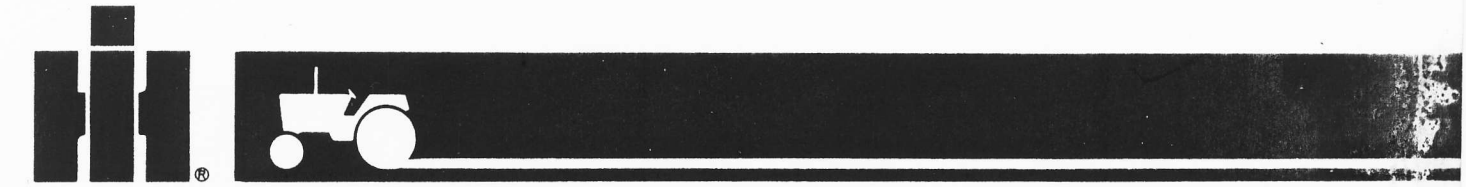

Service Manual

ENGINE, FUEL AND ELECTRICAL SYSTEMS (Kubota Diesel)

GSS-1509
July, 1984

INTERNATIONAL HARVESTER
NORTH AMERICA OPERATIONS
AGRICULTURAL EQUIPMENT GROUP
401 NORTH MICHIGAN AVENUE • CHICAGO, ILLINOIS, 60611, U.S.A.

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.

NOTE: Some illustrations in this manual show equipment not currently available. The illustrations are used primarily to cover serviceability and may not always represent production equipment.

LIBRARY FILING INFORMATION

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ENGINE, FUEL AND ELECTRICAL SYSTEMS (Kubota Diesel)

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CAUTION! Some photographs in this manual may show shields or cover panels removed for purposes of clarity. NEVER OPERATE unit without all shields and cover panels in place.

General Contents

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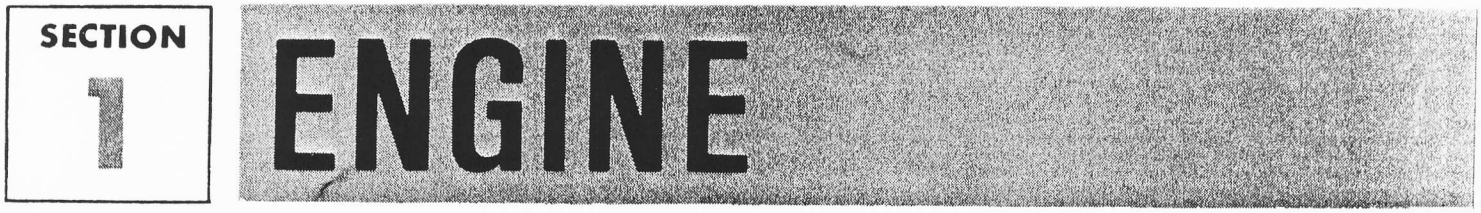
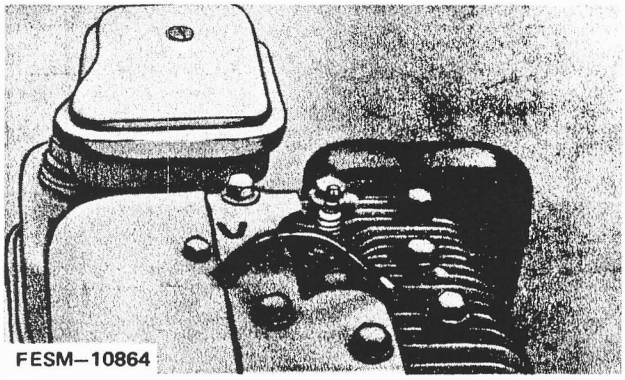


WORK SAFELY – FOLLOW THESE RULES

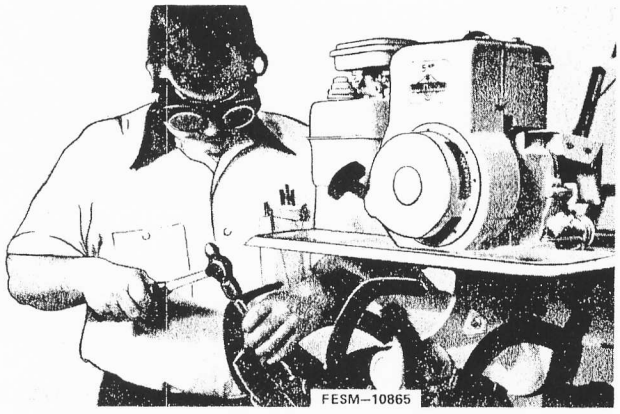
This symbol is used to call your attention to instructions concerning your personal safety. Be sure to observe and follow these instructions.


FESM–10864

1. To prevent accidental starting, always pull the high tension wire(s) off of the spark plug(s) before servicing and/or adjusting the machine.

2. To prevent injury, do not allow children or by-standers around the machine while it is being adjusted and/or serviced.

3. Do not wear rings, wrist watches or loose fitting clothing when working on machinery, they could catch on moving parts causing serious injury. Wear sturdy, rough-soled work shoes. Never adjust and/or service a machine in bare feet, sandals or sneakers.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4. Always wear safety glasses when using a hammer, chisel or other tools that may cause chips to fly.

5. Be sure to reinstall safety devices, guards or shields after adjusting and/or servicing the machine. Also, replace missing or damaged safety and/or instruction decals.

6. When operating a power washer to clean a machine before servicing, be careful at all times to avoid injury. Maintain proper footing and balance at all times. Never direct the spray at people or animals, as high pressure spray can cause serious injury.

7. If a portable heater is used to heat the service area the following precautions must be observed:

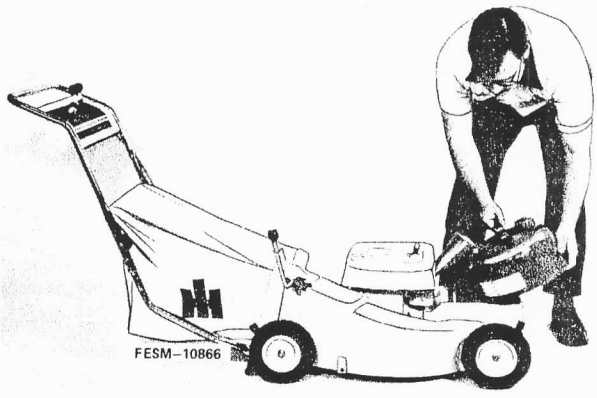
(a) Do not use portable heaters in presence of volatile materials such as gasoline or paint, as fire or explosion may result.

(b) To avoid being burned, do not touch the heater during operation.

(c) Portable heaters consume oxygen and combustion fumes can be hazardous. Heater should be used only in a well ventilated area. Keep a window or door partially open to provide ventilation.

(d) Keep the heater at least four (4) feet from combustible materials.

(e) Never use gasoline as fuel.


FESM–10866

8. Handle gasoline with care - it is highly flammable:

(a) Use approved gasoline container.

(b) Never remove the fuel tank cap or fill the fuel tank when the engine is running, is hot, or indoors. Also, do not smoke when working around flammable fuel.

(c) Avoid fires — be sure container or funnel does not touch the battery. Do not overfill the fuel tank. Wipe up spilled gasoline.

(d) Replace fuel tank cap securely.

9. 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.

10. Never run an engine in a confined area such as a garage or storage building any longer than is necessary for immediate moving of the machine out of or into the area. EXHAUST GASES ARE TOXIC. OPENING DOORS AND WINDOWS MAY NOT PROVIDE ADEQUATE VENTILATION.

11. After servicing, be sure all tools, parts, or servicing equipment are removed from the machine.

12. Electrical storage batteries give off highly inflammable hydrogen gas when charging 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. Always disconnect a battery cable before working on the electrical system.

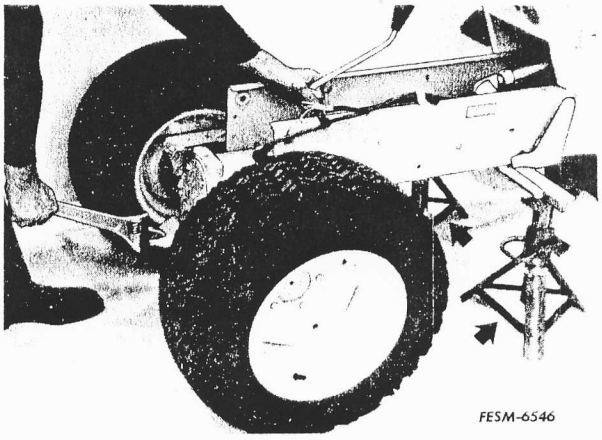
13. Hydraulic fluid escaping under pressure can have enough force to penetrate the skin. Hydraulic fluid may also infect a minor cut or opening in the skin. If injured by escaping fluid, see a doctor at once. Serious infection or reaction can result if medical treatment is not given immediately.

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.

14. When using an acetylene torch always wear welding goggles and gloves. Keep a "charged" fire extinguisher within reach. Do not weld or heat areas near fuel tanks or fuel lines and utilize proper shielding around hydraulic lines.

Revised August, 1981

15. 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. Always use a safety bar to block hydraulic cylinders.



FESM-6546

16. When splitting tractors, or disassembling machines, be sure to use safety stands and adequate supports to prevent tipping or rollover.

FESM-9718

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

18. 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.

19. 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.

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 METRIC NUTS AND BOLTS—

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

A. Surface finish is oxide coated, oil quenched or bright.

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

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

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

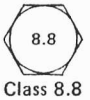
NOTE: Multiply the standard torque by:
.65 when finished jam nuts are used.
.70 when Molykote, white lead or similar mixtures are used as lubricants.
.75 when phosphate coated and oiled bolts or nuts are used.
.85 when cadmium or zinc dichromate bolts or nuts are used.
.90 when hardened surfaces are used under the nut or bolt head (this applies to standard unplated hardware only).

FOOT POUNDS

Bolt Diameter	 Class 5.8		 Class 8.8		 Class 9.8		 Class 10.9		 Class 10.9 Only when used* in cast (gray) iron	
Millimeters	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
6	5	6	8	9	9	10	11	13	10	11
7	9	10	14	15	15	18	19	21	17	18
8	13	14	20	23	23	25	28	31	24	27
10	25	28	40	45	45	50	54	61	48	54
12	43	49	70	78	78	88	95	106	83	93
14	70	78	111	125	124	140	151	170	133	150
16	108	121	172	194	193	216	233	263	206	232
18	149	168	238	268	—	—	324	364	285	320
20	210	237	336	378	—	—	458	515	403	453
22	287	323	458	516	—	—	624	702	549	618
24	363	409	581	654	—	—	791	890	696	783

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

NEWTON METERS

Bolt Diameter	 Class 5.8		 Class 8.8		 Class 9.8		 Class 10.9		 Class 10.9 Only when used* in cast (gray) iron	
Millimeters	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
6	7	8	11	13	13	14	15	17	13	15
7	12	13	19	21	21	24	26	29	23	25
8	17	19	27	31	30	34	37	42	33	37
10	34	38	54	61	60	68	73	83	64	73
12	59	66	94	106	105	118	128	144	113	127
14	94	106	150	169	168	189	205	230	180	202
16	146	164	233	263	261	293	318	357	280	314
18	202	227	323	363	—	—	439	493	386	434
20	285	321	456	513	—	—	620	689	546	606
22	389	437	622	699	—	—	846	952	744	838
24	493	554	788	886	—	—	1072	1206	943	1061

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

June 1981

STANDARD TORQUE DATA FOR INCH NUTS AND BOLTS – NEWTON METERS

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

A. Surface finish is oxide coated, oil quenched or bright.

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

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

D. 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 phosphate coated or oiled bolts or nuts are used.
.85 when cadmium or zinc dichromate bolts or nuts are used.
.90 when hardened surfaces are used under the nut or bolt head (this applies to standard unplated hardware only).

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	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1/4	7	8	8	9	5	5	12	14	15	18	18	19
5/16	16	18	15	18	9	11	24	27	30	34	34	38
3/8	28	33	28	33	18	19	45	50	56	62	61	68
7/16	47	52	47	52	27	31	72	81	88	100	102	115
1/2	71	79	71	80	42	47	109	122	136	152	156	176
9/16	95	109	102	115	61	69	156	176	197	217	224	251
5/8	133	149	141	159	84	95	217	244	271	305	305	346
3/4	236	265	251	278	149	170	387	434	482	543	543	611
7/8	380	427	244	271	244	271	624	780	773	868	875	984
1	570	638	360	407	360	407	929	977	1160	1303	1316	1479
1-1/8	807	909	516	577	516	577	1153	1289	1642	1845	1866	2096
1-1/4	1140	1282	726	814	726	814	1628	1832	2313	2605	2632	2958
1-3/8	1492	1682	950	1065	950	1065	2130	2388	3033	3412	3446	3881
1-1/2	1995	2225	1255	1418	1255	1418	2822	3175	4030	4532	4579	5149

† 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.

Revised March 1984

STANDARD TORQUE DATA FOR INCH NUTS AND BOLTS — FOOT POUNDS

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

A. Surface finish is oxide coated, oil quenched or bright.

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

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

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NOTE: Multiply the standard torque by:
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.75 when phosphate coated and oiled bolts or nuts are used.
.85 when cadmium or zinc dichromate bolts or nuts are used.
.90 when hardened surfaces are used under the nut or bolt head (this applies to standard unplated hardware only).

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	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1/4	5	6	6	7	4	4	9	10	11	13	13	14
5/16	12	13	11	13	7	8	18	20	22	25	25	28
3/8	21	24	21	24	13	14	33	37	41	46	45	50
7/16	35	38	35	38	20	23	53	60	65	74	75	85
1/2	52	58	52	59	31	35	80	90	100	112	115	130
9/16	70	80	75	85	45	51	115	130	145	160	165	185
5/8	98	110	104	117	62	70	160	180	200	225	225	255
3/4	174	195	185	205	110	125	285	320	355	400	400	450
7/8	280	315	180	200	180	200	460	575	570	640	645	725
1	420	470	265	300	265	300	685	720	855	960	970	1090
1-1/8	595	670	380	425	380	425	850	950	1210	1360	1375	1545
1-1/4	840	945	535	600	535	600	1200	1350	1705	1920	1940	2180
1-3/8	1100	1240	700	785	700	785	1570	1760	2235	2515	2540	2860
1-1/2	1470	1640	925	1045	925	1045	2080	2340	2970	3340	3375	3795

†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.

Revised Nov. 1983

INCH-METRIC HARDWARE

NOTE: This unit contains both inch and metric hardware. Be sure to use the correct inch or metric size and type (class) hardware when replacing or when mounting attachments to tapped holes. Also, use the correct inch or metric tools with each kind of hardware.

The following chart is provided to help you distinguish between inch and metric hardware by observing the head markings.

BOLT CLASSIFICATION AND IDENTIFICATION CHART

INCH			METRIC	
SAE GRADE	IH GRADE	BOLT HEAD MARKINGS	CLASS	BOLT HEAD MARKINGS
2	1		5.8	
5	5		8.8	
8	8		10.9	

The following chart is provided to further help identify an approximate size in inch or metric hardware. **THIS IS NOT A RECOMMENDATION FOR SUBSTITUTION, AND THEY ARE NOT INTERCHANGEABLE.** This chart is only a means of quickly determining the approximate size.

Metric Series mm	Approximate Inch Series
6	1/4
8	5/16
10	3/8, 7/16
12	1/2
14	9/16
16	5/8
18	
20	3/4
22	7/8
24	1
27*	1
30	1-1/8, 1-1/4
36	1-1/2

*Non-preferred

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

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.

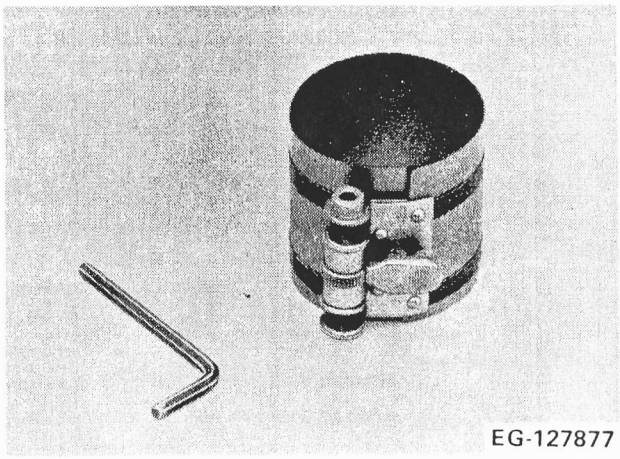
For example to convert 75.384 millimeters to inches:

75.000 millimeters = 2.9527559 inches
.380 millimeters = .0149606
.004 millimeters = .0001574
75.384 mil meters = 2.9678739 inches
Correct to decimal places.
75.384 milli eters = 2.96787 inches

SPECIAL TOOLS

Piston Ring Compressor

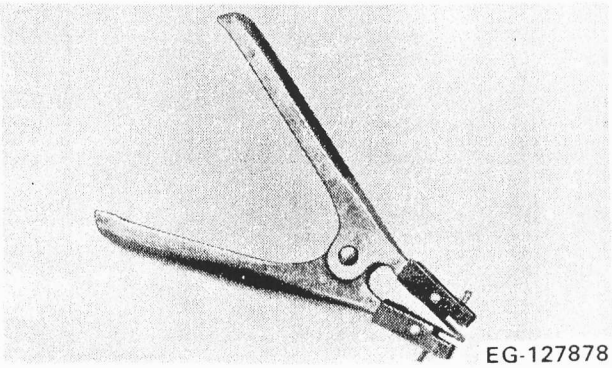
Application: Use exclusively for pushing in the piston with ease.



Piston ring compressor.

Piston Ring Tool

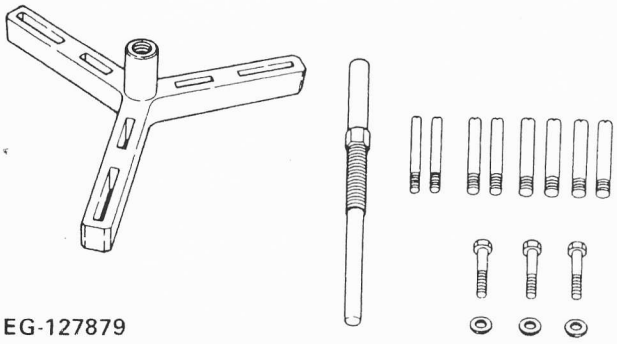
Application: Use exclusively for removing or installing the piston ring with ease.



Piston ring tool.

Crankshaft Pulley Puller

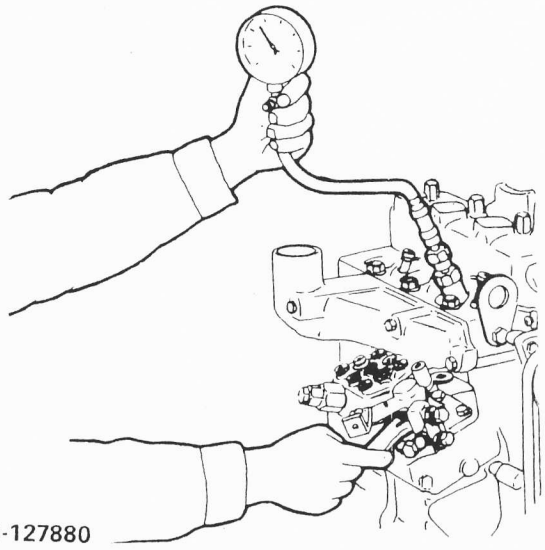
Application: Use to take off the crankshaft pulley of all types of diesel engines safely and easily.



Crankshaft pulley puller.

Diesel Engine Compression Tester

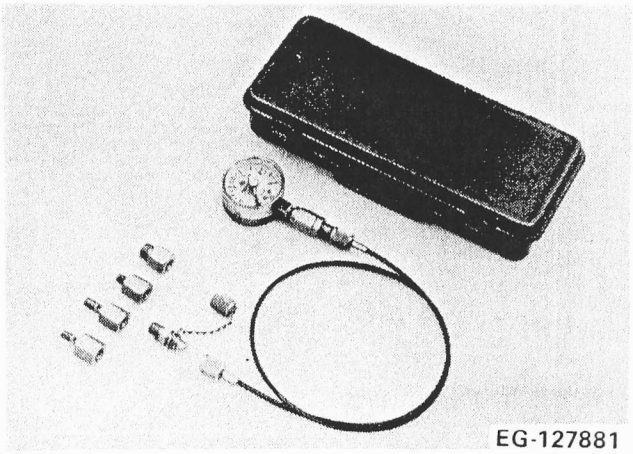
Application: Use to measure diesel engine compression and to diagnose the engine for a major overhaul.



Compression tester.

Oil Pressure Tester

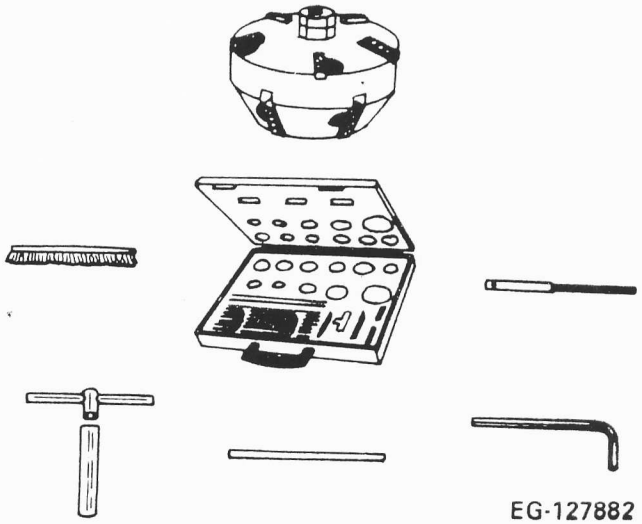
Application: A tester to measure lubricating oil pressure for all kinds of diesel engines.



Oil pressure tester.

Valve Seat Cutter

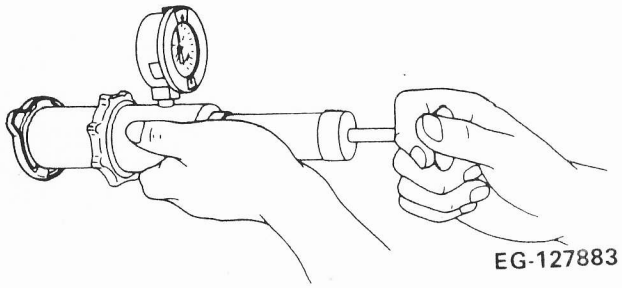
Application: Use to reseat valves.
Angle: 45°
15°
Diameter: 1.126 in.
1.244 in.
1.378 in.
1.496 in.
1.626 in.
2.000 in.



Valve seat cutter.

Radiator Cap Tester

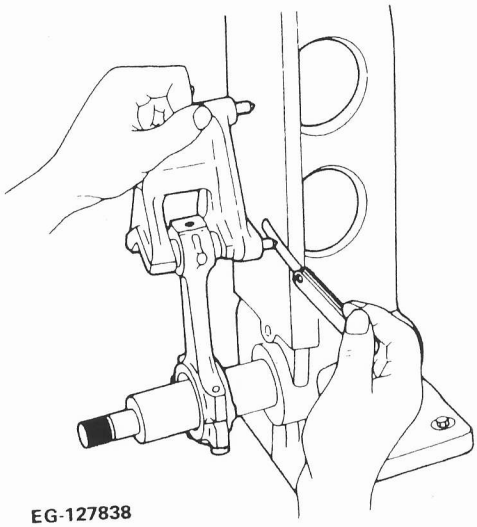
Application: Use to check radiator cap pressure and leaks from cooling systems.



Radiator cap tester.

Connecting Rod Alignment Tool

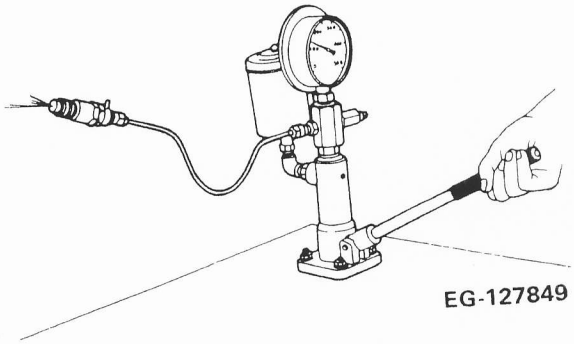
Application: Use to check the connecting rod alignment.
Applicable range: Connecting rod large end I.D. 1.18 to 2.95 in. dia. Connecting rod length 2.56 to 12.99 in.



Connecting rod alignment tool.

Nozzle Tester

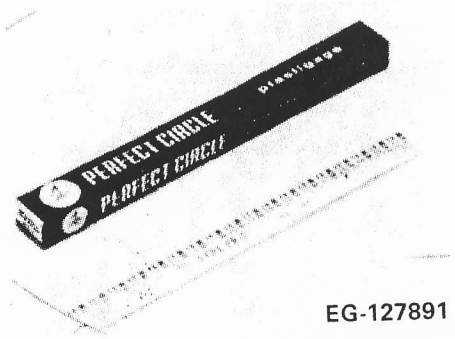
Application: Use to check the fuel injection pressure and spraying condition of nozzle.
Measuring range: 0 to 7112 psi.



Nozzle tester.

Press Gauge

Application: Use to check the oil clearance between crankshaft and bearing, etc.
Measuring range: Green — 0.01 to 0.03 in.
Red — 0.02 to 0.06 in.
Blue — 0.04 to 0.09 in.



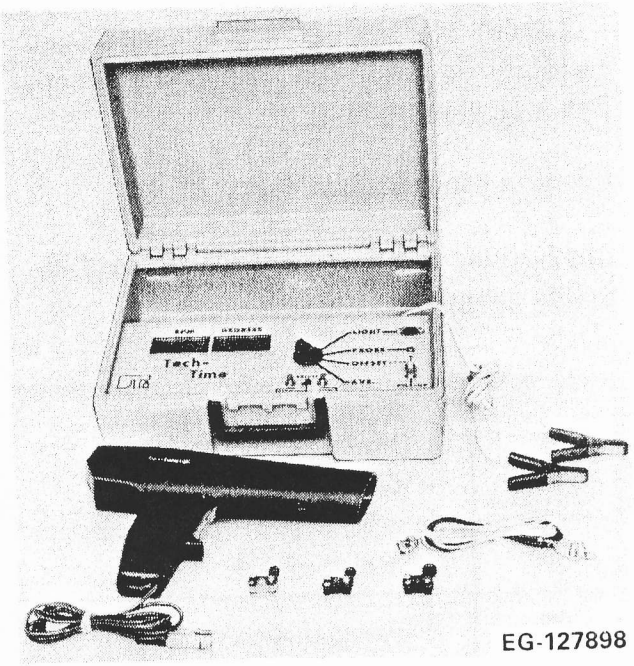
Press gauge.

Diesel Timing Unit

Model No. 15-3354 (OTC Service Tool Division)

Application: No tools required. Use to clamp transducer on fuel injection line. The transducer senses the pulses in the fuel line and sends a signal to the timing unit which counts the pulses and displays rpm digitally to an accuracy of ± 1 rpm.

The same pulse signal fires a timing light, with which the mechanic can pick up the top dead center (TDC) mark on the flywheel. The timing light is adjustable up-or-down with two buttons on the tester. Degrees off top dead center are displayed digitally on the unit, simultaneously with rpm.



Diesel timing unit - Model No. 15-3354.

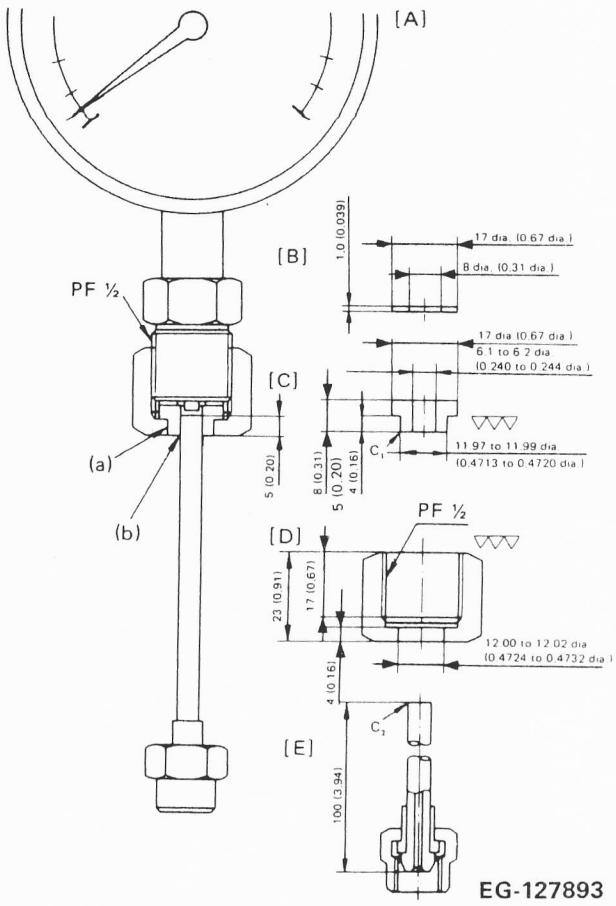
NOTE: The following special tools are not available. However, they can be made from the following illustrations.

Injection Pump Pressure Tester

Application: Use to check fuel pressure of injection pumps.

A	Pressure gauge (Full scale: More than 6000 psi)
B	Copper gasket
C	Flange (Material: S45C)
D	Hex. nut 1.06 in. across the flat (Material: S45C)
E	Injection pipe

a	Adhesive application
b	Fillet welding on the entire circumference



Injection pump pressure tester.

*Chamfer	mm	in.
C_1	0.5	0.020
C_2	0.5	0.020

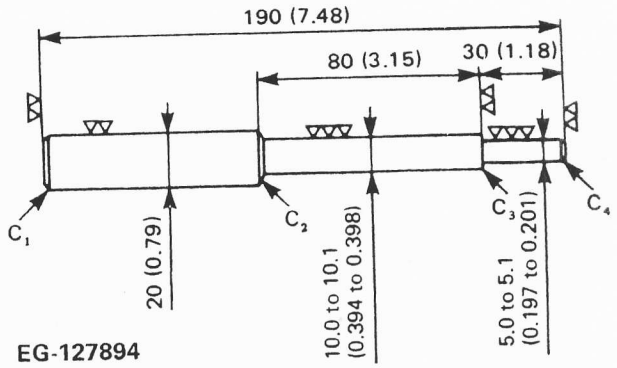
*Unit: mm (in.)

Valve Guide Replacing Tool

Application: Use to press out and to press fit the valve guide.

*Chamfer	mm	in.
C_1	2.0	0.079
C_2	1.0	0.039
C_3	0.3	0.012
C_4	1.0	0.039

*Unit: mm (in.)



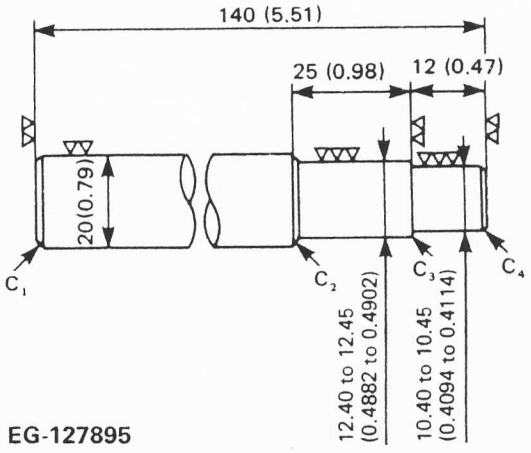
Valve guide replacing tool.

Rocker Arm Bushing Replacing Tool

Application: Use to press out and to press fit the rocker arm bushing.

*Chamfer	mm	in.
C_1	2.0	0.079
C_2	1.0	0.039
C_3	0.3	0.012
C_4	1.0	0.039

*Unit: mm (in.)



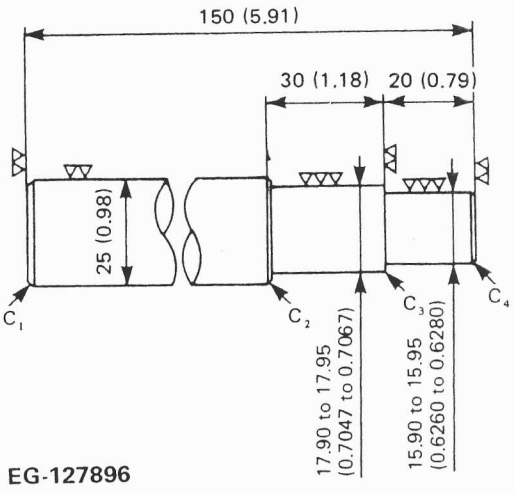
Rocker arm bushing replacing tool.

Idler Gear Bushing Replacing Tool

Application: Use to press out and to press fit the idler gear bushing.

*Chamfer	mm	in.
C_1	2.0	0.079
C_2	1.0	0.039
C_3	0.3	0.012
C_4	1.0	0.039

*Unit: mm (in.)



EG-127896

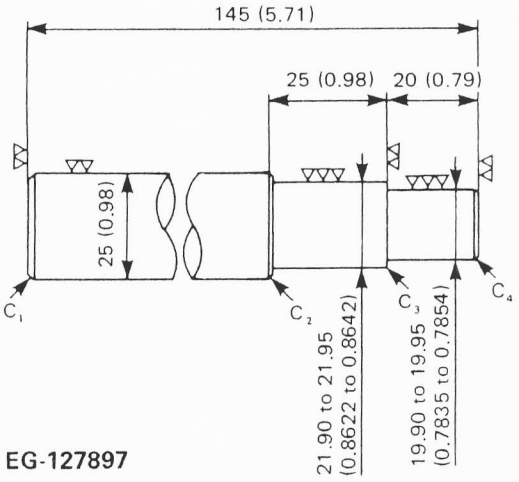
Idler gear bearing replacing tool.

Connecting Rod Piston Pin Bushing Replacing Tool

Application: Use to press out and to press fit the connecting rod piston pin bushing.

*Chamfer	mm	in.
C_1	2.0	0.079
C_2	1.0	0.039
C_3	0.3	0.012
C_4	1.0	0.039

*Unit: mm (in.)



EG-127897

Connecting rod piston pin bushing replacing tool.

Section 1

ENGINE

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Some of the illustrations and information in this manual are furnished courtesy of the Kubota Engine Division.

SPECIFICATIONS

General

Type	Vertical-in-line, water-cooled, naturally-aspirated, 4-cycle diesel
Number of cylinders	3
Type of cylinder sleeves	Dry, replaceable
Injection (firing) order	1-2-3
Direction of rotation	Counterclockwise (viewed from flywheel end)
Bore and stroke	2.52 x 2.45 in. (64 x 62.2 mm)
Compression ratio	23:1
Total displacement	36.61 in. (600 cm^3)
Combustion chamber	Spherical type
Horsepower	
SAE Net intermittent	15.0 hp @ 3600 rpm
SAE Net continuous	12.75 hp @ 3600 rpm
Governed speed	
Minimum	1200 rpm + 100 rpm - 0 rpm
Maximum	3600 rpm
Governor	Centrifugal ball, mechanical
Fuel injection nozzle	Bosch throttle type
Fuel injection pressure	1991 psi
Injection timing	21° before TDC
Fuel injection pump	Bosch MD mini pump
Fuel	Diesel fuel oil, No. 2-D
Lubricating oil	
Grade	Must meet or exceed CC grade (APICD)
Capacity	0.769 U.S. gal. (2.91 l)
Starting system	12 V, 0.7 kW electric starter and glow plug
Alternator (charging system)	12 V, 150 W
Dry weight (fully equipped)	136.0 lbs. plus

NEW DIMENSIONS AND ALLOWABLE WEAR LIMITS

NOTE: Unless specified otherwise, all dimensions are given in inches.

