INTERNATIONAL 221, 263 SERIES CARBURETED AND 236, 282 SERIES DIESEL ENGINES

CONTENTS

PRINTED IN UNITED STATES OF AMERICA

The instructions contained in this service manual are for the information and guidance of servicemen who are responsible for overhauling and repairing any part of International 221 and 263 Series Carbureted Engines and 236 and 282 Series Diesel Engines.

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

LUBRICATION

Instruction on the lubrication of each assembly is given in the Lubrication Chart in the Operator's Manual for the particular engine. 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.

GASKETS AND SEALS

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

DIESEL FUEL SYSTEM

If detailed information on the diesel fuel system is desired, refer to the "ROOSA MASTER FUEL INJECTION PUMP MANUAL," ISS-1042.

SERVICE TOOLS

International carbureted and diesel engines are designed so that few service tools are required other than those in the mechanic's tool kit. However, when the use of inexpensive special service equipment will facilitate work, such equipment is mentioned in this manual. Other than this, it is assumed that servicemen will select such tools as are required. Information regarding most special tool equipment is given in the "SERVICE TOOLS MANUAL," ISS-1002. The IH Construction Equipment distributors and dealers have most of this equipment and are in an excellent position to service these engines.

SERVICE PARTS

IH Engines deserve genuine IH service parts. The best material obtainable and experience gained through many years of engine manufacturing, 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 that particular engine. The loose-leaf parts catalogs are accurate and are brought up to date continually by issuing new pages covering any changes in part numbers.

SERIAL NUMBERS

The engine serial number is stamped on the crankcase where it is plainly visible.

ENGINE APPLICATION CHART

Series	Machines Used On
221	UC-221
263	UC-263 T-6 (62 Series)
236	UD-236
282	UD-282 TD-6 (62 Series) TD-9 (92 Series) (turbocharged) TD-9 (Series B) Model 150 Loader TD-9 (Series B) Agricutural Tractor

PRINTED IN UNITED STATES OF AMERICA

1. DESCRIPTION

The 221, 263 series carbureted and 236, 282 series diesel engines are all six cylinder in line, valve-in-head, four cycle engines.

The carbureted and diesel engines are almost identical in design, the basic difference being the fuel and the compression ratios. The higher compression ratio is necessary for diesel engines.

The crankshaft main and connecting rod bearing journals are fully hardened. The main bearings support the crankshaft with the No. 3 bearing absorbing the crankshaft end thrust. These bearings are the precision insert type and require no machining during assembly or replacement.

The camshaft is supported by bearings and is driven by the crankshaft gear. The end thrust of the camshaft is controlled by a thrust flange located between the front camshaft journal and the camshaft gear.

The pistons are cam ground and are fitted with two compression and one oil control ring. The full-floating type piston pins are held in place by snap rings at each end of the pin.

The cylinder sleeves are the replaceable dry type and are specially hardened for maximum service.

The connecting rods are heat-treated pressed steel and contain a bronze bushing at the upper end. The lower end and cap contain the locking type selective fit bearing inserts which require no machining during assembly or replacement. The rods and caps are numbered for identification and reassembly.

The full pressure lubrication system assures positive lubrication to all working parts. A gear type oil pump is internally mounted to the bottom of the crankcase and is gear driven by the camshaft. Oil is drawn from the oil pan by the pump through a screened float and is distributed under pressure, through rifle-drilled passages in the crankcase, crankshaft and cylinder head. A single element full-flow lubricating oil filter effectively cleans all of the lubricating oil. A crankcase breather and cylinder head breather assures positive crankcase ventilation.

Coolant is circulated through the engine and radiator by a belt driven centrifugal water pump mounted at the front of the engine. The thermostat, located in the water outlet, controls the coolant temperature in the system.

The diesel fuel system consists of the fuel lines, fuel filters, a water trap, an injection pump, injection nozzles and lines. For complete detailed information on all diesel fuel system components, refer to the "ROOSA MASTER FUEL INJECTION PUMP SERVICE MANUAL," ISS-1042.

The carbureted fuel system consists of the fuel pump and filter, carburetor and fuel pipe and connections. Further information on the carbureted fuel system can be found in the sections of this book covering each of the components of the fuel system.

DESCRIPTION	221 Series	263 Series	236 Series	282 Series
GENERAL DATA				
Number of cylinders	6	6	6	6
Type of cylinder sleeves	Replaceable dry	Replaceable dry	Replaceable dry	Replaceable dry
Bore and stroke - inches	3-9/16 x 3-11/16	3-9/16 x 4.390	3-11/16 x 3-11/16	3-11/16 x 4.390
Displacement - cubic inches	221	263	236	282
Engine speed - rpm				
Full load, governed	2400	2400 (Power Unit) 1550 (T-6 (62)	2400 ± 10	2400 ± 10 (Power Unit) 1550 ± 10 (TD-6(62) 1700 ± 10 (TD-9(92)
High idle	2640 ± 25	2640 ± 25 (Power Unit) 1770 ± 25 (T-6(62)	2615 ± 40	2615 ± 40 (Power Unit) 1690 ± 30 (TD-6(62) 1855 ± 35 (TD-9(92)
Low idle	450 to 550	450 to 550 (P.U.) 425 ± 25 (T-6(62)	650 ± 25	650 ± 25
Compression ratio	7.2:1	7.2:1	17.6:1	18:1
Compression pressure psi (measured at cranking motor speed at sea level)	145 to 165	145 to 165	350 - 400	350 - 400
(naturally aspirated - measured at 1000 rpm)	- - - - - -	- - - - - -	- - - - - -	515
Firing order	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4
Fuel	Gasoline	Gasoline	Diesel	Diesel
CRANKSHAFT				
Crankpin diameter - inches	2.373 to 2.374	2.373 to 2.374	2.373 to 2.374	2.373 to 2.374
Main journal diameter - inches	2.748 to 2.749	2.748 to 2.749	2.748 to 2.749	2.748 to 2.749
Maximum permissible journal out-of-roundness- inch	.004	.004	.004	.004
Number of main bearings	4	4	4	4
Main bearing running clearance-inch	.0012 to .0042	.0012 to .0042	.0012 to .0042	.0012 to .0042
Maximum permissible main bearing running clearance-inch	.0060	.0060	.0060	.0060
End clearance - inch	.005 to .013	.005 to .013	.005 to .013	.005 to .013
Maximum permissible end clearance - inch	.024	.024	.024	.024
Main bearing bore in crankcase (Line reamed), inches	2.941 to 2.942	2.941 to 2.942	2.941 to 2.942	2.941 to 2.942

ISS-1040A (4-63)
PRINTED IN UNITED STATES OF AMERICA

DESCRIPTION	221 Series	263 Series	236 Series	282 Series
CAMSHAFT				
Running clearance - inch	.0005 to .0050	.0005 to .0050	.0005 to .0050	.0005 to .0050
Maximum permissible running clearance - inch	.006	.006	.006	.006
End clearance - inch	.002 to .010	.002 to .010	.002 to .010	.002 to .010
Maximum permissible end clearance - inch	.025	.025	.025	.025
Service bushings furnished	Reamed to size	Reamed to size	Reamed to size	Reamed to size
Maximum permissible camshaft lobe wear - inch	.020	.020	.020	.020
Number of bearings	4	4	4	4
Bearing journal diameter - inches				
Front	2.109 to 2.110	2.109 to 2.110	2.109 to 2.110	2.109 to 2.110
Second	2.089 to 2.090	2.089 to 2.090	2.089 to 2.090	2.089 to 2.090
Third	2.069 to 2.070	2.069 to 2.070	2.069 to 2.070	2.069 to 2.070
Rear	1.4995 to 1.5005	1.4995 to 1.5005	1.4995 to 1.5005	1.4995 to 1.5005
Backlash - inches	.0032 to .0076	.0032 to .0076	.0032 to .0076	.0032 to .0076
Cam lobe lift (total)	.2647 ± .002	.2647 ± .002	.2647 ± .002	.2647 ± .002
CONNECTING RODS				
Side clearance on crankshaft-inch	.007 to .013	.007 to .013	.007 to .013	.007 to .013
Maximum permissible side clearance on crankshaft - inch	.013	.013	.013	.013
Bearing running clearance - inch	.0009 to .0034	.0009 to .0034	.0009 to .0034	.0009 to .0034
Maximum permissible bearing running clearance - inch	.0050	.0050	.0050	.0050
Bearing O.D. and spread	2.500 + .030	2.500 + .030	2.500 + .030	2.500 + .030
Connecting rod bolts				
Number per rod	2	2	2	2
Length - inches	1-7/8	1-7/8	1-7/8	1-7/8
Diameter and thread	3/8 x 24NF	3/8 x 24NF	3/8 x 24NF	3/8 x 24NF
PISTONS				
Skirt clearance - measured 90° from pin hole at				
Bottom - inch	.0015 to .0025	.0015 to .0025	.0040 to .0056	.0040 to .0056
Top - inch	.0020	.0020	.0068	.0068
Number of rings per piston	3	3	3	3
Piston pin hole bore	.8751 to .8752	.8751 to .8752	.8749 to .8751	.8749 to .8751 * 1.249 to 1.251 **

* - Small diameter piston pin used on early UD-282 engines.
** - Large diameter piston pin used on late UD-282 and all 62 series and 92 series crawler tractor engines.

DESCRIPTION	221 Series	263 Series	236 Series	282 Series
PISTONS - Continued				
Width of ring groove				
Top compression-inch	.097 to .098	.097 to .098	Tapered	Tapered
Second compression - inch	.0955 to .0965	.0955 to .0965	.1265 to .1275	.1265 to .1275
Oil control - inch	.2505 to .2515	.2505 to .2515	.2515 to .2525	.2515 to .2525
Ring clearance in groove				
Top compression - inch	.0035 to .0050	.0035 to .0050	Tapered	Tapered
Second compression-inch	.0020 to .0035	.0020 to .0035	.0025 to .0040	.0025 to .0040
Oil control - inch	.0031 to .0074	.0031 to .0074	.0025 to .0040	.0025 to .0040
Maximum permissible ring clearance in groove - inch	.008	.008	.0100	.0100
PISTON RINGS - Compression				
Number of rings per piston	2	2	2	2
Type (face and finish)				
Top	Chrome, T.F.	Chrome, T.F.	Chrome $\frac{1}{2}$ Keystone	Chrome $\frac{1}{2}$ Keystone
Second	Counterbored	Counterbored	Taper face-Chrome	Taper face-Chrome
Width				
Top - inch	.0930 to .0935	.0930 to .0935	Tapered	Tapered
Second - inch	.0930 to .0935	.0930 to .0935	.1235 to .1240	.1235 to .1240
Ring gap (top compression rings) - inch	.010 to .020	.010 to .020	.015 to .025	.015 to .025
Ring gap (second compression rings) - inch	.010 to .020	.010 to .020	.010 to .020	.010 to .020
Maximum permissible ring gap-inch	.060	.060	.070	.070
PISTON RINGS - Oil Control				
Number of rings per piston	1	1	1	1
Type	Wide slot	Wide slot	Chrome-wide slot	Chrome-wide slot
Width - inch	.2441 to .2474	.2441 to .2474	.2485 to .2490	.2485 to .2490
Ring gap - inch	.018 to .028	.018 to .028	.010 to .023	.010 to .023
Maximum permissible ring gap - inch	.060	.060	.060	.060
Oil ring expander	Flat spring	Flat spring	Coil spring	Coil spring

DESCRIPTION	221 Series	263 Series	236 Series	282 Series
PISTON PINS				
Diameter - inches (standard)	.8748 to .8749	.8748 to .8749	.8748 to .8749	.8748 to .8749 * 1.1247 to 1.1249 **
(oversize)	.8799 ± .0001	.8799 ± .0001	.8798 to .8799	.8798 to .8799 * 1.1297 to 1.1299 **
Pin length - inches	2.9505 ± .0055	2.9505 ± .0055	2.945 to 2.956	2.945 to 2.956 * 3.127 to 3.138 **
Clearance Between end of pin and retainer ring - inch	.009 to .030	.009 to .030	.013 to .035	.013 to .035 * .017 to .041 **
Clearance in rod bushing - inch	.0002 to .0005	.0002 to .0005	.0002 to .0007	.0002 to .0007 * .0005 to .0009 **
Maximum permissible clearance in rod bushing - inch	.0015	.0015	.0040	.0040
Clearance in piston - inch	.0002 to .0004	.0002 to .0004	.0000 to .0003	.0000 to .0003 * .0000 to .0004 **
Maximum permissible clearance in piston - inch	.0015	.0015	.0025	.0025
Piston pin bushing, finish reamed	.8751 to .8753	.8751 to .8753	.8751 to .8755	.8751 to .8755 * 1.1254 to 1.1256 **
CYLINDER SLEEVES				
Type	Dry	Dry	Dry	Dry
Fit	.0006 in. tight	.0006 in. tight	Hand push	Hand push
Wall thickness - inch	1/16	1/16	1/16	1/16
Sleeve OD - inches	3.6876 to 3.6886	3.6876 to 3.6886	3.8112 to 3.8122	3.8112 to 3.8122
Sleeve ID - inches	3.5608 to 3.5628	3.5608 to 3.5628	3.6875 to 3.6891	3.6875 to 3.6891
Maximum permissible sleeve wear (ID), inch	.0100	.0100	.0100	.0100
Maximum permissible taper in sleeve (ID), inch	.0100	.0100	.0100	.0100
Maximum permissible out-of-round (ID), inch	.0100	.0100	.0050	.0050
Crankcase bore for sleeve	3.6875 to 3.6890	3.6875 to 3.6890	3.8125 to 3.8135	3.8125 to 3.8135
Height of sleeve flange above crankcase, inch	.000 to .007	.000 to .007	.001 to .005	.001 to .005
Flange thickness, inch	.188 to .191	.188 to .191	.186 to .189	.186 to .189

* - Small diameter piston pin used on early UD-282 engines.
** - Large diameter piston pin used on late UD-282 and all 62 Series, 92 Series and TD-9B crawler tractor and 150 loader engines.

DESCRIPTION	221 Series	263 Series	236 Series	282 Series
INTAKE VALVES				
Stem diameter, inch	.3715 to .3725	.3715 to .3725	.3715 to .3725	.3715 to .3725
Port diameter, inches	1.38	1.50	1.30	1.30
Head diameter, inches	1.651 to 1.661	1.651 to 1.661	1.647 to 1.657 ***	1.647 to 1.657 ***
			1.674 to 1.684 ****	1.674 to 1.684 ****
Stem clearance in guide, inch	.003 to .005	.003 to .005	.0015 to .0040	.0015 to .0040
Maximum permissible stem clearance in guide, inch	.0080	.0080	.0080	.0080
Valve face angle, between seat and bottom of valve head, degrees	30	30	45	45
Valve seat angle in cylinder head, degrees	30	30	45	45
Tappet clearance				
Hot-inch	.027	.027	.027	.027
Cold - inch	.030	.030	.030	.030
EXHAUST VALVES				
Stem diameter, inch	.371 to .372	.371 to .372	.3715 to .3725	.3715 to .3725
Port diameter, inches	1.31	1.31	.980	.980
Head diameter, inches	1.511 to 1.521	1.511 to 1.521	1.295 to 1.305 ***	1.295 to 1.305 ***
			1.370 to 1.380 ****	1.370 to 1.380 ****
Stem clearance in guide, inch	.0035 to .0055	.0035 to .0055	.0015 to .0040	.0015 to .0040
Maximum permissible stem clearance in guide, inch	.0080	.0080	.0080	.0080
Valve face angle, between seat and bottom of cylinder head, degrees	30	30	45	45
Valve seat angle in cylinder head, degrees	30	30	45	45
Tappet clearance				
Hot, inch	.027	.027	.027	.027
Cold, inch	.030	.030	.030	.030

*** - TD-9BGM-6081 and below; TD-9BGAM-6081 and below; TD-9BPM-6081 and below; L-150GM-6081 and below; L-150PM -6081 and below; also UD-282M-3623 and below; TD-62M-2215 and below, and UD-236M-2873 and below.
**** - TD-9BGM-6082 and up; TD-9BGAM-6082 and up; TD-9BPM-6082 and up; L-150GM-6082 and up; L-150PM-6082 and up; Also UD-282M-3624 and up; TD-62M-2216 and up, and UD-236M-2874 and up.

ISS-1040A (4-63)
PRINTED IN UNITED STATES OF AMERICA

DESCRIPTION	221 Series	263 Series	236 Series	282 Series
INTAKE AND EXHAUST VALVE GUIDES				
Length, inches	2.50 ± .031	2.50 ± .031	2.85	2.85
Inside diameter, inch	.3755 to .3765	.3755 to .3756	.3740 to .3755	.3740 to .3755
Set height of guide measured up from	Spring recess	Spring recess	Spring recess	Spring recess
Intake, inches	1.19 to 1.25	1.19 to 1.25	.938	.938
Exhaust, inch	.81 to .87	.81 to .87	.938	.938
INTAKE AND EXHAUST VALVE SPRINGS				
Outside diameter, inches *	1.2813	1.2813	1.2813	1.2813
**	-	-	1.273	1.273
Free length, inches *	2.438	2.438	2.438	2.438
**	-	-	2.242	2.242
Test length, inches *	1.592	1.592	1.592	1.592
**	-	-	1.363	1.363
Test load, pounds *	152.7 ± 5	152.7 ± 5	152.7 ± 5	152.7 ±5
**	-	-	159 - 164	159 - 164
VALVE LEVER AND SHAFT				
Valve lever shaft diameter, inch	.748 to .749	.748 to .749	.748 to .749	.748 to .749
Running clearance, valve lever on shaft, inch	.0015 to .0040	.0015 to .0040	.0015 to .0040	.0015 to .0040
Maximum permissible running clearance, valve lever on shaft, inch	.0100	.0100	.0100	.0100
Valve lever bushing Inside diameter, inch	.7505 to .7520	.7505 to .7520	.7505 to .7520	.7505 to .7520
VALVE TAPPETS				
Diameter	.9975 to .9985	.9975 to .9985	.9975 to .9985	.9975 to .9985
Bore in crankcase	.9999 to 1.0005	.9999 to 1.0005	.9999 to 1.0005	.9999 to 1.0005
Clearance in bore	.0014 to .0030	.0014 to .0030	.0014 to .0030	.0014 to .0030
Maximum permissible clearance in bore	.0100	.0100	.0100	.0100

* - Part No. 367 192 R1
** - Part No. 315 744 R1

DESCRIPTION	221 Series	263 Series	236 Series	282 Series
VALVE TIMING				
Intake opens-degrees before TDC	12°	12°	12°	12°
Intake closes - degrees after BDC	38°	38°	38°	38°
Exhaust opens - degrees before BDC	55°	55°	55°	55°
Exhaust closes - degrees after TDC	15°	15°	15°	15°
VALVE PUSH ROD				
Diameter - inch	3/8	3/8	3/8	3/8
Length - inches	12-17/32	12-17/32	12-17/32	12-17/32
CYLINDER HEAD STUDS				
Diameter - inch	1/2-13	1/2-13	1/2-13	1/2-13
CYLINDER HEAD GASKET				
Thickness (compressed) - inch	.048 ± .003	.048 ± .003	.048 to .050	.048 to .050
TIMING GEARS				
Backlash between any pair of gears - inch (except idler and injection pump gear)	.003 to .007	.003 to .007	.003 to .007	.003 to .007
Backlash between idler gear and injection pump gear - inch	- -	- -	.003 to .009	.003 to .009
Maximum permissible back lash between any pair of gears-inch	.0100	.0100	.0100	.0100
Idler gear end clearance - inch	.009 to .011	.009 to .011	.009 to .011	.009 to .011
Maximum permissible idler gear end clearance, - inch	.0250	.0250	.0250	.0250
Idler gear bushing to shaft clearance - inch	.0010 to .0023	.0010 to .0023	.0010 to .0023	.0010 to .0023
Maximum permissible idler gear bushing-to-shaft clearance, inch.	.0060	.0060	.0060	.0060
Idler gear bushing ID - inches	2.0625 to 2.0650	2.0625 to 2.0650	2.0625 to 2.0650	2.0625 to 2.0650
LUBRICATING SYSTEM				
Type	Forced feed	Forced feed	Forced feed	Forced feed
Oil filter (Purolator, radial fin) - type	Full flow	Full flow	Full flow	Full flow
Number used	1	1	1	1

ISS-1000A (4-63)
PRINTED IN UNITED STATES OF AMERICA

DESCRIPTION	221 Series	263 Series	236 Series	282 Series
LUBRICATING OIL VALVE LOCATIONS				
Pressure regulating	Filter base	Filter base	Filter base	Filter base
By-pass	Center tube	Center tube	Center tube	Center tube
LUBRICATING OIL VALVE SPRINGS				
Pressure regulating				
Free length - inches	3	3	3	3
Test length - inches	1-13/16	1-13/16	1-13/16	1-13/16
Test load - pounds	18	18	18	18
By-pass				
Free length - inches	2.231	2.231	2.231	2.231
Test length - inches	2	2	2	2
Test load - pounds	3.4	3.4	3.4	3.4
PRESSURE REGULATING VALVE				
Opening pressure - psi	30 to 40	30 to 40	30 to 40	30 to 40
Valve diameter - inch	.743 to .745	.743 to .745	.743 to .745	.743 to .745
Valve clearance in bore - inch	.002 to .007	.002 to .007	.002 to .007	.002 to .007
LUBRICATING OIL PUMP				
End play between gear and end plate - inch	.0025 to .0055	.0025 to .0055	.0025 to .0055	.0025 to .0055
Clearance, gear to housing-inch	.0068 to .0108	.0068 to .0108	.0068 to .0108	.0068 to .0108
Backlash between idler and body gears-inch	.003 to .006	.003 to .006	.003 to .006	.003 to .006
Backlash between drive pinion and camshaft - inch	.000 to .008	.000 to .008	.000 to .008	.000 to .008
Drive shaft diameter - inch	.4885 to .4890	.4885 to .4890	.4885 to .4890	.4885 to .4890
Drive shaft running clearance-inch	.0015 to .0030	.0015 to .0030	.0015 to .0030	.0015 to .0030
Idler gear running clearance-inch	.0025 to .0045	.0025 to .0045	.0025 to .0045	.0025 to .0045
Idler gear shaft diameter-inch	.4845 to .4855	.4845 to .4855	.4845 to .4855	.4845 to .4855
OIL PUMP SHAFT SUPPORT ASSEMBLY				
Support housing bushing ID, inch				
Upper	.6859 to .6865	.6859 to .6865	.6859 to .6865	.6859 to .6865
Lower	.4909 to .4915	.4909 to .4915	.4909 to .4915	.4909 to .4915
Pinion shaft OD-inch (Bearing contact surfaces)				
Upper	.6845 to .6850	.6845 to .6850	.6845 to .6850	.6845 to .6850
Lower	.4895 to .4900	.4895 to .4900	.4895 to .4900	.4895 to .4900

DESCRIPTION	221 Series	263 Series	236 Series	282 Series
GOVERNOR - Continued				
Governor shaft dimensions				
Sleeve contact area - inch	.3735 to .3745	.3735 to .3745	- - - - - -	- - - - - -
Carrier contact area - inch	.4723 to .4726	.4723 to .4726	- - - - - -	- - - - - -
Sleeve I.D. - inch	.377 to .382	.377 to .382	- - - - - -	- - - - - -
Rockshaft bushing I.D. - inch	.375 to .376	.375 to .376	- - - - - -	- - - - - -
Governor shaft bushing I.D. - inch	.375 to .376	.375 to .376	- - - - - -	- - - - - -
IDLER GEAR AND SHAFT				
Shaft length - inch	1.635 to 1.637	1.635 to 1.637	1.635 to 1.637	1.635 to 1.637
Shaft O.D. - inch	2.0610 to 2.0615	2.0610 to 2.0615	2.0610 to 2.0615	2.0610 to 2.0615
Shaft lubrication	Pressure drilled	Pressure drilled	Pressure drilled	Pressure drilled
Bushing I.D. - inch	2.0625 to 2.0650	2.0625 to 2.0650	2.0625 to 2.0650	2.0625 to 2.0650
Bushing clearance on shaft - inch	.0010 to .0023	.0010 to .0023	.0010 to .0023	.0010 to .0023
End clearance on shaft - inch	.009 to .011	.009 to .011	.009 to .011	.009 to .011
Gear backlash	.003 to .007	.003 to .007	.003 to .006	.003 to .006
GOVERNOR SPRING				
Test length - inch	3.59	3.59	- - - - - -	- - - - - -
Test load - pounds	64.4	64.4	- - - - - -	- - - - - -
Minimum length in use - inch	2.35	2.35	- - - - - -	- - - - - -
Maximum length in use - inch	3.59	3.59	- - - - - -	- - - - - -
FLYWHEEL HOUSING SAE No. 3 Flange	When assembled on the engine, the large bore of the housing is to be concentric with the crankshaft within .008 inch total indicator reading. The rear face of the housing is to be square with the crankshaft within .008 inch total indicator reading.			
GLOW PLUG				
Operating temperature degrees F	- - - - - -	- - - - - -	1800 - 1900	1800 - 1900
Glow plug rating (11 or 24 Volts) watts	- - - - - -	- - - - - -	95	95
SPARK PLUG				
Gap, inch (gasoline)	.023-.028	.023 - .028	-	-
(LPG or Natural Gas)	.015-.020	.015 - .020	-	-
Thread size, inch	18 MM	18 MM	-	-
Hex size, inch	7/8	7/8	-	-

DESCRIPTION	221 SERIES	263 SERIES	236 SERIES	282 SERIES
SPECIAL NUT AND BOLT TORQUE DATA - IN FOOT POUNDS * (Except where indicated.)				
Cylinder head bolts	85 to 95	85 to 95	110 to 120	110 to 120
Connecting rod bolts	45 to 55	45 to 55	40 to 50	40 to 50
Main bearing cap bolts	75 to 85	75 to 85	75 to 85	75 to 85
Oil pan to crankcase bolts	6 to 8	6 to 8	11 to 19	11 to 19
Flywheel to crankshaft bolts	55 to 65	55 to 65	55 to 65	55 to 65
Governor gear nut	23 to 28	23 to 28	- - - - - -	- - - - - -
Starting crank nut	90 to 100	90 to 100	90 to 100	90 to 100
Camshaft nut	110 to 120	110 to 120	110 to 120	110 to 120
Spark plug (see NOTE 1)	27 to 34	27 to 34	- - - - - -	- - - - - -
Glow plug (see NOTE 2)	- - - - - - -	- - - - - - -	60 to 80 inch lbs.	60 to 80 inch lbs.
Nozzle fitting	- - - - - -	- - - - - -	60 to 70	60 to 70
Rear plate to crankcase bolt	- - - - - -	- - - - - -	105 to 120	105 to 120
Nozzle body bolts	- - - - - -	- - - - - -	20 to 25	20 to 25
Exhaust manifold nuts	- - - - - -	- - - - - -	20 to 25	20 to 25
Lubricating oil cooler mounting stud nuts	- - - - - -	- - - - - -	10 to 12	10 to 12
Pump-drive shaft nut	- - - - - -	- - - - - -	40 to 45	40 to 45
Injection pipe connector screw-pump end	- - - - - -	- - - - - -	23 to 27	23 to 27

*All torques are given with bolts, studs, and nuts lubricated with SAE-30 engine oil.

NOTE 1: Threads are to be clean and dry.

NOTE 2: Threads are to be coated with "Never-Seez." Refer to Section 16, "Installation."

ISS-1040A (4-63)
PRINTED IN UNITED STATES OF AMERICA

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 are 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 Min.	Type 2 Max.	Type 4 Min.	Type 4 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.

3. CHECKING MECHANICAL PROBLEMS

Much can be learned about the condition of an engine if a good visual inspection is performed before the actual cleaning operations are begun. Many engine parts give external evidence of some failure or defect which can be looked for when the engine is later disassembled. For example, a heavy accumulation of oil or grease at some spot might indicate a leaking seal or gasket; or, excessive rust and other corrosion at another place might well mean leaks in the cooling system. If an engine can be operated, unusual noises also help determine what defects to look for. However, before engine disassembly is started, the outer surfaces should always be given a thorough cleaning. Methods used will depend on the facilities available or other local conditions. The dry steam vapor method is recommended since this is both fast and effective. After steam cleaning, the engine should be wiped dry with a clean cloth to minimize possible rusting.

After cleaning, the exterior of the engine should once more be inspected carefully and a note made of any parts such as brackets, covers, bolts, etc., that are bent, broken, rusted or missing completely. The crankcase or cylinder block should be checked for evidence of freezing around core plugs or for actual breaks in the water jacket.

PROBABLE CAUSE	REMEDY
ENGINE	
Engine Fails to Turn Over	
1. Cranking motor inoperative or defective .	Refer to "Cranking motor will not operate or operates slowly."
2. Battery faulty	Refer to "Battery Testing Chart", Paragraph 4.
3. Cables and terminals faulty	Inspect ground cable and battery-to-starting switch cable for any faults which may cause shorting; also inspect for incorrect connections. Replace cables if necessary.
4. Starting switch button defective	Replace starting switch button.
5. Internal seizure	Hand crank engine with spark plugs or glow plugs removed and clutch disengaged. If engine does not turn easily, internal damage is indicated.
6. Engine oil too heavy	Use correct grade of lubricating oil. Refer to "Operator's Manual."
Engine Turns But Will Not Start	
1. Fuel system faulty (carbureted)	
a. No fuel in tank	Fill tank with fuel.
b. Fuel pump bowl screen clogged . . .	Clean bowl and screen.
c. Water in gasoline	Drain gasoline tank, strainer and carburetor. Refill with clean fuel.
d. No gasoline at carburetor	Clean fuel line from tank to carburetor; clean fuel inlet screen in carburetor. Check fuel pump as outlined in Section 11.

PROBABLE CAUSE	REMEDY
ENGINE	
Engine Turns But Will Not Start - Continued	
2. Fuel system faulty (diesel)	
a. Injection pump not operating properly	Refer to "ROOSA MASTER FUEL INJECTION PUMP MANUAL", ISS-1042.
b. Fuel lines clogged or air in lines	Clean fuel lines and vent fuel system. Refer to Operator's Manual.
3. Battery charge low and does not turn engine fast enough	Refer to "Battery Testing Chart", Paragraph 4.
4. Ignition system faulty (carbureted)	
a. Broken distributor rotor	Replace rotor.
b. Moisture in the distributor	Remove cap and rotor and dry thoroughly.
c. Condenser shorted or open	Replace condenser.
d. Broken distributor cap	Replace cap.
e. Excessively pitted distributor cap contact terminals	Clean contact terminals with fine sandpaper. Blow all sand out of cap before reinstalling.
f. Points not properly adjusted	Readjust points. Refer to "SPECIFICATIONS", Section 1.
g. Short or open circuit in distributor	Correct or replace.
h. Ignition circuit broken	Check cable from distributor cap-to-ignition coil and check spark plugs for correct wiring or loose connections.
i. Wet or fouled spark plugs	Remove spark plugs, wipe off moisture and dry plugs. Remove carbon. Reset plug gap, refer to "SPECIFICATIONS", Section 1.
j. Cracked or broken spark plug insulators	Replace spark plugs.
k. Ignition switch inoperative	Place a jumper wire across the two ignition switch terminals on the back of switch. Attempt to start the engine. If engine starts, the switch is inoperative and must be replaced.
5. Carburetor choked too much (carbureted)	Open the choke. Wait a few minutes before attempting again to start engine.
6. Air intake restricted or exhaust clogged	Service the air cleaner and clean exhaust system.
7. Defective glow plugs	Check glow plugs and replace as necessary. (Refer to Section 12.)
Missing and Backfiring But Fails to Start (Carbureted)	
1. Water in gasoline	Drain fuel tank, fuel pump bowl and carburetor. Refill with clean gasoline.
2. Air leaks around intake manifold	Tighten manifold stud nuts. Replace gasket if necessary.
3. Improper firing order	Check spark plug cables for correct installation at spark plugs and distributor cap.
4. Distributor not correctly timed to engine	Check and adjust timing. Refer to Section 12.
5. Moisture in the distributor	Remove cap and rotor and dry thoroughly.
6. Distributor cap shorting out	Check for loose contact terminals or dirt in cracked cap.

3. CHECKING MECHANICAL PROBLEMS - Continued

PROBABLE CAUSE	REMEDY
ENGINE	
Excessive Pinging - Detonation (Carbureted)	
1. Distributor	
a. Point gap incorrect	Readjust point gap. Refer to "SPECIFICATIONS", Section 1.
b. Spark advanced too far	Check and adjust timing. Refer to Section 12.
c. Fouled spark plugs	Clean and reset plugs. Refer to "SPECIFICATIONS", Section 1.
2. Carburetor	
a. Main metering system too lean	Refer to Section 9.
b. Float level set too low	Check float level and reset. Refer to Section 9.
3. Improper or broken thermostat causing overheating	Replace.
4. Cylinder head not bolted down tight	Torque cylinder head bolts. Refer to Section 2 for tightening chart. Refer to Section 1, "SPECIFICATIONS" for correct cylinder head torque.
Missing or Cutting Out at High Speed (Carbureted)	
1. Distributor breaker plate not grounded properly	Check ground lead wire and screws.
2. Primary lead not tightened or partially broken	Check primary lead wire and screws.
3. Weak point spring tension	Adjust point spring tension or replace points. For correct tension see "SPECIFICATIONS", Section 1.
4. Spark plugs faulty	Check plug gap. Refer to "SPECIFICATIONS", Section 1, for correct plug gap. Replace plugs if necessary.
5. Point gap incorrect	Readjust point gap.
6. Low voltage to spark plugs caused by defective coil	Replace coil.
7. Carburetor	
a. Float level set too low	Check float level and reset if necessary. Refer to Section 9.
b. Inoperative accelerator pump	Repair or replace. Refer to Section 9.
c. Dirt in main jet	Clean out main jet. Replace if necessary.
d. Partially closed choke plates	Reposition choke control linkage.
e. Restriction in filter	Clean out fuel inlet filter in carburetor.
8. Defective fuel pump	Check the fuel pump as outlined in Section 11.
9. Poor compression	
a. Head gasket leaks	Replace head gasket.
b. Burned valves	Grind valves.
c. Worn piston rings	Replace piston rings.

PROBABLE CAUSE	REMEDY
ENGINE	
Engine Does Not Develop Full Power	
1. Moisture in fuel tank	Drain fuel system and refill with clean, good grade fuel.
2. Fuel oil filter and strainer clogged (diesel)	Disassemble and clean.
3. Air cleaner clogged	Remove and clean. Refer to Operator's Manual.
4. Pre-cleaner clogged (when used)	Remove and clean.
5. Insufficient fuel	Check fuel tank.
6. Poor fuel	Use proper grade fuel.
7. Injection pump not operating properly or not properly timed to engine (diesel)	Refer to "ROOSA MASTER FUEL INJECTION PUMP MANUAL", ISS-1042.
8. Distributor (carbureted)	
a. Point gap incorrect	Readjust point gap. Refer to "SPECIFICATIONS", Section 1.
b. Ignition timing incorrect	Check and adjust timing. Refer to Section 12.
9. Low voltage to spark plugs caused by defective coil (carbureted)	Replace coil.
10. Fouled spark plugs (carbureted)	Clean plugs and reset the gaps. Refer to "SPECIFICATIONS", Section 1
11. Carburetor (carbureted)	
a. Float level set too low	Check float level and reset. Refer to Section 9.
b. Accelerating pump not operating	Repair or replace. Refer to Section 9.
c. Power or economizer valve inoperative	Repair or replace. Refer to Section 9.
d. Choke plate partially restricted	Reposition choke control linkage.
e. Restricted throttle linkage	Repair or replace.
12. Defective fuel pump (carbureted)	Check fuel pump as outlined in Section 11.
13. Insufficient air to engine	Service the air cleaner. Refer to the Operator's Manual.
14. Late valve timing	Check and adjust timing. Refer to Section 2.
15. Air leaks around intake manifold	Tighten manifold or install new gasket if necessary.
16. Exhaust restricted	Remove restriction.
17. Lack of compression	See "Lack of Compression" in this chart.
18. Governor worn out or out of adjustment	Refer to Section 8.
Loss of Oil Pressure	
1. Low lubricating oil level	Add sufficient oil to bring level up to specified mark on level gauge.
2. Clogged oil filter	Change filter element.
3. Oil leaks	See "Excessive lubricating oil consumption" in this chart.
4. Engine oil pressure indicator or line defective	Replace.
5. Worn main, connecting rod or camshaft bearings	Replace. Refer to Sections 3, 6 or 7.

3. CHECKING MECHANICAL PROBLEMS - Continued

	PROBABLE CAUSE	REMEDY
	ENGINE	
	Loss of Oil Pressure - Continued	
6.	Dirt in oil filter relief valve or relief valve spring broken	Clean valve or replace spring.
7.	Oil pump worn or defective	Repair or replace.
8.	Oil diluted or not as specified	Change oil regularly using correct grade.
9.	Defective cylinder head gasket	Replace.
10.	Broken valve spring	Replace.
	Lack of Compression	
1.	Valves sticking	Clean valve guides and stems. Grind valves if needed.
2.	Worn pistons, rings and cylinder walls	Replace pistons, rings and cylinder sleeves. Refer to Section 3.
	Smoky Exhaust	
1.	Engine overload	Reduce load.
2.	Incorrect grade lubricating oil	Use grade of oil specified in Operator's Manual.
3.	Worn valve guides, valve stems, pistons and sticky or worn oil control rings	Repair or replace.
4.	Distributor not properly timed (carbureted)	Check and adjust timing. Refer to Section 12.
5.	Defective fuel pump (carbureted)	Check fuel pump. Refer to Section 11.
6.	Too much oil in air cleaner	Remove air cleaner and remove any excess oil.
7.	Air cleaner pipe clogged	Remove air cleaner and clean pipe.
8.	Improper fuel (diesel)	Use good grade fuel.
9.	Defective injection nozzle (diesel)	Repair or install new nozzle. Refer to ISS-1042, "ROOSA MASTER FUEL INJECTION PUMP MANUAL."
10.	Pre-cleaner clogged	Remove and clean.
11.	Incorrect valve adjustment	Adjust valves properly.
12.	Injection pump not properly timed (diesel)	Time injection pump. Refer to "ROOSA MASTER FUEL INJECTION PUMP MANUAL."
	Engine Overheats	
1.	Insufficient coolant in cooling system	Check level of coolant in radiator and add necessary coolant.
2.	Radiator cap loose	Tighten cap.
3.	Loose hose connections	Tighten hose connections.
4.	Fan belt slipping	Check and adjust fan belt tension.
5.	Cooling system clogged	Drain and flush cooling system.
6.	Dirt and trash on outside of radiator	Clean between the tube fins with air or water pressure.
7.	Lack of sufficient lubricating oil	Add sufficient oil to bring up to the specified mark on the level gauge.
8.	Engine overloaded	Reduce load.
9.	Clogged oil filter	Replace filter element.
10.	Thermostat inoperative	Replace thermostat.
11.	Water pump defective	Repair pump.
12.	Engine oil diluted with fuel	Drain oil and refill using correct grade.

PRINTED IN UNITED STATES OF AMERICA

PROBABLE CAUSE	REMEDY

ENGINE

Excessive Lubricating Oil Consumption

1. Oil leaks	Check and service where necessary; valve covers, tappet cover plate, crankcase front cover, oil seals at front and rear of crankshaft, oil pan plug and gasket, oil filter and oil pressure indicator tube.
2. Worn valve guides, piston rings, pistons and clogged oil control rings	Replace worn parts.
3. Incorrect grade of lubricating oil	Use grade of oil specified in Operator's Manual.
4. Overheated engine	Refer to "Engine Overheats" in this chart.
5. Excessive oil poured into crankcase	Drain oil and add amount specified in Operator's Manual.

Excessive Fuel Consumption

1. Distributor (Carbureted)	
a. Point gap incorrect	Readjust point gap. Refer to "SPECIFICATIONS", Section 1.
b. Ignition timing incorrect	Check and adjust timing. Refer to Section 12.
2. Low voltage to spark plugs caused by defective coil (carbureted)	Replace coil.
3. Worn or fouled spark plugs (carbureted)	Clean and reset plugs. Refer to "SPECIFICATIONS", Section 1.
4. Carburetor (carbureted)	
a. Float level set too high	Check float level and reset. Refer to Section 9.
b. Power or economizer valve stuck open	Repair. Refer to Section 9.
c. Leaking needle or seat	Repair or replace. Refer to Section 9.
d. Choke plate not fully open	Reposition choke control linkage.
5. Fuel pump pressure too high (carbureted).	Check the fuel pump as outlined in Section 11.
6. Restriction in air cleaner or cleaner oil level too high	Service air cleaner. Refer to the Operator's Manual.

Engine Noises

1. Loose piston pin - a sharp rap at idling speed. The pin at fault can be found by short circuiting the spark plugs, one at a time, until the noise stops	Repair or replace.
2. Loose piston - flat slap when advancing engine speed under load	Replace piston and sleeve.
3. Worn or loose connecting rod bearings - the bearings at fault can be found by short-circuiting the spark plugs, one at a time, until the noise stops (carbureted).	Replace necessary parts.
4. Combustion knock in one or more cylinders. Poor grade of fuel or water in fuel	Use good grade of fuel and check for water in fuel.
(a) Injection pump timed incorrectly	Time the injection pump correctly. Refer to "ROOSA MASTER FUEL INJECTION PUMP MANUAL", ISS-1042.
(b) Incorrect engine temperature	Keep temperature in "RUN" range of heat indicator.

3. CHECKING MECHANICAL PROBLEMS - Continued

	PROBABLE CAUSE	REMEDY
	ENGINE	
	Bearing Failure	
1.	Low oil pressure	Refer to problem "Loss of Oil Pressure."
2.	Lack of oil	Maintain proper oil level. Check for leaks.
3.	Engine runs too hot	Keep engine at normal operating temperature.
4.	Loose bearings	Install new bearings.
5.	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 the engine are in good condition.
7.	Oil lines clogged	Clean all oil passages.
8.	Connecting rod bent	Align or install new connecting rod.
9.	Crankshaft out of alignment	Straighten or install new shaft.
	Valves Sticking	
1.	Valve springs weak or broken	Install new springs.
2.	Gummy deposits from inferior fuel or oil	Clean and use proper fuel or oil.
3.	Valve stems scored or carboned	Clean. Install new valves if necessary.
4.	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 cleaner and pre-cleaner regularly.
5.	Piston rings not fitted properly to cylinder	Install new rings and fit properly. (Refer to "SPECIFICATIONS" in paragraph 2.)
6.	Dirty containers used for lubricating oil	Lubricating oil should be kept in a clean place and clean containers used when filling crankcase.
	Engine Operates Unevenly and Vibrates	
1.	Valve and spring assembly inoperative	Repair or install parts needed.
2.	Incorrect injection pump timing (diesel)	Time injection pump correctly. Refer to "ROOSA MASTER FUEL INJECTION PUMP MANUAL", ISS-1042.
3.	Governor inoperative or not correctly adjusted (carbureted)	Repair or adjust governor. Refer to Section 8.

PROBABLE CAUSE	REMEDY

ENGINE

Poor Compression

1.	Piston rings worn, broken or cracked . . .	Install new rings.
2.	Cylinder sleeves excessively worn	Install new sleeves.
3.	Valves damaged	Install new valves.
4.	Broken valve springs	Install new valve springs.
5.	Worn cylinder head gasket	Install new gasket.
6.	Valve seats worn or damaged	Grind the valve seats.
7.	Worn pistons	Install new pistons.
8.	Excessive valve guide wear	Install new valve guides.
9.	Sticking valves	Free the valve stem and correct the cause.
10.	Faulty valve action	Adjust the valve clearance.

Defective Cooling System

1.	Insufficient water	Add water, inspect for leaks.
2.	Faulty thermostat	Test. If necessary, replace.
3.	Dirty water	Drain and clean system.
4.	Defective connections	Replace swelled or worn hose and defective hose clamps.
5.	Radiator defective	Repair radiator. If necessary, replace.
6.	Fan defective	Inspect fan. If damaged, replace.
7.	Defective water pump	Inspect water pump impeller and shaft. If necessary, replace.
8.	Water pump leaks	Repair or replace pump.
9.	Dirty, scaled coolant passages	Clean and flush passages.
10.	Radiator clogged	Flush out radiator.
11.	Fan belt slippage	Check the tension; replace if greasy or worn.

Noisy Turbocharger Operation or Vibration

1.	Bearings are not being lubricated	Supply required oil pressure, clear or replace oil line, or clean oil strainer. After correcting the condition, replacement of the center housing rotating assembly may be required.
2.	Leakage in engine intake, or exhaust manifold	Tighten loose connections or replace manifold gaskets if necessary.
3.	Loose fit of rotating cartridge assembly journals or bearings	Replace rotating cartridge assembly.

Turbocharged Engines Will Not Deliver Rated Power

1.	Clogged manifold system	Clear all ducting.
2.	Foreign material lodged in compressor or impeller, or turbine wheel	Replace center housing rotating assembly.
3.	Leakage in engine intake or exhaust manifold	Tighten loose connections or replace manifold gaskets if necessary.
4.	Rotating assembly bearing seizure	Replace center housing rotating assembly.

3. CHECKING MECHANICAL PROBLEMS - Continued

	PROBABLE CAUSE	REMEDY
	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 to "GENERATOR" in Section 14.) 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 15.)
3.	Defective voltage regulator	(See "Improper voltage regulator setting".)
4.	Grounded generator field circuit (in either generator, regulator or wiring)	(See "Improper voltage regulator setting".)
	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 16.)
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 14.) If output does increase the regulator is at fault. (Refer to "VOLTAGE REGULATOR" in Section 15.)
4.	Oxidized regulator contact points	Refer to "VOLTAGE REGULATOR" in Section 15.
5.	Defective generator	Refer to "GENERATOR" in Section 14.

PROBABLE CAUSE	REMEDY

ELECTRICAL

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 springs.

Ammeter Show 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.

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 battery	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.

3. CHECKING MECHANICAL PROBLEMS - Continued

PROBABLE CAUSE	REMEDY
ELECTRICAL	
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.
Distributor Contact Points Burned or Pitted	
1. Points set too closely	Inspect to ensure correct clearance.
2. Excessive resistance in condenser due to broken strands in condenser lead . . .	Replace as necessary.
3. High voltages 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. Leakage of current to ground due to faulty wiring	Inspect wiring for fraying and broken strands. Replace.

PRINTED IN UNITED STATES OF AMERICA

4. BATTERY TESTING CHART

HYDROMETER TEST (80°F.) (SEE NOTE "A" BELOW)	CONDITION	REMEDY
A. 1.250 to 1.280 Specific Gravity.	Charged.	No remedy is required if variation among the 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.
B. 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 generator regulator. On adjustable third brush generators, increase the charging rate. Make a thorough check of the electrical system for short circuits, loose connections, and corroded terminals.
C. Less than 1.225 Specific Gravity.	Poor.	Battery should be recharged. Adjust gravity of cells if not uniform. Proceed as outlined in "B."
D. Cells show more than 25 points (.025 Sp. Gr.) variation in gravity. Look for:	1. Short circuit in low cell. 2. Loss of electrolyte by leakage or excessive overcharge. 3. Improper addition of acid or "dopes." 4. Natural or premature failure.	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 voltages 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 "A" - 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
E. If the voltage drop is more than .2 volt (2/10) between the cranking motor cable and the frame while cranking, look for:	Poor contact between terminal and frame or between clamp terminal and battery post.	Locate the high resistance; repair or replace.
F. 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, look for:	Defective cell or cells.	Compare voltage readings with hydrometer readings - low voltage is usually accompanied by low gravity. Apply remedy given for "D."

The presence of short circuits in the wiring can be determined by switching off all electrical equipment and, with the ground strap connected, tapping the other cable terminal against its battery post. Sparking will be produced if there is substantial short circuit in the wiring. Be sure that fuses have not been burned out before making the test. To detect a very slight short circuit, place a low reading ammeter in the circuit.

5. TUNE-UP

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.

Diesel

1. Check the injection pump for correct timing and operation. Refer to the "ROOSA MASTER FUEL INJECTION PUMP MANUAL," ISS-1042.

2. Remove the injection nozzles and check for leaks and opening pressures. Refer to the "ROOSA MASTER FUEL INJECTION PUMP MANUAL," ISS-1042 for detailed information.

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

4. Check the throttle control.

   (a) Check the operation of the control.

   (b) Check the r.p.m. of the engine using a tachometer.

5. Check the clearance on intake and exhaust valves and make adjustments if necessary. Refer to "Valve Clearance Adjustments" in Section 2.

6. Check the air cleaner and connections for possible leaks. Clean the oil cup and screen. Refer to the Operator's Manual.

7. Replace the lubricating oil filter element, and clean the filter case assembly thoroughly.

8. Inspect the fuel filter elements and replace them if necessary. Refer to the Operator's Manual.

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

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

11. Check the fan belt or belts for wear and for correct tension. Replace if necessary.

12. Inspect the generator and cranking motor commutators and clear as instructed in the Operator's Manual. Also refer to Sections 13 and 14 for additional information.

13. Check all electrical connections and switches.

14. Check the diesel compression pressure.

   (a) Remove the No. 1 nozzle body from the cylinder head.

   (b) Insert the proper adapter into position in the head, and secure in place. Attach the pressure indicator to the adapter. Refer to "SERVICE TOOLS MANUAL" ISS-1002.

   (c) Start the engine, and with the engine operating at 1,000 r.p.m., check the compression reading on the indicator. (See "SPECIFICATIONS" in this section for compression pressure.) Check the other cylinders in the same manner, installing each nozzle assembly after checking.

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

Carbureted

1. Check the throttle control.

   (a) Check the operation of the control.

   (b) Check the operation of the springs on the governor control rod.

   (c) Check the r.p.m. of the engine, using a tachometer.

2. Check the clearance on intake and exhaust valves and make adjustments if necessary. (Refer to "Valve Clearance Adjustments" in Section 2.)

3. Check the air cleaner and connections for possible leaks. Clean the oil cup and screen. Refer to the Operator's Manual.

4. Replace the lubricating oil filter element and clean the filter case assembly thoroughly.

5. Remove the water trap. Clean thoroughly and install a new ceramic filter.

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

PRINTED IN UNITED STATES OF AMERICA

5. TUNE - UP - Continued

Carbureted - Continued

7. Check the fan belt for wear and correct tension. Replace if necessary.

8. Check the distributor points, cap and condenser. Replace necessary parts and reset point gap.

9. Check spark plugs. Replace broken plugs and clean and reset all plugs to be reinstalled.

10. Check the ignition coil and the primary wires, be certain of clean and tight connections. A few broken wire strands on an otherwise sound connection will still result in difficult starting and improper engine performance.

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

12. Check all switches.

13. Remove and clean the carburetor inlet screen.

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

15. Check the float valve assembly for leakage.

16. Inspect the generator and cranking motor commutators and clean as instructed in the Operator's Manual. Also refer to Sections 13 and 14 for additional information.

17. Check the ignition timing and correct if necessary.

18. Check the ignition compression pressures. Refer to "SPECIFICATIONS" in this Section.

19. Be certain the manifold heat control valve functions correctly.

Engines Equipped with Turbocharger

1. Remove and clean the turbocharger oil strainer.

2. Inspect all air duct connections for possible leaks. Make this inspection with the engine shut down and with the engine running.

3. Inspect the mountings of the turbocharger to be certain they are secure.

4. Inspect lubricant leakage and be certain that none exist.

5. Check the engine crankcase breather and clean if necessary to be sure that there are no restrictions to air flow.

6. With the inlet duct removed, turn the rotating assembly by hand and check for binding or rubbing. Listen carefully for unusual noises. Remove the turbocharger for disassembly and inspection if binding or rubbing is evident. If the binding or rubbing is caused by dirt build-up in the compressor follow the cleaning procedure outlined in Section 10.

7. Check the turbocharger for unusual vibrations while the engine is operating at the approximate rated output. Remove and service the turbocharger if necessary.

8. Operate the engine at the approximate rated output, and listen for unusual noises. If a shrill high pitch whine is heard, shut down the engine immediately. The whine is indicative of imminent turbocharger bearing failure.

NOTE: Do not confuse the whine heard during run down with that which would indicate a bearing failure.

Other noises can result from improper clearance between the turbine wheel and the turbine housing. If such noises are heard, the turbocharger must be removed and serviced. Refer to Section 10.

MANIFOLDS

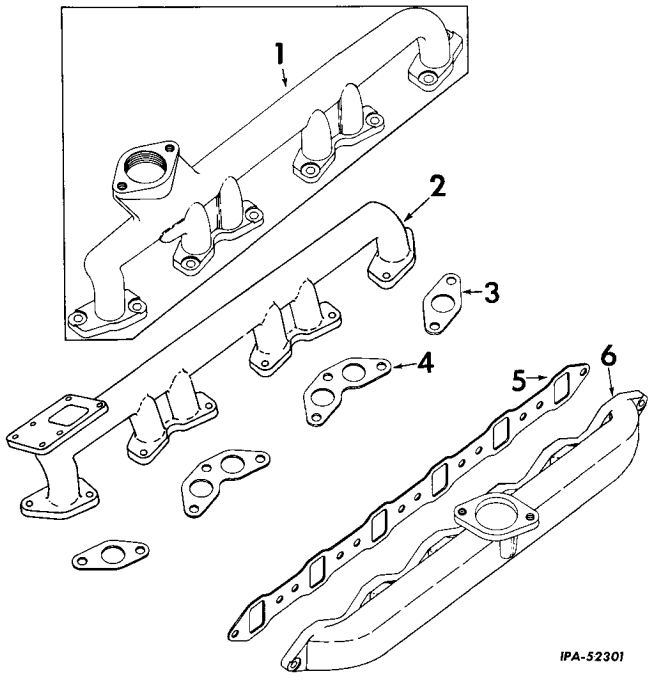
1. DESCRIPTION

Intake Manifold (Diesel Engine)

The intake manifold is mounted on the left side of the engine and contains six outlets, each supplying an individual cylinder.

Exhaust Manifold (Diesel Engine)

The exhaust manifold is mounted on the right side of the engine and contains six inlets, each removing exhaust gases from an individual cylinder.

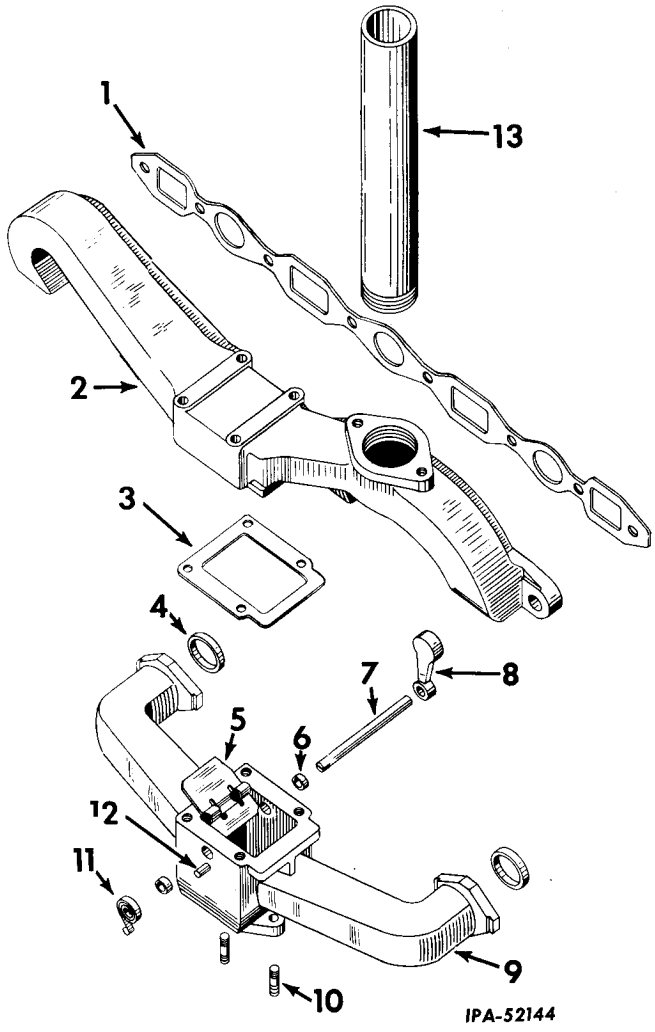


Illust. 1 - Intake and Exhaust Manifolds (Diesel Engine).

1. Exhaust manifold.
2. Exhaust manifold (turbocharged engine only).
3. Manifold gasket.
4. Manifold gasket.
5. Manifold gasket (intake).
6. Intake manifold.

Intake and Exhaust Manifolds (Carbureted Engine)

The intake and exhaust manifolds are bolted together, and fastened to the right side of the cylinder head. The intake manifold contains a manifold heat control valve. This valve redirects the flow of exhaust gases, when the engine is cold, to preheat the intake manifold air and fuel vapor within the intake manifold.



Illust. 2 - Intake and Exhaust Manifold (Carbureted Engine).

1. Manifold gasket.
2. Manifold, exhaust.
3. Gasket.
4. Manifold pilot.
5. Heat valve.
6. Bushing.
7. Valve shaft.
8. Valve weight.
9. Manifold, intake.
10. Carburetor stud.
11. Valve spring.
12. Dowel pin.
13. Exhaust pipe.

2. REMOVAL

221 and 263 Series Carbureted Engines

1. Remove the choke wire from the carburetor.

continued on next page

MANIFOLDS

2. REMOVAL - Continued

221 and 263 Series Carbureted Engines - Continued

2. Remove the carburetor-to-governor control rod.

3. Disconnect the air cleaner inlet pipe from the carburetor.

4. Disconnect the fuel inlet pipe and remove the carburetor. Tape the opening in the fuel inlet pipe, also wrap the carburetor or seal all openings to prevent the entry of dirt.

NOTE: Allow the manifolds to cool before removing them from the engine.

5. Remove the cap screws and washers fastening the manifolds to the head, and remove the intake and exhaust manifolds.

6. To separate the two manifolds, remove the cap screws from the center of the manifolds.

7. If the intake manifold pilot rings are loose, remove and store them until reassembly to prevent loss.

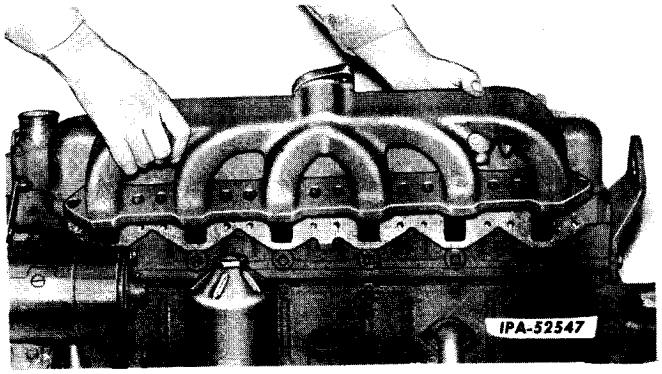
8. The manifold heat control valve need not be removed from the intake manifold unless part replacement is necessary.

236 and 282 Series Diesel Engines

1. Remove the turbocharger, if so equipped. (Refer to Section 10.)

2. Disconnect the air cleaner inlet pipe from the intake manifold.

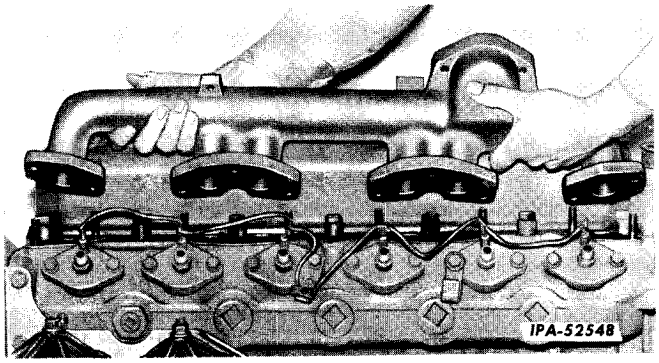
NOTE: Allow the manifolds to cool before removing them from the engine.



Illust. 3 - Removing the Intake Manifold (282 Series Shown).

3. Remove the cap screws fastening the intake manifold to the left side of the head and remove the manifold and gasket. (See Illust. 3.)

4. Remove the stud nuts fastening the exhaust manifold to the top right side of the head and remove the manifold and four gaskets. (See Illust. 4.)



Illust. 4 - Removing the Exhaust Manifold (282 Series Shown).

3. INSPECTION AND REPAIR

1. Inspect the intake and exhaust manifolds for cracks or breakage. If it is cracked or broken, weld or replace.

2. Place manifolds on a surface plate and check for warping. If slightly warped, true-up on a surface grinder, but replace with a new one if it is extremely warped.

3. 221 AND 263 SERIES CARBURETED ENGINES ONLY: Inspect the heat control valve for sticking or binding. This can usually be overcome by removing any carbon build-up on the shaft or valve. Inspect the spring for cracks or breakage and replace if necessary.

4. INSTALLATION

221 and 263 Series Carbureted Engines

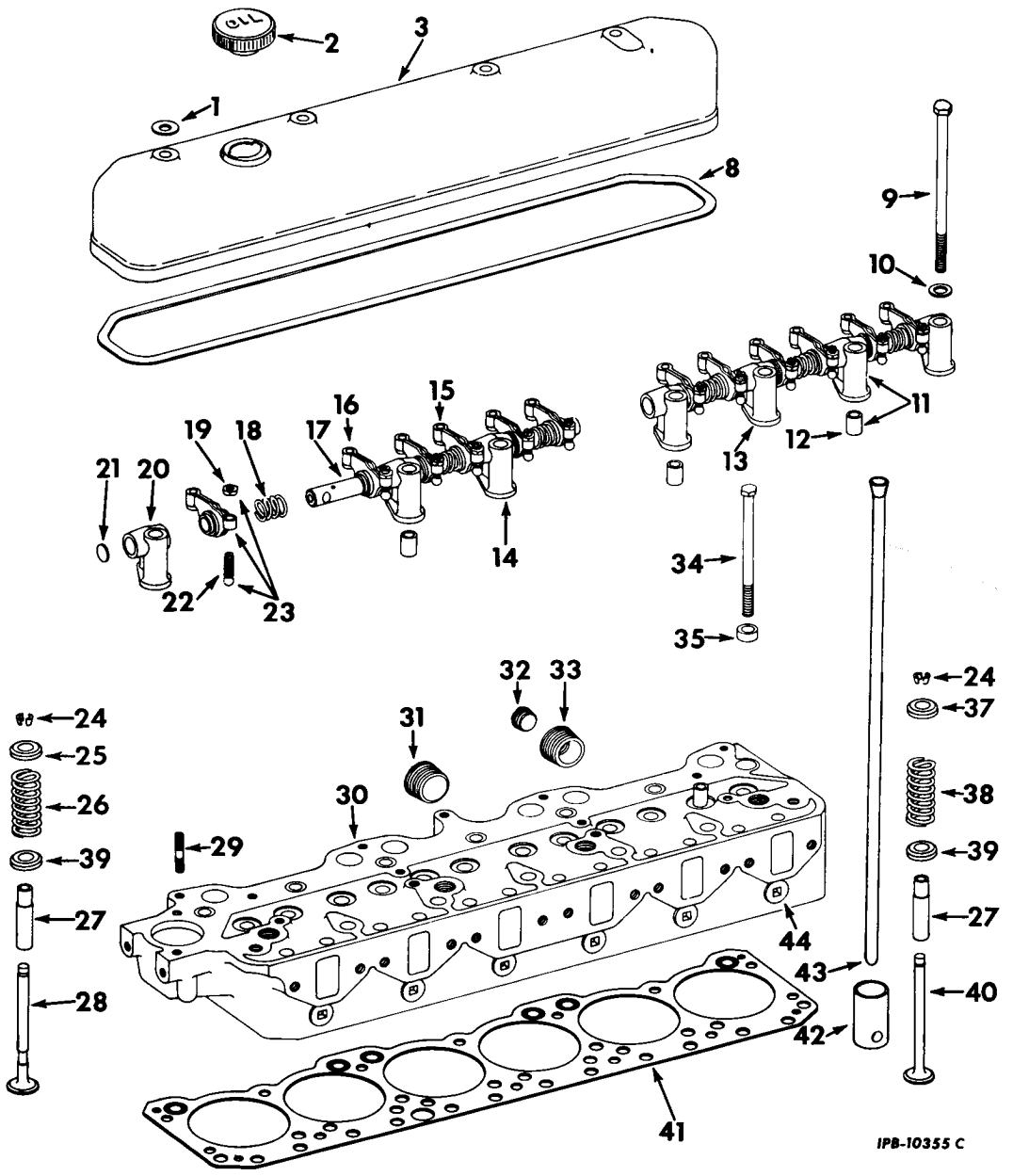
1. Assemble the intake and exhaust manifolds using a new intake-to-exhaust manifold gasket and the cap screws.

