fuel or water, or any other foreign material, evidence of the latter being found in the lube oil filters, screens or engine oil pan. When such a situation arises, ALL the lower main bearings should be inspected.

This should be a visual inspection made by actually dropping the cap and bearing. The lead-tin overlay on the bearing is primarily provided for "break-in" purposes. The fact that part, or all, of this coating may have worn away should cause no concern, as long as all bearing shells have the same relative appearance. DO NOT UNDER ANY CIRCUMSTANCES REVERSE THE BEARING IN THE CAP.

Replacement of an individual bearing in distress should only be made if after inspection all other lower main bearings still have evidence of some lead-tin overlay remaining in the loaded areas. If one, or more, of the lower main bearings has all the lead-tin overlay worn off the loaded area, then ALL lower main bearings must be renewed to insure proper crankshaft alignment.

If upon such an inspection any lower main bearing shows DEFINITE signs of distress, the upper main bearing should also be examined.

Used bearings should positively not be reinstalled on any crankshaft journal other than the journal from which it was removed. Used bearings reapplied must be installed in their original position relative to shaft rotation, to avoid probable serious bearing trouble.

5. Limits

When engines are torn down for purposes other than main bearing troubles, it will be necessary to outline a condemning limit, and in these cases, we recommend the following rules be followed for both upper and lower main bearings.

a. Minimum wall thickness of any main bearing measured with ball micrometer should be:
standard .368"; undersize 1/32"-.3835", 1/16"-.3990", 3/32"-.415", 1/8"-.4305".

b. Maximum wall thickness variation between adjacent main bearings which have a crankpin between them should be .002".

c. Maximum allowable wall thickness variation between center main bearings on a 16 cylinder engine, that is, with no crankpin between them, should be .0015".

6. Undersize Main Bearing

Main bearing shells are available in 1/32", 1/16", 3/32", and 1/8" undersizes.

7. Harmonic Balancer

The harmonic balancer should be inspected at intervals as specified in the Scheduled Maintenance Program covering the particular locomotive service. The balancer should be disassembled, spring leaves or packs replaced and push pin dowels rotated to present a new contact surface to the springs.

On disassembly, support the balancer slightly above wooden top of work bench by use of hoist and sling in the large holes in top of coupling. Using a brass or other soft metal drift slightly less in diameter than top of push pins, drive push pins from top coupling. Drive push pins alternately 180°, making sufficient rounds of light driving on each pin until top coupling is free.

After top coupling is free, repeat driving procedure, after supporting spring housing, to drive push pins from spring packs and housing. Repeat procedure on bottom coupling. Couplings should be identified to hold reamed parts together.

Examine components of the balancer, smooth up any roughness or burrs, particularly on spring housing, thrust pin ends and push pins. Replace thrust pins having flats exceeding 1/8" wide, loose in spring housing or galled on the ends. Check thrust pin equal height above each side of spring housing. Oversize thrust pin and mounting dowels are available. Oversize push pins are not available.

Check 1/2" thrust pin impressions in the coupling inner face. Replace couplings having impressions exceeding .020" in depth. All impressions within allowable depth must be blended.

Check surfaces of spring cells nearest circumference of spring housing for non-uniform wear, due to centrifugal force and flexing of the spring. Replace spring housing if this wear exceeds .050" in depth. Replace all outer spring leaves. If inner spring leaves of spring packs are galled, replace with new packs throughout.

Clean oil passages in coupling and drilled oil passages in spring housing.

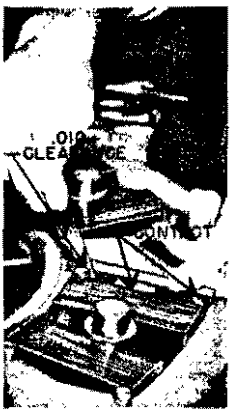
In preparation for reassembly, lightly file coupling contact surfaces which contain the two oil passages to remove any burrs or roughness. Place the coupling on a wooden topped bench and drive push pins in place, being sure previously worn surfaces will not be in a position to contact springs. Use white lead or other similar lubricant on push pin ends.

Place spring housing on the coupling, with side marked "FRONT" up.

Apply spring packs to each side of push pins. Approximately 82 to 84 spring leaves are required for each pack and their weight is about 4 lbs. 5-1/4 oz. Stack leaves before applying and remove any over length, short length or overwidth leaves as compared with the majority of other leaves. The leaves do vary in thickness. The difference between spring width and 1/2" thrust pins is .040". Space springs to obtain same clearance on both sides in relation to thrust pin ends. Apply packs with several leaves less than normally required, as it is much better to add leaves when checking, than attempt leaf removal once assembled. Leaves can be added by starting one corner of the leaf and tapping into pack working along top of leaf, using a light steel hammer.

After all packs of about right quantity have been applied, each pack should be gauged using deflection gauge #8080197, Fig. 5-8. Apply gauge as shown in Fig. 5-8 (a) and check for clearance between springs and gauge block. With gauge in position (a) there should not be any clearance between gauge block and springs. However, due to applying packs minus several spring leaves, on first check there likely will be a clearance. Make this check on each pack. If one pack indicates more clearance than opposite side, insert leaf in side

Spring Gauging Block To Spring
Fig. 5-8a



Spring Gauging Bar To Pin L.S.
Fig. 5-8b

Spring Gauging Bar To Pin R.S.
Fig. 5-8c

having least clearance. If clearance still exists, add leaves to each pack until there is no clearance between gauge block and springs when pushed in position shown in Fig. 5-8 (a), and the gauge bar ends just clear the thrust pins. When the gauge block is held so center block contacts the springs and one end of bar contacts a thrust pin as shown in Fig. 5-8 (b) or (c), there should be at least .010" clearance between the opposite bar end and thrust pin. This clearance should also be obtained with gauge bar contact reversed. Although the .010" clearance should be maintained, in most cases it will exceed the .010" due to varying leaf thickness.

Follow the preceeding gauging sequence on pairs of spring packs diametrically opposite starting packs. Repeat sequence on adjacent packs until all packs have been gauged and proper quantity of spring leaves added. This will tend to equalize the assembly. Recheck all spring packs.

Upon completion of spring pack assembly, place remaining coupling over the assembly in such a position that the oil passages are matched. Clean up any burrs or roughness on bottom of coupling hub. Using a raw-hide mallet or press, force lubricated top ends of push pins in their respective holes in the coupling. Drive coupling down evenly to contact the shoulder of the push pins. Mark location of oil passages on coupling hub to facilitate the installation of balancer to the crank-shaft, so oil passage line-up may be assured with matching oil holes in the crankshaft.

Raise the assembled coupling clear of the bench using a hoist and a sling in the mounting holes. Check for any clearance between the mounting flanges with a .0015" feeler. A .0015" feeler should not enter between the mounting flanges. If it does, foreign particles or burrs are indicated on the flange surface which will necessitate disassembly of the balancer to clean.

Also, with the balancer suspended as in the pre-ceeding paragraph, check clearance between top of spring pack and coupling. A .010" feeler should pass between coupling and spring pack. If feeler does not pass, tap the coupling lightly above the pack using a rawhide mallet, at same time checking with the feeler. This procedure will provide the necessary clearance. By taking care during assembly to assure equal height of thrust pins above each side of spring housing, it will not be necessary to check thrust pin end to coupling clearance.

Prior to installing the harmonic balancer, clean with air blast to remove any foreign particles, and oil springs using engine lube oil. Install on crankshaft with "FRONT" stamping facing toward you. Apply washers 8174659 under mounting bolts. This washer prevents mutilation of coupling and aids in proper torque. It is used on 16 B engines, serial 52-A-171 and all engines thereafter.

8. Crankshaft Gear

Details of crankshaft gear are shown on Fig. 5-2. When assembling the crankshaft gear assembly, be sure that any burrs or nicks are removed from mating parts. Check for concentricity can be made by using a feeler gauge between the crankshaft gear and the first idler gear. This check should be made at four positions (90° apart) of the crankshaft. Backlash between gears should be .007" to .014". Limit .030".

9. Accessory Drive Gear

The accessory drive gear should be inspected at intervals specified in the Scheduled Maintenance Program or at the time of a complete engine overhaul.

Accessory drive gears have in the past been doweled to the crankshaft by two long dowels. Accessory drive gears are now being made with dowels through the gear, but not entering the crankshaft. Dowels previously used are 3-9/16" long, but dowels on new assemblies are 2-7/16" long. Long dowels in stock may be reworked to the 2-7/16" dimension.

The short dowel accessory drive gear is interchangeable with the older assemblies for installation on the crankshaft with the dowel holes. All short dowel jig reamed accessory drive gear parts will be interchangeable for use as replacement parts in the old 8 pack accessory gears, provided that the dowel holes are reamed at assembly for use of the oversize dowels.

Major parts of all accessory drive gears, except the 8 spring pack gears have been discontinued. Consequently, when replacement of any part (except spring pack) of other than 8 pack gears is needed, it will be necessary to replace the gear with an improved 8 spring pack gear.

REBUILDING ACCESSORY DRIVE GEAR ASSEMBLY NOS. 8084764 & 8070656

Accessory Drive Gear No. 8070657

This gear need not be replaced for spring slot condition until a flat spot on the driven side exceeds 3/8" in length. The gear may be reversed to carry the load on the opposite side of the slot. Therefore, it is unnecessary to replace the gear until wear has occurred on both sides of the spring slot.

Accessory Drive Gear Hub No. 8070659

Soft hubs in service should be replaced at first rebuilding. Hardened hubs which may be identified by the dark lubrizing color, need not be replaced until flat spots exceeding 3/8" in length occur on the driving side. The hub may be reversed to prolong life, the same as the gear.

Disc No. 8070658

No differentiation need be made between the soft and hard accessory drive gear discs, the latter being identified by the letter "H" stamped adjacent to the safety dowel drive holes unless, as is often the case, the discs are scored by the edges of the springs or broken spring packs. The hard disc prevents this condition.

Spring Pack No. 8039738

At each gear rebuilding the spring packs should be replaced. No attempt should be made to assemble packs from used spring leaves, as spring pack to slot clearance is critical and is controlled by factory assembly of the spring pack. Clearance should be .003"-.009". However, clearance cannot be measured in assembly because spring pack thickness must be determined in a clamping fixture with springs not oiled.

Gear Assembly

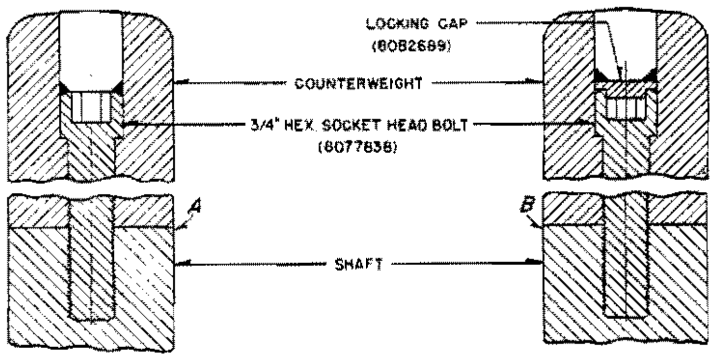
At assembly the accessory drive gear to hub clearance should be checked and should not exceed .010". At assembly, all pieces should be carefully cleaned and oiled to insure best condition during break-in. On old engines using long dowel #8031883, it is satisfactory to apply short dowel #8078168 if desired. Also, hardened washer #8140912 should be used under the head of the accessory drive gear mounting bolts to prevent mutilation of the oil slinger and assure better torque tightening. This washer #8140912 is the same as that used under the cylinder head to liner nuts.

10. Procedure for Removing Bolted Crankshaft Counterweights

Bolted counterweights on the crankshaft can be checked for tightness by tapping of the counterweight with a light hammer. The sound produced will indicate a tight or loose weight. If tight the sound will be sharp metallic; if loose a dull sound. The rebound of the hammer to some extent will also serve to detect a loose weight, for the rebound will not be as snappy as with a tight weight. If any looseness is evident, the counterweight should be removed.

Several methods have been used to secure the counterweight bolts to prevent their loosening. Some have a cap fitting the bolt socket and welded to the weight; others have a strap and cap covering the bolt as on some 12 cylinder engine crankshafts. In these cases the cap is accessible for removal, and removal of the counterweight bolt is no problem, because the weld can be ground off freeing the cap. Additional methods used in securing the bolts are shown in Fig. 5-9, "A" and "B". These methods of securing the bolts necessitate a procedure for their removal as follows:

To remove a counterweight fastened as in "A", Fig. 5-9, with sunken welded bolts, drill down through the center of the allen head bolts #8077838 with a 23/32" diameter high speed drill to a depth of 3/4". After both bolts have been drilled in this manner, a sharp



Bolted Crankshaft Counterweight
Fig. 5-9

blow on the side of the counterweight with a hammer will crack the remaining shell of the body of the bolt and allow the counterweight to be removed. The remaining portion of the bolt head can be removed by using a 1-1/16" bottoming drill. This can best be done on a drill press where a steady pressure can be applied to break through the weld around the edge of the bolt head. The remaining portion of the bolt in the crankshaft can be removed with a stud extractor or pliers.

A counterweight fastened to the crankshaft as in "B", Fig. 5-9, having sunken bolt and cap, can be removed as follows: Use a 1-1/16" diameter bottoming drill, to remove the weld around the locking cap. The cap can then be removed and the bolt taken out with a 9/16" allen wrench.

Extreme care must be taken in all the preceding cases to remove drill chips and other foreign material. Before re-installation of the counterweight, the mating contact surfaces should be cleaned and smoothed off. If necessary, the dowel fit should be restored by using an oversize dowel. Always re-install counterweights using new bolts. Torque values for tightening the counterweight bolts are 200 foot pounds.

New bolts, caps and dowels may be obtained by placing an order with our Parts Department under the following part numbers; cap #8082689; cap and strap assembly, 12 cylinder engines, #8082692; dowel #8081200 and bolt #8077838.

C. SPECIFICATIONS

Crankshaft

Diameter, main journal	7.498"-7.500"
Diameter, crankpin journals	6.498"-6.500"
Crankpin bearing clearance	New .007" - .011"
	Limit .015"

Journals out-of-round — not over	New .001" Limit .004"

Main Bearings:

Diameter (inside) installed (Average of 3-60° measurements) Standard	New 7.5065" - 7.5095"
Diametric clearance - bearing to crankshaft	New .007" - .011" Limit .015"
Minimum bearing thickness — Standard	.368"

Undersizes: 1/32" - .3835", 1/16" - .3990", 3/32" - .415", 1/8" - .4305"

Total end clearance (thrust bearing):

6-567 Series	New .010" - .017" Limit .030"
8-567 Series	New .008" - .015" Limit .030"
12-567 Series	New .008" - .015" Limit .030"
16-567 Series	New .008" - .018" Limit .030"

Thrust bearing collar thickness:

12-567B	New .869" - .870"
6, 8 and 16-567B	New .368" - .369"

Number of main bearings:

6-567B	4
8-567B	5
12-567B	7
16-567B	10

Harmonic Balancer:

Number of leaf springs per pack (approx.)	84

Accessory Drive Gear:

Thickness of each spring gear	.373" - .375"
Clearance - hub to gear	New .001" - .003" Limit .010"

Flywheel and Flexible Coupling:

Diameter	36"
Combined weight of flywheel, rim and flexible coupling	410 lbs.
Coupling bolts to engine torque value	1200 ± 5% ft. lbs.

Accessory End Gear Train	No. of Teeth	Ratio to Crankshaft
Governor Drive Gear	113	1:1
Water Pump Gear	37	3.05:1
Lube Oil Pump Gear	80	1.412:1
Scavenging Oil Pump Gear	80	1.412:1
Accessory Drive Gear	113	1:1

Backlash Accessory Drive Gear (all)	New .008" - .016" Limit .030"

D. EQUIPMENT LIST

Name	Part No.
Flexible coupling bolt removing tool	8068028
Upper main bearing removing tool	8055837
Harmonic balancer hub dowel puller	8070854
Spring pack deflection gauge (Harmonic Bal.)	8080197
Main bearing powerwrench	8155363

SECTION VI

CAMSHAFT GEAR TRAIN, CAMSHAFT ASSEMBLIES, TIMING AND OVERSPEED TRIP

A. DESCRIPTION

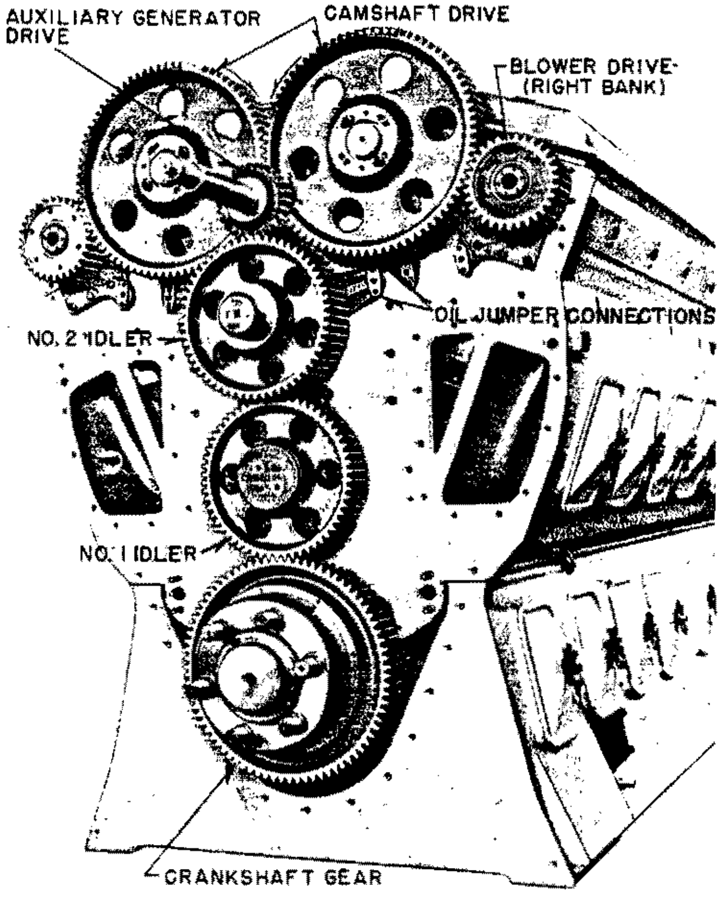
1. Camshaft Drive Gear Train

Power necessary to drive the camshafts and engine blowers on 567 engines is supplied from the crankshaft through a series of gears or gear train at the rear of the engine. Fig. 6-1 shows the gear arrangement used on the 567B engines and is similar to that used on 567A except for the auxiliary generator drive provision and oil supply provision. Fig. 6-2 shows cross-section of 567B gear train.

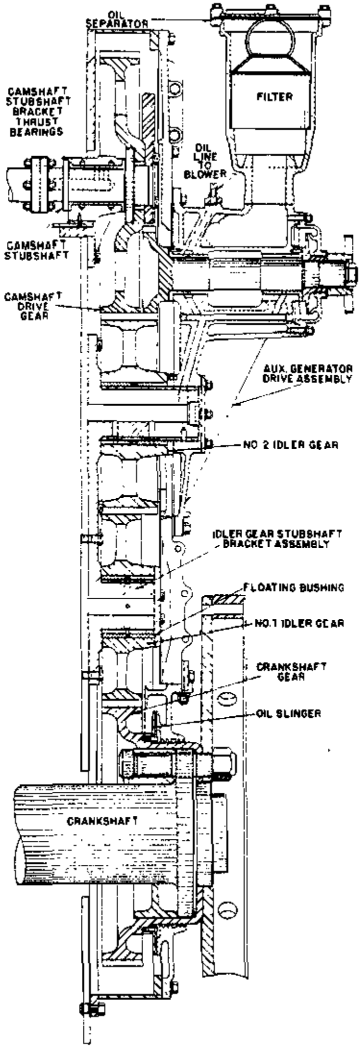
VI

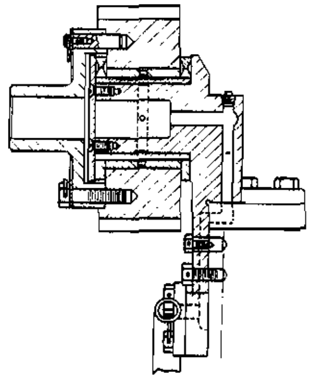
As shown in Fig. 6-1, the gear train consists of spur tooth gears, a crankshaft gear mounted on the crankshaft, and two idler gears to the left bank camshaft drive gear which meshes with and drives the right bank camshaft drive gear. The second idler gear on "B" engines is given greater tooth length to accommodate the auxiliary drive. Both blower drive gears are driven by their respective camshaft drive gears. Rotation of the camshaft drive gears is inboard of the engine and at the same speed as the crankshaft. Blower drive gear rotation is outboard, speed depending on gear size, which differs, being smaller on 8 and 16 cylinder engines as compared to 6 and 12 cylinder engines. Hence, the blower speed on 8 and 16 cylinder engines is greater than that on 6 and 12 cylinder engines. Only one blower drive gear is used on 6 and 8 cylinder engines.

The idler and blower drive gears are equipped with floating bushings and thrust bearings. These gears rotate on stubshafts mounted on the engine rear end plate. Idler gear stubshafts on "B" engines are integral on the stubshaft bracket. All other stubshafts are separate. The "B" engine stubshaft brackets have cast oil passages connected with cast oil passage jumpers, for lubrication and camshaft oil supply from the main lube oil manifold. The gear train is enclosed in a



Camshaft Gear Train
Fig. 6-1





Blower Drive
Stubshaft Assembly

Cross Section Of 567B At Camshaft Drive End
Fig. 6-2

gasketed housing, the cover consists of several parts to facilitate inspection and handling.

2. Camshafts

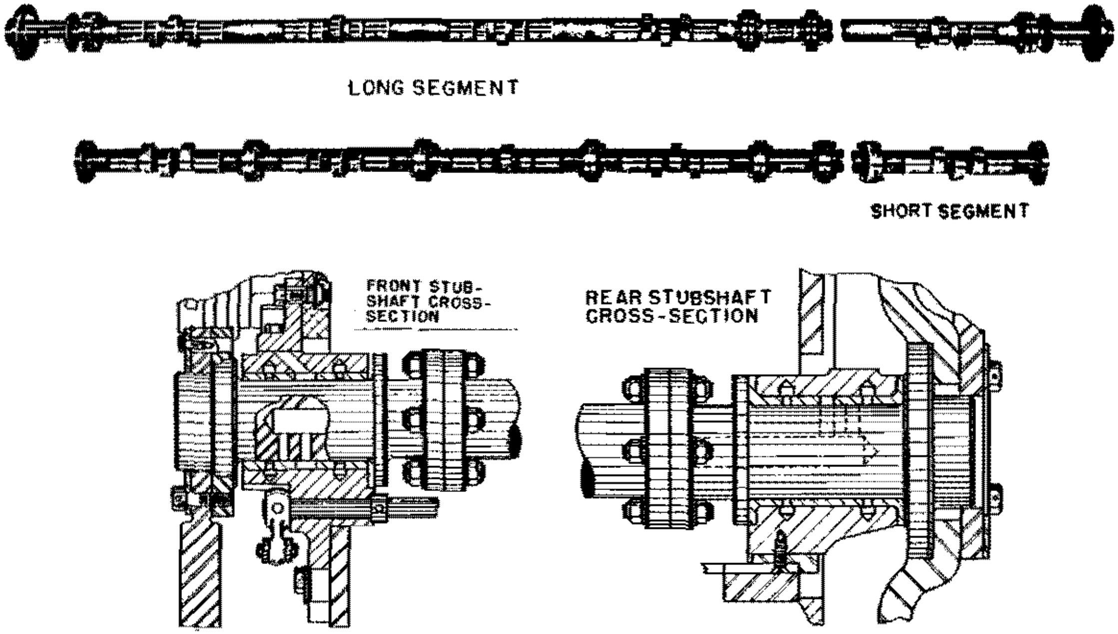
The camshafts are made up of flanged segments, stubshafts, and on 12 and 16 cylinder engines a spacer is applied at their center. See Fig. 6-3. Camshaft segments may be short segments or long segments. Short segments span only one cylinder and are provided with two bearings, two exhaust cams and one injector cam, and are flanged at each end to connect with adjacent cylinder segments or stubshafts at the camshaft ends. Long segments span several cylinders and have integral continuity of bearings and cams for the several cylinders spanned and are also flanged at each end. Long segments are interchangeable with groups of short segments when installed in proper location and sequence, providing hydraulic valve lash adjusters are used.

The segments, both long and short, are marked at each end on the flange to aid in correct assembly. Also, one of the four holes in each flange is small to assure relative positioning of the segments. The camshaft is supported at each cylinder by two bearing blocks and caps, provided with bearing bushings.

Flanged stubshafts are at each end of the camshaft. The camshaft drive gear and counterweight assembly is bolted and doweled to the rear stubshafts. A counterweight is mounted on front stubshafts. The right front stubshaft incorporates the overspeed trip.

Stubshaft bearing brackets support the camshaft at each end and are provided with split bushings. Rear stubshaft brackets are provided with thrust bearings.

Camshaft oil supply from the main lube oil manifold and gear train oil lines is received at the rear stubshaft bearings through drilled oil passages in each stubshaft. Each camshaft segment bearing is supplied



Camshaft Assemblies
Fig. 6-3

oil from the camshaft center bore. One segment bearing cap is flanged to provide for an oil line to rocker arm shaft and valve mechanism.

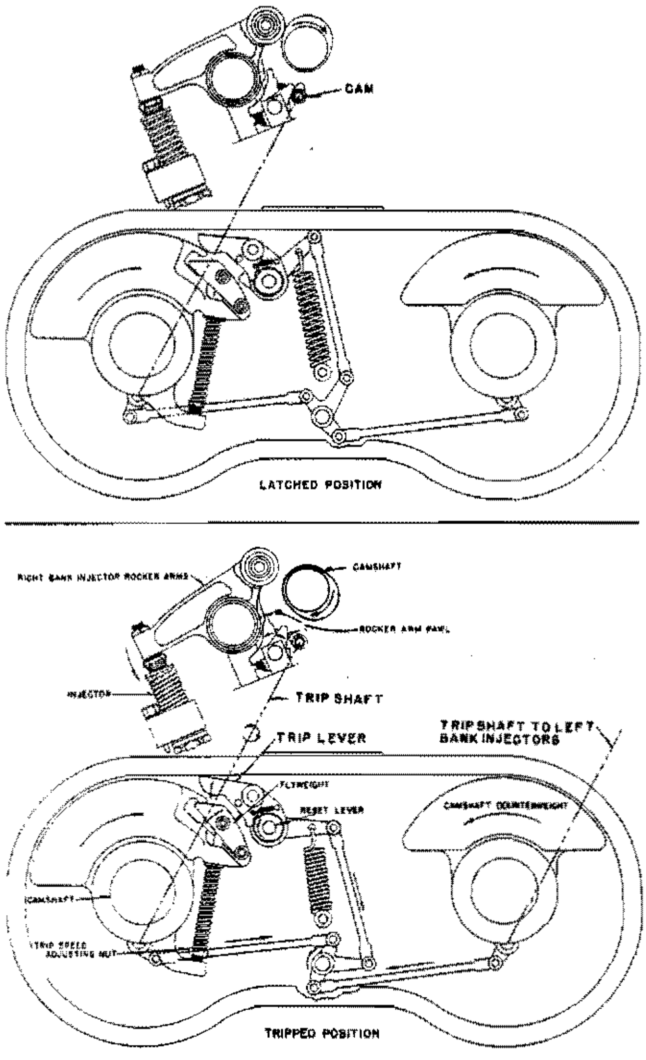
3. Overspeed Trip

An overspeed mechanism is provided as a safety feature, to stop the injection of fuel into the cylinders should the engine speed become excessive.

If the engine speed should increase to approximately 900 RPM, the overspeed mechanism will shut down the engine. Fig. 6-4 shows the overspeed mechanism in both the normal latched position and the tripped position.

A trip shaft extending the length of the engine banks under each main camshaft is provided with a cam at each cylinder, which when rotated contacts a spring loaded catch pawl mounted on each cylinder head, located directly under each injector rocker arm. In the overspeed trip housing on the front of the engine, the trip shafts are connected to spring operated links and lever mechanism. A reset lever on a spring lever arm shaft when rotated counter-clockwise puts a tension on an actuating spring; tension being held by a trip lever engaging a notch in the reset lever arm shaft. This is the normal running position, in which the cams on the trip shaft are held away from the rocker arm catch pawls.

Incorporated in the right bank front camshaft counter-weight is the overspeed trip release mechanism. It consists of a flyweight held by an adjustable tension spring. When engine speed exceeds the safe limit, the set tension of the spring is overcome by the centrifugal force acting on the flyweight, causing the flyweight to move outward to contact the trip lever. This allows the actuating spring acting through connecting links to rotate the trip shafts. Consequently, the trip shaft cams contact and raise the injector rocker arm pawls, preventing full effective injector rocker arm roller



Overspeed Trip
Fig. 6-4

contact on its cam. This prevents fuel injection and stops the engine.

Upon resetting, by counter-clockwise movement of the reset lever, the trip shaft cams release the injector rocker arm catches. Rotation of the camshafts on starting the engine lift the rocker arms slightly allowing the catch pawls to resume unlatched position, releasing the injector rocker arm for normal operation.

B. MAINTENANCE

1. Camshaft Gear Train

Familiarity with the engine and its particular sound serves as a fairly good guide to engine operation. This is also true regarding the gear train. Any pronounced unusual noise originating at the gear train warrants gear inspection at the earliest convenient opportunity, as well as at intervals of regular engine overhaul and inspection periods. Gears should be inspected for failure at the tooth profile, fatigue indications, cracks, pits, and other evidence of failure or impending failure. Wherever possible inspection by magnaflux methods are recommended. If any defects are discernible, the gear or gears should be replaced.

Backlash of the gears is another important inspection item. Backlash may be determined either by feeler gauge, lead wire, plastigage, or dial micrometer measurement. When using feeler gauge, be sure gauge extends the entire length of the teeth. Lead wire may be inserted and held on the trailing side of the driving tooth at its middle and the gear rotated. Measurement of the wire indicates the backlash. By rotating the gear in one direction, then placing a dial indicator button against a drive gear tooth and reversing rotation, noting movement or contact with tooth of the driven gear, the reading may be taken directly from the indicator. Excessive backlash will result in improper valve timing and injection periods, as well as general poor gear operation. Backlash, new and condemning limits for the gear train are listed under specifications.

Clearances between gear stubshaft and gear bushings and thrust clearances must also be maintained within limits as listed, for the various gears on the engine, under Specifications.

NOTE: The "inboard" and "outboard" thrust washers on the blower drive stubshaft differ in material. Washer #8069139 (bronze) is used "outboard" while washer #8166495 (cast iron) is used "inboard." Care should be taken to install these washers in their correct location.

Although no wear should occur at the oil slinger, the .100" ± .010" dimension between the slinger and housing cover should be checked on assembly. This measurement is obtained by laying a straight edge across the camshaft drive housing flange, with crankshaft positioned toward the generator and measuring the distance to face of the oil slinger. Then determine the protrusion of slinger mating surface on lower housing cover from its flange. The difference between these measurements equals the clearance. If necessary add or remove shims, or in some cases in rebuilt crankcases metal may have to be removed from cover mating surface to obtain the necessary clearance. The cover labyrinth seal should be installed so as to have equal space around crankshaft gear on all but 567B engines which should be approximately .010" greater on top.

The gear train housing of all 12 and 16 cylinder "A" and "B" engines since May 1950 have been modified to assure more positive sealing against oil leaks. This has been accomplished by a change in gasket material and additional bolts of improved material which allow increased torque values on bolts used in these locations.

All 12 and 16 cylinder complete engines returned for rebuilding will have these modifications applied.

When the crankcase, oil pan and cover frame assemblies ONLY are returned on either Unit Exchange or Rebuild and Return basis, the additional bolt holes will be applied at the rear gear train end. It will then be necessary for the customer to drill and tap the additional bolt holes in the rear gear train housing and covers. Complete modification instructions for these engines are 5019 for 567B, and 5027 covering 567A engines.

2. Camshafts

There are several types of camshafts used in the 567 series engines. Camshafts are made up of either short segments or long segments. Short segments span only one cylinder, whereas long segments span three cylinders on 6 and 12 cylinder engines and four cylinders on 16 cylinder engines. Short segments only are used on 8 cylinder engines. Long segments are interchangeable, when properly assembled, with groups of respective cylinder short segments. Long segment camshafts can be used only on engines equipped with hydraulic lash adjusters.

There is a difference in valve timing obtained with early (original) 567 camshaft segments and all subsequent segments following and superseding them. Earlier segments gave a 4° later exhaust valve opening and 4° earlier exhaust valve closing than those following and presently used camshaft segments. Original segments may be identified by flanges being stamped with cylinder numbers, where segment is used on right or left bank, and stamping "front" or "rear" as to how the segment should be installed on the numbered cylinders.

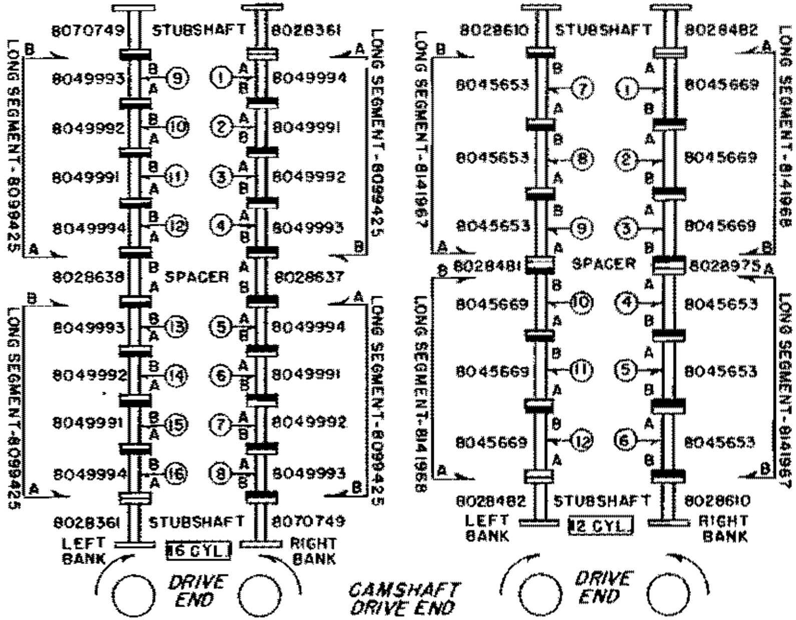
Segments superseding the original are stamped "4-4" or "A" and "B" on the flanges. The "4-4" segments are identified similar to the original as to cylinder numbers and front and rear identification on the flanges, but in addition had the "4-4" stamping not found on the original segments. Camshafts of the "4-4" and "A"-"B" type are the same as regards valve opening and closing, since both type open the exhaust valve 4° before and allow the valve to close 4° later than the original camshaft segments. All 4-4 type segments should, if any exist, be remarked with the "A"-"B" identification on their respective flanges.

The flange markings assure proper location of the segments in sequence to make up a camshaft since similar segments are used in various cylinder locations on engines to which they apply. The same segments used on one model of an engine may be used on any other model providing the number of cylinders are equal. Segments used on 6 and 12 cylinder engines are interchangeable. The proper sequence and location must be maintained to give proper valve and injector operation. Figs. 6-5, 6-6 and 6-7 indicate camshaft segment arrangement on the various engines. Figure 6-7 covering camshaft segments on early model engines is included to aid in interchangeability for customers having all models of 567 engines.

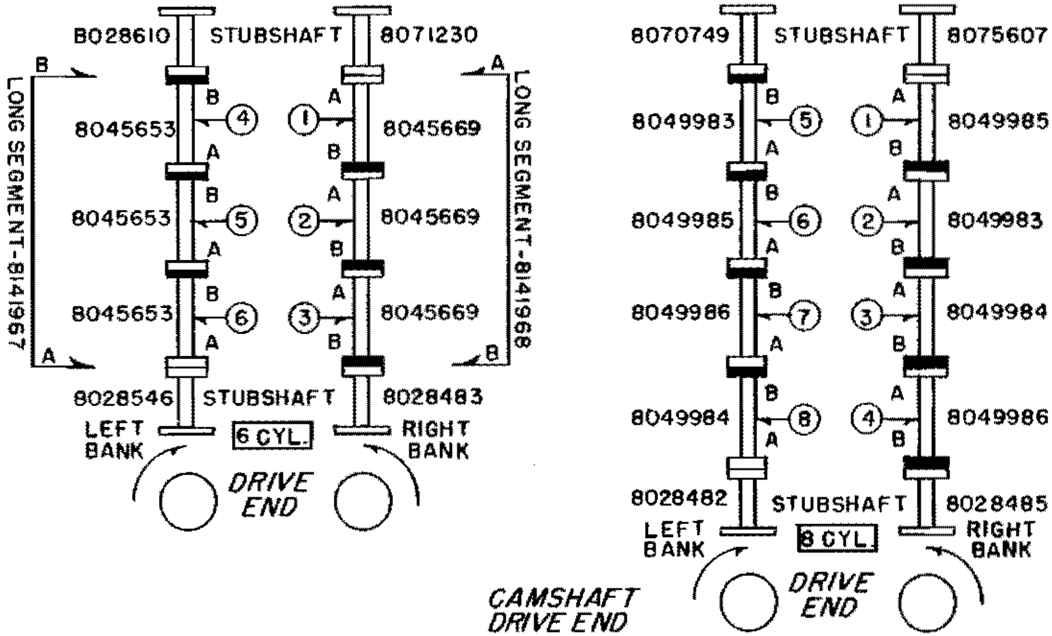
In addition, each segment flange has four dowel bolt holes, one of which is smaller to assure proper angular positioning of the segment in sequence on the camshaft assembly. All segments having the flanges marked "A" on one flange and "B" on the other should be positioned as follows.

When used on 567B or 567A engines, on right bank camshafts the "A" marked flange must be toward front of engine and on left bank camshaft the "B" mark must be toward the front of the engine. When used on 567 "U" and "V" channel engines, the opposite is true, on right bank camshaft the "B" marked flange must be toward the front of the engine and on left bank camshaft the "A" must be toward the front of the engine. See Figs. 6-5, 6-6 and 6-7. Otherwise bolt holes in the flange will not line up due to offset of the smaller locating holes.

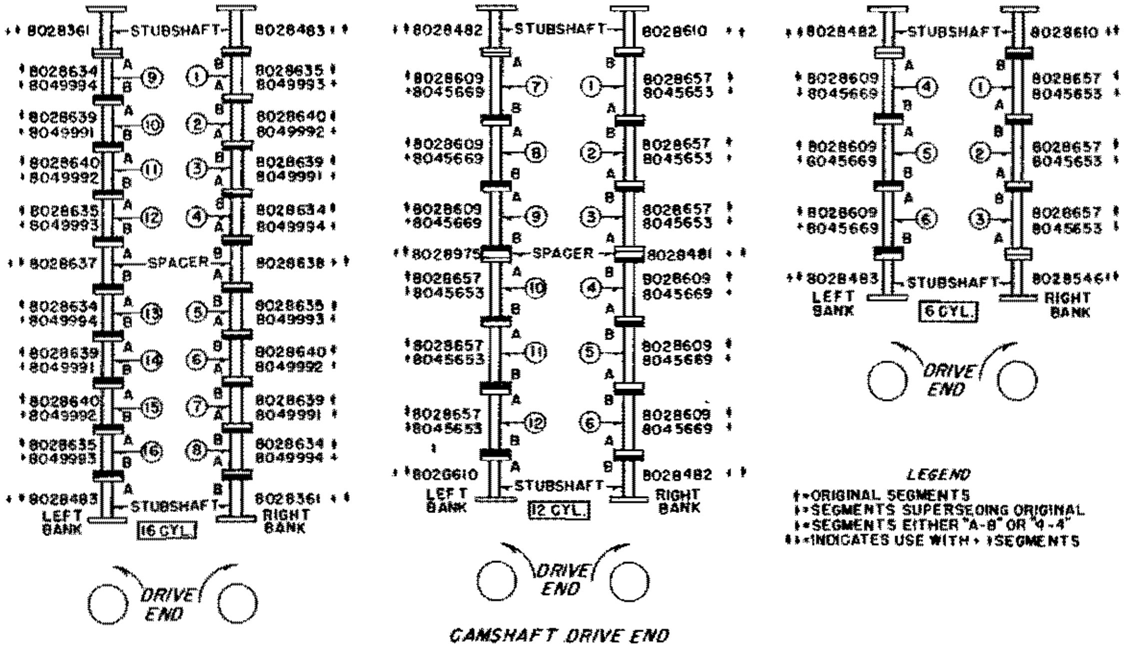
Due to opposite rotations of early 567 cast top deck "U" and fabricated top deck "V" channel engines,



Long And Short Camshaft Assemblies — 12, 16 Cylinder 567A And B Engines
Fig. 6-5



Long And Short Camshaft Assemblies — 6, 8 Cylinder 567A And B Engines
Fig. 6-6



Camshaft Assemblies — Early 567 Cast And Fabricated Top Deck Engines
Fig. 6-7

camshaft assemblies minus stubshafts on respective banks are directly opposite to either 567A or 567B camshafts. That is, a left bank 567A or 567B camshaft minus stubshafts has the same segment sequence as applied to a right bank 567 "U" or "V" channel engine. Hence a 567A or 567B engine, right or left bank camshaft minus stubshaft is applicable to the opposite bank in a 567 "U" or "V" channel engine without disturbing segment sequence as taken from the front of the "A" or "B" engine.