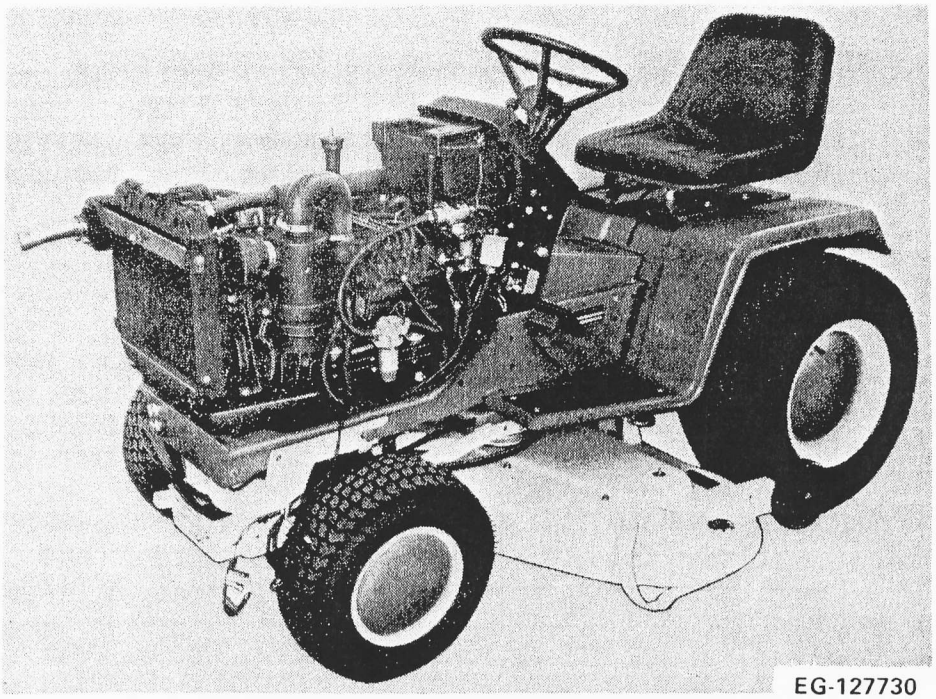
	NEW DIMENSION	ALLOWABLE LIMIT
CYLINDER HEAD		
Cylinder head surface flatness	—	0.0019 per 3.94
Gasket thickness: Free	0.0453-0.0512	—
Tightened	0.0413-0.0453	—
Gasket shim thickness	0.0079	—
Compression pressure	448 psi	337 psi
Variance between cylinders	—	10%
VALVES AND VALVE SEATS — INTAKE AND EXHAUST		
Valve clearance (cold)	0.0059-0.0071	—
Valve seat width	0.055	—
Valve seat angle	45°	—
Valve face angle	45.5°	—
Valve recessing	0.0295-0.0374	0.047
Valve stem to guide clearance	0.00118-0.00224	0.0039
Valve stem O.D.	0.23496-0.23543	—
Valve guide I.D.	0.23661-0.23721	—
VALVE TIMING		
Intake valve: Open	20° before TDC	—
Closed	45° after BDC	—
Exhaust valve: Open	50° before BDC	—
Closed	15° after TDC	—
VALVE SPRINGS		
Free length	1.244	1.118
Tilt	—	0.047
Test length	1.063	1.063
Test load	14.6 lbs.	12.3 lbs.
ROCKER ARM		
Clearance between rocker arm and bushing	0.00063-0.00268	0.0059
Rocker arm shaft O.D.	0.41232-0.41276	—
Rocker arm bushing I.D.	0.41339-0.41500	—
CAMSHAFT		
Camshaft alignment	0.0004	0.0031
Cam lobe lift (intake and exhaust)	1.0583	1.0563
Camshaft running clearance	0.00197-0.00358	0.0059
Journal O.D.	1.29662-1.29725	—
Bearing I.D.	1.29921-1.30020	—

	NEW DIMENSION	ALLOWABLE LIMIT
TIMING GEAR		
Timing gear backlash	0.0016-0.0047	0.0059
Idler gear side clearance	0.0079-0.0201	0.024
Clearance between idler gear shaft and idler gear bushing	0.00063-0.00177	0.0020
Idler gear shaft O.D.	0.62886-0.62929	—
Idler gear bushing I.D.	0.62992-0.63063	—
CYLINDER LINER		
Cylinder liner I.D.	2.51969-2.52043	0.0059 of wear
Available oversize liner	+0.20	—
PISTON AND PISTON RINGS		
Piston pin O.D.	0.70870-0.70902	—
Piston pin hole I.D.	0.70866-0.70910	0.7106
Piston ring clearance		
Top and second compression	0.00335-0.00441	0.0059
Oil ring	0.0008-0.0024	0.0059
Piston ring gap		
Top and second compression	0.0098-0.0157	0.0492
Oil ring	0.0079-0.0157	0.0492
Available oversize piston rings	+.020	—
CRANKSHAFT		
Crankshaft alignment	0.0008	0.0031
Main bearing running clearance	0.00134-0.00417	0.0079
Main journal O.D.:		
Front and intermediate	1.57221-1.57284	—
Rear	1.72969-1.73032	—
Main bearing I.D.:		
Front and intermediate	1.57418-1.57638	—
Rear	1.73166-1.73386	—
Crankpin running clearance	0.00075-0.00319	0.0079
Crankpin O.D.	1.33697-1.33760	—
Crankpin bearing I.D.	1.33835-1.34016	—
Crankshaft end clearance	0.0059-0.0122	0.020
Available undersize crankshaft bearings	-0.008 - -0.016	—
Available oversize thrust bearing	+0.008 - +0.016	—
Thrust bearing location	Flywheel end	—
CONNECTING ROD		
Connecting rod alignment	—	0.002
Piston pin bushing I.D.	0.70965-0.71024	—

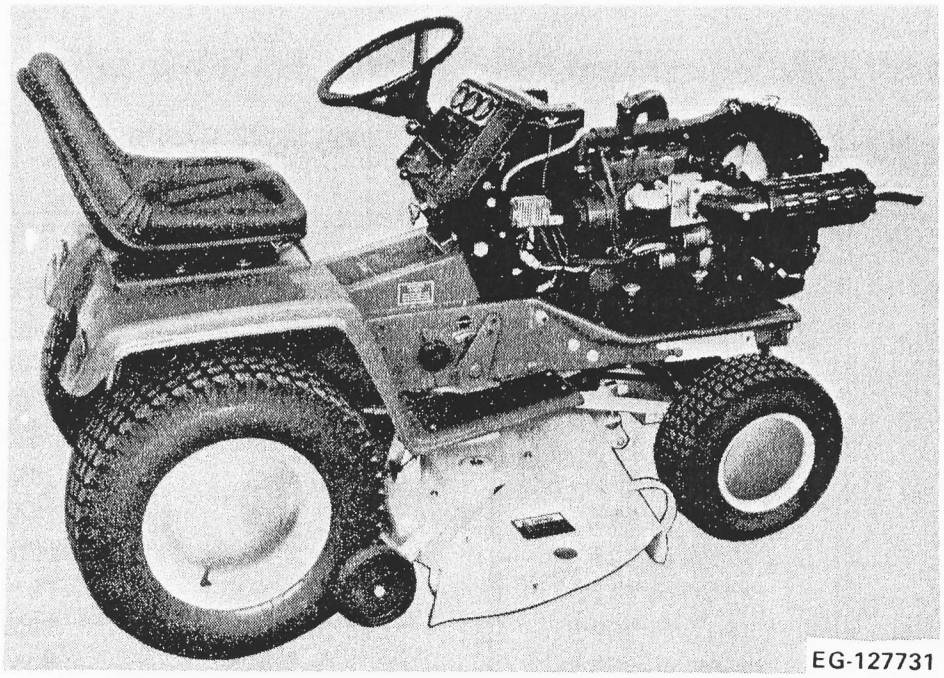
	NEW DIMENSION	ALLOWABLE LIMIT
CONNECTING ROD — Continued		
Piston pin O.D.	0.70870-0.70902	—
Running clearance between piston pin and piston pin bushing	0.00063-0.00154	0.0059
LUBRICATING SYSTEM		
Oil pressure:		
At idle speed	—	10 psi
At rated speed	28 to 64 psi	—
Oil pump		
Rotor lobe clearance	—	0.0098
Radial clearance between outer rotor and pump body	0.0059-0.0083	0.0118
End clearance between rotor and cover	0.0031-0.0051	0.0079
Oil filter		
Opening pressure of by-pass valve	14.2 psi of pressure difference	—
COOLING SYSTEM		
Water pump and alternator belt		
Belt deflection under load of 21 lbs.	0.28-0.35	—
Deflection of fan belt	0.28-0.35	
Radiator		
System pressure	20 psi	—
Radiator cap opening pressure	10 seconds or more of pressure falling time from 13 to 9 psi	—
Thermostat		
Open at	176.9-182.3°F	—
Fully open at	203°F	—
Full stroke	0.236	—
FUEL SYSTEM		
Injection pump		
Injection timing (static)	19-21° before TDC	—
Fuel pressure of pump element:		
60 seconds or more of pressure falling time from 39.23 to 34.32 MPa	5689 to 4978 psi	—
30 seconds or more of pressure falling time from 39.23 to 34.32 MPa	—	5689 to 4978 psi
Fuel pressure of delivery valve:		
10 seconds or more of pressure falling time from 21.57 to 20.59 MPa	3129 to 2987 psi	—
5 seconds or more of pressure falling time from 21.57 to 20.59 MPa	—	3129 to 2987 psi

	NEW DIMENSION	ALLOWABLE LIMIT
FUEL SYSTEM — Continued		
Injection nozzle		
Fuel injection pressure, 13.73 to 14.71 MPa	1991 to 2133 psi	—
Fuel pressure at nozzle seat — no fuel leak at 12.75 MPa	1849 psi	—
ELECTRICAL SYSTEM		
Starter		
Commutator: O.D.	1.26	1.22
Out of roundness	—	0.002
Mica undercut	—	0.008
Brush length	0.669	0.453
Glow plug		
Resistance (approx.)	1.6 ohm	—
Alternator		
No load output, AC volt or more @ 5200 rpm	20 volts	—
Voltage regulator		
Regulating voltage	14 to 15 volt	—

ENGINE VIEW



Illust. 1-1. 782D Tractor equipped with Kubota 3-cylinder diesel engine. Left-front view with hood, side panels and grille support removed. Tractor equipped with optional 44-C Mower.



Illust. 1-2. 782D Tractor equipped with Kubota 3-cylinder diesel engine. Right-side view with hood, side panels and grille support removed. Tractor equipped with optional 44-C Mower.

Special Nut and Bolt Torque Data (In Foot Pounds)

TIGHTENING TORQUES FOR SPECIAL USE OF SCREWS, BOLTS AND NUTS

NOTE: For "○" marked bolts and nuts, apply engine oil to their threads and seats before tightening. Cylinder head bolts and nuts must be tightened in proper sequence and at the proper torque.

o Crankshaft bolt	72.3 to 79.6
o Connecting rod bolts	10.8 to 13.7
o Cylinder head bolts and nuts	28.9 to 32.5
o Cylinder head cover cap nuts	2.9 to 4.3
o Cylinder head stud	17.4 to 20.3
Drain plug (engine oil)	23.9 to 27.5
o Flywheel bolts	39.8 to 43.4
Flywheel stub shaft screws	28 ft. lbs.
Fuel limit cap nut	5.8 to 7.2
Glow plugs	14.5 to 18.1
Injection pipe retaining nuts	18.1 to 25.3
o Idler gear shaft bolts	7.23 to 8.32
o Main bearing bolts: Intermediate	14.5 to 17.4
Rear	8.7 to 10.8
Nozzle holders	36.2 to 50.6
Oil pressure switch	10.8 to 14.5
Rocker arm nut	7.23 to 8.32

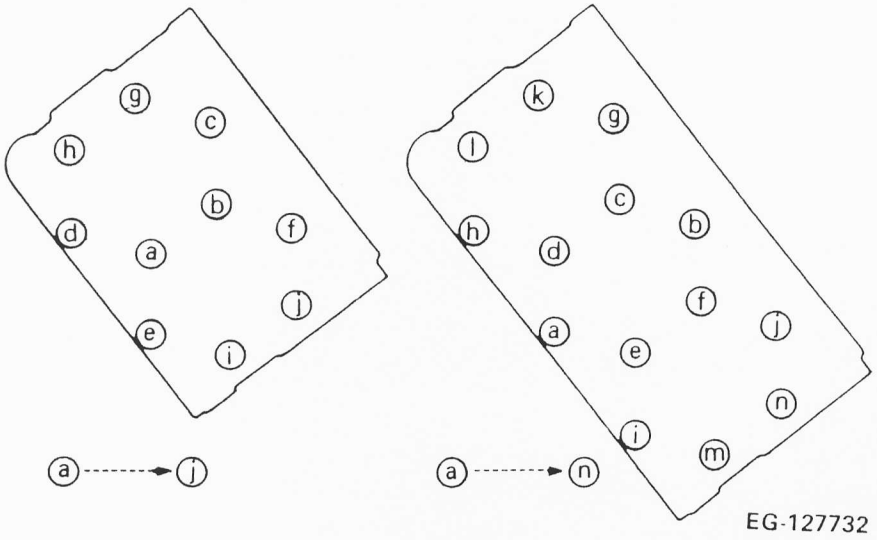
TIGHTENING TORQUES FOR GENERAL USE OF SCREWS, BOLTS AND NUTS

When the tightening torques are not specified, tighten according to the table below:

Nominal Diameter	Standard Screw and Bolt SS41, S20C	Special Screw and Bolt S43C, S48C	Special Screw and Bolt SCr435, SCM435
M6	5.79 to 6.87	7.23 to 8.32	9.04 to 10.49
M8	13.0 to 15.2	17.4 to 20.3	21.7 to 25.3
M10	28.9 to 33.3	35.4 to 41.2	44.8 to 52.1
M12	46.3 to 53.5	57.1 to 66.5	75.9 to 86.8
M14	79.6 to 92.6	91.1 to 108.5	123.0 to 144.7
M16	123.0 to 141.0	144.7 to 166.4	191.7 to 224.2
M18	180.8 to 209.8	202.5 to 235.1	253.2 to 296.6
M20	245.9 to 289.3	271.2 to 318.3	361.7 to 419.5

Screw and bolt material grades are shown by numbers punched on the screw and bolt heads. Prior to tightening, be sure to check the numbers as shown below.

Punched Number	Screw and Bolt Material Grade
None	Standard screw and bolt SS41, S20C
7	Special screw and bolt S43C, S48C (refined)
9	Special screw and bolt SCr435, SCM435 (refined)



Cylinder head tightening sequence.

TROUBLESHOOTING

Symptom	Probable Cause	Solution	Reference Page
Engine does not start (starter turns)	No fuel	Replenish fuel	
	Air in the fuel system	Bleed fuel system	
	Water in the fuel system	Replace fuel and repair or replace fuel system	
	Fuel pipe clogged	Clean	
	Fuel filter clogged	Clean or replace	1-18
	Excessively high viscosity of fuel or engine oil at low temperature	Use the specified fuel or engine oil	
	Fuel with low cetane number	Use the specified fuel	
	Fuel leak due to loose injection pipe retaining nut	Tighten nut	1-17
	Incorrect injection timing	Adjust	
	Fuel camshaft worn	Replace	
	Injection nozzle clogged	Clean	1-26
	Injection pump malfunctioning	Repair or replace	1-56
	Fuel pump malfunctioning	Check wiring or repair or replace	1-17
	Seizure of crankshaft, camshaft, piston, cylinder liner or bearing	Repair or replace	
	Compression leak from cylinder	Replace head gasket, tighten cylinder head bolt, glow plug and nozzle holder	1-110
	Improper valve seat alignment, valve spring broken, valve seized	Repair or replace	1-69
	Improper valve timing	Correct or replace timing gear	
	Piston ring and liner worn	Replace	1-81
	Excessive valve clearance	Adjust	1-67
(Starter does not turn)	Battery discharged	Charge	
	Starter malfunctioning	Repair or replace	1-28
	Starter switch malfunctioning	Repair or replace	1-28
	Wiring disconnected	Connect	
Engine runs rough	Fuel filters clogged or dirty	Clean or replace	1-18
	Air cleaner clogged	Clean or replace	
	Fuel leak due to loose injection pipe retaining nut	Tighten nut	1-17
	Defective fuel pump	Replace	1-19
	Injection pump malfunctioning	Repair or replace	1-19

Symptom	Probable Cause	Solution	Reference Page
Engine runs rough — Continued	Incorrect nozzle opening pressure	Adjust	1-26
	Injection nozzle stuck or clogged	Repair or replace	1-26
	Fuel overflow pipe clogged	Clean	1-17
	Governor malfunctioning	Repair	1-22
Either white or blue exhaust gas is observed	Excessive engine oil	Reduce to the specified level	
	Piston ring and liner worn or stuck	Repair or replace	
	Incorrect injection timing	Adjust	
	Deficient compression	Adjust top clearance	1-109
Either black or dark gray exhaust gas is observed	Overload	Lessen the load	
	Low grade fuel used	Use the specified fuel	
	Fuel filters clogged	Clean or replace	1-18
	Air cleaner clogged	Clean or replace	
Deficient output	Incorrect injection timing	Adjust	
	Defective fuel pump	Replace	1-17
	Engine's moving parts seem to be seizing	Repair or replace	
	Uneven fuel injection	Repair or replace the injection pump	1-19
	Deficient nozzle injection	Repair or replace the nozzle	1-26
	Compression leak	Replace head gasket, tighten cylinder head bolt, glow plug and nozzle holder	1-109
Excessive lubricant oil consumption	Piston ring's gap facing the same direction	Shift ring gap direction	1-81
	Oil ring worn or stuck	Replace	
	Piston ring groove worn	Replace the piston	1-81
	Valve stem and guide worn	Replace	1-67
	Crankshaft bearing and crank pin bearing worn	Replace	1-78
Fuel mixed into lubricant oil	Injection pump's plunger worn	Replace pump element or pump	1-19
Water mixed into lubricant oil	Head gasket defective	Replace	
	Cracked crank case or cylinder head	Replace	

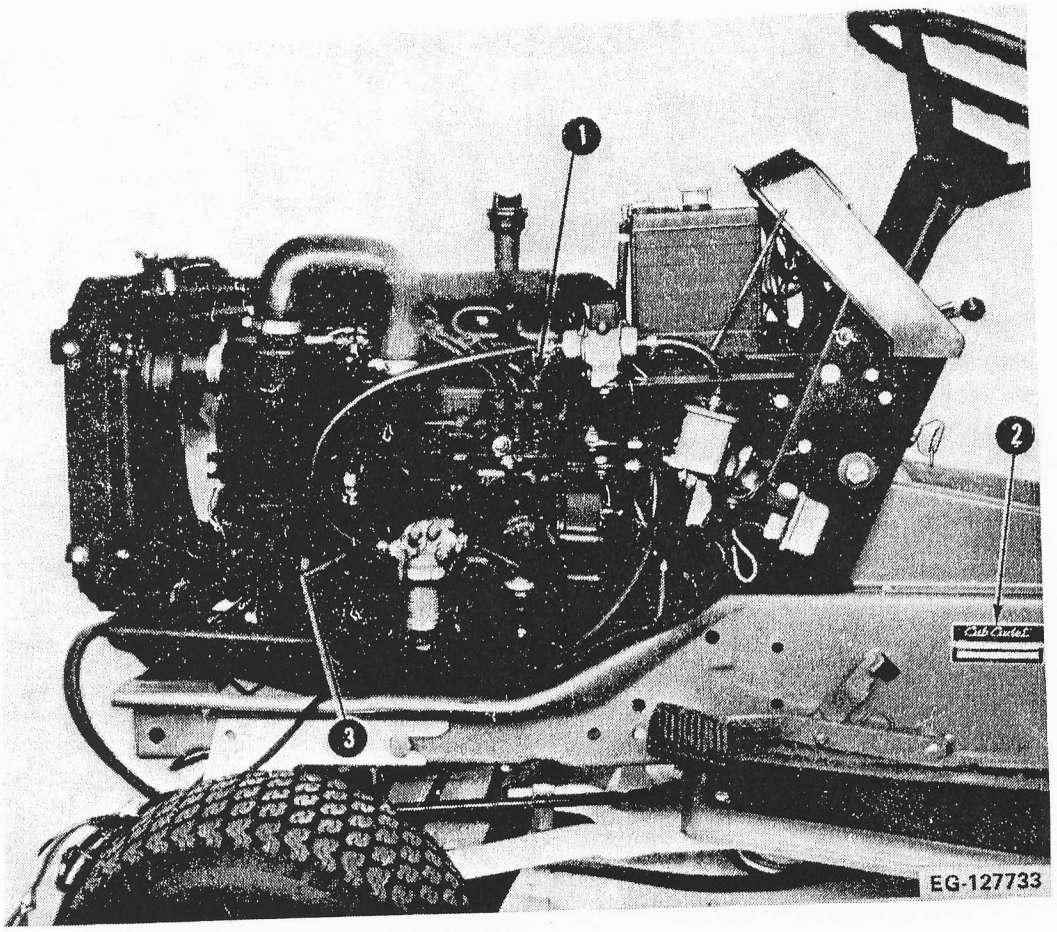
Symptom	Probable Cause	Solution	Reference Page
Low oil pressure	Engine oil insufficient	Replenish	
	Oil strainer clogged	Clean	1-34
	Oil filter cartridge clogged	Replace	1-37
	Relief valve stuck with dirt	Clean	1-36
	Relief valve spring weaken or broken	Replace	1-36
	Excessive oil clearance of crankshaft bearing	Replace	1-77
	Excessive oil clearance of crank pin bearing	Replace	1-78
	Excessive oil clearance of rocker arm bushing	Replace	1-71
	Oil passage clogged	Clean	1-35
	Different type of oil	Use the specified type of oil	
	Oil pump defective	Repair or replace	1-36
High oil pressure	Different type of oil	Use the specified type of oil	
	Relief valve defective	Replace	1-36
Engine overheats	Engine oil insufficient	Replenish	
	Fan belt or alternator belt broken or tensioned improperly	Replace or adjust	
	Insufficient cooling water	Replenish	1-30
	Radiator net and radiator fin clogged with dust	Clean	1-33
	Inside of radiator corroded	Clean or replace	1-33
	Cooling water flow route corroded	Clean or replace	1-32
	Defective radiator cap	Replace	1-33
	Defective water hose	Replace	
	Defective thermostat	Replace	1-32
	Defective water pump	Replace	1-31
	Defective mechanical seal	Replace	
	Overload running	Loosen the load	
	Defective head gasket	Replace	
	Incorrect injection timing	Adjust	
	Unsuitable fuel used	Use the specified fuel	
Battery discharges quickly	Battery electrolyte level low	Add distilled water and recharge	
	Fan or alternator belt slips	Adjust belt tension or replace	
	Disconnected wiring	Connect	
	Defective regulator	Replace	1-29
	Defective alternator	Replace	1-29
	Defective battery	Replace	

GENERAL DESCRIPTION

Tractor Identification

These instructions contain information for the maintenance and service of the International Cub Cadet Tractor Model 782D, equipped with the Kubota 3-cylinder diesel engine.

The model designation and serial number shown on the nameplate illustrated below should be included in any correspondence regarding the tractor.



Illust. 1-3. Tractor identification.

1. No. 1 cylinder injection tube
2. Chassis serial number plate
3. Engine serial number plate

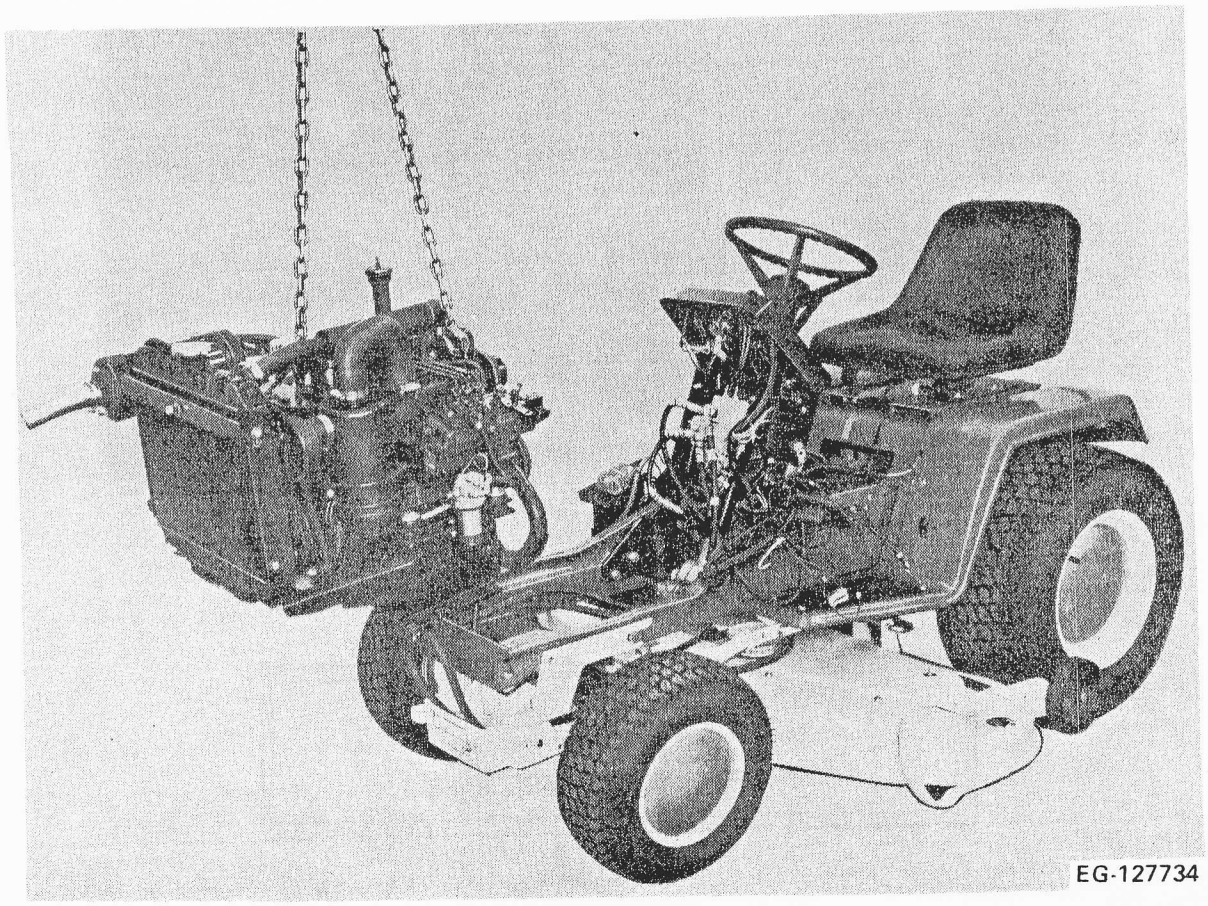
Cylinder Numbers

The sequence of cylinder numbers is given as No. 1, starting from the gear case end of the engine, closest to the steering column. The flywheel and power take-off unit are mounted at the front of the tractor, closest to the radiator and grille.

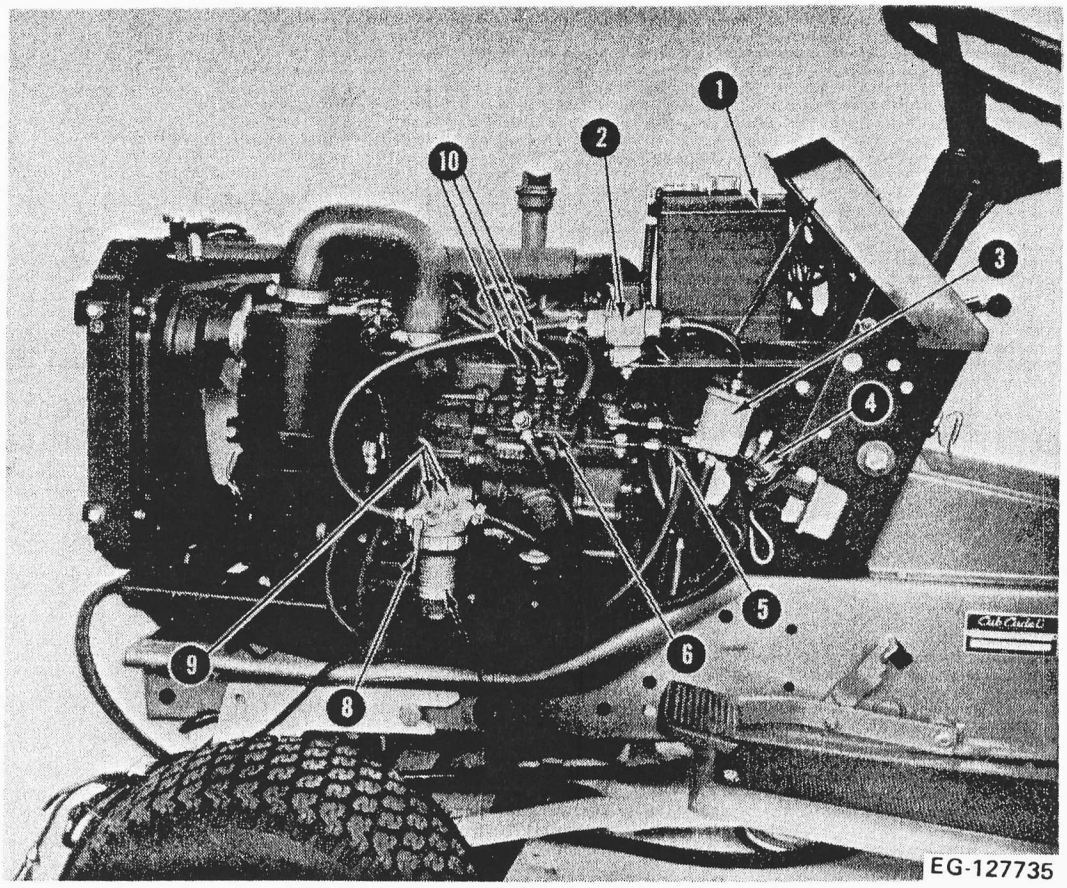
In describing the various maintenance and service procedures, after engine removal, the front of the engine will always be designated as the gear case end.

Detailed Description

POWER UNIT (See Illust. 1-4)
The power unit, which consists of the Kubota 3-cylinder diesel engine, radiator, fan assembly and power take-off clutch, together with interconnecting hoses and piping are cradled in the engine and radiator mount, which is removed as a unit for servicing.



Illust. 1-4. Power unit removed from chassis.



Illust. 1-5. Battery and fuel system components.

1. Battery	6. Fuel injection pump
2. Electric fuel pump	7. Secondary fuel filter
3. Primary fuel filter	8. Fuel shut-off valve
4. Engine stop lever cable	9. Air vent plugs
5. Speed control lever cable	10. Fuel injection lines

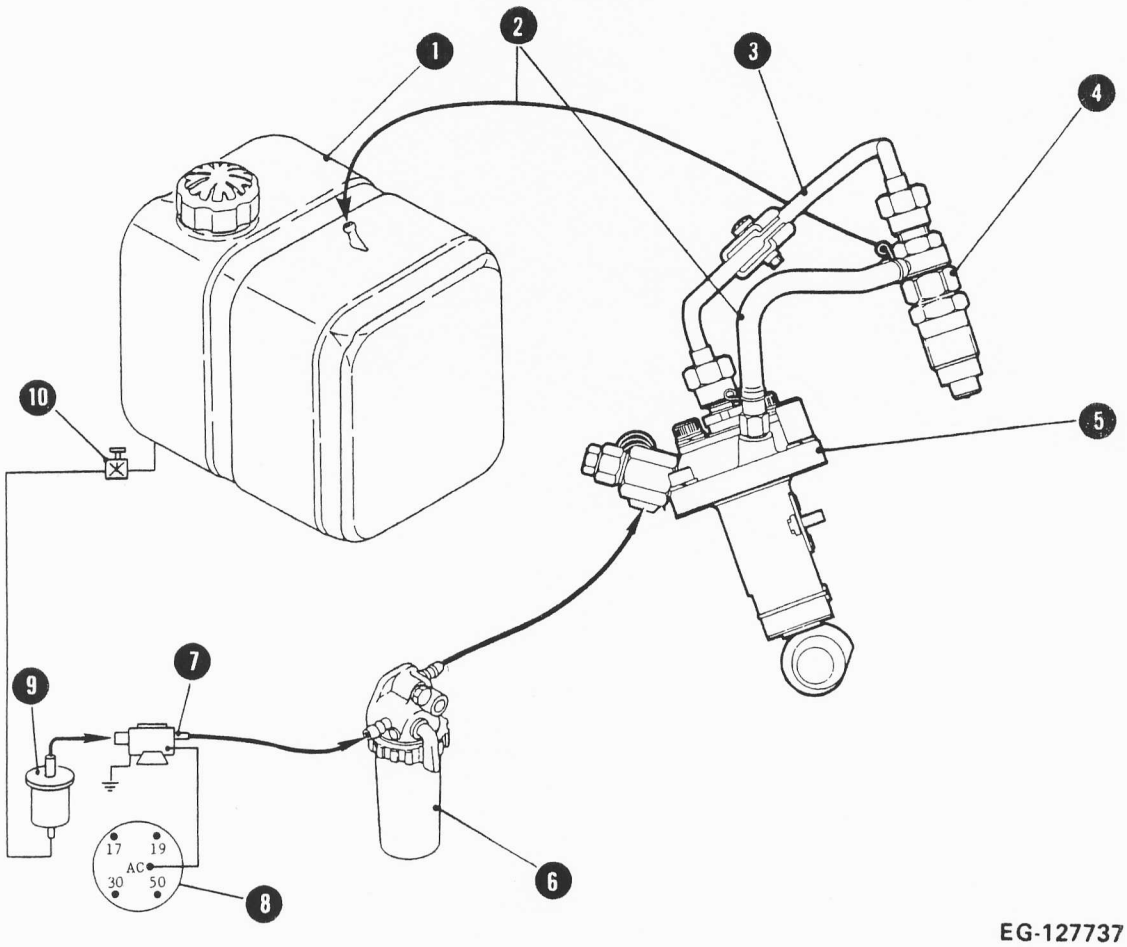
ELECTRIC FUEL PUMP (See Illust. 1-5)
The electric fuel pump (2) is mounted on a bracket attached to the battery support. The pump is energized in all key switch positions, except "OFF."

FUEL SYSTEM (See Illust. 1-6)
The fuel is fed from the fuel tank (1) through the tank fuel shut-off valve (10), and primary in-line fuel filter (9) to the inlet side of the electric fuel pump (7).

Actuating the key switch (8) energizes the electric fuel pump (7) which pumps the fuel through the engine mounted secondary fuel filter (6) to the injection pump (5). The secondary fuel filter is equipped with a shut-off valve and two air bleed screws.

The injection pump force-feeds the fuel through the injection pipes (3) to the injection nozzles (4), which inject the fuel into the cylinders for combustion.

The excessive fuel in the injection pump and the injection nozzle is collected in the fuel overflow pipes (2) and returns to the fuel tank.

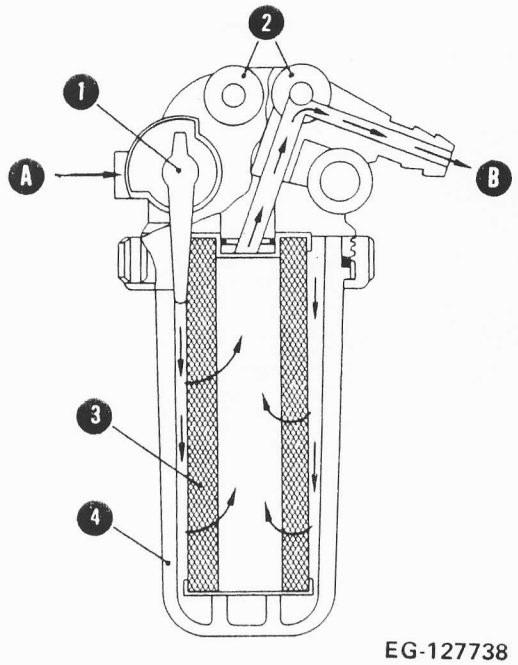


Illust. 1-6. Fuel system.

1. Fuel tank	6. Secondary fuel filter
2. Fuel overflow pipe	7. Electric fuel pump
3. Injection pipe	8. Key switch
4. Injection nozzle	9. Primary fuel filter
5. Injection pump	10. Tank shut-off valve

SECONDARY FUEL FILTER (See Illust. 1-7)
The fuel filter is installed in the fuel line from the fuel pump to the injection pump.

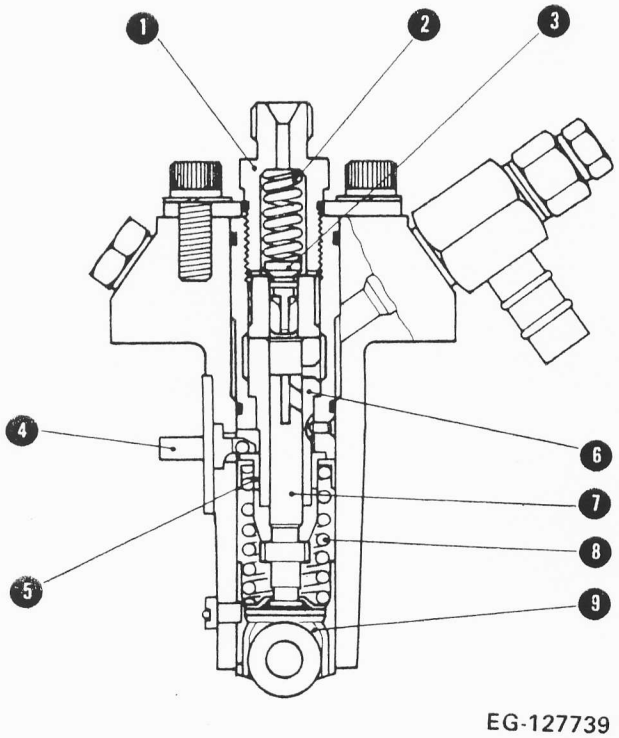
As the fuel from the inlet (A) moves through the filter element (3), the dirt and impurities in the fuel are filtered, allowing only clean fuel to enter the inside of the filter element. The cleaned fuel flows out from outlet (B) to the injection pump.



Illust. 1-7. Secondary fuel filter.

Before starting or after disassembling and reassembling, loosen the air vent plugs (2) to bleed the air in the fuel line.

A. Inlet
B. Outlet
1. Fuel cock
2. Air vent plug
3. Filter element
4. Filter cup

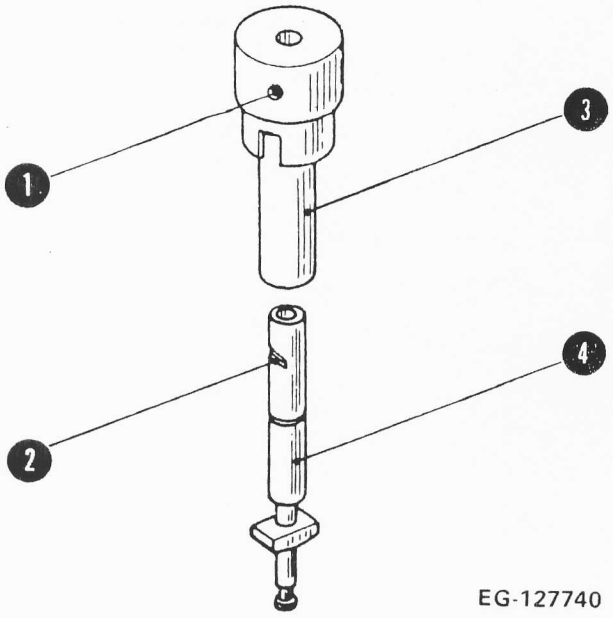


Illust. 1-8. Fuel injection pump.

FUEL INJECTION PUMP (See Illust. 1-8)
The injection pump is a Bosch MD type mini-injection pump, which gives high injection quality even at low engine speeds. The plunger is reciprocated by the cam on the camshaft with the tappet and forces the fuel into the injection nozzle.

The control rack (4) is pushed or pulled by the fork lever of the governor and rotates the control sleeve (5) and the plunger, which has a left-hand lead control groove, to vary the amount of fuel forced into the injection nozzle.

1. Delivery valve holder
2. Delivery valve spring
3. Delivery valve
4. Control rack
5. Control sleeve
6. Cylinder
7. Plunger
8. Plunger spring
9. Tappet



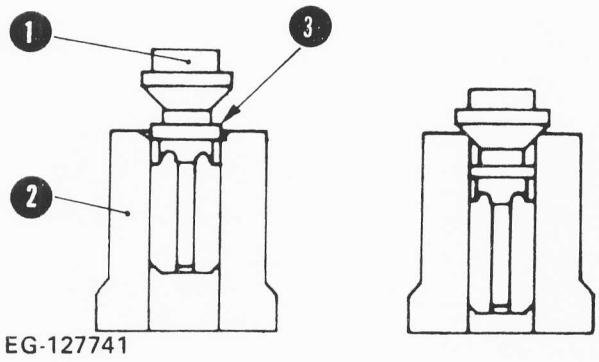
Illust. 1-9. Pump element.

1) Pump Element (See Illust. 1-9)
The pump element consists of the plunger (4) and cylinder (3), and their sliding surfaces are super precision-machined to maintain fuel pressure.

The plunger fits in the control sleeve which is engaged with the control rack.

The plunger has a control groove with a left-hand helix lead.

1. Feed hole
2. Control groove
3. Cylinder
4. Plunger



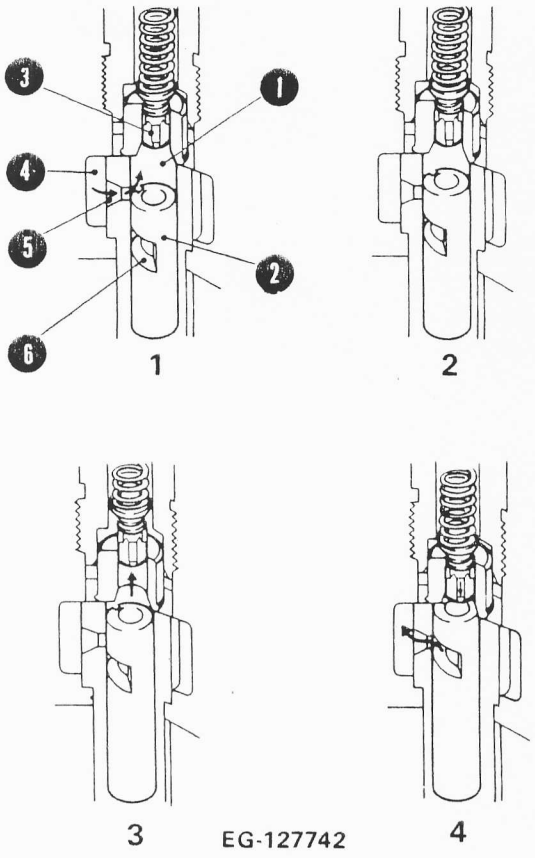
Illust. 1-10. Delivery valve.

1. Valve
2. Valve seat
3. Relief plunger

2) Delivery Valve (See Illust. 1-10)
The delivery valve consists of the valve (1) and the valve seat (2).

The delivery valve prevents the fuel from flowing back into the delivery chamber through the injection pipe. It also prevents the fuel from dribbling at the injection nozzle.

When the delivery stroke ends, the relief plunger moves into the bore of the valve seat and seals the delivery line from the delivery chamber. The relief plunger lowers further until the valve seats suck back the fuel to prevent dribbling at the injection nozzle.



Illust. 1-11. Operation of pump element.

1. Delivery chamber
2. Plunger
3. Relief plunger
4. Fuel chamber
5. Feed hole
6. Control groove

3) Operation of Pump Element (See Illust. 1-11)

1. Before delivery

As the tappet lowers, the plunger (2) also lowers and fuel is drawn into the delivery chamber (1) through the feed hole (5) from the fuel chamber (4).

2. Beginning of delivery

When the plunger is pushed up by the cam and the head of the plunger closes the feed hole, the pressure in the delivery chamber rises to push the relief plunger (3) open.

Fuel is then force-fed into the injection pipe.

3. Delivery

While the plunger is rising, the delivery of fuel continues.

