Due to a continuous program of research and development, some procedures, specifications and parts may be altered in a constant effort to improve machines.

Periodic revisions may be made to this publication and mailed automatically to distributors. It is recommended that customers contact their distributor or dealer for information on the latest revision.

16, 525, 554, 24 and 1091 DIESEL ENGINES and 1091 CARBURETED ENGINE

FORM

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(Includes Revision No. 1 (10-60) and Revision No. 2 (11-63))

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CONTENTS

INTRODUCTION

GENERAL

The instructions contained in this service manual are for the information and guidance of servicemen who are responsible for overhauling and repairing 16, 525, 554, 24 or 1091 series engines.

This manual provides the serviceman with a fast, convenient reference to information on maintenance, and repairs, as well as descriptions of the major units and their functions in relation to other components.

LUBRICATION

Instructions on the lubrication of each assembly are given in the Lubrication Chart in the operator's manual. When assembling any parts, always coat all wearing surfaces with the lubricant specified in the chart. Except for such installations as taper pins, etc., whose surfaces should be clean and dry, use sufficient quantities of lubricant to prevent any danger of seizing, scoring, or excessive wear when the assembly is first operated. Failure to provide "starting lubrication" may result in serious damage.

Always use new gaskets and seals. When installing a leather seal, be sure to install it as specified in the instructions. Be extremely careful not to damage the seal in any way during installation.

SERVICE TOOLS

IH Construction Equipment engines are designed so that few service tools are required other than those in the mechanic's tool kit. Wherever the application of inexpensive special service equipment will facilitate work, it is shown. Otherwise, it is assumed that servicemen will select from their tool kits such tools as are required. Information regarding special tool equipment is given in the "Service Tools Manual" ISS-1002. The Construction Equipment distributors have most of this equipment and are in an excellent position to service these engines.

SERVICE PARTS

IH Construction Equipment engines deserve genuine IH service parts. The best material obtainable, and experience gathered through many years of manufacturing power equipment, enable International Harvester to produce quality that will not be found in imitation or "just as good" repair parts. No serviceman can afford to guarantee a repair job that is not serviced with genuine IH parts. No owner should be satisfied with other than genuine IH parts.

For the correct service parts to be used, always refer to the parts catalog for the particular machine. The loose-leaf parts catalogs are accurate and are continually being brought up to date by the issuance of new pages covering any changes in part numbers.

SERIAL NUMBERS

Engine serial numbers are stamped on the crankcase where they are easily visible.

DIESEL FUEL SYSTEMS

If detailed information on the diesel fuel system of the engine is desired, refer to the "Diesel Injection Pump" Manual, ISS-1003.

ENGINE APPLICATION CHART

Series	Machines Used On
16	UD-16
525	UD-525
554	UD-554 and TD-15 (150 Series)
24	UD-24 and TD-24 (Engine Serial No. TDEM-506 - 8000)
1091	U-1091, UD-1091, UDT-1091, TD-24 (241 Series) (Engine Serial No. TDEM 8001 and up) and TD-24 Torque Converter Tractor

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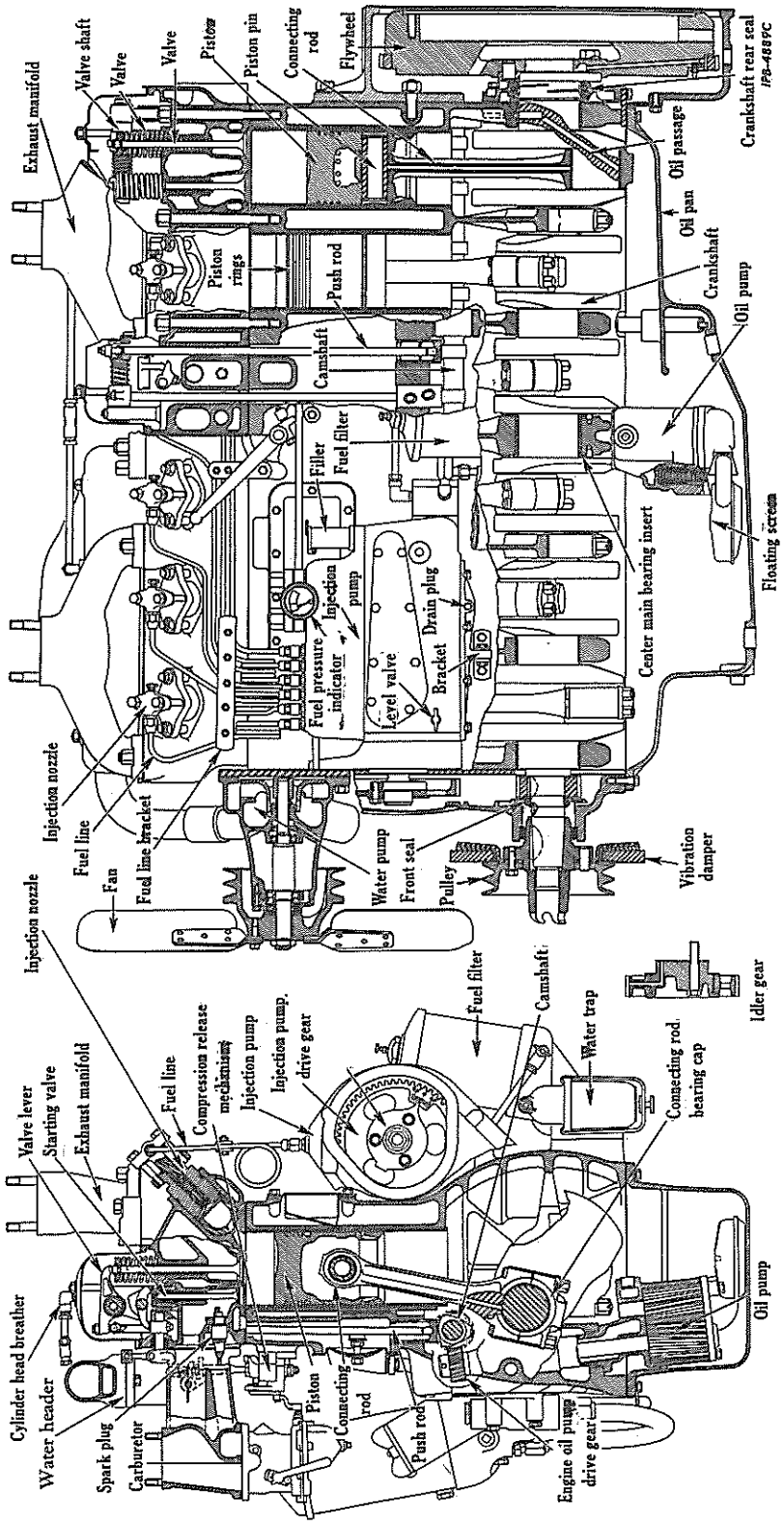
ENGINE

1. DESCRIPTION

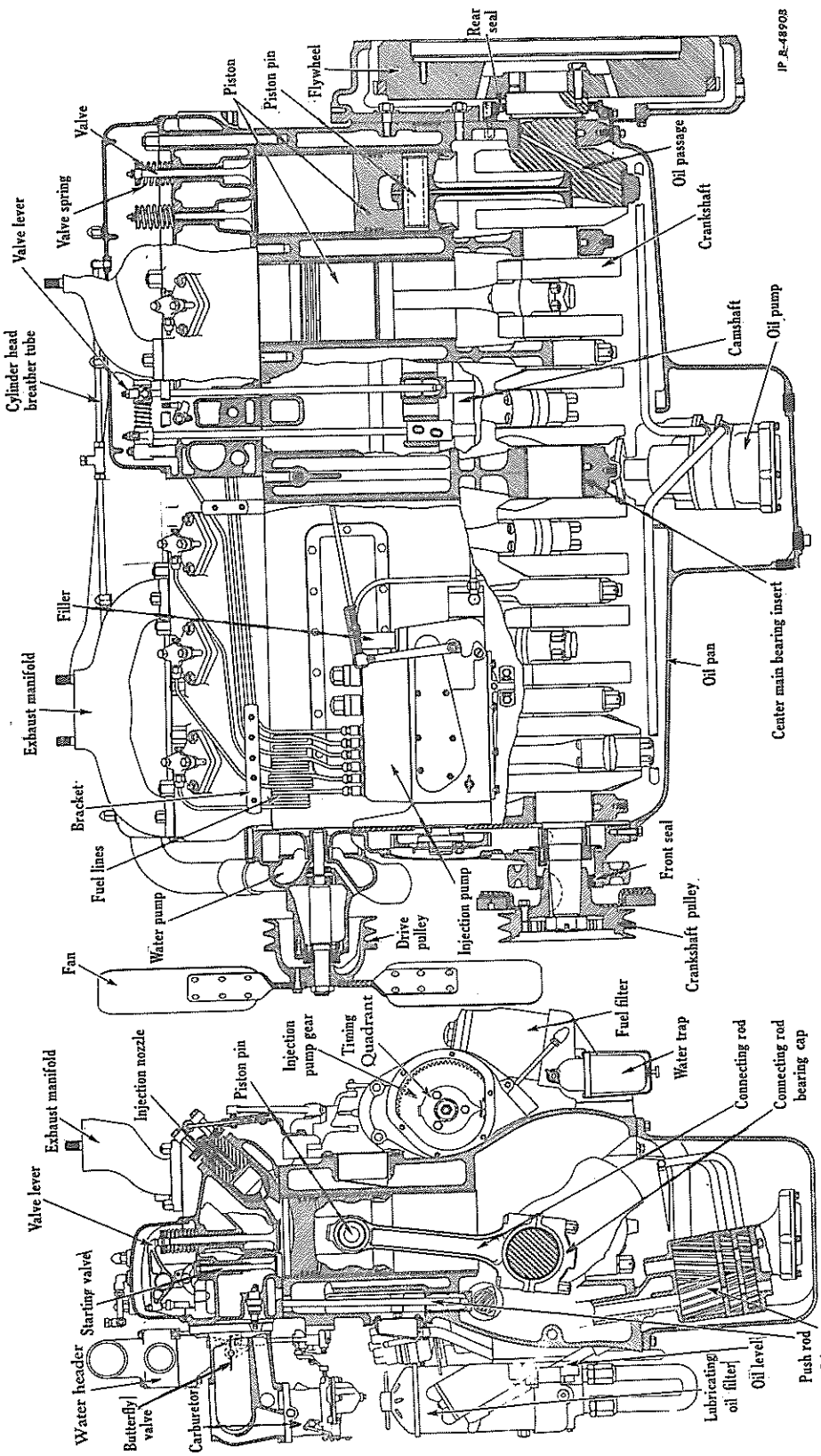
The 16, 525, 554, 24 or 1091 series IH diesel engines are all six-cylinder in line, valve-in-head, four cycle, full diesel engines. A built in gasoline-diesel conversion starting system is a basic design feature of the IH diesel engine. The engine is started on gasoline and, after a brief cylinder warm up, is changed over to operate as a full diesel engine.

The four cycle carbureted U-1091 engine is almost identical in design to the 1091 diesel engine. The basic difference is that a natural gas fuel system is substituted for the diesel fuel system. Starting valves and gasoline-diesel conversion system are eliminated. Shorter pistons provide the lower compression ratio necessary for carbureted operation. The U-1091 is also equipped with replaceable stellite exhaust valve seat inserts.

The crankshaft main and connecting rod bearing journals are induction hardened. The main and connecting rod bearings are steel-backed precision insert type and require no fitting during assembly or replacement. The cylinder sleeves are the replaceable dry type and are heat treated to file hardness for maximum service. The piston pins are full-floating and are held in place with snap rings. The engine has a full pressure lubrication system. A gear type lubricating oil pump supplies oil under pressure at all operating angles. Rifle-drilled passages carry oil under pressure through the crankcase, crankshaft, connecting rods and cylinder heads. A double or triple element full-flow lubricating oil filter effectively cleans all of the lubricating oil. A crankcase breather and cylinder head breather assure positive crankcase ventilation. Water is circulated through the engine and radiator by a belt driven centrifugal water pump mounted at the front of the engine. One, two or four thermostats (variation due to engine series and model), located in the water outlet header, control the water temperature in the system.



Illust. 1 - Cross Section of UD-525 Diesel Engine (UD-554 and UD-16 Similar).



Illust. 2 - Cross Section of TD-24 Diesel Engine (UD-1091 Similar).

DESCRIPTION	16 SERIES	525 SERIES	554 SERIES	24 SERIES	1091 SERIES
Number of cylinders	6	6	6	6	6
Type of cylinder sleeves	Replaceable, dry	Replaceable, dry	Replaceable, dry	Replaceable, dry	Replaceable, dry
Bore and stroke-inches(Nominal).	4.4 x 5.5	4.4 x 5.5	4-5/8 x 5-1/2	5-3/4 x 7	5-3/4 x 7
Displacement - cubic inches	501.8	524.9	554	1090.6	1090.6
Engine speed - rpm					
Full load, governed	1800	1800	1800 (power unit) 1650 (tractor)	1400 ± 10	1500 ± 10 (UD-1091)
High idle	2000	1960 ± 30	1960 ± 30 (power unit) 1800 ± 30(tractor)	1525 ± 30	1635 ± 30 (UD-1091)
Low idle	450 - 550	450 - 550	450 - 550	450 - 550	450 - 550 (UD-1091)
Gasoline cycle, starting	900 - 1100	900 - 1100	900 - 1100	900 - 1100	900 - 1100
Compression ratio					
Starting	6.5 : 1	6.5 : 1	6.5 : 1	6.3 : 1	6.3 : 1
Running	16.0 : 1	16.0 : 1	16.0 : 1	15.2 : 1	15.2 : 1 7.5 : 1 (U-1091)
Compression pressure, psi (measured at 1000 rpm)	503 - 557	503 - 557	503 - 557	484 - 536	484 - 536
CRANKSHAFT					
Crank pin, diameter - inches	2.7475 - 2.7485	2.7475 - 2.7485	2.7475 - 2.7485	3.6225 - 3.6235	3.6225 - 3.6235
Main journal diameter - inches	3.5673 - 3.5683	3.5673 - 3.5683	3.5673 - 3.5683	4.1218 - 4.1228	4.1218 - 4.1228
Maximum permissible journal out-of-roundness, before reconditioning - inch	.004	.004	.004	.004	.004
Number of main bearings	7	7	7	7	7
Main bearing running clearance - inch	.0036 - .0066	.0036 - .0066	.0036 - .0066	.0044 - .0074	.0022 - .0052
Maximum permissible main bearing clearance, before reconditioning - inch	.009	.009	.009	.010	.0078
End clearance - inch	.006 - .014 .010 - .014 for flanged bearing	.010 - .014	.010 - .014	.010 - .014 *	.010 - .014 *
Maximum permissible end clearance, before reconditioning - inch	.024	.024	.024	.024	.024
Counterbalanced	Yes	Yes	Yes	Yes	Yes
Main bearing bore in crankcase (line reamed), inches	3.8015 - 3.8025	3.8015 -3.8025	3.8015 - 3.8025	.4.377-4.378	4.377 - 4.378

*Only flanged bearings are furnished for repairs.

DESCRIPTION	16 SERIES	525 SERIES	554 SERIES	24 SERIES	1091 SERIES
CAMSHAFT					
Running clearance - inch	.0015 - .0035	.0015 - .0035	.0015 - .0035	.0015 - .0035	.0015 - .0035
Maximum permissible running clearance - inch	.006	.006	.006	.006	.006
End clearance - inch	.005 - .011	.005 - .011	.005 - .011	.005 - .013	.005 - .013
Maximum permissible end clearance - inch	.025	.025	.025	.025	.025
Service bushings furnished	Reamed to size	Reamed to size	Reamed to size	Reamed to size	Reamed to size
Cam lobe lift - inch	329	.329	.329	.389	.389
Maximum permissible camshaft lobe wear - inch	.020	.020	.020	.020	.020
Number of teeth in drive gear	54	54	54	54	54
Number of bearings	4	4	4	4	4
Bearing journal diameter					
Front - inches	2.4305 - 2.4315	2.4305 - 2.4315	2.4305 - 2.4315	2.6805 - 2.6815	2.6805 - 2.6815
Second - inches	2.3680 - 2.3690	2.3680 - 2.3690	2.3680 - 2.3690	2.6180 - 2.6190	2.6180 - 2.6190
Third - inches	2.1805 - 2.1815	2.1805 - 2.1815	2.1805 - 2.1815	2.5555 - 2.5565	2.5555 - 2.5565
Rear - inches	1.8680 - 1.8690	1.8680 - 1.8690	1.8680 - 1.8690	2.4930 - 2.4940	2.4930 - 2.4940
CONNECTING RODS					
Side clearance - inch	.005 - .015	.005 - .015	.005 - .015	.005 - .015	.005 - .015
Bearing running clearance - inch	.0019 - .0049	.0019 - .0049	.0019 - .0049	.0029 - .0059	.0017 - .0047
Maximum permissible bearing running clear - inch	.008	.007	.007	.008	.0068
Connecting rod bolts					
Number per rod	4	4	4	4	4
Length - inches	3-13/16	3-13/16	3-13/16	5-1/4	5-1/4
Diameter and thread	7/16 x 20NF	7/16 x 20NF	7/16 x 20NF	1/2 x 20NF	1/2 x 20NF
Piston pin bushing ID (Reamed after assembly) - inches	1.5007 - 1.5009	1.5007 - 1.5009	1.5007 - 1.5009	1.8759 - 1.8761	1.8759 - 1.8761

DESCRIPTION	16 SERIES	525 SERIES	554 SERIES	24 SERIES	1091 SERIES
PISTONS					
Length over-all - inches . . .	6-7/16	6-7/16	6-7/16	7-1/2	7-1/2 6-19/32 (U-1091)
Skirt clearance - measured 90° from pin hole					
Bottom - inch	.0066 - .0074	.0077 - .010	.0066 - .0090	.0142 - .0150	.0096 - . 0120
Top - inch	.0086 - .0094	.0097 - .0121	.0096 - .0120	.0162 - .017	.0124 - .0148 .0126 - .0150 (U-1091)
Number of rings per piston .	5	5	5	5	5
Number of rings below pin .	1	1	None	1	None
Width of ring groove					
Top compression - inch .	.1275 - .1285	.1275 - .1285	.0955 - .0965	.0975 - .0985	Tapered groove
Second compression - inch.	.1575 - .1585	.1575 - .1585	.1265 - .1275	.1270 - .1280	.1270 - .1280
Third compression - inch .	.1885 - .1895	.1885 - .1895	.1265 - .1275	.1270 - .1280	.1270 - .1280
Oil control - inch	.2515 - .2525	.2515 - .2525	.2515 - .2525	.2515 - .2525	.2515 - .2525
Ring clearance in groove					
Top compression - inch . .	.0035 - .0050	.0035 - .0050	.0020 - .0035	.0040 - .0055	.0040 - .0055
Second compression - inch.	.0025 - .0040	.0025 - .0040	.0025 - .0040	.0030 - .0045	.0030 - .0045
Third compression - inch .	.0020 - .0035	.0020 - .0035	.0025 - .0040	.0030 - .0045	.0030 - .0045
Oil control - inch	.0025 - .0040	.0025 - .0040	.0025 - .0040	.0025 - .0040	.0025 - .0040
PISTON RINGS - Compression					
Number of rings per piston .	3	3	3	3	3
Type (face and finish)					
Top	Tapered-chrome	Tapered-chrome	Tapered-chrome	Tapered-key-stone - chrome	Tapered-key-stone - chrome
Second	Plain	Plain	Tapered-fer-rox	Tapered-fer-rox	Tapered-fer-rox
Third	Tapered	Tapered	Tapered-fer-rox	Tapered-fer-rox	Tapered-fer-rox
Width					
Top-inch	.1235 - .1240	.1235 - .1240	.0930 - .0935	.0930 - .0935	Tapered

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DESCRIPTION	16 SERIES	525 SERIES	554 SERIES	24 SERIES	1091 SERIES
PISTON RINGS - Compression Continued					
Width - Continued					
Second - inch	.1545 - .1550	.1545 - .1550	.1235 - .1240	.1235 - .1240	.1235 - .1240
Third - inch	.1860 - .1865	.1860 - .1865	.1235 - .1240	.1235 - .1240	.1235 - .1240
Ring gap					
Top - inch	.013 - .029	.013 - .029	.013 - .023	.030 - .046	.030 - .046
Second - inch	.013 - .029	.013 - .029	.013 - .023	.019 - .035	.019 - .035
Third - inch	.013 - .029	.013 - .029	.013 - .023	.019 - .035	.019 - .035
Maximum permissible ring Gap, before replacing - inch	.070	.070	.070	.070	.070
PISTON RINGS - Oil Control					
Number of rings per piston	2	2	2	2	2
Type	1-piece slotted	1-piece slotted	Top-2-piece slotted with spring expander Lower-1-piece slotted	Top-2-piece with spring expander Lower-1-piece slotted	Top-2-piece with spring expander Lower-1-piece slotted
Width - inch	.2485 - .2490	.2485 - .2490	.2485 - .2490	.2485 - .2490	.2485 - .2490
Ring gap - inch	.013 - .029	.013 - .029	Top-.013 - .028 Lower - .013 - .023	Top-.019 - .035 Lower - .019 - .035	.019 - . 035 Top - .019 - .034 (U-1091)
Maximum permissible ring gap, before replacing - inch	.060	.060	.060	.060	.060
PISTON PINS					
Diameter - inches	1.5000 - 1.5002	1.5000 - 1.5002	1.5000 - 1.5002	1.8750 - 1.8752	1.8750 - 1.8752
Length - inches	3.704 - 3.709	3.704 - 3.709	3.704 - 3.709	4.995 - 5.000	4.995 - 5.000
* Clearance - between end of pin and retainer ring - inch	.016 - .035	.016 - .035	.016 - .035	.016 - .035	.016 - .035
Clearance - in rod - inch	.0005 - .0009	.0005 - .0009	.0005 - .0009	.0007 - .0011	.0007 - .0011
Maximum permissible clearance in rod, before replacing - inch	.004	.004	.004	.004	.004
Clearance - in piston - inch	.0001 (tight)** .0003 (loose)**	.0001 (tight)** .0003 (loose)**	.0001 (tight)** .0003 (loose)**	.0001 (tight)** .0003 (loose)**	.0001 (tight)** .0003 (loose)**
Maximum permissible clearance in piston, before replacing - inch	.0025	.0025	.0025	.0025	.0025

DESCRIPTION	16 SERIES	525 SERIES	554 SERIES	24 SERIES	1091 SERIES
PISTON PINS - Continued					
* For method of checking clearance, refer to section 3. ** "Loose" means clearance; "tight" means interference.					
CYLINDER SLEEVES					
Diameter, inside - inches	4.3990 - 4.4010	4.499 - 4.501	4.6240 - 4.6256	5.755 - 5.757	5.755 - 5.757
Length - inches	11-7/8	11-7/8	11-3/4	14-5/32	14-5/32
Maximum permissible diameter sleeve wear (at top of ring travel) before replacement - inch	.015	.015	.015	.015	.015
Vertical distance, top surface of sleeve extends above top surface of crankcase - inch	.039 - .047	.037 - .049	.037 - .049	.037 - .049	.037 - .049
INTAKE VALVES					
Stem diameter - inch	.4015 - .4025	.4015 - .4025	.4015 - .4025	.495 - .496	.495 - .496
Port diameter - inches	1-21/32	1-21/32	1-21/32	2-5/16	2-5/16
Head diameter - inches	1-7/8	1-7/8	1-7/8	2-17/32	2-17/32
Stem clearance in guide - inch	.002 - .004	.002 - .004	.002 - .004	.002 - .004	.002 - .004
Maximum permissible stem clearance in guide before reconditioning - inch	.008	.008	.008	.008	.008
Valve face angle, between seat and bottom of valve head - degrees	44	45	45	44	45
Valve seat angle in cylinder head - degrees	45	45	45	45	45
Tappet clearance					
Hot - inch	.017	.017	.017	.023	.023
Cold - inch	.019	.019	.019	.025	.025
EXHAUST VALVES					
Stem diameter - inch	.4015 - .4025	.4015 - .4025	.4015 - .4025	.494 - .496	.494 - .495
Port diameter - inches	1-13/32	1-13/32	1-13/32	1-7/8	1-7/8

DESCRIPTION	16 SERIES	525 SERIES	554 SERIES	24 SERIES	1091 SERIES
EXHAUST VALVES - Continued					
Head diameter - inches	1-5/8	1-5/8	1-5/8	2-3/32	2-3/32
Stem clearance in guide - inch	.002 - .004	.002 - .004	.002 - .004	.003 - .005	.003 - .005
Maximum permissible stem clearance in guide before reconditioning - inch	.008	.008	.008	.008	.008
Valve face angle, between seat and bottom of cylinder head - degrees	44	45	45	45	45
Valve seat angle in cylinder head - degrees	45	45	45	45	45
Tappet clearance					
Hot - inch	.017	.017	.017	.023	.029
Cold - inch	.019	.019	.019	.025	.031
INTAKE AND EXHAUST VALVE GUIDES					
Length - inches	3-31/32	3-31/32	3-31/32	4-13/16	4-13/16
Inside diameter - inch	.4045 - .4055	.4045 - .4055	.4045 - .4055	.498 - .499	.498 - .499
Set height of guide - inch	3/4	3/4	3/4	5/32	5/32
measured upward from	Valve lever bracket pad	Valve lever bracket pad	Valve lever bracket pad	Valve cover gasket surface	Valve cover gasket surface
INTAKE AND EXHAUST VALVE SPRINGS					
Outside diameter - inches	1-19/32	1-19/32	1-19/32	1-3/4	1-3/4
Free length - inches	2-7/8	2-7/8	2-7/8	3-7/16	3-7/16
Length, valve open - inches	2	2	2	2	2
Length, valve closed - inches	2-1/2	2-1/2	2-1/2	2-5/8	2-5/8
Test load, valve open - pounds	147 - 158	147 - 158	147 - 158	142	138 - 146
Test load, valve closed-pounds	50 - 56	50 - 56	50 - 56	68 - 72	68 - 72
STARTING VALVES (Not U-1091)					
Stem diameter - inches	.3085 - .3095	.3085 - .3095	.3085 - .3095	.3710 - .3720	.3710 - .3720
Port diameter - inches	7/8	7/8	7/8	1-5/16	1-5/16
Head diameter - inches	31/32	31/32	31/32	1-13/32	1-13/32
Stem clearance in guide - inch	.002 - .004	.002 - .004	.002 - .004	.002 - .004	.002 - .004

DESCRIPTION	16 SERIES	525 SERIES	554 SERIES	24 SERIES	1091 SERIES
STARTING VALVES (Not U-1091) - Continued					
Maximum permissible stem clearance in guide before re-conditioning - inch	.008	.008	.008	.008	.008
Valve angle - degrees	45	45	45	45	45
Width of valve seat - inch	3/64	3/64	3/64	3/64	3/64
Approximate free movement of valve spring cover in cylinder head (gasoline position) - inch	1/64	1/64	1/64	1/64	1/64
STARTING VALVE GUIDES (Not U-1091)					
Length - inches	2-1/16	2-1/16	2-1/16	3	3
Inside diameter - inch	.3115 - .3125	.3115 - .3125	.3115 - .3125	.3740 - .3750	.3740 - .3750
Set height of guide - inches measured downward from	1-1/8 Valve lever bracket pad	1-1/8 Valve lever bracket pad	1-1/8 Valve lever bracket pad	1-13/16 Valve cover gasket surface	1-13/16 Valve cover gasket surface
STARTING VALVE SPRINGS (Not U-1091)					
Outside diameter - inch	29/32	29/32	29/32	7/8	7/8
Free length - inches	1-31/32	1-31/32	1-31/32	2-7/16	2-7/16
Test length - inches	1-5/32	1-5/32	1-5/32	1-5/32	1-5/32
Test load - pounds	21.5 - 26.3	21.5 - 26.3	21.5 - 26.3	24.9 - 30.5	24.9 - 30.5
VALVE LEVER AND SHAFT					
Valve lever shaft diam. - inch	.872 - .873	.872 - .873	.872 - .873	.9655 - .9665	.9655 - .9665
Running clearance, valve lever on shaft - inch	.002 - .004	.002 - .004	.002 - .004	.0005 - .0025	.0005 - .0025
Maximum permissible running clearance, valve lever on shaft - inch	.010	.010	.010	.010	.010
Valve lever bushing					
Inside diameter - inch	.875 - .876	.875 - .876	.875 - .876	.967 - .968	.967 - .968
Length - inches	1-3/16	1-3/16	1-3/16	1-1/4	1-1/4

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DESCRIPTION	16 SERIES	525 SERIES	554 SERIES	24 SERIES	1091 SERIES
VALVE TAPPETS					
Diameter - inches	1.373 - 1.374	1.373 - 1.374	1.373 - 1.374	1.498 - 1.499	1.498 - 1.499
Length - inches	2-21/32	2-21/32	2-21/32	3-1/4	3-1/4
Clearance in guide - inch	.0005 - .0025	.0005 - .0025	.0005 - .0025	.0005 - .0025	.0005 - .0025
VALVE TIMING					
Intake opens - degrees before TDC	20	20	20	20	20
Intake closes - degrees after BDC	40	40	40	40	40
Exhaust opens - degrees before BDC	40	40	40	40	40
Exhaust closed - degrees after TDC	10	10	10	10	10
VALVE PUSH ROD					
Diameter - inch	7/16	7/16	7/16	1/2	1/2
Length - inches	18-15/32	18-15/32	18-15/32	21-43/64	21-43/64
CYLINDER HEAD STUDS					
Diameter - inch	9/16	9/16	9/16	3/4	3/4
CYLINDER HEAD GASKET					
Thickness (compressed) - inch	.062 - .067	.062 -.067	.062 - .067	.062 - .067	.062 - .067
TIMING GEARS					
Backlash between any pair of gears (except injection pump and idler gears) - inch	.003 - .006	.003 - .006	.003 - .006	.003 - .006	.003 - .006
Maximum permissible backlash between any pair of gears (except injection pump and idler gears) before reconditioning - inch	.010	.010	.010	.010	.010
Idler gear end clearance - inch	.009 - .013	.009 - .013	.009 - .013	.009 - .013	.009 - .013
Maximum permissible idler gear end clearance before reconditioning - inch	.020	.020	.020	.020	.020
Idler gear bushing to shaft clearance - inch	.0005 - .0045	.0005 - .0045	.001 - .005	.0005 - .0045	.0005 - .0045
Idler gear shaft OD	3.6235-3.6240	3.6235-3.6240	3.6235-3.6240 (large dia.) 3.3735-3.3740 (small dia.)	3.6235-3.6240	3.6235-3.6240

DESCRIPTION	16 SERIES	525 SERIES	554 SERIES	24 SERIES	1091 SERIES
TIMING GEARS - Continued					
Idler gear bushing ID (assembled) - inches	3.6245-3.6280	3.6245-3.6280	3.6245-3.6280 (large dia.) 3.3750-3.3785 (small dia.)	3.6245-3.6280	3.6245-3.6280
Maximum permissible idler gear bushing to shaft clearance before reconditioning - inch	.0055	.0055	.0055	.0055	.0055
Backlash between idler gear and injection pump gear	.003 - .009	.003 - .009	.003 - .009	.003 - .009	.003 - .009
Maximum permissible backlash between idler gear and injection pump gear	.013	.013	.013	.013	.013
LUBRICATING SYSTEM					
Type	Forced feed	Forced feed	Forced feed	Forced feed	Forced feed
Oil filter (Purolator, radial fin) type	Full-flow	Full-flow	Full-flow	Full-flow	Full-flow
Number used	2	2	2	3	3
LUBRICATING OIL VALVE LOCATIONS (Full-Flow System)					
Pressure regulating	Oil filter base	Oil filter base	Oil filter base	Oil filter base	Oil filter base
Safety	Oil pump	Oil pump	Oil pump	Oil pump	Oil pump
By-pass	By-pass housing	By-pass housing	By-pass housing	By-pass housing	By-pass housing
LUBRICATING OIL VALVE SPRINGS (Full-Flow System)					
Pressure regulating					
Free length - inches	3-13/16	3-63/64	3-63/64	3-63/64	3-63/64
Test length - inches	2-3/32	2-3/32	2-3/32	2-3/32	2-3/32
Test load - pounds	30.5 - 37.5	34.2 - 37.8	34.2 - 37.8	34.2 - 37.8	34.2 - 37.8
Safety					
Free length - inches	3-39/64	3-39/64	3-39/64	3.132 - 3.226	3.132 - 3.226
Test length - inches	2-3/32	2-3/32	2-3/32	2-3/32	2-3/32
Test load - pounds	36.3 - 40.1	36.3 - 40.1	36.3 - 40.1	53.9 - 59.5	53.9 - 59.5
By-pass					
Free length - inches	5.28	5.28	5.28	4.39	4.39
Test length - inches	2-5/32	2-5/32	2-5/32	2-5/32	2-5/32
Test load - pounds	9 - 11	9 - 11	9 - 11	13.3 - 14.7	13.3 - 14.7

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DESCRIPTION	16 SERIES	525 SERIES	554 SERIES	24 SERIES	1091 SERIES
PRESSURE REG. VALVE					
Opening pressure - p.s.i.	38 - 46	38 - 46	38-46	38 - 46	38 - 46
LUBRICATING OIL PUMP					
End play between gear and auxiliary gear housing - inch	.0055 - .0105	.0055 - .0105	.0055 - .0105	.0055 - .0105	.0055 - .0105
Radial clearance between gear and housing - inch	.0080 - .0095	.0080 - .0095	.0080 - .0095	.0080 - .0095	.0080 - .0095
Backlash between idler and body gears - inch	.008 - .012	.008 - .012	.008 - .012	.008 - .012	.008 - .012
Backlash between drive pinion and camshaft - inch	.005 - .010	.005 - .010	.005 - .010	.005 - .010	.005 - .010
Drive shaft journals, diameter - inch	.8595 - .8600	.8595 - .8600	.8595 - .8600	.8594 - .8602	.8594 - .8600
Drive shaft running clearance - inch	.0013 - .0031	.0013 - .0031	.0013 - .0031	.0013 - .0031	.0013 - .0031
Idler gear to shaft running clearance - inch	.0015 - .0030	.0015 - .0030	.0015 - .0030	.0015 - .0030	.0015 - .0030
Clearance between oil pump body and drive pinion - inch	.010 - .020	.010 - .020	.010 - .020	.010 - .020	.010 - .020
FAN, WATER PUMP AND THERMOSTATS					
Thermostats					
Number used	2-partial flow	2-partial flow 1-full flow	1-full flow	4-partial flow	4-partial flow 2-full flow
Open at - degrees	165°	165°	165°	165°	165°
Wide open at - degrees	190°	190°-partial flow 180°-full flow	180° - full flow	190°	190°-partial flow 180°-full flow
Fan					
Type	Suction	Suction	Suction	Suction	Suction
Diameter	24 in.	24 in.	24 in.	32 in.	32 in.
Number of blades	4	6	6 (power unit) 4 (tractor)	4	4 (U-1091, UD-1091 power unit and gear drive tractor) 6 (torque converter tractor and UDT-1091 Power Unit)

DESCRIPTION	16 SERIES	525 SERIES	554 SERIES	24 SERIES	1091 SERIES
FAN, WATER PUMP AND THERMOSTATS - Continued					
Pump					
Clearance between face of body and face of impeller hub	.120 - .130	.120 - .130 ⊕	.120 - .130 ⊕	.120 - .130	.120 - .130 @
Type	Packless	Packless	Packless	Packless	Packless
Rotation - Drive end	Clockwise	Clockwise	Clockwise	Clockwise	Clockwise
SPARK PLUG					
Gap, inch	.023	.023	.023	.023	.023
Thread diameter	18 mm	18 mm	18 mm	18 mm	18 mm
Hex size, inch	7/8	7/8	7/8	7/8	7/8
SPECIAL NUT AND BOLT TORQUE DATA - In Foot Pounds *					
Cylinder head stud nuts ***	120 - 140	120 - 140	120 - 140	250 - 270	250 - 270
Connecting rod nuts or cap screws	55 - 60 **	55 - 60 **	55 - 60 **	70 - 75 **	70 - 75 **
Main bearing stud nuts					
3/4 inch	- - -	- - -	- - -	225 - 245	225 -245
9/16 inch	100 - 120	100 - 120	100 - 120	- - - -	- - -
Flywheel bolts	170 - 190	170 - 190	170 - 190	170 - 190	170 - 190
Manifold stud nuts (intake)	75 - 80	75 - 80	75 - 80	75 - 80	75 - 80
Nozzle body stud nuts	45 - 50	45 - 50	45 - 50	45 - 50	45 - 50
Nozzle fitting cap screws	30 - 35	30 - 35	30 - 35	30 - 35	30 - 35
Idler gear shaft nut or cap screw	85 - 95	85 - 95	85 - 95	85 - 95	85 - 95
Water pump drive shaft nut or cap screw to shaft	150 - 175	150 - 175	150 - 175	100 - 120	100 - 120
Front pulley nut to crankshaft	325 - 375	325 - 375	325 - 375	325 - 375	325 - 375
Camshaft gear nut	275 - 300	275 - 300	275 - 300	275 - 300	275 - 300
Injection pump drive hub nut	115 - 125	115 - 125	115 - 125	115 - 125	115 - 125
Manifold stud nuts (exhaust)	75 - 80	75 - 80	75 - 80	55 - 65	55 - 65
Timing pointer cap screws	21 - 24	21 - 24	21 - 24	21 - 24	21 - 24
Push rod side cover cap screw	- - -	- - -	- - -	7 - 10	7 - 10
Lubricating oil filter inlet hose adapter to lubricating oil filter	- - -	- - -	- - -	150 - 175	150 - 175
Water pump cap screws	60 -70	60 - 70	60 - 70	60 - 70	60 - 70
Belt tensioner yoke pivot bolt	- - -	- - -	- - -	- - -	85 - 95
Valve lever bracket cap screw	- - -	- - -	45 - 50	- - -	- - -
Spark plug	37	37	37	37	37

* All torques are given with bolts, studs and nuts lubricated with SAE-30 engine oil, unless as specified.
** Torque given for connecting rod bolts are for threads lubricated with white lead and oil mixture.
*** Nuts must be torqued in the manner and sequence given in Section 2.
@ .055 - .065 on engines equipped with jet type cylinder heads.
⊕ .050 - .060 on engines equipped with jet type cylinder heads.

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STANDARD TORQUE DATA FOR NUTS AND BOLTS
(For applications not covered in preceding "Special Nut and Bolt Torque Data")

Recommended torques, in foot-pounds, for standard application nuts and bolts shown below is applicable, provided:

A. All threads are lubricated with engine oil or chassis grease. (Refer to NOTE.)

B. Joints are rigid; for example, no gaskets or compressible materials are used.

NOTE:

1. Multiply the standard torque by .85 when metallic plated bolts or nuts are used.
2. Multiply the standard torque by .75 when parkerized bolts or nuts are used.
3. Multiply the standard torque by .70 when Molykote, white lead or similar mixtures are used as lubricants.
4. Multiply the standard torque by .90 when hardened surfaces are used under the nut or bolt head.

Bolt Size	Type 2		Type 4	
	Min.	Max.	Min.	Max.
1/4	9	10	12	14
5/16	19	21	27	30
3/8	33	37	45	50
7/16	53	60	75	85
1/2	80	90	115	130
9/16	110	125	160	180
5/8	160	180	220	250
3/4	290	320	400	450
7/8	420	470	650	730
1	630	710	970	1090
1-1/8	850	950	1380	1550
1-1/4	1200	1350	1940	2180

BOLT TYPE IDENTIFICATION CHART

IH Type	SAE Grade	DESCRIPTION	BOLT HEAD * MARKING
2	5	WILL HAVE AN IH AND 3 RADIAL LINES Quenched and tempered medium carbon steel	
4	8	WILL HAVE AN IH AND 6 RADIAL LINES Quenched and tempered special carbon or alloy steel	

* The center marking identifies the bolt manufacturer. The IH monogram is currently used. Some bolts may still have a raised dot which previously identified IH bolts.

2. SPECIFICATIONS - Continued

ELECTRICAL

GENERATOR MODEL NUMBER	MAKE	TYPE	FIELD CURRENT (THIRD BRUSH LIFTED)	COLD OUTPUT	HOT OUTPUT	BRUSH SPRING TENSION (Oz) *	ROTATION	COMMUTATOR END BEARING	DRIVE END BEARING	VOLTAGE
1100971 and 1100987	D.R.	Adj. third brush	2.0 - 2.14 amps. at 12 volts	8 - 10 amps. at 14.5 - 14.9 volts at 2100 rpm.	6-8 amps. at 14.1 - 14.5 volts at 2300 rpm.	16	Clockwise	Bronze bushing	Ball bearing	12
1100988	D.R.	Adj. third brush	2.0 - 2.14 amps. at 12 volts	11 - 13 amps. at 14.0 volts at 2300 rpm.	9-11 amps. at 13.8 - 14.2 volts	16	Clockwise	Bronze bushing	Ball bearing	12
1101737	D.R.	Adj. third brush	1.48 - 1.56 amps. at 12 volts	8 - 10 amps. at 14.4 - 14.9 volts at 2200 rpm.	6 - 8 amps at 14.1 - 14.5 volts at 2400 rpm.	16	Clockwise	Bronze bushing	Ball bearing	12
1105102	D.R.	Two brush shunt	1.54 - 1.67 amps. at 12 volts	17 amps. at 14.0 volts at 1400 rpm.	Maximum output controlled by current regulator	16	Clockwise	Bronze bushing	Ball bearing	12
1105106	D.R.	Two brush shunt	1.54 - 1.67 amps. at 12 volts	17 amps.at 14.0 volts at 1400 rpm.	Maximum output controlled by current regulator	16	Clockwise	Ball bearing	Ball bearing	12
1105922	D.R.	Two brush shunt	1.22 - 1.32 amps. at 12 volts	13 amps. at 15.0 volts at 1300 rpm. **	Maximum output controlled by current regulator	28	Clockwise	Ball bearing	Ball bearing	12
1105935	D.R.	Two brush shunt	1.54 - 1.67 amps. at 12 volts	13 amps. at 14.0 volts at 1500 rpm. **	Maximun output controlled by current regulator	28	Clockwise	Ball bearing	Ball bearing	12
1105990	D.R.	Two brush shunt	.94 - 1.02 amps. at 24 volts	15 amps. at 28.5 volts at 1800 rpm.	Maximum output controlled by current regulator	28	Clockwise	Ball bearing	Ball bearing	24
1106895, 1106898, 1106952 and 1106953	D.R.	Two brush shunt	.83 - .89 amps. at 24 volts	15 amps. at 26 volts at 1600 rpm. **	Maximum output controlled by current regulator	20	Clockwise	Ball bearing	Ball bearing	24

CRANKING MOTOR MODEL NUMBER	MAKE	TYPE OF DRIVE	NO LOAD TEST	LOCK TEST	NUMBER OF BRUSHES	BRUSH SPRING TENSION (Oz)	ROTATION	NUMBER OF FIELDS	BEARINGS	VOLTAGE
1108867	D.R.	Bendix	65 amps. at 11.4 volts at 6000 rpm.	32 ft-lb. at 525 amps. at 3 volts	8	36 - 40	Clockwise	4	Bushing type	12
1108868	D.R.	Dyer Solenoid	100 amps. at 23 volts at 8000 rpm.	32 ft-lb. at 525 amps. at 3 volts	8	36 - 40	Clockwise	4	Bushing type	24
1109108	D.R.	Bendix	65 amps. at 12 volts at 4500 rpm.	44 ft-lb. at 725 amps. at 4.8 volts	6	36 - 40	Clockwise	6	Bushing type	12
1109853	D.R.	Dyer Solenoid	65 amps. at 11.4 volts at 6000 rpm.	32 ft-lb. at 525 amps. at 3 volts	8	36 - 40	Clockwise	4	Bushing type	12
1109854	D.R.	Dyer Solenoid	100 amps. at 23 volts at 8000 rpm.	32 ft-lb. at 525 amps. at 3 volts	8	36 - 40	Clockwise	4	Bushing type	24
1113307	D.R.	Bendix	65 amps. at 11.4 volts at 6000 rpm.	28 ft-lb. at 500 amps. at 3.2 volts	4	48	Clockwise	4	Bushing type	12
1113345 and 1113367	D.R.	Solenoid overrunning clutch	65 amps. at 11.4 volts at 6000 rpm.	28 ft-lb. at 500 amps. at 3.2 volts	4	48	Clockwise	4	Bushing type	12
1113712	D.R.	Dyer Solenoid	65 amps at 11.4 volts at 6000 rpm.	28 ft-lb. at 500 amps. at 3 volts	8	35	Clockwise	4	Bushing type	12
1113713 and 1113814	D.R.	Dyer Solenoid	100 amps at 23 volts at 8000 rpm.	28 ft-lb. at 500 amps. at 3 volts.	8	35	Clockwise	4	Bushing type	24

* Third brush spring tension - 19 ounces.
** Rated performance without regulator. Regulated output will depend on type of regulator used.

ELECTRICAL

2. SPECIFICATIONS – Continued

REGULATOR MODEL NUMBER	MAKE	TYPE	GROUND	CUTOUT RELAY				VOLTAGE REGULATOR			CURRENT REGULATOR		
				AIR GAP	POINT OPENING	CLOSING VOLTAGE	ADJUST TO	AIR GAP	SETTING RANGE	ADJUST TO	AIR GAP	SETTING RANGE	ADJUST TO
1118322	D.R.	Three unit regulator	P	.020	.020	11.8 - 13.8	12.8	.075	13.9 - 14.9	14.3	.075	10.5 - 13.5	12.0
1118365	D.R.	Three unit regulator	P	.020	.020	11.8 - 13.8	12.8	.075	13.9 - 14.9	14.3	.075	10.5 - 13.5	12.0
1118796	D.R.	Three unit regulator	P	.017	.032	24.0 - 27.0	25.5	.075	27.5 - 29.5	28.5	.075	13.5 - 16.5	15.0
1118908	D.R.	Three unit regulator	P	.020	.020	11.8 - 13.5	12.6	.075	13.8 - 14.8	14.3	.075	11 - 13	12.0
1119152	D.R.	Three unit regulator	P	.020	.020	11.8 - 13.5	12.6	.075	13.8 - 14.8	14.3	.075	15.5 - 18.5	17.0
1119153	D.R.	Three unit regulator	P	.020	.020	11.8 - 13.5	12.6	.075	13.8 - 14.8	14.3	.075	15.5 - 18.5	17.0
1119178	D.R.	Three unit regulator	P	.017	.032	24.0 - 27.0	25.5	.075	27.5 - 29.5	28.5	.075	13.5 - 16.5	15.0
1119199	D.R.	Three unit regulator	P	.017	.032	24.0 - 27.0	25.5	.075	27.5 - 29.5	28.5	.075	13.5 - 16.5	15.0

REGULATOR MODEL NUMBER	MAKE	TYPE	GROUND	CUTOUT RELAY				STEP - VOLTAGE CONTROL						
				AIR GAP	POINT OPENING	CLOSING VOLTAGE	ADJUST TO	AIR GAP	POINT OPENING	CONTACT SPRING TENSION	ARMATURE TRAVEL	OPENING RANGE	ADJUST TO	CLOSING RANGE
5838	D.R.	Two unit regulator	P	.015	.020	12.5 - 14.0	13.3	.030	.010	8 oz.	.030	14.0 - 15.5	14.7	12.5-14.0

REGULATOR MODEL NUMBER	MAKE	TYPE	GROUND	CUTOUT RELAY				CURRENT - VOLTAGE REGULATOR		
				AIR GAP	POINT OPENING	CLOSING VOLTAGE	ADJUST TO	AIR GAP	OPENING RANGE	ADJUST TO
1118306	D.R.	Two unit regulator	P	.020	.020	11.8 - 14.0	12.8	.075	13.6 - 14.5	14.0

DISTRIBUTOR MODEL NUMBER	MAKE	NUMBER OF CYLINDERS	ROTATION	POINT GAP INCH	SPARK ADVANCE	VOLTS
1110152	D.R.	6	Counterclockwise *	.020	20° manual	12
K	I.H.	6	Counterclockwise *	.020	Fixed	12

* As viewed from rotor end.

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3. CHECKING MECHANICAL PROBLEMS

ENGINE

PROBABLE CAUSE	REMEDY
ENGINE FAILS TO TURN	
1. Starting switch inoperative.	Inspect for faulty cables and terminals.
2. Battery too low to turn engine	Charge battery or install new one.
3. Engine oil too heavy	Use correct grade lubricating oil.
4. Internal seizure	Crank engine with spark plugs removed, engine clutch disengaged and compression release lever in starting position. If engine does not turn easily, seizure due to internal damage is indicated.
5. Cranking motor inoperative.	Inspect cables and terminals. Check for tightness of mounting screws. Inspect commutator for damage.
ENGINE WILL NOT OPERATE AS A DIESEL ENGINE	
1. Injection pump does not deliver fuel	Refer to "Diesel Injection Pumps" manual, ISS 1003.
2. Compression release faulty (starting control).	Adjust linkage. (Refer to "Adjustment of Release Mechanism" paragraph in section 8.)
ENGINE DOES NOT DEVELOP FULL POWER	
1. Moisture in fuel tank.	Drain entire system including water trap and filter. Refill with fuel oil and vent air from system.
2. Fuel oil filter and strainer clogged	Disassemble and clean each unit.
3. Air cleaner clogged.	Remove and clean oil cup.
4. Precleaner clogged (when used)	Clean precleaner.
5. Insufficient fuel	Check fuel tank.
6. Poor fuel	Use good grade fuel.
7. Injection pump not properly timed to engine.	Remove pump gear cover and make proper timing adjustments.
8. Injection pump not operating properly . . .	Remove injection pump and test it.
9. One or more cylinders misfiring.	Locate and correct cause.
ENGINE TURNS BUT WILL NOT START	
1. Gasoline system inoperative.	Inspect gasoline tank and check shut-off valve in gasoline strainer.
2. Ignition system inoperative.	Check ignition system and make necessary repair.
3. Intake or exhaust system clogged	Remove air flow restriction and clean exhaust system.
4. On natural gas supply:	
a. Shut-off valve in the line is closed . . .	Open the valve.
b. Lack of sufficient gas pressure	Remove pipe plug at regulator and check gas pressure.

3. CHECKING MECHANICAL PROBLEMS – Continued

ENGINE

PROBABLE CAUSE	REMEDY
ENGINE TURNS BUT WILL NOT START - Continued	
c. Overpriming at regulator, letting too much gas into carburetor.	Raise engine speed control lever, which will open carburetor throttle, and crank the engine until the excess gas is expelled.
d. Moisture in gas supply	Install a dehumidifier in the main gas line.
POOR COMPRESSION	
1. Piston rings worn, broken or cracked. . . .	Install new rings.
2. Cylinder sleeve worn.	Install new sleeves.
3. Valves damaged or worn	Install new valves.
4. Broken valve spring.	Install new springs.
5. Worn cylinder head gasket	Install new gasket.
6. Valve seats worn	Grind valves and seats.
7. Worn pistons	Install new pistons.
8. Excessive valve guide wear	Install new valve guides.
9. Sticking valves or bent valve stems	Free stem and correct cause. Replace valves with bent stems.
10. Faulty valve action	Adjust valve clearance.
ENGINE OVERHEATS	
1. Insufficient water in cooling system	Check water level and add water if necessary.
2. Cooling system clogged.	Clean out radiator and engine.
3. Fan and water pump belt slipping	Check tension and make proper adjustments.
4. Insufficient oil	Maintain proper oil level.
5. Engine oil diluted with fuel	Change oil and inspect fuel connections on injection nozzles.
6. Defective thermostat	Remove and test thermostat. Replace if necessary.
7. Water pump defective	Repair pump.
ENGINE MISSES ON ONE OR MORE CYLINDERS	
1. Insufficient air to engine.	Remove and clean air cleaner and air cleaner pipe.
2. Injection nozzle valve dirty or sticking . . .	Remove and clean nozzle valve. If defective, replace.
3. Air lock in fuel pump	Vent air from system and check all fuel lines and connections for leaks.
4. Poor fuel	Use good grade of fuel.
5. Air leaks around manifold	Remove and install new manifold gasket.

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3. CHECKING MECHANICAL PROBLEMS – Continued

ENGINE

PROBABLE CAUSE	REMEDY
EXCESSIVE OIL CONSUMPTION	
1. Piston ring worn or broken	Install new rings.
2. Oil level in crankcase too high	Maintain proper oil level.
3. Crankcase oil pan gasket leaking	Install new gasket.
4. Worn valve guides	Install new valve guides.
5. Cylinder sleeves worn	Install new sleeves.
6. Front and rear crankshaft oil seal leaking	Install new oil seals.
7. Piston rings not seating	Install new rings.
8. Clogged oil ring	Remove and inspect and, if necessary, replace.
9. Oil pan drain plug loose or worn	Install new drain plug, gasket and tighten plug.
10. Overheating	Refer to "Engine Overheats" on preceding page.
ENGINE DOES NOT IDLE PROPERLY *	
1. Gummy and sticky delivery valves and plunger. (Bosch fuel injection pump.)	Remove valves and plunger; test and clean. Replace them if necessary.
2. Toothed segment securing screw of injection pump loose. (Bosch fuel injection pump.)	Align the mark on toothed segment with mark on control sleeve and tighten securing screw firmly.
3. Incorrect timing of injection pump. (Bosch fuel injection pump.)	Time pump properly.
4. Plunger spring broken	Install new spring.
5. Control sleeve damaged due to broken plunger spring. (Bosch fuel injection pump.)	Repair or replace control sleeve.
6. Governor springs loose or broken, (IH injection pump.)	Repair or replace spring.
7. Plunger scored, stuck, or worn. (IH injection pump.)	Install new plunger.
8. Loose governor spring levers on control lever shaft. (IH injection pump.)	Tighten screw and nut.
9. Restriction to fuel delivery. (IH injection pump.)	Inspect fuel lines and valves, inspect for proper level in fuel tank.

* Also refer to "Diesel Injection Pumps" Manual, ISS-1003.

ENGINE NOISES	
1. A sharp rap at idling speed indicates a loose piston pin. The pin at fault can be located by short-circuiting the spark plugs one at a time with the engine running on the gasoline cycle. The noise will disappear when the plug in the cylinder with the defective piston is short-circuited	Replace piston pin.
2. A flat slap, when advancing engine speed under load, indicates a loose piston	Replace piston and sleeve.
3. A metallic knock when idling and retarding engine speed, but disappears under load indicates worn or loose connecting rod bearings. The bearings at fault can be found by short-circuiting the spark plugs one at a time with the engine running on the gasoline cycle. The noise will disappear when the plug in the cylinder with loose connecting rod bearings is short-circuited	Replace worn bearings.

3. CHECKING MECHANICAL PROBLEMS – Continued

PROBABLE CAUSE	ENGINE	REMEDY
	ENGINE NOISES - Continued	
4. Constant rapid clicking indicates incorrect valve clearance		Adjust valve clearance.
5. Combustion knock in one or more cylinders:		
(a) Leaky injection nozzle valve		Replace nozzle valve.
(b) Poor fuel and/or water in fuel		Drain entire diesel fuel system and refill with a good grade of clean diesel fuel. Remove and clean the water trap.
(c) Faulty injection pump timing		Retime pump to engine.
(d) Improper engine temperature		Keep temperature in working range of heat indicator.
	EXCESSIVE SMOKE	
1. Too much oil in air cleaner		Remove air cleaner cup and remove any excess oil.
2. Air cleaner pipe clogged		Remove air cleaner and clean the pipe.
3. Improper fuel		Use good grade of fuel.
4. Defective injection nozzle		Repair or install new nozzle.
5. Worn pistons, rings and sleeves		Install new parts.
6. Precleaner clogged		Remove and clean. If defective, install new parts.
7. Injection pump not properly timed		Time injection pump.
8. Incorrect valve adjustment		Adjust valves properly.
	BEARING FAILURE	
1. Low oil pressure		Keep proper oil pressure.
2. Lack of oil		Maintain proper oil level.
3. Engine runs too hot		Keep engine at normal operating temperature.
4. Loose bearings		Install new bearings.
5. Use of improper lubricating oil		Use a suitable oil, of noncorrosive type, correct grade and viscosity.
6. Foreign materials entering engine		Use clean oil containers when filling engine with oil and see that all gaskets on engine are in good condition.
7. Oil lines clogged		Clean all oil passages.
8. Connecting rod bent		Align rod or install new.
9. Crankshaft out of alignment		Straighten, or install new shaft.
	VALVES STICKING	
1. Valve springs weak		Install new springs.
2. Valve springs broken		Install new springs.
3. Gummy deposits from inferior fuel or oil		Clean, and use proper fuel or oil.
4. Valve stems scored or carboned		Clean. If necessary, install new valves.
5. Insufficient clearance between valve stem and guide		Ream guides for proper clearance.
	PISTON AND CYLINDER SLEEVE WEAR	
1. Oil of unsuitable grade or viscosity		Change to oil of suitable specifications.
2. Piston rings stuck or broken		Install new rings.
3. Lack of oil		Keep oil at proper level.
4. Foreign materials entering engine		Inspect and service air cleaners and precleaners. Proper care of these cleaners is very important.

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3. CHECKING MECHANICAL PROBLEMS – Continued

PROBABLE CAUSE	ENGINE	REMEDY

PISTON AND CYLINDER SLEEVE WEAR -Continued

5. Piston rings not fitted properly to cylinder.	Install new rings and fit properly.
6. Dirty containers used for lubricating oil . .	Lubricating oil should be kept in a clean place and clean containers used when filling engines.

LOSS OF OIL PRESSURE

1. Low oil level	Add sufficient oil to bring up to specified mark on level gauge.
2. Oil pressure indicator or line defective . .	Replace defective parts.
3. Main or connecting rod bearings worn . .	Replace defective parts.
4. Dirt in regulating valve, or regulating valve spring broken	Clean, or replace spring.
5. Oil pump worn	Remove, and repair or replace.
6. Camshaft bearings worn excessively . . .	Install new bearings.
7. Oil diluted or not as specified	Change oil regularly using correct grade.
8. Oil leaks	Check and service where necessary - at valve lever housing, valve cover, side plates, dust seal at rear of oil pan, crankcase front cover, oil seals at front and rear of crankshaft, oil pan, oil filters, and oil pressure indicator tube.
9. Clogged oil filters	Change filter elements.

IMPROPER DIESEL FUEL PRESSURE

(Refer to "Diesel Injection Pump" Manual, ISS-1003.)

LOW ENGINE RPM

1. Governor control rod linkage binding or damaged	Repair and install new parts needed.
2. Butterfly valves in intake manifold improperly adjusted	Make proper adjustments.
3. Governor control rod improperly adjusted .	Adjust rod to proper length.

ENGINE RUNS UNEVENLY AND VIBRATES

1. Valve and spring assembly inoperative . .	Repair or install parts needed.
2. Incorrect injection pump timing	Time injection pump correctly. (Refer to ISS-1003)
3. Injection pump plungers not equalized . .	Equalize the plungers. (Refer to ISS-1003)

NOISY TURBOCHARGER OPERATION OR VIBRATION

1. Bearings are not being lubricated	Supply required oil pressure, clear or replace oil line. Be sure oil inlet filter has been removed from turbocharger.
2. Impeller seal glands rubbing	Impeller seal glands will wear in after 10 minutes of operation.
3. Leakage in engine intake or exhaust manifold	Tighten loose connections or replace manifold gaskets is necessary.

(Continued on next page.)

3. CHECKING MECHANICAL PROBLEMS – Continued

PROBABLE CAUSE	REMEDY
ENGINE	
NOISY TURBOCHARGER OPERATION OR VIBRATION - Continued	
4. Turbocharger rotating assembly seals rubbing	Replace seals.
5. Loose fit of rotating cartridge assembly journals or bearings	Replace parts as necessary.
6. Excessive build-up of dirt in compressor or impeller	Thoroughly clean all dirt from compressor impeller. Clean air cleaner and check air inlet ducting for leakage.
7. Excessive build-up of carbon, or deposits on turbine wheel	Clean turbine wheel.
TURBOCHARGED ENGINES WILL NOT DELIVER RATED POWER	
1. Clogged manifold system	Clear all ducting.
2. Foreign material lodged in compressor, impeller or turbine wheel	Disassemble and clean or replace parts as necessary.
3. Leakage in engine intake or exhaust manifold	Tighten loose connections or replace manifold gaskets if necessary.
4. Rotating assembly bearing seizure	Replace bearings.
ELECTRICAL	
DISCHARGING BATTERY	
1. Connections loose	Tighten connections.
2. Short circuits	Locate shorts and correct cause.
3. Connections dirty	Clean connections.
4. Voltage control unit out of order	Adjust or replace control unit.
5. Generator not charging	Check voltage control unit and make necessary adjustments.
BATTERY OVERHEATING	
1. High charging rate	Inspect voltage control unit.
2. Voltage control unit out of order	Adjust voltage control unit. If necessary, replace.
BATTERIES FULLY CHARGED AND GENERATOR CHARGING RATE HIGH	
1. Poor ground connection at voltage regulator.	Check ground wire and connections.
2. Improper voltage regulator setting	With engine operating at 1000 r.p.m., disconnect the lead from the "F" terminal on the voltage regulator. If the output remains high, the generator field is grounded in the generator or in the wiring harness. (Refer

3. CHECKING MECHANICAL PROBLEMS – Continued

ELECTRICAL

PROBABLE CAUSE	REMEDY
BATTERIES FULLY CHARGED AND GENERATOR CHARGING RATE HIGH - Continued	
2. Improper voltage regulator setting . . . . . - Continued	to "GENERATOR" in section 17.) If the output drops off, the voltage regulator is at fault and should be checked for high voltage setting or grounds. (Refer to "VOLTAGE REGULATOR" in section 18.)
3. Defective voltage regulator	(See 2 above.)
4. Grounded generator field circuit (in either generator, regulator or wiring)	(See 2 above.)
BATTERIES LOW IN CHARGE AND LOW OR NO GENERATOR CHARGING RATE	
1. Loose connections, frayed or damaged wiring	Check wiring.
2. Defective batteries	Check batteries (refer to "BATTERIES" in section 19).
3. Low voltage regulator setting	Momentarily touch a jumper from the "F" terminal on the regulator to the ground terminal on the regulator and increase the generator speed. If output does not increase, check generator for no output. (Refer to "GENERATOR" in section 17.) If output does increase, the regulator is at fault. (Refer to "VOLTAGE REGULATOR" in section 18.)
4. Oxidized regulator contact points	Refer to "VOLTAGE REGULATOR" in section 18.
5. Defective generator	Refer to "GENERATOR" in section 17.
NO GENERATOR OUTPUT	
1. Worn brushes	Replace brushes.
2. Burned commutator bars	Recut commutator.
3. Sticking brushes	Clean brushes.
4. Rough, dirty or greasy commutator bars .	Clean commutator bars.
5. Commutator out-of-round	Recut commutator.
6. Low brush tension.	Adjust or replace brush spring.
AMMETER SHOWS DISCHARGE WITH ENGINE OPERATING	
1. Generator inoperative	Service or replace generator.
2. Faulty generator relay	Adjust relay or replace if necessary.
3. Short circuits	Test cables for shorts.
4. Fan drive belt loose or broken	Tighten or replace belt.

3. CHECKING MECHANICAL PROBLEMS – Continued

ELECTRICAL

PROBABLE CAUSE	REMEDY
NOISY GENERATOR	
1. Loose mountings	Tighten mounting bolts.
2. Loose pulley	Tighten pulley.
3. Worn bearings	Install new bearings.
AMMETER POINTER FLUCTUATES RAPIDLY	
1. Shorted or loose connections	Test for short circuits and tighten connections.
2. Generator defective	Service or replace generator.
3. Fan drive belt loose or broken	Adjust belt; if necessary, replace.
4. Low idling speed	Adjust idling speed; check voltage control unit.
CRANKING MOTOR WILL NOT OPERATE OR OPERATES SLOWLY	
1. Faulty batteries	Recharge or install new battery.
2. Cables or terminals loose or defective	Check all cables for secure mounting to terminals. Replace all corroded or broken cables.
3. Starting switch defective	Inspect for burned or corroded switch parts. Clean up the points.
4. Cranking motor burned out	Install a new cranking motor.
5. Commutator worn or dirty	Remove cover band and clean commutator. Inspect brushes.
6. Brushes not making proper contact	Inspect to see that brushes are seating properly.
DISTRIBUTOR INOPERATIVE	
1. Contact lever spring broken due to corrosion attacking metallic materials	Replace spring and clean distributor carefully to avoid repetition.
2. Wiring to or from distributor broken, frayed or damaged by moisture, oil or corrosion	Inspect all wiring and replace if faulty.
3. Poor electrical connections at distributor or plugs	Inspect connections and be sure they are free from dirt and oil.
4. Rotor or cap cracked or having carbonized surfaces providing escape for current to ground	Replace rotor or cap if necessary.
5. Condenser short-circuited (due to insulation breakdown caused by cracks in condenser sealing materials allowing moisture to enter)	Inspect condenser and sealing for cracks. Replace condenser if necessary.

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3. CHECKING MECHANICAL PROBLEMS – Continued

ELECTRICAL

PROBABLE CAUSE	REMEDY
DISTRIBUTOR CONTACT POINTS BURNED OR PITTED	
1. Points set too closely	Inspect to ensure correct clearance.
2. Excessive resistance due to broken strands in condenser lead	Replace condenser.
3. High voltage due to overcharged battery (high voltage in starting system may be caused by loose connections at batteries, etc.)	Check voltage in battery. Check connections for secure fitting on terminals. Clean points.
4. Oil or foreign substances on contact points.	Clean points.
5. Hexagon shaft or rubbing block in distributor worn	Replace as necessary.
INTERMITTENT SPARKING	
1. Weak tension on distributor contact points. Vibration causing chatter	Correct tension.
2. Dirty points or incorrect setting on contact point gap	Clean points and check contact gap.
WEAK SPARKING	
1. Dirty distributor contact points or poor rotor connections	Clean contacts and wipe off rotor with carbon tetrachloride on clean cloth.
2. Ignition timing too slow	Check ignition timing.
3. Leakage of current to ground due to faulty wiring	Inspect wiring for fraying and broken strands. Replace.

To determine the presence of short circuits in the wiring, turn off all electrical equipment. Disconnect the "battery to cranking motor solenoid switch cable" at the battery. Tap the cable terminal against its battery post. Sparking will be produced if there is a substantial short circuit in the wiring. Be sure that fuses have not burned out before making the test. To detect a very slight short circuit, install a low reading ammeter (in series) in the circuit.

4. BATTERY TESTING CHART

HYDROMETER TEST (80°F.) (See note)	CONDITION	REMEDY
1.250 TO 1.280 SPECIFIC GRAVITY.	Charged.	No remedy required if variation among cells is not over .015 Sp. Gr. If variation is much more than .015 Sp. Gr. give high rate discharge test. If cells test O.K. recharge and adjust gravity of all cells uniformly.

4. BATTERY TESTING CHART – Continued

HYDROMETER TEST (80°F.) (See note)	CONDITION	REMEDY
1.225 TO 1.250 SPECIFIC GRAVITY.	Fair.	Advisable to recharge, especially in cold weather. Adjust gravity of cells if not uniform. Check operation and setting of voltage regulator. Make a thorough check of the electrical system for short circuits, loose connections, corroded terminals, etc.
LESS THAN 1.225 SPECIFIC GRAVITY.	Poor.	Battery should be recharged. Adjust gravity of cells if not uniform. Check operation and setting of voltage regulator. Make a thorough check of the electrical system for short circuits, loose connections, corroded terminals, etc.
CELLS SHOW MORE THAN 25 POINTS (.025 SP. GR.) VARIATION IN GRAVITY.	Short circuit in low cell. Loss of electrolyte by leakage or excessive overcharge. Improper addition of acid or "dopes." Natural or premature failure.	Try to recharge battery at rate of one ampere for each positive plate in one cell until gravity readings show no rise in three consecutive readings when taken one hour apart. Cell voltages on charge should also be fairly uniform. Adjust gravity of cells to 1.280 - 1.290 at 80°F. by addition of water to lower, or 1.400 Sp. Gr. acid to raise the gravity of the acid. Make high rate discharge test after not less than 12 hours and not more than 96 hours standing on open circuit, and check discharge voltage of each cell; if more than .15 volt between cells is shown on discharge, the battery may be considered to be no longer serviceable.

~~NOTE -~~ Electrolyte level should be 1/4 to 1/2 inch above the separators. Do not take the reading soon after adding water. Hydrometer readings should be corrected for temperature if temperature is extremely low or high.

VOLTMETER TEST	CONDITION	REMEDY
IF THE VOLTAGE DROP IS MORE THAN .2 VOLT (2/10) BETWEEN THE CRANKING MOTOR CABLE AND THE FRAME WHILE CRANKING.	Poor contact between terminal and frame or between clamp terminal and battery post.	Locate the high resistance; repair or replace.

4. BATTERY TESTING CHART – Continued

VOLTMETER TEST	CONDITION	REMEDY
WHILE OPERATING THE CRANKING MOTOR, WITHOUT IGNITION TURNED ON, CHECK THE VOLTAGES OF ALL CELLS. (THIS TEST CAN ALSO BE DONE ON THE HIGH RATE TESTER.) IF THE VOLTAGE VARIES MORE THAN .15 VOLT BETWEEN CELLS.	Defective cell or cells.	Compare voltage readings with hydrometer readings - low voltage is usually accompanied by low gravity. Apply remedy given for "Cells show more than 25 points (.025 Sp. Gr.) variation in gravity" above.

5. TUNE-UP

General

The following steps outline the operations which should be followed in an engine tune-up. These steps point out the various parts of the engine to be checked, cleaned, timed or repaired, as needed.

Injection Pump (Not U-1091)

1. Remove the injection pump from the engine, place it on an injection test stand, and run a calibration test on the pump.

2. Test the primary pump.

3. Check the timing of the injection pump.

4. For additional information on the injection pump, refer to "Diesel Injection Pumps" manual ISS-1003.

Injection Nozzles (Not U-1091)

1. Remove the injection nozzles and check for leaks and opening pressure. Adjust and repair.

2. Remove the nozzle precombustion chambers and inspect for pitted or burned surfaces. Install new gaskets and replace precombustion chambers if necessary.

3. For additional information on injection nozzles, refer to "Diesel Injection Pump" manual ISS-1003.

Diesel Throttle Control (Not U-1091)

1. Check the operation of the control.

2. Check the operation of the springs on the governor control rod.

3. Check the rpm of the engine using a tachometer.

Valves

1. Check the clearance on intake and exhaust valves, and make adjustments. (Refer to "Valve Clearance Adjustments" in section 2.)

Air Cleaner

1. Check the air cleaner and connections for possible leaks.

2. Clean the oil cup on the air cleaner and the screen on the air intake cap. (Refer to the operator's manual.)

Filters

1. Replace the lubricating oil filter elements, and clean the filter case assembly thoroughly.

2. (NOT U-1091) Inspect the fuel filter elements and replace them if necessary. (Refer to the operator's manual.)

(Continued on next page)

5. TUNE-UP – Continued

Water Traps

1. Remove the water trap. Clean thoroughly, and inspect the screen for damage.

Spark Plugs

1. Clean and adjust the spark gap, (refer to section 19).

2. Replace broken plugs.

Magneto

1. Check the breaker points.

2. Clean the breaker point chamber.

3. For additional information on the magneto, refer to section 14.

Condenser and Ignition Coil

1. Check the condenser and replace it if necessary. (Refer to section 15.)

2. Check the ignition coil and replace it if necessary. (Refer to section 19.)

Distributor

1. Check the distributor contact points.

2. For additional information on distributors refer to section 15.

Generator

1. Inspect the commutator; clean thoroughly at frequent intervals.

2. For additional information on generators refer to section 17.

Cranking Motor

1. Inspect the commutator; clean thoroughly at frequent intervals.

2. For additional information on cranking motors refer to section 16.

Electrical Connections

1. Check all electrical connections in both the high tension and low tension circuits of the ignition system.

2. Check all switches.

Starting System Control and Linkage (Not U-1091)

1. Check the entire linkage of the starting system. (Refer to section 8.)

2. Check approximate clearance travel of the valve spring cover in cylinder head (starting position). (Refer to section 8.)

Carburetor

1. Remove the screen retainer and clean it.

2. Remove the fuel bowl and check the float level. Adjust if necessary.

3. Check float valve assembly for leakage.

4. For additional information on carburetors refer to section 10 or 11.

Cooling System

1. Flush the radiator with clean water, then drain and refill with soft water if available, or anti-freeze solution in cold weather.

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2. Check the fan belts for wear and replace if necessary.

3. Check the fan belt tension. (Refer to section 5.)

Diesel Compression Pressure

Check the compression of each cylinder on the diesel cycle.

1. Remove the No. 1 nozzle body from the cylinder head.

2. Insert the proper adapter into position in the cylinder head and secure in place. Attach the pressure indicator to the adapter. (Refer to "Service Tools Manual" ISS-1002.)

Start the engine; then switch to the diesel cycle. With the engine operating at 1,000 rpm speed, check the compression reading on the indicator. (See "Specifications," section 1, for compression pressure.) After the above procedure, remove the adapter and check the other cylinders in the same manner. Install each nozzle assembly after checking.

NOTE: Be certain that the compression gauge used is in working order and is free of leaks.

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MANIFOLDS

1. DESCRIPTION

Intake Manifold

The intake manifold on a diesel engine is a dual type. A small, high-velocity passageway is used during the starting operation only, and a large passageway is used when operating on the diesel cycle.

Four butterfly valves in the large passage open to air when the engine is switched to diesel operation. An ignition cut-out switch that functions automatically with the starting mechanism opens the distributor primary circuit or, in the case of magneto ignition, grounds the magneto primary circuit when the engine is on diesel operation. It is located in the front end of intake manifold. The lever and springs at the end of the butterfly valve shaft provide an over-center action and hold the butterfly valves securely open or closed.

Exhaust Manifold

The exhaust manifolds are secured to the cylinder head exhaust ports with studs and nuts.

2. REMOVAL

Intake Manifold

1. On engines equipped with battery ignition, disconnect the electrical leads from the ignition cut-out switch terminals at the manifold front end cover. On all engines equipped with magneto ignition, the manifold front end cover must be removed to disconnect the leads from the ignition cut-out switch.

2. Turn off the gasoline at the tank and remove the gasoline supply tube at the carburetor.

3. Remove the cotter and disconnect the choke control rod from the carburetor. Remove the primer control connections, if so equipped.

4. Disconnect the injection pump air cleaner line (if so equipped).

5. Remove the cap screws securing the air intake flange.

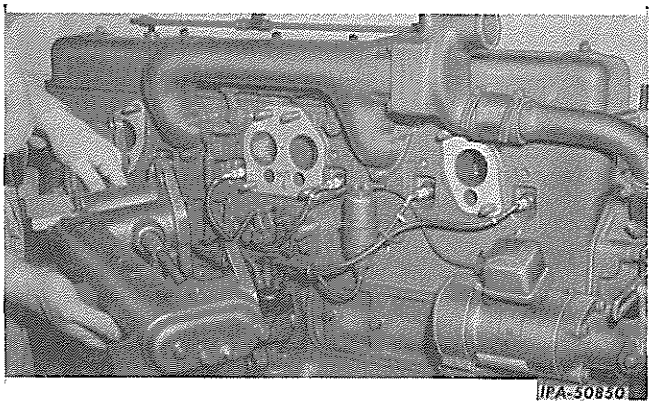
6. POWER UNIT ENGINES ONLY: Disconnect and remove the gasoline tank.

7. Remove the nuts from each intake port flange and remove the manifold with carburetor.

Exhaust Manifold

8. Remove the turbocharger (if equipped). Refer to Section 12.

9. Remove the nuts securing the manifold to the engine and lift the manifold and gaskets from position.



Illust. 1 - Removing the Intake Manifold.

3. DISASSEMBLY (Refer to Illust. 2)

Intake Manifold

1. Remove the carburetor.

2. Remove the end covers and gaskets (1, 2 and 26, Illust. 2).

3. Disconnect the control springs (7), and remove the ignition cut-out switch assembly from the front end of the manifold. File the peened end of the screws holding the butterfly valves to the control shafts. Remove the screws. On engines equipped with the rotary type switch, the contact blades are mounted inside the end cover and are freed by removing the two screws. The contact disc is secured to the front manifold control shaft with an eyelet.

4. Remove the butterfly valves (8) from the shafts (6, 13, 17 and 18).

NOTE: Do not use force to remove the valves.

5. Remove the control shaft flange pins from the control shaft flanges and end couplings. Remove the shafts by tapping them lightly.

6. Remove the seals (21) if necessary to replace them.

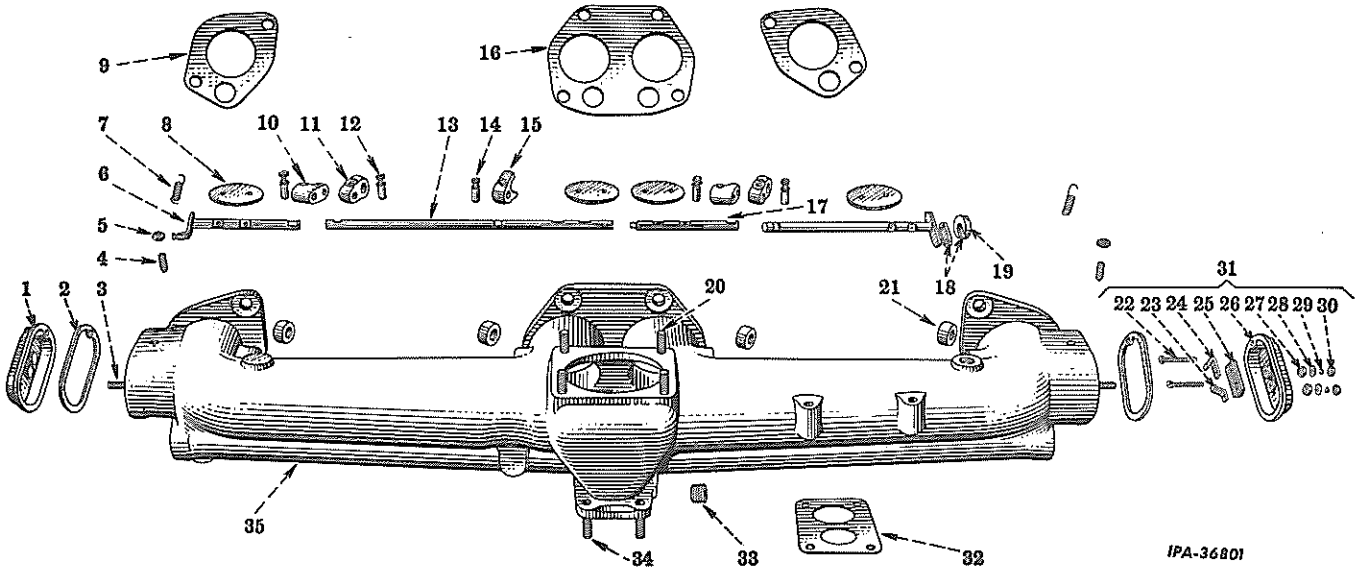
MANIFOLD

4. INSPECTION AND REPAIR

1. Remove the injection pump air cleaner (used with "A" type injection pumps) before washing or cleaning the intake manifold. If the injection pump air cleaner is not removed, the cleaner gets full of water or solvent and, when the engine is started, it either pulls this moisture into the pump or engine or the heat causes the water to boil away and seal the felt, restricting the air flow to the injection pump. When the injection pump air cleaner is removed, it is advisable to disassemble and replace the elements if clogged.

NOTE: Diesel engines equipped with the "B" type injection pump, no longer use an injection pump air cleaner.

2. Clean all parts thoroughly, using a cleaning solvent. Dry them with compressed air. Inspect all parts and replace with new any parts showing damage or excessive wear. Inspect the ignition cut-out switch terminals and insulation. Clean off any oxidation with a tungsten file.



Illust. 2 - Exploded View of Intake Manifold (24 and 1091 Series).

1. End cover, rear.
2. End cover gasket.
3. Control spring stud.
4. Screw.
5. Nut.
6. Control shaft, rear.
7. Control spring.
8. Butterfly valve.
9. Gasket, end.
10. Control shaft coupling.
11. Control shaft flange.
12. Control shaft flange pin.
13. Control shaft, rear, intermediate.
14. Control lever pin.
15. Control lever.
16. Gasket, center.
17. Control shaft, front, intermediate.
18. Control shaft and contact with disc.
19. Disc with eyelet.
20. Air intake flange stud.
21. Control shaft seal.
22. Terminal insulator screw.
23. Switch contact blade, right.
24. Switch contact blade, left.
25. Switch blade mounting strip.
26. End cover, front.
27. Terminal insulator.
28. Terminal insulator screw washer.
29. Lock washer.
30. Hex nut.
31. End cover, complete, front.
32. Carburetor flange gasket.
33. Pipe plug.
34. Carburetor flange stud.
35. Intake manifold.

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MANIFOLDS

5. REASSEMBLY (Refer to Illust. 2)

Intake Manifold

1. Install new control seals (21) if necessary. The lips of the seals must face the inside of the manifold in order to seal effectively.

2. Install the control shafts, couplings and levers into the manifold. Be careful not to damage the seals (21).

3. Insert the butterfly valves into the slots in the control shafts and secure each with two screws.

4. Install the ignition cut-out switch assembly in the front end of the manifold (if so equipped). Hook the spring (7) onto the stud (3) and to the end of the shaft (6). Hook the other spring (7) to the stud (3) and to the front of the shaft (18).

5. Adjust the butterfly valves by loosening the lock nuts of the set screws on top of the manifold. Adjust the set screws until the butterfly valves are horizontal within the manifold air passage when the levers contact the set screws. The butterfly valve screws have a V-cut at the bottom and will cause expansion when installed. This is to prevent any possibility of the screw coming loose during operation.

NOTE: Butterfly valves should fit the bore of the manifold without cocking or binding. They should not have more than .0015-inch clearance measured with a feeler gauge 1/8 inch wide between the circumference of the valve and the bore of the manifold.

6. Install the carburetor and secure with nuts and washers.

6. INSTALLATION

Intake Manifold

The surfaces of the cylinder head around the ports should be clean. Also be sure that the mounting faces of the manifold are clean.

1. Place new gaskets on the mounting studs, and attach the manifold to the cylinder head.

Torque the stud nuts to the amount specified in section 1.

2. POWER UNIT ENGINES ONLY: Fasten the gasoline tank to the manifold and connect the tubing.

3. Install the carburetor and gasket. (Refer to section 10 or 11.)

4. Install the carburetor gasket and supply tubing.

5. On all engines with magneto ignition, connect the electrical leads to the ignition cut-out switch in the manifold. On engines with battery ignition, connect the leads to the ignition cut-out switch terminals on the manifold front end cover.

6. Install the manifold front end cover and gasket.

7. Connect the injection pump air cleaner line (if so equipped).

8. Connect the choke control rod and the primer connections, if so fitted.

9. Install the linkage connecting the carburetor shut-off cam to the cross shaft.

Exhaust Manifold

10. Place the gaskets into position on the studs of the cylinder head and install the exhaust manifold. Be certain that the cylinder head port surfaces and the mounting surface of the manifold are clean.

11. Torque the retaining stud nuts to the amount specified in section 1.

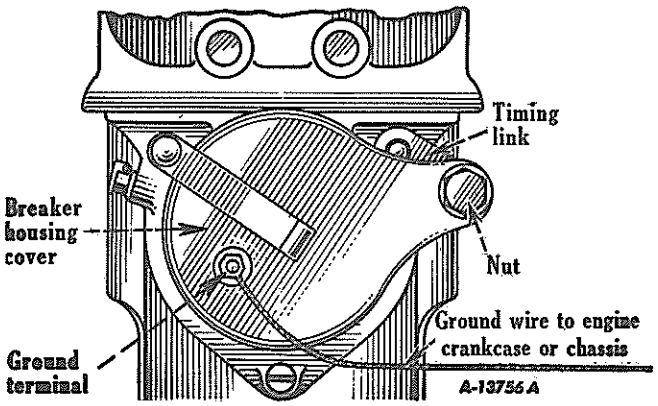
12. Install the turbocharger (if equipped). Refer to Section 12.

CYLINDER HEAD AND VALVES

7. DESCRIPTION

The IH diesel engine cylinder head differs from the conventional gasoline engine cylinder head in that it contains an auxiliary combustion chamber which, when opened to the regular combustion chamber by a poppet valve, increases the cylinder volume and decreases the compression ratio. It contains the conventional intake and exhaust valves of overhead design. The valve lever mechanism must be removed to gain access to the cylinder head. The cylinder head must be removed when valve seats need reconditioning, or when cylinder sleeves are to be removed.

The engines have front and rear cylinder heads, connected by a water manifold. Either the front or rear head can be removed independently of the other. Slight modifications in design prevent the front and rear cylinder heads from being interchangeable. A separate cylinder head gasket is provided for each head.



Illust. 3 - Breaker Housing Cover With Timing Link and Ground Terminal.

8. VALVE CLEARANCE ADJUSTMENT

1. DIESEL ENGINE EQUIPPED WITH F-6 MAGNETO: Ground the magneto by connecting a wire to the ground terminal. (See Illust. 3.)

DIESEL ENGINE EQUIPPED WITH DISTRIBUTOR: Cut out the distributor by removing the cable leading to distributor cap from the high tension coil. (See Illust. 5.)

2. Pull the compression release lever all the way back to the gasoline position. Remove the valve housing cover and the spark plugs.

3. ENGINES WITH PULLEY TIMING MARK: Crank engine until the exhaust valve for number six cylinder commences to close. The opening and closing of the valve can be seen plainly by observing the valve which is the furthest valve to the rear. Continue cranking slowly until the "DC" mark is in line with the timing pointer. (See Illust. 6.)

ENGINES WITH FLYWHEEL TIMING MARKS: Crank the engine as outlined in step 3 until the "DC" mark on the flywheel is in line with the timing pointer. (See Illust. 7.)

Engines equipped with extended shaft cranking motors provide an improved method of turning the engine during service periods for timing purposes (Illust. 4).

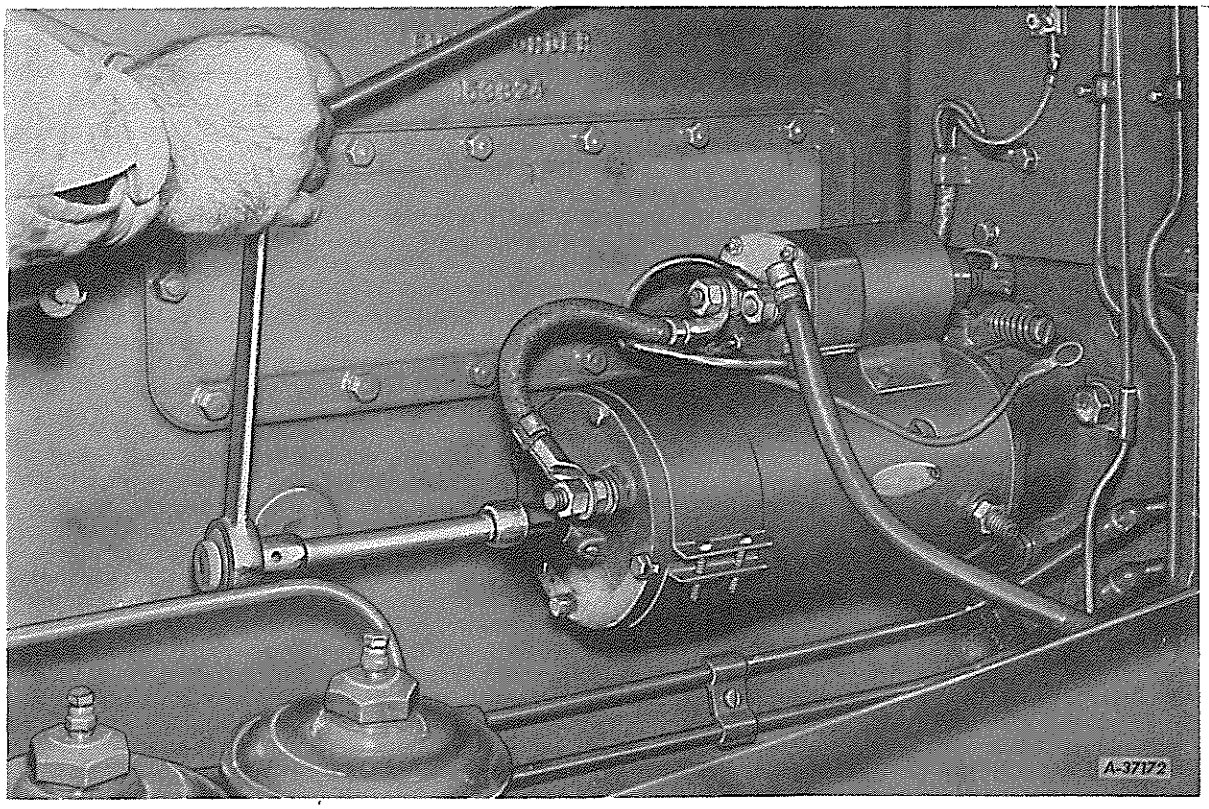
CAUTION: Disconnect and tape the "battery-to-cranking motor cable" and "cranking motor-to-solenoid cable" before any service work is done.

Engage the starter gear by hand (push shift lever toward solenoid). Turn the armature shaft with a 7/16-inch socket wrench (turn wrench toward the engine) as shown in Illust. 4.

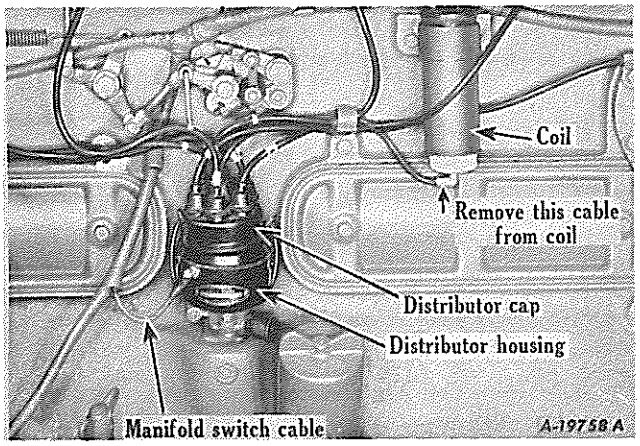
4. Insert a feeler gauge of the specified cold clearance (refer to section 1,"Specifications") between the valve lever and valve stem of number one intake valve. Loosen the adjusting screw lock nut and adjust the valve clearance. Turn the adjusting screw as shown in illustration 8 until the feeler gauge is snug. Tighten the lock nut and recheck the clearance.

5. Place the feeler gauge between the valve lever and valve stem of number one exhaust valve. Adjust as in step 4.

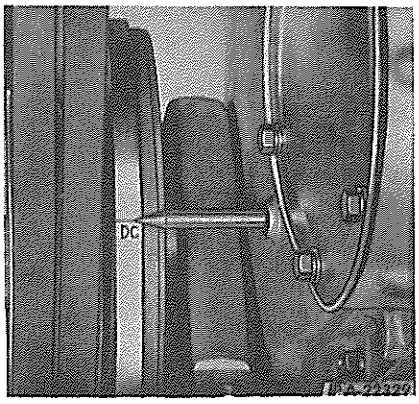
CYLINDER HEAD AND VALVES



Illust. 4 - Turning Engine Over Using the Extended Shaft of Cranking Motor.



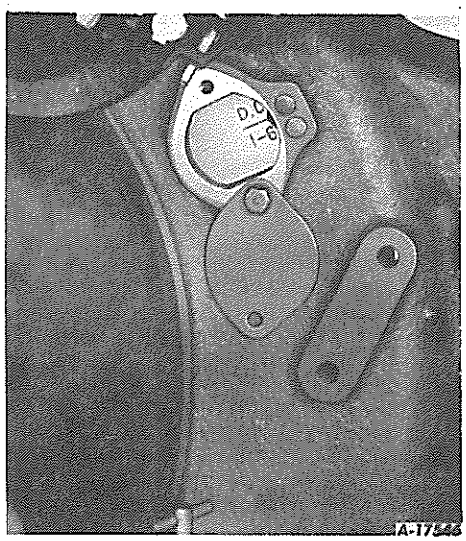
Illust. 5 - Distributor With Manifold Switch Cable Identified.



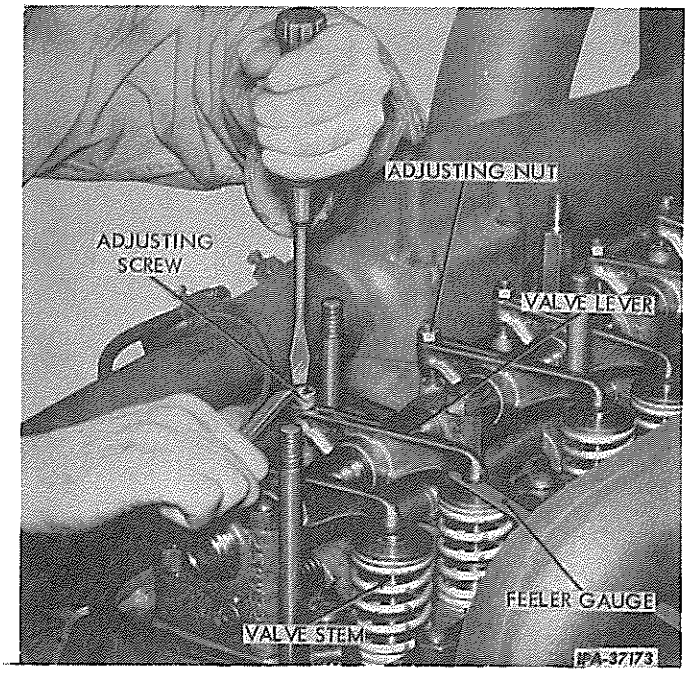
Illust. 6 - Timing Mark and Pointer (16, 525 and 554 Series Engines).

CYLINDER HEAD AND VALVES

8. VALVE CLEARANCE ADJUSTMENT – Continued



Illust. 7 - Showing the "DC" and "1 and 6" Marks on the Flywheel.



Illust. 8 - Adjusting the Valve Clearance.

6. Crank the engine one-third revolution at a time, measuring and adjusting the clearance of each cylinder's valves in succession according to the firing order of the engine, which is 1-5-3-6-2-4.

7. Install the valve housing gaskets and the covers. For diesel engines equipped with the F-6 magneto, remove the grounding wire. For engines equipped with distributors, install the coil end of the coil-to-distributor-cap cable to the bottom of the coil. (See Illust. 5).

9. REMOVAL

1. Drain the cooling system.

2. Open the valve located on the left side of the cylinder wall to drain any remaining coolant in the engine block.

3. Remove the lifting eye from engine if so equipped.

4. Remove the exhaust manifold and the cylinder head breather pipe.

5. Remove the valve cover and gasket.

6. Disconnect the carburetor choke control, the fuel shut-off rod and the primer control. Disconnect the gasoline tube at the carburetor.

7. Remove the cover and gasket from the forward end of the intake manifold and disconnect the wires to the manifold switch. Pull the wires free of the manifold.

8. Remove the intake manifold assembly and gaskets.

9. Remove the water outlet elbows and thermostats. On engines so equipped, remove the water outlet header. The thermostats for the cooling system on these engines are located in the water outlet header.

10. Remove the nuts from the studs securing the valve assembly to the cylinder head. On later 554 engines, the valve assembly is secured to the cylinder head with bolts. Remove the assembly and the bottom brackets. Lift the assembly evenly from the studs. (See Illust. 12.)