2. Install the intake manifold pilot rings into the intake openings in the cylinder head.

continued on page 5

PRINTED IN UNITED STATES OF AMERICA

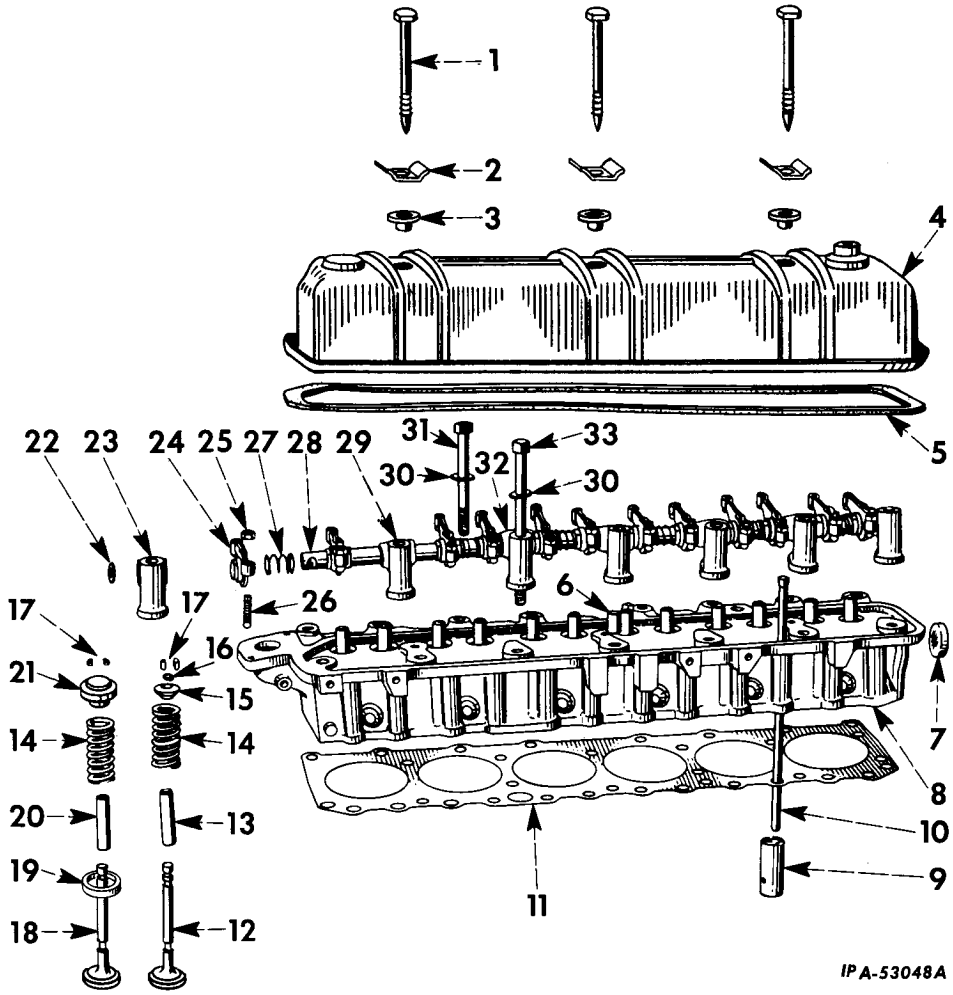
MANIFOLDS



Illust. 5 - Exploded View of Cylinder Head and Valves (Diesel Engine).

1. Washer.
2. Oil filler cap.
3. Valve cover.
8. Cover gasket.
9. Head bolt (long).
10. Bolt washer.
11. Shaft bracket (No. 2, 4 and 6).
12. Shaft bracket dowel.
13. Shaft bracket (No. 5).
14. Shaft bracket (No. 3).
15. Exhaust rocker arm.
16. Intake rocker arm.
17. Rocker arm shaft.
18. Shaft spring.
19. Lock nut.
20. Shaft bracket (No. 1 and 7).
21. Cup plug.
22. Adjusting screw.
23. Exhaust rocker arm.
24. Spring seat key.
25. Spring retainer.
26. Valve spring (exhaust).
27. Valve guide.
28. Exhaust valve.
29. Stud.
30. Cylinder head.
31. Pipe plug.
32. Pipe plug.
33. Pipe bushing.
34. Head bolt (short).
35. Bolt spacer.
36. Sleeve (not TD-9 Series B).
37. Spring retainer.
38. Valve spring (intake).
39. Rotocoil.
40. Intake valve
41. Head gasket.
42. Valve tappets.
43. Valve lifter rods.
44. Pipe plug.

MANIFOLDS



Illust. 6 - Exploded View Cylinder Head and Valves (Carbureted Engine).

1. Cover bolt.
2. Cover stiffner.
3. Cover grommet.
4. Cover.
5. Cover gasket.
6. Dowel.
7. Plug.
8. Cylinder head.
9. Tappet.
10. Push rod.
11. Head gasket.
12. Intake valve.
13. Valve guide.
14. Valve spring.
15. Spring retainer.
16. Seal.
17. Retainer key.
18. Exhaust valve.
19. Valve seat (exhaust).
20. Valve guide.
21. Roto cap.
22. Plug.
23. Valve lever bracket.
24. Lever.
25. Nut.
26. Screw.
27. Valve lever spring.
28. Valve lever shaft.
29. Valve lever bracket.
30. Washer.
31. Head bolt, short.
32. Valve lever bracket.
33. Head bolt, long.

PRINTED IN UNITED STATES OF AMERICA

MANIFOLDS

4. INSTALLATION - Continued

221 and 263 Series Carbureted Engines - Continued

3. Place the manifold assembly against the head and fasten in position using the cap screws and washers. Secure the fuel inlet pipe clip with the foremost manifold cap screw.

4. Install a new carburetor-to-manifold gasket, fasten the carburetor to the intake manifold and connect the fuel inlet pipe to the carburetor.

5. Connect the carburetor-to-governor control rod.

6. Connect the choke wire to the carburetor.

7. Connect the air cleaner inlet pipe to the carburetor.

236 and 282 Series Diesel Engines

1. Install the intake and exhaust manifolds and secure, using the necessary cap screws or stud nuts. Always use new gaskets when installing the manifolds.

2. Connect the air cleaner inlet pipe to the intake manifold.

3. Connect the turbocharger, if so equipped. (Refer to Section 10.)

CYLINDER HEAD AND VALVES

5. DESCRIPTION

The engines covered in this manual are all of the overhead valve type. The valve lever assembly is mounted to the top of the cylinder head and is pressure lubricated through rifle-drilled passages from the crankcase through the cylinder head. The cylinder head is a one-piece casting.

All 221 and 263 carbureted and UD-236 and UD-282 diesel power units are equipped with positive action valve rotators on the exhaust valves. Later models UD-236 and UD-282 and all TD-6 (62 series), TD-9 (92 Series), TD-9 (Series B) and 150 loader tractor engines have valve rotators on all valves.

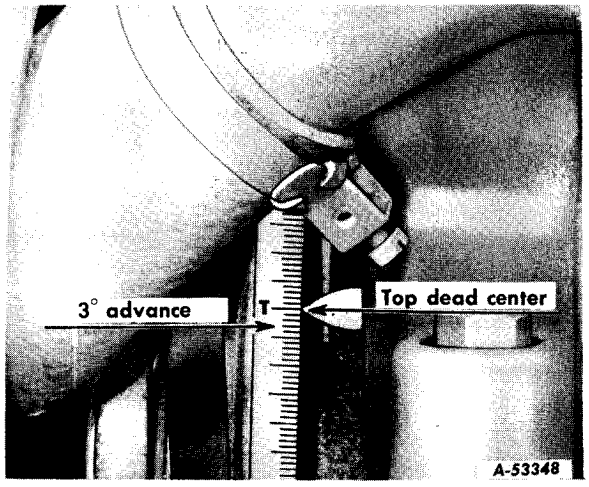
6. VALVE CLEARANCE ADJUSTMENT

1. (a) 221 AND 263 SERIES CARBURETED ENGINES: Disconnect the high tension cable leading from the coil to the distributor cap. Remove the spark plugs.

   (b) 236 AND 282 SERIES DIESEL ENGINES: Disconnect the glow plug wires and remove the glow plugs.

2. Remove the valve cover. Turn the crankshaft until the number one piston is on the compression stroke and the timing pointer on the front cover is in line with the "T" mark on the fan drive pulley. (See Illust. 7.)

NOTE: Be sure that the number one piston is on the compression stroke by turning both push rods by hand to determine that both valves are closed. Valves are closed when push rods are loose and can be turned easily.



Illust. 7 - Timing Pointer.

3. Turn the rocker arm adjusting screws in or out until the correct feeler gauge clearance is obtained. (Refer to "SPECIFICATIONS," Section 1.)

4. Turn the crankshaft one-third revolution (120°) at a time and check the valve clearance of each cylinder and adjust if necessary. Do this on each set of cylinder valves in succession according to the firing order of the engine, which is 1, 5, 3, 6, 2, 4.

Continued on next page.

CYLINDER HEAD AND VALVES

6. VALVE CLEARANCE ADJUSTMENT - Continued

5. Install a new valve cover gasket and replace the valve cover. Be sure the gasket makes an oil tight seal with the cylinder head.

6. (a) 221 AND 263 SERIES CARBURETED ENGINES: Install the spark plugs, spark plug cables and the high tension coil-to-distributor cap wire.

(b) 236 AND 282 SERIES DIESEL ENGINES: Install the glow plugs and connect the glow plug wires.

7. REMOVAL

1. 236 AND 282 SERIES DIESEL ENGINES ONLY: Remove the generator brace and generator.

2. Drain the cooling system. Remove the thermostat housing (with thermostat), upper radiator hose and water pump-to-thermostat housing hose. Remove the fan pulley and adjuster or bracket.

TD-9 (SERIES B) AND 150 LOADER: Remove the fan pulley and bracket with fan idler.

3. Remove the intake and exhaust manifolds as outlined in Par. 2 of this section. Remove the water temperature gauge bulb from the cylinder head.

4. Disconnect the valve cover breather tube (if so equipped) and remove the valve cover.

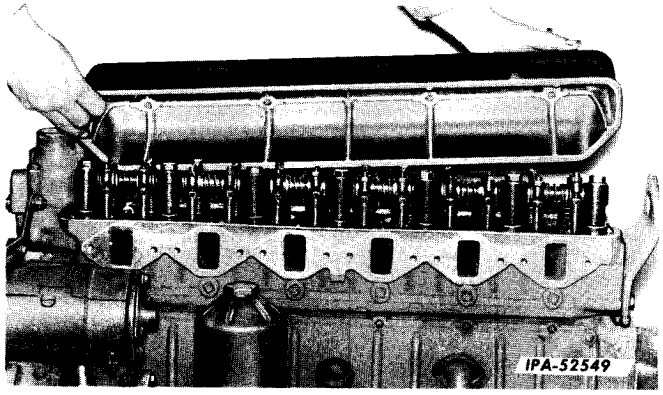
5. 236 AND 282 SERIES DIESEL ENGINES ONLY: Loosen the injection pipe nuts and disconnect the injection pipes from the nozzle assemblies.

NOTE: Immediately plug or seal the openings in the nozzle assemblies and the injection pipes.

6. 221 AND 263 SERIES CARBURETED ENGINES ONLY: Remove the spark plugs, the coil and bracket assembly.

7. 236 AND 282 SERIES DIESEL ENGINES ONLY: Disconnect the oil filter-to-injection pump fuel line. Tape both openings to avoid the entry of dirt.

8. 236 AND 282 SERIES DIESEL ENGINES ONLY: Disconnect the glow plug switch-to-glow plug wire from the junction block on the cylinder head.



Illust. 8 - Removing the Valve Housing Cover. (282 Series Shown.)

9. 236 AND 282 SERIES DIESEL ENGINES ONLY: Disconnect the fuel inlet pipe at the fuel filter.

10. 236 AND 282 SERIES DIESEL ENGINES ONLY: Remove the cap screws securing the fuel filter bracket to the cylinder head and remove the bracket and fuel filters.

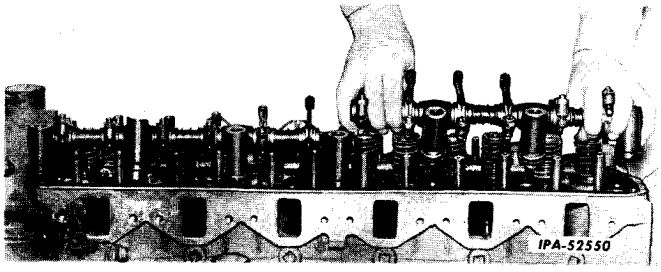
11. Remove the water temperature gauge bulb from the cylinder head.

12. Remove the cap screws securing the rocker shaft brackets and remove the rocker arms and shafts assembly as a unit. (Illust. 9.)

13. Remove the push rods.

14. Remove the side cover and gasket from the left side of the engine. Lift the valve tappets from position.

15. Remove the remaining cylinder head bolts and remove the cylinder head and gasket. The cylinder head is doweled to the crankcase.



Illust. 9 - Removing the Valve Rocker Arms. (282 Series Shown.)

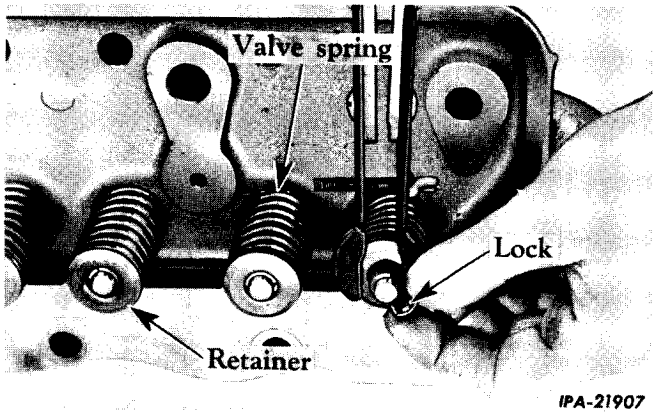
PRINTED IN UNITED STATES OF AMERICA

CYLINDER HEAD AND VALVES

8. DISASSEMBLY

Cylinder Head

1. Compress the valve springs with a valve compressor and remove the valve spring retainer locks. (See Illust. 10.)



Illust. 10 - Removing the Valve Springs.

2. Remove the retainers and/or rotators, valve springs and oil deflectors (236 and 282 intake valves) or oil seals (221 and 263 intake valves).

3. Invert the cylinder head and remove all the valves. Keep each valve in a suitable rack to assure replacement of the valve in its original location.

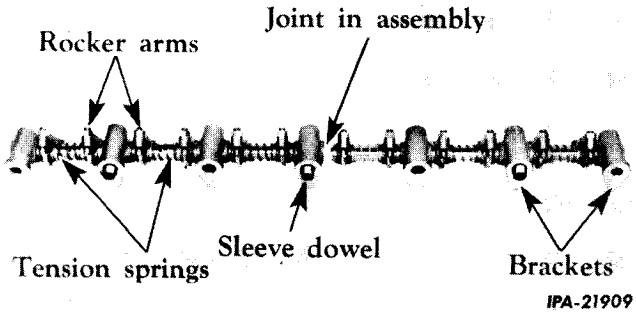
Rocker Arms

The rocker arm assembly is composed of front and rear shafts, joined at the center, on which are mounted 12 rocker arms and six tension springs. The shafts are mounted in seven brackets and are prevented from turning by grooves in the ends of the shafts, positioned at the two end brackets, through which the cylinder head bolts (236 and 282 series diesel engines) or roll pins (221 and 263 series carbureted engines) are inserted. (Illust. 11.)

4. Separate the shafts, and slide the rocker arms, springs and brackets from the shafts.

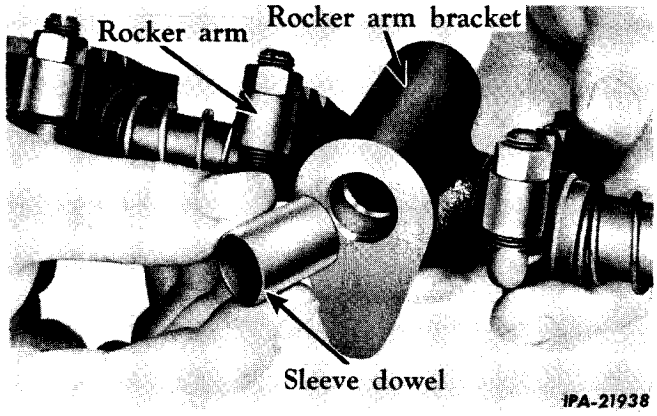
5. The number two, four and six (front to rear) rocker arm brackets have sleeve dowels which keep the rocker arm assembly aligned.

6. These sleeve dowels measure approximately 5/8 inch in diameter, 7/8 inch long and 1/32 inch wall.



Illust. 11 - Rocker Arm Assembly.

7. The three hold-down brackets are reamed from the bottom side (Illust. 12), so that the sleeve dowels will fit tight into the brackets. About half of the dowel is in the bracket, the remaining half fits into the head. When removing the rocker arm assembly, the dowels will remain in the hold-down brackets.



Illust. 12 - Rocker Arm Bracket Dowel.

9. INSPECTION AND REPAIR

General

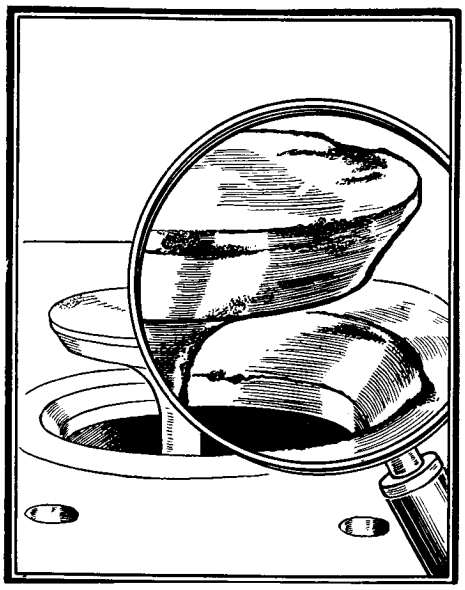
Carbon deposits on the valves and valve seats are normal and cannot be avoided completely. (See Illust. 13.) However, such deposits are detrimental to engine efficiency and valve assembly life as the amount of carbon in the engine increases.

Continued on next page.

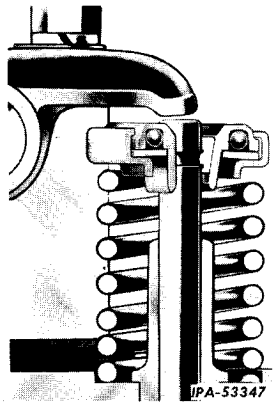
CYLINDER HEAD AND VALVES

9. INSPECTION AND REPAIR - Continued

General - Continued



Illust. 13 - Carbon, Corrosion and Wear are Inevitable Products of Normal Engine Operation.



Illust. 14 - Cutaway View Showing Exhaust Valve Stem with Rotator (Carbureted Engines).

The rotating mechanism used on the exhaust valves greatly extends the service life of the valves. (See Illust. 14.) To retain the efficiency of this mechanism, it is imperative that the recommended clearances be maintained. (See "SPECIFICATIONS," Section 1.)

Whenever the cylinder head of an engine is removed for service - all carbon should be removed from the surfaces of the parts affected. 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, in turn, 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 sucked past worn intake valve stems and guides into the combustion chamber, cause excessive oil consumption and forms excessive carbon.

PRINTED IN UNITED STATES OF AMERICA

CYLINDER HEAD AND VALVES

221 AND 263 SERIES CARBURETED ENGINES ONLY: When excessive oil consumption is evident, note if the intake valves or parts appear to have an excess quantity of oil on their surface, indicating that oil is being pulled through valve intake guides even when within the specified dimensions. Replacement of intake valve stem seals will be found helpful in correcting this condition.

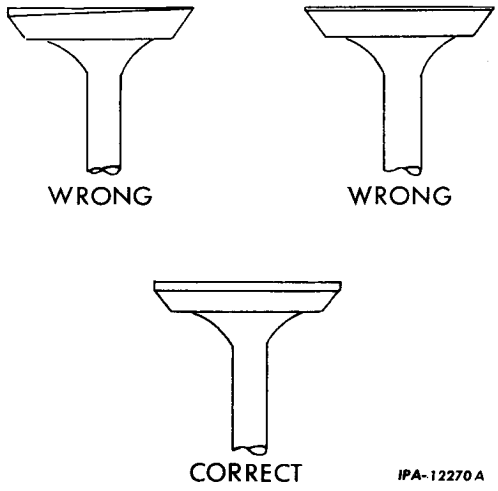
Examine the engine for signs which may indicate the reason for the need of valve reconditioning. Dry and rusted valve springs are an indication that the oil passages to the valve levers may be blocked, causing wear on the valves and guides, and resulting in improper valve action. A defective gasket under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

Valves

1. Remove all carbon from the valve head and stem. Valve stems should be lightly polished with an extremely fine abrasive cloth sufficiently to remove the carbon deposits only. Because of the nature of the valve deposits, solvent cleaning ordinarily will not remove all the deposits from the valves. Wire brushes will do this job satisfactorily, but only brass wire brushes should be used since steel brushes may scratch the surface. Such scratches are likely to cause localized stresses in an operating valve and may eventually result in fatigue fractures of the valve. For this reason, do not use coarse emery paper.

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.

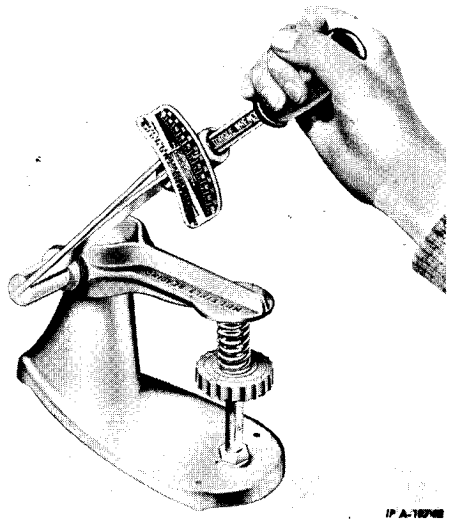
3. All valves having bent, worn, warped or seriously pitted stems should be replaced. Replace any valve that cannot be satisfactorily refaced with a definite margin maintained. (See Illust. 15.) The amount of grinding necessary to true the valve face is a definite indication of the valve head warpage 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.



Illust. 15 - Examples of Right and Wrong Valve Refacing.

Valve Springs

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



Illust. 16 - Testing Valve Springs.

continued on next page

CYLINDER HEAD AND VALVES

9. INSPECTION AND REPAIR - 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.

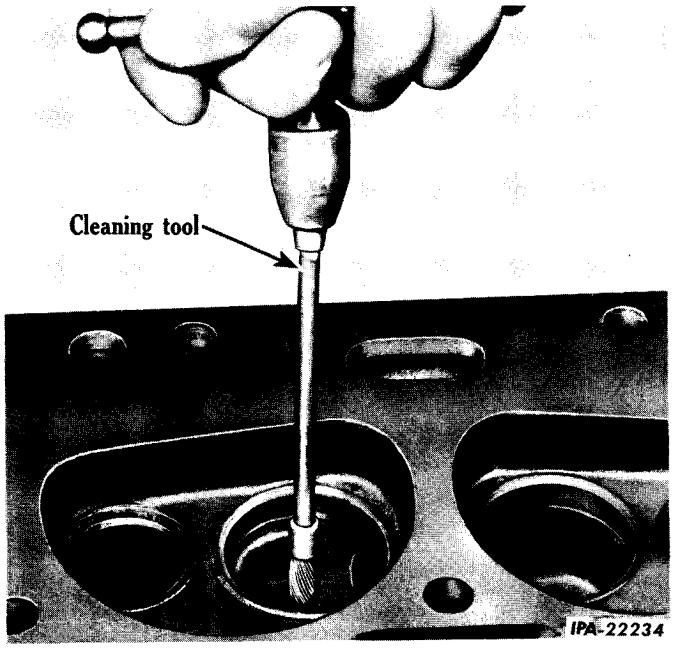
Valve Spring Retainer Locks

6. 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 allow the valve spring retainer to slide over the lock.

Valve Rotators

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

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



Illust. 17 - Valve Guide Cleaning Tool.

When using a spring tester, place the valve spring together with the rotator in a tester. Place a bearing ball between the rotor cap and the ram of the spring tester. By compressing the valve spring, the valve rotator can be observed as it turns.

Valve Guides

8. Clean the bores of the valve guides, using a wire rifle brush and solvent as shown in Illust. 17. Blow out all carbon with compressed air. Position a light at the bottom of the guide 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 "SPECIFICATIONS," Section 1. Replace any guides considered unserviceable or that appear close to a serviceable borderline. (See "Valve Guides" in paragraph 10.)

NOTE: All valve reconditioning equipment requires the installation of a pilot in the valve guide to produce a seat concentric with the guide bore. For this reason the guides must be clean and meet the engine specifications before the valve seats can be reconditioned.

Valve Seats

9. Remove all carbon and any remaining gasket material from the cylinder head. Inspect all valve seats for cracks or loose valve seat inserts. Replace loose or burned inserts. Remove all carbon from the valve seat recesses or counterbores. (See "Valve seats and valve seat inserts" in paragraph 10.)

Rocker Arm Assembly

10. Clean all parts in a cleaning solvent being careful to clean all accumulated sludge and carbon deposits from oil holes and slots.

11. Inspect the rocker-arm shaft expansion plugs. Check the shafts on a surface plate for signs of bending, also check for wear from rocker arms. If either shaft is bent or shows rocker arm wear, it must be replaced.

12. Inspect rocker arm adjusting screws for wear at contact surface and for thread wear. Replace worn screws.

13. Check rocker-arm bushings for wear. If clearance on shaft exceeds .004 inch, replace the rocker arm.

14. Inspect valve stem contact pad surface of the rocker arms and resurface if wear is indicated.

15. Inspect tension springs for breakage or loss of tension. (See "SPECIFICATIONS," Section 1.) Replace defective springs.

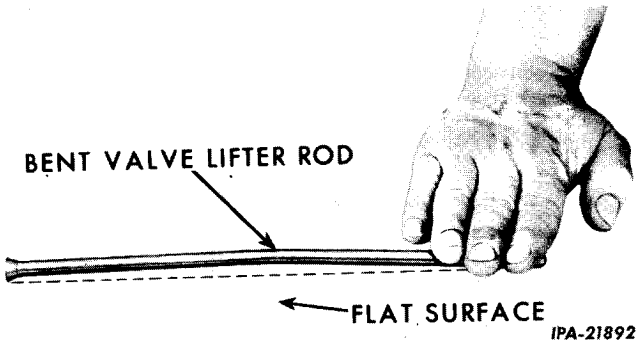
16. Check all of the valve lifter rods for straightness by rolling on a flat surface (Illust.

PRINTED IN UNITED STATES OF AMERICA

CYLINDER HEAD AND VALVES

18). Replace any rods that are bent, have loose ends or are damaged in any way.

17. Inspect each of the engine valve tappets for irregular wear, chipping, cracking or scoring. Replace any that may be defective.



Illust. 18 - Checking Valve Lifter Rods for Straightness.

Cylinder Head

18. Remove any remaining carbon or grease accumulation from the cylinder head. Clean the water passages of the cylinder head. Inspect the cylinder head for signs of cracks or sand holes. Check the areas surrounding the exhaust valve ports for indications of blow-by such as burning away of the metal. If the head is found defective, repair or replace it, as necessary. Do not remove the six cylinder head stud sleeves unless leakage is apparent.

19. At the time of a major engine overhaul, be sure to clean the breather elements inside the valve lifter rod cover before installing it in place. Rinse the cover in cleaning solvent and blow dry with compressed air. If the breather element is at the breather pipe flange, as is the case with older series engines, clean the element before installing the cover. A new cover gasket should also be installed.

10. RECONDITIONING

Valve Guides

1. Press the guide from the cylinder head.

2. Install a new guide from the top of the head, and press it into the head until the specified length remains above the top surface of the head. (See "SPECIFICATIONS," Section 1.)

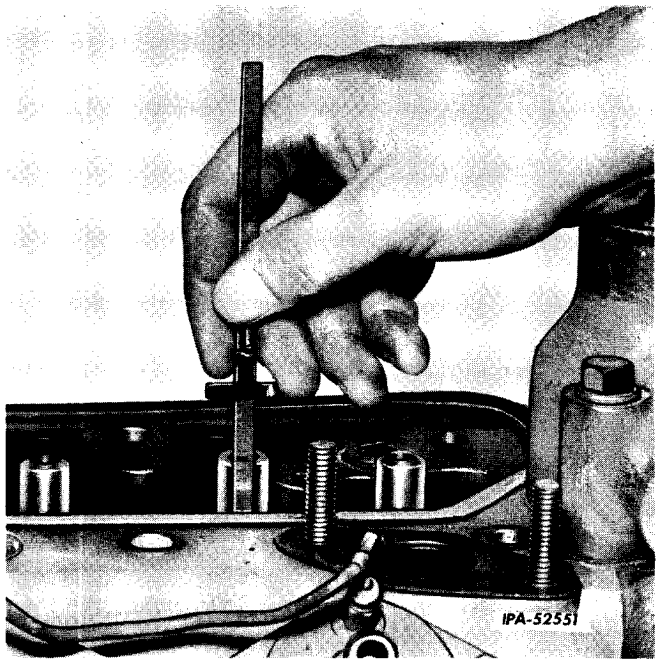
3. All guides furnished as service parts are reamed to size; however, as they are a press fit, it is necessary to ream them after installation to remove any possible burrs or slight distortion caused by the pressing operation. (Refer to "SPECIFICATIONS," Section 1.)

Valves

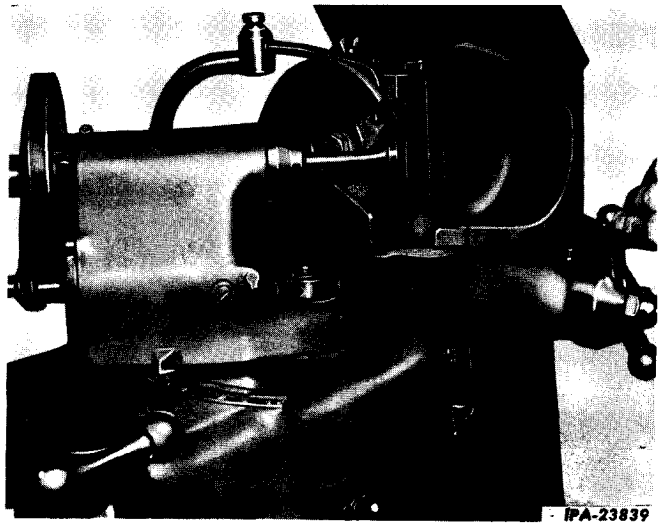
After being thoroughly cleaned and inspected, valves that are fit for continued use should be reconditioned as follows: Determine the correct face angle as given in the "SPECIFICATIONS," Section 1.

1. Set the valve refacing machine to grind the desired angle (see Illust. 20), and dress the grinding stone.

Continued on next page



Illust. 19 - Measuring the Valve Guide Height.



Illust. 20 - Grinding the Valve Face Angle Taking Light Cuts Only.

CYLINDER HEAD AND VALVES

10. RECONDITIONING - Continued

Valves - Continued

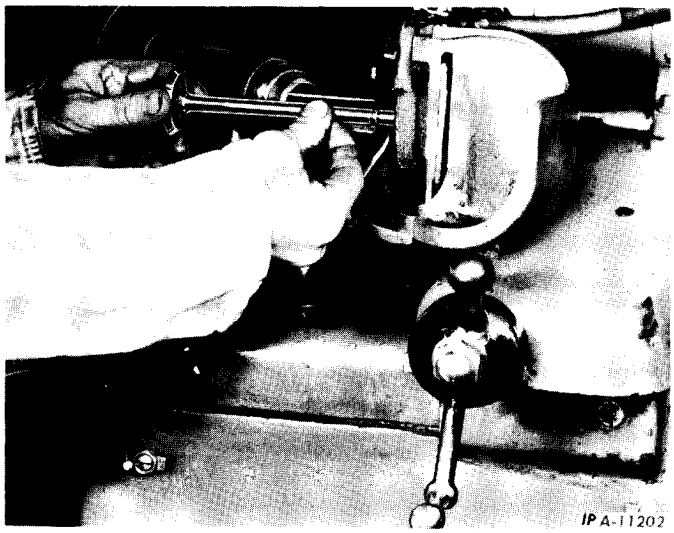
2. Insert a valve in the chuck and take a light cut across its face. (See Illust. 20.) This is a check to determine whether the valve can be reconditioned to service standards with a correct amount of margin maintained. Warpage that may not be apparent in the visual inspection will be clearly definable. (See Illust. 15.)

Avoid taking heavy grinding cuts as this heats the valve head excessively, producing 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. (See Illust. 15.)

One of the principal difficulties in reconditioning valves is to obtain nearly identical angles on the valve seat and valve face. The importance of these angles in the grinding operation cannot be overemphasized, because it is impossible to produce a flat or square seat by lapping.

The grinding stones on both the valve-refacing machine and valve-seat grinder should be dressed before starting a reconditioning job.

You will be unable to determine how closely the angle of the seat will match the valve face until the valve and seat have been ground and a check made with a very light tint of Prussian blue. If a full seat-width contact around the entire circle of seated valve is not shown, the angles do not match. It will then be necessary to redress the valve seat grinding stones, changing the angle sufficiently to correct the error. The correction should be made on the valve seat, and not on the valve. No more material should be removed from the valve face than is necessary to true it up and remove the burned or pitted portion. New valves should not be refaced, but should be checked for trueness. When a satisfactory match of valve seat and valve face angles has been obtained the adjustment of both the valve refaces and the seat grinder should be locked in position, in order to eliminate this trial-by-error method on additional valves having the same angle.



Illust. 21 - Refacing the Valve Stem End.

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. (See Illust. 21.) Grind sufficiently to true-up the end of the stem.

Valve Seats and Valve Seat Inserts

The primary purpose of a valve seat is to seal the combustion chamber against pressure losses and to provide a path to dissipate the heat accumulated in the valve head so as to prevent burning of the seat and warping of the valve head.

The location of the valve seat on the valve face and its width, controls the amount of valve head that protrudes into the combustion chamber. It is obvious that the greater the exposure within the combustion chamber, the higher the valve temperature; or in other words, the more heat it will collect. High valve temperature and poor heat dissipation also produce excessive valve stem temperatures. This will hasten the accumulation of carbon on the stems, causing them to stick in the guides.

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

PRINTED IN UNITED STATES OF AMERICA

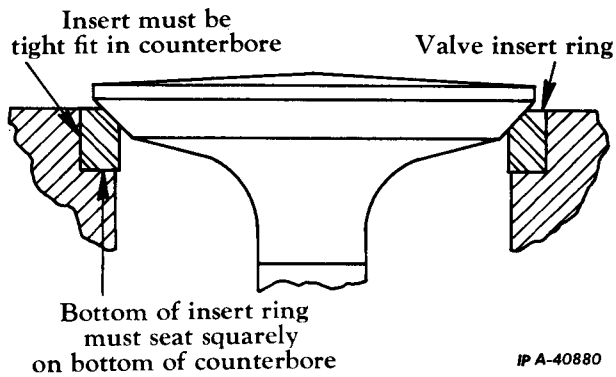
CYLINDER HEAD AND VALVES

or a dull-pointed chisel, 1/4 inch wide, to peen cylinder head metal over the outer edge of the valve seat insert.

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 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. 22. 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 which 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, 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. When properly seated, the insert should be recessed into the head from .009 to .017 inch. Using a suitable peening tool, peen the head metal over the edge and around the entire circumference of the insert.



Illust. 22 - Insert Ring Properly Installed.

The following procedure applies for refacing seats or seat inserts or facing new inserts.

1. Remove all carbon, scale and oil before attempting to reface valve seats. The grinding stone, when placed against an oily seat, will become fouled, and uneven grinding will occur.

NOTE: Before installing the pilot, be certain that the valve guides are perfectly clean and meet the engine specifications. This is important; otherwise, an eccentric seat will be cut.

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

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. Very little pressure other than the normal weight of the stone should be used. Sudden hard pressure 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, roundness and valve face contact using 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. 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. If a full seat-width contact around the entire circle of seated valve is not shown, the angles do not match. It will then be necessary to redress the valve seat grinding stones, changing the angle sufficiently to correct the error. The correction should be made on the valve seat, and not on the valve.

The location of the area of contact between the valve and the seat is a very important factor in

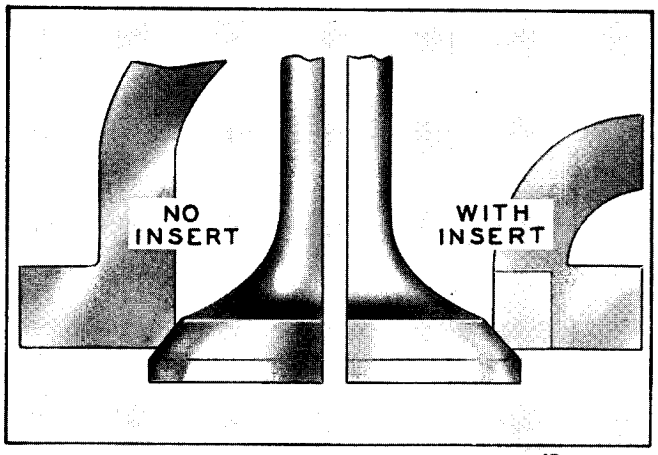
continued on next page

CYLINDER HEAD AND VALVES

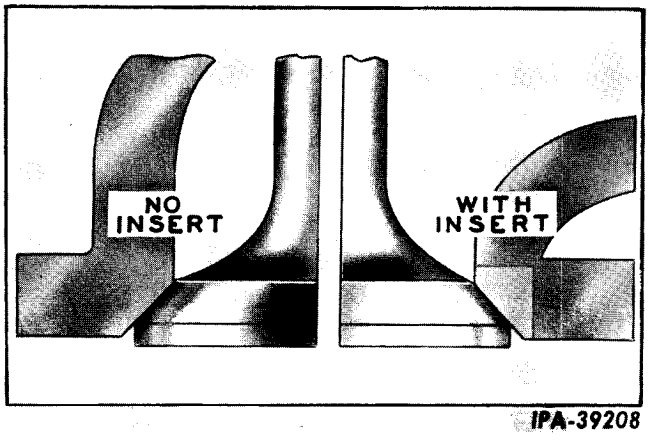
10. RECONDITIONING - Continued

Valve Seats and Valve Seat Inserts - Continued

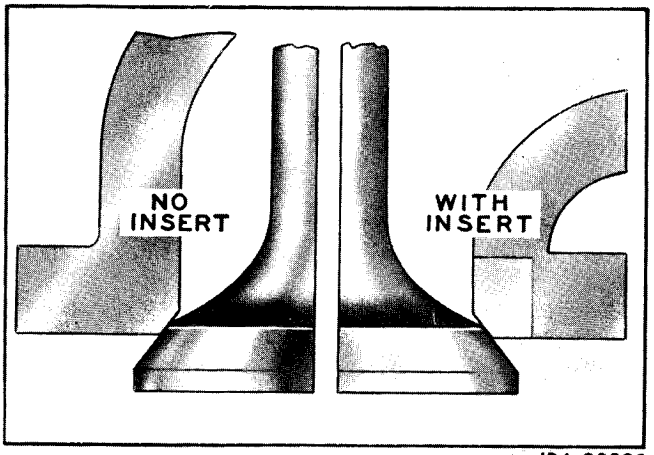
securing maximum valve life. The correct position of the valve face on the seat is shown in Illust. 23. Seating the valve as shown in Illust. 24 is undesirable, since the sharp edge of the seat does not contact the valve face. This sharp edge tends to break off face deposits which may lead to valve failure. Similarly, the location of the upper line of contact well below the top of the valve face as shown in Illust. 25 is also undesirable because a large overhang prevents rapid cooling of the outer edge of the valve.



Illust. 23 - Correct Valve Seat Location.

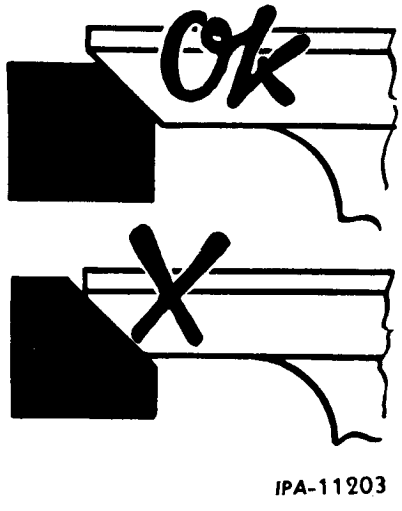


Illust. 24 - Valve Seat Too Deep into Cylinder Head.



Illust. 25 - Valve Protrudes Too Far into Combustion Chamber.

The width of the exhaust seat should range between the average and maximum specifications and the intake seats should range between the average and minimum specifications. The intake seats may be narrower than the exhaust seats because they are usually larger in diameter. This provides a total seat area approximately equal to the smaller exhaust valve with the wider seat. Also the less severe heat conditions do not require as large a seat area for heat dissipation purposes.



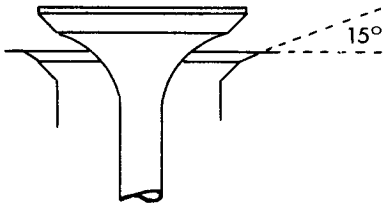
Illust. 26 - Valve Seat Width Should Conform to Specifications for That Engine and Center on the Valve Face.

5. 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. 26) may be narrowed by grinding down the top edge

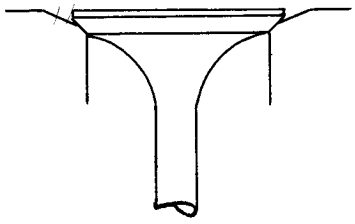
PRINTED IN UNITED STATES OF AMERICA

CYLINDER HEAD AND VALVES

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. 27.)



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



Valve face now contacts the seat

IPA-11205

Illust. 27 - Narrowing Valve Seat Widths.

DIMENSIONAL CHART

Reference Letters Refer to Illust. 28, 29 and 30

	221 and 263	236 and 282
A	30° Int. 30° Exh.	45° Int. 45° Exh.
B	1-21/32 Int. 1-33/64 Exh.	1-41/64 * 1-43/64 ** Int. 1-9/32 * 1-3/8 ** Exh.
C	.3715 to .3725 Int. .371 to .372 Exh.	.3715 to .3725 Int. .3715 to .3725 Exh.
D	5-5/64 Int. 5-1/16 Exh.	6-1/16 * 6-1/32** Int. 6-1/16 Exh.
E	1-3/8 (221) 1-1/2 (263) Int. 1-5/16 Exh.	1-19/64 Int. 63/64 * 1-1/8 ** Exh.
F	1-5/8 Int. 1-7/16 Exh.	1-9/16 * 1-41/64** Int. 1-3/16 * 1-11/32 ** Exh.
G	3/64 Int. 5/64 Exh.	3/32 Int. 3/32 Exh.
H	3/32 Int. 1/16 Exh.	3/32 Int. 3/32 Exh.
I	1-25/32 Int. 1-1/64 Exh.	1-25/32 * 1-13/16 ** Int. 1-25/32 * 2-1/16 ** Exh.
J	2-1/2 Int. 2-1/2 Exh.	2-27/32 Int. 2-27/32 Exh.
K	.3755 to .3765 Int. .3755 to .3765 Exh.	.3740 to .3755 Int. .3740 to .3755 Exh.
L	.6260 to .6265 Int. .6260 to .6265 Exh.	.6260 to .6265 Int. .6260 to .6265 Exh.
M	1.19 to 1.25 Int. .81 to .87 Exh.	.938 Int. .938 * 1.088 ** Exh.
N		.129 to .135 * Int. and Exh. .103 to .109 ** Int. and Exh.
O	.228 to .232 Exh. only	
P	1.5605 to 1.5630 Exh. only	

* - TD-9 BGM-6081 and below; TD-9BGAM-6081 and below; TD-9BPM-6081 and below; L-150GM-6081 and below; L-150PM-6081 and below; Also, UD-282M - 3623 and below; TD-62M - 2215 and below, and UD-236M-2873 and below.

** - TD-9BGM-6082 and up; TD-9BGAM-6082 and up; TD-9BPM-6082 and up; L-150GM-6082 and up; L-150PM-6082 and up; Also UD-282M-3624 and up; TD-62M-2216 and up; and UD-236M-2874 and up.

Continued on next page.

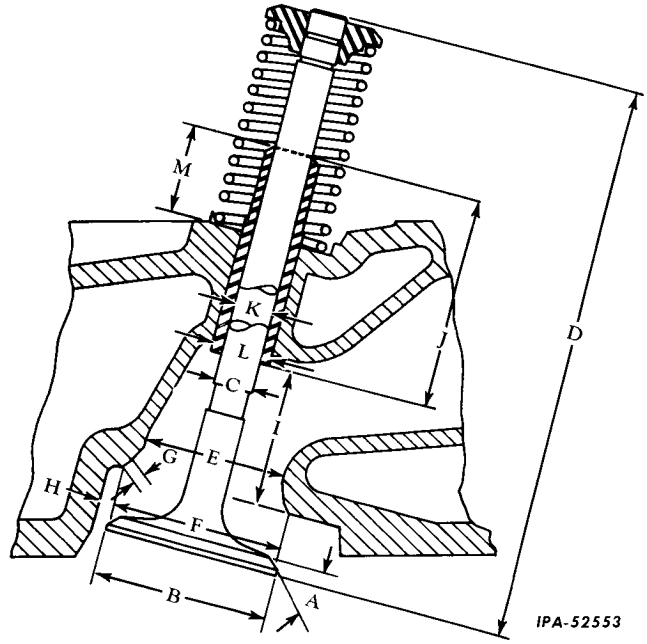
CYLINDER HEAD AND VALVES

10. RECONDITIONING - Continued

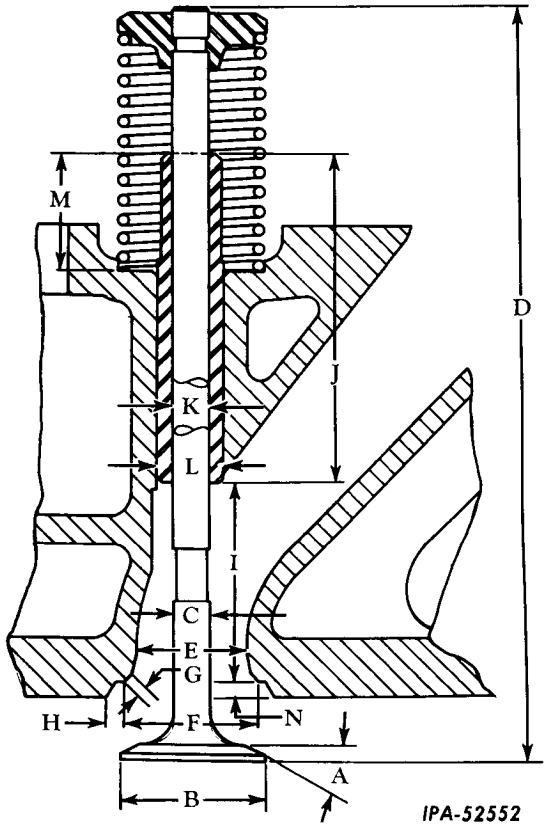
Valve Seats and Valve Seat Inserts - Continued

KEY TO VALVE CHARTS
(See "Dimensional Chart" and Illusts. 28, 29 and 30.)

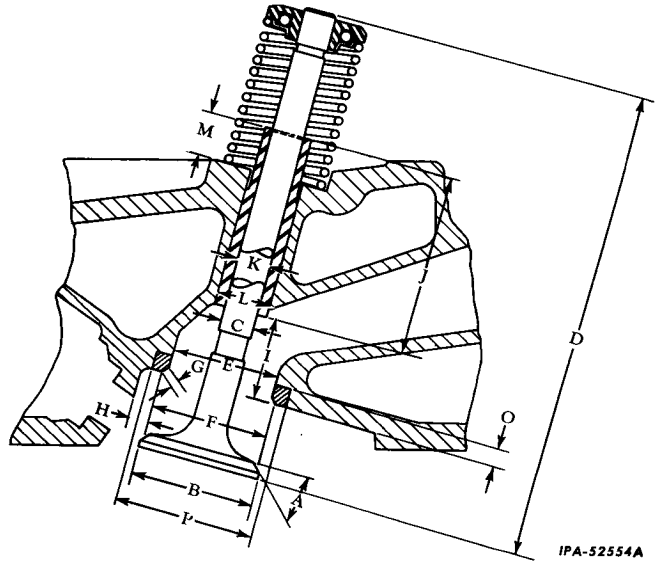
A. Valve face angle.
B. Valve head diameter.
C. Valve stem diameter.
D. Valve length.
E. Valve port inside diameter.
F. Valve seat outside diameter.
G. Valve seat width.
H. Minimum distance from outside diameter of valve seat to the edge of the combustion chamber in the head.
I. Distance from the valve 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. Distance from top of valve guide to bottom of the spring recess.
N. Distance from the face of the cylinder head to the face of the valve seat (diesel only).
O. Depth of counterbore (carbureted only).
P. Diameter of counterbore (carbureted only).



Illust. 29 - Intake Valve (221 and 263).



Illust. 28 - Intake and Exhaust Valve (236 and 282).



Illust. 30 - Exhaust Valve (221 and 263).

PRINTED IN UNITED STATES OF AMERICA

CYLINDER HEAD AND VALVES

11. REASSEMBLY

Cylinder Head

NOTE: If leakage is apparent at the pipe plugs, it is not recommended to tighten the plugs any further in an attempt to eliminate the leakage. This would create the danger of cracking or warping the cylinder head. The plug should be removed, cleaned, coated with a sealer and reinstalled to a depth of from two threads above being flush with the cylinder head to one thread below flush.

1. If one or all of the cylinder head stud sleeves were removed, they must be pressed into the head.

2. Coat the valve stems with Lubriplate or its equivalent and insert them from the bottom of the head. Valve guide installing tools should be used when installing the guides. The intake valve guide driver tool number is ED-4019, the exhaust number ED-4019A. (Refer to the "Service Tools Manual," ISS-1002.) Each valve and its parts should be returned to its original position.

3. Install the oil deflector (if so equipped) (236 and 282 series diesel engine intake valves), valve springs and the oil seals (221 and 263 series carbureted engine intake valves).

4. Install the retainers and/or valve rotators, compress the springs and install the valve spring retainer locks.

Rocker Arm Assembly (236 and 282 Series Diesel Engines Only)

The two rocker arm shafts are identical, all six intake rocker arms are alike; however, there are three left hand and three right hand exhaust rocker arms and three different types of rocker shaft brackets.

Four of the rocker shaft brackets are of one type and are used in positions 2, 4, 5 and 6 (see Illust. 31). These brackets are drilled and reamed to accept the sleeve dowel, used to obtain proper rocker arm assembly alignment. The sleeve dowel is used only in the brackets located in positions 2, 4 and 6 (see Illust. 31), the remaining bracket is used in position 5 without a sleeve dowel. The two end brackets are alike.

The remaining bracket, used in position 3, contains an enlarged bolt hole, and is used as the oil supply inlet for the rocker arm assembly.

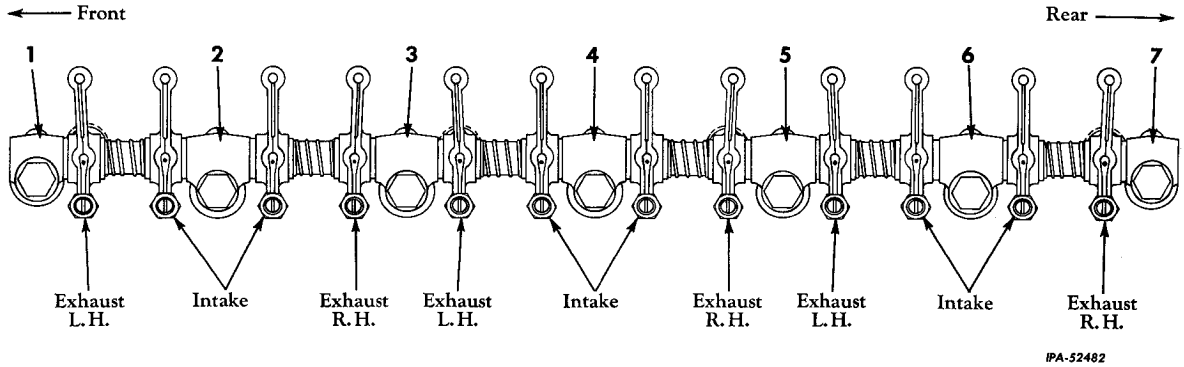
For correct reassembled positions of the rocker arms and brackets, refer to Illust. 31.

Rocker Arm Assembly (221 and 263 Series Carbureted Engines Only)

The two rocker arm shafts are identical, all 12 rocker arms are alike; however, there are three different types of rocker shaft brackets. Three of the rocker shaft brackets are of one type and are used in positions 2, 4 and 6. (See Illust. 31.) These brackets are drilled and reamed to accept the sleeve dowel, used to obtain proper rocker arm assembly alignment. The two brackets used in the end positions (1 and 7) are identical.

The remaining two brackets, used in positions 3 and 5, contain an enlarged bolt hole, the number 3 is used as the oil supply inlet for the rocker arm assembly.

For correct reassembled positions of the rocker shaft brackets, refer to Illust. 31.



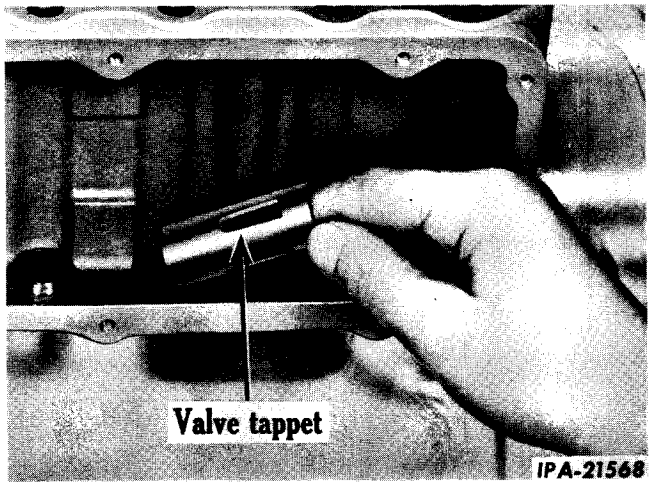
Illust. 31 - Rocker Arm Assembly (236 and 282 Series Diesel Engine Rocker Arms Illustrated).

CYLINDER HEAD AND VALVES

12. INSTALLATION

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

2. Coat each of the valve tappets with a heavy engine oil and insert each, flat side down, through the opening in the left side of the cylinder block, into the sockets in the block. (See Illust. 32.)



Illust. 32 - Installing the Valve Tappets.

3. Using a new cylinder head gasket, place the gasket on the cylinder block and algin the bolt holes on engines equipped with cylinder head dowels, the bolt holes will be automatically aligned.

4. Place the cylinder head on the crankcase; be careful not to damage or shift gasket position.

NOTE: On engines not equipped with cylinder head-to-crankcase dowels, use aligning tool ED-4030 when installing the gasket and head to retain correct head-to-gasket alignment.

5. Install, but do not tighten the seven short cylinder head bolts and washers on the top right side of the head.

6. Insert the valve push rods in the cylinder head; being certain that they enter the valve tappets.

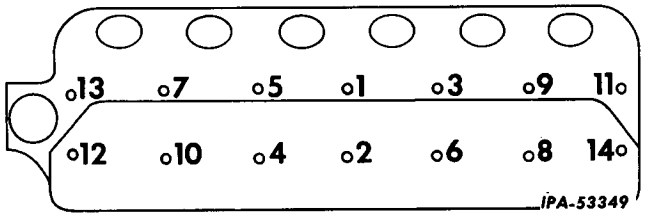
7. Install the side cover and gasket on the left side of the engine.

8. Place the rocker arm assembly into position on the cylinder head.

NOTE: Be certain that the sleeve dowels in numbers 2, 4 and 6 (front to rear) rocker arm brackets are in place in the rocker arm assembly before installing it on the head.

9. Install the remaining cylinder head bolts into the rocker arm brackets and tighten all the bolts in the proper sequence (see Illusts. 33 or 34) and to the proper torque. (See "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.

CAUTION: When retorquing cylinder head bolts, only those below proper torque are to be retorqued to specifications. The remaining bolts, complying with or above torque specifications are to remain untouched.



Illust. 33 - Cylinder Head Mounting Bolt Tightening Sequence. (236 and 282 Series Diesel Engines Only.)

10. Adjust the valve clearances, refer to paragraph 6 of this section.

11. Install and fasten the valve housing cover, and the breather tube, if so equipped.

12. Install the thermostat and thermostat housing, upper radiator hose and water pump-to-thermostat housing hose. Install the fan pulley and adjuster or bracket.

TD-9 (Series B) AND 150 LOADER: Install the fan pulley and bracket with fan idler.

13. Install the water temperature gauge bulb into the cylinder head.

14. Install the intake and exhaust manifolds, see paragraph 4 of this section.

15. 236 AND 282 SERIES DIESEL ENGINES ONLY: Install the generator brace and generator.

16. 236 AND 282 SERIES DIESEL ENGINES ONLY: Connect the injection pipes to the

CYLINDER HEAD AND VALVES

nozzle assemblies and tighten the injection pipe nuts.

17. 236 AND 282 SERIES DIESEL ENGINES ONLY: Install the fuel filters and fuel filter bracket to the cylinder head using the three cap screws.

18. 236 AND 282 SERIES DIESEL ENGINES ONLY: Connect the oil filter-to-injection pump fuel line.

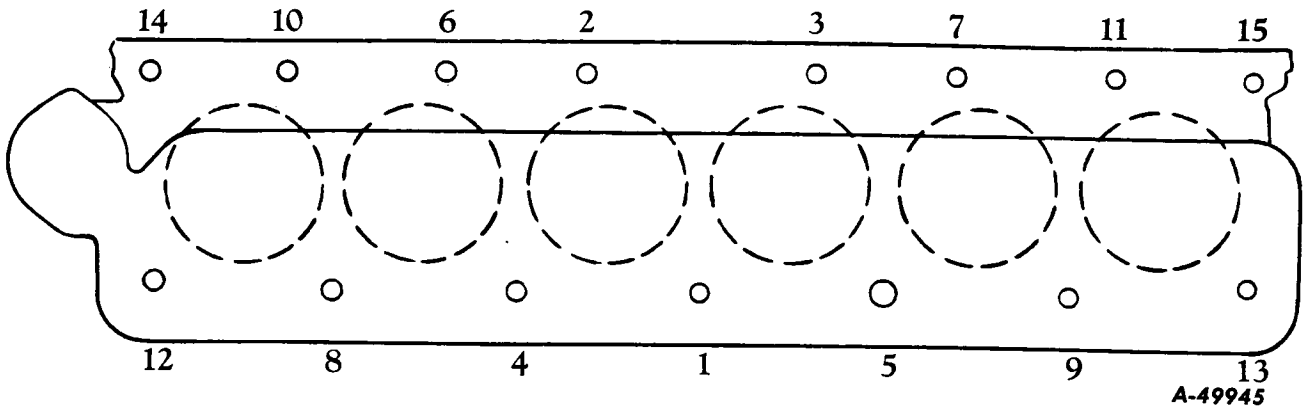
19. 236 AND 282 SERIES DIESEL ENGINES ONLY: Connect the glow plug-to-glow plug switch wire to the junction block on the cylinder head.

20. 236 AND 282 SERIES DIESEL ENGINES ONLY: Connect the fuel inlet pipe at the fuel filter.

21. 221 AND 263 SERIES CARBURETED ENGINES ONLY: Install the spark plugs and fasten the coil and bracket assembly to the cylinder head. Connect the spark plug cables. (Refer to Section 16.)

22. Before starting the engine be certain that the battery cables are properly connected and the fuel lines have been vented of air. (See Section 16.)

23. Fill the cooling system to the proper level. (Refer to the operator's manual.)



Illust. 34 - Cylinder Head Mounting Bolt Tightening Sequence. (221 and 263 Series Carbureted Engines Only.)

PRINTED IN UNITED STATES OF AMERICA

CONNECTING RODS, PISTONS AND PISTON RINGS

1. DESCRIPTION

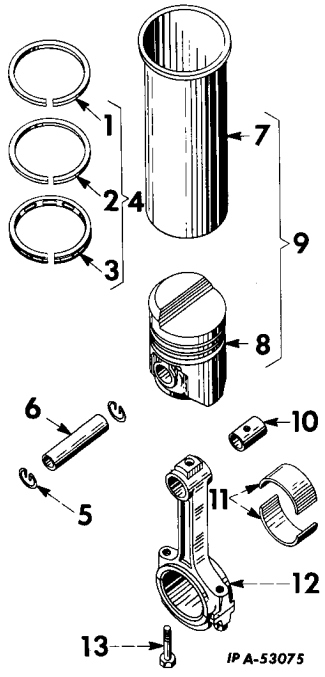
Connecting Rods

The connecting rods serve as the links between the pistons and the crankshaft. 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 bushing at the upper end 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.

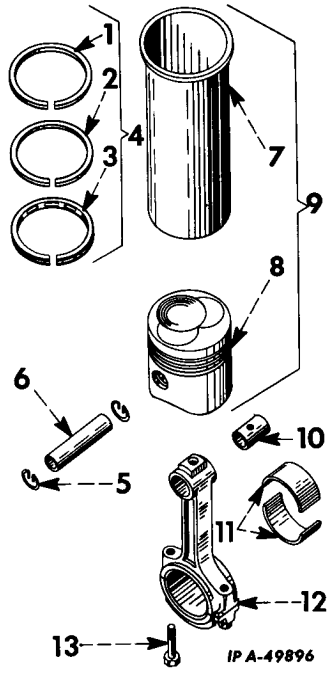
The lower bearings used in these engines are the replaceable insert type and insure correct running clearances when they are properly installed. This is possible without boring, reaming, scraping or using shims. The three important fundamentals on bearings and bearing fitting are "bearing crush," "bearing spread," and "bearing clearance." An explanation of these will be covered later.

Pistons

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 crankshaft. 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



Illust. 1 - Connecting Rod, Bearings, Piston, Rings and Sleeve (221 and 263 Series Carbureted Engines).



Illust. 2 - Connecting Rod, Bearings, Piston, Rings and Sleeve (236 and 282 Series Diesel Engines).