Camshaft stubshafts used on all camshaft assemblies are not completely interchangeable due to location of offset locating hole in the flange.

Diametrical clearance of segment and stubshaft journal to bearing may be obtained by feeler gauge lead wire or plastigage method. Thrust bearings are used only at the rear stubshaft to absorb and limit longitudinal camshaft movement. Thrust clearance may be obtained by inserting a feeler gauge between bearing and thrust plate on stubshaft. To replace all segment bearing bushings the entire camshaft must be removed. Replacement of all camshaft bushings is usually required to assure proper camshaft alignment.

NOTE: When the new heavier rocker arms (see Section 2) are installed in an old engine, the clearance between the rocker arm and camshaft bearing cap should be checked in all positions, by barring the crankshaft around. If clearance is not 1/64", the bearing cap should be removed and ground off until sufficient clearance is obtained.

Engines in locomotives delivered after March, 1950, have the new rocker arms with bearing caps machined to insure sufficient clearance.

Stubshaft bearings on all 567 series engines consist of four half bushings.

Stubshaft brackets for 567A and 567B engines are similar and use the same bushings both on the front and rear stubshafts. Rear stubshaft brackets on 567B engines incorporate cast oil passages for camshaft oil supply, whereas all other engines have oil supply lines.

Camshaft Removal

The camshaft may be removed without disturbing the stubshafts by removing the dowel bolts connecting the segment flange and stubshaft flange, removing oil lines from segment bearing blocks to rocker arms and removing rocker arms. Remove segment bearing block caps to allow camshaft removal. If the camshaft is removed for other reasons than bearing replacement an attempt should be made to retain relative position of the bearing bushings on reinstallation of the camshaft. This may be accomplished by immediately replacing caps after camshaft removal, or if the entire block is removed, re-insert block bolts and wire the free ends of the bolts. It is important that shims, if used under the bearing blocks, be kept with the original block and marked as to original location for re-assembly.

Upon installation or replacement of the camshaft, lubricate freely all moving parts, place the assembly in proper aligned position after replacing blocks and bearings as removed. Rotate camshaft to check for binding. Apply flange dowel bolts and reassemble rocker arms and associated parts. Check valve timing of at least one cylinder to check segment positioning and then make other adjustments such as exhaust valve setting and injector timing.

Camshaft Segment Removal

Short segments and long segments on 16 cylinder engines can be removed separately after removing oil lines, bearing block caps, rocker arms, and flange dowel bolts. Short segments adjacent spacers on 12 cylinder engines have offset dowel bolt heads fitting into the spacers and are covered by the abutting segment flange. The threaded end of these bolts extend through the spacers and segment flange. Since the bolt heads are covered by opposite segment adjacent the spacers, it is necessary to first remove the segment preceding or following the segments abutting the spacers, to give clearance of the dowel bolts through the spacer and flange.

In the case of long segments on 12 cylinder engines it is necessary to remove the entire camshaft to enable one long segment to be removed since no clearance is available for longitudinal movement to clear the spacer bolts. The long segment on the 6 cylinder engines comprise the entire camshaft and are removed as previously outlined.

Camshaft Stubshaft Bearing Bracket Removal

To remove the stubshaft bracket on the front of the engine, it is necessary first to remove the overspeed trip housing cover, overspeed trip and counterweights and remove segment flange to stubshaft mounting bolts.

The rear end stubshaft brackets can be removed after first removing gear train housing covers, camshaft drive gears and counter-weights, oil supply lines and segment dowel bolts to stubshaft flange.

Stubshaft brackets are mounted on the crankcase. Care should be taken on some repaired engines, which have had the end plate machined resulting in crankcase undersize length, as shims are used under stubshaft bracket to bring their length to standard to accommodate without interference a standard camshaft assembly.

3. Firing Order and Top Dead Center

Column A - Firing Order.

Column B - Position of flywheel in degrees when piston is at top dead center.

6 Cylinder		8 Cylinder		12 Cylinder		16 Cylinder	
A	B	A	B	A	B	A	B
1	0°	1	0°	1	0°	1	0°
4	45	5	45	12	19	8	22-1/2
3	120	3	90	7	45	9	45
6	165	7	135	4	94	16	67-1/2
2	240	2	180	3	120	3	90
5	285	6	225	10	139	6	112-1/2
		4	270	9	165	11	135
		8	315	5	214	14	157-1/2
				2	240	4	180
				11	259	5	202-1/2
				8	285	12	225
				6	334	13	247-1/2
						2	270
						7	292-1/2
						10	315
						15	337-1/2

4. Locating Top Dead Center

If it should become necessary to check the position of the flywheel or the flywheel pointer for top dead center proceed as follows:

a. Remove injector from No. 1 cylinder.

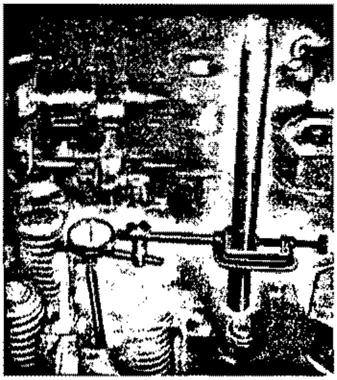
b. Turn crankshaft in normal direction of rotation until piston is just before top center.

c. Insert threaded rod #8051833 through injector hole and screw into threaded piston pulling eye hole in crown of piston.

d. Attach dial indicator #8039138 to a bolt screwed into threaded lifter hole in cylinder head, Fig. 6-8. Place indicator as shown, and depress a few thousandths of an inch.

e. Set indicator at zero and mark flywheel at pointer. Turn crankshaft in normal direction until piston moves up to and past top dead center and indicator returns to zero.

NOTE: The distance the piston travels after the indicator is attached should be within the range of the indicator.



Locating Top Dead Center
Fig. 6-8

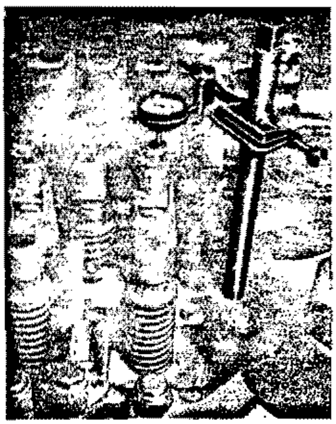
f. Continue turning crankshaft until piston moves approximately .010" past zero, then turn crankshaft in opposite direction until indicator returns to zero. This will compensate for backlash in gear train and rod bearings.

g. Mark flywheel again at pointer. Divide distance between the two marks. This point will be top dead center for No. 1 piston.

The top dead center of any piston can be determined in the same manner.

5. Checking Exhaust Valve Timing

To check timing, place a dial indicator on the rocker arm adjusting screw as shown in Fig. 6-9. Valve end of rocker arm must be in its highest position, so



Timing Exhaust Valves
Fig. 6-9

that the exhaust valves are closed. Press indicator down approximately .100" and set dial to zero.

Turn crankshaft in normal direction of rotation until flywheel is at 106° A.T.D.C. of cylinder being checked. If timing is correct, the valve bridge will have moved down .014". Timing must not be later than 110° or earlier than 104° A.T.D.C. of cylinder being checked.

6. Timing Exhaust Valves

When blowers, oil separator, camshaft drive housing covers are removed for replacement of camshaft assembly, stubshafts or gears, the exhaust valves are timed as follows:

a. Remove or loosen all rocker arms except the one on which the dial indicator is resting. Each camshaft must be timed to the crankshaft. Checking timing of any one cylinder of each bank is usually sufficient.

b. Locate top dead center for the cylinder to be checked (See item 4). Remove the dowels and bolts from the camshaft drive gear and remove gear. The camshaft can be rotated by placing a socket and wrench on flange bolt nuts.

c. Rotate the camshaft in its normal direction of rotation until the exhaust valve being checked opens .014".

d. Turn the crankshaft in the normal rotation until flywheel pointer reads 104° after top dead center of the cylinder being checked. If a new gear train has been installed, the timing may be as early as 104° but not later than 106°. Unless a new gear train has been installed, it is preferable to set timing as nearly to the 106° marks as possible. With flywheel at 104° A.T.D.C. of the cylinder being checked, the dowel holes in the camshaft drive gear applied and dowel holes in the camshaft stubshaft should be in line or approximately in line with each other. If by turning the crankshaft from 104° to 106° A.T.D.C., the dowel holes can be made to line up, then the bolts should be tightened. If the dowel holes do not line up within this tolerance, remove the camshaft gear from its stubshaft. Turn the gear 180° and replace on stubshaft or move the gear one tooth and replace on the stubshaft. The dowel holes should then line up.

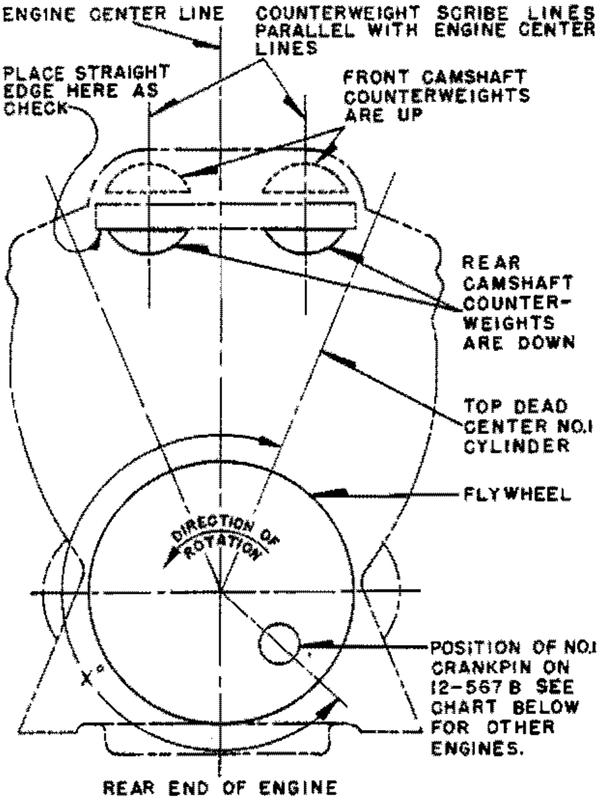
e. If it is not possible to line up the dowel holes perfectly, they may be reamed oversize and oversize dowels installed. This will eliminate the necessity of redrilling the gear and stubshaft. Secure gear to its stubshaft.

f. The crankshaft should now be rotated in its normal direction and the timing checked so that the exhaust valve being checked is open .014" when the crankshaft flywheel and timing pointer are between 104° - 106° A. T. D. C.

7. Counterweights

Counter-weight replacement is rarely necessary. When applying counter-weights be sure they are installed in their proper position as indicated in Fig. 6-10.

To improve engine operation, 12 and 16 cylinder engine camshaft counter-weights have been made heavier. The first heavier counter-weights were leaded, that is, they were drilled and lead plugs inserted in the weight. These leaded heavier counter-weights were first used in engines having the following serial numbers; 12-567A #C50-10567, 12-567B #C50-10442 and 16-567B #C50-10572. Leaded weights were used until later counter-weight castings were made heavier to alleviate the use of the leaded plug inserts. Engines having the following



X = DEGREES AFTER T.D.C. OF NO.1 CYLINDER. TO GET THE CRANKSHAFT IN THIS POSITION, TURN THE FLYWHEEL UNTIL THIS NUMBER IS AT THE POINTER.

ENGINE MODEL	X EQUALS
6 - 567B	172½°
8 - 567B	247½°
12 - 567B	249½°
16 - 567B	105°

Counterweight Timing
Fig. 6-10

serial numbers were the first to have the heavier cast counter-weights, 12-567A #G50-11396, 12-567B #H50-11461 and 16-567B #G50-11400. Engines having serial numbers after these will have the heavier counterweights. Leaded and cast heavier counter-weights used in the same location on a particular engine have the same part number, but differ in part number from previously used light counter-weights.

The heavier counter-weights may be applied to 12 and 16 cylinder "A" and "B" engines originally equipped with light counter-weights, but must be replaced in complete sets, and not individually.

It is recommended that engines having leaded counter-weights be inspected when available to determine if the lead plug inserts are securely in place. If a lead plug is loose or missing, the counter-weight should be replaced by a new heavier casting weight having a part number corresponding to its location on the camshaft. Preferably all four leaded counter-weights should be replaced with the heavier casting weights. In any event do not intermix light counter-weights with either leaded or heavier casting counter-weights.

Since one of the four counter-weights is in the overspeed trip assembly, it may be possible to attribute improper overspeed trip function to a leaded counter-weight with the lead inserts dislodged.

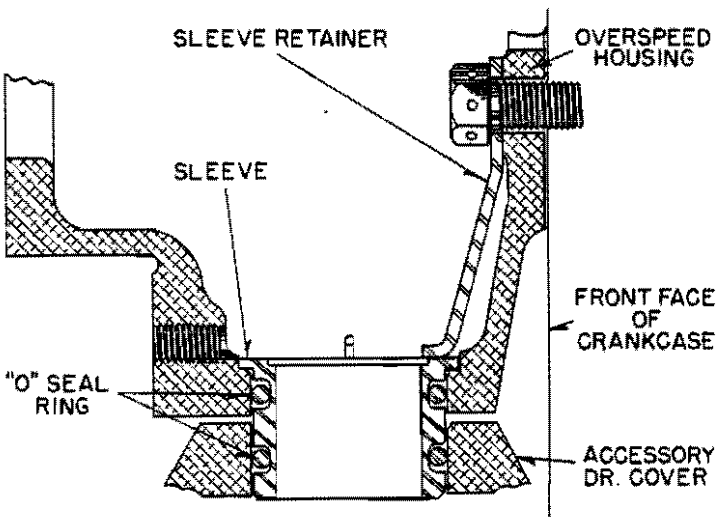
8. Adjusting Overspeed Trip

To adjust the overspeed trip, shut engine down, remove the cover from right side of overspeed trip housing and turn adjusting nut to increase or decrease spring tension as required. To increase engine speed at which overspeed trip operates, increase spring tension.

After the adjusting nut has been moved, the lock-nut must be tightened and the engine run to test speed at which trip operates. The speed rise of the engine from idle to trip should be made in 20 to 30 seconds. Several adjustments may be required before final setting of 900-910 RPM tripping speed is reached.

See Scheduled Maintenance Program for frequency of checking overspeed trip.

NOTE: A new overspeed trip spring 8190036 replaces prior used spring 8059628. The new spring provides greater stability of overspeed trip settings. Spring 8190036 is larger in diameter than spring 8059628 and requires the use of washer 116097 between the adjusting nut and spring. This is the same washer used at top of spring. Adjustment of the new spring gives about 15 RPM per revolution of the adjusting nut. Spring length of 4 3/16"-4 7/32" gives about 900 RPM tripping speed.



New Overspeed Trip Housing Sealing Arrangement
567B Engines
Fig. 6-11

Overspeed Trip Housing Seal

Figure 6-11 shows a new overspeed trip housing to accessory cover sealing arrangement used on later 567B engines. On previous "B" and other engines a gasket is used between the housing and cover.

Because of insufficient metal it is not advisable to rework older type cored holes to accommodate the new sealing arrangement. Modification Instructions may be obtained from the Service Department to improve earlier "B" engine accessory drive housing to overspeed trip housing seal.

In the event of disassembly, new seals should be used upon reassembly.

C. SPECIFICATIONS

Gear Ratio To Crankshaft

Gear	No. of Teeth	Ratio to Crankshaft
Crankshaft	79	1:1
Idlers	58	1.362:1
Camshaft Drive	79	1:1
Blower (6 and 12 cyl.)	41	1.925:1
Blower (8 and 16 cyl.)	31	2.55:1
Aux. Gen. Drive (B Eng. Only)	26	3.037:1

Gear Backlash

Crankshaft gear to 1st idler	New .007" - .014" Limit .030"
1st idler to 2nd idler	New .007" - .014" Limit .030"
2nd idler to camshaft drive	New .007" - .016" Limit .030"
Camshaft drive to camshaft drive	New .007" - .022" Limit .030"
Camshaft drive to blower drive	New .007" - .016" Limit .030"

Aux. gen. drive to 2nd idler B engine	New .007" - .016" Limit .030"

Camshaft Drive Gear Clearances

Idler gears - Diametric clearance bushing to stubshaft	New .005" - .008" Limit .016"
Bushing to gear	New .008" - .010" Limit .018"
Thrust clearance #1 idler	New .009" - .017" Limit .025"
Thrust clearance #2 idler	New .050" - .068" Limit .080"
Blower drive gears - diametric clearance bushing to stubshaft	New .003" - .005" Limit .016"
Bushing to gear	New .007" - .009" Limit .018"
Thrust clearance	New .009" - .017" Limit .025"

Auxiliary Generator Drive ("B" Engine)

Diameter of journal	New 2.499" - 2.500"
Diametrical clearance - drive shaft to bushing	New .0025" - .0045" Limit .0085"
End clearance	New .0105" - .0235" Limit .035"

Camshaft And Stubshaft

Camshaft journal diameter	New 2.496" - 2.498" Limit 2.495"
Diametric clearance - segment journal to bushing (all)	New .002" - .006" Limit .010"
Stubshaft journal diameter (all)	New 2.497" - 2.498" Limit 2.495"
Diametric clearance - journal to bushing	New .0035" - .0075" Limit .010"
Stubshaft - thrust clearance	New .010" - .018" Limit .025"

Camshaft Timing

Limit of lag - camshaft behind crankshaft due to worn gears "4-4" or "A" - "B" camshafts	4° Max. (or 110° A.T.D.C. at .014" lift).
Other than "4-4" or "A" - "B"	2° Max. (or 112° A.T.D.C. at .014" lift).

Timing - with new gear train, not earlier than:

"4-4" or "A" - "B" camshafts	2° Max. (or 104° A.T.D.C. at .014" lift).
Other than "4-4" or "A" - "B"	2° Max. (or 108° A.T.D.C. at .014" lift).

Ideal timing setting

"4-4" or "A" - "B" camshafts	106° A.T.D.C. valve open .014"
Other than "4-4" or "B"	110° A.T.D.C. valve open .014"
Flywheel pointer setting	0° T.D.C. of #1 cylinder

Overspeed Trip

Clearance - trip latch to flyweight	.010" Min.
Trip setting	900-910 RPM

D. EQUIPMENT LIST

	Part No.
Rod For Locating Top Dead Center	8051833
Dial Indicator	8039138

NOTES

SECTION VII

BLOWER

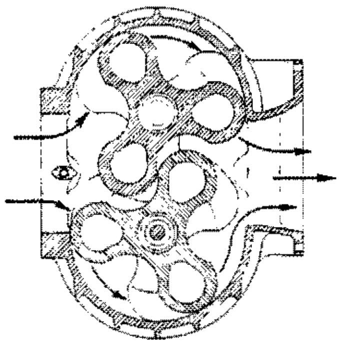
A. DESCRIPTION

1. Blower

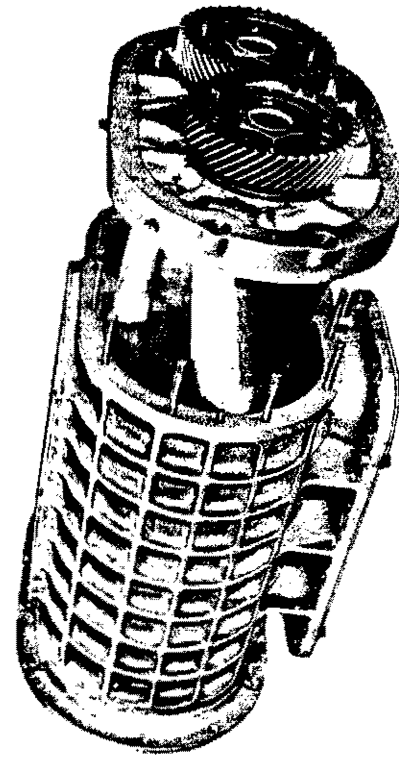
The blower, Fig. 7-1, consists of a pair of helical three-lobed rotors which revolve in a closely fitted housing. This type of construction produces a large volume of air at low pressure and insures a positive supply of air to the engine proportional to engine speed. The 6-567B and 8-567B engines have one blower and the 12-567B and 16-567B engines have two blowers.

Each rotor is pressed on a tubular steel shaft. The engine ends of these shafts form journals which carry the rotors in bearing blocks bolted to the blower end plate. The ends of the shafts which extend through the end plate on the rear end of the blower are serrated. Flanged hubs, with a serrated bore, are pressed onto the serrated tubular shafts and serve as bearing journals and drive flanges for a matched pair of helical rotor gears. This construction provides a fixed relationship between the rotors and the rotor gears. Bearing blocks on the outer end of the blower are bolted to the end plate and carry the thrust from both directions. All bearing blocks in the blower have sleeve type bearings.

The blower bearings are pressure lubricated by oil from the auxiliary generator drive housing. Lubricating oil for the bearings is supplied through drilled passages in the blower end plates. The oil is conducted from the rear to the front end plate through a steel tube which is cast into the blower housing. The rotor gears are lubricated by the gear teeth dipping into a reservoir of oil, the level of which is maintained by a standpipe at the inlet end of the blower drain line.



Blower Operation



Blower
Fig. 7-1

Oil seals are fitted in the end plates to prevent oil from leaking around the rotor shafts and entering the rotor housing.

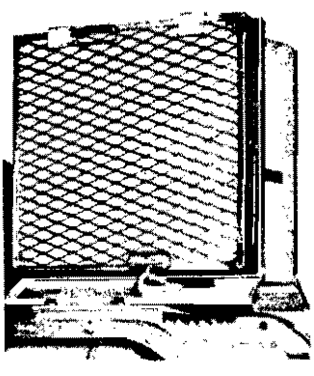
Gaskets are not used between the end plates and the blower housing. A fine silk thread around the housing, inside the stud line, together with a very thin coating of non-hardened gasket compound, provide an air-tight and oil-tight seal.

A cross-section of the blower is shown in Fig. 7-3.

2. Blower Drive

Each blower is driven by a blower drive gear in the camshaft gear train. A flanged quill shaft extends through the outside tubular rotor shaft and is bolted to a rotor gear. The opposite end of the quill shaft is serrated and fits into a hub mounted on the blower drive gear.

The quill shaft extends through the rotor adjacent to the narrow flange or outside of the blower on 567B and 567A engines and through the inboard rotor or wide flange side of 567 engine blowers, on either right or left bank blowers. The wide side of the mounting base is inboard of the engines on all blowers.



Engine Air Filters
Fig. 7-2

3. Engine Air Filters

The intake air for the engine is cleaned before it reaches the blower by the engine air filters, Fig. 7-2. Intake air silencers also are used. The silencers are an integral part of the blower adapter and filter housing, Fig. 7-2. Previously used silencers were separate units connected to the blower adapter.

B. MAINTENANCE

1. Servicing Blower

Blowers needing repair should be returned to Electro-Motive. See Factory Rebuild Service Bulletin #301.

2. Blower Inspection

It is recommended that blowers be inspected at intervals specified in the Scheduled Maintenance Program.

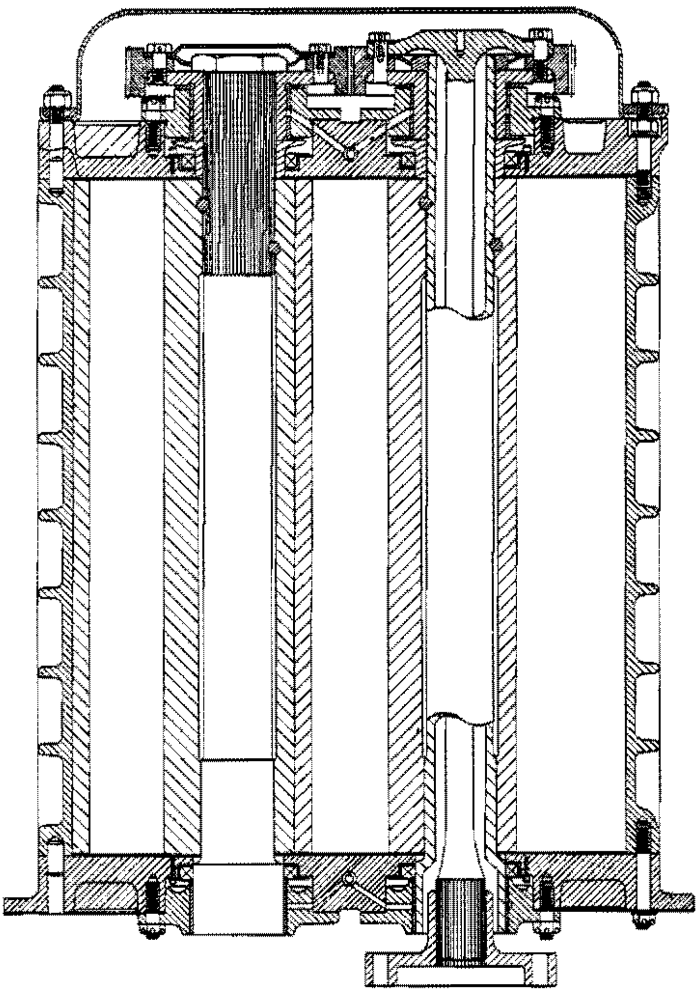
If blower bearings become worn enough for rotor interference, aluminum dust will appear in the blower support housing and in the air box. A blower in this condition must be replaced at once.

A leak at the blower oil seals will show an excessive amount of oil running down the blower support and into the air box, and excessive oil on rotors and end plates.

NOTE: Air pressure should not be used to test blower seals.

When inspecting blower rotors, a clean strip on the crown radius or high part of the lobes, running the entire length of the lobes, may be seen on some rotors. The strip appears to be flat, but actually is hand worked to conform to the housing bore. The hand working operation is done to match pairs of rotors for close clearance, and the width of the strip will vary on different rotors.

The strip on the lobes is the closest point of rotor contact and therefore is usually cleaner than other lobe areas. Scratches may appear on the strip due to dirt particles finding their way into the blower,



Engine Blower Cross-Section
Fig. 7-3

but generally they are of no consequence. Accordingly, the clean strip or evidence of scratches on it should not be interpreted as an indication of rotor to rotor or rotor to housing contact.

3. Blower Removal

General removal procedure is as follows:

a. Remove oil separator lines to blower adapter. Remove tachometer drive (if used).
b. Remove blower lube oil supply and drain lines and apply blank flange or otherwise cover openings.
c. Remove air filter element, element housing, blower adapter and flexible duct (if used).
d. Remove stud nuts and capscrews securing blower to support and camshaft drive housing.
e. Slide blower straight back from the engine until splined shaft clears spline drive on blower drive gear.
f. With the aid of a chain hoist or equally safe means, carefully raise and remove the blower from its support.

4. Installing Blower

To install a blower, reverse the procedure outlined in paragraph 3 above. Grease the blower to blower support gasket so that the blower can be moved into place without moving or tearing the gasket. Line up spline drive and slide blower straight into position.

5. Blower Changeover

Blowers used on 567B engines are similar to blowers on other 567 series engines. Blowers used on the same bank may be exchanged from 567A to 567B without alteration. To change over a 567 blower to a 567A or 567B, of the same bank, the drive quill shaft is changed from the inside blower rotor gear to the outside gear, or vice-versa from 567A or B to 567 engine. Each engine retains its blower oil return line.

Installation of the blowers are the same, with the wide mounting flange inward of the engine.

To change a 567 blower to same bank on 567A or 567B engine or vice-versa:

a. Remove blower end cover, quill shaft and gear cover on opposite gear from quill shaft.
b. Drill and ream two dowel holes in gear opposite original quill shaft location and dowel quill shaft to gear.
c. Replace gear cover on opposite gear and replace blower end cover. Cover nut torque values are 35-40 foot pounds.

Due to the difference in location of the spline drive in the 567 engine blower from the 567B or 567A engine blowers, there are different part numbers identifying 567 engine blowers from 567B and 567A blowers.

Also, blowers originally equipped with a tachometer drive provision, used on some earlier locomotives, have been discontinued. If tachometer drive is desired for a replacement blower, a separate and additional list of parts are required, and may be obtained from our Parts Department.

6. Engine Air Filters

It is extremely important that the air filters be kept clean. Spare elements which have been cleaned, oiled and drained, should be on hand at all times to avoid delay. Remove and replace with clean elements at intervals listed in Scheduled Maintenance Program. Refer to Maintenance Instruction 1706 for details of equipment and procedure for cleaning, oiling and draining air filter elements. When filters are removed for cleaning, cover the blower air inlet.

To provide improved air filtration engines are now equipped with 4" thick Farr type filters, instead of prior used 2". Information concerning application of latest design engine air filters as replacements may be obtained from the Service Department.

C. SPECIFICATIONS

Blower	6 & 12 Cyl.	8 & 16 Cyl.
Blower speed (at 800 RPM of engine)	1540 RPM	2040 RPM
Blower capacity (per blower at 7-1/2" Mercury)	2000 CFM	2700 CFM
Blower pressure at 800 RPM of engine (approx.)	6" to 8" of Mercury	

	NEW Min. - Max.	LIMIT
*Clearance - Rotor to Rear End Plate (away from gears)	.012" - .023"	.025"
*Clearance - Rotor to Front End Plate (near blower gears)	.0085" - .0195"	.022"
Clearance - Housing to Rotor	.008" - .012"	.015"
Clearance - Rotor to Rotor	.008" - .012"	.015"
Diametric Clearance Rotor Shaft Bearing	.002" - .0045"	.008"
Thrust Clearance - Rotor Bearing	.002" - .0035"	.008"
Backlash - Synchronizing Gears	.000" - .0025"	.006"
Runout - Timing Gear Face	.002" T.I.R.	.002"
Runout Quill Shaft (after assembly)	.025"	.025"

*Rotor end clearance to be measured with rotors pushed toward the end of which clearance is being measured.

	NEW Min. - Max.	LIMIT
Blower Drive Gear		
Diametric clearance - Bushing to Stubshaft	.003" - .005"	.016"
Diametric clearance - Bushing to Gear	.007" - .009"	.018"
Thrust Clearance	.009" - .017"	.025"

D. EQUIPMENT LIST

Name	Part No.
Blower Lifting Plate	8072929
Feeler Gauge	8070965
Blower Nut Ratchet Wrench (Long handle for inaccessible nuts)	8177166

NOTES

SECTION VIII

LUBRICATING OIL SYSTEM

A. GENERAL DESCRIPTION

The engine lubricating system is a combination of three separate systems: the engine lubricating oil system, piston cooling oil system, and scavenging oil system. The engine lubricating system supplies oil for lubrication of the various moving parts of the engine. Piston cooling system supplies oil for the cooling of the pistons and lubrication of the piston pin bearing surfaces. The scavenging oil system serves the purpose of supplying the other two systems with cooled and filtered oil, by taking the oil drained into the oil pan sump and forcing it through the filter and coolers from where it flows to the suction strainer housing supplying the lubricating and piston cooling oil pumps. Parts of the lubricating system mounted on the front of the engine are shown in Fig. 8-1.

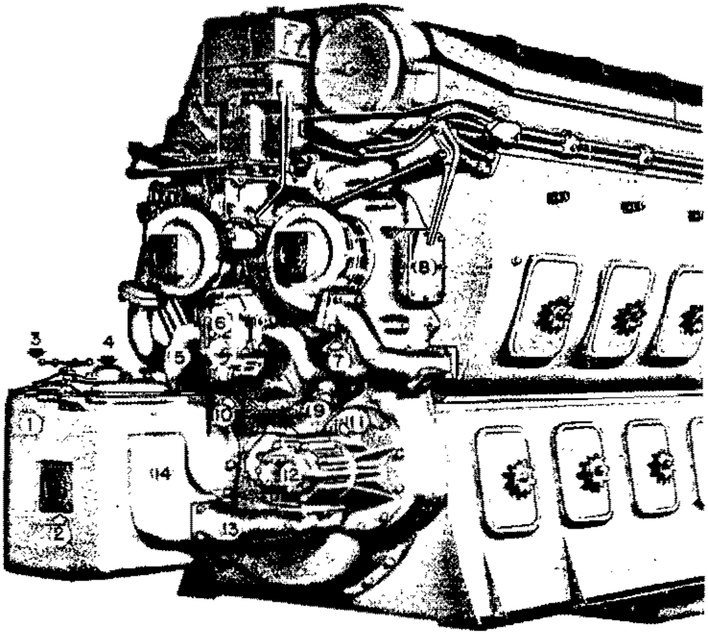
B. UNIT DESCRIPTION

1. Oil Pan

The oil pan, Fig. 1-2, serves as the support for the crankcase and enclosure for the lower part of the engine. It is rectangular in shape, having handholes on each side. It serves as the reservoir for the lubricating oil. The bottom is made sloping toward a longitudinal channel running from each end of the pan into a rectangular reservoir in the center of the oil pan. When the engine is stopped the lubricating oil drains to this sump except that oil trapped in the lines, filters, cooler and strainer housing. A large diameter suction line is welded into the oil pan at the right side, extending from the reservoir at the center of the oil pan to the front end of the oil pan where it connects to an inlet, Fig. 8-8, Item 1, of the scavenging pump suction

EXPLANATION

1. Strainer Housing.
2. Cooler Oil Inlet to Housing.
3. Lube Strainers Hold Down Crab.
4. Filler Opening Cover.
5. Lube Oil Suction to Lube and Piston Cooling Pumps.
6. Lube and Piston Cooling Pumps.
7. Lube Oil Discharge.
8. Oil Manifold Relief Valve Cover.
9. Piston Cooling Discharge.
10. Strainer Seal Oil Supply Line.
11. Scavenging Pump Outlet.
12. Scavenging Oil Pump.
13. Scavenging Oil Pump Suction Line From Strainer Housing.
14. Scavenging Suction Strainer Oil Outlet Channel.

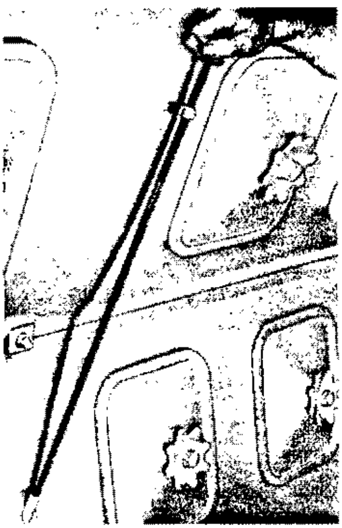


Lubricating System Components
Fig. 8-1

screen. The suction end of this line is rectangular box shaped and extends down into the oil in the sump, a few inches from the bottom, being under oil at all times to provide good scavenging pump operation.

A bayonet type oil level gauge, Fig. 8-2, is provided at the center of the oil pan. Each gauge, Fig. 8-3, shows engine oil capacity, oil level marks, and has a part number to identify it for use in a particular model engine. Gauges with different oil level marks are used. Gauge shown in Fig. 8-3 (a) is currently used in all "B" engines, but gauge shown in Fig. 8-3 (b) is used in earlier "B" engines.

The currently used gauge has only the "Low" and "Full" oil level marks and states oil level to be checked while engine is at idle speed and hot oil. The level should be maintained between these marks while the engine is running. Oil system capacity is stamped on the gauge.



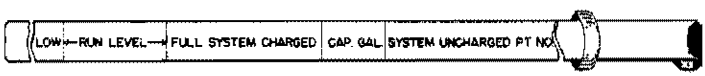
Lube Oil Level Gauge
Fig. 8-2

Upon adding the required oil capacity to a new engine or refilling after draining, the oil level will be above the full mark. Running engine will bring the level to the full mark; if not add oil up to this mark. Oil level will be lower when the engine is running than when the engine is stopped, because of oil contained in the lines and system auxiliaries.

The prior gauge, Fig. 8-3 (b), has "Low" and "Full" marks which are used identically to like marks on the new gauge Fig. 8-3 (a). Oil level must be maintained between the "Low" and "Full" marks while the engine is running. This gauge has two additional marks, "System Uncharged" and "System Charged." System Uncharged level corresponds to the oil level after filling a new engine or refilling a drained engine to its proper capacity before the engine is run. The "System Charged" mark indicates oil level after running an engine previously filled to the "Uncharged" mark, run, and then shut down. The difference in their level marks indicates oil held in the system while and after running.

Any oil supplied to the engine lube oil system should be added through the square opening in the strainer housing, with housing drain valve closed. Do not attempt removal of the circular covers or crab of the pump suction strainers while the engine is running.

(a)



(b)

Oil "Dip-Stick"
Fig. 8-3

2. Oil Strainer Housing

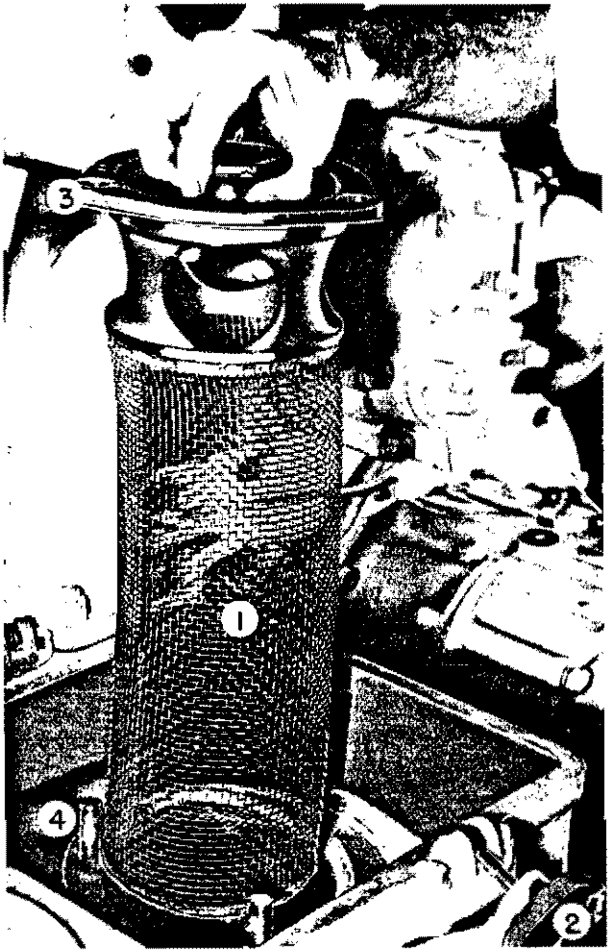
The oil strainer housing is a large rectangular cast aluminum housing mounted on the front right side of the engine on the accessory drive cover, Fig. 8-1, Item 1. The scavenging pump strainer, located in the strainer housing, is a coarse mesh strainer on the suction side of the scavenging oil pump. The lube oil and piston cooling pressure pumps are both contained in one housing and have a common suction from the two fine mesh suction strainers in the strainer housing.

The scavenging and lube oil pump strainers are independent of each other, each having their own inlet and outlet openings. All oil entering or leaving engine will pass through these strainers entering the pumps.

The coarse mesh strainer for scavenging pump suction, Fig. 8-4, Item 1, is located under the square filler opening cover, held by knurled nuts, Item 2, and contained in a cylindrical chamber. The screen is held in this chamber by 3 studs and nuts, and a gasket is provided to seal the top of the screen, Items 3 and 4. A perforated metal filler basket is mounted above the scavenging screen to exclude large objects while adding oil.

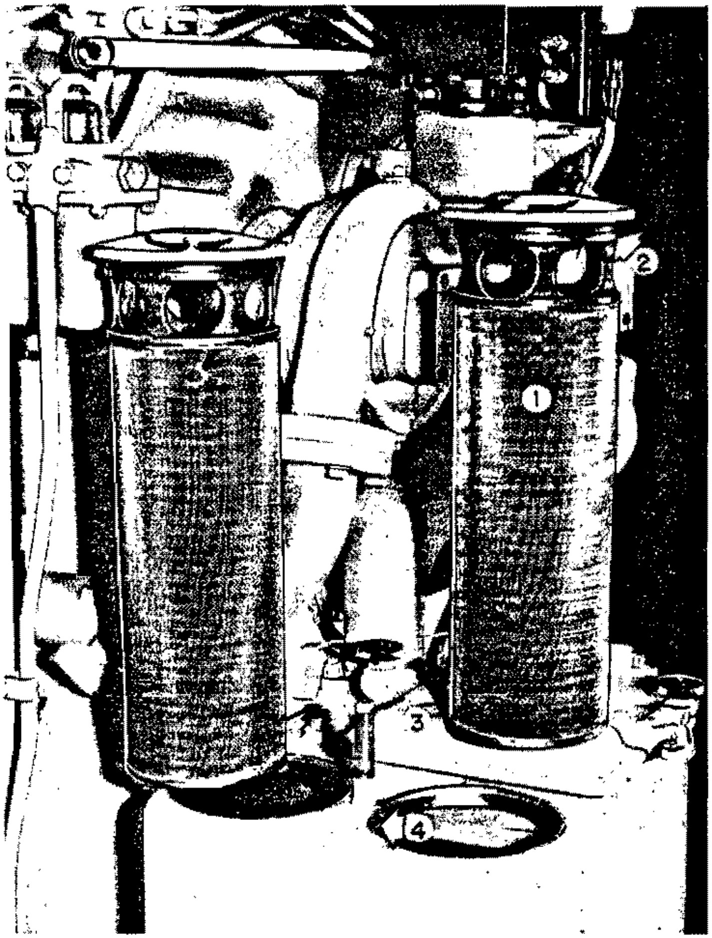
The two lube oil pressure pump strainers fit in the two cylindrical chambers shown in Fig. 8-5. They are provided with a ring seal, Item 2, at their top and held in place by the strainer crab and handwheel, Fig. 8-1, Item 3. To assure no air enters the suction passage at the top of the strainers, lube oil under pressure from the lube oil pump is admitted to a groove around the top of each strainer, Fig. 8-5, Item 2. This oil is admitted through a horizontal drilled passage at the back of the strainer housing, Fig. 8-6, Item 6, to the groove of the first strainer and through a connecting line opposite the groove, Fig. 8-5, Item 4, to the second strainer. Any leak at the outside top of the strainers will be noted by lube oil coming out of the housing, preventing the suction of air through the leak by the lube oil pressure from the lube oil pump. An opening is provided for the application of the lube oil high suction line to the pressure pump suction passage in the housing as shown in Fig. 8-6, Item 7. This line extends to the high suction protective device contained in the governor on the electro-hydraulic and pneumatic-hydraulic governor and to the lube oil suction switch on engines with electro-pneumatic governor.