11. Lift and remove the valve push rods.

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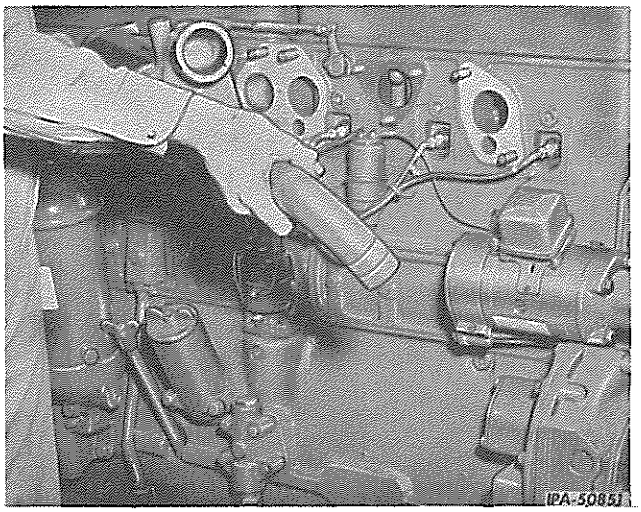
CYLINDER HEAD AND VALVES

9. REMOVAL – Continued

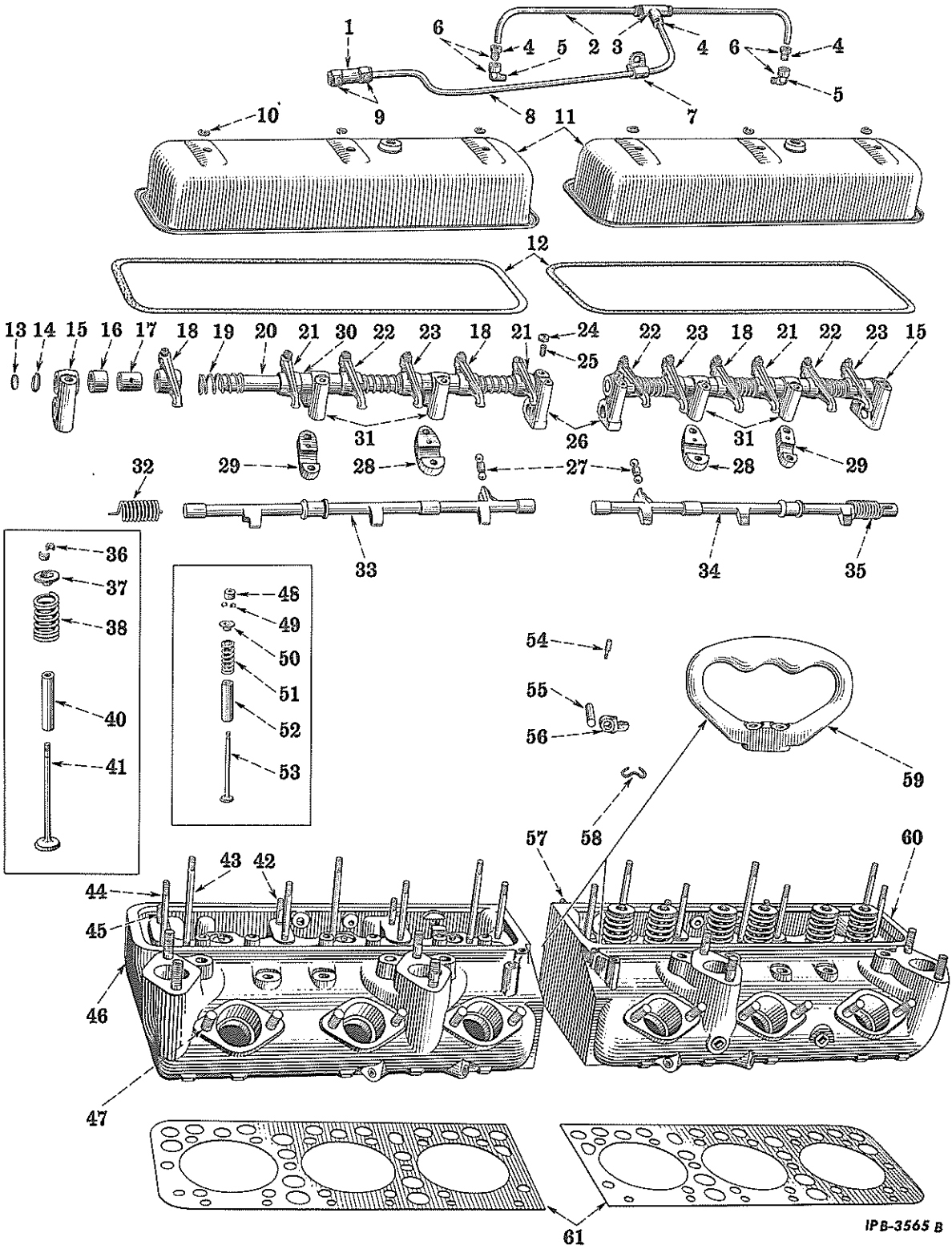
12. (Not U-1091). Remove the injection pipes from the nozzles and from the injection pump. Install caps on the injection pump connections to prevent the entry of dirt. Remove the spark plugs.

13. Remove the cylinder head stud nuts and remove each cylinder head and gasket by lifting it evenly from position. (See Illust. 13.)



Illust. 9 - Removing the Water Header.

CYLINDER HEAD AND VALVES



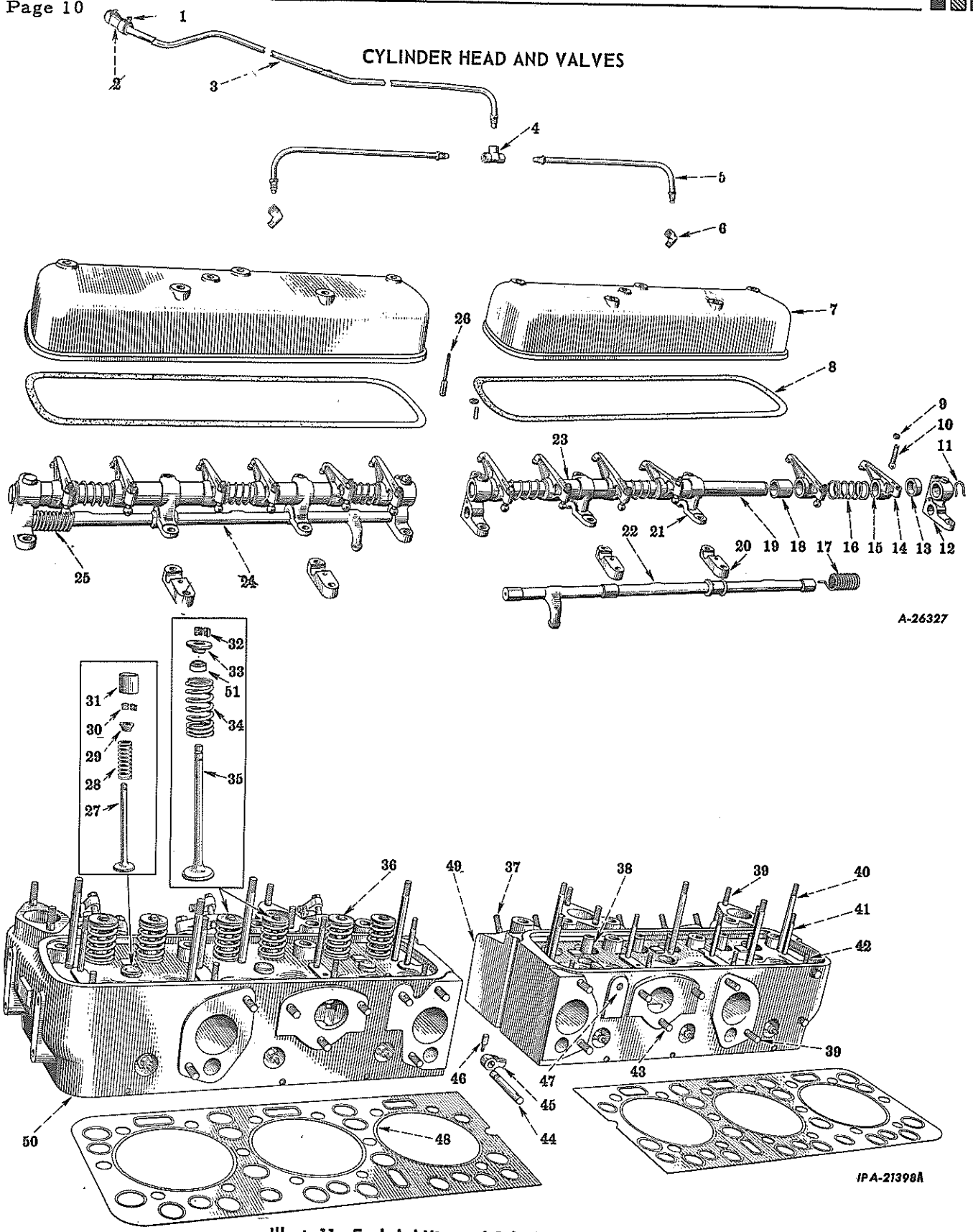
Illust. 10 - Exploded View of Cylinder Heads, Valves, and Related Parts (16, 525 and 554 Series).

CYLINDER HEAD AND VALVES

Legend for Illust. 10

1. Hose.
2. Breather tube.
3. Pipe tee.
4. Nut.
5. Elbow.
6. Elbow.
7. Tube clip.
8. Breather tube.
9. Hose clamp.
10. Washer.
11. Valve cover.
12. Cover gasket.
13. Plug.
14. Retaining ring.
15. Valve lever bracket.
16. Valve lever spacer.
17. Valve lever bushing.
18. Valve lever (exhaust).
19. Valve lever spring.
20. Valve lever shaft.
21. Valve lever (intake).
22. Valve lever (intake).
23. Valve lever (exhaust).
24. Nut.
25. Screw.
26. Valve lever bracket.
27. Starting valve lever push rod.
28. Valve lever bracket.
29. Valve lever bracket.
30. Valve lever spacer.
31. Valve lever bracket.
32. Starting valve shaft spring.
33. Starting valve shaft.
34. Starting valve shaft.
35. Starting valve shaft spring.
36. Spring seat key.
37. Valve spring seat or rotator.
38. Valve spring.
39. Not used.
40. Valve guide.
41. Valve.
42. Valve lever bracket stud.
43. Valve cover stud.
44. Valve lever bracket stud.
45. Valve lever bracket stud.
46. Cylinder head, front.
47. Injection nozzle stud.
48. Starting valve cover.
49. Spring seat key.
50. Spring seat.
51. Valve spring.
52. Valve guide.
53. Starting valve.
54. Operating lever pin.
55. Operating shaft.
56. Operating lever.
58. Push rod lockwire. (Not TD-15)
59. Lifting eye. (Not TD-15)
59. Lifting eye.
60. Cylinder head, rear.
61. Cylinder head gasket.

CYLINDER HEAD AND VALVES



Illust. 11 - Exploded Views of Cylinder Heads, Valves, and Related Parts (24 and 1091 Series).

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CYLINDER HEAD AND VALVES

Legend for Illust. 11

1. Hose clamp.
2. Hose.
3. Breather tube.
4. Pipe tee.
5. Breather pipe.
6. Pipe elbow.
7. Valve cover.
8. Cover gasket.
9. Nut.
10. Adjusting screw.
11. Retaining ring.
12. Valve lever bracket.
13. Valve lever spacer.
14. Valve lever.
15. Valve lever bushing.
16. Valve lever spring.
17. Starting valve shaft spring. (Not U-1091)
18. Valve lever spacer.
19. Valve lever shaft.
20. Valve lever bracket (lower).
21. Valve lever bracket (upper).
22. Starting valve shaft. (Not U-1091)
23. Valve lever spacer.
24. Starting valve shaft.
25. Starting valve shaft spring.
26. Stud adapter.
27. Starting valve.
28. Starting valve spring.
29. Spring seat.
30. Spring seat key.
31. Starting valve cover.
32. Spring seat key.
33. Valve spring seat or rotator.
34. Valve spring.
35. Intake valve.
36. Exhaust valve.
37. Nozzle stud.
38. Valve guide.
39. Manifold stud.
40. Valve cover stud.
41. Bracket stud (long).
42. Bracket stud (short).
43. Engine water outlet stud.
44. Operating shaft. (Not U-1091)
45. Operating lever. (Not U-1091)
46. Operating lever pin. (Not U-1091)
47. Oil seal.
48. Cylinder head gasket.
49. Cylinder head, front.
50. Cylinder head, rear.
51. Intake valve oil deflector.

10. DISASSEMBLY (Refer to Illust. 11)

Intake and Exhaust Valves

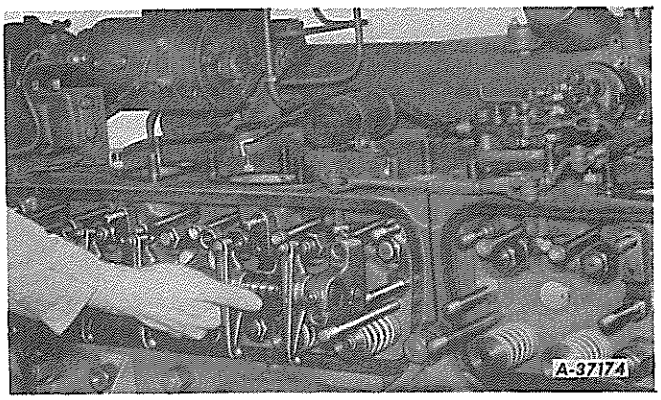
1. Using a C-type compressor or valve lifter, compress the valve springs and remove each set of valve seat keys (32). Remove the compressor and lift each valve spring seat (33) (or positive valve rotator, whichever is used) and spring from position, and remove the valves. On intake valves equipped with an oil deflector (51), remove the deflector before removing the valve from the cylinder head. Keep each set in a numbered envelope or box so that they can be reassembled to their original positions.

Starting Valves

2. Remove the starting valve covers (31) (Illust. 11). Use the service tool 1 020 073 R1 (refer to "Service Tools" Manual ISS-1002) to compress the springs and remove the keys (30). (See Illust. 15.) Lift out the valve spring seats (29), the springs and slide the valves from position.

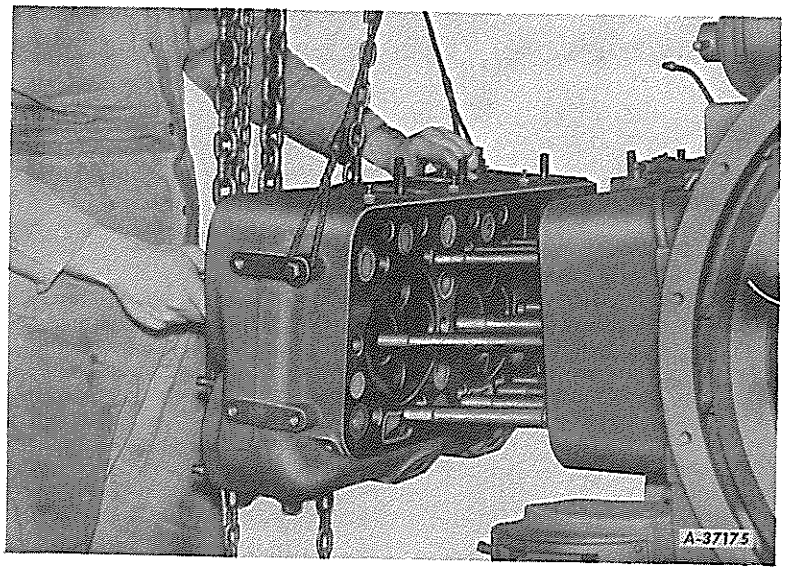
Injection Nozzles

3. Remove the nuts securing the injection nozzles to the studs (37). Remove the nozzles by pulling them from position with service tool 1 020 284 R91. (Refer to "Service Tools" Manual ISS-1002.) For disassembly of nozzles refer to "Diesel Injection Pump" Manual ISS-1003.



Illust. 12 - Removing the Valve Lever Assembly.

CYLINDER HEAD AND VALVES



Illust. 13 - Removing the Cylinder Head.

10. DISASSEMBLY – Continued

Valve Lever and Shaft (Not U-1091)

4. Remove the nuts from the bracket studs and remove the retainer rings (11) from the ends of the shaft (19) (Illust. 11). Slide the parts from the shaft. Lift out the starting valve shaft.

NOTE: Remove the valve guides, using the service tool described in "Service Tools" Manual ISS-1002.

11. INSPECTION AND REPAIR

1. Clean all parts thoroughly. Remove the carbon from the bottom face of the cylinder head, out of the valve ports, guide bores, and from the valve head and faces. Flush out the water passages.

2. Inspect all parts for damage. Check dimensions of valves and specifications for valve springs against those listed in section 1, "Specifications" (Illust. 16). Any score marks or scratches on valves and related parts, if not too severe, can be cleaned off with a fine abrasive.

3. The cylinder head must have parts replaced if any doubt as to serviceability of the parts exists. Reface each valve seat and valve head. Install new valve seat inserts if necessary (U-1091). Guides must be especially checked and replaced if worn. The sharp edged, chamfered end of the guide must be installed at the top of the cylinder head. Intake exhaust and starting valve guides must extend the specified distance from either the top surface of the cylinder head, or the valve lever bracket pads. (Refer to Section 1, "SPECIFICATIONS," for the distance involved.)

The valve guides furnished for service are reamed to size, but installation may tend to diminish the bore slightly. Correct after installation by reaming out the valve guides to the dimension specified in Section 1, "SPECIFICATIONS" (Illust. 17).

4. Check the oil deflector (51, Illust. 11) (if so equipped) for deterioration or damage and replace if necessary.

Valve Lever and Shaft Assembly

Replace the bushings if necessary. Be certain that the oil hole in the bushing corresponds in position with that of the valve lever and shaft when installed. Bushing running clearances are given in section 1, "Specifications."

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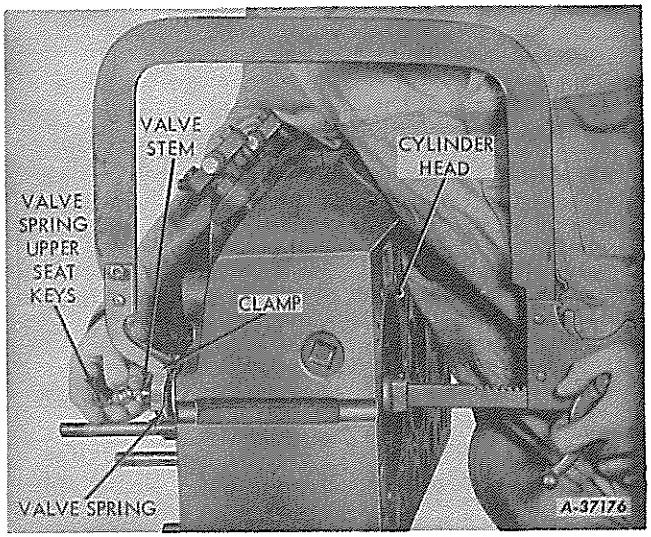
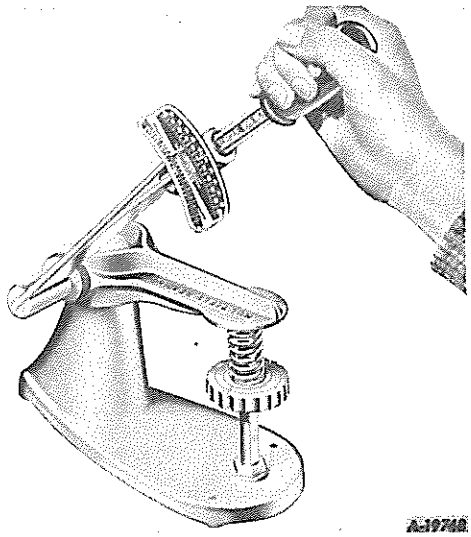
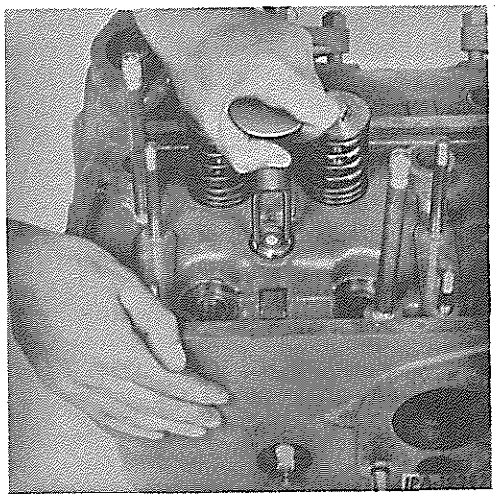
CYLINDER HEAD AND VALVES



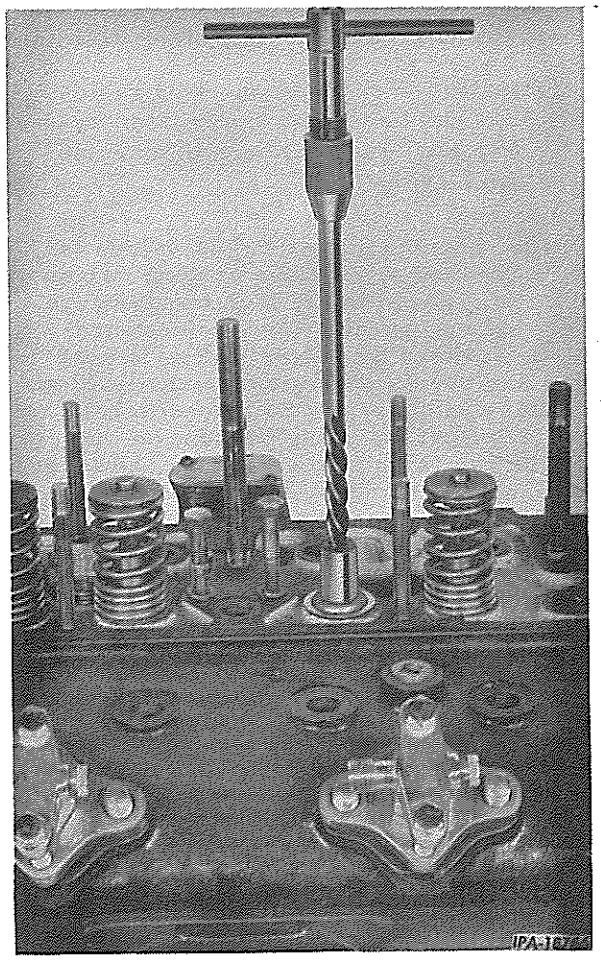
Illust. 14 - Compressing Valve Springs With a Valve Lifter Tool.



Illust. 16 - Testing Valve Springs.



Illust. 15 - Compressing Starting Valve Spring For Valve Removal.



Illust. 17 - Reaming a Valve Guide.

12. VALVE RECONDITIONING

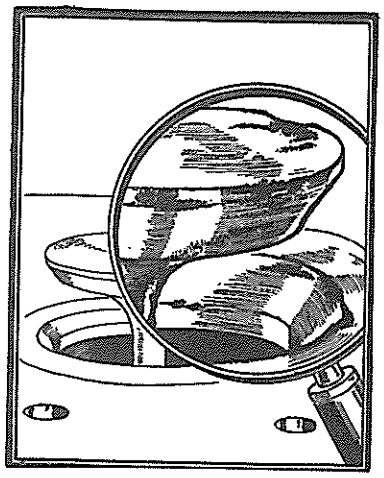
General

Carbon deposits on the valves and valve seats are normal and cannot be avoided completely. (See Illust. 18.) However, such deposits are detrimental to engine efficiency and valve assembly life as the amount of carbon in the engine increases.

Whenever the cylinder head of an engine is removed for service - all carbon should be removed from the surfaces of the parts affected.

CYLINDER HEAD AND VALVES

12. VALVE RECONDITIONING – Continued



Illust. 18 - Carbon, Corrosion and Wear are Inevitable Products of Normal Engine Operation.

Valves and valve seats should be examined for pitting, burning, warping and other defects.

The formation of carbon cannot be avoided. However, it can be held to a minimum by the use of only good grade fuels and accurate engine timing.

Warpage, burning and pitting of valves is mainly directed against the exhaust valves which are exposed to the high temperature flow of exhaust gases. Such defects are generally caused by valves failing to seat tightly and evenly, permitting exhaust blow-by. This can generally be traced to hard particles of carbon being present on the slopes of the valve seats. It may, however, be due to weak springs, insufficient valve clearance, or warpage and misalignment of the valve stem or guide.

Warpage chiefly occurs on the valve stem due to its exposure to heat. Out-of-round wear occurs when the seat has been pounded by a valve head which is not in line with its stem or guide.

Misalignment is a result of wear, warpage and distortion. Wear, when accentuated by insufficient lubrication, will eventually create sloppy clearances with resultant misalignment.

Warpage of the valves, and in known extreme instances, that of the crankcase, can result from the engine overheating due to a blocked, dirty or insufficiently filled cooling system.

Most frequently, however, warpage of a valve stem or a guide is due to uneven temperatures being applied along its length. The lower part of the guide and stem is near the combustion heat, and the upper portions are closer to cylinder head water passages. Valve materials are carefully chosen to withstand such varying temperatures. However, an engine that is allowed to operate continually in an overheated condition is definitely open to valve stem and guide distortion and warpage. Distortion can also be caused by failure to tighten cylinder head bolts to the specified foot-pounds torque and in the sequence recommended. Valve clearances are also affected in this manner.

Thus any abnormal wear, warpage or distortion affecting a valve guide will destroy its function as an accurate bearing to maintain the valve head concentric with its seat, and will prevent leak-proof seating.

Oil and air are sucked past worn intake valves, stems and guides into the combustion chamber, causing excessive oil consumption, forming excessive carbon and diluting fuel.

Inspection Prior to Valve Reconditioning

Examine the engine for signs which may indicate the reason for the need of valve reconditioning. Dry and rusted valve springs are an indication that the oil passages to the valve levers may be blocked, causing wear on the valves and guides and resulting in improper valve action. A defective gasket under the valve cover will permit the entrance of dirt which will cause undue wear on valve stems and guides and damage to valve springs. Observing the cause of a valve failure will aid the servicemen in the reconditioning.

Valves

1. Remove all carbon from the valve face head and stem. A wire brush or buffing wheel (Illust. 19) can be used for this operation. Valve stems should be lightly polished with an extremely fine abrasive cloth sufficiently to remove the carbon deposits only.

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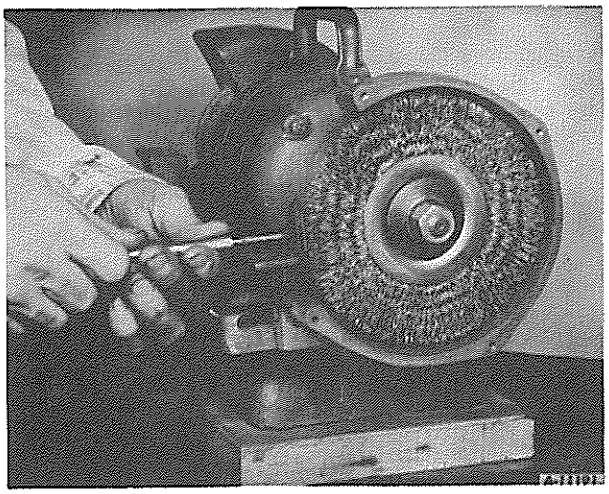
CYLINDER HEAD AND VALVES

2. Inspect each valve. See that the stem is not worn excessively, and that the head is not burned or warped. Check the grooves in the stem to see that they have not lost the shoulders through wear, which prevents the valve **spring retainer locks from** fitting snugly.

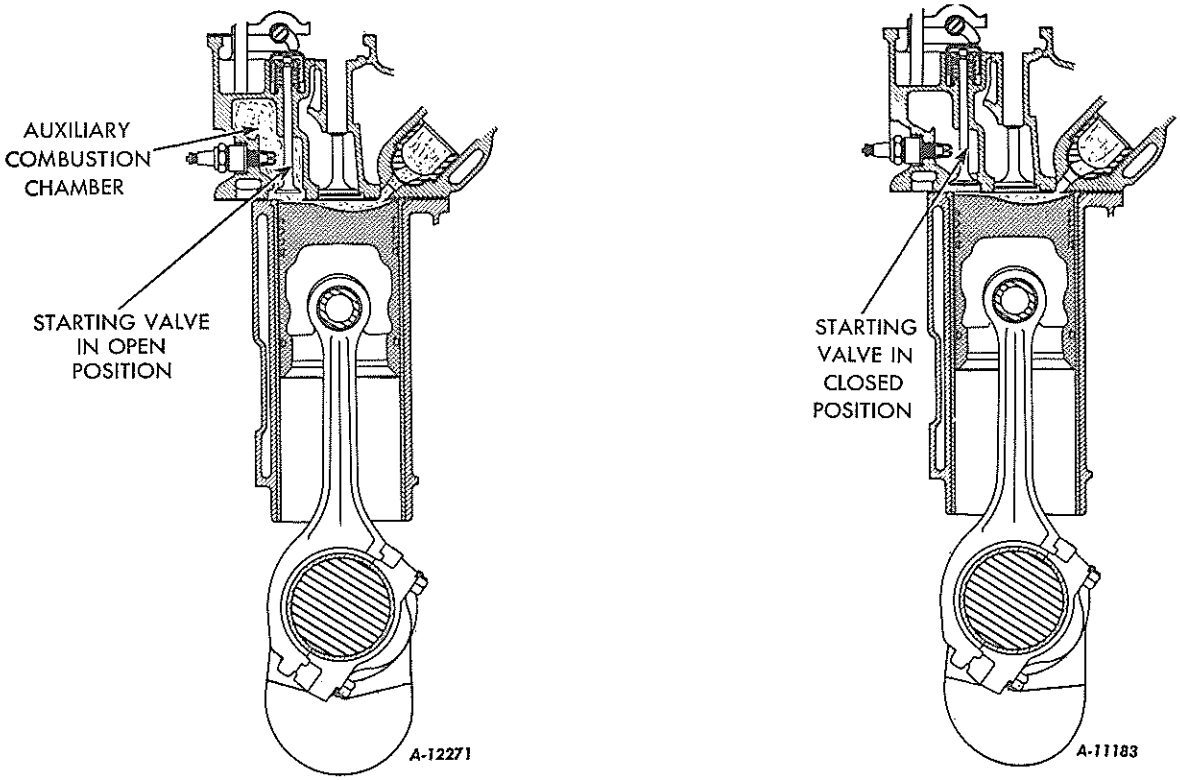


Illust. 19 - Cleaning Carbon From the Valve.

3. All valves having bent, worn, warped or seriously pitted stems should be replaced. Replace any valve that cannot be satisfactorily refaced with a definite margin maintained. (See Illust. 21.) The amount of grinding necessary to true the valve face is a definite indication of the valve head warpage from the axis or centerline of its stem. With excessive warpage, a knife edge will be ground on part or all of the valve head due to the considerable amount of metal that must be removed to completely reface. Maximum heaviness in a valve head is required for strength and to provide as large an area as possible for heat dissipation. Knife-edge valves lead to breakage and warpage.

Valve Springs

4. Clean and examine all valve springs for rust, pitting, broken or set coils. Test each spring against the spring specifications (refer to "Specifications," section 1) using a spring load tester. (See Illust. 16.) (Refer to "Service Tools" Manual ISS-1002.)



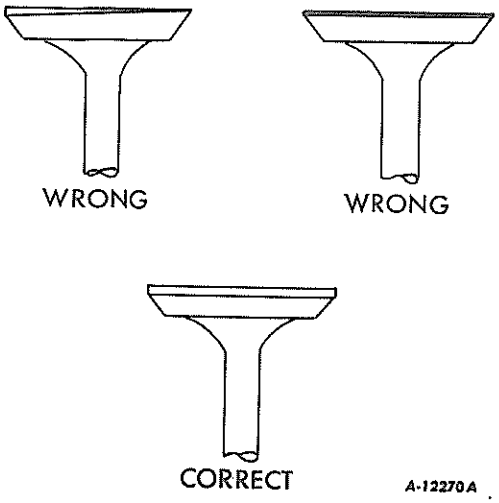
Illust. 20 - Diesel Engine Starting Valve Operation, Showing Valve Open and Closed.

CYLINDER HEAD AND VALVES

12. VALVE RECONDITIONING – Continued

Valve Spring Retainers

5. Clean all valve spring retainers with solvent, and examine them for rust, cracks and bending characteristics. Replace parts as necessary.



Illust. 21 - A Definite Margin Must Be Obtainable and Be Maintained During Reconditioning.

6. Check the valve rotators for proper operation. A valve rotator in the free state (not assembled in the engine) may rotate in either direction, rotate in one direction or not rotate in any direction and still be satisfactory for use.

To properly test a valve rotator for rotation, the valve spring load must be applied to the rotator. This can be done in a spring tester or assembled in an engine.

When using a spring tester, place the valve spring together with the rotator in the tester. Place a ball bearing between the rotator cap and the ram of the spring tester. Turning of the valve rotator can then be observed by compressing the valve spring.

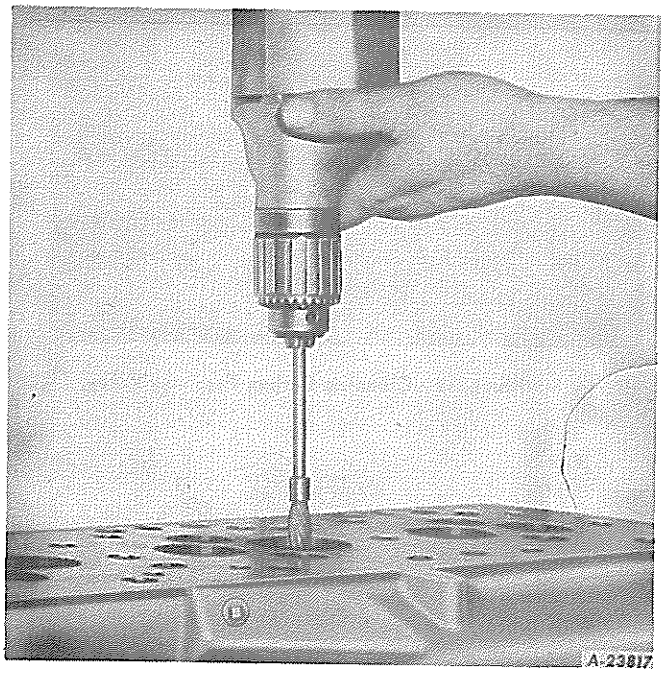
Valve Spring Retainer Locks

7. Clean parts thoroughly in solvent. Check the ribs in the inside of the locks to see that none are worn sufficiently to cause looseness.

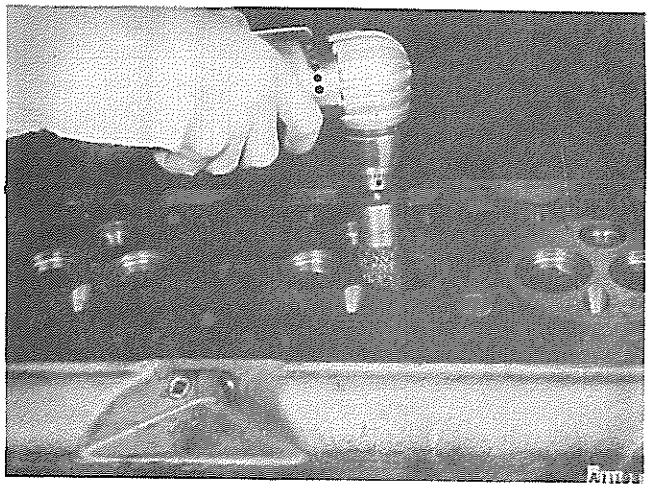
The locks must fit snugly into the valve stem groove. Check the locks for wear, on the outside surface, which might cause the valve spring retainer to slide over the lock.

Valve Guides

8. Clean the bores of the valve guides using a wire rifle brush and solvent, as shown in Illust. 22. Blow out all carbon with compressed air. Position a light at the bottom of the bore, and examine the walls for burning, cracking and signs of excessive wear. Check the inside diameter of the guide bore at several points around its circumference and along its length. Specifications for the guides are given in the table following. Replace any guides con-



Illust. 22 - Cleaning Valve Guide, Using Wire Rifle Brush.



Illust. 23 - Cleaning Carbon From the Cylinder Head and Valve Parts.

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CYLINDER HEAD AND VALVES

sidered unserviceable or that appear close to a service borderline.

NOTE: Guides require very careful cleaning. Carbon left in the guide will deflect the pilot, resulting in inaccurate reconditioning of the valve seat.

Valve Seats

9. Remove all carbon from the cylinder head (Illust. 23). Inspect all valve seats for cracks or loose valve seat inserts on engines so fitted. Replace loose or burned inserts. Remove all carbon from the valve seat recesses or counterbores.

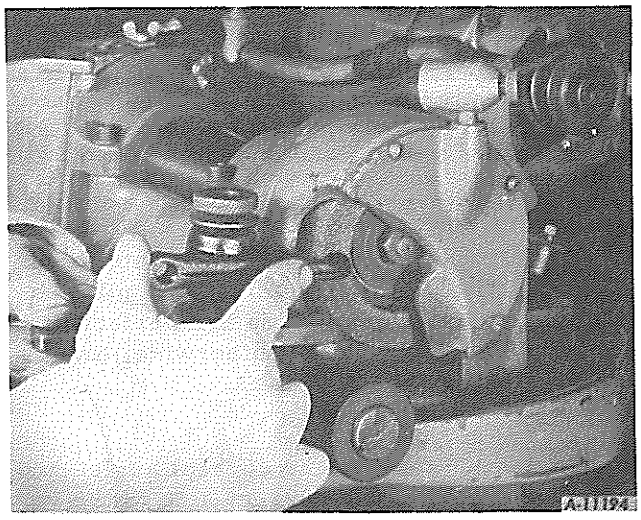
Valve Lever Assembly

10. With a micrometer, check the diameter of the valve lever shaft at the valve lever bushings. (Refer to "SPECIFICATIONS," Section 1.) If the shaft is worn excessively or out-of-round, replace the shaft.

11. Inspect and replace worn valve lever bushings. If the valve levers show excessive hammering and wear at the ends which contact the valves, they should be reground. (Illust. 24.) Worn valve levers place side thrust on the valve stem, thereby causing wear on the guides. True valve levers make possible a more accurate valve tappet setting. Remove only enough material to give a new even face on the end of the valve lever.

Cylinder Head

12. After cleaning, inspect the cylinder head for cracks. Check the areas surrounding the exhaust valve ports for indications of blow-by, such as burning away of the metal. Clean thoroughly the water passages of the cylinder head.



Illust. 24 - Grinding the Valve Lever Face Assures Proper Contour of Contact Face.

Reconditioning

VALVES: After being thoroughly cleaned and inspected, valves that are fit for continued use should be reconditioned as follows: Both intake and exhaust valves are ground to the same face angle. Determine the correct face angle as given in the table following.

1. Set the valve refacing machine to grind the desired angle (Illust. 25), and dress the grinding stone.

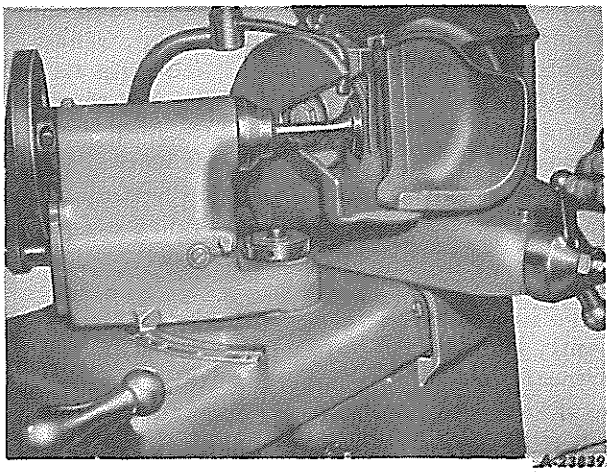
2. Insert a valve in the chuck and take a light cut across its face. This is a check to determine whether the valve can be reconditioned to service standards with a correct amount of margin maintained. Warpage that may not be apparent in the visual inspection will be clearly definable. (Illust. 21.)

Avoid taking heavy grinding cuts as this heats the valve head excessively, produces an unsatisfactory valve face, and necessitates dressing the grinding wheel frequently. Repeated light grinding cuts are preferred until a true face of even width is obtained around the valve. Avoid passing the stone beyond the face of the valve as this will cause ridging and grooving of the stone surface and make dressing of the stone necessary. Reject all valves with distorted heads which produce an uneven face and valves which grind down to a thin edge. (Illust. 21.)

At times, unusually large amounts of heat scale may be found on exhaust valves, which is hard on the grinding stone. Frequent redressing of the stone will be necessary to maintain a smooth, even surface, and a uniform set of valve face angles.

After refacing each valve, inspect the end of the stem. If wear is noticeable, reface the end of the stem. (Illust. 28.) Grind sufficiently to true-up the end of the stem.

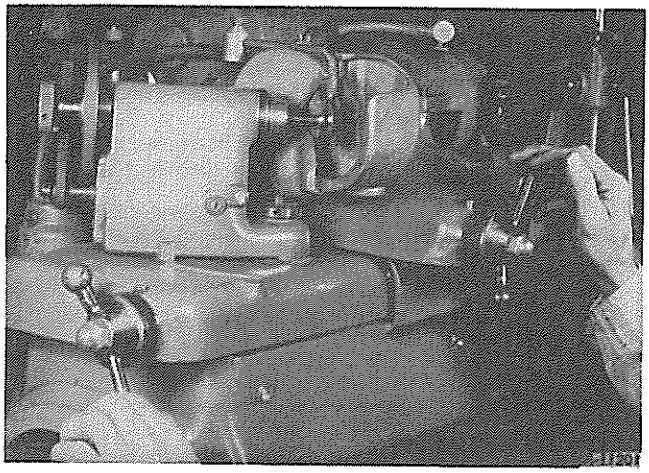
(Continued on next page)



Illust. 25 - Locating the Valve and Grinding Stone to the Specified Angle.

CYLINDER HEAD AND VALVES

12. VALVE RECONDITIONING – Continued



Illust. 26 - Grinding the Valve Face Angle Taking Light Cuts Only.

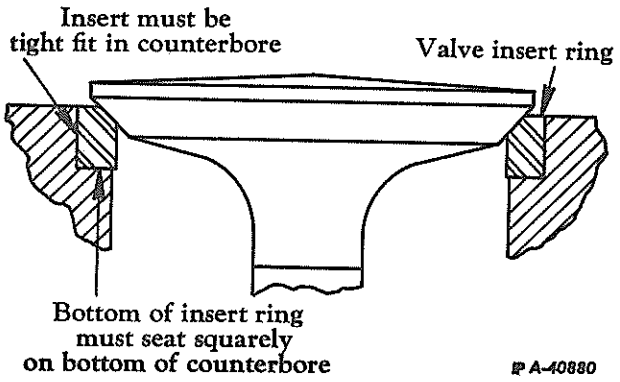
VALVE SEAT INSERTS: (U-1091): Valve seat inserts should seldom need replacement. However, if a replacement is made, it is important that new inserts be peened securely in place by using either an insert peening tool or a dull-pointed chisel, 1/4-inch wide, to peen cylinder head metal over the outer edge of the valve seat insert.

Valve seat inserts supplied for the U-1091 engine are .015-inch oversize.

To assure maximum valve and valve insert life, it is essential that the valve insert ring be installed to obtain maximum contact with the bottom and sides of the ring counterbore. Proper exhaust heat dissipation through the valve insert ring can only be accomplished by the valve insert ring being a good tight fit in the cylinder head, with the bottom of the insert ring squarely seated on the bottom of the counterbore, as shown in Illust. 27. It is recommended that a skin cut be taken from the bottom of the ring counterbore (in head) to assure a square seat for the insert ring.

Valve insert rings that are not fitted sufficiently tight work loose, permitting carbon formations to collect on the outer surface of the insert ring, thus insulating the exhaust heat within the insert ring, preventing proper heat dissipation through the cylinder head.

When replacing the valve seat inserts, machine the recess to a depth of .427-.423-inch and to a diameter of 2.201-2.200-inch with a 1/32-inch radius in the bottom of the counterbore. (Refer to Illust. 34.) The insert rings should be thoroughly chilled in dry ice for at least one-half hour before installing, so that when installed with a driver, only two or three light blows with a hammer will be required to set the ring in place, also preventing shearing of the side walls of the counterbore. Using a suitable peening tool, peen the head metal over the edge and around the entire circumference of the insert.



Illust. 27 - Insert Ring Properly Installed.

VALVE SEATS: Remove all carbon, scale and oil before attempting to reface the valve seats. The grinding stone will become fouled, if placed against an oily seat, and uneven grinding will occur.

1. Use a clean, oiled rag to lubricate the pilot shank lightly. Before installing the pilot, be certain that the valve guides are perfectly clean. This is important; otherwise, an eccentric seat will be cut.

2. Dress the stone to the correct angle and install the pilot of the correct size to the valve guide bore.

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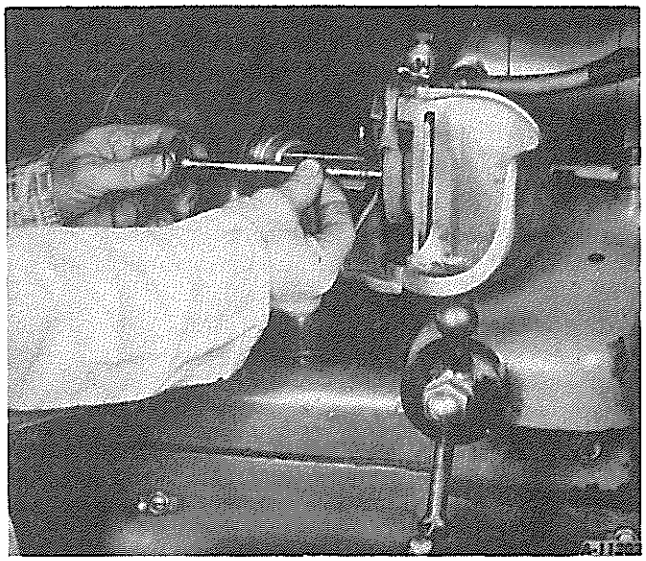
CYLINDER HEAD AND VALVES

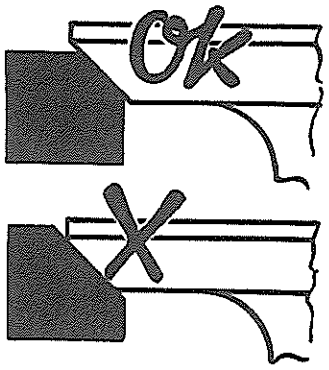
3. Lower the grinder head over the pilot shank until the stone just clears the valve seat. Turn on the power and very gently allow the stone to contact the valve seat. (See Illust. 31.) Very little pressure other than the normal weight of the stone should be used. Sudden, hard pressures can cause cocking of the pilot in the guide and result in eccentric grinding. Raise the stone frequently from the valve seat to prevent overheating and to clear away grinding dust. Grind the seat sufficiently to provide an even, smooth surface.

4. Check the seat concentricity with the valve guide, using a dial indicator mounted on the pilot. Run the indicator around the seat surfaces. **Run-out must not exceed a total of .002 inch.**



Illust. 28 - Refacing the Valve Stem End.

5. The finish left by the regular type grinding stone is usually satisfactory. Lapping valves into their seats is unnecessary if precision equipment is used and extreme care taken. A simple method of testing refaced valves and seats for roundness and concentricity employs Prussian blue. Spread an extremely thin film of this blue on the valve face and insert the valve into its guide. With pressure on the exact center of the valve head, make a quarter turn rotation in the seat. (See Illust. 33.) Remove the valve and inspect the impression made upon the seat by the transfer of blueing, and upon the valve face by the removal of blueing. Check several times to guarantee that no error was made.



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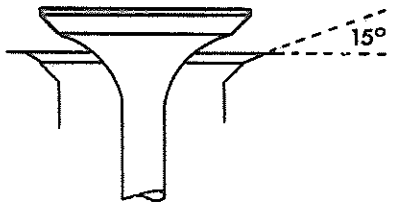
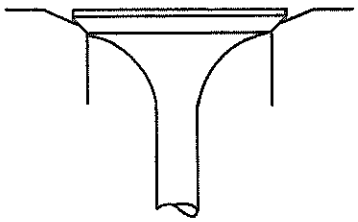
Illust. 29 - Valve Seat Width Should Conform to Specifications for that Engine and Center on the Valve Face.

6. After grinding the seats it may be found that the seats are considerably wider than the width recommended in the following table for that engine. Valve seats that are too wide (Illust. 29) may be narrowed by grinding down the top edge of the seat with a stone mounted on the grinder head. The stone must be a **smaller angle than the valve seat (15° preferably). (Illust. 30.)**



Seat grinding stone 15° smaller than angle of valve seat, narrows seat



Valve face now contacts the seat

A-11205

Illust. 30 - Narrowing Valve Seat Widths.

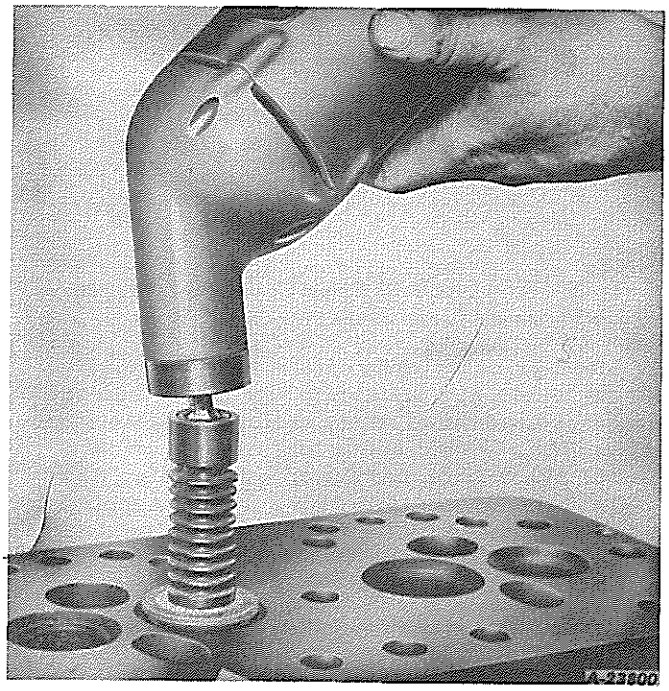
VALVE SPRINGS: Valve springs of uneven tension or unequal free length will cause faulty operation. Test all valve springs, whether new or used, as shown in Illust. 16, and select a set which is uniform. (Refer to "Specifications," section 1.)

(Continued on next page.)

CYLINDER HEAD AND VALVES

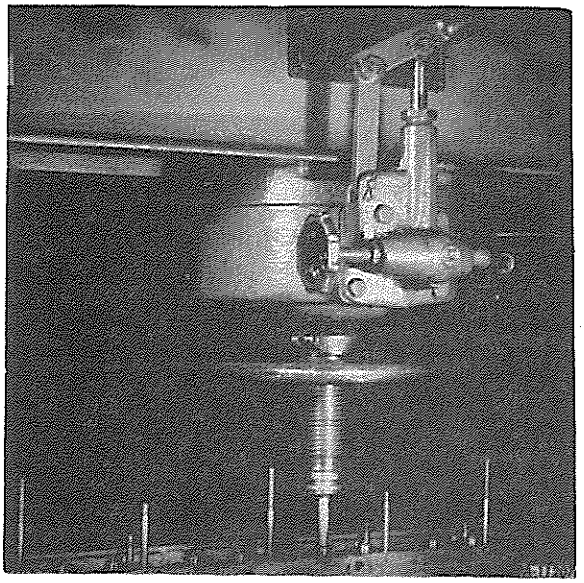
12. VALVE RECONDITIONING - Continued

VALVE LEVERS: When replacing valve lever bushings, line up the oil hole in the valve lever. After installation, the bushing should be reamed. (See "Specifications," section 1 for bushing sizes.)



Illust. 31 - Grinding the Valve Seat, Using One of the Many Grinding Tools Available.

VALVE GUIDES: Worn valve guides in the cylinder head are pressed out from the underside of the cylinder head, from the valve port up through the top. Use a mandrel slightly smaller in size than the guide to prevent jamming in the guideway.



Illust. 32 - Pressing Valve Guides Into the Cylinder Head.

Press replacement guides into the cylinder head from the top of the cylinder head. (See Illust. 32.) Valve guides that are improperly installed, even to within minute fractions of an inch, will cause faulty operation.

All guides furnished as service parts are reamed to size; however, as they are a press fit, it is necessary to ream them after installation to remove any possible burrs or slight distortion caused by the pressing operation. (Refer to the table following for specifications.)

VALVE CHART
(See Illust. 34, 35 and 36)

Symbol	24 and 1091 Series (Except U-1091)	16 Series	525 and 554 Series	U-1091	Symbol	24 and 1091 Series (Except U-1091)	16 Series	525 and 554 Series	U-1091
A	45° Int. 45° Exh. 45° Str.	44° Int. 44° Exh. 45° Str.	45° Int. 45° Exh. 45° Str.	45° Int. 45° Exh.	I	2-9/64 Int. 2-9/64 Exh. 1-25/32 Str.	1-63/64 Int. 1-63/64 Exh. 1-7/8 Str.	1-63/64 Int. 1-63/64 Exh. 1-7/8 Str.	2-9/64 Int. 2-19/64 Exh.
B	2-17/32 Int. 2-3/32 Exh. 1-13/32 Str.	1-7/8 Int. 1-5/8 Exh. 31/32 Str.	1-7/8 Int. 1-5/8 Exh. 31/32 Str.	2-17/32 Int. 2-3/32 Exh.	J	4-13/16 Int. 4-13/16 Exh. 3 Str.	3-31/32 Int. 3-31/32 Exh. 2-1/16 Str.	3-31/32 Int. 3-31/32 Exh. 2-1/16 Str.	4-13/16 Int. 4-13/16 Exh.
C	.495 Int. .494 Exh. .371 Str.	.402 Int. .402 Exh. .309 Str.	.402 Int. .494 Exh. .371 Str.	.495 Int. .494 Exh.	K	.498 Int. .498 Exh. .375 Str.	.405 Int. .405 Exh. .312 Str.	.405 Int. .405 Exh. .312 Str.	.498 Int. .498 Exh.
D	8-53/64 Int. 8-53/64 Exh. 6-1/16 Str.	7-13/16 Int. 7-27/32 Exh. 5-1/64 Str.	7-13/16 Int. 7-27/32 Exh. 5-1/64 Str.	8-53/64 Int. 9-1/64 Exh.	L	.812 Int. .812 Exh. .626 Str.	.751 Int. .751 Exh. .564 Str.	.751 Int. .751 Exh. .564 Str.	.812 Int. .812 Exh.
E	2-5/16 Int. 1-7/8 Exh. 1-5/16 Str.	1-21/32 Int. 1-13/32 Exh. 7/8 Str.	1-21/32 Int. 1-13/32 Exh. 7/8 Str.	2-5/16 Int. 1-7/8 Exh.	M	5/32 Int. 5/32 Exh. 1-13/16 Str.	3/4 Int. 3/4 Exh. 1-1/8 Str.	3/4 Int. 3/4 Exh. 1-1/8 Str.	5/32 Int. 5/32 Exh.
F	2-1/2 Int. 2 Exh. 1-25/64 Str.	1-27/32 Int. 1-19/32 Exh. 31/32 Str.	1-27/32 Int. 1-19/32 Exh. 31/32 Str.	2-1/2 Int. 2 Exh.	N	15/64 Int. 15/64 Exh. 13/32 Str.	11/64 Int. 11/64 Exh. 5/16 Str.	11/64 Int. 11/64 Exh. 5/16 Str.	15/64 Int. 3/64 Exh.
G	3/32 Int. 3/32 Exh. 3/64 Str.	3/32 Int 3/32 Exh. 3/64 Str.	3/32 Int. 3/32 Exh. 3/64 Str.	3/32 Int. 5/64 Exh.	O				.423-.427 Exh.
H	5/16 Int. 7/32 Exh. 7/64 Str.	7/64 Int. 7/64 Exh. 3/64 Str.	7/64 Int. 7/64 Exh. 3/64 Str.	5/16 Int. 3/32 Exh.	P				2.200-2.201 Exh. (.015 Oversize)

Abbreviations used: Int. = intake; Exh. = exhaust; Str. = starting.

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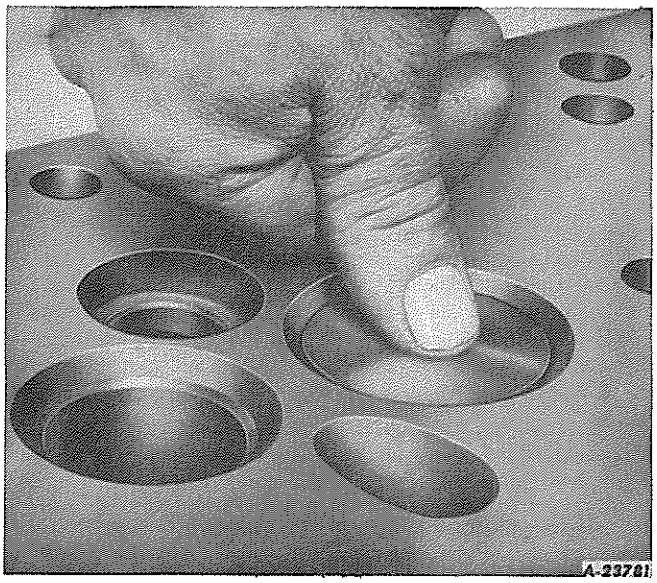
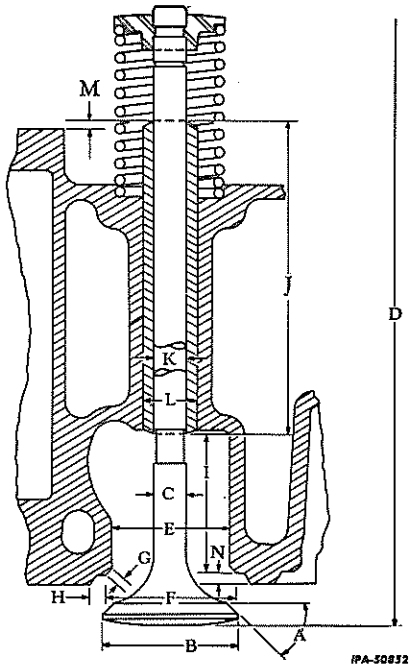
CYLINDER HEAD AND VALVES



Illust. 33 - Testing Valve Seat and Face Contact, Using Prussian Blue.

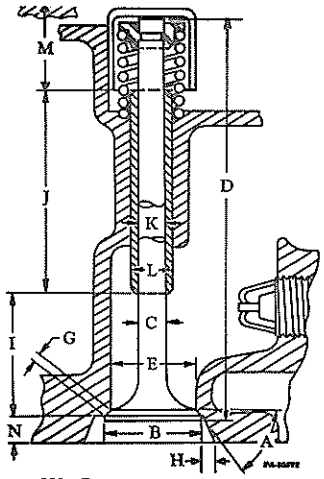


Illust. 34 - Intake and Exhaust Valve (Refer to Illust. 36 for Exhaust Valve on U-1091 Engine).

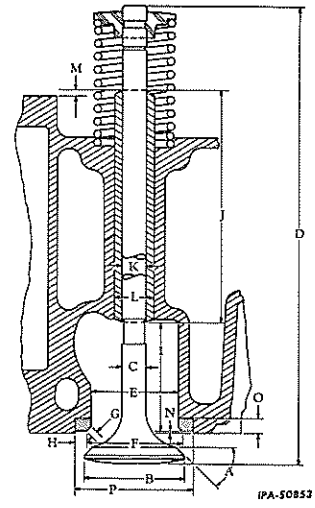
KEY TO VALVE DIMENSIONS

(See Valve Chart and Illust. 34, 35 and 36.)

A. Valve face angle.
B. Valve head diameter.
C. Valve stem diameter.
D. Valve length.
E. Valve port inside diameter.
F. Valve seat outside diameter.
G. Valve seat width.
H. Distance from outside diameter of valve seat to the edge of the combustion chamber in the head.
I. Distance from the valve seat face to the head end of the valve guide.
J. Valve guide length.
K. Valve guide inside diameter.
L. Valve guide outside diameter.
M. 24 and 1091 series: distance from top of valve guide to top edge of valve cover gasket surface. 16, 525 and 554 Series: distance from top of valve guide to top edge of valve lever bracket pad.
N. Distance from the face of the cylinder head to the face of the valve seat.
O. Depth of counterbore.
P. Diameter of counterbore (for .015 oversize insert).



Illust. 35 - Starting Valve.



Illust. 36 - Exhaust Valve (U-1091 Engine) (Refer to Illust. 34 for Intake Valve on U-1091 Engine).

CYLINDER HEAD AND VALVES

13. REASSEMBLY

Intake and Exhaust Valves

1. Coat the valve stems with engine oil and insert them from the bottom of the head. Each valve and its parts should be returned to the position from which it came.

2. Position the oil deflector (if equipped) with the large diameter down on each intake valve stem so that it will be between the valve seat or valve rotator and the valve guide.

NOTE: The oil deflector will position itself during operation.

3. Place the spring and seat or valve rotator on each valve stem. (Illust. 14.) With the valve lifter tool, compress the springs and install the upper seat keys in the groove of each valve stem. (Illust. 14.)

Starting Valves

4. Insert each valve, dipped in engine oil, into the valve guides. Install the springs and seats. Compress the springs and insert the seat keys. Install the valve covers.

Starting Valve Shaft Assembly (Not U-1091)

5. Install the starting valve shaft.

Injection Nozzles (Not U-1091)

6. Install the nozzle gaskets into the cylinder head. Insert the pre-combustion chambers (the word "UP" stamped at the side must be at the top of the cylinder head). Install the second set of gaskets. Dip the dust seal into a thick soap solution and install it carefully into the groove of the nozzle retainer body.

7. Place the retainer in position on the studs. Install and tighten the nuts to the specified torque. (Refer to Section 1, "SPECIFICATIONS.")

Valve Lever and Shaft

8. Place the nozzle body into the nozzle body retainer; install the cap screws and torque as specified in "SPECIFICATIONS" in Section 1.

9. Install the valve levers on the shaft, being certain that the spacers are in the correct location and that the levers are positioned correctly. Install the set screws and retainer rings (11, Illust. 11).

14. INSTALLATION

1. Clean all carbon from the pistons and top surface of the crankcase.

NOTE: When installing cylinder head gasket, be sure to use the correct gasket. All engines (except the 16 series unless equipped with service kits increasing the engine cubic inch displacement) use a head gasket(s) that partially covers the cylinder sleeve shoulder.

2. Install and secure the cylinder heads and gaskets to the crankcase. The nuts should be tightened in the proper sequence (Illust. 37) and to the proper torque (refer to "SPECIFICATIONS" in Section 1). Do not tighten to the full torque immediately; it is advisable to tighten to full torque in three steps. Retighten the cylinder head after the engine has been operated for 50 to 100 hours.

NOTE: It is important to line up both cylinder heads in order to provide a good seal at the intake manifold. A suggested method for obtaining proper alignment is as follows:

(a) Install the cylinder heads on the crankcase but do not secure with the stud nuts.

(b) Install the intake manifold without gaskets to cylinder heads and secure with stud nuts.

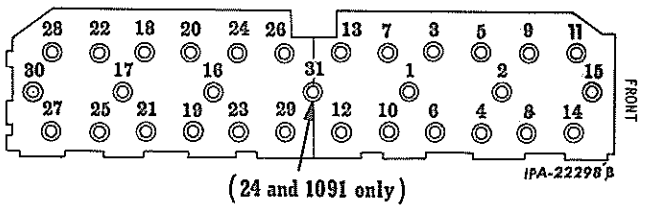
(c) Secure the cylinder heads with stud nuts as in step (2).

(d) Remove the intake manifold.

3. Install the push rods and the valve lever assembly.

4. Assemble the operating shaft (44) (Illust. 11), the operating lever (45 and 39), and the lever pins and nuts.

5. (Not U-1091) Install the starting valve shaft push rod to the cup of the lever attached to the starting valve shaft (22). Secure it with the lock wire. The starting valve operating shaft with integral push rod eliminates the separate push rod and lock wire on later model engines.



Illust. 37 - Showing the Proper Sequence for Tightening the Cylinder Head.

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CYLINDER HEAD AND VALVES

6. (Not U-1091) Connect the starting valve linkage to the operating shaft (44) and secure.

7. Install the cylinder head breather.

8. Adjust the valves as described in "Valve Clearance Adjustment". Set the valve clearances as specified for the cold setting in section 1, "Specifications". Install the valve cover and gasket; and oiling felt on engine if so equipped.

9. Install the intake and exhaust manifold, the water outlet header and thermostats.

10. Connect the carburetor fuel line, and connect other linkage and controls which were removed to provide access to the cylinder head. Connect the wiring to the manifold switch.

11. (Not U-1091) Install the injection pipes and tighten the connections finger-tight. With a wrench, give the connection a further 1/8 turn - never more. If, however, new pipes and connections are being installed and have just been made up from new parts, tighten the connections finger tight and give a further 1-1/2 turns with a wrench. Never tighten more than this amount as damage to the seal and subsequent leakage will result. In the future, the new lines and connections will be given only 1/8 turn past finger tight when removed and installed.

12. Install the lifting eye on engine so equipped and torque to specified amount. (Refer to section 1.) Install the spark plugs and spark plug cables in their correct positions.

13. Fill the complete cooling system. Be certain that the drain valves below the radiator and on the left side of cylinder wall are closed and that the vent valve on the water manifold is also closed after venting (if so equipped). Check the oil level in the crankcase.

14. With all fuel lines and controls connected, start the engine and allow it to operate for one hour after reaching normal operating temperature. Stop the engine and remove the valve cover and gasket. Remove the valve rocker arm assemblies and recheck the torque of the cylinder head nuts. Tighten to the specified torque where necessary. Install the valve rocker arm assemblies and back off on rocker arm adjusting screws to insure adequate clearance. Adjust the valves for clearance. Install the cover and gasket.

15. On new engines, or whenever new cylinder head gaskets have been installed, the valve rocker arm assemblies must be removed and the cylinder head stud nuts retorqued and the valve clearances adjusted after the first 50 to 100 hours of operation.

CAUTION: When retorquing cylinder head stud nuts, only those nuts below torque are to be retorqued to proper specifications. Those above torque are to remain as they are.

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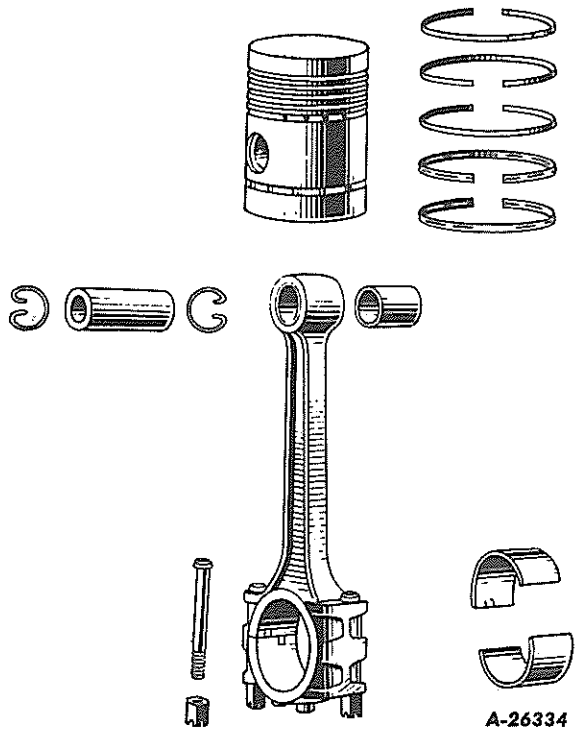
CONNECTING RODS, PISTONS AND PISTON RINGS

1. DESCRIPTION

Connecting Rods (Refer to Illust. 1)

The connecting rods serve as the links between the pistons and the crank throw. The surfaces of the rods must be kept free of scoring and dents because of the high stresses under which they function. The rod has a bearing at each end, the one at the upper end is a bushing for the piston pin which anchors it to the piston. The bearing at the crankshaft or lower end is inserted in two halves which fit around the crankshaft and are secured by a bearing cap. The bearing cap is furnished only with its connecting rod. The rods are drilled to provide passage for lubricating oil flow to the piston pin bushing.

The bearings are precision, copper-lead, steel-backed type. Both halves of each bearing are identical, and they are held in place by nibs which engage in notches in the connecting rod and bearing cap. The bearings can be replaced easily without having to remove the rods.



Illust. 1 - Showing Piston and Positions of Piston Ring Gaps (All Models Except Late 1091 Series).

Pistons (Refer to Illust. 1)

The piston is one of the most important units in the engine, and its condition has much to do with the performance of the engine. Its function is to receive the force of the combustion pressure and transmit it to the connecting rod and crank throw. The escape of combustion pressure past the piston is prevented by the piston rings. The fit of the piston and rings in the sleeve must be close enough to prevent the escape of combustion gases but must be free enough to keep friction to its working minimum.

Piston Rings (Refer to Illust. 1)

The pistons are fitted with five piston rings. Two oil regulating rings are fitted to each piston. Late model 1091 engines have both oil regulating rings located above the piston pin. The oil regulating rings provide an even circulation of lubricating oil and, therefore, an all-over lubricating and cooling action for the piston and sleeve. Excess oil is wiped by the rings back down to the crankcase. The remaining rings are compression rings. One of these is chrome plated and tapered, and is located as the top ring of the piston. Tapered rings have the word "TOP" marked on them, and must be assembled in the manner indicated. Ring gaps and other dimensions are given in the "SPECIFICATIONS" Section 1. Rings should be installed on a piston so that the gaps are 90 degrees from the thrust side of the piston and 180 degrees from one gap to another. (Refer to Illust. 9.)

Piston Pins (Refer to Illust. 1)

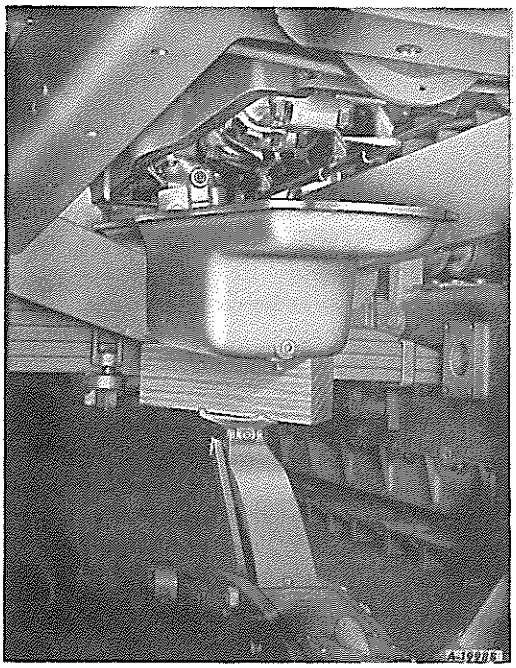
The piston pin or wrist pin is made of steel and is cylindrical shape. Its purpose is to anchor the piston to the connecting rod. The pin is retained in the piston by retainer rings that lock into grooves of the piston pin bore. The pin is allowed to float in its bushing in

(Continued on next page)

CONNECTING RODS, PISTONS AND PISTON RINGS

1. DESCRIPTION – Continued

Piston Pins – Continued



Illust. 2 - Removing the Engine Oil Pan (TD-24 Shown).

the upper end of the rod. The aluminum of the piston is an excellent bearing material, and no bushing is provided, therefore, between the pin and the piston. The bearing of the steel pin in the aluminum piston is the reason for the tight fit of the pin when the piston is cold. It is sometimes necessary to heat the piston in order to remove the pin. The specified clearance for the piston pin is given in "Specifications" (Section 1).

2. REMOVAL

NOTE: For a method of detecting excessive connecting rod bearing clearances, prior to "removal" and "disassembly" procedures, refer to "oil pressure test for detecting worn bearings", section 4.

1. Remove the cylinder head assemblies. (Refer to section 2.)

2. Remove the drain plug and drain the engine oil pan

CAUTION: On engines equipped with loose fitting sleeves it will be necessary to block the sleeves in some manner when the cylinder heads are removed. This will prevent them from being pushed out when the engine is cranked or from falling out if the engine is inverted in the service stand.

3. Remove the crankcase oil pan. Position a shop jack below the oil pan as shown in Illust. 2. Remove the cap screws securing the pan and allow the jack pressure to escape until the pan is clear of the lubricating oil pump.

TD-24 CRAWLER TRACTOR ONLY: With the oil pan lowered approximately as shown in Illust. 2, remove the rear oil suction line from the oil pump and crankcase. Remove the oil level gauge sleeve. Continue to lower the oil pan. Roll the jack and the oil pan carefully from position.

4. Crank the engine until the connecting rod to be removed is at its lowest position.

5. Remove the cotters from the nuts on the connecting rod studs. Remove the nuts and the bearing cap. Tap the cap lightly with a mallet if necessary to aid removal. The lower bearing insert is removed with the cap where it is held by a nib in the notch.

NOTE: If a ridge exists on the cylinder wall at the upper end of the ring travel, the ridge must be removed by using a ridge grinder before the piston is removed. This prevents damage to the piston ring lands during removal of pistons, and prevents damage to new top piston rings after the installation of new rings.

6. Push up on the connecting rod until the piston is clear of the sleeve and lift the assembly out of the top of the sleeve.

CAUTION: Pistons must be handled with care to avoid damage and knocking out-of-round or alignment. When removing a piston from the crankcase, do not allow the skirt of the piston to strike the crankcase or connecting rod. Mark the pistons so that they can be installed in the same cylinders from which they were removed, and in the same position.

3. DISASSEMBLY

1. With the aid of a piston ring expander, remove the piston rings; remove the top ring first and the remaining rings in order. (See Illust. 3.)

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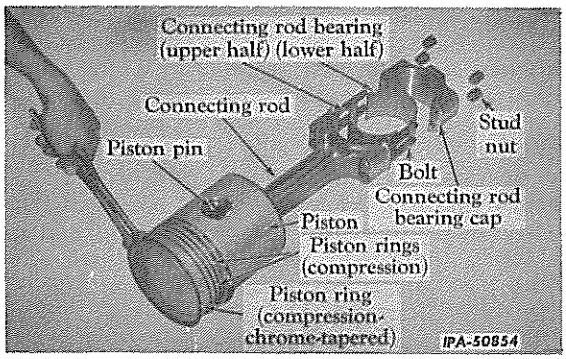
CONNECTING RODS, PISTONS AND PISTON RINGS

2. Remove the piston pin retainer rings from each side of the piston and remove the piston pin. If the piston pin cannot be removed by hand, it is recommended to heat the piston in water at 160° to 180° F, at which temperature the pins are a light, hand-press fit. This heating of the piston makes it unnecessary to use force in removing the pins.

3. Remove the piston pin and separate the piston from the connecting rod. Be sure that the parts are marked so they may be reinstalled in their respective cylinders (unless defective).

4. INSPECTION AND REPAIR

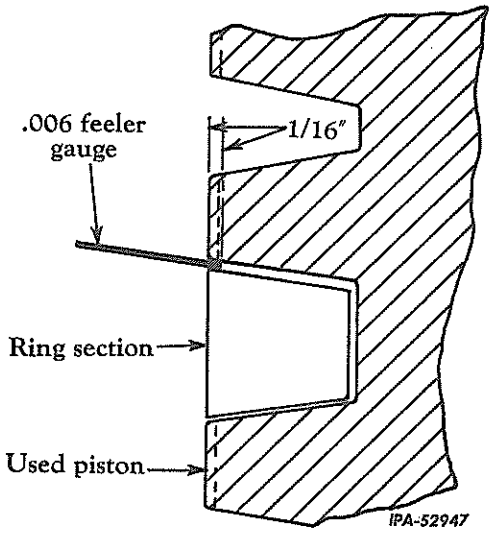
Wash all parts in a dry-cleaning solvent and dry them with compressed air. Clean the passages in the oil control rings. Use a groove cleaning tool, or a broken piston ring which fits the ring grooves, to clean carbon from the ring grooves. Clean the holes in the oil control ring grooves in each piston. Clean the oil passages in each connecting rod. Wash all parts again and dry them with compressed air. Be sure to blow out the oil holes.



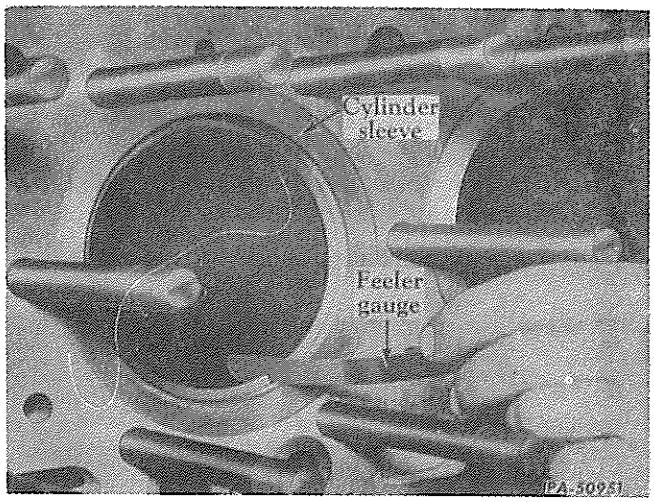
Illust. 3 - Removing the Piston Rings From the Piston (1091 Shown – 16, 525, 554 and 24 Similar).

Pistons

Measure the inside of the cylinder sleeves with an inside micrometer at the top and bottom. Take the measurements at right angles to determine if the sleeves are out-of-round. Pistons can be checked with an outside micrometer. If any pistons are scored, new pistons and sleeves must be installed, together with new piston pins, connecting rod bushings and rings. New pistons are selected to give a certain clearance with the sleeves. For clearances, refer to section 1, "Specifications". Inspect the piston ring grooves for wear. (See Illust. 4.) For the clearance of new piston rings in the grooves of a piston, refer to section 1.



Illust. 4 - Checking a Piston Ring in a Piston Groove for Correct Fit.



Illust. 5 - Checking Piston Ring Gap in Cylinder Sleeve.

Rings should be checked also for the specified side clearance (Illust. 4). (Refer to Par. 2, "SPECIFICATIONS" in Section 1 for ring clearance in groove.)

Insert a .006 inch feeler gauge in 1/16 inch against the top edge of the ring groove of the piston. Insert a small section of a new ring, for the groove being checked, in the groove.

(Continued on next page.)

CONNECTING RODS, PISTONS AND PISTON RINGS

4. INSPECTION AND REPAIR - Continued

If the ring section does not go in flush to the land of the piston, the side clearance is less than .006 inch.

If the ring section goes in flush or below the land of the piston, the side clearance is .006 inch or greater and the piston should be replaced.

NOTE: On a used piston, it will probably be found that the side clearances tend to increase toward the top of the piston due to the greater operating temperatures prevalent at this point.

Connecting Rods

Inspect the connecting rods for straightness. The rods should be free of twist and be parallel to the pistons. Cylinder numbers are stamped on the sides of the rods and on the bearing caps; number 1 being that at the front of the engine. Inspect the piston pin bushings and crankshaft bores for scratches and burrs; dress off any such unevenness. Inspect the threads on the bearing cap studs.

Piston Rings

Inspect the piston rings for damage. Faulty rings cannot always be detected by the eye. Engine performance and irregularities such as excessive oil consumption must be taken into consideration. Wherever there is doubt as to the serviceability of the piston rings, it is advisable to replace them immediately.

Coat the sleeve, piston and ring with clean engine oil. Insert each ring into the sleeve for that piston. Use the piston to force them squarely down inside the sleeve. Position a feeler gauge between the ends of the ring (see Illust. 5) and compare the gap present against that specified for the ring in section 1 "Specifications." If it is necessary to remove material from the ring ends because the end gap is too close, clamp a mill file in a vise, hold the ring in proper alignment and dress off the ends squarely to obtain the desired gap.

Inspect the "windows" of the oil regulating rings for blocked oilways. Failure to keep the oilways clear will result in uneven lubrication of the piston and sleeve and hot spots on the cylinder sleeve and piston and due to absence of the heat absorbing oil flow. All rings should fit loosely in the piston grooves without binding.

The bearing surfaces of the rings should be of a smooth and satin-like finish. Remove any burrs that may be present on new or old rings.

CAUTION: When new rings are being installed to a used piston for operation in a used sleeve, wear on the sleeve may have left a ridge where the piston reaches the top of its stroke. This ridge will cause noisy engine operation and breakage of the top ring. Remedy this by removing the ridge with a ridge grinder before installing the piston and ring.

Piston Pins and Bushings

Inspect the piston pins for score marks. Clean with a fine abrasive if not too severe. Inspect the bushings for wear, and replace with new if necessary. The bushings are furnished for service reamed to size but, after installation in the connecting rods, a burnishing rod and reamer should be passed through then as a check on whether the ID is as specified in par. 2 "SPECIFICATIONS." (See "Service Tools" Manual ISS-1002.) Piston pins also are furnished for oversize installations. (See parts catalog.)

5. REASSEMBLY

1. With the piston pin as cool as possible and generously coated with clean engine lubricating oil, heat the piston in hot water to approximately 160° F. to 180°F., at which point the piston pin can be entered into one boss of the piston by pushing with the hand. With the piston hot, correctly position the connecting rod inside the piston. Align the bushing in the rod bore with the piston pin holes in the piston and push the piston pin completely into position. Thoroughly dry the piston with compressed air.

NOTE: The piston and connecting rod must be assembled so the off-center depression in the piston head and the position number stamped on the lower end of the connecting rod, are on opposite sides.

2. Squeeze the pronged ends of the piston pin retainer rings, and install a ring in the groove at each side of the piston to secure the piston pin.

3. Check the fit of the piston pin in the piston for proper end clearance as follows:

(a) Push one end of the piston pin until it reaches a definite stop against the retainer ring on the opposite side of the piston.
(b) Position a feeler gauge between the end of the pin that was pushed in and the retainer ring to check for end clearance as specified in section 1, "Specifications."

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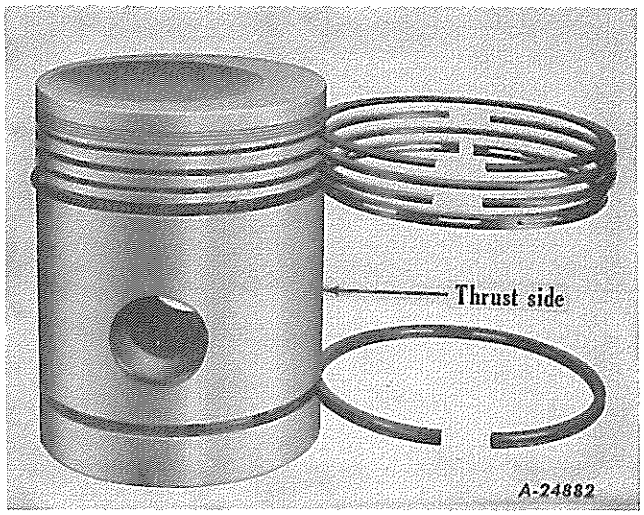
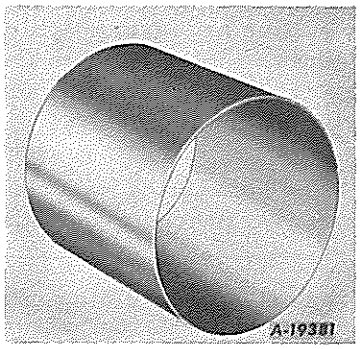
CONNECTING RODS, PISTONS AND PISTON RINGS

4. Using a piston ring expander, install the rings into the grooves of the pistons. The tapered ring must be installed as directed by the word "TOP" stamped on its edge.

Position the rings so that the gaps are 90 degrees from the thrust side of the piston (in line with the piston pin bore) and 180 degrees from one gap to another as shown in Illust. 6.



Illust. 6 - Showing Position of Piston Ring Gaps (All Models Except Late 1091 Series).



Illust. 7 - Piston Ring Compressor.

6. INSTALLATION

NOTE: When installing a piston and connecting rod assembly that was formerly used in the engine, install the assembly in the same cylinder sleeve from which it was removed. When a new piston or a new piston and connecting rod assembly is being installed, install a matched set piston and sleeve. (See parts catalog.)

1. The piston and connecting rod assemblies must be installed through the top of the crankcase.

2. Position the ring compressor (Illust. 7) on the piston sleeve. Generously coat the piston ring compressor and sleeve with lubricating oil and lower the connecting rod and piston into the ring compressor. Push down on the piston carefully until it is in the sleeve.

3. Fit the connecting rod bearings as outlined in the following step.

NOTE: If virgin lead wire is to be used, wipe clean and oil the crankshaft journal. If Plastigage is to be used, wipe the bearing surface and exposed half of the crankshaft journal free of oil as the plastic material is soluable in oil.

4. Torque the connecting rod bearings to the specified foot-pounds (see "SPECIFICATIONS," Section 1). Use Plastigage or virgin lead wire to check the clearance present between the crankshaft and the lower bearing of the connecting rod. Remove the bearing cap and bearing, place a suitable length of .015-inch virgin lead wire or a piece of Plastigage across the bearing, and install the bearing and bearing cap. Tighten the nuts to the specified torque; then remove the nuts and bearing cap. If virgin lead wire was used, use a micrometer to measure the wire which will have been crushed down to the dimension of the clearance between the crankshaft journal and the connecting rod bearing by the torque applied to the nuts. The micrometer measurement should fall between the figures specified in Section 1. If Plastigage was used, the flattened plastic material will be found adhering to either the bearing shell or the crankshaft. DO NOT REMOVE THE PLASTIGAGE. To determine the bearing clearance, compare the width of the flattened plastic material at its widest point with the graduations on the envelope. The number within the graduation on the envelope indicates the clearance in thousandths of an inch. The measurement should fall between the figures specified in Section 1. Reinstall the bearing and cap to the connecting rod, and torque to the specified amount if reading was as specified. Do this to all the connecting rod bearings.

NOTE: Do not turn the crankshaft during the above procedure.

NOTE: Should the readings not fall within the specified limits, and the torque wrench is known to be accurate in its measurement, remove the bearing from the connecting rod and replace it with a new one. However, with the precision bearings used, no trouble should be encountered providing the crankshaft and connecting rods are in good order.

(Continued on next page.)

CONNECTING RODS, PISTONS AND PISTON RINGS

6. INSTALLATION - Continued

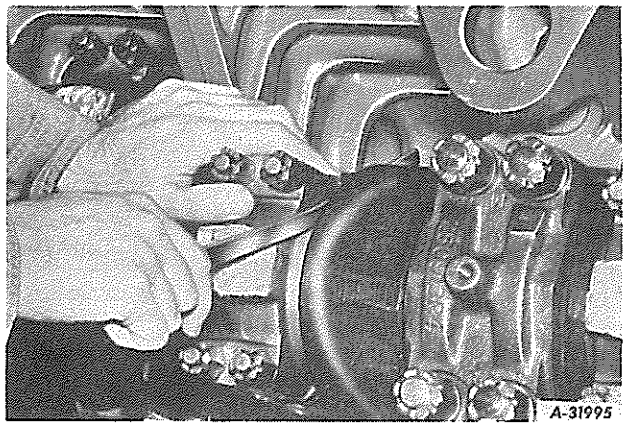
5. Install the other pistons, connecting rods and bearings in the same manner.

NOTE: Check the connecting rod side clearance by inserting a feeler gauge between the bearing cap and lobe of the crankshaft. (See Illust. 8) Proper clearance is given in "SPECIFICATIONS" in Section 1.

6. Install the crankcase oil pan and gasket, using shellac to seal the gasket in place. Fill the crankcase to the level mark on the gauge with the specified grade of engine oil.

7. Install the cylinder heads and gaskets. (Refer to "Cylinder Head and Valves," section 2.)

8. After the installation of new piston sets or new piston rings, the engine must be "run-in" according to the conditioning schedule given in the "Engine run-in schedule," paragraph 11, before operating at normal load and speed.

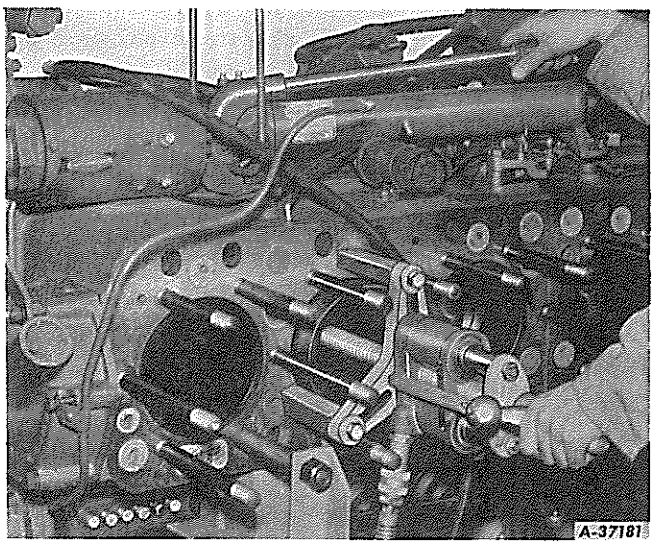


Illust. 8 - Checking Connecting Rod Side Clearance.

CYLINDER SLEEVES

7. DESCRIPTION

The cylinder sleeves are the dry type. Matched or fitted sleeves and pistons are available for service. (See parts catalog.) Sleeves and their mated pistons should be marked and kept in sets when removed and installed back to their original positions.



Illust. 9 - Removing the Cylinder Sleeve.

8. REMOVAL

1. Remove the cylinder head assembly. (Refer to section 2.)

CAUTION: On engines equipped with loose fitting sleeves, it will be necessary to block the sleeves in some manner to prevent them from falling out, if the engine is to be inverted in a service stand with the cylinder heads removed.

2. Remove the connecting rods and pistons. (Refer to removal procedure in this section.)

NOTE: Wrap oil-soaked cloth around the crankshaft connecting rod bearing journals to keep them as clean as possible. Wrap the piston and connecting rod assemblies in clean cloth also to protect them until installation.

3. On engines equipped with tight fitting sleeves, remove the cylinder sleeves with a sleeve puller. These tools are listed in the "Service Tools" Manual ISS-1002.

NOTE: If more than one sleeve is to be removed and they are to be used again, it is important that the sleeves be marked as to location in the crankcase and position in the sleeve bore.

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CYLINDER SLEEVES

When all six tight fitting type sleeves are to be replaced on the 1091 series engines, use the loose fitting type sleeve and install the new type cylinder head gaskets specified for use with loose fitting type sleeves.

CAUTION: Do not use the old type gasket with loose fitting sleeves, or serious damage to the engine will result.

9. INSPECTION AND REPAIR

1. Clean the sleeves in a dry-cleaning solvent and dry them with compressed air.

NOTE: Abrasive material is not to be used to clean the cylinder sleeves.

2. Measure inside of the sleeve with an inside micrometer from top to bottom of sleeve where subject to piston and ring travel. Take measurements at right angles to determine if the sleeve is out-of-round. If a sleeve is out-of-round or scored, a new piston and sleeve must be installed. For new piston and sleeve clearance, refer to Section 1, "SPECIFICATIONS."

10. INSTALLATION

1. Before installing a new individual or set of cylinder sleeves, be sure to check the crankcase cylinder bore(s), for out-of-round and taper (cylinder sleeves removed). The allowable taper in the full length of the bore is .002 inch maximum. The allowable out-of-round is .002 inch maximum. These checks are made with a three point dial bore indicator as follows:

(a) Take indicator readings in the bore at three locations; approximately one inch from the top, one inch from the bottom, and in the middle.

(b). Take two readings at each location 90 degrees apart.

NOTE: Oversize sleeves are available and must only be used when the standard service sleeve does not give the required "fit" necessary.

2. When the crankcase cylinder bore taper and/or out-of-round does not exceed .002 inch, but the standard sleeve does not give the necessary "fit" required, the bore can be enlarged with a Lisle CH-45 cylinder hone to accommodate a .002 inch oversize sleeve.

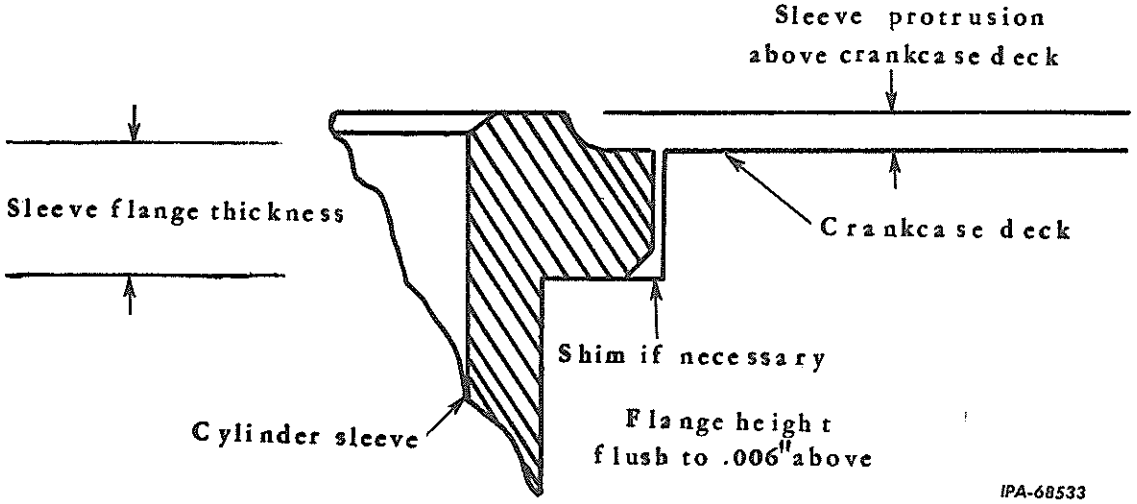
525 AND 554 SERIES ENGINES ONLY: When the crankcase cylinder bore taper and/or out-of-round exceeds the .002 inch limit, the crankcase bore must be enlarged to 4.760 - 4.761 inches with a maximum of .001 inch taper in the full length of the bore and .0007 inch maximum out-of-round to accommodate the .010 inch oversize sleeve.

3. Clean the crankcase cylinder bore and counterbore carefully. Use a dry-cleaning solvent and wipe dry with a lint-free wiper. Clean the cylinder sleeve in the same manner.

NOTE: Install sleeves dry. Lubricant must not be used on either the cylinder sleeve or crankcase bore.

4. ENGINES EQUIPPED WITH TIGHT SLEEVES: For easier installation, set the sleeve in dry ice for a short period of time, then carefully press the sleeve into position.

(Continued on next page.)



Illust. 10 - Cross Section of Cylinder Sleeve.

CYLINDER SLEEVES

10. INSTALLATION – Continued

ENGINES EQUIPPED WITH "PUSH-FIT" SLEEVES: Insert the sleeve in the bore and push down. This should require a force of 50 to 100 lbs. If a greater force is required, remove the sleeve and hone the bore until the proper push-fit is obtained. If a bore of less than 50 lbs. is used, remove the sleeve and try another. If this selection fails, an oversize sleeve should be tried and fitted as described previously.

5. Be sure that the flange of the cylinder sleeve is firmly seated in the crankcase counterbore.

6. Check the sleeve inside diameter for taper and out-of-round. Taper must not exceed .0008 inch maximum. Out-of-round must not exceed .0005 inch maximum.

7. Check the overall height of the sleeve protruding above the crankcase deck (Illust. 10). This distance must be within the limits given in "SPECIFICATIONS" in Section 1.

8. Check the sleeve flange with the crankcase deck. The flange must be flush to .006 inch maximum above the crankcase deck to assure good cylinder head gasket contact to the cylinder sleeve flange for the proper sealing that is required to eliminate combustion leakage (Illust. 10). If necessary, shims are available and can be placed under the sleeve flange in the crankcase counterbore to obtain the proper sleeve flange height (Illust. 10).

9. Install the pistons and connecting rods. (Refer to installation procedure in this section.)

10. Install the cylinder heads. (Refer to Section 2.)

11. ENGINE RUN-IN SCHEDULE

After the installation of new sleeve and piston sets or piston rings, the engine must be "run in" according to the following conditioning schedule, before operating at normal load and speed.

Diesel

1. Check and fill the cooling system.

2. Fill the crankcase with a MIL lubricating oil as specified in the latest service bulletin on "Fuels and Crankcase Lubricating Oils for IH Diesel Engines."

3. Install an oil inlet filter into the turbocharger (on units so equipped). Be sure to remove this filter after 25 hours of operation. Refer to Section 12, "TURBOCHARGER."

4. Start the engine and run it for two minutes on the gasoline cycle.

5. Switch to the diesel cycle and run the engine at 1/4 throttle with no load, until normal operating temperature is reached. Cover the radiator, if necessary, to bring the engine up to operating temperature.

6. CONDITIONING SCHEDULE:

The following schedule is safe to follow after the engine has reached operating temperature.

TRACTOR

Period 1: 1 hour	Operate the tractor in 4th gear without load at 3/4 rated speed.
Period 2: 2 hours	Operate the tractor at 3/4 rated speed on light work.
Period 3: 1 hour	Operate the tractor at full rated speed on medium work.

POWER UNIT

Period 1: 1 hour	Operate the engine on work about 1/4 max. load at 3/4 rated speed.
Period 2: 2 hours	Operate the engine on work about 1/2 max. load at 3/4 rated speed.
Period 3: 1 hour	Operate the engine on 3/4 max. load at full rated speed.

CAUTION: Do not run the engine at idle speed for long periods after installing new rings or sleeves, as rings will not seat during idle operation.

7. Recheck for oil, air and water leaks and adjust tappets. Inspect and replace the oil filter elements if necessary.

8. After the engine has operated for 25 hours, the oil should be drained while the engine is hot, and the crankcase refilled with a MIL lubricating oil as specified in the latest service bulletin on "Fuels and Crankcase Lubricating Oils for IH Diesel Engines."

Carbureted

1. Before starting the engine, fill the cooling system with the specified amount of coolant.

2. Fill the crankcase with a MIL lubricating oil as specified in the latest service bulletin on "Fuels and Crankcase Lubricating Oils for IH Diesel Engines."

CYLINDER SLEEVES

3. Warm up engine at approximately 3/4 throttle and no load until normal operating temperature is reached. Depending on the application, it may be necessary to cover the radiator or bypass the water coolers to bring engine up to operating temperature. During the warm-up, the cooling system should be vented of air and the oil pressure noted. The pressure should be within the specified range.

4. All rubbing surfaces in a rebuilt engine require mating during the break-in process, and good piston ring seating is the major target. Until ring seating and good sealing of the combustion space occurs, the following conditions will be noted:

(a) Compression will be low, combustion poor and smoking can be expected.

(b) Lubricating oil consumption will be high since all rings play a part in oil control.

(c) Blow-by will be high and will be reflected in a high crankcase pressure.

5. CONDITIONING SCHEDULE: The first phase of break-in must be accomplished gently enough to reduce welding process dangers. Rubbing surfaces should not be subjected to excessive pressures and temperatures. However, breaking the engine in too gently may result in cylinder wall glazing before the rings can seat properly. This glazing, caused by low combustion temperatures and incomplete combustion, results in short engine life, loss of power and high oil consumption.

To avoid these undesirable conditions, the following conditioning schedule is recommended after the engine has reached operating temperatures.