1. Compression ring.
2. Compression ring.
3. Oil control ring.
4. Ring set.
5. Retainer ring.
6. Piston pin.
7. Sleeve.
8. Piston.
9. Sleeve and piston set.
10. Pin bushing.
11. Bearings.
12. Connecting rod.
13. Cap screw.

Continued on next page.

CONNECTING RODS, PISTONS AND PISTON RINGS

1. DESCRIPTION - Continued

Pistons - Continued

escape of combustion gases but must be free enough to keep friction to its working minimum.

Piston Rings

The pistons are fitted with three piston rings. One oil regulating ring is fitted to each piston. The oil regulating ring provides an even circulation of lubricating oil and, therefore, an all-over lubricating and cooling action for the piston and crankcase sleeve. Excess oil is wiped by the rings, back down to the crankcase. The remaining rings are compression rings. Ring gaps and other dimensions are given in Section 1, "SPECIFICATIONS".

Piston Pins

The piston pin is made of steel and is cylindrical in 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 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 usually 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

1. Remove the intake and exhaust manifolds and cylinder head assembly. (Refer to Section 2.)

2. Remove the drain plug and drain the engine lubricating oil from the crankcase oil pan. Replace the drain plug.

3. Remove the cap screws securing the oil pan, and remove the oil pan and gasket.

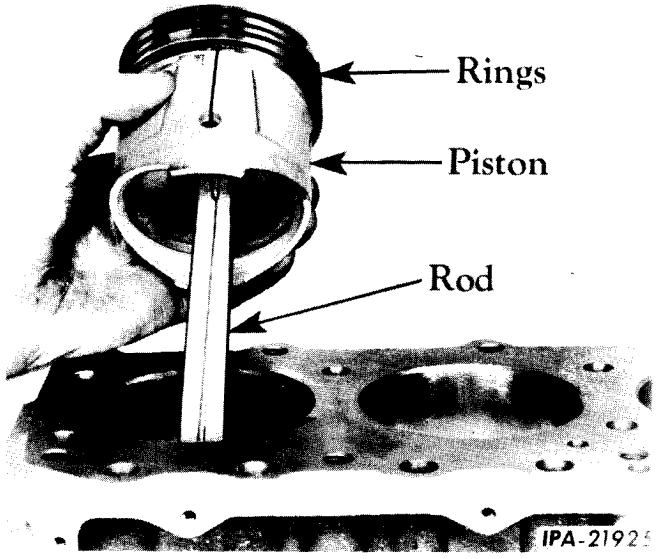
CAUTION: Before proceeding with piston and connecting rod removal, the ridge, existing on the cylinder wall at the upper end of the ring travel, must be removed by using a grinder. This prevents damage to the piston ring lands during removal of pistons, and prevents damage to new top piston rings after the installation of new rings.

4. Remove the oil pump. (Refer to Section 4.)

5. Each connecting rod is numbered, on the camshaft side of the rod, indicating its position in the engine. Remove the self-locking cap screws from the connecting rod cap and remove the cap.

6. Push the connecting rod and piston assembly to the top and lift out from the crankcase, (Illust. 3.). Replace the cap on the connecting rod to avoid damage.

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 they can be installed in the same position and cylinder from which they were removed.



Illust. 3 - Removing the Piston and Rod.

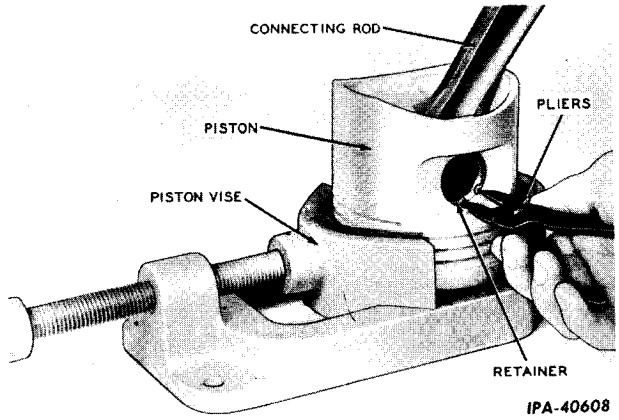
7. Crank the engine by hand to make each rod and cap accessible and remove all pistons and connecting rods in the same manner.

3. DISASSEMBLY

1. Remove the piston pin retainers from each piston. (See Illust. 4.) Remove the piston rings with the aid of a piston ring expander. Remove the top ring first and the remaining rings in order.

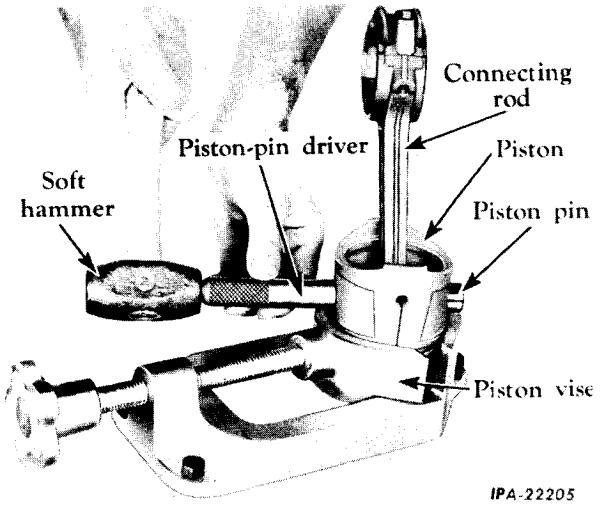
PRINTED IN UNITED STATES OF AMERICA

CONNECTING RODS, PISTONS AND PISTON RINGS



Illust. 4 - Removing the Piston Pin Retainer.

2. Heat the piston in boiling water or a piston heater. Place the piston in the piston vise, and, using a pin driving tool, drive the piston pin from the piston and connecting rod (Illust. 5).



Illust. 5 - Driving the Piston Pin from Piston.

4. INSPECTION AND REPAIR

1. Wash all parts in a cleaning solvent.

CAUTION: Do not use a caustic solution for aluminum pistons. Clean the carbon from the piston ring grooves with a broken ring or ring groove cleaner.

2. Inspect the connecting rods, caps, bearing shells and pin bushings as follows:

(a) All connecting rod bearings and piston pin bushings should be replaced in a major overhaul. Refer to "SPECIFICATIONS," Section 1, for piston pin bushing finished dimension.

(b) Test rods for alignment. Rods only slightly misaligned can be straightened using the proper equipment. Badly twisted or bent rods must be replaced.

3. Inspect the pistons for cracks, breaks, or scores.

4. Inspect the piston pins for wear; if wear is perceptible, replace pins. Replace piston pins showing signs of corrosion or etching.

5. Inspect the connecting rod bushings for scratches and burrs; dress off any such unevenness. Replace if necessary.

6. Connecting rod bolts must be cleaned of all foreign matter including the anti-rust materials that may be caked in the threads. This is also true of the connecting rod thread holes.

A good method of checking to determine thread condition is to turn the connecting rod bolt (threads lubricated with a light engine oil) all the way into the connecting rod with the fingers. If the bolt runs in relatively free without sticking or without the need for applying more than a very light (2-4 ft. lb.) wrench effort, the bolt is satisfactory for use.

Connecting Rods

Connecting rod cap bolt thread condition is most important. Threads that are dry, excessively rough, battered or that are filled with dirt, require considerable effort just to rotate the bolt. Then, when the clamping load is first developed, or the bolt tension is applied, the torque reading mounts rapidly (due to thread friction) to the specified figure without approaching the desired bolt tension and maximum clamping effect. Under these conditions the desired torque reading is obtained but the clamping effect might be far below requirements, leading to bearing failure or to connecting rod bolt breakage. The proper bolt tension and clamping effect can never be attained if the bolt is dry. The bolt must have a film of lubricant in the thread section and under the head. (Illust. 6.)

Due to the close fit of connecting rod bolts, the slightest thread imperfection increases thread friction to the extent that incorrect bolt tension

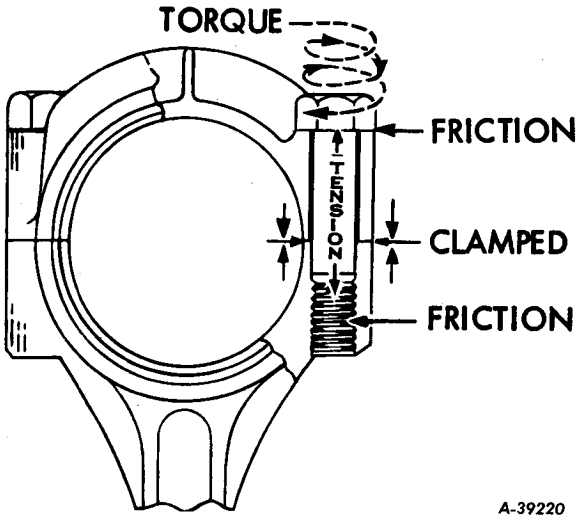
Continued on next page.

CONNECTING RODS, PISTONS AND PISTON RINGS

4. INSPECTION AND REPAIR - Continued

Connecting Rod - Continued

is likely. The threads in the rod should also be examined. Be sure that they are free of chips or hard foreign material.



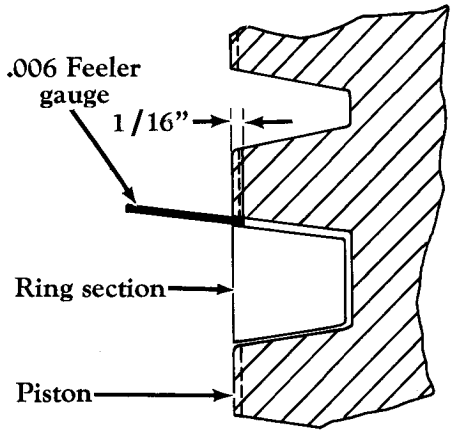
Illust. 6 - Connecting Rod, Cap and Bolt.

Pistons

7. Measure the piston skirt at right angles to the pin to determine if it is worn excessively, replace if necessary.

8. Ring grooves should be checked for the specified side clearance. Keystone rings should have a minimum of .0015 to .002 inch side clearance. If the grooves are worn to the point where there is .006 inch or more side clearance, the grooves are excessively worn and the piston should be replaced. The following is a fast and simple method of checking the side clearances.

Install the correct new ring in the groove being checked. Insert a .006 inch feeler gauge between the top of the ring and the groove, a distance of 1/16 inch. (Illust. 7.) Push the ring into the groove. If the ring face is flush with or to the inside of the land below the ring, the groove is excessively worn. If the ring extends outside the surface of the land, the groove is still within allowable limits and the piston can be reused if otherwise serviceable.



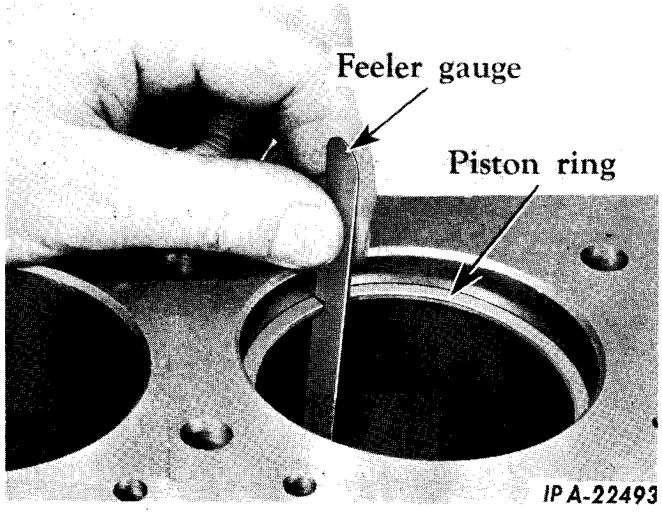
Illust. 7 - Checking Piston Groove for Wear.

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

9. Standard ring grooves should be checked also for the specified side clearance by placing each ring in its groove on the piston and inserting a feeler gauge around its edge.

Piston Rings

10. 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 such parts.



Illust. 8 - Checking Ring Gap.

PRINTED IN UNITED STATES OF AMERICA

CONNECTING RODS, PISTONS AND PISTON RINGS

11. Insert each ring into the sleeve or cylinder bore for that piston. Force them squarely down inside the sleeve or cylinder bore. Position a feeler gauge between the ends of the ring (Illust. 8) and compare the existant gap against the specified gap for a new ring. (Refer to "SPECIFICATIONS," Section 1.)

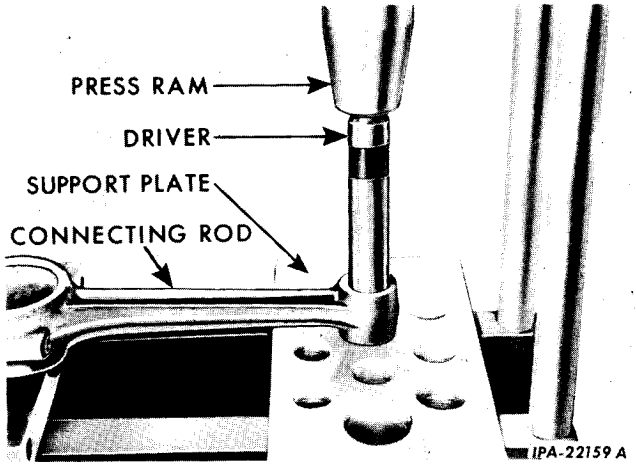
If it is necessary to remove material from the ring ends because the end gap is too close, clamp a mill file in a vise, hold the ring in proper alignment and dress off the ends squarely to obtain the desired gap.

12. Inspect the "Windows" of the oil regulating ring and piston for blocked oil ways. Failure to keep the oilways clear will result in uneven lubrication and "hot-spots" of the piston and cylinder sleeve. All rings should fit loosely in the piston grooves without binding.

Piston Pin Bushing Replacement

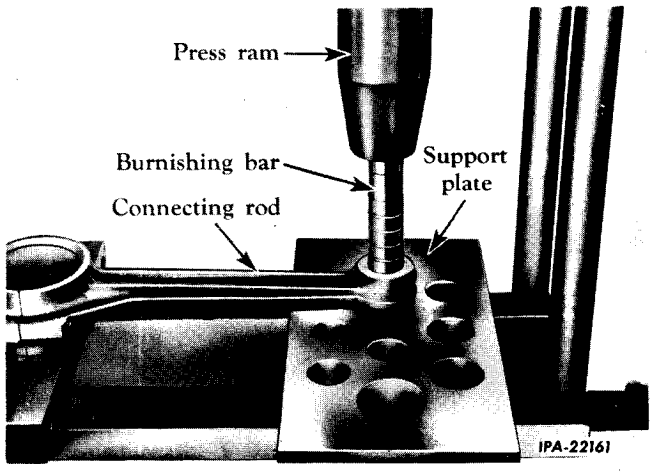
1. Place connecting rod in arbor press and press old piston pin bushing from the connecting rod. (Illust. 9.)

2. Align the new piston pin bushing on the connecting rod so that the oil hole in the bushing will match with the oil hole in the connecting rod. Press the bushing into the rod.



Illust. 9 - Removing Piston Pin Bushing.

3. Burnish bushing into place in the connecting rod (Illust. 10) and then ream bushing to provide the dimension shown in "SPECIFICATIONS," Section 1.



Illust. 10 - Burnishing Connecting Rod Bushing.

5. REASSEMBLY

1. Before assembling the piston and connecting rod, check the fit of the piston pin in the piston for proper end clearance as follows:

(a) Prepare the piston and the pin for assembly as outlined in step (2).

(b) Push the pin into the piston and install a retainer ring at each side of the piston.

(c) Push one end of the piston pin until it stops against the retainer ring on the opposite side of the piston.

(d) Using a feeler gauge, in the gap between the piston pin and the retainer ring, check for end clearance. See "SPECIFICATIONS" Section 1.

(e) Remove the retainer rings and proceed with the reassembly as follows:

NOTE: When assembling the pistons to the rods, the front of the piston will be indicated by an arrow on the carbureted engines, and by the letter "F" on the diesel engines.

2. With the piston pin at room temperature (70°) and generously coated with clean engine lubricating oil, and the piston heated in hot water to approximately 150° F., the piston pin can be entered into one boss of the piston by pushing with the hand. While the piston is hot,

continued on next page

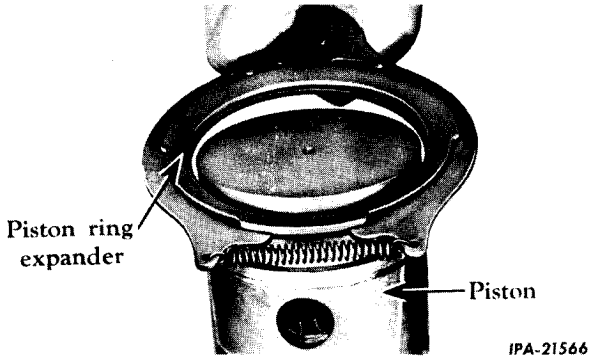
CONNECTING RODS, PISTONS AND PISTON RINGS

5. REASSEMBLY - Continued

quickly and 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.

3. Install a retainer ring in the groove at each side of the piston to secure the piston pin.

4. Using a piston ring expander, install the rings, oil control ring first, into the grooves of the pistons. (Illust. 11.)



Illust. 11 - Installing the Piston Rings.

Position the ring gaps 90° from the thrust side of the piston (in line with the piston pin bore) and 180° from one gap to another.

6. INSTALLATION

NOTE: When reinstalling a piston and connecting rod assembly, install the assembly in the same cylinder sleeve and in the same position from which it was removed.

1. Generously coat the piston ring compressor and sleeve with lubricating oil. Install the ring compressor on the piston and insert the piston and connecting rod assembly through the top of the crankcase.

2. Push down on the piston carefully until it is in the crankcase sleeve. (Illust. 12.)

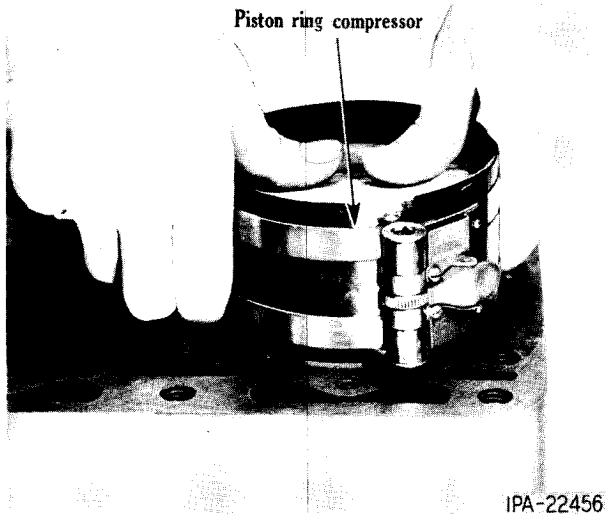
3. Wipe clean and oil the crankshaft journals and fit the connecting rod bearings as outlined in "Bearing Fitting Procedure," Par. 7.

4. Install all the pistons, connecting rods and bearings in the same manner.

5. Check the connecting rod side clearance (refer to "SPECIFICATIONS" Section 1) by inserting a feeler gauge between the bearing cap and lobe of the crankshaft.

6. Install the oil pump. (Refer to Section 4.)

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



Illust. 12 - Installing the Piston and Connecting Rod Assembly.

8. Install the cylinder head and gasket. (Refer to "Cylinder Head and Valves", Section 2.)

9. 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," Par. 12, before operating at normal load and speed.

7. BEARING FITTING PROCEDURE

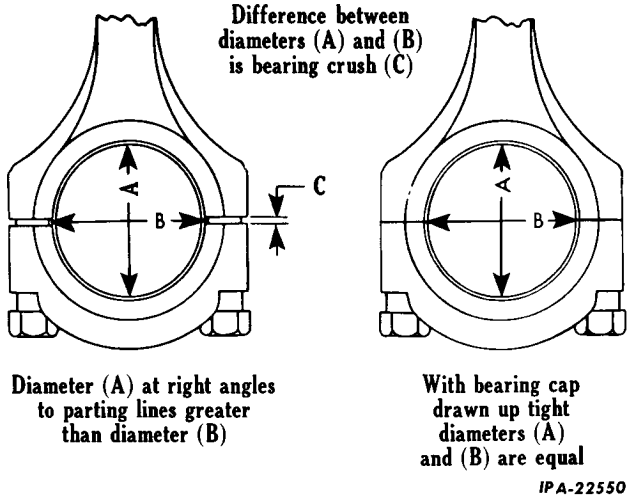
CAUTION: Except when fitting replacement crankshaft bearing caps (Par. 5 or 6), bearings or bearing caps must not be filed, lapped or modified in any other manner. Premature bearing failure will result from attempts to reduce journal-to-bearing running clearances by modifying of the bearing caps, bearings or both. Such modifying will alter the engineered fit of the bearing shells in their bores and destroy the specifically desired "crush." While such practices will make a tighter fit at top and bottom of the bearing, it will result in an out-of-round bore and bearing shell distortion. New bearing

PRINTED IN UNITED STATES OF AMERICA

CONNECTING RODS, PISTONS AND PISTON RINGS

shells will have to be installed eventually and that is when additional problems are encountered.

1. When installing precision type bearings, it is important that the bearing shells fit tightly in the rod or case bore. To accomplish this, the diameter of the bearing at right angles to the parting line is slightly larger than the actual diameter of the bore into which the bearing will be assembled. When the bearing cap is drawn up tight the bearing is compressed, assuring a positive contact between bearing back and bore. This increased bearing diameter is called "bearing crush" (Illust. 13).



Illust. 13 - Graphical Illustration of Bearing Crush.

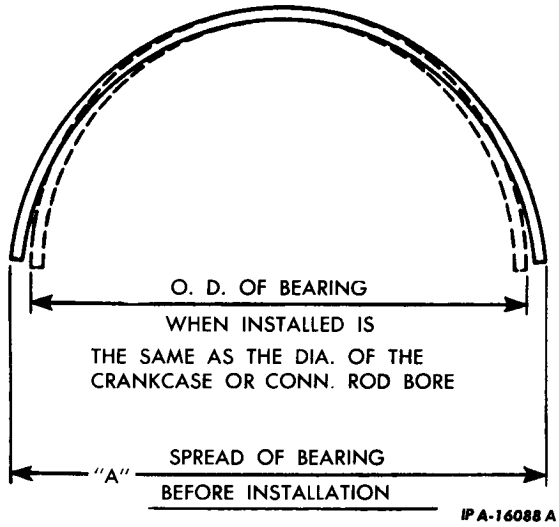
2. To obtain bearing assembly with the correct "bearing crush," care must be taken when tightening the clamping bolts to be sure they are tightened alternately and evenly, using a tension wrench and tightening to the correct torque specifications.

3. Main and connecting rod bearings are designed with the "spread" (width across the open ends) slightly greater than the diameter of the crankcase bore or connecting rod bore into which they are to be assembled (Illust. 14). For example, the width across the open ends of the connecting rod bearing not in place is approximately .025 inch more than when the bearing is in position in the rod. This condition causes the bearing to fit snugly in the rod bore and the bearing must be "snapped" or lightly forced into its seat.

Rough handling in shipment, storage, or normal use in an engine, may cause the bearing spread to be increased or decreased from the specified width. Bearing spread should therefore be carefully measured and corrected as necessary before installation in an engine. Bearing spread can be safely adjusted as follows if care and judgement are exercised.

(a) EXCESSIVE SPREAD: If measurement of bearing (Illust. 14) indicates that dimension "A" is excessive (refer to "SPECIFICATIONS," Section 1) place bearing on a wood block (Illust. 15) and strike the side lightly and squarely with a soft mallet. Recheck measurement and if necessary continue until correct width is obtained.

(b) INSUFFICIENT SPREAD: If measurement of bearing (Illust. 14) indicates insufficient spread, place bearing on a wood block (Illust. 15) and strike the back of the bearing lightly and squarely with a soft mallet. Recheck measurement and if necessary continue until correct width is obtained.



Illust. 14 - Diagram Showing Bearing Spread.

Bearing Clearance

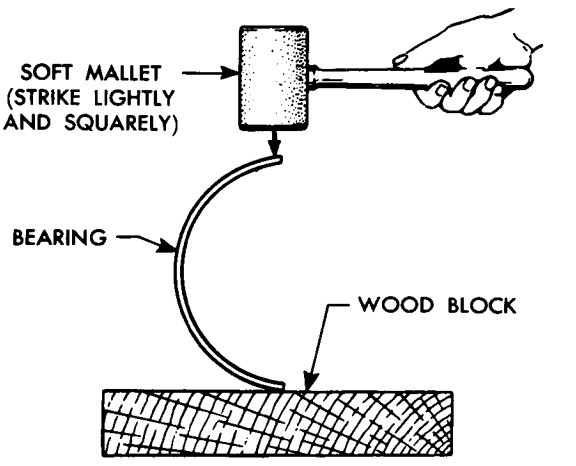
4. When installing bearings in an engine, the proper clearance between bearing surfaces should be checked closely. Refer to "SPECIFICATIONS," Section 1, for allowable limits. To get an accurate measurement of this clearance, the "plastigage" method is recommended. The following instructions can be used when measuring with "plastigage:"

Continued on next page.

CONNECTING RODS, PISTONS AND PISTON RINGS

7. BEARING FITTING PROCEDURE - Continued

Bearing Clearance - Continued



Illust. 15 - Method of Increasing or Decreasing Bearing Spread.

(a) Remove bearing cap and wipe bearing surface and exposed half of crankshaft journal free of oil.

(b) Place a piece of "plastigage" the full width of bearing insert.

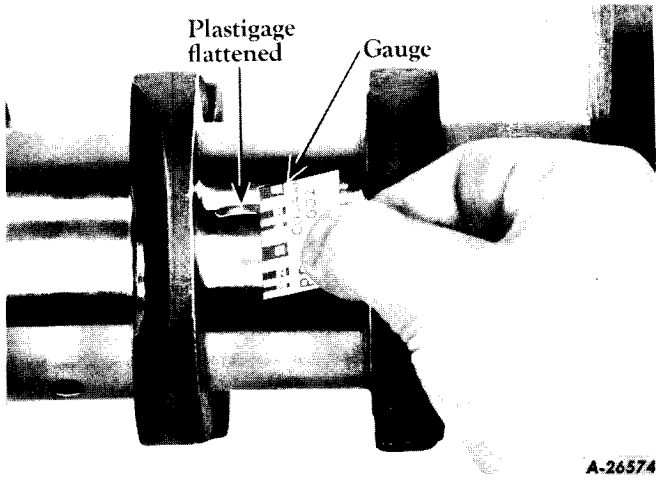
(c) Reinstall the bearing cap and tighten the self-locking cap screws to recommended torque (see Torque Chart in Section 1).

(d) Remove the bearing cap. The flattened plastic material will be found adhering to either the bearing shell or the crankshaft.

(e) To determine the bearing clearance compare the width of the flattened plastic material at its widest point with the graduations on the envelope (Illust. 15). The number within the graduation on the envelope indicates the clearance in thousandths of an inch.

NOTE: Do not turn crankshaft during the above procedure.

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 problems should be encountered providing the crankshaft and/or connecting rod are in proper condition.



Illust. 16 - Using "Plastigage" Method for Checking Bearing Clearance.

CYLINDER SLEEVES

8. DESCRIPTION

The cylinder sleeves are of the dry type. Cylinder sleeves and their mated pistons should be marked and kept in sets when removed, and installed back to their original position and location when reassembled.

9. REMOVAL

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

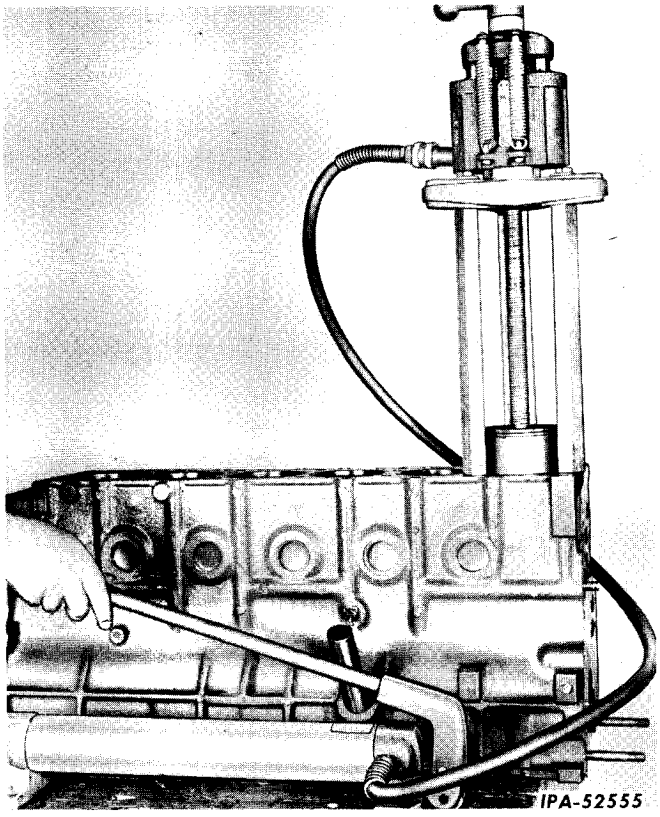
2. Remove the connecting rods and pistons. (Refer to "Removal Procedure" in this Section.)

PRINTED IN UNITED STATES OF AMERICA

CYLINDER SLEEVES

NOTE: It is advisable to wrap oil-soaked cloth around the crankshaft connecting rod bearing journals to keep them as clean as possible. Also wrap the piston and connecting rod assemblies in clean cloth to protect them until installation.

3. Remove the cylinder sleeves with a sleeve puller.



Illust. 17 - Removing the Cylinder Sleeve. (221 Series Carbureted Engine Shown.)

(a) The 221 and 263 series carbureted engines use an I.H.-970 sleeve puller with a 970-7E removing adapter. (Refer to NOTE.)

(b) The 236 and 282 series diesel engines use a I.H.-970 sleeve puller with a 970-7F removing adapter. (Refer to NOTE.)

NOTE: For further information or to order these tools, write to "Service Tool Inc., 1901 S. Indiana Ave., Chicago 16, Illinois.

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 crankcase sleeve bore.

10. 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.

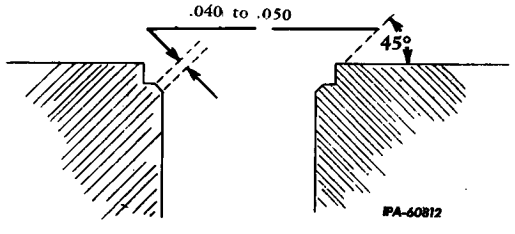
2. Each cylinder sleeve should be checked with an inside micrometer to determine taper, out-of-round or worn condition. Measure the diameter of the cylinder sleeve, at the top of the piston ring travel, at a right angle to the centerline of the crankshaft. Record the readings. Next, measure each bore so the gauge reading coincides with the centerline of the crankshaft. The difference between the read ings is the out-of-round condition at the top of the bore. Repeat this same procedure at the bottom of the ring travel. The difference between the diameters measured at the top and bottom of the bore is the taper of the bore. Replace sleeves if worn beyond a serviceable clearance or taper. Refer to "SPECIFICATIONS" in Section 1.

3. Measure the crankcase sleeve bore with an inside micrometer to be sure it is within specifications. (Refer to "SPECIFICATIONS" in Section1.) If the bore is undersize, it can be honed to proper size. Replacement sleeves will be a hand push fit only.

4. Check the crankcase to be sure that the .040 to .050 inch by 45 degree chamfer at the flange counterbore is present and free of burrs (Illust. 18). If the counterbore chamfer does not meet specifications, a small high speed grinder can be used to remove the required material.

5. Clean the bottom surface of the cylinder head and the top deck of the crankcase thoroughly. All residue of aluminum coating from the old gasket must be completely removed.

6. All excessive oil should be removed from the crankcase cap screw holes and the holes cleaned. A pocket of oil will form a hydraulic lock and give a false torque indication, also the oil will be forced up around the threads and into the cylinder head gasket contributing to premature gasket failure.



Illust. 18 - Chamfer at Sleeve Counterbore.

CYLINDER SLEEVES

11. INSTALLATION

NOTE: The sleeve bore of the crankcase should be checked with a cylinder dial gauge, and any condition in the crankcase which may result in a distorted sleeve must be corrected before a new sleeve is installed.

1. The cylinder bore and counterbore must be clean and free of hard carbon or rust. Emery paper or wire brush may be used to clean the bore after which it should be wiped with a clean rag so it is dry and free of grit.

2. The crankshaft must be protected to keep any grit from getting in the oil passages or on the journals.

3. 236 AND 282 SERIES ENGINES ONLY: Cylinder sleeves must be CLEAN and DRY. Desirable sleeve fit in the crankcase is:

(a) Sleeve should not fall into place nore should it slip more than two inches from its own weight.

(b) Pressure in excess of that which can be exerted with the two thumbs indicates the sleeve is too tight. (About 40 pounds of push.)

(c) A sleeve may go into the bore with two or three pounds push until it is one inch from being fully seated and suddendly requires 20 or 30 pounds effort. This is permissible.

(d) Turn the sleeve to different positions to find its looser fit.

(e) Try different sleeves in the bore to find the most desirable fit.

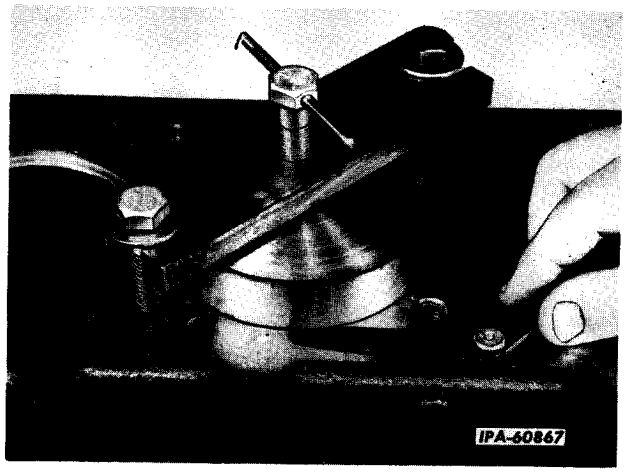
(f) When the bore is too tight, it is permissible to hone the sleeve bore to obtain a satisfactory fit.

(g) If, after trying several sleeves, the fit is too loose, then .002 inch oversize sleeve can be installed. In most cases, it will be necessary to hone the sleeve bore in order to obtain the desired fit. If the sleeve is still too loose, it will be necessary to replace the crankcase.

4. Re-usable sleeves that meet specifications, should be installed in their previously identified positions and locations in the crankcase.

The 221 and 263 series carbureted engines use an IH-970 sleeve puller with a 976-2 installing adapter (refer to "NOTE").

NOTE: The special tools mentioned in this paragraph may be ordered from "Service Tools, Inc., 1901 South Indiana Avenue, Chicago 16, Illinois.

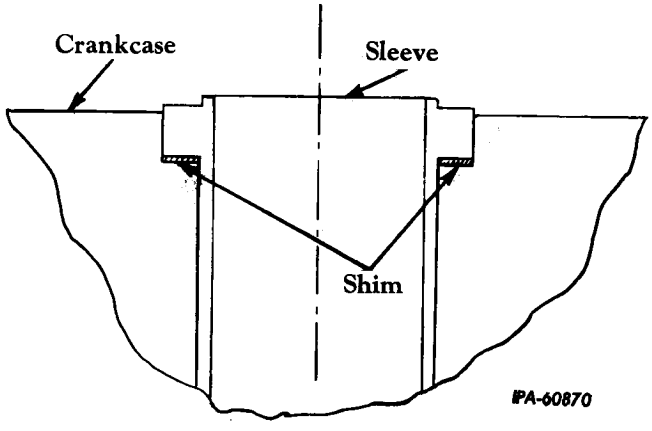


Illust. 19 - Cylinder Sleeve Flange Height Gauge Tool, FES-49.

5. 236 AND 282 SERIES ENGINES ONLY: Shims are to be used (as required), to obtain a sleeve flange height above the crankcase deck from .001 to .005 inch with the cylinder sleeve clamped down.

NOTE: Shims are available in .003 and .005 inch thickness. The shim gap should be .080 to .100 inch. Cut off the end of the shim if necessary to obtain specified gap.

The sleeve should be clamped down with "cylinder sleeve flange height gauge tool," FES-49. (Illust. 19.) Proceed as follows:



Illust. 20 - Location of Cylinder Sleeve Shims.

PRINTED IN UNITED STATES OF AMERICA

CYLINDER SLEEVES

(a) After a sleeve is clamped down, measure the gap between the crankcase deck and the gauge tool (Illust. 19) at four locations, 90 degrees apart. This gap is the height of the sleeve flange above the crankcase deck. If it is not within the specified limits of .001 to .005 inch, add shims as required. (Refer to Illust. 20.)

(b) To install shims, lift the cylinder sleeve about one inch and spiral the split shim over the flange and then under and into the flange bore. Stagger the shim gaps if more than one is used.

(c) Clamp the sleeve down once more with the "Flange Height gauge Tool," FES-49 and recheck the flange height as in (a) above.

Change or remove shims as necessary to obtain the desired flange height. All six sleeves must be within specifications. The same overall flange height on all six sleeves is desirable. Attempt to maintain any variation within .002 inch between adjoining sleeves.

6. Install the pistons and connecting rods. Refer to installation procedure in this section.

7. On engines not equipped with cylinder head dowels, install two aligning dowels ED-4030, one in the front and one in the rear on the right side of the crankcase. These dowels align the cylinder head gasket. Be sure the gasket ring is centered on the sleeve flanges.

8. Place the cylinder head in position over the dowels. Clean the cap screw threads and lubricate with SAE-30 engine oil. After all the cap screws have been installed except for two, remove the aligning dowels ED-4030 and install the remaining two cap screws.

9. Torque the cylinder head cap screws in proper sequence as given in Section 2.

12. 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 lubricating oil as specified in the latest service bulletin on "Crankcase Lubricating Oils for IH Engines."

3. Install an oil inlet screen into the turbocharger (on units so equipped) for the first 5 to 25 hours of operation. Be certain to remove this screen after the proper number of hours have elapsed.

4. Start 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.

5. 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.

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

7. After the engine has operated for 25 hours, the oil should be drained while the engine is hot, and the crankcase refilled with Series 3 oil of the viscosity and grade specified in the operator's manual.

8. After the first 50 to 100 hours of operation, the cylinder head stud nuts must be retorqued and the valve tappets adjusted. (Refer to Section 2 for proper torquing sequence.)

Continued on next page.

CYLINDER SLEEVES

12. ENGINE RUN-IN SCHEDULE -Continued

Carbureted

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

2. Fill the crankcase with lubricating oil not lighter than SAE-20 and as specified in the latest service bulletin on "Crankcase Lubricating Oils for IH Engines."

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 run-in schedule is recommended after the engine has reached operating temperatures.

Tractor

Period 1: 15 min. Operate tractor in 4th gear without load at 75% rated speed.

Period 2: 45 min. Operate tractor at 75% rated speed on light work.

Period 3: 2 hours Operate tractor at full rated speed on medium heavy work.

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 element if necessary.

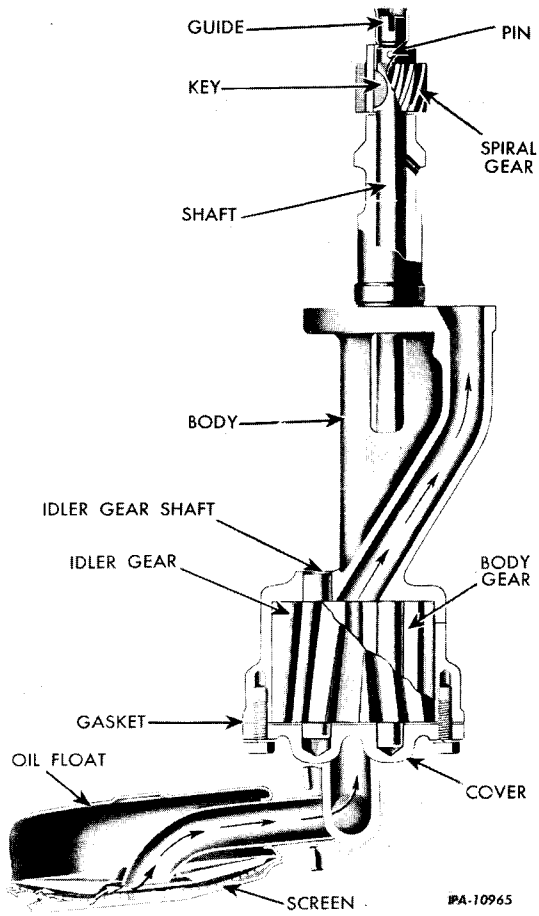
8. The oil can be used for the duration of the recommended oil change period.

9. After the first 50 to 100 hours of operation, the cylinder head must be retorqued and the valve tappets adjusted. (Refer to Section 2 for proper torquing sequence.)

OIL PUMP

1. DESCRIPTION

The engine lubricating oil is taken from the oil sump through a floating screened intake, to the oil pump. From the oil pump it is directed under pressure through the rifle-drilled passages in the crankcase, to the main bearings, camshaft bearings, timing gears, governor, valve lever assembly, oil cooler and the oil filter.



Illust. 1 - Sectional View of the Oil Pump.

2. REMOVAL

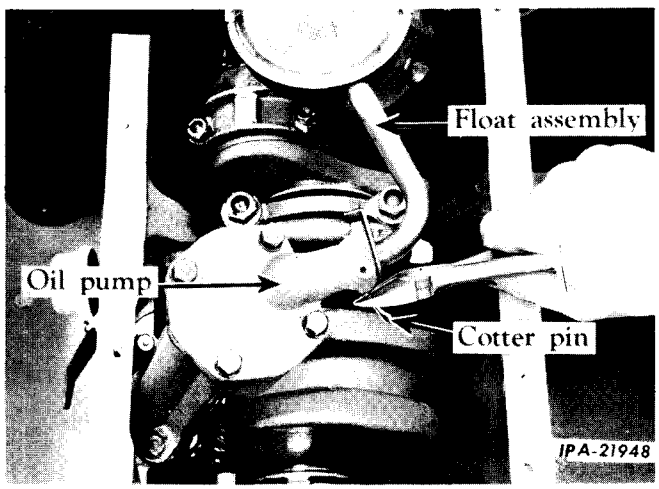
NOTE: On engines equipped with battery ignition (221 and 263 series carbureted engines), it is necessary to have the oil pump correctly timed with the camshaft. Correct timing is necessary because the pump drive gear also drives the distributor through a slotted connection. Before removing the oil pump from the engine, 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 number one piston is on top dead center of the compression stroke. Using a punch, mark the pump shaft and the pump body so that the shaft can be reinstalled in the same position.

1. Drain the oil from the engine and replace the drain plug when empty.

2. Remove the cap screws securing the oil pan, and remove the pan and gasket.

3. PUMPS WITH REMOVABLE FLOAT: Remove the cotter pin fastening the float to the oil pump (Illust. 2). Remove the float from the pump. Do not lose the seal on the float tube.

4. Remove the cap screws securing the pump to the block, and remove the oil pump.



Illust. 2 - Removing the Float Assembly.

3. DISASSEMBLY

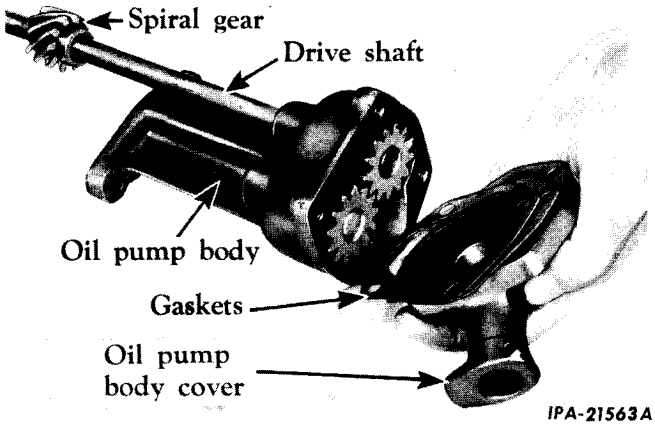
1. Remove the cap screws and lock washers from the oil pump body cover, and lift the cover and gaskets from the oil pump body. (See Illust. 3.) On later pumps the float is integral with the body cover.

2. With the pump cover removed and gears and shaft in place, exert pressure against the gears with the thumb, pushing the gears away from the outlet side of the pump.

continued on next page

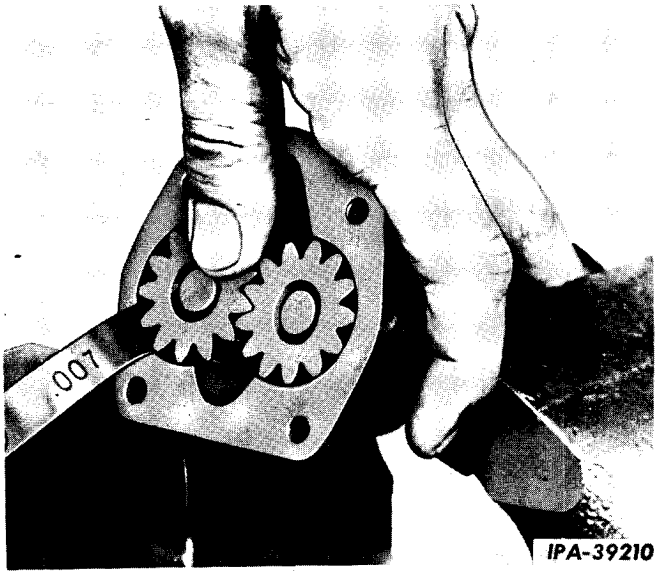
OIL PUMP

3. DISASSEMBLY - Continued



Illust. 3 - Removing the Oil Pump Cover Plate.

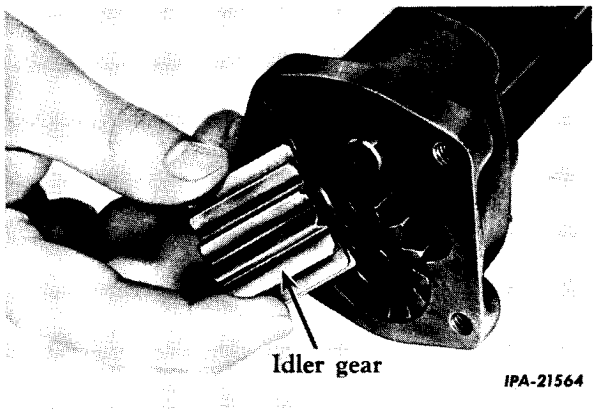
3. Hold the gears in this manner and measure the clearance between the outside diameter of the gear and the bore of the housing. (See Illust. 4.) Clearance should be within the limits given in Section 1, "SPECIFICATIONS".



Illust. 4 - Measuring Pump Gear to Body Clearance.

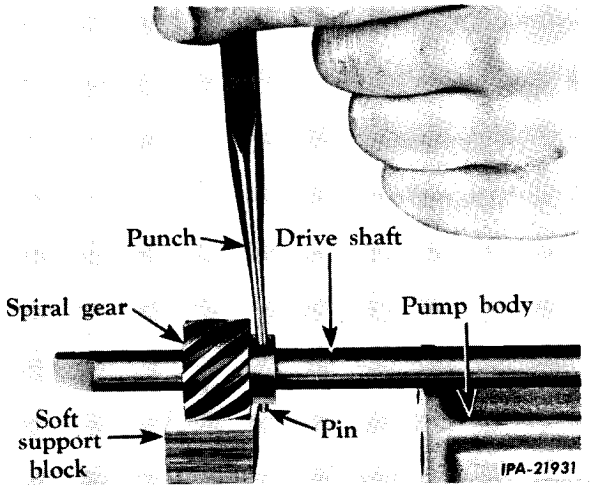
4. Check backlash between the pump body gears. If this exceeds the figure shown in "SPECIFICATIONS" Section 1, replace the gears.

5. Remove the oil pump idler gear from the idler gear shaft. (See Illust. 5.)



Illust. 5 - Removing the Idler Gear.

6. Support the oil pump shaft to prevent bending, and drive out the pin from the oil pump spiral gear. (See Illust. 6.)



Illust. 6 - Removing the Spiral Gear Pin.

7. Press the spiral gear from the oil pump shaft using the proper support to avoid damaging the gear or bending the shaft.

8. Remove the Woodruff key from the shaft.

9. Remove the oil pump drive gear and drive shaft assembly from the oil pump body. The shaft and gear are serviced as one part.

10. The idler shaft need not be removed from the oil pump body unless replacement is necessary.

PRINTED IN UNITED STATES OF AMERICA

OIL PUMP

4. INSPECTION AND REPAIR

1. Clean all parts thoroughly using a dry-cleaning solvent, being certain that all openings in the oil pump float screen are free and clean. If the screen has been crushed, replace it, do not attempt to make a repair.

2. Check the pump shaft clearance in the shaft bore. To correct for wear beyond limits given in "SPECIFICATIONS", Section 1, replace the body and shaft with gear.

3. Inspect all gears for wear, scoring and chipped teeth. If any gear is damaged it must be replaced to obtain normal pump function. The drive gear and shaft are serviced as one part.

4. Inspect the body and oil pump cover for wear (gear contact) or damage.

5. Inspect the idler shaft, if the shaft diameter does not conform to "SPECIFICATIONS" Section 1 or is loose in the pump body, replace the shaft.

6. Refer to the inspection made during "Disassembly" in determining the gear-to-body clearance and gear backlash. Replace the necessary parts if this inspection revealed variation from the "SPECIFICATIONS" shown in Section 1.

5. REASSEMBLY

NOTE: When installing pump gears and shaft, these parts should be oiled liberally with engine oil for initial lubrication. The pump drive pinion and camshaft gear should also be similarly coated when the pump is installed in the engine.

1. Install the idler shaft into the pump body, if replacement is necessary.

2. Insert the oil pump drive shaft and body gear assembly into the oil pump body.

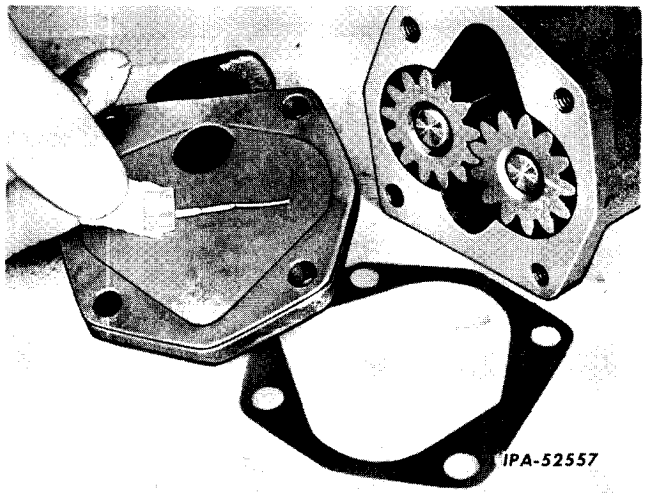
3. Place the Woodruff key into the slot at the top end of the shaft and install the oil pump spiral gear. Be certain the spiral gear hub is down. Press the spiral gear down onto the shaft until the pin hole in the gear hub aligns with the pin hole in the shaft.

4. Install the spiral gear pin.

5. Install the idler gear on the idler gear shaft.

6. Install the gaskets and oil pump body cover and secure with cap screws and lock washers.

7. Check the oil pump body gear end clearance using "plastigage" as shown in Illust. 7.



Illust. 7 - Checking the End Clearance of the Pump Shaft and Body Gear.

If the end play is in excess of that shown in "SPECIFICATIONS" Section 1, remove one gasket from the cover. If the end play is less than that shown, add one gasket. Always recheck the end play after alterations.

6. INSTALLATION

Correctly install the oil pump into the cylinder block as outlined below.

1. Engines not equipped with distributors: Pump timing need not be considered when reinstalling these pumps. Insert the pump shaft and gear into the opening in the block, correctly engage the camshaft gear and pump spiral gear and secure the pump to the engine block.

2. Engines equipped with distributors: If the crankshaft has not been moved or rotated following the removal of the oil pump, follow step (a). If the crankshaft has been moved or rotated following the removal of the oil pump, follow step (b).

(a) Remove the distributor before installing the oil pump. Install the pump being certain that the marks, made on the

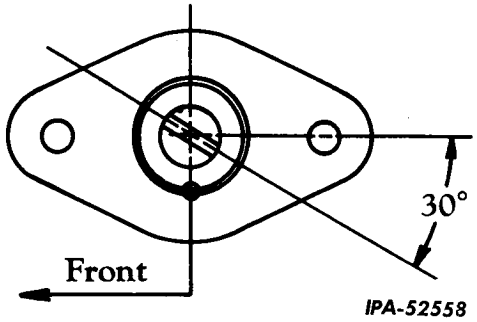
continued on next page

OIL PUMP

6. INSTALLATION - Continued

shaft and the pump body before removal, align when the pump is completely seated and the gears are engaged.

(b) Remove the distributor before installing the oil pump. Place the No. 1 piston at top dead center of the compression stroke. Insert and seat the oil pump into the cylinder block being certain the tang at the top of the oil pump shaft is at a 30° angle to the side of the engine. (See Illust. 8.)



Set engine on firing position of No. 1 Cyl. Mesh oil pump gear so that tang of pump shaft is as shown.

Illust. 8 - Correct Oil Pump Tang Position (221 and 263 Series Carbureted Engines).

3. Secure the pump to the engine block.

4. PUMPS WITH REMOVABLE FLOAT: Position the oil pump float, being certain to install the seal, line up the cotter pin holes and insert a new cotter pin and fasten securely. On later pumps, the float is integral with the body cover.

5. Replace the oil pan and gasket, using a new gasket if necessary, and secure to the crankcase with the cap screws. Refer to "SPECIFICATIONS" Section 1 for the correct torque.

6. Fill the crankcase with the proper quantity and grade of lubricating oil. (Refer to the Operator's Manual.)

7. Install and time the distributor, if so equipped. (Refer to Section 12.)

8. Install the oil pump shaft support on engines so equipped.

OIL PUMP SHAFT SUPPORT
(Power Unit Diesel Engines Only)

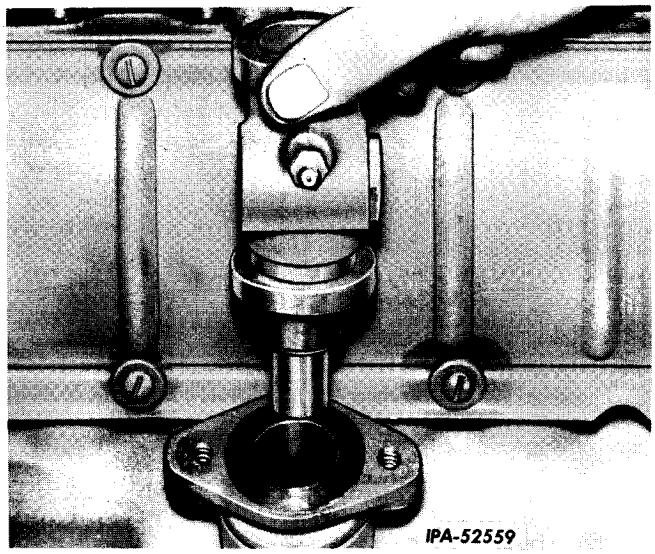
7. DESCRIPTION

The oil pump shaft support, located in the distributor mounting also serves as the tachometer drive housing (if so equipped).

The support assembly should usually require little more than the specified maintenance in the operator's manual. However, if excessive pinion or bushings wear is indicated, the assembly can be disassembled and repaired as described in the following paragraphs.

8. REMOVAL

Remove the clamps securing the support assembly to the engine, and remove the support assembly. (See Illust. 9.)



Illust. 9 - Removing the Oil Pump Shaft Support Assembly.

PRINTED IN UNITED STATES OF AMERICA

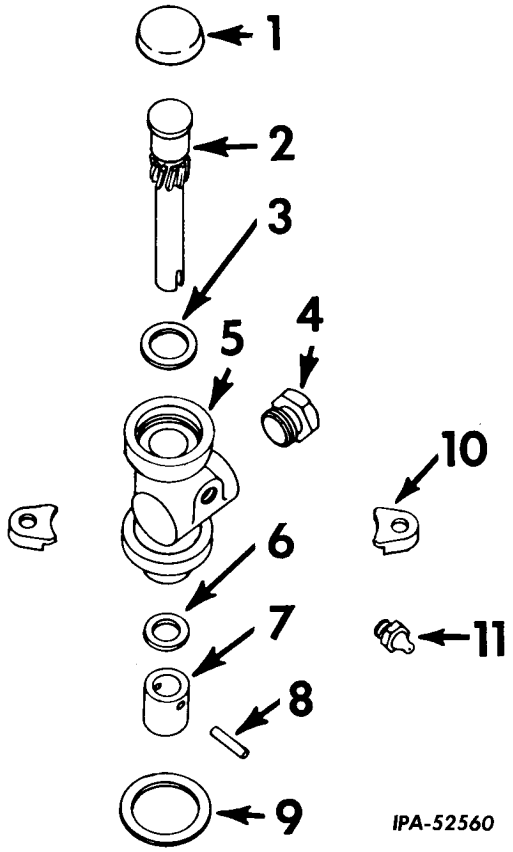
OIL PUMP SHAFT SUPPORT
(Power Unit Diesel Engines Only)

9. DISASSEMBLY (Refer to Illust. 10)

1. Remove the collar pin (8), and slide the collar (7) and lower thrust washer (6) from the shaft (2).

NOTE: Remove the tachometer spiral gear if so equipped.

2. Remove the housing plug (1), and slide the shaft (2), and upper thrust washer (3) from the housing (5).



Illust. 10 - Oil Pump Shaft Support.

1. Plug.
2. Pinion shaft.
3. Thrust washer.
4. Plug.
5. Housing.
6. Thrust washer.
7. Collar.
8. Collar pin.
9. Gasket.
10. Clamp.
11. Fitting.

10. INSPECTION AND REPAIR

1. Clean all parts using a dry solvent, and dry thoroughly.

2. Inspect the pinion bearing surfaces for wear and the groove for cracks or chips. Replace if necessary.

3. Inspect the tachometer drive teeth, if used, for worn or cracked teeth. Replace if necessary.

4. Inspect the thrust washers and replace if necessary.

5. Inspect the housing for cracks. The housing also contains two bushings; these should be checked for wear. The housing and bushings are serviced only as an assembly and must be replaced if either is worn or cracked.

6. Inspect the collar, being certain it was not damaged when removing the pin.

11. REASSEMBLY (Refer to Illust. 10)

1. Place the upper thrust washer (3) on the shaft (2) and insert the shaft into the housing.

2. Install the tachometer spiral gear (if so equipped) into the housing.

3. Place the lower thrust washer (6) on the shaft.

4. If the shaft (2) is to be reused, slide the collar (7) on the shaft, align the holes and insert and peen the collar pin (8).

5. If a new shaft (2) is to be used, slide the collar (7) on the shaft. Insert .003 to .009 inch shim stock between the thrust washer (6) and the housing. Using a number 30 (.1285) drill, drill through the shaft and insert the collar pin (8). Peen the pin ends so that the pin completely fills the hole. Remove the shim stock

continued on next page

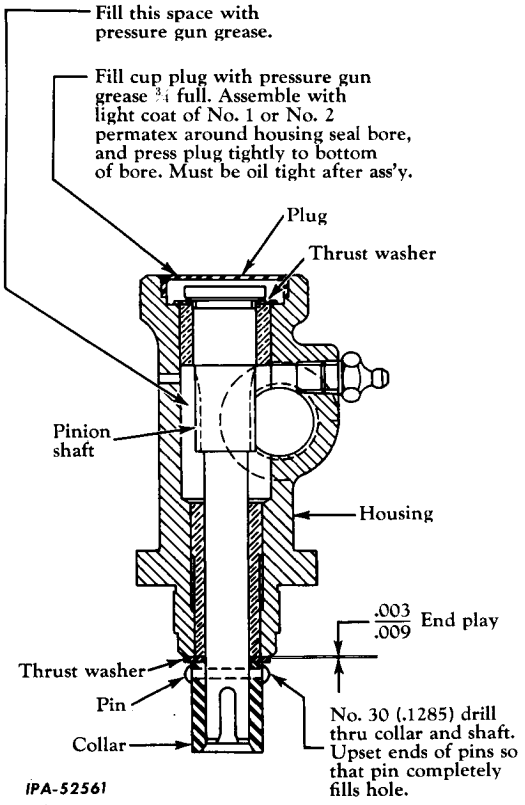
OIL PUMP SHAFT SUPPORT
(Power Unit Diesel Engines Only)

11. REASSEMBLY (Refer to Illust. 10) - Continued

and recheck using a feeler gauge for .003 to .009 inch end play between the thrust washer and the housing. (See Illust. 11.)

6. Fill the housing cavity in the area of the gear on the pinion shaft (2) with pressure gun grease. (See Illust. 11.)

7. Fill the plug (1) with pressure gun grease 3/4 full, coat the outer edge of the plug with permatex and press the plug tightly to the bottom of the housing bore, this must be oil tight after assembly. (See Illust. 11.)



Illust. 11 - Cross Section of Support Assembly.

12. INSTALLATION

1. Install the support assembly into the crankcase with the lubrication fitting facing away from the crankcase. Engage the tang of the oil pump shaft into the slot in the pinion shaft in the support assembly.

2. Secure the assembly to the crankcase using the clamps and cap screws.

OIL FILTER

13. DESCRIPTION

The purpose of the lubricating oil filter 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.

Oil is delivered by the oil pump into the filter case, it then flows through the filter and into the center tube to be returned to the crankcase. On 236 and 282 series diesel engines, the oil first flows through the oil cooler before entering the oil filter.

14. REMOVAL AND DISASSEMBLY

1. Remove the crankcase drain plug and drain the engine oil.

2. 236 AND 282 SERIES DIESEL ONLY: Remove the oil cooler. (Refer to Illust. 12 and Par. 18.)

3. Unscrew the center tube and remove the filter cover and element.

4. Remove the cap screws securing the filter base to the crankcase and remove the filter base assembly.

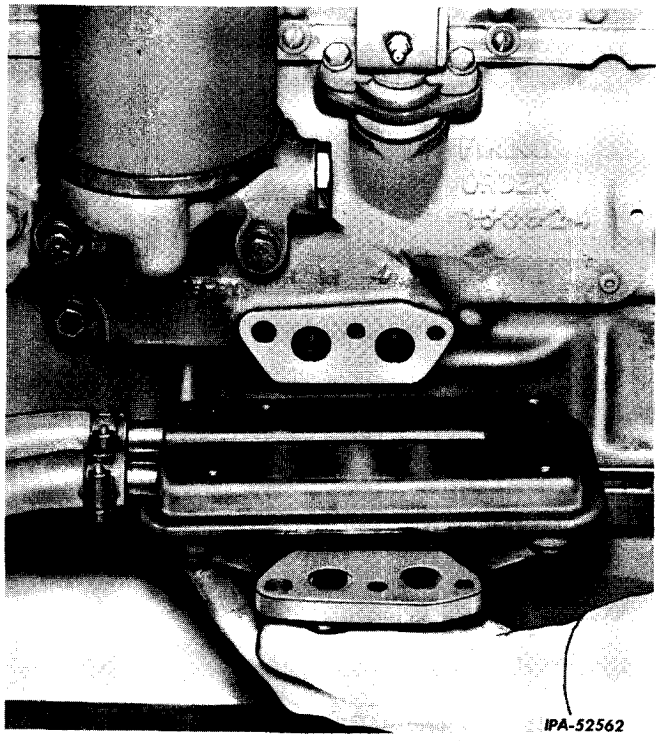
5. Unscrew the valve cap and remove the valve and spring.

