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

When changes and improvements are made in our products, periodic revisions may be made to this manual to keep it up-to-date. It is suggested that customers contact their dealer for information on the latest revision.

ENGINE & FUEL SYSTEM
C-123, C-135, C-146 & C-153
Engines

GSS-1295-J W/Revision 2
March, 1977

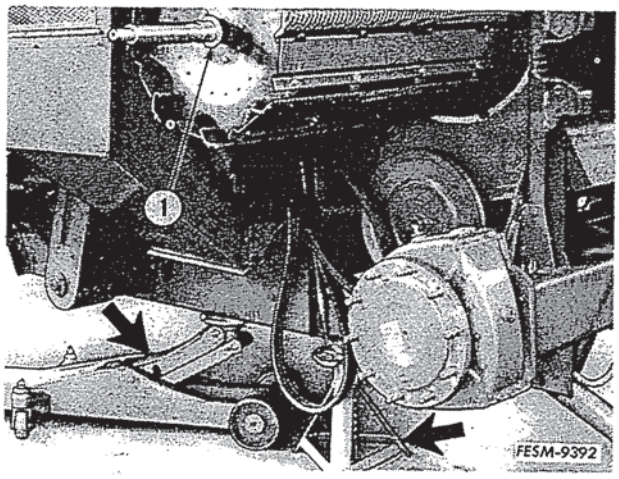
General Contents

GSS-1295-J (Rev. No. 2)

Printed in United States of America

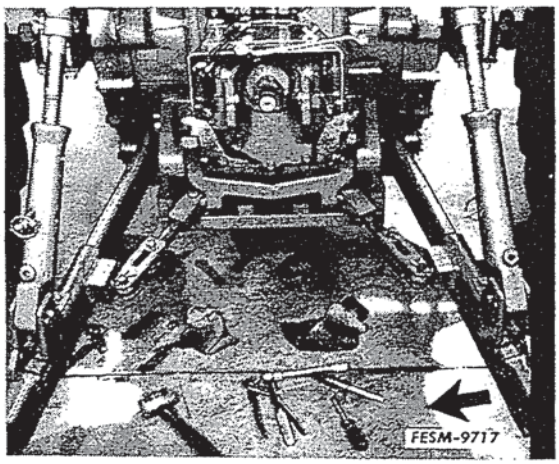
WORK SAFELY – FOLLOW THESE RULES

This symbol is used to call your attention to instructions concerning your personal safety. Be sure to observe and follow these instructions.

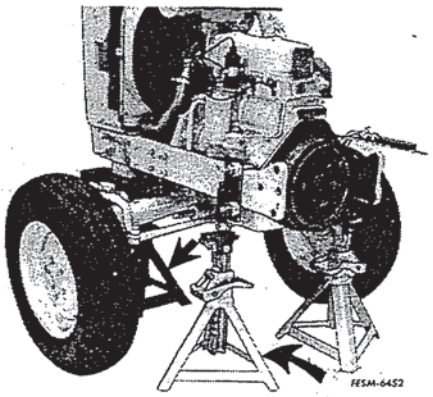


1. Always use safety stands in conjunction with hydraulic jacks or hoists. Do not rely on the jack or hoist to carry the load, they could fail.

2. Always wear safety glasses when using a hammer, chisel or other tools that may cause chips to fly.

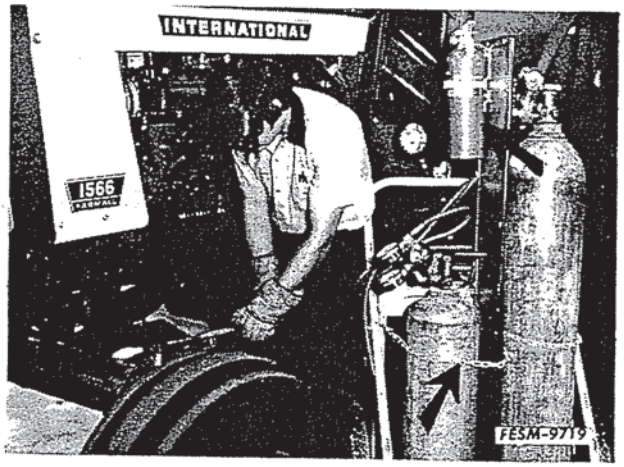


3. Keep work area organized and clean. Wipe up oil or spills of any kind. Keep tools and parts off of the floor. Eliminate the possibility of a fall which could result in a serious injury.

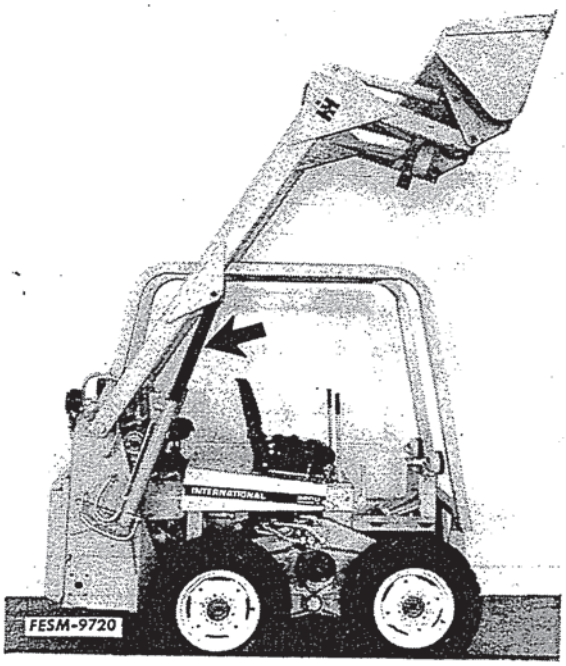


4. When splitting tractors, or disassembling machines, be sure to use safety stands and adequate supports to prevent tipping or roll-over.

5. Use a safety catch on all hoist hooks. Do not take a chance, the load could slip off of the hook.



6. When using an acetylene torch always wear welding goggles and gloves. Keep a "charged" fire extinguisher within reach. Be sure the acetylene and oxygen tanks are separated by a metal shield and are chained to the cart. Do not weld or heat areas near fuel tanks or fuel lines and utilize proper shielding around hydraulic tanks or hydraulic lines.



7. Always use a safety bar to block hydraulic cylinders. Never rely on the machine hydraulic system to hold when working on loaders etc. A hydraulic line or cylinder could fail or someone could accidently strike the control levers causing the loader to fall.

8. When reassembling subassemblies, parts, hoses, hydraulic lines, fuel lines, wiring etc., be sure they are positioned properly for alignment and clearance with related parts to their original setting and/or position.

9. Electrical storage batteries give off highly inflammable hydrogen gas when charging and and continue to do so for some time after receiving a steady charge. Do not under any circumstances allow an electric spark or an open flame near the battery. Do not lay tools across battery terminals as this may result in a spark or short circuit which may cause an explosion. Be careful to avoid spilling any electrolyte on hands or clothing.

10. Hydraulic fluid escaping under pressure can have enough force to penetrate the skin. Hydraulic fluid may also infect a minor cut or opening in the skin. If injured by escaping fluid, see a doctor at once. Serious infection or reaction can result if medical treatment is not given immediately.

Do not attempt to repair or tighten hoses that are under pressure, when the boom is raised, or with the tractor engine running. Cycle all hydraulic control valves to relieve all pressure before disconnecting the lines or performing other work on the hydraulic system. Make sure all connections are tight and hoses and lines are in good condition before applying pressure to the system. To locate a leak under pressure, use a small piece of cardboard or wood. Never use hands.

11. When refueling, keep the hose and nozzle or the funnel and container in contact with the metal of the fuel tank to avoid the possibility of an electric spark igniting the fuel. Do not overfill the fuel tank — overflow creates fire hazard. Do not smoke when refueling. Never refuel when engine is hot or running.

12. Always use a protective fixture when inflating tubeless tires that have been repaired or are loose on the rim. Do not inflate over 30 psi to seat the tire bead.

13. Use pullers to remove bearings, bushings, gears, cylinder sleeves etc. when applicable. Use hammers, punches and chisels only when absolutely necessary. Then, be sure to wear safety glasses.

14. Never use trouble lights or electric powered tools that have cut and/or damaged cords or plugs. Be sure all electric tools are properly grounded.

15. Be careful when using compressed air to dry parts. Use approved air blow guns, do not exceed 30 psi, wear safety glasses or goggles and use proper shielding to protect everyone in the work area.

16. Do not wear rings, wrist watches or loose fitting clothing when working on machinery, they could catch on moving parts causing serious injury.

17. Excessive or repeated skin contact with sealants or solvents may cause skin irritation. In case of skin contact, remove sealant or solvent promptly by washing with soap and water.

IMPORTANT: The above is only a partial list of safe work rules. In addition, always refer to the Operator's Manual for the specific machine for additional safe work rules regarding the machine operation.

STANDARD TORQUE DATA FOR NUTS AND BOLTS— FOOT POUNDS

Recommended torque for all Standard Application Nuts and Bolts, provided:

A. All thread surfaces are clean and lubricated with SAE-30 engine oil. (See NOTE.)

B. Joints are rigid, that is, no gaskets or compressible materials are used.

C. When reusing nuts or bolts use minimum torque values.

NOTE: Multiply the standard torque by:

.65 when finished jam nuts are used.
.70 when Molykote, white lead or similar mixtures are used as lubricants.
.75 when parkerized bolts or nuts are used.
.85 when cadmium plated bolts or nuts and zinc bolts w/waxed zinc nuts are used.
.90 when hardened surfaces are used under the nut or bolt head.

1 FOOT POUND = 1.355 NEWTON METERS

Bolt or Stud Diameter		Type 1 Studs Only		Type 1 Bolts 6" length or less		Type 1 Bolts longer than 6"		Type 5 (all lengths)		Type 8 (all lengths)			
										Only when used† in cast (gray) iron		All other applications	
Inches	MM	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1/4	6.4	5	6	5	6	3	3	9	10	11	13	12	14
5/16	8.0	12	13	12	13	6	7	19	21	24	27	27	30
3/8	9.5	21	24	21	24	11	13	33	37	43	47	45	50
7/16	11.1	35	38	35	38	19	21	53	60	69	76	75	85
1/2	12.7	52	58	52	58	29	32	80	90	104	117	115	130
9/16	14.3	70	80	70	80	41	46	115	130	150	170	165	185
5/8	15.9	98	110	98	110	57	63	160	180	210	230	220	250
3/4	19.0	174	195	174	195	100	112	290	320	350	390	400	450
7/8	22.2	300	330	162	181	162	181	420	470	570	630	650	730
1	25.4	420	470	250	270	250	270	630	710	850	950	970	1090
1-1/8	28.6	600	660	350	380	350	380	850	950	1200	1350	1380	1550
1-1/4	31.8	840	940	490	540	490	540	1200	1350	1700	1900	1940	2180
1-3/8	34.9	1100	1230	640	710	640	710	1570	1760	2300	2500	2600	2800
1-1/2	38.1	1470	1640	850	940	850	940	2000	2300	3000	3300	3300	3700
1-3/4	44.5	2350	2450	1330	1490	1330	1490	3300	3700	4700	5200	5300	6000
2	50.8	3500	3900	2000	2200	2000	2200	5000	5500	7000	7800	8000	9000

†When bolt penetration is 1-1/2 times the diameter of the bolt.

BOLT TYPE IDENTIFICATION CHART

IH TYPE	S.A.E. GRADE	DESCRIPTION	BOLT HEAD MARKING *
1	1 or 2 (equivalent)	WILL HAVE A IH STANDARD MONOGRAM IN THE CENTER OF THE HEAD Low or Medium Carbon Steel Not Heat Treated	
5	5	WILL HAVE A IH AND 3 RADIAL LINES Quenched and Tempered Medium Carbon Steel	
8	8	WILL HAVE A 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 an IH or a raised dot which previously identified IH bolts.

STANDARD TORQUE DATA FOR NUTS AND BOLTS— NEWTON METERS

Recommended torque for all Standard Application Nuts and Bolts, provided:

A. All thread surfaces are clean and lubricated with SAE-30 engine oil. (See NOTE.)

B. Joints are rigid, that is, no gaskets or compressible materials are used.

C. When reusing nuts or bolts use minimum torque values.

NOTE: Multiply the standard torque by:

.65 when finished jam nuts are used.
.70 when Molykote, white lead or similar mixtures are used as lubricants.
.75 when parkerized bolts or nuts are used.
.85 when cadmium plated bolts or nuts and zinc bolts w/waxed zinc nuts are used.
.90 when hardened surfaces are used under the nut or bolt head.

1 NEWTON METER = 0.738 FOOT POUND

Bolt or Stud Diameter		Type 1 Studs Only		Type 1 Bolts 6" length or less		Type 1 Bolts longer than 6"		Type 5 (all lengths)		Type 8 (all lengths)			
										Only when used† in cast (gray) iron		All other applications	
Inches	MM	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1/4	6.4	7	8	7	8	4	4	12	14	15	18	16	19
5/16	8.0	17	18	17	18	8	10	26	29	33	37	37	41
3/8	9.5	29	33	29	33	15	18	45	50	58	64	61	68
7/16	11.1	48	52	48	52	26	29	72	81	94	103	102	115
1/2	12.7	71	79	71	79	39	43	108	122	141	159	156	176
9/16	14.3	95	108	95	108	56	62	156	176	205	230	225	250
5/8	15.9	133	149	133	133	77	85	220	245	285	310	300	340
3/4	19.0	240	265	240	265	136	152	390	430	470	530	540	610
7/8	22.0	400	450	220	245	220	245	570	640	770	850	880	990
1	25.4	570	640	340	365	340	365	850	960	1150	1290	1300	1480
1-1/8	28.6	810	900	470	510	470	510	1150	1290	1630	1830	1870	2100
1-1/4	31.8	1140	1270	660	730	660	730	1600	1830	2300	2600	2600	3000
1-3/8	34.9	1490	1670	870	960	870	960	2100	2400	3100	3400	3500	3800
1-1/2	38.1	2000	2200	1150	1270	1150	1270	2700	3100	4100	4500	4500	5000
1-3/4	44.5	3200	3300	1800	2000	1800	2000	4500	5000	6400	7000	7100	8100
2	50.8	4750	5300	2700	3000	2700	3000	6800	7500	9500	10500	10800	12200

†When bolt penetration is 1-1/2 times the diameter of the bolt.

BOLT TYPE IDENTIFICATION CHART

IH TYPE	S.A.E. GRADE	DESCRIPTION	BOLT HEAD MARKING *
1	Equivalent 1 or 2	WILL HAVE A IH STANDARD MONOGRAM IN THE CENTER OF THE HEAD Low or Medium Carbon Steel Not Heat Treated	
5	5	WILL HAVE A IH AND 3 RADIAL LINES Quenched and Tempered Medium Carbon Steel	
8	8	WILL HAVE A 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 an IH or a raised dot which previously identified IH bolts.

CONVERSION TABLE
—inches to millimeters—

Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
1	25.4	26	660.4	51	1295.4	76	1930.4
2	50.8	27	685.8	52	1320.8	77	1955.8
3	76.2	28	711.2	53	1346.2	78	1981.2
4	101.6	29	736.6	54	1371.6	79	2006.6
5	127.0	30	762.0	55	1397.0	80	2032.0
6	152.4	31	787.4	56	1422.4	81	2057.4
7	177.8	32	812.8	57	1447.8	82	2082.8
8	203.2	33	838.2	58	1473.2	83	2108.2
9	228.6	34	863.6	59	1498.6	84	2133.6
10	254.0	35	889.0	60	1524.0	85	2159.0
11	279.4	36	914.4	61	1549.4	86	2184.4
12	304.8	37	939.8	62	1574.8	87	2209.8
13	330.2	38	965.2	63	1600.2	88	2235.2
14	355.6	39	990.6	64	1625.6	89	2260.6
15	381.0	40	1016.0	65	1651.0	90	2286.0
16	406.4	41	1041.4	66	1676.4	91	2311.4
17	431.8	42	1066.8	67	1701.8	92	2336.8
18	457.2	43	1092.2	68	1727.2	93	2362.2
19	482.6	44	1117.6	69	1752.6	94	2387.6
20	508.0	45	1143.0	70	1778.0	95	2413.0
21	533.4	46	1168.4	71	1803.4	96	2438.4
22	558.8	47	1193.8	72	1828.8	97	2463.8
23	584.2	48	1219.2	73	1854.2	98	2489.2
24	609.6	49	1244.6	74	1879.6	99	2514.6
25	635.0	50	1270.0	75	1905.0	100	2540.0

1 inch = 25.4 millimeters

To convert inches to millimeters, the inch value to be converted should be written down, carried to as many decimal places as the desired accuracy requires. It should then be split into groups of not more than two figures each. The equivalent of each group should then be taken from the table, proper regard being given to the position of the decimal point in each case, and the equivalent of the inch value given.

For example, to convert 2.4635 inches to millimeters:

2.0000 inches = 50.80000 millimeters
.4600 inches = 11.68400
.0035 inches = .08890
2.4635 inches = 62.57290 millimeters
Correct to 3 decimal places.
2.4635 inches = 62.573 millimeters

Printed in United States of America

CONVERSION TABLE
—millimeters to inches—

Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches
1	0.03937008	26	1.0236220	51	2.0078740	76	2.9921260
2	0.07874016	27	1.0629921	52	2.0472441	77	3.0314961
3	.11811024	28	1.1023622	53	2.0866142	78	3.0708661
4	.15748031	29	1.1417323	54	2.1259842	79	3.1102362
5	.19685039	30	1.1811024	55	2.1653543	80	3.1496063
6	.23622047	31	1.2204724	56	2.2047244	81	3.1889764
7	.27559055	32	1.2598425	57	2.2440945	82	3.2283465
8	.31496063	33	1.2992126	58	2.2834646	83	3.2677165
9	.35433071	34	1.3385827	59	2.3228346	84	3.3070866
10	.3937008	35	1.3779528	60	2.3622047	85	3.3464567
11	.4330709	36	1.4173228	61	2.4015748	86	3.3858268
12	.4724409	37	1.4566929	62	2.4409449	87	3.4251968
13	.5118110	38	1.4960630	63	2.4803150	88	3.4645669
14	.5511811	39	1.5354331	64	2.5196850	89	3.5039370
15	.5905512	40	1.5748031	65	2.5590551	90	3.5433071
16	.6299213	41	1.6141732	66	2.5984252	91	3.5826772
17	.6692913	42	1.6535433	67	2.6377953	92	3.6220472
18	.7086614	43	1.6929134	68	2.6771654	93	3.6614173
19	.7480315	44	1.7322835	69	2.7165354	94	3.7007874
20	.7874016	45	1.7716535	70	2.7559055	95	3.7401575
21	.8267717	46	1.8110236	71	2.7952756	96	3.7795276
22	.8661417	47	1.8503937	72	2.8346457	97	3.8188976
23	.9055118	48	1.8897638	73	2.8740157	98	3.8582677
24	.9448819	49	1.9291339	74	2.9133858	99	3.8976378
25	.9842520	50	1.9685039	75	2.9527559	100	3.937008

1 mm = .03937008 inches

To convert millimeters to inches the millimeter value to be converted should be written down, carried to as many decimal places as the desired accuracy requires. It should then be split up into groups of not more than two figures each. The equivalent of each group should then be taken from the table, proper regard being given to the position of the decimal point in each case, and the equivalent of the several groups found by addition. This sum will be the inch equivalent of the millimeter value given.

For example to convert 75.384 millimeters to inches:

75.000 millimeters = 2.9527559 inches
.380 millimeters = .0149606
.004 millimeters = .0001574
75.384 millimeters = 2.9678739 inches
Correct to 5 decimal places.
75.384 millimeters = 2.96787 inches

SPECIAL SERVICE TOOLS REQUIRED

Section 1

FES 6-4	Valve guide driver (intake)
FES 6-5	Valve guide driver (exhaust)
FES 6-15	Oil seal retainer and seal installing tool (C-135, C-146 and C-153)
FES 22	Universal cylinder sleeve puller
FES 23-2	Pulling adapter plate (C-123 engine)
FES 23-3	Pulling adapter plate (C-135 engine)
FES 33-1	Fan drive puller (C-123 and C-135)
FES 33-4	Fan drive pulley wear sleeve installer
FES 52	Engine stand
FES 52-11	Attaching plate (C-123)
FES 52-12	Attaching ears, use with FES 52-11 (C-135, C-146 and C-153)
FES 101	Camshaft bearing puller and installing set
FES 108	Piston fitting set
SE 1721	Water pump seal installer

Section 2

FES 36	Fuel adjusting screw seat removal and installation tool
FES 36-1	Carburetor bushing remover for 1/4 inch bushings
FES 36-3	Carburetor liquid level hose assembly
FES 36-5	Screw starter
FES 36-6	1/4 inch adjustable bushing reamer
FES 36-8	Bushing driver for 1/4 inch bushing

Section 3

Ensign No. TSE-17885 - Bench Test Fixture

FES 36-1	Carburetor bushing remover for 1/4 and 5/16 inch bushings
FES 36-2	Bushing driver for 5/16 inch bushing
FES 36-4	Special plier for screw upsetting on throttle plate and choke shaft
FES 36-5	Screw starter
FES 36-7	5/16 inch adjustable bushing reamer

Refer to Agricultural Equipment Approved Service Tool Manual, GSS-1251-K for source and ordering proceedures.

Section 1

ENGINE

CONTENTS

SPECIFICATIONS

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
General					
Number of cylinders	4	4	4	4	4
Bore and stroke - inches	3-1/8 x 4	3-1/4 x 4-1/16	3-1/4 x 4-1/16	3-3/8 x 4-1/16	3-3/8 x 4-1/4
Displacement - cubic inches	123	135	135	146	153
Engine RPM (Governed)					
Low Idle					
F-140, I-140	425 ± 25	------	------	------	------
F-240, I-240	425 ± 25	------	------	------	------
F-340, I-340	------	425 ± 25	------	------	------
F-404, I-404	------	------	425 ± 25	------	------
I-424, 2424	------	------	------	425 ± 25	------
I-444, 2444	------	------	------	------	425 ± 25
F-504, I-504, 2504	------	------	------	------	425 ± 25
3514 Loader (w/s.n. 1705 and below)	------	------	------	------	650 ± 25
56, 57 Balers	425 ± 25	------	------	------	------

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
91 Combine	------	425 ± 25	------	------	------
93 Combine	------	------	------	------	425 ± 25
105 Combine	------	------	------	------	650 ± 25
203 Combine	------	------	------	------	650 ± 25
201 Windrower	------	425 ± 25	------	------	------
210 Windrower	------	------	------	------	650 ± 25
225 Hay Swather	------	------	------	------	650 ± 25
275 Windrower	------	------	------	------	650 ± 25
375 Windrower (w/s.n. H-200 and below)	------	------	------	------	650 ± 25
500 Crawler	------	------	------	425 ± 25	------
500 Series C Crawler	------	------	------	450 ± 25	------
2500 Constructall Tractor	------	------	------	------	425 ± 25
4000 Series Forklift	------	------	------	------	425 ± 25
5000 Series Forklift	------	------	------	------	425 ± 25
High Idle					
F-140, I-140	1575 ± 25	------	------	------	------
F-240, I-240	2200 ± 25	------	------	------	------

* Includes gasoline and distillate unless otherwise designated.

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
General--Continued					
High Idle - Continued					
F-340, I-340	------	2200 ± 25	------	------	------
F-404, I-404	------	------	2320 ± 25	------	------
I-424, 2424	------	------	------	2200 ± 25	------
I-444, 2444	------	------	------	------	2200 ± 25
F-504, I-504, 2504	------	------	------	------	2420 ± 25
3514 Loader (w/s.n. 1705 and below)	------	------	------	------	2570 ± 25
56, 57 Balers	2060 ± 25	------	------	------	------
91 Combine	------	2200 ± 25	------	------	------
93 Combine	------	------	------	------	2150 ± 25
105 Combine	------	------	------	------	2570 ± 25
203 Combine	------	------	------	------	2570 ± 25
201 Windrower	------	2200 ± 25	------	------	------
210 Windrower	------	------	------	------	2570 ± 25
225 Hay Swather	------	------	------	------	2570 ± 25
275 Windrower	------	------	------	------	2570 ± 25
375 Windrower (w/s.n. H-200 and below)	------	------	------	------	2570 ± 25
500 Crawler	------	------	------	2200 ± 25	------
500 Series C Crawler	------	------	------	2730 ± 25	------

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
2500 Constructall Tractor	------	------	------	------	2420 ± 25
4000 Series Forklift . . .	------	------	------	------	2200 ± 25
5000 Series Forklift . . .	------	------	------	------	2420 ± 25
Rated Load					
F-140, I-140	1400 ± 10	------	------	------	------
F-240, I-240	2000 ± 10	------	------	------	------
F-340, I-340	------	2000 ± 10	------	------	------
F-404, I-404	------	------	2000 ± 10	------	------
I-424, 2424	------	------	------	2000 ± 10	------
I-444, 2444	------	------	------	------	2000 ± 10
F-504, I-504, 2504	------	------	------	------	2200 ± 10
3514 Loader (w/s.n. 1705 and below)	------	------	------	------	2380 ± 10
56, 57 Balers	1800 ± 10	------	------	------	------
91 Combine	------	2000 ± 10	------	------	------
93 Combine	------	------	------	------	2000 ± 10
105 Combine	------	------	------	------	2380 ± 10
203 Combine	------	------	------	------	2380 ± 10

* Includes gasoline and distillate unless otherwise designated.

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
General—Continued					
Rated Load - Continued					
201 Windrower	------	2000 ± 10	------	------	------
210 Windrower	------	------	------	------	2380 ± 10
225 Hay Swather	------	------	------	------	2380 ± 10
275 Windrower	------	------	------	------	2380 ± 10
375 Windrower (w/s.n. H-200 and below)	------	------	------	------	2380 ± 10
500 Crawler	------	------	------	2000 ± 10	------
500 Series C Crawler	------	------	------	2500 ± 10	------
2500 Constructall Tractor	------	------	------	------	2200 ± 10
4000 Series Forklift	------	------	------	------	2000 ± 10
5000 Series Forklift	------	------	------	------	2200 ± 10
Horsepower (Rated) @ PTO Shaft (Rated eng. speed)					
F-140, I-140	23.7	------	------	------	------
F-240, I-240	31	------	------	------	------
F-340, I-340	------	36			
F-404, I-404					
Gas	------	------	36.7	------	------
LPG	------	------	33	------	------

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
I-424, 2424	------	------	------	35	------
I-504, 2504					
Gas	------	------	------	------	46.2
LPG	------	------	------	------	44.4
3514 Loader (w/s.n. 1705 and below)	------	------	------	------	46
500 Crawler	------	------	------	36	------
500 Series C Crawler	------	------	------	44	------
Compression ratio:					
Gas	7.3:1‡	7.6:1	7.5:1	7.6:1	7.5:1
LPG	------	------	7.8:1	------	7.8:1
** Compression pressure at cranking speed (150 rpm) with a motorite tester - psi:					
Gas	175 #	180	180	180	180
LPG	------	------	185	------	185

* Includes gasoline and distillate unless otherwise designated.

** Compression pressures are based on the following conditions: Engine warmed up, battery fully charged, throttle wide open and all spark plugs removed.

Compression gauge readings given will apply at sea level barometric pressure. For each 1000 feet above sea level deduct 3-1/2 percent. For engines with high altitude pistons, the readings given will apply at 5000 feet. Deposits in combustion chambers will increase readings to some extent.

‡ Distillate - 4.8:1

Distillate - 95

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
General—Continued					
Crankcase refill capacity - quarts	5	5	5	5	5
Firing order	1-3-4-2	1-3-4-2	1-3-4-2	1-3-4-2	1-3-4-2
Crankcase					
Cylinder bore dia. - inches	------	------	------	3.3750-3.3775	3.3750-3.3775
Maximum allowable diametrical wear (at top of ring travel) - inch	------	------	------	.006	.006
Depth of cylinder sleeve flange bore - inches	.222-.224	.222-.224	.222-.224	------	------
Tappet bore, I.D. - inches	.5615-.5630	.5615-.5630	.5615-.5630	.5615-.5630	.5615-.5630
Crankshaft and Main Bearings					
Type	Counterbalanced	Counterbalanced	Counterbalanced	Counterbalanced	Counterbalanced
Number of main journals	3	3	3	3	3
Main journal diameter - inches	2.124-2.125	2.244-2.245	2.6235-2.6245	2.6235-2.6245	2.6235-2.6245
Maximum allowable out-of-round - inch	.003	.003	.003	.003	.003

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Maximum allowable taper - inch	.003	.003	.003	.003	.003
Crankpin diameter - inches	1.749-1.750	1.809-1.810	2.059-2.060	2.059-2.060	2.059-2.060
Maximum allowable out-of-round - inch	.003	.003	.003	.003	.003
Maximum allowable taper - inch	.003	.003	.003	.003	.003
Main bearings, type	Precision	Precision	Precision	Precision	Precision
Main bearings, running clearance - inch	.0009-.0039	.0009-.0039	.0009-.0039	.0009-.0039	.0009-.0039
Maximum allowable main bearing running clearance - inch	.0055	.0055	.0055	.0055	.0055
Thrust bearing location	Rear main bearing	Rear main bearing	Rear main bearing	Rear main bearing	Rear main bearing
Thrust bearing end clearance - inch	.004-.010	.004-.010	.004-.010	.004-.010	.004-.010
Maximum allowable end clearance - inch	.012	.012	.012	.012	.012

* Includes gasoline and distillate unless otherwise designated.

NOTE: For Ignition Timing Specifications, Refer to Page 1-26.

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Camshaft					
Drive	Helical gear	Helical gear	Helical gear	Helical gear	Helical gear
Cam lobe lift (total) - inch					
Intake	.2400 ± .0020 †	.2400 ± .0020	.2740 ± .0020	.2740 ± .0020	.2740 ± .0020
Exhaust	.2400 ± .0020 †	.2400 ± .0020	.2780 ± .0020	.2780 ± .0020	.2780 ± .0020
Maximum allowable camshaft lobe wear - inch	.020	.020	.020	.020	.020
Front bearing journal diameter - inches	1.8110-1.8120	1.8110-1.8120	1.8110-1.8120	1.8110-1.8120	1.8110-1.8120
Center bearing journal diameter - inches	1.5770-1.5780	1.5770-1.5780	1.5770-1.5780	1.5770-1.5780	1.5770-1.5780
Rear bearing journal diameter - inches	1.4990-1.5000	1.4990-1.5000	1.4990-1.5000	1.4990-1.5000	1.4990-1.5000
Thrust taken by	Thrust plate	Thrust plate	Thrust plate	Thrust plate	Thrust plate
Number of bearings	3 (one replaceable two integral)	3 (one replaceable two integral)	3 (one replaceable two integral)	3 (one replaceable two integral)	3 (one replaceable two integral)
Bearing running clearance - inch	.0009-.0054	.0009-.0054	.0009-.0054	.0009-.0054	.0009-.0054
Maximum allowable running clearance - inch	.006	.006	.006	.006	.006
Camshaft end play	.003-.012	.003-.012	.003-.012	.003-.012	.003-.012

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Connecting Rods					
Type	I - Beam	I - Beam	I - Beam	I - Beam	I - Beam
Side clearance - inch	.005-.014	.005-.014	.005-.014	.005-.014	.005-.014
Bearing running clearance - inch	.0009-.0034	.0009-.0034	.0009-.0039	.0009-.0039	.0009-.0039
Maximum allowable bearing running clearance - inch	.006	.006	.006	.006	.006
Bearing type	Precision	Precision	Precision	Precision	Precision
Bearing O.D. and spread	1.876 + .030	1.9375 + .020	2.1875 + .020	2.1875 + .020	2.1875 + .020
Pistons					
Type	Cam ground	Cam ground	Cam ground	Cam ground	Cam ground
Material	Aluminum alloy	Aluminum alloy	Aluminum alloy	Aluminum alloy	Aluminum alloy
Overall length (std. alt.) - inches:					
Gasoline	3-47/64	3-31/64	3-45/64	3-31/64	3-31/64
Distillate	3-31/64	------	------	------	------

* Includes gasoline and distillate unless otherwise designated.

† Engines with serial number 95097 and up: Intake .2740 ± .0020
Exhaust .2780 ± .0020

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Pistons—Continued					
Diameter - inches	3.1232-3.1257	3.2482-3.2507	3.2482-3.2507	3.3735-3.3760	3.3735-3.3760
Skirt clearance, bottom - inch (measured at 90° from pin hole) (Refer to instructions on page 1-39)	.0011-.0019	.0011-.0019	.0011-.0019	.0010-.0020	.0010-.0020
Number of rings per piston	3	3	3	3	3
Piston pin hole bore - inch	.9195-.9198	.8593-.8596	.8593-.8596	.8593-.8596	.8593-.8596
Width of ring groove:					
Top compression - inch	.0965-.0975	.0965-.0975	.0965-.0975	.0965-.0975	.0965-.0975
Second compression - inch	.095-.096	.095-.096	.095-.096	.095-.096	.095-.096
Oil control - inch	.2505-.2515	.1880-.1890	.1885-.1895	.1885-.1895	.1885-.1895
Ring clearance in groove:					
Top compression - inch	.0030-.0045	.0030-.0045	.0030-.0045	.0030-.0045	.0030-.0045
Second compression - inch	.0015-.0030	.0015-.0030	.0015-.0030	.0015-.0030	.0015-.0030
Oil control - inch	.0015-.0030	.0015-.0030	.0015-.0030	.0020-.0035	.0020-.0035

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Piston Pins					
Type	Full floating	Full floating	Full floating	Full floating	Full floating
Diameter - inch	.9192-.9195	.8591-.8593	.8591-.8593	.8591-.8593	.8591-.8593
Length - inches	2.483-2.493	2.738-2.753	2.738-2.753	2.738-2.753	2.738-2.753
Clearance between end of pin and retainer ring - inch	.005-.039	.005-.039	.005-.055	.005-.055	.005-.055
Maximum allowable clearance in rod bushing - inch	.004	.004	.003	.003	.003
Maximum allowable clearance in piston - inch	.0025	.0025	.0025	.0025	.0025
Piston Rings					
Compression:					
Number of rings per piston	2	2	2	2	2
Type:					
Top	Chrome, thickwall	Chrome, thickwall	Chrome, thickwall	Chrome, thickwall	Chrome, thickwall
Second	Plain	Plain	Plain	Plain	Plain

* Includes gasoline and distillate unless otherwise designated.

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Piston Rings—Continued					
Width of ring:					
Top	.0930-.0935	.0930-.0935	.0930-.0935	.0930-.0935	.0930-.0935
Second	.0930-.0935	.0930-.0935	.0930-.0935	.0930-.0935	.0930-.0935
Oil Control Rings					
Type	Chrome wide slot	Chrome wide slot	Chrome wide slot	Chrome wide slot	Chrome wide slot
Number per piston	1	1	1	1	1
Width - inch	.2485-.2490	.1860-.1865	.1860-.1865	.1860-.1865	.1860-.1865
Ring gap	See Note	See Note	See Note	See Note	See Note
Cylinder Sleeves					
Type	Wet, replaceable	Wet, replaceable	Wet, replaceable	------	------
Diameter, inside - inches	3.1252-3.1272	3.2502-3.2522	3.2502-3.2522	------	------
Length - inches	7.000	7.000	7.000	------	------

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Flange thickness - inch	.227-.229	.227-.229	.227-.229	------	------
Depth of cylinder sleeve flange bore in crankcase - inch	.222-.224	.222-.224	.222-.224	------	------
Maximum allowable diametrical sleeve wear (at the top of ring travel) (out-of-round) - inch	.006	.006	.006	------	------
Top surface of cylinder sleeve flange extends above top surface of crankcase - inch	.003-.007	.003-.007	.003-.007	------	------
Cylinder sleeve taper (top to bottom of piston travel) - inch	.005	.005	.005	------	------
Valves					
Head diameter:					
Intake:					
Gasoline - inches	1.495-1.505	1.495-1.505	1.495-1.505	1.495-1.505	1.495-1.505
Distillate - inches	1.337-1.347	------	------	------	------
Exhaust					
Gasoline - inches	1.307-1.317	1.307-1.317	1.307-1.317	1.307-1.317	1.307-1.317
Distillate - inches	1.151-1.161	------	------	------	------

* Includes gasoline and distillate unless otherwise designated.

NOTE: Chrome rings must not be filed to increase the gap since the chrome will chip.

Ring gaps are checked by inserting the ring into the bore and measuring the gap with a feeler gauge. The minimum permissible gap is .010". Maximum gap in a new sleeve or bore (except .010" O.S. bore) should not exceed .035". On sleeveless engines a standard ring in a .010" O.S. bore should not exceed .065" gap.

Each .001" of bore wear will increase the ring gap about .0032".

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Valves—Continued					
Face angle - degrees	45-1/2	45-1/2	45-1/2	45-1/2	45-1/2
Stem diameter:					
Intake and exhaust - inch	.3405-.3415	.3405-.3415	.3405-.3415	.3405-.3415	.3405-.3415
Clearance in guide:					
Intake and exhaust - inch	.0015-.0035	.0015-.0035	.0015-.0035	.0015-.0035	.0015-.0035
Maximum allowable stem clearance in guide - inch	.006	.006	.006	.006	.006
Valve Seats					
Seat angle - degrees	45	45	45	45	45
Seat width:					
Intake and exhaust - inch	.070-.080	.070-.080	.070-.080	.070-.080	.070-.080
Valve Guides					
Length - inch	2-11/16	2-11/16	2-11/16	2-11/16	2-11/16
Inside diameter - inch	.343-.344	.343-.344	.343-.344	.343-.344	.343-.344
Maximum allowable flat on ends - inch	.010	.010	.010	.010	.010
Installed height above cylinder head surface - inch	13/16	13/16	13/16	13/16	13/16

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Valve Springs					
Free length - inches:					
Gasoline (Note 1)	2-13/32	2-47/64	2-13/32	2-13/32	2-13/32
Distillate	2-47/64 ± 3/64	------	------	------	------
Test length - inches					
Gasoline (Note 1)	1-11/16	1-11/16	1-11/16	1-11/16	1-11/16
Distillate	1-43/64	------	------	------	------
Test load - pounds:					
Gasoline (Note 1)	73-81	49-54.6	73-81	73-81	73-81
Distillate	40-44	------	------	------	------
Springs used with roto cap:					
Free length - inches	2-1/4	2-1/4	2-1/4	2-1/4	2-1/4
Test length - inches	1-29/64	1-29/64	1-29/64	1-29/64	1-29/64
Test load - pounds	80-87	80-87	80-87	80-87	80-87

* Includes gasoline and distillate unless otherwise designated.

NOTE 1: C-123 w/serial number 120979 and below, C-135 w/serial number 120229 and below, C-146 w/serial number 015949 and below and C-153 w/serial number 042264 and below use springs with a free length of 2-47/64 inches, test length of 1-11/16 inches and test load of 49 to 54.6 pounds.

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Valve Tappets					
Diameter - inches	.560-.561	.560-.561	.560-.561	.560-.561	.560-.561
Length - inches	2-5/16	2-5/16	2-5/16	2-5/16	2-5/16
Tappet clearance in guide - inch	.0005-.0030	.0005-.0030	.0005-.0030	.0005-.0030	.0005-.0030
Push rod diameter - inch	9/32	9/32	9/32	9/32	9/32
Push rod (bottom of cup to ball tip) length - inches	10-19/32-10-41/64	10-19/32-10-41/64	10-19/32-10-41/64	10-19/32-10-41/64	10-19/32-10-41/64
Valve Lever and Shaft					
Valve lever shaft diameter - inch	.748-.749	.748-.749	.748-.749	.748-.749	.748-.749
**Valve lever bushing inside diameter - inch	.751-.752	.751-.752	.751-.752	.751-.752	.751-.752
Valve lever clearance on shaft - inch	.002-.004	.002-.004	.002-.004	.002-.004	.002-.004
Maximum allowable valve lever clearance on shaft - inch	.006	.006	.006	.006	.006
Tappet clearance (engine warm, not running) - inch	.014 †	.014	Int. .014 Exh. .020	Int. .014 Exh. .020	Int. .014 Exh. .020

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Valve Timing					
NOTE: Tolerance for valve time is $\pm 8^{\circ}$. Valve clearance MUST be set to the specified clearance.					
Intake opens - degrees	15 before TDC	15 before TDC	15 before TDC	15 before TDC	15 before TDC
Intake closes - degrees	45 after BDC	45 after BDC	45 after BDC	45 after BDC	45 after BDC
Exhaust opens - degrees ...	45 before BDC	45 before BDC	45 before BDC	45 before BDC	45 before BDC
Exhaust closes - degrees ..	10 after TDC	10 after TDC	10 after TDC	10 after TDC	10 after TDC
Timing Gears					
Backlash - inch	.003-.006	.003-.006	.003-.006	.003-.006	.003-.006
Maximum allowable backlash - inch.....	.009	.009	.009	.009	.009

* Includes gasoline and distillate unless otherwise designated.

** Valve lever bushing is not replaceable.

† Engines with Serial Number 95097 and up: .014 int. .020 exh.

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Lubrication System					
Oil pressure at rated rpm - psi	45-55	45-55	45-55	45-55	45-55
Oil pump					
Type	Spur gear	Spur gear	Spur gear	Spur gear	Spur gear
Oil intake	Floating screen	Floating screen	Floating screen	Floating screen	Floating screen
Drive from	Camshaft	Camshaft	Camshaft	Camshaft	Camshaft
End clearance between gear and end plate - inch	.0035-.0060	.0035-.0060	.0035-.0060	.0035-.0060	.0035-.0060
Clearance, gear to housing - inch	.007-.013	.007-.013	.0068-.0108	.0068-.0108	.0068-.0108
Backlash - inch	.004-.006	.004-.006	.004-.006	.004-.006	.004-.006
Drive shaft diameter - inch	.4885-.4890	.4885-.4890	.4885-.4890	.4885-.4890	.4885-.4890
Drive shaft running clearance - inch	.0010-.0025	.0010-.0025	.0010-.0035	.0010-.0035	.0010-.0035
Idler gear running clearance, in on shaft - inch	.0015-.0030	.0015-.0030	.0015-.0030	.0015-.0030	.0015-.0030
Clearance between body and drive pinion - inch	.002-.004	.002-.004	.002-.004	.002-.004	.002-.004

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Oil filter (engine)					
Number used	1	1	1	1	1
Oil pressure valve location	Oil pump body	Oil pump body	Oil pump body	Oil pump body	Oil pump body
Oil pressure valve regulating spring					
Free length - inches	2.398	2.398	2.398	2.398	2.398
Test length - inches	1.674	1.674	1.674	1.674	1.674
Test load - pounds	24.2	24.2	24.2	24.2	24.2
Pressure regulating valve					
Valve diameter - inch	.743-.745	.743-.745	.743-.745	.743-.745	.743-.745
Valve clearance in bore - inch	.003-.007	.003-.007	.003-.007	.003-.007	.003-.007
Water Pump					
Type of seal	Packless	Packless	Packless	Packless	Packless
Rotation, drive end	Clockwise	Clockwise	Clockwise	Clockwise	Clockwise
Clearance from shaft to face of impeller hub - inch	.112 ± .005	.112 ± .005	.112 ± .005	.112 ± .005	.112 ± .005
Drive	Fan belt	Fan belt	Fan belt	Fan belt	Fan belt
Shaft bearing lubrication	Sealed	Sealed	Sealed	Sealed	Sealed

* Includes gasoline and distillate unless otherwise designated.

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Thermostat					
Number used	1	1	1	1	1
Open at, degrees F	167-172	167-172	167-172	167-172	167-172
Wide open at, degrees F	192	192	192	192	192
Engine Governor					
Governor pin to weight clearance - inch	.001-.003	.001-.003	.001-.003	.001-.003	.001-.003
Spring Number					
140 Tractor series	389 987 R1	------	------	------	------
240 Tractor series	369 686 R2	------	------	------	------
56 and 57 Balers	46 944 DA	------	------	------	------
340 Tractor series, 91 Combine and 201 Windrower	------	369 686 R2	------	------	------
404 Tractor series	------	------	46 944 DA	------	------
424 and 2424 Tractor series and 500 Crawler Tractor	------	------	------	389 452 R1 (1)	------
444 and 2444 Tractor series and 4000 series Forklift	------	------	------	------	389 452 R1
500 series C Crawler Tractor	------	------	------	381 242 R1	------

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
504 and 2504 Tractor series, 3514 Loader Tractor, 5000 series Forklift, Constructall 2500 Loader-Backhoe	------	------	------	------	369 686 R2
93 Combine.....	------	------	------	------	69 235 D
105 and 203 Combine, 210, 275 and 375 Windrowers and 225 Hayswather.....	------	------	------	------	381 242 R1
Outside diameter - inch					
No. 46 944 DA	.5625	------	.5625	------	------
No. 389 987 R1	.8125	------	------	------	------
No. 369 686 R2	.6875	.6875	------	------	.6875
No. 389 452 R1	------	------	------	.865	.865
No. 381 242 R1	------	------	------	.707	.707
No. 69 235 D	------	------	------	------	.5625

* Includes gasoline and distillate unless otherwise designated.

(1) High speed spring part number and spring specifications are shown. Low speed spring part number is 389 451 R1. Refer to page 1-46 and Illust. for correct spring installation procedure.

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Engine Governor—Continued					
Wire size - inch					
No. 46 944 DA	.080	------	.080	------	------
No. 389 987 R1	.0915	------	------	------	------
No. 369 686 R2	.092	.092	------	------	.092
No. 389 452 R1	------	------	------	.110	.110
No. 381 242 R1	------	------	------	.105	.105
No. 69 235 D	------	------	------	------	.080
Number of coils					
No. 46 944 DA	15	------	15	------	------
No. 389 987 R1	11	------	------	------	------
No. 369 686 R2	9	9	------	------	9
No. 389 452 R1	------	------	------	7	7
No. 381 242 R1	------	------	------	10	10
No. 69 235 D	------	------	------	------	13

	C-123 Serial Number 65001 and Up*	C-135 Below Serial Number 100,501	C-135 Serial Number 100,501 and Up Gas and LPG	C-146	C-153 Gas and LPG
Electrical	Refer to Electrical Specifications Manual GSS-1308-C				
Nut and Bolt Torque Data (Foot-pounds torque)					
Cylinder head	80-90	80-90	80-90	80-90	80-90
Connecting rod	43-49	43-49	43-49	43-49	43-49
Crankcase oil pan	11-19	11-19	11-19	11-19	11-19
Crankshaft pulley nut	130-150	130-150	130-150	130-150	130-150
Main bearing	75-80	75-80	75-80	75-80	75-80
Flywheel	37-45	45-52	45-52	45-52	45-52
Manifold	33-37	33-37	33-37	33-37	33-37
Spark plugs	30-35	30-35	30-35	30-35	30-35

* Includes gasoline and distillate unless otherwise designated.

Ignition Timing (BTDC unless otherwise specified)	At Low Idle	*At High Idle
C-123 (w/s.n. 65001 and up)		
F-140, I-140 (up to s.n. 103556)	1°	22°
F-140, I-140 (s.n. 103557 and up)	1° ATDC	14°
F-240, I-240	1°	30°
56, 57 Balers	1°	30°
C-135 (w/s.n. 100,500 and below)		
F-340, I-340 (w/fire crater pistons)	1° ATDC	25°
F-340, I-340 (w/flat top pistons)	1°	30°
91 Combine (w/fire crater pistons)	1° ATDC	25°
91 Combine (w/flat top pistons)	1°	30°
201 Windrower	1°	30°
C-135 (w/s.n. 100,501 and above)		
F-404, I-404 (Gas and LPG)	0°	20°
C-146		
I-424, 2424	0°	17°
500 Crawler	0°	17°
500 Series C Crawler	2°	20°
C-153		
I-444, 2444	0°	17°
F-504, I-504, 2504 (Gas)	1°	21°
F-504, I-504, 2504 (LPG)	0°	25°
3514 Loader (w/s.n. 1705 and below)	1°	21°
93 Combine	0°	17°
105 Combine	1°	21°
203 Combine	1°	21°
210 Windrower	1°	21°
225 Hayswather	1°	21°
275 Windrower	1°	21°
375 Windrower (w/s.n. H-200 and below)	1°	21°
Constructall 2500 backhoe-loader	1°	21°
4000 Series fork lift	0°	17°
5000 Series fork lift	1°	21°

* Proper ignition timing at high idle is essential for best performance and engine life. Therefore, the distributor should be set to give the exact timing at high idle. Any variance that may exist then will occur at the low idle end of the advance curve.

SERVICE PROCEDURE

Valve Timing

Valve timing can be determined by checking only one valve. If the timing on the valve is within specification the other valves, barring extreme camshaft lobe wear or poor adjustment, will be in time.

The procedure for checking valve timing is as follows:

NOTE: The point of valve opening obtained here will not correspond with the specified valve opening. This checking procedure is used only to determine if valve timing is correct.

1. Adjust the No. 1 intake valve, with the engine set at No. 1 top dead center compression stroke to .021 inch valve lash.

2. Turn the engine forward to approximately bottom dead center.

3. Place a .004 inch feeler gauge between the valve lever and valve stem of the No. 1 intake valve and slowly rotate the engine forward until the feeler gauge becomes tight. This is the point at which the No. 1 intake valve starts to open which should be 11 degrees ± 4 degrees before top dead center.

NOTE: One tooth "out of time" equals approximately 11 degrees.

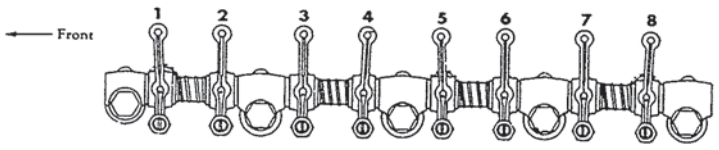
4. Readjust the No. 1 intake valve to its proper lash of .014 inch.

Valve Lash Adjusting Procedure

By referring to the chart below and using the simplified procedure outlined, all valves can be adjusted by cranking the engine only twice. The valve lash is adjusted with the engine warm which means any temperature above freezing. Valve lash can be adjusted while the engine is hot - however the quality of workmanship usually suffers due to the heat.

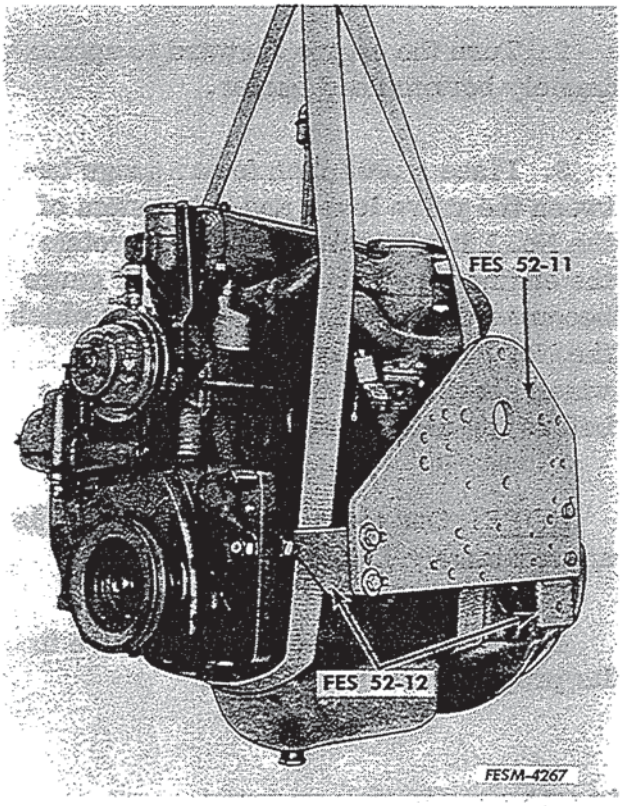
Four valves are adjusted when the No. 1 piston is at T.D.C. (Compression) and the remaining four are adjusted when the No. 4 piston is at T.D.C. (Compression). The following chart shows the numbering sequence of the valves which correspond to the chart. Refer to "Specifications" for specified clearance.

WITH	ADJUST VALVES (Engine Warm)							
No. 1 Piston at T.D.C. (Compression)	1	2	3		5			
No. 4 Piston at T.D.C. (Compression)				4		6	7	8



FESM-2324

Mounting the Engine to the Stand

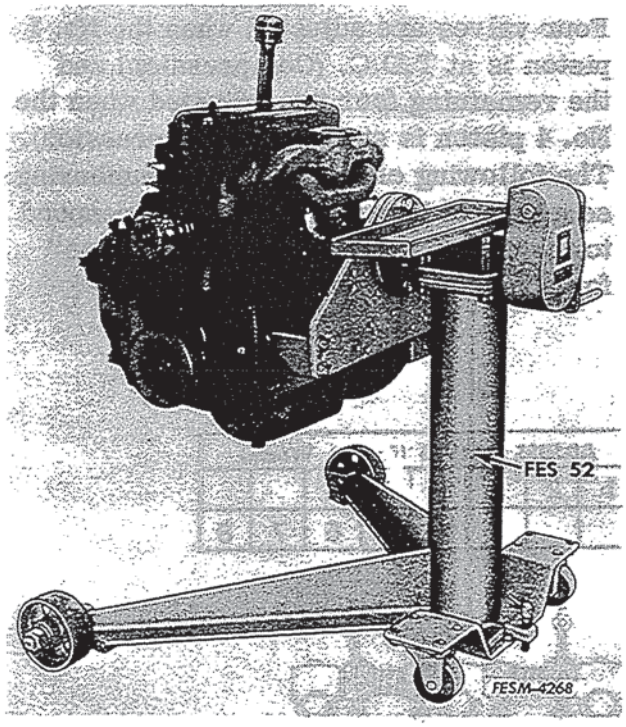


Install engine attaching plate FES 52-11 as follows:

Remove the starter, generator and generator bracket from the engine.

C-123: Install attaching plate FES 52-11.

C-135, C-146 and C-153: Install attaching plate FES 52-11 with attaching ears FES 52-12 as shown.



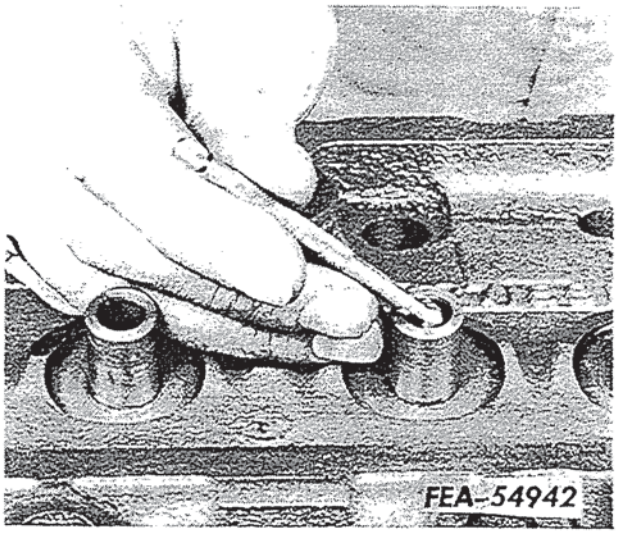
Mount the engine to engine stand FES 52.

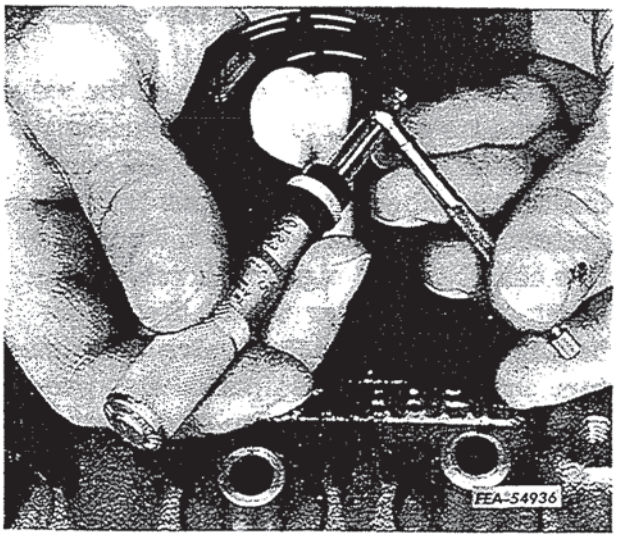
Cylinder Head and Valves

Cylinder Head

With the valves installed to protect the seats, clean the carbon deposits from the combustion chambers and valve heads with a wire brush and scraper.