POWER UNITS

Period 1: 15 min.	Operate without load at 75% rated speed.
Period 2: 30 min.	Operate at 25-50% of rated load at 75% rated speed.
Period 3: 45 min.	Operate at 60-75% of rated load at 75-90% rated speed.
Period 4: 1 hour 30 min.	Operate at 80-100% of rated load at 90-100% rated speed.

6. Recheck for oil, air and water leaks and adjust tappets.

7. Inspect and replace the oil filter elements if necessary.

8. For engines equipped with bypass oil filter systems, the oil should be drained after 20 to 25 hours of operation while the engine is hot. Refill the crankcase with a MIL lubricating oil specified in the latest service bulletin on "Fuels and Crankcase Lubricating Oils for IH Diesel Engines," and at the viscosity grade recommended for the existing ambient temperature.

For engines equipped with the full flow lubricating oil filter system, the oil can be used for the duration of the recommended oil change period.

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OIL PUMP

1. DESCRIPTION

The engine lubricating oil pump is located in the crankcase oil pan below the crankcase. On crawler tractor engines, the oil pump is equipped with extra pump gears that transfer the oil from the front or rear of the oil pan when the tractor is working on inclines. The extra gears are also used in the lubricating oil pump furnished for power units intended for grader equipment installation.

The oil pressure in the system is controlled by a plunger type regulating valve which is set at the specified pressure. (See "Specifications," section 1.)

The engine oil system is filtered by elements located on the side of the engine which are easily accessible for service.

2. INSPECTION PRIOR TO REMOVAL

To check the wear of the oil pump drive gears on diesel engines with distributor ignition:

Remove the distributor cap, rotor and dust shield; reinstall the rotor, turn the rotor as far as it will go in one direction, noting the travel of the outer end of the rotor by using a dial indicator or a scale graduated in 1/32's. The maximum travel should not be greater than 1/8 inch. When the 1/8 inch maximum travel is reached, the oil pump drive gears and camshaft should be inspected for wear.

3. REMOVAL

NOTE: On all power units and crawler tractors that are equipped with battery ignition starting systems (instead of magneto ignition), it is necessary to have the oil pump correctly timed with the camshaft. Correct timing is necessary because the pump drive gear also drives the distributor through a slotted connection. Before removing the oil pump from an engine equipped with battery ignition starting system, it is advisable first to mark the position of the pump shaft so that the pump can be readily replaced in correct time. To do this, crank the engine over until the No. 1 piston is on top dead center of the compression stroke. Then, with a punch, mark the lower end of the pump shaft and the pump cover so that the shaft can be again set in the same position. (See Illust. 2.)

1. Drain the oil from the engine. Remove the cap screws holding the oil pan to the crankcase, and then remove the pan and gasket.

NOTE: The TD-24 oil pan will not clear the oil return lines. Lower the oil pan on a jack as far as shown in Illust. 1; then remove the rear suction pipe from the oil pump and crankcase. Remove the oil level gauge sleeve. Then lower the oil pan to the floor.

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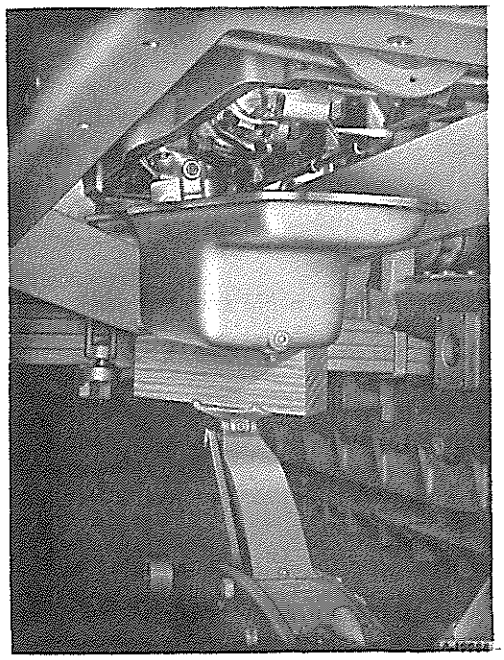
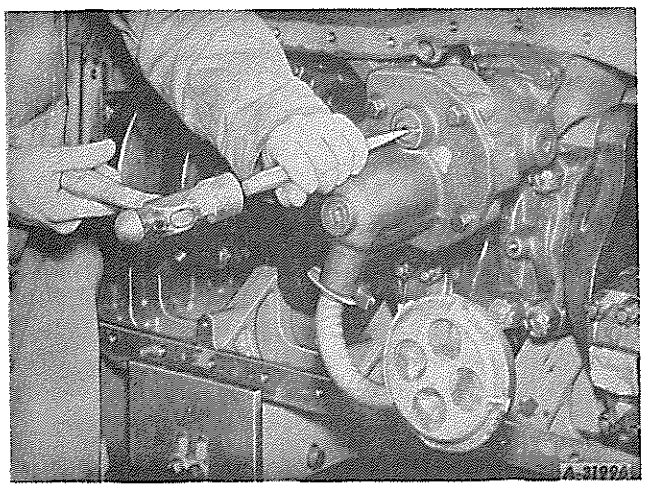


Illust. 1 - Removing the Engine Oil Pan (TD-24 Shown).



Illust. 2 - Marking the Oil Pump Shaft and Cover.

OIL PUMP

3. REMOVAL – Continued

2. The lubricating oil pump can be pulled out after removing the lock wire and the cap screws. (Also remove the cap screws holding the two oil return pipe clips on the tractor engines.)

4. DISASSEMBLY

Single Gear Oil Pump (Refer to Illusts. 3 and 4)

1. (NOT UD-554 OR TD-15(150): Remove the cotter pin from the oil pump cover (18); then pull the oil pump screen assembly (10) from the cover (18).

2. Remove the cap screws and pull cover (18) and gasket (17) from the pump body.

3. Remove the oil regulating valve spring (9) and oil regulating valve (8). On engines equipped with full-flow lubricating oil filters, a heavier valve spring is installed in the oil pump and an oil regulating valve and spring is located in the lubricating oil filter base.

4. Slide off idler gear (7) from the idler shaft (6) in body (5).

5. Remove drive shaft (14) from body (5) by driving pin (13) from pinion (1)(as shown in Illust. 6): then press the pinion off the shaft (Illust. 7) and remove the Woodruff key (2).

6. Remove gear (16) from the shaft (14) by driving out pin (15) (as shown in Illust. 8) and pull the gear off the shaft. Do not attempt to remove idler shaft (6) from pump body (5).

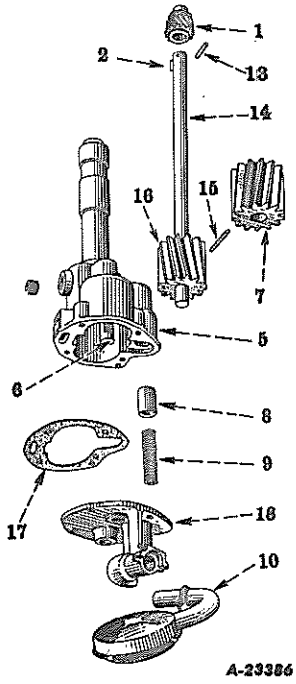
NOTE: The body gear (16) on the 24 and 1091-series diesel engines cannot be removed from the shaft. Therefore, when replacement parts are necessary, drive shaft and gear must be ordered under one part number.

Triple Gear Oil Pump (Refer to Illust. 5)

1. Remove the cap screws and lock washers which secure the cover (18) to the pump body (5). Then tap the cover lightly with a rawhide hammer until the cover breaks free of the lower auxiliary gear housing (14). The cover gasket will adhere to the cover and will come out together with the cover.

2. Remove the lower auxiliary gear housing (14) by tapping the housing downward until free of the drive shaft (1) and the idler gear shaft. The auxiliary drive gear (15) and auxiliary idler gear (12) will come out with the cover.

3. Tap the upper auxiliary gear housing (10) lightly with a rawhide hammer until the housing breaks free of the auxiliary housing dowel (19). The cover will then come off with the cover gasket (7), auxiliary housing gasket (13),



Illust. 3 - Exploded View of Single Gear Oil Pump (UD-24 Shown, UD-16, UD-525 and UD-554 Similar).

1.	Drive pinion.	10.	Float.
2.	Key.	13.	Pinion pin.
5.	Pump body.	14.	Drive shaft.
6.	Shaft.	15.	Pin.
7.	Idler gear.	16.	Body gear.
8.	Regulating valve.	17.	Gasket.
9.	Valve spring.	18.	Cover.

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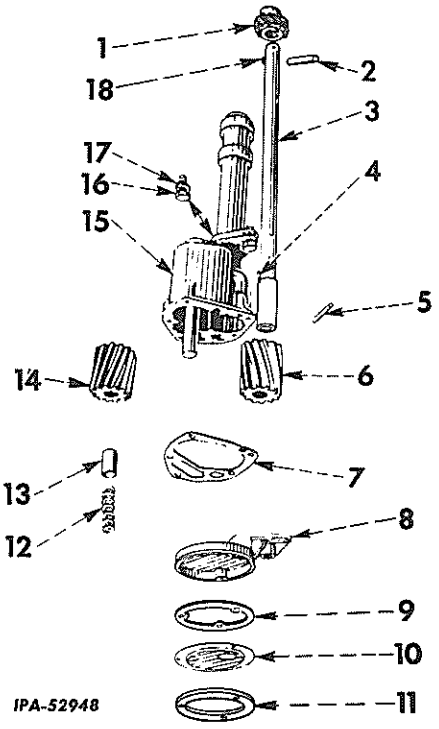
OIL PUMP



Illust. 4 - Exploded View of Single Gear Oil Pump (UD-554 and TD-15).

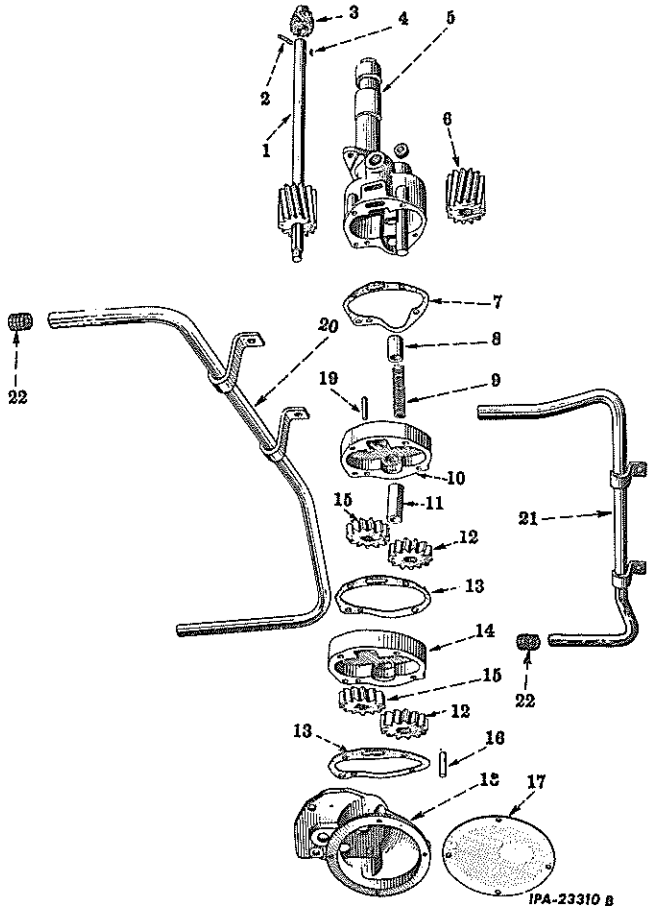
1. Drive pinion.
2. Pin.
3. Drive shaft.
4. Key.
5. Gear pin.
6. Body gear.
7. Cover gasket.
8. Pump cover.
9. Plate gasket.
10. Bottom plate.
11. Stiffener ring.
12. Regulating valve spring.
13. Regulating valve.
14. Idler gear.
15. Body.
16. Screw.
17. Lock washer.
18. Key.

auxiliary idler gear (12), auxiliary drive gear (15) and inlet tube (11). The inlet tube (11) can be removed if necessary.

4. Remove the oil pump safety valve spring (9) (pressure regulating valve spring on older engines) and valve (8) (regulating valve on older engines) from the recess in the oil pump body (5).

5. Slide the oil pump idler gear (6) from its position on the idler gear shaft.

6. Remove the drive shaft from the pump body by driving the pin from the pinion. (See Illust. 6.) Then press the pinion off the shaft and remove the Woodruff key. (See Illust. 7.)



Illust. 5 - Exploded View of Triple Gear Oil Pump (TD-24 Shown).

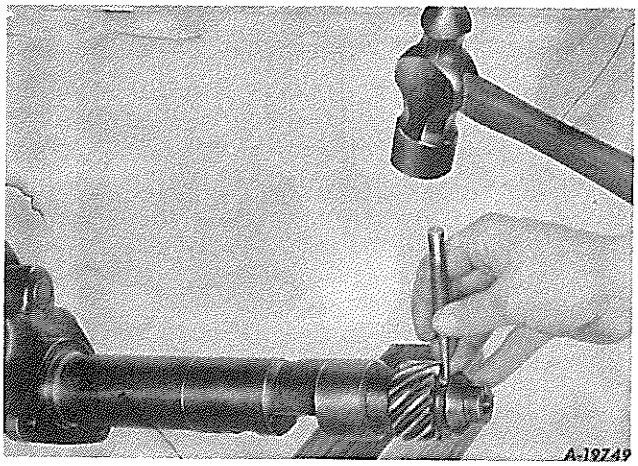
1. Drive shaft and gear.
2. Drive pinion pin.
3. Drive pinion.
4. Drive pinion key.
5. Pump body.
6. Idler gear.
7. Cover gasket.
8. Oil pressure safety valve.
9. Valve spring.
10. Auxiliary gear housing (upper).
11. Inlet tube.
12. Idler gear.
13. Housing gasket.
14. Auxiliary gear housing (lower).
15. Auxiliary drive gear.
17. Bottom plate.
18. Cover.
19. Dowel.
20. Return pipe (front).
21. Return pipe (rear).
22. Pipe screen.

5. INSPECTION AND REPAIR

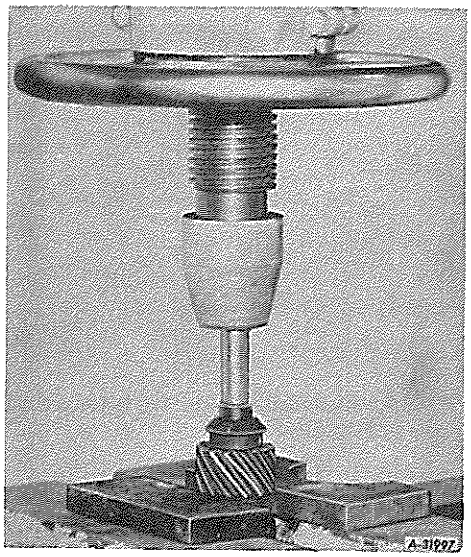
1. Clean all parts thoroughly, being sure that all the openings in the bottom plate screen are free and clean. If the bottom plate screen has been crushed, it is better to replace the bottom plate rather than attempt to make a repair. The opening in the center of the bottom plate is a by-pass and should not be closed.

(Continued on next page.)

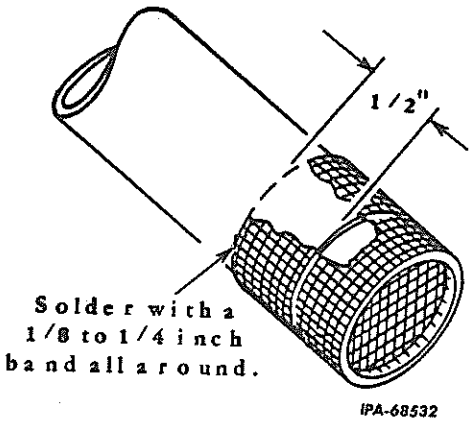
OIL PUMP



Illust. 6 - Driving the Pin From the Pinion.



Illust. 7 - Removing the Pinion Gear.



Illust. 7A - Oil Pipe Screen Installation (TD-24 and TD-24 (241 Series) only).

On crawler tractors, clean and flush out the return pipes. Clean all other parts thoroughly in a dry-cleaning solvent and dry them with compressed air.

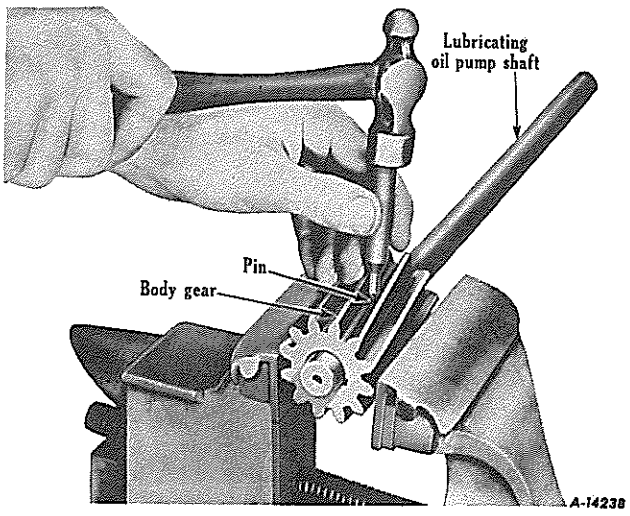
TD-24 AND TD-24 (241 SERIES) ONLY: If the pipe screen (22, Illust. 5) needs replacement, the wire ends of the new screen must be soldered securely in place with a 1/8 to 1/4 inch band all around (Illust. 7A).

NOTE: End of screen must not be more than 1/2 inch from end of pipe (Illust. 7A) to insure proper amount of filter area at end of pipe.

2. Inspect all gears for wear, scoring and chipped teeth. If any gear is damaged it must be replaced. Inspect the body and oil pump cover for any evidence of wear (gear contact) or damage. Replace any parts that are worn or damaged.

If the idler shaft in the pump body is loose, replace the body; the idler shaft is not furnished as a separate part.

Assemble the body gear to the drive shaft (the body gear on 24 and 1091 series diesel engines is not serviced separately) and then assemble to the pump body. Check the clearance between the gear and the bore of the body.



Illust. 8 - Removing Body Gear From Shaft (Not 24 or 1091 Series).

On later 16 series engines, the hole for the pin in the pump body gear is not reamed all the way through, but rather to a point just short of that. This leaves a seat for the new, shorter pin to rest on (Illust. 9). After

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OIL PUMP

the pin is pressed in against this seat, the gear is peened over the pin, holding the pin in place. This method gives double protection against the pin working itself loose.

Place a feeler gauge between the gear and the body and turn the gear one complete revolution while holding the gauge in one position.

Move the gauge around the body bore and again turn the gear one complete revolution to check the clearance. Repeat this operation until the entire distance around the body has been checked. Refer to "Specifications," section 1, for clearance between the gear and body and between the body and idler gear. Check the clearance between the idler gear and pump body in the same manner used to check the clearance between the body gear and body.

When the idler and body gears are assembled, check the backlash. The cover gasket is also used as a shim (.006 inch thick). This gasket should be replaced whenever the pump is disassembled. Do not attempt to cut a new gasket unless material of the correct thickness is used. The cover gasket provides a clearance of .003 to .006 inch between the gears and the cover. It is very important that this clearance be maintained to prevent wear on gears and cover.

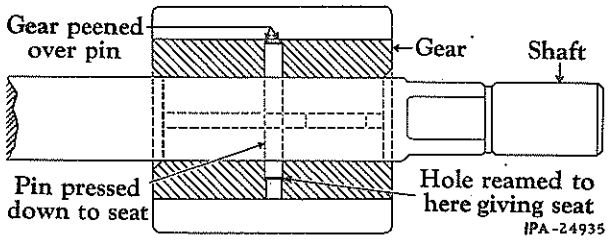
3. Check the safety valve spring for proper length, action and condition. For the specified free length, test load and the test length, refer to "Specifications," section 1. A valve spring which falls below these standards should be replaced.

The outside diameter of the oil safety valve on the 16, 525 and 554 series diesel engines is .900 to .901 inch, and the valve bore in the pump body is .905 to .906 inch; the running clearance between the valve and body is .004 to .006 inch. On the 24 and 1091 series, the outside diameter of the safety valve is 1.124 to 1.125 inches and the valve bore in the pump body is 1.129 to 1.130 inches; the running clearance between the valve and body is .004 to .006 inch.

Be sure that the valve is in good condition, that it slides freely, and that the valve seat in the body is not damaged.

6. OIL PRESSURE TEST FOR DETECTING WORN BEARINGS

To pre-determine the location of excessive clearances or bearing failures without having to tear down an engine, an oil leak detector No. 1 020 183 R2 is shown in service tool manual (Illust. 11). It is especially designed for full pressure lubrication. Complete instructions for its use are included.

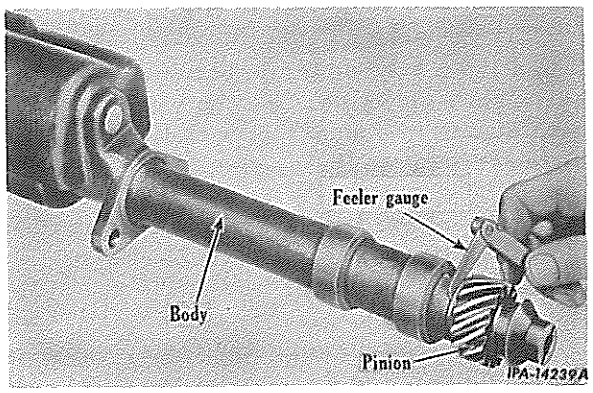


Illust. 9 - Cross Sectional Drawing Showing New Method of Pinning Gear to Shaft (16 Series Only).

The general purpose of this device is to supply oil at a pre-determined pressure to an engine lubrication system, so that with the oil pan removed, the oil leakage at the main, connecting rod and cam shaft bearings can be observed, and the worn or improper clearance of bearings picked out by the amount of leakage, which appears in the form of drops or spurts of oil.

A similar tester can be made up from available parts, and has been found to be effective; Secure a section of 6-inch pipe approximately 24 inches long. (Illust. 12.) Weld a plate for a base on one end, and thread the other end to take a cap. Drill and tap the cap to take a tee connection and, in one side, weld a standard tire valve and the other side, a pressure gauge registering at least 75 pounds.

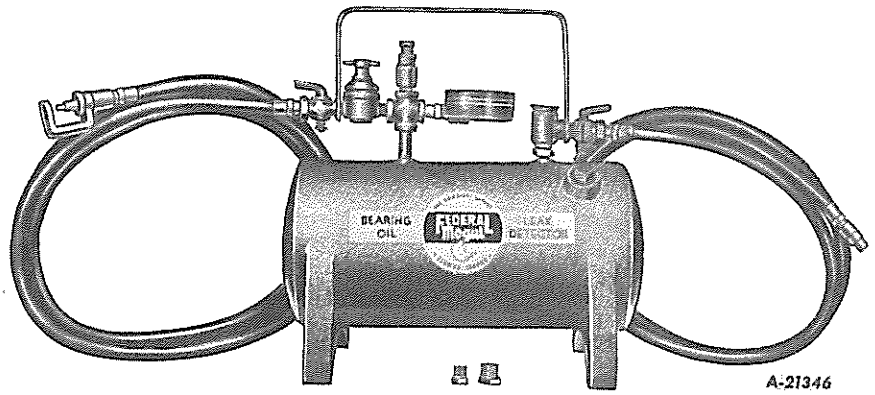
(Continued on next page.)



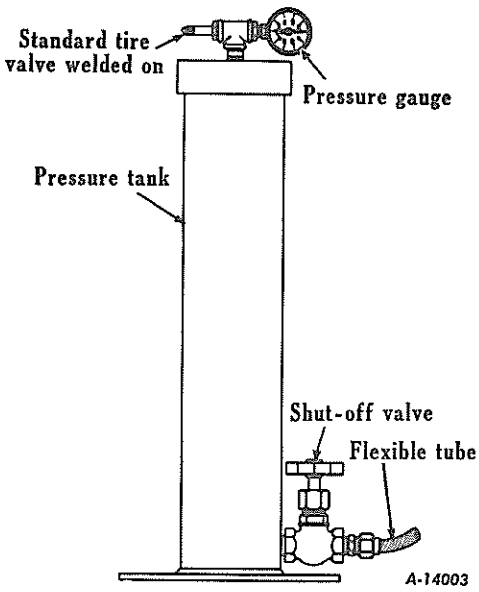
Illust. 10 - Checking End Clearance Between the Pinion and the Body.

OIL PUMP

6. OIL PRESSURE TEST FOR DETECTING WORN BEARINGS – Continued



Illust. 11 - Leak Detector.



Illust. 12 - Oil Leakage Test Tank.

Drill and tap a hole near the bottom of the pipe to take a shut-off valve. To the valve attach a flexible hose to connect up with the oil pressure connections on the engine.

The capacity of the tank will be in excess of 10 quarts. Fill the tank with SAE-10W oil, by removing the tank cap.

CAUTION: Before running any tests, remove the filter elements and clean out the filter base to remove all dirt accumulation that might otherwise be forced into the oil channels of the lubricating system.

Begin the test by applying air pressure through the air valve on top of the tank to 25-30 pounds gauge reading. With the flexible hose connected to the oil pressure line on the engine, open the valve at the bottom of the tank to allow the oil to flow into the lubrication system. Approximately half of the oil in the tank will be required to fill the oil lines. The pressure should be maintained at 25 pounds throughout the test.

A bearing condition is indicated by the drip or leakage from the ends. If this leakage appears as a steady stream, it is evident that a bearing is extremely worn or excessive clearance exists. Care must be exercised to differentiate between a stream coming from a faulty bearing and a stream existing because of engagement of oil holes (such as spurt holes in connecting rods for cylinder lubrication) and grooves.

It is advisable to re-position the shaft for each bearing, so that the leakage from the bearing under observation can be properly segregated and not confused with leakage from another source.

The frequency of the drops indicates the condition. A satisfactory bearing might pass 25 to 100 drops per minute.

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OIL PUMP

If the time element between drops is excessive, the bearing is open to suspicion, and should be investigated. It is either too tightly fitted or an obstruction in the oilway to the bearing exists.

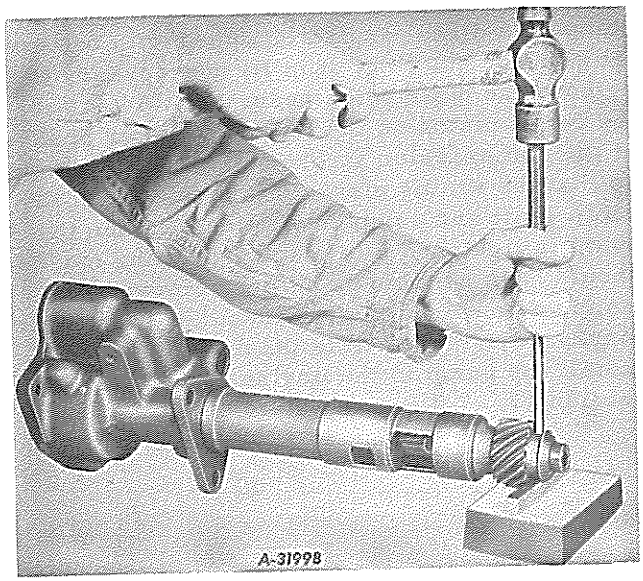
On completing the tests, close the shut-off valve and relieve the tank pressure through the air valve.

7. REASSEMBLY

Single Gear Oil Pump (Refer to Illusts. 3 and 4)

1. (NOT UD-554 OR TD-15 (150): Insert Woodruff key (2) into shaft (14) and assemble the body gear (16) to the drive shaft (14). Drive pin (15) into place and install drive shaft (14) with gear (16) into pump body (5).

2. Insert Woodruff key (2) into the upper end of shaft (14); then press drive pinion (1) and drive the pin (13) into place. With the shaft forced as far toward the top of the pump body as possible, there should be .010 to .020 inch clearance between the top of the pump body (5) and the bottom face of the pinion (1). (Refer to Illust. 10.) Excessive clearance at this point indicates worn gears and pump body. Parts should be replaced or noisy operation, increased wear and decreased pumping efficiency will result. When the assembly is made from all new parts, file or grind off the tops of the pump body if necessary to obtain a minimum of .010 inch clearance between the pump body and the pinion.



Illust. 13 - Peening the Pinion Pin.

After checking the end clearance of shaft (14), lock both ends of pins (13 and 15)into the gears (1 and 16) by using a small punch and peening each end of the pins. (Illust. 13.) Be careful not to damage the gears when using a punch to lock the ends of the pins, and be sure that the ends of the pins do not project out into the bottom of the gear teeth.

3. Insert safety valve (8), closed end first, and valve spring (9) into place in the pump body (5). Be sure that the spring (9) does not cock the valve (8) in the body bore, causing improper seating.

4. Assemble idler gear (7) onto the idler shaft in pump body (5).

5. Put a thin coating of grease on the gasket surfaces of body (5) and cover (18). Install and secure gasket (17) and cover (18) to body (5). Hand turn the pinion to make sure that no binding exists in the oil pump assembly.

6. Insert the tube end of the oil pump screen (10) into the opening in cover (18). When doing this, be sure that the V-shaped lug at the inlet opening of cover (18) is fitted between the projecting lugs on the tube end of the screen. After pushing the screen (10) into place, install the cotter pin in the cover to prevent the screen assembly from falling out of the cover.

Triple Gear Oil Pump (Refer to Illust. 5)

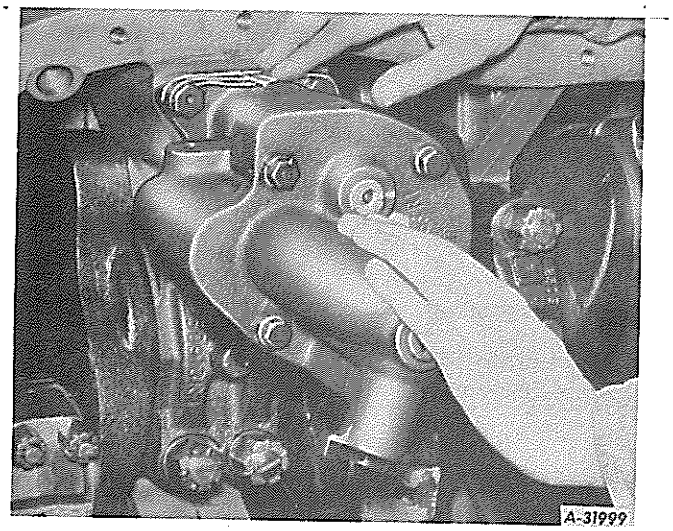
1. Install drive shaft (1) with gear into the pump body (5).

2. Insert drive pinion key (4) into the upper end of drive shaft (1); then install drive pinion (3) and drive the pin (2) into place. With the shaft forced as far toward the top of the pump body as possible, there should be .010 to .020 inch clearance between the top of the pump body (5) and the bottom face of the drive pinion (1). (See Illust. 10.) Excessive clearance at this point indicates worn gears and pump body. Parts should be replaced or noisy operation, increased wear and decreased pumping efficiency will result. When the assembly is made from all new parts, file or grind off the tops of the pump body if necessary to obtain a minimum of .010 inch clearance between the pump body and the pinion. After checking the end clearance of drive shaft (1), lock both ends of the pin (2) into the drive pinion (3) by using a small punch and peening each end of the pins. Exercise care not to damage the gear when using a punch to lock the end of the pin, and be sure that the end of the pin does not project out into the bottom of the gear teeth.

(Continued on next page.)

OIL PUMP

7. REASSEMBLY - Continued



Illust. 14 - Installing the Oil Pump.

3. Insert safety valve (8) and valve spring (9) into place in the pump body (5). Be sure that the spring (9) does not cock the valve (8) in the body bore, causing improper seating.

4. Assemble idler gear (6) onto the idler shaft in the pump body.

5. Put a thin coating of grease on the gasket surface of pump body (5) and upper auxiliary gear housing (10). Install and secure gasket (7) and upper housing (10) to body (5) with gear housing dowel (10).

6. Assemble inlet tube (11) into gear housing (10). Install idler gear (12) and auxiliary drive (15) onto their respective shafts in the gear housing (10).

7. With a thin coating of grease on the surfaces of the upper housing (10) and the lower housing (14), install and secure gasket (13) and lower housing (14) to housing (10).

8. Install idler gear (12) and auxiliary drive gear (15) onto their respective shafts in the lower auxiliary gear housing (14).

9. Put a thin coating of grease on the surface of the lower auxiliary gear housing (14). Install and secure housing gasket (13) and cover (18) to housing (14) with cap screws and lock washers.

8. FIELD CHECK

To make a fast field check of the lubricating oil pump to determine if it is working properly, proceed as follows:

1. Submerge the oil pump in a bucket of oil.

2. Place your hand over the outlet hole, located at the top of the pump.

3. Turn the drive pinion until pressure is built up in the pump and the drive pinion "freezes" or cannot be turned; this indicates that the lubricating oil pump is in working condition.

9. INSTALLATION

1. Insert the oil pump into the crankcase (see Illust. 14) and attach it with lock washers and cap screws. Lock the cap screws by placing a wire through the holes in the heads of the cap screws and twisting the ends of the wire together. (Install the oil return pipes and attach the brackets on tractor engines.)

NOTE: Before installing a lubricating oil pump on a diesel engine equipped with battery ignition for starting, it is first necessary to remove the distributor assembly. Then set the No. 1 piston on the top dead center position of the compression stroke. Install the pump so that the timing marks on the bottom of the pump shaft and pump cover line up when the pump is tightened into place. (Timing marks should have been made before removing the pump, as outlined in "Removal".) If no timing marks were made, time the distributor and install the pump in the engine as outlined in section 15.

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OIL PUMP

2. Shellac new gaskets to the oil pan and attach the pan to the crankcase. Fill the engine with the correct quantity and grade of oil as specified in the operator's manual.

LUBRICATING OIL FILTERS

10. DESCRIPTION

The purpose of the lubricating oil filters is to separate and remove the dirt and other foreign substances from the engine oil and to prevent these injurious materials from being circulated to the engine.

The current diesel engines are equipped with full-flow lubricating oil filters. These filters have the no-drain-back feature which eliminates the necessity of pumping the oil up into the filters when starting the engine.

On the full-flow filters, an oil pressure regulating valve, located in the oil filter base, maintains a pressure of 38 to 46 pounds per square inch. The by-pass valve is located in its own housing on the outside of the engine crankcase, and is connected to the filter assembly by an oil line.

The filter assembly is located on the right side of the engine.

11. REMOVAL (Refer to Illust. 15)

Drain the filter cases and base of all oil by removing the hex-head drain plugs in the filter cases and the square-head pipe plug at the front end of the base. Remove four cap screws and lock washers from the filter base, and four cap screws and lock washers from the by-pass valve housing. Remove the filter assembly as a unit. Disconnect the two inlet pipe unions at the filter base and at the by-pass valve housing. Remove the oil filter inlet pipe or hose.

12. DISASSEMBLY

Full-Flow Filters (Refer to Illust. 15, 16 and 17.)

Loosen the cover retaining nut and remove the case cover; discard the cover gasket. The retaining nut can be separated from the cover by removing the snap ring. Remove the spring and sealing cup from the cover (if equipped). Lift out the filter element. Remove three cap screws which secure the standpipe and case in the base. Lift out the standpipe and discard the gasket. Remove the filter case and unscrew the filter case stud. Discard the filter case gasket. Remove all filters in a similar manner.

Remove the pressure regulating valve retainer nut and gasket and remove the spring and valve. Remove the by-pass valve retainer nut and gasket from the by-pass valve housing. Remove the spring and by-pass valve.

By-pass Type Filters

Loosen the retaining bar and remove the case with the bar. Remove the bar pin from the bar and slide the case off the bar. Discard the bar gasket. Remove the element and case gasket off the base. Discard the case gasket. Remove the pressure regulating valve nut, gasket and spring. Remove the regulating valve.

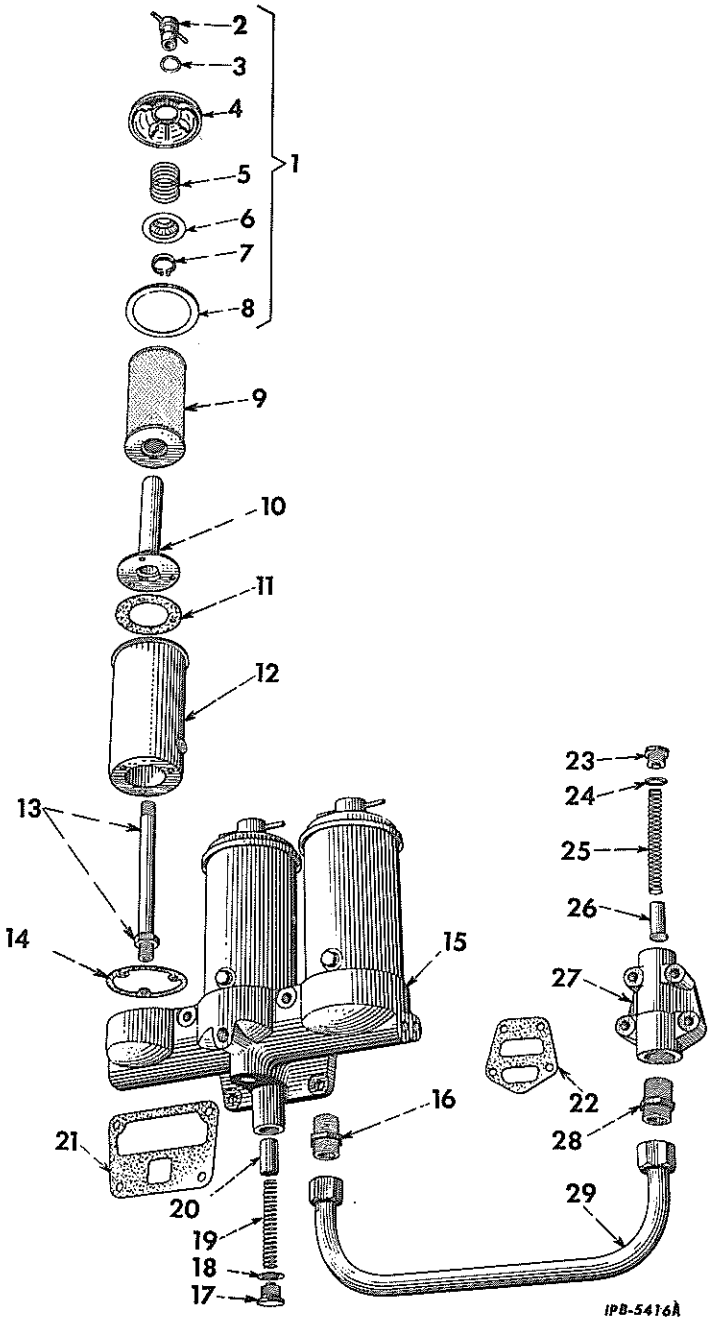
13. INSPECTION AND REPAIR

Clean the filter cases, standpipes, base and all other parts thoroughly with a dry-cleaning solvent. Flush out the oil filter inlet pipe and clean the by-pass valve housing.

(Continued on next page)

13. INSPECTION AND REPAIR - Continued

LUBRICATING OIL FILTERS



Illust. 15 - Full-Flow Lubricating Oil Filter (TD-24 Gear Drive and UD-1091).

1. Cover, complete.
2. Retaining nut.
3. Nut, "O" ring.
4. Cover.
5. Spring.
6. Sealing cup.
7. Snap ring.
8. Gasket.
9. Filter element.
10. Standpipe.
11. Standpipe gasket.
12. Case.
13. Stud.
14. Case gasket
15. Filter base.
16. Pipe union.
17. Valve retaining nut.
18. Gasket.
19. Oil pressure regulating valve spring.
20. Pressure regulating valve.
21. Base gasket.
22. By-pass valve housing gasket.
23. Valve retaining nut.
24. Nut gasket.
25. By-pass valve spring.
26. By-pass valve.
27. By-pass valve housing.
28. Pipe union.
29. Inlet pipe or hose.

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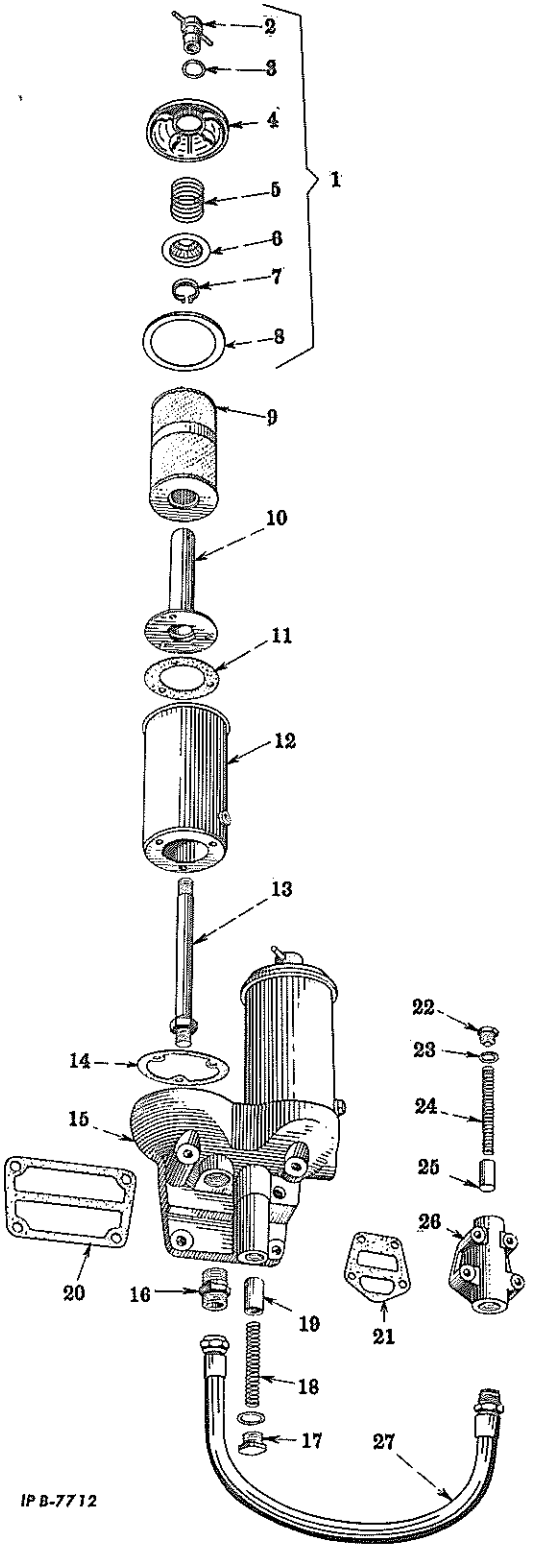
LUBRICATING OIL FILTERS



Illust. 16 - Full-Flow Lubricating Oil Filter (16, 525 and 554 Series).

Legend for Illust. 16

1.	Cover assembly.	15.	Base.
2.	Retaining nut.	16.	Adapter.
3.	"O" ring.	17.	Nut.
4.	Cover.	18.	Spring.
5.	Spring.	19.	Regulating valve.
6.	Sealing cup.	20.	Gasket.
7.	Snap ring.	21.	Gasket.
8.	Gasket.	22.	Retaining nut.
9.	Filter element.	23.	Gasket.
10.	Stand pipe.	24.	Spring.
11.	Gasket.	25.	By-pass valve.
12.	Case.	26.	Housing.
13.	Stud.	27.	Inlet pipe or hose.
14.	Gasket.		

Check the pressure regulating valve spring and by-pass valve spring for proper length, action and condition. For the specified free length, test load and test length, refer to "Specifications," section 1. A valve spring outside of these standards should be replaced.

On the by-pass type filters, the outside diameter of the pressure regulating valve is .900 to .901 inch; the valve bore is .905 to .906 inch; the running clearance is .004 to .006 inch.

The outside diameter of the pressure regulating valve on full-flow filters is 1.040 to 1.041 inch; the valve bore is 1.043 to 1.045 inch; the running clearance is .002 to .005 inch.

The outside diameter of the by-pass valve on full-flow filters is .918 to .919 inch; the valve bore (in the by-pass valve housing) is .921 to .923 inch; the running clearance is .002 to .005 inch.

Be sure that the valves are in good condition, that they slide freely, and that the valve seats in the housing and filter base are not damaged.

14. REASSEMBLY

Full-Flow Filters (Refer to Illust. 15, 16 and 17.)

Install the pressure regulating valve and spring, closed end first, into place in the housing in the filter base. Be sure that the spring does not cock the valve in the housing,

(Continued on next page)

LUBRICATING OIL FILTERS

14. REASSEMBLY – Continued

which would cause improper seating. Install a new valve retainer gasket and the retainer nut.

Install the by-pass valve and spring in the same manner as the pressure regulating valve. (The by-pass valve is located in the by-pass valve housing.)

Install a new filter case gasket. Install the filter case stud. Position the filter case, standpipe gasket and filter standpipe over the stud, and secure them to the filter base with three cap screws.

Grease or otherwise lubricate the sealing rings, located in each end of the filter element, to prevent possible damage. Install the element over the stud, using a slight twisting motion.

Install a new greased or lubricated cover gasket. Secure the cover retaining nut and gasket and the spring and sealing cup (if equipped) to the cover with the snap ring. Position the cover on the case and tighten the retaining nut. Install all filters in a similar manner. Connect the oil filter inlet pipe or hose at the filter base and by-pass valve housing. Be sure to check the flare on each end of the inlet pipe; be certain that it is a good flare and will freely pass into the bore of the inlet pipe union.

Dip the inlet pipe sleeve in oil and assemble onto the inlet pipe approximately 1/4 inch below the flare. Thread the inlet pipe nut onto the pipe union and tighten until the nut contacts the hex on the union.

By-pass Type Filters

Install the pressure regulating valve and spring, closed end first, into place in the housing in the filter base. Be sure that the spring does not cock the valve in the housing, which would cause improper seating. Install a new valve retainer gasket and the retainer nut.

Install a new filter case gasket. Grease or otherwise lubricate the sealing rings located in each end of filter element to prevent possible damage. Place the element in position on the base. Install a new retaining bar gasket on the bar and insert the bar through the case. Install the bar pin. Using a slight twisting motion, install the case and bar over the element and tighten the bar.

15. INSTALLATION

Position the filter assembly and by-pass valve housing on the right side of the engine, using new gaskets. Secure with eight cap screws. Install the hex-head drain plugs in the filter cases and the square-head pipe plug at the front end of the base.

Fill the crankcase with the required amount of oil. When refilling an engine with oil, the filter cases are to be filled (1 quart of oil per case) after the drain plugs have been installed and new filter elements have been inserted.

The lubricating oil used in the filter cases should be deducted from the amount added to the crankcase oil pan, so that the sum of these two quantities equals the amount of oil specified for the engine. Adding oil to each filter case speeds up lubrication to the bearings, oil pump drive gears and other vital parts of the engine, eliminating the time required by the oil pump to fill the filter cases. Refer to the operator's manual for the correct amount and type of lubricant to use.

When checking the oil level with the bayonet gauge, on engines equipped with full-flow filters, it will be noted that the level reading is high. This level will recede after the engine is started and the filter cases fill up with oil. Start the engine and see that the oil pressure indicator is registering pressure.

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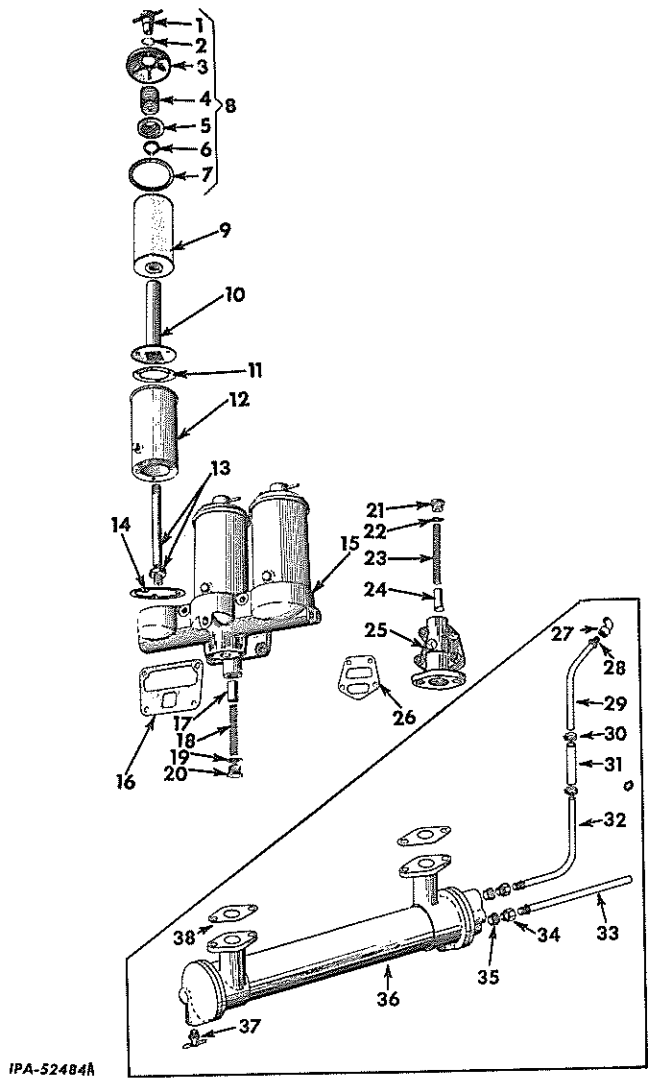
ENGINE OIL COOLER



Illust. 17 - Engine Oil Cooler and Related Parts (TD-24 Torque Converter Tractor and UDT-1091 Power Unit).

Legend for Illust. 17

1. Retaining nut.
2. Retaining nut "O" ring.
3. Case cover.
4. Retaining spring.
5. Sealing cup.
6. Retaining snap ring.
7. Case cover gasket.
8. Filter case cover, assembly.
9. Filter element.
10. Stand pipe.
11. Stand pipe gasket.
12. Filter case .
13. Stud.
14. Case gasket.
15. Filter base.
16. Filter base gasket.
17. Regulating valve.
18. Regulating valve spring.
19. Gasket.
20. Retainer nut.
21. Retainer nut.
22. Retainer nut gasket.
23. By-pass valve spring.
24. By-pass valve.
25. Housing.
26. By-pass valve housing gasket.
27. Elbow (45°).
28. Coupling nut.
29. Inlet pipe, upper.
30. Hose clamp.
31. Hose.
32. Inlet pipe, lower.
33. Outlet pipe, rear.
34. Water pipe connector.
35. Reducing bushing.
36. Oil cooler.
37. Drain valve.
38. Flange gasket.

ENGINE OIL COOLER

16. DESCRIPTION

The oil cooler for the engine oil is mounted on the right side of the engine to the lubricating oil filter base and the by-pass valve housing. All of the engine oil is circulated from the crankcase through the cooler and into the oil filters.

17. REMOVAL (Refer to Illust. 17)

1. Drain the cooling system, oil filters and oil cooler.

2. Remove the right engine side sheet.

3. Remove the batteries and battery support on the right side of the engine.

4. Remove the inlet and outlet hoses (9).

5. TRACTOR ENGINES BELOW SERIAL 1560: Disconnect the two unions (2) and remove the oil cooler from the engine.

6. TRACTOR ENGINES, SERIAL 1560 AND UP: Remove the four screws from the flanges and remove the oil cooler from the engine.

18. INSPECTION AND REPAIR

Improper care of the cooling system or the lubricating oil system are the most probable reasons for poor engine oil cooler performance. Immerse the oil cooler assembly into a cleaning solvent to loosen any sludge or foreign matter. Drain and blow out any solvent and foreign matter inside of the oil cooler, being certain that all passages are clean and clear before reinstallation.

19. INSTALLATION (Refer to Illust. 17)

1. TRACTOR ENGINES BELOW SERIAL 1560: Install the oil cooler to the engine by connecting the two unions (2).

2. TRACTOR ENGINES, SERIAL 1560 AND UP: Position the oil cooler on the engine and secure with four flange screws.

3. Replace and tighten the two hoses (9), being certain that the hoses are not cracked, swollen or show other signs of deterioration.

4. Fill the cooling system and the lubricating oil system as specified in the operator's manual, and check all connections for leaks.

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WATER PUMP

1. DESCRIPTION

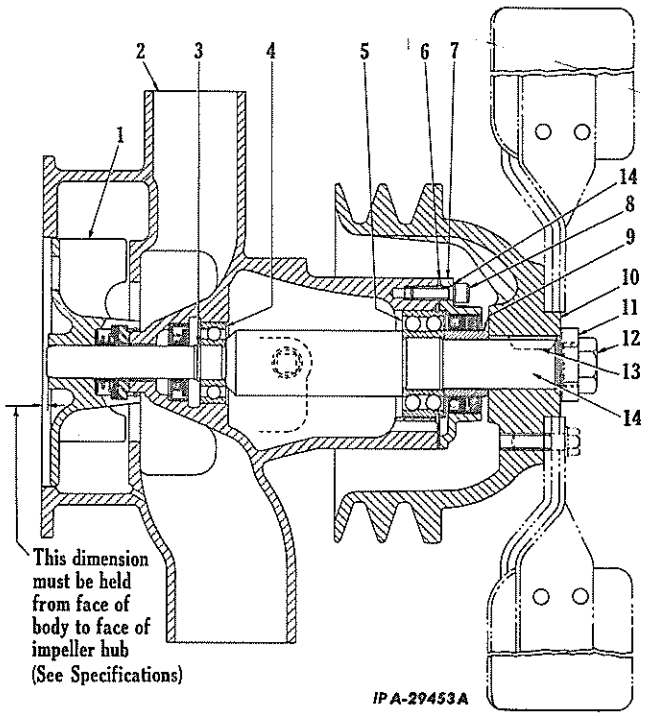
The water pumps used on these engines are centrifugal design, fastened to the front end of the crankcase.

The shaft is supported by two ball bearings. Water sealing is accomplished by a spring loaded seal assembly. The seal and impeller form one assembly that is pressed onto the pump shaft.

NOTE: For testing engines equipped with jet type cooling systems, refer to Par. 26 in this section.

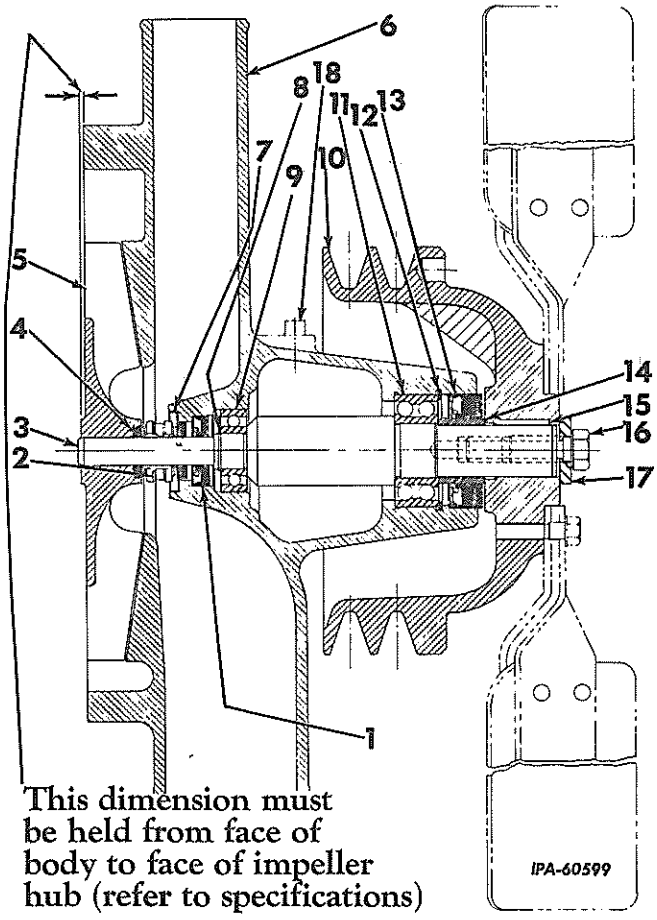
2. MAINTENANCE

If a water leak develops, the sealing parts are worn. Disassembly of the pump is necessary to replace these parts. After installing new pump sealing parts, check the level of the lubricant in the water pump by removing the plug on the side of the housing. If no lubricant is visible, fill with chassis lubricant. Install the plug.



Illust. 1 - Water Pump and Fan Drive Cross Section (1091 Series Shown) (Conventional Type Cooling System).

1. Impeller.
2. Water pump body.
3. Snap ring.
4. Bearing, inner.
5. Bearing, outer.
6. Housing gasket.
7. Oil seal housing.
8. Cap screw.
9. Bearing spacer.
10. Pulley.
11. Washer.
12. Cap screw.
13. Key.
14. Shaft.



Illust. 2 - Water Pump and Fan Drive Cross Section (1091 Series Shown) (Jet Type Cooling System).

1. Oil seal.
2. Seal.
3. Shaft.
4. Seal seat.
5. Impeller.
6. Water pump body.
7. Retainer.
8. Snap ring.
9. Bearing, inner.
10. Pulley.
11. Bearing, outer.
12. Snap ring.
13. Oil seal.
14. Bearing spacer.
15. Key.
16. Cap screw.
17. Washer.
18. Pipe plug.

3. REMOVAL

1. Drain the cooling system.

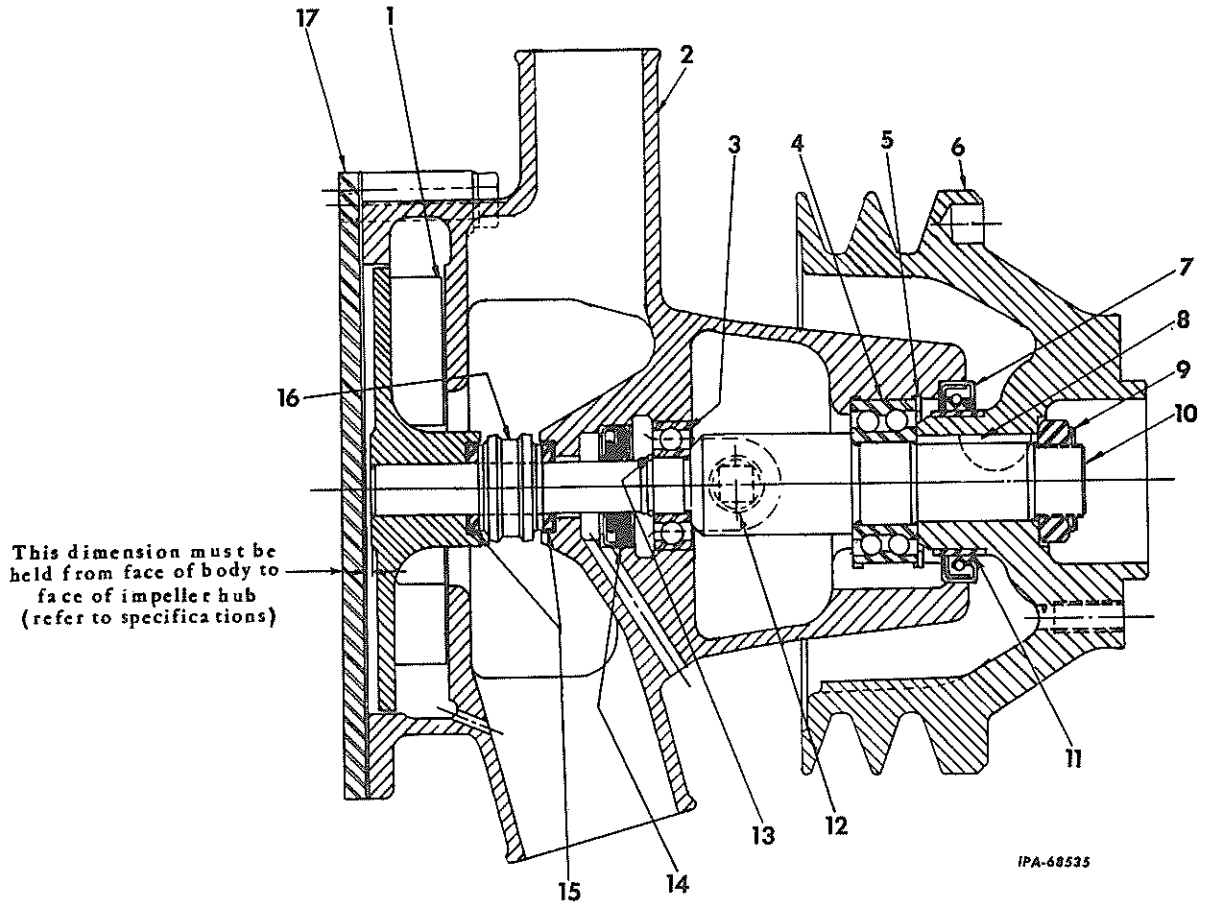
2. Remove the fan guards.

3. Loosen the generator or fan belt idler mounting screws and the bracket or fan belt tensioner. Move the generator or idler toward the engine to slacken the drive belts.

4. Remove the cap screws which secure the fan to the pulley and remove the fan sideways from the engine.

(Continued on next page.)

WATER PUMP



Illust. 2A - Cross Section of Water Pump (554 Series shown) (Jet type cooling system).

1. Impeller.
2. Body.
3. Inner bearing.
4. Outer bearing.
5. Snap ring.
6. Pulley.
7. Outer oil seal.
8. Pulley key.
9. Pulley nut.
10. Shaft.
11. Wear ring.
12. Pipe plug (in body).
13. Snap ring.
14. Inner oil seal.
15. Water pump seal.
16. Water pump seal.
17. Pump cover (if equipped).

3. REMOVAL – Continued

5. Remove the fan belts from the water pump pulley.

6. Loosen the hose clips and force the hoses away from the water pump.

7. Loosen the fan guard support bracket on the forward face of the engine, and push it upward.

8. Fasten a rope around the pump and over the radiator brace; the sling will support the weight of the water pump when the retaining cap screws are removed.

9. Remove the cap screws that secure the pump to the engine, and lift the pump sideways from its position between the radiator and the engine.

4. DISASSEMBLY

Pump for Conventional Type Cooling System
(Ref. Nos. Refer to Illust. 4.)

1. Remove the water pump shaft cap screw (17) and washer or the shaft nut. Some engines are equipped with water pumps having slotted shafts. Remove the staked nut; those having shafts not slotted will have a self-locking nut to be removed. Remove the fan pulley from the pump either by pressing or by using a puller. Remove the pulley key (10).

NOTE: Be careful not to damage the pulley flanges.

2. Remove the three cap screws and lock washers and remove the oil seal housing (15) with oil seal (14), gasket (13) and bearing spacer (12). (Illust 6.) On 16, 525 and 554 Series, first remove the pump cover.

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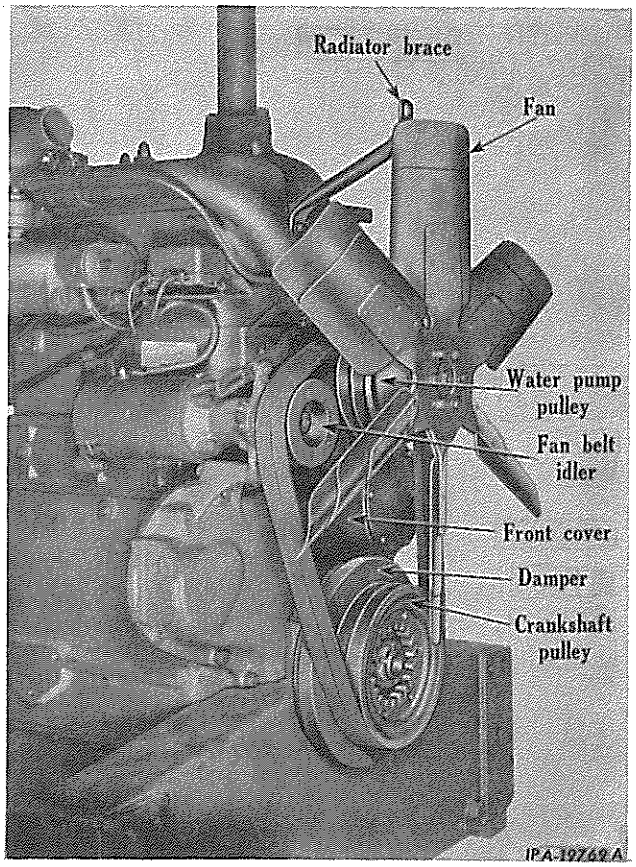
WATER PUMP



Illust. 3 - Fan, Belts and Pulleys (24" Series Engines).

3. Press the impeller shaft (9) out of the impeller (2) and body (5) from the rear (Illust. 7). The bearings (8 and 11) will remain on the shaft.

4. Remove the snap ring (4) from the groove in the impeller (Illust. 8). Remove the seal assembly (3). On earlier type pumps, remove the seal washer, seal, clamp ring and spring (Illust. 9).

5. Remove the inner bearing snap ring (7) from the water pump shaft. Support the inner bearing in a press and push the shaft from the bearing. Reverse the shaft and press it from the outer bearing.

6. Remove the oil seal (14) from the oil seal housing and the oil seal (6) from the water pump body.

NOTE: The oil seal (6) must be pressed from the rear out of the pulley end of the pump body.

Pump for Jet Type Cooling System
(Ref. Nos. Refer to Illust. 5.)

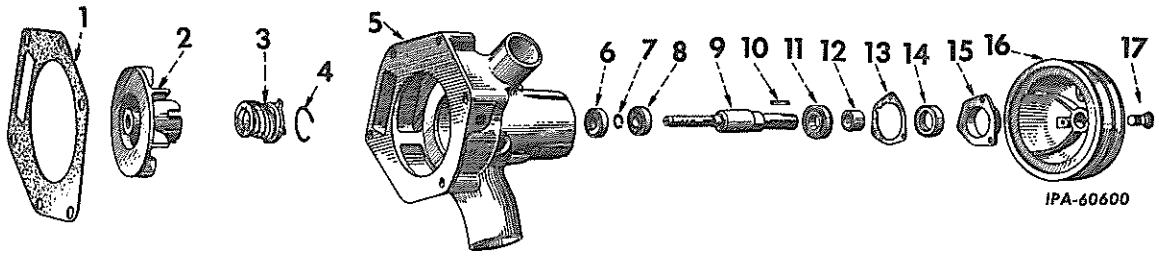
1. Remove the cap screw (18) and washer (17) or the nut (9, Illust. 2A) on 525 and 554 Series. Remove the pulley from the pump by either pressing or by using a puller. Remove the pulley key (11).

2. Remove the outer oil seal (15) and bearing spacer (14) or wear ring (11, Illust. 2A).

3. Remove the snap ring (13) from the groove in the pump body (6). If equipped, remove the pump cover (17, Illust. 2A) and cover gasket.

4. Press the shaft (10) out of the impeller (2) and pump body from the rear (Illust. 7). The bearings (9 and 12) will remain on the shaft.

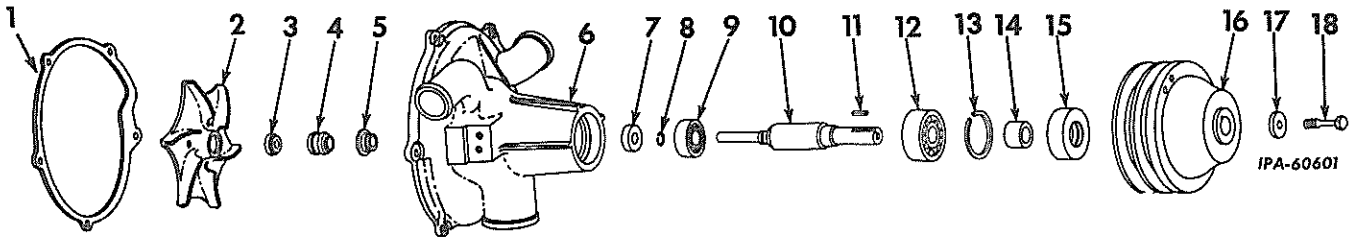
(Continued on next page.)



Illust. 4 - Water Pump Components (UD-1091 Shown, Others Similar) (Conventional Type Cooling System).

1. Gasket.
2. Impeller.
3. Seal assembly.
4. Snap ring.
5. Pump body.
6. Oil seal, inner.
7. Snap ring.
8. Bearing, inner.
9. Shaft.
10. Pulley key.
11. Bearing, outer.
12. Bearing spacer.
13. Seal housing gasket.
14. Oil seal, outer.
15. Oil seal housing.
16. Pulley.
17. Cap screw.

WATER PUMP



Illust. 5 - Water Pump Components (1091 Series Shown, Others Similar) (Jet Type Cooling System).

1. Gasket.
2. Impeller.
3. Seal seat.
4. Seal.
5. Seal retainer.
6. Pump body.
7. Oil seal, inner.
8. Snap ring.
9. Bearing, inner.
10. Shaft.
11. Pulley key
12. Bearing, outer.
13. Snap ring.
14. Bearing spacer.
15. Oil seal, outer.
16. Pulley.
17. Washer.
18. Cap screw

4. DISASSEMBLY - Continued

Pump for Jet Type Cooling System
(Ref. Nos. Refer to Illust. 5.) - Continued

5. 1091 SERIES: Remove the retainer (5), seal (4) and seal seat (3) from the impeller.

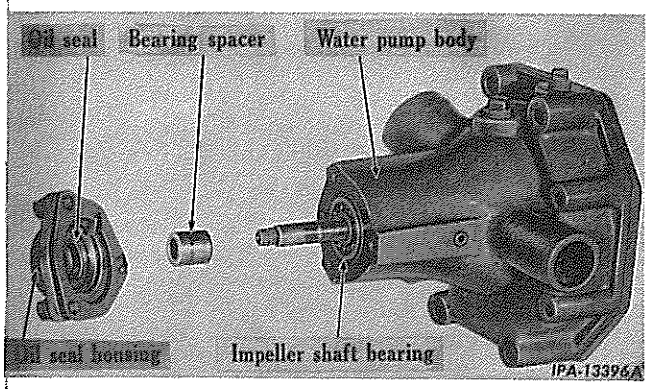
525 AND 554 SERIES: Remove the water pump seals (15 and 16, Illust. 2A) from the impeller.

6. Do not remove the bearings unless replacement is necessary. Remove the snap ring (8) from the water pump shaft. Support the inner bearing (9) in a press and push the shaft from the bearing. Reverse the shaft and press it from the outer bearing (12).

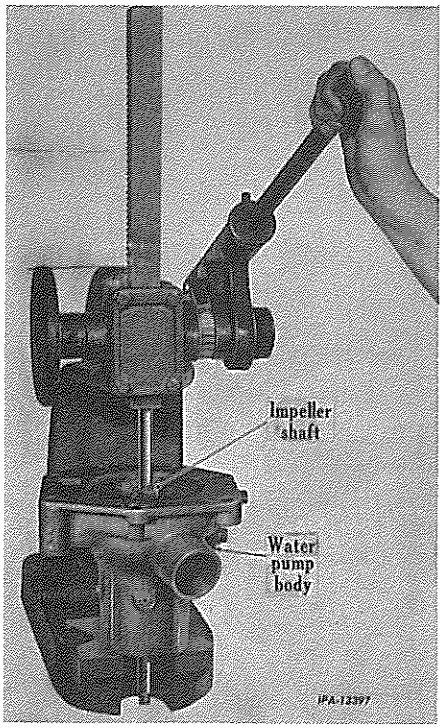
7. Remove the inner oil seal (7) by pressing it out toward the pulley end of the water pump body (6).

5. INSPECTION AND REPAIR

1. Clean and inspect all of the disassembled parts. Examine the parts for wear and for rust or scale. Replace parts as necessary if they cannot be polished to give satisfactory servioe, especially shaft to seal contact surfaces.



Illust. 6 - Removing Water Pump Oil Seal Housing.



Illust. 7 - Removing Impeller Shaft From Pump Body.

2. Use new seals to replace the water seal assembly and the inner and outer oil seals, but do not install until reassembly.

3. Thoroughly clean the inner and outer bearings with dry-cleaning solvent and blow dry with compressed air. Be absolutely sure that no chip particles remain in the bearing races to impair bearing service. If in doubt or if bearings appear worn or damaged, replace with new.

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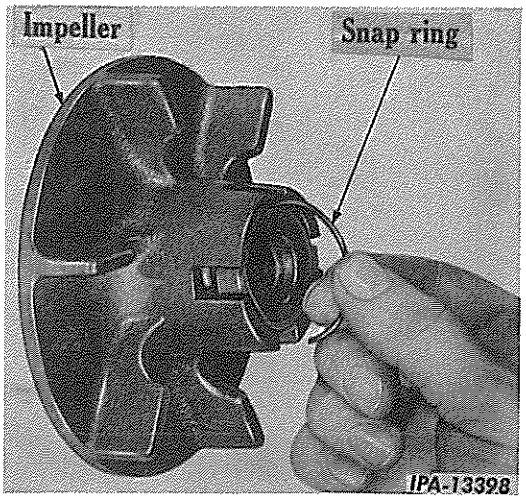
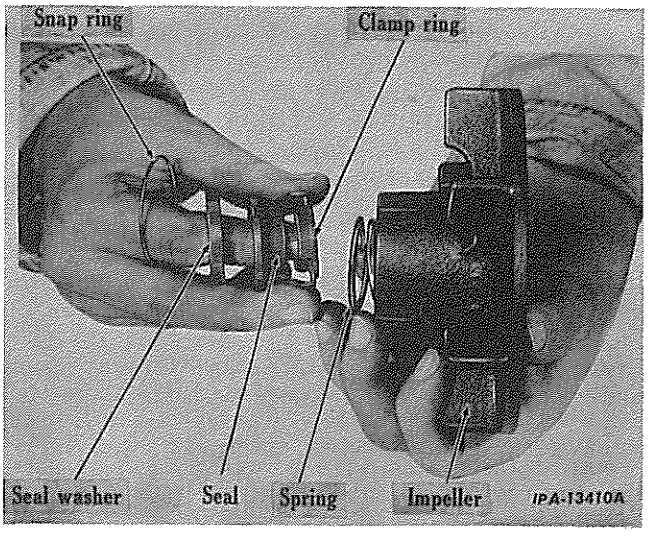
WATER PUMP



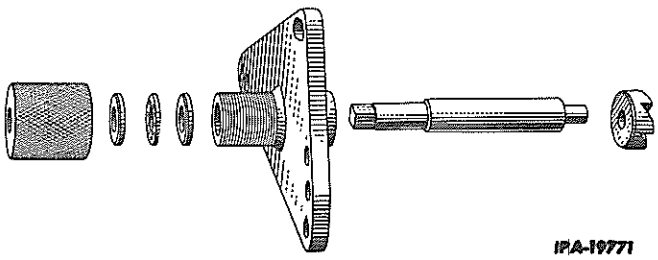
Illust. 8 - Removing Snap Ring From Impeller.

4. Examine the finished impeller hub contact surface for evidence of wear or grooving. Polish this surface or replace the impeller according to condition. Inspect the impeller vanes; remove any nicks, burrs or roughness, particularly along the edges.

5. A resurfacing tool should be used for the removal of rust and pitting from the seal seat in the packless type water pump. (Illust. 10 and 11.) Blueprints are available for making this tool. For blueprints write to: International Harvester Co., Construction Equipment Division, 10400 W. North Ave., Melrose Park, Illinois, attention Service Publications Section.



Illust. 9 - Removing Seal Assembly From Impeller.



Illust. 10 - Exploded View of Packless Type Water Pump Resurfacing Tool.

6. REASSEMBLY

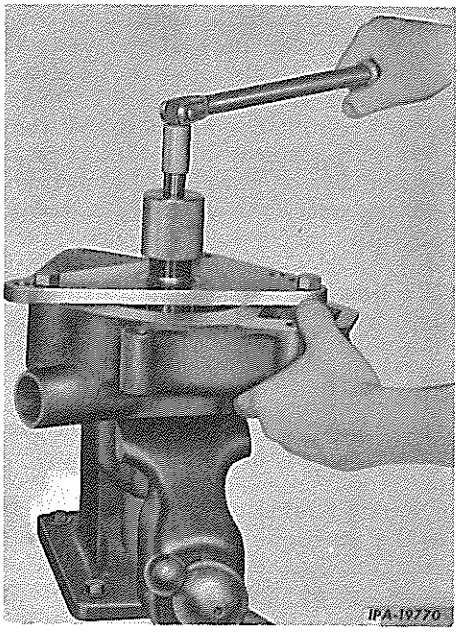
Pump for Conventional Type Cooling System
(Ref. Nos. Refer to Illust. 4.)

1. Install a new oil seal (6) into the pump body by driving it in from the pulley end.

NOTE: The seal is to be installed so that the seal lip faces toward the impeller end of the pump body.

2. Pack the lubricant into the bearings (8 and 11) and then install on the pump shaft (9). Be sure that both the inner and outer races of each bearing are supported when the shaft is pressed into the bearings to avoid distortion and bearing damage. Install the snap ring (7) for the inner bearing.

(Continued on next page.)



Illust. 11- Resurfacing Seal Seat in Packless Type Water Pump.

WATER PUMP

6. REASSEMBLY - Continued

Pump for Conventional Type Cooling System (Ref. Nos. Refer to Illust. 4.) - Continued

3. Insert the shaft, with both bearings installed, into the pump body and into the inner oil seal. Use a rotary motion when passing the shaft through the seal to avoid damage to the sealing surface. Work the shaft in as far as it will go.

4. Place the pump body in a press, impeller end down and supported so that the shaft can emerge beyond the body. Select a cylindrical fixture, having a wall thickness that will contact both races of the outer bearing, to avoid bearing distortion and damage when pressure is applied. Place this fixture over the pulley end of the shaft and onto both races of the outer bearing. Apply pressure until the outer bearing ring bottoms in the shoulder of the pump body. This operation also seats the inner bearing and positions the shaft in the body.

5. Install a new seal assembly (3) into the impeller (2) and secure with the snap ring (4). On earlier type pumps, install the spring (small end first), clamp ring, new seal and new washer in the impeller and secure with the snap ring (Illust. 9).

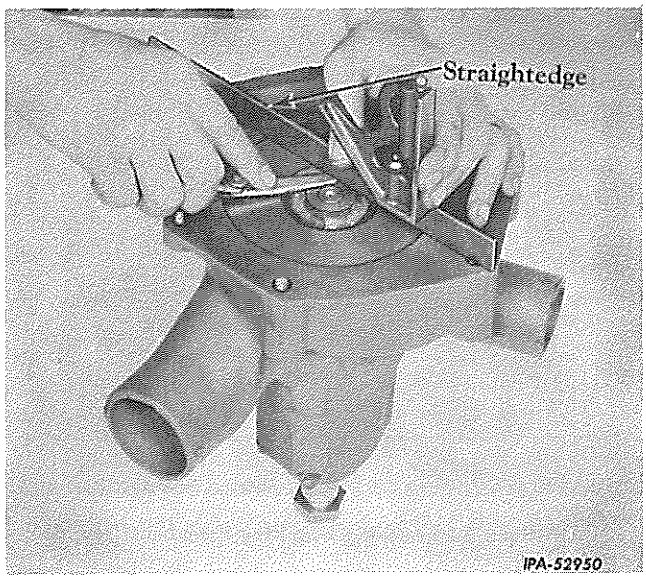
6. With the impeller end up, place the pump in a press to rest the pulley end of the shaft on a support. Position the impeller on the shaft and press the impeller onto the shaft until the impeller hub is flush with the end of the shaft The distance from the face of the body to the face of the impeller hub must be held to the dimensions given in "SPECIFICATIONS" in Section 1, to prevent impeller vanes from scraping the pump chamber. Measure this distance (refer to Illust. 1 and 12) and continue to apply pressure until the correct measurement is obtained.

7. Install a new oil seal (14) into the housing (15) so that, when the oil seal housing is installed, the seal lip will be facing the water pump body.

8. Install the bearing spacer (12) on the shaft until it is up against the outer bearing.

9. Using a new gasket, secure the oil seal housing to the pump body with the three cap screws and lock washers. (Illust. 6.) On 16, 525 and 554 series, install the pump cover.

10. Insert the pulley key into the slot in the shaft and drive or press on the pulley.



Illust. 12 - Checking the Clearance Between Face of Body and Face of Impeller Hub.

11. Install the cap screw (17) and washer or the shaft nut (as equipped) and tighten to the torque given in "SPECIFICATIONS" in Section 1.

NOTE: On pumps equipped with a slotted shaft, stake the shoulder of the nut into the shaft slot. Do not install a self-locking nut on a slotted shaft.

Pump for Jet Type Cooling System (Ref. Nos. Refer to Illust. 5.)

1. Install a new inner oil seal (7) into the pump body by driving it in from the pulley end.

NOTE: The seal is to be installed so that the seal lip faces toward the impeller end of the pump body.

2. Pack lubricant into the bearings (9 and 12) and install on the pump shaft (10). Be sure that both the inner and outer races of each bearing are supported, when the shaft is pressed into the bearings, to avoid distortion and bearing damage. Install the snap ring (8) for the inner bearing.

3. Insert the shaft, with both bearings installed, into the pump body and into the inner oil seal. Use a rotary motion, when passing the shaft through the seal, to avoid damage to sealing surface. Work the shaft in as far as it will go.

4. Place the pump body in a press, impeller end down and supported so that the shaft can emerge beyond the body. Select a cylindrical fixture, having a wall thickness that will contact both races of the outer bearing, to avoid bear-

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WATER PUMP

ing distortion and damage when pressure is applied. Place this fixture over the pulley end of the shaft and onto both races of the outer bearing. Apply pressure until the outer bearing bottoms in its bore and the snap ring (13) can be installed in the groove of the body. This operation also seats the inner bearing and positions the shaft in the body.

5. 1091 SERIES: Install the new seal seat (3), new seal (4) and new seal retainer (5) into the impeller (2).

525 AND 554 SERIES: Install the new water pump seal assembly (15 and 16) onto the impeller (1) Refer to Illust. 2A.

6. With the impeller end up, place the pump in a press to rest the pulley end of the shaft on a support. Position the impeller on the shaft and press the impeller onto the shaft.

The distance from the face of the body to the face of the impeller hub must be held to the dimensions given in "SPECIFICATIONS" in Section 1, to prevent impeller vanes from scraping the pump chamber. Measure this distance (refer to Illust. 2, 2A and 12) and continue to apply pressure until the correct measurement is obtained.

7. 1091 SERIES: Install the bearing spacer (14) on the shaft until it is up against the outer bearing.

8. Install the oil seal (15) (lip facing toward the impeller end) so that it rests against the shoulder in the pump body.

9. 1091 SERIES: Insert the pulley key (11) into the shaft slot and drive or press on the pulley.

525 AND 554 SERIES: Insert the pulley key (8) in the shaft slot. Place the wear ring (11) on the pulley and drive or press the pulley on the shaft. Refer to Illust. 2A.

10. Install the washer (17) and cap screw (18) or the nut (9, Illust. 2A) on 525 and 554 Series, and tighten to the torque given in "SPECIFICATIONS" in Section 1.

11. Install the pump cover (17, Illust. 2A) and new gasket to the pump body with the cap screws and washers (if equipped).

7. INSTALLATION

1. Fasten a rope around the pump and over the radiator brace; the sling will take the weight of the water pump as the retaining cap screws are installed.

2. Place the pump in position between the radiator and the engine and, using a new gasket (1, Illust. 4 or 5), secure the pump to the crankcase. Torque the cap screws to the amount shown in "SPECIFICATIONS" in Section 1.

3. Install all hose connections to the pump and secure with clamps.

4. Position the fan guard support bracket on the face of the engine and tighten the cap screw.

5. Install the fan belts on the water pump pulley.

6. Place the fan sideways between the engine and radiator and secure the fan to the pulley with the cap screws.

7. Install the fan belt tensioner (if equipped) to the pump body.

8. Adjust the fan belts as described in the pertinent operator's manual.

9. Install the fan guards.

10. Fill the cooling system.

WATER HEADER AND THERMOSTATS

8. DESCRIPTION

Engines covered in this manual are equipped with one, two or four thermostats, depending upon the engine series and type of cooling system.

There are two types of cooling systems used on these tractors. The partial flow by-pass system and the full-flow by-pass system.

When the engine is started cold, the thermostats are closed, preventing circulation of lower temperature coolant from the radiator. The coolant circulates only through the water pump and engine water passages. This circulation during the warm-up period prevents the formation of steam pockets. When the engine reaches operating temperature, which is determined by the thermostat specifications, the thermostat expands and opens the passage for the coolant to flow from the engine water passages through the radiator and back to the water pump. The temperature of the coolant controls the extent of thermostat opening which, in turn, controls the amount of coolant circulating through the radiator.

The later type system or full-flow by-pass system uses less thermostats (two in 1091 series, one in 525 and 554 series) and, during the warm-up period when the thermostats are closed, the rate of coolant flow within the engine is greater as there is less chance for any restriction.

When operating below thermostat opening temperature, approximately the total water pump output is allowed to flow, giving a better scrubbing action in the water jacket, and a better cooling action to the usual hot-spot areas.

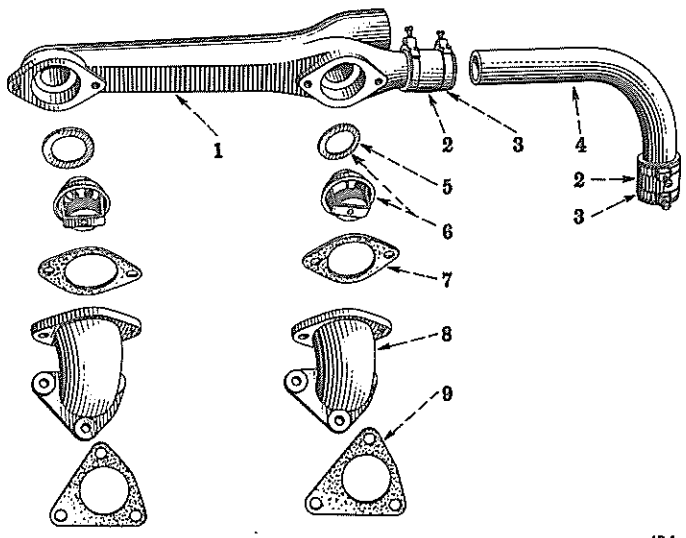
9. MAINTENANCE

The thermostat can be checked by removing it and placing it in water. Place a thermometer in the water and then start heating the water. The thermostat should start to open and be wide open at the temperatures given in "SPECIFICATIONS," Section 1. Replace the thermostat if it does not operate within the above range.

10. REMOVAL

1. Drain the coolant to at least the level of the water header.

2. Loosen the hose clamps and push back the hoses connecting to the by-pass pipe and radiator inlet pipe (Illust. 17).



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Illust. 13 - Water Header and Thermostats (16 and Early 525 Series Engines).

1. Water header.
2. By-pass hose.
3. Hose clamp.
4. By-pass pipe.
5. Thermostat seal.
6. Thermostat.
7. Gasket.
8. Outlet elbow.
9. Elbow gasket

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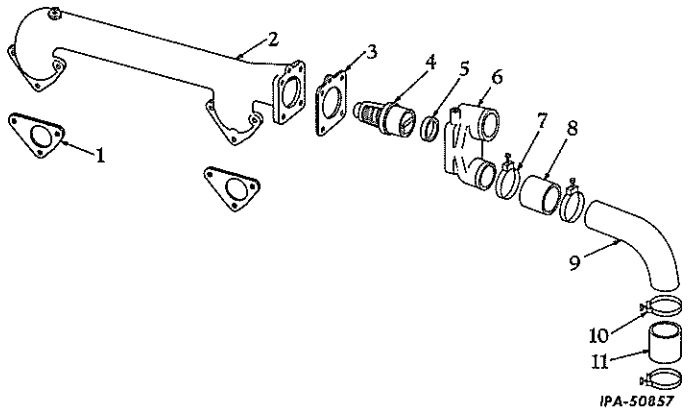
WATER HEADER AND THERMOSTATS

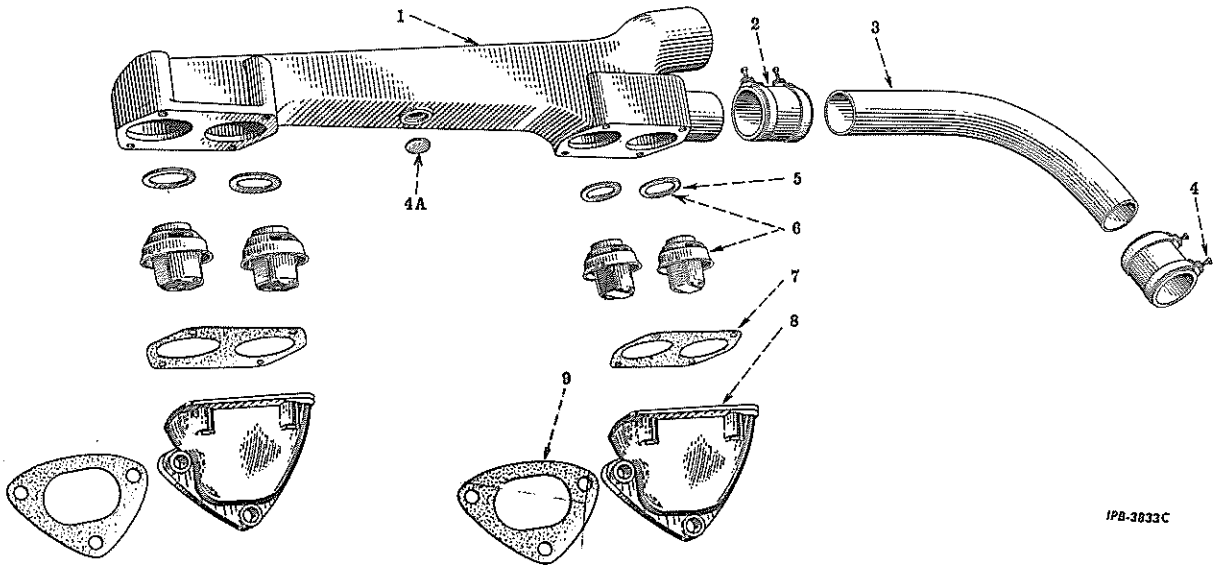
3. FULL-FLOW BY-PASS SYSTEM: Remove the cap screws securing the thermostat housing to the water header (Illust. 14 and 16). Remove the housing with the thermostat (two thermostats in 1091 series), take the gasket off of the housing and remove the thermostat from the housing.

4. PARTIAL FLOW BY-PASS SYSTEM: Remove the cap screws securing the water outlet header to the elbows, lift off the water header and remove the thermostats (Illust. 13 and 15).



Illust. 14 - Water Header and Thermostats (Late Series 525 and 554 Engines).

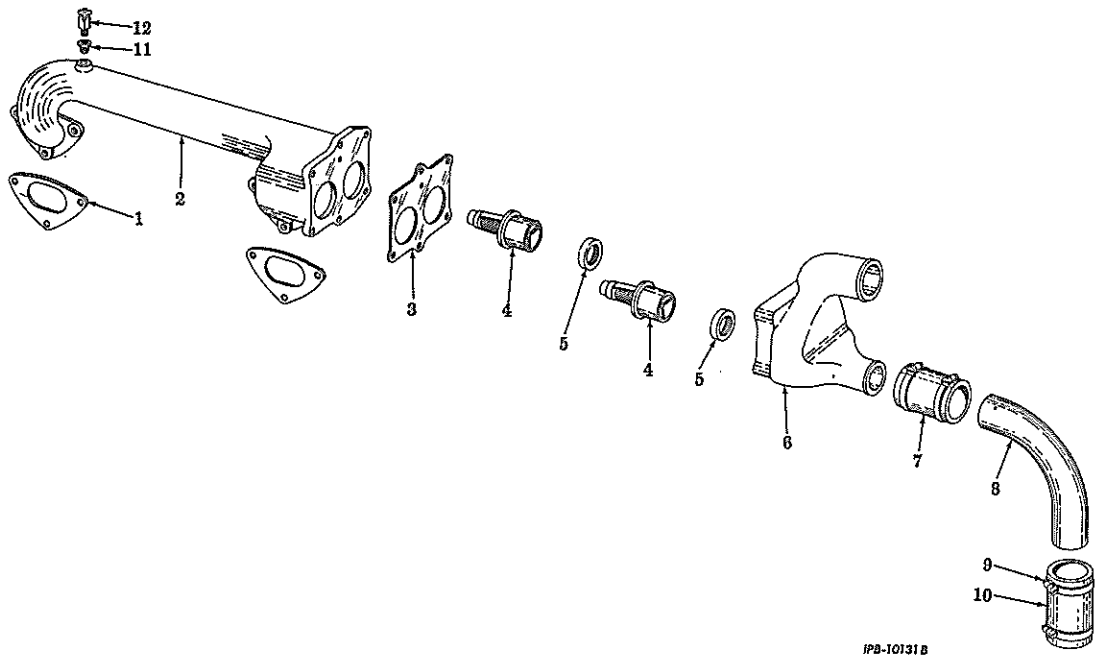
1. Gasket.
2. Water header.
3. Housing gasket.
4. Thermostat.
5. Seal.
6. Housing.
7. Hose clamp.
8. By-pass hose.
9. By-pass pipe.
10. Hose clamp.
11. By-pass hose.



Illust. 15 - Water Header and Thermostats (24 and Early 1091 Series Engines).

1. Water header.
2. By-pass hose.
3. By-pass pipe.
4. Hose clamp.
5. Thermostat seal.
6. Thermostat.
7. Gasket.
8. Outlet elbow.
9. Gasket.

WATER HEADER AND THERMOSTATS



Illust. 16 - Water Header and Thermostats (Late Series 1091 Engines).

1. Gasket.
2. Water header.
3. Housing gasket.
4. Thermostat.
5. Ring and seal.
6. Housing.
7. By-pass hose.
8. By-pass pipe.
9. Hose clamp.
10. By-pass hose.

11. INSTALLATION

Full-Flow By-pass System

1. Place thermostat (or thermostats) into the thermostat housing, being certain that the rubber seal inside of the thermostat housing seats snugly around the thermostat.

2. Apply sealer to the gasket surfaces of the thermostat housing and the water header. Be sure that the thermostat housing gasket is in good condition; if not, replace the gasket.

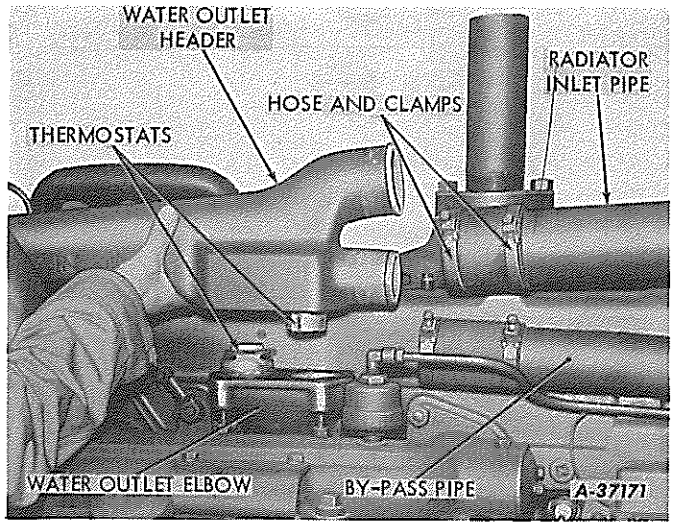
Partial Flow By-pass System

3. Assemble the thermostat housing with the thermostat (or thermostats) to the water header and install the hoses and clamps.

4. Insert the thermostats into the water outlet header, each with the bellows end down and the mark "FRONT" (stamped on the lip of the thermostat) toward the radiator.

5. Apply sealer to the gasket surfaces of the header and the elbows, and install new gaskets. Be sure to insert the thermostats before installing the gaskets.

6. Assemble the water outlet header, with thermostats, to the elbows, and install the hoses and clamps (Illust. 17).

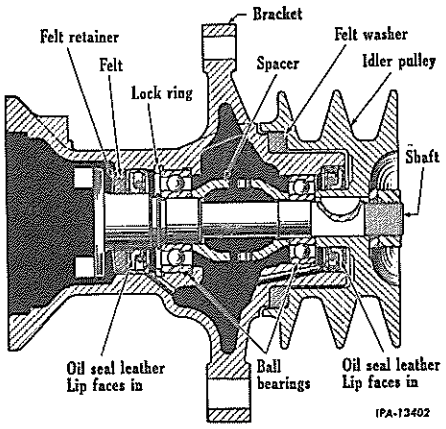


Illust. 17 - Water Outlet Header and Thermostat Removal.

FAN IDLER PULLEY AND BRACKET

12. REMOVAL

Remove the bolts which secure the idler bracket to the pulley brace and crankcase front cover.



Illust. 18 - Fan Idler Bracket and Pulley (Old Style).

13. DISASSEMBLY

Old Style

1. (a) POWER UNITS: Remove the bracket cover.

   (b) TRACTORS: Remove the generator from the idler bracket.

2. Remove the nut and lock washer from the end of the idler shaft.

3. Using a pulley, remove the idler pulley from the idler shaft.

4. Remove the key from the idler shaft and tap the idler shaft from the bracket.

5. Tap out the front oil seal by placing a drift against the front bearing and tapping evenly all around. The bearing drives out the seal. The idler bearing and the spacer will then drop out.

6. Drive out the felt retainer, remove the felt, and drive out the oil seal.

7. Remove the bearing lock ring. Tap the bearing evenly around the outer race to remove it.

New Style

1. (a) POWER UNITS: Remove the bracket cover.

   (b) TRACTORS: Remove the generator and coupling spacer from the idler bracket.

