MODELS
D-155, D-179, D-206, D-239
DT-239, D-246, D-268, D-310, D-358
DT-358 and DT-402
DIESEL ENGINES

FORM
CGES-310-1

JANUARY 1982

PAYLINE, TRUCK, AGRICULTURAL
EQUIPMENT AND OEM APPLICATIONS
(Supersedes Form CGES-310)

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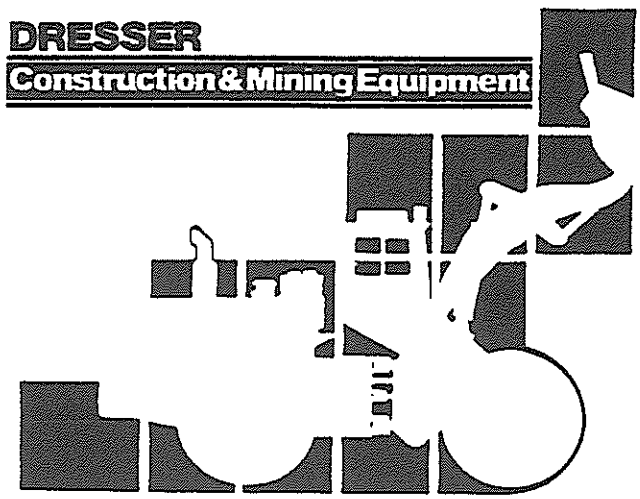

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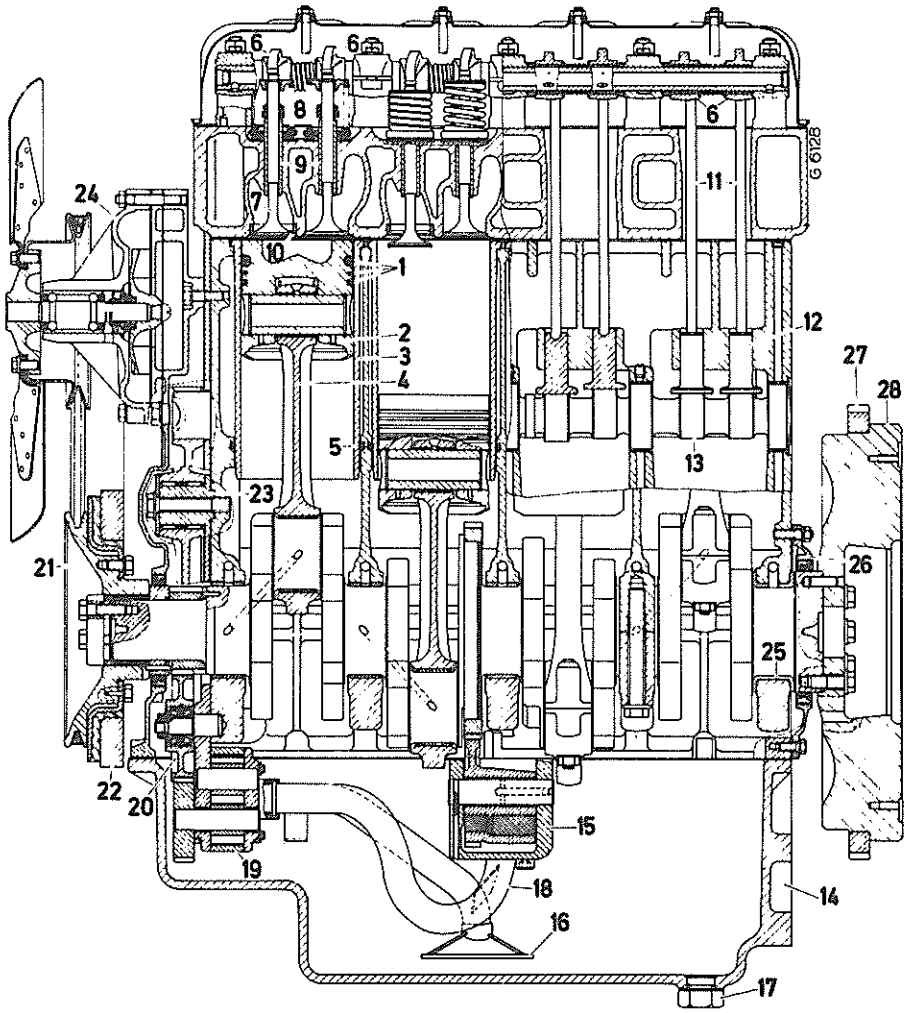
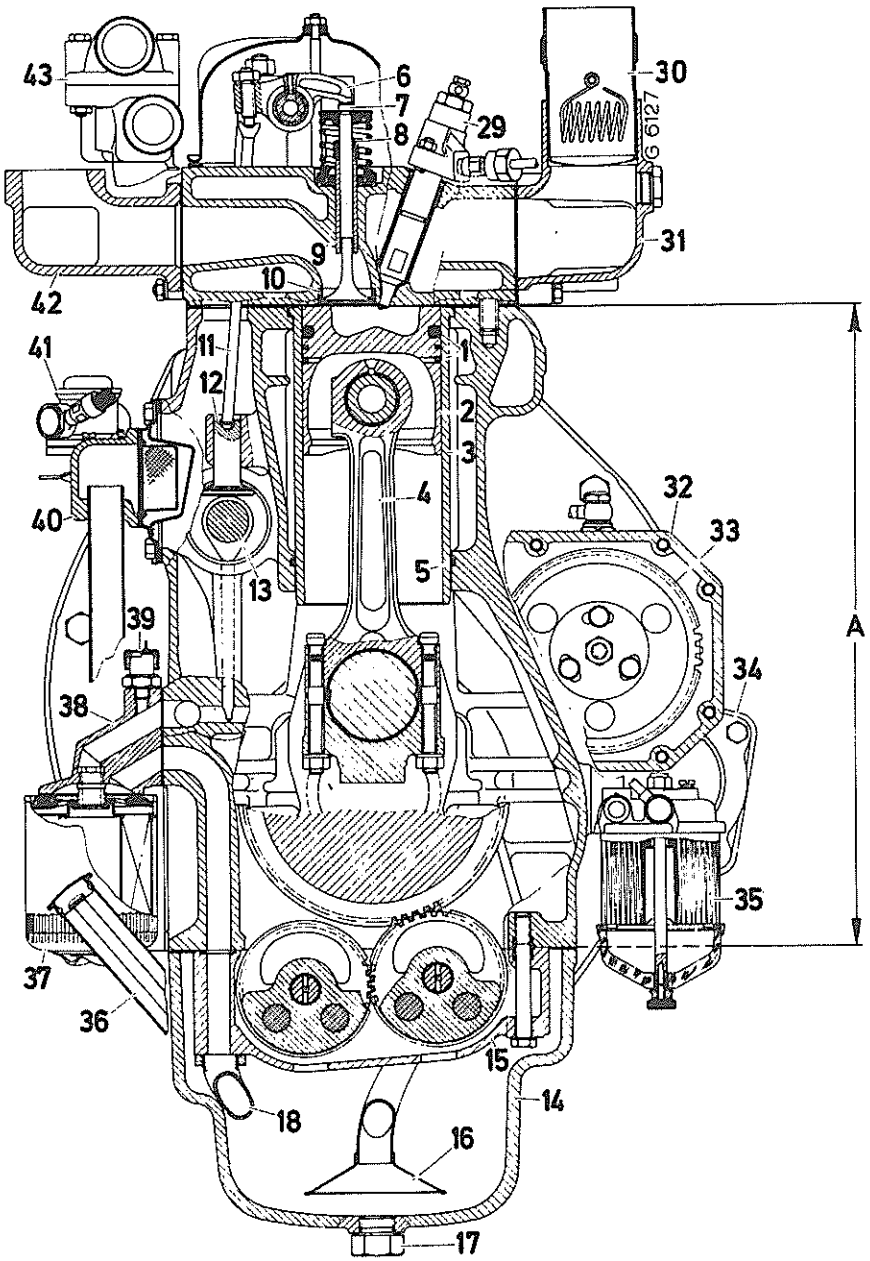
LONGITUDINAL SECTION OF ENGINE
(4-Cylinder Engine)



Illust. 1
Ref. Nos. apply equally to Illust. 1 and 2

1 – Piston rings
2 – Piston, 3-ring type
3 – Cylinder sleeve
4 – Connecting rod
5 – O-ring
6 – Valve lever
7 – Valve, exhaust
8 – Valve seal
9 – Valve stem guide
10 – Valve seat insert, exhaust
11 – Valve push rod
12 – Valve tappet
13 – Camshaft
14 – Oil pan
15 – Balancer
16 – Oil suction Screen
17 – Oil drain plug
18 – Oil pipe
19 – Oil pump
20 – Idler gear
21 – V-belt pulley
22 – Vibration damper (if used)
23 – Idler gear carrier
24 – Water pump
25 – Thrust bearing, crankshaft
26 – Rear oil seal retainer
27 – Flywheel ring gear
28 – Flywheel
29 – Nozzle holder
30 – Heating pipe
31 – Manifold, intake
32 – Front plate, crankcase
33 – Gear, injection pump
34 – Starting motor
35 – Filter, fuel
36 – Oil filler neck
37 – Oil filter
38 – Oil filter socket
39 – Oil pressure switch
40 – Breather
41 – Feed pump, fuel (if so equipped)
42 – Manifold, exhaust
43 – Thermostat (short coolant manifold)

CROSS SECTION OF ENGINE
(4-Cylinder Engine)



Illust. 2

ENGINE	CYLINDER	BORE		STROKE		DISPLACEMENT		DIMENSION "A"	
		mm	Inch	mm	Inch	Litre	Cubic Inch	mm	Inch
D-155	3	98.4	3.875	111.1	4.375	2.54	155	424.18	16.70
D-179	3	98.4	3.875	128.5	5.059	2.94	179	458.72	18.06
D-206	4	98.4	3.875	111.1	4.375	3.38	206	424.18	16.70
D/DT-239	4	98.4	3.875	128.5	5.059	3.92	239	458.72	18.06
D-246	4	98.4	3.875	128.5	5.059	4.03	246	458.72	18.06
D-268	4	100	3.937	139.7	5.500	4.40	268	464.32	18.28
D-310	6	98.4	3.875	111.1	4.375	5.08	310	424.18	16.70
D/DT-358	6	98.4	3.875	128.5	5.059	5.87	358	458.72	18.06
DT-402	6	100	3.937	139.7	5.500	6.59	402	464.32	18.28

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TYPE	4—Cycle—Diesel—Engines
Direction of rotation, facing flywheel	L.H.
Compression ratio	16:1 (except D—268 and DT—402) 15:1 (D—268 and DT—402)
Compression at starting speed, MPa (PSI)	2.2—2.4 (313—341)
Firing order	
D—155, D—179	1—3—2
D—206, D—239, D—246, D—268, DT—239	1—3—4—2
D—310, D—358, DT—358, DT—402	1—5—3—6—2—4
Valve clearance, engine hot	0.30 mm (.012 in.)
COOLING SYSTEM	
Most favorable operating temperature	90°—95°C (194°—203°F)
AIR SYSTEM	
Max. permissible restriction before servicing the air cleaner	635 mm (25 inch) of water
LUBRICATING SYSTEM	
Oil pressure at rated speed, Pa (PSI)	303—414 (44—60)
Oil pressure at low idle speed and 90°C (194°F) oil temperature, Pa (PSI)	min. 90 (12.8)
Lubricant	see "Operator's Manual"
Oil consumption, less than	1 g/HP hr
INJECTION SYSTEM	
Injection pump	Robert Bosch Rotary
Nozzle opening pressure: Flange mounted nozzle holder, MPa (PSI)	20—21 (2845—3000)
Nozzle opening pressure: Crab mounted nozzle holder, see "Nozzle Holder Combinations" Page 177	
ELECTRICAL SYSTEM	
Alternator	"Bosch" 14 V—28 A 14 V—35 A 14 V—55 A 28 V—27 A 28 V—45 A
Starting Motor	"Bosch" 12 V 3kW (4 HP) 24 V 4kW (5.3 HP) 24 V 4.8kW (6.4 HP)

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Crankcase Pressure and Blow-by Chart

Engine	Max. Crankcase Pressure (High Idle, No Load)		Max. Permissible Blow-By		
	mm H_2O	in H_2O	RPM	at Engine Idling cu. m./hr (cu. ft./hr)	at Rated Load cu. m./hr (cu. ft./hr)
D-155	38	1.5	1500 2500	1.0 (35.3) 1.5 (53.0)	2.0 (70.6) 2.5 (88.0)
D-179	38	1.5	2100 2500	1.5 (53.0) 1.5 (53.0)	2.0 (70.6) 2.5 (88.0)
D-206	51	2.0	2100 2500	1.5 (53.0) 1.5 (53.0)	2.5 (88.0) 3.0 (106.0)
*D-239	51	2.0	2100	1.5 (53.0)	2.5 (88.0)
**D-239	114	4.5	2200	1.5 (53.0)	2.5 (88.0)
DT-239	152	6.0	2500	2.0 (70.6)	3.5 (123.0)
D-246	51	2.0	2500 2 00	2.0 (70.6) 2.0 (70.6)	3.0 (106.0) 3.5 (123.0)
D-268	51	2.0	2500 2200 2300	2.0 (70.6) 1.5 (53.0) 2.0 (70.6)	3.0 (106.0) 3.5 (123.0) 3.5 (123.0)
D-310	64	2.5	2400 3000	2.0 (70.6) 2.0 (70.6)	3.5 (123.0) 4.0 (141.0)
D-358	127	5.0	2200 3000	1.5 (53.0) 2.0 (70.6)	3.0 (106.0) 4.0 (141.0)
DT-358	165	6.5	2200 2500	4.0 (141.0) 4.0 (141.0)	6.0 (212.0) 6.0 (212.0)
DT-402	165	6.5	2200 2500	2.0 (70.6) 2.0 (70.6)	3.0 (106.0) 3.0 (106.0)

*With rectangular top ring
**With full keystone top ring

NOTE: Refer to "Checks" for testing procedure and proper tools.

IMPORTANT

Pressure readings obtained must not be used as the main source of engine condition. Oil consumption trend data must also be used if the pressure readings are beyond the specified limits. Neither changes in oil consumption trends nor crankcase pressure trends can establish a specific component problem but are only indicators that some problem exists.

Static Timing (Degrees BTDC) *

D – 155	*
423, E–423	10
383	10
500 C/E	12
453	10
V/E–433, V/E–533	10
V/E 433 Series II	8
V/E 533 Series II	10
S.U. 533	10
5033	12
433	8
533	10

D – 179	
553	14
633	14
4500 B T.C.	14
454 G.D./454 H.S.	14
464 G.D./H.S.	14
3654 S.U.	14
484, 248 IT	14
SU–644–LD	14
2454 G.D./H.S.	14
240A S.M/H.S./T.C.	14
3400 A G.D./H.S.	14
2400 A G.D./H.S.	14
Irrigation – Unit	14

D – 206	
554, 654, 644	12
221	14
TD–7 C G.D.	12
100 G.D.	12
733	12
474 G.D./H.S.	14
100 B Series II	10
584	12
TD–6 B	10
100 B, 624	10
258 IT	12
624 (Mexico)	12

D – 239 DT – 239	*
724, 734	14
824, 744 S.U.	16
824, 834, 744 Crane	16
TD–7 E, 100 E P.S.	12
TD–8 C, P.S.	12
125 G.D./P.S.	14
H–30 B, Galion Gr.	16
H–30 B Nico	16
321, 431	12
Ingersoll-Rand	16
5000/5500 W.R.	16
1130/1230 TOE	12
743, 745 S	16
574 H.S.	16
574 G.D.	12
3654, 3654 S.U.	14
3500 A G.D./H.S.	14
674 G.D.	14
2500 A G.D.	12
125 B u. TD–8B Ser. II	12
S.U. 644–H.D. 4–WD.	14
3400 B S.M. H.S./T.C.	18
684	16
2574 G.D.	12
250 A. S.M.	12
260 ATC SM./H.S.	18
Irrigation Unit	18
2500 AH.S.	14
2574 H.S.	14
250 A H.S./T.C.	14

D – 246	*
824	18
834	18
844	18
784	16
84 Hydr.	16
268 IT	16
278 IT	16

D – 268	
844 S	8
845	8
620 B	8
510	18
TD–8 CA	8
884	16
270 A	16

D – 310	
946 (2100 RPM)	16
946 (2200 RPM)	10
686	14
766	10
955	12
431, 531	16
H–50 B	12
DU–2 D	16
D–1500 C	18
616/622 H.S.	16
711 S.P. Header Harv.	10
165 C	8
696	14
I–3820 A	14
9000 F.L.	14
715 Comb.	12
782 Cotton Picker	16
786	10
86 Hydr.	8

D – 358 DT – 358	*
1055, 955	14
1630 A, 1730 A, 1830 A	18
531, 541, (8–111)	18
Acco 1820 with AT–540	18
1730 B – 1930 B	18
Galion 102 Grader	16
DU–2 D	16
H–60	16
Series 200 ATk. M.T.	18
1046	16
1521 S	18
725 SP	14
H 65 B	17
866–HS (Austr.)	16
3964/3965	18
3980	16
515	16
976, 986, 886 (U.S.)	16
S–8A, S–10	16
H–60–B, 520 A	16
H–65 C	16
530 A	16
943	18
953	16
923	16
933	18
1420	10
3990	16
650	16
3980 B/3984 B	20
630	18
280 PH	20
1246	16
1255	8
786	18
1400	12
Irrigation – Unit	16
640 (D – 358)	16
640 (DT – 358)	20

DT – 402	
3994, 650 HD	16
953 HS, 953 GD	16
1455	14
530 AS II	16

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SPECIAL SERVICE TOOLS REQUIRED

TOOL DESCRIPTION	AGRICULTURAL EQUIPMENT	* (FES)	CONSTRUCTION EQUIPMENT	TRUCK EQUIPMENT
Piston Ring Drop Fixture	04-68-3	(68-3)	PLT-501	SE-2206
Camshaft Bearing Remover/Installer Set	04-101	(101)	PLT-543	–
ENGINE TOOL KIT	– – –		PLT-511	–
Rear oil seal installing tool	04-149-2	(149-2)	PLT-511-1	–
Installing tool spacers	04-149-21	(149-21)	PLT-511-2	–
Injection nozzle sleeve pulley	17-25-12	(25-12)	PLT-509-11	–
Engine valve guide driver	04-112-5	(112-5)	PLT-511-4	–
Cylinder head offset wrench	04-112-6	(112-6)	PLT-511-5	–
Cylinder head special bolt wrench	04-112-8	(112-8)	PLT-511-6	–
Front engine seal installer	04-112-7	(112-7)	PLT-511-7	–
Cylinder Deglazer Brush	04-130-4	(130-4)	PLT-547-4	SE-2314-4
Valve Guide Cutter	04-145	(145)	–	–
Nozzle Sleeve Installer	04-148-2	(148-2)	PLT-510-2	–
Valve Spring Compressor	04-462	(462)	–	SE-1846
Piston Ring Compressor	04-464-2	(464-2)	–	SE-1610
Cylinder Ridge Reamer	04-467	(467)	–	SE-1405
Cylinder Hone	04-468	(468)	–	SE-1574
Valve Guide Reamer	04-478-1	(478-1)	PLT-545	–
Pressure/vacuum Compound Gauge	14-1-3	(1-3)	PLT-866-3	–
Male Connector	14-2-78	(2-78)	PLT-864-62	–
Hose Assembly	14-2-33A	(2-33A)	PLT-864-23)	–
"O" Ring and Packing Tool	14-57-3	(57-3)	PLT-106	–
Pressure Snubber	14-94-6	(94-6)	PLT-860-6	–
Thermomelt Pencil 198°C (388°F)	15-115-1	(115-1)	PLT-118-1	–
Thermomelt Pencil 93°C (200°F)	15-115-3	(115-2)	PLT-118-3	–
Dial Indicator	15-67-1	(67-1)	PLT-102-1	–
Valve Spring Tester	15-233	(233)	PLT-100	–
Compression Tester	15-13-1	(13-1)	PLT-519-1	–
Compression Tester Adapter	15-14-2	(14-2)	PLT-520-2	–
Nozzle cup nut	and 3 056 945 R1		and 3 056 945 R1	
Copper sealing washer	116102		116102	
Diesel Timing and Tachometer Kit	15-3005	(3005)	PLT-301	SE-2528
Nozzle Tester	15-71A	(71)	PLT-360	SE-2002
Nozzle Tube Assembly	15-72-1	(72-1)	PLT-360-1	SE-2004-13
Adapter	15-72-2	(72-2)	PLT-360-2	SE-2757
Hose Assembly	15-72-3	(72-3)	PLT-361-3	–

* (FES) refers to old numbering system

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SPECIAL SERVICE TOOLS REQUIRED

TOOL DESCRIPTION	AGRICULTURAL EQUIPMENT	* (FES)	CONSTRUCTION EQUIPMENT	TRUCK EQUIPMENT
Fuel rator with fittings and hoses	15-136	(136)	—	—
Fuel Diverting Kit	15-132	(132)		—
Injection Pipe Assembly (For use on D-239 Engine)	15-132-10	(132-10)	—	—
Diesel Field Test Kit	15-126	(126)	—	—
Engine Stand	17-52A	(52)	PLT-540	
Engine Attaching Plate	17-52-11	(52-11)	PLT-540-2	
Nozzle sleeve puller adapter (Use with slide hammer with 5/8" - 18 thread)	17-25-12	(25-12)	PLT-509-11	
Universal Wet Sleeve Puller	17-22-2	(22-2)	PLT-502-3	SE-2536
Injection Nozzle Puller	05-46	(46)	PLT-359	—
Injection Pump Kit (Includes:	— — —		PLT-357	— — —
Holding fixture	05-111-1	(111-1)	PLT-357-1	—
Drive hub puller	05-111-2	(111-2)	PLT-357-2	—
Combination metric wrench	— — —		PLT-357-3	—
Delivery valve gasket remover	05-111-4	(111-4)	PLT-357-4	—
Timing window	05-111-5	(111-5)	PLT-357-5	—
Banjo fitting	05-111-6	(111-6)	PLT-357-6	—
6mm Allen wrench	— — —		PLT-357-7	—
Control plunger spring pre-load tool)	05-111-8	(111-8)	PLT-357-8	—
Nozzle Orifice Cleaning Needle Kit	05-131	(131)	PLT-368	SE-2202
SAE Test Nozzle	05-137-20	(137-20)	PLT-375-1	—
"CR" Injection Pump Kit (Includes:	05-504	(504)	PLT-356	— — —
Timing window adapter	05-504-1A	(504-1A)	PLT-356-1	—
Pressure port adapter plate	05-504-2	(504-2)	PLT-356-2	—
Rotor retainer	05-504-3	(504-3)	PLT-356-3	—
Alignment tool	05-504-4	(504-4)	PLT-356-4	—
Shaft seal protector	05-504-5	(504-5)	PLT-356-5	—
Slide hammer	05-504-6	(504-6)	PLT-356-6	—
Bullet tool (seal)	05-504-7	(504-7)	PLT-356-7	—
Bullet tool (seal)	05-504-8	(504-8)	PLT-356-8	—
Roller Assembly retainer	05-504-9	(504-9)	PLT-356-9	—
Plastic box	05-504-10	(504-10)	PLT-356-10	—
Timing window	— — —		PLT-357-5	—
Control plunger gauge)	05-504-11	(504-11)	PLT-356-11	—
Counterbore Tool (Includes:	—		PLT-546	—
Driver Unit, handle and tool bits	—		1 020 553 R91	SE-2514
Adapter plate	—		1 020 554 R1	SE-2514-1
Tool holder	—		1 020 556 R1	—
Tool bit)	—		1 020 561 R1	—
Depth Gauge (not included in Kit)	—		1 020 560 R91	SE-2515
Crankshaft Balance Weight Socket Adapter	04-575		—	—
Crankcase Pressure Orifice Restrictor	15-533-6		PLT-556	—
Crankcase Pressure Orifice Restrictor	15-533-5		PLT-554	—

* (FES) refers to old numbering system

SPECIAL NUT AND BOLT TORQUE DATA

NOTE: Torque values are in Newtonmeters (N•m) and pound feet (lbs-ft) except where pound inches are specified (#).

		N•m			lbs-ft		
		1st Step	2nd Step	Final Step	1st Step	2nd Step	Final Step
*Balance weight necked-down bolts	***	30	—	58	22	—	43
*Balance weight pitch diameter bolts		60	—	103	44	—	76
*Main bearing cap necked-down bolts 10.9	***	40	80	110	30	59	81
*Main bearing cap necked-down bolts 12.9	***	40	80	135	30	59	100
*Main bearing cap pitch diameter bolts 12.9		40	80	195	30	59	144
*Main bearing cap pitch diameter bolts 10.9		40	80	145	30	59	107
*Connecting rod nuts		25	—	□	18	—	□
*Annular spring tightener element or clamping ring		30	60	63	22	44	46
**Idler gear necked-down bolt	***	—	—	93	—	—	69
**Idler gear pitch diameter bolt		30	70	103	22	52	76
*Flywheel bolts		40	80	145	30	59	107
Bolts, seal ring retainer, rear		15	—	19	11	—	14
*Cylinder head nuts	***	40	80	120	30	59	89
*Cylinder head studs	***	—	—	55	—	—	41
*Cylinder head cap screws with round washer	***	40	80	115	30	59	85
*Cylinder head cap screws with collar		40	80	149	30	59	110
Valve lever bracket studs		—	—	38	—	—	28
*Valve lever bracket stud nuts		—	—	65	—	—	48
Valve set screw — clamping movement		—	—	31	—	—	23
Valve lever bracket clamping screw		—	—	11	—	—	(97)#
Side cover screws		—	—	17	—	—	13
Engine breather screw (use new packing ring)		—	—	9	—	—	(80)#
Oil pressure gauge		—	—	Max. 10	—	—	(Max. 88)#
Temperature sender unit		—	—	Max. 20	—	—	Max. 15
Exhaust manifold stud nuts		—	—	38	—	—	28
Exhaust manifold stud		—	—	38	—	—	28
Nozzle holder stud	Flange Mounted Nozzle Holder	—	—	16	—	—	12
Nozzle holder stud nuts	Flange Mounted Nozzle Holder	5	—	11	(44)#	—	(97)#
Nozzle union nut	Flange Mounted Nozzle Holder	—	—	70	—	—	52

( )# Represents pound-inch.
* Oil while mounting.
** Use liquid locking compound while mounting (Loctite # 271).
*** No longer used in production.
□ After pre-torque tighten additional two edges or 120°.

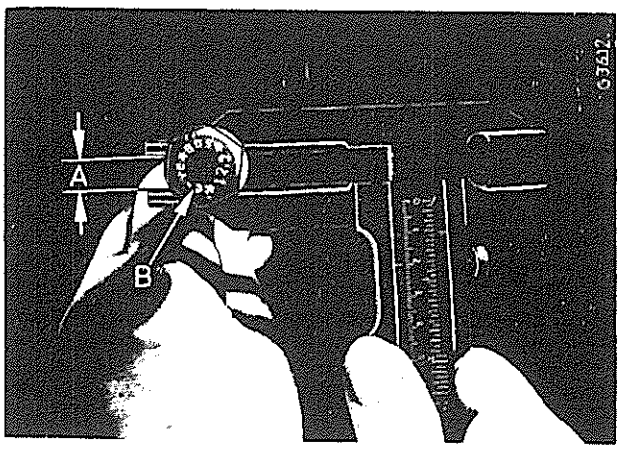
SPECIAL NUT AND BOLT TORQUE DATA – Continued

NOTE: Torque values are in Newtonmeters (N•m) and pound feet (lbs-ft) except where pound inches are specified (#).

	N•m			lbs-ft		
	1st Step	2nd Step	Final Step	1st Step	2nd Step	Final Step
*Bolt, Crab Mounted Nozzle Holder	—	—	25	—	—	18
Nozzle union nut, Crab Mounted Nozzle Holder	—	—	60	—	—	44
Nozzle holder leak oil connection hollow screw	—	—	5	—	—	(44)#
Injection line union nuts	—	—	23	—	—	17
Valve cover adapter stud	—	—	17	—	—	13
Valve cover stud nut	—	—	6	—	—	(53)#
Valve cover screw	—	—	6	—	—	(53)#
Valve cover housing bolt	—	—	16	—	—	12
Oil pan drain plug (when asbestos-filled packing ring is used)	—	—	55	—	—	41
Oil pan drain plug (when copper ring is used)	—	—	145	—	—	107
Plug with socket head (oil gallery-crankcase)	—	—	Max. 12	—	—	Max. 9
Injection pump gear bolt	15	—	27	11	—	20
Injection pump cover bolt (tighten crosswise)	4	—	9	(35)#	—	(80)#
Injection pump flange nut	15	—	24	11	—	18
Injection pump plunger end plug	—	—	50	—	—	37
Injection pump drive shaft nut (for VA injection pump)	—	—	65	—	—	48
Injection pump drive shaft nut (for VE injection pump)	—	—	93	—	—	69
Hollow screws (SW17 and SW19)	—	—	23	—	—	17
Bolts, sheet metal oil pan	—	—	13	—	—	10
Bolts, grey iron oil pan	—	—	32	—	—	24
Turbocharger V-Clamp	—	—	12	—	—	9
Front P.T.O. Clamping Ring Capscrew	15	—	29	11	—	21
Support Angle Bolt (for VE injection pump)	—	—	8	—	—	(71)#

( )# Represents pound-inch.
* Oil while mounting.
** Use liquid locking compound while mounting (Loctite #271).
*** No longer used in production.

IDENTIFICATION OF DIFFERENT BOLTS



Illust. 3

A – Shaft diameter
B – Stamping on bolt head

A – Different shaft diameter

Main bearing bolts, necked down	10.4 mm = .4094"
Main bearing bolts, pitch diameter	12.7 mm = .4999"
Balance weight bolts, necked-down	8.6 mm = .3385"
Balance weight bolts, pitch diameter	10.2 mm = .4015"
Idler gear bolt, necked-down	9.6 mm = .3779"
Idler gear bolt, pitch diameter	11.3 mm = .4449"

B – Different stamping on bolt head, e.g. 10K, 12K, 10.9, 12.9 or a circular stamping on idler gear pitch diameter bolt

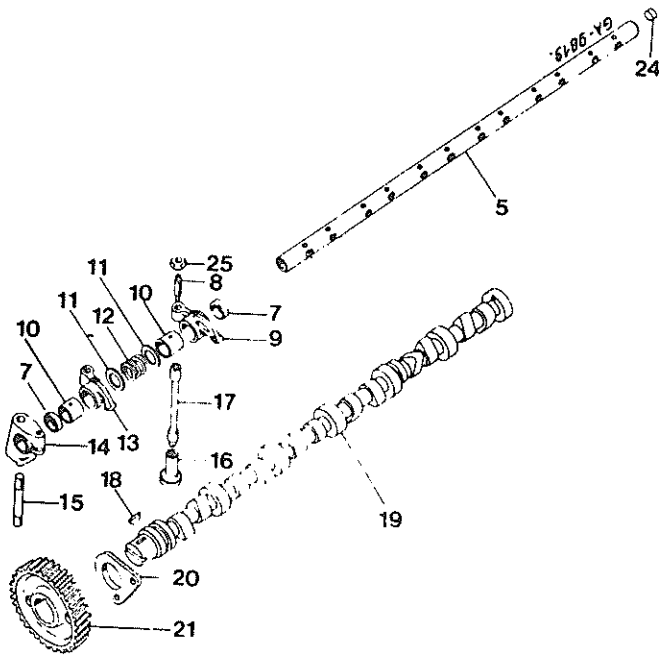
Note: Same bolts receive a special shot peening treatment at the engine assembly line. It is important, therefore, to use only the specified bolts to comply with our quality standards.

SPECIAL TOOLS

"International" Diesel engines are designed so that few service tools are required other than those in the mechanic's tool kit. However, when the use of inexpensive special tools will facilitate work, such equipment is mentioned in this manual.

Where local manufacture of special tools is recommended, details are shown in the respective sections of this manual.

VALVE LEVER ASSEMBLY



Illust. 4

General

The valve lever assembly receives its lubrication through the hollow valve lever shaft. Oil holes are provided in the valve lever shaft (5) Illust. 5 to lubricate individual valve levers.

An oil port is provided in the shaft which must line up with the respective oil-way in the bracket. The mark (3) Illust. 9 must be in line with the clamping slot of the front bracket. Replaceable oil plugs (24) Illust. 4 are used to close up both ends of the shaft.

Valve levers for intake and exhaust valves differ in length but are provided with the same replaceable bushings which must be reamed to size after installation.

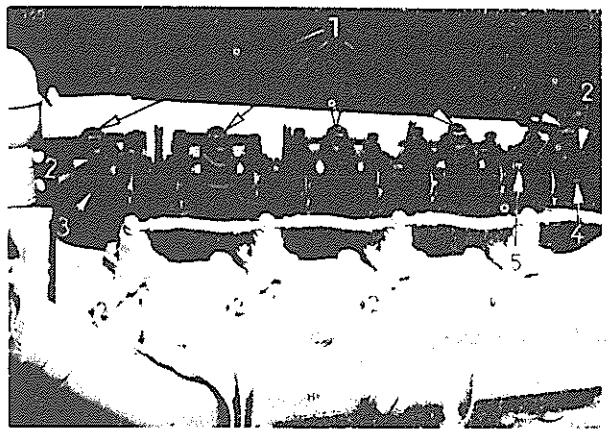
Replacement levers are supplied with bushings in place.

Removal and Disassembly

Thoroughly clean the engine externally.

Remove valve housing cover.

Remove nuts from studs (1) Illust. 5 and lift the complete valve lever assembly clear of the cylinder head. Loosen clamping bolts (2) and press in brackets slightly towards the center; taking care they do not slide off the shaft, resulting in levers and springs, etc. being scattered all over the floor. Slide all parts off the shaft and place them on a table in removal order to facilitate correct reassembly.



Illust. 5

1 — Stud nuts
2 — Clamping bolts
3 — Bracket, front
4 — Bracket, rear
5 — Spring

Specifications

In brackets ( ) max. permissible wear before reconditioning.

Valve lever shaft, dia	21.593—21.568 mm = .850—.849"
	(0.03 mm = .0012" out of round)
Valve lever bushing, dia	21.615—21.640 mm = .851—.852"
	(0.03 mm = .0012" out of round)
Clearance on shaft	0.022—0.062 mm = .0009—.0025"
	(+ 0.5 mm = .020")
Radius on contact end (3) Illust. 6	12.70 mm = .050"
Hardness on radius	RC 55
Depth of hardness	0.8 mm = .031"
Spring (12) Illust. 4, Free length	37.7 mm = 1.48"
Test length	25.0 mm = 1.00"
Test load	29N = 3 kg = 6.6 lbs.

Cleaning, Inspection and Repair

Clean all parts in kerosene or Diesel fuel and blow dry with compressed air. Be sure all oil passages are free from sludge and sediment.

Check valve lever shaft, lever bushings, thrust washers, and spacer rings. Check bushings and valve lever shaft for scoring and out-of-round wear and replace, if necessary. Use a suitable drift punch and press plate and drive bushings out of valve levers.

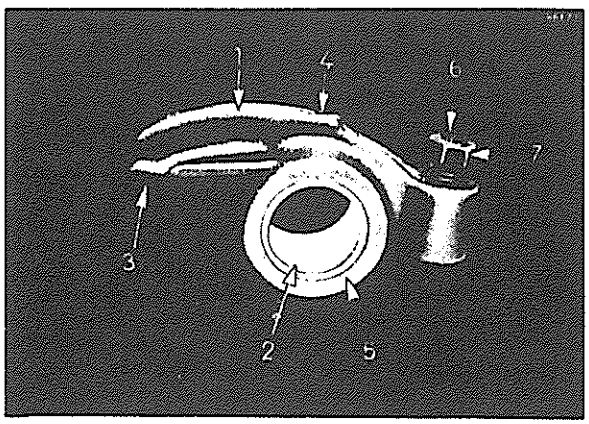
Install new bushings (2). The new bushing must be flush with the two side faces (5) Illust. 6. Use a 3 mm = 1/8" drill to open the oil passage (4) in the bushing and remove chips and burrs. Ream the bushing to size, see "Specifications"

Valve Lever

Regrind valve levers that show excessive wear or hammering at the ends (3) which contact the valves. Remove only enough material to give an even face on the end of the valve lever and take care that the rounding is maintained lengthways to assure perfect gliding action on the valve stem. Be sure that the surface is not ground out of line with the valve lever shaft in the lateral plane as this would place side thrust on the valve stem, thereby causing out-of-round wear on the valve guides.

When reconditioning contact end (3):

a) Use special refacing machine.
b) Maintain specified radius.
c) Be sure depth of hardness is sufficient after reworking.



Illust. 6

1 – Exhaust valve lever
2 – Lever bushing
3 – Valve contact end
4 – Oil passage, 3 mm Ø = 1/8" Ø
5 – Side face
6 – Valve adjusting screw
7 – Lock nut

Where appropriate grinding facilities for valve levers are not available it is advisable to install new valve levers as a complete set.

Inspect contact face of the valve adjusting screw (6) for hammering.

Adjusting Screw

Check and replace damaged screws with new ones.

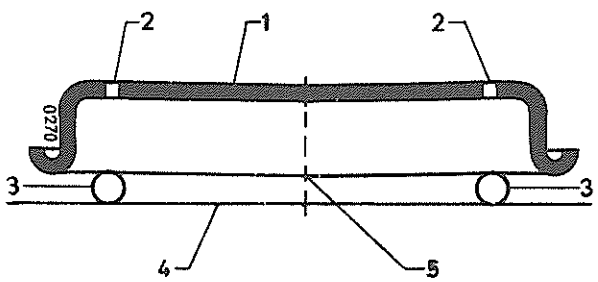
SHAFT

Check for out-of-round. Replace a worn shaft with a new one.

NOTE: New design rocker arm shafts are Deep-Nitroc treated so that the surface will be dull, mat gray in appearance, rather than the earlier design induction hardened polished appearance.

Check expansion plugs on both ends of the lever shaft for leakage and replace plugs, if necessary, using liquid sealer: Check valve lever springs against specifications and replace with new ones if signs of corrosion, chafing or fatigue begin to show.

Valve Housing Cover



Illust. 7

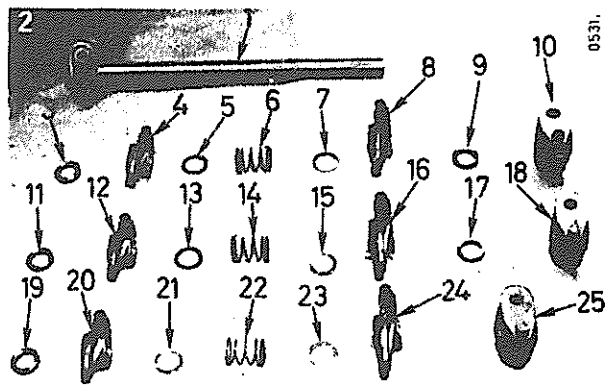
1 – Valve housing cover
2 – End holes
3 – Gauge bars
4 – Leveling plate
5 – Measuring point

Inspect valve housing cover for cracks and distortion.

Place the valve housing cover on a leveling plate, Illust. 7. Check the cover contacts bars (3) on four points. A gap up to 0.5 mm = .02" at one point is permissible. Check the height on both cover ends at measuring points (5). A difference up to 1 mm = .04" is permissible. Check valve housing cover also for cracks and other damage.

If cracked or if warpage exceeds above limits, replace.

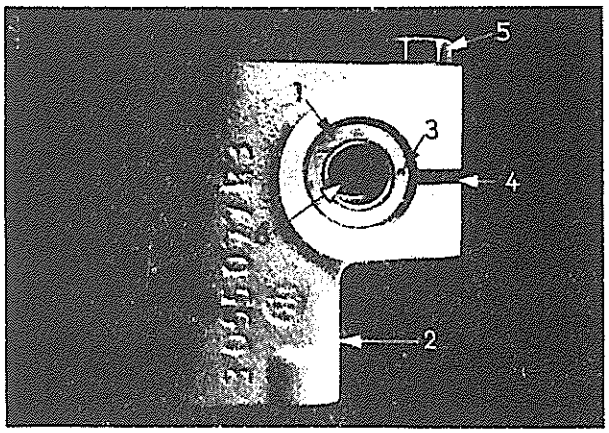
Reassembly and Installation



Illust. 8

Figures of Illust. 8 show sequence of reassembly

Reassemble the valve lever shaft in accordance with Illust. 8 commencing with front bracket (2). Oil all parts before reassembly.



Illust. 9

1 – Valve lever shaft
2 – Valve lever shaft bracket, front
3 – Punch mark
4 – Clamping slot
5 – Clamping bolt
6 – Expansion plug

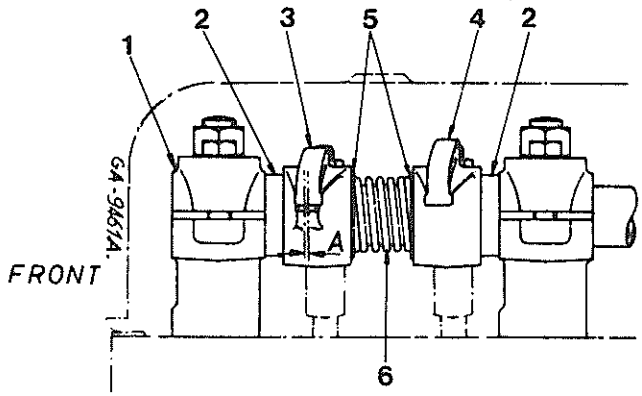
Punch mark (3) Illust. 9 of the shaft must be in line with clamping slot (4). Be sure the shaft end is flush with bracket (2). This will ensure that oil passages in bracket and shaft correspond.

Tighten clamping bolt (5) lightly to secure this adjustment.

Take care to alternate intake and exhaust valve levers.

On reassembly observe the following:

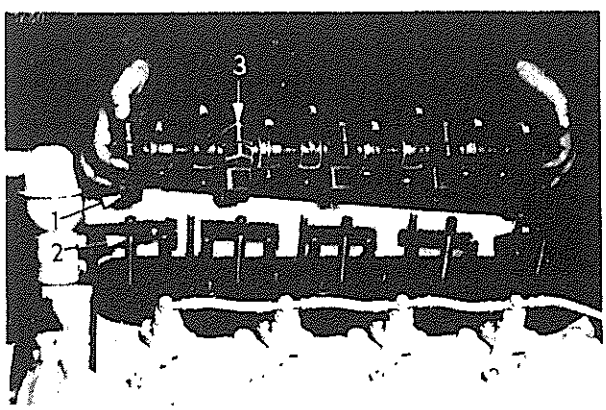
Spacer rings are installed on either side of every inner valve lever shaft bracket and on the inner side of the front bracket (1) Illust. 9a. There is no spacer ring between the rear bracket and the adjacent valve lever.



Illust. 9a

1 – Bracket, front
2 – Spacer
3 – Exhaust valve lever (short)
4 – Intake valve lever (long)
5 – Washer
6 – Spring
A – Max. 1.2 mm (0.047 in.) deviation of center line between lever and valve stem

Springs (6), located between each valve lever pair, have thrust washers on both sides. Take care to alternate intake and exhaust valve levers. Slide the assembly on studs (2) Illust. 10.



Illust. 10

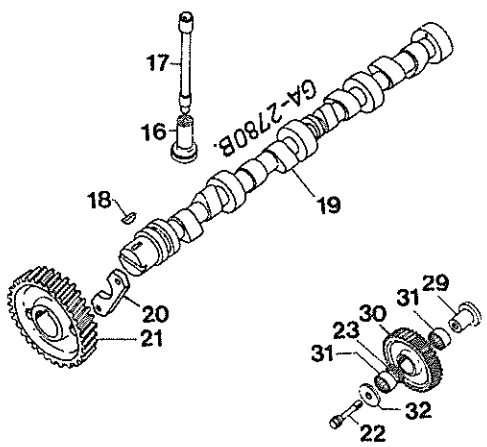
Removal or installation of valve lever shaft assembly

1 – Valve lever shaft bracket
2 – Stud
3 – Clamping bolt

Tighten stud nuts and clamping bolts to specified torque.

Check dimension "A" (Illust. 9a) and adjust valve clearance.

CAMSHAFT, IDLER GEAR, TAPPETS and PUSH RODS



Illust 11

General

The camshaft (19) Illust. 11 (and the injection pump) are driven from the front end of the crankshaft through a train of gears. All gears are punch-marked to ensure correct tuning.

The camshaft is supported in bushings.

End float is controlled by thrust plate (20). The drive gear (21) is keyed and shrunk to the camshaft end.

The camshaft bushings are pressure lubricated from the oil gallery and have drilled holes.

Specifications

In brackets ( ) maximum permissible wear before reconditioning.

Camshaft, Dia (Early type)	29.0–31.0 mm = 1.14–1.22"
Camshaft, Dia (Current type)	30.0–32.0 mm = 1.18–1.26"
Cam lobe width (Early type)	22.0 mm = .87"
Cam lobe width (Current type)	26.0 mm = 1.02"
Cam lobe lift	8.05–8.13 mm = .317–.320"
Cam lobe lift	8.05–8.13 mm (.317–.320")
Journals, Dia	58.00–57.97 mm = 2.2835–2.2823" (- 0.03 mm = .0012")
Bushings, i. Dia	58.054–58.024 mm = 2.856--2.844" (0.03 mm out-of-round)
Camshaft running clearance in bushings	0.024– 0.084 mm = .0010– .0033 (+ 0.03 mm = .0012")
Camshaft end float	0.10 – 0.45 mm = .004 – .018 "
Gear (21) Illust. 11	
Bore, Dia	41.275–41.300 mm = 1.6250–1.6259"
Gear seat, Dia	41.333–41.317 mm = 1.627 –1.6260"
Backlash, Drive Gear (21) / Idler Gear (30)	0.09 – 0.27 mm = .0035– .0106" (+ 0.3 mm = .012")
Idler Gear (30)	
Bore, Dia	42.038–42.022 mm = 1.6550--1.6543"
Running, clearance	0.010– 0.040 mm = .0004– .0016"
End float	0.20 – 0.33 mm = .008 – .013 "
Backlash Idler Gear / Crankshaft Gear	0.18 – 0.38 mm = .007 – .015 " (+ 0.3 mm = .012")
Idler gear carrier, Dia	35.000–34.989 mm = 1.3779–1.3775
Valve Tappets (16)	
Dia	19.970–19.985 mm = .7865– .7868" (- 0.03 mm = .0012")
Bore in crankcase	19.997–20.030 mm = .7873– .7885" (+ 0.05 mm = .0020")
Effective length	48.100–47.700 mm = 1.8937–1.8779" (- 0.10 mm = .004 ")
Clearance in crankcase	0.012– 0.060 mm = .0004– .0023" (+ 0.08 mm = .003 ")
Push Rods (17)	
Effective length, D-155, D-206 and D-310	177.00–176.50 mm = 6.968–6.949" (- 0.40 mm = .016")
D-179, D-239, DT-239, D-246, D-358, and DT-358	211.50–211.00 mm = 8.326–8.307" (- 0.40 mm = .016")
D-268 and DT-402	217.00–216.50 mm = 8.543–8.524" (- 0.40 mm = .016")
Thrust Plate (20)	
Thickness	7.01– 6.96 mm = .276–.274"
Bore, Dia	45.2 mm = 1.779" (present)
Bore, Dia	44.2 mm = 1.740" (displaced)

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Removal and Disassembly

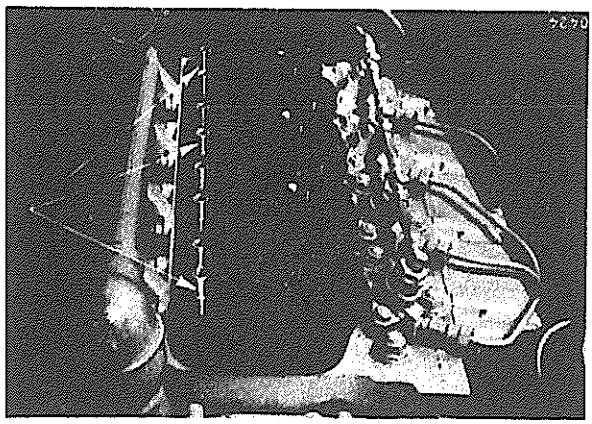
Note 1:

Before camshaft removal check:

a) Backlash of camshaft drive gear
b) Camshaft end float
c) Cam lobe lift

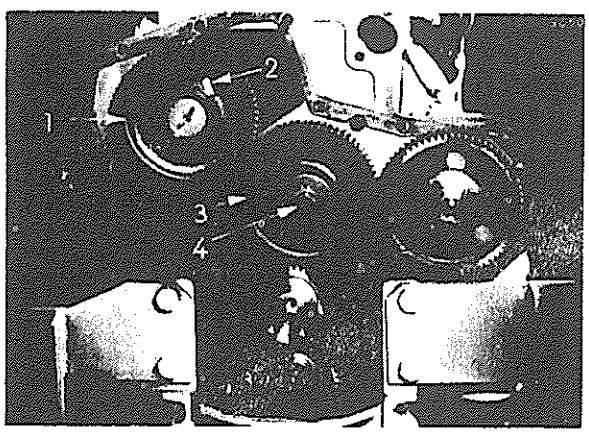
Note 2:

Cam lobe lift may be checked by means of a dial indicator gauge.
Rest the stylus of the dial indicator on one of the push rods.
Rotate the engine one revolution and note dial indicator reading.
Compare reading with "Specifications".



Illust. 12

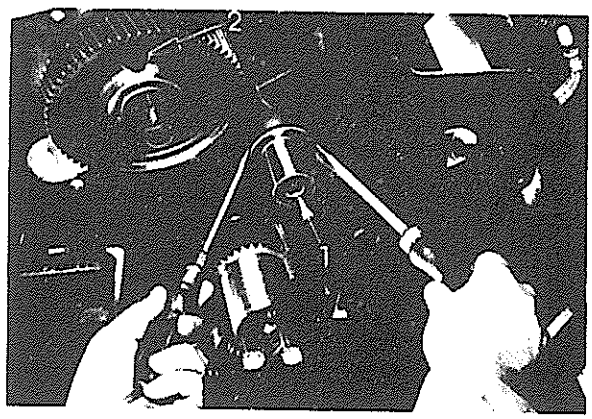
Remove valve housing cover, valve lever shaft assembly and crankcase front cover. Refer to respective sections. Lift out push rods. (Arrows, Illust. 12)



Illust. 13

1 — Camshaft drive gear
2 — Aperture.
3 — Idler gear
4 — Idler gear bolt, LH thread

Check backlash, running clearance and end float of idler gear (3) Illust. 13 before removing it.
Remove bolt (4) (LH thread) with washer. Take off idler gear with needle bearings and thrust ring.

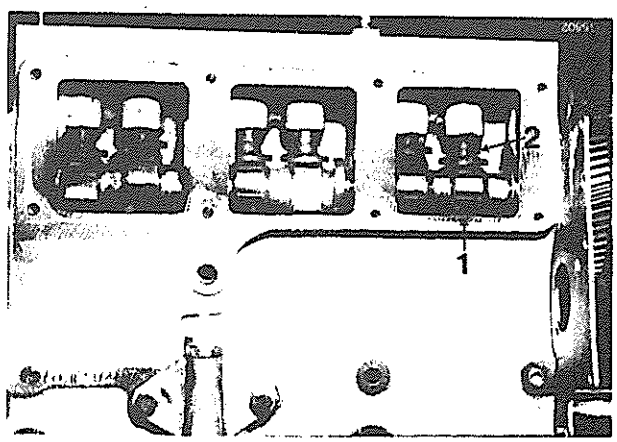


Illust. 14

1 — Idler gear carrier
2 — Aperture

Remove idler gear carrier (1) Illust. 14.

Remove camshaft thrust plate retainer bolts. These can be reached through apertures (2).

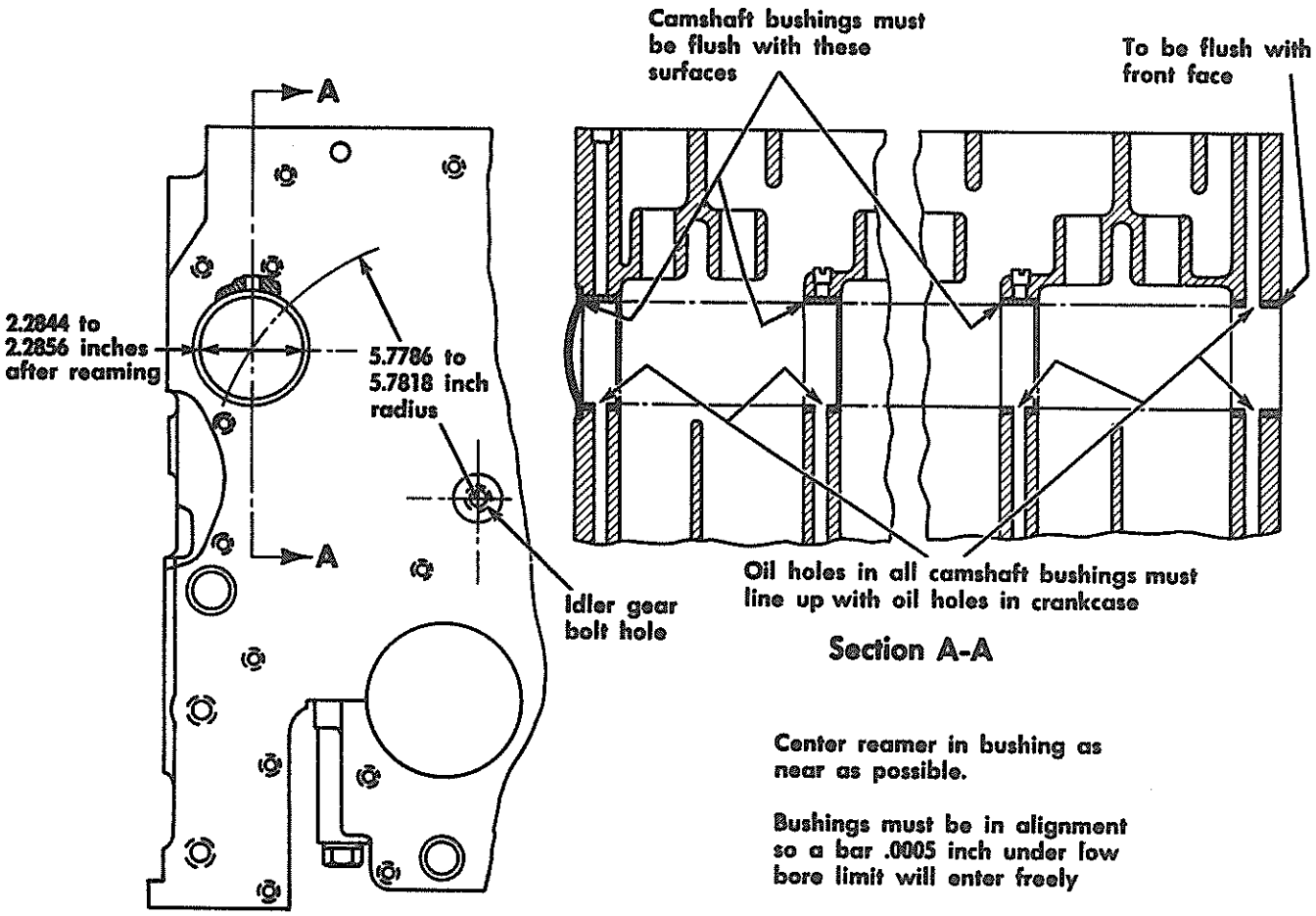


Illust. 15

1 — Camshaft
2 — Valve tappet

Remove crankcase side cover.
Hold tappets in their top-position, using a rubber band or turn engine on its side or pan side up.
Carefully pull out camshaft (1) Illust. 15 and remove tappets (2).
If necessary press off camshaft drive gear, taking care not to damage the drive slot for the tachometer.

Cleaning, Inspection and Repair

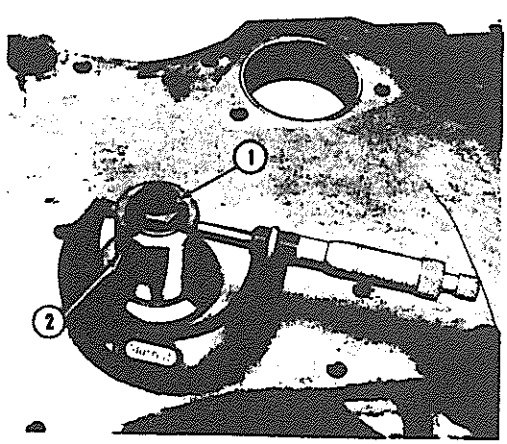


Illust. 16

If the camshaft bushings need to be replaced, steam clean the engine block and replace the old bushings with semi-finished bushings as shown in Illust. 16 using FES 101 camshaft Bearing—Driver.

The following line boring equipment or its equivalent is required to line bore the camshaft bushings.

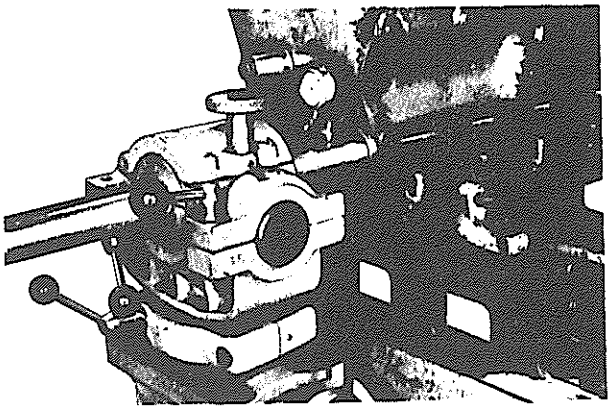
Kwik-Way or Lempco	Model LB 2000 or LB 2600
AMC BERCO	Danish Mfg. Italian Mfg.



Illust. 17

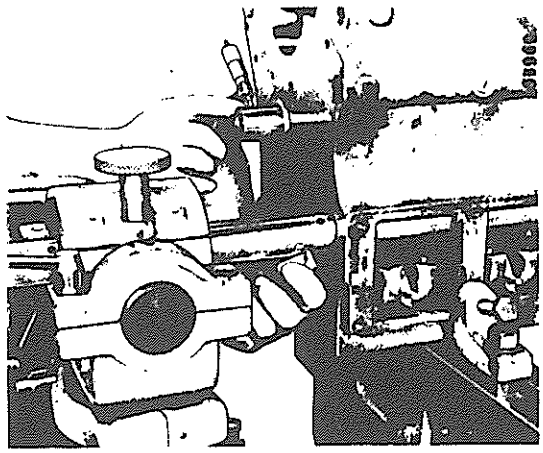
1 — Idler gear carrier retaining bolt
2 — Idler gear carrier

Note: The idler gear carrier (2) with retaining bolt (1) must be furnished as shown in Illust. 17 to the machine shop for locating the radius $\frac{146.787\text{ mm}}{146.858\text{ mm}} = \frac{5.7790''}{5.7818''}$



Illust. 18
Establishing minimum run-out

With the engine block positioned on the table of the machine, indicate to the semi-finished bushing on both ends of the boring bar and position the block so as not to exceed 0.025 mm = .001" run-out from front to rear, Illust. 18.

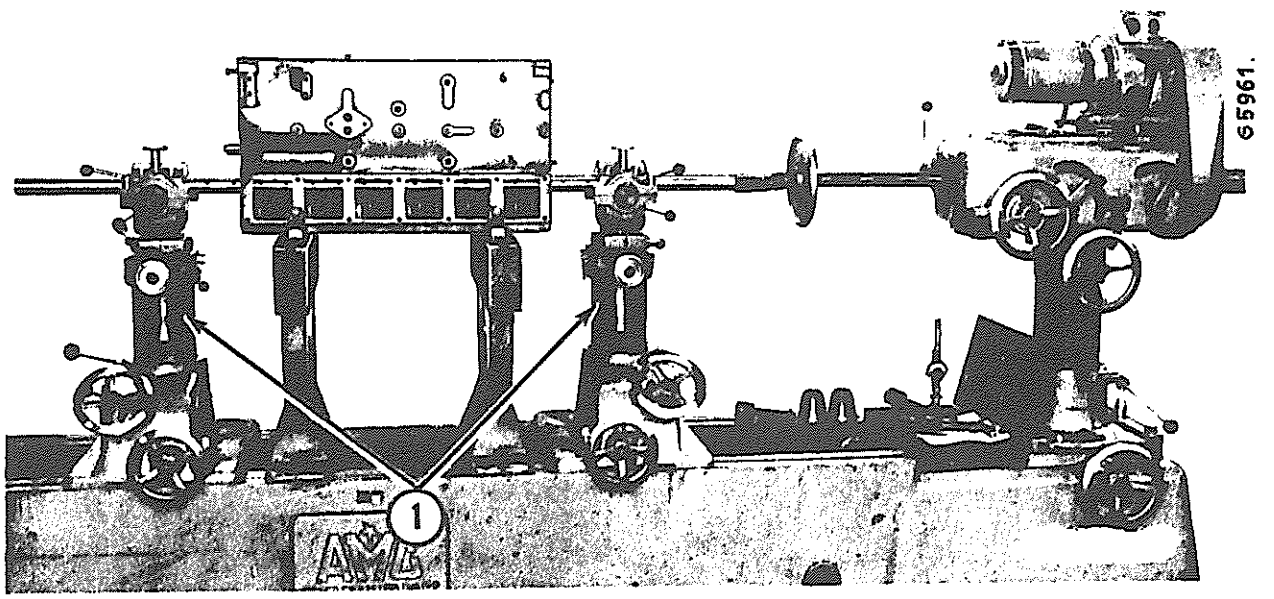


Illust. 19
Checking radius

Check for the specified radius (146.787÷ 146.858 mm = 5.7790 – 5.7818") as follows:

a) Add one half of the outside diameter of the idler gear carrier and one half of the boring bar diameter to the specified radius. Using an outside micrometer, check as shown in Illust. 19.

b) If the radius does not fall within specifications, the boring bar must be moved accordingly to fall within specifications on both heads (1), see Illust. 20.

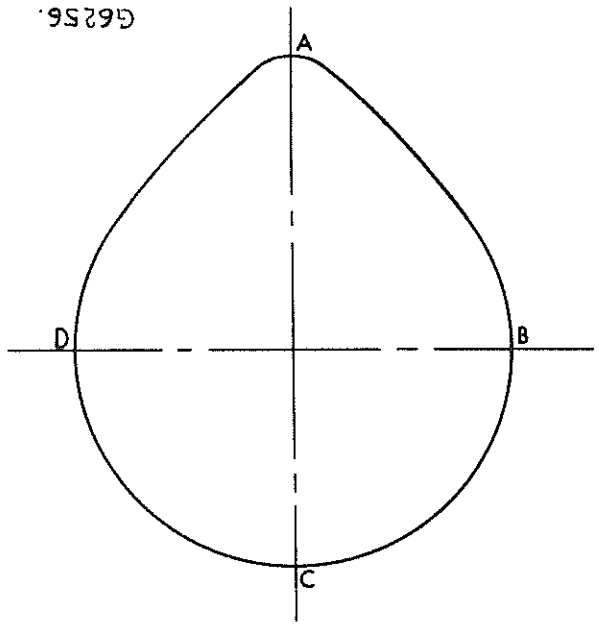


Illust. 20

1 – Boring bar heads

With the camshaft gear and idler gear installed check for proper gear backlash, see "Specifications".

Camshaft



Illust. 21
Points of measurement to determine cam lobe wear

Inspect cam lobes for wear. Compare with a new camshaft. If a new camshaft is not available, use a micrometer and take a reading across "A–C" Illust. 21 and deduct dia "B–D". This will give the cam lobe lift. Refer to "Specifications".

Inspect camshaft journals for wear, refer to "Specifications".
Replace the camshaft if wear is excessive.

Camshaft Gear, Thrust Plate and Idler Gear

Replace the camshaft gear and the idler gear if gear backlash (as checked prior to removal) is not within specified limits.
Inspect the teeth of these gears also for chipping, cracks and burrs. Replace damaged gears.

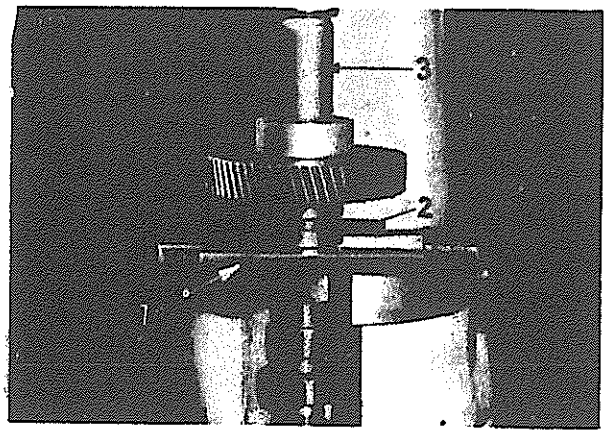
Check the condition of the thrust plate. Refer to "Specifications".
If wear is excessive, replace the thrust plate.

Replace camshaft gear as follows:

Install the thrust plate on the end of the camshaft and insert the Woodruff-key. Heat the camshaft gear to approximately 400°F (200°C), install it on the shaft with the timing marks pointing outwards and press flush with camshaft front end.

Important: Use FES 118-1 Thermomelt Stick to determine the temperature. Mark the surface to be heated.

The mark will appear dull and chalky. When the desired temperature is reached, the mark will melt and become a glossy liquid. Do not be concerned with a change in color.



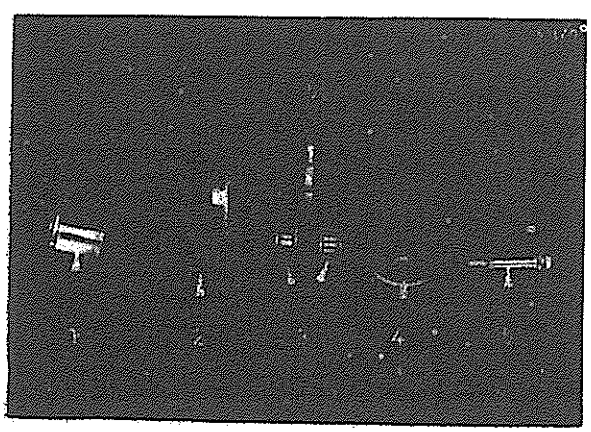
Illust. 22
Pressing drive gear onto camshaft

1 – Supporting plate 2 – Bearing journal 3 – Drift punch

It may be necessary to press the gear into its proper position on the shaft.

Note 1:
The thrust plate clearance should be set to 0.088 mm (.0035") / 0.440 mm (.0173") while the gear is still hot, Illust. 22.

Idler Gear Carrier and Needle Bearings



Illust. 23

1 – Idler gear carrier
2 – Idler gear
3 – Needle bearings
4 – Thrust washer
5 – Necked-down bolt (displaced)
6 – Spacer ring

Replace parts (1–4) Illust. 23, if running clearance and/or end float of the gear (as checked prior to removal) is excessive.
Replace needle bearings (3) as a set only. Replace necked-down bolt (5) with the new pitch diameter bolt (LH thread).

Valve Tappets

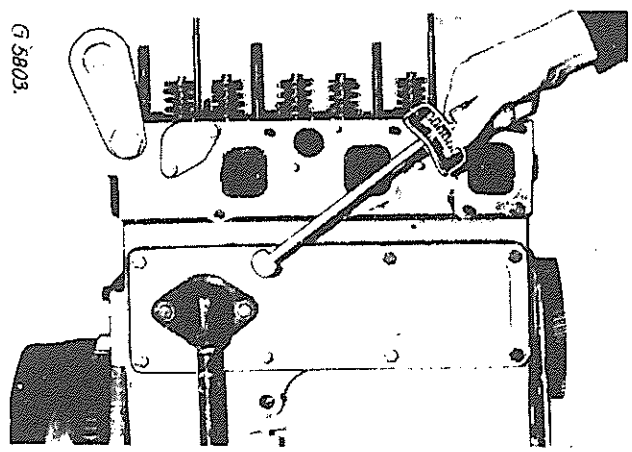
Inspect the tappets against "Specifications" and replace any worn, chipped or scratched tappets.

Push Rods

Inspect valve push rods for wear and distortion. See "Specifications".
Replace worn or damaged push rods with new ones.

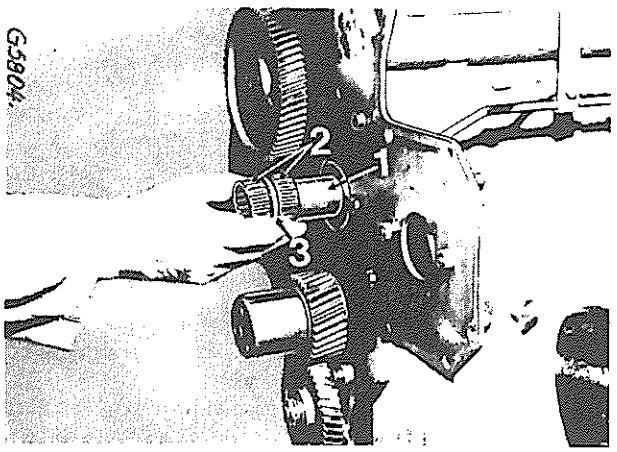
Reassembly and Installation

Turn the engine on its side or bottom side up.
Lubricate valve tappets and camshaft with SAE 30 and install into the crankcase.
Tighten thrust plate retainer bolts alternately. Check camshaft end play.



Illust. 24

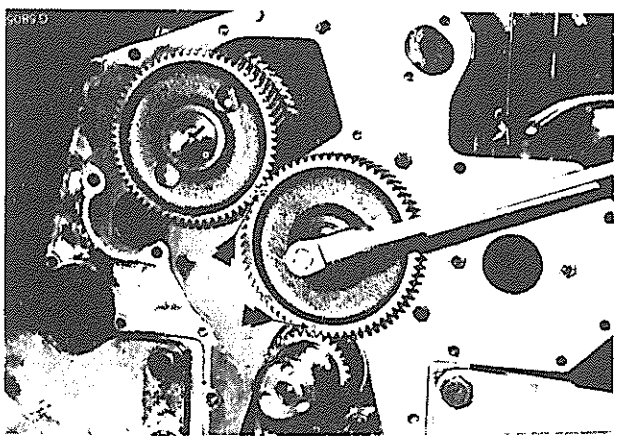
Install the crankcase side cover and tighten the bolts to specified torque, Illust. 24.



Illust. 25

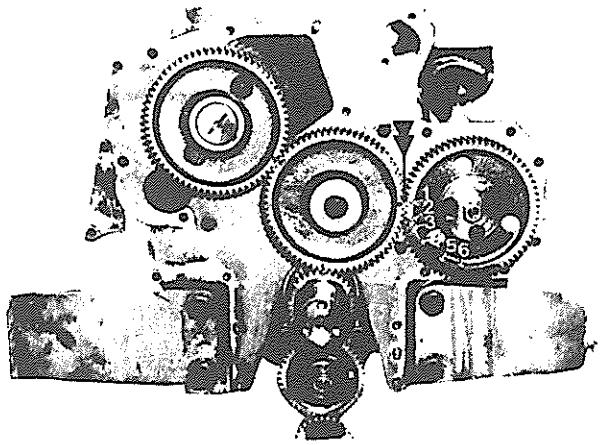
1 – Idler gear carrier
2 – Needle bearings
3 – Spacer

Install parts (1–3) as shown in Illust. 25. Lubricate needle bearings (2).



Illust. 26
Arrows – Timing marks aligned

When installing the idler gear make sure the timing marks of the gear train are in line, Illust. 26.
Coat the threads of the idler gear bolt with loctite No. 41 or 271.
Install the thrust washer and tighten to specified torque.
Check idler gear end play.



Illust. 27
Gear train and timing marks

If the injection pump is installed the following must be observed:

The injection pump drive gear is used for more than one engine and carries a serie of timing marks, numbered from 1 to 6, Illust. 27.
For details refer to Illust. 431 and respective chart.

CAMSHAFT DESIGN CHANGE

Description

The camshafts for all Neuss engines have been changed as follows:

1. The cam lobe width of all 3, 4 and 6 cylinder engine camshafts has been increased from 22 to 26 mm (.87 to 1.02 inch).

2. The camshaft diameter of all 3, 4 and 6 cylinder engines has been increased from 31 mm to 38 mm (1.22 to 1.50 inch) in the area between the bearing journal and the intake cam lobe.

3. The bearing journals of 4 cylinder engine camshafts have been reduced in number from 5 to 3 journals.

4 The bearing journals of 6 cylinder engine camshafts have been reduced in number from 7 to 4 journals.

5. 3 cylinder camshafts remain at 4 journals.

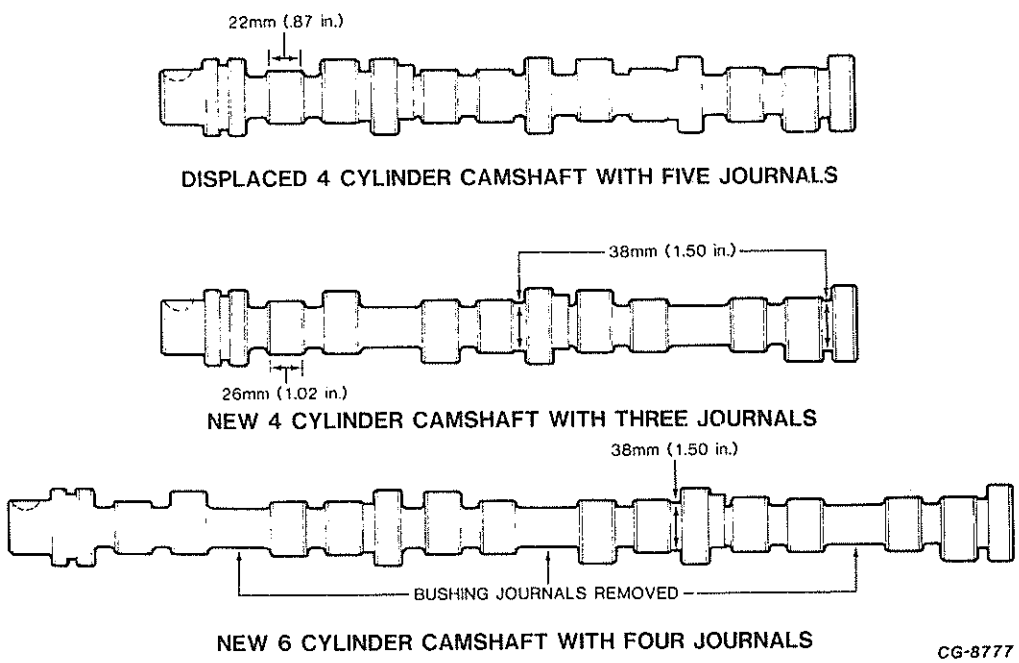
Lead bronze camshaft bearing bushings have replaced old style tin-babbit bearings for all engines.

Service Instruction

NOTE: Refer to Crankcase Section for additional service instructions.

1. New lead bronze bearings must be used with new style camshafts.

2. Displaced type (tin-babbit) bearings are to be used on 3 cylinder engines or 4 and 6 cylinder crankcases equipped with displaced type camshaft.



Illust. 27a
Camshaft Design Change

3. A displaced type camshaft may not be used in a new style crankcase.

4. When installing a new type camshaft in a displaced style crankcase, remove old style (tin-babbit) bearings. Before installing new type camshaft, the oil bores of the free journals must be closed with plugs (IH Part No. 3 228 562 R1) to maintain oil pressure at remaining bearings. These plugs are to be installed in the lower camshaft bearing seat oil bore.

CYLINDER HEAD, VALVES AND VALVE GUIDES

General

Carbon deposits and wear on valves, valve seats and guides are normal effects of fuel combustion.

Excessive deposits and wear however reduce engine efficiency.

Moreover the cylinder head may suffer frost damage and warpage due to improper torque of bolts.

Valves and their condition are a key factor in obtaining proper compression.

Cylinder heads of naturally aspirated engines (NA engines) are fitted with valve seat insert for exhaust valves.

Cylinder heads of turbocharged engines are fitted with valve seat inserts for both intake and exhaust valves.

The valve seat inserts can be replace if necessary.

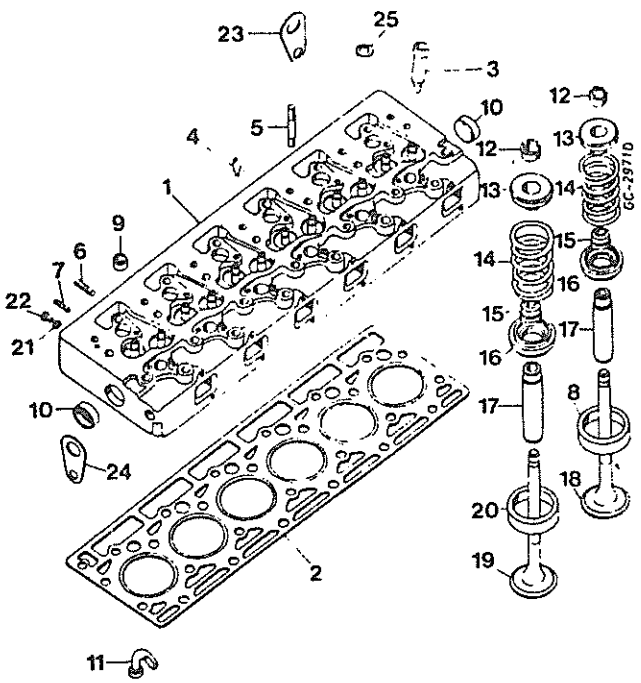
For this purpose valve seat inserts of two oversizes and a respective cutting tool assembly are available.

Specifications

(Refer to Illust. 28)

Cylinder head (1)

	mm	(inch)
Thickness, new,	98.81	(3.8902)
	99.31	(3.9098)
Min. permissible thickness when sealing face has been reworked,	98.54	(3.8795)
Warpage on sealing surface, max.	0.12	(0.0047)
Nozzle tip Protrusion	2.5 / 3.6	(.10) / (.14)



1 — Cylinder head
2 — Gasket, refer to Illust. 60
3 — Nozzle holder sleeve
4 — *Adapter
5 — Stud, valve lever shaft bracket
6 — Stud, exhaust manifold
7 — Stud, coolant manifold
8 — *Seat insert, intake valve
9 — U-plug
10 — U-plug
11 — *Coolant jet
12 — Valve spring lock
13 — Valve spring retainer cap
14 — *Valve spring
15 — Valve stem seal
16 — *Rotocap
17 — Valve stem guide
18 — Intake valve
19 — *Exhaust valve
20 — Seat insert, exhaust valve
21 — Seal ring
22 — Plug
23/24 — Lifting eyes

*Equipment of cylinder head depends on application refer to Parts Catalog.

Illust. 28
Cylinder head for turbocharged engines

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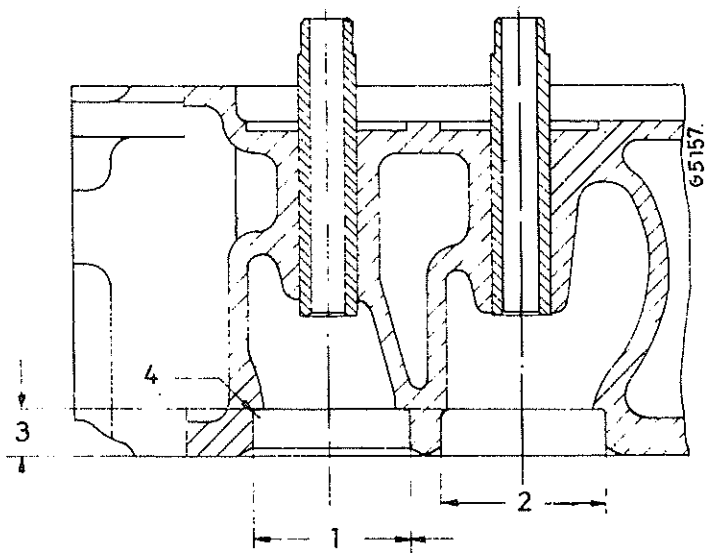
Valve spring (14) (yellow spot) *		3 136 000 R1	3 055 060 R1 (red or green spot)*
Free length,	mm	52.5-55.5	55.3
	inch	2.06-2.19	2.18
Test length,	mm	34.2	34.2
	inch	1.34	1.34
Test load	kg	69-76	66-72
	lbs	152-168	145.5-158.7

*For application see parts catalog.

NOTE: Before testing a new valve spring, load it all the way to blocking height.



Illust. 29
Oversize valve seat insert counterbore chart

Exhaust mm (inch)	Counterbore Dia. (1) Illust. 29		Insert Size	
0.15 (0.006) oversize	42.15 / 42.17	(1.659) / (1.6602)	42.22 / 42.24	(1.6622) / (1.6630)
0.40 (0.016) oversize	42.40 / 42.42	(1.6692) / (1.6700)	42.47 / 42.49	(1.6720) / (1.6728)
Intake	Counterbore Dia. (2) Illust. 29			
0.15 (0.006) oversize	44.183 / 44.204	(1.7395) / (1.7406)	44.22 / 44.24	(1.7409) / (1.7417)
0.40 (0.016) oversize	44.433 / 44.454	(1.7493) / (1.7502)	44.47 / 44.49	(1.7509) / (1.7516)

3 – 12.24 mm / 12.29 mm (0.482) / (0.484)

4 – 0.5 mm / 0.7 mm (0.020) / (0.028) (R)

Counterbore dia (1) and (2) Illust. 29 must be at right angles and concentric to the valve guide bore within 0.10 mm (0.004 inch) T.I.R.

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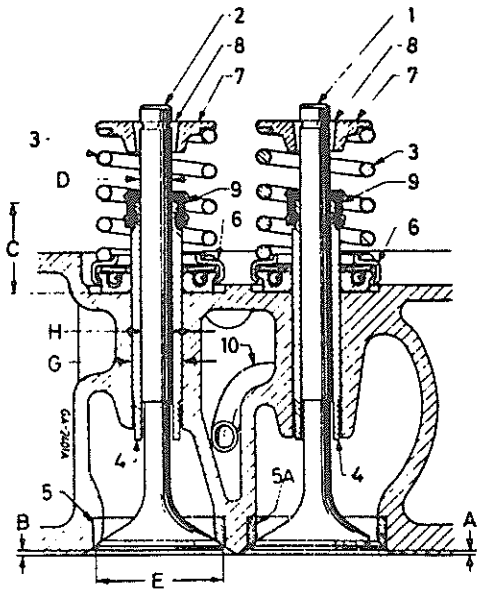


Illust. 29a

1 – Intake valve
2 – Exhaust valve
3 – Valve spring
4 – Valve stem guide
5 – Valve seat insert exhaust
6 – Rotocap
7 – Valve spring retainer cup
8 – Valve spring locks
9 – Valve stem seal
10 – Coolant jet

5A – Valve seat insert, intake (turbocharged engines only)

Valve Timing

Intake opens – degrees before TDC	13
Intake closes – degrees after BDC	43
Exhaust opens – degrees before BDC	46
Exhaust closes – degrees after TDC	10

Valve Dimensional Chart, Illust. 29a

		Intake		*Exhaust*	
		mm	inch	mm	inch
A/B.	Distance from the face of the cylinder head to the face of the valve	1.0 – 3.0	0.04 – 0.12	1.2 – 3.0	0.047 – 0.12
C.	Distance from top of valve guide to bottom of the spring recess	28	1.102	28	1.102
D.	Valve stem diameter	9.955 – 9.965	0.3920 – 0.3924	9.935 – 9.945	0.3912 – 0.3915
E.	Valve head diameter	42.8 – 43.0	1.685 – 1.693	40.8 – 41.0	1.606 – 1.614
G.	Valve guide OD	16.060 – 16.078	0.6323 – 0.6330	16.060 – 16.078	0.6323 – 0.6330
H.	Valve guide ID (after reaming)	10.00 – 10.02	0.3940 – 0.3945	10.00 – 10.02	0.3940 – 0.3945
	Valve guide ID (before reaming)	9.86 – 9.90	0.3882 – 0.3898	9.86 – 9.90	0.3882 – 0.3898
	Valve stem guide bore in cylinder head	16.00 – 16.04	0.6299 – 0.6316	16.00 – 16.04	0.6299 – 0.6316
	Valve length	145.9 – 146.1	5.744 – 5.752	145.9 – 146.1	5.744 – 5.752
	Minimum valve seat contact width	1.5	0.059	1.5	0.059
	Maximum allowable stem clearance in guide before reconditioning (valve play)	0.15	0.006	0.15	0.006
	Valve face angle, between seat and bottom of valve head, degrees	45 & 15		45 & 15	
	Valve seat angle in cylinder head, degrees	45		45	
	Maximum allowable eccentricity: – valve seat bore to valve guide bore	0.10	0.004	0.10	0.004
	– valve face to valve guide bore	0.02	0.0008	0.02	0.0008
	Minimum valve face width	1.2	0.047	1.2	0.0047
	Valve lash (engine warm)	0.30	0.012	0.30	0.012

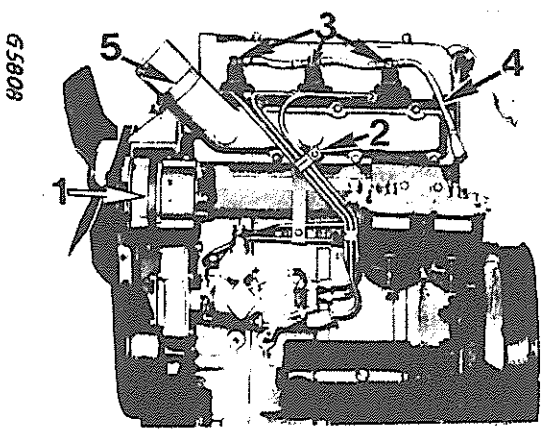
Removal and Disassembly

The cylinder head can be rmeoved without removing injection nozzles, intake- exhaust -and water manifolds. However, disassembly is necessary when cleaning intake and exhaust bores.

It is also possible to remove the cylinder head without removing the valve lever assembly. If the cylinder head is removed without removing the nozzle holders, it must be supported on wood blocks to prevent damage to the nozzle tips.

When the engine is overhauled however, it is recommended that above mentioned components be removed prior to taking the cylinder head off, so that the cylinder head can be properly cleaned and inspected.

Clean the engine externally. Mark disassembled parts, such as valves, valve stem guides and springs and place them on a table in removal order to facilitate reassembly.

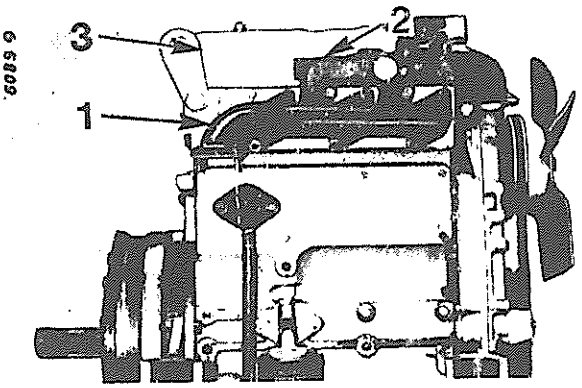


Illust. 30

1 – Alternator
2 – Injection pipes
3 – Nozzle holders
4 – Fuel return line
5 – Intake manifold

On the left hand engine side remove components (1) to (5) Illust. 30.

Plug all openings of injection pump, injection pipes, fuel line and nozzle holder to prevent entry of dirt into the fuel system.

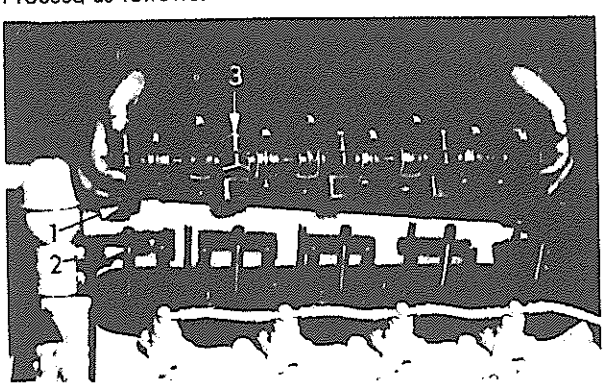


Illust. 31

1 – Exhaust manifold
2 – Water manifold
3 – Valve housing cover

On the right hand engine side remove components (1) to (3) Illust. 31.

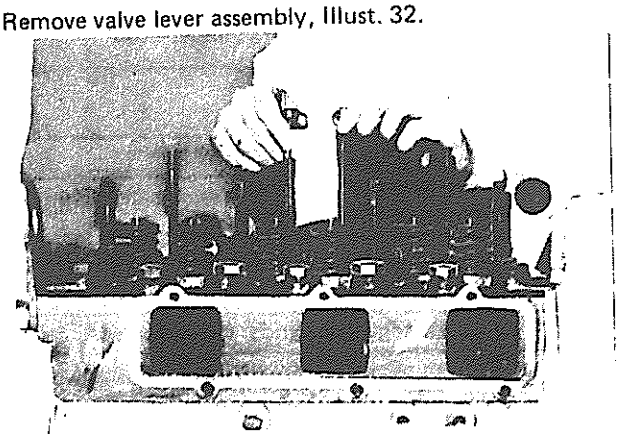
Proceed as follows:



Illust. 32

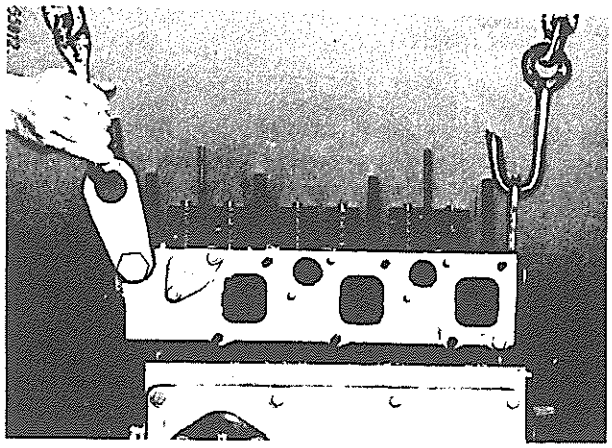
1 – Valve lever shaft brackets
2 – Studs
3 – Clamping bolts

Remove valve lever assembly, Illust. 32.



Illust. 33

Take out valve push rods, Illust. 33.

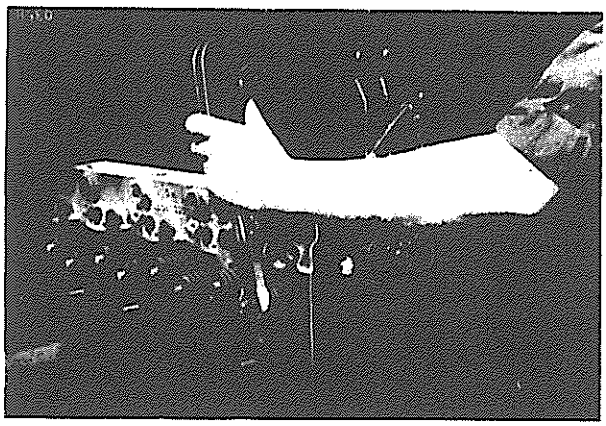


Illust. 34

Loosen cylinder head bolts evenly and alternately after checking torque value.

NOTE: To avoid warpage do not remove cylinder head unless the engine has cooled down.

Lift off cylinder head, using engine lifting eyes, Illust. 34.



Illust. 35
Removing valves

To remove valves compress valve springs with compresor tool and take out spring retainer locks, Illust. 35.

Cleaning, Inspection and Repair

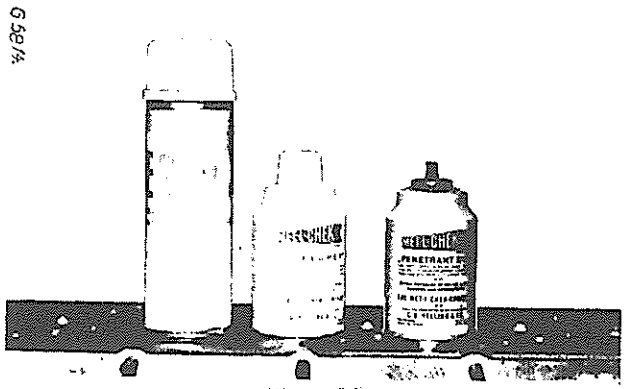
Clean cylinder head thoroughly.

Remove carbon deposits from the bottom of the cylinder head and out of exhaust valve ports.

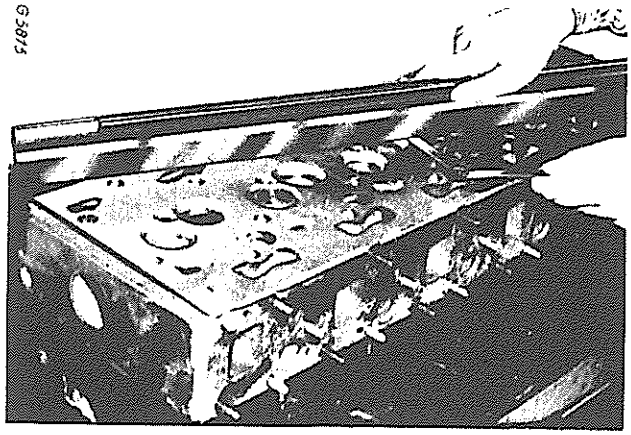
Flush out water jacket to remove scale and dirt.

NOTE: Make sure water passages are free of obstructions, rust or scale.

Inspect cylinder head (including nozzle bore/valve seat area) for hair cracks, using modern spraying methods, Illust. 36.



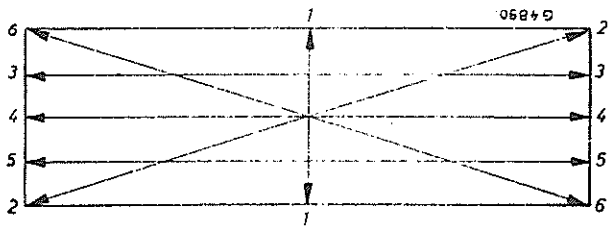
Illust. 36
Crack check



Illust. 37

Inspect the cylinder head (and the crankcase) for warpage, if engine has been run with a blown head gasket. illust. 37.