The lube oil pressure and piston cooling oil pump strainers receive their oil supply from the chamber in



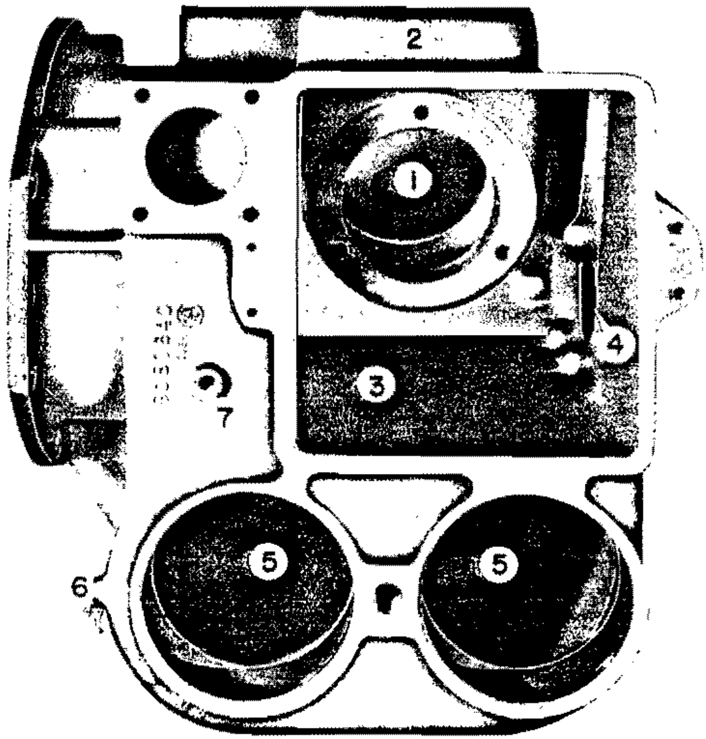
1. Scavenging Oil Strainer
2. Filler Cover Knurled Nut
3. Strainer Gasket
4. Strainer Holding Stud

Scavenging Pump Strainer
Fig. 8-4



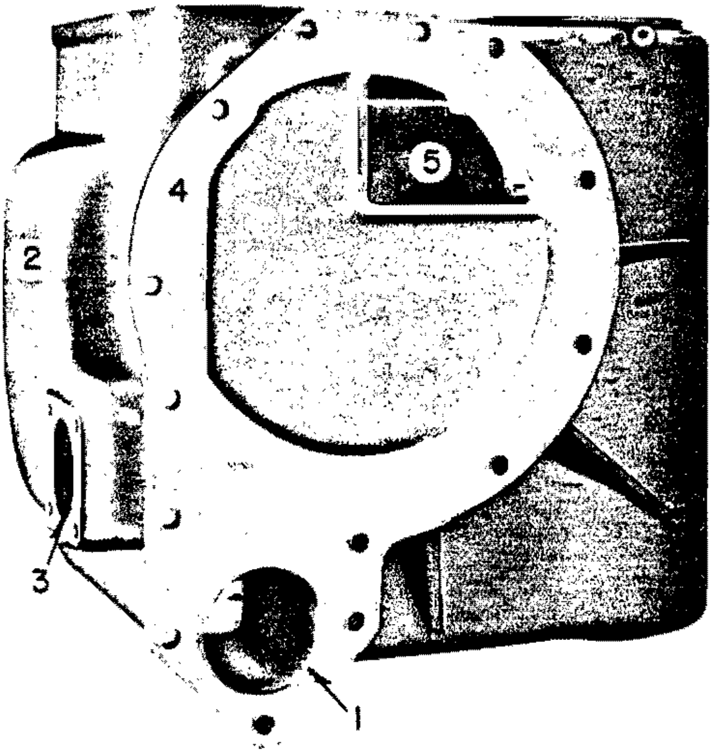
1. Strainer
2. Ring Seal
3. Filler Cover
4. Oil Passage

Pressure Pump Strainers
Fig. 8-5



1. Scavenging Screen Hole
2. Scavenging Suction
3. Oil Cooler Discharge Chamber
4. Cooler Discharge Inlet
5. Suction Strainer Holes
6. Oil Inlet To Strainer Groove
7. High Suction Oil Line Connection

Strainer Housing Passages
Fig. 8-6



1. Scavenging Oil Suction Inlet
2. Scavenging Oil Discharge Channel
3. Scavenging Oil Outlet To Pump
4. Housing Mounting Flange
5. Oil Overflow

Back Of Strainer Housing
Fig. 8-7

the strainer housing for the return oil from the lube oil cooler, Fig. 8-6, Item 3. The strainer chamber, Item 5, is separated from this chamber by a dividing partition which is open at the bottom edge permitting the oil to flow to the strainers.

Excess oil, or oil not required by the pressure pumps is allowed to overflow into the accessory gear housing through an opening at the back of the strainer housing, Fig. 8-7, Item 5. The bottom of this opening forms a dam which maintains an oil level for the pump suction strainers.

Draining of the strainer housing is accomplished either by an external or an internal drain. A flange (no longer used on present housings) at the front of the housing provides a connection for an external drain line and shut off valve. The internal drain provided in new housings, Fig. 8-8, consists of an oil passage between the oil storage portion of the housing and the scavenging suction screen which is normally closed by a valve. The valve handle extends up through the perforated filler basket and is normally held down by a spring, closing the valve. When the valve handle is raised and turned to hold it open, oil drains from the housing into the oil pan through the scavenging screen and suction pipe. This valve should be kept closed at all times except while used to drain the housing.

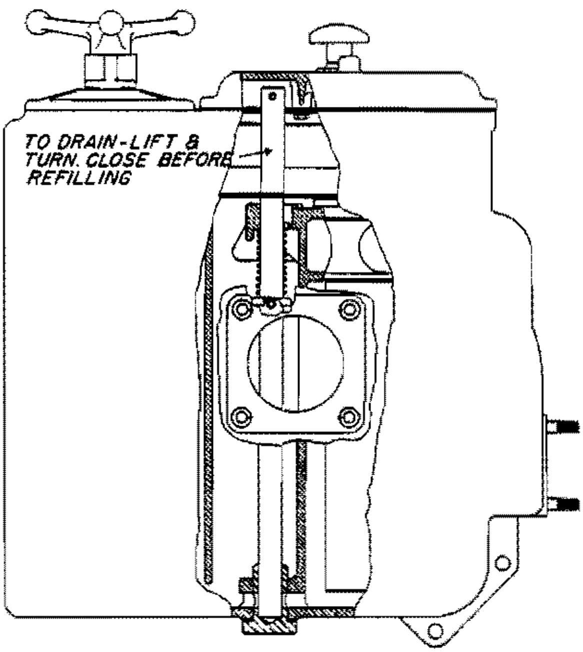
3. Scavenging Oil Pump

The scavenging oil pump, Fig. 8-1, Item 12, is mounted on the accessory gear cover in line with and to the left of the crankshaft and is driven by the accessory drive gear.

The scavenging oil pump, Figs. 8-9 and 8-10, is a positive displacement, helical gear type pump, and self priming. The pump housing, which is split transversely for ease of maintenance, houses a double set of mated pumping gears. The driving gears are retained on the pump drive gear shaft by Woodruff keys. The idler shaft is held stationary in the housing by a lock screw, and driven pump gears rotate on this shaft on bushings pressed into the gear bore. The drive shaft turns in bushings pressed into the pump housing. These bushings are made with thrust collars which protrude slightly above the pump body and absorb the thrust of the drive gears.

4. Lube Oil and Piston Cooling Pressure Pump

The lube oil and piston cooling pressure pump is similar to the scavenging oil pump except for a division plate between the two sections of the housing which

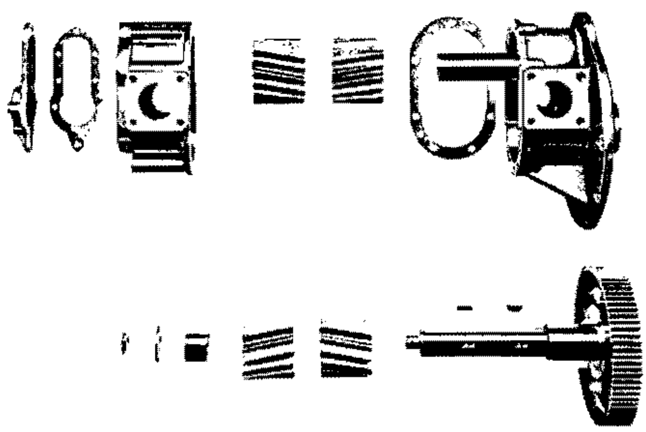


Strainer Housing — Internal Drain
Fig. 8-8

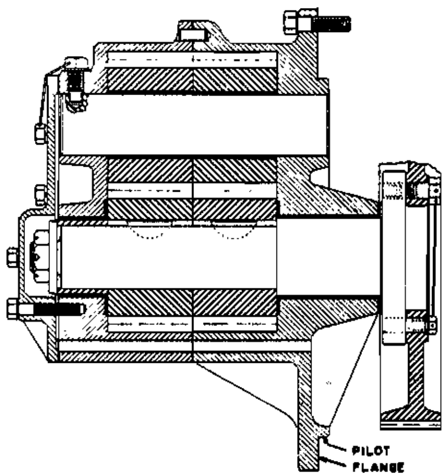
separates the two sets of pumping gears, giving a separate discharge for each set, Figs. 8-11 and 8-12. The outer set of gears, which delivers the piston cooling oil, are much narrower across the face than the inner gears, which supply the lubricating pressure oil. The pump housing is mounted in the center of the accessory gear cover directly over the crankshaft, Fig. 8-1, Item 6, and is driven by the accessory drive gear. The lube oil pumps of all 567, 12 and 16 cylinder "B" engines are approximately 20% greater capacity than lube oil pumps formerly used on 567 engines. The greater capacity pumps can be identified by a large "L" on the pump mounting flange. The large capacity pump can replace a small pump, but a small capacity pump cannot be used on engines originally equipped with the large capacity pump. Small capacity pumps returned for rebuild will be converted to large capacity pumps.

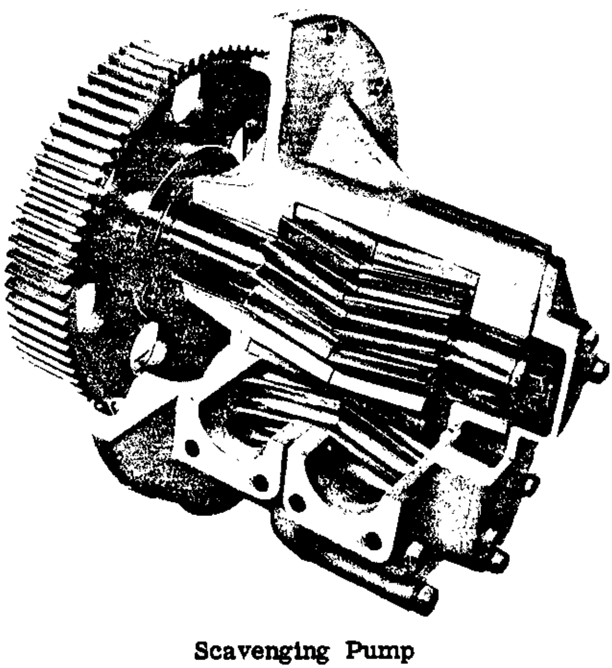
5. Lube Oil Pressure Relief Valve

The lube oil pressure relief valve, Fig. 8-13, is mounted on the lube oil cross-over manifold under

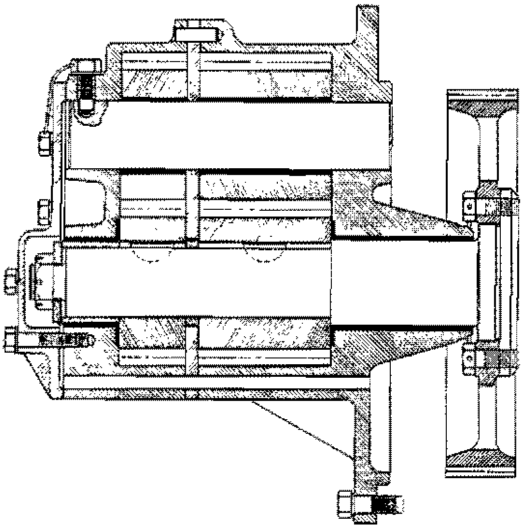


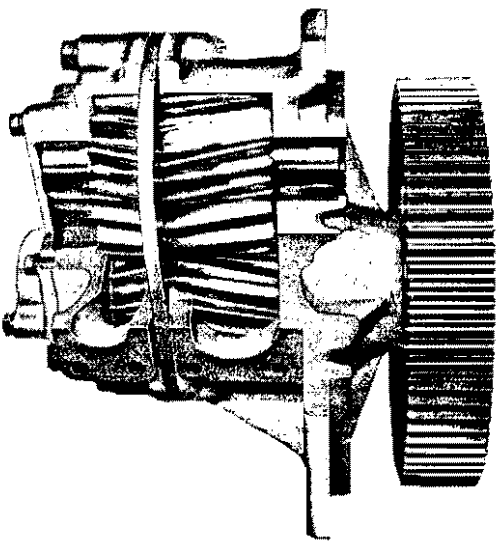
Scavenging Pump Exploded
Fig. 8-9





Scavenging Pump
Fig. 8-10





Lubricating And Piston Cooling Pump
Fig. 8-11

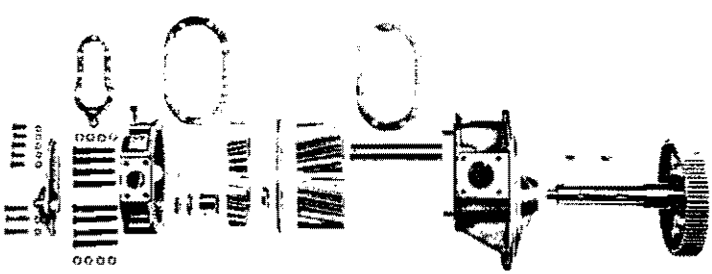
the accessory gear train cover on the left side of the engine, Fig. 8-1, Item 8. A cover plate, easily removable, is provided for access to the valve for inspection and adjustment.

The purpose of the valve is to limit the maximum pressure of the lube oil entering the engine lube oil system. When the pump pressure exceeds the spring tension on the valve it will lift the valve off its seat and relieve the excess pressure. This oil drains into the accessory housing and to the oil pan sump.

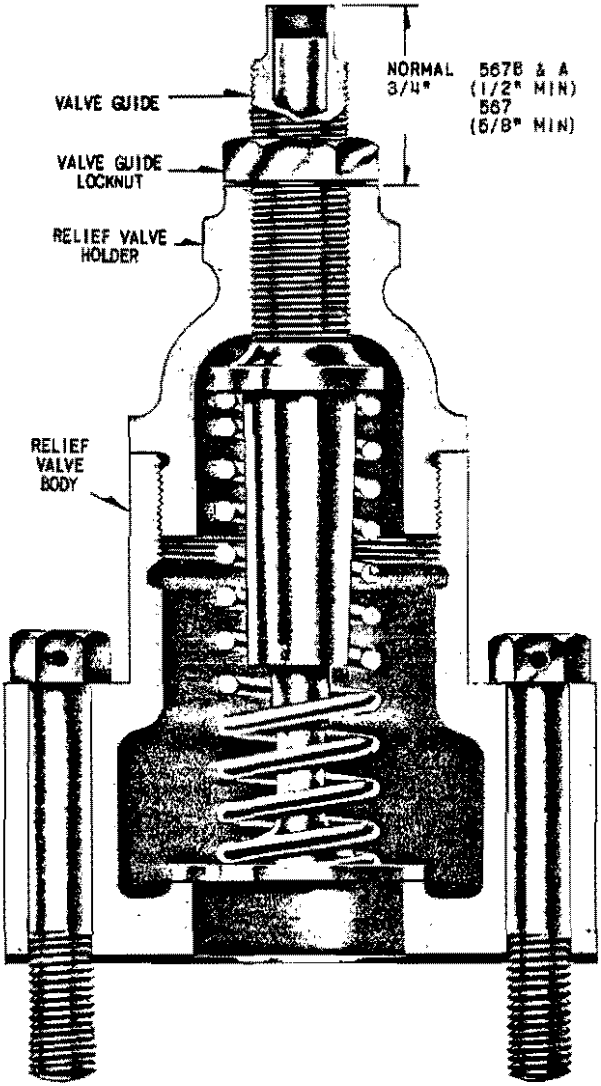
6. Lube and Piston Cooling Oil Manifold

The lubricating and piston cooling oil manifold is a one piece casting with cored passages, Fig. 8-14. The manifold is mounted and doweled in the front end plate under the accessory drive cover. Connecting tubes passing through the accessory drive cover, protected against leakage by seal rings, connect the manifold to the discharge of the lube oil and piston cooling pressure pumps.

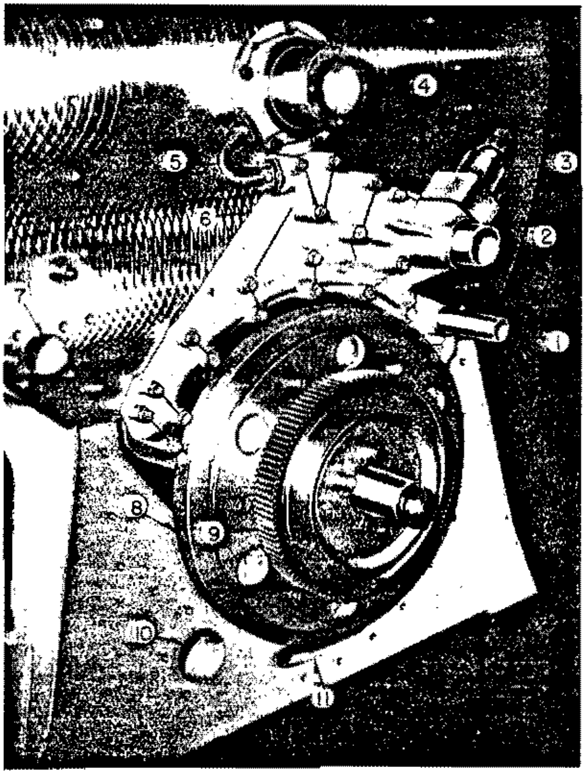
The purpose of the manifold is to transfer the oil supplied by the lube oil and piston cooling pumps to the main bearing oil header in the center of the engine and to the piston cooling oil header pipes on each side of the crankcase just inside the oil pan mounting flange.



Exploded View Of Lube And Piston Cooling Pump
Fig. 8-12



Engine Oil Pressure Relief Valve
Fig. 8-13



1. Piston Cooling Oil Inlet
2. Lubricating Oil Inlet
3. Lubricating Oil Relief Valve
4. Governor Drive Gear Stubshaft
5. Stubshaft Oil Line
6. Lubricating and Piston Cooling Oil Manifold
7. Right Bank Water Inlet
8. Harmonic Balancer
9. Accessory Drive Gear
10. Scavenging Oil Suction Line Outlet
11. Oil Pan Return Oil Opening

Lubricating And Piston Cooling Oil Manifold
Fig. 8-14

7. Lube Oil Filter

Discharge oil from scavenging pump is filtered before reaching the lubricating and piston cooling oil pump strainers through lube oil filters as shown in Fig. 8-15.

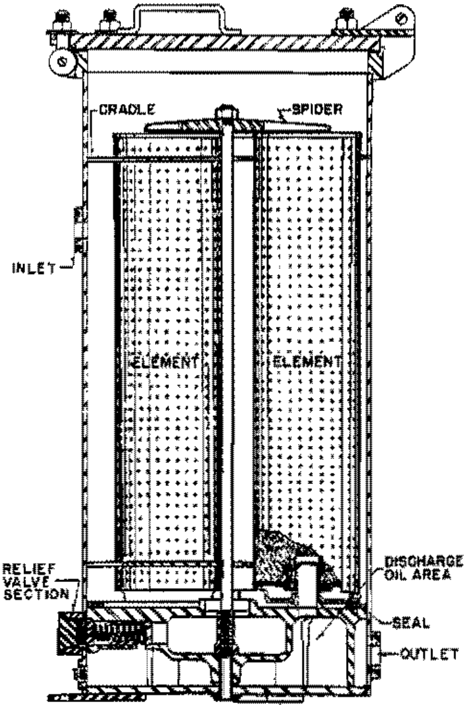
Partial view of the elements in the circular type filter is shown in Fig. 8-16. This type filter may be mounted vertically or horizontally depending on the locomotive. Internally the filter is divided into inlet and outlet compartments by a plate or false bottom above the true bottom of the filter housing. The filter elements seat on the bottom with the center discharge portion communicating with the outlet compartment between the false and true bottom. Spring loaded by-pass valves located at the bottom end of the filter housing allow passage of oil to supply the engine oil requirements by by-passing the elements in the event of cold oil, or oil in volume which cannot be handled by the elements, or in cases when the oil pressure in the inlet compartment exceeds the setting of the relief valves. The filter housing is provided with vent and oil drain lines to drain oil at filter element changes.

Cartridge or sock type elements filled with proper material (Wastex) and consistency for efficient filtering are used. These elements save much labor compared to an earlier method of hand packing with Wastex, and give greater efficiency. (See Maintenance Item 9 for particulars on filter containers and cartridges.)

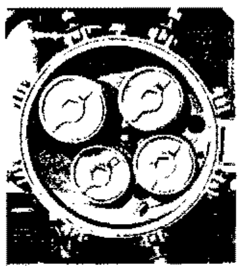
8. Lube Oil Cooler

Since the oil also serves as a coolant in the engine a means must be provided to extract the heat absorbed and condition the oil for re-use. This is accomplished by the oil cooler.

Lube oil coolers may be divided into two types: the water tube type in which cooling water passes



Four Element Oil Filters
Fig. 8-15



Michiana Filter Assembly
Fig. 8-18

through the tubes, and the oil tube type having oil passing through the tubes. The water tube type oil cooler (used on F7, GP7, F3 and F2 locomotives) is shown in the F7 schematic lube oil and cooling water system, at end of this Section. The oil tube type of oil coolers as used on E8, SW8 and SW9 locomotives have the oil cooler contained in the bottom of the water tank, the oil cooler being immersed in water.

Relief valves or other means are provided to protect the oil cooler from over pressure when the oil is cold or in the event of oil passage restriction. The F7 type, shown in the F7 Schematic, has a perforated baffle or dam plate immediately in front of the oil cooler radiator to maintain the oil level at proper height and prevent oil passage around the radiator. Holes in the dam allow oil flow, and if necessary oil may pass over the top of the baffle or dam permitting oil flow to the pump suction strainers.

In other installations, as E8 locomotives, a relief valve across the scavenging pump discharge and oil suction line to the lube pump strainers allows oil to by-pass the cooler and filter housing in the event of cooler inlet oil pressure above the relief valve setting.

9. Lube Oil Separator

The oil separator is mounted on top of the auxiliary generator drive housing. It is a cylindrical metal housing containing a securely held mesh screen element. The housing cover has two openings for suction lines leading to the suction side of the blowers.

Blower suction draws the hot oil vapor and fumes from the oil pan up through the rear end gear train and through passages in the auxiliary generator drive housing into the openings in the center of the base of the separator housing. The oily vapor then passes through the mesh screen, causing the oil to be deposited on the screen. The oil collects in a trough at the bottom of the screen and drains back to the rear end gear train through passages in the oil separator base and auxiliary generator drive housing.

C. OPERATION

1. Scavenging Oil System

The scavenging oil pump draws oil from oil pan sump or reservoir, through scavenging oil strainers, forces the oil through the filter and coolers to supply the lube oil and piston cooling oil pump. As previously stated under respective paragraphs covering filters and coolers, provisions are made to assure oil supply to the pumps if oil from scavenging pump is restricted by unusual conditions in either the filters or coolers.

2. Lube Oil and Piston Cooling Oil System

The lube oil and piston cooling oil pressure pumps draw the filtered and cooled oil through the two fine mesh strainers in the oil strainer housing through a common suction elbow from the top of the strainer housing and discharges it under pressure through separate piston cooling oil pump and lube oil pressure pump discharge elbows to the manifold connections on the accessory gear cover.

The piston cooling oil manifold delivers oil to the two piston cooling header pipes. The oil is forced out of the headers through the piston cooling "pee" pipes which direct a stream of oil into a hole in each piston pin carrier. This oil cools the piston pin crown, the compression ring section of the piston skirt, and lubricates the piston pin bushings, then drains out of the piston through another hole in the carrier diametrically opposite the inlet hole.

The lube oil manifold delivers the oil from the lube oil pressure pump to the main "V" shaped oil header running throughout the length of the crankcase. An oil line taken off the pressure oil manifold extends to the governor drive gear stubshaft. Pressure oil in the "V" shaped header flows down the main bearing "A" frame oil tubes to lubricate the main bearings and then through drilled passages in the crankshaft to the connecting rod bearings. Leak-off oil from the adjacent main bearing will lubricate the thrust bearings. The harmonic balancer and accessory drive gear assembly are lubricated by oil flowing under pressure from #1 main through radial drillings in the crankshaft, which align with similar drilling in the harmonic balancer hub and accessory drive gear, allowing pressure oil to lubricate the spring packs and rim to hub bearing surface.

The oil flowing from the rear end of the "V" shaped main bearing oil header lubricates the gear bearings in the camshaft and blower drive and passes into the camshaft. The camshaft bearings are lubricated by radial holes in each segment bearing. From one bearing cap of each camshaft segment oil flows through a line to the rocker arm shaft bushings and through drilled passages in the rocker arm to the cam follower roller bushings and hydraulic lash adjusters. Leak-off oil from the camshaft and rocker arms flows across the tops of the cylinder heads into a drain channel extending the length of the engine. Vertical drain pipes from this channel allow the oil to drain to the oil pan.

Oil from the upper idler gear stubshaft lubricates the auxiliary generator drive bushings and then through the blower oil lines to the bearings and blower rotor gears.

3. Lubricating Oil Pressure

Lubricating oil pressure must be maintained at all times the engine is running. When starting an engine allow it to idle for some time and see that the oil pressure builds up almost immediately. The pressure may rise on a cold engine to the relief valve setting. The pressure under this condition will be approximately 50 pounds.

The lube oil pressure will depend on numerous conditions, such as, wear of pumps, engine parts, engine and cooling water temperature, oil dilution and engine speed. Therefore, no set operating oil pressures will be given. The minimum pressure at 275 RPM idle and 800 RPM maximum governed speed of the engine must be maintained. The minimum lube oil pressure at idle is 6 pounds. The minimum lube oil pressure at 800 RPM is 20 pounds. The lube oil pressure usually runs 30 to 50 pounds at 800 RPM and 16 to 25 pounds at idle 275 RPM.

The 20 pound minimum pressure is given for 800 RPM governed speed with the water temperature under 180° F. If it is impossible to maintain the water temperature at 180° F. or under, it will be permissible under this condition to operate the engine at 15 pounds at 800 RPM. If the lube oil pressure drops below the minimum pressures, shut the engine down and check for trouble. See "Possible Lube Oil Troubles".

4. Piston Cooling Oil Pressure

No pressure gauge for piston cooling oil is provided. Piston cooling oil pressure can be checked by application of connecting line and gauge at the 3/4" plugged opening of the piston cooling discharge elbow from the pump. Pressure of the piston cooling oil will be governed by oil viscosity, speed of engine, temperature of the oil, and wear of pump parts. The minimum pressure at idle 275 RPM is 3 pounds, and at 800 RPM, 15 pounds.

5. Low Oil Pressure and High Lube Oil Suction Shutdown

Engines equipped with either electro-hydraulic or pneumatic-hydraulic speed control governors have the low oil pressure and high lube pump suction shutdown as a part of the governor. Under either condition of low oil pressure or high lube pump suction, the alarm switch mechanism will set off the alarm circuit and allow the governor to shut down the engine after a short time delay at idle, or immediately at 425 RPM and over. The time delay at idle allows the engine to be started with zero oil pressure. It also allows the engine to be started and operated long enough, after it has been shut down by either device, to aid in locating the cause. Details of these devices are outlined in Section XI covering the governors.

Supplementary low oil pressure and high suction alarm switches are employed on engines requiring the use of governors other than electro-hydraulic and pneumatic-hydraulic controlled governors. These switches when actuated by low oil pressure or high suction reduce the engine speed to idle but do not normally shut down the engine. (Modification can provide shutdown, if desired.) In the case of the high suction switch, cycling may occur, since reducing engine speed reduces suction, only to re-occur on resumption of engine speed. This action may cause the overspeed trip to operate.

The low oil pressure switch connection is made at the rear of the engine, where oil pressure will be lowest due to drop through the engine. The high suction connection is made at the suction inlet to the lube oil pump. In either event of actuation of these switches no attempt should be made at continued engine operation until cause is corrected.

A modification may be made to locomotives equipped with low oil switches to bring about positive engine shutdown in the event of low oil pressure. If desired, information for the modification may be obtained from the Service Department. Also, if any locomotives exist without the low oil pressure or high suction provision, information giving necessary details and parts may be obtained on request.

6. Possible Lubrication Troubles

a. Absence of Oil in Strainer Chamber
This may be caused by inoperative scavenging system or open drain valve. Failure of scavenging system may be due to a broken or loose oil line connection causing an air leak, a faulty scavenging pump or clogged suction screen, or low oil level.

b. Low Lubricating Oil Pressure
This may be due to stuck oil relief valve or foreign material on valve seat holding valve open, broken oil lines, clogged suction strainers, excessive bearing wear, low oil viscosity, faulty pump or diluted oil, or insufficient oil in strainer housing.

c. Failure of Oil Pump
This may be due to sheared pump gear keys, broken housing or damaged gears.

d. Dilution
It is possible for fuel oil to get into the lubricating oil if a fuel line connecting the injector to the fuel manifold is loose or broken or an injector is defective. If such a condition has existed the lube oil viscosity should be checked. The lube oil may also be contaminated by water, this can be checked visually on top cylinder heads or oil pan, also by taking test sample of oil.

e. Excessive Oil Consumption
This may be caused by oil leaks, broken or stuck piston rings, worn cylinder liners, damaged blower oil seals, leaking crab stud seals, clogged oil separator screen, improper grade of oil or clogged oil drain holes under oil control rings of piston.

f. Little or No Lube Oil Consumption
This may be due to water or fuel leaking into the oil.

D. MAINTENANCE

1. Prelubrication of Engines

The prelubrication of newly installed overhauled engines or engines having been in storage a considerable length of time, before their initial running, is a necessary and important practice. This procedure alleviates engine loading of unlubricated parts during the interval until normal lube oil pump operation starts. Also, it offers the protection in seeing that oil distribution throughout the engine is in proper working order. The oil supply should be warm and the pressure need not exceed 35 pounds per square inch.

NOTE: When an engine is replaced due to mechanical breakdown, it is important that the entire oil system such as oil coolers and filters be thoroughly cleaned before the replacement or reconditioned engine is put into service. A reoccurrence of trouble may be evident in the clean engine, if other oil system components are neglected.

At the time of supplying external oil to the engine, inspection should be made of the rocker arms, camshaft bearings and main bearings to see that oil is reaching these parts. When oil is observed freely flowing at these places, it will indicate oil is flowing throughout the oil system without restriction. The crankshaft should then be rotated at least one revolution during operation of the external pump to distribute oil over the various moving parts. Sufficient oil should be pumped to assure oil reaching all parts of the engine.

Before starting the engine, at least three gallons of oil should be poured over the cylinder mechanism on each bank. This applies also to engines in newly delivered locomotives before their initial starting.

Inasmuch as new locomotive engines have been filled and run with oil before leaving the factory, prelubrication of these engines is considered unnecessary. However, their cylinder mechanism should be well lubricated before starting as stated in the preceeding paragraph.

2. Oil Change

Engine lube oil should be drained, filters renewed, suction strainers and screens cleaned at intervals specified in the Scheduled Maintenance Program. Before the oil is drained the viscosity should be checked for indications of fuel leaks and contamination to allow their correction before adding the new oil.

a. General Procedure

(1) After providing a container or run off line for drain oil, remove plug at end of oil drain line, oil strainer housings, or oil tank, and open drain valve. Allow all oil to drain out.

(2) Remove suction strainers, screens, filter containers and elements. Clean strainers, screens and filter element containers as recommended in Maintenance Instruction 1706.

(3) Wash down top deck, oil pan, oil tank, strainer screen and filter housings using fuel oil or kerosene. Drain off all cleaning liquid and wipe areas free of excess cleaning liquid with bound edge absorbent towels.

(4) Replace pipe plugs in drain lines and close drain valves. Where necessary, replace gaskets.

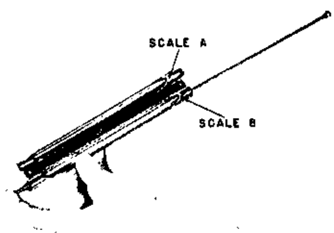
(5) Re-install cleaned strainers, screens and filter containers with new cartridges. Be sure filter element containers are installed properly so its closed end is at the proper location. (See Item 9, Michiana Filters)

(6) Recharge engine with lube oil within specifications as outlined in Maintenance Instruction 1607 (latest revision). Add the quantity of oil indicated on the oil gauge for for engine, filling through the square filler opening of the strainer housing. Pour three gallons of oil over cylinder mechanism on each bank.

(7) Inspect engine prior to starting, then run engine. Allow engine to run until complete circulation of oil through the engine is assured. With the engine at idle, check oil level. Oil level should be at "Full" mark, if not add sufficient oil to bring level to the "Full" mark.

3. Checking Oil Viscosity

Oil viscosity should be checked at intervals as specified in the Scheduled Maintenance Program. By comparing the oil viscosity at different intervals taken at the same temperature or compensated to the oil viscosity when the oil was new, a close check can be kept on the oil to assure its replacement before its condition is rendered unusable and dangerous, within the recommended oil drain period.



Checking Oil Viscosity
Fig. 8-17

Although laboratory oil analysis is desirable, it may not always be available or convenient for numerous checks. To provide a check on oil viscosity at frequent intervals a "Visgage", 8042091, shown in Fig. 8-17, may be obtained from our Parts Department. This gauge serves as a practical useful tool for this frequent oil inspection. Instruction on the application of the "Visgage" is furnished by the maker with each gauge.

Oil having viscosity changed to a great extent will, if not renewed, result in oil cooler clogging, strainer clogging, insufficient oil supply, carbon build-up on vulnerable places such as rings, grooves and small clearances with resulting damage. Therefore, to provide protection to the engine, the oil and system components should be carefully observed for proper functioning.

4. Oil Pressure Relief Valve

At intervals specified in the Scheduled Maintenance Program, disassemble the relief valve and inspect its component parts. Beginning with engine serial number 51-K-226 vulnerable relief valve parts have been improved. The material of the valve has been changed and the lower shoulder of the stem lowered 1/4" to give a 1" undercut instead of a prior 1-1/4", thus keeping this shoulder out of the valve guide when the valve is open, eliminating guide wear step. Valve guide material has been changed from steel to lubrized cast iron. If older valve parts indicate trouble, or at their first inspection, the valve and guide should be replaced with the improved parts. These improved parts retain the same part number.

The setting of the oil relief valve connected to the lube oil manifold determines the maximum pressure at the lube oil pump. It is not set by pressure gauges, but by specific dimension from the top of the valve guide to the top of the valve holder.

To set the relief valve, Fig. 8-13 and Fig. 8-1, shut down the engine and remove the relief valve cover. Loosen the locknut. Applying a wrench to the flats on the valve guide, position the top of the guide 3/4" above the top of the valve body and retighten the locknut. This 3/4" dimension applies to all 567 series engines.

With relief valve set to 3/4" dimension it will allow a maximum lube oil pressure of approximately 60 pounds and provide sufficient valve lift under cold oil conditions.

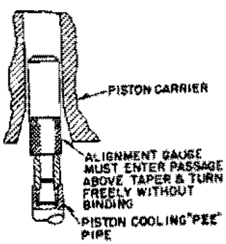
Under some conditions, such as weakening of the spring, it may be necessary to increase the spring tension of the valve, but under no condition should the top of the valve guide be less than 5/8" on 567 square channel or "V" channel engines or 1/2" on 567A or 567B engines from the top of the valve holder.

Lube oil manifold pressure or oil pressure at the valve may be determined, if desired, by application of a pressure gauge either at the oil pump discharge elbow or manifold connection. Whenever the relief valve is disassembled examine stem and guide for any roughness or galling and replace if required. If valve stem is good visually, check its diameter. Minimum valve stem diameter is .4925". Check squareness of valve face to stem; should not exceed .002" total indicator reading. Using a telescoping gauge, check valve guide inside diameter; maximum inside diameter should not exceed .5025". Load test valve spring; to compress spring to 3-3/8" should require at least 200 pounds.

5. Piston Cooling "Pee" Pipe Alignment

The alignment of the piston cooling oil "pee" pipe to the inlet hole of the piston carrier is checked with alignment gauge, #8071720, shown in Fig. 8-18.

The small end of the gauge fits into the nozzle of the "pee" pipe and by bringing the piston to bottom center it should enter the inlet hole in the piston carrier above the tapered portion of the hole and turn freely in this position. This gauge is not to be used for bending of the "pee" pipe in case of misalignment. If the gauge will not freely enter the carrier hole, the "pee" pipe should be removed and replaced with a new one of correct alignment.



"Pee" Pipe Alignment
Fig. 8-18

The piston cooling "pee" pipe is a very important part of the engine and should be inspected carefully not only for misalignment, but also the condition of the nozzle should be examined for ragged edge that might cause the oil to spray out instead of shoot out in a stream.

A cleaning tool for the "pee" pipe may be obtained under part number 8087086.

6. Oil Pumps

a. Removal and Disassembly

(1) Disconnect oil lines from the suction and discharge elbows and remove elbows. Remove pump mounting cap-screws, allowing the pump to be removed. Clean outer area of pump before disassembly.

(2) Remove the cap-screws securing the outermost small cover to allow access to the main drive shaft holding nut. Remove cotter pin and remove nut and lock-washer. (The drive shaft must first be removed to allow drive gear removal on large capacity pumps, but on other pumps the pump drive gear is on the outer side of the drive shaft flange and may be removed directly.)

(3) Remove cap-screw which holds the pump idler shaft stationary. Removal of the other pump housing cap-screws permits entire housing disassembly for removal of pump gears and pump drive shaft. Do not press shaft from pump housing as the Woodruff key may damage inner drive shaft bearing.

b. Inspection and Repair

Clean all parts and examine for signs of failure, such as gear teeth, key ways and inside pump surfaces. Check clearances as given in the Specifications. Clearances may be determined by measuring separate parts or by pump re-assembly using soft lead wire or plastigage to determine clearance. Replace parts as inspection or clearances indicate. Parts for the various pumps are listed by number in their respective engine catalog.

NOTE: Later pump drive gears are no longer doweled to the pump drive shaft flange. Drive shaft flange to gear dowel where used should be checked and if any question as to fit is warranted, the dowels should not be re-applied. Otherwise, if desired, the dowels may again be used.

c. Pump Assembly

To assemble pump, reverse general procedure given for disassembly. On replacement of internal pump gears, they must be replaced in mated pairs. (in many cases individual pump parts are interchangeable with other pumps having different part numbers). Pump drive gears are interchangeable on all pumps employing same tooth design in the drive gear.

7. Lube Oil Coolers

See Maintenance Instruction 1706 for cleaning information. Oil coolers should be serviced at intervals as specified in the Scheduled Maintenance Program according to locomotive type.

8. Lube Oil Cooler By-Pass Valve Settings

To protect the oil cooler and provide a supply of oil to the engine in the event of clogged oil cooler, means are provided for the oil to circumvent the cooler allowing supply to the pumps.