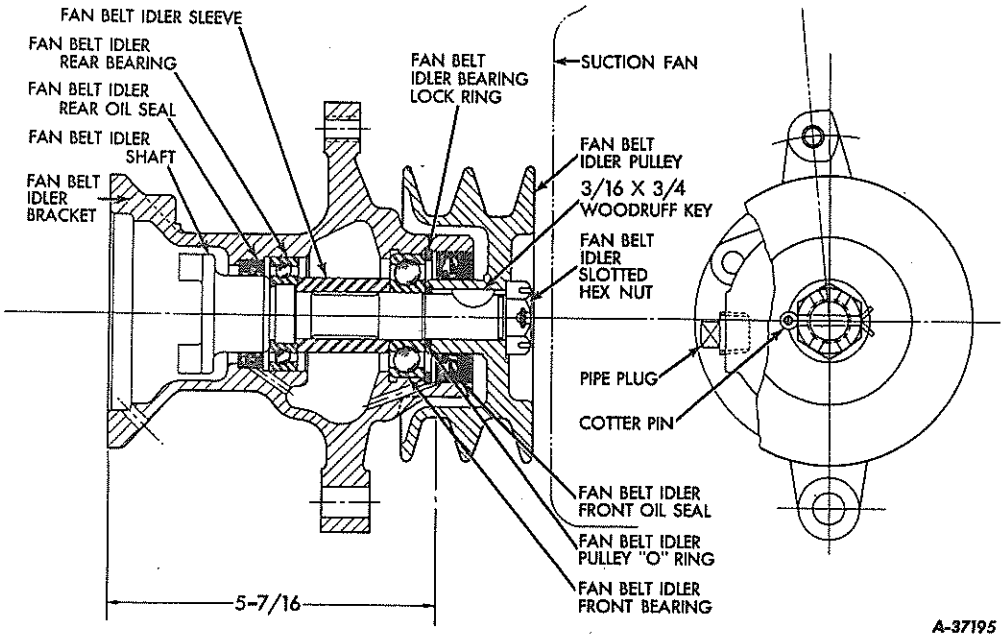
2. Remove the cotter pin and nut from the end of the idler shaft.

3. Use a puller and remove the idler pulley from the idler shaft.

4. Remove the key and "O" ring from the idler shaft and tap the shaft from the bracket.

5. Remove the front oil seal from the idler bracket with a puller.

(Continued on next page.)



Illust. 19 - Cross Section of Fan Belt Idler (New Style).

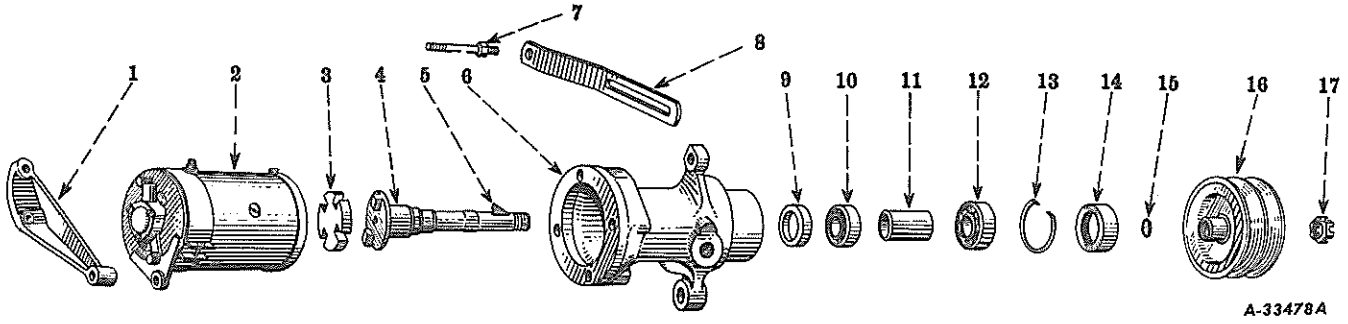
FAN IDLER PULLEY AND BRACKET

13. DISASSEMBLY - Continued

New Style - Continued

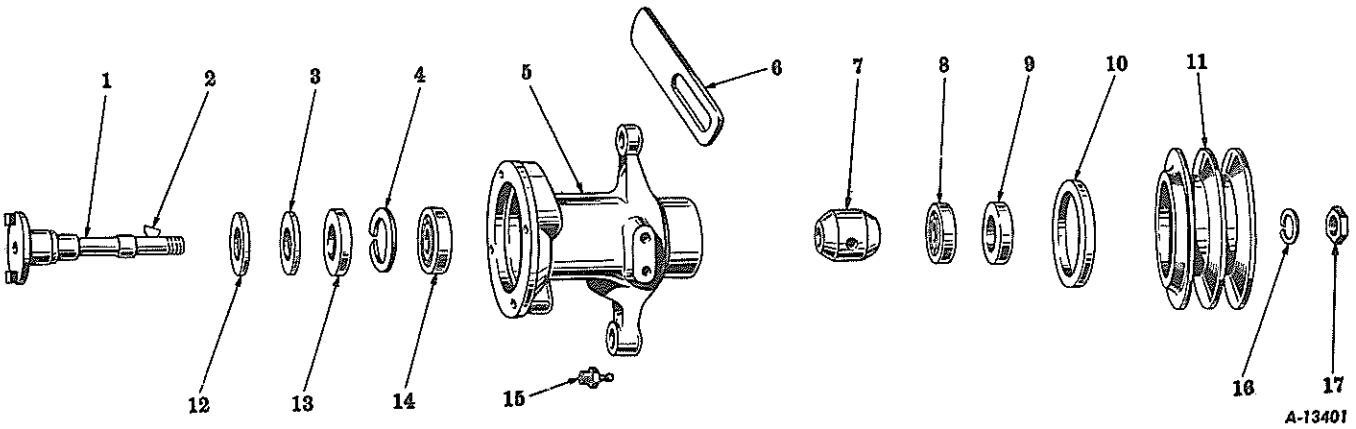
6. Remove the front bearing lock ring. Using a 15/16 inch diameter brass rod, press the sleeve and front bearing out the front of the fan belt idler housing bracket.

7. Press the rear oil seal out the front of the idler bracket. The oil seal will drive the rear bearing out ahead of it.



Illust. 20 - Exploded View of Fan Belt Idler, Pulley, Generator and Bracket (U and UD-1091).

1. Generator bracket.
2. Generator.
3. Coupling spacer.
4. Idler shaft.
5. Idler pulley key.
6. Idler bracket.
7. Idler brace bolt.
8. Idler brace.
9. Idler oil seal, rear.
10. Idler bearing, rear.
11. Idler sleeve.
12. Idler bearing, front.
13. Idler bearing lock ring.
14. Idler oil seal, front.
15. Idler pulley "O" ring.
16. Idler pulley.
17. Idler nut.



Illust. 21 - Exploded View of Fan Idler (Old Style) (24 Series Shown).

1. Idler shaft.
2. Pulley key.
3. Shaft felt.
4. Bearing lock ring.
5. Idler bracket.
6. Pulley brace.
7. Bearing spacer.
8. Ball bearing, front.
9. Oil seal, front.
10. Pulley felt.
11. Idler pulley.
12. Felt retainer.
13. Oil seal.
14. Idler ball bearing.
15. Idler lubricator.
16. Lock washer.
17. Jam nut.

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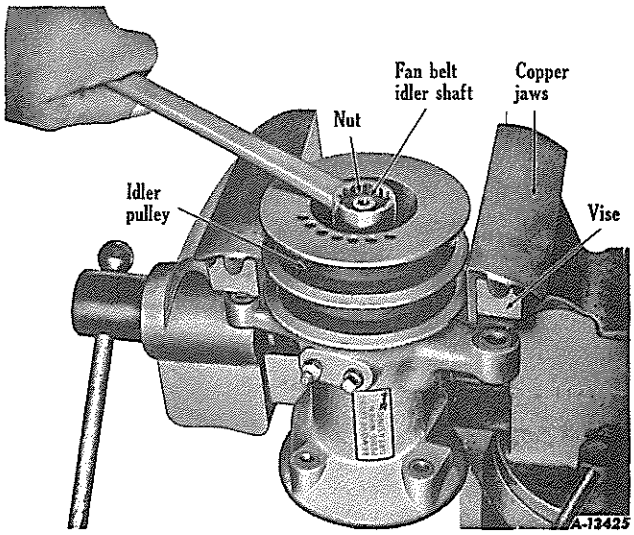
FAN IDLER PULLEY AND BRACKET



Illust. 22 - Removing Nut From Idler Shaft.

14. INSPECTION AND REPAIR

1. Clean all parts thoroughly in clean solvent.

2. Check the bearings and be sure each bearing fits tightly on the shaft and in the bracket.

3. Be sure that there is no stoppage in the lubricator on the idler bracket.

15. REASSEMBLY

Old Style

1. Tap the rear bearing into place against the shoulder in the housing. Be sure to use a drift in the outer race and tap it evenly all around.

2. Install the lock ring and a new oil seal. Place the new oil seal in the housing with the lip toward the bearing.

3. Install a new felt washer on the oil seal. Install a new shaft felt retainer, placing the flared edge toward the bearing.

4. Tap the idler shaft into place, and install the bearing spacer so the end with the largest opening goes on first.

5. Position the front bearing snugly against the spacer. Set a wooden block under the idler shaft to keep the shaft from pushing out of the bracket while the bearing is being tapped into place.

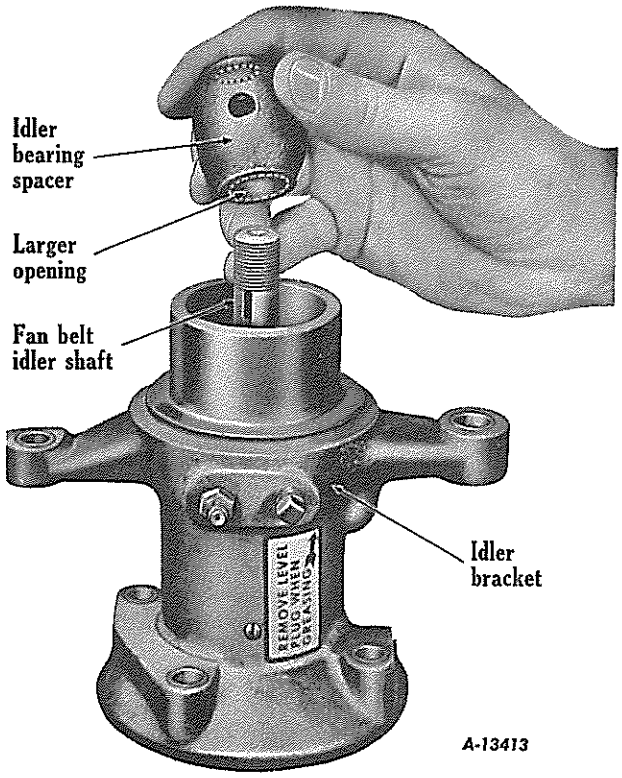
6. Install a Woodruff key to the shaft and insert an oil seal over the shaft, with the lip of the oil seal toward the inside of the bracket. Tap the seal down into the bracket until it is flush with the end of the bracket.

NOTE: Be sure to install the key before installing the oil seal.

7. Install a new felt on the idler bracket. Tap the pulley down into position so the slot in the pulley lines up with the key in the idler shaft. Secure the pulley to the shaft with a lock washer and nut.

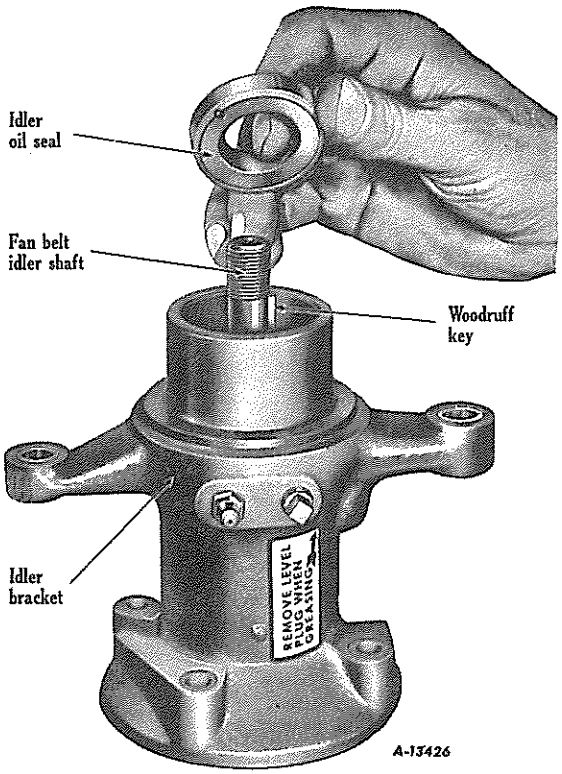
8. (a) POWER UNITS: Fasten the bracket cover to the bracket.

(Continued on next page.)

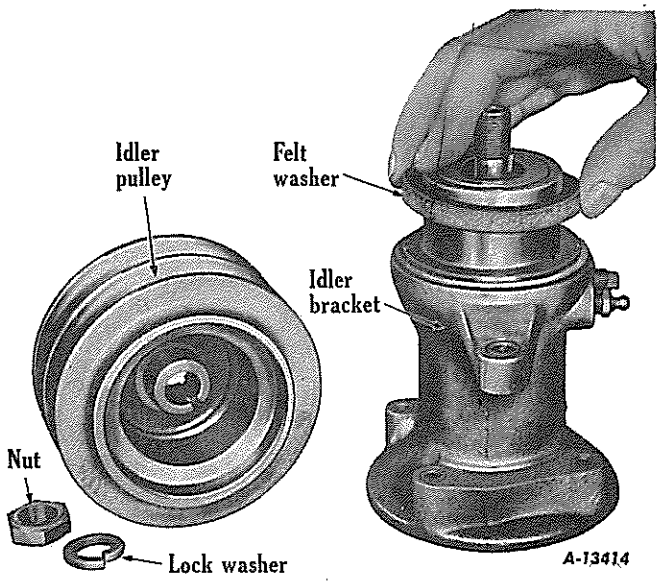


Illust. 23 - Installing Idler Bearing Spacer.

FAN IDLER PULLEY AND BRACKET



Illust. 24 - Installing Idler Oil Seal.



Illust. 25 – Installing Felt Washer.

15. REASSEMBLY - Continued

Old Style-Continued

(b) TRACTORS: Turn the pulley until the male part of the coupling on the idler shaft engages with the coupling on the generator shaft. Then fasten the idler to the generator with a cap screw.

New Style

1. Install a new rear bearing oil seal in the bracket, with the lip toward the bearing. Be sure the seal is seated firmly against the shoulder in the bracket.

2. Using the outer race, press the rear bearing into place evenly, approximately 2-15/16 inches below the machined front face of the idler bracket.

3. Install the idler sleeve and the front bearing. Press the outer race of the front bearing evenly until it is firmly seated against the shoulder of the bore in the idler bracket. Install the front bearing lock ring. The idler sleeve should be loose between the two bearings at this stage of assembly.

4. Install the idler shaft from the rear of the idler bracket and tap into place so that all play is taken up between the bearings and sleeve.

5. Install the "O" ring on the idler shaft against the front bearing. Insert the key in the idler shaft.

6. Install a new front bearing oil seal in the idler bracket, with the lip toward the bearing. Tap the seal in until it is flush with the end of the bracket.

NOTE: Be sure to install the shaft key before installing the oil seal.

7. Tap the pulley into position on the shaft so the key and the keyway are aligned. Secure the pulley to the shaft with the castellated nut and cotter pin.

8. (a) POWER UNITS: Install the bracket cover on the bracket.

FAN IDLER PULLEY AND BRACKET

(b) TRACTORS: Install the generator coupling spacer on the drive lugs of the idler shaft. Turn the pulley until the generator coupling engages with the spacer. Secure the idler to the generator with cap screws and lock washers.

16. INSTALLATION

Fasten the fan idler assembly to the pulley brace and the crankcase front cover.

NOTE: Lubricate with the proper amount and grade of oil. See operator's manual lubrication chart.

FAN AND FAN BELT

17. DESCRIPTION

A fan is mounted on the same pulley that drives the water pump. The pulley revolves on two single row ball bearings.

18. MAINTENANCE

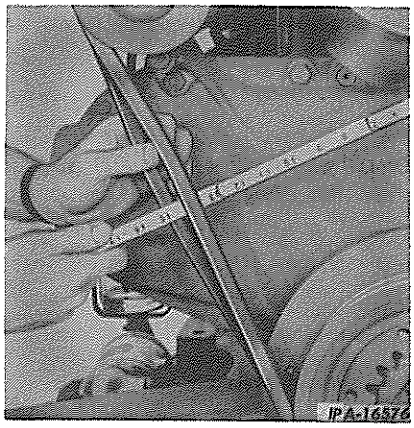
Check and tighten the studs and cap screws holding the fan to the pulley. Check the fan blades for runout and bend into line if necessary.

The life of a fan belt depends, to a great extent, on proper tension adjustment when it is first installed and readjustments made at proper intervals. If it is damaged, grease soaked, bottoming in the drive pulley or can no longer be adjusted, the belt should be replaced. By depressing the belt with the thumb midway between the pulleys (Illust. 26), the allowable slack for most units is 3/4 to 1 inch.

On engines equipped with the fan belt tensioner, the possibility of fan belt slippage (which results in fan belt wear and engine overheating) is prevented.

19. REMOVAL

1. Remove the fan guard.



Illust. 26 - Checking Tension of the Fan Belt.

2. Remove the right fan housing sheet. (On "24" series engines with new type fan housing sheets, this is not necessary.)

3. Remove the cap screws holding the fan to the pulley.

20. INSTALLATION

1. Attach the fan to the pulley with cap screws.

2. Install the fan housing sheet.

3. Install the fan guard.

FAN BELT TENSIONER

21. REMOVAL (Refer to Illust. 27)

1. Loosen the nut (1) and turn the slotted end of the spring guide (5) to remove the tension on the belts.

2. Remove the generator pivot bolt (10) and the retainer ring (8), and remove the fan belt tensioner complete.

22. DISASSEMBLY (Refer to Illust. 27)

1. Remove the nut (1) from the spring guide (5) and the roll pin (2) from the slide block (3).

2. Remove the spring guide (5) from the tensioner yoke (9).

3. Remove the roll pin (6) from the spring guide (5) and slide the spring guide out of the slide block (3).

4. Remove the spring (4) from the spring guide (5).

5. Bushings (11) may be removed if inspection proves replacement is necessary.

FAN BELT TENSIONER

23. REASSEMBLY (Refer to Illust. 27)

1. Insert the tensioner spring guide (5) into the tensioner spring (4).

2. Insert the tensioner spring guide (5) through the tensioner slide block (3).

3. Insert the roll pin (6) through the spring guide on the outside of the block. The roll pin must be centered in the guide.

4. Insert the spring guide (5) into the tensioner yoke (9), at the same time inserting the roll pin (2) under the tensioner yoke (9), making sure the pin is centered with the split in the pin in a downward position. Secure the guide to the yoke by turning the guide (5) into the threaded block in the yoke (9) and turn the nut (1) on to the guide (5).

5. Insert the two bushings (11) into the tensioner slide block (3).

24. INSTALLATION (Refer to Illust. 27)

1. Secure the tensioner yoke pivot bolt (7) to the water pump body. Torque the bolt to the amount specified in Section 1.

2. Slip the forward end of the tensioner yoke (9) over the yoke pivot bolt (7) and secure it with the retainer ring (8).

3. Locate the tensioner slide block (3) so it is in line with the generator bracket by turning the tensioner spring guide (5) with a screwdriver. By turning the guide in a clockwise rotation the slide block will move forward, while turning the guide in a counter-clockwise rotation the slide block will move backward.

4. Attach the tensioner slide block (3) to the generator bracket using the belt tensioner generator pivot bolt, upper (10), with a nut and lock washer.

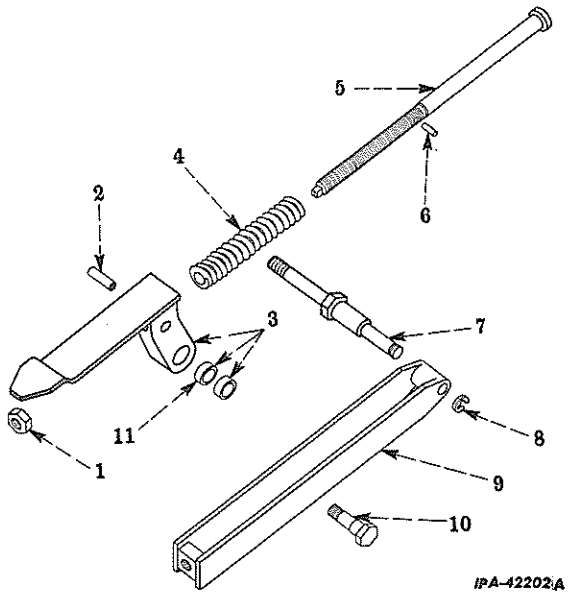
25. ADJUSTMENT (Refer to Illust. 28)

1. To adjust for correct tension, turn the slotted end of spring guide (2) counterclockwise until pointer (1) is approximately one inch back from the slotted end of spring guide. Tighten the nut (4). The belt tensioner is correctly adjusted when the pointer is in position as shown in Illust. 28.

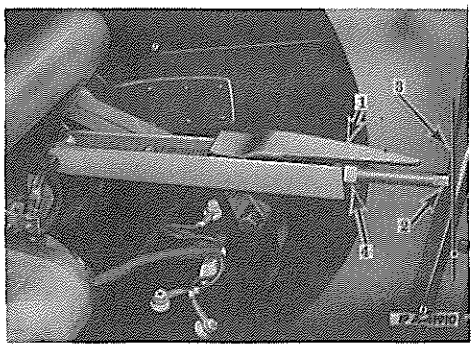
2. The belt tensioner must be readjusted when the end of the pointer (1) and the slotted end of the spring guide (2) are in line with each other at 3.

3. When end of pointer and slotted end of spring guide are in line with each other in outermost extended position at point of hood line, belts must be changed.

CAUTION: Do not continue to tighten belts after spring has been compressed to solid height, as severe fan belt damage may occur.



Illust. 27 - Exploded View of Fan Belt Tensioner.



Illust. 28 - Fan Belt Tensioner Adjustment.

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26. FIELD TEST OF JET TYPE COOLING SYSTEMS

In order to realize the full potential of the jet type cooling system's ability to prevent deposit formation and thereby increase the service life of the cylinder head, it is essential to maintain coolant flow rates above a specified minimum. Whether a particular installation meets these requirements can be determined by pressure testing the cooling system and analyzing the data obtained as described below.

Test Setup

Drain the cooling system and install gauges as indicated; then refill the system.

Pressure Gauge Location	Pressure Gauge Range	
Jet type cooling system	554 diesel engines	1091 diesel engines
Pump Inlet *	0-15 psi & 0-30" hg. (Mercury)	0-15 psi & 30" hg. (Mercury)
Pump Outlet	0-30 psi	0-60 psi
Crankcase drain	0-30 psi	0-60 psi
Cylinder head	0-15 psi	0-30 psi

* Combination pressure and vacuum gauge

Test Procedure

Check fan belt tension and adjust, if required. With coolant cold, check level in radiator or auxiliary tank and add if below the baffle. With the pressure cap installed, start the engine and allow it to warm up. When the hand of the heat indicator begins to move, bring the engine up to high idle. Partially block the radiator with strong paper or cardboard and adjust until the temperature stabilizes in the middle of the green or RUN band. Record coolant pressures at the locations indicated, remove the pressure cap and again take pressure readings. Remove paper or cardboard and allow engine to cool at low idle for five minutes before reinstalling pressure cap.

Analysis :Data

The prevention of deposit formation is dependent upon the scrubbing action of high velocity jet streams directed at the critical areas of the cylinder head lower deck. It has been established that flow through the jet tubes is proportional to the difference between coolant pressures in the crankcase and cylinder head referred to as pressure differential. As indicated by the chart, the maximum benefit of jet cooling will be obtained when at high idle, pressure differential of 8 psi (554 diesel engine) and 12 to 16 psi (1091 diesel engine) depending on whether the gear drive or torque converter package is used are maintained in the respective jet type cooling systems. When these figures are not obtained, it will be necessary to investigate various cooling system components as follows:

(Continued on next page)

FAN BELT TENSIONER

26. FIELD TEST OF JET TYPE COOLING SYSTEMS - Continued

Analysis Data - Continued

Pressure Gauge Location	Pressure Data Range **		
		1091 Diesel Engine	
Jet Type Cooling System	554 Diesel Engines	Gear Drive	Torque Converter
Pump Inlet (1)	4" Hg (Mercury) Vacuum to 3 psi	4" HG (Mercury) Vacuum to 2 psi	4" HG (Mercury) Vacuum to 2 psi
Pump Outlet (2)	26-30 psi	26-30 psi	24-28 psi
Crankcase Drain (3)	20-24 psi	28-32 psi	24-28 psi
Cylinder Head (4)	12-16 psi	12-16 psi	10-14 psi
Maximum Pump Inlet Vacuum ***	0 to 4" Hg (Mercury) Vacuum	0 to 4" Hg (Mercury) Vacuum	0 to 4" Hg (Mercury) Vacuum
Minimum Pressure Differential (3 minus 4)	8 psi	14-16 psi	12-14 psi

** At high idle speeds with pressure cap installed, pressures should be at high limit range.
*** With pressure cap removed.

1. If the pump inlet vacuum WITH THE THERMOSTAT(S) OPEN and the pressure cap removed exceeds the limits specified, restriction in the radiator core is indicated. (This may be due to partially plugged tubes.) Rod out radiator core or replace, if necessary and repeat test. (Pressurization of the cooling system decreases the vacuum reading, thereby introducing an error relative to determining radiator restriction; the maximum vacuum figure refers to data obtained with the pressure cap removed.)

2. Coolant pressures should decrease by 2 to 4 psi when the pressure cap is removed, providing that the cooling system is full and that the cap was installed with the coolant cold. If this drop does not occur, allow engine to cool, install a new cap and repeat test. A defective pressure cap will affect coolant pressures and flow rates under extreme weather conditions where cooling is marginal, and will also contribute to coolant loss.

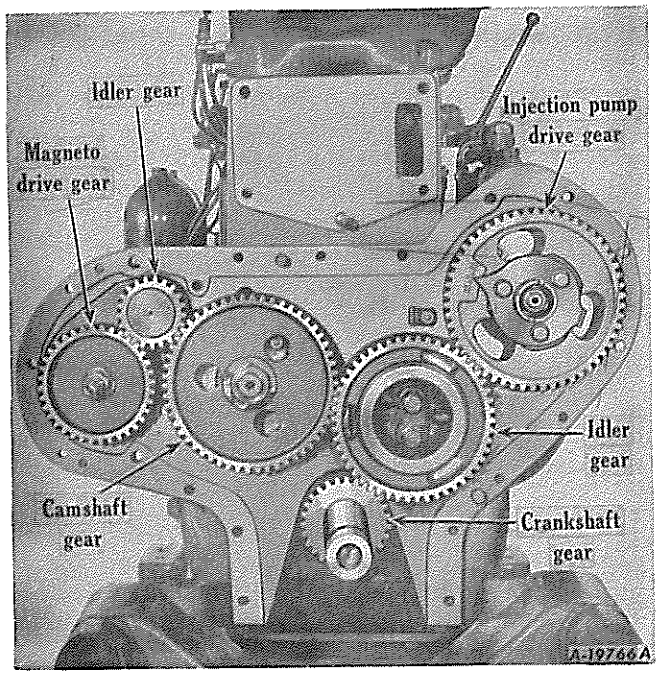
3. When all coolant pressures with the pressure cap removed are insufficient, investigate the operation of the water pump. If the fan belt(s) or pulleys are worn, replace with new parts as required and repeat test. If pressures are still too low, inspect the impeller and replace where justified. Rebuild water pump and repeat test.

4. If the pump inlet vacuum, pump outlet and crankcase pressure appear to be normal while pressure in the cylinder head is high, thereby resulting in a low differential, the cylinder head gauge should be checked. This may be done by removing the pump outlet gauge, plugging the hole at this location and installing the gauge at the cylinder head pressure tap. Then by taking a set of readings at high idle, shutting down and reversing the crankcase drain and cylinder head gauges and repeating the test, the accuracy of all three gauges can be checked.

TIMING GEAR TRAIN AND FRONT COVER

1. DESCRIPTION (Refer to Illust. 1 and 2)

The timing gear train is accessible when the crankcase front cover is off. The timing gears are driven off the front end of the crankshaft, and they provide a positive and accurate drive to the camshaft, injection pump and magneto (when used). These gears also provide the drive for the hydraulic pump or the transfer pump on the 24 and 1091 diesel engines. These gears must be in their proper places to have the engine timed correctly. The gears are punch-marked for proper timing. Install the idler gear last after all the other gears have been timed with their similarly marked teeth opposite each other.

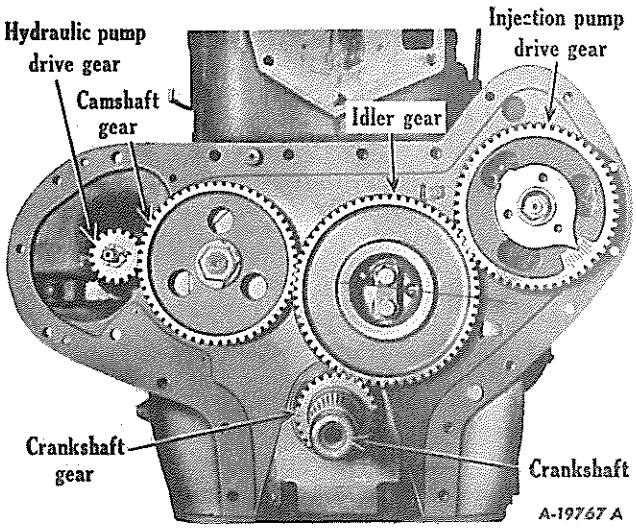


Illust. 1 - Gear Train Assembly (16 - Series Diesel Engine Shown).

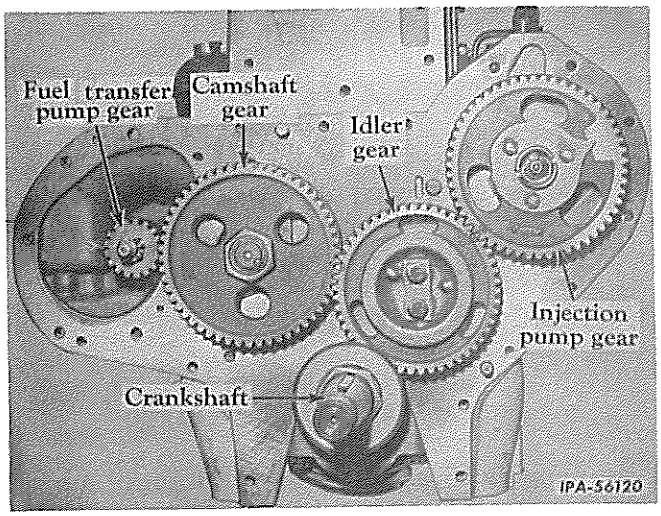
2. REMOVAL

1. Remove the engine from the front frame support. (Crawler tractors only.)
2. Remove the foot type base front support. (Power units only.)
3. Remove the fan and the water pump.
4. Remove the cotter from the front of the crankshaft; then remove crankshaft nut. (See Illust. 4.)
5. Remove the fan drive pulley and vibration damper from the crankshaft. Position service tool 1 020 077 R91 (see "Service Tool" Manual ISS-1002) in place on the pulley, and secure it with cap screws to the pulley. Then, by turning the bolt, which is a part of the puller, the

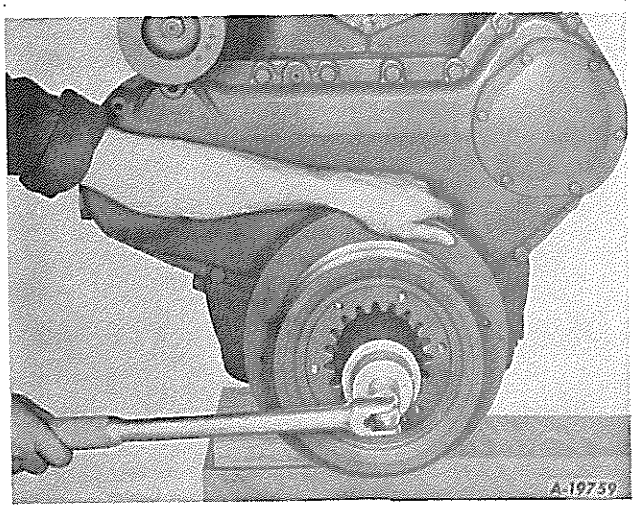
(Continued on next page)



Illust. 2 - Gear Train Assembly (24 - Series Diesel Engine Shown).



Illust. 3 - Gear Train Assembly (UD-554 Power Unit Shown).



Illust. 4 - Removing the Crankshaft Nut.

TIMING GEAR TRAIN AND FRONT COVER

2. REMOVAL – Continued

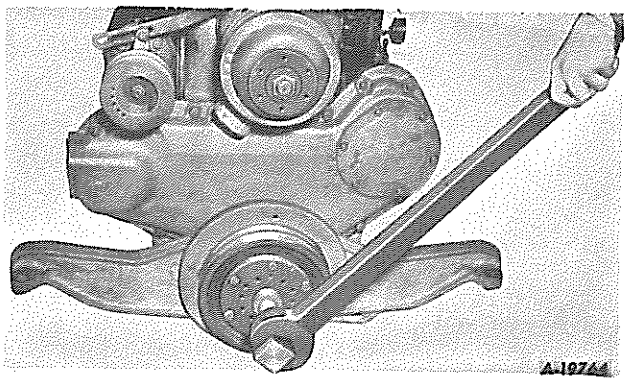
damper and pulley will slide off the crankshaft. (See Illust. 5.)

CAUTION: Care should be exercised when removing the pulley and damper; in breaking free of the key in the crankshaft, the pulley may spring outward.

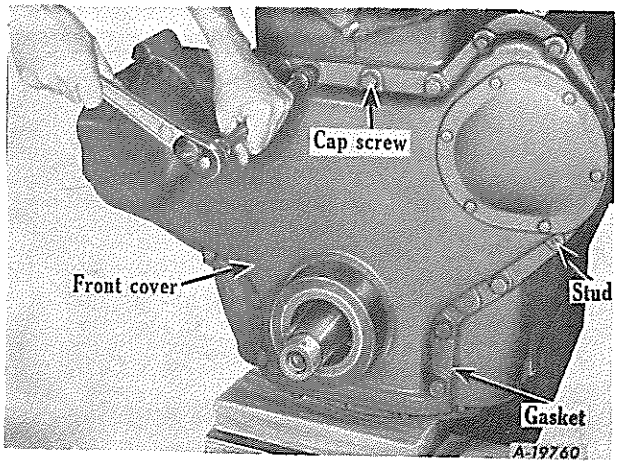
6. Remove the front engine support. (Crawler tractors only.)

7. At the front end of the oil pan, remove the three cap screws which screw into the cover. On certain units, studs are used instead of cap screws. Therefore, it will be necessary to drop the front end of the oil pan far enough to clear the studs in the front cover.

8. Remove the cap screws holding the front cover to the crankcase front plate, and pry off the cover. (See Illust. 6.) The front cover gasket will adhere to the cover. Remove the fan drive pulley key from the crankshaft.



Illust. 5 - Removing the Damper and Fan Drive Pulley.



Illust. 6 - Removing the Front Cover.

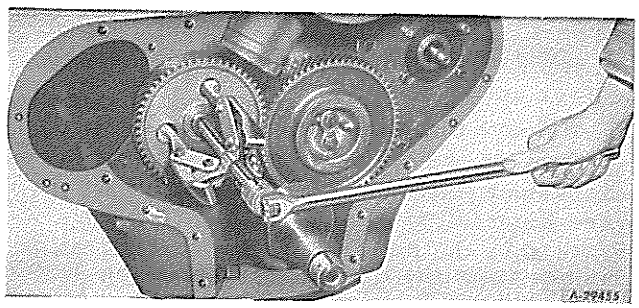
9. Remove the cap screws holding the thrust washer to the idler gear shaft and remove the idler gear.

10. Remove the nut and washer holding the magneto drive gear to the shaft and pull the gear from the shaft. The magneto idler gear can be removed by taking the washer and nut off the idler shaft, removing the magneto from the bracket, and pushing the shaft out of the bracket. Then lift off the magneto idler gear. The transfer pump drive gear on the 24 and 1091 diesel engines can be removed by removing the transfer pump. (Refer to section 13.) When the hydraulic pump drive gear requires replacement on the TD-24 diesel engines, it will be necessary to remove the hydraulic pump since the gear and shaft are one piece. (Refer to "Chassis Manual," Form No. ISS-1020.)

11. Remove the nut and washer from the camshaft, and remove the camshaft gear. (See Illust. 7.)

12. Remove the cap screws holding the injection pump gear timing indicator and gear to the hub, and remove the gear and indicator.

13. Remove the Woodruff key from the crankshaft, slide off the spacer and oil flinger, and pull off the crankshaft gear. On the 24 and 1091 series engines, it will be necessary to remove the self-locking crankshaft nut to remove the oil flinger from the crankshaft.



Illust. 7 - Removing the Camshaft Gear.

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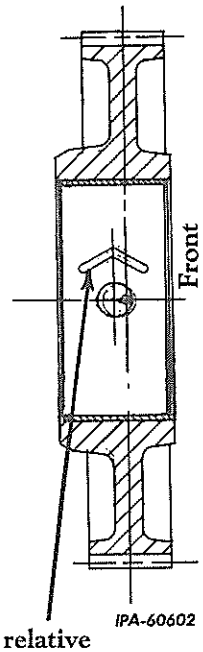
TIMING GEAR TRAIN AND FRONT COVER

3. INSPECTION AND REPAIR

1. Clean all parts thoroughly in dry-cleaning solvent, and dry them with compressed air.

2. Inspect all parts for wear, and replace as necessary. Refer to "SPECIFICATIONS," Section 1, for the correct diameter of a new idler gear bushing and shaft. Refer to Illust. 8 for proper installation of the idler gear bushing.

3. Inspect the oil seal in the front cover for damage, and replace if necessary. Pry out the oil seal and drive in a new oil-soaked seal with the lips facing inward.



Oil groove to be in relative position to oil hole as shown

Illust. 8 - Correct Installation of Idler Gear Bushing.

4. INSTALLATION

1. Install the camshaft gear, and assemble the magneto and drive assembly to the front plate. On the UD-24 and 1091 diesel engines, assemble the transfer pump drive assembly into place on the front cover.

On the TD-24 diesel engines, assemble the hydraulic pump to the front plate with the hydraulic pump gear meshing with the camshaft gear. (There are no timing marks to line up on the hydraulic pump gear.)

On 16 and 525 series engines with magnetos, be sure that the punch marks match on the magneto gear, magneto drive gear and the camshaft gear.

2. Install the injection pump gear into place on the front plate. Assemble the injection pump gear on the gear hub so the groove in the hub and the groove in the hub surface of the gear match. Place the timing indicator on the gear with the point set at zero. Install the cap screws and cap screw locks.

3. Install the crankshaft gear, oil flinger and the crankshaft self locking nut into place on the crankshaft. First, install the crankshaft gear key. Then heat the crankshaft gear to 250°F. Position the gear on the crankshaft with the timing mark facing out. Be sure the gear is not cocked on the crankshaft. Drive the gear into position.

4. Install the idler gear after all the other gears have been installed. Coat the idler gear shaft with engine oil; then slide the gear onto the shaft. Match the camshaft gear, injection pump gear and crankshaft gear so the punch marked spaces match with corresponding punch marked teeth (Illust. 9).

5. Shellac a new gasket on the front cover; then install the front cover and secure with cap screws and dowels. If the oil pan was removed, install the oil pan and fill with oil. If the oil pan was not removed, install the front cap screws and tighten those that were loosened.

6. Install the tractor front engine support or the foot base front support.

7. Install the Woodruff key into the crankshaft, and drive on the pulley and damper. The fan drive pulley should be seated firmly and fully upon the key. Install the nut lock and nut. Install the crank pin in the crankshaft. On the 24 and 1091 series engines, install the crankshaft nut in place on the crankshaft. (See Illust. 3.)

These series engines are not equipped with crank pins.

8. Install the fan and the water pump. (Refer to section 5.)

9. Install and tighten the fan belt.

10. Install the radiator (power units only).

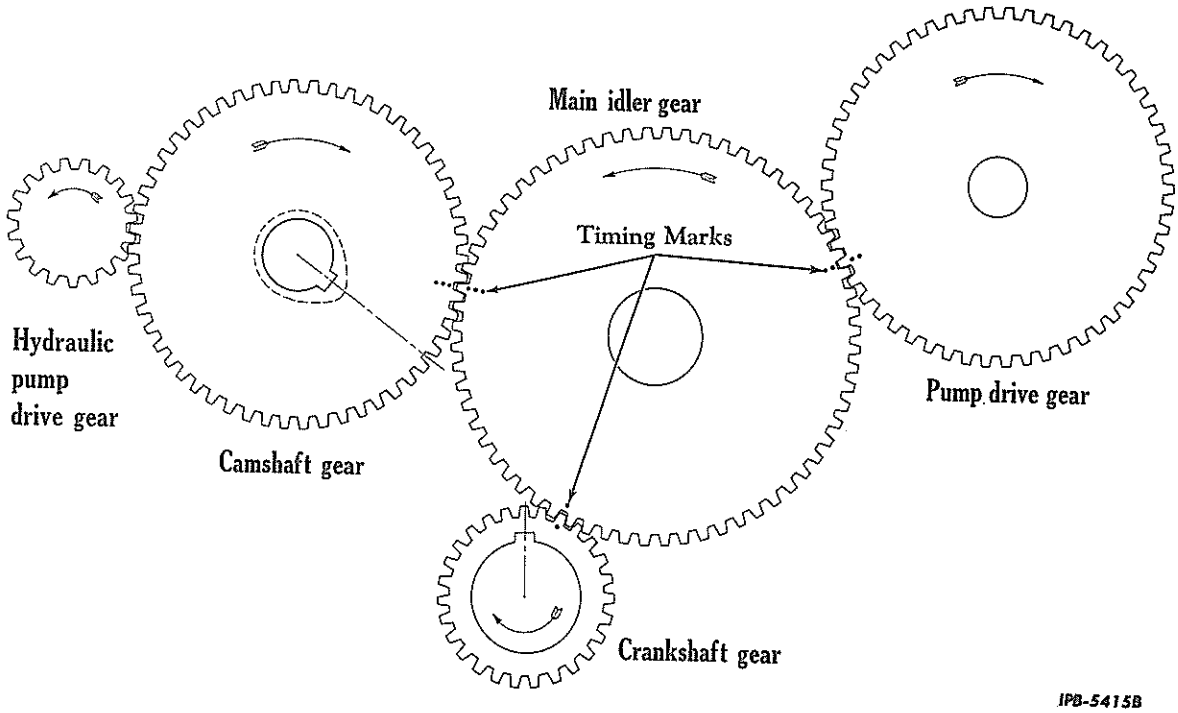
(Continued on next page.)

TIMING GEAR TRAIN AND FRONT COVER

4. INSTALLATION - Continued

11. On the TD-24 diesel engines, install the engine into position on the front frame support.

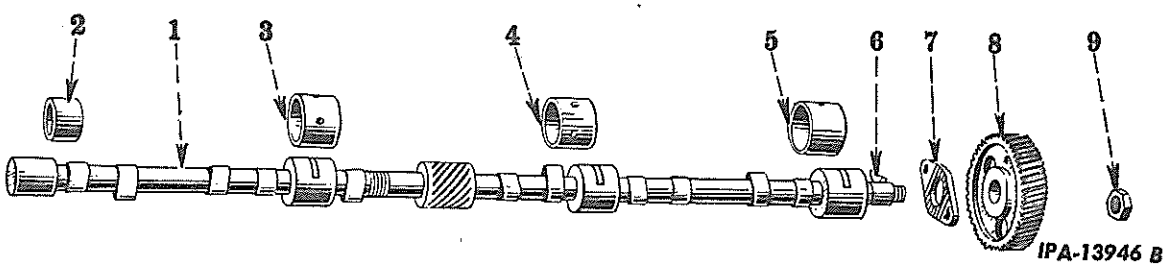
12. Start the engine and check the timing of the magneto or distributor, the valves, and the injection pump.



Illust. 9 - Gear Train in Time.

CAMSHAFT

5. DESCRIPTION (Refer to Illust. 9)



Illust. 10 - Camshaft Components (1091 Series Engine Shown).

1. Camshaft.
2. Bearing - rear.
3. Bearing - No. 3.
4. Bearing - No. 2.
5. Bearing - front.
6. Key.
7. Plate.
8. Gear.
9. Stake nut.

The camshaft is located in the crankcase on the right-hand side of the engine, and it is held to the crankcase by a thrust plate. The camshaft is supported at intervals along its length by four bushings. The bushings are removable and are furnished for service reamed to size. The illustration shows camshaft components used in 1091 diesel engine series; the series not illustrated have similar assemblies. The bushings are a press fit in the crankcase.

CAMSHAFT

The camshaft drives the engine lubricating oil pump by the gear located approximately in the center of the shaft. The camshaft has the main function of operating the intake and exhaust valve mechanism by action of its lobes upon the push rods during rotation. It is important to notice that the camshaft gear is twice the size of the crankshaft gear which primarily drives it.

The camshaft, therefore, rotates at one-half the crankshaft speed due to the requirement to open and close the valves to each cylinder once for every two revolutions of the crankshaft.

The camshaft bearings are pressure lubricated and have oil holes drilled in them. When the bushings are installed, the oil holes must align with the ones drilled in the crankcase. Slots in the camshaft permit lubricating oil to travel to the valve lever mechanism.

6. REMOVAL

NOTE: For a method of detecting excessive camshaft bearing clearances, prior to "removal" and "disassembly" procedures, refer to "Oil Pressure Test for Detecting Worn Bearings," section 4.

1. Remove the valve mechanism and valve push rods. Mark the push rods so that they can be returned to their original positions. (Refer to "Cylinder Head and Valves", section 2.)

2. Remove the ignition distributor on engines so fitted. (Refer to section 15.)

3. Remove the crankcase oil pan and lubricating oil pump. (Refer to "Oil Pump", section 4.)

4. Remove the side covers and gaskets from the right-hand side of the engine. Lift the valve tappets from position. (Illust. 11.) Mark the tappets as to their location in the crankcase, so that they can be returned to their original position when installing.

NOTE: On 16, 525 and 554 engines, numbers 1, 6, 7 and 12 tappets (counting from front to rear), cannot be removed from the engine through the side cover opening. Raise and restrain these tappets up from the camshaft to allow camshaft removal.

5. Remove the crankcase front cover and idler gear. (Refer to "Timing Gear Train" in this section).

6. Rotate the camshaft gear until the cap screws holding the thrust plate to the crankcase can be removed through the holes in the gear.

7. Pull the camshaft assembly from the crankcase.

7. DISASSEMBLY

1. Remove the staked nut holding the gear on the camshaft. (Illust. 10.)

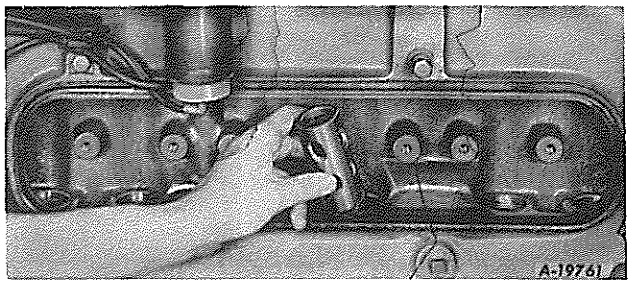
2. Use a gear puller to pull the gear from the shaft. The gear is keyed to the shaft.

3. Remove the key from the shaft, and remove the thrust plate.

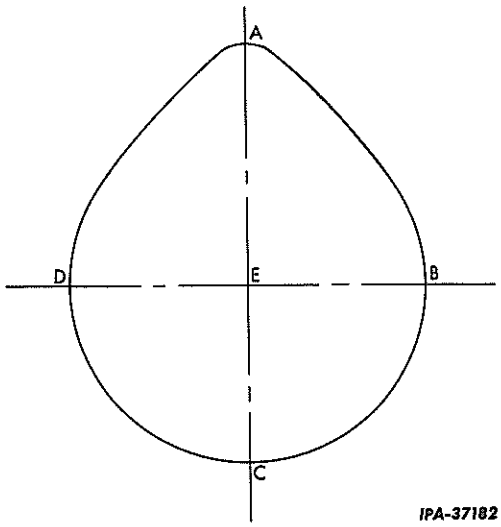
8. INSPECTION AND REPAIR

1. Clean all parts in a cleaning solvent, and dry with compressed air. As inspection of parts is completed, coat each with clean engine oil and store safely until reassembly. Do not damage the journals and lobes of the camshaft, or the teeth of the gear.

(Continued on next page)



Illust. 11 - Removing the Valve Tappets.



Illust. 12 - Points of Measurement to Determine Cam Lobe Wear.

CAMSHAFT

8. INSPECTION AND REPAIR – Continued

2. Inspect the journals for wear. Dimensions for the camshaft are given in "Specifications," section 1. Compare those of the camshaft being serviced with the ones listed. If the journals are worn beyond the limits specified, replace with a new part.

3. Inspect the lobes for wear. If the lifting areas of the cam lobes, when compared with a new camshaft, show amounts of wear exceeding .020 inch, the camshaft should be replaced. If a new camshaft is not available for comparison, the cam lobe wear can be measured with a micrometer in the following manner (Illust. 12). Take a reading across A-C and deduct the reading B-D; this will give the cam lobe lift. Refer to "SPECIFICATIONS" in Section 1.

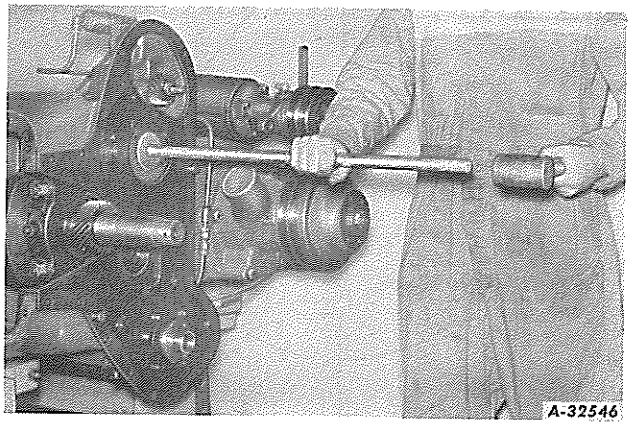
4. Inspect the teeth of the oil pump drive gear integral with the camshaft. Replace the shaft if necessary.

5. Inspect the drive gear and thrust plate for wear due to lack of specified end clearance. Replace parts if necessary.

6. Inspect the bushings for wear and, if replacement is necessary, remove the flywheel and engine rear support. Remove the expansion plug from the rear of the camshaft bore. Drive or press the bushings from position. (Illust. 13.)

7. Inspect the bore in the crankcase for burrs and other roughness liable to damage the bushings when installation takes place.

8. Inspect the valve push rods for wear. Replace if necessary.



Illust. 13 - Driving Out the Camshaft Bore Expansion Plug.

9. Inspect the valve tappets. Replace any that are scuffed, scored or cracked. If the tappet face is badly chipped, extreme wear can be expected on the cam lobe and a new camshaft must be installed.

9. REASSEMBLY

1. Assemble the camshaft by installing the thrust plate on the shaft. The countersunk side must be toward the threaded end. Install the camshaft gear key to the shaft.

2. Install the gear to the shaft, with the timing marks facing away from the shaft.

3. Install the stake nut. Torque the nut to the foot-pounds specified in section 1. Secure the nut by staking the nut into the keyway in the camshaft. Stake the nut using a cape chisel or an ordinary cold chisel rounded off at the cutting edge. Be extremely careful not to fracture the nut.

NOTE: Torque can be applied to the nut after installation of the camshaft in the engine if this is easier; in which case, do not lock the nut until later.

10. INSTALLATION

1. Install the camshaft rear bearing expansion plug if bushings were removed. Use a sealing compound on the plug and in the plug seat.

2. Install the engine rear support and flywheel. (Refer to "Flywheel" in section 7.)

3. Coat the cam lobes with SCL (sulfo-chloro-lead) heavy duty axle lubricant before installing the camshaft. Install the camshaft assembly to its position in the crankcase.

4. Secure the thrust plate to the crankcase, using the cap screws through the holes in the camshaft gear. Check the clearance between the thrust plate and the gear against that listed in section 1.

NOTE: On certain of the engine series, the magneto and camshaft drive gears must be assembled in a specific manner. On these engines, the magneto gear has a marked tooth and the camshaft gear has two marked teeth. The marked tooth on the former, should mesh between the two marked teeth on the camshaft gear. (Refer to "Timing Gear Train" in this section for complete assembly details.)

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CAMSHAFT

5. Install the idler gear. Check the complete gear train for correct timing. (Illust. 9.)

6. Install the crankcase front cover. (Refer to "Timing Gear Train" in this section.)

7. Install the distributor, and check the distributor timing. (Refer to Section 15.)

8. Install the valve tappets, gasket and cover. Be sure to install the tappets in their original positions using the marks made in removal.

9. Install the valve mechanism. (Refer to "Cylinder Head and Valves", section 2.)

10. Start the engine and check its operation.

11. Engine valves should have the clearances checked against those specified in section 1, "Specifications". Adjust if necessary as described in section 2, "Cylinder Head and Valves".

NOTE: It is recommended that the engine be run at 1000 rpm from three to five minutes after finishing assembly of the engine. At this rpm, the tappets are under lighter load, thus initial lubrication of the tappets and tappet bores will be assured.

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CRANKSHAFT AND MAIN BEARINGS

1. DESCRIPTION

The crankshaft supports the connecting rods and pistons along its length. Located at the forward end is the crankshaft drive gear which supplies the drive for the camshaft, injection pump, magneto, and on power units for the fuel transfer pump, by means of the timing gear train. The flywheel is mounted to the rear end of the crankshaft. Two seals, one at the front and one at the rear, prevent leakage of engine lubricating oil around the ends of the crankshaft.

Bearing caps are furnished with the crankcase, and these support the crankshaft in true alignment. Webs integral with the crankcase provide the upper half of the main bearing supports, and removable caps provide the lower support. The caps are held in place with studs and castellated nuts or cap screws. The nuts are torqued as specified in Section 1, "Specifications" and are locked in place with cotters after correct tension is applied. The bearing caps are not interchangeable, and each has a number stamped upon it which signifies its correct location in the crankcase. Number 1 is at the front of the engine. It is good practice to keep the nuts identified so that they may be returned to their original studs. This will make installation easier with reference to cotter hole alignment in nuts and studs when the specified torque and clearance is obtained.

The bearings are inserted between the crankshaft and the crankcase, and between the crankshaft and the bearing caps. The center main bearing is the thrust bearing, and it has thrust flanges. Some engines are equipped with the old type six-piece center bearing. When the six-piece bearing is to be replaced, it must be replaced with the two-piece bearing as the six-piece bearing is not serviceable. When replacing the six-piece bearing with the two-piece bearing, the center main bearing cap and the crankcase must be reworked to provide the specified fit. (Refer to "Crankshaft and Main Bearings," under "Installation.")

CAUTION: Extreme care must be taken to guarantee cleanliness of the crankcase, crankshaft, and bearings after service has been completed. Whenever possible, the crankshaft should be removed when new bearings are being installed in order to clean the crankcase thoroughly. All bearing surfaces must be free of grit and burrs. Small particles of dust and dirt left between the crankshaft and bearings will cause rapid wear and scoring of the crankshaft journal and insert. Any foreign material left between the bearings and the crankcase and bearing caps will cause distortion of the bearing and a reduction in operating bearing clearance at that point. The frictional heat thus produced will in turn cause the bearing material to melt away from the steel back of the bearing at that point. Such melted material will create further hot spots until complete bearing failures takes place. Anything that interferes with the operating clearance of any bearing, or proper heat dissipation has its effect upon bearing life. Cleanliness cannot be overstressed.

2. REMOVAL

Crankshaft Bearings

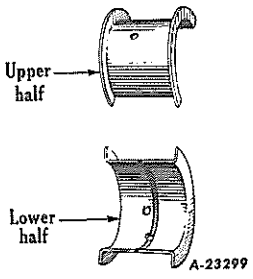
NOTE: For a method of detecting excessive main bearing clearances, prior to "Removal" and "Disassembly" procedures, refer to "Oil Pressure Test for Detecting Worn Bearings", section 4.

1. Remove the oil pan and oil pump (Refer to "Oil Pump", section 4.)

2. Remove the spark plugs, and set the engine for gasoline operation to lower the compression ratio.

3. Remove the dust seal, gasket, oil seal retainer plate with gasket, and oil seal retainer felt plugs, located at the rear underside of the crankcase.

(Continued on next page)



Illust. 1 - Two-Piece Center Main Bearing.

CRANKSHAFT AND MAIN BEARINGS

2. REMOVAL – Continued

4. Remove the cotters or lock wire and the nuts or cap screws securing the crankshaft bearing caps. Tap the caps lightly with a soft metal hammer or mallet if they tend to bind on the studs. If the bearings are to be reassembled, be certain that they are identified as to their original positions. Remove the lower bearing from the caps. If the center main bearing is of the six-piece type, remove also the thrust washers. Wrap the pieces in a clean cloth and store until reassembly.

NOTE: If the crankshaft is to be removed, disregard steps 5 and 6.

5. Remove the upper bearing halves from between the crankshaft and the crankcase by using a thin piece of flexible soft metal to push against the end of the bearing farthest from the nib holding the bearing in the crankcase support and at the same time turning the crankshaft in the direction of rotation. The bearing will slide easily from position.

An alternate method of removing the upper halves of the bearings is to hammer the closed end of a small cotter to form a "T" and then insert the prongs of the cotter into the oil hole of the crankshaft journal with the flattened head just protruding. Rotate the crankshaft, and the cotter head will push the bearing from position.

6. With the six-piece bearing, push the separate thrust washer upper halves from the crankcase.

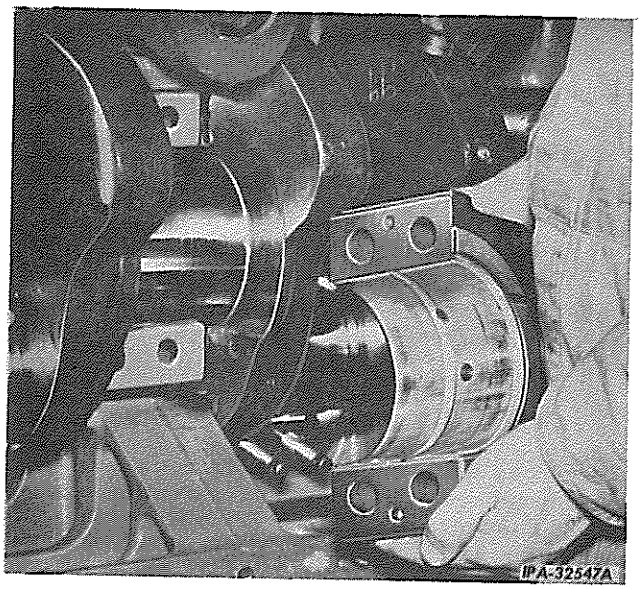
Crankshaft

7. Remove the flywheel. (Refer to "Flywheel" in this section.)

8. Remove the engine rear support from the crankcase.

9. Remove the crankshaft rear upper and lower oil seal retainers. On older model engines, remove split-type seal from the crankcase by removing the spring holding it in its circular shape.

10. Remove the front cover assembly. (Refer to "Timing Gear Train and Front Cover", section 6.)



Illust. 2 - Removing the Main Bearing Caps.

11. Remove the connecting rod bearing caps, and push the assemblies to the top of their travel.

12. Lift the crankshaft out of the crankcase. (See Illust. 3.) Remove the upper main bearing halves.

3. INSPECTION AND REPAIR

1. Clean all parts, except rubber, with cleaning solvent, dry with compressed air, and inspect the bearings for wear and evidence of uneven bearing support. If such evidence is present, examine the bearing caps and supporting surfaces of the crankcase for high spots and burrs.

2. Inspect the crankshaft journals for scoring, and measure the diameter of each journal, using a micrometer. (See Illust. 4.) Check the dimensions obtained against those specified in section 1, "Specifications". Measure each journal at two points, one at right angles to the other, in order to show any tendency of out-of-round. Move the micrometer over the entire width of the journal (See Illust. 4.)

3. Inspect the vibration damper for breaks or for signs of poor bonding between the rubber and the metal portion of the damper. If either

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CRANKSHAFT AND MAIN BEARINGS

condition is found, the vibration damper should be replaced.

4. Inspect the crankshaft gear teeth for wear and chipping and replace the gear if necessary.

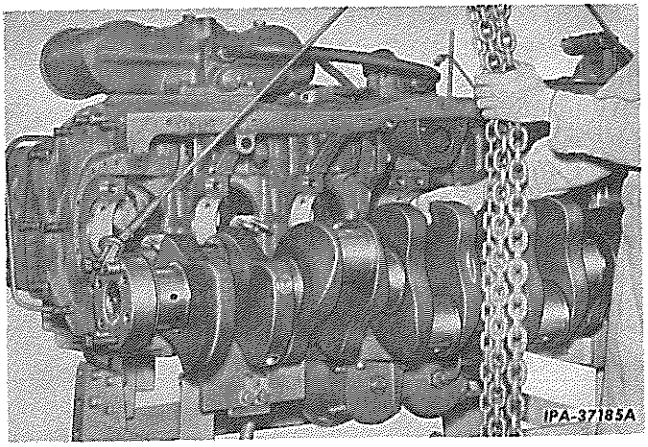
5. Inspect the crankcase for sludge deposits, especially in the corners. The crankcase should be thoroughly cleaned and inspected.

6. Replace the front and rear seals with new seals.

4. INSTALLATION

NOTE: Prior to crankshaft installation, check the crankcase for trueness, using the crankshaft as follows:

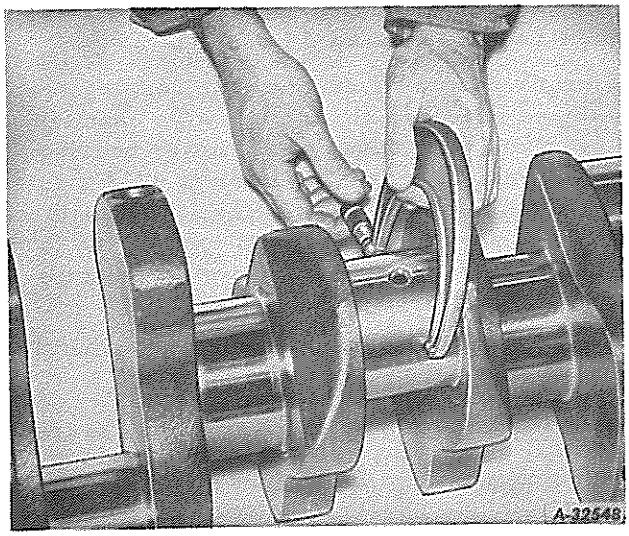
1. Wipe the crankcase bearing supports free of oil with a lint-free clean cloth. The crankcase should be bottom side up and levelly supported with blocks.



Illust. 3 - Lifting the Crankshaft From the Crankcase.

2. Install the upper halves of the bearings to the crankcase. If the original bearings are being reinstalled, be sure that they go to the original positions. The nibs of the bearings must fit into the notches in the crankcase bearing supports.

3. Smear blueing on the crankshaft main journals, and lower it carefully and evenly onto the bearings. Do not install the bearing caps and lower bearings.



Illust. 4 - Measuring the Crankshaft Journals.

4. Rotate the crankshaft back and forth through approximately one-half revolution. Remove the crankshaft evenly, and inspect the upper bearings for an even transfer of blueing from journals to bearings. Any bearings not showing an all-over even blueing should be replaced. It is advisable to replace all bearings if one of the original bearings has to be replaced. Bearings, crankshaft journals, and the parts of the crankcase supporting the upper bearing must be free from oil when the test is performed.

5. When satisfied that the crankcase is in good order and free from any distortion, and free of any burrs around the upper bearing seats, continue to install the crankshaft. Clean all blueing from the bearings and crankshaft journals. Install the upper bearing halves (and thrust washers on six-piece bearings) after coating the bearing surface only with a small amount of clean engine oil. Install the crankshaft carefully.

NOTE: The two-piece center main bearing consists of the upper and lower halves. Some engines are equipped with a six-piece main bearing. The six-piece bearings are not serviceable. Should the six-piece center main bearing be replaced with the two-piece flanged type bearing, it will be necessary to modify the crankcase and center main bearing cap as follows: (See Illust. 5.)

(Continued on next page)

CRANKSHAFT AND MAIN BEARINGS

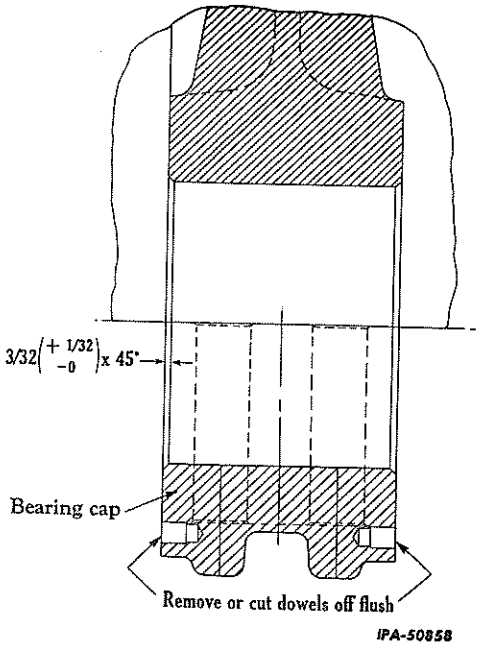
4. INSTALLATION – Continued

The crankcase upper center main bearing seat must have its edges chamfered; also chamfer the front and rear edges of the lower bearing cap. The amount of the chamfer is 3/32 x 45 degrees. Remove or cut off flush the dowels in the side of the bearing cap that located the lower thrust washer halves of the six-piece bearing.

CAUTION: Be certain that no burrs or metal particles remain on the parts modified.

6. Install the lower main bearings and bearing caps, and torque the stud nuts or cap screws to the amount specified in Section 1, "Specifications." Do not install the cotters. It is necessary to check the clearance between the crankshaft journals and the main bearings.

7. Pull the connecting rods down onto the crankshaft. Be sure that the bearings are in place. Install the connecting rod bearings and bearing caps, being sure that the correct cap is located on its rod and that the position numbers on the caps and rods face the camshaft side of the engine. Oil the bearings with clean engine oil. **Torque the connecting rod stud nuts as specified in section 1, "Specifications".**



Illust. 5 - Crankcase and Center Main Bearing Cap Modifying Diagram to Fit Two-Piece Flange Type Bearing in Place of Six-Piece Bearing (Early 16 and 24 Series).

8. Install the crankshaft rear oil seal.

NOTE: To eliminate any possibility of oil leaking through the crankshaft rear oil seal, due to incorrect installing of the rear oil seal, it is imperative that step-by-step procedures as outlined below be followed.

24 and 1091 Series Only

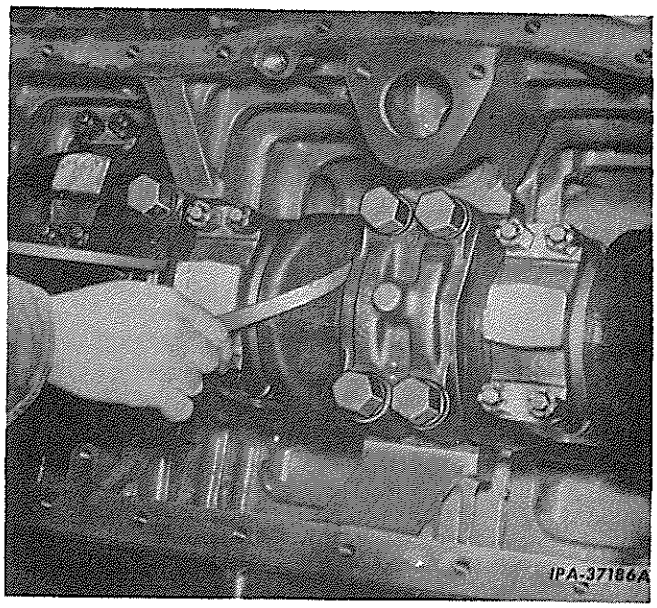
(a) Press the seal into the retainer.

(b) Apply a small amount of permatex sealer to the rear of the crankcase, and place the crankshaft rear oil seal retainer gasket on the case, aligning gasket with holes in crankcase.

(c) Apply permatex sealer on the rear gasket face of the retainer, assemble on the crankshaft rear flange, and hold in position with bolts inserted by hand.

(d) Trim the rear oil seal retainer gasket flush with the bottom of the crankcase.

(e) Apply permatex sealer to gasket surface. Assemble the crankcase oil seal retainer plate and gasket to the crankcase and retainer. Install the four bolts holding the plate to the retainer and screw in by hand only. Pull the plate up tight to the crankcase with two bolts, one on each end. These bolts are to be removed after the seal assembly is completed.



Illust. 6 - Checking the End Clearance of the Crankshaft.

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CRANKSHAFT AND MAIN BEARINGS

(f) Run up the bolts holding the seal plate to the crankcase just enough to put slight pressure on the lock washers.

(g) Run up the bolts holding the retainer to the crankcase just enough to put slight pressure on the lock washers.

(h) Finally, tighten all bolts to a torque of approximately 30 foot-pounds in the following order:

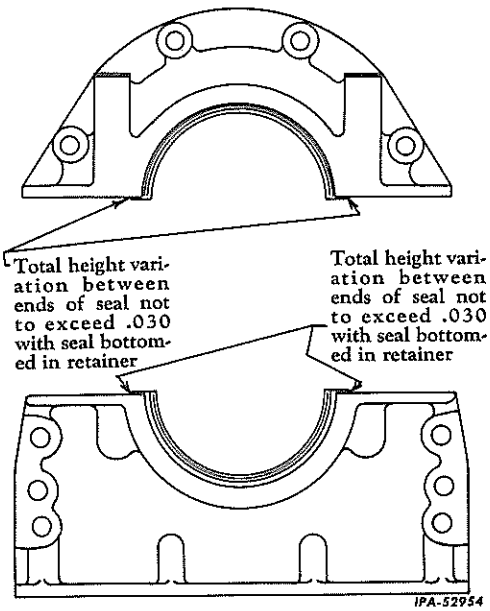
1. Bolts holding seal plate to retainer.
2. Bolts holding retainer to crankcase.

(i) The crankcase oil seal retainer neoprene plug must be assembled with the rounded corner in the hole and flush with the plate and crankcase. The plug must not be spread over the hole; this would prevent the oil pan from pulling up flat against the gasket and case.

(j) Upon completion of assembly, remove the two bolts holding the seal plate to the crankcase.

16, 525 and 554 Series Only

(a) Some oil seal retainers have match marks stamped on the right hand side. When the retainers are installed on the engine these marks must be aligned to assure proper alignment of the retainer bores and concentricity of the oil seal. If the retainers do not have matched marks, proceed as follows. Assemble the retainer halves off the engine and secure with bolts being sure that the upper and lower bores are concentric. With the retainers correctly aligned, take a cold chisel and stamp a match mark on the right hand side of the retainers. Separate the retainer halves.



Illust. 7 - Crankshaft Rear Oil Seal (16, 525 and 554 Only).

(b) Press the seal into the retainer. The seals must be assembled into the grooves of the retainers as shown in Illust. 7.

(c) Apply a thin coating of Permatex sealer to the rear of the crankcase, and place the crankshaft rear oil seal retainer gasket on the case, aligning the gasket with the holes in the crankcase.

(d) Apply Permatex sealer on the top, bottom and mounting surfaces of the lower retainer, and place in position on the crankcase. Insert the bolts and tighten finger tight just enough to hold the retainer in position.

(e) Trim the rear oil seal retainer gasket flush with the bottom of the crankcase.

(f) Apply Permatex sealer to the gasket surface. Assemble the crankcase oil seal retainer plate and gasket to the crankcase and retainer. Install the four bolts holding the plate to the retainer and screw in by hand only. Pull the plate up tight to the crankcase with two bolts, one on each end. These bolts are to be removed after the seal assembly is completed.

(g) Place the two center gaskets in position on the lower retainer. Apply Permatex to the lower and mounting face surfaces of the upper retainer and place in position. Install the two bolts holding the two halves together and tighten the bolts holding the lower retainer to the crankcase enough to slightly compress the lock washers.

(h) Adjust the two center gaskets to be against the horseshoe gasket. Hold the upper retainer flat against the crankcase and tighten the bolts holding the two halves together, just enough to slightly compress the lock washers. Then insert the bolts in the upper retainer to hold the retainer to the crankcase and tighten just enough to slightly compress the lock washers.

(i) Tighten the bolts holding the seal plate to the retainer just enough to put slight pressure on the lock washers.

(j) Finally, tighten all bolts to a torque of approximately 30 foot-pounds in the following order:

1. Bolts holding the two halves together.
2. Bolts holding both upper and lower retainer to the crankcase.
3. Bolts holding the seal plates to the lower retainer.

(Continued on next page.)

CRANKSHAFT AND MAIN BEARINGS

4. INSTALLATION - Continued

16, 525 and 554 Series Only - Continued

NOTE: Be sure the match marks described in step (a) are aligned.

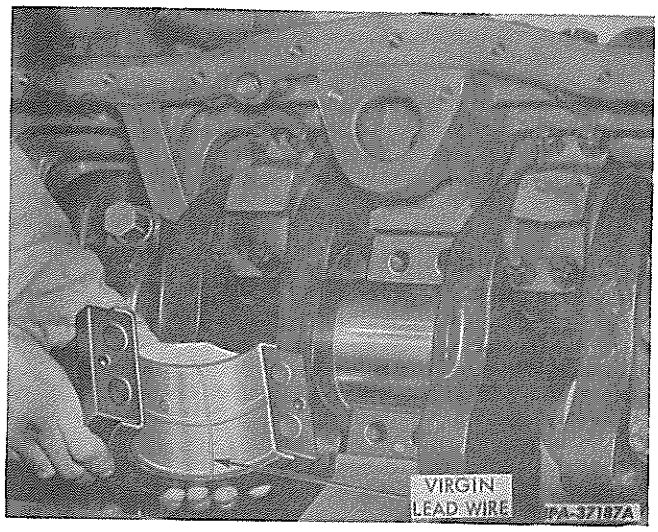
(k) The crankcase oil seal retainer neoprene plug must be assembled with the rounded corner in the hole and flush with the plate and crankcase. The plug must not be spread over the hole; this would prevent the oil pan from pulling up flat against the gasket and case.

(m) When the assembly has been completed, remove the two bolts holding the seal plate to the crankcase.

9. Install the rear engine support to the crankcase. Install the flywheel, and bend the locks over the retaining cap screws. (Refer to "Flywheel" in this section.)

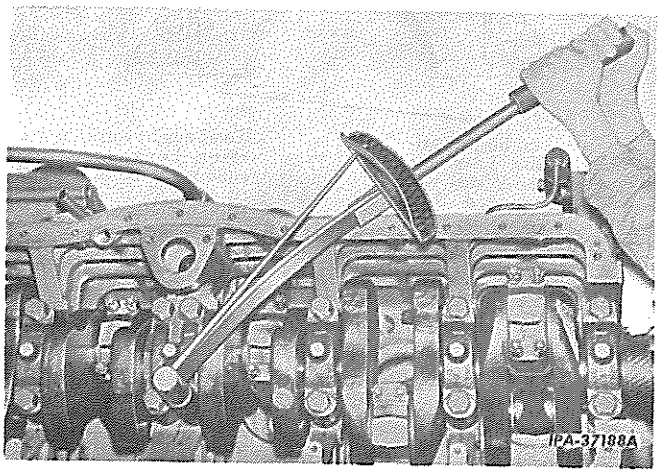
10. Check the end thrust present in the crankshaft by inserting a feeler gauge equal to the amount specified in Section 1, "Specifications" and as shown in Illust. 6. Should the clearance present be less than the amount specified, remove the center main bearing and rub off material evenly from the flange surface. Should the clearance be more than specified, replace the center main bearing.

11. Remove the center main bearing cap and the lower bearing. If virgin lead wire is to be used to check bearing clearance, wipe clean and oil the crankshaft journal. If Plastigage is to be used, wipe the bearing surface and exposed half of the crankshaft journal free of oil so the plastic material is soluable in oil. Place a suitable length of .015 inch virgin lead wire or a piece of Plastigage across the bearing surface (Illust. 8) and install the bearing and cap. Torque the nut or cap screws to specified torque. ("SPECIFICATIONS" in Section 1.) Refer to Illust. 9. Then remove the nuts or cap screws and bearing cap. If virgin lead wire was used, carefully remove the wire which will have been crushed to the amount of clearance present. Measure the wire using a micrometer. (Illust. 10.) If Plastigage was used, the flattened plastic material will be found adhering to either the bearing or the crankshaft. DO NOT REMOVE THE PLASTIGAGE. To determine the bearing clearance, compare the width of the flattened plastic material at its widest point with the graduations on the envelope. The number within the graduation on the envelope indicates the clearance in thousands of an inch. If the crankshaft, bearings and crankcase are in good condition, the measurement taken should fall within the specified clearance given in "SPECIFICATIONS" in Section 1. Should the clearance obtained be more or less than the specified amount, replace the bearing. Should the clearance remain excessive, it may be necessary to grind the crankshaft and install undersize bearings (refer to parts catalog) for the ground crankshaft. Bearings are available in .002 inch, .010 inch, .020 inch and .030 inch undersize. Illust. 11 shows the maximum dimensions to which the crankshaft journal may be ground. Do not grind beyond these limits. If the results obtained are within the specified amount, add clean engine oil to the bearing, and install the center main bearing cap. Torque the nuts or cap screws to the amount specified, and install the cotters or lockwire.



Illust. 8 — Checking Main Bearing Clearance.

NOTE: Do not turn the crankshaft during the above procedure.



Illust. 9 - Tightening the Main Bearing Cap Nut With a Torque Wrench.

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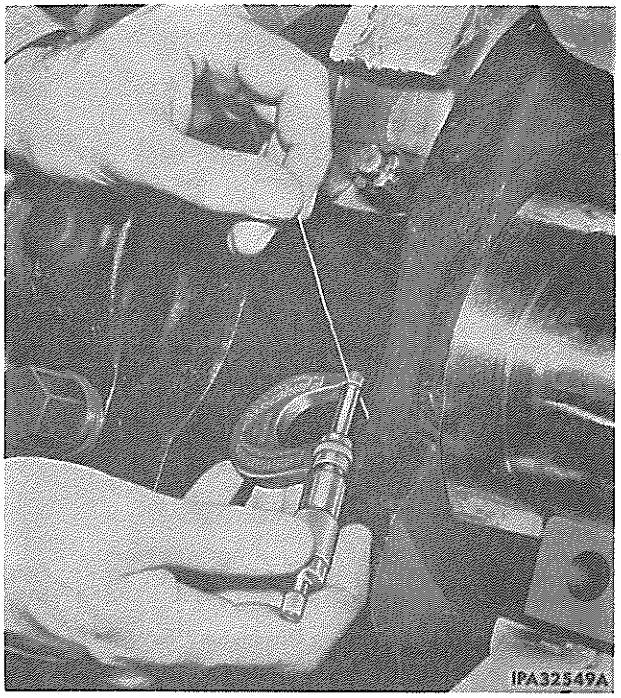
CRANKSHAFT AND MAIN BEARINGS



Illust. 10 - Checking Main Bearing Clearance using Virgin Lead Wire.

12. Continue checking the other main bearings in the same manner. Check the rear main next, followed by the front main and then the intermediates.

13. Install the rear oil seal retainer plate gasket, neoprene plugs, and plate to the rear of the crankcase. Attach the dust seal and gasket to the retainer plate and rear engine support. (See Illust. 12.)

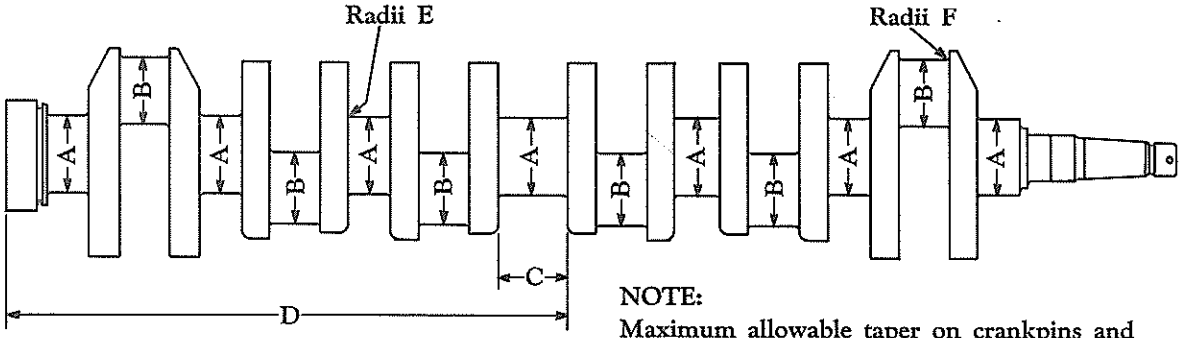
14. Install the crankcase front cover. (Refer to "Timing Gear Train and Front Cover, "Section 6.) Be sure that the timing gears line up properly.

15. Install the oil pump and oil pan. (Refer to "Oil Pump," Section 4.)

16. Fill the crankcase with a MIL lubricating oil as specified in the latest "Fuels and Crankcase Lubricating Oils for I. H. Diesel Engines" Service Bulletin.

17. Install an oil inlet filter in the turbocharger (if equipped) for the first 25 hours of operation and then remove the filter. Refer to Section 12, "Turbocharger."

18. Check the water in the cooling system and start the engine. Observe the engine oil pressure and the engine operating temperature. Run the engine under light load for a period of five hours. At the end of this short run-in period, drain the oil while the engine is hot. Inspect and, if necessary, replace the oil filter elements. Then refill with oil as specified in the operator's manual. This procedure will shorten the period required for complete run-in of the new parts.



NOTE:
Maximum allowable taper on crankpins and journals .00015 per inch of length. Crankpins and journals must be polished, and must not be over .0005 out of round.

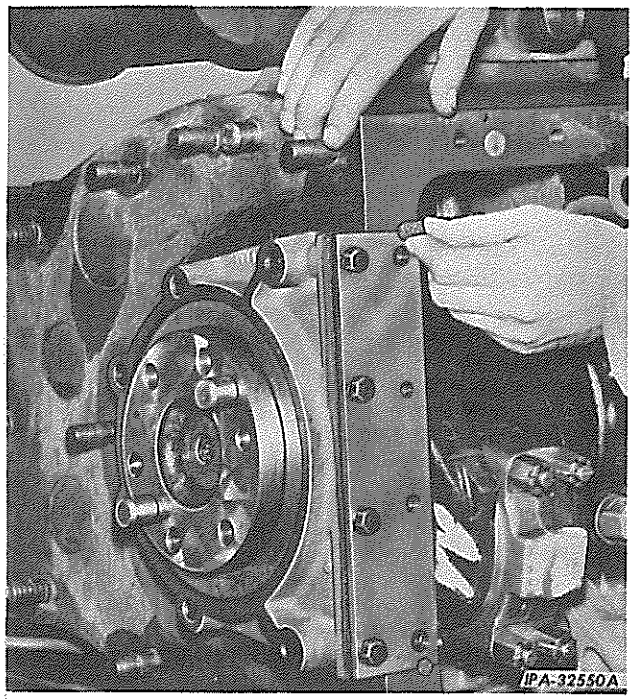
IPA-50859.

Illust. 11 - Limits for .030-Inch Undersize Crankshaft.

Model	A	B	C	D	E - All Main Bearings	F - All Crank Pin Bearings
16, 525, 554 Series	3.5373-3.5383	2.7175-2.7185	2.636-2.638	23.115-23.135	.150-.165	.180-.200
24 and 1091 Series	4.0918-4.0928	3.5925-3.5935	3.825-3.827	29.896-29.916	.240-.255	.240-.255

CRANKSHAFT AND MAIN BEARINGS

4. INSTALLATION - Continued



Illust. 12 - Installing Retainer Plate and Neoprene Plugs.

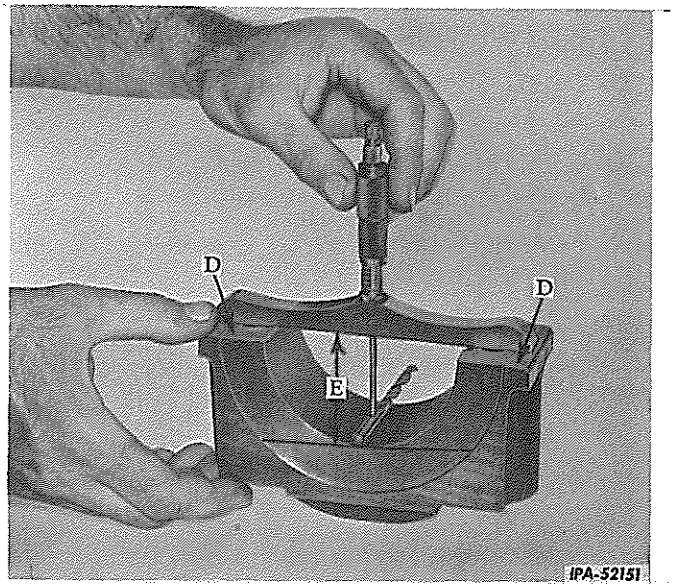
5. CRANKSHAFT BEARING CAPS (24 and 1091 Series Only)

Crankshaft main bearing caps are rough machined and line reamed while fitted to the crankcase. This results in each cap being fitted only for its respective position. Therefore, a main bearing cap cannot be furnished as a regular service part due to the need for line reaming to fit the particular bore where it is intended to mate.

Accidents do occur occasionally and, in many cases, it is undesirable to scrap a crankcase if only the bearing cap needs replacement. A main bearing cap, that is machined in the rough for such emergency cases, is available, and can be obtained as specified in the parts catalog. However, it is necessary to have facilities available to line ream the bore for the finishing operation.

DIMENSION OF MAIN BEARING BORE IN CRANKCASE

MODEL	LINE REAM FINAL TO:
24 and 1091 Series	4.377 - 4.378



Illust. 13 - Measuring Dimension "E."

6. FITTING CRANKSHAFT BEARING CAPS (Machine Method) (16, 525 and 554 Series Only)

Replacement main bearing caps of nodular iron are available for service. The bore of these caps is finish machined, which eliminates the need of line boring after installation. However, the face and sides of the caps must be modified to the dimensions of the old cap to assure a perfect fit in the crankcase. Enough material has been left on the face and sides of the caps to allow for this modification. Following are detailed instructions for modifying the caps.

1. Place a drill rod or new drill of any size from 1/4 to 1/2 inch in the bore of the old caps. Measure the distance from the face of the cap to the drill rod or shank of the drill with a depth gauge (Illust. 13) and record the reading.

Measure the diameter of the drill rod or drill shank with a micrometer and add this reading to the one taken with the depth gauge. This will be dimension "E."

2. Mill or grind surface "D" (Illust. 13) of the new cap to dimension "E" plus .002 inch.

NOTE: The .002 inch is added to dimension "E" to allow enough stock for a finish cut on surface "D" after the cap and bearing have been fitted to the crankcase.

NOTE: The bearing cap must be located on its machined side when milling or grinding surface "D" to hold squareness.

3. Clamp the old bearing cap to a surface plate.

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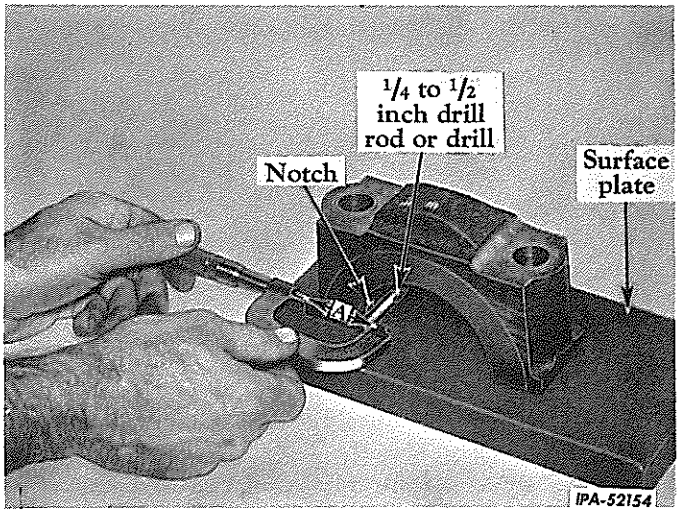
CRANKSHAFT AND MAIN BEARINGS



Illust. 14 - Measuring Dimension "A."

4. Place a drill rod or new drill of any size from 1/4 to 1/2 inch on the inside of the cap (against notched side). Measure dimension "A" with a micrometer as shown in Illust. 14 and record the reading.

5. Measure dimension "A" of the new cap in the same manner and record the reading.

6. Subtract dimension "A" of the old cap from dimension "A" of the new cap and record the difference. Mill or grind this amount from surface "C" (Illust. 15) of the new cap. Dimension "A" of both caps will now be equal.

NOTE: Surface "C" must be held square with surface "D" (Illust. 13) and parallel to the bearing bore.

7. Mill or grind surface "B" (Illust. 15) of the new cap until the dimension "F" (6.312 - 6.313 inches), shown from surface "C" to "B" in Illust. 15, is obtained.

NOTE: Surface "B" must be held square with surface "D" and parallel to the bearing bore.

8. Install a new bearing in the new bearing cap. Place a length of virgin lead or Plastigage across the bearing (Illust. 16).

9. Install the new bearing and new bearing cap and tighten to the torque specified in "SPECIFICATIONS" in Section 1.

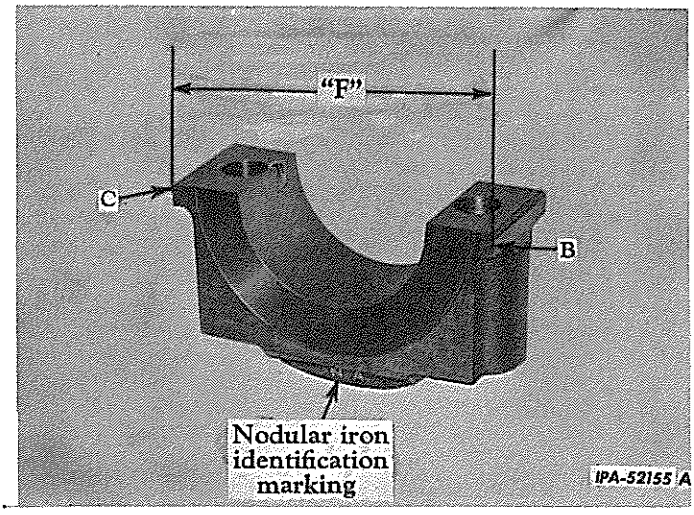
10. Remove the bearing cap and measure the virgin lead with a micrometer and record the reading. If Plastigage was used, follow procedures outlined in Par. 4, "INSTALLATION" and record the reading.

11. Measure the diameter of the crankshaft journal and record this reading. If it is less than the main bearing journal size given in "SPECIFICATIONS" in Section 1 for new crankshafts, subtract the difference from the virgin lead or Plastigage reading.

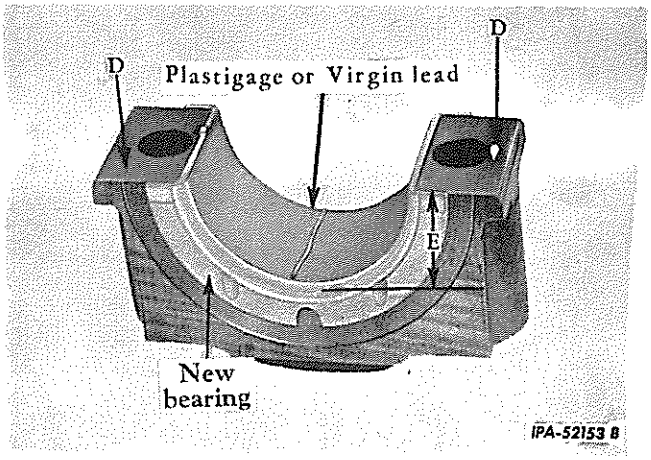
12. Subtract the bearing running clearance as given in "SPECIFICATIONS" in Section 1, from the measurement obtained in Step 11. Mill or grind this amount from surface "D" of the new bearing cap.

NOTE: Surface "D" must be held square with the bearing cap bore.

13. Recheck the bearing running clearance with virgin lead or Plastigage. The correct clearance is given in "SPECIFICATIONS," Section 1.



Illust. 15 - Bearing Cap Finish Length.



Illust. 16 - Position of Virgin Lead.

CRANKSHAFT AND MAIN BEARINGS

7. FITTING CRANKSHAFT BEARING CAPS (Hand Method) (16, 525 and 554 Series Only)

In the absence of machining or grinding facilities, nodular iron crankshaft bearing caps can be fitted satisfactorily, using materials commonly available in the field, as follows:

1. Place the new and old bearing cap in a vise. Surface "D" (Illust. 13) must be level so the drill rod is in the center of the bearing cap.

2. Place a drill rod or new drill of any size from 1/4 to 1/2 inch in the bore of the new and old caps. Measure the distance from the face of the cap to the drill rod or shank of the drill with a depth gauge (Starrett 440-D is shown in Illust. 13 or any similar depth gauge) and record the reading.

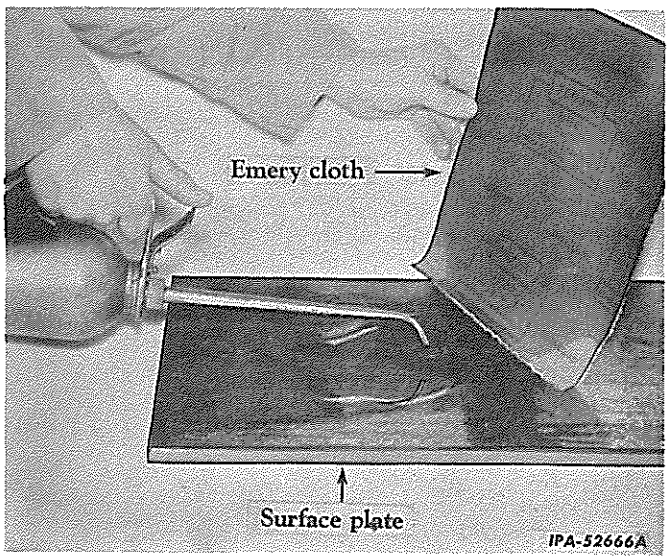
Measure the diameter of the drill rod or drill shank with a micrometer and add this reading to the one taken with the depth gauge. This will be dimension "E" (Illust. 13).

3. To remove stock from surface "D" quickly and accurately, use a smooth metal or glass surface plate, extra coarse emery cloth (No. 430 grit) and heavy duty engine oil.

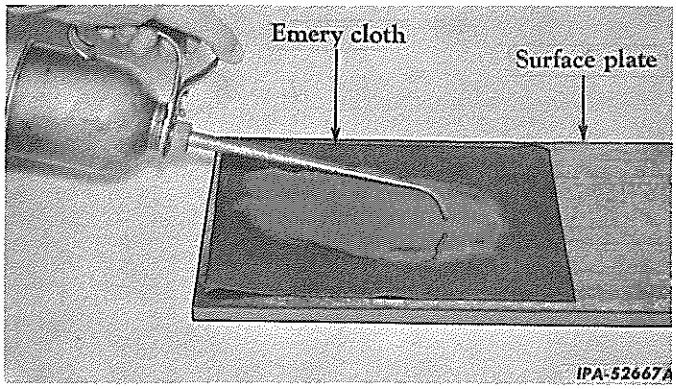
4. Oil the surface of the plate (Illust. 17) to keep the emery cloth from wrinkling and sliding.

5. Oil the emery cloth (Illust. 18) to speed cutting and to carry cuttings away from the face of the bearing cap. ("Rule of thumb" for cutting speed is .001 inch per 100 strokes.)

6. Place the bearing cap on the emery cloth and, with hand pressure, move the cap back and forth (Illust. 19). Turn the cap after every 50 strokes to equalize the cutting width of surface "D."



Illust. 17 - Oiling Surface Plate.



Illust. 18- Oiling Emery Cloth.

7. With a fine file or fine emery cloth, remove the slight high spot immediately around the holes of the bearing cap (Illust. 20). (Usually about .0005 inch.)

8. Clamp the old bearing cap to a surface plate.

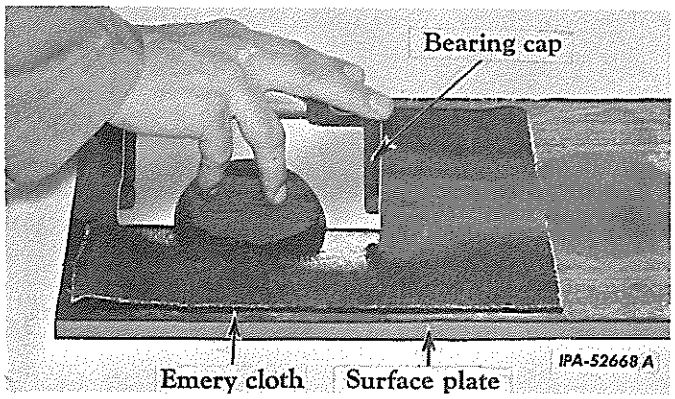
9. Place a drill rod or new drill of any size from 1/4 to 1/2 inch on the inside of the old cap (against notched side). Measure dimension "A" with a micrometer as shown in Illust. 14 and record the reading.