Observe checking pattern, Illust. 38, see "Specification".



Illust. 38
Checking pattern, cylinder head and crankcase

If more than a 0.12 mm (.0047 inch) feeler gauge can be entered under the straightedge, the head (not the crankcase) may be reworked to true up on possible warpage or distortion.

NOTE: Check the cylinder head height before reworking.

Do not reface the head, if its minimum allowable reconditioned height is below specified limits.

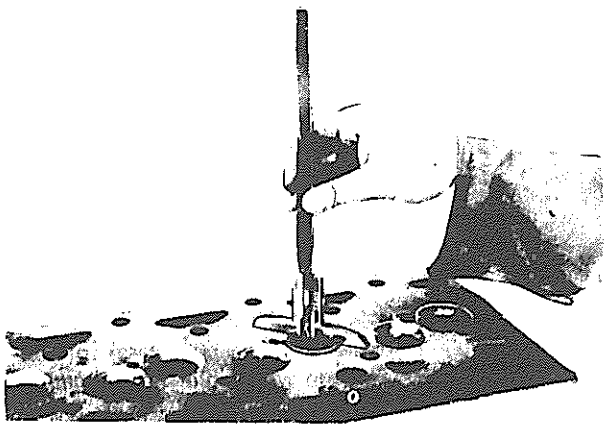
Replace distorted or cracked head.

If leakage is suspected in the water jacket of the cylinder head and crankcase, make the following test:

Mount cylinder head with valves and nozzle bushings on crankcase. Remove oil pan, crankcase front cover, intake and exhaust manifolds and thermostat.

Seal water intake port properly with a gasket and a suitable cover plate. Connect the hose of a suitable pump to the coolant manifold in place of the connecting hose. Pump in water at a pressure of 200 kPa (29 psi) preferably adding a corrosion inhibitor. Check for leakage at lower O-rings of cylinder sleeves, coolant pipes, nozzle bushings, etc. Eliminate any possible leakage.

Where testing facilities are available, this test can more easily be made on a block. The cylinder head must be mounted on the block in the same manner as on the crankcase. For this purpose the block must be level within 0.05 mm = .002".



Illust. 39
Measuring valve recession (wear)
(max. recession – 3.0 mm = .12")

Inspect valves for wear, Illust. 39. Excessive wear will make for hard starting and impair engine efficiency.

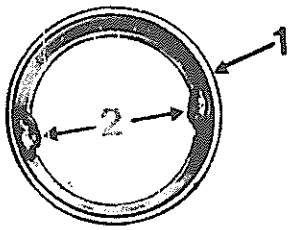
Remedy:

a) Install new valves
b) Install new valve seat inserts (NA engines, exhaust only)
c) Rework cylinder head sealing face.

Before work:

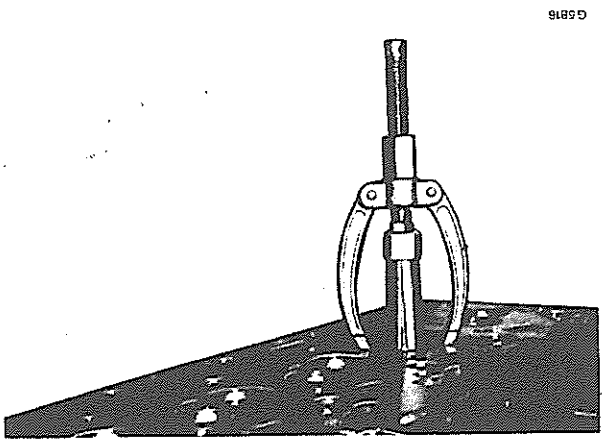
a) Check whether the cylinder head height permits reworking.
b) Check to see if nozzle tip protrusion will remain within specified limits after rework.

Valve Seat Insert



Illust. 40

1 – Exhaust valve seat insert
2 – Welded lugs



Illust. 41
Removing valve seat inserts

To remove valve seat inserts, first weld two opposite lugs (2) Illust 40 to provide puller grip.

Oversize Valve Seat Inserts

Rework counterbore in the cylinder head, refer to "Specifications".

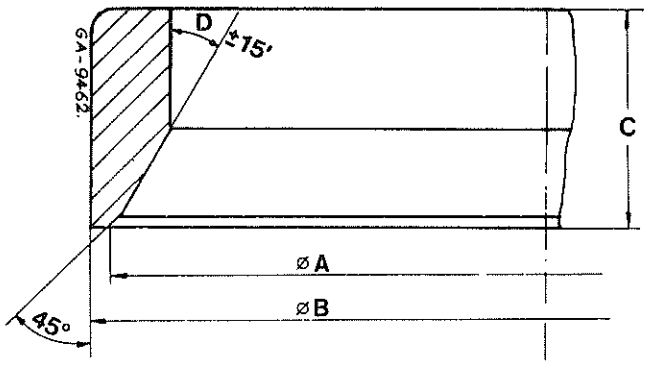
Before enlarging the counterbore, be certain valve guides and the pilot of the special cutting tool are in order.

Chill the new valve seat inserts to at least -60°C = 76°F in dry ice before installation. This prevents metal scraping from the side of the counterbore, insuring full contact of the insert on the bottom and sides of the counterbore.

Install new insert using an insert driver provided for this purpose.

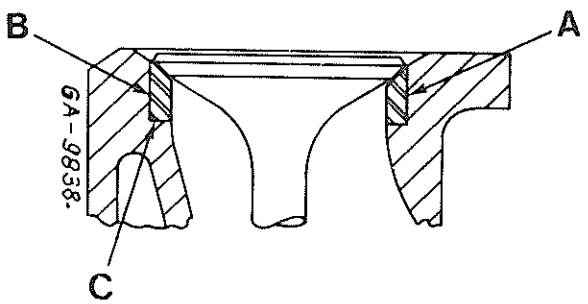
Caution: When using carbon dioxide strictly adhere to instructions to avoid injuries. Do not touch deep frozen parts with bare hands.

Reconditioning Valve and Valve Seat



Illust. 42
Valve Seat Insert

A – Intake valve, mm (inch)
42.7 ± 0.2 (1.68 ± 0.008)
A – Exhaust valve, mm (inch)
40.7 ± 0.2 (1.60 ± 0.008)
B – Refer to illust. 29
C – Early design: 10 mm (0.39 inch)
C – Late design: intake valve, 9.0 mm
(0.35 inch)
exhaust valve, 8.75 mm (0.34 inch)
D – Early design: 30°
D – Late deisign: 15°



Illust. 43
Insert Ring Properly Installed

A – Valve insert ring
B – Insert must be tight fit in counterbore
C – Bottom of insert ring must seat squarely on bottom of counterbore;

NOTE: Do not install inserts by hammering or striking insert driver.

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

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

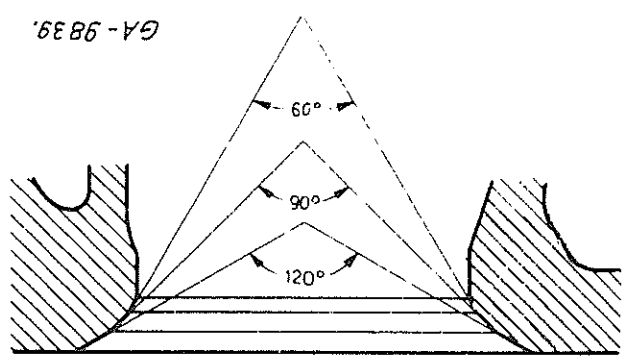
NOTE: Before installing the pilot, be sure that the valve guides are perfectly clean and meet the engine specifications. This is important; otherwise, an eccentric seat will be cut.

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

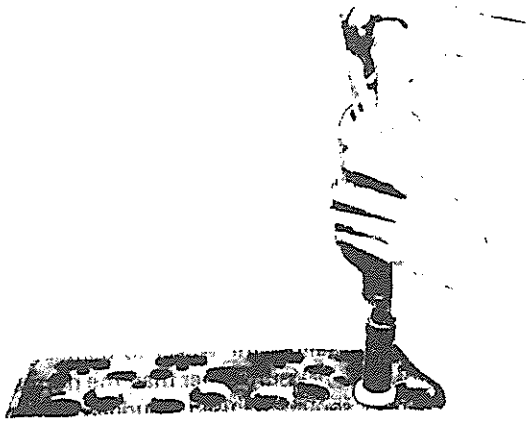
3. Lower the grinder head over the pilot shank until the wheel just clears the valve seat. Turn on the power and very gently allow the wheel to contact the valve seat. Very little pressure other than the normal weight of the wheel should be used. Sudden hard pressure can cause cocking of the pilot in the guide and result in eccentric grinding. Raise the wheel frequently from the valve seat to prevent overheating and to clear away grinding dust. Grind the seat sufficiently to provide an even, smooth surface. Valve seat angles for intake and exhaust valves are identical, Illust. 40.

4. Check the seat concentricity, roundness and valve face contact using Prussian blue. Spread an extremely thin film of this blue on the valve face and insert the valve into its guide. With pressure on the exact center of the valve head, make a quarter turn rotation in the seat. Remove the valve and inspect the impression made upon the seat by the transfer of bluing, and upon the valve face by the removal of bluing. The valve seat should center on the valve face and must be concentric with the bore of the valve guide within 0.000 – 0.10 mm (0.000 – 0.004 inch). Check several times to guarantee that no error was made. If a full seat-width contact around the entire circle of seated valve is not shown, the angles do not match. It will then be necessary to redress the valve seat grinding wheels, changing the angle sufficiently to correct the error.

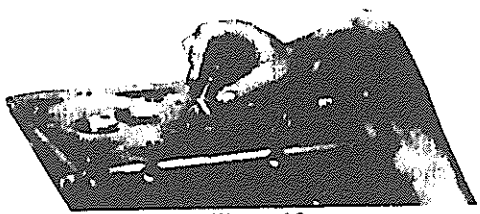
   The correction should be made on the valve seat, not on the valve.



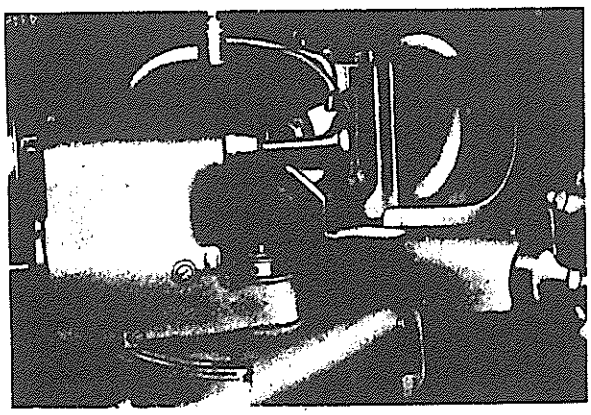
Illust. 44
Valve Seat Angles



Illust. 45
Refacing Valve Seat with Grinding Tool



Illust. 46
Measuring Valve Seat Width



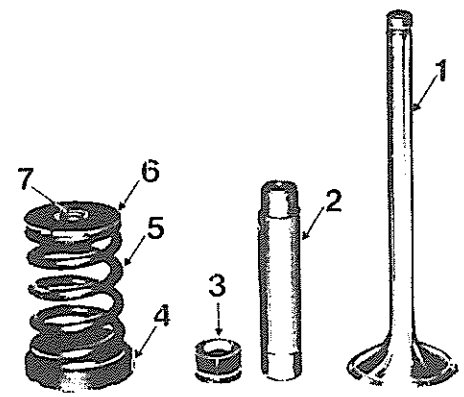
Illust. 47
Grinding Valve Face with Refacing Machine

Inspect valves for wear against "Specifications". Scrap excessively worn valves.

If reconditioning valves make sure head margin and concentricity are within specifications, if not, use new.

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

Wear Parts



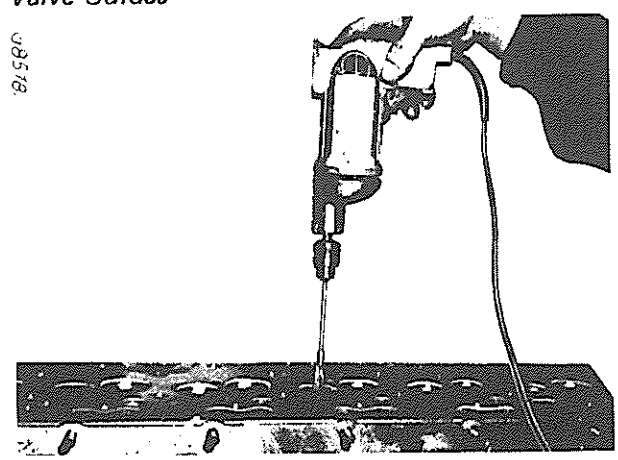
Illust. 48

1 – Valve
2 – Valve guide
3 – Valve stem seal
4 – Rototcap or spring retainer cup
5 – Valve spring
6 – Valve spring retainer
7 – Valve spring retainer locks

On major engine overhaul it is recommended to replace the wear parts (1) to (7) Illust. 48.

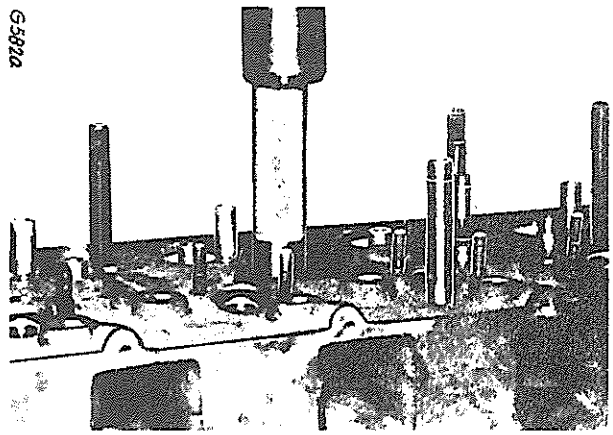
Occasionally, when the cylinder head has been stripped down inspect above parts and replace them as necessary. Renew valve stem seal (3) whenever valves have been removed.

Valve Guides

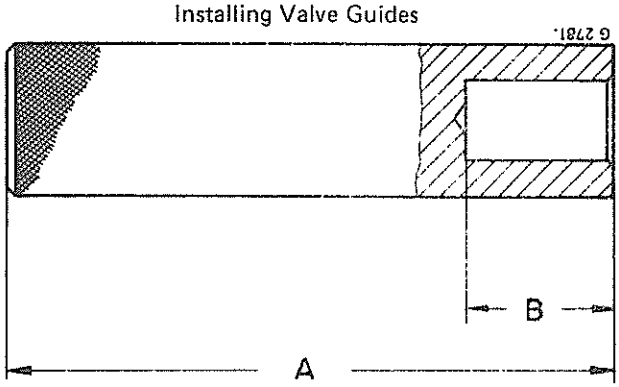


Illust. 49

Use a steel spiral brush to remove carbon deposits in the guide bore. Illust. 49. Wash down guides, using cleaning solvent. Blow out all carbon with compressed air. Position a light at the bottom of the guide bore, and examine the walls for burning, cracking and signs of excessive wear. Check the inside diameter of the guide bore at several points around its circumference and along its length. Specifications for the guides are given in "Specifications". Replace any guides considered unserviceable or that appear close to a serviceable borderline.



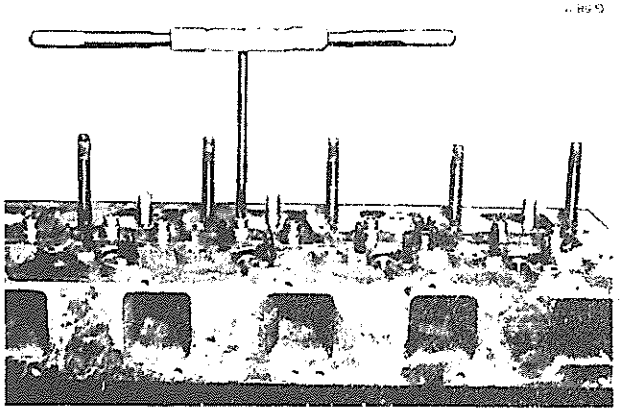
Illust. 50
Installing Valve Guides



Illust. 51
Valve Guide Installing Tool

A – 120 mm = 4.72"
B – 28 mm = 1.102"

Use special tool, Illust. 50 and 51 to ensure correct depth of guides in the cylinder head. Be sure the stepped end of the guide is up. Check the tool for dimension "B" and grind down if necessary.

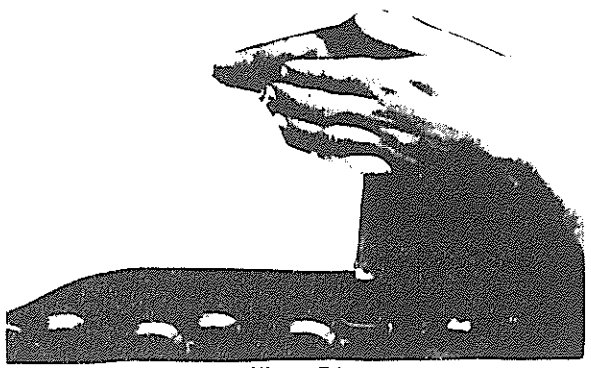


Illust. 52

New valve guides must be reamed to size, Illust. 52, see "Specifications".

Clean guides after reaming.

Lapping

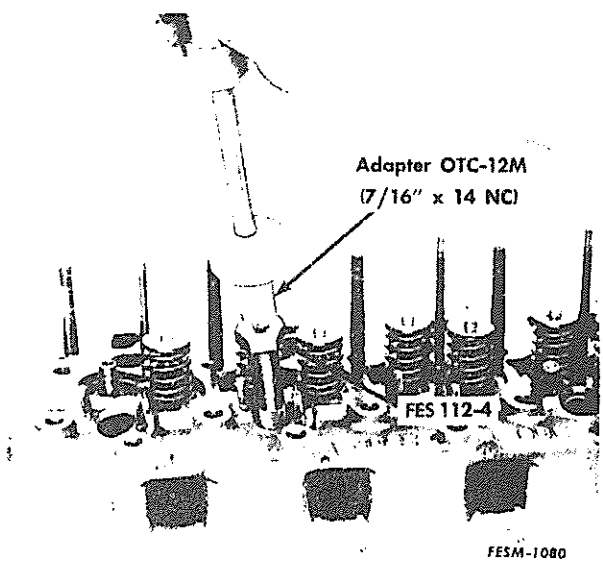


Illust. 53
Lapping Valves Into Their Seats

After lapping, valve faces and seats must be perfectly smooth and show even markings. Be sure to clean away all remnants of grinding compound.

Again check the valve recession. See "A" and "B", Illust. 29a.

Nozzle Holder Sleeves



Illust. 54
Removing Nozzle Sleeve

The injection nozzle sleeve can be replaced without removing or disassembling the cylinder head. If done this way, be sure engine coolant is drained below the cylinder head level before removing the sleeves.

To remove the nozzle sleeve use special bolt (7/8 x 4 inch) PLT-509-11 (FES-25-12) and turn it into the sleeve. The bolt will cut its own threads into the brass sleeve. Then screw slide hammer adapter OTC-12M (7/16 in. x 14 NC) into the end of the bolt and use the slide hammer to remove the nozzle sleeve, Illust. 54. Remove the sleeve from the tool and discard.

Inspect the nozzle sleeve bore in the cylinder head and be sure it is clean and free of grease, oil, scale or rust.

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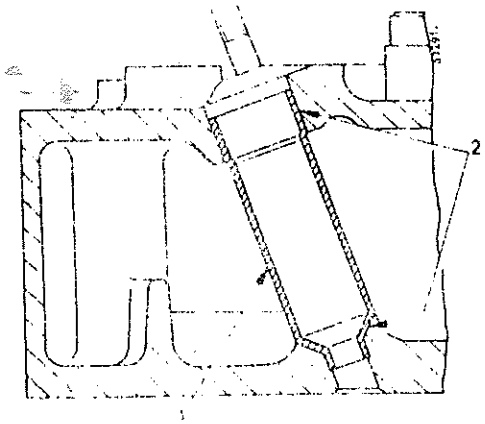
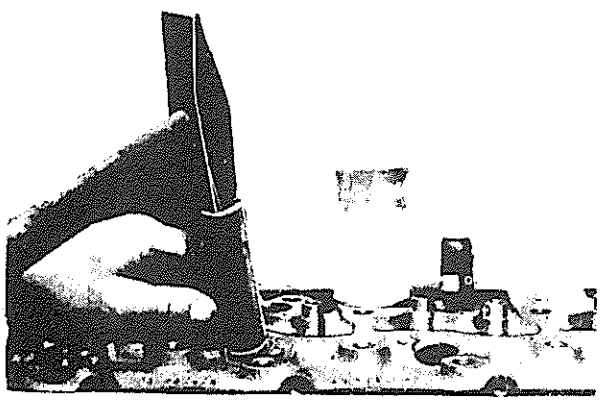


Illust. 55

1 – Nozzle holder sleeve
2 – Sealing areas (Loctite grade 5)

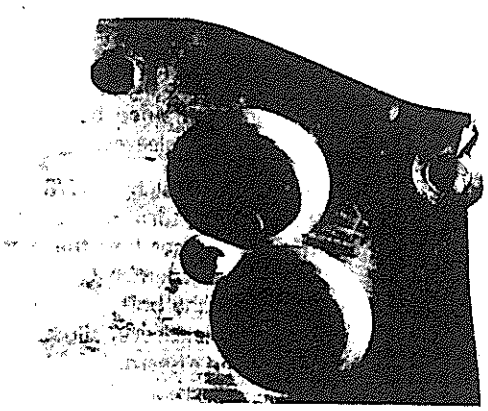
Thoroughly clean the bore and the sealing areas of the cylinder head before installing new sleeve. Coat the sealing areas of the new nozzle sleeve with Loctite, Illust. 55.



Illust. 56
Installing Nozzle Holder Sleeve with Special Tool

Use the tool provided to drive the new sleeve into position, Illust. 56. Be sure that the sleeve is completely bottomed in the cylinder head.

Coolant Jet

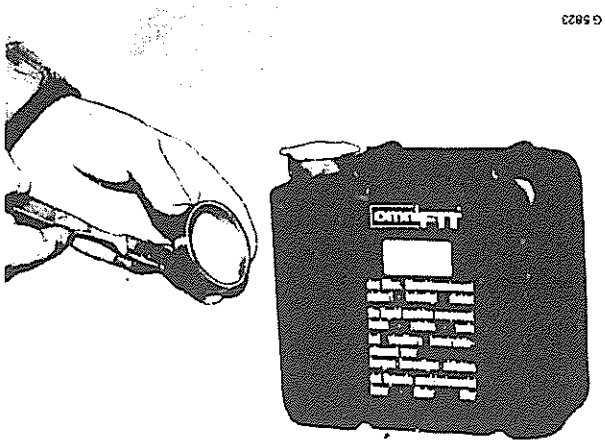


Coolant Jet, if so equipped

To remove the coolant jets it is good practice to tap the inside, see arrow, Illust. 57 and pull out the jet with a suitable screw. Always inspect jet for proper water flow.

When installing new jets, take care that sealing faces (arrow) are flush with the cylinder head.

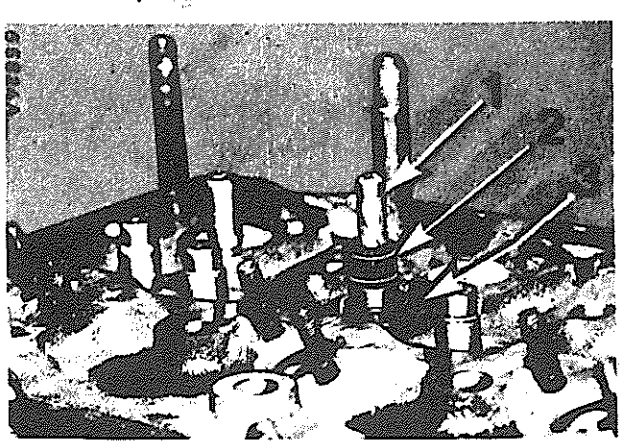
U-Plugs



Illust. 58

If leakage is apparent at the plugs, replace the plugs. Install new plugs with a suitable drift punch using heat resistant liquid sealer. Plugs must not protrude from sealing surface of the cylinder head.

Reassembly and Installation



Illust. 59
Installing Valve Stem Seals

1 – Plastic jumper
2 – Valve stem seal
3 – Rotocap or spring retainer cup

When installing valve stem seal (2) Ilust. 59 first place the rotocap (3) on the valve guide, insert the valve and slide jumper (1) over the valve stem end. Install the seal so that it will bottom on the stepped valve guide.

After the new seal is installed do not remove the valve.

To fit valve springs proceed as follows:

With jumper (1) Illust. 59 on the valve stem fit valve springs (3) Illust. 29a with retainer cups (7).

Using a spring compression tool depress springs only far enough to insert spring locks (8). Remove jumper from valve stem and fit spring locks (8).

Check valve recession "A" and "B" against "Specifications". Check that nozzle tip protrusion is between 2.5 – 3.6 mm (.10–.14).

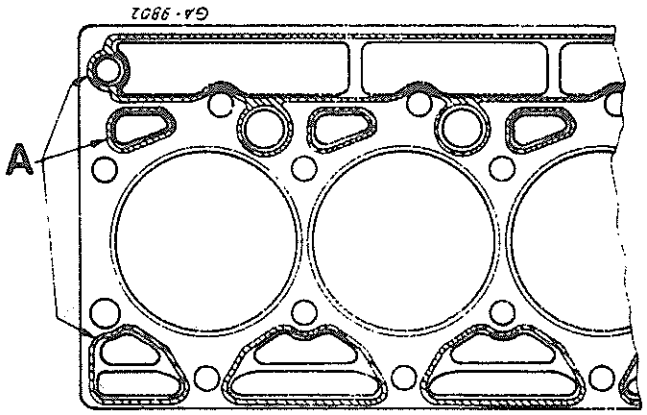
Cylinder Head

1. Clean the carbon from the pistons and be sure the gasket surfaces of the crankcase and cylinder head are clean and dry.

2. Be sure there is no oil in the bottom cylinder head bolt holes to prevent hydraulic lock when the bolts are torqued.

3. Before installing the cylinder head, check cylinder sleeve protrusion, refer to Illust. 83. If the sleeve protrusion is not within specifications, remove the sleeve and follow the complete procedure under Illust. 79.

4. Install a new cylinder head gasket Illust. 60 to the crankcase. Using a hoist and sling, move the cylinder head into place on the crankcase.



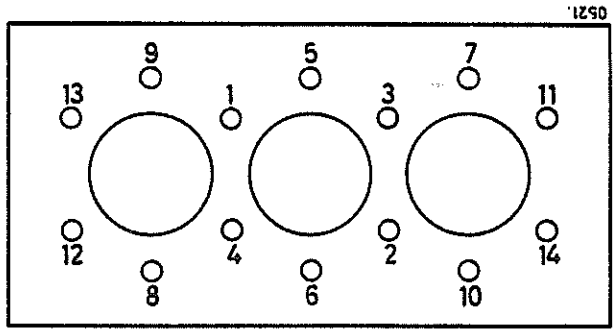
Illust. 60
"Non-Retorque" or "Maintenance-free" Cylinder Head Gasket

A – Identification characteristic; red plastic borders around the water and oil sealing faces

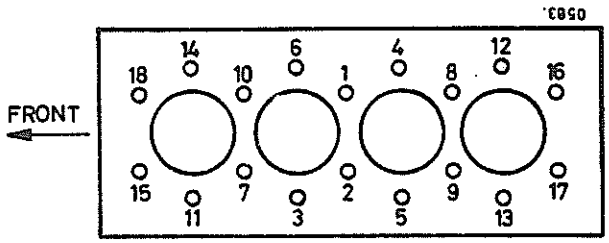
5. Following the sequence given in diagram Illust. 61, 62 or 63 tighten the cylinder head bolts in three steps. Refer to "Special nut and bolt torque data". Never use bolts with damaged or marred threads as these trend to show a high torque reading.

NOTE: Cylinder head is mounted either with studs, bolts with washers or with flange bolts, depending on year of manufacture.

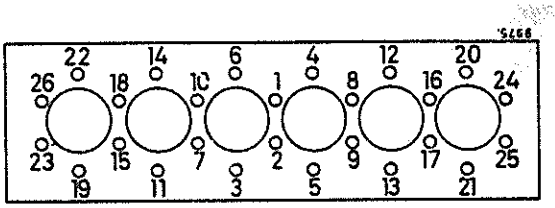
NOTE: If bolts or studs must be replaced, do not mix-up parts, replace complete sets.



Illust. 61



Illust. 62



Illust. 63
Torque Sequence for Cylinder Head

6. Follow the reassembly procedure as below, referring to the respective sections of this manual where necessary.

   Install valve lever shaft assembly.

   Adjust valve clearance.

   Replace valve housing cover, using a new gasket.

   Replace manifolds and thermostat.

   Install turbocharger.

   Install injection nozzles and nozzle holders.

   Reconnect fuel lines.

   Fill the fuel tank and vent the fuel system.

   Fill in engine oil.

   Fill the cooling system.

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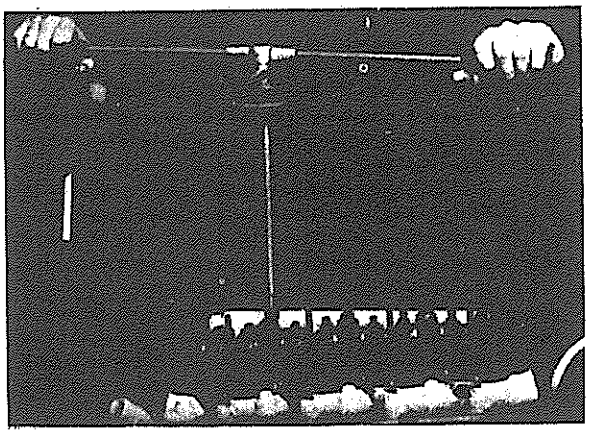


Illust. 64

7. Start and run the engine at 3/4 rated engine speed with no load, until operating temperature (80 – 85°C) [176 – 185°F] is reached, cover the radiator if necessary. DO NOT run for over 15 minutes prior to retightening cylinder head bolts.

   Retighten cylinder head bolts to specified torque, to Illust. 61, 62 or 63 for sequence. When retightening head bolts first loosen every bolt 1/4 turn then tighten to specified torque of 145 N•m (107 lbf-ft).

NOTE: If new cylinder head gasket (with red plastic borders) is installed in engines equipped with studs and nuts, old bolts with round washers tightening torque is 145 N•m (107 lbf-ft).

8. Check valve clearance,and readjust as necessary.

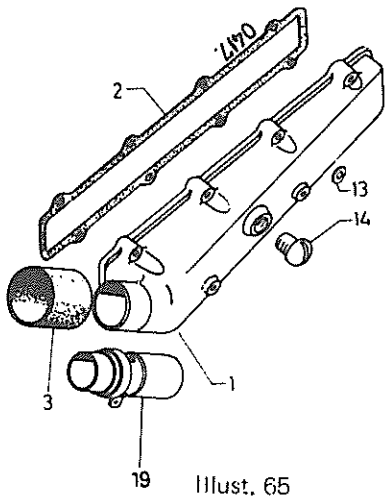
NOTE: When retorquing cylinder head nuts or bolts, only those below proper torque are to be retorqued to specifications. The remaining nuts or bolts, complying with or above torque specifications must not be loosened.

Retorquing cylinder head nuts or bolts using torque wrench and special wrench Illust. 64.

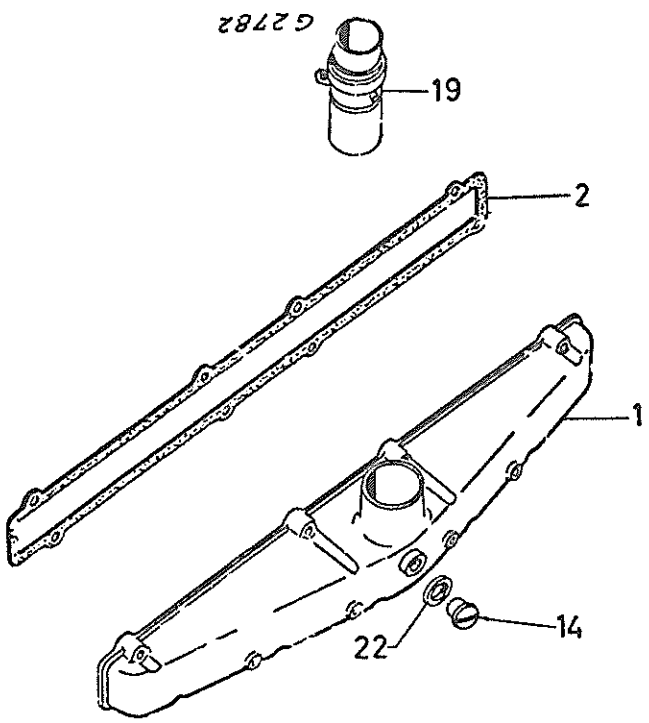
NOTE: Re-torquing of cylinder head bolts or nuts in the field is not necessary when the new "Maintenance-free" cylinder head gasket Illust. 60 has been installed.

If early style cylinder head gasket (without red plastic seal) is installed, retighten cylinder head bolts, etc. at approximately 250 operating hours later.

INTAKE MANIFOLD



Illust. 65



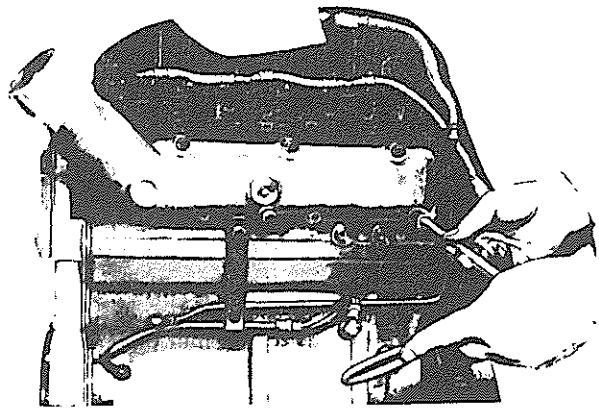
Illust. 66

General (Intake)

The intake manifold is used in various designs, depending on the arrangement of the air cleaner and on engine type and application, Illust. 65 and 66. See Parts Catalog for specific variation.

Inspect the manifold for tight sealing, whenever engine overhaul is necessary.

Removal and Disassembly



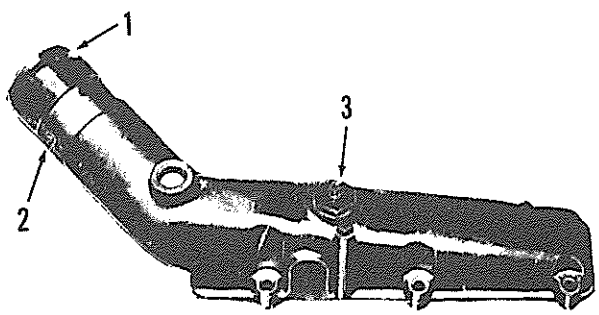
Illust. 67
Removing or installing intake manifold

Remove injection pipes and air intake hose before removing the intake manifold, Illust. 67.

Cleaning, Inspection and Repair

Clean the manifold and inspect for cracks and distortion. Replace the manifold with new one, whenever distortion is more than 0.4 mm = .016" per 250 mm = 10" length.

Inspect air hose and hose clamps.
Inspect retainer bolts and their washers.
Replace damaged parts.



Illust. 68

1 – Heating pipe
2 – Spade terminal
3 – Air cleaner service indicator connection

Check the condition of the heating pipe (1) Illust. 68.

At a testing voltage of 10.5 V and an amperage of 52 A the coil must glow brightly.

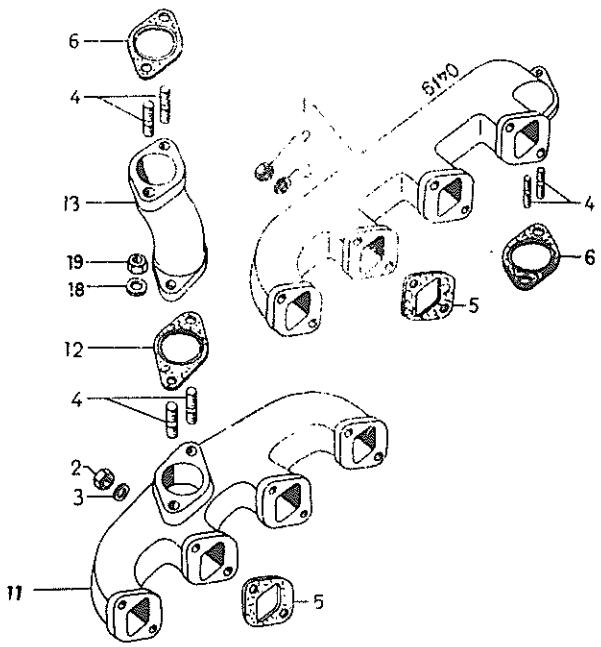
Replace a defective heating pipe as follows:

Heat up manifold on the bench, for area and quickly pull out the pipe.

Heat manifold to 200°C = 400° F when inserting the new pipe.

Be sure the new pipe protrudes 65 mm (2-9/16") from the manifold, its spade terminal (2) is properly positioned and between coil and pipe there is at least 1.5 mm (.06") of space.

EXHAUST MANIFOLD



Illust. 69

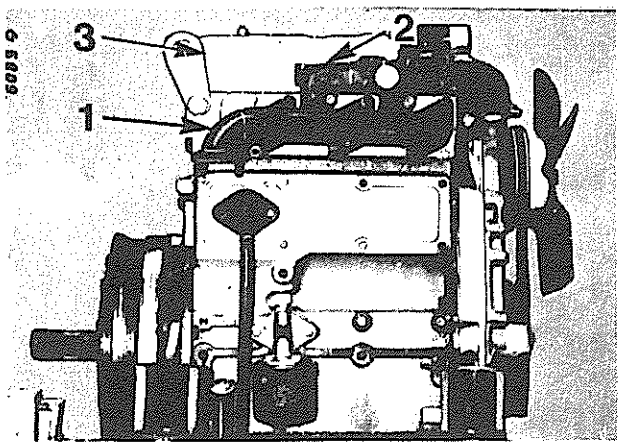
1 – Exhaust manifold for downswept exhaust connection
11 – Exhaust manifold for upswept exhaust connection

General (Exhaust)

The exhaust manifold is used in various designs depending on the position of the muffler and the machine in which the engine is installed, Illust. 69. See Parts Catalog for specific variation.

On engine overhaul remove the manifold so that it can be cleaned and inspected.

Removal and Disassembly



Illust. 70

1 – Exhaust manifold
2 – Water manifold
3 – Valve housing cover

Remove exhaust pipe and/or muffler. Remove exhaust manifold (1) Illust. 70.

Cleaning, Inspection and Repair

Remove carbon deposits etc. from the exhaust manifold.

A light accumulation of carbon deposits will not affect engine operation.

Inspect the manifold for signs of heat corrosion, warpage and cracks.

Replace an excessively corroded, warped or cracked manifold with new one.

Inspect studs and nuts and replace if necessary.

Manifold Reassembly and Installation

Install manifolds taking special care to ensure tight sealing.

Always use new gaskets when installing a manifold.

Tighten stud nuts or bolt to specified torque. Retighten fasteners after engine is hot and again after not later than 250 operating hours.

Install any injection piping, air intake piping or exhaust piping/turbocharger that were removed.

CRANKCASE FRONT COVER AND FRONT PLATE

Illust. 71

General

The crankcase front cover (6) Illust. 71 is a light metal alloy casting. It seals the timing gear train and carries the crankshaft front oil seal and the timing pointer.

Repairs to the front cover and plate are normally restricted to replacement of seals and gaskets. However, the cover must always be removed, whenever removal of crankshaft, camshaft or idler gear become necessary. If the cover and plate are removed, replace all gaskets and oil seal on reassembly.

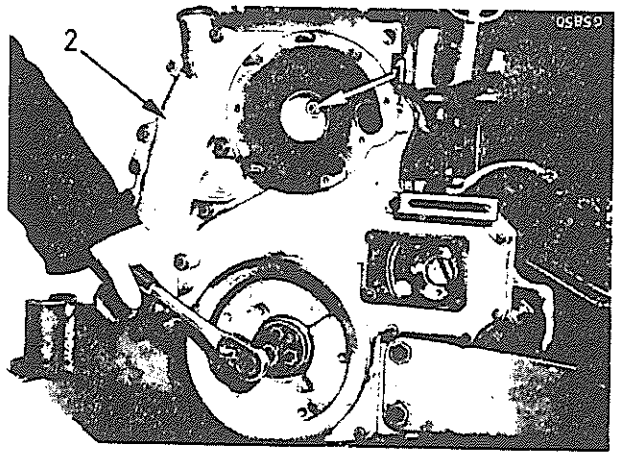
Specifications

Bore diameter for oil seal (9) Illust. 71	100.00 mm / 99.95 mm	=	3.937" / 3.935"
Bore diameter for engine timing pointer (10)	9.395 mm / 9.420 mm	=	.3698" / .3709"
Diameter of timing pointer (10)	9.48 mm / 9.53 mm	=	.373" / .375"
Front plate (4)			
Bore diameter for hydraulic pump and injection pump flange	50.025 mm / 50.000 mm	=	1.9695" / 1.9685"

Removal and Disassembly

Clean engine externally. Drain coolant and engine oil.

Remove fan, V-belt pulley, generator, thermostat connecting hose, flange (2) Illust. 71 and water pump, as described under the respective sections.



Illust. 72

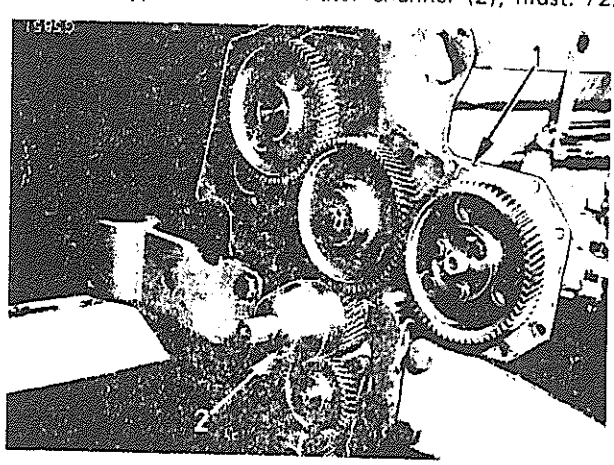
1 — Stud nut
2 — Water channel

Remove all retainer bolts after taking off water pump.

NOTE: On engines equipped with water channel (13) Illust. 71 the crankcase front cover is also secured by stud (1) Illust. 72 located behind the water pump, above the idler gear.

Remove the stud nut before attempting to take off the front cover. It is also advisable to loosen the first 2 or 3 front bolts on both sides of the oil pan. This will help to release tension from the oil pan gasket, thus protecting it from damage.

If necessary, also remove water channel (2), Illust. 72.



Illust. 73

1 — Front plate
2 — Seal jumper

To remove the front plate it is necessary to remove the camshaft, idler gear, injection pump gear and the injection pump first. For details refer to the respective sections of this manual. Remove front plate retainer bolts and lift off front plate.

Cleaning, Inspection and Repair

Clean all parts in a suitable solvent. Remove any possible deposits from water channel, water pump carrier, and front cover.

Inspect the front cover for corrosion, cracks and distortion. Replace the crankshaft front oil seal (3) Illust. 74, O-ring (9) and spacer ring (6) whenever the front cover is removed.

NOTE: Install the new oil seal, spacer ring and O-ring with the front cover in place, refer to Illust. 74.

Inspect front plate for distortion and warpage. Install a new front plate, if necessary.

Check the two injection pump studs for tight fit. When installing studs use liquid sealer and tighten to 10.8 N•m (8 lbf-ft). Tighten lock nuts and secure in place by punching in threads.

When installing the timing pointer (10) Illust. 71 use liquid sealer.

Reassembly and Installation

Use new seals and gaskets throughout.

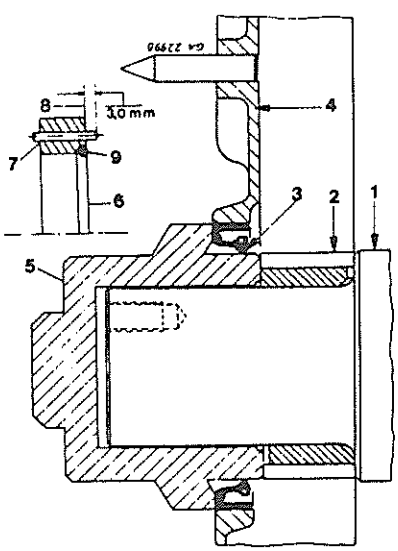
Replace front plate on crankcase dowels.

Install injection pump, camshaft and idler gear.

Refer to "Tuning" for correct meshing of timing gears.

Replace crankcase front cover on dowel pins, using a new gasket to assure tight sealing.

Installation of the front oil seal, crankcase front cover in place



Illust. 74

1 – Crankshaft
2 – Pinion
3 – Oil seal
4 – Crankcase front cover
5 – Special tool PLT-511-7
6 – Spacer ring
7 – Dowel pin
8 – Pin protrusion (3 mm = .118)
9 – O-Ring

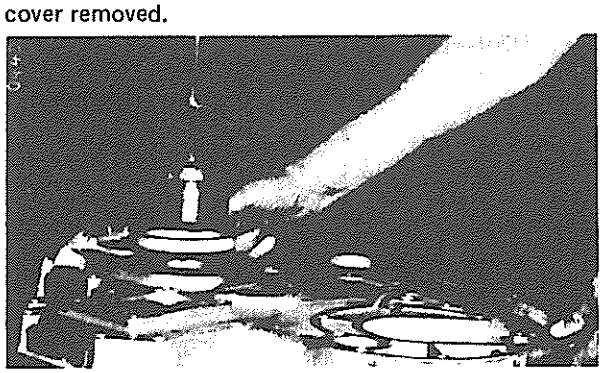
To remove old spacer (6) grip dowel (7) with a pair of pliers.

When mounting the crankshaft front oil seal observe the following points:

1. Handle oil seals with care and protect against contamination and/or damage.
2. Prior to assembly, apply some engine oil to the sealing lips (3) Illust. 74. The outer cage of the seal must be dry when being pressed in.
3. The sealing lip (3) must be installed towards the oil side as shown. Use tool (5) to ensure correct depth control and a perpendicular seat to the crankshaft.
4. Place O-Ring (9) onto crankshaft against pinion (2).
5. Install dowel pin (7) (same length as removed pin) into spacer ring (6), observing dimension (8).
6. Install spacer ring on crankshaft, taking care to engage its roll pin in the timing slot of the crankshaft pinion.

Careful: Do not damage sealing face. Never attempt to remove minor damage by polishing. Leakage will result.

Although it is preferable to install the front oil seal with the front cover in place it can also be installed with front cover removed.



Illust. 75

Install the new oil seal, using the installing tool provided for this purpose, Illust. 75.

NOTE: When using the dual lip seal *do not* smear grease between dust lip and oil sealing lip.

Be sure the seal seats squarely in its bore and that it is flush with the adjacent face of the front cover.

Whenever the front oil seal is replaced, the spacer ring (12) Illust. 85 on which this seal runs, must also be replaced.

Install V-belt pulley, generator, water pump, V-belt and fan.

Fill in egine oil and fill the cooling system.

Vent the fuel system.

Make a test run and check for leakage, check engine timing, etc. and rectify, if necessary.

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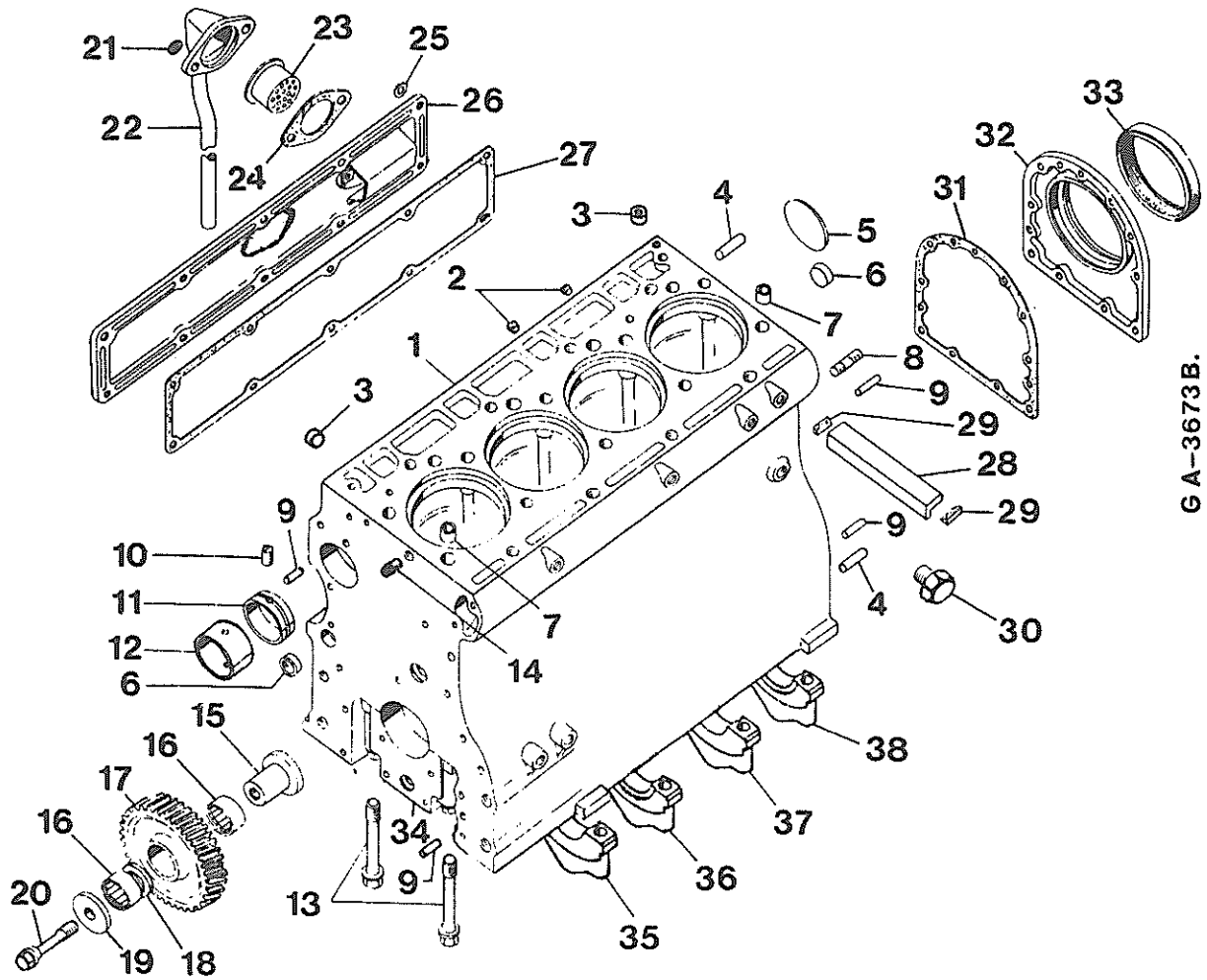
CRANKCASE, OIL PAN, FLYWHEEL HOUSING



Illust. 76

General

Due to the different stroke and number of cylinders, crankcases of the engines differ in height and length. All other dimensions, machined faces, and material quality are identical.

All machined faces on the crankcase and the oil pan are seat surfaces and, therefore, require careful handling. Small dents will cause trouble which may not be apparent until the engine is running.

Due to different engine application the main bearing caps may be located by dowel bushings or are guided laterally in the crankcase with a light press fit.

The crankcase (1) and main bearing caps (35 thru 38) are drilled in one operation. Main bearing caps are numbered from 1 to , beginning at front of engine so that they can be reinstalled in proper position and sequence.

Individual bearing caps are not supplied separately. However, for repair purposes, field packages are available containing bearing cap with bolts and an instruction leaflet.

NOTE: Repairs are restricted to every second bearing cap. The front bearing cap is not available for service.

Repairs on crankcase are generally restricted to replacement of sealing parts and cleaning of oil and water passages.

As a general rule, machined faces of the crankcase should always be examined for damage prior to reassembly of the engine.

For camshaft bushings (11 and 12) Illust. 76 rear oil seal retainer (32), and idler gear (17) refer to the respective sections of this manual.

Removal and Disassembly

Remove the engine and mount it on a suitable stand to facilitate repair work.

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To have free access to the crankcase, the following parts must be removed:

Cylinder head, oil pan, camshaft, crankshaft, connecting rods, pistons, cylinder sleeves; see the respective sections.

Cleaning, Inspection and Repair

Thoroughly clean the crankcase and the oil pan. The most effective way of doing this is to boil these parts in water to which a cleaning solvent is added. Flush out as much scale and other sediment as possible.

Clean oilways with compressed air or a wire rifle brush.

Examine the crankcase for possible warpage and cracks.

Check crankcase sealing face for distortion, if engine has been run with a blown cylinder head gasket or evidence of water leakage is present. Refer to Illust. 38.

If cracks or fissures are detected, do not attempt welding or brazing; replace the crankcase with a new one.

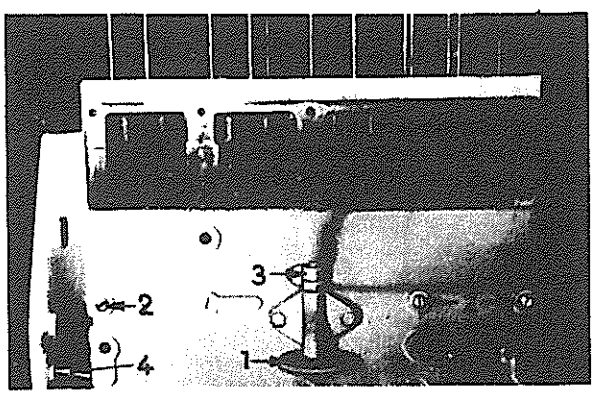
Inspect cylinder sleeves to make sure protrusion is within specified limits. If cracks are detected do not attempt welding or brazing. Replace the crankcase with a new one also when protrusion is insufficient, see Illust. 83.

NOTE: To provide the correct cylinder sleeve protrusion (5) Illust. 83, shims (4) may be used between the sleeve flange and crankcase counterbore.

IMPORTANT

Before installing the shims it is necessary to check the counterbore depth (A) Illust. 83c at four points equally spaced around the counterbore, using a depth gauge. Maximum variation between points of measurement must not exceed 0.04 mm (0.0016 inch). If variation exceeds 0.04 mm (0.0016 inch) the counterbore must be refaced. Refer to "Crankcase Counterbore Refacing" in this section.

Observe maximum permissible salvage depth (A2).



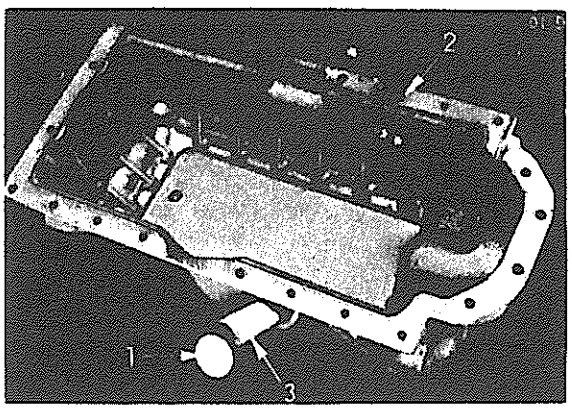
Illust. 77

1 – Oil filter socket
2 – Plugs
3 – Sender unit, engine oil pressure
4 – Dowel pin

Check for proper seat of sealing parts, such as U-plugs and expansion plugs and replace with new ones, if necessary.

To install U-plug and expansion plugs use special tools provided for this purpose.

Plugs (2) Illust. 77 need not be removed except for more effective cleaning of oil passages.

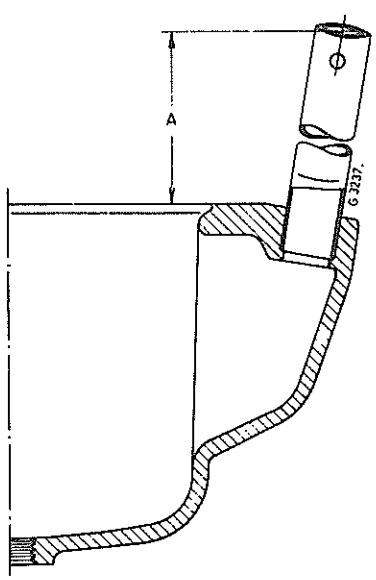


Illust. 78

1 – Oil level gauge
2 – Machine face
3 – Oil filler pipe

Inspect the oil pan for cracks. Do not attempt welding repairs. Also check the oil level gauge (1) Illust. 78 and replace damaged parts.

If the oil filler pipe (3) requires replacement, proceed as follows:



Illust. 79

A – Protrusion of filler pipe

Before removing the old filler pipe measure and note its protrusion "A", Illust. 79.

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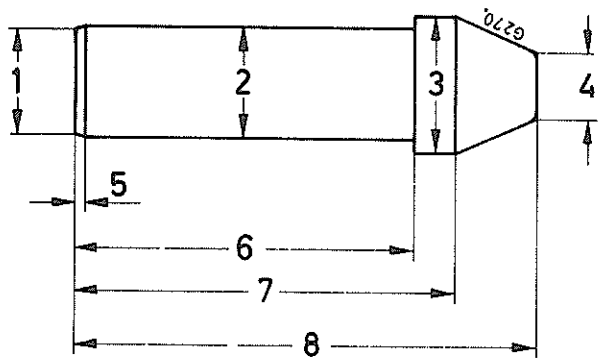
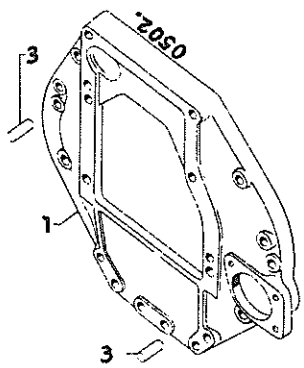


Illust. 80

1 –	26 mm Ø	=	1.02"
2 –	27.9 mm Ø	=	1.09"
3 –	34 mm Ø	=	1.34"
4 –	16 mm Ø	=	.62"
5 –	2 mm	=	.08"
6 –	85 mm	=	3.35"
7 –	95 mm	=	3.75"
8 –	115 mm	=	4.5 "

Use a drift punch as shown on Illust. 80 to protect oil pipe top while driving in.

Take care to observe dimension "A" Illust. 79 to ensure proper oil level readings. Secure the pipe by welding or brazing all around or use "Loctite".



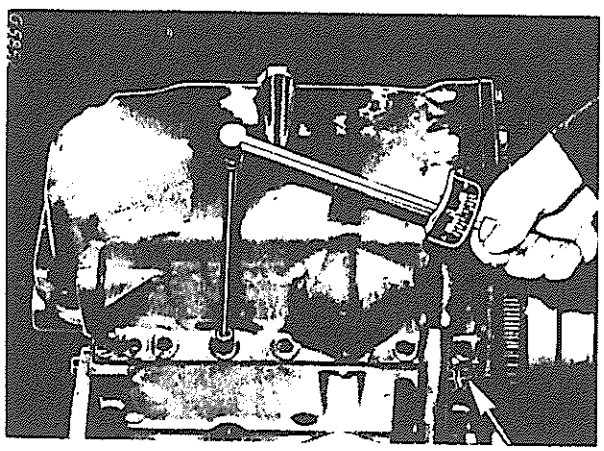
Illust. 81
Flywheel Housing

Inspect flywheel housing for cracks and damage. Dowel pins (3) Illust. 81 must seat properly to ensure alignment. Use special punch provided to install new dowel pins.

Reassembly and Installation

Reassemble all parts, reversing the order of disassembly, using new gaskets throughout to ensure tight sealing.

Refer to the respective sections of this manual for reassembly and installation of the following: Crankshaft, Pistons, Cylinder Head, Water Pump, Flywheel, etc.



Illust. 82
Installing Oil Pan

When installing grey iron oil pans (used for tractor engines) care should be taken that the oil pan is exactly flush with the crankcase rear end.

NOTE 1:

1. Bolts used for grey iron oil pans must be tightened to regular torque.

2. Bolts, used for sheet metal oil pans must be tightened to a lower torque, see "Specifications".

3. Insert bolt (arrow Illust 82) before oil pan installation.

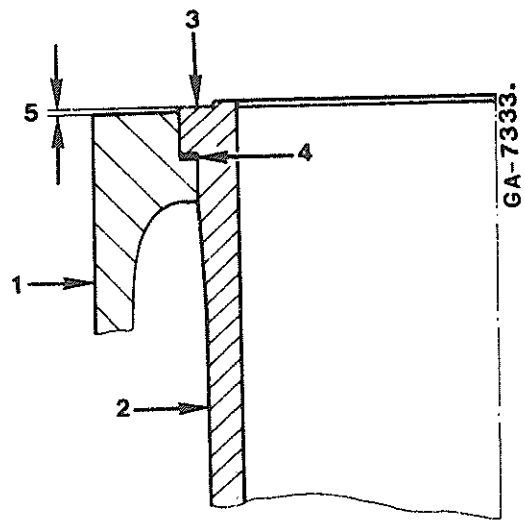
Checking Sleeve Protrusion

1. Check counterbore depth (A) Illust. 83c and reface counterbore if necessary.

2. Place the sleeve to be checked in the crankcase without the "O" ring.

3. Clamp the sleeve down using four holding adapters shown in Illust 83a. Make sleeve holding adapters locally. Space the bolts to obtain uniform pressure on the sleeve flange as shown in Illust. 83a. Torque the bolts to 41 N•m (30 lbf-ft) in three stages at 14 (10), 27 (20) and 41 N•m (30 lbf-ft) see Note).

NOTE: If the crankcase is equipped with studs use suitable spacer pipes over four studs and secure the holding adapters in place using hardened washers and stud nuts.

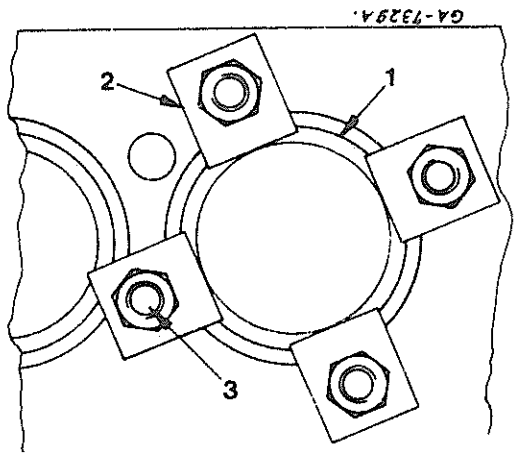


Illust. 83
Cylinder Sleeve Protrusion

1 – Crankcase
2 – Sleeve
3 – Outer flange
4 – Shim (use only if necessary)
5 – Protrusion, 0.08 – 0.12 mm (0.0031 – 0.0047 inch)

IMPORTANT

Protrusion (5) must not fall below 0.08 mm, use shims (4) is necessary.



Illust. 83a
Cylinder Sleeve Clamped Down for Protrusion Check

1 – Sleeve
2 – Holding adapter
3 – Capscrew

4. Place a dial indicator, with block, across the cylinder sleeve.

a) With the dial indicator pointer set on the flange of the cylinder sleeve, adjust the indicator to zero. Move the indicator block until the pointer drops to the crankcase deck and take a reading.

b) If the sleeve flange is below the crankcase deck, rest the indicator pointer on the crankcase deck and set the indicator at zero. Move the indicator block until the pointer drops to the sleeve flange and take a reading.

c) Take readings at three or four points around the sleeve and use the average reading to determine which shim, if any, is needed to make protrusion (5) Illust. 83.

d) Mark each sleeve before removing so that it can be reinstalled in the same bore and in the same position as it was while making the protrusion check.

NOTE: Shims of following thicknesses are available:

mm	(inch)
0.05	(.002)
0.10	(.004)
0.25	(.010)
0.50	(.020)
0.80	(.031)

5. Check each sleeve that is to be installed for protrusion in the same manner as above.

a) Remove the clamping bolts and washers. Clean the top deck of the crankcase and the cylinder sleeve counterbore. Clean the sleeve.

b) Install the shim (if necessary) in the counterbore.

c) Coat the sealing "O" ring with specified clean engine oil and install into the groove (without twist).

NOTE: Refer to Illust. 144 for correct "O" ring selection and installation.

d) Brush the sealing ring contacting surface in the crankcase with clean engine oil.

e) Install the sleeve carefully into the same bore as removed from and press into place by hand.

NOTE: After installing a cylinder sleeve in the crankcase, check the clearance between the deck of the crankcase and the top surface of the outer sleeve flange. This amount must not exceed the maximum dimension (5) Illust. 83.

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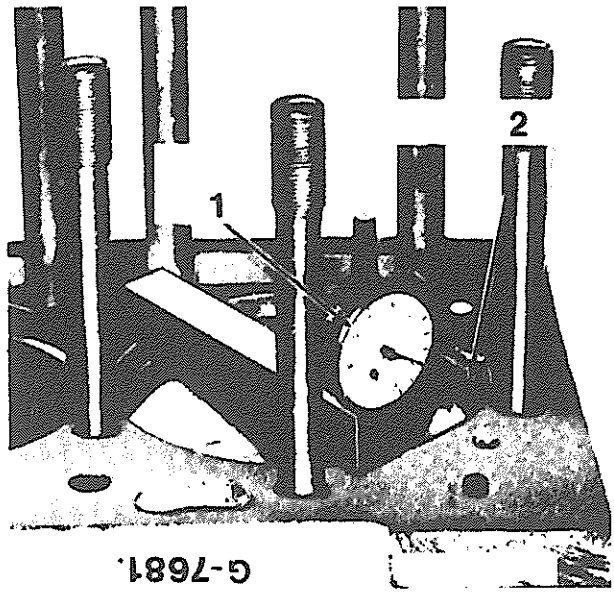
Crankcase Counterbore Resurfacing

General

The counterbore cutting tool Illust. 83d (No. 3 218 536 R91) or PLT-546 is used for resurfacing crankcase cylinder counterbores for all wet sleeve engines as mentioned in this manual.



Illust. 83b

1 – Indicator 1 020 560 R91
2 – ledge of counterbore

1. Using an indicator or a depth micrometer measure counterbore dimension from top of the crankcase to the counterbore ledge. Illust. 83b.

   Measure at four points, at right angles.

2. If one of the four measurements differs more than 0.04 mm (0.0016 inch) the ledge of the counterbore must be resurfaced.

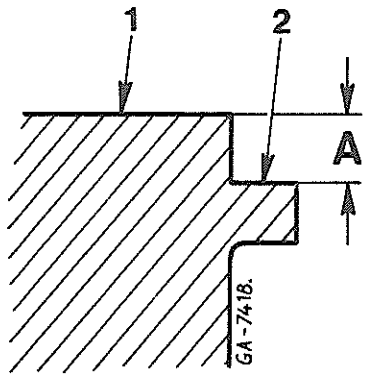
   NOTE: If all counterbore ledges of one particular engine are to be cut to the same depth, measure all counterbores and set up cutting tool on the lowest counterbore ledge to ensure clean-up of all counterbores.

   NOTE: The depth of the counterbores is limited. Never exceed maximum counterbore salvage depth. See Illust. 83c.

Operation of Cutting Tool

3. Remove all carbon deposits and water sediments from counterbores.

4. Clean and smooth the crankcase deck as necessary.



Illust. 83c

1 – Crankcase deck
2 – Ledge
A 1 – Counterbore dimension, new 7.595 – 7.620 mm (.2990 – .3000 inch)
A 2 – Maximum permissible salvage depth 9.020 mm (.3551 inch)
A 3 – Maximum permissible warpage of surface (2) 0.04 mm (0.0016 inch)

5. Slowly and gently rest the tool onto the lowest counterbore ledge of the crankcase.

6. Back-out set screw (10) Illust. 83d.

   Back off adjusting nut (11) by rotating it in counter-clockwise direction.

7. Place a feeler gauge of 0.10 mm (.004") thickness between crankcase deck and stop-bell (2).

8. Screw down adjusting nut (11) until it contacts stop-bell (2).

   Tighten set screw (10).

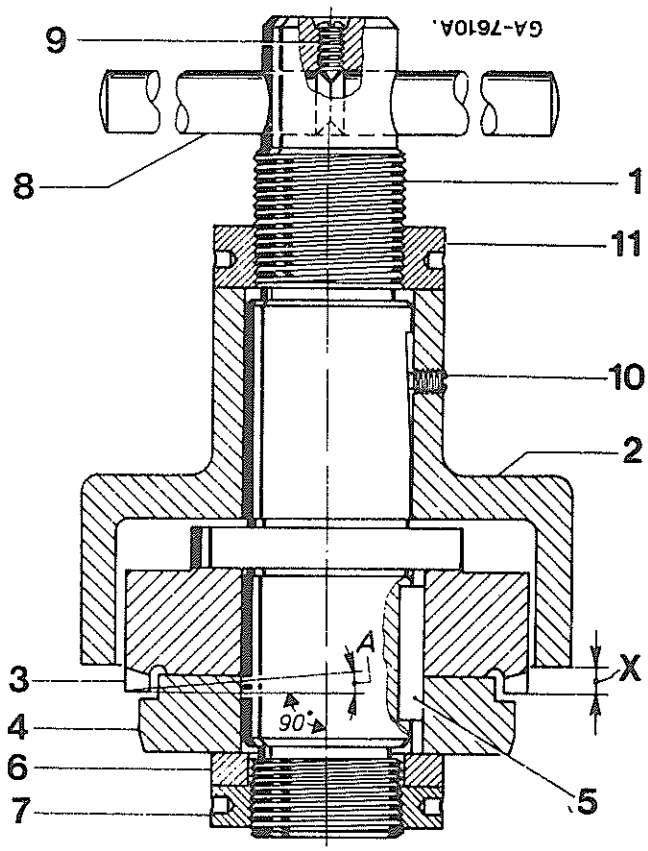
   Remove feeler gauge.

9. The gap between crankcase and stop-bell coincides with the amount of material to be removed from the counterbore ledge.

10. Rotate the cutter in a clockwise direction until the stop-bell contacts the crankcase.

11. While rotating in clockwise direction lift off the tool and check to make sure that ledge of the counterbore is properly cleaned-up.

    NOTE: Adjusting nut (11) Illust. 83d has graduated markings to estimate the amount of cut. Each mark is 0.10 mm (.004").



Illust. 83d
Cutting Tool

A – Max. permissible inclination when regrinding: 30 minutes
X – Cutting depth, adjustable.

1 – Spindle
2 – Stop-bell
3 – Cutter
4 – Guide
5 – Key
6 – Washer
7 – Ring nut
8 – Handle
9 – Set screw
10 – Set screw
11 – Adjusting nut

If a second cut is needed, rotate the adjusting nut counterclockwise to the next marking only and repeat step 10 and 11.

12. Repeat resurfacing procedure until the ledge of the counterbore is properly cleaned up and exactly parallel to the crankcase deck.

13. Resurface the remaining counterbores as necessary.

NOTE: To obtain specified cylinder sleeve protrusion place shims between counterbore ledge and sleeve. See Illust. 83. Shims of following thicknesses are available:

0.05 mm	(.002")
0.10 mm	(.004")
0.25 mm	(.010")
0.50 mm	(.020")
0.80 mm	(.031")

DO NOT exceed maximum protrusion.

Grinding the Cutter

The cutter is of a select grade of carbide to give maximum tool-life and is accurately ground with precise angles on the cutting edges. Never attempt to grind the tool without special equipment.

After regrinding cutting edges must be square, permitting a tolerance (A) Illust. 83d.

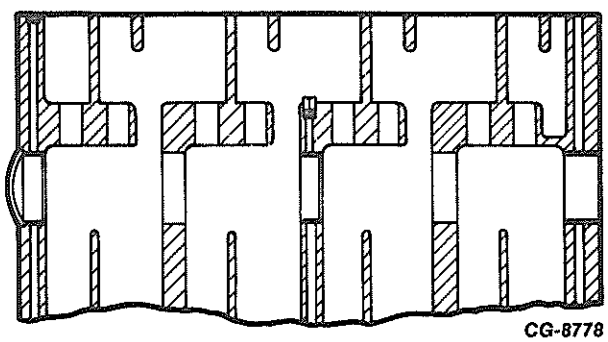
NOTE: If counterbore service tool PLT-546 is used, refer to instructions sent with the tool.

CRANKCASE DESIGN CHANGE

Description

The crankcases for 4 and 6 cylinder engines have been changed as follows:

1. The camshaft bearing seals and oil supply bores which are not used any longer have been eliminated from new style crankcases.



Illust. 84
New 4 Cylinder Crankcase

2. The quantity of camshaft bearings has been reduced from 5 to 3 (including front bearing) on 4 cylinder crankcases and from 7 to 4 on 6 cylinder crankcases.

Lead bronze camshaft bearing bushings have replaced old style tin-babbit bearings for all engines.

Service Instructions:

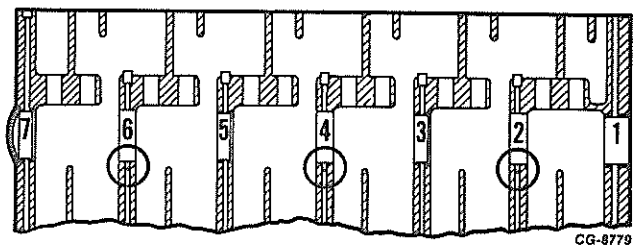
NOTE: Refer to camshaft section for additional service instructions.

1. New lead bronze bearings must be used with new style camshafts.

2. Displaced type (tin-babbit) bearings are to be used on 3 cylinder engines or 4 and 6 cylinder crankcases equipped with displaced type camshaft.

3. A displaced type camshaft may not be used in a new style crankcase.

4. When installing a new type camshaft in a displaced style crankcase, remove old style (tin-babbit) bearings; Before installing new type camshaft, the oil bores of the free journals must be closed with plugs (IH Part No. 3 228 562 R1) to maintain oil pressure at remaining bearings. These plugs are to be installed in the lower camshaft bearing seat oil bore.



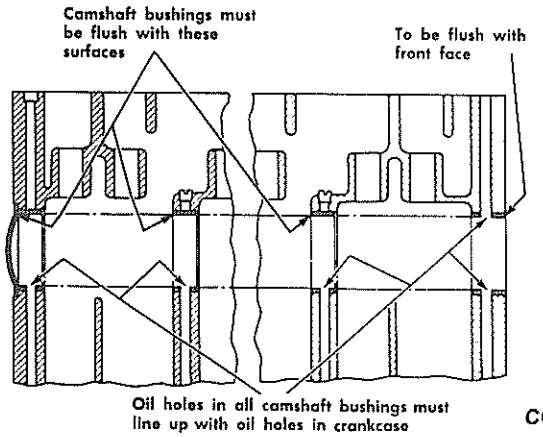
Illust. 84a
Oil Bore Plug Positions for 6 Cylinder Crankcase

NOTE: Oil bore plugs are installed only at those positions where there will be no camshaft bearing.

Three oil bore plugs are to be installed at the number 2, 4 and 6 free journal bearing positions for 6 cylinder crankcase.

Two oil bore plugs are to be installed at the number 2 and 4 bearing positions for 4 cylinder crankcases.

Be sure to drive plugs deep enough to allow installation of new type lead-bronze camshaft bearings.



Illust. 84b
Camshaft Bushing/Bearing Positioning

IMPORTANT: After boring camshaft bushings all machining chips must be cleaned from crankcase. All oil passage plugs must be removed and passages flushed with solvent followed by compressed air. Flushing should start at each of the camshaft oil passages which are between the tappet bores. The camshaft bushing I.D. oil holes should be blocked to ensure that the bushing O.D. oil passage is clean. Each main bearing oil passage and main oil gallery must also be flushed and cleaned.

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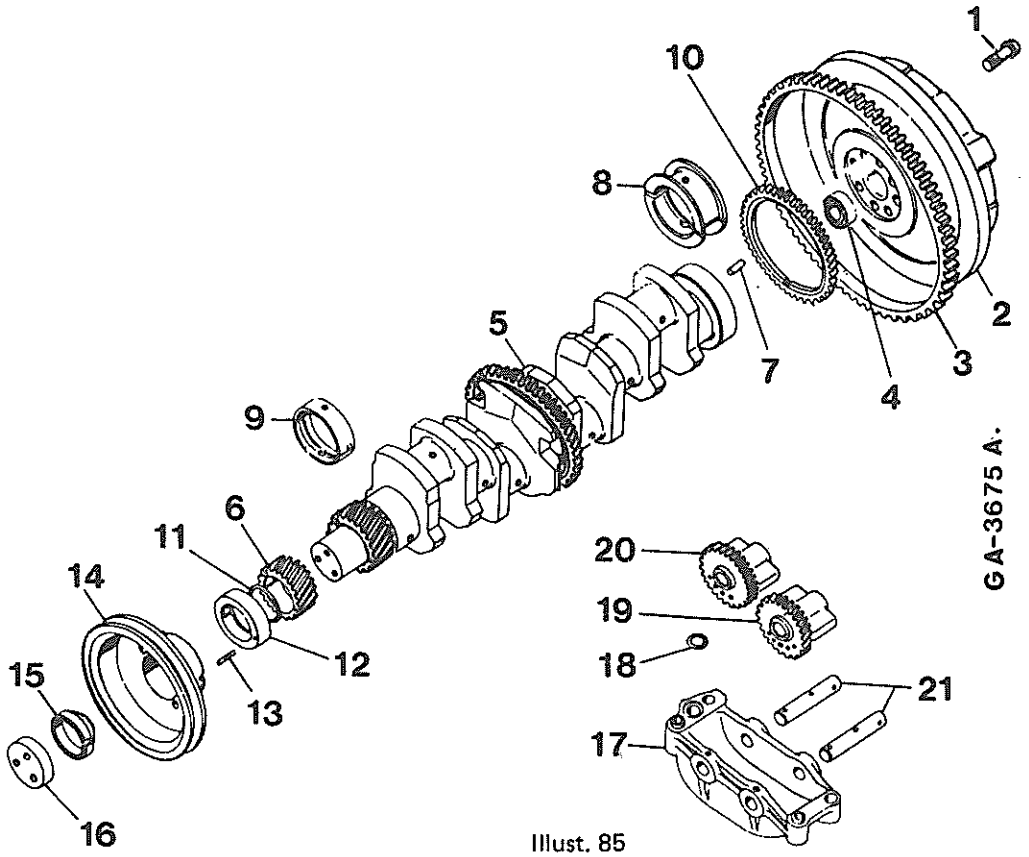
CRANKSHAFT, V-BELT PULLEY



Illust. 85
Crankshaft and Balancer (4-cyl-engine)

General

Crankshafts for 3, 4 and 6 cylinder engines are designed in such a way that basic dimensions of crankpins and journals are the same on all shafts, see "Specifications".

NOTE 1: If crankshaft regrinding to the second or third undersize (Illust. 86) becomes necessary, it is important to determine the process by which the crankshaft has been hardened at the factory.

Hardening Processes:

a) "Deep Nitroc" (gas nitriding process) present crankshaft hardening.

Deep-Nitroc hardened crankshafts have an "N" stamped on the front face of the first web for identification. These crankshafts require re-hardening after regrinding to second or third undersize, see Illust. 86.

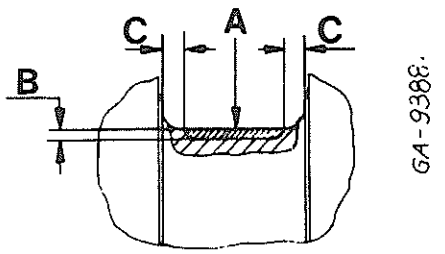
b) "Tufftriding" (bath nitriding process). These crankshafts can be ground to a first or a second undersize only. Re-hardening is necessary after regrinding to second undersize. (Refer to Note 2).

c) "Induction" hardened crankshafts can be reconditioned to a first, second or third undersize without rehardening. (Refer to Note 2).

NOTE 2: Tufftrided and induction hardened crankshafts are without identification marks. These crankshafts may be identified by a hardness check on a crankshaft web.

DO NOT CHECK HARDNESS ON JOURNALS.

While on tuffrided crankshafts journals and webs are hardened, induction hardened crankshafts have a limited hardness area (A) Illust. 85a on crankpins and journals only.



Illust. 85a

A – Hardness area on journals and crankpins of induction hardened crankshafts.
B – 2 – 3 mm (0.079 – 0.12 inch)
C – 5.5 ± 0.5 mm (0.216 ± 0.02 inch)

It is recommended that reconditioning be done at Renewal Stations where equipment and experience can produce quality standards as outlined in "Specifications".

Main and connecting rod bearing inserts are available for standard, first, second or third undersize. Engine models DT-239, D-268, DT-358 and DT-402 DO NOT have third undersize bearings.

Two seals, one at each end, prevent leakage of engine lubricating oil around the ends of the crankshaft. The rear oil seal can be offset twice in the rear oil seal retainer.

Handle the crankshaft with care and protect it against dropping, striking etc. to prevent damage.

Straightening

Induction hardened crankshafts can be straightened.

However, "Deep-Nitroc" and "Tufftrided" crankshafts MUST NOT be straightened. Even slight straightening with complete absence of cracks will endanger the high strength built into the shaft.

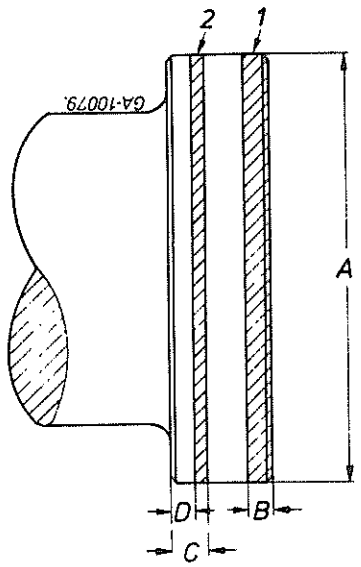
Refer to Parts Catalog for availability of undersize inserts for main and connecting rod bearings.

When installing a reground crankshaft be sure to use the respective undersize bearing inserts.

Crankshaft Rear End Sealing Flange

The rear oil seal, running on the sealing flange can be offset twice in the oil seal retainer or in the flywheel housing, see Illust. 93 and 95 respectively.

If the sealing face of the flange is worn, it may be reconditioned by hard chromium plating.



Illust. 85b

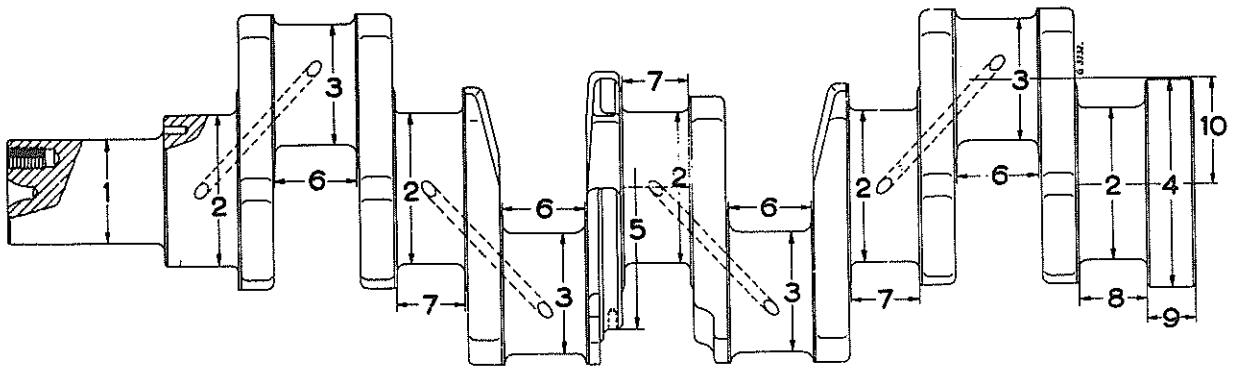
1 – Flywheel seat
2 – Permissible working range of oil seal lip.

A – 110.00 – 109.9 mm
(4.3307 – 4.3299 inch)
B – 6.5 mm (.25 inch)
C – 9.5 mm (.37 inch)
D – 6.2 mm (.24 inch)

NOTE: Finish sealing face to DIA (A) Illust. 85b by plunge-cut grinding.

Specifications

In brackets ( ) max. permissible wear-rating before replacing or reconditioning crankshaft.



Illust. 86

1 — 55.00 mm / 54.98 mm = 2.1653" / 2.1645"

2 — Standard size 79.99 mm / 79.97 mm = 3.1492" / 3.1484" *

1st undersize 79.740 mm / 79.721 mm = 3.1393" / 3.1386" *

2nd undersize 79.490 mm / 79.471 mm = 3.1295" / 3.1287" *

**) 3rd undersize 79.240 mm / 79.221 mm = 3.1194" / 3.1189" *

3 — Standard size 63.99 mm / 63.97 mm = 2.5193" / 2.5185" *

1st undersize 63.740 mm / 63.721 mm = 2.5094" / 2.5087" *

2nd undersize 63.490 mm / 63.471 mm = 2.4996" / 2.4988" *

**) 3rd undersize 63.240 mm / 63.221 mm = 2.4898" / 2.4890" *

4 — 110.00 mm / 109.98 mm = 4.3307" / 4.3299"

5 — 4 cylinder engines only

150.025 mm / 150.000 mm = 5.9065" / 5.9055" (D-206 up to 2200/min)

150.200 mm / 150.175 mm = 5.9134" / 5.9124" (D-239, D-246, D-206 above 2200/min)

160.210 mm / 160.235 mm = 6.3075" / 6.3085" (D-268)

* (max. out-of-round 0.004 mm (.00015")
** (except DT-239, D-268, DT-358, DT-402

6 — 44.05 mm / 43.95 mm = 1.7342" / 1.7303" (all engines, except early type D-268 and DT-402)

42.05 mm / 41.95 mm = 1.6555" / 1.6515" (Early type D-268 and DT-402 only)

7 — 36.60 mm / 36.70 mm = 1.4409" / 1.4449"

8 — Standard size 36.65 mm / 36.69 mm = 1.4429" / 1.4445"

1st undersize 36.90 mm / 36.94 mm = 1.4528" / 1.4543"

2nd undersize 37.15 mm / 37.19 mm = 1.4626" / 1.4642"

** 3rd undersize 37.40 mm / 37.44 rnm = 1.4724" / 1.4740"

9 — 26.00 mm = 1.0236" Standard size
25.875 mm = 1.0187" 1st undersize
25.750 mm = 1.0137" 2nd undersize
**) 25.625 mm = 1.0088" 3rd undersize

10 — 55.60 mm / 55.52 mm = 2.1889" / 2.1858" (D-155, D-206, D-310)

64.302 mm / 64.222 mm = 2.5316" / 2.5284" (D-179, D-239, DT-239, D-246, D-358, DT-358)

69.81 mm / 69.89 mm = 2.7484" / 2.7515" (D-268, DT-402)

Surface finish:
journals and crankpins (2 & 3) Ra 0.2 µm (8 Micro-inch)
flange (4) Ra 0.25 — 0.5 µm (10 — 20 Micro-inch)
Rt max. 5 µm (200 Micro-inch)

Journals and Crankpins

Hardness	(induction hardened crankshafts)	50–55 HRc
Hardness depth		2–3 mm = .078–.118"
Hardness	(tufftrided crankshafts)	400 HV
Hardness depth		min. 0.25 mm = .0098"
Hardness	(Deep-Nitroc hardened crankshafts)	450 HV
Hardness depth		min. 0.25 mm = .0098"
Radii on journals		4.9–5.5 mm = .1929–.2165"
Radii on crankpins		5.7–6.3 mm = .2244–.2480"
Max. permissible out-of-round		0.004 mm = .00015 (before reconditioning 0.05 mm = .002)
Permissible taper per 1 inch length		0.004 mm = .00015"
Run-out on every one of the journals, with ends of the crankshaft placed in V-blocks,		
D-155, D-179		0.20 mm = .0078"
D-206. D-239, DT-239, D-246, D-268		0.40 mm = .0157"
D-310, D-358, DT-358, DT-402		0.60 mm = .0236"
Parallelism crankpins to journals, permissible deviation		0.010 mm = .00039"
Permissible eccentricity of dia (5) Illust. 86 to journals No 2+4		0.020 mm = .00078"

Main and Connecting Rod Bearing Inserts

Actual bearing material thickness	0.020 – 0.024 mm = .0008 – .0010"

Main Thrust Bearing Insert (8) Illust. 86

Width, Standard	$\frac{36.500\ mm}{36.461\ mm} = \frac{1.4370"}{1.4354"}$
Width, 1st undersize	$\frac{36.750\ mm}{36.711\ mm} = \frac{1.4468"}{1.4453"}$
Width, 2nd undersize	$\frac{37.000\ mm}{36.961\ mm} = \frac{1.4567"}{1.4552"}$
*) Width, 3rd undersize	$\frac{37.250\ mm}{37.211\ mm} = \frac{1.4665"}{1.4650"}$

Crankshaft Rear Sealing Flange

Permissible run-out	0.050 mm = .0020"
Permissible out-of-true	0.020 mm = .00078"

Crankshaft Running Clearance and End Play

Running clearance in the main bearings (new)	0.070 – 0.140 mm = .00275 – .00551"
End play	0.15 – 0.23 mm = .0059 – .0090 "
	(+ 0.07 mm = .003")

Connecting Rod

Running clerance on crankpins (new)	0.060 – 0.120 mm = .0023 – .0047"
Side clearance	0.15 – 0.25 mm = .006 – .010 "

Crankshaft

Max. permissible imbalance, measured at the front and rear journal	
D-155, D-179, D-206, D-268, D-239, DT-239, D-246 (3 and 4 cylinder)	45 cmg = .626 oz.inch
D-310, D-358, DT-358, DT-402 (6 cylinder [with counterweights])	60 cmg = .835 oz.inch

*)except DT-239, D-268, DT-358, DT-402

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Balancer Drive Gear (10) Illust. 85

Engine	Number of teeth	ID mm	ID (inch)	Run-out *) mm	Run-out *) (inch)	Out of True mm	Out of True (inch)	Shrinking Temperature °C	Shrinking Temperature (°F)
D-206 up to 2200/min	80	150.000 / 150.025	(5.9055) / (5.9064)	0.08	(.0031)	0.10	(.0039)	100	(212)
D-239 D-246 D-206 above 2200/min	80	150.035 / 150.075	(5.9069) / (5.9085)	0.06	(.0024)	0.04	(.0016)	180–200	(356–392)
D-268	90	160.035 / 160.075	(6.3006) / (6.3022)	0.06	(.0024)	0.04	(.0016)	180–200	(356–392)

*) Installed and in relation to journals No. 2 + 4

Crankshaft Pinion (6) Illust. 85

Number of teeth 33

I D $\frac{54.914 \text{ mm}}{54.935 \text{ mm}} = \frac{2.1619''}{2.1628''}$

NOTE: Remove balancer drive gear (10) Illust. 85 (4 cyl.) and pinion (6) before nitriding the crankshaft.

Re-hardening processes for nitrided crankshafts:

I = short time gas nitriding (4h)
II = bath nitriding. tufftriding process (4h)
III = inducation hardening

Surface hardness: "I and II" HV_{10} 400
"III" 50 HRc Rockwell (undersize minimum 40 HRc)

Undersize	Factory Process	
	Gas Nitrided	Bath Nitrided (Tufftrided)
U1, re-hardening	Not necessary	Not necessary
U2, re-hardening	I or III	II
U3, re-hardening	I	U3 not permissible

Instructions for Regrinding Crankshafts

The most important consideration is to avoid any burns in the regrinding operation. Refer to Illust. 86 for regrinding dimensions.

The crankshafts are reground similar to any precision crankshaft with the following precautions:

1. A mechanical or an automatic wheel dresser is mandatory to prevent chatter, burning and poor surface finish. A hand stone should NEVER be used to rough or fine dress the face or radii of the wheel. The radii should blend evenly into the journal.
2. Selection of the grinding wheel is important because too hard a wheel will increase the possibility of burning. An aluminum oxide wheel with a grit size of approximately 50 and a maximum hardness of "M" will produce satisfactory results, with other conditions being suitable.
3. Carefully check crankshaft for hair line cracks before starting rework.

   If cracks are present, do not grind.
4. Do not grind journals and crankpins beyond the limits specified in (2 and 3) Illust. 86.
5. Do not change the radii of journals and crankpins and strictly observe their cylindricity.
6. Break all sharp edges.
7. Highly polish journals and crankpins.

NOTE: Before regrinding "Nitrided" crankshafts align journals individually to a T.I.R. of max. 0.05 mm (.002 inch) with the shaft in the machining tool.

NOTE: If the sealing face of the crankshaft rear end is worn, it may be reconditioned by hard chromium plating.

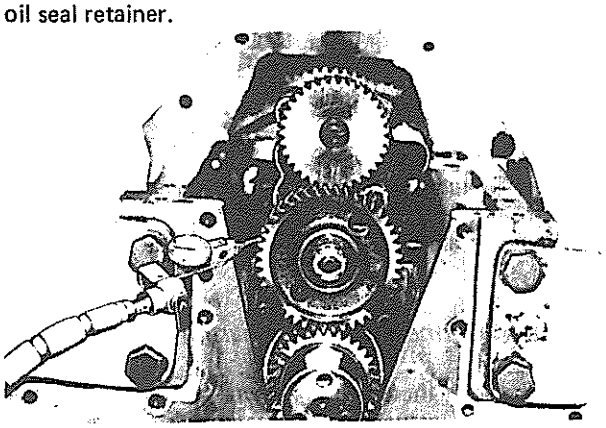
Regrind and polish the reconditioned end to dimension Illust. 85b.

Observe max. out-of-round = .0508 mm (.002")
out-of-true = .0203 mm (.0008")

It is recommended to use the plunge cutting method for maximum sealing efficiency.