Wash the head in cleaning solvent to remove dirt and grease from all surfaces and dry thoroughly. Check all water passages to make sure they are clear and open.





Examine the cylinder head for water leaks or cracks in the combustion chambers, exhaust ports, or around the valve seats. Inspect the machined or gasket surfaces for scratches or mars which may cause leakage after assembly.

Check the gasket surface of the cylinder head for trueness with a straightedge. Test by attempting to insert a .003" feeler gauge ribbon between the straightedge and cylinder head. If this is possible, either resurface or replace the cylinder head.

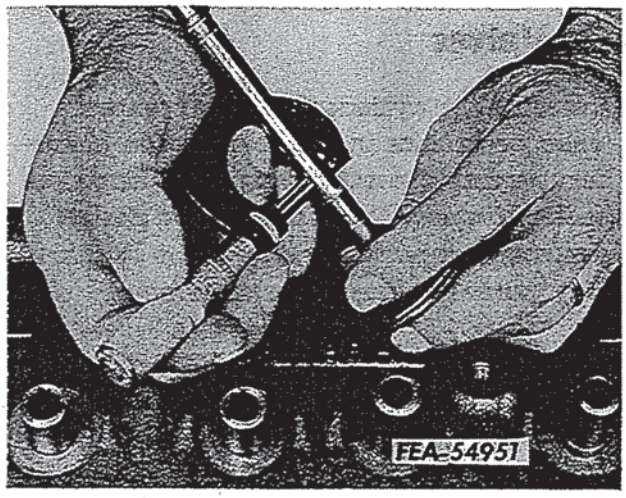
NOTE: When resurfacing the cylinder head do not remove more than .005" material, otherwise, contact between top of piston and head of valve may result.

Valves and Valve Guides

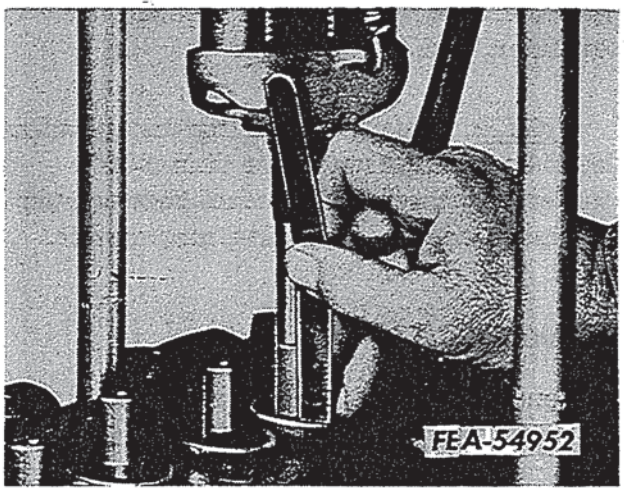
Discard valves which are obviously burned. Valves which are "necked" or "cupped" or which obviously will not have sufficient margin after refacing should be discarded. Valves with worn keeper grooves or badly worn tips should also be discarded. Clean the remaining valves on a brass wire brush.

Use a valve guide cleaning brush in an electric drill to clean the I.D. of the valve guides. A cleaning solvent should be used on the brush.

Check valve guides and valve stems for excessive wear. Measure valve guides with a telescoping gauge and a micrometer as shown. Pay particular attention to guide wear at right angle to the valve lever shaft at the top of the valve guide.



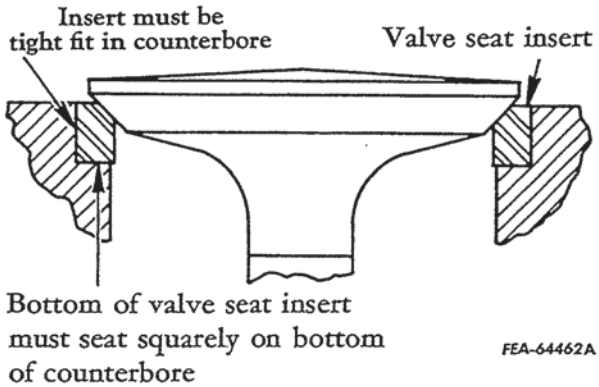
After the size of the valve guides has been determined, measure the valve stems at both top and bottom of the stem bearing area.



If valve guides require replacement, use valve guide tools FES 6-4 (intake) and FES 6-5 (exhaust) with a press to remove the old guides and to install the new guides as shown. Use of these tools allow for guide installation from the top of the cylinder head without damage to the guide, thus facilitating checking of valve guide height during installation. Specified installed height is 13/16 inch. Valve guides installed with these tools will not require reaming. Check, however, to be sure that any burrs are removed from the upper and lower ends of the guide.

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.

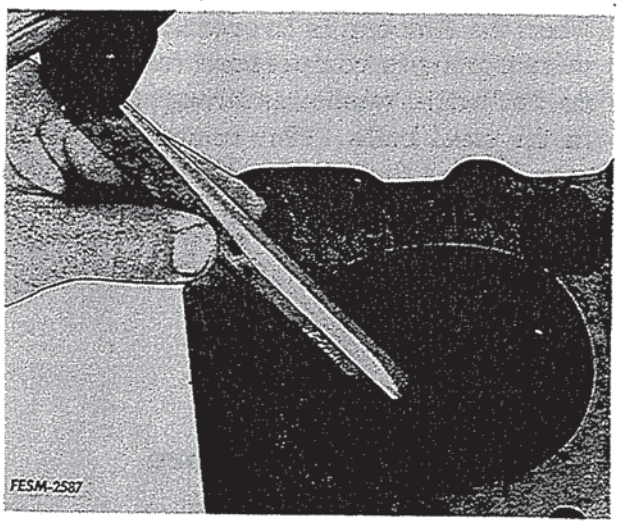


The location of the valve seat on the valve face and its width, controls the amount of valve head that protrudes into the combustion chamber. It is obvious that the greater the exposure within the combustion chamber, the higher the valve temperature; or in other words, the more heat it will collect. 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 or a dull pointed chisel, 1/4 inch wide, to peen cylinder head metal over the outer edge of the valve seat.

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

To assure maximum valve and valve seat insert life, it is essential that the valve insert be installed to obtain maximum contact with the bottom and sides of the counterbore in the head. Proper exhaust heat dissipation through the valve seat insert can only be accomplished by the insert being a tight fit in the cylinder head with the bottom of the insert squarely seated on the bottom of the counterbore as shown.



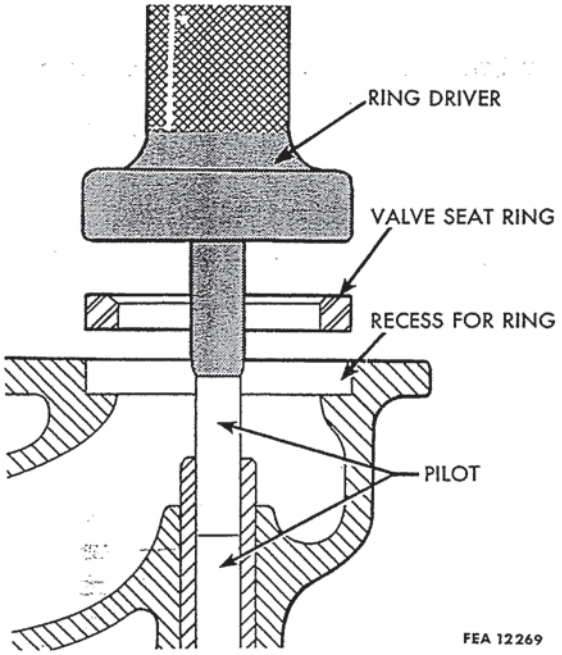
Removal

If necessary, remove valve seats with valve seat puller or use the large end of a punch to pry out old valve seat. Put the punch under valve seat and tap with hammer. Do not use the sharp end of a chisel as there is the danger of damaging the underside of the seat area, causing a poor contact around the insert or premature cylinder head failure.

Repair

1. Clean the counterbore in the cylinder head, to insure good heat transfer.

2. Using a valve seat insert tool, cut the counterbore .010 inch oversize from the bottom of the insert counterbore (in head) to assure a square seat for the insert.



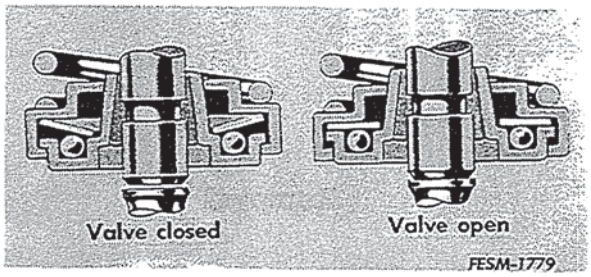
Installation

1. Chill the new valve seats with Liquid Freon or in dry ice before installation. This prevents metal scraping from the side of the counterbore, insuring full contact of the insert on the bottom and sides of the counterbore.

2. Install new insert using an insert driver as shown. Only two or three light blows with a hammer will be required to set the ring in place.

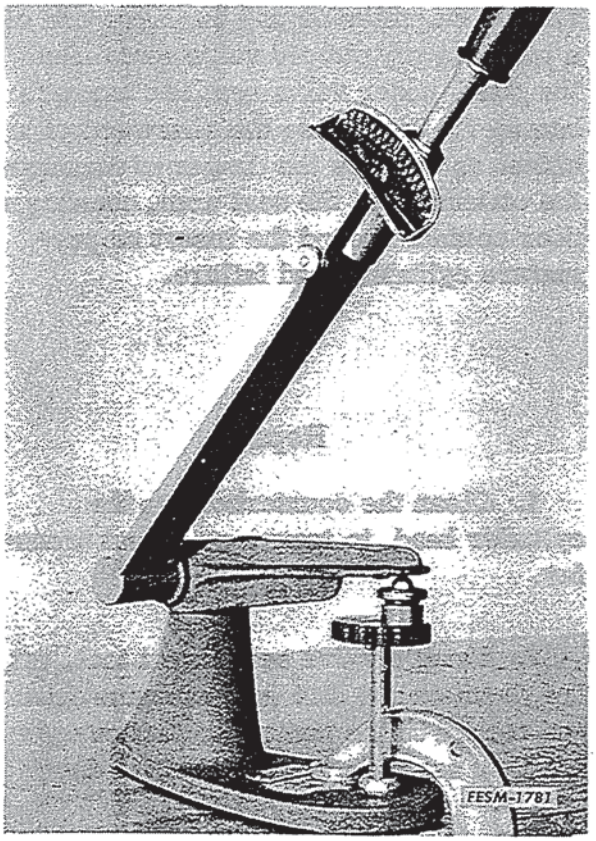
3. Properly seated, the insert should be recessed into the head from .008 to .030 in.

4. Using a suitable peening tool, peen the head metal over the edge and around the entire circumference of the insert.



Rotocap

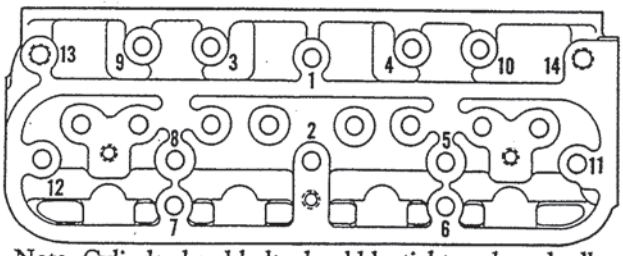
When the Rotocap is in operation, the valve spring is compressed (valve opened), the belleville washer is brought to bear on the steel balls. This causes the balls to roll down the ramp in the retainer thus rotating the valve.



Testing Rotators

Use any valve spring tester and a steel ball placed on an inner sleeve, then rapidly oscillate the load.

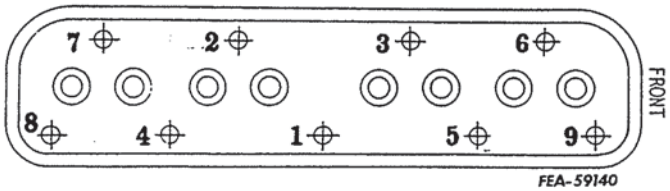
You should perform this oscillation up to the test load indicated in "Specifications". Be sure the rotator is lubricated internally. The rotators should be cleaned, checked and reinstalled at each overhaul period.



Note: Cylinder head bolts should be tightened gradually and alternately in the sequence shown.

FEA-64468

135 series serial number 100, 501 and up, 146 series and 153 series.



FEA-59140

123 series and 135 series below serial number 100, 501.

Cylinder Head Installation

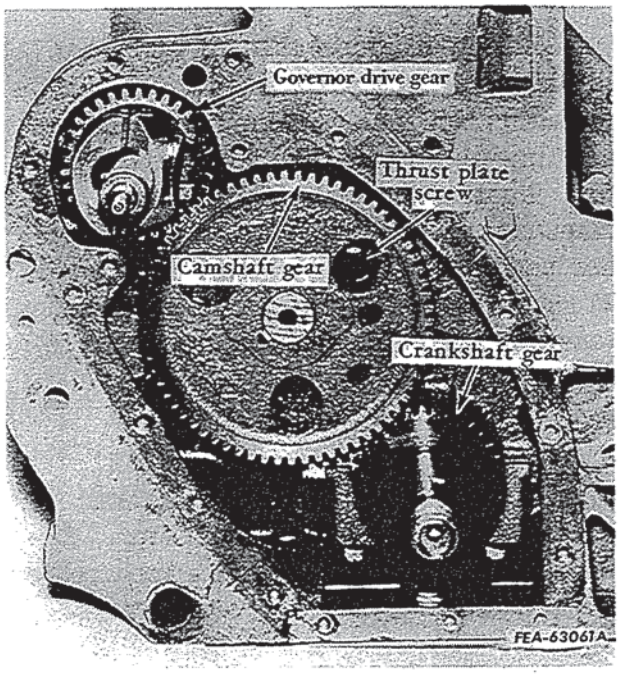
1. Apply a light coating of lubricant to the top of the crankcase, and install the cylinder head gasket. The gasket is suitably marked to prevent incorrect assembly. Position the cylinder head on the crankcase. Install and tighten the cylinder head nuts to 80 to 90 ft. lbs. torque. Torque must be applied to the nuts with a torque wrench. Torque the nuts in correct sequence as shown.

NOTE: 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.

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

2. Start engine and operate it until normal operating temperature is obtained. Check the ammeter and the engine oil pressure gauge as soon as engine is started. Listen for sounds or appearances indicative of faulty engine operation. Also recheck the cylinder head nut torque and tighten to 80 to 90 foot-pounds where necessary.

Timing Gear Train and Front Cover



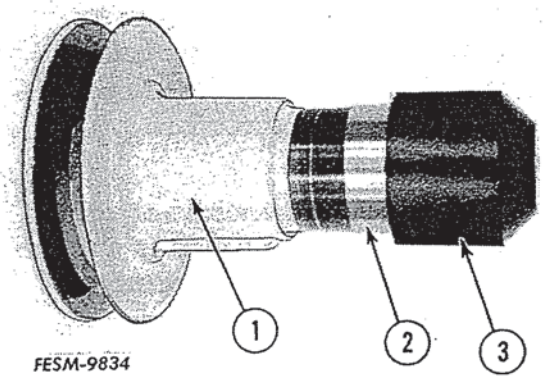
Crankshaft Pulley Removal

Remove the crankshaft pulley nut if present. Remove the crankshaft pulley using a suitable puller if necessary. C-123 and C-135 engines require a puller and special tool FES 33-1.

Front Cover

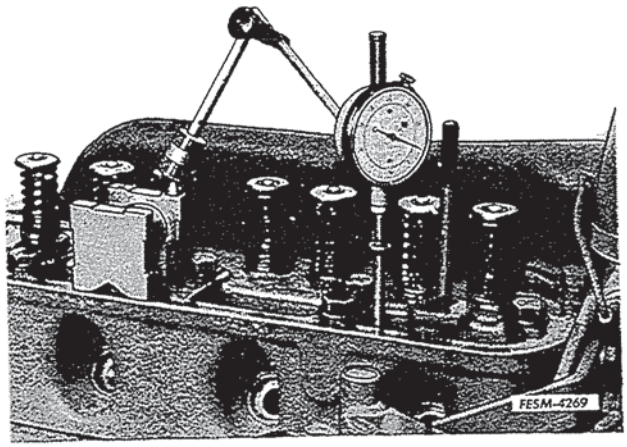
Remove the engine governor. Remove the cap screws securing the front cover and remove the cover. Shown is the complete timing gear train with timing gear marks aligned.

NOTE: Install a new wear sleeve onto the crankshaft pulley using the FES 33-4 fan drive pulley wear sleeve installer as shown. Be sure to apply a sealer onto the pulley O.D. or the I.D. of the wear sleeve before installing the wear sleeve onto the pulley.



1. Crankshaft pulley
2. Wear sleeve
3. FES 33-4 Fan drive pulley wear sleeve installer

Camshaft



Checking Camshaft Lobe Lift (Camshaft in Engine)

Preferred Method

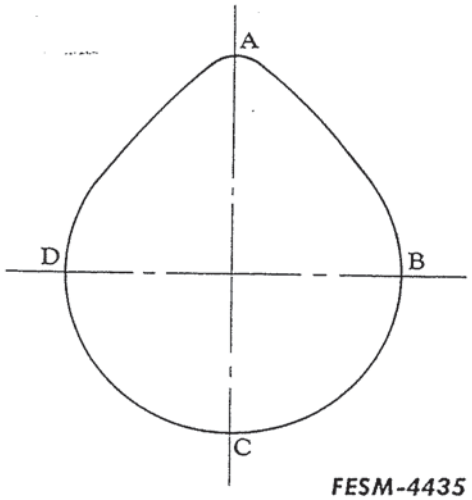
Camshaft lobe wear can be checked by the use of a dial gauge as shown.

Record the lift reading of each lobe and compare these readings with those listed in specifications. The camshaft must be replaced when .020 inch wear is indicated.

Checking Camshaft Lobe Wear (Camshaft Removed from Engine)

Alternate Method

Inspect the camshaft for indication of excessive lobe wear. If the lifting areas of the cam lobes, when compared with new camshaft, show amount of wear exceeding .020 inch, the camshaft must be replaced. If a new camshaft is not available for comparison, the cam lobe wear can be measured with a micrometer in the following manner. Take a reading across A-C and deduct the reading B-D; the difference should be the specified cam lift (refer to "Specifications"). The camshaft must be replaced when .020 inch wear is indicated. Inspect the camshaft journals and the oil pump drive gear for wear.



FESM-4435

Inspection and Repair

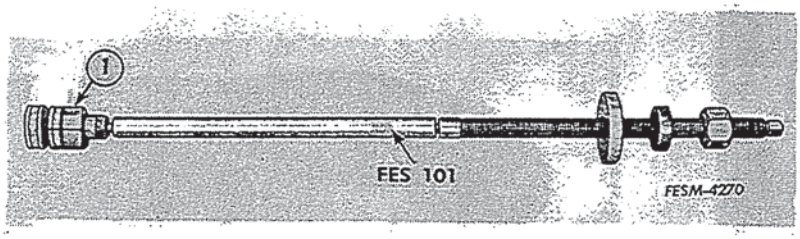
Measure camshaft bearings and camshaft journals to determine clearance. Maximum allowable running clearance is .006 inch.

Check the camshaft lobe wear and replace if necessary. (Refer to "Checking Camshaft Lobe Wear.")

Check for specified camshaft end play of .003 to .012 inch. Replace the thrust plate if necessary.

Installation

Camshaft bearing puller and installer set FES 101 (collet assembly 817-9) is used to remove the old bearing and install the new one.



1. Collet 817-9

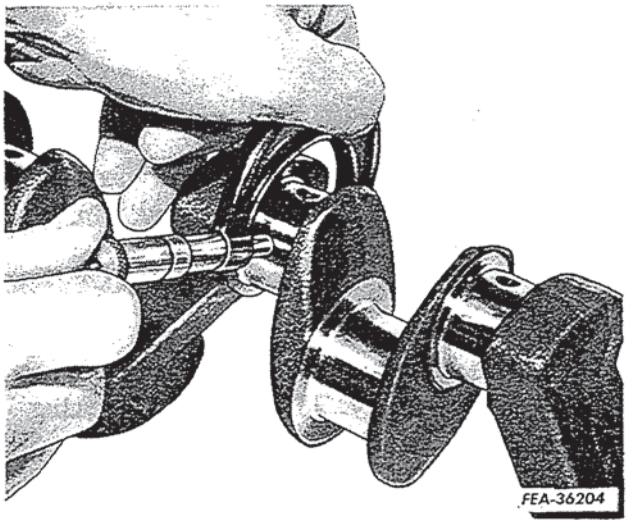
NOTE: No reaming is required, therefore, be sure to prevent damage to bearing surface. Install camshaft bearing as follows:

Front Bearing

Press in the front bearing with 20 degree chamfered edge to the rear. Align the bushing hole with the hole in the crankcase. The bushing must be pressed in until flush with the face of the crankcase.

Inspection and Repair

1. Inspect the bearings for wear and evidence of uneven bearing support. Examine the bearing caps and supporting surfaces of the crankcase for high spots and burrs.



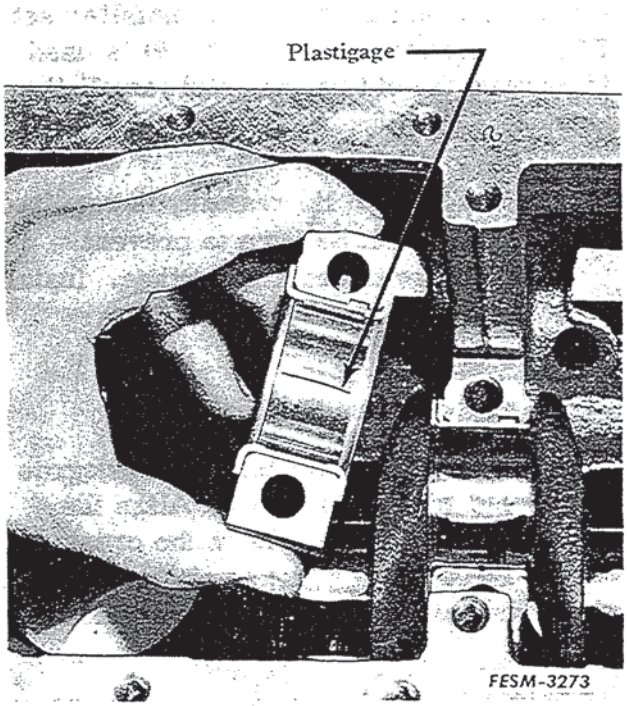
2. Inspect the crankshaft journals for scoring and measure the diameter of each journal with a micrometer. Refer to "Specifications" for specified journal diameter. Measure each journal at two points, one at right angles to the other, in order to detect any out-of-roundness.

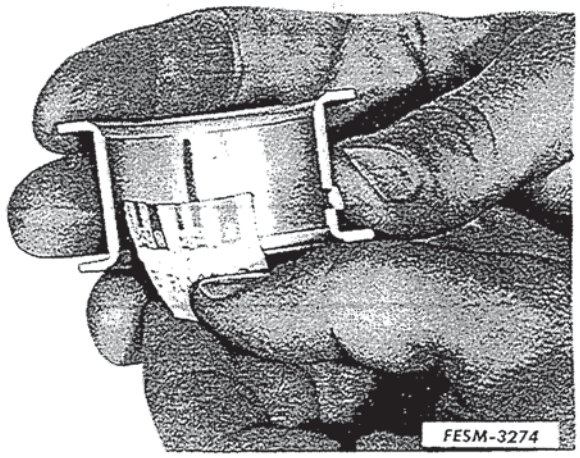
Move the micrometer over the entire width of the journal.

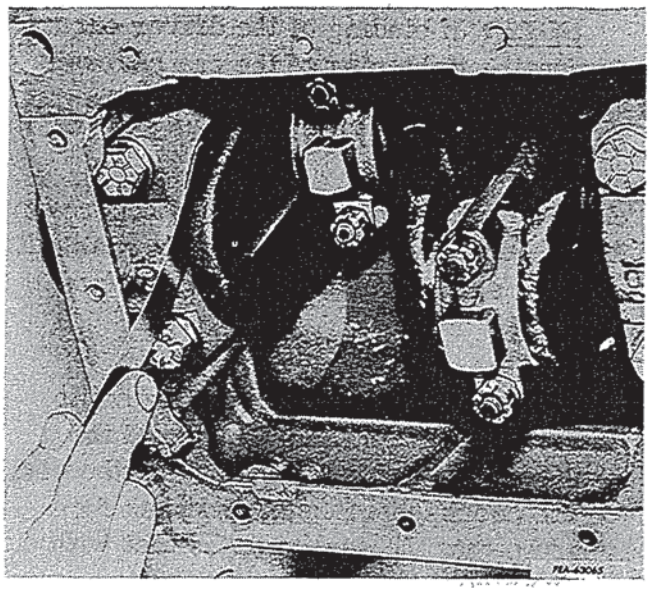
3. Check the connecting rod journals for out-of-round condition. Use a micrometer and take measurements at least three places around the journals. (Refer to "Specifications".)

4. Inspect the crankshaft gear teeth for excessive wear and chipping. If necessary to replace it, pull the gear with a puller.

5. Inspect the main bearing clearances using Plastigage or virgin lead. Specified bearing running clearance is .0009 to .0039 inch.





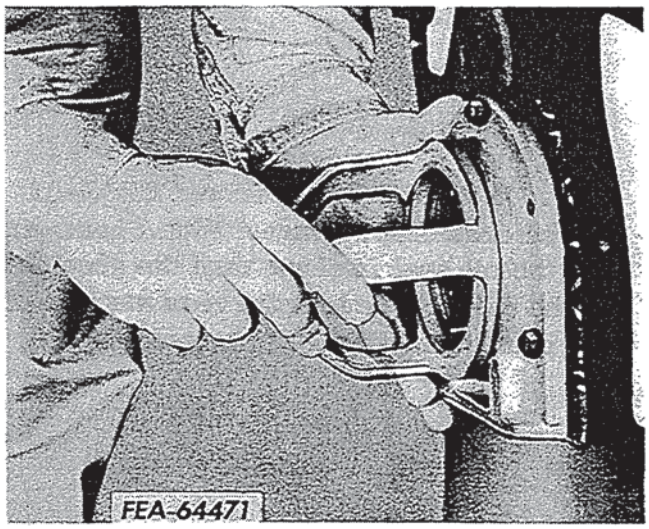


6. Check the crankshaft thrust bearing side clearance with a feeler gauge at the front side of the rear bearing on both upper and lower thrust faces. Specified side clearance is .004 to .010 inch.

While making this check, be sure the crankshaft is held against the rear thrust face of the bearing to show total clearance at front side.

7. Check the crankshaft end clearance with a feeler gauge. Maximum allowable end clearance is .012 inch.

Crankshaft Rear Oil Seal Installation



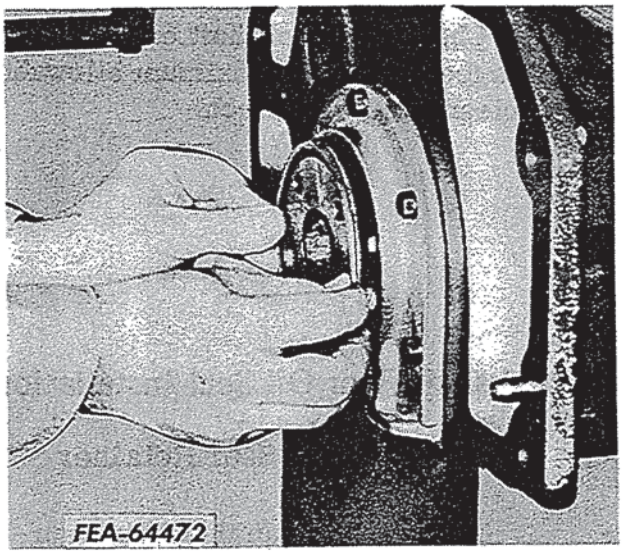
One Piece Oil Seal Retainer

1. Thoroughly clean the gasket surfaces of the crankcase and the oil seal retainer.

2. Apply sealer to a new gasket and position the gasket on the retainer. Place three cap screws (one at the top and one opposite the other) through the retainer and gasket to keep the gasket in position on the retainer.

3. Using oil seal driver tool FES 6-15 to line up the retainer with the crankshaft oil seal surface, install the retainer over the crankshaft flange and to the crankcase as shown. DO NOT REMOVE the driver from the retainer until step 4 is completed.

4. With the driver remaining in position on the crankshaft and in the retainer, install the cap screws. Tighten the cap screws in sequence (one across from the other) rotating the driver in the retainer at the same time. Remove the driver after all the cap screws have been tightened.

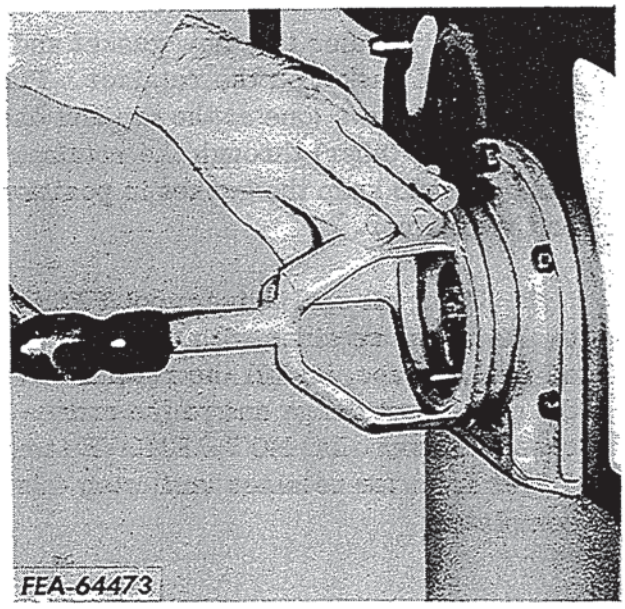


NOTE: If binding of the driver occurs during the tightening of the cap screws the cap screws must be loosened and the tightening procedure repeated.

A freely rotating driver after the screws have been tightened means the crankshaft oil seal surface is aligned with the retainer.

5. Apply a film of lubricating oil to the oil seal, crankshaft flange and the seal bore in the retainer. Install the seal on the crankshaft flange, and push forward so that the seal is in contact with the retainer.

6. Push the seal forward by hand to insure that the sealing lip on the O.D. of the seal has entered the chamfer on the retainer around the entire circumference of the seal.



7. Position oil seal driver FES 6-15 on the crankshaft flange. With a hammer, tap the oil seal in place until the shoulder of the driver contacts the rear surface of the crankshaft flange.

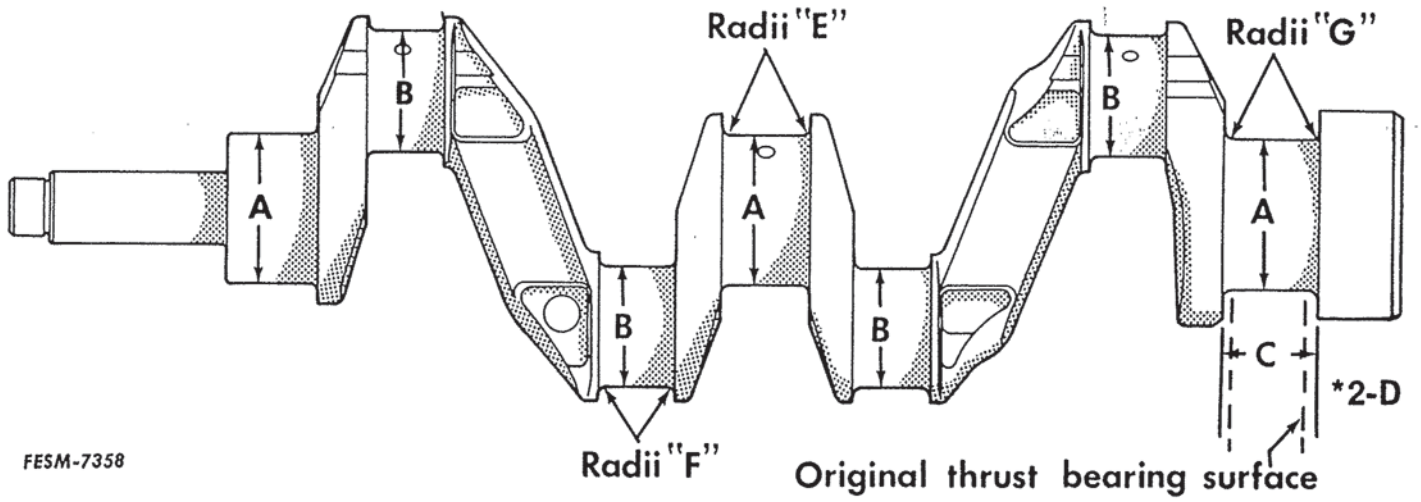
Split Type Retainers

(C-123 and C-135,
with serial number 100,500 and below)

1. Install new rear oil seal felts in the oil seal retainer.

2. Install the retainer halves and tighten the cap screws.

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.



Engine	Undersize - inch	Main journal and thrust bearing journal A	Connecting rod journal B	Width for thrust bearing C	Distance from basic surface D*	Main brng. journal radius E	Connecting rod journal radius F	Thrust bearing journal radius G
C-123	.010	2.114-2.115	1.739-1.740	1.8495-1.8515	.002 *2-D	.039-.069	.100-.133	.118-.149
	.020	2.104-2.105	1.729-1.730	1.8535-1.8555	.004 *2-D			
	.030	2.094-2.095	1.719-1.720	1.8555-1.8575	.005 *2-D			
C-135	.010	2.6135-2.6145	2.049-2.050	1.636-1.638	.002 *2-D	.110-.130	.135-.155	.118-.149
C-146	.020	2.6035-2.6045	2.039-2.040	1.640-1.642	.004 *2-D			
C-153	.030	2.5935-2.5945	2.029-2.030	1.644-1.646	.006 *2-D			

*Distance from original surface: *2-D = Remove specified material from thrust surface on rear side of crankshaft.

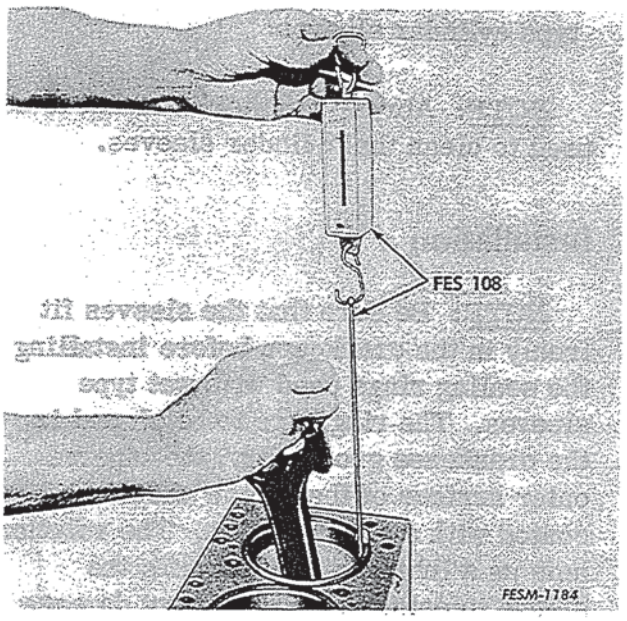
NOTE: Except for the thrust bearing width, all other journal widths must remain standard.

Printed in United States of America

Piston Fit in Bore

Piston-to-bore clearance can be determined using a 1/2 inch wide feeler gauge and a spring-type tension scale (FES 108). Refer to "Specifications" for specified piston to bore clearance.

The thickness of the feeler gauge that can be removed with a 2 to 8 pound pull represents the piston-to-bore clearance as outlined in the "Piston Clearance Chart." Clearances should conform to specifications.



The chart at right shows the relationship between the feeler gauge thickness and pounds pull in measuring piston-to-bore clearance. Note that with a given feeler gauge thickness the actual clearance is less than the feeler gauge used when the pound pull is towards the high side of the pound pull range. This is especially true with the thinner feeler gauges.

To determine piston-to-bore clearance proceed as follows:

1. Select a feeler gauge (free of dents or burrs) of one of the thicknesses listed in the chart. Position the feeler gauge in the cylinder bore so that it extends the entire length of the piston 90° from the piston pin location.

2. Invert the piston and install it in the bore so that the end of the piston is about 1-1/2 inches below the top of the cylinder block and the piston pin is parallel to the crankshaft axis.

3. Hold the piston and slowly pull the scale in a straight line with the feeler gauge noting the pull required to remove the feeler gauge. Check three times and record the average of the three readings obtained. Do not bend or kink the feeler gauge.

4. Refer to the chart to determine the actual clearance. The clearance is shown where the horizontal column indicating pounds pull and the vertical column indicating the thickness of the feeler gauge used intersect.

EXAMPLE: If a .0015 inch feeler gauge is used and it takes 4 pounds pull to remove the feeler gauge, the clearance is .0013 inch.

5. Repeat step 3 with the piston at right angles to the crankshaft axis. Determine the clearance as instructed in step 4.

6. Measuring piston-to-bore clearance with the piston pin parallel and at right angles to the crankshaft axis will reflect any "out-of-round" in the bore.

PISTON CLEARANCE CHART

	Feeler Gauge Thickness					
Pull in Lbs.	.0015	.002	.003	.0035	.004	.0045
	Clearance in Inches					
2	.0016	.0022	.0033	.0039	.0044	.005
4	.0013	.0018	.0029	.0035	.004	.0046
6	.001	.0015	.0026	.0031	.0036	.0042
8	.0008	.0013	.0023	.0028	.0033	.0038

Cylinder Sleeves

Description

The C-123 and C-135 engines use cylinder sleeves of the replaceable, wet liner type. When furnished as service parts, the cylinder sleeves cannot be obtained separately but only in combination with matched pistons. When installing a new set of sleeves and pistons, do not interchange the pistons and sleeves, or the piston pins, between the pistons.

Removal, Inspection and Repair

1. Each cylinder sleeve should be checked with an inside reading 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 readings 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."

2. Cylinder sleeve puller FES 22 with adapter plates FES 23-2 (C-123) and FES 23-3 (C-135) is used to remove cylinder sleeves. If difficulty is encountered, use dry ice packed in the sleeve around the puller to cold-shrink the sleeve.

3. Clean the sleeves in a cleaning solvent, and dry them with compressed air. Clean out the water jacket in the crankcase, and clean out the cylinder sleeve sealing ring grooves on the wet type cylinder sleeves.

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

Installation

NOTE: Be sure that the sleeves fit freely in the crankcase before installing the sealing rings used with wet type sleeves. The rings are to be placed in the crankcase groove dry; the tapered outer surface of the sleeve should be coated with a soap solution. The solution acts as a lubricant and permits the sleeve to enter the ring without damage to it.

1. Install the sealing rings in the crankcase grooves.

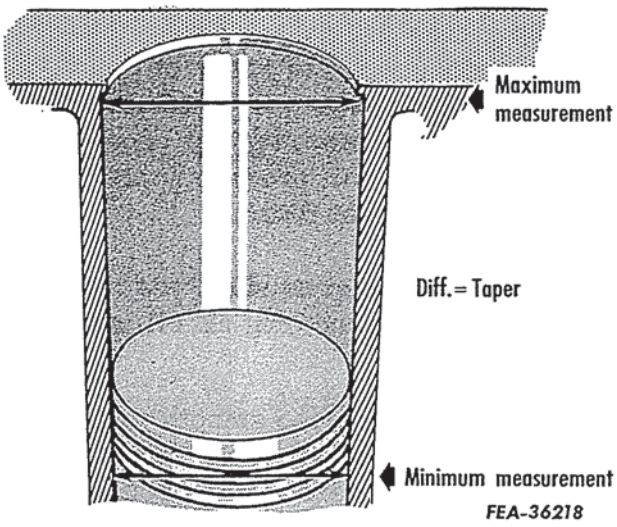
2. Insert the cylinder sleeves into the crankcase and hand-push them into position. If the rubber sealing ring is accurately installed and not pinched, the sleeve should enter easily into its position.

3. Install the connecting rods and pistons. Install the bearing caps.

Crankcase Cylinder Re-Boring Procedure

This section covers re-boring of the cylinder bore with the engine disassembled. However, if re-boring is the only service to be performed on the engine, the crankshaft need not be removed.

NOTE: When the crankshaft is not removed, cover the crankshaft and plug all oil passages.



When to Re-Bore

Replacement piston ring kits may be used to extend the life of the piston if cylinder wear has not been excessive. Inspect cylinder bores for scoring and roughness which indicate excessive wear. Check cylinder bores for taper and out-of-round by the use of a cylinder gauge placed at the top, middle, and bottom of bores, both parallel and at right angle to the centerline of crankshaft. To be within safe limits, the taper from top to bottom of the ring travel area must not exceed 0.005 in. and the out-of-round (egg-shape) condition must not exceed .005 in. in the cylinder bores. If the bore is worn beyond these limits, a re-boring job is required. It is advisable to re-bore for the smallest possible oversize pistons and rings. If only one or two bores require correction, it is not necessary to re-bore all cylinders to the same oversize.

Preparing the Block

Clean the water jackets with materials that will remove rust and scale and then flush thoroughly. Degrease the crankcase so that the abrasive material from the boring operation may be completely removed before reassembly.

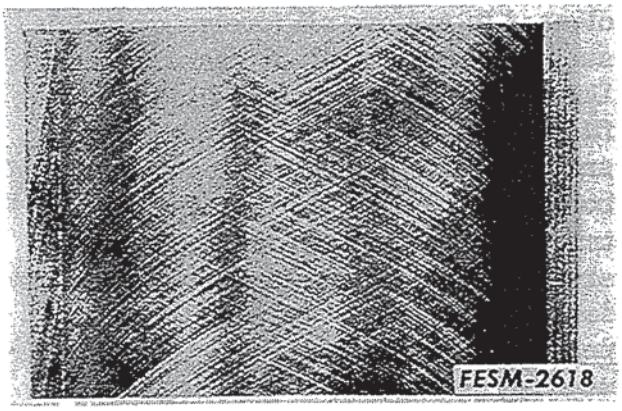
Before setting up a boring machine on the block, the top of block must be carefully cleaned to remove all foreign materials, such as carbon, rust, or gasket cement. Use a 14 in. fine-cut, mill file to draw-file the block for removal of all burrs and high spots around the top edge and bolt holes. This will provide a smooth, true working surface for the boring operation. This is very important because the alignment of the cylinder bores depends entirely on the trueness of this working surface.

Re-Boring

When re-boring cylinders, all crankshaft bearing caps must be in place and torqued to specifications to avoid possible distortion of bores in final assembly. If all bores require the same correction, to save time, bore the cylinder having the greatest amount of wear and taper first. If this cylinder cleans up to the smallest desired oversize, you can be sure that the remaining, smaller cylinder bores will clean up to the same size. Oversize pistons normally furnished for service are .010 in., .020 in., .030 in., and .040 in. oversize. No attempt should be made to cut down oversize pistons to fit cylinder bores.

To center the boring machine on each cylinder, follow closely the instructions of the boring machine manufacturer.

NOTE: If the crankshaft has not been removed, be sure the crankshaft is out of the way of the boring cutter when boring each cylinder.



Use a good single point boring bar with a sharp tool and bore all cylinders the same size, to within .002 to .001 in. of the desired finished oversize to permit finishing honing operations.

Honing

For best results, hone the cylinders to the finished size. This operation must remove all boring tool marks. Final finish should be in the range of 20 to 35 micro-inches. If you have no means for measuring the finish, the use of about 120 grit stones will produce approximately the correct finish.

NOTE: If the crankshaft was not removed, cover it and plug all oil passages.

Cylinders that are too smooth will retard run-in and may result in ring scuffing. When cylinders are too rough, rapid ring wear will result. A rigid type wet hone is preferred for the final sizing operation, but a spring hone of the glaze-breaking type may be used if the other is not available. Spring hones should be equipped with 220 grit stones and stock removal should not exceed 0.003 in. This type of hone should be dipped into SAE 10 or 20 lubricating oil before beginning the operation. Dull or dirty stones cut unevenly and generate excessive heat. Keep honing equipment sharp and clean. When finished honing, pass the hone through the entire cylinder bore at a rate of 60 cycles per minute or as necessary to provide a 30 degree (relative to the top of the sleeve) cross-hatch pattern on cylinder walls. This will insure maximum ring life and minimum oil consumption.

Cleaning

The success of any re-boring job depends on the accuracy and smoothness of the finished bores, the amount of piston clearance, and the thoroughness with which you clean the block and crankcase of all cuttings and abrasive materials resulting from boring and honing. The best re-boring job will be a total loss unless the crankcase is thoroughly cleaned. Foreign material which remains causes rapid wear of pistons, rings, and cylinder walls, and will seriously damage engine bearings.

For thorough cleaning of the crankcase, washing in a tank of hot, agitated cleaning solution is the recommended procedure. If this cannot be done, use a good cleaning solution and air pressure blast followed by careful wiping with clean cloths and light lubricating oil. Surfaces should be wiped until a clean cloth shows no discoloration. Wash and blow out oil passages.

Checking Clearance

Refer to "Piston Fit In Bore".

Engine Governor

Principles of Operation

The governor is a fly-ball, variable speed type. It is designed to maintain a selected speed (rpm) within reasonably constant limits. The governor regulates the action of the carburetor by means of a balance between governor spring tension and weight force.

As the governor control handle is moved to increase engine speed, the tension of the governor spring is increased. The increased tension of the spring moves the rockshaft lever and, in turn, the carburetor control rod, which opens the throttle plate on the carburetor allowing more fuel to enter the engine.

As engine speed increases, the governor weights move outward by centrifugal force. The movement of the weights forces the thrust bearing sleeve and bearing against the rockshaft fork which, in turn, moves the rockshaft lever decreasing the throttle plate opening. The forces of the weights and spring tension will balance out maintaining the selected engine speed.

An increase in load causes a decrease in engine speed. Any speed variation on the engine activates the governor. As the speed decreases, the weights move in reducing thrust sleeve and bearing

pressure against the rockshaft fork. This allows governor spring tension to move the rockshaft lever, opening the carburetor throttle plate, increasing the amount of fuel to the engine, thereby maintaining the selected engine speed.

To maintain a governed speed, all three factors (spring tension, centrifugal weight force and load) must remain balanced. A change in any one of these will cause the other two to react and restore the balance.

To insure smooth, surgeless, and prompt response of the governor, all of its moving parts and linkage must move freely to follow slight changes in engine load-speed. Should binding occur at any point, a greater change in speed will take place before sufficient centrifugal force or spring tension is built up to overcome the friction and move the throttle valve. Friction increases and binding often occurs because of wear and misalignment of the carburetor throttle shaft. Sludge deposits in the governor housings can cause sluggish or rough action of governor parts and linkage. Wear of governor weights, pins, sleeve, rockshafts, or rockshaft lever also result in surging and erratic governor action.

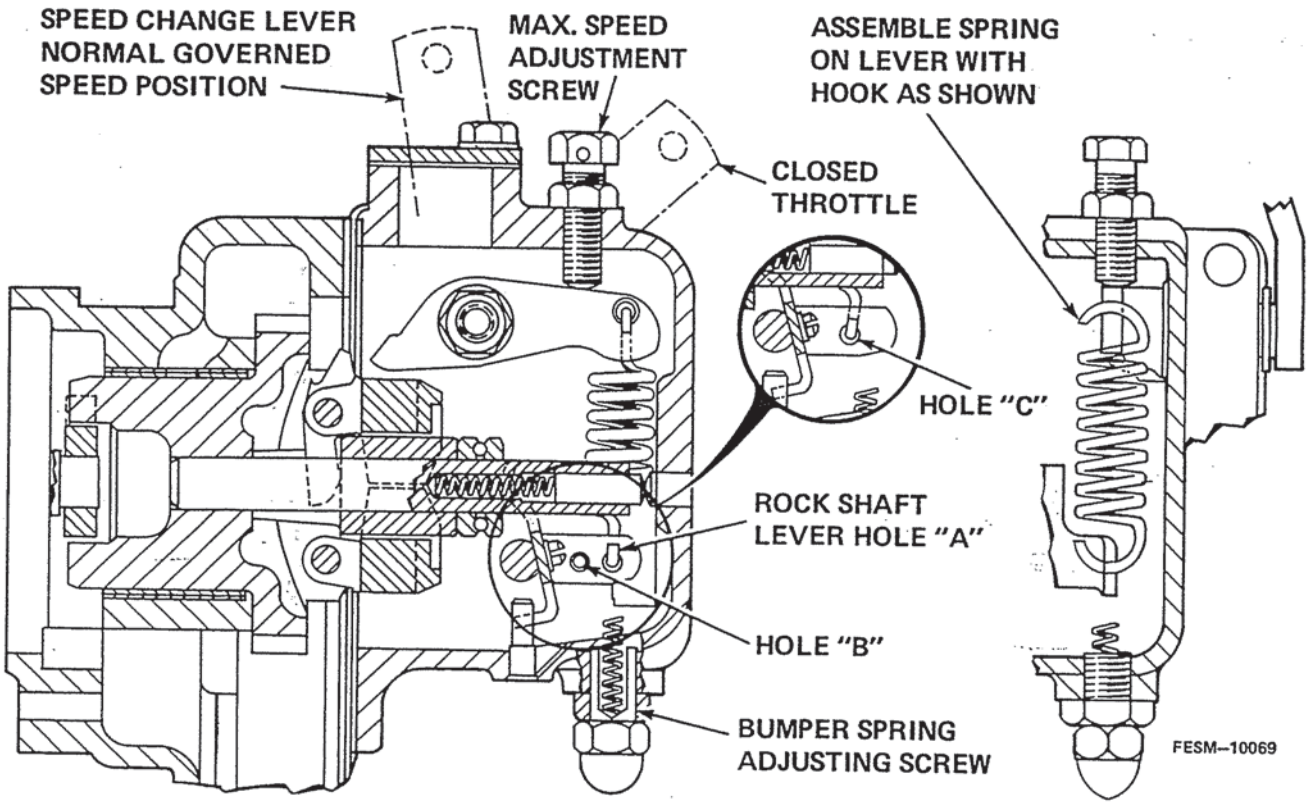
Removal, Inspection and Repair

Before removing any of the governor assemblies for inspection or repair, clean the surrounding area and the various connecting points to prevent entry of dirt into those parts which remain with the engine. After disassembly of the governor, start the cleaning of parts with a clean container of clean solvent. Wash ball bearings first. Do not spin bearings while washing. Turn them slowly back and forth while dipping the bearing up and down in the solvent to dislodge dirt. Blow out with compressed air, holding the parts to prevent the air blast from spinning them, to avoid possible scratching of balls and grooves. Flush again in clean solvent and blow-dry a second time. Examine under good light to determine if further cleaning is necessary. Add a few drops of oil to the balls and grooves, then, and only then, spin by hand to test for roughness and wear.

Wash and clean the remainder of the rotating parts in solvent, examining the weights, carrier and weight pins for damage or wear. Clearance between new weights and new pins for each governor are shown on specification page. Clearances found to exceed those specified by 0.003 inch or more would be considered excessive and parts should be renewed.

Wash and clean the housing and remaining parts and examine each for damage or excessive wear. No attempt should be made to salvage old gaskets or seals. They should be carefully removed from the assembly and replaced with new to insure an oil tight, dust proof operation.

Where sludge accumulations are found in the governor housing, corrosion of bearing surfaces may have occurred. These rough bearing surfaces and their increased frictional drag are responsible for poor governor action. Excessive bearing clearance also results from sludge corrosion.



NOTE: Moisture and sludge accumulations in the engine indicate that the engine has been running over long periods of time below normal operating temperature. Thermostat operation should be checked and the operator informed on his need to maintain operating temperature.

The decision on what new parts should be used to rebuild the governor assembly will be based upon the wear found and the condition of the following groups of parts:

1. Weights, pins, and weight carrier: Clearance in excess of 0.003 inch over that specified between pins and weights or carrier.

2. Governor shaft bearings and thrust bearing: Rough, pitted bearing surfaces of either plain or ball type bearings.

3. Rockshaft, rockshaft fork, bearings and levers: Worn or damaged rockshaft, rockshaft fork or spring levers. Rough, pitted bearings and bearing surfaces.

Where all three conditions are found, the use of new complete governor assembly should be considered, since the few parts which can be salvaged may not cover the labor cost of overhaul.

Where conditions 1 and 2 are involved, the rotating assembly, including new bearings, weights and pins, should be used.

Where only the governor weight and pin clearance is found questionable, only these individual parts need be replaced. In all cases new gaskets and new seals must be used to prevent entry of dirt and loss of oil.

Examine hook ends of governor springs and mating holes in spring levers for wear. Replace these parts where appreciable wear is found.

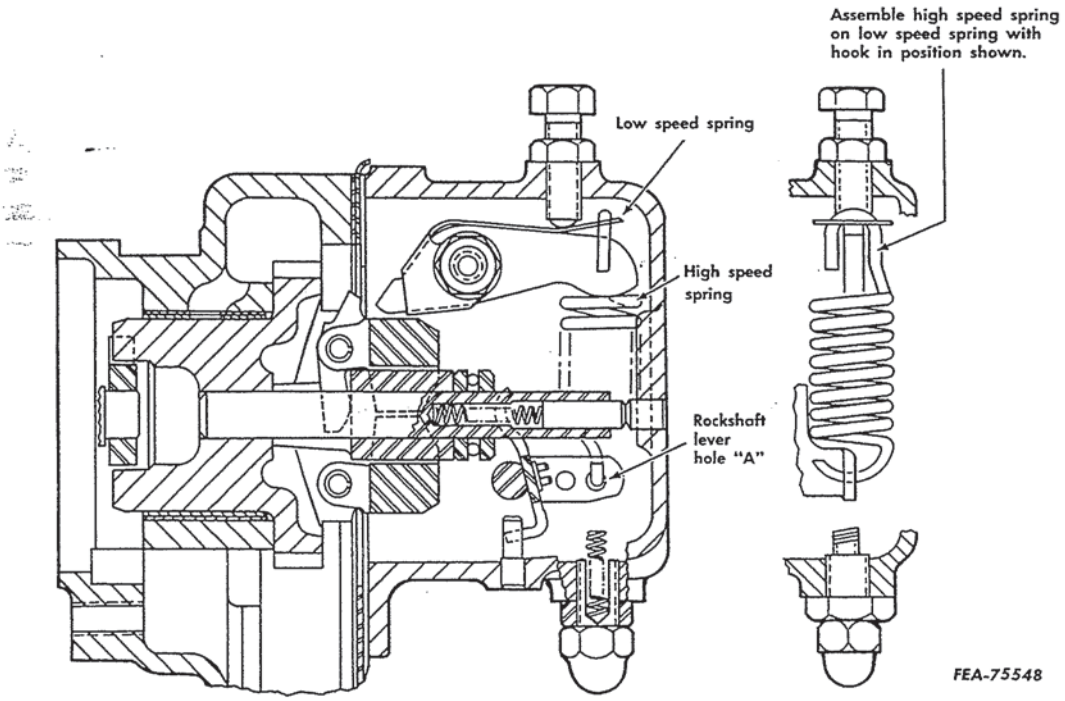
Care must be taken in the reassembly of the governor rockshaft, rockshaft fork, bearings and seal to insure uniformly smooth movement of the rockshaft from one extreme of movement to the other. Lubricate the rockshaft oil seal thoroughly upon installation. Some slight friction resulting from drag of the oil seal on the shaft is unavoidable, but friction from any other source must be held to a minimum. Any rough, jerking movement of the rockshaft must also be eliminated to prevent surging and erratic governor action.