6. Remove the cotter pin from the center tube, and slide the washer, spring, cover and gasket from the tube.

7. Remove the roll pin in the center tube and remove the spring and valve from within the tube.

PRINTED IN UNITED STATES OF AMERICA

OIL FILTER



Illust. 12 - Removing the Oil Cooler.

15. INSPECTION AND REPAIR

1. Clean the filter case, center tube, base and all other parts thoroughly with a dry-cleaning solvent.

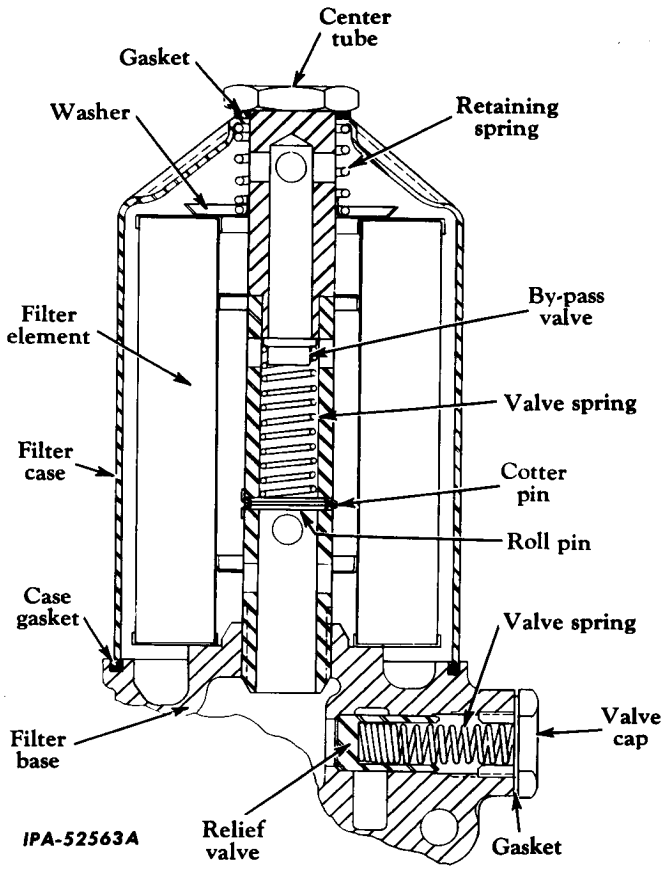
NOTE: Do not attempt to wash out the old filter element. Replace with a new element.

2. Inspect the condition of the valves. Be certain they slide freely and that the valve seats in the base and center tube are not damaged.

3. Check the valve springs against the specifications shown in Section 1. Replace any springs not conforming to these specifications.

4. Discard all gaskets and sealing rings. Use only new gaskets when reassembling.

16. REASSEMBLY AND INSTALLATION



Illust. 13 - Lubricating Oil Filter.

1. Install the relief valve, relief valve spring and cap, using a new gasket, into the filter base.

2. Position the filter base on the crankcase and secure with the cap screws. Use a new gasket between the filter base and the crankcase.

3. Assemble the by-pass valve assembly into the center tube as follows:

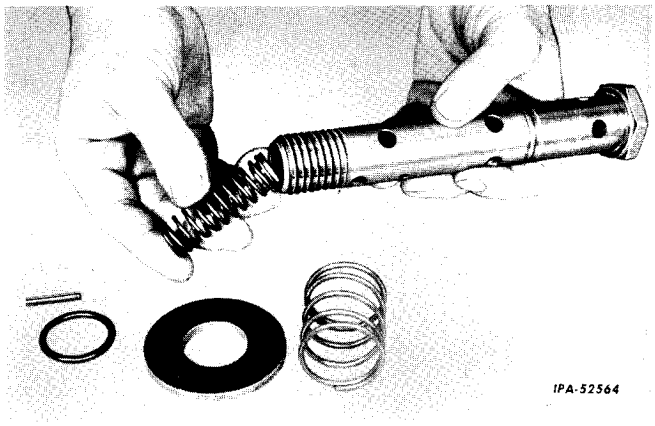
(a) Insert the valve and spring into the lower end of the tube (Illust. 14) in the correct position as shown in Illust. 13.

(b) Invert the tube and install the roll pin into the hole (Illust. 15) in the tube to retain the valve and spring in the position shown in Illust. 13.

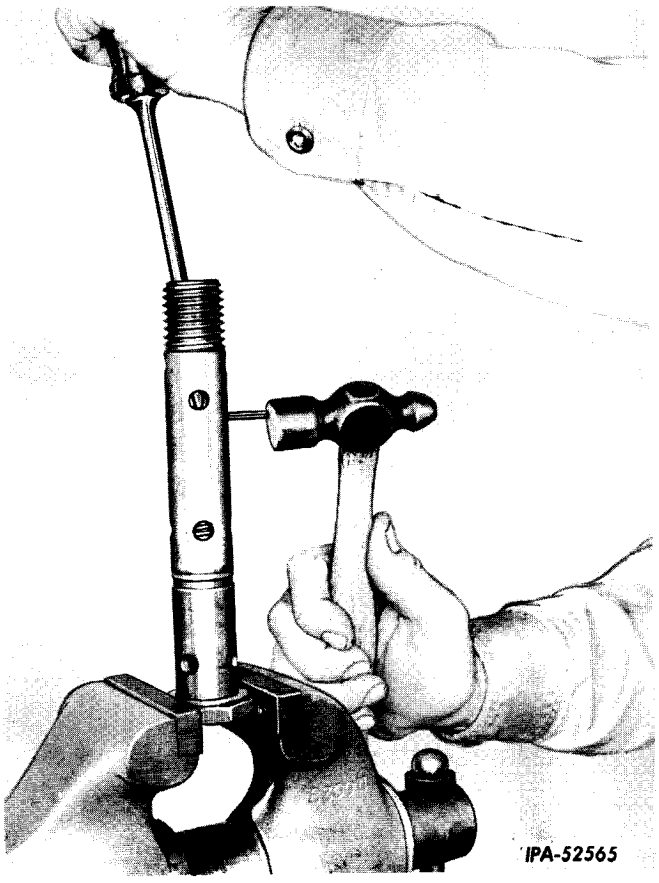
continued on next page

OIL FILTER

16. REASSEMBLY AND INSTALLATION - Continued



Illust. 14 - Installing the Valve and Spring.



Illust. 15 - Installing the Roll Pin.

4. Assemble the filter case and center tube assembly in the following manner:

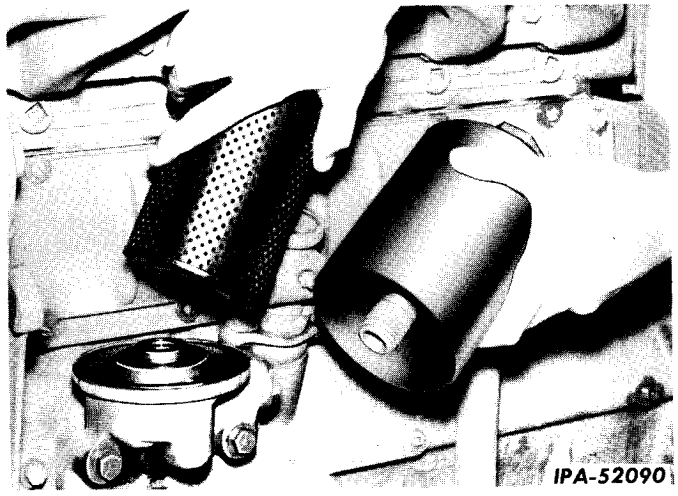
(a) Place the center tube gasket on the center tube.

(b) Assemble the center tube and filter case.

(c) Install the spring and retaining washer on the center tube.

(d) Install the cotter pin through the roll pin in the center tube.

5. Install the new filter element. Be certain to use a new gasket in the base. (See Illust. 16.)



Illust. 16 - Installing the Oil Filter Element.

6. Install the filter case and tighten the retaining bolt (center tube). Tighten the bolt as shown in "SPECIFICATIONS" Section 1.

7. Install the oil filter base drain plug.

8. 236 AND 282 SERIES DIESEL ENGINES ONLY: Install and secure the oil cooler to the filter base.

9. Install the crankcase drain plug and refill the crankcase with the specified quantity and grade oil. (Refer to the "Operator's Manual".)

10. Start the engine and allow it to run for at least ten (10) minutes to fully saturate the filter element. Check the oil pressure. (Refer to "SPECIFICATIONS" Section 1.)

11. Stop the engine and check the filter thoroughly for leaks. Also check the crankcase oil level.

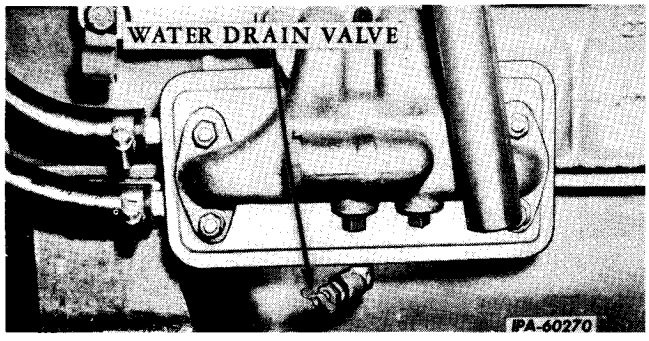
PRINTED IN UNITED STATES OF AMERICA

ENGINE OIL COOLER
(236 and 282 Series Diesel Engines Only)

17. DESCRIPTION

The oil cooler for the engine is mounted on the left side of the engine, to the oil filter base. The engine oil is circulated from the crankcase through the cooler and into the oil filter.

Two plugs are located in the oil manifold to allow draining the oil, and one plug is located in the bottom of the oil cooler to drain the cooler of water. On later Model TD-9 (92 Series) and TD-9 (Series B) tractors and 150 loaders, there is a valve in the bottom of the base to drain the water from the tubes. (Refer to Illust. 17.)



Illust. 17 - Engine Oil Cooler.

18. REMOVAL

1. Drain the cooling system, oil cooler and manifold and the oil filter.

2. Disconnect the water hoses connected to the oil cooler.

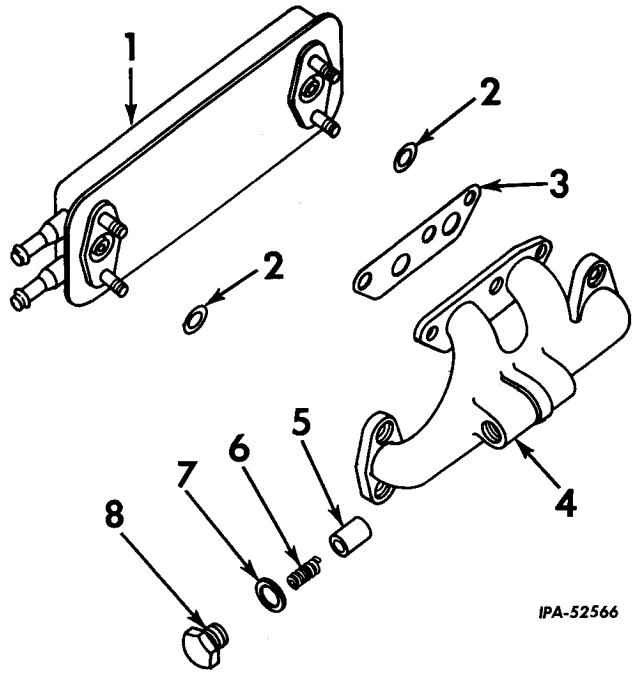
3. Remove the cap screws securing the oil manifold to the oil filter base. Also remove the gasket and discard, always use a new gasket to avoid oil leakage.

19. DISASSEMBLY (Refer to Illust. 18)

1. Separate the oil manifold (4) and oil cooler (1) by removing the four nuts.

2. Remove the "O" rings (2) located between the oil cooler and the oil manifold.

3. Remove the relief valve plug (8), gasket (7), spring (6) and valve (5) from the oil manifold (4). Remove the drain valve and elbow for cleaning.



Illust. 18 - Exploded View of Oil Cooler Assembly.

1. Oil cooler.
2. "O" ring.
3. Gasket.
4. Oil manifold.
5. Relief valve.
6. Spring.
7. Gasket.
8. Plug.

20. 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.

1. Immerse all parts into a cleaning solvent to loosen any sludge or foreign matter. Drain and blow out any solvent and foreign matter inside the oil cooler or oil manifold. Be certain that all passages are clean and clear before reassembly.

NOTE: Do not use caustic solutions or wire brushes to remove deposits.

2. Inspect the relief valve spring and check against the specifications in Section 1.

3. Inspect the relief valve and relief valve seat, being certain the valve slides freely and that the seat is not damaged.

4. Discard all gaskets and sealing rings. Use only new gaskets and "O" rings when reassembling.

ENGINE OIL COOLER
(236 and 282 Series Diesel Engines Only)

21. REASSEMBLY (Refer to Illust. 18)

1. Assemble the oil cooler (1) and oil manifold (4) using new "O" rings (2). Secure the assembly with the four (4) nuts. Refer to "SPECIFICATIONS" Section 1 for the special torque.

2. Install the valve (5), spring (6) and plug with gasket (7 and 8) into the manifold (4) in the order shown in Illust. 18.

3. Install and tighten the two plugs in the oil manifold and the drain plug or drain valve in the oil cooler.

22. INSTALLATION

1. Using a new gasket, secure the oil cooler assembly to the oil filter base.

2. Install and secure the two hoses to the oil cooler.

3. Install or close all cooling system and lubricating oil system drain plugs or valves. Be certain to not overlook the drain plug in the filter base.

4. Fill the cooling system, following the procedure outlined in the operator's manual.

5. Add one quart of the proper grade engine oil to the crankcase. Run the engine to refill the oil filter and oil cooler.

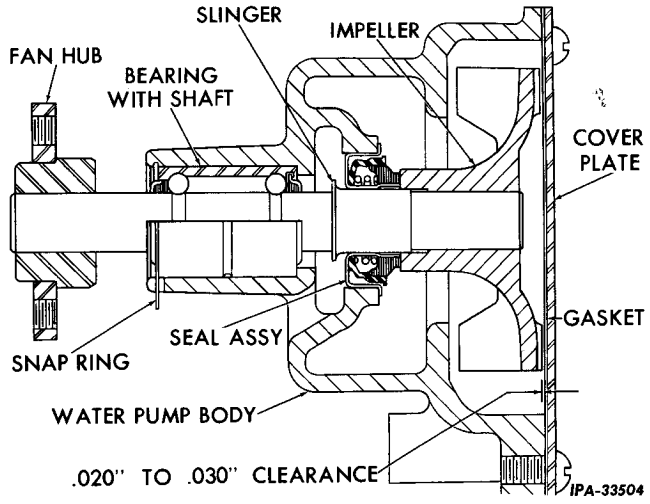
6. Stop the engine and check thoroughly for leaks. Also check the crankcase oil level and add the necessary oil to obtain the correct oil level.

PRINTED IN UNITED STATES OF AMERICA

WATER PUMP

1. DESCRIPTION

The water pump assembly is composed of a body and cover plate which houses a ball-bearing mounted pump shaft and impeller. The pump is of the centrifugal packless type, is bolted to the front end of the engine and is belt driven.



Illust. 1 - Sectional View of Water Pump.

The pump, by means of centrifugal force developed by the impeller rotation, draws water from the lower part of the radiator into the water passages in the cylinder block and cylinder head. The water circulates through the cylinder block and out through the thermostat housing into the radiator upper tank.

No lubrication of the pump is required as the bearings are of the permanently sealed type and are packed with special lubricant at the factory for the life of the bearing.

The water pump requires no attention other than bearing replacement when they show excessive looseness or if a water leak develops which indicates that a damaged or badly worn seal assembly needs replacement.

2. REMOVAL

1. Drain the cooling system to at least below the level of the water pump.

2. POWER UNIT ENGINES: Remove the fan-generator belt.

TRACTOR ENGINES: Remove the fan drive belt; also the generator - water pump belt.

3. Disconnect the water pump-to-thermostat housing hose.

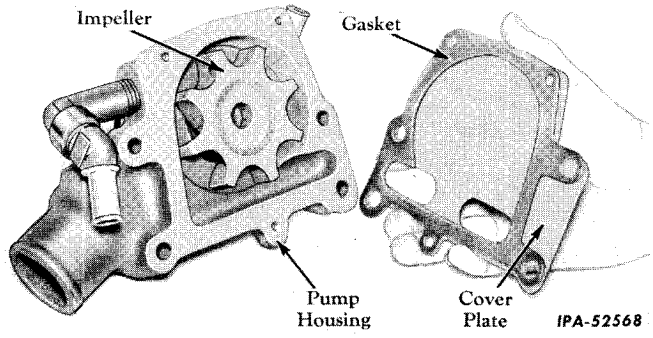
4. Disconnect and remove the water inlet hose from the water pump.

5. 236 AND 282 SERIES DIESEL ENGINES ONLY: Disconnect the water pump-to-oil cooler hose from the water pump.

6. Remove the cap screws securing the water pump to the engine and remove the water pump.

3. DISASSEMBLY

1. Remove the screws from the back cover plate. Remove the plate and gasket from the pump body. (Refer to Illust. 2.)



Illust. 2- Removing the Pump Cover Plate.

Illust. 3- Removing the Retaining Ring.

2. Remove the retainer ring from the front of water pump shaft bearing (Illust. 3). Sup-

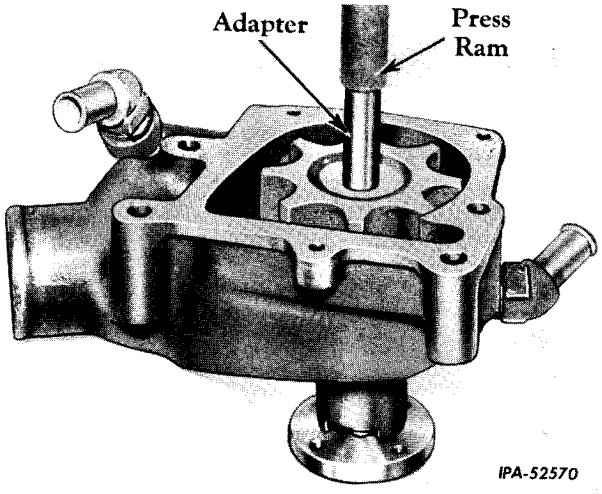
Continued on next page.

WATER PUMP

3. DISASSEMBLY - Continued

port the water pump on an arbor press and push the shaft and bearing out as one assembly. (Refer to Illust. 4.)

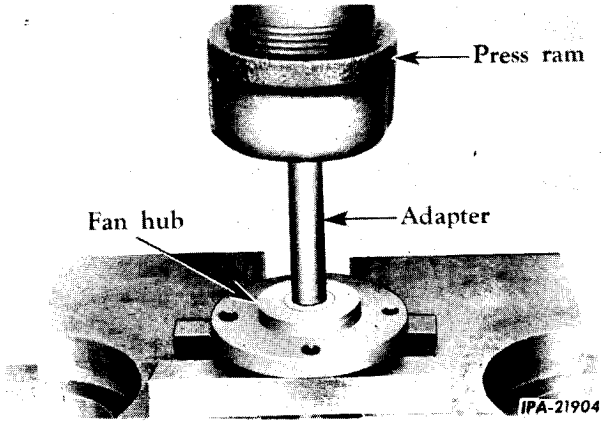
3. Place the shaft assembly in a press and press the hub from the shaft. (Refer to Illust. 5.)



Illust. 4 - Removing the Shaft and Bearing.

NOTE: Do not attempt to remove the bearing or slinger; they are factory installed on the shaft in the proper location. The shaft, bearing and slinger are serviced as an assembly.

4. If leakage or damage is apparent, remove the seal. Remove the seal from the housing through the back side of pump. Use a drift and carefully drive the seal from the pump body. Discard the seal, always use a new seal in reassembly.



Illust. 5 - Separating the Shaft and Hub.

4. INSPECTION AND REPAIR

1. Clean all parts (except pump shaft and bearing) in a cleaning solvent.

2. Examine the seal or seal assembly for wear or damage and replace complete seal if service is necessary. If the seal was removed from the pump body, it must be replaced with a new seal.

3. Inspect the pump shaft bearing. If worn, replace the shaft, bearing and slinger as an assembly.

4. Examine the shaft. If worn, replace the shaft, bearing and slinger as an assembly.

5. REASSEMBLY

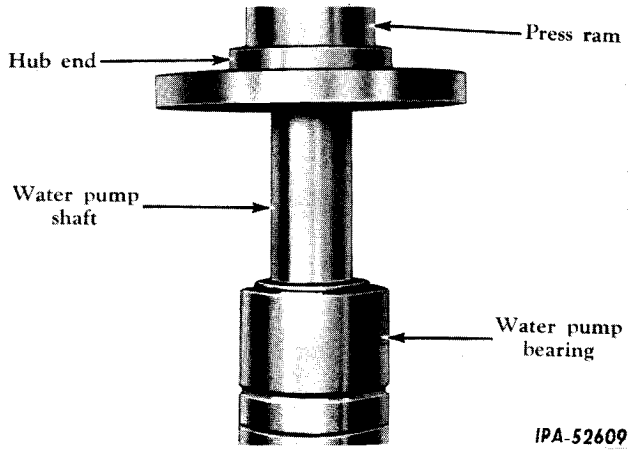
1. Press the hub on the shaft with the small diameter of the hub to the front. (Refer to Illust. 6.)

2. Place the new water pump seal assembly on installing tool (Illust. 7). Place the pump body in the press and, after aligning the seal and installing tool (SE-1721, see NOTE), press the seal into the body. (Refer to Illust. 8.)

NOTE: Information and ordering procedures on special service tools can be found in the "CONSTRUCTION EQUIPMENT SERVICE TOOLS" manual, ISS-1002.

3. Install the shaft in the housing from the front end by pressing the shaft, bearing, slinger and hub in as an assembly. (Refer to Illust. 9.)

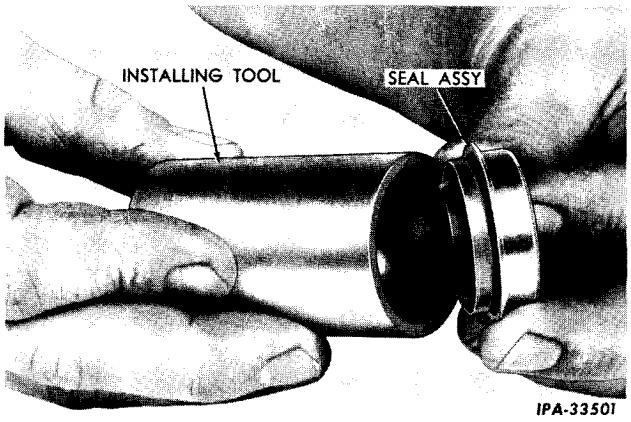
4. Install the retainer ring in place behind the hub. (Refer to Illust. 3.)



Illust. 6 - Installing the Hub.

PRINTED IN UNITED STATES OF AMERICA

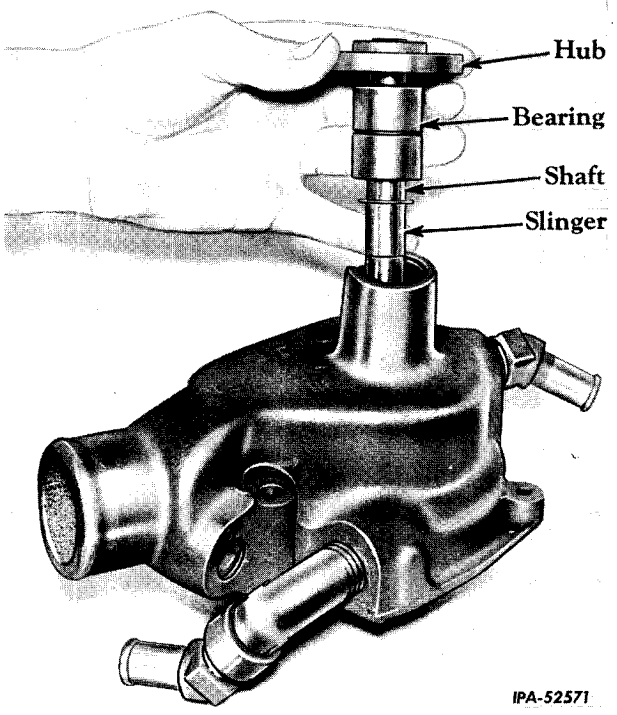
WATER PUMP



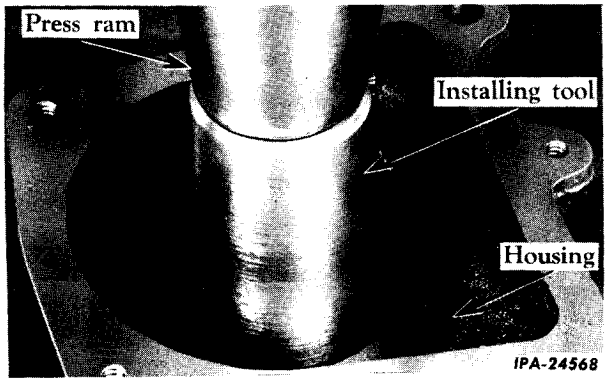
Illust. 7 - Installing Tool for Water Pump Seal Assembly.

5. Mount the assembly in a press and install the impeller on the rear end of the shaft. Place a straight edge across the back of the water pump housing and check the clearance between the straight edge and the impeller. There should be from .020 to .030 inch clearance. (Refer to Illusts. 1 and 10.)

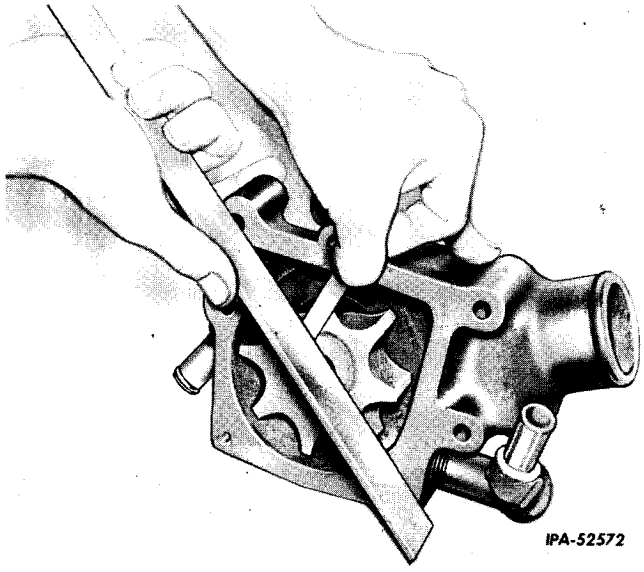
6. Install the cover plate using a new gasket.



Illust. 9 - Installing the Shaft Assembly.



Illust. 8 - Water Pump Seal Installation.



Illust. 10 - Checking the Impeller Clearance.

WATER PUMP

6. INSTALLATION

1. Using a new gasket, position the pump on the front end of the crankcase and install the mounting bolts.

2. Install the water pump pulley.

3. POWER UNIT ENGINES ONLY: Install the fan to the water pump pulley.

4. TRACTOR ENGINES ONLY: Install the fan adjuster and fan.

5. 236 AND 282 SERIES DIESEL ENGINES ONLY: Connect the water pump-to-oil cooler hose.

6. Connect the water inlet hose to the water pump.

7. Connect the water pump-to-thermostat housing hose.

8. POWER UNIT ENGINES ONLY: Work the belt over the fan blades and on the fan pulley. Slide the belt over the crankshaft pulley. Hold the generator in toward the engine and slide the belt over the generator pulley. (Refer to "Adjusting the Fan Belt," in operator's manual.)

9. T-6 (62 SERIES) AND TD-9 (92 SERIES) CRAWLER TRACTOR ENGINES ONLY: Place the belt on the crankshaft, generator and water pump pulley. Install the fan belt over the crankshaft pulley and the fan pulley. (Refer to "Adjusting the Fan Belt" in the operator's manual.)

TD-9 (SERIES B) AND 150 LOADER ONLY: Place the generator and water pump belt over the crankshaft, generator and water pump pulleys. Install the fan belt over the crankshaft, fan and fan idler pulleys. (Refer to "Adjusting the Generator and Fan Belts" in the operator's manual.)

THERMOSTAT HOUSING AND THERMOSTAT

7. DESCRIPTION

When the engine is cold, a thermostat (by-pass type) prevents the circulation of the coolant to the radiator and allows the coolant to circulate only through the cylinder head and around the cylinders. When the engine reaches an efficient operating temperature (determined by the thermostat specifications) the thermostat opens, allowing the coolant to circulate through the engine block, cylinder head and radiator. The thermostat is of the nonadjustable type.

8. REMOVAL

1. Drain the cooling system to a point below the level of the thermostat housing.

2. TRACTOR ENGINES ONLY: Remove the fan belt, fan and fan belt adjuster.

3. Remove the radiator inlet hose.

4. Remove the water pump-to-thermostat housing hose.

5. Remove the cap screws securing the thermostat housing to the cylinder head, and remove the housing, thermostat and gasket. Discard the gasket.

9. INSPECTION AND REPAIR

1. Clean the thermostat. If the thermostat is coated with scale, it must be replaced. Scale will not allow the thermostat to function correctly.

2. Submerge the thermostat in water along with a high temperature thermometer and heat the water. Check the temperature of the water when the thermostat starts to open, which should be approximately 170°F and again when the thermostat is fully open at approximately 190°F. If the thermostat does not function as stated above, it must be replaced with a new one. (Refer to "SPECIFICATIONS," in Section 1.)

NOTE: When placing the thermostat and thermometer in the water, be sure they do not touch the sides or bottom of the container at any time.

10. INSTALLATION

1. Place the thermostat with a new gasket into the housing with the valve end up.

2. Position the housing on the cylinder head, using a new gasket, and secure to the head.

PRINTED IN UNITED STATES OF AMERICA

THERMOSTAT HOUSING AND THERMOSTAT

3. Install and secure the radiator inlet hose and the water pump-to-thermostat housing hose.

4. TRACTOR ENGINES ONLY: Install the fan belt adjuster, fan and fan belt and adjust the fan belt. (Refer to "Adjusting the Fan Belt," in the operator's manual.)

5. Fill the cooling system as outlined in the Operator's Manual.

6. Operate the engine; inspect the water temperature gauge for correct thermostat performance and observe all cooling system hoses and points of connections for leaks. Correct all leaks, no matter how minor.

FAN ADJUSTER (TRACTORS ONLY)

11. DESCRIPTION

The fan adjuster is mounted to the thermostat housing. It's sole function is to furnish a fan pulley and a method of fan belt adjustment. The bearing assembly used, is factory lubricated and sealed, and should require no further lubrication for the life of the bearing.

12. REMOVAL

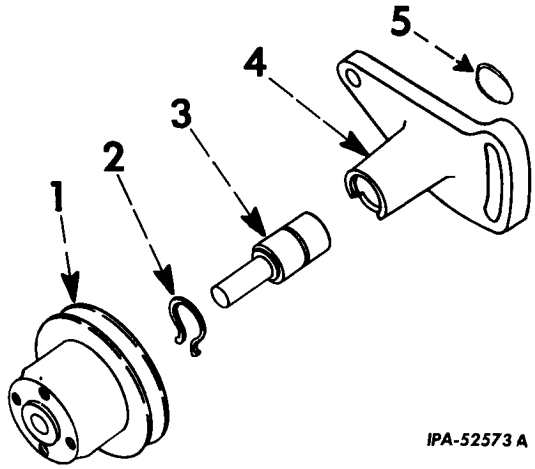
1. Remove the fan and fan belt.

2. Remove the cap screws securing the adjuster to the thermostat housing.

13. DISASSEMBLY

TD-6 (62) and TD-9 (92)
(Refer to Illust. 11)

1. Press the fan pulley (1) off of the adjuster shaft (3).

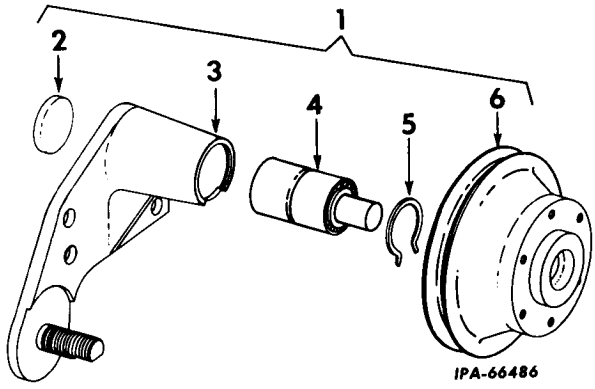


Illust. 11 - Fan Adjuster (Tractor Engines Only).

1. Fan pulley.
2. Retaining ring.
3. Shaft and bearing.
4. Pulley adjuster.
5. Core plug.

2. Remove the retaining ring (2) from the adjuster (4).

3. Remove the core plug (5) and press the shaft and bearing assembly (3) out of the adjuster (4).



Illust. 12 - Fan Drive Pulley and Bracket (TD-9 (Series B) and 150 Loader).

1. Fan drive assembly.
2. Core hole plug.
3. Fan drive bracket.
4. Shaft w/bearing.
5. Retainer ring.
6. Fan pulley.

TD-9 (Series B) and 150 Loader)
(Refer to Illust. 12 and 13)

1. Press the pulley (6) off the shaft (4).

2. Remove the retaining ring (5) from the adjuster (3).

3. Remove the core plug (2) and press the shaft and bearing (4) out of the adjuster (3).

4. Remove the idler assembly (7) from the fan drive bracket (3).

Continued on next page.

FAN ADJUSTER (TRACTORS ONLY)

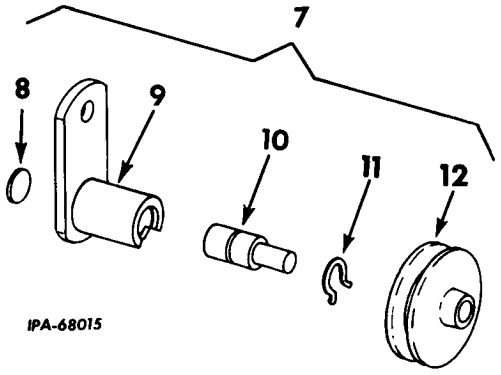
13. DISASSEMBLY - Continued

TD-9 (Series B) and 150 Loader
(Refer to Illust. 12 and 13) - Continued

5. Press the pulley (12) off the shaft (10).

6. Remove the retaining ring (11) from the adjuster arm (9).

7. Remove the core plug (2) and press the shaft and bearing (4) out of the adjuster arm (3).



Illust. 13 - Fan Idler (TD-9 (Series B) and 150 Loader).

7. Idler assembly.
8. Expansion plug.
9. Adjuster arm.
10. Bearing and shaft.
11. Shaft retrainer.
12. Idler pulley.

14. INSPECTION AND REPAIR

1. Clean all parts except shaft and bearing in a dry-cleaning solvent and blow dry.

NOTE: Do not immerse the shaft and bearing assembly into a cleaning solvent; to do so will ruin the lubricant in the bearing.

2. Wipe the shaft and bearing clean with a dry clean cloth.

3. Replace any fan pulley with cracks or chips in the hub or pulley flanges.

4. Inspect the adjuster fan drive bracket or adjuster arm for cracks or chips and replace if necessary.

5. Inspect the shaft and bearing. If either one is worn, replace the shaft and bearing as an assembly.

15. REASSEMBLY (Refer to Illust. 15)

TD-6 (62) and TD-9 (92)
(Refer to Illust. 11)

1. Press the shaft and bearing assembly (3) into the adjuster (4) and install the retaining ring (2).

2. Install a new core plug (5).

3. Press the pulley (1) on the shaft, bearing and adjuster assembly, being certain to furnish support under the shaft to avoid damaging the bearings when pressing.

TD-9 (Series B) and 150 Loader)
(Refer to Illust. 12 and 13)

1. Press the shaft and bearing (10) into the adjuster arm (9) and install the core plug (8).

2. Install the retaining ring (11) in the adjuster arm (9).

3. Press the pulley (12) on the shaft (10).

4. Press the shaft and bearing (4) into the adjuster (3).

5. Install the retaining ring (5) into the adjuster (3).

6. Press the pulley (6) on the shaft (4).

7. Install the idler assembly (7) on the fan drive bracket (3, Illust. 12).

16. INSTALLATION

1. Install and fasten the adjuster assembly to the thermostat housing.

2. Install the fan and fan belt.

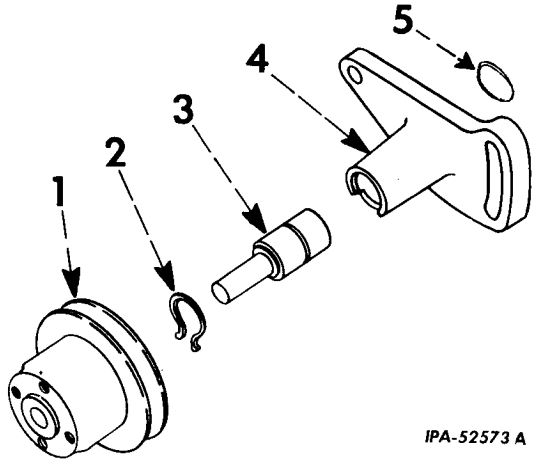
3. Adjust the fan belt. (Refer to "Adjusting the Fan Belt" in the operator's manual.)

PRINTED IN UNITED STATES OF AMERICA

FAN ADJUSTER

14. DISASSEMBLY (Refer to Illust. 15)

1. Press the fan pulley (1) off of the adjuster shaft (3).



Illust. 15 - Fan Adjuster (Tractor Engines Only).

1. Fan pulley.
2. Retaining ring.
3. Shaft and bearing.
4. Pulley adjuster.
5. Core plug.

2. Remove the retaining ring (2) from the adjuster (4).

3. Remove the core plug (5) and press the shaft and bearing assembly (3) out of the adjuster (4).

15. INSPECTION AND REPAIR

1. Clean the pulley (1) and adjuster (4) in a dry-cleaning solvent and blow dry.

CAUTION: Do not immerse the shaft and bearing assembly into a cleaning solvent, to do so will ruin the lubricant in the bearing.

2. Wipe the shaft and bearing clean with a dry clean cloth.

3. Inspect the fan pulley for cracks or chips in the hub or pulley flanges and replace if any exist.

4. Inspect the adjuster for cracks or chips and replace if necessary.

5. Inspect the adjuster shaft bearing. If worn, replace the shaft and bearing as an assembly.

6. Examine the shaft. If worn, replace the shaft and bearing as an assembly.

16. REASSEMBLY (Refer to Illust. 15)

1. Press the shaft and bearing assembly (3) into the adjuster (4) and install the retaining ring (2).

2. Install a new core plug (5).

3. Press the pulley (1) on the shaft, bearing and adjuster assembly, being certain to furnish support under the shaft to avoid damaging the bearings when pressing.

17. INSTALLATION

1. Install and fasten the adjuster assembly to the thermostat housing.

NOTE: ENGINES USED ON TD-9 TRACTORS ONLY: When installing the adjuster on an engine used in the TD-9, the adjuster is secured to the upper two holes in the thermostat housing.

2. Install the fan and fan belt.

3. Adjust the fan belt. (Refer to "Adjusting the Fan Belt" paragraph 7.)

TIMING GEAR TRAIN AND FRONT COVER

1. DESCRIPTION

The gear train consists of the crankshaft gear, the camshaft gear, the idler gear and the injection pump gear (diesel engine only). These gears provide a positive and accurate drive for the oil pump, mechanical governor (carbureted engines), injection pump (diesel engines), and the distributor (carbureted engines). These gears are accessible by removing the crankcase front cover. They are punch marked for proper timing and must be installed in the proper positions to have the engine timed correctly.

2. REMOVAL

1. Remove the fan, fan belt (remove both belts on engines so equipped) and water pump. (Refer to Section 5.)

2. Position the No. 1 piston on top dead center of the compression stroke.

NOTE: Remove the spark plugs or glow plugs as equipped, also disconnect the ignition coil on carbureted engines before cranking the engine.

3. Remove the generator.

4. DIESEL ENGINES ONLY: Remove the hoses connected to the oil cooler.

5. Remove the engine front support.

6. Remove the starting crank nut and washer.

7. On engines equipped with a crankshaft pulley having three slots on the inside diameter, remove the pulley with a three-jaw puller as shown in Illust. 1. Then remove the Woodruff key.

8. On engines equipped with crankshaft pulley having tapped holes in its face and no slots on the inside diameter, remove the pulley with puller No. 1 020 323 R91 (Illust. 2). Then remove the Woodruff key.

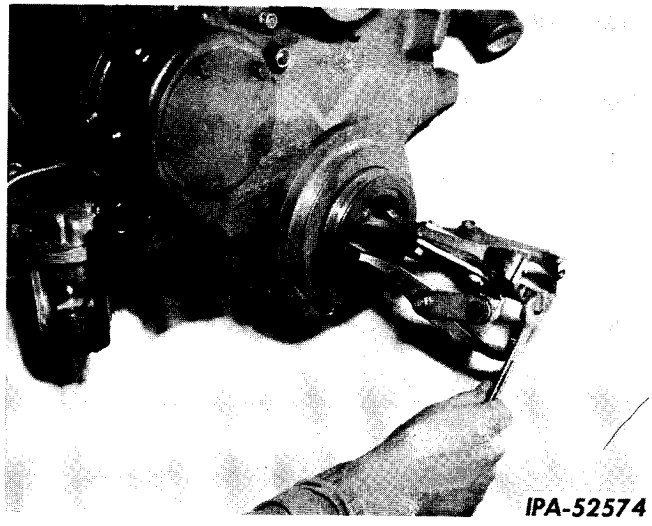
NOTE: Information and ordering procedures on special service tools can be found in the "Construction Equipment Service Tools" manual, ISS-1002.

9. Remove the front two oil pan bolts in the front cover.

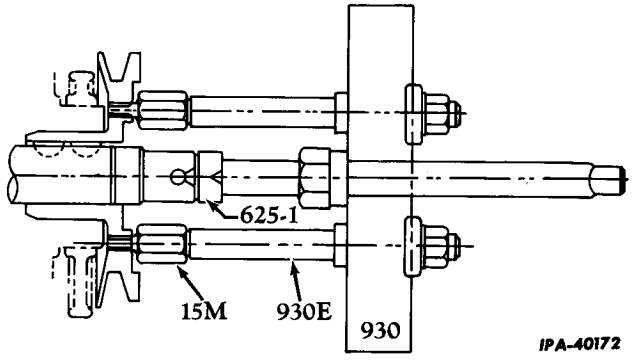
10. Remove the bolts and nuts securing the front cover and remove the cover and gasket. Remove the crankshaft oil slinger.

NOTE: Before removing any gears, it is advisable to check the backlash and end play of the gears to determine which, if any, require service.

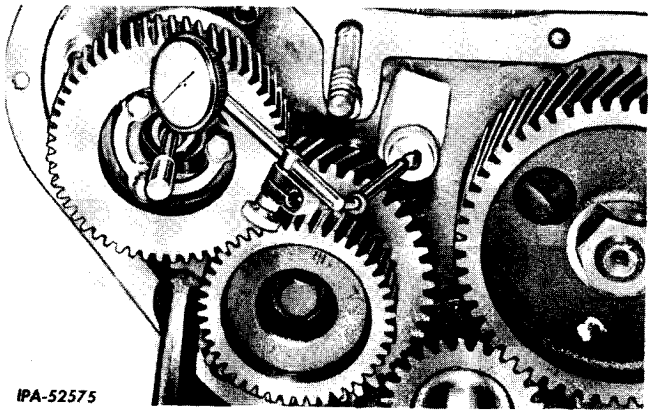
Continued on next page.



Illust. 1 - Removing the Crankshaft Pulley and Damper (282 Series Diesel Engine Shown).



Illust. 2 - Removing the Crankshaft Pulley and Damper, Using Service Tool No. 1 020 323 R91.

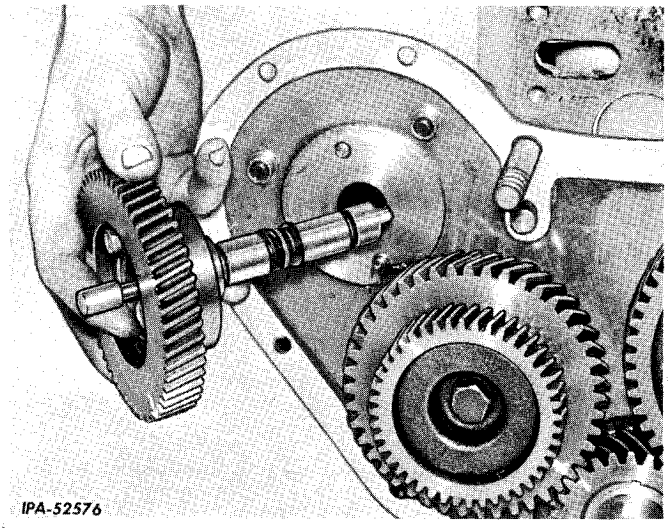


Illust. 3 - Checking Injection Pump Gear Backlash.

TIMING GEAR TRAIN AND FRONT COVER

2. REMOVAL - Continued

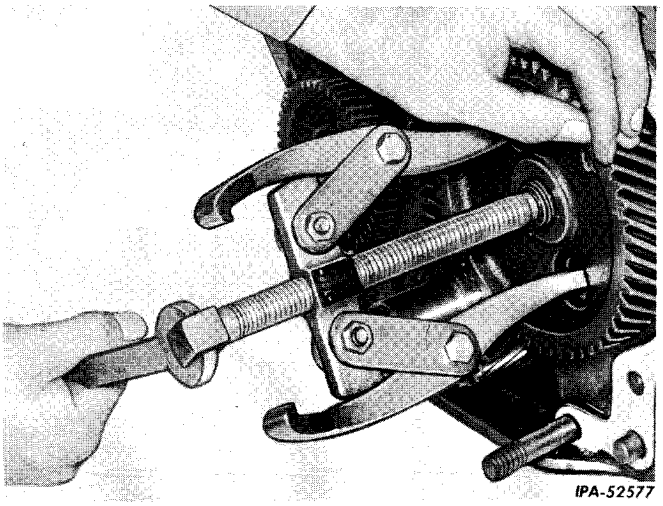
11. Check the injection pump gear backlash (Illust. 3). (Refer to "SPECIFICATIONS," Section 1.) After obtaining the backlash, remove the gear and shaft (Illust. 4). Do not drop or lose the thrust button or the spring inside the button.



Illust. 4 - Removing the Injection Pump Gear.

12. DIESEL ENGINES ONLY: Remove the injection pump. (Refer to the "Roosa Master Fuel Injection Pump Manual," ISS-1042. For engines with IH RD pump, refer to service manual ISS-1052.)

13. CARBURETED ENGINES ONLY: Remove the governor from the engine. (Refer to Section 8.)



Illust. 5 - Removing the Camshaft Gear.

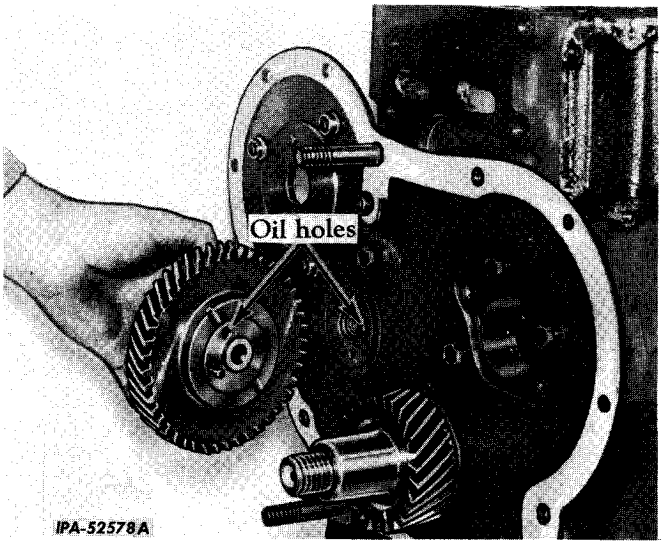
14. Check the backlash and end clearance of the camshaft and idler gears. (Refer to "SPECIFICATIONS," Section 1.)

15. Loosen the camshaft gear nut lock and remove the nut and lock.

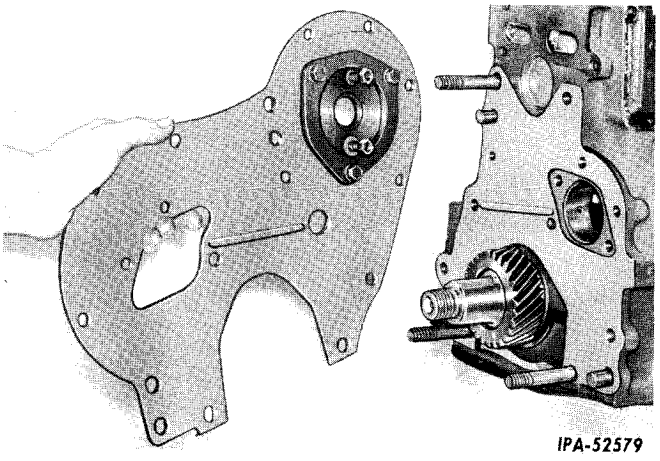
NOTE: After the camshaft gear is removed, DO NOT TURN the crankshaft. To do so will damage the valves and pistons.

16. Install a puller and remove the camshaft gear. (Illust. 5.)

17. Remove the cap screws securing the camshaft thrust plate to the crankcase and remove the thrust plate.



Illust. 6 - Removing the Idler Gear (282 Diesel Engine Shown).



Illust. 7 - Removing the Front Plate (282 Diesel Engine Shown).

PRINTED IN UNITED STATES OF AMERICA

TIMING GEAR TRAIN AND FRONT COVER

18. Remove the bolt securing the idler gear shaft. Remove the shaft and gear. (Illust. 6.)

19. Remove the cap screws securing the front plate to the crankcase and remove the front plate. (Illust. 7.)

20. Remove the crankshaft gear if necessary.

3. INSPECTION AND REPAIR

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

2. Inspect the idler gear shaft for wear or scoring. Inspect and clean if necessary the idler shaft oil hole in the shaft and the crankcase.

3. Inspect the idler gear bushing for damage and proper clearance. (See "SPECIFICATIONS" Section 1.)

4. Inspect the teeth of all gears for chips or damage and replace if necessary.

5. Inspect the oil seal in the front cover and replace if necessary.

6. Remove all traces of front plate gasket from the crankcase.

7. When installing a new idler shaft bushing, check the shaft O.D. and bushing I.D. to be certain of the correct running clearance.

4. INSTALLATION

1. Cement a new gasket to the crankcase and install and secure the front plate. Be certain that the oil holes are not blocked with cement.

2. Back off all the valve lever adjusting screws to release the valve levers. This will allow the crankshaft or camshaft to be rotated if necessary, without damaging the valves or pistons.

3. If the crankshaft gear was removed, install the crankshaft gear key and heat the crankshaft gear to 250°F. Position the gear on the crankshaft with the timing mark facing out. Be certain the gear is not cocked on the shaft, and drive into position.

4. Install the camshaft thrust plate and secure.

NOTE: When assembling the camshaft gear, align the single punch mark space on the camshaft gear with the single punch tooth on the crankshaft gear.

5. Tap the camshaft gear onto the camshaft being certain to line up the key and keyway. Install the nut lock and nut, block the gear to prevent its turning, and torque the nut. (See "SPECIFICATIONS" Section 1 for the proper torque.) Secure the nut by bending the nut lock.

6. DIESEL ENGINES ONLY: Install the idler gear being certain to match the double punch mark space on the crankshaft gear with the double punch mark on the tooth of the idler gear. When installing the shaft align the oil hole in the shaft with the hole in the front plate and the locating pin with the hole in the front plate. The upper hole is the oil hole (Illust. 6). Install the cap screw and secure the shaft.

7. CARBURETED ENGINES ONLY: Install the idler gear being certain to correctly align the oil hole and the locating pin. There are no timing marks to align. Install the cap screw and secure the shaft.

8. DIESEL ENGINES ONLY: Install the injection pump gear lining up the single punch mark tooth of the gear with the single punch mark space of the idler gear.

9. DIESEL ENGINES ONLY: Install the injection pump. (Refer to the "ROOSA MASTER FUEL INJECTION PUMP MANUAL," ISS-1042. For engines with IH RD pump, refer to service manual ISS-1052.)

10. CARBURETED ENGINES ONLY: Install and connect the governor to the engine. (Refer to Section 8.)

11. Check the backlash between all gears and check the idler gear and camshaft gear end play. (Refer to "SPECIFICATIONS" in Section 1 for clearances.) Apply a film of engine oil to the teeth of all gears in the gear train.

12. Install the fan drive pulley key and oil flinger.

DIESEL ENGINES ONLY: Install the thrust button and spring into the injection pump gear.

13. Use a new gasket and install the crankcase front cover. Secure with cap screws, nuts and washers.

14. Install the oil pan front cap screws and tighten those that were loosened.

15. Install the engine front support.

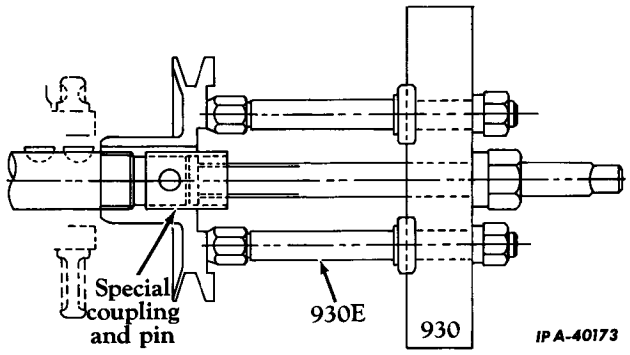
16. Install the Woodruff key and press the pulley on until it bottoms against the shoulder on the crankshaft. On engines equipped with crankshaft pulley having tapped holes in its

Continued on next page.

TIMING GEAR TRAIN AND FRONT COVER

4. INSTALLATION - Continued

face, the pulley must be installed using special puller 1 020 322 R91 and 1 020 323 R91. (Illust. 8.) Install the pulley nut and washer and torque as specified in "SPECIFICATIONS" in Section 1.



Illust. 8 - Installing the Crankshaft Pulley, Using 1 020 322 R91 and 1 020 323 R91.

17. DIESEL ENGINES ONLY: Connect the oil cooler water hoses.

18. Install the generator.

19. CARBURETED ENGINES ONLY: Install the spark plugs and connect the ignition coil.

20. DIESEL ENGINES ONLY: Install and connect the glow plugs.

21. Install and connect the water pump and fill the cooling system. (Refer to Section 5.)

22. Install the fan and fan belt.

23. Adjust the valve clearances. (Refer to Section 2.)

24. CARBURETED ENGINES ONLY: Check the distributor timing. (Refer to Section 12.)

25. DIESEL ENGINES ONLY: Check the injection pump timing. (Refer to the "ROOSA MASTER FUEL INJECTION PUMP MANUAL," ISS-1042. For engines with IH RD pump, refer to service manual ISS-1052.)

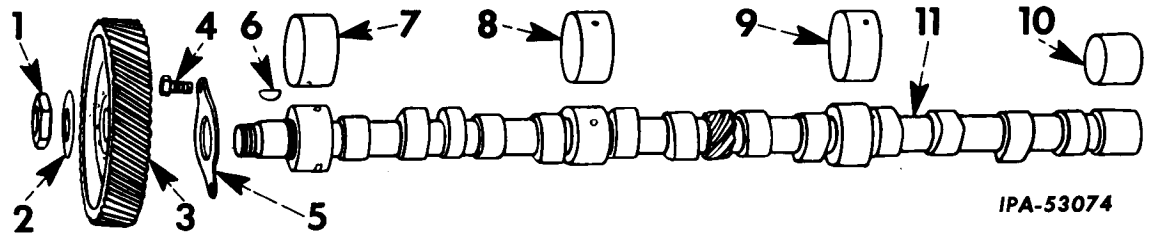
CAMSHAFT

5. DESCRIPTION

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 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.

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.



Illust. 9 - Camshaft Components.

1. Nut.
2. Lock.
3. Gear.
4. Cap screw.
5. Thrust plate.
6. Key.
7. Bearing, front.
8. Bearing, Intermediate front.
9. Bearing, intermediate rear.
10. Bearing, rear.

PRINTED IN UNITED STATES OF AMERICA

CAMSHAFT

6. REMOVAL

1. Remove the valve mechanism and push rods. (Refer to "Cylinder Head and Valves," Section 2.)

2. Remove the side cover and gasket from the engine. Remove the valve tappets. Identify the position of each tappet as removed so it can be reinstalled in its original bore. This is important.

3. Remove the ignition distributor on engines so equipped.

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

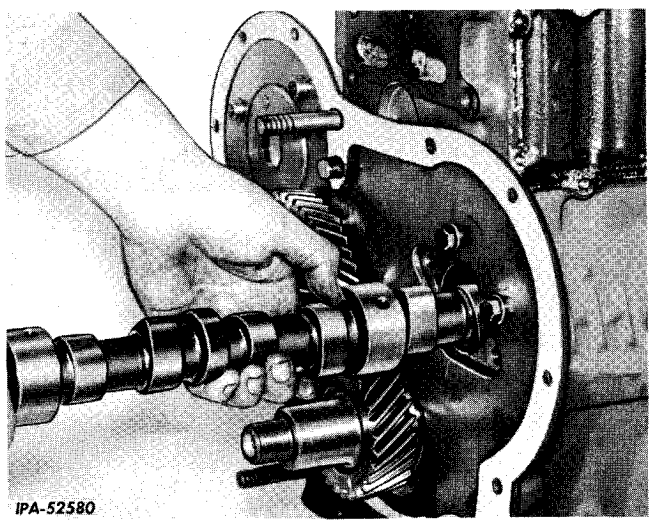
5. Remove the water pump. (Refer to "Water Pump" Section 5.)

6. Remove the engine front support, if so equipped.

7. Remove the crankcase front cover. (Refer to "Timing Gear Train and Front Cover" in this Section.)

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

9. Pull the camshaft assembly from the crankcase. (Illust. 10.)



Illust. 10 - Removing the Camshaft (282 Series Diesel Engine Shown).

7. DISASSEMBLY

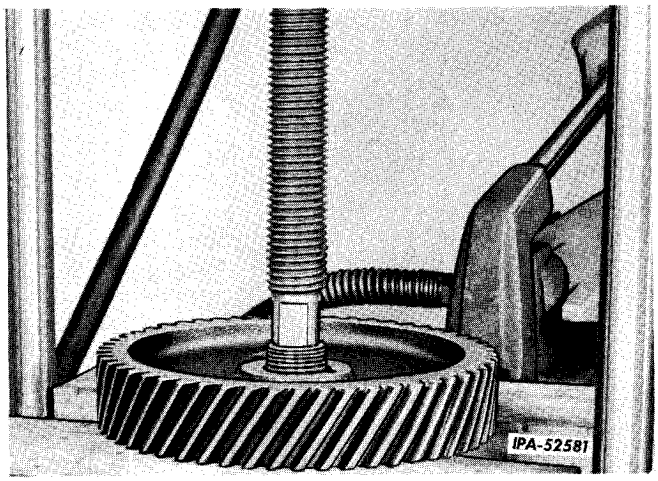
1. Remove the nut and nut lock holding the gear on the camshaft.

2. Press the gear from the shaft. (Illust. 11.) 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 is completed, coat each part with clean engine oil and store safely until reassembly.



Illust. 11 - Removing the Gear from the Camshaft.

2. Inspect the camshaft journals for wear. Dimensions for the camshaft journals are given in "SPECIFICATIONS" Section 1. Compare the dimensions of the camshaft being serviced with the dimensions listed. Inspect for signs of wear or out-of-round condition, if wear or out-of-round is excessive, replace the camshaft.

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 comparision, the cam lobe wear can be measured with a micrometer in the following manner (refer to 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. Replace the timing gear if worn or damaged. Small nicks or burrs can be removed with a hone or fine mill file.

5. Check the condition of the thrust flange. If wear is excessive, replace thrust flange.

Continued on next page.

CAMSHAFT

8. INSPECTION AND REPAIR - Continued

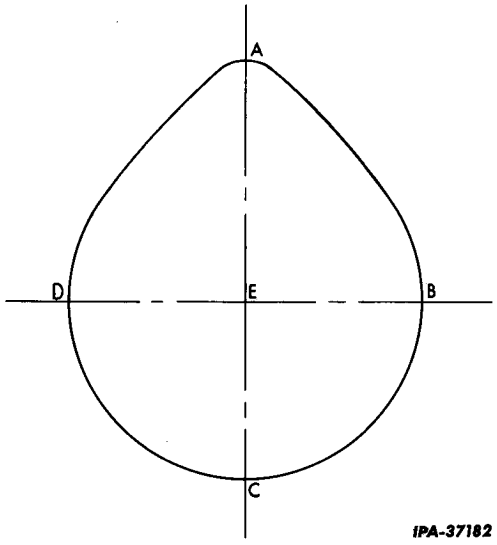
6. Inspect the oil pump drive gear. If the gear teeth are worn or damaged, the camshaft must be replaced.

7. Inspect the camshaft bearings and determine the running clearance. Compare the existant dimensions against those shown in "SPECIFICATIONS " in Section 1. If camshaft bearing replacement is necessary, remove the flywheel and engine rear support. (Refer to Section 7, "CRANKSHAFT MAIN BEARINGS AND FLYWHEEL.") Remove and install new bushings with the special camshaft bearing tools HC-23-12, HC-23-13, HC-23-14 and HC-23-15.

NOTE: For further information or to order these tools, write to "Service Tools Inc.," 1901 S. Indiana Ave., Chicago 16, Illinois.

8. Before installing the camshaft bushings, inspect the bore in the crankcase for burrs and other roughness liable to damage the bushings during installation.

9. When installing new bushings, be sure that the oil holes in the bushings line up with the oil holes in the crankcase.



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

10. Inspect the tappets carefully for wear, chips or scratches. If the face is badly spalled, extreme wear can be expected on the cam lobe, in which case the camshaft must be replaced. Replace defective tappets.

9. REASSEMBLY

1. Install the plug at the rear of the camshaft bore in the crankcase if it was removed to service the camshaft bushings. When replacing this plug be certain the rear bushing is not covering the oil drain hole or that excessive permatex from the plug does not block the drain hole.

2. Place the camshaft thrust plate on the camshaft and install the camshaft gear key in the shaft keyway.

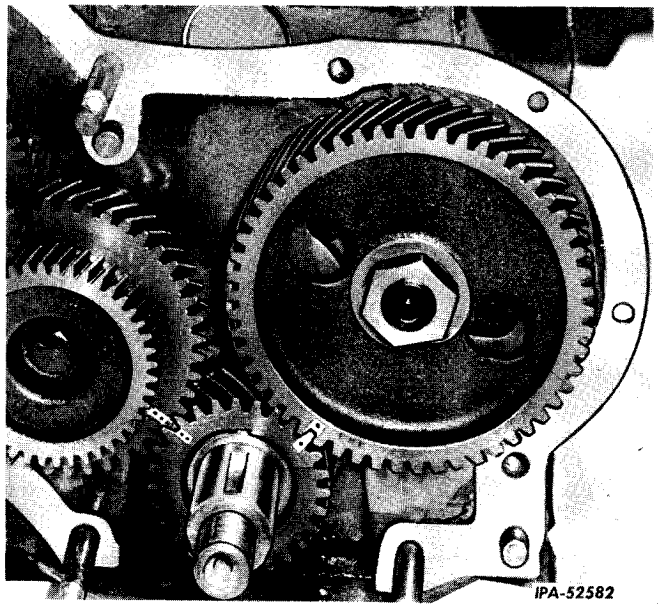
3. Heat the camshaft gear in boiling water and install the gear (with the timing mark facing away from the shaft) on the camshaft.