4. End of delivery

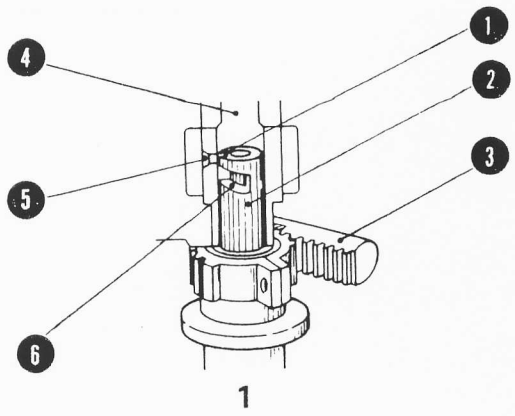
When the plunger rises further and the control groove (6) on its periphery meets the feed hole, the fuel returns to the fuel chamber from the delivery chamber through the control groove and the feed hole.

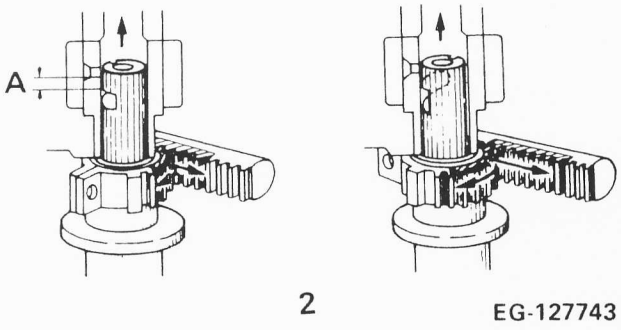
4) Plunger Position (See Illust. 1-12)

1. No fuel delivery

At the engine stop position of the control rack (3), the lengthwise slot (1) on the plunger (2) aligns with the feed hole (5). And the delivery chamber (4) is led to the feed hole during the entire stroke of the plunger.

The pressure in the delivery chamber does not build up and no fuel can be forced to the injection nozzle.



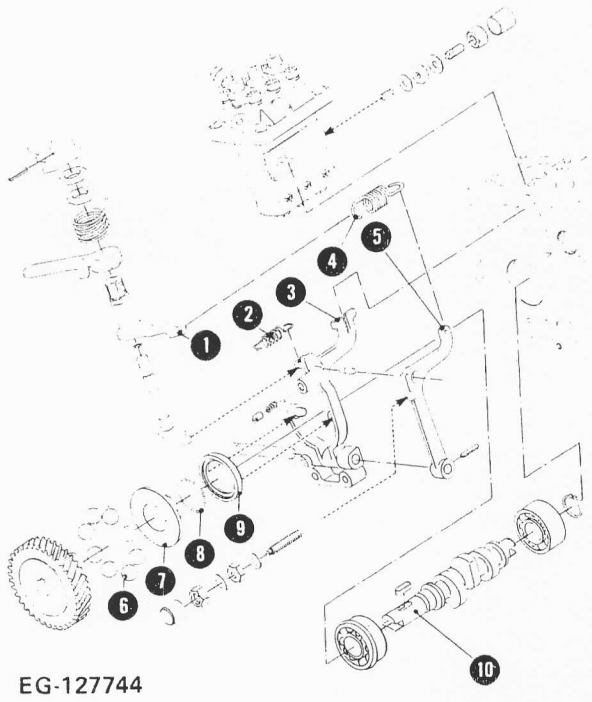


Illust. 1-12. Plunger position.

2. Fuel delivery
The plunger is rotated by the control rack. When the plunger is pushed up, the hole is closed. The pressure in the delivery chamber builds up and force-feeds the fuel to the injection nozzle until the control groove (6) meets the feed hole.

The amount of the fuel corresponds to the distance "A."

1. Slot
2. Plunger
3. Control rack
4. Delivery chamber
5. Feed hole
6. Control groove

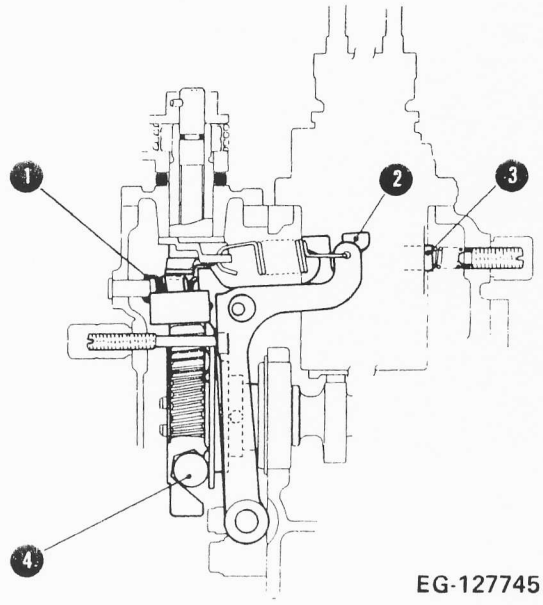


Illust. 1-13. Governor.

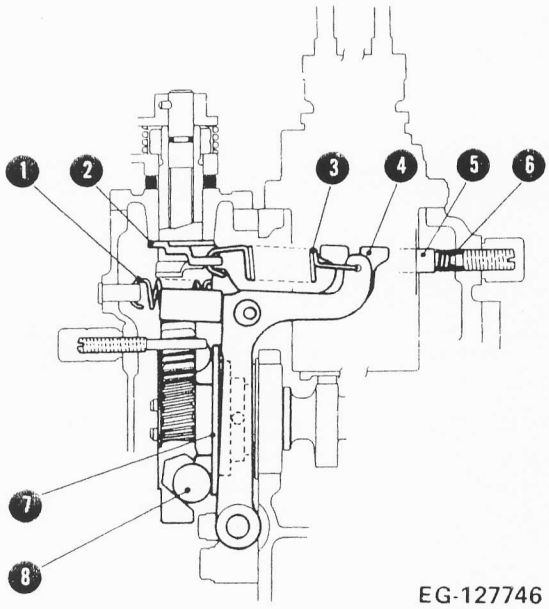
GOVERNOR (See Illust. 1-13)
The governor controls the amount of the fuel to be fed in the entire speed range to prevent the engine from changing its speed according to the load.

The fork lever 1 (3) is held where two forces on it are balanced. One is the force that fork lever 2 pushes, which is caused by the tension of the governor spring (4) between the governor lever (1) and fork lever 2 (5). Another is the component of the centrifugal force produced by the steel balls (6) which are rotated by the fuel camshaft (10).

1. Governor lever
2. Start spring
3. Fork lever 1
4. Governor spring
5. Fork lever 2
6. Steel ball
7. Governor sleeve
8. Steel ball
9. Governor ball case
10. Fuel camshaft



Illust. 1-14. Governor at start position.



Illust. 1-15. Governor at idling position.

1. Start spring
2. Speed control lever
3. Governor spring
4. Fork lever 1
5. Control rack
6. Idling adjust spring
7. Governor sleeve
8. Steel ball

1) At Start
The steel ball (4) has no centrifugal force.

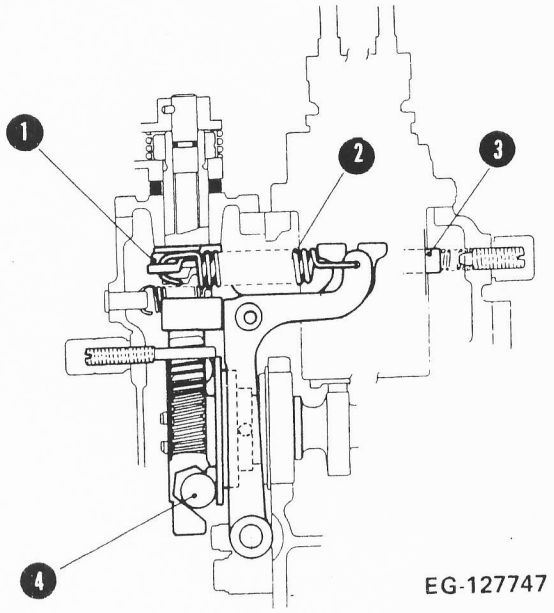
Fork lever 1 (2) is pulled by the start spring (1) and the control rack (3) moves to the maximum injection position for easy starting.

1. Start spring
2. Fork lever 1
3. Control rack
4. Steel ball

2) At Idling
When the speed control lever (2) is set at the idling position, the governor spring (3) is pulled slightly.

As the camshaft rotates, the steel balls (8) increase their centrifugal force and push the governor sleeve (7). Fork lever 1 (4) pushed by the governor sleeve, pushes the control rack (5) and the control rack compresses the idling adjust spring (6).

The control rack is kept at a position where the centrifugal force is balanced with the spring tension on the control rack, providing stable idling.



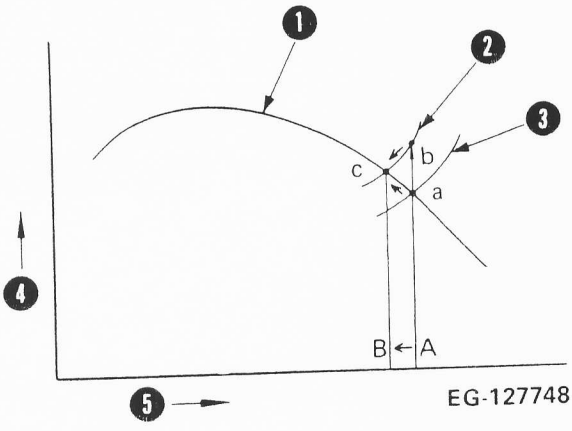
Illust. 1-16. Governor at medium or high speed running.

1. Speed control lever
2. Governor spring
3. Control rack
4. Steel ball

3) At Medium or High Speed Running (See Illust. 1-16 and 1-17)
When the speed control lever (1) is turned further, the governor spring (2) increases the tension and the control rack (3) is pulled to increase the engine speed.

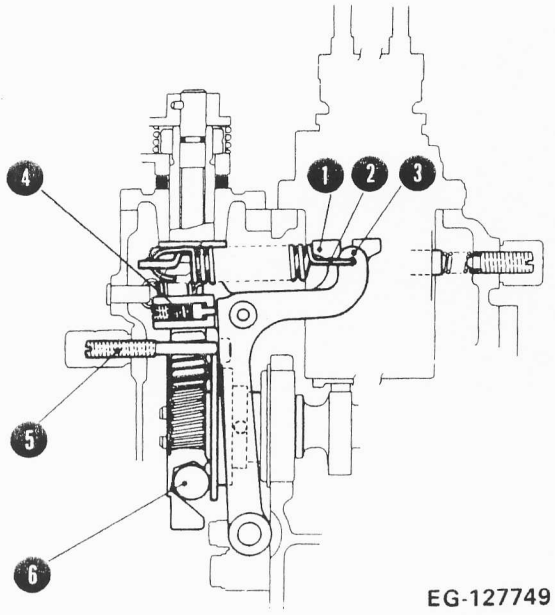
The steel balls (4) increase their centrifugal force and the control rack is pushed, decreasing the engine speed, until the centrifugal force and the spring tension are balanced.

When the engine speed is dropped (A→B) with the increase of the load (a→b), the centrifugal force of the steel ball decreases and the control rack is pulled. The amount of the fuel to the injection nozzle is increased to produce a higher engine torque required for the load.



Illust. 1-17. Torque curve chart.

1. Engine torque curve
2. Large load torque curve
3. Small load torque curve
4. Torque
5. Engine speed



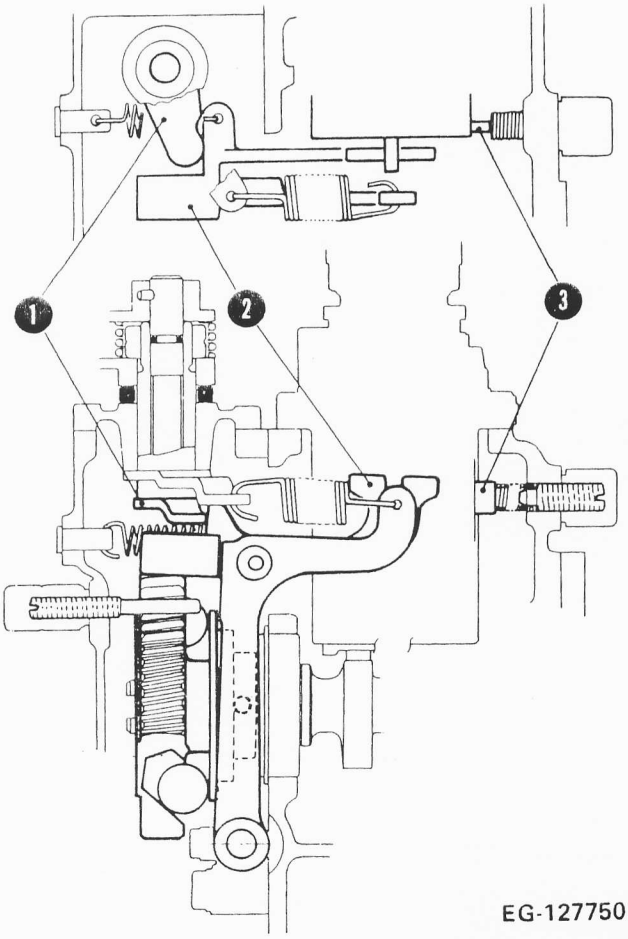
Illust. 1-18. Governor at maximum speed running with an overload.

4) At Maximum Speed Running with an Overload (See Illust. 1-18)
When the engine is overloaded at the high speeds and the engine speed drops, the centrifugal force of the steel balls (6) decreases and the governor spring (2) pulls fork lever 1 (1) and 2 (3).

When fork lever 2 contacts the adjusting screw (5), the spring (4) which is built in fork lever 2 begins to push the fork lever 1 to pull the control rack.

The fuel to the injection nozzle is increased to run the engine at high speed and torque.

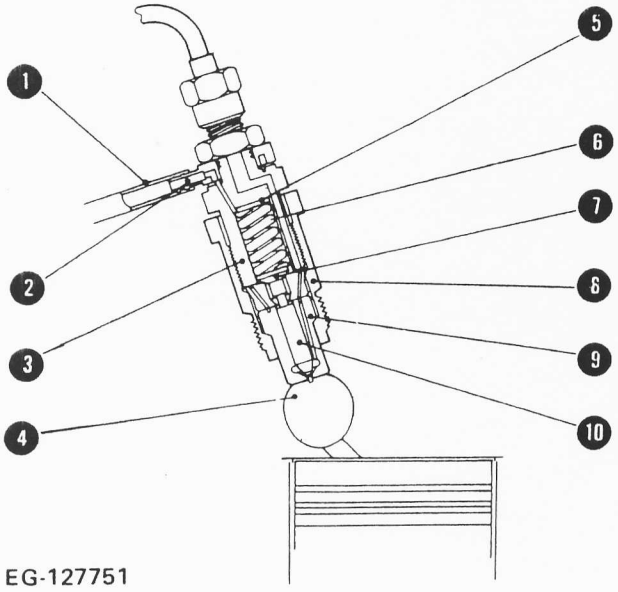
1. Fork lever 1	4. Spring
2. Governor spring	5. Adjusting screw
3. Fork lever 2	6. Steel ball



Illust. 1-19. Governor at engine stop.

5) To Stop the Engine (See Illust. 1-19)
When the stop lever (1) is moved to the stop position, fork lever 1 (2) is pushed and the control rack (3) is moved to stop the fuel injection.

1. Stop lever
2. Fork lever 1
3. Control rack



Illust. 1-20. Injection nozzle.

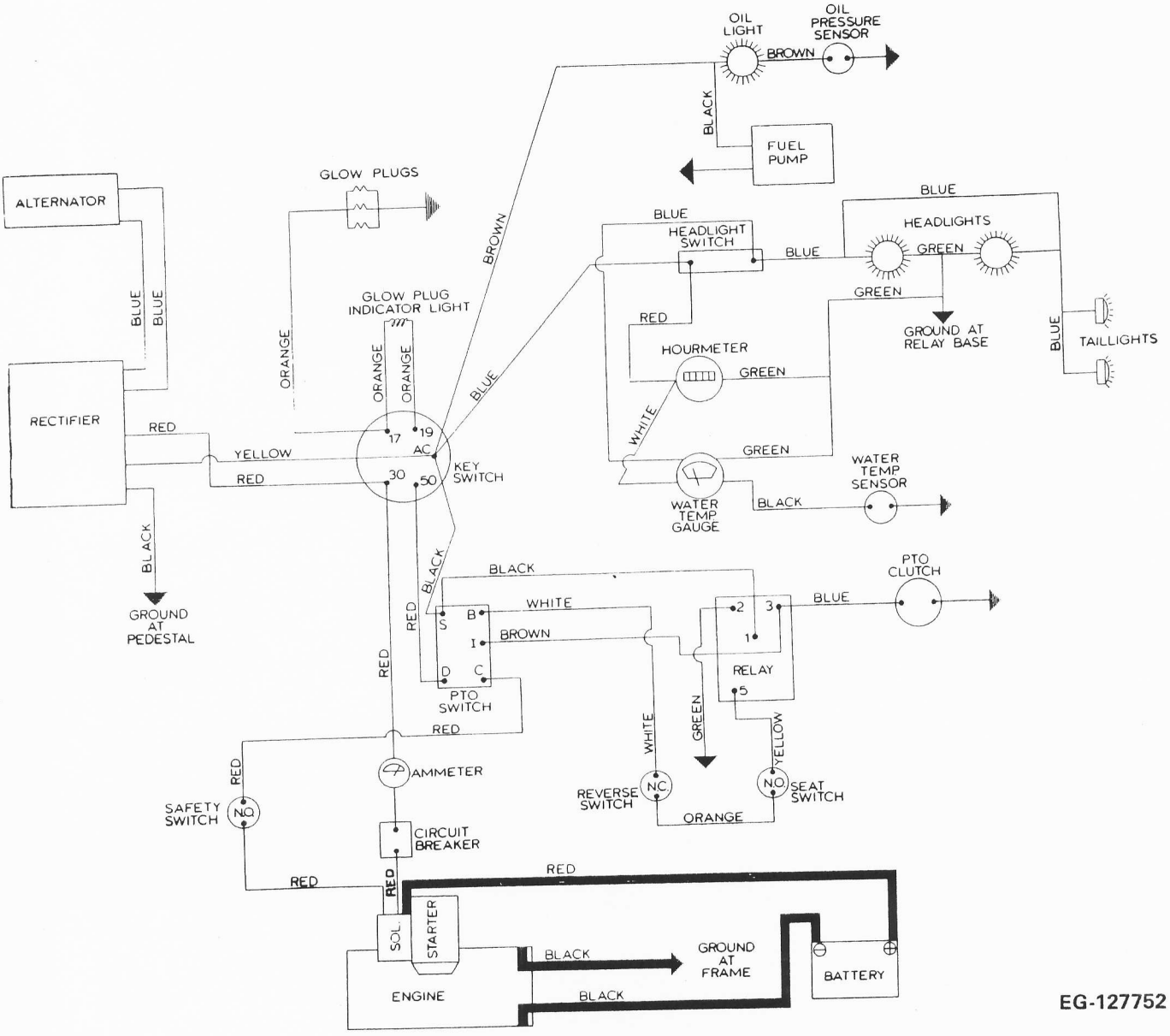
1. Fuel overflow pipe
2. Eye joint
3. Nozzle holder body
4. Sub-combustion chamber
5. Adjusting washer
6. Nozzle spring
7. Push rod
8. Retaining nut
9. Nozzle body
10. Needle valve

INJECTION NOZZLE (See Illust. 1-20)
The nozzle is of the throttle type. The needle valve (10) is pushed against the nozzle body (9) by the nozzle spring (6) with the push rod (7).

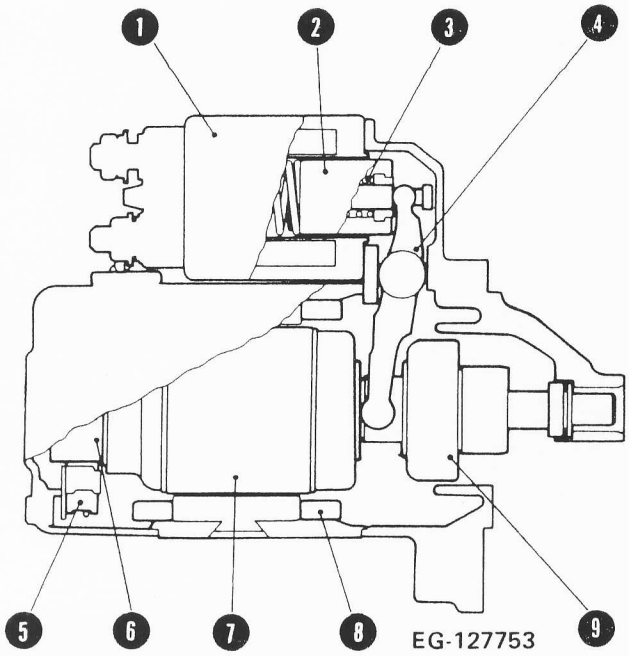
The fuel forced from the injection pump pushes up the needle valve and is injected into the sub-combustion chamber (4). The excessive fuel which is not injected returns through the center chamber of the nozzle holder and the eye joint (2) to the fuel tank.

The injection pressure can be adjusted with the adjusting washer (5) from 1991 to 2133 psi.

ELECTRICAL SYSTEM (See Illust. 1-21)
The electrical system consists of the 12-volt battery, alternator and regulator (rectifier), starting motor, glow plugs, PTO clutch, headlights, taillights, ignition key switch, various safety switches, meters, relays, gauges and connecting wiring.



Illust. 1-21. Wiring diagram.



Illust. 1-22. Starting motor.

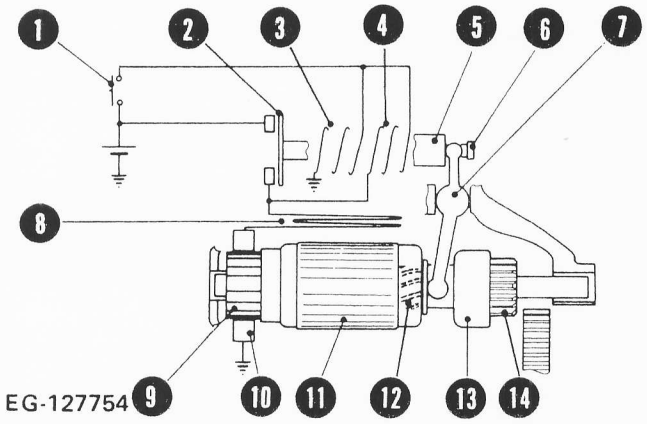
STARTING SYSTEM (See Illust. 1-22 and 1-23)

1) Starting Motor

The starter is of the electromagnetic drive type.

Type of motor	DC, Series, Electro-magnetic drive
Supply voltage	12V
Rated output	0.7 kW
Rate	Less than 30 seconds
Direction of rotation	Clockwise as viewed from pinion side

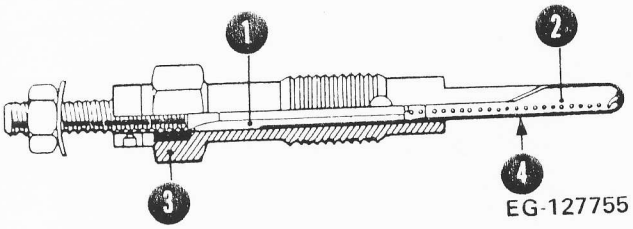
1. Solenoid switch
2. Plunger
3. Spring
4. Shift lever
5. Brush
6. Commutator
7. Armature
8. Field coil
9. Overrunning clutch



Illust. 1-23. Starting motor circuit schematic.

1. Starting switch
2. Magnetic switch
3. Holding coil
4. Pull-in coil
5. Plunger
6. Rod
7. Shift lever
8. Field coil
9. Commutator
10. Brush
11. Armature
12. Spiral spline
13. Overrunning clutch
14. Pinion

2) Glow Plug
Each sub-combustion chamber has a glow plug for easy starting. The glow plug is of the quick-heating type.



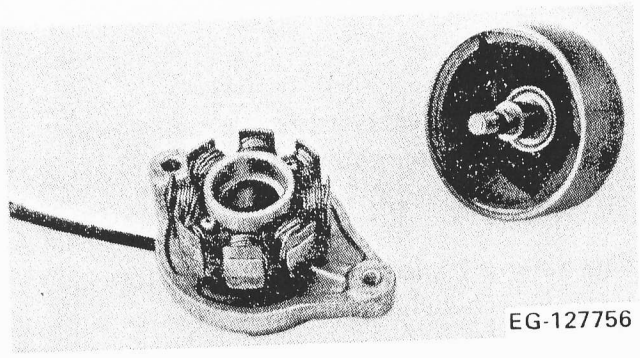
1. Insulating powder
2. Metal tube
3. Housing
4. Heat coil

Illust. 1-24. Glow plug.

CHARGING SYSTEM
1) Alternator
The alternator is an 8-8 pole rotating magnet type generator, which consists of a stator and a rotor and is simple in construction.

The rotor has eight permanent magnet poles and rotates around the stator, which has eight coils.

The alternator can produce high voltage even at slow engine rpm and charge the battery during engine idling.

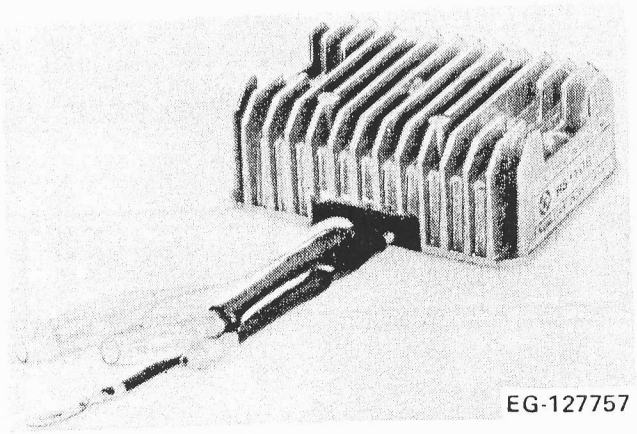


Illust. 1-25. Alternator.

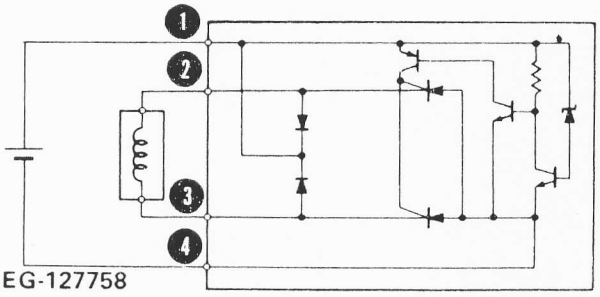
2) Regulator
The regulator is a transistorized regulator with SCR.

When the battery voltage is low, SCRs turn on to charge the battery with the current from the alternator.

When the generated voltage rises excessively, they turn off to stop charging.



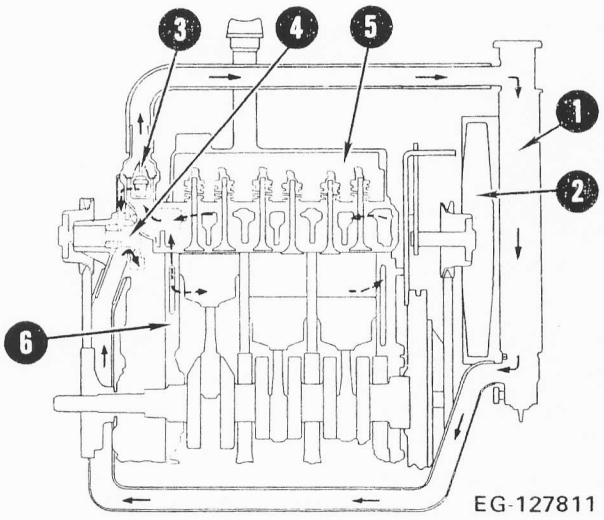
Illust. 1-26. Regulator.



Illust. 1-27. Alternator/regulator schematic.

1. To AC terminal of key switch (yellow)
2. To alternator (light blue)
3. To alternator (light blue)
4. To ground (black)

Cooling System



Illust. 1-28. Cooling system.

1. Radiator
2. Cooling fan
3. Thermostat
4. Water pump
5. Cylinder head
6. Cylinder block

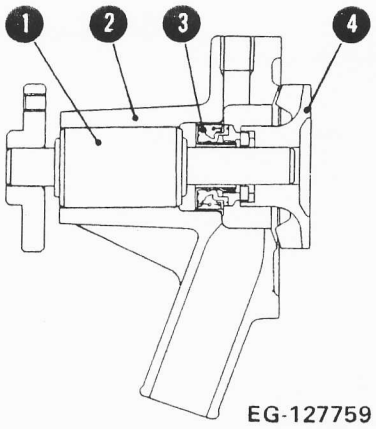
The cooling system consists of a radiator (1), a centrifugal water pump (4), a suction fan (2) and a thermostat (3).

The water is cooled through the radiator core, and the fan behind the radiator pulls the cooling air through the core to improve cooling.

The water pump sucks the water from the radiator or from the cylinder block and forces it into the crankcase.

The thermostat opens or closes according to the water temperature, to allow the water to flow from the cylinder block to the radiator while open, or only to the water pump while closed.

Thermostat opening temperature	Approx. 82°C (180°F)



Illust. 1-29. Water pump.

1. Bearing unit
2. Water pump body
3. Mechanical seal
4. Water pump impeller

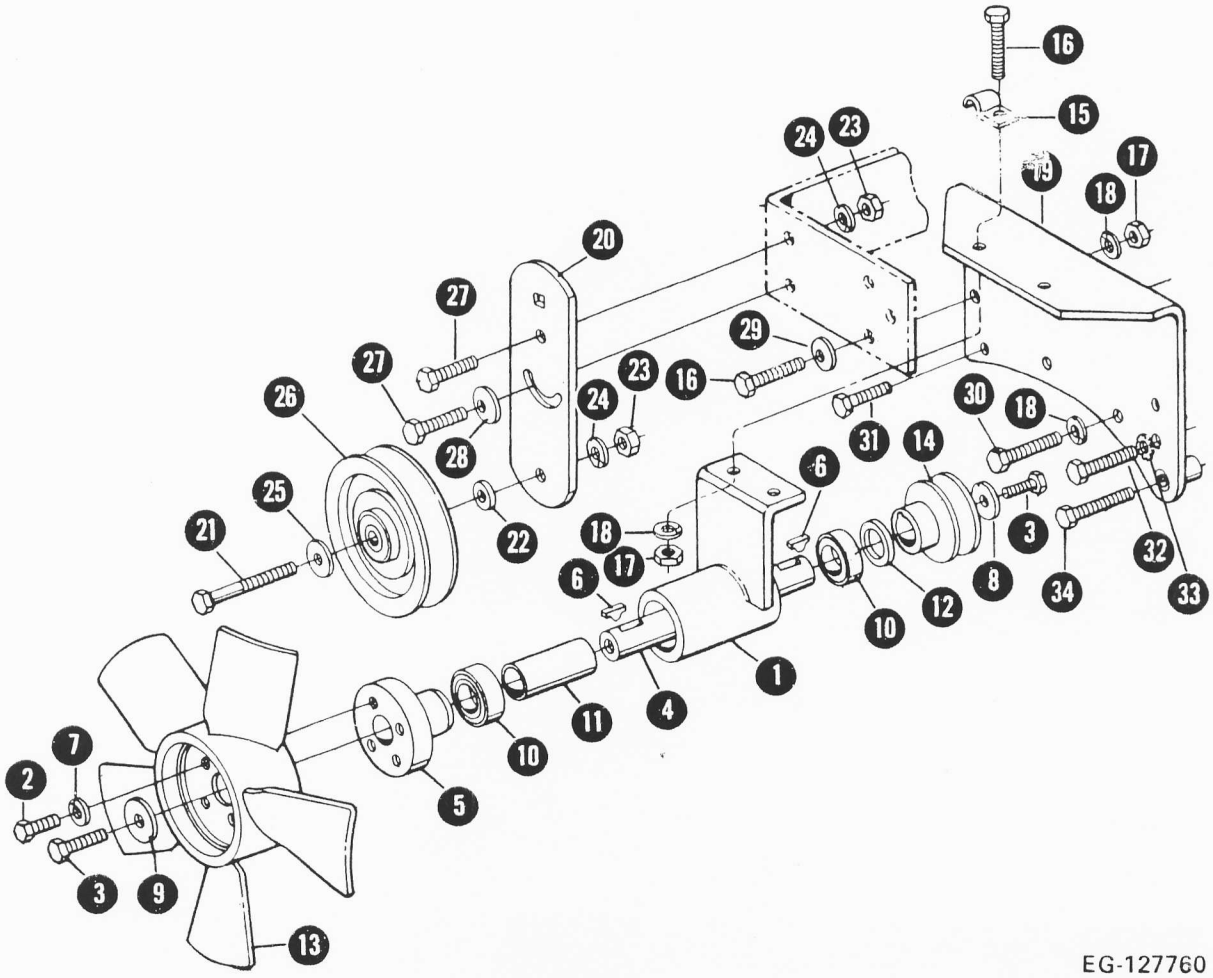
WATER PUMP

The water pump is driven by the crankshaft and a "V" belt. The rotating impeller (4) in the water pump sucks the cooled water from the radiator and sends it into the water jacket in the crankcase.

The mechanical seal (3) prevents the water from entering the bearing unit (1).

COOLING FAN (See Illust. 1-30)

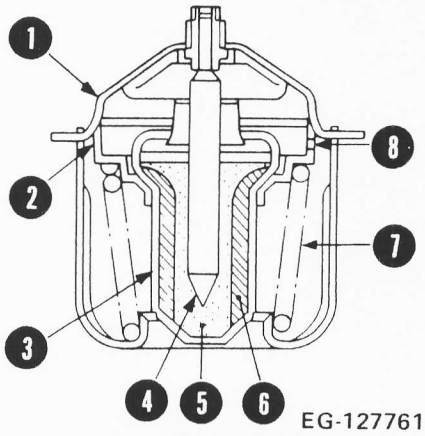
The cooling fan is mounted on a bracket above the flywheel and belt driven from a stub shaft pulley attached to the flywheel. An idler pulley is provided for belt tension.



Illust. 1-30. Cooling fan assembly.

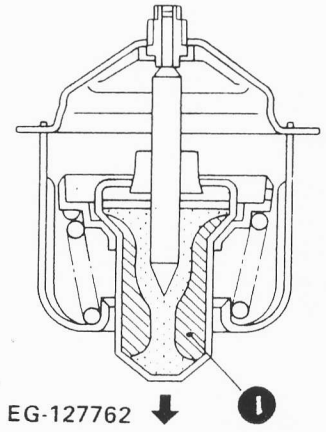
Legend for Illust. 1-30.

1. Fan support	10. Ball bearing	19. Fan mount bracket	27. Bolt
2. Bolt	11. Spacer	20. Idler support bracket	28. Washer
3. Bolt	12. Spacer	21. Bolt	29. Washer
4. Fan shaft	13. Fan	22. Spacer	30. Bolt
5. Fan hub	14. Pulley	23. Nut	31. Bolt
6. Special key	15. Clip	24. Washer	32. Bolt
7. Lock washer	16. Bolt	25. Washer	33. Washer
8. Washer	17. Nut	26. Idler pulley	34. Bolt
9. Washer	18. Lock washer		



Illust. 1-31. Thermostat, valve closed.

1. Seat	5. Synthetic rubber
2. Valve	6. Wax (solid)
3. Pellet	7. Spring
4. Spindle	8. Leak hole



Illust. 1-32. Thermostat, valve open.

1. Wax (liquid)

THERMOSTAT (See Illust. 1-31 and 1-32)
The thermostat is of the wax pellet type.

The thermostat controls the flow of the cooling water to the radiator to keep the proper temperature.

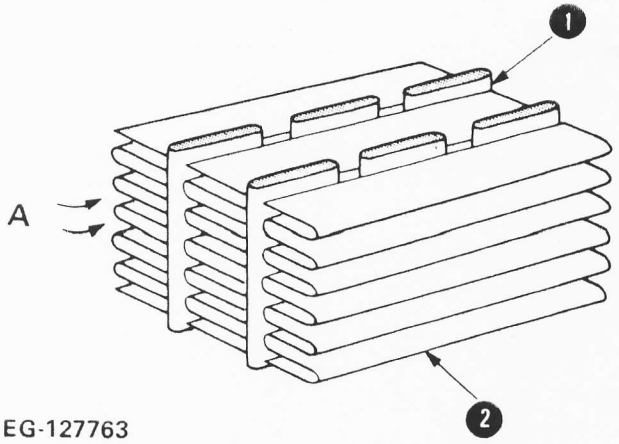
The case, which serves as a valve seat (1), has a spindle inserted in the pellet (3) which is installed to the valve (2). The spindle is covered with the synthetic rubber (5) in the pellet. The wax is charged between the pellet and the rubber.

1) At Low Temperatures (Lower than 82°C [180°F])
The valve (2) is seated by the spring (7) and the cooling water circulates in the engine through the water return pipe without running into the radiator.

Only the air in the water jacket escapes to the radiator through the leak hole (8) on the thermostat.

2) At High Temperatures (Higher than 82°C [180°F])
As the water temperature rises, the wax in the pellet (3) turns liquid and expands, repelling the spindle, which causes the pellet to lower.

The valve (2) opens to send the cooling water to the radiator.



Illust. 1-33. Radiator core.

A. Cooling air
1. Tube
2. Fin

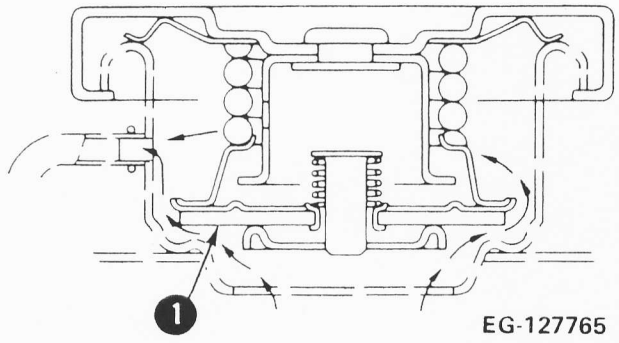
RADIATOR

The radiator core consists of water carrying tubes (1) and fins (2) at a right angle to the tubes. The fin is a louverless corrugated type which is light in weight, high in heat exchange ratio and less apt to clog.

The water in the tubes is cooled by the air flowing through the tube walls and fins.

Illust. 1-34. Radiator fins.

1. Louverless corrugated fin
2. Louvered corrugated fin



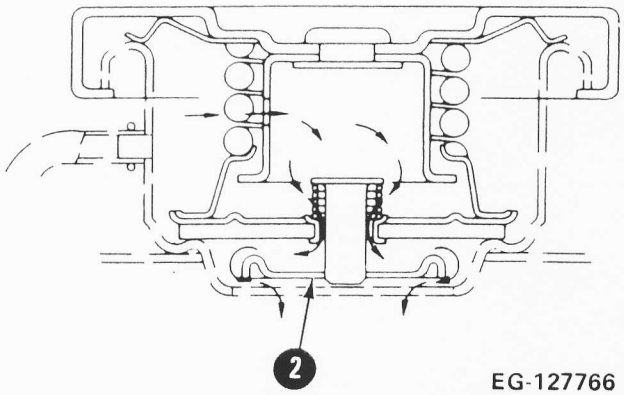
Illust. 1-35. Radiator cap, pressure valve.