The internal fit of the governor shaft ball bearing controls its end clearance. A new ball bearing will have end clearance in the range of 0.004 to 0.0065 inch. This bearing should be replaced when, after thorough cleaning, it is found rough.

Engine Governor High Speed and Low Speed Spring Installation

(Refer to Illust.)

Hook the upper end of the high speed governor spring through both holes of the low speed spring so that the open ends of the high speed spring will be toward the center of the governor housing. Hook the bottom end of the high speed spring into hole "A" of the rockshaft fork. Install the spring lever and low speed spring as a unit on the spring lever shaft.



Installation

Install the engine governor assembly using new mounting gaskets. The governor drive gear must be meshed in time with the camshaft gear in these engines, since the ignition unit is involved in the governor drive.

After installation of either new or overhauled governor assemblies in the engines covered in this manual section, it is important that a thorough check of all four adjustments be made. The basic governor assembly may be in perfect condition, but in order to insure its full range of control it must be adjusted to its individual engine.

Adjustments

Because of possible change in center-to-center distance between governor and carburetor, due to removal and replacement of manifold, carburetor or governor assemblies, the linkage between the governor and carburetor must be adjusted to establish the throttle position in relation to governor weight position. This adjustment insures the full power response of a wide open throttle when the governor weights are collapsed by reduction in rpm by application of heavy load. This governor-to-carburetor linkage must be free from binding throughout its range of movement.

1. Governor linkage adjustment procedure:

a. With the engine stopped, advance the speed change lever to about 3/4 speed position, sufficient to create tension on the governor spring.

b. Disconnect governor-to-carburetor control rod (either end). Hold carburetor throttle against its stop in wide-open position. Move governor rockshaft lever to rear of its travel and adjust length of governor-to-carburetor control rod so that it may be reconnected freely without moving throttle lever or governor lever.

c. Lengthen the control rod one turn from the above condition and reconnect.

d. After tightening the control rod clevis lock nut, check to be sure that both ends of the control rod are in the same plane to eliminate possibility of binding on levers.

e. Move the speed change lever a few times between half speed and low speed position, checking the governor-to-carburetor control rod in all positions for interference or binding.

2. Governor speed adjustment procedure:

a. After the engine has been started and the manifold is warmed up, the low idle speed setting should be made on the carburetor.

b. With the engine running, the governor speed change lever should be pulled back against its stop then the speed adjusting screw (the vertical screw on top of the governor housing) should be adjusted to obtain the specified high idle speed.

c. The governor action should be checked by moving the speed change lever back against the high idle stop suddenly. If the governor surges more than twice, screw in the bumper spring just enough to stop excessive surging.

d. After the bumper spring has been properly adjusted, lock it in place with a jam nut. Where use of the bumper spring is not required to control surging, it should be screwed in until it just touches the stop at low idle speed and then backed out 1/4 turn and locked.

NOTE: Excessive use of the bumper spring can cause an increase in low idle speed.

Lubricating Oil Pump

Description

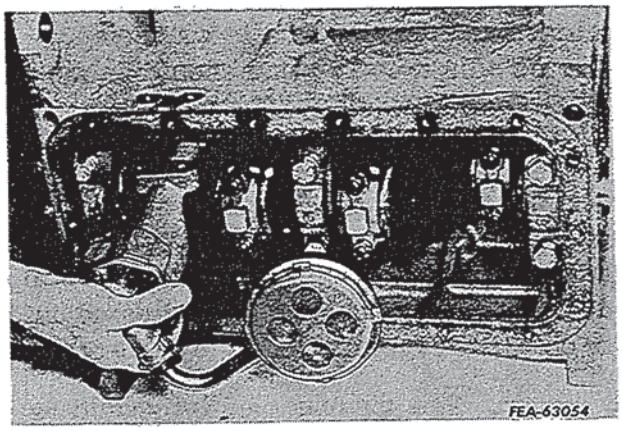
The engine lubricating oil pump is a gear type pump internally mounted to the bottom of the crankcase and is gear driven from the camshaft.

The lubricating oil is drawn from the oil sump through a screened intake to the oil pump.

The floating screened inlet is pivoted from the oil pump cover and must be free to move up and down.

From the oil pump, the oil is directed under pressure through rifle-drilled passages in the crankcase to the main bearings, camshaft bearings, timing gears, governor, valve lever assemblies and to the oil filter.

A plunger type, spring-loaded relief valve, located in the pump body, maintains the required circulating pressure. Should the oil pressure become excessive, the relief valve will by-pass the oil to the crankcase oil pan in sufficient amounts to reduce the pressure.



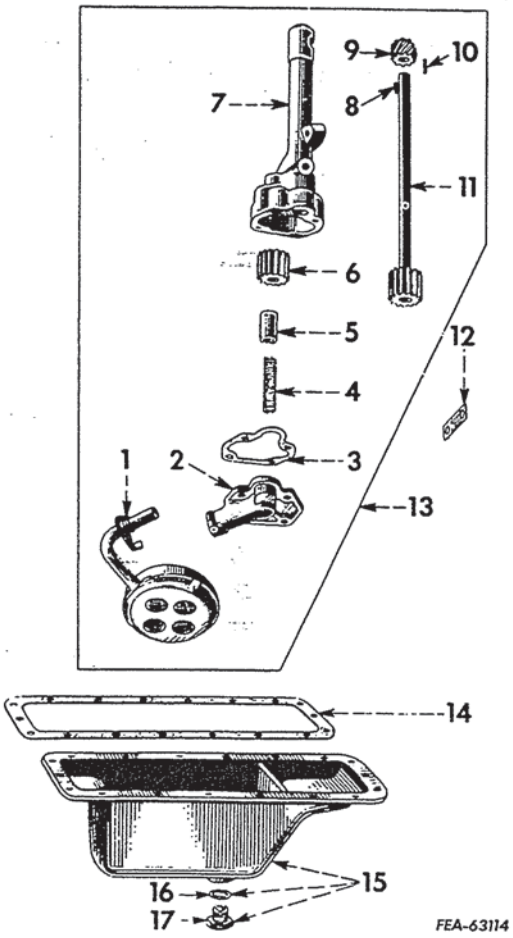
Removal

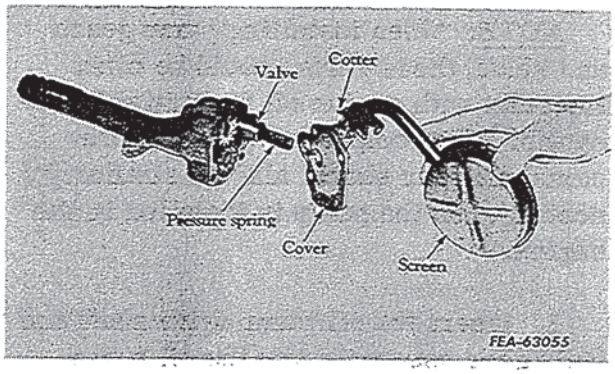
1. Drain the crankcase oil and remove the oil pan.

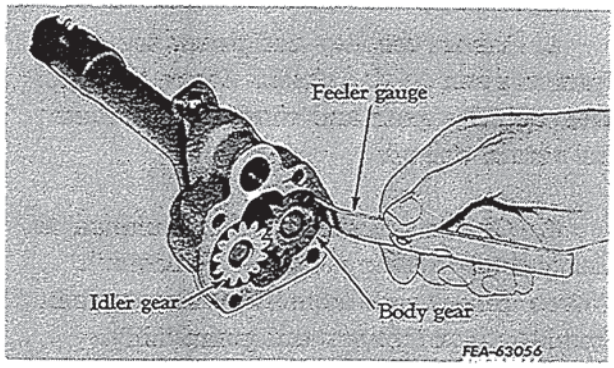
2. Remove the two cap screws that secure the oil pump to the crankcase. These cap screws are located on the outside of the crankcase on the right and toward the rear. Remove the pump, complete with screen, from the crankcase.

Disassembly

1. Remove the four cap screws securing the cover (2) to the oil pump body (7) and remove the cover and screen (1) as a unit. To separate the cover from the screen, remove the cotter pin.







2. Remove the pressure spring (4) and valve (5).

1. Screen	10. Pin
2. Cover	11. Gear and shaft
3. Gasket	12. Lock
4. Pressure spring	13. Pump assembly
5. Pressure valve	14. Gasket
6. Idler gear	15. Pan
7. Body	16. Gasket
8. Key	17. Plug
9. Gear	

3. Measure the clearance between the outside diameter of the gear and the bore of the housing. Clearance should be within the limits given in "Specifications".

4. Check backlash between the pump body gears. If this exceeds the figure shown in "Specifications" replace the gears.

5. Remove the oil pump idler gear (6) from the idler gear shaft.

6. Support the oil pump shaft (11) to prevent bending, and drive out the pin (10) from the oil pump spiral gear (9).

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 (8) 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.

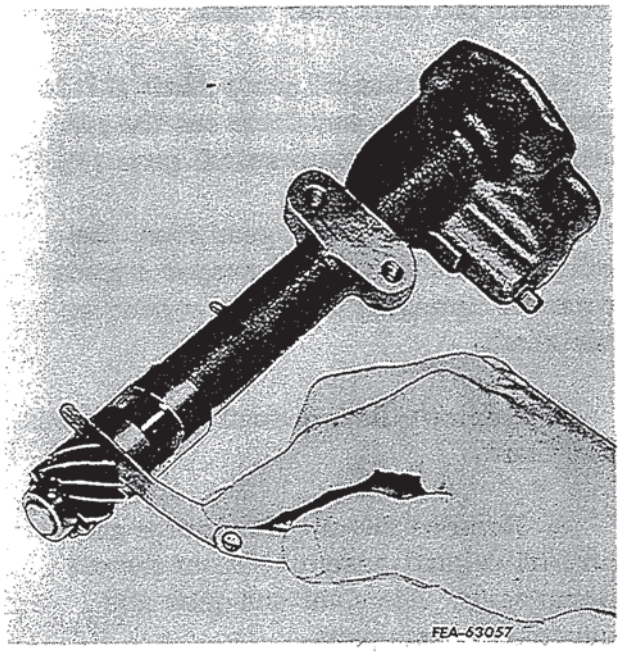
Inspection and Repair

1. Clean the pump parts thoroughly in cleaning solvent and dry with compressed air.

2. Inspect the gears for wear, scoring and chipped teeth. If either the body or idler gear is damaged, replace both.

3. Inspect the body and cover for traces of gear contact or other damage. Replace all worn or damaged parts. If the idler shaft is loose in the pump body, replace the body assembly as the idler shaft is not serviced separately.

4. Both the idler shaft and the drive shaft, when assembled, should be square with the face of the body within .001 inch.



5. Check the pump shaft clearance in the shaft bore. To correct for wear beyond limits given in "Specifications" replace the body and the shaft with gear.

6. The gasket is also a shim and should be replaced whenever a pump is serviced. If a replacement gasket is not available, do not use a makeshift gasket -- use the old one. When necessary, two gaskets are used to maintain the proper end clearance between the gears and the cover. Refer to "Specifications". It is important to maintain this clearance to prevent wear on the gears and cover.

7. Inspect the condition of the pressure valve. Be certain it slides freely and that the valve seat is not damaged.

8. Check the pressure valve spring (4) against the "Specifications". Replace the spring if it does not conform to specification.

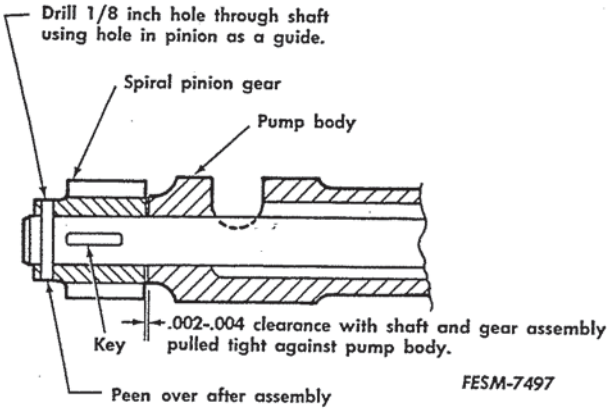
Reassembly

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

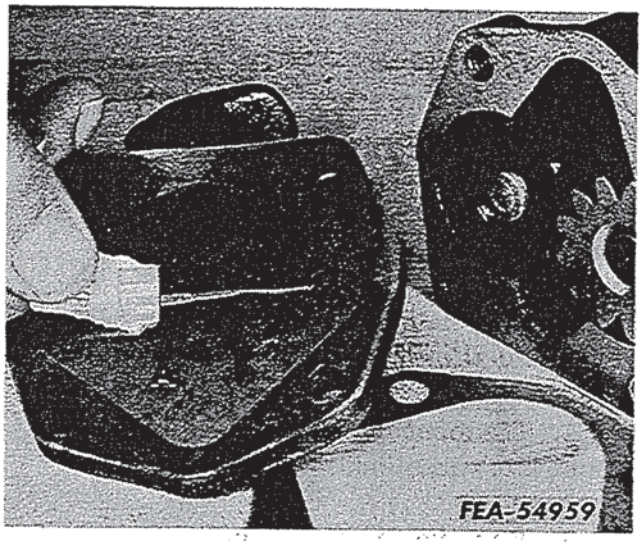
1. Insert the oil pump drive shaft and body gear assembly into the oil pump body.

2. Insert the key and press the spiral pinion gear on the shaft. Drive the pin through the gear and shaft. Peen over to retain the pin.

3. Check the pinion end clearance as indicated. Refer to "Specifications". When clearances cannot be maintained, replace worn gears and pump body.



NOTE: Service pump shaft and gear assemblies are not drilled for the pump drive gear pin. A 1/8 inch hole must be drilled through shaft after the gear is assembled to the dimensions shown.



4. Install the pressure valve and pressure spring.

5. With the idler gear in place, put a thin coating of grease on the gasket surfaces of the body and cover. Install the gasket or gaskets and cover to the body with cap screws and lock washers.

6. Check the oil pump body gear end clearance using "Plastigage" or virgin lead as shown. If the end play is in excess of that shown in "Specifications" remove one gasket from the cover. If the end play is less than shown add one gasket. Always recheck the end play after adding or removing gaskets. Be sure that there is no binding in the pump assembly.

7. Install the screen if removed and secure with a cotter pin.

Installation

1. Lift the oil pump assembly into position and secure it to the crankcase with the cap screws and lock washers.

2. Install a new oil pan gasket and attach the oil pan to the crankcase. Tighten the cap screws to standard torque for size and class.

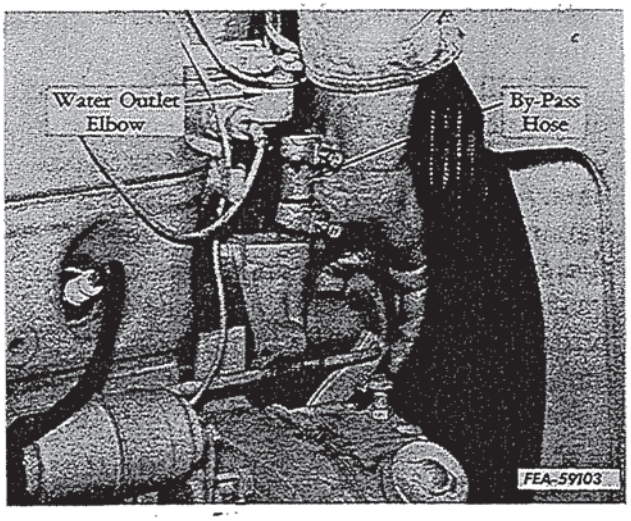
Water Pump

Description

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

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.

If a water leak develops in the pump, it indicates that the sealing parts are worn. Disassembly of the pump is necessary to replace these parts.



Removal

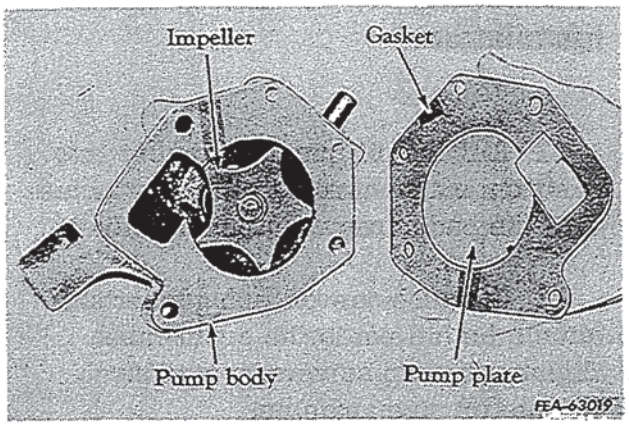
1. Drain the cooling system.

2. Remove the fan, water pump pulley and fan belt.

3. Disconnect the water pump inlet hose and slide it off of the water pump.

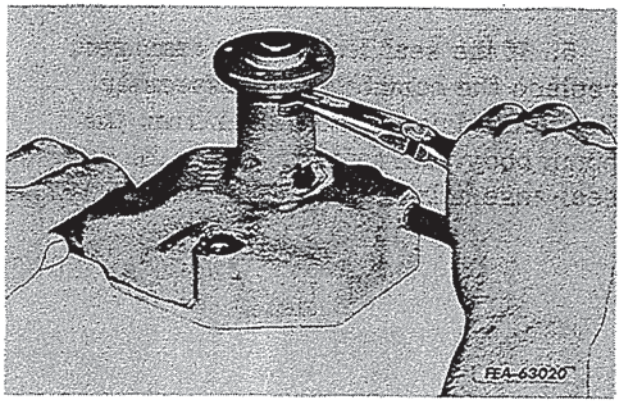
4. Disconnect the water by-pass hose from the water outlet elbow.

5. Remove the three cap screws securing the water pump to the crankcase and remove it from the engine.

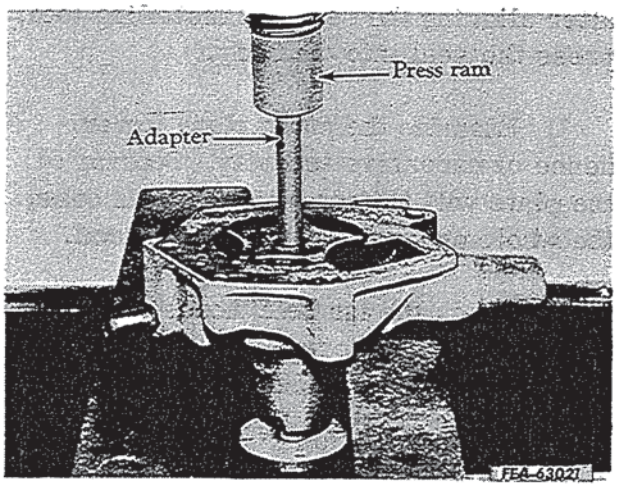


Disassembly

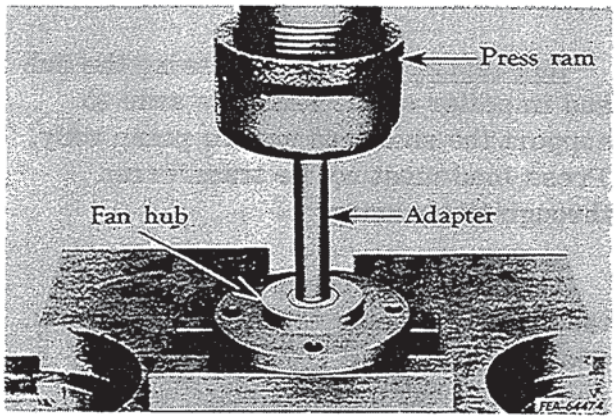
1. Remove the screws from the water pump plate. Remove the plate and gasket from the pump body.



2. Remove the front snap ring that retains the water pump shaft bearing. Support the water pump in an arbor press and push the shaft and bearing out as one assembly.



3. Place the shaft assembly in a press and press the shaft from the hub.



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

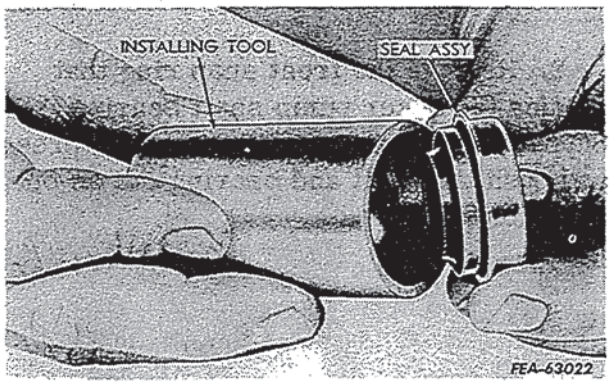
Inspection and Repair

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

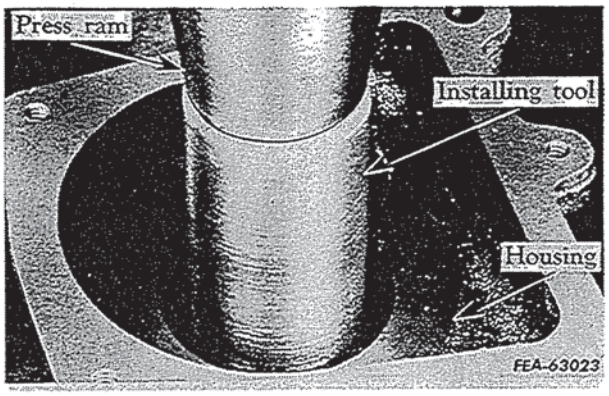
2. Examine the pump shaft and bearing for wear and damage. If necessary, replace the shaft, bearing and slinger as an assembly.

3. Replace the impeller if badly eroded.

4. Replace all gaskets.



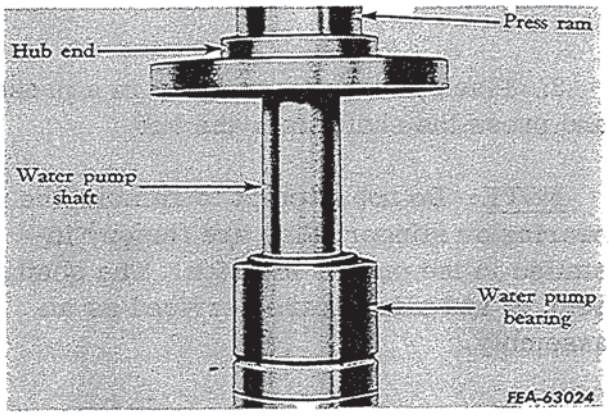
5. If the seal leaks or is damaged, replace the complete seal assembly. Carefully drive the old seal from the pump body with a drift. Place the new seal assembly on installing tool SE-1721.



6. Place the pump body in a press and, after aligning the seal and installing tool, press the seal into the body.

7. Examine the pump plate for evidence of excessive end play. Scoring of the plate will indicate this. In this case, the whole assembly must be replaced.

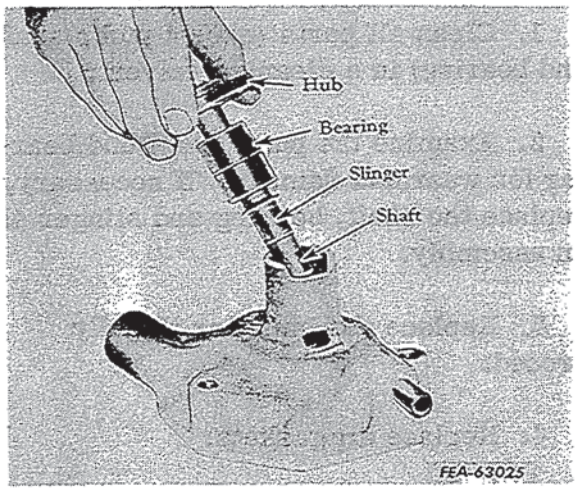
8. Check the fan belt, hoses and clamps. Cracked or oil soaked hoses and belt must be replaced. Make sure clamps have retained their strength.



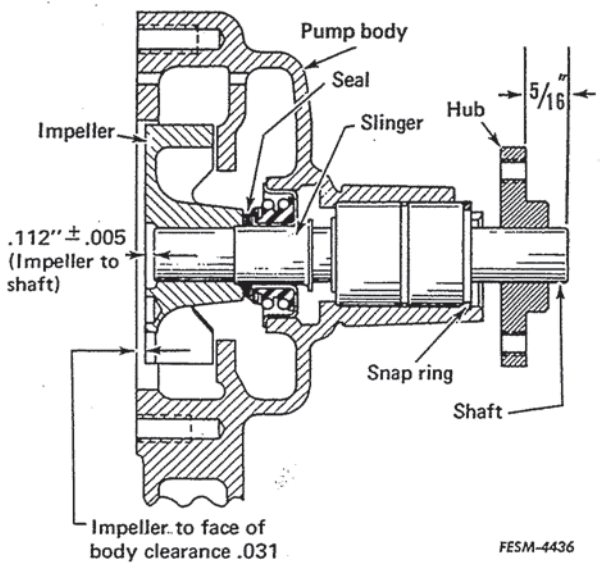
Reassembly

IMPORTANT: When pressing the hub and impeller on the shaft, be sure to support the shaft and not the pump body. Press load must not be transferred through the bearing.

1. Press the hub on the shaft with the small diameter of the hub facing out. See Illust. on page 1-55 for correct position of hub on the shaft.

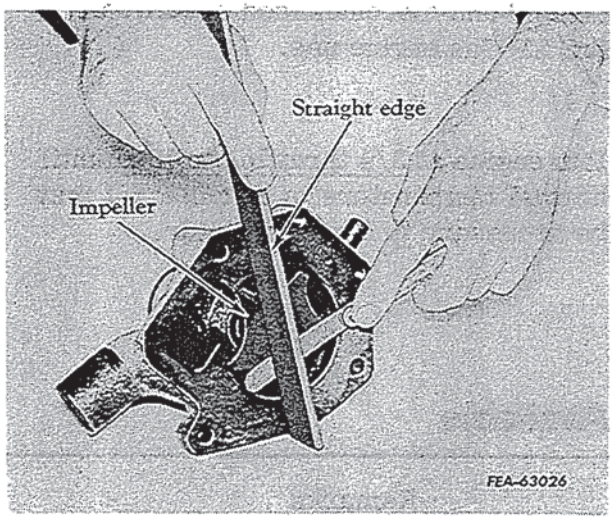


2. Install the shaft, bearing and slinger assembly in the front end of the pump body. Tap the shaft into place so that the bearing is firmly seated and clears the front snap ring groove.



3. Install the snap ring in its groove at the front end of the pump body.

IMPORTANT: Be sure to support the shaft and not the pump body when pressing. Press load must not be transferred through the bearing.



4. Support the front end of the shaft, and press the impeller on the rear of the shaft so there is .031 inch clearance between the machined face of the pump body and the face of the impeller. Check the clearance with a straight edge and feeler gauge.

5. Install the water pump plate with a new gasket.

Installation

1. Secure the water pump to the crankcase with three cap screws and a new gasket.

2. Connect the water by-pass hose to the water outlet elbow.

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

4. Install the water pump pulley, fan and fan belt.

BREAK-IN PROCEDURE OF REBUILT GASOLINE AND LPG ENGINES

Gas Engines

Fill crankcase with MIL-L-2104A or Service "MS" oil of SAE 30 weight to the proper level.

LPG Engines

Fill crankcase with a "Low Ash" engine oil of SAE 30 grade to the proper level.

"Low Ash" engine oils which do not contain barium or calcium additive compounds are recommended. These oils are usually designated as "Supplement 1" oils for API Service "MS" in LP Gas engines. Oils of this type are usually labeled and merchandised specifically for LP Gas engine use.

Run engine at 3/4 throttle, no load until normal temperature is reached. It may be necessary to cover radiator.

"Run-In" When Dynamometer is Not Available

Period	Engine RPM	Load	Remarks
15 Min.	3/4 of rated	None	Operate tractor in fourth gear on road.
45 Min.	3/4 of rated	Light	Operate tractor 2 full gear below normal for load connected to drawbar.
2 Hours	Full	Medium	Operate tractor 1 full gear below normal for the load connected to drawbar. *Retorque head and adjust valves.

*NOTE: When retorquing cylinder head bolts, only those below proper torque are to be torqued to specifications. Those within specified torque or above torque are to remain as they are.

"Run-In" When Dynamometer is Available

Period	Engine RPM	Load	Remarks
1/2 Hour	1/2 of rated	Set dynamometer to show 1/2 of rated hp.	Load on the engine will be about 1/4 of rated due to reduced rpm.
1/2 Hour	3/4 of rated	Set dynamometer to show 3/4 of rated hp.	Load on engine will be slightly over 1/2 of rated.
1/2 Hour	Full	3/4 of rated hp	Dynamometer will read correct hp.
*Retorque Head and Adjust Valves			
1 Hour	Full	3/4 of rated	Dynamometer will read correct hp.

*NOTE: When retorquing cylinder head bolts, only those below proper torque are to be torqued to specifications. Those within specified torque or above torques are to remain as they are.

Tractor is then ready for normal operation. After 100 hours, the cylinder head bolts should be retorqued and the valves adjusted.

If SAE weight is correct for prevailing temperature, oil used for break-in can be used for the duration of the normal change period, otherwise, recommendations in owner's manual as to SAE weight should be followed.

Section 2

GASOLINE FUEL SYSTEM

CONTENTS

CARBURETOR SPECIFICATIONS

	C-123				
IH part number	366 462 R94	366 463 R93	367 822 R91	372 095 R91	372 096 R93
Machine used on	F & I-140 w/s.n. 103, 556 and below	56, 57 Balers	F & I-240	F & I-240 (distillate)	F & I-140 (distillate)
Model	Zenith 68X7	Zenith 68X7	Zenith 68X7	Zenith 68X7	Zenith 68X7
Liquid level - inch	15/32	15/32	15/32	15/32	15/32
Float height - inch*	1-5/32	1-5/32	1-5/32	1-5/32	1-5/32
Main metering jet	20-L†	21†	21†	20-L†	20-L†
Idle jet	11-S†	11-S†	11-S†	11-S†	11-S†
Discharge nozzle - drill size	45†	50†	50†	45†	45†
Venturi	15 m.m.	16 m.m.	16 m.m.	15 m.m.	15 m.m.
Needle valve seat	35†	35†	35†	35†	35†

	C-123			
IH part number	372 983 R91	372 984 R91	385 607 R91	385 608 R91
Machine used on	F & I-140 w/s.n. 103, 556 and below	F & I-240	F & I-140 w/s.n. 103, 557 and above	F & I-140 w/s.n. 103, 557 and above
Model	Marvel-Schebler TSX-730	Marvel-Schebler TSK-744	Marvel-Schebler TSX-864	Zenith 68X7
Liquid level - inch	1/2	1/2	1/2	15/32
Float height - inch *	1/4	1/4	1/4	1-5/32
Main metering jet	142 c.c.	184 c.c.	150 c.c.	19-L †
Idle jet	85 c.c.	101 c.c.	85 c.c.	11-S †
Discharge nozzle - drill size . . .	#40 (.098")	#35 (.110")	#40 (.098")	45 †
Venturi	19/32 inch	11/16 inch	5/8 inch	15 m.m.
Needle valve seat	.070 inch	.070 inch	.070 inch	35 †

* IH & Zenith: Measured from the top of the bowl gasket to the bottom of the float.

Marvel-Schebler: Measured from the bottom of the gasket to the top of the float.

† Figures shown are flow check numbers - not drill sizes. These figures are stamped on individual parts.

CARBURETOR SPECIFICATIONS — Continued

	C-135		
IH part number	367 700 R93	372 985 R92	396 478 R91
Machine used on	F & I-340, 404 & 91 Combine	F & I-340, 404 & 91 Combine	201 Windrower
Model	Zenith 68X7	Marvel-Schebler TSX-827	Marvel-Schebler TSX-926
Liquid level - inch	15/32	1/2	1/2
Float height - inch *	1-5/32	1/4	1/4
Main metering jet	24-L †	184 c.c.	218 c.c.
Idle jet	11-S †	101 c.c.	101 c.c.
Discharge nozzle - drill size	50 †	#35(.110")	#35(.110")
Venturi	17 m.m.	11/16 inch	11/16 inch
Needle valve seat	35 †	.070 inch	.070 inch

	C-146			
IH part number	389 683 R94	397 341 R91	404 120 R91	404 140 R91
Machine used on	I-424, 2424	500 Crawler	500 Series C Crawler (G.D.)	500 Series C Crawler (P.S.)
Model	Marvel-Schebler TSX-896	Marvel-Schebler TSX-930	Marvel-Schebler TSX-948	Marvel-Schebler TSX-949
Liquid level - inch	1/2	1/2	1/2	1/2
Float height - inch *	1/4	1-1/2 (Note 1)	1-1/2 (Note 1)	1-1/2 (Note 1)
Main metering jet	242 c.c	260 c.c.	275 c.c.	307 c.c.
Idle jet	85 c.c.	85 c.c.	85 c.c.	85 c.c.
Discharge nozzle - drill size	#35(.110")	#35(.110")	#31(.120")	#31(.120")
Venturi	25/32 inch	25/32 inch	7/8 inch	7/8 inch
Needle valve seat	.082 inch	.070 inch	.070 inch	.070 inch

* IH & Zenith: Measured from the top of the bowl gasket to the bottom of the float.
Marvel-Schebler: Measured from the bottom of the gasket to the top of the float.

† Figures shown are flow check numbers - not drill sizes. These figures are stamped on individual parts.

Note 1: Measured from the bottom of the gasket to the bottom of the float.

CARBURETOR SPECIFICATIONS – Continued

	C-153				
IH part number	380 490 R94	381 945 R93	389 683 R94	396 738 R92	405 530 R91
Machine used on	Constructall 2500 Backhoe-Loader	F & I-504, I-2504, 3514 Loader Tractor, 93 Combine, 5000 Series Forklift, Constructall 2500 Backhoe-Loader	I-444, 2444 and 4000 Series Forklift	105, 203 Combine, 225 Hayswather, 210, 275, 375 Windrowers	105, 203 Combine, 225 Hayswather, 210, 275, 375 Windrowers
Model	Zenith 267X9	Marvel-Schebler TSX-857	Marvel-Schebler TSX-896	Marvel-Schebler TSX-925	Zenith 267X9
Liquid level - inch . . .	15/32	1/2	1/2	1/2	15/32
Float height - inch* . . .	1-5/32	1/4	1/4	1/4	1-5/32
Main metering jet	25†	232 c.c.	242 c.c.	232 c.c.	25†
Idle jet	14†	101 c.c.	85 c.c.	101 c.c.	14†
Discharge nozzle - drill size	70†	#26(.147")	#35(.110")	#26(.147")	70†
Venturi	21MM Offset	7/8 inch	25/32 inch	7/8 inch	21MM Offset
Needle valve seat	35†	.101 inch	.082 inch	.070 inch	55†

* IH & Zenith: Measured from the top of the bowl gasket to the bottom of the float.

Marvel-Schebler: Measured from the bottom of the gasket to the top of the float.

† Figures shown are flow check numbers - not drill sizes. These figures are stamped on individual parts.

CARBURETORS

General Description

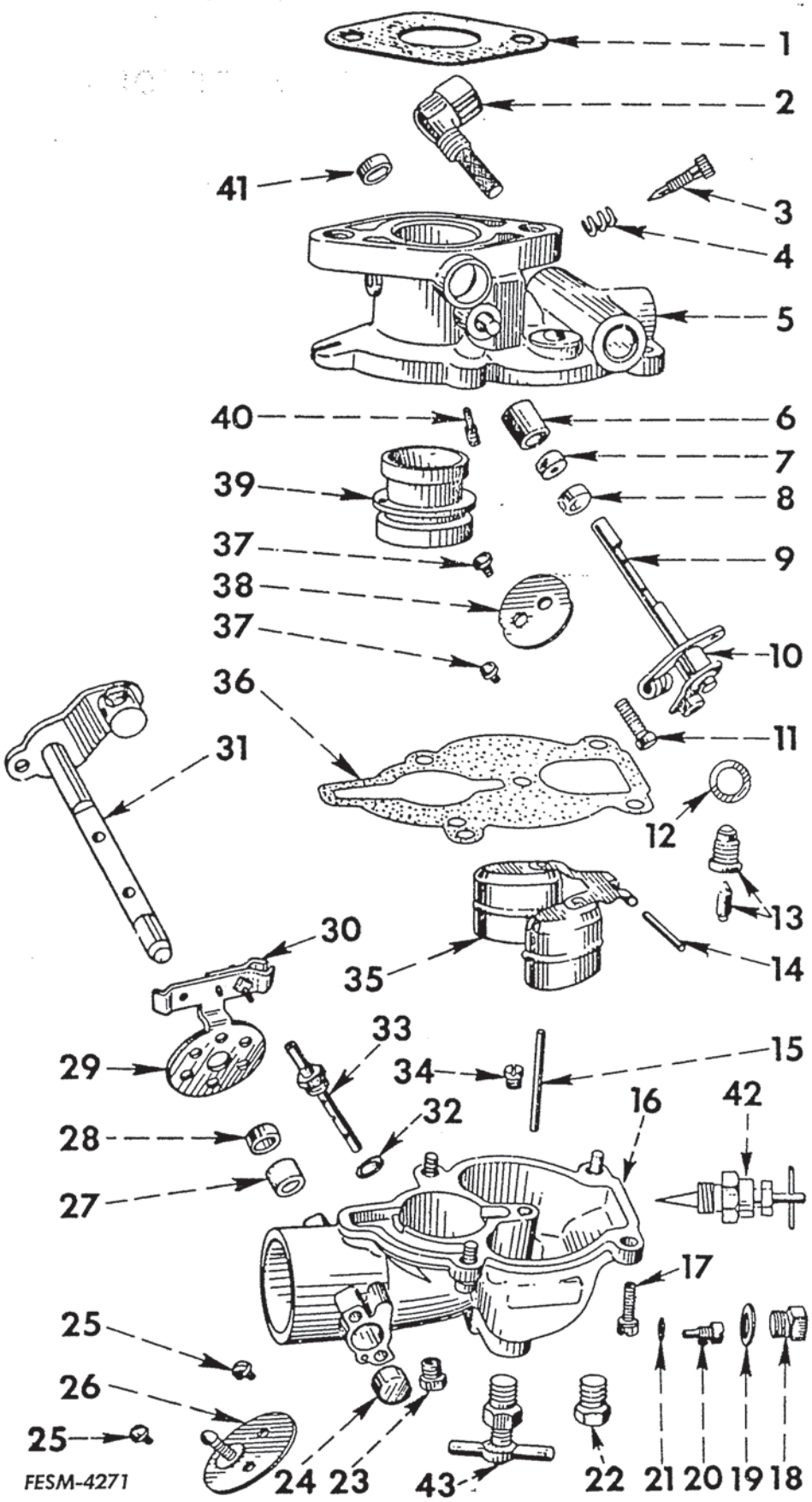
The fuel system consists, basically, of a fuel supply tank, fuel shut-off valve, fuel strainer, carburetor, intake-exhaust manifold, air cleaner and a variable speed governor.

Liquid fuel flows from the supply tank by gravity or by means of an electric fuel pump through the fuel strainer and sediment bulb to the carburetor. Air enters these naturally aspirated systems through the air cleaner, where dirt and abrasive material are removed.

Clean air and fuel is metered to the engine by the carburetor; in varying proportions to meet the changing demands of load and speed.

The variable speed governor controls the carburetor throttle to admit a greater or lesser volume of air-fuel mixture. This supports the operator's demand for engine speed, and provides power to maintain that speed, up to the capacity of the engine.

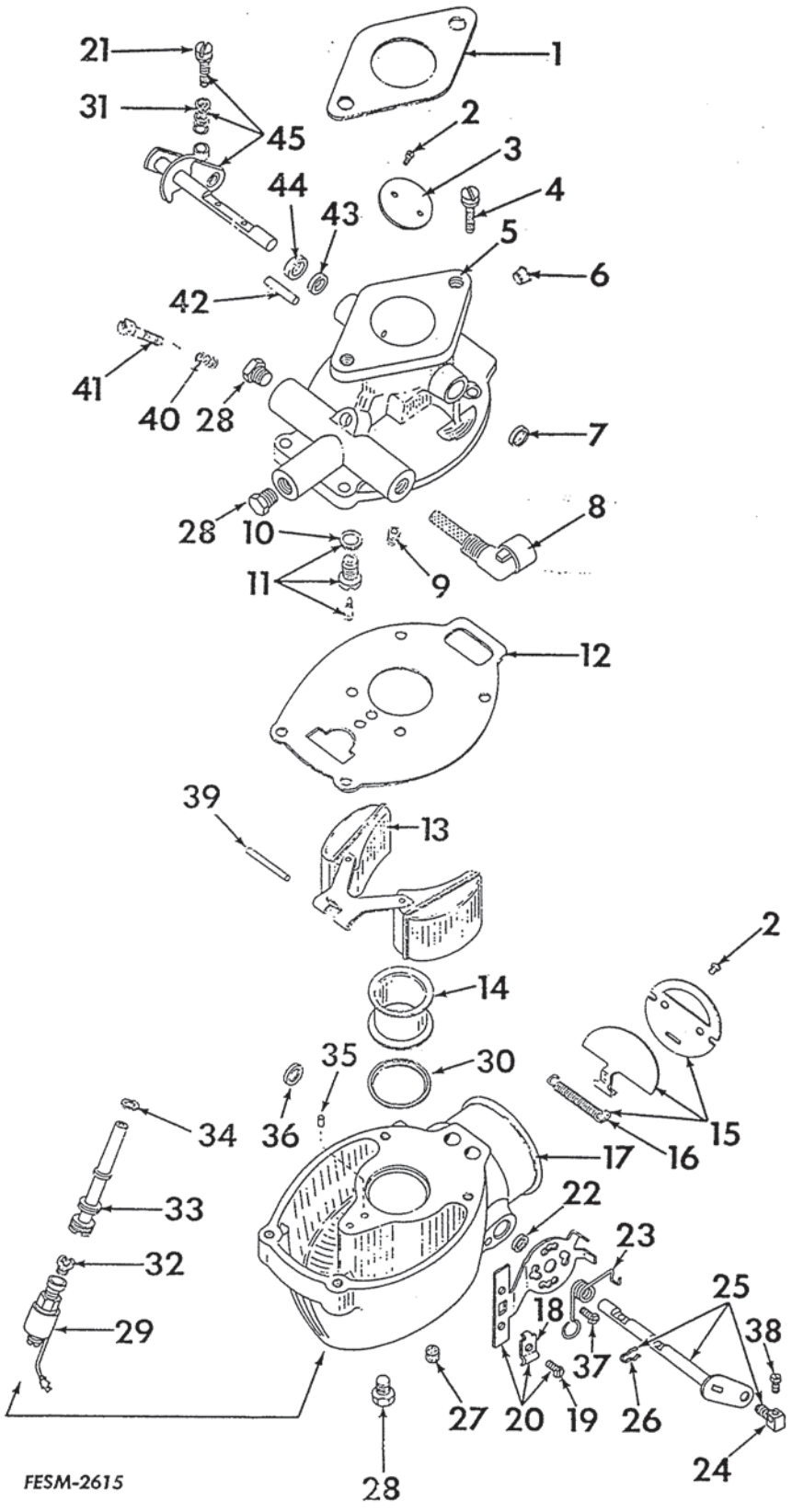
1. Gasket
2. Elbow and strainer
3. Idle adjusting needle
4. Spring
5. Throttle body
6. Throttle shaft bushing (if used)
7. Throttle shaft seal
8. Seal retainer
9. Lever and shaft
10. Taper pin
11. Throttle stop screw
12. Fuel valve washer
13. Fuel valve and seat
14. Float axle
15. Idle filler tube
16. Fuel bowl
17. Screw
18. Lower plug
19. Fibre washer
20. Main jet
21. Washer
22. Drain plug
23. Drip plug filter
24. Plug
25. Screw
26. Choke plate
27. Washer
28. Packing retainer
29. Choke valve bracket
30. Bracket clamp
31. Lever and shaft
32. Fibre washer
33. Main discharge jet
34. Well vent jet
35. Float assembly
36. Gasket
37. Screws
38. Throttle valve plate
39. Venturi
40. Idling jet
41. Plug
42. Not used
43. Not used



Exploded view of typical Zenith carburetor.

1. Gasket
2. Screw
3. Throttle plate
4. Screw
5. Throttle body
6. Plug
7. Cup
8. Strainer assembly
9. Idling jet
10. Gasket
11. Float valve assembly
12. Gasket
13. Float
14. Venturi
15. Choke plate assembly
16. Spring
17. Fuel bowl
18. Clip
19. Screw
20. Bracket
21. Stop screw
22. Packing
23. Return spring
24. Swivel
25. Choke shaft assembly
26. Retainer spring
27. Bowl strainer
28. Drain plug
29. Solenoid fuel shut-off valve
30. Venturi retainer
31. Spring
32. Power jet*
33. Nozzle
34. Gasket
35. Well vent
36. Cup
37. Screw
38. Screw
39. Float axle
40. Spring
41. Idle adjusting screw
42. Throttle stop pin
43. Packing
44. Packing retainer
45. Throttle shaft assembly

* Not part of carburetor assembly.



Exploded view of typical Marvel Schebler carburetor.

Operation

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 rich fuel mixture; full load, full speed operation requires the leanest fuel mixture. To simplify the explanation of how the carburetor functions, we will divide it into four systems and discuss each, separately.

- FUEL SUPPLY SYSTEM
- IDLING SYSTEM
- LOAD SYSTEM
- STARTING SYSTEM

Fuel Supply System

The fuel supply system is that portion of the carburetor consisting 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 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.

While the engine is in operation, fuel flows from the bowl through the main metering jet to the load system or idling system and the float valve maintains just enough opening to keep 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.

The ratio of air and fuel mixture from a "balanced" carburetor will not be seriously affected by changes in condition of the air cleaner as it becomes restricted by accumulation of dirt. However, a power loss will be caused. A balanced type carburetor must have an airtight seal between the bowl and the bowl cover, since any air admitted into the bowl other than through the calibrated vent, will upset the ratio of air-fuel delivery and also allow entry of dirt.

In review, sustained constant level of fuel in the bowl, together with controlled venting of the bowl, insures a stable supply of fuel to the various metering systems and is unaffected by the height of fuel in the supply tank or normal operating changes in air cleaner condition.

Idling System

The idling system consists of idle discharge port, idle adjusting needle, idle jet and the connecting channels and air bleed. 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 well through the main metering jet and is drawn through the idle jet calibration into the idle passage where it is mixed with air from the idle air bleed.

The air-fuel mixture enters the air stream past the throttle plate, from the idle discharge port. The idle air adjusting screws on the carburetors are turned toward their seat to enrich the air-fuel mixture.

Load System

The load system consists of the venturi, discharge nozzle, well, well air bleed, and main metering jet. 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, a sufficient amount and velocity of air passes the venturi and discharge nozzle 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 diminished delivery of fuel from the idling system. Ultimately, all delivery of fuel from the idling system is stopped and air is being drawn from this source into the well.

The main metering jet 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 and discharge nozzle is similar 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 by the main metering jet. This lowers the level of fuel in the well.

As the load and throttle opening is increased, the fuel level in the metering well drops below a series of air bleed holes in the discharge nozzle, admitting an increasing amount of air from the well air bleed. This metered addition of air to the discharge nozzle is necessary to compensate for the fact that the partial vacuum produced at the nozzle increases out of proportion with the increased velocity of air through the venturi.

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.

A small additional amount of fuel is necessary to insure prompt response for engine acceleration. When the throttle is suddenly opened, the resulting rush of air through the venturi picks up this necessary extra fuel which remains above the main metering jet in the metering well during part throttle operation.

Most carburetors are equipped with a main jet adjustment screw or an electric fuel shut-off valve which incorporates a main jet adjustment screw. The screw is used to limit the amount of fuel going into the engine.

The fuel adjusting screw must be set six turns off its seat. The fuel adjusting screw on carburetors with electric fuel shut-off should be set 4-1/2 turns off its seat.

The main metering jet 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

The starting system consists of a manually operated choke valve mounted in the carburetor main air intake. When the choke valve plate is turned to the closed position, it restricts the air entering the carburetor. It does not, however, restrict the main air vent passage. This upsets the balance of the carburetor, allowing the increased suction to draw strongly upon the fuel discharge openings when starting the engine.

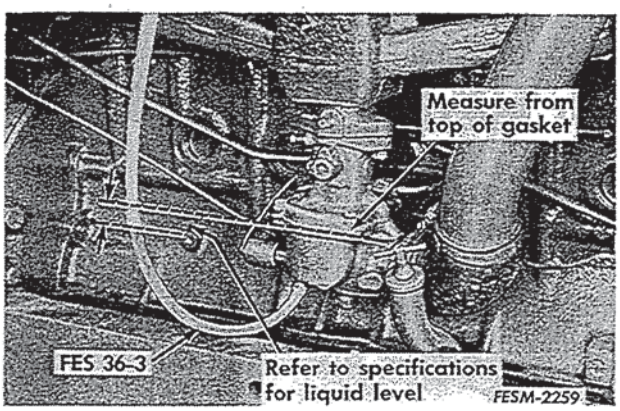
When the outside air, manifold, and engine combustion chambers are cold, it is necessary to supply a very "rich" starting mixture. Only the "light-ends" or more volatile portions of the fuel can be vaporized because of the low temperature and the slow movement of air past the discharge nozzle due to low cranking speed. The necessary large quantity of fuel is supplied by closing the choke valve during the cranking period.

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 and warms up, the choke valve is manually opened to further lean out the air-fuel ratio to a normal mixture.

An opening is provided in the bottom of the carburetor main air intake to drain off any excess unvaporized fuel which may return from the manifold. This opening is protected against the entry of dust and abrasives by a drop filter. Should this filter shrink and deteriorate from age, dirt may be drawn into the engine contributing to excessive engine wear. Should this opening be painted over or otherwise plugged, no drainage is possible and flooding with raw fuel can occur if the fuel float valve leaks.

Liquid Level Check (Carburetor on Engine)

The liquid level in the carburetor can be checked with the carburetor on the engine using tool FES 36-3.



1. Close the fuel shut-off at the fuel tank.

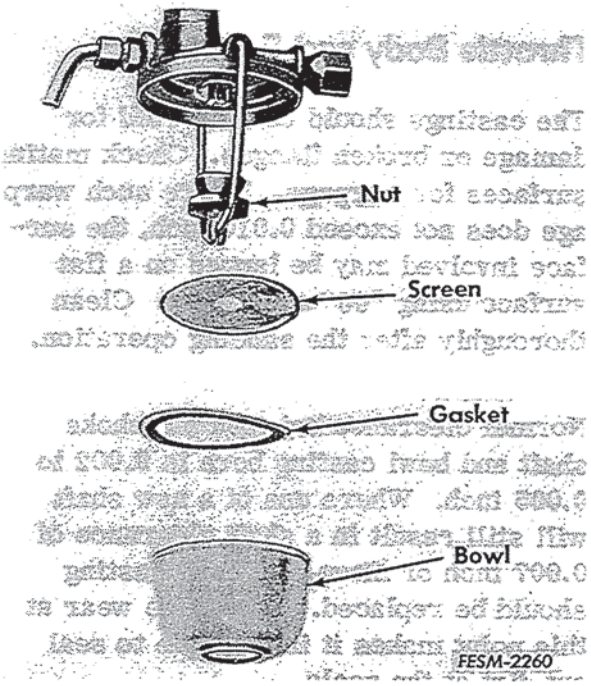
2. Remove the drain plug at the bottom of the carburetor. Attach the tool FES 36-3 as shown.

3. Open the fuel shut-off. Fuel will flow into the tube and seek the same level as the liquid level in the carburetor.

4. Measure the distance between fuel level in the tube to the top of the fuel bowl gasket. This will be the liquid level in the carburetor. Refer to specification for specified liquid level.

Removal and Installation

Before removing the carburetor from the engine for cleaning, inspection or repair, clean the area and various connecting points to prevent entry of dirt into those parts which remain with the engine. Failure to perform this simple operation may result in an ultimate condition much worse than that which made the carburetor removal necessary.



After the carburetor is removed, inspect the air cleaner pipe and hose for possible air leaks wherein dirt and abrasives could enter the engine. Discard the carburetor flange gasket. Clean manifold flange of any scraps of old gasket which may adhere and would prevent sealing of new gasket.

When reinstalling the carburetor, care must be used in securing air and dust tight connections of air cleaner pipe and hose. Renew if necessary. Before reconnecting the fuel line to the carburetor, remove and clean sediment bowl and screen. Use new bowl gasket in replacing sediment bowl. Open the fuel tank valve momentarily to flush line and observe for free flow of fuel.

After the carburetor is reinstalled on the manifold, recheck the adjustment of the governor-to-carburetor control rod to insure wide open throttle at full load demand of governor, as follows. With engine stopped, advance engine speed control hand lever to create tension on the governor spring. Adjust length of governor-to-carburetor control rod so that the rod slides freely into the throttle lever, when the throttle is wide open. Lengthen governor-to-carburetor control rod by one turn in its clevis to place spring load on throttle lever, insert cotter pin and tighten lock nut on clevis. Return the speed control hand lever to a position slightly advanced from low idle position. In this condition, check the governor-to-carburetor control rod for any tendency toward binding. It may be necessary to loosen the clevis lock nut and reposition the clevis slightly to insure both ends being in the same plane to eliminate binding (after which the lock nut is retightened). Refer to section 1 for governor adjustments.

Assemble the choke control wire and tube, being sure full movement of choke valve is assured with the full movement of choke control knob.

Inspection and Repair

Before disassembly of the carburetor, clean the outside surfaces of dirt accumulations so that the solvent used to clean the dismantled parts will not become contaminated.

In order that individual parts may be given a thorough inspection, cleaning is important. The use of a good carburetor cleaning solvent is necessary to dissolve gum and varnish-like coatings. The slow buildup 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. Where a good commercial carburetor cleaner is not available, equal parts of alcohol and benzol may be used.

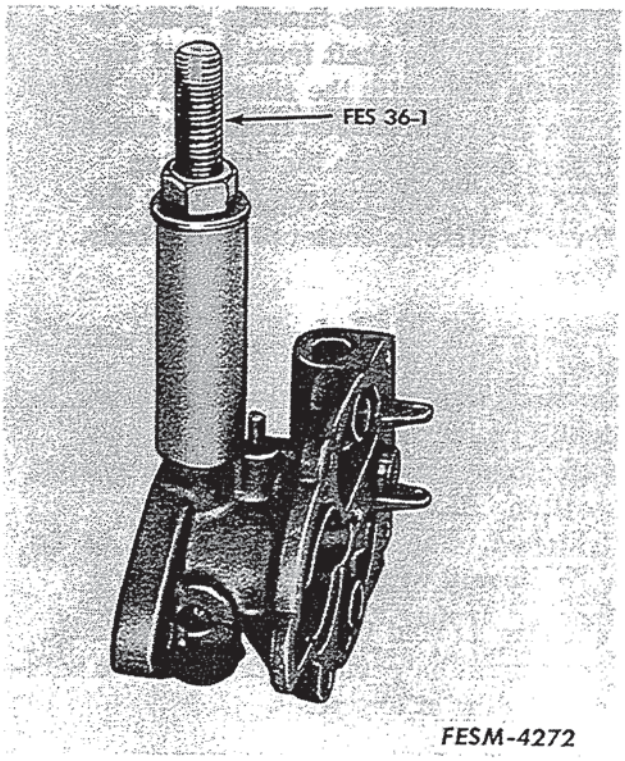
After the dismantled parts have remained in the solvent long enough to dissolve the coatings, remove and rinse in petroleum base cleaning solution. Dry all parts with compressed air, blowing through all jets and channels in both directions to assure that they are clear and clean.

IMPORTANT: Do not use drills or wires to clean calibrated openings; any slight enlargement of these jet openings will affect the operation. Use only gum solvent and compressed air for cleaning.