Removal and Disassembly

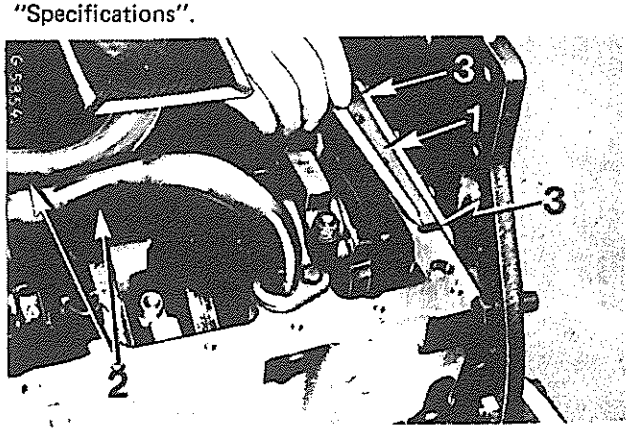
Remove oil pan, crankcase front cover, flywheel and rear oil seal retainer.



Illust. 87
Checking Gear Backlash

NOTE: It is good practice to check end play of the crankshaft before removing it.

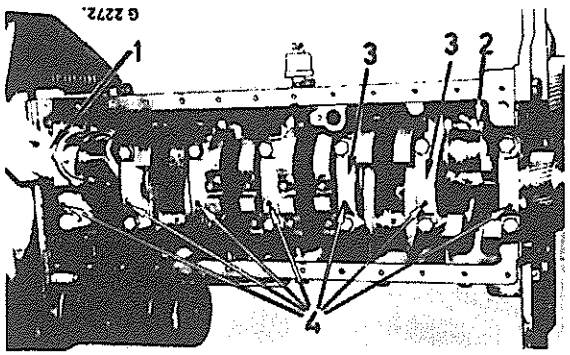
Also check the backlash of every gear of the timing gear train, Illust. 87. See "Camshaft" for gear backlash "Specifications".



Illust. 87a

1 — Sealing bar
2 — Oil suction and pressure pipe
3 — Seal strip

Turn the engine bottom side up and remove sealing bar (1) Illust. 87a, pipes (2) and the balancer (4-cyl-engines).



Illust. 88
Crankshaft (6-cyl-engine shown)

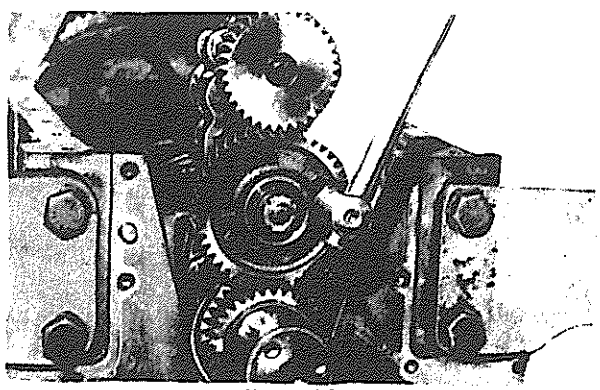
1 — Connecting rod bearing cap
2 — Connecting rod
3 — Main bearing caps
4 — Cast dimples (on injection pump side)

NOTE:

1. Main bearing caps (3) Illust. 88 are numbered consecutively so they can be reinstalled to their original positions.

2. Connecting rods are not numbered. However, it is recommended to mark these accordingly so that they can be reassembled to their original positions. On DT-402 engines bearing cap of connecting rod No. 1 is marked with figure 1.

3. Also main bearing and connecting rod bearing inserts are without any markings. On removal carefully store them so they can be reassembled to their original positions when reused.



Illust. 88a
Removing or Installing Oil Pump

The oil pump may be removed as illustrated or as a unit with main bearing cap No. one.

6-cyl.-engines:

To remove the crankshaft, pistons must be taken out of their sleeves individually towards the cylinder head side. As soon as a pair of connecting rod caps, Illust. 88 is lifted off, turn the crankshaft until respective pistons can be pushed out of their sleeves.

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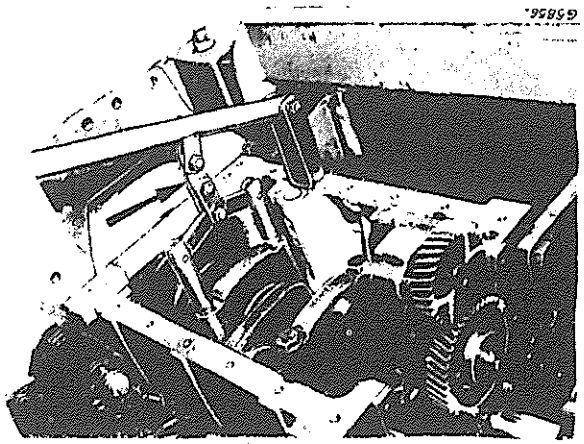
3 and 4-cyl.-engines:

To remove the crankshaft only the connecting rod bearing caps must be removed.



Illust. 89
Removing Main Bearing Caps

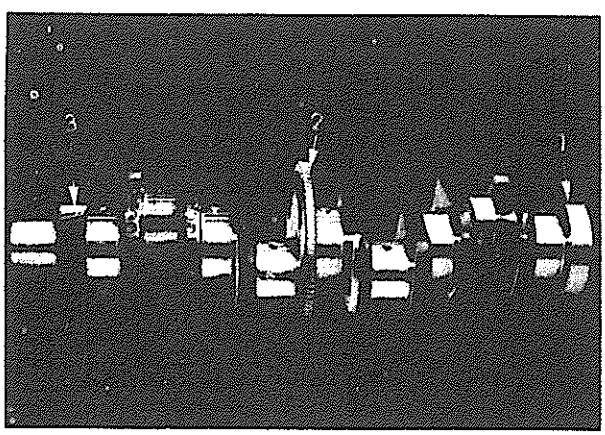
Remove bearing cap bolts and use a locally made lever tool (illust. 89) to lift out bearing caps.

NOTE: Two full length straight pins enter the bearing cap. The clamping effect resulting from the lever arrangement will grip the cap for removal.

Remove the crankshaft taking care not to damage machined areas by the lifting tackle.

Cleaning, Inspection and Repair

Clean all parts thoroughly with kerosene or Diesel fuel. Blow through oilways with compressed air.

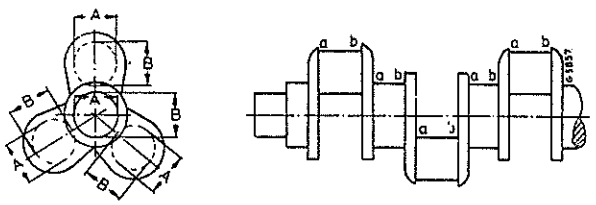


Illust. 90
Crankshaft (4-cyl.-engines)

1 – Sealing face
2 – Balancer drive gear
3 – Crankshaft pinion

Journals and Crankpins

Check the crankshaft for wear on journals and crankpins. Due to intermittent load characteristics of engine operation wear becomes usually apparent as out-of-round wear. Measure at right angles, see "A" and "B", Illust. 90a.



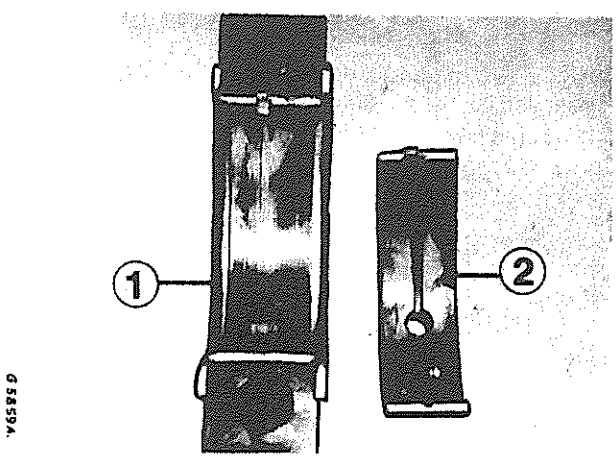
Illust. 90a
Measuring Points, Crankshaft

Replace the crankshaft if out-of-round wear exceeds 0.05 mm (.002").

Crankshafts may be fitted with new bearing inserts, if out-of-round is less than 0.03 mm (.0012"), provided that journals are free of scoring marks and "hot spots".

Main and Connecting Rod Bearing Inserts

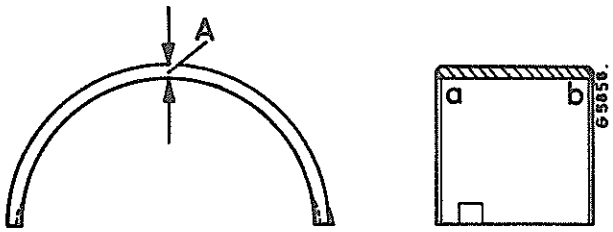
When checking these bearing inserts it should be born in mind that the actual bearing material is not more than 0.020 – 0.024 mm (.008 – .0010"). If this material is worn away, journals are liable to scoring by contacting the lead bronze base material.



Illust. 91
Visual Inspection of Inserts

1 – Even bearing pattern, insert o.k.
2 – Bearing material partly worn, replace

Bearing inserts found to be o.k. on visual inspection should be measured to ensure sufficient life expectancy. For details see Illust. 92 and dimensions.



Illust. 92
Measuring Points, Bearing Inserts

A – Thickness of Inserts

Main Bearing	New mm	New (inch)	Worn Out mm	Worn Out (inch)
Standard	2.960 2.972	(.1165) (.1170)	2.952	(.1162)
1st undersize	3.085 3.097	(.1214) (.1219)	3.077	(.1211)
2nd undersize	3.210 3.222	(.1263) (.1268)	3.202	(.1260)
3rd undersize	3.335 3.347	(.1313) (.1318)	3.327	(.1310)

Connecting rod bearing:

Standard	1.963 1.975	(.0772) (.0777)	1.955	(.0769)
1st undersize	2.088 2.100	(.0822) (.0826)	1.988	(.0782)
2nd undersize	2.213 2.225	(.0871) (.0875)	2.205	(.0868)
3rd undersize	2.338 2.350	(.0920) (.0925)	2.330	(.0917)

If in doubt install new bearing inserts.

Main Thrust Bearing Insert (8) Illust. 86

Inspect actual bearing material of this insert similar to main bearing inserts.

Replace the insert if:

a) actual bearing material wear is evident,

b) crankshaft end play (as checked before removal) is excessive or nearing its wear limit.

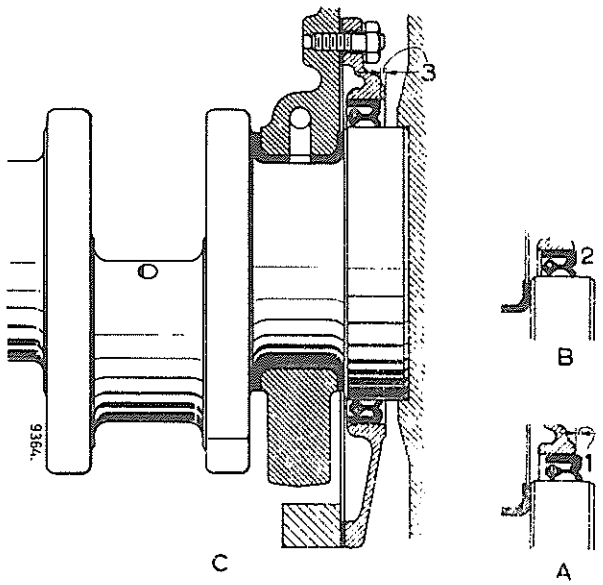
NOTE: When installing a new crankshaft always install new bearing inserts.

Crankshaft Rear Sealing Flange

Check condition of the sealing face for the rear oil seal.

Offset the new oil seal in the oil seal retainer, if the sealing lip has worked into the sealing face.

NOTE: Depending on application oil seals may be installed as shown in Illust.

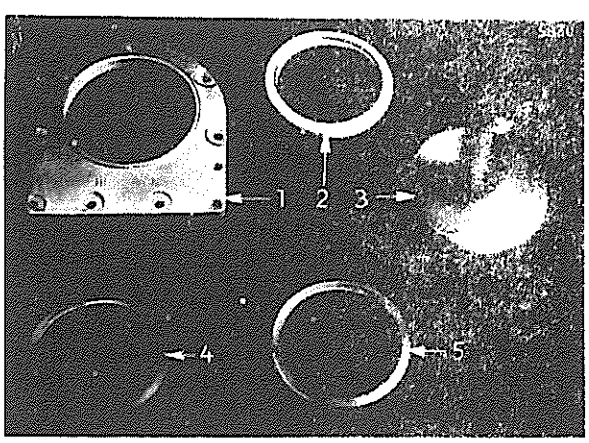


Illust. 93
Oil Seal Installed in Seal Retainer

A – First location
B – Second location
C – Third location

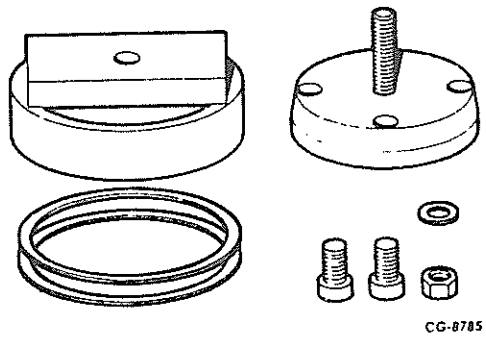
1 = 1.5 mm (.059 inch)
2 = 0-0.1 mm (0-.004 inch)
3 = 1.5 mm (.059 inch)

Section "A" Illust. 93 shows the normal position of the oil seal when installed. In section "B" the oil seal is offset to the front by approx. 1.5 mm (.059"). The oil seal can again be offset by 1.5 mm (.059") as shown in section "C". Special tool for offset installation is shown in Illust. 94 or PLT 511-1 as set with 1.5 mm.



Illust. 94

1 – Oil seal retainer
2 – Oil seal
3 – Installing tool
4 – Spacer ring for offsetting, section "B"
5 – Spacer ring for offsetting, section "C"



Illust. 94a
PLT 511-1 Rear Oil Seal Installing Tool

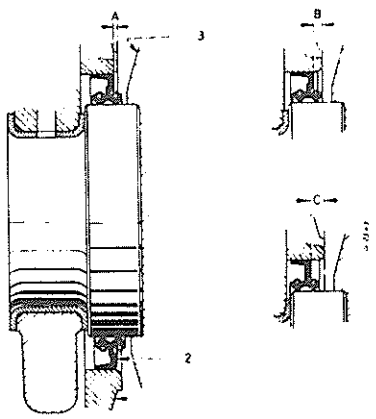
If the sealing face (1) Illust. 90 is undamaged use either special tool to install the oil seal. To offset the oil seal as shown in section "B" Illust. 93 place the thinner ring (4) Illust. 94 on the tool and press the oil seal in. For offsetting as shown in section "C" place the thicker or both ring(s) (5) on the tool (3) and press the oil seal in.

NOTE: When offsetting always use a new seal.

Install the seal with its open side toward the engine.

Keep the outer case of the seal dry when the seal is pressed in.

When in place the seal must be at right angles to the crankshaft otherwise oil leakage may develop.



Illust. 95
Oil Seal Installed in Flywheel Housing

A – First location = 1.5 mm (.059 in.)
B – Second location = 3.5 mm (.138 in.)
C – Third location = 5.5 mm (.217 in.)

1 – Flywheel housing present design
2 – Double lip oil seal, outer DIA 140 mm (5.512 in.)
3 – Flywheel

Either service tool can be used to install rear oil seal in an engine equipped with a flywheel housing.

When renewing the double lip oil seal be certain its main lip is toward the engine, i. e. the dust lip must be installed toward the flywheel.

For installation and offsetting the oil seal (2) Illust. 95 use the respective tool and spacer rings available for this purpose.

Install the seal with its open side toward the engine.

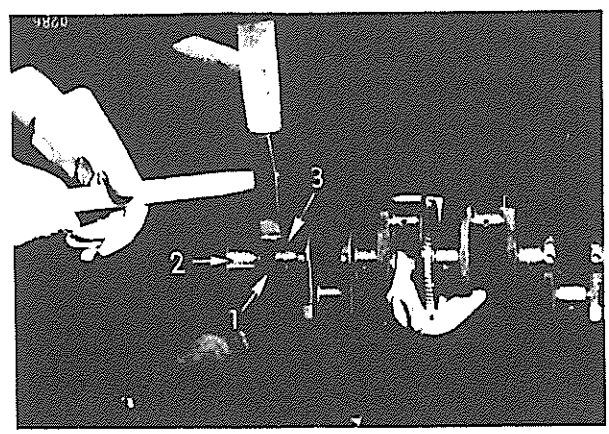
Keep the outer case of the seal dry when the seal is pressed in.

NOTE: Current engines equipped with a flywheel housing use a 130 mm (5.12") DIA single lip oil seal. Follow dimensions for offsetting the oil seal shown in Illust. 93.

Crankshaft Pinion

Check crankshaft pinion for wear and chipping. If damaged replace the pinion as follows:

Remove spacer ring (12) Illust. 85 and O-ring (11) from crankshaft front end.

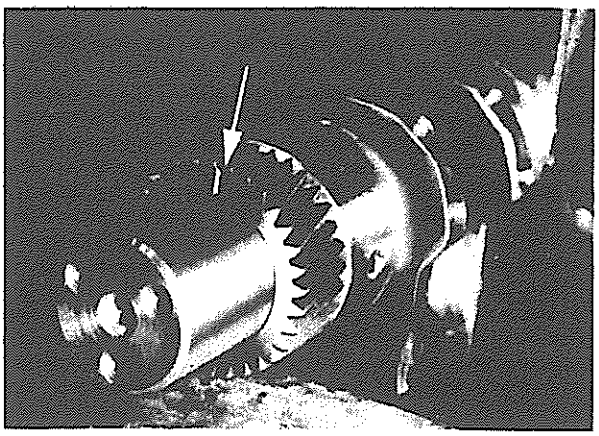


Illust. 96

1 – Crankshaft pinion
2 – Finished surface
3 – Main bearing journal

Place the crankshaft pinion on an anvil and hold it in position, Illust. 96. The bearing journal (3) must not touch the anvil edge.

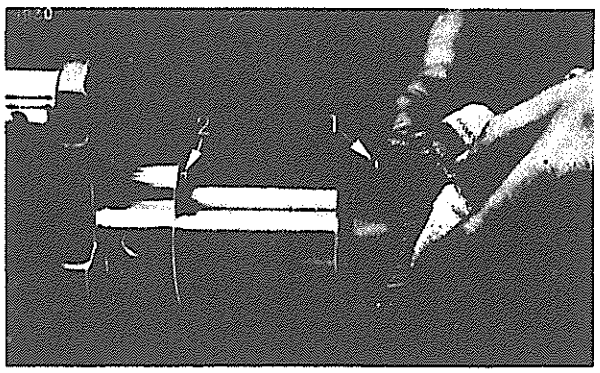
Slide a metal sleeve over the finished surface (2) to protect it from damage. Wrap a rag around the chisel to catch any possible chippings.



Illust. 97

Split the pinion with a few firm hammer blows at its weakest point, i.e., at the timing slot, see arrow Illust. 97.

Caution: Beware of chippings! Use protective gloves and safety goggles.



Illust. 98

1 – Timing slot
2 – Roll pin

Smooth the pinion seat before installing the new pinion. Heat replacement pinion to approx. 200° C = 400° F.

Use thermomelt stick FES 115-2 to determine gear temperature. Do not overheat!

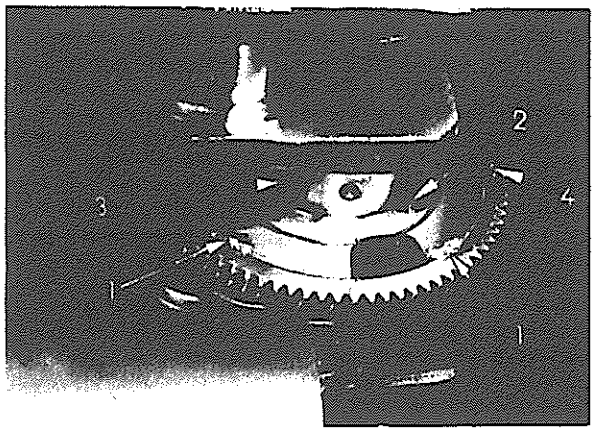
Slide the pinion on the shaft with the chamfered side towards the bearing journal and make sure that roll pin (2) engages in timing slot (1) Illust. 98.

Balancer Drive Gear (Welded)

Check the balancer drive gear for wear and replace with a new one, if necessary.

Grind off welded joint (1) Illust. 99 and drive the gear from the crankshaft.

Remove all traces of the broken or damaged drive gear.



Illust. 99

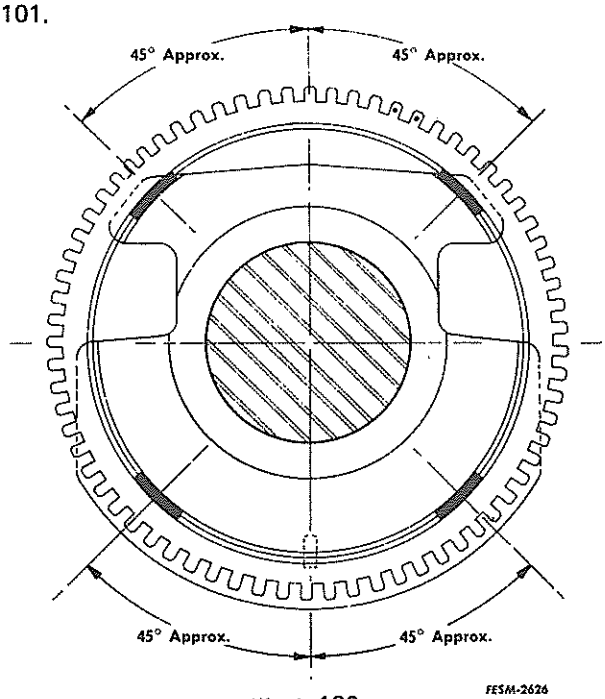
1 – Welded joint
2 – Thrust face
3 – Bearing journal
4 – Meshing marks

Deburr and remove nicks and scratches from the mating surfaces of the crankshaft and balancer drive gear.

Install a new roll pin the crankshaft and slip the drive gear on the crankshaft with the two marked teeth to the flywheel side.

NOTE: On later production engines the gear must be heated before installation. See "Specifications". Use a suitable thermomelt stick to determine specified shrinking temperatures.

Weld the gear in four places as shown in Illust. 100 or 101.



Illust. 100
Installing Diagram for Balancer Drive Gear on Early Production Engines (D-206)

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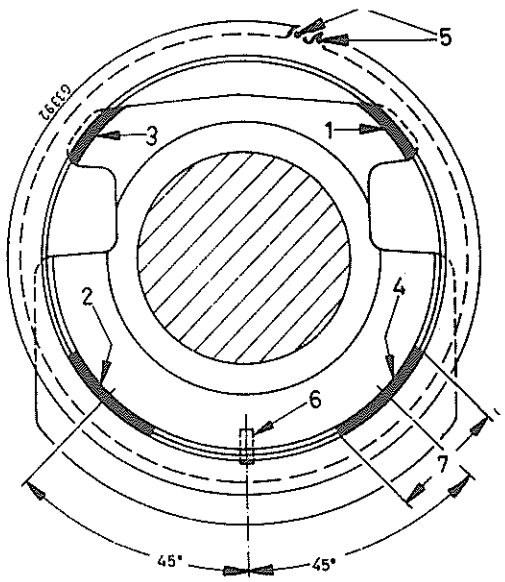
The weld must not project above the finished bearing thrust surface of crankshaft. Weld 4 places 20 mm = 3/4" wide.

Use low hydrogen electrodes to prevent under weld cracking.

While welding, protect journals against damage caused by molten electrode particles.

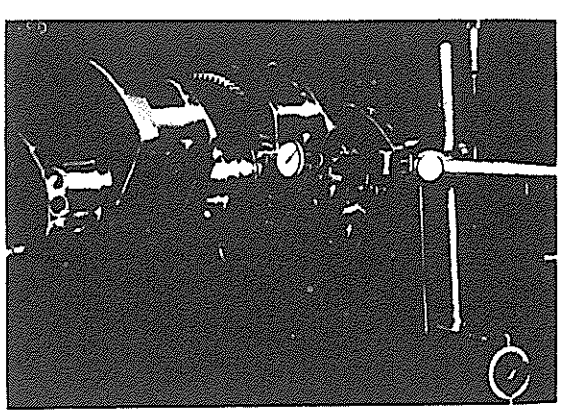
On later production engines replace the balancer drive gear as described above.

However, weld the gear as shown in Illust. 101.



Illust. 101

1+3 – Welded joints over full contact length on both sides of gear.
2+4 – Welded joints
5 – Marked teeth on flywheel side
6 – Roll pin
7 – 45 mm = 1-3/4"



Illust. 102

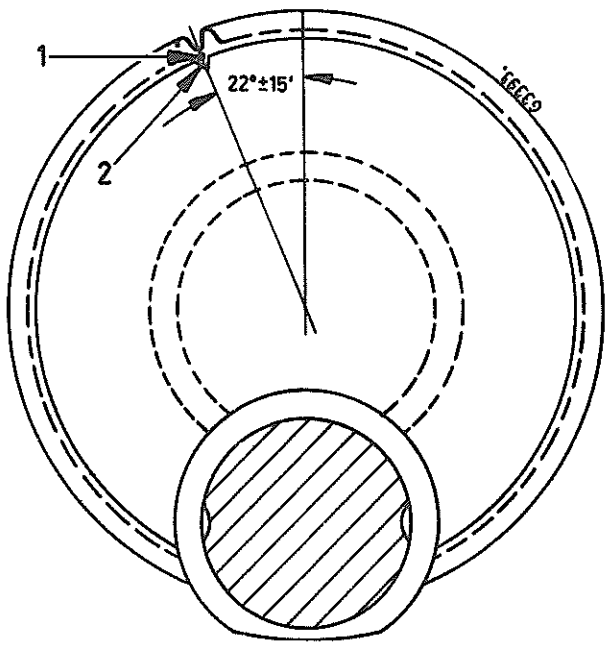
After Welding:

1. Check the balancer drive gear for run-out and out-of-true, Illust. 102. See "Specifications".

2. Rebalance crankshaft. See "Specifications".

NOTE: Drill balancing holes in web areas provided for this purpose. Observe dia. depth and spacing of the existing balancing holes.

Balancer Drive Gear (shrink-fit)



Illust. 103

1 – Mark on tooth
2 – Notch on crankshaft

The balancer drive gear, Illust. 103 is a shrink-fit on the crankshaft.

Before removing a worn gear be certain the crankshaft is marked with notch (2) Illust. 103. If there is no notch (2) on the crankshaft flange, mark the crankshaft in a suitable way.

When replacing the gear, it must be split similary as the crankshaft pinion is split, see Illust. 96.

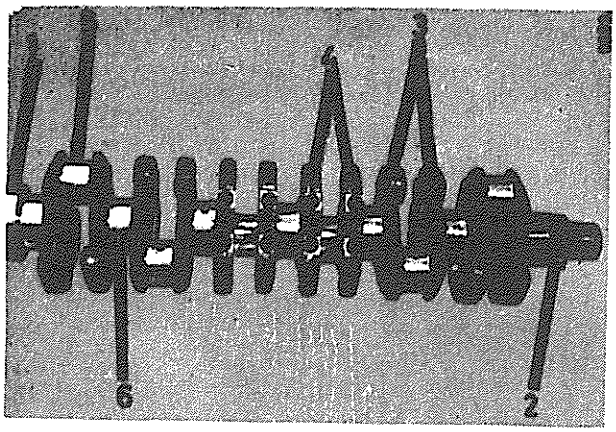
Deburr and remove nicks and scratches from the mating surfaces of the crankshaft and balancer drive gear.

Heat the drive gear (see Specifications). Use thermomelt stick FES 115-1 to determine gear temperature. Align the single mark (1) with the notch (2), on the crankshaft flange (Illust. 103).

Do not weld the shrink-fit gear.

After installation check for run-out, Illust. 102.

Balance Weights (6-cyl. only)



Illust. 104

1 – Sealing face
2 – Crankshaft pinion
3 – Balance weight
4 – Balance weight bolts
5 – Crankpin
6 – Main bearing journal

Check balance weight bolts (4) Illust. 104 for proper torque load. Retighten, if necessary.

NOTE: Service tool 04-575 socket adapter is to be used for servicing balance weight retaining bolts.

IMPORTANT

Bolts (4) may not be loosened as a change in position of the screws would disturb the crankshaft balance.

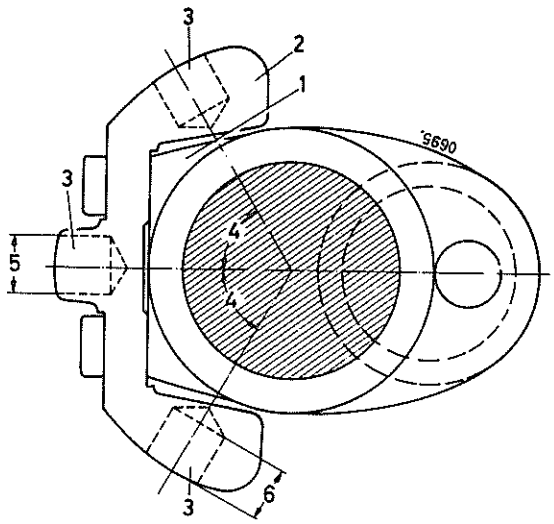
If, for some reason or other, balance weights have to be removed this should be done only if a proper balancing machine is available to rebalance the crankshaft.

Proceed as follows:

Balance weights Illust. 105 are numbered consecutively from 1–12, beginning at the front end, corresponding to crankshaft webs. This order may not be altered.

The two mounting holes are drilled slightly off-center. When mounting the weight make sure that its protruding flank is on the crankpin side. Balance weights must be at right angles to the crankshaft center line. Contact faces of balance weights and crankshaft webs must be absolutely clean, dry, level and free from burrs.

Tighten balance weight bolts in two steps to specified torque, see "Special Nut and Bolt Torque Data". Rebalance crankshaft, see "Specifications" and Illust. 105.



Illust. 105

1 – Crankshaft web
2 – Balance weight
3 – Balance bores
4 – 60°
5 – 19 mm = .75
6 – 20.0 mm = .79" (D-310)
25.0 mm = .98" (D-358, DT-358, DT-402)

Figures (5) and (6) Illust. 105 represent the permissible maximum dimensions and positions of the balancing holes. Observe details (Illust. 105) whenever holes must be drilled.

Reassembly and Installation

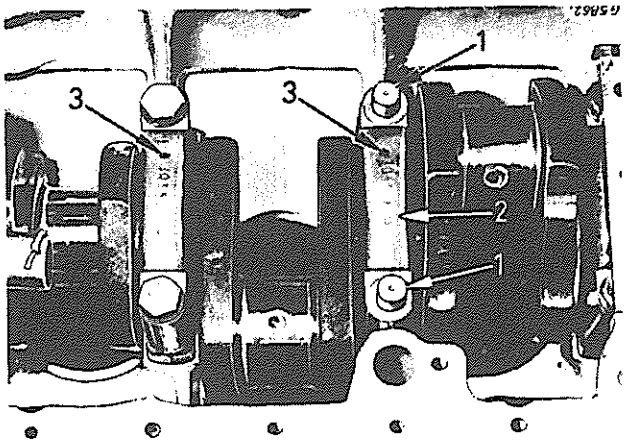
NOTE: When installing new main bearing caps refer to instructions furnished with the caps for assembly procedure.

Place upper bearing insert halves (free of oil) in the crankcase.

Be certain the inserts are fully seated, oil holes are in line and locking tangs on the inserts fit into recesses.

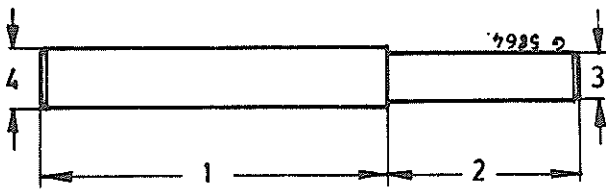
Spread a film of SAE 30 engine oil on the bearing inserts and place the crankshaft in the crankcase bearings.

Bearing caps (2) Illust. 106 are numbered from front to rear with consecutive numbers. Be certain to install the caps in their correct positions with the cast dimples (3) pointing to the injection pump side of the engine.



Illust. 106

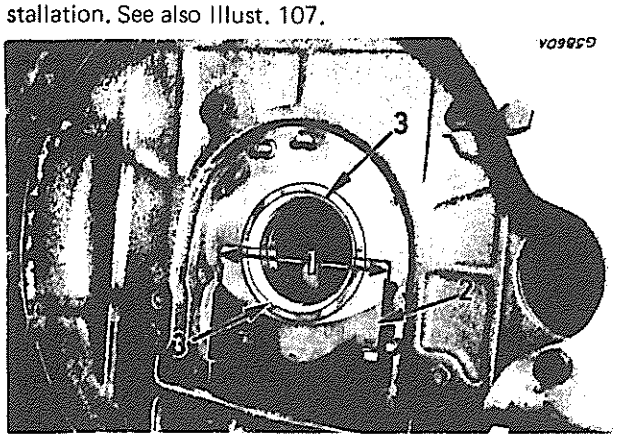
1 – Guide pins (for alignment)
2 – Main bearing cap (lateral alignment)
3 – Cast dimples (on injection pump side)



Illust. 107
Guide pin (two required)

1 – 125 mm = 4.92 "
2 – 55 mm = 2.17 "
3 – 12.2 mm = .480"
4 – 14.9 mm = .587"

Whenever installing main bearing caps without dowel bushings use guide pins (1) Illust. 106 to facilitate installation. See also Illust. 107.

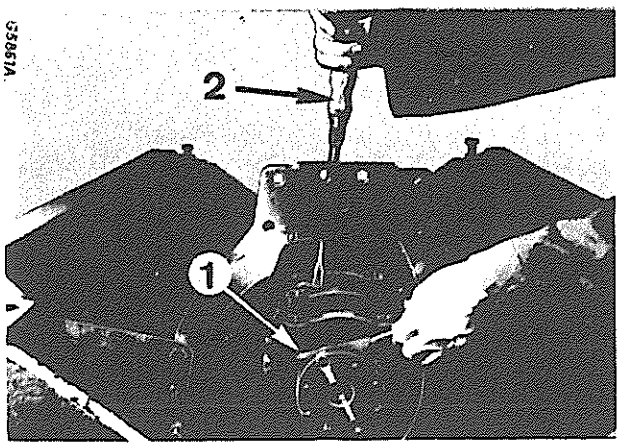


Illust. 108
Main thrust bearing (shown without crankshaft to permit unobstructed view)

1 – Lateral alignment faces in crankcase
2 – Bearing cap (without dowel bushings)
3 – Thrust bearing flanges

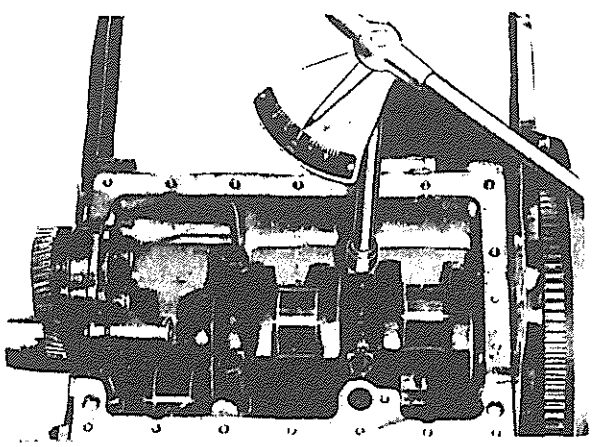
When installing the main thrust bearing cap (without dowel bushings) be certain the thrust flanges (3) Illust. 108 of the upper and lower bearing insert are absolutely in line.

Check thrust flange alignment with feeler gauge (1) Illust. 109 on top and bottom.



Illust. 109
Checking thrust flange alignment

1 – Feeler gauge
2 – Screwdriver or lever



Illust. 110
Torquing main bearing bolts

Torque main bearing bolts in three steps. Refer to "Special nut and bolt torque data", see Illust. 110.

When torquing main bearing bolts, observe the following sequence:

3-2-4-1	(3-cylinder engines)
3-4-2-5-1	(4-cylinder engines)
4-5-3-6-2-7-1	(6-cylinder engines)

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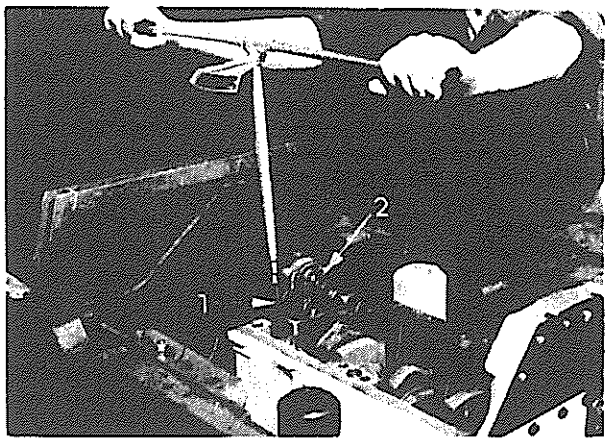


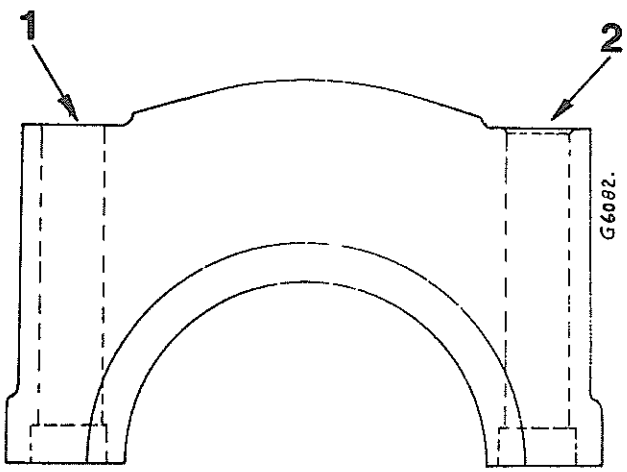
Illust. 110a

1 — Special wrench
2 — Oil pump

The oil pump is mounted on bearing cap number 1. These two parts can be installed as a unit. A special wrench (1) Illust. 110a is required to tighten the RH main bearing cap screw. After main bearing cap screws are tightened, the crankshaft must rotate freely when turned by hand.

Take care, that main bearing bolts of the same material designation are used.

NOTE 1:
Pitch diameter bolts and correspondingly higher torque values may be used in place of necked-down bolts, provided the bearing caps are chamfered to clear the radius on the underside of the bolt head. See (2) Illust. 111.



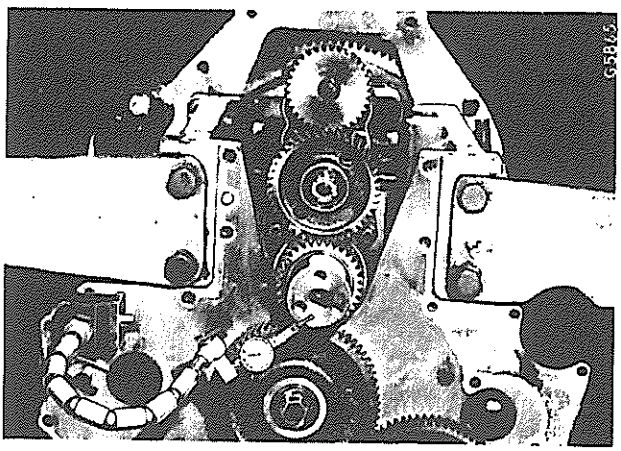
Illust. 111
Main Bearing Cap

1 — Square corner
2 — Reworked cap with chamfered corner
0.8 — 1.2 mm x 45° (.03 — .05" x 45°)

NOTE 2:
Whenever a reground crankshaft is installed, be sure running clearance of the journals is within "Specifications". Proceed as follows:

Remove the center main bearing cap and the lower bearing, and insert a suitable length of 0.20 mm (.008") virgin lead wire across the bearing surface of the lower bearing and the crankshaft journal. Install the bearing cap and tighten the cap bolts to specified torque.

Do not turn the crankshaft while the wire is in place. Remove the bearing cap, and carefully remove the wire, which will have been crushed to the amount of clearance present. Measure the wire, using a micrometer. The clearance desired is given in "Specifications".

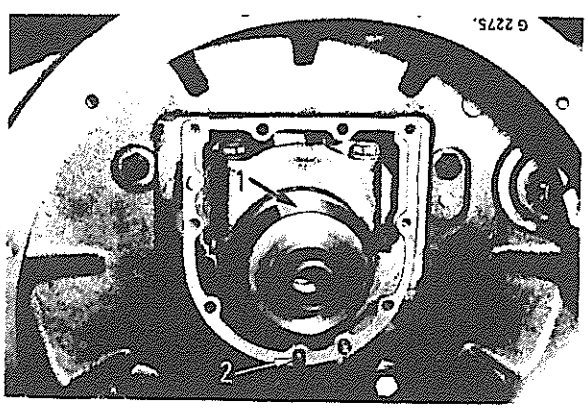


Illust. 112
Checking Crankshaft End Play

Check end play of crankshaft. See "Specifications", and Illust. 112.

Installing Rear Oil Seal

a. Seal must be clean and lubricated as follows:



Illust. 113

1 — Seal jumper
2 — Stud

Single Lip-Coat lip with clean engine oil.

Double Lip-Fill cavity between lips approx. 2/3 with "Molykote BR2" or "Shell Alvania 3".

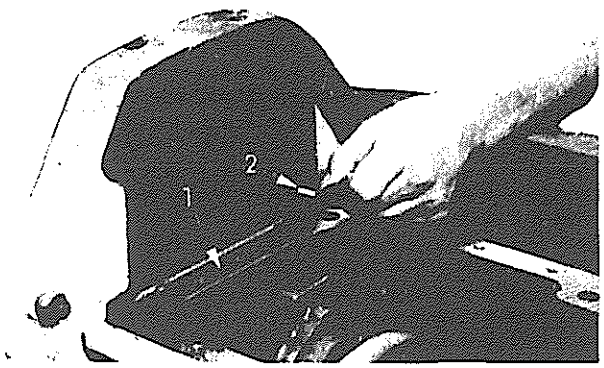
b. Apply some engine oil onto crankshaft sealing face.

Install stud (2) Illust. 113 using liquid sealer. Install the rear oil seal retainer with new gasket. Take care not to damage the oil seal.

Use seal jumper (1) for protection.

NOTE: Seal jumper (1) must be made locally as follows:

Cone angle of the jumper 130 – 150°. The smaller taper diameter must be 5.50 mm = .217" less than the seal lip diameter. The taper face must be polished.

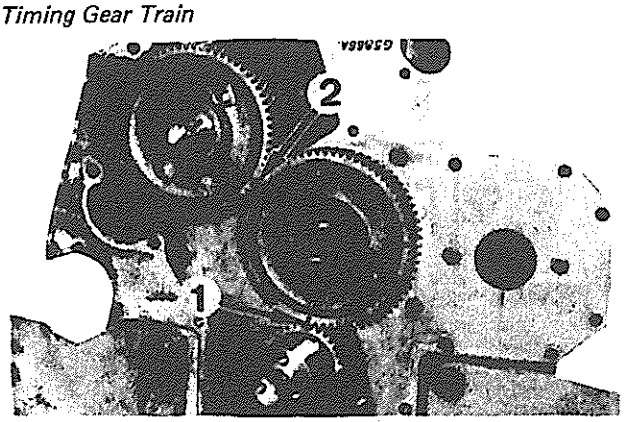


Illust. 114

1 – Sealing bar
2 – Seal strip

Replace sealing bar (1) Illust. 114 and insert the two seal strips (2), using liquid sealer. The sealing bar must be exactly in line with the adjacent crankcase flange. Check with a straight edge before tightening cap screws and re-align, if necessary.

Timing Gear Train



Illust. 115
Timing Gear Train Adjustment

1 – Single punch marks
2 – Double punch marks

When meshing timing gears be sure single punch marks (1) Illust. 115 are in line. Double punch marks (2) line-up with the camshaft gear.

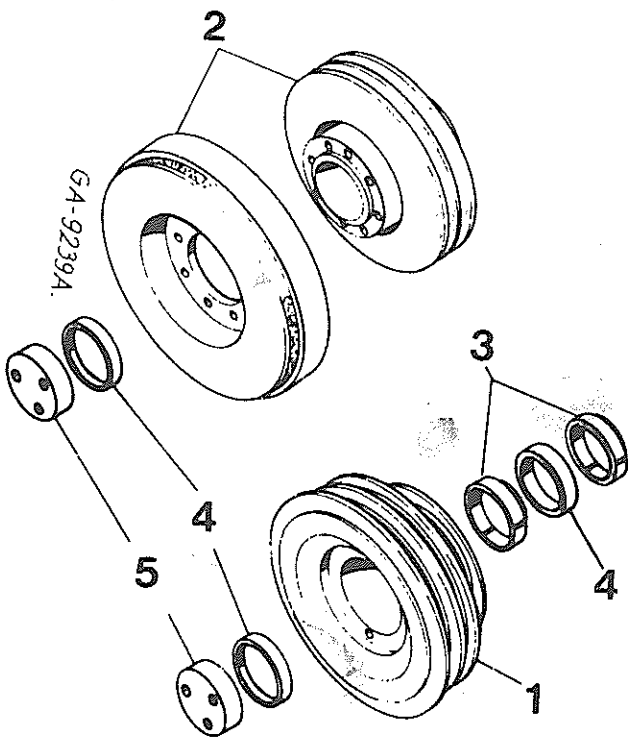
CRANKSHAFT PULLEY/VIBRATION DAMPER

General

The crankshaft pulley acts as a vibration damper.

On DT-358 and DT-402 engines an additional vibration damper, version (2) Illust. 116 is installed.

NOTE: Vibration damper and pulley (2) are balanced as one unit. Therefore, it is not recommended to separate them; otherwise the unit has to be rebalanced to a maximum residual imbalance of 20 cmg (0.275 oz-inch) after reassembly.



Illust. 116

1 – Crankshaft pulley
2 – Crankshaft pulley with vibration damper
3 – Wedge rings
4 – Thrust rings
5 – Retainer plate

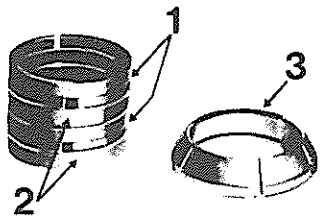
The pulleys are fastened either with wedge rims, Illust. 118 or with clamping ring, Illust. 119.

Removal

a) Remove the cap screws, retainer plate and thrust ring.

b) Tap the pulley with a hammer to loosen it and it will slide off the wedge rings.

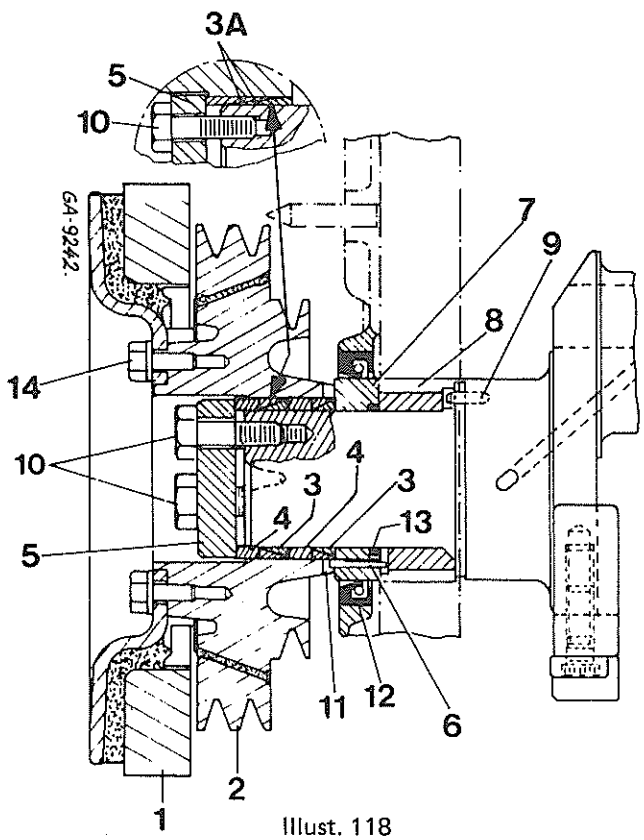
G 5801.



Illust. 117

1 — Pair of wedge type rings
2 — Thrust rings
3 — Clamping ring, see (2) Illust. 121

NOTE: It should not be necessary to use a puller to remove the crankshaft front pulley.



Illust. 118
Crankshaft Pulley, Fastened with Wedge Rings

1 — Vibration damper
2 — Pulley
3 or 3A — Wedge rings
4 — Thrust rings
5 — Retainer plate
6 — Dowel pin
7 — Spacer ring
8 — Crankshaft pinion
9 — Roll pin
10 — Bolts
11 — Timing slot
12 — Oil seal
13 — O-ring
14 — Bolts

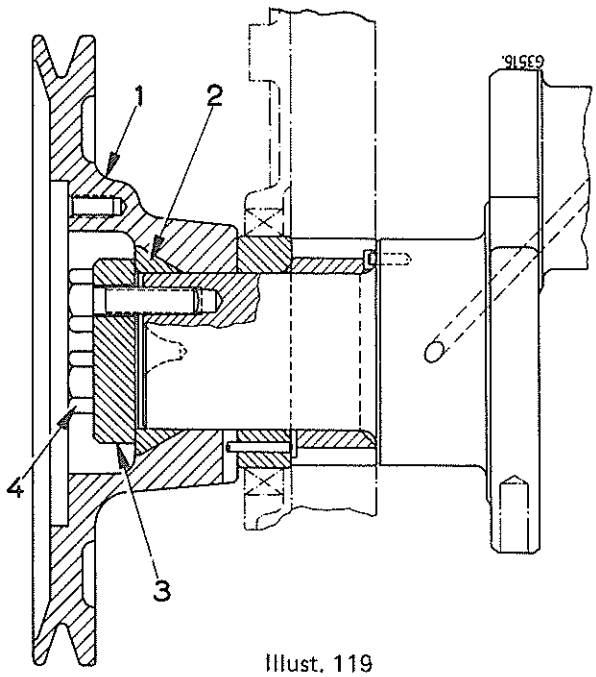
Cleaning, Inspection and Repair

Thoroughly clean all parts. Inspect pulley for cracks, wear, burrs on the belt grooves and damage to the bore. Since a repair is unpracticable, a damaged pulley must be replaced with a new one.

Inspect wedge rings for cracks and rust and replace as necessary.

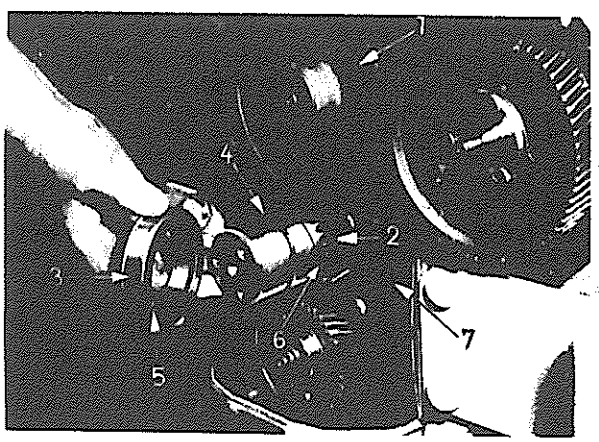
Reassembly and Installation

Reassemble all parts as shown in Illust. 118 or 119.



Illust. 119
V-belt Pulley, Fastened with Clamping Ring

1 — V-belt pulley
2 — Clamping ring
3 — Retainer plate
4 — Retainer bolts



Illust. 120

1 — Idler gear
2 — Crankshaft pinion
3 — Spacer ring
4 — O-ring
5 — Groove pin
6 — Timing slot
7 — Gasket

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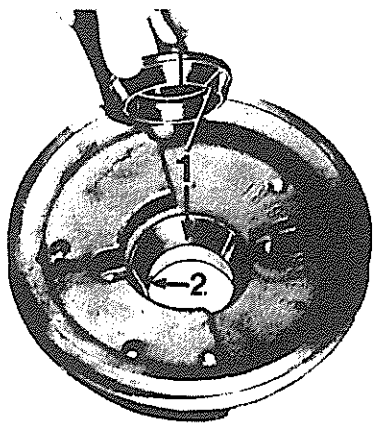
Slide spacer ring (3) with O-ring (4) in the crankshaft, Illust. 120. The chamfered side of the spacer ring must face the O-ring. The protruding groove pin (5) must engage in the timing slot (6).

Be sure that wedge rings (3) Illust. 118 as well as the pulley bore are completely clean and dry, i. e., free from oil and grease. First slide one inner wedge ring (3) on the crankshaft front end.

Insert the outer wedge rings and one thrust ring (4) into the belt pulley bore.

Slide the belt pulley on the crankshaft front end, engaging timing slot (11) over dowel pin (6). Fit the remaining inner wedge ring. Slots of wedge ring should be evenly distributed over the entire circumference.

G 5795.



Illust. 121

1 – Contact face
2 – Timing slot

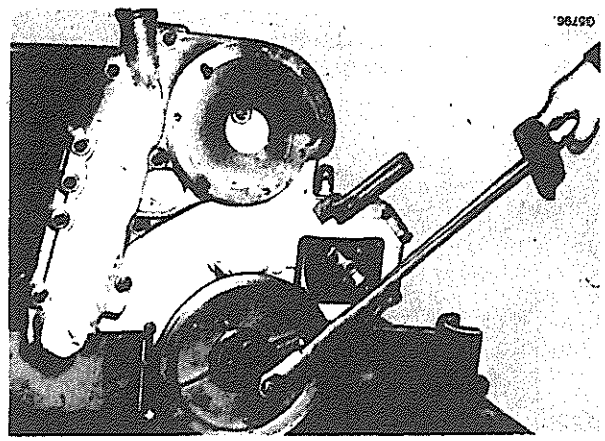
Insert outer thrust ring (4). Replace retainer plate (5) and secure with oiled retainer bolts (14).

To obtain necessary static friction all contact faces (1) Illust. 121 of clamping ring and crankshaft front end must be free of oil, rust and dirt.

Be sure that spacer ring dowel pin engages timing slot.

Oil and tighten retainer bolts in three steps as specified in "Special Nut and Bolt Torque Data".

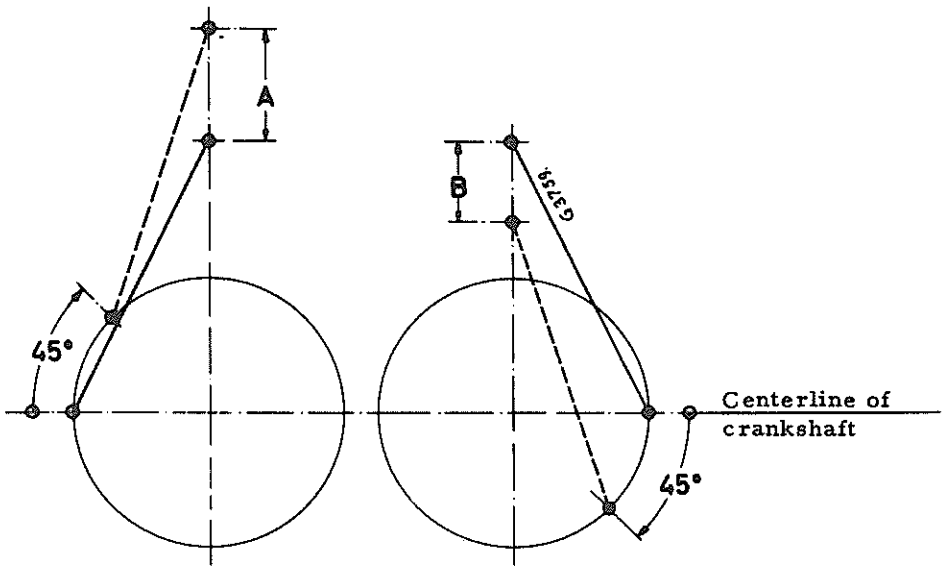
Replace and tighten V-belt.



Illust. 122

General

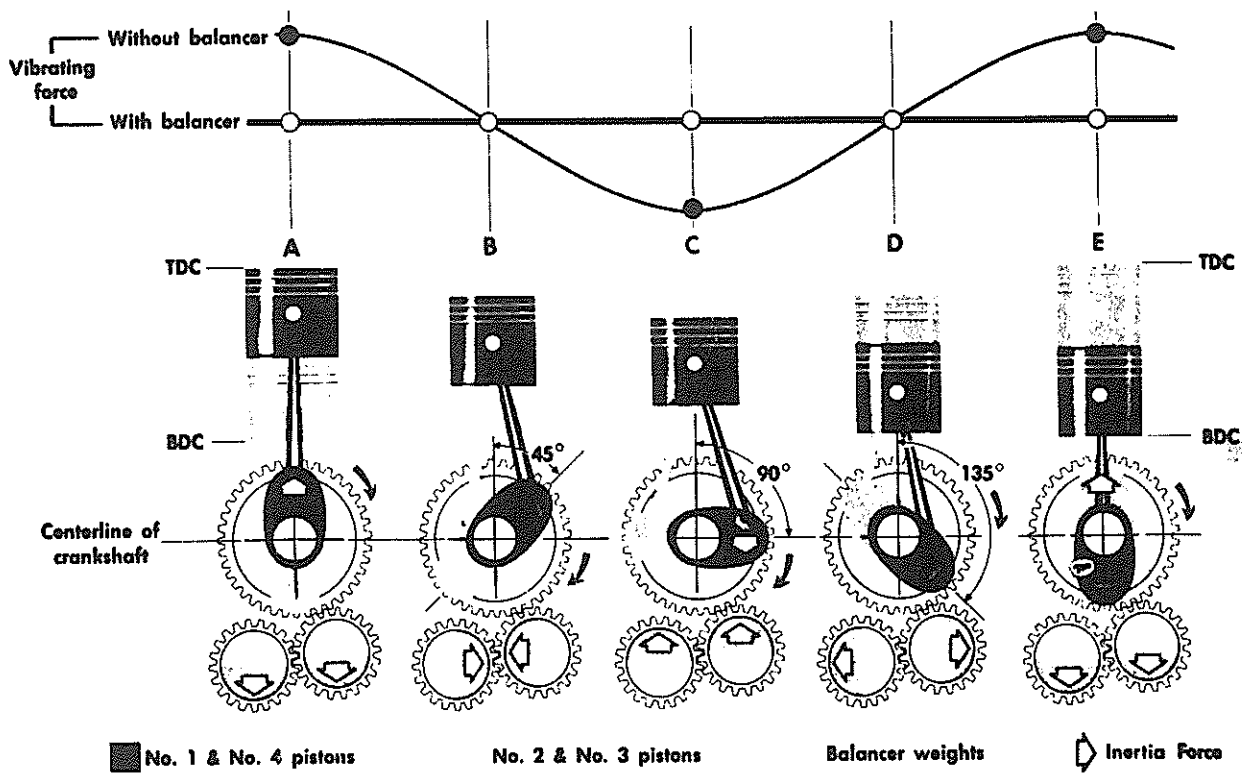
The function of the balancer is to reduce engine vibrations. Engine vibrations result from pistons travelling faster and having higher accelerations during the upper half of their stroke than they do during the lower half of the stroke. See Illusts. 123 and 124.



A = Increased piston travel in the upper half of the stroke

Illust. 123
Diagram of piston travel in relation to stroke

B = Reduced piston travel in the lower half of the stroke



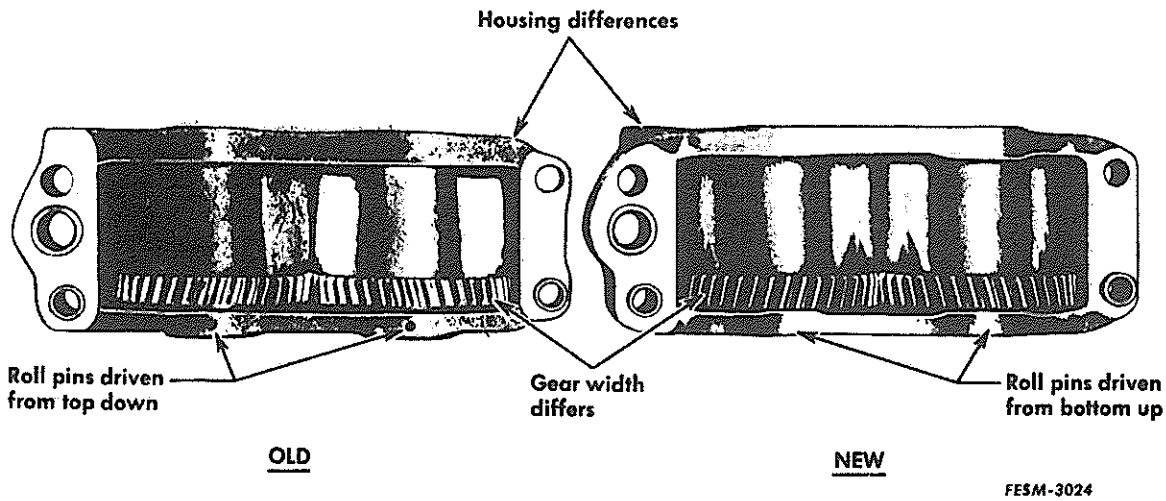
Illust. 124
Engine balancer operation

The engine balancer is mounted to the underside of the engine. Lubrication is provided by a drilled oil passage in the crankcase from the engine main oil gallery that lines up with a passage in the balancer when it is installed.

The balancer consists of two eccentric weights located below the crankshaft in the exact center of the engine. The weights are driven by a ring gear, which is shrunk on to the crankshaft.

The ring gear drives the weights in opposite directions at twice crankshaft speed because the vertical shaking forces occur at twice engine speed. The balancer gears are matched and timed to each other (Illust. 129) by means of timing marks stamped on the gears. They are also timed to the engine by means of a marked tooth on the balancer drive gear which is indexed between two marked teeth on the ring gear.

Important: The engine balancer has been changed to accommodate the higher rpm for use in other applications. The balancer weights and balancer housing have been made heavier (Illust. 125). The crankshaft gear which drives the balancer has been made wider and has a full back-up surface on the crankshaft. The crankshaft gears and balancers must be serviced with the same design parts as originally equipped unless all parts are changed.



Illust. 125
Balancer comparison

Specifications

Weight shaft bushing I.D.	23.069 mm / 23.097 mm	= .9082" / .9094"
Shaft diameter at bearing surface area	22.989 mm / 23.000 mm	= .9051" / .9055"
Weight assembly running clearance on shaft	0.069 mm / 0.108 mm	= .0027" / .0042"
Weight assembly end clearance in housing	0.20 mm / 0.40 mm	= .008 " / .016"

Balancer weight shaft bore in housing

Roll pin side of housing	23.58 mm / 23.60 mm	= .9283" / .9292"
Opposite side of roll pin	23.00 mm / 22.98 mm	= .9055" / .9047"
Backlash - between crankshaft ring gear and driving weight gear	0.25-0.40 mm = .01-.016"	
on D-268	0.23-0.50 mm = .009-.020"	
Backlash - between mating weight gears	0.18-0.23 mm = .007-.009"	

Removal and Disassembly

Drain the engine lubricating oil. Remove the oil pan, and oil level gauge.

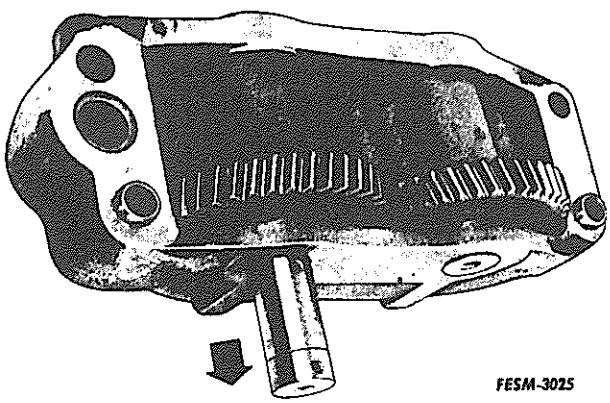
Remove the two cap screws holding the oil suction tube in place and remove the oil suction tube assembly and O-ring.

Locate No. 2 piston at top dead center. Check to see that the marked teeth on the crankshaft gear and the balancer drive gear are aligned. Also, check to see that the timing marks on the balancer idler gear and balancer drive gear line up. Also check the backlash between crankshaft ring gear and balancer before removing the balancer. See "Specifications".

Remove the two remaining cap screws holding the balancer in place and remove the balancer from the crankcase.

Wash assembly in clean solvent and blow dry with compressed air.

Check the backlash of the balancer gears to determine their condition before disassembly, Illust. 131.



Illust. 126
Weight shaft partially removed

Drive the roll pins out of the housing and into the shaft. (Refer to Illust. 130).

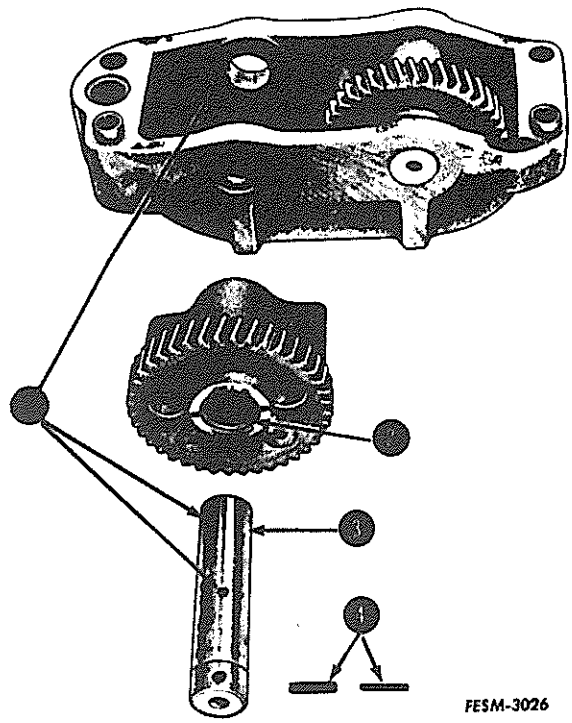
Press the shafts out of the housing and weights by pressing against the plug end (opposite the roll pin end).

Note: The diameter of the weight shaft is slightly larger on the pin end. Therefore the shafts can only be driven out of the housing towards this end.

Remove the weights from the housing and remove the pins from the shafts.

Inspection and Repair

Clean all parts thoroughly in solvent and blow dry with compressed air.



Illust. 127
Inspection points of a typical balancer.

1 — Oil passages
2 — Bushings
3 — Shaft
4 — Roll pins

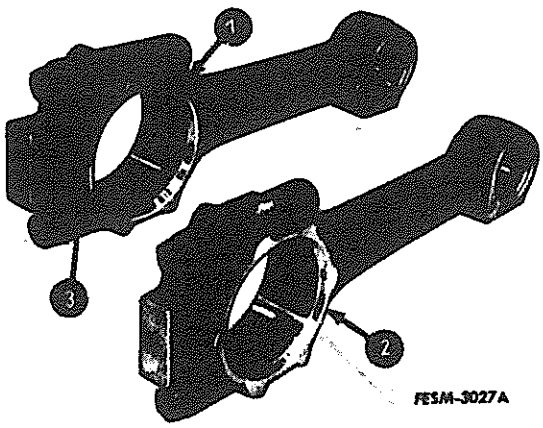
Check the bushings in the weights for wear (Illust. 127), refer to "Specifications" for bushing I.D. Replace the weight assembly as necessary.

Check the weight shaft bearing surfaces for signs of excessive wear. Clearance are given in "Specifications" in this supplement.

Check the weight shaft housing bores, shaft diameters and shaft fit in housing. Replace shaft or housing, whichever is necessary for proper fit. Refer to "Specifications".

Check and, if necessary, clean out the lubricating oil passages in the housing.

Inspect the gear teeth for chipping or other signs of excessive wear. Replace both weights as an assembly if necessary.



Illust. 128

1 – Present connecting rod (change on bearing cap) (D-239)
2 – Former connecting rod (D-239)
3 – Milled face

Where a new balancer assembly has replaced the old assembly, NEW connecting rod assemblies (Illust. 128) with manufactured clearances in the bearing caps must be installed. Refer to "Installation".

Note: Present connecting rods (with milled face (3)) are installed from 1973 and up.

Reassembly

When installing the balancer weights make sure that the single punch mark "B", Illust. 129, of the drive weight (1) is in line with the double punch mark "C" of the driven weight (2) and the timing mark "A" is on the top for all models except D-268.

NOTE: D-268 balancer assemblies have a single punch timing mark located at point "A" but a double punch mark at point "B". The driven weight has a single punch mark located at point "C".

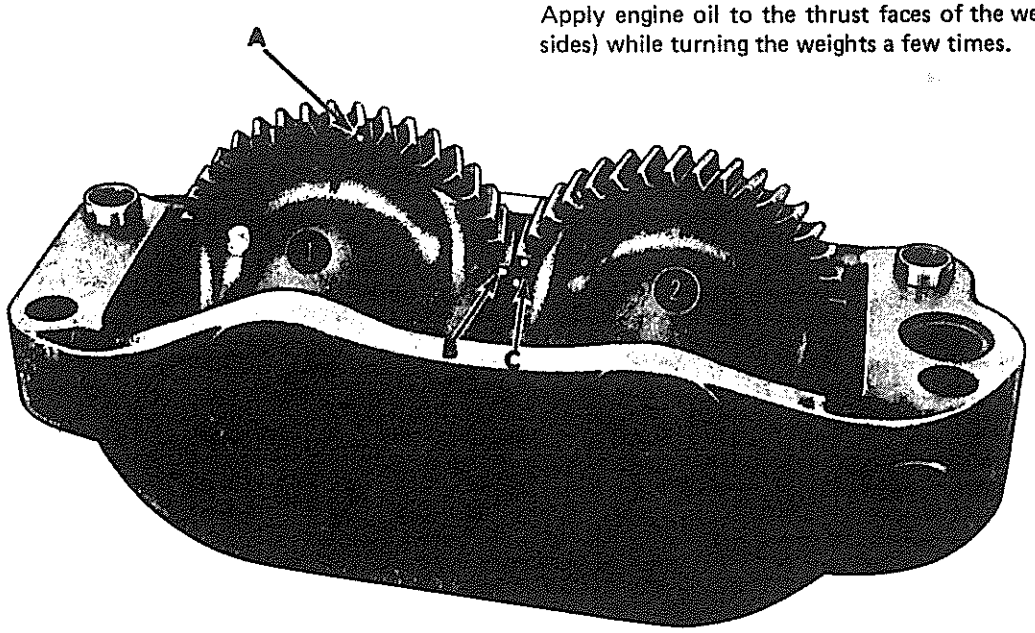
Apply lubricating oil to the weight shafts and the bushings in the weights.

Install the drive weight in the weight housing by driving the weight shaft (plug end first) into place with a brass hammer, taking care the roll pin bores of the shafts are in line with the pin bores of the housing.

Drive new double roll pins (one driven inside the other) into the housing and weight shafts as shown in Illust. 130. Note that the roll pin installation differs between housings.

Check the backlash of the balancer gears (Illust. 131) to determine their condition before installing the balancer. Refer to "Specifications".

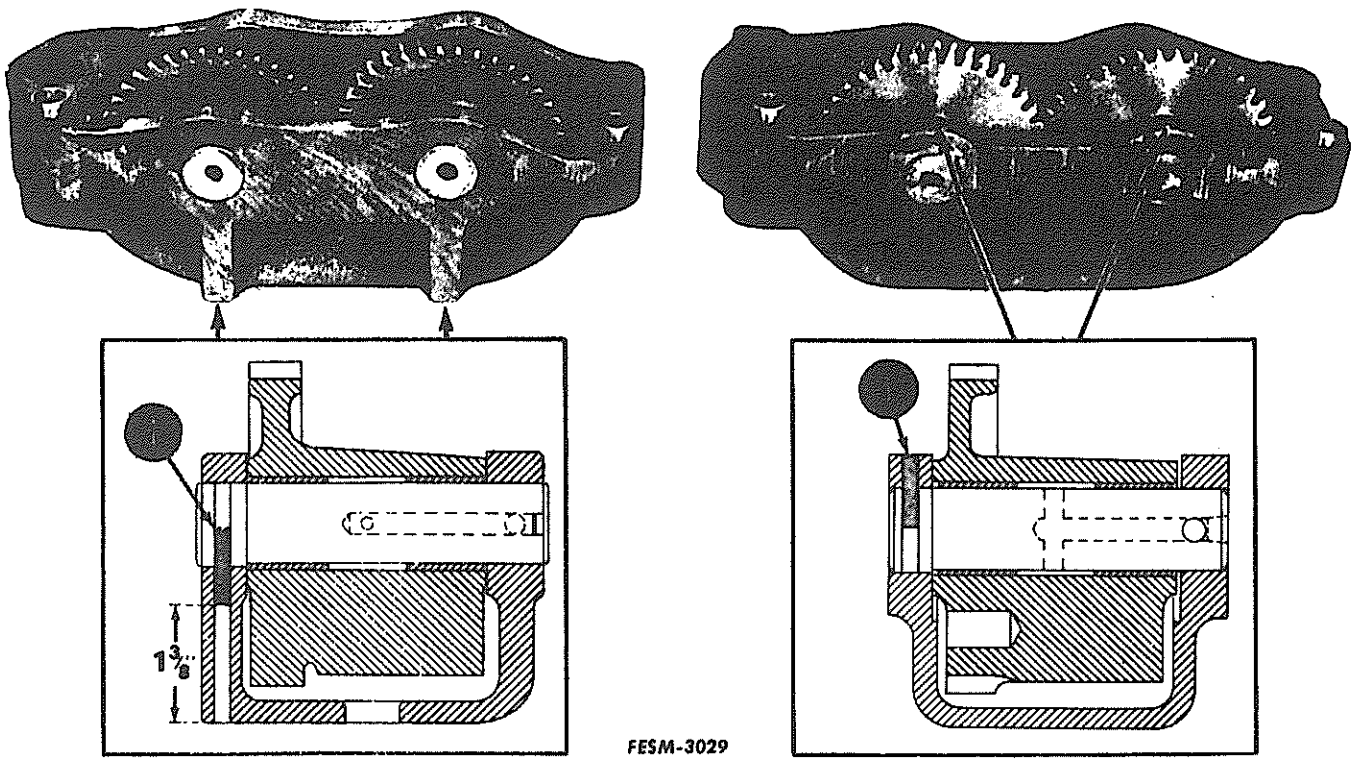
Apply engine oil to the thrust faces of the weight (both sides) while turning the weights a few times.



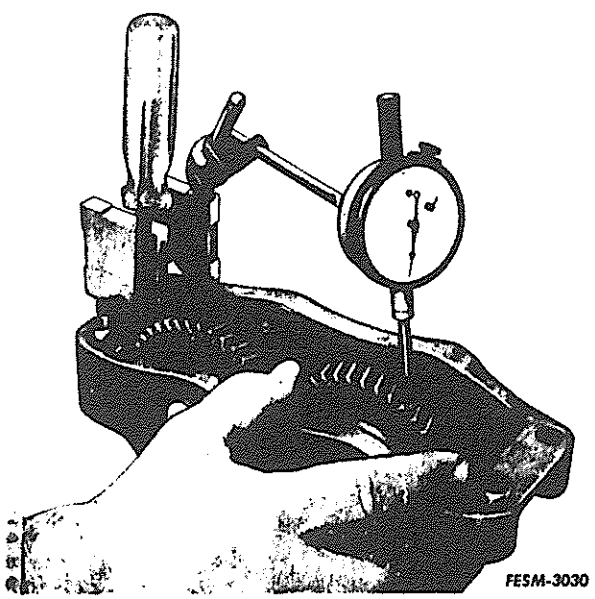
Illust. 129
Balance Weight Assembly Timing Marks on the Gears
For Models D-206, D-239, DT-239 and D-246

FESM-3028

1 – Drive weight
2 – Driven weight
A - B - C – Punch marks



Illust. 130
Location of installed roll pin (1)



Illust. 131
Checking backlash

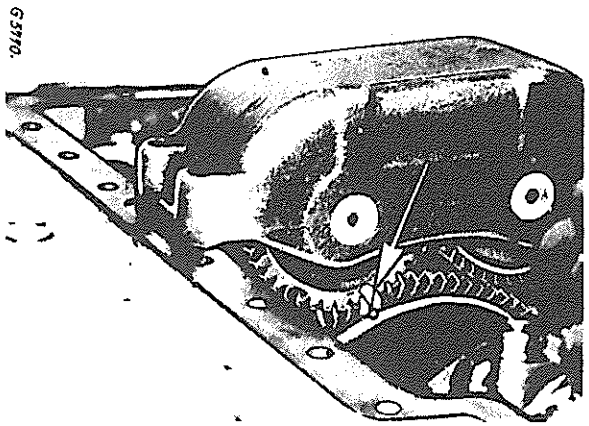
Installation

Position No. 2 piston at TDC.

Position a new O-ring ((4) Illust. 134) in the recessed seat on the mounting face of the balancer housing.

Install the balancer. Be certain punch mark "A" Illust. 129 matches with the punch marked teeth on the crankshaft ring gear.

Chalk markings (arrow Illust. 132) will facilitate proper balancer installation.

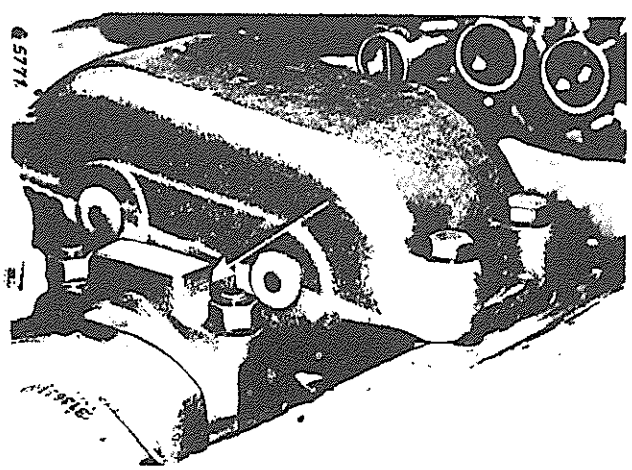


Illust. 132
Marked teeth in mesh

After balancer installation proceed as follows:

1. With the engine up-side down check the backlash between crankshaft ring gear and balancer drive gear. See "Specifications".

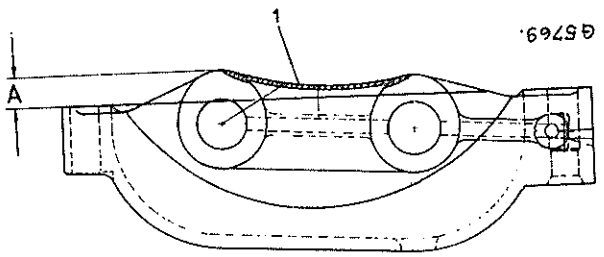
2. Turn the crankshaft and check for sufficient clearance between balancer housing and connecting rods, Illust. 132a.



Illust. 132a
Arrow – Check connecting rod clearance here

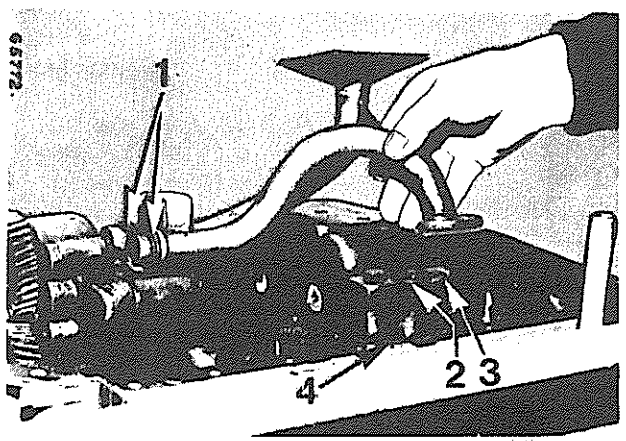
If connecting rod clearance is less than 2 mm (.078") remove and disassemble the balancer.

Rework the balancer housing on its central radius (1) Illust. 133 to obtain dimension "A".



Illust. 133
1 – Reworked radius
A – 13 mm = .50"

Note: Reworking of the balancer housing may become necessary when replacing connecting rods on D-239/246 engines.



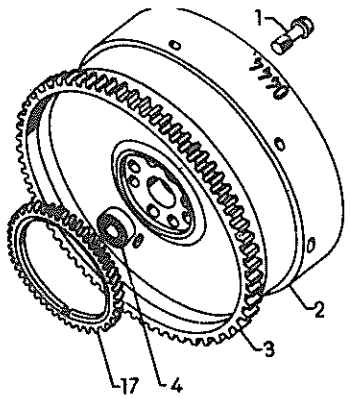
Illust. 134

1 – O-rings, pipe sealing
2+3 – O-rings, flange sealing
4 – O-ring, housing sealing

Finally install lub. manifold, Illust. 134.

Be certain all O-rings are properly seated.

FLYWHEEL WITH RING GEAR



Illust. 135

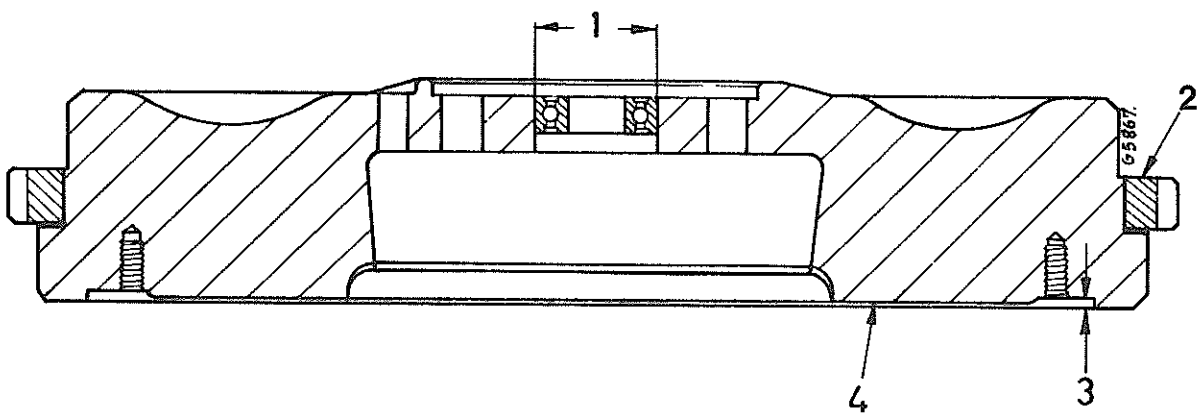
General

The flywheel (2) Illust. 135 is secured to the crankshaft with seven special bolts (1) of the pitch diameter type. A dowel pin in the crankshaft rear flange ensures correct location of the flywheel. The flywheel varies, depending on engine application, clutch or torque converter make. The ring gear is the same for all engine versions.

Tractor engines may be equipped with a single or a dual clutch. In PAY Loaders and Crawlers a torque converter is used instead of the regular clutch. Flywheels for combine engines are somewhat differently designed. Tractors have the clutch shaft supported in a prelubricated ball bearing (1) Illust. 141.

For repairs on torque converters see respective Service Manual.

Specifications



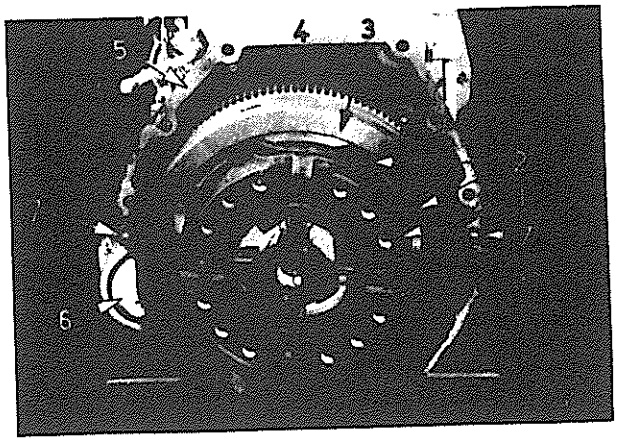
Illust. 136
Flywheel for 946/1046 tractor engines
with dual clutch

1 – $\frac{46.970\ mm}{46.986\ mm} = \frac{1.8492''}{1.8498''}$

2 – Ring gear (shrink-fit)
3 – Recess for dual clutch cover
4 – Friction surface

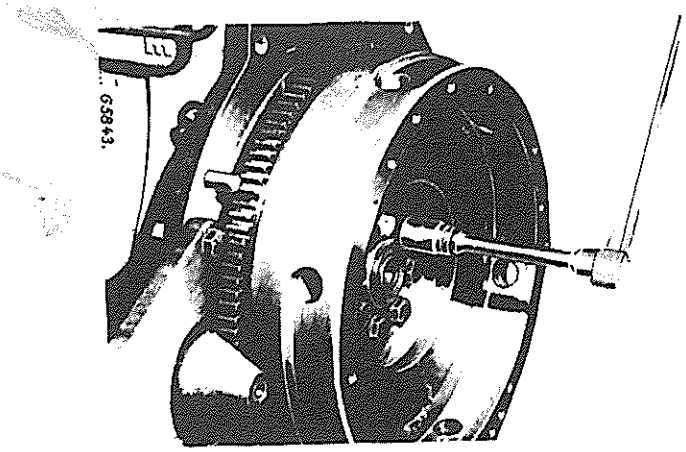
Removal and Disassembly

Remove clutch assembly or torque converter, Illust. 137.



Illust. 137
Flywheel for tractor engine with single clutch

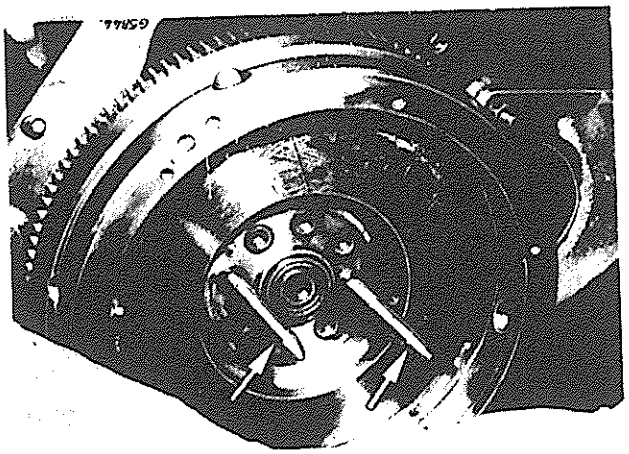
1 – Clutch assembly
2 – Clutch assembly retainer bolts
3 – Flywheel
4 – Flywheel ring gear
5 – Flywheel housing
6 – Starter pinion protective cap
7 – Clutch housing dowel pins



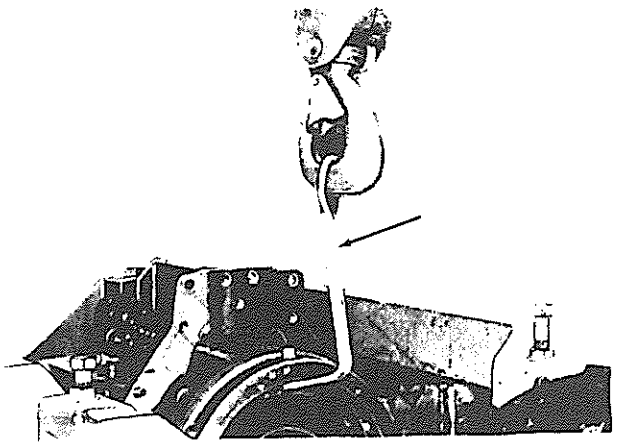
Illust. 138

Remove flywheel bolts, Illust. 138.

Support the flywheel before removing the last bolt.



Illust. 139
Guide pins in place



Illust. 140
Angular lifting hook

Tools as shown in Illust. 139 and 140 facilitate removal and installation of the flywheel. It is recommended to make them locally.

Cleaning, Inspection and Repair

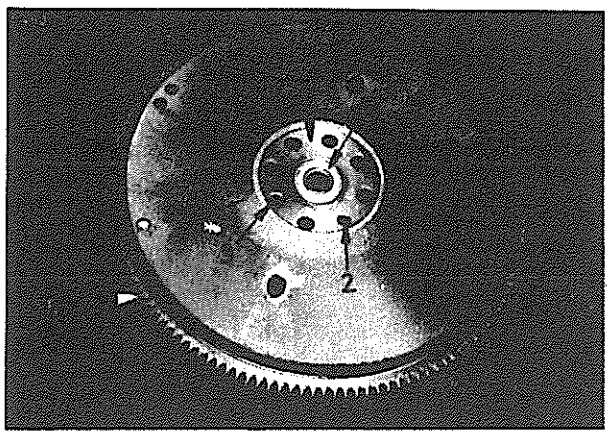
Clean the flywheel thoroughly and inspect the friction surface for ridges, scores, grooves, heat cracks, and burned spots.

If the friction surface is in bad condition, replace the flywheel with a new one.

If only slightly damaged, reface by surface grinding or trueing-up in a lathe and polish over with a fine grade of emery cloth.

Take care to remove only as much material as is necessary to true up the friction surface, otherwise clearance between flywheel bolts heads and clutch disk is reduced to a dangerous degree.

Care should be taken to rework the flywheel recess (3) Illust. 136 for the clutch cover by the same amount as the friction surface to maintain sufficient spring tension.



Illust. 141

1 — Ball bearing, prelubricated
2 — Dowel pin bore
3 — Bore for retainer bolt
4 — Seating face
5 — Flywheel ring gear

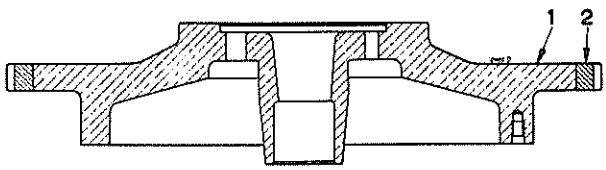
Caution: Be sure the flywheel is exactly centered when rotating it. The friction surface must be parallel with the seating face (4) Illust. 141. Deviations of more than 0.05 mm = .002" are not permissible.

Check condition of ball bearing (1) and replace, if necessary. Use a suitable drift punch for removal. Inspect bearing seat against specifications. Press in new bearing, making sure that it is flush with the seating face (4).

The ring gear (5) for the starter is a shrink-fit on the flywheel. Replace this gear if teeth are badly worn or chipped or if the gear has worked loose on its seat. Use a blunt cold chisel to remove the ring gear.

Check the seating face on flywheel for damage. Remove burrs etc., if necessary.

Heat the new ring gear to 200°–270°C = 400°–520°F, place on flywheel and allow to cool down. Be sure the ring gear is tight against the shoulder of the flywheel. The camfered sides of the teeth (clash sides) must be toward the crankshaft (starter side). Permissible out-of-true of ring gear = 0.3 mm (.02").



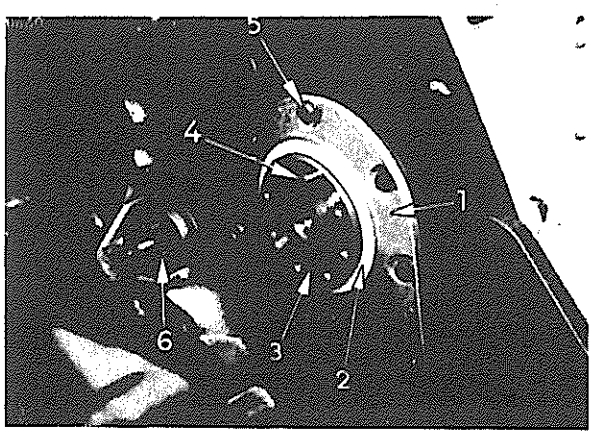
Illust. 142

1 — Surface, flush with ring gear
2 — Starter side of ring gear

With flywheels for torque converters the ring gear must be flush with surface (1) Illust. 142.

Catuion: If a ring gear has worked loose on the flywheel, do not attempt to secure by welding. Remove the loose gear and replace with a new one or replace flywheel with ring gear.

Installation



Illust. 143

1 — Rear oil seal retainer
2 — Oil seal
3 — Crankshaft flange, rear
4 — Dowel pin
5 — Stud
6 — Starter pinion

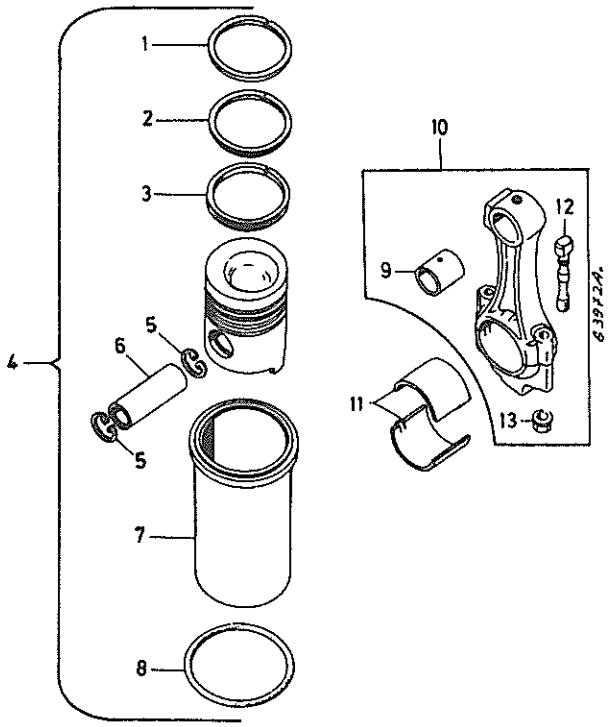
Replace flywheel with ring gear on crankshaft flange (3) Illust. 143 taking care that dowel pin (4) seats properly in the flywheel bore. Use guide pins (Illust. 139) and lifting hook (Illust. 140).

Be sure all seating faces are clean and dry.

Tighten flywheel bolts in crosswise sequence in two passes. Refer to "Special Bolt and Nut Torque Specifications".

Replace clutch assembly or torque converter.

PISTONS, CYLINDER SLEEVES AND CONNECTING RODS



Illust. 144

1 – Piston ring (first compression)
2 – Piston ring (second compression)
3 – Oil control ring
4 – Piston and sleeve package
5 – Retainer plug
6 – Piston pin
7 – Sleeve
8 – Cylinder sleeve O-ring
9 – Bushing
10 – Rod assembly
11 – Bearing
12 – Bolt
13 – Nut

General

Neuss–build IH–engines have been changed from four to three ring type pistons.