1. Pressure valve

RADIATOR CAP

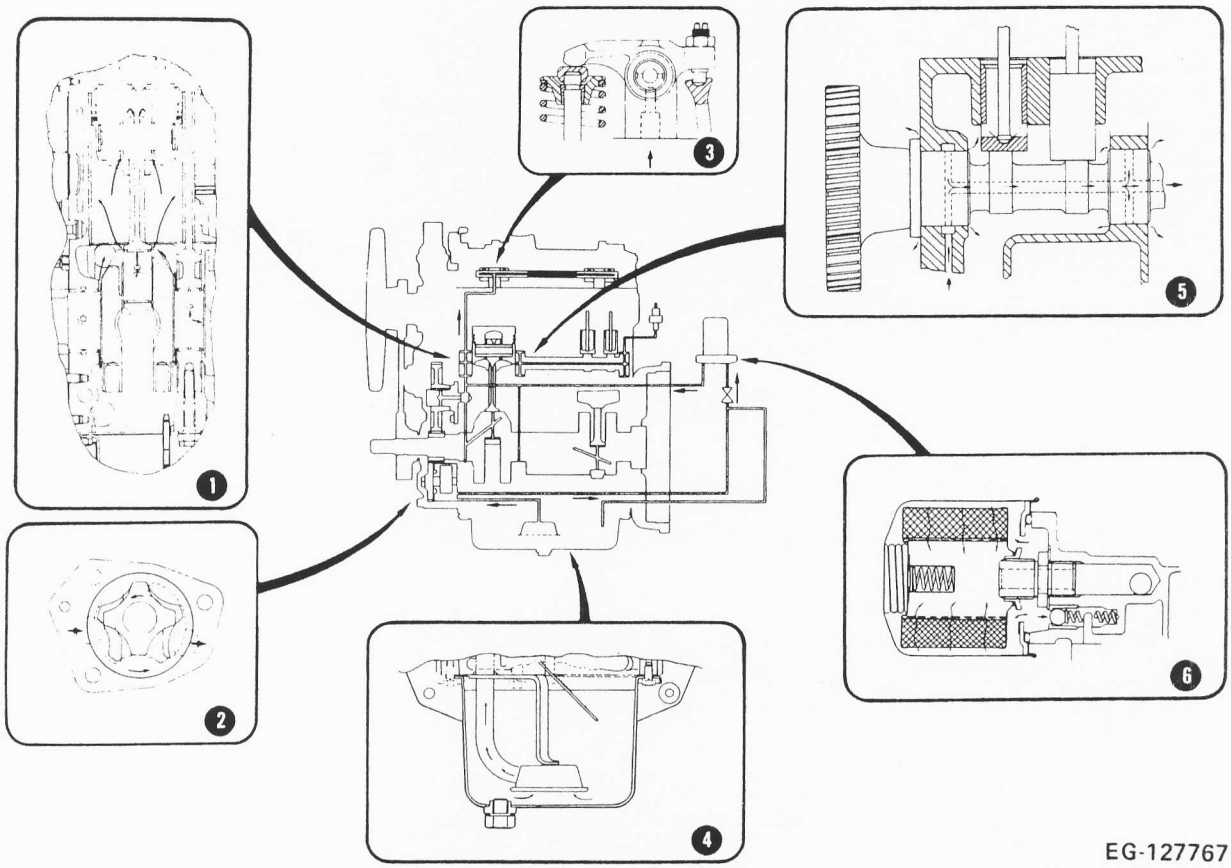
The pressure type radiator cap prevents differences in pressure between the inside and the outside of the radiator.

When the water temperature rises and the pressure in the radiator increases above the specified pressure, the pressure valve (1) opens to reduce the internal pressure. When the water temperature falls and a vacuum forms in the radiator, the vacuum valve (2) opens to introduce air into the radiator.



Illust. 1-36. Radiator cap, vacuum valve.

2. Vacuum valve



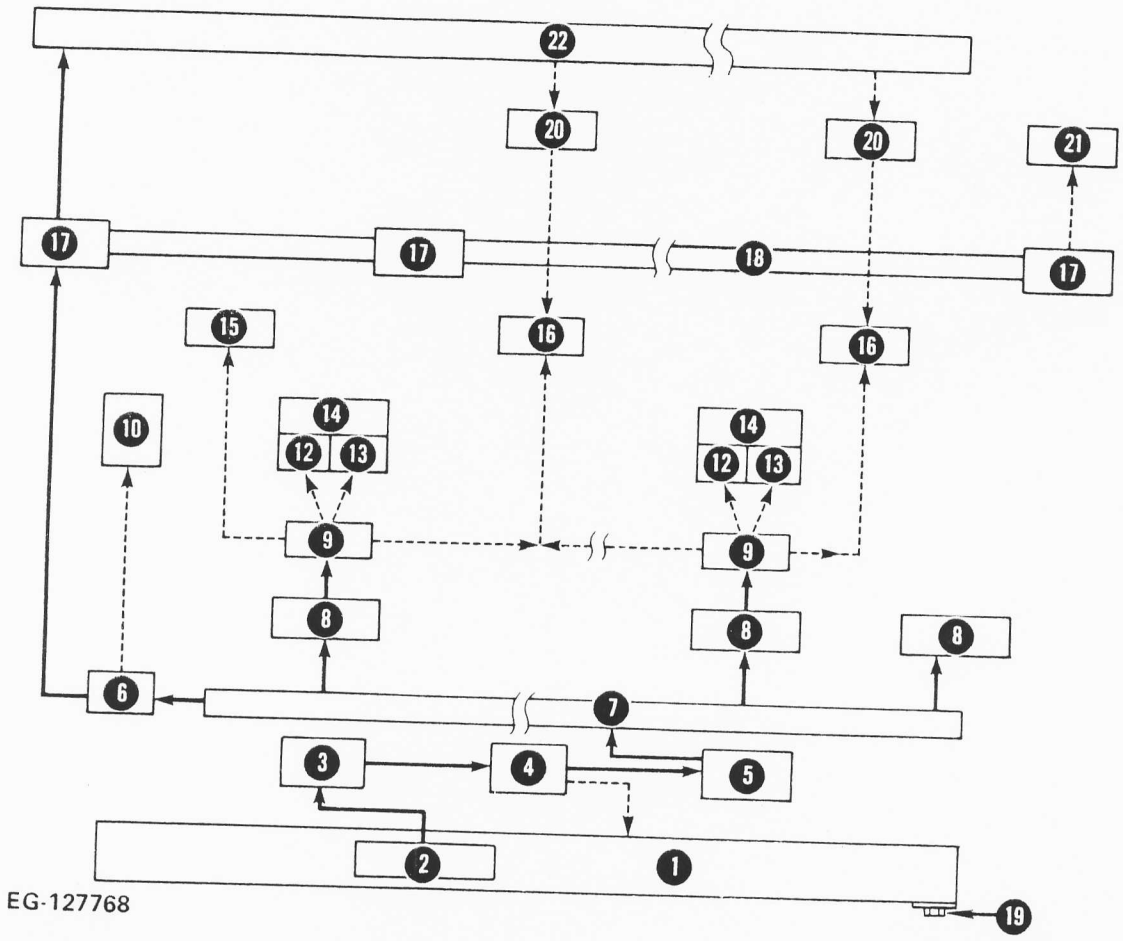
Illust. 1-37. Lubricating system.

1. Piston	4. Oil strainer
2. Oil pump	5. Camshaft
3. Rocker arm and rocker arm shaft	6. Oil filter cartridge and relief valve

The lubricating system consists of an oil strainer, an oil pump, a relief valve, an oil filter cartridge and an oil pressure switch. The oil pump sucks the lubricating oil in the oil pan through the strainer and sends it to the oil filter cartridge, where the oil is further filtered.

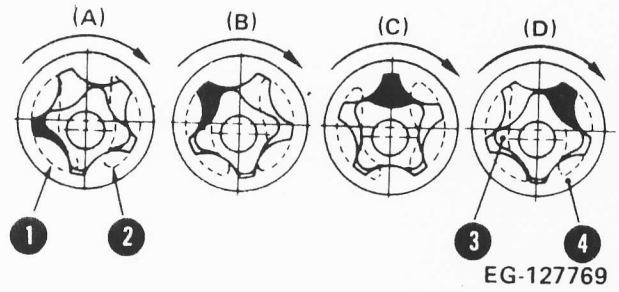
The filtered oil is forced to the crankshaft, the connecting rods, the idle gear, the camshaft and the rocker arm shaft through the oil passage in the crankcase and the shafts to lubricate the bearings.

Some oil, splashed by the crankshaft or thrown off from the bearings, lubricates other engine parts: the pistons, the cylinder walls, the piston pins, the tappets, the pushrods, the timing gears, and the inlet and exhaust valves.



Illust. 1-38. Engine oil flow diagram.

1. Oil pan
2. Oil strainer
3. Oil pump
4. Relief valve
5. Oil filter cartridge
6. Idle gear
7. Main oil gallery
8. Main bearing
9. Connecting rod big end
10. Timing gear
11. Splash
12. Cylinder
13. Connecting rod small end
14. Piston
15. Fuel camshaft
16. Tappets
17. Camshaft bearing
18. Camshaft
19. Drain
20. Rocker arm
21. Oil switch
22. Rocker arm shaft



Illust. 1-39. Oil pump.

1. Inlet port
2. Outlet port
3. Inner rotor
4. Outer rotor

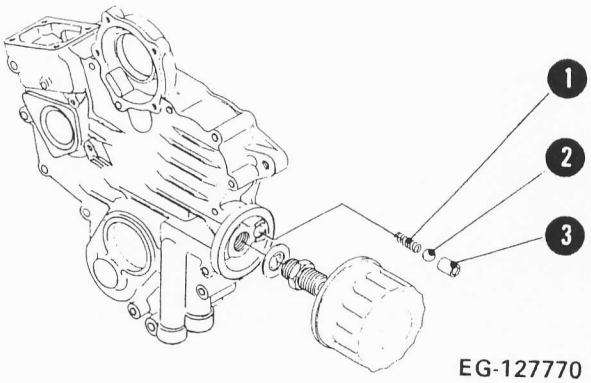
OIL PUMP

The oil pump is a gear pump, whose rotors have trochoid lobes. The inner rotor (3) has 4 lobes and the outer rotor (4) has 5 lobes, and they are eccentrically engaged with each other. The inner rotor, which is driven by the crankshaft through the gears, rotates the outer rotor in the same direction, varying the space between the lobes.

While the rotors rotate from (A) to (B), the space leading to the inlet port increases, which causes the vacuum to suck in the oil from the inlet port.

When the rotors rotate to (C), the connection to the space switches from the inlet port to the outlet port.

At (D), the space decreases and the sucked oil is discharged from the outlet port.



Illust. 1-40. Relief valve.

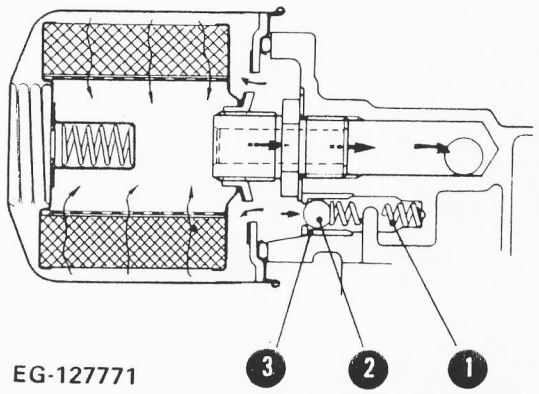
1. Spring
2. Ball
3. Valve seat

RELIEF VALVE

The relief valve prevents damage to the lubricating system due to the high pressure of the oil.

The relief valve is a ball type direct acting one, and is best suited for low pressures.

When the pressure of the oil, forced by the pump, exceeds the specified value, the oil pushes back the ball (2) and escapes to the oil pan.



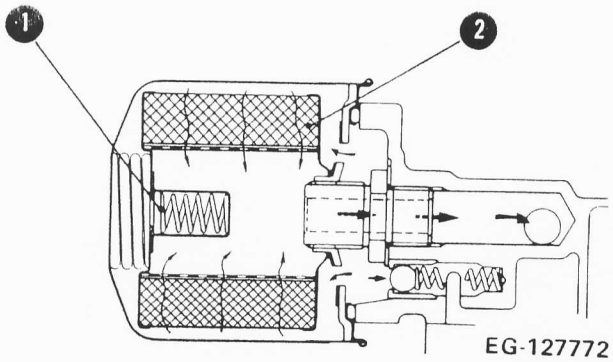
Illust. 1-41. Relief valve.

1. Spring
2. Ball
3. Valve seat

OIL FILTER CARTRIDGE

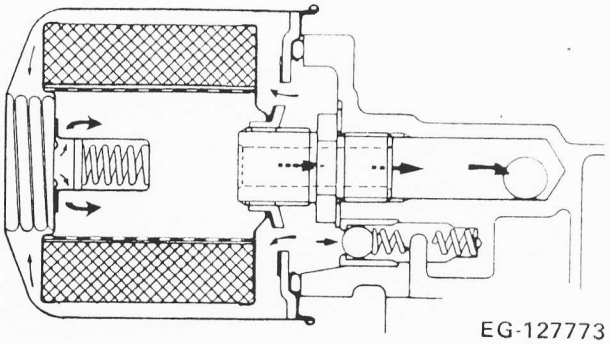
After lubricating, the lubricating oil brings back various particles of grit and dirt to the oil pan. Those particles and the impurities in the lubricating oil can cause wear or seizure of the engine parts. It may also impair the physical and chemical properties of the oil itself.

The lubricating oil, which is force-fed by the pump, is filtered by the filter cartridge with the filter element (2). When the filter element accumulates an excessive amount of dirt and the oil pressure in the inlet line builds up by 14 psi more than the outlet line, the by-pass valve (1) opens to allow the oil to flow from the inlet into the outlet line, by-passing the filter element.



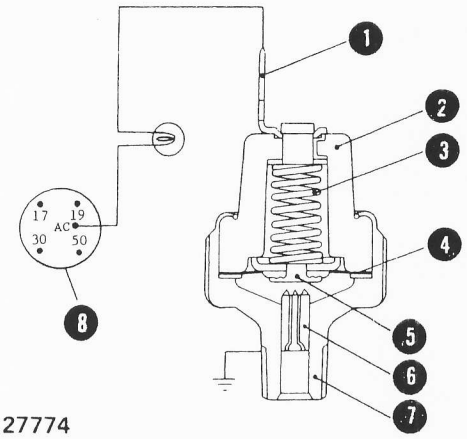
Illust. 1-42. By-pass valve - closed.

1. By-pass valve
2. Filter element



Illust. 1-43. By-pass valve - opened.

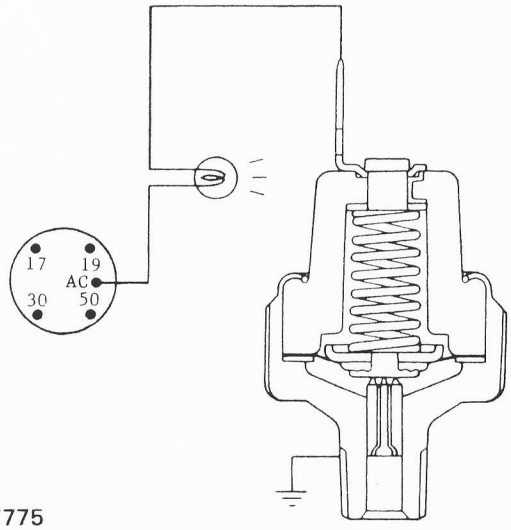
[A]



EG-127774

Illust. 1-44. Oil pressure switch at proper oil pressure.

[B]



EG-127775

Illust. 1-45. Oil pressure switch at 7 psi or lower pressure.

OIL PRESSURE SWITCH

The oil pressure switch is mounted on the crankcase and is led to the lubricating oil passage.

When the oil pressure falls below the specified value, the oil pressure warning lamp lights.

A. At the proper oil pressure
B. At lower oil pressure, 7 psi or less
1. Terminal
2. Insulator
3. Spring
4. Rubber gasket
5. Contact rivet
6. Contact
7. Oil switch body
8. Key switch

Alternator Belt

REMOVAL

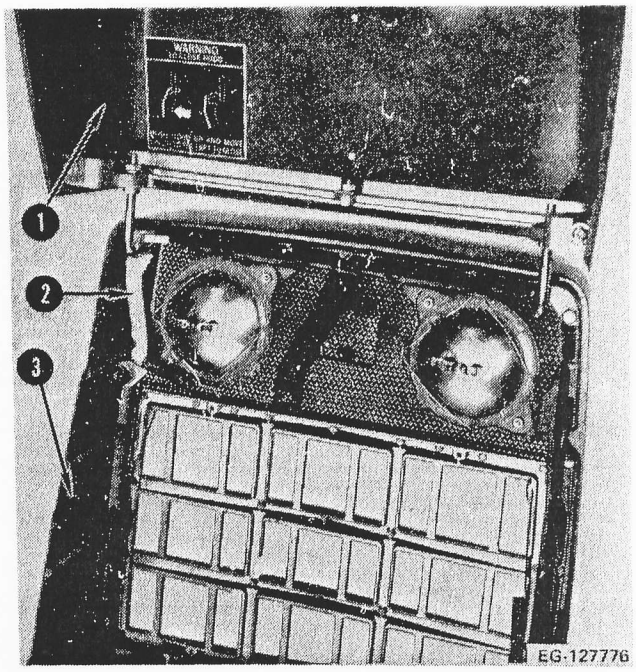
To replace the alternator belt, it is necessary to disconnect the drive shaft and move the engine and radiator mount forward. Use the following procedure:

1. Raise the hood and remove the side panels. See Illust. 1-46.

2. Disconnect the battery ground cable from the battery.

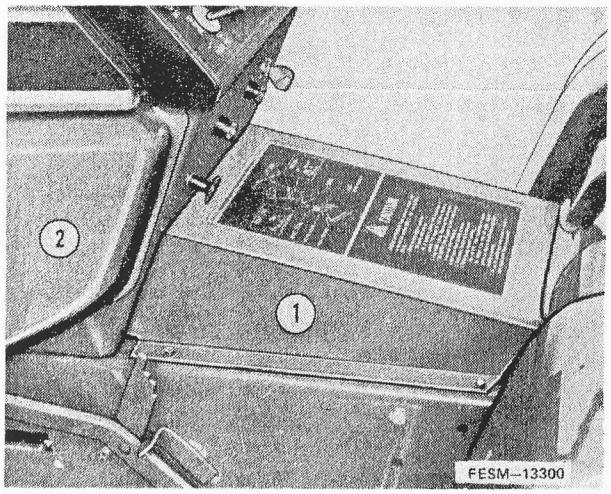
3. Remove the nut and washer securing the radiator support to the radiator.

4. Disconnect the headlight wiring and remove the hood and grille as an assembly.



Illust. 1-46. Hood latch.

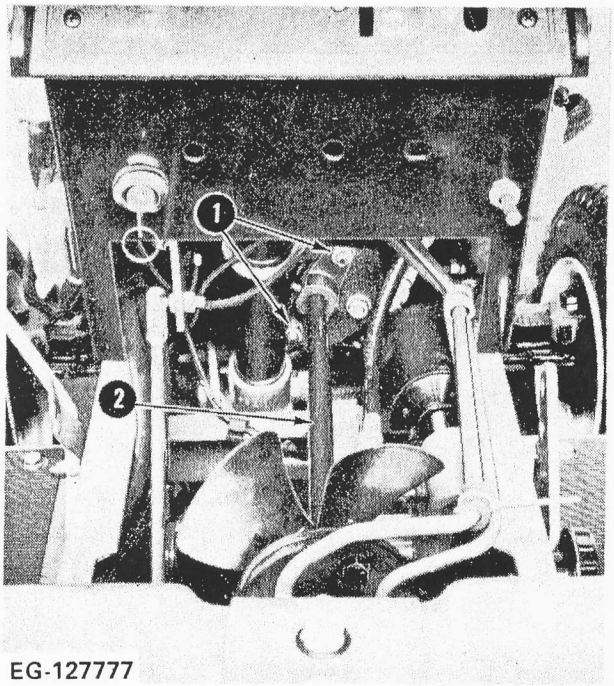
1. Hood
2. Latch
3. Radiator and grille support



Illust. 1-47. Frame cover and side panel.

1. Frame cover
2. Engine side panel

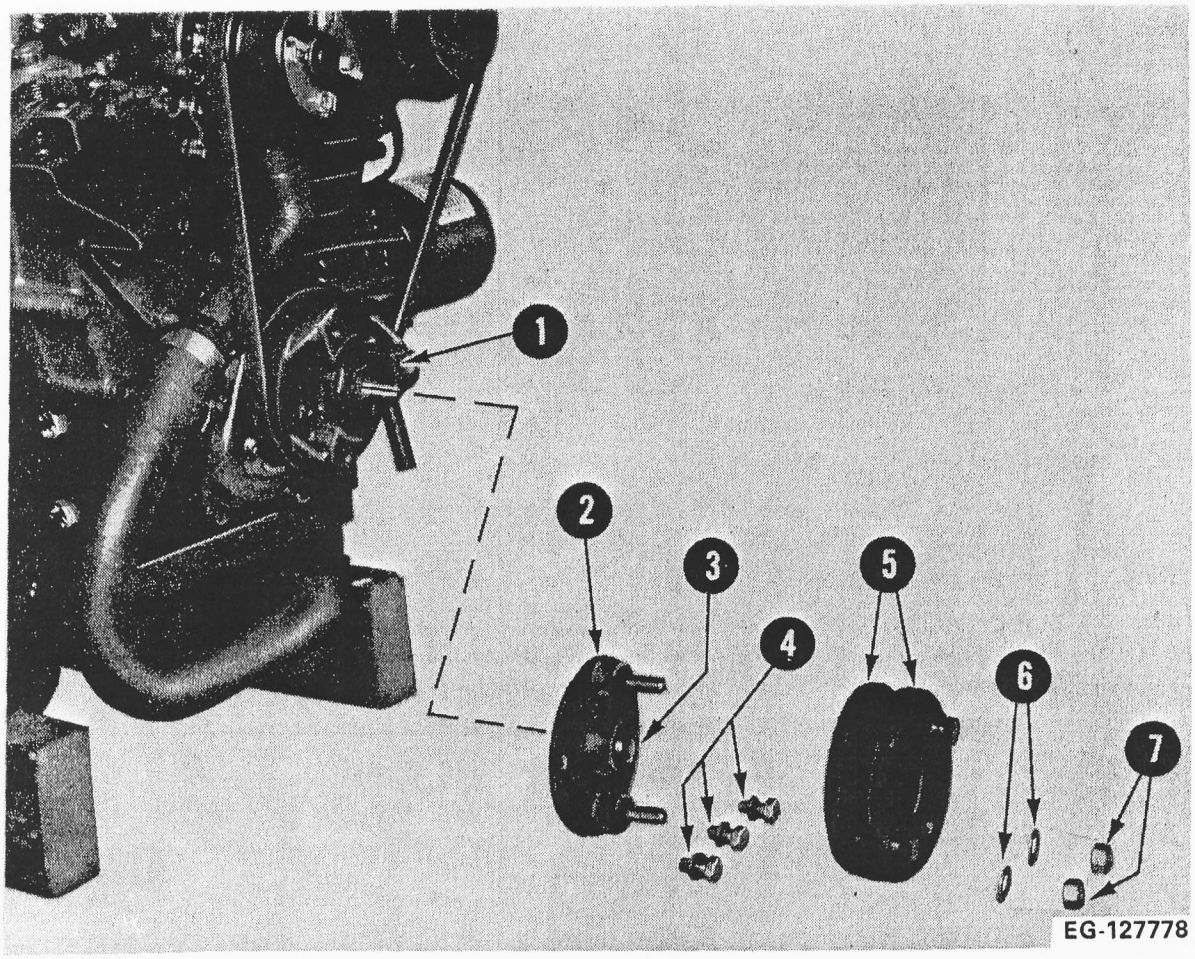
5. Remove the frame cover. See Illust. 1-47.



Illust. 1-48. Drive shaft.

1. Flange nuts
2. Drive shaft

6. Working through the frame cover opening, remove two nuts (1, Illust. 1-48) securing the drive shaft (2) to the drive shaft flange on the crankshaft pulley. See Illust. 1-49.

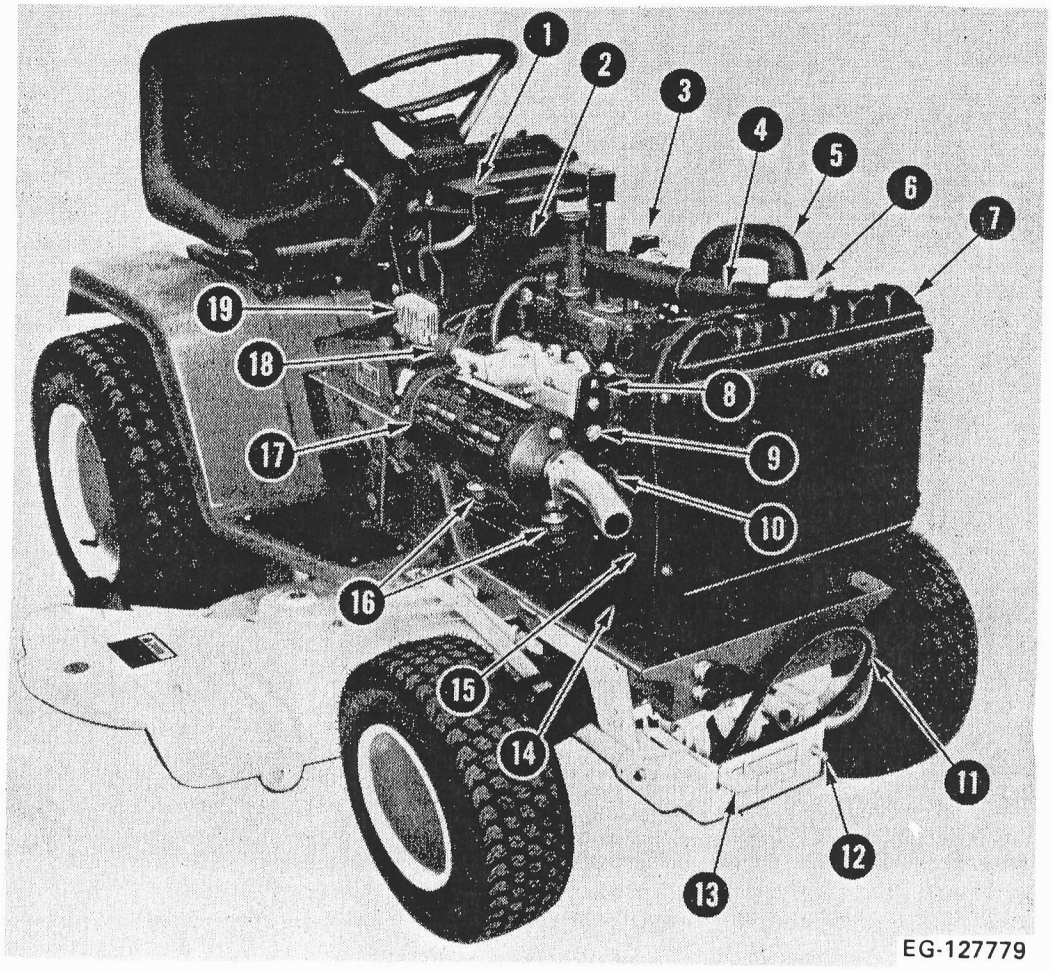


Illust. 1-49. Drive shaft flange and flexible coupling.

1. Crankshaft pulley
2. Drive shaft flange
3. Pilot bearing
4. Flange attaching bolts and washers
5. Flexible discs
6. Washer
7. Nut

7. Slacken the tension on the main drive belt (11, Illust. 1-50) and slip the belt from the power take-off pulley.

8. Disconnect the regulator (19) to alternator (18) wiring connector. Check that there is enough slack in wiring to starter, glow plugs, and sending units to allow engine to move forward for belt removal.

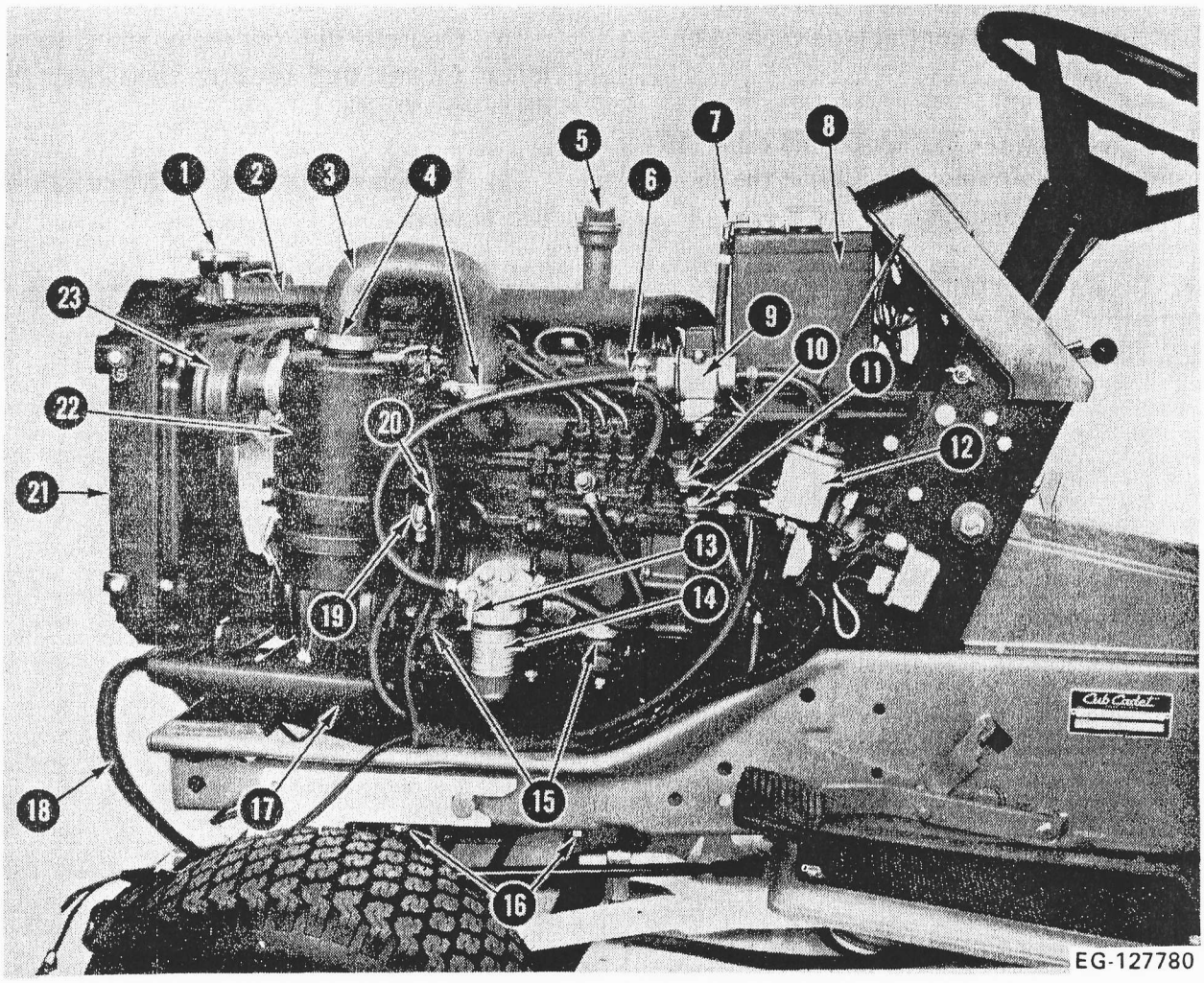


Illust. 1-50. Right front view of 782D Tractor with sheet metal removed.

1. Battery cover
2. Battery
3. Electric fuel pump
4. Upper radiator hose
5. Air cleaner hose
6. Radiator cap
7. Radiator
8. Idler pulley bracket
9. Bolt
10. Starter
11. Main drive belt for mower
12. Tension bolt
13. Idler pulley bracket for mower
14. Engine and radiator mount
15. Flywheel
16. Engine mounts
17. Muffler
18. Alternator
19. Regulator

9. Close the fuel shut-off valve at the fuel tank.

10. Close the fuel shut-off valve (13, Illust. 1-51) at the secondary fuel filter (14).



Illust. 1-51. Power unit and components.

1. Radiator cap
2. Upper radiator hose
3. Air cleaner hose
4. Air cleaner hose clamps
5. Oil filler cap
6. Fuel hose
7. Battery ground cable
8. Battery
9. Electric fuel pump
10. Engine stop lever and cable
11. Engine speed control lever and cable
12. Primary fuel filter
13. Fuel shut-off valve
14. Secondary fuel filter
15. Engine mounts
16. Engine and radiator mount attaching bolts
17. Engine and radiator mount
18. Main drive belt
19. Battery ground cable
20. Ground-to-frame cable
21. Radiator
22. Air cleaner
23. Pre-cleaner

11. Disconnect the fuel hose (6) at the electric fuel pump (9). Plug both openings.

12. Disconnect the engine stop lever cable (10) and engine speed control lever cable (11) at the levers.

13. Disconnect the battery ground cable (19) and the ground-to-frame cable (20) at the air cleaner mounting bracket.

14. Remove four bolts (16) and washers securing the engine and radiator mount to the tractor frame.

15. Cut the plastic tie which binds the lower radiator hose to the hydraulic hoses underneath the tractor.

16. Carefully slide the engine and radiator mount forward until the drive shaft clears the drive shaft flange.

17. Replace the alternator belt and adjust belt tension.

18. Reassemble in reverse order of disassembly.

Starter

REMOVAL

To replace the starter, it is necessary to remove the engine from the tractor. See "Engine Removal" page 1-45.

PTO Clutch Assembly

REMOVAL

To remove PTO clutch assembly with engine mounted in the chassis, it is necessary to separate the clutch so that the parts will clear the engine and radiator mount.

ENGINE REMOVAL

1. Park the tractor on a flat level surface.

2. Close the shut-off valve at the fuel tank.

3. Raise the hood. See Illust. 1-46.

4. Remove the battery cover (1, Illust. 1-50). Disconnect the battery cables and remove the battery. Slip the two battery cover hold-down bolts out of the battery tray.

5. Unhook the side panel spring (2, Illust. 1-46).

6. Remove the wing nut and washer securing each panel to the chassis.

NOTE: Lock the brake pedal in the "down" position for ease of side panel removal. The exhaust manifold side panel must be "worked" out of position.

7. Disconnect headlight wiring.

8. Remove nut and washer securing grille support to radiator bracket.

9. Support hood and grille assembly and remove two bolts and lock washers securing each side of grille support to the tractor frame.

10. Carefully lift hood and grille assembly from the tractor. Slide the two nut plates from the grooves in the grille support.

11. Remove the nut from the belt tension bolt (12, Illust. 1-50). Push back on the spring loaded pulley and slip the main drive belt (11) off of the PTO pulley.

NOTE: Position fan blade correctly to slip belt from PTO pulley.

12. Disconnect positive cable from starter solenoid terminal. Disconnect switch spade from solenoid terminal.

13. Remove nut and washer from alternator's lower mounting bolt securing the wire cable holder to the engine. Remove wire holder and cable assembly.

NOTE: Loosely re-install nut and washer on engine.

14. Remove the screw securing the wire to the oil sending unit terminal. Remove the wire and re-install the screw.

15. Disconnect the two blue alternator wires from the wiring connectors in the wiring harness.

16. Loosen hose clamps and remove inlet and outlet fuel hose (6, Illust. 1-51) from the fuel pump (9). Disconnect and remove fuel hoses from the primary fuel filter (12). Cap all hoses and inlet and outlet openings.

17. Disconnect fuel pump positive wire from the connector.

18. Remove one bolt and lock washer from each side of the battery tray lower mounting position. Remove one bolt and flat washer from each side of the battery tray upper mounting (slotted hole) position.

19. Lift out the battery tray with the attached fuel pump, regulator and circuit breaker. Tie off to the side of the tractor.

20. Remove the battery-to-ground cable (19, Illust. 1-51), and ground-to-frame cable (20) at the air cleaner bracket.

NOTE: The bolts that secure the ground cables to the air cleaner bracket also secure the air cleaner, so that the air cleaner is now loose.

21. Loosen the hose clamp (4) securing the air cleaner hose (3) to the engine intake manifold and remove the air cleaner assembly.

22. Disconnect the water temperature sending unit, glow plug and PTO wiring from their terminals and connections.

23. Remove the engine stop lever cable (10) and engine speed control lever cable (11) from the levers. Remove the cable hold-down clips.

NOTE: The top lever (engine stop lever [10]) has a swivel connection, and the attaching nut is at the top of the lever. The lower lever (engine speed control lever [11]) is wire connected and the attaching nut is at the bottom of the lever.

24. Disconnect the fuel return line from the forward cylinder injector (No. 3 cylinder). Slide out of plastic tie and plug openings.

25. From underneath the tractor, clip the plastic tie that binds the lower radiator hose and hydraulic hoses to the engine and radiator mount.

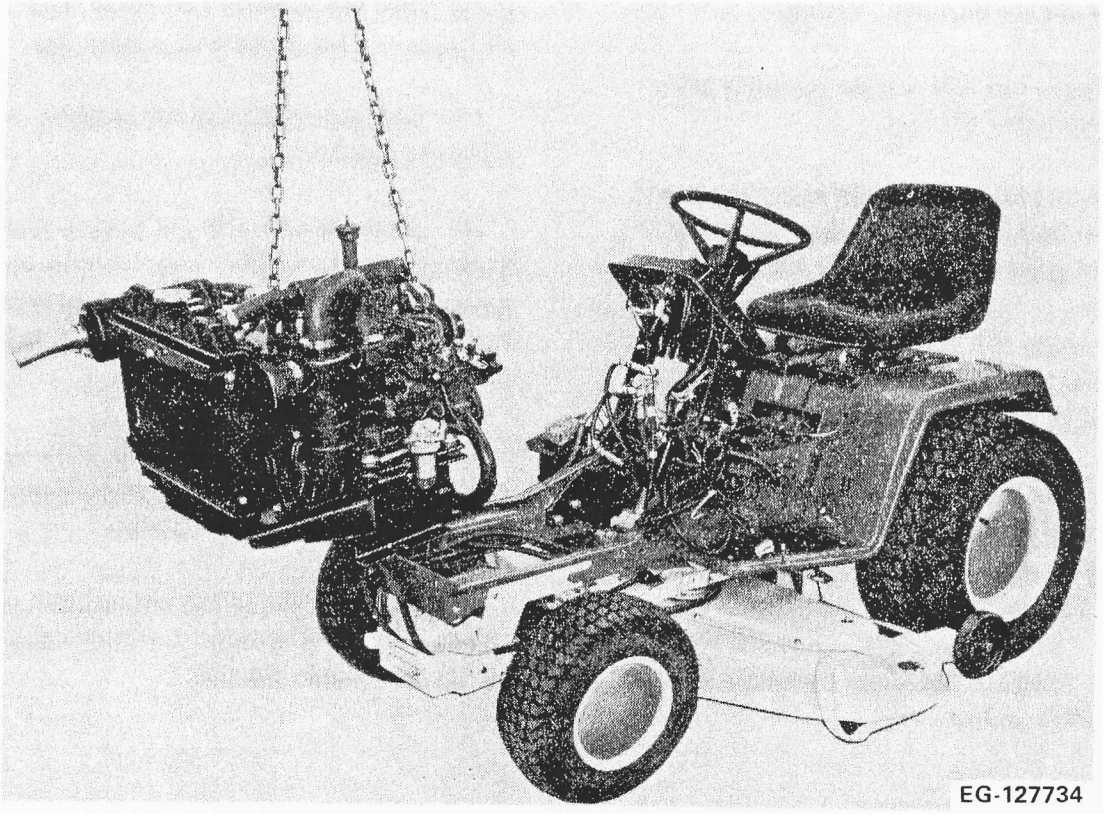
26. Remove the frame cover (1, Illust. 1-47).

27. Working through the frame cover opening, remove two nuts (1, Illust. 1-48) and washers securing drive shaft to the drive shaft flange on the crankshaft pulley.

28. Attach a suitable hoist and chain to the engine lifting eyes.

29. Remove four bolts (16, Illust. 1-51) and washers securing the engine and radiator mount (17) to the tractor frame.

30. Slide the engine and radiator mount forward to disengage the drive shaft. Raise the assembled power unit from the tractor chassis. See Illust. 1-52.



Illust. 1-52. Power unit removed from chassis.

POWER UNIT DISASSEMBLY

1. Support the power unit on suitable blocking on a stable work bench (refer to Illust. 1-53). Leave the hoist attached to the engine.