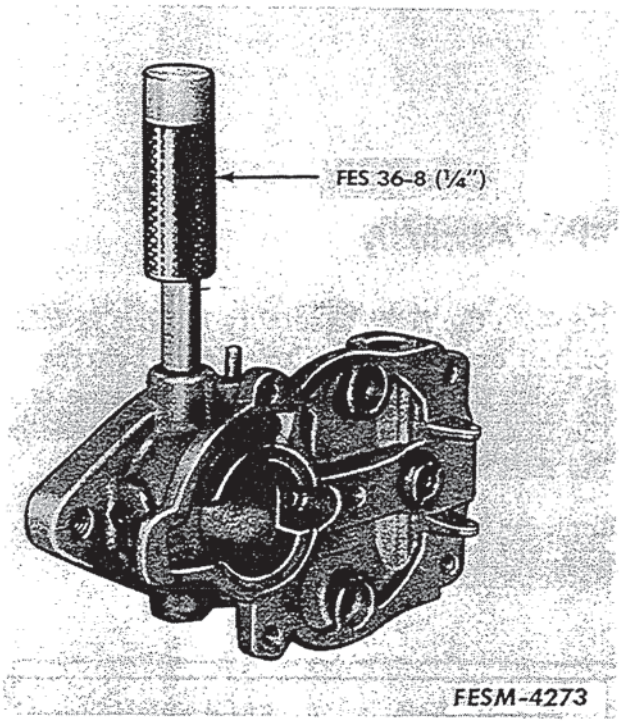
Throttle Body and Fuel Bowl

The castings should be inspected for damage or broken flanges. Check mating surfaces for warpage. Where such warpage does not exceed 0.010 inch, the surface involved may be lapped on a flat surface using "00" sandpaper. Clean thoroughly after the sanding operation.

Normal clearance between the choke shaft and bowl casting bore is 0.002 to 0.005 inch. Where use of a new shaft will still result in a shaft clearance of 0.007 inch or more, the bowl casting should be replaced. Excessive wear at this point makes it impossible to seal out dirt at the seals.

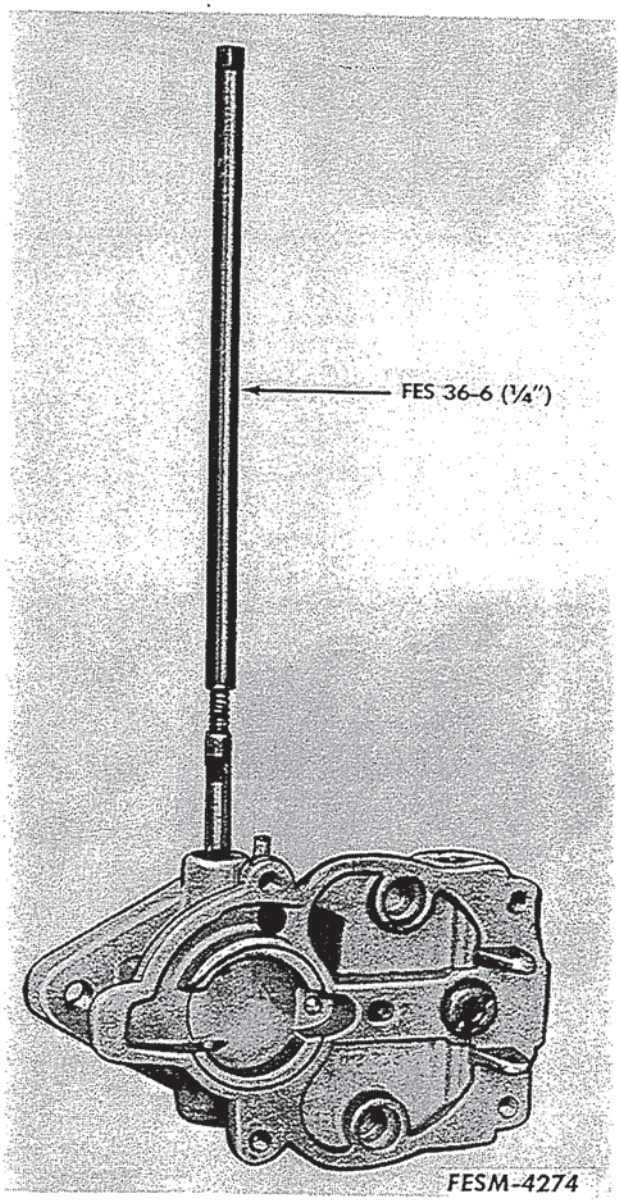


Removing throttle shaft bushing (Zenith).



Installing throttle shaft bushing (Zenith).

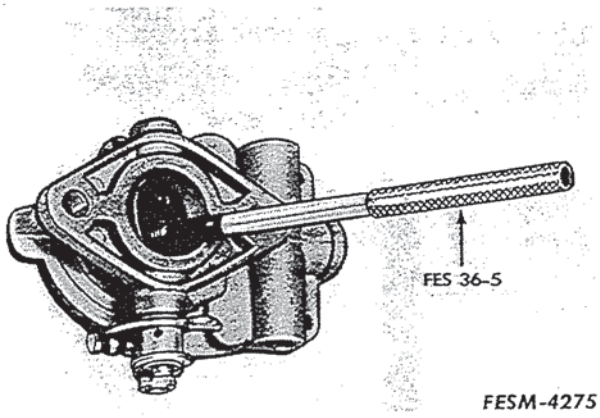
The normal clearance between the throttle shaft and throttle body bore is 0.001 to 0.003 inch. Where the use of a new throttle shaft will not hold the clearance below 0.005 inch, the throttle shaft bushings (Zenith) or body assembly (Marvel-Schebler) should be replaced. Excessive wear of this throttle shaft bore or bushings will result in dirt and air leakage past seals and poor alignment of the throttle plate, affecting engine idling and governor action. Bushings can be replaced using tools shown in Illusts. on this page.



Reaming throttle shaft bushing (Zenith).

Throttle Plate

The throttle plate should be inspected for burrs or damaged edges which would prevent good contact with the throttle body bore when fully closed. Never use a buffing wheel or wire brush to clean this plate, its sharp edges must not be deformed.

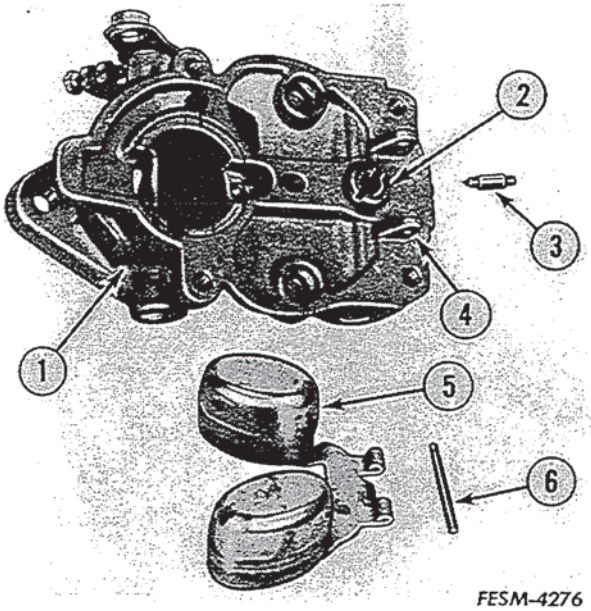


FESM-4275

When installing the throttle plate, insert it into the shaft from top of the throttle body with the short end of the plate down (measured from the holes). Insert screws from the top, using FES 36-5 but do not tighten until the throttle plate is centered in the body bore.

Unscrew the throttle stop screw until the plate is allowed to close fully. Holding 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. The screws may then be tightened. The throttle plate must fit the bore closely with a minimum of light showing around its edges. The throttle shaft must be perfectly free to turn without binding at any point.

Flatten the exposed ends of the throttle plate screws to lock them in place. This must be done with care to prevent distortion of throttle shaft or plate.



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Float Assembly

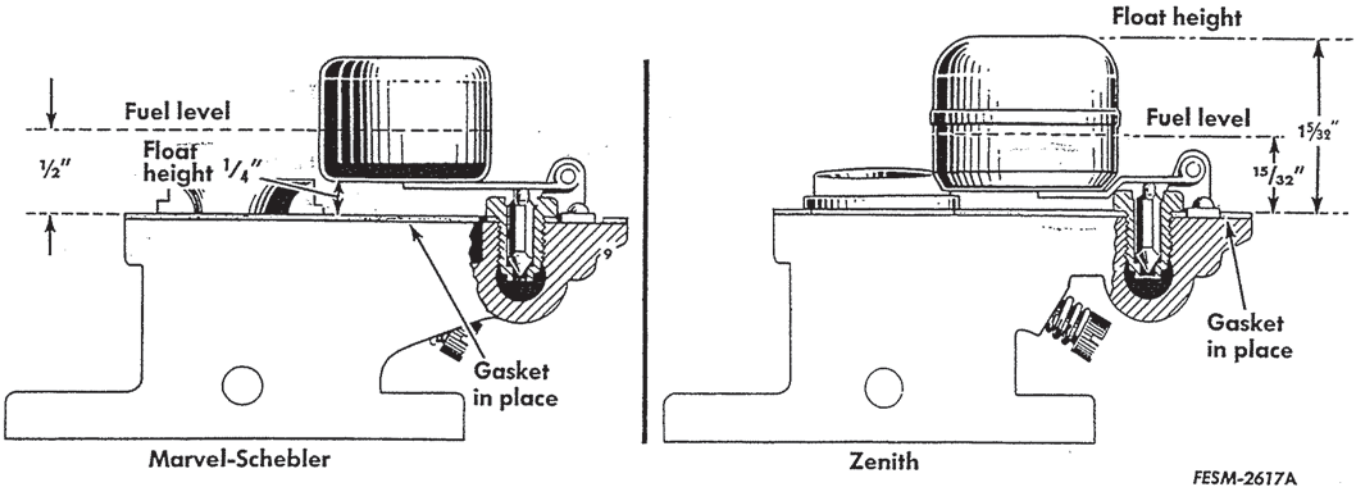
Replace the float assembly if float is full of fuel or if the float lever axle bearing is worn excessively. Inspect top side of the float lever for wear where it contacts the fuel needle valve.

Replace the float axle if any wear can be detected on its bearing surfaces.

1. Throttle body	4. Float axle support
2. Fuel valve seat	5. Float
3. Fuel valve	6. Float axle

Fuel Needle Valve and Seat

If any wear can be detected on the valve face, the needle valve and seat assembly should be replaced. The float assembly, its axle, and the fuel valve are responsible for maintaining a stable and correct fuel level; all parts must be maintained in good condition. Only slight bending of the float lever should be necessary to secure the correct float height. The float lever stop where used, should be adjusted to control float drop. Proper setting of float drop prevents the float from striking and wearing on the bottom of the bowl when operating over rough terrain.



Float measurement and liquid level.

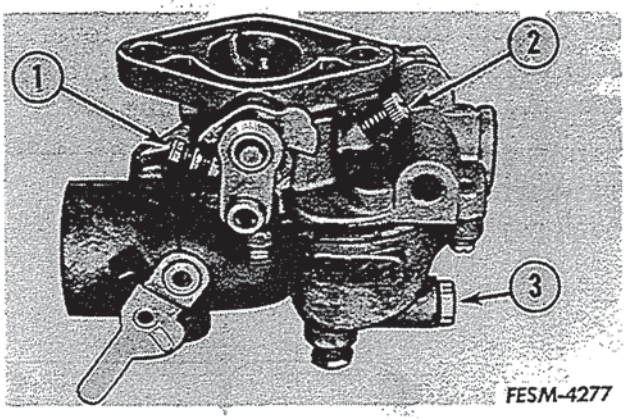
Adjusting Screws

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.

The main jet adjusting screw or adjusting screw in the electric fuel shut-off valve (where used) and seat should be inspected for damage caused by the screw having been forced against its seat. Where evidence of this is found, the screw should be replaced.

Venturi and Jets

Inspect the venturi, jets, main adjusting screw seat, and other calibrated openings for possible damage from improper probing in previous cleaning operations. Use the carburetor identifying part number to be found stamped on a metal disc riveted to the throttle body when selecting replacement parts. Make sure you are using the parts catalog for the particular unit and engine involved and that parts selected are from list headed with the carburetor identifying parts number. Failure to take this precaution when renewing parts could result in a carburetor completely out of calibration and an operation lacking power or economy.



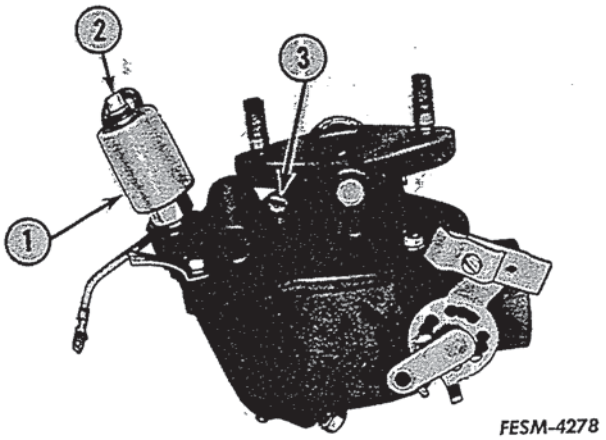
Zenith carburetor adjusting screws (not equipped with electric fuel shut-off).

1. Throttle idle stop screw
2. Idle adjusting screw
3. Main jet plug

Upon reassembly of the carburetor, be sure all new gaskets and seals are used throughout and are properly installed to insure gas tight connections. Use care when assembling fuel bowl to throttle body to prevent damage to the float assembly or the idle jet tube.

When replacing the idle adjusting screw and the main jet adjusting screw (if equipped), turn them down carefully until lightly seated. Forcible seating of these screws will result in damage to the tapered face of the screw and to its seat. Turn the idle screw out one turn. On carburetors with a main fuel adjustment screw, turn the screw six turns off its seat. On carburetors with electric fuel shut-off the adjusting screw must be set 4-1/2 turns off its seat. The throttle stop screw should be set to hold the throttle plate slightly open. These settings of the idle screw and the throttle stop screw serve only as a starting point for idle adjustment.

Adjustment of the carburetor should not be attempted until the engine has reached



Marvel-Schebler carburetor adjusting screws (equipped with electric fuel shut-off).

1. Electric fuel shut-off
2. Main fuel adjusting screw
3. Idle adjusting screw

normal operating temperature. Then adjust throttle stop screw for the specified low idle speed and set the idle adjusting screw for smoothest engine operation. Advance the engine speed control lever for a few seconds and again idle the engine, rechecking the idle adjustments for specified low idle speed and smoothest operation.

Where gasoline carburetor is equipped with a main fuel adjustment screw, its only function is to limit the fuel going to the engine. The main fuel adjusting screw must be set six turns off its seat. On carburetors with electric fuel shut-off the adjusting screw must be set 4-1/2 turns off its seat. The main metering jet which forms the fuel adjustment screw seat, has been calibrated to provide a full-power mixture and must not be restricted by use of the adjusting screw when the full power of the engine is required. The main fuel adjusting screw packing nut should be tightened sufficiently to prevent leakage and to hold screw firmly in position.

Section 3

LPG FUEL SYSTEM

CONTENTS

SPECIFICATIONS

Ensign LPG Carburetor Specifications

	C-135	C-153
IH part number	378 292 R93	377 641 R93
Ensign model number	CBM-100A121B	CBX-125A5412B
Machine used on	F&I-404	F&I-504
Venturi number	30	34
Delivery nozzle	Four - #10 drill	Two - .344 inch
Economizer bleed - drill size number	42	44
Economizer spring number	383 068 R1	359 622 R1
Starting adjustment screw - turns off seat	1-1/4	1-1/4
Main adjustment screw - turns off seat	1-5/8	2-5/8

Ensign LPG Regulator-Vaporizer Specifications

	C-135	C-153	
IH part number	377 640 R91	378 319 R91	382 494 R91
Ensign model number	RDG-55A5425A	RDG-55A5431B	RDG-55A5490A
Machine used on	I-404	I-504	F-504
Idle bleed - drill size	68	68	68
Idle adjustment - turns off seat	1-1/2	1-1/2	1-1/2

SAFETY PRECAUTIONS

CAUTION: Handling of equipment designed to use Liquefied Petroleum Gas fuel requires simply the exercise of common sense, based upon the knowledge of the nature of the fuel, and an understanding of the equipment in which it is handled and consumed.

The hazards of fire and explosion connected with leakage of Liquefied Petroleum Gas are similar to those which surround the leakage of gasoline. However, it is more difficult to detect dangerous accumulations of LP Gas. Escaping LP Gas is invisible and the volume of gas which has escaped cannot be determined by its odor in the area.

Leaking gasoline gives some visual evidence of its presence and volume, because it retains its liquid form for longer periods of time. Individuals are automatically on the alert when they smell the familiar gasoline odor and see the escaping fluid.

The vapors of both fuels are heavier than air. They are both able to disperse rapidly in moving air, which reduces them to a non-flammable mixture. But in still air, the vapors may accumulate in dangerous concentration, even flowing along the floor or ground into areas a considerable distance from the source, where they may lie as an explosive mixture for a considerable time.

No area in the vicinity of leaking gasoline or LP Gas may be regarded as safe until the leak is stopped and the concentration of vapors have been dispersed by a thorough ventilation. This ventilation must be accomplished without the production of sparks from electrical switches or other possible sources of ignition.

Safety precautions in the handling of Liquefied Petroleum Gas cannot be over emphasized. Sales and Servicing Organizations must familiarize themselves with City, County, and State regulations, governing the Sales and Servicing of LP Gas Equipment. Such laws, ordinance and fire regulations must be adhered to in addition to the following safety rules. Where local rules are more stringent than those given below, the local rules are to be given priority.

These rules apply to servicing any tractor or engine using Liquefied Petroleum Gas (butane-propane) for engine fuel, regardless of the nature of the service operations to be performed.

1. Select a position for servicing the machine with good air circulation. This is to avoid accumulation of gas-air mixture in and about the vehicle caused by undetected leaks.

2. Such location should be as far as possible from steam cleaners, hot water cleaners, hot dip tanks, etc., and any other device operating with open flame.

3. Shut off the main valves at fuel tank and allow engine to run. This is to exhaust all fuel in the system from the tank to the engine. In the event tractor is disabled and engine is inoperative, shut valve at tank. Bleed fuel system of LP Gas outside of building before towing unit into shop.

4. DANGER signs should be placed on both sides of the machine. There is to be no smoking in the vicinity. No work is to be performed on this unit or others in a nearby zone involving open flames such as cutting or welding, grinding, chiseling or any similar operation which may produce sparks.

5. In order to avoid possible accumulations of explosive gas-air mixtures, these machines, whenever possible, should be removed from the shop at the end of the working day.

6. A fire extinguisher (dry powder or carbon dioxide, CO^2) should be removed from its regular location and placed adjacent to mechanics working point . . . handy for immediate use. If LP Gas accidently 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.

7. Never use LP Gas from fuel tank for cleaning parts, blowing of horns, inflating tires, or other uses for which it is not intended.

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. Any inspections, adjustments or operations on the fuel system which require venting or releasing gas from the system should be performed outside of the building, where the released gas may be dissipated harmlessly into the open air.

b. All pipe threads on LP Gas connection fittings are to be lubricated with a non-hardening compound, insoluble in petroleum, such as:

"Tite Seal" made by Radiator Specialty Co., Charlotte, N. C.

"Rectorseal #2" made by Rector Well Equipment Co., Houston, Texas.

"Plastic Lead Seal #2" made by Crane Packing Co., Chicago, Ill.

"Permatex #2" (made by Permatex Co., Inc., Brooklyn, N. Y. Permatex Aviation). Use compound sparingly on threaded portion only, to prevent forcing compound into the system.

Replace worn or defective fittings.

c. Synthetic rubber compounds are used in Fuel hose to resist the strong solvent action of LP Gas. Be sure hose of correct type and part number is used when replacement is necessary.

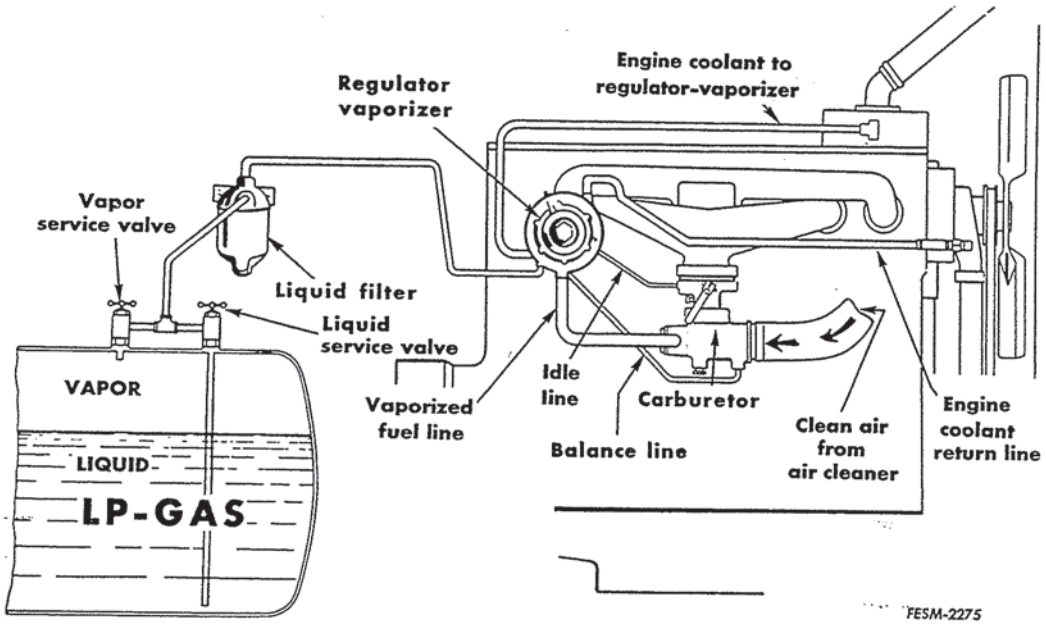
d. After connecting up fuel system, check for leaks. NO LEAKS ARE PERMISSIBLE. The appearance of frost at any point in the fuel system (when the engine is not running) is an indication of leakage. Strong smelling compounds are added to LP Gas to aid in leak detection. Household liquid soap of a foamy type should be applied to all fuel connections with a soft brush, leakage is indicated by forming bubbles. NEVER use open flame to check for leakage.

9. NO WORK WHATEVER IS TO BE PERFORMED ON THE FUEL TANKS OF LIQUEFIED PETROLEUM GAS FUELED VEHICLES. Any necessary work should be performed by qualified concerns who normally service such pressure vessels and are familiar with local regulations, inspection and approved tests after any repairs are made.

10. Vehicles of this type which have been involved in an accident should not be brought into the shop for repair until the shop foreman has checked the fuel tanks and fuel systems for possible leaks.

11. It is important to remember that all LP Gas systems are pressurized. Be sure the tank valves are tightly closed and all fuel is exhausted from lines before starting any repair work on the fuel system.

GENERAL DESCRIPTION



Typical LPG system schematic.

The Liquefied Petroleum Gas fuel system consists of the following basic parts:

- Fuel Supply Tank and Fittings
- Fuel Filter
- Regulator-Vaporizer Unit
- Carburetor
- Intake-Exhaust Manifolds
- Air Cleaner
- Variable Speed Engine Governor

The LP Gas fuel used must always have a boiling point temperature below the temperature of the surrounding atmosphere, which results in the fuel in the tank being under pressure at all times. Fuel from the supply tank passes through the fuel filter to the regulator-vaporizer unit. Here the varying pressure of fuel from the tank is stabilized and reduced to slightly below atmospheric pressure. With this reduction in pressure and the application of heat from engine coolant, the liquid fuel expands rapidly and is completely converted from a liquid to a gas.

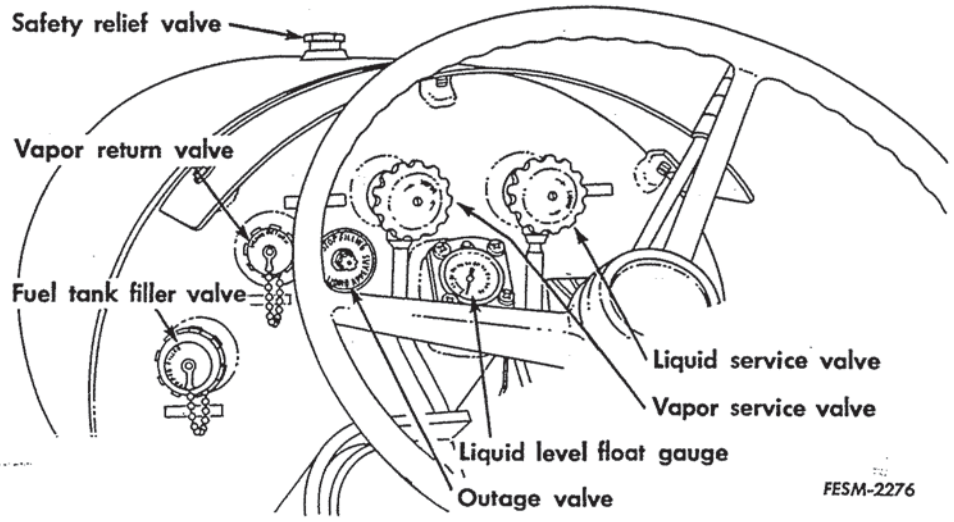
The vaporized fuel is drawn into the carburetor by a combination of pressure drop at the venturi and in the intake manifold. When the engine is stopped, no manifold vacuum exists and therefore the withdrawal of fuel from the regulator is stopped. Air enters these naturally aspirated systems through the air cleaner, where dirt and abrasive material is removed. Cleaned air and gaseous fuel is metered by the carburetor to the engine in varying proportions to meet the changing demands of load and speed.

A balance line connected between the atmospheric side of the low pressure diaphragm and the carburetor air horn provides further assurance that proper fuel-air ratio will be maintained even if airflow is restricted such as when the air cleaner accumulates dirt.

The variable speed engine governor controls the carburetor throttle to admit a greater or lesser volume of air-fuel mixture. This supports the operator's demand for engine speed, and provides power to maintain that speed up to the capacity of the engine.

Since all vaporization of the fuel takes place in the regulator-vaporizer, the intake manifold does not require heating, therefore, the intake and exhaust manifolds do not have a heat exchange feature.

OPERATION
Fuel Tank and Fittings



Typical LP gas fuel system controls.

Liquefied Petroleum Gas is exactly what its name implies. It is a petroleum gas (vapor) which for convenience in storing, transporting and handling, has been compressed into a liquid. This reduction in volume amounts to approximately 250 gallons of vapor to one gallon of liquid. Since LP Gas at mean temperatures can only be kept in liquid state under pressure, the fuel supply tanks and fittings are built to withstand a pressure of 500 pounds per square inch.

Actual saturated vapor pressure of the confined liquid will vary with its temperature and with the proportion of propane and butane it contains. The level of liquid in the fuel tank has no effect on pressure as long as vapor space is maintained and the tank is not overfilled. Under normal temperature range the gas in the tank will be under pressures ranging from a few pounds per square inch to 300 psi.

The fuel tank is of heavy, welded steel construction and is equipped with a safety relief valve, a filler valve, a vapor return valve, an outage valve, a liquid level float gauge and two service valves.

The safety relief valve protects the tank from excessive pressure by releasing vapor. It starts to open at 312 pounds per square inch and being spring loaded the valve closes with the reduction in pressure. A plastic cap is snapped into the outlet to exclude dust and the cap is displaced when the valve opens. Should tank be overfilled, resulting in too small an area above the liquid for expansion from temperature increase, the relief valve will open to prevent excessive pressure rise.

If tank is subjected to fire, the excessive temperature will result in a pressure increase above 300 psi. The relief valve will open allowing vapor to escape and burn. The fuel burns very fiercely, as in a blow torch, but since no air can enter the tank there is no explosion. With the reduction in temperature and pressure the relief valve will close preventing further loss of gas vapor.

The safety relief valve is serviced only by replacement of complete valve assembly. Adjustment or replacement of components must not be attempted.

The filler valve serves as a connection for the transfer of liquid fuel from storage. The filler valve is spring-loaded and automatically closes when pressure from the transfer hose connection is released. The valve is equipped with a screw cap which keeps out dust and forms an additional seal against leakage after transfer of fuel is completed. With the exception of the screw cap and its retaining chain, no components of this valve will be furnished for service. When damage or malfunction occurs, the complete valve must be replaced.

The vapor return valve is used to connect the vapor space in the tractor tank with the vapor space in the storage tank. This equalizes the pressure in the two tanks, permitting transfer of fuel by gravity or reducing the pump pressure required to transfer fuel. A built-in excess flow valve closes if the flow through the valve becomes excessive. A screw cap (with attached chain) is also provided to exclude dirt.

The outage valve is used to determine when the fuel tank is filled to the maximum permitted level. It is also a positive check on the accuracy of the float type gauge. The outage valve is opened by turning the thumb screw counterclockwise, venting vapor from the tank through a small opening. The moment liquid is ejected from this valve, the maximum permitted filling level has been reached. The filling operation should be stopped and the outage valve closed. The thumb screw is retained with a keeper ring to prevent its complete removal in normal use. This retainer ring and the valve stem are available for service.

The liquid level gauge is a float type gauge which rotates a small bar magnet as the liquid level in the tank carries the float up or down. The motion of this magnet moves another bar magnet mounted on the external portion of the gauge. The external magnet forms the gauge indicating needle. While these gauges are fairly accurate, some deviation will occur with various mixtures of butane-propane and because of the moving parts involved, the wear of certain parts effect the accuracy. The outage valve is fixed in its location in the tank and is always an accurate check on the float type gauge at maximum permitted liquid level. When damage or wear occurs to the liquid level gauge, the complete unit must be replaced.

The vapor and liquid service valves are well tagged for identification on the fuel tank. Except for their position in the tank, both valves are identical. Internal tank piping delivers vapor from the top of the tank to the vapor service valve. Liquid from the bottom of the tank is delivered to the liquid service valve. External tubing connects both valves to the inlet port of the fuel filter.

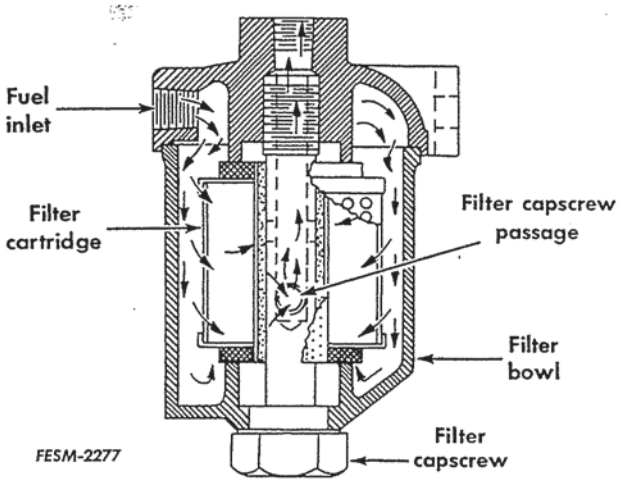
Both the liquid and vapor service valves are fitted with automatic excess flow check valves which close instantly whenever the flow exceeds the normal amount used to operate the engine. If a fuel line should accidentally be broken or a valve torn off the tank, the check valve located ahead of the mounting thread of the valve body, will close and stop the flow of gas, except for a small amount bypassed for valve relief purposes. Operator's instructions warn against opening these service valves too rapidly, because the resulting initial rapid surge of gas through the valve will cause the excess flow check valve to slam shut. Should this occur, about 50 seconds is required for pressures to equalize through a small bypass opening at which time the check valve will automatically reopen.

With the exception of the hand wheels and their retaining screws, no components of these valves are furnished for service. When damage or malfunction occurs, the complete valve is replaced.

CAUTION: The fuel tank must be empty and pressure reduced to atmospheric before removing any valve or the liquid level gauge assemblies.

Fuel Filter Assembly

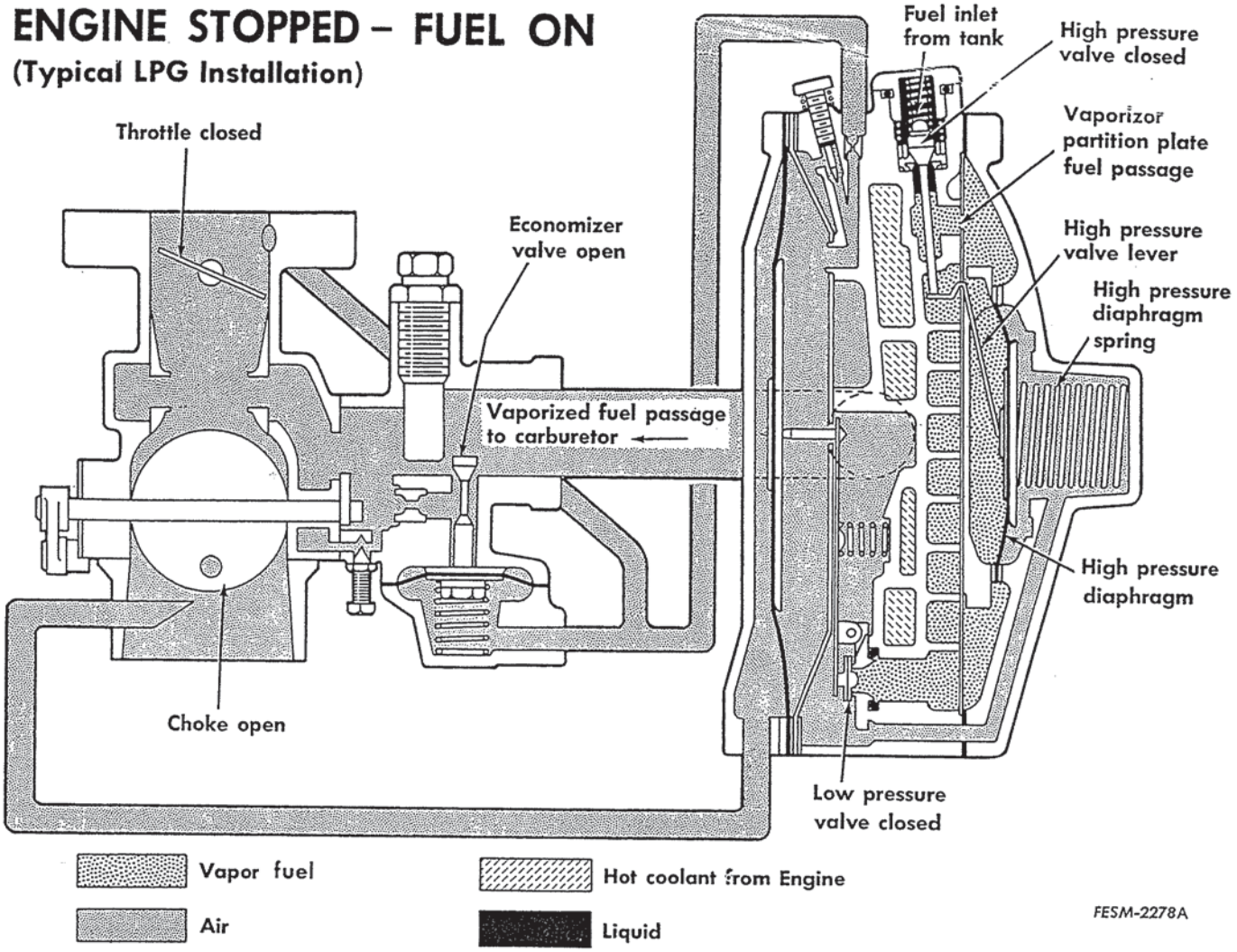
The fuel filter is provided to stop the passage of scale, rust or other foreign solids that may be carried by the liquid fuel from any source. Such material must be prevented from reaching the regulator valves and orifices. These finely finished surfaces or edges may be easily damaged by grit or hard material that might lodge between the seats and the valves. Fuel from either the vapor or liquid service valves enters the fuel filter inlet, passing through the treated paper filter element to the outlet passage and then to the regulator-vaporizer unit.



As the filter element loads up with foreign material sufficiently to restrict the flow of fuel, a pressure drop will occur within the filter. The resulting vaporization occurring in the filter will cause frost to form on the outside of the filter. If the filter is definitely cold to the touch when the engine is running under load, it indicates a need for cleaning or replacing the filter element.

Before opening the filter, close the service valves at the tank and continue to operate the engine to use up the fuel remaining in the lines, filter and regulator-vaporizer. If operation of the engine is not possible, the unit must be moved out into the open air where the system may be safely vented. Examine the filter element closely for damage which would allow dirt to pass, replace if badly loaded with dirt or damaged. Use new gaskets upon reassembly and check for possible leakage by opening the vapor service valve for a moment and applying liquid detergent to areas of fuel bowl gaskets. No leakage is permissible. Do not over tighten the cap screw as the gasket may roll-up and leak.

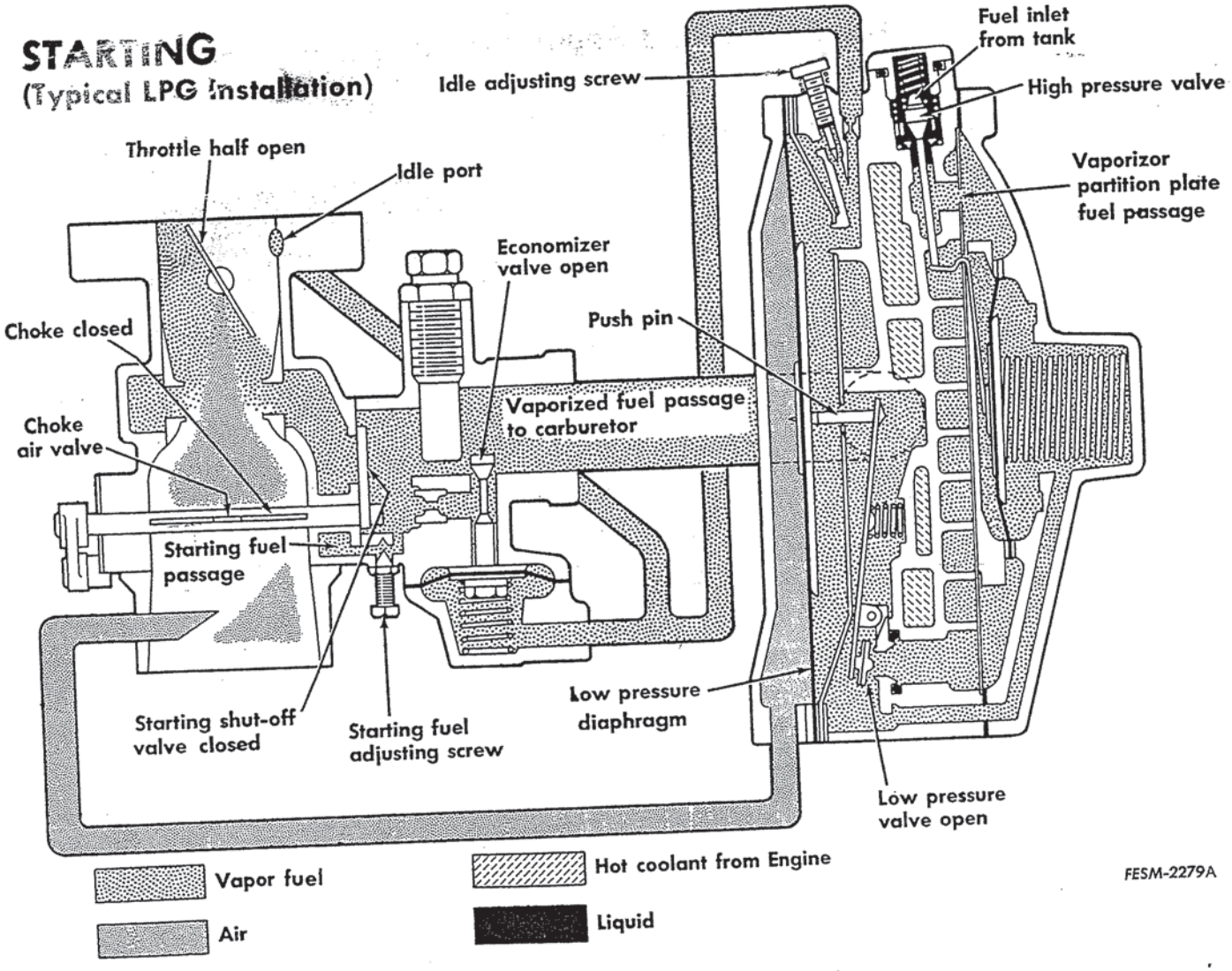
Carburetor and Regulator Vaporizer



Engine Stopped – Fuel On

The Illust. shows the carburetor throttle closed and the choke open. The economizer valve is open. The regulator high pressure valve and the low pressure valve are both closed.

The regulator high pressure valve was open until vapor fuel forced the high pressure diaphragm against its spring. When the vapor fuel pressure reaches 3-1/2 to 5 psi, the high pressure diaphragm spring will have been compressed enough to allow the high pressure valve to close.



Starting

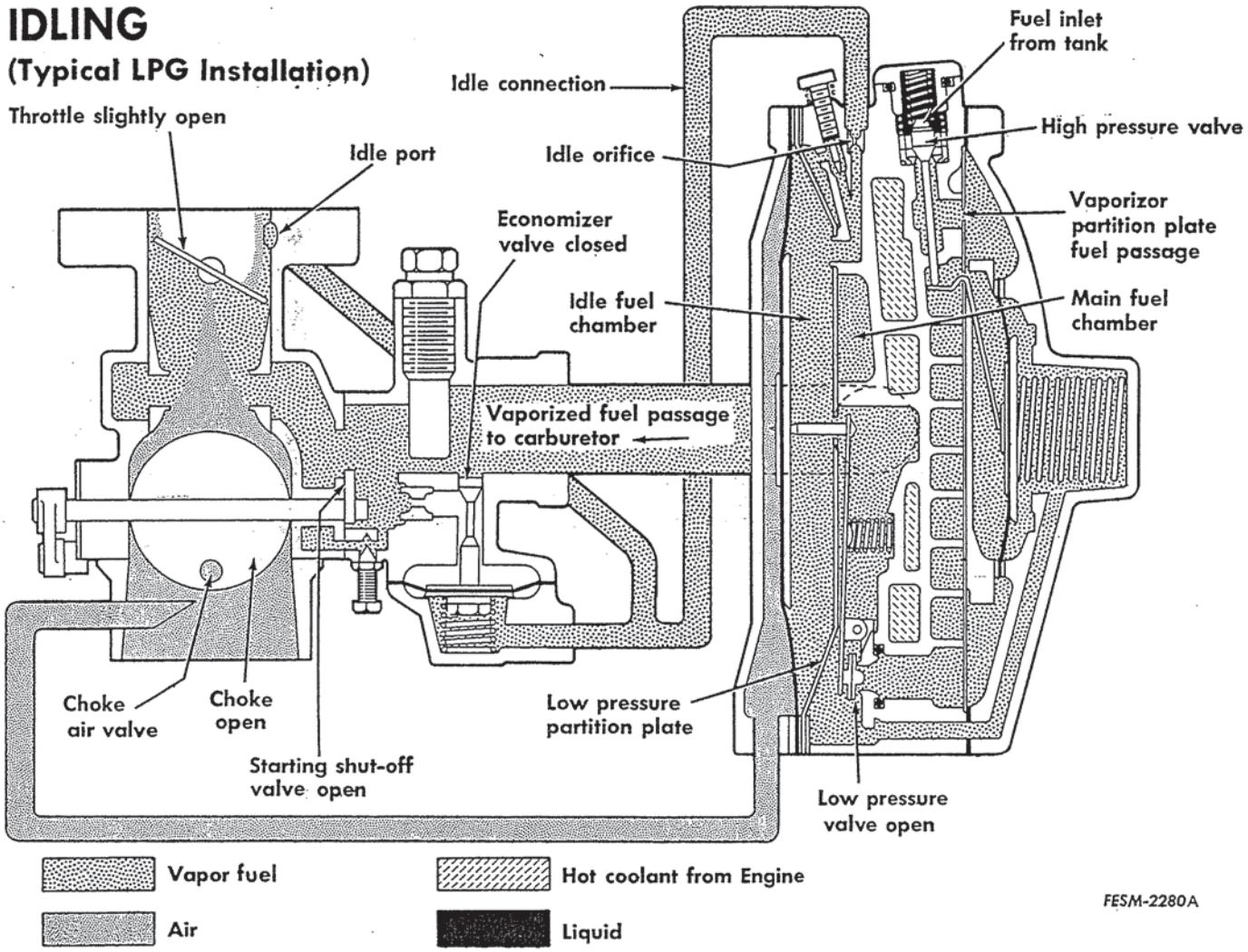
The Illust. shows the carburetor choke closed, starting shut-off valve closed (which is attached to the choke shaft), and the throttle half open. The economizer valve is open, regulator low pressure valve open and the high pressure valve maintaining a pressure of 3-1/2 to 5 psi as the engine is being cranked.

Vacuum developed (as the engine is being cranked) in the intake manifold, carburetor, vaporized fuel passage to carburetor and low pressure chamber has moved the low pressure diaphragm against the push pin with sufficient force to open the low pressure valve.

Vapor fuel is drawn past the vaporized fuel passage, the starting fuel adjusting screw, through the starting fuel passage of the carburetor where it is mixed with clean air, drawn through the choke air valve in the choke plate and on through the intake manifold to the engine cylinders.

IDLING

(Typical LPG Installation)



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Idling

The Illust. shows the carburetor choke open, starting shut-off valve open, and the throttle slightly open. The economizer valve is closed, regulator low pressure valve open and the high pressure valve continues to maintain a pressure of 3-1/2 to 5 psi.

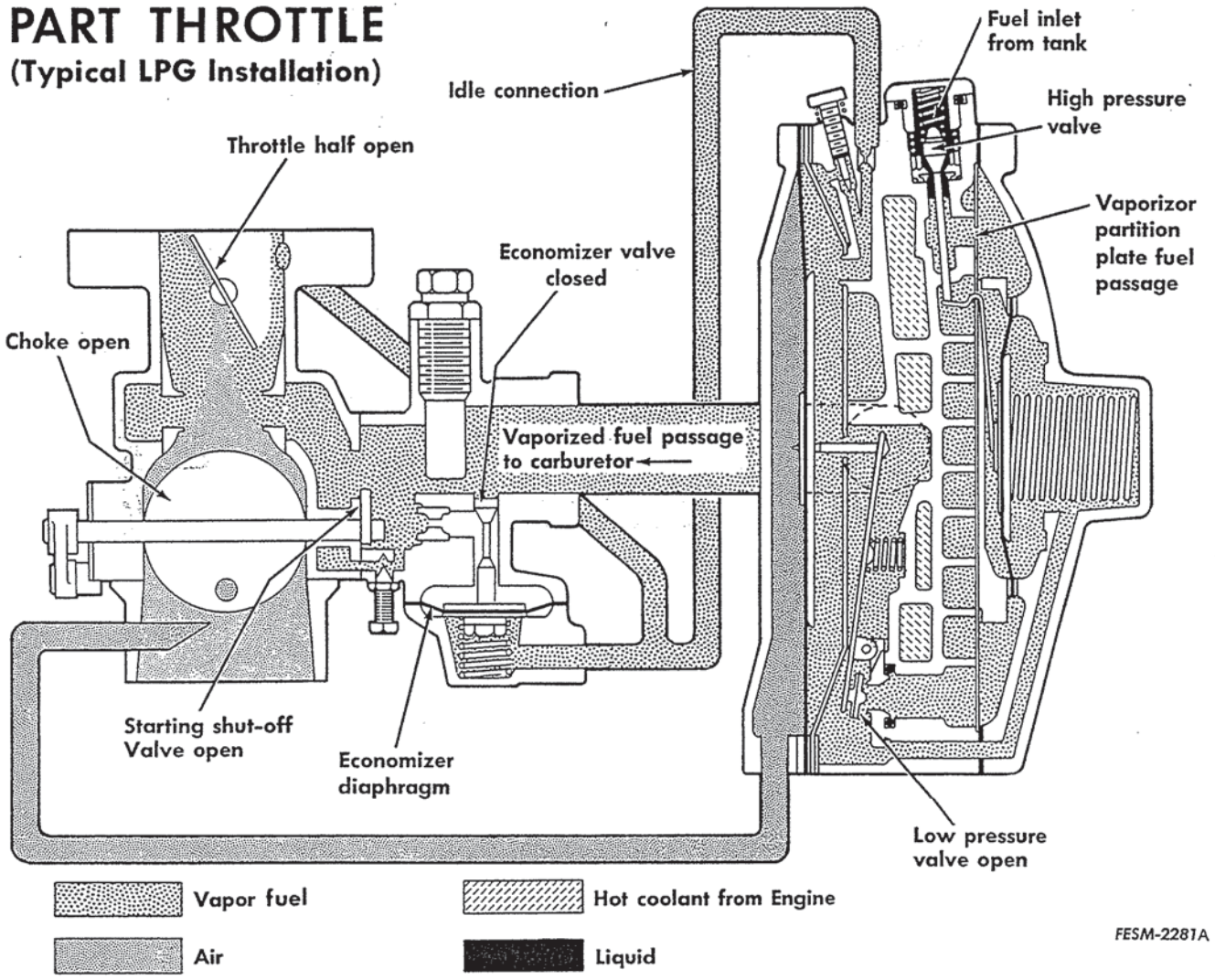
With the engine running and the throttle valve slightly open, the vacuum in the idle connection is sufficient to close the economizer valve.

The low pressure partition plate separates the main fuel chamber from the idle fuel chamber.

The idle orifice provides a restriction between these two chambers, sufficient to make manifold vacuum, applied through the idle passageway in the regulator to be instantly effective on the low pressure diaphragm.

This causes the low pressure valve to open and vapor fuel is drawn from the main fuel chamber past the idle adjusting screw into the idle connection to the idle port in the carburetor.

The greater portion of the vapor fuel required for controlling the idle mixture is drawn through the idle connection from the main and idle fuel chambers of the regulator. The remainder is drawn through the vaporized fuel passage to the carburetor.



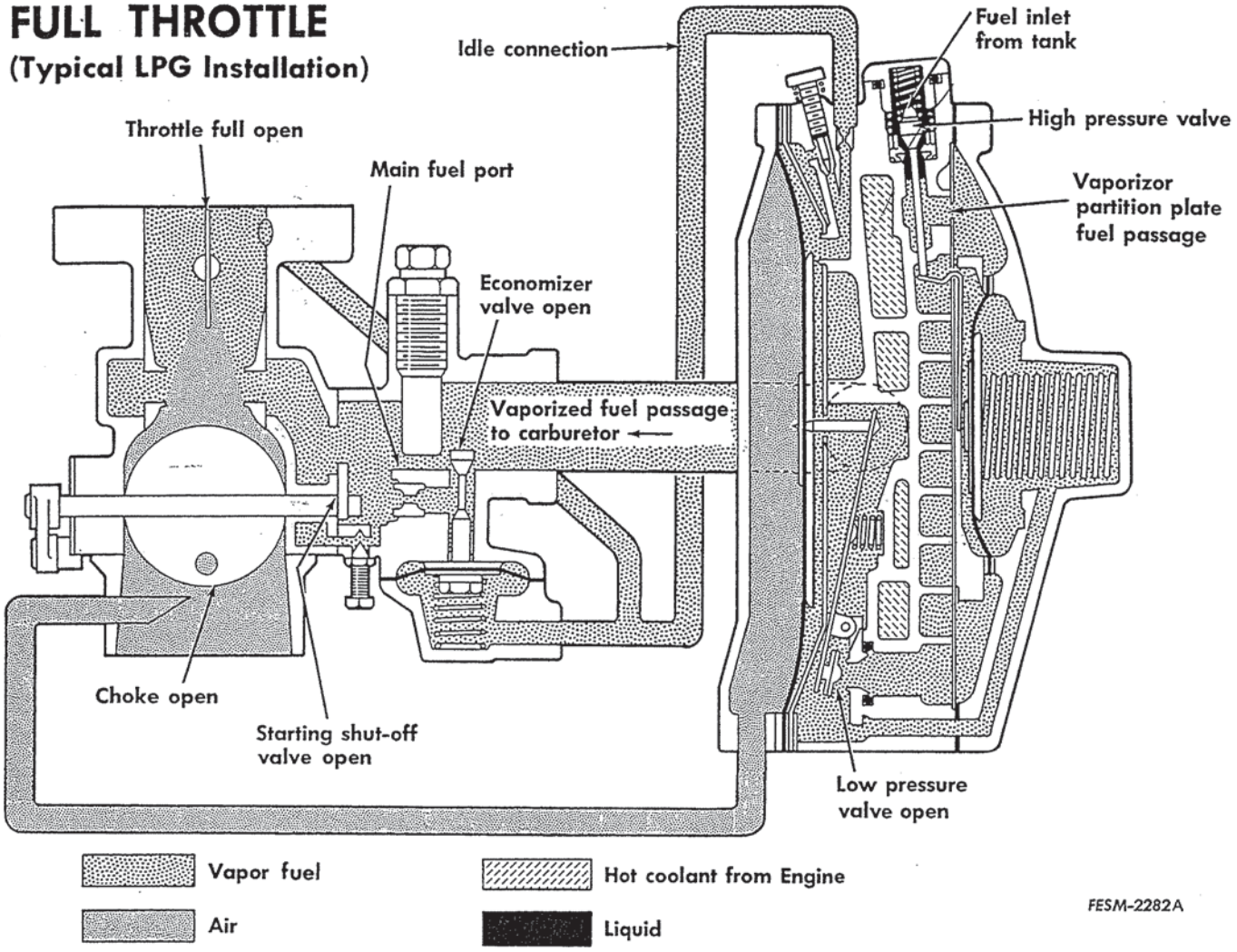
Part Throttle

The Illust. shows the carburetor choke open, starting shut-off valve open, and the throttle half open. The economizer valve is closed, regulator low pressure valve open and the high pressure valve continues to maintain a pressure of 3-1/2 to 5 psi.

Vapor fuel is drawn through the vaporized fuel passage and the idle connection to the carburetor.

The valve of the economizer, during part throttle operation, is normally held shut by manifold vacuum acting on the economizer diaphragm. This assures maximum economy. However, if the throttle is opened to provide for greater speed or load, the drop in manifold vacuum permits the spring to open the economizer valve and allow more vaporized fuel to flow into the carburetor.

FULL THROTTLE
(Typical LPG Installation)



Full Throttle

The Illust. shows the carburetor choke open, starting shut-off valve open, and the throttle full open. The economizer valve is open, regulator low pressure valve open and high pressure valve continues to maintain a pressure of 3-1/2 to 5 psi.

Vacuum in the idle connection is not high enough to close the economizer valve, therefore vapor fuel is being drawn through the vaporized fuel passage and economizer valve.

TROUBLE SHOOTING

Trouble shooting the LP Gas burning engines should follow the same general sequence as used with gasoline burning engines, since the same basic requirements are necessary to their continued good operation. However, the points of emphasis are changed somewhat due to operating characteristics of the LP Gas engine. Many of the common causes of trouble in the gasoline engine rarely occur in the operation of the LP Gas engine and visa versa.

LP Gas purchased from reputable producers and distributors will generally be free of harmful solids or moisture. Since LP Gas is, of necessity, handled and stored in closed systems and under pressure, it is not exposed to dirt contamination and moisture condensation which often cause plugged lines, strainers and jets in gasoline systems.

The metering of completely vaporized, dry gas is done through jets and nozzles which are many times larger than those required for liquid fuel. These jets and adjusted openings for dry gas do not become enlarged from wear and are not readily clogged by foreign material. Once properly adjusted, the LP Gas system will retain its calibration over long periods of time without need for service.

The range of air-fuel ratios of LP Gas which will ignite and support combustion is similar to that of gasoline but in somewhat narrower range. This means that excessively lean or excessively rich fuel mixtures will not ignite. An engine "flooded" with an excessively rich LP Gas mixture (from any cause) will remain in that condition until the combustion chambers, intake manifold and induction system are cleared of gas. LP Gas vapor does not condense and drain off like gasoline, the source of fuel must be shut off and the engine cranked with open throttle to expel the overrich mixture.