4. Install the nut lock and nut and tighten the nut to the torque specified in Section 1, "SPECIFICATIONS." Secure the nut by bending the nut lock.

10. INSTALLATION

1. Install the engine rear support and flywheel, if removed. (Refer to "FLYWHEEL" in Section 7.)

2. Coat the camshaft lobes with a sulfo-chlorolead (SCL) heavy duty axle lubricant. This will provide initial lubrication and prevent possible cam lobe scuffing when the engine is first started. Lubricate the balance of the shaft with engine oil and install it into the crankcase being sure that the timing mark on the camshaft gear is correctly indexed with the timing mark on the crankshaft gear. (Refer to Illust. 13.)



Illust. 13 - Matching the Camshaft and Crankshaft Timing Marks.

CAMSHAFT

3. Secure the thrust plate to the crankcase by inserting the cap screws through the holes in the camshaft gear. Check the camshaft end play and gear backlash against the "SPECIFICATIONS," Section 1.

4. Install the front cover and fan drive pulley as outlined in this section.

5. Install the engine front support, if so equipped.

6. Install the water pump, fan and fan belt. (Refer to "WATER PUMP" in Section 5.)

7. Coat the tappets generously with engine oil and install each one in the same bore from which it was removed. Install a new side cover gasket and then secure the side cover.

8. Install the valve push rods and valve mechanism. (Refer to "CYLINDER HEAD AND VALVES," Section 2.)

9. Install the lubricating oil pump and crankcase oil pan. Be certain to correctly time the oil pump to the camshaft gear. (Refer to "OIL PUMP," Section 4.)

10. Install the distributor, if so equipped, and check and adjust the timing. (Refer to Section 12.)

11. Start the engine and check its operation:

(a) Inspect for oil leaks and check for correct oil pressure.

(b) Check and adjust the ignition timing. (Refer to Section 12.)

(c) Check and adjust the valve clearance. (Refer to "CYLINDER HEAD AND VALVES," Section 2.)

PRINTED IN UNITED STATES OF AMERICA

CRANKSHAFT AND MAIN BEARINGS

1. DESCRIPTION

The crankshaft supports the connecting rods and pistons along its length. At the forward end is the crankshaft drive gear which supplies the drive for the camshaft and for the other gears in the timing gear train. Two seals, one at each end, prevents leakage of engine lubricating oil around the ends of the crankshaft.

The crankcase bearing caps support the crankshaft in true alignment. Webs integral with the crankcase provide the upper half of the main bearing supports, and the removable caps provide the lower support. The caps are held in place with bolts. The bearing caps are not interchangeable, and each has a number stamped upon it which signifies its correct location in the crankcase. No. 1 is at the front of the engine.

The bearings are inserted between the crankshaft and the bearing caps. The intermediate rear bearing is the thrust bearing and has thrust flanges.

The crankshaft is a drop forging of heat-treated steel. It is counterweighted, balanced both statically and dynamically, and ground to close limits. The shaft is mounted in precision-type replaceable shell bearings.

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 localized 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 failure takes place. Anything that interferes with the operating clearance of any bearing or the proper heat dissipation has its effect upon bearing life. Cleanliness cannot be overstressed.

2. REMOVAL

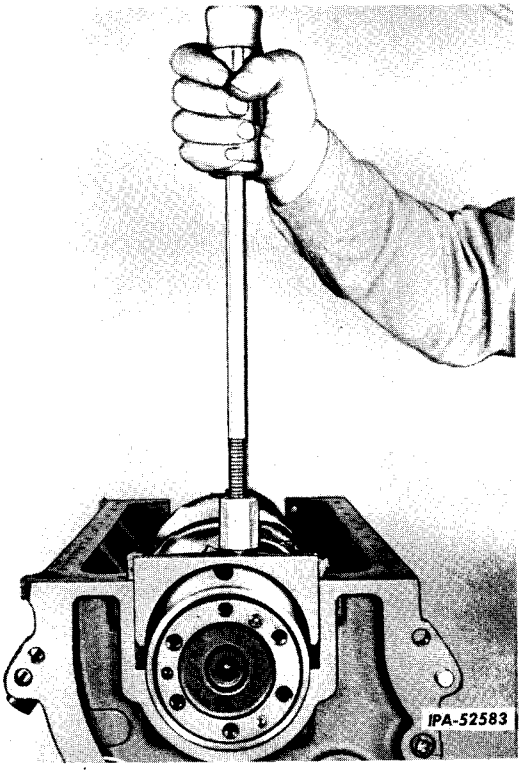
Crankshaft Bearings

1. Remove the oil pan and oil pump. (Refer to "Oil Pump", Section 4.)

2. Remove the spark plugs, if so equipped.

3. The crankshaft bearing caps are numbered to identify their position. They must be marked to assure reinstallation in their respective positions.

4. Remove the cap screws from each bearing cap and remove all crankshaft main bearing caps.



Illust. 1 - Removing the Crankshaft Rear Bearing Cap.

5. Remove the lower bearings from the caps. If the bearings are to be reassembled, be certain they are identified as to their original positions.

NOTE: If the crankshaft is to be removed, disregard step 6.

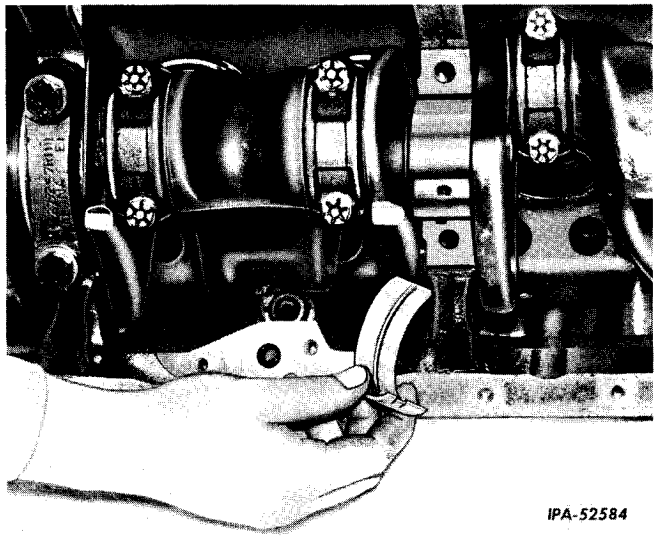
continued on next page

CRANKSHAFT AND MAIN BEARINGS

2. REMOVAL - Continued

Crankshaft Bearings - Continued

6. Remove the upper bearing halves (see Illust. 2), from between the crankshaft and the crankcase in the following manner.



IPA-52584

Illust. 2 - Upper Bearing Half (No. 2) Removed.

With a thin piece of flexible soft metal, push against the end of the bearing without the positioning nib while turning the crankshaft in the direction of rotation. The bearing will slide easily from position.

Crankshaft

7. Remove the flywheel. (Refer to "Flywheel" in this Section.)

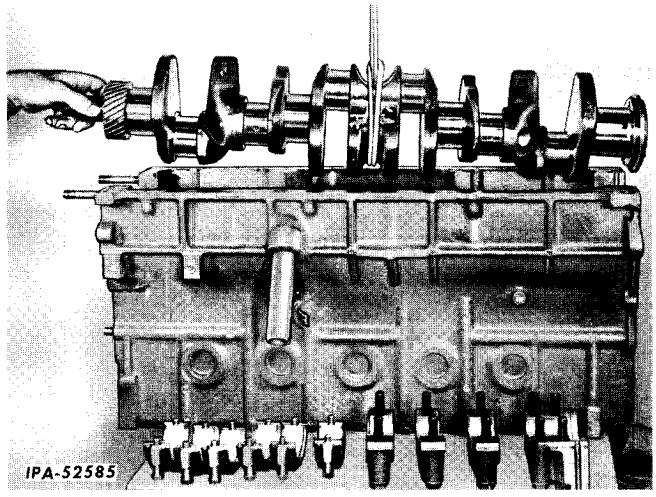
8. Remove the flywheel housing from the crankcase.

9. Remove the front cover assembly. (Refer to "Timing Gear Train and Front Cover", Section 6.)

10. Remove the connecting rod bearing caps, and push the piston and connecting rod assemblies to the top of their travel.

NOTE: The caps are numbered and can easily be returned to the correct rod in reassembly, however, do not allow the bearings to become mixed as these also must be returned to their original positions.

11. Lift the crankshaft out of the crankcase.



IPA-52585

Illust. 3 - Removing the Crankshaft.

12. Remove the upper main bearing halves from the crankcase.

3. INSPECTION AND REPAIR

1. Clean all parts, except rubber, with a cleaning solvent and dry with compressed air.

2. 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.

3. Inspect the crankshaft journals for scoring, and measure the diameter of each journal, using a micrometer. (See Illusts. 4 and 5.) 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.

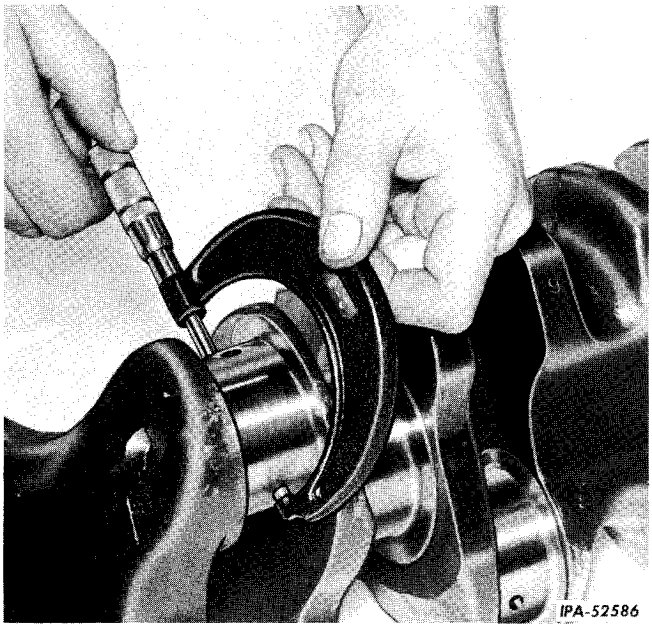
4. Inspect the vibration damper for breaks or for signs of poor bonding between the rubber and the metal portion of the damper. If either condition is found, the vibration damper should be replaced.

5. Inspect the crankshaft gear teeth for wear and chipping, and replace if necessary. (Refer to "Timing Gear Train and Front Cover", Section 6.)

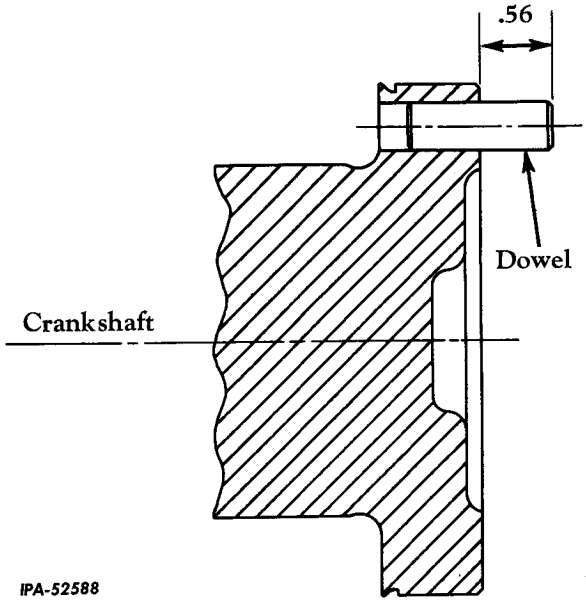
6. Discard the front and rear seals, using new seals when installing the crankshaft.

PRINTED IN UNITED STATES OF AMERICA

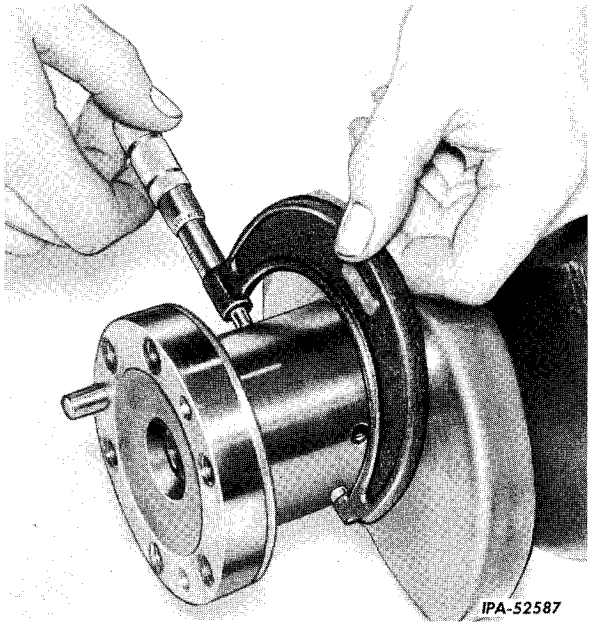
CRANKSHAFT AND MAIN BEARINGS



Illust. 4 - Measuring the Crank Pin Diameter.



Illust. 6 - Flywheel to Crankshaft Dowel Pin Installation.



Illust. 5 - Measuring the Main Bearing Journals.

7. Inspect the flywheel location dowel in the rear flange of the crankshaft, and replace if necessary. (See Illust. 6.)

4. INSTALLATION

After the crankcase and crankshaft have been thoroughly cleaned and reconditioned, and the necessary replacement parts have been procured, proceed as follows:

1. Wipe all surfaces of the crankshaft bearing bores of crankcase and bearing caps free of oil, and place bearing shell halves in the bore of the crankcase and bearing caps. Be certain the shells are fully seated, oil holes are in alignment, and locking tangs on the bearings fit into the recesses.

2. Apply a film of engine oil on the bearing shell surfaces and place the crankshaft into position.

NOTE: When installing the crankshaft, be certain to correctly index the timing marks on the crankshaft gear, idler gear and camshaft gear. (Refer to Section 6.)

3. Install the bearings and bearing caps over the crankshaft journals, being certain to install the caps in their correct positions and with the numbered side of the caps to the cam-

continued on next page

CRANKSHAFT AND MAIN BEARINGS

4. INSTALLATION - Continued

shaft side of the engine. Torque the main bearing cap bolts as specified in "SPECIFICATIONS," Section 1.

NOTE: For information on fitting bearings, refer to "Bearing Fitting Procedure" in Section 3. For fitting replacement of crankshaft bearing caps, refer to Par. 5 or 6 in this section.

4. Check the main bearing clearances as follows and compare with the "SPECIFICATIONS," Section 1. To obtain an accurate reading using the "plastigage" method of checking, all main bearing caps must be in place and torqued.

(a) Remove one bearing cap and insert and wipe the bearing surface and exposed half of crankshaft journal free of oil.

(b) Place a piece of "Plastigage", the full width of the bearing insert, on the crankshaft journal.

(c) Reinstall the bearing cap and tighten the cap screws to the recommended torque. (Refer to "SPECIFICATIONS", Section 1.)

(d) Remove the bearing cap and insert. The flattened plastic meterial will be found adhering to either the bearing shell or the crankshaft. Do not disturb 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. Follow the same procedure for the remaining bearings.

NOTE: Do not turn the crankshaft during the bearing clearance check procedure.

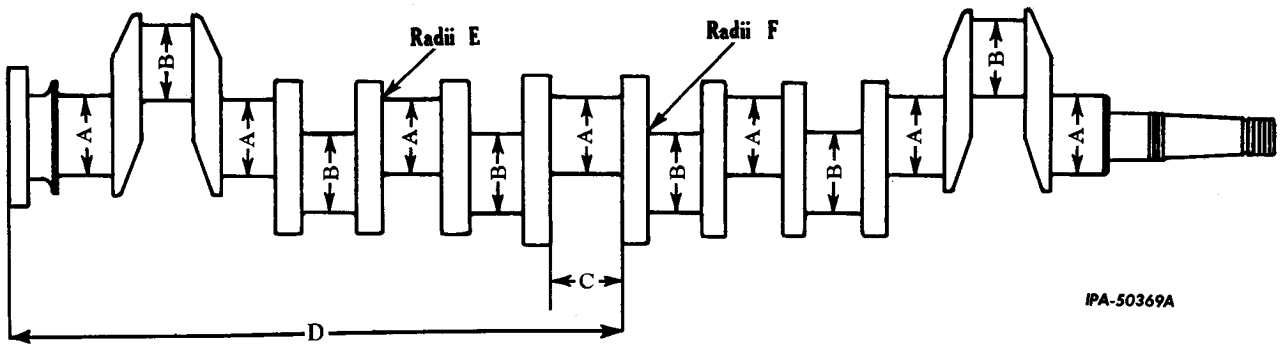
(e) Should the readings not fall within the specified limits, and the torque wrench is known to be accurate in its measurement, remove the bearing and replace it with a new one. However, with the precision bearings used, no difficulty should be encountered providing the crankshaft and/or crankcase and caps are in good order.

(f) Should the clearance remain excessive, it may be necessary to grind the crankshaft and install a bearing service package for the ground crankshaft. Refer to Illust. 7 for journal dimensions of undersize crankshaft. If the results obtained were 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 lock with cotter pins or lockwire.

NOTE: Do not grind the crankshaft beyond the limits specified in Illust. 7.

Continue checking the other main bearings in the same manner. Check the rear main next, followed by the front main and then the intermediates.

Grinding Limits—
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.



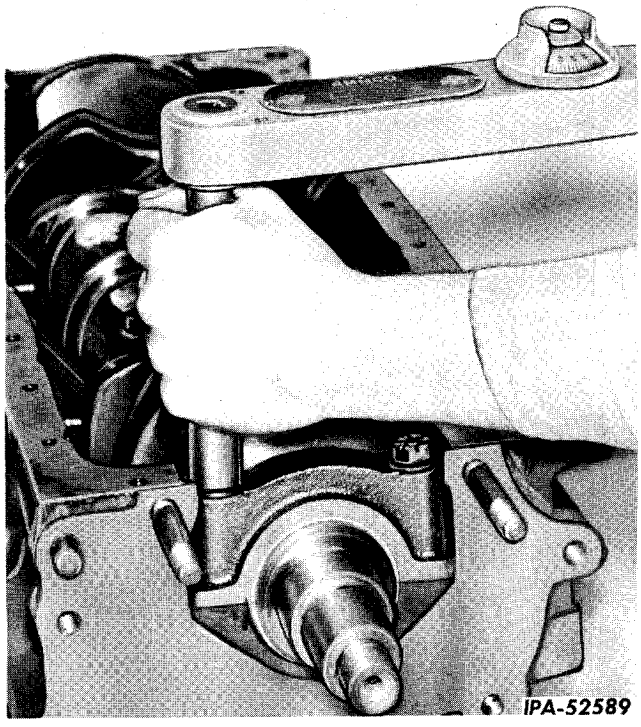
Illust. 7 - Limits for Undersize Crankshaft Grinding.

CRANKSHAFT AND MAIN BEARINGS

Limits for Undersize Crankshaft Grinding - Inches							
MODEL	Under Size Inch	A	B	C	D	E Main Bearings	F Crank Pin Bearings
UD-236	.010	2.738 - 2.739	2.363 - 2.364	1.519 - 1.522	12.156 - 12.172	.156 - .187	.156 - .187
	.020	2.728 - 2.729	2.353 - 2.354	1.523 - 1.526	12.156 - 12.172	.156 - .187	.156 - .187
	.030	2.718- 2.719	2.343 - 2.344	1.527 - 1.530	12.156 - 12.172	.156 - .187	.156 - .187
UD-282, TD-6 (62 Series), TD-9 (92 Series) and TD-9 (Series B)	.010	2.738 - 2.739	2.363 - 2.364	1.515 - 1.518	12.156 - 12.172	.156 - .187	.156 - .187
	.020	2.728 - 2.729	2.353 - 2.354	1.515 - 1.518	12.156 - 12.172	.156 - .187	.156 - .187
	.030	2.718 - 2.719	2.343 - 2.344	1.527 - 1.530	12.156 - 12.172	.156 - .187	.156 - .187

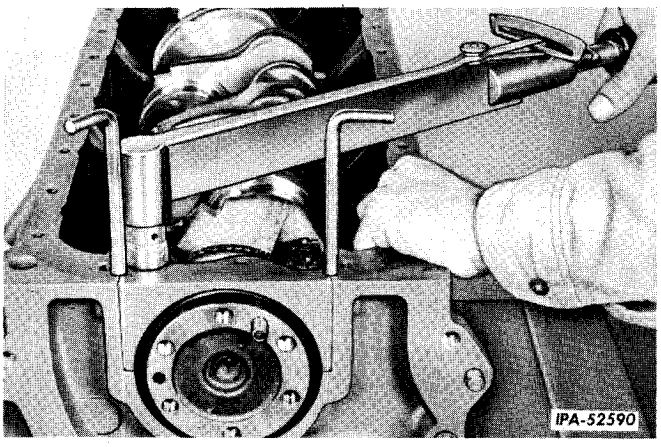
5. Torque all cap screws except the number three (thrust) bearing (Illust. 8). (Refer to "SPECIFICATIONS," Section 1.)

6. Hold the crankshaft toward the front of the engine by means of a suitable fixture so that the crankshaft thrust surface is tight against the rear of the thrust flange.



Illust. 8 - Torquing the Main Bearings.

NOTE: When installing and torquing the rear main bearing cap, the use of special tools ED-4000 as shown in Illust. 9 will help establish and retain correct cap alignment. For further information or to order these tools, write to "Service Tools Inc.," 1901 South Indiana Avenue., Chicago 16, Illinois.



Illust. 9 - Installing the Rear Main Bearing.

7. Tap the number three (thrust) bearing cap toward the rear of the crankcase so that the rear thrust flange is tight against the crankshaft. (See Illust. 10.)

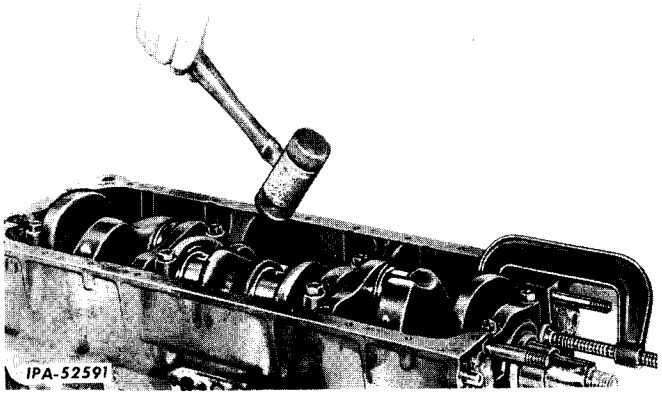
8. Torque the number three bearing cap screws. (Refer to "SPECIFICATIONS," Section 1.)

Continued on next page

CRANKSHAFT AND MAIN BEARINGS

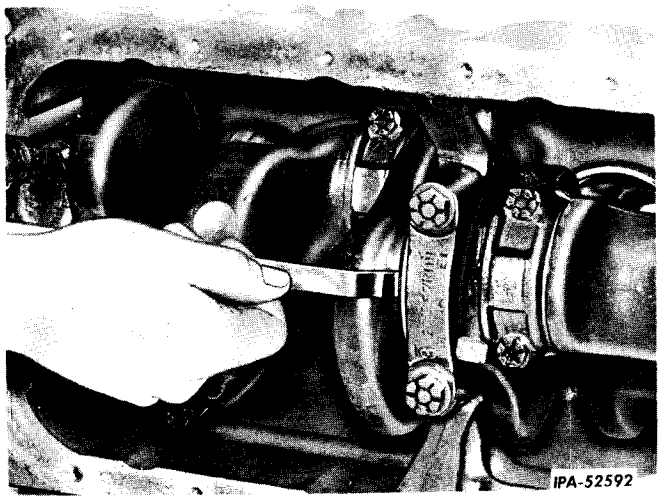
4. INSTALLATION - Continued

9. Check the thrust bearing end clearance. (Refer to "SPECIFICATIONS, " Section 1.)



Illust. 10 - Positioning the Thrust Bearing.

10. Oil the connecting rod bearings after wiping them clean and install the connecting rods, connecting rod bearings and caps to the crankshaft. Be certain 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. Torque the connecting rod bolts as specified in "SPECIFICATIONS," Section 1.



Illust. 11 - Checking Thrust Bearing End Clearance.

11. Check the connecting rod side clearance on the crankshaft. (Refer to "SPECIFICATIONS," Section 1.)

Illust. 12 - Installing the Rear Main Bearing Cap Packing Plugs.

12. Remove the aligning dowels from the rear main bearing cap install new rubber plug-type packing in each packing hole in the rear bearing cap as follows:

(a) Lubricate the plug with engine oil to aid in installation.

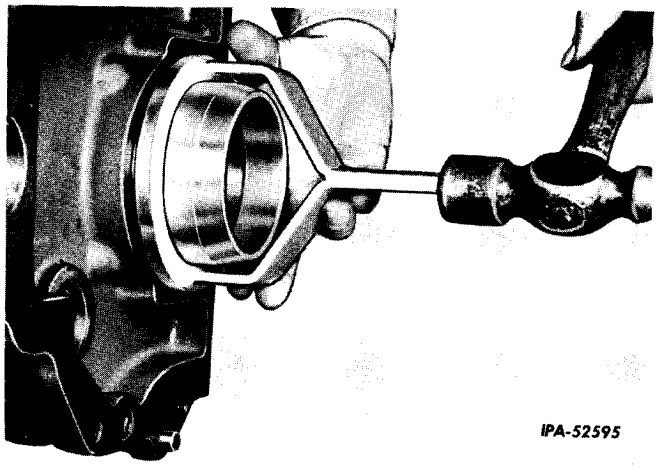
(b) Use a 3/16 inch piece of drill rod five or six inches long, to force the plug in the hole. (Illust. 12.)

Illust. 13 - Placing Seal on Installing Tool.

PRINTED IN UNITED STATES OF AMERICA

CRANKSHAFT AND MAIN BEARINGS

13. Install the rear oil seal using special tools ED-4017A and ED-4018 to insure correct installation. Lubricate the seal generously when placing it on the aligning tool (Illust. 13 and 14).



Illust. 14 - Installing the Rear Seal.

NOTE: For further information or to order these tools, write to "Service Tools Inc.," 1901 South Indiana, Chicago 16, Illinois.

14. Install the flywheel housing. (Refer to "Flywheel" in this Section.)

15. Install the flywheel. (Refer to "Flywheel" in this Section.)

16. Install the front cover. (Refer to "Timing Gear Train and Front Cover", Section 6.)

17. Install the oil pump and oil pan. (Refer to "Oil Pump", Section 4.)

18. Install the spark plugs, if so equipped.

CAUTION: If only main bearings, connecting rod bearings or the crankshaft have been replaced, the following steps should be used. If however, the engine has been completely serviced and new sleeves, pistons or rings have also been installed, follow the run-in schedule outlined in Section 3.

19. Fill the crankcase with lubricating oil as specified in the Operator's Manual.

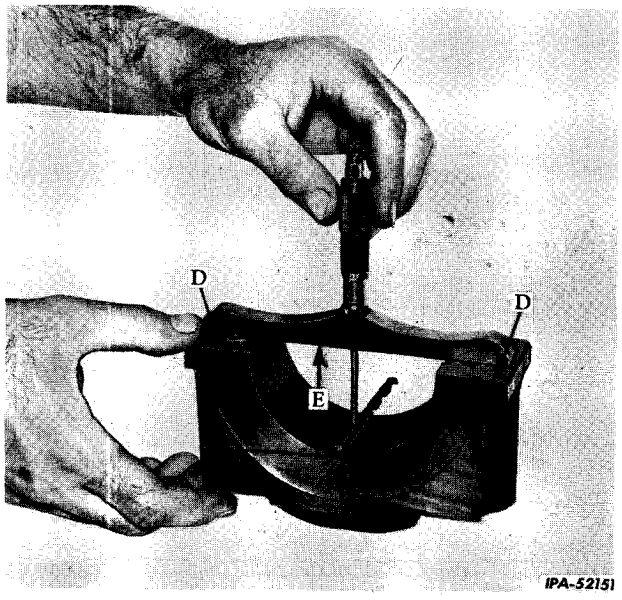
20. Install an oil inlet screen into the turbocharger (on units so equipped) for the first 5 to 25 hours of operation. Be certain to remove this screen after the 5 to 25 hours have elapsed.

21. Fill 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 period, drain the oil while the engine is hot. Inspect and replace the oil filter element if necessary. Then refill with oil as specified in the Operator's Manual.

5. FITTING CRANKSHAFT BEARING CAPS (Machine Method)

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. 15) 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. 15 - Measuring Dimension "E."

2. Mill or grind surface "D" (Illust. 15) of the new cap to dimension "E" plus .002 inch.

Continued on next page.

CRANKSHAFT AND MAIN BEARINGS

5. FITTING CRANKSHAFT BEARING CAPS
(Machine Method) - Continued

NOTE: .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.

IMPORTANT: The bearing cap must be located on its machined side when milling or grinding surface "D" to hold squareness.

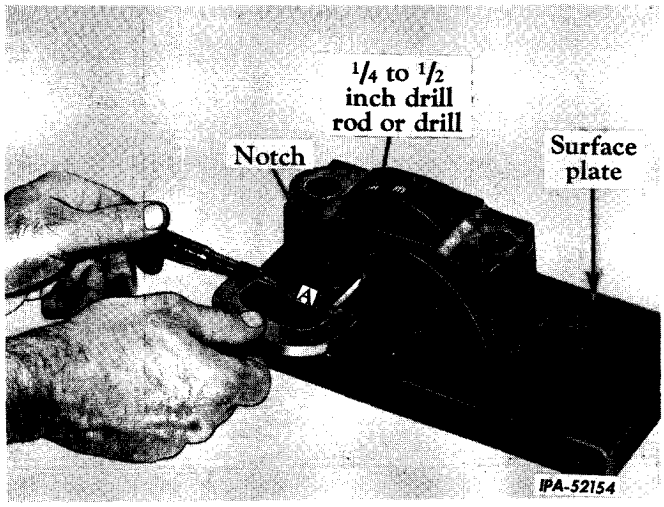
3. Clamp the old bearing cap to a surface plate.

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. 16, 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. 17) of the new cap. Dimension "A" of both caps will now be equal.

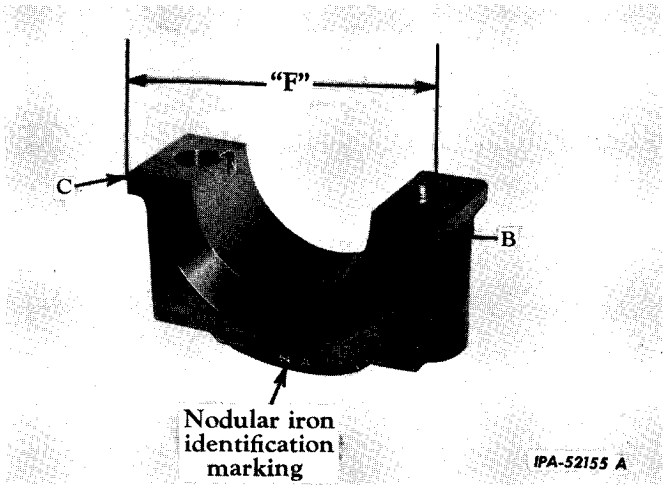
IMPORTANT: Surface "C" must be held square with surface "D" (Illust. 15) and parallel to the bearing bore.



Illust. 16 - Measuring Dimension "A."

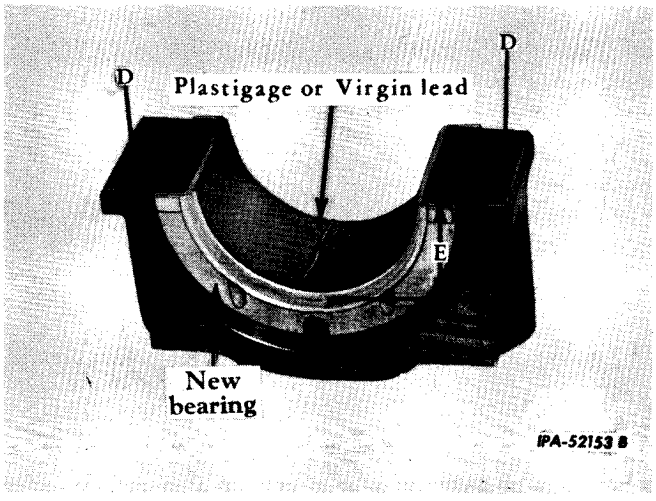
7. Mill or grind surface "B" (Illust. 17) of the new cap until the dimension "F" (5.126 - 5.128 inches) shown from surface "C" to "B" in Illust. 17 is obtained.

IMPORTANT: Surface "B" must be held square with surface "D" and parallel to the bearing bore.



Illust. 17 - Bearing Cap Finish Length.

8. Install a new bearing in the new bearing cap. Place a length of virgin lead or Plastigage across the bearing (Illust. 18).



Illust. 18 - Position of Virgin Lead.

9. Install the new bearing and bearing cap and tighten to the torque specified in "SPECIFICATIONS" in Section 1.

10. Remove the bearing cap. When virgin lead is used, measure the crushed thickness with a

CRANKSHAFT AND MAIN BEARINGS

micrometer and record the results. When Plastigage is used, follow the procedures outlined in Section 3, "Bearing Fitting Procedures" and record the results.

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.

IMPORTANT: Surface "D" must be held square with the bearing cap bore.

13. Recheck the bearing running clearance with virgin lead. The correct clearance is given in "SPECIFICATIONS," Section 1.

6. FITTING CRANKSHAFT BEARING CAPS (Hand Method)

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. 15) 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. 15), 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. 15).

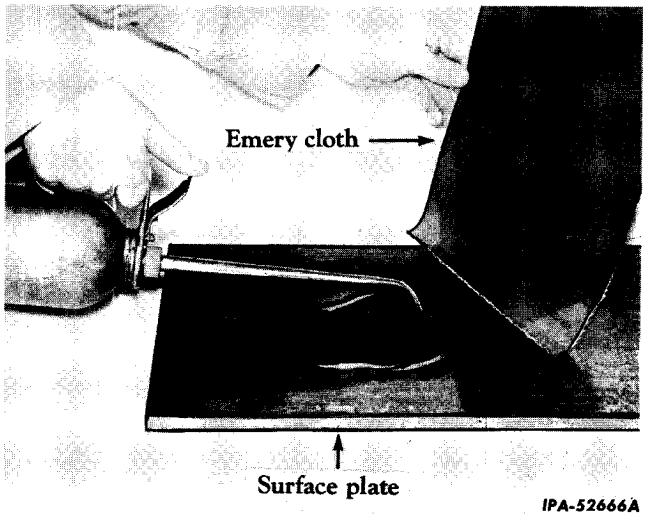
3. To remove stock from surface "D" quickly and accurately, use a smooth metal or glass surface plate, extra coarse emery cloth (No. 430 grit) and heavy duty engine oil.

4. Oil the surface of the plate (Illust. 19) to keep the emery cloth from wrinkling and sliding.

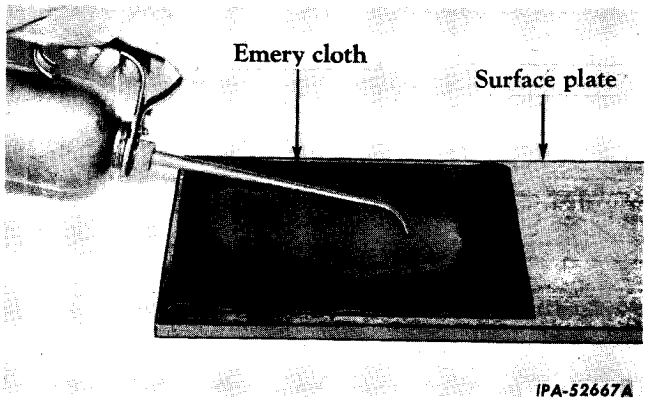
5. Oil the emery cloth (Illust. 20) to speed cutting and to carry cuttings away from the face of the bearing cap. ("Rule of thumb" for cutting speed is .001 inch per 100 strokes.)

6. Place the bearing cap on the emery cloth and with hand pressure, move the cap back and forth (Illust. 21). Turn the cap after every 50 strokes to equalize the cutting width of surface "D."

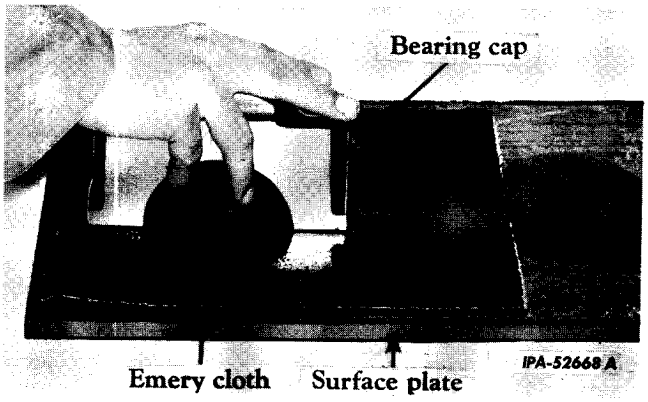
Continued on next page



Illust. 19 - Oiling Surface Plate.



Illust. 20 - Oiling Emery Cloth.



Illust. 21 - Working Surface "D."

CRANKSHAFT AND MAIN BEARINGS

6. FITTING CRANKSHAFT BEARING CAPS

(Hand Method) - Continued

7. With a fine file or fine emery cloth, remove the slight high spot immediately around the holes of the bearing cap (Illust. 22). (Usually about .0005 inch.)

Illust. 22 - Removing High Spots.

8. Clamp the old bearing cap to a surface plate.

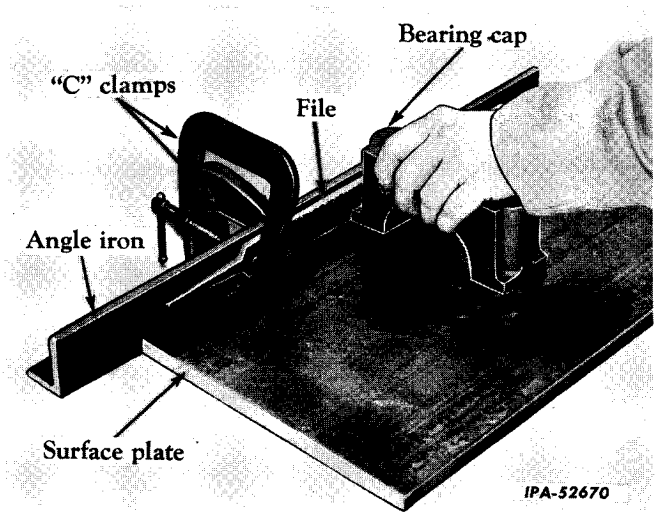
9. Place a drill rod or new drill of any size from 1/4 to 1/2 inch on the inside of the old cap (against notched side). Measure dimension "A" with a micrometer as shown in Illust. 16 and record the reading.

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. 23).

13. File from surface "C" (Illust. 17) of the new cap. Dimension "A" of the new and old caps will now be equal.



Illust. 23 - Working Surfaces "B" and "C."

IMPORTANT: Surface "C" must be held square with surface "D" and parallel to the bearing bore.

14. File surface "B" (Illust. 17) of the new cap until the dimension "F," (5.126 - 5.128 inch) shown from surface "C" to "B" in Illust. 17 is obtained.

IMPORTANT: 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. 18) in the usual way in bottom of bearing.

16. Install the new bearing and bearing cap and tighten the nut to 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 limits as given in "SPECIFICATIONS," Section 1. If this measurement has not been obtained, repeat Steps 6 and 7.

PRINTED IN UNITED STATES OF AMERICA

FLYWHEEL

7. 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 self-locking bolts. Dowels are provided as an aid to installation. Correct mounting of the flywheel to the crankshaft is assured since mounting holes are not equidistant and the flywheel can be installed only one way. The cranking motor drive ring gear is a shrink fit and is replaceable.

8. REMOVAL

1. Remove the self-locking bolts from the flywheel and, using a soft hammer, tap on the flywheel to loosen it from the crankshaft.

2. Remove the bolts and lock washers from the flywheel housing. Drive out the crankcase dowels and remove the flywheel housing.

9. INSPECTION AND REPAIR

1. Wash the flywheel and ring gear assembly and flywheel housing in dry cleaning solvent.

2. Check the flywheel ring gear teeth, if worn or damaged the gear must be replaced.

Replacing the Ring Gear

(a) Heat the gear with a torch and remove it from the flywheel with a hammer and drift.

(b) Install a new ring gear by first heating the gear to expand it, and then placing it onto the flywheel while the ring gear is hot. The chamfered edge of the ring gear (I.D.) is placed on the flywheel first so that when assembled, the edge faces away from the engine.

3. Inspect the flywheel housing for cracks or breakage and replace if damaged.

4. Remove the pilot bearing from the flywheel, if so equipped. Clean the bearing in dry cleaning solvent and inspect it for wear or damage. Replace if necessary.

5. Inspect the rear support dust seal and replace if necessary.

Replacing the Flywheel Housing

When replacing the flywheel housing, it is suggested that the flywheel bore and face be checked relative to the crankshaft to establish proper alignment between the engine, clutch and/or converter. Misalignment between the flywheel housing and engine will cause corresponding misalignment of the clutch and transmission resulting in damage to the clutch plates or pilot bearing and transmission main drive gear or main drive gear pilot bearing. The dowel pins between the crankcase and flywheel housing are for the purpose of maintaining this alignment once the flywheel is mounted within tolerances.

NOTE: The mating surfaces of the crankcase and 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.

6. Place the flywheel housing over the two flywheel housing-to-crankcase dowels and tap into place with a soft hammer.

7. Install the bolts and lock washers and secure the housing.

8. Check the concentricity of the housing bore and the squareness of the face with the crankshaft as described below. (See "SPECIFICATIONS," Section 1 for the proper tolerances.) If the concentricity is not within specifications, remove the housing and continue with the next step.

9. Remove the dowels from the crankcase.

10. Assemble the housing to the crankcase. Do not tighten the bolts to full torque. Just run the bolts down snug for housing adjustment.

11. Position the housing to meet the tolerances given in "SPECIFICATIONS" in Section 1.

12. Tighten all the bolts to full torque. Recheck the flange tolerances and reposition the housing if necessary.

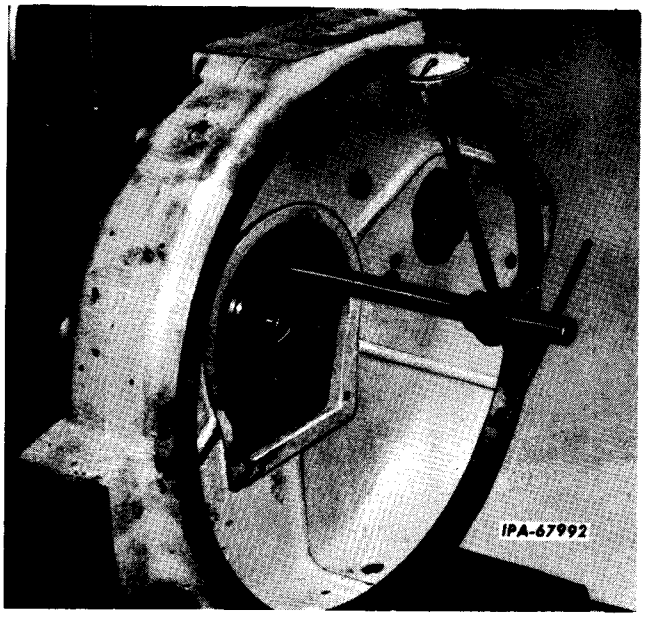
13. Ream the dowel holes for oversize dowels and install oversize dowels.

FLYWHEELS

9. INSPECTION AND REPAIR - Continued

Checking Flywheel Housing Face Run-out

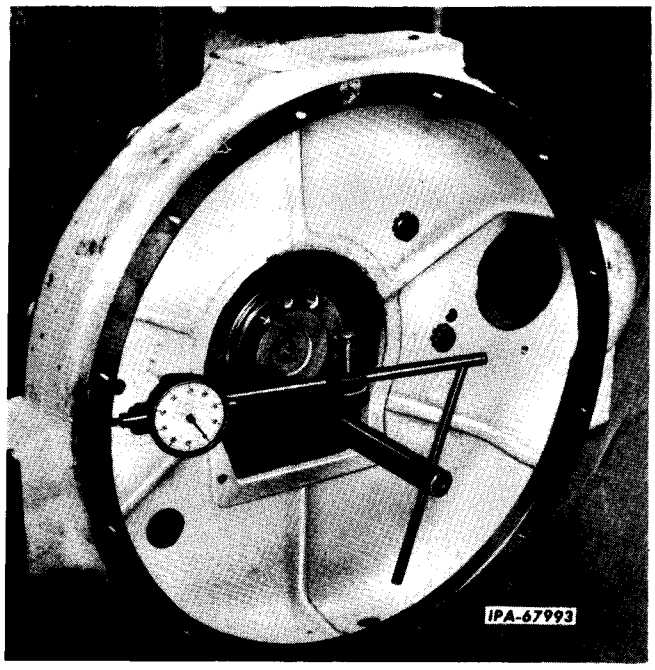
To check the run-out of the flywheel housing face, attach a dial indicator to the crankshaft flange placing the indicator pointer against the flywheel housing face. Remove crankshaft "end-play" and note reading. Check at four points 90 degrees apart for total face variation. Keep crankshaft "end-play" at zero in the same direction for all readings. (Refer to Illust. 24.) For allowable housing face run-out tolerance refer to "SPECIFICATIONS," Section 1.



Illust. 24 - Checking Run-out of Flywheel Housing Face in Relation to the Axis of the Crankshaft.

Checking Flywheel Housing Bore Concentricity

To check the concentricity of the flywheel bore relative to the crankshaft axis, attach a dial indicator to the crankshaft placing the indicator pointer against the flywheel housing bore as shown in Illust. 25. Rotate the crankshaft slowly and note total indicator reading variation. For allowable housing bore concentricity tolerance refer to "SPECIFICATIONS," Section 1.



Illust. 25 - Checking the Concentricity of the Flywheel Housing Bore in Relation to the Axis of the Crankshaft.

10. INSTALLATION

1. Lubricate the pilot bearing (if equipped) and install it into the flywheel.

2. Place the flywheel and ring gear assembly into position on the dowel in the crankshaft flange.

3. Install the self-locking bolts in the flywheel and torque to the amount shown in "SPECIFICATIONS," Section 1.

PRINTED IN UNITED STATES OF AMERICA

1. 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 tends to counteract 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, tending to throw the weights against the springs. Thus, at a certain point, both spring and governor forces are balanced and the engine speed will remain constant, at the speed at which the forces, spring and governor weight, became equal.

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 the throttle control handle increasing or decreasing the governor spring tension and not by direct connection with the carburetor throttle valve.

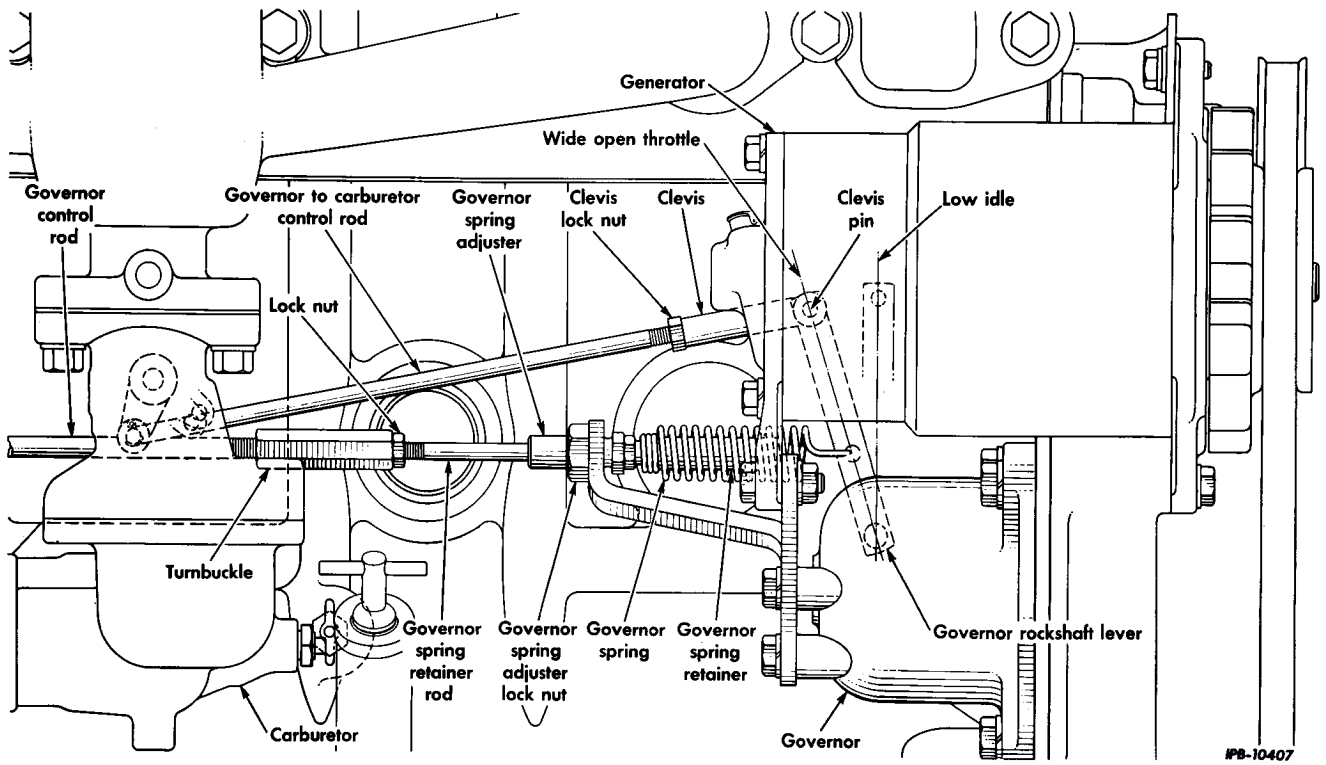
Increasing the governor spring tension allows the throttle to be pulled farther open, increasing the engine speed until the added centrifugal force of the governor weights balance the increased spring tension. Decreasing the spring tension will result in the opposite action.

2. REMOVAL

1. Remove the voltage regulator wires and tag each to facilitate replacement.

2. Remove the regulator and bracket.

continued on next page



Illust. 1 - Carburetor and Linkage.

2. REMOVAL - Continued

3. Loosen the generator mounting bolts and generator brace bolt, move the generator in toward the engine, and remove the belt.

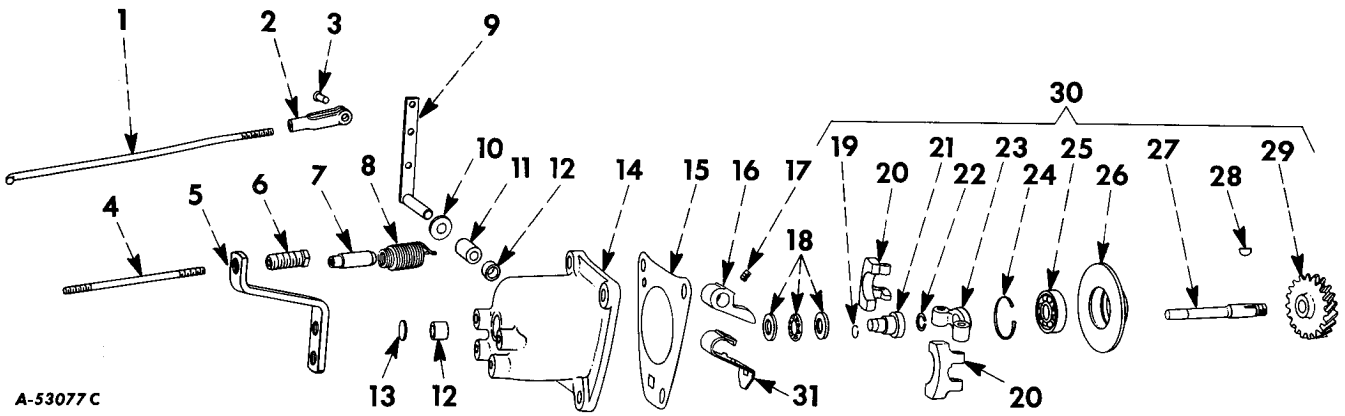
4. Disconnect the wires from the generator, tag each to facilitate replacement, and remove the generator.

5. Disconnect the governor-to-carburetor control rod.

6. Loosen the lock nut and separate the governor spring retainer rod from the governor control rod by turning the turnbuckle.

7. Remove the cap screws securing the governor to the front plate and remove the governor.

3. DISASSEMBLY (Refer to Illust. 2)



Illust. 2 - Exploded View of Governor.

1. Rod.
2. Fork.
3. Pin.
4. Rod.
5. Bracket.
6. Adjuster.
7. Retainer.
8. Spring.
9. Rockshaft.
10. Oil seal.
11. Bearing.
12. Bearing.
13. Plug.
14. Housing.
15. Gasket.
16. Fork.
17. Set screw.
18. Ball bearing.
19. Stop ring.
20. Weight.
21. Sleeve.
22. Snap ring.
23. Carrier.
24. Snap ring.
25. Ball bearing.
26. Retainer.
27. Shaft.
28. Key.
29. Gear.
30. Governor gear and weight assembly.
31. Bumper spring.

1. Remove the governor spring bracket (5) and the generator support bracket.

2. Remove the governor spring and governor spring retainer rod assembly from the rockshaft lever (9).

3. Remove the gear and weight assembly (30) from the housing (14).

4. Remove the snap ring (19) and slide the sleeve (21) and bearing (18) from the shaft (27).

5. Separate the bearing (18) from the sleeve (21).

6. Remove the nut from the end of shaft (27), and remove the gear (29).

7. Remove the roll pins securing the governor weights (20) to the carrier (23).

8. Remove the key (28) and press the bearing (25), retainer (26) and carrier (23) from the shaft.

9. Remove the snap ring (24) from the retainer (26) and press the bearing (25) from the retainer.

10. Remove the snap ring (22) from the shaft.

PRINTED IN UNITED STATES OF AMERICA

11. Loosen the set screw (17) in the fork (16). Slide the rockshaft (9) from the housing (14). Remove the fork (16) and bumper spring (31).

12. If inspection proves replacement of the bushings (11) and (12) necessary, the plug (13) and oil seal (10) must be removed from the housing. When the seal (10) is removed, discard it and replace with a new one.

4. INSPECTION AND REPAIR

1. Wash all parts in a dry cleaning solvent and blow dry. Clean the oil inlet hole in the governor housing.

2. Check the I.D. of the bushings (11) and (12). The original dimensions of the bushings are .375 to .376 inch I.D. of wear is excessive, replace.

3. Inspect the oil seal (10) and plug (13). If the seal is damaged, or if the seal or plug show signs of leakage, replace.

4. Inspect the gear for chips or cracks. Replace if necessary.

5. Inspect the thrust bearing (18) for pitting, scoring or cracks, and for excessive wear on the surface of the race contacting the fork (16). Usually the wear, if any, will occur on the contact surface of the fork.

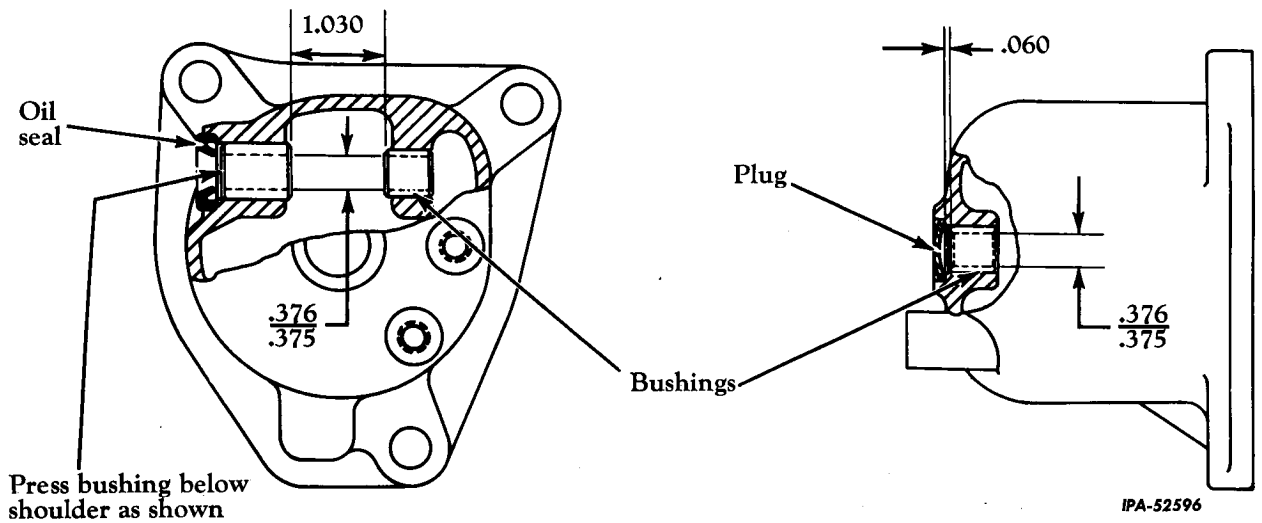
6. Inspect the fork (16), if the contact surface is worn excessively, replace.

7. Check the sleeve (21) and shaft (27) for correct fit. The original clearance of the sleeve on the shaft is .0025 to .0085 inch. If the clearance is in excess of these figures, refer to "SPECIFICATIONS", Section 1 for correct dimensions of the sleeve or shaft. Be certain that the sleeve does not bind or stick on the shaft.

8. Check the governor weights (20) for excessive wear on the thrust cam surface, and replace if necessary.

9. Inspect the carrier (23) for cracks, and for correct roll pin fit. The roll pins should fit tight in the carrier.

10. Inspect the bearing (25) for pitting, scoring or cracks, replace if necessary.



Illust. 3 - Correct Bushing Assembly.

5. REASSEMBLY (Refer to Illust. 2)

1. If the bushings (11) and (12) or the oil seal (10) were removed, replace them as shown in Illust. 3.

2. Slide the rockshaft (9) part way into the housing. Position the fork (16) with bumper spring (31) inside the housing, in line with the

continued on next page

5. REASSEMBLY (Refer to Illust. 2) - Continued

shaft and slide the shaft through the fork bore and into the bushing (12). Align the set screw hole in the fork with the counter sink in the shaft, install and tighten the set screw (17).

3. Install the bearing (25) into the retainer (26) and install the snap ring (24).

4. Install the snap ring (22) on the shaft (27). Place the carrier (23) on the shaft and position the recessed area over the snap ring (22).

5. Place the bearing and retainer assembly (24), (25) and (26) on the shaft with the bearing facing the carrier. Position the inner bearing race against the carrier.

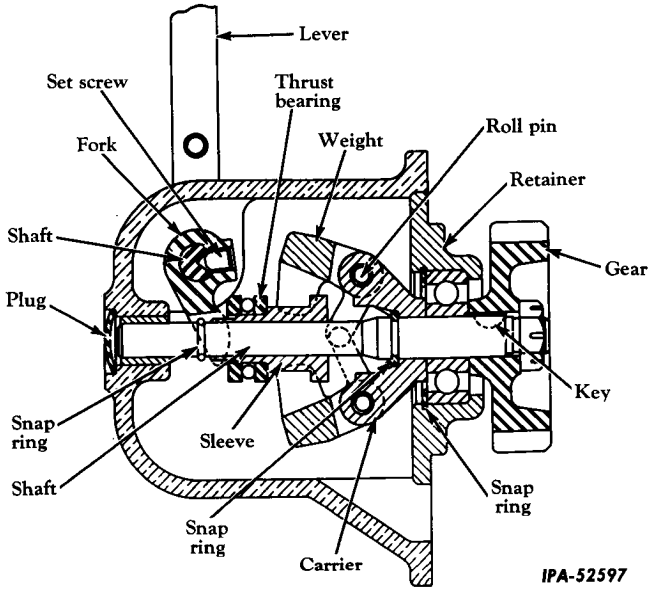
6. Install the key (28) and press the gear (29) on the shaft. Install and tighten the nut to the torque specified in "SPECIFICATIONS", Section 1.

7. Assemble the weights (20) to the carrier (23) with the roll pins. Check the weights for binding or sticking and be certain they are free to pivot on the pins.

8. Press the bearing (18) on the sleeve (21).

9. Install the sleeve and bearing assembly onto the shaft. (See Illust. 4.)

NOTE: Check the sleeve for binding or sticking and be certain the sleeve is free to slide on the shaft.



Illust. 4 - Cross Section of Governor Assembly.

10. Install the snap ring (19) on the shaft, being certain the ring fits tight in the ring groove.

11. Install the weight and gear assembly (30) into the housing (14) after first freely lubricating all internal parts with engine oil. Be especially certain the bearings are lubricated.

6. INSTALLATION (Refer to Illust. 1)

1. Using a new gasket, secure the governor to the rear of the front plate.

2. Fasten the two brackets to the rear of the governor housing, hook the governor spring to the rockshaft lever and connect the governor control rod to the governor spring retainer rod using the turnbuckle. Tighten the lock nut.

3. Connect the governor-to-carburetor control rod.

4. Install the generator and connect the wires, using the tags made in "Removal" to facilitate correct replacement.

5. Install the fan belt and adjust the belt to the correct tension. (Refer to Section 5.)

6. Install the regulator and bracket and connect the regulator wires, using the tags made during "Removal" to facilitate correct replacement.

7. ADJUSTMENTS

Governor action should be smooth and steady without surging. To obtain efficient operation the cause of surging should be determined and corrected. Check to be certain that the rockshaft turns freely and that the oil seal is not causing a drag, as a drag has the tendency to make the governor surge or hunt.

If the governor linkage bends or the length of the governor-to-carburetor rod has been moved, make the necessary adjustments as follows:

1. Loosen generator brace bolt and the generator mounting bolts. Then move the generator in toward the engine, remove the belt from the generator pulley, and move the generator away from the engine.

PRINTED IN UNITED STATES OF AMERICA

2. Pull the engine speed control handle to create tension on the governor spring.

3. With the governor to carburetor control rod connected to the carburetor, and the governor rockshaft lever in the wide open throttle position, adjust the length of the rod so the clevis pin slides freely into the clevis and governor rockshaft lever hole.

4. Remove the clevis pin and turn the clevis one complete turn longer.

5. Reassemble the clevis pin and tighten the clevis lock nut.

6. Check to be sure there is no binding by moving the engine speed control handle a few times.

7. Move the generator in toward the engine, reinstall the generator belt on the pulley and tighten the generator mounting bolts. Then adjust the belt tension as shown in Section 5.

8. With the engine running, pull the governor spring retainer rod back against the stop. Adjust the spring adjuster screw to obtain the specified fast idle speed. (Refer to the Operator's Manual.)

9. Loosen the governor spring adjuster lock nut to adjust the governor spring adjuster in or out.

Moving the governor spring adjuster out (toward the rear) increases the spring tension which increases the engine speed.

Moving the spring adjustment in (toward the front) decreases the spring tension which decreases the engine speed.

10. Governor action can be checked by suddenly moving the governor spring retainer rod back against the stop. The governor should not surge more than twice. If the governor surges more than twice, screw in the bumper spring screw just enough to stop excessive surging. Lock the adjusting screw with the jam nut.

PRINTED IN UNITED STATES OF AMERICA

1. DESCRIPTION

The gasoline fuel system consists, basically, of a fuel supply tank, fuel strainer, carburetor, air cleaner and governor.

The function of the carburetor is to meter the required amount of fuel to meet varying demands of engine load and speed, and to discharge this fuel into the intake air stream in as fine a spray as possible.

The air-fuel ratio is not constant for all loads and speeds. Idle and low speeds require a rich fuel mixture and full load, full speed operation requires a lean fuel mixture. This carburetor, with its air-bleed-well method of compensation, will give these proportionate air-fuel mixtures to meet load-speed demands.