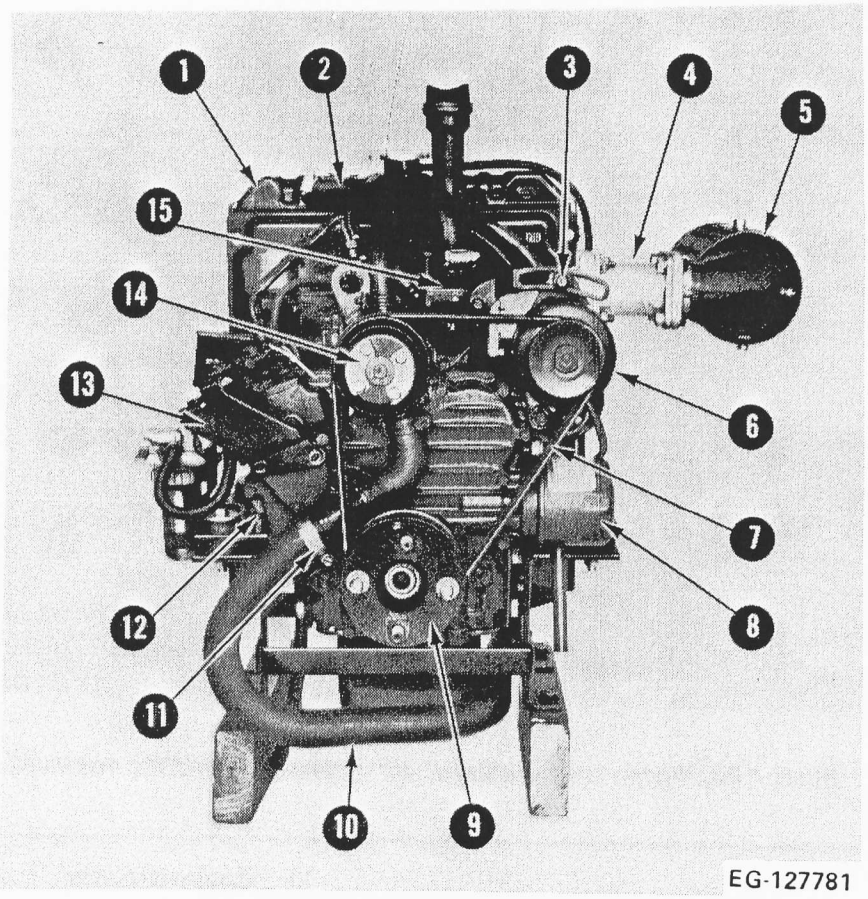
2. Remove the radiator cap and drain the radiator (1) and open the engine block drain cock (12).

3. Loosen the clamps on the radiator upper hose (2) and remove the upper hose.

4. Loosen the clamp on the lower radiator hose (10) at the radiator (1) and water pump outlet. Remove the lower hose.

5. Loosen the two radiator mounting bolts. Support the radiator and remove the bolts and radiator with screen.

6. Slide the flexible coupling (9) from the drive shaft flange on the crankshaft pulley. Remove the drive shaft flange from the crankshaft.



Illust. 1-53. Power unit removed - gear case end of engine facing forward.

1. Radiator	6. Alternator	11. Hose clamp
2. Radiator upper hose	7. Alternator belt	12. Block drain cock
3. Alternator adjusting bolt	8. Oil filter	13. Cable support bracket
4. Exhaust extension	9. Flexible coupling	14. Water pump pulley
5. Muffler	10. Lower radiator hose	15. Thermostat housing

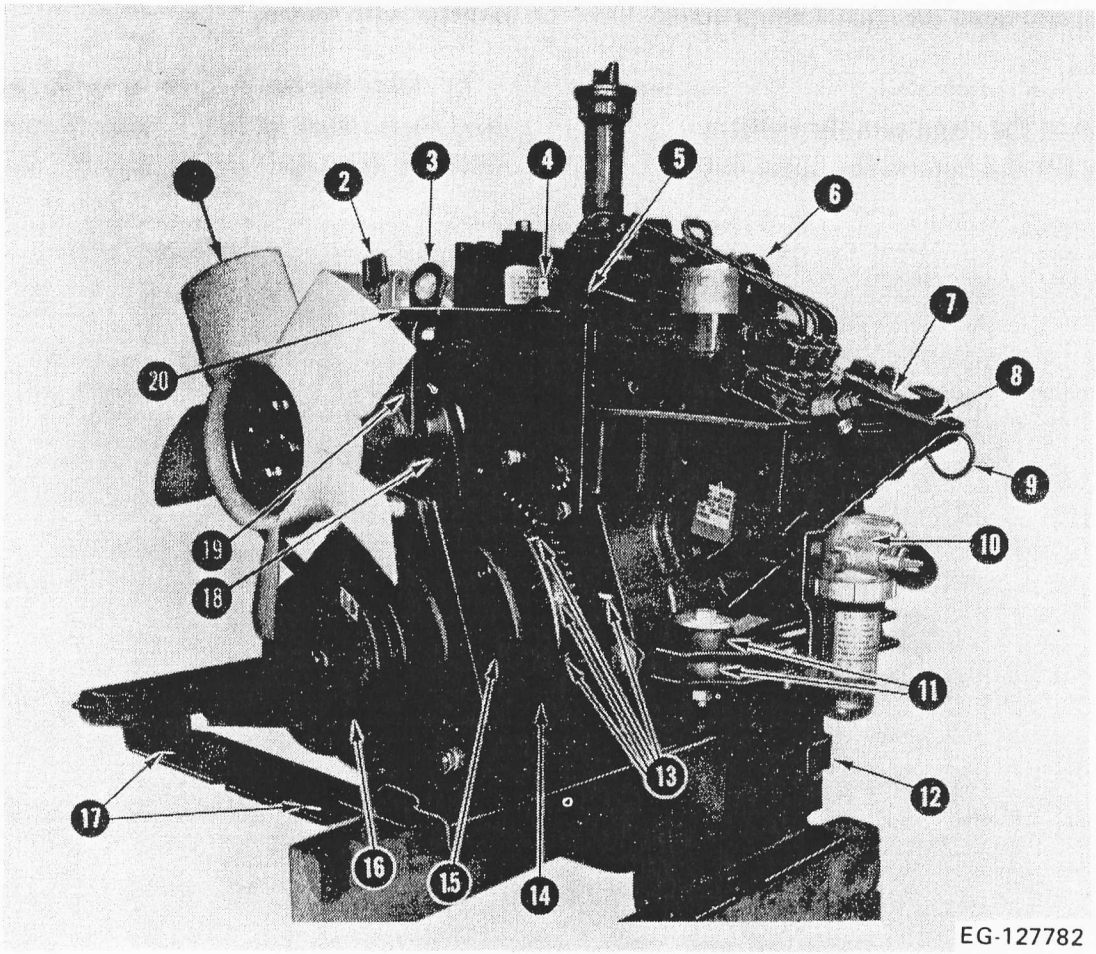
7. Loosen the alternator adjusting bolt (3) and remove the alternator belt (7).

8. Disassemble the muffler (5) from the exhaust extension (4).

9. Loosen the fan drive idler pulley and slip the fan belt off of the fan drive pulley (18, Illust. 1-54).

NOTE: Although the fan faces the front of the tractor, for rebuilding and servicing procedures, this is the rear of the engine.

10. Remove the bolts and nuts securing the fan and fan drive support (19) to the support bracket (20). Set the assembly aside.



Illust. 1-54. Power unit - radiator, air cleaner and muffler removed.

1. Fan blade
2. PTO electrical connector
3. Lifting eye
4. Water temperature sending unit
5. Fuel return line fitting
6. Lifting eye
7. Engine stop lever
8. Engine speed control lever
9. Engine oil dipstick
10. Secondary fuel filter
11. Engine mounts
12. Engine and radiator mount
13. Timing marks
14. Flywheel
15. Stub shaft
16. PTO clutch assembly
17. Radiator mounting holes
18. Fan drive pulley
19. Fan drive support
20. Support bracket

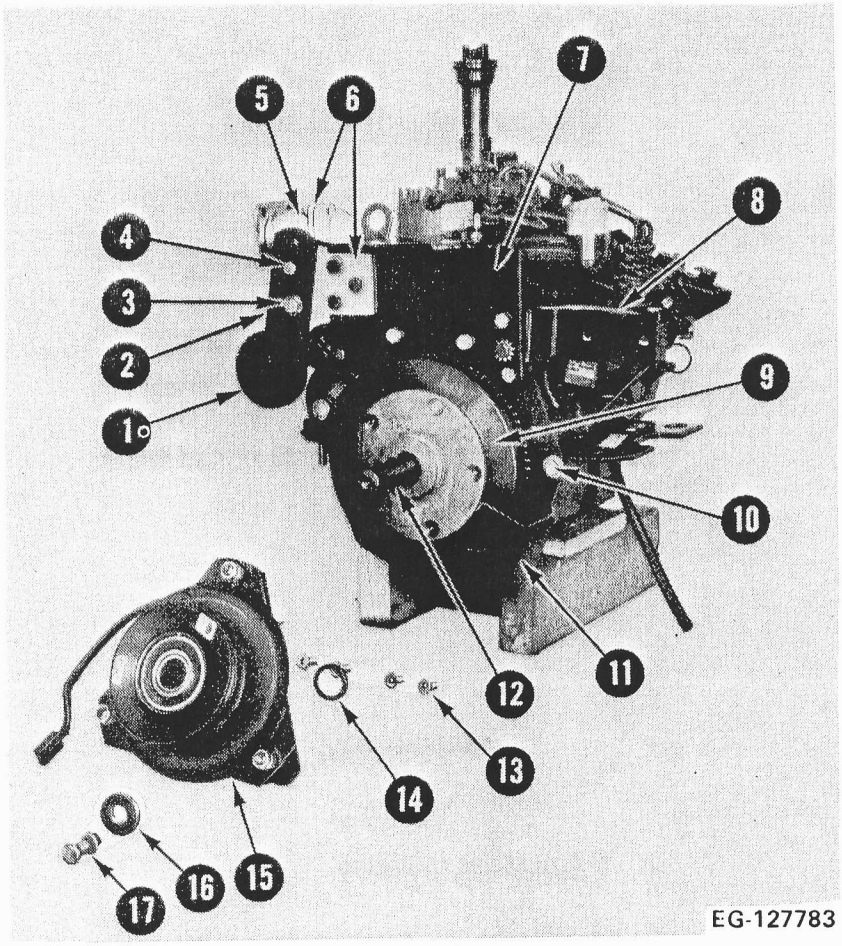
11. Lock the crankshaft by inserting a bar between the two drive shaft flange bolts at the front of the engine. Loosen, but do not remove, the bolt and washer securing the PTO clutch assembly (16) to the stub shaft (15).

12. Support the engine again with the hoist. Remove the mounts (11) on each side of the engine and raise the engine out of the engine and radiator mount (12). Remove the secondary fuel filter (10), and left and right engine mounting plates.

13. Drain the engine oil and re-block the engine on suitable blocking on a stable work bench.

14. Remove the PTO clutch assembly (15, Illust. 1-55), fan belt and spacer (14).

15. Remove five screws (13) securing stub shaft (12) to flywheel (9) and remove stub shaft.



Illust. 1-55. Engine with PTO clutch assembly removed.

1. Idler pulley
2. Idler pulley bracket
3. Adjusting lock bolt
4. Pivot bolt
5. Exhaust extension
6. Muffler support bracket
7. Fan drive support bracket
8. Air cleaner bracket
9. Flywheel
10. Bolt
11. Torque bracket
12. Stub shaft
13. Screw
14. Spacer
15. PTO clutch assembly
16. Flat washer
17. Bolt and lock washer

16. Remove idler pulley and bracket (2).

17. Separate exhaust extension (5) from muffler support bracket (6).

18. Remove muffler support bracket (6) from fan drive support bracket (7).

Cleaning and Inspection

1. Clean all parts in cleaning solvent.

2. Inspect bearings, pulleys, shafts, keys and keyways for wear. Replace as necessary.

3. Inspect brackets for cracks or bad welds. Replace as necessary.

Reassembly

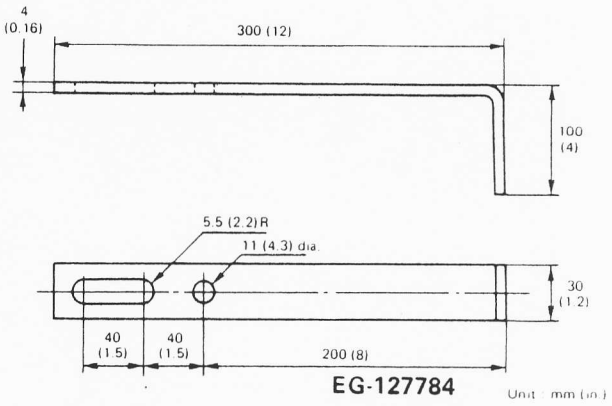
1. Lubricate as required.

2. Reassemble in reverse order of disassembly.

Engine Stands

1. Prepare the engine stands, if desired, referring to Illust. 1-56.

2. Bolt the engine stands to the engine plate mounting holes on the engine.



Illust. 1-56. Engine stands.

External Components

NOTE: Drain engine cooling system and engine oil as outlined under "Engine Removal." Cover all openings and pressure clean the exterior of the engine to facilitate disassembly and inspection.

CYLINDER HEAD

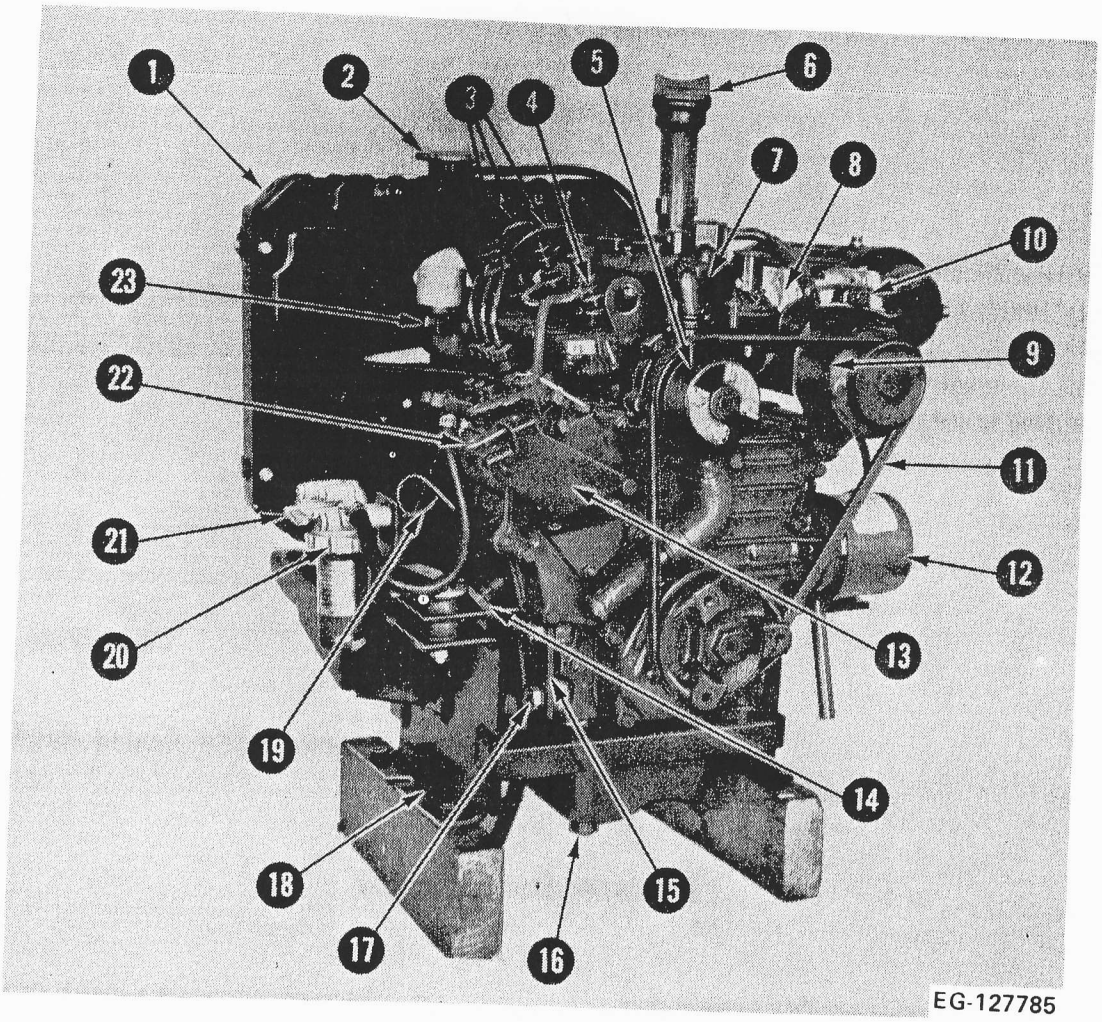
1) Injection Pipes, Intake and Exhaust Manifold and Cylinder Head Cover

1. Remove the injection pipes, overflow pipes and the nozzle holders (4, Illust. 1-57).

2. Remove the intake manifold (23) and the exhaust manifold (8).

3. Remove the cylinder head cover (7).

4. Remove the alternator (9) and the oil filter cartridge (12).



Illust. 1-57. Power unit.

1. Radiator
2. Radiator cap
3. Injection tubes
4. Nozzle holder
5. Water pump
6. Oil port fill plug
7. Cylinder head cover
8. Exhaust manifold
9. Alternator
10. Adjusting bolt
11. Alternator belt
12. Oil filter cartridge
13. Cable support
14. Block drain cock
15. R.H. engine plate
16. Oil drain plug
17. Mounting bolt
18. Engine and radiator mount
19. Dipstick
20. Secondary fuel filter
21. Radiator drain cock
22. Fuel injection pump
23. Intake manifold

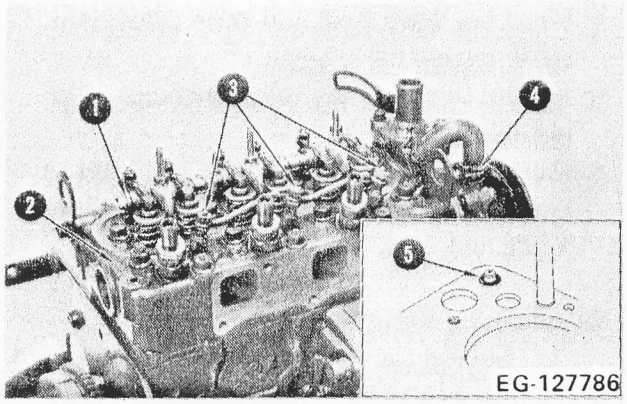
When reassembling:

- Apply engine oil to the head cover nuts.

Tightening torque	Injection pipe nut	18.1 to 25.3 ft-lbs
	Overflow pipe nut	14.5 to 18.1 ft-lbs
	Head cover nut	2.9 to 4.3 ft-lbs
	Nozzle holder	36.2 to 50.6 ft-lbs

2) Rocker Arm and Cylinder Head

1. Remove the glow plugs (3, Illust. 1-58).



Illust. 1-58. Cylinder head and O-ring location.

1. Rocker arm shaft assembly
2. Cylinder head
3. Glow plug
4. Hose clamp
5. O-ring

2. Remove the rocker arms and shaft assembly (1).

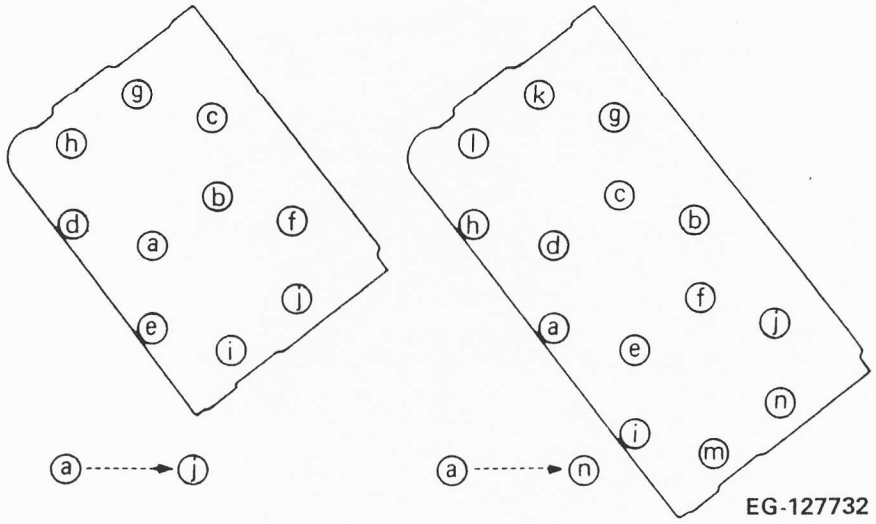
3. Remove the push rods and tappets.

4. Loosen the hose clamp (4), and remove the screws, the nuts and the cylinder head (2).

When reassembling:

- Be sure to place the O-ring (5, Illust. 1-58).
- Apply engine oil to the head screws and nuts. Tighten them in the specified sequence (refer to Illust. 1-59), in several steps and to the specified torque.
- After tightening all the screws and the nuts, run the engine until it warms up and tighten them again to the specified torque.

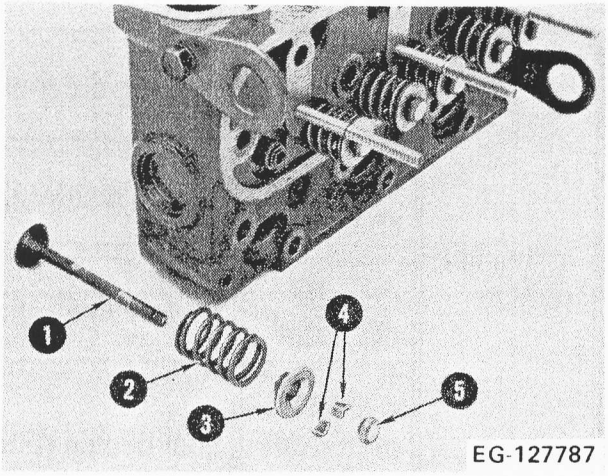
Tightening torque	Glow plug	14.5 to 18.1 ft-lbs
	Rocker arm nut	7.23 to 8.32 ft-lbs
	Cylinder head stud	17.4 to 20.3 ft-lbs
	Cylinder head screw and nut	28.9 to 32.5 ft-lbs



Illust. 1-59. Cylinder head tightening sequence.

3) Valve

1. Remove the valve cap (5, Illust. 1-60) and the valve spring collets (4), compressing the valve spring (2) with the valve spring retainer (3).



Illust. 1-60. Cylinder head and valve parts.

1. Valve
2. Valve spring
3. Valve spring retainer
4. Collet
5. Valve cap

2. Remove the valve spring retainer (3) and the valve spring (2).

When reassembling:

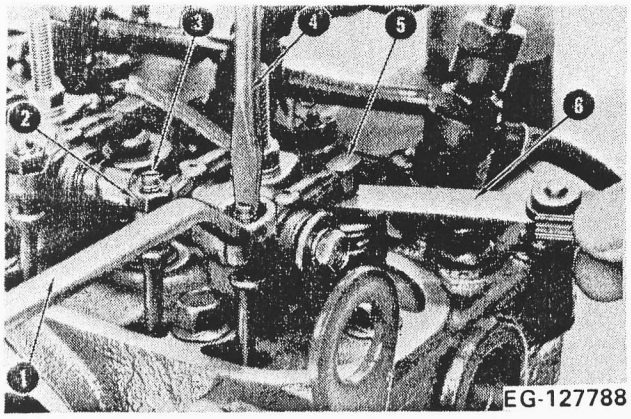
- Clean the valve stem and valve guide, and apply engine oil to them.
- Be sure to adjust the valve clearance after installing the valve.
- Be sure to lap the valve on its seat after replacing the valve, referring to "Correcting Valve and Seat."

4) Adjusting Valve Clearance

1. Loosen the locknut (2, Illust. 1-61) and the adjusting screw (3) on the rocker arm (5).

2. Turn the adjusting screw to adjust the valve clearance at the top dead center (T.D.C.) during compression stroke of the piston.

3. Tighten the locknut and check the valve clearance again after several turns of the flywheel.

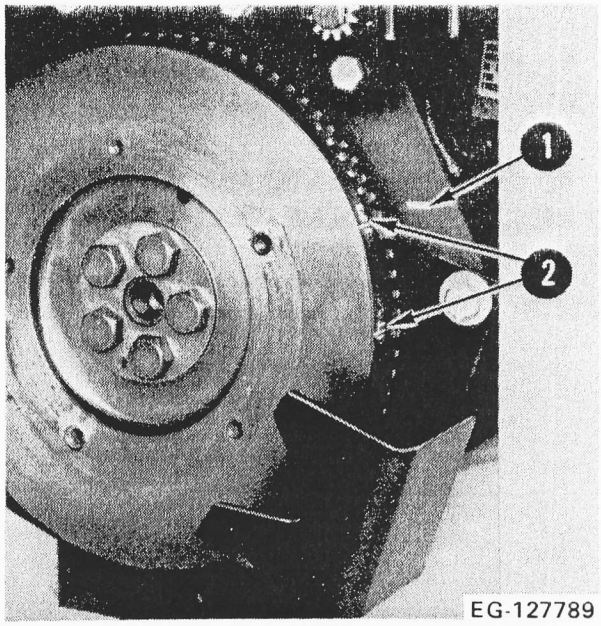


Illust. 1-61. Adjusting valve clearance.

1. Box wrench
2. Locknut
3. Adjusting screw
4. Screwdriver
5. Rocker arm
6. Feeler gauge

NOTE: To get T.D.C. of piston, find its "TC" mark on the flywheel and align it with the timing mark on plate (1, Illust. 1-62).

Valve clearance	Factory specification	0.00571 to 0.00728 in.



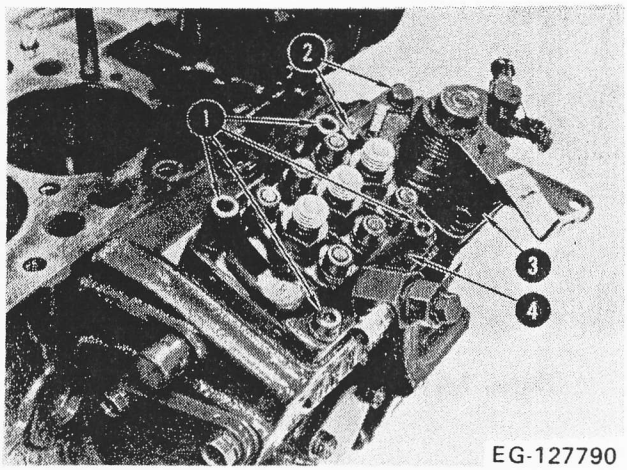
Illust. 1-62. Timing marks.

1. Timing mark on plate
2. Flywheel markings

INJECTION PUMP AND SPEED CONTROL PLATE

1. Remove the socket head screws (1, Illust. 1-63) and remove the injection pump (4).

2. Remove the bolts (2) with copper washers securing the speed control plate (3) to the engine.



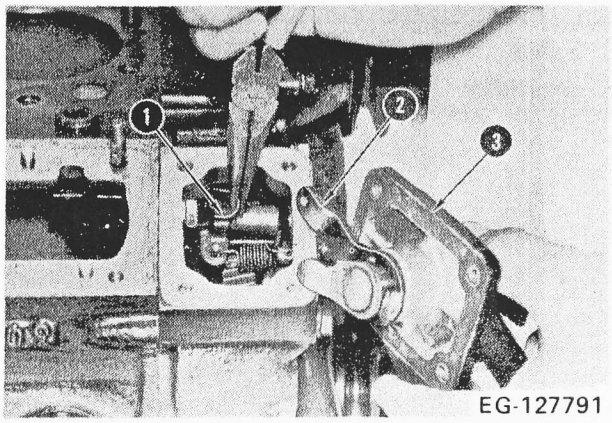
Illust. 1-63. Injection pump.

1. Socket head screw
2. Bolt with copper washer
3. Speed control plate
4. Injection pump

3. Carefully lift the plate and using long nose pliers, disconnect the spring (1, Illust. 1-64) from the lever (2) on the plate (3). Remove the speed control plate.

When reassembling:

- Hook the spring (1, Illust. 1-64) to the lever first and install the speed control plate (3).
- Be sure to place the copper washers underneath the bolts (2, Illust. 1-63).



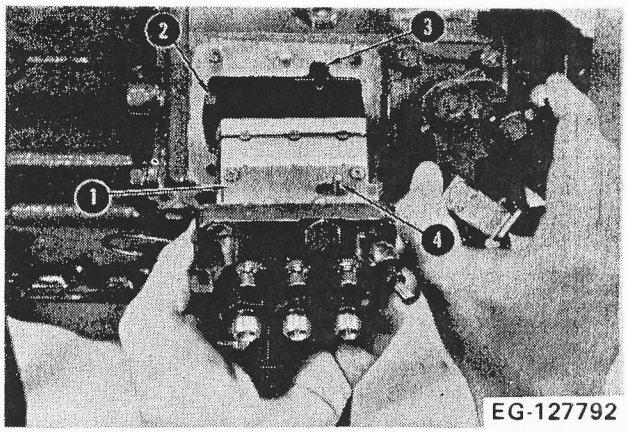
Illust. 1-64. Removing the speed control plate.

1. Spring
2. Lever
3. Speed control plate

When reassembling:

- Slide the control rack (1, Illust. 1-65) until its end is flush with the pump housing.
- Position the slot (3) on the fork lever just under the slot on the crankcase.
- Insert the injection pump so that the control rack (1) will be pushed by the spring (2) at its end and the pin (4) on the rack engages with the slot (3) on the fork lever.

Tightening torque	Injection pump	7.23 to 7.32 ft-lbs



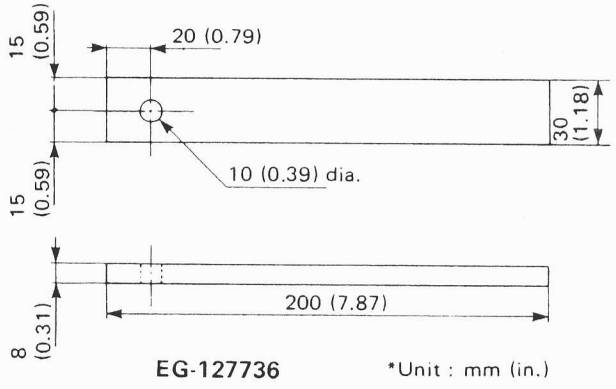
Illust. 1-65. Control rack.

1. Control rack
2. Spring
3. Slot
4. Pin

Gear Case and Flywheel

PULLEY AND GEAR CASE

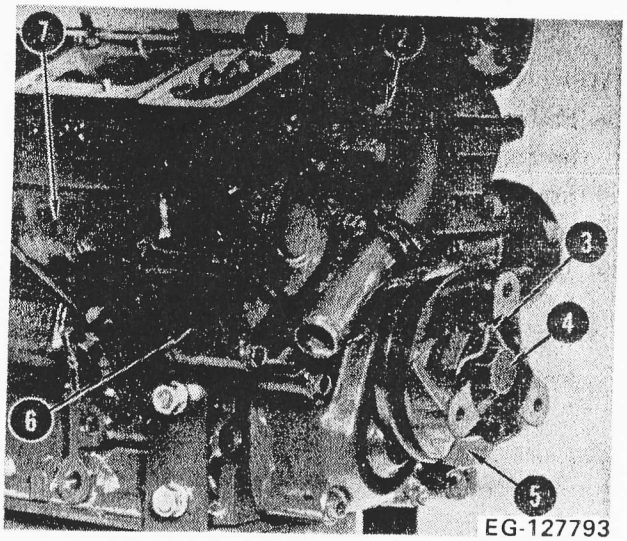
1. Prepare the flywheel stop tool (Illust. 1-66) and install it on the flywheel so that the crankshaft does not turn.



Illust. 1-66. Flywheel stop tool.

2. Flatten the metal lock plate (3, Illust. 1-67) and remove the lock bolt (4). Using a puller, remove the pulley (5) from the crankshaft.

3. Remove the bolts (1 and 2) securing the gear case (6) to the cylinder block (7).

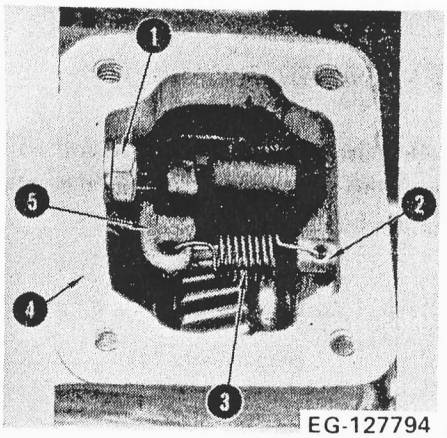


Illust. 1-67. Gear case and pulley.

1. Bolt (inside gear case)
2. Bolt
3. Lock plate
4. Bolt
5. Pulley
6. Gear case
7. Cylinder block

4. Disconnect the spring (3, Illust. 1-68) from the lever (5). Remove the gear case (4).

NOTE: Be sure to remove the bolt (1) inside the gear case (4).



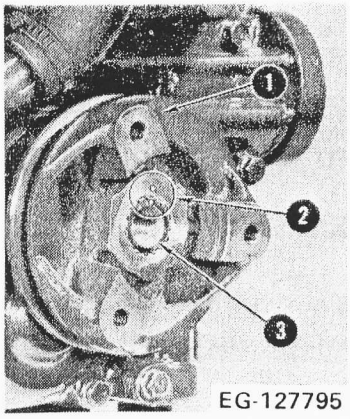
Illust. 1-68. Gear case - speed control plate removed.

1. Bolt
2. Pin
3. Spring
4. Gear case
5. Lever

When reassembling:

- Be sure to tighten the bolt (1) and hook the spring (3).
- Install the pulley (1, Illust. 1-69) to the crankshaft (3), aligning the marks (2).
- Apply engine oil to the lock bolt. Install the lock plate and tighten it to the specified torque. Bend a tang of the lock plate over a flat on the bolt head.

Tightening torque	Lock screw	98.1 to 107.9 N·m 10.0 to 11.0 kgf·m 72.3 to 79.6 ft-lbs
	Gear case screw	9.81 to 11.28 N·m 1.00 to 1.15 kgf·m 7.23 to 8.32 ft-lbs



Illust. 1-69. Crankshaft-to-pulley alignment marks.

1. Pulley
2. Alignment marks
3. Crankshaft

Flywheel

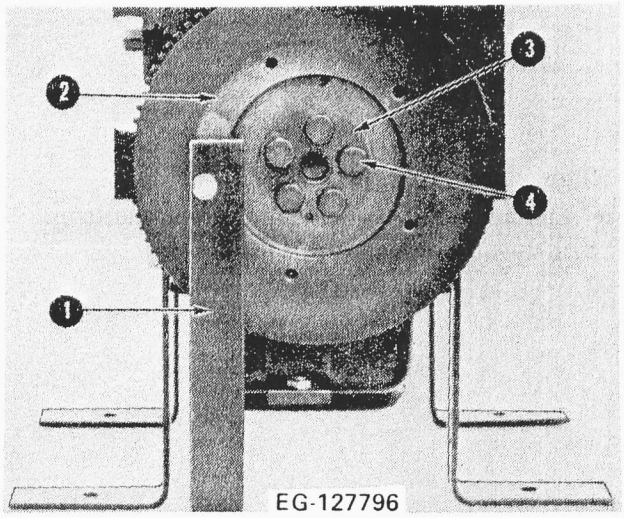
1. With the flywheel stop tool installed (Illust. 1-70), remove the flywheel lock bolts (4).

2. Remove the washer plate (3) and flywheel (2).

When reassembling:

- Place the flywheel washer on the flywheel and install them to the crankshaft, noting the location of the holes.

Tightening torque	Flywheel screw	39.8 to 43.4 ft-lbs



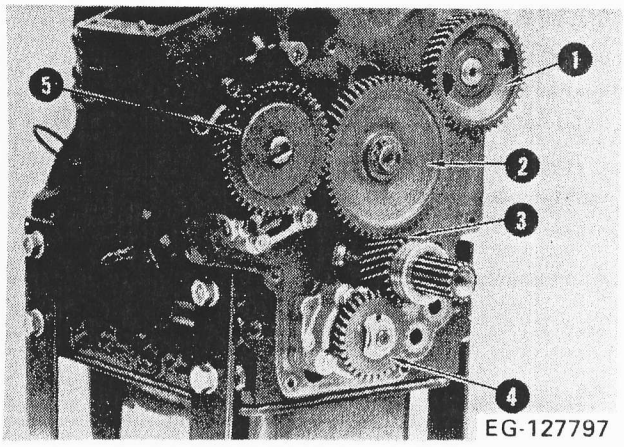
Illust. 1-70. Flywheel stop tool - installed.

1. Flywheel stop tool
2. Flywheel
3. Washer plate
4. Bolt

NOTE: Check the gear backlashes before disassembly.

IDLER GEAR

1. Remove the retaining ring, the thrust washers and the idler gear (2, Illust. 1-71).

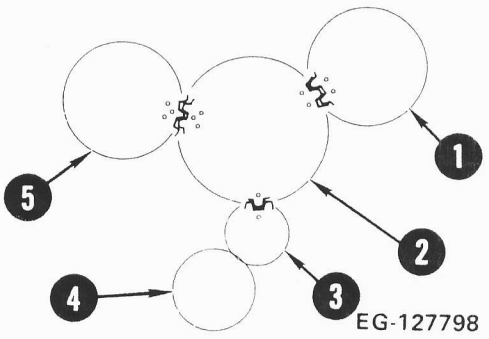


Illust. 1-71. Gears, gear cover removed.

1. Camshaft gear
2. Idler gear
3. Crankshaft gear
4. Oil pump drive gear
5. Fuel camshaft gear

When reassembling:

- Install the idler gear, aligning the marks on the gears referring to Illust. 1-72.



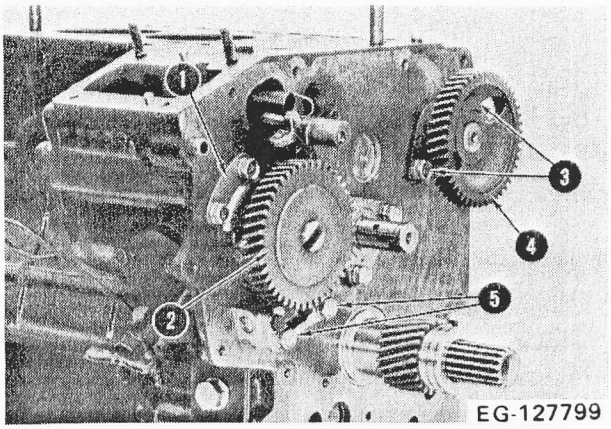
Illust. 1-72. Gears and timing marks.

1. Camshaft gear
2. Idler gear
3. Crankshaft gear
4. Oil pump drive gear
5. Fuel camshaft gear

1. Remove the bolts (3, Illust. 1-73) and draw out the camshaft (4) with the gear on it.

2. Remove the retaining plate (1).

3. Remove the bolts (5) and draw out the fuel camshaft (2) with the governor fork assembly.

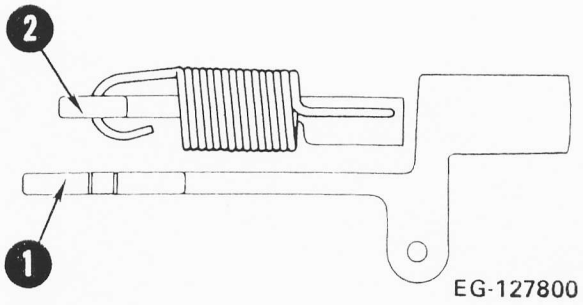


Illust. 1-73. Camshaft gears.

1. Retaining plate
2. Fuel camshaft gear
3. Bolt
4. Camshaft
5. Bolt

When reassembling:

- Hook the spring to the fork lever 1 (1, Illust. 1-74), as shown, before installing the fork lever assembly to the crankcase.
- Install the fork lever assembly so that the pins on the fork position are evenly apart from the governor sleeve and make sure that the fork lever 1 is kept apart from the rack plate more than 0.059 in.