Oil by-passed around the cooler will increase in temperature and lower in viscosity, eventually resulting in low oil pressure. Also, oil not properly cooled will break down at a fast rate, consequently affecting engine lubrication with accompanying damage. Therefore, oil cooler by-pass valve setting and oil cooler maintenance is of prime importance due to their effect on the highly essential lubricating oil and its function in the engine.

Table 1, shows expected lube oil and water temperatures for the locomotives listed and recommended guide in oil cooler cleaning on these locomotives.

LUBE OIL AND WATER TEMPERATURES
CLEAN SYSTEM

TABLE I

Model	Normal Water Temp. out of Engine	Normal Lub. Oil Temp. into Eng. Above Water Temp. Into Engine	Maximum Expected Water Temperature Above Ambient Temperature	Water Temp. Rise Across Engine Full Load	Idle
FT	160° - 180°	40°	95°	11.5°	2°
F2	163° - 178°	42°	76°	11.5°	2°
F3	163° - 178°	45°	90°	13°	2°
*F7	163° - 178°	35°	90°	13°	2°
BL2	163° - 178°	45°	90°	13°	2°
E7	155° - 165°	40°	100°	10.5°	2°
**E8	160° - 162°	28°	90°	10.5°	2°
*GP7	165° - 180°	35°	90°	13°	2°
**SW8	160° - 170°	28°	90°	9°	2°
**SW9	160° - 170°	28°	95°	10.5°	2°
**SD7	160° - 162°	35°	90°	13°	2°

*Round tube core with fins.
**Round tube core with tube agitator and no fins.

NOTE: SD7 core is 15% larger than E8, SW8 and SW9 cores.
SD7 core can be used in E8, SW8 and SW9, but cores of these locomotives should not be used in SD7.

The oil cooler should be cleaned when oil temperatures are 15 or more degrees higher than those shown in column headed "Normal Lube Oil Temperature into Engine" above water temperature into engine.

Locomotives equipped with radiator type oil coolers as FT with 567A engines and combination oil cooler and water tank, and F2, F3, F7, BL and GP7, oil may flow over the top of the radiator in the event of closing and therefore do not have a cooler by-pass.

All other locomotives are equipped with oil cooler by-pass valves, the settings of which are as follows;

E8, SW8, SW9 and SD7 locomotive oil cooler by-pass is arranged so the oil not only by-passes the oil cooler of horizontal radiator type, but also by-passes the Michiana filter, in case the scavenging oil pressure exceeds the by-pass valve setting. A sight glass is provided to observe oil by-passed. The by-pass valve is a spring loaded "pop" valve and is set to open under 60 p.s.i. and should be maintained.

E7 locomotives have the oil cooler by-pass valve located on the engine side of the oil filter tank and a pressure gauge is provided above the valve on the tank and is connected to the valve. This spring loaded relief valve has a dimensional setting. The top of the valve guide should be adjusted to be 5/8" above the top of the valve holder. With this setting the valve will relieve at a pressure of approximately 60 p.s.i.

The pressure on the gauge will read approximately 60 p.s.i. at 800 RPM engine speed, but gauge pressure at idle should be used as a guide in determining oil cooler condition. Pressure on the gauge at idle will be 15 to 20 p.s.i. or slightly higher even on new engines and is considered normal operating pressure. If pressure at the gauge exceeds 30 p.s.i. at engine idle speed (275 RPM), examination of the oil cooler is indicated.

E6, transfer, road switchers and switcher locomotives (except SW8, SW9, TR5, TR6) are provided with a spring loaded "pop" by-pass valve and are set to relieve pressure at 50 p.s.i. and should be so maintained. Model FT locomotives having the oil tank, water tank and oil cooler mounted one on the other in this order, have a relief valve located in the oil tank. This relief valve should be set to relieve at 40 p.s.i. Also, inside the oil storage tank is an air reservoir equipped with a valve for bleeding air. This valve should be open 2-1/2 turns. The oil level in the tank should be maintained at least 2 inches above the top of the lube oil pump suction strainers located at the bottom of the tank.

9. Michiana Oil Filter

Oil filter elements should be changed and containers cleaned at intervals specified in the Scheduled Maintenance Program.

There are three Michiana filter element containers in use since the advent of the new element container #8168621, which replaces previously used container #8035047, and an additional element container #8054713.

The primary difference as regards application of these containers is in the plugging of the center tube at the top in containers #8168621 and #8035047, whereas in #8054713 the center tube is entirely open, no plug being used. Containers #8168621 and #8035047 are used in the circular filter tanks as used in F7 and E8 and so forth, where the filtered oil is discharged out the center tube at the bottom, but container #8054713 is used in combination oil filter and strainer tanks similar to E7 applications in which the filtered oil is discharged out the top of the center tube.

Element container #8168621 differs from #8035047 in that the cover retaining spring and handle at the top of the container has been redesigned to provide a cover which is held by a wing nut bolt assembly which screws into a threaded plug at the upper end of the center tube. The #8035047 containers may be modified to the cover arrangement as used in #8168621 by adherence to instructions contained in Modification Instruction 5032 which covers the change.

Care should be exercised in the application of these containers for proper installation. Elements #8035047 and #8054713 may be made interchangeable by the removal or application of the center tube plug at the upper end.

Filtering material used is Wastex, either loose for hand packing or in cartridge form, which form is superior due to consistant filter density for effecient filtering and a reduction in maintenance.

Filter cartridges are of two types, packed type and blanket type. Standard packed cartridges are packed with loose Wastex in a sock. Blanket type cartridges are made by assembly of four layers or blankets of needled waste covered by a sock. Both of these cartridge type filters may be obtained with white waste, when available, or a colored waste, and either large or small center tube inside diameters. The small inside diameter center tube cartridges are for use only in filter cans or containers that have had their center removed. There is a slight difference in weight between these types of cartridges.

In addition, in the event that the screen on the outer shell of the filter container or can is torn, it is recommended that this screen be removed. If this is done, do not hand pack the container but use only cartridge type filters in these containers.

For other information on filters and oil tanks, see the latest revision of Maintenance Instruction 1604.

10. Lube Oil Strainers

Lube oil strainers should be removed at each oil change period as specified in the Scheduled Maintenance Program and cleaned as specified in Maintenance Instruction 1706.

On re-application, care should be taken to see they are seated squarely and if a spring is employed, that the elements contact the spring evenly. The gaskets used with the strainers should be replaced.

As described under "unit description", "B" engine lube oil strainers have an oil seal in addition to seal rings. The sealing oil will leak out the strainer flanges if the rubber seal ring is not seated properly or is damaged. When the strainers are replaced, care should be taken to see that the sealing surfaces are free from nicks and scratches and the seal ring is in good condition. Also, that the oil passages to the seal surfaces are free from restriction.

The oil may be checked, with the engines at idle speed, by loosening slightly the large wing nut holding the strainers in place. Carefully raise the strainer furthest from the engine. Oil should leak out around the top of the strainer flange. If no oil appears, the engine should be shut down and the oil supply passages inspected and cleaned.

Any air which may enter the system at this location will be discharged with the lubricating oil and may cause engine damage, even though normal oil pressure is indicated.

11. Flushing Lube Oil System

See latest revision of Maintenance Instruction 1608 for complete lube oil system flushing information.

12. Lube Oil Separator

The oil separators should be cleaned at intervals listed in the Scheduled Maintenance Program.

Oil separator screens are removed by first shutting the engine down, then removing separator cover allowing access for screen removal. The element should be cleaned as recommended in Maintenance Instruction 1706.

E. SPECIFICATIONS

Lube Oil

Lube oil to be used in the engine should be S.A.E. #40, according to specifications outlined in Maintenance Instruction 1607.

	New	Limit
Lubricating Oil Pump		
Clearance - drive shaft to bushing	.0015" - .0045"	.007"
Clearance - idler gear shaft to gear bushing	.0015" - .0051"	.007"

	New	Limit
Clearance - gears to separator plates	.002" - .018"	should not wear
Clearance- gear to housing endwise	.018" - .022"	
Clearance -gear to thrust bearing	.005" - .016"	.022"
Protrusion - thrust bearing from housing	.001" - .007"	Flush
Backlash - pump gears	.012" - .016"	.030"
Backlash of drive gear spur	.008" - .016"	.030"

Scavenging Oil Pump

Clearance - drive shaft to bushing	.0015" - .0045"	.007"
Clearance - idler gear shaft to gear bushing	.0015" - .0051"	.007"
Clearance - gear to housing endwise	.018" - .022"	should not wear
Clearance - gear to thrust washer	.008" - .016"	.022"
Protrusion - thrust bearing from housing	.001" - .007"	Flush
Backlash - pump gears	.012" - .016"	.030"
Backlash - drive gear spur	.008" - .016"	.030"

Pump Capacity (GPM at 1130 RPM)

		Piston	Lube Oil	
Engine	Scavenging	Cooling	Small	Large
6 cyl.	117	31	59	—
8 cyl.	117	31	59	71
12 cyl.	170	43	86	103
16 cyl.	234	59	117	140

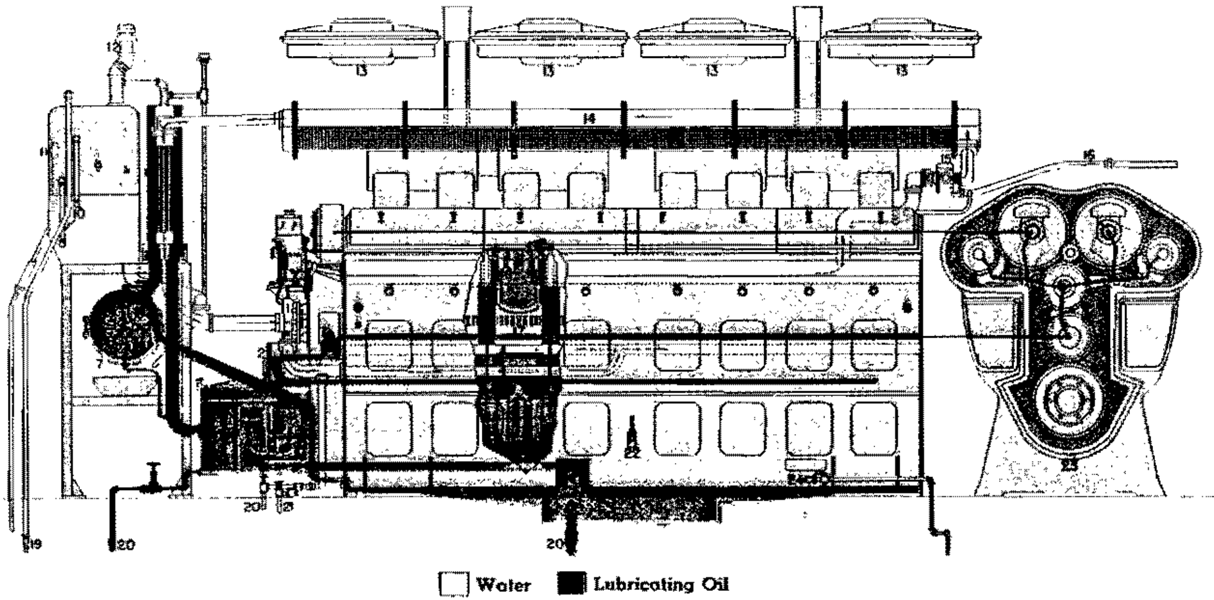
Oil Capacity (Wet Sump Engines)

6-567A&B	120 gal.
8-567B	130 gal.
12-567A&B	165 gal.
16-567A&B	200 gal.

F. EQUIPMENT LIST

Name	Part Number
"Visgage"	8042091
Spray gun	8072902
Alignment gauge, piston cooling pipe	8071720
Piston cooling pipe cleaning tool	8087086
Lube oil suction testing device	M-File 110
Lube oil system (Pre-Test) drawing	M-File 294

For additional tools see Tool Catalog 91A.



1. Water Pump
2. Lubricating Oil Pump
3. Scavenging Oil Pump
4. Sump Oil Strainer
5. Lube Oil Strainers
6. Lube Oil Filter
7. Lube Oil Relief Valves
8. Lube Oil Cooler
9. Cooling Water Tank
10. Water Level Gauges
11. "G" Valve
12. Roof Filler
13. Cooling Fans
14. Radiator
15. Thermostat Switch
16. To Cab Heater
17. Cylinder Liner
18. Engine Sump
19. Side Filler
20. Drains
21. Steam Admission Line
22. Bayonet Gauge
23. Camshaft Drive Gear Train
24. Air Box Drain

Fig. 8-19 - Schematic Of Cooling And Lube Oil Systems

NOTES

NOTES

SECTION IX

COOLING SYSTEM

A. GENERAL DESCRIPTION

The cooling system of the engine consists of the water passages in the cylinder liners and heads, and the inlet and outlet manifolds through which cooling water is circulated under pressure and volume proportional to engine speed. Centrifugal water pumps mounted on the accessory drive housing and driven by the governor drive gear circulate the cooling water.

The heated discharge water from the engine is cooled by passing through radiator banks made up of sections of tube and fin type radiators. The water is cooled by air, either drawn or forced by fans through the radiators, depending on the locomotive. The fans, of propeller type, are mechanically or electrically driven depending on locomotive model. After cooling, the water discharges into the lube oil cooler to return to the water tank. On some locomotives the water discharges directly into the water tank. Cooling air admission is controlled by automatically or manually operated shutters. All late locomotives have automatic shutter control and early locomotives not so equipped may be modified to incorporate automatic shutter operation. Automatic shutter operation is controlled by the engine water discharge temperature through thermostatic switches.

Electric cooling fan motors are also thermostatically controlled to cut in or out according to the water temperature. Mechanically driven cooling fans are all belt driven at speeds proportional to engine speed.

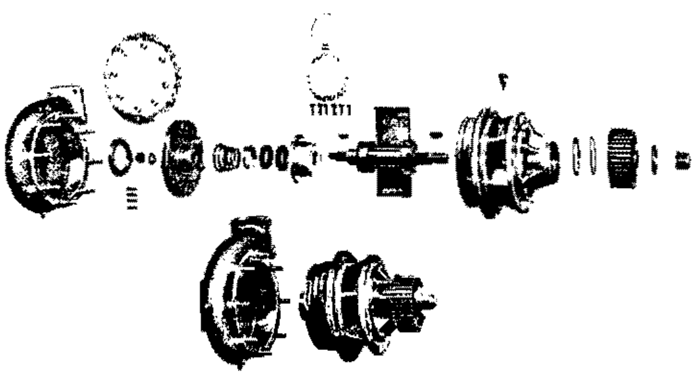
Water temperature gauges, water level gauges, fill and drain lines, and connecting piping complete the cooling system. A representative schematic of the cooling system on the latest F7 locomotive is shown at the end of Section VIII. For particular locomotive cooling system outlines, see the operating manual covering the locomotive.

B. DESCRIPTION

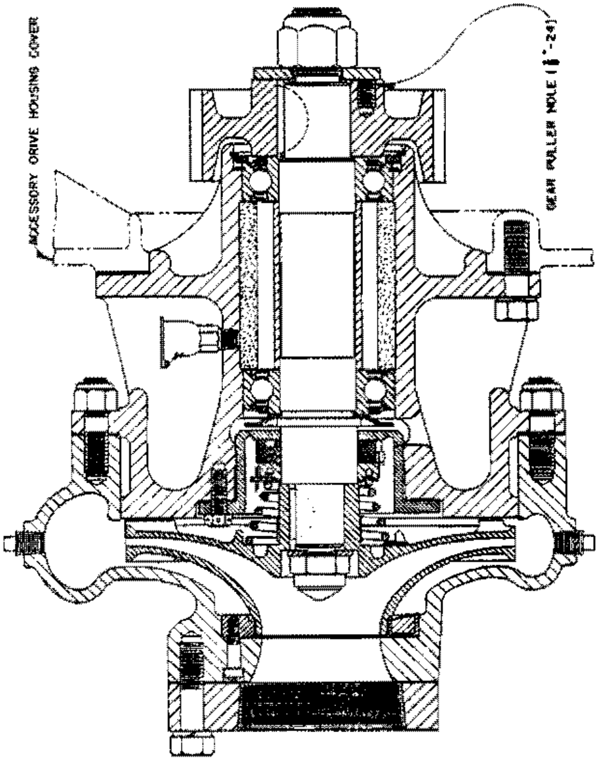
1. Pumps

The engine cooling water pumps are of the centrifugal type and rotate counter-clockwise. Two pumps are used on the 12 and 16 cylinder engines and only one pump on the 6 and 8 cylinder engines. The pumps are carried under two part numbers to identify the right or the left bank pumps. The difference in the bank designation is only because of the position of the impeller housing to enable line up to the pump discharge pipe. The impeller housing position on either pump may be changed to permit use on either engine bank.

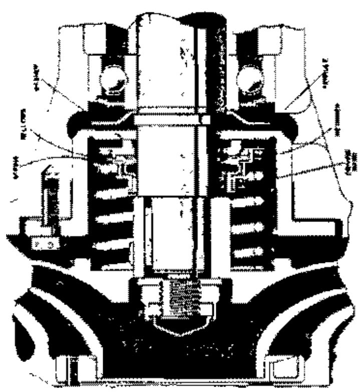
The various parts of the water pump are shown in Fig. 9-1. The main parts are: impeller, impeller housing, drive shaft, drive shaft housing, bearing, seal assemblies and drive gear. A cross section of the pump is shown in Fig. 9-2.



Water Pump — Exploded View
Fig. 9-1



Water Pump Cross Section
Fig. 9-2



Bellows Type Seal

The pump drive shaft is supported in the main pump housing by two ball bearings separated by a steel spacer. The spacer is covered by a felt pad which receives the bearing lubricating oil from the oil cup in the housing. The outer bearing abuts a water slinger against a shoulder on the shaft. The inner bearing is held in place by a retainer and snap ring to absorb any thrust in the shaft. The pump drive gear is keyed to the pump shaft abutting the inner bearing and is held by a washer and nut on the shaft.

A stationary bushing fits over the pump shaft at the impeller end and is mounted on the main housing. This bushing provides a smooth flat surface for the carbon seal which is between the bushing and the impeller. The impeller is keyed to the pump shaft and is held by washer and nut. It is enclosed by the impeller housing, which is mounted by studs and nuts to the main pump housing. Plugged drain holes are provided in the impeller housing and a telltale drain is provided in the main pump housing to dispose of any water leak past the seal.

2. Engine Water Passages

Inlet cooling water manifolds are formed for each bank of cylinders by two parallel plates running the entire length of each cylinder bank at the bottom of the crankcase. These plates are bored to receive and support the cylinder liners. A seal ring is used between each plate and the liner, connecting the liner water passage to the manifold and preventing water leaks to the oil pan and air box. An inlet water line connects the manifold to the water pump at the front of the engine. The liner water passages line up with passages in the cylinder head, which discharge the water to the discharge manifold. The discharge manifold extends the entire top length of the crankcase, between the inward sides of the cylinders. Water drain pipes connect the discharge with the inlet manifold, to drain the discharge manifold when the engine water is drained. Water seal rings are used between the cylinder head and retainer, water discharge being between the two seals. A gasket is used between the cylinder head and liner.

3. Radiators

Each radiator bank consists of separate radiator sections connected together with "L" shaped supporting and strengthening straps. Gaskets are used between sections, and between sections and the inlet and outlet headers. The inlet headers have a screen the full length of the header to protect the radiators.

4. Water Tanks

The water tanks are located at the forward end of each engine, convenient for supply to the engine water pumps. They differ in general construction, but all are internally baffled to prevent water surging. Water glasses or try cocks are provided to indicate the water level. Water filler lines extend from the tank to the outside of the locomotive at ground level and also to the roof level. The roof filler pipe also serves as a system vent. The water tanks are provided drain valves, otherwise they are drained with the engine drain, through the pumps. For particulars for each type of locomotive see the operating manual for that locomotive.

5. Engine Water Temperature

Temperature gauges are provided in the cooling system for visual indication of engine water temperature. The recommended operating range is a water discharge temperature between 160°F. and 180°F. The minimum water temperature at which the engine should be loaded is 120°F. Locomotives equipped with automatic engine water temperature control are set to maintain the water discharge temperature within the 160°F-180°F. range.

To warn of hot engine water temperature, all road locomotives have a hot engine alarm. Hot engine water would result due to improper water or cooling air circulation, or loss of water. In the event of a hot engine alarm, the engine load should be removed and the engine speed reduced, but not stopped until the water temperature returns to a value which allows the alarm to stop. Before resuming operation, the cause of the hot engine water should be found and corrected.

For the proper water temperature settings for the hot engine alarm and the engine temperature shutter control switches see the latest revision of Maintenance Instruction #1530. This instruction outlines the proper setting procedure of these switches for all locomotives.

6. Engine Cooling Water

The water used in the cooling system should be the equivalent of distilled water produced by condensing live steam or by chemical treatment. When raw water is heated to normal engine operating temperatures, minerals separate from the water causing scale and sludge. Scale and sludge restricts heat transfer and circulation and cannot be removed from the engine in a practical manner.

Also, the addition of rust and corrosion inhibitors to the purified water is necessary to protect metals of the engine. The treatment compound should be obtained from a reputable company and treatment used should provide the following protection:

a. Be non-corrosive to the metals of the cooling system.

b. Will not cause deterioration of engine seal rings or cooling system hose.

NOTE: When chromate type inhibitors are used, the resultant coolant should contain a minimum of

100 grains per gallon of chromate and have a PH value of 8.5 to 9.7.

It is important that the proper concentration of treatment be maintained in the cooling water at all times. A most satisfactory way of maintaining this concentration is to have all stations where water is added to the system equipped with a supply tank in which good water having the proper amount of treatment is always available.

Proper water and attention to the cooling system cannot be too highly emphasized. Failure to recognize their value will most likely result in increased maintenance, replacement and repair of parts, and damage to the engine and cooling system. Necessity for flushing of the cooling system also will be increased. Information on cleaning and flushing the cooling system is contained in Maintenance Instruction 1706 which is the general cleaning bulletin.

7. Engine Water Heating

To prevent the freezing of the engine water during cold weather when the locomotive is temporarily inactive, some means of heating the water must be provided. Methods for this protection are live steam admission to the cooling system, separate small water heaters (either oil burning or electric), or by running the engine at idle.

Each engine cooling system is equipped with a steam admission line with a check valve allowing steam supply from an external source or from a steam generator on units so equipped. If steam is applied for heating, the pressure must not exceed 50 p.s.i. and the "G" valve of the cooling system should be opened to permit condensation to drain and maintain the water level below the radiators. A disadvantage accompanies this method of engine water heating since some of the water inhibitor will be lost, resulting in a weak inhibitor solution.

Separate oil heaters may be applied to heat the engine water. Information on these heaters is contained in Maintenance Instruction 2109.

Information concerning installation of an electric immersion heater may be obtained from the Service Department.

Running the engine at idle speed is an acceptable means of maintaining the engine water temperature above freezing during reasonable periods of locomotive inactivity in cold weather. Extensive idling of the engine will not materially affect the engine and they may be idled for indefinite periods to prevent freezing. Although this method has the advantage of probably less cost than with any of the preceeding water heating methods, on units equipped with a steam generator in operating condition it is recommended the steam generator be used to supply the steam to the cooling system.

The number and type of units involved as well as other factors will influence the selection of equipment best suited, such as availability of external heat supply, frequency of need for heat and so forth.

C. MAINTENANCE

1. Pumps

a. Removing Pump

(1) Drain cooling system.

(2) Mark flanges on bellows suction tube so it can be re-installed in its original position. This tube is not flexible enough to be bent, twisted or stretched too far without damage.

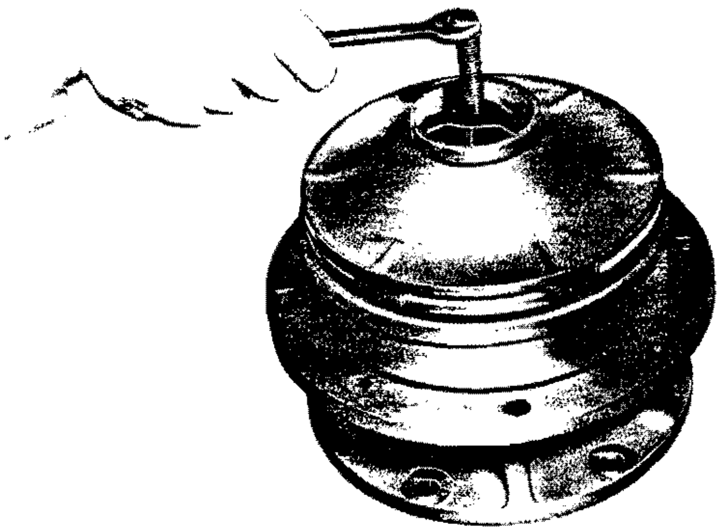
(3) Remove suction line and disconnect pump discharge flange connection.

(4) Remove pump mounting capscrews, allowing pump to be removed from the engine.

b. Removing Impeller

(1) Remove nuts holding impeller housing and remove the housing. The impeller housing can be more easily removed if the pump is held suspended slightly above the work bench by hoist or other means, impeller end down, and by tapping on the housing with a rawhide or wooden mallet.

(2) Remove impeller shaft nut and washer and apply impeller puller #8067245 to remove the impeller as shown in Fig. 9-3. The thrust cup which is part of the puller is placed over the end of the shaft to protect the shaft threads. Remove holding key.



Removing Impeller
Fig. 9-3

c. Replacing Shaft Seal

(1) Remove impeller as outlined in item b.

(2) Remove seal spring and seal assembly. Use care to prevent damage to the stationary bushing bearing surface. Some seal assemblies offer little resistance to removal but some are quite firm on the shaft. Seal assemblies tight on the shaft may be removed with the stationary bushing.

(3) Remove brass lockwire from capscrews of stationary bushing. Removal of the bushing may require force. In this event, insert 3/8" × 2" capscrews in the puller holes provided in the bushing, Fig. 9-7, and force the bushing out from the housing. The bushing may sometimes be loosened by tapping on the bushing flange with a rawhide mallet, allowing removal without force.

(4) Clean the stationary bushing and pump shaft.

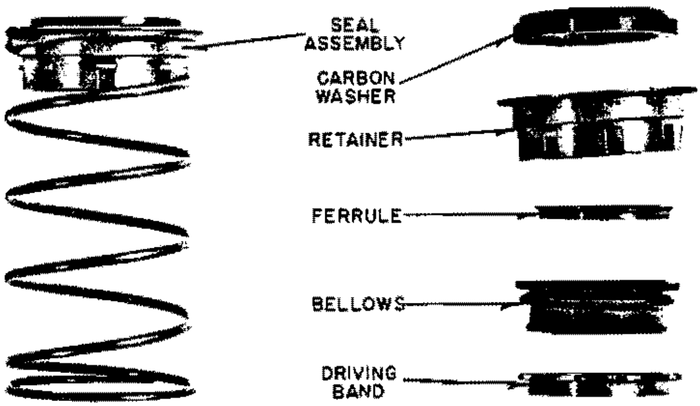
CAUTION: Do not damage bushing or shaft sealing surface. The sealing surface of the stationary bushing must be absolutely smooth and flat, so as not to cause undue wear of the carbon washer of the seal. A stationary bushing having a rough surface must be refinished to provide a smooth flat surface or be replaced with a new bushing. A new seal will likely leak if the sealing surface of the bushing is not perfectly smooth.

(5) Replace stationary bushing gasket and re-install stationary bushing. Pull capscrews down evenly so bushing will not bind. Lockwire the capscrews using brass lockwire.

(6) Install new seal assembly. Two types of seal assemblies are used in the water pumps

and are shown in Fig. 9-4 and Fig. 9-5. Either seal assembly can be used in either pump but individual parts of the two seals are not interchangeable. It is recommended the seal assembly shown in Fig. 9-4 be replaced as a unit if any parts are damaged, although the carbon washer alone may be replaced. To aid in the installation of this bellows type seal, a special tool #8143316, shown in Fig. 9-6, is available. Lubricate the friction portion of the bellows on seal application. Springs of this seal have been shortened from 4-7/16" to 3-7/16"; on replacement of seal, the short spring should be used.

NOTE: Some pump shafts, temporarily, were made using magnetic substitute material, in place of basic non-magnetic material. Magnetic shafts were later silver plated at the seal area. Pumps having magnetic shafts without silver plate



Water Pump Seal — Bellows Type
Fig. 9-4

should be assembled using the seal assembly shown in Fig. 9-4. EMD type seals, Fig. 9-5, should only be used in pumps having non-magnetic shafts or magnetic shafts with the seal area silver plated. Also, EMD seal carbons, Fig. 9-5, have their inside diameter increased from 1.579 ± .001" to 1.589 ± .001", and have been improved to alleviate interference on stationary bushing. It is recommended carbons with small diameter be reamed to larger diameter. EMD carbon seals of 1.579 ± .001" I.D. should be used only with these seals on non-magnetic pump shafts; large diameter may be used with either non-magnetic or magnetic silver plated shafts.

(7) Assemble pump (see item e) and install impeller, (see item f).

d. Removing Pump Shaft And Bearings

(1) Remove impeller housing, impeller, shaft seal and stationary bushing as outlined in items b and c.

(2) Remove nut and gear retaining washer from drive gear end of pump shaft.

(3) Remove gear using gear puller set #8068025.

(4) Remove bearing retainer snap ring and bearing retainer ring.

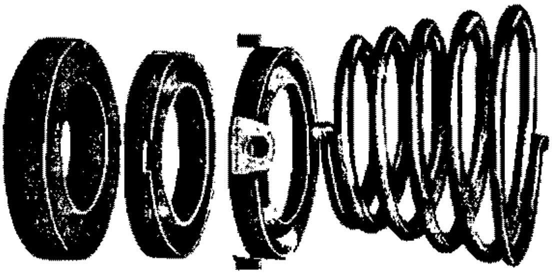
(5) The shaft and bearing assembly may be pressed out of the shaft housing, pressing from the impeller end of the shaft, with copper or other soft metal block protecting the threads of the shaft. Unscrew oil cup several turns to assure tip end will not protrude and restrict pressing operation.

(6) The bearing assembly can be pressed off the shaft, pressing from gear end of the shaft.

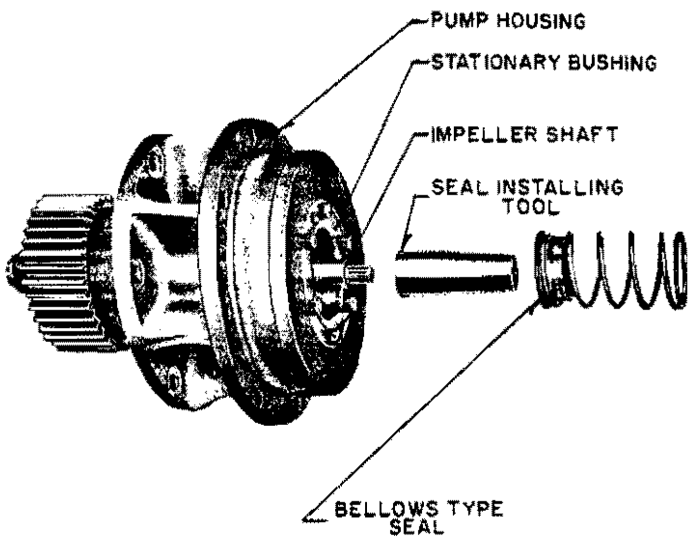
(7) Clean and inspect parts for defects and replace damaged parts.

e. Pump Assembly

(1) Assemble water slinger, inner bearing, spacer and outer bearing to the pump shaft, making



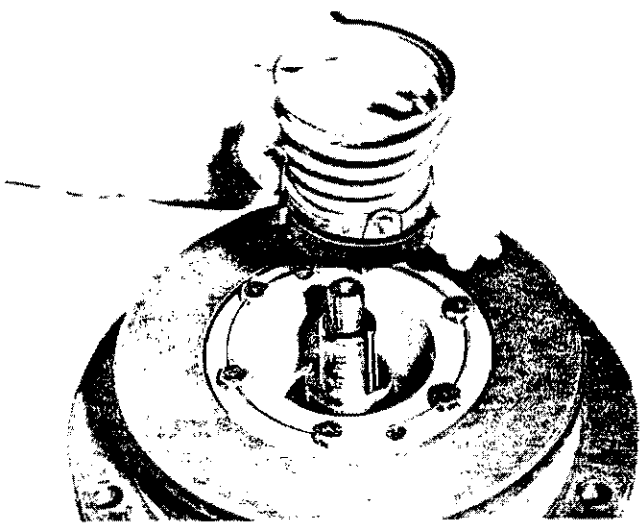
Water Pump Seal Assembly — Exploded
Fig. 9-5



Seal Applying Tool
Fig. 9-6

sure that the rear bearing with the retainer ring is positioned correctly with the retaining ring to the outside. These parts are assembled, first with the slinger next to the shoulder on the shaft, concave side toward the impeller end, followed by the inner bearing (without retainer), spacer and outer bearing, abutting each other snugly. The seal sides of the bearings go toward the outer ends of the assembly, being distinguished by the seal side of the bearing protruding slightly beyond the outer race.

(2) To apply the shaft and bearing assembly to the housing, invert the housing impeller end down on a wooden block with a hole in the center large enough to allow the shaft to extend down.



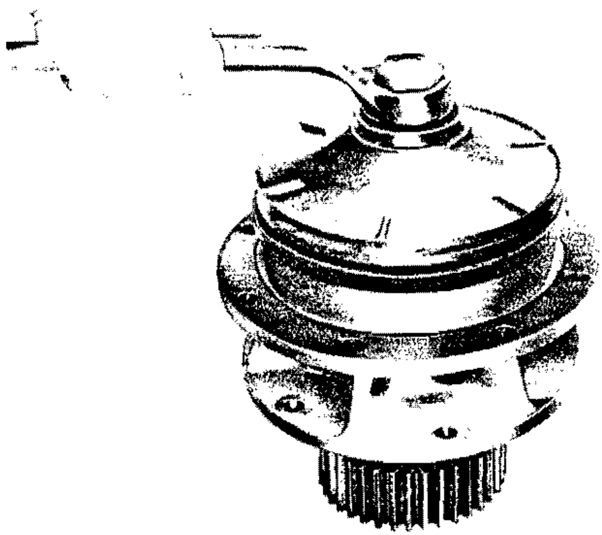
Installing Pump Seal Assembly
Fig. 9-7

(3) Start the assembly in the housing, tapping lightly with a wooden mallet. Wrap the oil soaked felt pad around the spacer when the first bearing clears the housing boss, and continue down with the assembly until the outer bearing rests on the housing boss.

NOTE: If the felt pad feels gritty or is dirty, replace with a new oil soaked pad.

(4) Apply the bearing retainer first and then the snap ring back of the rear bearing.

(5) Apply the drive gear to shaft, gear puller taps outside. Check the shaft key and way for fit. Use the collar on the impeller end of the shaft to absorb thrust when installing the gear, the retainer washer and the nut. The gear



Installing Pump Impeller
Fig. 9-8

fit is such that it can be tapped on the shaft all the way down.

(6) Apply stationary bushing and gasket to shaft housing and replace seal assembly as given in item c.

f. Installing Impeller

(1) Fig. 9-8 shows the impeller pressing on tool #8052959 in use. The threaded bushing of the tool is screwed on pump shaft threads. Then by turning outer portion of the tool, the impeller is pressed into position. Care must be taken to start the impeller straight on the shaft and to see that the key and way are aligned.

(2) Apply the impeller retaining washer, nut and impeller housing using new gasket between housings.

g. Installing Pump

The impeller housing is positioned differently on pumps used on the right and left bank of the engine. Before installation of the pump, determine whether the pump is to be used on right or left bank. The relative position of the impeller housing with relation to the oil cup on the pump housing is shown in Fig. 9-9.

An arrow is cast in the edge of the flange on the bottom of the pump. The flange of the impeller housing has letter "R" (right) and "L" (left). For a right hand pump, assemble the impeller housing so that "R" is opposite the arrow, or for a left hand pump, the "L" should be opposite the arrow.

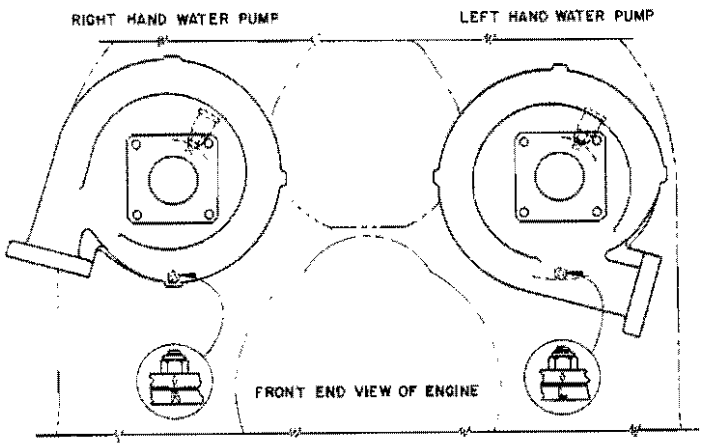
2. Water Leaks

If loss of water in the cooling system is noticed, check for leaks in piping, pumps for leaky seals, condition of cylinder head and liner seals and the cylinder head to liner gasket, or for possible cracked cylinder head or liner.

Unless very obvious, the location of a crack in the cylinder head or liner is very difficult to find and requires careful examination. Any indication of a water leak on the head or liner surfaces necessitates their removal. Inspect cylinder interior through liner ports. Observe liner surface for scuffing or other lack of lubrication.

The vicinity of the upper head seal and the lower liner seals should be very carefully examined in the event of loss of water, since leaks at this location would be directly into the lubricating oil. Lubricating oil contaminated by water will necessitate changing oil and flushing the oil system as outlined in Maintenance Instruction 1608.

Lube oil contamination is best determined by laboratory analysis, but in the absence of such means, a



Position Of Impeller Housing
Fig. 9-9

method for checking for water in the oil is as follows. Draw or dip a gallon of lube oil from the bottom of the engine lube oil sump. Let it stand for about ten (10) minutes, then spill about three-fourths (3/4) of the oil from the container. Place remaining one-fourth (1/4) in a glass bottle and allow sample to stand another ten minutes. If any water is indicated in the bottom of the bottle, it is suggested that the lube oil system be drained and flushed. Replace with new oil. Lube oil containing much water has a brownish color and bubbles may be noticed in the oil.

Examination of the lower head seals and upper liner seals should also be made in the event of water loss. Although leaks at these places are not as danerous as other seal locations, nevertheless they should be remedied. Leaks from these seals will be noticed in the air box.

Leaky cylinder head to liner gaskets may allow water to enter the cylinder or air box or both.

Sometimes loss of cooling water may be observed on running the engine but no visual indication can be seen. It is possible that the leak may be in the cylinder head to liner gasket or lower head seal. In either event the water may vaporize and escape with the exhaust gases.

These leaks may sometimes be located by removing the cylinder test valve packing; then with the engine working at 800 r.p.m. water may leak to outside of the engine and be visible at the test valve of leaky cylinder.

3. Radiators

The radiators should require maintenance at very infrequent intervals when proper water and inhibitors are used in the cooling system. The air passages should be inspected periodically (see Scheduled Maintenance Program) and blown out with air, with the engine at full speed, all fans operating, and the air intake shutters open. Also, the radiator inlet header screens should be inspected and cleaned if necessary, at regular maintenance intervals. Locomotives having orifice nipples in the radiator vent line at the roof filler vent pipe should have these orifices checked and cleaned so they may function properly. Road locomotives prior to F3 and switching locomotives prior to the SW7 have orifices in the vent lines but locomotives subsequent to these models do not have the vent orifices.

In the event one radiator section must be removed due to leaky tubes, sufficient room for removal of the section is made possible by removal of the inlet and outlet pipes to the radiator headers, loosening the holding bolts of the section to be removed, and moving adjacent sections away from the damaged section. It may be necessary in some cases to provide access to the upper strap radiator bolts through the roof hatch, by removing a cooling fan near the section on locomotives having fans in the roof, or by access through a roof hatch. By removing the lower section strap bolts, the section may be lowered from the radiator.

On re-application of the section, the core mating surfaces must be clean and smooth. To aid in proper gasket sealing, it is recommended a gasket compound such as Garlock compound #8061029 be used, which may be obtained from our Parts Department.

In case the entire radiator bank is removed, it would be more practical to remove the roof hatch to allow the radiators to be removed through the roof. The radiator banks may be flushed with the cooling system if necessary, as outlined in Maintenance Instruction 1706.

4. Additional Cooling System Information

Due to the prohibitive length and detail required to completely cover all components and modifications of the cooling system, separate instructions have been written. Modifications to and instructions on cooling system components may be found in the latest revision of the following bulletins:

Maintenance Instruction		NO.
Automatic Shutter Operation - FT And E7 Locomotives		608
Cooling Fan Motor KF-326		903
FT - 90° Fan Drive		906
AC Cooling Fan I-442		908
AC Cooling Fan I-666		910
Hot Engine Alarm and Engine Temperature Control Switches		1530
Thermostat Switches Operation and Adjustment	#8178411	1563
	#8097916	1545
Water Inlet Pipe - Repair and Replacement		1802
Water Drain Pipe Repair and Replacement		1603
Overnight Engine Cooling Water Heater		2109

Modification Instruction	NO.
Automatic Clutch and Shutter Control Application - FT	5005
Automatic Shutter Control Application, SW-NW2 Switcher Locomotives	5011
Cab Heater Improvement For Switcher Locomotives	5014
Cooling System Improvement For 2000 H.P. Passenger Locomotives E3, E6 and E7	5017

Modification Instruction	NO.
Cooling System By-Pass Valve Application SW1 and NW2, SW8 and SW9 Switching Locomotives	5025
Improved Exhaust Manifolds and Water Piping - NW2 and SW7 Locomotives	5057

D. SPECIFICATIONS

Water pump speed at 800 RPM engine speed	2440 RPM

Pump Capacity

Actual pump capacity is 240 g.p.m. with 26 p.s.i. discharge pressure. The resistance of the various cooling systems affect the capacity and are varied.