The LP Gas regulator unit is comparable to the diaphragm type fuel pump as used on some applications of gasoline burning engines. Both of these units control the volume and pressure of fuel as supplied to the carburetor. In service life, the LP Gas regulator unit has the advantage of a cleaner fuel and less inherent wear in a reduced number of working parts as compared to the gasoline unit.

In reviewing the above comparisons, it is evident that in trouble shooting the LP Gas burning engine, greater emphasis should be placed on condition of the engine and the electrical system than on the fuel system. Fuel system conditions which can affect fuel economy, loss of power, smooth engine operation and good starting characteristics, while important, are relatively few in number.

Before disturbing carburetor adjustments or removing LP Gas equipment for inspection, check the general condition of the engine with particular attention to the ignition and electrical system. Refer to Blue Ribbon Service Manual Section, Form GSS-1052-C, for full information on the Electrical System. Basic engine information will be found in Section 1, of this manual.

Problem	Cause
Fuel system conditions affecting Fuel Economy:	1. Poor setting of fuel adjustments to meet conditions of fuel and operation. 2. Leakage of fuel through regulator valves or high-pressure diaphragm. 3. Lack of economizer action, due to diaphragm leakage, valve damage, or vacuum line and connections leaking. 4. Low-pressure regulator valve opening at less than 3/8 inch water manometer, resulting in over-sensitive action or leakage. 5. Unbalanced regulator due to air leak in balance line or connections. 6. Plugged air intake and/or air cleaner.
Other factors that can influence fuel economy:	1. Loss of engine compression due to piston and ring condition or valve leakage. 2. Loss of valve lift due to cam wear or valve lever adjustment. 3. Valve timing error. 4. Ignition timing error. 5. Misfiring due to poor condition of ignition points, plugs and insulation. 6. High friction loss in engine, transmission or final drive due to improper lubrication. 7. Brakes dragging. 8. Excessive drive wheel slippage due to worn tire lugs or lack of sufficient wheel weight. 9. Improper adjustment of implement, resulting in excessive draft requirements. 10. Excessive drive belt slippage, in belt drive applications. 11. Excessive amount of tractor wheel weight used for field conditions, resulting in increased power requirement.

Problem	Cause
Fuel system conditions affecting Power Loss:	1. Excessively lean air-fuel settings of fuel adjustments. 2. Lack of regulator valves response to fuel demand of engine, due to gummy, sticky action of either valve and/or pressures out of range. 3. Plugged fuel filter or inlet screens. 4. Plugged regulator balance lines or connections. 5. Air leakage at throttle shaft, carburetor gaskets, intake manifold gaskets, fuel hose or idle tubing. 6. Poor governor action due to wear, misalignment, binding of moving parts, or failure of governor to fully open throttle, due to adjustment of governor linkage. 7. Plugged air intake or air cleaner. 8. Lack of fuel vaporizing capacity due to insufficient water circulation through regulator-vaporizer unit, from obstructed water lines or frozen water lines. Freeze-up may occur when cold engine is placed under full load before water temperature has approached normal range.
Other factors that can influence power output:	1. Loss of engine compression due to piston blow-by or valve leakage. 2. Loss of valve lift due to cam wear or valve lever adjustment. 3. Valve timing error. 4. Ignition timing error. 5. Excessive intake valve stem and guide clearance. 6. Misfiring due to poor condition of ignition points, plugs and insulation. 7. Obstruction in exhaust system, muffler or spark arrester.

Problem	Cause
Other factors that can influence power output: (Cont.)	8. Detonation (audible or inaudible) due to: a. "Hot Spots" in the combustion chambers, exposed sharp corners or projections or burned spark plug elements. Surface ignition. b. Use of LP Gas Fuel having poor anti-knock characteristics. c. Overadvanced ignition timing. d. Excessive combustion chamber deposits. NOTE: Detonation results in "blown" cylinder head gaskets, damaged pistons, shortened valve life and damaged spark plugs in addition to power loss. 9. High pressure loading of hydraulic power supply. 10. High friction losses in transmission of power. 11. Indicated power loss, due to excessive draft demand from improperly adjusted implement, or from use of excessive amount of tractor wheel weight. 12. Slippage of drive wheels or drive belt.
Fuel system-conditions affecting Starting Characteristics:	1. Poor adjustment of starting fuel screw and/or idle fuel screw. 2. Leakage of fuel through regulator valves or high-pressure diaphragm. 3. Failure of choke operating cable and/or choke lever to place choke valve and starting shut-off valve in starting position. 4. Leakage of fuel past starting shut-off valve in starting position. 5. Obstruction in starting gas passages in carburetor.

Problem	Cause
Fuel system conditions affecting Starting Characteristics: (Cont.)	6. Air leakage at throttle shaft, carburetor gaskets, intake manifold gaskets or idle fuel line and connections. 7. Plugged fuel filter, fuel intake screens, lines or fittings. 8. Excess flow check valve in tank service valve closed due to defect or from too rapid opening of service valve.
Other factors affecting starting characteristics:	1. Condition of storage battery, its ability to furnish ignition and cranking power. 2. Continuous load in excess of generator capacity, such as frequent cranking demand in combination with too short an operating time to replace battery loss. 3. Excessive starting current draw due to worn starting motor bearings or sprung armature shaft, etc. 4. High friction loss in engine, due to improper lubrication for season of use. 5. Condition of spark plug electrodes and insulators, must be of heat range to meet extremely severe service classification to result in good service life. See also Detonation, Condition and Under Power Loss. 6. Condition of distributor points, condenser, insulation and cables. 7. Ignition coil condition and connected into the circuit in proper polarity. 8. Ignition timing error. 9. Valve timing error.

Problem	Cause
Fuel system conditions affecting control of idling:	1. Poor setting of fuel adjustments to meet idling conditions. Poor adjustment of speed change linkage to secure specified idle speed. 2. Loss of idling adjustment control due to leakage of fuel through regulator valves or high-pressure diaphragm. 3. Loss of idling adjustment control due to ruptured or leaking economizer diaphragm. 4. Air leakage at throttle shaft, carburetor gasket, intake manifold gaskets or idle fuel lines and connections. 5. Foreign material in idle fuel passages or calibrations.
Other factors affecting control of idling:	1. Excessive intake valve stem and guide clearance. 2. Loss of engine compression due to piston blow-by or valve leakage. 3. Condition of spark plug electrodes, insulators, and cables. 4. Condition of distributor points, condenser, coil, and insulation. 5. Ignition timing error. 6. Valve timing error. 7. Loss of valve lift due to cam wear or valve lever adjustment.

REGULATOR-VAPORIZER SERVICE

Removal and Installation

CAUTION: Before attempting removal of the regulator-vaporizer unit, both the liquid and vapor service valves must be closed and the engine operated until all fuel in lines, filter and vaporizer is exhausted. If operation of the engine is not possible, the unit must be moved out into the open air where the system may be safely vented.

Where the condition which prompted the removal of the regulator-vaporizer was lack of power, or lean mixtures from insufficient fuel delivery, inspect the fuel filter element for restriction at the same time.

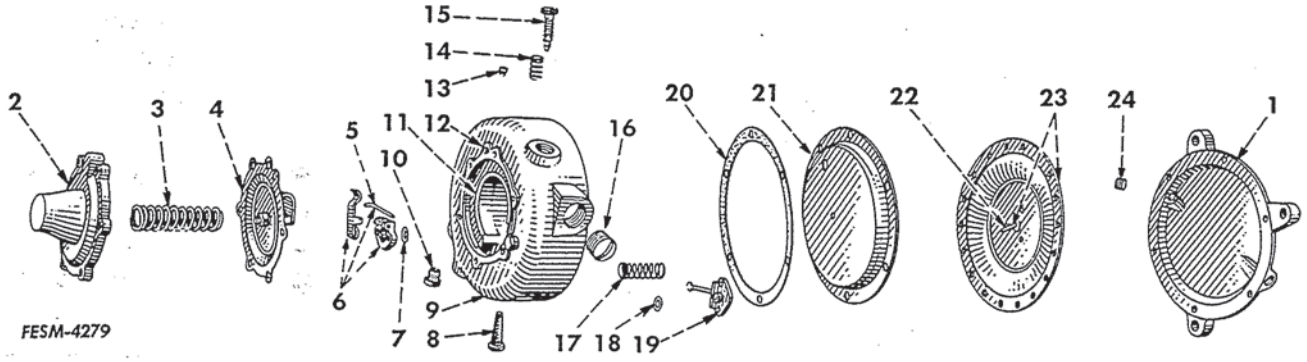
The engine cooling system should be drained, so that water inlet and outlet lines to the vaporizer may be removed. Clean the area surrounding the regulator-vaporizer unit to prevent entry of dirt into lines or connections which remain with the engine. This is insurance against induction of dirt into the system upon reassembly of the reworked unit.

Inspect fuel hose, idle fuel tubing and balance line connecting the vaporizer to the carburetor for possible leakage. Since these lines operate below atmospheric pressure, leakage or poor connections will be a source of entry of dirt or abrasives into the engine. Leakage of these connections or lines will also result in loss of engine power through lean mixtures. Renew tubing, fittings and hose where the old is found to be in questionable condition. Be sure hose used is of correct part number so that correct material is furnished and will not be affected by the dissolving action of the fuel.

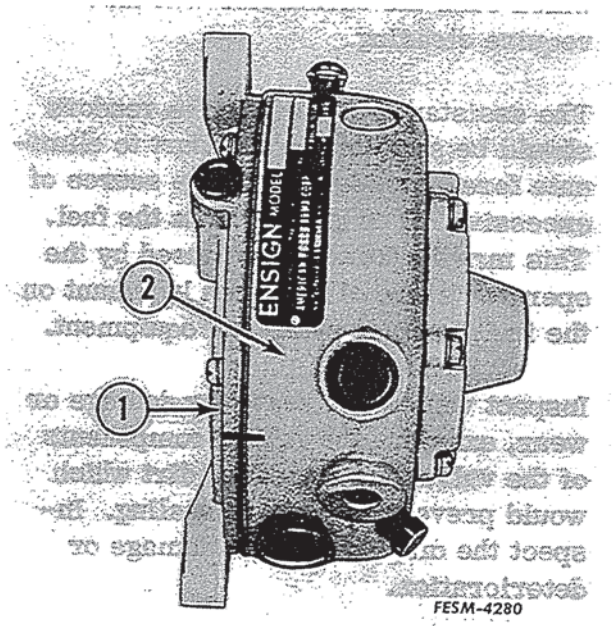
Be sure there are no restrictions in the vaporizer water jacket or the water inlet, or outlet lines connecting the vaporizer to the engine cooling system. Such restriction could result in a freeze-up of the vaporizer and insufficient vaporization of fuel when engine demand for fuel is increased by an increasing load.

When reinstalling the regulator-vaporizer unit, be sure to secure air and fuel tight connections. Fuel lines, fittings and connections which are normally under pressure may be checked for leaks by brushing them with liquid household detergent after momentary opening and closing of the vapor service valve at the tank. No leaks are permissible.

Inspection and Repair



1. Back cover plate
2. Pressure regulator cover
3. High pressure spring
4. High pressure diaphragm
5. Pivot pin
6. High pressure valve
7. O-ring
8. Fuel inlet strainer
9. Regulator body housing
10. Pipe plug
11. Partial plate
12. Bushing
13. Bleed screw
14. Spring
15. Idle adjusting screw
16. Plug
17. Low pressure spring
18. O-ring
19. Low pressure valve
20. Gasket
21. Partition plate
22. Push pin
23. Low pressure diaphragm
24. Plug



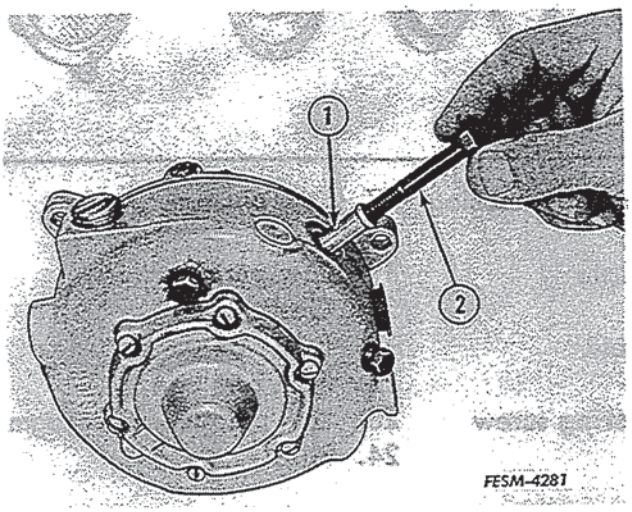
1. Back cover plate
2. Regulator body housing

After removal of the regulator-vaporizer unit from the engine, clean the outside surfaces of the unit of dirt accumulations so that the solvent used to clean the parts will not be contaminated.

Before disassembling the regulator unit, place a mark across the back cover plate and body so upon reassembly the cover can be readily replaced in its proper position.

The solvent used to clean internal parts of the regulator-vaporizer must be of petroleum base type, such as kerosene, oleum spirits, etc. Other types of solvents, such as carbon tetrachloride will destroy the material used in diaphragms and valves.

Disassemble the regulator-vaporizer, using care to prevent damage to sealing surfaces of diaphragm covers. Discard old gaskets, since new must be used upon reassembly. Remove flakes of gasket material which may adhere to the sealing surfaces. Thoroughly wash all parts in clean solvent, blow out all passageways with compressed air. Be sure that all loose scale or particles of hard foreign material is removed.



1. Fuel inlet strainer
2. 5/16" N.C. capscrew

On units so equipped, remove and clean or replace the inlet strainer. Install a 5/16 inch N.C. cap screw into the strainer bore. Turn the cap screw into the strainer approximately 1 to 1-1/2 turns. Pull the cap screw and strainer out of the bore.

Grease or oil picked up and held in solution in the liquid fuel from pumps and handling equipment, will be found in the vaporizing chamber where conversion of fuel from liquid to vapor occurs. Where a considerable amount of grease is found, it is possible that some of this material has been carried over into the carburetor, where channels may be plugged, upsetting gas-air mixtures. In which case the carburetor will also require cleaning.

The assistance of the LP Gas vendors should be solicited in an effort to eliminate foreign material and the source of excessive oil or grease from the fuel. This may be found to be caused by the operator's use of too much lubricant on the fuel transfer pump and equipment.

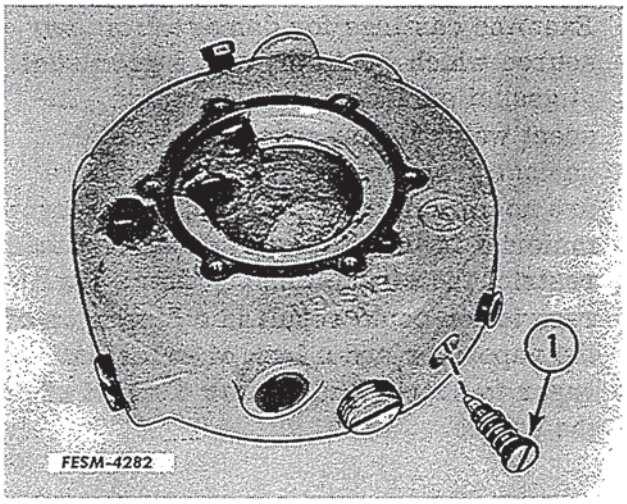
Inspect valves and seats for damage or wear, examine the rubber components of the valves for imbedded dirt which would prevent good valve sealing. Inspect the diaphragms for damage or deterioration.

Leakage of the high-pressure valve will result in test gauge pressures above the specified range of 3-1/2 to 5 pounds per square inch. When this pressure builds up as high as ten pounds or more, the control of idle fuel adjustment will be upset, poor fuel economy will be experienced, and the engine will become increasingly hard to start due to rich mixtures. Leakage through the high-pressure diaphragm will have an identical effect, but no increase in test gauge pressure beyond the normal range may be indicated.

Leakage at the low-pressure valve will also upset the control of idle fuel adjustment and result in poor fuel economy. Because of this leakage of vapor into the carburetor and air induction system, the engine becomes "flooded" with fuel and starting is increasingly difficult. Leakage at the low-pressure valve may not be caused by any defect in this valve itself, but it may be forced open by pressures exceeding five psi from leakage at the high-pressure valve. Leakage of the low-pressure diaphragm effects only the sensitive response of that valve to the fuel demand of the engine, the response dropping off rapidly with the increase in size of hole in the diaphragm.

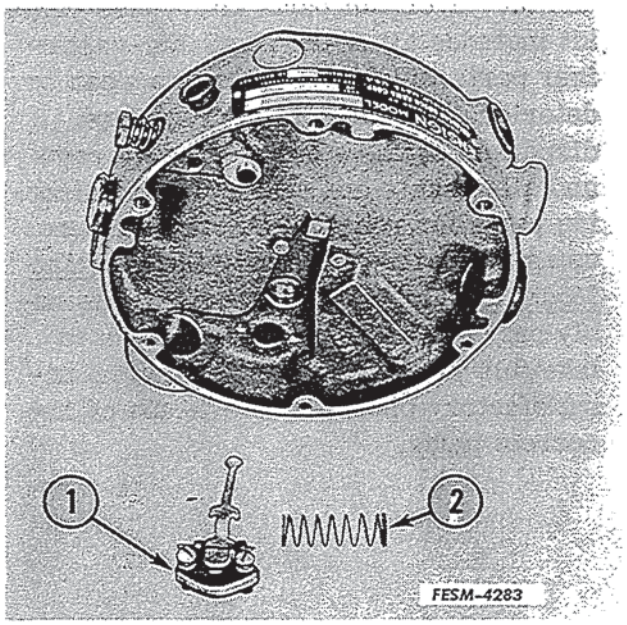
Examine castings for damage from any source which would prevent a good seal at gasket surfaces or connections. Inspect water jacket area for possible damage from freezing. Be sure there are no accumulations of mud or foreign material in the water jacket which would restrict the circulation of water. Such restriction could result in a freeze up of the vaporizer and a lack of sufficient vapor to support full power demand of the engine.

Where both the valves and diaphragms are found to be in questionable condition, use the "overhaul parts kit". This parts kit includes all of the regulator-vaporizer parts which are subject to wear or deterioration; the strainer, springs, diaphragms, valve assemblies, screws and all gaskets and seals. When selecting parts for renewal, be sure you are using the parts catalog for the Machine Model and Regulator-Vaporizer assembly part number involved. Failure to take this precaution could result in unsatisfactory operation due to use of incorrect parts.



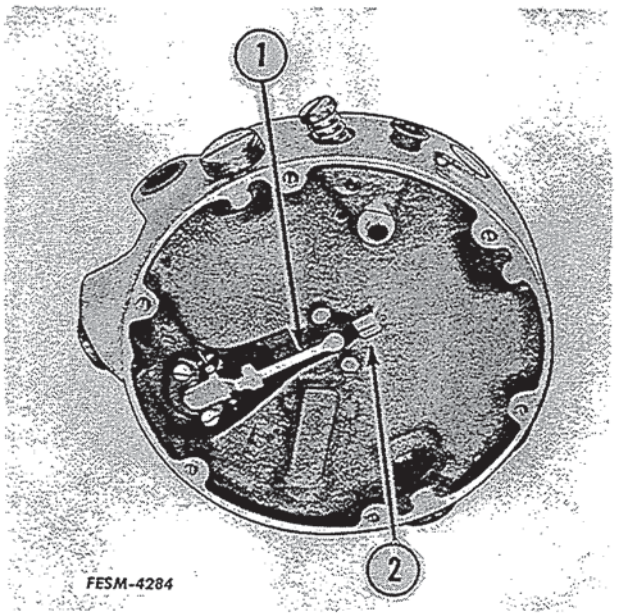
Install the idle adjusting screw and its retaining spring. Turn screw clockwise, down lightly against its seat and then turn counterclockwise 1-1/2 turns for a tentative adjustment. The idle adjustment will be completed after installing the regulator and in conjunction with adjustment of engine idle speed. Refer to "Fuel Adjustments", on page 3-36.

1. Idle adjusting screw and spring

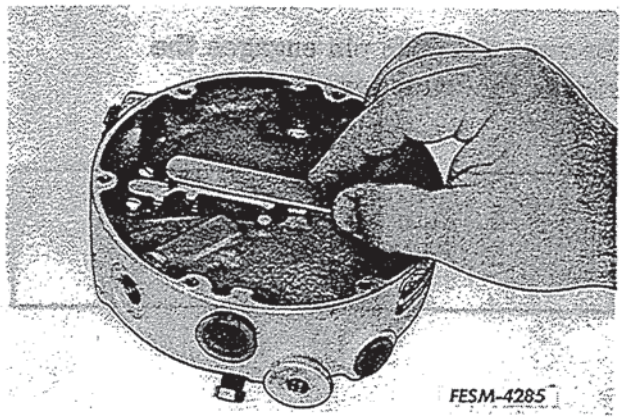


Install the low-pressure valve assembly and spring, using a small amount of clean light oil on the valve seat and O-ring seal. A post or boss is machined and marked with a line for the purpose of setting the low pressure valve lever. The valve lever should be centered on the line before tightening the screws holding the valve block.

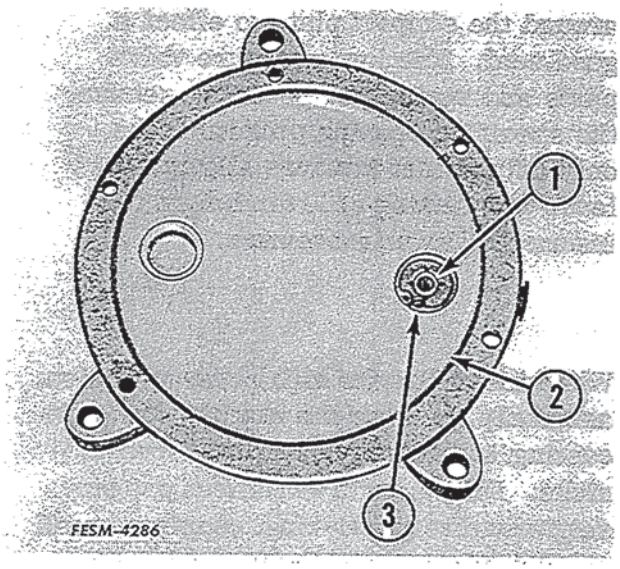
1. Low pressure valve assembly
2. Low pressure valve spring



1. Valve lever
2. Machined post with line



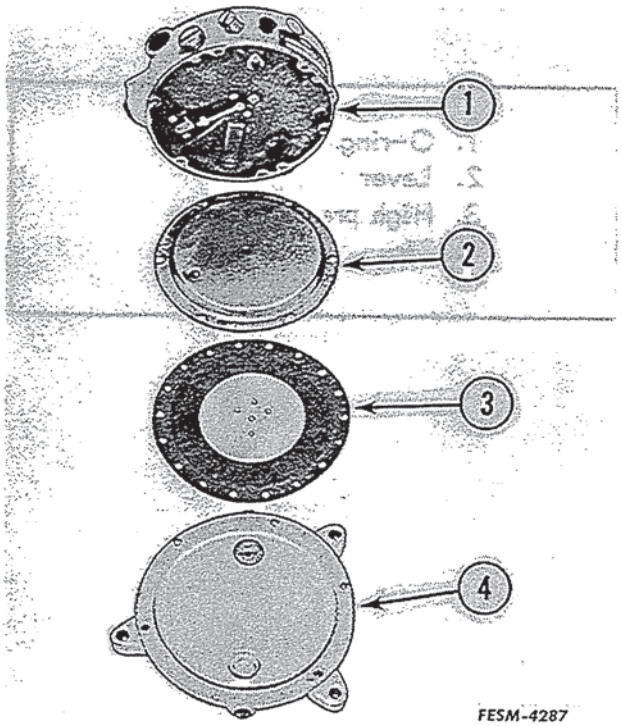
The top of the valve lever should be flush with the top of the post. Check with a straight edge, and bend the lever if necessary to correct height.



Install the compensator assembly in the back cover plate and secure with the snap ring.

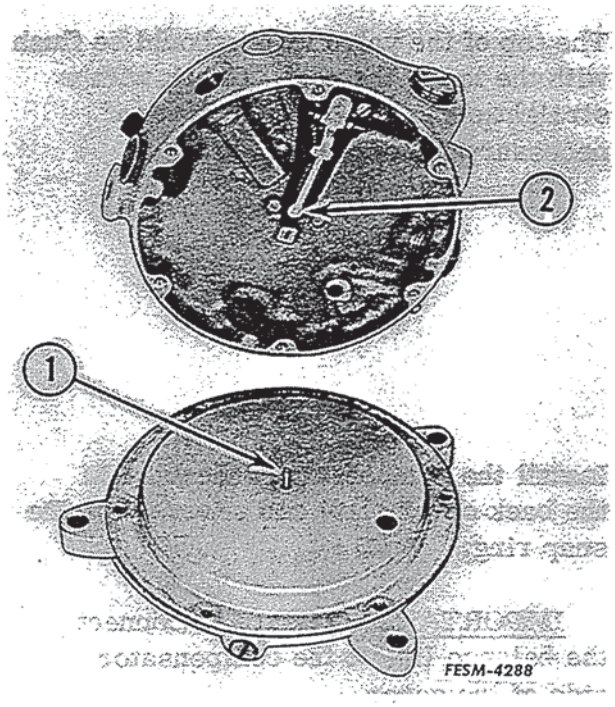
IMPORTANT: Be sure to connect the balance line to the compensator side of the cover.

1. Compensator assembly
2. Back cover plate
3. Snap ring



Using new gaskets, align the marks on the cover and body made during disassembly (see page 3-21), and install the partition plate, low pressure diaphragm and back cover plate on the body.

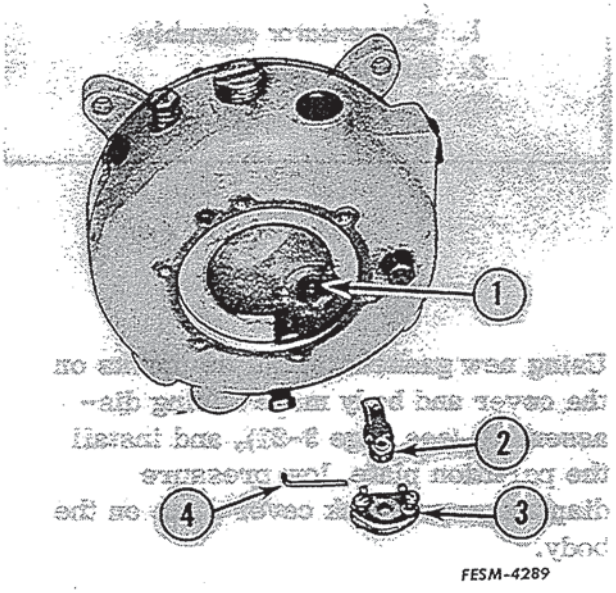
1. Regulator body
2. Partition plate
3. Low pressure diaphragm
4. Back cover plate



Be sure the push pin engages the slot in the valve lever.

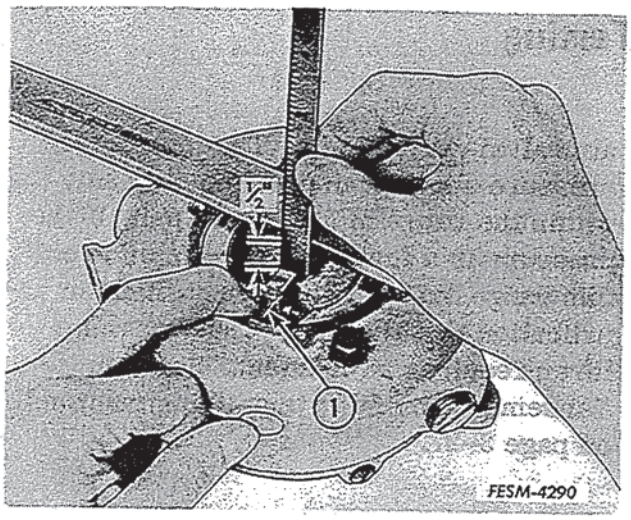
1. Push pin
2. Push pin to engage slot

Tighten the retaining screws evenly around the support plate to effect a good seal. The low-pressure valve parts and spring are preset to secure the specified opening pressure, the only adjustment involves alignment of lever and setting of lever height to insure full valve movement.



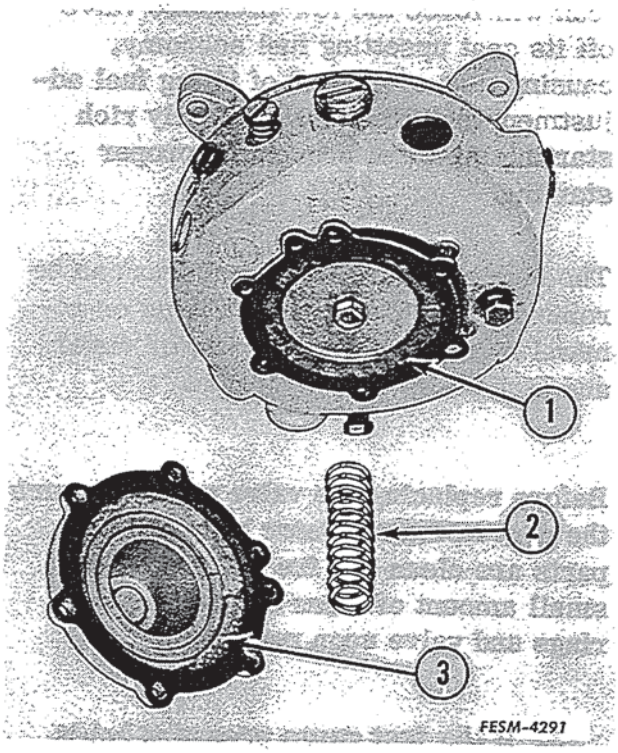
When installing the high pressure valve assembly, be sure the machined seat in casting is perfectly clean and free of nicks. Dirt or grit will affect proper seal of valve and O-ring. Apply a small amount of oil to the O-ring and valve seat to aid in initial sealing.

1. O-ring
2. Lever
3. High pressure valve
4. Pin



The high pressure lever height with valve closed, should be 1/2 inch. This is measured from the high pressure side of the body casting to the inside of the groove in the valve lever with the valve held firmly shut.

1. Valve held closed



Use new gaskets and install the high pressure diaphragm, spring and regulator cover.

1. High pressure diaphragm
2. Pressure spring
3. Regulator cover

Regulator Testing

A check of the regulator high and low-pressure reducing valve may be made with the regulator on the engine, or it may be removed and tested at the work bench. If tests are to be made on the engine, using fuel vapor as a pressure source, the machine must be moved out into the open air where fuel vapor may be safely vented. Where the tests are to be made at the work bench, the regulator must be supported in the same position as it is on the engine. Clean compressed air at 75 to 120 psi is substituted for fuel vapor and supplied to the regulator through inlet (A). Be sure to prevent entry of dirt during preparations, small particles caught on the valve seats will cause leakage.

A bench test fixture, Ensign TSE-1788-5 available, which includes a water manometer, a pressure gauge and necessary fittings and connections for attaching regulator to a source of compressed air. Full instructions for use are included. Order from Backarach Instrument Co., Division of American Bosch Arma Corp., 200 N. Braddock Ave., Pittsburgh, Pa., 15208.

The following procedure is outlined for testing the unit on the engine, the same sequence is used for bench test.

1. With both the vapor and liquid service valves closed, operate the engine until all of the fuel remaining in the lines is exhausted. Engine will stop when fuel filter and lines are empty. Remove 1/8" pipe plug and install 0 to 30 psi test gauge at location (R).

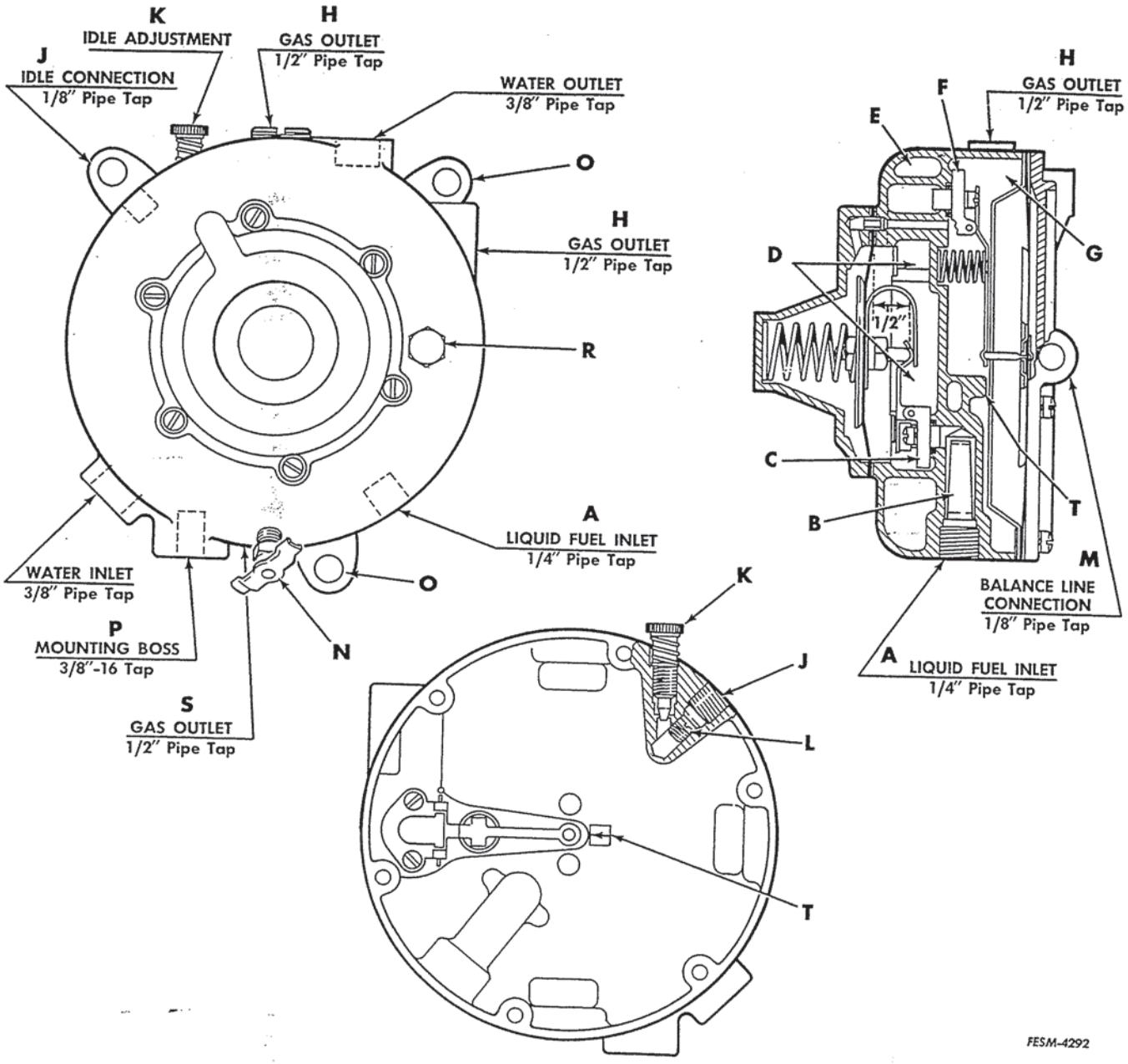
2. Open the vapor service valve (or air valve) very slowly. The test gauge pressure should raise and hold steady within the range of 3-1/2 to 5 psi. If the pressure is a few pounds under or over this range but remains steady, it is an indication that the high-pressure valve lever requires adjustment. Refer to "Assembly and Adjustment" instructions on page 3-27.

If test gauge pressure continues to increase beyond five psi, the high-pressure valve is leaking. A substantial leak will force the low-pressure valve off its seat upsetting fuel economy, causing loss of control of idling fuel adjustment and produces an overly rich starting mixture, preventing proper starting.

The high pressure valve and seat can be removed for inspection, cleaning or renewal by removing the regulator cover and high pressure diaphragm.

Before replacing the valve parts, be sure the port in the regulator body and the parts are clean and free of dirt. Use small amount of clean light oil on seal rings and valve upon reassembly.

3. If the test gauge pressure holds steady within the range of 3-1/2 to 5 psi and there is no control of idle adjustment or if improper starting is experienced, the low-pressure valve (F) may be leaking. A severe leak at the low-pressure valve can actually be heard. With engine stopped, if regulating unit is cold, showing moisture or frost after standing, the low-pressure valve is leaking.



4. There is also a possibility of the regulator unit passing fuel, even though both high and low-pressure valves are holding. This would be leakage past the diaphragm of the high-pressure valve. Notice that the spring loaded side of this diaphragm is vented to the low-pressure chamber (G).

The only positive method of checking this diaphragm is to remove the back cover plate, low-pressure diaphragm and partition plate. Adjacent to the valve (F) will be found the drilled passage venting the high-pressure diaphragm. Connect a pressure source to the fuel inlet (A) and apply liquid soap to opening of passage mentioned. If bubbles form, the high-pressure diaphragm is leaking and regulator unit must be further dismantled for repair.

5. The test gauge pressure may be satisfactory but the low-pressure valve will not pass fuel due to gummy or greasy residue deposited from fuel on valve parts. A ruptured diaphragm will prevent the operation of the low-pressure valve. Pinpoint openings in this diaphragm will not materially affect the normal operation but with increased size holes, the response of the valve will be reduced in proportion. The alignment of the valve may also prevent normal operation of the low-pressure valve.

Use of a water manometer (U-tube) for checking the response of the low-pressure regulator valve is outlined below:

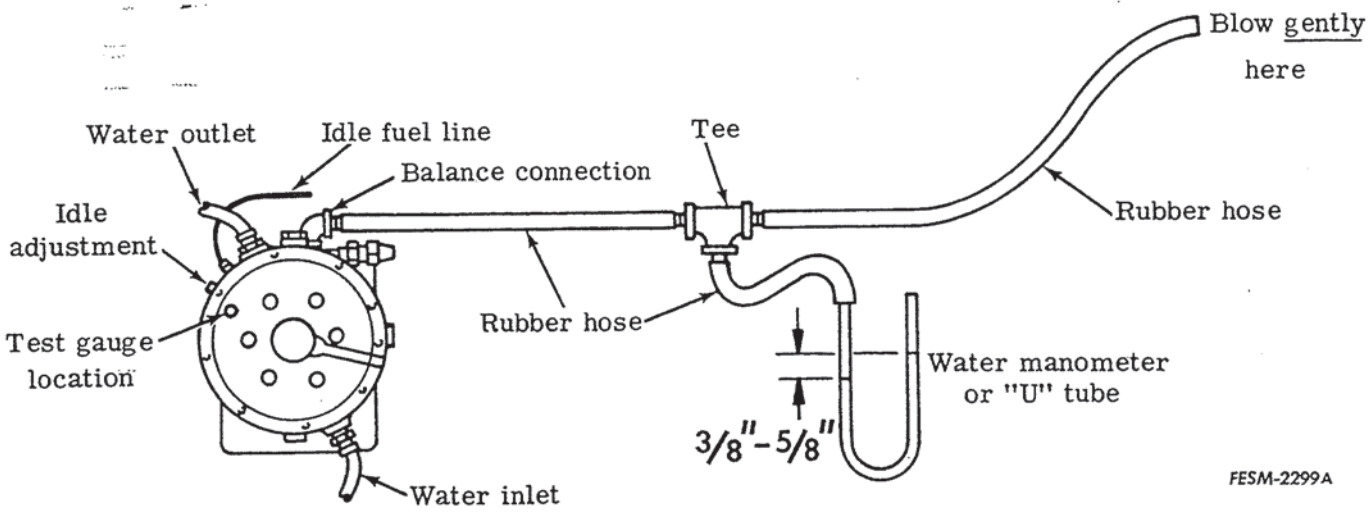
a. Disconnect balance line at (M) on regulator cover plate.

b. Connect a water manometer with suitable hose connections and a tee to the regulator balance connection. See Illust. below.

c. Open the vapor service valve (or air valve) slowly. Then blow very gently into open end of the manometer hose, carefully observing reading of manometer at which low-pressure valve opens and fuel (or air) begins to flow. This can be heard readily when the main fuel hose is removed from the regulator gas outlet (H). The manometer reading should show 3/8 to 5/8 inch. If it is substantially more than 5/8 inch, the valve is gummy or sticky or lacks response as outlined in test (5) above.

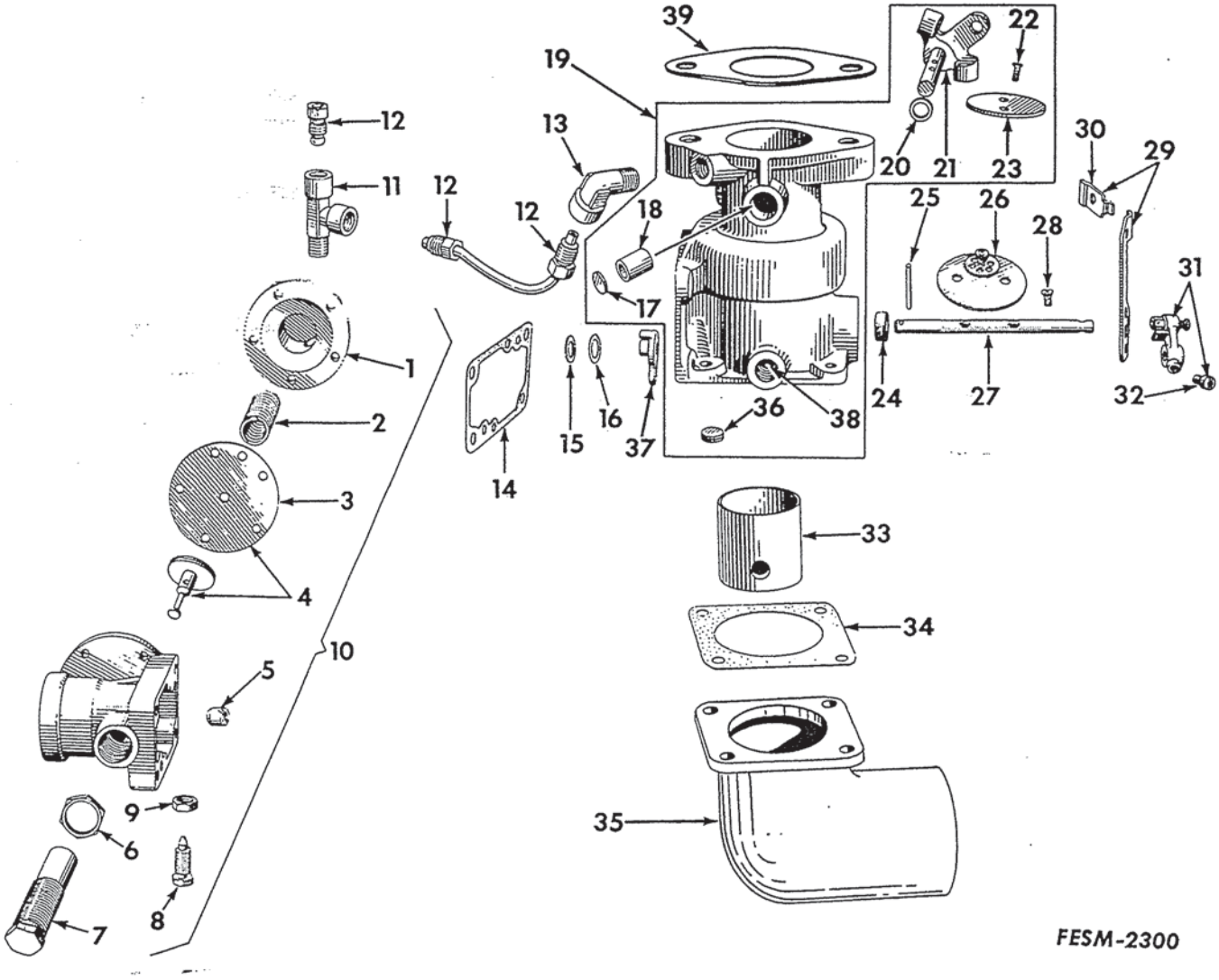
If the manometer reading is substantially less than 3/8 inch, the valve action is too sensitive. This may be caused by a valve (F) spring which has become weak, or wear on valve parts has increased height of valve lever. Replace spring, reset valve lever or renew valve assembly as required.

Idle control may be affected by foreign matter plugging the idle bleed screw (L). To check bleed screw, disconnect idle line at connection (J) and make certain it is not plugged. This orifice should be a #68 drill size. Examine the tip of the idle adjusting screw (K), and if damaged, replace it.



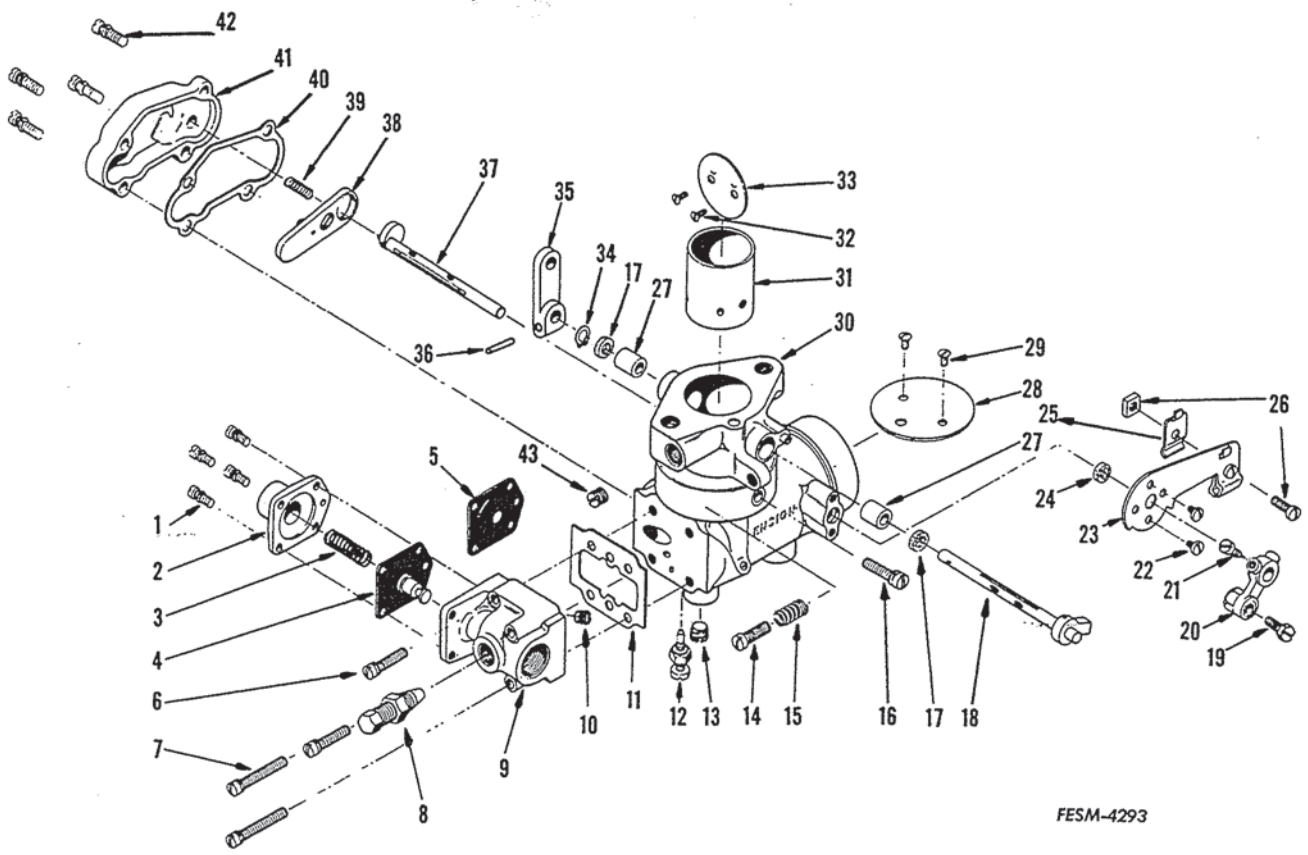
CARBURETOR SERVICE

Removal and Installation



Exploded view LP gas carburetor (C-153).

1. Economizer cover
2. Economizer spring
3. Diaphragm
4. Economizer valve with diaphragm
5. Economizer bleed orifice
7. Main fuel adjusting screw
8. Starting fuel adjusting screw
10. Inlet and economizer assembly
11. Economizer and idle line tee
13. Economizer and idle line elbow
14. Inlet assembly gasket
15. Shut-off valve washer
16. Spring washer
17. Expansion plug
18. Bushing
19. Body assembly
20. Throttle shaft seal
21. Throttle shaft
23. Throttle disc
24. Choke shaft seal
26. Choke disc assembly
27. Choke shaft
29. Choke tube bracket
31. Choke lever
33. Venturi
34. Gasket
35. Air intake elbow
36. Expansion plug
37. Starting shut-off valve
38. Balance tube nozzle
39. Gasket



Exploded view LP gas carburetor (C-135).

1. Screw
2. Economizer cover
3. Economizer spring
4. Economizer diaphragm assembly
5. Economizer diaphragm
6. Screw
7. Screw
8. Fuel adjusting screw
9. Economizer and gas inlet housing
10. Orifice screw
11. Gasket
12. Starter adjusting screw
13. Pipe plug
14. Screw
15. Spring
16. Set screw
17. Dust seal
18. Throttle shaft and stop assembly
19. Swivel screw
20. Choke lever
21. Set screw
22. Screw
23. Choke tube support
24. Dust seal
25. Clamp
26. Screw
27. Throttle shaft bushing
28. Choke disc
29. Screw
30. Partial body assembly
31. Venturi
32. Screw
33. Throttle disc
34. Snap ring
35. Throttle lever
36. Groove pin
37. Choke shaft and cam
38. Valve lever
39. Thrust spring
40. Gasket
41. Valve cover
42. Screw
43. Plug

Before removing the carburetor from the engine for cleaning, inspection or repair; clean the area and various connections to prevent entry of dirt into those parts which remain with the engine.

After the carburetor is removed, inspect the air cleaner pipe, idle line, balance line, main fuel hose and their connections for possible air leaks. Since these lines operate below atmospheric pressure, leakage or poor connections will be a source of entry of dirt and abrasives into the engine.

Discard the carburetor flange gasket, clean manifold flange of any scraps of the old gasket which may adhere and would prevent sealing of new gasket. Renew tubing, fittings and hose where the old is found to be in questionable condition. Be sure the main fuel hose replacement is the correct part number so that hose material furnished will not be dissolved by contact with fuel. Be sure replaced lines and connections are air and dirt tight; no leakage is permissible.

After the carburetor is reinstalled on the manifold, recheck the adjustment of the governor to carburetor control rod to insure a wide open throttle at full load demand of the governor. Proceed as follows: With the engine stopped, advance the operator's speed control hand lever to create tension on governor spring. Adjust length of governor to carburetor control rod so that rod slides freely into the throttle lever, when throttle is wide open. Lengthen this control rod by one turn of its clevis, insert cotter pin and tighten lock nut on clevis.

Return the speed control hand lever to a position slightly advanced from low idle position. In this condition, check the governor to carburetor control rod for any tendency toward binding or interference through its full range of movement. Refer to Section 1 on "Governor" for full coverage on adjustments.

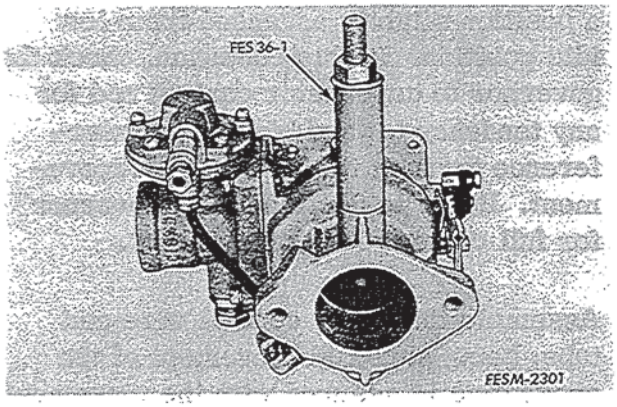
Assemble the choke control wire and tube, being sure full movement of the choke disc is assured with the movement of the operator's choke control knob.

Inspection and Repair

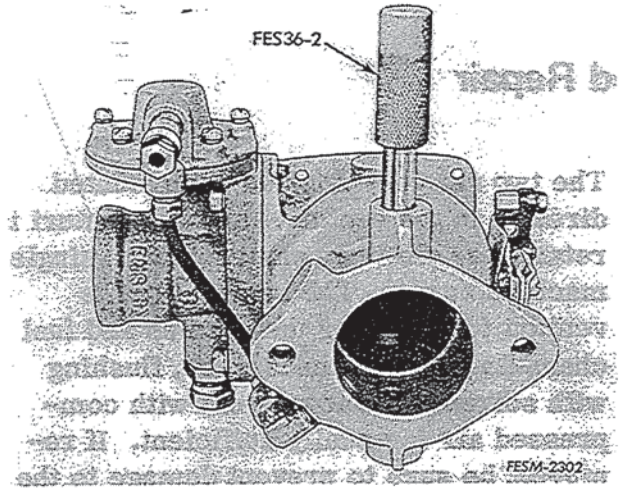
Before disassembly of the carburetor, clean the outside surface of dirt and accumulations, so that the solvent used to clean the dismantled parts will not become contaminated with excessive dirt. The solvent used to clean internal parts of the carburetor must be of petroleum base types such as kerosene, oleum spirits, etc. Do Not Use carbon tetrachloride since it will destroy the diaphragm material.

The two delivery nozzles are mounted directly in the venturi. And the venturi is retained in the body casting with a single machine screw. The removal of the venturi for cleaning the nozzles and fuel channels is rarely necessary, flushing with solvent and blowing out with compressed air is usually sufficient. If removed, be sure to prevent damage to the outside diameter of the venturi or to the bore of the body casting.

Examine the economizer diaphragm for damage or deterioration. A ruptured diaphragm will result in little or no economizer action and will also upset control of fuel for idling. The economizer valve must be free in its bore so that it may be moved freely by action of its diaphragm and spring. After considerable service, the valve and its bore in the inlet assembly may become worn, reducing the effectiveness of economizer action and increasing part throttle fuel consumption. When this occurs, renew the complete economizer assembly, transferring the bleed orifice to the new assembly.



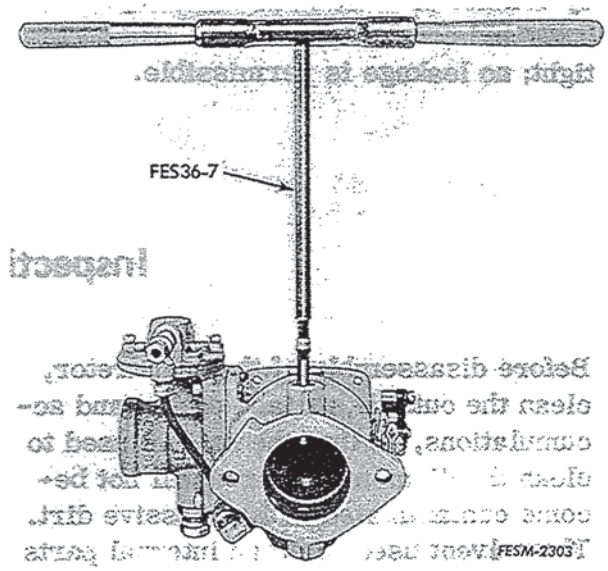
Removing throttle shaft body bushings (CBX carburetor shown).



Installing throttle shaft body bushings (CBX carburetor shown).

There are no adjustments for the economizer, its calibration is assured by use of the specified spring and the specified economizer bleed orifice. Where economizer parts are questionable, replace with new, being sure that the correct replacements are selected from parts list covering the machine model and part number of carburetor involved. Surfaces of the economizer cover and body must be undamaged to effect a seal at the diaphragm. The five retaining screws for the cover must be tightened evenly to prevent cocking of the cover.