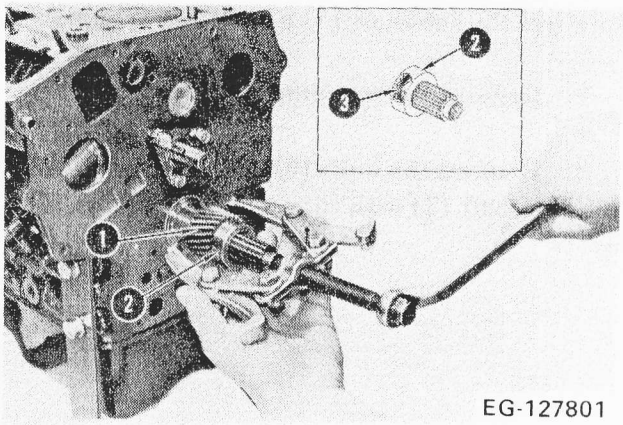
Illust. 1-74. Fork levers and spring.

1. Fork lever 1
2. Fork lever 2

Oil Seal Sleeve and Gear

1. Pull out the oil seal sleeve (2, Illust. 1-75) together with the gear (1) using a gear puller.

When reassembling:
- Install the idler gear before installing the sleeve.
- Be sure to place the O-ring (3) before installing the sleeve (2).



Illust. 1-75. Oil seal sleeve and gear.

1. Gear
2. Oil seal sleeve
3. O-ring

Crankshaft and Piston

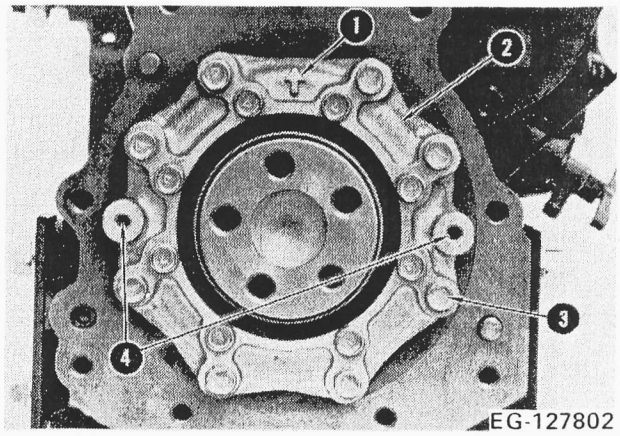
MAIN BEARING CASE COVER

1. Remove the bolts (3, Illust. 1-76) securing the main bearing case cover (2) to the cylinder block.

2. Lift the cover away from the cylinder block by threading two bolts into the threaded holes (4) of the cover. Tighten the two bolts gradually and evenly until the cover is off.

When reassembling:
- Place the case cover and the gasket noting alignment mark, and tighten the bolts.

Tightening torque	Main bearing case bolt	7.23 to 8.32 ft-lbs



Illust. 1-76. Main bearing case cover.

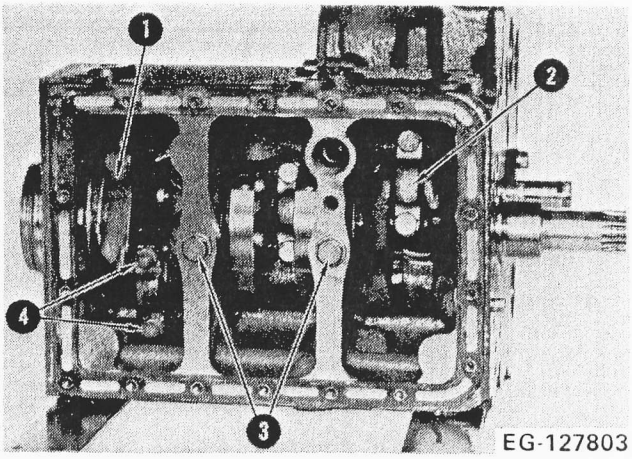
1. Alignment mark
2. Main bearing case cover
3. Bolt
4. Threaded holes

CRANKSHAFT

1. Remove the oil pan and the strainer.

2. Remove the bolts (4, Illust. 1-77) and the connecting rod caps (2), and push out the pistons.

3. Remove the bolts (4) and pull out the crankshaft (1).

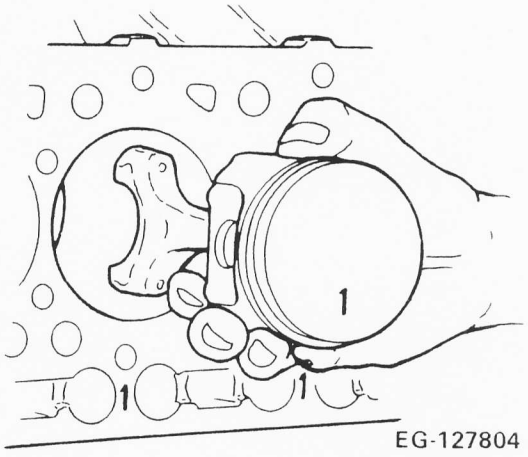


Illust. 1-77. Main and connecting rod bolts.

1. Crankshaft
2. Connecting rod cap
3. Main bearing bolt
4. Connecting rod bolts

When reassembling:

- Insert the piston in its cylinder in such a manner that the mark "1" on its head aligns with the mark "1" on the crankcase (refer to Illust. 1-78).
- Align the marks on the side of the connecting rod and cap.
- Apply engine oil to the bearing surface and the bolts. Tighten them to the specified torque.

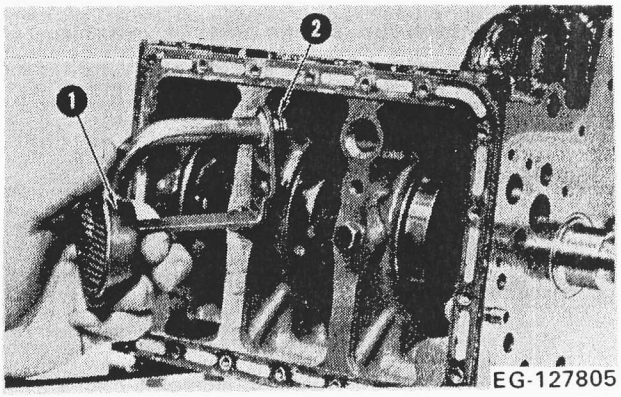


Illust. 1-78. Piston aligning numbers.

Tightening torque	Oil pan screw	7.23 to 8.32 ft-lbs
	Connecting rod screw	10.8 to 13.7 ft-lbs
	Main bearing case screw	14.5 to 17.4 ft-lbs
	Oil pressure switch	10.8 to 14.5 ft-lbs

When reassembling:

- Be sure to install the O-ring on the pipe extending from the strainer (refer to Illust. 1-79).



Illust. 1-79. Oil strainer and O-ring.

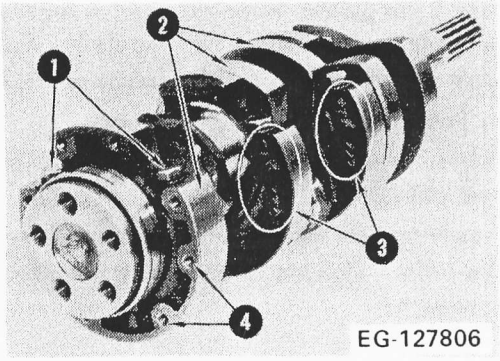
1. Oil strainer
2. O-ring

MAIN BEARING CASE

1. Remove the bolts (1, Illust. 1-80) and separate the bearing cases (refer to Illust. 1-81).

When reassembling:

- Apply engine oil to the bearing surface and install the bearing case so that its casting marks (3, Illust. 1-80) or the holes (4) face the flywheel.
- Place washers with their round edge on the seat of the bolts and apply engine oil to the bolts and tighten them to the specified torque.



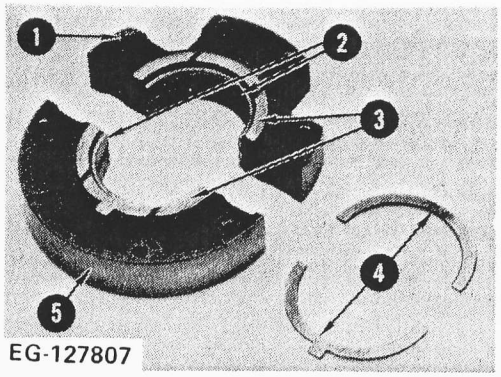
Illust. 1-80. Crankshaft and main bearing cases.

1. Bolt
2. Main bearing cases
3. Casting marks
4. Threaded holes

When reassembling:

- Place the thrust washers (4, Illust. 1-81) with their oil groove outside.

Tightening torque	Main bearing case screw	14.7 to 19.6 N·m 1.2 to 1.5 kgf·m 10.8 to 14.5 ft-lbs



Illust. 1-81. Main bearing case - exploded view.

1. Upper case halve
2. Bearing insert
3. Thrust washers (installed)
4. Thrust washers (exploded)
5. Lower case halve

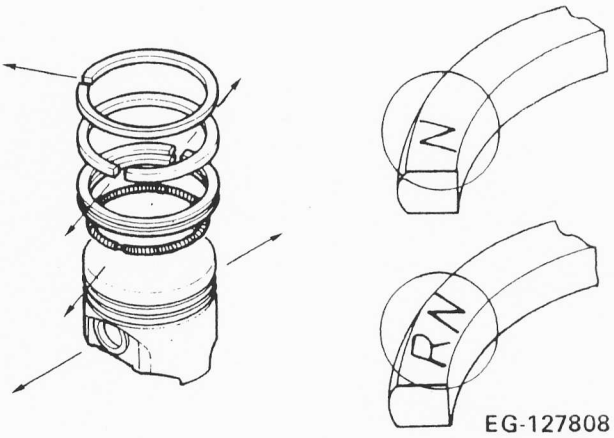
PISTON AND CONNECTING ROD

1. Remove the retaining ring and the piston pin.

2. Remove the piston rings using a piston ring tool.

When reassembling:

- Install the piston rings with their manufacturer's mark up and so that their gaps and the expander will not be positioned in line (refer to Illust. 1-82).

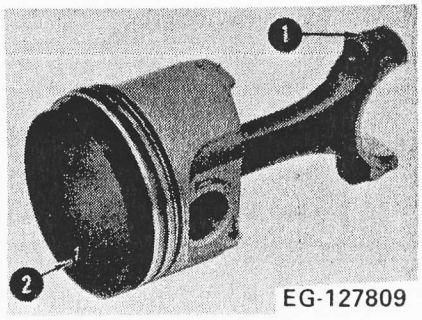


Illust. 1-82. Proper ring positioning.

When reassembling:

- Apply engine oil to the piston pin and the bushing. Install the connecting rod so that the mark on its side positions opposite the mark "1" on the piston (refer to Illust. 1-83).
- When inserting the piston pin to the piston, heat the piston in oil (176°F) for 10 to 15 minutes.

Fitted I.D. of the piston pin bushing	Factory specification	0.0000 to 0.0000 in.



Illust. 1-83. Proper piston-to-connecting rod positioning.

1. Connecting rod marking
2. Piston head marking

UNIT SERVICING

Cylinder Head

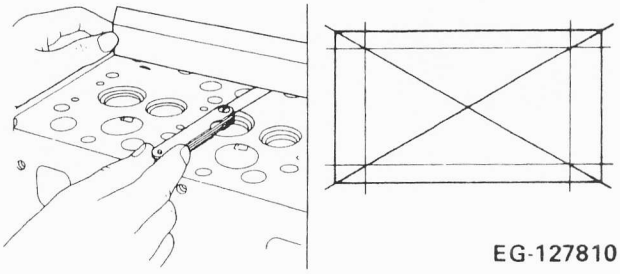
CYLINDER HEAD SURFACE FLATNESS

1. Clean the cylinder head surface.

2. Place the straight edge on the cylinder head and measure the clearance with a feeler gauge at the positions shown (refer to Illust. 1-84).

3. If the measurement exceeds the allowable limit, correct it with a surface grinder.

NOTE: Do not place a straight edge over the combustion chamber insert.



Illust. 1-84. Checking cylinder head surface flatness.

Flatness	Allowable limit	0.0020 per 3.94 in.

VALVE STEM CLEARANCE

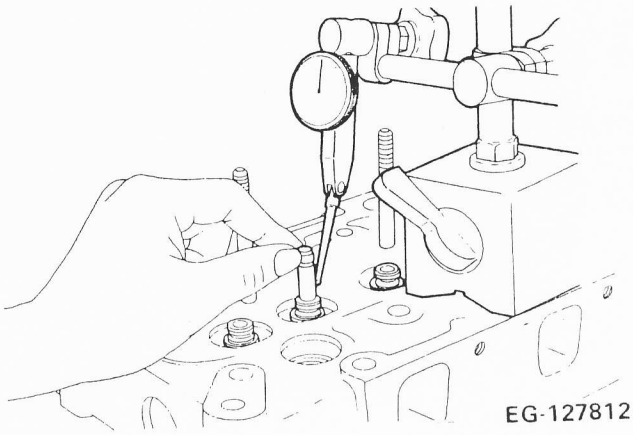
1. Remove the carbon from the valve guide.

2. Make sure that the valve stem is straight and insert the valve into the valve guide.

3. Set the dial indicator with its tip on the stem near the end of the valve guide.

4. Measure the clearance, moving the valve sideways. If the measurement exceeds the allowable limit, replace the valve guide or the valve.

Clearance between valve stem and valve guide	Factory specification	0.00118 to 0.00224 in.
	Allowable limit	0.004 in.
Valve guide bore I.D.	Factory specification	0.23661 to 0.23721 in.
Valve stem O.D.	Factory specification	0.23496 to 0.23543 in.



Illust. 1-86. Checking clearance between valve stem and valve guide.

REPLACING VALVE GUIDE

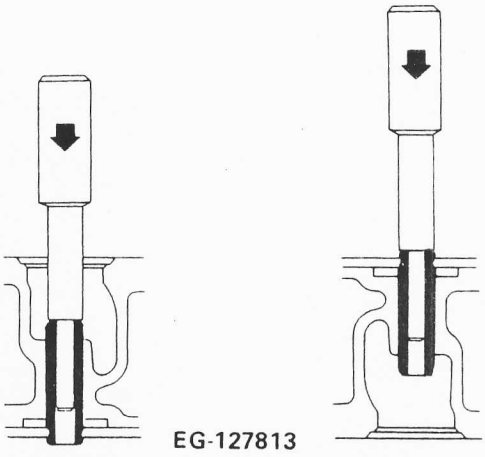
When removing:

- Press out the valve guide toward the head cover using a valve guide replacing tool.

When installing:

- Clean the valve guide bore and apply engine oil to the bore, before installing the valve guide.
- Press in the bushing so that its end comes flush with the cylinder block surface using a valve guide replacing tool.
- Press in the valve guide until its end comes flush with the cylinder head surface.

IMPORTANT: Ream precisely the bore to the specified dimension shown in Illust. 1-87, after installing the valve guide.



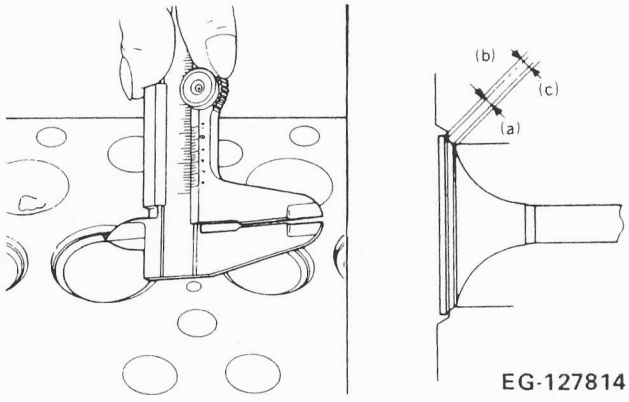
Illust. 1-87. Removing and installing valve guide.

VALVE SEAT WIDTH

1. Check the valve seat surface and the width ([a], Illust. 1-88).

2. If the seat width is not within the specified values or (b) is not equal to (c), correct the valve seat referring to "Correcting Valve and Seat."

Valve seat width	Factory specification	0.055 in.



Illust. 1-88. Checking valve seat width.

CORRECTING VALVE AND SEAT

1. Correct the valve using a valve refacer.

2. Correct the valve seat surface using a valve seat cutter (Code No.: 07909-33102), following the steps below.

3. Cut the valve seat surface with a 45° valve seat cutter.

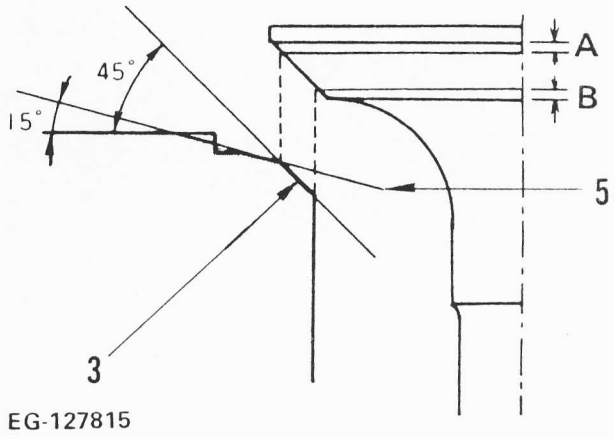
4. Check the seating surface on the valve face using a red lead.

5. Cut the valve seat surface with a 15° valve seat cutter so that width A becomes equal to B (refer to Illust. 1-89).

6. Check the seating surface using a red lead. If needed, repeat the steps above from 3, until the valve contacts correctly.

7. Lap the valve onto its seat using lapping compound, until the valve contacts with its seat evenly.

NOTE: Before correcting the valve and seat, check the valve stem and the valve guide, and repair them if necessary.



Illust. 1-89. Correcting valve and seat.

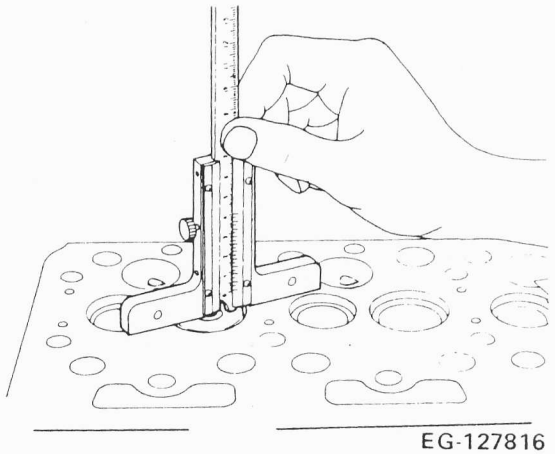
VALVE RECESSING

1. Clean the valve face and install it in its guide.

2. Measure the valve recessing with a depth gauge.

3. If the recessing exceeds the allowable limit, replace the valve, cylinder head or both.

Valve recessing	Factory specification	0.0295 to 0.0374 in.
	Allowable limit	0.047 in.



Illust. 1-90. Measuring valve recessing.

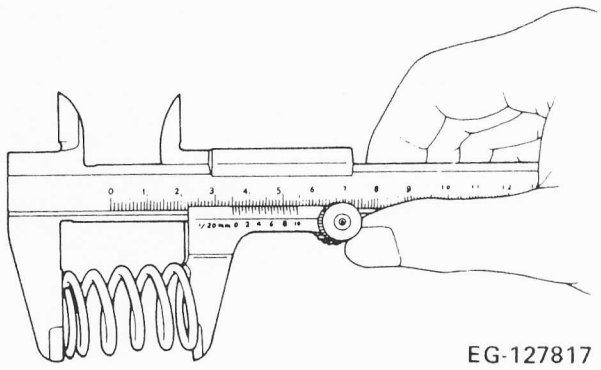
VALVE SPRING FREE LENGTH AND TENSION

1. Measure the free length of the spring with vernier calipers.

2. Place the spring on a spring compression tester and compress to the specified length, and get the tension.

3. If the measurement is less than the allowable limit, replace the valve spring.

Free length	Factory specification	31.6 mm 1.244 in.
	Allowable limit	28.4 mm 1.118 in.
Spring tension	Factory specification	64.7 N (27.0 mm) 6.6 kgf (27.0 mm) 14.6 lbs (1.063 in.)
	Allowable limit	54.9 N (27.0 mm) 5.6 kgf (27.0 mm) 12.3 lbs (1.063 in.)



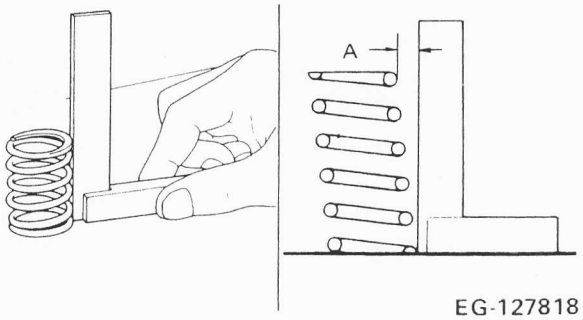
Illust. 1-91. Measuring valve spring free length.

VALVE SPRING SQUARENESS

1. Place the spring on the surface plate and a square at its side.

2. Measure the maximum distance A (refer to Illust. 1-92), rotating spring.

Valve spring squareness	Allowable limit	1.2 mm 0.047 in.



Illust. 1-92. Checking valve spring squareness.

ROCKER ARM BUSHING AND SHAFT CLEARANCE

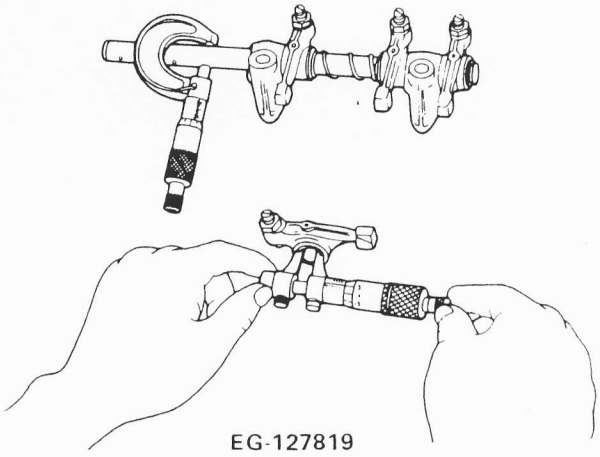
1. Measure the rocker arm bushing I.D. with an inside micrometer (refer to Illust. 1-93).

2. Measure the rocker arm shaft O.D. with an outside micrometer.

3. If the clearance exceeds the allowable limit, replace the bushing.

4. If the clearance still exceeds the allowable limit after replacing the bushing, replace the rocker arm shaft.

Rocker arm bushing and shaft clearance	Factory specification	0.00063 to 0.00268 in.
	Allowable limit	0.0059 in.
Bushing I.D. shaft O.D.	Factory specification	0.41339 to 0.41500 in.
	Factory specification	0.41232 to 0.41276 in.



Illust. 1-93. Measuring rocker arm shaft and bushing.

REPLACING ROCKER ARM BUSHING

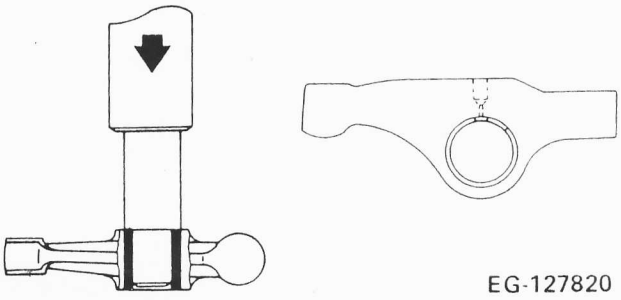
When removing:

- Press out the rocker arm bushing using a rocker arm bushing replacing tool (refer to Illust. 1-94).

When installing:

- Clean the rocker arm bushing and the bore, and apply engine oil to them.
- Press in the bushing so that its end comes flush with the rocker arm, using a rocker arm bushing replacing tool.

IMPORTANT: Be sure to align the oil holes on the rocker arm and the bushing, and check that the seam of the bushing position is as shown in Illust. 1-94.



Illust. 1-94. Removing rocker arm bushing.

GEAR BACKLASH

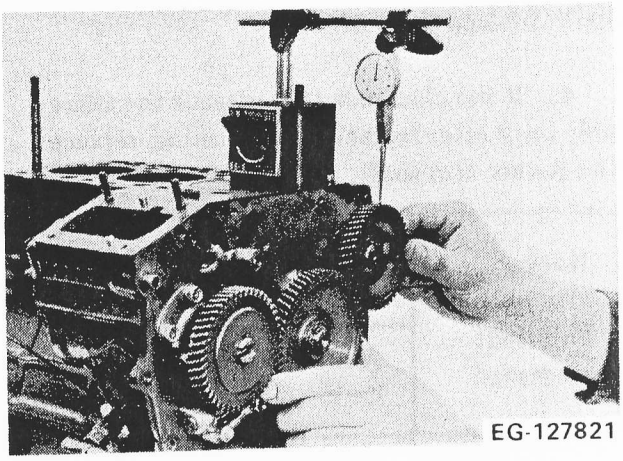
1. Set a dial indicator (lever type) with its indicator tip on the gear tooth (refer to Illust. 1-95).

2. Move the gear to measure the backlash, holding its mating gear.

3. If the backlash exceeds the allowable limit, check the oil clearance of the shafts and the gear.

4. If the oil clearance is proper, replace the gear.

Oil pump gear to crank gear	Factory specification	0.00161 to 0.00484 in.
Idler gear to crank gear	Factory specification	0.00169 to 0.00488 in.
Idler gear to cam gear	Factory specification	0.00185 to 0.00484 in.
Idler gear to injection pump gear oil clearance	Factory specification	0.00181 to 0.00488 in.
	Allowable limit	0.0059 in.



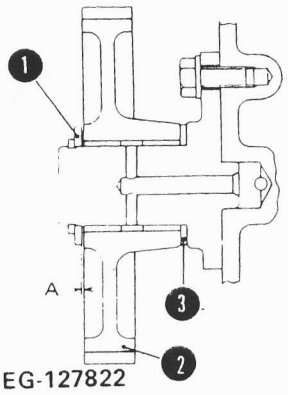
Illust. 1-95. Measuring gear backlash.

IDLER GEAR SIDE CLEARANCE

1. Pull the idler gear collar (1) and push the idler gear (2) and measure the clearance (A) between the idler gear and the idler gear collar with a feeler gauge.

2. If the clearance (A) exceeds the allowable limit, replace the idler gear collar (1).

Side clearance	Factory specification	0.0079 to 0.0201 in.
	Allowable limit	0.024 in.



Illust. 1-96. Idler gear side clearance.

1. Collar
2. Idler gear
3. Bushing
A. Clearance measurement

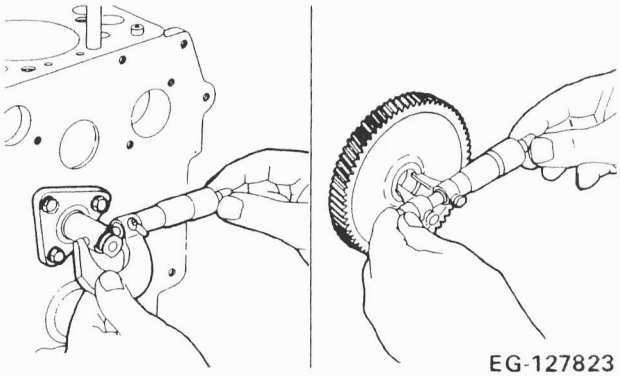
IDLER GEAR OIL CLEARANCE

1. Measure the I.D. of the idler gear bushing with an inside micrometer (refer to Illust. 1-97).

2. Measure the O.D. of the idler gear shaft with an outside micrometer.

3. If the clearance exceeds the allowable limit, replace the bushing.

Oil clearance	Factory specification	0.00063 to 0.00177 in.
	Allowable limit	0.0020 in.
Bushing I.D.	Factory specification	0.62992 to 0.63063 in.
Shaft O.D.	Factory specification	0.62886 to 0.62929 in.



Illust. 1-97. Measuring idler gear and shaft.

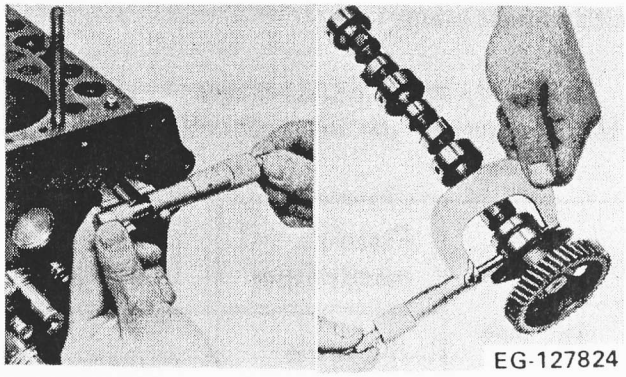
CAMSHAFT OIL CLEARANCE

1. Measure the I.D. of the camshaft bore on the crankcase with an inside micrometer (refer to Illust. 1-98).

2. Measure the O.D. of the camshaft journal.

3. If the clearance exceeds the allowable limit, replace the shaft.

Oil clearance	Factory specification	0.00197 to 0.00358 in.
	Allowable limit	0.0059 in.
Camshaft bore I.D.	Factory specification	1.29921 to 1.30020 in.
Camshaft journal O.D.	Factory specification	1.29662 to 1.29725 in.



Illust. 1-98. Measuring camshaft and camshaft bore.

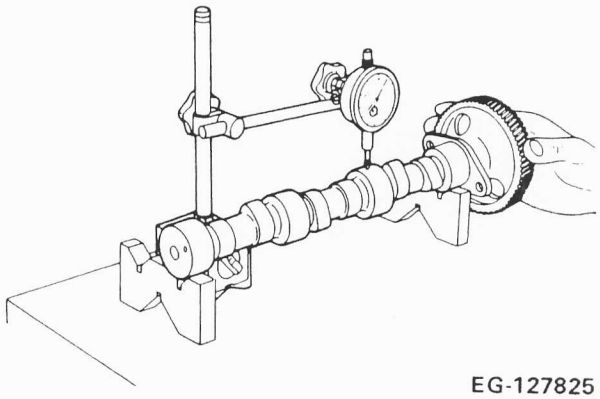
CAMSHAFT ALIGNMENT

1. Place the camshaft on the V blocks and set a dial indicator with its indicator tip on the intermediate journal (refer to Illust. 1-99).

2. Rotate the camshaft in the V block and get the eccentricity (half of the measurement).

3. If the eccentricity exceeds the allowable limit, replace the camshaft.

Eccentricity	Factory specification	0.01 mm 0.0004 in.
	Allowable limit	0.08 mm 0.0031 in.



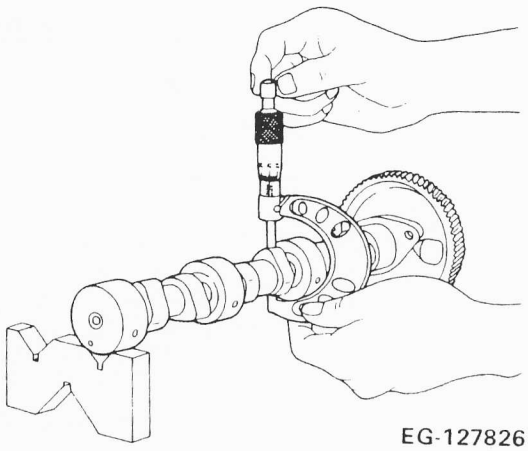
Illust. 1-99. Checking camshaft alignment.

CAMSHAFT LOBES HEIGHT

1. Measure the height of the camshaft lobes at their largest O.D. with an outside micrometer (refer to Illust. 1-100).

2. If the measurement is less than the allowable limit, replace the camshaft.

Cam height	Factory specification	1.0583 in.
	Allowable limit	1.0563 in.



EG-127826

Illust. 1-100. Measuring camshaft lobe.

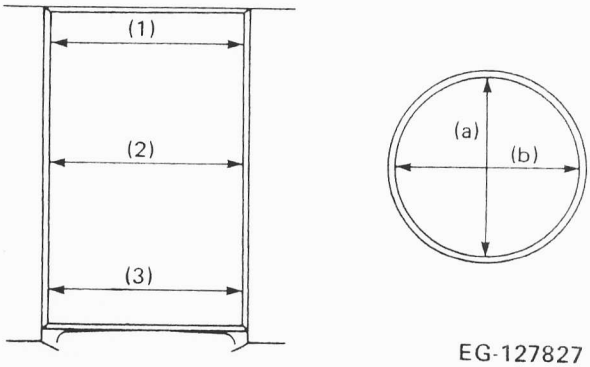
Cylinder Block

CYLINDER LINER

1. Measure the I.D. of the cylinder liner at six positions (refer to Illust. 1-101) with a cylinder gauge to find the maximum and minimum I.D.'s.

2. Get the difference between the maximum and the minimum I.D.'s as the maximum wear.

3. If the wear exceeds the allowable limit, replace the cylinder liner.



EG-127827

Illust. 1-101. Measuring cylinder liner inside diameter.

Cylinder liner I.D.	Factory specification	2.59843 to 2.59917 in.
Maximum wear	Allowable limit	0.0059 in.

CYLINDER BLOCK INSPECTION

Carefully inspect all mating surfaces, studs, dowel pins, springs, threaded holes, expansion plugs and brackets for damage. Repair or replace, as required.

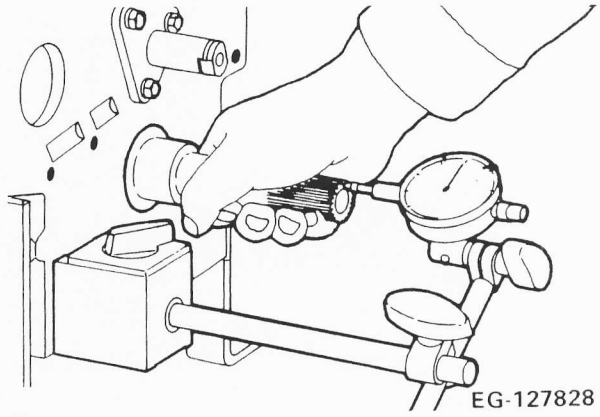
CRANKSHAFT END PLAY

1. Set a dial indicator with its indicator tip touching the end of the crankshaft (refer to Illust. 1-102).

2. Measure the end play by moving the crankshaft to the front and rear.

3. If the play exceeds the allowable limit, replace the side bearing.

NOTE: Oversize side bearings are available if the standard size side bearings do not meet end play clearance specifications.



Illust. 1-102. Checking crankshaft end play.

End play	Factory specification	0.0059 to 0.0122 in.
	Allowable limit	0.020 in.

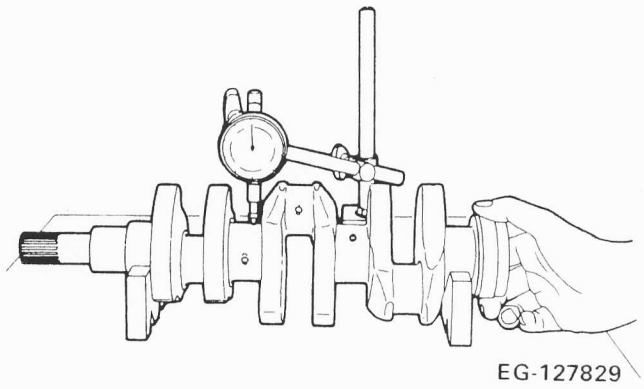
CRANKSHAFT ALIGNMENT

1. Support the crankshaft with V blocks on the surface plate at both end journals (refer to Illust. 1-103).

2. Set a dial indicator with its indicator tip touching the intermediate journal.

3. Rotate the crankshaft on the V blocks and get the eccentricity (half of the measurement).

4. If the eccentricity exceeds the allowable limit, replace the crankshaft.



Illust. 1-103. Checking crankshaft alignment.

Eccentricity	Factory specification	0.0008 in.
	Allowable limit	0.0031 in.

OIL CLEARANCE BETWEEN CRANKSHAFT JOURNAL AND BEARING 1

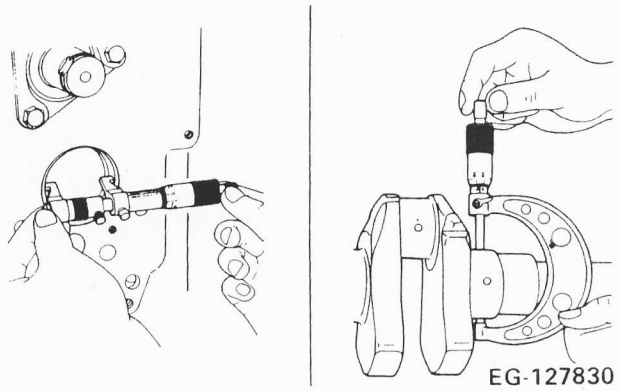
1. Measure the I.D. of the crankshaft bearing 1 with an inside micrometer (refer to Illust. 1-104).

2. Measure the O.D. of the crankshaft front journal with an outside micrometer.

3. If the oil clearance exceeds the allowable limit, determine which part is worn. Replace as required.

IMPORTANT: Install the bearing using a replacing tool, so that its seam faces the exhaust side in the crankcase.

Oil clearance	Factory specification	0.00134 to 0.00417 in.
	Allowable limit	0.0079 in.
Crankshaft bearing I.D.	Factory specification	1.57418 to 1.57638 in.
Crankshaft journal O.D.	Factory specification	1.57221 to 1.57284 in.



Illust. 1-104. Checking bearing 1 and crankshaft front main journal.

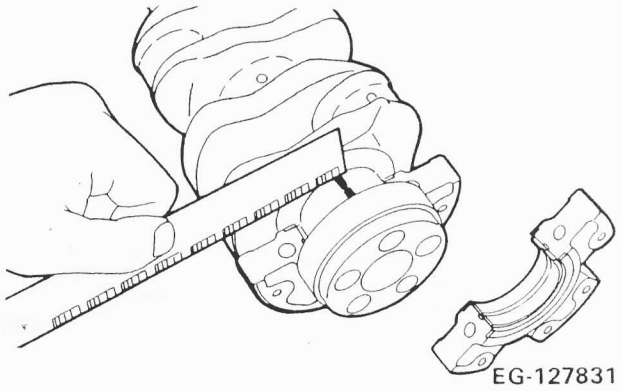
OIL CLEARANCE BETWEEN CRANKSHAFT JOURNAL AND BEARINGS 2 AND 3

1. Using an outside micrometer, measure the O.D. of the main journals. If within specifications, proceed with steps 2 through 4.

2. Put a strip of Plastigage lengthwise in the center of the journal.

3. Install the bearing cap and tighten the bolts to the specified torque, and remove the bearing cap.

4. Measure the amount of the flattening with the scale and get the oil clearance (refer to Illust. 1-105).



Illust. 1-105. Checking bearing clearance.

5. If the oil clearance exceeds the allowable limit, replace the crankshaft bearing.

NOTE: Undersize bearings are available for service.

Tightening torque	Bearing bolts	8.7 to 10.8 ft-lbs
Oil clearance	Factory specification	0.00134 to 0.00417 in.
	Allowable limit	0.0079 in.

Rear

Bearing 2 I.D.	Factory specification	1.73166 to 1.73386 in.
Crankshaft journal O.D.	Factory specification	1.72969 to 1.73032 in.

Intermediate

Bearing 3 I.D.	Factory specification	1.57418 to 1.57583 in.
Crankshaft journal O.D.	Factory specification	1.57221 to 1.57284 in.