Backlash of Pump Drive Gear

Spur	New .008" - .016" Limit .030"

E. EQUIPMENT LIST

Name	Part No.
Impeller Puller	8067245
Impeller Pressing on Tool	8052959
Gear Puller Set (General Use)	8068025
Seal Applying Tool	8143316
Engine Cooling System (Pre-Test)	Drawing 294

For additional engine tools, see the latest revision of Tool Catalog 91A.

NOTES

SECTION X

FUEL SYSTEM

A. GENERAL DESCRIPTION

The most important part of the fuel system is the unit injector, which is a high pressure fuel metering pump and spray valve combined in one housing. The injectors (one per cylinder) are supplied with a continuous flow of low pressure fuel delivered by a separate pump. A fuel supply tank, strainers, filters, fuel manifold, supply and return fuel lines complete the system.

B. DESCRIPTION

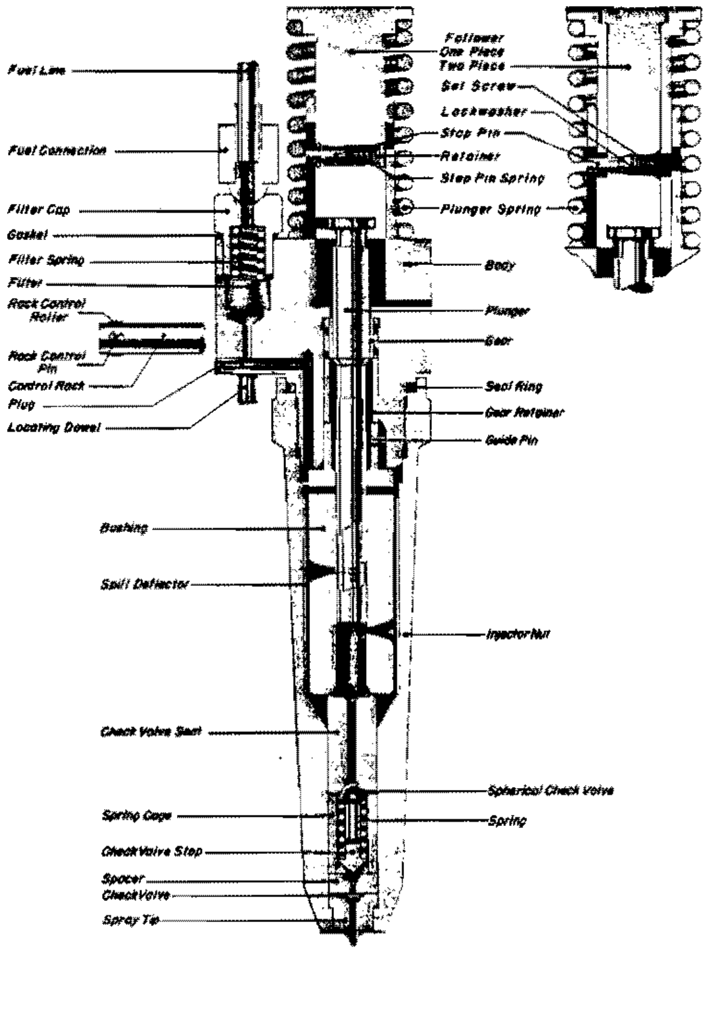
1. Injectors

A cross section of the unit injector and names of the various parts is shown in Fig. 10-1. It is located and seated in a tapered hole in the center of the cylinder head, the spray tip protruding slightly below the bottom of the head. It is positioned in the head by a dowel and held tightly by an injector hold down crab and nut.

The external working parts of the injector are lubricated by oil from the end of the injector rocker arm adjusting screw. The internal working parts are lubricated and cooled by the flow of fuel oil through the injector.

The main working parts of the injector are: rack, gear, plunger, follower, spring and spherical check valve.

The plunger is given a constant stroke reciprocating motion by the injector cam acting through the rocker arm and plunger follower. The timing of the injection period during the plunger stroke is set by an adjusting screw at the end of rocker arm. Fig. 10-2 shows flow of fuel through injector during one downward stroke.



Cross Section Of Unit Injector
Fig. 10-1

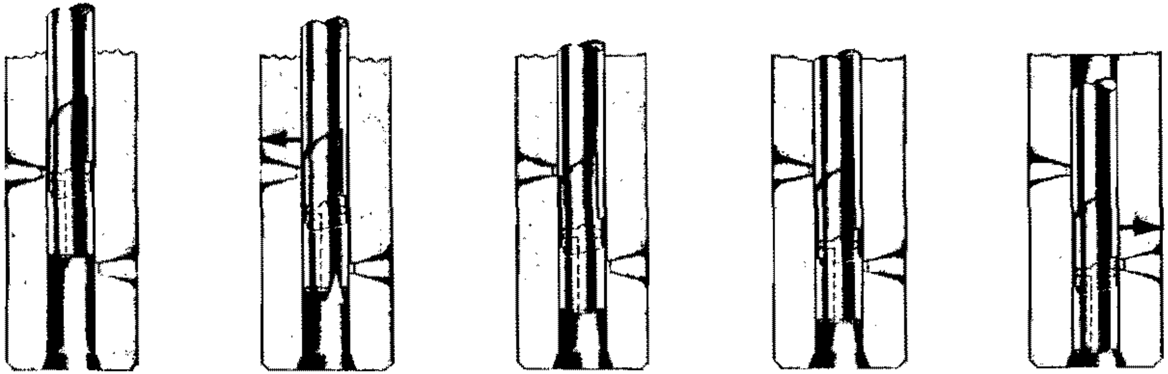
Rotation of the plunger by means of the rack and gear controls the quantity of fuel injected into the cylinder during each stroke. Rack position is controlled by the governor power piston through the injector layshaft and linkage. The gear is keyed with a sliding fit to the plunger to allow plunger vertical movement. Injector rack setting adjustments are given in Section 12 of this manual.

The helices near the bottom of the plunger control the opening and closing of both fuel ports of the plunger bushing. Rotation of the plunger regulates the time that both ports are closed during the downward stroke, thus controlling the quantity of fuel injected into the cylinder as shown in Fig. 10-3. As the plunger is rotated from idling load position to full load position, the pumping part of the stroke is lengthened, and injection is started earlier.

Proper atomization of the fuel is maintained by the high pressure created by the downward stroke of the plunger, which forces fuel past the injector spherical valve and out through the six spray holes in the tip of the injector. The spherical valve prevents fuel leakage out the tip and insures minimum fuel injection pressure for starting. The flat check valve under the lower spacer excludes combustion gases from the injector.

The injector has fuel filters at the inlet and outlet openings, to protect the working parts.

Injectors having different diameter plungers and bushings are now in use. The current production injectors have a plunger diameter of .421" whereas the earlier injectors have a plunger diameter of .375". The .421" plunger and bushing injector, because of its superior operating characteristics, supersedes the smaller plunger injector and may be identified by a "L" stamped on the fuel connection hold down stud or by the new part number on the injector body. Large or small



TOP OF STROKE
BOTH PORTS OPEN TO ADMIT FUEL

BY-PASS POINT
FUEL BELOW PLUNGER ESCAPES THROUGH UPPER PORT. NO EFFECTIVE STROKE

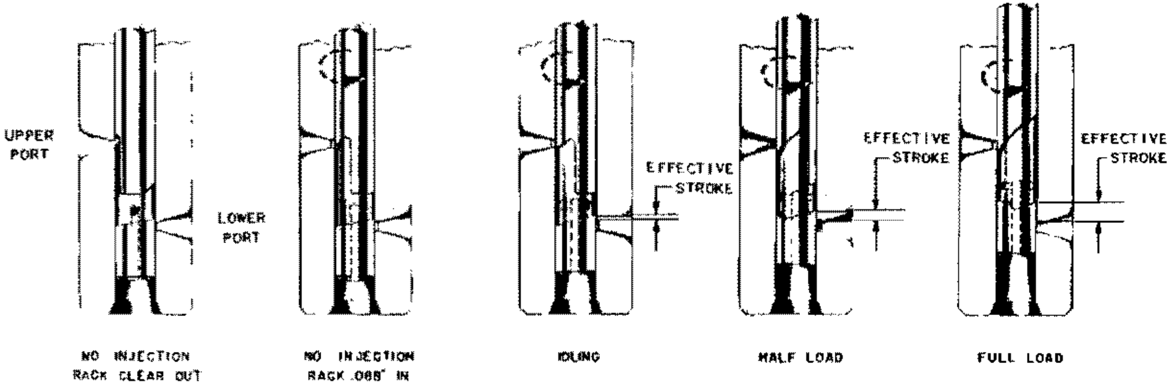
INJECTION STARTS
BOTH PORTS CLOSE FORCING FUEL INTO CYLINDER

INJECTION ENDS
LOWER PORT STARTS TO OPEN ALLOWING FUEL BELOW PLUNGER TO ESCAPE

BOTTOM OF STROKE
LOWER PORT FULLY OPEN NO EFFECTIVE STROKE

ONE COMPLETE DOWN STROKE OF PLUNGER AT "HALF LOAD" POSITION

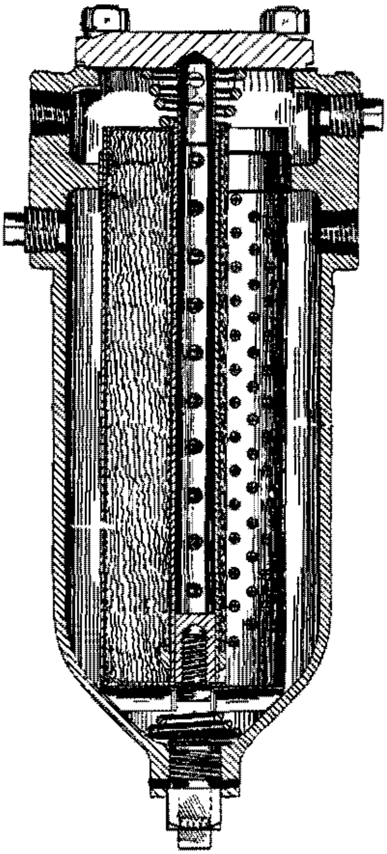
Pumping Action Of Injector Plunger
Fig. 10-2



Quantity of Fuel Injected Is Controlled by Rotating Plunger with Control Rack

Fuel Control By Plunger Rotation
Fig. 10-3

plunger injectors can be used together in an engine, but it is recommended that the .421" plunger injector be used in engine sets. Timing of the large and small plunger injector is identical. The same quantity of fuel for a particular rack setting is injected by each, regardless of the plunger diameter. This is due to a difference in helix design in large diameter plunger injector.



Cross Section
Fuel Suction Filter
Fig. 10-4

Injectors in engines since December 1951 have a one piece follower, Fig. 10-1, replacing the follower guide and small follower of the prior used injectors. The stop pin in this follower is backed by a spring, allowing it to be pushed in for release, whereas the stop pin of the two piece follower is secured by an Allen set screw.

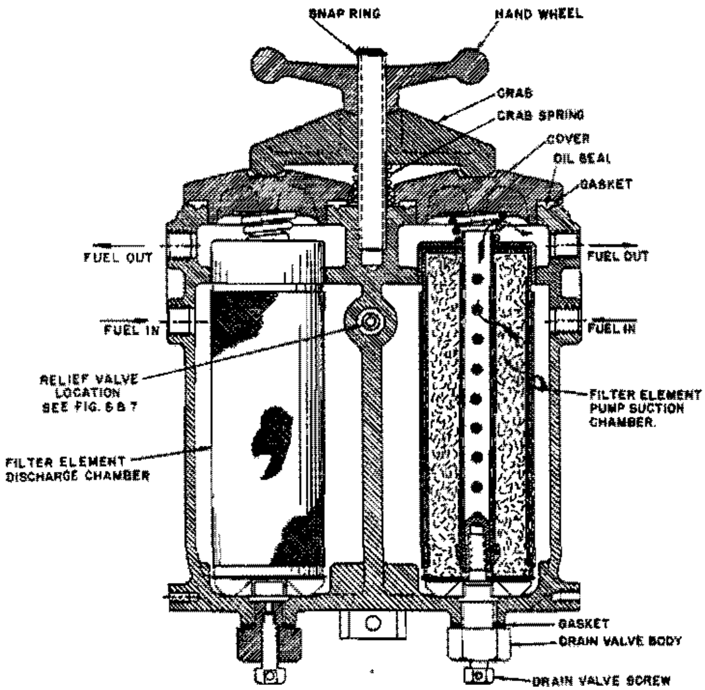
2. Filters

Fuel filters are used in the fuel system in the suction line to the low pressure fuel supply pump, on the discharge to the injector, and at the injector.

a. Suction Filter

The suction filters may be either a single element type as shown in Fig. 10-4 or a dual filter assembly comprising of a pump suction filter and discharge filter in one housing as shown in Fig. 10-5.

Dual filter assemblies are of two types, differing in the method of fuel by-pass provision around the discharge filter. Earlier dual filters #8124180 have a 60# by-pass between the discharge and suction filters as shown in Fig. 10-6 so that in the event of a dirty discharge filter, when fuel pressure exceeds 60#, the fuel will return to the suction filter through the by-pass valve and not reach the engine. These 60# by-pass filters were used on BL type locomotives.



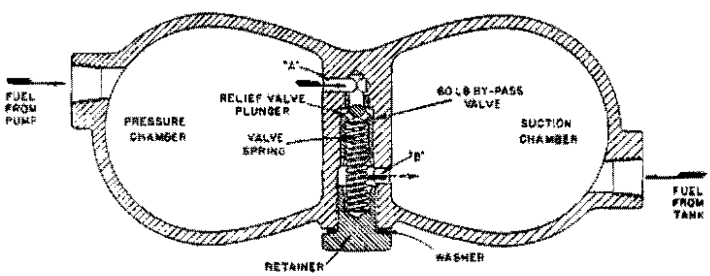
Longitudinal Cross-Section Of Filter Assembly
Fig. 10-5

The by-pass arrangement provided on current dual filters #8147239 on locomotives other than F7, is shown in Fig. 10-7. This is a 15# by-pass. The fuel does not return to the suction filter, but circumvents the discharge filter by passing from the inlet area of the filter to the discharge portion of the filter. In the event of a dirty element or restricted fuel reaching a pressure difference exceeding 15# between the inlet and outlet area, this arrangement will provide continued fuel supply to the sintered bronze filter on the engine.

All suction filters and dual discharge filter elements originally employed Waśtex in the element container, but subsequent to June 1950, a Fulflo filter cartridge has been used. Although the cartridge is used in all new production filters, Wastex may be obtained if desired. The Fulflo cartridge used in these filters is identical in construction to those used in the rectangular Fulflo discharge filter assembly shown in Fig. 10-8, but are of a different size and have a different part number.

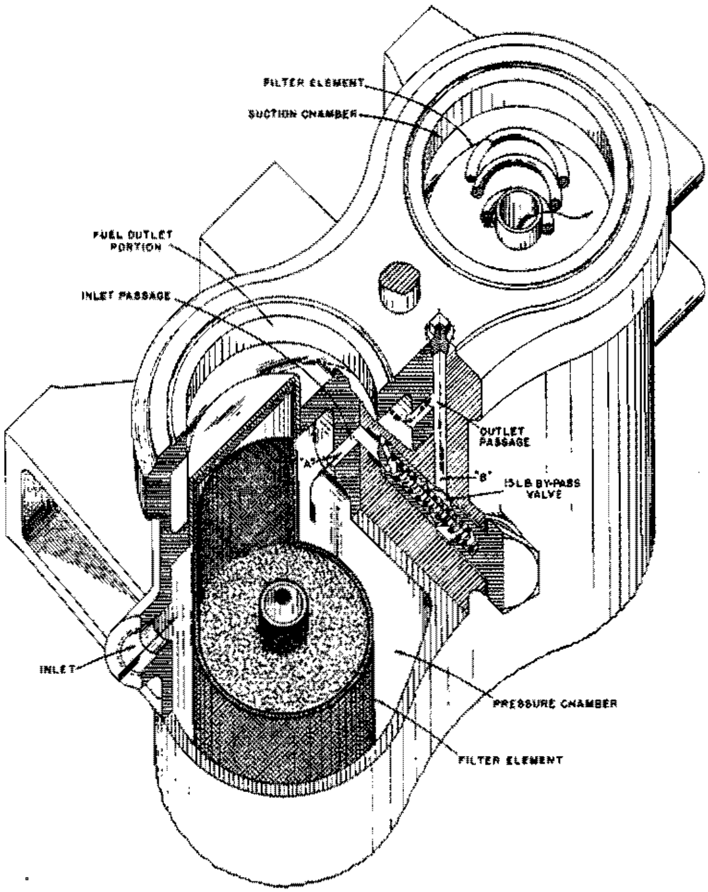
b. Discharge Filters

Discharge filters are located in the fuel line between the fuel pump and injectors. In addition to the discharge filter mentioned under Item "a" preceeding,



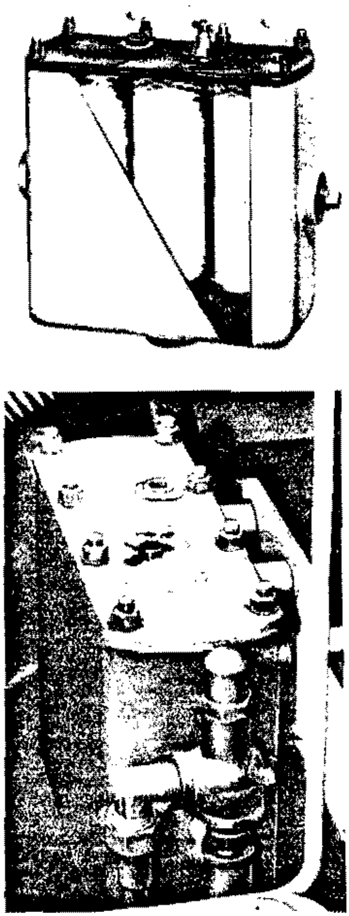
Cross-Section Of By-Pass Valve
Fig. 10-6

in conjunction with the dual filter assemblies comprising a suction and discharge filter in one housing, there are two additional discharge filters in use, shown in Fig. 10-8 and Fig. 10-9. The discharge filter shown in Fig. 10-8 is used on locomotives such as F7 and others not provided with the dual filter assembly. As shown, these



Isometric View — By-Pass Valve Assembly
Fig. 10-7

string wound filter elements are contained in a rectangular housing, the bottom of the element connecting into a discharge manifold. Fuel enters the housing, passes through the filter into the inside center tube and into the discharge manifold.



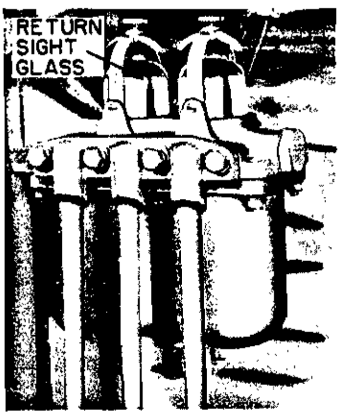
Two Views of Ful-flo Filter
Fig. 10-8

On F7 type locomotives, a 15 pound by-pass valve is connected across the inlet and outlet fuel lines of the filter to allow fuel to circumvent the filter in the event of 15# difference between outlet and inlet fuel pressure. Constant supply to the engine is thereby assured.

On other locomotives, a 60# relief valve in the fuel pump discharge line to the filter provides for return of fuel to the fuel supply tank when pressure to the filter exceeds 60 p.s.i.

The duplex sintered bronze filter, Fig. 10-9, is mounted on the engine front end plate. It consists of a housing with drilled passages for the flow of fuel and a built-in relief valve, to by-pass the fuel in the event of dirty filter elements. Two sintered bronze elements are used. To provide better anti-corrosion protection the elements have been given a tin plating, since August 1951. Fig. 10-10 shows a cross section of the filter assembly. Two standpipes are applied on top and are covered by glass-gasketed covers held by a yoke and screw. The fuel returning from the injectors flows through the return sight glass nearest the engine. An orifice restricts the flow of fuel into the glass and maintains a back pressure of fuel on the injectors of approximately 5 pounds at 800 RPM. (On 8-567B and 12-567B engines, an additional orifice is located in the return sight glass standpipe). The fuel from this glass returns to the fuel supply tank. The fuel returning through this sight glass indicates the condition of the fuel system by the quantity of fuel or presence of air in the fuel. Normally this glass is full of fuel with the engine running.

The sight glass away from the engine is termed the by-pass sight glass because it receives the oil by-passed through the relief valve in the event the sintered bronze filter elements are dirty, and fuel pressure in the housing reaches approximately 45 pounds or about 60 pounds fuel pump discharge pressure. There will be a slight leakage of fuel into this glass that will be noticed at a small opening at the bottom of the standpipe. This is fuel that purposely is allowed to leak around the relief valve and does not indicate dirty filters. In the event the filters are allowed to become so dirty that the by-pass valve opens, fuel will be returned to the supply tank starving the engine of fuel.

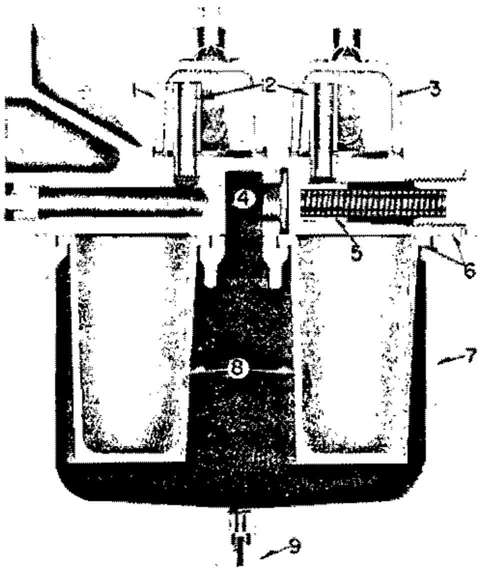


Sintered Bronze Fuel Filter
Fig. 10-9

As shown in Fig. 10-10, the two filter elements seat on gasketed recesses in filter body to which is bolted the filter housing. Fig. 10-11 shows a schematic fuel flow through the filter assembly.

3. Fuel Manifold

The fuel manifolds are made up of the fuel supply and return line from the fuel filters to the injectors. They are mounted on the outside of the cylinder head frame assembly, extending lengthwise of the engine and provided with a connection for a supply and return fuel line to each injector.

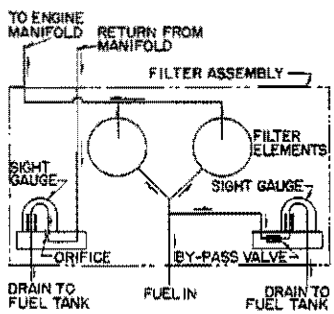


1. Return sight glass-5 lb.	4. Fuel inlet passage	7. Case
2. Stand pipe	5. Relief valve	8. Elements
3. By-pass sight glass	6. Gaskets	9. Drain

Cross Section Sintered Bronze Fuel Filter
Fig. 10-10

C. OPERATION

Fuel from the fuel supply sump is drawn by the fuel pump through the suction strainer and discharges the fuel to the discharge filters. It then passes through the elements to the fuel manifold supply line from where it flows through a jumper line at each cylinder into the injector through the injector inlet filter. A small portion of this supply fuel to each injector is pumped into the cylinder, at a very high pressure, through the spherical check valve and spray tip of the injector. The quantity of fuel depends upon the rotative position of the plunger as set by the governor. The excess fuel not used by the injector flows through the injector, serving to lubricate and to cool the working parts. The fuel then leaves the injector through the return fuel filter. This filter is to protect the injector in the event of a backward flow of fuel into the injector from the return fuel line. From the return fuel filter on the injector the excess fuel returns through the fuel return line in the manifold to the orifice inlet of the return sight glass. This orifice restricts the return fuel to the extent of maintaining a back pressure of approximately 5 pounds. The fuel continues into the return sight glass filling the glass and down through the standpipe under the glass through return line to the fuel supply tank.



Schematic Diagram
Flow Through Fuel Filter
Fig. 10-11

D. MAINTENANCE

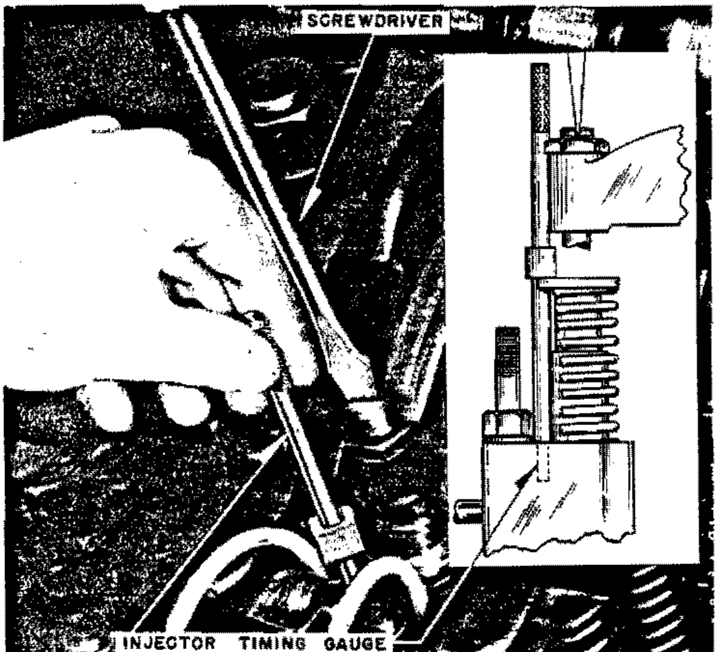
1. Injectors

a. Installing and Timing

When installing an injector in an engine, back off on the injector rocker arm adjusting screw locknut and screws before tightening down the rocker arm shaftnuts.

With the injector installed, time the injector as follows:

(1) Set the flywheel at 4° before top dead center of the cylinder being timed. (See Section 6 for firing order).
(2) Insert gauge #8034638 into the hole provided for it in the injector body, Fig. 10-12.
(3) Turn the rocker arm adjusting screw until the shoulder of the gauge just passes over the follower.



Timing Injector
Fig. 10-12

(4) Tighten adjusting screw locknut, holding adjusting screw in position with screwdriver.
(5) Recheck setting.

b. Injector Sticking

Engines may encounter injector sticking difficulties due to fuel, lube oil or filter maintenance conditions. Since these conditions very often are momentary, injector removal may be minimized by utilizing alcohol to free up injectors in place. Ordinary commercial methanol (wood alcohol) can be applied to the injectors through a hole opposite the timing tool hole, and "popping" the injector or motoring the engine. This sticking condition usually occurs on injectors which are held with the plungers down when the engine is stopped. Should injector racks show signs of sticking, they should be checked for gum or varnish deposits. If they are present, the rack should be cleaned with alcohol and re-checked; if after these remedies, sticking persists, the injectors should be removed and replaced with injectors in proper working order. In no case should injectors be crutched out or cut out and the engine operated. If injectors operating unsatisfactorily cannot be remedied or replaced, the engine should be shut down until corrective measures to overcome the trouble have been carried out.

c. Servicing Injectors

When servicing the injectors, clean conditions must be maintained. Dust or dirt in any form is the most common cause of injector failure. When an injector is in an engine it is protected against dirt, dust and other foreign materials by the various filters employed. When an injector is in storage it is protected against harmful material by the filters which seal the body openings, these in turn are protected by shipping blocks.

However, an entirely different set of conditions are encountered when it becomes necessary to disassemble an injector for repair or overhaul. These conditions necessitate provision of special shops, equipment and trained personnel. These items are expensive, and in most cases the customer would not be warranted in the expense. Electro-Motive maintains this service for our customers and recommends the injector be returned to the nearest Factory Branch for rebuilding. See Factory Rebuild Service Bulletin #302.

d. Injector Testing Procedure

In order to insure satisfactory engine performance, injectors should be tested whenever removed from an engine regardless of the reason for removal. In addition, it would be well to set up a program for testing all injectors in an engine during each annual inspection in order to insure qualification of injectors in complete engine sets.

It is important that the individual doing the testing understands the basic principals of injector operation and testing procedures in order to prevent qualification of defective injectors and condemning of good ones. Instructions in the use of the injector test stand and an outline of each separate test procedure along with a basic explanation of injector operation follows. These instructions cover the testing of new style 201A and all 567 injectors using test stand 8202944 or revised test stand 8171779, Fig. 10-13, but are not applicable to other types of testing equipment since injector leak-off rates vary greatly in proportion to the volume of fuel contained in the high pressure portion of the test stand. (In testing new style 201A injectors, it is necessary to use 201A connector assembly 8204188 instead of the 567 standard assembly.)

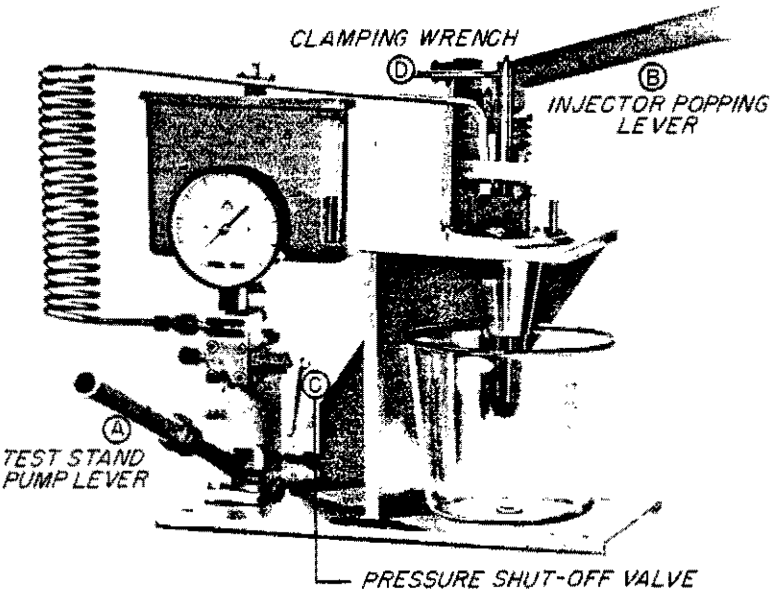
Injector Test Stand

Basically the stand consists of a fuel reservoir, filter, high pressure pump, pressure gauge and necessary connecting lines and fittings to supply fuel to the injectors under test. On placing the stand in operation, it should be set up as instructed by the manufacturer. Inspect carefully for dirt or foreign material in tank and lines. Fill the tank with fuel and operate the pump to purge all free air from the system.

Investigation has shown that the viscosity of fuel oil used in the test stand has a marked effect on the test results obtained. Regular fuel oil may be used providing the viscosity is not less than 32 S.S.U. at 100° F. Do not reuse fuel oil pumped through injector into the plastic bowl.

(1) Test the stand for leaks.

Install the test block in place of an injector on the stand and pump the pressure to 2000 pounds



Injector Testing Stand
Fig. 10-13

as indicated by the stand gauge. This pressure should not drop below 1975 pounds in 5 minutes. Release the block and recheck at 500 and 1000 p.s.i. These pressures should hold 1 minute with no apparent gauge drop. These tests are to be made with the pressure shutoff valve, Fig. 10-13, Item C, open all the way. It the tests are satisfactory, all injector tests may be made without using the shutoff valve. If the above tests indicate leakage in the stand, repeat the tests, closing the shutoff valve, before timing the leak off rate. If tests are satisfactory with the shutoff valve closed, it will be necessary to use the shutoff valve when making the injector holding pressure test.

(When placing a new test stand in operation, or after removing and replacing the gauge, fuel tank, filter or pump for any reason, the test block should be installed as described above, and the pressure raised to 2500 p.s.i. and vented at least six times, before testing the stand for leaks.)

(2) Operation of the stand.

In using the test stand, the operator must consider it as an instrument, rather than a tool. Effort should be made to make the manual operations of repeated tests the same. The following general procedures are listed to help in obtaining uniform operation.

(a) When operating the pump, use a rate of 60 strokes a minute. This gives enough fuel rate to operate the check valve smoothly and circulate fuel within the injector.

(b) When using the popping lever, do not use such force as to damage either the injector or lever. Do not permit the lever to fly up freely.

(c) In making holding tests, do not pump the stand above 2500 p.s.i.

(d) Stands regularly in use should be checked daily for leaks, using the test block.

(e) Fuel oil used for testing should not be re-used.

Injector Testing

(1) Rack Freeness Test

(a) Explanation

The rack engages with a small pinion on the injector plunger and serves to rotate the plunger with respect to two ports in the injector bushing, thus regulating the amount of fuel injected per stroke of the plunger. Binding of the rack is generally caused by damaged gear teeth, scored plunger and bushing, or galling of the rack itself. In an engine, a binding rack may cause sluggish or erratic speed changes and overspeed trip action.

(b) Test

To be considered satisfactory, the rack must fall in and out through full travel by its own weight when injector is held horizontally and rotated about its axis.

(2) Binding Plunger Test

(a) Explanation

Failure of the injector plunger to move up and down freely indicates scoring of the plunger and the bushing, or weak or broken spring. In an engine, a binding plunger will cause erratic cylinder firing and, in extreme cases, overspeed trip action.

(b) Test

Place injector in test stand but do not attach the fuel line. Place rack in the full fuel position and pump all the fuel out of the injector with injector popping lever, Fig. 10-13, Item B. When all the fuel has been exhausted, depress the injector plunger to the extent of its full travel and release popping lever. Plunger should return to the top of its stroke with a definite snap action. Repeat this test with the rack in the half fuel and no fuel positions. Care should be used in the test to prevent the plunger from snapping back so violently that the plunger stop pin becomes broken.

(3) Spray Tip Orifice Test

(a) Explanation

The six small holes in the injector spray tip serve to control injection pressure, fuel penetration and fuel atomization. Plugging of one or more of the holes may change injection characteristics enough to cause poor combustion. In an engine, this might cause a smoky exhaust and in extreme cases, pressure build-up in the injector body might lead to broken spray tips and injector rocker arms.

(b) Test

Attach the test stand fuel line to the injector, being careful to bleed all air from the system. This is best accomplished by holding the fuel line on the left hand injector filter cap or oil inlet hole and slowly pumping the test stand pump lever, Fig. 10-13, Item A, until clear fuel flows from the outlet side of the injector. Slip the clamp bar over the injector stud and tighten with clamping wrench, Item D. Operate the test stand pump lever at the rate of sixty full strokes per minute and observe the spray at injector tip. Fuel should discharge from each orifice. Distribution and angle of the spray should be uniform.

CAUTION: Do not put hands near spray tip as the high pressure fuel is capable of penetrating the skin and entering into the blood stream causing severe injury.

(4) Valve Opening Pressure Test

(a) Explanation

The spherical check valve in the injector tip serves only to prevent the flow of fuel into the cylinder during the time when injection is not taking place. It does not control injection characteristics. In a new injector, this valve will open at a pressure of from 1000 to 1400 pounds per square inch. The nature of the valve spring, however, is such that it takes a slight "set" in the first several hundred hours of operation causing the opening pressure to drop 100 to 150 p.s.i. below the reading taken when new, prior to use in an engine. Any additional drop in pressure is the result of normal wear of the working parts of the valve. When the valve opening pressure drops to a point below 600 p.s.i. valve action is likely to become erratic due to cocking of the valve stem through lack of spring pressure and excessive wear. The valve is then prone to leak which can result in smoky exhaust and possibly a scored liner and piston.

(b) Test

Test is to be made with the injector installed in the test stand as outlined in the preceeding section. Place injector rack in the full fuel position. Operate pump lever at least twenty full strokes to insure that any observed leakage is not due to dirt or a cocked valve. Give pump lever one additional full stroke and immediately note pressure at which test gauge settles out. This is valve closing pressure but since there is very little differential between valve opening and valve closing pressures, the two can be considered as identical for the purpose of this test. If this pressure is less than 600 p.s.i., the injector should be rejected.

(5) Body Pressure Test

(a) Explanation

No external fuel leakage at the injector body seal, the body plugs or the filter cap gaskets is permitted. Such leakage would cause fuel dilution of the engine lube oil which, if not caught in time, could result in ser.ous engine damage.

(b) Test

With the injector installed in test stand as outlined in (3) and (4) depress the popping lever and, at the same time, slowly operate test stand pump lever. When the injector plunger has heen depressed to a point where the ports in t .e bushing are covered, no fuel will discharge from the injector tip and the pressure within the injector body will rise above valve opening pressure. Hold popping lever in this position and operate pump lever until the body pressure builds up to about 2000 p.s.i. Injector should be rejected if leakage is observed at the body nut seal, body plugs or filter cap gaskets. Leakage at the rack should be disregarded for the purpose of this test as this is covered in the following section.

During this test, observe the tops of the filter caps for any sign of leakage between the ball seats on the fuel supply line and filter caps. If such leakage is suspected, blow the fuel oil accumulation off with compressed air and repeat test. If leakage is evident, loosen the fuel line from the injector, retighten, and test again, before changing filter cap or rejecting the injector.

(6) Holding Pressure Test

(1) Explanation

All injectors loose pressure due to leakage at one of several points, but this leakage must be controlled to a satisfactory degree during injector manufacture in order to prevent excessive engine lube oil dilution and, at the same time, achieve dependable injector operation. The Holding Pressure Test will qualify injectors having specified leak off rates providing this leakage is at the proper point and is satisfactorily controlled as outlined below:

1-No leakage is permitted at the nut to body seal, filter gaskets or body plugs as outlined in (5) above.

2-Injectors must be qualified for leakage at the tip. This is caused by leakage:

a-Past the spherical valve.

b-Past lapped joints between valve seat, spring cage, spacer, and/or spring tip.

Care must be exercised in making this qualification that this test is not influenced by raising the pressure just above valve opening pressure. If this is done, the injector may leak a few drops of fuel as the valve opens. An injector should be "popped" hard several times if leakage occurs to insure the leakage is not due to a cocked valve.

Leakage is limited to no fuel dropping from the tip during the hold test outlined in (3) following, starting with 1000 p.s.i. or valve opening pressure, if lower. The tip should be blown or wiped off at the start of this check and the injector nut dried, to prevent interference from fuel accumulated on the outside of the injector above the tip. Formation of a drop of fuel on the tip is acceptable, provided it does not fall.

3-Leakage occuring other than as indicated in (1) and (2) above will show as fuel at the injector rack. This will be due to either:

a-Leakage past the ground joint between the injector body and the injector bushing.

b-Leakage at top of plunger and bushing lapped fit.

The leakage in (3) preceeding is controlled by timing the interval required for the pressure in the injector body to leak off from 1000 p.s.i. or valve opening pressure if the latter is less than 1000 p.s.i., to 400 p.s.i. A fast leak-off rate usually indicates excessive wear between the plunger and the bushing since the ground joint between the injector body and the bushing seldom leaks unless disturbed. The amount of fuel leakage noted at the rack during this test is not indicative of the amount which will leak into the oil when the injector is operating in an engine at normal pressure of 20 to 40 p.s.i.

(b) Test

With injector installed in test stand as in test (3), pop injector smartly with the test stand pump lever 15 to 20 strokes and with a suitable stop watch, time the interval required for the pressure to drop from 1000 p.s.i. (or valve opening pressure, whichever is lower) to 400 p.s.i. If this interval is less than 35 seconds, repeat the test but close the pressure shut-off valve (Fig. 10-13, Item C) immediately after popping the injector. If the interval is still less than 35 seconds, the injectors should be rejected.

Any injector failing to pass any one of the tests outlined above should be returned to the Electro-Motive Division or one of the Electro-Motive Factory Branches for remanufacturing.

e. Replacing Injector Filters

Injector filters should not be disturbed or removed except during injector reconditioning (when all parts are completely cleaned) or otherwise in the event of fuel stoppage to the injector.

f. Storage Injectors

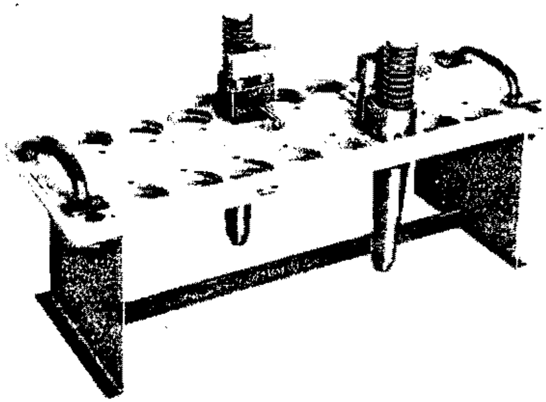
Injectors not to be used for a long period of time should be treated with a rust preventative. Use a stable, non-corrosive, straight run petroleum in the kerosene volatility range, #8203258 (50 gal.). A drawing, file 207, giving details of the construction of an injector storage box, which will accommodate an injector storage rack #8159228 (holding 16 injectors) similar to the rack shown in Fig. 10-14 may be obtained on request.