To simplify the explanation of the carburetor, consider it divided into four systems. The Fuel Supply System, Idling System, Load System and Starting System.

Fuel Supply System

The fuel supply system consists of the fuel inlet strainer, fuel needle valve and seat, fuel float, fuel bowl and the bowl air vent.

The function of the float and fuel needle valve is to maintain an even level of fuel in the bowl. The float assembly consits of two float bodies soldered to a float lever. This assembly hinges on the float axle supported by a bracket on the bowl cover. Fuel from the supply tank enters the bowl through the inlet strainer and the float needle valve. As the level of fuel rises in the bowl, the float is carried upward until the float lever forces the needle valve against its seat, stopping further flow of fuel into the carburetor.

When the engine is running, fuel flows from the bowl through the main metering jet to either the load system or idling system and the float valve maintains a constant level of fuel in the bowl.

The bowl air vent passage is a drilling in the throttle body connecting the float chamber with an air vent channel surrounding the venturi. Air for the bowl vent, the well bleed and the idling system is taken from this channel in the venturi, which, in turn, is vented to the carburetor main air intake. In this manner, all air taken into the carburetor is supplied through the air cleaner. This not only prevents entry of dirt and abrasives, but creates what is called a "balanced" vent.

Idling System
(Refer to Illust. 1)

The idling system consists of idle discharge port (5), idle adjusting needle (14), idle jet (7), the connecting channels and air bleed (6). This system controls the mixture at partially opened throttle for idle and slow engine speeds, until the throttle is opened sufficiently to allow the load system to function.

Fuel for the idling system enters the metering well (15) through the main metering jet (11) and is drawn through the idle jet (7) into the idle passage where it is mixed with air from the idle air bleed (6). The air-fuel mixture enters the air stream past the throttle plate, from the idle discharge port (5).

Load System
(Refer to Illust. 1)

The load system consists of the venturi (2), discharge nozzle (17), well (15), well air bleed (13) and main metering jet (11). The load system, as the name implies, controls the air-fuel mixture during the time the engine is loaded or is operating above idle speed.

When the throttle plate is opened a short distance beyond the idle port (5), a sufficient amount and velocity of air passes the venturi (2) and the disharge nozzle (17) to draw fuel from this source. This condition starts the load system functioning. Within a partial load-speed range of throttle plate movement, both the idling system and load system are delivering fuel. Further opening of the throttle plate, due to increased engine load speed results in reducing the delivery of fuel from the idling system. Ultimately, all delivery of fuel from the idling system is stopped.

The main metering jet (11) has a calibrated opening large enough to permit the flow of the maximum amount of fuel necessary for full load operation. When the engine is stopped or idling, the level of fuel in the well (15) and discharge nozzle (17) is similiar to the level in the fuel bowl. As the load system goes into operation with increased load and throttle opening, the fuel is drawn from the discharge nozzle at a higher rate than supplied to the well (15) by the main metering jet (11). This lowers the level of fuel in the well (15). As the load and throttle opening is increased, the fuel level in the metering well (15) drops below a series of

(Continued on next page.)

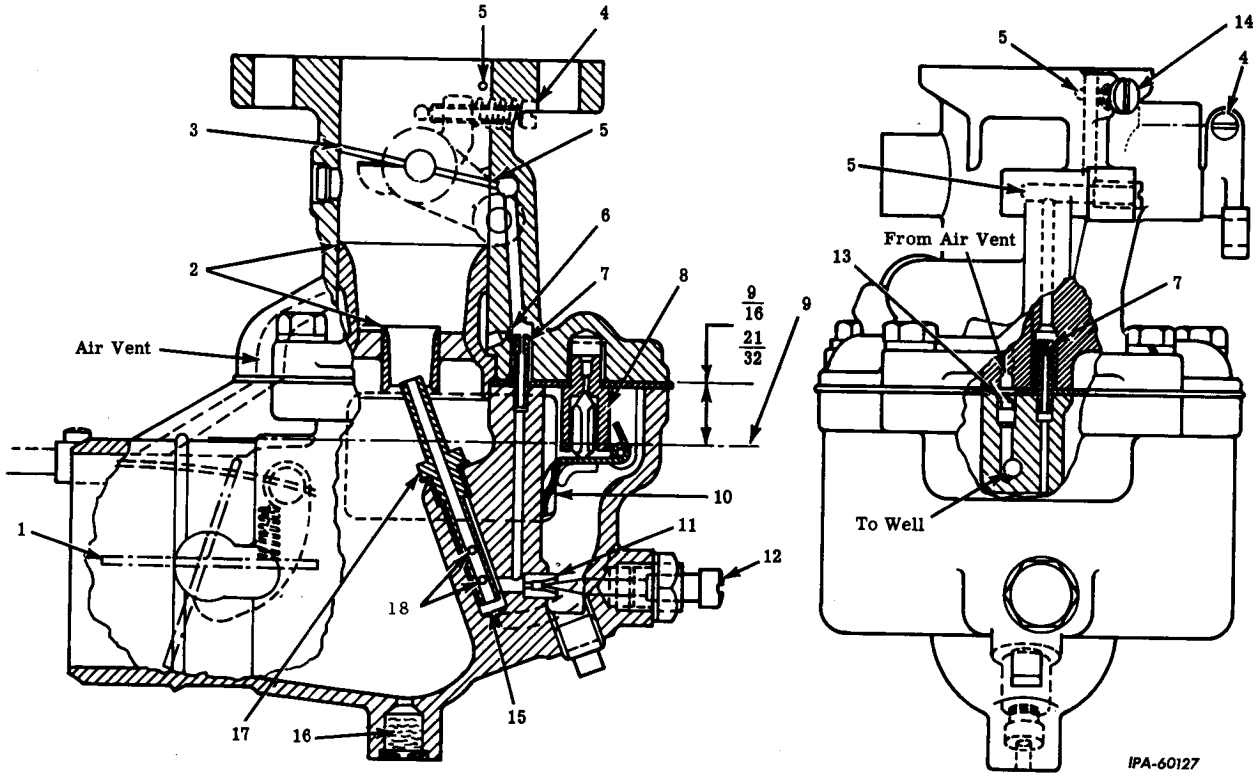
Load System - Continued
(Refer to Illust. 1)

air bleed holes (18) in the discharge nozzle, admitting an increasing amount of air from the well air bleed (13). This metered addition of air to the discharge nozzle is necessary to compensate for the partial vacuum produced at the nozzle. Were it not for this well-air-bleed compensation, the proportion of fuel to air would rapidly increase with the throttle opening, producing an extremely "rich" mixture at full throttle, full load operation.

The main jet adjustment screw (12) may be used to limit the amount of fuel going into the engine when operating under light load conditions. An increase in fuel economy can be obtained for periods of light load operation in this manner. However, when heavy work is to be performed in which the full power of the engine is required, the fuel adjusting screw must be set five turns off its seat. The main metering jet (11) in the carburetor has been calibrated to provide an economical, full-power mixture and must not be restricted by use of the adjusting screw when full power of the engine is required.

Starting System
(Refer to Illust. 1)

The starting system consists of a manually operated choke valve mounted in the carburetor main air intake. When the choke valve plate (1) is turned to the closed position, it restricts the air entering the carburetor. This upsets the balance of the carburetor, allowing the increased suction to draw strongly upon the fuel discharge



Illust. 1 – Cross Section of Carburetor Showing Principal Parts

1. Choke valve.
2. Venturi.
3. Throttle plate.
4. Throttle stop screw.
5. Idle ports.
6. Idle air bleed.
7. Idle jet.
8. Needle valve and seat.
9. Fuel level.
10. Float assembly.
11. Main metering jet.
12. Main jet adjustment screw.
13. Well air bleed.
14. Idle adjusting needle.
15. Metering well.
16. Drip hole filler.
17. Discharge nozzle.
18. Discharge nozzle bleed holes.

openings when starting the engine. As the engine fires and engine speed increases, a spring-loaded valve in the choke plate opens to let in more air and lean out the "rich" mixture. As the engine gathers speed, the choke valve is manually opened to further "lean" the mixture.

2. REMOVAL

1. Disconnect the fuel pump-to-carburetor tubing from the carburetor.

2. Disconnect the mechanical governor connecting rod from the carburetor.

3. Disconnect the choke control wire.

4. Loosen the hose clamp and disconnect the air cleaner pipe from the carburetor.

5. Remove the retaining nuts and the carburetor from the engine.

3. DISASSEMBLY
(Refer to Illust. 2)

1. Separate the throttle body assembly (13) from the fuel bowl assembly (32).

2. Remove and discard the gasket (27).

Throttle Body.

3. Remove pivot (25) and the float (26). This will also allow the needle (23) to drop free.

4. Remove the float lever pivot support (24).

5. Remove the needle valve cage (22) and gasket (21).

6. Remove the venturi (20).

7. Remove the strainer (17) and gasket (16).

8. Remove the idle adjusting screw (10) and spring (11).

9. Unscrew and remove the idle passage plug (9).

10. Remove the screws (4) fastening the throttle butterfly (5) to the throttle shaft (1).

11. Remove the butterfly (5) and slide the shaft (1) from the throttle body (13).

12. The retainer (6), dust seal (7), bushings (8 and 15) and plug (14) need not be removed unless inspection shows one or all of these parts are unfit for further service.

Fuel Bowl

13. Remove the idle metering jet (28).

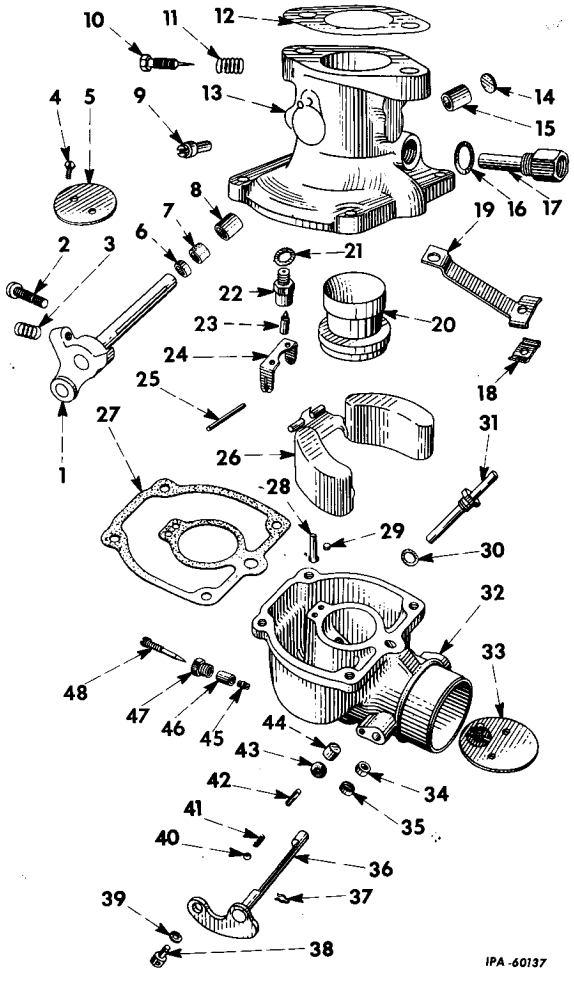
14. Remove the metering nozzle (31) and gasket (30).

15. Loosen the fuel adjusting screw packing nut (47); remove the screw (48) and the packing nut (47).

16. Remove the fuel adjusting screw packing (46).

17. Remove the screw securing the starting shutter (33) to the starting shutter shaft (36).

18. Remove the shutter and slide the shaft (36) from the fuel bowl (32).



Illust. 2 – Exploded View of Carburetor

Legend for Illust. 2 on next page.

3. DISASSEMBLY - Continued
(Refer to Illust. 2)

Legend for Illust. 2

1. Throttle lever and shaft.
2. Adjusting screw.
3. Retainer spring.
4. Throttle plate screw.
5. Throttle plate.
6. Dust seal retainer.
7. Dust seal.
8. Throttle shaft bushing.
9. Idle passage plug.
10. Idle adjusting screw.
11. Retainer spring.
12. Gasket.
13. Throttle body.
14. Expansion plug.
15. Throttle shaft bushing.
16. Screen retainer gasket.
17. Screen retainer.
18. Shutter control clamp.
19. Shutter control bracket.
20. Venturi.
21. Valve gasket.
22. Valve cage.
23. Valve needle.
24. Float lever pivot support.
25. Float lever pivot.
26. Float.
27. Fuel bowl gasket.
28. Idle metering jet.
29. Main air bleed.
30. Nozzle gasket.
31. Metering nozzle.
32. Fuel bowl.
33. Starting shutter.
34. Dust seal.
35. Dust seal retainer.
36. Starting shutter lever and shaft.
37. Swivel retainer.
38. Swivel.
39. Swivel washer.
40. Friction spring ball.
41. Friction spring.
42. Shutter stop pin.
43. Filler plug.
44. Drip hole filler.
45. Adjustment screw seat.
46. Adjustment screw packing.
47. Packing nut.
48. Fuel adjustment screw.

4. INSPECTION AND REPAIR

1. Place all metal parts of the carburetor into a carburetor cleaning solvent to dissolve the gum and varnish-like coatings. The build-up of these coatings in jets and calibrated openings of the carburetor restricts the normal flow of fuel, and must be completely dissolved and removed to restore the original fuel flow characteristics.

2. After the parts have remained in the solvent long enough to dissolve the coatings, remove and rinse in a petroleum base cleaning solvent. Dry all parts with compressed air, blowing through all jets and channels in both directions to assure that they are completely clear and clean.

CAUTION: Do not use drills or wires to clean calibrated openings.

3. Inspect the throttle body and fuel bowl for damage or broken flanges. Check mating surfaces for warpage. Where warpage does not exceed .010 inch, the surface involved may be lapped on a flat surface using No. 00 sandpaper. Clean thoroughly after the sanding operation.

4. Inspect the clearance between the choke shaft and the fuel bowl casting bore and the throttle shaft and throttle body bore. Excessive wear at these points makes it impossible to seal out dirt at the seals. Wear resulting in .007 inch or more clearance on a new choke shaft or .005 inch or more on a new throttle shaft requires that the involved casting be replaced.

5. Inspect the throttle plate for burrs or damaged edges which would prevent good contact with the throttle body bore when fully closed.

NOTE: Never use a buffing wheel or wire brush to clean this plate; its sharp edges must not be deformed.

6. Inspect the float assembly. If the float is filled with fuel or if the float lever axle bearing area is worn excessively, the float must be replaced.

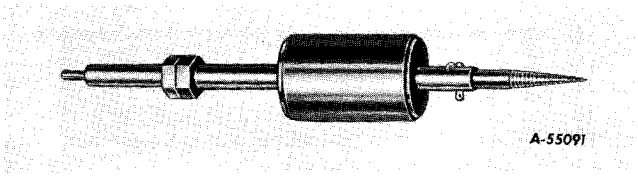
7. Inspect and replace the float axle if any wear can be detected on its bearing surfaces.

8. Inspect the needle valve and seat assembly. If any wear can be seen on either the valve or seat, replace the complete assembly.

9. The idle adjusting needle point must be smooth and free from grooves, caused by being closed forcibly against its seat. Where this condition is found, a new screw should be used.

PRINTED IN UNITED STATES OF AMERICA

10. Inspect the fuel adjusting screw and seat for damage caused by the screw having been forced against its seat. If evidence of this is found on either part, both the screw and seat should be replaced. Use special service tool ST-81 (refer to NOTE) to remove the seat. The opposite end of the special service tool is used to install the new seat. (Illust. 3.) Discard the removed seat, as it is destroyed through removal.



Illust. 3 – Main Adjusting Screw Seat Installing and Removing Tool.

NOTE: The special service tool, ST-81 may be ordered from Sterling Products Company, 121 North Jefferson Street, Chicago 6, Illinois.

11. Inspect the drip hole filler at the bottom of the fuel bowl. Should this filler shrink or deteriorate from age, dirt can be drawn into the engine. Should the filler be painted or otherwise plugged, no drainage is possible. If either of these conditions exist, replace the filler and plug.

5. REASSEMBLY

(Refer to Illust. 2.)

Use all new gaskets when reassembling the carburetor.

Fuel Bowl

1. Install the fuel adjusting screw packing (46), the packing nut (47) and the adjusting screw (48) Turn the screw down carefully until lightly seated, then back out five turns. This position may be changed later to limit the fuel going to the engine for greater economy when the unit is to be used for extended periods under light loads.

2. Install the seal (34) and seal retainer (35) if they were removed.

3. Insert the shaft (36) part way into shaft bore in the fuel body (32). Install the spring (41) and ball (40) into the fuel bowl and push the shaft (36) completely into the body to retain the spring and ball. While holding these parts in this position, install and secure the starting shutter (33). Install the shutter with the valve towards the top.

4. Using a new washer (30), install the metering nozzle (31).

5. If the main air bleed (29) was removed, install a new air bleed.

6. Install the idle metering jet (28). Be certain to avoid damaging the slotted end when installing.

Throttle Body

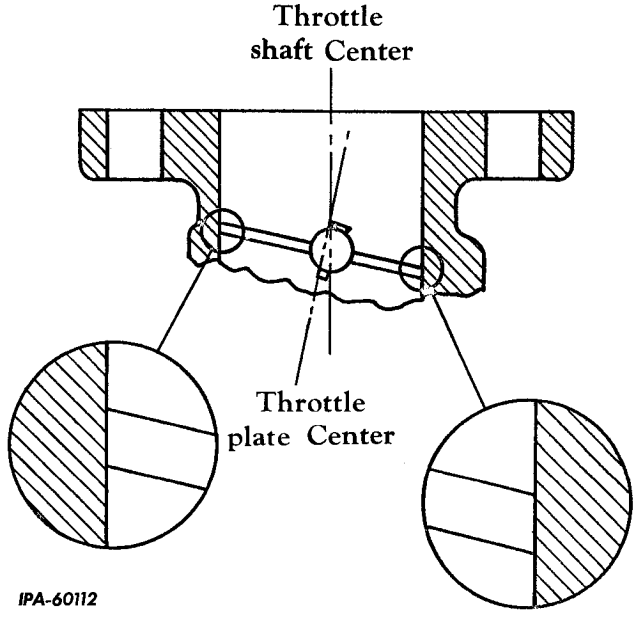
7. Install the bushings (8 and 15) into the body; install the seal (7) and retainer (6) and the plug (14).

8. Insert the throttle shaft (1) into the throttle body (13).

9. Insert the throttle plate (5) into the throttle shaft. Be certain the short end of the plate is down (measured from the off center mounting holes) and that the angle on the edge of the plate (5) corresponds with bore surface of the throttle body. (See Illust. 4.) Insert the screws (4) from the top, but do not tighten until the throttle plate is centered in the body bore in the following manner.

Unscrew the throttle stop screw (2) until the plate (5) is allowed to close fully. Hold the shaft lightly in the closed position, tap lightly on the face of the throttle plate with a brass rod to jar it into a centered position and tighten the screws. The throttle plate must fit the bore closely and the throttle shaft must be perfectly free to turn without binding at any point.

(Continued on next page.)



Illust. 4 – Proper Throttle Plate Installation.

5. REASSEMBLY - Continued
(Refer to Illust. 2.)

Throttle Body - Continued

10. Flatten the exposed end of the throttle plate screws to lock them in place. This can be done by clamping a 1/4-inch square rod vertically in a vise. Locate the throttle body on the rod, through the verturi bore, positioning the end of the rod directly under the exposed side of the screw. A flat punch can then be tapped against the opposite side of the screw. This must be done with care to prevent distortion of the throttle shaft or plate.

11. Install the idle passage plug (9).

12. Install the idle adjusting screw (10) and spring (11). Turn the screw down carefully until lightly seated. Then open the screw one turn.

13. Install the strainer screen retainer (17) and a new gasket (16).

14. Install the venturi (20) into the throttle body (13).

15. Using a new gasket (21), install the needle valve cage (22).

16. Install the float lever pivot support (24).

17. With the throttle housing upside down, place the needle (23), into the needle valve cage (22).

18. Place the float (26) into position and insert the float lever pivot (25) through the float and support.

19. Using a new gasket (27) assemble the throttle body assembly to the fuel bowl assembly. Use care when assembling to prevent damage to the float assembly or the idle jet tube.

20. Secure the throttle body to the fuel bowl and also the shutter control bracket (19) with the four cap screws.

6. INSTALLATION

1. Using a new gasket, secure the carburetor to the intake manifold.

2. Secure the air cleaner pipe to the carburetor.

3. Connect the choke control wire.

4. Secure the mechanical governor connecting rod to the throttle lever.

5. Connect the fuel pump-to-carburetor tubing to the carburetor inlet.

7. ADJUSTMENTS

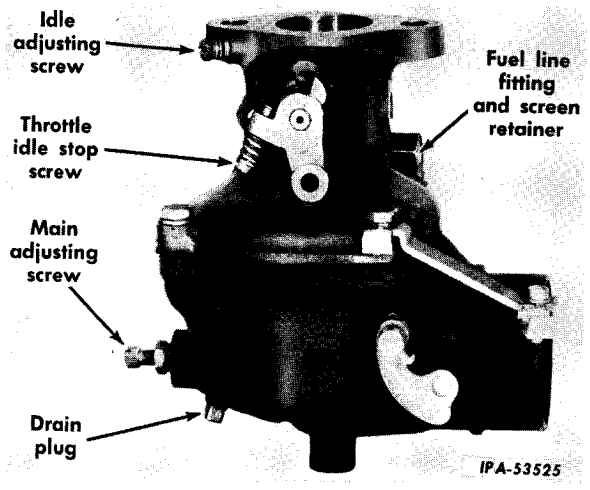
Idle Adjustment

1. Close the idle adjusting screw (Illust. 5) carefully until lightly seated; then open (counter-clockwise) one turn.

2. Operate the engine at fast idle, without load, until operating temperature has been reached.

3. While the engine is running at fast idle, screw in the throttle idle stop screw a few turns to prevent the engine from stopping when the throttle is closed.

4. When the engine is thoroughly warmed, close the throttle by pushing in the engine speed control handle. The engine will then be idling at a fairly high speed and the throttle stop screw should be backed out a little at a time until the desired idle speed is obtained.



Illust. 5 – Carburetor Adjustment Locations

5. If the engine misses or rolls while backing out the throttle idle stop screw, the idle adjusting screw may be adjusted either in or out until the engine operates smoothly.

NOTE: Turning the adjusting screw clockwise makes the idle mixture leaner. After each adjustment, speed up the engine for a few seconds; then recheck the idle adjustment.

Main Fuel Adjustment.

The carburetor is equipped with a main fuel adjustment screw which can be used to reduce the

amount of fuel going into the engine when operating under light load conditions. However, when heavy work is to be performed where the full power of the engine is required, the fuel adjusting screw should be set five full turns off its seat. The fuel adjusting screw seat is calibrated to provide a full power mixture and should not be restricted by use of the adjusting needle when the full power of the engine is required. Be certain the main jet adjusting screw is not loose. If necessary, tighten the adjusting screw packing nut securely.

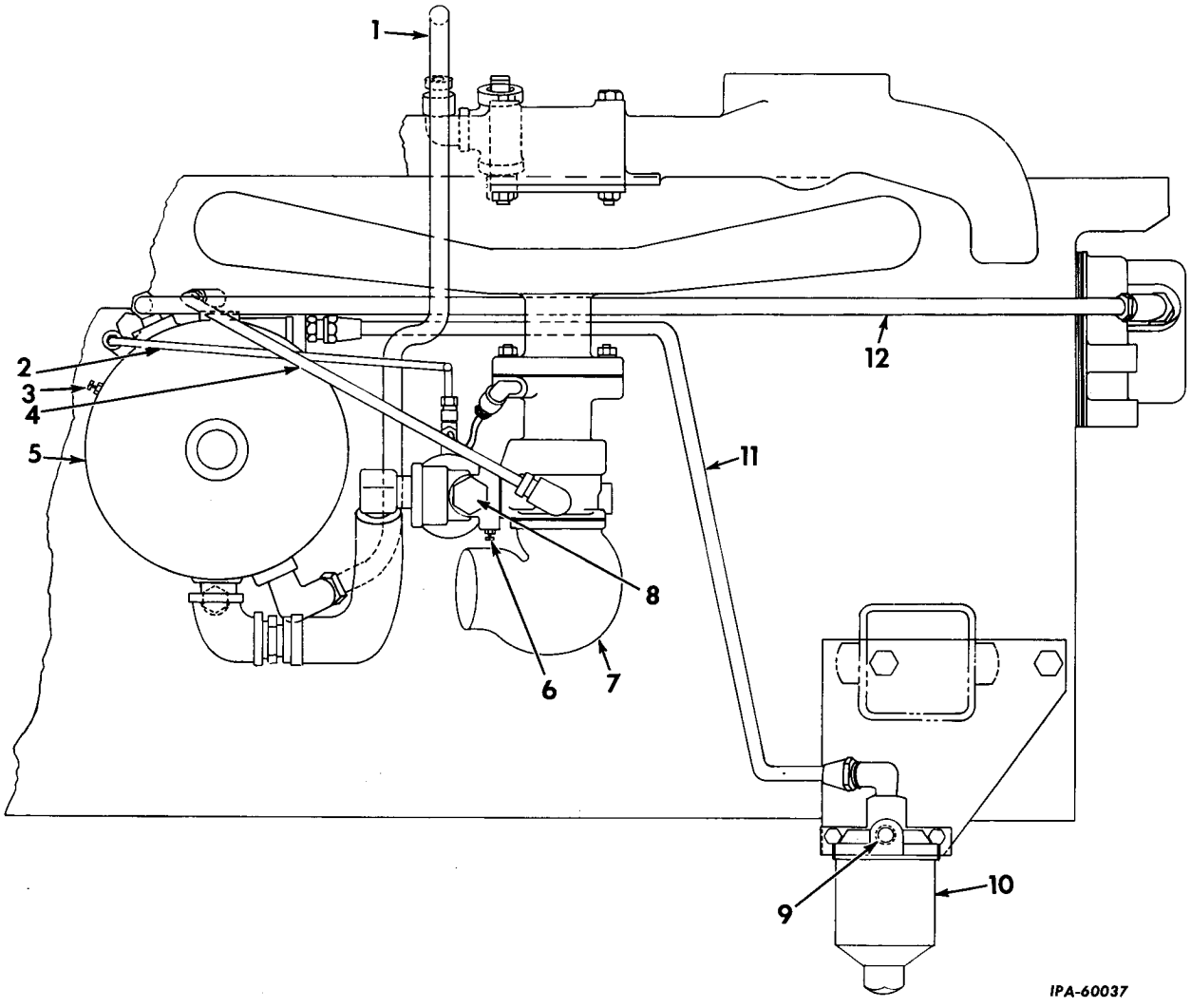
PRINTED IN UNITED STATES OF AMERICA

1. DESCRIPTION

The three main fuel system components of liquefied petroleum gas burning engines are the liquid LP gas filter, the converter or gas regulator and the carburetor.

The flow of fuel from the tank to the engine is as follows (refer to Illust. 1): The LPG liquid fuel flows from the tank to the liquid LP gas filter and then through the filter outlet fuel line to the inlet side of the converter or gas regulator. In the converter, the liquid becomes a vapor and then leaves the outlet side of the converter and flows to the carburetor through the flexible fuel line. In the carburetor, the gaseous fuel becomes mixed with air in the correct proportions for maximum engine efficiency.

(Continued on next page.)



Illust. 1 - Schematic View of Engine Equipped with LPG.

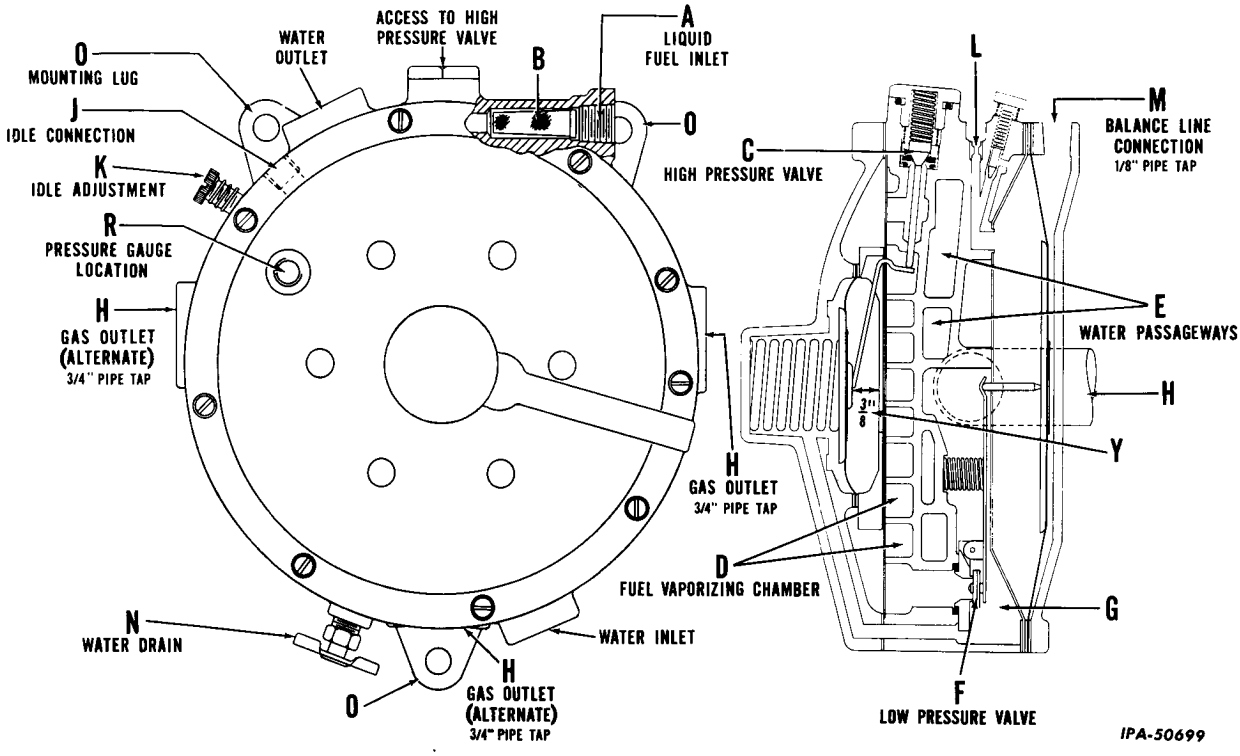
1. Water inlet tube.
2. Idle tube.
3. Idle adjusting screw.
4. Balance tube.
5. Regulator assembly.
6. Starting adjusting screw.
7. Carburetor assembly.
8. Load adjusting screw.
9. LPG inlet from fuel tank.
10. Filter assembly.
11. Filter to regulator tube.
12. Water outlet tube.

1. DESCRIPTION Continued

Operation of Ensign Model "NS" LP - Gas Regulator. (Refer to Illust. 2.)

Liquid LP gas enters the regulating unit at "A," passes through strainer "B" and is reduced from tank pressure to approximately 9-11 psi at the high pressure reducing valve "C." Fuel passing through valve "C" expands very rapidly into the vaporizing chamber "D." Within this vaporizing chamber the fuel is converted from a liquid to a gas. Vaporization comes from the temperature differential between the expanding fuel and the castings surrounding the expansion chamber. The heat for continuous vaporization is supplied from the engine's cooling water system and is jacketed through water passageways "E." The vaporized gas then passes through low pressure reducing valve "F" and into low pressure chamber "G" where it is drawn off through gas outlet "H" to the carburetor. At the carburetor, the gas is mixed with air in correct proportions for ideal engine combustion.

Fuel for idling is taken from the regulator at "J" which is connected by tubing to the idle connection on the carburetor. Idle fuel adjusting screw "K" and orifice "L" control the flow of fuel for idling. The balance line connection "M" is connected with tubing to the carburetor. This balance line communicates air horn depression to the atmospheric side of the low pressure diaphragm of the regulator, thereby automatically balancing the air fuel system for variation in air cleaner and other air entrance losses. Both high and low pressure valves "C" and "F" are actuated by conventional diaphragm and spring mechanisms and are designed to result in a smooth and sensitive response to the gas flow demands of the engine.



Illust. 2 - Model "NS" LP - Gas Regulator.

Operation of Ensign 1-1/4" 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 operation. A fixed bleed screw controls the flow of fuel through the economizer.

When the engine manifold vacuum is reduced from four to six inches 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 diaphragm.

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.

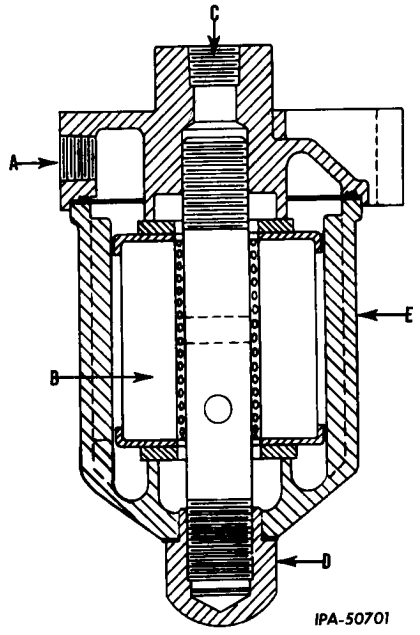
The flow of gas from the gas regulator to the carburetor is regulated by the main gas load adjusting screw, located on the carburetor. The idle adjustment screw is located on the gas regulator. (Refer to Par. 14, "ADJUSTMENTS" for adjusting screw settings.)

Operation of Ensign Liquid LP - Gas Filter (Refer to Illust. 3.)

The liquid LP gas filter is located between the fuel supply tank and the gas regulator. Its purpose is to stop the passage of scale, rust or other foreign matter that may be carried by the liquid fuel, as it flows from the tank. The filter catches and retains in its settling bowl any solid particles coming through with the liquid fuel.

The liquid fuel from the tank enters at "A" and flows down, around and through the filter element "B," up through the center tube and out outlet "C" to the gas regulator.

When a thorough cleaning or replacement of parts is necessary, the filter may be disassembled by removing nut (D) and filter case (E)



Illust. 3 - Sectional View of LP - Gas Filter.

which enables the filter element (B) to be removed. The filter element should be handled so as not to crush or crack the sides of the element. New gaskets should be installed each time the filter is disassembled for cleaning or repair to prevent leaks at these points.

2. SAFETY PRECAUTIONS

Safety precautions in the handling of LPG (liquefied petroleum gas) cannot be over-emphasized. There are state, county or city laws, ordinances and fire regulations covering the utilization of liquefied petroleum gas. Such laws, ordinances and fire regulations on this subject must be adhered to in addition to the safety rules given below.

Where local rules are more stringent than those given, the local rules are to be given priority.

These rules apply to servicing any engine using liquefied petroleum 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 dip tanks and other devices operating with open flame.

(Continued on next page.)

2. SAFETY PRECAUTIONS – Continued

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. Drain the fuel system of liquefied petroleum gas outside the building before moving the unit into the shop.

4. "WARNING" signs should be placed on both sides 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 glames 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. When liquefied petroleum gas ignites, it should be allowed to burn, if possible, until the source of fuel is shut off. Extinguishing the fire before this is accomplished can result in dangerous accumulations of gas which might cause a more serious flash or explosion.

6. After completing service work and before starting the engine, allow air to circulate around the engine to remove any possible gas accumulation.

7. Never use liquefied petroleum gas from the fuel tanks for cleaning parts.

NOTE: This is mentioned because inspections have revealed that operators have used it as a substitute for solvents and compressed air not realizing the extreme danger of this practice.

8. 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 sealer. Replace worn or defective fittings.

(b) After connecting the fuel system, check it for leaks. Leaks are not permissible. Odorants, which are strong smelling compounds having an odor similar to spoiled cabbage, are added to liquefied petroleum gas as warning agents to indicate leakage of even small quantities of gas.

(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.

9. No work whatever is to be performed on liquefied petroleum gas 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 any repairs are made.

10. It is important to remember that all liquefied petroleum gas systems are pressurized. Be certain that the tank valves are tightly closed and all fuel has been exhausted from the lines before starting any repair work on the fuel system.

LP - GAS REGULATOR (ENSIGN MODEL "NS")

3. REMOVAL

1. Close the fuel supply valve at the LP gas tank.

2. Drain the coolant from the radiator and engine block.

3. Disconnect the regulator water inlet and outlet lines at the regulator.

4. Disconnect the idle tube, balance tube, fuel inlet line (from filter) and fuel outlet line (to carburetor) at the regulator.

5. Remove the three cap screws, nuts and washers securing the regulator to the mounting bracket.

4. DISASSEMBLY (Reference numbers refer to Illust. 4.)

1. Remove the screws (1) securing the vaporizer cover assembly (3) to the body (31). Remove the high pressure spring (4), diaphragm (5) and cover (6) from the vaporizer cover (3).

2. Remove the three screws (9) and separate the partition plate (10) and valve lever (11) from the body (31).

3. Remove support plate (38) and lift off low pressure diaphragm and push pin assembly (37), partition plate (35) and gasket (34).

4. Remove the valve lever (23), spring (24) and seat (26).

PRINTED IN UNITED STATES OF AMERICA

LP - GAS REGULATOR (ENSIGN MODEL "NS")

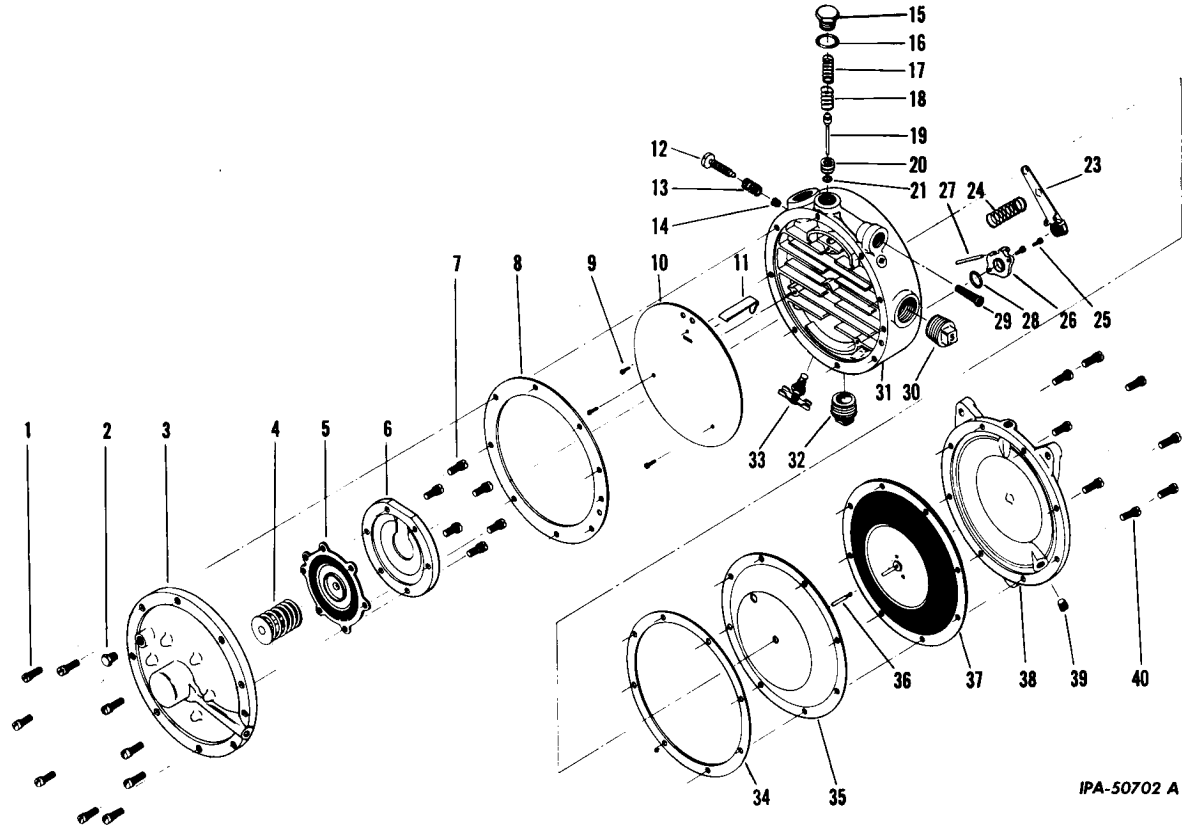
5. Remove the high pressure valve spring retainer (15) with gasket (16). Lift out valve spring (17), valve seat retainer spring (18), valve (19), valve seat (20) and seal (21).

6. Remove idle adjusting screw (12), spring (13) and bleed screw (14). Also remove fuel inlet strainer assembly (29).

5. INSPECTION AND REPAIR
(Reference numbers refer to Illust. 4.)

1. Wash all metal parts in a cleaning solvent and blow out all passageways with compressed air.

(Continued on next page.)



Illust. 4 - Exploded View of LP - Gas Regulator (Ensign Model "NS").

1. Screw
2. Pipe plug.
3. Vaporizer cover.
4. High pressure spring.
5. High pressure diaphragm.
6. High pressure diaphragm cover.
7. Screw.
8. Gasket.
9. Screw.
10. Vaporizer partition plate.
11. High pressure valve lever.
12. Idle adjusting screw.
13. Idle adjusting screw retainer spring.
14. Bleed screw.
15. High pressure valve spring retainer.
16. Gasket.
17. High pressure valve spring.
18. High pressure valve seat retainer spring.
19. High pressure valve.
20. High pressure valve seat.
21. High pressure valve seal.
23. Low pressure valve lever.
24. Low pressure valve spring.
25. Screw.
26. Low pressure valve seat.
27. Pivot pin.
28. Low pressure valve seal.
29. Fuel inlet strainer.
30. Pipe plug.
31. Regulator body.
32. Pipe plug.
33. Drain valve.
34. Gasket.
35. Low pressure partition plate.
36. Push pin.
37. Low pressure diaphragm.
38. Support plate.
39. Pipe plug.
40. Screw.

LP - GAS REGULATOR (ENSIGN MODEL "NS")

5. INSPECTION AND REPAIR - Continued
(Reference numbers refer to Illust. 4.)

2. Inspect the high pressure valve seat (20) and seal (21) for nicks or excessive wear. Replace if necessary.

3. Inspect the high and low pressure diaphragm (5 and 37) for stiffness or ruptures. Replace if either of these conditions are found.

4. Inspect the water passageways in the body (31) to be sure that they are open and are free of excessive scale or rust.

5. Inspect all remaining parts carefully and replace any that show signs of wear. New gaskets should be installed where needed.

6. REASSEMBLY (Reference numbers refer to Illust. 4.)

1. Install idle adjusting screw (12), spring (13) and bleed screw (14). Also install fuel inlet strainer assembly (29).

2. Be certain that the high pressure valve seal seat (Illust. 5) is perfectly clean. Install seal (21), valve seat (20), valve (19), valve seat retainer spring (18) and valve spring (17). Install and tighten high pressure valve spring retainer (15) with gasket (16).

3. Install the low pressure valve seat (26), spring (24) and valve lever (23).

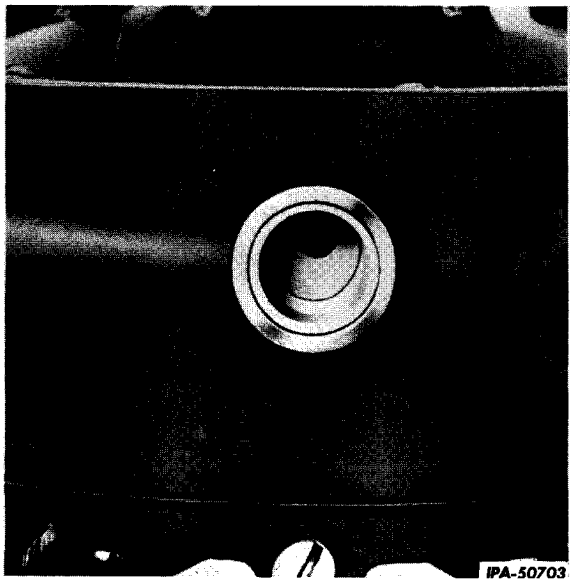
NOTE: A post or boss (T, Illust. 6) is machined and marked with an arrow for the purpose of setting the low pressure valve lever. The valve lever should be centered on the arrow as the screws are tightened. The height of the lever should then be set to the boss height, bending the lever if necessary.

4. Install gasket (34), partition plate (35), low pressure diaphragm and push pin assembly (37), and support plate (38). Secure with eight screws and lock washers (40).

5. Insert high pressure valve lever (11) into the slot in partition plate (10) from the rear. Install partition plate (10) to the body (31), being sure the valve lever contacts the high pressure valve (Illust. 2), and secure with three screws (9).

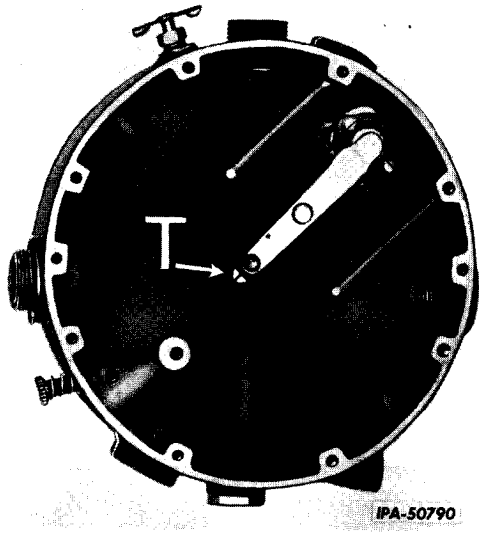
NOTE: The high pressure lever height should be approximately 3/8 inch from the top of the lever to the top of the partition plate ("Y," Illust. 2). The high pressure lever and valve parts are pre-set and therefore interchangeable without adjustment.

6. Install the high pressure spring (4), diaphragm (5) and cover (6) in the vaporizer cover (3) and secure with screws (7).



Illust. 5 - High Pressure Valve Seal Seat.

7. Using a new gasket (8), secure the vaporizer cover assembly (3) to the body (31) with screws (1).



Illust. 6 - Low Pressure Valve Lever Centering Arrow.

7. TESTING ENSIGN MODEL "NS" 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 Com-

LP - GAS REGULATOR (ENSIGN MODEL "NS")

pany. 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.

8. INSTALLATION

Installation of the regulator is the reverse of the removal procedure, outlined in par. 3. Adjust the regulator as outlined in par. 14.

CARBURETOR (ENSIGN 1-1/4" XG)

9. REMOVAL (Refer to Illust. 1.)

1. Disconnect the idle tube, balance tube and fuel inlet line at the carburetor.

2. Disconnect the choke control wire and the throttle control wire.

3. Remove the 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.

10. DISASSEMBLY (Reference numbers refer to Illust. 7.)

1. Remove the air cleaner elbow (35) and gasket (34).

2. Remove the gas inlet and economizer body (12) from the carburetor body (19). Remove the fuel adjusting screw (8), lock nut (6), starting adjusting screw (9), lock nut (11) and bleed screw (5) from the body (10).

3. Remove the economizer cover (1) and spring (2). Remove the diaphragm assembly (4).

4. Remove two screws (28) and lift out choke disc (26) from choke shaft (27). Remove valve lever pin (25) and lift off valve lever washer (39), spring washer (38) and valve lever (37).

5. Remove set screw (32) and pull choke lever (31) off choke shaft (27). Remove choke tube support screws and choke tube support (29). Pull choke shaft (27) out of carburetor body (19). Remove Pitot tube bleed screw (7) (natural gas engine only).

6. Remove venturi set screw and remove venturi (33) from the carburetor body (19).

7. Remove two screws (22) and lift out throttle disc (23) from throttle shaft (21). Remove the set screw and throttle shaft plug (17). Pull throttle shaft with throttle stop and throttle lever (21) out of throttle body (19).

8. Remove dust seals (20) and press out throttle bearing bushings (18), if necessary.

11. INSPECTION AND REPAIR

1. Wash all metal parts in a cleaning solvent and dry thoroughly with compressed air.

2. Inspect the economizer diaphragm (3) for stiffness or ruptures. Replace if either of these conditions are found.

3. Inspect the throttle shaft (21) and throttle bearing bushings for excessive wear. Replace if necessary.

4. Be sure all passages are open. Also check the small hole in the Pitot tube bleed screw (7) to be sure it is open.

5. Carefully check the vacuum control connections to the economizer for air leaks.

12. REASSEMBLY

1. Install the throttle bearing bushings (18) if they were removed.

2. Place one dust seal (20) on the throttle shaft (21), and install the throttle shaft with throttle lever and throttle stop into the throttle tube. Place the other dust seal (20) on the throttle shaft and install the throttle shaft plug (17). Lock the collar on the shaft.

3. Install the throttle disc (23) and secure with screws (22).

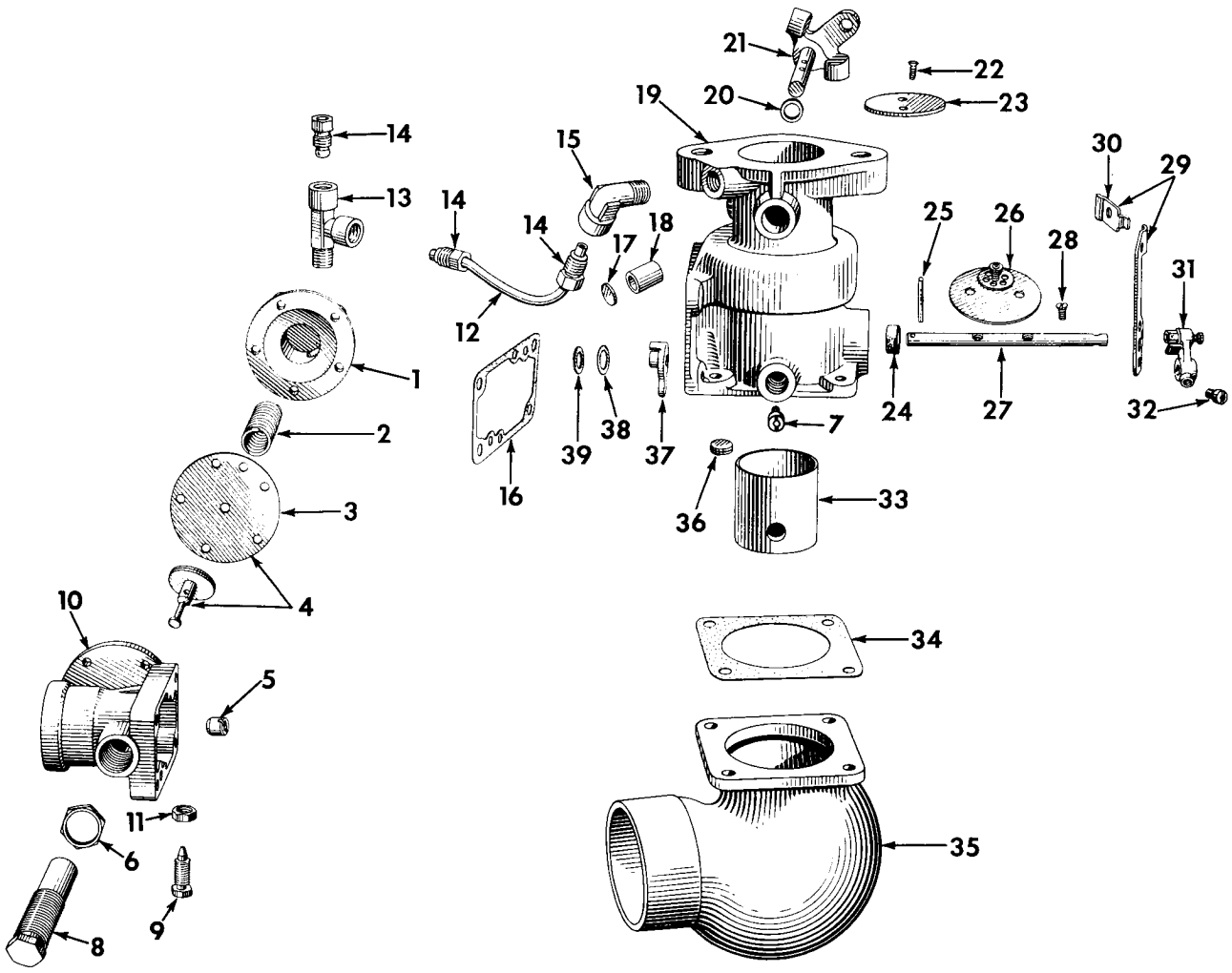
4. Place the venturi (33) in the carburetor body (19) and lock in place with venturi set screw.

5. Install Pitot tube bleed screw (7) in carburetor body (19) (natural gas engine only). Install the choke shaft (27) into the carburetor body. Place the choke tube support (29) over the choke shaft and secure with screws. Install the choke lever (31) onto the choke shaft and secure with set screw (32).

6. Install valve lever (37), spring washer (38), valve lever washer (39) and valve lever pin (25). Install the choke disc (26) and secure with screws (28).

Continued on page 9.

CARBURETOR (ENSIGN 1-1/4" XG)



Illust. 7 - Exploded View of LPG Carburetor (Ensign 1-1/4" XG)

1. Economizer cover.
2. Economizer spring.
3. Economizer diaphragm.
4. Diaphragm assembly.
5. Bleed screw.
6. Lock nut.
7. Pitot tube bleed screw.
8. Fuel adjusting screw.
9. Starting adjusting screw.
10. Gas inlet and economizer body.
11. Lock nut.
12. Tube.
13. Tee.
14. Nut.
15. Elbow.
16. Gasket.
17. Throttle shaft plug.
18. Throttle bearing bushing.
19. Carburetor body.
20. Dust seal.
21. Throttle shaft.
22. Screw.
23. Throttle disc.
24. Dust washer.
25. Valve lever pin.
26. Choke disc.
27. Choke shaft.
28. Screw.
29. Choke tube support.
30. Choke tube clamp.
31. Choke lever.
32. Set screw.
33. Venturi.
34. Gasket.
35. Air cleaner elbow.
36. Plug.
37. Valve lever.
38. Spring washer.
39. Valve lever washer.

PRINTED IN UNITED STATES OF AMERICA

CARBURETOR (ENSIGN 1-1/4" XG)

7. Install the diaphragm assembly (4), spring (2) and economizer cover (1) to the gas inlet and economizer body (10) with screws.

8. Install bleed screw (5), starting adjusting screw (9) with lock nut (11) and fuel adjusting screw (8) with lock nut (6) into the gas inlet and economizer body (10).

9. Using a new gasket (16) attach the gas inlet and economizer body (10) to the carburetor body (19) with screws. Place a new gasket (34) on the carburetor body (19) and attach the air cleaner elbow with cap screws.

13. INSTALLATION

Installation of the carburetor is the reverse of the removal procedure outlined in par. 9. Adjust the carburetor as outlined in par. 14.

14. ADJUSTMENTS

Regulator (Ensign Model "NS") and Carburetor (Ensign 1-1/4" XG)

The instructions outlined below cover the adjustments required on a rebuilt regulator and/or carburetor before and after the engine is started.

1. Open the fuel supply valve at the fuel tank.

2. Before starting, open the idle adjusting screw on the regulator 1-1/2 turns.

3. Open the load adjusting screw 4 turns.

4. Open the carburetor starting adjusting screw 1-1/4 turns.

NOTE: All three adjusting screws 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 1/3 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 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 liquefied petroleum gas burning engines.

PRINTED IN UNITED STATES OF AMERICA

1. DESCRIPTION

The two main fuel system components of natural gas burning engines are the gas regulator and carburetor.

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.

A gas idle adjusting screw is located on the regulator. It controls the idle fuel entering the carburetor. A gas load adjusting screw is located on the carburetor. It regulates the main gas flow from the regulator to the carburetor. (Refer to Par. 11, "ADJUSTMENTS" for adjusting screw settings.)

The gas balance tube connects the carburetor intake with the gas regulator. This balance tube communicates any air fluctuations in the carburetor air horn to a diaphragm in the top of the regulator. This automatically regulates the flow of gas in correct proportion to the air flow through the air cleaner. The breather expels or supplies the air for this balance line.

The carburetor is used to mix,accurately,the correct proportion of fuel with air to satisfy every speed and load demand of the engine. The fuel is controlled by the starting and load adjustments plus the suction existing at the venturi, depending upon engine speed and load.

The carburetor is equipped with a choke which provides the correct fuel-air mixture whenever the choke is completely closed during starting. There is no intermediate position for the choke. It should be completely closed whenever a start is attempted.

NOTE: For additional information on the Ensign 1-1/4" XG carburetor, refer to Section 9A, "Carburetor and Regulator (LPG)."

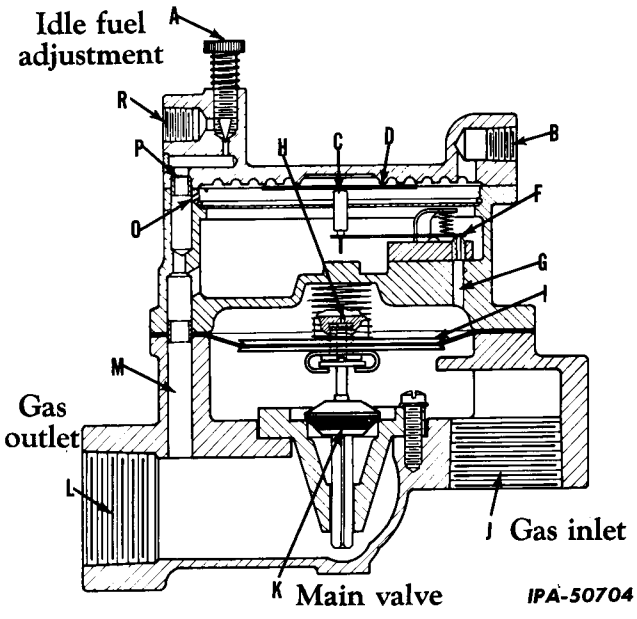
Operation of Ensign Model "B" Gas Regulator (Refer to Illust. 1)

With the engine stopped, the main valve "K" 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 side of 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 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,

(Continued on next page.)



Illust. 1 - Sectional View of Ensign Model "B" Gas Regulator.

1. DESCRIPTION - Continued

permitting "F" and "K" to close and completely shut off the supply of gas to the engine.

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 this 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 dip tanks and any other device operating with 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 wateful. 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 any 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 Par. 8. 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:

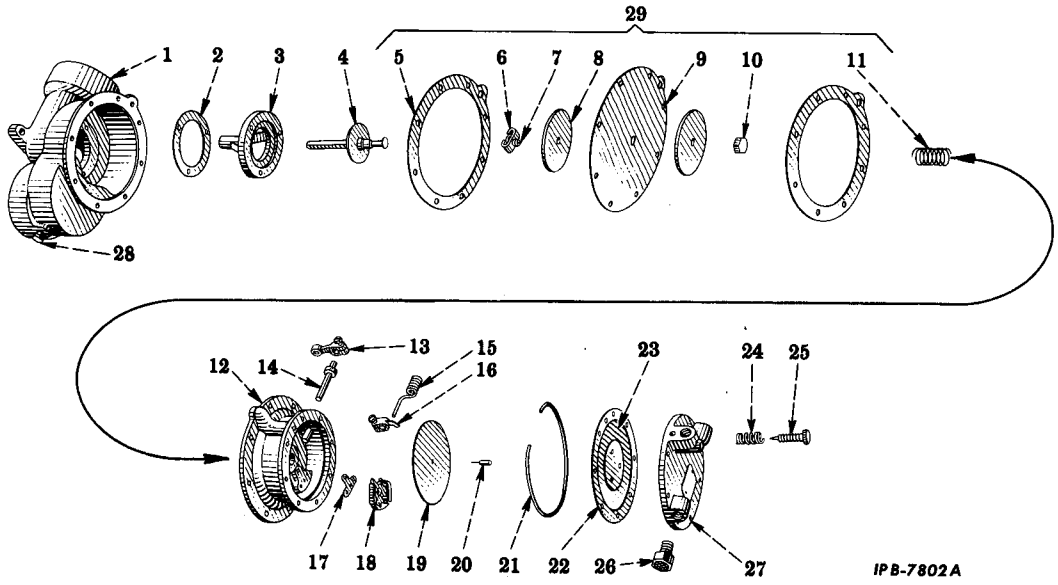
3. SERVICING THE ENSIGN MODEL "B" GAS REGULATOR - Continued

1. Close off the fuel supply and remove the pipe plug near the inlet. 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 four to six 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. 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.



Illust. 2 - 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. Upper diaphragm.
24. Spring.
25. Idle adjusting screw.
26. Breather.
27. Bowl cover.
28. Pipe plug.
29. Lower diaphragm assembly.

4. REMOVAL

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 cap screws securing the regulator to the mounting bracket and lift off the regulator.

5. DISASSEMBLY (Refer to Illust. 2)

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).

6. INSPECTION AND REPAIR (Refer to Illust . 2)

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.

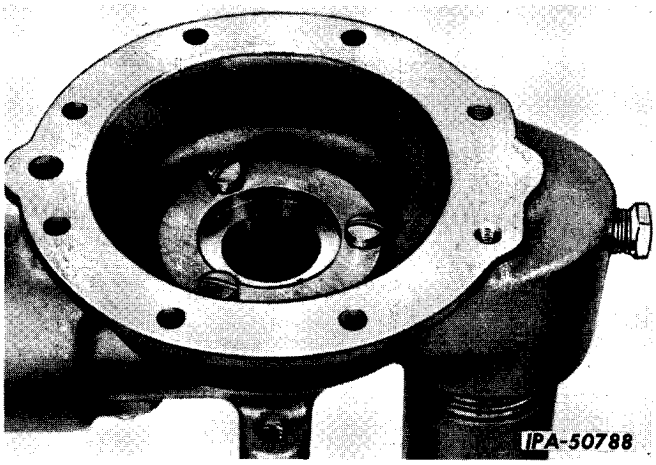
4. Inspect the upper and lower diaphragm (23 and 9) for stiffness or ruptures. Replace if either of these conditions are found.

5. Be 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. REASSEMBLY (Refer to Illust. 2)

1. Using a new gasket, install the valve seat in the body (Illust. 3). Install the main valve (4) into the seat (3).



Illust. 3 - Main Valve Seat Assembled.

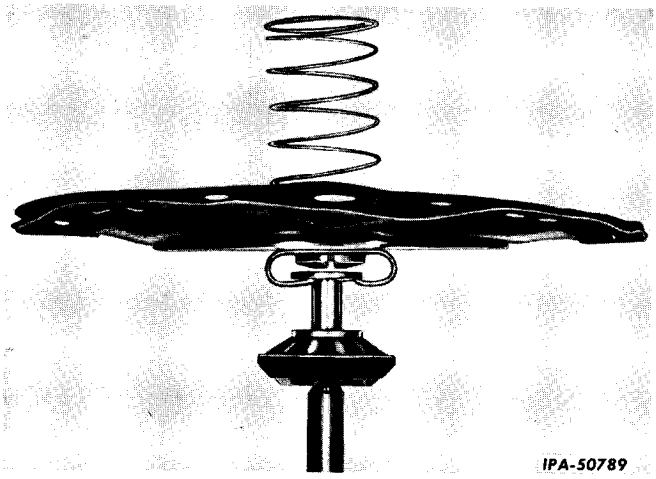
2. Place the lower diaphragm assembly (29) in position on the body with the diaphragm screw head plate (6) engaged with the head of the main valve (Illust. 4).

3. Place the diaphragm spring (11) in position over diaphragm screw nut (10). Install the bowl (12) to the body (Illust. 5) and secure with screws.