The maximum clearance between the throttle shaft and the body bushings should not exceed .007 inch. If a new shaft will not bring the clearance down to an acceptable figure, the bushings can be replaced. Use tool FES 36-1 to remove the worn bushings and FES 36-2 to install the new bushings. Ream the bushings after installation using FES 36-7.

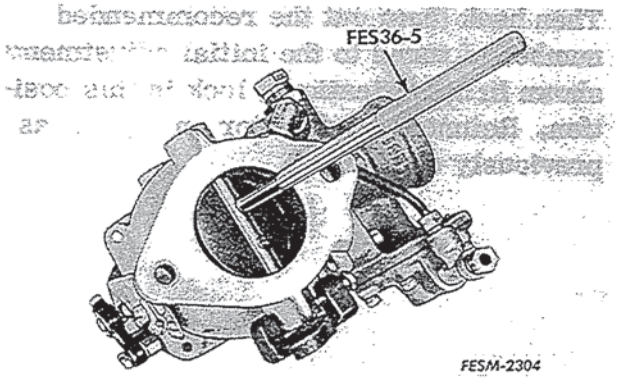


Reaming bushings after installation (CBX carburetor shown).

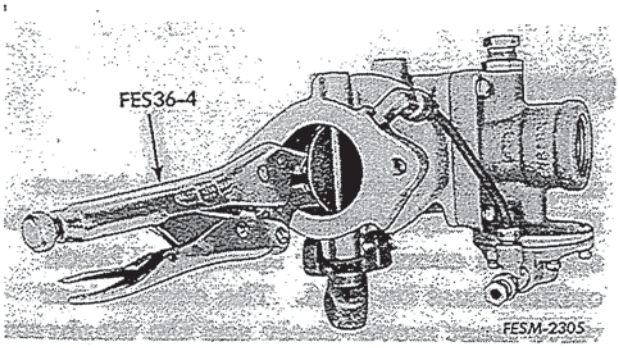
The maximum clearance between the choke shaft and the bores in the body should not exceed 0.007 inch. Where the use of a new shaft will not bring the clearance down to an acceptable figure, a new body is recommended.

The spring loaded air valve in the choke disc must be free to open against its spring tension. Where the air valve is worn and damaged, replace, using a new complete choke disc of the correct part number for the carburetor involved.

The starting shut-off valve is lightly spring loaded to hold it against the machined face of the body inlet. With the closing of the choke disc, the starting shut-off valve covers the main fuel inlet. On rare occasions, the starting shut-off valve may become raised from its machined surface by scale or coating of foreign matter, causing excessive flow of fuel during starting procedure. Where found, this condition must be corrected to restore good starting characteristics.



Installing throttle disc screws (CBX carburetor shown).



Locking throttle disc screws (CBX carburetor shown).

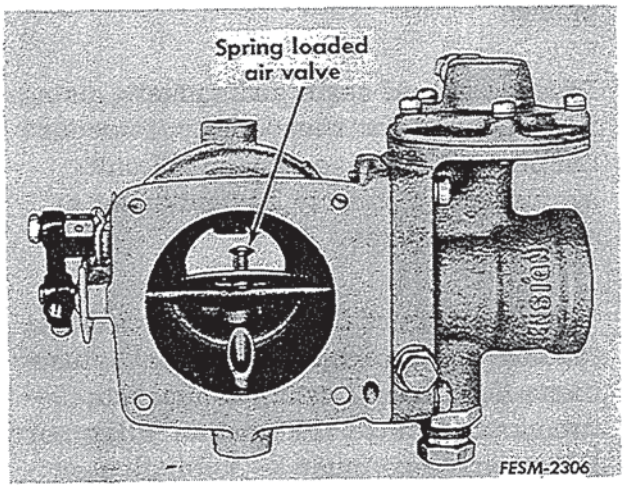
Flush out the starting gas passages in the inlet assembly and blow out thoroughly with compressed air. When heavy accumulations of oil or grease are found in the carburetor, the regulator-vaporizer will also be loaded with this material and will require cleaning.

Examine the starting fuel adjusting screw point for damage from being forceably seated, renew if necessary. Examine, also, the inner end of the main fuel adjusting screw; if this has been bent or damaged by rough handling, it should be replaced.

Discard all old seals and gaskets, using new material for reassembly, to secure the best possible sealing of the unit against entry of dirty air and upset of air-fuel mixtures.

The assembly of the throttle disc in the throttle body bore is not critical, since there is no relationship to maintain between the throttle disc and an idling port. However, there must be no binding or interference with the throttle movement from fully closed to fully opened position. Install but do not tighten the two throttle disc screws using FES 36-5 until the disc has been centered in the throttle bore at fully closed position. Clinch over the exposed ends of the throttle disc screws to lock them in place using FES 36-4. This must be done carefully to prevent distortion of the throttle disc or shaft. Set the throttle stop screw to 3 or 4 turns open from fully closed position as a tentative idle speed. Final idle speed adjustment will be made after the carburetor is installed and the engine started.

The choke disc is assembled on its shaft with the spring loaded air valve up, in order that manifold vacuum will cause air valve to open. Center the choke disc in its bore before tightening its retainer screws. Be sure that the choke disc opens fully and closes fully without interference. Check the shaft lever travel, being sure that its movement is sufficient to completely open and close both the choke and fuel shut-off valves. Inspect the starting shut-off valve to be sure that it is held in contact with the machined face of the body by its spring loading washer. Only a light spring loading is required, but the contact must be held to prevent drawing fuel through the main fuel inlet port in the starting position.



Proper installation of choke disc spring loaded air valve (CBX carburetor shown).

After assembly of the economizer diaphragm and cover, diaphragm leakage may be checked by placing the mouth over the opening in the economizer cover. If you can continue to draw air through this opening, leakage is occurring and the unit must be reopened. Leakage may be at the juncture of diaphragm and cover or at juncture of diaphragm and valve or through a puncture of the diaphragm material.

Mount the inlet and economizer assembly and the air intake elbow and their gaskets on the carburetor body, tightening the retaining screws evenly. Recheck the choke lever movement to be sure there is still no interference.

Upon returning the main adjusting screw and the starting fuel adjusting screw to their positions in the carburetor, turn them down lightly against their seats. Then back them out the recommended number of turns to the initial adjustments shown in Specifications, lock in this position. Reinstall carburetor on engine, as previously outlined.

Fuel Adjustments

Due to the action of the economizer, final adjustment of the air-fuel mixture can be accurately made without the necessity of placing the engine under load.

The condition of the fuel economizer must however be determined and, where necessary, corrections must be made before final fuel adjustments are attempted. The specified economizer spring and bleed orifice must be used. The economizer valve must move freely and the diaphragm and tubing must be air tight. See instructions on economizer on page 3-34.

Proceed with the fuel adjustments in the following sequence, after condition of economizer has been approved.

1. Set the starting fuel screw, main fuel screw and idle fuel screw to the initial adjustments for the machine model involved, as listed in Specifications.

2. The setting of the starting fuel screw should be as specified in specifications. Should a greater or lessor setting be found necessary it may be due to fuel leakage from regulator to carburetor, poor adjustment of idle fuel screw (in regulator) or air leaks into carburetor or manifold which make unusual starting adjustments necessary. Should these defects be an extreme condition, it may be impossible to secure a satisfactory starting adjustment.

3. Start and operate the engine until it is warm and is operating on liquid from the fuel tank. Adjust the throttle stop screw to result in a slow idle speed of 425 RPM. Adjust the idle fuel screw on the regulator-vaporizer to secure smoothest engine operation. Each small change in the throttle stop screw and in resulting engine speed change may require a slight readjustment of the idle fuel screw for smoothest operation.

4. The recommended initial main adjustment for each machine model, as shown in "Specifications", will be found to be very accurate with very slight changes for fuel variations. Should changes in excess of 1/2 turn from these recommended settings be found necessary, it may be due to fuel leakage from regulator to carburetor, poor adjustment of idle fuel screw or air leaks into the carburetor or manifold.

A manifold vacuum gauge can be a useful tool in adjustment of idle and main fuel screws. The gauge used should have a damper or throttling screw to reduce oscillations of the indicating pointer so that slight changes in mean manifold vacuum can be observed. The ideal adjustment has been reached when the manifold vacuum reading is the highest. The vacuum gauge must be closely observed since very small changes in gauge readings occur with changes in carburetor adjustment.

The use of exhaust gas analyzers is not recommended as a method of air-fuel adjustment, due to serious errors which often occur in LP Gas system calibration as a result of their use. The short exhaust system of these engines contribute to analyzer error, slight amounts of soot, moisture or oil fog will rapidly foul the analyzer units greatly affecting their accuracy. There is no convenient method in the field for quickly checking the accuracy of an analyzer reading.

All analyzers have an inherent scale reversing characteristic, in that, as the air-fuel mixture is leaned out beyond a certain point, the analyzer will begin to show a progressively richer mixture. Some confusion exists in connection with the dial readings of exhaust analyzers, the greater number of which are calibrated only for gasoline. While these meters will react to the combustion products of LP Gas, the actual dial calibration for LP Gas differs considerably from that calibrated for gasoline. The higher proportion of hydrogen to carbon in LP Gas accounts for this difference. Some analyzers have a dual scale covering both fuels, others furnish a conversion chart. Due to these many opportunities for error, the manifold vacuum gauge method of air-fuel adjustment outlined is advised.

FOREWORD

The instructions and special tools shown in this Blue Ribbon Service Manual are for use by International Harvester Dealers and their factory trained servicemen.

The specifications as listed in this manual are current as of the printing date. Due to changes and improvements in our products, dealers are periodically issued service bulletins to keep this manual up-to-date. We suggest you refer to the most recent information when performing service work on this equipment.

International Harvester Factory Trained servicemen are best qualified to service IH equipment.

CONTENTS

SPECIFICATIONS

	BC-144	BD-144A	BD-154
General			
Number of cylinders	4	4	4
Bore and stroke-inches	3-3/8 x 4	3-3/8 x 4	3-1/2 x 4
Displacement-cubic inches	144	144	154
Engine RPM (Governed)			
Low Idle	500 ± 25	520 - 580	520 - 580
High Idle	2200 ± 25	2075 ± 25	2200 ± 25
Rated Load	2000	1875	2000
Horsepower (Rated) @ PTO Shaft (Rated Engine Speed)			
B-275 Tractors	--------	32.3	--------
B-414 and 3414 Tractors	36.5	--------	36.0
I-424 and 2424 Tractors	--------	--------	36.5
Compression ratio	6.3:1	21.1:1	23.0
Compression pressure at cranking speed psi	80 - 105	330 - 355	445 - 470
Crankcase refill capacity - quarts	5	5	5
Firing order	1-3-4-2	1-3-4-2	1-3-4-2
Crankcase			
Tappet bore, I.D. - inch	.5615 - .5630	.5615 - .5630	.5615 - .5630
Cylinder head bolt heli-coil inserts (below surface) - inch	3/32 - 1/8	3/32 - 1/8	3/32 - 1/8
Crankshaft and Main Bearings			
Number of main journals	5	5	5
Main journal diameter - inches	2.124 - 2.125	2.124 - 2.125	2.124 - 2.125
Crankpin diameter - inches	1.7495 - 1.750	1.7495 - 1.750	1.7495 - 1.750
Main bearings, running clearance - inch	.002 - .004	.002 - .004	.002 - .004
Thrust bearing location	Rear main	Rear main	Rear main
Thrust bearing end clearance - inch	.004 - .008	.004 - .008	.004 - .008

	BC-144	BD-144 A	BD-154
Camshaft			
Camshaft bearings (reamed to size) diameter - inches	For Camshaft Bearing Installation Refer to Page 15.		
Front bearing	1.8135 - 1.8145	1.8135 - 1.8145	1.8135 - 1.8145
Center bearing	1.5795 - 1.5805	1.5795 - 1.5805	1.5795 - 1.5805
Rear bearing	1.5015 - 1.5025	1.5015 - 1.5025	1.5015 - 1.5025
Cam lobe lift (total) - inch			
Intake	.2195	.2195	.2195
Exhaust	.1975	.1975	.1975
Front bearing journal diameter - inches	1.811 - 1.812	1.811 - 1.812	1.811 - 1.812
Center bearing journal diameter - inches	1.577 - 1.578	1.577 - 1.578	1.577 - 1.578
Rear bearing journal diameter - inches	1.499 - 1.500	1.499 - 1.500	1.499 - 1.500
Thrust taken by	Thrust plate	Thrust plate	Thrust plate
Number of bearings	3	3	3
Bearing running clearance - inch	.0015 - .0035	.0015 - .0035	.0015 - .0035
Camshaft end play	.008 - .017	.008 - .017	.008 - .017
Connecting Rods			
Side clearance - inch	.003 - .010	.003 - .010	.003 - .010
Bearing running clearance - inch	.001 - .0029	.001 - .0029	.001 - .0029
Bearing O.D. and spread - inches	1.876 + .025	1.876 + .025	1.876 + .025
Pistons			
Skirt clearance - measured 90° from pin hole at bottom - inch			
Graded	.0031 - .0039	.0031 - .0039	.0031 - .0039
Individual replacements	.0031 - .0047	.0031 - .0047	.0031 - .0047
Number of rings per piston	4	5	5

	BC-144	BD-144 A	BD-154
Pistons—Continued			
Width of ring groove:			
Top compression - inch	.0953 - .0963	.0963 - .0969	.0972 - .0982
Second compression - inch	.0953 - .0963	.0967 - .0973	.0965 - .0975
Third compression - inch	.0953 - .0963	.0959 - .0965	.0965 - .0975
Oil control - inch	.189 - .190	.1877 - .1883	.1887 - .1893
Ring clearance in groove:			
Top compression - inch	.0018 - .0033	.0028 - .0039	.0035 - .0055
Second compression - inch	.0018 - .0033	.0032 - .0043	.0028 - .0048
Third compression - inch	.0018 - .0033	.0024 - .0035	.0028 - .0048
Oil control			
Top - inch	.0025 - .0040	--------	--------
Lower - inch	--------	.0012 - .0023	.0012 - .0028
Piston Pins			
Diameter-inch (standard)	1.1021 - 1.1023	1.1021 - 1.1023	1.1021 - 1.1024
Length-inches	2.898 - 2.902	2.898 - 2.902	3.1097 - 3.0236
Clearance between end of pin and retainer ring - inch	.012 - .019	.012 - .019	.012 - .020
Maximum allowable clearance in rod bushing - inch	.0005 - .0010	.0005 - .0010	.0005 - .0010
Maximum allowable clearance in piston - inch	.0003 Loose .0004 Tight	.0003 Loose .0004 Tight	.0003 Loose .0004 Tight
Piston Rings			
Compression:			
Number of rings per piston	3	3	3
Type:			
Top	Chrome	Chrome (Internally stepped)	Chrome (Internally stepped)
Second	Taper face	Plain	Internally stepped
Third	Taper face	Plain	Internally stepped

	BC-144	BD-144 A	BD-154
Piston Rings—Continued			
Width of ring:			
Top - inch	.0930 - .0935	.0930 - .0935	.0927 - .0937
Second - inch	.0930 - .0935	.0930 - .0935	.0927 - .0937
Third - inch	.0930 - .0935	.0930 - .0935	.0927 - .0937
Oil Control Rings			
Type			
Top	Slotted	Multi-piece	Multi-piece
Lower	--------	Slotted	Drilled and Grooved
Number per piston	1	2	2
Ring Gap:			
Top compression - inch	.012 - .018	.012 - .018	.010 - .015
Second compression - inch	.012 - .018	.012 - .018	.010 - .015
Third compression - inch	.012 - .018	.012 - .018	.010 - .015
Oil control			
Top - inch	.012 - .018	.015 - .045	--------
Lower - inch	--------	.012 - .018	.010 - .015
Cylinder Sleeves			
Type	Replaceable wet	Replaceable wet	Replaceable wet
Diameter, outside (at packing ring location) - inches	3.6865 - 3.688	3.6865 - 3.688	3.6865 - 3.688
Wall thickness - inch	.2134 - .2235	.2134 - .2235	.15065 - .16125
Flange thickness - inch	.227 - .229	.227 - .229	.227 - .229
Top surface of cylinder sleeve extends above top surface of crankcase - inch	.001 - .005	.001 - .005	.001 - .005
Valves			
Head Diameter:			
Intake - inches	1.407 - 1.417	1.465 - 1.475	1.465 - 1.475
Exhaust - inches	1.245 - 1.255	1.171 - 1.181	1.171 - 1.181
Face angle - degrees	45 +0 -30'	45 +0 -30'	45 +0 -30'

	BC-144	BD-144A	BD-154
Valves—Continued			
Stem Diameter:			
Intake - inch	.341 - .342	.341 - .342	.341 - .342
Exhaust - inch	.341 - .342	.341 - .342	.341 - .342
Clearance in guide:			
Intake - inch	.002 - .004	.002 - .004	.002 - .004
Exhaust - inch	.002 - .004	.002 - .004	.002 - .004
Valve Seats			
Seat angle - degrees	45	45	45
Valve Guides			
Length - inches			
Intake	2.469 *	3-1/4	3-1/4
Exhaust	2.625 *	3	3
Inside Diameter - inch	.344 - .345	.344 - .345	.344 - .345
Installed height above cylinder head surface - inch	--------	.940 ± .030	.940 ± .030
Installed height measured up from spring recess - inch	.828 *	--------	--------
Valve Springs			
Free length - inches			
Intake and exhaust	2.085	2.531 ± .047	Inner 2.125 Outer 2.550
Test length - inches			
Intake and exhaust	1.700	1.922	Inner 1.653 Outer 1.870
Test load - pounds			
Intake and exhaust	36.4 ± 5%	30.2 ± 5%	Inner 13.0 ± 5% Outer 31.0 ± 5%

* For Specifications of valve guides and springs used on engines when equipped with dual valve springs (early models) refer to following page.

	BC-144	BD-144 A	BD-154
Valve Guides **			
Length - inch	2.625	--------	--------
Inside diameter - inch	.344 - .345	--------	--------
Set height of guide measured up from spring recess-inches	1.047	--------	--------
Intake and Exhaust Valve Springs **			
Outside diameter - inch			
Intake and exhaust			
Inner	.879	--------	--------
Outer	1.316	--------	--------
Free length - inch			
Intake and exhaust			
Inner	2.125	--------	--------
Outer	2.550	--------	--------
Test length - inch			
Intake and exhaust			
Inner	1.653	--------	--------
Outer	1.870	--------	--------
Test load - pound ± 5%			
Intake	13.0	--------	--------
Exhaust	31.0	--------	--------
Valve Tappets			
Diameter - inches	.560 - .561	.560 - .561	.560 - .561
Bore in crankcase - inch	.5615 - .5630	.5615 - .5630	.5615 - .5630
Tappet clearance in bore - inch .	.0005 - .003	.0005 - .003	.0005 - .003
Push rod diameter - inch	5/16	5/16	5/16
Push rod (bottom of cup to ball tip) length - inches	10.690 - 10.720	10.510 - 10.540	10.510 - 10.540

** Specifications of valve guides and springs used when equipped with dual valve springs (early models).

	BC-144	BD-144 A	BD-154
Valve Lever and Shaft			
Valve lever shaft diameter - inch	.748 - .749	.748 - .749	.748 - .749
Valve lever bushing inside diameter - inch	.751 - .752	.751 - .752	.751 - .752
Valve lever clearance on shaft - inch	.002 - .004	.002 - .004	.002 - .004
Tappet clearance (engine hot, not running) - inch	.020	.020	.020
Clearance (engine cold) - inch	.020	.020	.020
Valve Timing			
Intake opens - degrees	20 BTDC	20 BTDC	20 BTDC
Intake closes - degrees	40 ATDC	40 ATDC	40 ATDC
Exhaust opens - degrees	40 BBDC	40 BBDC	40 BBDC
Exhaust closes - degrees	10 ATDC	10 ATDC	10 ATDC
Cylinder Head			
Bolt diameter - inch	7/16 x 14 UNC 2A	7/16 x 14 UNC 2A	7/16 x 14 UNC 2A
Timing Gears			
Backlash between any pair of gears - inch	.0025 - .0045	.0025 - .0045	.0025 - .0045
Idler gear end clearance - inch	.007 - .012	.007 - .012	.007 - .012
Idler gear to shaft clearance - inch	.0015 - .0028	.0015 - .0028	.0015 - .0028
Idler gear I.D. - inches	3.0005 - 3.0013	3.0005 - 3.0013	3.0005 - 3.0013
Lubrication System			
Oil pressure at rated rpm - psi	30 - 35	30 - 35	30 - 35
Oil pump			
End clearance between gear and end plate - inch	.0035 - .006	.0035 - .006	.0035 - .006

	BC-144	BD-144 A	BD-154
Lubrication System—Continued			
Clearance, gear to housing - inch	.0053 - .0083	.0053 - .0083	.0053 - .0083
Backlash between idler and body gears - inch	.003 - .006	.003 - .006	.003 - .006
Backlash between drive pinion and camshaft - inch	.008 - .012	.008 - .012	.008 - .012
Drive shaft diameter - inch	.4930 - .4940	.4930 - .4940	.4930 - .4940
Drive shaft running clearance - inch	.002 - .0035	.002 - .0035	.002 - .0035
Idler gear shaft diameter - inch	.4945 - .4955	.4945 - .4955	.4945 - .4955
Idler gear running clearance, - inch	.0015 - .0035	.0015 - .0035	.0015 - .0035
Clearance between body and drive pinion - inch	.002 - .004	.002 - .004	.002 - .004
Oil filter (engine)			
Number used	1	1	1
Oil pressure valve location	Oil pump body	Oil pump body	Oil pump body
Oil pressure valve regulating spring			
Free length - inches	2.556	2.556	2.556
Test length - inches	1.73	1.73	1.73
Test load - pounds	15.510 ± 3%	15.510 ± 3%	15.510 ± 3%
Pressure regulating valve			
Valve diameter - inch	.738 - .740	.738 - .740	.738 - .740
Valve clearance in bore - inch	.008 - .012	.008 - .012	.0018 - .012
Water Pump			
Type of seal	Diaphram	Diaphram	Diaphram
Rotation, drive end	Clockwise	Clockwise	Clockwise
Clearance from face of body to face of impeller hub	Flush	Flush	Flush
Electrical	Refer to Electrical Specifications Manual GSS-1308-C		

	BC-144	BD-144A	BD-154
Thermostat			
Number used	1	1	1
Open at, degrees F	170 - 179	170 - 179	170 - 179
Wide open at, degrees F	199	199	199
Carburetor			
Type	Down draft	--------	--------
Make and size	Zenith 30VNN	--------	--------
External adjustments	Idle and speed	--------	--------
Fuel level (from surface of float chamber) - inch	7/8	--------	--------
Venturi size m.m.	22	--------	--------
Compensating jet number	75	--------	--------
Slow running jet number	50	--------	--------
Main jet	77	--------	--------
Main air bleed size	2.6	--------	--------
Needle valve size m.m.	1.5	--------	--------
Governor			
Type	Centrifugal	--------	--------
Governor shaft dimensions			
Sleeve contact area - inch	.501 - .502	--------	--------
Carrier contact area - inch	.613 - .623	--------	--------
Sleeve I.D. - inch	.5045 - .5060	--------	--------
Governor shaft bushing I.D. - inch	.5035 - .5045	--------	--------
Governor Spring			
Test length - inch	3.810	--------	--------
Test load - pounds	20.7	--------	--------
Minimum length in use - inches	2.50 - .06	--------	--------
Maximum length in use - inches	4.047	--------	--------

	BC-144	BD-144A	BD-154
Special Nut and Bolt Torque Data (Foot-Pounds Torque)			
Cylinder head bolts	75 - 80	75 - 80	75 - 80
Connecting rod bolts	40 - 45	40 - 45	40 - 45
Main bearing cap bolts	70 - 75 †	70 - 75 †	80 - 85
Rear oil seal retainer bolts	27 - 31	27 - 31	27 - 31
Front pulley nut to crankshaft	225 - 250	225 - 250	225 - 250
Idler gear shaft bolt	75 min.	75 min.	75 min.
Nozzle body stud or bolt to cylinder head	--------	20 - 30	20 - 30
Nozzle body nut to stud	--------	30 - 35	30 - 35
Flywheel bolt	65 - 70	65 - 70	65 - 70
Water pump locating screw	10 - 11	10 - 11	10 - 11
Tappet adjusting screw nut	20 - 25	20 - 25	20 - 25
Governor gear nut	110 - 125	--------	--------
Flywheel Housing	When assembled on the engine, the large bore of the housing is to be concentric with the crankshaft within .005 inch (.010" total indicator reading). The rear face of the housing is to be square with the crankshaft within .003 inch (.006" total indicator reading).		
For Injection Pump and Injection Nozzle Service	Refer to GSS-1326-B		
For Venting Procedure of the Diesel Fuel System	Refer to the Operator's Manual		

† With place bolts 80 - 85 ft. lbs. of torque.

SERVICE PROCEDURE

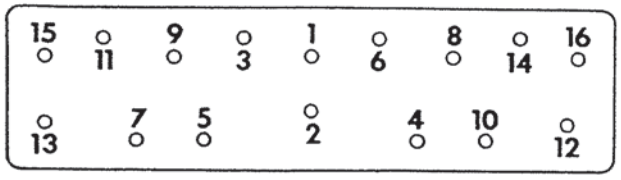
Cylinder Head Installation

1. Apply a light coating of lubricant to the metal sides of the cylinder head gasket. (All gaskets used in reassembly must be new.) If the gasket is copper faced asbestos the upper face is marked TOP to prevent incorrect assembly.

2. Install two cylinder head aligning dowels FES 44-11 into the crankcase. These dowels hold the gasket in position and ensure correct alignment of the cylinder head.

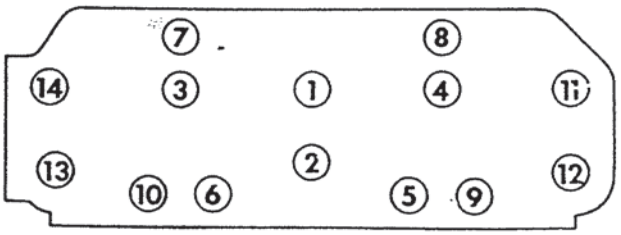
3. Install the cylinder head on the guide dowels and screw in the capscrews. Remove the guide dowels and replace them with capscrews.

4. Position the center valve lever shaft bracket and secure with the long capscrew.



FEA-75549

Illust. 1. Diesel cylinder head bolt tightening sequence.



FEA-75550

Illust. 2. Gasoline cylinder head bolt tightening sequence.

5. Torque the capscrews in the sequence shown in Illusts. 1 and 2 to 75-80 ft. lbs.

6. Remove the capscrew from the center valve lever shaft bracket and remove the bracket.

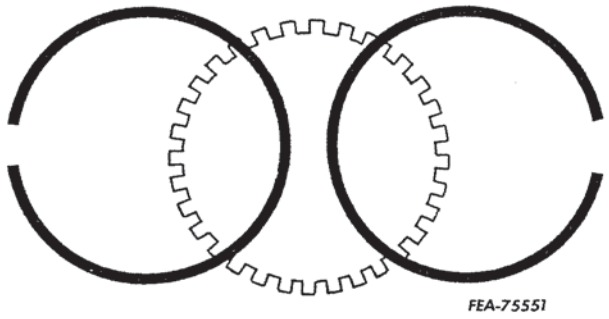
7. Install the valve push rods into the same locations from which they were removed.

8. Loosen the locknuts on each valve lever and back off the adjusting screws.

9. Install and secure the valve lever assemblies on the studs, maintaining inward pressure.

10. Install and torque the center bracket capscrew to 75-80 ft. lbs.

Multi-Piece Oil Control Ring Installation



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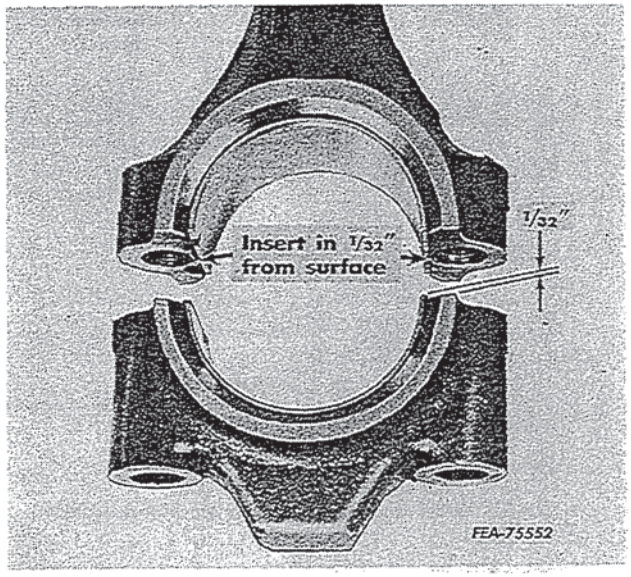
Illust. 3. Oil ring.

The multi-piece oil control ring must be fitted to the top oil ring groove. The expander must be installed first, followed by the two flat rings which must seat correctly on the expander. The gaps in the flat rings must be at 180 degrees to each other.

NOTE: Pistons in early carbureted engines have an additional oil ring groove below the piston pin. Do not install a ring in this groove.

Connecting Rod Bearing Installation



Illust. 4. Correct connecting rod bearing installation.

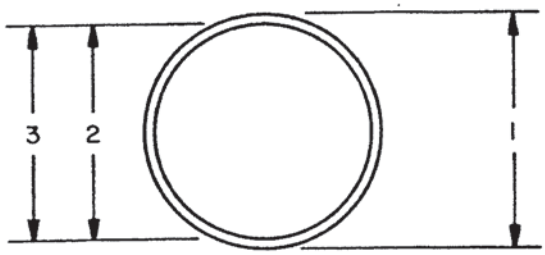
When correctly positioned, the connecting rod cap bearing half will stand out 1/32 inch on both sides above the cap surface and engage inside the rod half bore. See Illust. 4.

Install connecting rod assemblies in the engine so that the nibs on the connecting rod bearings face the camshaft, regardless of where the connecting rod number is stamped.

Camshaft Bearing Installation

When installing the front and rear bearings ensure that the edges marked 'FRONT' are to the front of the engine and that the holes in the bearings line up with the oil passages in the crankcase. The holes in the center bearing are equal distance from either edge. There is no front marking, but the oil holes must line up with the oil passages.

Press the center bearing into position first, then the other bearings. The rear bearing must be pressed in flush with the front of the bore in the crankcase.



BEARING DIMENSIONS			REAR	CENTER	FRONT
1	O.D.		1.634-1.637	1.712-1.715	1.947-1.950
2	I.D.	SEMI-FINISH	1.490-1.493	1.568-1.571	1.803-1.806
3	I.D.	LINE REAMED AFTER ASSEMBLY	1.5015-1.5025	1.5795-1.5805	1.8135-1.8145

FEA-75553

Illust. 5. Dimensions of camshaft bearing.

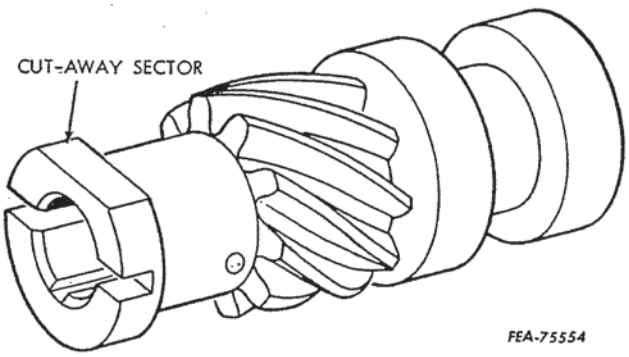
Bearings supplied for service are semi-finished and are to be line-reamed after installation. See Illust. 5.

NOTE: For specified bearing clearances refer to "Specifications."

After reaming, thoroughly blow-out the casting and oil passages to ensure that there are no metal deposits present. Install the rear bearing expansion plug. Use a sealing compound on the plug and seat.

Lubricating Oil Pump Removal

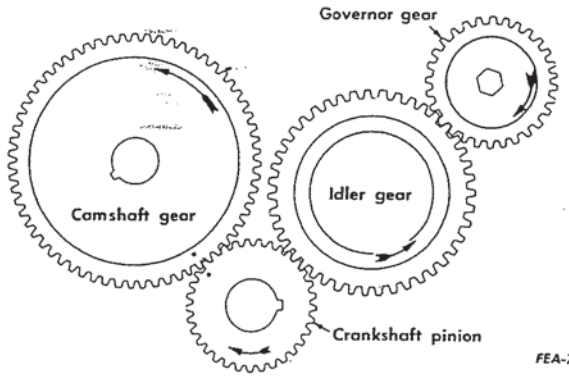
(Engine Model BC-144 Only)



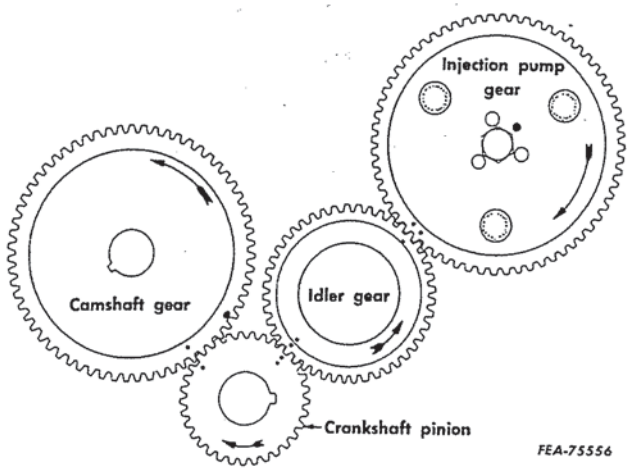
Illust. 6. Oil pump drive pinion.

On the BC-144 series engine the oil pump can only be removed and installed when No. 4 piston is at top dead center of the compression stroke. This is due to the flange of the distributor drive having to pass the teeth of the oil pump drive gear on the camshaft. The distributor drive flange has a sector cut away to allow it to pass the gear. See Illust. 6.

Gear Train Timing



Illust. 7. BC-144 gear train in time (TDC).



Illust. 8. BD-144 and BD-154 gear train in time (TDC).

Break-In Procedure of Rebuilt Diesel Engines

1. The cylinder head bolts should be properly torqued and valve levers adjusted to proper clearance.

2. The engine crankcase should be filled to the proper level with "Mil" SAE 20 lubricating oil. These oils are Mil-L-2104A or MS classification. Series 3 should not be used for break-in since this oil does not contain adequate "break-in" qualities. Use of Series 3 for break-in can result in improper "wear-in" of piston rings and excessive oil consumption. Supplementary oil additives are not to be used during the break-in period.

3. Start the engine and run at 1/4 throttle with no load until normal operating temperature is reached. Cover radiator if necessary to bring engine up to temperature.

"RUN-IN" WHEN DYNAMOMETER IS NOT AVAILABLE

Period	Engine RPM	Load	Remarks
1st Hour	3/4 of rated	None	Fourth gear on road.
2nd and 3rd Hours	3/4 of rated	Light	Operate 2 full gears below normal for load connected to drawbar.
4th Hour	Full	Medium	Operate 1 full gear below normal for load connected to drawbar.

Retorque the Head and Adjust Valves. Tractor is then ready for normal operation, except that it should not be run at low idle or high idle for long periods, nor should the engine be overloaded during the first 25 hours.

After 25 hours, drain the oil and replace with the proper quantity of Series 3 oil of the viscosity recommended for the prevailing temperatures.

Retorque the head and adjust valves after 100 hours of use.

"RUN-IN" WITH DYNAMOMETER

Period	Engine RPM	Load	Remarks
1/2 Hour	1/2 of rated	Set dynamometer to indicate 1/2 of rated hp of tractor.	Portable dynamometers indicate accurately only at full throttle. The actual load will be about 1/4 of rated.
1/2 Hour	3/4 of rated	Set dynamometer to indicate 3/4 of rated hp of tractor.	Load will be slightly over 1/2 of rated.
1/2 Hour-	Full	3/4 of rated hp.	Dynamometer will indicate correct hp.
Retorque Head and Adjust Valves.			
1-1/2 Hours	Full	3/4 of rated hp.	Dynamometer will indicate correct hp.

During the last hour, fuel adjustments, timing and pump advance should be adjusted. Do not operate engine at full load for more than 5 minutes at a time. Tractor is then ready for normal operation, except it should not be run at low idle or high idle for long periods, nor should the engine be overloaded during the first 25 hours.

After 25 hours, retorque the cylinder head bolts, adjust the valves, drain the oil and replace with the proper quantity of Series 3 oil of the viscosity recommended for the prevailing temperatures.

Break-In Procedure of Rebuilt Gasoline Engines

Fill crankcase with Mil-L-2104A or Service "MS" oil of SAE 20 weight to the proper level.

Run engine at 3/4 throttle, no load until normal temperature is reached. It may be necessary to cover radiator.

"RUN-IN" WHEN DYNAMOMETER IS NOT AVAILABLE

Period	Engine RPM	Load	Remarks
15 Min.	3/4 of rated	None	Operate tractor in fourth gear on road.
45 Min.	3/4 of rated	Light	Operate tractor 2 full gears below normal for the load connected to drawbar.
2 Hours	Full	Medium	Operate tractor 1 full gear below normal for the load connected to drawbar. Retorque head and adjust valves.

"RUN-IN" WHEN DYNAMOMETER IS AVAILABLE

Period	Engine RPM	Load	Remarks
1/2 Hour	1/2 of rated	Set dynamometer to show 1/2 of rated hp.	Load on the engine will be about 1/4 of rated due to reduced rpm.
1/2 Hour	3/4 of rated	Set dynamometer to show 3/4 of rated hp.	Load on engine will be slightly over 1/2 of rated.
1/2 Hour	Full	3/4 of rated hp.	Dynamometer will read correct hp.
Retorque Head and Adjust Valves.			
1 Hour	Full	3/4 of rated hp.	Dynamometer will read correct hp.

Tractor is then ready for normal operation. After 50 hours, retorque the cylinder head bolts, adjust the valves, drain the oil and replace with the proper quantity and the correct SAE weight for the prevailing temperature.

FOREWORD

The instructions and special tools shown in this Blue Ribbon Service Manual are for use by International Harvester dealers and their factory trained servicemen.

The specifications as listed in this manual are current as of the printing date. Due to changes and improvements in our products, dealers are periodically issued service bulletins to keep this manual up-to-date. We suggest you refer to the most recent information when performing service work on this equipment.

International Harvester Factory Trained servicemen are best qualified to service I.H. equipment.

INTRODUCTION

The purpose of this manual is to provide servicemen with the necessary information regarding overhaul and field adjustments for the C.A.V. (D.P.A. type) Fuel Injection Pump and Nozzle Service.

The "Principles of Operation" portion of the manual has been prepared to familiarize servicemen with the general function of the pump with specific detailed information covering the components which are affected by field adjustments.

Cleanliness cannot be overemphasized when performing service on any part of the diesel fuel system. Completely clean the injection pump and the surrounding area on the tractor before performing any service work.

LIBRARY FILING INFORMATION

1. File this manual in Book 10 after Divider Tab GSS-1326.
2. Enter the following information in the Service Manual Index. In the Tractor Fuel System Section on Page 7, Print or preferably Type in, the Manual Description, Form Number, and the Book filed in.

CONTENTS

SPECIFICATIONS

Injection Pump

Make	C.A.V.
Type	D.P.A.
Pump speed	1/2 engine speed
Drive	Gear in engine timing train
Rotation (viewed from drive end)	Clockwise
Injection timing	Mark on pump mounting flange and crankcase front cover plate

Transfer Pump

Type	Rotary vanes
Pressure at low idle	16-39 psi
Pressure at rated speed	38-51 psi
Pressure at cranking speed (fuel shut-off lever in off position)	Minimum of 5 psi
Vacuum (at full throttle)	10-15 inches Hg. before engine stalls

Feed Pump

Type	Diaphragm
Drive	Actuated from lobe on engine camshaft
Static fuel pressure (engine stopped)	6-10 psi

Governor

Type	Mechanical flyweight

Injection Nozzles

Type	Inward opening - Pintle No. BDN4SD6299
Nozzle opening pressure	2350 to 2425 psi
No face leakage (10 seconds)	150 psi below opening pressure
Nozzle back leakage	Back leakage should not allow pressure to exceed a fall from 1500 to 1100 psi in less than 10 seconds

Roller to roller dimension (for maximum fuel delivery)-inches	B-275 and TD-5 1.976	B-414 and 3414 1.978
Governor linkage length (measured from rear barrel surface of the stud to the rear end of the spring retainer) inches	2-1/16 ± 1/32	

Plungers

Diameter-inch	.275

End plate regulating valve spring

Free length-inches	....
Test length-inch	....
Test load-lbs.	....

Transfer pump liner I. D. -inches	1.094

Transfer pump vanes

Length-inches	....
Width-inch	....

Hole location for idling spring guide ..... Center hole in control arm.

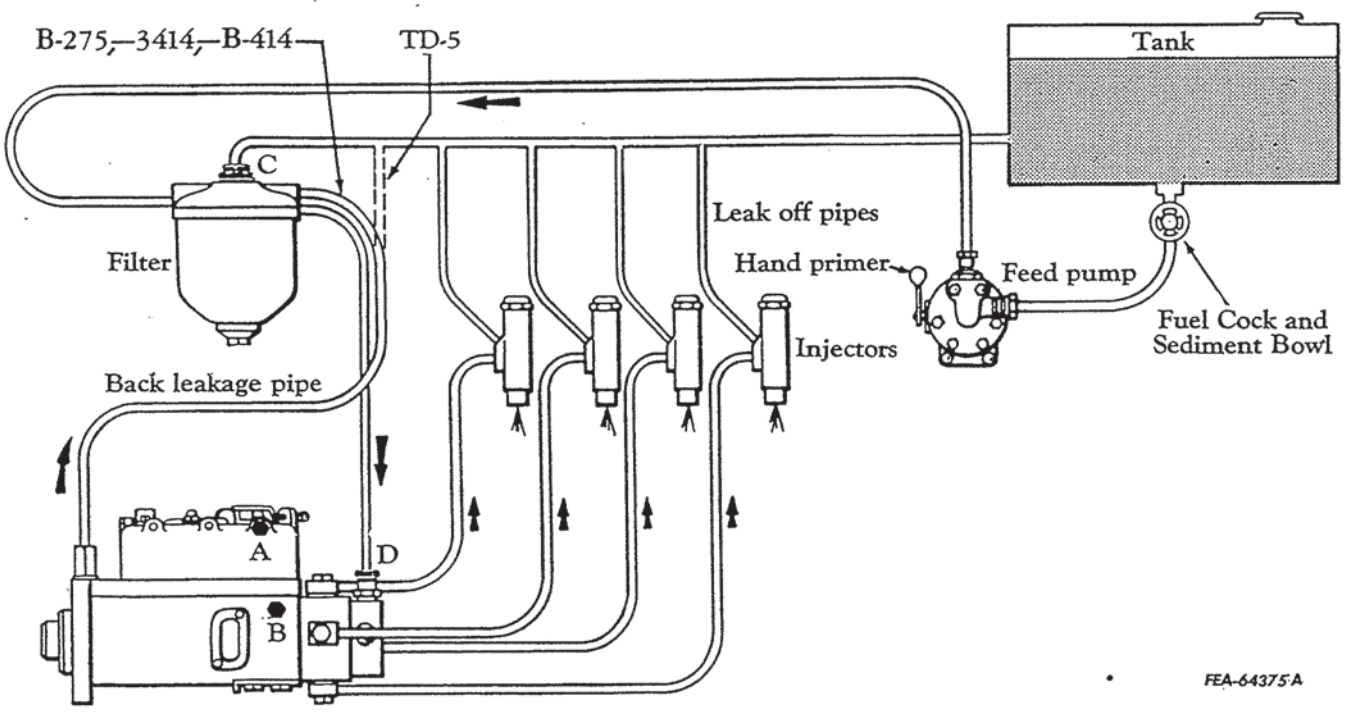
Hole location for governor spring in governor link ..... Front hole.

Torque Specifications

Nozzle cap nut	50 ft. lbs.
Nozzle hold-down nuts	40-50 ft. lbs.
Drive hub securing screw	285 inch lbs.
Cam ring securing screw	265 inch lbs.
Drive plate screws	160 inch lbs.
Hydraulic head locating screw	285 inch lbs.
Hydraulic head locking screws	170 inch lbs.
Transfer pump rotor	65 inch lbs.
End plate fuel inlet connection	360 inch lbs.
End plate screws	45 inch lbs.
Acorn nuts	30 inch lbs.

GENERAL INFORMATION

Fuel System



Illust. 1. Fuel system schematic.

As shown in Illust. 1, fuel flows by gravity from the fuel tank through the fuel cock and sediment bowl to the feed pump. The diaphragm type feed pump is actuated by a lobe on the engine crankshaft. A hand primer is incorporated in the feed pump to facilitate venting air and priming of the system with fuel. Fuel flows under low pressure from the feed pump to the fuel filter. The fuel filter has a replaceable element. A pressure relief valve or a reverse check ball and bleed orifice is incorporated in the filter cover to maintain proper, and relieve excess, fuel pressure. Filtered fuel, now under regulated low pressure, flows to the injection pump where a portion of the fuel is metered, increased in pressure and distributed to the injection nozzles. Fuel which is not injected is used to lubricate and cool the injection pump, then flows from the pump through the excess fuel return line to the fuel filter on the B-414, 3414 and B-275 or to the fuel tank on the TD-5 tractor.

Venting the Fuel System

(Refer to Illust. 1.)

1. Open the fuel cock on the sediment bowl.

2. Vent the sediment bowl.

3. Vent the inlet to the feed pump.

4. Operate the feed pump hand primer and while doing so, proceed as follows:

Note: It may be necessary, in some cases, to rotate the crankshaft approximately one revolution to permit hand operation of the priming pump.

(a) Vent the fuel filter. (Loosen the center capscrew in the filter cover.)

(b) Vent point "B" on the injection pump housing.

(c) Vent point "A" on the pump (governor housing).

5. Loosen two injector lines at the nozzle (1 and 4 are most convenient). Crank the engine until fuel spurts from these connections. Tighten the connections.

6. Engine is now ready to start and run. Further venting of the system or nozzles should not be necessary, however, smoother engine operation may be obtained sooner by venting each injector line at the nozzle fitting while the engine is running.

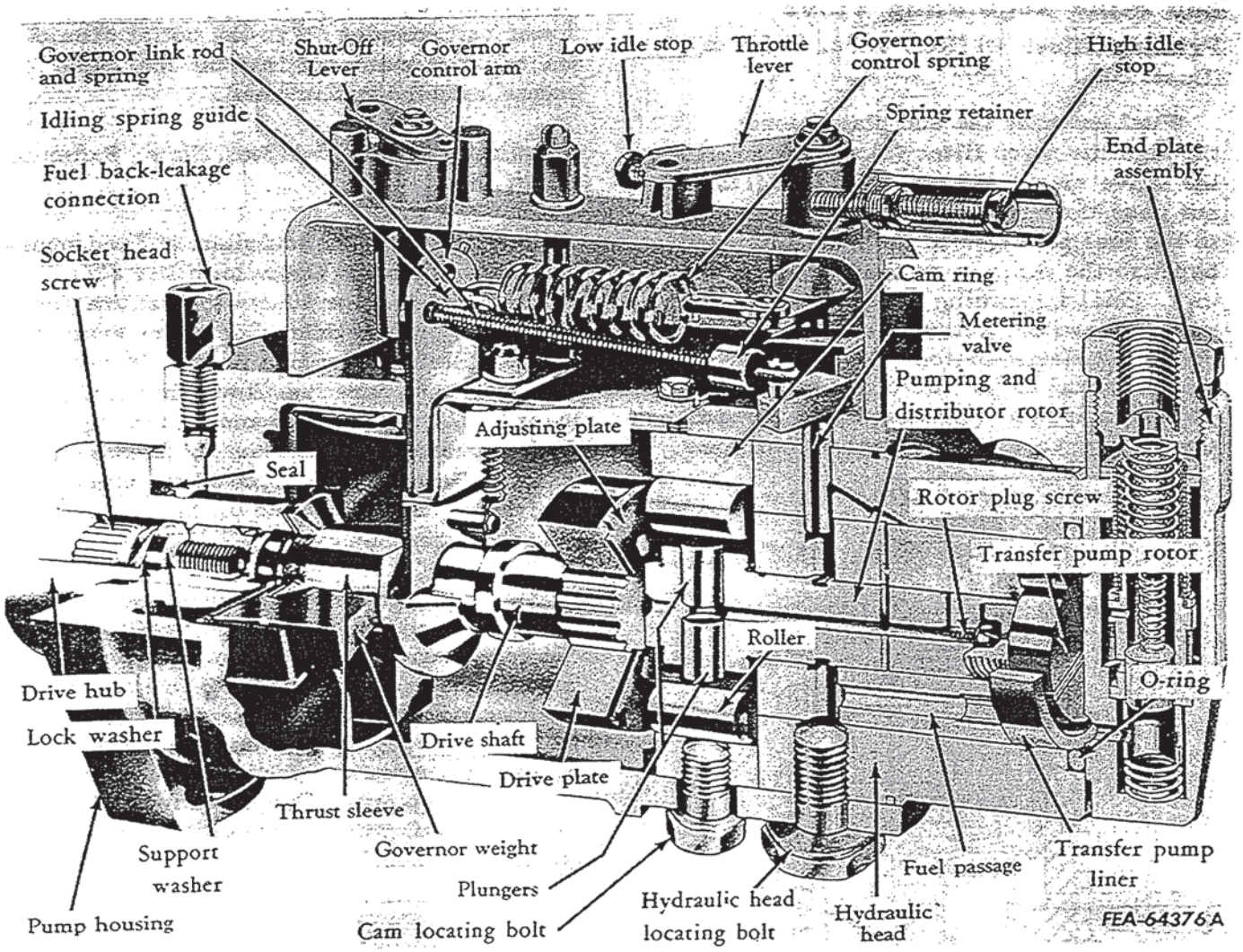
PRINCIPLES OF OPERATION

General

This injection pump is a single cylinder, opposed plunger, inlet metering, distributor type pump.

The function of the injection pump is to provide the engine with fuel in quantities exactly timed and proportioned to the amount of work it is required to do. Maximum efficiency can be possible only when these conditions are met.

A gear, dowel located on the pump drive shaft hub, is indexed to and driven from the idler gear of the engine timing gear train. The pump drive shaft, master spline - connected, drives the pumping and distributing rotor. A vane type transfer pump rotor is attached to and driven from the rear end of the pumping and distributing rotor. This transfer pump supplies fuel to the complete injection pump assembly for lubrication, cooling, metering and distribution to the nozzles. A metering valve, located in the hydraulic



Illust. 2. Cut-away of injection pump..

head, meters the fuel (within limits) for distribution to the nozzles. A piston sleeve type valve located in the end plate of the transfer pump permits venting and priming of the injection pump assembly and regulates the pressure of the fuel from the transfer pump. A cam ring having four opposite opposed lobes is located stationary in the pump housing. Attached to and rotating with the rotor shaft and within the cam ring are two movable opposed rollers and shoes which are in contact with the outer ends of the opposed plungers. The pumping action of this assembly increases the pressure of the fuel for injection. A flyweight type governor attached to and rotating with the drive shaft actuates linkage which in turn controls the rotary position of the metering valve.

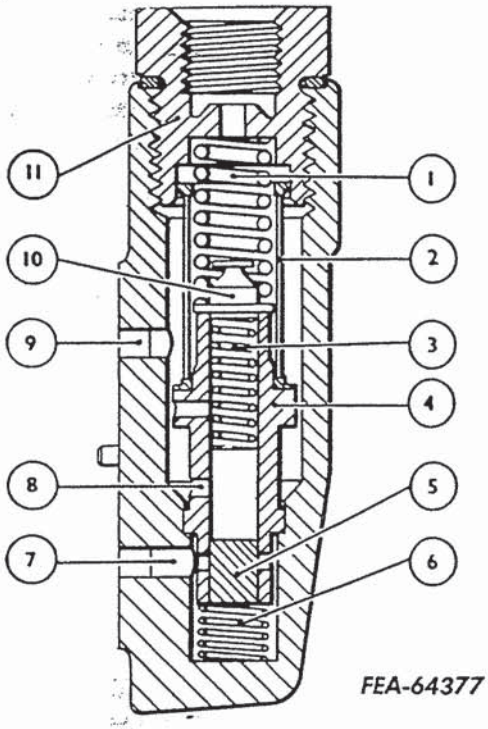
High idle and low idle adjustable stops restrict the movement of the throttle lever and shaft. A shut-off lever and linkage facilitates rotation of the metering valve to shut-off position regardless of throttle position.

There is no timing advance mechanism in this pump, therefore, end of injection is constant. Start of injection varies with the outward travel of the roller shoes and plungers. Due to the master spline connection of the drive shaft to the pumping and distributor shaft and the dowel location of the drive shaft hub to the injection pump drive gear, it is impossible, within limits, for the pump to be out of time with the engine.

End Plate Regulating Valve

Priming (Illust. 4) (Ref. No's. Refer to Illust. 3)

Fuel entering the end plate passes through the nylon filter (2) and surrounds the valve sleeve assembly (4). Fuel cannot pass through the transfer pump and into the fuel passages in the hydraulic head because the pump is stationary (not turning). Fuel at priming pressure enters the valve sleeve and acts against the upper face of the regulating piston (5). The piston is forced to the lower end of the valve sleeve, compressing the retaining spring (6) and uncovering the priming parts. Fuel then passes through the priming parts, the lower fuel passage (7) to the outlet side of the transfer pump and into the fuel passages in the hydraulic head.



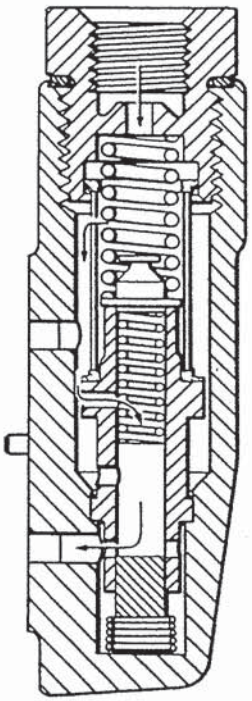
Illust. 3. Cut-away of end plate.

1. Sleeve retaining spring.
2. Nylon filter.
3. Regulating spring.
4. Valve sleeve.
5. Piston.
6. Retaining spring.
7. Fuel passage to transfer pump outlet.
8. Regulating port.
9. Fuel passage to transfer pump inlet.
10. Spring guide.
11. Fuel inlet connection.

Regulating (Illust. 5) (Ref. No's. Refer to Illust. 3)

Fuel entering the end plate at feed pressure flows through the nylon filter (2), surrounds the valve sleeve (4) out the fuel passage (9) to the inlet side of the transfer pump. The transfer pump rotor is rotating. Transfer pressure fuel flows through fuel passage (7) to the lower end of the regulating piston (5) and forces the piston upwards. This force is opposed by pressure exerted on the upper face of the piston by the regulating spring (3).

As transfer pressure increases, with increasing engine speed, the piston is forced upwards and the regulating spring is compressed. Movement of the piston progressively uncovers the regulating port (8) and regulates transfer pressure by by-passing excess fuel to the inlet side of the transfer pump. The effective area of the regulating port increases or decreases as engine speed increases or decreases.