2. Filters

Filters should be cleaned as specified in Maintenance Instruction 1706 and changed at intervals specified in Scheduled Maintenance Program. Maintenance Instructions 831 and 832 cover two filter types.

3. Air Leaks

Air entering the fuel line at any point on the suction side of the pump will cause the engine to miss fire or stop. Air or gas in the fuel system will appear



Injector Holding Rack
Fig. 10-14

in the return sight glass in the form of bubbles. The presence of bubbles with the engine shut down and fuel pump running indicates an air leak on the suction side of the pump. If bubbles appear only with the engine running it indicates leaking valves in the injector, allowing combustion gases to get into the fuel.

4. Fuel Supply Pump

Fuel supply pump and remote fuel level gauges are covered in Maintenance Instructions 802 and 808. A kit of parts #8186329 for testing remote fuel and water gauges is available from our Parts Department. It consists of two "U" gauges, one graduated for fuel, the other water, four 1/4" bar stock valves, reducing relief valve and strainer. Connecting pipes are to be furnished by the customer. Print 8186329 shows installation and instructions are included.

5. Testing Emergency Fuel Cutoff Valves

If a test is desired of the emergency fuel cutoff valve the following procedure is suggested.

1. Fill fuel tank.

2. Stop engine to prevent starving.

3. Trip emergency fuel trip.

4. Pump fuel from fuel supply sump with the engine fuel pump and then stop pump.

5. Remove drain plug from fuel supply sump and drain remaining fuel into a container.

6. After the sump drains there should be no further flow of fuel. If there is, it will be known that the valve is dirty or defective.

As built, the valves are not required to be leak tight with an air test. The above test is suggested as a practical test.

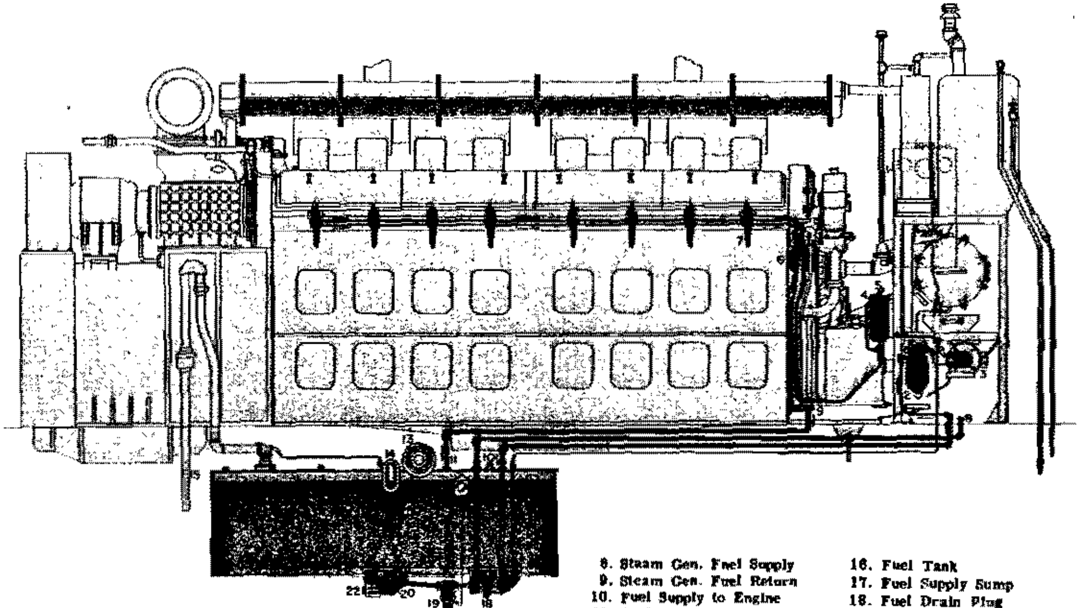
A push rod reset of the emergency fuel cutoff valve may be applied to F2, 3, 7, GP7 and E7 locomotives if desired. See Modification Instruction 5067.

6. Diesel Fuel Recommendations

For information on Fuel Oil Specifications see Maintenance Instruction 1606.

E. EQUIPMENT LIST

Name	Part No.
Holding Vise (Pin)	8069988
Remote Fuel Gauge Test Kit	8186329
Injector Holding Rack (16 injectors)	8159228
Injector Pry Bar	8041183
Timing Gauge	8034638
Test Stand (complete)	8202944
Plastic Spray Cup (extra, used with 8202944)	8171780
201A Injector Adapter (for 8202944)	8204188
Injector Storage Box (drawings)	File 207
Fuel System (pre-Test)	Drawing 294



1. Engine Control and Instrument Panel
2. Suction Filter
3. Fuel Pump and Motor
4. Fulflo Filter
5. Filter By-Pass Relief Valve
6. Sintered Bronze Filter and Sight Glass Assembly
7. Injector
8. Steam Gen. Fuel Supply
9. Steam Gen. Fuel Return
10. Fuel Supply to Engine
11. Fuel Return from Engine
12. Emergency Fuel Cutoff Pull Ring
13. Fuel Filler
14. Sight Gauge
15. Vent and Flame Arrestor
16. Fuel Tank
17. Fuel Supply Sump
18. Fuel Drain Plug
19. Emergency Fuel Cutoff Valve
20. Fuel Drain Plug
21. Fuel Tank Sump
22. Fuel Tank Water Drain Plug

Fig. 10-15 - Schematic Of Fuel Oil System

SECTION XI

GOVERNOR, ENGINE SPEED CONTROL

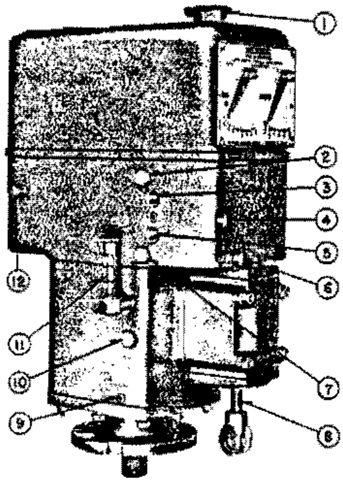
A. GENERAL DESCRIPTION

The governor is a device used for controlling the speed of the engine at a setting determined by the engineman's throttle.

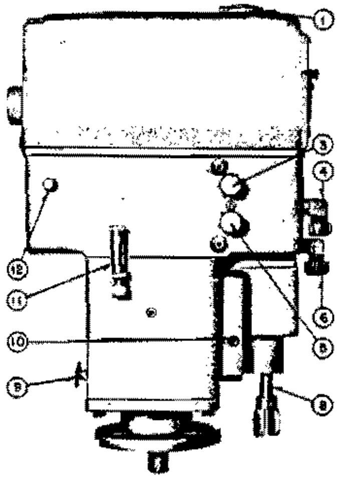
Governors used on the engine are of two types, PG and SI. In external appearance they are similar as shown in Fig. 11-1. The main difference between the PG and SI governors is in the power case portion which houses the governor pilot valve, compensating mechanism and oil pump as shown in schematic diagrams Fig. 11-2 and Fig. 11-3. Governor control used may be electro-hydraulic, pneumatic-hydraulic, electro-pneumatic or manual control, depending on the locomotive application. Speed adjustment is the same on either type governor having the same speed control.

The main parts of the governor are: a speed measuring mechanism (speeder spring and flyweights), fuel regulator (power piston), compensating mechanism (receiving compensating piston integral on pilot valve, buffer piston and springs on PG or actuating and compensating piston and springs on SI), and an independent oil system (oil sump, oil pump, accumulators and oil passages).

All SI type governors have been superseded by the improved PG type governors, however, replacement SI parts are still available. Also, if desired, SI type governors, either electro-hydraulic or pneumatic-hydraulic may be converted to PG type at Electro-Motive Branch shops. In addition, Modification Instructions may be obtained in the use of either electro-hydraulic or pneumatic-hydraulic governors to replace governors other than those types used on respective locomotives.



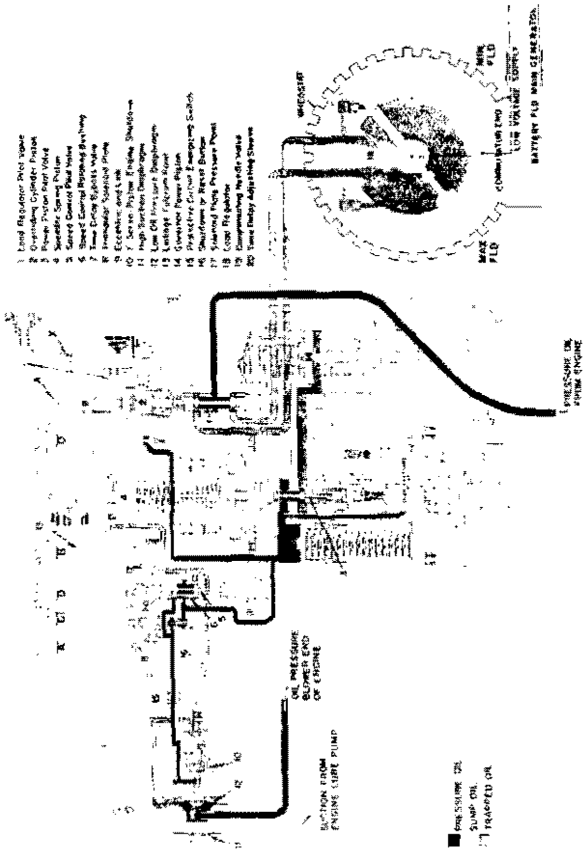
SI Governor



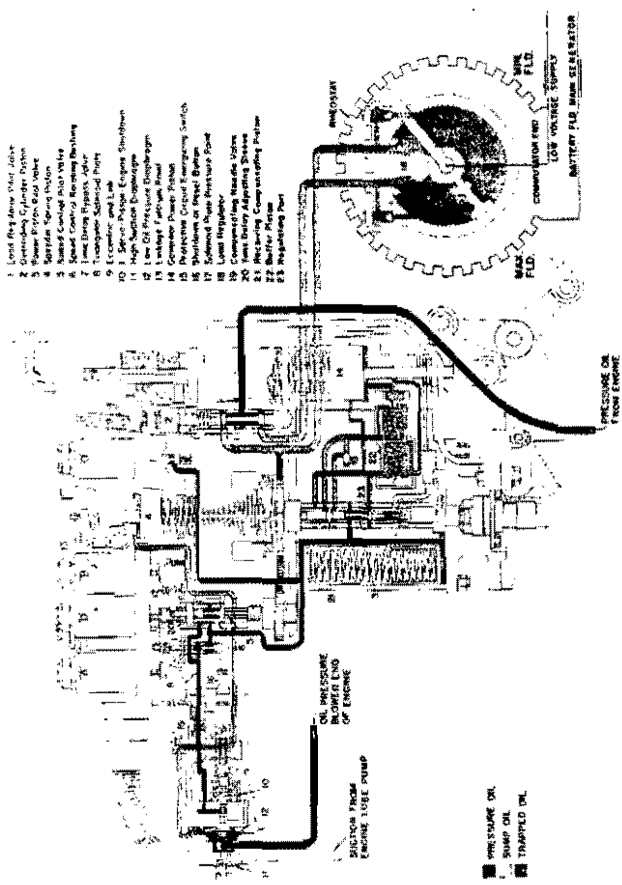
PG Governor

1. Oil filler opening.
2. Pilot valve needle valve, regulate timing Minimum Field to Maximum Field. (If 4 or 5 port bushing not used).
3. Vane motor oil line connection; decrease excitation.
4. Pilot valve engine oil supply.
5. Vane motor oil line connection; increase excitation.
6. Pilot valve oil drain.
7. Pilot valve needle valve, regulate timing Maximum Field to Minimum Field. (If 4 or 5 port bushing not used).
8. Power piston rod.
9. Governor oil drain.
10. Compensating adjusting screw location.
11. Oil level sight glass.
12. Low oil pressure and high suction shutdown rod.

Electro-Hydraulic Governors
Fig. 11-1



Schematic of SI Governor with Electro-Hydraulic Speed Control
Fig. 11-2



Schematic of PG Governor with Electro-Hydraulic Speed Control

Fig. 11-3

Special Governor Applications

Electro-hydraulic and Pneumatic-hydraulic governors are equipped with 5 port and 4 port pilot valve bushings respectfully and have basic speed control bushings which give a definite allowable engine speed acceleration. There are exceptions to these basic governors which differ either in allowable speed increase or pilot valve bushing, or both, to suit specific locomotive requirements. These governors are identified by separate part numbers as follows:

Governor 8157679, is a basic SI electro-hydraulic governor but is equipped with a 4 port pilot valve bushing instead of the basic 5 port bushing. This governor is used specifically with D15 generator on E8 locomotive. Its speed control bushings also allow engine acceleration slightly faster than basic SI electro-hydraulic governors.

Governor 8166358 differs from a basic PG electro-hydraulic governor in as much that it has a 4 port pilot valve bushing in place of a basic 5 port and is equipped with a speed control bushing allowing engine acceleration from idle to full speed in 5-7 seconds. This governor is specifically used on multiple unit transfer locomotives.

Governor 8188853 (PG) used on SD7 locomotives differs in several respects from any other governor. It is equipped with two additional electrical switches in addition to the oil system alarm switch. These are the OLS and LRS switches. Both switches protect against engine overload and are actuated by a bar attached to the upper end of the power piston tailrod. When the power piston reaches 3/16" gap the OLS is contacted which energizes the ORS to move the load regulator toward minimum field. At 5/16" power piston, LRS is de-energized dropping out LRC cutting out the quick start resistance in parallel with the load regulator resistance. Both of these switches are contained in a bracket mounted on the solenoid base near the power piston tailrod and ORS solenoid Fig. 11-18. Setting procedure of the switch will be found on page 1137. In addition this governor has a different pilot valve assembly than any other governor.

B. DESCRIPTION

1. Electro-Hydraulic and Pneumatic-Hydraulic Controlled Governors

The electro-hydraulic governor, and the pneumatic-hydraulic governor, PG and SI, have as a part of the governor, control apparatus for the governor speeder spring, indicators to show throttle position, engine speed, power piston gap, pilot valve setting and other devices for engine protection and operation, such as: load regulator pilot valve and overriding cylinder, low oil pressure and lube oil pump high suction shut down as shown schematically in Figs. 11-2 and 11-3 on the electro-hydraulic governor.

a. Speed Control With The Electro-Hydraulic Governor

Speed control with the electro-hydraulic governor is accomplished in steps by the energizing of different combinations of four solenoids (A, B, C and D) shown in Fig. 11-2 or 11-3. Solenoids (A, B and C) have plungers bearing on a triangular fulcrum plate, Item 8, at varying distances from a set fulcrum point of the plate, Item 17, bearing on a lever connected to a speed control pilot valve Item 5, which operates inside the speed control rotating bushing.

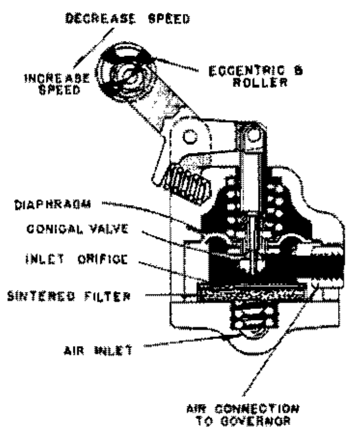
The D solenoid plunger bears on the speed control rotating bushing through the D solenoid cap and bearing. Different combinations of energized solenoids cause the speed control pilot valve to be raised or lowered. Lowering of the speed control pilot valve allows oil from the governor accumulators to flow to the governor speeder spring piston increasing governor spring tension. Raising the speed control pilot valve permits oil trapped above the governor speeder spring piston to drain, lessening governor spring tension, which lowers engine speed.

Energizing of the "D" solenoid is equivalent to raising the speed control pilot valve, since it lowers the speed control rotating bushing. When energized in combination with other solenoids the "D" solenoid lowers supply port opening, lowering the balance point, making the downward movement of the speed control pilot valve less effective. Also, lessening the amount of necessary upward movement of the speed control pilot valve to close the control port when the speeder spring piston is forced down.

b. Speed Control With The Pneumatic - Hydraulic Governor.

Speed control with the pneumatic - hydraulic type governor consists of a transmitter and a receiver which through linkage raises or lowers the speed control pilot valve which is identical in operation as used in the electro-hydraulic governor.

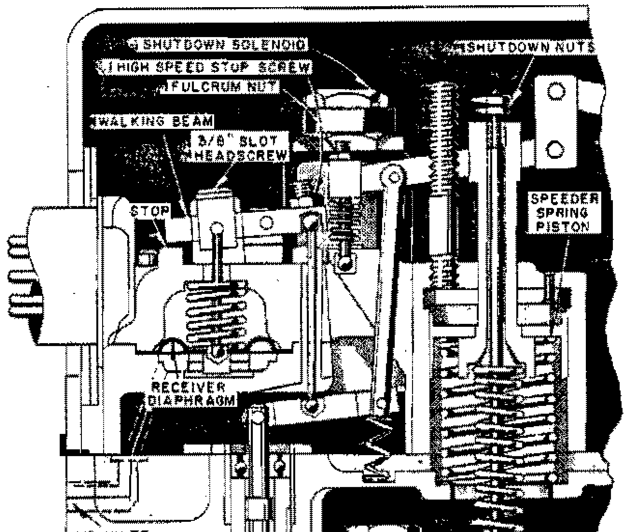
The transmitter, Fig. 11-4, is located in the control stand in the locomotive cab. It is actuated through the



Transmitter
Fig. 11-4

throttle lever, shaft and cam. As shown, it consists of a spring loaded diaphragm and tapered seat valve. Inlet air from the locomotive control air reservoir is supplied the transmitter through a sintered filter and inlet orifice, to give a constant supply of air.

The air supplied through the orifice causes the pressure to raise until the air pressure against the diaphragm balances spring tension, at which time the conical valve is unseated and the air bleeds off to maintain constant pressure. There should be a continuous discharge of air around



Pneumatic-Hydraulic Speed Control
Fig. 11-5

the transmitter stem except during an increase in speed. Varying the diaphragm spring tension, through the throttle and cam, varies the air pressure in the transmitter.

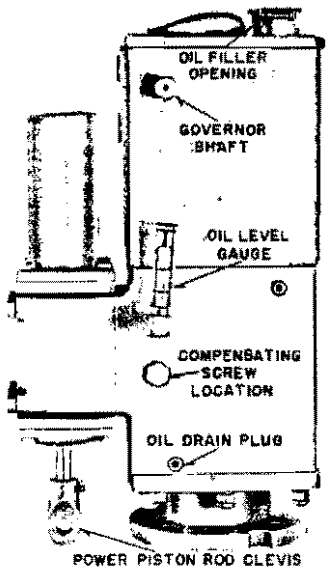
The transmitter air pressure is piped directly to the receiver, located in the governor, Fig. 11-5, and exerts its pressure against the receiver diaphragm. As the air pressure is varied in the transmitter, it is also varied in the receiver.

The diaphragm responds to the varied pressure and moves the speed control pilot valve linkage to raise or lower the speed control pilot valve, operation of which is identical as in the electro-hydraulic governor.

2. Electro-Pneumatic Manually Controlled Governor

a. The electro-pneumatic controlled governor, Fig. 11-6, has its speeder spring control mounted separately on the engine which operates the governor speeder spring through linkage and pneumatic pistons actuated through the air magnet valves. The electro-pneumatic control is shown in Fig. 11-7. An indicator on the back of the control registers according to the throttle position.

b. Governors used with manual speed control are similar to the governor shown in Fig. 11-6, except that a high speed

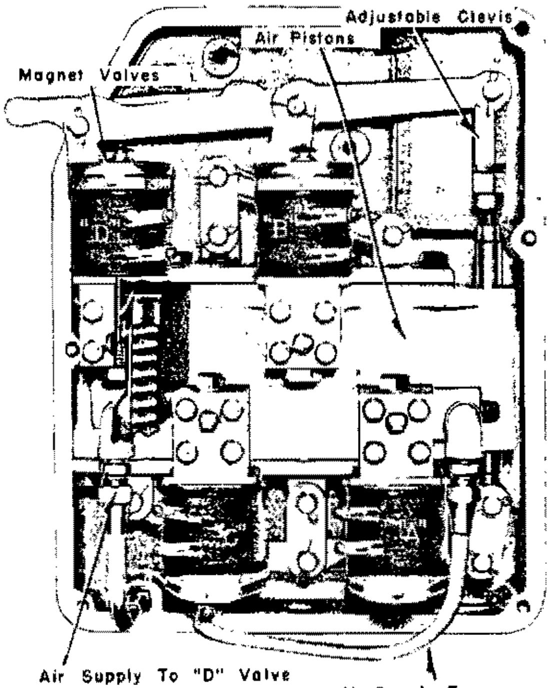


Electro-Pneumatic Controlled Governor
Fig. 11-6

stop is mounted on the governor cover. Engine speed is controlled by increasing or decreasing governor spring tension through mechanical linkage between throttle and governor shaft.

3. Engine Speed Control

The following portions of the governor are similar on all governors used on the engine, whether they are electro-hydraulic, electro-pneumatic, pneumatic-hydraulic or manually controlled. They have in common an independent oil supply, speed control column, power piston and compensating mechanism.



Electro-Pneumatic Governor Control
Fig. 11-7

a. Oil Supply

The governors have a self-contained oil system, consisting of storage sump, rotary gear pump, ball check valves and accumulators. The oil lubricates the moving parts and provides force necessary to operate various parts of the governor.

b. Speed Control Column

To vary the speed of the engine with throttle changes, or to maintain a constant engine speed with load changes, the amount of fuel injected into the cylinders must be varied. This is determined by the position of the power piston. See Fig. 11-8 for SI or 11-11 for PG type governor. To move the power piston (D), the tension on the speeder spring (A) is varied. Whether the throttle changes or the engine speed changes (due to a load change), the flyweights (C) will move. This changes the position of the pilot valve plunger (B) and controls the supply of oil to the power piston.

c. Power Piston

The power piston (D) supplies the energy to move the injector control rack through the injector linkage. The upward motion of the power piston results from oil pressure, controlled by the power piston pilot valve plunger (B), raising the piston against the pressure of the power piston spring (E).

d. Compensating Mechanism

The compensating mechanism prevents the engine from racing or hunting by arresting the movement of the power piston after it has traveled a sufficient amount to give the desired speed. The compensating mechanism includes the actuating plunger (F), receiving plunger (G), and compensating spring (H), compensating needle valve (K) on SI type governors Fig. 11-8; or integral receiving piston, buffer piston and springs, and compensating needle valve on PG type governors Fig. 11-11.

e. Fuel Control - SI Type Governor

The figures 11-8 to 11-10 illustrate the operation of the fuel control portion of the SI governor. The figures are schematic and are not intended to show the relative size or exact likeness or position of the parts.

(1) Constant Speed

Fig. 11-8 represents the governor with the engine running at constant speed with no throttle or load changes. Under this condition, the centrifugal force of the flyweight (C) balances the tension of the speeder spring (A). Therefore, port (Y) in the pilot valve bushing (J) is covered by the pilot valve plunger (B) trapping the oil on the bottom side of the power piston. This holds the power piston motionless. The oil being pumped by the oil pump is stored under pressure in the accumulator (O) and the excess oil is relieved through port (N) in the side of the accumulator.

(2) Load Decreased or Throttle Decreased - Fig. 11-9

If the load on the engine is decreased momentarily, the speed will increase causing the flyweights (C) to move out. If the throttle position is reduced, the tension on the speeder spring (A) will be less and the flyweights will move out. In either event the pilot valve plunger (B) will raise uncovering port (Y) in the pilot valve bushing (J). This will allow the oil trapped on the underside of the power piston (D) to flow through port (W) to the sump. This permits the power piston spring (E) to push the power piston down, reducing the supply of fuel being delivered by the injectors.

As the power piston moves down, a partial vacuum is formed in the chamber above the actuating plunger (F) of the compensating mechanism, which draws the receiving plunger (G) upward against the tension of compensating spring (H). At the same time oil is being drawn into passage (X) through needle valve (K) to relieve the vacuum and allow the compensating spring to recenter the receiving plunger.

The passage through the needle valve is small, so that its effect on the vacuum is slight while the power piston is in motion, but is considerable the instant the power piston stops moving. The port (Y) in the pilot valve bushing would be fully uncovered if it were not for this compensating action which raises the pilot valve bushing closing port (Y).

As soon as port (Y) is covered, the power piston will stop moving down. If the needle valve (K) is set correctly, the amount of fuel supplied to the engine will have been reduced just enough to hold the engine speed constant if the load was reduced, or to reduce the engine speed if the throttle was reduced.

When the engine balances at the new speed setting, the flyweights will return to their central position and the pilot valve plunger to its central position. It is necessary to keep the power piston stationary until the engine speed balances the new setting. To keep the power piston stationary, port (Y) must be kept covered. Consequently, the pilot valve bushing must return to its central position in unison with the flyweights and pilot valve plunger. This is accomplished by adjusting the flow of oil through the needle valve (K) to permit the compensating spring (H) to recenter the compensating receiving plunger and pilot valve bushing in exact unison with the return of the engine speed to the new setting.

(3) Load Increased or Throttle Increased - Fig. 11-10

If the load on the engine is increased, the speed will momentarily decrease, causing the flyweights to move in. If the throttle position is increased, the tension on the speeder spring will be greater and the flyweights will move in. In either event, the pilot valve plunger will lower, allowing oil under pressure to flow from the accumulator, through port (Y) to the power piston. The events occurringfrom this point on, are the opposite to those shown on Fig. 11-9. The power piston moves up, forcing oil through passage (X) to the needle valve (K) and forces the receiving compensating plunger (G) down until port (Y) is again covered by the pilot valve plunger. As the engine speed returns to the new setting, the flyweights, plunger and the bushing are recentered. The port (Y) will then be covered, holding the speed constant.

f. Fuel Control -- Type PG Governor

Fig. 11-11 illustrates the operation of the fuel control portion of the PG governor. The power piston spring acts to shut off fuel to the engine. Oil pressure is used only to increase the supply of fuel to the engine.

The governor drive shaft, pump, rotating bushing and flyballs rotate together. Two accumulators are provided for pressure oil storage capacity; the maximum pressure of governor oil is regulated by a by-pass in one of them. A buffer piston centered by springs is in the hydraulic circuit between the pilot valve plunger and the power piston. It is by-passed by the needle valve, and also by passages which are uncovered when it moves more than a certain distance away from its central position. The small difference in oil pressure on the two sides of the buffer piston is transmitted to the receiving compensating piston on the pilot valve plunger.

(1) Load Decreased or Throttle Decreased

As shown in the schematic diagram, the engine is running normally under steady load and at constant speed. The flyballs, pilot valve plunger and buffer piston are in normal positions. The control land on the pilot valve plunger covers the regulating port holes in the rotating bushing. The power piston is stationary.

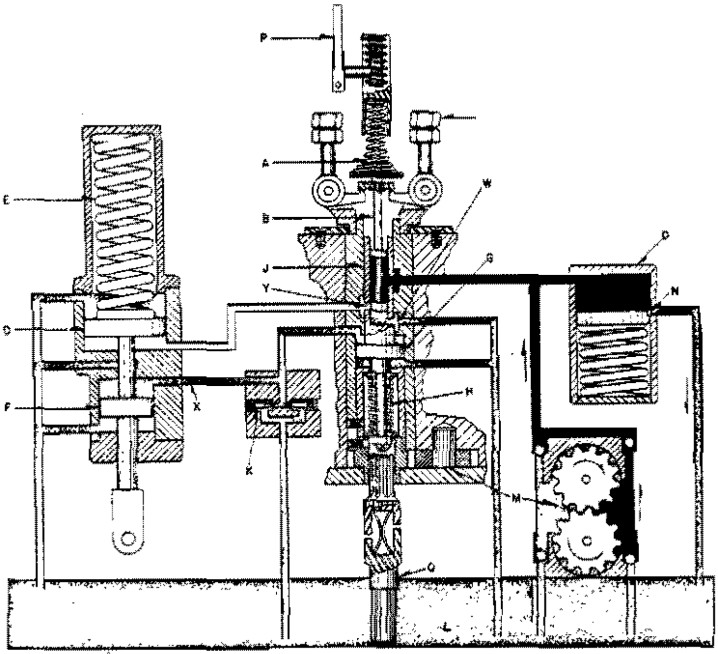
Assume that the engine load is decreased, thus increasing the speed. As the speed increases, the flyballs move out, raising the control land of the pilot valve plunger and uncovering the regulating ports in the rotating bushing. Uncovering the regulating ports in this direction permits oil to escape from the area right of the buffer piston; it moves to the right, and the power piston moves down. It is apparent that since this compresses the right-hand buffer spring, the oil pressure on the left of the buffer piston is a little higher than that on the right. These pressures are connected to the areas above and below the receiving compensating piston on the pilot valve plunger, and since the higher pressure is above this piston, it is forced downward, so that the land of the pilot valve plunger starts to close the ports and stop the power piston movement. The governor is so designed that this action will stop the movement of the power piston when it has moved far enough to correct for the load change that started the action.

Oil leaking through the needle valve then allows the buffer piston to return to center, which gradually releases the force on top of the receiving compensating piston. This force is no longer needed to hold the pilot valve plunger in its central position, because during this time the engine speed has been returning to normal, and the outward force of the flyballs has been returning to normal.

It is apparent that the compensating mechanism described above produces stable operation by permitting the governor to move rapidly in response to a speed change, and then wait for the speed to return to normal.

(2) Load Increased or Throttle Increased

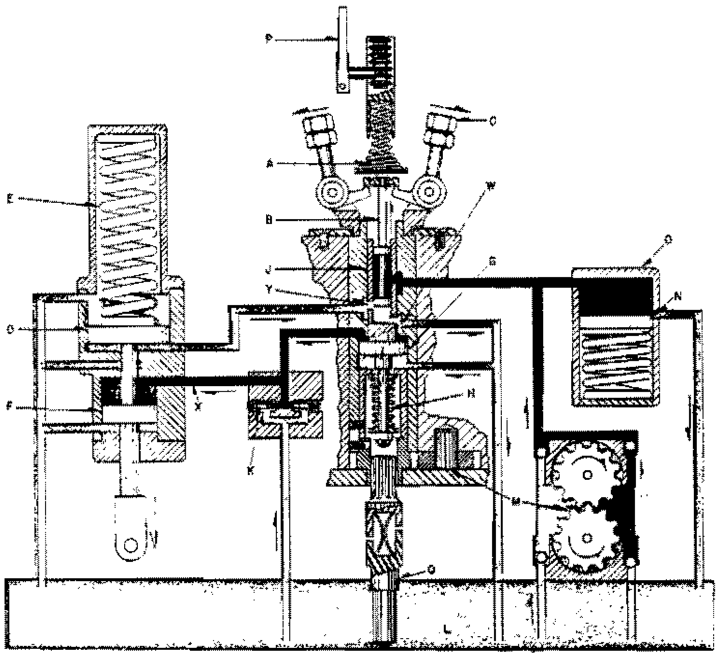
As before, all parts of the governor are centered, and there is no power piston movement. Assume that the engine load is increased, resulting in a decrease in speed. The governor will go through a cycle of operations just the reverse of those described above, as follows: The decrease in speed will cause the flyballs to move inward, which lowers the pilot valve plunger and opens the port. Oil from the accumulators passes through the pilot valve, forces the buffer piston to the left, and moves the power piston upward to give the engine more fuel. The compression of the left-hand



A-SPEEDER SPRING
B-PILOT VALVE PLUNGER
C-FLYWEIGHTS
D-POWER PISTON
E-POWER PISTON SPRING
F-ACTUATING COMPENSATING PLUNGER
G-RECEIVING COMPENSATING PLUNGER
H-COMPENSATING SPRING
J-PILOT VALVE BUSHING
K-COMPENSATING NEEDLE VALVES
L-OIL SUMP
M-OIL PUMP
N-ACCUMULATOR BY-PASS
O-ACCUMULATOR
P-SPEED ADJUSTMENT LEVER
Q-DRIVE SHAFT

REGULATING OIL
PRESSURE OIL
COMPENSATING OIL
PRESSURE-FREE OIL

Type SI Governor Operating Diagram Constant Speed
Fig. 11-8

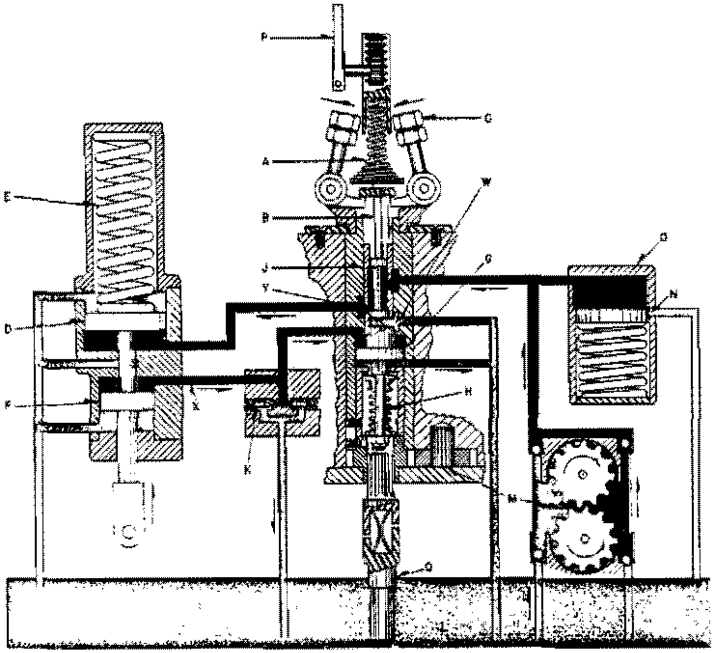


A-SPEEDER SPRING
B-PILOT VALVE PLUNGER
C-FLYWEIGHTS
D-POWER PISTON
E-POWER PISTON SPRING
F-ACTUATING COMPENSATING PLUNGER
G-RECEIVING COMPENSATING PLUNGER
H-COMPENSATING SPRING

J-PILOT VALVE BUSHING
K-COMPENSATING NEEDLE VALVES
L-OIL SUMP
M-OIL PUMP
N-ACCUMULATOR BY-PASS
O-ACCUMULATOR
P-SPEED ADJUSTMENT LEVER
Q-DRIVE SHAFT

REGULATING OIL
PRESSURE OIL
COMPENSATING OIL
PRESSURE-FREE OIL

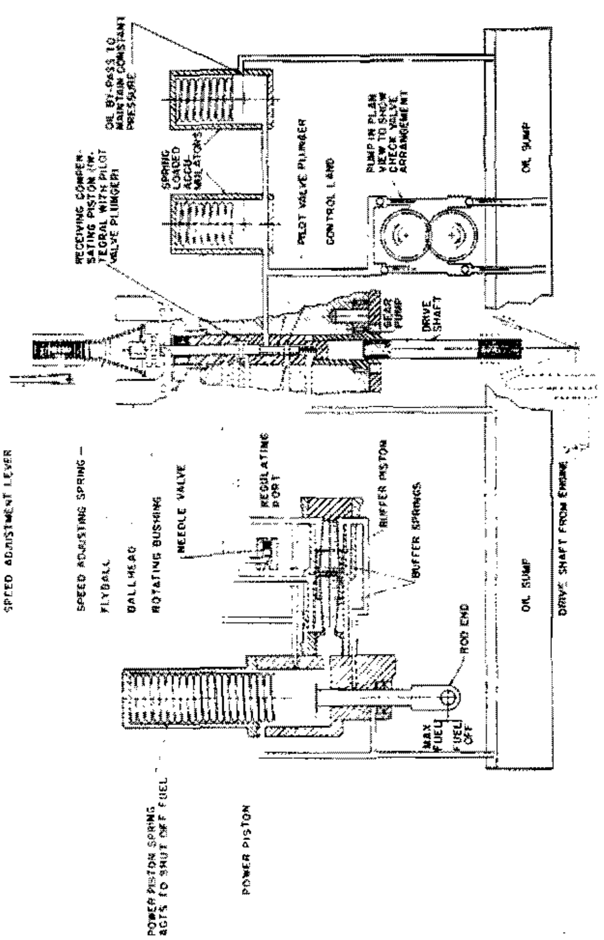
SI Governor Operating Diagram
Load Decreased or Throttle Decreased
Fig. 11-9



A-SPEEDER SPRING
B-PILOT VALVE PLUNGER
C-FLYWEIGHTS
D-POWER PISTON
E-POWER PISTON SPRING
F-ACTUATING COMPENSATING PLUNGER
G-RECEIVING COMPENSATING PLUNGER
H-COMPENSATING SPRING
J-PILOT VALVE BUSHING
K-COMPENSATING NEEDLE VALVES
L-OIL SUMP
M-OIL SUMP
N-ACCUMULATOR BY-PASS
O-ACCUMULATOR
P-SPEED ADJUSTMENT LEVER
Q-DRIVE SHAFT

REGULATING OIL
PRESSURE OIL
COMPENSATING OIL
PRESSURE-FREE OIL

SI Governor Operating Diagram
Load Increased or Throttle Increased
Fig. 11-10



Schematic Diagram PG Governor
Fig. 11-11

buffer spring results in a higher pressure on the right-hand side of the buffer plunger and on the under side of the receiving compensating piston. This pressure moves the pilot valve plunger upward and stops the movement of the power piston when it has moved far enough to correct for the load change that started the action.

Oil leaking through the needle valve gradually releases the force under the receiving compensating piston, allowing the buffer piston to return to center. This force is no longer needed to hold the pilot valve plunger in its central position, because during this time the engine speed has been returning to normal.

In the foregoing description, speed changes as a result of load changes have been considered. Similar governor movements occur when a difference between actual governor speed and governor speed setting is produced by changing speeder spring tension through the speed adjusting control particular to the type of speed control used on the governor. With large speed changes the buffer piston travel is much greater, to the left or right, depending on increase or decrease in speed, opening a passage for the flow of oil to or from the power piston.

4. Engine Shutdown (Adjustments Given Under Maintenance)

a. Electro-Hydraulic Governor

Engine shutdown is manually accomplished by pressing the "Stop" button on the engine instrument panel on locomotives so equipped, or the engine may be shut down by moving the throttle to "Stop" position. Either action will energize the "D" solenoid. This action depresses the speed control rotating bushing so its port is below the land of the speed control pilot valve. This allows the trapped oil above the governor speeder spring piston to drain. The spring under the piston forces the speeder spring piston upward and the piston extension contacts the shutdown nuts on the shutdown rod, lifting the power piston pilot valve up, which action drains the oil from under the governor power piston, allowing the power piston to bring the injectors to "no fuel" position.

b. Pneumatic-Hydraulic Governor

On engines equipped with pneumatic-hydraulic governors, shutdown of the engine is accomplished by releasing the throttle to "Stop" position, which action completes a circuit to the shutdown solenoid shown in Fig. 11-12. Energizing the shutdown solenoid moves its plunger downward to open a valve in the oil line from the speeder spring piston, to the governor sump. The oil released above the speeder spring piston allows the piston to move upward, its extension contacting the shutdown nuts, Fig. 11-5, and bringing about engine shutdown as with the electro-hydraulic governor.

c. Electro-Pneumatic Governor

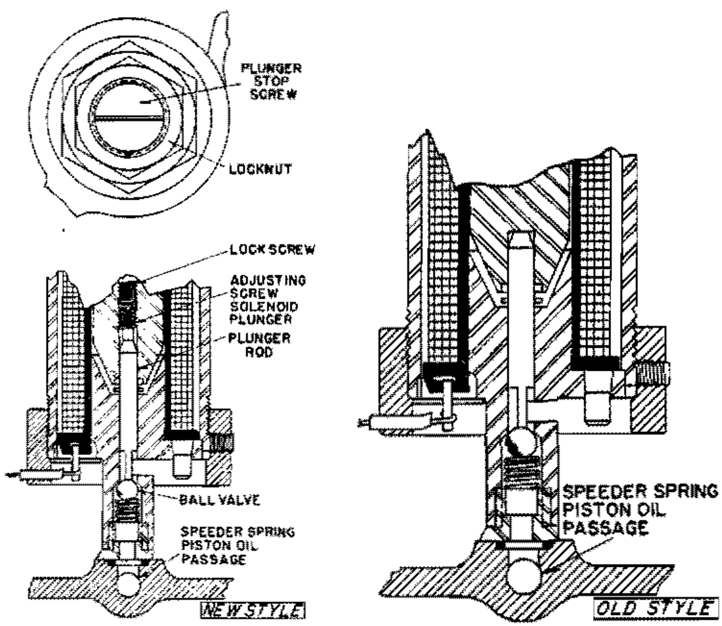
The "D" magnet valve used with electro-pneumatic control is energized to shut the engine down, either with the stop button on the engine instrument panel or by placing the throttle in "Stop" position. The "D" magnet valve, when energized, causes the electro-pneumatic control through connecting linkage to raise the speeder spring plug in the governor, Fig. 11-24, which contacts the shutdown nuts to bring the injector to the "no fuel" position as in the other governors.

d. Manually Controlled Governors

Engine shutdown with manually controlled governors is brought about through the operation of the shutdown lever, shown in Fig. 11-21, which through mechanical linkage raises the speeder plug in the governor, Fig. 11-24, contacting the shutdown nuts, causing the power piston to bring the injectors to the no fuel position through the injector linkage.