10. Measure dimension "A" of the new cap in the same manner and record the reading.

11. Subtract dimension "A" of the old cap from dimension "A" of the new cap and record the difference.

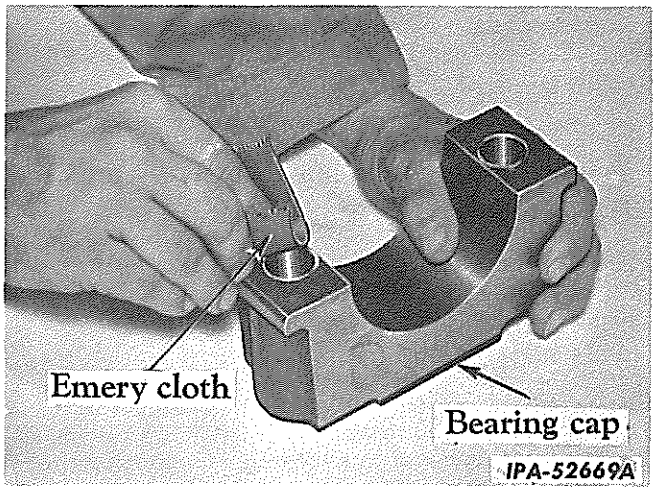
12. Clamp an angle iron to the surface plate, then clamp a file to the angle iron (Illust. 21).

13. File from surface "C" (Illust. 15) of the new cap. Dimension "A" of the new and old caps will now be equal.

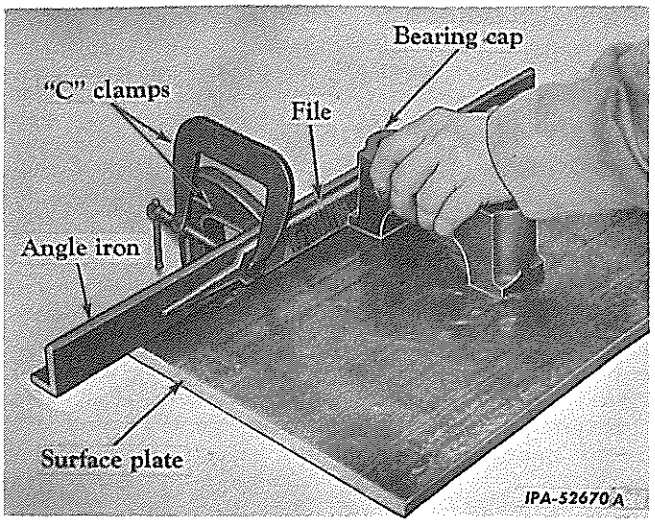


Illust. 19 - Working Surface "D."

CRANKSHAFT AND MAIN BEARINGS



Illust. 20 - Removing High Spots.



Illust. 21 - Working Surfaces "B" and "C."

NOTE: Surface "C" must be held square with surface "D" and parallel to the bearing bore.

14. File surface "B" (Illust. 15) of the new cap until the dimension "F" (6.312-6.313 inches), shown from surface "C" to "B" in Illust. 15, is obtained.

NOTE: Surface "B" must be held square with surface "D" and parallel to the bearing bore.

15. Install a new bearing in the new bearing cap. Place a length of virgin lead wire or Plastigage (Illust. 16) in the usual way in the bottom of the bearing.

16. Install the bearing and bearing cap and tighten the nut to the specified torque as given in "SPECIFICATIONS" in Section 1.

17. Remove the bearing cap and measure the virgin lead or Plastigage.

This measurement must be within the limits as given in "SPECIFICATIONS," Section 1. If the correct clearance has not been obtained, repeat Steps 6 and 7.

FLYWHEEL

8. DESCRIPTION

The flywheel is attached to the rear of the crankshaft. Its purpose is to oppose and moderate by its inertia any fluctuations in the speed of the engine. It counteracts variable torques during the stroke of the engine, and provides a rotating balance weight that carries the engine crankshaft over dead centers on the pistons.

It is secured to the end of the crankshaft with bolts and locks. Dowels are provided as an aid to installation. One bolt is offset in order to prevent flywheel installation in any other position with regard to its balanced point. The cranking motor drive ring gear is a shrink fit and is replaceable. (See parts catalog.)

The flywheel has a "DC" mark on its forward face near the rim. A pointer is provided on the flywheel housing and enables the mark to be set so, when in line with the pointer, the number one cylinder piston is at top dead center. A small aperture on the forward side of the flywheel housing, having a removable cover plate, permits the serviceman to observe the rim of the flywheel and the flywheel markings.

9. REMOVAL

1. Remove the engine clutch. (Refer to "Chassis Manual," Form No. ISS-1020.)

2. Bend back the locks from the bolt heads holding the flywheel to the crankshaft, and remove the bolts and locks. Insert two cap screws into the tapped holes in the flywheel. Then tighten the cap screws evenly until the flywheel has been pulled from the crankshaft. Lift the flywheel out of the flywheel housing.

NOTE: Support the weight of the flywheel with a hoist or other means to prevent any damage to the flywheel housing or ring gear, and as a safety measure.

FLYWHEEL

10. INSPECTION AND REPAIR

1. Wash the flywheel and ring gear in dry-cleaning solvent.

2. (Used with clutches having bi-metallic driven members.) Inspect the contact face of the flywheel for heat checks and scoring. If it is not in serviceable condition, replace the flywheel.

(Used with clutches having cerametallic driven members.) Scoring of the flywheel is normal. When the score marks or grooving is considered excessive, the flywheel may be refaced. The maximum allowance for removal is 1/16 inch. It is not necessary to remove all grooving or scoring.

To remove more surface material than specified above will result in interference of the driven member hub with the clutch pilot bearing in the flywheel.

3. Drive the dowel pins flush with the face of the flywheel. Inspect the ring gear for broken teeth, and replace the ring gear if necessary.

4. Remove the ring gear from the flywheel either by heating the gear with a torch to expand it, following that operation by driving it from the flywheel, or the ring gear may be driven off the flywheel by using a hammer and punch around the outer edges of the gear.

5. Install a new ring gear by first heating the gear to expand it, and then placing it onto the the flywheel while the ring gear is hot. The chamfered edge of the gear teeth must be toward the front of the engine.

6. Remove the pilot bearing from the flywheel. Clean the bearing in dry-cleaning solvent and then inspect it for wear and damage. If in serviceable condition, lubricate the bearing with engine lubricating oil, and install it into the flywheel. If the bearing has had considerable service, it must be replaced.

11. INSTALLATION

1. Place the flywheel into position in the flywheel housing, and line up the bolt and dowel pin holes with the crankshaft flange. Place bolt locks on the bolts and start the bolts, holding the flywheel to the crankshaft, but do not tighten them. Drive two dowel pins into place. Torque the bolts to the amount specified in section 1 "Specifications" and lock the bolts.

2. Install the engine clutch. (Refer to "Chassis Manual," Form No. ISS-1020.)

3. Lubricate the pilot bearing.

12. INSTALLING A NEW FLYWHEEL HOUSING (Power Units only)

When installing a new flywheel housing, the flywheel housing bore and face must be checked for concentricity and run-out in relation to the axis of the crankshaft. Misalignment between the flywheel housing and engine will cause corresponding misalignment of the clutch, power take-off and transmission (if equipped) resulting in serious damage. The dowel pins between the crankcase and flywheel housing are for the purpose of maintaining this alignment (within tolerances) once the flywheel is mounted.

NOTE: The mating surfaces of the crankcase and flywheel housing must be inspected and free from foreign material, burrs, ridges from nicks, thread pullout, etc. These surfaces must be flat and without assembly projections within the assembly area. Failure to clean mating surfaces will result in excessive face run-out.

Install the housing to the engine using the existing dowels. Check the flange concentricity and run-out tolerances as described under "Checking Flywheel Housing Face Run-out" and "Checking Flywheel Housing Bore Concentricity." If not within these tolerances, remove the housing and continue as follows:

(a) Remove the dowels from the crankcase.

(b) Assemble housing to crankcase. Do not tighten bolts to full torque; only enough to snug position for housing adjustment.

(c) Position the housing until it meets the tolerances described under "Checking Flywheel Housing Face Run-Out" and "Checking Flywheel House Bore Concentricity."

(d) Tighten all bolts to full torque.

(e) Recheck tolerances and reposition housing, if necessary.

(f) Ream dowel holes for oversize dowels and install the dowels.

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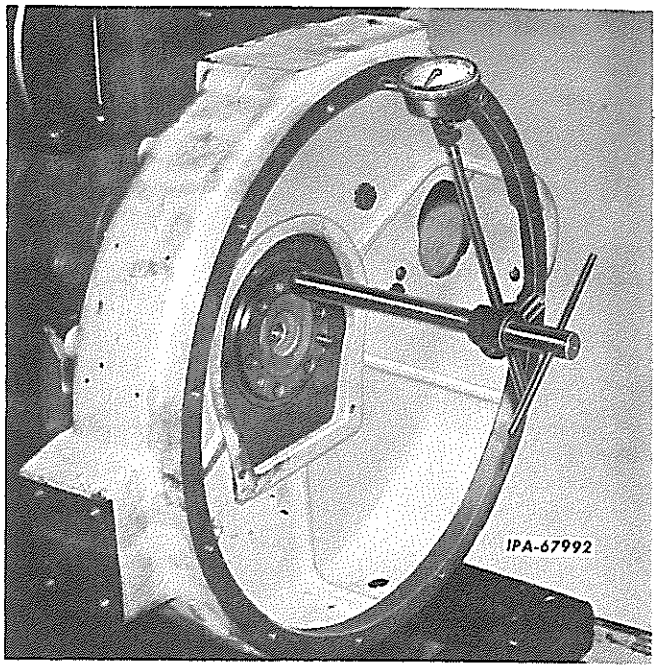
FLYWHEEL

Checking Flywheel Housing Face Run-out.

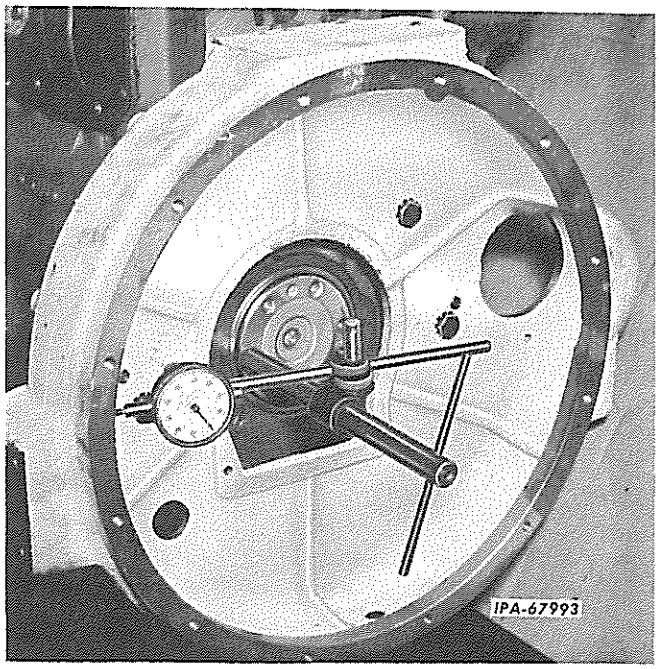
Attach a dial indicator to the crankshaft flange placing the indicator pointer against the flywheel housing face as shown in Illust. 22. Remove crankshaft "end play" and take a minimum of four checks approximately 90 degrees apart for total face variations. Care must be taken to keep crankshaft "end play" at zero in the same direction for all readings. The face run-out should not deviate more than .008 inch total indicator reading (.010 inch total indicator reading on 24 and 1091 Series engines.)



Illust. 22 - Checking Flywheel Housing Face Run-out.

Checking Flywheel Housing Bore Concentricity

Attach a dial indicator to the crankshaft, placing the indicator pointer against the flywheel housing bore as shown in Illust. 23. Rotate the crankshaft slowly and note any variations on the gauge. The reading should not vary more than .008 inch total indicator reading (.010 inch total indicator reading on 24 and 1091 Series engines.)



Illust. 23 - Checking Flywheel Housing Bore Concentricity.

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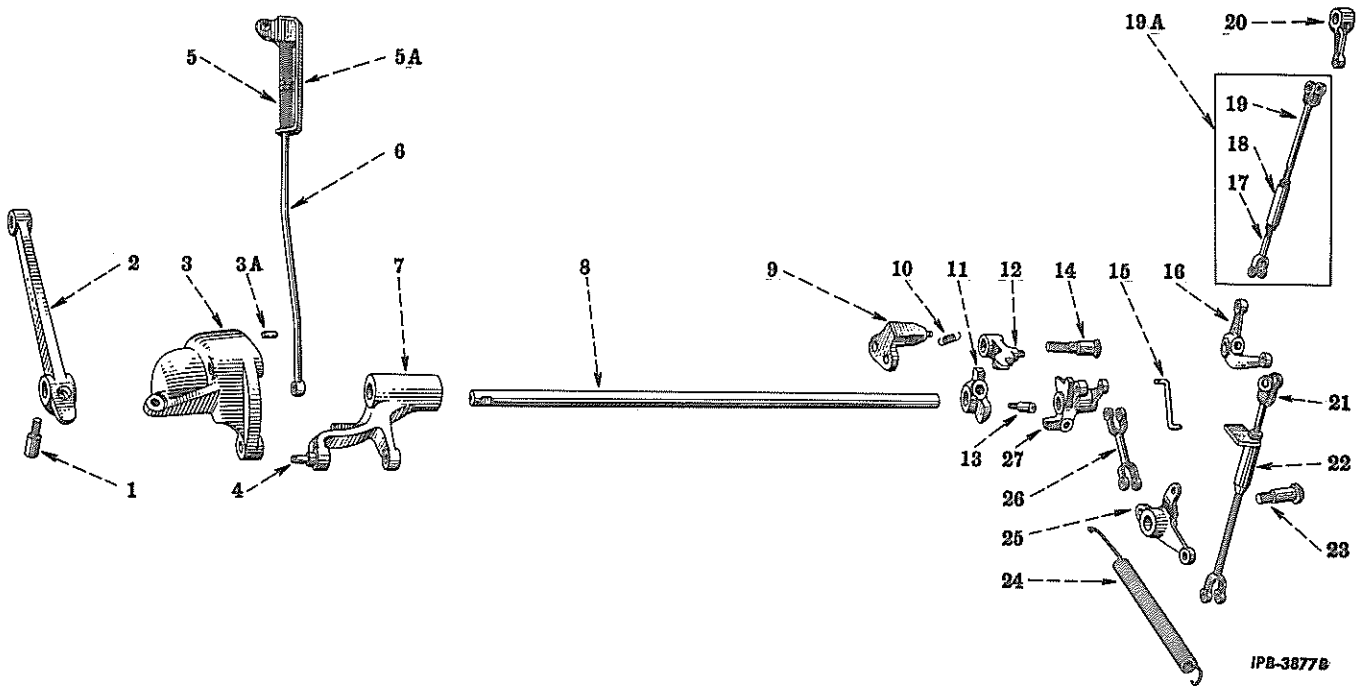

Illust. 1 - Exploded View of Compression Release Mechanism.

1. Lever pin.
2. Cross shaft operating lever.
3. Cross shaft bracket.
3A. Locating pin.
4. Lever pin.
5. Control rod spring.
5A. Governor control rod trunnion.
6. Governor control rod.
7. Governor control lever.
8. Control cross shaft.
9. Cross shaft latch bracket.
10. Cross shaft latch spring.
11. Cross shaft jaw.
12. Cross shaft latch.
13. Jaw lever pin.
14. Cross shaft latch pin.
15. Carburetor control rod.
16. Cross shaft lever (rear).
17. Cross shaft lever rod (L.H.).
18. Cross shaft lever rod turnbuckle.
19. Cross shaft lever rod (R.H.).
19A. Cross shaft lever rod assembly (R.H.).
20. Cross shaft lever (front).
21. Cross shaft operating rod (upper).
22. Cross shaft operating rod.
23. Bell crank pin.
24. Cross shaft return spring.
25. Operating bell crank.
26. Bell crank yoke.
27. Cross shaft jaw.

1. DESCRIPTION

The starting mechanism consists of the parts which change the engine from gasoline to diesel operation, and from diesel to gasoline operation. The starting mechanism cross shaft passes through the crankcase. This shaft is connected on the left side of the crankcase to the compression release lever, and on the right side to the rods which operate the starting valve shaft, the carburetor fuel shut-off cam, and the magneto or distributor grounding switch.

The engine is temporarily converted into a gasoline engine during the starting process and, after operating for approximately one to three minutes, is switched to diesel operation. This method is positive regardless of weather conditions or temperature. When the starting lever is placed in the gasoline starting position, four operations are accomplished as follows:

1. The starting valves in the cylinder head are opened, thus enlarging the combustion chambers and thereby reducing the compression ratio to that of a gasoline engine.

2. The diesel air passage from the air cleaner to the intake ports is closed, and the carburetor outlet passage above the carburetor is opened. This permits air to pass from the air cleaner into the carburetor, and the flow of a mixture of air and gasoline into the cylinders.

(Continued on next page)

1. DESCRIPTION - Continued

3. The shut-off valve in the fuel bowl is released, permitting the needle valve to be actuated by the float.

4. The magneto or distributor is placed into operation by closing the primary circuit in the manifold, thus permitting a flow of current to the spark plugs.

2. REMOVAL (Refer to Illust. 1)

For removal of the starting valve shaft, the starting valve operating shaft and the starting valves, refer to "Cylinder Head and Valves", section 2.
Remove the cross shaft as follows:

1. Remove the carburetor. (Refer to section 10.)

2. Remove the compression release rod from the operating lever (2).

3. Remove operating lever pin (1) from the operating lever and remove the lever from the shaft (8).

4. Remove the governor control rod (6) after removing the cotter pin and flat washer.

5. Disconnect the diesel throttle control lever at the governor control lever (7) by removing a cotter pin, washer and clevis pin.

6. Remove the three cap screws securing the cross shaft bracket (3) to the crankcase. Slide the cross shaft bracket (3) and governor control lever (7) off the control cross shaft (8).

7. Move to the opposite side of the engine and remove the cross shaft return spring (24) from the stud in the crankcase and the cross shaft jaw (27).

8. Disconnect the bell crank yoke (26) from the operating bell crank (25) and the cross shaft jaw (27). Disconnect cross shaft operating rod (21) from cross shaft lever (16). Remove bell crank pin (23) and operating bell crank (25) with cross shaft operating rod (22).

9. Remove the carburetor control rod (15) from the cross shaft jaw (27). Remove the cross shaft jaw by removing the cotter pin and washer securing it to shaft (8).

10. Remove the cross shaft latch pin (14), latch (12) and spring (10). Remove the nut which holds the latch bracket (9) to the crankcase, and remove the bracket.

11. Remove jaw lever pin (13) and cross shaft jaw (11) from shaft (8). Pull the shaft out of the crankcase.

3. INSPECTION AND REPAIR

1. Clean all parts thoroughly with solvent, and dry them with compressed air.

2. If any parts show wear to the extent that the latches or jaws will not hold, replace them with new parts.

3. Do not remove the set screws unless the part in which they are located must be replaced.

4. The cross shaft rotates in two bushings in the crankcase. It will not be necessary to remove them unless replacement is necessary.

4. INSTALLATION

1. Install the cross shaft through the crankcase. The cross shaft should be coated with a good high-melting-point short-fibre or wheel-bearing grease. Ordinary greases will tend to run out at high operating temperatures.

2. Install the cross shaft jaw (11) and secure with lever pin (13).

3. Attach the latch bracket (9) to the crankcase. Assemble the latch pin (14) into the latch (12) and assemble to the latch bracket.

4. Place the cross shaft jaw (27) on the shaft (8) and secure with a flat washer and cotter pin. Install the carburetor control rod (15) to the cross shaft jaw.

5. Install spring (10) between the cross shaft latch (12) and the cross shaft latch bracket (9). Insert bell crank pin (23) into the operating bell crank (25) and attach to crankcase. Install bell crank yoke (26) between the operating bell crank (25) and the cross shaft jaw (27). Connect the cross shaft operating rod (22) between the operating bell crank (25) and cross shaft lever (16).

6. Connect the cross shaft return spring (24) between the cross shaft jaw (27) and the stud in the crankcase.

7. Move to the left side of the engine and slide the governor control lever (7) and cross shaft bracket (3) onto the control shaft. Secure the cross shaft bracket (3) to the crankcase with three cap screws.

8. Connect the diesel throttle control lever to the governor control lever (7). Secure with a clevis pin, flat washer and cotter pin.

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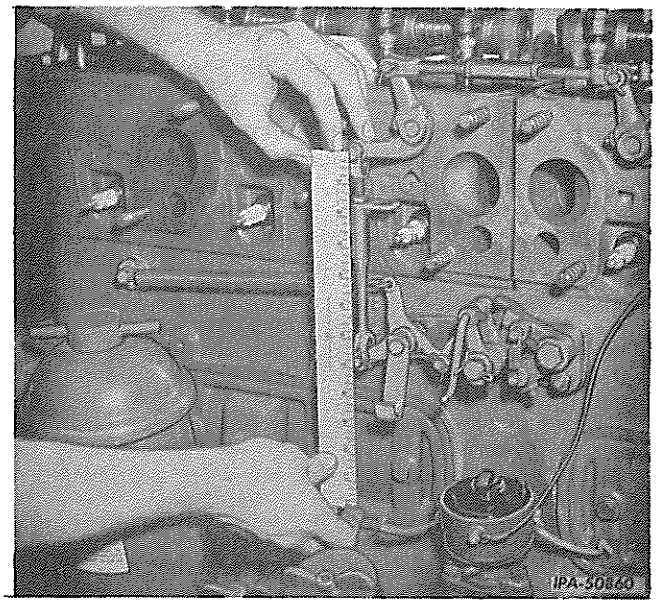
4. INSTALLATION – Continued

9. Connect the governor control rod (6) to the lever pin (4) in the governor control lever (7). Secure with a flat washer and cotter pin. Install operating lever (2) and secure with pin (1).

10. Install the carburetor. (Refer to section 10.)

11. Adjust the compression release mechanism. **(Refer to following paragraph.)**



Illust. 2 - Adjusting the Length of the Operating Rod.

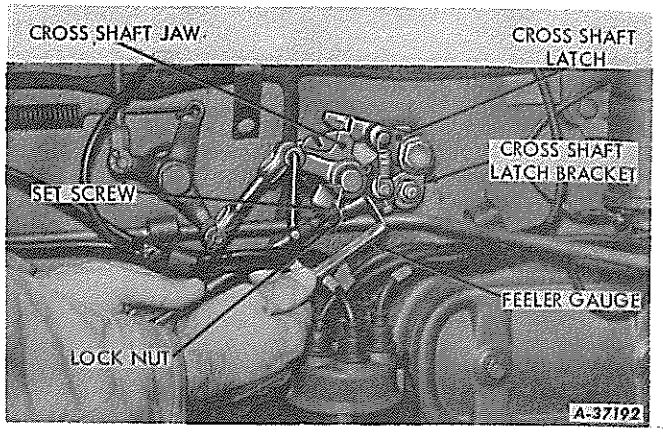
5. ADJUSTMENT OF RELEASE MECHANISM

Before adjustments are made, the engine should be completely reassembled with the exception of the intake and exhaust manifolds and the valve cover. Parts should be clean and lubricated with oil to assure free operation.

1. Adjust the cross shaft operating rod to obtain a length of 6-25/32 inches on the 16, 525 and 554 series, and a length of 8-1/2 inches on the 24 and 1091 series. This dimension is measured between the pin hole centers. (See Illust. 2.)

2. Adjust the starting valve cross shaft lever rod to a length of 7-1/4 inches on the 16, 525 and 554 series and to a length of 9-23/32 inches on the 24 and 1091 series. Dimensions to be measured between the pin hole centers. (See Illust. 9.)

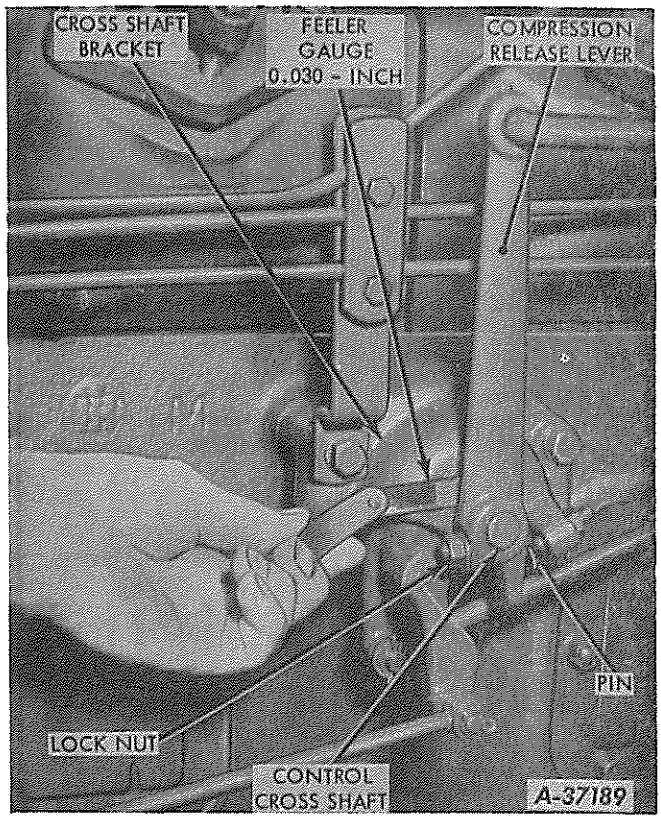
3. Adjust the cross shaft to obtain .030 inch end play between the cross shaft compression release lever and the cross shaft bracket. This is accomplished by loosening the nuts on the operating lever and on the cross shaft jaw lever at **opposite ends of the cross shaft.**



Illust. 3 - Checking Clearance Between Set Screw in Cross Shaft Jaw and Latch Bracket.

Tighten the nuts when end play has been obtained and recheck to be sure that clearance has been maintained. (See Illust. 4.)

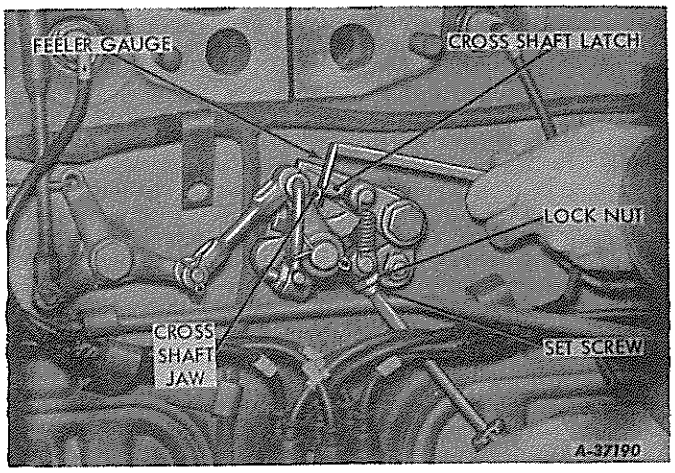
(Continued on next page.)



Illust. 4 - Checking and Adjusting the Cross Shaft End Play.

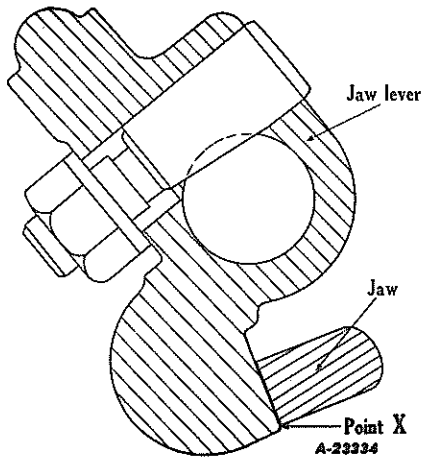
5. ADJUSTMENT OF RELEASE MECHANISM – Continued

4. Back off the adjusting screws on the cross shaft latch bracket (Illust. 3), the cross shaft jaw (Illust. 5), and the cross shaft bracket (Illust. 7).



Illust. 5 - Checking and Adjusting the Clearance Between the Cross Shaft Latch and the Cross Shaft Jaw.

5. Adjust the set screw in cross shaft latch bracket to obtain .060 inch clearance between the latch lever and the jaw. (See Illust. 3.) Lock the nut and recheck the clearance.

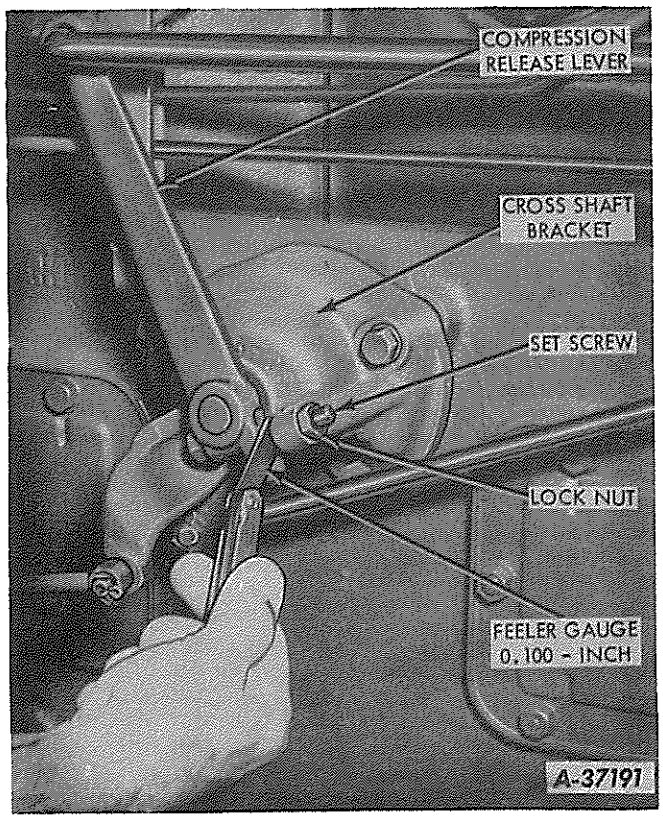


Illust. 6 - Showing Point X, Between Faces on Cross Shaft Jaw and Lever.

6. Turn the cross shaft release lever clockwise until the pick-up faces on the jaw and cross shaft jaw lever are contacting at point X shown in Illust. 6. Adjust the set screw in the cross shaft bracket to obtain a .100 inch clearance between the set screw and the compression release lever. (See Illust. 7.) Lock the nut and recheck the clearance.

7. Turn the compression release lever clockwise until the latch lever locks in place on the cross shaft jaw. The mechanism is now in gasoline position.

8. Increase the length of the operating rod (see Illust. 2) by turning the rod end to the left one-half turn at a time until the closest fitting of the starting valve covers in the rear cylinder head has a slight additional travel (approximately 1/64 inch) before bottoming in the cylinder head. After each half-turn, check all the starting valve covers in the rear head by applying pressure to the covers with a screwdriver, as shown in Illust. 8, to determine which has the least amount of travel. When this adjustment has been made, lock the yoke and insert cotters in rod end pins.



Illust. 7 - Checking and Adjusting Clearance Between the Cross Shaft Release Lever and the Cross Shaft Bracket Set Screw.

9. Keep the controls in the gasoline position, and increase the length of the starting valve shaft cross shaft lever rod. (See Illust. 9.) Turn the turnbuckle one-half turn at a time until the

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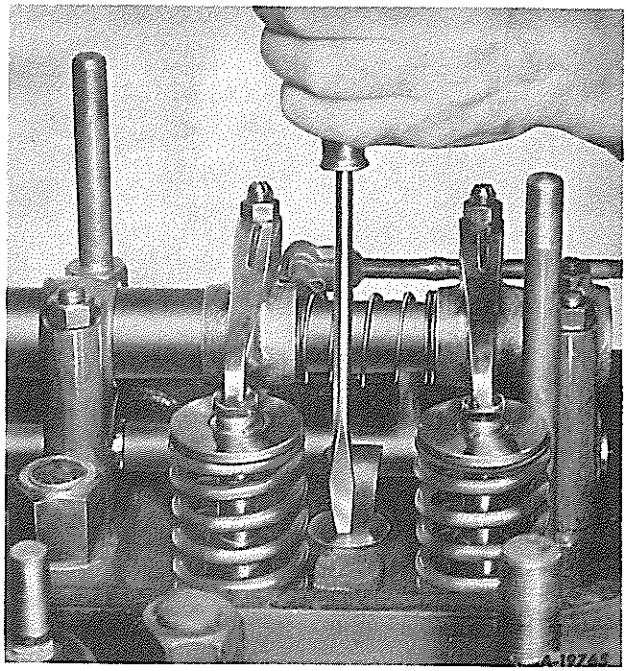
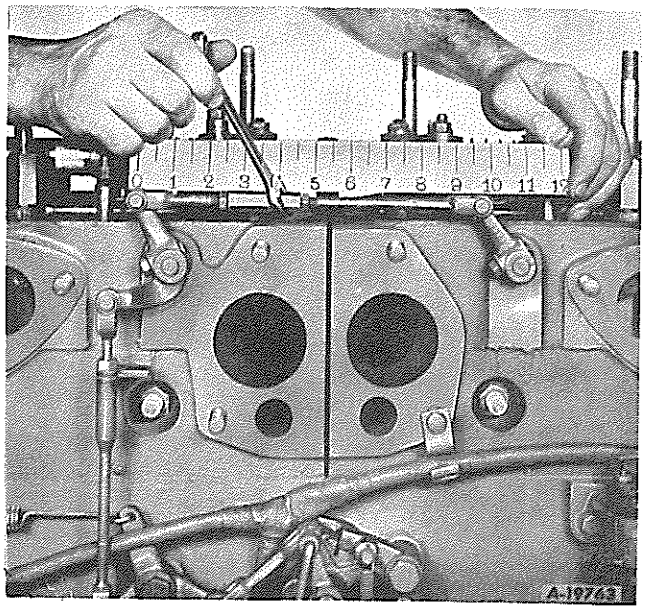
closest fitting of the starting valve covers in the front cylinder head has an additional travel of approximately 1/64 inch before bottoming in the cylinder head. After each half-turn, check all the front cylinder head covers by applying pressure to the tops of the covers with a screwdriver, as shown in Illust. 8, to determine which one has the least amount of travel. When adjustment has been completed, insert the cotters into the rod end pins after locking the yoke.

10. Adjust the set screw in the cross shaft jaw to obtain a .015 inch clearance between the set screw and the stop on the cross shaft latch bracket. (See Illust. 5.) Lock the set screw and recheck the clearance.

11. Trip the release mechanism to the diesel position by moving the compression release lever to the left (toward the injection pump). In that position, check to determine that there is clearance between the starting valve shaft and the valve covers. **Check all covers.**



Illust. 8 - Checking Starting Valve Cover.



Illust. 9 - Adjusting the Starting Valve Cross Shaft Lever Rod.

NOTE: After the above adjustments have been made satisfactorily, and with the controls in the gasoline position, each starting valve cover should have an additional travel before bottoming in the cylinder head. Check this with the screwdriver as in Illust. 8. If a check shows no additional travel before bottoming, recheck the adjustments for possible errors.

12. Prior to installing the manifolds, check the butterfly valves in the intake manifold to be sure that they are in an exactly horizontal position. Any adjustment necessary can be accomplished with the set screws provided on top of the manifold. Butterfly valve shafts must operate freely. The valves must fit the bore of the manifold in the diesel position with not more than a .0015 inch clearance measured with a feeler gauge 1/8 inch wide only.

13. Install the manifolds and valve housing cover after setting the exhaust and intake valves to their specified cold setting. (Refer to "Specifications", section 1.)

14. Latch and trip the mechanism several times as a check that all adjustments are holding satisfactorily.

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GOVERNOR CONTROL

1. DESCRIPTION

Friction Disc Type

The governor speed control is a separate unit attached to the flywheel housing. Two types are used: one consists of friction discs separated by a stationary plate that serves also as the mounting bracket. The discs are sandwiched between the control body to which is attached the control lever. The body has a projecting apron with an adjusting set screw at each end. These screws contact and limit the movement of the control lever. (See Illust. 1 and 2.)

Ratchet Lever Type

The second type of control is a vertically moving lever riding in a ratchet bracket mounted to the dash. It is connected to the speed control lever on the fuel injection pump by two rods and a bell crank. By raising or lowering the hand lever, the speed of the engine may be controlled under varying loads. Low and high idle adjustments are made at the pump.

2. REMOVAL AND DISASSEMBLY

UD-525 and 554 (Refer to Illust. 1 and 2)

1. Disconnect the control rod (14) from the governor control body (4).

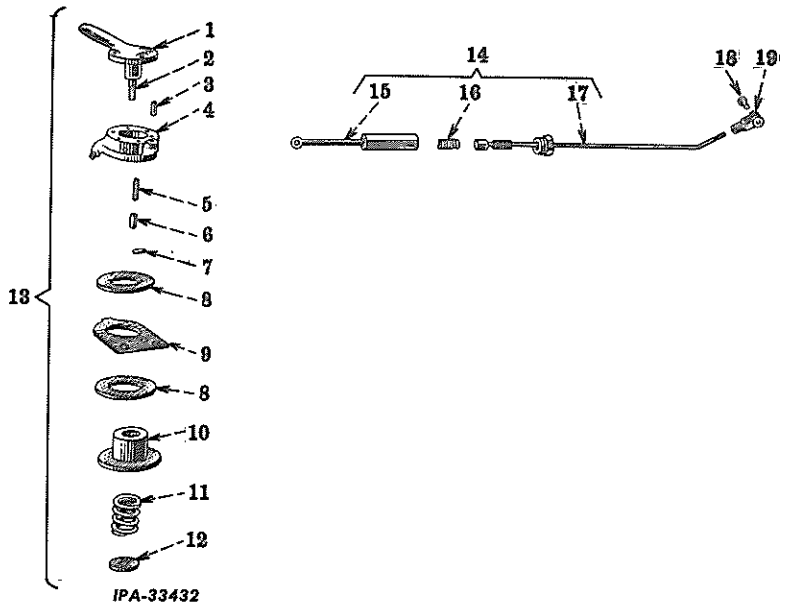
2. Remove the control lever bracket (9) from the flywheel housing and lift off the governor control lever (13).

3. Remove the governor control rod (14). Remove the cotter and yoke pin (19) securing the governor control rod to the governor control lever; then remove the governor control lever.

4. Remove the spring tension nut from the governor control lever stud (2), thus releasing spring retainer (12). Remove spring (11), spring cup (10), lower friction disc (8), bracket (9) and upper friction disc (8), from the control body (4).

5. Scratch a mark on the edges of the control lever and the control body for a guide when reassembling.

(Continued on next page)

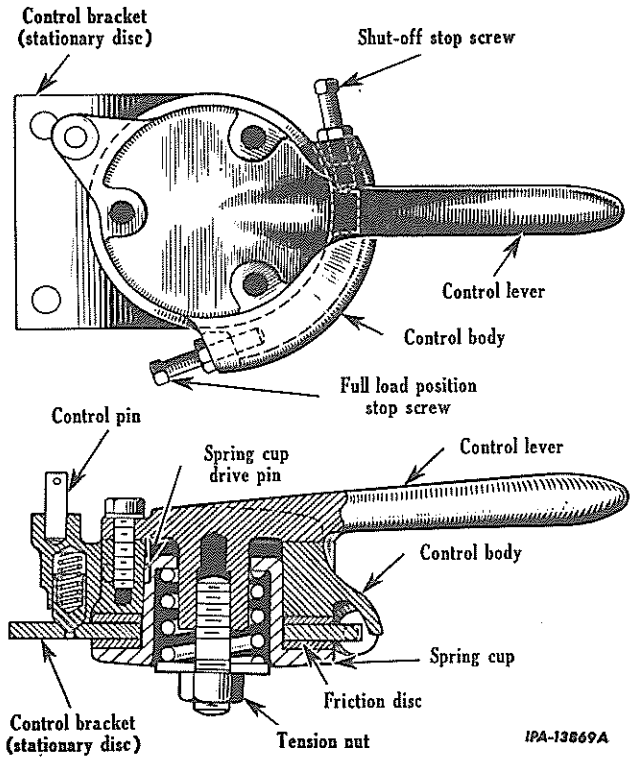


Illust. 1 - Exploded View of the Governor Control Assembly (Friction Disc Type) (UD-525 and UD-554) (UD-16 Similar).

1. Governor control lever.
2. Stud.
3. Pin.
4. Body.
5. Poppet spring.
6. Poppet.
7. Drive pin.
8. Friction disc.
9. Bracket.
10. Cup.
11. Friction spring.
12. Retainer.
13. Control lever, complete.
14. Control rod, complete.
15. Rear rod.
16. Spring.
17. Spring housing nut.
18. Front rod.
19. Pin.
20. Yoke.

GOVERNOR CONTROL

2. REMOVAL AND DISASSEMBLY - Continued



Illust. 2 - Governor Friction Control (UD-525 and 554) (UD-16 Similar).

UD-525 and 554 (Refer to Illust. 1 and 2) - Continued

6. Remove the cap screws, with lock washers, from the top of the control lever, thereby separating it from the body.

7. The control rod pin (3) is a press fit in the control body.

UD-24 and 1091 (Refer to Illust. 3)

1. To remove the governor control, it is necessary first to remove the compression release lever. Remove the cotter securing the compression release rod (1) to the cross shaft lever.

2. Remove the cap screws securing the bracket (3) to the governor control body.

3. Remove the compression release lever by pulling it through the rear hood sheet.

4. Remove cotter from governor control rod connection (10) at the cross shaft assembly.

5. Remove cap screws securing governor body to the flywheel housing, and remove the assembly from inside of the rear hood sheet.

6. Remove screws securing governor ratchet (16) to the governor body.

7. Remove cotter holding the governor control rod adjusting sleeve (9) to the lever (6).

8. Remove the cotter securing the lever pin (12) to the body, and remove the pin.

9. Remove the spring (11 from lever (6).

10. Remove cotter securing the hand lever to lever (6) and remove lever pin and hand lever.

11. Remove cotter securing the low idle bumper plate (5) to the governor body, and unhook the bumper plate spring (14).

TD-15 (150 Series) (Refer to Illust. 4)

1. Disconnect the rod, front (4) by pulling the yoke pin (3). The rod, rear (6) is disconnected in the same manner.

2. To remove the hand lever (12), it will be necessary to remove the four cap screws which secure the ratchet (14) to the dash.

3. Remove the hand lever shaft (8) by removing the jam nut (not shown) and washer. Remove the hand lever pin (10) and take out the hand lever with pawl (11). The hand lever spring (9) and hub (7) will be free to remove.

TD-24 (Refer to Illust. 5)

1. Remove the four screws securing the ratchet (7) to the dash and remove the ratchet.

2. Disconnect the governor control rod (16) from the lever (13) by removing pin (14) from adjusting yoke (15).

3. Remove the governor control lever tapered lock pin and remove lever (13) from shaft (6). Move lever (8) to the side and remove spring (12). Remove pin (11) from lever (8) and separate the lever (8) from the hub (10).

4. Remove the cotter pin that passes through the left side of the shaft (6). Remove the lock tapered in the hand lever hub (10) and pull the shaft (6) out of the mounting bosses on the dash and slide the hub (10) and flat washers off the shaft (6).

3. INSPECTION AND REPAIR

Inspect the condition of all parts, and replace all parts that are not serviceable.

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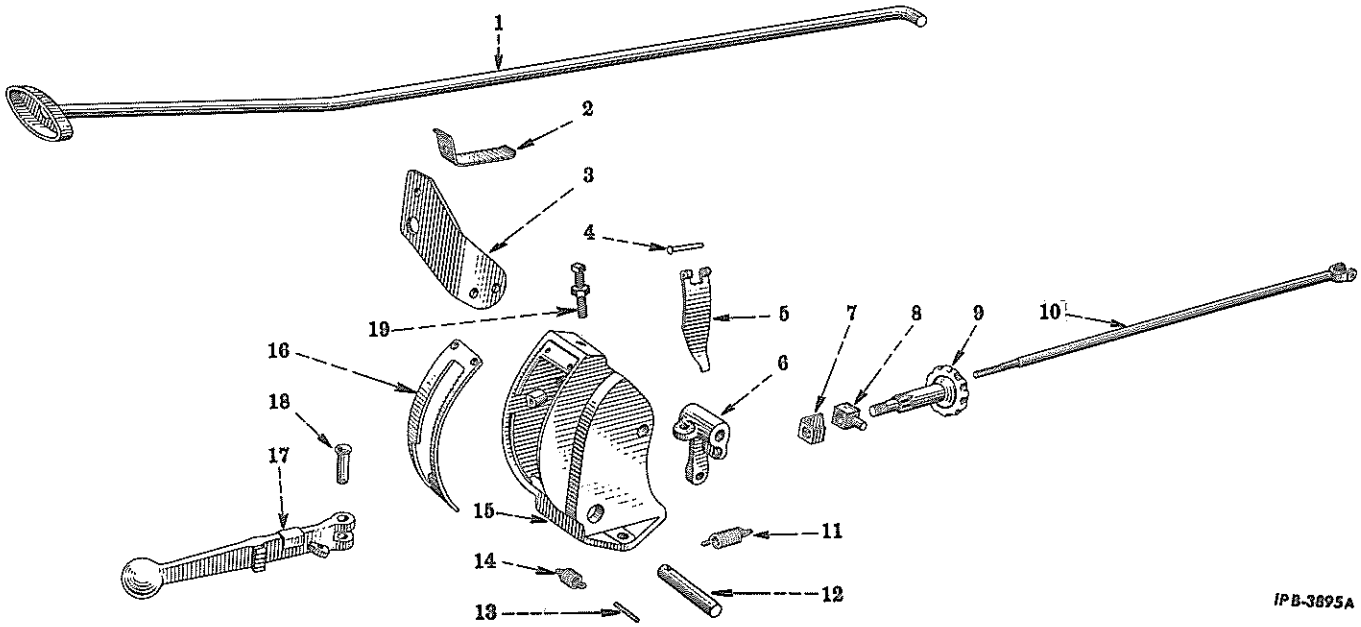
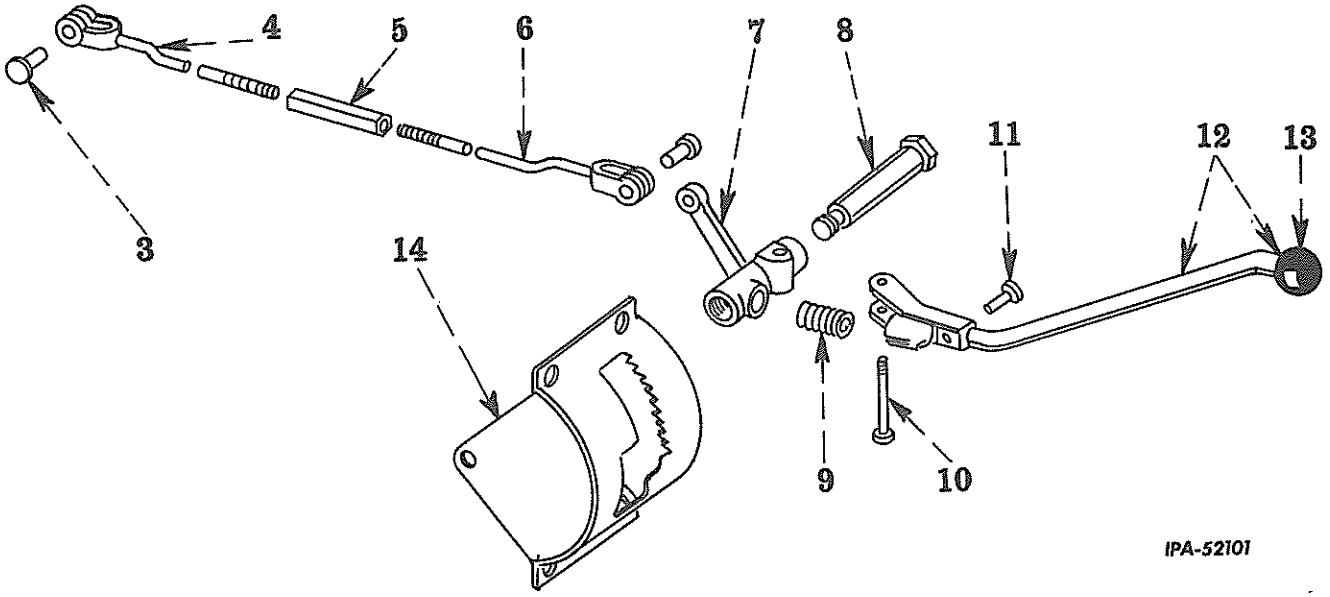
GOVERNOR CONTROL



Illust. 3 - Exploded View of Governor and Compression Release Controls (Ratchet Lever Type)(UD-24 and 1091).

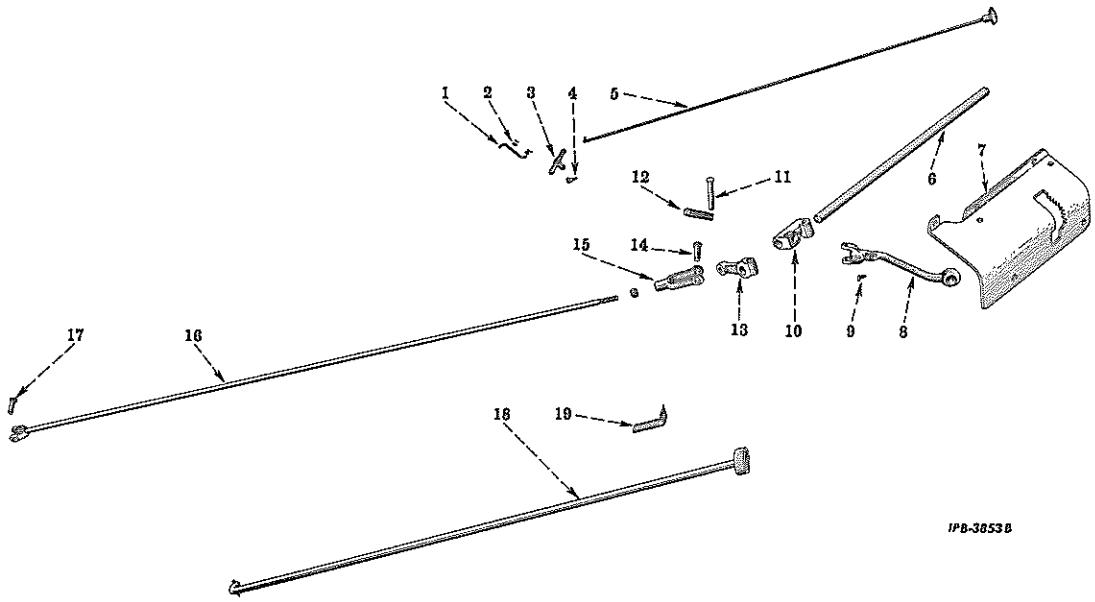
1. Compression release rod.
2. Compression release rod spring.
3. Compression release rod bracket.
4. Low idle bumper plate pin.
5. Low idle bumper plate.
6. Governor control rod lever.
7. Governor adjusting sleeve spring.
8. Governor control trunnion.
9. Governor rod adjusting sleeve.
10. Governor control rod.
11. Governor hand lever spring.
12. Governor lever pin.
13. Low idle bumper plate spring anchor.
14. Bumper plate spring.
15. Governor body.
16. Governor control ratchet.
17. Hand lever.
18. Hand lever pin.
19. Full load adjusting set screw.



Illust. 4 - Exploded View of Governor controls (Ratchet Type) (TD-15).

3. Yoke pin.
4. Rod, front.
5. Turnbuckle.
6. Rod, rear.
7. Hand lever hub.
8. Hand lever shaft.
9. Hand lever spring
10. Hand lever pin.
11. Hand lever pawl.
12. Hand lever.
13. Hand lever ball.
14. Ratchet.

GOVERNOR CONTROL



Illust. 5 - Exploded View of Governor Control and Related Parts (Ratchet Lever Type) (TD-24).

1. Choke bell crank connecting rod.
2. Washer.
3. Choke bell crank.
4. Screw.
5. Choke control rod.
6. Shaft.
7. Ratchet.
8. Governor control hand lever.
9. Pawl.
10. Hub.
11. Pin.
12. Spring.
13. Governor control rod lever.
14. Pin.
15. Yoke.
16. Governor control rod.
17. Pin.
18. Compression release rod.
19. Compression release rod spring.

4. REASSEMBLY AND INSTALLATION

UD-525 and 554 (Refer to Illust. 1 and 2)

1. Position the control lever (1) on control body (4) and line up the scratch marks which were made before disassembly.

2. Insert three cap screws, with lock washers, through the top of the control lever, and secure it in place.

3. With the flange side of spring cup (10) on a flat surface, place a friction disc (8), over the cup end; then add control bracket (9), and add another friction disc (8) on top.

4. Place the spring cup, with discs and bracket over the control lever stud and into the recess in the control body.

5. Place the friction spring (11) over the control lever stud (2); the add the spring retainer (12), and secure with a nut.

6. Tighten the nut to 10 foot-pounds torque for the proper friction tension of the control lever.

7. Attach the complete governor control lever to the flywheel housing.

8. Attach the control rod (14) to the control body (4).

9. Attach the front rod (18) to the control lever on the governor with pin (19) and a cotter pin.

UD-24 and 1091 (Refer to Illust. 3)

1. Install low idle bumper plate (5) and spring (14) into the governor body.

2. Install hand lever to lever (6), and secure with pin and cotter. Insert into body and secure with pin and cotter.

3. Install springs (11) and lever (6).

4. Connect governor control rod adjusting sleeve (9) to the lever (6).

5. Install governor control ratchet plate to the governor body.

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GOVERNOR CONTROL

6. Position governor assembly on the flywheel housing, and secure with cap screws.

7. Connect governor control rod to the cross shaft assembly, and secure with cotter.

8. Install compression release lever bracket, and secure with cap screws.

9. Install compression release lever and connect end to the cross shaft lever with cotter.

TD-15 (150 Series) (Refer to Illust. 4)

1. Insert the hand lever (12) through the front of the ratchet (14), and install the hub (7) and spring (9) to the lever and secure with the hand lever pin (10).

2. Install the hand lever (12) with hub (7) by screwing the nut on the hand lever shaft (8).

3. Install the ratchet (14) to the dash and secure it with four screws, washers and nuts.

4. Install the front and rear rods (4 and 6) by using the yoke pins (3) to secure them.

TD-24 (Refer to Illust. 5)

1. Slide the shaft (6) through the boss in the right hand mounting bracket on the dash (cotter pin hole end first).

2. Slide the hub (10) onto the shaft with the spring socket on the left side as shown in Illust.

5. Place the flat washer on the shaft and push the shaft through the boss in the left hand mounting bracket on its dash.

3. Secure hub (10) to the shaft with tapered lock pin and nut. Install cotter pin in the hole in the shaft (6) just behind the flat washer. (The cotter pin and washer keep the shaft from drifting.)

4. Install the governor control rod lever (13) to the shaft (6) and secure with tapered lock pin and nut.

5. Place the forked end of the governor control hand lever over the boss on the end of the hub (10) and install clevis pin (11). Secure with cotter pin.

6. Move the lever (8) to the right and install spring (12) into the socket of the hub (10) and lever (8). Place the ratchet (7) over the lever (8) and secure to the mounting brackets with four screws.

7. Place the governor control hand lever (8) in the low idle position (at the lower end of the ratchet teeth). With the injection pump governor speed control lever also in low idle position, adjust the yoke (15) on the governor control rod (16) until the holes in the yoke and the lever (13) are aligned. Insert clevis pin (14) and tighten lock nut on the yoke.

NATURAL GAS GOVERNOR

5. DESCRIPTION

The engine governor is fly-ball, variable speed type, designed to maintain engine speed within reasonably constant limits, under varying load conditions, by proportioning the fuel to the load. The governor depends upon centrifugal force for its action, developed by weights rotating about a shaft. A spring counteracts the outward movement of the weights. The movement of the weights is passed to the carburetor throttle valve by linkage.

As the engine starts and its speed increases, the governor weights move outward by centrifugal action until the spring tension force equals that of the centrifugal force, throwing the weights against the spring. Thus, at a certain point, both spring and governor forces are balanced and the engine speed will remain constant.

When changes in engine speed occur through variations in load while operating, the change in speed causes a small movement in or out of the governor weights due to centrifugal force. This weight movement causes a change in throttle valve position and allows more (or less) fuel to enter the cylinders, thus maintaining an engine speed capable of supplying the power needed for the load imposed.

The engine speed settings are controlled by increasing the speed range lever or decreasing the governor spring tension.

6. REMOVAL

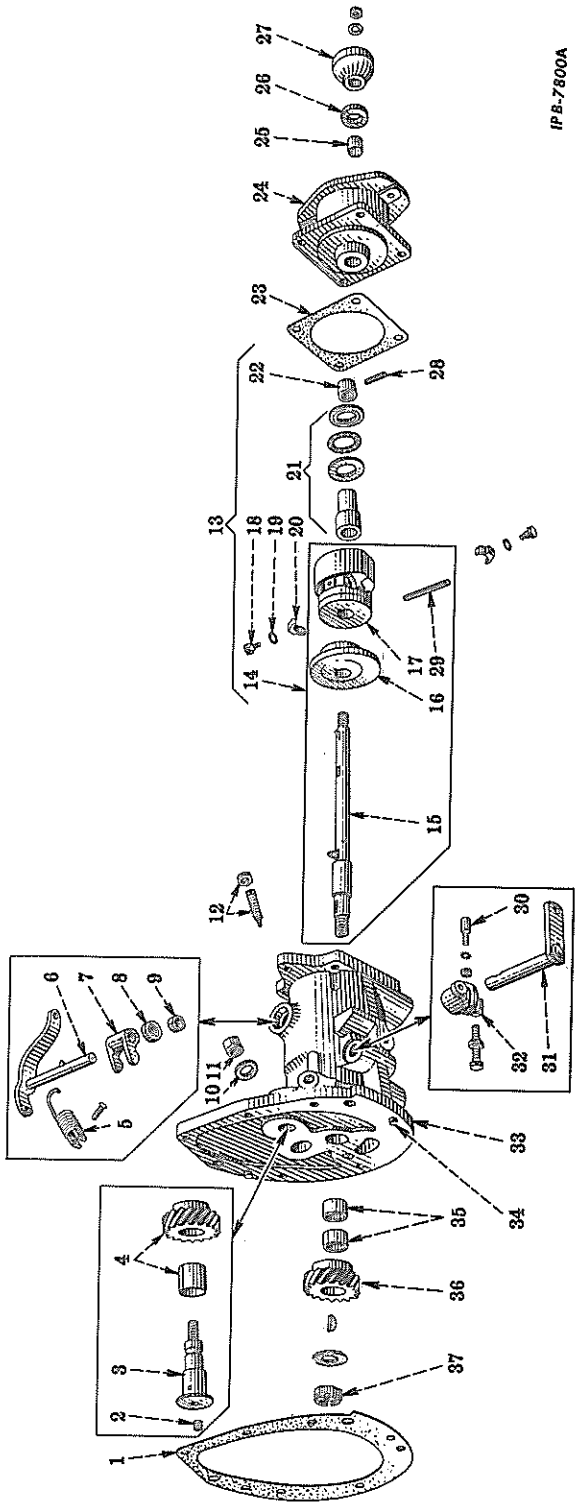
1. Disconnect the magneto grounding wire and spark plug cables from the magneto if so equipped.

2. Remove the two bolts fastening the magneto to the magneto drive housing, and remove the magneto, if so equipped.

3. Disconnect the throttle control rod and governor control rod from the governor.

4. Remove the governor from the crankcase front cover.

NATURAL GAS GOVERNOR



Illust. 6 - Exploded View of Governor.

1. Gasket.
2. Plug.
3. Idler shaft.
4. Idler gear.
5. Governor spring.
6. Rockshaft.
7. Thrust fork.
8. Oil seal.
9. Roller bearing.
10. Washer.
11. Nut.
12. Bumper body and spring.
13. Shaft assembly - complete.
14. Shaft and weight assembly.
15. Shaft.
16. Fuel pump cam.
17. Governor weight.
18. Thrust shoe pin.
19. Lockwasher.
20. Thrust shoe.
21. Bearing and sleeve.
22. Sleeve stop.
23. Gasket.
24. Magneto bracket.
25. Bushing.
26. Oil Seal.
27. Coupling.
28. Pin.
29. Pin.
30. Pin.
31. Lever.
32. Lever.
33. Housing.
34. Pin.
35. Bushing.
36. Drive gear.
37. Nut.

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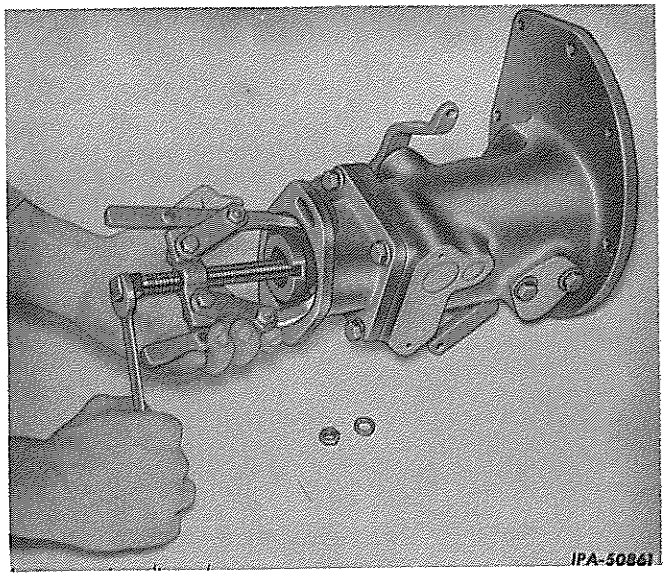
NATURAL GAS GOVERNOR

7. DISASSEMBLY (Refer to Illust. 6)

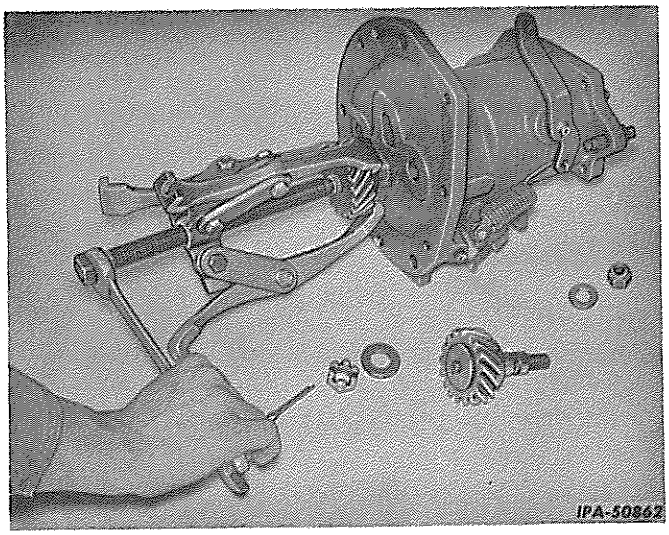
1. Remove the nut and lock washer and the magneto drive coupling (27). (See Illust. 7.)



Illust. 7 - Remove the Magneto Drive Coupling.

2. Remove the magneto bracket (24) with bushing (25) and seal (26).

3. Remove the nut (11) and lockwasher (12) from the idler gear shaft (3). Remove the shaft (3), and gear and bushing (4).



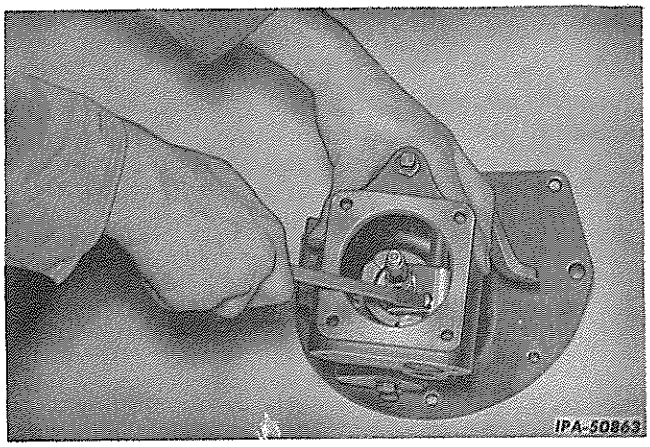
Illust. 8 - Removing the Drive Gear.

4. Remove the castellated nut(37) and washer.

5. Remove the gear (36). (See Illust. 8.)

6. Remove the cotter pin and clevis pin fastening the governor spring (5) to the governor spring throttle lever (32).

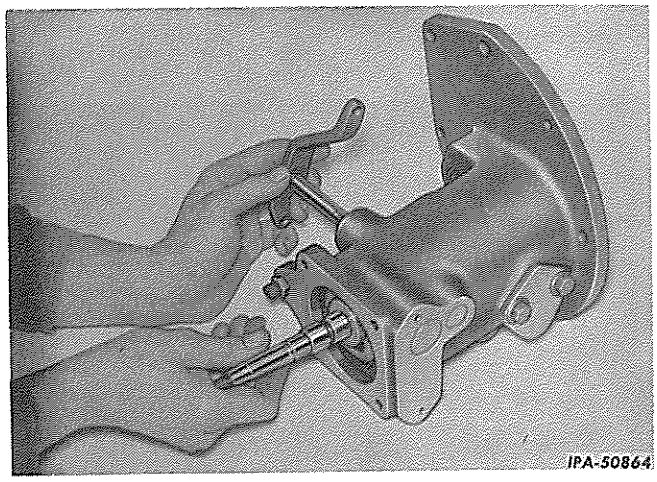
7. Remove the machine screw and lock washer fastening the thrust fork (7) to the rockshaft (6). (See Illust. 9.)



Illust. 9 - Removing or Installing the Thrust Fork.

8. Slide the rockshaft (6) out and remove the thrust fork (7), and the governor shaft assembly (13). Immediately replace the rockshaft (6) to avoid loss of the rockshaft needle bearings in the governor housing (33). (See Illust. 10.)

(Continued on next page)



Illust. 10 - Removing or Installing the Governor Shaft Assembly.

NATURAL GAS GOVERNOR

7. DISASSEMBLY (Refer to Illust. 6) - Continued

9. Remove the throttle lever pin (30), throttle lever (32) and speed change lever (31) from the housing (33).

10. Inspect the bushings (35), needle bearings (9) and oil seal (8); removal of these parts will not be necessary unless replacement is necessary. (Refer to "Inspection and Repair" paragraph.) When removing the needle bearings (9) or oil seal (8), it is necessary to remove the expansion plug.

11. Inspect the bushing (25) and oil seal (26). Removal of these parts will not be necessary unless replacement is necessary. (Refer to "Inspection and Repair" paragraph.)

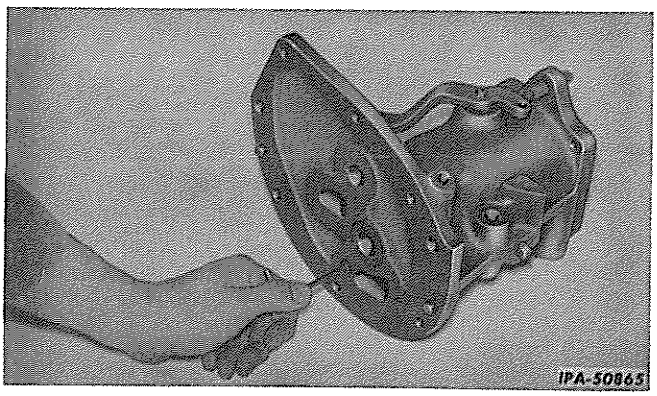
12. Remove the thrust sleeve stop pin (28). Slide the thrust sleeve stop (22) and the thrust sleeve bearing and sleeve (21) from the shaft (15). (See Illust. 17 and 18.)

13. Remove the carrier pin (29). Slide the fuel pump cam (16) and the governor weight and carrier assembly (17 thru 20) from the shaft (15). (See Illust. 14 and 15.)

14. Remove the thrust shoe pin (18), lock washer (19) and thrust shoe (20) from each of the weight assemblies.

8. INSPECTION AND REPAIR (Refer to Illust. 6)

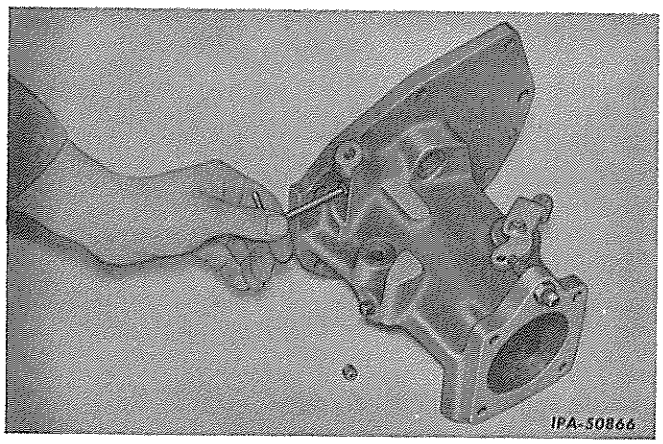
1. Clean all parts in a cleaning solvent and dry with compressed air.



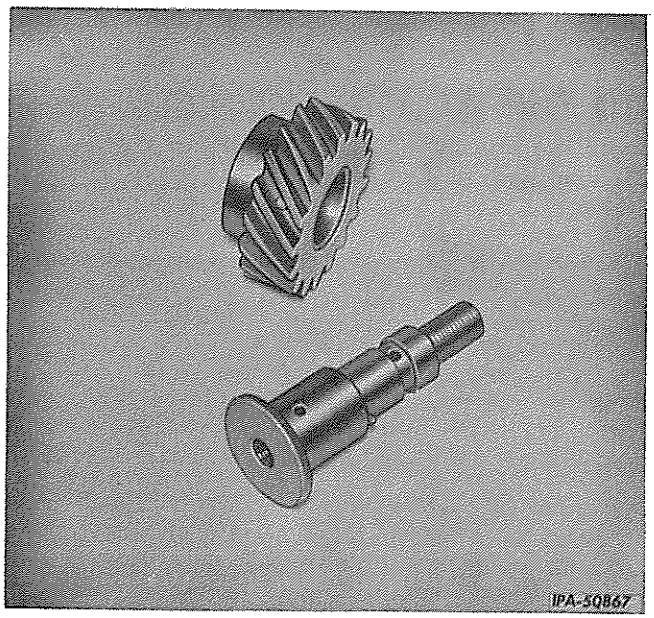
Illust. 11 - Removing or Installing Oil Passage Pipe Plug.

2. Remove the three allen head pipe plugs in the housing (33) and clean the oil holes in the housing. (See Illust. 11 and 12.)

3. Remove the plug in the idler shaft and clean the oil passages in the idler shaft. (See Illust. 13.)



Illust. 12 - Removing or Installing Oil Passage Pipe Plugs.



Illust. 13 - Idler Gear and Shaft Oil Passages.

4. Inspect the rockshaft oil seal (8) and the magneto bracket oil seal (26). If either seal shows signs of wear, damage or leaking, it must be replaced.

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NATURAL GAS GOVERNOR

5. Inspect the magneto bracket bushing for wear or damage. The original inside diameter is .5922-.5932. When replacing a magneto bracket bushing, carefully align the oil hole in the bushing with the oil hole in in the magneto bracket.

6. Inspect the thrust bearing and sleeve assembly (21). Check the ball bearings for wear or pitting, and check each of the outer races for wear or cracking. If any part of this assembly is not serviceable, the entire sleeve and bearing assembly must be replaced.

7. Inspect the thrust shoes (20); replace if necessary.

8. Check the governor weight and carrier assembly (17) to be certain that the weights do not bind on the pins.

9. Check the bearing areas of the governor shaft (15). The original diameter of the shaft at the magneto bracket bushing area is .5912-.5906; at the governor housing bushing area the diameter is .8735-.8730.

10. Inspect the governor housing bushings (35) for wear or damage; the original inside diameter is .8745-.8755.

11. Check the idler gear and bushing (4); the original inside diameter is 1.000-1.001. If the bushing is worn excessively, the gear and bushing must be replaced as an assembly.

12. Check the idler gear bearing area on the idler shaft (3). The original diameter of the shaft in this area is .9990-.9985.

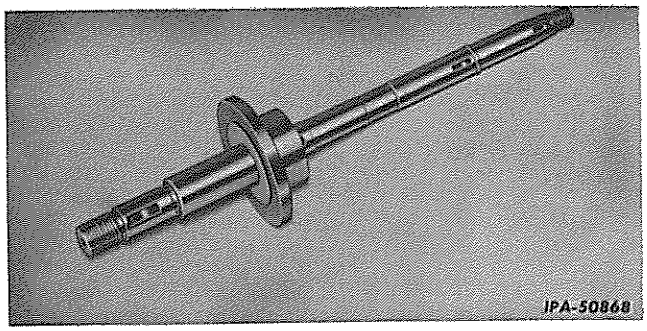
9. REASSEMBLY (Refer to Illust. 6)

1. Install the fuel pump key into the shaft (15). Slide the cam (16) on the shaft, placing the larger diameter end against the shoulder of the shaft. (See Illust. 14.)

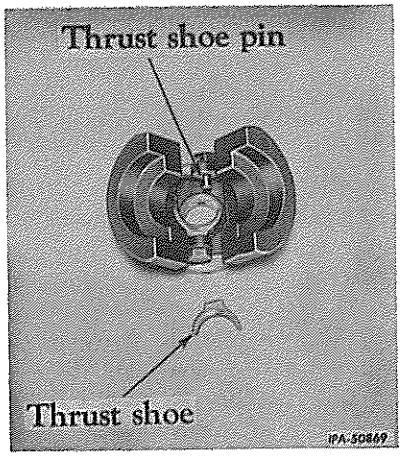
2. Assemble the thrust shoes (20) to the governor weight and carrier assembly (17) as follows:

(a) Fasten a thrust shoe pin and lockwasher to each weight.

(b) Spread the weights apart. Place each thrust shoe into the center of the assembly and onto the short length of exposed thrust shoe pin. **(See Illust. 15.)**



Illust. 14 - Governor Shaft with Fuel Pump Cam.



Illust. 15 - Thrust Shoes, Pins and Governor Weight Assembly.

3. Slide the governor weight and carrier assembly (17) on the shaft (15). Align the holes in the carrier with the hole in shaft and install the carrier pin (29). (See Illust. 16.)

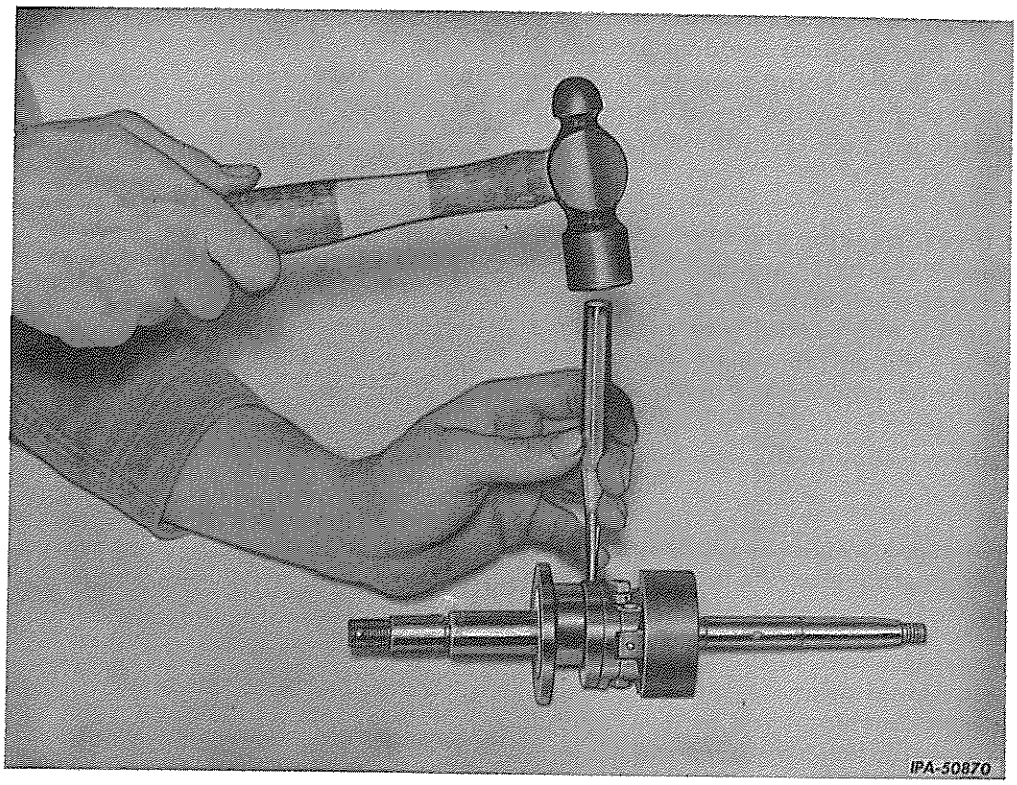
4. Install the bearing and sleeve assembly (21) on the shaft (15). The larger diameter end of the sleeve fits in between the weights and against the thrust shoes (20). (See Illust. 17.)

5. Place the thrust sleeve stop (22) on the shaft and insert the thrust sleeve stop pin (28). (See Illust. 18.)

6. When new bushings (35) are installed into the governor housing, they must be reamed to .8745-.8755 after installation. Press the forward bushing in from the front of the housing and the rear bushing in from the rear of the housing. Each bushing should be positioned 1/32 inch in from the outside edge of the bushing bore.

(Continued on next page)

NATURAL GAS GOVERNOR



Illust. 16 - Installing or Removing the Carrier Pin.

9. REASSEMBLY (Refer to Illust. 6) - Continued

7. Install new needle bearings (9) and oil seal (8), if necessary. The lip on the oil seal faces toward the inside of the housing. Clean the expansion plug recess and install a new plug.

NOTE: After installing the needle bearings, temporarily insert the rockshaft (6) to avoid loss of the bearing rollers.

8. Install the three pipe plugs in the housing (33) that were removed during "Inspection and Repair." (See Illust. 11 and 12.)

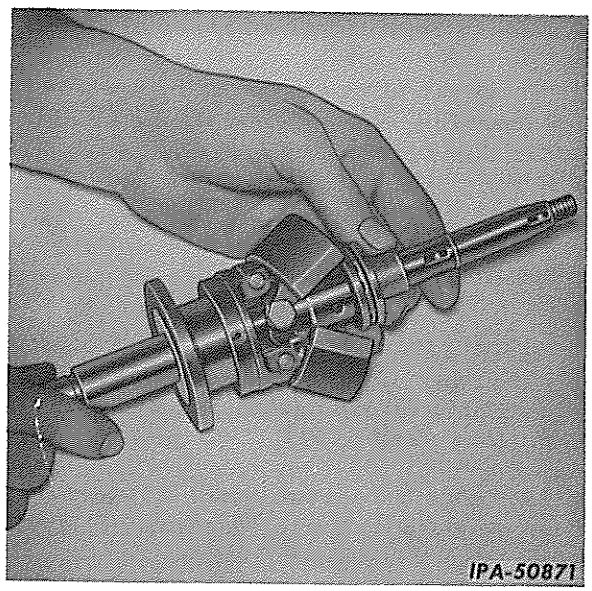
9. Insert the shaft assembly (13) into the housing (33). Slide the rockshaft (6) out for enough to allow clearance for the shaft and return it to its original position when the shaft is completely inserted. (See Illust. 10.)

10. Install the thrust fork (7) on the rockshaft (6) and fasten with the machine screw and lock washer. (See Illust. 9.)

11. Install the drive gear (36) and secure with the washer, nut (37) and cotter pin.

12. Place the gear and bushing (4) on the idler shaft (3) and install the shaft in the housing (33). After installing the shaft, replace the plug (2) into the idler shaft.

13. Place the speed change lever (31) into the housing (33) and fasten the throttle lever (32) on the change lever shaft using the throttle lever pin (30), lockwasher and nut.



Illust. 17 - Installing or Removing the Thrust Bearing Assembly.

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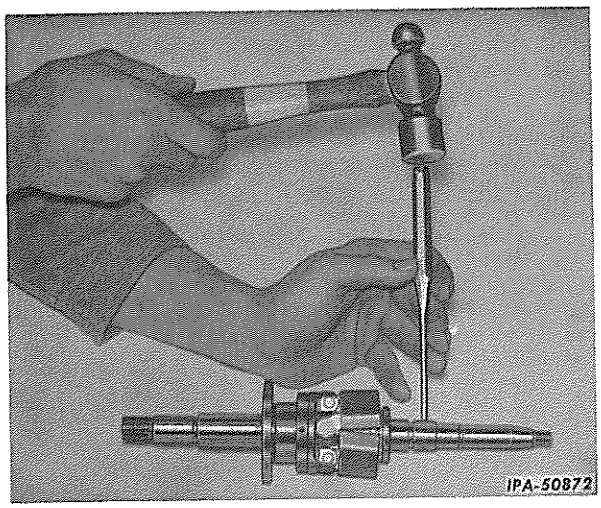
NATURAL GAS GOVERNOR



Illust. 18 - Installing or Removing the Thrust Sleeve Stop Pin.

14. Hook the governor spring (5) to the short arm on the rockshaft (6). Connect the opposite end of the governor spring to the throttle lever (32) using the clevis pin and cotter pin.

15. Install the bumper body and spring (12) into the housing (33).

16. Install the cap screw and jam nut assembly into the throttle lever (32).

17. Install a new magneto bracket bushing (25) or oil seal (26), if necessary. Align the hole in the bushing with the oil hole in the magneto bracket. Press until the bushing is recessed 1/32 inch in from the bore face. Install the oil seal from the opposite end of the bracket with the lips of the seal facing toward the bushing.

18. Assemble the magneto bracket (24) and gasket (23), using a sealer, to the governor housing (33) using the four capscrews and lockwashers.

19. Install the magneto drive coupling key into the shaft (15) and press the coupling (27) on the shaft. Fasten the coupling to the shaft using the nut and lockwasher.

10. INSTALLATION

1. Using a new gasket with a sealer, install the governor to the rear of the crankcase front cover as follows:

(a) Turn the engine over until the No. 1 piston comes upward on the compression stroke.

(b) Align the "V" groove on the face of the magneto drive coupling to match the "V" groove on the magneto bracket.

(c) Engage the idler gear with the camshaft gear and fasten the governor to the front cover being certain to retain the "V" groove alignment established in (b) of Step 1.

2. Connect the throttle control rod and governor control rod to the governor.

3. Magneto ignition: Connect the magneto grounding wire and spark plug cables to the magneto and time the magneto.

11. ADJUSTMENTS

1. Before starting the engine, adjust the length of the carburetor connecting rod as follows:

Lift the governor control handle to close the governor weights. While in this position the carburetor lever is in the wide open position. Adjust the connecting rod yoke to just fit the governor rockshaft, allowing no "play".

2. Run the engine until normal operating temperature is attained. Adjust the regulator until the engine runs smoothly at low idle speed.

3. Raise the governor control handle to obtain the specified high idle speed. Apply sufficient load to reduce the engine speed to the normal rated rpm, and determine whether the throttle is in its wide open position on the carburetor. If the throttle lever is in the wide open position, manually move the carburetor control rod slightly toward the closed position and then release. The rod should slowly return the carburetor lever to the wide open position.

4. Adjust the stop screw to make a light contact with the governor housing. After this adjustment, be sure that the high idle speed is within the specified range.

5. If a surge occurs at the "no-load" end of the range, screw the bumper spring into the housing just enough to remove the surge. Do not turn the spring in too far as it will interfere with the low idle operation of the engine.

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1. DESCRIPTION

The starting carburetor on IH diesel engines is of the updraft type, and is mounted directly on the underside of the intake manifold at the right side of the engine. The carburetor is used only on the gasoline starting cycle.

The carburetor is equipped with starting shutters which are actuated by a choke control lever on the dash with connecting linkage to the carburetor.

2. MAINTENANCE

The carburetor must be removed, cleaned, and inspected whenever the following conditions exist:

(a) Faulty carburetion.

(b) Engine speed exceeds maximum allowable value as given in "Specifications", section 1.

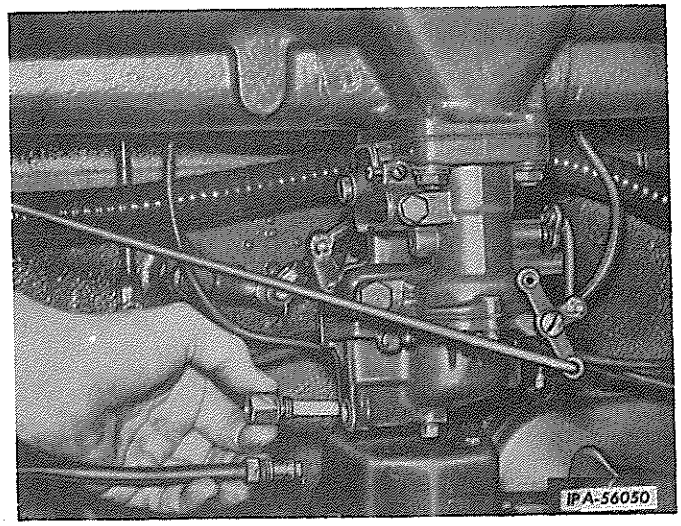
Cleaning Strainer Screen (Refer to Illust. 1)

At regular intervals the strainer screen must be cleaned.

1. Turn the stem on the gasoline strainer to shut off the gasoline supply.

2. Disconnect the gasoline strainer-to-carburetor tube at the carburetor.

3. Unscrew and remove the strainer screen retainer with screen.



Illust. 1 - Removing the Strainer Screen From the Carburetor.

4. Clean the retainer and screen thoroughly in cleaning solvent.

5. Install the retainer with screen in the carburetor.

6. Install the gasoline strainer-to-carburetor tube to the carburetor and secure the tube.

7. Turn the stem on the gasoline strainer to open the gasoline supply.

Drip Hole Filler (Refer to Illust. 2)

The drip hole filler must be inspected for tightness in the drip hole and for cleanliness. A loose filler may allow foreign material to enter the fuel system.

1. Check the opening in the drip hole filler plug (27). Clean a clogged hole with a small wire.

2. Check the filler plug for tightness in the drip hole; replace a loose filler.

3. After the filler and plug have been installed, expand the plug and secure it in place by staking the bottom plate casting (47) in four places.

3. REMOVAL (Refer to Illust. 2)

1. Turn the valve stem on the gasoline strainer, and shut off the gasoline supply.

2. Remove the plug underneath the carburetor, and allow all gasoline to drain from the bowl.

3. Disconnect the gasoline strainer-to-carburetor tube at the carburetor.

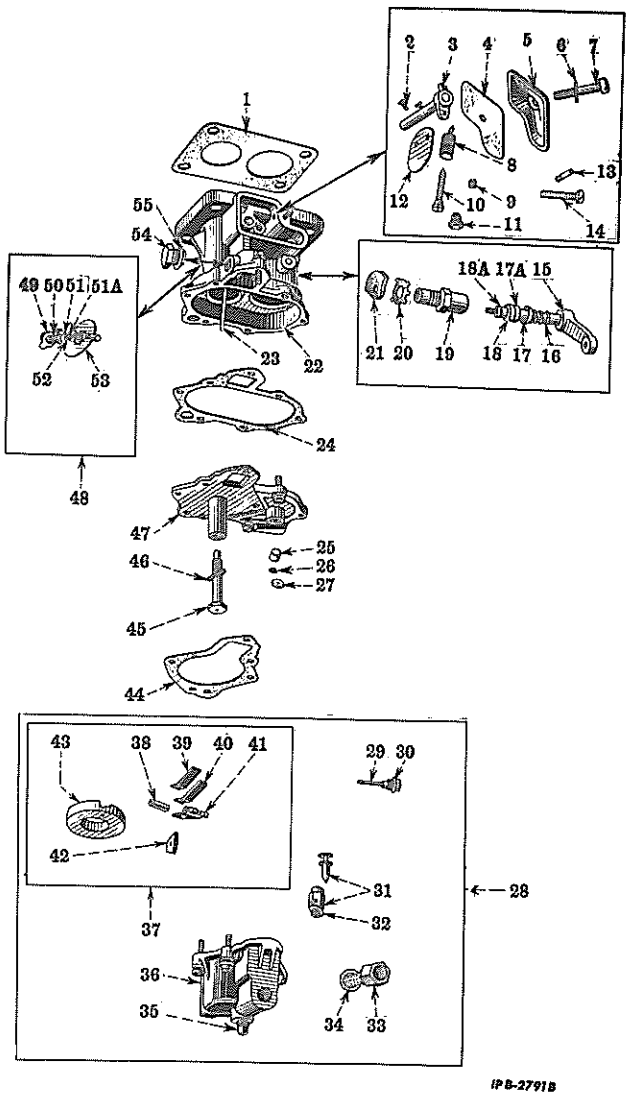
4. Move the compression release lever to the starting position. Disconnect the link attached to the locking shaft and lever assembly (15).

5. Disconnect the choke control lever linkage from the carburetor at the starting shutter shaft lever (49).

6. Remove the nuts and lock washers securing the carburetor to the intake manifold; remove the carburetor gasket.

4. DISASSEMBLY

(Ref. Nos. Refer to Illust. 2.)



IPB-2791B

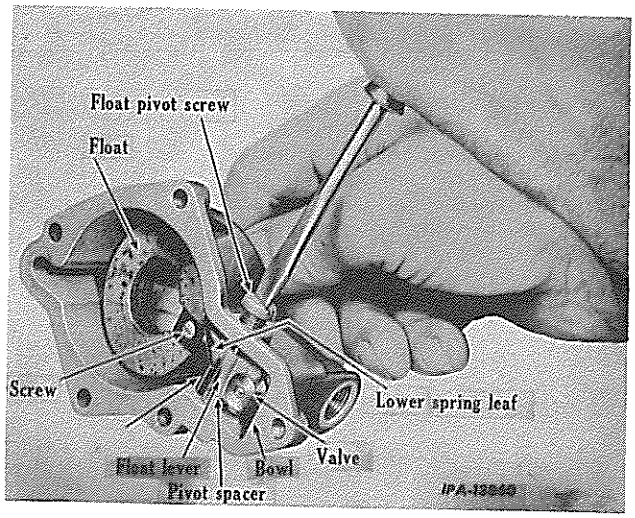
Illust. 2 - Exploded View of Starting Carburetor.

1. Carburetor gasket.
2. Butterfly screw.
3. Throttle shaft.
4. Gasket.
5. Cover.
6. Gasket.
7. Screw.
8. Spring.
9. Throttle spring screw lock.
10. Throttle spring screw.
11. Throttle spring screw plug.
12. Butterfly.
13. Stop pin.
14. Stop screw.
15. Locking shaft with lever.
16. Spring.
17. Retainer.
17A. Washer (cork).
18. Washer (if equipped).
18A. "O" ring (if equipped).
19. Bearing.
20. Locking shaft bearing lock.
21. Locking shaft cam.
22. Carburetor body.
23. Idling tube.
24. Gasket.
25. Drip hole filler.
26. Drip hole screen (if equipped).
27. Drip hole plug.
28. Fuel bowl, complete.
29. Float lever pivot.
30. Gasket.
31. Needle valve and cage.
32. Gasket.
33. Strainer screen retainer with screen.
34. Gasket.
35. Pipe plug.
36. Fuel bowl.
37. Float and lever.
38. Spacer.
39. Float lever spring, upper leaf.
40. Float lever spring, lower leaf.
41. Float lever.
42. Plate (if equipped).
43. Float.
44. Fuel bowl gasket.
45. Metering well.
46. Gasket.
47. Bottom plate.
48. Starting shutter shaft assembly.
49. Starting shutter shaft with lever.
50. Spring.
51. Retainer.
51A. Packing.
52. "O" ring.
53. Starting shutter.
54. Locking shaft body plug.
55. Gasket.

1. Remove the cap screws securing the bottom plate (47) to the body (22). Pry off the bottom plate and gaskets (24 and 44).

2. Remove strainer screen and retainer (33) and strainer screen gasket (34) from the fuel bowl (36).

3. Remove float lever pivot (29) and pivot gasket (30) from the fuel bowl; remove the float assembly (37).



Illust. 3 - Removing the Float Assembly.

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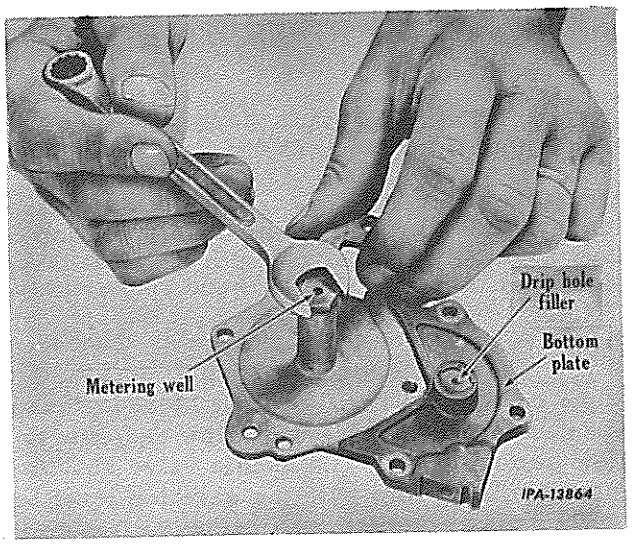
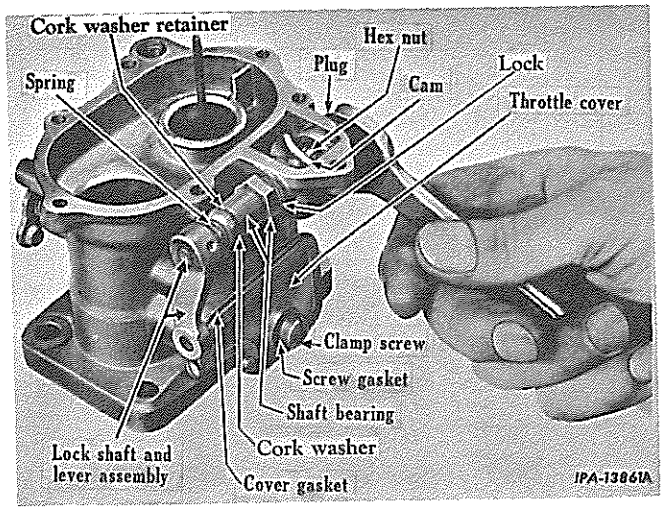


Illust. 4 - Removing the Metering Well.

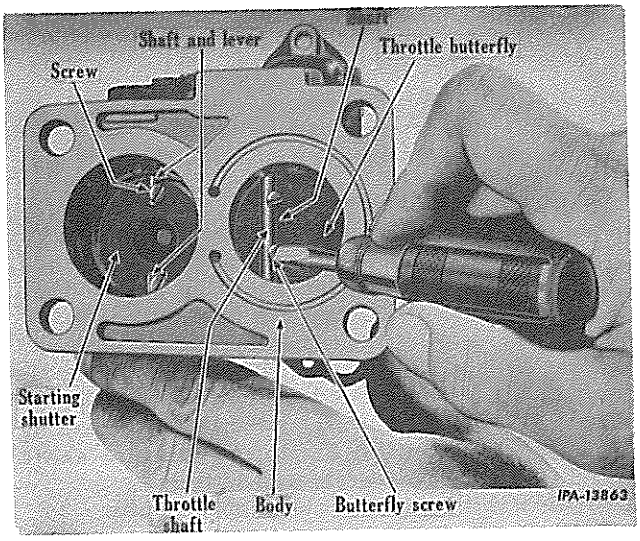
4. Lift needle valve out of cage (31); remove needle valve cage and needle valve cage gasket (32) from fuel bowl.

5. Remove the metering well (45). Take care not to bend the bottom plate (47). Remove the metering well gasket (46). Drive the drip hole filler (25), screen (26) (if equipped) and plug (27) from bottom plate, and discard.

6. Remove the locking shaft body plug (54) and gasket (55) from the carburetor body. Remove the nut and lock washer from the locking shaft and lever (15) with a thin open end wrench. Withdraw the shaft, together with the "O" ring (18A) (if equipped), washer (18) (if equipped), cork washer (17A), cork washer retainer (17) and spring (16). Lift out the cam (21). Bend



Illust. 5 - Remove the Locking Shaft.

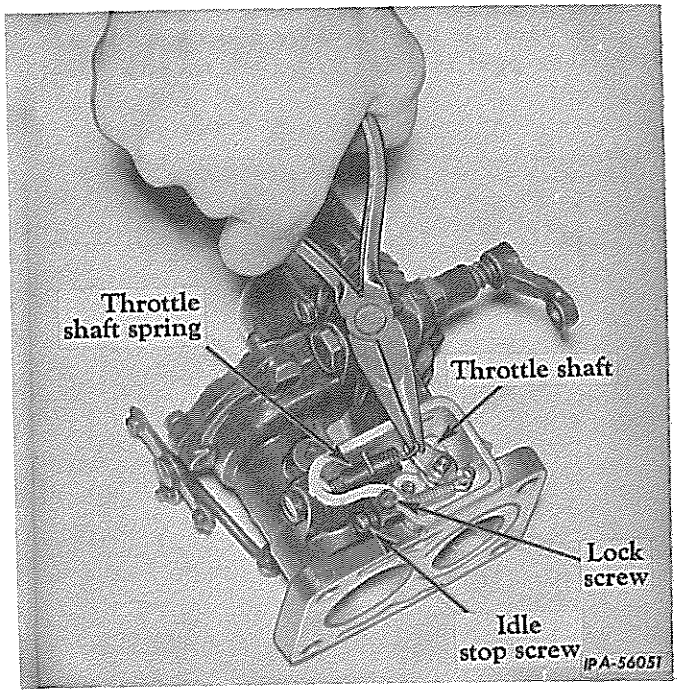


Illust. 6 - Removing the Throttle Butterfly.

the tabs on the lock (20) and remove the locking shaft bearing (19) and lock (20).