Priming

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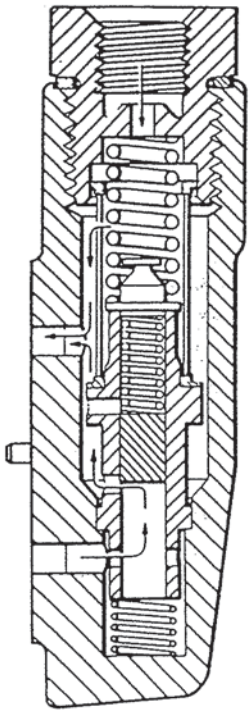
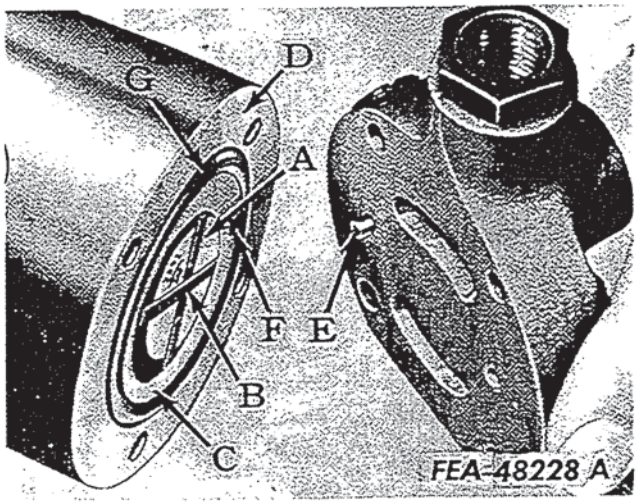
Illust. 4. Priming position of valve piston.



Illust. 5. Regulating position of valve piston.

Transfer Pump (Illust. 6.)

The transfer pump rotor "A" supports and rotates a pair of sliding vanes "B" in a liner "C".



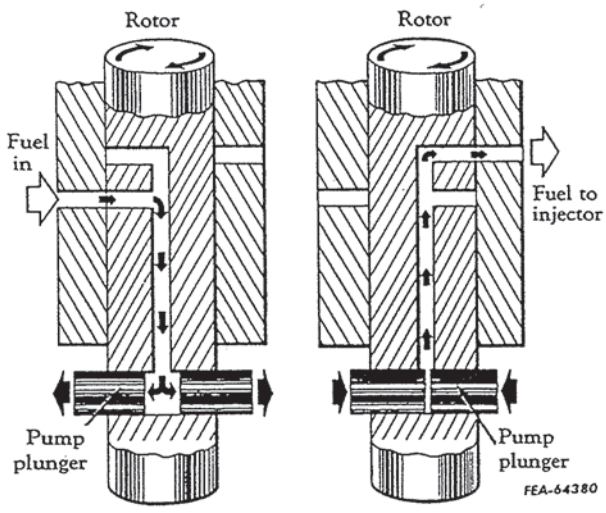
Illust. 6. Transfer pump assembly.

The liner is located and held in the hydraulic head "D" by a dowel "E" in the pump end plate. The dowel engages a slot "F" in the liner. An "O" ring "G" acts as a seal between the end plate and the hydraulic head.

Fuel Pumping and Distribution

Fuel Pumping (Illust. 7)

Transfer pressure fuel, metered by the metering valve, flows through a drilled passage in the hydraulic head to the rotor. When a charging port, drilled in the rotor, aligns with the drilled passage in the hydraulic head, as shown in Illust. 7, fuel is forced through the centrally drilled passage in the rotor and forces the pump plungers outward. As the rotor turns, the charging port in the rotor is closed. Further rotation of the rotor aligns the discharge port of the rotor with a discharge port in the hydraulic head. During this rotation the pump plungers are forced inward thus increasing the fuel pressure and forcing the fuel through the aligned discharge ports. A fuel line connected to the hydraulic head discharge port carries this high pressure fuel to the nozzle for injection.



Illust. 7. Charging and discharging principle.

A stationary cam ring, having four opposite opposed internal lobes, is located in the injection pump housing. The front

end of the rotor has a cross bore containing two opposed plungers and carries with it a pair of rollers, roller shoes, and adjustable plates. As the rotor revolves the rollers ride over the lobes thereby forcing the plungers inward. Fuel is forced from between the plungers, through the central bore in the rotor and through the discharge ports of the rotor and hydraulic head.

Distribution (Illust. 8)

There is one charging port in the hydraulic head. There are four charging ports drilled crosswise through the rotor. Rotation of the rotor within the hydraulic head causes each rotor charging port to line up, in turn, with the charging port in the hydraulic head.

One discharge port is drilled in the rotor and four discharge ports are drilled in the hydraulic head. The centrally drilled passage in the rotor connects the plunger chamber and charging ports to the single discharge port. As the rotor turns, fuel is distributed to each of the four discharge ports in the hydraulic head.

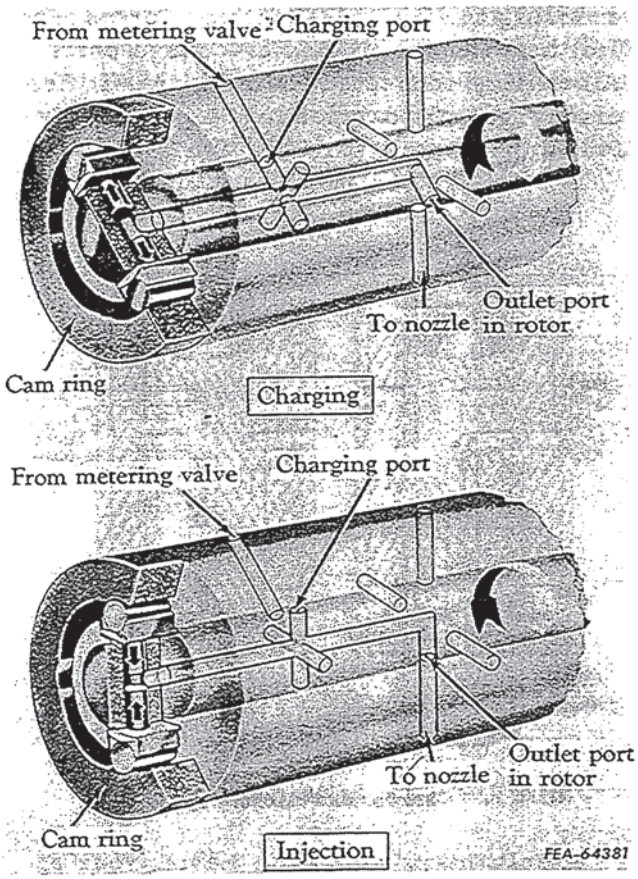
The quantity of fuel, entering the pumping chamber and available for discharge, depends on the following factors:

1. Metering valve position.

2. Fuel pressure at the charging ports.

3. Duration of time that the charging ports are in register.

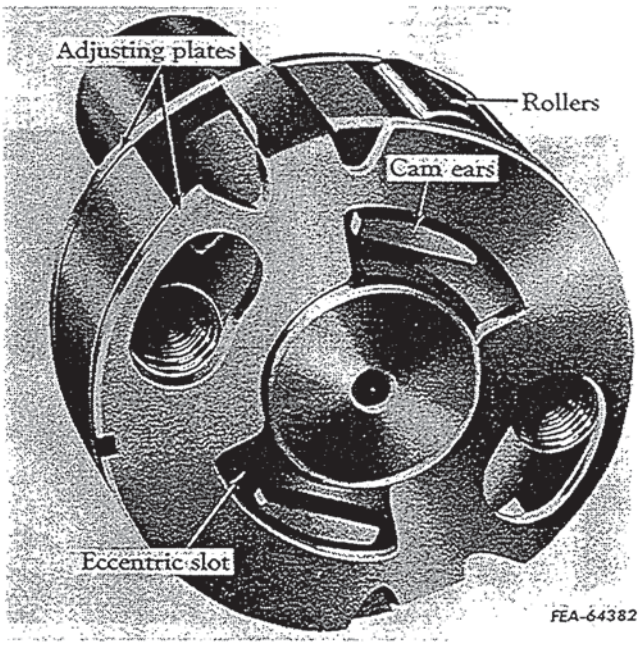
4. Total plunger displacement available as limited by the roller shoe adjusting plates.



Illust. 8. Fuel distribution.

Maximum Fuel Control

Roller shoes have protruding cam ears at each end. Interlocking adjusting plates, having internal eccentric slots, are positioned at each end of the rollers and turn with the rotor. Two small locking screws secure the driving head and adjusting plates to the rotor. The outward travel of



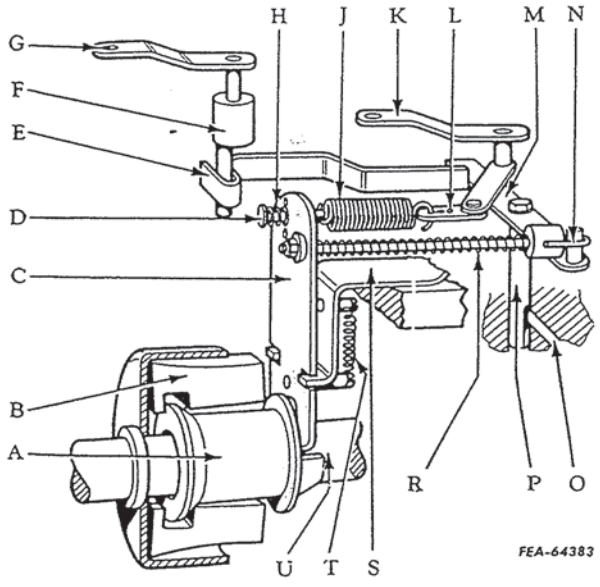
Illust. 9. Maximum fuel control. (Rotor assembly)

the rollers, shoes and plungers is restricted as the protruding cam ears of the shoes contact the eccentric slots of the plates. See Illust. 9.

Maximum fuel delivery required for high altitude operation is somewhat less than that for sea level. This coincides with altitude horsepower derating of the engine and must not be overlooked. Adjustments may be necessary to both service and production pumps.

Governor Control Linkage (Illust. 10)

Movement of the governor weights "B" causes the control sleeve "A" to move axially along the drive shaft "U". The governor control arm "C" is free to pivot about a fulcrum provided on the control bracket "S" and is held in contact with the end face of the thrust sleeve by spring tension. A spring-loaded hook rod "N" connects the upper end of the governor control arm with the lever "M" which is secured to the metering valve "P". Any movement of the governor weights in response to fluctuations of engine speed results in movement of the metering valve and a corresponding change of fuel quantity.



Illust. 10. Governor control linkage.

The "shut-off" shaft "F" is operated by movement of the lever "G". Movement of the shaft is transmitted to the control lever "M" on the metering valve by the "shut-off" bar "E", and rotates the metering valve to a position where the metering port "O" is completely closed. The hook rod "N" is spring-loaded so that this movement can be achieved without overcoming the resistance of the governor weights. When the "shut-off" control is operated, the light spring "R" is compressed and the front end of the hook rod passes through the governor control arm.

Speed selection is made by moving the throttle lever "K" which is mounted on the throttle shaft. A swivel link "L" is connected to a lever which is integral with the throttle shaft. The governor spring "J" connects the swivel link with the idling spring guide "D" which passes through a hole in the governor control arm. When the lever is moved to obtain increased engine speed, the light idling spring "H" is compressed as the guide is drawn through the control arm and tension is then applied to the main spring. Tension of the main spring acting on the control arm is transmitted to the control sleeve, and provides resistance to movement of the governor weights.

The application of the D.P.A. pump requires the idling spring guide "D" to be located through the center of the three holes in the upper end of the governor control arm "C". The governor spring "J" should be hooked in the front hole of the swivel link "L".

The metering valve "P" consists of a small shaft, slotted at one end. The valve is situated in a chamber in the hydraulic head, through which the fuel passes from the transfer pump to the inlet ports of the rotor. Rotation of the valve controls the effective area of the metering orifice, and regulates the fuel supply to the rotor by controlling the metering pressure in the passage "O".

TROUBLE SHOOTING CHART

Problem	Cause
Engine fails to start or is hard to start	1. Injection pump fuel shut-off arm and throttle lever not in the "run" position. 2. Air in fuel system. 3. Fuel does not meet specifications, or water is in fuel. 4. Cranking speed too slow. 5. Fuel not reaching transfer pump. 6. Glow plugs not hot. 7. Fuel return line plugged. 8. Injection pump not correctly timed to engine. 9. Faulty nozzles. 10. No fuel pressure to the injection pump plungers. 11. Piston rings or valves in poor condition. 12. No fuel injection occurring.
Engine starts, then stops	1. Insufficient fuel reaching the injection pump. 2. Water in fuel. 3. Air in fuel system. 4. Fuel return line restricted. 5. Engine seizure.
Engine surges	1. Air in fuel system. 2. Insufficient fuel reaching injection pump. 3. Improper governor action.

Problem	Cause
Rough and/or noisy engine operation (see also engine misfiring)	1. Injection pump timing not correct. 2. Air in fuel system. 3. Faulty nozzles. 4. Engine valves faulty. 5. Uneven engine compression.
Engine not developing full power	1. Restricted engine induction system. 2. Restricted exhaust system. 3. Throttle control does not move the throttle lever against high idle stop. 4. Timing of injection pump to engine not correct. 5. Fuel does not meet specifications. 6. Insufficient fuel reaching transfer pump. 7. Restriction in fuel return line. 8. Incorrect fuel transfer pump pressure. 9. Incorrect high idle speed. 10. Faulty nozzles. 11. Poor engine compression. 12. Insufficient fuel delivery.
Engine misfiring (also see rough and/or noisy engine operation and white exhaust smoke)	1. Injection pipes or fittings leaking. 2. Air lock in fuel system. 3. Faulty injection nozzle. 4. Incorrect engine valve lever adjustment, burned or stuck valve.
White exhaust smoke	1. Low engine temperature. 2. Air lock in fuel system. 3. Faulty nozzles. 4. Incorrect compression pressure.

Problem	Cause
Excessive black smoke at rated load speed	1. Restriction in engine induction system. 2. Low engine temperature. 3. Faulty nozzles. 4. Injection pump delivering excessive fuel.
Excessive black smoke during engine overload only	1. Injection pump delivering excessive fuel when engine is overloaded.
Blue smoke	1. Excessive oil consumption.
Incorrect vacuum	1. Loose or damaged inlet connections. 2. Unserviceable copper washer on inlet adaptor to end plate. 3. Regulating spring missing or broken. 4. End plate not tightened square to hydraulic head. 5. Faulty transfer pump seal. 6. Worn or damaged transfer pump blades. 7. Transfer pump liner improperly located. 8. Air leak in vacuum gauge connection.
Low transfer pressure	1. Regulating spring or piston missing. 2. Incorrect regulating spring. 3. Worn or damaged transfer pump blades. 4. Faulty transfer pump seal. 5. Loose or incorrectly tightened end plate. 6. Faulty washers on head locking and head locating screws. 7. Damaged seals on head locating fitting.
High transfer pressure	1. Sticking regulating piston. 2. Incorrect regulating spring - too strong.
Low and fluctuating transfer pressure	1. One transfer pump blade chipped or broken.

Problem	Cause
Incorrect maximum fuel delivery	1. Throttle not fully open. 2. Incorrect maximum fuel setting. 3. Faulty washer on rotor plug screw. 4. Loose rotor plug screw. 5. Sticking metering valve. 6. Air in system. 7. Sticking plungers or roller shoes. 8. Damaged washers on radial connections. 9. Incorrect transfer pressure. 10. Shut off mechanism fouling metering valve. 11. Governor link adjustment incorrect. 12. Governor spring linkage incorrectly assembled. 13. Cam ring reversed.
Low fuel delivery at cranking speed	1. Low transfer pressure. 2. Throttle not fully open. 3. Rotor plug screw washer damaged. 4. Rotor plug screw loose. 5. Sticking metering valve. 6. Sticking plungers and roller shoes. 7. Damaged washers on radial connections. 8. Plungers scored. 9. Outlet ports scored. 10. Excessive clearance, rotor to hydraulic head. 11. Air in system. 12. Scored metering valve.

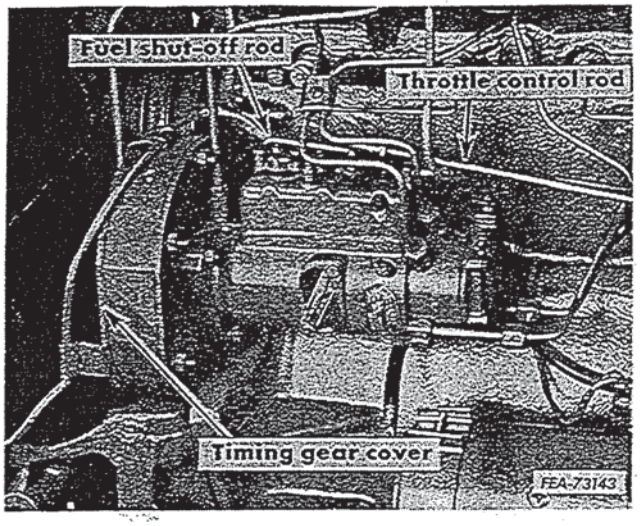
Problem	Cause
Fuel shut-off not working	1. Cut off lever fitted incorrectly to cut off shaft. 2. Cut off bar fouling control cover or control bracket. 3. Governor link binding in control arm. 4. Governor link length too long. 5. Excessive clearance, metering valve to hydraulic head. 6. Sticking metering valve.
Low fuel delivery at maximum speed	1. Maximum speed stop screw incorrectly adjusted. 2. Faulty or incorrect governor spring. 3. Governor spring linkage coupled to wrong holes. 4. Sticking metering valve.
Difficulty in obtaining proper fuel delivery setting	1. Governor spring damaged or of wrong type. 2. Governor link setting incorrect. 3. Governor spring linkage incorrectly coupled. 4. Drive hub securing screw loose. 5. Sticking metering valve. 6. Sticking governor thrust sleeve.

Removal (Illust. 11 and 12.)

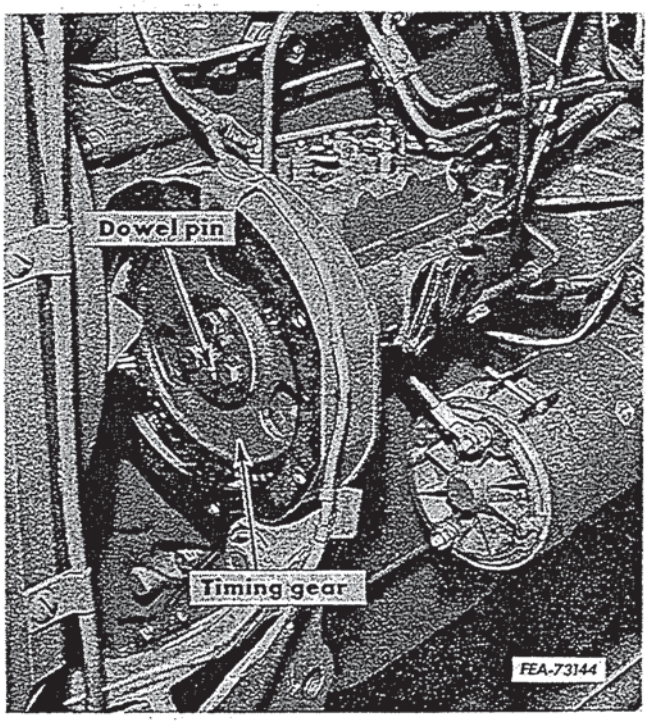
1. Completely clean the area surrounding the injection pump.

2. Close the fuel shut-off. Disconnect all fuel lines connected to the injection pump. Cap all fuel lines and plug all openings to prevent entry of dirt. Loosen the fuel inlet connection on the pump end plate.

3. Disconnect the throttle control rod and fuel shut off rod from their levers on the pump.



Illust. 11. Injection pump disconnects.



Illust. 12. Injection pump timing gear.

4. Remove the injection pump timing gear cover.

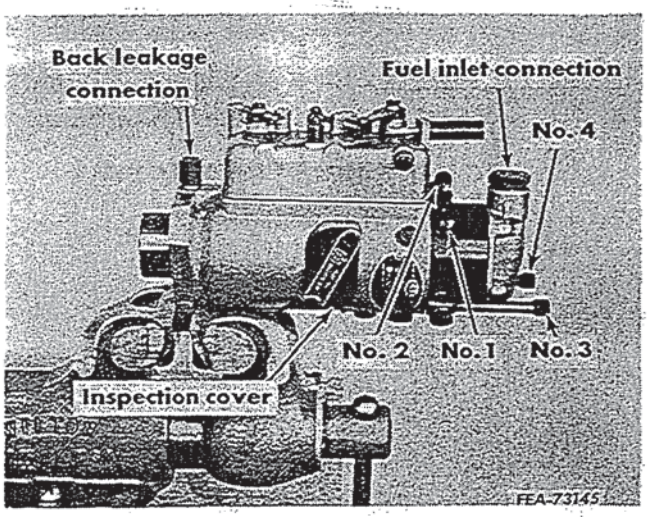
5. Remove the capscrews securing the timing gear to the pump flange.

6. Remove the nuts securing the injection pump to the crankcase front plate and remove the pump.

Disassembly

IMPORTANT: Before disassembling the pump, remove all external grease and dirt. Wash the pump with clean fuel oil and blow it dry with compressed air. Keep in mind that dirt, dust, and foreign matter are the greatest enemies of the fuel injection pump. As a precaution, keep all openings temporarily plugged.

The work bench and the area around it should be clean, as well as the tools to be used. A clean pan should be available in which all parts may be placed as disassembly proceeds, and also a pan of clean fuel oil, in which the parts may be washed.

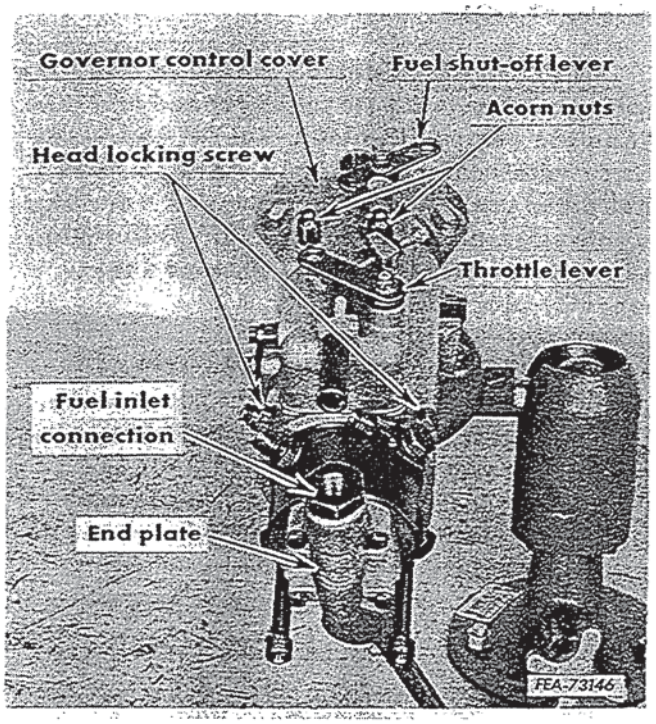


Illust. 13. Pump mounted in vise.

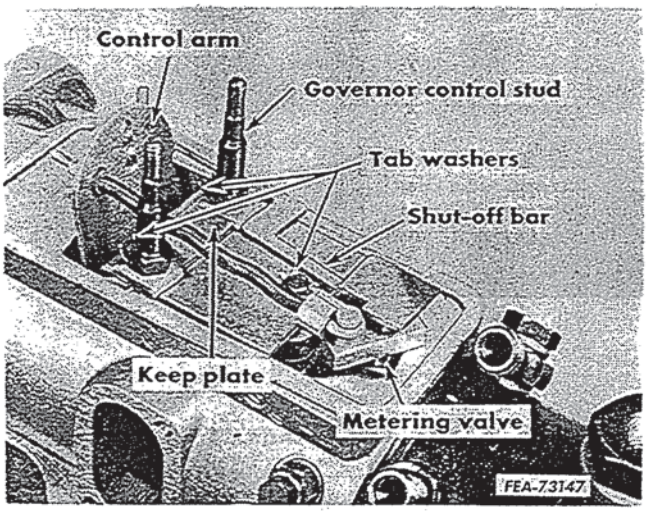
1. Mount the pump flange in a vise that has brass shields. (Illust. 13.) Remove the inspection cover and drain the fuel from the pump housing. Remove the injector lines and banjo bolts.

2. Remove the nuts securing the fuel shut-off and throttle levers to their shafts, (Illust. 14). Note the location of the star and plain washer to aid in reassembly. Remove the levers.

3. Remove the two acorn nuts and fiber washers securing the cover to the housing. (Illust. 14.)



Illust. 14. Fuel shut-off and throttle levers.

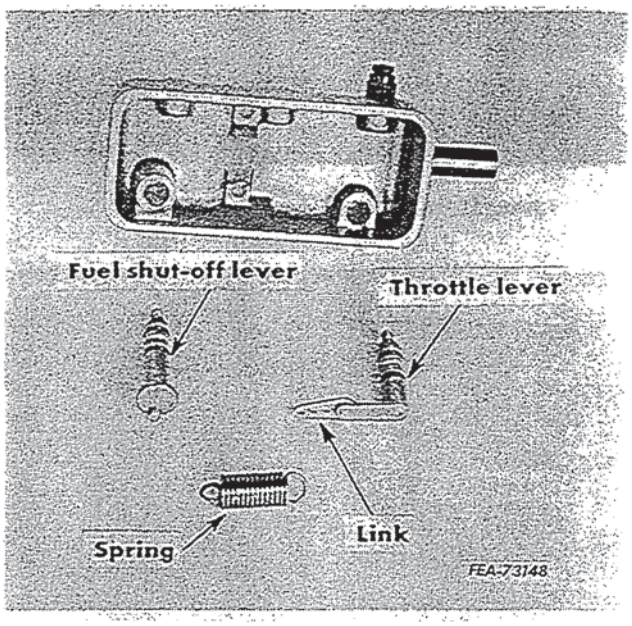


Illust. 15. Governor control linkage.

4. Lift the governor control cover and unhook the governor spring from the idling spring guide. Remove the governor control cover from the pump housing. Note the location of the spring guide in the control arm. Remove the idling spring guide and spring from the control arm, (Illust. 15).

5. Unlock the tab washers from the two governor control studs and the capscrew securing the linkage in the pump housing, (Illust. 15). Remove the studs and capscrew. Remove the keep plate shut-off bar. Remove the linkage assembly with metering valve from the housing.

6. Disconnect the metering valve from the hook lever and protect the precision ground surface from damage and corrosion by immersing it in clean fuel oil.



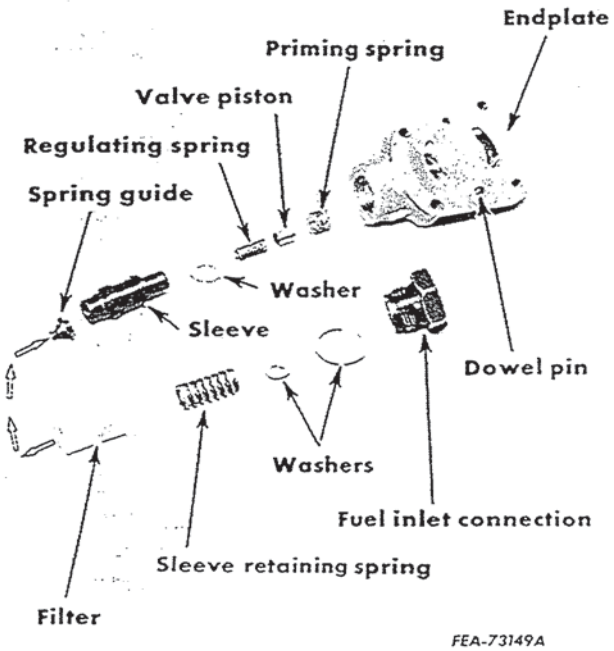
Illust. 16. Governor control spring location.

7. Remove the fuel shut-off and throttle levers from the governor control cover. Note the location of the spring hook up in the link. (Illust. 16.) Disconnect the control spring from the throttle lever link.

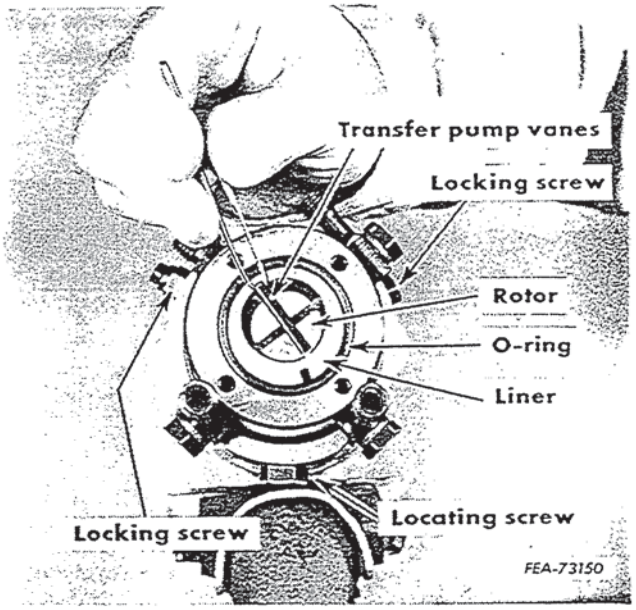
8. Remove the end plate from the pump housing (Illust. 14).

9. Remove the fuel inlet connection and remove the component parts from the end plate. (Illust. 17.)

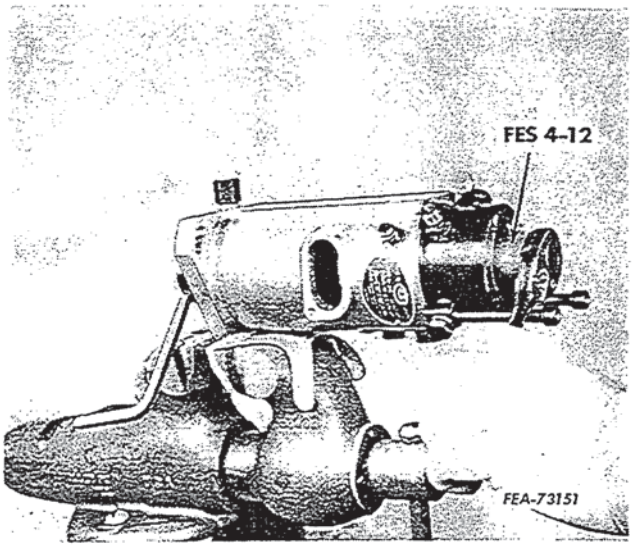
10. Using a pair of tweezers, remove the transfer pump vanes from the slots in the rotor, (Illust. 18). Remove the O-ring and the transfer pump liner from the housing.



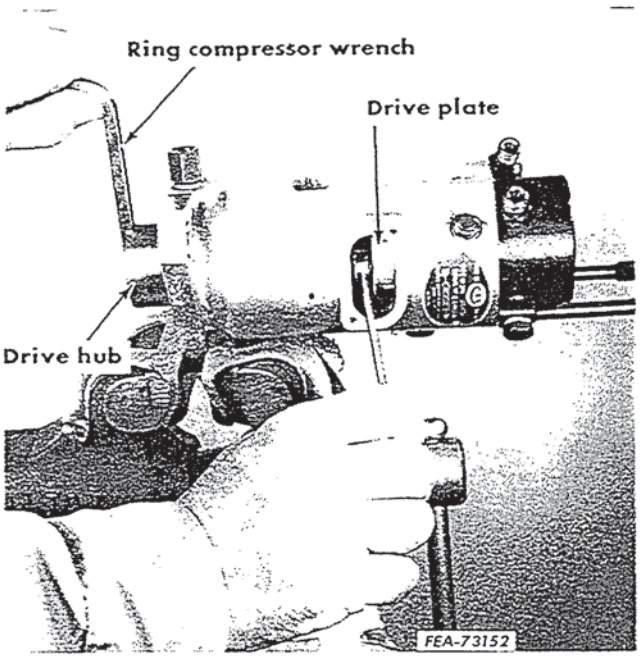
Illust. 17. End plate disassembled.



Illust. 18. Removing transfer pump vanes.



Illust. 19. Removing the transfer pump rotor.

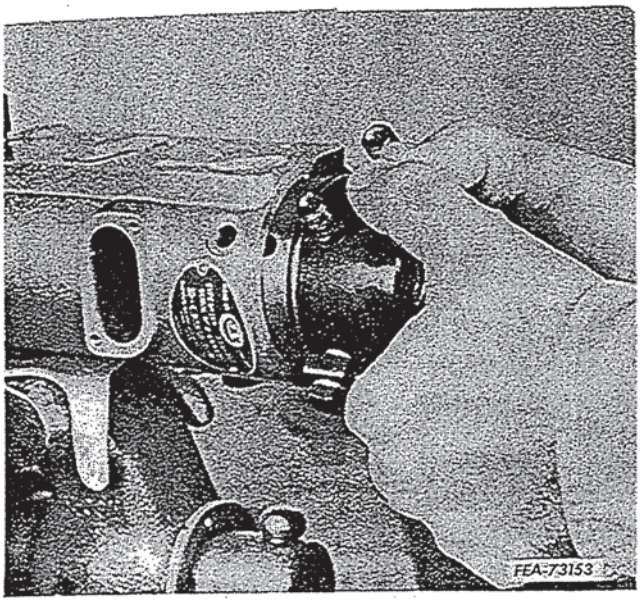


Illust. 20. Loosening drive plate screws.

11. Hold the drive hub with the square key and loosen the transfer pump rotor. using the transfer pump rotor wrench (FES 4-12) (Illust. 19). The direction for rotor removal is indicated by an arrow on the face of the rotor. (Illust. 18.) Do not remove the rotor at this time.

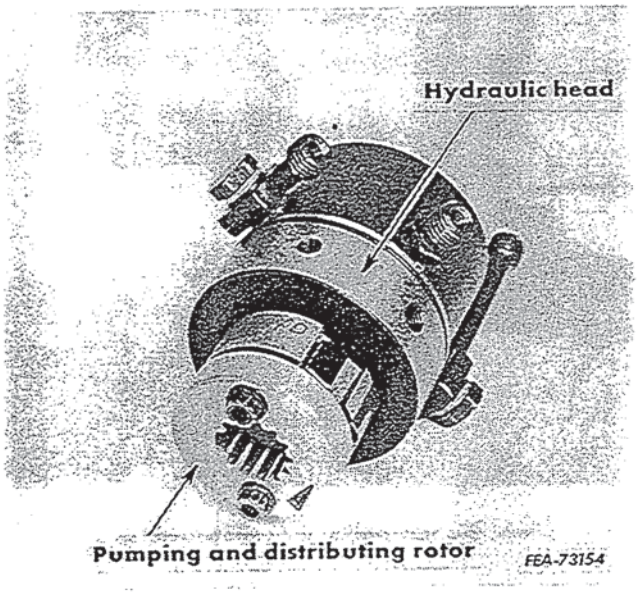
12. Loosen the two drive plate screws while holding the drive hub secure. (Illust. 20.)

13. Remove the three locking screws securing the hydraulic head in the pump housing. (Illust. 18.)



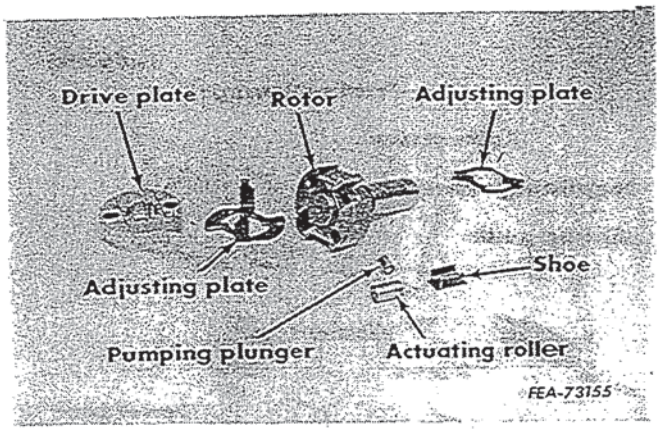
Illust. 21. Removing hydraulic head and rotor.

14. Remove the hydraulic head and rotor as an assembly. (Illust. 21.)



Illust. 22. Hydraulic head and pumping and distributing rotor.

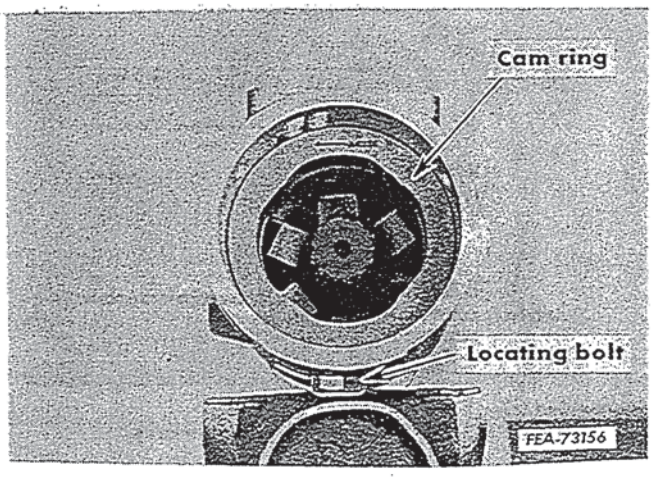
15. Remove the rotor. Separate the pumping and distributing rotor from the hydraulic head. (Illust. 22.) Note the position of the roller shoes and lock plates in the rotor as an aid in reassembly.



Illust. 23. Rotor disassembled.

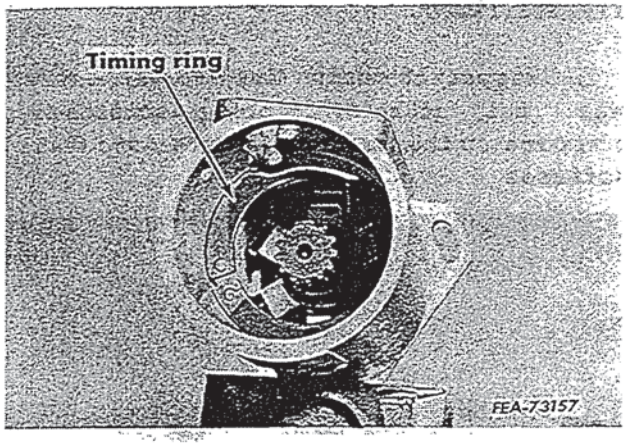
16. Remove the drive plate screws and drive plate. Disconnect the top and bottom adjusting plates and remove the actuating rollers and shoes from the rotor. Remove the two pumping plungers from the bore in the rotor (Illust. 23).

17. Remove the allen head setscrew and copper sealing washer from the transfer rotor and flush the rotor thoroughly in clean diesel fuel.



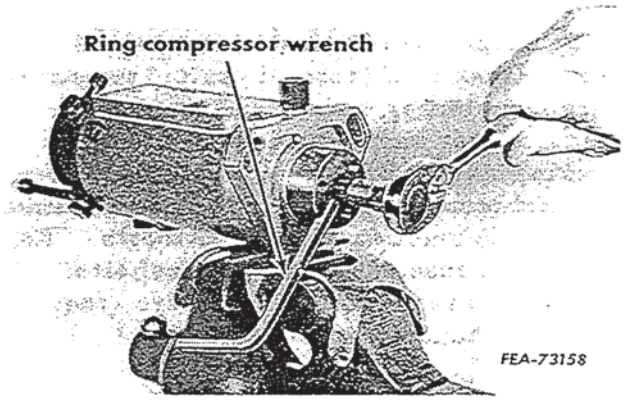
Illust. 24. Cam ring and locating bolt.

18. Remove the cam ring locating bolt and remove the cam ring (Illust. 24). The arrow on the cam ring corresponds to the arrow on the pump housing showing direction of pump rotation.



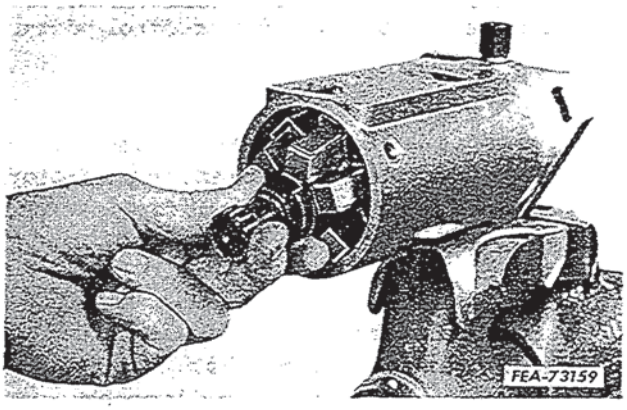
Illust. 25. Timing ring location.

19. On pumps equipped with a timing ring (Illust. 25), remove the timing ring from the housing and discard it as it is not needed.



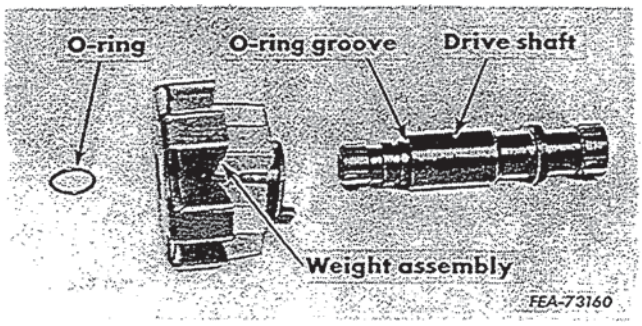
Illust. 26. Removing hub securing screw.

20. Lock the drive hub with the ring compressor wrench and remove the hub securing screw (Illust. 26).



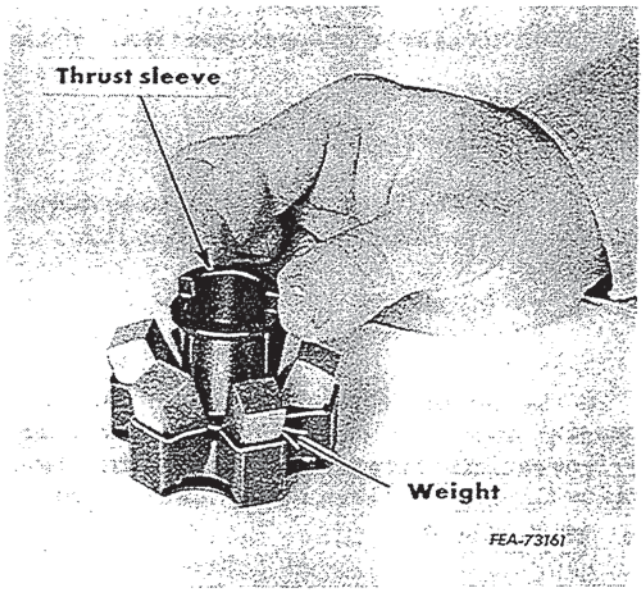
Illust. 27. Removing governor weight assembly.

21. Remove the governor weight assembly and splined shaft (Illust. 27).



Illust. 28. Governor weight and drive shaft.

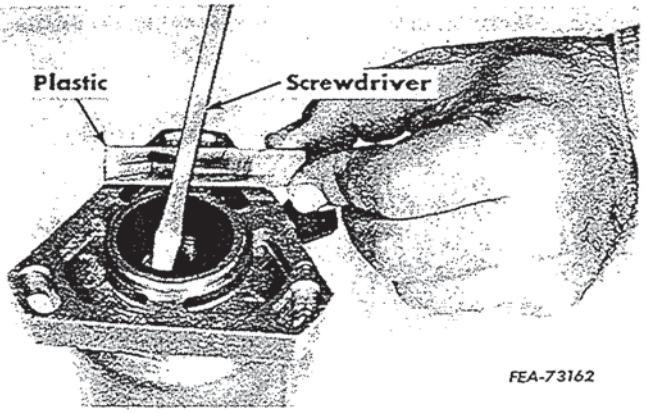
22. Remove the O-ring from its groove in the drive shaft. Pull the shaft out of the weight assembly (Illust. 28).



Illust. 29. Removing thrust sleeve and weights.

23. To remove the weights from their housing, lift out the thrust sleeve thereby allowing the weights to be removed with the thrust washer (Illust. 29).

24. Place a plastic or brass block on the flanged end of the housing, as shown in Illust. 30. Insert a dull screwdriver between the lower face of the seal and the bottom of the seal housing. Apply downward pressure on the screwdriver to pry out the oil seal. NOTE: The block keeps the screwdriver from contacting the housing.



Illust. 30. Removing housing oil seal.

Inspection and Repair

NOTE: Clean all parts of the injection pump in clean diesel fuel or solvent. All parts and drilled passages must be open and clean to assure proper operation of the pump.

End Plate (Illust. 17).

1. Check the pressure regulating valve sleeve for rust and the bypass port for clogging.

2. Check the regulating plunger for excessive wear, nicks or chipping, scratches or scores, and freedom of movement. Replace the part if there is any doubt as to its serviceability.

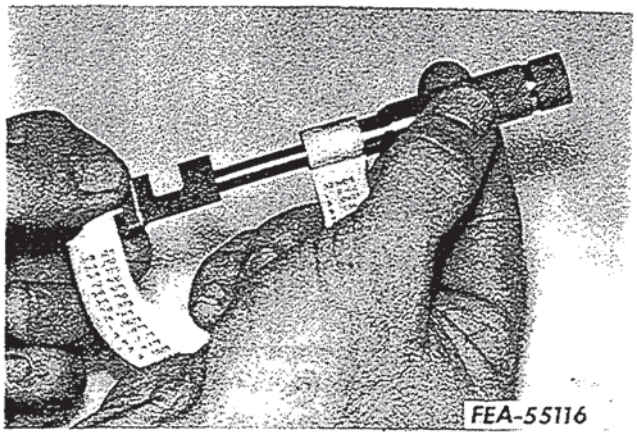
3. Inspect the end plate for wear from transfer pump end thrust; for rust, cracks or thread damage.

4. Check the bottom surface of the fuel inlet connection for rust and the threads for damage.

5. Inspect the inlet strainer for foreign material, or damage to the screen. Clean it thoroughly. Replace the strainer if it is damaged.

Transfer Pump

1. Inspect the pump liner for excessive wear, rust, nicks or chipping, scratches or scores on the inside diameter and flat surfaces.



Illust. 31. Measuring the blade length.

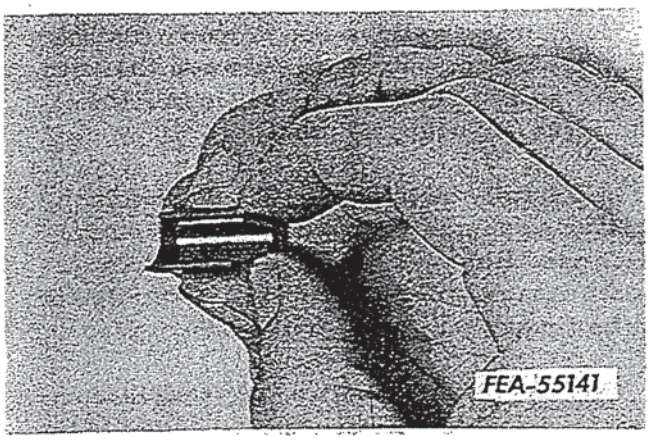
2. Inspect the blades for excessive wear, nicks or chipping of any of the edges. Check for pitting, embedded foreign particles or wear on the rounded ends. Determine this wear by measuring the length with a micrometer. Refer to "Specifications" on pages 5 and 6 for specified length. The blades are made of copper impregnated carbon and are brittle. Therefore, they should be handled with care. (Illust. 31.)

Hydraulic Head and Rotor

1. Inspect the head for excessive wear, rust, nicks or chipping, scratches or scores and thread damage. Inspect the metering valve bore and fuel control ports.

2. Inspect the plungers and check for complete freedom of movement in the rotor, then remove and examine them for scratches, nicks or signs of excessive wear.

3. If the plungers were sticking, but not visibly damaged, clean both plungers and bore with a soft brush and lacquer solvent such as lacquer thinner or acetone.



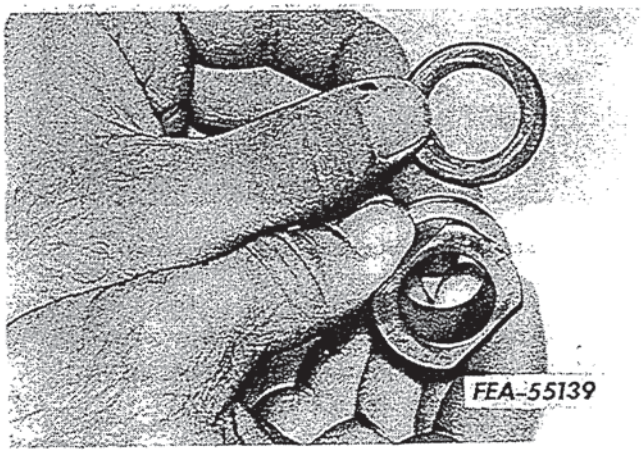
Illust. 32. Checking the cam roller and shoe.

4. Inspect each cam roller in its shoe for freedom of rolling and sliding, and the top edge of each shoe for chipping or excessive wear (Illust. 32).

5. Do not remove the rotor plug screw and sealing washer in the end of the rotor, as these parts are not serviced separately.

Governor

1. Examine the retainer sockets where the weights pivot, and the pivot points of all weights.



Illust. 33. Inspecting the governor sleeve and washer.

2. Inspect the thrust sleeve and washer for excessive wear, rust, nicks, scratches or scores, cracks or distortion; especially at points of contact with the governor arm. (Illust. 33.)

3. Inspect the pivot points of the governor arm and pivot bracket and the governor arm fork where it contacts the thrust sleeve.

4. Examine the metering valve linkage hook, the spring retainer, throttle shaft lever, shut-off cam, and the throttle and shut-off shaft assemblies for excessive wear.

5. Check the metering valve arm for looseness. The valve must be tight in the arm. Be sure the metering valve arm pin is tight in the arm.

Cam, Drive Shaft, Drive Hub and Pump Housing

1. Since only the working surfaces of the lobes on the cam I.D. are ground, the tool marks between the lobes should not be considered damaged. The cam finish is discolored from heat treatment rather than from operation. Carefully inspect the I.D. and edges of all flat surfaces. If there is evidence of excessive wear, rust, nicks, scratches or scores, cracks or distortion, or "flaking out," replace the cam.

2. Check the drive shaft for rust, excessive wear or nicks where the governor thrust sleeve slides. The drive hub seal grooves must be smooth for the seals to function properly.

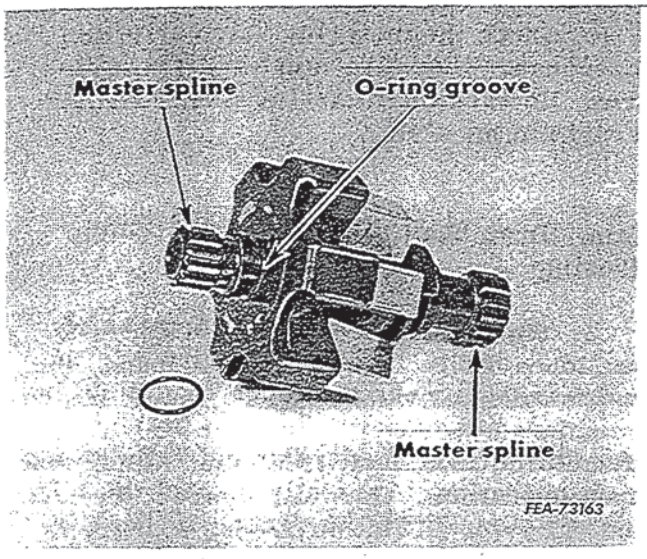
3. Inspect the pump housing internally for burrs or scratches and remove any found--carefully. A scratch at the point of contact with the seal could be a source of leakage. Inspect the drive shaft bore in the housing for excessive wear, scratches and nicks.

Reassembly

1. Use all new O-rings and oil seals when reassembling the injection pump. Dip all parts in clean diesel fuel.

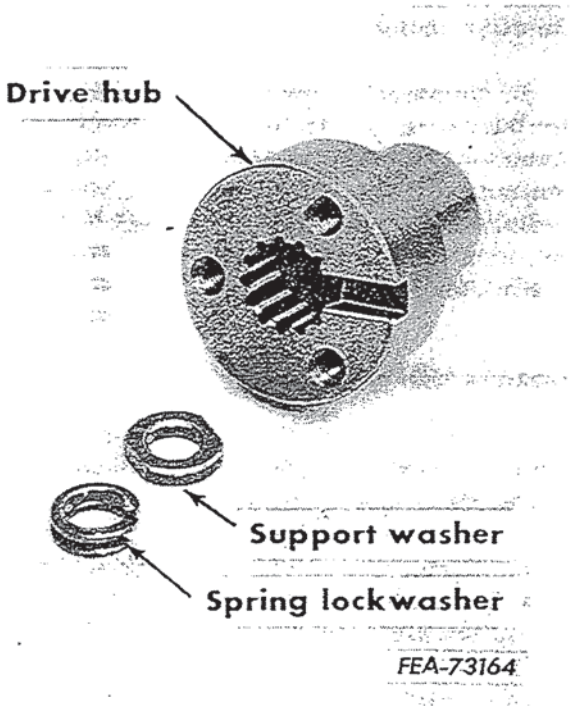
2. Using step plate No. 630-4, install a new drive hub oil seal into its bore in the pump housing. Be sure the seal bottoms on its seat. The seal is correctly seated, when a continuous black line can be seen when the seal is viewed through the flanged end of the pump housing.

3. Reassemble the weights in the carrier being sure the thrust washer and the flange of the thrust sleeve engage the slots of all the weights.



Illust. 34. Weight carrier assembly.

4. Install the splined drive shaft in the carrier and install a new O-ring in the shaft groove (Illust. 34).



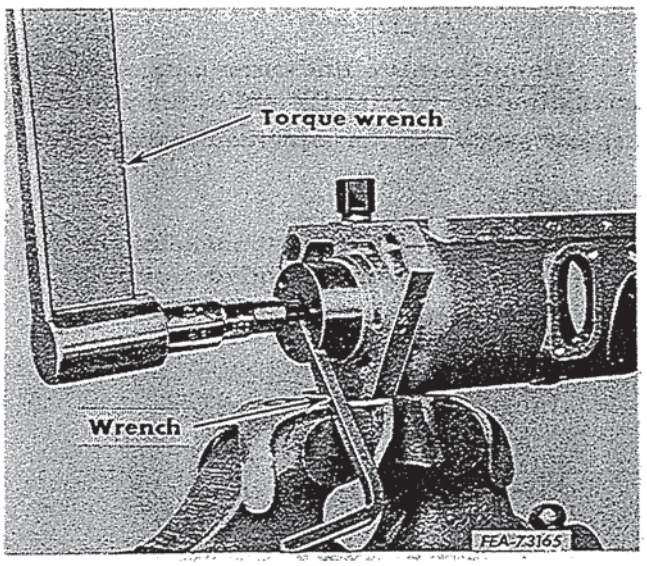
Illust. 35. Drive hub and support washer.

5. Install the drive hub support washer (Illust. 35), in the recess between the two sets of splines in the hub and install the hub in the oil seal and housing.

6. Install the drive shaft and weight carrier assembly into the pump housing (Refer to Illust. 27). Engage the drive shaft master spline with the master spline in the inner end of the drive hub.

NOTE: In this position the weight carrier is trapped between the end face of the drive hub and a shoulder on the drive shaft.

7. Install the drive hub spring lock washer and allen screw.



Illust. 36 Torquing drive hub allen screw.

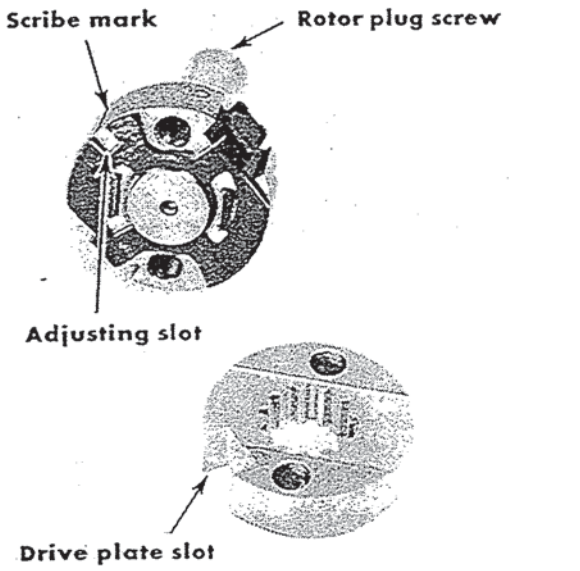
8. Using the piston ring compressor wrench to lock the hub, torque the allen screw to 285 inch lbs (Illust. 36).