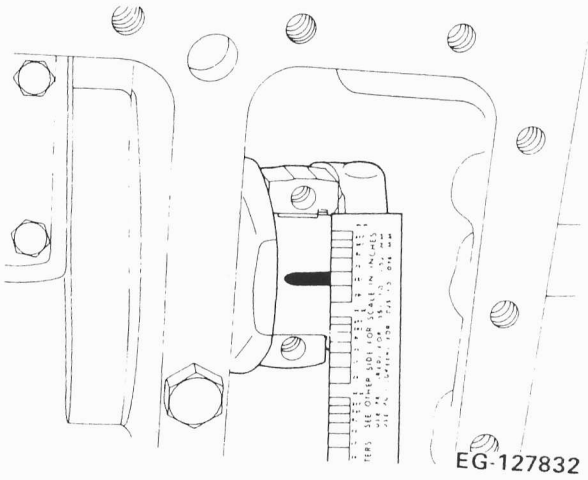
OIL CLEARANCE BETWEEN CRANK PIN AND CONNECTING ROD BEARING

1. Using an outside micrometer, measure the O.D. of the crank pin journal. If within specifications, proceed with steps 2 through 4.

2. Put a strip of Plastigage lengthwise into the bearing cap.

3. Install the bearing cap noting that the gauge may not meet with the hole on the crank pin. Tighten the bolts to the specified torque, and remove the cap.

4. Measure the amount of the flattening with the scale and get the oil clearance (refer to Illust. 1-106).



Illust. 1-106. Checking crank pin bearing clearance.

5. If the clearance exceeds the allowable limit, replace the connecting rod bearing.

NOTE: Undersize bearings are available for service.

NOTE: Be sure not to move the crankshaft while the bearing cap screws are tightened.

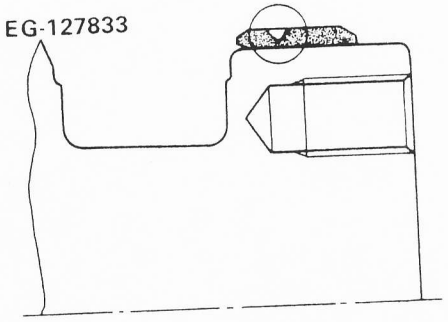
Tightening torque	Bearing bolts	10.8 to 13.7 ft-lbs
Oil clearance	Factory specification	0.00075 to 0.00319 in.
	Allowable limit	0.0079 in.
Connecting rod bearing I.D.	Factory specification	1.33835 to 1.34016 in.
Crank pin O.D.	Factory specification	1.33697 to 1.33760 in.

CRANKSHAFT SLEEVE (See Illust. 1-107)

1. Check the wear on the crankshaft sleeve.

2. If the wear exceeds the allowable limit or when the engine oil leaks, replace the crankshaft sleeve.

Sleeve wear	Allowable limit	0.004 in.

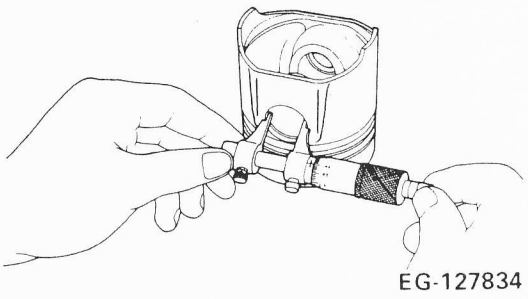


Illust. 1-107. Crankshaft sleeve.

PISTON PIN HOLE (See Illust. 1-108)

1. Measure the I.D. of piston pin hole lengthwise and widthwise of the piston with a cylinder gauge.

2. If the measurement exceeds the allowable limit, replace the piston.



Illust. 1-108. Measuring piston pin I.D.

Piston pin hole I.D.	**Factory specification**	0.70886 to 0.70910 in.
	Allowable limit	0.7106 in.

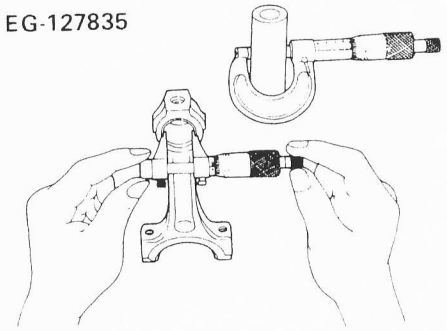
CLEARANCE BETWEEN PISTON PIN AND BUSHING (See Illust. 1-109)

1. Measure the O.D. of the piston pin with an outside micrometer.

2. Measure the I.D. of the piston pin bushing with a cylinder gauge.

3. If the clearance exceeds the allowable limit, replace the bushing.

4. If the clearance still exceeds the allowable limit after replacing the bushing, replace the piston pin.



Illust. 1-109. Measuring piston pin and bushing.

Clearance between piston pin and bushing	Factory specification	0.00063 to 0.00154 in.
	Allowable limit	0.0059 in.
Piston pin bushing I.D.	Factory specification	0.70965 to 0.71024 in.
Piston pin O.D.	Factory specification	0.70870 to 0.70902 in.

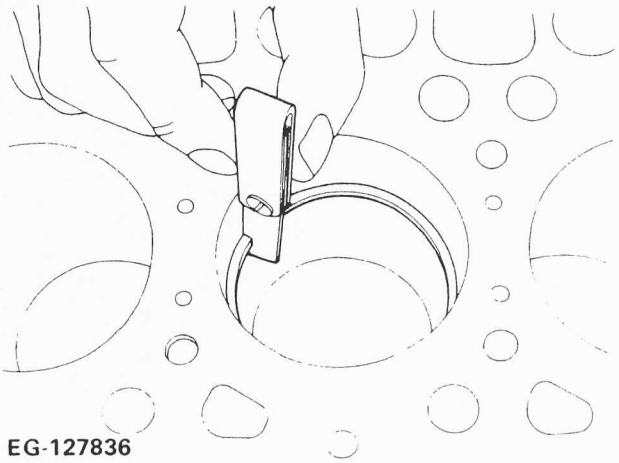
PISTON RING GAP (See Illust. 1-110)

1. Insert the piston ring into the cylinder and push down to the bottom, where the wear is least, using a piston head.

2. Measure the ring gap with a feeler gauge.

3. If the ring gap exceeds the allowable limit, replace the ring.

Piston ring gap	Top and second ring	Factory specification	0.0098 to 0.0157 in.
	Oil ring	Factory specification	0.0079 to 0.0157 in.
		Allowable limit	0.047 in.



Illust. 1-110. Measuring piston ring gap.

PISTON RING CLEARANCE (See Illust. 1-111)

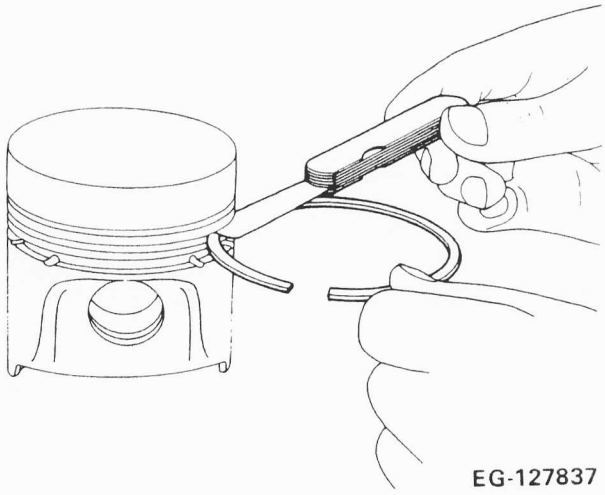
1. Clean the rings and the ring grooves, and install each ring in its groove.

2. Measure the clearance between the ring and the groove with a feeler gauge.

3. If the clearance exceeds the allowable limit, replace the piston ring.

4. If the clearance still exceeds the allowable limit after replacing the ring, replace the piston.

Piston ring clearance	Top and second ring	Factory specification	0.00335 to 0.00441 in.
	Oil ring	Factory specification	0.0008 to 0.0024 in.
		Allowable limit	0.0059 in.



Illust. 1-111. Checking piston ring clearance.

CONNECTING ROD ALIGNMENT (See Illust. 1-112)

1. Remove the connecting rod bearing and install the bearing cap.

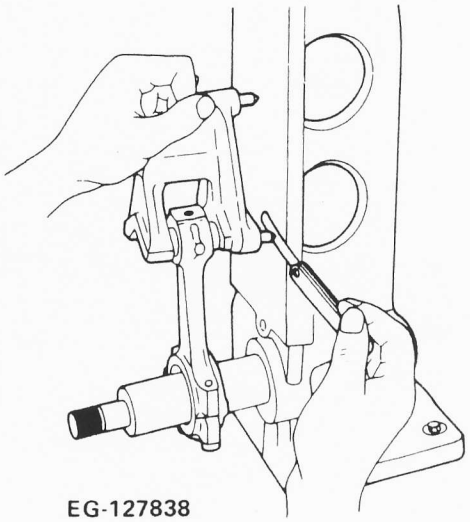
2. Install the piston pin in the connecting rod.

3. Install the connecting rod on the connecting rod alignment tool (Code No.: 07909-31661).

4. Put a gauge over the piston pin and move it against the faceplate.

5. If the gauge does not fit squarely against the faceplate, measure the space between the pin of the gauge and the faceplate.

6. If the measurement exceeds the allowable limit, replace the connecting rod.



Illust. 1-112. Checking connecting rod alignment.

Space between pin and faceplate	Allowable limit	0.0020 in. (gauge pin span at 3.94 in.)

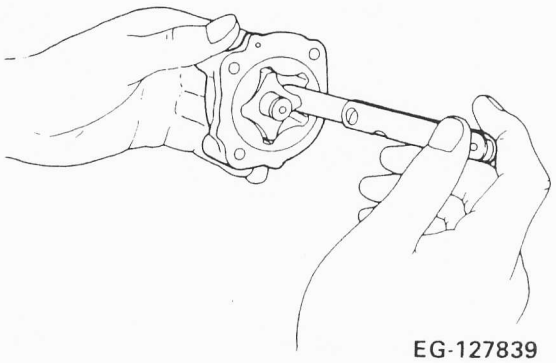
Lubricating System

OIL PUMP

Pump Rotor and Lobe Clearance (See Illust. 1-113)

1. Remove the oil pump from the crankcase.

2. Remove the screw and the port plate.



Illust. 1-113. Measuring inner and outer rotor clearance.

3. Measure the clearances between the outer rotor and the housing, and between the outer and inner rotor with a feeler gauge.

If the clearance exceeds the allowable limit, replace the pump.

Clearance between outer rotor and housing	Factory specification	0.0059 to 0.0083 in.
	Allowable limit	0.0118 in.
Clearance between outer and inner rotor	Allowable limit	0.0098 in.

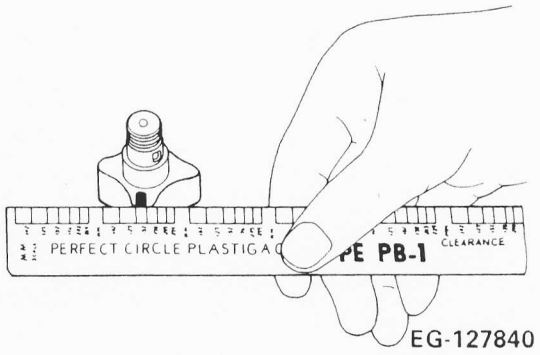
Rotor End Clearance (See Illust. 1-114)

1. Put a strip of Plastigage on the rotor and install the pump to the crankcase with the port plate.

2. Remove the pump and the port plate.

3. Measure the amount of the flattening with the scale, and get the clearance.

4. If the clearance is not within the specifications, replace the pump.



Illust. 1-114. Measuring rotor end clearance.

End clearance	Factory specification	0.0031 to 0.0051 in.

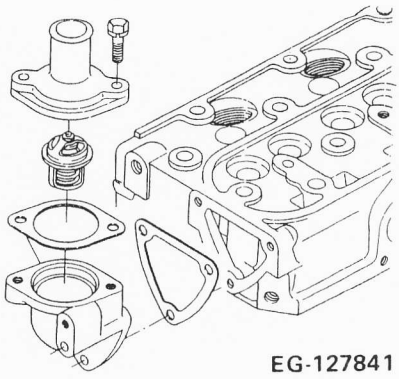
THERMOSTAT

Removal (See Illust. 1-115)

1. Remove the thermostat cover.

2. Remove the thermostat.

When reassembling:
- Apply liquid gasket (Three Bond 1215 or equivalent) to the gasket.



Illust. 1-115. Thermostat, housing and cover.

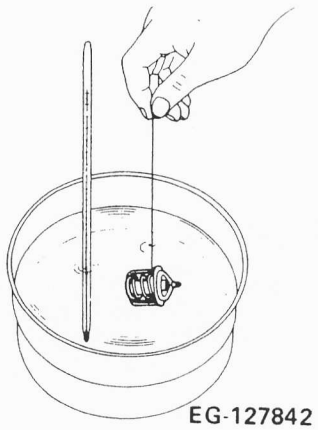
Thermostat Valve Opening Temperature (See Illust. 1-116)

1. Suspend the thermostat in the water by a string with its end inserted between the valve and the seat.

2. Heating the water gradually, read the temperature when the valve opens and leaves the string.

3. Continue heating and read the temperature when the valve opens approximately 0.236 in.

4. If the measurement is not within the specified values, replace the thermostat.



Illust. 1-116. Testing valve opening temperature.

Opening temperature	Factory specification	176.9° to 182.3°F at beginning, below 203°F at 0.236 in. of opening

WATER PUMP

Disassembly

1. Remove the water pump from the gear case cover.

2. Remove the pulley and flange (1, Illust. 1-117).

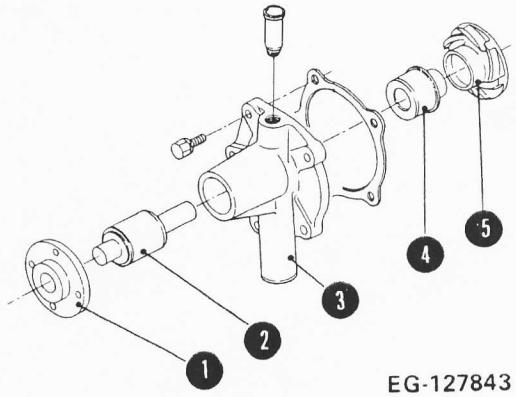
3. Press out the water pump shaft (2) with the impeller (5) on it.

4. Remove the impeller from the water shaft.

5. Remove the mechanical seal (4).

When reassembling:

- Apply liquid gasket (Three Bond 1215 or equivalent) to the gasket.
- Replace the mechanical seal with the new one.



Illust. 1-117. Water pump.

1. Water pump flange
2. Water pump shaft
3. Water pump body
4. Mechanical seal
5. Impeller

RADIATOR CAP

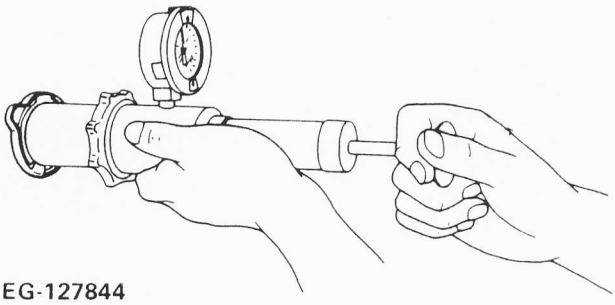
Radiator Cap Opening Pressure (See Illust. 1-118)

1. Set a radiator tester on the radiator cap.

2. Apply the pressure of 13 psi and measure the time for the pressure to fall to 9 psi.

3. If the measurement is less than the specified value, replace the radiator cap.

Pressure falling time	Factory specification	More than 10 seconds from 13 to 9 psi



Illust. 1-118. Testing radiator cap.

FAN AND FAN DRIVE

Disassembly, Inspection and Reassembly (See Illust. 1-119)

1. Remove four bolts (1) and lock washers (2) securing fan (3) to flange (4). Remove fan to shaft bolt (17) and flat washer (16).

2. Separate fan from flange (4).

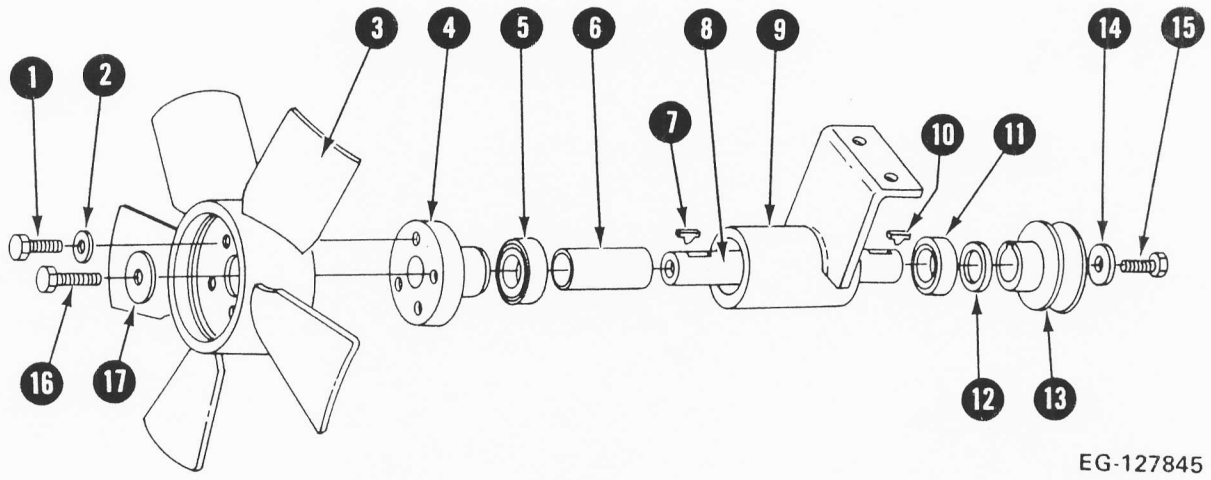
3. Pull flange (4) from shaft (8). Remove key (7).

4. Remove bolt (15) and flat washer (14) securing pulley (13) to shaft (8). Pull pulley (13) from shaft and remove key (10) and spacer (12).

5. Press shaft (8) out of housing (9). Remove bearing spacer (6) and bearings (5 and 11).

6. Inspect parts for wear and replace as required.

7. Reassemble in reverse order of disassembly.



Illust. 1-119. Fan and fan drive assembly - exploded view.

1. Bolt	6. Spacer	10. Key	14. Washer
2. Lock washer	7. Key	11. Bearing	15. Bolt
3. Fan	8. Shaft	12. Spacer	16. Bolt
4. Flange	9. Housing	13. Pulley	17. Washer
5. Bearing			

CHECKING AND ADJUSTMENT

Injection Pump

Injection Timing (See Illust. 1-120 and 1-121)

1. Remove the injection pipes.

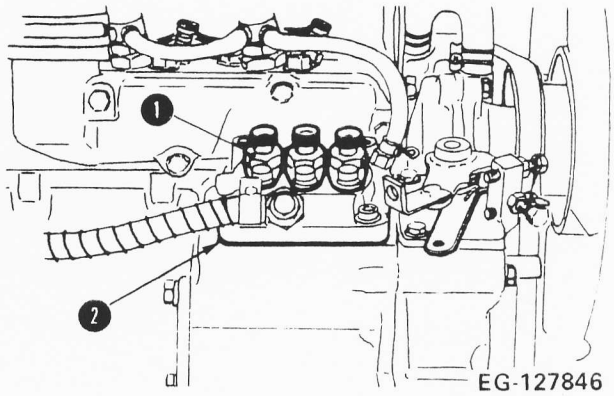
2. Set the speed control lever to the maximum fuel discharge position.

3. Turn the flywheel until the fuel fills up to the hole of the delivery valve holder.

4. Turn the flywheel further and stop turning when the fuel begins to flow over again, to check the injection timing.

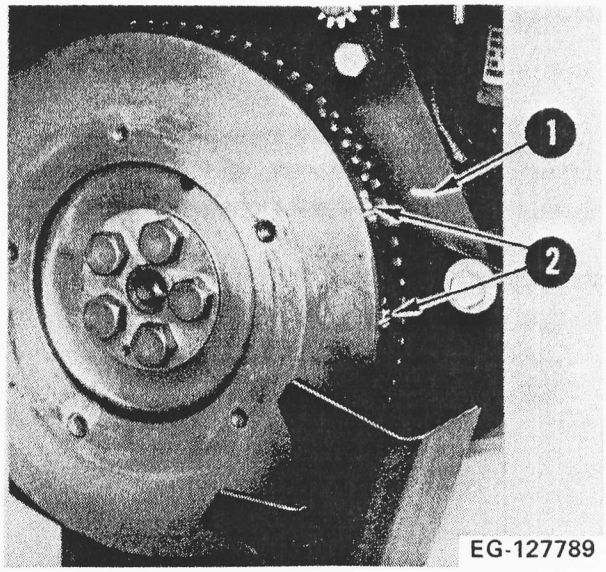
5. If the "FI" mark does not align with the mark on the rear plate, add or remove the shim (2) to adjust it.

Reference:
- 1.5° to 2.0° at flywheel, 0.0059 in. of shim.



Illust. 1-120. Injection pump and shim.

1. Injection pump
2. Shim



Illust. 1-121. Timing marks.

1. Timing mark on plate
2. Flywheel markings

Pump Element Fuel Pressure

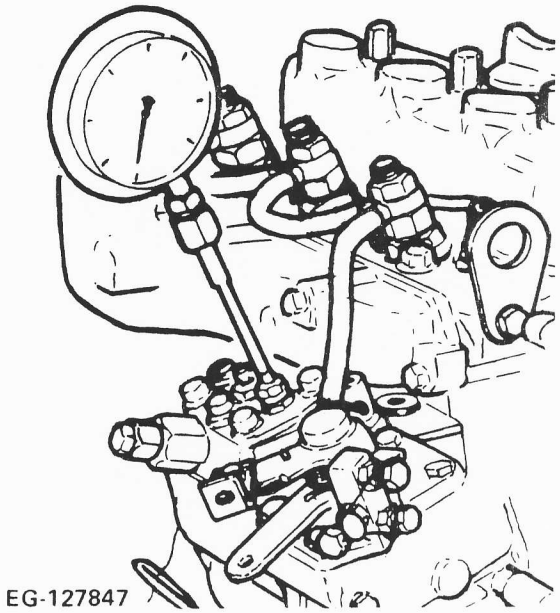
1. Install the pressure tester to the fuel injection pump without the delivery valve.

2. With the speed control lever at the maximum position of the fuel injection, rotate the flywheel to raise the fuel pressure to 5689 psi.

3. Measure the falling time of the fuel pressure from 5689 to 4978 psi.

4. If the measurement is less than the allowable limit, replace the pump element or the injection pump assembly.

Pressure falling time	Factory specification	60 seconds or more
	Allowable limit	30 seconds



Illust. 1-122. Pressure tester.

IMPORTANT: After replacing the pump element, adjust the amount of the fuel injection on the specified test bench.

Reference:

- Test Bench:
  Code No. 105760-0010 (50 Hz)/105760-0020 (60 Hz) [DIESEL KIKI CO. LTD]

- Test Conditions:

Driving stand	Code No. 10578-4160 [DIESEL KIKI CO. LTD]
Nozzle	DN12SD12T
Opening pressure	1707 psi
Injection pipe	0.24 in. dia. x 0.08 in. dia. x 23.62 in. long
Fuel feed pressure	7 psi
Test fuel	Diesel fuel No. 2-D
Pre-stroke	0.0728 to 0.0768 in. (with valve)
Cam profile	(See Illust. 1-123)

- Data for Adjustment:

Control rack (from stop position)	Camshaft speed	Amount of fuel
0.177 in.	1800 rpm	0.0714 to 0.0751 c. in./100st
0.039 in.	1800 rpm	less than 0.006 c. in./100st

NOTE: If the pump test outlined above is satisfactory, check delivery valve pressure as follows:

Delivery Valves Fuel Pressure

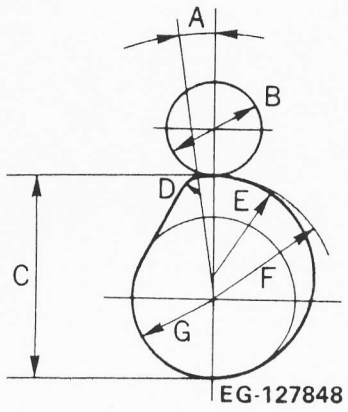
1. Install the pressure tester (refer to Illust. 1-122) to the delivery valve.

2. With the speed control lever at the maximum position of the fuel injection, rotate the flywheel to raise the fuel pressure to 3129 psi.

3. Measure the falling time of the fuel pressure from 3129 to 2987 psi.

4. If the measurement is less than the allowable limit, replace the delivery valve.

Pressure falling time	Factory specification	10 seconds or more
	Allowable limit	5 seconds



Illust. 1-123. Cam profile.

A. 7°
B. 0.55 in.
C. 1.18 in.
D. 0.12 in.
E. 0.59 in.
F. 0.71 in.
G. 0.47 in.

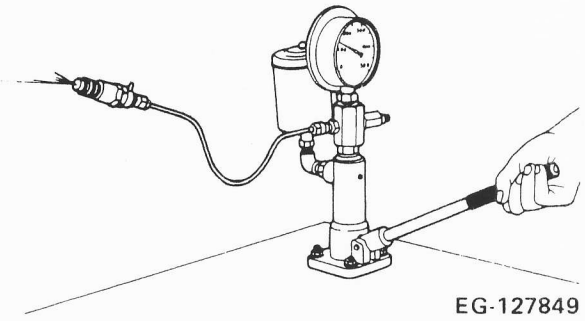
CAUTION! Never come in contact with spraying diesel fuel under pressure, which can have sufficient force to penetrate the skin, causing serious personal injury. Be sure nobody is in the direction of the spray.

Fuel Injection Pressure (See Illust. 1-124)

1. Set the injection nozzle to the nozzle tester.

2. Measure the injection pressure.

3. If the measurement is not within the specified values, replace the adjusting washer in the nozzle holder to adjust it.



Illust. 1-124. Testing injection nozzle.

Fuel injection pressure	Factory specification	1991 to 2133 psi

NOTE: Adjusting washer (Kubota Assembly Code No. 15841-98101) includes 43 sizes as listed below.

Adjusting Washer	Thickness in.	Code Number
0900	0.03543	15481-98501
0925	0.03642	15481-98511
0950	0.03740	15481-98521
0975	0.03839	15481-98531
1000	0.03937	15481-98541
1025	0.04035	15481-98551
1050	0.04134	15481-98561
1075	0.04232	15481-98571
1100	0.04331	15481-98581
1125	0.04429	15481-98591
1150	0.04528	15481-98601
1175	0.04626	15481-98611

Adjusting Washer	Thickness in.	Code Number
1200	0.04724	15481-98621
1225	0.04823	15481-98631
1250	0.04921	15481-98641
1275	0.05020	15481-98651
1300	0.05118	15481-98661
1325	0.05217	15481-98671
1350	0.05315	15481-98681
1375	0.05413	15481-98691
1400	0.05512	15481-98701
1425	0.05610	15481-98711
1450	0.05709	15481-98721
1475	0.05807	15481-98731

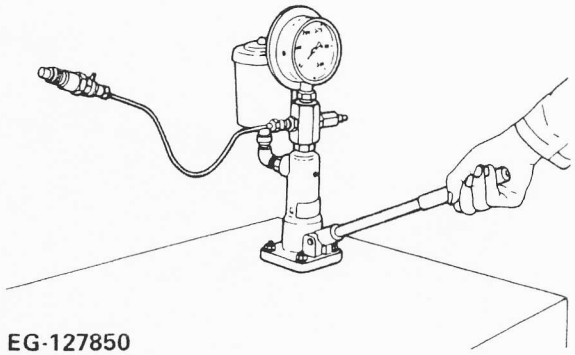
Valve Seat Pressure (See Illust. 1-125)

1. Set the nozzle to a nozzle tester.

2. Raise the fuel pressure and keep at 1849 psi for 10 seconds.

3. If any fuel leak is found, replace the nozzle piece.

Valve seat pressure	Factory specification	No fuel leak at 1849 psi

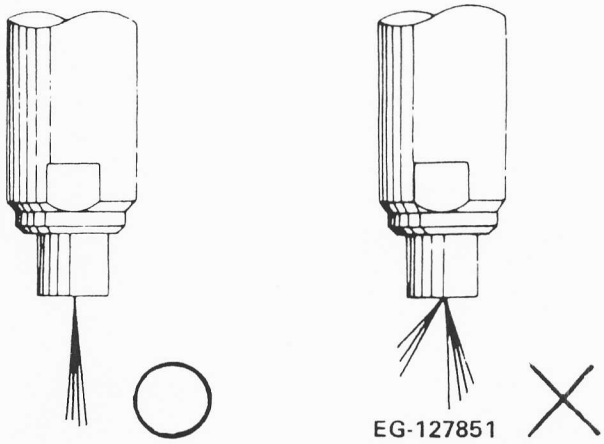


Illust. 1-125. Testing valve seat pressure.

Spraying Pattern (See Illust. 1-126)

1. Set the nozzle to a nozzle tester and check the nozzle spraying pattern.

2. If the nozzle does not spray in a good pattern, replace the nozzle piece.



Illust. 1-126. Checking spray pattern.

Injection Nozzle (See Illust. 1-127)

Nozzle Holder

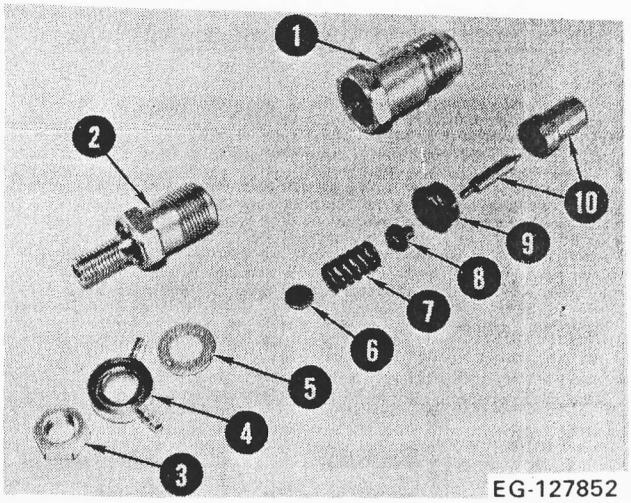
1. Secure the nozzle nut (1) in a vise.

2. Remove the nut (3), the eye joint (4) and the plain washer (5).

3. Remove the nozzle holder (2), and take out the parts.

When reassembling:
- Assemble the nozzle in clean light oil.
- Install the push rod (8), noting its direction.

Tightening torque	Nozzle holder	36.2 to 50.6 ft-lbs



Illust. 1-127. Injection nozzle - exploded view.

1. Nozzle nut	6. Adjusting washer
2. Nozzle holder	7. Nozzle spring
3. Nut	8. Push rod
4. Eye joint	9. Distance piece
5. Plain washer	10. Nozzle piece

IMPORTANT: The nozzle piece is precisely finished. Do not use a piece of metal but a piece of wood to remove the carbon deposits. After assembling the nozzle, be sure to adjust the injection pressure (see "Fuel Injection Pressure").

Air Bleeding

Bleed the air from the fuel system before attempting to start the engine whenever:
- The fuel filter has been removed or the fuel system lines have been disconnected.
- The fuel tank has been empty.
- The engine has not been run for a long period of time.

CAUTION! Never bleed the air while the engine is hot. Never come in contact with escaping diesel fuel under pressure, which can have sufficient force to penetrate the skin, causing serious personal injury. Be sure to relieve all pressure before disconnecting. Make sure that no fuel can escape from the system before applying pressure. Keep the engine stop lever at the "STOP" position to shut off the fuel, while bleeding the air.

Bleeding Fuel System (See Illust. 1-128 and 1-129)

1. Fill the fuel tank and open the fuel cock.

2. Loosen the bleeding screws (1 and 2, Illust. 1-128) at the top of the filter by two turns.

3. Turn ignition key switch to "ON" position to activate fuel pump until bubbles disappear.

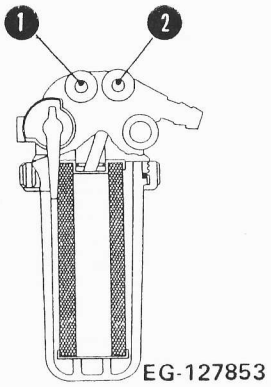
4. Tighten the bleeding screw (1) and turn ignition switch to "OFF" position.

5. Turn ignition key switch to "ON" position again until the fuel without air flows from the loose screw (2).

6. Tighten the bleeding screw (2). Turn ignition switch to "OFF" position.

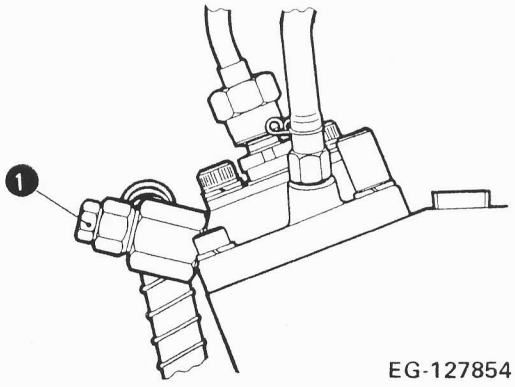
NOTE: If the engine will not start after the above bleeding, bleed the air further in the system, as follows.

- Loosen the plug (1, Illust. 1-129).
- Turn ignition key switch to "ON" position, until the fuel without air flows from the loose plug.
- Tighten the plug (1). Turn ignition switch to "OFF" position.



Illust. 1-128. Air vent plugs.

1. Air vent plug No. 1 2. Air vent plug No. 2



Illust. 1-129. Injection, pump air vent plug.

1. Air vent plug

NOTE: There is no service required on the electric fuel pump. If the electrical circuit to the fuel pump is complete and the pump is inoperative, replace the pump.

Electrical System

STARTER

Testing

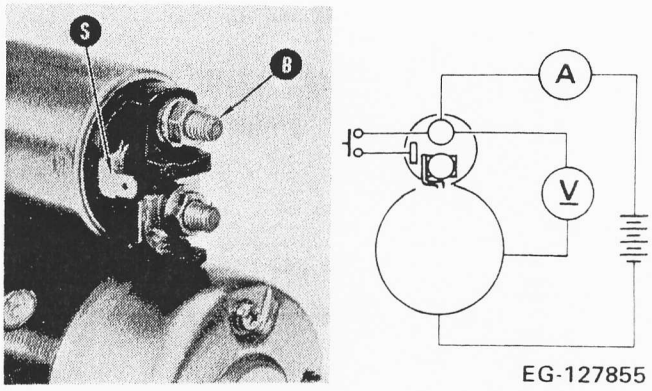
No-Load Test (See Illust. 1-130)

1. Connect a cable from the negative terminal of the battery to the body of the starter.

2. Connect a voltmeter across "B" terminal and the body of the starter, and an ammeter across the positive terminal of the battery and "B" terminal of the starter.

3. Connect a switch between "B" and "S" terminals of the starter, and run the starter.

4. The starter should run at the specified rate (see table below).



Illust. 1-130. No-load test points.

Supply voltage	11.5V
Current	Less than 53A
Speed	More than 7,000 rpm

NOTE: Test with a cable and an ammeter for large current, and a fully charged battery.

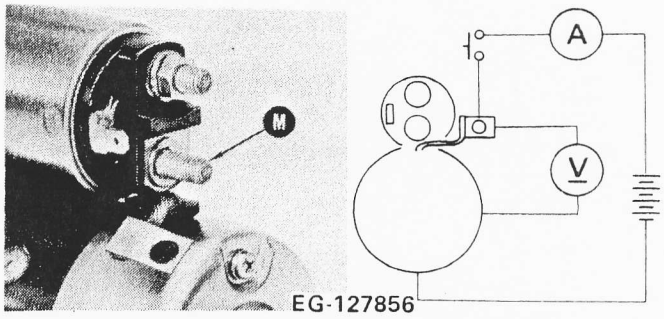
Motor Test (See Illust. 1-131)

1. Disconnect the connecting lead to "M" terminal and connect a voltmeter across the lead and the body of the starter.

2. Connect a cable between the negative terminal of the battery and the starter body.

3. Connect an ammeter and a switch in series between the positive terminal of the battery and the connecting lead, and run the starter.

4. The starter should run at the specified rate (see "No-Load Test").

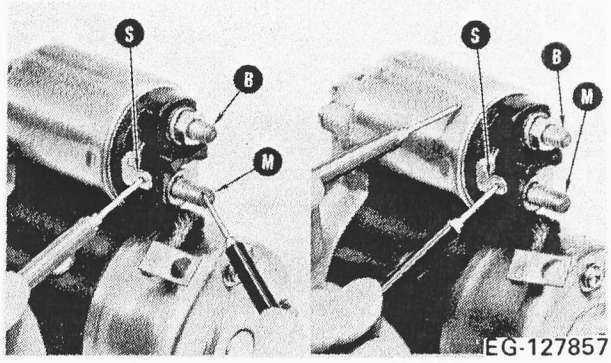


Illust. 1-131. Motor test points.

Solenoid Switch (See Illust. 1-132)

1. Check the continuity across "S" and "M" terminals, and across "S" terminal and the body with an ohmmeter.

2. If not continuous, replace.



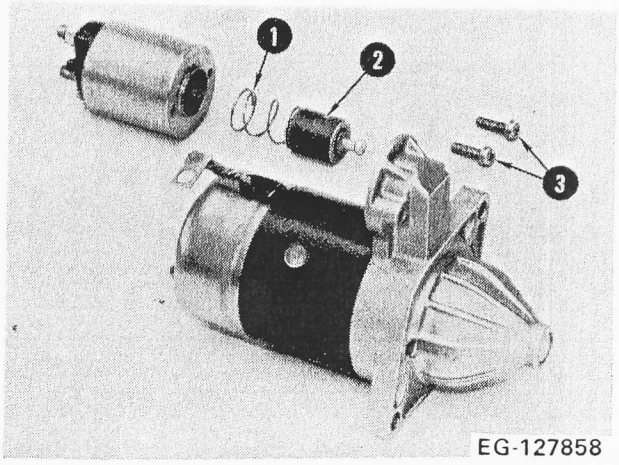
Illust. 1-132. Solenoid test points.

Solenoid Switch (See Illust. 1-133)

1. Remove the screws (3) to separate the solenoid switch.

2. Pull out the plunger (2) and the spring (1).

1. Spring
2. Plunger
3. Screw



Illust. 1-133. Solenoid switch, disassembled.

End Frame (See Illust. 1-134)

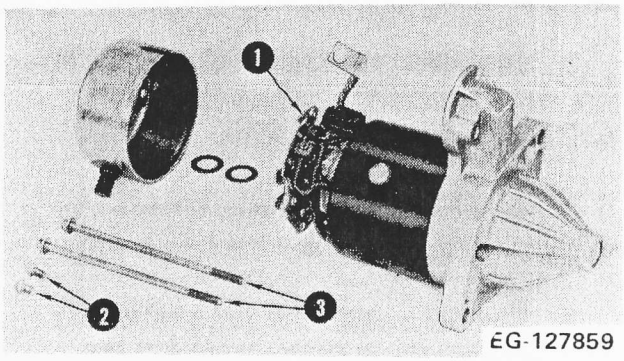
1. Remove the through bolts (3) and the screw (2).

2. Remove the rear end frame.

3. Lift the brush and remove the brush holder (1).

4. Remove the yoke assembly.

NOTE: Do not miss the thrust washers behind the commutator.



Illust. 1-134. End frame, removed.

1. Brush holder
2. Screw
3. Through bolt

Armature (See Illust. 1-135)

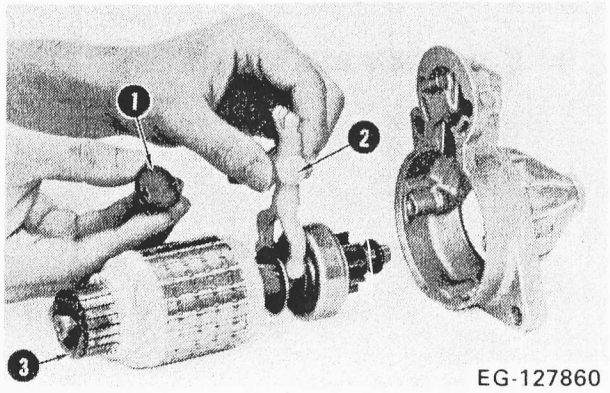
1. Pull out the armature.

2. Remove the plate (1) and the lever (2).

When reassembling:

- Install the lever, noting its direction (refer to Illust. 1-135).