5. Low Oil Pressure and High Oil Pump Suction Shutdown

The electro-hydraulic and pneumatic-hydraulic governors have as a part of each governor an oil



Shutdown Solenoid Pneumatic-Hydraulic Governor
Fig. 11-12

failure alarm system which in the event of low oil pressure or high oil pump suction, shuts the engine down and operates the low oil pressure alarm switch. Do not start engine until trouble is corrected, if engine dies on start after resetting governor shutdown rod. See Section 8, Possible Lube Oil Troubles.

As shown in Fig. 11-2 this feature consists of oil pump suction diaphragm, Item 11, with adjusting screw, lube oil diaphragm and plunger, Item 12, actuating servo-piston, two ball check valves, shutdown alarm rod and alarm circuit switch.

The area to the right of the suction diaphragm is connected to the lube oil pump suction. Oil pressure from the blower oil supply is admitted to the left of the lube oil diaphragm. On the right side of the lube oil diaphragm is oil under pressure from the governor speeder spring piston. Governor oil flowing through a milled passage in the outer circumference of the speed control rotating bushing, Item 6, Fig. 11-2, every revolution of the bushing operates the servo-piston in the event of low oil pressure or high pump suction when the engine is at idle. This oil admittance is adjustable through the speed control rotating bushing ports, by rotating the port sleeve, Item 20, Fig. 11-2, to give greater or less admittance of oil, thus regulating the time interval until sufficient oil is available to operate the servo-piston. This gives the time delay necessary for building up oil pressure when starting the engine and is adjusted to operate after approximately 40 seconds with engine at idle position. At 425 RPM and over, a time delay by-pass, Item 7, Fig. 11-2, is opened to nullify the delay period and engine will shut down in about two seconds, should pressure fail or high pump suction exist. This safety feature differs in the electro-hydraulic and the pneumatic-hydraulic governors only in the actuation of the time delay by-pass and its setting. The operation is identical for both the governors.

6. Overriding Solenoid

The overriding solenoid "O," Fig. 11-2, is employed on the electro-hydraulic and pneumatic-hydraulic governors (if used) to position the load regulator in minimum field position. The cylinder does this by lifting the load regulator pilot valve plunger, Item 1, to force the load regulator vane motor, Item 18, toward the minimum field position. The cylinder is solenoid operated; the solenoid being energized when the battery field contactor is open. When the solenoid is energized, it moves a small cylindrical valve downward admitting governor accumulator oil pressure under the overriding cylinder piston, Item 2. This piston moves up carrying the load regulator pilot valve plunger with it. (The lift is fixed at 1/8"). When the solenoid is de-energized, a spring moves the pilot valve back to normal position. The solenoid travel should be approximately 3/32" and is adjusted by screwing down on the adjusting screw, until the armature bottoms; then backing off on the screw two and one-half turns and locking.

Improper adjustment of the overriding solenoid may result in a loss of accumulator oil pressure. This is caused by the overriding solenoid adjusting screw being backed out too far, allowing its valve to open the oil supply port, permitting governor oil pressure to be by-passed directly back to the governor oil sump.

In cases where the engine dies in the lower throttle positions, the adjustment of the overriding solenoid should be checked among other checks. The pilot valve is covered in Section XII of this manual.

C. MAINTENANCE

1. Setting Governer for Engine Speeds

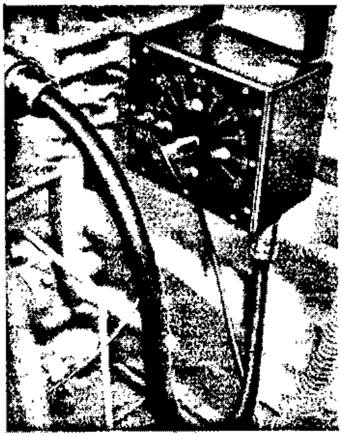
NOTE: Before setting speeds, check speed jack or cover nut stud screwed into speeder piston cylinder for looseness. If loose, check thread length. Shorten to 1/4" if longer and re-apply. Too long a thread may cause spacer in speeder spring piston cylinder to be forced down preventing engine shutdown or not permitting idle speed adjustment. Loose studs may back out due to engine vibration and cause dumping of speeder spring piston oil and engine shutdown.

a. Electro-Hydraulic Governor

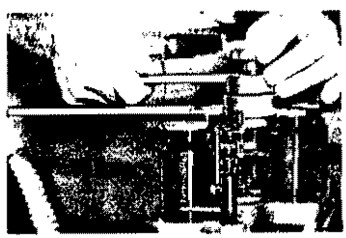
Due to the difference in expansion between the metals in the governor, no attempt should be made to accurately set the engine speeds until the temperature of the metal has equalized.

Then with the use of a tachometer applied either to the governor drive extension or front camshaft, set the engine speed as follows:

(1) Put the isolation switches in units other than the one being worked on in "Start" positions. Be sure necessary precautions are



Portable Speed Controller
Fig. 11-13



Solenoid Adjustment Wrench
Fig. 11-14

taken so the generator on the engine being worked on will not supply power. Special speed setting tools are available for use with electro-hydraulic governors, Fig. 11-13 and Fig. 11-14. Fig. 11-13 shows a portable controller #8182320 having duplicate throttle steps to the main control stand and is placed near the governor on the engine of the unit being checked. A 5 point adapter plug #8182319 converts this controller for use on electro-pneumatic governor control.

The solenoid adjustment wrench #8174868, Fig. 11-14, facilitates speed setting because it prevents solenoid case movement while releasing or tightening solenoid locknut. A screw driver bit with knurled handle as a part of this tool facilitates solenoid adjustment screw setting. For solenoids energized at different engine speeds see the Engine Speed Chart.

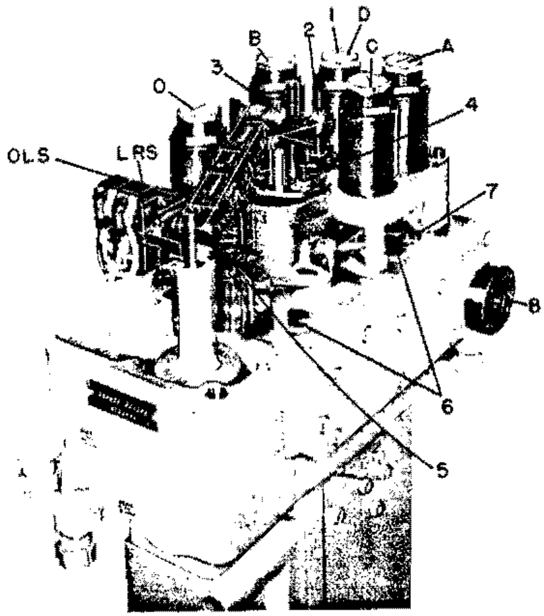
ENGINE SPEED CHART

Electro-Hydraulic Governor

Adjustment Solenoid	Adjustment Sequence	Throttle Position	Solenoid Energized A	B	C	D	Engine RPM
		Off					0
		Idle					275
"C"	5	1					275
		2	*				350
		3			*		425
"B"	4	4	*		*		500
		5		*	*	*	575
Fulcrum Nut	1	6	*	*	*	*	650
"A"	3	7		*	*		725
"D"	2	8	*	*	*	Stop	800
RPM Effect of Solenoids			+75	+300	+150	-150	

(2) Set the throttle in #6 position and bring engine speed to 650 $\pm$ 2 RPM by adjusting fulcrum nut, Fig. 11-15, Item 2, at the end of the linkage, Raising the fulcrum nut increases speed.

(3) Set the throttle to #8 position and bring engine speed to 800 $\pm$ 2 RPM by adjusting the



1. D VALVE
2. FULCRUM NUT
3. SHUTDOWN NUTS
4. SPEEDER SPRING PISTON STOP SCREW
5. POWER PISTON TO FLOATING LINK PIN
6. CONTROL COLUMN HOLDING BOLTS
7. TIME DELAY ADJUSTMENT POINTER
8. HIGH LUBE OIL SUCTION

A. A VALVE
B. B VALVE
C. C VALVE
D. D VALVE
O. OVERRIDING SOLENOID

Speed Control — Electro-Hydraulic Governors
Fig. 11-15

"D" solenoid stop screw, Item 1. Back off stop screw to increase speed.

(4) With the throttle in #7 position, adjust the "A" solenoid stop screw for 725 ± 2 RPM. Turn stop screw in to increase speed.

(5) Set throttle in #4 position and bring engine speed to 500 ± 2 RPM by adjusting "B" solenoid stop screw. Turning in increases engine speed.

(6) With throttle at idle adjust "C" solenoid to give 275 ± 2 RPM engine speed. Turn screw in to increase speed.

(7) Check the above settings and, if correct, all the other speeds will be within limits, with all solenoids set. Check engine speed at all 8 throttle positions. Speeds at intermediate throttle positions must be within 15 RPM of standard.

(8) Also, the speed pointer should be observed to register at correct speed on the speed scale when setting engine speeds at idle and full speed, (275 and 800 RPM). If not, scale must be relocated or remarked so pointer and scale correspond at idle and full speed.

b. Pneumatic-Hydraulic Governor

On engines equipped with pneumatic-hydraulic governors, the engine is adjusted for idle speed and full speed as follows:

(1) Release the throttle from "Stop" position to "Idle" position.

(2) Connect air pressure gauge in air line from transmitter in the control stand to receiver of the governor. (The gauge may be fitted so as to be connected between the air line and the governor, at the governor).

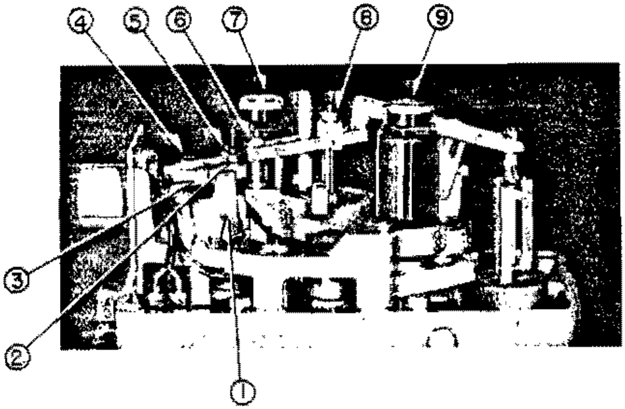
At Control Stand

(3) With throttle in idle, adjust eccentric on transmitter, Fig. 11-4, to give 14 p.s.i. on air gauge.

(4) With throttle in full speed position check air pressure on gauge. The air pressure should be 29 p.s.i. or greater.

At The Governor

(5) Start the engine, controlling speed with the layshaft lever. No air pressure is necessary. Set engine speed at 275 RPM by adjusting fulcrum nut, Item 6, Fig. 11-16. (Be sure shutdown solenoid is not bottomed, see adjusting solenoids for shutdown). The end of the



1. GOVERNOR RECEIVER
2. HIGH SPEED STOP SCREW
3. WALKING BEAM
4. 3/8" SLOT HEAD SCREW
5. LOW OIL TIME DELAY BY-PASS ADJUSTING SCREW
6. FULCRUM NUT
7. SHUTDOWN SOLENOID
8. SHUTDOWN NUTS
9. OVERRIDING SOLENOID

Speed Control — Pneumatic-Hydraulic Governor
Fig. 11-16

walking beam should rest against its stop on the top of the receiver, under the walking beam, directly behind the control cable plug. (The walking beam is the 1-3/16" × 2" rectangular plate on the receiver with two 10-32 Allen screws and one 3/8" slot head screw and locknut). On later governors the walking beam is slotted as shown in Fig. 11-17, to provide adjustment for variation in assembly tolerances, but on earlier governors the walking beam is not slotted.

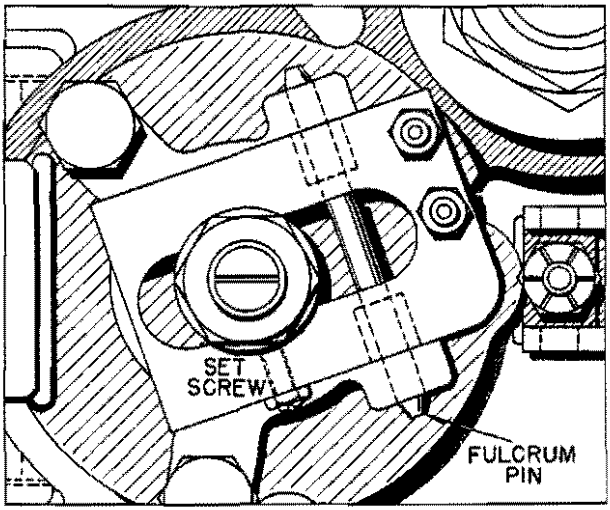
(6) Establish 15 p.s.i. on air gauge by opening throttle. Loosen 3/8" locknut on top of the walking beam and adjust 3/8"-24 screw so as to give a .001" - .002" clearance between bottom of the walking beam and its stop on the receiver. Tighten locknut.

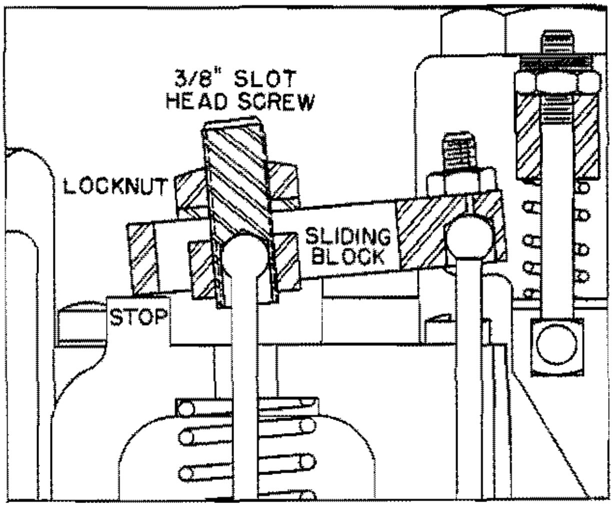
(7) Back off high speed stop screw on walking beam so not to limit travel of beam. Establish 28 p.s.i. on air gauge, by opening throttle. With 28 p.s.i. on gauge, engine speed should be 800 RPM.

(8) If speed is not 800 RPM at 28 p.s.i. gauge pressure, adjust movable block of walking beam (on governors so equipped). Loosen set screw and 3/8" locknut and move block "in" if speed is low, or "out" if speed is high. Tighten locknut and set screw and repeat steps 6 and 7 until engine speed is 800 RPM at 28 p.s.i. gauge pressure.

NOTE: If 800 RPM cannot be attained with 28 p.s.i. air pressure with adjustments provided on earlier governor without adjustable walking beam, the governor may be modified to include the adjustable walking beam.

(9) With throttle at full open position and pressure greater than 29 p.s.i. reduce engine





Slotted Walking Beam Details
Fig. 11-17

speed to 800 RPM by adjusting high speed stop screw on the walking beam.

c. Adjusting Shutdown Nuts, Electro-Hydraulic And Pneumatic-Hydraulic Governors.

Fig. 11-15, Item 3, shows the shutdown nuts on the electro-hydraulic governor, Figure 11-16, Item 8 on the pneumatic-hydraulic governor. The shutdown nuts on the governors should be adjusted to give clearance (3/32" on SI, 1/32" on PG) between the bottom of the lower nut and top of speeder spring piston extension or speeder plug with the engine speed at 275 RPM.

d. Adjusting Solenoids For Shutdown

(1) Electro-hydraulic governor

The "D" shutdown solenoid is adjusted at the time of engine speed adjustment.

(2) Pneumatic-hydraulic governor

There are two designs of shutdown solenoids used on pneumatic-hydraulic governors, Fig. 11-12, although they are similar, the adjustment on each is different.

(a) The solenoid without set screws in the plunger, Fig. 11-12, is adjusted by bottoming the plunger with top adjusting screw, then backing off two turns and locking, with solenoid de-energized, engine dead.

(b) The shutdown solenoid in later pneumatic-hydraulic governors is as shown in Fig. 11-12 (New). The solenoid plunger is drilled and partially tapped for application of two 1/8" Allen head screws. The lower one serves as an adjustment screw while the upper serves as a lock to hold the adjusting screw in place.

The adjustment is made with engine dead, solenoid de-energized, as follows:

(1) Remove the solenoid plunger stop screw and large lock nut, making the solenoid plunger accessible.

(2) Insert small width rule in solenoid case so as to just rest on top of solenoid plunger. Observe dimension from top of plunger to top of case. Using rule, push solenoid plunger down as far as it will go and observe reading on rule at top of case. The plunger travel should be .060" or approximately 1/16". If plunger travel is over, .060", back off on adjusting screw, and if under .060" run adjusting screw down. (The plunger may be removed by using a 1/4"-28 bolt as a lifter). Remove plunger if adjustment is to be made and remove lock screw. Make necessary adjustment of lower screw until .060" plunger travel is obtained, then replace upper lock screw in plunger. Replace plunger and solenoid stop screw and run down until plunger bottoms, then back off 2-1/2 turns and lock with lock-nut. Observe shutdown valve during operation of governor. There should be no leakage at the valve.

e. Adjusting Speeder Spring Piston Stop, Electro-Hydraulic And Pneumatic-Hydraulic Governors.

The speeder spring piston stop is the Allen head set screw shown as Item 4, Fig. 11-15. The location of the stop is the same on the pneumatic-hydraulic governor and is set as follows. With the engine at 275 RPM, run the set screw down until it contacts the top of the speeder spring piston, then back off on screw (5 turns on SI and 1-1/2 turns on PG) and lock. This prevents the piston from hitting top of the cylinder.

f. Adjustment of OLS and LRS switches on governor 8188853.

(1) With engine dead, place 1/32" feeler or shim on top operating arm stop on switch assembly, Fig. 11-18. Resting end of operating arm on 1/32" shim, slip spline end on lever shaft. Fig. 11-19. Hold operating arm in this position.

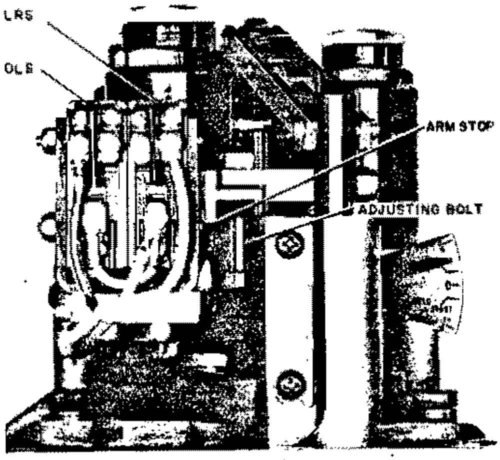
(2) Tighten lever capscrews so levers are snug, but free to move on their shaft. With operating arm in position as given in Item 1, using a screw driver in lever slot, position LRS lever (without locknut) to just open LRS. Tighten LRS lever capscrew.

(3) With operating arm as in Item 1, using screw driver, position OLS lever (with locknut) approximately 5° behind LRS lever. Tighten lever holding capscrew. Remove 1/32" shim from stop.

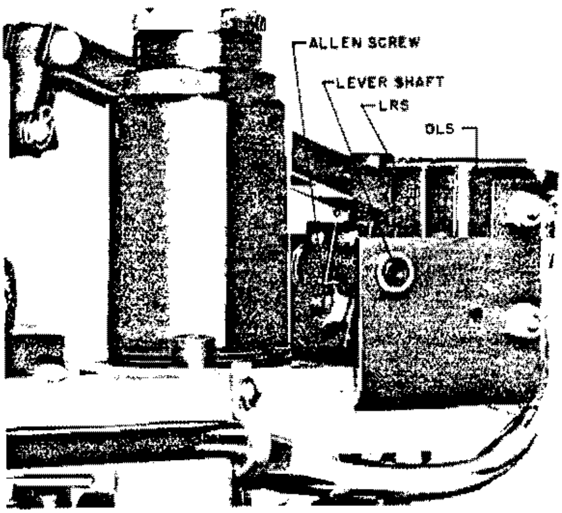
(4) Using governor jack on power piston tailrod, raise power piston to a gap of 5/16" ± 1/64". Adjust knurled end bolt on power piston tailrod bracket to contact operating arm so as to just open LRS switch.

(5) Raise power piston to 3/16" ± 1/64" gap. Loosen locknut on Allen screw, Fig. 11-19, of OLS lever and adjust Allen screw so as to energize ORS switch.

LRS switch should be opened at a power piston gap of 5/16" ± 1/64". OLS switch should be closed at 3/16" ± 1/64" power piston gap.



OLS And ORS Application (Front View)
Fig. 11-18



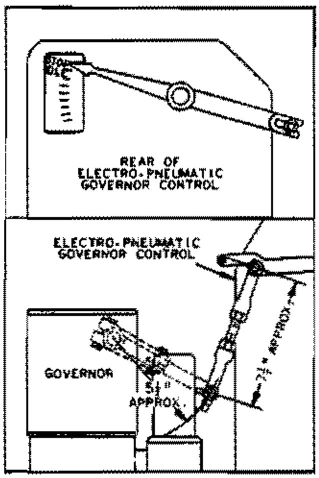
OLS And ORS Application (Back View)
Fig. 11-19

(g) Electro-Pneumatic Governor (Speed Setting)

The linkage between the governor speed control mechanism and the electro-pneumatic throttle controls consist of two links, described as the slide link and the turnbuckle link, as shown in Fig. 11-20.

To set engine speed, adjust linkage length to approximate dimension as shown in Fig. 11-20.

Start engine and check idle speed for 275 RPM. Adjust turnbuckle to correct if necessary. Lengthen turnbuckle to decrease the speed, shorten to increase speed.



Governor Linkage
Fig. 11-20

Bring throttle out to run 8 and check engine speed. See the Engine Speed Chart, page 1129. The difference between idle (275) and full speed (800) RPM should be 525 RPM. If difference is high lengthen slide link, if low shorten slide link to maintain correct differential or difference between 275 and 800 RPM of 525 RPM.

Return engine to idle and check speed, re-adjust turnbuckle if necessary to maintain correct idle and full speed.

(h) Mechanical Controlled Governor (Speed Setting).

Engine speeds at idle and full speed 275 and 800 RPM are set by varying adjustable links in the mechanical throttle linkage used with governors employing direct mechanical throttle control.

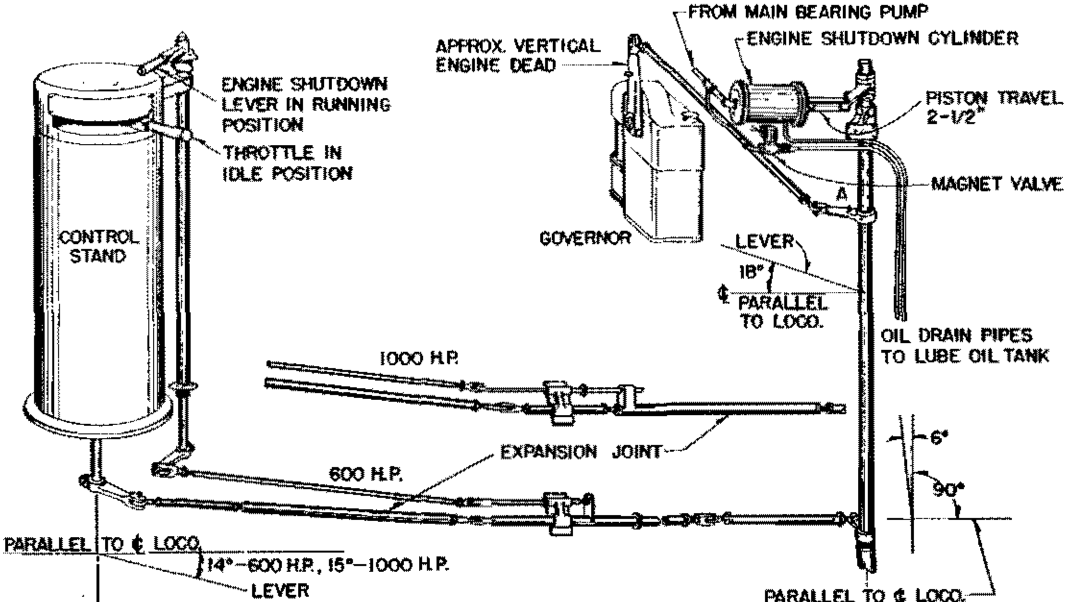
These adjustable links are shown in Fig. 11-21. The upper link connected to the governor vertical arm and arm "A" of the vertical shaft is used to set the idle speed, and if necessary arm "A" may be varied to obtain correct engine speed.

The lower adjustable link connected to the lower arm on vertical shaft is used to adjust full speed. Varying the length of this lower link varies the angle of the lower arm on the vertical shaft giving it a greater or lesser degree of arc. The angle of the arm on the bottom of the vertical shaft in the control stand is important and should be checked with a protractor before any other adjustments are attempted.

The full engine speed should be attained with approximately 1/8" spring bounce in the throttle handle with the throttle in the wide open position. This is done by setting the linkage to give approximately 830 RPM at full throttle and then screwing in on the stop screw on the top of the governor until the engine speed is 800 RPM. This should give approximately 1/8" spring bounce at wide open position of the throttle handle.

2. Adjusting Low Oil Pressure and High Oil Pump Suction Shutdown

a. Low Oil Pressure Shutdown - Electro-Hydraulic And Pneumatic-Hydraulic Governors.



THROTTLE LINKAGE DIAGRAM

Mechanical Controlled Governor
Fig. 11-21

The low oil pressure time delay shutdown period with the engine at idle may be checked by shutting off the oil supply to the lube oil diaphragm by pressing in on the #10 Allen screws, Fig. 11-15 Item 8, of the high pump suction diaphragm. Regulate the time delay period by adjusting the time delay pointer, Fig. 11-15, Item 7.

As explained previously the delay should be regulated at 40 ± 5 seconds by rotation of the manual time delay pointer, Fig. 11-15, Item 7, located under the "A" and "C" solenoids on electro-hydraulic and under shutdown solenoids on pneumatic-hydraulic governors. Rotation of the pointer counter-clockwise increases the time delay period. A very slight change in pointer position is very effective.

(1) Time Delay By-pass Adjustment - Electro-Hydraulic Governor

The time delay by-pass adjustment on the electro-hydraulic governor is made by regulating the clearance between the 3/32" Allen set screw located centrally, down between the "A," "C" and "D" solenoids and screwed into the triangular fulcrum plate, and the time delay by-pass extension, Fig. 11-2, Item 7. The clearance at idle should be .010" to .015". It may be set by backing off on the screw several turns, placing the throttle in #3 position with the engine running and screw down carefully until, pressing on the #10 Allen screw of the high suction diaphragm will give a shutdown in about two seconds. Then turn the screw 1/4 turn further down and lock.

(2) Time Delay By-pass Adjustment - Pneumatic-Hydraulic Governor

The time delay by-pass is checked in the pneumatic-hydraulic governor the same as with the electro-hydraulic governor, by pressing in on the #10 Allen set screw on the high suction diaphragm. The adjustment is made as follows: With the throttle at idle, put a 1/32" shim between the idle stop (control plug end of the receiver) and the walking beam of the receiver. Set the by-pass valve screw, Fig. 11-16, Item 5, which is next to the 800 RPM screw and bears on the spring loaded by-pass extension, to just push the valve off its seat. Check the setting by pressing in on the #10 Allen set screw of the high suction diaphragm with the engine speed at 425 RPM. The shutdown tripping time at 425 RPM and over should be no greater than 2 seconds.

b. High Suction Shutdown - Electro - Hydraulic And Pneumatic-Hydraulic Governors

The high suction shutdown should operate at 17 to 19 inches of vacuum to initiate the shutdown feature.

The adjustment is made with the #10 Allen set screw shown in Fig. 11-15, Item 8. Screwing the set screw in decreases the suction tripping pressure. The setting adjustment may be made by disconnecting the suction line connection at the governor and attaching a device capable of creating a vacuum in the diaphragm chamber of 17" to 19" vacuum, and adjusting the set screw to operate under this suction.

One suitable instrument for this purpose can be made from information in Maintenance Instruction 1529 which gives details of construction from ordinary available parts.

The operation of the suction alarm may be checked manually by pressing in on the #10 set screw. The engine should shut down in 2 seconds when this screw is held in as far as it will go, when engine speed is 425 RPM or higher. In the event a suction diaphragm is broken a small amount of air will be drawn into the lube oil system. The diaphragm may may be checked under external oil pressure not greater than 10 p.s.i. to check for leaks.

3. Electro-Pneumatic Governor Control

a. Parts Replacement

If piston leathers are worn and are to be replaced with new leather, remove cylinder head assembly. To insert piston with leathers in place, lubricate leather with Neatsfoot oil. Care should be taken when installing leathers not to cut them on edge of cylinder casting.

The air piston springs can be removed by removing cylinder heads and retainer nuts.

b. Linkage Adjustment

The clevis on the rod in upper right hand corner (see Fig. 11-7) should be set so it does not strike the housing when at its extreme upward position.

The approximate length of this rod between hole centers is 10-11/16". Increasing this length decreases engine speed, and vice versa.

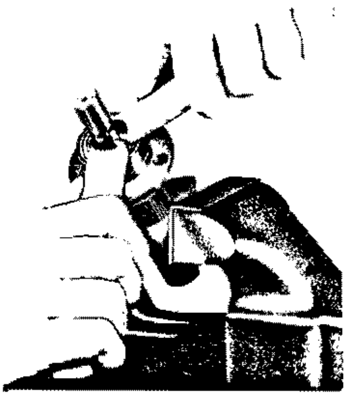
c. Magnet Valves

See Maintenance Instruction 636 for repairing magnet valves used with electro-pneumatic control.

d. Lubrication Of Air Engine

See Maintenance Instruction 1704.

4. Governor Repair



Removing Drive Shaft
Snap Ring
Fig. 11-22

There are certain repairs which can be made to the governor if proper tools and facilities are available. The tools listed and illustrated in Tool Catalog 91A. Under ordinary circumstances, when any of the repairs covered in the following paragraphs are necessary, there may be other parts which require adjusting or replacing. Therefore, we recommend that the governor be returned on a unit exchange, or rebuild and return basis, to be completely cleaned and overhauled.

a. Replacing Drive Shaft Oil Seal (SI Governors).

If a leak should develop at the drive shaft oil seal, oil will be lost from the governor into the engine. To replace seal, remove governor from engine, drain oil, and proceed as follows:

(1) Removing oil seal.

(a) Remove lockwire and four capscrews holding the drive shaft bearing retainer.

(b) Pull or pry (with two screwdrivers) the drive shaft assembly out of the base.

(c) Remove the drive shaft snap ring using tool #8055831 as shown in Fig. 11-22. Discard snap ring, using a new ring when reassembling.

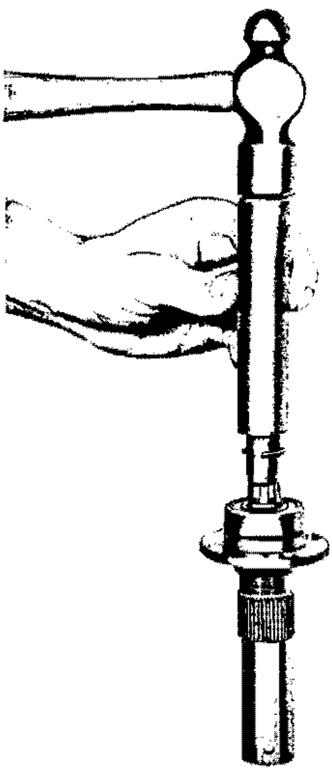
(d) Press the drive shaft through bearing and retainer.

(e) Remove the bearing retainer and press out oil seal.

(2) Installing Oil Seal (SI Governors)

(a) Press a new oil seal in retainer and apply to shaft using oil seal guide #8042684.

(b) Press bearing on shaft and apply a new snap ring using tool #8061015 as shown in Fig. 11-23.



Installing Drive Shaft Snap Ring
Fig. 11-23

(c) Apply small amount of Glyptol around vertical outside edge of oil seal retainer being careful to use sparingly, and install drive shaft assembly in the base of the governor.

(d) Apply oil seal retainer cap screws and lockwire.

CAUTION: The oil seal retainer cap screws should be pulled up evenly and not too tightly, to avoid cocking the retainer or warping it out of shape, causing an oil leak.

b. Replacing Drive Shaft Bearing (SI Governors)

The drive shaft bearing should be inspected whenever shaft is removed. If bearing is to be replaced at any other time, follow procedure for replacing oil seal outlined in Item 1. A new oil seal should be installed whenever shaft is removed.

c. Adjusting End Clearance Of Rotating Sleeve (SI Governors)

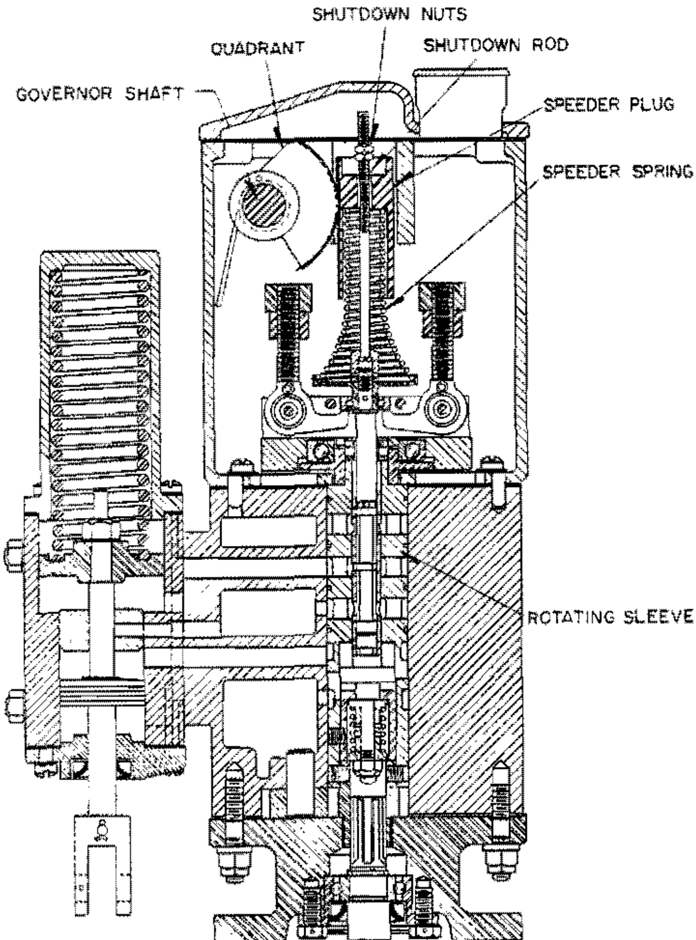
The rotating sleeve is the central rotating part of the governor driven directly by the governor drive shaft. The pilot valve and bushing are in the center of the sleeve and an oil pump gear is attached to the bottom. The flyweights are driven by this sleeve, Fig. 11-24.

(1) Electro-Hydraulic and Pneumatic-Hydraulic Governors

To adjust the rotating sleeve end clearance on the electro-hydraulic and pneumatic-hydraulic governor, it is necessary first to remove governor cover and control column to give access to the sleeve retainer and flyweight assembly. Remove the shut-down nuts, Item 3, on the end of the pilot valve tailrod, Fig. 11-15, and the link pin, Item 5, of the top of the power piston tailrod. Remove the control column hold down bolts, Item 6 (two of these are shown in Fig. 11-15, the other two are directly opposite). With the above parts removed, the control column may be lifted up clear of the power case without disturbing the parts of the control column. On reassembly, new gaskets must be applied, with the exception of the neoprene seal ring on the power piston cylinder.

(2) Electro-Pneumatic and Manual Controlled Governors

On these governors the rotating sleeve is accessible after removing the governor



Cross-Section Of SI Governor
Used With Electro-Pneumatic Control
Fig. 11-24

cover, governor tailrod shutdown nuts and removing the control column hold down screws and lifting the control column off the power case.

Adjustment

The end clearance of the rotating sleeve determines the end clearance of the oil pump drive gear. This can be checked by prying up and down gently on the flyweight support. Excessive clearance will reduce pump capacity. If not sufficient, will cause excessive wear. Pump gear end clearance is determined by the thickness of the shims under the rotating sleeve retainer. These are round shims and fit directly under the retainer screws. Clearance should be .001" to .003".

(a) Remove one lamination from under each end of retainer.

(b) Replace the retainer and screw down tight. Turn the rotating sleeve, if it turns freely, repeat Item 1 until the sleeve turns hard.

(c) Put back sufficient shims under each screw to obtain proper clearance and tighten screws. If the retainer shims were all removed, and there is still too much clearance, the retainer must be replaced. The retainer is removed by pressing the rotating sleeve out of the flyweight support, replacing retainer and adjusting clearance as above.

If a new retainer is not available, the old one may be used by grinding the surface flat to remove any wear groove.

d. Replacing Power Piston Oil Seal (SI Governors)

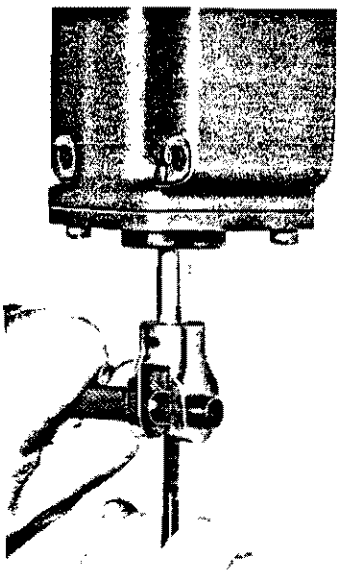
(1) Remove power piston clevis taper pin. Support power piston rod on opposite side, so rod will not be bent.

NOTE: Some governors have a screw on clevis. This may identified by flats on power piston rod.

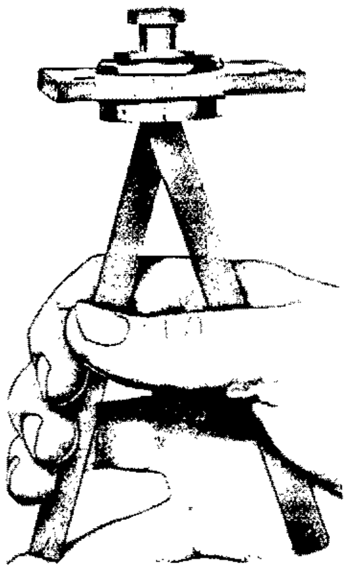
(2) Remove clevis with tool #8068026 as shown in Fig. 11-25.

(3) Remove lower cylinder cover screws and remove cover.

(4) With cover removed, remove oil seal, using tool #8061014 as shown in Fig. 11-26. Insert



Removing Power Piston Clevis
Fig. 11-25



Removing Power Piston Oil Seal
Fig. 11-26

the pointed end of the tool in the seal, close handles, apply pressing plug to upper side of seal and press out.

(5) Press new seal in cover and apply cover back to cylinder. Use guide #8042682 on power piston rod, to protect seal when applying over rod, or if tool is not available use thin shim stock as a guide. Apply new gaskets with thin shellac sparingly, apply gaskets when shellac is nearly dry to avoid forcing excess shellac into cylinder.

(6) Tighten cover screws, being careful to draw them up evenly.

(7) Apply clevis to piston rod and pin with taper pin. Work piston rod with layshaft lever to determine freeness of seal application. A light tap on the corners of the cylinder cover with wooden mallet will sometimes help to free rod.

e. Replacing Flyweight Bearings (SI Governors).

To remove flyweight bearings, it will be necessary to remove the rotating sleeve as already given. Pilot valve and speeder spring are also removed.

As a test for condition of the flyweight bearings remove rotating sleeve and invert at an angle of approximately 5°, push ball arms outward and release, they should return inwardly freely. The bearing may also be tested by moving side ways, at right angles to the rod and measuring movement. If the arms move 1/16" the bearing should be replaced.

(1) Remove cotter and ball arm pins, using care not to bend pins.

(2) Remove ball arm bearing screw and nut. The nut is prick punched to prevent loosening but can be removed by using force. Push out bearing.

(3) Turn bearing between fingers, test for roughness. If slightly rough or worn excessively, replace with new bearing and replace retaining screws. Do not alter position of flyweights.

f. Adjusting Compensation.

(1) SI Governors

If the rotating sleeve assembly should be disassembled for any reason, extreme care will be necessary in locating the nut on the lower end of the pilot valve bushing when reassembling. This nut holds the compensating spring so that there can be no movement of the bushing without compressing the spring. In other words, the nut should be drawn up until the lower face of the lower compensating spring collar, the upper face of the hub of the drive gear and the upper face of the nut are all in the same plane. This is very important and if it is possible to move the pilot valve bushing without compressing the spring after assembling the bushing in the sleeve, the adjustment is wrong and must be corrected.

Compensating needle valves are provided on the front and rear of the SI governor. The needle valve on the front side should be screwed all the way in before the governor is mounted on the engine on the electro-pneumatic or manual controlled governor, as the clearance between the pilot valve and governor will not permit adjustment. All compensation adjustments should be made by the needle valve on the rear of these governors. On the electro-hydraulic and pneumatic-hydraulic SI governors the front compensating screw is open and adjustments are made by this front screw. Back screw out with screwdriver until engine hunts at idle position, then screw in slowly until hunting stops.