Four ring pistons are no longer available for service.

Pistons fitted with three rings and their cylinder sleeves are not classified in groups, however, they should be replaced as a set.

Whenever individual four ring type pistons fail, it is recommended to replace all piston sleeve assemblies of the respective engine to avoid imbalance.

Piston dia and "FRONT" arrow are stamped on the piston crown.

For cylinder sleeve identification see "Specifications".

NOTE: Pistons and cylinder sleeves must be handled with care. Any fall or knock might result in out-of-round.

NOTE: Tightening procedure for connecting rod nuts has been changed.

A new "angle" tightening procedure for connecting rod nuts must now be used replacing the old "torque" tightening method.

Whenever the oil pan is removed, slightly loosen the connecting rod nuts and retighten them using the "angle" tightening procedure according to Illust. 168a.

IMPORTANT

Diameter of cylinder sleeve O-ring groove in the crankcase has been reduced by 0.22 mm (.0086 inch) in the fall of 1979.

Groove Diameter:

A – NEW = 118.32 – 118.58 mm Serial no. up
A (4.658 – 4.668 inch)

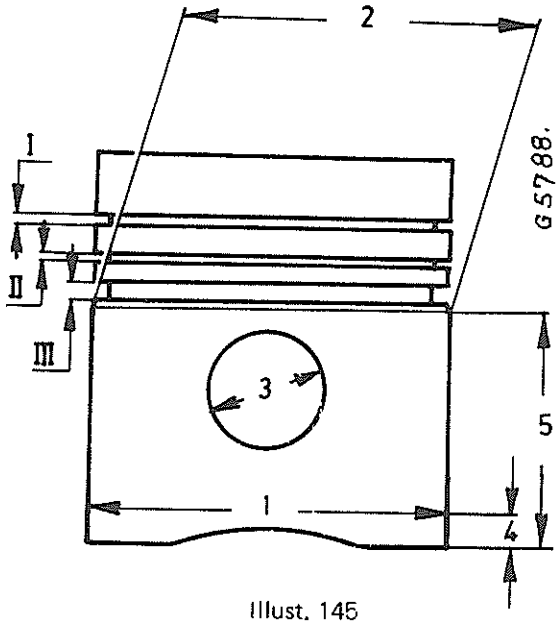
B – OLD = 118.54 – 118.80 mm
(4.667 – 4.677 inch) up to Serial no.

Together with this change two new O-rings (8) have been introduced which must be used as follows:

A – for NEW groove DIA, O-ring with golden tracers.
B – for OLD groove DIA, O-ring with red tracers.

Specifications

In brackets ( ) max. permissible wear before reconditioning.



Illust. 145
Piston, measuring points

Piston clearance in sleeve measured 90 degrees from pin hole, mm (inch)
at DIA. (1): 0.09 – 0.13 (.0035 – .0050)
at DIA. (2): 0.15 – 0.20 (.0059 – .0079)

1 – $\frac{98.32\text{ mm}}{98.35\text{ mm}} = \frac{3.871''}{3.872''}$ (-0.10 mm = .004") x

1 – $\frac{99.90\text{ mm}}{99.92\text{ mm}} = \frac{3.933''}{3.934''}$ (-0.10 mm = .004") xx

1 – $\frac{99.92\text{ mm}}{99.95\text{ mm}} = \frac{3.934''}{3.935''}$ (-0.10 mm = .004") xxx

2 – $\frac{98.25\text{ mm}}{98.28\text{ mm}} = \frac{3.868''}{3.869''}$ (-0.10 mm = .004") x

2 – $\frac{99.81\text{ mm}}{99.85\text{ mm}} = \frac{3.930''}{3.931''}$ (-0.10 mm - .004") $\frac{xx}{xxx}$

3 – $\frac{35.997\text{ mm}}{36.002\text{ mm}} = \frac{1.4172''}{1.4173''}$ (+0.03 mm = .0012") z

3 – $\frac{37.997\text{ mm}}{38.002\text{ mm}} = \frac{1.4959''}{1.4961''}$ (+0.03 mm = .0012") zz

4 – 9.5 mm = .37" y
4 – 4 mm = .16" yy

5 – 59.3 mm = 2.33" y
5 – 50 mm = 1.97" yy

Piston ring grooves:

I – Keystone (See NOTE on page 73)

I – $\frac{3.24\text{ mm}}{3.26\text{ mm}} = \frac{.127''}{.128''}$ (+ 0.05 mm = .002") yy

II – $\frac{2.44\text{ mm}}{2.47\text{ mm}} = \frac{.096''}{.097''}$ (+0.05 mm = .002")

II – Keystone (DT-402 only) (See NOTE on page 73)

III – $\frac{4.79\text{ mm}}{4.82\text{ mm}} = \frac{.188''}{.190''}$ (+0.05 mm = .002")

Piston ring height:

I – Keystone y

I – $\frac{3.15\text{ mm}}{3.14\text{ mm}} = \frac{.1240''}{.1236''}$ (-0.05 mm - .002") yy

II – $\frac{2.375\text{ mm}}{2.363\text{ mm}} = \frac{.0935''}{.0930''}$ (.0.05 mm = .002")

II – Keystone (DT-402)

III – $\frac{4.737\text{ mm}}{4.725\text{ mm}} = \frac{.1865''}{.1860''}$ (-0.05 mm = .002")

x = except for D-246/268/DT-402
xx = D-246/268
xxx = DT-402
y = Piston with Full Keystone top ring and insert
yy = Piston with rectangular top ring without insert
z = Naturally aspirated engine
zz = Turbocharged Engine

Specifications — Continued

Piston ring grooves: (Mexico only)

I — 3.24 mm / 3.26 mm = .1275" / .1283" (+0.05 mm = .002")

II — 3.24 mm / 3.26 mm = .1275" / .1283" (+0.05 mm = .002")

III — 3.24 mm / 3.26 mm = .1275" / .1283" (+0.05 mm = .002")

IV — 4.80 mm / 4.82 mm = .1889" / .1898" (+0.05 mm = .002")

Piston ring height: (Mexico only)

I — 3.15 mm / 3.14 mm = .1240" / .1236" (-0.05 mm = .002")

II — 3.15 mm / 3.14 mm = .1240" / .1236" (-0.05 mm = .002")

III — 3.15 mm / 3.14 mm = .1240" / .1236" (-0.05 mm - .002")

IV — 4.737 mm / 4.725 mm = .1865" / .1860" (-0.05 mm = .002")

Piston ring clearance in grooves:

I — .089 - .122 mm (.0035" - .0048") yy

I — .051 - .381 mm (.0020" - .0150") y

II — .076 - .107 mm (.0030" - .0042")

II — .051 - .381 mm (.0020" - .0150") (DT-402)

III — .036 - .061 mm (.0014" - .0024")

Piston ring gap:

Compression rings

0.35 mm / 0.55 mm = .014 " / .022 " (+0.5 mm = .02")

Bottom ring

0.25 mm / 0.40 mm = .010" / .016" (+1.0 mm = .04")

Piston pin:

Dia

35.991 mm / 35.987 mm = 1.4170" / 1.4168" (-0.015 mm = .0006") z

37.991 mm / 37.987 mm = 1.4957" / 1.4955" (-0.015 mm = .0006") zz

Clearance in piston

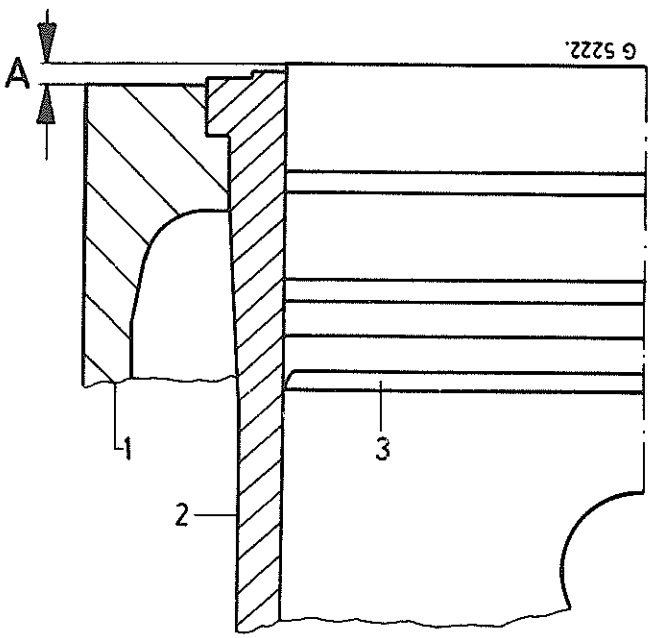
0.006 mm / 0.015 mm = .0002" / .0006" (+0.05 mm = .002")

Clearance in bushing

0.021 mm / 0.035 mm = .0008" / .0014" (+0.05 mm = .002") z

0.035 mm / 0.049 mm = .0014" / .0019" (+0.05 mm = .002) zz

y = Piston with Full Keystone top ring and insert
yy = Piston with rectangular top ring without insert
z = Naturally aspirated engine
zz = Turbocharged engine

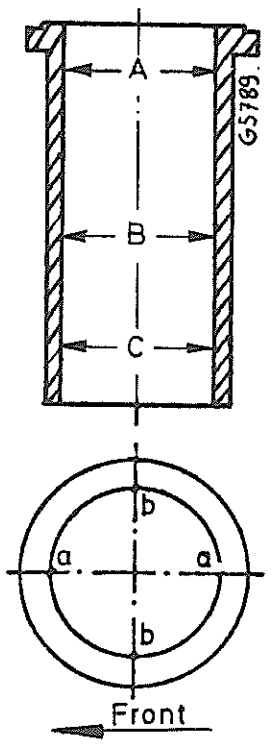


Illust. 146
Protrusion of Pistons

$A - {}^{0.32}_{0.70}$ (.0126) (.0275) (4-3/8" stroke engines)

$A - {}^{0.36}_{0.74}$ (.0141) (.0291) (5.06" and 5-1/2" stroke engines

1 – Crankcase
2 – Cylinder sleeve
3 – Piston



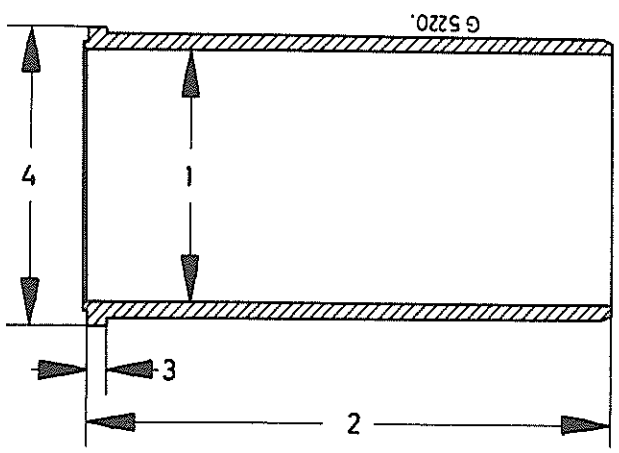
Illust. 147
Measuring points, cylinder sleeve

Note: Piston ring groove, ring height and clearance cannot be accurately measured on full Keystone rings except as follows:

a) Insert Perfect Circle Piston Ring Gauge No. 1 (1/8-inch x 15°) in ring groove.

b) If one or both of the shoulders of the gauge touch ring groove land, piston must be replaced.

c) Measure clearance of Keystone ring in groove by ring drop method to assure adequate clearance of .051-.381 mm (.002 - .015").



Illust. 148
Cylinder sleeve

Refer to Illust. 148

1 – $\frac{98.425\ mm}{98.449\ mm} = \frac{3.8750''}{3.8759''}$ (- 0.10 mm = .004" or 0.05 mm = .002" out-of-round) x)

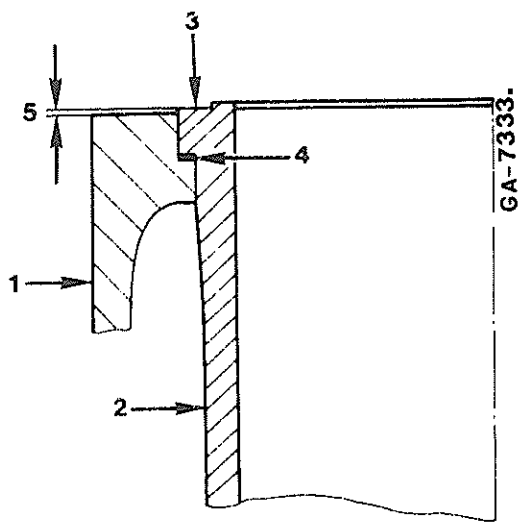
1 – $\frac{100.000\ mm}{100.024\ mm} = \frac{3.9370''}{3.9379''}$ (- 0.10 mm = .004" or 0.05 mm = .002" out-of-round) xx)

2 – 200 mm = 7.874" (4 3/8" stroke engines)
2 – 215 mm = 8.464" (5.06" and 5 1/2" stroke engines)

3 – $\frac{7.700\ mm}{7.715\ mm} = \frac{.3031''}{.3037''}$

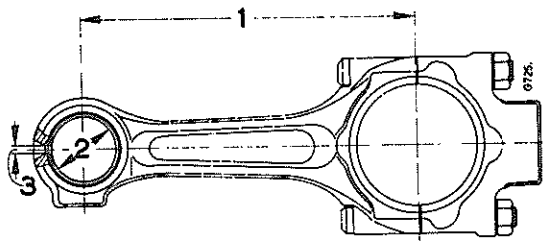
4 – 119 mm = 4.685"

x = except for D-246/268/DT-402
xx = D-246/268/DT-402



Illust. 149
Cylinder Sleeve Protrusion

1 – Crankcase
2 – Sleeve
3 – Outer flange
4 – Shim (use only if necessary)
5 – $\frac{0.08\ mm}{0.12\ mm} = \frac{.0031''}{.0047''}$ (-0.05 mm = .002")



Illust. 150
Connecting rod

NOTE: For DT-358 and DT-402 refer to Illust. 162 for additional information.

1 – $\frac{187.96\ mm}{188.01\ mm} = \frac{7.400\ ''}{7.402\ ''}$ (4 3/8" stroke engines)

1 – $\frac{213.84\ mm}{213.89\ mm} = \frac{8.419''}{8.421''}$ (5.06 and 5 1/2" stroke engines)

2 – $\frac{36.012\ mm}{36.022\ mm} = \frac{1.4178''}{1.4182''}$ (+0.03 mm = .0012")

2 – $\frac{38.026\ mm}{38.036\ mm} = \frac{1.4971''}{1.4975''}$ (+0.03 mm = .0012")

3 – 4.06 mm = .16" (except DT-358/DT-402)

3 – 1.5 mm = .06 (DT-358/DT-402)

x = Naturally Aspirated engines
xx = Turbocharged engines

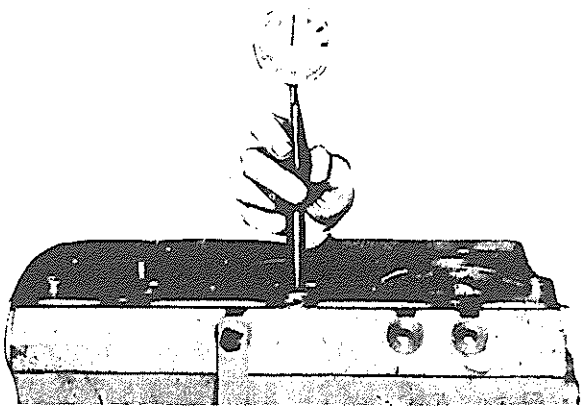
Removal and Disassembly

Remove cylinder head and oil pan. See respective sections of this manual.

Turn the engine bottom side up and remove connecting rods individually.

Mark the connecting rods from front to rear with consecutive figures.

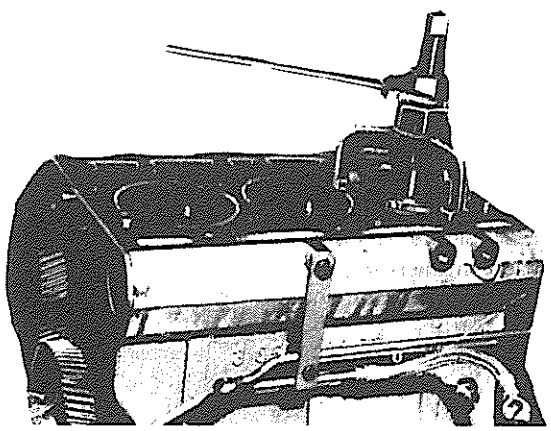
Carefully store connecting rod bearing inserts, so that they can be reinstalled in their original positions when reused.



Illust. 151
Checking cylinder sleeve wear

Check cylinder sleeve wear before removal, Illust. 151. See "Specifications". Sleeve bore can be measured with a cylinder dial gauge.

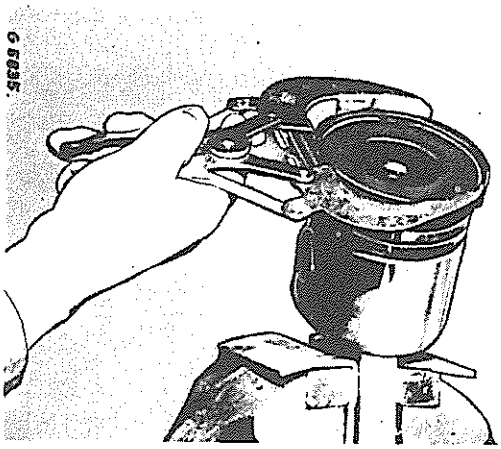
If excessively worn, remove the cylinder sleeves, using the removing tool as shown in Illust. 152, see parts catalog.



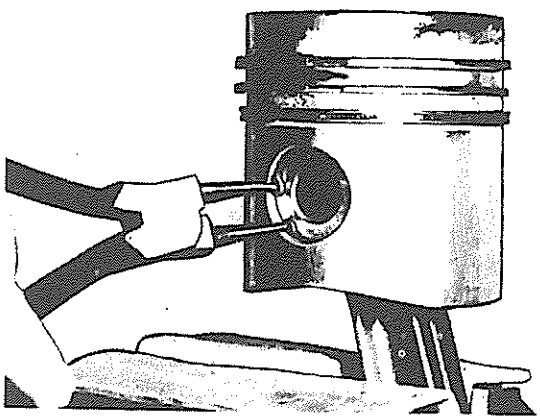
Illust. 152
Removing cylinder sleeves

Mark pistons from front to rear with consecutive figures before they are removed.

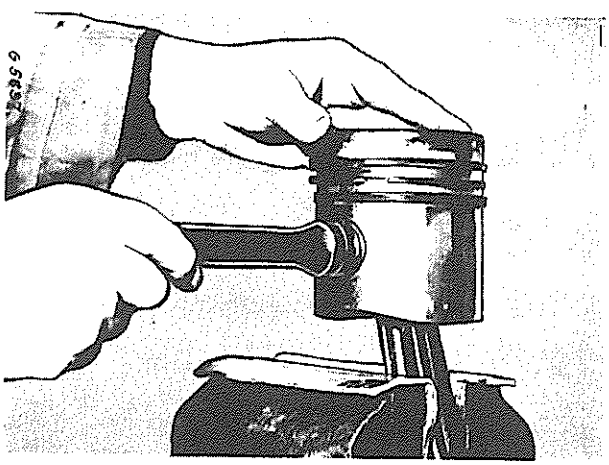
Continue as shown in Illusts. 153 to 155.



Illust. 153
Removing or installing piston rings with ring expander



Illust. 154
Removing or installing piston pin circlips



Illust. 155
Removing or installing piston pin

Cleaning, Inspection and Repair

Remove carbon deposits from the piston, cleaning also ring grooves and lubricating holes.

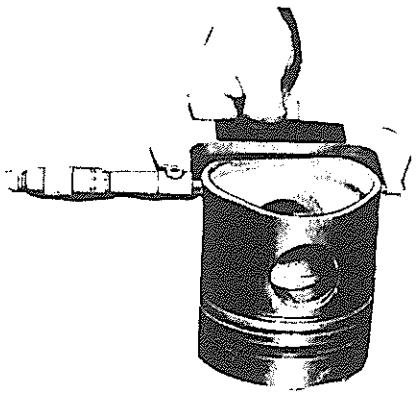
Wash all parts in Diesel fuel and dry with compressed air.

Cylinder Sleeves

Measure wear with sleeves in place (Illust. 151) and replace worn cylinder sleeves with new ones.

NOTE: Replace cylinder sleeves and pistons as a set. To avoid imbalance do not mix up three and four ring type pistons in one engine.

Pistons



Illust. 156
Checking Piston OD

The piston is cam ground, therefore it has two different diameters. To determine piston wear (piston clearance to cylinder sleeve) its bigger diameter, across the thrust face must be measured, see Illusts. 156 and 145. Compare the result with "Specifications".

Inspect the piston for scuffed or scored skirt and the piston ring grooves for wear, see "Specifications".

Check piston pin and its bores in the piston against "Specifications".

Discard any worn and/or damaged pistons.

Replace pistons and cylinder sleeves as a set.

NOTE: New piston pins may be used individually, provided that the diameters of the pin bores in the piston bosses are less than 36.04 mm (1.419") for naturally aspirated engines or 38.04 mm (1.498") for turbocharged engines. Out-of-round of pin bore must be less than 0.03 mm (.0012").

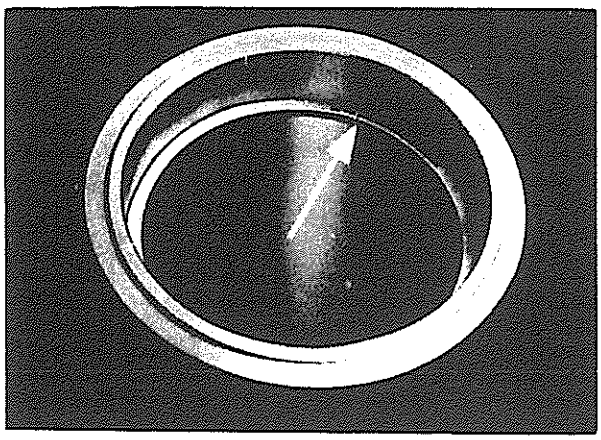
Piston Rings

To determine piston ring wear:

a) Check piston ring height using a micrometer.

b) Check piston ring gap using a feeler gauge.

Compare the results with "Specifications".



Illust. 157
Piston Ring Gap

To check piston ring gap the ring must be placed squarely in a new cylinder sleeve, Illust. 157. Replace piston rings as a set only.

NOTE 1: Pistons may be fitted with new ring sets provided float wear on sleeves and pistons is negligible. Especially out-of-round of cylinder sleeves 0.05 mm (.002") must not be exceeded.

NOTE 2: Before new piston rings are fitted, remove the ridges left in the sleeves at the top of ring travel to avoid noisy engine operation and the danger of top ring breakage.

CONNECTING RODS

Replacing Piston Pin Bushings

To determine the piston pin clearance to piston pin bushing subtract the diameter of a new pin (see "Specifications") from the inner diameter of the used bushing.

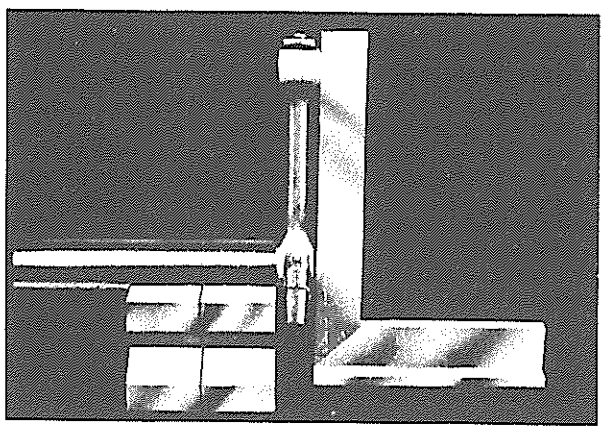
The pin clearance to the bushing should be less than 0.085 mm (.0034"), otherwise use new connecting rods or replace the piston pin bushings as follows:

A) Naturally Aspirated and DT-239

1. Remove the old bushing and clean the eye.

2. Lubricate and press in the new bushing taking care its split is towards the side and the bushing clears the edge of the connecting rod eye evenly on both sides.

3. Drill the lubricating hole. See (3) Illust. 150.

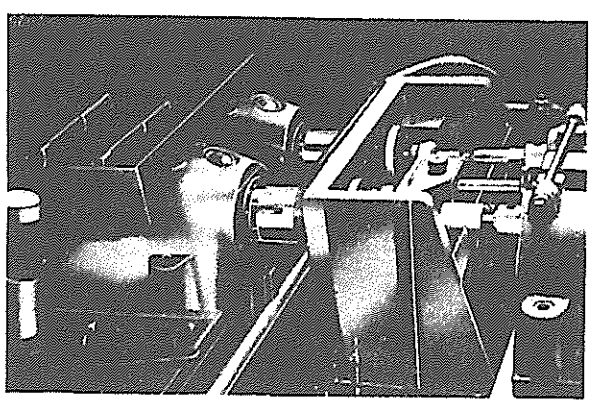


Illust. 158
Checking connecting rod for squareness

4. Before fine-boring the new piston pin bushing, check the connecting rod for squareness and distortion, Illust. 158.

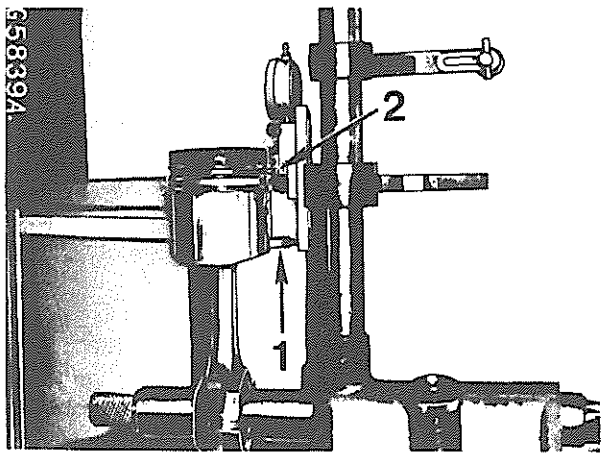
5. Strictly observe dimensions (1) and (2) Illust. 150, when fine-boring the bushing, Illust. 159, to ensure correct piston head clearance.

6. A deviation of up to 0.10 mm (.004") from the upper tolerance measurement of distance (1) Illust. 150 is permissible.



Illust. 159
Fine-boring piston pin bushing

7. Never attempt to replace piston pin bushings unless the necessary tools and machines are available. Use a new connecting rod with bushing if necessary.

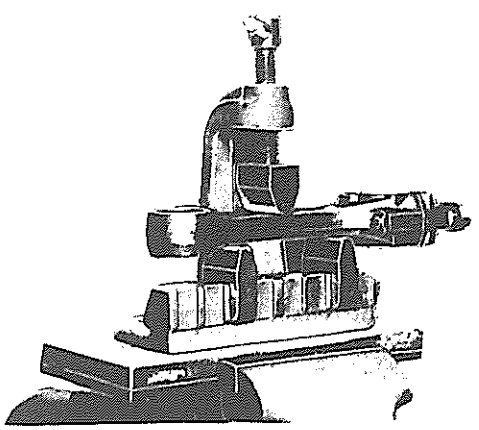


Illust. 160
Checking alignment

1 – Stop
2 – Dial indicator, stylus with bellcrank

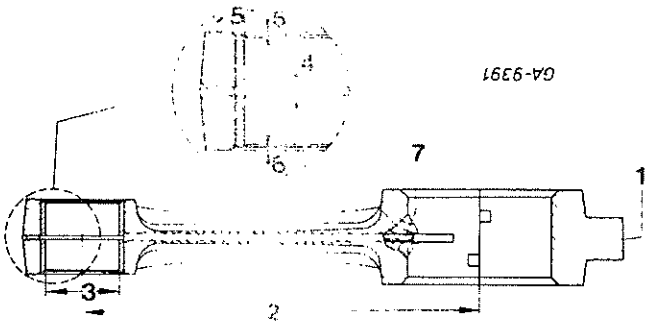
8. After fine-boring install the piston and check for crank pin to piston pin alignment, Illust. 160.

9. If necessary realign by straightening the connecting rod, Illust. 161.
A misalignment of max. 0.04 mm (.0016") is permissible.



Illust. 161
Straightening the connecting rod

B) DT-358 and DT-402 engines



Illust. 162
mm (inch)

1 – (DT-402 only) marking on No. 1 rod

2 – 213.84 (8.419)
213.89 (8.421)

3 – 38.026 (1.4970)
38.036 (1.4974)

4 – DT-358: 3.5 (.14)

4 – DT-402: 1.5 (.06)

5 – 0.5 mm x 45° (.02 x 45°)

6 – Evenly on both sides

7 – Oil-passage

To replace piston pin bushings, proceed as follows:

With a support plate and a properly fitting adapter press the old piston pin bushings from the connecting rod. Do not damage the connecting rod bore. Remove burrs and clean the bore thoroughly. Press in the new bushings from both sides in the connecting rod bore with a hydraulic precision press.

Make sure the gap between the bushings is within the specifications, see (4) Illust. 162. Chamfer both bushings, see (5).

Continue according to steps 4 to 9 under A).

IMPORTANT

On DT-402 engines the No. 1 connecting rod is of controlled length so as not to interfere with the oil pump. To prevent mixing up of connecting rods the first rod is marked with a "1" at the bottom of the rod cap, see (1) Illust. 162. For service purposes only connecting rods with controlled length are used.

Reassembly and Installation

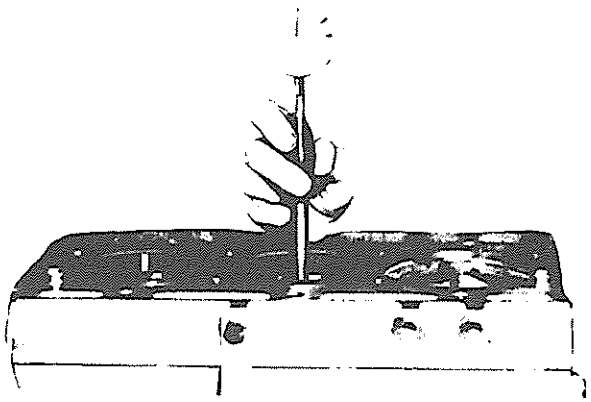
Cylinder Sleeves

NOTE: Measure cylinder sleeve O-ring groove to determine correct O-ring replacement. Refer to General for groove diameter dimension.

Use new O-rings when reinstalling cylinder sleeves. Make sure O-rings and crankcase grooves are clean and dry.

Coat the O-ring with engine oil and carefully install the O-ring into the crankcase groove. Be sure the O-ring is properly seated in its groove.

Apply a light film of engine oil to sealing face of each cylinder sleeve to ensure O-rings are not twisted in their grooves as the sleeve is installed.

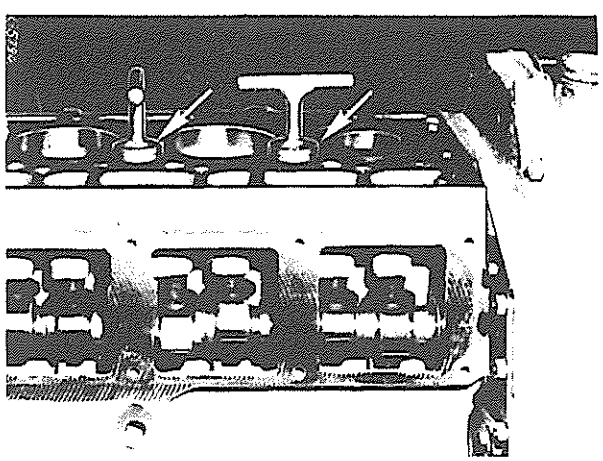


Illust. 163
Checking Cylinder Sleeves for Out-of-Round

Check the cylinder sleeves for possible out-of-round especially in their sealing areas, Illust. 163.

If out-of-round exceeds 0.02 mm (.0008") check for twisted O-rings, dirt, etc. and remedy the fault.

NOTE: Check cylinder sleeve protrusion according to Illusts. 83 and 83a.

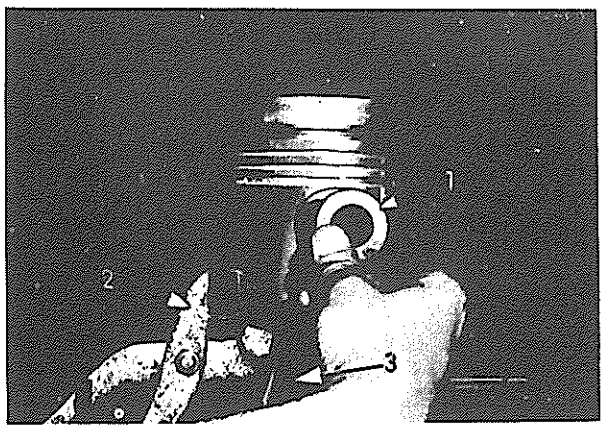


Illust. 164
Cylinder Sleeves Locked

Before turning the engine bottom side up lock the cylinder sleeves as shown in Illust. 164, to protect them against dropping out.

Pistons

When installing the piston, be certain the arrow on the piston crown points to the front of the engine and the boss of the upper connecting rod end is on the camshaft side.

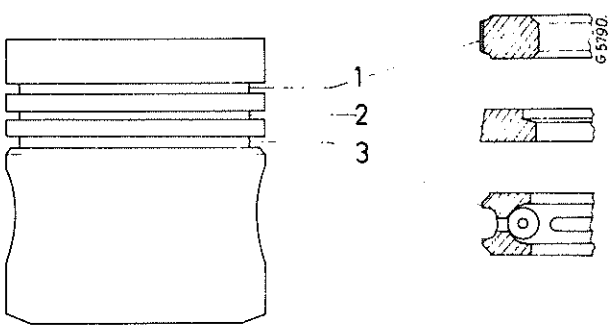


Illust. 165
Installing the Piston

1 – Piston pin
2 – Special pliers
3 – Connecting rod clamped in vise

Heat the piston to approx. 75°C (170° F) before installing it, Illust. 165.

Insert piston pin circlips, Illust. 154.

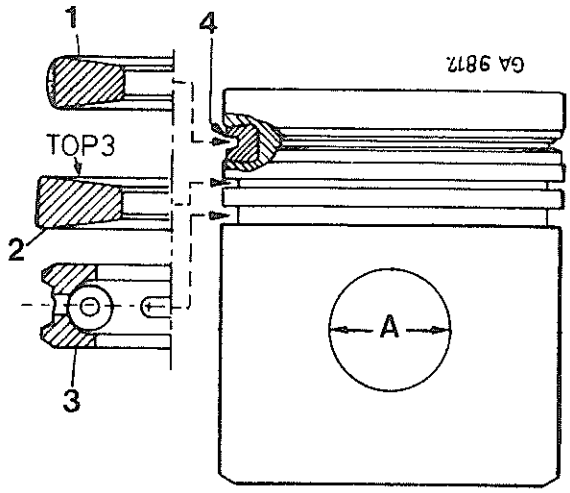


Illust. 166
Arrangement of Piston Rings
(Pistons without insert for "1")

1 – 1st compression ring
2 – 2nd compression ring
3 – Oil control ring

NOTE: Illust. 166a shows piston ring equipment of DT-402 engine. On this version ring (2) is marked with "TOP 3" for identification.

Use a ring expander (Illust. 153) and install piston rings as shown in Illust. 166 or 166a.



Illust. 166a
Arrangement of Piston Rings
(Piston with insert (4)

1 – 1st compression ring
2 – 2nd compression ring
3 – Oil control ring
4 – Insert
A – Piston pin bore nominal
DIA: N. A. engines:
36 mm (1.4 in.)
DT-engines:
38 mm (1.5 in.)

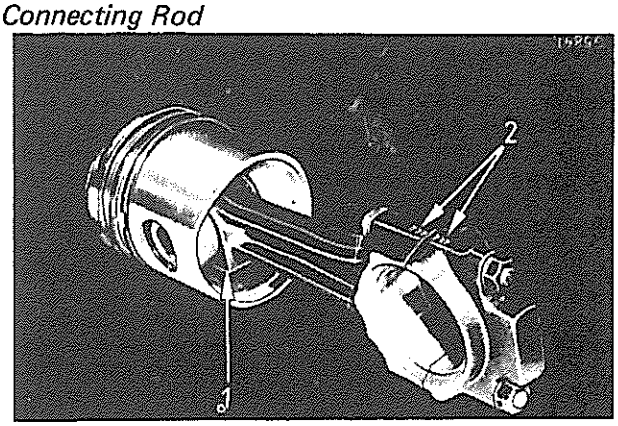
Note: Illust. 166a shows piston ring equipment of DT-402 engine. On this version ring (2) is marked with "TOP 3" for identification.

Use a ring expander (Illust. 153) and install piston rings as shown in Illust. 166 or 166a.

Take care the word TOP on the rings points to the cylinder head. Start by installing the oil control ring and work upwards toward the piston crown.

Caution: Do not overspread rings.

Connecting Rod



Illust. 167

1 – Boss of the upper connecting rod end
2 – Identical mating figures on connecting rod and bearing cap

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Observe the following when installing the piston and connecting rod assembly.

a) Boss (1) Illust. 167 must be on the camshaft side.

b) Mating figures (2) must be in line.

c) Reused pistons and/or reused bearing inserts must be reinstalled in their original positions.

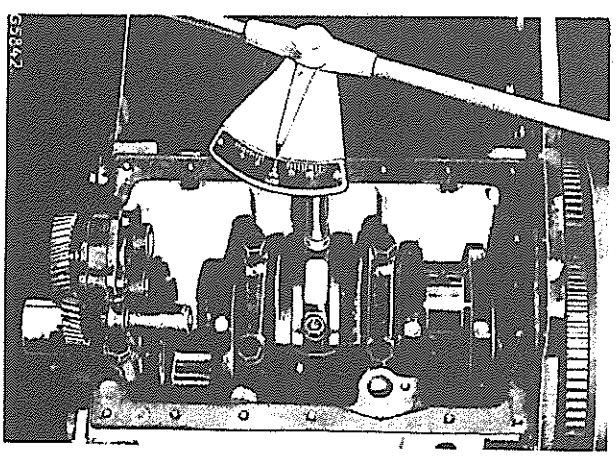
d) On DT-402 observe No. 1 marking on first connecting rod.

e) Be sure to install bearing inserts with oil bores in the correct position.

f) Lubricate pistons and cylinder sleeves with engine oil SAE 30 before installation. Also lubricate crankpins and bearing inserts.

g) Use a piston ring compressor and insert piston with connecting rod assembly through top of crankcase.

"Angle" Tightening Procedure for Connecting Rod Nuts



Illust. 168
Tightening Connecting Rod Nuts

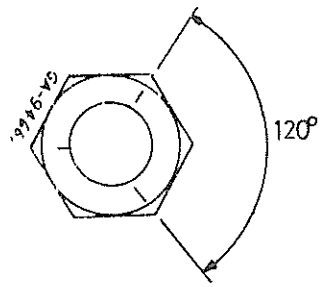
Proceed as follows:

1. Pre-tighten connecting rod nuts to a torque load of 25 N•m (18.5 lb/ft), Illust. 168.

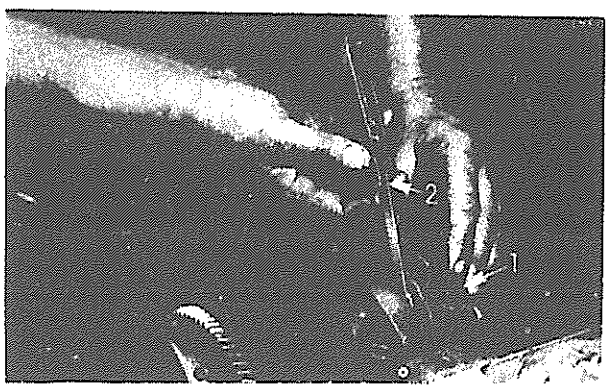
2. Tighten the nuts further by turning them through an angle of 120° which corresponds to 2 flats of the nut, Illust. 168a.

NOTE: The 120° angle can be easily controlled by marking the connecting rod nuts (socket) in relation to the bearing cap.

After connecting rod bearing caps are installed, check for proper side clearance 0.16 – 0.30 mm (.006 – 012"), see Illust. 169.



Illust. 168a
"Angle" Tightening Procedure for Connecting Rod Nuts



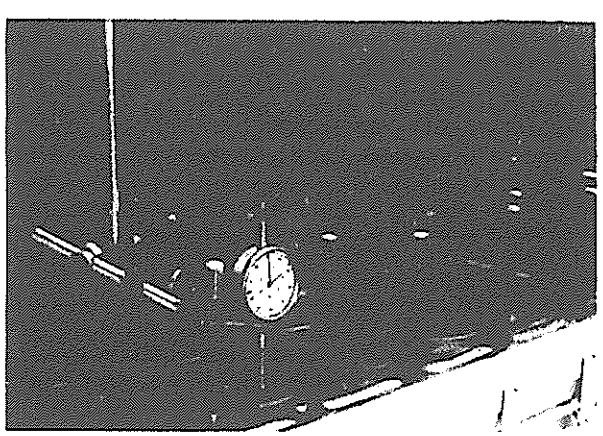
Illust. 169
Checking Connecting Rod Side Clearance

1 – Connecting rod nut
2 – Feeler gauge

NOTE 1: Whenever the crankshaft is reground to any undersize the crankpin running clearance should be checked.

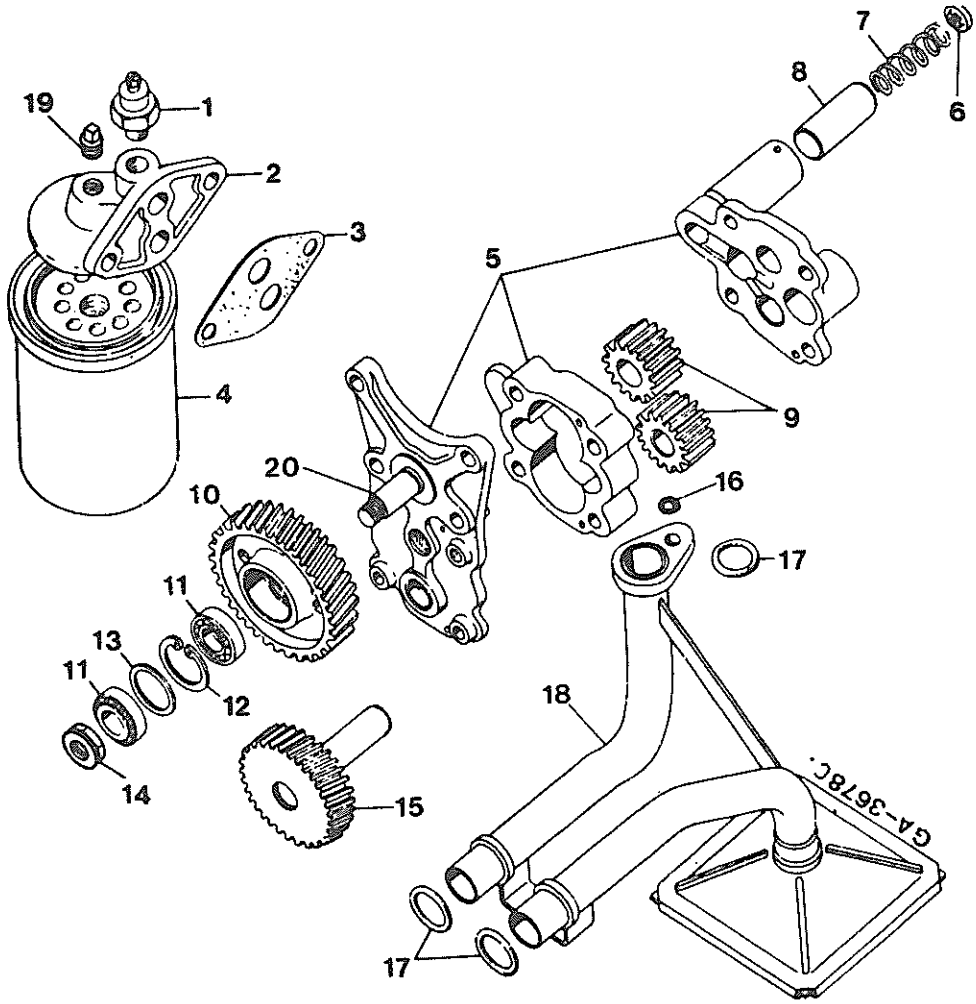
Use the virgin lead wire method for this purpose as outlined in "Main bearing fitting procedure". See "Specifications".

NOTE 2: Check the protrusion of every piston whenever the piston pin bushings have been replaced, see Illusts. 170 and 146.



Illust. 170
Checking piston protrusion

OIL PUMP



Illust. 171
Oil Pump, Present Design

General

The gear-type oil pump, Illust. 171, supplies all bearings and moving parts of the engine with the necessary lubricant. The oil pump is driven by the crankshaft pinion via idler gear (10) and oil pump drive gear (15). Idler gear is carried on two tapered roller bearings.

The oil is taken in from the crankcase oil sump through the suction screen and passes under pressure through a pipe to the oil filter, whence it is distributed via the main oil gallery to the oil passages in crankcase and cylinder head and to all bearings.

Body gears for 3, 4 and 6 cyl. engines differ in effective width, resulting in a different pump capacity to meet the lubricating oil demand of the various engines. See "Specifications".

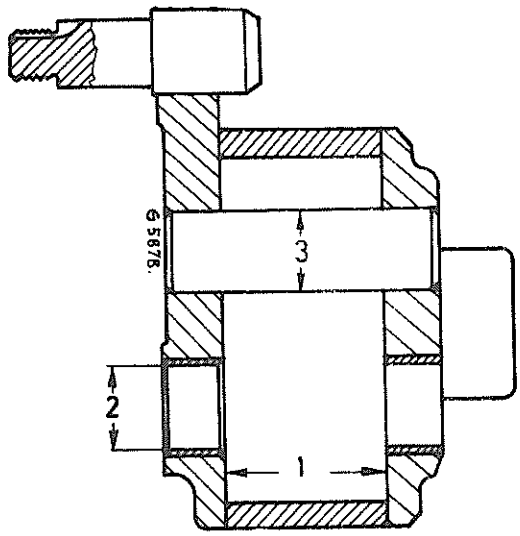
A spring-loaded relief valve (8) is provided in the pump body to maintain the specified circulating pressure by returning oil in excess of requirements direct to the oil sump.

NOTE: Self-locking nut (14) Illust. 171 replaces the former fastening method with shaft nut, lock washer and tab washer.

IMPORTANT

The new self-locking nut (14) must not be used on idler gear shafts with milled slots for the old tab washers. When using the new locking nut, remove the slotted shaft and install the new idler gear shaft (20) without a slot, see Illust. 183a.

Specifications



Illust. 172
Oil pump housing

In brackets ( ) max. permissible wear before reconditioning.

1 – Pump housing	(3-cyl.- engines)	16.776 mm / 16.797 mm = .6606" / .6613"	(+0.05 mm = .0019")
	(4-cyl.- engines)	30.051 mm / 30.071 mm = 1.1831" / 1.1839"	(+0.05 mm = .0019")
	(6-cyl.- engines)	38.62 mm / 38.64 mm = 1.5204" / 1.5212"	(+0.05 mm = .0019")
2 – Bushing, ID		19.05 mm / 19.08 mm = .7500" / .7512"	(+0.05 mm = .0019")
3 – Idler gear shaft, OD		19.101 mm / 19.075 mm = .7520" / .7510"	(- 0.05 mm = .0019")
Idler gear bore, dia		19.146 mm / 19.171 mm = .7537" / .7547"	(+ 0.05 mm = .0019")
Drive gear (15) Illust. 171, shaft dia		19.008 mm / 19.021 mm = .7483" / .7489"	(- 0.05 mm = .0019")
Body gears (9), width	(3-cyl.- engines)	16.708 mm / 16.726 mm = .6578" / .6585"	(- 0.05 mm = .0019")
	(4-cyl.- engines)	29.974 mm / 30.000 mm = 1.1801" / 1.1811"	(- 0.05 mm = .0019")
	(6-cyl.- engines)	38.494 mm / 38.520 mm = 1.5155" / 1.5165"	(- 0.05 mm = .0019")

End play	
Idler gear (10)	0.0 –0.05 mm = .0 –.0019"
Drive gear (15)	0.05–0.10 mm = .0019–.0039" (+0.10 mm = .004")
Running clearance	
Body gears (9)	0.03–0.08 mm = .0012–.0031" (+0.10 mm = .004")
Backlash	
Crankshaft pinion/idler gear (10)	0.15–0.38 mm = .006–.015" (+0.2 mm = .008")
Idler gear (10) / drive gear (15)	0.20–0.36 mm = .008–.014" (+0.3 mm = .012")

Spring (7)	NEW	OLD
Free length	72.4 mm = 2.85" or 85.8 mm = 3.38"	64 mm = 2.520"
Test length	47.2 mm = 1.86" or 47.2 mm = 1.86"	47.2 mm = 1.858"
Test load	147N = 33 lbs or 223N = 50 lbs.	80–89 N = 18–20 lbf

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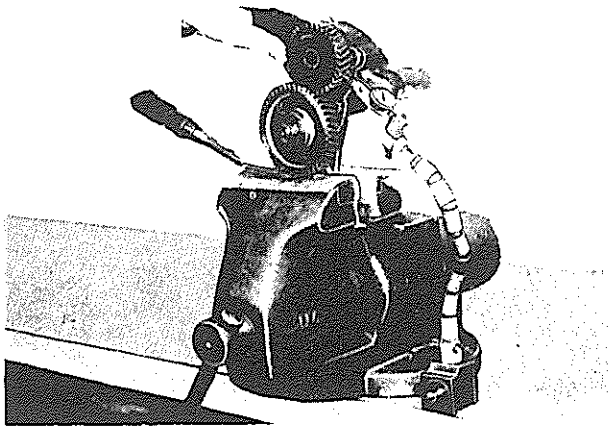
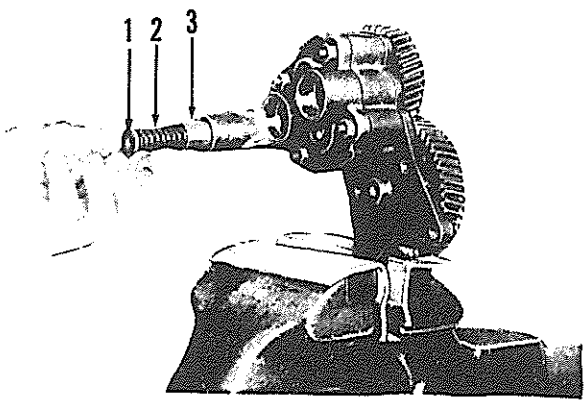
Removal and Disassembly

Removal of the oil pump, see Illust. 88a.



Illust. 173
Checking gear backlash

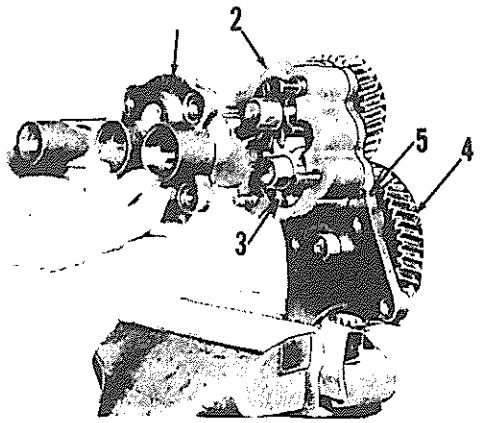
It is a good practice to check oil pump gear backlash and end play before removing (and disassembling) the pump. See "Specifications".



Illust. 174
Removing the relief valve

1 – Retainer washer
2 – Spring
3 – Valve

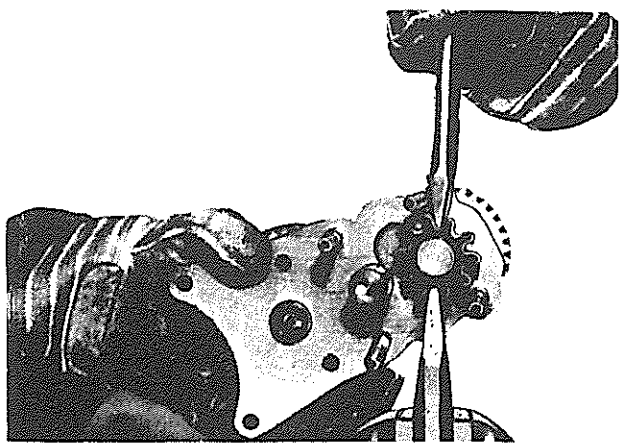
Remove the relief valve, Illust. 174.



Illust. 175

1 – Cover
2 – Housing
3 – Idler body gear
4 – Idler gear
5 – Carrier

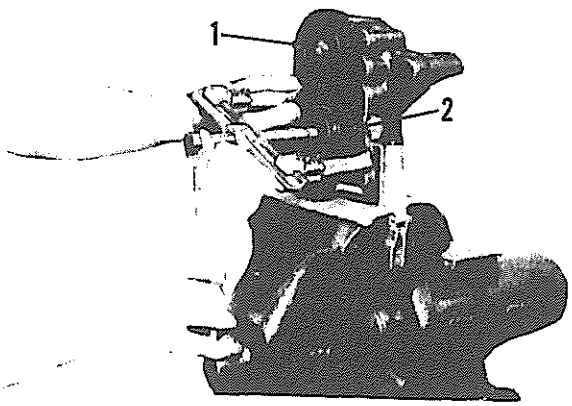
Remove cover (1), housing (2), and idler gear (3), Illust. 175.



Illust. 176

Split off and remove driving body gear, Illust. 176.

Use protective gloves and goggles.



Illust. 177

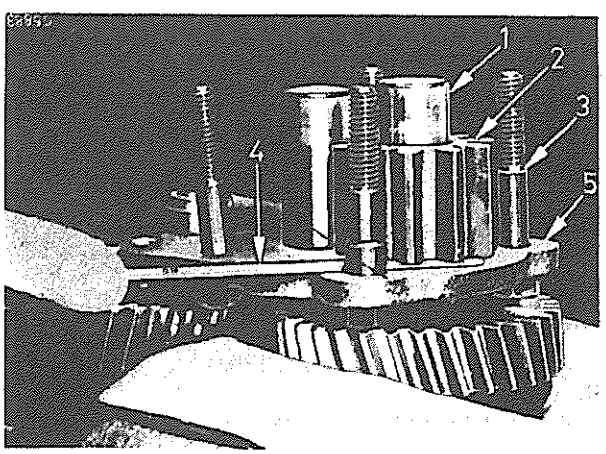
1 – Oil pump drive gear
2 – Idler gear

If necessary, remove the idler gear (2) Illust. 177.

Cleaning, Inspection and Repair

Wash all parts and check them against "Specifications".

Replace worn parts or the complete pump if worn excessively.



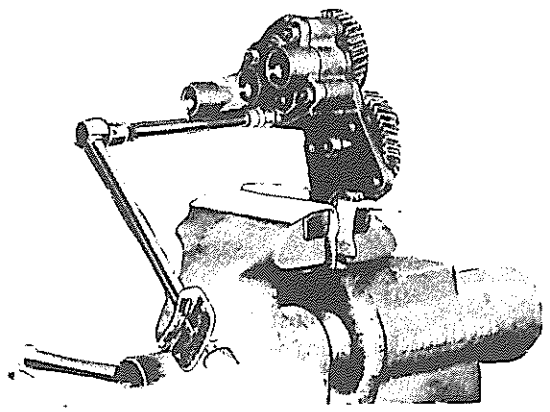
Illust. 178

1 – Drive gear shaft
2 – Driving body gear (shrink-fit)
3 – Housing bolts
4 – Feeler gauge (0.10 mm = .004")
5 – Pump carrier

Note: Insert bolts (3) before installing the gear (2) Illust. 178.

Heat body gear (2) to 200–400°C (390–750°F).

Slide the hot gear onto shaft (1), making certain, that a gap of 0.10 mm (.004") is obtained between gear and pump carrier (5). Check with a feeler gauge (4).

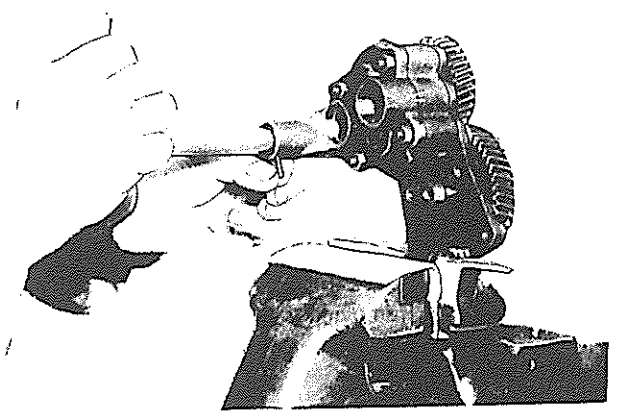


Illust. 179

Install gear (3) Illust. 175 and reassemble the oil pump as shown in Illust. 179.

Tighten the housing bolts evenly, observing a crosswise sequence.

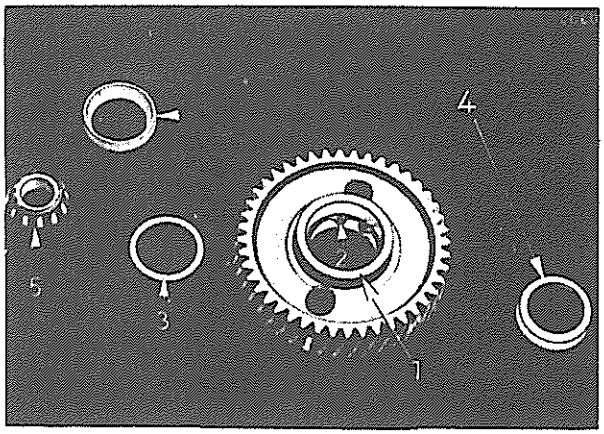
Be sure the pump rotates without binding.



Illust. 180

Install the relief valve, using special tool, Illust. 180. See also Illust. 174.

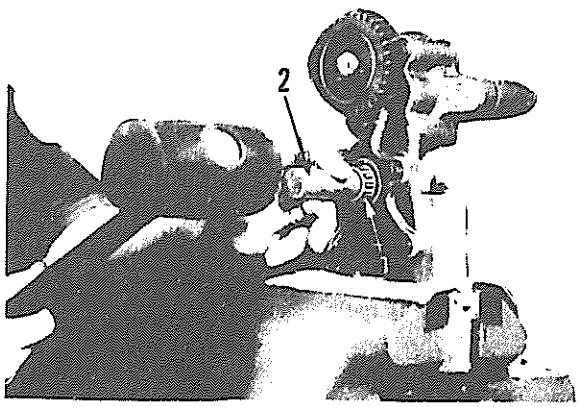
Install the idler gear as follows:



Illust. 181

1 – Long hub end
2 – Circlip
3 – Washer
4 – Outer race
5 – Inner roller bearing

Insert circlip (2) Illust. 181 in its groove. Replace washer (3) facing the long hub end side (1) of the gear. Install the two outer races (4) with their small diameter facing the inside of the gear.



Illust. 182

1 – Inner roller bearing
2 – Drift punch

Use the drift punch provided for this purpose and drive the inner roller bearing on the shaft, see Illust. 179.

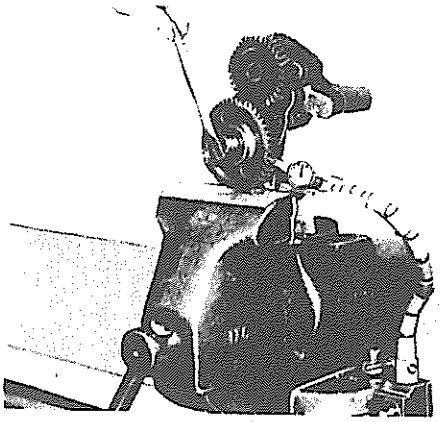
Lubricate roller bearings with engine oil SAE 30.

Place idler gear on shaft with short hub end facing the oil pump.

Install the second roller bearing, tab washer, lock washer and shaft nut in this sequence.

Tighten the shaft nut until an idler gear end play of 0 – 0.05 mm (0 – .002 in.) is obtained, Illust. 180.

Lock the shaft nut.



Illust. 183
Adjusting Idler Gear End Play

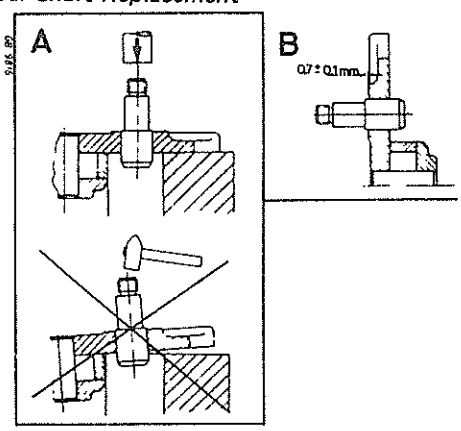
Idler Gear Fastening with Self-Locking Nut

NOTE: The self-locking nut must have a minimum (thread-resistance) torque of 4.5 N•m (3.3 lbf-ft) on the total thread area before the specified end play of idler gear (Illust. 183) is obtained. Nuts not reaching this torque have to be replaced. Do not reuse. Replace the self-locking nut after every dismantling.

IMPORTANT

Do not use the self-locking nut on slotted idler gear shaft. Replace these shafts as follows:

Idler Gear Shaft Replacement



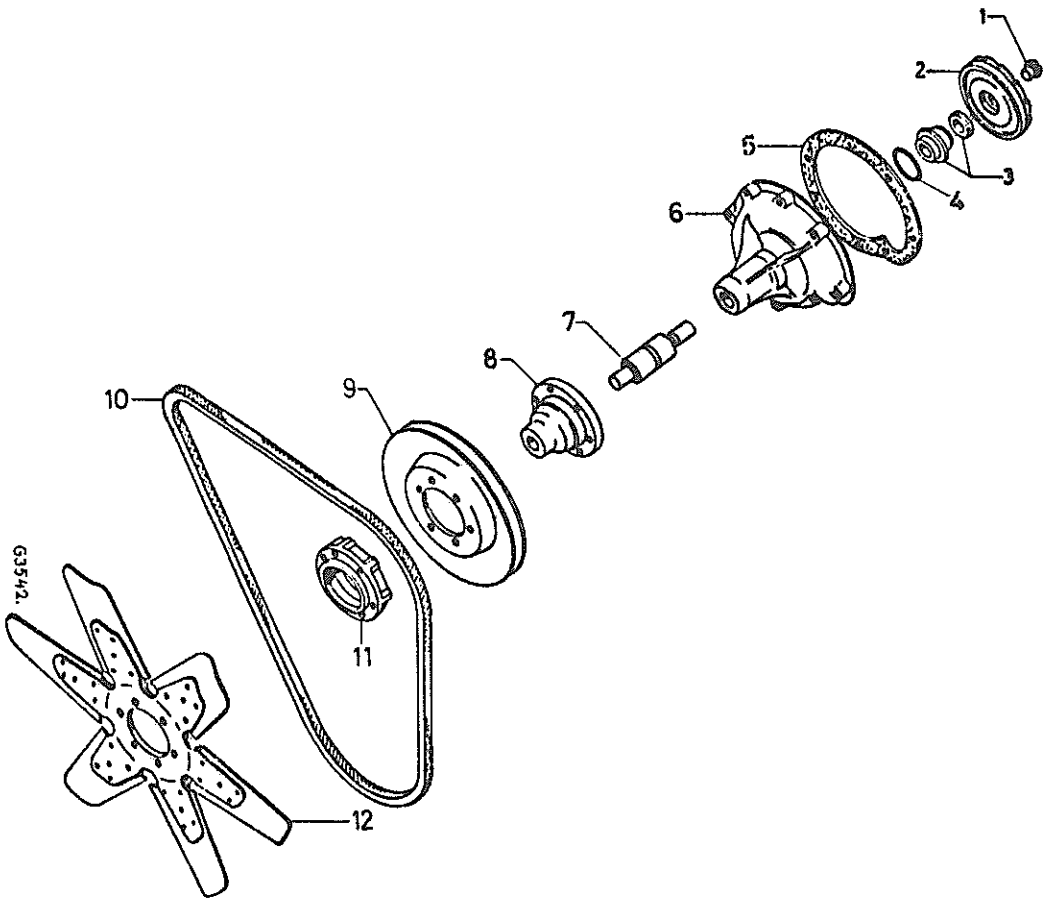
Illust. 183a

1. Press out idler gear shaft (A), Illust. 183a, taking care not to damage the shaft bore.
2. Measure the shaft bore diameter. If the diameter exceeds 19.95 mm (.785") use a new oil pump carrier and shaft without slot.
3. Apply liquid loctite into the bore and press in the new shaft, observing dimension (B), .6 – .8 mm (.023 – .031").

Installation

See Illusts. 88a and 110a.

WATER PUMP



Illust. 184

1–8 components of water pump

General

Depending on application, some components of the water pump may vary in design. See "Specifications".

The HD bearing and housing (7+6) may be used instead of the lighter version but not vice–versa.

Refer to Parts Catalog for detailed information.

Specifications

Hub (8) Illust. 184

Bore, dia (large)	23.957 mm / 23.939 mm	=	.9432" / .9425"
(small)	16.962 mm / 16.944 mm	=	.6677" / .6670"

Max. permissible imbalance 20 cmg = .27802 inch

Impeller (2)

Bore, dia	16.972 mm / 16.945 mm	=	.6681" / .6671"

Bearing (7)

Shaft ends, dia (large)	24.000 mm / 23.987 mm	=	.9449" / .9444"
(small)	17.005 mm / 16.993 mm	=	.6694" / .6690"

Note: Bearing shaft ends may be both small diameter or a large and small diameter.

OD (large)	47.000 mm / 46.987 mm	=	1.8500" / 1.8498"
(small)	38.100 mm / 38.087 mm	=	1.500 " / 1.499 "

Body (6)

Bore, dia (large)	46.963 mm / 46.979 mm	=	1.8489" / 1.8495"
(small)	38.063 mm / 38.079 mm	=	1.4985" / 1.4991"

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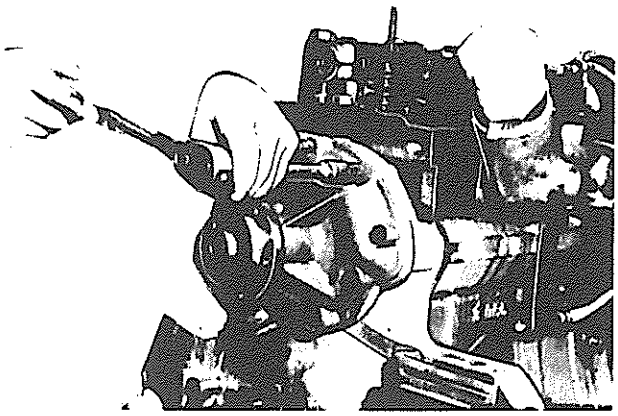
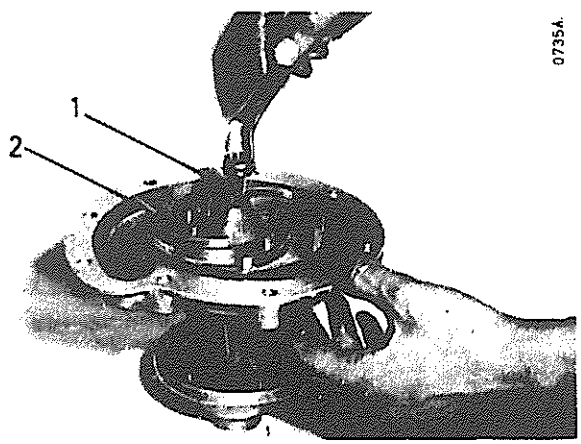
Removal and Disassembly



Illust. 185
Removal or installation of water pump

Remove fan, V-belt pulley and pump (Illust. 185).



Illust. 186
Removing impeller

1 — Jack screw 1/2" — 13
2 — Impeller

Use screw (1) Illust. 186 to remove impeller (2).

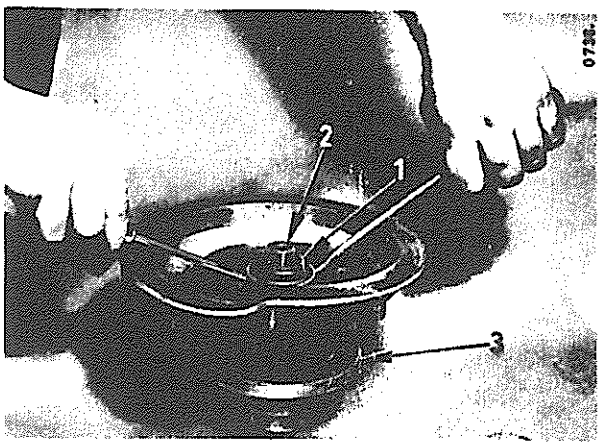
Cleaning, Inspection and Repair

Clean all parts and dry with compressed air.

Replace bearing assembly (1) Illust. 190 with a new one, if pump has been running rough and/or noisy.

NOTE: When servicing the water pump always replace spring loaded packing bearing face ring (5) and O-rings (6 and 7) Illust. 190.

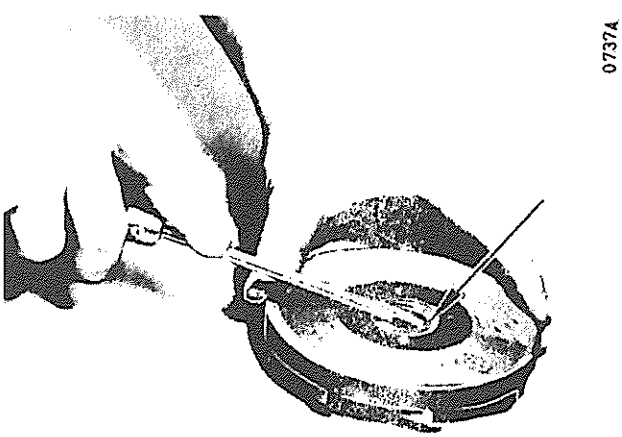
Replace V-belt pulley when inside of "V" is worn and belt is riding low.



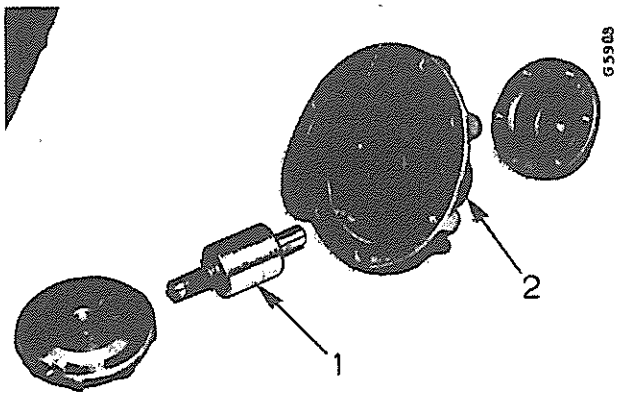
Illust. 187
Removal of bearing

1 — Spring loaded packing
2 — Rear shaft end
3 — Hub

Remove bearing face ring and O-ring out of impeller, Illust. 188.



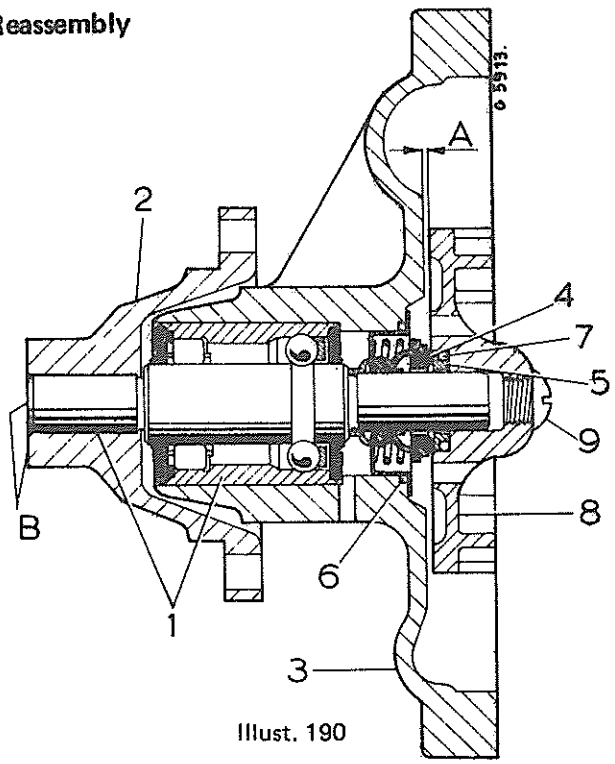
Illust. 188
Removing bearing face ring



Illust. 189
Disassembled pump

1 – Bearing
2 – Body

Reassembly



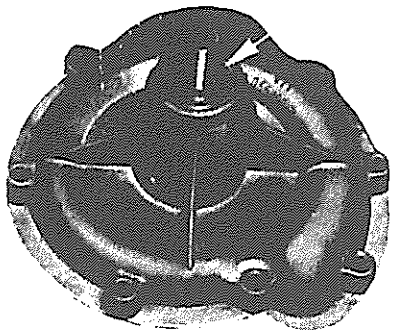
Illust. 190

A – Gap 0.3 – 0.5 mm = .012 – .020"
B – Hub must be flush with shaft end

1 – Bearing	6 – O-ring (early version only)
2 – Hub	
3 – Body	7 – O-ring
4 – Springloaded packing	8 – Impeller
5 – Bearing face ring	9 – Plastic plug

Reassemble pump as shown in Illust. 190.

For details see Illusts. 191–193.

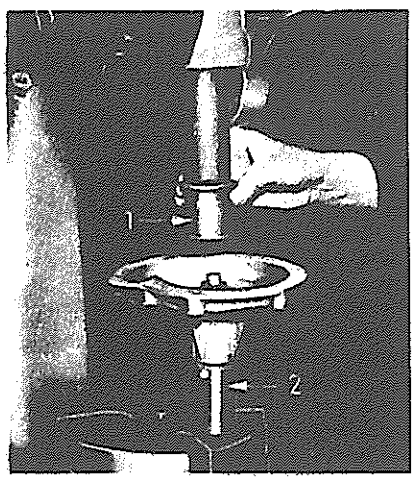


Illust. 191
Pump bearing flush with front face of pump body

Clean and coat the bore of the pump body with engine oil SAE 20 before installing the bearing.

Use an arbor press and suitable mandrel and support sleeve for bearing installation.

Bearing must be flush with body (see arrow Illust. 191).



Illust. 192
Installing packing

1 – Installing sleeve, packing
2 – Support sleeve, body front

When installing spring-loaded packing (4) Illust. 190 and bearing face ring (5) make sure that

a) O-rings (6 and 7) are installed,

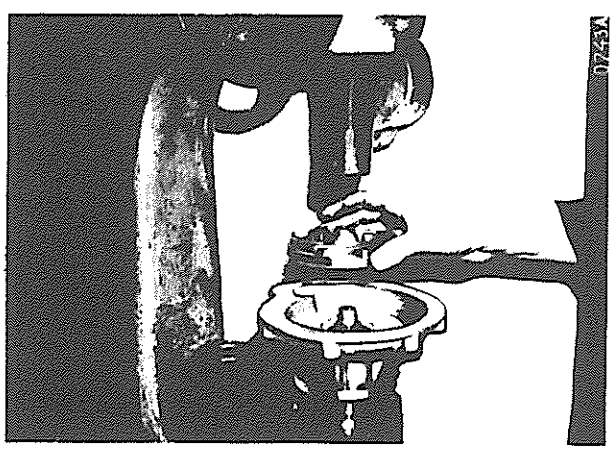
b) packing and face ring are properly seated,

c) sealing faces of packing and face ring are not damaged.

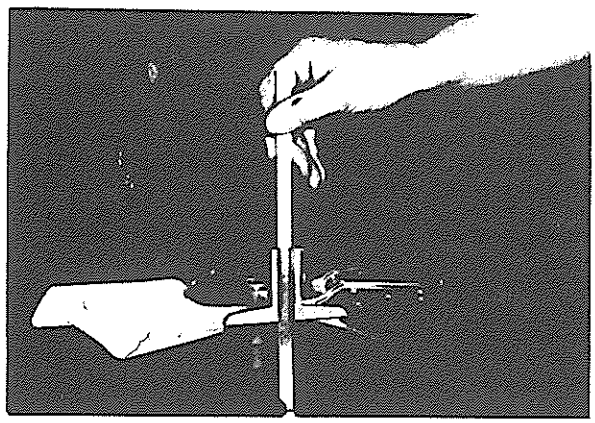
Clerance "A" Illust. 190 must be maintained when pressing on impeller.

To correct clearance, use a 1/2" jack screw as shown in Illust. 186.

Press on hub flush, see "B" Illust. 190.



Illust. 193
Pressing on impeller



Illust. 194
Checking height of blade edges

Clean the fan.
Inspect fan for cracks and distortion. Check to see that all blade leading edges are in line, as shown in Illust. 194.

NOTE: Fans differ in shape of blades, effective diameter, number of blades and direction of air flow; see resp. Parts Catalog.

Check for loosened rivets.

If blades are cracked or distorted, replace the fan with new one.

Max. permissible run-out at the fan blade tip (installed), 1.5 – 2.0 mm (0.06 – 0.08 inch).

Installation

Sealing faces on pump and engine front cover must be clean and even.

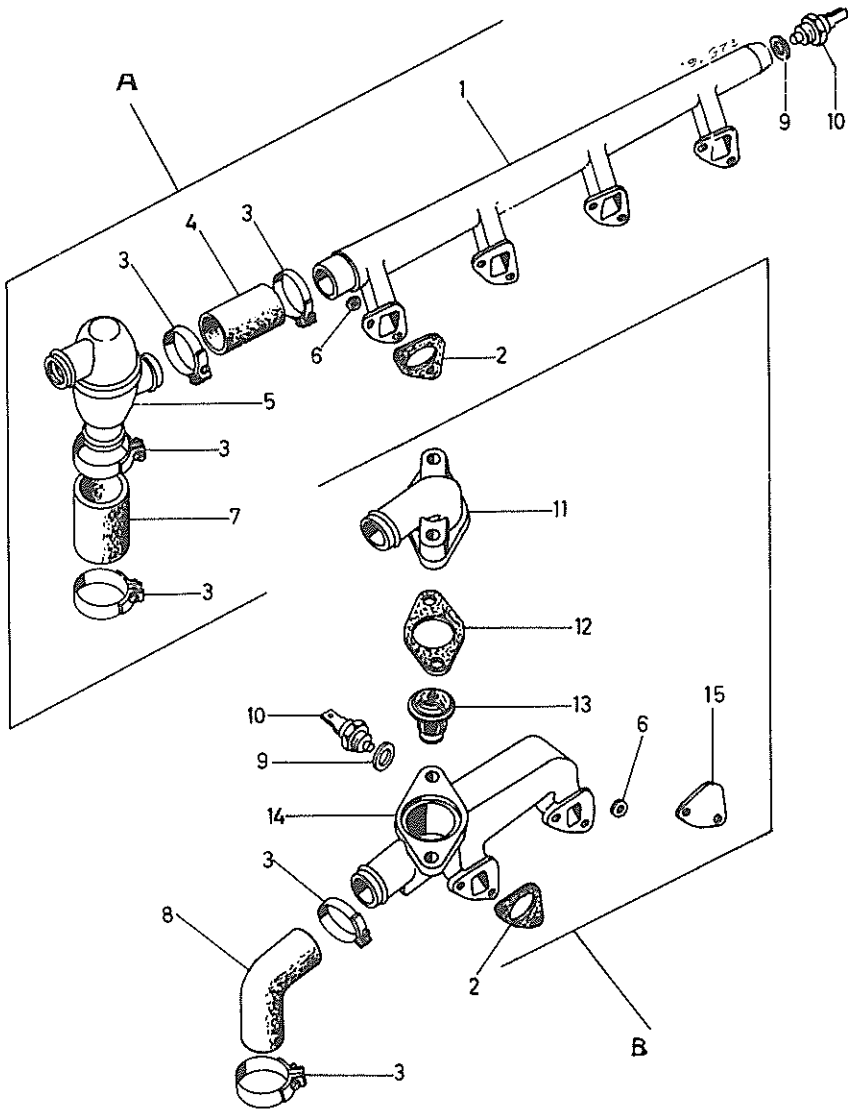
Torque bolts equally and in a crosswise sequence.

Install V-belt pulley, spacer and fan.

Adjust V-belt according to "Operator's Manual".

When using new V-belt inform customer to readjust in time.

THERMOSTAT AND COOLANT MANIFOLD



Illust. 195

A – Long coolant manifold
B – Short coolant manifold

General

Upper and lower section of Illust. 195 show two different versions of thermostat and coolant manifold used at present, see "A" and "B".

The thermostat controls the coolant flow within the engine.

When the thermostat is closed, coolant is circulated by the water pump through the crankcase into the cylinder head and to the water manifold and back to the water pump.

When the thermostat opens, the coolant leaves the cylinder head and water manifold and enters the radiator.

Coolant temperature is controlled by temperature sender unit (10) and transmitted to a temperature gauge on the instrument panel.

Specifications

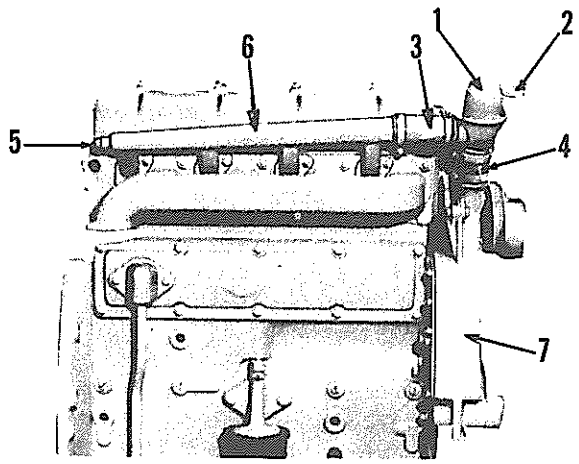
Thermostat (5) Illust. 195

Opening temperature	78–82°C = 172–180°F
Fully open at	88–92°C = 190–198°F
Full stroke	8 – 9 mm = .315–.355"

Thermostat (13)

Opening temperature	80–84°C = 176–183°F
Fully open at	95°C = 203°F
Full stroke	9 mm = .355"

Removal and Disassembly



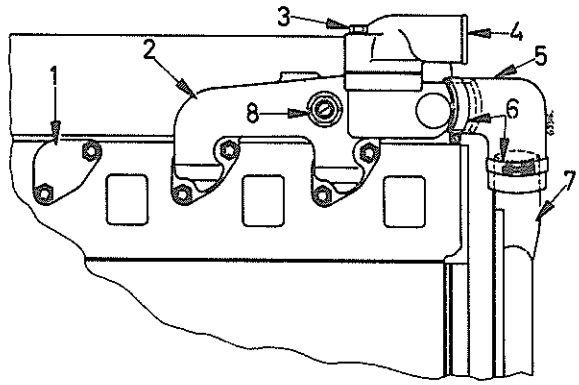
Illust. 196

1 – Thermostat
2 – Connection to radiator
3 – Hose connection to coolant manifold
4 – Hose connection to water channel
5 – Temperature sender unit
6 – Coolant manifold
7 – Water channel (by-pass)

Drain the cooling system. Remove exhaust manifold and coolant manifold.

To remove thermostat (1) Illust. 196 loosen hose clamps of connections (3) and (4).

To remove the thermostat of the short coolant manifold, Illust. 197, remove thermostat housing (4) and lift out the insert.



Illust. 197

1 – Cover
2 – Coolant manifold
3 – Retainer bolts
4 – Housing,thermostat
5 – Connecting hose
6 – Hose clamps
7 – By-pass
8 – Temperature sender unit

Inspection and Repair

Place the thermostat in water. Heat the water and observe opening begin and check if the full stroke of the thermostat is within "Specifications".

Make a similar test with the temperature sender unit. Check the registered temperature on the heat indicator against a reading taken with a reliable thermometer.

Repairs on temperature sender unit and thermostat should not be attempted. In case of failure, unsatisfactory service or damage, replace defective parts with new parts.

Check the coolant manifold for cracks and/or distortion of connecting flanges.

Check all hose connections for cracks and replace brittle parts with new ones.

Installation

Use new gaskets (2) and (12) Illust. 195 for manifold and thermostat.

To obtain a positive earth connection a copper washer (instead of a lockwasher) must be placed under one of the lower stud nuts.

Tighten the temperature sender unit to specified torque.

See "Special Nut and Bolt Torque Data".

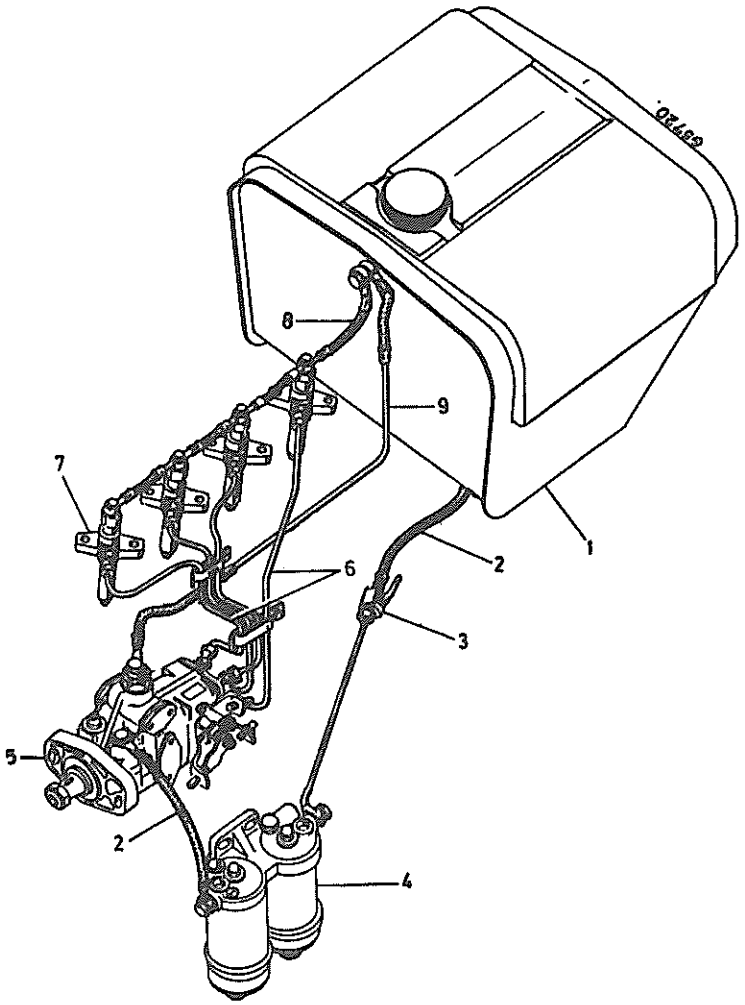
FUEL SYSTEM

NOTE:

> Refer to GSS-1460-3 or ISS-1522-3 for Fuel Injection Pump Test Bench and Fuel Rate Specifications.

INTRODUCTION

This manual contains servicing instructions for Robert Bosch fuel injection pump models EP/VA and EP/VE. Refer to information for appropriate pump model when servicing.



Illust. 198

1 – Fuel tank
2 – Suction lines
3 – Shut-off valve
4 – Dual filter
5 – Injection pump
6 – Injection pipes
7 – Nozzle holder assembly
8 – Fuel return line
9 – Excess fuel return line

General

Illust. 198 shows a typical fuel system with fuel tank located above the injection pump level to provide gravity flow.

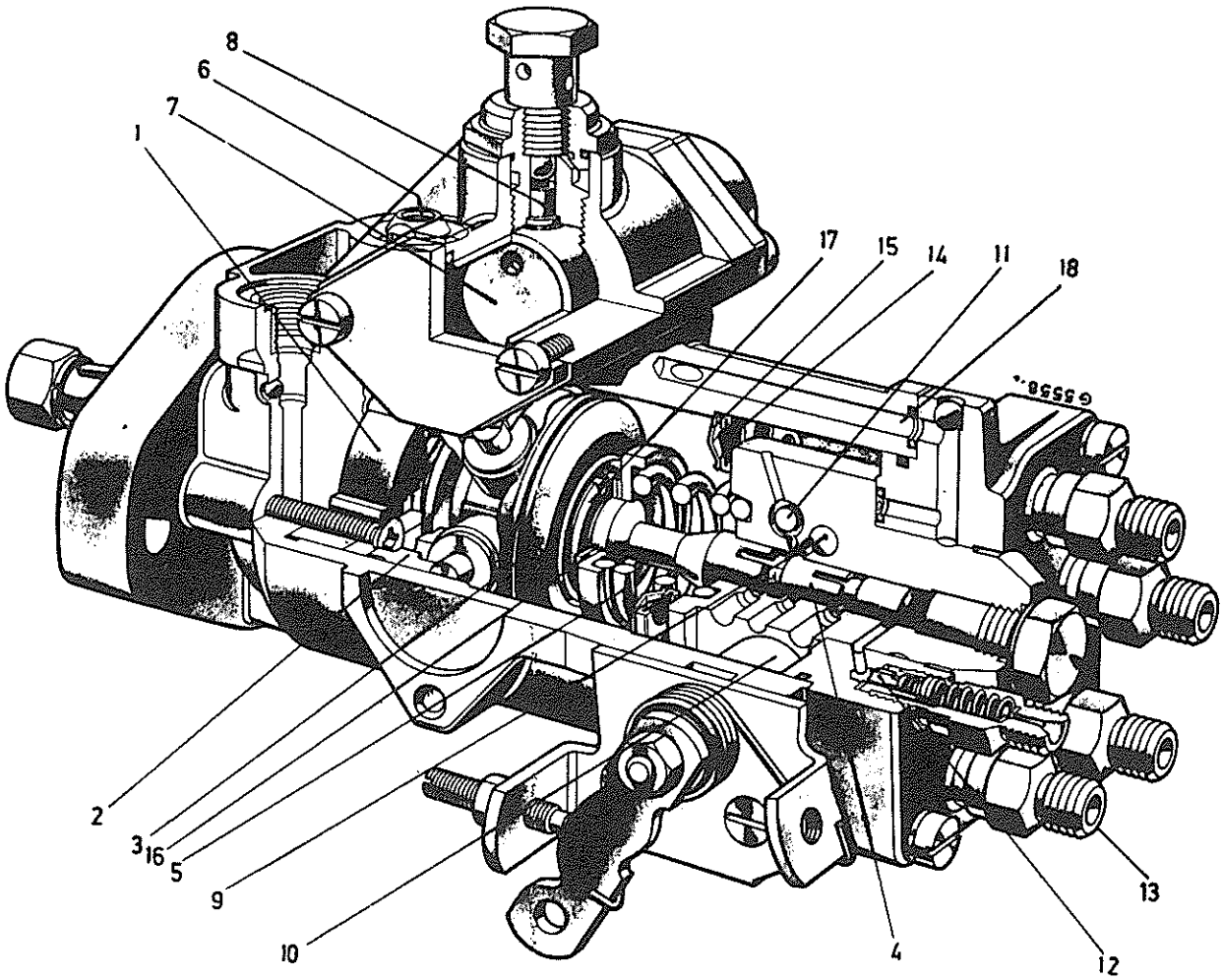
Depending on application, the fuel tank may also be in line or below the injection pump, using a camshaft driven feed pump to ensure a positive fuel supply.

Depending on operating conditions a water trap and a "watch-dog" filter can be installed in addition to the regular filters.

The main units of the fuel system are covered individually in the following.

Engines may also be equipped with "CAV" Pumps. However, this manual does not contain maintenance and servicing instructions regarding "CAV"pumps.

Where necessary, therefore, such information should be obtained from the manufacturer.



Illust. 199

Supply and return fuel

Charging pump pressure

Auxiliary governing circuit

Injection pressure

Legend to Illust. 199:

1 – Charging pump
2 – Roller retainer
3 – Face cam
4 – Distributor plunger
5 – Return spring
6 – Charging pressure regulating valve
7 – Automatic timing device
8 – Fuel return valve
9 – Throttle
10 – Control plunger assembly
11 – Automatic control plunger for excess fuel (turbocharged engines only)
12 – Delivery valve
13 – Holder, delivery valve
14 – Screen
15 – Spring
16 – Shims
17 – Shim

General

The Robert Bosch model EP/VA ... H ... CR ... fuel injection pump is a single plunger, rotary distributor type pump incorporating a hydraulic spill port governor.

A single plunger, actuated by a face cam, pressurizes the fuel in two separate circuits. Primarily, it supplies high-pressure fuel to the nozzles and, secondly, a lower-pressure fuel to an auxiliary circuit for controlling fuel delivery to the engine. At the same time, rotation of the plunger distributes pressurized fuel from the primary circuit to the individual nozzles.

The accessory units, such as the hydraulic governor, charging pump, and automatic timing device are located inside the pressurized fuel filled housing.

The main component parts of the pump are:

1. Charging pump (1) Illust. 199, charging pump pressure regulating valve (6), and fuel return valve (8).
2. Automatic timing device (7) consisting of a spring-loaded piston, roller retainer (2), and connecting pin.
3. Hydraulic head, housing the mated distributor plunger (4) and the hydraulic governor, the latter consisting of throttle (9), control plunger (10), control plunger spring (21) Illust. 200, check valve (19), and delivery valves (12) Illust. 199.