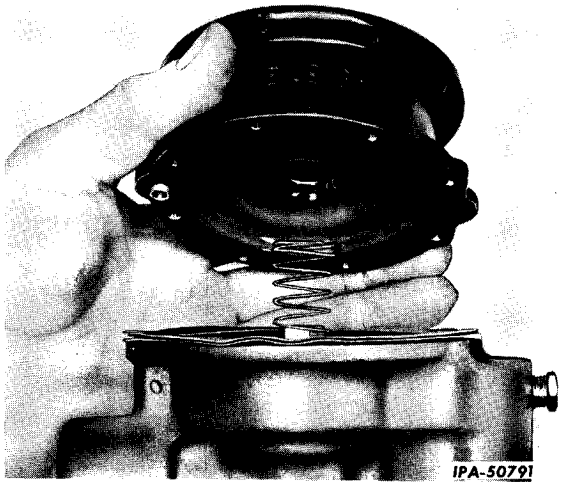
4. Using a new gasket install pilot valve (18).

NOTE: If a test stand is available, check the pilot valve for leakage, also refer to Par. 8.

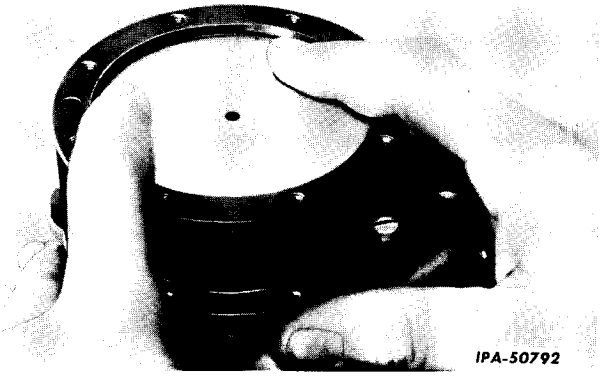
5. Install the primer control shaft (14) and primer lever (13) into the bowl (12). Install the primer stop lever (16) and primer spring (15) onto the control shaft (14).



Illust. 4 - Diaphragm Engaged with Main Valve.



Illust. 5 - Installing Bowl.

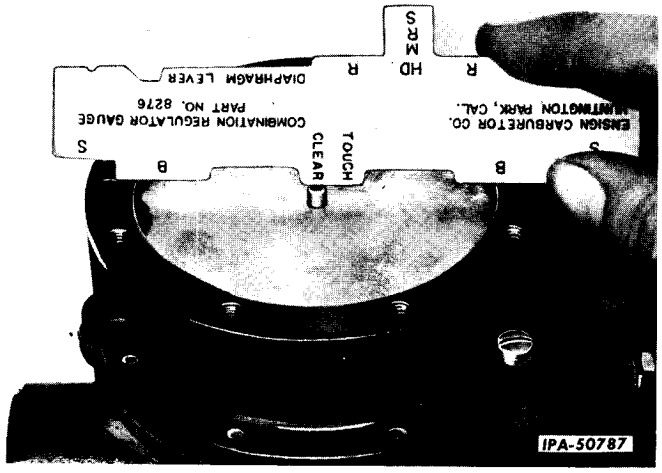


Illust. 6 - Installing Partition Plate.

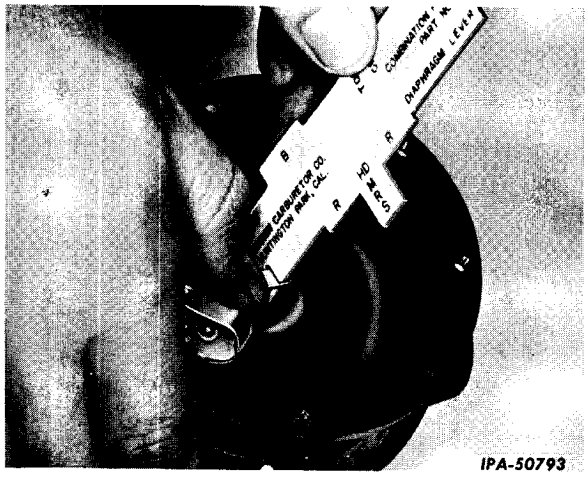
6. Place partition plate (19) into the bowl and check to see that it floats freely (Illust. 6). Install locking wire (21).

7. Install pilot valve pin (20) into partition plate (19) being 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 7), the pilot valve pin should not touch the "clear" position on the gauge but must touch the "touch" position.



Illust. 7 - Checking Height of Pilot Valve Pin.



Illust. 8 - Adjusting Height of Pilot Valve Pin.

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

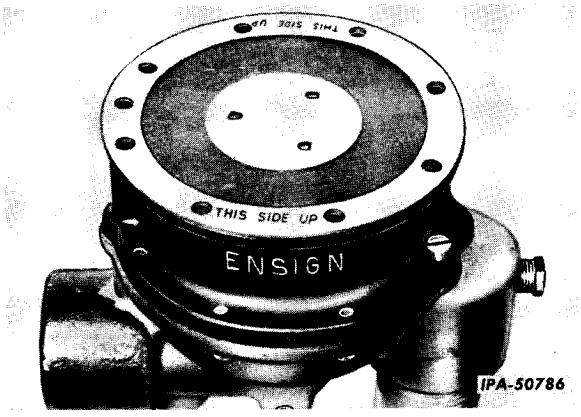
(Continued on next page.)

7. REASSEMBLY - Continued

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 (Illust. 8). 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.

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 (Illust. 9). Be sure that a cover gasket (22) is on each side of the diaphragm. Install cover (27) and secure with screws.



Illust. 9 - Upper Diaphragm Installed.

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 regulator is the reversal of the removal procedure outlined in Par. 4. Adjust the regulator as outlined in Par. 11.

10. REMOVAL

1. Disconnect the idle tube, balance tube and fuel line at the carburetor.

2. Disconnect the choke control wire and the throttle control wire from the carburetor.

3. Remove the 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.

NOTE: The natural gas carburetor is identical to the LPG (Liquefied Petroleum Gas) carburetor. Refer to Section 9A, "CARBURETOR AND REGULATOR (LPG)" for disassembly, inspection and repair and reassembly procedure.

11. ADJUSTMENTS

Regulator (Ensign Model "B") and Carburetor (Ensign 1/4"XG)

The instructions outlined below cover the adjustments required on a rebuilt regulator and/or carburetor before and after the engine is started.

1. Open the fuel supply valve at the fuel tank.

2. Before starting, open the idle adjusting screw on the regulator two turns.

3. Open the load adjusting screw one and one-half turns.

4. Open the carburetor starting adjusting screw one and one-half turns.

NOTE: All three adjusting screws 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

PRINTED IN UNITED STATES OF AMERICA

11. ADJUSTMENTS - Continued

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 one-quarter turn. These adjustments will give the best performance with 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.

PRINTED IN UNITED STATES OF AMERICA

1. DESCRIPTION

The turbocharger is designed to increase diesel engine power output by supplying compressed inlet air to the engine. The unit consists essentially of a single stage centrifugal compressor mounted on a common shaft with a single stage radial inflow turbine, a one-piece main housing, a turbine housing and a compressor housing.

The turbine wheel which drives the compressor impeller during operation, is driven by engine exhaust gases.

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 foregin 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 should not be rigidly attached to the turbocharger. They should be supported by the hood. The exhaust stack 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 in storage for 30 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. It is recommended that after an engine or turbocharger overhaul, an oil inlet screen be installed for the first 5 to 25 hours of operation and then removed. If engine oil becomes contaminated by water the turbocharger must be drained to prevent sludge formation.

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 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.

9. During normal operation the turbocharger should be free from vibration or unusual noises.

10. Cap screws, hold down nuts, air connections, and oil connections to and from the turbocharger should be checked for tightness at periodic intervals. Retorque after initial warm-up following assembly of these parts. General condition of hoses and oil lines should be noted.

11. The exhaust stack should be covered to prevent water from entering and damaging turbine during shut down periods.

12. Periodic inspection of the compressor wheel should be made to check for soft carbon deposits, damaged blading, interference, or excessive end play.

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 lubrication oil. The machines must not be placed under load until normal oil pressure is reached.

14. It is important that the engine be operated at one-half throttle (no load) for three to five minutes before final shut-down after operating under load. This will aid in the cooling off of both the engine and turbocharger, thus minimizing the possibility of damage.

15. It is advisable to allow exhaust manifolds to cool before removing from engine. This will prevent warping.

3. REMOVAL

1. Remove the cap screws securing the exhaust pipe elbow to the brace and remove the elbow and sleeve.

2. Loosen the clamp and separate the air cleaner-to-compressor housing duct hose at the turbocharger end. Plug or cap all openings to protect against the entrance of dirt.

3. Loosen the clamp and separate the compressor housing-to-intake manifold duct hose at the turbocharger end. Plug or cap all openings to protect against the entrance of dirt.

4. Remove the oil inlet and outlet hoses.

5. Remove the cap screws securing the turbocharger to the exhaust manifold and remove the turbocharger and gasket.

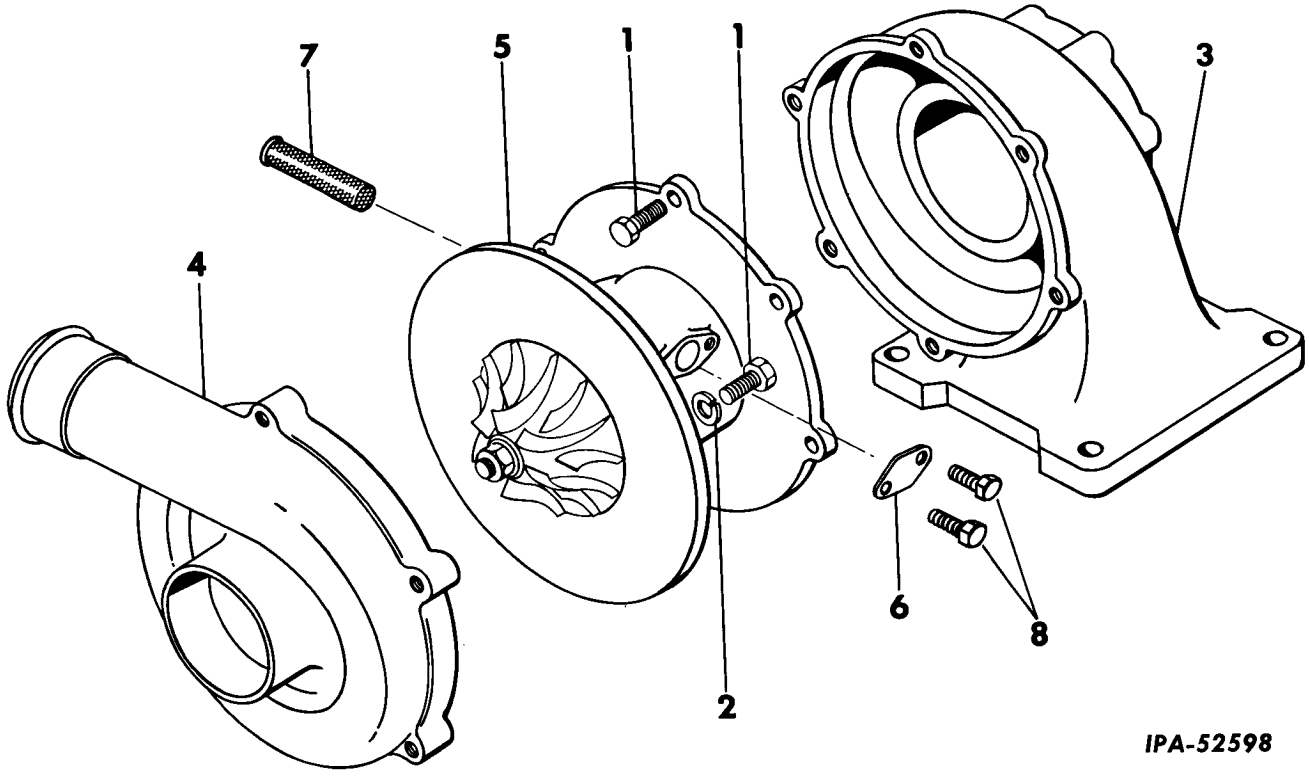
6. For servicing information on the Airsearch turbochargers, refer to service manual ISS-1047, "Turbochargers for International Diesel Engines."

4. INSTALLATION

1. Inspect the air intake system for loose bolts, nuts or any foreign material.

2. Inspect the exhaust manifold for fins or projections which may become loose, and for pieces of gasket 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. Inspect the oil supply line for dirt, clogging or deterioration.



Illust. 1 - Exploded View of Turbocharger.

1. Cap screw.
2. Lock washer.
3. Turbine housing.
4. Compressor housing.
5. Center housing and rotating assembly.
6. Plate.
7. Oil inlet screen.
8. Cap screw.

PRINTED IN UNITED STATES OF AMERICA

4. Inspect the turbocharger mounting pad on the manifold for flatness. Be sure that 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. Install the turbocharger onto the exhaust manifold using a new gasket.

7. Apply "NEVER-SEEZ" compound or a similar compound to the manifold stud nuts and install the four nuts that secure the turbocharger to the manifold.

8. Install the oil inlet and outlet hoses.

9. Install the exhaust pipe elbow brace to the engine.

10. Connect the air cleaner-to-compressor housing duct hose and secure with the clamps.

11. Install the compressor housing-to-intake manifold duct hose and secure with the clamps.

12. Before starting the engine, disconnect the turbocharger oil inlet pipe at the turbocharger end. Using an oil squirt can, put three or four ounces of oil (same type and grade as used in the crankcase) into the oil inlet hole of the turbocharger. This will provide sufficient lubrication for the turbocharger bearings until normal engine lubricating oil pressure is established. Connect the oil inlet pipe.

NOTE: If the engine was overhauled, install an oil inlet screen for the first 5 to 25 hours of operation and then remove it.

13. Start the engine and operate at a low idle, and allow the engine and turbocharger to operate for a short period of time.

14. 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.

15. Retighten the cap screws, hold-down nuts, air connections and oil connections to and from the turbocharger after the initial warm-up.

PRINTED IN UNITED STATES OF AMERICA

FUEL PUMP

1. DESCRIPTION

The fuel pump is installed on the engine between the fuel tank and the carburetor. The suction side of the pump is connected to the fuel tank and the discharge side to the carburetor. The purpose of the pump is to suck fuel from the supply tank and push it into the carburetor float bowl as it is required by the engine.

The pumping operation is accomplished through the cam lever on the pump, contacting an eccentric on the engine camshaft.

2. REMOVAL

1. Disconnect the fuel inlet pipe from the pump.

2. Disconnect the fuel pump-to-carburetor pipe, from the fuel pump.

3. Remove the two cap screws securing the pump to the engine.

3. DISASSEMBLY (Refer to Illust. 1)

1. Loosen the hex head screw on the filter bowl retainer (12) and remove the retainer, filter bowl (11), gasket (14) and ceramic filter (10).

2. Use pliers and remove the cam lever return spring (13).

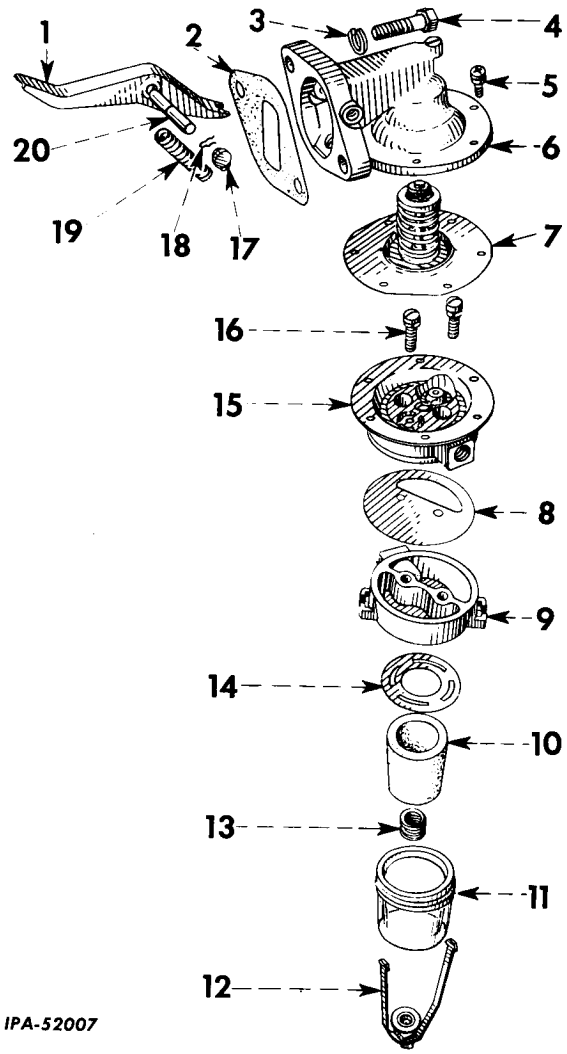
3. Pry out the cam lever shaft seal plug (17) and also remove the shaft retaining spring pin (18) to permit removal of the cam lever pin (20). Remove the cam lever (1).

4. Mark the edges of the valve housing (15) and pump body (6) to assure correct alignment in reassembly.

5. Remove the valve housing to pump body mounting screws (5) and separate the valve housing assembly from the pump body (6).

6. Pull the diaphragm and spring assembly (7) from the pump body (6).

7. Take out the two valve housing-to-air dome and filter cover mounting screws (16) and separate the valve housing (15) from the air dome and filter cover (8) and (9).



Illust. 1 - Exploded View of Fuel Pump.

1. Lever.	11. Bowl.
2. Gasket.	12. Retainer.
3. Washer.	13. Spring.
4. Cap screw.	14. Gasket.
5. Screw.	15. Valve housing.
6. Pump body.	16. Screw.
7. Diaphragm.	17. Plug.
8. Diaphragm.	18. Pin.
9. Cover.	19. Spring.
10. Filter.	20. Pin.

4. INSPECTION AND REPAIR

Whenever the fuel pump is serviced, there are some parts which should always be replaced

continued on next page

FUEL PUMP

4. INSPECTION AND REPAIR - Continued

whether or not the old parts appear to need service. These parts are the diaphragm assembly (7), air dome diaphragm (8), filter bowl gasket (14), ceramic filter (10), cam lever shaft seal plug (17) and the pump to crankcase gasket (2). Fuel pump field service packages containing all these parts except the pump to crankcase gasket (2) are available. The pump to crankcase gasket must be ordered separately. All other parts should be inspected as follows:

1. Inspect the pump body (6), valve housing (15), air dome and filter cover (9) for cracks or breakage in castings.

2. Check the mating surfaces of castings for warpage.

3. Inspect the body (6) and cover (9) for stripped screw threads.

4. Check the rocker arm (1) for wear at the cam shaft contact point and also at the pivot point.

5. If the inlet or outlet valve is defective, the valve housing assembly (15) must be replaced as a complete unit since the valves are factory installed only.

5. REASSEMBLY

1. Place the new air dome diaphragm (8) on the dome section of the air dome and filter cover (9). Position the open half of the diaphragm over the inlet section of the air dome.

2. Assemble the valve housing assembly (15) to the air dome and filter cover assembly (9) so that the intake side of the housing mates with the intake side of the air dome. Insert the two mounting screws (16) with lock washers and tighten securely.

3. Install the new diaphragm assembly (7) to the pump body (6).

4. Insert the cam lever (1) into the opening in the pump body (6). Compress the diaphragm spring slightly so that the forked end of the cam lever engages under the retainer on the end of the diaphragm spring.

5. Fasten the cam lever (1) in the pump body (6) with the cam lever pin (20) and secure the pin with cam lever shaft retaining spring pin (18). Seal the pin opening in the pump body with a new cam lever shaft seal plug (17).

6. Align the marks made during "Disassembly" on the pump body (6) and valve housing assembly (15) and install the valve housing assembly to the pump body.

7. Install mounting screws (5) with lock washers but tighten only enough for the screws to just touch the lock washers.

8. Clamp the pump in a vise having soft jaws. Pull the cam lever to the full intake position and hold while tightening the housing to the pump body mounting screws (5). This will allow the diaphragm to position itself properly.

9. Place the filter bowl gasket (14), ceramic filter (10), filter spring (13) and filter bowl (11) over the cover section of the air dome and filter cover (9) and secure in place with the retainer (12).

6. INSTALLATION

1. Using a new gasket (2) install and secure the pump assembly to the crankcase.

2. Connect the fuel pump-to-carburetor pipe to the fuel pump.

3. Connect the fuel inlet pipe to the fuel pump.

PRINTED IN UNITED STATES OF AMERICA

1. DESCRIPTION

The distributor has three functions: First, it opens and closes the low voltage circuit, between the source of current and the ignition coil, so that the primary winding (of the ignition coil) (Illust. 1) 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 circuit. This in turn induces a high voltage surge in the secondary winding (of the ignition coil) (Illust. 1).

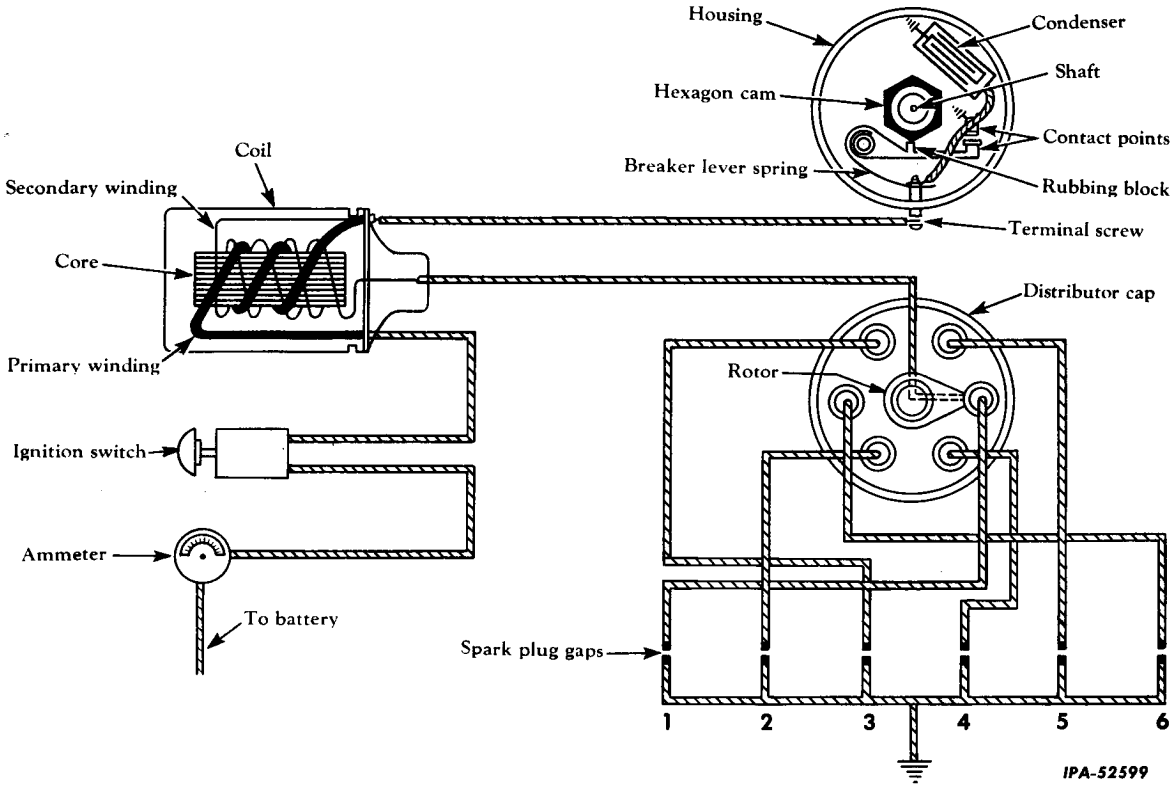
The second function is to time these surges to the requirements of the engine. This is accomplished by the advance mechanism.

The third function is to direct the high voltage surge through the rotor, cap and high tension wiring to the proper spark plug at the proper time.

On distributors of IH manufacture, there are two letters and a number stamped on the housing. The first letter designates the model distributor, the second letter designates the month of manufacture, and the number designates the year when built.

2. REMOVAL

1. Remove the distributor cap by loosening the spring clips from the cap. Place a mark on the housing, in line with the rotor tip.



Illust. 1 - Schematic View of the Ignition System.

2. Disconnect the primary (coil-to-distributor) cable from the distributor housing.

3. Remove the distributor clamps securing the distributor to the mounting adapter.

4. Lift out the distributor.

3. DISASSEMBLY (Refer to Illust. 2)

1. Remove the distributor rotor (2).

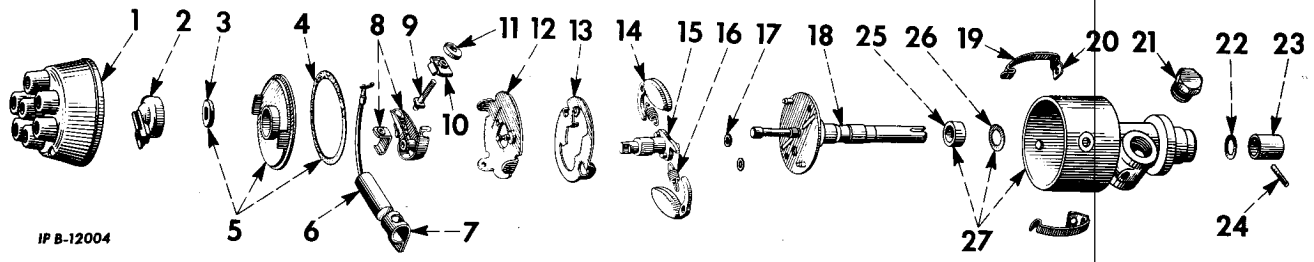
NOTE: The distributor rotor is made of bakelite, and will crack or break easily if dropped.

2. Remove the housing cover (5) and felt seal (3); rotating the cover will ease removal.

3. Remove the screw from the condenser clamp; remove the primary terminal screw nut (the nut inside the housing), and remove the condenser (6). (See Illust. 3.)

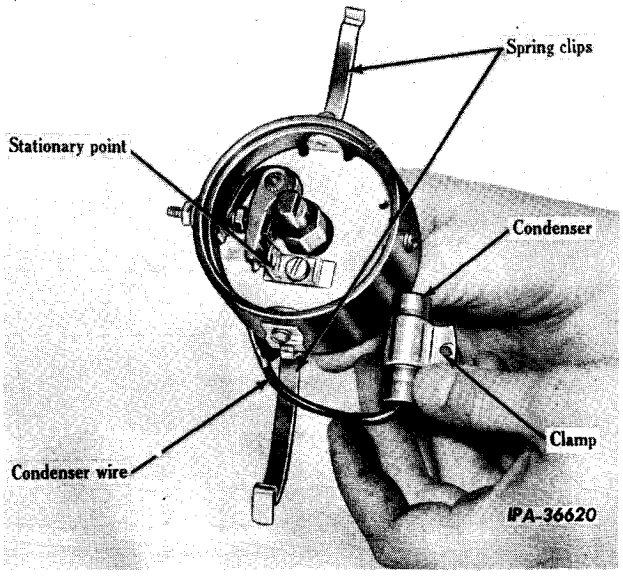
4. Lift the breaker lever (8) off the pivot (Illust. 4); remove the stationary point.

continued on next page

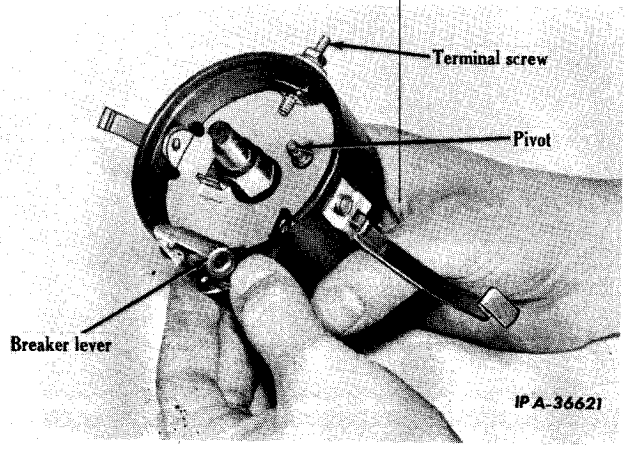


Illust. 2 - Battery Ignition Distributor.

1. Cap.
2. Rotor.
3. Felt seal.
4. Gasket.
5. Cover.
6. Condenser.
7. Clamp.
8. Breaker points.
9. Screw.
10. Insulator.
11. Washer.
12. Plate.
13. Guard.
14. Weight.
15. Cam.
16. Spring.
17. Spacer.
18. Shaft.
19. Spring.
20. Support.
21. Plug.
22. Washer.
23. Collar.
24. Pin.
25. Oil seal.
26. Washer.
27. Housing, washer, oil seal.



Illust. 3 - Removing the Condenser.

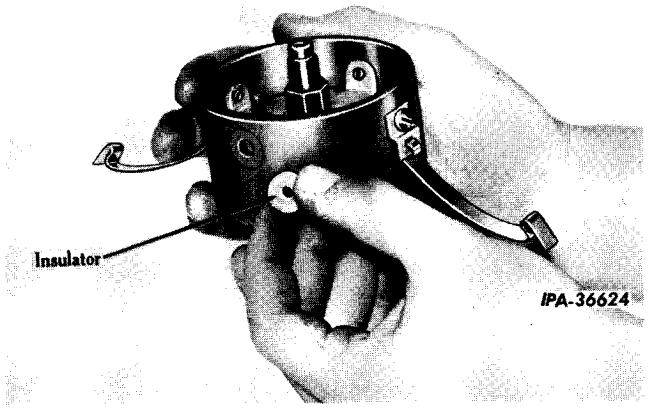


Illust. 4 - Removing the Breaker Lever.

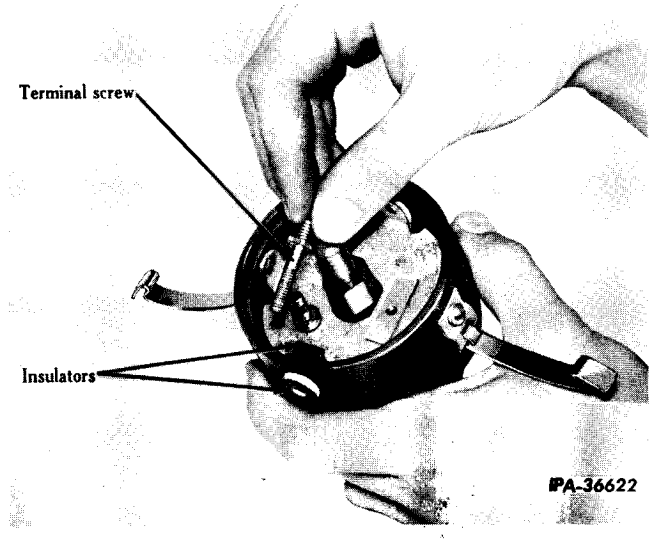
PRINTED IN UNITED STATES OF AMERICA

3. DISASSEMBLY (Refer to Illust. 2) - Continued

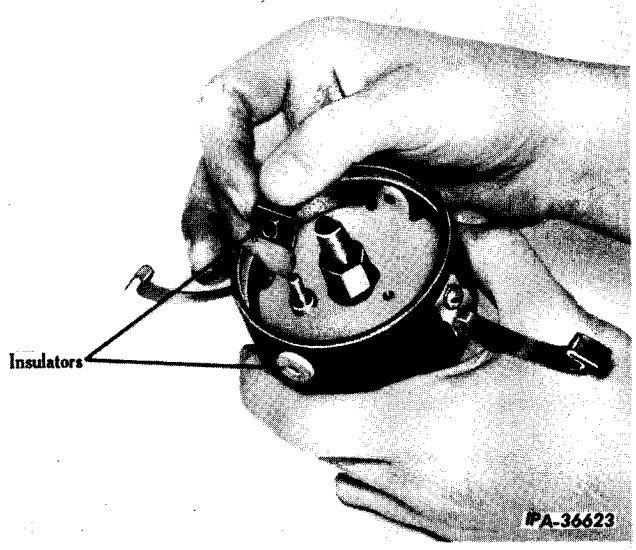
5. Remove the terminal screw nuts, lock washers, terminal insulators (10 and 11) and the terminal screw (9) from the housing. (See Illusts. 5, 6 and 7.)



Illust. 5 - Removing the Outside Terminal Insulator.



Illust. 6 - Removing the Terminal Screw.



Illust. 7 - Removing the Inside Terminal Insulator.

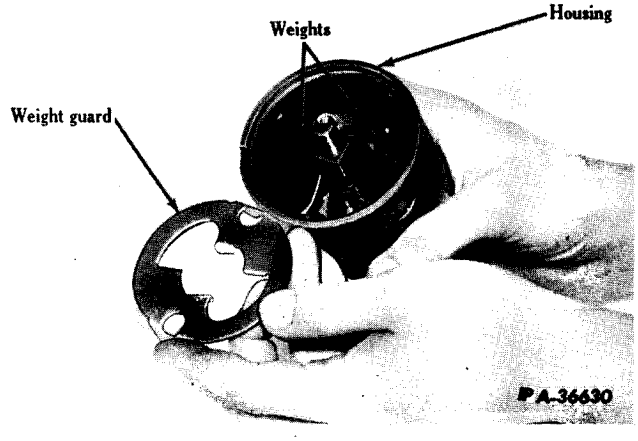
6. Remove the two screws which secure the spring clip support (20) to the housing; remove the clips and supports.

7. Remove the remaining screw securing the breaker plate (12) to the housing; lift the breaker plate from the housing.

8. Remove the securing screws and lift the governor weight guard (13) from the housing. (See Illust. 8.)

9. Remove the governor weight springs (16).

continued on next page



Illust. 8 - Removing the Weight Guard.

3. DISASSEMBLY (Refer to Illust. 2) - Continued

10. Lift out the governor weights (14) and spaces (17). (See Illust. 9.)

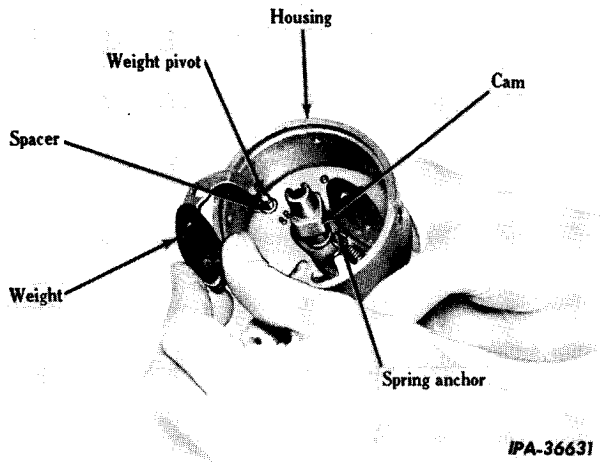
11. Lift the cam (15) off the shaft (18). (See Illust. 10.)

12. Remove the pin (24) that secures the collar (23) to the shaft (18) and remove the collar and thrust washer (22).

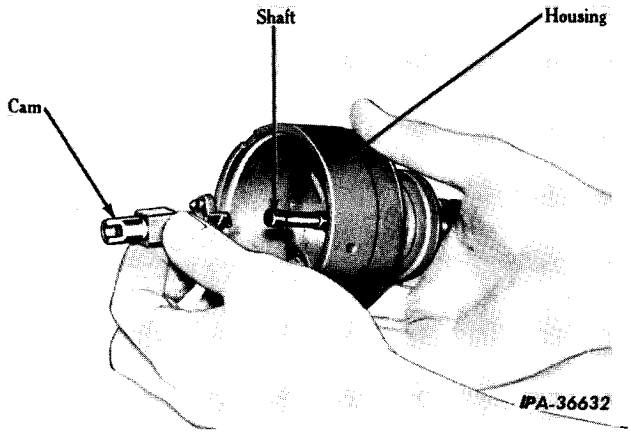
13. Remove the shaft (18) from the housing.

NOTE: The seal does not need to be removed unless it is cracked or shows other signs of wear or leakage.

14. If the bushings are badly worn or scored, the complete housing which includes an assembly of the oil seal, thrust washer (upper), upper and lower bushings and housing, must be replaced.



Illust. 9 - Removing the Governor Weights.



Illust. 10 - Removing the Cam.

4. INSPECTION AND REPAIR

The distributor cap, rotor, seal, 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 a similar dry cleaning solvent.

CAUTION: Do not immerse the distributor in a degreasing tank; to do so will ruin electrical parts.

INSPECTION	REMEDY
1. Inspect the distributor cap, rotor and insulating washers for cracks, chips or burned surfaces	Such damage can cause a leakage of high voltage to ground. Replace as necessary.
2. Inspect bushings for looseness or wear. (See "SPECIFICATIONS", Section 1.)	Replace housing assembly.

PRINTED IN UNITED STATES OF AMERICA

INSPECTION	REMEDY
3. Inspect contact points for pitting and burning, for oil and dirt and for correct gap setting	Clean points with a few strokes of a fine file or contact stone. Replace parts as necessary. Gap setting should be as shown in "SPECIFICATIONS", Section 1. 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 embed in the point surface and cause rapid burning and pitting.
4. Inspect for oxidized contact points	Replace as necessary. This condition is usually caused by high resistance due to loose connections in the condenser circuit, oil or foreign matter on the contact surfaces, or excessive high voltage caused by bad connections or broken strands.
5. Inspect condenser for secure connections . .	Be sure the condenser cable is not frayed or corroded, with broken stands or defective connections. Broken strands will cause high resistance in the condenser circuit, burning the points.
6. Inspect condenser sealing for cracks	Replace as necessary. Openings in condenser sealing may admit water or oil and cause a short circuit in the condenser.
7. Inspect condenser insulation for breakdown.	Replace as necessary. Such breakdown will cause a short in the condenser.
8. Inspect rubbing block for excessive wear . .	Replace points.
9. Check breaker lever spring for correct tension	Weak tension on the spring may permit contacts to bounce and chatter, causing heavy burning and arcing of the points. Replace points.
10. Inspect ignition coil for secure terminals .	Tighten terminal connections.
11. Inspect ignition coil for cracks and burns, or dents and punctures, in the coil insulation and containers.	Replace as necessary.
12. Inspect oil seal for wear, cracks or leakage	Replace.
13. Inspect weight pivots on the shaft for looseness	Replace shaft.
14. Inspect breaker point pivot on breaker plate for looseness.	Replace breaker plate.
15. Inspect governor springs. (See "SPECIFICATIONS", Section 1.)	Replace.

Installing A New Oil Seal

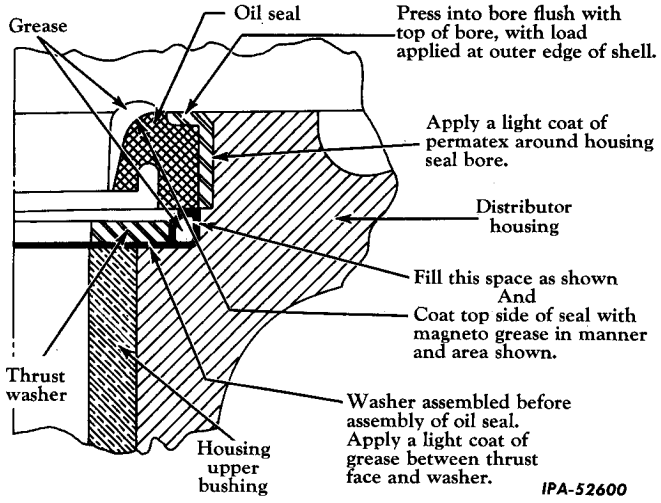
When it is necessary to replace the oil seal, remove the seal and the thrust washer. Clean the housing of old grease and inspect the thrust washer, replacing it if necessary.

For proper installation of the new oil seal, refer to Illust. 11.

continued on next page

4. INSPECTION AND REPAIR - Continued

Installing A New Oil Seal - Continued



Illust. 11 - Oil Seal Installation (Sectional View).

5. REASSEMBLY (Refer to Illust. 2)

1. If a new oil seal (25) is to be installed, refer to paragraph 4, "Inspection and Repair".

2. Install the drive shaft (18) through the seal (25), thrust washer (26) and into the housing (27) using a twisting motion.

3. Place the lower thrust washer (22) on the shaft, and install the collar (23) securing it with the pin (24).

NOTE: DO NOT PEEN THE PIN.

4. Check the end play of the shaft, between the collar and the lower thrust washer. This end play should be .003 to .009 inch.

5. Upset the ends of the pin so that it fills the entire hole, after the correct end play has been obtained.

6. Place the cam (15) over the shaft.

7. Place a governor weight spacer (17) over each of the pivots.

8. Install the governor weights (14) on the pivot so that the spring anchor is closest to the weight.

9. Install a second spacer on each pivot.

10. Install the governor weight spring (16) to the pivots and the spring anchors.

11. Install the weight guard (13) and secure it with the screws.

12. Install the breaker plate (12) so that the threaded holes are facing upward.

13. Install the two spring clip assemblies (19 and 20) and the remaining screws into the breaker plate.

14. Install the terminal screw insulators (10 and 11).

15. Install the terminal screw (9) and secure with the lock washer and hex nut on the outside of the housing.

16. Install the breaker point (8) on the pivot so that the rubbing block is against the cam and the spring is on the terminal screw.

17. Install the stationary point and adjust the point gap. (Refer to "SPECIFICATIONS", Section 1.)

18. Place the lock washer and nut on the inside threaded end of the terminal screw, but do not tighten.

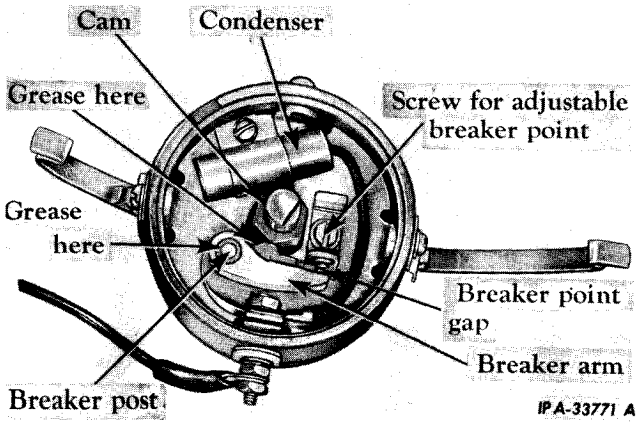
19. Place the condenser (6) on the breaker plate (12) and secure the clamp (7).

20. Connect the condenser wire to the terminal screw so that it is under the washer. Tighten the terminal screw nut.

21. Lubricate the distributor felt and cam block as shown in Illust. 12.

22. Install the gasket (4), housing cover (5) and felt washer (3), into the housing.

23. Place the rotor (2) on the shaft.



Illust. 12 - Adjusting the Breaker Points.

PRINTED IN UNITED STATES OF AMERICA

6. INSTALLATION

NOTE: The following instructions under "Crankshaft Position Known" will apply only if the engine crankshaft has not been rotated since the distributor was removed. If for any reason the engine has been rotated or the spark plug wires disconnected, refer to instructions under "Crankshaft Position Unknown."

Crankshaft Position Known

1. Place the rotor on the distributor shaft and carefully press it into position.

2. Rotate the rotor so the tip is in alignment with the scribe mark on the housing during removal.

NOTE: Install a new gasket between the distributor and the crankcase.

3. Install the distributor into the mounting adapter. Be sure the distributor drive shaft tang mates with the oil pump drive shaft slot and the distributor bottoms in place. It may be necessary to turn the rotor and shaft clockwise or counterclockwise slightly to correctly engage the tang with the slot of the oil pump shaft. The correct position of the distributor is shown in Illust. 13.

4. Install the mounting clamps and cap screws, and tighten enough to prevent the distributor from turning freely.

5. Connect the primary (coil-to-distributor) cable to the primary terminal on the housing. Be certain the connection is clean and tight.

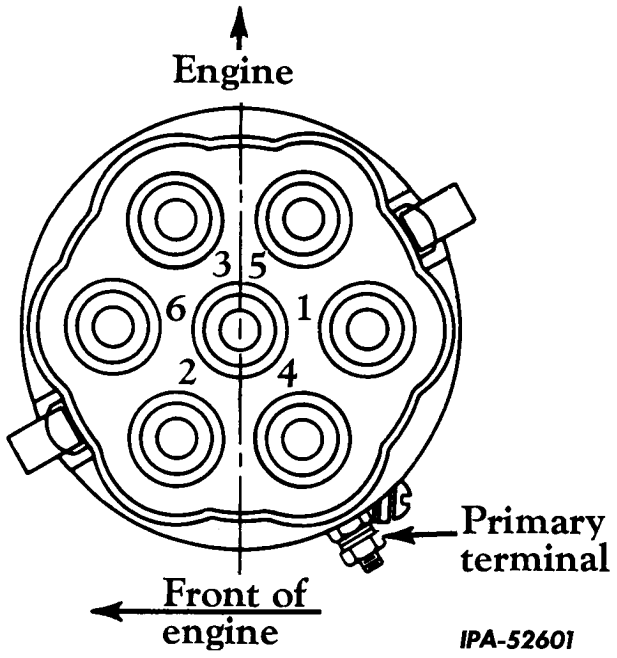
NOTE: If the spark plug cables have been removed from the distributor cap, insert them in a counterclockwise rotation in their proper firing order. (See Illust. 13.)

6. Install the distributor cap, being certain to align the tang in the cap with the slot in the housing to assure correct installation.

NOTE: If the cap is incorrectly positioned on the housing, it will result in a broken rotor when attempting to start the engine.

7. Connect the coil-to-distributor cable (secondary) to the distributor cap.

8. Start the engine and allow a brief warm-up period, then set the timing as described under "Ignition Timing," Par. 7.



Illust. 13 - Positioning the Distributor.

Crankshaft Position Unknown

1. Remove the No. 1 spark plug. Crank the engine and hold the thumb over the spark plug hole until an outward pressure is felt. Continue cranking the engine slowly until the "T" mark on the fan drive pulley is in line with the pointer on the front cover.

2. Install the distributor into the distributor mounting adapter so that the primary terminal is positioned as shown in Illust. 13, and the rotor tip aligns with the No. 1 spark plug wire terminal in the cap.

NOTE: It may be necessary to move the rotor slightly to engage the tang in the slot of the oil pump shaft, but the rotor will line up with the No. 1 terminal post when the distributor is down in place.

3. Install the mounting clamps and cap screws, and tighten enough to prevent the distributor from turning freely.

4. Connect the distributor-to-coil cable (primary) to the terminal on the side of the distributor housing.

Continued on next page.

6. INSTALLATION - Continued

Crankshaft Position Unknown - Continued

5. Install the distributor cap, being certain to align the tang in the cap with the slot in the housing to assure correct installation.

NOTE: If the distributor cap is incorrectly positioned on the housing, the rotor will be damaged when attempting to start the engine.

6. Install the spark plug cables. Insert them in a counterclockwise rotation in their proper firing order. (Refer to Illust. 13.)

7. Connect the coil-to-distributor cable (secondary) to the distributor cap.

8. Start the engine and allow a brief warm up period, then time the engine as outlined in "Ignition Timing," Par. 7.

7. IGNITION TIMING (DISTRIBUTOR)

An accurate check and adjustment of ignition timing is possible with a neon-type flashing timing light, synchronized to the ignition system, using the timing mark and running the engine at low idle speed. This flashing light requires that the timing marks on the fan drive pulley be whitened with white lead or chalk to make them more visible, and the engine be adjusted to the correct low idle speed. A higher engine speed will cause the automatic spark advance to function, thus advancing the spark to occur before top-dead-center.

1. Be sure that the distributor cap is properly located on the distributor housing and that both bail clips are in place.

The firing order is 1,5,3,6,2,4 and the spark plug cables must be assembled in a counterclockwise rotation viewing from the cap end of the distributor.

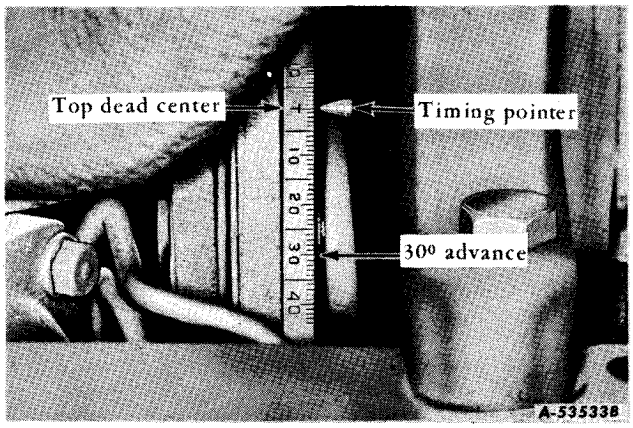
2. Connect the timing light to the No. 1 spark plug.

NOTE: Follow the manufacturer's instructions for connection and use of the timing light.

3. Start the engine and notice if the timing light is flashing.

4. Rotate the throttle stop screw on the carburetor to reduce the idle speed of the engine to approximately 500 rpm for timing purposes.

5. Direct the light to the timing location on the fan drive pulley. Each light flash should be fast and accurate, and the timing mark "T" should be readily seen in line with the timing pointer.



Illust. 14 - Timing Pointer and Timing Marks on the Fan Drive Pulley.

6. If the "T" mark is not in line with the pointer, loosen the distributor clamp holding the distributor housing. This will permit rotation of the distributor housing until the timing mark "T" is in alignment with the pointer (when the timing light flashes).

7. Tighten the distributor clamp, and re-check to be sure that tightening the bolt did not disturb the timing setting.

8. Operate the engine at high idle speed. Direct the timing light on the pointer and timing mark on the fan drive pulley. The distributor is correctly timed when the 30 degree spark advance line is aligned with the pointer. If the timing mark does not align with the pointer, loosen and rotate the distributor in its mounting until the 30 degree line on the pulley is in line with the pointer. After the above adjustment has been made, reduce the engine speed to adjusted low idle speed. The "T" mark on the pulley should align with the pointer or be slightly past the pointer in the direction of rotation. If the "T" is before the pointer, rotate the distributor until the "T" mark is in line with the pointer. Never time the spark to occur before top-dead-center.

PRINTED IN UNITED STATES OF AMERICA

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 an overrunning clutch drive.

The overrunning clutch is designed to provide positive meshing and demeshing of the drive pinion and flywheel ring gear. The overruning clutch cranking motor uses a shift lever which slides the clutch and drive pinion assembly along the armature shaft so that it can be meshed and demeshed as required. The clutch transmits cranking torque from the cranking motor armature to the engine flywheel but permits the drive pinion to overrun or run faster than, the armature after the engine is started. This protects the armature from excessive speed during the brief interval that the drive pinion remains in mesh.

2. MINOR REPAIRS AND ADJUSTMENTS

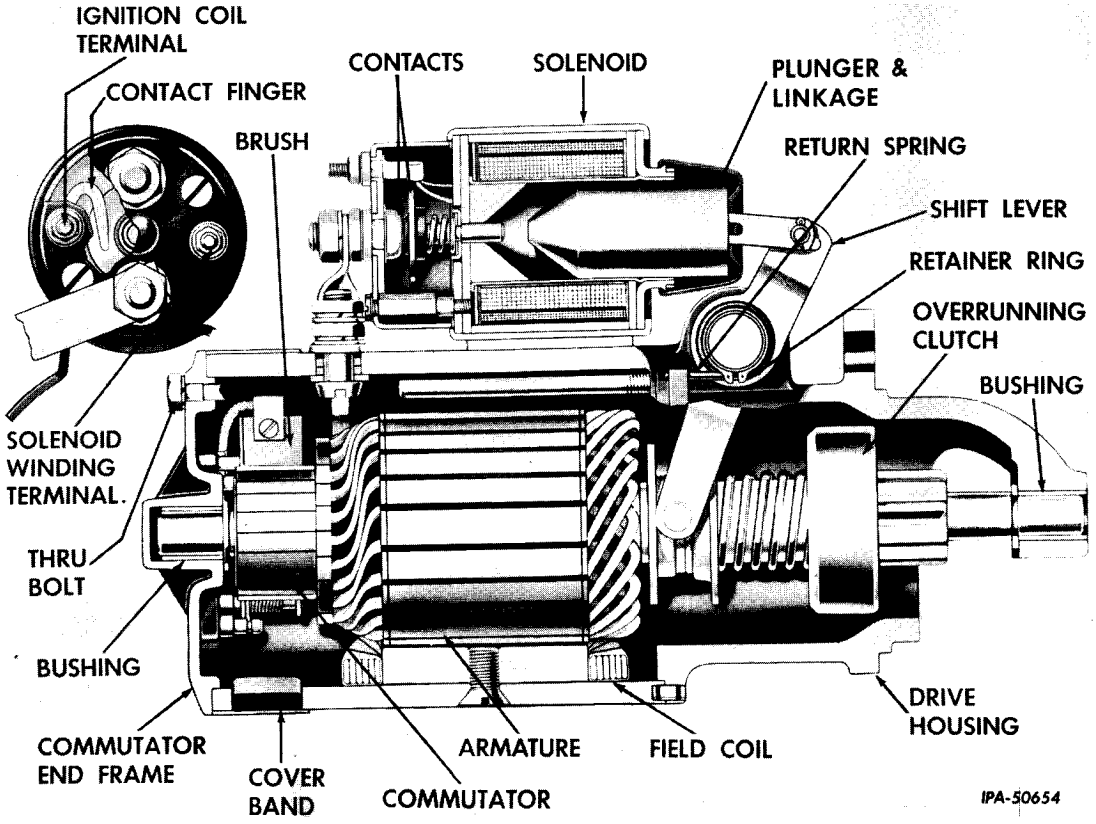
At periodic intervals, the cranking motor should be inspected to determine its condition, as outlined below. These inspections can be made with the cranking motor mounted. However, they should also be made when the cranking motor is removed and disassembled for any service or repair.

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.

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.

continued on next page



Illust. 1 - Cranking Motor with Overrunning Clutch and Solenoid Operated Shift Lever.

2. MINOR REPAIRS AND ADJUSTMENTS - Continued

Hold the sandpaper against the commutator with a flat 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.

IMPORTANT: 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 correct tention be maintained, 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 overheating (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 must be removed from the engine and tested with special testing equipment.

3. REMOVAL

1. Disconnect the electrical leads from the cranking motor. Tag each to identify for correct replacement.

2. Remove the cap screws that 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.

PRINTED IN UNITED STATES OF AMERICA

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

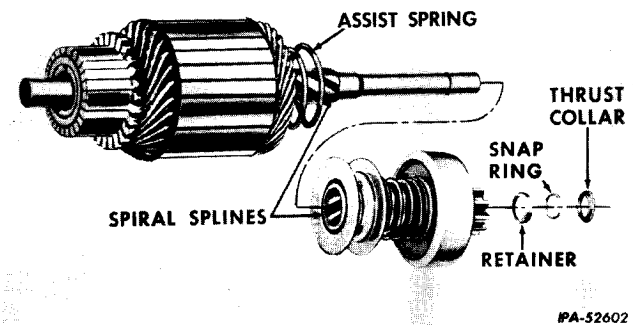
Normally, disassembly should proceed only so far as is necessary to make repair or replacement of the defective parts. For example, the field coils should be checked for opens or grounds and, if found to be in normal condition, should not be removed from the field frame.

1. Disconnect the field coil connectors from the solenoid "motor" terminal.

2. Remove the thru bolts.

3. Remove the solenoid from the motor housing. On enclosed shift lever type cranking motors, remove the solenoid and drive housing.

4. Remove the commutator end frame.



Illust. 2 - Exploded View of Armature and Overrunning Clutch Assembly.

5. Remove the armature assembly from the field frame.

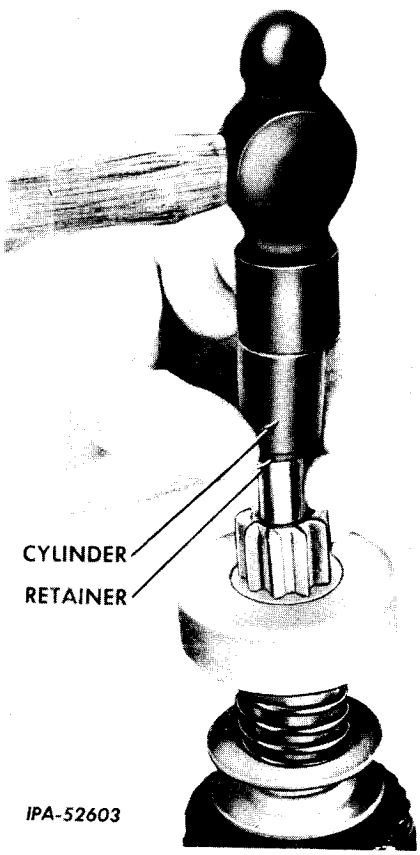
6. Remove the overrunning clutch from the armature as follows:

(a) Slide the thrust collar (Illust. 2) off the end of the armature shaft.

(b) Slide a standard half-inch pipe coupling or other metal cylinder of suitable size (an old pinion of suitable size can be used if available) on the shaft so the end of coupling or cylinder butts against the edge of the retainer (Illust. 2). Tap the end of coupling with a hammer, driving the retainer towards the armature and off the snap ring.

(c) Remove the snap ring from groove in shaft using a pliers or other suitable tool. If the snap ring is too badly distorted during removal, replace when reassembling.

continued on next page



Illust. 3 - Removing the Retainer from Snap Ring.

5. DISASSEMBLY - Continued

(d) Slide the retainer, clutch and assist spring from the armature shaft.

7. If the field coils are to be removed from the field frame assembly, use a pole shoe screwdriver. A pole shoe spreader should also be used, since this prevents distortion of the field frame (Illust. 4).

6. INSPECTION AND REPAIR

1. Wash all metal parts except armature overrunning clutch and fields in cleaning solvent. Degreasing solvents will damage the insulation in fields and armature, and dissolve the lubricant in the clutch mechanism.

2. The overrunning clutch drive may be cleaned by wiping with a clean cloth.

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 causes 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.

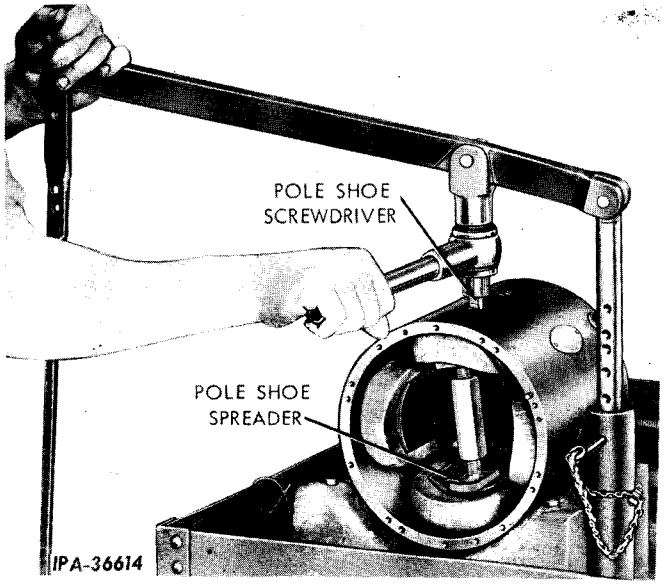
Grounds in the armature are detected by use of a test lamp and test points. Place one lead of the test lamp on the armature core or shaft and the other lead on each commutator bar. If the lamp lights, the commutator is grounded. Repairs can sometimes be made if grounds are at core ends (where coils come 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. (See Illust. 4.) 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)



Illust. 4 - Removing the Pole Shoes.

PRINTED IN UNITED STATES OF AMERICA

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

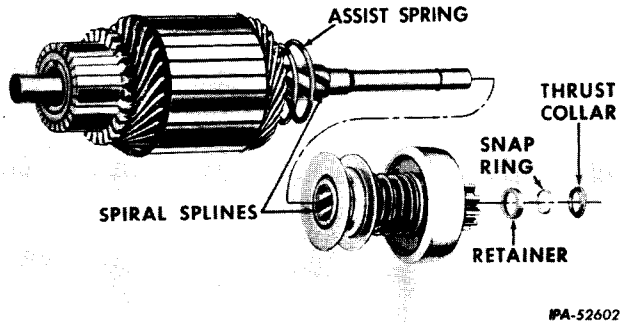
Normally, disassembly should proceed only so far as is necessary to make repair or replacement of the defective parts. For example, the field coils should be checked for opens or grounds and, if found to be in normal condition, should not be removed from the field frame.

1. Disconnect the field coil connectors from the solenoid "motor" terminal.

2. Remove the thru bolts.

3. Remove the solenoid from the motor housing. On enclosed shift lever type cranking motors, remove the solenoid and drive housing.

4. Remove the commutator end frame.



Illust. 2 - Exploded View of Armature and Overrunning Clutch Assembly.

5. Remove the armature assembly from the field frame.

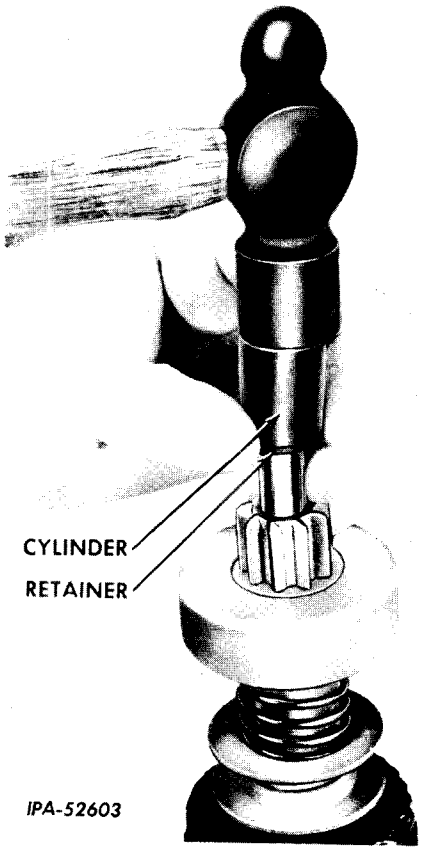
6. Remove the overrunning clutch from the armature as follows:

(a) Slide the thrust collar (Illust. 2) off the end of the armature shaft.

(b) Slide a standard half-inch pipe coupling or other metal cylinder of suitable size (an old pinion of suitable size can be used if available) on the shaft so the end of coupling or cylinder butts against the edge of the retainer (Illust. 2). Tap the end of coupling with a hammer, driving the retainer towards the armature and off the snap ring.

(c) Remove the snap ring from groove in shaft using a pliers or other suitable tool. If the snap ring is too badly distorted during removal, replace when reassembling.

continued on next page



Illust. 3 - Removing the Retainer from Snap Ring.

5. DISASSEMBLY - Continued

(d) Slide the retainer, clutch and assist spring from the armature shaft.

7. If the field coils are to be removed from the field frame assembly, use a pole shoe screwdriver. A pole shoe spreader should also be used, since this prevents distortion of the field frame (Illust. 4).

6. INSPECTION AND REPAIR

1. Wash all metal parts except armature overrunning clutch and fields in cleaning solvent. Degreasing solvents will damage the insulation in fields and armature, and dissolve the lubricant in the clutch mechanism.

2. The overrunning clutch drive may be cleaned by wiping with a clean cloth.

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 causes 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.

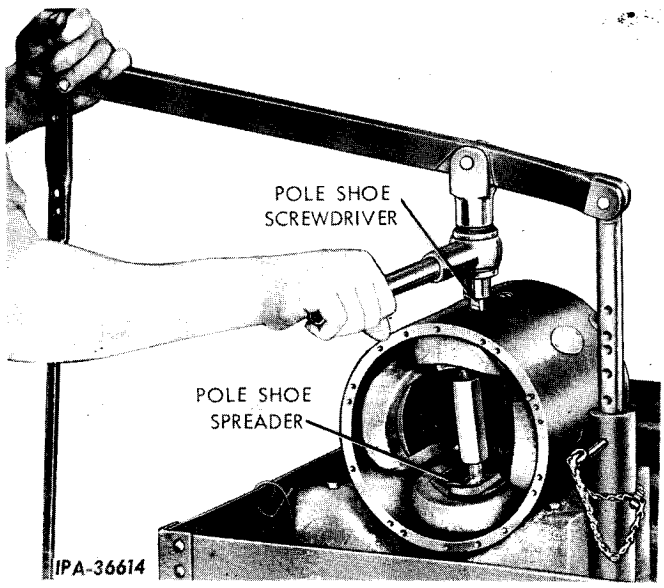
Grounds in the armature are detected by use of a test lamp and test points. Place one lead of the test lamp on the armature core or shaft and the other lead on each commutator bar. If the lamp lights, the commutator is grounded. Repairs can sometimes be made if grounds are at core ends (where coils come 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. (See Illust. 4.) 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)



Illust. 4 - Removing the Pole Shoes.