NOTE: The compensating screws have two slots on the end. The shallow slot is a screwdriver slot, the other slot is used as a lock by spreading the screw to hold it in a given position, once it is set. Do not use the deep slot for a screwdriver slot as this will result in damage to the screw and to the threads in the housing. Determine which slot to use by trying screwdriver in both slots before attempting to turn in screw.

(2) PG Governors.

When the engine is started for the first time or started after the governor has been drained and cleaned, it is important that the compensating needle valve, located near the power cylinder, shown in Fig. 11-1, be opened several turns and the vent plug (on rear of governor identified by triangular plate), be loosened (not removed) and the engine allowed to surge for approximately 30 seconds to work air out of the governor. After the engine has surged sufficiently to remove air from the system, tighten the vent plug, and close compensating needle valve gradually until surging is just eliminated. The proper setting depends on the characteristics of the engine. Keep the needle valve as far open as possible to prevent sluggishness. After it has been adjusted correctly for the engine it should not be necessary to change it, except for a large permanent temperature change affecting the viscosity of the governor oil. The needle valve setting will vary from 1/8 to 2 turns open.

g. Governor Needle Valves (SI Governors Only)

Needle valves are used in the governor for compensation adjustment and also for adjusting load regulator timing on SI type electro-hydraulic and pneumatic-hydraulic governors not equipped with the 4 or 5 port pilot valve bushing. Bushing application may be obtained on request. Frequent readjustments of the needle valves indicates looseness of the valve. To alleviate loose needle valves the following procedure is recommended:

(1) Insert screwdriver blade in shallow slot of needle valve and back valve out until the deep slot in the valve head clears the governor housing.

(2) Insert screwdriver blade in the deep slot and gently expand valve screw head sufficiently to give snug fit in female thread.

(3) Make necessary adjustment to valve using screwdriver blade in shallow slot. The shallow slot should always be used for adjustments.

(h) Flushing Governor

It is not recommended to flush the governor as a regular maintenance item. Instead, the governor should be disassembled and cleaned if operation is impaired due to dirt or other foreign particles in the governor.

Although in cases of necessity where the governor is suspected of being dirty and it would not be practical to remove the governor from the engine, it may be flushed on the engine as follows:

The engine should be shut down and the drain plug removed from the governor case or petcock opened. Close valve or replace plug and add two pints of filtered kerosene to governor and start engine. By using layshaft manual control lever, vary the speed of the engine from 400 to 500 RPM, for about five minutes. Shut the engine down and drain kerosene from the governor. Repeat this operation several times until the kerosene drained from the governor appears clean. Add two pints of lubricating oil to governor and repeat the above procedure, and drain. This will remove any kerosene trapped in the governor. Fill governor with lubricating oil to proper level and start engine. Vary speed of engine for several minutes to work the air out of the system. The oil level should then be checked and oil added, if necessary.

(i) Governor Oil Supply.

The oil capacity of the governor is 3 pints. Oil having specifications similar to Texaco Regal F (R & O) oil should be used. The oil level should be maintained between marks in sight glass or up to the mark in single marked glasses. The vent at top of sight glass must always be open to assure correct readings. Change governor oil twice a year. Be sure container and oil used are clean.

(j) Governor Storage

In the event the governor is to be stored or out of use for an appreciable length of time, it should be protected against rust. Regular governor oil, Texaco Regal F (R & O) is recommended as it is a good governor oil and in addition has rust preventative properties.

If oil is used in the governor having specification unlike Texaco Regal F (R & O) the governor should be prepared for storage as follows. Drain the oil from the governor and flush governor with kerosene. Refill using oil having similar specifications to Texaco Regal F (R & O). Fill to the proper mark on the sight glass and run for several minutes. If not convenient to run, fill with this oil. When putting the governor again in service, it may be operated on this oil.

All engine governors beginning with engine serial number 51-E-53 have been supplied with Texaco Regal F (R & O) oil.

D. GOVERNOR TROUBLES - ELECTRO AND PNEUMATIC HYDRAULIC

1. If Engine Fails to Start

a. Check overspeed trip lever.

b. Check fuel supply and return in sight glass.

c. Check governor speed indicator pointer to see that it comes to the idle position (while engine is cranking, or running at idle speed) (by manual layshaft control).

d. Check shutdown button, must be "in" (no red showing).

e. Start engine and hold injector layshaft lever at idle position (1 - 1/32" power piston gap), until engine lube oil pressure gauge reaches minimum of 5 pounds per square inch, then release. If engine will not continue to run and above items are O.K., the power piston probably is not getting oil due to internal governor defect.

2. If Engine Stops Under Load

a. Check shutdown button (kicks out and stops engine for low oil pressure or high suction).

b. If pressure is O.K. and button pops out, check suction head on lube oil pumps. This must be less than 18 inches mercury (approximately 9 pounds suction). If it is greater than 18 inches, clean suction screens. Shutdown button should not pop out below 17 inches mercury suction.

c. Check fuel supply and return.

d. Check overspeed trip lever.

3. Improper Speed Settings

a. Check idle and full speed setting at transmitter and receiver or speed setting solenoids.

4. Engine Not Loading Properly

a. Check pilot valve linkage adjustment.

b. See that engine is operative, i.e. has fuel, air.

c. Check vane motor to see that it moves from minimum field position. If not, check operation of overriding solenoid to see if its hydraulic valve is operative (will move pilot valve up and down). Also, check overriding solenoid plunger operation to see that it moves downward when energized. (Interlock on BF contactor closes when BF contactor opens).

5. Engine Running Consistantly Over Or Unloaded

a. Check engine speed and speed indicating scale (inside governor), pilot valve scale, and power piston gap scale (inside governor), for accuracy under running, loaded conditions. If scales are off location for full load operation, reset and pin in place. Then reset pilot valve linkage.

6. Engine "Hunting"

NOTE: This can be caused by three systems. They are (1) Governor, (2) Pilot Valve and Injector Linkage, and (3) Load Regulation.

a. Check oil level in governor, must be between 2 lines on sight glass when running and under normal running temperatures.

b. Check injector linkage for binding.

c. Check load regulator vane motor travel timing. If hunting under load, remove load and check at same speed. If regulator timing is off and causing hunting, unloading the engine should stop the hunting. (The hunting can be greatly helped by steadying the engine speed with the layshaft lever).

d. If all other checks above are O.K. then reset compensating needle of speed governor as necessary.

e. Flush the governor to remove dirt in the system.

7. Governor Overflows with Oil

a. Defective pilot valve oil seal (not to be confused with foaming due to overfilling). Later electro and pneumatic-hydraulic governors have a tell-tale hole in the power piston pocket to indicate leaking pilot valve oil seals. If oil flows from tell-tale, seal is defective.

b. Broken "lube oil pressure" diaphragm.

c. Leaking oil — failure of piston valve bushing gasket.

d. Porous casting.

E. SPECIFICATIONS

Governor

Governor speed at 800 RPM of engine	872 RPM
Governor oil	Specification similar to Texaco Regal F (R & O) oil
Governor oil capacity	3 pints

Governor Drive

	Min.	Max.
Bushing Bore Diameter (as assembled in housing)		1.8785"
Distance between thrust faces	1.868"	
Diameter of drive shaft	1.872"	
Diametric clearance (drive shaft and driven gear to bushings)		.0065"
Governor drive shaft, thrust face to shoulder	1.876"	
Governor drive shaft end thrust	.002"	.013"
Driver gear, thrust face to shoulder	1.878"	
Driven gear end thrust	.004"	.015"

NOTE: Limit of thrust clearance is governed by gear backlash.

	Min.	Max.
Bevel gear backlash	.002"	.012"
Seal area, tachometer drive shaft	.365"	.375"

NOTE: If groove from seal wear is not rough or fluted and diameter remains within limits, use in this condition, do not attempt to polish surface.

Bell crank end thrust	.001"	.018"

Replace bell crankshaft if irregularly worn by needle bearing contact or diameter worn to less than .748". Replace all questionable ball or needle bearings.

Governor Drive Gear

Drive gear bushing to stubshaft	New .003" - .006" Limit .010"
Thrust clearance	New .007" - .014" Limit .020"
Backlash	New .008" - .016" Limit .030"

Electro-Pneumatic Control

	Min.	Max.
Air cylinder bore diameter		1.753"
Piston - outside diameter	1.744"	
Inside diameter of Body Bushing Bores		.6275"
Adjusting rod diameter	.621"	
Male and female piston rod diameter	.622"	
Piston rod guide bores in body covers		.630"
Inside diameter of upper and lower Piston Rod Sleeves		.646"

Air cylinder piston spring

Free length	4-9/16" ± 1/16"
Loaded	52 to 62 pounds at 3-1/8" long

Piston Travel

A and C valve pistons	7/16"
B and D valve pistons	1/2"

F. EQUIPMENT LIST

Name	Part No.
Snap ring removing tool	8055831
Oil seal guide	8042684
Snap ring applying tool	8061015
Power piston clevis removing tool	8068026
Power piston seal removing tool	8061014
Power piston seal applying guide	8042682
Governor drive locknut removing tool	8116968
Governor drive tachometer seal guide	8062027
Vacuum pump device (Drawing No.)	110

SECTION XII

PILOT VALVE, PILOT VALVE LINKAGE, SETTING INJECTOR RACK AND LINKAGE

A. DESCRIPTION

1. Pilot Valve

The pilot valve is a device for controlling the flow of oil to the vane motor of the load regulator.

Electro-hydraulic and pneumatic-hydraulic governors have the pilot valve embodied in the governor housing as shown schematically in Fig. 11-3, Item 1, Section XI. On installations employing electro-pneumatic, or mechanical control governors, the pilot valve is a separate unit, located in front of and adjacent to the governor as shown in Fig. 12-1. In each case the operation of the pilot valve depends on the action of the governor.

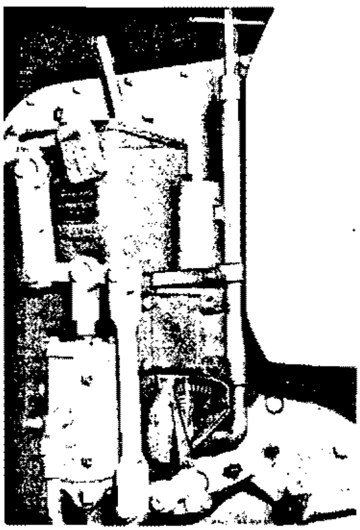
Although the actuating, connecting linkage is different, and the location of the pilot valve in and out of the governors is different (along with additional devices used with the pilot valve in electro and pneumatic-hydraulic governors, such as overriding piston) the function of the pilot valves are the same, and their main parts are: housing, valve plunger, and bushing as shown in Figs. 11-3 and 12-9.

Pilot valves used with electro-pneumatic and mechanical controlled governors are equipped with needle valves for manually regulating load regulator timing. Electro-hydraulic and pneumatic-hydraulic governors have the pilot valve in the governor and were originally equipped with needle valves in the governor for manual adjustment of the load regulator timing. Subsequent to March, 1949, these governors were equipped with either a 4 or 5 port pilot valve bushing having orifices at the lower end which automatically govern load regulator timing, consequently making the needle valves unnecessary. For load regulator timing for various locomotives see Maintenance Instruction 629.

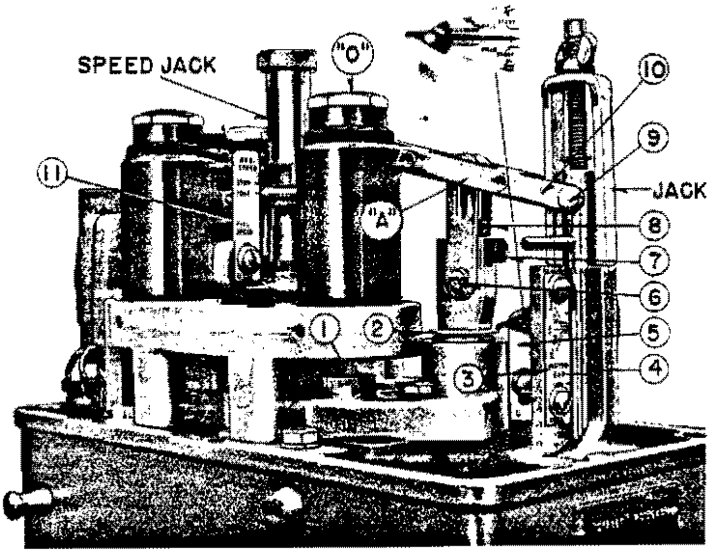
2. Pilot Valve Linkage

The pilot valve linkage on the electro-hydraulic and pneumatic-hydraulic governors are the same and consist of a horizontal floating link shown on the electro-hydraulic governor in Fig. 12-2, Item 10, and vertical slide link, Item 8, eccentric adjustment, Item 6, clevis and holding cap screw, Item 7, which connects the pilot valve plunger to the floating link.

The pilot valve and linkage used with the electro-pneumatic or mechanical controlled governors is shown in Fig. 12-1. The linkage consists of a horizontal link



Pilot Valve Linkage
Fig. 12-1



1. Overriding solenoid valve
2. Pilot valve indicating disc
3. Power piston gap scale
4. Power piston tailrod
5. Pilot valve scale (See Insert)
6. Eccentric adjustment
7. Clevis holding cap-screw
8. Vertical slide link
9. Floating link to tailrod pin
10. Floating Link
11. Engine speed scale

"O" Overriding solenoid

Top Of Electro-Hydraulic Governor
Fig. 12-2

to which the pilot valve plunger is connected by a clevis, and long and short vertical links connecting the horizontal link to the injector linkage bell crank and governor shaft lever.

3. Injector Linkage

The injector linkage connects the governor power piston to the injector racks, through the layshaft and injector rack micrometer adjustments as shown schematically in Fig. 12-9.

A bell crank connected to the power piston and to two links, one to each layshaft, makes up the injector linkage. One link from the bell crank to the layshaft, is adjustable.

B. OPERATION

1. Pilot Valve

The pilot valve in conjunction with the load regulator requires each cylinder to assume a predetermined load for each throttle position within the limits of the load regulator range of action, by controlling the loading of the main generator through the battery field.

Fig. 12 - 9 shows schematically the pilot valve operating diagram used on engines with electro-pneumatic and mechanical controlled governors. A schematic diagram of pilot valve used with electro-hydraulic or pneumatic-hydraulic governors is shown in Fig. 11-3, Section XI. The linkage connection to pilot valve in the electro-hydraulic governor, which is the same as the pneumatic-hydraulic governor, is shown in Fig. 12-2.

Point "A", Fig. 12-9, on the horizontal link corresponds with a similar point "A" on Fig. 12-2, on the pilot valve floating link on the electro-hydraulic and pneumatic-hydraulic governor. When engine output is correct for a certain throttle position, the lands of the pilot valve plunger close ports "B" and "C" in the pilot valve sleeve, Fig. 12-9. In this position of the plunger no oil can flow through the ports to or from the load regulator vane motor. This position is the balance position of the pilot valve. As shown in Fig. 12-9, lubricating oil under pressure enters the pilot valve at a point between the lands of the plunger and is trapped when the pilot valve is balanced.

When the horsepower demand on the engine is greater or less than the engine is set to develop at a given throttle position, a change will be made in the position of the governor power piston to meet the changed horsepower demand. Since the throttle position has not changed, the pilot valve plunger will either be raised or lowered, through the action of the power piston and linkage. This action unbalances the pilot valve and it operates to cause the load regulator to adjust the generator load to the engine's output.

If the engine is overloaded, the power piston will move upward to increase fuel. This action raises the pilot valve plunger, opening port "B" with its upper land. Oil under pressure can then flow through port "B" through connecting line to the vane motor of the load regulator, causing the vane to rotate, and reduce the main generator output by the load regulator increasing the electrical resistance of the main generator battery field. As the vane is rotated, it pushes the oil ahead of it through a line to port "C" of the pilot valve. The oil passage is restricted out of the pilot valve through the lower needle valve and therefore regulates the speed of the vane in this direction. The restricted oil also causes a pressure on the lower shoulder "D" of the pilot valve sleeve. The oil pressure on the sleeve shoulder moves the sleeve upward, until balanced with upper spring pressure. As the load on the engine is reduced, the power piston and pilot valve plunger move downward, closing ports "B" and "C" by the lands of the pilot valve plunger.

The operation of the pilot valve for an underload on the engine is opposite for that given for an overload, again controlling the engine to assume its proper load for a certain throttle position, within the range of action of the load regulator.

The pilot valve may be set, either for maximum or minimum field, for starting the locomotive. In maximum field, port "C" is open to operating pressure when starting; in minimum field, port "B" is open to oil pressure when starting.

An additional setting is used, known as modified maximum field start. With modified maximum field start, the pilot valve is set for maximum field, but through the action of the overriding solenoid, when energized, the pilot valve is positioned in minimum field position. Immediately after de-energizing of the overriding solenoid the pilot valve assumes the position as originally set, maximum field. See "Overriding Solenoid," Section XI. Provision is made to allow oil to circulate through the system with the engine at idle. This keeps warm oil in the system, improving the operation of the mechanism.

With pilot valve set for minimum field position, an unbalanced condition exists for the first several throttle positions, until the greater proportional movement of the power piston to speeder spring piston on electro-hydraulic or pneumatic-hydraulic governors, or governor speed control shaft on electro-pneumatic or mechanical governor, allows the pilot valve plunger to assume balance position. With maximum field start, the greater movement of power piston in the first throttle position, will allow plunger to assume balance position.

C. MAINTENANCE

1. Setting Injector Rack and Linkage

a. Check racks and injector control linkage. Before attempting to set the injector rack, all injector racks, injector rack control linkage and the governor power piston should be checked for binding, sticking or wear, which would affect the correct setting or the operation of the racks.

To test injector racks for sticking, remove the clevis pin from the right and left bank injector layshaft and control rod clevis. Move each layshaft slowly through its entire travel, using only light pressure. This will move the injector racks in and out, thereby enabling any sticking racks to be located. (See Section X for remedy of sticking injectors.)

The control linkage from the governor power piston to the injector layshafts should also be checked for binding. The governor power piston rod should also be checked for scoring which would cause it to bind or stick. After completing checking of linkage, replace the clevis pin as removed, then proceed with power piston and injector rack setting.

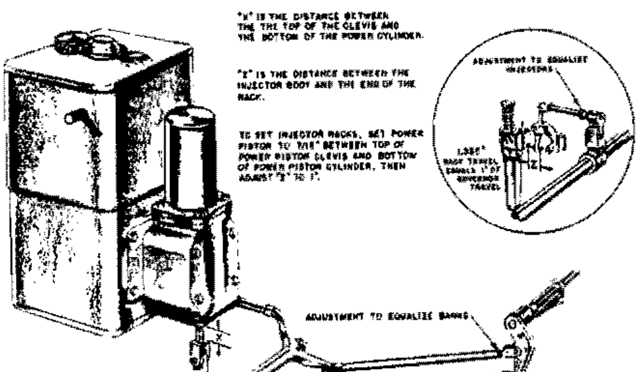
b. Setting governor power piston to 7/16" dimension.
For proper injector rack setting, all injector racks should be set one (1) inch out of the injector body with the dimension between top of governor power piston clevis to bottom of power piston cylinder held to 7/16" dimension, Fig. 12-3, as follows:

(1) Electro-hydraulic and pneumatic-hydraulic controlled governor setting.
Place the power piston gauge, 7/16" dimension, between the power piston clevis and cylinder head, Fig. 12-6. Apply power piston jack to top of tailrod as shown in Fig. 12-2. Raise the power piston up slowly, using layshaft handle, until the 7/16" portion of the gauge is nearly contacted (approx. 1/8" clearance). Tighten

tailshaft jack to hold gauge snugly. Do not force power piston tailrod excessively as it may be broken in tension. With the 7/16" gauge in place the locating circumferential mark on the power piston tailrod should line up with 7/16" setting mark on the indicating plate shown in Fig. 12-2.

(2) Electro-pneumatic or mechanical controlled governors.
Remove the stop collar from the governor power piston (if used). Place the power piston jack in position on the governor as shown in Fig. 12-1. Place the power piston gauge with the 7/16" dimension on top of the power piston clevis as shown in Fig. 12-6. Slowly raise the power piston with jack. Do not use a wrench on the jack. Raise the power piston until the gauge is held snugly in place.

c. Setting injector racks to 1" dimension.
Injectors are properly set when the end of all

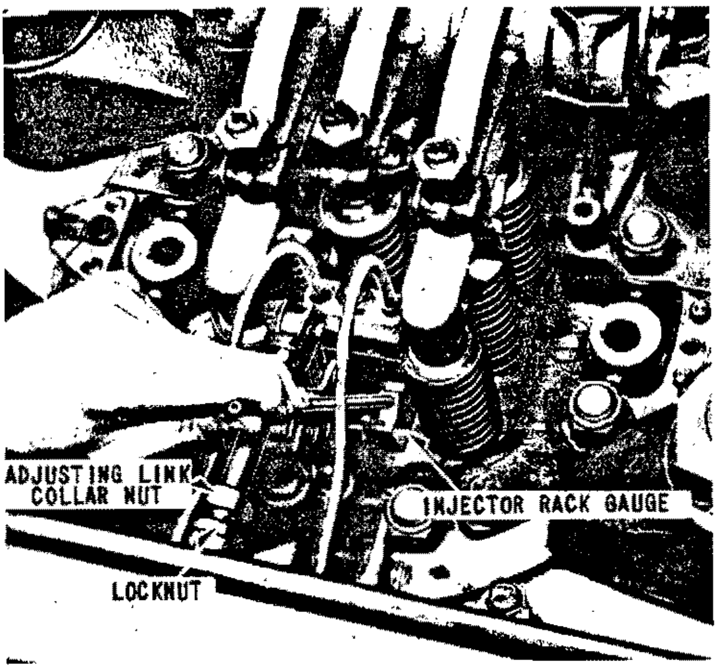


Injector Linkage
Fig. 12-3

injector racks are set 1" from the injector body with power piston gap "x" held at 7/16" as shown in Fig. 12-3. This operation is very important to assure equal cylinder loading.

Beginning November 1951, injector racks have a circumferential scribe line 1" from the rack end. Injectors having scribed racks do not require the use of the injector rack setting gauge #8107751 - 1" that must be used on previous injectors having racks without scribe lines.

Using two 7/8" open end wrenches, hold the adjusting nut, Fig. 12-4, and loosen the locknut. Turn the adjusting nut to the left, moving the injector rack in toward the injector body,



Setting Injector Rack
Fig. 12-4

checking for rack sticking. Move the rack in until about 3/4" extends outward.

(1) Setting without gauge.
Turn the adjusting nut to the right until the scribe line is visible, before it emerges completely from the injector body. Holding the adjusting nut from moving, run in the locknut and tighten securely so this position of the rack will be held.

(2) Setting with gauge.
If the injector rack has no scribe line, the use of injector rack setting gauge #8107751 is necessary. Place the gauge as shown in Fig. 12-4, over the rack. Press the gauge firmly against the injector body. Turn the adjusting nut to the right. Bring the injector rack out of the injector body until end of rack just contacts the rack gauge. This will give the 1" dimension as obtained when gauging to the scribe line. Do not turn adjusting nut so as to force the gauge away from the injector body. Holding the adjusting nut stationary, run locknut in to hold the setting obtained.

An optional rack setting gauge #8195904 may be used to set injector racks. This gauge consists of a housing having a movable high ratio lever pointer. A magnet holds the gauge against the rack end allowing freedom of both hands for adjustment. As the rack is moved in or out, the gauge housing also moves. A plunger extending from the gauge housing contacts the injector body, sliding in the housing to cause pointer movement to indicate proper rack length out of the injector. A master gauge is provided to permit checking and setting pointer position.

Recheck all settings to be sure rack extension is 1" out of the injector with power piston gap (top of power piston rod clevis to governor cylinder bottom) at the 7/16" dimension.

After all racks have been set, remove governor power piston jack. Replace governor power piston stop collar (if used).

2. Setting Pilot Valve Linkage

Before setting the pilot valve, the injector linkage and the racks should be properly adjusted as above, and the engine speeds correctly set, as given in Section XI.

NOTE: If any change is made in speed adjustment or injector racks and linkage at any time, the pilot valve should be checked for correct setting. Once the pilot valve is properly set, it should not be changed to correct the engine output until all other conditions are investigated. A list of probable causes of low output follows:

Engine
- Inoperative injectors.
- Insufficient fuel due to air leak or dirty filters in fuel system.
- Incorrect injector timing or control rack setting.
- Incorrect governor speed setting.

Electrical
- Power contactors not in same position in all units.
- Motor shunting contactors stuck in closed position.
- Dirty interlocks.
- Broken or loose connections.

The following settings are to be considered standard for specific usage, for pilot valve settings on the locomotive listed in table "A".

TABLE "A"

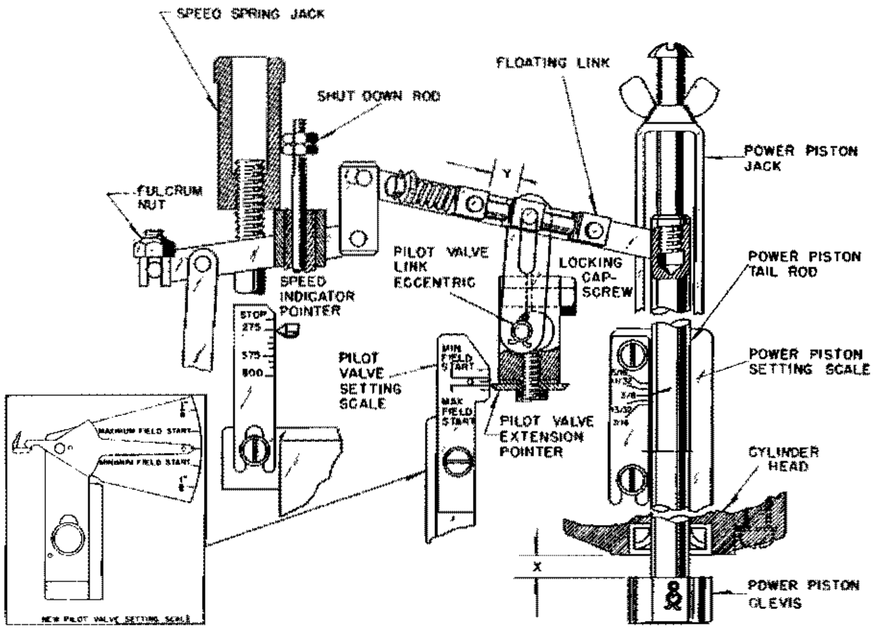
Type of Locomotive	Engine Model	Horsepower Rating	Power Piston	Type of Start
SW1	6-567A	600	5/16"	Max. field
SW8, TR6	8-567B	800	5/16"	Max. field
NW-2, 3	12-567A	1000	7/16"	Max. field
NW5	12-567B	1000	7/16"	Max. field
E3, 6, 7	12-567A	1000	7/16"	Min. field
SW7	12-567A	1200	5/16"	Max. field
SW9, TR5	12-567B	1200	5/16"	Max. field
E8	12-567B	1125	11/32"	Max. field
FT	16-567A	1350	7/16"	Min. field
F2	16-567B	1350	7/16"	Min. field
SD7, F3, 7 GP7, BL1, 2	16-567B	1500	11/32"	Max. field

a. Setting pilot valve — electro-hydraulic and pneumatic-hydraulic governors.

The pilot valve linkage on the electro-hydraulic and pneumatic-hydraulic governors is the same and consists of a horizontal adjustable floating link and a vertical link with eccentric for adjustment, as shown in Fig. 12-5 (schematic) and Fig. 12-2, for the electro-hydraulic governor. Changing the location of the movable block varies the total travel of the pilot valve plunger, while changing the eccentric raises or lowers the plunger.

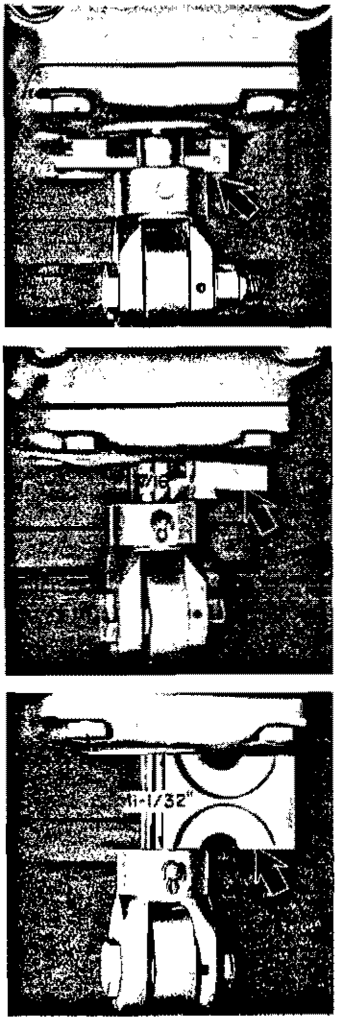
The tools necessary for setting the pilot valve are: power piston gauge #8122072 shown in Fig. 12-6, and speeder spring piston and power piston jacks, shown in position in Fig. 12-5 and 12-2.

NOTE: Before setting the pilot valve, the actual balance point of the pilot valve should be checked against the scale indicator, by locating the position of the pilot valve which does not permit



Pilot Valve Linkage Electro-Hydraulic Governor
Fig. 12-5

load regulator movement between minimum and maximum field positions. If the pilot valve indicator and scale do not correspond at actual balance of the pilot valve, the scale will have to be relocated or remarked, or the pilot valve disc readjusted. Also, speed scale must agree with actual engine speed at full and idle positions or be reset to agree.



Power Piston Gauges
Fig. 12-6

All electro-hydraulic governors that were shipped subsequent to May 9, 1949 plus replacement governors of these types will be set at maximum field. Therefore, if minimum field setting is contemplated, the pilot valves on the governors must be reset. The engine must not be running when making the following adjustments.

(1) Insert power piston gauge #8122072 with 1-1/32" dimension between the power piston

clevis and housing as shown in Fig. 12-6. With the layshaft, raise the power piston until the gauge is held in place snugly and tighten jack. Do not use a wrench or too much force to tighten the power piston jack or the power piston tailrod will be broken in tension.

(2) Set speed indicator pointer at idle speed setting, 275 RPM, with the power piston dimension "X" at 1-1/32". The total length of the floating link, Fig. 12-5, is approximately 4-1/8" long. Adjust the location of the movable block with the knurled thumb screw to obtain dimension "Y" given in Table No. 1, for the particular engines and field setting. This dimension "Y" is between

TABLE I

Pilot Valve Setting, Electro-Hydraulic and Pneumatic-Hydraulic Governors

Engine Horsepower	"X" Speed Scale at 800 RPM	"X" Speed Scale at 275 RPM	"X" at 1-1/32" Speed Scale 275 "Y" *	Pilot Valve Scale Pointer X as set Column 1	Pilot Valve Scale Pointer X as set column 2
600 800-1200 Max. Fld. Start	5/16"	1-1/32"	31/64"	"0" or Balance	.040" Below Balance
600 Min. Fld. Start	5/16"	1-1/32"	17/64"	"0" or Balance	.040" Above Balance
1000 1350 Max. Fld. Start	7/16"	1-1/32"	47/64"	"0" or Balance	.040" Below Balance
1000 1350 Min. Fld. Start	7/16"	1-1/32"	15/32"	"0" or Balance	.040" Above Balance
1500-1125 Max. Fld. Start	11/32"	1-1/32"	17/32"	"0" or Balance	.040" Below Balance
1500 Min. Fld. Start	11/32"	1-1/32"	5/16"	"0" or Balance	.040" Above Balance
Column	1	2	3	4	5

the inward sides of the two blocks of the floating link.

(3) Next set speed indicator pointer, Fig. 12-5, at full engine speed, 800 RPM, with speeder spring piston jack, and power piston at dimension "X" (with gauge #8122072), as shown in Table No. 1, for 800 RPM. Pointer on pilot valve extension, Fig. 12-5, should read "0", or balance as shown in the table. If the pointer does not read "0" or balance, adjust pilot valve plunger, up or down, by rotating the pilot valve eccentric, Fig. 12-5, after loosening eccentric clevis locking screw. The balanced position of the pilot valve must be maintained.

(4) Return speed indicator pointer to 275 RPM, and 1-1/32" power piston gap. The pilot valve extension pointer should read Maximum or Minimum Field Start, .040" below or above balance on pilot valve setting scale, depending on how dimension "Y" was adjusted.

(5) If the pointer of the pilot valve does not show correct setting, shorten dimension "Y" if pointer is too low; lengthen dimension "Y" if pointer is too high. Then recheck and reset, if necessary, steps 3 and 4, until proper conditions are met for both full speed, 800 RPM, and idle speed, 275 RPM.

b. Setting pilot valve used with the electro-pneumatic or mechanical controlled governor.
To set the pilot valve linkage, the balanced position of the pilot valve must be known. All original pilot valves have a figure stamped on the top of the pilot valve body, which is

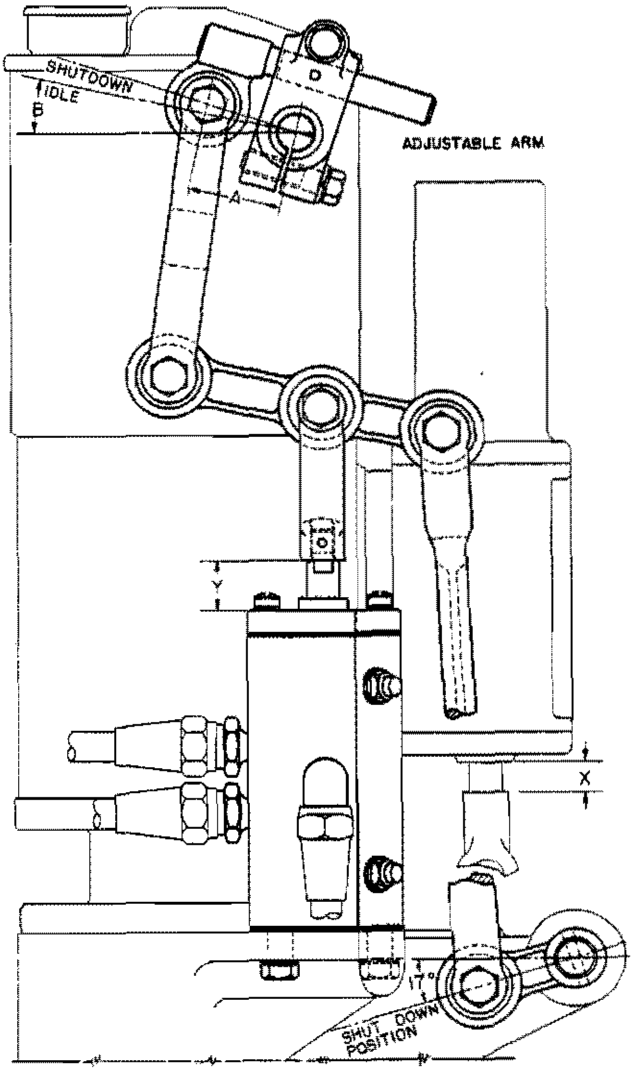
the distance in 64ths of an inch from the top of the pilot valve body to the bottom of the clevis. If the figure is 56, this means the distance is 56/64 of an inch. This is the dimension "Y" on Fig. 12-7 when the pilot valve is balanced. To check this dimension insert gauge #8062916 between top of pilot valve and clevis. See Fig. 12-8. If replacement pilot valve is installed, cover should be stamped when balance point is found. To determine balance point, disconnect linkage "A" on Fig. 12-9 and, with engine running at 425 RPM (throttle in Run 3 position, no load), move pilot valve plunger up and down by hand until a point is found in the range between maximum and minimum where the vane motor does not move.

Note the position of the pointer on the gauge. This is the balance position. The pilot valve linkage has two adjustments: the angular position of the governor arm on the serrated speeder shaft, and the length of the arm. Changing the angular position of the governor arm raises or lowers the pilot valve plunger; changing the length of arm changes the total travel of the pilot valve plunger.

To set pilot valve linkage, proceed as follows: With Engine Shut Down.

(1) With the throttle in idle position and the power piston held so that the dimension "X" is 1-1/32", set the adjustable arm to the approximate dimension "A" as shown on Table II. Use governor power piston jack #8064843 as shown on Fig. 12-1. Use power piston gauge #8122072 as shown on Fig. 12-6.

(2) With the throttle in full or Run 8 position and control circuit operating, energizing the

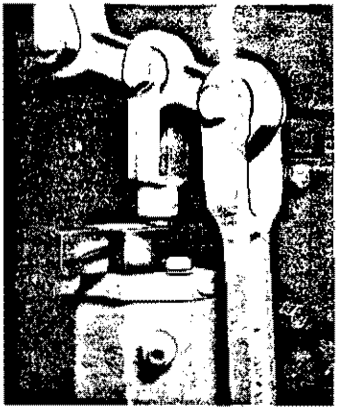


Pilot Valve Linkage Electro-Pneumatic Governor
Fig. 12-7

TABLE II
DIMENSIONS FOR PILOT VALVE LINKAGE WITH ELECTRO-PNEUMATIC AND MECHANICAL CONTROLLED GOVERNORS

Engine Horsepower	600 HP (Max. Field Start)	1000 HP (Max. Field Start)	1350 HP Frt. 1000 HP (Min. Field Start)
Dimension "A" on Fig. 12-7	2" approx.	1-11/16" approx.	2-1/4" approx.
"Y" - Throttle in Full Speed Position and "X" at Full Load Position	Balance	Balance	Balance
"X" at Full Load	5/16"	7/16"	7/16"
"Y" - Throttle in Idle Position with "X" at 1-1/32"	"Y" at balance less 1/32" to 3/64"	"Y" at balance less 1/32" to 3/64"	"Y" at balance plus 1/32" to 3/64" (*See Note Below)
Angle "B" on Fig. 12-7 (At Idle)	8° approx.	9° approx.	13° approx.

*NOTE: In setting the pilot valve linkage for throttle at "Idle" position, the dimension "Y" on Fig. 12-7 should be held closer to "balance plus 1/32 inch" rather than "3/64 inch," but should not be less than "balance plus 1/32 inch."



Checking Pilot Valve Balance
Electro-Pneumatic Governor
Fig. 12-8

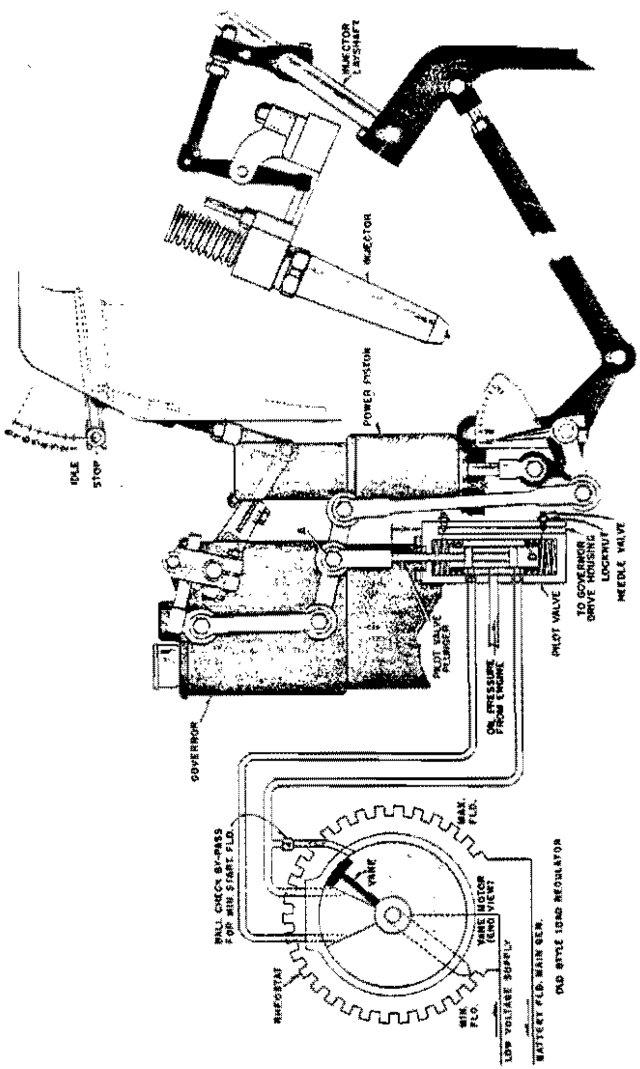
electro-pneumatic governor control (on mechanical control, release oil shut down link) and power piston held to the dimension "X" as given in Table II, the pilot valve should be balanced. The adjustable arm may be raised or lowered to give this position. This dimension is important and must be held.

(3) Move throttle to idle position and hold power piston so that dimension "X" is 1-1/32"; the pilot valve piston should now be in position so that dimension "Y" is as shown on Table II.

(5) Repeat steps (1) and (2) until proper conditions are met for both idle and full speed conditions.

D. EQUIPMENT LIST

Name	Part No.
Power Piston Gauge	8122072
Governor Jack	8064843
Injector Rack Gauge	8107751
Pilot Valve Gauge	8062916



Pilot Valve Operating Diagram
Fig. 12-9

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