7. Remove the two screws holding the starting shutter (53) in place and lift out the starting shutter. Withdraw the starting shutter shaft (49), together with the spring (50), packing retainer (51), packing (51A), "O" ring (52) (if equipped) and "O" ring retainer (if equipped). Remove the short starting shutter shaft from

(Continued on next page)



Illust. 7 - Removing the Throttle Shaft Assembly.

4. DISASSEMBLY – Continued

(Ref. Nos. Refer to Illust. 2.)

the side of the carburetor body opposite the choke.

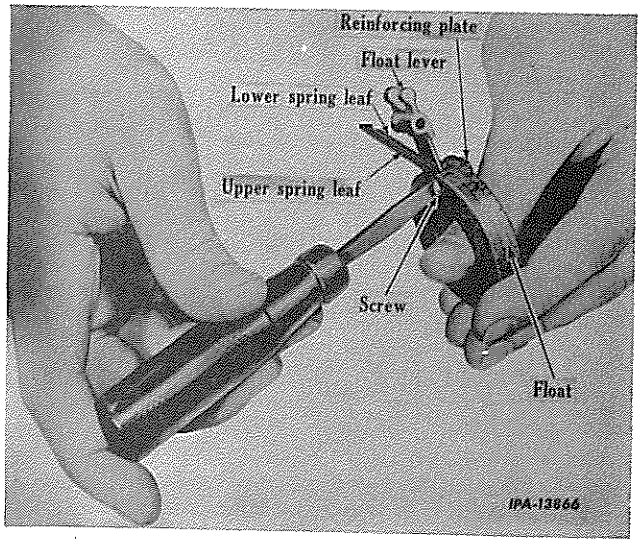
8. Unscrew the throttle lever cover clamp screw (7) and remove the throttle lever cover (5) and gasket (4). Remove the idle stop lock screw and loosen the throttle stop screw (14). Remove the throttle stop pin (13), throttle spring screw plug (11) and throttle spring screw (10) and lift out the throttle lever spring (8) with the throttle spring screw lock (9). Remove the two butterfly screws (2) securing the throttle butterfly (12) to the throttle shaft (3), lift out the butterfly and withdraw the throttle shaft from the carburetor body.

5. INSPECTION AND REPAIR

1. Clean all metal parts thoroughly with cleaning solvent; dry with compressed air. If gum deposit is present, clean the parts with acetone and blow out with compressed air.

2. Inspect the float for evidence of deterioration; replace if necessary by assembling a new float to the float lever and spring. (Illust. 8.)

3. Inspect the needle valve and cage for wear. If either part is defective, both must be replaced.



Illust. 8 - Removing or Attaching the Float Lever and Spring.

6. REASSEMBLY

(Ref. Nos. Refer to Illust. 2.)

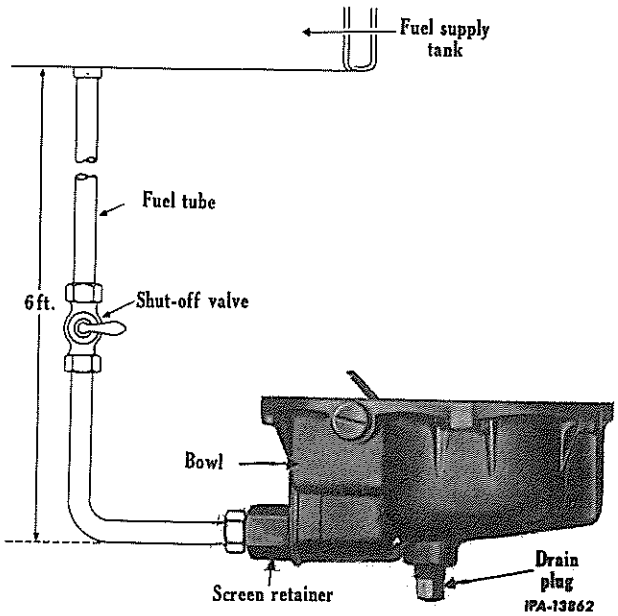
1. Install the new gasket (34) and retainer screen (33) in the bowl (36).

2. Use a new gasket (32) and install the cage. Place the needle valve in its cage, position the float assembly and secure with the float lever pivot (29), a new gasket (30) and spacer (38).

3. Perform a leak test as follows: Connect carburetor bowl to a source of gasoline (6 ft. head). Make certain the bowl drain is closed. Slowly open the shut-off valve and allow gasoline to flow into the bowl. The needle valve should close and stop flow with the gasoline level between 13/32 and 7/16 inch below the top face of the fuel bowl. If the needle valve does not shut off the flow of gasoline, replace the needle valve and cage assembly. (See Illust. 9 and 11.)

4. Hold the needle valve against its cage, and check the float level. The float must be 1/4 inch below the surface of the bowl. (Illust. 10.) If the setting is incorrect, bend the float lever slightly to get the correct level.

5. With needle valve seated, check height of spring above surface of bowl. This height should be 0.234 to 0.312 inch. (See Illust. 11.) Replace spring leaves with new parts if measurement does not fall within these limits.



Illust. 9 - Checking the Fuel Level of the Starting Carburetor.

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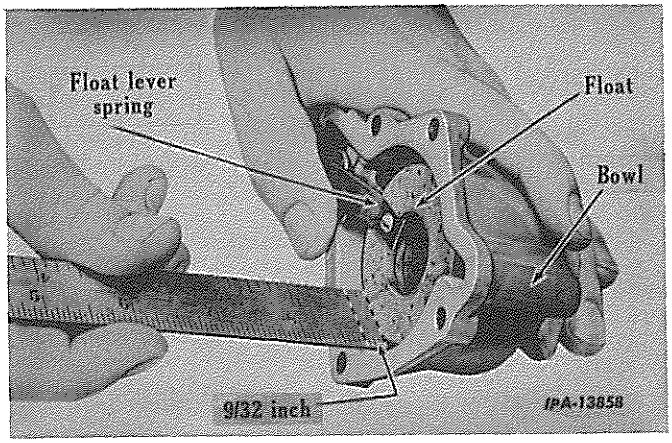


Illust. 10 - Checking the Float Level of the Carburetor.

6. Insert the short starting shutter shaft into the carburetor body. Slip the spring (50), packing retainer (51), packing (51A), "O" ring retainer (if equipped) and "O" ring (52) (if equipped) onto the starting shutter shaft (49). Insert the shaft part way into the carburetor body. Slide the shutter (53) through the slots in the shaft and attach with the screws.

7. Install the throttle shaft (3) into the carburetor body. Insert the butterfly (12) into the shaft. Be sure the short end of the butterfly is up (measured from the mounting holes) and that the angle on the edge of the butterfly corresponds with the bore surface of the throttle body. Insert the screws (2) from the top, but do not tighten until the butterfly is centered in the bore in the following manner.

Unscrew the throttle stop screw (14) until the butterfly (12) is allowed to close fully. Hold the shaft lightly in the closed position, tap lightly on the face of the butterfly with a brass rod to jar it into a centered position and tighten the screws. The butterfly must fit the bore closely and the throttle shaft must be perfectly free to turn without binding at any point.

Hook the throttle lever spring (8) into the throttle shaft (3) and secure it to the carburetor body (22) with the throttle spring screw (10). Install plug (11), replace the throttle stop pin (13), and throttle stop lock screw. Install the throttle lever cover gasket (4) and cover (5) and secure with the throttle cover clamp screw gasket (6) and clamp screw (7).

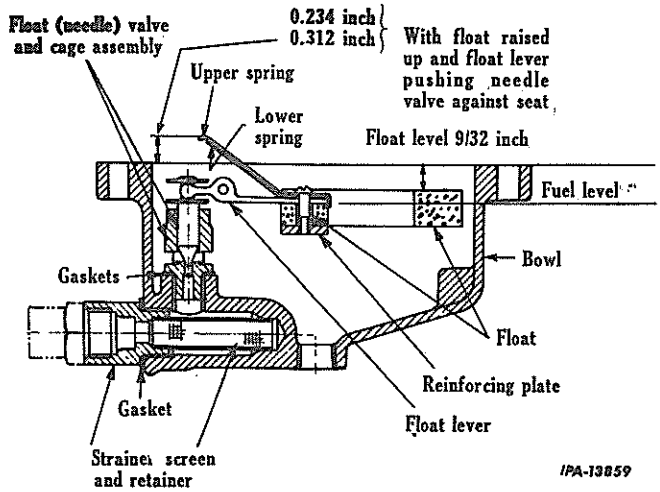
8. Install the bearing (19) to the carburetor body (22) with the lock (20). Slip the spring (16), retainer (17), cork washer (17A), "O" ring washer (18) and "O" ring (18A) (if equipped) over the locking shaft (15). Insert the shaft into the body (22). Place the cam (21) on the shaft and secure it with the washer and nut. Install the body plug (54) with the new gasket (55).

9. Install the new filler (25) and plug (27) in bottom plate (47). Expand the plug (27) and stake casting (47) in four places.

10. Install the metering well (45) and gasket (46).

11. Fasten the bottom plate (47), with new gasket (24), to the body with lock washers and screws.

12. Use the new gasket (44) and secure the bowl (36) to the bottom plate and body (22) with lock washers and screws.



Illust. 11 - Cross Section of Carburetor Bowl and Float Assembly.

7. INSTALLATION

1. Use a new carburetor gasket, and secure the carburetor to the intake manifold studs with washers and nuts.

2. Connect the choke control lever linkage at the starting shutter shaft lever. Be sure full travel of shutter can be obtained.

3. With compression release lever in starting position, connect linkage to locking shaft and lever assembly.

4. Connect the gasoline strainer-to-carburetor tube at the strainer screen retainer.

5. Turn the valve stem on the gasoline strainer and open the gasoline supply.

8. ADJUSTMENT

1. Attach an accurate tachometer to the engine. (Follow tachometer manufacturers instructions.)

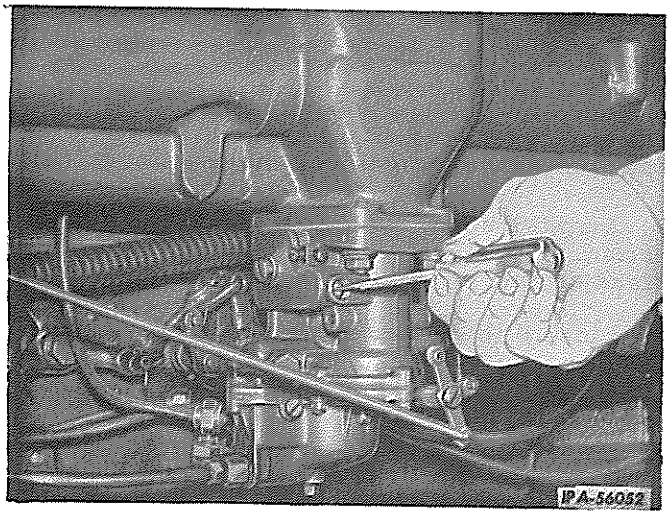
2. Start the engine and operate on gasoline cycle. Note the initial surge or high idle speed. If it is below or above 1100 rpm the throttle spring tension requires adjusting.

NOTE: This speed will be held only until the correct velocity has been obtained, after which the engine speed will decrease to idle speed.

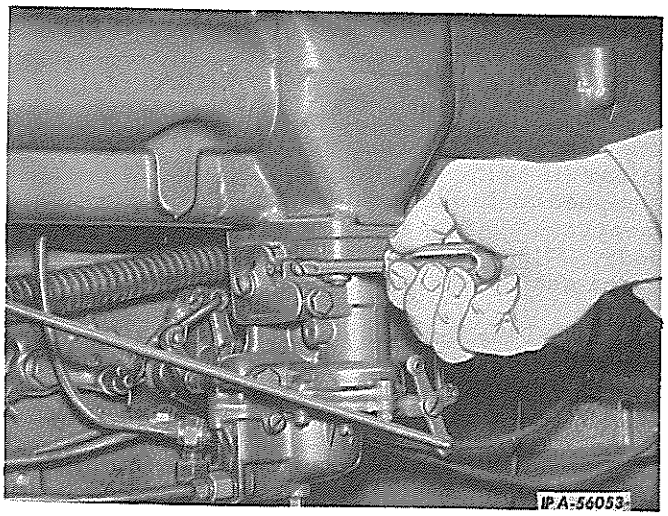
3. To make the adjustment, remove the plug (11, Illust. 2) which covers the adjusting screw. Turn the adjusting screw in to increase the speed and out to decrease the speed (Illust. 12). Reinstall the cover plug after completing the adjustment.

4. Check the engine idle speed. If it is below or above 900 rpm the idle screw requires adjusting.

5. Loosen the idle throttle lock screw. Turn the idle stop screw in to increase the engine speed and out to decrease the speed, (Illust. 13). When the engine idles at the correct speed, lock the idle stop screw in position with the lock screw.



Illust. 12 - Adjusting Carburetor Spring Tension.



Illust. 13 - Adjusting Carburetor Idle Screw.

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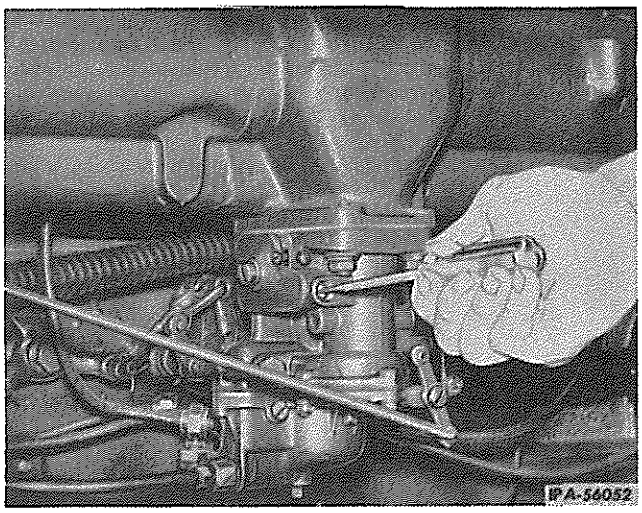
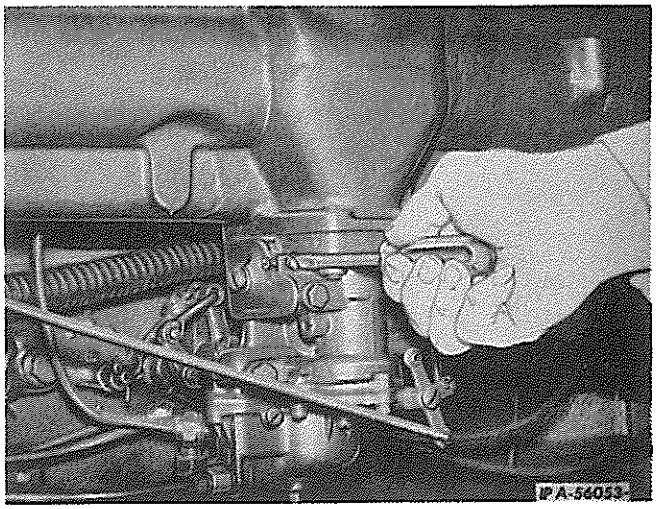


Illust. 12 - Adjusting Carburetor Spring Tension.



Illust. 13 - Adjusting Carburetor Idle Screw.

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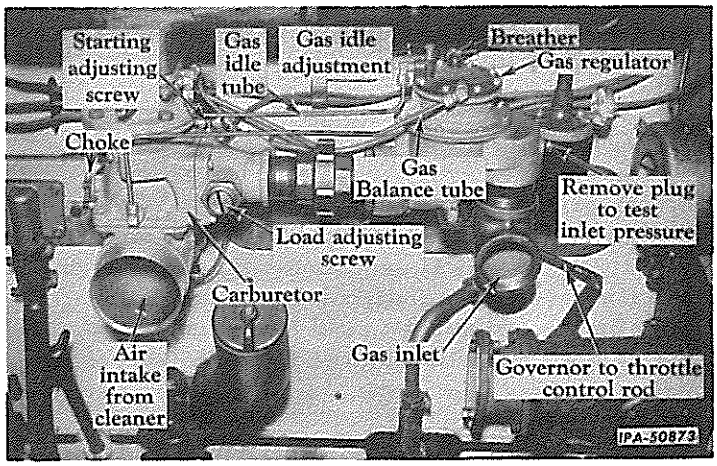
1. DESCRIPTION (Refer to Illust. 1)

The two main fuel system components of natural gas burning engines are the gas regulator and carburetor. A fly-ball type governor (located on the right side of the engine at the rear of the crankcase front cover) is used to maintain governed speed.

The Ensign Model "B" gas regulator accurately regulates the supply of natural gas to the carburetor, and shuts off the supply of gas when the engine demand has ceased. Rich or lean mixture strength required for continuous power, or for every intermittent variable condition, is automatically controlled by the regulator from light to instantly heavy loads, and from fast acceleration to idle speed.

A primer lever is provided on the side of the regulator to facilitate starting when the engine has been stopped for short periods of time, when the engine is cold, or under cold weather conditions.

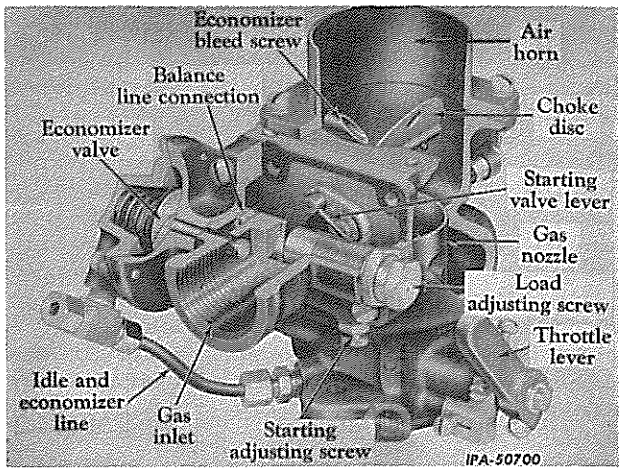


Illust. 1 - Engine Equipped to Use Natural Gas.

Operation of Ensign 2½" XG Carburetor

The carburetor is a venturi and nozzle type. The gas nozzle is located at a point in the venturi to provide the most effective control on the gas regulator with resultant mixtures correct for all operating conditions.

Built into the carburetor is a fixed-jet economizer. The purpose of the economizer is to produce two different mixtures, depending on the engine load. A richer, maximum power mixture is produced for high engine loads and a leaner economy mixture for part throttle operations. A fixed bleed screw controls the flow of fuel through the economizer.



Illust. 2 - Cutaway View of Model 2½" XG Carburetor.

When the engine manifold vacuum is reduced from four to six inches Hg of mercury, the economizer spring forces the economizer valve open to supply additional fuel for a power mixture. The economizer valve is closed by high manifold vacuum applied through the idle and economizer line to the diaphram.

The gas balance tube connects the carburetor intake with the gas regulator. The balance tube communicates any air fluctuations in the carburetor air horn to a diaphragm in the regulator, which automatically regulates the flow of gas in correct proportion to the air flow through the air cleaner.

A separate set of gas-air orifices are provided which produce a more positive mixture for starting. This starting mechanism is connected to the choke control on the dash. It is not intended to function in intermediate positions; it must be wide open or completely closed.

When the choke disc is closed, air for starting is drawn through the orifice in the choke disc. The starting valve lever simultaneously closes off the main gas passage, and gas for starting is drawn through a small orifice adjusted by the starting adjusting screw.

(Continued on next page)

1. DESCRIPTION – Continued

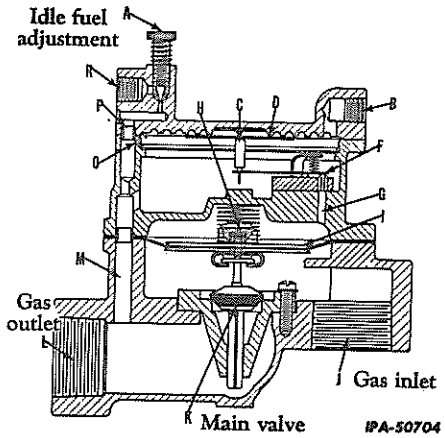
Operation of Ensign 2½" XG Carburetor - Continued

The flow of gas from the gas regulator to the carburetor is regulated by the main gas load adjusting screw located on the carburetor. The idle adjustment screw is located on the gas regulator. (Refer to paragraph 10, "Adjustments", for adjusting screw settings.)

With the engine stopped, the main valve "K" (Illust. 3) is closed and gas supply through the inlet "J" exerts a pressure below the lower diaphragm "I" and equally above "I" through orifice "H." Atmospheric pressure through the carburetor air intake is exerted on the upper diaphragm "D" through opening B" and on the under side of "D" through orifice "O," passage "M" and outlet "L."

When the engine is started, suction from the carburetor is applied to the regulator at "L" and communicated by way of passage "M" and orifice "O" to the under side of diaphragm "D" which is pulled down. As diaphragm "D" moves down, push rod "C" opens pilot valve "F". The reduction in pressure of gas over "I", bled through passage "G" by the opening of "F", permits "I" to lift and to open main valve "K" which in turn passes gas through to the carburetor.

Passage of gas through "K" into "L" relieves some suction on "D" by way of "M" and "O" thus partly closing "F", allowing pressure to increase over "I" which in turn partly closes "K" to accurately maintain pressure at "L" of 3/16 inch water column below atmosphere. When the engine stops, suction ceases entirely, permitting "F" and "K" to close and completely shut off the supply of gas to the engine.



Illust. 3 - Cross Section of Model "B" Fuel Regulator.

At engine idle speed, the carburetor throttle is nearly closed and therefore, little suction is applied at "L". The Ensign differential type regulator functions accurately at slow idle speed by means of a patented idle fuel connection system. This system applies suction from the engine side of the carburetor throttle through the idle connection tube directly to the under side of upper diaphragm "D" by way of "R", "P" and "O" to operate the valve "K" as described above. Fuel for the engine at idle is controlled therefore, by the idle fuel adjustment "A". Part of the idle fuel is supplied directly through the idle tube.

"B" is connected to the carburetor intake by a small tube known as the balance line. This balance tube communicates any air fluctuations in the carburetor air horn to the top of regulator diaphragm "D", thereby automatically reducing the flow of gas in correct proportion to any reduction in air flow as caused by air cleaner restrictions.

2. SAFETY PRECAUTIONS

Safety precautions in the handling of natural gas cannot be overemphasized. There are state, county or city laws, ordinances, and fire regulations covering the utilization of natural gas. Such laws, ordinances, and fire regulations on the subject must be adhered to in addition to the safety rules given below.

Where local rules are more stringent than those given below, the local rules are to be given priority.

These rules apply to servicing any engine using natural gas for engine fuel, regardless of the nature of the work to be performed.

1. Select a location for servicing the engine where there will be good air circulation. This is to avoid accumulation of gas-air mixtures in and about the engine caused by undetected leaks.

2. Such location should be as far as possible from steam cleaners, hot water cleaners, hot

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dip tanks, etc., and any other device operating with an open flame.

3. Shut off the main valves at the fuel tanks and allow the engine to run until all fuel in the system from the tank to the engine is exhausted. In the event the engine is inoperative, shut the valve at the tank.

4. "WARNING" signs should be placed on either side of the engine. There is to be NO SMOKING in the vicinity. No work is to be performed on this engine or on others in a nearby zone involving open flames such as cutting, welding, grinding, chiseling, or any similar operation which may produce sparks.

5. A fire extinguisher (dry powder or carbon dioxide, CO_2) should be placed adjacent to the mechanic's working area, handy for immediate use.

6. After completing service work and before starting the engine, allow air to circulate around the engine to remove any possible gas accumulation.

7. Whenever the nature of service work requires any operation on the fuel system, the following should be observed:

(a) All threaded connections should be treated with an insoluble lubricant (Permatex or aviation gasket maker). Replace worn or defective fittings.

(b) After connecting the fuel system, check it for leaks. Leaks are not permissible.

(c) A lather of soap, brushed on with a soft brush, will indicate the presence of leaks which are dangerous and wasteful. Never use open flame to check for leakage.

NOTE: Pay particular attention to short lengths of rubber hose used anywhere in the piping system to relieve stress and vibrations.

No work whatever is to be performed on natural gas fuel tanks. Any necessary work should be performed by qualified concerns who normally service such containers and who are familiar with local regulations, inspections and tests after repairs are made.

3. SERVICING THE ENSIGN MODEL "B" GAS REGULATOR

In many cases the regulator may be quickly serviced without removing it from the engine and without the use of the test stand described in paragraph 7. The two most common causes of regulator failure are, dirt under the main valve and/or a stiff diaphragm. To check the regulator on the engine proceed as follows:

1. Close off the fuel supply and remove the pipe plug near the inlet. (See Illust. 1.) Install a gauge calibrated in ounces. Open the fuel supply valve and note the reading on the gauge. This is the inlet pressure and should be 4 to 6 ounces. If the pressure is low, check the fuel supply tank and lines for possible leaks.

2. If the inlet pressure is correct, disconnect the balance line at the carburetor. (See Illust. 1.) By blowing into the balance line the regulator should open and close. This can be easily detected by the sound of discharge gas within the regulator.

3. If the regulator does not open and close with slight blowing on the balance line, remove the bowl cover and check for dirt under the main valve, an obstruction in the diaphragm orifice or a leaking pilot valve.

4. If after the above checks are made, the regulator is still inoperative, it will have to be removed from the engine, completely disassembled and rebuilt.

4. REMOVAL (Refer to Illust. 1)

Regulator (Ensign Model "B")

1. Close the fuel supply valve at the fuel tank and disconnect the fuel line at the inlet side of the regulator.

2. Disconnect the idle tube, balance tube and outlet fuel line at the regulator.

3. Remove the two capscrews securing the regulator to the mounting bracket and lift off the regulator.

(Continued on next page)

4. REMOVAL – Continued

Carburetor (Ensign Model 2½" XG)

4. Disconnect the idle tube, balance tube and fuel line at the carburetor.

5. Disconnect the choke control wire and the throttle control rod from the carburetor.

6. Remove the four nuts and washers securing the carburetor to the intake manifold and remove the carburetor. Cover the opening in the manifold with tape to prevent the entry of dirt.

5. DISASSEMBLY

Regulator (Ensign Model "B")
(Refer to Illust. 4)

1. Remove the cover screws and separate the cover (27) from the bowl (12). Remove the upper diaphragm (23).

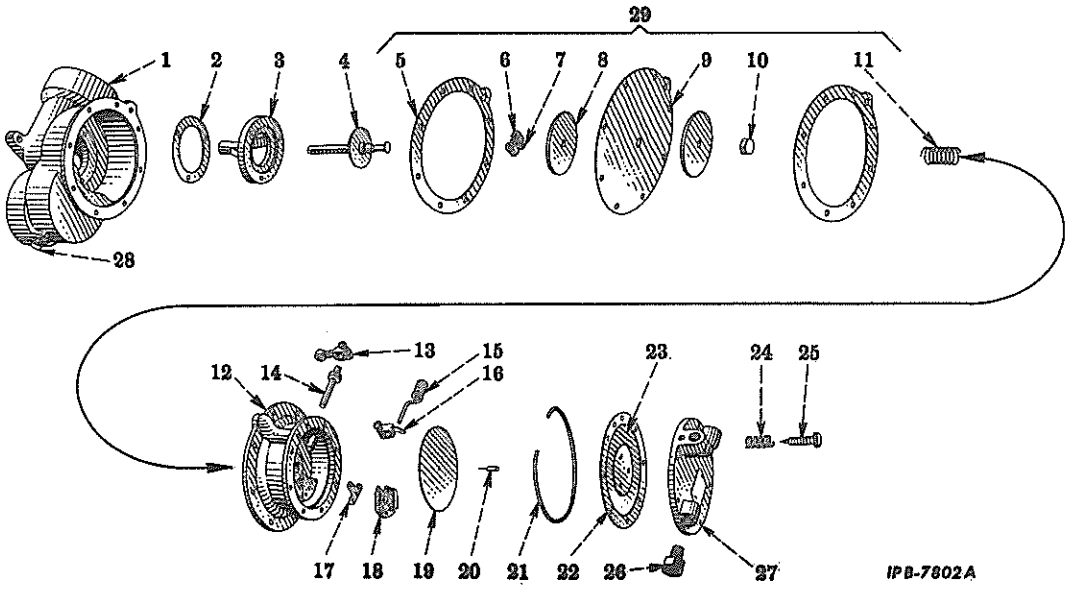
2. Remove the partition plate locking wire (21) and remove the partition plate (19). Lift out the pilot valve pin (20) and remove pilot valve assembly (18).

3. Remove the primer stop lever (16) and primer spring (15). Pull primer control shaft (14) and primer lever (13) out of the bowl (12).

4. Remove the screws securing the bowl (12) to the body (1) and lift off the bowl. Remove the diaphragm spring (11) and lower diaphragm assembly (29).

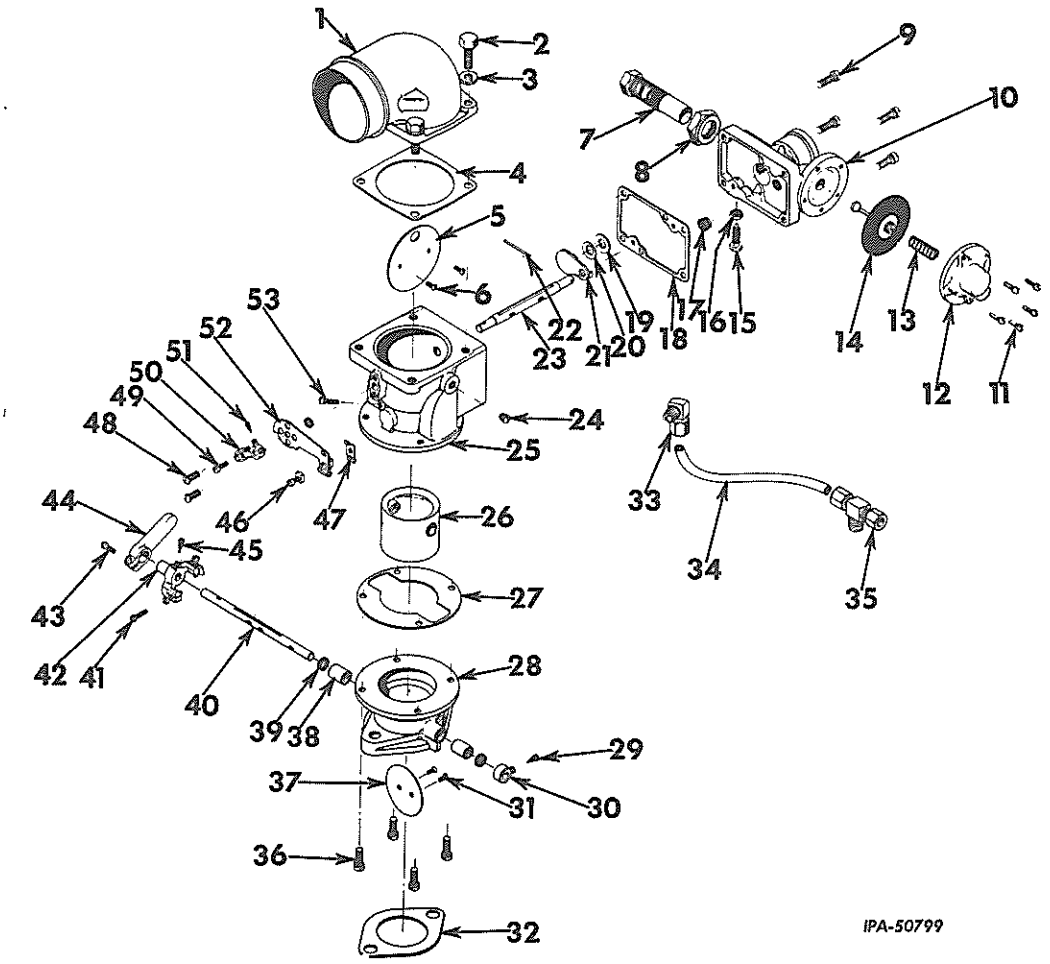
NOTE: The lower diaphragm assembly (29) can be disassembled if necessary by removing diaphragm screw nut (10) from the diaphragm screw (7) and separating the diaphragm plates (8) from the diaphragm (9).

5. Lift out valve (4) and remove valve seat (3) by removing the three screws securing it to the body (1).



Illust. 4 - Exploded View of Ensign Model "B" Natural Gas Regulator.

1. Body.
2. Valve seat gasket.
3. Valve seat.
4. Valve.
5. Bowl to diaphragm gasket.
6. Diaphragm screw head plate.
7. Diaphragm screw.
8. Diaphragm plate.
9. Lower diaphragm.
10. Diaphragm screw nut.
11. Diaphragm spring.
12. Bowl.
13. Primer lever.
14. Primer control shaft.
15. Primer spring.
16. Primer stop lever.
17. Pilot valve gasket.
18. Pilot valve.
19. Partition plate.
20. Pilot valve pin.
21. Locking wire.
22. Cover gasket.
23. Diaphragm.
24. Spring.
25. Idle adjusting screw.
26. Breather.
27. Bowl cover.
28. Pipe plug.
29. Lower diaphragm assembly.



Illust. 5 - Exploded View of Natural Gas and LPG Carburetor (Ensign 2½" XG).

1. Air cleaner elbow.
2. Cap screw.
3. Lockwasher.
4. Gasket.
5. Choke disc.
6. Screw.
7. Fuel adjusting screw.
8. Lock nut.
9. Screw.
10. Gas inlet and economizer body.
11. Screw.
12. Economizer cover.
13. Economizer spring.
14. Economizer diaphragm.
15. Starting adjusting screw.
16. Lock nut.
17. Bleed screw.
18. Gasket.
19. Valve lever washer.
20. Spring washer.
21. Valve lever.
22. Valve lever pin.
23. Choke shaft.
24. Pitot tube bleed screw (natural gas only).
25. Air horn.
26. Venturi.
27. Gasket.
28. Throttle tube.
29. Set screw.
30. Throttle shaft collar.
31. Screw.
32. Gasket.
33. Elbow.
34. Tube.
35. Tee.
36. Screw.
37. Throttle disc.
38. Throttle bearing bushing.
39. Dust seal.
40. Throttle shaft.
41. Throttle stop adjusting screw.
42. Throttle stop.
43. Clamp screw.
44. Throttle lever.
45. Set screw.
46. Screw.
47. Choke tube clamp.
48. Screw.
49. Swivel screw.
50. Choke lever.
51. Set screw.
52. Choke tube support.
53. Venturi set screw.

5. DISASSEMBLY – Continued

Carburetor (Ensign Model 2-1/2" XG) (Refer to Illust. 5)

6. Remove the air cleaner elbow (1) and gasket (4).

7. Remove the gas inlet and economizer body (10) from the air horn (25). Remove the fuel adjusting screw (7), locknut (8), starting adjusting screw (15), locknut (16) and bleed screw (17) from the body (10).

8. Remove the economizer cover (12) and spring (13). Remove the diaphragm assembly (14).

9. Remove two screws (6) and lift out choke disc (5) from choke shaft (23). Remove valve lever pin (22) and lift off valve lever washer (19), spring washer (20) and valve lever (21).

10. Remove set screw (51) and pull choke lever (50) off choke shaft (23). Remove choke tube support screws (48) and choke tube support (52). Pull choke shaft (23) out of air horn (25). Remove pitot tube bleed screw (24) (natural gas engines only).

11. Remove capscrews (36) and separate the throttle tube (28) from the air horn (25). Remove venturi set screw (53) and remove venturi (26) from the air horn (25).

12. Remove two screws (31) and lift out throttle disc (37) from the throttle shaft (40). Remove setscrew (29) and throttle shaft collar (30). Pull throttle shaft (40) with throttle stop (42) and throttle lever (44) out of throttle body (28).

13. Remove dust seals (39) and press out throttle bearing bushings (38) if necessary.

6. INSPECTION AND REPAIR

Regulator (Ensign Model "B")
(Refer to Illust. 4)

1. Wash all metal parts in a cleaning solvent and blow out all passageways with compressed air.

2. Inspect the valve seat (3) for nicks or excessive wear. Replace if necessary.

3. Inspect the neoprene rubber portion of valve (4). If found to be dry and hard, the valve must be replaced.

4. Inspect the upper and lower diaphragms (23) and (9) for stiffness or ruptures. Replace if either of these conditions are found.

5. Make certain that the passageway through the diaphragm screw nut (10) is open by inserting a No. 70 drill in the hole.

6. Inspect all the remaining parts carefully and replace any that show signs of wear. New gaskets should be installed where needed.

7. Wash all metal parts in a cleaning solvent and dry thoroughly with compressed air.

Carburetor (Ensign Model 2-1/2" XG) (Refer to Illust. 5)

8. Inspect the economizer diaphragm (14) for stiffness or ruptures. Replace if either of these conditions are found.

9. Inspect the throttle shaft (40) and throttle bearing bushings for excessive wear. Replace if necessary.

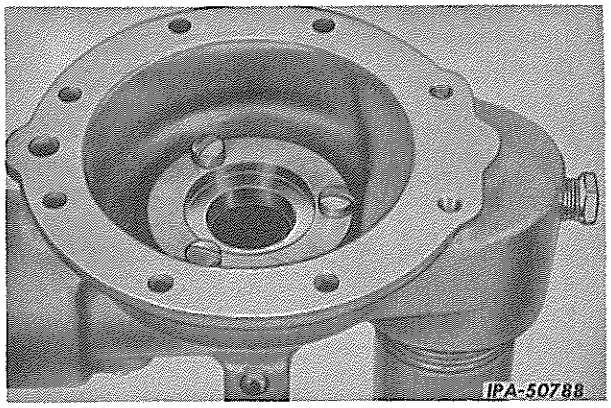
10. Be sure all passages are open. Also check the small hole in the pitot tube bleed screw (24) to be sure it is open.

11. Carefully check the vacuum control connections to the economizer for air leaks.

7. REASSEMBLY

Regulator (Ensign Model "B")
(Refer to Illust. 4)

1. Using a new gasket, install the valve seat in the body. (See Illust. 6.) Install the main valve (4) into the seat (3).



Illust. 6 - Main Valve Seat Assembly.

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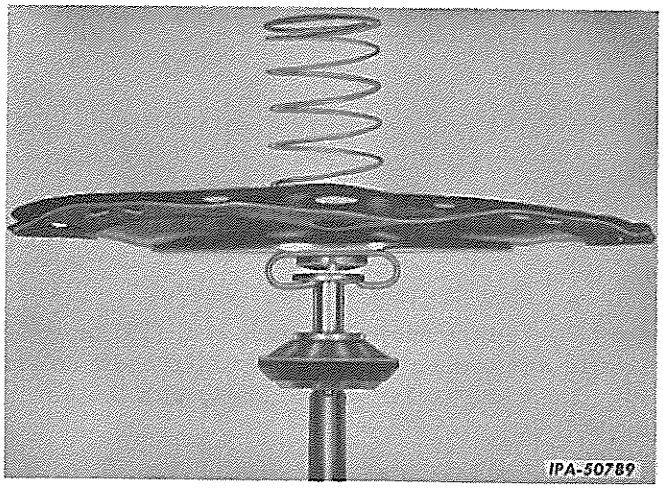
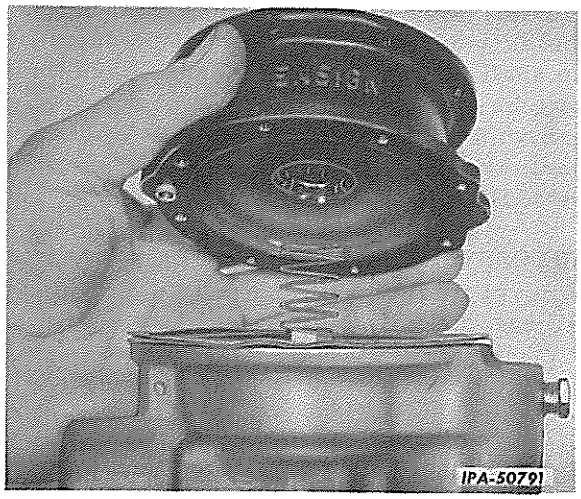
2. Place the lower diaphragm assembly (29) in position on the body with the diaphragm screw head plate (6) engaged with the head of the main valve. **(See Illust. 7.)**



Illust. 7 - Diaphragm Engaged with Main Valve.

3. Place the diaphragm spring (11) in position over diaphragm screw nut (10). Install the bowl (12) to the body (Illust. 8) and secure with screws.



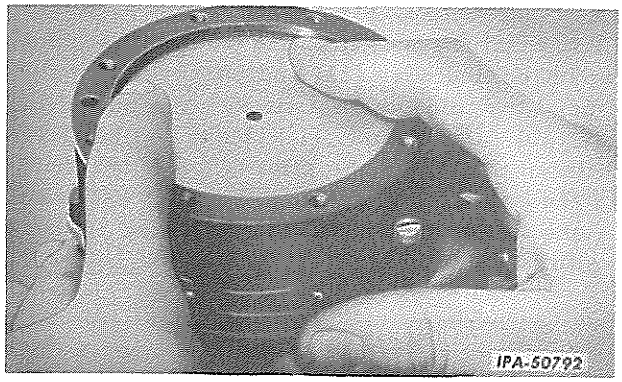
Illust. 8 - Installing the Bowl.

4. Using a new gasket install pilot valve (18).

NOTE: If a test stand is available, check the pilot valve for leakage.

5. Install the primer control shaft (14) and primer lever (13) into the bowl (12). Install the primer stop lever (16) and primer spring (15) onto the control shaft (14).

6. Place partition plate (19) into the bowl and check to see that it floats freely. (See Illust. 9.) Install locking wire (21).

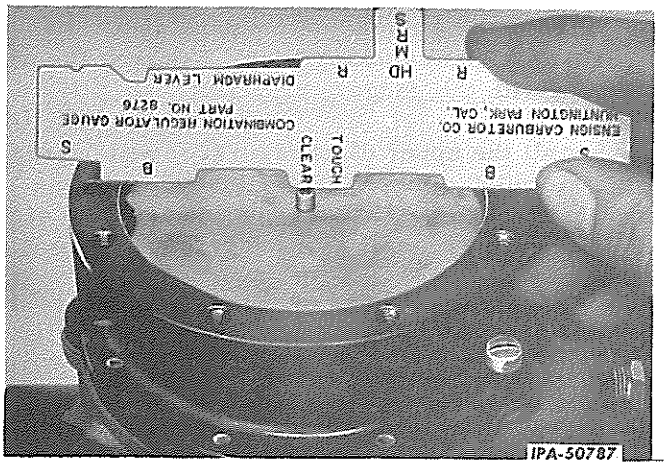


Illust. 9 - Installing the Partition Plate.

7. Install pilot valve pin (20) into partition plate (19) making sure it engages the hole in the pilot valve arm.

8. Measure the distance between the top of the pilot valve pin and the top of the bowl with the Ensign Combination Regulator Gauge No. 8276. This is a two position gauge having two steps marked "clear" and "touch". By holding the gauge in position (Illust. 10), the pilot valve pin should not touch the "clear" position on the gauge but must touch the "touch" position.

(Continued on next page)



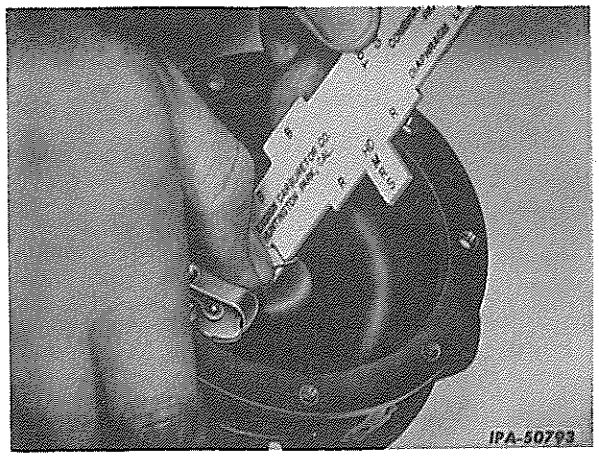
Illust. 10 - Checking Height of Pilot Valve Pin.

7. REASSEMBLY – Continued

NOTE: The Ensign Combination Regulator Gauge No. 8276 is available upon request at no cost. Send your requests to:

Ensign Carburetor Company
2330 West 58th Street
Chicago 36, Illinois

9. To adjust the height of the pilot valve pin, remove locking wire (21) and partition plate (19) and bend the pilot valve arm with the end of the gauge tool. (See Illust. 11.) Make the bend 1/4 inch from the end of the pilot valve lever arm. Hold the valve lever down to the pilot valve body with one finger to prevent distortion or injury to **the pilot valve and seat.**



Illust. 11 - Adjusting the Height of the Pilot Valve Pin.

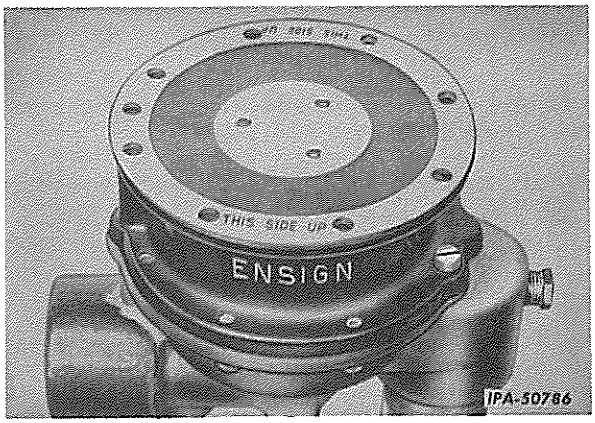
10. After making the adjustment reinstall the partition plate and locking wire. Recheck the adjustment with the gauge.

11. Install the upper diaphragm (23) with words "This Side Up" visible. (See Illust. 12.) Make sure that a cover gasket (22) is on each side of the diaphragm. Install cover (27) and secure with screws.

Carburetor (Ensign Model 2-1/2" XG) (Refer to Illust. 5)

12. Install the throttle bearing bushings (38) if they were removed.

13. Place one dust seal (39) on the throttle shaft (40) and install the throttle shaft with throttle lever (44) and throttle stop (42) into the throttle



Illust. 12 - Upper Diaphragm Installed.

tube (28). Place the other dust seal (39) on the throttle shaft and install the throttle shaft collar (30). Lock the collar on the shaft with the set screw (29).

14. Install the throttle disc (37) and secure with screws (31).

15. Place the venturi (26) in the air horn (25) and lock in place with venturi set screw (53). Using a new gasket (27), assemble the throttle tube (28) to the air horn (25) and secure with screws (36).

16. Install pitot tube bleed screw (24) in air horn (25) (natural gas engines only). Install the choke shaft (23) into the air horn. Place the choke tube support (52) over the choke shaft and secure with screws (48). Install the choke lever (50) onto the choke shaft and secure with set screw (51).

17. Install valve lever (21), spring washer (20), valve lever washer (19) and valve lever pin (22). Install the choke disc (5) and secure with screws (6).

18. Install the diaphragm assembly (14), spring (13) and economizer cover (12) to the gas inlet and economizer body (10) with screws (11).

19. Install bleed screw (17), starting adjusting screw (15) with locknut (16) and fuel adjusting screw (7) with locknut (8) into the gas inlet and economizer body (10).

20. Using a new gasket (18) attach the gas inlet and economizer body (10) to the air horn (25)

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with screws (9). Place a new gasket (4) on the air horn (25) and attach the air cleaner elbow with capscrews (4).

8. TESTING ENSIGN MODEL "B" REGULATOR

To test the regulator it will be necessary to use an Ensign regulator test stand. The stand can be purchased from the Ensign Carburetor Company. Complete instructions covering the testing of the regulator are included with the test stand. Refer to the "Service Tool" Manual ISS-1002 for model numbers and ordering procedure.

9. INSTALLATION

Installation of the carburetor and regulator is the reversal of the removal procedure outlined in paragraph 4.

10. ADJUSTMENTS

The instructions outlined below cover the adjustments required on a rebuilt regulator and/or carburetor before and after the engine is started. (See Illust. 1.)

1. Open the fuel supply valve at the fuel tank.

2. Before starting, open the idle adjusting screw on the regulator 1/2 turn.

3. Open the load adjusting screw 7-3/4 turns.

4. Open the carburetor starting adjusting screw 1 turn.

NOTE: All three adjusting screw provide a leaner fuel mixture when turned in (clockwise) and a richer fuel mixture when turned out (counterclockwise).

5. Set the engine throttle control about one-third open.

6. Close the choke valve (pull out the choke control button) all the way.

7. Pull out the ignition switch knob, and press the starting switch button.

8. When the engine starts, leave the choke closed and the throttle as set; then adjust the starting adjusting screw for the highest rpm, and lock the adjusting screw in position.

9. Open the choke valve (push in the choke control button), reduce the engine speed to idle and adjust the idle adjustment screw for the best idle operation. If the engine fails to respond when changing from starting to running position, open or close the load adjusting screw until this condition is overcome.

10. With the choke valve open and the engine throttle set to just under governed speed, adjust as follows: Turn the load adjusting screw in (clockwise) until the engine loses speed, then out (counterclockwise) approximately 1/4 turn. These adjustments will give the best performance with a minimum gas consumption.

11. Adjust the regulator idle screw to give the best idle after the engine is warmed up and readjust the throttle linkage for the proper idle speed.

NOTE: The above adjustments are necessary only when starting a new engine or one with a rebuilt regulator and/or carburetor. After the above adjustments have been made follow the instructions given in the operator's manual for starting natural gas burning engines.

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1. DESCRIPTION

The turbocharger is designed to increase diesel engine power output by supplying compressed inlet air to the engine. The turbine wheel which drives the compressor impeller during operation, is driven by engine exhaust gases.

The following procedures give general handling, maintenance, removal and installation of the turbocharger. For information on servicing the turbocharger refer to service manual ISS-1047, "TURBOCHARGERS FOR INTERNATIONAL DIESEL ENGINES."

2. GENERAL HANDLING AND MAINTENANCE

General Handling

1. Cover or plug all openings in the turbocharger when handling to prevent entrance of foreign material.

2. After servicing and before installation, prime the lubrication system of the turbocharger by adding clean filtered oil into the oil inlet connection. Rotate the shaft and check for interference of compressor or turbine wheel in the housing.

3. All connections to the turbocharger (manifolds and piping) must be clean and free of foreign material since serious damage to the turbocharger or engine could result. All connections must be air tight.

4. Install turbocharger support brackets as provided to relieve excess stress on the turbocharger inlet flange and exhaust manifold. Exhaust stacks of extra long length and other fixtures must not be rigidly attached to the turbocharger. If extended stacks are used, they should be supported by the hood. Exhaust stacks must be higher than the intake stack.

Maintenance

5. For initial running when installing a new or rebuilt turbocharger or after the engine has been overhauled or put in storage for thirty days or more, or when the filters have been changed, it is recommended that four or five ounces of oil (same type and grade as used in the crankcase) be put into the oil inlet opening in the turbocharger with a squirt can. This will provide sufficient lubrication for the turbocharger bearings until normal engine lubrication is established. Connect the oil inlet line.

6. If engine oil becomes contaminated by water, the turbocharger must be drained to prevent sludge formation. It is recommended that after an engine overhaul, an oil inlet filter (Illust. 1) be installed and used during the first 5 to 25 hours of operation and then removed.

NOTE: Do not leave this filter in the turbocharger more than 25 hours as this filter can clog with carbon that is normally suspended in the oil of a diesel engine. This clogging will "starve" the turbocharger bearings of oil resulting in premature failure of the turbocharger.

7. It is imperative that the air cleaner service outlined in the operator's manual be rigidly followed because of the oil carry-over and power losses that can be incurred with a restricted air cleaner.

NOTE: Air flow requirements for diesel turbocharged engines are considerably greater than for a non-turbocharged engine of the same size running at the same speed. Air inlet accessories such as pre-cleaners must be selected to minimize the restriction at this higher air flow and to maintain performance of the turbocharger unit.

8. Engine crankcase breather should be cleaned periodically to assure that there is no restriction.

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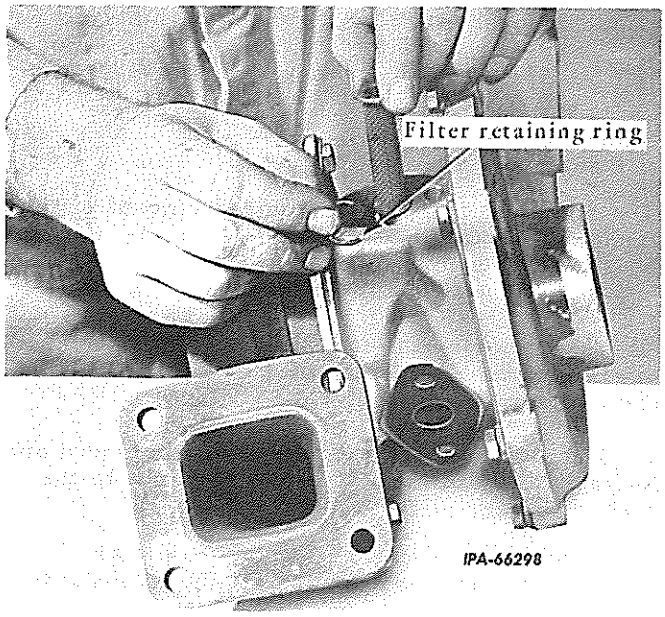


Illust. 1 - Installing Filter (Airesearch Model T-705 shown).

2. GENERAL HANDLING AND MAINTENANCE - Continued

Maintenance - Continued

9. During normal operation the turbocharger should be free from vibration or unusual noises.

10. Exhaust stack should be covered to prevent water from entering and damaging turbine during shut-down periods, or when the unit is being transported.

11. Periodic inspection of the compressor wheel should be made to check for soft carbon deposits, damaged blading, interference, or excessive end play.

12. It is advisable to allow exhaust manifolds to cool before removing from engine. This will prevent warping.

13. When starting turbocharged diesel engines, do not fully advance the engine speed control lever immediately. Run the engine at part throttle for a few minutes to allow thorough distribution of the lubricating oil. The machine must not be placed under load until normal oil pressure is reached.

14. It is important to operate the engine at 1/2 throttle (no load) for three to five minutes before final shut-down after operating under load to allow the turbocharger to cool down. This will aid in heat dissipating of both engine and turbocharger thus minimizing possibility of damage.

15. Periodically, check the cap screws, hold-down nuts, air connections and oil connections to and from the turbocharger for tightness. Retorque these parts after initial warm-up. Hoses and oil lines must be inspected and replaced when necessary.

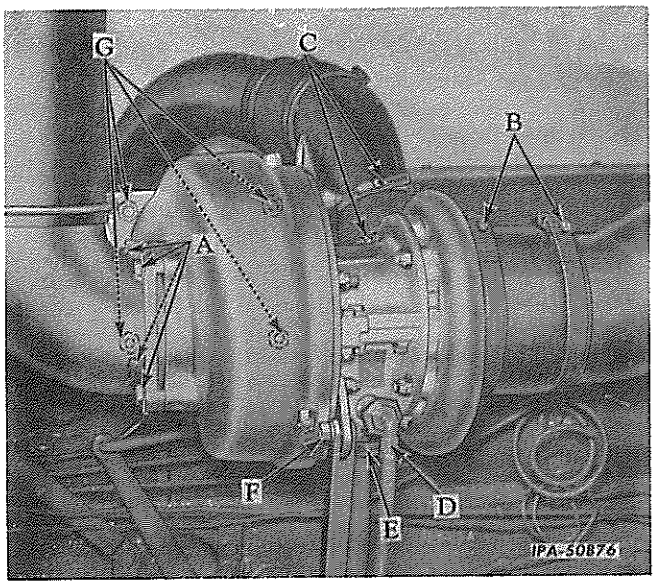
3. REMOVAL

The following procedure covers removal of the turbocharger used on 1091 series engines. Disconnect points for removal of turbocharger on 554 series engines are similar.

Before removing the turbocharger from the engine, remove as much dirt as possible from the exterior surfaces.

1. Remove the two clamps with cap screws and locks holding the exhaust pipe and elbow to the turbocharger. (See "A," Illust. 2.)

2. Loosen the clamp and separate the air cleaner to compressor housing duct hose at the turbocharger end. (See "B," Illust. 2.) Plug or cap both openings to protect against the entrance of dirt.



Illust. 2 - Disconnect Points for Turbocharger Removal (1091 series shown).

A. Exhaust elbow cap screws.	D. Oil inlet hose.
B. Air cleaner duct hose clamps.	E. Oil drain hose.
C. Intake manifold duct hose clamps.	F. Lower brace cap screw.
	G. Turbine to exhaust manifold nuts.

3. Loosen the clamp and separate the compressor housing to intake manifold duct hose at the turbocharger end. (See "C," Illust. 2.) Plug or cap both openings to protect against the entrance of dirt.

4. Remove the oil inlet and outlet hoses. (See "D" and "E," Illust. 2.)

5. Support the turbocharger with a hoist using the lifting eye at the top of the turbocharger. Remove the cap screw and nut fastening the lower brace assembly to the support bracket on the turbocharger. (See "F," Illust 2.)

6. Remove the four nuts fastening the turbocharger to the exhaust manifold. Slide the turbocharger off the studs, and remove the turbine inlet gasket. (See "G," Illust. 2.)

4. INSTALLATION

The following procedure covers installation of the turbocharger on 1091 series engines. Procedure for 554 series engines is similar.

1. Inspect the air intake system for loose bolts, nuts or any foreign material.

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2. Inspect the exhaust manifold for fins or projections which may have become loose and for pieces of gaskets or other foreign material. If any foreign material is evident either remove the manifold and clean or before installing the turbocharger, run the engine to blow out any pieces left in the manifold.

3. Inspect the oil drain line to be sure the inside diameter has not been reduced by swelling or that the line is not clogged. Also inspect the oil supply line for dirt, clogging or deterioration.

4. Inspect the turbocharger mounting pad on the manifold for flatness. Be sure all of the old gasket has been removed.

5. Check the oil change period. If the next change period is near, it is recommended that the oil and oil filter element be changed before operating the turbocharger.

6. Place a new turbine inlet gasket on the exhaust manifold studs, slide the turbocharger onto the studs, and fasten it in place, using the four special nuts.

NOTE: Apply "NEVER-SEEZE" or a similar compound to the studs before securing turbocharger with nuts to provide easier future removal.

7. Fasten the lower brace assembly to the support bracket on the turbocharger with the cap screw, lock washer and nut.

8. Fasten the turbine exhaust elbow and exhaust pipe to the turbine housing, using the clamps, locks and cap screws. After tightening the cap screws, bend one corner of each lock to secure the cap screws. It is recommended that "NEVER-SEEZE" or similar compound be applied to the cap screw threads.

9. Connect the air cleaner duct hose and the intake manifold duct hose to the turbocharger and secure with clamps. Be sure that the piping is not causing a strain on the compressor housing.

10. Connect the oil outlet line to the turbocharger.

11. Using a squirt can, put three or four ounces of oil into the oil inlet opening in the turbocharger. Connect the oil inlet line.

NOTE: If the engine was overhauled, install a filter (Illust. 1) for the first 5 to 25 hours of operation and then remove it. DO NOT LEAVE THE FILTER IN LONGER THAN 25 HOURS OF OPERATION.

12. Operate the engine observing the turbocharger for any of the following:

(a) Unusual turbocharger noises.

(b) Lubrication leaks.

(c) Fastening to the engine not secure.

(d) Excessive vibration.

(e) Excessive exhaust smoke.

(f) Air leaks in the air cleaner-to-turbocharger or turbocharger-to-intake manifold ducting.

Investigate and correct any of these conditions immediately to avoid possible turbocharger or engine failure.

13. Retighten cap screws, hold down nuts, air connections, and oil connections to and from the turbocharger after the initial warm-up.

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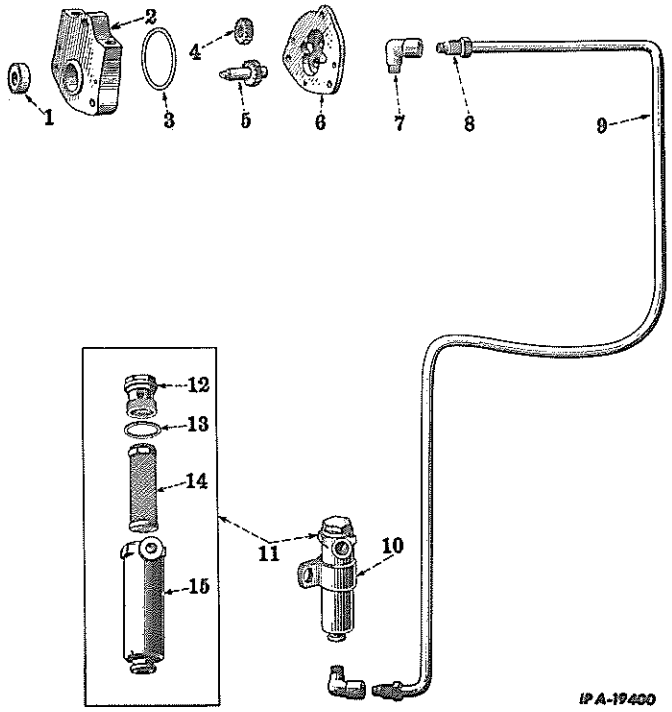
TRANSFER PUMP (POWER UNITS)

1. DESCRIPTION

The IH transfer pump is a positive gear type fuel pump which draws fuel from the main supply tank. It is mounted to the front gear case cover. (See Illust. 2 and 3.) The pump is driven by the magneto drive shaft on units equipped with magnetos, or by a gear driven by the camshaft gear. Rotation is counterclockwise as viewed from drive end of the pump. A rubber "O" ring is used to provide a tight seal.



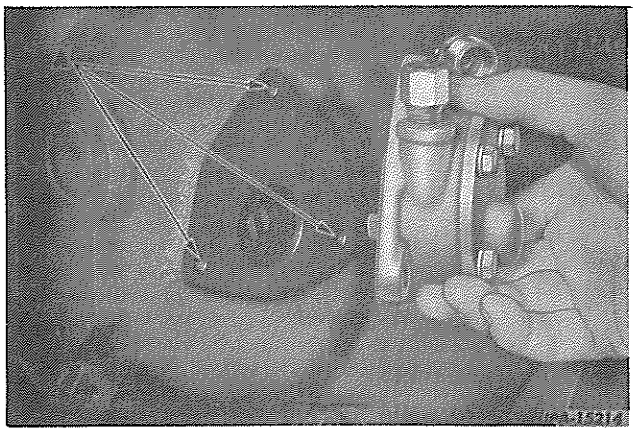
Illust. 1 - IH Fuel Transfer Pump, Strainer, and Connections.

1. Drive shaft oil seal.
2. Pump body.
3. Gasket.
4. Idler gear.
5. Drive shaft and gear.
6. Cover.
7. Elbow.
8. Coupling nut.
9. Fuel strainer to transfer pump tube.
10. Strainer bracket.
11. Strainer.
12. Plug.
13. Gasket.
14. Strainer screen.
15. Strainer body.

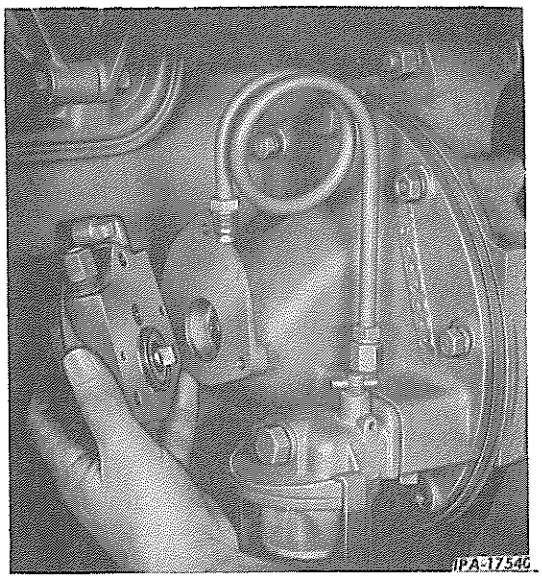
2. REMOVAL (Refer to Illust. 2 and 3)

1. Disconnect fuel lines from pump housing.

2. Remove the cap screws securing the pump to the front gear cover.



Illust. 2 - Removing the IH Transfer Pump.



Illust. 3 - Removing the IH Transfer Pump.

3. DISASSEMBLY (Refer to Illust. 1)

1. Remove the cap screws securing the cover to the pump body.

2. Remove the idler and drive gear from the pump. Press out the oil seal.

4. INSPECTION AND REPAIR

1. Remove rust, corrosion and dirt from all parts of the pump. Remove any packed dirt from between teeth of gears. Wash all parts in dry-cleaning solvent. Thoroughly clean inlet and outlet parts.

(Continued on next page)

TRANSFER PUMP (POWER UNITS)

4. INSPECTION AND REPAIR - Continued

2. Check for excessive idler gear running clearance which must not be more than 0.001 to 0.003 inch.

3. Check fit of gears on shaft. No perceptible play should be present between gear and shaft. Gear must turn freely.

4. Replace "O" ring and oil seal with new.

5. Check gear shafts for grooves and scratches. Remedy by stoning or filing shaft. Replace if necessary.

6. Check for excessive backlash of gears. It must not be more than 0.004 to 0.006 inch.

5. REASSEMBLY

1. Press the oil seal into the pump body. Exercise care not to damage the seal.

2. Install the idler gear on the shaft mounted in the pump body.

3. Install the drive gear and shaft into the pump body.

4. Install new "O" ring in the groove in the pump body, and then secure the cover to the pump body with cap screws.

6. INSTALLATION

1. Install pump and new gasket. Engage the slot of the magneto drive shaft or transfer pump drive shaft with the pump drive shaft.

2. Secure the pump to the front gear cover with cap screws.

TRANSFER PUMP STRAINER (POWER UNITS)

7. DESCRIPTION

The diesel fuel is filtered through a fine mesh wire screen in the transfer pump strainer before it enters the transfer pump.

8. REMOVAL

1. Shut off the flow of fuel.

2. Remove the fuel inlet pipe from the strainer, and remove the cap screws securing the strainer bracket. Remove the strainer and bracket.

9. DISASSEMBLY (Refer to Illust. 1)

1. Unscrew the strainer plug (12) and gasket (13).

2. Disconnect the screen by unscrewing the integral nut from the plug. Lift the screen (14) from the strainer body (15).

10. INSPECTION AND REPAIR

The strainer screen must be removed and cleaned at regular intervals. Wash the screen in kerosene, fuel oil or solvent. Also clean out the plug and strainer screen body. If the strainer screen is cracked or broken, it should be replaced with a new strainer screen.

11. REASSEMBLY

Reassemble the strainer in the reverse order of disassembly.

12. INSTALLATION

Install the strainer in the reverse order of removal.

TRANSFER PUMP DRIVE (POWER UNIT ENGINES)

13. DESCRIPTION

On UD-16 power units the transfer pump was driven by the magneto drive shaft. Later model power unit engines (UD-525, UD-554, UD-24 and UD-1091) were equipped with a transfer pump drive assembly. This assembly fastens to the rear of the crankcase front cover, is driven by the camshaft gear, and basically consists of a drive housing, drive shaft and a drive gear.

14. REMOVAL

For information on the UD-16 power unit transfer pump drive, refer to the magneto drive in section 14.

1. Remove the fuel line connections to the transfer pump.

2. Remove the transfer pump and strainer.

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TRANSFER PUMP DRIVE (POWER UNIT ENGINES)

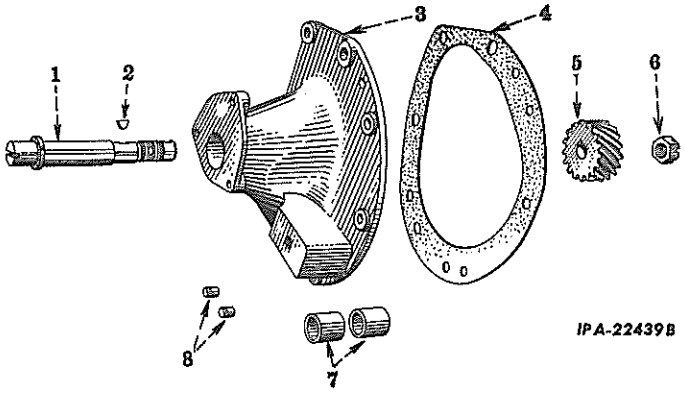
3. Remove the capscrews securing the drive housing to the crankcase front cover, and remove the drive housing and gasket.

15. DISASSEMBLY (Refer to Illust. 4)

1. Remove cotter pin and nut (6).

2. Press shaft (1) out of gear (5), removing also the seal, if so equipped.

3. Do not remove the bushings (7) unless replacement is necessary.



Illust. 4 - Fuel Transfer Pump Drive.

1. Drive shaft.
2. Key.
3. Drive housing.
4. Gasket.
5. Drive gear.
6. Nut.
7. Bushing.
8. Dowel.

16. INSPECTION AND REPAIR

1. Inspect the gear (5) for worn or chipped teeth; replace if necessary.

2. Inspect the shaft (1) and bushings (7) for scoring and wear. The shaft diameter at the bearing area is .8720 to .8725, the bushing inside diameter (installed in housing) is .874 to .875. Replace all worn or scored parts.

3. When repairing a fuel transfer pump drive equipped with seal, always use a new seal when reassembling.

17. REASSEMBLY

1. If new bushings (7) are to be installed, press one bushing into the housing from each side until they are flush with the edge of the shaft bore.

2. After pressing the bushings into the housing, ream to a .874-.875 dimension.

3. Insert the key (2) into the shaft (1) and slide into the housing (3), invert the housing and press gear (5) into the shaft. Lock the gear (5) onto the shaft using the nut (6) and cotter pin.

4. On transfer pump drives equipped with seal, press the seal into the opening on the transfer pump mounting face until it seats against the shoulder. The lips of the seal must face inward toward the bushings.

18. INSTALLATION

1. Using a new gasket (4, Illust. 4) assemble and fasten drive housing assembly to the rear of the crankcase front cover.

2. Fasten the fuel transfer pump to the drive housing using a new fuel transfer pump gasket. Be certain that the tang on the transfer pump shaft engages the slot in the drive housing shaft.

3. Fasten the fuel transfer pump strainer to the drive housing and connect the piping from the fuel supply to the strainer, from the strainer to the transfer pump and from the transfer pump to the engine.

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MAGNETO MOUNTING BRACKET

1. DESCRIPTION

The magneto is driven from a shaft and gear support on a bracket which attaches to the right rear side of the crankcase front plate (Illust. 3). The magneto is mounted to the bracket and is driven by two lugs which engage in slots in the magneto coupling block.

2. REMOVAL

Remove the grounding switch cable from the bottom side of the magneto (Illust. 3). Remove the distributor cap and spark plug cables as a unit. Run out the cap screws holding the magneto bracket to the front plate, and remove the magneto and bracket as a unit.

3. DISASSEMBLY (Refer to Illust. 1)

Remove cover (1) and magneto by removing four cap screws from the bottom side of the bracket (18). Remove two cap screws from coupling (7). Remove nut (25) and key (21). Press shaft (23) out of gear (17) by removing nut (24) and washer (26). The shaft will slide out of a bushing (10) in the bracket. Idler gear (14) and shaft (15) can be removed by removing nut (11) and lock washer (12).

4. INSPECTION AND REPAIR

Wash all parts except the magneto in dry-cleaning solvent, and dry with compressed air. Inspect all parts for wear and damage. Replace parts if necessary. The new shaft diameter is .8720 to .8725 inch; the bushing diameter is .874 to .875 inch. Particular care must be taken to have bushing bore square within .006 inch for a 4-inch radius. If it is not, the gear will run out, causing a noisy magneto drive.

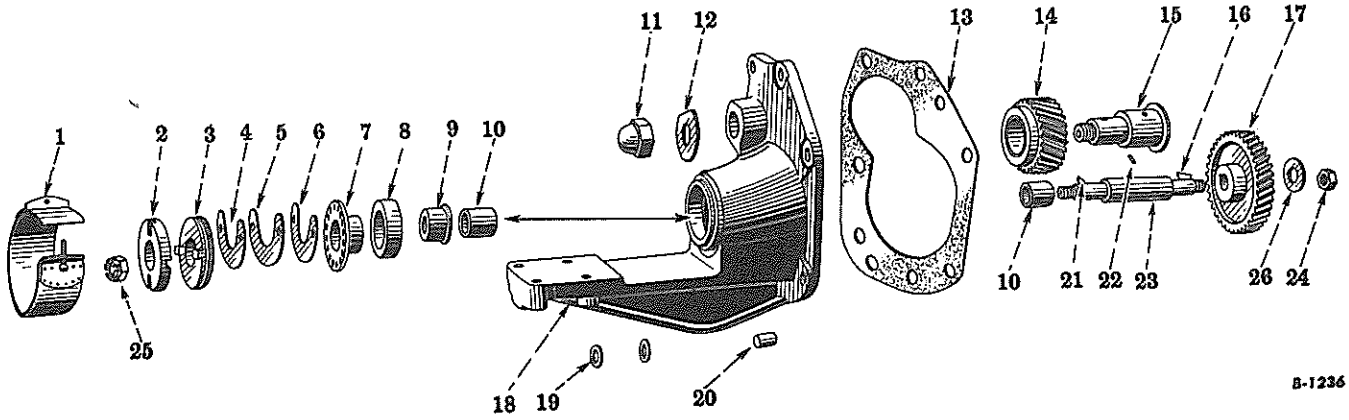
5. REASSEMBLY (Refer to Illust. 1)

Lubricate shaft (23) with engine oil. Install gear (17) on the shaft and secure it with washer (26) and nut (24). Slide bushing (10) on the shaft and place it in the bracket (18). Assemble spacer (9) and seal (8) in place with coupling (7) and spacer (2). Secure it with nut (25). Place shaft (15) through gear (14) and place it in the bracket. Secure with nut (11) and washer (12). The flat side of the gear must face toward the crankcase front plate. The end clearance of the shaft should be .004 to .014 inch.

6. INSTALLATION

Shellac a new gasket to bracket (18, Illust. 1). Attach the bracket to the crankcase front plate so the pump timing mark on the magneto gear tooth lines up with chamfered tooth on the camshaft gear. Install the magneto (Illust. 7).

(Continued on next page)



Illust. 1 - Magneto Mounting Bracket Components.

1. Cover.
2. Spacer.
3. Coupling block.
4. Shim, medium.
5. Shim, heavy.
6. Shim, light.
7. Coupling.
8. Oil seal.
9. Spacer.
10. Bushing.
11. Nut.
12. Lock washer.
13. Gasket.
14. Idler gear.
15. Idler shaft.
16. Key.
17. Gear.
18. Bracket.
19. Gasket.
20. Dowel.
21. Key.
22. Pin.
23. Shaft.
24. Nut.
25. Nut.
26. Washer.

MAGNETO

7. DESCRIPTION

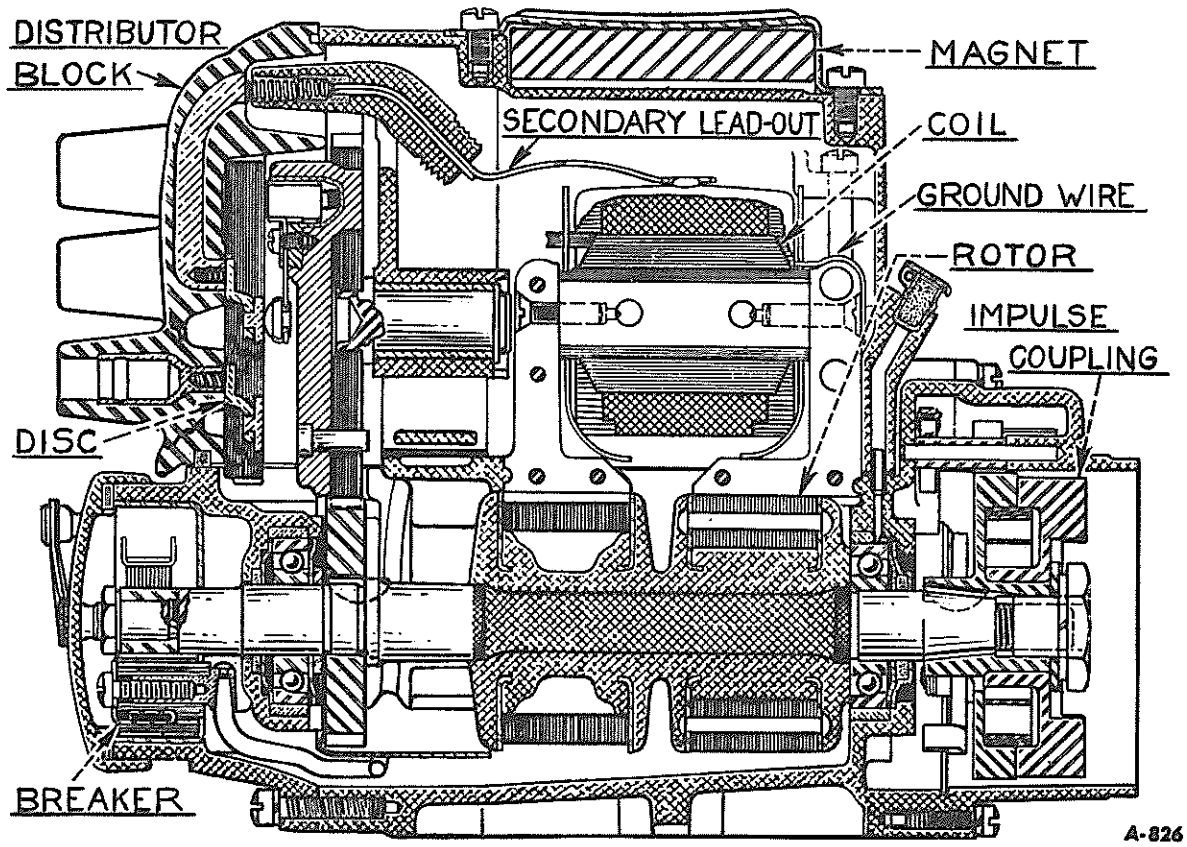
The International model F-6, inductor-type, high-tension magneto develops three sparks per crankshaft revolution, rotates at 3/4 engine speed, and is fully enclosed against entrance of dust, dirt and moisture. It is equipped with an automatic impulse starter coupling which makes possible the production, at cranking speed, of a spark equal to that when the engine is operating.

The magneto runs continuously when the diesel engine operates either on the gasoline starting cycle or on the diesel cycle.

When the engine is operating on the diesel cycle, the magneto is shorted through a cut-out switch which operates off the manifold butterfly valve shaft. When the magneto is shorted, it will not supply sparks to the spark plugs. The magneto is secured to a bracket by four cap screws and lock washers, and is mounted to the crankcase front plate on the right front side of the engine.

8. REMOVAL

Remove the grounding switch cable from the magneto (Illust. 3). Loosen the set screw that secures the cover to the magneto drive. Remove the cap screws that secure the magneto coupling to the magneto (Illust. 6). Remove the distributor cap. Remove the cap screws that secure the magneto to the magneto bracket and lift the magneto from its position.



Illust. 2 - Cross Section of Magneto.

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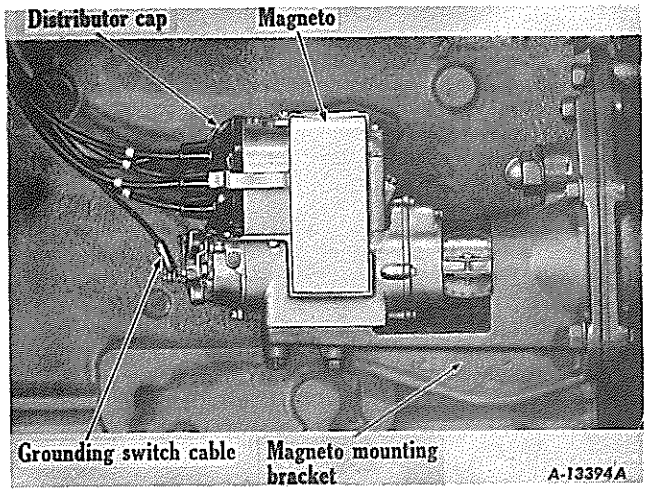
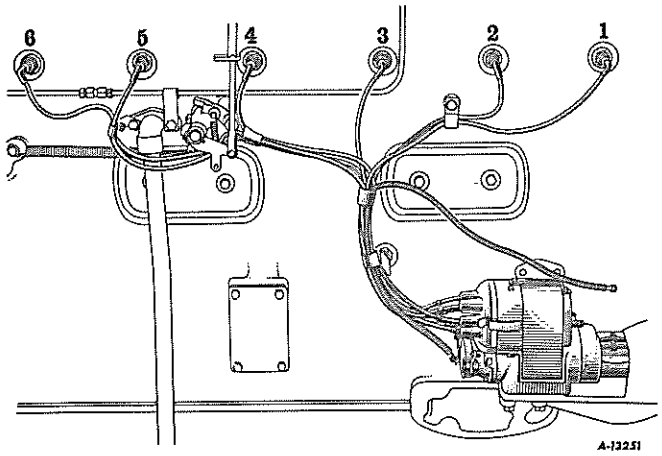
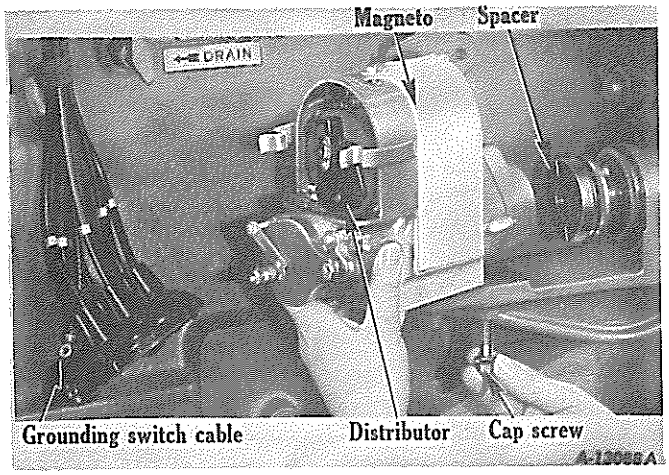
MAGNETO



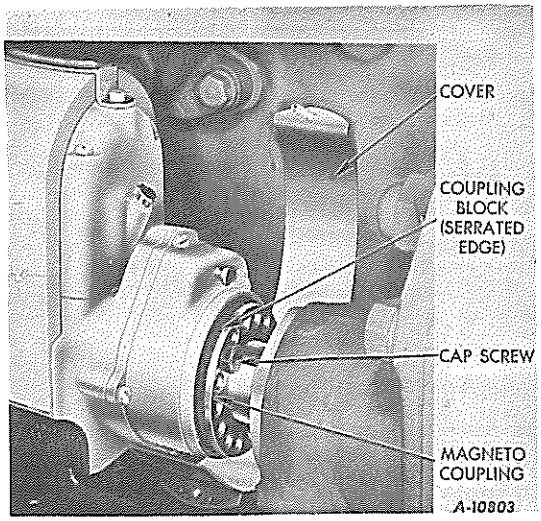
Illust. 3 - Magneto Installed on Engine.



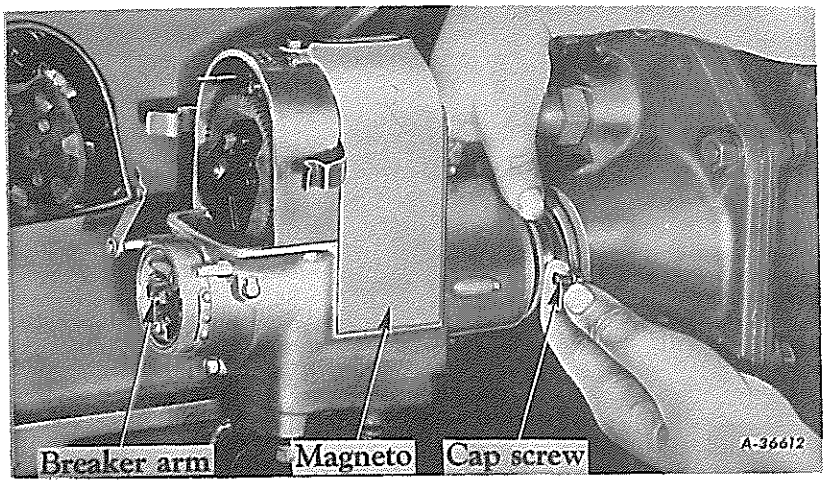
Illust. 4 - Wiring Chart for Magneto. The Engine Firing Order is 1, 5, 3, 6, 2, 4.



Illust. 5 - Removing the Magneto.

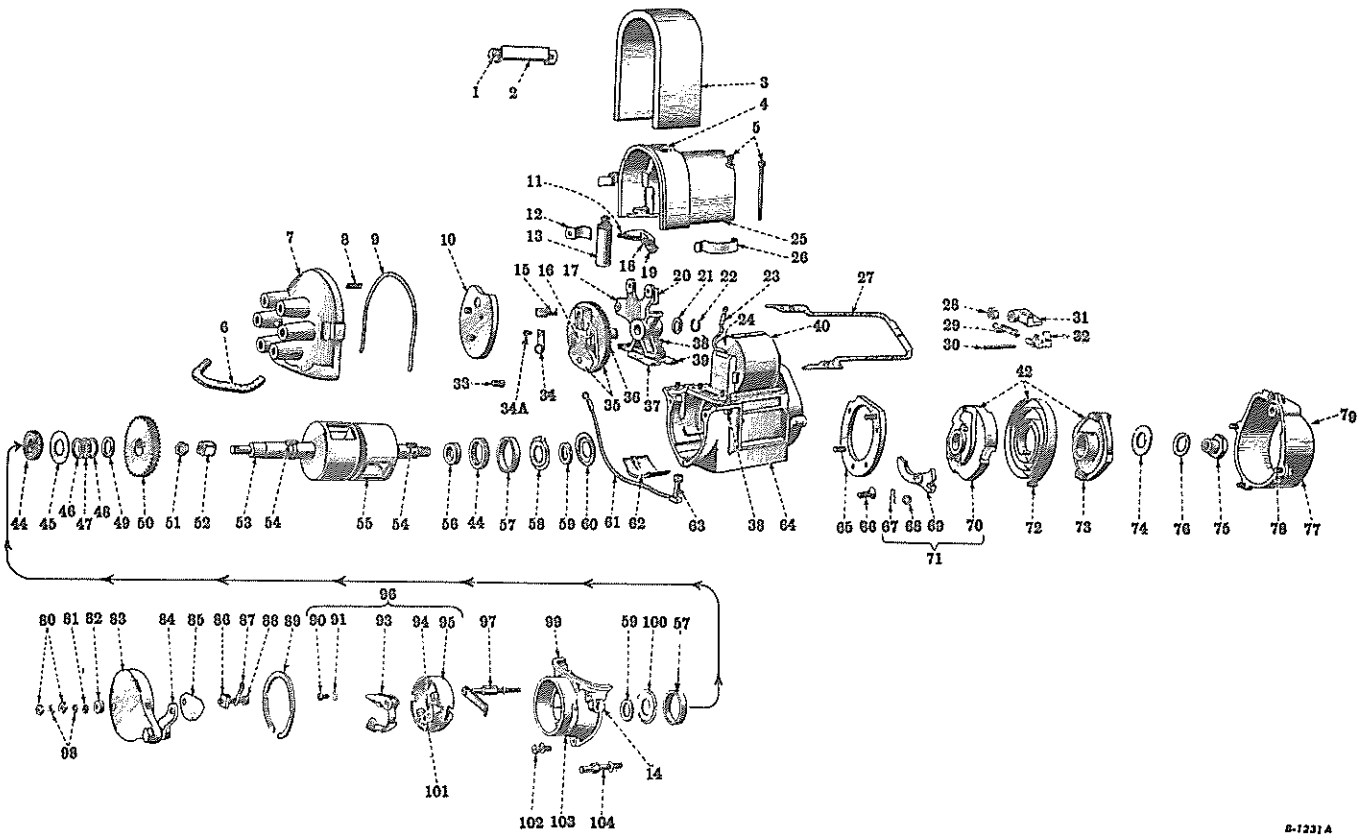


Illust. 6 - Removing the Magneto.



Illust. 7 - Installing Magneto on the Engine.

MAGNETO



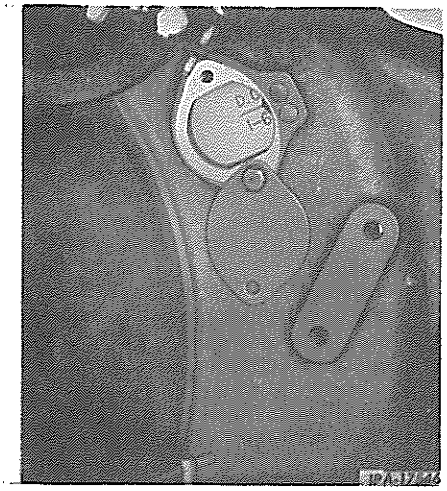
Illust. 8 - Exploded View of Magneto.

9. TIMING THE MAGNETO TO THE ENGINE

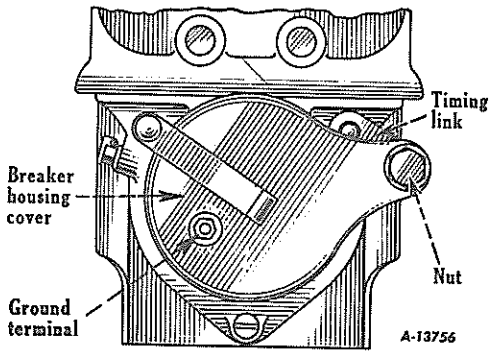
If the magneto has been moved for any reason, the following instructions must be followed when installing the magneto on the engine.

Set the compression release lever in the low compression position for gasoline operation.

Crank the engine until the No. 1 piston is on the upper dead center of the compression stroke. The compression stroke can be determined by removing the No. 1 spark plug, placing a thumb over the opening, and cranking the engine until an outward pressure is felt. Continue cranking until the "DC 1 and 6" mark (Illust. 9) on the flywheel is in line with the pointer.



Illust. 9 - "DC" Mark on Flywheel.



Illust. 10 - Breaker Housing Cover.

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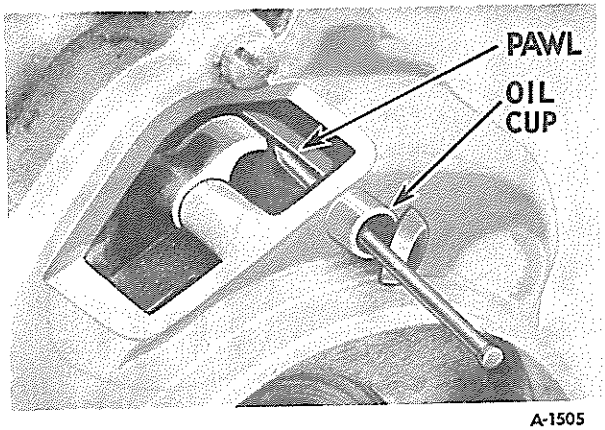
MAGNETO

Legend for Illust. 8

1. Screw.
2. Magneto strap.
3. Magnet.
4. Distributor bearing oiler.
5. Frame cover screw.
6. Distributor seal, lower.
7. Distributor block.
8. Distributor disc contact spring.
9. Distributor seal, upper.
10. Distributor disc.
11. Secondary leadout spring.
12. Condenser clamp.
13. Condenser.
14. Bearing oiler.
15. Distributor brush.
16. Distributor.
17. Distributor bearing.
18. Washer.
19. Secondary leadout.
20. Felt.
21. Washer.
22. Snap ring.
23. "Primary to condenser" leadout tube.
24. Coil end insulator.
25. Magneto frame cover.
26. Distributor block spring.
27. Frame cover gasket.
28. Pawl spacer.
29. Latch spring.
30. Pawl latch pin.
31. Pawl.
32. Pawl latch.
33. Distributor disc screw.
34. Contact spring.
34A. Screw.
35. Distributor shaft with gear and distributor.
36. Distributor shaft and gear.
37. Distributor bearing shim.
38. Distributor bearing screw.
39. Distributor bearing shim.
40. Coil.
42. Magneto impulse coupling rotating member.
44. Bearing retainer.
45. Oil flinger.
46. Rotor shim, light.
47. Rotor shim, medium.
48. Rotor shim, heavy.
49. Bearing spacer.
50. Rotor pinion (40 teeth).
51. Breaker cam nut.
52. Breaker cam.
53. Breaker cam key (not seen).
54. Rotor shaft key.
55. Rotor.
56. Bearing inner race.
57. Bearing outer race.
58. Felt retainer, inner.
59. Bearing felt.
60. Felt retainer, outer.
61. Primary leadout.
62. Primary leadout shield.
63. Leadout terminal screw.
64. Magneto frame.
65. Frame ring.
66. Machine screw.
67. Pawl pin snap ring.
68. Engaging pawl washer.
69. Engaging pawl.
70. Magneto member with pins.
71. Magneto member with pawls.
72. Drive spring.
73. Cam member.
74. Lock washer.
75. Impulse coupling nut.
76. Lock washer.
77. Impulse coupling cover.
78. Machine screw.
79. Impulse coupling oiler (not seen).
80. Nut.
81. Washer.
83. Breaker housing cover.
84. Magneto timing link.
85. Spring insulator.
86. Terminal insulator.
87. Short-circuiting spring.
88. Short-circuiting screw.
89. Breaker cover packing.
90. Point support screw.
91. Point support washer.
93. Breaker arm.
94. Cam felt.
95. Circuit breaker cup.
96. Breaker.
97. Breaker cover spring post.
98. Lock washer.
99. Breaker housing.
100. Felt retainer.
101. Spring anchor.
102. Breaker housing screw.
103. Breaker stop and gasket.
104. Magneto timing link post.



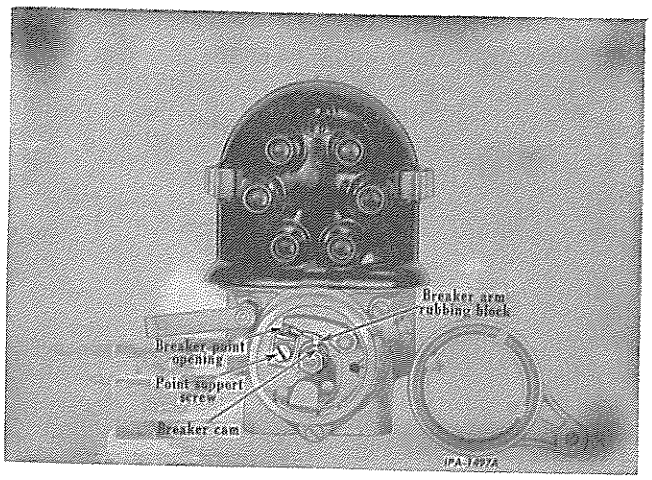
Illust. 11 - Disengaging Impulse Coupling.

Fully retard the spark. To do this, remove the link (Illust. 10) and raise the breaker housing cover as high as it will go.

The impulse coupling then can be locked out of engagement by inserting a nail or wire into the oil cup in the impulse coupling housing, as shown in Illust. 11, and lifting the main pawl so the pawl latch will hold it out of engagement and the rotor is free to rotate. Rotate the magneto clockwise until the rubbing block in the breaker assembly is on the high point of the cam. Check or adjust the point opening for proper setting of .020 inch (Illust. 12).

(Continued on next page)

9. TIMING THE MAGNETO TO THE ENGINE – Continued



Illust. 12 - Breaker Point Adjustment.

Assemble the magneto and drive coupling parts on the engine, inserting the magneto base screws loosely into the magneto. Remove the distributor block, grasp the adjustable coupling (magneto half) and rotate it clockwise (as viewed from the coupling end) until the brush in the distributor disc is under the distributor block terminal marked No. 1 and the breaker points are just beginning to open.

With the magneto in this position, locate the holes in the adjustment coupling that line up. Insert shims between the halves of the coupling so cap screws will pass through the holes in the shims and enter the holes in the tapped half of the adjustment coupling.

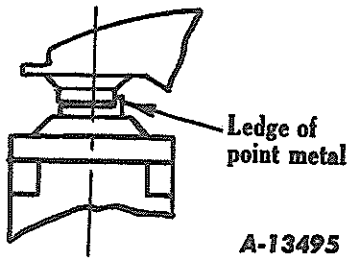
NOTE: The holes in the adjustment coupling are so spaced that only two pairs of holes will line up exactly. Do not force the cap screws, or the setting will be incorrect.

Tighten the magneto base cap screws; replace the circuit breaker cover and distributor block, exercising care not to damage the brush or the contact spring.

To check the timing, fully retard the spark as previously described. Crank the engine until the points are just beginning to open. If the timing is correct, the "DC" mark on the flywheel will be in line, or not more than eight degrees below (1 inch on flywheel rim), and never above, the timing pointer.