Principle of Operation

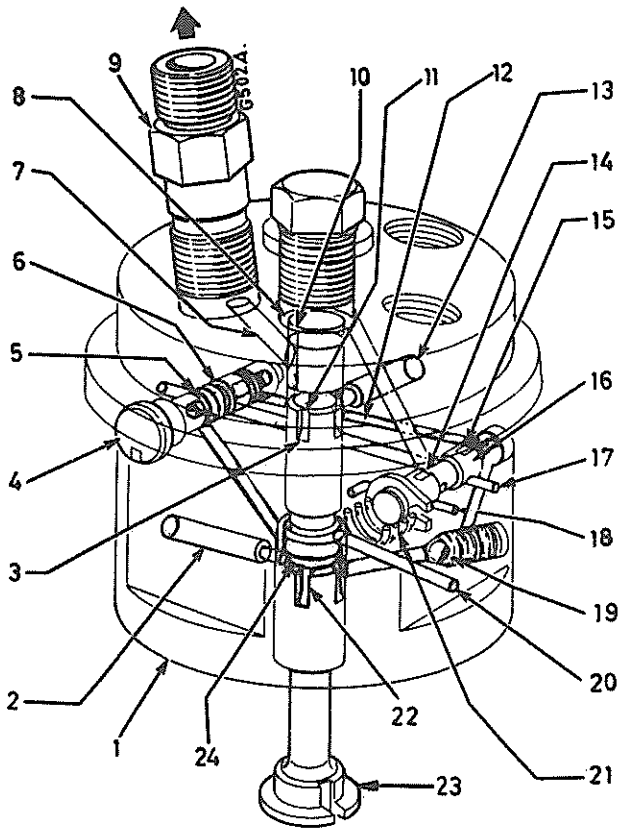
Charging Pump

The vane type charging pump (1) Illust. 199 having six steel vanes, is built around the drive shaft. The capacity of the charging pump is greater than the requirements of the engine. The excess fuel is used to cool and lubricate the pump and is recirculated to the fuel tank. Charging pump pressure is controlled by a pressure regulating valve (6). Pump output is exposed to the automatic timing device (7) and to the charging chamber around the hydraulic head. Charging pump pressure will vary with the speed of the engine.

Automatic Timing Device

Automatic timing advance is accomplished by the rotation of the cam roller retainer. Charging pump fuel pressure is exposed to one end of the spring loaded advance piston (7). As the pressure increases, due to an increase in pump speed, the piston moves over against the pressure of the advance spring. This rotates the roller retainer (2) in the advance direction.

Hydraulic Head



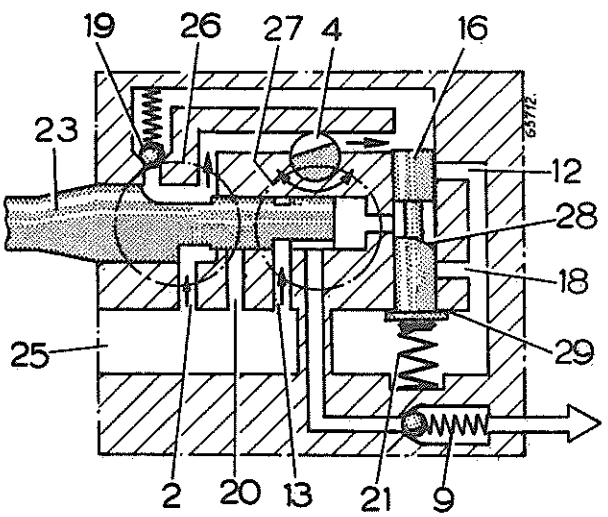
Illust. 200
Phantom view of hydraulic head

Injection pressure

Auxiliary governing circuit

Charging pump pressure

1 – Hydraulic head
2 – Filling port, auxiliary circuit
3 – Filling groove
4 – Throttle
5 – Throttle flow area
6 – Throttle compensating area
7 – Outlet port
8 – Delivery valve, pressure chamber
9 – Outlet nipple with delivery valve
10 – Distributing groove
11 – Annulus, upper
12 – Overflow passage
13 – Filling passage, upper
14 – Stop slot
15 – Restriction
16 – Control plunger
17 – Spill port for maximum control plunger lift
18 – Spill port for end of delivery
19 – Check valve
20 – Spill port, auxiliary circuit
21 – Control plunger spring
22 – Control groove
23 – Plunger
24 – Annulus, lower



Illust. 201
Distributor plunger (23) in BDC

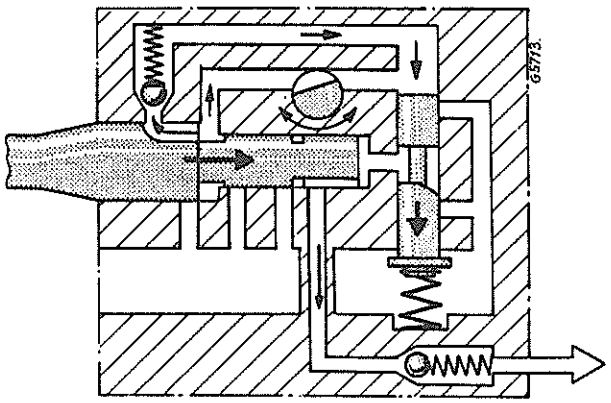
For legend 1–24 refer to Illust. 200

25 – Charging pump circuit
26 – Auxiliary governing circuit pump
27 – Injection circuit pump
28 – Control helix of the control plunger
29 – Mechanical control plunger stop

BDC – Position of the Distributor Plunger

The inner pump housing, the governing – and injection circuits – are under charging pump pressure, Illust. 201.

Fuel Delivery

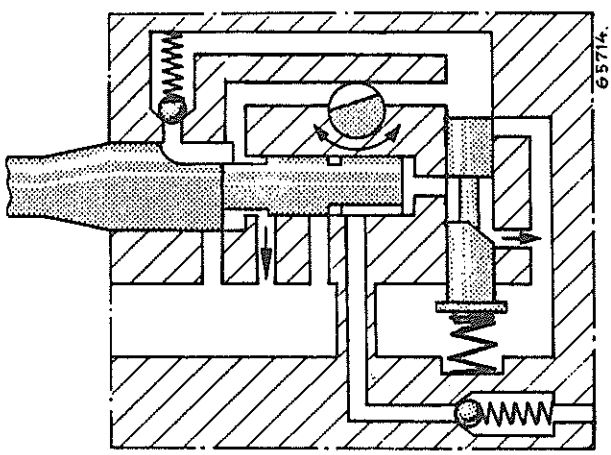


Illust. 202

a) On the injection stroke, fuel in the injection circuit (27) Illust. 201 is pressurized and directed by the distributing groove through the various outlet ports to the individual delivery valves (9).

b) Fuel in the governing circuit (26) is also pressurized and directed via throttle (4) and check valve (19) behind the control plunger (16) and forces the latter against control plunger spring (21). See also Illust. 202.

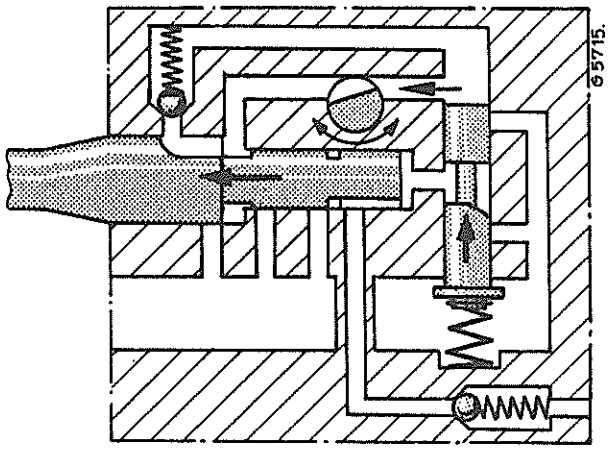
End of Fuel Delivery



Illust. 203

The end of fuel delivery is reached as soon as helix (28) Illust. 201 of the control plunger clears the spill port (18). See also Illust. 203.

Return Stroke

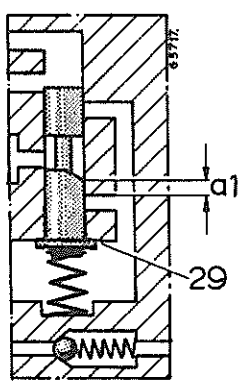


Illust. 204
Distributor plunger in TDC

On the plunger return stroke check valve (19) Illust. 201 and delivery valve (9) are closed.

Control plunger spring (21) forces control plunger (16) against its mechanical stop (29) displacing governor circuit fuel via throttle (4).
See also Illust. 204

Max. Torque

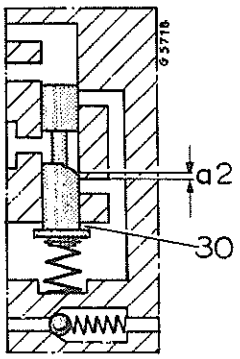


Illust. 205

a1 – Control plunger travel at max. torque
29 – Mechanical stop

At maximum torque the control plunger is using its full stroke (a1) Illust. 205 returning to its mechanical stop (29) every time.

Partial Load

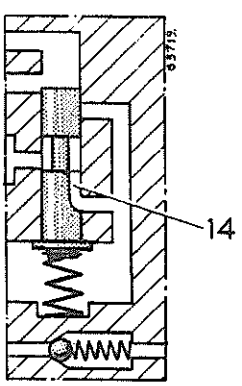


Illust. 206

a2 – Control plunger travel at partial load
30 – Hydraulic stop

In partial load position the return flow of fuel in the governing circuit is restricted by helixes on the throttle. This creates a hydraulic stop (30) Illust. 206 resulting in a minor travel (a2) of the control plunger to end fuel delivery.

Stop Position

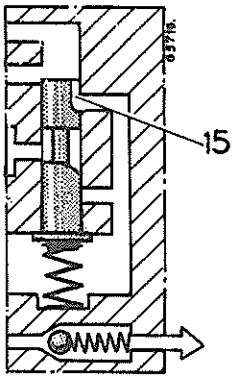


Illust. 207

14 – Stop slot of the control plunger

By rotating the control plunger to stop position the stop slot (14) Illust.207 is brought into alignment with the spill port (18) Illust. 200. This connects high pressure circuit to the inner pump housing stopping all injection.

Excess Fuel for Starting

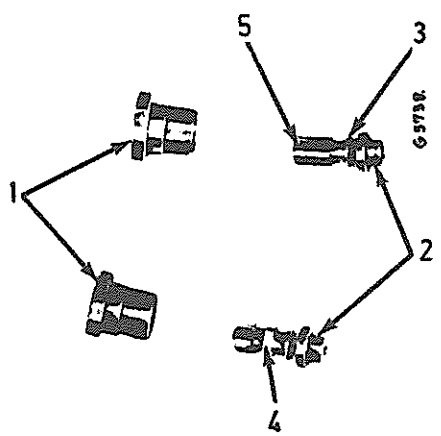


Illust. 208

Fuel delivery is at its maximum when the control plunger is rotated so that it does not open the high pressure circuit, that is, when there is no reciprocating movement of the control plunger. To accomplish this, a restriction (15) Illust. 208 on the control plunger travels across the passage between the plunger section for the auxiliary fuel circuit and the charging chamber. This keeps the passage open for excess starting fuel. For starting, the operator manually holds the control plunger in the excess-fuel-for-starting position.

When the engine starts and attains sustaining speed, the auxiliary fuel quantity is increased to a point where it no longer can be returned through the restriction (15) Illust 200 and the throttle helix (6). Pressure builds up behind the control plunger and the plunger starts reciprocating, thus reducing the fuel quantity by spill port action, even if the control lever is not immediately returned to the normal operating position.

Delivery Valves



Illust. 209

1 – Seat and guide
2 – Valve
3 – Retraction land
4 – Torque land with flat
5 – Identification number

The delivery valves (Illust. 209) are designed to furnish line retraction and torque rise as needed for good performance. The delivery valve and its seat are a selective fit and must not be interchanged.

All valves are identified with a number imprinted on the outside of the valve seat or on the flutes of the valve. Some have only the last six numerals of the complete number.

All valves have a retraction land, and some also have flats on the lands. The size of the flats, plus engine speed and fuel rate are considerations in determining the injection line "leak back" or line retraction.

Some valves have a torque land while others have not. If the valve has a torque land, it will have at least one flat. The presence or absence of a torque land, the number and size of the flats, plus fuel rate and engine speed are design considerations in providing the fuel delivery differential for overload torque rise.

Checks and Adjustments

Low and High Idle

1. Start the engine and disconnect the throttle linkage as soon as the engine is hot.

2. Loosen the low idle screw locknut and adjust the screw in or out until specified low idle rpm is reached. Use a portable tachometer to read the rpm. Refer to "Specifications" for correct rpm in Service Manual GSS-1460-3 or ISS-1522-3.

3. Secure the locknut and recheck rpm.

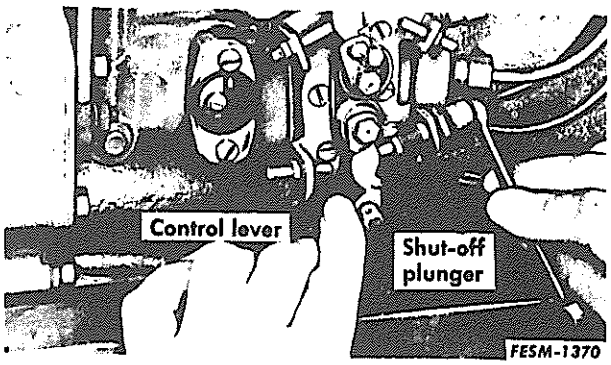
4. To adjust high idle, hold the throttle lever against the high idle stop with a large rubber band or O-ring. Loosen the locknut and adjust the screw in or out until the correct rpm is reached. Refer to "Specifications" for correct speed.

5. When correct rpm is reached, secure locknut. Recheck high and low idle and correct as necessary.

Start and Stop Position Adjustment

1. Disconnect the shut-off cable. Loosen the locknut on the shut-off plunger, see Illust. 210. Back the stop out several turns.

2. With the engine running at approx. 900 rpm, move the control lever rearward until engine speed increases. Turn the stop in until the plunger just contacts the lever, see Illust. 210. Recheck several times.



Illust. 210
Setting excess fuel for starting

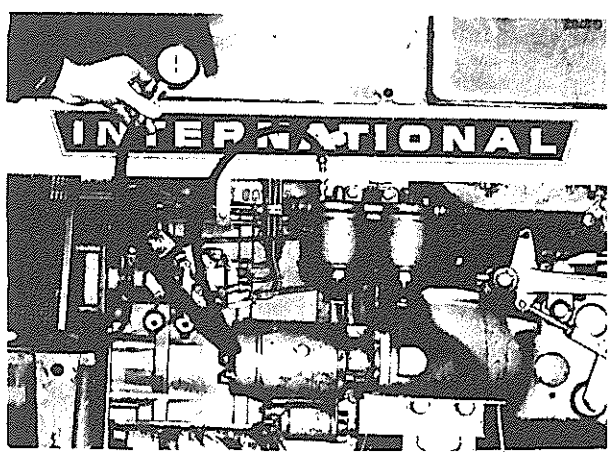
If the control lever is moved slowly rearward, the engine may die before this position is reached.

3. Move the control lever fully rearward to depress the plunger. The engine must shut off at all throttle settings. Check for shut-off at high idle Readjust if necessary.

4. Be certain the cable works freely before reconnecting to the control lever.

Note: Power output adjustment, see Illust. 221.

Fuel Supply Pressure



Illust. 211
Vacuum gauge installed

Install a vacuum gauge of -0.1 to +0.15 MPa (-14 to +21 PSI) range, as shown in Illust. 211.

With engine warm and running at rated load speed, the vacuum reading should not exceed -0.02 MPa (-2.8 PSI).

Otherwise, check for restricted fuel filters, shut-off valve and/or supply line.

Charging Pump Efficiency

To check charging pump effeciency install a vacuum gauge as shown in Illust. 211.

With engine running at high idle speed close the shut-off valve.

Before the engine dies, take a vacuum reading which should be 0.06–0.08 MPa (8 to 11 PSI).

Note: If, after the engine has died, the pointer of the gauge drops to zero too quickly, check the shut-off valve and the fuel supply line for possible leaks. Remedy the fault and recheck charging pump efficiency.

Charging Pump Pressure and Automatic Timing Device

Recommended equipment:

Precision tachometer, 0 – 3000 rpm
Precision pressure gauge, 0 – 1.5 MPa (0 – 210 PSI)
Timing Piston Gauge, R. Bosch order number 1688 130 121 and Intermediate Mounting Flange R. Bosch number 1 685 700 104.
Roll pin removing tool, R. Bosch order number KDEP 1027 or Puller PLT-356-6
Home made regulating valve adjusting tool, as shown in Illust. 223.

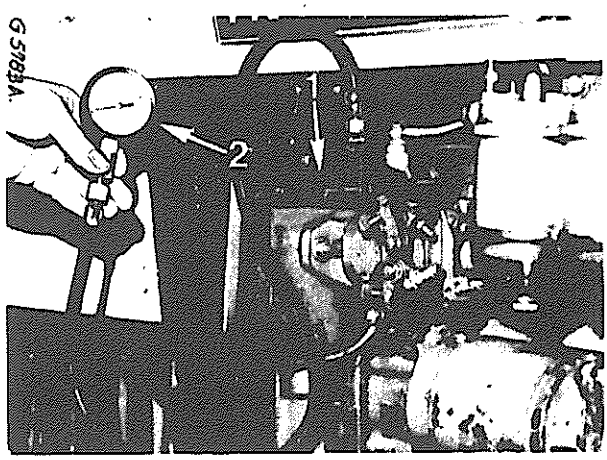
A) Charging Pump Pressure

Close fuel shut-off valve.

Remove cover plate at timing advance piston.

Install timing gauge (1) and pressure gauge (2), Illusts. 212 and 213. See Note.

Open the fuel shut-off valve.



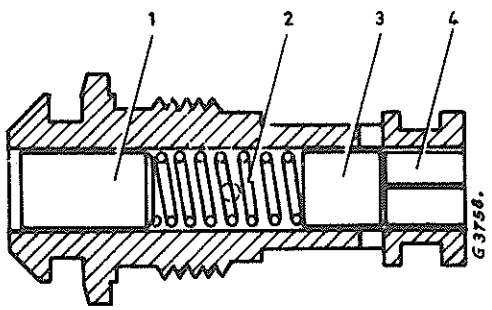
Illust. 212/213

1 – Timing gauge
2 – Pressure gauge, 0–1.5 MPa (0–210 PSI)

Start the engine and check charging pump pressure at minimum overload speed and rated load speed. Refer to "Specifications". It is necessary to load the engine when making these checks. These Figures are located in Service Manual GSS-1460-3 or ISS-1522-3.

To increase charging pump pressure place the adjusting tool (Illust. 223) onto the head of the regulating valve (6) Illust. 199 and carefully turn its spindle clockwise while the engine is running.

If the adjusting tool is not available "tap" in the plug (1) Illust. 214 to increase charging pump pressure.



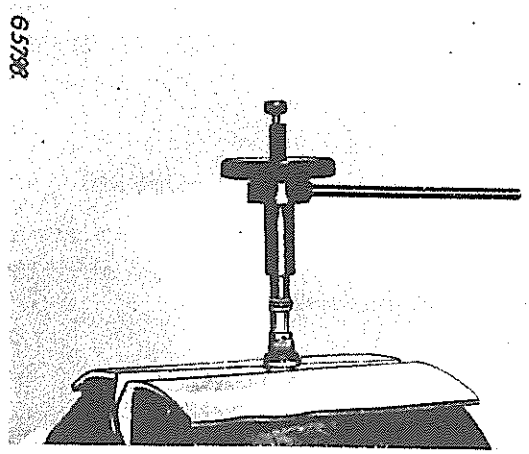
Illust. 214
Cross section of regulating valve

1 – Plug
2 – Spring
3 – Piston
4 – Roll pin

To reduce charging pump pressure remove the regulating valve and proceed as follows:

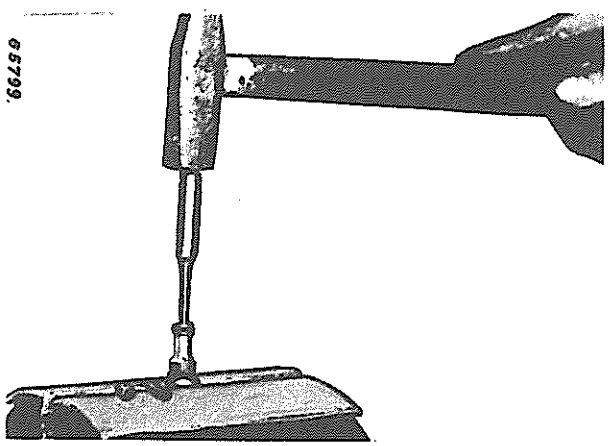
Pull out the roll pin (4) Illust. 214, using Bosch tool KDEP 1027, Illust. 215.

Roll pin can be removed using puller tool PLT-356-6. Force puller end of tool through roll pin until it compresses the spring enough to expand the puller. Then tap roll pin out with the slide hammer.



Illust. 215
Removing roll pin (4) Illust. 214

Remove piston (3) and spring (2) Illust. 214 and "tap" the plug (1) outwards, as shown in Illust. 216.



Illust. 216
"Tapping" back plug (1) Illust. 214

NOTE to Timing Gauge:
Instead of using Robert Bosch Timing Piston Gauge to adjust charge pump pressure install timing window adapter PLT-356-1 and timing window PLT-357-5.

Also install charge pressure plate adapter PLT-356-2, snubber PLT-860-6 and a 0-150 psi gauge PLT-354.

When reinstalling the regulating valve be sure the roll pin is flush with the valve body.

B) Automatic Timing Device

Install the timing gauge (1) Illust. 212/213.

Before checking timing device operation be sure that:

a) Engine is at operating temperature

b) Charging pump pressure is within "Specifications".

Run the engine and note the advance piston travel readings at minimum overload engine speed and at full injection pump advance.

Compare the readings with "Specification" in Service Manual GSS-1460-3 or ISS-1522-3.

To adjust advance piston travel, remove injection pump from the engine.

Increase the shimming behind the advance piston spring to retard timing, decrease shims to advance timing.

Note to A and B: If adjustments as outlined above are not successful, the injection pump must be repaired.

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Flow Bench Testing

The necessary drive and fitting adapters have been made available to connect the Robert Bosch EP/VA series injection pumps to the Bacharach test stand.

This manual ***will not*** attempt to instruct the servicemen on operating the test bench. This must be obtained from the supplier of that equipment.

Prior to Test

Make the necessary connections and run the pump to purge the air from the lines and pump housing.

Adjust the supply pump on the test bench to furnish specified pressure.

Test Conditions

Test oil	OL 61 v 11 (R. Bosch) or Shell calibration fluid B
Test oil temperature	40–45°C (104–113°F)
Supply pressure	2 kPa (2.8 PSI)
Nozzle holder (R. Bosch)	EP 8511/9
Nozzle (R. Bosch)	EF EP 182
Nozzle opening pressure for checking excess fuel for starting	15 MPa (2133 PSI) 20 MPa (2844 PSI)
Fuel injection pipes	6x2x840 mm (.236x.078x33")

Maximum Fuel Delivery

Maximum fuel delivery must be adjusted on loaded engine. There are two methods of loading the engine.

a) with a dynamometer, measuring horse power.

b) with a hydraulic loading valve, measuring fuel consumption.

We are not observing horse power here, we are only setting the injection pump to deliver the specified amount of fuel, which should result in correct horse power.

While a) generally requires that the engine is removed from the machine b) is generally applied when only the injection pump has been taken down and the engine remained "in situ".

As a) is generally known only b) is described here.

Warning: Do not attempt to reset the injection pump at random since overfueling and uncontrolled horsepower above specified limits are dangerous.

Before setting the injection pump be sure to check the following:

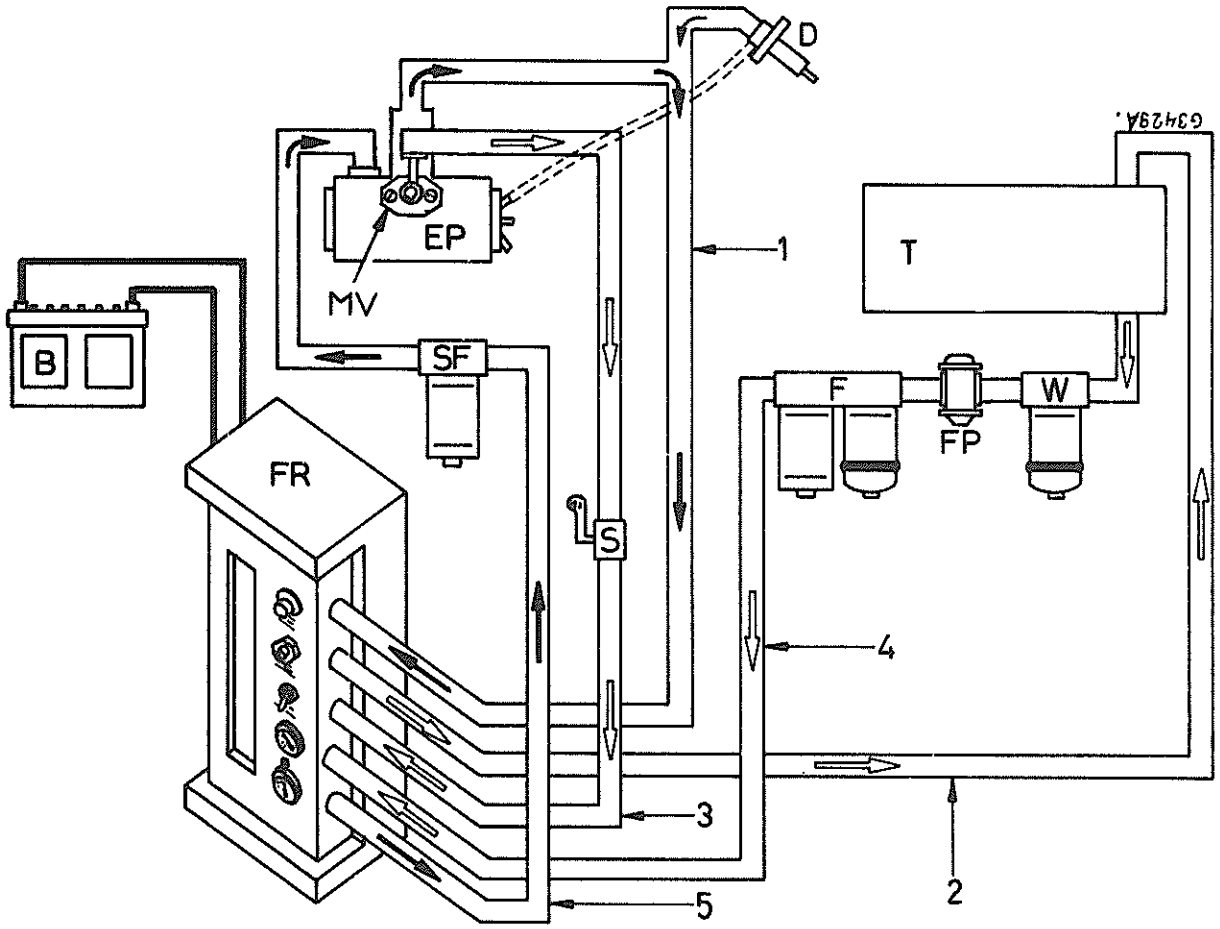
Engine and Nozzles

1. Air cleaner restriction
2. Compression
3. Blow-by
4. Nozzle opening pressure) (nozzle
5. Nozzle leakage) mounted)
6. Delivery valve leakage)
7. High idle rpm
8. Lubricating oil pressure
9. Fuel temperature
10. Operating temperature
11. Valve clearance
12. Static timing

Injection Pump

13. Supply pressure
14. Charging pump efficiency and pressure
15. Timing advance

Note: Power output adjustment, see Illust. 221.



Illust. 217
Fuel rator hook up

Install the fuel rator, F ES 97-1, using the following fittings and hoses: (see Illust. 217)

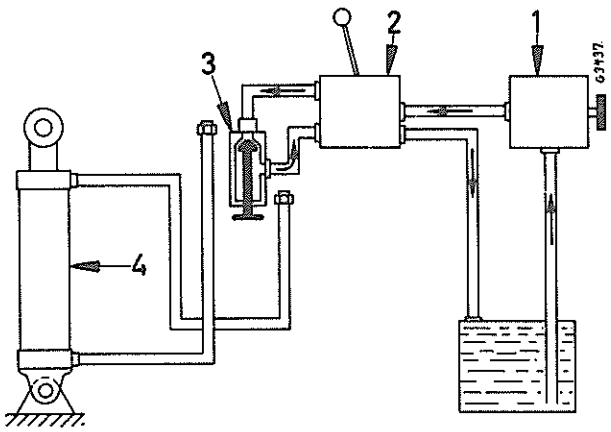
1 — Fuel return in	F ES 97 - 27 connector
	F ES 97 - 7 hose
2 — Fuel return out	F ES 97 - 28 connector
	F ES 97 - 7 hose
3 — Transfer pump	F ES 97 - 29 adapter
	F ES 97 - 6A hose
4 — Fuel supply in	F ES 97 - 21 connector
	F ES 97 - 6 hose
5 — Fuel supply out	F ES 97 - 20 connector
Phantom arrow = warm up	F ES 97 - 21 connector
Full arrow = warm up and test	F ES 97 - 6 hose

B = Battery 12 V
D = Injection nozzle
EP = Injection pump
F = Fuel filters
*FP = Feed pump
FR = Fuel rator
S = Shut-off valve
*SF = Safety filter (watchdog)
T = Tank fuel
*W = Water trap
MV = Timing gauge 3 144 778 R2

* = if so equipped

For further details on Fuel Rator method refer to pamphlet "GSS 1393 Measuring Fuel Consumption on Diesel Engines".

Testing for Fuel Consumption using the Hydraulic System to Load the Engine.



Illust. 218

1 – Hydraulic pump
2 – Control valve
3 – Loading valve (restriction control)
4 – Power cylinder (disconnected)

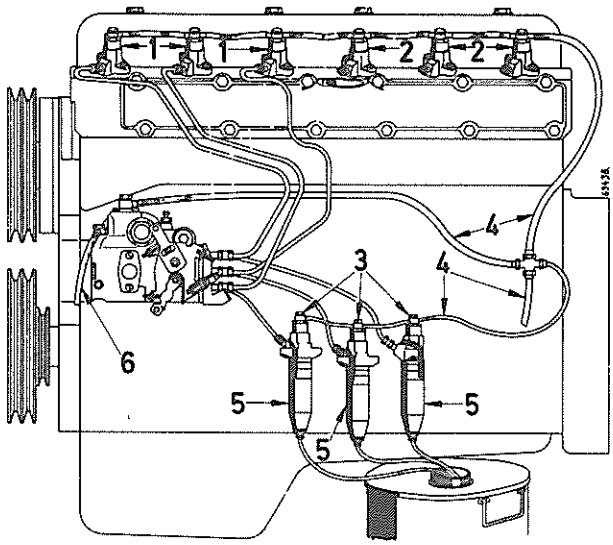
Schematic view of hydraulic loading valve method (can only be applied with diverter method Illust. 219 or 220).

For starting and warm-up loading valve (3) Illust. 218 is wide open, then put the system on demand with control valve (2) and adjust engine speed at full throttle by loading the hydraulic system, i.e. gradually closing loading valve (3).

Consumption of active nozzles (1) Illust. 219 and diverter nozzles (3) is measured in the Fuel Rator.

After warm-up, adjust loading valve to the required rpm speed and hold test lines (10) Illust. 220 (not line (7)) into measuring glass (9) for a specified time controlled with stop watch (8).

Note: As only three (two) nozzles are used in this test either the time factor or the quantity measured must be multiplied by 2 to obtain actual consumption.



Illust. 219
Diverter method, using Fuel Rator and hydraulic loading valve

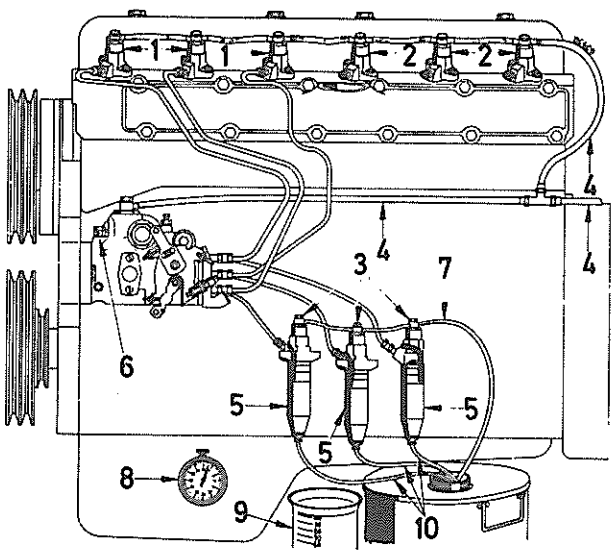
1 – Active nozzles, cyl. 1-3 (cyl 2 and 3 *)
2 – Dead nozzles, cyl. 4-6 (cyl 1 and 4 *)
3 – Diverter nozzles
4 – Return line to Fuel Rator
5 – Spray screen
6 – Inlet from Fuel Rator

* = On 4-cylinder engines

Load the engine with the loading control valve or dynamometer until engine rpm drops to rated speed.

Check fuel consumption with the Fuel Rator at rated load speed. Readjust the maximum fuel stop screw (Illust. 221) as necessary to obtain specified fuel consumption, keeping rpm at rated speed with the loading valve. **Refer to "Specifications" in Service Manual GSS-1460-3 or ISS-1522-3.**

When specified fuel consumption is obtained, check the fuel consumption at 100 rpm below rated load speed. The fuel consumption must show a decrease as is stated in "Specifications". If this does not occur, check for improper control plunger spring or replace spring.



Illust. 220
Diverter method using measuring glass
and hydraulic loading valve

1 — Active nozzles, cyl 1-3 (cyl 2 and 3 *)
2 — Dead nozzles, cyl 4-6 (cyl 1 and 4 *)
3 — Diverter nozzles
4 — Return line to fuel tank
5 — Spray screen
6 — Injection pump
7 — Leak line from diverter nozzles
8 — Stop watch
9 — Graduated measuring glass
10 — Test lines

* = on 4-cylinder engines

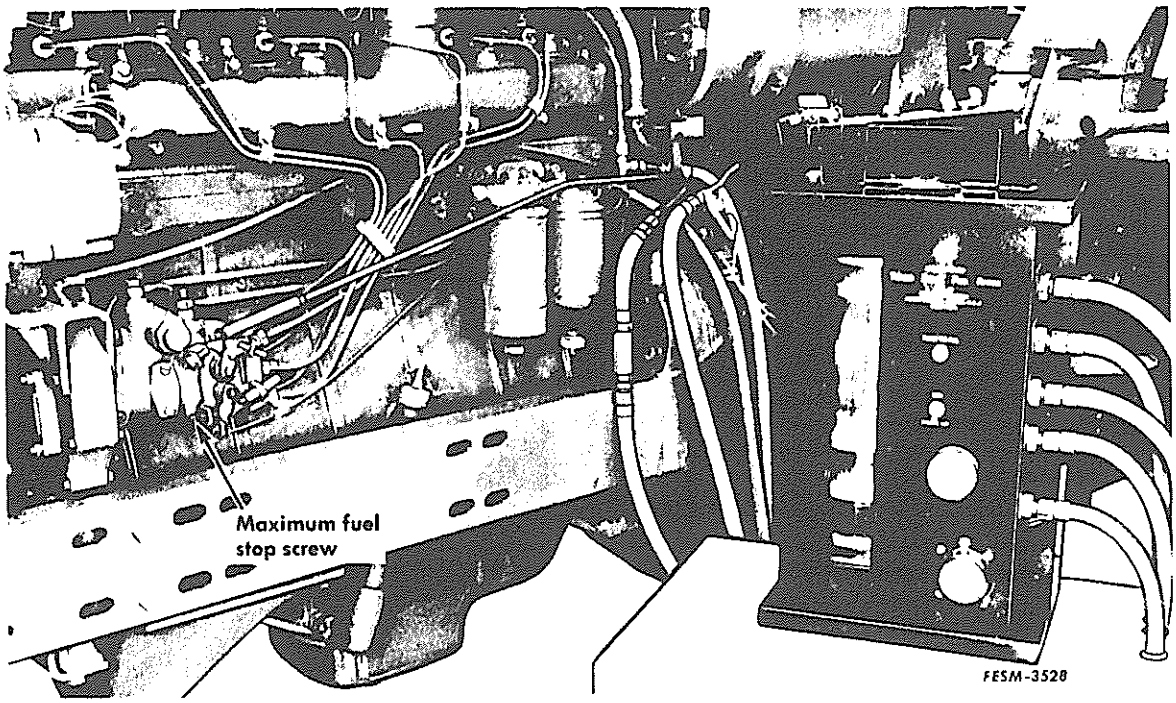
Increase load on engine until overload is reached. Check fuel consumption at minimum overload speed. Never adjust the fuel stop screw in excess of the specified maximum in an attempt to rectify poor engine performance. Apart from excessive fuel consumption the condition of the engine would deteriorate rapidly due to the additional load.

Adjusting Power Output

To increase power output turn the maximum fuel stop screw (Illust. 221) counter clockwise, while keeping the engine test rpm constant with the dynamometer or loading device (3) Illust. 218.

To reduce power output turn the screw in respectively.

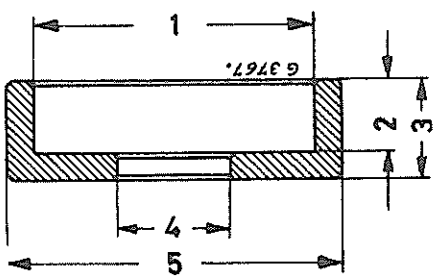
Tighten the lock nut of the stop screw after adjustment is made.



Illust. 221
Adjusting maximum fuel delivery, typical
injection pump "BR" shown.

Servicing "CR" Fuel Injection Pump

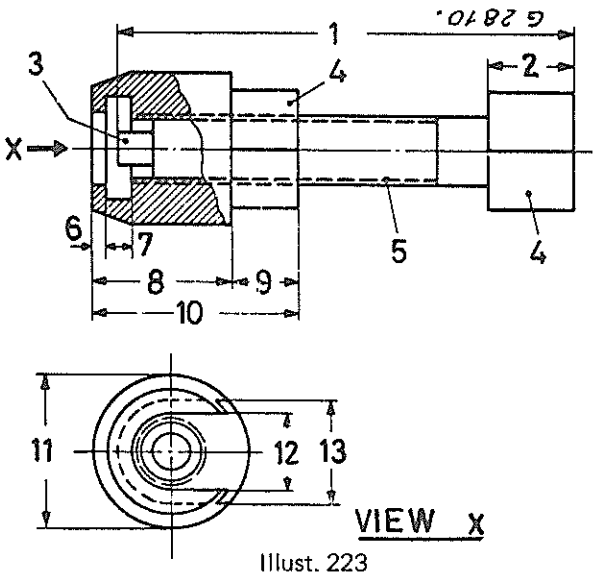
The following tools are recommended to be made locally for servicing the fuel injection pump.



Illust. 222
Container for storing charging pump rotor assy

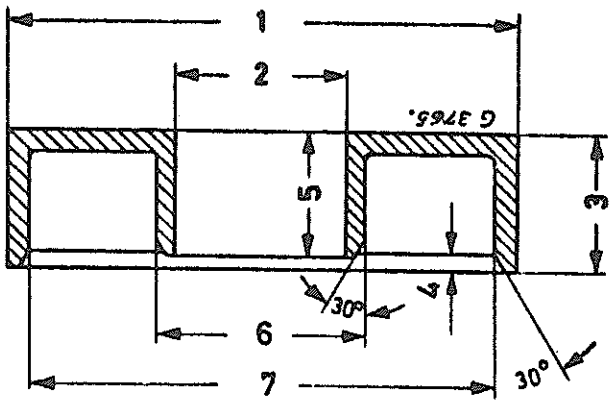
Material: Hard wood or alu

1 – 42 mm = 1.654" Dia
2 – 11 mm = .42 "
3 – 15 mm = .59 "
4 – 18 mm = .71 " Dia
5 – 50 mm = 2" Dia



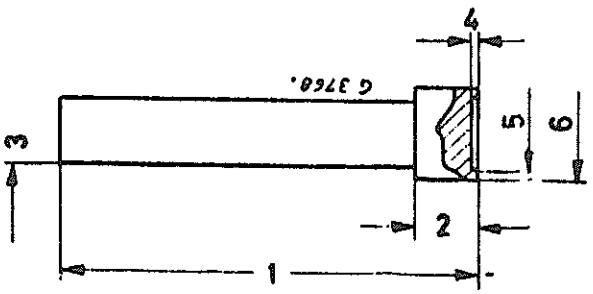
Illust. 223
Charging pump pressure setting tool
Material: Steel

1 – 70 mm = 2.76 "
2 – 12 mm = .50 "
3 – 5 mm = .197" Dia and
6 mm = .24 " long
4 – 5/8" wrench
5 – 3/8" thread
6 – 2 mm = .08 "
7 – 3.5 mm = .14 "
8 – 20 mm = .79 "
9 – 10 mm = .395"
10 – 30 mm = 1.18 "
11 – 21 mm = .83 " Dia
12 – 10.5 mm = .413"
13 – 15 mm = .59 "



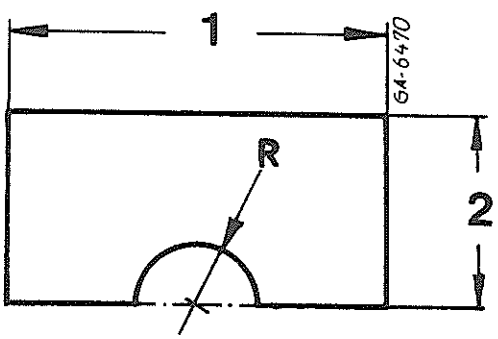
Illust. 224
Container for storing roller retainer assembly,
Material: Hard wood or plastic.

1 – 74 mm = 3 " Dia
2 – 25 mm = 1 " Dia
3 – 20 mm = .80 "
4 – 2 mm = .08 "
5 – 18 mm = .71 "
6 – 30 mm = 1.18 " Dia
7 – 68 mm = 2.68 " Dia



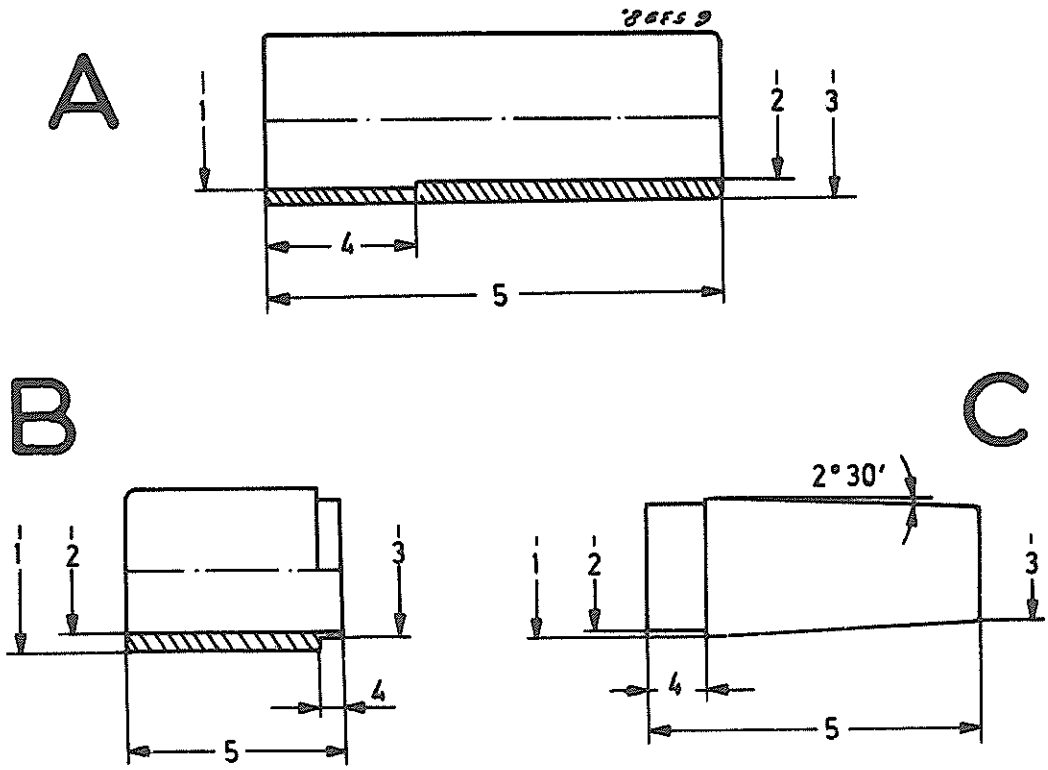
Illust. 226
Alignment tool, hydraulic head
Material: Mild Steel

1 – 76.0 mm = 3"
2 – 11.0 mm = .43"
3 – $\frac{12.90 \text{ mm}}{13.00 \text{ mm}} = \frac{.508"}{.512"}$ Dia
4 – 0.5 mm = .02"
5 – 15.0 mm = .59" Dia
6 – $\frac{17.5 \text{ mm}}{17.7 \text{ mm}} = \frac{.689"}{.697"}$ Dia



Illust. 225
Protection sheet, used for snap ring removal
(two required)
Material: Alu, 1 mm (.04") thick

1 – 50.8 mm = 2"
2 – 25.4 mm = 1"
R – 8.6 mm = .34"



Illust. 227
Drive shaft snap ring installing tool
Material: Steel

A – Bushing

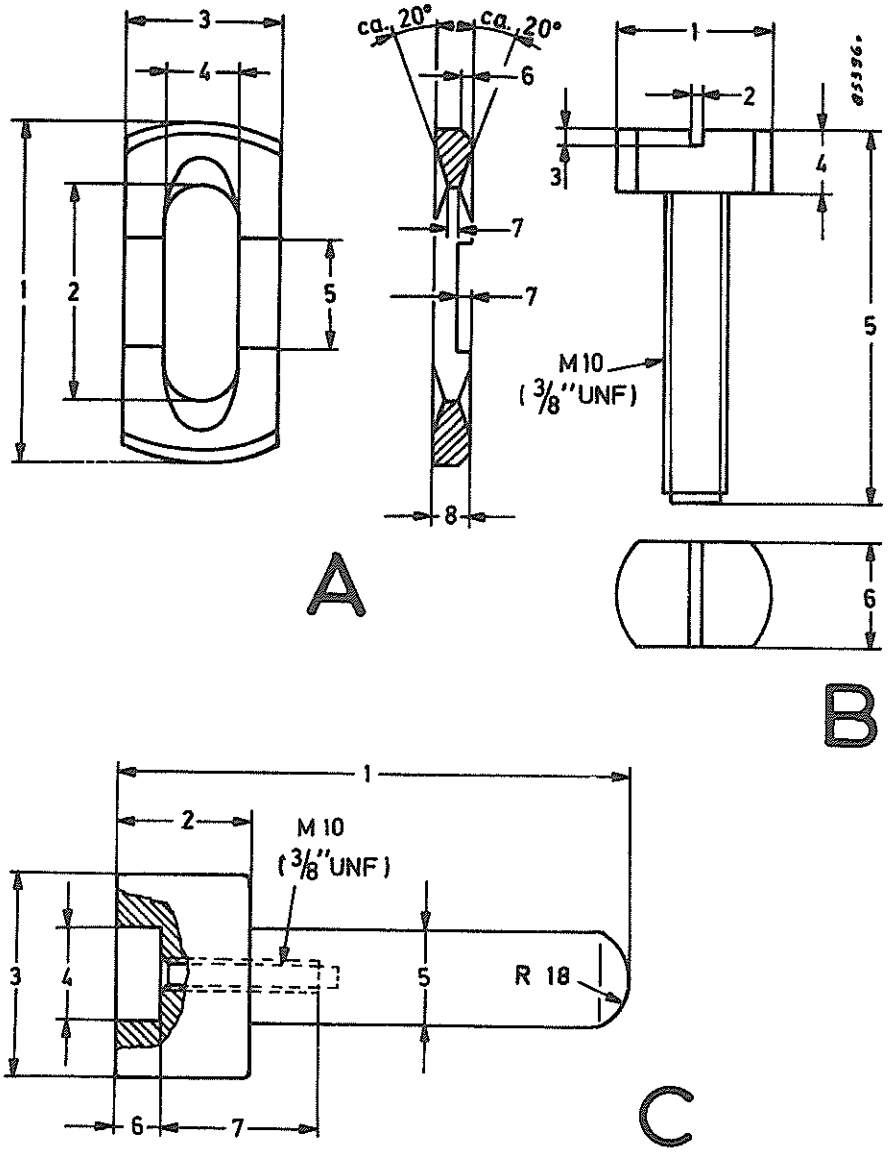
1 – 18.1 mm = .713" Dia
2 – 17.5 mm = .689" Dia
3 – 22.0 mm = .86 " Dia
4 – 20.0 mm = .79 "
5 – 60.0 mm = 2.36 "

B – Bushing

1 – 22.0 mm = .86 " Dia
2 – 17.1 mm = .673" Dia
3 – 18.0 mm = .71 " Dia
4 – 3.0 mm = .12 "
5 – 28.0 mm = 1.10 "

C – Cone

1 – 18.0 mm = .71 " Dia
2 – 16.9 mm = .665" Dia
3 – 15.0 mm = .59 " Dia
4 – 8.0 mm = .32 "
5 – 44.0 mm = 1.73 "



Illust. 228
Eccentric race removing tool

A – Plate
Material: Steel

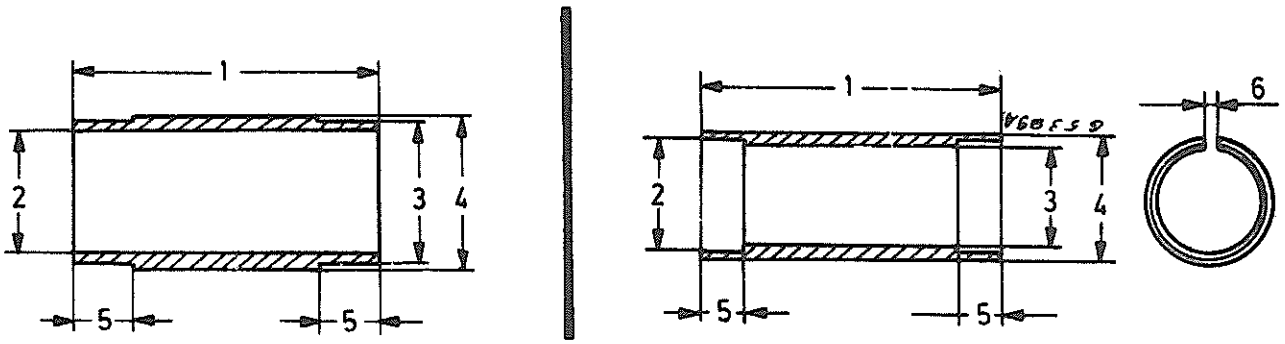
1 – 55.0 mm = 2.15 "
2 – 34.0 mm = 1.34 "
3 – 25.0 mm = 1.0 "
4 – 10.5 mm = .413"
5 – 17.5 mm = .69 "
6 – 2 x 45° = .08 " x 45°
7 – 2.0 mm = .08 "
8 – 5.0 mm = .20 "

B – Bolt
Material: Steel

1 – 25.0 mm = 1.0 "
2 – 2.0 mm = .08 "
3 – 2.5 mm = .10 "
4 – 10.0 mm = .40 "
5 – 60.0 mm = 2.4 "
6 – 17.0 mm = .67 "

C – Handle
Material: Hardwood or Alu.

1 – 165.0 mm = 6.5 "
2 – 43.0 mm = 1.7 "
3 – 65.2 mm = 2.567"
4 – 29.9 mm = 1.177"
5 – 30.0 mm = 1.2 "
6 – 15.0 mm = 6 "
7 – 50.0 mm = 2.0 "



Illust. 229
Telescopic tool for determining control plunger spring shim thickness
Material: Steel

LH

1 – 19.5 mm = .77 "
2 – 8.00 mm / 8.01 mm = .315 " / .3154" Dia
3 – 9.4 mm = .37 " Dia
4 – 10.0 mm = .394" Dia
5 – 4.0 mm = .16 "

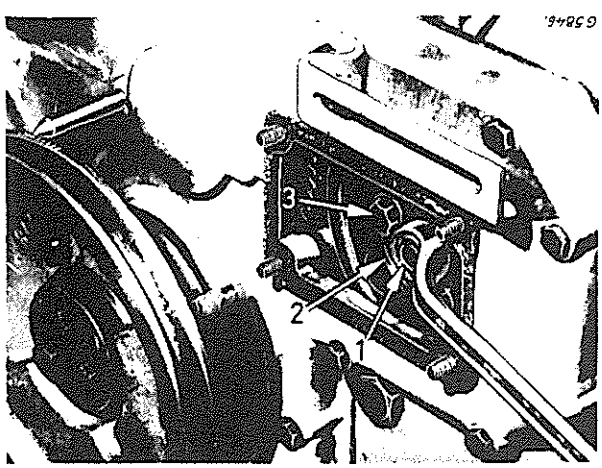
RH

1 – 20.0 mm = .79 "
2 – 7.4 mm = .292" Dia
3 – 6.5 mm = .256" Dia
4 – 8.01 mm / 8.03 mm = .3154" / .3162" Dia
5 – 3.0 mm = .118"
6 – 0.5 mm = .02 "

Removal and Disassembly of VA Pump

Thoroughly clean the left side of the engine to prevent dirt from entering the pump. Cap or plug all lines and ports as they are opened.

Remove the injection pipes. Disconnect all lines from the pump. See Illust. 198.

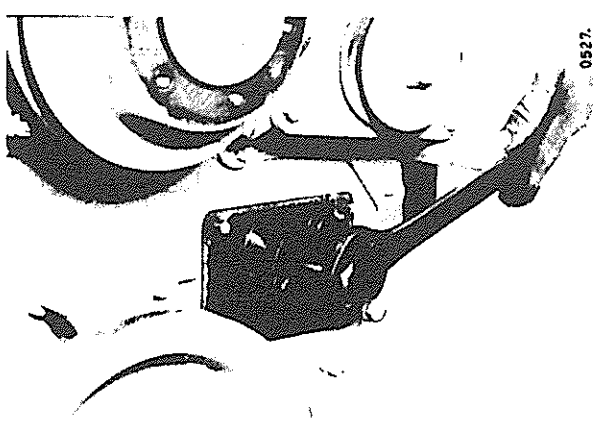


Illust. 230

1 – Drive shaft nut
2 – Hub
3 – Hub cap screws (three)

Remove rectangular cover plate from the crankcase front cover.

Remove nut (1) Illust. 230 and hub capscrews (3).



Illust. 231
Pulling hub from drive shaft

Remove gear with hub from the shaft, Illust. 231.

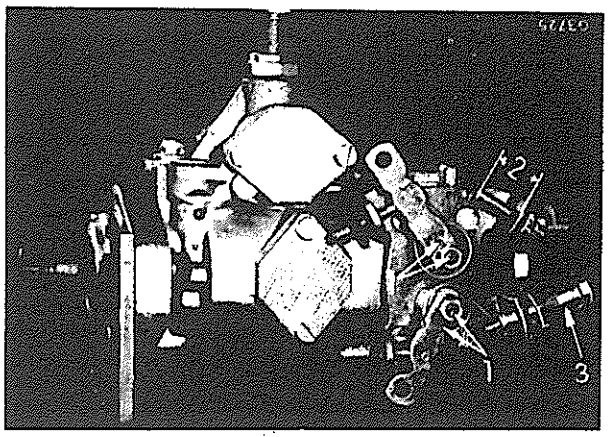
Note: Turn engine if necessary to place keyway in "up position" (eleven o'clock) to prevent the Woodruff-key from dropping into the oil pan, when the hub is removed.

Remove injection pump retainer nuts, using a special wrench extension for loosening the inner nut, see Illust. 436.

NOTE: When removing the injection pump be sure mating gears (pump drive gear — idler gear) are not disengaged to maintain the original timing.

Take off injection pump after cleaning externally.

To disassemble the pump proceed as follows:

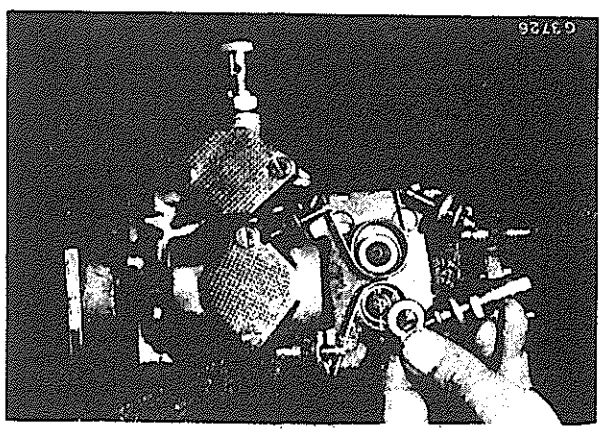


Illust. 232
Injection pump mounted in holding fixture

1 — Chisel marks
2 — Effective length of stop screw
3 — Shut-off plunger

Mount the pump in F ES 111-1 holding fixture. Clamp the fixture in a vise. Before removing the throttle lever and control plunger lever, mark the levers.

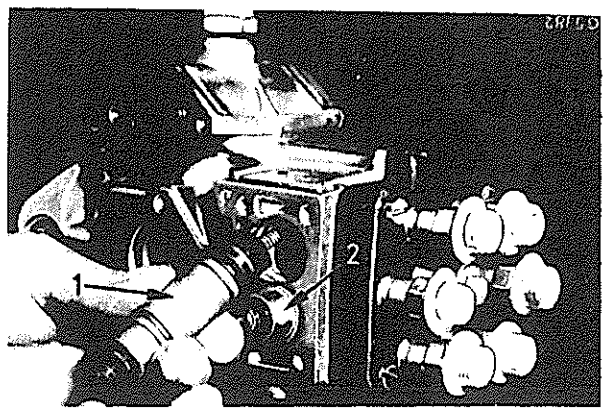
Before loosening the lock nuts of the lever stop screws, note the effective length of all stop screws and of the shut-off plunger, this will facilitate reassembly, see Illust. 232.



Illust. 233
Throttle and control plunger lever removed

Unhook the torsion springs from both levers.

Remove the nut on both levers using a 10 mm wrench. Draw off the levers. Do not loose the washer located under the control plunger lever. See Illust. 233. Remove the stop plate.

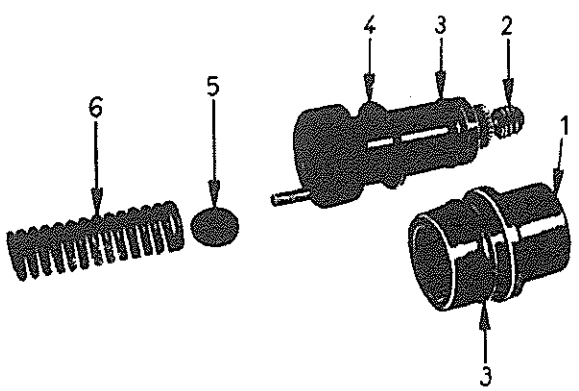


Illust. 234

1 — Throttle shaft assembly
2 — Control plunger shaft assembly

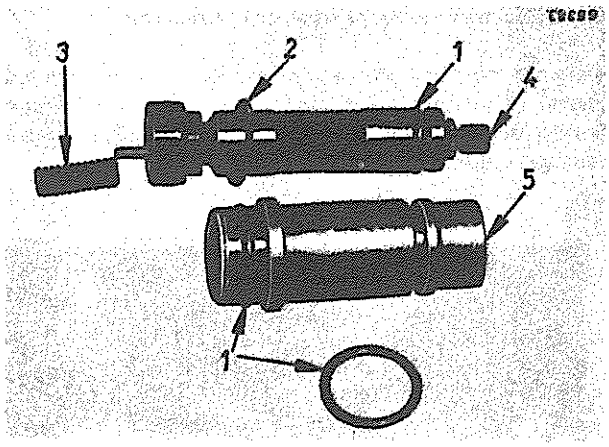
Remove assemblies (1) and (2) Illust. 234.

Disassemble the throttle and control plunger shaft assemblies as shown in Illusts. 235 and 236.



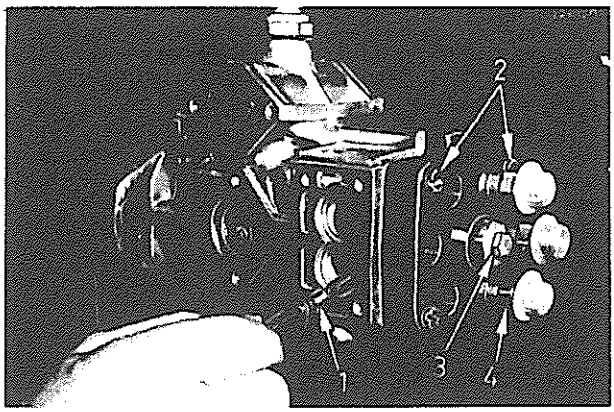
Illust. 235
Components of control plunger shaft assembly

1 — Bushing
2 — Shaft
3 — O-rings
4 — Washer
5 — Selected shim
6 — Spring



Illust. 236
Components of throttle shaft assembly

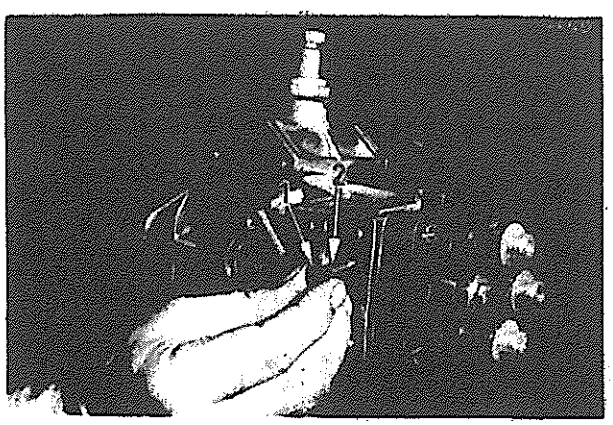
1 – O-rings
2 – Washer
3 – Spring
4 – Shaft
5 – Bushing



Illust. 238

1 – Control plunger
2 – Screws
3 – End plug
4 – Delivery valves

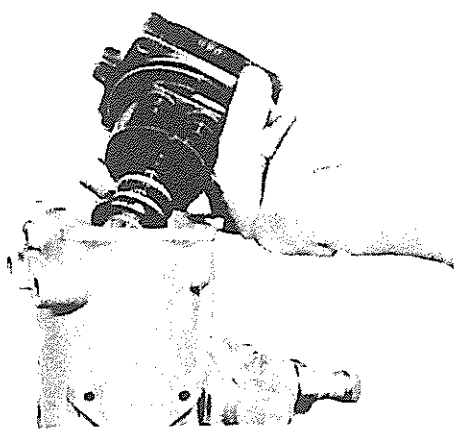
Remove control plunger (1) Illust. 238, delivery valves (4) end plug (3) and screws (2) in this sequence.



Illust. 237

1 – Throttle
2 – Spacer

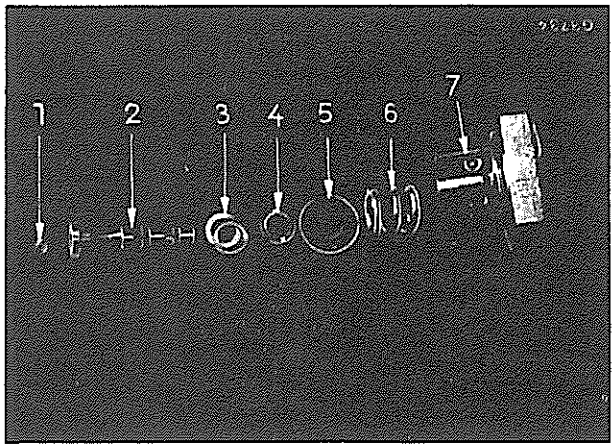
Remove throttle (1) Illust. 237. Do not loose the ground spacer (2) as it is mated to the distributor head.



Illust. 239

Remove the distributor head with a slight twisting motion. See Illust. 239.

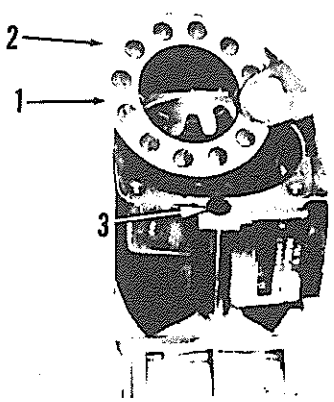
Do not drop the plunger. The plunger may remain in the distributor head or it may remain within the pump housing. Remove the shim located under the plunger foot.



Illust. 240
Plunger assembly

1 – Shim
2 – Plunger
3 – Trufftrided shims
4 – Grooved washer
5 – Spring seat
6 – Plunger return spring
7 – Distributor head

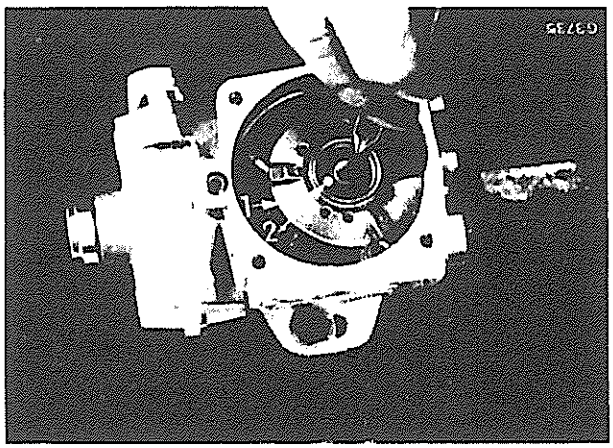
Note: Shim (1) Illust. 240 is used to correct plunger lift to port closure. It is available in different thicknesses. Numbers and thickness of shims (3) may also differ, they are used to correct plunger return spring preload. Do not lose shims.



Illust. 241

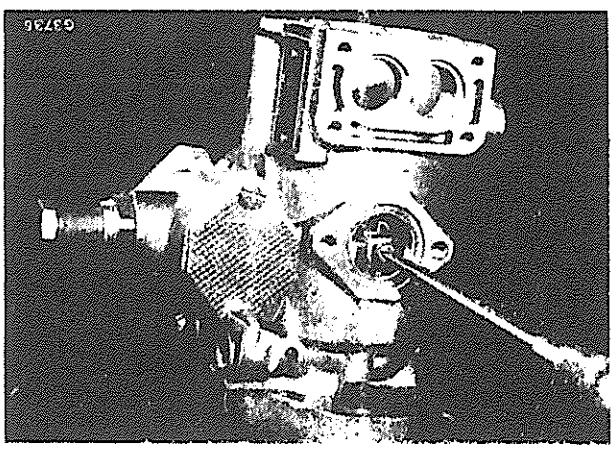
1 – Screen
2 – Screen spring
3 – O-ring

Remove the screen (1), screen spring (2) and O-ring (3), Illust. 241.



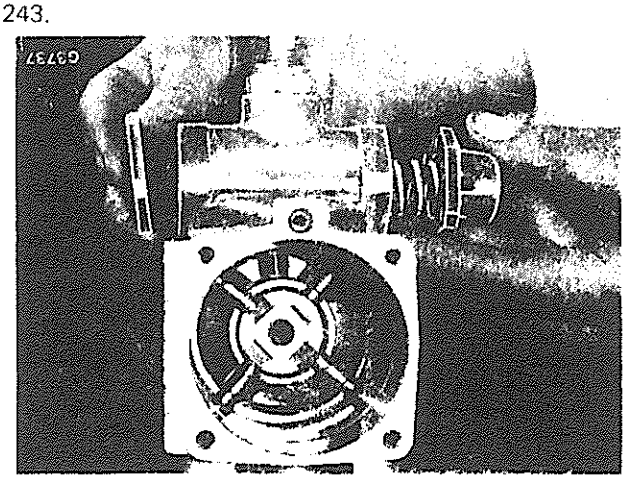
Illust. 242
1 – Face cam 2 – Index pin

Remove face cam (1) Illust. 242.



Illust. 243

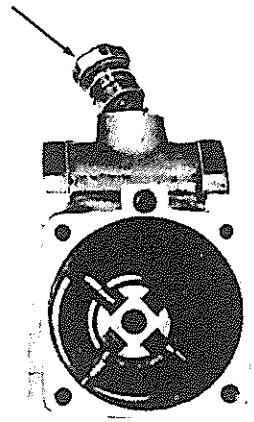
Remove the timing hole cover and timing pin Illust. 243.



Illust. 244

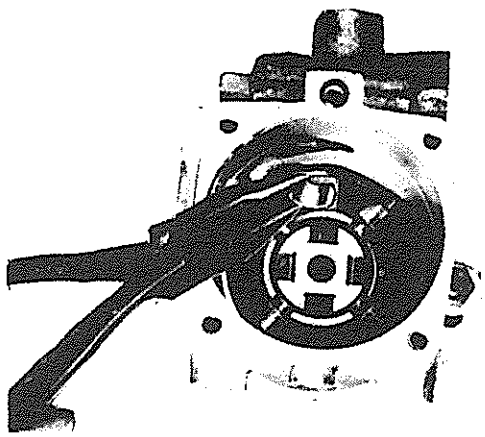
Remove advance piston [illegible] and spring, Illust. 244.

Do not lose shim(s) which may be located in the end cap.



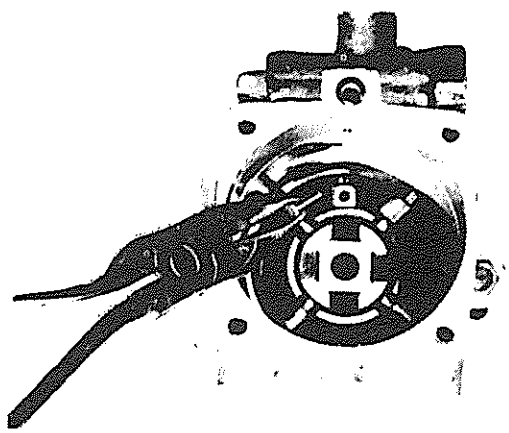
Illust. 245

Remove fuel return valve, Illust. 245.



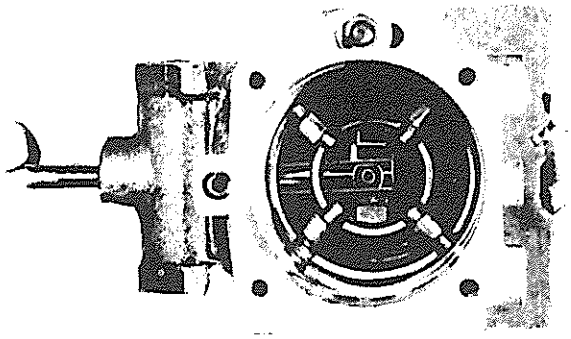
Illust. 246

Remove clamp from advance piston pin, Illust. 246.



Illust. 247

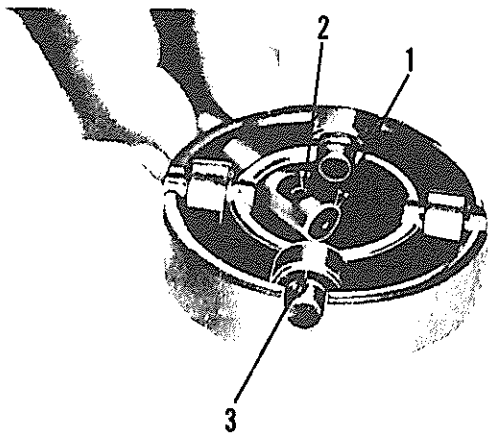
Remove retainer pin and flexible coupling, Illust. 247.



Illust. 248
Removing roller retainer assembly

To remove the roller retainer, push the advance piston pin into the pump using a suitable punch, Illust. 248.

Lift the roller retainer out of the pump housing.



Illust. 249
Roller retainer assembly removed

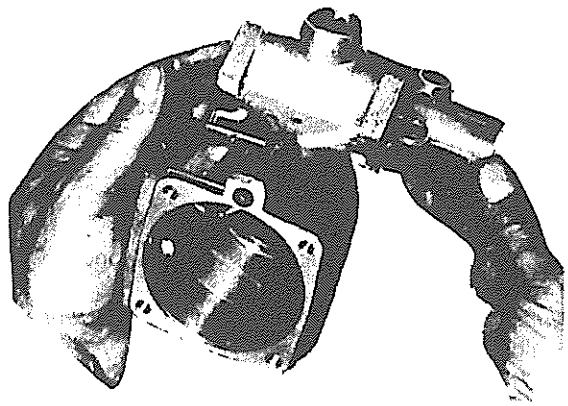
1 – Advance piston pin
2 – Milled area
3 – Dished washer

Remove advance piston pin, Illust. 249.

Note: The rollers, bushings and pins are a selective fit and must be kept with their respective parts and in the same location on the retainer.

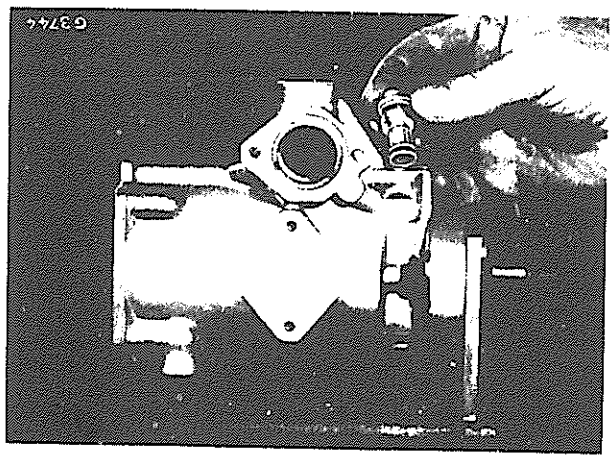
Carefully store the roller retainer assembly so as not to dislocate any of the parts of the assembly.

A home made container (Illust. 224) is recommended for this purpose.



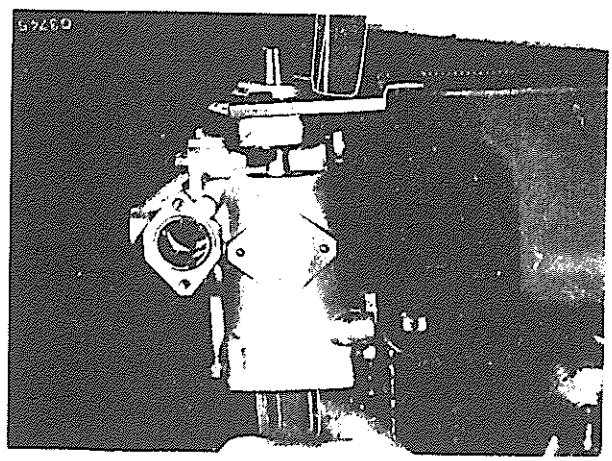
Illust. 250

Remove advance piston, Illust. 250.



Illust. 251

Remove charge pressure regulating valve, Illust. 251.



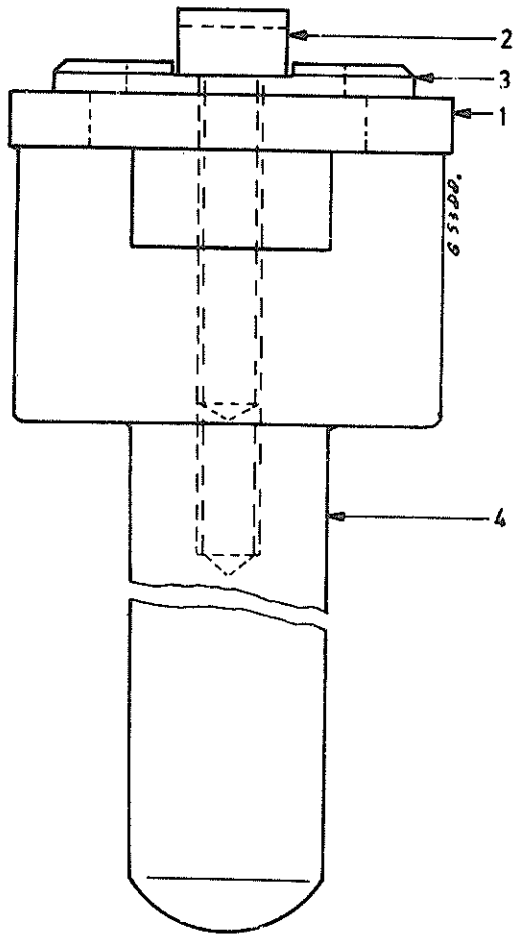
Illust. 252
Removing drive shaft assembly

Remove the two cross-recess retainer screws in the support ring.

Position the pump in a vise as shown in Illust. 252.

Hold handle "C" of tool (Illust. 228) against the retainer ring to prevent dropping and slightly tap the fixture to facilitate drive shaft removal.

If the eccentric race (5) Illust. 254 sticks in the pump housing, proceed as follows:



Illust. 253
Use of the eccentric race removing tool

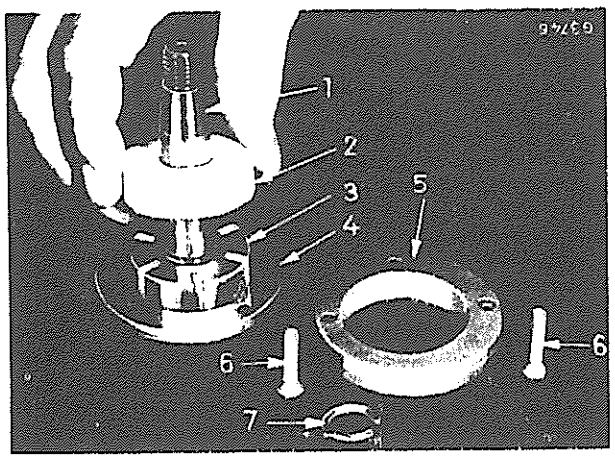
1 – Eccentric race	3 – Plate
2 – Bolt	4 – Handle

Use the home-made tool (Illust. 228) and clamp the eccentric race as shown in Illust. 253.

Move the handle of the tool to and fro to free the eccentric race.

Just as the race comes loose, back it out together with the tool.

Carefully remove all metal chips, which may be caused in removal.

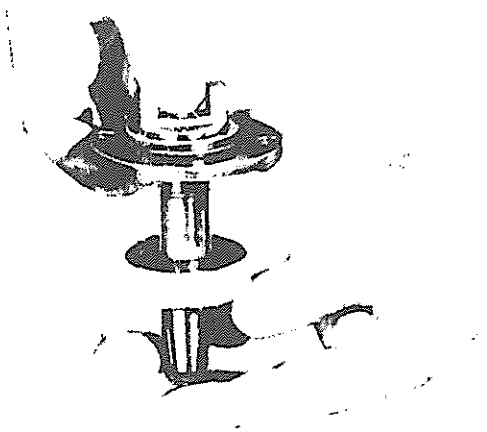


Illust. 254
Drive shaft assembly components

1 – Drive shaft
2 – Container (Illust. 225)
3 – Charging pump rotor
4 – Support ring
5 – Eccentric race
6 – Retainer screws
7 – Snap ring

Use protection sheet (Illust. 225) when removing the snap ring (7) Illust. 254 from the drive shaft.

Place the container (2) over the charging pump rotor assembly, to prevent vanes from falling out.



Illust. 255
Removing rotor and support ring

Invert the drive shaft and slide the rotor from the drive shaft. See Illust. 255.

Remove Woodruff key and support ring with grooved thrust washer.

Cleaning, Inspection and Repair

Note: All parts of the injection pump should be thoroughly cleaned in clean Diesel fuel. All ports and drilled passages must be open and clean to assure proper operation of the pump.

Inspect each component of the injection pump for wear, cracks and other damage.

Replace worn or damaged parts with new ones.

Note: Replace the distributor head with a new one if the engine tends to surge at low idle or if low idle speed cannot be properly adjusted.

The following components must be replaced as a set.

a) Distributor head with injection plunger, throttle and control plunger.

b) Pump housing with advance piston.

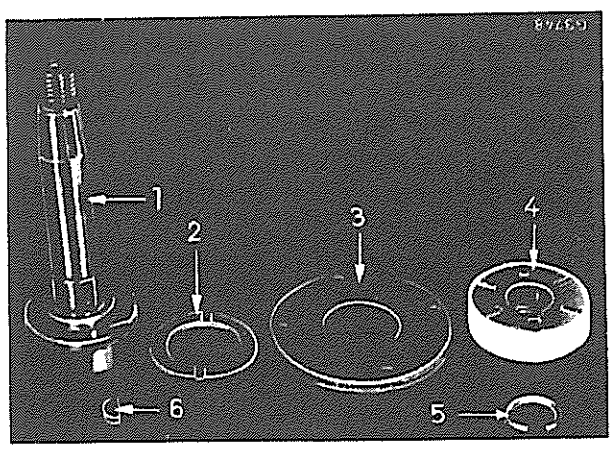
c) Roller retainer ring with rollers and pins.

d) Charging pump rotor with vanes and eccentric race.

Reassembly

Replace all O-rings, gaskets and drive shaft seal. Immerse each component (also O-rings and gaskets) in clean Diesel fuel before reassembly.

Observe strict cleanliness.

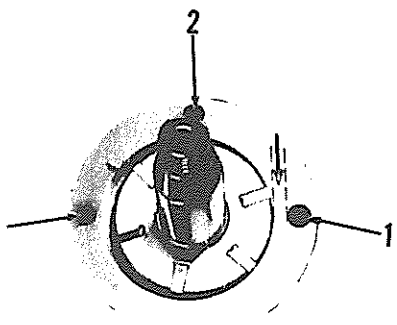


Illust. 256
Drive shaft and rotor assembly

1 – Drive shaft
2 – Grooved washer
3 – Support ring
4 – Rotor assembly
5 – Snap ring
6 – Woodruff key

Place washer (2) Illust. 256 on the drive shaft. Place the support ring (3) on the drive shaft, so that its smooth side will contact the rotor.

Insert the Woodruff key (6). Slide the rotor assembly (4) in place with the recess in its bore facing the threaded shaft end. Take off the container used for storing the rotor assembly. Secure the rotor with snap ring (5), using the snap ring installing tool, Illust. 226.



Illust. 257
Drive shaft and charging pump assembly

1 — Retainer screw holes
2 — Fuel passage

The screw holes (1) differ in their relation to the inner diameter of the eccentric race. See arrow Illust. 257.

Place the eccentric race over the rotor in such a way that the screw hole with the greater distance to the inner diameter is on the right-hand side and the fuel passage (2) is on top, see Illust. 257.

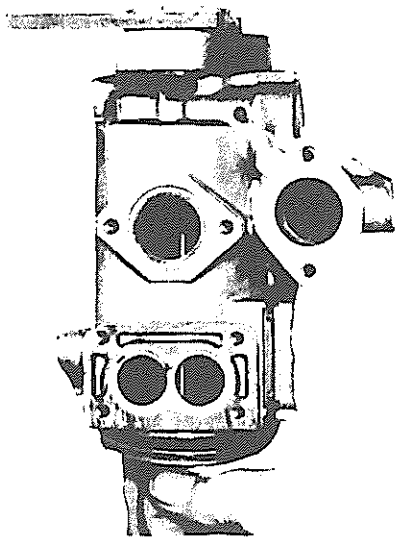
Align the holes of the support ring and eccentric race.

Invert the pump housing as shown in Illust. 258. Carefully insert the drive shaft assembly using the handle (4) Illust. 253 to facilitate installation.

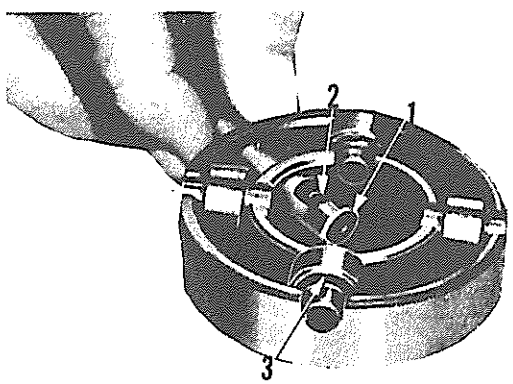
Holde the drive shaft assembly in position and turn the pump open side up.

Before installing the retainer screws make sure that all holes of the support ring are in line with the holes of the eccentric race and the fuel passage (2) Illust. 257 is on top of the pump housing.

Install the retainer screws and torque them alternately and evenly to 57.6 kpcm (50 lbs.in.).



Illust. 258
Installing drive shaft assembly



Illust. 259

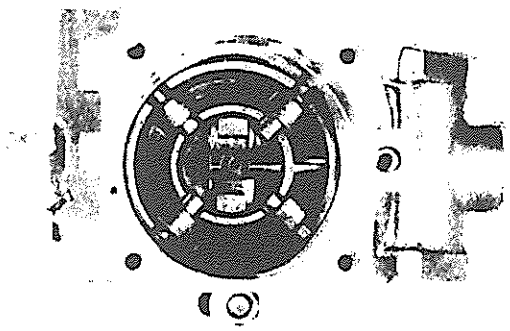
1 — Advance piston pin
2 — Milled area
3 — Dished washer

Push the advance piston pin (1) Illust. 259 in its bores in the retainer ring. Be sure its milled area (2) goes to the center of the ring and is facing up.

Note: In case the roller pins have been dropped during disassembly and rollers have been mixed up, check to see the protrusion of each roller is equal.

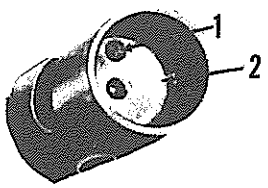
A deviation in roller protrusion up to 0.020 mm (.0008") is permissible.

When installing rollers do not overlook dished washers (3). Make sure the dished-out side of the washer goes to the retainer ring.



Illust. 260
Installing roller retainer ring assembly

Carefully install the roller retainer ring assembly into the pump housing. The advance piston pin goes to the top of the pump housing. Position drive shaft tangs as shown in Illust. 260.



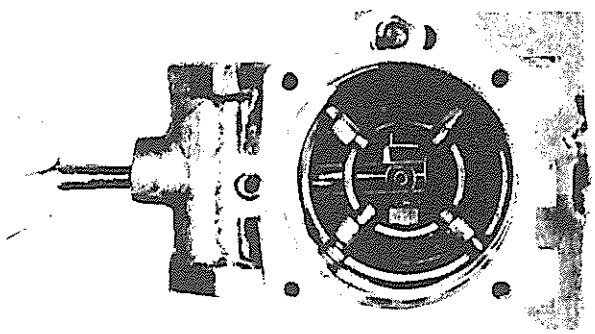
Illust. 261
Advance piston

1 – Nozzle bore
2 – Piston recess (power side)

A calibrated nozzle bore is provided on the power side of the advance piston. See (1) and (2) Illust. 261.

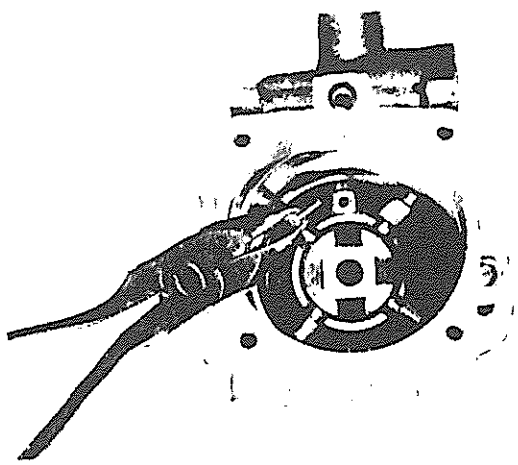
When installing the advance piston be sure its power side goes to the timing hole side of the pump housing. Also, the smallest of the central cross-bores goes to the top of the pump housing.

Before pushing the piston in its bore install the pin bushing with some petroleum jelly.



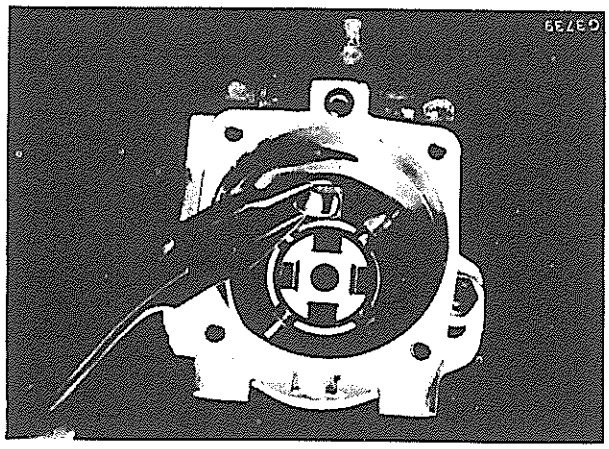
Illust. 262
Installing advance piston pin

Center the bushing in the advance piston using a slightly tapered pin. See Illust. 262. Push the pin into the bushing and secure the pin as shown in Illust. 263 and 264.



Illust. 263
Installing retainer pin

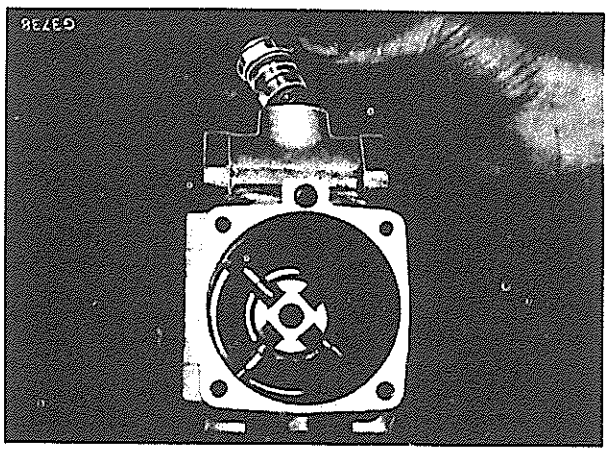
Install the retainer pin. Install the flexible coupling, Illust. 263 and retainer pin clamp, Illust. 264.



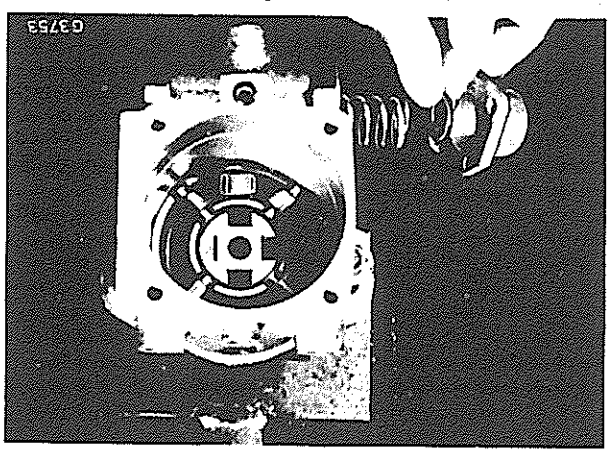
Illust. 264
Installing clamp

Move the advance piston full stroke a few times to make sure there is no binding.

Install the cover on the power side of the advance piston.

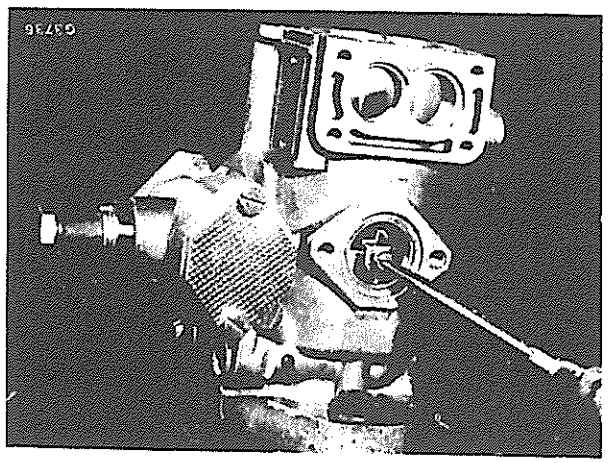


Illust. 265
Installing fuel return valve



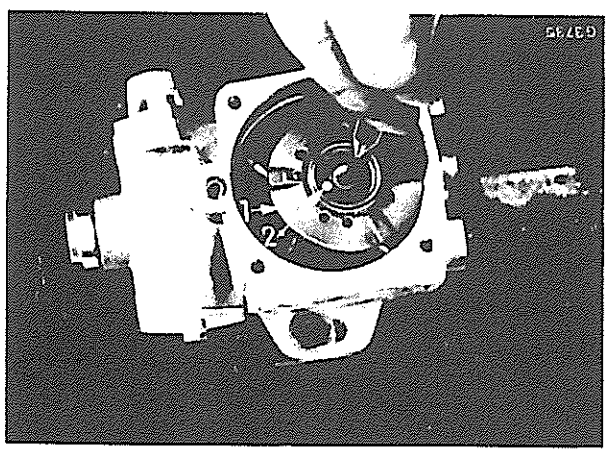
Illust. 266
Installing advance piston spring

Install shims, if any, in the end cap and place the end cap over the spring, See Illust. 266.



Illust. 267
Installing timing pointer

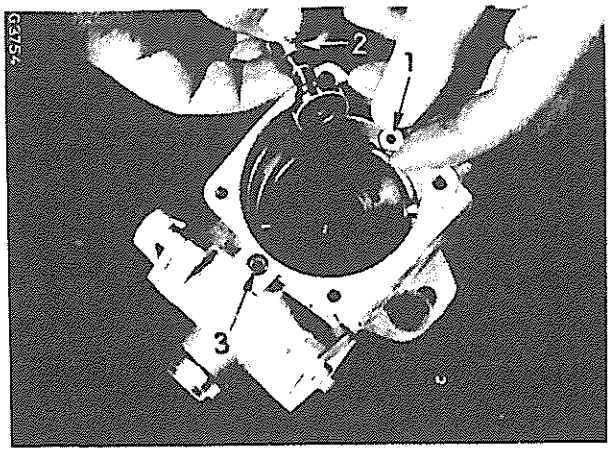
Position the pointer half-way in its adjusting slot, cutaway section up. See Illust. 267.



Illust. 268
Installing face cam

1 – Face cam
2 – Index pin

Align the plunger index pin in the face cam with the keyway in the drive shaft and install the face cam. See Illust. 268.



Illust. 269
Installing plunger

1 – Shim
2 – Plunger
3 – O-ring

Install shim (1) Illust. 269) as found in disassembly in the face cam. Install the plunger (2) indexing the slot in the plunger foot with the index pin in the face cam. Place O-ring (3) in the recess of the pump housing.

Note: Do not install the plunger return spring, spring seat, shims, grooved washer, and screen yet.