PRINTED IN UNITED STATES OF AMERICA

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 be 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 drive mechanism with a small amount of light motor oil. Heavy oil or 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.

CAUTION: Never lubricate the commutator and never lubricate any part of the cranking motor while it is operating.

8. REASSEMBLY

1. Assemble the overrunning clutch to armature shaft as follows:

(a) Lubricate the drive end and splines of armature shaft with SAE No. 10 oil. If heavier oil is used it may cause failure to mesh at low temperatures.

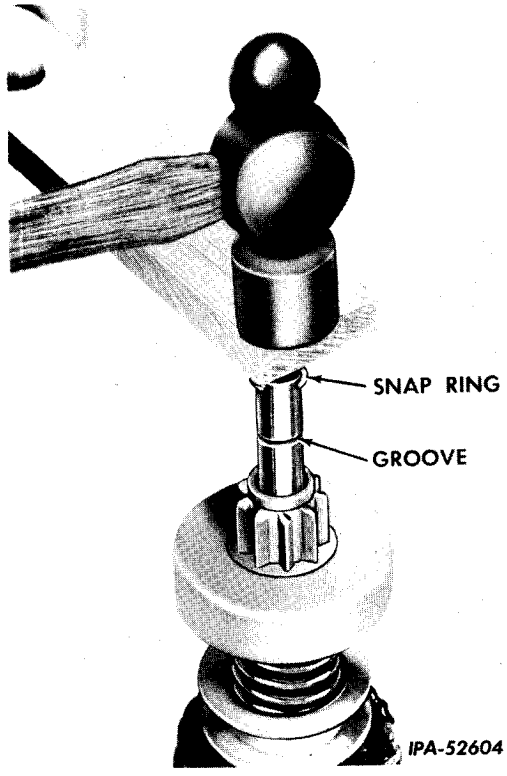
(b) Place the assist spring (Illust. 2) on the drive end of shaft next to the armature, with the small end against the lamination stack.

(c) Slide the clutch assembly onto the armature shaft with pinion outward. (See Illust. 2.)

(d) Slide retainer (Illust. 2) onto the shaft with cupped surface facing end of shaft.

(e) Stand the armature on end, on a wood surface, with the commutator down.

Position snap ring on upper end of shaft and hold in place with a block of wood. Tap the wooden block with a hammer forcing the snap ring over the end of the shaft. (See Illust. 5.)



Illust. 5 - Forcing the Snap Ring Over Shaft.

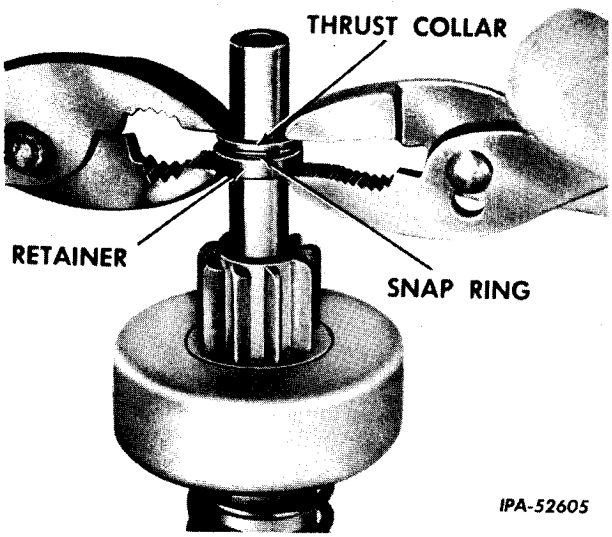
(f) Slide the snap ring down into the groove, and squeeze the snap ring so it fits well into the groove.

(g) Assemble the thrust collar (Illust. 2) on the shaft with the shoulder next to the snap ring.

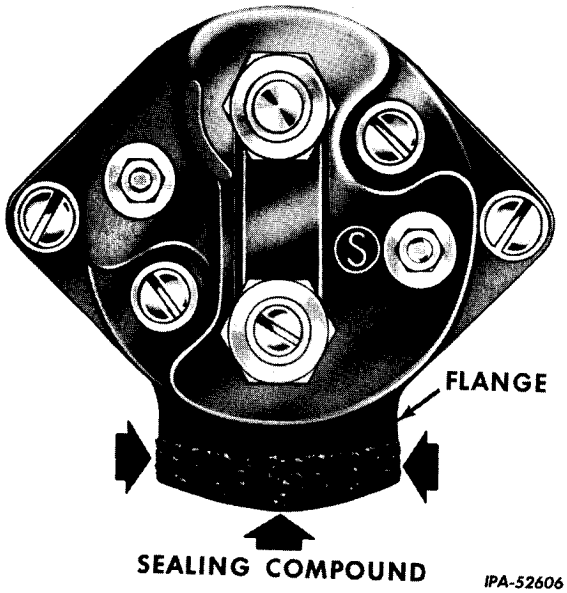
(h) Position the retainer and thrust collar next to the snap ring. With the clutch pressed against the assist spring, for clearance next to the retainer, use two pliers (one pair on either side of shaft) to grip the retainer and thrust collar, then, squeeze until the snap ring is forced into the retainer. (See Illust. 6.)

continued on next page

8. REASSEMBLY - Continued



Illust. 6 - Forcing the Retainer Over Snap Ring.



Illust. 7 - Sealing Solenoid Housing to Frame.

2. Place four or five drops of SAE No. 10 oil in the drive housing bushing. Make certain the thrust collar is in place against the snap ring and retainer then slide the armature and clutch assembly into the drive housing.

3. Attach the shift lever assembly to the drive housing.

4. Position the field frame over the armature and assemble the field frame, drive housing and solenoid.

NOTE: On cranking motors having the enclosed shift lever, apply sealing compound between the frame and solenoid. (See Illust. 7.)

5. Place four or five drops of SAE No. 10 oil in the end frame bushing. Be certain the leather brake washer is on the armature shaft, then slide the commutator end frame on the shaft.

6. Install the thru bolts and tighten securely.

7. Reconnect the field coil connectors to the solenoid "motor" terminal.

NOTE: After assembling the cranking motor, the pinion clearance will have to be adjusted as follows:

Cranking Motor with Exposed Shift Lever

8. Disconnect the solenoid to cranking motor cable, so the cranking motor will not operate. Place feeler gauge between the pinion and housing. (See Illust. 8.)

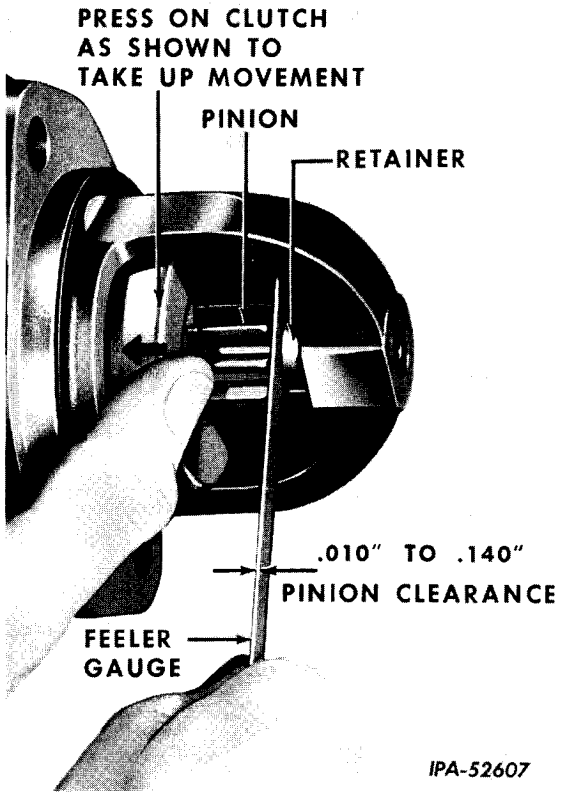
9. Connect a 12 volt battery between the "switch" terminal of the solenoid and the solenoid base (ground), and push the solenoid plunger in by hand. Battery current will hold the plunger in the "bottomed" position while the pinion clearance is adjusted.

10. Loosen the solenoid switch mounting screws and pull the solenoid switch away from the shift lever until play is taken out of the lever and clutch mechanism. DO NOT COMPRESS OVERRUNNING CLUTCH SPRING.

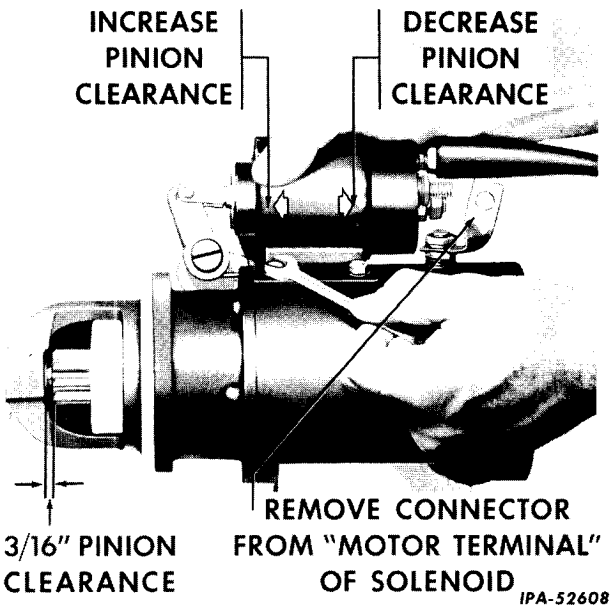
11. Moving the switch toward the shift lever increases clearance and moving the switch away from the shift lever decreases pinion clearance. (See Illust. 9.)

12. After completing the adjustment, disconnect the battery, tighten the solenoid switch mounting screws and reconnect the "Solenoid to Cranking Motor" cable.

PRINTED IN UNITED STATES OF AMERICA



Illust. 8 - Checking Pinion Clearance.



Illust. 9 - Adjusting the Pinion Clearance.

Cranking Motor with Enclosed Shift Lever

13. Connect a voltage source of 6 volts between the solenoid switch terminal and the ground.

CAUTION: Do not connect the voltage source to the ignition coil terminal "R" of the solenoid. Do not use a 12 volt battery instead of the 6 volts specified as this will cause the motor to operate. As a further precaution to prevent motoring connect a heavy jumper lead from the solenoid motor terminal to the ground.

14. After energizing the solenoid with the clutch shifted towards the pinion stop retainer, push the pinion back toward the commutator end as far as possible to take up any slack movement, then check the clearance with a feeler gauge. (See Illust. 8.)

There are no provisions for adjusting pinion clearance on the enclosed shift lever cranking motor. When the shift lever mechanism is correctly assembled the pinion clearance should fall within the specified limits (.010" - .140"). When the clearance is out of these limits it may indicate excessive wear of solenoid linkage or shift lever yoke buttons.

9. 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.

PRINTED IN UNITED STATES OF AMERICA

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 side of the engine and is V-belt driven from the crankshaft pulley. The direction of rotation for the generator is clockwise, viewed from drive end.

2. MINOR REPAIRS AND ADJUSTMENTS

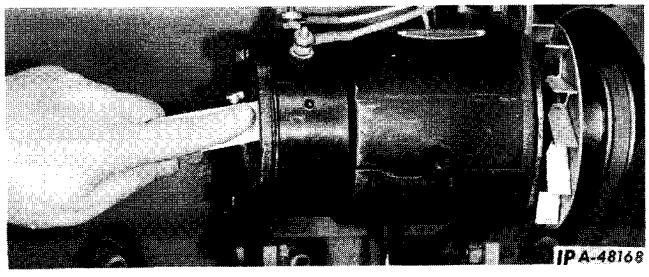
Before any repairs or adjustments are made, refer to "Checking Mechanical Problems," Section 1, to be sure that the generator and not the voltage regulator is at fault. Often the generator can be repaired by following the simple procedure of minor checks and adjustments, as outlined below, without removing 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, it may be cleaned with a strip of No. 00 sandpaper. Never use emery cloth to clean the commutator.

The sandpaper may be used by holding it against the commutator with a flat 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 "Adjusting the Fan Belt," in operator's manual. 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.

3. TESTING THE GENERATOR

If the generator still fails to function properly after checking as outlined under "Minor Repairs and Adjustments", paragraph 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-2". References to the "A" terminal in the following tests for no output should be interpreted to mean the "A-1" or armature terminal.

continued on next page

3. TESTING THE GENERATOR - Continued

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 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", paragraph 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", paragraph 6.) If the short circuit is obvious, it can often be repaired so the armature can be saved.

Unsteady or Low Output

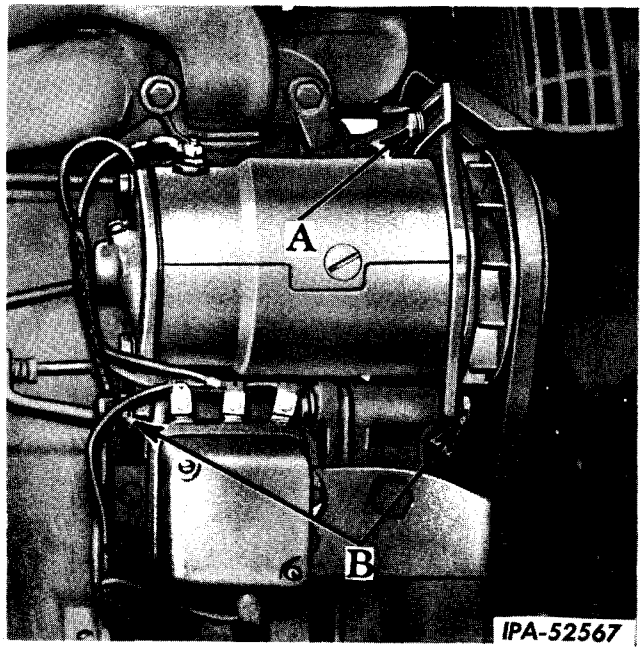
1. A loose fan belt or generator pulley will cause low or unsteady output.

2. Brushes which stick in their holders, or low brush spring tension, will prevent good 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", paragraph 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, new insulating washers or bushings.



Illust. 2 - Generator (Carbureted Engine).

PRINTED IN UNITED STATES OF AMERICA

4. REMOVAL (See Illust. 2)

1. Remove the nuts and lock washers and leads from the terminals on the generator, tagging each lead to facilitate replacement.

2. Remove the adjusting cap screw, lock washer and plain washer "A", which secure the brace to the generator, and push the brace upward and out of the way.

3. Loosen the mounting screws "B" at the front and rear of the generator, push the generator toward the engine and remove the drive belt.

4. 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. Remove 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 nut, washer, pulley, key 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 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, key, pulley, washer and nut 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.

2. Tighten the drive belt or fan belt tensioner to the correct tension. (See "Adjusting the Fan Belt" in Section 5) and secure the generator in position.

3. Connect the leads to the correct terminals.

4. Repolarize the generator. (Refer to paragraph 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.

PRINTED IN UNITED STATES OF AMERICA

1. DESCRIPTION

The output of a generator is controlled or limited according to the requirements of the tractor or power unit with which it is used. This adjustment of output is accomplished by using a regulator of specific design for use with certain type generators, and described in the following paragraphs.

The combined current-voltage regulator (two-unit) consists of a cutout relay and a combination current-voltage regulator.

The standard three-unit regulator consists of a cutout relay, a voltage regulator and a current regulator unit.

CUTOUT RELAY: The cutout relay is used to close the circuit between the generator and the battery when the generator voltage is sufficient to charge the battery. It opens the circuit when the generator slows or stops, to prevent the battery from discharging through the generator.

VOLTAGE REGULATOR: The voltage regulator is a voltage-limiting device, which prevents the voltage from exceeding a specified maximum and reduces the generator output to a value required for any particular condition of battery charge and electrical load.

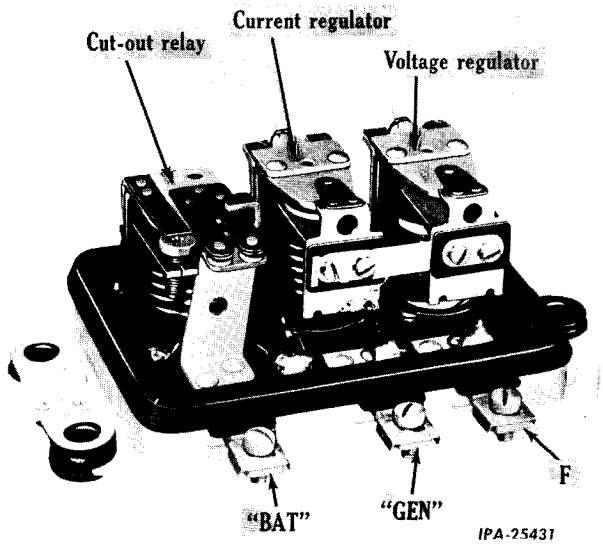
CURRENT REGULATOR: The current regulator is a current-limiting device, which prevents the generator from overloading itself when the voltage regulator is not operating.

2. GENERAL

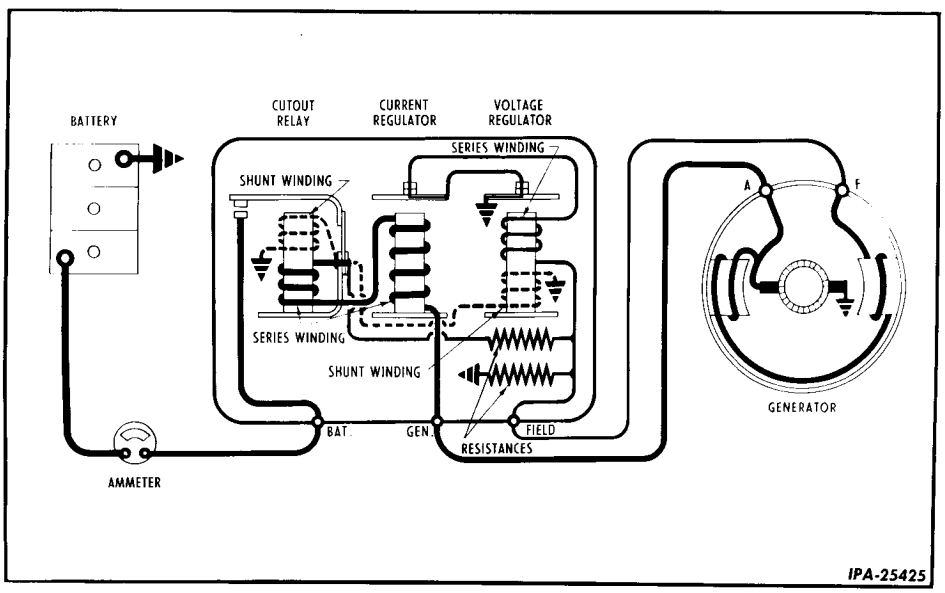
Before any repairs or adjustments are made refer to "CHECKING MECHANICAL PROBLEMS," in Section 1 to see if possibly the regulator, and not the generator, might be at fault.

While some voltage regulators are designed for use with a positive (+) grounded battery, others are to be used with a negative (-) grounded battery.

continued on next page



Illust. 1 - Three Unit Regulator Cover Removed.



Illust. 2 - Circuit Wiring Diagram - Three-Unit Regulator.

2. GENERAL - Continued

CAUTION: Never use the wrong polarity regulator on an application.

Generators have a specific field draw, output, speed range and internal connections. Be sure that the proper regulator and generator are used. Improper substitutions may not function correctly.

3. ADJUSTMENTS (Three-Unit Regulator)

If the regulator is inoperative or if tests show the unit is not adjusted according to specifications, proceed as follows:

Mechanical checks and adjustments (air gaps and point openings) should be made with the regulator off the unit. Electrical checks and adjustments may be made with the regulator either on or off the unit, mounted in operating position and at operating temperature.

To check the electrical settings outlined in the following paragraphs, special test equipment will be required. Instructions for use of this equipment will be found in the literature furnished with the test equipment. Refer to "SPECIFICATIONS," in Section 1.

Contact Points

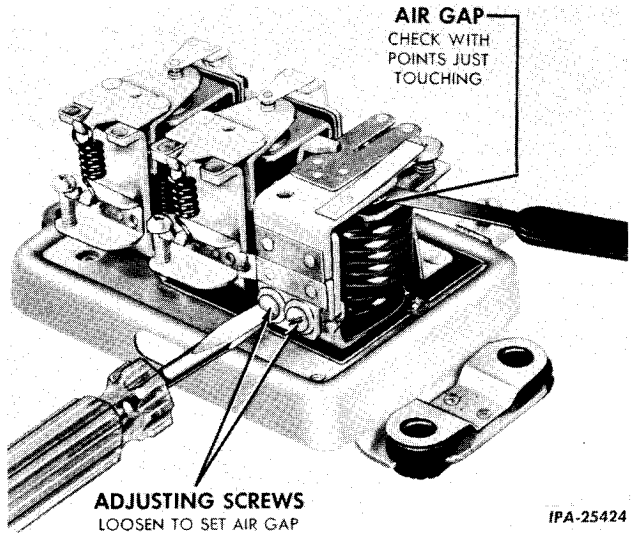
A majority of regulator problems can be eliminated by cleaning the contact points of the current and voltage regulator, plus some possible readjustments. Clean the flat points with a spoon or riffler file. On positive grounded regulators, the flat point is in the upper contact bracket, therefore the bracket must be removed for cleaning the points (Illust. 10). A flat file cannot be used to clean flat contact points, because it will not touch the center where point wear generally occurs. Contact files should not be allowed to become greasy or be used to file other metals. Never use sandpaper or emery cloth to clean contact points.

Cutout Relay Unit

The cutout relay requires three checks and adjustments; air gap, point opening and closing voltage.

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 other electrical equipment. Air gap and point opening must be made with the battery lead disconnected from the regulator.

1. AIR GAP: Hold the armature down so the contact points are just closed. Measure the air gap (Illust. 3) between armature and center of the core Adjust the gap according to "SPECIFICATIONS," in Section 1. Tighten the screws after adjustment.

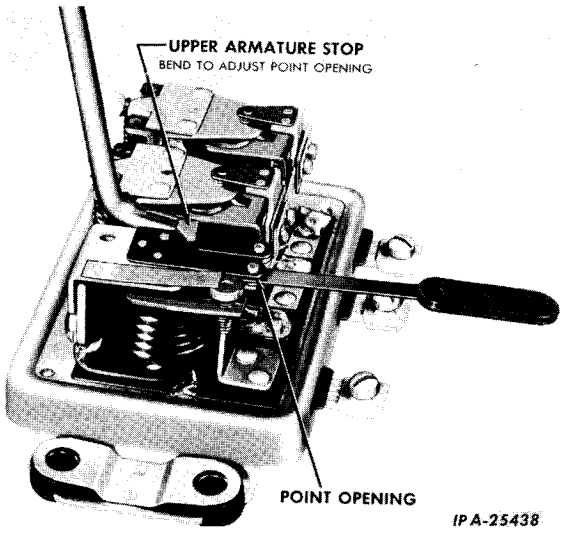


Illust. 3 - Cutout Relay Air Gap Adjustment (Three-Unit Regulator).

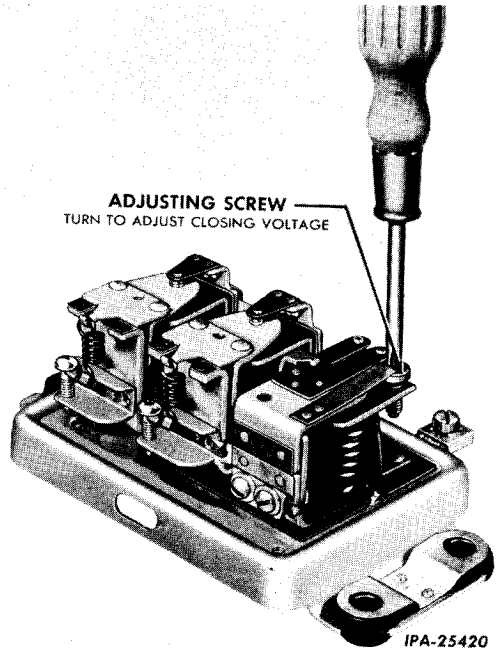
2. POINT OPENING: Check the point opening and adjust by bending the upper armature stop (Illust. 4). Refer to "SPECIFICATIONS," in Section 1.

3. CLOSING VOLTAGE: Follow the instructions for test equipment being used. Adjust the closing voltage by turning the adjusting screw clockwise to increase spring tension and closing voltage, or counterclockwise to decrease the closing voltage (Illust. 5). Refer to "SPECIFICATIONS," in Section 1.

PRINTED IN UNITED STATES OF AMERICA



Illust. 4 - Cutout Relay Point Opening Adjustment (Three-Unit Regulator).

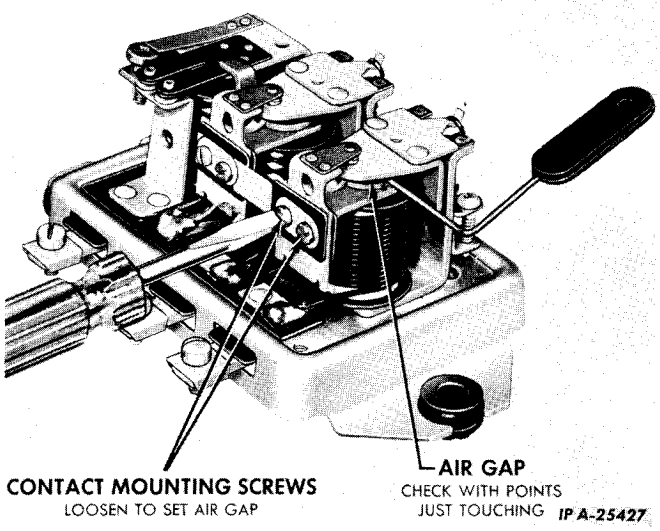


Illust. 5 - Adjustment of Cutout Relay Closing Voltage (Three-Unit Regulator).

Voltage Regulator Unit

Two checks and adjustments are required on the voltage regulator unit.

1. AIR GAP: To check air gap, push the armature down until the contact points are just touching and measure the air gap (Illust. 6). Adjust by loosening the contact mounting screws and raising or lowering the contact bracket as required. Be sure the points line up. Tighten the screws after adjustment. Refer to "SPECIFICATIONS," in Section 1.



Illust. 6 - Air Gap Adjustment, Voltage Regulator Unit (Three-Unit Regulator).

2. VOLTAGE SETTING: Turn the adjusting screw clockwise to increase voltage setting or counterclockwise to decrease voltage setting. Refer to "SPECIFICATIONS," in Section 1.

CAUTION: If adjusting screw is turned down (clockwise) beyond normal adjustment range, the spring support may fail to return when pressure is relieved. If this occurs, turn the screw counterclockwise until there is sufficient clearance between the screw head and spring support. Then carefully bend the spring support upward with small pliers until contact is made with the screw head. Always approach the final setting of the unit by increasing the spring tension; never by reducing it. If the setting is too high, adjust until it is below required value and then raise to exact setting by increasing the 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

continued on next page

3. ADJUSTMENTS (Three-Unit Regulator) - Continued

Voltage Regulator Unit - Continued

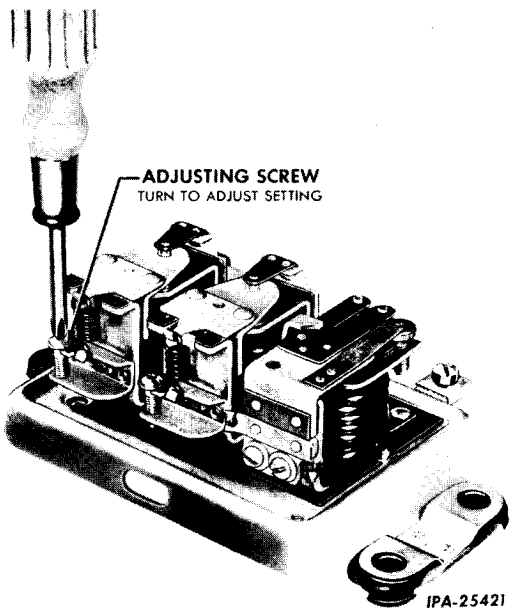
occur; this will be indicated by excessive use of water. Ordinarily the battery should require water about every 100 hours. If water must be added more frequently than this, there is an indication of overcharge.

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, increase the settings of the voltage regulator and cutout relay to specified limits to avoid undercharging the battery.

Current Regulator Unit

1. AIR GAP: Check and adjust the air gap in the same manner as for the voltage regulator (Illust. 6). Refer to "SPECIFICATIONS," in Section 1.

2. CURRENT SETTING: Check and adjust the current setting in the same manner as for the voltage setting. Refer to "SPECIFICATIONS," in Section 1.



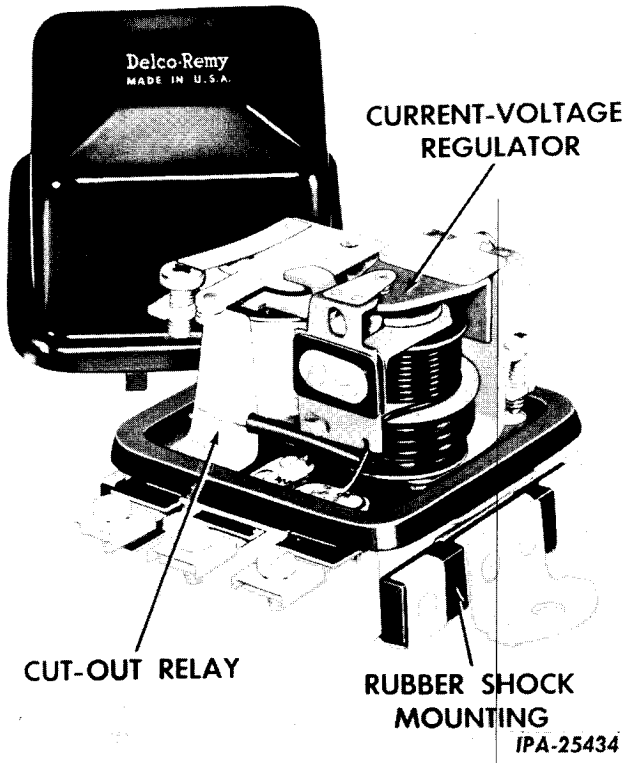
Illust. 7 - Voltage Setting, Voltage Regulator Unit (Three-Unit Regulator).

4. REPOLARIZING THE GENERATOR

The generator must be repolarized 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 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. Establishing the proper polarity is important.

5. OPERATION OF CURRENT-VOLTAGE REGULATOR

The combined current-voltage type or two unit regulator protects the battery by providing better control when the equipment is operated for days or weeks at a time with no electrical load other than the ignition coil and occasional cranking.



Illust. 8 - Combined Current-Voltage Regulator.

PRINTED IN UNITED STATES OF AMERICA

Although the combined current-voltage regulator is somewhat similar in appearance and construction to conventional voltage regulators, the two types are not interchangeable because of the difference in the wiring circuits. For the same reason, special testing procedures are also necessary. Follow the manufacturers' instructions furnished with the testing instruments.

The charging circuit consists of the battery, generator and combined current-voltage regulator. (Illust. 8.) The combined current-voltage regulator consists of two units, a cutout relay and a combination current-voltage regulator.

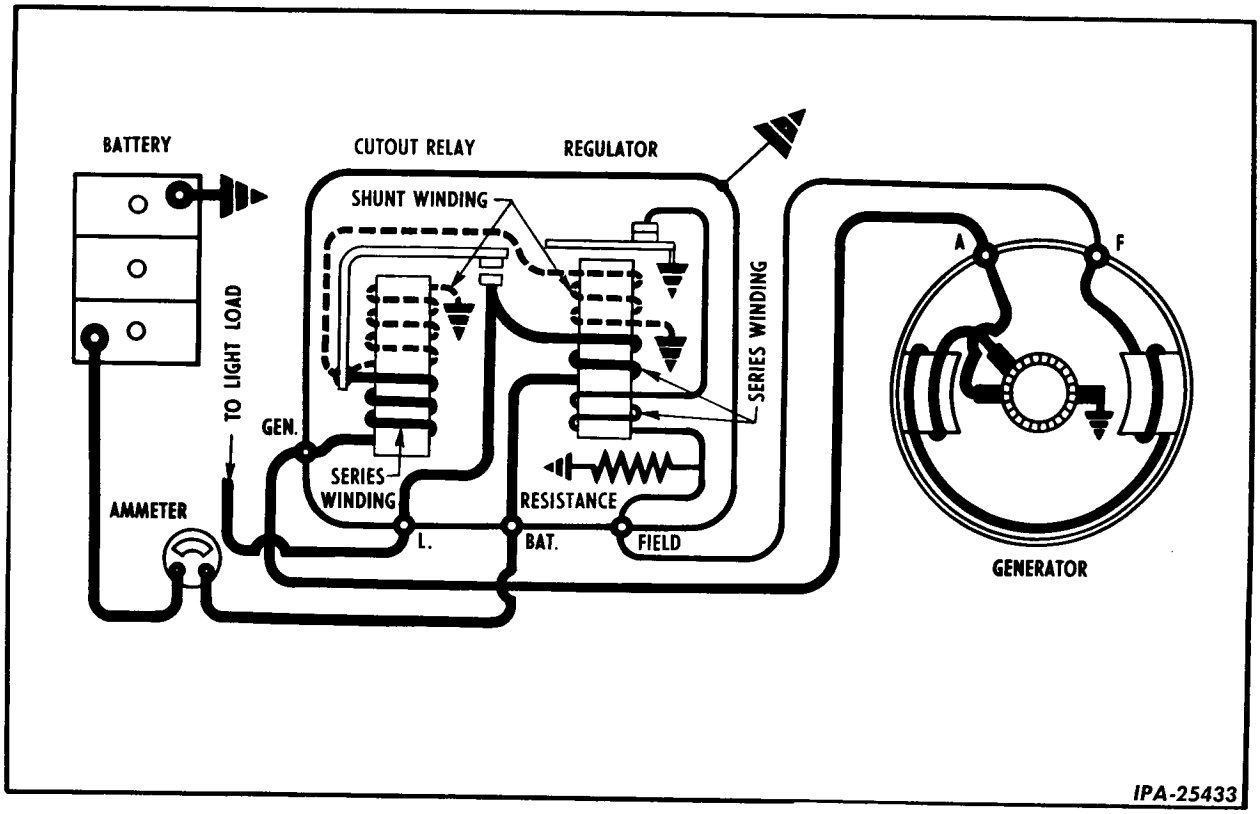
Cutout Relay Operation

The cutout relay points are open when the generator is not operating, thus preventing the battery from discharging through the generator. When the generator begins to operate, voltage builts up in the two relay windings, the series winding and the shunt winding. This creates two magnetic fields which, working together, overcome the armature spring tension and close the points.

The shunt winding is the working coil and does most of the work in attracting the armature. With the point closed, the circuit between the generator and the battery is complete. Current flowing from the generator to the battery passes through the series winding of the relay in the proper direction to add to the magnetism which holds the points closed.

When the generator slows or stops, and the battery voltage is higher than the generator voltage, current flows from the battery to the generator. It flows through the shunt winding in the same direction as before, but the direction of current flow through the series winding is reversed, and this causes the magnetic fields of the two windings to oppose each other. As a result, the total magnetic field is no longer strong enough to hold the armature down and the spring tension pulls the armature away from the winding core and the points open, breaking the circuit between the battery and the generator.

continued on next page



Illust. 9 - Wiring Circuit of Combined Current-Voltage Regulator.

5. OPERATION OF CURRENT-VOLTAGE REGULATOR - Continued

Current-Voltage Regulator Action

The combined current-voltage regulator consists of a voltage-sensitive shunt winding and a current-sensitive series winding wound on the same core. Both windings work together to insert a resistance in the field circuit. This regulator is of the vibrating type. Due to the added safety feature of preventing excessive overcharging, the charging rate will never exceed 50% of generator capacity, regardless of battery condition.

A feature of the combined current-voltage regulator is that generator output increases as the electrical load is added to the "L" terminal of the regulator. Since the load current bypasses the regulator current winding, it has no effect on the battery charging rate as long as the total load does not exceed the maximum output, which is controlled by the third brush of the generator at operating speed.

6. ADJUSTMENT AND REPAIR OF CURRENT-VOLTAGE REGULATOR

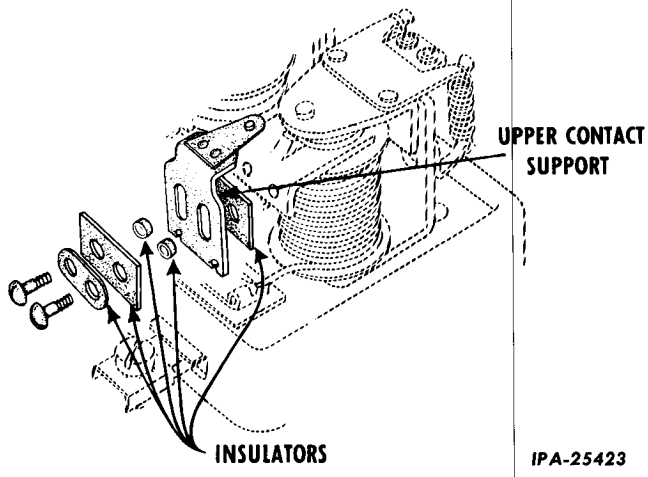
NOTE: Because of similarities in the two unit and three unit regulators, the procedure for "checking" and "adjusting" are common for both.

If the regulator fails to operate or if tests show that the units are outside specifications, check and the adjust according to the procedures given for the three unit regulator in Par. 3, "ADJUSTMENTS."

To avoid damaging the wire-wound resistor beneath the base, extreme care must be used in removing and replacing the cover. In order that a good seal will be obtained, be sure the rubber gasket is compressed before the cover tangs are forced over.

Cleaning Contact Points

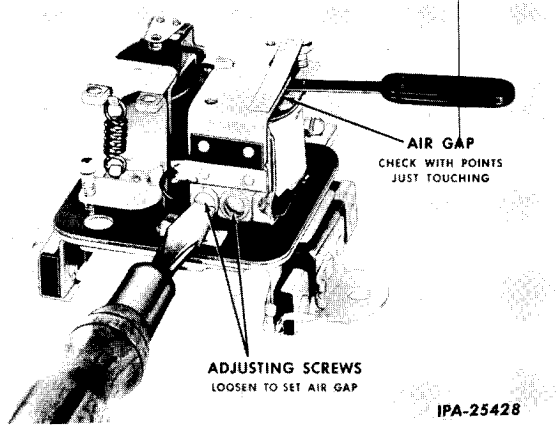
For cleaning the contact points, refer to the instructions given in Par. 3 and Illust. 10.



Illust. 10 - Disassembly of Upper Contact Support for Cleaning or Replacement.

Cutout Relay Unit

The cutout relay requires three checks and adjustments; air gap, point opening and closing voltage. The air gap and point opening adjustments are made with the battery disconnected.



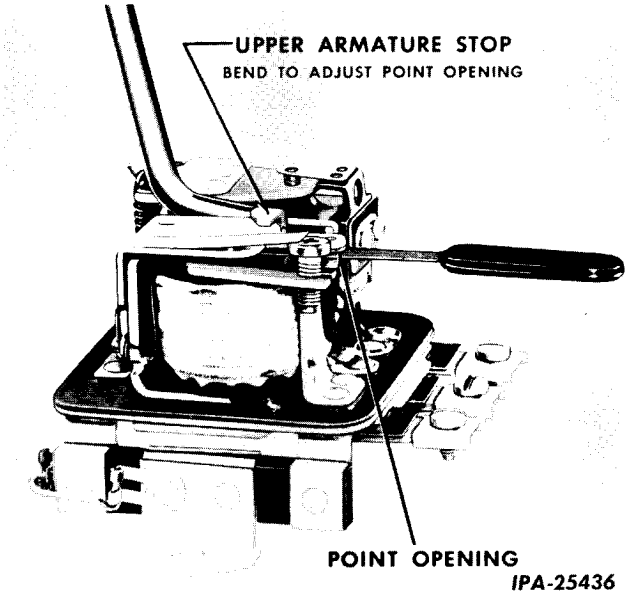
Illust. 11 - Cutout Relay Air Gap Check and Adjustment.

1. AIR GAP: (Illust. 11) Refer to "SPECIFICATIONS," in Section 1.

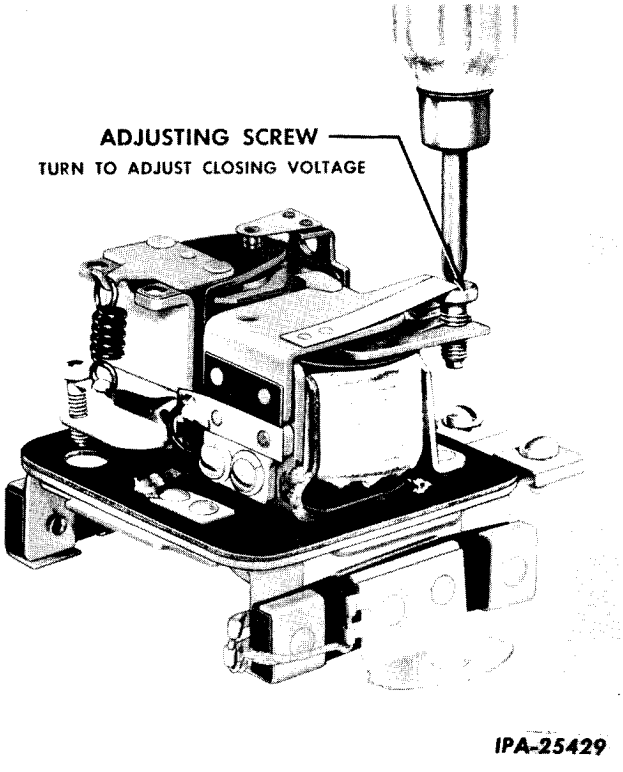
2. POINT OPENING: (Illust. 12) Refer to "SPECIFICATIONS," in Section 1.

3. CLOSING VOLTAGE: (Illust. 13) Refer to "SPECIFICATIONS," in Section 1.

PRINTED IN UNITED STATES OF AMERICA



Illust. 12 - Cutout Relay Point Opening Check and Adjustment.



Illust. 13 - Adjustment of Cutout Relay Closing Voltage.

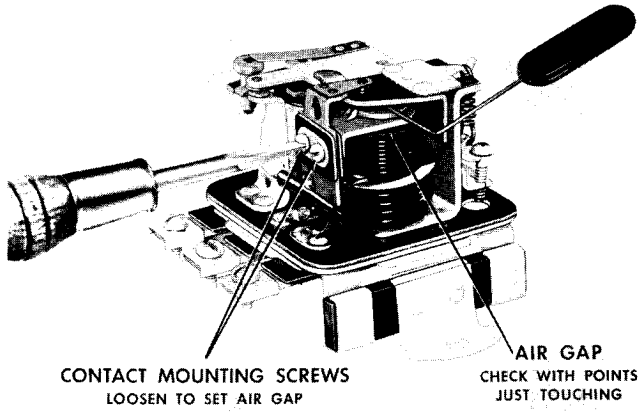
Current-Voltage Unit

The current-voltage unit requires two checks and adjustments; air gap and voltage setting.

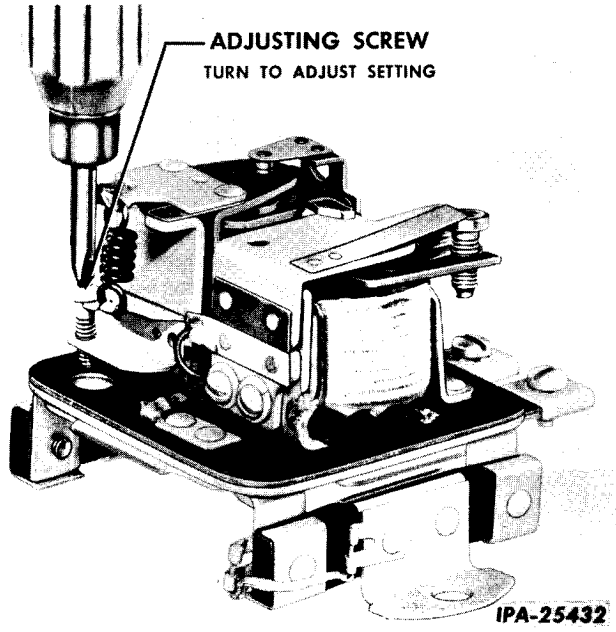
1. AIR GAP: (Illust. 14) Refer to "SPECIFICATIONS," in Section 1.

2. VOLTAGE SETTING: (Illust. 15) Refer to "SPECIFICATIONS," in Section 1.

continued on next page



Illust. 14 - Current-Voltage Unit Air Gap Check and Adjustment.



Illust. 15 - Adjusting Voltage Setting of Current-Voltage Regulator Unit.

6. ADJUSTMENT AND REPAIR OF CURRENT-VOLTAGE REGULATOR - Continued

Current-Voltage Unit - Continued

CAUTION: If the 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 the screw counterclockwise until there is sufficient clearance between the screw head and spring support; then, carefully bend the spring support upward, with small pliers, until contact is made with the screw head. Final setting of the unit should always be approached by increasing spring tension; never by reducing it. In other words, if the setting is found to be too high, the unit should be adjusted below the required value and then raised to the exact setting by increasing the spring tension. Be sure that the screw is exerting force on the hanger.

Regulator Spring Replacement

When the current-voltage unit is out of adjustment or requires spring replacement, the following procedures must be followed:

When installing a new spring, care must be taken to avoid bending or distorting the spring supports or armature hinge. Preferably the spring should be hooked at the lower end first and then stretched upward (by means of a screwdriver blade inserted between the turns or by the use of any other suitable tool) until the upper end of the spring can be hooked. Do not try to pry the upper end of the spring over the spring support. Adjust as described under "VOLTAGE SETTING OF CURRENT-VOLTAGE UNIT."

Replacing Contact Support Bracket

The current-voltage unit contact support bracket can be replaced by following the diagram as shown in Illust. 10. New bushings should always be used when installing a contact support bracket since the old bushing may be distorted or damaged.

PRINTED IN UNITED STATES OF AMERICA

IGNITION COIL

1. DESCRIPTION

The ignition coil transforms the low voltage of the batteries or generator into high voltage sufficient to jump the gap 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, rain, snow and high pressure washing, particularly when the engine and the coil are hot after working, will 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 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 new.

4. INSTALLATION

Install the coil in the reverse order of removal. Be sure the connections are secure.

SPARK PLUGS

5. DESCRIPTION

Spark plugs are 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 combustion chamber.

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.

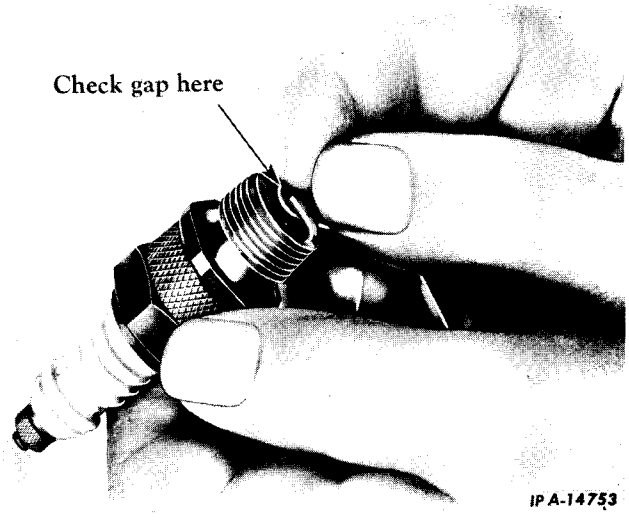
1. Disconnect the spark plug cables.

2. Unscrew the spark plugs with a standard spark plug wrench and flex handle. Remove the spark plugs and gaskets.

7. INSPECTION AND REPAIR

1. Remove oil deposits using a solvent and blow dry with compressed air. Sand blasting is the recommended method to remove carbon deposits found between the porcelain and the spark plug body. Plugs should be cleaned at 125 hour intervals to maintain proper performance.

Continued on next page.



Illust. 1 - Checking the Spark Plug Gap.

SPARK PLUGS

7. INSPECTION AND REPAIR - Continued

2. Never use any cleaning material on the insulator 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.

3. Never scrape the insulator.

4. Never bend the center electrode as this will cause straining or cracking of the porcelain insulator. If the electrode burns off shorter than the shell skirt, replace the plug.

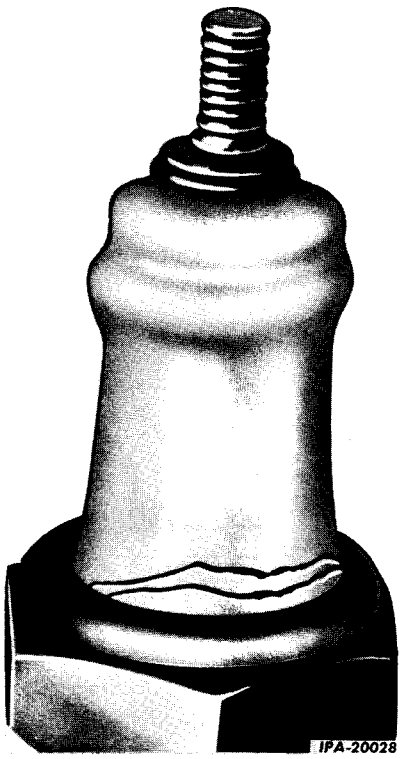
5. Never use graphite or other lubricants on the threads of spark plugs.

6. When removing or installing spark plugs, use only a correctly fitting socket wrench. An end wrench can easily slip and break the porcelain.

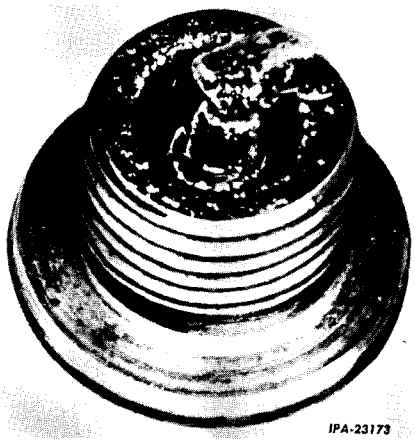
7. Do not screw a cold spark plug tightly into a hot cylinder head. Allow the cylinder head to cool first and then properly torque it.

8. If a spark plug is thought to be faulty, it should be tested in a spark plug tester.

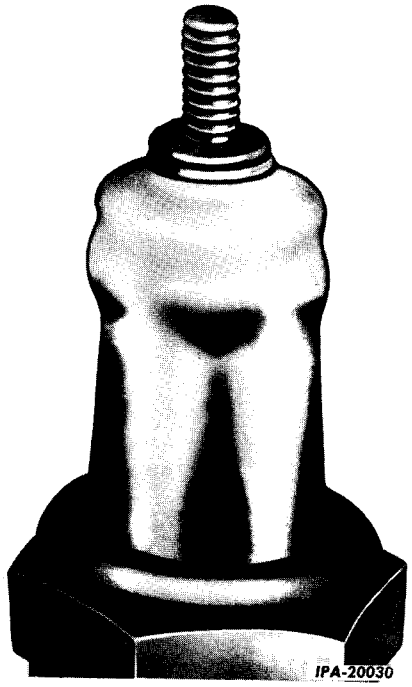
INSPECTION	REMEDY
1. Inspect for cracked or blistered porcelain . .	Replace spark plugs as necessary.
2. Inspect for dirty or burned electrodes	Clean dirty electrodes by scraping, brushing, or sand blasting. Replace spark plugs having excessively burned electrodes. The sparking surface should be filed flat to obtain maximum firing surface.
3. Check gap between electrodes	Adjust to dimension shown in "SPECIFICATIONS", Section 1.
4. Inspect cables for defective insulation	Replace oil-soaked, worn, cracked or otherwise damaged cables to eliminate the possibility of misfiring from this source.



Illust. 2 - Broken Insulator (Careless Handling).



Illust. 3 - Carbon Coating (Rich Mixture, Oil Pumping, or Cold Plug).



Illust. 4 - Streaked Insulator Top (Blow-by).

PRINTED IN UNITED STATES OF AMERICA

SPARK PLUGS

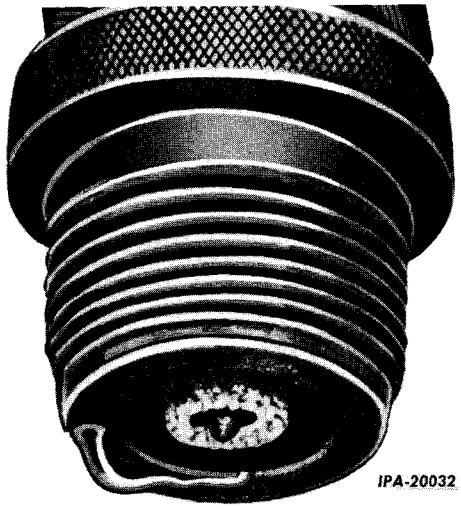
8. INSTALLATION

1. Before installing the spark plugs, clean the seat around the spark plug holes in the cylinder head.

2. Check the spark plug gaps. (Illust. 1.) (Refer to "SPECIFICATIONS," Section 1.)

3. Screw the spark plugs into the cylinder head using a new copper gasket with each one. 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 27 to 34 ft. lbs. If a torque wrench is not available, tighten plug 1/2 to 3/4 turns past finger tight.

4. Connect the spark plug cables in the proper firing order.

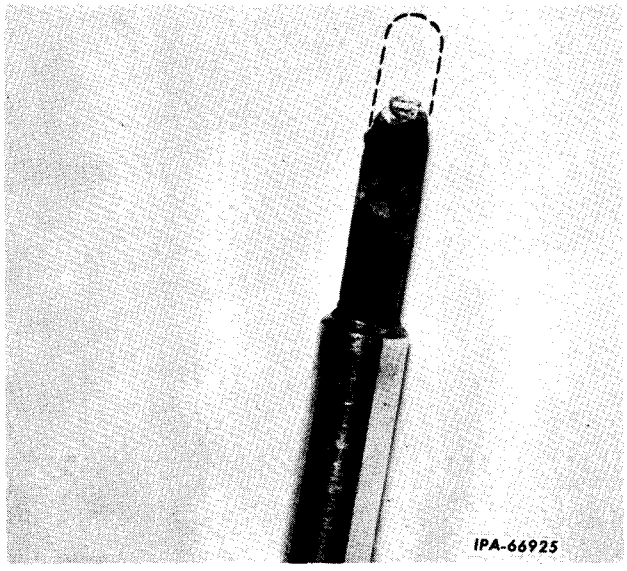


Illust. 5 - Badly Burned (Pre-ignition or Poor Cooling).

GLOW PLUGS

9. DESCRIPTION

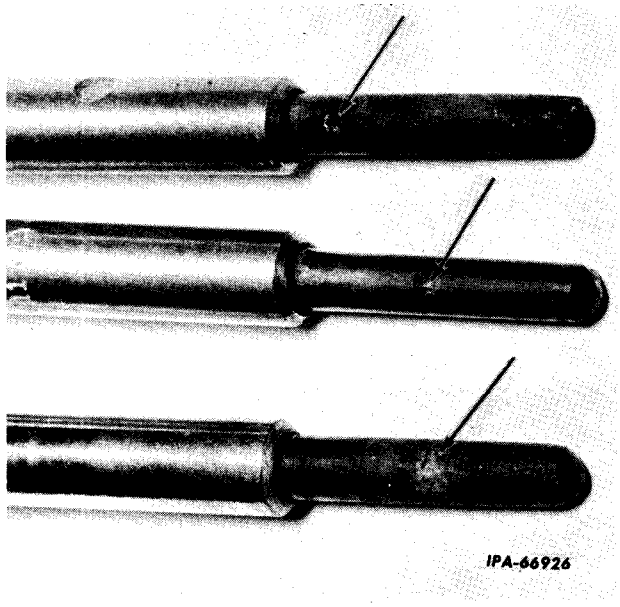
A glow plug is primarily a heating element. IH direct starting diesel 236 and 282 series engines are equipped with glow plugs, their purpose being to ignite the fuel sprayed into the precombustion chambers at the time the engine is being started. (Refer to operator's manual for starting procedures.) (Refer to Illust. 8.)



Illust. 6 - Tip Burned Away.

Caused by:

1. Leaking nozzle valve.
2. End of useful life.



Illust. 7 - Sheath Ruptured.

Caused by:

1. Excessive starting voltage by using high voltage booster.
2. Excessive torque.
3. Internal short against sheath.

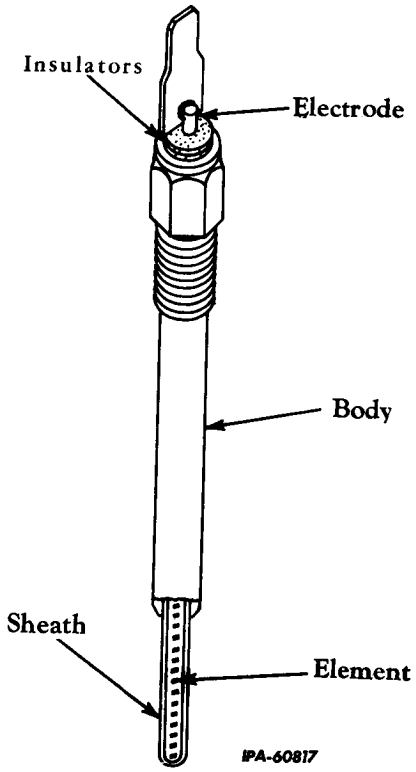
10. REMOVAL

1. Remove all the terminal connections to the glow plugs.

GLOW PLUGS

10. REMOVAL - Continued

2. Remove the plugs carefully with a 3/8 inch box wrench or a deep socket.



Illust. 8 - Glow plug showing cutaway of sheath and element.

11. CLEANING AND INSPECTION

1. Due to operating temperatures, no great amount of carbon will form on the glow plugs under normal conditions.

2. Excessive carbon deposits may be scraped off if and when necessary.

Clean the threads with a brass wire brush and cleaning solution.

3. Inspect the glow plugs for erosion or burned or ruptured sheath. Refer to Illusts. 6 and 7. Be sure the terminal connection or "spade" is not cracked or broken.

CAUTION: If a test of the glow plug is desired, DO NOT make a connection to the plug unless it is screwed into a nozzle to help dissipate the heat, and observe the results quickly and disconnect the current. The plug will be damaged if checked out in the open.

When tips are burned away, check the nozzle valve as outlined in Section 3 in the Roosa Master Injection Pump Service Manual, ISS-1042. Recondition the nozzle valve or replace.

12. CHECKING FOR DEFECTIVE GLOW PLUGS

Machines with Glow Plug Meter

When the glow plug meter pointer is in the "CHECK" zone, one or more of the glow plugs are defective and must be replaced. Check as follows:

1. Press the glow plug switch (push type) and note the meter reading. Release the switch.

2. Disconnect the wire to the glow plug in No. 1 cylinder.

3. Press the glow plug switch and again observe the meter reading. If the pointer has moved slightly to the left (further into the check zone) from the original reading, the glow plug is functioning. If the reading is the same as the original reading, the glow plug is defective and must be replaced. Connect the wire to the No. 1 plug before checking the No. 2 glow plug.

4. Check all the remaining glow plugs in the same manner. Be sure that the wire to the glow plug is connected again before checking the next glow plug.

Machines with Ammeter

1. Check the headlight and key switches to be sure they are in the "OFF" position.

2. Disconnect the terminal wires from all of the glow plugs except No. 1.

CAUTION: Tape the end of each terminal wire as it is disconnected to avoid accidental grounding and danger of fire during test.

3. Press the glow plug button. The ammeter will show a discharge of approximately eight amperes if the glow plug is good. If the glow plug is defective, there will be no discharge indicated.

4. Disconnect the terminal wire from No. 1 glow plug and tape the terminal. Connect the No. 2 terminal wire to No. 2 glow plug and check in the same manner as Step 3.

5. Continue the same procedure until all the glow plugs have been checked, replacing any defective plugs as found. (Refer to "SPECIFI-

PRINTED IN UNITED STATES OF AMERICA

GLOW PLUGS

CATION" in Section 1 for torquing procedure, and to Par. 13 for installation procedure.)

13. INSTALLATION

1. To facilitate removal of the glow plugs from engines that have been in service, coat the threads with "Never-Seez" (Part No. 999 617 R1) whenever installing the glow plugs.

2. Install the glow plugs. When the plugs are properly torqued and seated, the tapered step on the plug body is securely seated against the seat in the bottom of the nozzle body retainer with approximately three of the threads exposed.

3. Tighten the glow plugs to proper torque as given in "SPECIFICATIONS" in Section 1.

STORAGE BATTERY

14 GENERAL

A storage battery is an electrochemical device for converting chemical energy into electrical energy. The battery has three major functions:

(a) To provide a source of current for cranking the engine.

(b) To act as a stabilizer to the voltage in the electrical system.

(c) It can, for a limited period, furnish current when the electrical demands of the vehicle exceeds 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 system, or excessive use of accessories.

5. Dirt and electrolyte on top of battery causing a constant drain.

6. Hardened battery plates, commonly called "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, warped plates, broken terminal, 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 Step 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 and prevent recurrence of the trouble.

STORAGE BATTERY

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. This may be important when analyzing the results of the electrical tests.

7. Inspect electrolyte level. If electrolyte is below the top of the plates, add 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. (Paragraph 20.)

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 the temperature and the true specific gravity determined.

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 table following.

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

Test Indications

1.250 to 1.290 specific gravity - normal state of charge.

1.290 specific gravity or above - Possible overcharging; voltage regulator setting and regulator ground must be tested.

PRINTED IN UNITED STATES OF AMERICA

STORAGE BATTERY

Less than 1.250 specific gravity - Undercharged; entire charging system must be tested.

Specific gravity readings vary .025 or more between cells - Loss of acid or defective cell.

CAUTION: Some tractor batteries and "stay-full" type 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.

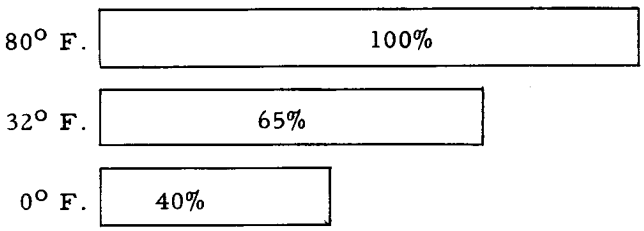
18. FREEZING POINTS OF ELECTROLYTE

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.

19. EFFECT OF LOW TEMPERATURES ON BATTERY PERFORMANCE

Battery capacity is greatly reduced by cold, as cold has a decided retarding 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.



20. BATTERY TEST INDICATIONS AND RECOMMENDATIONS

POSSIBLE CAUSE	RECOMMENDATIONS
SPECIFIC GRAVITY ABOVE 1.290	The battery is overcharged. See NOTE 2 on next page.
SPECIFIC GRAVITY BELOW 1.225	The battery is undercharged. Recharge to full specific gravity. See NOTE 1 on next page.
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 recharging at a very slow rate. 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.

Continued on next page.

STORAGE BATTERY

20. BATTERY TEST INDICATIONS AND RECOMMENDATIONS - Continued

POSSIBLE CAUSE	RECOMMENDATIONS
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.