10. CHECKING CIRCUIT BREAKER

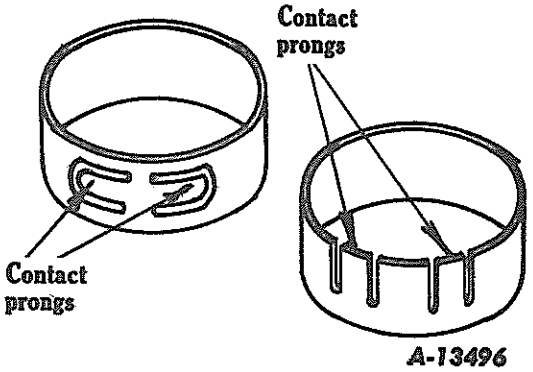
Remove the breaker housing cover and examine the circuit breaker for correct point performance and setting. A ledge of point metal (Illust. 13) running up the side of the companion point causes a slow break and poor performance.



Illust. 13 - Ledge of Point Metal Causes a Slow Break and Poor Performance.

Breaker points should be set to .020 inch with the rubbing block on the high part of the cam. To adjust the point opening, loosen the stationary point support screw (Illust 12) slightly, and use a screwdriver as a pry to move the stationary point support as necessary. This setting should be maintained as close as possible for maximum efficiency and checked periodically. See that the points are reasonably flat. File them a little if uneven point contact is formed.

Examine the breaker for excess oil around the outside and at the bottom. This may interfere with the proper primary circuit from the cup member to the breaker housing. The contact prongs of the breaker cup (Illust. 14) are supposed to be bent out at the factory to make a firm electrical circuit between this cup and the housing in which it fits. The oil interferes with



Illust. 14 - Contact Prongs Should Be Bent to Make a Firm Electrical Circuit.

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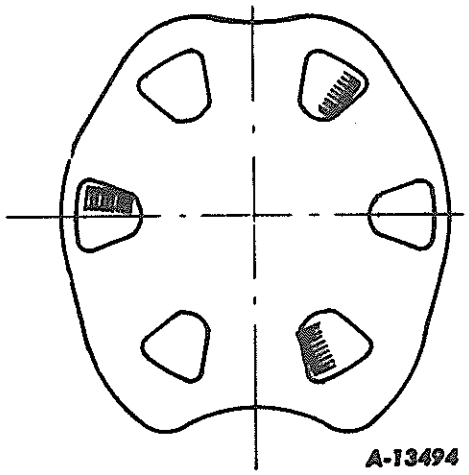
this contact. Likewise, a loose-fitting cup produces the same effect. Bend the prongs out if need be and reduce the oil supply.

11. CHECKING DISTRIBUTOR

Remove the distributor block. Examine the brush track for black carbon, burns, and for the spot on the bronze insert that tells whether the spark has been occurring at the correct place. A magneto spark is a rather long drawn out discharge. It has a tendency to burn the brush track unless the spark is started soon enough to permit a rather complete discharge before the brush runs off of the insert and onto the distributor disc surface. The distributor disc brush tract can readily be cleaned of black carbon with a soft rubber eraser. DO NOT USE SANDPAPER.

All sparks from the spark spots should always come on the leading edge of the inserts as shown in Illust. 15; otherwise, the distributor disc will burn as the brush leaves at the other side.



Illust. 15 - Correct Timing Spots on the Distributor Disc.

12. CHECKING SAFETY GAP

If the breaker and the distributor of the magneto are both found to be in good condition, carry the examination further. Leave the distributor block off, advance the spark, disengage the impulse coupling, and then turn the magneto briskly by hand. A spark should jump regularly across the safety gap. The regular safety gap setting is 7/16 inch to 15/32 inch.

13. CHECKING SAFETY GAP SPARKING

We will assume that the spark is unsatisfactory, intermittent and weak. The examination must then proceed still further. Remove the magnet and frame cover. Replace the condenser and test the magneto for spark once more.

The frame cover may be left off for the test; however, it is necessary to place magnet on the magneto. The spark should jump the safety gap, with the breaker in the advance position, when the rotor is being turned briskly by hand. If performance is now satisfactory, the condenser was at fault. Reset the magneto safety gap to 7/16 inch to 15/32 inch.

Assuming that the condenser exchange did not correct the faulty operation, it will be necessary to check the primary leadout wire for open circuit and grounding.

14. CHECKING GROUND CONNECTION

Examine the ground connection of the winding to the interpole (Illust 17). The new type grounding strip is secured to the interpole by the coil core screw.

Earlier type coils are equipped with a grounding wire which is soldered to the hole in the interpole. On these coils, make sure that the tinning or adhesion of the ground wire is complete to the bottom of the hole in the interpole.

Laying the ground wire along the interpole and making a surface joint is not secure enough. The solder will crack through in time. Be sure that this is not the case in the magneto. The coil housing should be a tight press fit between the interpoles endwise so it cannot shift and wear loose from engine vibrations. If this happens, the ground connections, or the wire to the condenser, will crack in two. A very slight amount of motion will bring this about. Be sure that this fault does not exist in the magneto being examined.

If the spark still is unsatisfactory, it will then be necessary to replace the coil, as everything else has gradually been eliminated as the source of failure.

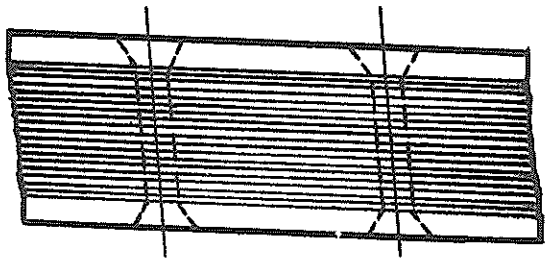
(Continued on next page)

MAGNETO

15. COIL CORE FIT BETWEEN INTERPOLES

The least defect on the joining surfaces between the coil core and the interpole will permanently impair the operation of the magnet.

This joint must be a clean "sucking" fit, similar to the fit when two Johannsen gauge blocks are put together. No rust, oil, or foreign matter of any kind should be on these surfaces. By all means, do not try to correct defects by filing the ends of the coil core. This can end only in failure. The coil core is made of laminated electrical sheet steel. It is held together by two rivets. If struck vigorously with a metal tool, it will burr and may be knocked **out of line, as shown in Illust. 16.**

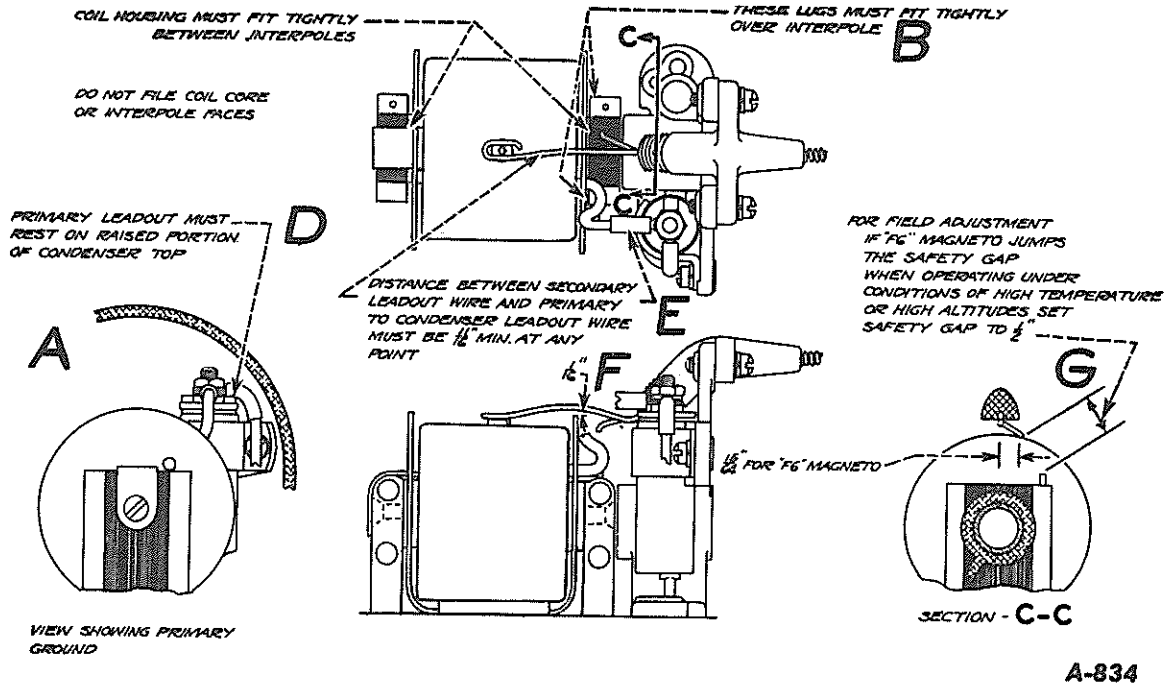


Illust. 16 - Coil Core Knocked Out of Square.

16. COIL REMOVAL

As a final check for a faulty coil, it may be tested with a coil tester. Magneto coils must be detached from the magneto.

Disconnect the condenser. Then remove the distributor gear and the bearing. (See Illust. 18.) Next, remove the coil core screws. On coils equipped with a grounding wire, unsolder the wire from the interpole. Use a large soldering copper; have it quite hot so it can be done quickly. Pour out all extra solder from the countersunk hole. Finally, force the coil upward slowly with the aid of a screwdriver. The core should always be in position in the center of the windings when testing the coil on the electrical testing instrument. If the core is not in place, the transformer setup of the coil is not complete and no spark will appear at the gap. This test should not be prolonged any more than is necessary to obtain the check. Subjecting the coil to the test conditions for a prolonged period may damage it.



Illust. 17 - Drawing of Magneto Coil Assembled in Place, With Service Pointers for Installing Coil Properly.

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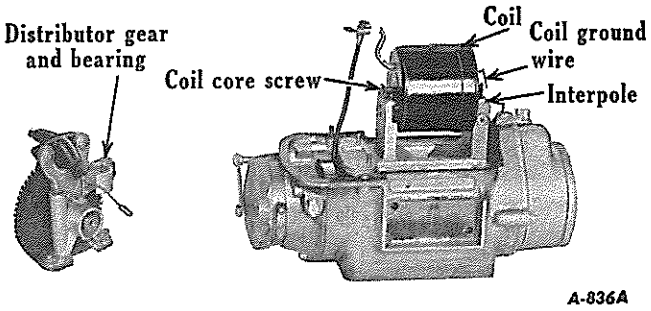


Illust. 18 - Removing Coil from Magneto.

17. COIL DISASSEMBLY

Remove the coil core from the defective winding. Hold the coil in one hand, preferably with the coil lid up. By the use of a flat end hardwood or fibre punch, at least 5/8 to 11/16 inch in diameter, drive the core downward between the fingers. Be sure to hold the coil firmly when driving out the core (Illust 19). The bakelite coil case is brittle and it will break if dropped. Do not use a metal punch of any kind.

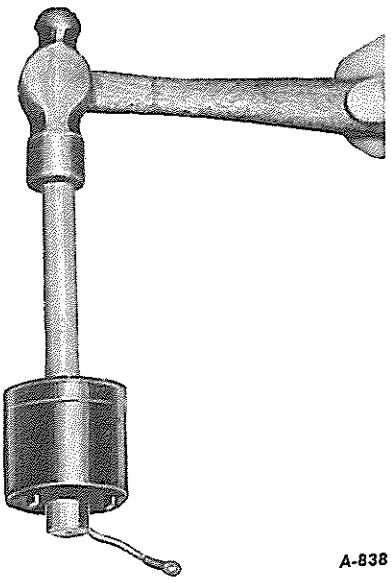
18. COIL REASSEMBLY AND INSTALLATION

The coil must be a hand-press between the interpoles and on the coil core. Otherwise, vibration will loosen it and cause failure. Also, do not attempt to file the diameter of the coil core so that it will slip into the winding easily, nor file the ends to make it fit between the interpoles easier. Paint the coil hole generously all around with a thick asphalt solution for a 3/8-inch length at each end before pressing in the core. The core should be a hand-press fit in the winding and it may have to clear a path by removing a small amount of varnish as it is pressed in; this is permissible and will cause no damage, providing that it is started and pressed in straight. Clean the core ends thoroughly of paint. These surfaces must be absolutely clean.

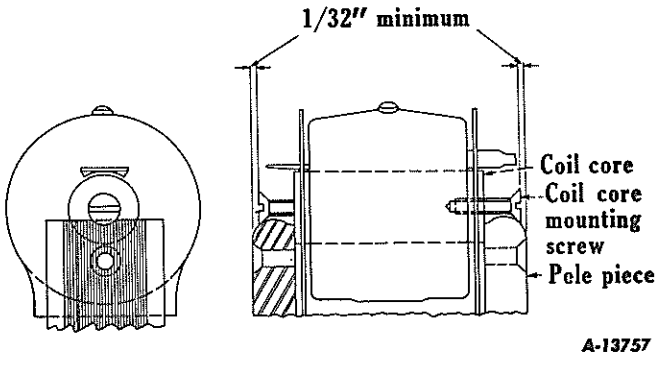
The bakelite housing will normally be a little longer than the coil core and should not be filed. The guide lugs on the coil housing should fit the interpole so that they bear against it lightly, just enough to keep the winding from moving sidewise or turning around on the screws.

A check should be made on the length of the coil core screws. They should be bottomed lightly in the core, and the winding placed on top of the interpoles with the screws in place. (See Illust. 18.) In this position it can be seen readily whether the screws bottom before they would tighten. If the guide lugs are too tight on the interpole, they may be filed until they fit properly. Be careful not to touch the end of the core with the file during this operation. Test the coil core mounting screw length by bottom-pressing the assembly into position.

(Continued on next page)



Illust. 19 - Removing Coil Core With Hardwood or Fibre Punch.



Illust. 20 - Testing Coil Core Screws Before Assembling Coil Core to Magneto.

18. COIL REASSEMBLY AND INSTALLATION – Continued

If either screw head does not fall back of the face of the pole piece by 1/32 inch minimum (as in Illust. 20), it must be removed and enough cut off the end to meet this requirement. This is done so that, when coil core is in place, the screws will tighten up in the pole piece countersunk hole before the screws bottom in the coil core.

CAUTION: Do not file or in any way deface the ends of the coil core or face of pole pieces, as this will impair the magnetic circuit and the efficiency of the magneto. The coil core should be a light press fit between the pole pieces.

19. COIL CONNECTION

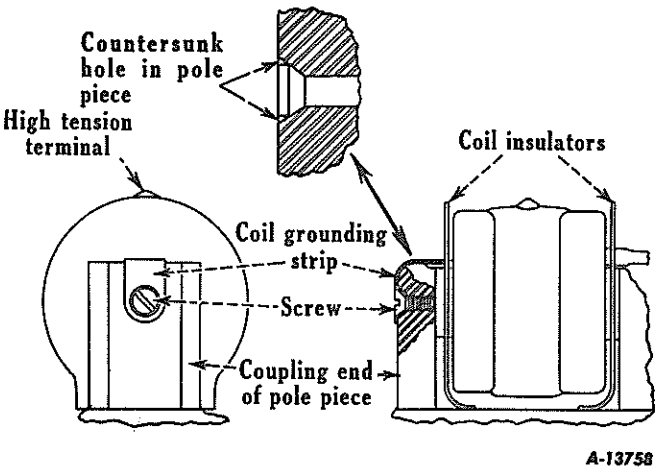
On coils equipped with a grounding wire, this connection must be bent and inserted into the bottom of the hole to prevent the wire from breaking due to vibration. Be sure that the countersunk hole and the end of the leadout wire are clean, and that a thorough soldering job is done. Do not use acid; use a resinous flux that will not corrode or eat the metal.

Remove the old coil core and assemble the new coil on the core with a coil end insulator at each end. Locate the coil and core in the magneto so the high tension terminal is on a vertical centerline. On coils equipped with a grounding strip, assemble the coil grounding strip under the coil mounting screw in the pole piece as shown in (Illust. 17). Tighten the screws firmly. The surface of the countersink in the pole piece and the grounding strip must be clean and bright before assembling.

If there is a shoulder in the countersunk hole in the pole piece, the shoulder must be removed.

20. HIGH TENSION LEADOUT

Do not allow this leadout to touch the bakelite coil housing at any point. Maintain a 1/16-inch space between the secondary leadout and the coil housing. (See Illust. 17.) This is to prevent a drop of moisture from bridging at this



Illust. 21 - Method of Grounding Coil With New Ground Strip.

place. If this wire is raised too high, the spark will jump upward to the roof of the aluminum cover.

21. CONDENSER - GENERAL

All metal surfaces contacting the condenser should be thoroughly cleaned to insure a good ground. Be sure that the condenser is pushed down as far as it will go before tightening the clamp. Refer to Illust. 17, references E and D, for instructions on the proper positioning of the lead wires to the condenser.

It is very important that these wires be positioned as shown in Illust. 17 to prevent shorting or grounding.

22. SAFETY GAP

The safety gap acts as a protection to the winding when abnormal sparking conditions are experienced. The regular safety gap setting is 7/16 inch to 15/32 inch.

High humidity, extremely high temperature, or high altitude, or a combination of all three, may cause internal jumping of the spark. If a magneto spark starts jumping the safety gap, determine the cause and correct it. These gaps are amply long for almost every condition where internal combustion engines are operated, except in high altitudes.

A spark which jumps the safety gap can be

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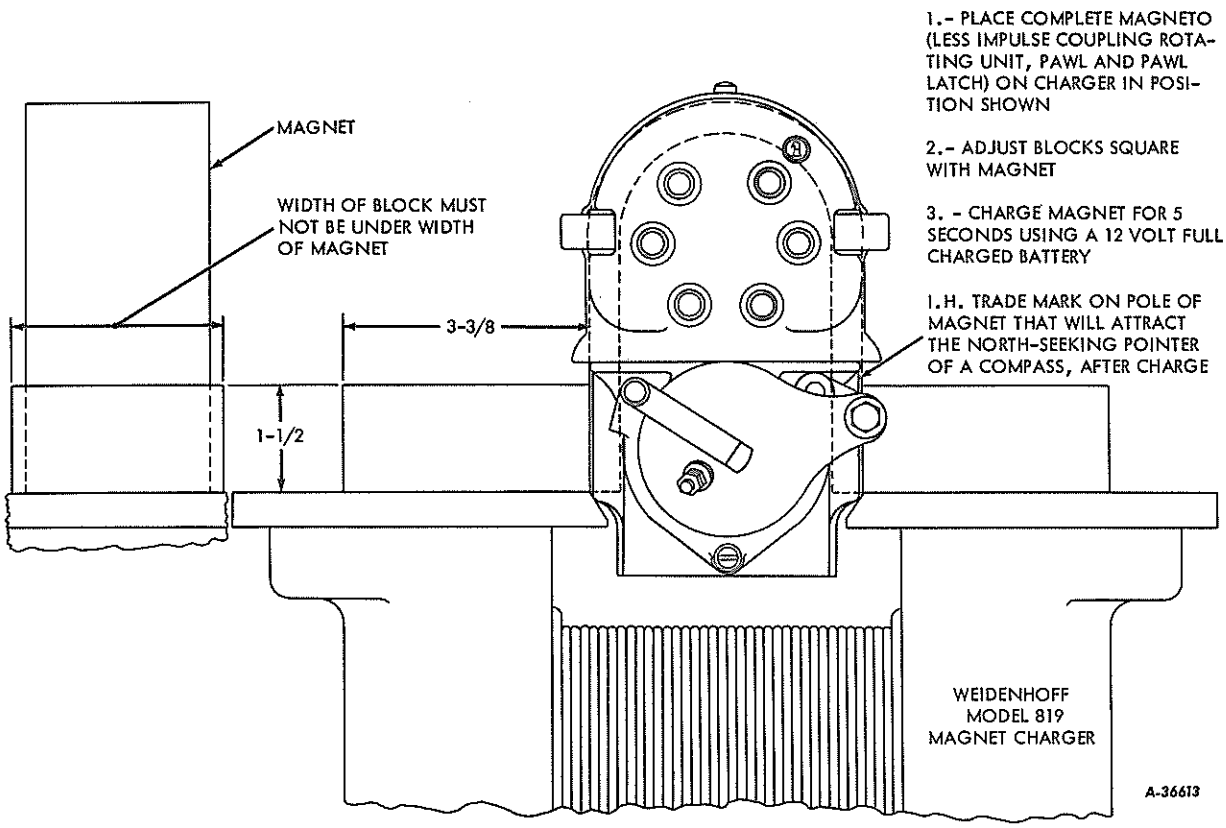
MAGNETO



Illust. 26 - Magneto Charging "F" Type Magneto.

pawl and pawl latch must be removed. The charging blocks must then touch the sides of the magnet. Follow the manufacturers' instructions for charging the magnets, either on or off the magneto.

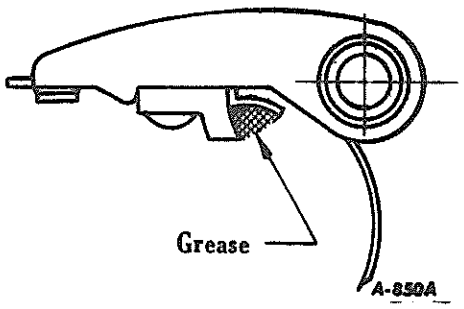
NOTE: The I. H. trade mark is on the pole of the magnet that will attract the north-seeking pointer of a compass after charge. If the magnet has been removed from the magneto, place a "keeper" across the base of the magnet until the magnet is installed in the magneto. Never slide the keeper up on the side of the magnet as this will result in partial demagnetization.

28. BREAKER POINTS

The life of the breaker points may be very materially increased by keeping the breaker arm rubbing fibre properly lubricated with magneto grease. Also keep the points set to gauge. Wide settings burn contacts rapidly.

29. BREAKER CUP

A simple tool for removing the circuit breaker cup may be made from a discarded, flat, impulse coupling spring.



Illust. 27 - Where Magneto Grease Should be Placed on Breaker Arm to Lubricate Rubbing Fibre.

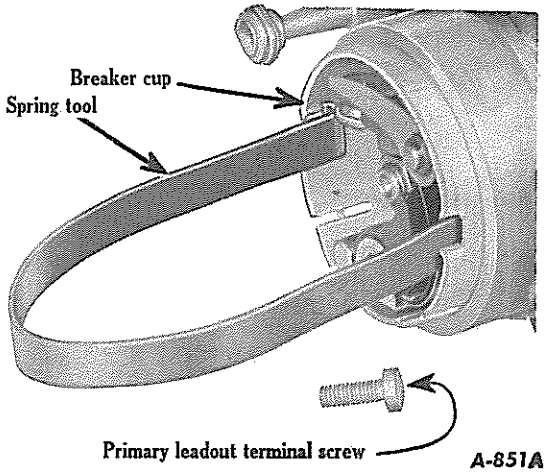
Bend the spring into a "U" shape and turn a short lip at a right angle on each leg of the "U." These two lips should be long enough to hook in back of the bent-over lips on the breaker cup slots which are used to move the cup to advance or retard the spark.

(Continued on next page)

MAGNETO

29. BREAKER CUP – Continued

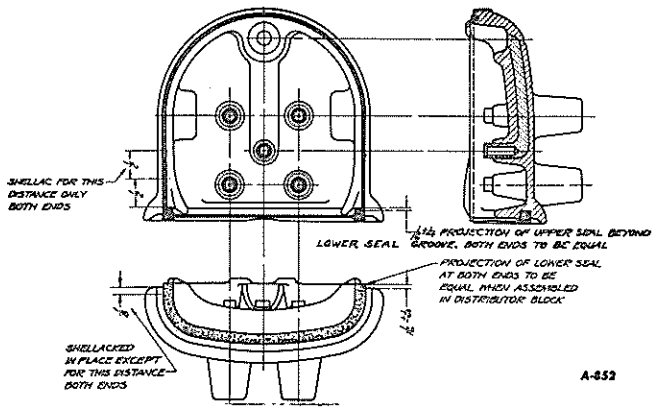
To remove the breaker cup, first remove the primary leadout terminal screw. A light blow on the head of this screw, after it has been loosened about two turns, will free the leadout terminal and facilitate the breaker cup removal. The breaker cup must be positioned so the slot in the rear of the cup registers with the pin which is a stop for the advance and retard action. A light pull on the puller tool as shown in Illust. 28 will then remove the breaker cup.



Illust. 28 - Using Tool to Remove Breaker Cup.

30. DISTRIBUTOR BLOCK AND GASKETS

For satisfactory performance of a magneto, water should not be permitted to find its way to the inside. The magneto has for some time been fitted with distributor block gaskets of waterproof construction. This is being done in two ways; one by water proofing the felt, and the other by applying a narrow lamination of artificial rubber in the gasket to prevent seepage from working through.



Illust. 29 - Proper Method of Assembling Distributor Block Gaskets.

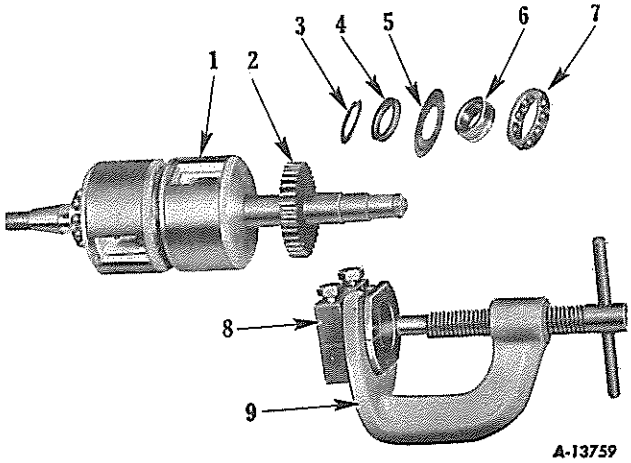
In wet localities, be sure that these gaskets are used in case ignition troubles are experienced. Assemble them as shown in Illust. 29.

Keep the outside of the distributor block clean of mud and water. Some soils produce a mud that is a very good conductor of electricity. With the exterior surfaces of the distributor block coated with such material, the electrical losses may easily reach values that jeopardize ignition.

31. ROTOR REMOVAL

To remove the rotor from the magneto, first remove the impulse coupling. Use puller tool (MT-50) to avoid damage to the rear of the magneto frame. Then take off the distributor block, magnet, magneto frame cover, distributor disc, bearing assembly, and breaker housing cover. Remove the primary leadout terminal screw and three breaker housing screws. The breaker housing can then be removed from the magneto frame, and the rotor taken from the frame.

The inner bearing race can be readily removed



Illust. 30 - Exploded View of Rotor Parts, With Inner Race Pull Tool SE-839.

1. Rotor.
2. Rotor pinion.
3. Rotor shims.
4. Rotor shaft bearing spacer.
5. Oil flinger.
6. Inner bearing race.
7. Ball bearings and separator assembly.
8. Bearing race adapter.
9. Puller.

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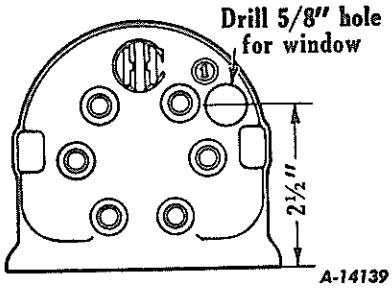
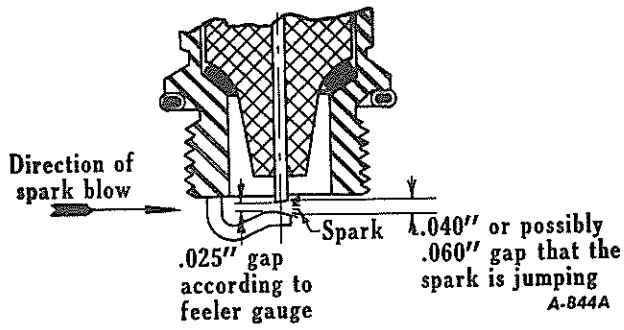


Illust. 22 - Hole for Window in Distributor Block for Observing Spark Across Safety Gap.

readily detected by placing on the magneto a regular distributor block in which a transparent window has been provided (Illust. 22). A window in the distributor block, rather than just an opening, must be used; otherwise air conditions in the magneto will change and probably will prevent the spark from jumping. Drill the holes in the block as shown in the illustration; then, with a drill slightly larger in diameter, counterbore the same hole. A window can be made of celluloid to fit the counterbored hole. It can be held in place with shellac. Operate the engine for a sufficient time to permit the air in the magneto to attain the normal operating temperature, and observe through the window if the spark is jumping the safety gap. If the spark is jumping the safety gap, check all spark plug gap settings. It may be necessary to file off the spongy metal at the tip of the spark plug wire and close the gap to .020 inch. If the spark continues to jump the safety gap, with the engine still operating, the safety gap may be increased. Cut off and reform the spark plug leadout closer to the secondary lead. (See "G," Illust. 17.)

Spark plug electrode wires burn off on one side more than on the other because the spark is blown there.



Illust. 23 - Showing How Sparks Jump Between Spark Plug Electrode Wires Which are Burned at an Angle.

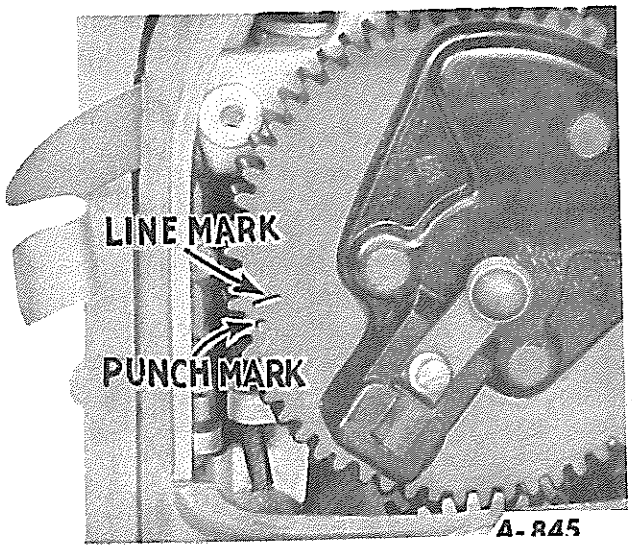
Keep the spark plug gap set close (.020 to .025 inch). In many cases even then the spark is jumping .040 to .060 inch due to turbulence in the combustion chamber. (See Illust. 23.)

If the spark still jumps to the frame cover after reforming the safety gap, three coats of insulating varnish may be applied to the inside of the frame cover, allowing sufficient time for drying between coats. A spaghetti insulator can be slipped over the high tension leadout, or it may be coated with insulating varnish with the exception of the contact point. Another method is to place a thin sheet of bakelite under the roof of the frame cover. The information is being given, however, as an extreme emergency measure for very high altitudes, and it should not be used unless absolutely necessary.

23. DISTRIBUTOR SHAFT AND BEARING

After the distributor gear has been properly meshed with the rotor pinion (Illust. 24), be sure that the teeth have a very slight amount of clearance so that no radial pressure is exerted on the distributor shaft bearing. Use shims under the bearing bracket, if necessary, to provide this clearance.

(Continued on next page)



Illust. 24 - Showing Punch Mark Used for Timing a 35-Degree Spark Range Magneto, and Line Mark Used for Timing Magneto of Reduced Spark Range.

23. DISTRIBUTOR SHAFT AND BEARING – Continued

The distributor shaft end play should not be more than .014 inch or less than .004 inch. Excess end play at this point allows the distributor disc to travel back and forth, causing more or less uneven brush pressure and creating excessive wear on the disc brush track. This end play may be adjusted by placing special shim washers (number 12583 C which are .004 inch thick and number 12589 C which are .008 inch thick) between the retainer spring and the rear thrust washer.

24. DISTRIBUTOR DISC

The distributor disc and brushes should be examined periodically and the disc should be kept clean. The disc can be cleaned with a soft rubber eraser which is free of grit and abrasives and which will not scratch the disc surface. If the disc becomes badly worn, it may be replaced by removing three bakelite screws which hold the disc to the distributor block. When installing the bakelite screws, the heads should be given a light coat of shellac. This will help to prevent them from loosening and it seals them against the possibility of changing shape from the effects of moisture.

When the brushes and the disc are properly related, the brush track will wear very slowly; it will be polished and reasonably smooth. If other than this condition exists, check the gaskets for moisture entrance, or dirt entry, and be sure that proper brushes are used.

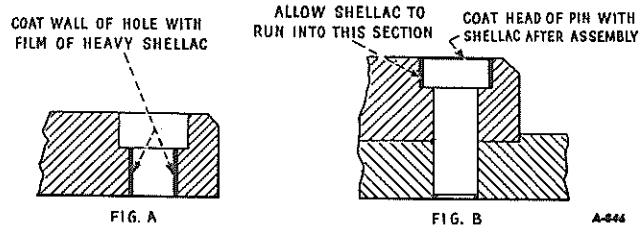
If the magneto has been operating with the proper spark advance in relation to the distributor gear setting, a slightly blackened condition (spark spot) will exist on the insert at the leading end of the brush contact. If the magneto has been operating with the spark not properly advanced, this blackened spot will be at the center of the insert. The longest life of the distributor disc can be secured only by proper timing and the exclusion of all water.

25. DISTRIBUTOR

When installing a distributor, the distributor pin should first be pushed into place in the distributor, before final assembly to the gear. Check the clearance between the body diameter of the pin and the hole in the distributor.

If any excessive amount of clearance exists, the distributor may eventually come loose after assembly, and cause excessive disc and brush wear, and may result in faulty performance of the magneto.

To correct such cases where excessive clearance exists, the following procedure should be used. Coat the hole in the distributor with a film of heavy shellac as shown in Fig. "A," Illust. 25. Allow the shellac to dry thoroughly. Place the distributor on the gear. Coat the pin with shellac and drive it into place through the distributor and into the gear. Be careful not to strike the distributor when doing this, since the distributor may readily be cracked. Then coat the head of the pin with shellac, allowing the shellac to run into the space between the head and the counterbore in the distributor. (See Fig. "B," Illust. 25.) Wipe off any excessive shellac from the face of the distributor. Be absolutely certain that no shellac remains in the brush path. This procedure, if carefully followed, will give an assembly which will remain tight indefinitely.



Illust. 25 - Installing New Distributor Pin.

26. DISTRIBUTOR BRUSHES

These brushes have to be of the proper material to match the disc they are rubbing against. This material has been worked out for each magneto by test.

27. CHARGING THE MAGNET

Always recharge the magnet during an overhaul, as it loses a little of its magnetism gradually.

The magnets can be charged while on or off the magneto. If they are charged while on the magneto, the impulse coupling, rotating unit,

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from the rotor by using puller and adapter (SE-839), shown in Illust. 30. It is necessary to remove the inner bearing race when removing or inserting rotor shims for preloading rotor bearings. (Refer to par. 32.)

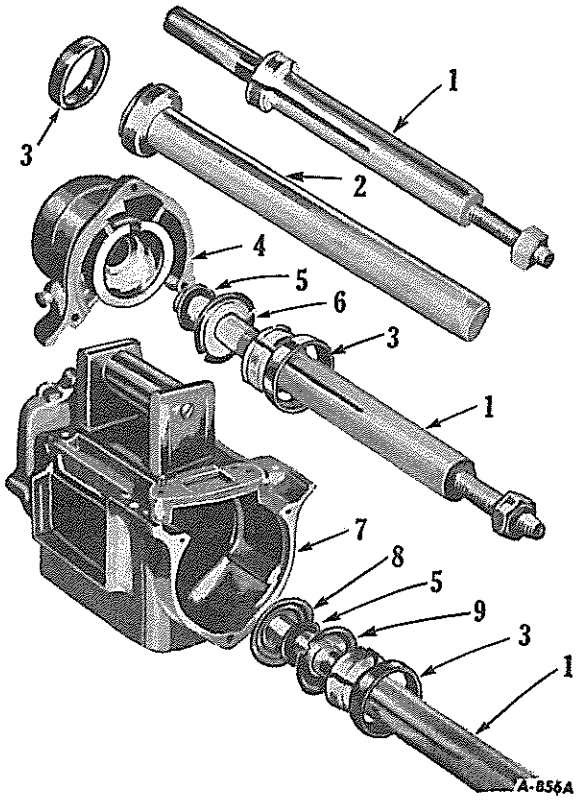
32. PRELOADING ROTOR BEARINGS

In order to maintain the high efficiency of this type of magneto, it is necessary to reduce the air gaps in the magnetic circuit to a minimum. To do this, the rotor clearance is held close. A small amount of end play would allow the rotor to rub due to the construction of the ball bearings. They are made to take a lateral as well as a radial load.

To avoid any possibility of the bearings becoming loose, they are preloaded from .000 to .002 inch lengthwise. To do this, assemble the rotor with just enough shims to set the end play as nothing, or to a point where no perceptible play can be felt and still be free. This is to be tried with the rotor in the frame, and the bearing housing in place, and all the screws in and tight. Keep the bearings free of grease and oil to get an accurate fit. Then remove the bearing housing, bearing inner race, and oil flinger, and add one .002 to .0025 inch shim (Illust. 30). The washer shims should be between the inner race and the gear on the rotor shaft. After this set-up has been completed, be sure that the shaft does not bind and that the preloading was completed with the last placed shim of .002 or .0025 inch. Too much preloading will ruin the bearing. Some relief to these bearings is provided as soon as the magneto starts to warm up on the engine. The aluminum frame expands more rapidly than the steel rotor shafts, and thus relieves the preloading to a large degree.

33. OUTER BEARING RACE REMOVAL AND INSTALLATION

The magneto outer bearing race in both the breaker housing and the magneto frame can be removed readily with tool (SE-1020) as shown in Illust. 31. Loosen the expander and insert the tool into the bearing race in the direction shown. Manipulate the split sleeve flange through the bearing race and hold it against the felt retainer. Now draw up on the expander by applying a wrench to the flats on the threaded end of the expander and turning in counter-clockwise direction until a definite pressure is



Illust. 31 - Tools Used for Removing and Installing Magneto Outer Bearing Races.

1. Magneto bearing race puller tool SE-1020.
2. Installing tool SE-1021.
3. Outer bearing race.
4. Breaker housing.
5. Felt.
6. Felt retainer, breaker housing end.
7. Frame.
8. Outer felt retainer.
9. Inner felt retainer.

felt; then tighten the hexagon nut, and carefully drive the bearing race from place.

Before installing the outer bearing races, be sure the felts and retainers are correctly assembled in place. Set the bearing race on the end of tool (SE-1021). A small amount of clean grease will hold the race on the tool. Carefully line up the tool over the hole and drive the race into place.

34. IMPULSE COUPLING - DESCRIPTION

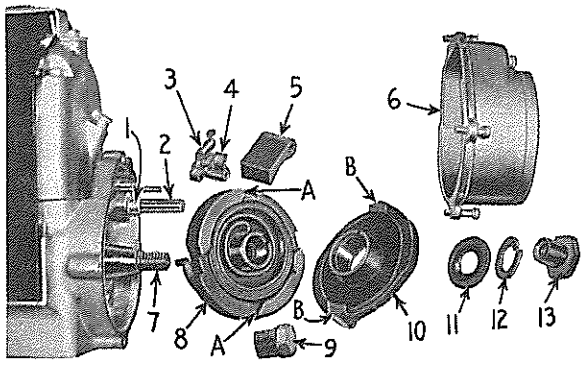
A magneto is capable of delivering suitable sparks at higher speeds but, for slower speeds for starting, it is necessary to drive the rotor

(Continued on next page)

34. IMPULSE COUPLING – DESCRIPTION – Continued

or armature through an impulse coupling. This impulse coupling permits the production of a strong magneto spark at the slowest cranking speeds. The impulse couplings furnished with the magnetos are completely automatic and require no adjustment and no manual engaging or disengaging. An occasional cleaning and generous lubrication with light engine oil is necessary for satisfactory impulse coupling performance.

The cam member (10, Illust. 32) is locked to the magneto drive shaft on the engine and it always rotates steadily at a definite ratio to the engine speed. The magneto member (8), with drive spring and engaging pawls, is keyed to the magneto rotor shaft driving end (7). The cam member and the magneto member are connected by a spiral drive spring, shown in magneto member (8).



Illust. 32 - Exploded View of Impulse Coupling.

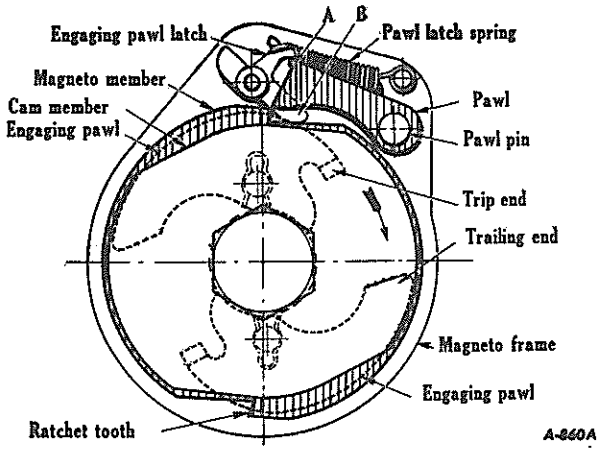
1. Pawl spacer.
2. Pawl pin.
3. Pawl latch spring.
4. Engaging pawl latch.
5. Pawl.
6. Coupling cover.
7. Magneto rotor shaft.
8. Magneto pawls with engaging pawls and drive spring.
9. Impulse coupling puller tool MT-50.
10. Cam member.
11. Washer.
12. Lock washer.
13. Coupling nut.

As the cam member and the magneto member rotate slowly, a pawl (5, Illust. 32) which pivots on a pawl pin (2) mounted to the magneto frame, engages in the upper ratchet slot in the magneto member and prevents the magneto member from turning. The cam member continues to turn and winds up the drive spring for approximately 46 degrees. The pawl is then tripped from the ratchet slot by the cam member (10). The spiral drive spring unwinds, hurling the magneto member unit and rotor rapidly forward until the end of the milled slot "A" in magneto member strikes the lugs "B" on the cam member (Illust. 32). The complete coupling then will rotate at the same speed as a unit until the pawl catches on the following ratchet slot.

There are four equally spaced ratchet slots in the magneto member of the magneto coupling. Tripping of the pawl is timed to cause a spark to occur between the top dead center position and 8 degrees after dead center, providing that the magneto is timed correctly to the engine.

The impulse coupling on the magneto is designed to throw out automatically at 130 to 200 rpm. As the speed of the impulse coupling increases, the cam member disengages the pawl from the ratchet teeth with greater force. When the throw-out speed is reached, the pawl is thrown high enough to catch the latch tip under pawl ledge "A" (Illust. 33).

In this position the pawl is supported out of engagement and the coupling rotates as a single unit, turning the magneto rotor at a steady speed with the engine. When the impulse coupling speed is reduced to between 125 to 145 rpm. on the magneto, the coupling automatically comes into operation again. As the throw-in speed is reached, the trailing ends of the engaging pawls, which are the heavier, drop down on the magneto member hub when passing over the center of rotation. By so doing, the trip ends raise to a position where they will strike the lower arm of the engaging



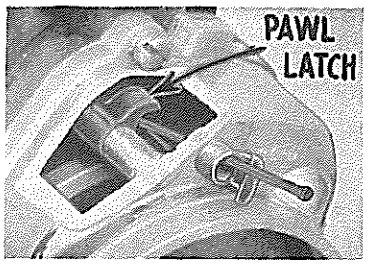
Illust. 33 - End View Drawing of Impulse Coupling.

pawl latch "B" (Illust. 33) releasing the latch from the pawl. The pawl then drops into working position and the impulse coupling is again in operation.

35. IMPULSE COUPLING TIMING

The oil cup has been installed in a position in the impulse coupling housing where it can be used for a double purpose. First, to furnish an opening for lubricating the impulse coupling and, second, to furnish an opening through which the main pawl may be lifted to allow rotation of the magneto without the impulse action during the timing operation. By manipulating a light finishing nail through the oil cup as shown in Illust. 11, the pawl may be lifted free for rotation during timing. By placing the nail in the position shown in Illust. 11 and prying downward on the outer end, the pawl may be lifted and the latch will hold it up. It may be necessary to turn the rotor (or to rotate the magneto) to a point just past the trip of the impulse to accomplish the lifting of the pawl. If the pawl is in the low position and the impulse spring is partly wound up, it will be impossible to move it with the nail.

To return the pawl to the operating position, place the nail in the position as shown in Illust 34 and press down on the outer end of the nail to lift the latch.



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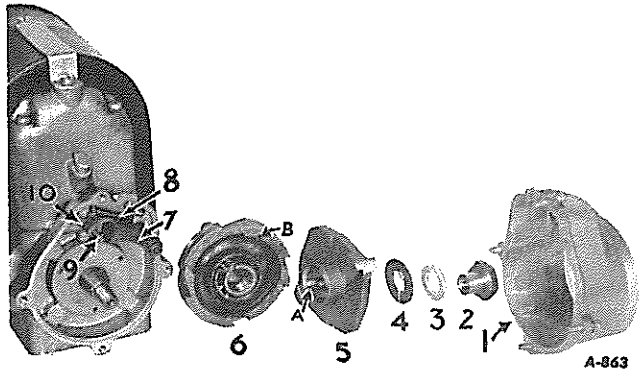
Illust. 34 - View Showing How the Latch is Tripped, Allowing the Pawl to Drop Into the Operating Position.

36. SERVICING IMPULSE COUPLING

To remove the coupling member (6, Illust. 35) start puller tool (MT-50) in the threads (9, Illust. 32), then lock the member with pawl (7, Illust. 35) and screw the puller until a considerable effort is required to turn it. If the impulse has been allowed to stand or operate without sufficient oil, the coupling member (6) may be rusted and stuck on the shaft. It may



Illust. 35 - Impulse Coupling Disassembled From the Magneto.

1. Cover.
2. Nut.
3. Lock washer.
4. Washer.
5. Cam member.
6. Coupling member.
7. Pawl.
8. Latch spring.
9. Pawl spacer.
10. Pawl pin.

be necessary to use two screwdrivers, one on each side between the coupling and the magneto frame, and to hit the puller tool (MT-50) a rather hard blow, at the same time exerting pressure on the screwdrivers. Care must be used, when this condition exists, to remove the member without damaging the threads or the magneto frame.

To separate the cam member from the magneto member, pull outward until the lugs clear; let it unwind about 1/2 turn, and then remove it. The drive spring can be pried out easily with a screwdriver. When installing the spring, first hook it into position at "B" (Illust. 35), being sure it will wind in the counterclockwise direction shown. Wind the spring into position, using the right hand to push it down gradually and the left hand to hold the wound coils in place.

When assembling the coupling, be sure that the hub of magneto coupling member (6) is clean and well oiled and, if the latch spring (8) is rusty, replace it with a new one. The couplings must be oiled generously with light engine oil at regular intervals. When the weather is extremely cold, kerosene should be used.

Snap rings are used to hold the pawls in place. They must be tight on the pawl pins when in place or they will wear and fall off, causing damage to the magneto frame.

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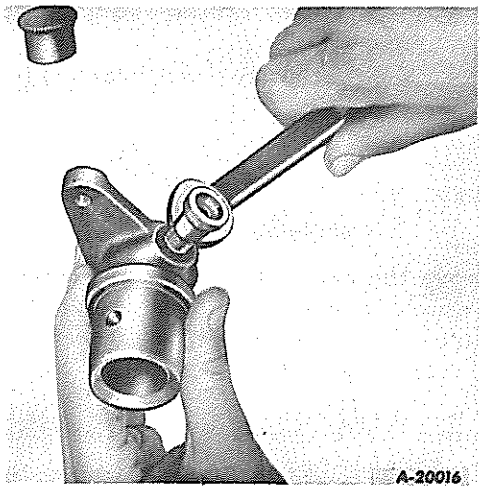
1. DESCRIPTION

Mounting Bracket



Illust. 1 - Removing Grease Cup from the Distributor Mounting Bracket (Delco-Remy Model No. 1110152).

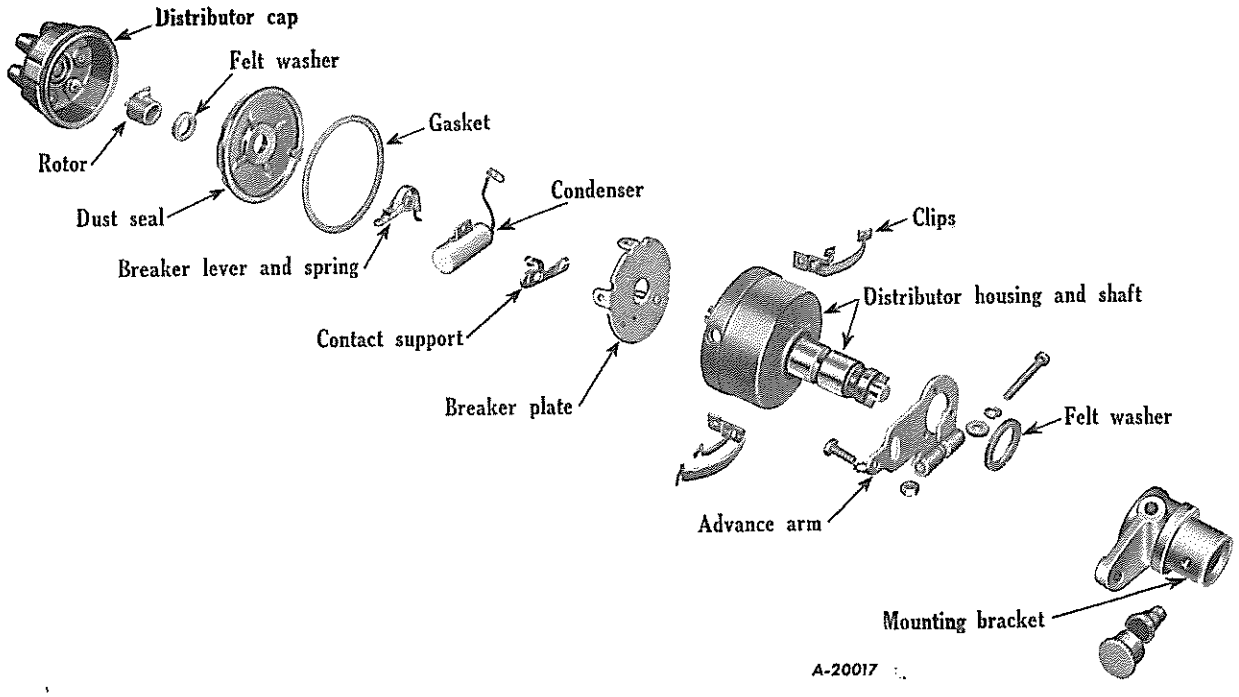
The distributor mounting bracket is located in a bore in the crankcase. It provides a seat for the distributor. The bottom surface of the mounting bracket is beveled and, with the similar surface of the oil pump drive pinion, provides an oil flinger to prevent engine oil from entering the distributor. Some mounting brackets have two "O" rings incorporated. The mounting bracket is held in position in the crankcase by a set screw with lock nut, engaging through the crankcase into a groove in the mounting bracket (Illust. 5).

On the Delco-Remy Model No. 1110152, a grease cup on the side of the mounting bracket supplies lubrication to the distributor shaft (Illust. 1). On the IH Model K, a grease filler plug on the side of the distributor housing supplies lubrication to the distributor shaft (Illust. 15).

Distributor

The distributor has three main functions. First, it opens and closes the low voltage circuit between the source of voltage and the ignition coil so that the primary winding (Illust. 3) is supplied with intermittent surges of current. Each surge of current builds up a magnetic field in the coil. The magnetic field is collapsed by opening the low voltage surge in the secondary winding of the ignition coil (Illust. 3).

(Continued on next page)



Illust. 2 - Exploded View of Distributor (Delco-Remy Model No. 1110152).

1. DESCRIPTION – Continued

The second function is to time these surges to the requirements of the engine.

The third function is to direct the high voltage surge through the rotor, cap and high tension wiring to the proper spark plug.

On distributors of IH Manufacture, there are two letters and a number stamped on the housing (Illust. 11). The first letter designates the model, the second letter designated the month of manufacture, and the number designates the year built.

2. REMOVAL

Delco-Remy Model No. 1110152 and IH Model K

1. Remove the distributor cap by springing the clips (Illust. 8).

2. Disconnect the primary (coil to distributor) cable from the distributor housing (Illust. 4).

3. Loosen the distributor bracket set screw lock nut and remove the set screw (Illust. 5).

4. Lift out the distributor and bracket (Illust. 5).

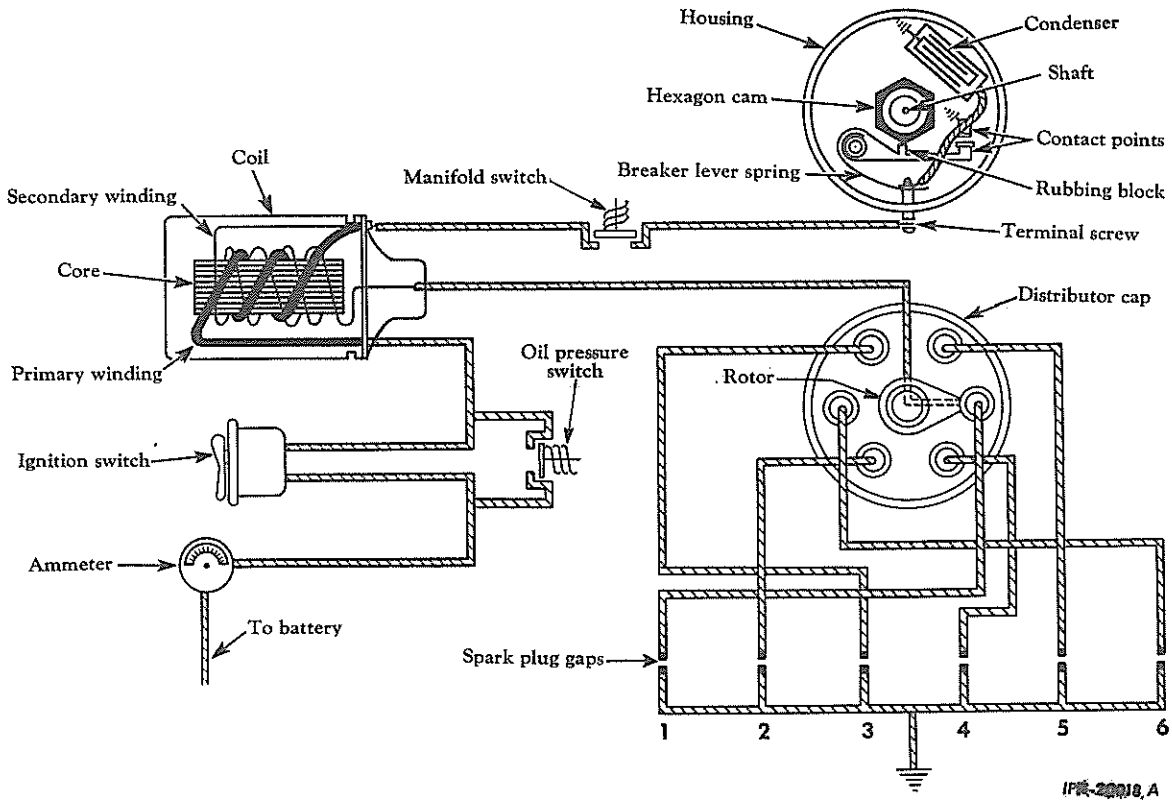
3. DISASSEMBLY

Delco-Remy Model No. 1110152

1. Remove the cap screw, lock washer and spacer which secure the mounting bracket to the advance arm, and slide the mounting bracket from the shaft (Illust. 6).

2. Remove the felt washer from the end of the mounting bracket bore.

3. Remove the fillister head lock screw which secures the advance arm, and remove



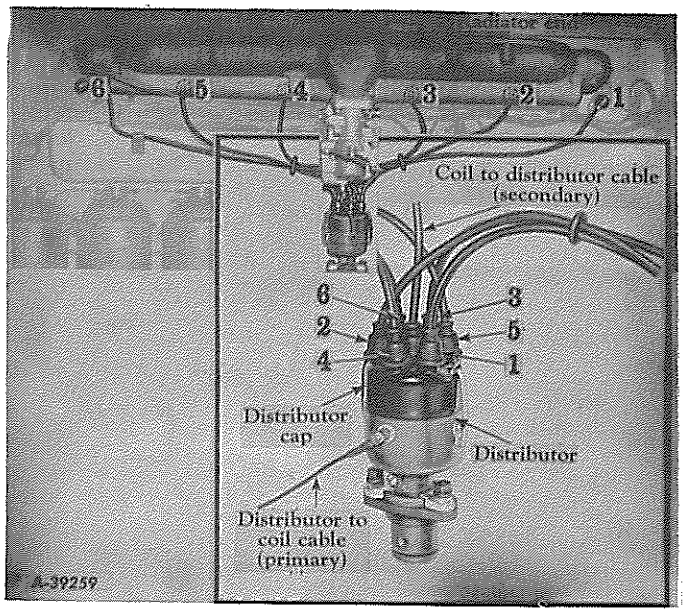
Illust. 3 - Diagrammatic View of Ignition System Using High Tension Distributor.

the arm from the shaft (Illust. 7).

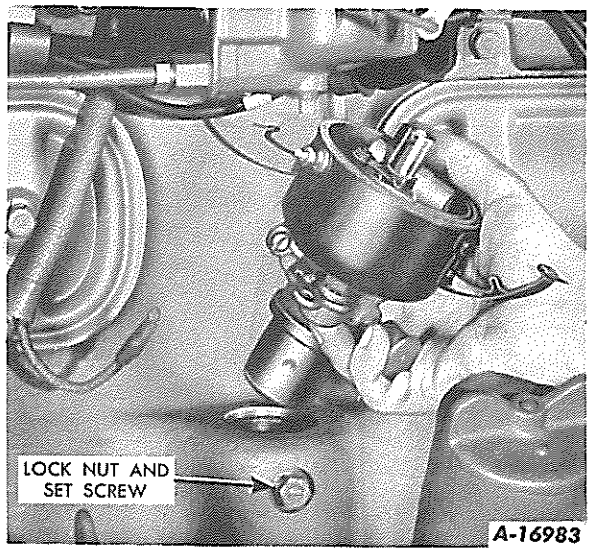
4. Unsnap the two outer spring clips which secure the distributor cap to the housing, and remove the cap (Illust. 8).

5. Remove the rotor.

6. Unsnap the two inner spring clips which secure the dust seal to the housing, and remove the dust seal with the felt washer (Illust. 9).



Illust. 4 - Cables From Distributor to Spark Plugs - Firing Order is 1, 5, 3, 6, 2,4.



Illust. 5 - Removing Distributor and Mounting Bracket (Delco-Remy Model No. 1110152).

7. Remove the dust seal gasket which is located on the upper rim of the distributor housing.

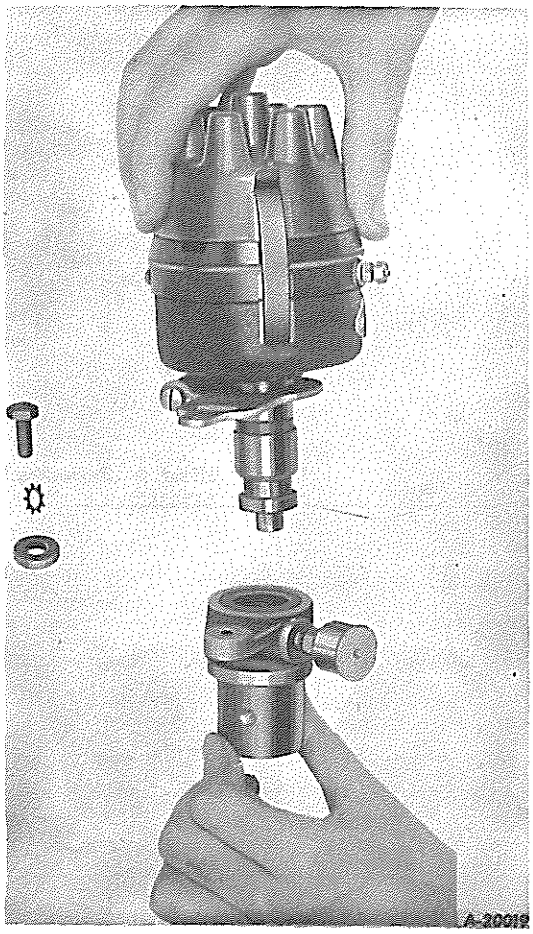
8. Remove the breaker lever by lifting it from the projecting stud rising from the breaker plate (Illust. 10).

9. Remove the nuts, lock washers and spacers from the terminal screw on the outside of the housing (Illust. 10).

10. Remove the nut, lock washer and spacer which secure the condenser cable to the terminal screw. Remove the condenser cable from the terminal screw (Illust. 10).

11. Remove the terminal screw and the insulating block mounted on it. Observe the position of the insulation block on the terminal

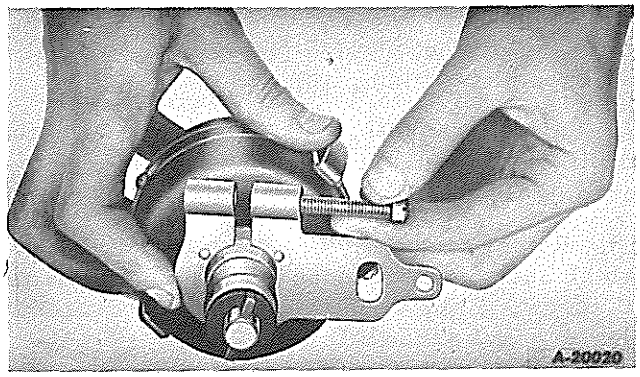
(Continued on next page)



Illust. 6 - Removing Mounting Bracket from Shaft (Delco-Remy Model No. 1110152).

3. DISASSEMBLY – Continued

Delco-Remy Model No. 1110152 - Continued



Illust. 7 - Removing Advance Arm Lock Screw (Delco-Remy Model No. 1110152).

screw in respect to the recess in the bore of the housing on the inside, through which the terminal screw passes (Illust. 22).

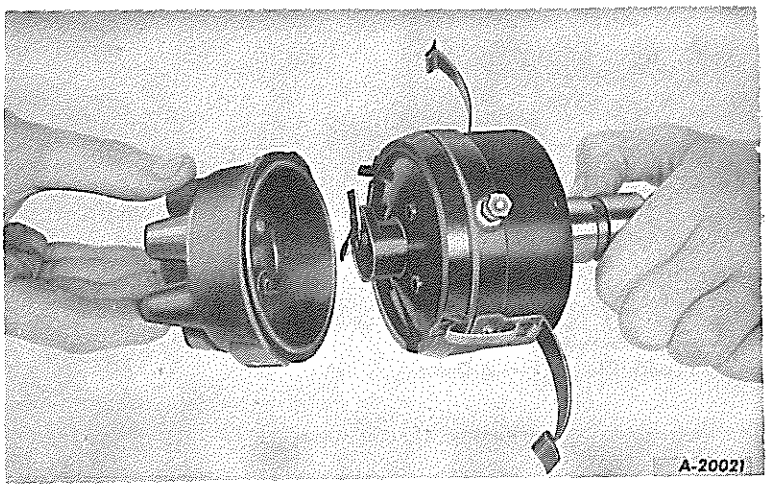
12. Remove the three screws and lock washers from the upper outer face of the housing. Remove the breaker plate.

13. Remove the condenser from the breaker plate.

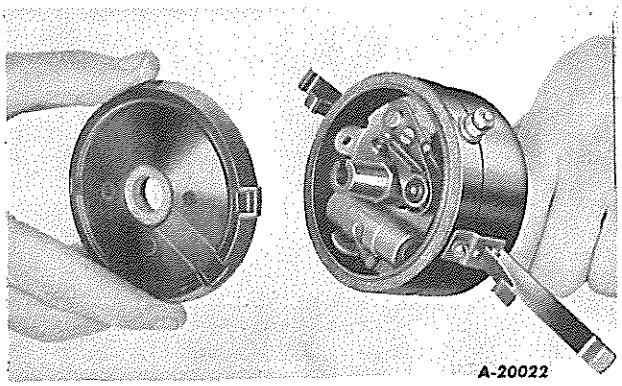
14. Remove the contact support from the breaker plate (Illust. 23).

IH Model K

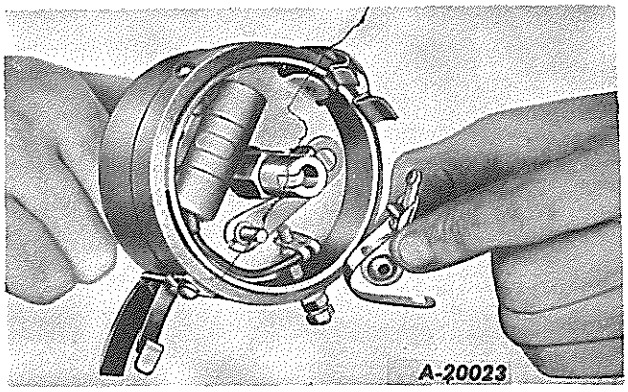
1. Remove the two slotted screws and mounting clamps from the bracket.



Illust. 8 - Removing Distributor Cap (Delco-Remy Model No. 1110152).



Illust. 9 - Removing Dust Seal (Delco-Remy Model No. 1110152).



Illust. 10 - Removing Breaker Lever (Delco-Remy Model No. 1110152).

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2. Remove the mounting bracket from the base of the housing.

3. Remove the distributor rotor (Illust. 13).

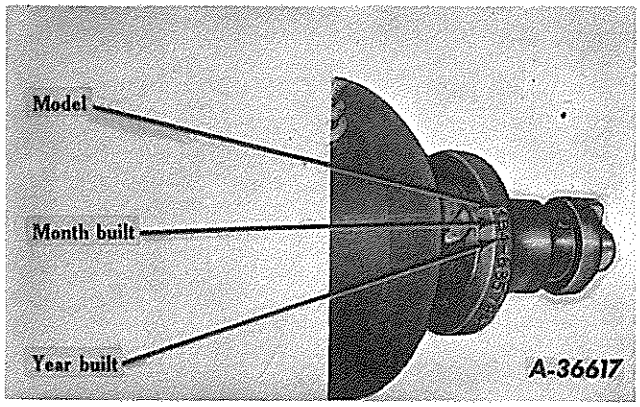
CAUTION: The distributor rotor is made of bakelite and will crack or break if not handled carefully.

4. Remove the housing cover and felt seal (Illust. 12). It will help to turn the cover when removing.

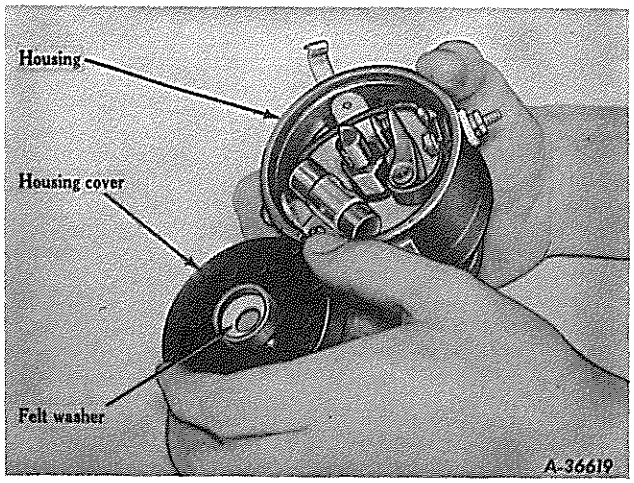
5. Remove the slotted screw from the condenser clamp.

6. Loosen the primary terminal screw nut (the nut inside the housing).

7. Remove the condenser (Illust. 14).



Illust. 11 - Model and Date of Manufacture (IH Model K Shown).



Illust. 12 - Removing Distributor Housing Cover and Felt Washer (IH Model K Shown).

8. Remove the breaker lever spring from the terminal screw and, at the same time, lift off the lever from the pivot (Illust. 16). Remove the stationary point.

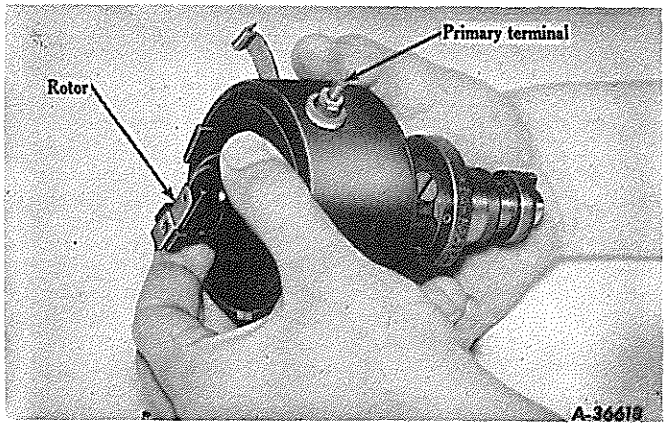
9. Remove the terminal screw nuts, lock washer, and brass washers.

10. Remove the terminal screw (Illust. 17).

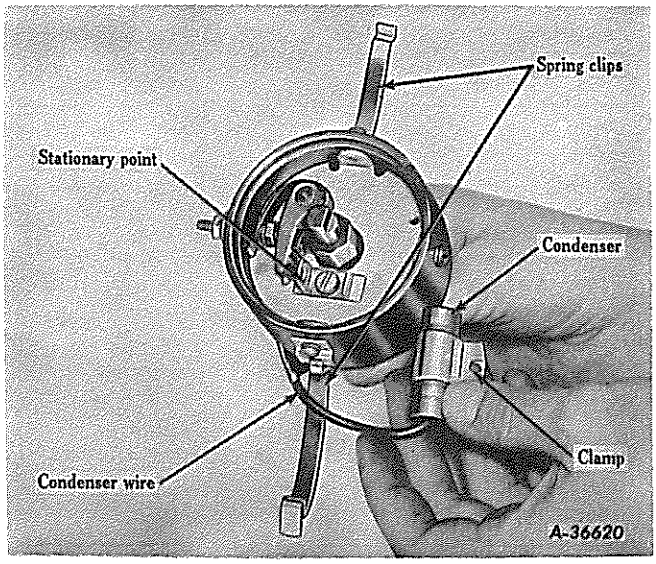
11. Remove the two terminal insulators (Illust. 17).

12. Remove the two spring clips by removing the slotted screws that secure them to the housing.

(Continued on next page)



Illust. 13 - Removing Distributor Rotor (IH Model K Shown).



Illust. 14 - Removing Condenser (IH Model K Shown).

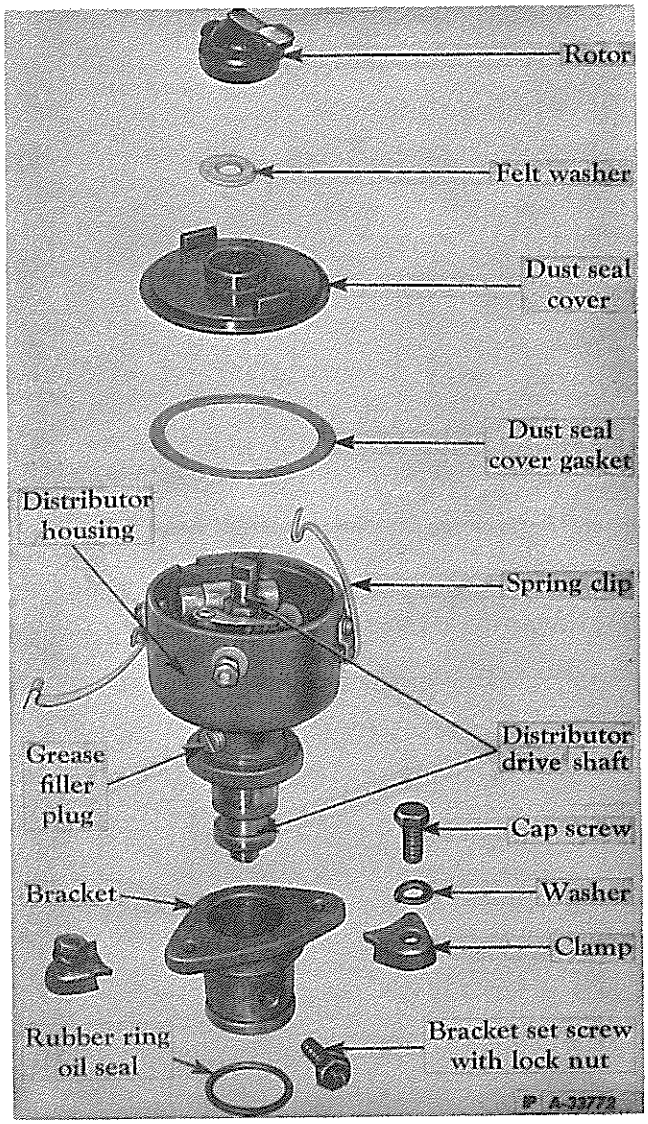
3. DISASSEMBLY – Continued

IH Model K - Continued

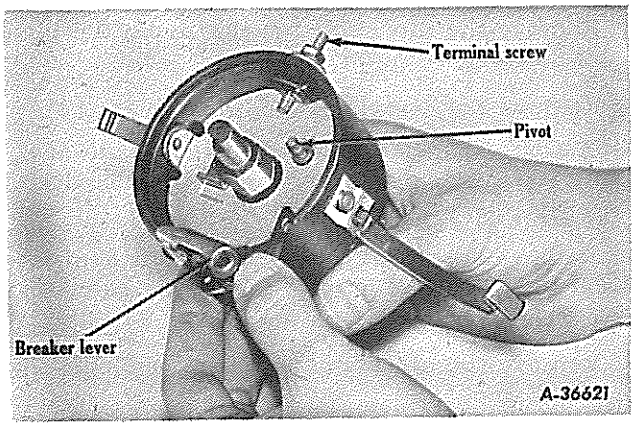
13. Remove the slotted screw from the housing (the screw opposite the terminal screw opening).

14. Lift the breaker plate from the housing (Illust. 18).

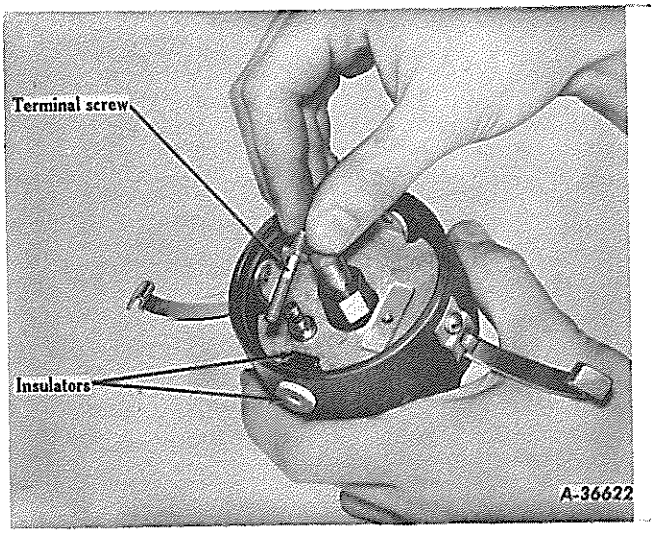
15. Remove the pin that secures the coupling to the shaft and remove the coupling (Illust. 19). Place a mark on the shaft and the coupling to assist obtaining the correct position in reassembly.



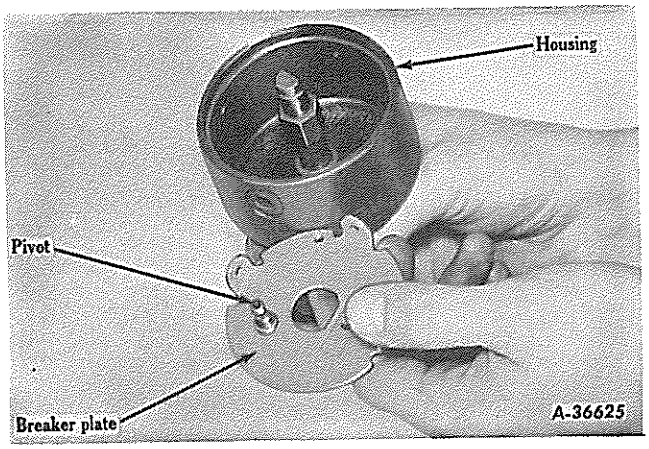
Illust. 15 - Partially Exploded View of Distributor (IH Model K Shown).



Illust. 16 - Removing Breaker Lever (IH Model K Shown).



Illust. 17 - Removing Primary Terminal Screw (IH Model K Shown).



Illust. 18 - Removing Breaker Plate (IH Model K Shown).

16. Remove the shaft from the housing, using a twisting motion (Illust. 20).

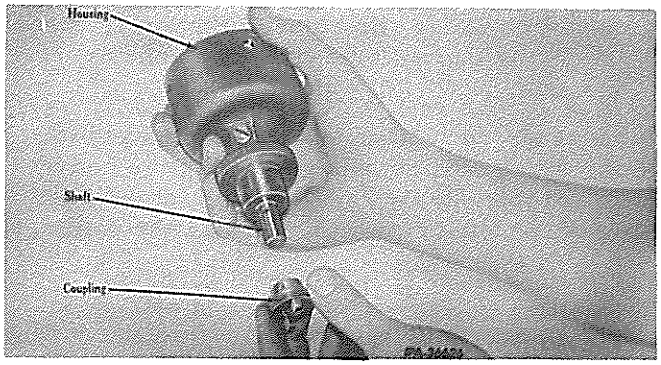
17. Remove the "O" ring from the retainer at the base of the housing (Illust. 21).

18. The retainer does not have to be removed unless it is badly worn or scored.

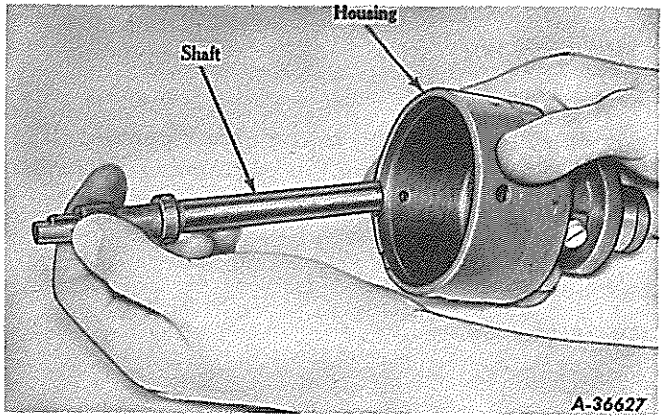
4. INSPECTION AND REPAIR

The distributor cap, rotor, insulating washers and bushings should be wiped thoroughly with a soft clean dry cloth; other parts should be cleaned with a cloth dampened with carbon tetrachloride or similar dry-cleaning solvent.

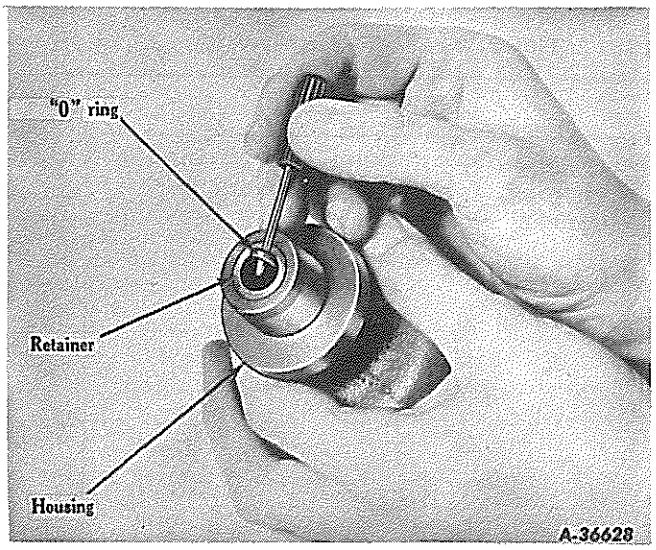
CAUTION: Do not immerse distributor in a degreasing tank; to do so will ruin electrical parts.



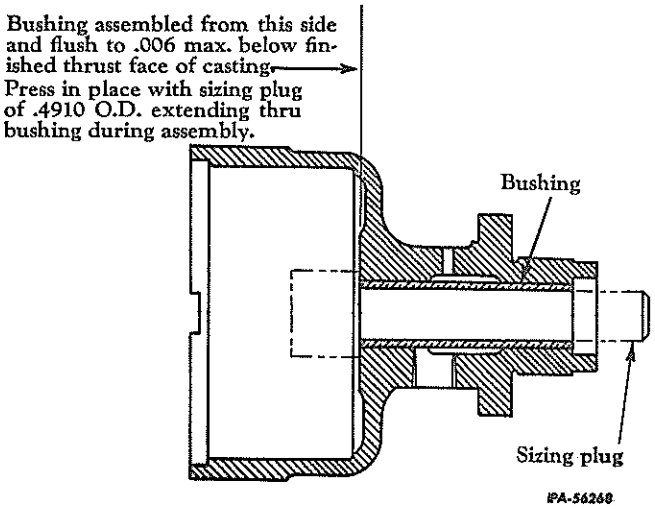
Illust. 19 - Removing IH Model K Drive Coupling.



Illust. 20 - Removing IH Model K Drive Shaft.



Illust. 21 - Removing Drive Shaft "O" Ring.



Illust. 22 - Distributor Shaft Bushing Installation.

INSPECTION	REMEDY
1. Inspect distributor cap, rotor and insulating washers for cracks, chips or burned surfaces.	1. Such damage can cause a leakage of high voltage to ground. Replace as necessary.
2. Inspect distributor shaft bushing for excessive wear, damage or looseness.	2. Replace. (See Illust. 22.)

(Continued on next page)

4. INSPECTION AND REPAIR – Continued

INSPECTION	REMEDY
3. Inspect contact points for pitting and burning, for oil and dirt, and for correct gap setting.	3. Clean points with a few strokes of a fine file, or contact stone. Replace parts as necessary. Gap setting should be .020 inch (Illust. 25). NOTE: It is not necessary to file contact points until all traces of pitting or burning have been removed. File only until the high spots have disappeared. Contact surfaces after usage may appear dull, but this does not indicate faulty contact. Never use emery cloth to clean contact points. Emery may imbed in the point surface and cause rapid burning and pitting.
4. Inspect for oxidized contact points.	4. Replace as necessary. This condition is usually caused by high resistance due to loose connections in the contact surfaces, or, most commonly, excessive high voltage caused by bad connections or broken strands.
5. Inspect condenser for secure connections.	5. Be sure that the condenser cable is not frayed or corroded, with broken strands or defective connections. Broken strands will cause high resistance in the condenser circuit, burning the points.
6. Inspect condenser sealing for cracks.	6. Replace as necessary. Openings in condenser sealing may admit water or oil and cause a short in the condenser.
7. Inspect condenser insulation for breakdown.	7. Replace as necessary. Such breakdown will cause a short in the condenser.
8. Inspect rubbing block for excessive wear.	8. Replace as necessary.
9. Check breaker lever spring for correct tension.	9. Weak tension on the spring may permit contacts to bounce and chatter, causing heavy burning and arcing of the points.
10. Inspect ignition coil for secure terminals.	10. Tighten terminal connections.
11. Inspect ignition coil for cracks and burns, or dents and punctures, in coil insulation and containers.	11. Replace as necessary.

5. REASSEMBLY

Delco-Remy Model No. 1110152

1. Place the contact support on the breaker plate projection and secure with the cap screw.

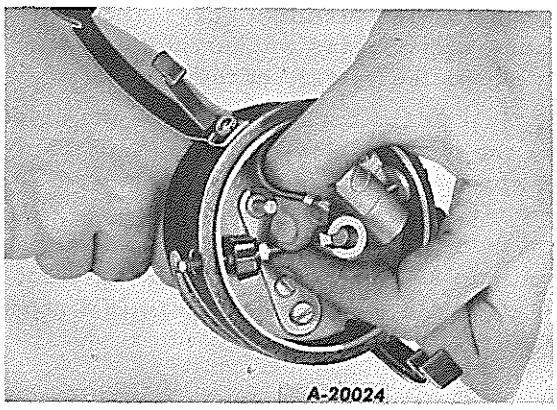
2. Secure the condenser to the breaker plate with cap screw and lock washer.

3. Insert the breaker plate, with the contact support and condenser attached, into position in the housing, aligning the three holes in the housing with the mounting holes in the breaker plate. This alignment can be obtained in only one position.

NOTE: It is advisable to hold the housing with the base upward when positioning the breaker plate as the latter tends to drop and jam too deeply into the housing when inserted from above (Illust. 26).

4. Secure the two sets of spring clips to the outside of the housing with the two spring clip screws and lock washers. These screws also serve, with a third screw and lock washer, to secure the breaker plate in the housing. Insert the third screw with lock washer into the hole in the housing, located near the condenser, and tighten all three securely.

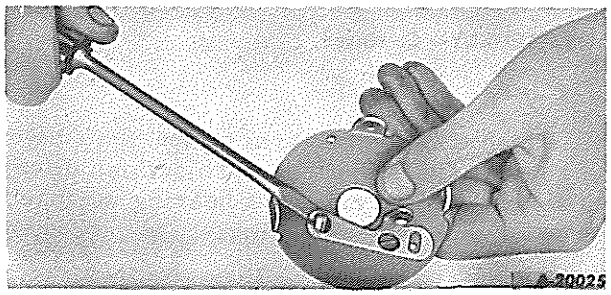
5. Place the insulating block on the terminal screw, being sure that the specially shaped recess in the end of the block is locked on the terminal screw. Insert the terminal screw into the bore in the housing, from inside the housing. Place two insulating spacers into the bore from outside the housing and on the terminal screw. Add the insulating washer, the flat steel washer, lock washer and the outside terminal nut (Illust. 23).



Illust. 23 - Removing Terminal Screw (Delco-Remy Model No. 1110152).

6. Place the condenser cable on the inside portion of the terminal screw, with two washers and the inside terminal nut. Do not tighten the nut.

7. Place the breaker lever on the projecting stud on the breaker plate, and insert the spring end on the terminal screw between the two washers mentioned in the preceding paragraph. Tighten the nut securely.



Illust. 24 - Removing Contact Support (Delco-Remy Model No. 1110152).

8. Place the dust seal gasket in position around the outer rim of the housing.

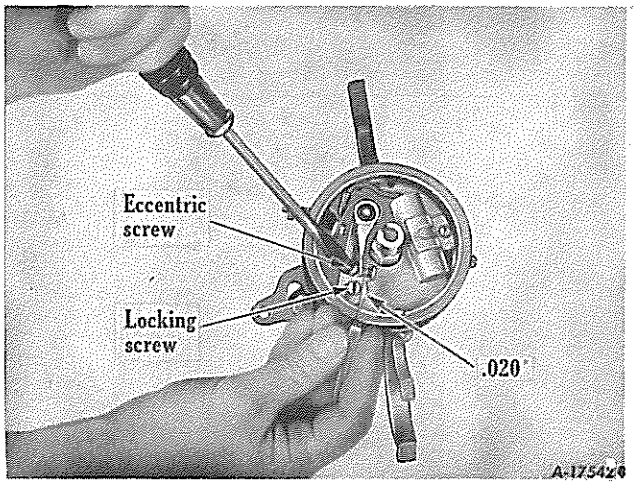
9. Insert the smaller felt washer in the dust seal bore and install the dust seal. The dust seal can be placed in position only when a lug on its under side coincides with a recess in the rim of the housing.

10. Snap on the smaller pair of spring clips to retain the dust seal in position.

11. Place the rotor in position on the shaft, being sure that the lug on its inside bore coincides with the recess in the shaft head.

12. Assemble the distributor cap, being sure that the lug on its under side coincides with a recess in the top edge of the dust seal.

13. Snap on the cap spring clips to secure the cap in position.



Illust. 25 - Adjusting Contact Points (Delco-Remy Model No. 1110152).

(Continued on next page)

5. REASSEMBLY – Continued

14. Place the advance arm on the shaft below the housing, with the three projections upward. These projections ride on a bearing surface on the under side of the housing.

15. Insert the fillister head lock screw through the holes in the advance arm, place the lock washer and nut on its end, but do not tighten.

16. Insert the felt washer into the recess in the head of the mounting bracket bore.

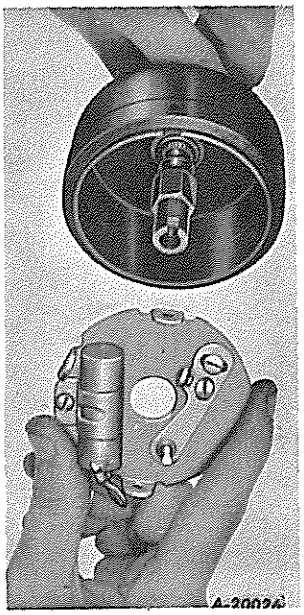
IH Model K

1. If the sealing ring retainer was removed, press in a new one so that it is snug against the shoulder in the base of the housing.

2. Install a sealing ring in the retainer and coat the exposed surface with IH magneto grease.

3. Place a thrust washer (in good condition) in the housing, over the bushing.

4. Install the drive shaft through the thrust washer and bushing (Illust. 20) using a twisting motion.



Illust. 26 - Inserting Breaker Plate (Delco-Remy Model No. 1110152).

5. Install a second thrust washer on the coupling end of the shaft.

6. Install the coupling on the shaft aligning the marks made in disassembly (Illust 19) and place a new pin through the coupling and shaft.

NOTE: Do not peen the pin.

7. Check the end play of the shaft between the coupling and the lower thrust washer. This end play should be .003 to .009 inch.

8. Upset the end of the pin so that it fills the entire hole after the correct end play has been obtained.

9. Install the breaker plate so that the threaded holes are facing upward (Illust. 18).

10. Install the spring clips and three slotted screws.

11. Install the two terminal screw insulators (Illust. 17).

12. Install the terminal screw (Illust 17) and secure with a brass washer, lock washer and a hex nut on the outside of the housing.

13. Install the breaker lever on the pivot so that the rubbing block is against the cam and the spring is on the terminal screw.

14. Install the stationary point and adjust the point gap so that, when the rubbing block is on the high point of the cam, there is a gap of .020 inch.

15. Place the brass washer and lock washer on the terminal screw. Start the hex nut but do not tighten it.

16. Place the condenser on the breaker plate (Illust. 14) and secure with a slotted screw.

17. Connect the condenser wire to the terminal screw so that it is under the brass washer. Tighten the terminal screw hex nut.

18. Install the housing cover and felt washer in the housing (Illust. 12).

19. Install the rotor on the shaft (Illust. 13).

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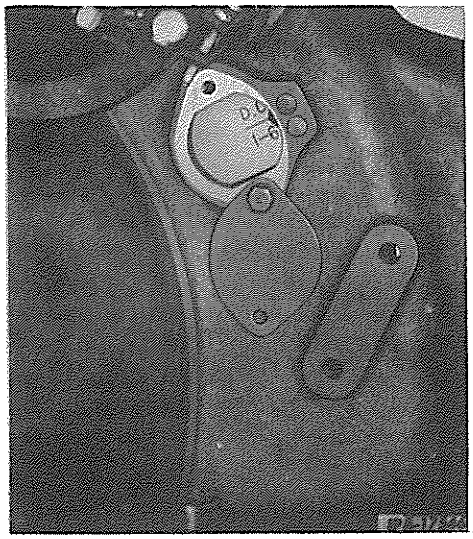
20. Install a new "O" ring in the mounting bracket.

21. Install a new "O" ring in the groove at the base of the mounting bracket.

6. INSTALLATION

Delco-Remy Model No. 1110152 and IH Model K

1. Insert the distributor mounting bracket into the bore in the crankcase with the drilled indentation in the bracket aligned with the set screw hole in the crankcase.



Illust. 27 - "DC/1-6" Mark on Flywheel.

2. Screw in the mounting bracket set screw and tighten the lock nut.

3. Place the distributor into the mounting bracket and rotate the distributor shaft until the offset lug on the end surface of the distributor coupling coincides with the offset slot in the top surface of the oil pump drive. This will allow the distributor to drop into and seat completely in the mounting bracket.

4. IH MODEL K ONLY: Install the mounting bracket clamps and secure lightly with two slotted screws.

DELCO-REMY MODEL NO. 1110152 ONLY: Secure the advance arm to the mounting bracket by inserting the cap screw, lock washer and spacer. Lightly fasten the advance arm to the distributor by tightening the fillister head lock screw in the advance arm.

5. Position and time the distributor to the engine as described in par. 8.

7. TESTING THE DISTRIBUTOR

Detailed instructions for performing tests can be found in the service literature furnished with a manufacturer's test equipment.

8. TIMING THE DISTRIBUTOR TO THE ENGINE

The timing operation must be performed while the engine is on the gasoline cycle.

1. Set the compression release lever in the gasoline (starting) position.

2. Before attempting ignition timing, see that the gap between distributor contact points is .020 inch. Points must be clean, free from pits and seating squarely on each other.

3. Turn over the engine until No. 1 piston (at radiator end) is at the top dead center of the compression stroke. The compression stroke can be determined by removing the No. 1 spark plug, placing your thumb over the opening and cranking the engine until an outward pressure is felt. Continue cranking the engine slowly until the "DC" mark on the flywheel is in line with the pointer (Illust. 27).

4. With the distributor cap and dust seal cover removed, put the rotor in place temporarily.

5. Rotate the distributor in the distributor bracket so that the spring clips approximately parallel the center line of the engine and the primary terminal post points away from the engine. The rotor arm should point toward the No. 1 cylinder spark plug cable terminal in the distributor cap.

(Continued on next page)

8. TIMING THE DISTRIBUTOR TO THE ENGINE - Continued

6. Fasten the distributor hold down clamp, washers and cap screws. Tighten the cap screws just enough to prevent distributor from turning freely.

7. The distributor is now in firing position for the No. 1 cylinder and the No. 1 spark plug cable is to be inserted into the distributor cap terminal hole directly above the rotor arm. Also the distributor, when correctly mounted, will allow the three vent holes in the distributor cap to face away from the fan blast to insure proper ventilation of the cap. These vent holes must be kept clear at all times.

8. The cylinder firing order is 1-5-3-6-2-4 and the spark plug cables must be inserted consecutively in counterclockwise rotation into the distributor cap in this firing order. At the same time, insert the coil-to-distributor cable (secondary) into the center terminal hole of the distributor cap.

9. Remove the rotor to replace the dust seal cover and gasket, then replace rotor, put on the distributor cap, and connect the coil to distributor cable (primary) to the terminal post on the side of the distributor housing.

10. To recheck the timing, pull out the ignition switch button and slowly crank the engine until the No. 1 piston is again coming up on the compression stroke. Hold the plug end of the No. 1 spark plug cable 1/4 inch from the cylinder head and continue cranking the engine very slowly until a spark occurs. At this point, the "DC" mark on the flywheel should be in line with the pointer. If the "DC" mark on the flywheel is below the pointer, turn the distributor clockwise to retard the spark. If the "DC" mark is above the pointer, turn the distributor counterclockwise to advance the spark.

11. Pull out the ignition switch button and start the engine. Should the engine fail to start, the timing probably is not exact enough for easy starting, that is, providing the spark plug cables are correctly located in the distributor cap. Check the cable. Loosen the distributor clamp screws just enough so that the distributor can be slightly turned left or right until the engine starts.

CAUTION: Do not operate the cranking motor more than 30 seconds at a time. Allow two or three minutes for the cranking motor to cool before repeating the starting operation.

12. Final timing adjustment may be made with the engine operating on the gasoline cycle, after a short warm-up period. Loosen distributor clamp screws and turn the distributor left or right until best performance is obtained. Rotating the distributor to the left (counterclockwise) advances the spark, to the right (clockwise) will retard the spark. Be sure to tighten the clamp screws after adjustment has been made.

9. TIMING THE DISTRIBUTOR WHEN REPLACING THE OIL PUMP

If the oil pump assembly has been removed from the engine, it will also be necessary to remove the ignition distributor before installing the pump. Then, turn the engine to the top dead center of the compression stroke of cylinder No. 1 and assemble the oil pump in the engine so the distributor drive slots are approximately parallel with the crankshaft and with the offset toward the engine. Assemble the distributor on the engine and retime the ignition.

NOTE: The distributor should be timed properly when the spring clips are approximately parallel to the center line of the engine. However, the distributor may be rotated slightly either way for exact timing. Then, secure the distributor by tightening the bracket clamp screws. When the distributor cap is in place, the metal strip on the rotor arm should be directly under the terminal to which the No. 1 spark plug cable is attached.

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1. DESCRIPTION

The cranking motor is flange-mounted to the flywheel housing, and the armature revolves in a clockwise direction when viewed from the flywheel end. The cranking motor is equipped with either a Bendix or Dyer drive.

The drive provides engagement of the drive pinion with the flywheel ring gear. As soon as the engine starts, the pinion is automatically demeshed by the reversal of torque.

Cranking Motor With Extended Shaft (241 Series)

The armature shaft extends from the front end of the cranking motor. It provides a manual method of gradually turning over the engine during servicing and maintenance periods for timing purposes, etc. (Illust. 1.)

CAUTION: Before attempting to turn over the engine, disconnect and tape the end of "battery to cranking motor cable," also remove the "cranking motor to solenoid cable" from the same terminal. This is to protect the cranking motor and to keep the starting solenoid switch inactive when pushing in the shift lever. To turn over the engine, engage the cranking motor pinion gear with the flywheel ring gear by hand (push in the shift lever toward the solenoid). Then rotate the armature shaft by turning the wrench handle toward the engine.

NOTE: The gears will remain in mesh until released by backing off wrench handle.