Aligning the Distributor Head

Illust. 270

1 – Control plunger bushing
2 – Alignment tool

Install the distributor head with O-ring, Illust. 270. To position the distributor head, a home-made tool (Illust. 227) should be used.

Proceed as follows:

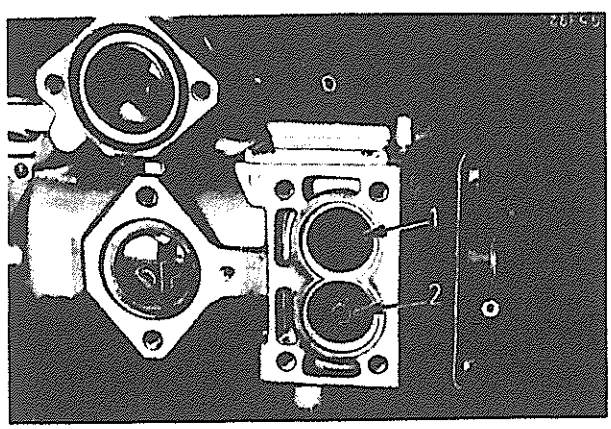
Tighten the distributor head retainer screws and back out each screw half a turn.

Slide the alignment tool in the control plunger bushing and insert the latter in its bore as shown in Illust. 270.

Slightly press the tool against the distributor head, while turning the head to and fro.

Alignment is felt by an even contact of the alignment tool.

Retighten the retainer screws and remove the alignment tool.



Illust. 271

1 – Throttle with ground spacer
2 – Control plunger

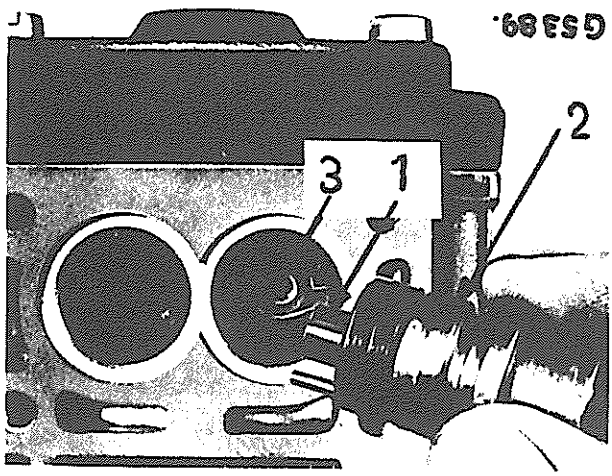
Install the throttle with ground spacer.

Install the control plunger, Illust. 271.

Determining Control Plunger Shim Thickness

To measure the distance from the spring seat on the installed control plunger to the bottom of the spring pocket in the plunger shaft use the home-made telescopic tool, Illust. 229.

Proceed as follows:

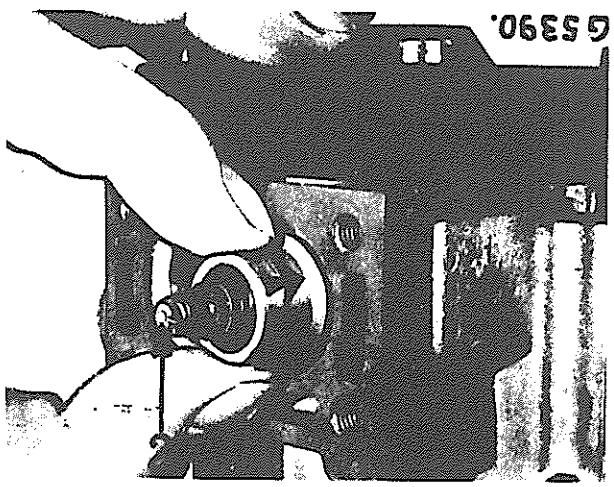


Illust. 272

1 – Telescopic tool
2 – Control plunger shaft assembly
3 – Control plunger

Adjust the initial length of telescopic tool to 27.00 mm (1.07") and insert it into the spring pocket of the plunger shaft, Illust. 272.

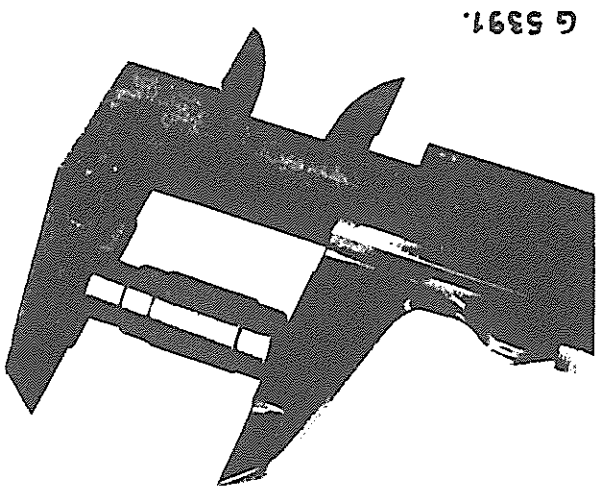
Be sure, no shim is in the spring pocket.



Illust. 273

1 – Control plunger bushing
2 – Control plunger shaft

Install control plunger shaft assembly without O-rings, Illust. 273. Depress bushing (1) only as illustrated (see arrow) until its flange is contacting the pump housing, compressing telescopic tool.



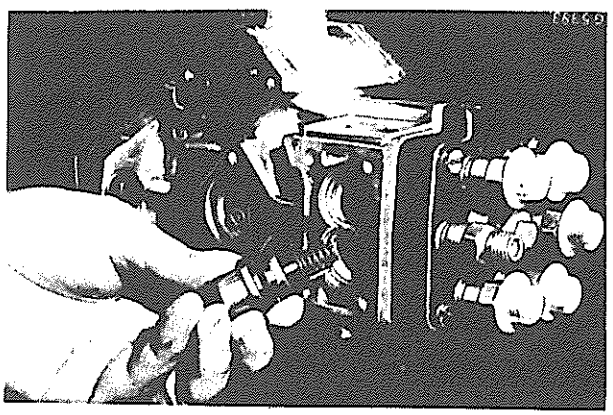
Illust. 274

Remove the control plunger shaft assembly and carefully measure the tool length as shown in Illust. 274.

Example:

Measured tool length	26.00 mm (1.024")
Pre-load length of control plunger spring as given in "Flow Bench Test Specifications"	24.65 mm (.970")
Thickness of shim, required	1.35 mm (.053")

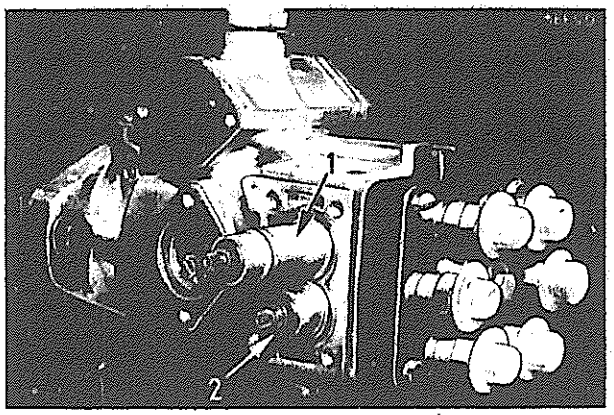
Note: Shim thickness must be determined whenever pump housing, distributor head or control plunger shaft assembly are replaced with new parts.



Illust. 275

Install the control plunger shaft with spring, selected shim, washer and new O-rings, Illust. 275.

Be sure the pin on the shaft engages the slot on the control plunger. This can be observed by looking through the throttle bore.



Illust. 276

1 – Throttle shaft assembly
2 – Control plunger shaft assembly

Install the throttle shaft assembly with spring and new O-ring. Do not overlook the washer, located between shaft and bushing, Illust. 276.

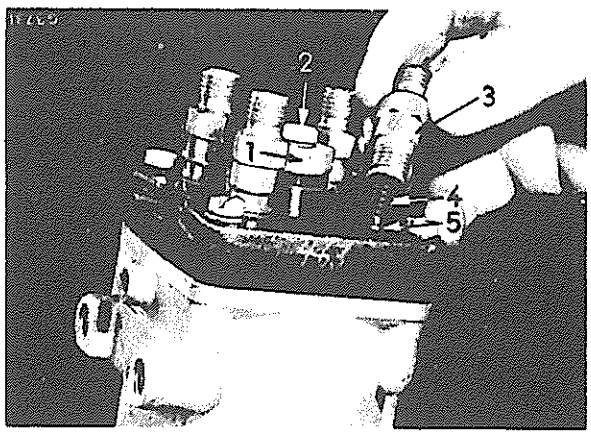
Be sure the pin on the shaft engages the notch on the throttle foot.

Note: The mark on the ends of the throttle and control plunger shaft are indexed with the shaft pin.

Position the throttle mark between 10 and 11 o'clock.

Position the control plunger mark at 6 to 7 o'clock.

Install the stop plate, so that the throttle and plunger shaft assemblies will be kept in place.



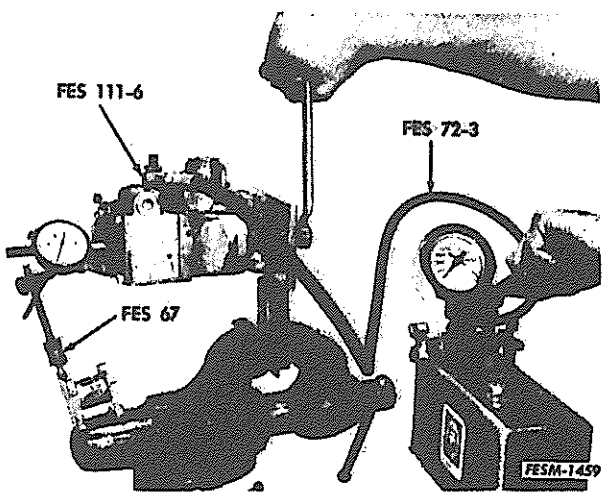
Illust. 277

1 – Plunger end plug
2 – Vent screw
3 – Holder
4 – Spring
5 – Delivery valve

Install delivery valves, Illust. 277. Do not install end plug (1) yet.

Checking Plunger Lift to Port Closure

To check plunger lift to port closure position the throttle and control plunger shafts as mentioned above.



Illust. 278
Checking plunger lift to port closure

Note: Illust. 278 shows the displaced "BR" injection pump. When checking the "CR" model, install the F ES 111-6 fitting with banjo bolt and gaskets in the fuel inlet port of the pump.

Connect F ES 72-3 hose and F ES 71 A hand pump. Position F ES 67 dial indicator to read plunger travel. See Illust. 278.

Install the drive shaft nut. Zero the dial indicator.

Apply pressure with the hand pump. Fuel will flow out the distributor head plunger bore. Slowly turn the drive shaft clockwise (viewed from the drive end) until the flow stops. Check and record the reading. Recheck the reading by slowly turning the drive shaft counterclockwise. Flow must start again within 0.025 mm (.001") of the figure recorded. If the fuel cut-off is not abrupt the plunger is probably worn and hard starting may result.

The figure recorded in the above step is the plunger lift to port closure. The specified reading must be as listed in Specifications. If the figure recorded was more than specified, place a thicker shim under the plunger foot. If the figure recorded was less than specified, place a thinner shim under the plunger foot.

Note: In case the actual shim thickness required lies between two available shims of the assortment, use the thicker shim to correct plunger lift to port closure.

The thickness of the shim located between plunger foot and face cam will also determine plunger return spring tension.

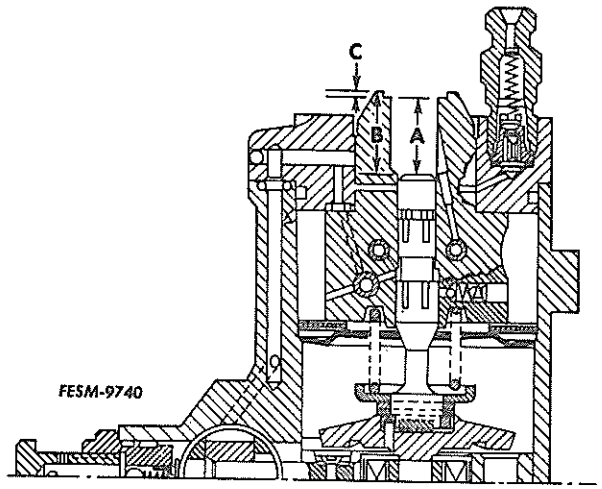
To maintain proper spring tension, the local thickness of the shim pack located under the spring seat must be decreased by the same amount as the thickness of the single shim under the plunger foot has been increased and vice versa.

Checking and Shimming Pumps with "O" Pre–Stroke

Note: The fuel leakage test does not apply to this pump.

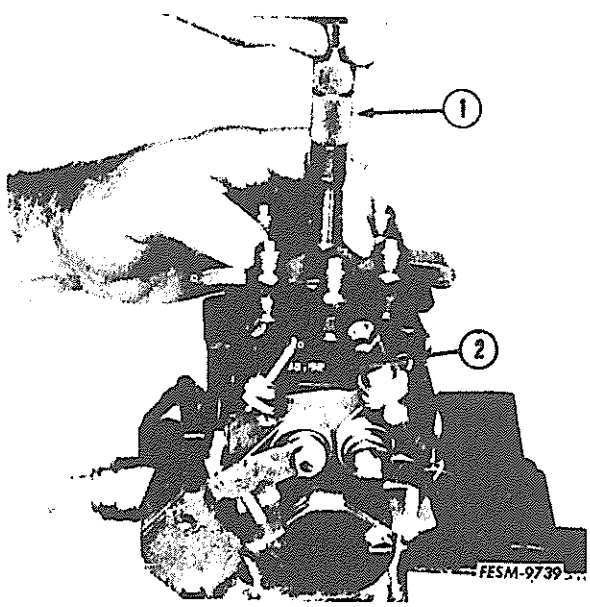
The "O" Pre–Stroke pumps have a different setting for each pump within pump models. The setting for each pump is marked on the pump. See (2) Illust. 278b.

Stamped on the pump head is the "O" Pre–Stroke code. This marking on the pump head is generally a four digit number, example: 23.52. If only a three digit number is shown, example: 352 place a number two (2) ahead of the number 23.52 and place a decimal in the second place. This figure is the mm depth from counterbore in the head to the top of the plunger at bottom dead center reference "A" or 23.52 mm.



Illust. 278a

A – Pre-Stroke dimension
B – Top face to plunger depth
C – Counterbore depth



Illust. 278b

1 – Depth micrometer
2 – Pre–Stroke code

Using a depth micrometer, establish the depth from top face of pump to plunger reference "B" and depth of counterbore reference "C". The difference between these dimensions is the counterbore to plunger measurement reference "A", Illust. 278a.

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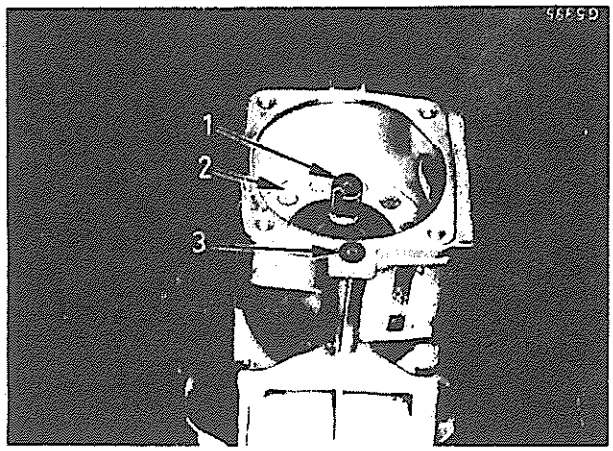
Select the proper shim to bring measured dimension to specified dimension.



Illust. 279

1 -- Distributor plunger
2 -- Screen
3 -- O-ring

After plunger lift to port closure is checked proceed as follows:

Remove the throttle and control plunger shaft assemblies and the distributor head.

Place the selected shim in the face cam. Place the selected shim pack, grooved washer, spring seat and return spring on the plunger in this order.

Install the plunger indexing the slot in the plunger foot with the index pin in the face cam.

Install the screen (2) with spring. Screen holes must be on top side.

Place O-ring (3) into its counterbore as shown, Illust. 279.

Carefully insert the distributor head into the pump housing and align the head. See Illus. 270.

Torque head retainer screws to 121 kpcm (105 lbs.in).

Install the throttle and control plunger, throttle and control plunger shaft assemblies and the stop plate.

Install the throttle and control plunger levers, observing the marks, made before removal. (Illust. 232.)

Recheck plunger lift to port closure and adjust the timing pointer.

Setting the Timing Pointer

With the plunger lift to port closure correct, turn the drive shaft until the plunger travels (lifts) 1.00 mm (.039"). At this point, align the pointer on the roller retainer with the scribe line on the face cam and lock screw. The keyway in the drive shaft must be up when setting the pointer.

Adjusting the Injection Pump

Set the injection pump to test bench specifications whenever possible.

In an emergency, adjust the repaired injection pump by using a dynamometer or using the fuel rator method.

Installing the Injection Pump

Refer to "Tuning–Up".

General

The fuel injection pump VE ... F ... is a development based on the field proven EP/VA series of rotary type pumps.

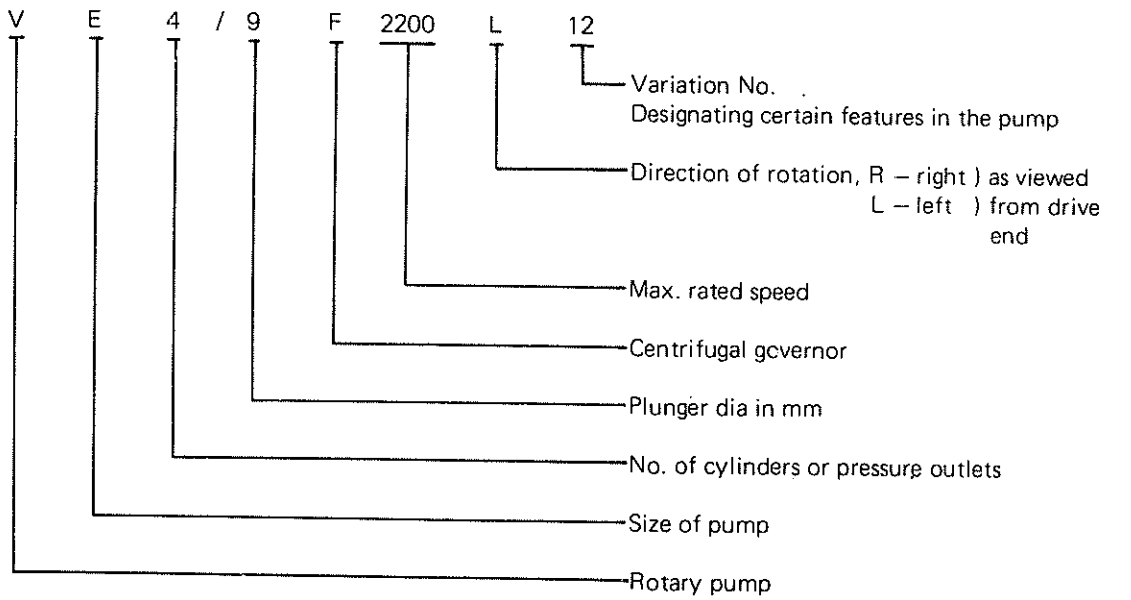
The new design incorporates a centrifugal variable speed governor acting on a metering sleeve via an assembly of control levers, as opposed to the hydraulic governing principle used with the previous EP/VA series.

The following variations are available to meet requirements in different applications:

a) Aneroid (turbocharged engines only)
b) Solenoid (electric shut down)
c) Auxiliary springs for metering control

Designation Code

The name plate on the pump housing shows the pump model in code form and indicates pump characteristics as shown in the example below:



This section covers the fuel injection system especially basic design features and operating principle of pump and governor.

Disassembly and repair should only be attempted if skilled personnel and the necessary equipment are available.

For removal and installation of the injection pump refer to following.

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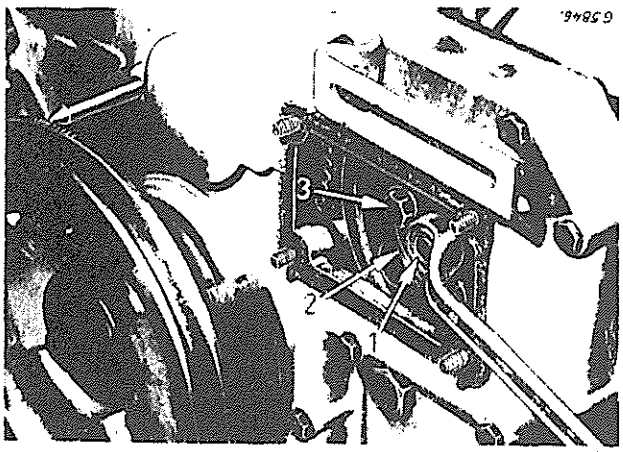
Removal of VE Injection Pump DT-402/DT-358

Thoroughly clean the left side of the engine to prevent dirt from entering the pump. Cap or plug all lines and ports as they are opened. Remove the injection pipes. Disconnect lines and linkage from the pump.

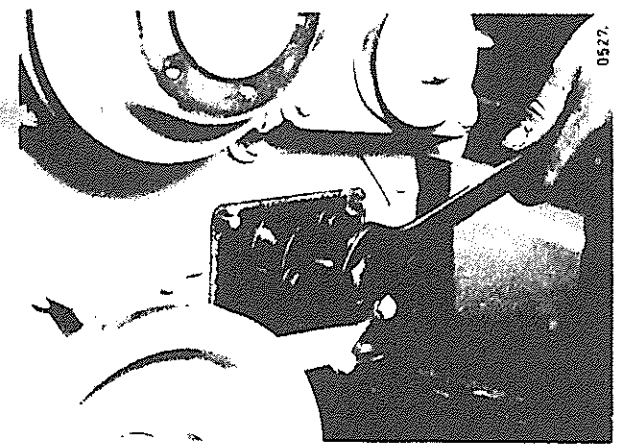


Illust. 280

1 – Drive shaft nut
2 – Hub
3 – Hub cap screw (three)

Remove rectangular cover plate from the crankcase front cover.

Remove nut (1) Illust. 280 and hub capscrews (3).



Illust. 281
Pulling hub from drive shaft

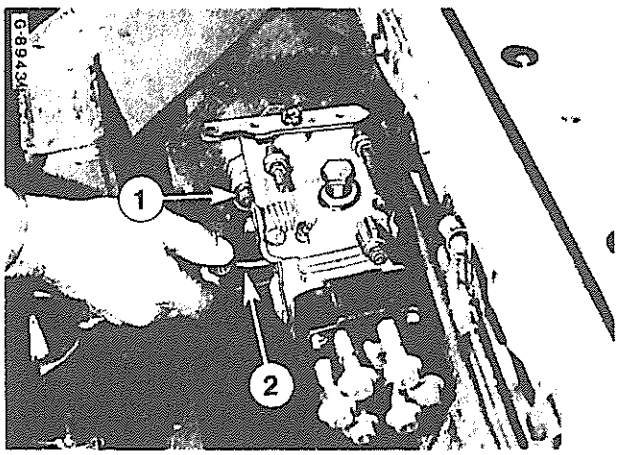
Turn engine if necessary to place keyway in "up position." (This is to prevent the woodruff key from dropping into the oil pan when the hub is removed).

NOTE: When removing the injection pump be sure mating gears (pump drive gear – idler gear) are not disengaged to maintain the original timing.

Note: Current VE fuel injection pumps have redesigned pump housings or redesigned water channel allowing use of normal socket extension for loosening and tightening inner flange nut. (See Illust. 436).

For early type units remove injection pump retainer nuts, using a special ring-wrench for loosening the inner nut, see Illusts. 282 and 263.

Note: Take care to mark the position of the pump on pump flange and front cover to facilitate reassembly.



Illust. 282
Removal or installation of pump

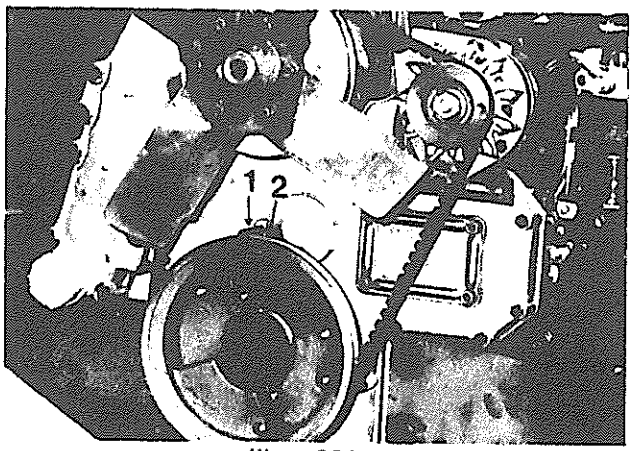
1 – Washer and nut
2 – Special ring-wrench

Illust. 283
Special ring-wrench (clearance 1/2")

Installing and Timing VE Injection Pump

1. Position the engine on the compression stroke number one cylinder (Intake and exhaust valves are closed).

2. Turn the crankshaft in direction of rotation until the timing pointer (1) is in line with the specified timing mark (2) on the graduation, Illust. 284.

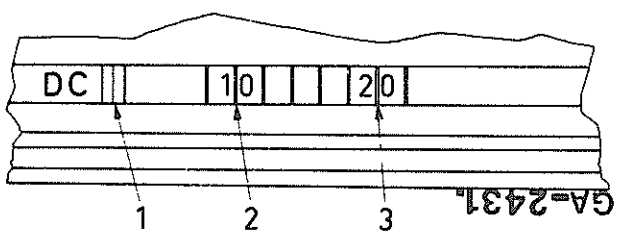


Illust. 284

1 – Pointer
2 – Graduation on the front pulley

For static degrees of the respective engine, see timing chart.

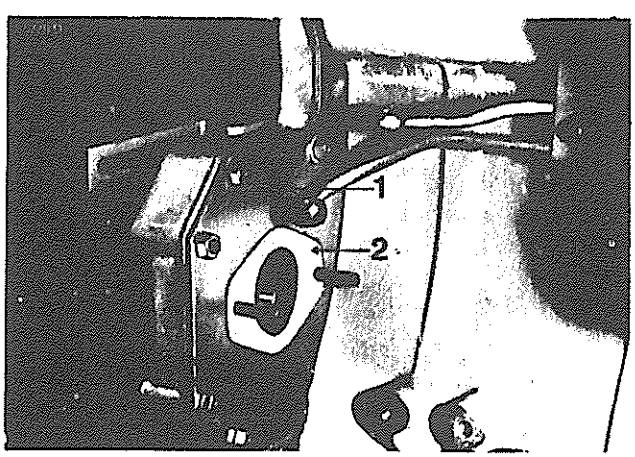
Read the graduation on the front pulley as outlined in Illust. 285.



Illust. 285
One graduation mark - 2°

1 – TDC mark
2 – 10° BTDC
3 – 20° BTDC

Remove cover plate of the injection pump Illust. 294.



Illust. 286

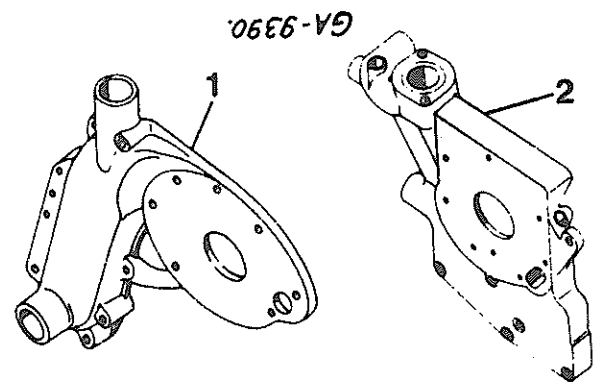
1 – Engine front plate
2 – Gasket

Apply liquid sealer to both sides of new gasket (2) Illust. 286.

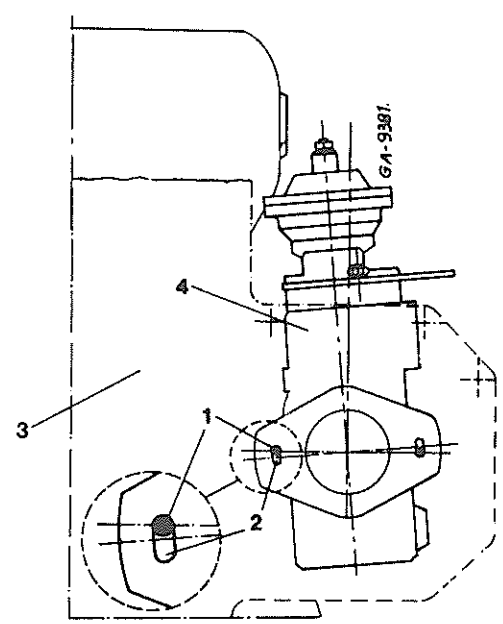
Place woodruff key into keyway of injection pump drive shaft.

Turn keyway in eleven o'clock position (in line with delivery valve outlet "A").

On engines with water pump carrier (2) Illust. 287 tighten the injection pump in a perpendicular position. On DT-402 engines with water channel (1) take care to tilt the injection pump toward the engine all the way within the play of the flange slots (2) Illust. 288 before tightening. Be sure washers (1) Illust. 282 are in place and tighten stud nuts in steps to 24 N•m (18 lbf-ft).



Illust. 287



Illust. 288
(DT-402 with (1) Illust. 287

1 – Stud
2 – Slot
3 – Engine
4 – Injection pump

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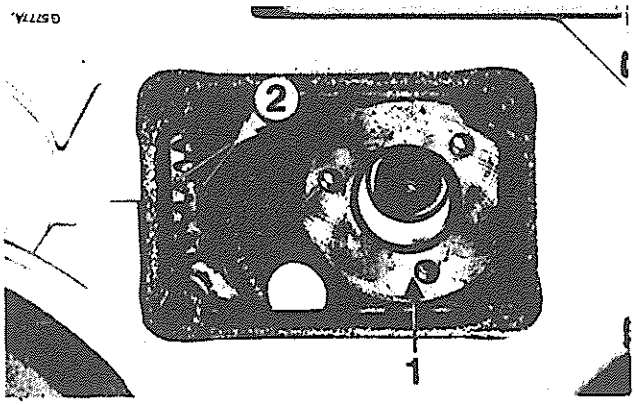


Illust. 289

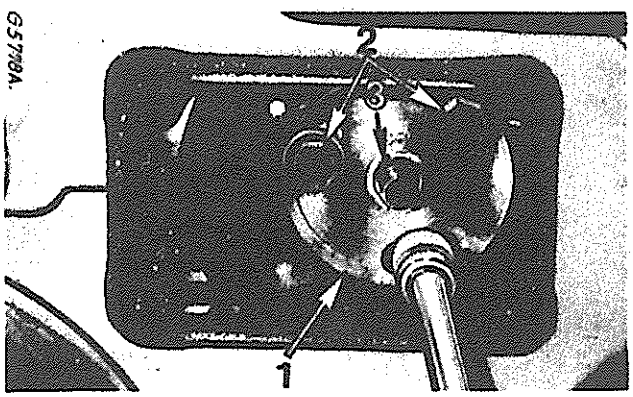
1 – Injection pump drive gear
2 – Timing marks

Make sure the timing mark (2) of idler gear aligns with the specified figure on the drive gear (1) Illust. 289 as outlined in the timing chart for injection pump drive gears. (Page 127 or 180)

NOTE: Since the idler gear is a walking gear, proper timing alignment (2) Illust. 289 will not always be noted.

If the engine is on number one compression at the specified static timing and the injection pump is installed with the timing pointer at the scribed line on the face cam, the pump will be "timed".

However, if the complete timing gear train has been removed, the timing of the gear train must be reset as shown in Illust. 431.

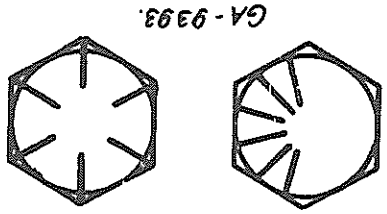


Illust. 290

1 – Hub
2 – Hub retainer bolts with washers
3 – Keyway (in 11 o'clock position)

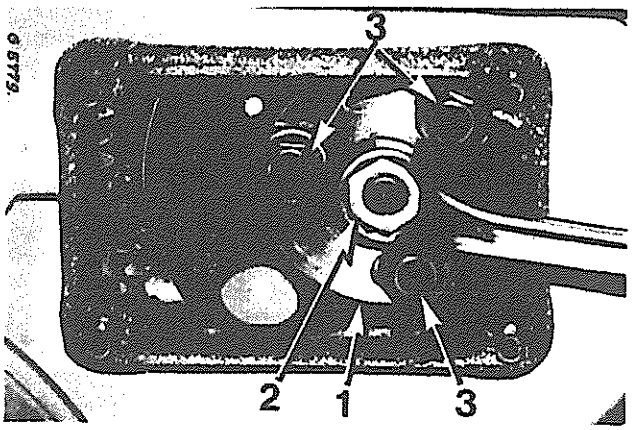
Install hub (1) Illust. 290, use quality bolts (six lines Illust. 291 and steel washers.

Tighten bolts (2) Illust. 290 slightly.



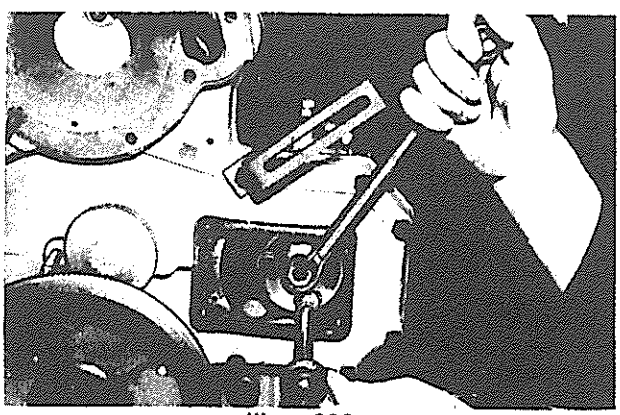
Illust. 291

Install lock washer and nut (2) Illust. 292. Block the engine and torque nut (2) to 93 N•m (69 lbf-ft.) Loosen bolts (3) Illust. 292.



Illust. 292

1 – Hub
2 – Hub retainer nut with lock washer
3 – Bolts, hub to gear, see Illust. 291



Illust. 293
Adjusting the injection pump

Turn the injection pump drive shaft until the pointer on the roller ring is in line with the scribe mark on the face cam Illust. 294.

At this point, tighten retainer bolts in steps to 27 N•m (20 lbf-ft).

Finally make sure that both timing points:

a) on the front pulley Illust. 284
and
b) on the roller ring Illust. 294 are in line with their respective marks as specified in timing chart.

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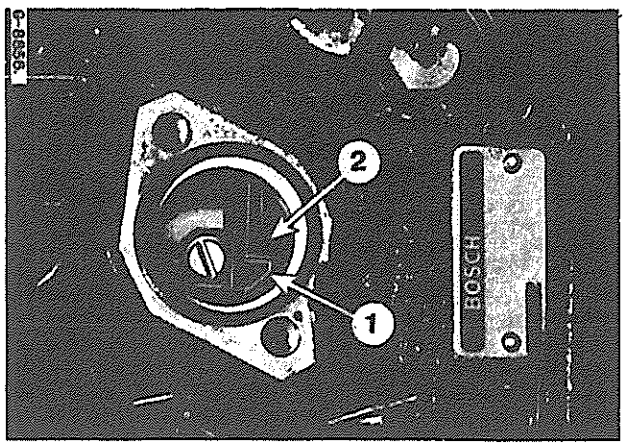
Timing Chart

Application	Engine	Marked tooth on pump gear	Static timing deg. BTDC
650 HD (3994) Hydr. Excavator	DT-402	5	16
953 HS Combine	DT-402		16
953 GD Combine	DT-402		16
1455 Wheel Tractor	DT-402		14
530 A Series II Payloader	DT-402	6	16
1255 Wheel Tractor	DT-358	5	10

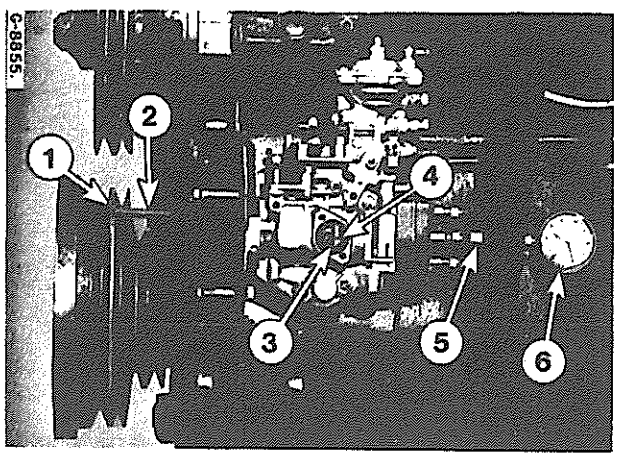


Illust. 294

1 – Pointer on roller ring
2 – Scribe line on face cam

NOTE: If the injection pump drive gear timing number is not known, the following procedure applies:

Bar engine to position number one piston on compression at the specified static timing. Install injection pump with the pump timing pointer in line with the scribed line on the face cam Illust. 294. The pump will now be timed.



Illust. 295

1 – Graduation marks, pulley
2 – Pointer on engine front cover
3 – Pointer on roller ring
4 – Scribe line on face cam
5 – Fitting, dial indicator
6 – Dial indicator

Checking VE Injection Pump Timing with Dial Indicator

Before checking injection pump timing the engine must be in static timing position (deg. BTDC).

1. Using a suitable fitting rest the stylus of the dial indicator on the face of the distributor plunger. Pre-load 1.0 – 2.0 mm (.04 to .08"), Illust. 295.

2. Slightly turn the crankshaft to and fro to find the bottom dead center for the distributor plunger.

3. With the distributor plunger in BDC zero the dial indicator.

4. Turn the crankshaft in direction of rotation until the pointer (3) Illust. 295 is in line with the specified static timing mark on the front pulley.

5. In this position the dial indicator reading should be 1.0 mm (.0394") and the pointer (2) Illust 295 should be in line with the scribe mark on the face cam.

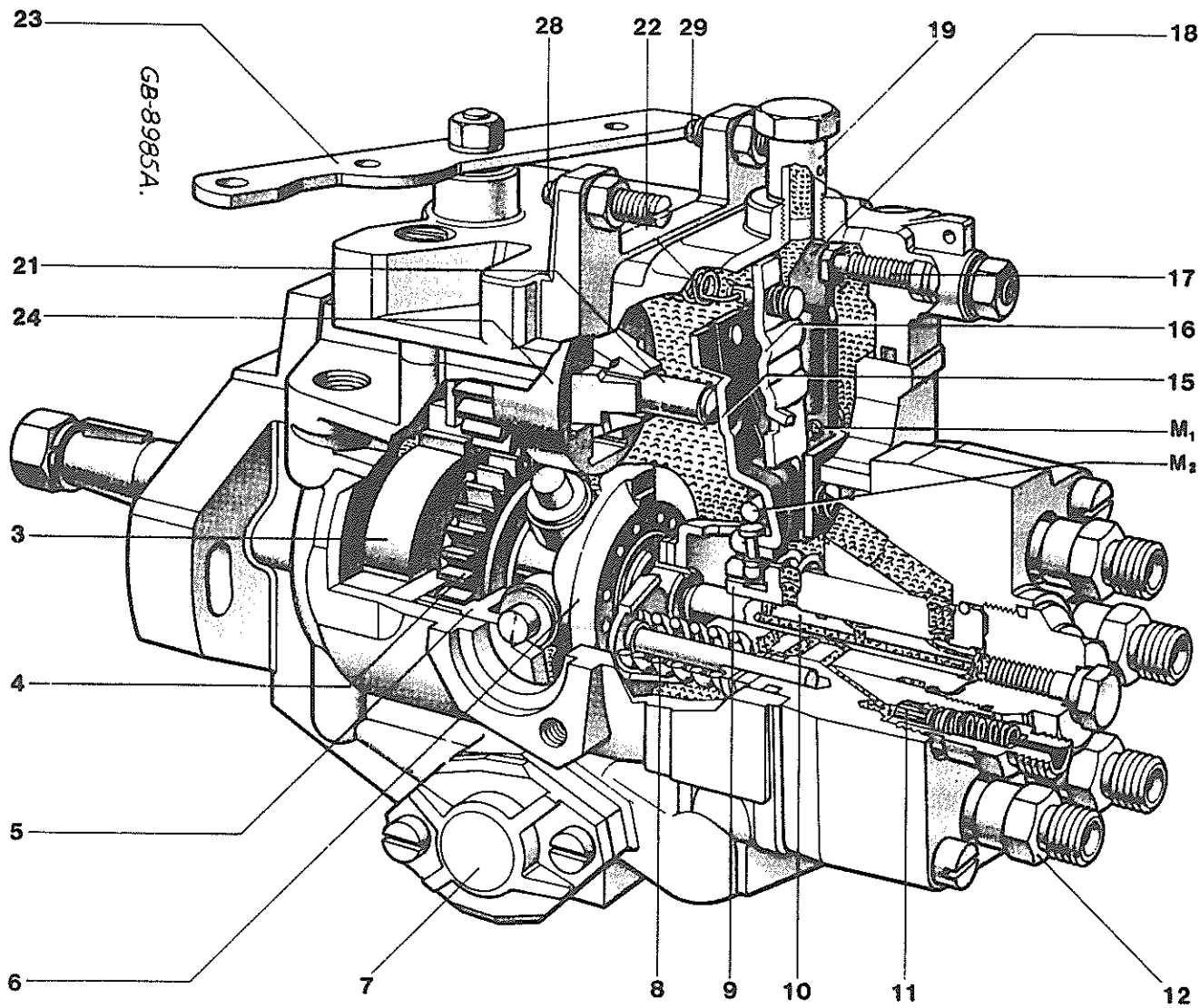
Note: If pre-stroke travel of the distributor plunger 1.00 mm (.0394") is correct, the pointer (2) may be re-adjusted as necessary.

Note to paragraph 4, prevent reading errors!

a) Be sure your eye is in line with timing pointer (2) and graduation mark on pulley (1) in a vertical position.

b) Be sure your eye is in line with timing pointer (3) and scribe line on face cam (4) in a horizontal position.

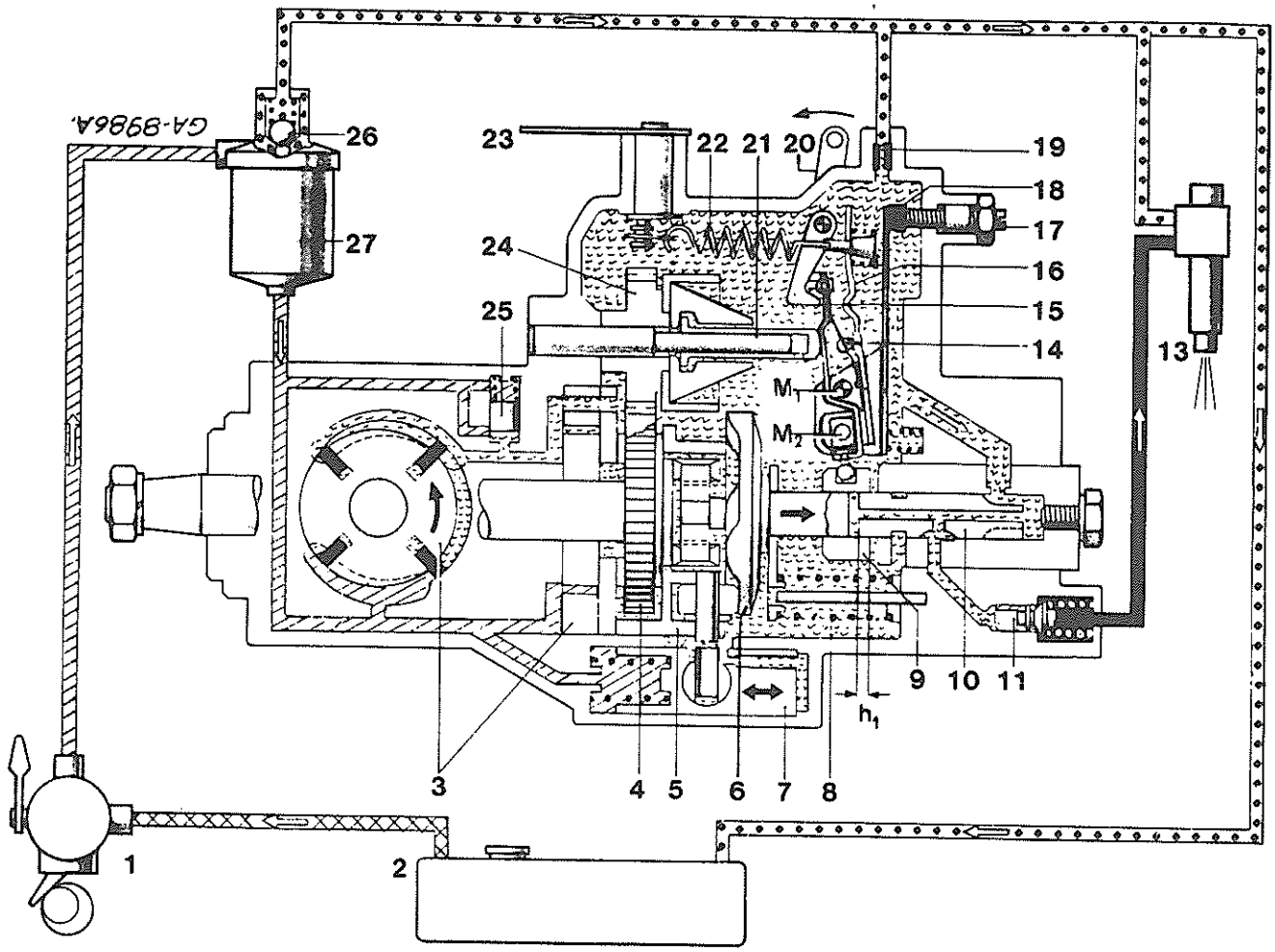
FUEL INJECTION PUMP VE ... F ...



illust. 296

Legend to Illust. 296 and 297

1 – Feed pump
2 – Fuel tank
3 – Charging pump
4 – Governor drive gear
5 – Roller retainer assembly
6 – Face cam
7 – Advance piston
8 – Return spring
9 – Metering sleeve
10 – Plunger
11 – Delivery valve
12 – Delivery valve holder
13 – Injection nozzle
14 – Stop, tensioning lever
15 – Starting lever
16 – Tensioning lever (speed control)
17 – Full load adjusting screw
18 – Torque control lever
19 – Fuel return valve
20 – Shut-off lever
21 – Governor sleeve
22 – Governor spring
23 – Throttle lever
24 – Governor
25 – Charging pressure valve
26 – Not used
27 – Fuel filter
28 – Max. speed stop screw
29 – Low idle stop screw



Supply to feed pump

Feed pump pressure

Charging pump pressure

Injection pressure

Return fuel to tank

h1 max. fuel for starting

M1 Fulcrum for 18

M2 Pivot for 15 and 16

M2 fixed in 18

Illust. 297

Principle of Operation

The Robert Bosch model VE ... F ... fuel injection pump is a single plunger, rotary distributor type pump incorporating a centrifugal spill port governor.

A single plunger (10) actuated by a face cam (16) pressurizes the fuel while rotation of the plunger distributes it to supply the delivery valves (11) and nozzles (13).

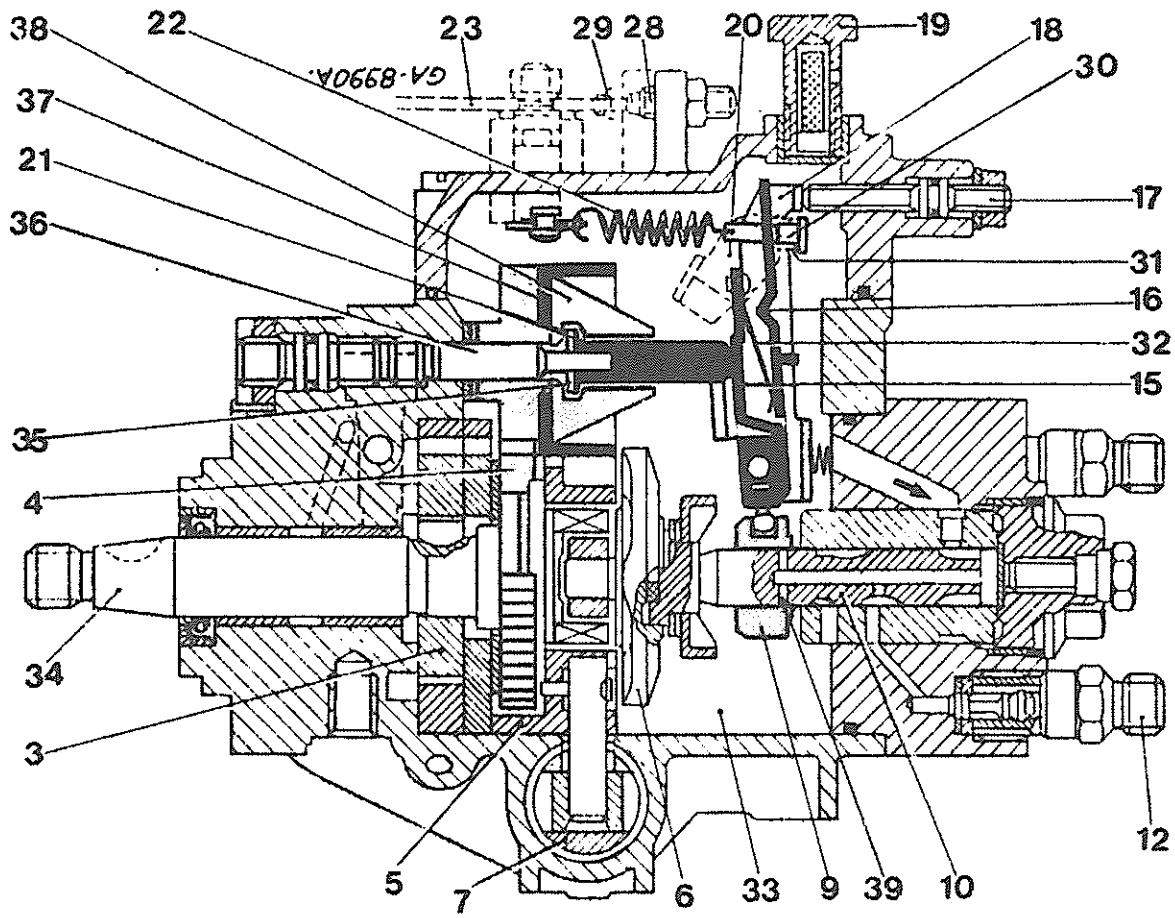
The accessory units, such as the centrifugal governor, charging pump, and automatic timing device are located inside the pressurized fuel filled housing.

The main component parts of the pump are:

1. Charging pump (3), charging pump pressure regulating valve (25), and fuel return valve (19).

2. Automatic timing device (7) consisting of a spring-loaded piston, roller retainer (5), and connecting pin.

3. Centrifugal governor (24) consisting of four fly-weights, sliding sleeve (21), control lever assembly (15, 16, 18), and metering sleeve (9).



Illust. 298

3 – Charging pump
4 – Governor drive gear
5 – Roller retainer assembly
6 – Face cam
7 – Advance piston
9 – Metering sleeve
10 – Pumping plunger
12 – Delivery valve holder
15 – Starting lever
16 – Tensioning lever (speed control)
17 – Full load adjusting screw
18 – Torque control lever
19 – Fuel return valve
20 – Shut-off lever
21 – Governor sleeve
22 – Governor spring
23 – Throttle lever
28 – Max. speed stop screw
29 – Low idle stop screw
30 – Retainer
31 – Idle spring
32 – Starting spring
33 – Pump housing
34 – Drive shaft
35 – Thrust washer
36 – Governor shaft
37 – Governor cage
38 – Flyweights
39 – Spill port

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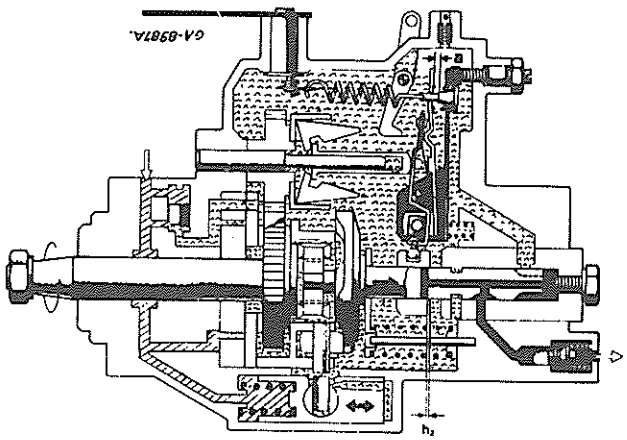
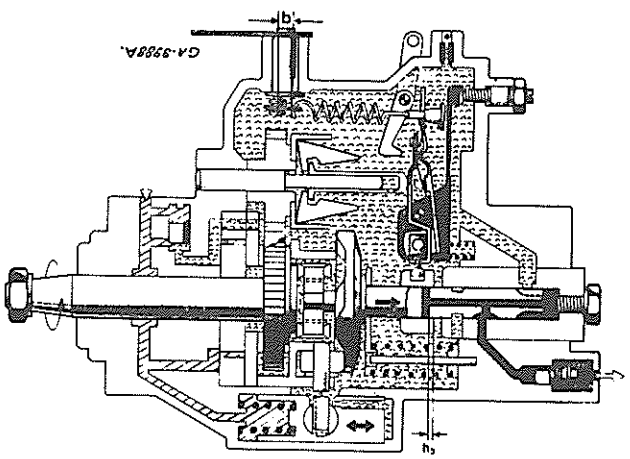


Illust. 299

Low idle position

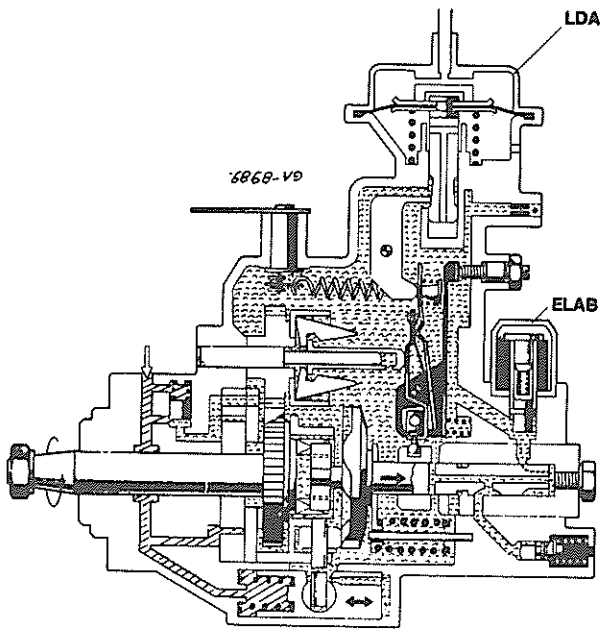
a – Idle governor range
h2 – min. effective plunger stroke



Illust. 300

Full load position

b – Tension range of governor spring
h3 – Effective plunger stroke



Illust. 301

Shut-off position
(no fuel displacement)

Special Equipment:
LDA = Aneroid (turbocharged engines)
ELAB = Electric shut-off (Solenoid)

Note: Other equipment may be used, depending on engine application.

Refer to Illust. 298:

Charging Pump

The vane type charging pump (3) having four steel vanes, is built around the drive shaft. The capacity of the charging pump is greater than the requirements of the engine. The excess fuel is used to cool and lubricate the pump and is recirculated to the fuel tank. Charging pump pressure is controlled by a pressure regulating valve. Pump output is exposed to the automatic timing device (7) and to the pump housing. Charging pump pressure will vary with the speed of the engine.

Automatic Timing Device

Automatic timing advance is accomplished by the rotation of the cam roller retainer. Charging pump fuel pressure is exposed to one end of the spring loaded advance piston (7). As the pressure increases, due to an increase in pump speed, the piston moves over against the pressure of the advance spring. This rotates the roller retainer (5) in the advance direction.

Centrifugal Governor

The governor cage assy (37) rotates on a stationary shaft (36), driven by gear (4) at engine speed.

With increasing speed centrifugal force, acting on rear ends of flyweights (38) results in an outward movement pushing governor sleeve (21) against lever assembly (15 and 16). As levers (15 and 16) pivot rearward, metering sleeve (9) is moved forward, resulting in an earlier spill port action (39), decreasing engine speed. Governor spring (22) resists movement of governor sleeve (21) depending on the throttle setting (23), resulting in a balance between spring force and centrifugal force of governor for a stable engine speed.

As the engine is loaded rpm speed tends to decrease resulting in less centrifugal force at the governor. Spring (22) pulls lever assembly (15–16) forward, while metering sleeve slides back to delay spill port action for an increase in engine speed until again a balance is achieved between spring (22) and governor.

Negative Torque Control

On some applications, this device, consisting of an additional lever and spring is fitted on the starting lever (15), see also Illust. 313.

The purpose of this device is to control lug or torque rise and to reduce smoke by cutting back excessive fuel delivery in the low rpm range.

RPM speed settings and adjustment of torque characteristics are independent of each other see (17, 28 and 29).

Starting lever (15) is provided with a weak leaf type spring to move metering sleeve (9) rearward for maximum starting fuel when the engine is stopped, see also h1 Illust. 297.

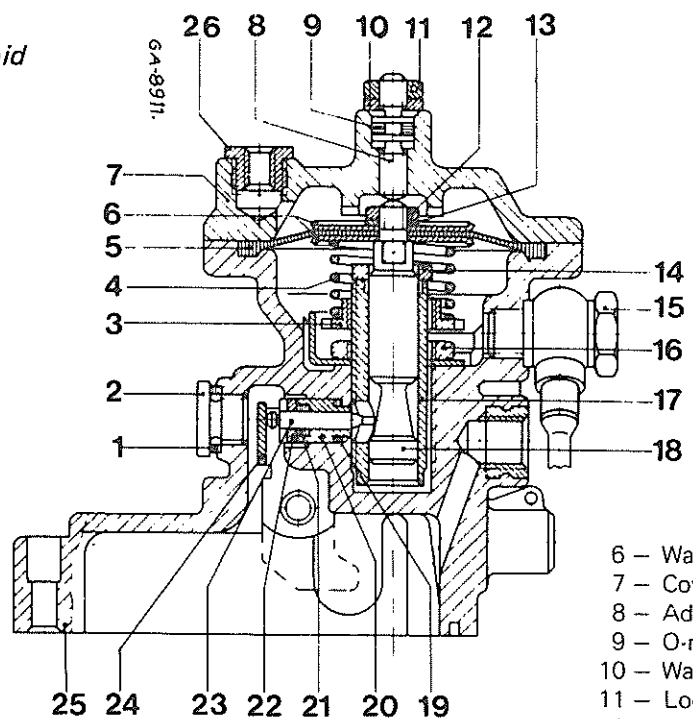
As the engine is started and picks up speed this spring is depressed by the governor, automatically cutting out maximum starting fuel.

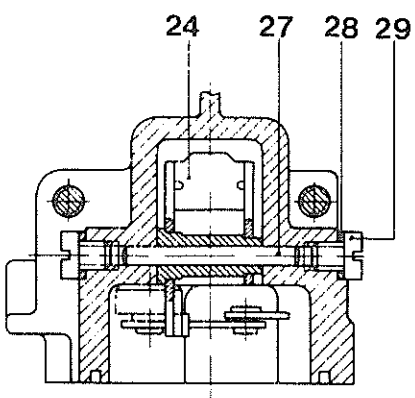
Shut-off Position

Shut-off is accomplished with lever (20) Illust. 298 which overrides governor spring (22) to move metering sleeve (9) forward, opening spill port all the way.

On some applications an electric shut-off is used. A solenoid valve controls fuel supply to the high pressure circuit. When cutting the current this valve closes the supply passage to stop the engine.

Aneroid





Illust. 302

1 – Packing ring
2 – Plug
3 – Nut, spring tension adjustment
4 – Spring
5 – Diaphragm
6 – Washer
7 – Cover
8 – Adjusting screw
9 – O-ring
10 – Washer
11 – Lock nut
12 – Jam nut
13 – Lock washer
14 – Spacer
15 – Hollow screw
16 – Jam nut
17 – Pilot sleeve
18 – Control rod
19 – Ring, seal
20 – Pilot union
21 – O-ring
22 – Washer tension
23 – Actuating pin
24 – Bellcrank
25 – Housing
26 – Boost pressure inlet
27 – Pivot pin for (24)
28 – Packing ring
29 – Screw

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Refer to Illust. 302:

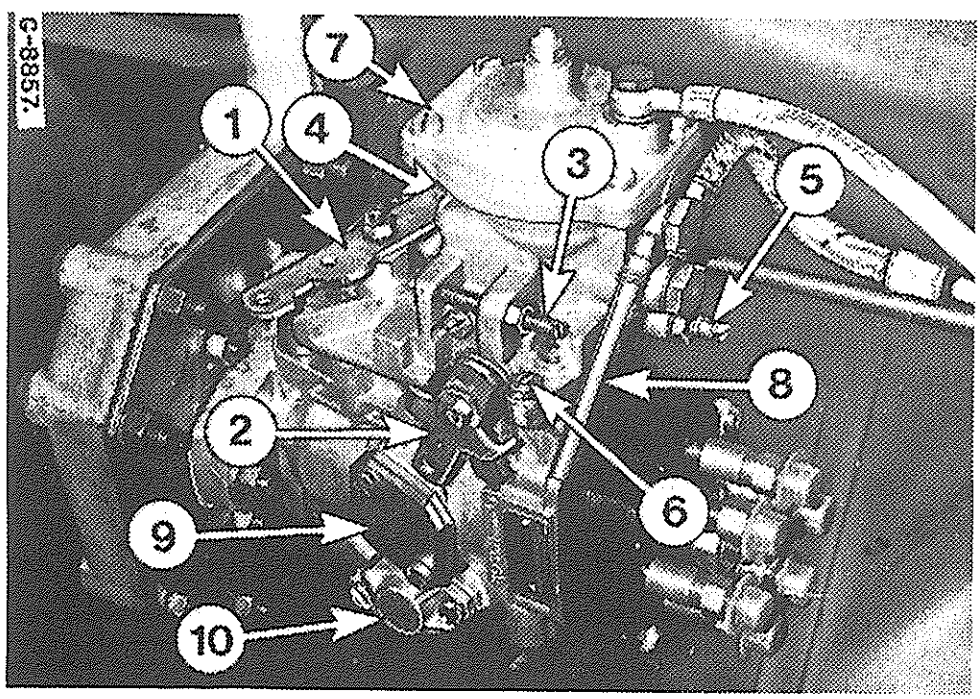
Some injection pumps used on turbocharged engines are equipped with an "Aneroid" which acts as a pneumatic regulating device in relation to the boost pressure.

The purpose of the aneroid is to reduce or eliminate exhaust smoke during fast acceleration, especially when starting

Whenever the throttle of the injection pump is turned rapidly to the full-load position, the pump will immediately deliver the maximum amount of governed fuel. The turbocharger, however, does not recover its rpm quite as fast and during this lag of time there is insufficient air (boost pressure) to provide complete combustion. The aneroid (when properly adjusted) will cut back fuel supply of the injection pump until sufficient boost pressure is delivered to the engine. With the aneroid in the fuel cut-back position, insufficient boost pressure allows the return spring 4 to move the diaphragm (5) and control rod (18) to the fully raised position. The control rod has a taper to convert vertical movement of rod (18) into horizontal movement of pin (23). This pin actuates the bellcrank (24) acting on the tension lever (16) Illust. 298 to cut back fuel delivery.

Increasing boost pressure from intake manifold pushes down the diaphragm and control rod. This movement is taken up and converted by pin (23). As bellcrank (24) is under tension from governor spring, actuating pin (23) is pushed in, permitting free oscillation of tension lever, i.e. fuel delivery is controlled by the centrifugal governor only.

Servicing the Pump

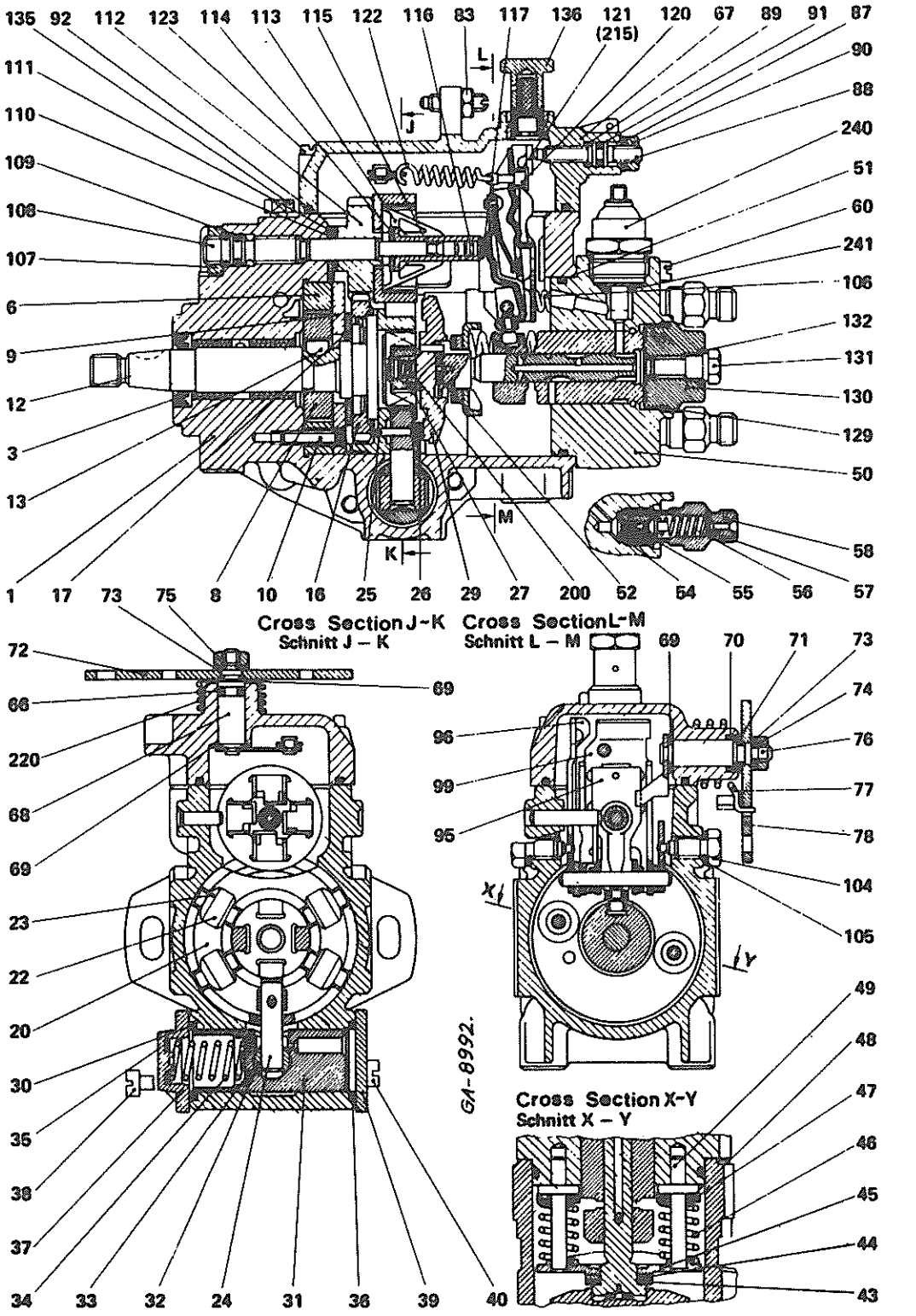


Illust. 303
Fuel Injection Pump (Rotary Model VE . . F . .)

1 – Throttle lever
2 – Shut-off lever
3 – Stop screw, low idle
4 – Stop screw, high idle
5 – Adjusting screw, full load
6 – Stop screw, shut-off lever travel
7 – Aneroid
8 – Breather hose (aneroid)
9 – Cover, timing hole
10 – End cover, advance piston (spring side)

For injection pump removal and installation see previous discussion.

Before attempting to service the pump it is strongly recommended to study "Principle of Operation" to get familiar with this pump model.



Illust. 304

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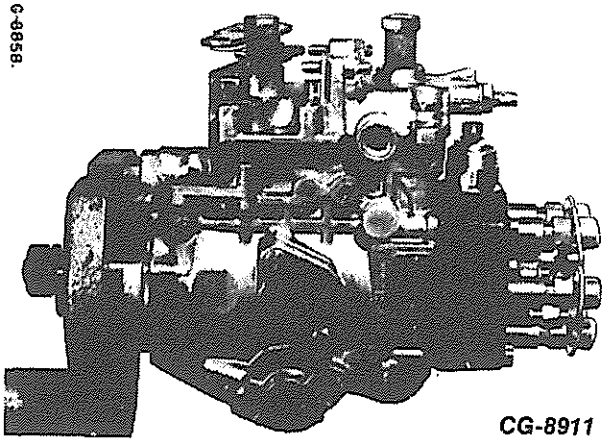
Disassembly

Note: Reference numbers correspond in the following illustrations to those in Illust. 304.

G-8858.

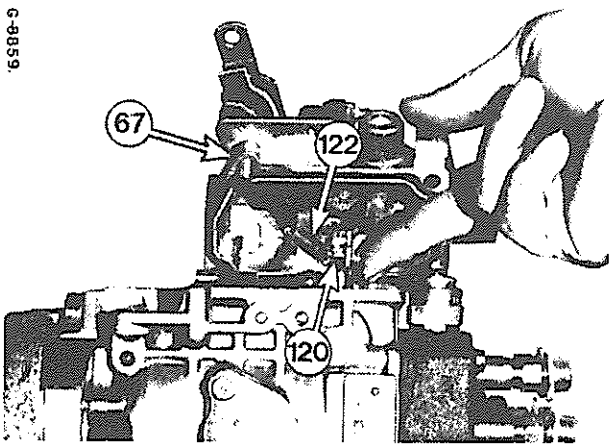


CG-8911

Illust. 305

Mount the pump in a holding fixture as shown in Illust. 305 (or similar).

G-8859.



Illust. 306 CG-8912

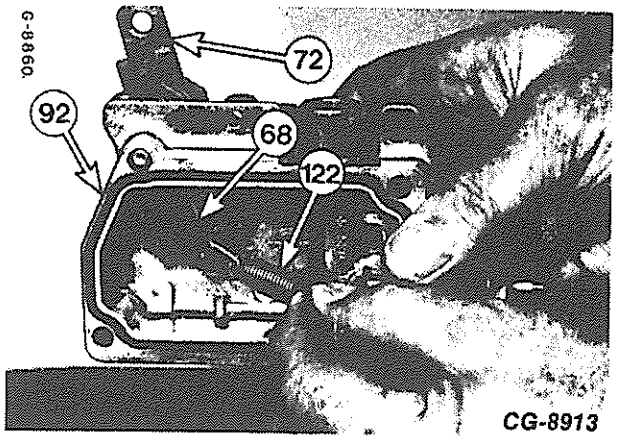
Remove pump cover retainer screws.
Tilt cover (67) as shown in Illust. 306.

First, unhook governor spring (122) from retainer pin (120). Do not overspread the spring.

Unhook the other end of the governor spring. Remove throttle lever (72) and outer washer (69). Push throttle lever shaft (68) out of the pump cover.

Remove O-ring (66), inner washer (69), and O-ring (92). Illust. 307.

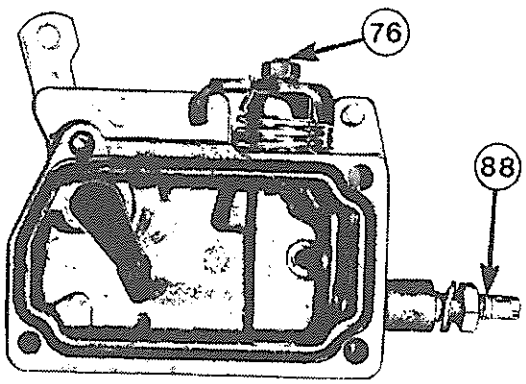
G-8860.



CG-8913

Illust. 307

G-8861

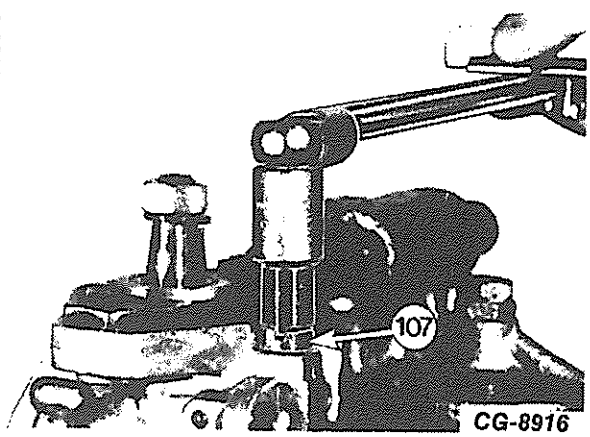


CG-8914

Illust. 308

Remove shut-off lever assy. (76) (if so equipped) in the same sequence as mentioned for the throttle lever. Remove full-load adjusting screw (88). Illust. 308.

G-8862



CG-8916

Illust. 309

Put the pump in vertical position.
Using tool KDEP 1082 loosen the slotted round nut (107) Illust. 309.
Remove the governor shaft (108). Take care not to drop governor components, Illust. 310, when removing the shaft.

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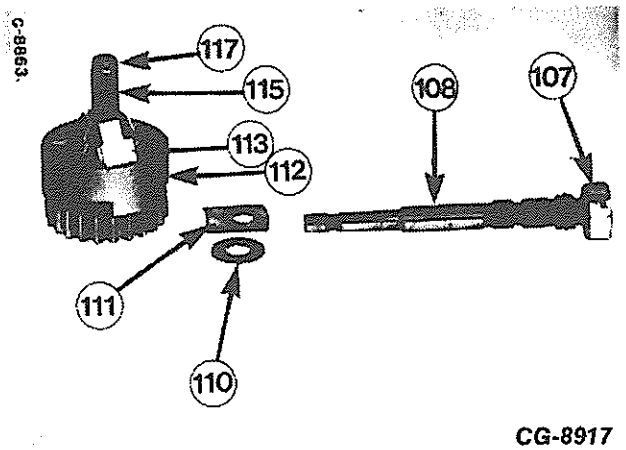
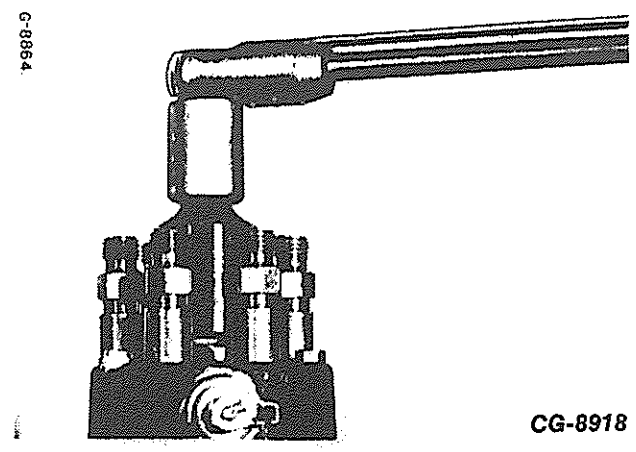


Illust. 310

107 – Slotted round nut
108 – Governor shaft
110 – Thrust washer
111 – Shim plate
112 – Governor assy
113 – Flyweight
115 – Governor sleeve
117 – Plug (replaceable)

Using socket KDEP 1080, remove plunger end plug (130).



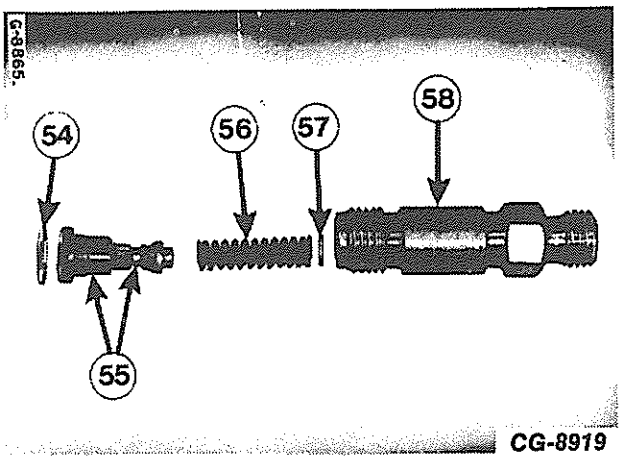
Illust. 311

Remove delivery valves.
Using tool KDEP 2938, remove packing ring (54).

Note: The outlet ports in the hydraulic head are marked with capitals A, B, etc., "A" being the outlet for the first cylinder of the engine.

Valve and guide are matched parts and must not be mixed up.

It is good practice to store each delivery valve assy. (Illust. 312) separately and to reinstall valves in their original places.



Illust. 312
Delivery valve components

54 – Packing ring
55 – Valve assy
56 - Spring
57 – Shim
58 – Holder

Remove the hydraulic head retainer screws (60).

Lift-off the hydraulic head (50) taking care springs (106), guide pins (49), shims (48), and spring seats (47) do not drop.

Lift the plunger with metering sleeve out of the pump housing taking care shim (43), slotted thrust washer (44), spring seat (45), springs (46), and the shim (52), the latter located in the recess in the plunger foot, do not drop.

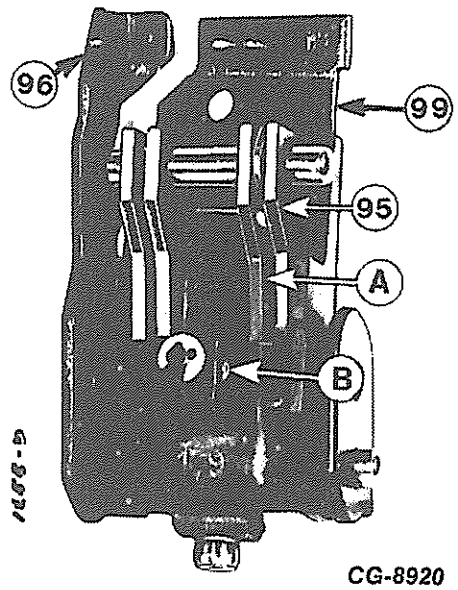
Remove dog point pin screws (104) and gasket (105).

Lift the governor lever assy. out of the pump housing.

Remove face cam (29).

Remove cover (9) Illust. 303.

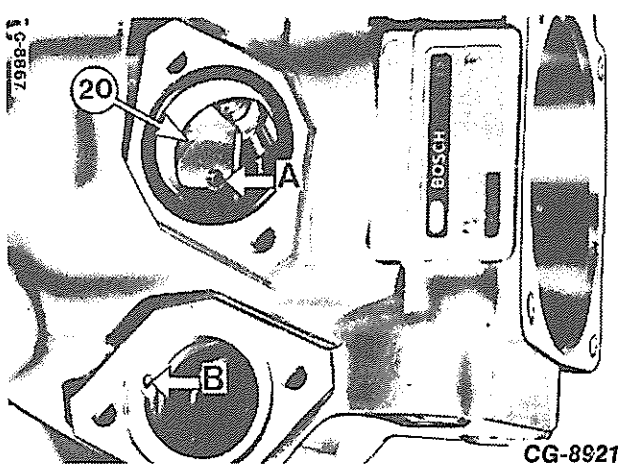
Remove the timing pointer from roller retainer ring (20). See arrow (A) Illust. 314.



Illust. 313

95 – Starting lever
96 – Torque control lever
99 – Tensioning lever

A – Lever, negative torque control
B – Spring, negative torque control



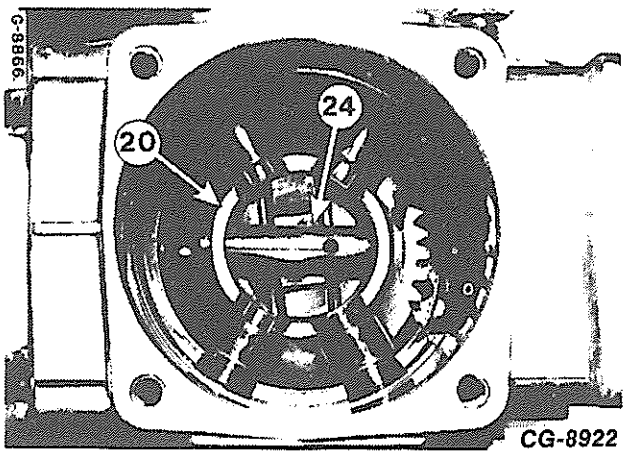
Illust. 314

20 – Roller retainer ring

A – Tap, timing pointer
B – Fuel return passage

Remove the advance piston end cap (37), gasket (30), shim (35), Spring (34), and washer (0.6 mm (.024") thick) (33).

Remove cover (39) and gasket (36).

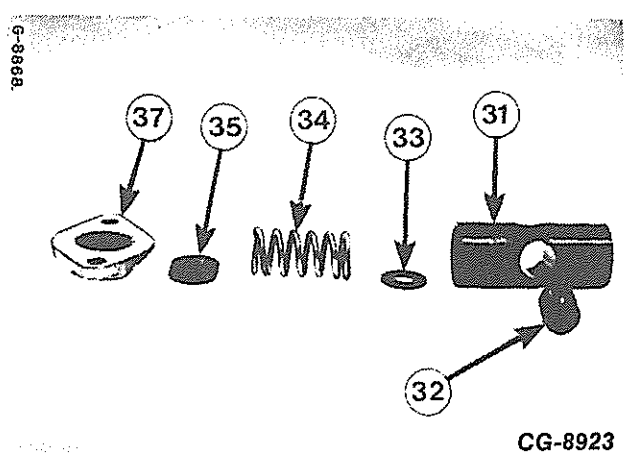


Illust. 315

Remove flexible drive coupling (27).
Remove retainer pin clamp (26).
Remove retainer pin (25).

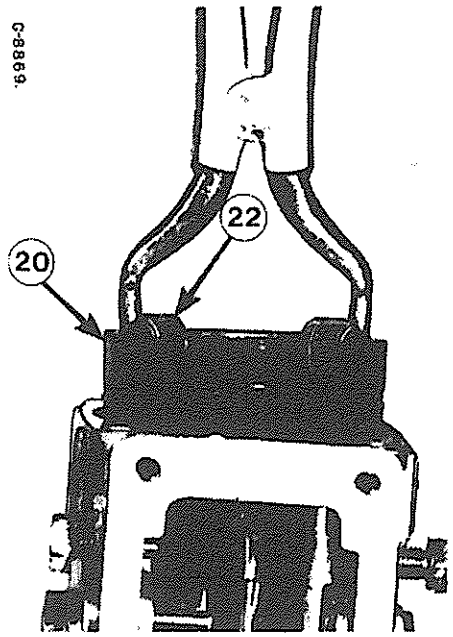
Push the connecting pin (24) in the center of the roller retainer ring (20), Illust. 315, to clear the advance piston.

Remove advance piston (31) and swivel bushing (32).



Illust. 316
Advance piston assy. removal

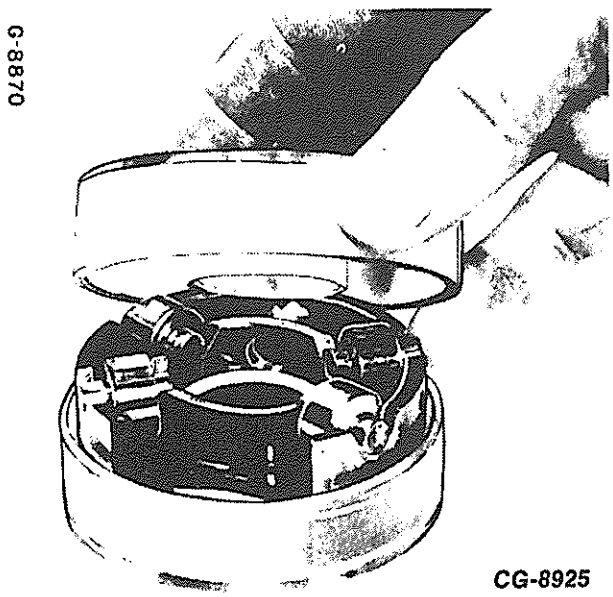
31 – Advance piston
32 – Swivel bushing
33 – **Washer, 0.6 mm (.024") thick**
34 – Spring
35 – Shims
37 – End cap



Illust. 317

Remove roller retainer ring (20) Illust. 317.
Do not allow roller pins to drop out of the rollers (22).

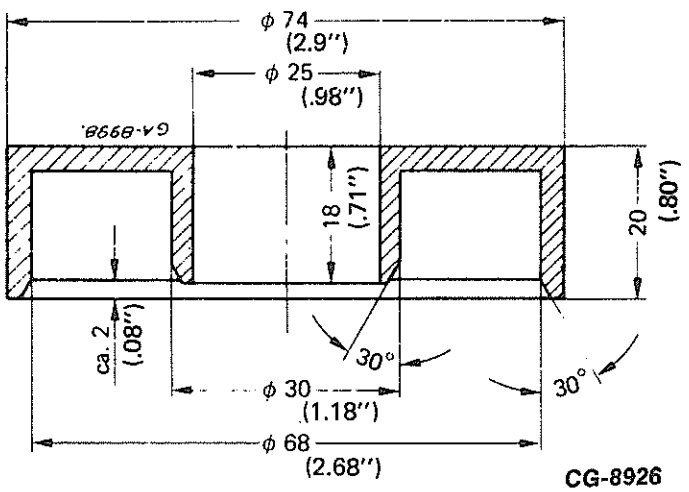
Note: Rollers, bushings and pin are a selective fit and must be kept with their respective part in the same location on the roller ring by using a storing container.



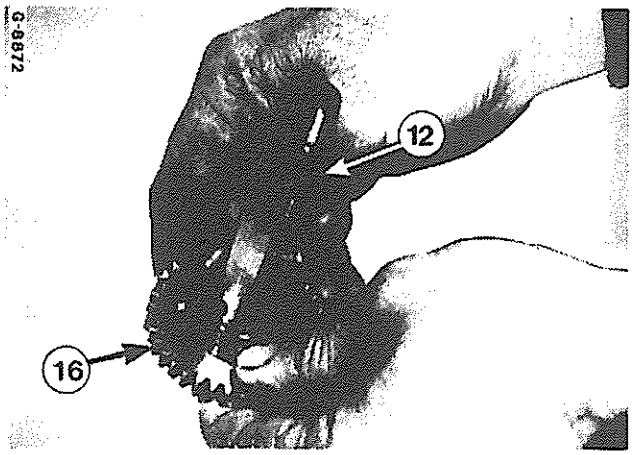
Illust. 318

Note: The storing container can be made locally. See Illust 319. Material: Alu or plastic.

Push drive shaft (12) out of the pump housing, taking care woodruff-key (13) does not drop.



Illust. 319
Dimensions in mm (inch)



Illust. 320

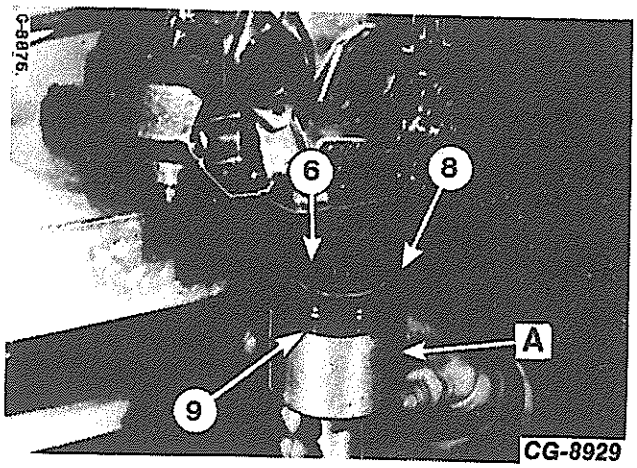
Remove gear (16) and the rubber buffers from drive shaft (12).

Remove slotted thrust washer (17).

Charging Pump Removal

Remove the two cross-recess retainer screws (10).

Slide home made tool (A), Illust. 321 into the pump housing against support ring (9) and charging pump assy. so that it cannot drop as the pump is turned in the holding fixture.



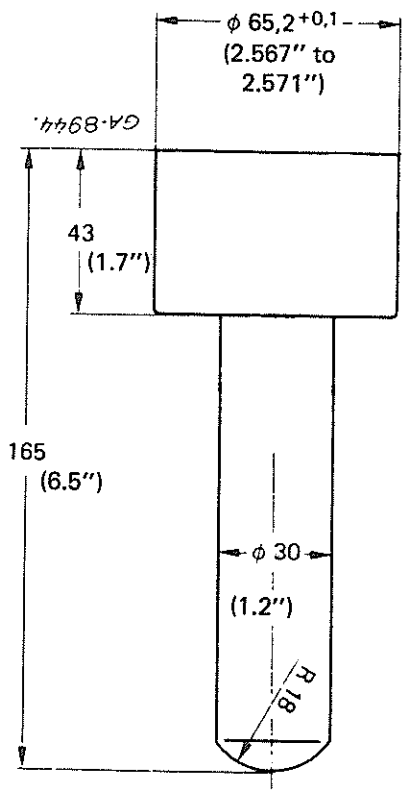
Illust. 321

A – Home-made tool

6 – Rotor)
8 – Eccentric race) charging pump
9 – Support ring

Position the pump as shown in Illust. 321.
Slowly back-off the tool (A). If necessary, slightly tap the holding fixture to facilitate charging pump removal.

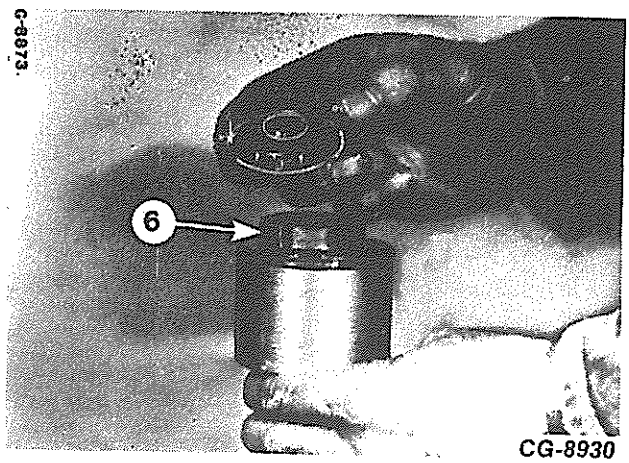
Note: Tool (A) Illust. 321 can be made locally. See Illust. 322. Material: Alu or plastic.



Illust. 322
Dimensions in mm (inch)

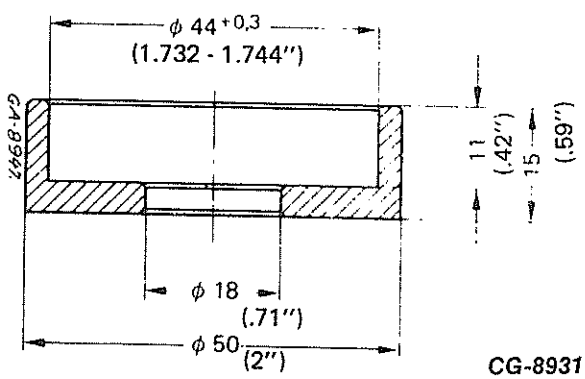
The charging pump rotor (6) Illust. 321 and its vanes are matched.

Store the rotor in a container so that the vanes cannot drop out. Illust. 323.

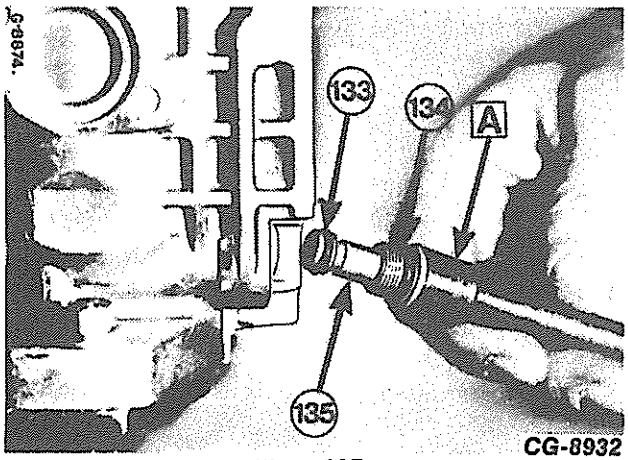


Illust. 323

Note: The storing container can be made locally. See Illust. 324.



Illust. 324
Dimensions in mm (inch)
Material: Alu or plastic



Illust. 325

A – Tool KDEP 1086

134 + 133 – O-rings
135 – Charging pressure regulating valve

Using tool KDEP 1086 remove the charging pressure regulating valve (135) Illust. 325.

Remove O-rings (133) and (134).

Inspection

Thoroughly clean all part of the injection pump in clean diesel fuel.

Carefully inspect each part of the pump.

Replace worn or damaged components with new ones.

Especially check the distributor plunger using a magnifying glass.

The surface of the plunger must have a mirror-like finish. If it has become dull or gray in appearance, the plunger is worn excessively, i.e. plunger, metering sleeve, and the hydraulic head must be replaced.

The edges of vertical slots and annular groove of the plunger must appear sharp-edged and not round, when examined with a magnifying glass.

Replace, if necessary.

Following components must be replaced as a unit.

a) Plunger, metering sleeve, and hydraulic head.

b) Roller retainer ring assy.

c) Charging pump assy.

Reassembly

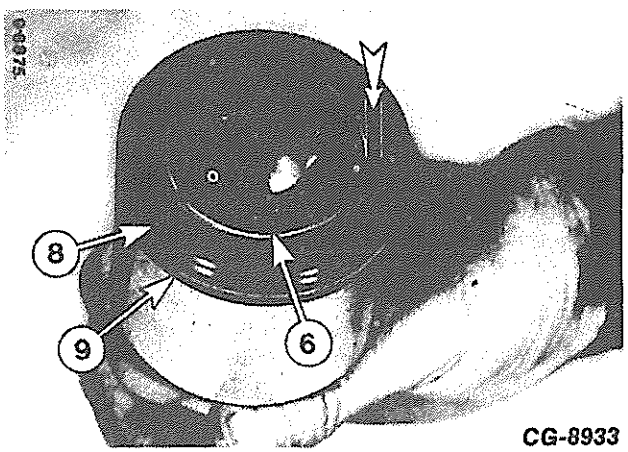
Observe strict cleanliness on the working place. Immerse each part, also O-rings and gaskets, in clean diesel fuel or test oil before reassembly.