9. Install the cam ring in the housing against the timing ring. The direction indicated by the arrow on the face of the cam ring should correspond with the arrow on the name plate showing direction of pump rotation (Illust. 24).

10. Install the cam ring locating bolt (Illust. 24).

11. Place the bottom adjusting plate in position on the pumping and distributor rotor so that the adjusting slot lines up with the scribe mark on the rotor head.

NOTE: Be sure to position the adjusting plate so the slots in the plate are in line with the roller shoe guides.



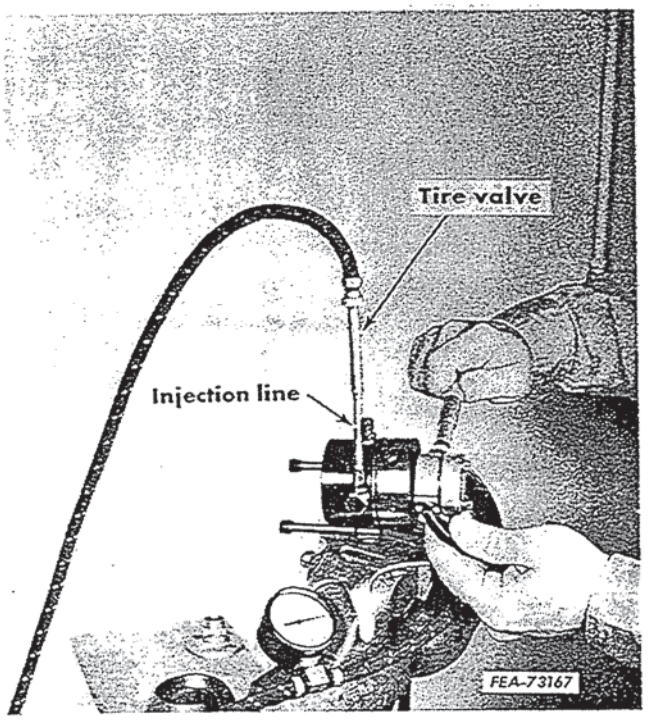
Illust. 37. Proper position of roller shoes and adjusting plates.

12. Install the twin plungers in their bore in the rotor, and install the roller and shoe assemblies in their guides in the rotor.

13. Install the top adjusting plate so the ears of the shoes engage the slots in the plates and the lugs of the top plate engage the slots of the bottom plate. (Illust. 32.)

14. Install the drive plate to the rotor, recessed side of the plate to the rotor, and install the plate capscrews finger tight. The slot in the drive plate should line up with the adjusting slot in the adjusting ring. (Illust. 37.)

15. Install the pumping and distributor rotor into its bore in the hydraulic head. Install the rotor, finger tight only at this time.

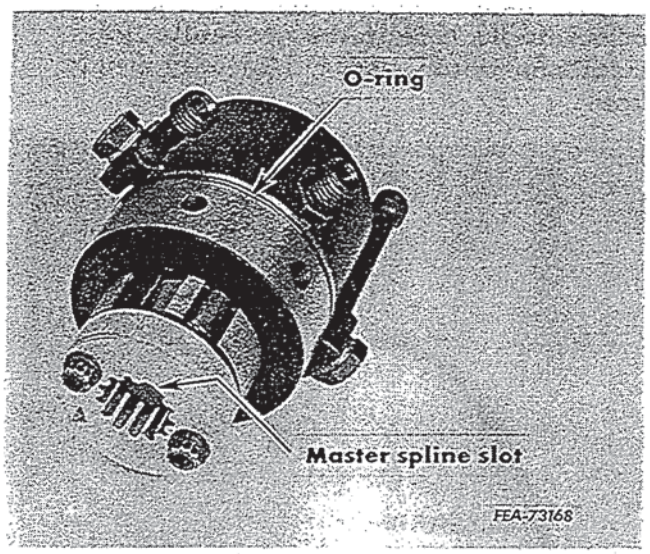


Illust. 38. Checking roller to roller dimension for maximum fuel adjustment.

16. Secure the hydraulic head and rotor assembly in a vise (Illust. 38). Be sure the machined circumference of the hydraulic head does not contact the vise. Apply air pressure (30 to 100 psi) to one of the fuel injector line connections. (Illust. 38.) Rotate the rotor until the plungers and roller shoes are forced to the maximum fuel position. Check the roller to roller dimension with a micrometer and if necessary, rotate the adjusting plate until the specified roller to roller dimension is obtained. Refer to "Specifications".

NOTE: The air pressure line installed on the hydraulic head can be made from an injection line with a tire valve brazed to it.

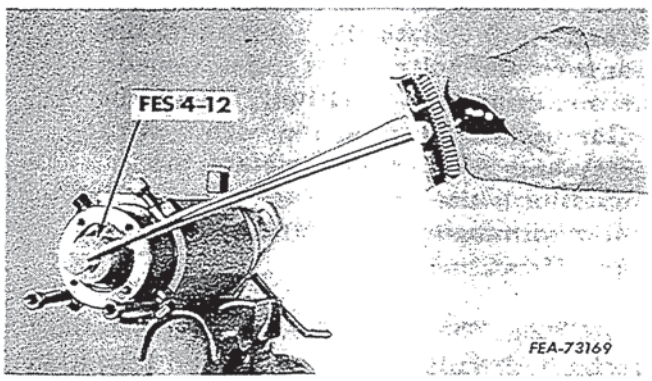
17. Disconnect the air pressure equipment.



Illust. 39. Drive plate master spline slot.

18. Install a new O-ring on the hydraulic head. Install the hydraulic head and rotor assembly into the housing, engaging the master spline on the inner end of the drive-shaft with the master spline slot of the drive plate (Illust. 39). Rotate the head to prevent damage to the O-ring as it enters the pump housing.

19. Locate and secure the head by installing the head locating screw. Tighten the screw to 285 inch lbs. torque. Install the two head locking screws and tighten them to 170 inch lbs. torque. Torque the cam ring locating bolt to 265 inch lbs.



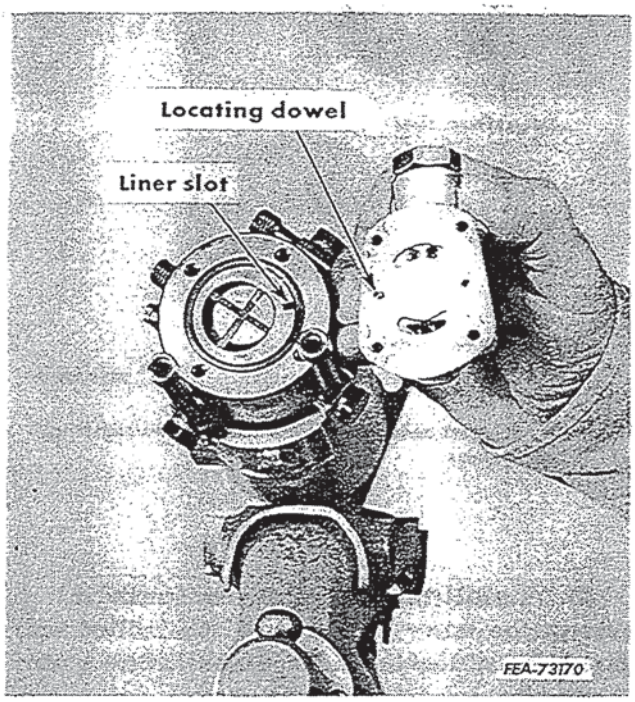
Illust. 40. Torquing transfer pump rotor.

20. Lock the drive hub from turning and tighten the rotor to 65 inch lbs. torque (Illust. 40).

21. Install the transfer pump liner in its bore in the hydraulic head. Install a new O-ring around the liner.

22. Install the pump vanes in the slots in the rotor. Refer to Illust. 18. Rotate the liner to be sure the vanes do not bind.

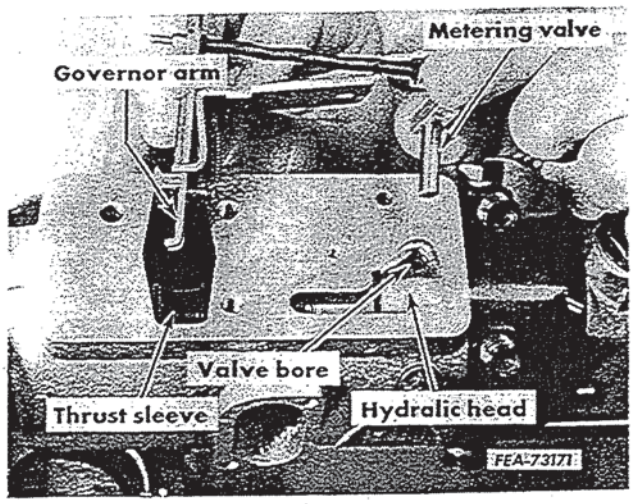
23. Install the priming spring in the base of the end plate valve chamber. Refer to Illust. 17. Insert the piston and regulating spring in the sleeve and a new washer on the sleeve. Install the spring guide filter retaining spring, washers and fuel inlet connection.



Illust. 41. End plate locating dowel.

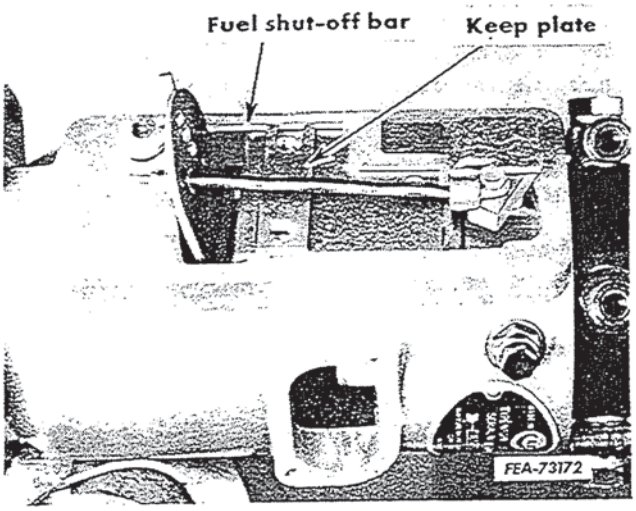
24. Install the end plate assembly on the pump housing, being sure the locating dowel on the face of the end plate engages the slot in the transfer pump liner (Illust. 41). Install the end plate capscrews and tighten them to 45 inch lbs. torque. Tighten the fuel inlet connection to 360 inch lbs. torque after the pump is installed on the engine.

25. Rotate the thrust sleeve so the seat for the governor arm is exposed and to the top. Install the governor control linkage



Illust. 42. Installing governor linkage.

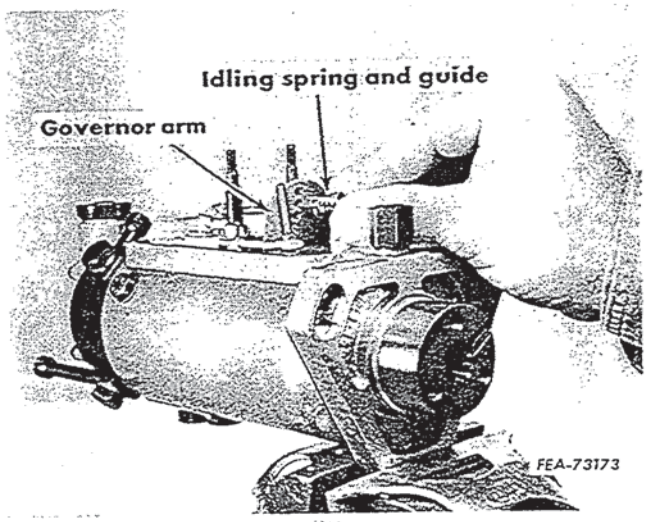
on the pump housing and engage the lower end of the governor arm with the thrust sleeve and position the metering valve in its bore in the hydraulic head (Illust. 42).



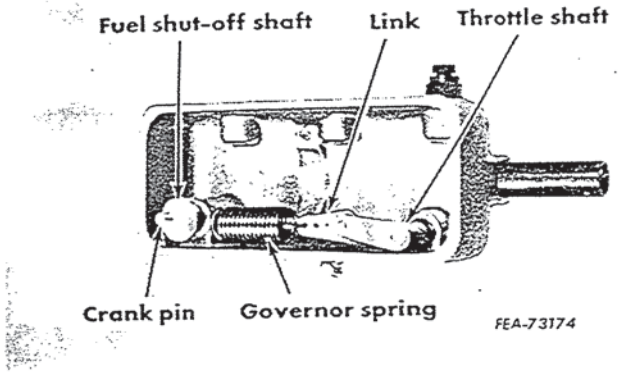
Illust. 43. Position of keep plate and fuel shut-off bar.

26. Install the keep plate in position on the governor control bracket (Illust. 43). Install the fuel shut-off bar. Install the governor control studs with new tab washers. Install the screw and tab washer at the end of the bracket near the metering valve. Tighten the screw and studs securely. Bend lock tabs up to lock screw and studs in place.

27. Install the idling spring and guide into the center of the three holes in the governor arm (Illust. 44).



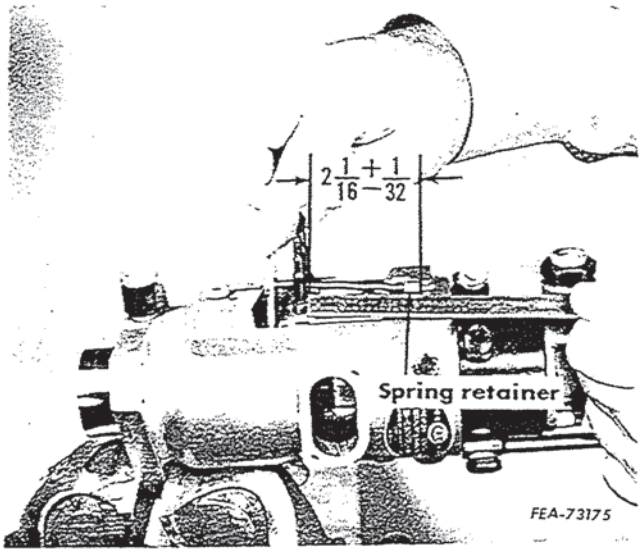
Illust. 44. Installing idling spring and guide.



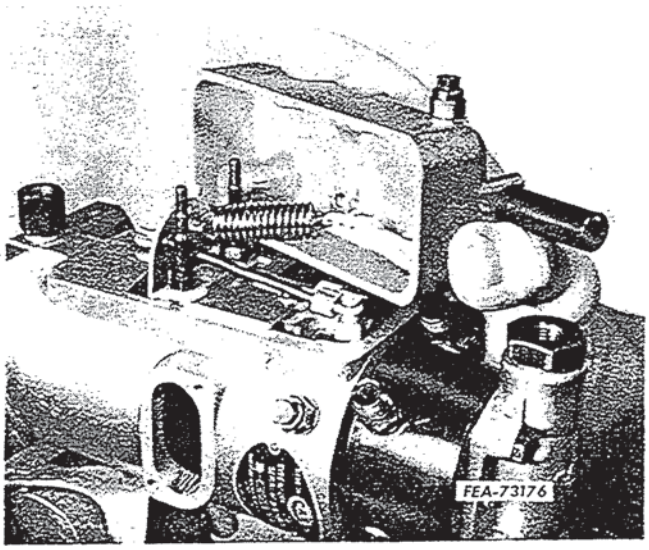
Illust. 45. Governor control housing assembled.

28. With new O-rings installed on the fuel shut-off and throttle shafts, press the shafts through their bores in the governor control housing. Install one end of the governor spring to the front hole in the link (Illust. 45).

29. Move the governor control arm to the full throttle position, (toward the rear



Illust. 46. Checking linkage setting.



Illust. 47. Installing governor control housing.

of the pump) and hold it in that position. Measure from the rear barrel surface of the stud (not the hex head) to the rear end of the spring retainer. Measurement should be 2-1/16 ± 1/32 inches (Illust. 46).

30. Install the governor control housing with new gasket on the pump housing. being sure to hook the governor spring to the idling spring guide and also being sure the fuel shut-off shaft crank pin engages the slot in the fuel shut-off bar. (Illust. 47.)

31. Install the acorn nuts with washers on the studs and tighten them to 30 inch lbs. torque.

32. Install the washers and levers on the throttle and fuel shut-off shafts. Secure the levers in place with the nuts.

Installation

The installation procedure is the reverse of the removal procedure. Refer to "Field Adjustments" for final adjustments on pages 29 to 32.

FIELD ADJUSTMENTS

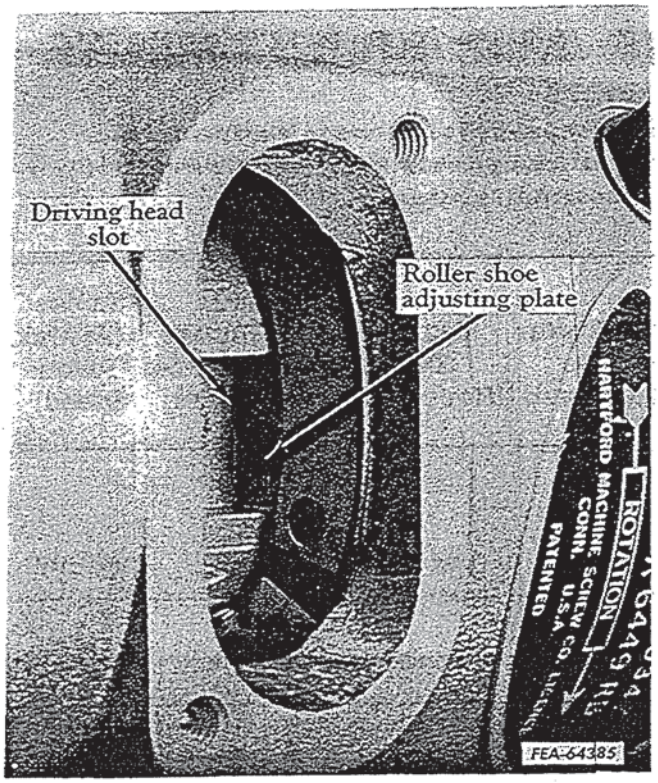
Maximum Fuel

1. Close the fuel cock at the fuel tank.

2. Remove the part number plate, inspection cover and gasket from the pump and drain the fuel.

3. Rotate the engine crankshaft clockwise as viewed from the front of the tractor, until the slot in the driving head is in position as shown in Illust. 48 (about 4 o'clock).

4. Loosen the two capscrews which secure the driving head to the rotor using a 5/16 inch 12 point straight shank, box end wrench.



Illust. 48. Rotor position for making maximum fuel adjustment.

NOTE: The roller shoe adjusting plates are now free and ready for adjustment.

5. Insert a small tool, such as a pin punch, screwdriver or allen wrench, through the inspection cover opening and engage the small slot in the roller shoe adjusting plate (inner black ring).

NOTE: Very small movement of the ring is required to change maximum fuel delivery.

Fuel delivery is increased by rotating the adjusting plate downward (direction of pump rotation as indicated by the arrow on the serial number plate). Decrease fuel delivery by rotating the plate in the opposite direction.

6. Tighten the drive plate capscrews to 125 inch pounds torque. (Approximately 31 lbs. pull on a spring scale hooked perpendicular to the end of a wrench 4 inches long.)

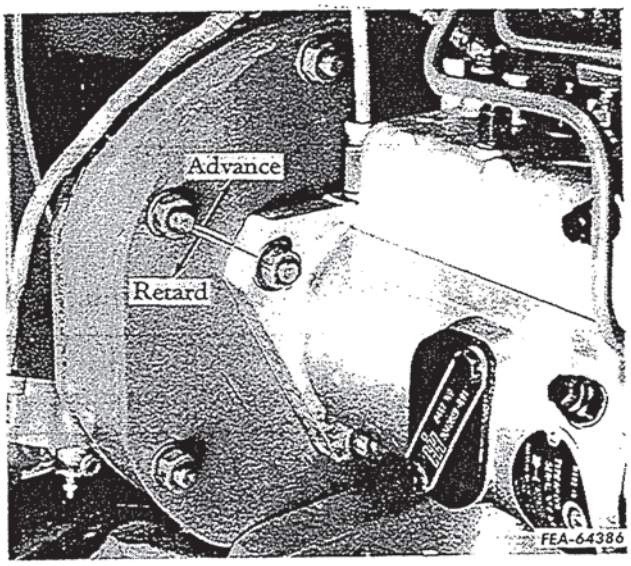
7. Install the gasket, inspection cover, part number plate and capscrews on the housing. Tighten the capscrews securely.

8. Vent the fuel system as outlined on page 7.

9. Start and operate engine to check results of adjustment. Readjust if necessary by repeating steps 1 through 8. Install and lock seal wire to the inspection cover capscrews.

10. Maximum fuel delivery is correct for existing conditions when medium exhaust smoke is visible when the engine is loaded to maximum torque speed.

Pump Timing to Engine



Illust. 49. Pump timing marks.

The injection pump has a single scribe mark on the pump mounting flange (Illust. 49). For normal timing this mark is located midway between two scribe marks on the engine front cover plate. Movement of the pump flange mark between the two marks on the front plate gives a variation of three (3) degrees. In some cases the scribe marks are not clear, therefore, should it be necessary to remove the injection pump from the tractor it is recommended that all three scribe lines be marked clearly before the pump is removed.

EFFECTS OF PUMP TIMING AND ADJUSTMENTS

Normal pump timing and adjustment results in a compromise between engine noise, power, color of exhaust and fuel consumption. The following chart shows the results of normal setting as well as results of deviating from the normal setting.

Settings	Engine Noise	Fuel Consumption	Horse Power at Rated Speed	Maximum Torque (Horse Power)	Smoke (At Rated Speed)	Smoke (At Max. Torque Speed)
Pump Timing						
Normal	normal	normal	normal	normal	light	medium
Advance (1-1/2°)	increase	slight decrease	slight decrease	decrease	light	medium
Retard (1-1/2°)	decrease	slight increase	increase	increase	light	medium
Governor Linkage (Hook Rod)						
Normal	normal	normal	normal	normal	light	medium
Longer (1/32")	normal	slight increase	increase	increase	medium light	medium
Shorter (1/32")	normal	slight decrease	decrease	decrease	very light	medium light
Maximum Fuel						
Normal	normal	normal	normal	normal	light	medium
Increase (1/32")	normal	no effect at rated	normal	increase	light	black
Increase (1/32")	normal	increase at max. torque	normal	increase	light	black
Decrease (1/32")	normal	no effect at rated	normal	decrease	light	medium light
Decrease (1/32")	normal	decrease at max. torque	normal	decrease	light	medium light

ENGINE—PTO RATIO CHART

The following chart is a guide to assist servicemen in performing proper Pre-delivery and Testing service.

SPEEDS	B-275	TD-5	B-414	3414
Maximum Idle Speed				
Engine crankshaft	2000	2200	2200	2200
Power take-off	593	1077	600	600
Rated Speed				
Engine crankshaft	1900	2000	2000	2000
Power take-off	563	979	545	545
Maximum Torque Speed				
Engine crankshaft	1300	1300	1400	1400
Power take-off	385	636	382	382
Minimum Idle Speed				
Engine crankshaft	550	550	550	550
Power take-off	163	269	150	150

The following formulas may be used to calculate speeds other than those shown above.

B-275	TD-5	B-414 and 3414
$\frac{\text{Crankshaft speed} \times 16}{54} = \text{PTO speed}$	$\frac{\text{Crankshaft Speed} \times 23}{47} = \text{PTO speed}$	$\frac{\text{Crankshaft Speed} \times 15}{55} = \text{PTO speed}$

TESTING

Transfer Pump Pressure

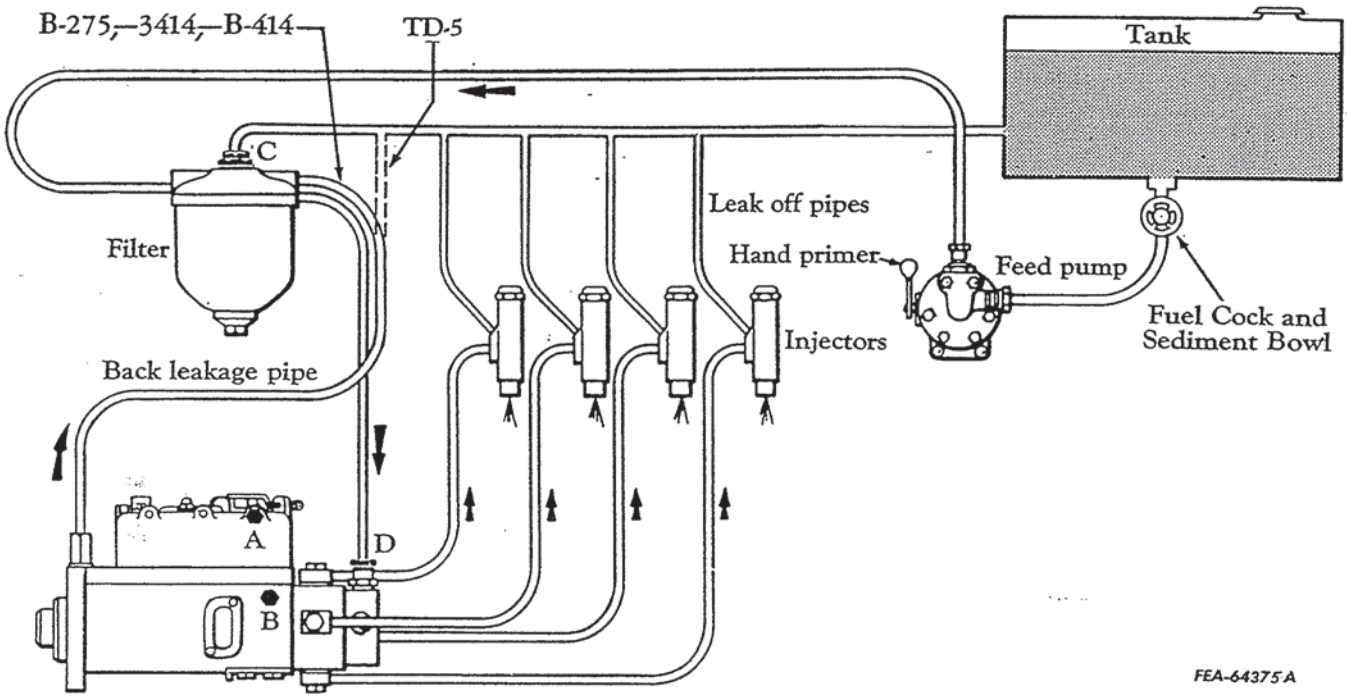
(Refer to Illust. 50.)

1. Remove the hydraulic head locking screw (with vent screw) "B" from injection pump housing.

2. Install adapter FES-4-16 with gasket and compound gauge. Vent air from pump before securing pressure gauge.

3. Vent governor cover at "A".

4. With hand throttle lever in low idle position and fuel shut-off lever in the off position, disengage engine clutch, crank engine and observe pressure reading on gauge. Specified pressure is a minimum of 5 psi.



Illust. 50. Fuel system schematic.

5. Leave hand lever in low idle position. Place fuel shut-off lever in run position. Start the engine and observe gauge reading. Specified reading is 16-39 psi.

6. Specified pressure at rated speed is 38-51 psi.

Feed Pump Static Pressure

1. Disconnect feed pump to filter fuel line at the feed pump.

2. Install adapter FES-4-15 with gaskets and low pressure gauge.

3. Vent fuel system. Refer to page 7.

4. Start and run engine for approximately one minute.

5. Stop the engine and observe static pressure reading on gauge. Specified pressure is 6-10 psi.

Transfer Pump Vacuum

This test to be performed only when transfer pump pressure test proves unsatisfactory.

1. Close the fuel cock at the fuel tank.

2. Remove the filter to transfer pump fuel line. Install a compound gauge and adapter FES-4-14 in the fuel inlet connection "D", (Illust. 1). Fuel line can be re-connected to filter for spill line.

3. With the hand throttle lever in the full throttle position and the fuel shut-off lever in the run position, disengage the engine clutch, start the engine and observe the reading on the gauge. A vacuum of 10-15 inches Hg. should be developed before engine stalls.

NOTE: Fuel system must be vented after completion of this test. Refer to page 7 for venting procedure.

NOZZLE SERVICE

Principles of Operation (Illusts. 51 and 52.)

The engine must receive each charge of fuel in such condition that it can be completely consumed. It is the function of the injection nozzle to meet this condition.

The injection nozzle is positioned in the cylinder head by the nozzle holder and injects fuel directly into the pre-combustion chamber. The pintle type nozzle has the desirable feature of being self-cleaning in action, which extends the injector service periods. The outer end of the valve is extended to form a pintle, the dimensions of which govern the spray form. The spray cone atomizes the diesel fuel, resulting in efficient combustion and maximum engine performance.

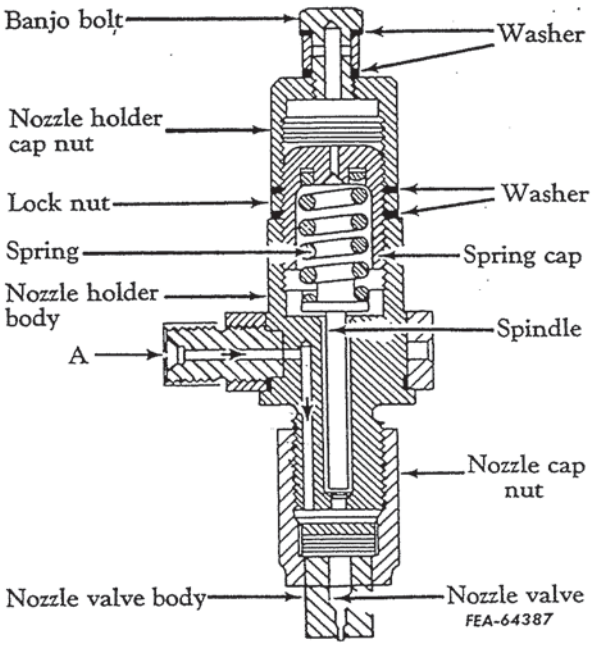
The pintle nozzle is closed after each injection.

An adjustable spring cap threaded into the nozzle holder body compresses the spring against the spindle which forces the nozzle valve against its seat in the nozzle valve body. This spring tension determines the opening pressure of the nozzle valve.

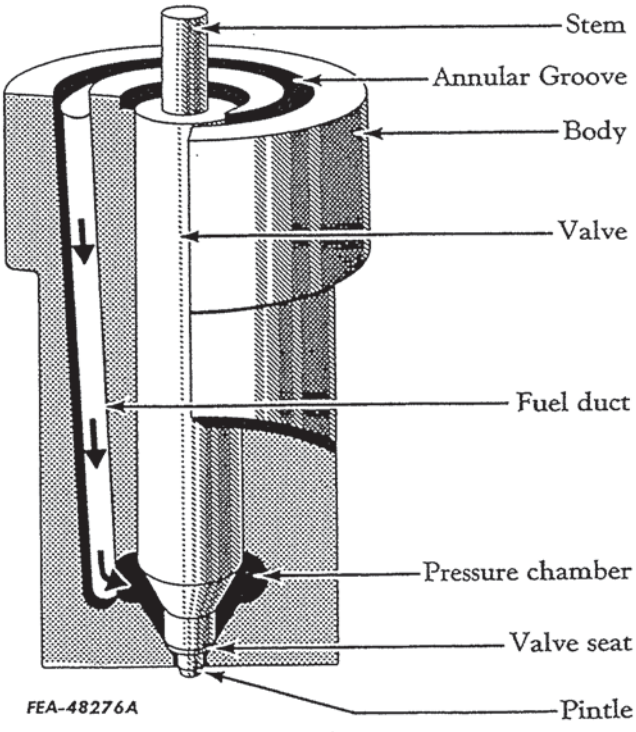
The lock nut secures the spring cap in its adjusted position.

The nozzle valve is precision lap fitted to the nozzle valve body. This close fit determines the back leakage of the nozzle valve and accurately guides the valve to its seat. The nozzle cap nut secures the nozzle valve body to the nozzle holder body.

The nozzle holder cap nut and banjo bolt receives and directs back leakage fuel to the return line. Copper washers provide a seal against fuel leakage and entry of foreign materials.



Illust. 51. Cross section of injection nozzle assembly.



Illust. 52. Cross section of injection nozzle.

Fuel is fed through the inlet connection "A" (Illust. 51) by way of drillings in the nozzle holder to the annular groove on the face of the nozzle body. The fuel is then fed through drillings in the nozzle body (fuel duct) to the pressure chamber just above the nozzle seat. The pressure of fuel from the injection pump, acting in the fuel already present in the annular groove, fuel duct and pressure chamber, exerts pressure on the nozzle valve, lifting it off its seat to allow fuel to be forced under high pressure into the pre-combustion chamber.

If the injection nozzle does not function properly, the fine adjustments and care given to the injection pump can be defeated at this stage of the fuel system.

Testing

NOTE: The isolating or check valve in the test equipment must be closed at all times except when taking pressure readings during the following tests. Sharp pressure fluctuations caused by pumping impose a high shock loading on the gauge mechanism.

CAUTION: When a nozzle is spraying during any of the following tests, the nozzle holder must be turned away from the operator. The spray has a very great penetrating power and the hands must not be brought into contact with it.

To be satisfactory a nozzle must have the following main characteristics.

1. Pressure tight seats.

2. Freedom from excessive back leakage.

3. Satisfactory spray form or atomization.

4. Correct opening pressure.

Before a nozzle is disassembled, it should be checked for the correct opening pressure range.. After reassembly and before installation, the nozzle opening pressure should again be checked.

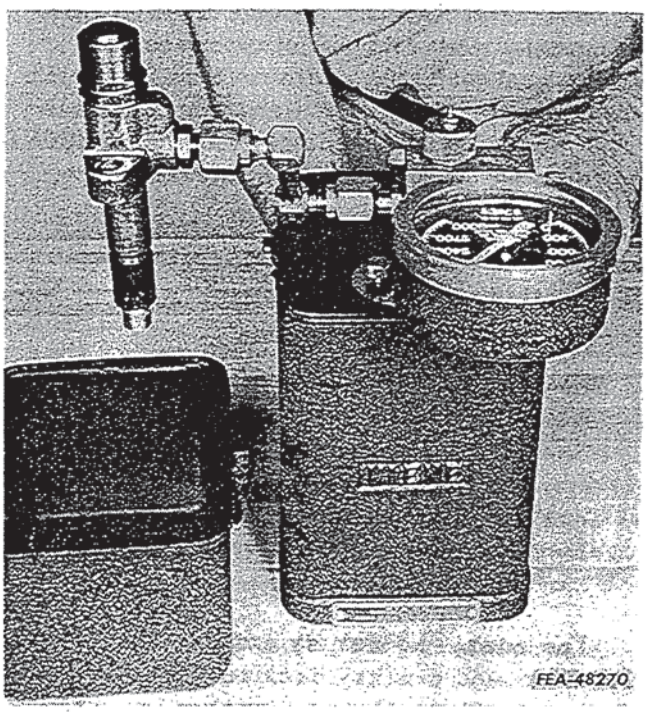
NOTE: To obtain a true indication of nozzle performance during the following tests, the fuel used in the test must be pure and clean.

Connect the nozzle to suitable hand operated equipment, one type shown in Illust. 53 using two C-4 nuts and a C-2 adapter, from the Kiene tester. The gauge must record up to 2500 psi.

With the nozzle connected and the check valve closed, pump several times quickly to flush out the nozzle passages and seat. Normally this will remove any small particles trapped between the valve and seat that might impair the efficiency of the nozzle.

Opening Pressure Test

After flushing the nozzle, open the check valve, allow the pressure to escape. Then pump the handle to raise the pressure steadily and observe the gauge pressure at which the valve opens. The opening pressure should be 2350 to 2425 psi.



Illust. 53. Testing nozzle opening pressure.

Seat Leakage Test

To check the tightness of the seat, first atomize the nozzle two or three times. Open the check valve and wipe the nozzle dry. Pump up the pressure to within 150 psi below the opening pressure and hold for 10 seconds and examine the face for leakage. There should be no leakage, however, a slight dampness will be present at the orifice due to the capillary action of the fuel below the seat.

Atomization and Dispersion

To check the spray formation and atomization efficiency with the hand lever type of equipment, operate the hand lever slowly. The nozzle should buzz or chatter with an evenly distributed spray free from irregular streaks. The spray must not be solid or streaky, and it must issue squarely from the nozzle face. As mentioned previously, this type of check gives only an approximate indication of nozzle performance.

Back Leakage Test

The test specifications for used injection nozzles may vary for back leakage. To check the back leakage, pump up the pressure to above 1500 psi and record the time required for the pressure to drop from 1500 psi to 1100 psi. A nozzle in good condition should not lose this pressure in less than ten seconds at 60°F. At higher temperatures a lower figure may be obtained.

Observe that no leakage occurs at the lapped pressure faces of the nozzle holder and nozzle. Leakage may be external (visible at the nozzle cap nut screw thread) or internal. In the latter case, it cannot be readily distinguished from excessive leakage past the journal and guide of the valve. Do not overtighten the cap nut to correct leakage at the lapped joint. Instead, remove the nozzle and recheck the pressure faces for signs of dirt or surface imperfections. Clean thoroughly and retest. If the pressure drop time is still low, excessive leakage past the journal and guide of the valve is indicated.

NOTE: Before removing the nozzle holder from the test equipment, slowly release the fuel pressure to prevent damage to the gauge due to a sudden pressure drop.

Disassembly (Ref. No's. Refer to Illust. 54.)

Cleanliness cannot be overstressed when working on any part of the fuel injection system. The close tolerances maintained in pumps and nozzles are to ensure long life and efficient operation. They become adversely affected by the entry of minute particles of grit, metal, or soft material which prevents the valve and other parts from functioning properly. A work bench suitable for nozzle maintenance should be absolutely free from dust, dirt, metal filings, grease, and acids. Cotton waste and fluffy rags should not be used around this bench. It should be provided with a small vise, with the jaws protected and a dust proof drawer for holding special nozzle cleaning tools.

1. Install the nozzle in a vise. Clamp the retaining flange only, being sure not to damage or distort the holder.

2. Remove the nozzle holder cap nut (3), lock nut (5) and spring cap (6).

3. Remove the spring (7) and spindle (8).

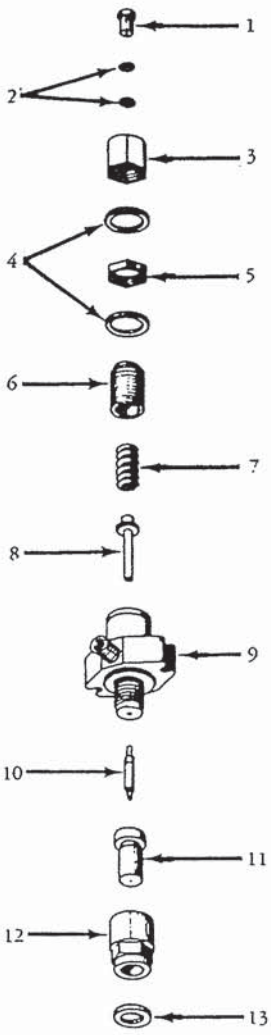
4. Remove the nozzle cap nut (12), nozzle valve body (11), and the nozzle valve (10) as an assembly.

5. Soak the nut, body and valve assembly in "Gunk" for several minutes to dissolve carbon and varnish.

6. Remove the valve from the valve body if it will slide out easily.

7. Remove the cap nut (12) from the body (11).

NOTE: If the valve body sticks to the cap nut, removal can be accomplished by additional soaking or by tapping the valve body from the nut using a plastic head hammer and driver (FES-5-4) as shown in Illust. 55. A wooden dowel or brass rod

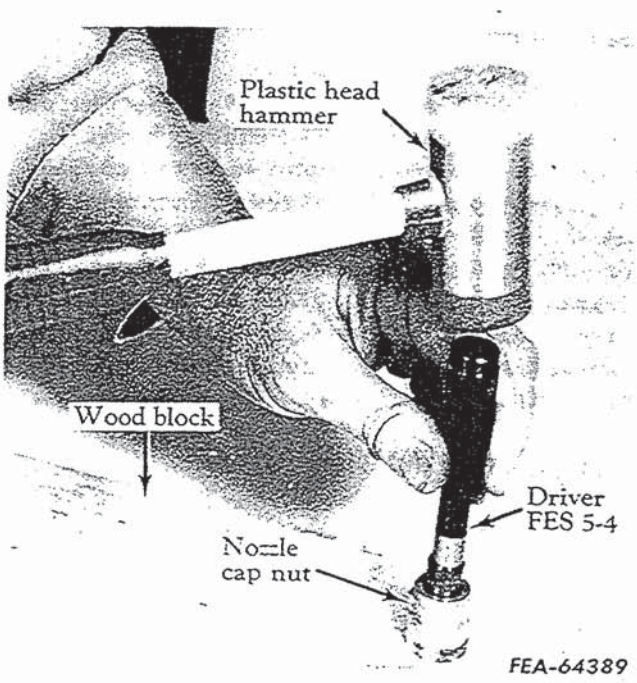


Illust. 54. Exploded view of injection nozzle.

1. Banjo bolt.
2. Washer.
3. Nozzle holder cap nut.
4. Washer.
5. Lock nut.
6. Spring cap.
7. Spring.
8. Spindle.
9. Nozzle holder body.
10. Nozzle valve.
11. Nozzle valve body.
12. Nozzle cap nut.
13. Washer

with recessed end can be used in place of the driver shown.

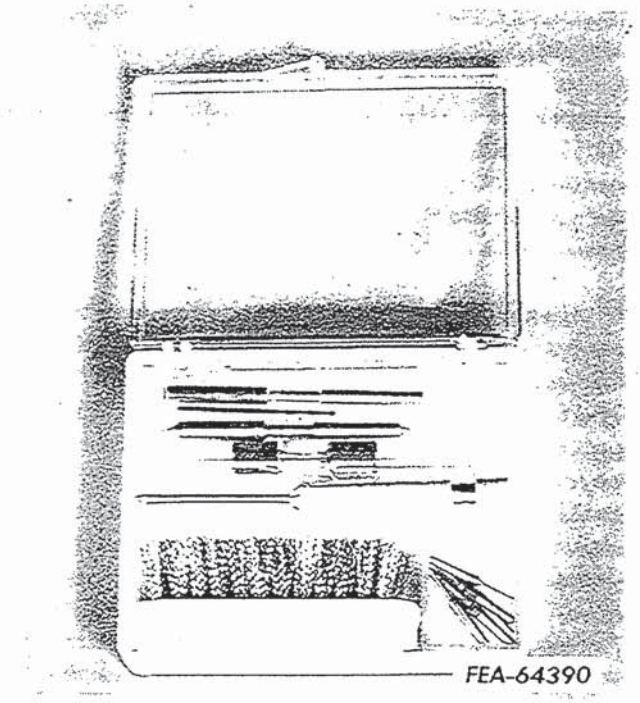
8. Place the valve and valve body on a clean cloth in a pan of clean diesel fuel.



Illust. 55. Driving valve body from nozzle cap nut.

Cleaning and Inspection

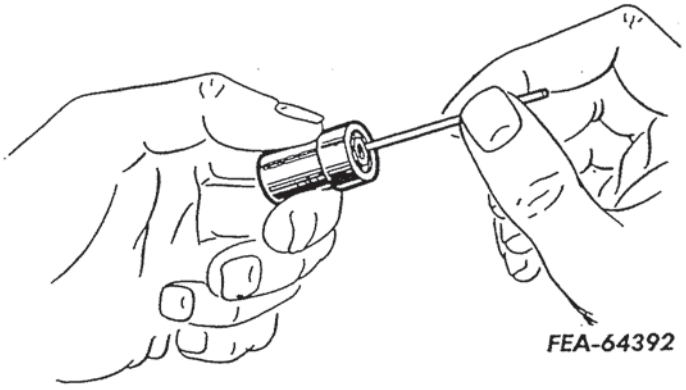
(Use Nozzle Cleaning Kit, Number FES-19-9.)



Illust. 56. Nozzle cleaning kit.

Illust. 57. Cleaning and polishing valve body (orifice end).

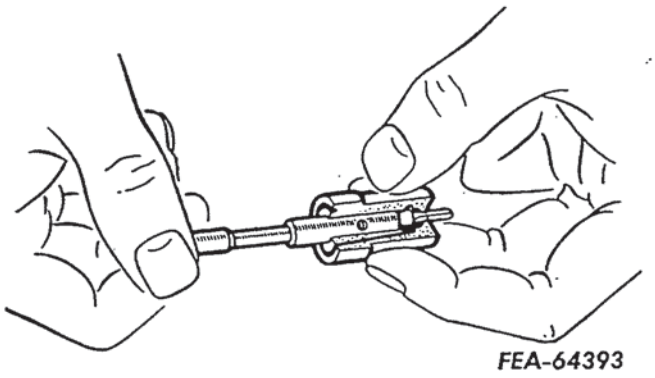
1. Rinse the pintle valve body in diesel fuel to remove gunk. Dip bristles of brass wire brush in diesel fuel. Brush valve body sufficiently to clean and polish it. (Illust. 57.) Particular attention is directed to the orifice end. Rinse in diesel fuel.



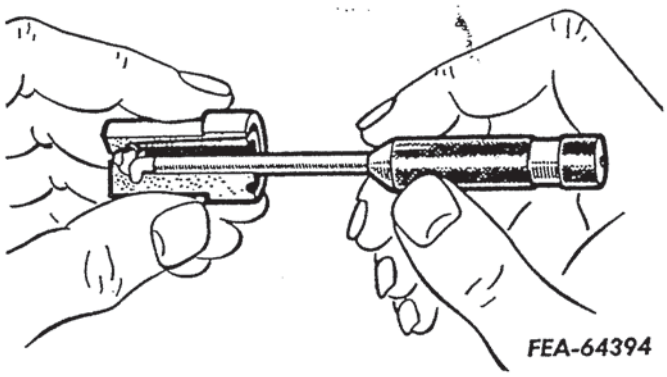
Illust. 58. Drill cleaning of fuel duct.

2. Clean the nozzle valve body bores with the drill provided in the Nozzle Cleaning Kit. These bores seldom become blocked. Rinse in diesel fuel. (See Illust. 58.)

3. Clean orifice in valve body using probe and holder as shown in Illust. 59. Turn holder and probe in a rotary motion until orifice is clean. Rinse in diesel fuel.

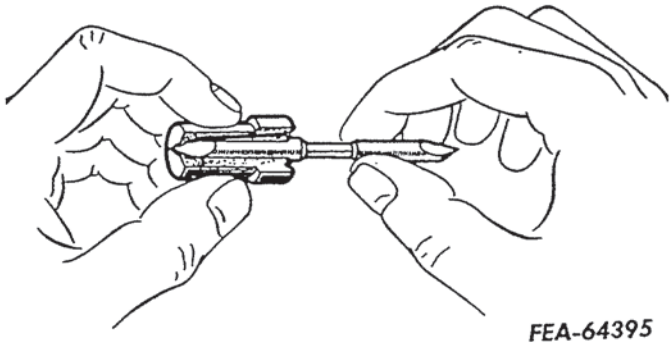


Illust. 59. Cleaning pintle orifice in valve body.



Illust. 60. Cleaning fuel pressure chamber.

4. Insert pressure chamber groove scraper into position as shown in Illust. 60. Press scraper against inside of valve body and rotate to remove carbon. Rinse in diesel fuel.

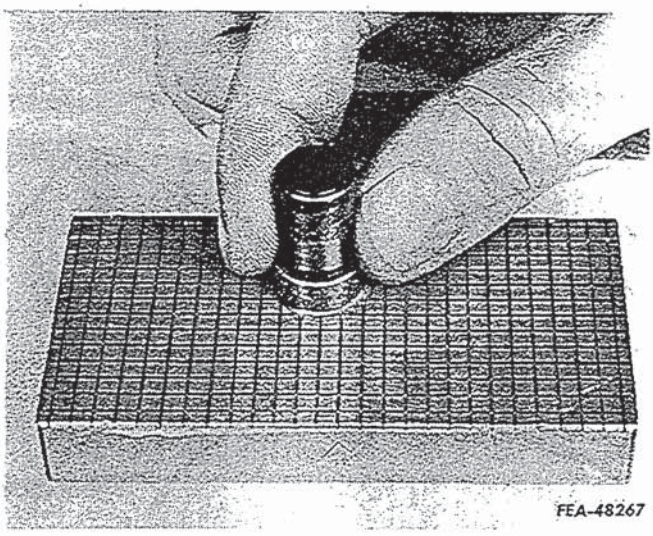


Illust. 61. Cleaning valve seat in valve body.

5. Insert seat cleaning tool against seat in valve body as shown in Illust. 61 and rotate to remove carbon. Rinse in diesel fuel.

6. If the upper end of the valve body and the lower end of the nozzle holder body require additional service to provide proper sealing proceed as follows:

(a) Use lapping plate No. FES-19-1 coated with mutton tallow.

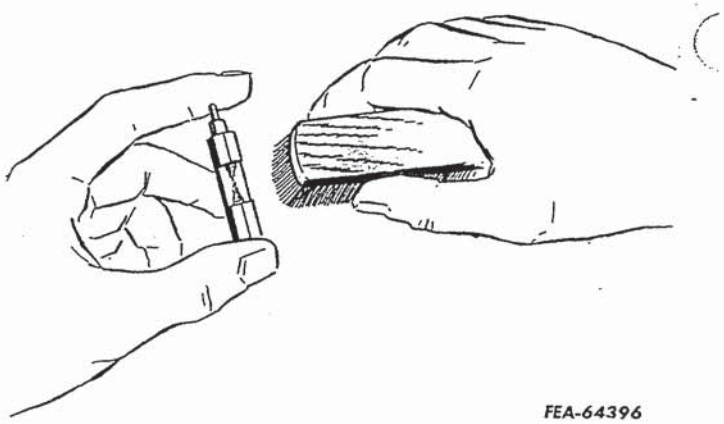


Illust. 62. Cleaning the lapped surface of the nozzle body.

(b) Place the lapped surface of the valve body on the lapping plate as shown in Illust. 62, and move in a circular motion being careful to hold even pressure on the valve body so that the entire surface will make contact. This cleaning operation will remove carbon or discoloration and leave a mirror finish. Scratches, nicks or pitting cannot be removed and may cause leakage.

(c) The nozzle holder body can be lapped as described in step (b).

7. Dip the valve and valve holder tool in clean diesel fuel. Slide the valve into the holder tool and remove carbon from the valve by brushing it with the brass wire brush. Rotate the valve in the holder while brushing until the entire pintle and seat on the valve is free of carbon.



Illust. 63. Removing carbon from valve.

Illust. 64. Cleaning and polishing valve and pintle.

8. Dip the valve and brass wire brush in diesel fuel. Gently polish the valve and pintle as shown in Illust. 64. It is important to be extremely careful with the valve and pintle to prevent damage. A scratch or burr may cause valve leakage or spray distortion. Clean in diesel fuel.

9. If additional cleaning and polishing of the valve and valve seat is required, proceed as follows:

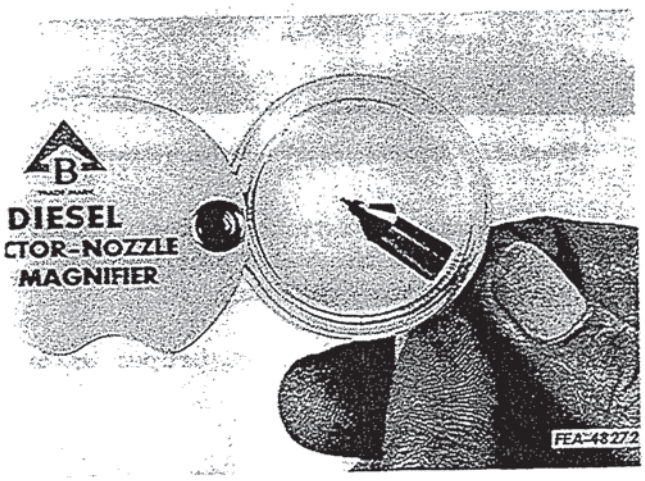
(a) Apply a very small amount of No. 400 lapping compound to the valve or seat.

(b) Insert the valve into the body against the seat.

(c) Rotate the valve against the seat while applying very light pressure.

NOTE: Be sure to keep lapping compound away from the pintle. Any lapping action to the pintle will destroy its fit.

(d) Remove the valve and thoroughly wash both parts in diesel fuel to remove all compound.

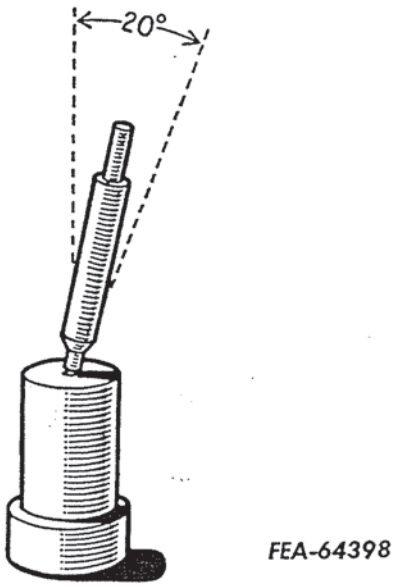


Illust. 65. Inspecting the nozzle under a magnifier.

10. Inspect the nozzle valve seat under a good magnifying glass for indication of a damaged seat. See Illust. 65. Check the lapped surface of the valve for scoring and scratches. If the valve seat is damaged the nozzle should be replaced. If the valve is satisfactory, place it on a clean cloth in a pan of clean diesel fuel.

11. Examine the fit of the nozzle valve stem to the guide bore in the nozzle valve holder.

NOTE: A good fit is essential as the clearance governs the degree of back leakage. The needle must be able to move freely yet not permit excessive back leakage. Too close a fit can result in seizure.



Illust. 66. Checking wear and alignment of the valve pintle.

Examine the clearance between the pintle and the spray hole. With the valve stem removed, reversed, and the pintle inserted into the spray hole, it should not tilt at greater than 20° from the axis of the spray bore.

If the nozzles meet the above inspection requirements, the nozzles can be reassembled.

Reassembly

Assemble the nozzle valve holder and nozzle valve after immersing in No. 2 diesel fuel to the nozzle holder body. Tighten the nozzle cap nut to a torque of 50 foot-pounds. Be careful not to overtighten as this may cause distortion and needle seizure.

Install the spindle assembly (8), spring (7), spring cap (6), new copper washer (4) and lock nut (5). See Illust. 54.

Adjustments and Final Testing

1. Connect the nozzle to the hand operated test pump as previously described.

2. Start with the spring cap screwed well out.

3. Thoroughly flush the nozzle assembly.

4. Slowly increase the opening pressure by screwing the spring cap clockwise while continuing the flushing. (Illust. 67.) This gradual buildup, to the specified opening pressure, aids in establishing a good sealing surface.

5. If the opening pressure is satisfactory, check the seat leakage, atomization and dispersion, and back leakage as previously described in the initial testing.

6. If the nozzle proves satisfactory complete the assembly by installing a new washer and nozzle holder cap nut.

Illust. 67. Adjusting nozzle opening pressure.

7. If the nozzle is to be stored, smear the orifice end of the valve body lightly with vaseline before packing.

8. Refer to GSS-1242 for proper installation of the nozzles.

SERVICE BULLETIN RECORD

Important: Information in this manual section is subject to change or supplementing from time to time as a result of field experience and engineering modifications. As Service Bulletins are received, record them on this page for handy reference whenever this manual is to be used... Print entries in ink.

Bulletin No.	Date Issued	Book No.	Topic or part of machine involved.