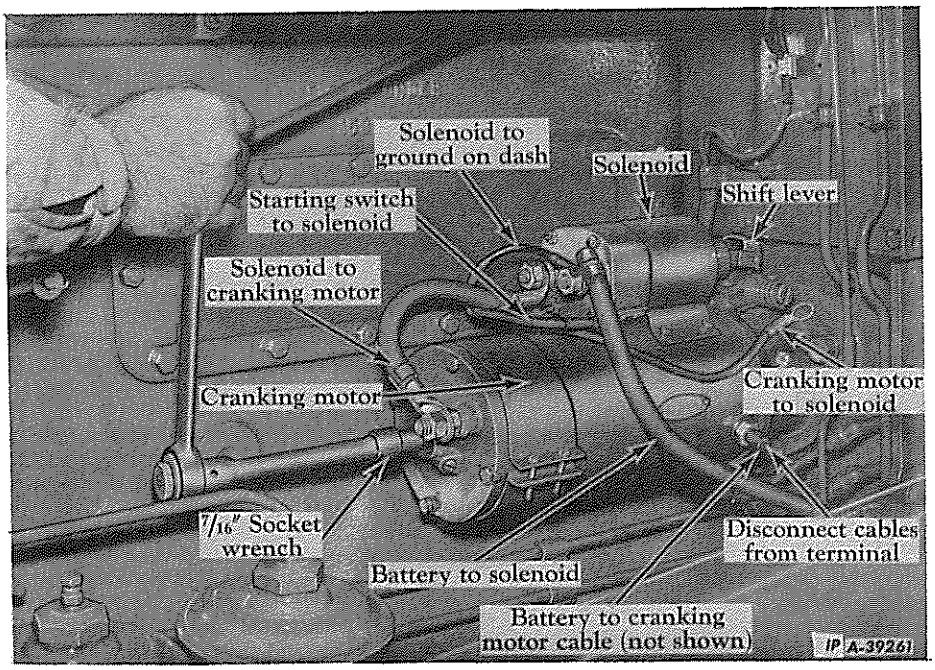
2. MINOR REPAIRS AND ADJUSTMENTS

At periodic intervals, the cranking motor should be inspected to determine its condition, as outlined below. These inspections can be made with the cranking motor mounted. However, they should also be made when the cranking motor is removed and disassembled for any service or repair.

1. Inspect the terminals, external connections, wiring and mounting.

2. Remove the cover band so that the commutator, brushes and internal connections can be inspected.

(Continued on next page)



Illust. 1 - Cranking Motor, Solenoid and Cables.

2. MINOR REPAIRS AND ADJUSTMENTS – Continued

3. If the commutator is glazed or dirty, it may be cleaned with a strip of No. 00 sandpaper. Never use emery cloth to clean the commutator.

Hold the sand paper against the commutator with a wood stick while the cranking motor is in operation, moving it back and forth across the commutator. Gum and dirt will be sanded off in a few seconds. Blow all dust from the cranking motor after the commutator has been cleaned. A brush seating stone can also be used to clean the commutator.

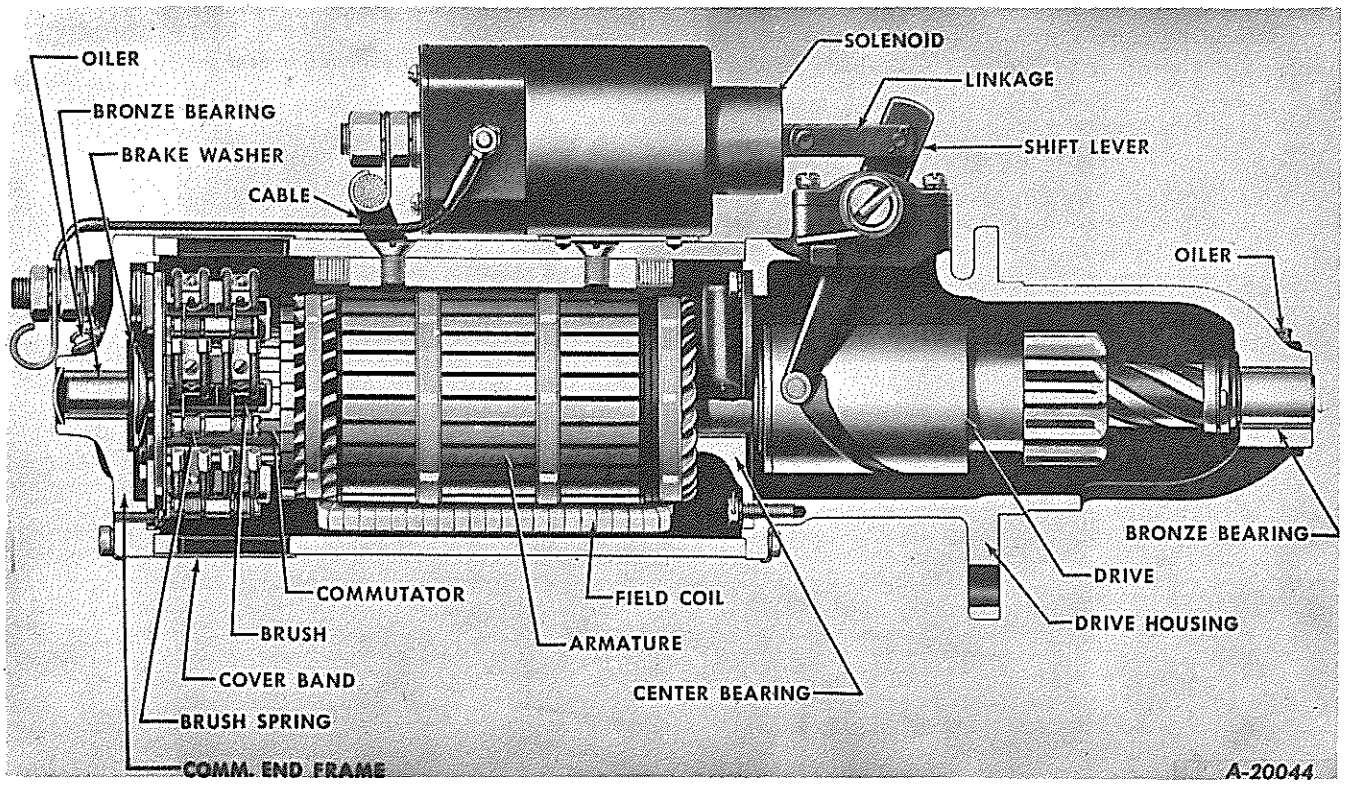
NOTE: Never operate a cranking motor for periods longer than 30 seconds. Allow at least two minutes between crankings for the cranking motor to cool.

4. If brush length is less than 1/2 inch or if the brush leads have broken strands or are otherwise damaged, the brushes should be replaced.

New brushes should be seated with a brush seating stone to make sure that they are in good contact with the commutator. Blow all dust from the cranking motor after the brushes are seated.

5. Check the brush spring tension with a spring gauge hooked on the brush arm or brush attaching screws. For correct tension see "Specifications," section 1. It is important that the tension is correct since excessive tension will cause rapid brush and commutator wear while low tension causes arcing and burning of the brushes and commutator. Correct the tension by bending the brush spring as required. If the brush spring shows evidence of over-heating (blued or burned), do not attempt to readjust it but install a new spring. Overheating will cause a spring to lose its temper.

If the cranking motor still fails to function properly, it will have to be removed from the engine and tested with special testing equipment.



Illust. 2 - Cranking Motor With Dyer Drive and Solenoid Operated Shift Lever.

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3. REMOVAL

1. Disconnect the electrical leads from the cranking motor and tag each to identify and to facilitate replacement. (See Illust. 1.)

2. Remove the cap screws which secure the cranking motor to the engine and remove the cranking motor.

4. TESTING THE CRANKING MOTOR

To check performance of the cranking motor or to determine the cause of abnormal operation, the cranking motor must be submitted to a no-load and a torque test. Detailed instructions for performing these tests can be found in the service literature furnished with the test equipment.

Interpreting Results of Tests

Rated torque, current draw and no-load speed are shown in "Specifications," section 1.

1. Low free speed and high current draw with low developed torque may result from:

   (a) Tight, dirty, or worn bushings, bent armature shaft or loose field pole screws which allow the armature to drag.

   (b) Shorted armature. Check armature further on growler.

   (c) A grounded armature or field. Check by raising the grounded brushes and insulating them from the commutator with cardboard, and then checking with a test lamp between the insulated terminal and the frame. If the test lamp lights, raise the other brushes from the commutator and check the fields and commutator separately to determine whether it is the field or armature that is grounded.

2. Failure to operate with high current draw:

   (a) A direct ground in the switch, terminal or fields.

   (b) Frozen shaft bushings which prevent the armature from turning.

3. Failure to operate with no current draw:

   (a) Open field circuit. Inspect the internal connections and trace circuit with test lamp.

   (b) Open armature coils. Inspect the commutator for badly burned bars. When running at free speed, an open armature will show excessive arcing at the commutator bar that is open.

   (c) Broken or weakened brush springs, worn brushes, high mica on the commutator or other causes which would prevent good contact between the brushes and commutator. Any of these conditions will cause burned commutator bars.

4. Low no-load speed with low torque and low current draw indicates:

   (a) An open field winding. Raise and insulate the ungrounded brush from the commutator and check fields with test lamp.

   (b) High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under item 3.

5. High free speed with low developed torque and high current draw indicates shorted fields. There is no easy way to detect shorted fields since the field resistance is already low. If shorted fields are suspected, replace the fields and check for improvement in performance.

5. DISASSEMBLY

Normally, disassembly should proceed only so far as it necessary to make repair or replacement of the defective parts. For example, the field coils should be checked for opens or grounds and, if found to be in normal condition, should not be removed from the field frame.

(Continued on next page)

5. DISASSEMBLY – Continued

Cranking Motor with Dyer Drive
(Refer to Illust. 5)

1. Remove the cranking motor solenoid switch (49). Remove shift lever spring (45). Remove the drive housing cover (44) and the shift lever (43).

2. Remove the five screws attaching the drive housing assembly (39) and center bearing (29) to the field frame (28). Discard the tang type lock washers.

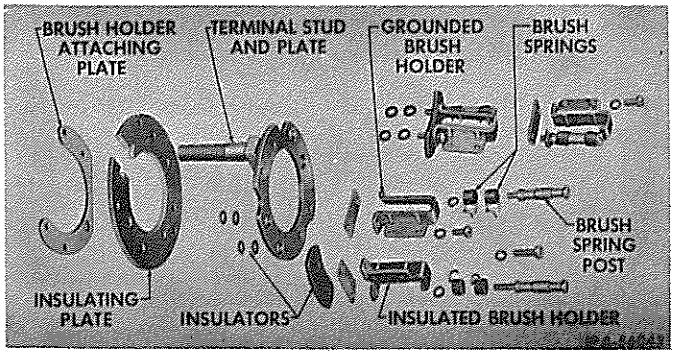
3. Pull the drive housing (39) off the armature shaft.

4. Remove the cover band (27) and detach the brush leads from the field leads. Remove the four screws securing the commutator end plate (5) to the field frame (28). Remove the commutator end plate with brush plate assembly (8) from the field frame.

5. Remove the armature (22) with center bearing (29) and Dyer drive assembly from the field frame (28).

6. Remove the two nuts from the terminal in the commutator end frame. Remove the screws holding the brush plate assembly (8) to the end frame (5) and remove the brush plate assembly.

7. The brush plate assembly may be disassembled by unscrewing the brush spring posts (20) and the brush holder attaching screws. Illust. 3 is an exploded view of the brush plate assembly and it can be used as a guide in disassembly.

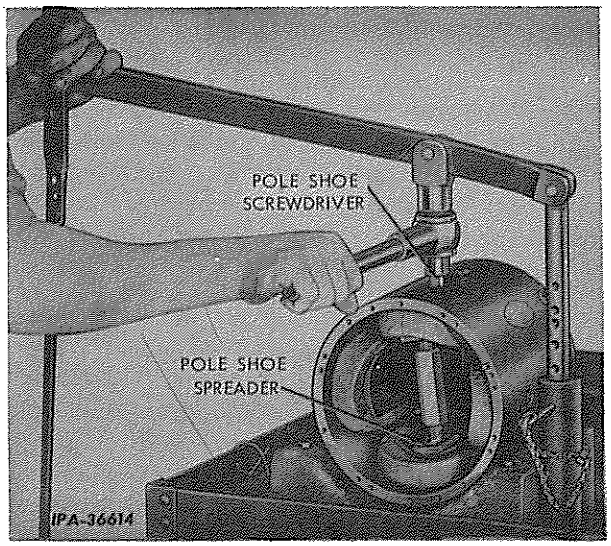


Illust. 3 - Exploded View of Brush Plate Assembly.

8. Disassemble the Dyer drive from the armature shaft by pulling out the cotter pin (36). Rotate the pinion stop (38) until the notches register with the shaft splines. Apply pressure against the shift sleeve (33) and slip off the pinion stop (38), pinion (37), spring (35), pinion guide (34), shift sleeve (33) and washers (31 and 32).

9. Remove the center bearing (29) from the armature shaft.

10. If the field coils are to be removed from the field frame, use a pole shoe screwdriver. A pole shoe spreader should also be used since this prevents distortion of the field frame (Illust. 4).



Illust. 4 - Removing the Pole Shoes.

Cranking Motor With Bendix Drive

1. Remove the cover band and detach the brush leads from the field leads.

2. Unscrew the three bolts, take off the commutator end frame and slide the armature and drive assembly out of the field frame.

3. Remove the bolts fastening the center bearing plate to the drive housing.

4. Remove the armature with the Bendix drive assembled to it, from the drive housing.

5. Remove the spring screw (head end) and separate the Bendix drive from the armature shaft.

6. Unscrew the spring screw (shaft end) and separate the drive spring from the drive pinion and shaft assembly.

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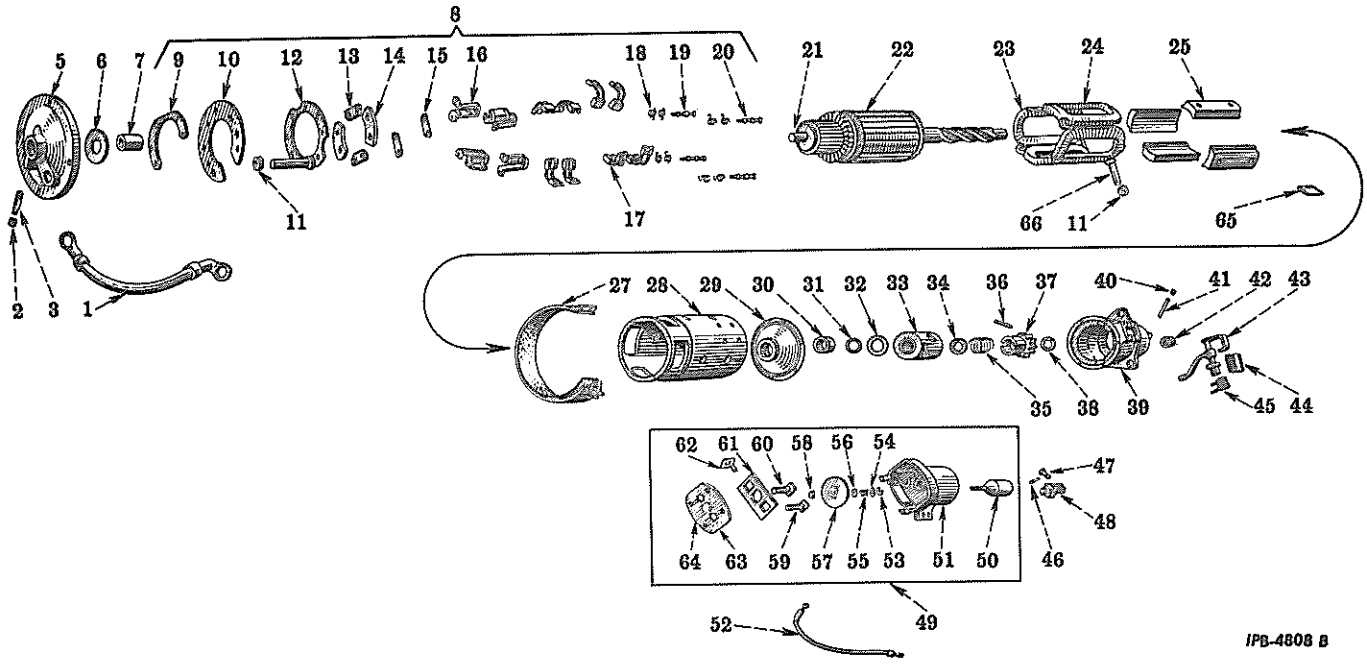
NOTE: Always use new tang lock washers when reassembling; repeated bending of the tang will likely cause it to break off.

7. Remove the center bearing plate from the armature shaft.

8. If the field coils are to be removed from the field frame assembly, use a pole shoe screw driver. A pole shoe spreader should also be used, since this prevents distortion of the field frame (Illust. 4).



Illust. 5 - Exploded View of Cranking Motor (Dyer Drive).

1. Cable.
2. Pipe plug.
3. Oil wick.
5. Commutator end plate.
6. Brake washer.
7. Bushing.
8. Brush plate assembly.
9. Support plate.
10. Insulation plate.
11. Insulation bushing.
12. Brush plate.
13. Spacer.
14. Insulation plate.
15. Spacer.
16. Brush holder.
17. Brush.
18. Brush spring.
19. Screw.
20. Screw.
21. Washer.
22. Armature.
23. Field coil (LH).
24. Field coil (RH).
25. Pole shoe.
27. Cover band.
28. Field frame.
29. Center bearing.
30. Center bearing bushing.
31. Washer.
32. Washer (cupped).
33. Shift sleeve.
34. Pinion guide.
35. Meshing spring.
36. Cotter pin.
37. Motor pinion.
38. Stop collar.
39. Drive housing.
40. Pipe plug.
41. Oil wick.
42. Drive end bushing.
43. Shift lever.
44. Drive housing cover.
45. Shift lever spring.
46. Cotter pin.
47. Shift lever pin.
48. Shift lever link.
49. Solenoid switch.
50. Plunger.
51. Case and coil.
52. Lead.
53. Washer (cupped).
54. Washer.
55. Contact spring.
56. Washer.
57. Contact disc.
58. Nut.
59. Terminal stud.
60. Terminal stud.
61. Insulating strip.
62. Support.
63. Gasket.
64. Terminal.
65. Field coil insulation.
66. Field terminal stud.

6. INSPECTION AND REPAIR

1. Wash all metal parts except armature and fields in cleaning solvent. Degreasing solvents will damage the insulation in fields and armature.

2. The Bendix drive may be cleaned by washing in kerosene and then relubricated with a trace of light engine oil after reassembly. Do not use heavy oil or grease as this may retard or prevent normal drive action.

3. Inspect cranking motor bushings for roughness or scoring; replace if necessary.

4. Inspect the armature commutator. If it is worn, dirty, out-of-round or has high mica, the armature should be put in a lathe, the commutator turned down and the mica undercut. The mica should be undercut 1/32 of an inch and the slots cleaned out carefully to remove any trace of dirt or copper dust. Sand the commutator lightly with No. 00 sandpaper to remove any slight burrs left from undercutting.

5. An open circuited armature can be saved if the open is obvious and repairable. The most likely place an open will occur is at the commutator riser bars. This usually results from excessively long cranking periods which causing overheating of the cranking motor and melting of the solder which will be thrown on the cover band. Resolder the leads in riser bars (using rosin flux). Turning down the commutator to remove the burned spot and undercut the mica as previously explained.

6. Short circuits in the armature are located by use of the growler. When the armature is revolved in the growler, with a steel strip such as a hacksaw blade held above it, the blade will vibrate above the area of the armature core in which the short is located. Copper or brush dust in the slots between the commutator bars sometimes causes shorts between bars which can be eliminated by cleaning out the slots. Shorts at cross-overs of the coils at the core end can often be eliminated by bending wires slightly and reinsulating the exposed bare wire.

Grounds in the armature are detected by use of a test lamp and test points. Place one lead of the test lamp on the armature core or shaft and the other lead on each commutator bar. If the lamp lights, the commutator is grounded. Repairs can sometimes be made if grounds are at core ends (where coils come out of slots) by placing insulating strips between the core and coil which has grounded.

7. Grounded field coils can sometimes be repaired by removing them so they can be reinsulated. Care must be used to avoid excessive bulkiness when applying new insulation since this might cause the pole shoe to cut through and cause another ground when the coils are reinstalled.

Usually, if a field coil is open or shorted internally, it will require replacement since it is difficult to repair such a defect.

Field Coil Removal and Service

Field coils can be most easily removed from the field frame assembly by use of a pole shoe screwdriver. (Illust. 3.) A pole shoe spreader should also be used since this prevents distortion of the field frame. Careful installation of the field coils is necessary to prevent shorting or grounding of the field coils as the pole shoes are tightened into place. Where the pole shoe has a long lip on one side and a short lip on the other, the long lip should be assembled in the direction of armature rotation so it becomes the trailing (not leading) edge of the pole shoe. If the varnish coating on the field coils becomes hard and interferes with assembly, they may be heated in an oven to soften sufficiently for easy installation.

Grounded field coils may sometimes by repaired by removing and reinsulating them. Care must be used in applying new insulation to avoid excessive bulkiness, since this might cause the pole shoe to cut through and produce another ground when the coils are installed.

7. LUBRICATION

When the cranking motor is removed from the engine and disassembled for any repair or service, careful lubrication service should be performed. Grease plugs should be repacked, oil wicks resaturated, and oil-less bushings given a few drops of light motor oil. Lubricate the Dyer drive mechanism with a small amount of light motor oil or kerosene. Heavy oil or

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grease must not be used, as this may retard or prevent normal action of the drive mechanism. Avoid excessive lubrication, since this will cause the lubricant to be forced onto the commutator, with a decrease in efficiency. Never lubricate the commutator and never lubricate any part of the cranking motor while it is operating.

8. REASSEMBLY

Cranking Motor With Dyer Drive

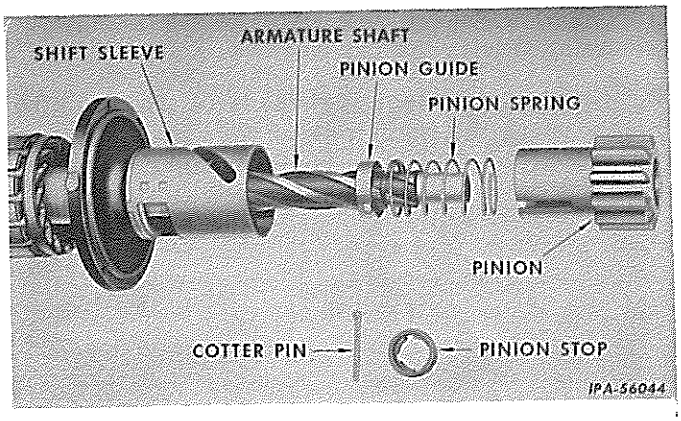
(Refer to Illust. 5)

1. Place the center bearing (29) on the armature shaft.

2. Install the plain washer (31) and cupped thrust washer (32) with the cupped section facing the shift sleeve.

3. Assemble the shift sleeve (33), pinion guide (34) and spring (35) on the armature shaft as shown in Illust. 6. The lugs of the pinion guide should be toward the pinion.

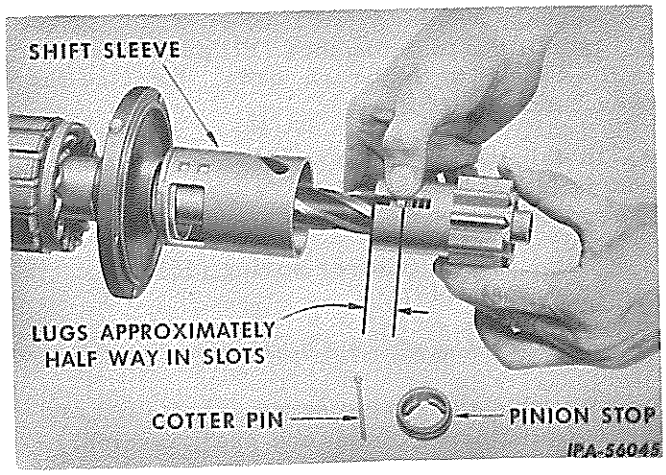
NOTE: This is the proper position for most pinion guides with the exception being pinion guides having an identifying "T" stamped on one side. Guides having "T" identification are heavy parts and are to be used only with pinions having an identification groove cut in the pinion skirt near the pinion teeth.



Illust. 6 - Dyer Drive Components.

4. Do not twist the pinion guide onto the spline shaft more than 1-3/4 inches from the end of the shaft. Hold the guide in this position and put the pinion on the shaft over the spring, compressing the spring into the pinion skirt (Illust 7).

5. Align the lugs on the pinion guide with the slots which are cut in the skirt of the pinion. With the thumb and forefinger (as shown in Illust. 7) hold the pinion onto the shaft so the lugs enter the slots in the pinion skirt.



Illust. 7 - Assembling Dyer Drive.

6. Remove the thumb and forefinger and twist the assembly back onto the armature shaft and into the shift sleeve. As it reaches the extreme position, a click will be heard which indicates that the pinion guide has dropped into the undercut section of the shaft splines so that the assembly is locked in the demeshed position.

7. Replace the pinion stop (38) by aligning it with the spline grooves and turning it on until it hits the undercut. It can then be rotated to align the holes in the shaft and pinion stop. This permits replacement of the cotter pin (36) so that the pinion stop will be held in position.

8. Lubricate the drive after reassembly with a small amount of light engine oil. Do not use heavy oil or grease as this might retard or prevent normal drive action.

9. Assemble the brush spring posts and brush holder attaching screws. Pay particular attention to the insulation which insulates the brush holder from the brush plate. (Use Illust. 3 as a guide in reassembly.)

10. Fasten the brush plate assembly (8) to the commutator end grame (5) with the screws and replace the nuts on the terminal post.

11. Assemble the commutator end frame to the field frame and secure with four screws and new tang lock washers.

(Continued on next page)

8. REASSEMBLY - Continued

12. Install the armature into the field frame. Place the drive housing (39) over the armature shaft and secure to the field frame with five screws and new tang lock washers.

13. Install the four brushes (17) and fasten the field leads to the brush leads. Replace the cover band (27).

14. Install the shift lever (43) into the drive housing (39). Install the drive housing cover (44) and secure with four screws.

15. Install the shift lever spring (45) and solenoid switch (49).

Cranking Motor With Bendix Drive

1. Assemble the spring screw (shaft end) and spring to the drive pinion and shaft assembly.

2. Place the center bearing plate on the armature shaft.

3. Place the Bendix drive on the armature shaft and fasten the spring screw (head end).

4. Place the Bendix drive and armature assembly into the drive housing and fasten the center bearing plate to the drive housing.

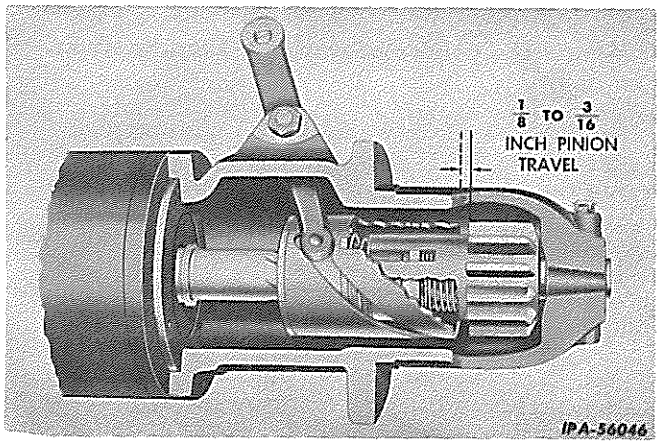
5. Slide the armature and drive assembly into the field frame.

6. Replace the commutator end frame and fasten it to the field frame, using the thru bolts.

7. Fasten the brush leads to the field leads and replace the cover band.

9. PINION FREE TRAVEL CHECK (DYER DRIVE)

When the shift lever is in the cranking position, it should be possible to push the pinion back against spring pressure 1/8 to 3/16 inch (Illust. 8). This free travel adjustment can be made by disconnecting the lead between the solenoid and cranking motor and connect a battery of the specified voltage to the two small solenoid terminals. Operate the shift lever by hand until the switch is closed. Battery current will then maintain it in operating position so that the pinion travel can be checked. Adjustment is made by turning the stud in the solenoid plunger in or out as required.



Illust. 8 - Pinion Travel Check.

10. INSTALLATION

1. Install the cranking motor on the engine, securing it with the cap screws.

2. Connect the electrical leads to the cranking motor using the markings or tags made in "Removal" to facilitate replacement.

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1. DESCRIPTION

The generator supplies current to keep the batteries in a charged condition by replacing electrical energy used by loads on the batteries. The generator is sealed against entrance of dirt, is mounted to the right side of the engine and is V-belt driven from the fan and water pump pulley. The direction of rotation for the generator is clockwise, viewed from drive end.

2. MINOR REPAIRS AND ADJUSTMENTS

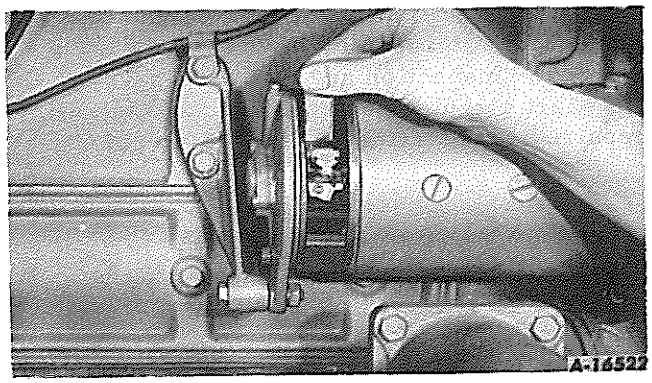
Before any repairs or adjustments are made, refer to "Checking Mechanical Problems," section 1, to be sure that the generator and not the voltage regulator is at fault. Often the generator can be repaired by following the simple procedure of minor checks and adjustments, as outlined below, without removing the generator from the engine.

1. Inspect the terminals, external connections, wiring and mounting.

2. Remove the cover band so that the commutator, brushes and internal connections can be inspected.

3. If the commutator is glazed or dirty, is may be cleaned with a strip of No. 00 sand paper. Never use emery cloth to clean the commutator.

The sandpaper may be used by holding it against the commutator with a wood stick while the generator is in operation, moving it back and forth across the commutator. Gum and dirt will be sanded off in a few seconds. All dust should be blown from the generator after the commutator has been cleaned. A brush seating stone can also be used to clean the commutator.



Illust. 1 - Cleaning Generator Commutator.

4. If brush length is less than 1/2 inch or if the brush leads have broken strands or are otherwise damaged, the brushes should be replaced.

New brushes should be seated with a brush seating stone to make sure that they are in good contact with the commutator. All dust should be blown from the generator after the brushes are seated.

5. Check the brush spring tension, see "Specifications," section 1. The tension can be checked with a spring gauge hooked on the brush arm or brush attaching screws. It is important that the tension is correct since excessive tension will cause rapid brush and commutator wear while low tension causes arcing and burning of the brushes and commutator. Tension can be changed by bending the brush spring as required. If the brush spring shows evidence of overheating (blued or burned), do not attempt to readjust it but install a new spring. Overheating will cause a spring to lose its temper.

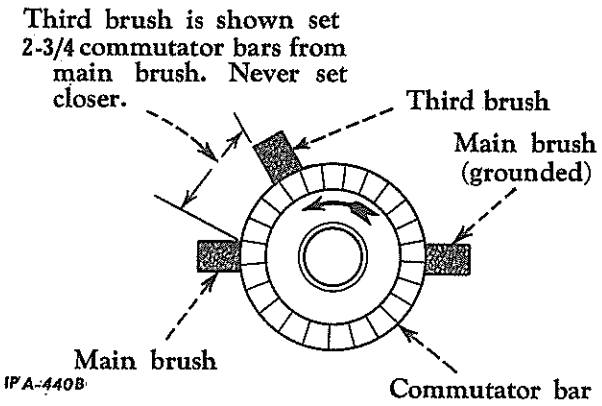
6. Check the fan belt tension. See "Fan Belt," section 5. Low belt tension will permit belt slippage with resulting rapid belt wear and low or erratic generator output. Excessive belt tension will cause rapid belt and generator bearing wear.

7. ADJUSTING GENERATOR CHARGING RATE - THIRD BRUSH TYPE: Loosen the third brush carrier lock screw in the rear face of the generator until the lock washer tension has been released. DO NOT REMOVE THE LOCK SCREW. Increase the charging rate by moving the third brush in a clockwise direction viewed from the drive end. Decrease the charging rate by moving the third brush in the opposite direction.

(Continued on next page)

2. MINOR REPAIRS AND ADJUSTMENTS – Continued

NOTE: Never set the third brush closer than 2-3/4 commutator bars from the main brushes (Illust. 2). When the required adjustment is made, secure the third brush and carrier by tightening the lock screw. Reassemble the cover band and recheck the charging rate.



Illust. 2 - Third Brush Setting.

3. TESTING THE GENERATOR

If the generator still fails to function properly after checking as outlined under "Minor Repairs and Adjustments," (par. 2), it may be checked as follows to determine the cause of failure:

The following tests can be performed using only a test lamp and leads. If the field current or cold output tests are to be made, special test equipment will be required. Instructions for performing these tests can be found in the literature furnished with the test equipment.

NOTE: If the generator has three terminals, it is of the insulated type. The armature terminal is marked "A-1." The field terminal is marked "F" and the insulated ground terminal is marked "A-2." References to the "A" terminal in the following tests for no output should be interpreted to mean the "A-1" or armature terminal.

No Output

1. Raise the grounded brush and insulate it from the commutator with cardboard. Check for a ground with a test lamp from the generator "A" terminal to the generator frame. If the test lamp lights, indicating ground, raise the remaining brush or brushes and insulate from the commutator. Disconnect the field lead from the brush and check the field circuit, commutator and armature lead separately to locate the ground. If a grounded field is found, check the regulator contact points since the grounded field may have caused the points to burn.

2. If no ground is found, check for an open field with the test lamp connected from the "A" to the "F" terminals. If the lamp does not light, the field circuit is open. If the open is due to a broken lead or bad connection, it can be repaired but, if the open is inside one of the field coils, the coil must be replaced.

3. If the field is not open, check for a short circuit in the field with a test ammeter and a battery of the specified voltage (See "Specifications," section 1) connected in series with the field, that is, from the "A" to the "F" terminal. Care must be used in this test since a shorted field will draw a high current which may damage test equipment. If a shorted field is found, check the regulator points since they will probably be burned. If the field is not within specification, new field coils will be required.

4. Inspect the armature for open circuits. Normally the effects of an open circuit in the armature can be seen readily since open circuits in the armature cause burned commutator bars. Where bars are not too badly burned, and the open circuit can be repaired, the armature usually can be saved. (Refer to "Inspection and Repair" par. 6). If the armature cannot properly be repaired, it must be replaced.

5. Short circuits in the armature can be detected after disassembly by use of a growler (refer to "Inspection and Repair," par. 6). If the short circuit is obvious, it can often be repaired so the armature can be saved.

Unsteady or Low Output

1. A loose fan belt or generator pulley will cause low or unsteady output.

2. Brushes which stick in their holders, or low brush spring tension, will prevent good

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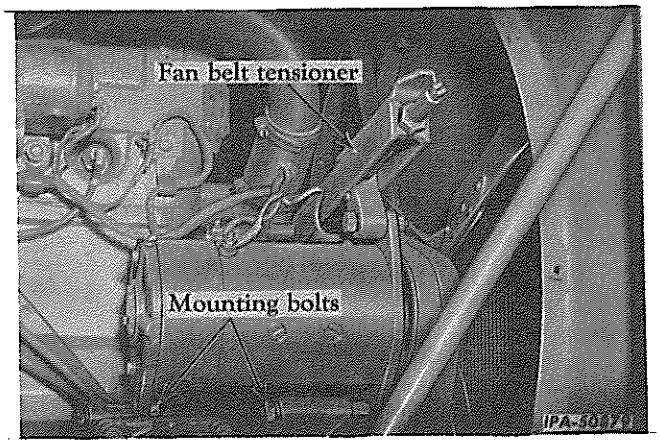
contact between the brushes and commutator so that output will be low and unsteady. This will also cause arcing and burning of the brushes and commutator.

3. If the commutator is dirty, out-of-round or has high mica, generator output is apt to be low and unsteady. (Refer to "Inspection and Repair," par. 6.) Burned commutator bars may indicate an open circuit condition in the armature as already explained under "No Output."

Excessive Output

An internally grounded field circuit, which would cause excessive output, can be located by connecting a test lamp between the "F" terminal and the generator frame. Disconnect the leads from the "F" terminal, raise the brush to which the field lead is connected and insulate it from the commutator. If the test lamp lights, the field is internally grounded. If the field has become grounded because the insulation on a field lead has worn away, reinsulate the lead. Where the ground has occurred at the pole shoes, remove the field coils, reinsulate and reinstall them. If grounded at the "F" terminal stud, install new insulating washers or bushings.



Illust. 3 - Generator.

4. REMOVAL

1. Remove the nuts and lock washers and leads from the terminals on the generator, tagging each lead to facilitate replacement.

2. LATE MODEL 1091 SERIES ONLY: Remove the cap screw, lock washer, flat washer and nut which secure the generator brace to the generator, and push the brace upward and out of the way.

On engines equipped with fan belt tensioners, loosen the nut and turn the slotted end of the spring guide to remove the tension on the belts. Remove the pivot bolt, lock washer and nut, attaching the tensioner slide block to the generator bracket and push the tensioner upward and out of the way.

3. 16, 525 AND EARLY 24 SERIES ENGINES: Remove the adjusting cap screw, lock washer and plain washer, which secure the idler brace to the idler bracket, and push the brace upward and out of the way.

4. Loosen the mounting screws at the front and rear of the generator, push the generator toward the engine and remove the drive belts.

5. Remove the mounting screws and lift the generator out.

5. DISASSEMBLY

Normally, disassembly should proceed only so far as is necessary to make repair or replacement of defective parts. For example, the field coils should be checked for opens, shorts or grounds before being removed from the field frame. They should be removed only if they require repair or replacement.

Remove the cover band and disconnect the brush leads from the brush holders, unscrew the thru bolts and remove the commutator end frame and the drive end frame with armature from the field frame. Place the armature in a vise (use soft jaws and avoid excessive tightening of the vise). Remove the coupling pin, coupling and drive end frame from the armature shaft.

Field Coil Removal

Field coils can be removed most easily from the field frame by use of a pole shoe screwdriver and spreader. The pole shoe spreader

5. DISASSEMBLY– Continued

Field Coil Removal – Continued

prevents distortion of the field frame while applying pressure to the pole shoe screw. The pole shoe screwdriver permits easy loosening and removal of the pole screws.

6. INSPECTION AND REPAIR

1. Wash all metal parts except armature and fields in cleaning solvent. Degreasing solvents will damage the insulation in fields and a armature.

2. Inspect generator bearings for roughness or scored races; replace, if necessary.

3. Inspect the armature commutator. If it is worn, dirty, out-of-round or has high mica, the armature should be put in a lathe, the commutator turned down and the mica undercut. The mica should be undercut 1/32 of an inch and the slots cleaned out carefully to remove any trace or dirt or copper dust. As a final step in this procedure, sand the commutator lightly with No. 00 sandpaper to remove any slight burrs left from undercutting.

4. An open circuited armature can be saved if the open is obvious and repairable. The most likely place an open will occur is at the commutator riser bars; this usually results from overloading of the generator, which causes overheating and melting of the solder which will be thrown on the cover band. Resolder the leads in riser bars (using rosin flux). Turn down the commutator in a lathe to remove the burned spot and undercut the mica as previously explained.

5. Short circuits in the armature are located by use of the growler. When the armature is revolved in the growler, with a steel strip such as a hacksaw blade held above it, the blade will vibrate above the area of the armature core in which the short is located. Copper or brush dust in the slots between the commutator bars sometimes causes shorts between bars which can be eliminated by cleaning out the slots. Shorts at cross-overs of the coils at the core end can often be eliminated by bending wires slightly and reinsulating the exposed bare wire.

Grounds in the armature are detected by use of a test lamp and test points. Place one lead of the test lamp on the armature core or shaft and the other lead on each commutator bar. If the lamp lights, the commutator is grounded. Repairs can sometimes be made if grounds are at core ends (where coils come out of slots) by placing insulating strips between the core and coil which has grounded.

6. Grounded field coils may sometimes be repaired by removing them so they can be reinsulated. Care must be used to avoid excessive bulkiness when applying new insulation since this might cause the pole shoe to cut through and cause another ground when the coils are reinstalled.

Usually, if a field coil is open or shorted internally, it will require replacement since it is difficult to repair such a defect.

7. REASSEMBLY

Replace the drive end frame, coupling and coupling pin on the armature shaft. Place the drive end frame with armature into the field frame. Assemble the commutator end frame to the field frame and commutator using the thru bolts. Assemble the brushes and connect the brush leads. Replace the cover band.

8. INSTALLATION

1. Place the generator in position on the bracket and install the generator mounting screws. Push the generator toward the engine and install the generator drive belt or fan belt tensioner.
2. Tighten the drive belt or fan belt tensioner to the correct tension (See "Fan Belts" in section 5) and secure the generator in position.
3. Connect the leads to the correct terminals.
4. Repolarize the generator. (Refer to par. 9.)
5. Check the generator output on the ammeter.

9. REPOLARIZING THE GENERATOR

The generator must be re-polarized after tests and adjustments have been completed. Connect all leads but, BEFORE the engine is started, proceed as follows: Use a jumper lead and, with one end on the "GEN" terminal on the regulator, touch the other end to the "BAT" terminal on the regulator. The resulting flash allows a surge of current to flow through the generator which correctly polarizes it. Reverse polarity causes vibration, arcing and burning of the relay contact points, so establishing the proper polarity is important.

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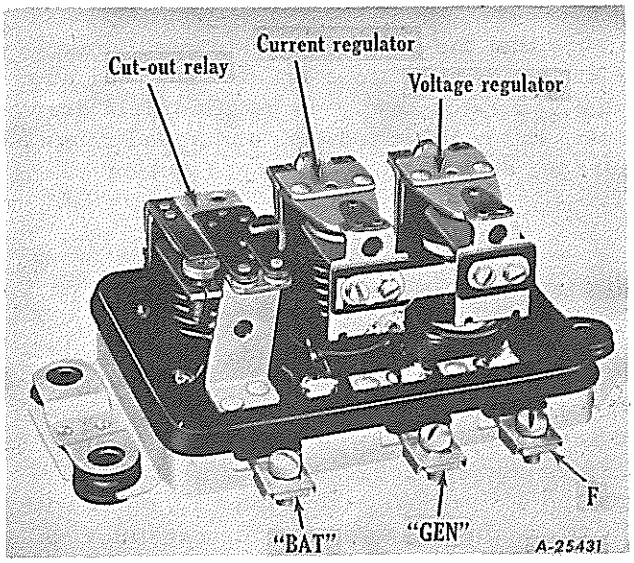
1. DESCRIPTION

Three Unit Type

The regulator contains a cutout relay, a voltage regulator and a current regulator. The cutout relay closes the generator-to-battery circuit when the generator voltage is sufficient to charge the battery, and it opens the circuit when the generator slows or stops. This prevents the battery from discharging through the generator. The voltage regulator is a voltage limiting device that prevents the voltage from exceeding a specified maximum and reduces generator output to the value required for any particular condition of battery charge and electrical load. The current regulator is a current limiting device which prevents the generator from overloading itself when the voltage regulator is not operating.



Illust. 1 - Three-Unit Regulator With Cover Removed.

The two unit type combined current-voltage or step-voltage control regulators contain a cutout relay and a combination current-voltage regulator or step-voltage control. The combined step-voltage type regulator is used in conjunction with a third brush generator. The current-voltage control type can be used with a third brush generator or a shunt wound generator.

On either regulator, the cutout relay closes the generator-to-battery circuit when the generator voltage is sufficient to charge the battery and it opens the circuit when the generator slows or stops. This prevents the battery

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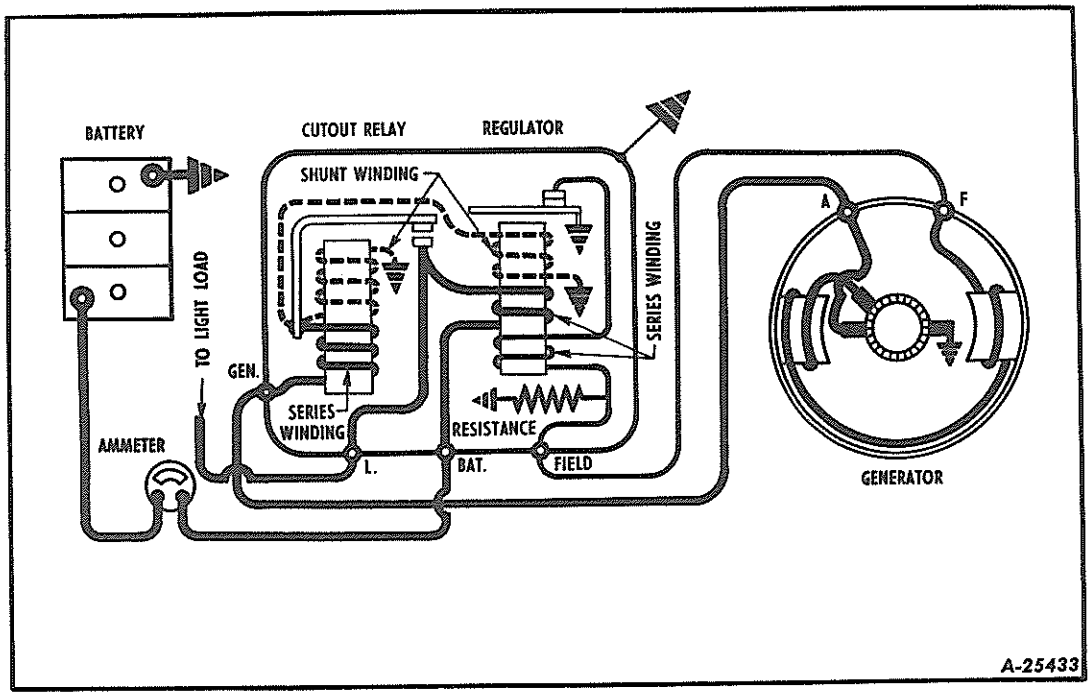


Illust. 2 - Wiring Circuit of Combined Current-Voltage Regulator.

1. DESCRIPTION - Continued

Three Unit Type – Continued

from discharging through the generator. On the current-voltage type regulator, the combined current-voltage unit prevents excessive overcharging by never allowing the charging rate to exceed 50% of the generator capacity, regardless of the battery condition.

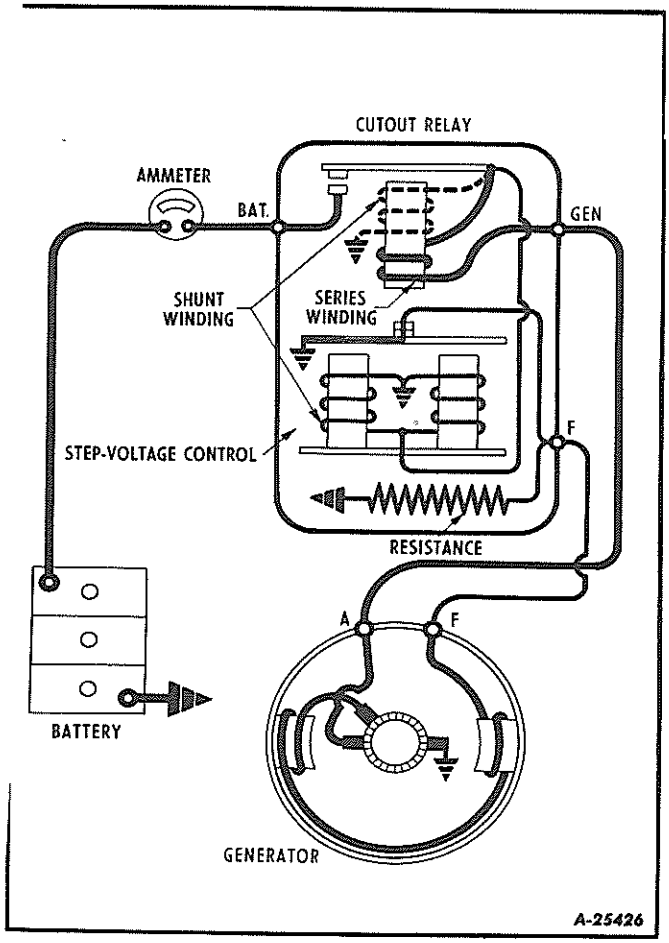
The step-voltage control unit inserts a resistance into the generator field circuit when the generator voltage reaches a predetermined maximum. This substantially reduces the generator output, and prevents overcharging the battery.

2. GENERAL

Before any repairs or adjustments are made, refer to "Checking Mechanical Problems", section 1, to be sure that the regulator and not the generator is at fault.

Many voltage regulators are designed to be used with a positive grounded battery; others are designed to be used with a negative grounded battery. Never attempt to use the wrong polarity regulator on an application.

Be sure that the proper regulator and generator are used; regulators are designed for use with a generator having a specified field draw, output, internal connections and speed range. Improper substitutions may not function correctly.



Illust. 3 - Circuit Wiring Diagram of Step-Voltage Control System.

3. MAINTENANCE AND ADJUSTMENTS

Regulator (Three Unit Type)

If the regulator fails to operate or if tests show that the units are outside specifications, check and adjust according to the following procedure: mechanical checks adjustments (air gaps, point openings, etc.) must be made with the battery disconnected and the regulator off the unit. Electrical checks and adjustments can be made with the regulator either on or off the unit. The regulator must be mounted in the operating position when electrical settings are checked and adjusted, and it must be at operating temperature.

To check the electrical settings as outlined in the following paragraphs, special test equipment will be required. Instructions for use of this equipment when checking these settings can be found in the literature furnished with the test equipment. For specifications see "Specifications", (section 1).

1. CLEANING CONTACT POINTS: Many reglator problems can be eliminated by a simple cleaning of the contact points and, possibly, some readjustment. Clean the flat points with a spoon or riffler file. On positive grounded regulators, the flat point is in the upper contact bracket; therefore, the bracket must be removed for cleaning the points. A flat file cannot be used successfully to clean the flat contact points because it will not touch the center, where point wear is most apt to occur. The contact file should not be allowed to be-

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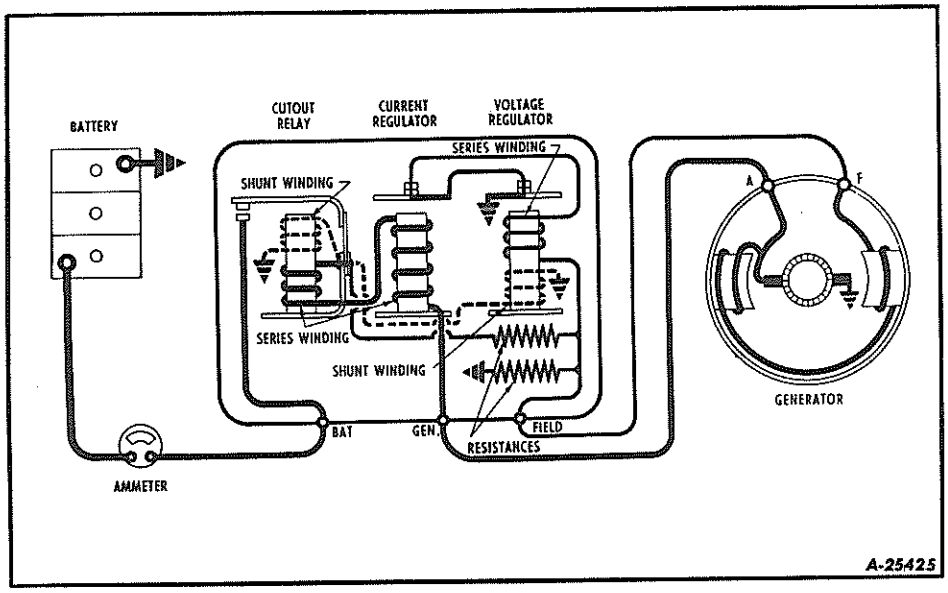

Illust. 4 - Circuit Wiring Diagram - Three - Unit Regulator.

come greasy and should not be used to file other metals. Never use sandpaper or emery cloth to clean contact points.

2. CUTOUT RELAY UNIT: The cutout relay requires three checks and adjustments: air gap, point opening and closing voltage. Air gap and point opening adjustments must be made with the battery lead disconnected from the regulator; closing voltage adjustments are made with the battery connected in the circuit.

CAUTION: The cutout relay contact points must never be closed by hand when the battery is connected to the voltage regulator. This would cause damage to the relay contact points and might also damage other electrical equipment.

(a) AIR GAP. Hold armature down so contact points are closed, and measure air gap

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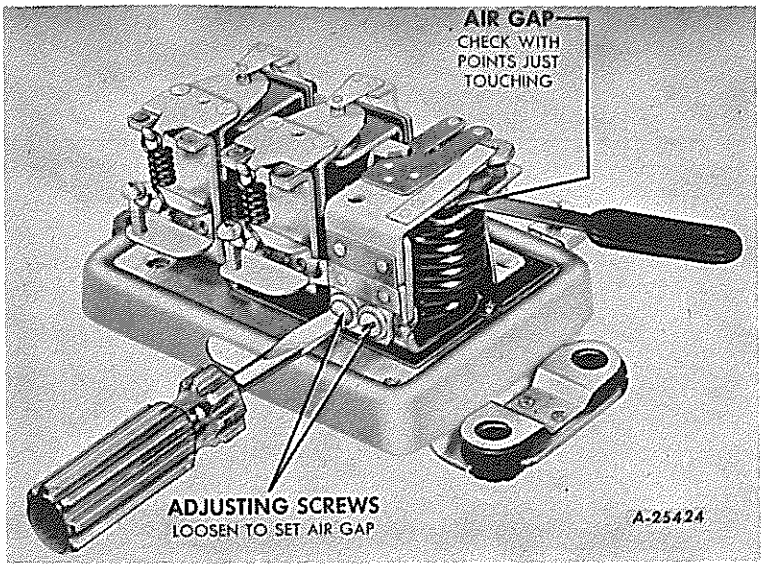


Illust. 5 - Cutout Relay Air Gap Adjustment.

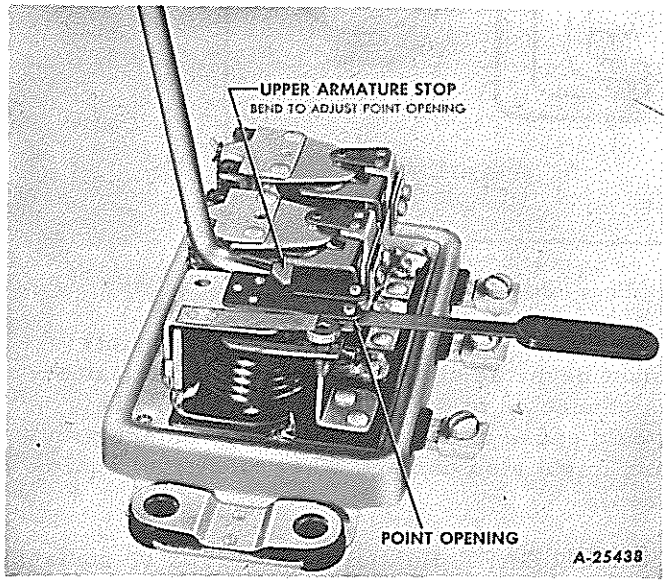
3. MAINTENANCE AND ADJUSTMENTS – Continued

Regulator (Three Unit Type) – Continued

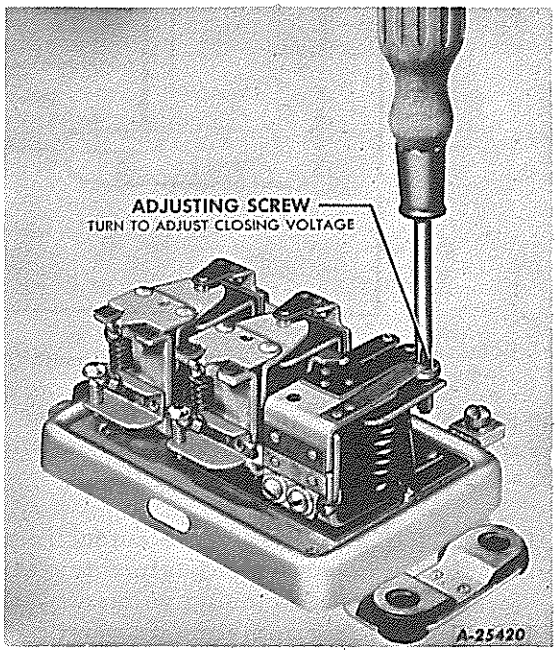
(Illust. 5) between armature and center of the core. Adjust the air gap, see "Specifications," section 1.

(b) POINT OPENING. Check point opening and adjust by bending the upper armature stop (Illust. 6). Adjust the point opening, see "Specifications," section 1.

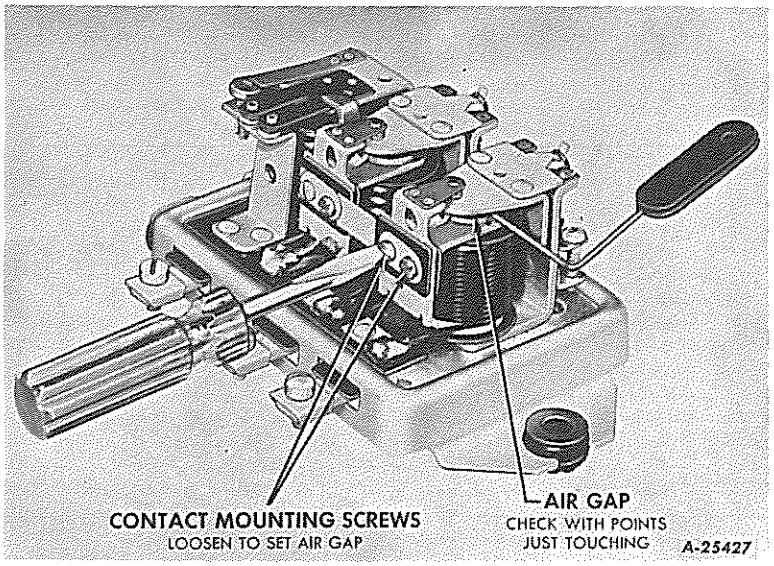
(c) CLOSING VOLTAGE. Adjust closing voltage by turning adjusting screw (Illust. 7). Turn screw clockwise to increase spring tension and closing voltage. Turn screw counterclockwise to decrease closing voltage. Adjust closing voltage, see "Specifications," section 1.



Illust. 6 - Cutout Relay Point Opening Adjustment.



Illust. 7 - Adjustment of Cutout Relay Closing Voltage.



Illust. 8 - Air Gap Adjustment, Voltage Regulator Unit.

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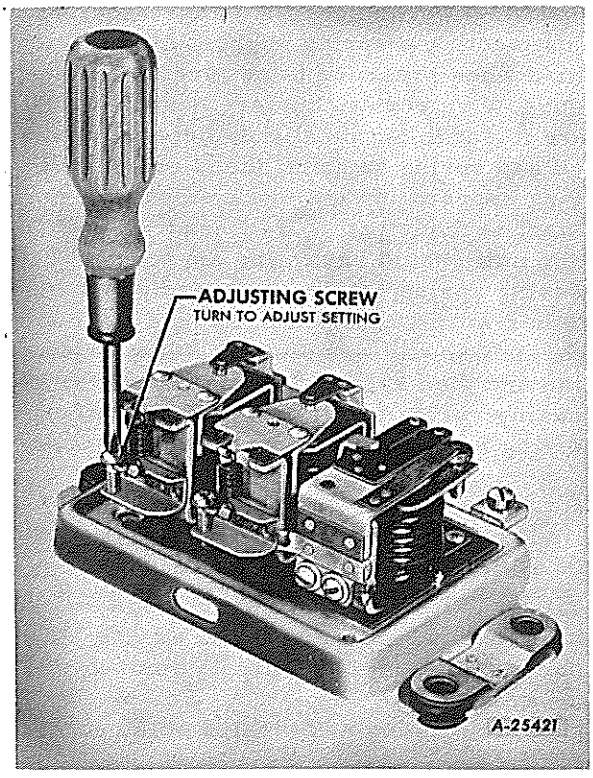
3. VOLTAGE REGULATOR UNIT: Two checks and adjustments are required on the voltage regulator unit: air gap and voltage setting. The air gap adjustment must be made with the battery lead disconnected from the regulator; voltage setting adjustments are made with the battery connected in the circuit.

(a) AIR GAP. To check air gap, push armature down until the contacts are just touching and then measure air gap (Illust. 8). Adjust by loosening the contact mounting screws and raising or lowering the contact bracket as required. Be sure the points are lined up, and tighten screws after adjustment. Adjust the air gap, see "Specifications," section 1.

(b) VOLTAGE SETTING. To adjust voltage setting turn adjusting screw (Illust. 9) clockwise to increase voltage setting or counterclockwise to decrease voltage setting. Adjust the voltage, see "Specifications," section 1.

CAUTION: If adjusting screw is turned down (clockwise) beyond normal adjustment range,



Illust. 9 - Voltage Setting, Voltage Regulator Unit.

spring support may fail to return when pressure is relieved. If this occurs, turn screw counterclockwise until there is sufficient clearance between screw head and spring support; then, carefully bend spring support upward, with small pliers, until contact is made with screw head. Always approach the final setting of the unit by increasing spring tension - never by reducing it. If setting is too high, adjust until below required value and then raise to exact setting by increasing spring tension.

NOTE: The voltage regulator unit should not be set outside of the specified limits, except in special cases.

Under conditions where constant high air temperatures prevail, battery overcharge may occur; this will be indicated by excessive use of water. Ordinarily, the battery should require water only about every 120 hours. If water must be added more frequently than this, and the voltage regulator setting is within specified limits, it is an indication of overcharge.

This condition can be corrected by reducing the voltage setting slightly. If the voltage setting is reduced, be sure to readjust the closing voltage of the cutout relay to approximately .5 of a volt below the voltage-regulator setting. At the beginning of cold weather to avoid under-charging battery conditions, increase the settings of the voltage regulator and cutout relay to within specified limits.

4. CURRENT REGULATOR UNIT: Two checks and adjustments are required on the current regulator unit: air gap and current setting. The air gap adjustment must be made with the battery lead disconnected from the regulator; current setting adjustments are made with the battery connected in the circuit.

(a) AIR GAP. The air gap on the current regulator is checked and adjusted in exactly the same manner as for the voltage regulator already described (Illust. 8). Adjust the air gap, see "Specifications," section 1.

(b) CURRENT SETTING. The current setting

(Continued on next page)

3. MAINTENANCE AND ADJUSTMENTS – Continued

Regulator (Three Unit Type) - Continued

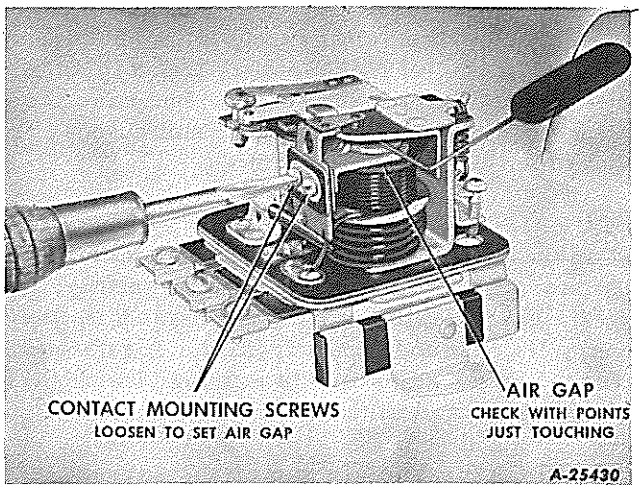
adjustment is made in exactly the same manner as the voltage setting adjustment already described (Illust. 9). Adjust the current, see "Specifications," section 1.

Current - Voltage Regulator
(Two Unit Type)

1. CUT-OUT RELAY UNIT: The cut-out relay unit is checked and adjusted in exactly the same manner as for the cut-out relay unit in the three unit voltage regulator. For proper air gap, point opening and closing voltage, see "Specifications," section 1.

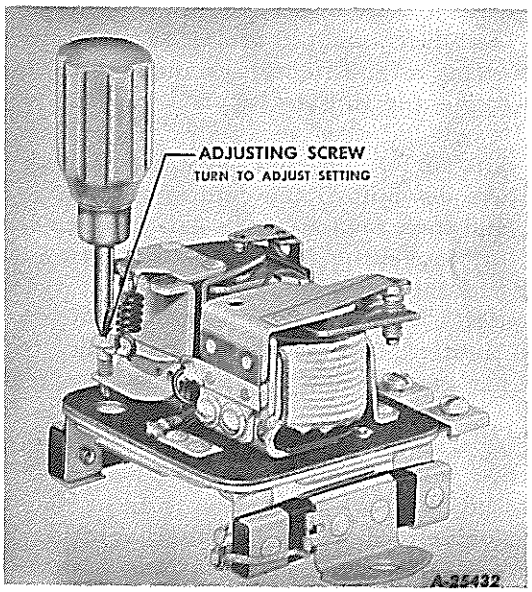
2. CURRENT-VOLTAGE UNIT:

(a) AIR GAP. To check air gap, push armature down until the contacts are just touching and then measure air gap (Illust. 10). Adjust by loosening contact mounting screws and raising or lowering contact brackets as required. Be sure that points are lined up and tighten screws after adjustment. For proper air gap, see "Specifications," section 1.



Illust. 10 - Current-Voltage Unit Air Gap Check and Adjustment.

(b) VOLTAGE SETTING. Adjust voltage setting by turning adjusting screw (Illust. 11). Turn screw clockwise to increase voltage setting and counterclockwise to decrease voltage setting. After each adjustment, set cover in place before checking setting. For proper voltage setting, see "Specifications," section 1.



Illust. 11 - Adjusting Voltage Setting of Current-Voltage Regulator Unit.

CAUTION: If adjusting screw is turned down (clockwise) beyond normal range required for adjustment, the spring support may fail to return when pressure is relieved. If this occurs, turn screw counterclockwise until there is sufficient clearance between screw head and spring support; then, carefully bend spring support upward, with small pliers, until contact is made with screw head. Final setting of the unit should always be approached by increasing spring tension - never by reducing it. In other words, if setting is found to be too high, unit should be adjusted below required value and then raised to exact setting by increasing spring tension. Be sure that screw is exerting force on hanger.

Step–Voltage Control Regulator
(Two Unit Type)

1. CUT-OUT RELAY UNIT: The cut-out relay unit is checked and adjusted in exactly the same manner as for the cut-out relay unit in the three unit voltage regulator. For proper air gap, point opening and closing voltage, see "Specifications," section 1.

2. STEP-VOLTAGE CONTROL UNIT: Five

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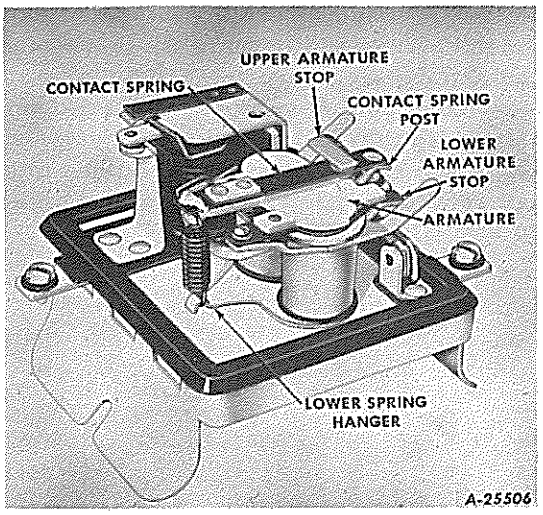
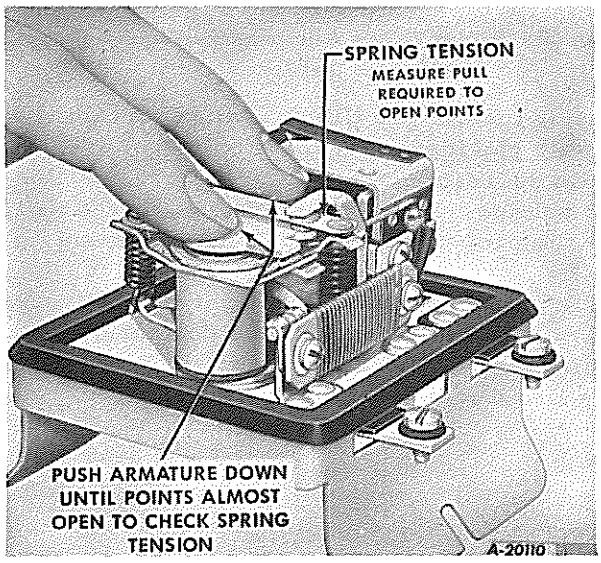
checks and adjustments are required on the step-voltage control unit: flat spring tension, air gap, armature travel, point opening and voltage setting. The various points of adjustment, and the posts and stops which must be bent to make adjustments, are shown in illustration 12.



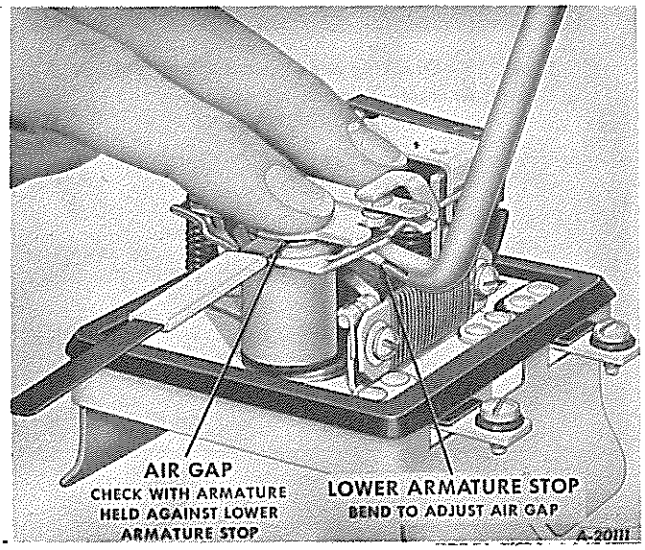
Illust. 12 - Places to Adjust on the Step-Voltage Control.

(a) FLAT SPRING TENSION. The flat spring tension determines the amount of pressure between the step-voltage contact points. This can be measured by pushing the armature down until the points almost open and, then, using a spring gauge to measure the upward pull required to open the points (Illust. 13). The correct spring tension can be found in "Specifications," section 1.

(b) AIR GAP. To check the air gap, hold the armature down against the lower armature stop by placing fingers on either side of the flat contact spring as shown in illustration 14. Adjust air gap by bending the lower armature stop. See "Specifications," section 1, for correct gap.



Illust. 13 - Checking Step-Voltage Control Contact Spring Tension.



Illust. 14 - Checking and Adjusting Step-Voltage Control Air Gap.

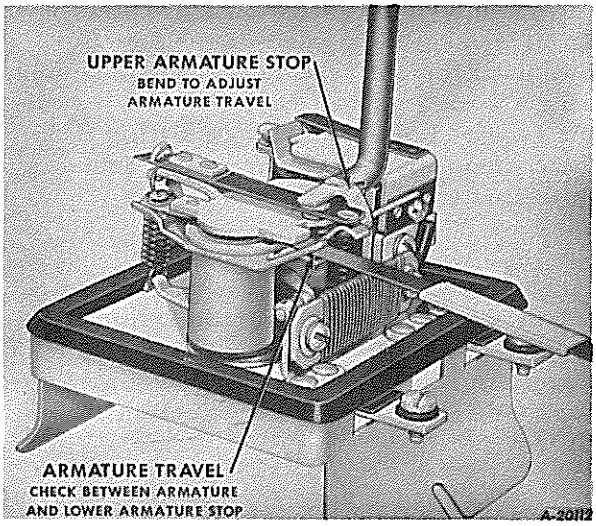
(c) ARMATURE TRAVEL. To check the armature travel, release the armature so that it moved up against the upper armature stop, and then measure the gap or armature travel between the armature and lower armature stop (Illust. 15). Adjust armature travel by bending the upper armature stop. For cor-

(Continued on next page)

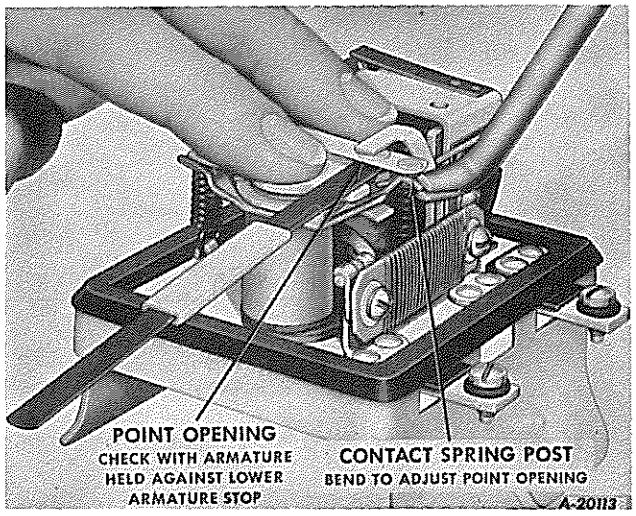
3. MAINTENANCE AND ADJUSTMENTS – Continued

Step–Voltage Control Regulator
(Two Unit Type) - Continued

rect armature travel or gap see "Specifications," section 1.



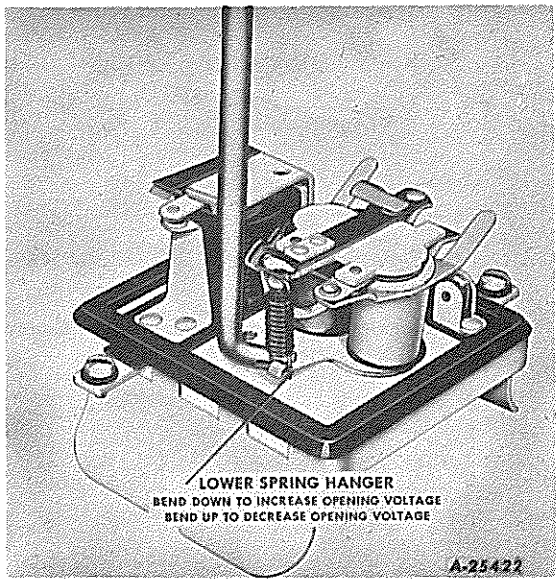
Illust. 15 - Checking and Adjusting Step-Voltage Control Armature Travel.



Illust. 16 - Checking and Adjusting Step-Voltage Control Contact Point Opening.

(d) POINT OPENING. Hold the armature down against the lower armature stop with the fingers placed on either side of the flat contact spring, and measure the contact point opening (Illust. 16). Adjust point opening by bending the contact spring post. Adjust the point opening to specifications listed in section 1.

(e) VOLTAGE SETTING. The voltage at which the step-voltage control contacts open is adjusted by bending the lower spring hanger (Illust. 17). Bend down to increase spring tension and opening voltage, and bend up to decrease the opening voltage. Adjust opening voltage to the specification listed in section 1. The voltage at which the step-voltage control contacts will close is changed by adjusting the air gap (Illust. 14). Increasing the air gap increases the closing voltage, while decreasing the air gap lowers the closing voltage. See "Specifications," section 1, for the proper closing voltage adjustment.



Illust. 17 - Opening Voltage Adjustment Step-Voltage Control.

NOTE: After this adjustment, it may be necessary to slightly readjust the contact point opening in order to keep it within the specifications listed in section 1.

4. REPOLARIZING THE GENERATOR

The generator must be re-polarized after tests and adjustments have been completed. Connect

all leads but, before the engine is started, proceed as follows: Use a jumper lead, and with one end on the "GEN" terminal on the regulator, touch the other end to the "BAT" terminal on the regulator. The resulting flash allows a surge of current to flow through the generator, which correctly polarizes it. Reverse polarity causes vibration, arcing and burning of the relay contact points, so establishing the proper polarity is important.

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IGNITION COIL

1. DESCRIPTION

The ignition coil transforms the low voltage of the batteries or generator into high voltage sufficient to jump the gaps at the spark plugs.

There are two windings in the coil. The primary winding is composed of a comparatively few turns of heavy wire wound on the outside of the secondary winding. The secondary winding is composed of many thousands of turns of fine wire.

Unless the coil is hermetically sealed, moisture in the form of rain, snow, road splash and high pressure washing, particularly when the engine and the coil are hot after working, tends to decrease the service that could otherwise have been expected.

2. REMOVAL

Remove the electrical leads from the coil, tagging each to facilitate correct replacement. Remove the cap screws which secure the coil.

3. INSPECTION AND REPAIR

Clean the terminals and lead ends. No repairs should be attempted if the coil is inoperative; replace with a new coil.

4. INSTALLATION

Install the coil in the reverse order of removal. Be sure that the connections are secure.

SPARK PLUGS

5. DESCRIPTION

The spark plug is made with a central electrode imbedded in porcelain or mica insulation which is securely clamped in the metal spark plug body. Attached to the lower end of the spark plug is the grounded electrode. The two electrodes are separated by the spark gap.

The function of the spark plug is to furnish a spark which jumps the gap and ignites the mixture of fuel and air in the cylinder.

A copper gasket is placed at the threaded end when the spark plug is screwed into position.

CAUTION: Never touch the spark plugs or the spark plug high tension cables while the engine is operating.

6. REMOVAL

NOTE: Before removing the spark plugs for inspection, blow the dirt away from the base of each plug to prevent the dirt from falling into the combustion chamber.

1. Disconnect the spark plug cables.

2. Unscrew the spark plugs with a spark plug wrench and remove the spark plugs and gaskets.

7. INSPECTION AND REPAIR

NOTE: The condition of a spark plug and the color of the deposits found on the plug along with the type of deposits can be used in analyzing engine performance. Refer to Illust. 2 through 7.

1. Remove oily deposits, using a petroluem solvent, and blow dry with compressed air. Sand blasting is the recommended method of cleaning spark plugs.

Do not use a wire brush to clean the spark plug electrodes. This will simply load the firing bore with electrically conductive metal

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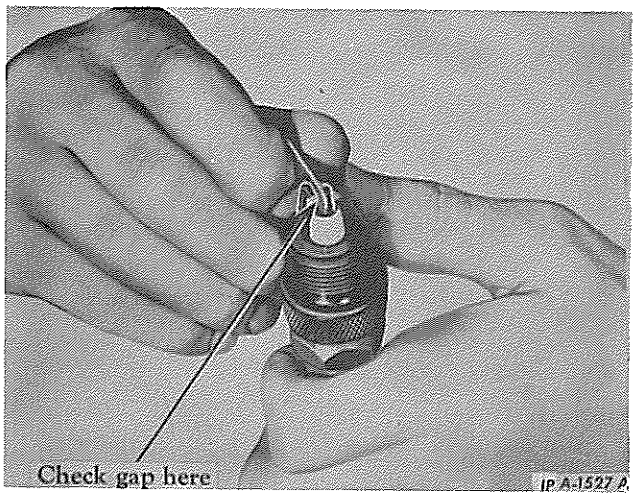


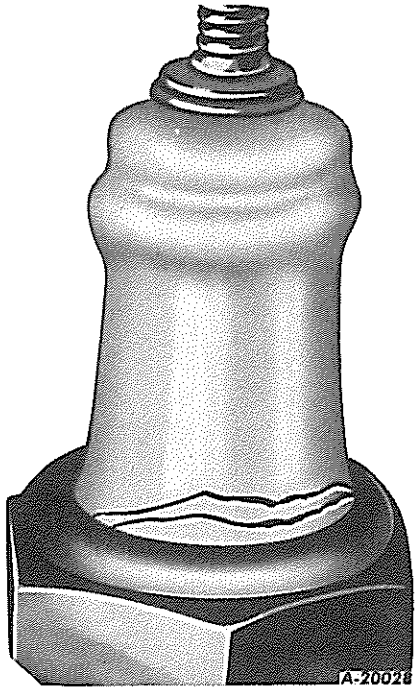
Illust. 1 - Checking Spark Plug Gap.

SPARK PLUGS

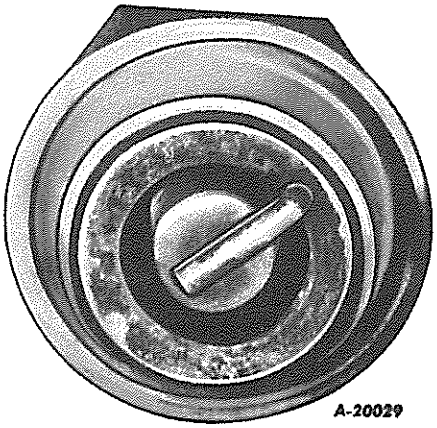
7. INSPECTION AND REPAIR - Continued

particles from the brush and cause misfiring when the plugs are reinstalled. Before setting the gap on used plugs that have the grounded electrode located directly above the center electrode, file the center electrode flat across the end. Use a wire gauge to measure the gap.

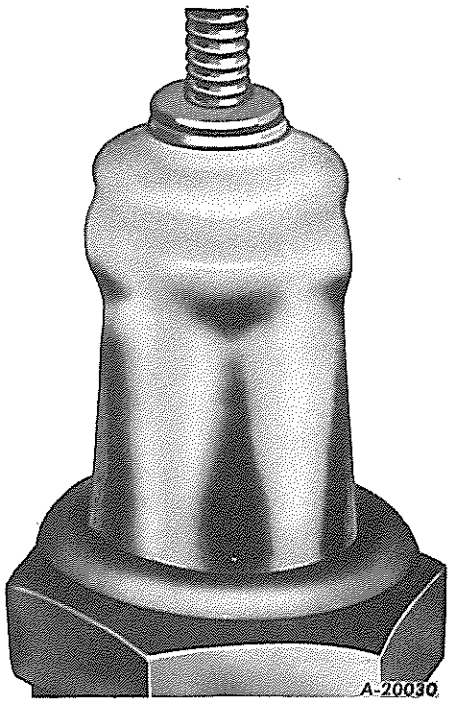
2. Never use any cleaning material on the insulation that may crack or chip it. Such cracks or chips will provide a recess for carbon deposits and provide a path for leakage of high tension current to ground.



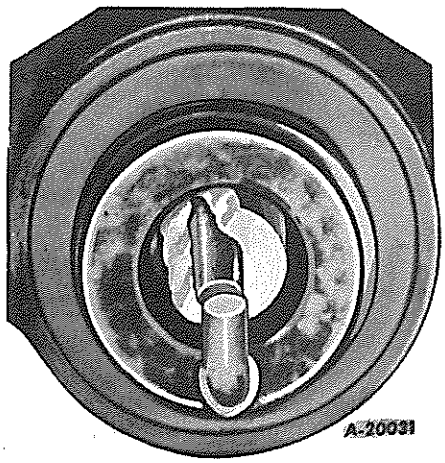
Illust. 2
Broken Insulator.
(Careless Handling)



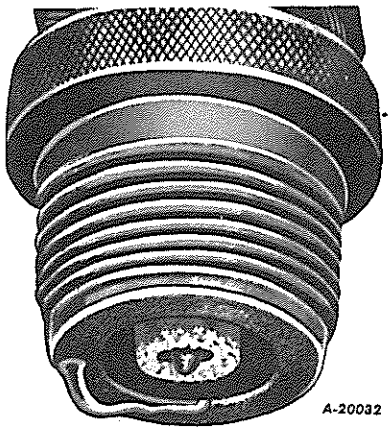
Illust. 3
Carbon Coating.
(Rich Mixture, Oil Pumping, or Cold Plug.)



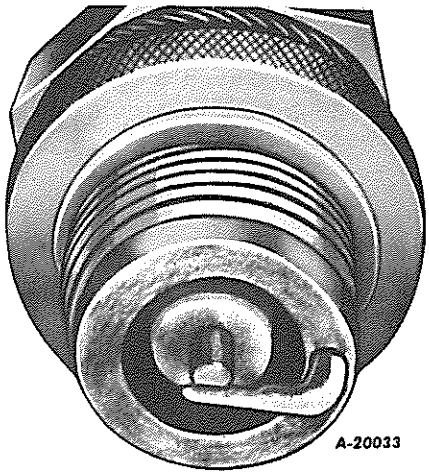
Illust. 4
Streaked Insulator Cap.
(Blow-By)



Illust. 5
Split Insulator.
(Bending Center Electrode)



Illust. 6
Badly Burned.
(Pre-Ignition or Poor Cooling)



Illust. 7
Worn Side Electrode.
(Loose Plug or Too Hot)

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SPARK PLUGS

3. Never scrape the insulator. Wipe clean with a clean rag dipped in solvent.

4. Never bend the center electrode. To do so will cause straining or cracking of the porcelain insulator. If the electrode burns off shorter than the shell skirt, replace the plug.

5. Never use graphite or other lubricants on the threads of spark plugs.

6. When removing or installing spark plugs, use only a correctly fitting socket wrench. An end wrench can easily slip and break the porcelain.

7. Do not screw a cold spark plug tightly into a hot cylinder head. Allow the cylinder head to cool first.

8. If a spark plug is thought to be faulty, it should be tested in a spark plug tester.

8. INSTALLATION

1. Before installing the spark plugs, clean the seats around the spark plug holes in the cylinder head.

2. Check the spark plug gaps.

3. Screw the spark plugs into the cylinder head, using a new copper gasket with each plug. Do not tighten more than enough to compress the gasket, to seal the plug and assure a good heat transfer between the plug and the cylinder head. Torque the spark plugs to the amount shown in Section 1 "GENERAL." If a torque wrench is not available, tighten the plug to 1/2 to 3/4 turns past finger-tight.

NOTE: If insufficient torque is applied, the plug gasket will not compress and seal properly; also heat transfer from the plug to the head will not be sufficient to keep the plug cool, possibly causing pre-ignition. An excessive amount of torque could change the carefully set plug gap or break the insulator seal; or the insulator itself could crack by distorting the plug shell.

4. Connect the spark plug cables in the proper firing order, which is 1, 5, 3, 6, 2, 4.

INSPECTION	REMEDY
1. Inspect for cracked or blistered insulation.	1. Replace spark plugs as necessary.
2. Inspect for dirty or excessively burned electrodes.	2. Clean dirty electrodes by scraping, brushing, or sand blasting. Replace spark plugs which have excessively burned electrodes. The sparking surfaces should be filed flat to obtain maximum firing surface.
3. Check gap between electrodes.	3. Adjust to the proper gap specified in your operators manual. Use a round wire gap gauge and pliers.
4. Inspect cables for defective insulation.	4. Replace oil soaked, worn, cracked or otherwise damaged cables, to eliminate the possibility of misfiring from this source.

OIL PRESSURE SWITCH (ON ENGINES SO EQUIPPED)

9. DESCRIPTION

The function of the oil pressure switch is to safeguard the engine in the event of oil pressure failure while operating on the gasoline (starting) cycle. The switch is located in the oil header on the right side of the crankcase, and it consists mainly of a diaphragm, spring, contact points and terminals.

To start the engine, put the ignition switch in the ignition position and operate the starter. When the engine starts, the oil pressure builds up and causes the switch to close the contacts in the switch circuit which is connected across the ignition switch. When the ignition switch is released, the engine will continue to operate while oil pressure of about eight pounds is maintained.

10. REMOVAL

Disconnect the electrical leads to the switch, tagging each to facilitate replacement. Use an open end wrench to unscrew the switch from the crankcase.

11. INSPECTION AND REPAIR

Clean terminals and lead ends with a wire brush. If the switch is faulty, other than adjustment, replace it.

12. INSTALLATION

Install the switch in the reverse order of removal.

13. ADJUSTMENT

Remove the ferrule and the switch case. Loosen the set screw and adjust until the switch closes with engine oil pressure of six to ten pounds per square inch. Tighten the set screw and install the ferrule and switch case.

STORAGE BATTERY

14. GENERAL

The purpose of the storage battery is to provide energy for starting the engine and to supply, for a limited period of time, electrical loads exceeding the output of the generator.

The amount of energy that a fully charged battery can produce depends primarily upon the size and number of the plates.

The total energy that a good battery can produce when at full charge is indicated by its ampere hour rating. A 120-ampere-hour battery has greater capacity for storing energy and doing work than a 100-ampere hour battery because the 120-ampere hour battery has larger plates or a greater number of plates.

The ampere hour rating of a battery is usually stamped or printed on the battery case.

A battery should be maintained at not less than 3/4 full charge in normal operation. If it is found that the battery is less than 3/4 charged, it is almost certain that some condition exists which should be corrected.

15. COMMON CAUSES OF BATTERY FAILURE

1. Resistance in the charging circuit.

2. Defective generator or slipping generator drive belt.

3. Improper regulator adjustment or faulty regulator.

4. Overload due to defective starting circuit or excessive use of accessories.

5. Dirt and electrolyte on top of battery causing a constant drain.

6. Hardened battery plates, commonly called

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STORAGE BATTERY

"sulphation," due to the battery being in a low state of charge over a long period of time.

7. Physical defects such as shorted cells, loss of active material from the plates, broken terminals, etc.

It is important to note that, of the seven common causes of battery failure listed above, the first five causes are outside the battery. Any one of these conditions will result in a battery being at less than normal state of charge.

The sixth cause listed can result from any one of the first five causes. That is, sulphation occurs when any condition causes the battery to be undercharged for long periods of time. When a battery becomes sulphated, it will not accept a normal rate of charge and, also, its capacity decreases. Sulphation can usually be overcome by prolonged slow charging or by discharging the battery completely, letting it stand discharged for 6 to 12 hours and then recharging it slowly.

The causes of battery failure listed in paragraph 15, item 7, are the defects that can occur in the battery itself. If shorted cells or loss of active material from the plates occurs when the battery has been in service for less than its guaranteed life, it is usually a result of overworking or overcharging of the battery. Cracked cases, broken terminals and, also, shorted cells can be caused by improper handling of the battery or a faulty battery carrier.

NOTE: When a battery fails, do not be satisfied to merely recharge or replace it. Find the cause of failure to prevent a recurrence.

16. BATTERY VISUAL INSPECTION

The battery should always be very carefully inspected before the actual testing is done. Many undesirable conditions can be seen and corrected before they result in battery trouble. Other visible indications are very important when analyzing the hydrometer readings.

Procedure

1. Inspect the battery case for cracks and leaks.

2. Inspect battery posts, clamps, and cables for breakage, loose connections, corrosion and other faults.

3. Note whether the top of the battery is clean and dry. Dirt and electrolyte on top of the battery causes excessive self-discharge.

4. Be sure that the cell vents are open.

5. Be sure that the battery carrier is solidly mounted and in good condition, and that the battery hold-down is properly tightened. A loose battery carrier or battery hold-down will allow the battery to be damaged by vibration and jarring. An excessively tightened battery hold-down may buckle or crack the battery case.

6. Inspect battery for raised cell covers or warped case which may indicate that the battery has been overheated or overcharged at some time.

7. Inspect electrolyte level. Electrolyte level should be 1/4 to 1/2 inch above the plates. If electrolyte is below the top of the plates, add

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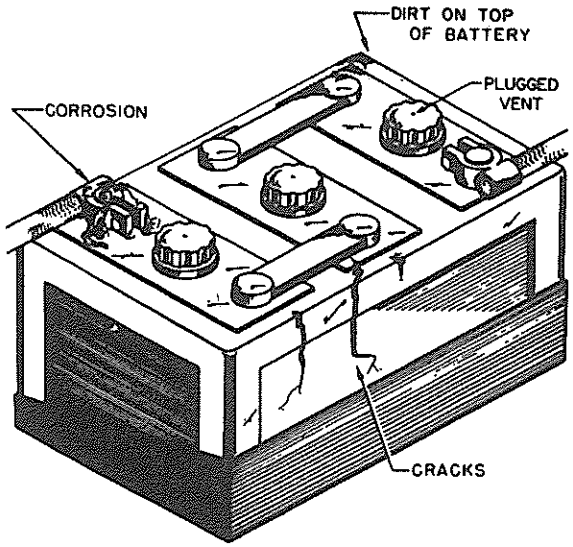


Illust. 8 - Battery Visual Inspection.

STORAGE BATTERY

16. BATTERY VISUAL INSPECTION – Continued

water. If not below the plates, make hydrometer test before adjusting electrolyte level.

8. Note the ampere hour rating of the battery (usually stamped on the case). If not indicated, refer to the manufacturer's specifications for battery capacity.

NOTE: Make battery visual and hydrometer test; then, see battery test indications and recommendations.

17. SPECIFIC GRAVITY TEST

A hydrometer is used to test the specific gravity (weight) of the battery electrolyte. The weight of the electrolyte indicates the approximate state of charge of the battery. A temperature corrected hydrometer must be used when testing specific gravity of battery fluid so that the hydrometer readings can be corrected for the effects of temperature and the true specific gravity determined.

Procedure

NOTE: If water has been recently added to the cells or the battery fast-charged, the hydrometer reading will be false.

1. Remove cell caps, being careful to keep dirt out of cells.

2. Draw enough fluid into the hydrometer from one cell to raise the float off the bottom of the tube but not enough for the float to touch the top of the tube.

3. Hold the hydrometer straight, so that the neck of the float does not touch the sides of the tube, and take the reading at eye-level.

4. Return all the fluid from the hydrometer to the cell being tested and record the reading for that cell.

5. Test the remaining cells in the same manner. Then note the reading on the thermometer on the side of the hydrometer and correct to standard reading at 80° F by referring to the following table.

At the top of the table, find the column headed by the temperature nearest to the electrolyte temperature; find in that column the figure nearest the observed specific gravity reading and trace horizontally across to the 80° F. column. The figure in the 80° F. column is the true electrolyte specific gravity and should form the basis for any adjustment.

0°F	20°F	40°F	80°F	100°F	110°F	120°F
1.251	1.243	1.236	1.220	1.213	1.209	1.205
1.261	1.253	1.246	1.230	1.223	1.219	1.215
1.271	1.263	1.256	1.240	1.233	1.229	1.225
1.281	1.273	1.266	1.250	1.243	1.239	1.235
1.291	1.283	1.276	1.260	1.252	1.248	1.245
1.301	1.294	1.286	1.270	1.262	1.258	1.255
1.312	1.304	1.296	1.280	1.272	1.268	1.265

CAUTION: Some batteries have approximately 20 points lower specific gravity at any given state of charge than standard batteries. Refer to manufacturer's specifications for proper information.

18. BATTERY TEST INDICATIONS AND RECOMMENDATIONS

Specific Gravity Above 1.290

Possible battery overcharge. See NOTE 2.

Specific Gravity Below 1.225

The battery is undercharged. Recharge to full specific gravity. Also see NOTE 1.

Low Temperature

Low temperature reduces capacity by retarding chemical reaction. Slow-charge battery until temperature is at least 60° F., and recheck specific gravity.

Hard Plates

Battery plates become hard (sulphated) if the battery is not maintained above approximately 1.240 specific gravity. Cycle the battery by discharging completely with a lamp load, then

STORAGE BATTERY

recharging at a VERY SLOW RATE. Also see NOTE 1.

New Battery

Sometimes a new battery does not reach full capacity until in normal use for 60 to 90 days. If necessary, as in cold weather, the battery can usually be brought quickly to full capacity by cycling.

Worn Out

A battery gradually loses active material from the plates in normal use, and more rapidly if overworked. When too much active material has been lost, the battery cannot be depended upon for cold weather starting or other severe operation, even when fully charged, and can be considered to be worn out.

Defective Cells

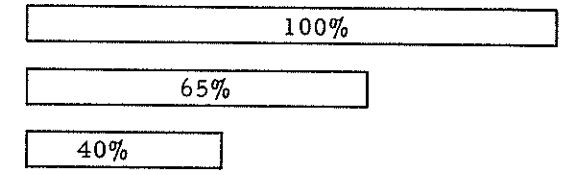
A defective cell or cells will result in low capacity and is indicated by wide variation in specific gravity readings between cells.

NOTE 1: A battery must be maintained at a specific gravity of at least 1.250 to prevent sulphation (hardening) of the battery plates, to assure cold weather starting, and normal battery life. Undercharging can be caused by low voltage regulator setting, high charging circuit resistance, high cranking motor amperage draw, faulty generator or generator drive belt, excessive use of accessories, etc.

NOTE 2: Overcharging of a battery can be caused by high voltage regulator setting or the battery being exposed to abnormally high external temperatures. Overcharging is indicated by excessive use of water, extremely high specific gravity and, eventually, raised cell covers and warped battery case.

19. EFFECT OF LOW TEMPERATURES ON BATTERY PERFORMANCE

Battery capacity is greatly reduced by cold, as cold has a decided numbing effect on the electro-chemical action in the battery. The following comparison indicates the reduction in cranking power of a fully charged battery when the temperature of the electrolyte drops from 80° F. to 32° F. and to 0° F.



The electrolyte of a battery will start to freeze (first ice crystals begin to appear in the electrolyte although it does not freeze solid until a lower temperature is reached) approximately as indicated below (specific gravity readings corrected to 80° F.):

1.280 sp. gr. . . . . Freezes at - 90° F.
1.250 sp. gr. . . . . Freezes at - 62° F.
1.200 sp. gr. . . . . Freezes at - 16° F.
1.150 sp. gr. . . . . Freezes at + 5° F.
1.100 sp. gr. . . . . Freezes at + 19° F.

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