Replace O-rings and gaskets with new ones.

Tighten each screw to specified torque.

Proceed as follows:

Press the seal ring (3) into the pump housing recess.

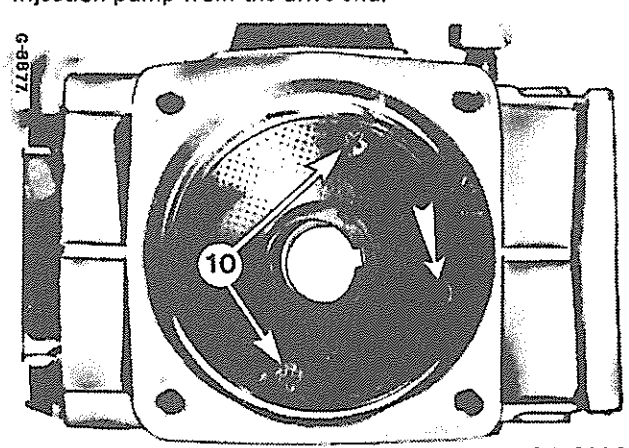


Illust. 326

Place support ring (9), charging pump rotor (with the convex side of its vanes outwards), eccentric race (6) onto the installing tool in this sequence. Illust. 326.

The screw holes in the eccentric race differ in their relation to the inner diameter of the race.

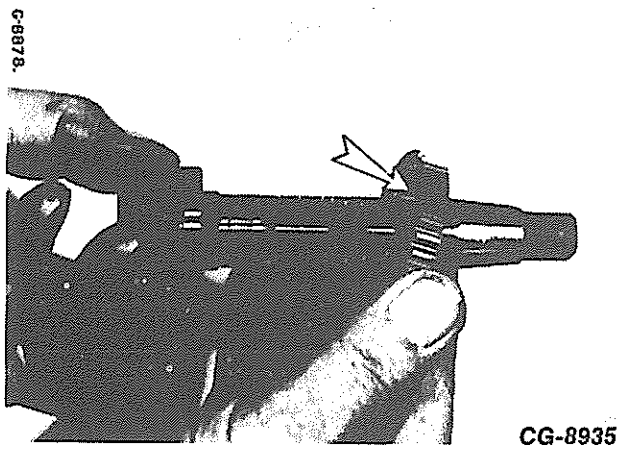
Place the eccentric race over the rotor in such a way that the screw hole with the greater distance to the inner diameter (see arrow Illust. 326) is on the right-hand side and the fuel passage is on the top, when facing the injection pump from the drive end.



Illust. 327

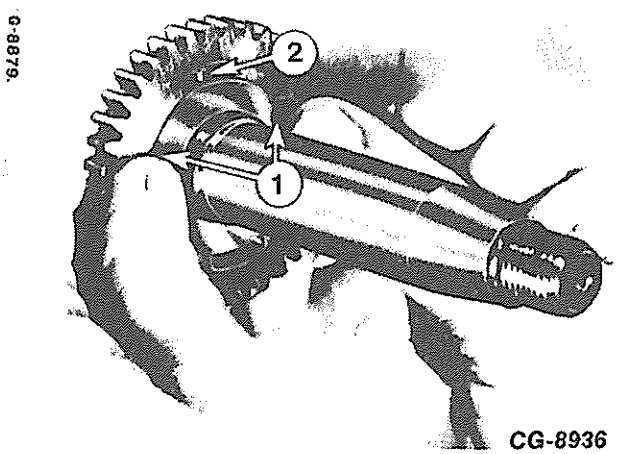
Align the screw holes in the support ring with the holes in the eccentric race and slide the charging pump assembly into the pump housing.

Insert the pump and install the cross-recess screws (10). Make sure the fuel passage (arrow) is positioned towards the top of the pump housing. Illust. 327.



Illust. 328

Slide gear (16) over the drive shaft, with its undercut side ahead. Illust. 328..

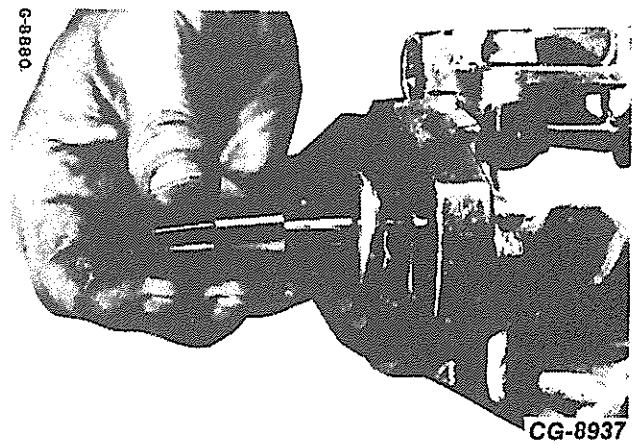


Illust. 329

1 – Rubber buffer
2 – Roll pin

Using new rubber buffers (1) Illust. 329 install gear (16) onto the drive shaft.

Use some grease to stick the slotted thrust washer (17) onto gear (16) and to hold woodruff-key (13) in the keyway of drive shaft.



Illust. 330

Insert the pump as shown in Illust. 330.

Install the drive shaft using the seal protecting sleeve KDEP 2939 to protect the lip of the seal (3).

Make sure the woodruff-key has engaged the slot in the charging pump rotor.

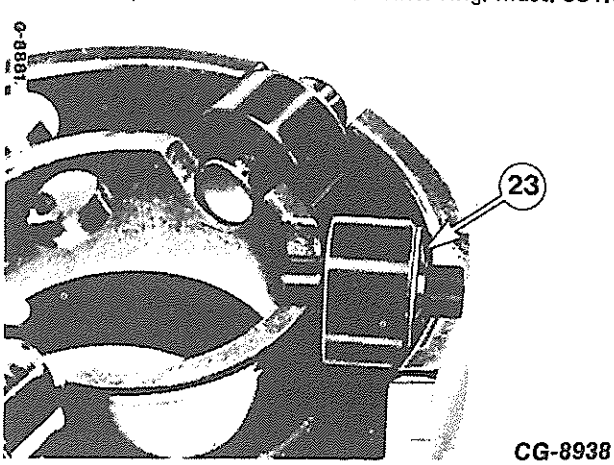
Remove the protection sleeve. Illust. 330.
Hold the drive shaft in position and insert the pump so the open side is up.

Roller Retainer Ring

Note: In case the roller pins have been dropped and rollers have been mixed up, check to see the protrusion of each roller is equal. A deviation in roller protrusion up to 0.02 mm (.0008") is permissible.

When installing the rollers do not overlook the dish washers (23).

Make sure the dished-out side of the washers goes against the outside portion of the roller retainer ring. Illust. 331..



Illust. 331

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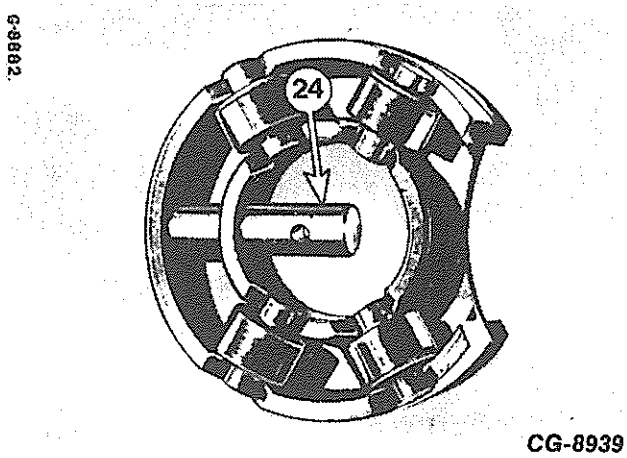
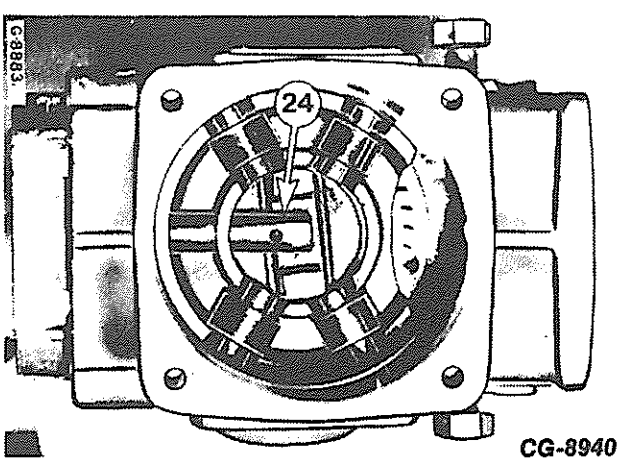
Push connecting pin (24) into the roller retainer ring. Make sure the cross hole in the pin goes to the center of the ring and is facing up. Illust. 332.



Illust. 332

Rotate the drive shaft so that its coupling tangs are parallel to the advance piston bore in the pump housing.

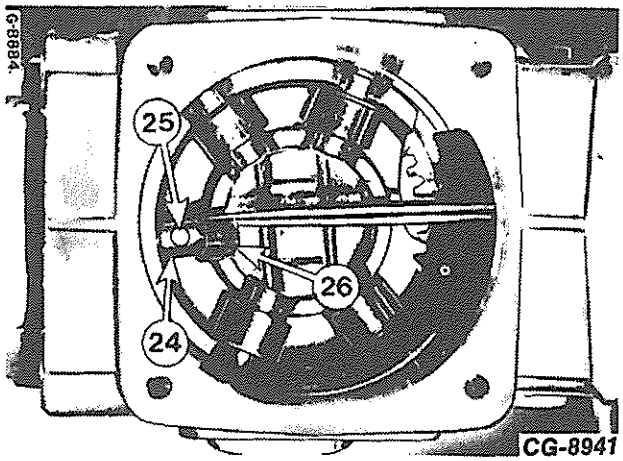
Place the roller retainer assy. into the pump housing so that the connecting pin (24) goes to the advance piston bore. Illust. 333.



Illust. 333

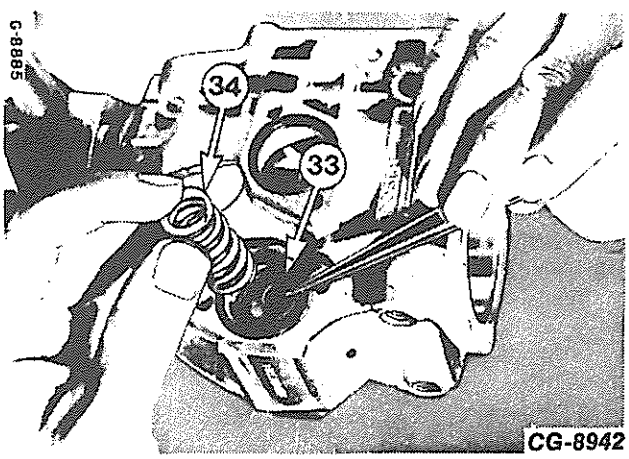
Using some petroleum jelly place the swivel bushing (32) into the bore in the advance piston.

Insert the advance piston into the bore in the pump housing. Make sure the spring pocket side of the piston is on the pump timing hole side and the bore in swivel bushing (32) is facing connecting pin (24).



Illust. 334

Push the connecting pin into the advance piston swivel bushing and secure the connecting pin by installing retainer pin (25) and clamp (26). Illust. 334.



Illust. 335

Total thickness of advance piston shim package is specified for each individual pump. See Service Manual GSS-1460-3 or ISS-1522-3.

Shim thickness as given in the chart comprises 0.6 mm (.024 in) for shim (33) Illust. 335 plus a variable thickness for shims (35). (Illust. 316)

First place shim (33) into the spring pocket, then enter spring (34) Illust. 335.
Place the required shims (35) in the end cap (37).

Note: At least one shim must be installed on each side of the advance piston spring.

Install gasket (30) and end cap (37), on the other advance piston side install gasket (36) and cover (39).

Install O-rings (133) and (134).
Using tool KDEP 1086 install the charging pressure regulating valve (135).

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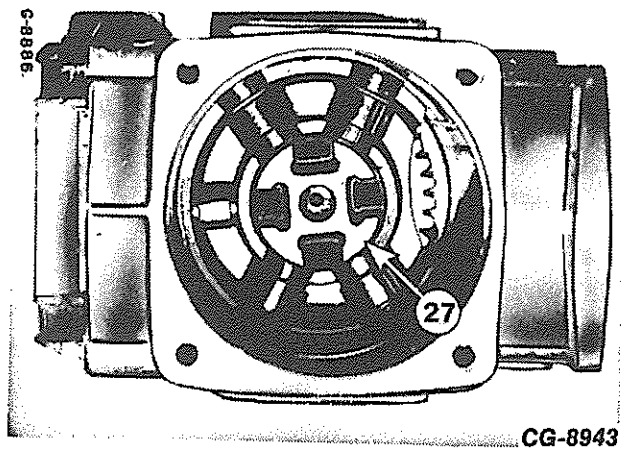
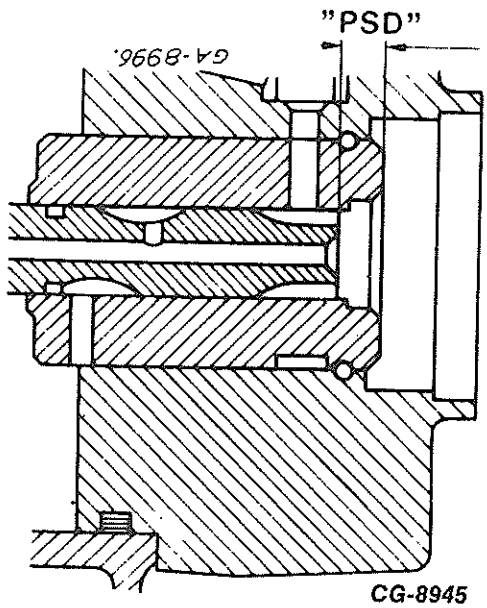
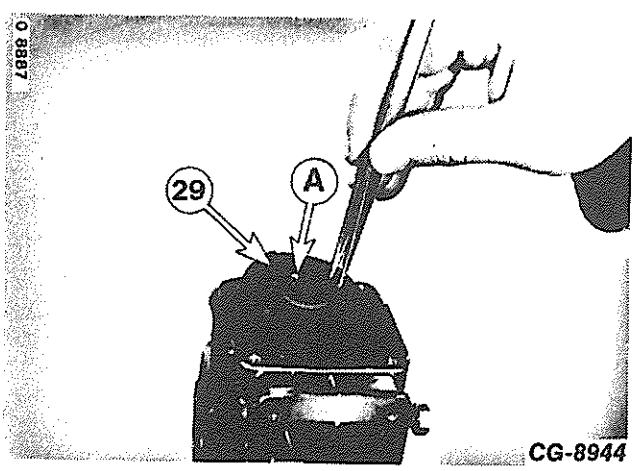


Illust. 336

Install flexible coupling (27).



Illust. 338

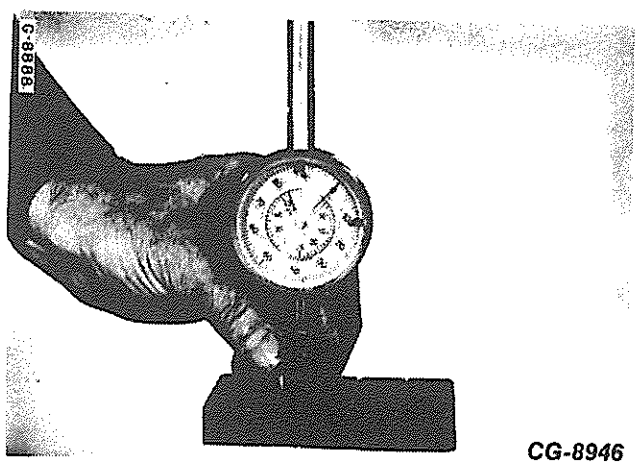


Illust. 337

Align the plunger index pin "A" in the face cam with the keyway in the drive shaft and install the face cam.

Checking Dimension "PSD"
(plunger spring dimension)

This dimension is the distance between the sealing face on the hydraulic head and the face of the distributor plunger. Illust. 338.



Illust. 339

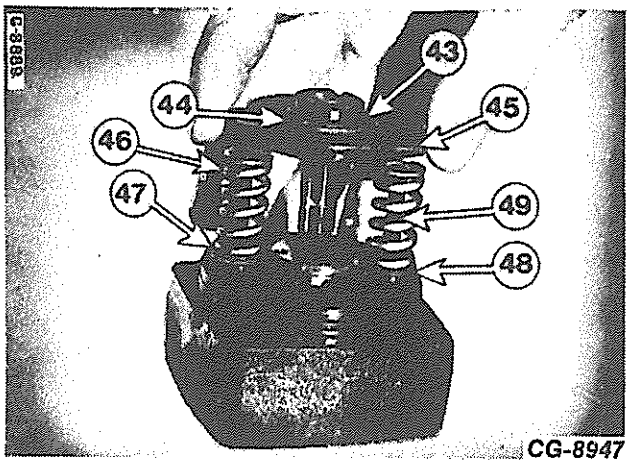
Clamp dial indicator 1 687 233 012 in the holder KDEP 1032.

Preload the indicator to about 25 mm (1 in.) and zero the dial. Illust. 339.

Enter guide pins (49) into their holes in the hydraulic head.

Place spring seats (47) and springs (46) (without shims (48)) on the hydraulic head.

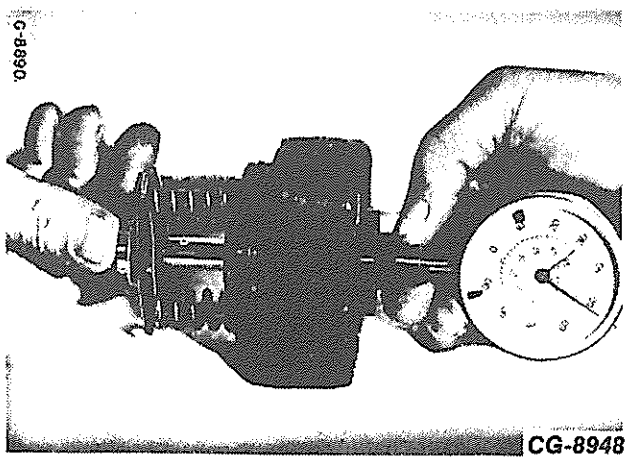
Reassemble the distributor plunger with shim (43), slotted thrust washer (44) and spring seat (45) and slide into the bore in the hydraulic head. Illust. 340.



Illust. 340

Hold the hydraulic head horizontally

Force the dial indicator holder against the hydraulic head and apply some thumb pressure to the plunger foot. Illust. 341.



Illust. 341
Checking dimension "PSD"

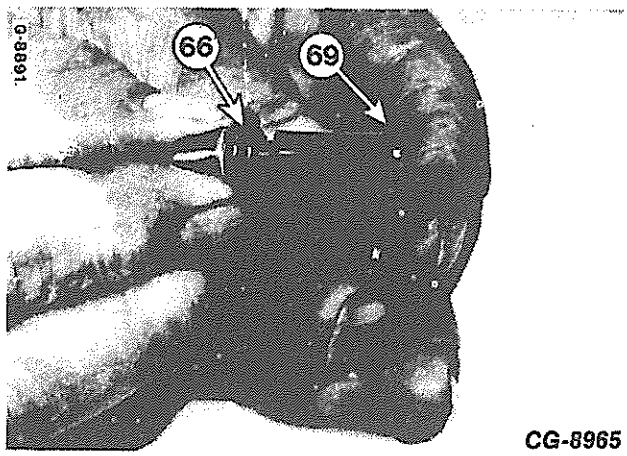
Record the dial indicator reading and compare with the "PSD" dimension listed in specifications of Service Manual GSS-1460-3 or ISS-1522-3.

Select shims (48) as necessary to obtain specified "PSD" dimension.

In case the actual shim thickness required lies between two available shims of the assortment, use the thicker shim to correct plunger spring dimension.

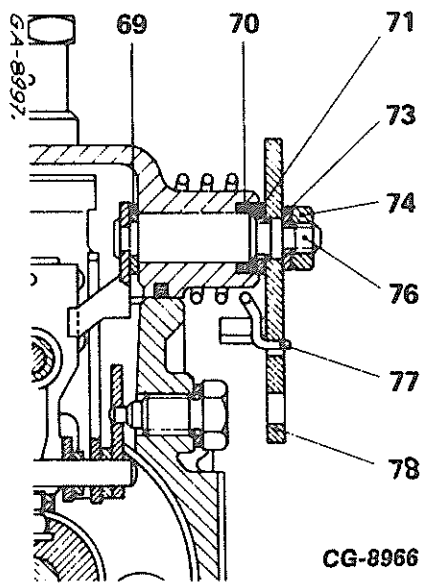
Note 1: Only one shim (48) of the same thickness must be placed underneath each of the spring seats (47).

Note 2: If necessary, replace springs (46) as a set.



Illust. 342

Assemble linkage on pump housing cover. Slide shim (69) over the throttle lever shaft and push O-ring (66) into its groove in the shaft, using protection sleeve KDEP 2937. Illust. 342.
Insert the shaft assy. into the bore in the housing cover. Install torsional spring (220) outer shim (69) and lever (72), the latter parallel to the inner rigid shaft lever. Secure lever (72) with lock washer (73) and nut (75). If so equipped, install the shut-off lever assy. as shown in Illust. 343.



Illust. 343

69 – shim
70 – O-ring
71 – washer
73 – lock washer
74 – nut
76 – shaft
77 – torsional spring
78 – shut-off lever

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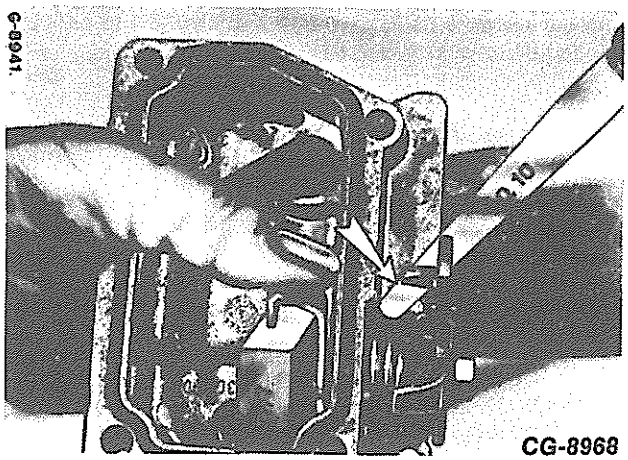


Illust. 344

If the position of the shut-off lever has not been marked before removal, install the shut-off lever as follows:

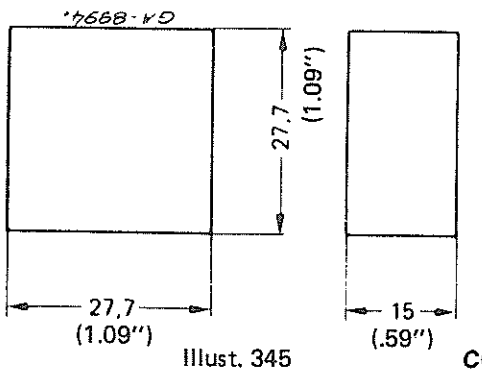
Place the home-made spacer bar into the housing cover as shown in Illust. 344.

Apply thumb pressure on the inner shaft lever and install the outer lever (78) in such a way that there is a minimum gap between the outer lever and the cover

Check and note this gap. See arrow Illust. 344.

Secure the lever (78) with lock washer (73) and nut (74).

Note: **The spacer bar used for shut-off lever adjustment can be made locally according to Illust. 345. Material: Mild steel.**



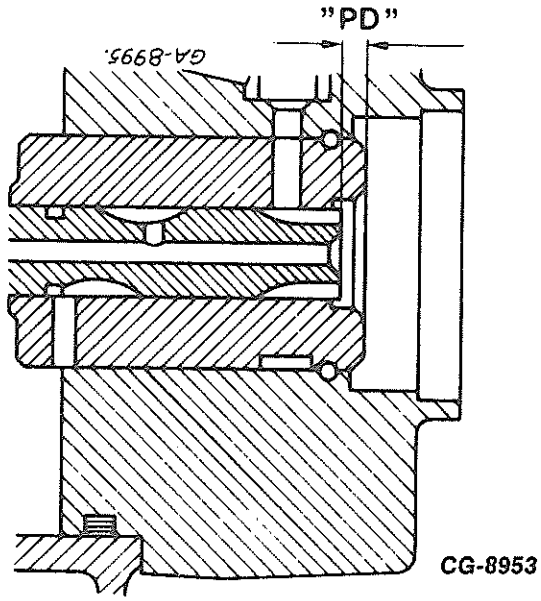
Illust. 345

Dimensions in mm

Injection Pump Timing

A. Plunger Dimension "PD"
(pumps without pre-stroke only)

Dimension "PD" Illust. 346 is the distance between the sealing face of the hydraulic head and the plunger face when the plunger is in bottom dead center.



Illust. 346

Check "PD" dimension as follows:

Place any shim (52) into the recess in the plunger foot (do not use petroleum jelly etc.).

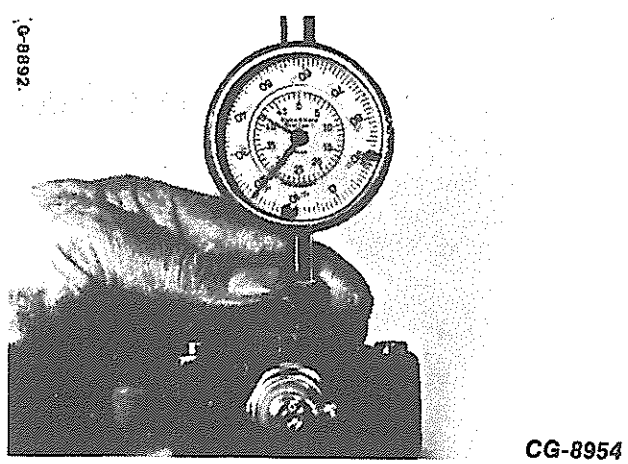
Align the index notch in the plunger foot with the index pin in the face cam and place the plunger onto the face cam.

Carefully slide the hydraulic head over the plunger and into the pump housing.

Install hydraulic head retainer screws. Tighten the screws to specified torque.

Pre-load and zero a dial indicator as mentioned before (Illust. 339).

Position the pump vertically.



Illust. 347

Checking plunger dimension

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Place the dial indicator on the sealing face of the hydraulic head. Illust. 347.

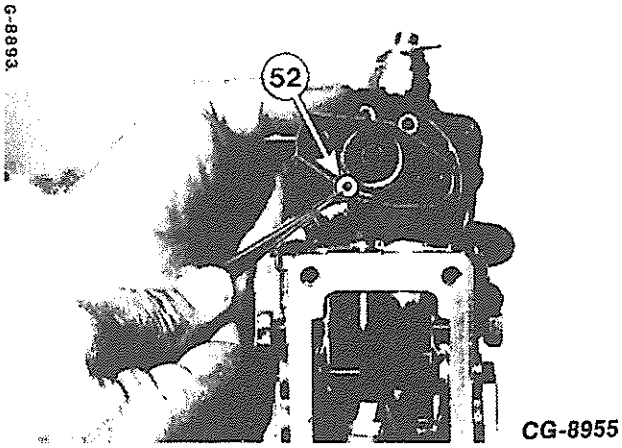
With the plunger in bottom dead center record the dial indicator reading.

Recheck the reading by slowly rotating the drive shaft to and fro.

The reading should correspond with the dimension in "Specifications" of Fuel Injection Pump Service Manual.

Correct by selecting a suitable shim (52) is necessary.

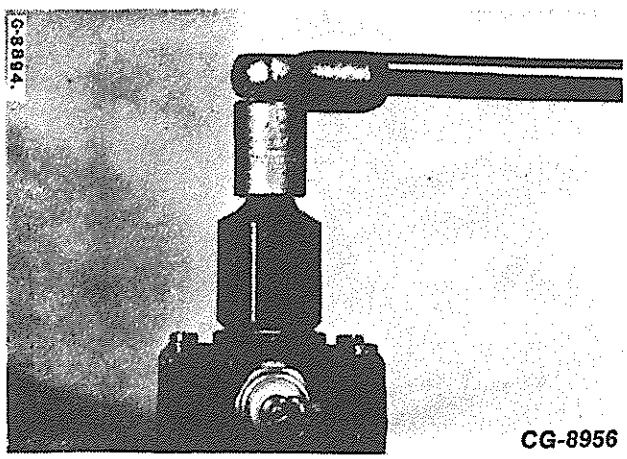
Select a thicker shim (52) Illust. 348, if the dial indicator reading is exceeding the specified "PD" and vice versa.



Illust. 348

In case the actual shim thickness required lies between two available shims of the assortment, use the thicker shim to correct the plunger dimension.

Recheck plunger dimension.



Illust. 349

Use the socket KDEP 1080 and tighten the end plug to specified torque. Illust. 349.

Note: Whenever removed, replace gasket (129) and plunger end plug (130) with new ones.

Install delivery valves (55), gasket (54), spring (56), shim (57), and holder (58).

Tighten holder (58) to specified torque.
Remove the hydraulic head.

Make sure the distributor plunger slides in the hydraulic head without binding.

B. Plunger Lift to Port Closure
(pump with pre-stroke only)

Employ the overflow method to check plunger lift to port closure as follows:

Place any shim (52) into the recess in the plunger foot (do not use petroleum jelly etc.).

Align the index pin in the face cam with the index notch in the plunger foot and place the plunger onto the face cam.

Place a soft auxiliary spring between the plunger foot and the metering sleeve to hold the latter against the hydraulic head during the measurement.

Slide the metering sleeve over the plunger making sure the machined face is towards the hydraulic head.

Carefully slide the hydraulic head over the plunger and into the pump housing.

Install and tighten hydraulic head retainer screws.

Install a new gasket (129) and a new plunger end plug (130).

Using socket KDEP 1080 tighten the end plug to specified torque.

Install delivery valves.
Install governor shaft (108) temporarily.
Install pump housing cover temporarily.

Install plug M12 x 1.5 into the overflow throttle hole in the pump housing cover to block the fuel return flow.

Install pre-stroke measuring device 1 688 130 045, extension and dial indicator 1 687 233 012 into the plunger end plug tap.

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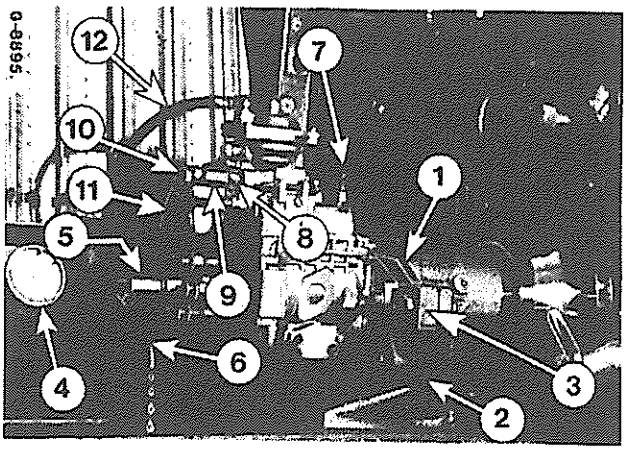
Using the proper bracket, flange and clamp, fit the injection pump on the test bench as shown in Illust. 350.

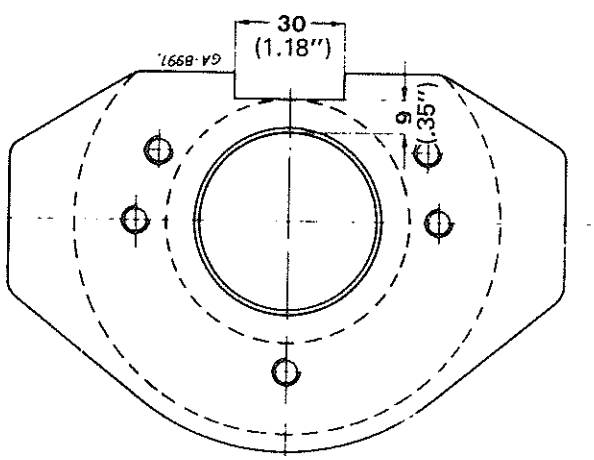
Eliminate drive line play.



Illust. 350

*1 – Flange
2 – Clamping bracket
3 – Clamp
4 – Dial indicator
5 – Pre-stroke measuring device
6 – Drip tube
7 – Hose, fuel supply
8 – Banjo fitting (pressure gauge connection)
9 – Fuel return valve (throttle)
10 – Inlet-union screw, extra long
11 – Hose, fuel return
12 – Hose, boost pressure

*** Previous flange 1 685 720 062 may be modified. See Illust. 351.**



Illust. 351
Modified flange 1 685 720 062
(dimensions in mm) (inch)

Connect fuel supply hose (7) Illust. 350.

Note: It is not necessary to connect parts (8) to (12) now. However the return fuel outlet must be plugged.

Switch on the test bench and adjust fuel supply pressure to 20 kPa (2.9 psi).

Position the plunger in bottom dead center and zero the dial indicator (fuel is flowing out of pipe (6)).

Slowly turn the test bench drive clockwise (viewed from pump drive end) until fuel outflow (6) is reduced to a mere tricle.

This is the point of port closure, i.e. injection begin.

Record the dial indicator reading at this point.

Compare the recorded figure with the specified "PL" as listed in "Specifications" of Fuel Injection Pump Service Manual.

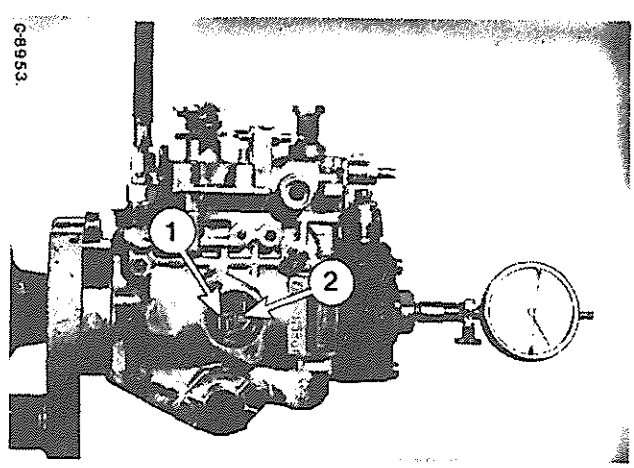
If the recorded figure exceeds the specified "PL" dimension, place a thicker shim (52) under the plunger foot and vice versa.

In case the actual shim thickness required lies between two available shims of the assortment, use the thicker shim to correct plunger lift to port closure.

Recheck injection pump timing.

Setting the Timing Pointer

With plunger dimension "PD" or plunger lift to port closure "PL" correct, adjust the timing pointer.



Illust. 352

1 – Timing pointer
2 – Scribe line on the face cam

Install a dial indicator in place of the plunger end plug. Illust. 352.

With the plunger in bottom dead center, pre-load the dial indicator to about 4 mm (.16") and zero the dial.

Turn the pump drive shaft clockwise (viewed from drive end) until the plunger travels (lifts) 1 mm (.039").

At this point align pointer (1) with the scribe line (2) and lock the pointer retainer screw.

The keyway in the drive shaft must be up (in 11 o'clock position) when setting the pointer.

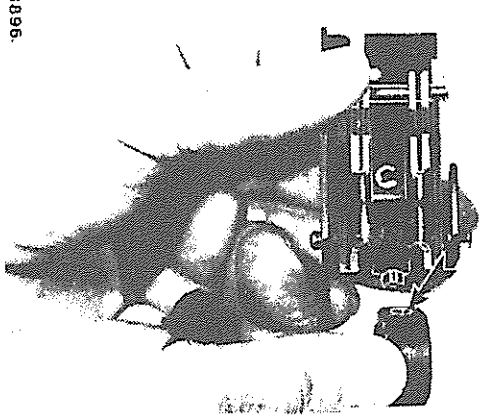
To complete the pump proceed as follows.

Remove dial indicator or pre stroke measuring device.

Remove the hydraulic head, auxiliary spring (if used) and selected shim (52).

Remove the temporarily installed parts, as pump housing cover, governor shaft (108), dog point screws (104), and plug M12 x 1.5.

C-8896

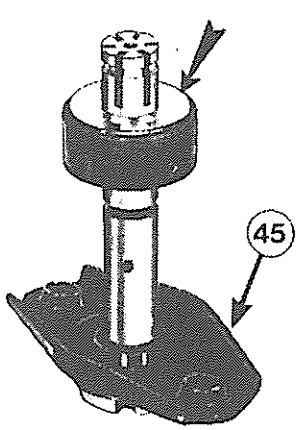


CG-8949

Illust. 353

Be sure the ball joint on the governor lever assy. slides freely in the bore in the metering sleeve. Illust. 353.

C-8897



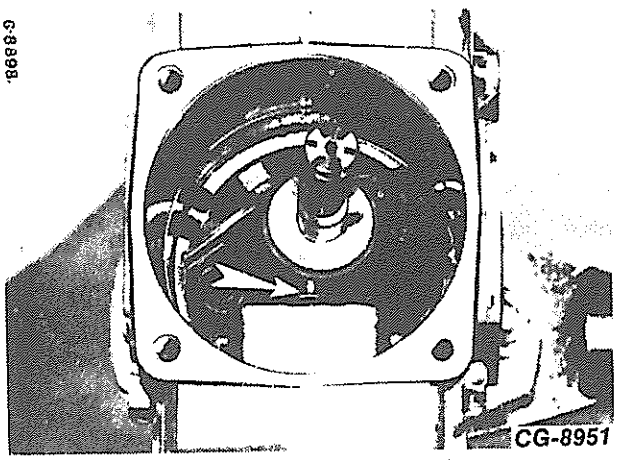
CG-8950

Illust. 354

Place shim (43), slotted thrust washer (44), and spring (45) on the plunger foot respectively.

Slide the metering sleeve over the plunger in such a way that is machined and polished face is toward the hydraulic head. Arrow Illust. 354.

C-8898



CG-8951

Illust. 355

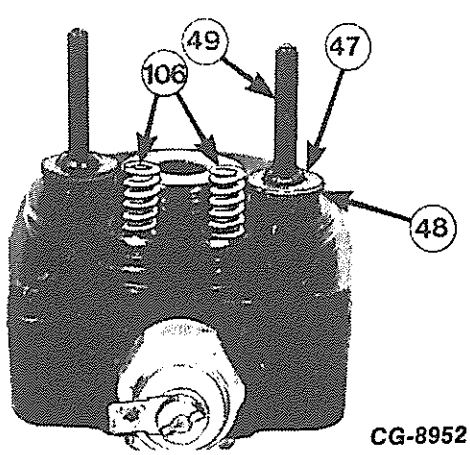
Install the plunger assembly with selected shim (52). Make sure the notch in the plunger foot engages the index pin in the face cam.

Install the governor lever assembly, making sure its ball joint engages the bore in the metering sleeve. Arrow Illust. 355.

Fasten the lever assy. by installing gaskets (105) and dog point screws (104).

Place the plunger return springs (46) onto spring seat (45).

C-8899



CG-8952

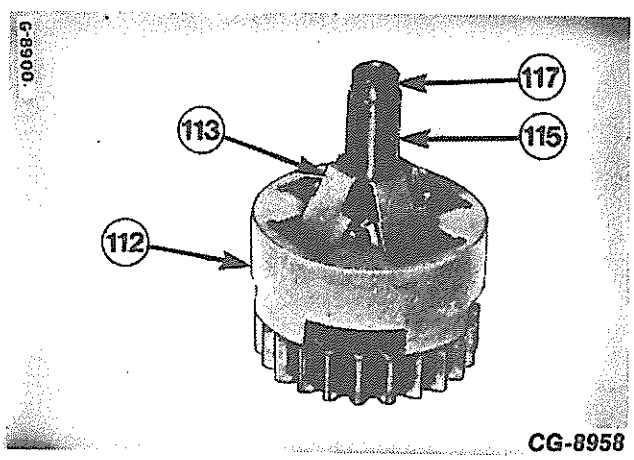
Illust. 356

Using some petroleum jelly, insert guide pins (49), selected shim (48) (see Checking "PSD" Dimension), spring seat (47), and springs (106) in their bores in the hydraulic head. Illust. 356.

Carefully install the hydraulic head making sure the springs (106) go to the lower parts of the governor lever assy.

Be sure guide pins (49) are still properly seated in the bores in the hydraulic head.

Tighten hydraulic head retainer screws (60) to specified torque.



Illust. 357

112 – Governor
113 – Flyweights
115 – Governor sleeve
117 – End plug

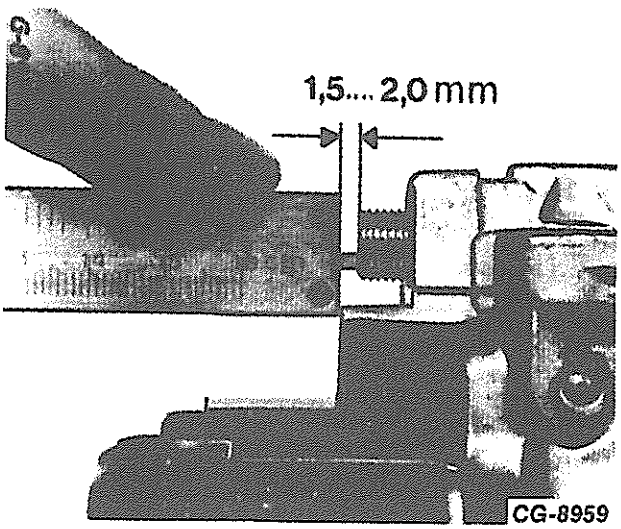
Reassemble governor unit. Illust. 357.

Do not overlook the spacer washer (114) located between sleeve (115) and the unit body.

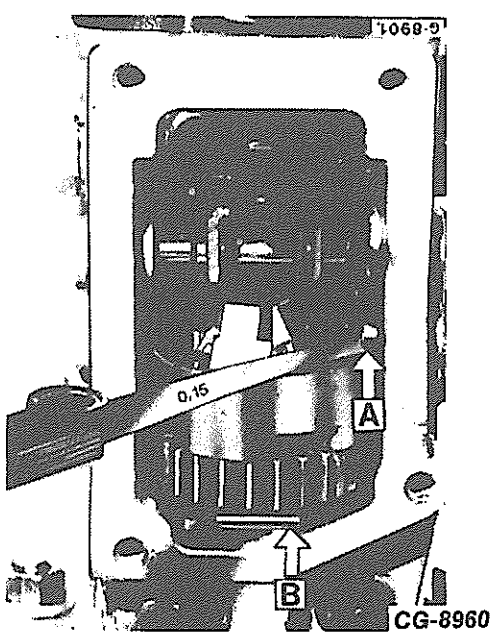
To facilitate installation of the governor, use petroleum jelly to stick the shim plate (110) and thrust washer (111) onto the pump housing wall.

Place O-ring (109) into the groove in governor shaft (108).

Slide the governor shaft through the tapped hole in the pump housing into the governor unit and screw in until a clearance of 1.5 to 2.0 mm (.059 to .079 in.), measured from the shaft end to the pump flange, is obtained. See Illust. 358.



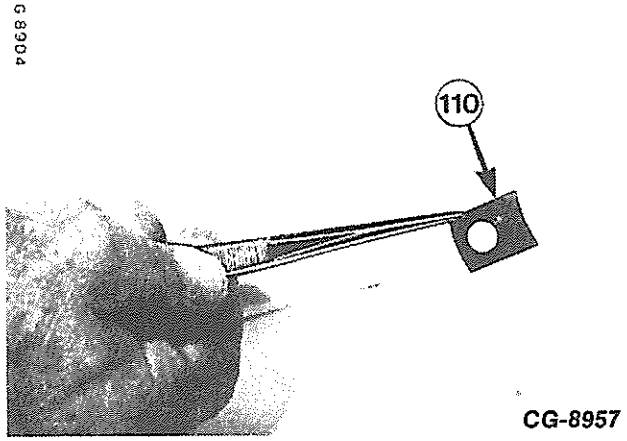
Illust. 358



Illust. 359

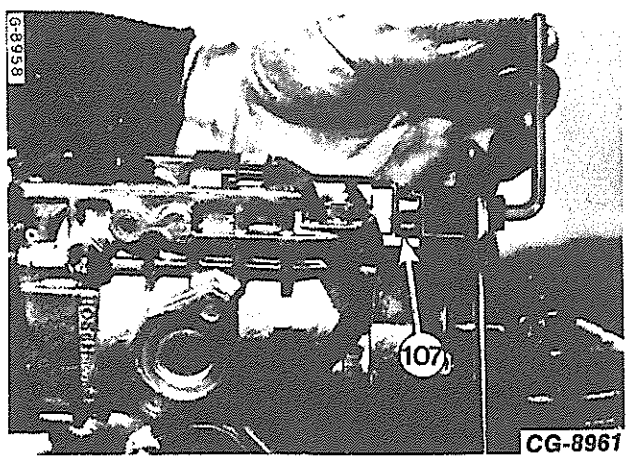
Using a feeler gauge check governor end play. Arrow (A) Illust. 359.

Correct end play to 0.15 to 0.35 mm (.006 to .014 in.) with shim plate (110) (arrow (B)), if necessary.



Illust. 360

110 - Shim plate (governor end play)



Illust. 361

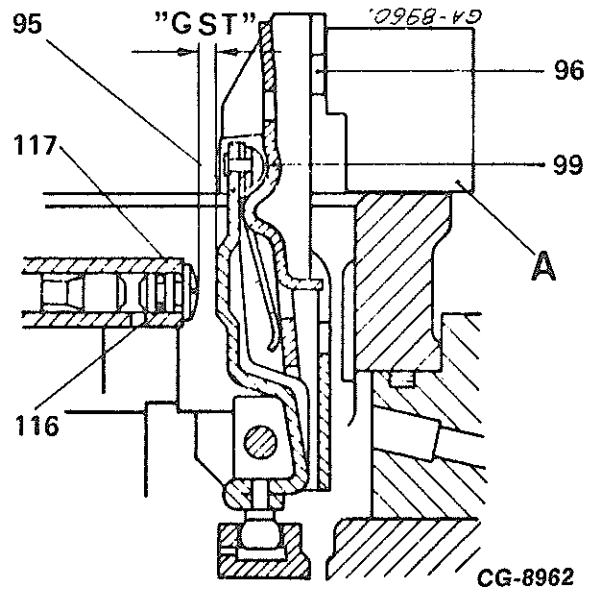
Position the pump horizontally.

Using the socket KDEP 1082 tighten the nut (107) to 25-30 N•m (18-22 lbf-ft).

Governor Sleeve Free Travel "GST"

Using two cover retainer screws bolt stop bar (A) Illust. 362 to pump housing, with its undercut side facing the governor lever assy.

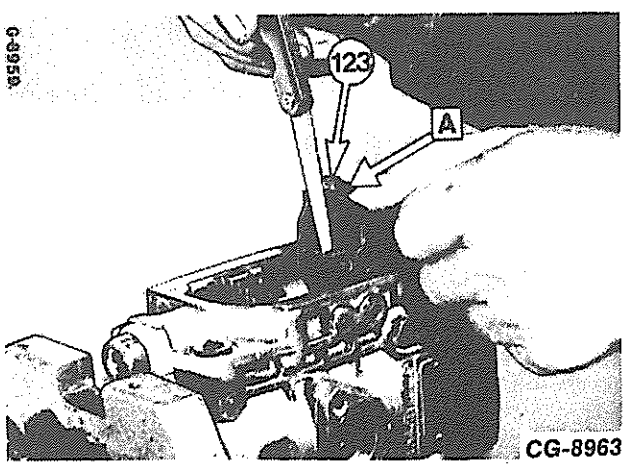
The "GST" dimension, i.e. free travel of governor sleeve is the clearance between plug (117) Illust. 362 and the starting lever (95) or, if so equipped, the negative torque control lever.



Illust. 362

"GST"-Governor sleeve free travel (clearance)

A – Stop bar KDEP 1084 (pump without negative torque control lever shown)



Illust. 363

Checking "GST" on pump with negative torque control lever

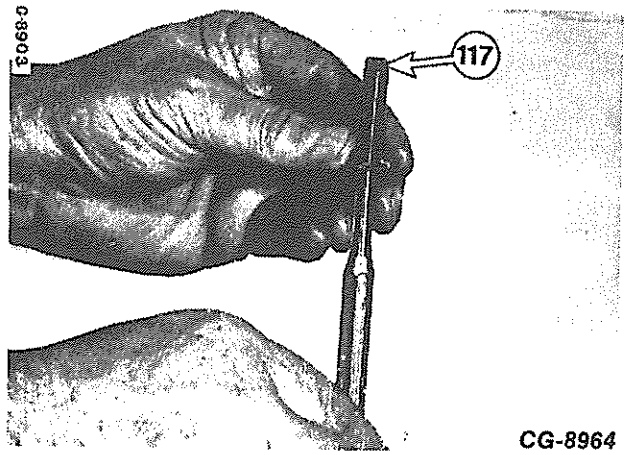
To check "GST" dimension force lever (96) against stop bar (A) and starting lever (95) against its stop pin in the pump housing.

Using a feeler gauge check and record "GST" clearance.

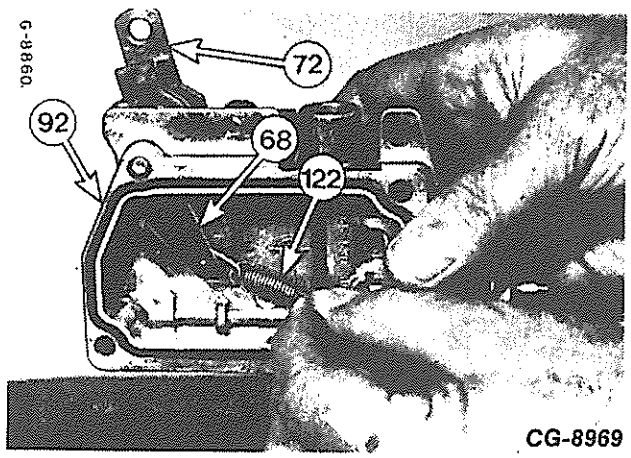
Compare the measured "GST" with the specified "GST" listed in the "Specifications" of Fuel Injection Pump Service Manual.

If necessary, remove the complete governor unit and install the proper end plug (117) Illust. 362 to bring the measured "GST" to specified "GST."

Remove plug (117) as shown in Illust. 364.
Do not overlook the circlip (116), Illust. 67, when installing the proper plug.
Reassemble governor unit and recheck "GST".

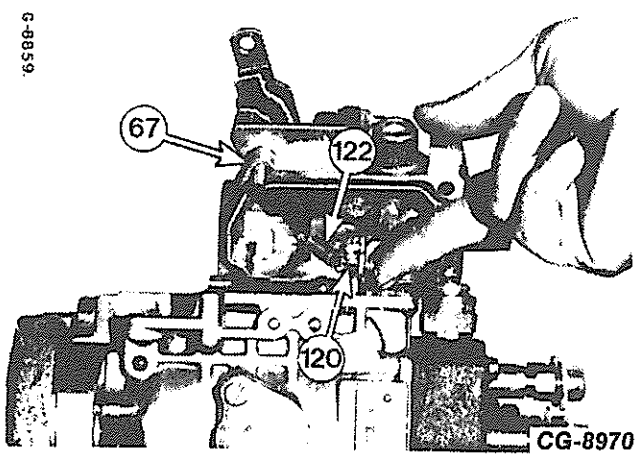


Illust. 364
Removing governor sleeve end plug (117)



Illust. 365

Install pump housing cover as follows:
Hook governor spring (122) in eye of lever (68) taking care that the hook end is down as illustrated. Illust. 365.



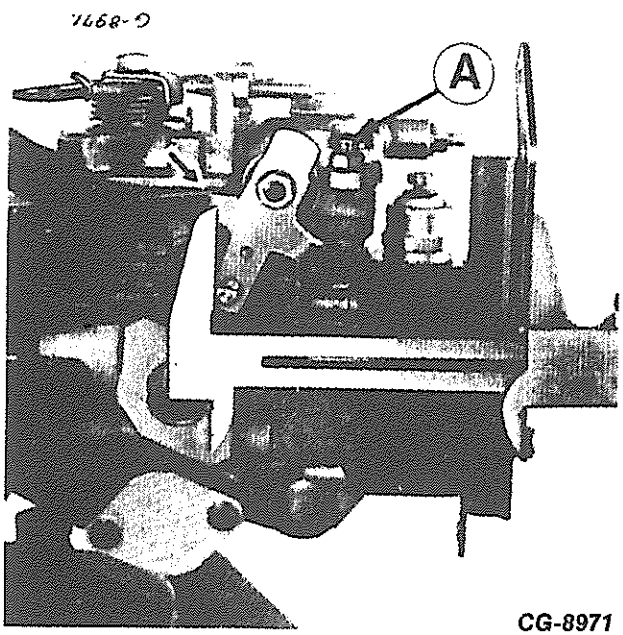
Illust. 366

Carefully hook the other end of the governor spring into retainer pin (120) taking care not to overlook idle spring (121).

Do not overspread spring (122).

Note: If necessary, replace retainer pin (120) and idle spring (121) as a set.

Tighten the cover retainer screws (123) to specified torque.



Illust. 367
Checking shut off lever travel

If the shut-off lever has been removed or stop screw (A) has been backed off, travel of the shut-off lever must be adjusted.

Place a feeler gauge of the same thickness as recorded (refer to Illust. 344) between the housing cover and the shut-off lever. (Arrow Illust. 367).

Using a caliper gauge check the shut-off lever travel from stop to stop.

Turn adjusting screw (A) in or out until 21.5 to 22.0 mm (.846 to .866 in.) lever travel is obtained.

Lock adjusting screw (A).

SERVICING THE ANEROID

Note 1: Before servicing the aneroid it is necessary to study the functional description at the start of this book.

Note 2: If difficulties arise and repair are doubtfull it is advisable to replace the complete aneroid with a new one. (See parts catalog).

Note 3: For reference numbers in the following text see **Illust. 371.**

Exceptions:

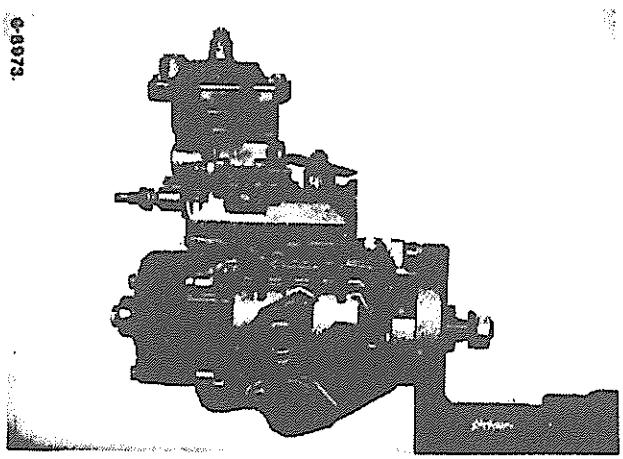
(136) inlet-union screw
(122) governor spring
(120) retainer pin
(88) full load adjusting screw
(90) nut

See Illust. 304.

Disassembly

Remove inlet-union screw (136) and drain the pump.

Bolt the pump to the holding fixture. Illust. 368.



Illust. 368

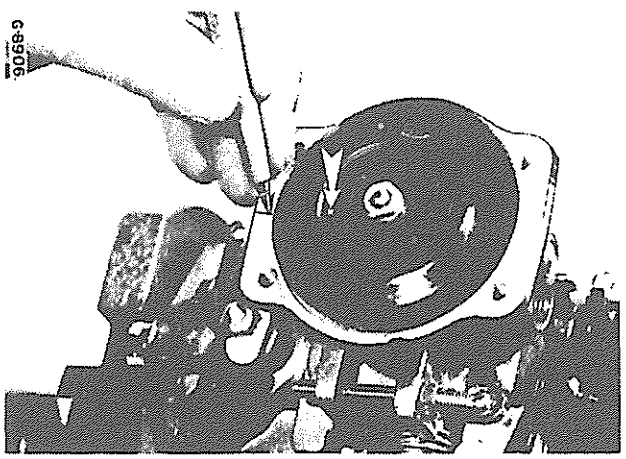
Install aneroid housing (1) temporarily.
Remove plug (39), plugs (58) and gaskets (59).

Using an appropriate punch, push the pivot pin (57) out of the aneroid housing.

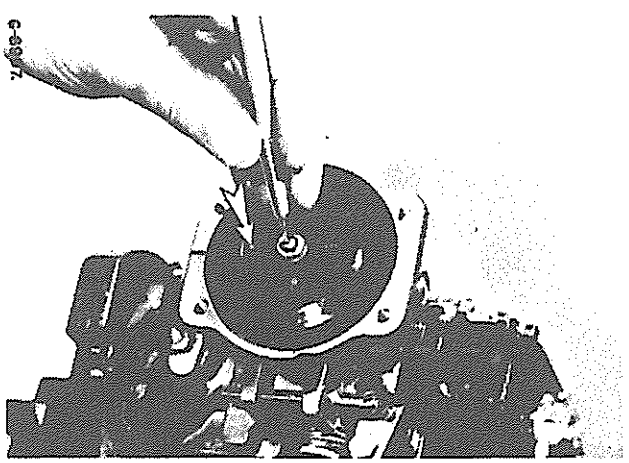
In doing so, control lever (56) should drop, push it downwards, if necessary.

Using a pair of needle nose pliers remove the actuating pin (34).

Remove cover (49).
Remove nut (53) and stop screw (50).



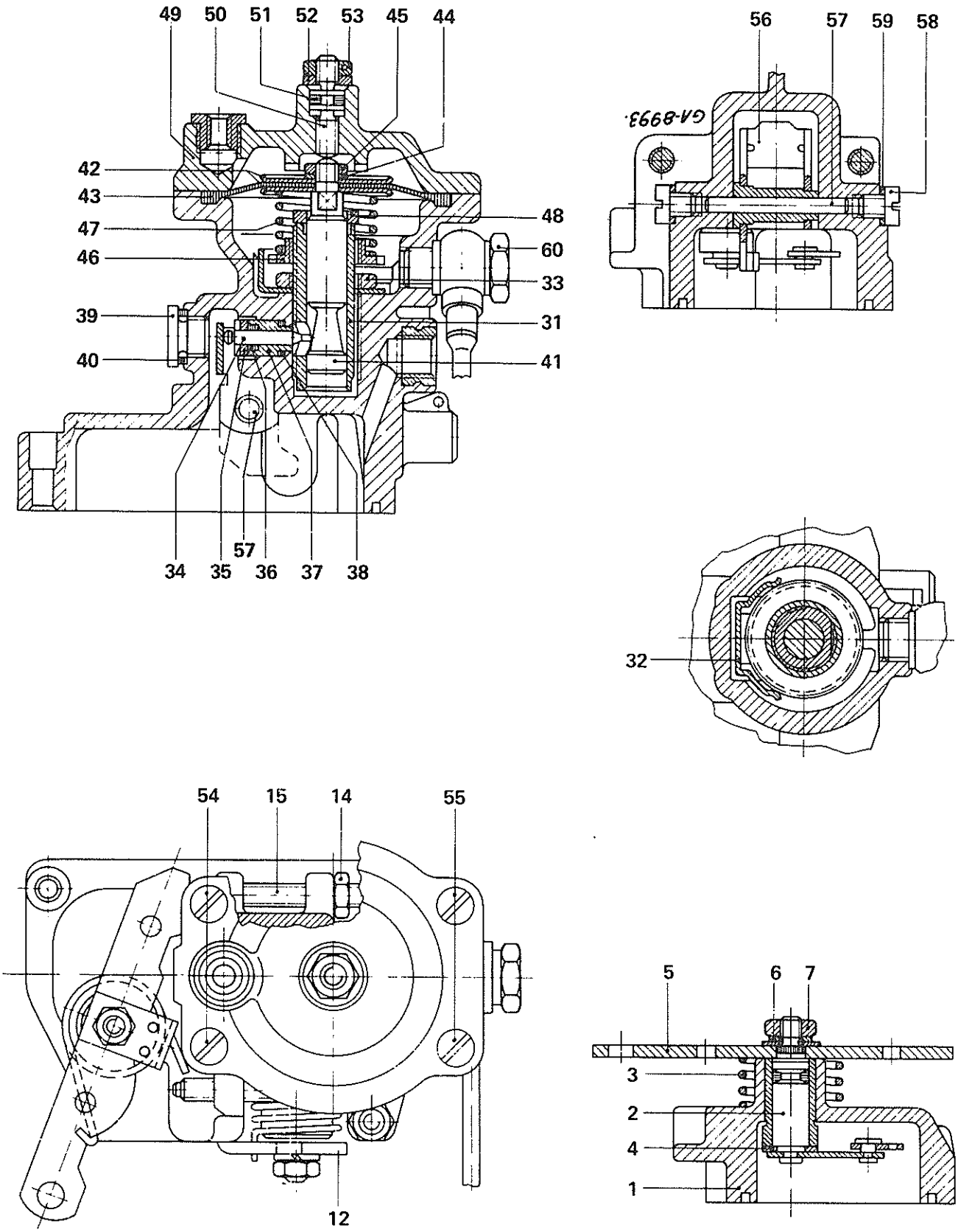
Illust. 369



Illust. 370

Mark the position of the dot mark on the retainer washer (42) to the aneroid housing (Illust. 369) and to the control shaft (41) as shown in Illustration 370.

FUEL INJECTION PUMP VE ... F ...



Illust. 371

Aneroid is installed on pumps for turbocharged engines only

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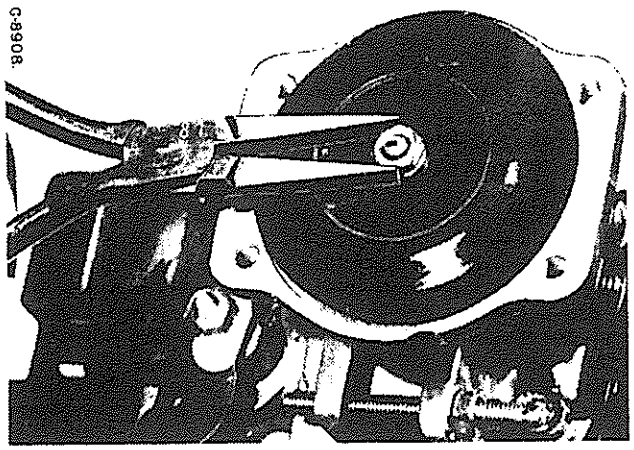
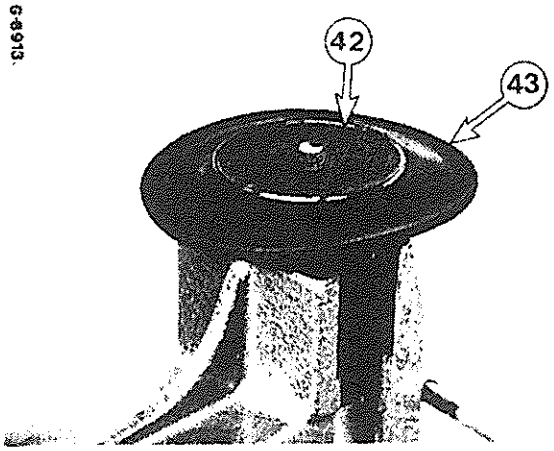


Illust. 372

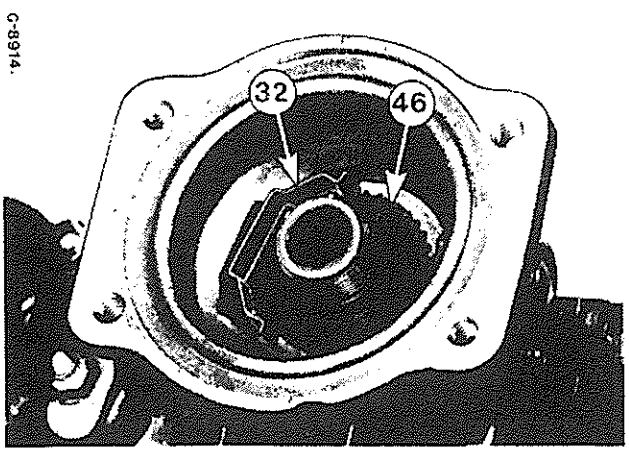
Remove the diaphragm with control shaft (41). Illust. 372



Illust. 373

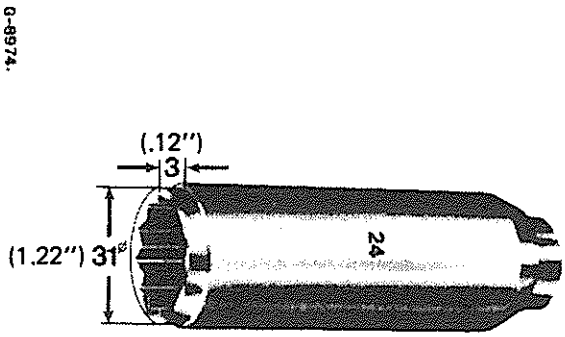
Clamp the control shaft (41) in a vise equipped with hard rubber jaws.

Remove nut (45), lock washer (44), retainer washer (42) and diaphragm (43) Illust. 373.



Illust. 374

Remove ratched nut (46) Illust. 374. Loosen hexagon nut (33). To do so modify a 24 mm socket as shown in Illust. 375.



Illust. 375

Screw out pilot sleeve (31).
Remove lock spring (32) and nut (33) from the pilot sleeve.

Remove breather screw (60).

Using the screw driver bit KDEP 1090 loosen the threaded tension washer (35).

Do not remove this washer now.
Remove the aneroid housing from the pump housing.
Lift control lever (56) out of the pump housing.
Remove tension washer (35).

Using puller tool KDEP 1104 remove bushing (37).
Remove gasket (38).

If necessary remove throttle lever and shut-off lever assembly.

Back-off full load adjusting screw (88).

Inspection

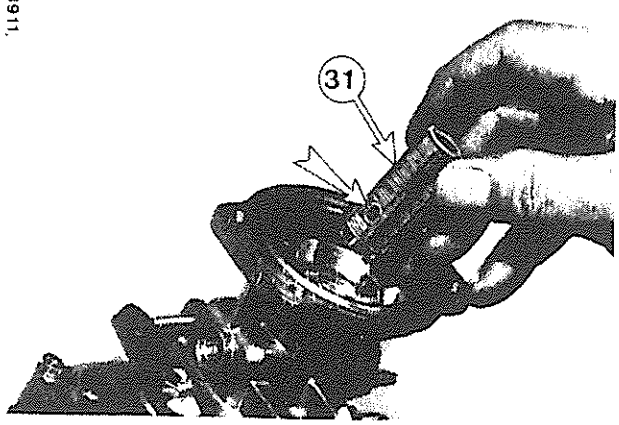
Inspect the diaphragm for any sign of wear, fatigue and/or leaks.

Inspect pilot sleeve and all moving parts for wear.
Replace worn parts with new ones.
Replace O-rings and gaskets with new ones.

Reassembly

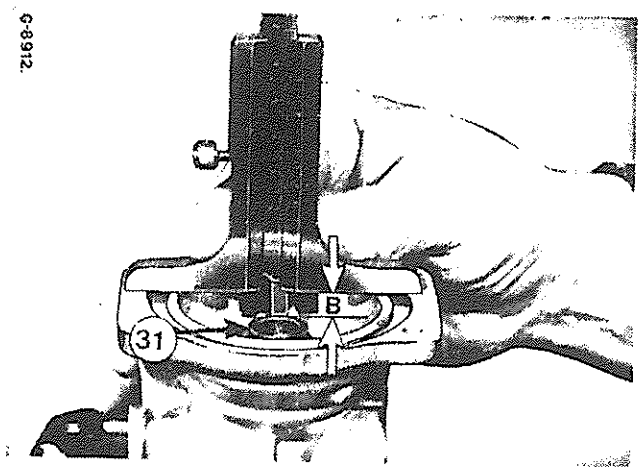
Install the aneroid housing temporarily.
With the cross hole side (arrow Illust. 376) ahead screw pilot sleeve (31) into the housing until dimension (B) = 7 to 8 mm (.28 to .31 in.) is obtained Illust. 377.

G-8911



Illust. 376

G-8912



Illust. 377

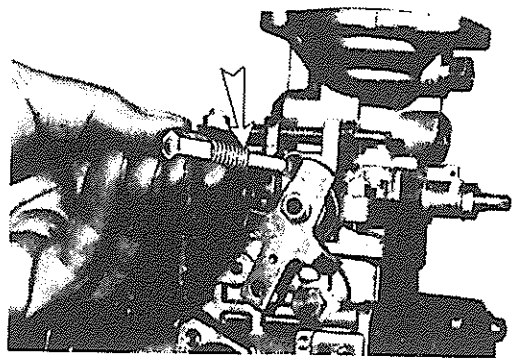
B – 7 to 8 mm (.28 to 31 in.)
31 – Pilot sleeve

To make sure the cross hole in sleeve (31) is in alignment with the bore in the aneroid housing, screw the alignment tool KDEP 1103 completely into the bore in the aneroid housing. Arrow Illust. 377.

With the alignment pin still in position install lock spring (32) and hexagon nut (33).

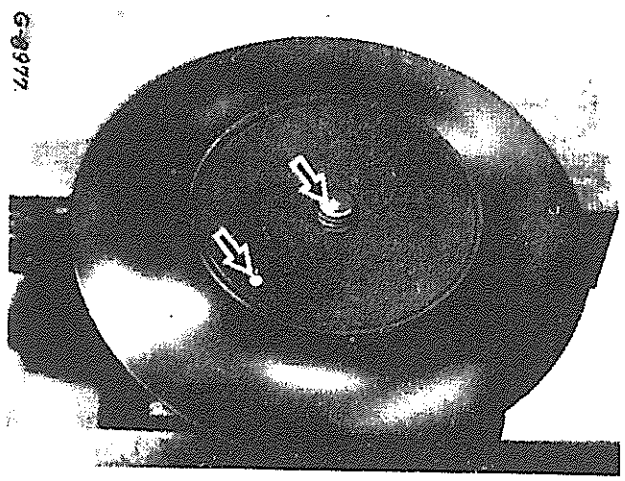
Torque the nut to 25 to 30 N•m (18 to 22 lbf. ft). Remove the alignment pin.

G-8905



Illust. 378

G-8947



Illust. 379

Clamp control rod (41) in holding fixture KDEP 1102, threaded end up.

Place the first retainer washer (42) onto the control rod dot mark downwards.

Position diaphragm (43) on the washer seal run downwards.

Place the second retainer washer (42) on the diaphragm, dot mark on top.

Rotate both washers to bring their dot marks in alignment with the color mark on the control rod top. Illust. 379.

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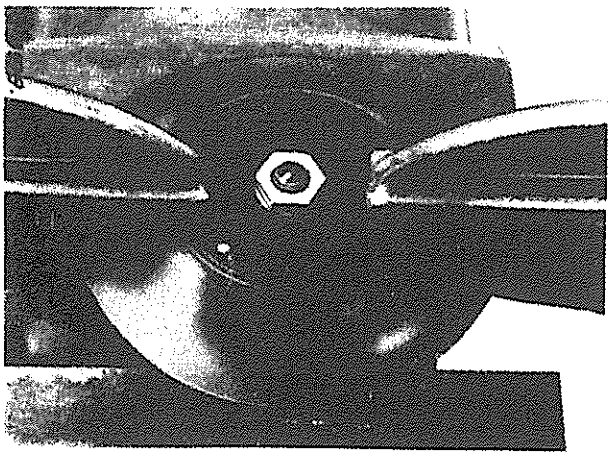
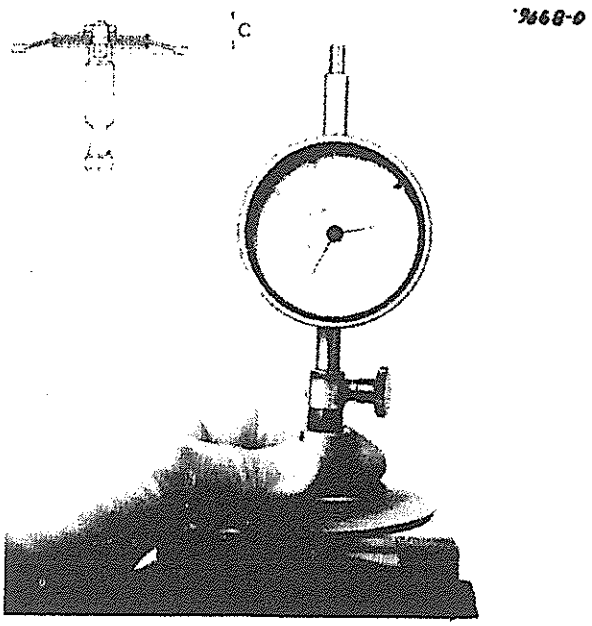


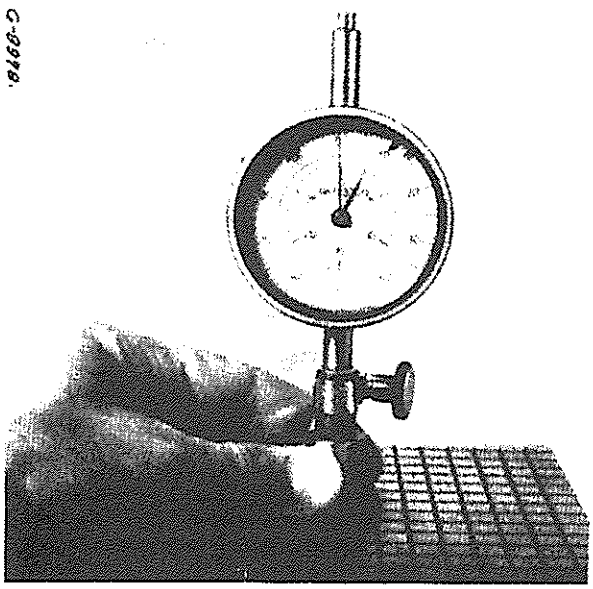
Illust. 380

To prevent damage to the diaphragm clamp both washers together using two small vice-grips. Illust. 380.

Install lock washer (44) and torque nut (45) to 5 to 6 Nm (44 to 53 lbf. in.).



Illust. 382



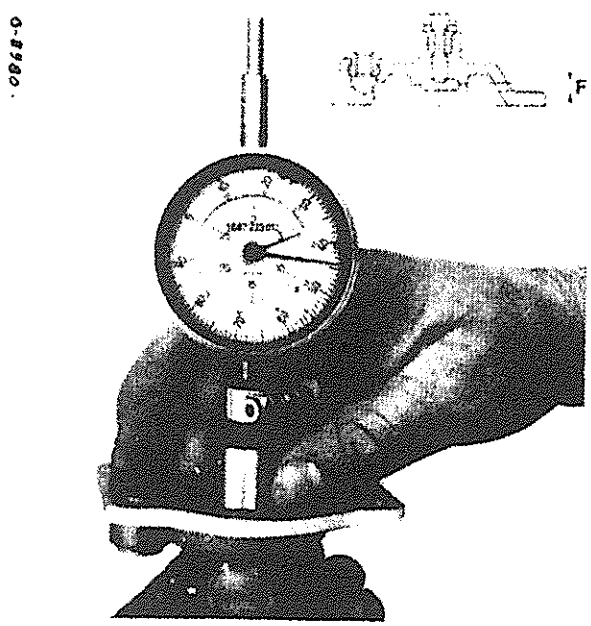
Illust. 381

To adjust stop screw (50) proceed as follows:

Clamp dial indicator 1 687 ?33 012 in holder KDEP 1088.

Pre-load indicator to approx. 10 mm (.39 in.) and zero the dial. Illust. 381.

Check and record dimension (C) Illust. 382.

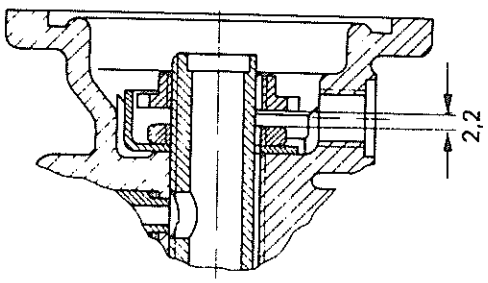


Illust. 383

Check and record dimension (F) Illust. 383.

Dimension (C) Illust. 382 should exceed dimension (F) by 0.5 to 0.6 mm (.020 to .024 in.), i.e. there should be 0.5 mm (.020 in.) of clearance between top retainer washer (42) and cover (49).

G-8910



Illust. 384

Install the ratched nut (46) to obtain a preliminary clearance of 2.2 mm (.087 in.). See Illust. 384.

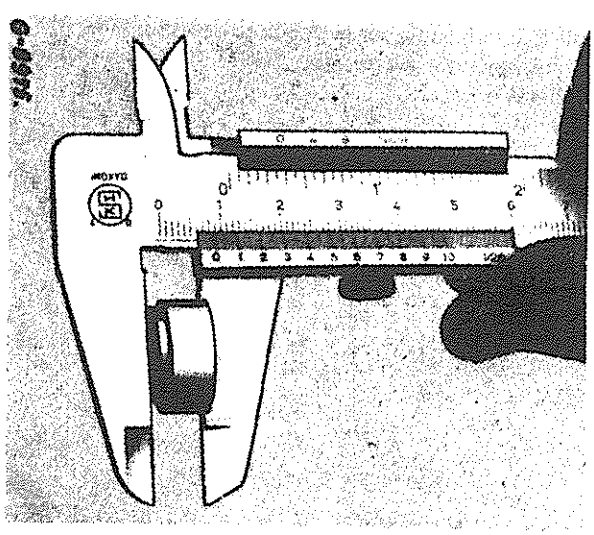
Slide a 2.2 mm (.087 in.) feeler gauge through the breather hole to check the required clearance.

Setting Diaphragn Stroke "DS"

The "DS" is controlled by the thickness of the spacer ring (48) which reduces clearance between pilot sleeve (31) and lower retainer washer (42).

To determine the thickness of this spacer a telescopic "crush" sleeve is used to gage the actual clearance as follows:

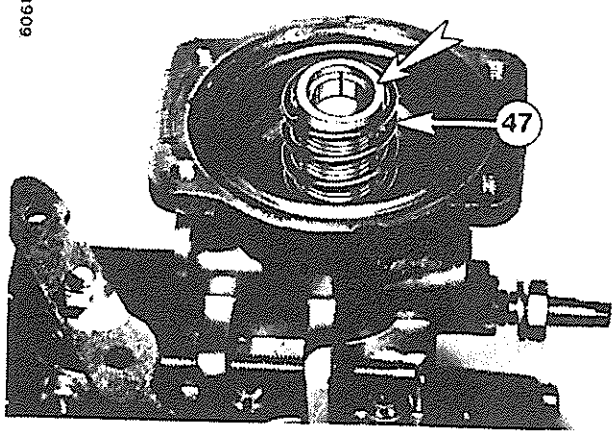
1) Extend crush sleeve KDEP 1105 to approx. 12 mm (.47 in.). Illust. 385.



Illust. 385

2) Fit spring (47) and crush sleeve, small diameter down as shown in Illust. 386.

G-8909



Illust. 386

3) Install diaphragm assembly and tighten cover (49) to crush the sleeve.

4) Remove cover, diaphragm, spring and sleeve.

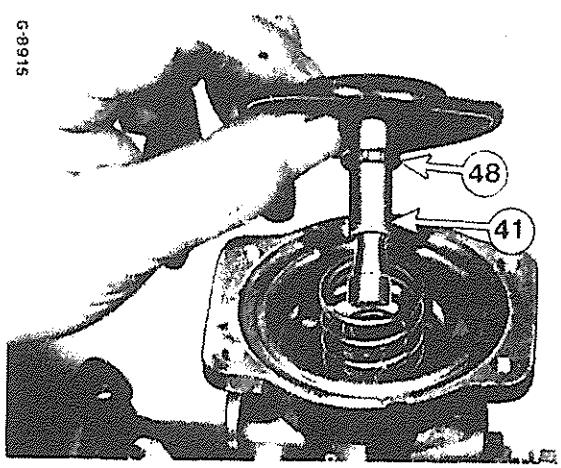
5) Measure crushed height of sleeve.

6) Deduct "DS" height in specification from "crushed dimension" to obtain the correct spacer.

Example:

crushed dimension	8.5 mm (.334 in.)
"DS" dimension in chart	−4.5 mm (−.177 in.)
required spacer (48)	4 mm (.157 in.)

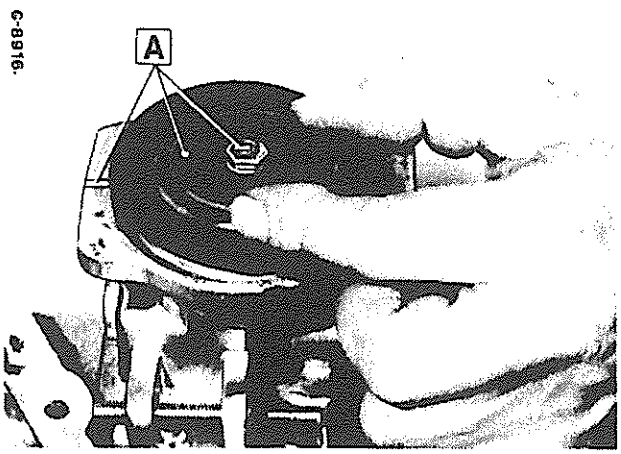
G-8915



Illust. 387

Coat control rod (41) with Molycote FT 70 v 1.
Slide selected spacer ring (48) over the control rod, Illust. 387.

Insert the diaphragm assy into pilot sleeve (31). Be sure the control rod slides in the pilot sleeve without binding.



Illust. 388

Line up marks (A) Illust. 388 and install cover (49). Torque screws (54) and (55) to 6–8 Nm (53–71 lbf.-in).

To install pilot union assy (37) use puller tool KDEP 1004.

Place O-ring (36) into recess of pilot union (37).

Slide union (37) over the puller tool large diameter ahead.

Place gasket (38) onto the puller tool.

Install union assy (37) with puller tool into the aneroid housing and remove the puller tool.

Insert the pump in the holding fixture so that the drive end is up.

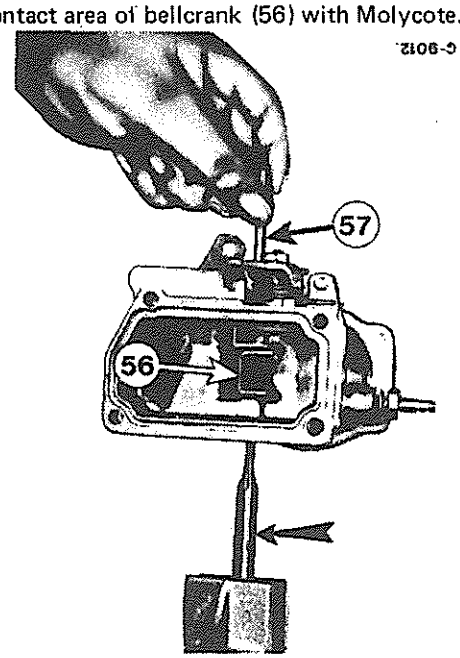
Install the threaded tension washer (35).

Using the screw driver bit KDEP 1090, torque the washer to 9–12 N•m (80–106 lbf. in.).

Position the pump horizontal.
Coat the actuating pin (34) with Molycote Ft 70 v 1.

With the smaller diameter ahead insert the pin into pilot union (37).

Coat contact area of bellcrank (56) with Molycote.



Illust. 389

Using an appropriate punch (arrow Illust. 389) position bellcrank (56) in the aneroid housing and insert pin (57).

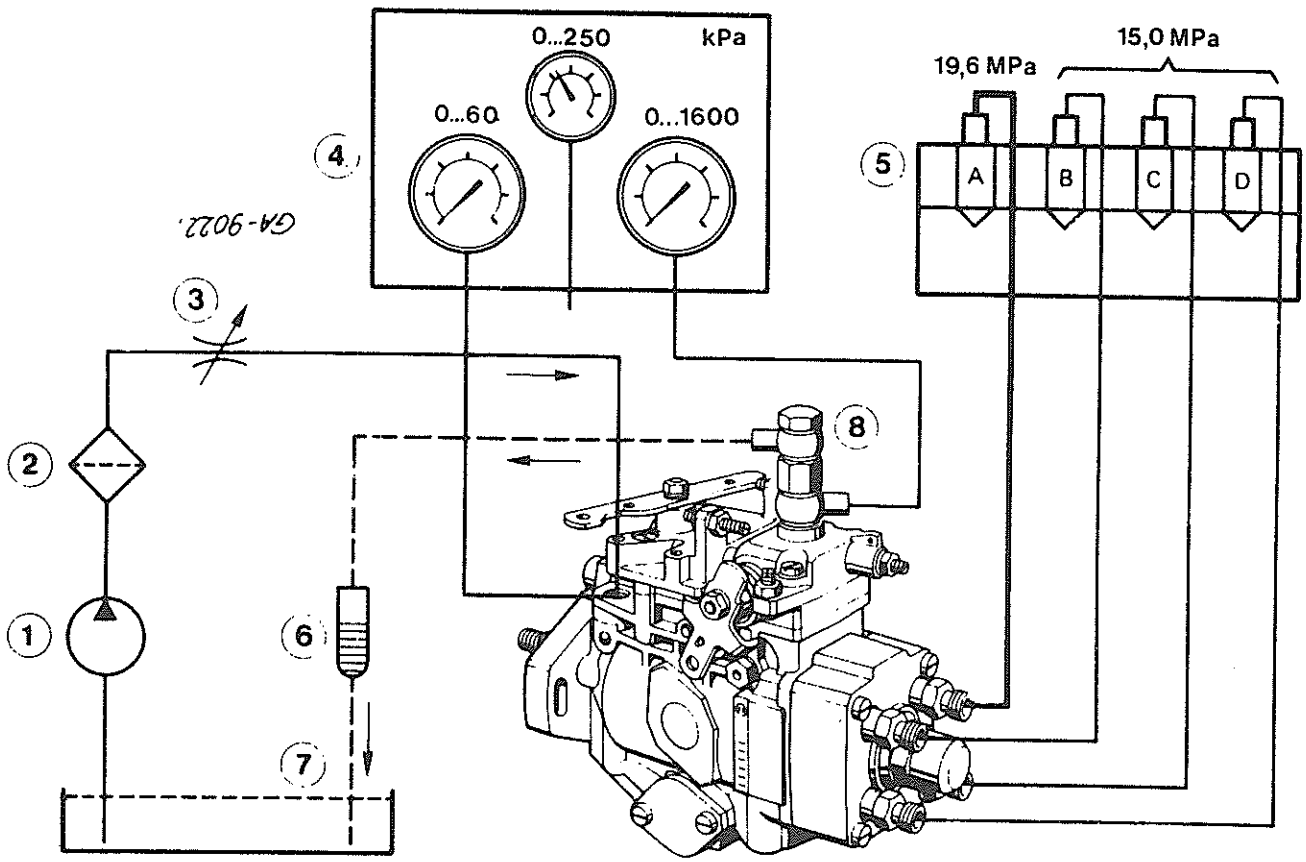
Secure gaskets (59) and plugs (58).
Torque the plugs to 6–7 N•m (53–62 lbf. in.).

Install full load adjusting screw (88), taking care O-ring (91) is completely seated in the aneroid housing recess.

Important: After fitting a repaired or a new aneroid the full load adjusting screw required resetting and free travel of governor sleeve (the "GST" dimension) must be rechecked.

TESTING AND ADJUSTING

Preparation



Illust. 390
Line Diagram

1 – Feed Pump
2 – Filter
3 – Feed pressure control (inlet)
4 – Pressure gauge

METRIC

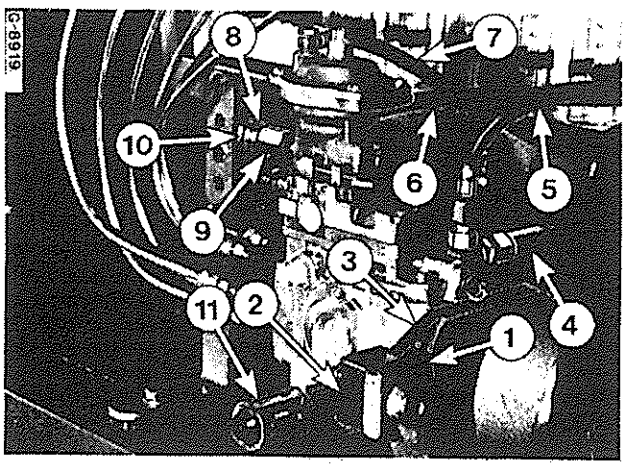
0 – 60 kPa (feed pressure)
0 – 250 kPa (boost pressure)
0 – 1600 kPa (charging pressure)

ENGLISH

0 – 15 PSI (feed pressure)
0 – 30 PSI (boost pressure)
0 – 300 PSI (charging pressure)

5 – Nozzle holder assy
1 x 19.6 MPa (2840 psi) opening pressure at outlet port "A" (when testing excess fuel for starting) as required: 15.0 MPa (2175 psi) opening pressure
6 – Measuring glass (overflow quantity)
7 – Fuel tank
8 – Fuel return valve

NOTE: Refer to GSS-1460-3 or ISS-1522-3 for Fuel Injection Pump Test Bench and Fuel Rate Specifications.



Illust. 391
Fuel injection pump equipped with aneroid, mounted on test bench

1 – Clamping bracket
2 – Clamp
3 – Flange
4 – Hose, fuel supply
5 – Hose, to gauge 0–60 kPa (0–15 psi) (feed pressure)
6 – Hose, to gauge 0 – 1600 kPa (0–300 psi) (charging pump pressure)
7 – Hose, boost pressure
8 – Hose, return flow to reservoir
9 – Overflow restriction
10 – Inlet-union screw (extra long)
11 – Timing advance gauge

Fit the pump on test bench. Connect up as illustrated. Take care to eliminate drive line play.

Be sure gauge (11) is properly zeroed to advance piston position.

Stylus should contact advance piston rim.
Back-off low and high idle speed stop screws.

Use "Sheel calibration Fluid B" at a temperature of 40+ 5° C (104° – 113° F) and a constant feed pressure of 20 kPa (2.9 psi).

Adjusting

A Make sure governor shaft setting is correct. See Illust. 358.

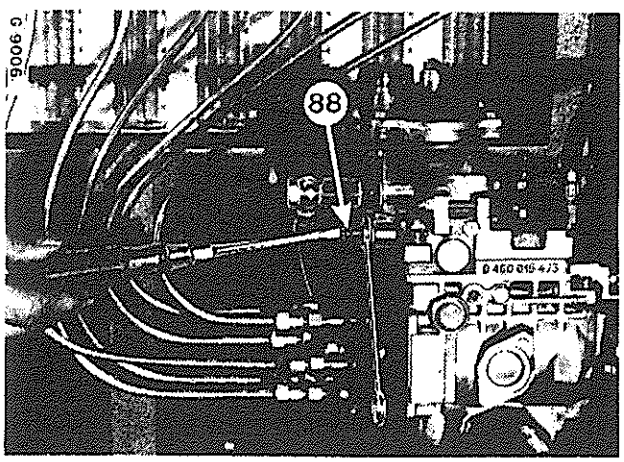
If so equipped connect the shut-off solenoid to a 12 V or 24 V power supply.

Using an auxiliary spring, hold the throttle lever against the high idle stop screw.

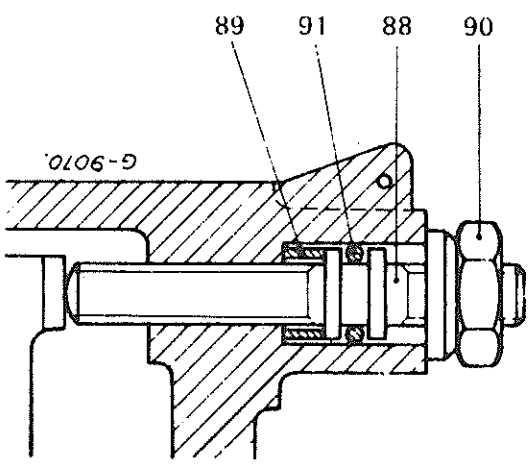
Set the fuel supply pressure to 20 kPa (2.9 psi) and run the pump at rated speed for about 10 min. to warm-up the test oil.

B Full Load Adjustment:

Push the throttle lever against the high idle stop screw.



Illust. 392



Illust. 393

88 – Full load adjusting screw
89 – Spacer ring
90 – Lock nut
91 – O-ring

At the pump speed given in "Specifications" set the specified full-load delivery turning screw (88), Illust. 392 and 393, in or out as required.

After adjustment be sure the O-ring (91) is fully seated in its recess.

If the O-ring protrudes install a shorter screw (88).

On the other hand, if the screw (88) is too short, either the full-load delivery adjustment can not be made or the thread for lock nut (90) is too short.

Full-load delivery Limit

After full-load delivery adjustment screw 88 should have no more than 1/3 of a turn before bottoming on spacering (89). Use a spacer of a different size if necessary.

C *Timing Advance and Charging Pump Pressure*

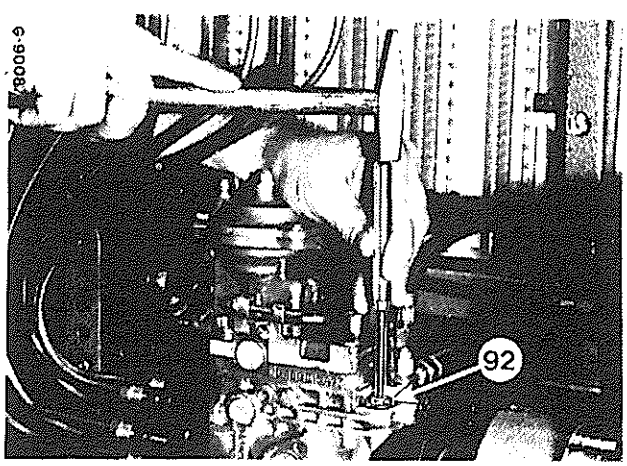
Hold the throttle lever against the high idle adjusting screw.