NOTE: Do not overlook the thrust washers on the front of the armature shaft.



Illust. 1-135. Armature.

1. Plate
2. Lever
3. Thrust washers

Overrunning Clutch (See Illust. 1-136)

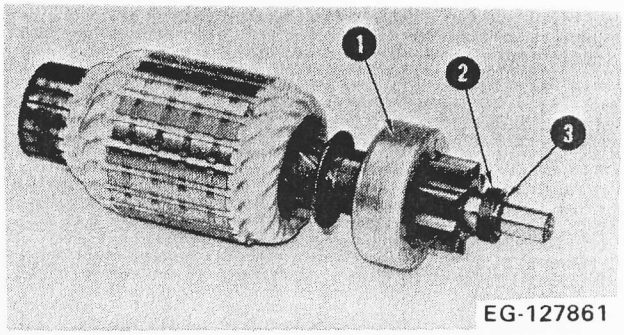
1. Tap in the stop ring (3).

2. Remove the retainer ring (2).

3. Remove the stop ring (3) and the overrunning clutch (1).

When reassembling:

- Install the stop ring first, then the retainer ring, and then pull up the stop ring with a puller.



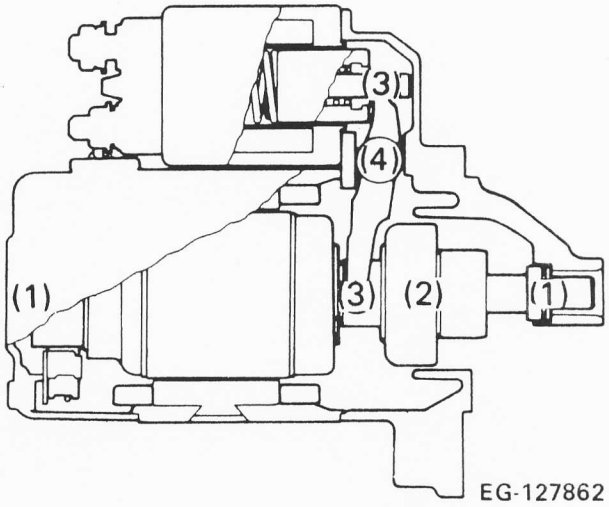
Illust. 1-136. Overrunning clutch and retainer.

1. Overrunning clutch
2. Retainer ring
3. Stop ring

Lubrication (See Illust. 1-137)

Before reassembling, lubricate the following:

(1) Bearings in the end frames and the washers.
(2) Sliding surface between the armature shaft and overrunning clutch (with low viscosity oil).
(3) Shift lever where it engages with the plunger and the overrunning clutch.
(4) Plunger where it contacts with solenoid housing.



Illust. 1-137. Starter lubrication.

Servicing

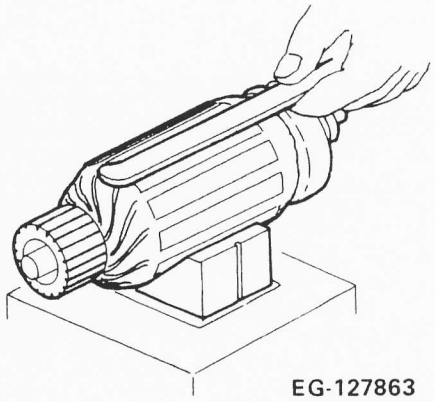
Armature Coil (See Illust. 1-138)

1. Place the armature on a growler to check for the short circuits, and slowly rotate the armature, holding an iron piece above the core.

2. If the iron piece vibrates against the core, replace the armature.

3. Check the continuity across each segment of the commutator and the armature shaft.

4. If continuous, replace the armature.



Illust. 1-138. Testing armature.

Commutator (See Illust. 1-139)

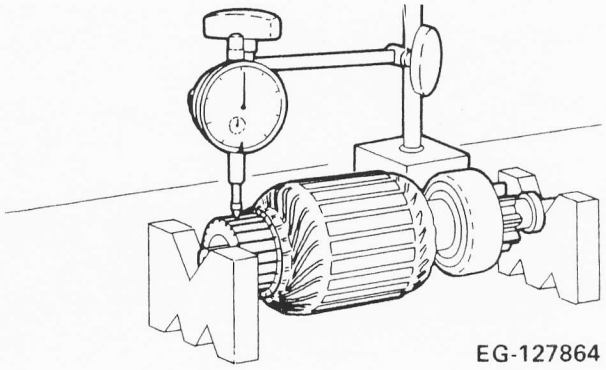
1. Rotate the armature in V blocks to check out-of-roundness and run-out, setting a dial indicator with its tip on the commutator.

2. If the variance among the readings is more than the allowable limit, turn the armature in the lathe.

3. If the depth of undercut is less than the allowable limit, undercut with a hacksaw blade or an undercutter.

4. Sand off all burrs with sandpaper.

NOTE: When the smallest radius of the commutator is less than the allowable limit, replace the armature shaft.



Illust. 1-139. Checking commutator.

Variance on commutator O.D.	Allowable limit	0.0020 in.
Commutator O.D.	Allowable limit	1.22 in.
Commutator undercut	Allowable limit	0.008 in.

Field Coil (See Illust. 1-140)

1. Check the continuity between the brushes.

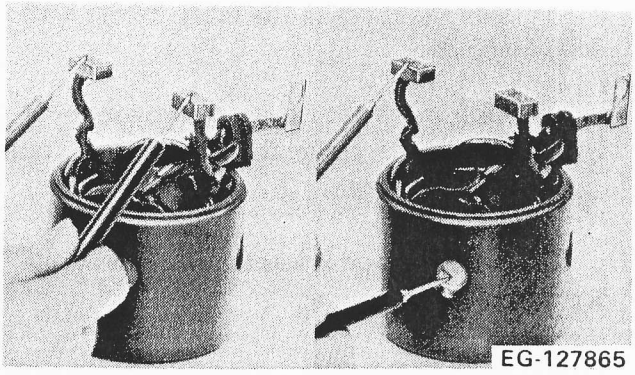
2. If not continuous, replace the yoke assembly.

3. Check the continuity across the yoke and the brush or the connecting lead.

4. If continuous, check for the breakage of the insulation.

5. If not repairable, replace the yoke assembly.

6. Check that the pole and windings are not loose.



Illust. 1-140. Testing field coil.

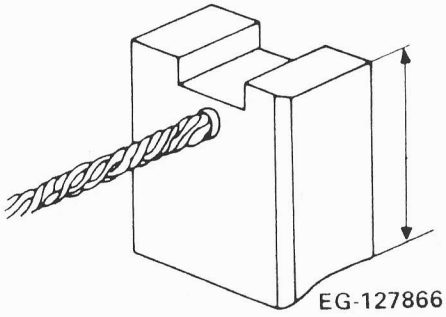
Brush (See Illust. 1-141)

1. Clean off the brush and check for wear.

2. If unevenly worn, correct.

3. If worn to more than the allowable limit, replace.

4. Check that the brushes move freely in the brush holder.



Illust. 1-141. Brush length.

Brush length	Factory specification	0.67 in.
	Allowable limit	0.453 in.

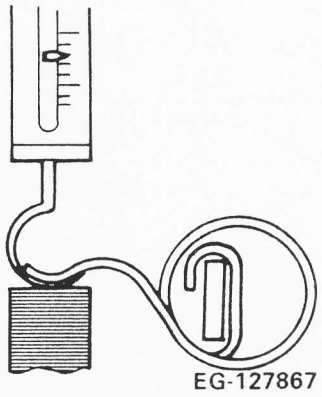
Brush Spring (See Illust. 1-142)

1. Pull the brush in the brush holder with a spring scale.

2. Measure the brush spring tension required to raise the spring from contact position with the commutator.

3. If the tension is less than the allowable limit, replace the spring.

Spring tension	Factory specification	3.1 to 5.7 lbs
	Allowable limit	2.0 lbs

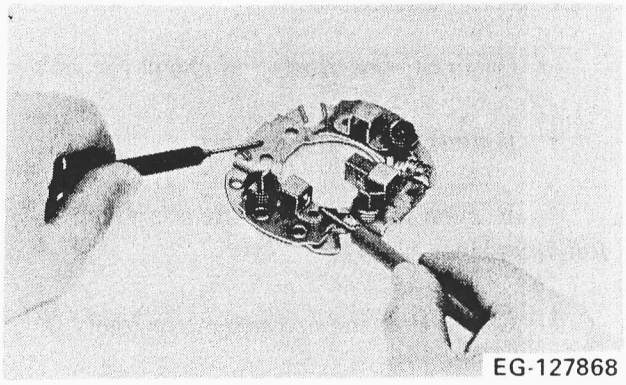


Illust. 1-142. Checking brush spring tension.

Brush Holder (See Illust. 1-143)

1. Check the continuity across the insulated brush holder and the brush holder support.

2. If continuous, replace the brush holder assembly.



Illust. 1-143. Checking brush holder.

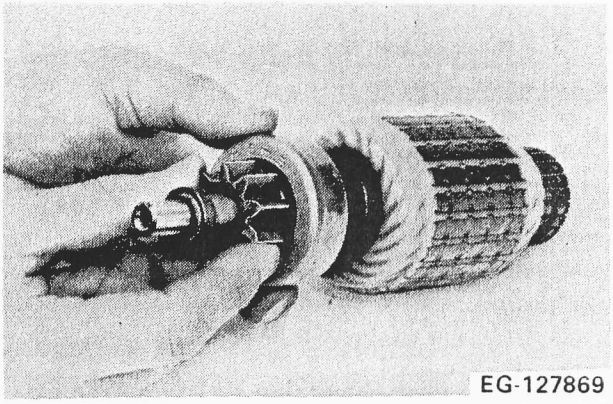
Overrunning Clutch (See Illust. 1-144)

1. Check the pinion and if worn or damaged, replace the clutch assembly.

2. Check that the piston turns freely and smoothly in the overrunning direction and does not slip in the cranking direction.

3. If the pinion slips or does not turn in both directions, replace the overrunning clutch assembly.

NOTE: Do not wash off the grease in the overrunning clutch with the chemicals or oils.



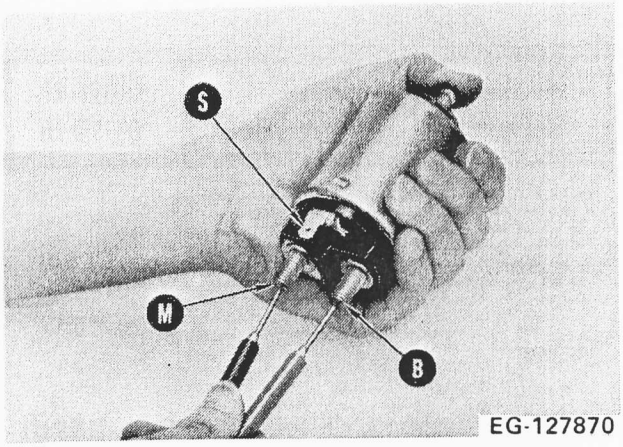
Illust. 1-144. Overrunning clutch.

Solenoid Switch (See Illust. 1-145 and 1-146)

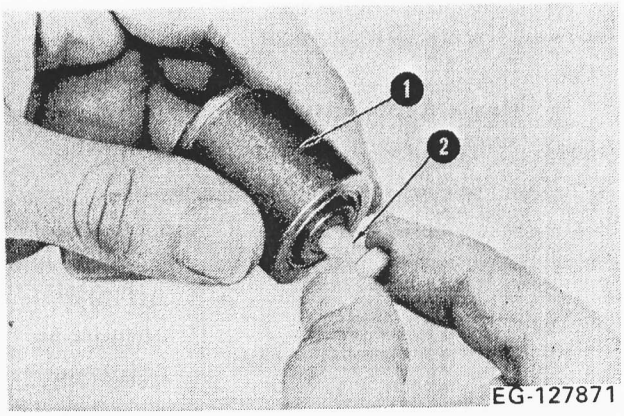
1. Check the continuity across "B" and "M" terminals with an ohmmeter, pushing in the plunger (refer to Illust. 1-145).

2. If not continuous or if a certain value is indicated, replace the solenoid switch.

3. Pull the pull-rod to check the spring built in the plunger (refer to Illust. 1-146).



Illust. 1-145. Checking solenoid switch.



Illust. 1-146. Checking pull-rod spring tension.

1. Plunger
2. Pull-rod

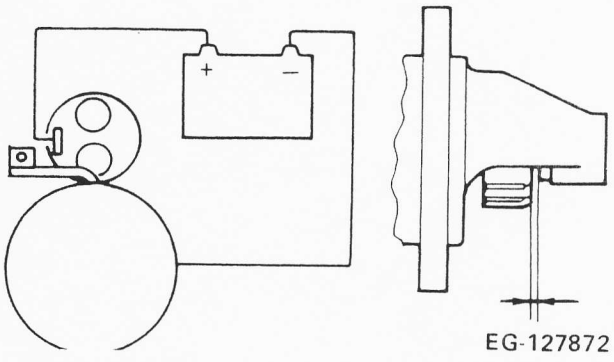
Pinion Clearance (See Illust. 1-147)

1. Reassemble the starter with connecting leads unconnected.

2. Connect a cable from the negative terminal of the battery to the starter body and a cable from "S" terminal of the starter to the positive terminal of the battery to force out the pinion.

3. Push back the pinion slightly to remove end play, and measure the pinion clearance.

4. If the clearance is not within the specified values, add or remove the washer between the solenoid switch and front end frame.



Illust. 1-147. Checking pinion clearance.

Pinion clearance	Factory specification	0.020 to 0.079 in.

ALTERNATOR AND REGULATOR

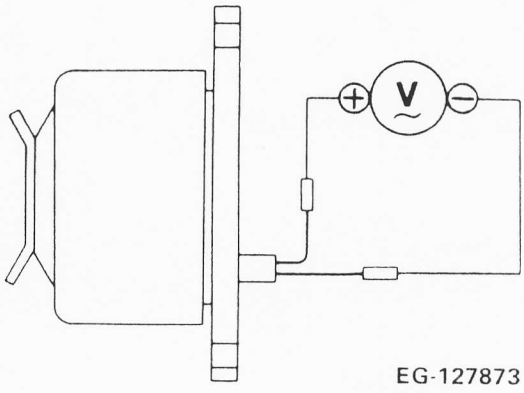
Testing

No-Load Alternator Output (See Illust. 1-148)

1. Disconnect the lead wires from the alternator.

2. Start the engine and operate the alternator at the specified speed.

3. Measure the output voltage with a voltmeter. If the measurement is not within the specified values, replace the alternator.



Illust. 1-148. Testing no-load alternator output.

No-load output	Factory specification	AC 20V or more at 5200 rpm

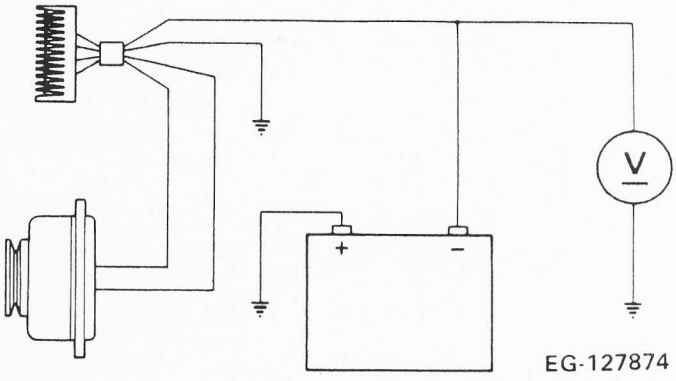
Regulating Voltage (See Illust. 1-149)

1. Complete the charging circuit with a fully charged battery and operate the alternator at the specified speed.

2. Measure the battery voltage with a voltmeter.

3. If the measurement is not within the specified values, replace the regulator.

Regulating voltage	Factory specification	14 to 15V at 5200 rpm



Illust. 1-149. Checking regulator output voltage.

GLOW PLUG

Testing

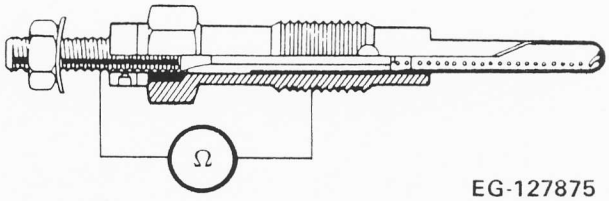
Heat Coil and Insulation (See Illust. 1-150)

1. Disconnect the lead wires from the glow plug.

2. Check the continuity across the thread at the end of the glow plug and its housing or the engine body with an ohmmeter.

3. If the ohmmeter indicates 0 ohm or infinity, replace the glow plug.

Heat coil resistance	Factory specification	Approximately 1.6 ohm when cold



Illust. 1-150. Testing glow plug.

POWER UNIT REASSEMBLY AND INSTALLATION

1. Assemble the complete engine with cylinder head, oil pan, gear case, water pump, alternator, starter, manifolds, pulley with alternator and water pump belt, injection pump, injectors and tubing, glow plugs, drain plugs, oil pressure and temperature sending units, and oil filter.

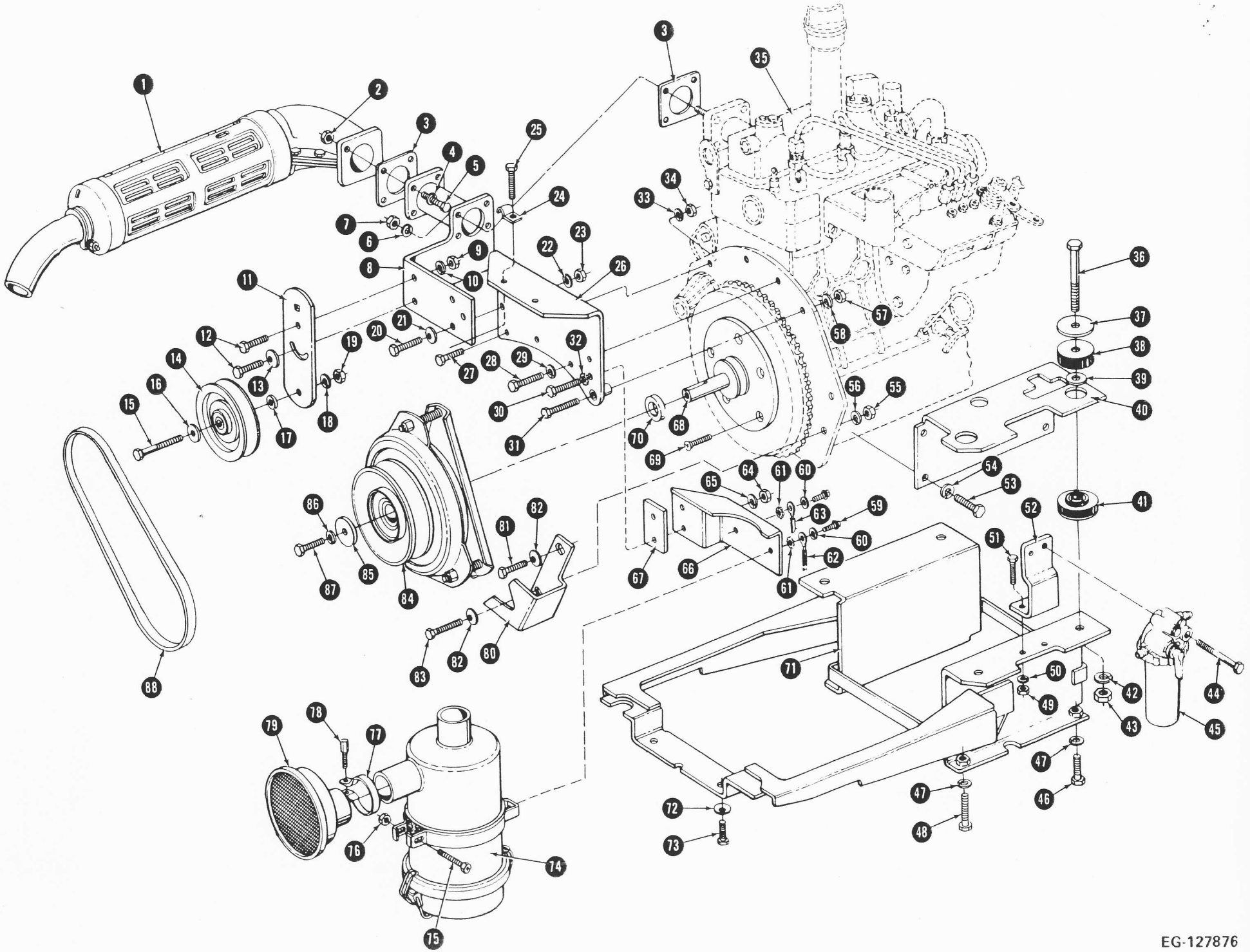
2. Remove the engine stands and install the left and right engine plate (40, Illust. 1-151).

3. Support engine on solid blocking.

4. Install stub shaft (68) using new screws (69). Torque screws to 28 ft. lbs.

Legend for Illust. 1-151.

1. Muffler assembly
2. Nut
3. Gasket
4. Lock washer
5. Bolt
6. Lock washer
7. Nut
8. Bracket
9. Nut
10. Lock washer
11. Idler pulley bracket
12. Bolt
13. Washer
14. Idler pulley
15. Bolt
16. Washer
17. Spacer
18. Lock washer
19. Nut
20. Bolt
21. Washer
22. Lock washer
23. Nut
24. Clip
25. Bolt
26. Bracket
27. Bolt
28. Bolt
29. Washer
30. Bolt
31. Bolt
32. External tooth lock washer
33. Lock washer
34. Nut
35. Engine assembly
36. Bolt
37. Flat washer
38. Mount pad (upper)
39. Washer
40. Engine plate
41. Mount pad (lower)
42. Lock washer
43. Nut
44. Bolt
45. Secondary fuel filter
46. Bolt (short)
47. Lock washer
48. Bolt (long)
49. Nut
50. Lock washer
51. Bolt
52. Support
53. Bolt
54. Lock washer
55. Nut
56. Lock washer
57. Nut
58. Lock washer
59. Bolt
60. Lock washer
61. External tooth lock washer
62. Ground-to-battery cable
63. Ground-to-chassis cable
64. Nut
65. Lock washer
66. Air cleaner support
67. Absorber
68. Stub shaft
69. Screw (special)
70. Spacer
71. Engine and radiator mount
72. Washer
73. Bolt
74. Air cleaner assembly
75. Bolt
76. Nut
77. Clamp
78. Clamp screw
79. Air cleaner screen
80. Torque bracket
81. Bolt
82. Bell washer
83. Bolt
84. PTO clutch assembly
85. Washer
86. Lock washer
87. Bolt
88. Fan belt



Illust. 1-151. Power unit - exploded view.

CAUTION! It is absolutely necessary that new screws are used. These screws are a metric patch screw that require a metric Allen wrench to install and torque properly. The "patch" on the bolt is Loctite #495 thread-lock that has already been applied to the threads of the screws on the threads farthest from the head of the screw. Re-torque these screws during the first few hours of operation after overhaul. Failure to follow these instructions may cause screw to back out of flywheel and destroy the fan belt.

5. Install the fan drive support bracket (26), muffler bracket (8), idler pulley bracket (11), and idler pulley (14).

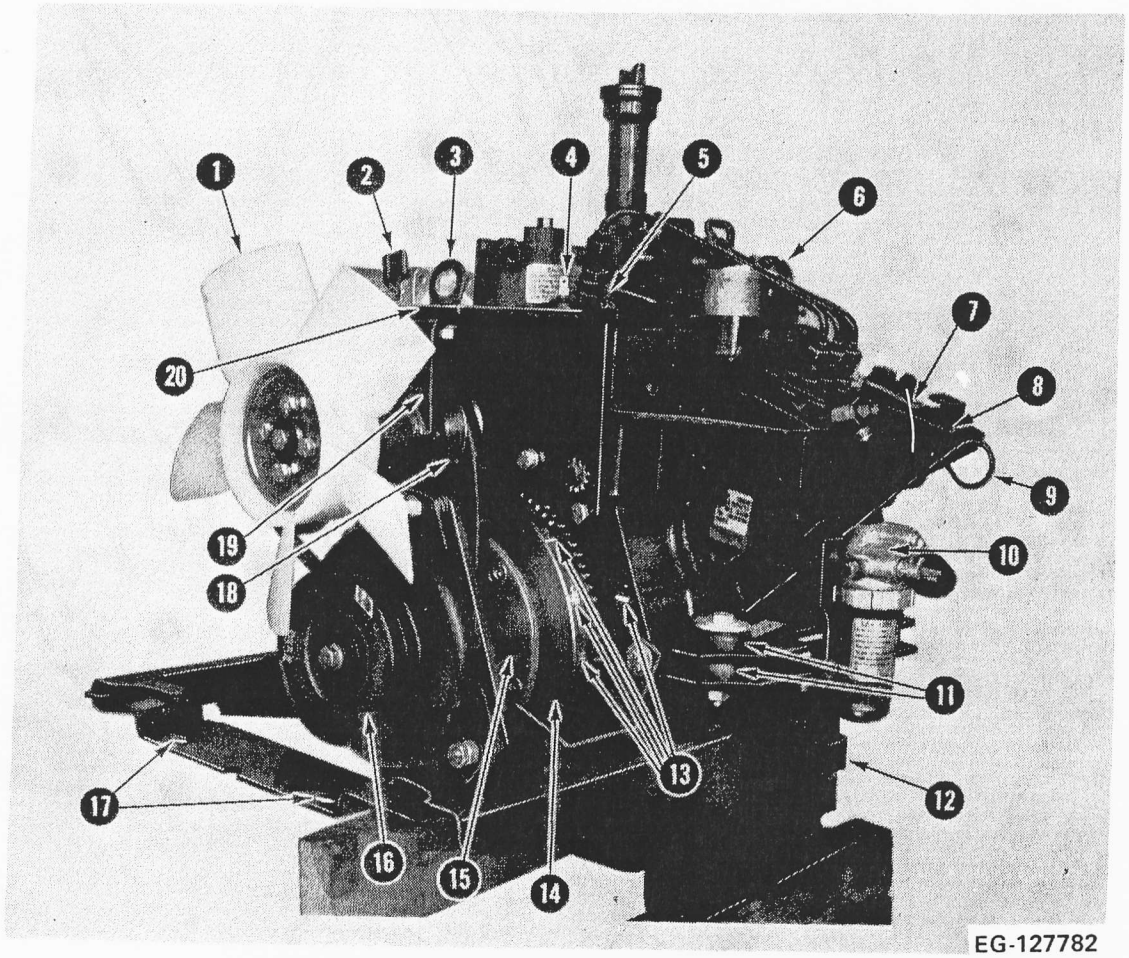
6. Install the air cleaner support (66).

7. Install the torque bracket (80).

8. Install the fan belt (88) and adjust the belt tension.

9. Slip the spacer (70) over the stub shaft (68). Install the PTO clutch assembly (84) and secure with the bolt (87), lock washer (86), and flat washer (85).

10. Install the assembled fan and fan drive support (19, Illust. 1-152).



Illust. 1-152. Power unit - radiator, air cleaner and muffler removed.

Legend for Illust. 1-152.

1. Fan blade	11. Engine mounts
2. PTO electrical connector	12. Engine and radiator mount
3. Lifting eye	13. Timing marks
4. Water temperature sending unit	14. Flywheel
5. Fuel return line fitting	15. Stub shaft
6. Lifting eye	16. PTO clutch assembly
7. Engine stop lever	17. Radiator mounting holes
8. Engine speed control lever	18. Fan drive pulley
9. Engine oil dipstick	19. Fan drive support
10. Secondary fuel filter	20. Support bracket

11. Hook a chain to the two lifting eyes (3 and 6, Illust. 1-152).

12. Using a suitable hoist, raise the assembled power unit and guide it into the engine and radiator mount (12). Install the engine mounts (11) and secure the assembled power unit to the engine and radiator mount.

13. Install the secondary fuel filter support (52, Illust. 1-151) and filter (45).

14. Position the radiator on the engine and radiator mount (71) and secure with two bolts (73) and washers (72).

15. Install the alternator belt (7, Illust. 1-153) and adjust the belt tension.

16. Install the drive shaft flange and flexible coupling (9) on the crankshaft pulley.

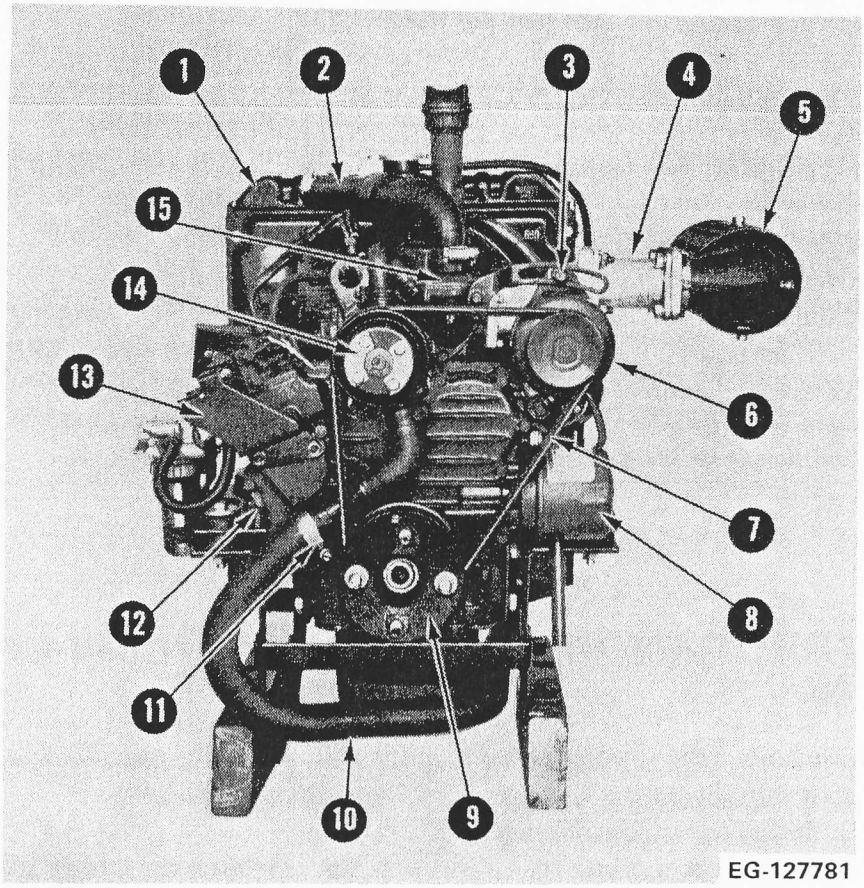
17. Install the radiator upper hose (2), and lower hose (10).

18. Raise the assembled engine and radiator mount with the hoist.

19. Position the tractor on a flat surface and guide the power unit onto the tractor frame.

20. Align the drive shaft with the flexible coupling on the engine and slide the power unit into position. Use a drift pin to align the engine and radiator mount welded nuts with the matching holes in the tractor frame.

21. Install the two shorter bolts (46, Illust. 1-151) and lock washers (47) to the rear mounting holes. Install the two longer bolts (48) and lock washers (47) to the front mounting holes. Tighten securely.



Illust. 1-153. Power unit removed - gear case end of engine facing forward.

1. Radiator	6. Alternator	11. Hose clamp
2. Radiator upper hose	7. Alternator belt	12. Block drain cock
3. Alternator adjusting bolt	8. Oil filter	13. Cable support bracket
4. Exhaust extension	9. Flexible coupling	14. Water pump pulley
5. Muffler	10. Lower radiator hose	15. Thermostat housing

22. Working through the frame cover opening, install two nuts (1, Illust. 1-154) and washers, securing the drive shaft to the drive shaft flange on the crankshaft pulley.

23. Install the battery tray with attached fuel pump, voltage regulator and circuit breaker.

24. Connect electrical wiring and fuel lines in the reverse order of disassembly.

25. Connect the engine stop lever cable and engine speed control lever cable.

26. Fill the engine with motor oil, as recommended in the "Specifications."

27. Fill the cooling system, as recommended in the "Specifications."

28. Fill the fuel tank as recommended in the "Specifications."

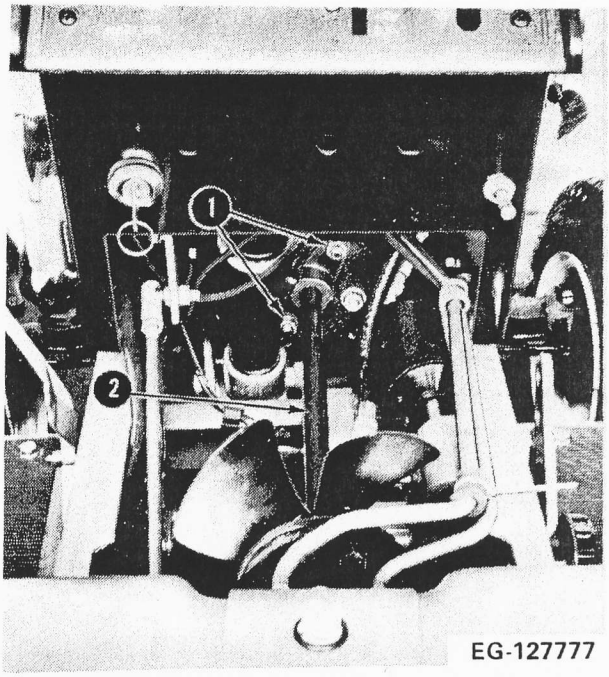
29. Bleed the fuel system as outlined under "Bleeding the Fuel System."

30. Start the engine, check ignition timing, oil pressure and cooling system temperature. Check for leaks. Tighten or replace, as required. Re-torque bolts as specified under separate headings, as required.

31. Install floor plate, hood and grille assembly and side panels.

32. Slip mower drive belt over PTO pulley. Adjust belt tension.

33. Road test tractor and make necessary adjustments as required. See Operator's Manual.



Illust. 1-154. Drive shaft.

1. Flange nuts
2. Drive shaft

CHECKS AND ADJUSTMENTS

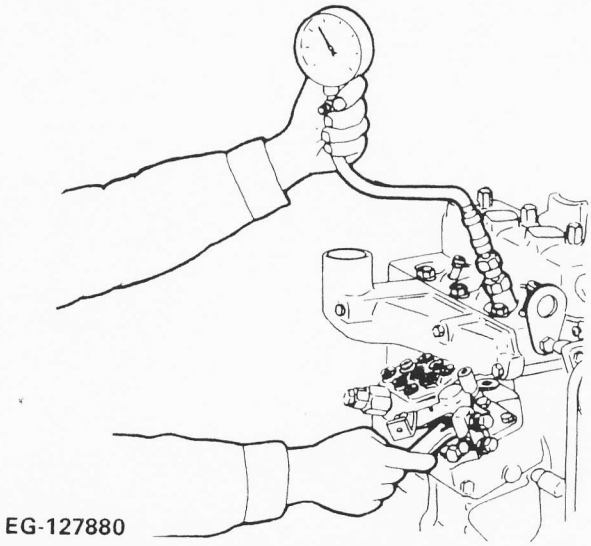
CHECKING COMPRESSION PRESSURE (See Illust. 1-155)

1. Run the engine until it is warmed up.

2. Stop the engine and remove the air cleaner, the muffler and all nozzle holders.

3. Set a compression tester with the adaptor to the nozzle holder hole.

4. Turn the engine with the starter at 200 to 300 rpm for 5 to 10 seconds and read the maximum compression pressure.



Illust. 1-155. Checking compression pressure.

5. Measure the compression pressure several times.

6. If the measurement does not reach the allowable limit, apply a small amount of oil to the cylinder wall through the nozzle holder hole and measure the compression pressure again.

7. If the pressure is still less than the allowable limit, check the top clearance, valve and cylinder head.

8. If the pressure increases after applying oil, check the cylinder wall and piston rings.

NOTE: Check the compression pressure with the specified valve clearance.

Compression pressure	Factory specification	448 psi
	Allowable limit	337 psi

ADJUSTING VALVE CLEARANCE (See page 1-54)

Checking Top Clearance (See Illust. 1-156)

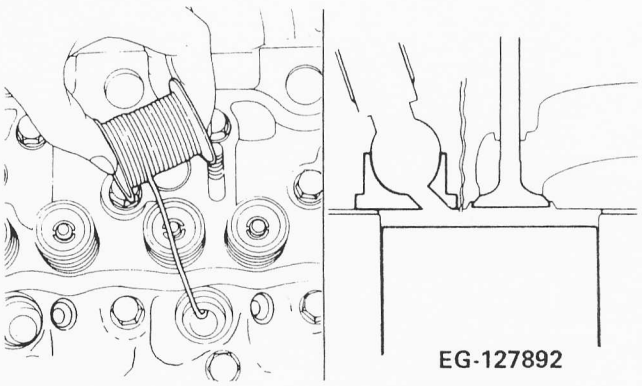
1. Remove the nozzle holder and lower the piston in the cylinder.

2. Insert a high-quality fuse from the nozzle holder hole on the piston (except where it faces the valve or the combustion chamber insert).

3. Rotate the flywheel until the piston is raised and lowered again.

4. Take out the flattened fuse carefully and measure its thickness with a micrometer.

5. If the measurement is not within the specified values, check the oil clearances of the crank pin journal and the piston pin.

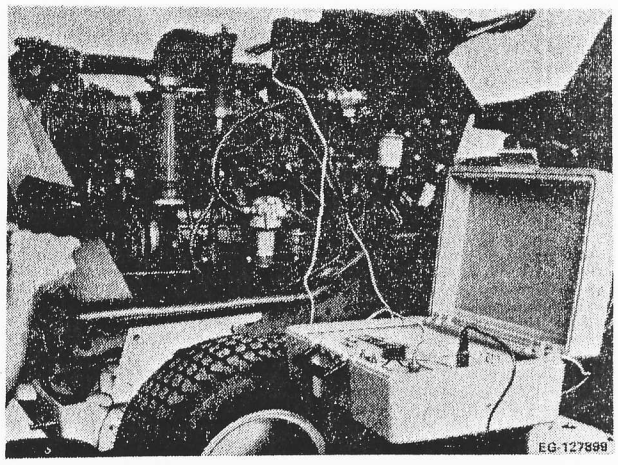


Illust. 1-156. Checking top clearance.

Top clearance	Factory specification	0.0236 to 0.0315 in.

Injection Timing (see page 87), Diesel Timing Unit (see page XV), and also see Illust. 1-157.

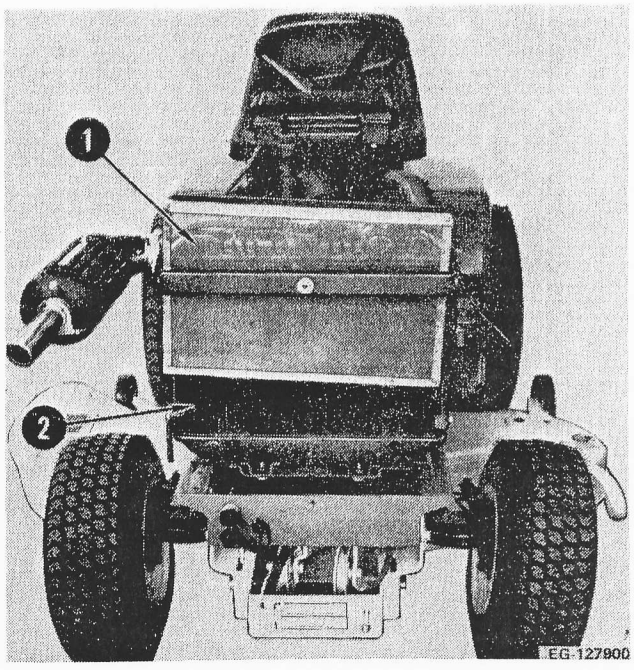
Air Bleeding the Fuel System (See page 1-92)



Illust. 1-157. Timing the engine using diesel timing unit - Model No. 15-3354. (See Special Tools section)

RADIATOR SCREEN (See Illust. 1-158)

Remove screen (1) and clean as often as necessary.



Illust. 1-158. Radiator screen.

1. Screen (partially removed)
2. Radiator