Vent timing gauge (11) Illust. 391 by loosening the slotted head screw.

At pump speed given in "Specifications" the specified charging pump pressure and at the speed given the specified travel of the advance piston must be attained.

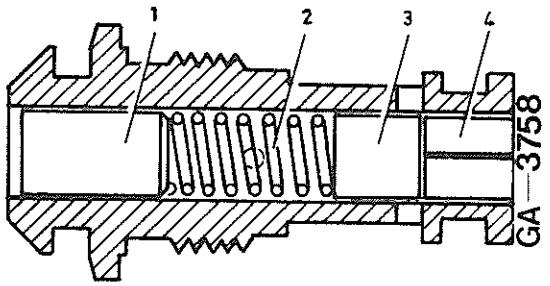
C 1. *Charging Pump Pressure*

If charging pump pressure is too low, slightly tap the plug of the pressure regulator (92) inwards as shown in Illust. 394.



Illust. 394

If the charging pump pressure is too high, remove the regulator (92), using socket wrench KDEP 1086.

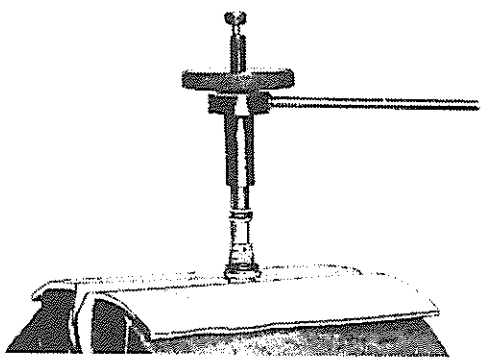


Illust. 395
Cross section of charging pump pressure regulator

1 – Plug
2 – Spring
3 – Piston
4 – Roll pin

Pull out the roll pin (4) Illust. 395 using puller tool KDEP 1027. Illust. 396.

G5798



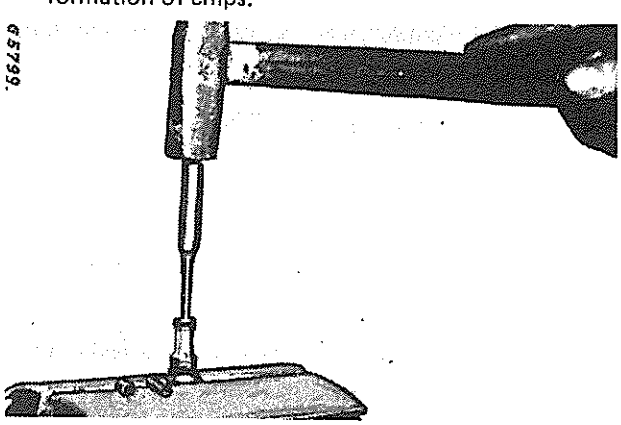
Illust. 396
Removing roll pin (4) Illust. 395

Remove piston (3) and spring (2) Illust. 395 and "tap" the plug (1) outwards, as shown in Illust. 397.

When reinstalling the pressure regulator use a new roll pin and be sure this pin is flush with the valve body.

Take care when installing the roll pin to prevent formation of chips.

G5799



Illust. 397
"Tapping" back plug (1) Illust. 395

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C2. Timing Advance

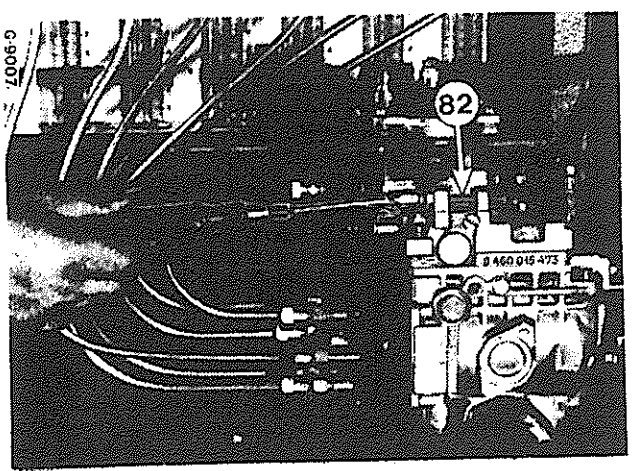
Timing advance is controlled by charging pump pressure and pressure of advance piston spring.

If correct advance piston travel cannot be attained by fully utilizing the limits of charging pump pressure, install a different shim to change the load of the advance piston spring.

To increase advance piston travel use a thinner shim and vice versa.

Readjust full-load delivery, see "B" above.

D Low Idle Delivery (Governor idel run-out)



Illust. 398

82 – Low idle stop screw

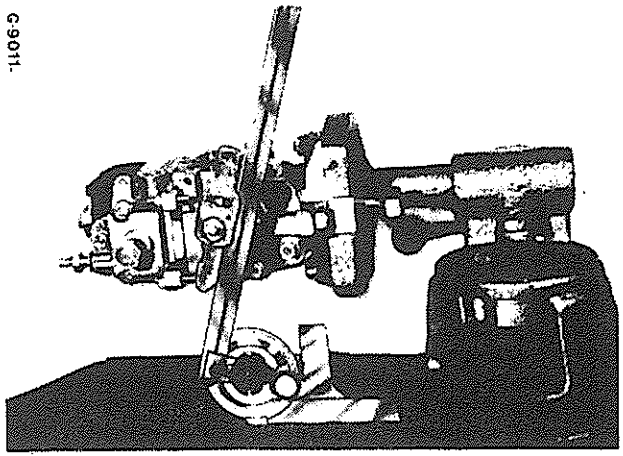
Hold the throttle lever against the low idle stop screw (82). Illust. 398.

At the pump speed given in "Specifications" adjust the screw until the specified quantity of fuel is delivered.

If this requires an extreme adjustment of the screw reposition the throttle lever on the serrations of the shaft.

To do this run the pump approx. 1000/min to provide internal pressure.

If in doubt use a universal bevel protractor to check the mounting angle of the lever. Illust. 389.



Illust. 399

Compare the reading with the specified angle in the "Specifications" of Fuel Injection Pump Service Manual GSS-1460-3 or ISS-1522-3.

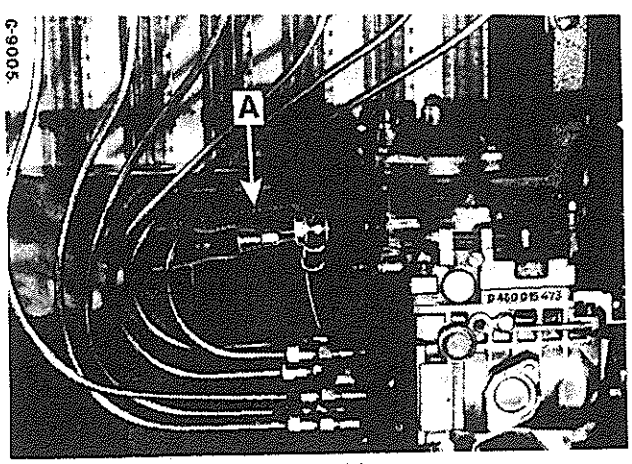
E Excess Fuel for Starting

Measure of outlet port "A," using a nozzle holder assembly set to an opening pressure of 19.6 MPa 2840 psi).

At the pump speed given in "Specifications" a marked increase in fuel quantity should be noted.

Note: If starting fuel is less than specified the dimension "GST" (the governor sleeve travel) may be incorrect. See "Determining Dimension GST." Illust. 362 and 363.

F Governor End Run-Out



Illust. 400

A – Auxiliary Spring

Using an auxiliary spring (A) Illust. 400 hold the throttle lever against high idle stop screw.

At the pump speed given in "Specifications" turn the screw in until the specified quantity of fuel is delivered.

G Testing the Injection Pump

See "Specifications."

G1. Check timing advance and charging pump pressure

Hold the throttle lever against the high idle stop screw.

At the speeds given in "Specifications" advance piston travel and charging pump pressure must be within specified limits.

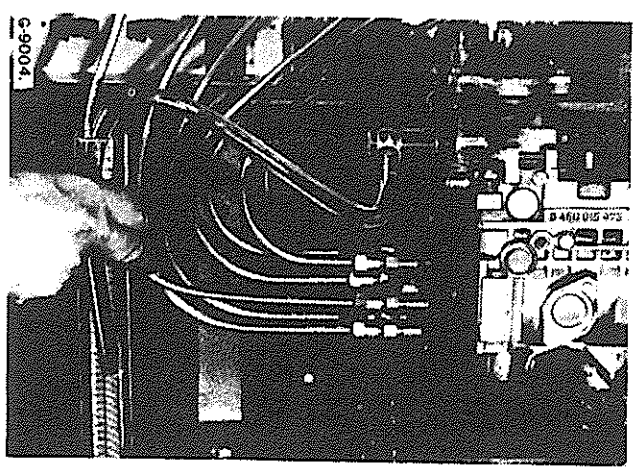
If corrections are necessary, see steps C1, and C2.

Note: A defective charging pump or charging pressure regulator will affect charging pressure and advance piston travel.

Defects in the timing advance mechanism affect only advance piston travel.

G2. Overflow Quantity

At the pump speed given in "Specifications" measure the overflow quantity. Illust. 401.



Illust. 401
Measuring overflow quantity

G3. Fuel Delivery and Lugging Characteristics

Measure fuel delivery at the speeds given and with the throttle lever and the shut-off lever positions as specified.

G4. Zero Delivery (Stop)

At the pump speed given and with the throttle lever in the specified position zero delivery should be reached when the shut-off lever is pulled back to its stop or the solenoid is switched off.

If this is not the case, readjust shut-off lever. See Illust. 344 and 367.

G5. Excess Fuel for Starting

At the pump speed given the specified quantity of fuel should be delivered (nozzle holder assy. at outlet part "A" set to 19.6 MPa (2840 psi) opening pressure.)

Note: Do not push the throttle lever hard against the high idle stop, when measuring excess fuel for starting.

H Checking

Check the pump by following steps in section "G," in same order.

If corrections are necessary, adjustment figures apply.

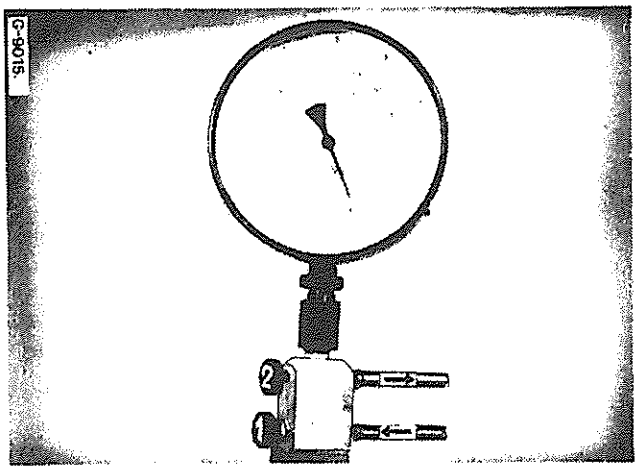
Testing and Adjusting Fuel Injection Fitted with Aneroid

Prepare the pump as described up to step "A" (adjusting).

1. Aneroid leakage

To test the aneroid for leaks, use a special pressure gauge as shown in Illust. 402.

Apply air pressure, equivalent to the specified max. boost pressure to the aneroid by opening adjusting screw (1) Illust. 402.



Illust. 402

1 – Pressure adjusting screw
2 – Plug screw

Close the plug screw (2) and observe pressure gauge. There should be no pressure drop.

2. Adjust Full-load delivery with boost pressure applied

Completely back-off high idle stop screw.

Hold the throttle lever against the high idler stop screw.

At the pump speed and boost pressure given in "Specifications" turn the full-load adjusting screw (88) Illust. 392 in or out until the specified quantity of fuel is delivered.

Be sure the O-ring (91) Illust. 393 is fully seated in the bore in the aneroid housing.

If the O-ring protrudes, install a shorter adjusting screw (88).

3. Adjustment Full-load Delivery without boost pressure

a) Full load delivery too high:
Back-off the full-load adjusting screw (88) until full-load delivery is on the upper tolerance limit.

After the correction is made, it is a must to re-check the full-load delivery with boost pressure applied.

b) Full-load delivery too low:
Remove aneroid housing cover.

Recheck distance "F" Illust. 88 and readjust to upper tolerance limit if necessary.
F = C – 0.5 x 0.1 mm
F = C – .020 x .004 in.

For distance "C" see Illust. 382.

c) Adjust Full-load delivery limit:

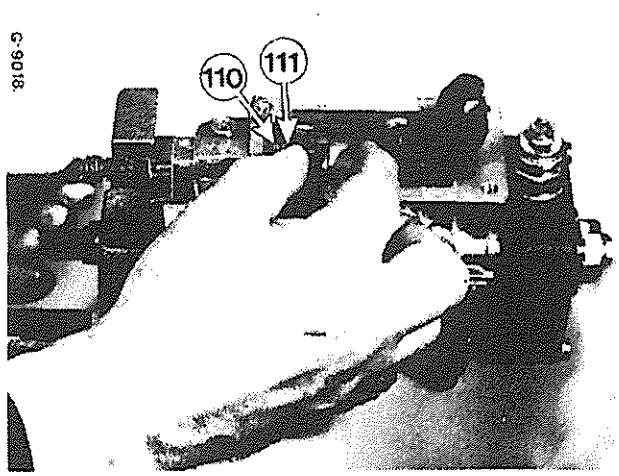
After correction is made, select and install the proper spacer ring (89) Illust. 393. The screw should only have an additional 1/3 of a turn before bottoming on the spacer.

4. Recheck and Adjust Governor Sleeve Free "Travel GST"

After adjusting full-load delivery it is necessary to recheck the travel of the governor sleeve. Proceed as follows:

Remove aneroid housing.

Remove governor shaft. Illust. 403, taking care shim plate (110) and washer (111) do not drop.



Illust. 403

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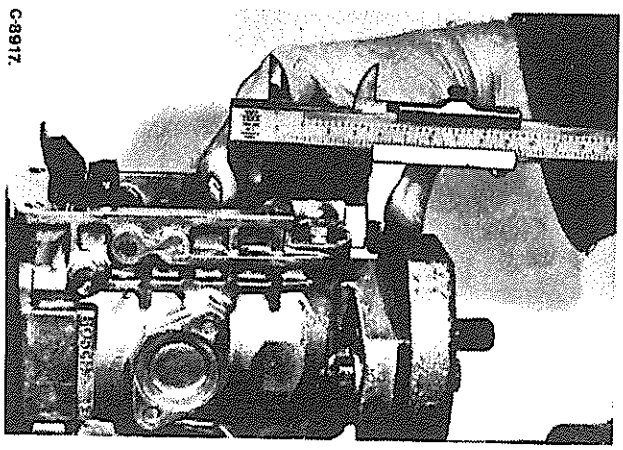
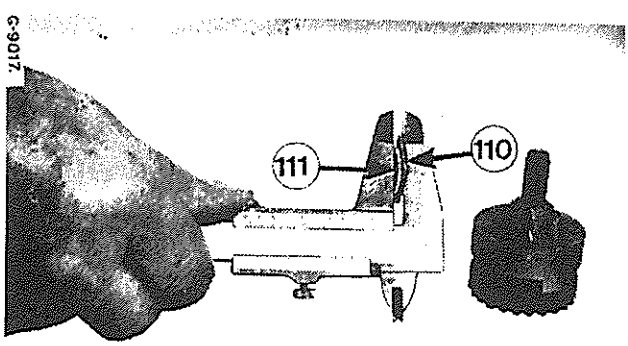
Measure and record thickness of pump housing wall at the governor shaft hole, Illust. 404 i.e. dimension "Z."



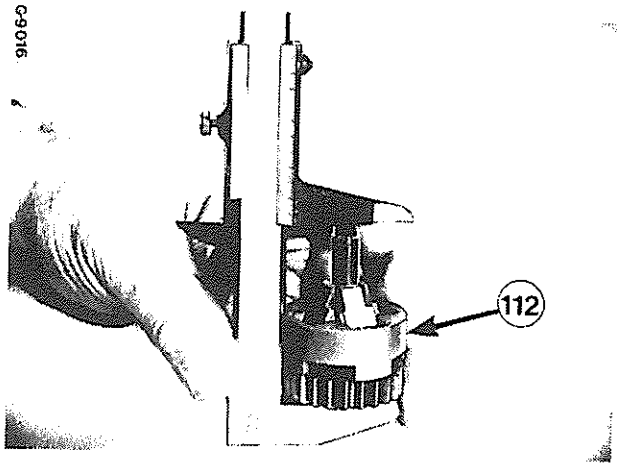
Illust. 404
Measuring dimension "Z"

Measure total thickness of shim plate (110) and washer (111) Illust. 405 and measure the length of governor (112) Illust. 406.

Add both measurements (Illust. 405 and 406) to obtain dimension "Y."

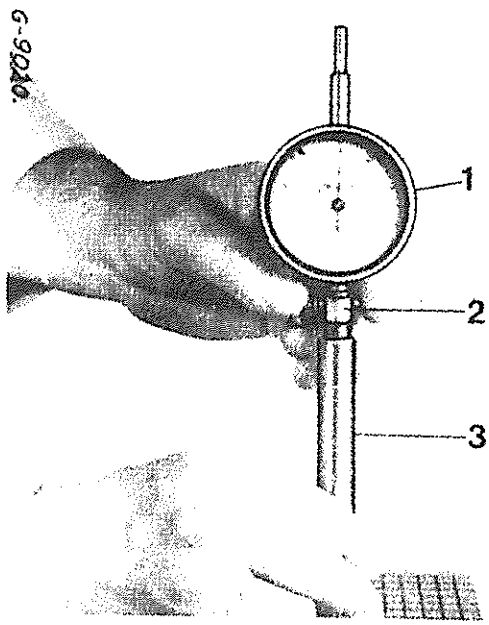


Illust. 405
Measuring total thickness of shim plate (110) and washer (111)



Illust. 406
Measuring length of governor assembly

Hook up governor spring properly and install the aneroid housing temporarily.



Illust 407

Clamp dial indicator (1) Illust. 407 (1 687 233 012) to measuring device (2). (KDEP 1089) and fit stylus extension.

Fit the 100 mm (3.94 in) long extension sleeve (3). Preload indicator (1) to about 15 mm (.59 in) and zero it. Illust. 407.

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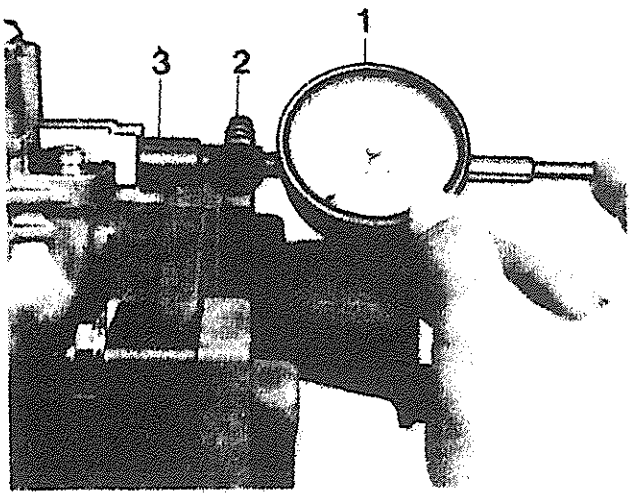
G-6021



Illust. 408

Slide extension sleeve (1) through the governor shaft hole in the pump housing until a resistance is felt. Apply a light finger pressure to the dial indicator pin, making sure the starting spring (32) Illust. 3 is fully depressed. Illust. 408.

At this point record the dial indicator reading. Add 100 mm (3.94) to this reading to obtain dimension "X."

Example:

Preload of dial indicator	15.0 mm (.59 in)
Dial indicator reading	– 11.2 mm (-.44 in)
Difference	+ 3.8 mm (+.15 in)
Length of extension sleeve (3)	100.0 mm (3.94 in)
Calculated difference	+ 3.8 mm (+ .15 in)
Dimension "X"	103.8 mm (4.09 in)

The dimension "GST" (the governor free travel) is calculated as follows:

GST = X–Y–Z

Compare the calculated "GST" with the specified "GST" given in the "Specifications" of GSS-1460-3 or ISS-1522-3.

If necessary, select and install the proper plug (117) Illust. 364 to bring the calculated "GST" in line with "GST" given in the "Specifications."

Proceed as follows:

Remove the aneroid housing.
Install the governor unit and governor shaft as described below Illust. 357.
Install the aneroid housing.

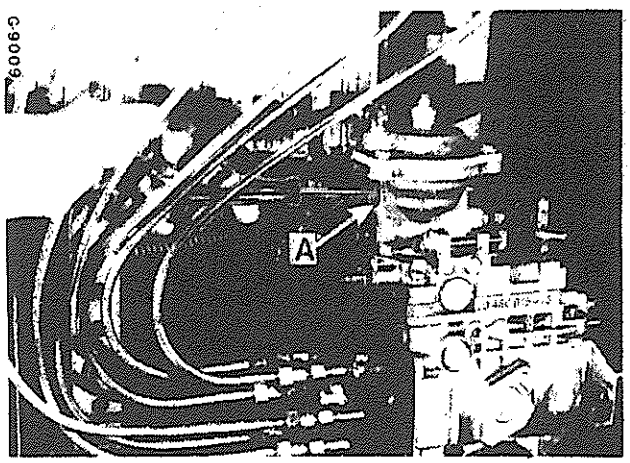
5. Adjust Charging Pump Pressure and Advance Piston Travel

See steps C, C1, and C2, pages 163 and 164.

6. Adjusting the Preload of Spring (47) Illust. 371

At the pump speed given and with the specified boost pressure applied to the aneroid, correct fuel delivery by turning ratched adjusting nut (46), accessible through hole "A" Illust. 409.

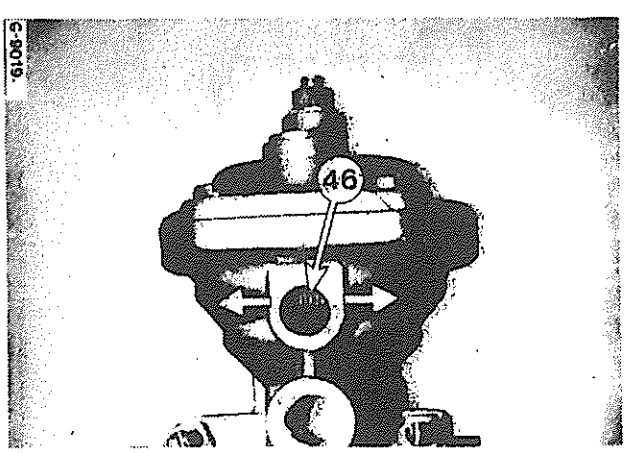
G-6009



Illust. 409
A – Access hole to adjusting nut (46)

Using a screw driver, turn adjusting nut 46, Illust. 410, to the left to increase fuel delivery and vice-versa.

G-6019



Illust. 410

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TEST EQUIPMENT AND SPECIAL TOOLS

Equipment-Tool	*Part No.**	*Application*
Clamping bracket Clamp	KDEP 2919 KDEP 2963	Servicing the pump on the working bench
Flange	1 685 720 062	Servicing the pump on the working bench and on the test bench
Coupling-Half Coupling-Half	1 416 430 012 1 686 430 010	Cone 17 mm (.67 in) Cone 20 mm (.79 in)
Protection sleeve	KDEP 2937	Installing O-rings (66) and (70) Illust. 304
Puller hook	KDEP 2938	Removing gasket (54) Illust. 304
Pre-Stroke measuring device	1 688 130 045 with KDEP 2931 + extension 1 683 458 019	Checking "PL" (plunger lift to port closure)
Measuring device	KDEP 1032 with dial indicator 1 687 233 012	Measuring "PSD" (plunger spring dimension) and "PD" (plunger dimension)
Socket wrench	KDEP 1080	Removing plunger end plug (130) Illust. 304
Adjusting tool	KDEP 1082	Installing governor shaft
Spacer bar	KDEP 1084	Measuring dimension "GST" (governor sleeve free travel)
Socket wrench	KDEP 1086	Removing charging pressure regulator
Puller tool	KDEP 1027	Removing roll pin (4) Illust. 395
Measuring tool	KDEP 1088	Checking dimension "C" Illust. 382
Screwdriver bit	KDEP 1090	Loosening threaded washer (35) Illust. 371
Alignment tool	KDEP 1103	Align guide bushing (31) Illust. 371
Puller	KDEP 1104	Removing bushing (37) Illust. 371
Crush sleeve	KDEP 1105	Determining crushing height
Adjusting throttle	1 688 130 132	Boost pressure control (pump fitted with aneroid)
Measuring device	KDEP 1089	Measuring "GST" (governor sleeve free travel)
Clamping bracket	1 688 010 010 1 688 010 011	Spindle height of test bench 125 mm (4.92 in) Spindle height of test bench 110 mm (4.33 in)
Test nozzle holder assy.	1 688 910 000	One set to 19.6 MPa (2840 psi) opening pressure, and, as required set to 15.0 MPa (2175 psi) opening pressure
Test nozzle	0 681 443 014	
Testing device	1 688 130 075	Pressure gauge set with set of fittings
Fuel injection tubing (6 x 2 x 840 mm) (.24 x .08 x 33.07 inch)	1 688 750	Same tubing as for VE/VA pump

* Robert Bosch Part Number

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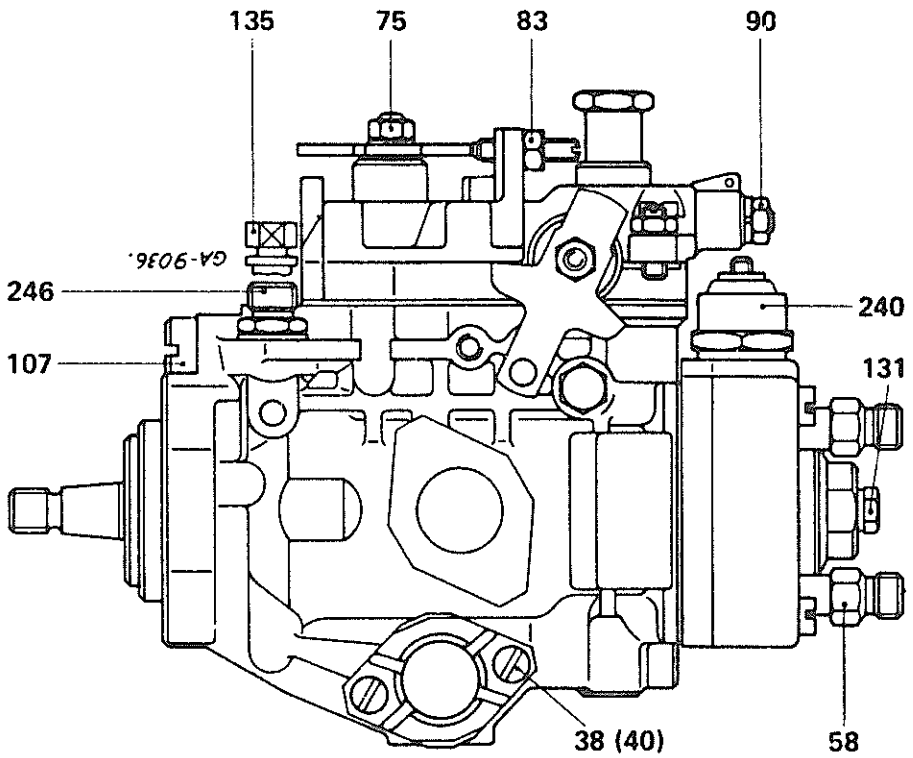
SPECIAL TORQUES



Illust. 411

Torques in Nm (lbf. in) (*lbf-ft)

Refer to Illust. 411	METRIC	ENGLISH
38, 40 – Screw	6–8	53–71
58 – Holder, delivery valve	35–45	*26–33
75 – Nut	5–10	44–89
83 – Nut	5–6	44–53
90 – Nut	7–9	62–80
107 – Slotted nut	25–30	*18–22
131 – Vent screw	8–10	71–89
135 – Charging pressure regulator	8–9	71–80
240 – Shut-off solenoid	40–45	*30–33
246 – Fitting	20–25	*15–18
Refer to Illust. 304:		
10 – Screw	2–3	18–27
40 – Screw	6–8	53–71
60 – Screw	11–13	97–115
74 – Nut	5–10	44–89
104 – Dog point screw	8–10	71–89
130 – Plug, plunger end	60–80	*44–59
136 – Screw, inlet union	20–25	*15–18

Refer to Illust 371:	METRIC	ENGLISH
55 – Screw	6–8	53–71
53 – Nut	7–9	62–80
45 – Nut	5–6	44–53
33 – Nut	25–35	*18–22
35 – Threaded washer	9–12	80–106
39 – Plug	14–18	*10–13
62 – Vent-screw	10–13	89–115
136 – Screw, inlet union (overflow valve)	20–25	*15–18
Without Reference Nos:		
Timing pointer screw	0.2–0.3	2–3

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GENERAL TEST SPECIFICATIONS

1. Test Bench Conditions

Use shell Calibration Fluid B
Test oil temperature 40 + 5°C (104 + 9°F)
Fuel feed pressure 20 kPa (2.9 psi)
Nozzle holder ED 8511/9
Nozzle EF EP 182
Fuel injection lines 6 x 2 x 840 mm (.24 x .08 x 33.07 in)
Nozzle opening pressure 15 MPa (2175 psi)
Nozzle opening pressure 19.6 MPa (2840 psi) (at outlet "A" when testing excess fuel for starting)

2. Fuel Rator Test Conditions

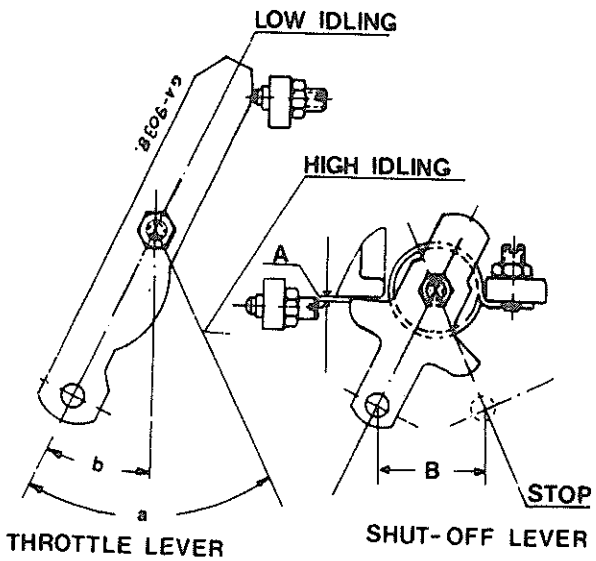
Max. permissible vacuum in charging pump suction line – 20 kPa (2.9 psi)
Fuel temperature in overflow line 50 – 55°C (122 – 131°F)
Fuel Gravity 0.83 kg/1000 cu. cm.
.03016/cu. in.

3. Timing Pointer Setting

Injection begin at 1 mm (.039 in) plunger stroke (lift)

4. Throttle Lever Setting

A – Minimum gap 0.5 to 1.0 mm (.020 to .039 in)
B – Shut-off lever travel 21.5 to 23 mm (.846 to .906 in)
a+b – See Specifications

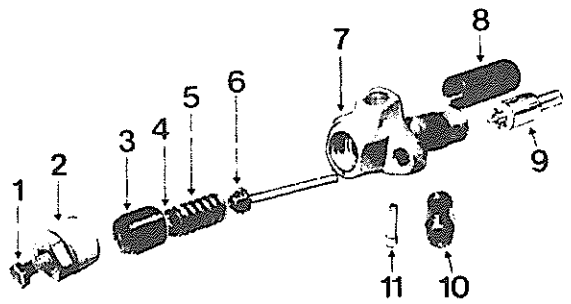


Illust. 412

5. Abbreviations

PL – Plunger lift to port closure (pumps with pre-stroke)
PD – Plunger dimensions (Pumps without pre-stroke)
PSD – Plunger spring dimension
GST – Governor sleeve free travel
APS – Advance piston, max. shim thickness
DS – Diaphragm stroke

Injection Nozzle and Nozzle Holder (flange mounted)



Illust. 413
Exploded view of nozzle holder assembly

1 — Hollow screw
2 — Locking cap
3 — Adjusting screw
4 — Spring seat
5 — Spring
6 — Spindle
7 — Nozzle holder body
8 — Holder nut
9 — Nozzle assy
10 — Inlet fitting
11 — Filter bar

General

The nozzle used is a direct injecting type, meaning that it injects fuel directly into the combustion chamber.

The nozzle serves the purpose of controlling the spray pattern and finely atomizing the fuel, plus serving as a hydraulic valve to block fuel remaining in the injection lines after injection has ceased.

Fuel metering, timing, and pressurization (pumping) is controlled by the injection pump.

The nozzles are in the cylinder head, within a brass sleeve insert that passes through the coolant passages. The nozzle is therefore cooled by both the diesel fuel supplied to the nozzle and the engine cooling system. Illust. 413 shows the basic parts of the nozzle.

Note: The nozzle needle and its seat are ground with interference angle. This is desirable to insure positive and immediate seating.

These precision ground surfaces do not lend themselves to lapping in the field servicing of these nozzles.

Nozzles can usually be cleaned by "soaking" them in a cold decarbonizing solution. The nozzle need not be disassembled. Place it in the solution for two hours. When removed, the nozzle should be flushed and tested.

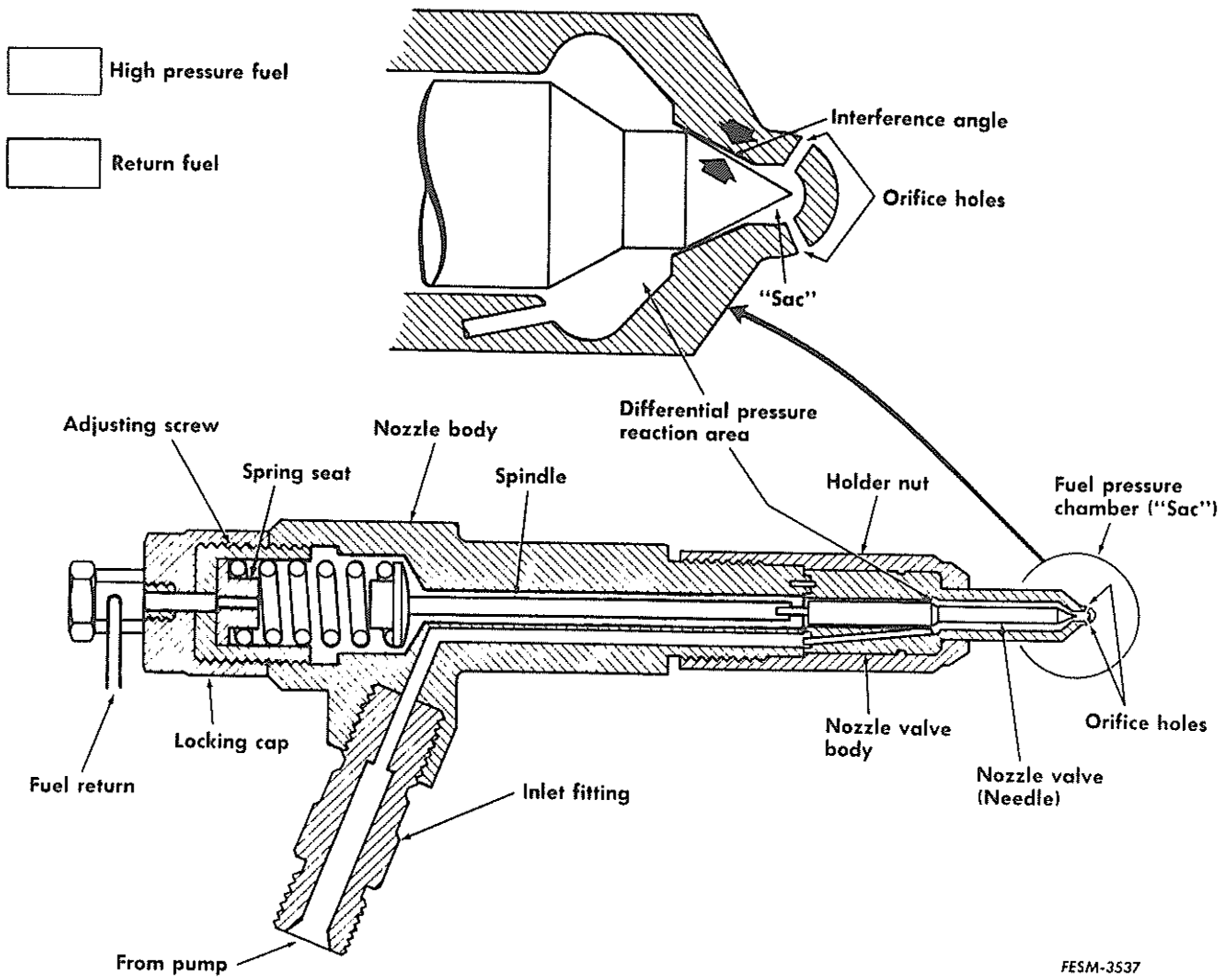
The large area of the needle is subjected to the pressure from the injection pump as it enters the fuel pressure chamber. This is opposed by the nozzle valve spring to control pressure at which the valve lifts from its seat. Return fuel which escapes past the needle serves to lubricate and help cool the needle and guide.

The "Chattering" present in "jerk" pump bench testing is the result of injection taking place in a rapid series of sharp bursts. The valve seats and unseats at a rapid rate, which insures that fuel is emitted from the orifice ports at a speed high enough to keep the nozzle tip dry.

Note: "Chattering" will not occur in every nozzle and therefore cannot be taken as an indication of good or bad nozzle performance.

Injection performance can only be judged by proper spray pattern at the correct opening pressure with no leakage from nozzle tip.

Testing the nozzle with a test pump of insufficient capacity will not give a true duplication of injection, thus indicating a bad nozzle. The lack of sharp injection when test pump is of sufficient capacity indicates that the nozzle valve is lifting to pass the fuel being supplied. In an engine, a nozzle which reacts this way would result in a "dribbling", accompanied by insufficient velocity to clear the orifices with result smoke and loss of power. Check the injection nozzles first after 250 operating hours and recondition after every 1500 operating hours. (or earlier if necessary) Nozzles should be serviced when evidence of a sudden increase in exhaust smoke or loss of power are present. Do not overlook the possibility of a restricted air cleaner or other fuel system problems.



Illust. 414

Specifications

Nozzle opening pressure	20–21 MPa (2845–3000 PSI)

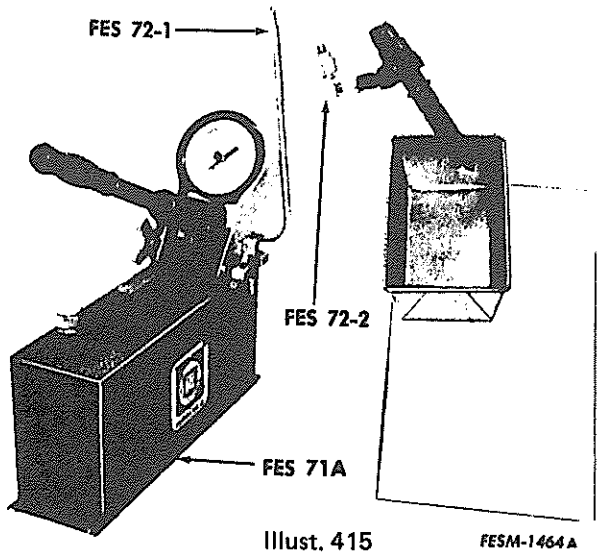
For torque load, refer to "Special bolt and nut torque data".

Nozzle Service

Caution: High velocities of fuel emitted from the tip orifice can penetrate human skin, causing severe injury:

Nozzle Testing

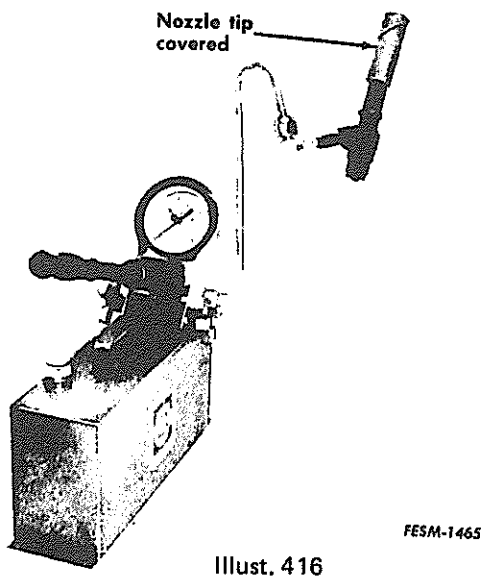
Most nozzles can be serviced and replaced without disassembly. Put the assembled nozzle in a container of decarbonizing solution for at least one hour; longer if possible. Remove, wash and "flush" with a tester. Then test as follows:



Illust. 415
Testing nozzle opening pressure

Connect the nozzle to the test pump, F ES 71A, using F ES 72-1 line and F ES 72-2 connector, see Illust. 415.

Use clean fuel and operate the test pump with rapid complete strokes (4-6 strokes per second). Check that all orifices are clear and a compact, symmetrically and completely atomized spray pattern cone without lateral "Flags" should emerge from the orifice holes of the nozzle tip. The spray should show no sign of "dribbling" between strokes.



Illust. 416
Checking stem leakage

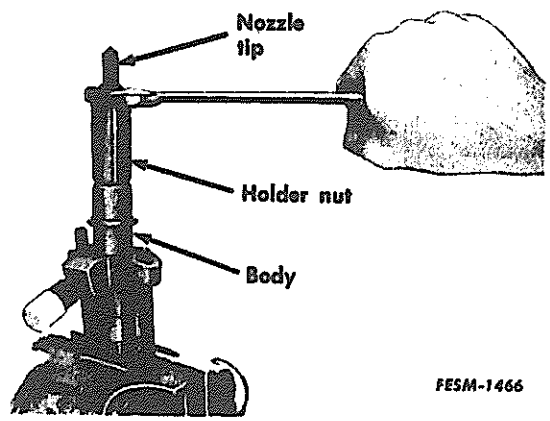
Check nozzle opening pressure. Refer to "Specifications" for proper opening pressure. Slowly depress the test pump handle until the spray pattern emerges. This is the opening pressure.

Dry the valve tip and raise the pressure to 1.9—2.1 Mpa (275 to 300 PSI) below the opening pressure. Visible wetting of the tip after 10 seconds at this pressure is permissible, but drop formation is not.

Invert the nozzle on the tester and cover the tip, see Illust. 416. Pressurize to 1.9—2.1 MPa (275 to 300 PSI) below the opening pressure. Leakage out of the return line port should not exceed 10 drops per minute.

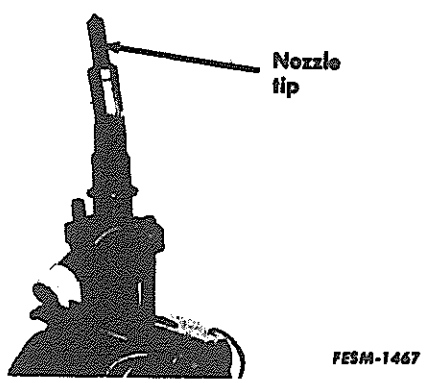
At one stroke per second of the test pump the spray pattern will be coarse and may occasionally appear as non-atomized streams. At a faster stroking rate the spray pattern will be compact and fully atomized.

Inspection and Repair



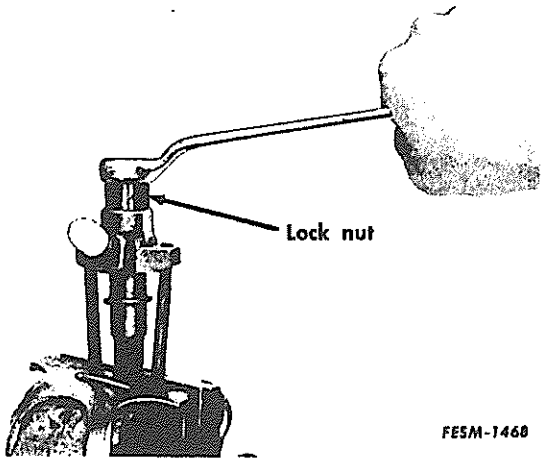
Illust. 417
Removing nozzle holder nut

If it has been determined that disassembly is necessary, clamp the nozzle assembly in a vase as shown in Illust. 417. Remove the nozzle holder nut, see Illust. 417.

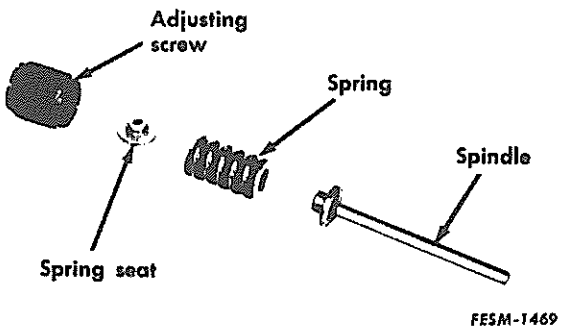


Illust. 418
Nozzle tip removal

Lift the nozzle tip with nozzle valve from the nozzles body. See Illust. 418.



Illust. 419
Removing adjusting locknut



Illust. 420
Nozzle adjusting screw and spring assembly removed

Invert the nozzle body and loosen the adjusting locknut. See Illust. 419. Remove the adjusting screw, spring seat, spring and spindle. See Illust. 420.

Remove the nozzle inlet fitting.

Inspect the mating surfaces of the nozzle body and nozzle tip face for cracks, scratches or other surface conditions which may cause leaks. Use F ES 5-1 (PLT-369-1) magnifying glass to examine the pieces.

Inspect the holder nut for cracks The gasket surface must be smooth and free from nicks.

Inspection of the nozzle valve and seat is best accomplished by a leakage test.

Note: Lapping the seat is not recommended. Excessive leakage requires a new valve assembly.

Reconditioning

Note: DO NOT scrape carbon from any surface of the nozzle with any hard object, such as a revolving steel wire brush, as it may damage the parts.

Put the disassembled nozzle in a container of decarbonizing solution for at least two hours.

Clean inside the orifice end of the nozzle tip with a wooden cleaning stick. The small holes in the tip may be cleaned by inserting a cleaning wire of the proper size, held in a pin vise. The cleaning wire should be slightly smaller than the size of the holes in the tip. Care must be taken in cleaning of these holes to prevent breakage of the wire in the hole, as it is difficult and very often impossible to remove the broken wire.

Clean the inlet fitting, filter and nozzle valve body.

Reassembly

Thoroughly wash both valve and valve seat in clean diesel fuel before reassembly.

If the valve stem is lifted approximately 1/3 of its length out of the nozzle tip (with a twisting motion), it should slide back to its seat under its own weight.

Do not interchange the nozzle valves and seats. To avoid interchanging, dismantle and reassemble one nozzle at a time.

Set the nozzle tip on the nozzle body and install the holder nut.

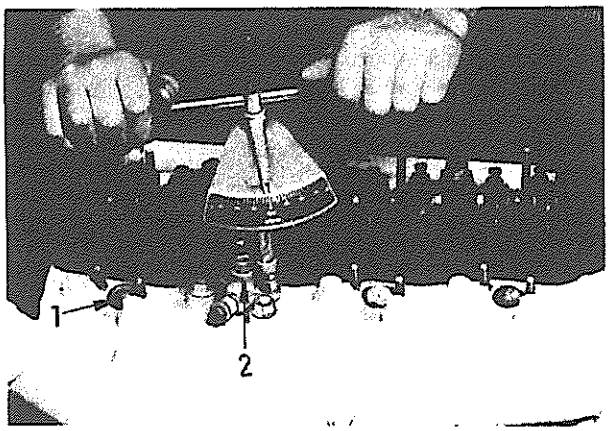
Invert the nozzle body in the vise. Install the spindle, spring, spring seat and adjusting screw. Install the inlet fitting.

Test and adjust nozzle.

Installation

Place the sealing O-ring approx. 6 mm (.24 in.) above the nozzle holder nut, then install the nozzle holder.

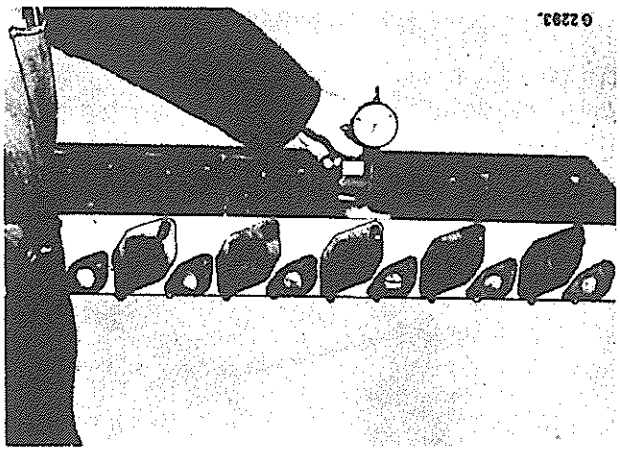
Make sure the O-ring is not twisted.



Illust. 421

1 – Nozzle holder seat capped up
2 – Nozzle holder

Tighten the stud nuts in two steps to specified torque. See "Special Nut and Bolt Torque Data."

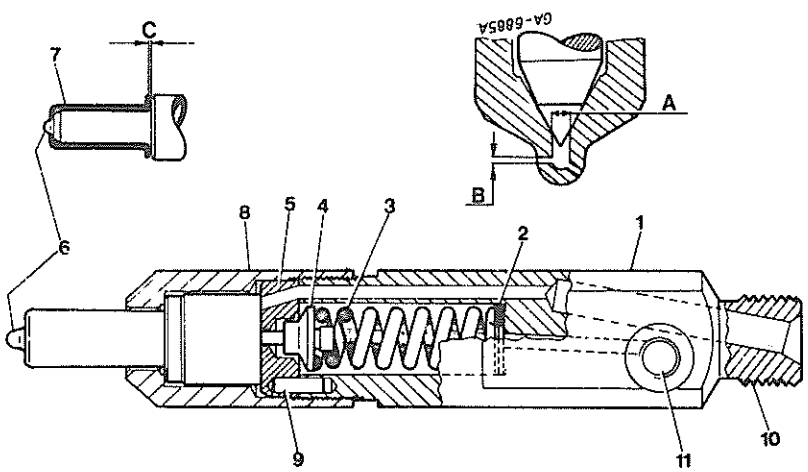


Illust. 422
Checking protrusion of nozzle tip

Check the protrusion of nozzle tips, if nozzle holder inserts are replaced or the cylinder head sealing face has been reworked. A dial indicator reading of 2.5–3.6 mm (.10 to .14") is acceptable.

After the cylinder head is installed test run the engine to see the cold engine works at low idle without misfiring.

Injection Nozzle and Nozzle Holder (crab mounted)



1 – Nozzle holder body
2 – Shims
3 – Spring
4 – Spring seat
5 – Spacer
6 – Nozzle
7 – Heat protection sleeve (if so equipped)
8 – Holder nut
9 – Locating pins
10 – Inlet connections M12x1.5
11 – Fuel return hole port, tapped M6

Illust. 423

Nozzle	Sac Hole A–Dia (mm)(inch)	Orifice Hole B–Dia (mm)(inch)	Orifice Hole C–Gap (mm)(inch)
DLLA 150 S 716	1.0 (.04)	0.27 (.010)	0.1–0.45 (check before mounting) (.004–.018")
DLLA 150 S 836	1.0 (.04)	0.27 (.010)	
DLLA 150 S 690	1.2 (.05)	0.29 (.011)	
DLLA 150 S 815	1.0 (.04)	0.29 (.011)	
DLLA 150 SV 12543	1.0 (.04)	0.29 (.011)	
DLLA 150 SV 3114305	1.0 (.04)	0.29 (.011)	
DLLA 150 S 728	1.2 (.05)	0.31 (.012)	
DLLA 150 S 843	1.0 (.04)	0.31 (.012)	
DLLA 150 S 717	1.2 (.05)	0.34 (.013)	
X DLL 150 S 2641	1.0 (.04)	0.28 (.011)	
X DLLA 150 S 417	1.2 (.05)	0.30 (.012)	

X = Flange Mounted Nozzles

Nozzle Holder Combination

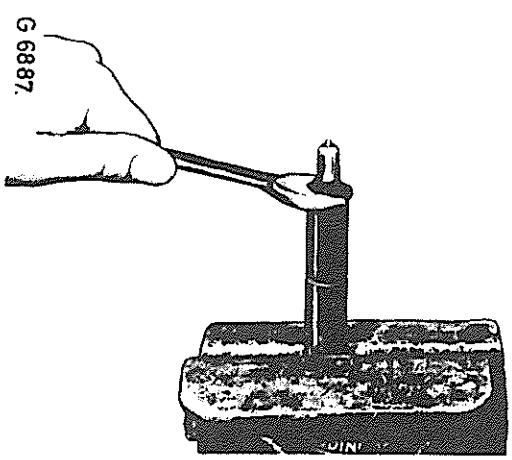
Nozzle Holder Assembly	Nozzle Holder Type — No.	Nozzle Type — No.	Nozzle I.H. Number	Opening Pressure kPa	Opening Pressure PSI
3 218 320 R91/R92*	KBEL 84 S 4/13	DLLA 150 S 717	3 218 321 R1	24000–24800	3480–3600
3 218 246 R91/R92	KBEL 84 S 4/13	DLLA 150 S 716	3 218 248 R1	22500–23300	3260–3400
3 218 246 R93	KBEL 84 S 4/13	DLLA 150 S 836	3 218 248 R2	22500–23300	3260–3400
3 218 249 R91/R92*	KBEL 84 S 4/13	DLLA 150 S 716	3 218 248 R1	22500–23300	3260–3400
3 218 249 R93*	KBEL 84 S 4/13	DLLA 150 S 836	3 218 248 R2	22500–23300	3260–3400
3 218 250 R91/R92	KBEL 84 S 4/13	DLLA 150 S 690	3 218 251 R1	22500–23300	3260–3400
3 218 250 R93	KBEL 84 S 4/13	DLLA 150 S 815	3 218 251 R2	22500–23300	3260–3400
3 218 252 R91/R92*	KBEL 84 S 4/13	DLLA 150 S 690	3 218 251 R1	22500–23300	3260–3400
3 218 252 R93*	KBEL 84 S 4/13	DLLA 150 S 815	3 218 251 R2	22500–23300	3260–3400
3 218 253 R91/R92	KBEL 84 S 4/13	DLLA 150 S 690	3 218 251 R1	24000–24800	3480–3600
3 218 253 R93	KBEL 84 S 4/13	DLLA 150 S 815	3 218 251 R2	24000–24800	3480–3600
3 218 254 R91/R92*	KBEL 84 S 4/13	DLLA 150 S 728	3 218 255 R1	22500–23300	3260–3400
3 218 254 R93*	KBEL 84 S 4/13	DLLA 150 S 843	3 218 255 R2	22500–23300	3260–3400
3 218 299 R91/R92	KBEL 84 S 4/13	DLLA 150 S 716	3 218 248 R1	24000–24800	3480–3600
3 218 299 R93	KBEL 84 S 4/13	DLLA 150 S 836	3 218 248 R2	24000–24800	3480–3600
3 218 492 R91/R92*	KBEL 84 S 4/13	DLLA 150 S 728	3 218 255 R1	24000–24800	3480–3600
3 218 492 R93*	KBEL 84 S 4/13	DLLA 150 S 843	3 218 255 R2	24000–24800	3480–3600
3 228 001 R91	KBEL 84 S 4/13	DLLA 150 SV 12543	3 228 002 R1	22500–23300	3260–3400
3 228 159 R91*	KBEL 84 S 4/13	DLLA 150 S 836	3 218 248 R2	24000–24800	3480–3600
3 228 167 R91*	KBEL 84 S 4/13	DLLA 150 S 815	3 218 251 R2	24000–24800	3480–3600
4 316 276 R91	KBEL 84 S 4/13	DLLA 150 SV 3114308	4 316 277 R1	20000–20800	2900–3020
3 055 422 R92#	KBL 90 S 104/4	DLL 150 S 2641	3 055 426 R92	20000–20700	2900–3000
3 055 423 R93#	KBL 90 S 104/4	DLLA 150 S 417	3 055 428 R92	20000–20700	2900–3000
3 144 633 R91 #	KBL 90 S 176/4	DLLA 150 S 417	3 055 428 R92	20000–20700	2900–3000

* = With heat protection sleeve
\# = Flange mounted

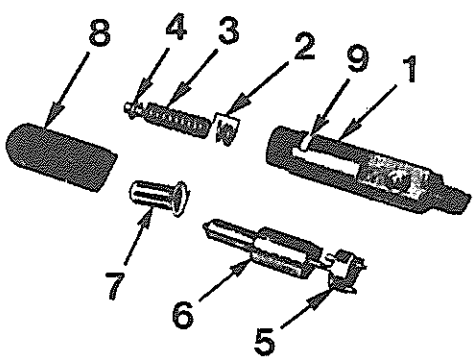
Note: For testing and reconditioning, see "Injection Nozzle and Flange Mounted Nozzle Holder."

For nozzle opening pressure, see "Nozzle Holder Combinations" above, see also (9) Illust. 425.

Disassembly



Illust. 424
Removing holder nut



Illust. 425

1 — Nozzle holder body
2 — Shims
3 — Spring
4 — Spring seat
5 — Spacer
6 — Nozzle
7 — Heat protection sleeve (if equipped)
8 — Holder nut
9 — Marking on nozzle holder

The components of the nozzle holder are accessible after the holder nut is removed. Illust. 424 and 425.

To avoid mix ups of mated parts disassemble only one nozzle holder assy. at a time.

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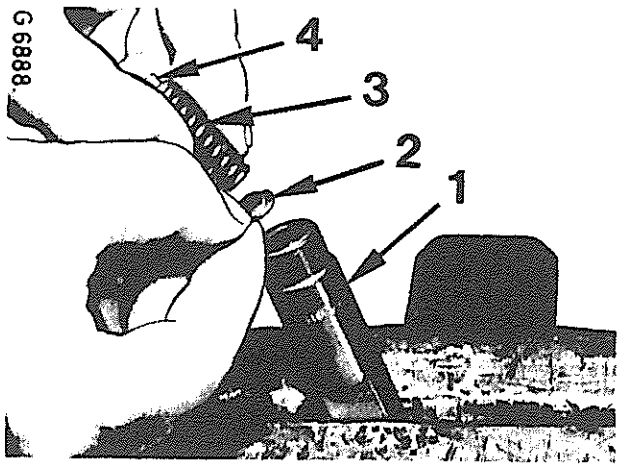
Reassembly and Installation



Illust. 426

1 – Nozzle holder body
2 – Shims
3 – Spring
4 – Spring seat

On reassembly, place shims (2) Illust. 426 (as found on disassembly) into the spring recess.

Install the remaining components in the sequence (3–8), shown in Illust. 423 or 425.

Tighten the holder nut to 60 N•m (44 lbf-ft) of torque.

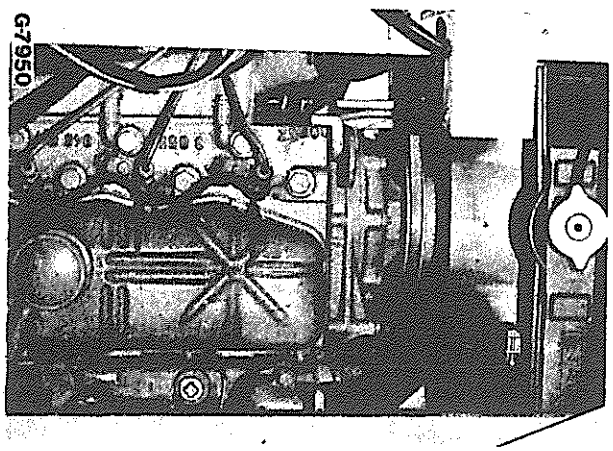
Test and adjust nozzles.

Shims for adjusting opening pressure are available in thickness of 0.5 mm (.020"), 0.525 mm (.021"), 0.575 mm (.023"), 0.60 mm (.024"), 0.70 mm (.028"), 0.80 mm (.031") and 0.90 mm (.035")

A shim stock difference of 0.025 mm (.001") will change opening pressure by approximately 400 kPa (58 psi).

Clean sleeves in cylinder head and install nozzle holders using new O-rings.

Make sure hollow screws, arrows Illust. 427, show to the valve cover.



Illust. 427

Place the nozzle crabs into position and install the dished washers and crab bolts.

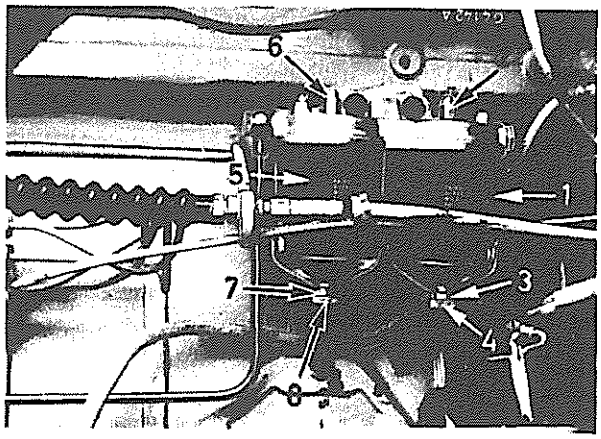
Tighten the bolts to 25 N•m (18 lbf-ft) torque, using a torque wrench.

Connect the fuel supply pipes and the leak fuel return line to the nozzle holders.

Torque pipe union nuts to 23 N•m (17 lbf-ft) and the fuel return hollow screws to 5 N•m (44 lbf-in).

Test run the engine.

FUEL FILTER



Illust. 428

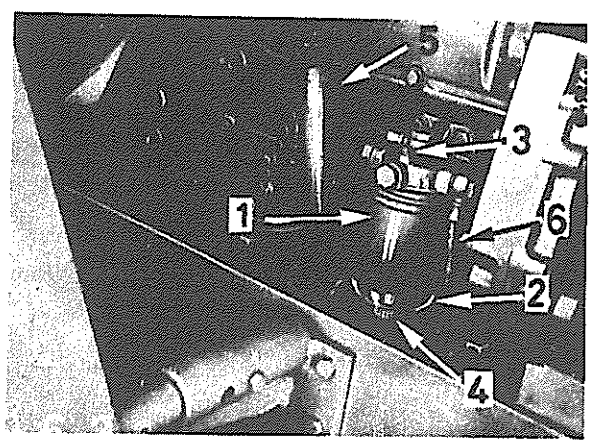
1 – Primary filter
2 – Cap nut
3 – Retainer bolt
4 – Drain screw
5 – Final filter
6 – Cap nut
7 – Retainer bolt
8 – Drain screw.

Most engines are equipped with a dual filter unit and a water trap.

Filters are either of replaceable element or throw-away cartridge type.

Instructions on servicing fuel filters and the water trap are contained in the Operator's Manual of the respective machine.

A special filter (watch dog) is recommended for severe operating conditions and poor quality fuel, see parts catalog for details. The watch dog filter is fitted below the injection pump as a final stage, before the fuel enters the pump.



Illust. 429

1 – Water trap
2 – Transparent bowl
3 – Vent screw
4 – Drain screw
5+6 - Fuel lines

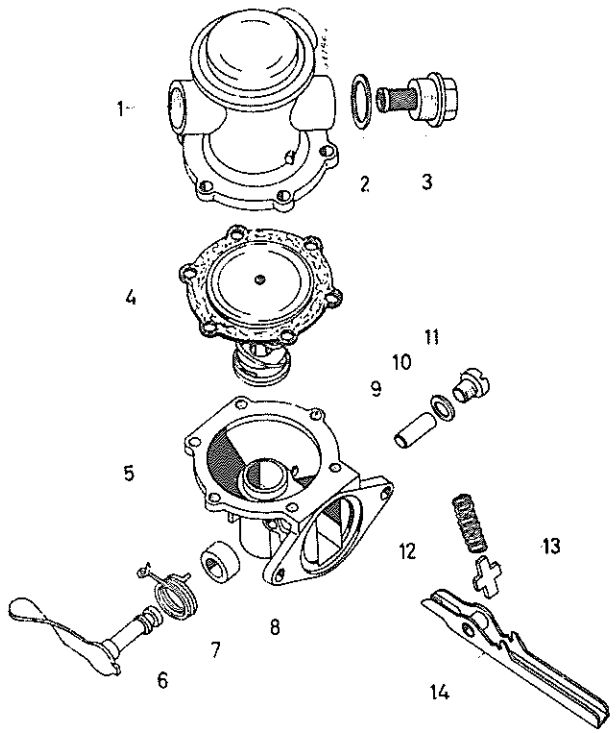
This watch-dog filter is seaied and should only be changed in the workshop when the engine is being overhauled.

Be sure to seal the filter again to prevent field tampering.

Should, in exceptional cases all fuel filters be restricted, so that engine power is affected, it may be necessary to change the watch-dog filter sooner.

However, it is best to leave this filter undisturbed.

FEED PUMP



Illust. 430

Engines are regularly equipped with feed pumps, Illust. 430 when fuel tanks are located below the injection pump level and fuel cannot, therefore, flow by gravity to the injection pump.

Where special operating conditions (steep gradients) require, a feed pump may be installed subsequently to assist the natural gravity feed and to assure a positive fuel supply to the injection pump under varying conditions.

The feed pump is a diaphragm-type pump driven by the engine camshaft. It can also be operated manually on hand lever (6) to fill the fuel system or for venting purposes.

A filter screen is installed in the feed pump to primarily filter the fuel from the fuel tank. When servicing the engine it is good practice to remove the filter screen. Use a soft brush and carefully clean in Diesel fuel. On reassembly make sure all parts seat properly to avoid leakage. Install a new feed pump if the diaphragm is damaged or the operating mechanism is defective.
Install plug (11) using liquid sealer.

Note: The fuel feed pump is attached to the crankcase side cover by means of an additional flange with two studs. To prevent dropping the flange into the crankcase on removal or installation, stud nuts should be cautiously removed and installed respectively.

INJECTION PIPES

Injection pipe failures can in most cases be traced to faulty assembly. Due to engine vibrations or to pressure fluctuations caused by the pump, fuel lines may vibrate and chafe through on contact points. If injection pipes are twisted or installed under tension their life period is reduced considerably. Such lines tend to become brittle and leaky.

With union nuts loosened, connecting cones must be exactly in alignment with their counter cones. Bend the lines slightly, if necessary.

Clean lines thoroughly before installation. Do not remove protection caps from new lines prior to assembly.

VENTING THE FUEL SYSTEM

To facilitate starting and to assure proper operation of the engine the fuel system must be free from air.

If parts of the fuel system have been disconnected or if the fuel tank has been allowed to run empty, thereby permitting air to enter the system, it will be necessary to vent the fuel system starting from the fuel tank towards the injection pump step by step.

Refer to respective "Operator's Manual" for details.

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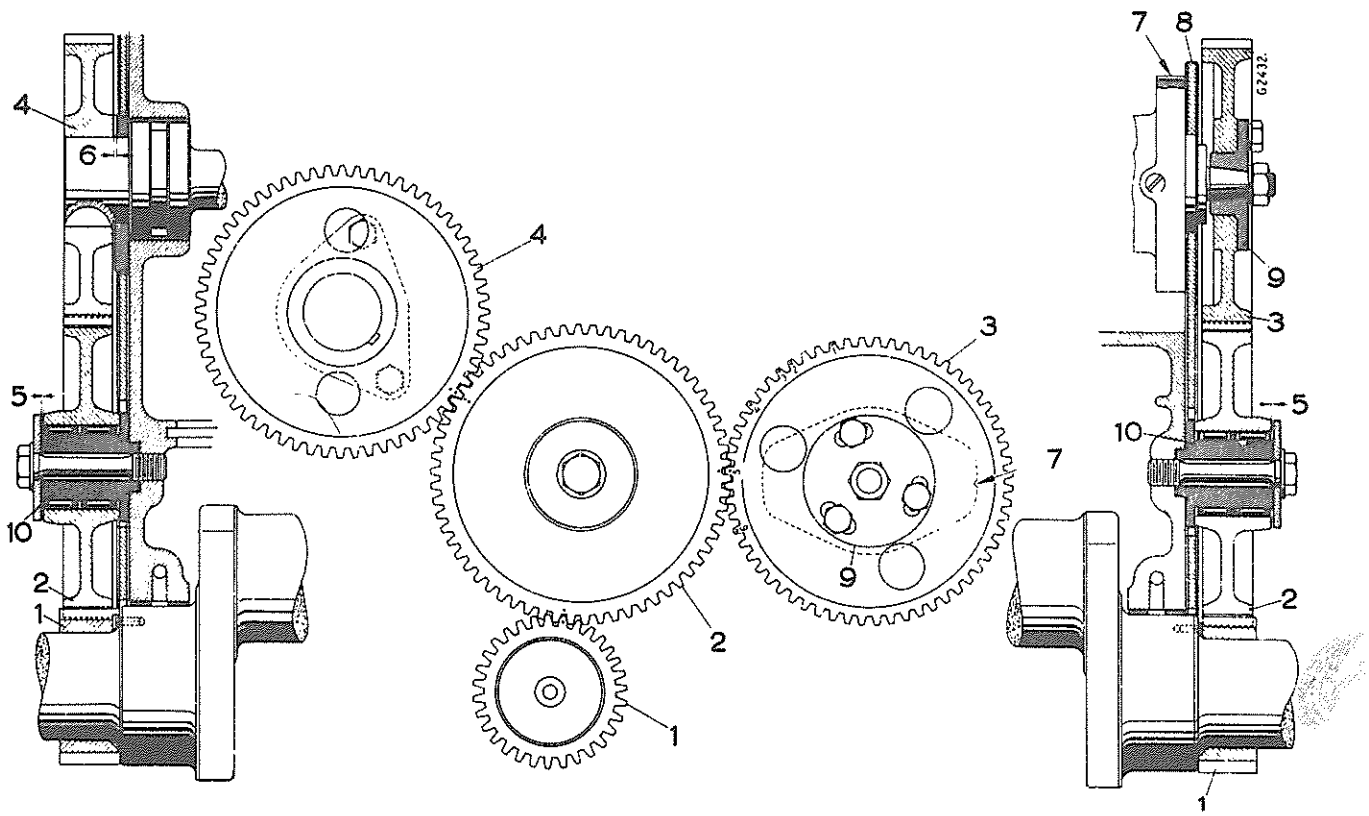
TUNING–UP

General

Engine tuning is an important factor in securing maximum power and operating economy.

To assure full engine power output strictly observe the following:

Timing Gear Train



Illust. 431

1 – Crankshaft pinion
2 – Idler gear
3 – Injection pump drive gear
4 – Camshaft drive gear
5 – End play of idler gear = 0.20–0.33 mm (.0078–.0130")
6 – End play of camshaft = 0.09–0.44 mm (.0035–.0173")
7 – Scribe mark on pump flange (displaced)
8 – Front plate
9 – Injection pump hub
10 – Idler gear carrier

Illust. 431 shows the gear train of a 6-cyl.-engine with piston number one on compression TDC.

On all engines the timing marks of gears (1) and (4) must be in line with the timing marks of the idler gear (2).

The injection pump drive gear (3) is marked with numbers 1 up to 6.

Note: Marks on injection drive gear are for easy assembly. It is not essential that the timing marks of injection pump drive gear be aligned for proper timing.

If the engine is on number one compression at the specified static timing and the injection pump is installed with the timing pointer at the scribed line on the face cam, the pump will be "timed".

However, the following timing chart should be used to facilitate gear installation.

Timing Chart for Injection Pump Gears 3 055 066 R3 / 3 056 885 R3 / 3 218 450 R1

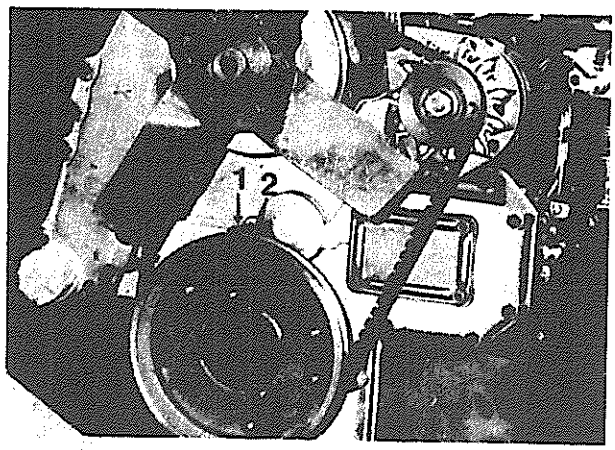
Mark 1	Mark 3	Mark 2	Mark 4	Mark 5	Mark 6
D-155		**D-206**		**D-310**	
423, E–423, 423 S.U. 383 500 C/E 453/S.U. V/E–433, V/E–533 433 Series II 533 Series II/TC S.U. 533 2–WD/4–WD 5033 433V/E–433 533V/E–533 PL503 S.U. 533V		554, 654, 644/645 221 TD–7 C G.D. 100 G.D. 105 275/375 733/E733/V733	474 G.D./H.S. 100 B Series II 584 TD–6 B 100 B, 624 258 Ind. Tr.	955, 946 431, 531 H–50 B DU–2 D D–1500 C 616/622 H.S. 711 S.P. Header Harv. HS 9	165 C 696, 766 1–3820 A 9000 F.L. 715 Comb. 782 Cotton Picker 95 Cotton Harv. 786 Wh. Tr. (Aus.) 686 Wh. Tr. (Visa) Hydro 86
		D–239/DT–239		**D–358/DT–358**	
		724, 824, 724 S.U. 824, 834, 744 Crane TD–7E, 100 E P.S. TD–8 C G.D./P.S. 125 G.D./P.S. H–30 B, Galion Gr. H–30 B Nico 321, 431 Ingersoll–Rand 5000/5500 W.R. 1120/1230 TOE TD-8E/125 E P.S. 743/744/745 745 Crane/745 (France)	574 G.D./H.S. 3654, 3654 S.U. 3500 A G.D./H.S. 674 G.D. 2500 A G.D./H.S. 125 B & TD–8 B Ser.II S.U. 644–H.D./4–WD 3400 B S.M./H.S./T.C. 684, 268 Ind. Tr. 2574 G.D./H.S. 250 A S.M./H.S./T.C. Irrigation Unit/OEM 260A SM/HS/TC/6D 252 F.L.	1046, 1055 1630 A, 1730 A, 1830 A 531, 541, (8–111) Acco 1820 with AT–540 Acco 1820 Galion 102 Grader DU–2 D TOE Loadstar/S-Series H–60, H–65 B Series 200 ATk. M.T. 1246/1255 725 Acco 1730B–1930B 1521 953, 955 SED. ATK. 650 EXC./3990 923/943/933	866–WT/WT–Mexico 3964/3965 EXC. 3980 EXC./3984B 515/280 976/986 (Aus) 3965 EXC.DUT.AR. H–60–B, 520 A 630/W EXC 640N/LN/HDN/EXC 520 A H–65C/530A 640/L/HD EXC 886/786 S-8A/S-10/520B 260/Irrigation Unit/OEM 1420/3088/3288 1400/782
D–179		**D–246**		**DT–402**	
553 633 V/E 633 633 Series II	4500 A 4500 B T.C. 454 G.D./454 H.S. 464 G.D./H.S. 3654 S.U. 484 248 Ind. Tr. SU–644–LD 2454 G.D./H.S. 240 A S.M./H.S./T.C. 3400 A G.D./H.S. 2400 A G.D./H.S. Irrigation Unit/OEM	824, 834, 844	784/Hydr. 84 3500 B SM/HS/TC 278 Ind. Trac. Hydro 268 Ind. Trac.	650 H.D. EXC/3994 953 H.S./G.D. 1455	530A II
		D–268			
		844S 845 620B	510 270A H.S./T.C. TD–8 CA Craw. Trac. 884 Wheel Trac.		

Injection Pump

Checking Static Timing

1. Position the engine on the compression stroke number one cylinder (Intake and exhaust valves are closed).

2. Turn the crankshaft in direction of rotation until the timing pointer (1) is in line with the specified timing mark (2) on the graduation, Illust. 432.

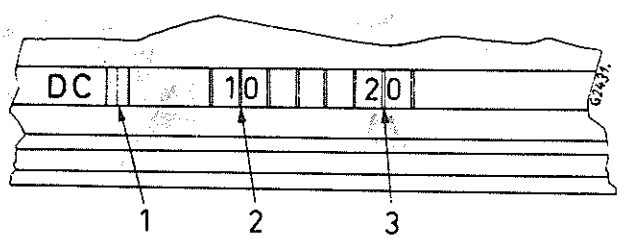


Illust 432

1 – Pointer
2 – Graduation on the front pulley

For static degrees of the respective engine, see timing chart.

Read the graduation on the front pulley as outlined in Illust. 433.



Illust. 433
One graduation mark = 2°

1 – TDC mark
2 – 10° BTDC
3 – 20° BTDC

3. Remove the lower cover plate of the injection pump, Illust. 434.

Illust. 434

1 – Pointer on roller ring
2 – Scribe line on face cam

With static timing correct, both pointers (Illusts. 433 and 434) must be in line with their respective timing marks.

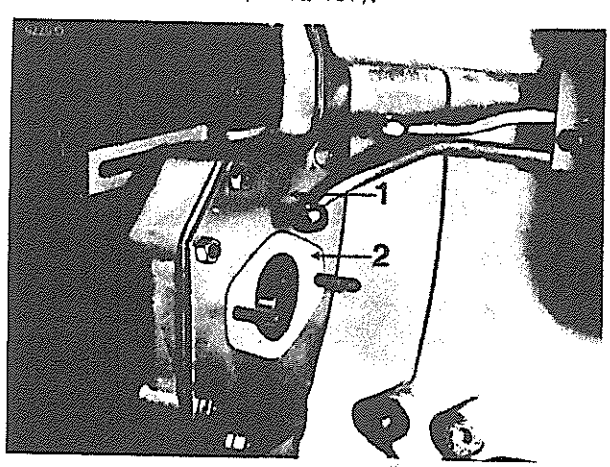
NOTE: On EP/VA pumps the face cam has a second scribe line marked with letter "L". Do not use this scribe line for adjustment.

Installing (Adjusting) the VA Injection Pump

The engine must be in static timing position. Refer to step 1 and 2 and Illust. 432.

Proceed as follows:

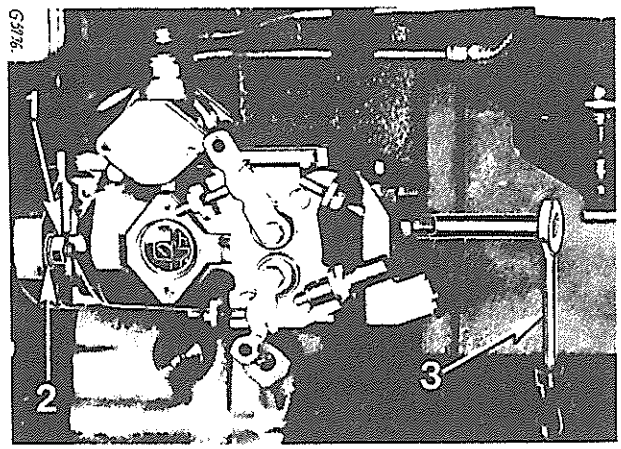
Remove cover plates of the injection pump (Illust. 434) and of the front cover (Illust. 437).



Illust. 435

1 – Engine front plate
2 – Gasket

Apply liquid sealer to both sides of new gasket (2).



Illust. 436

1 – Stud nuts (two)
2 – Washers (two)
3 – Wrench, with extension

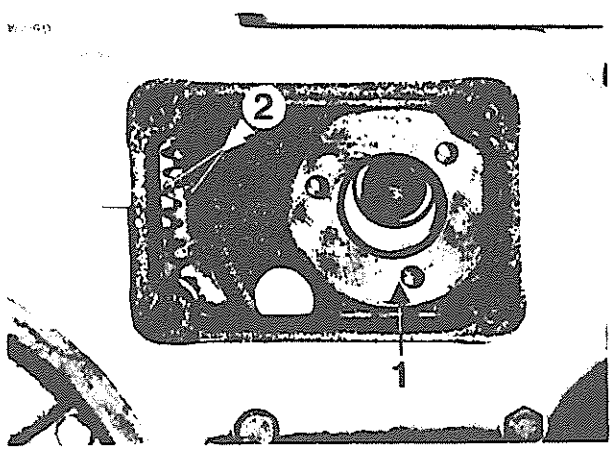
Place woodruff key into keyway of injection pump drive shaft.

Turn keyway in 11 o'clock position.

Install pump, taking care washers (2), Illust. 436 cover slotted holes of pump flange evenly, i.e. the pump is level.

Tighten stud nuts (1) to 24 N•m (18 lbf-ft).

NOTE: Since the idler gear is a walking gear, proper timing alignment (2) Illust. 437 will not always be noted.



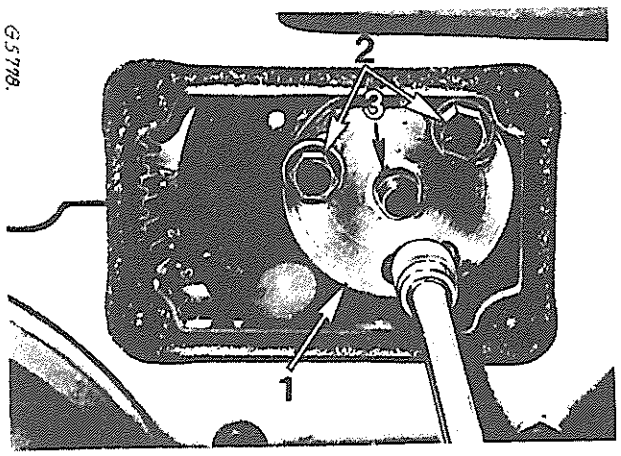
Illust. 437

1 – Injection pump drive gear
2 – Timing marks

Make sure the timing mark (2) of idler gear aligns with the specified figure on the drive gear (1) Illust. 437 as outlined in the timing chart for injection pump drive gears.

If the engine is on number one compression at the specified static timing and the injection pump is installed with the timing pointer at the scribed line on the face cam, the pump will be "timed".

However, if the complete timing gear train has been removed, the timing of the gear train must be reset as shown in Illust. 431.

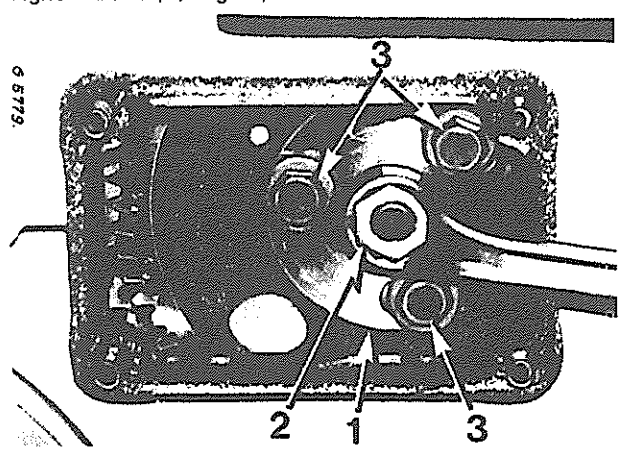


Illust. 438

1 – Hub
2 – Hub retainer bolts, with washers
3 – Keyway (in 11 o'clock position)

Install hub (1).

Tighten bolts (2) slightly.



Illust. 439

1 – Hub
2 – Hub retainer nut, with lock washer
3 – Bolts, hub to gear

Install lock washer and nut (2).

Block the engine and tighten nut (2) to 65 N•m (48 lbf-ft).

Loosen bolts (3).

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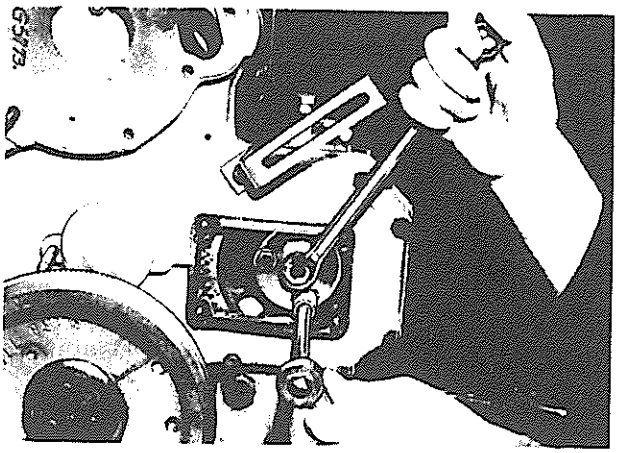


Illust. 440
Adjusting the Injection Pump

Turn the injection pump drive shaft until the pointer on the roller ring is in line with the scribe mark on the face cam (Illust. 434).

At this point tighten hub retainer bolts slightly, Illust. 440.

Block the engine and tighten the retainer bolt to:

1st step 15 N•m (11 lbf-ft)
Final step 27 N•m (20 lbf-ft)

Finally make sure that both timing pointers:

a) on the front pulley
and
b) on the roller ring are in line with their respective marks as specified.

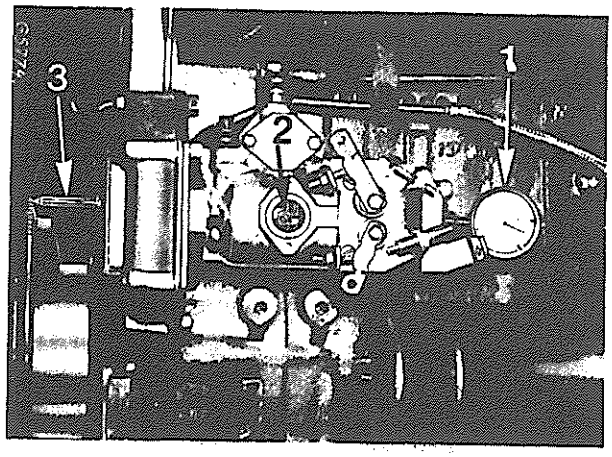
NOTE: If the injection pump drive gear timing number is not known, the following procedure applies:

Bar engine to position number one piston on compression at the specified static timing. Install injection pump with the pump timing pointer in line with the scribed line on the face cam Illust. 434. The pump will now be timed.

Checking VA Injection Pump Timing with Dial Indicator

Before checking injection pump timing the engine must be in static timing position.

See "Checking Static Timing".



Illust. 441

1 – Dial indicator
2 – Pointer on roller ring
3 – Pointer on engine front cover

1. Using a suitable fitting rest the stylus of the dial indicator on the face of the distributor plunger. Pre-load 1 – 2 mm (.04 to .08"), Illust. 441.

2. Slightly turn the crankshaft to and fro to find the bottom dead center of the distributor plunger.

3. With the distributor plunger in BDC zero the dial indicator.

4. Turn the crankshaft in direction of rotation until the pointer (3) is in line with the specified static timing mark on the front pulley.

Note to paragraph 4, prevent reading errors!

a) Be sure your eye is in line with timing pointer (2) and graduation mark on pulley (1) in a vertical position.

b) Be sure your eye is in line with timing pointer (3) and scribe line on face cam (4) in a horizontal position.

5. In this position the dial indicator reading should be 1.0 mm (.0394") and the pointer (2) should be in line with the scribe mark on the face cam.

NOTE: If pre-stroke travel of the distributor plunger (1.00 mm) is correct, the pointer (2) may be readjusted as necessary.

Valve Lash Adjustment

To adjust valve lash, use the simplified procedure as outlined in the following Illusts. 442 to 444.

All valves can be adjusted by cranking the engine only twice.

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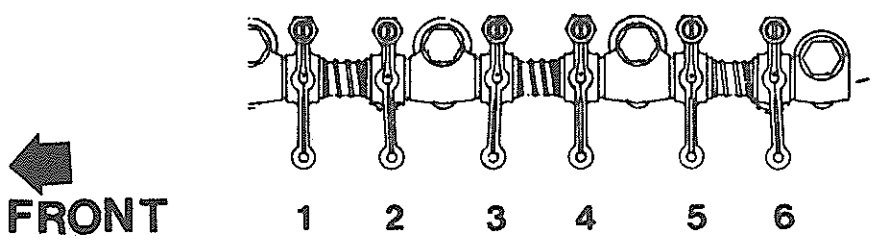
3—Cylinder Engines

With	Adjust Valves (Engine Warm) *					
No. 1 Piston at T.D.C. (Compression)	1	2		4	5	
No. 1 Piston at T.D.C. (Exhaust)			3			6

GA–7324.

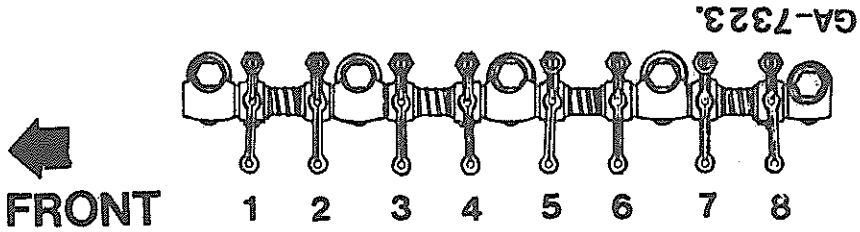


Illust. 442
Numbering sequence of the valves which correspond to the chart

4—Cylinder Engines

With	Adjust Valves (Engine Warm)*							
No. 1 Piston at T.D.C. (Compression)	1	2		4	5			
No. 4 Piston at T.D.C. (Compression)			3			6	7	8

GA–7323.

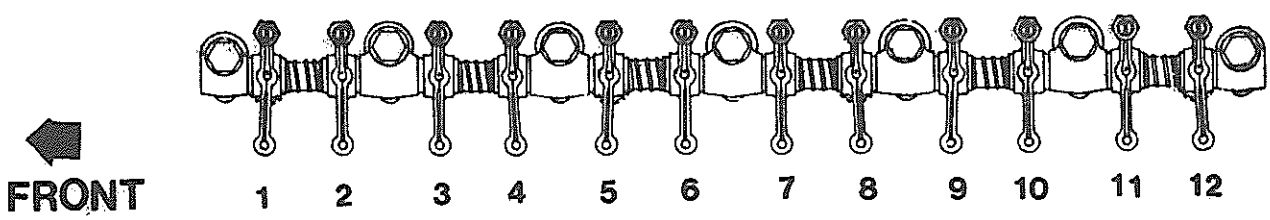


Illust. 443

6—Cylinder Engines

With	Adjust Valves (Engine Warm) *											
No. 1 Piston at T.D.C. (Compression)	1	2		4	5			8	9			
No. 6 Piston at T.D.C. (Compression)			3			6	7			10	11	12

GA–7322.



Illust. 444

Note: Even numbers are intake valves, uneven numbers are exhaust valves.

* Operating temperature

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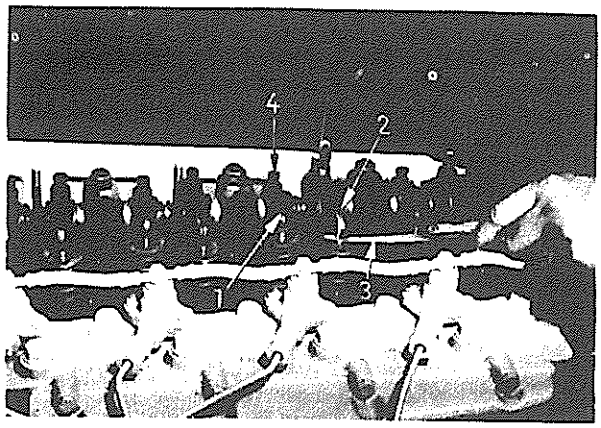


Illust. 445
Adjusting Valve Lash
Engine at Standstill)

1 – Valve lever, exhaust
2 – Valve lever, intake
3 – Feeler gauge
4 – Adjusting screw and lock nut

The valve lash should be adjusted with the engine warm. Adjust intake and exhaust valves to 0.30 mm (.012").

To adjust a valve, loosen the lock nut on the valve lever, and insert a feeler gauge between the valve lever and valve stem. Turn the adjusting screw to hold the feeler gauge snuggly, then while holding the adjusting screw firmly, tighten the lock nut. Then check the clearance once more.

NOTE: If valve lever adjusting screws (4) Illust. 445 are self-clamping and do not have lock nuts, they must turn with more than 16 N•m (12 lbf-ft) or a new screw, or new valve lever or both should be installed since it is possible that the screw will work loose.

Valve Timing

Valve timing is taken care of by the markings on timing gears of engine, Illust. 431.

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

One procedure for checking valve timing is as follows:

1. Adjust the No. 1 intake valve. with the engine set at No. 1 top dead center compresson stroke to 0.36 mm (0.014 in.) valve lash.

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

3. Place a 0.10 mm (0.004 in.) feeler gauge between the valve lever and valve stem of the No. 1 intake valve and slowly rotate the engine *forward* until the feeler gauge becomes tight. This is the point at which the No. 1 intake valve starts to open which should be 26 degrees ± 3 degrees before top dead center. (See NOTES 1 and 2).

NOTE 1: This valve opening figure will not agree with specified valve opening. This figure is provided for checking purposes only.

NOTE 2: One tooth "out of time" equals approximately 11 degrees.

4. Readjust the No. 1 intake valve to its proper lash of 0.30 mm (0.012 in.).

Valve timing can also be checked with a dial indicator as follows:

1. Check valve clearance.

2. Adjust the No. 1 intake valve with the engine set at No. 1 top dead center exhaust stroke to 0.30 mm (0.012 in.). [Exhaust valve beginning to close and intake valve beginning to open.]

3. Position dial indicator on cylinder head and set stylus against valve spring retainer seat of number 1 intake valve.

4. Adjust dial indicator to zero.

5. Rotate the engine to obtain maximum valve opening.

6. Read valve opening TDC-maximum on dial indicator.

7. Timing is correct when reading is 10.10 to 10.25 mm (.398 to .404 in.).

8. With 1 tooth out of time a reading of either 9.00 mm (.354 in.) (early) or 10.60 mm (.417 in.) (late) will be obtained.

CHECKS

(Checking without IH–Diagnostic Center)

Wherever possible use IH Diagnostic Center for maximum convenience and economy.

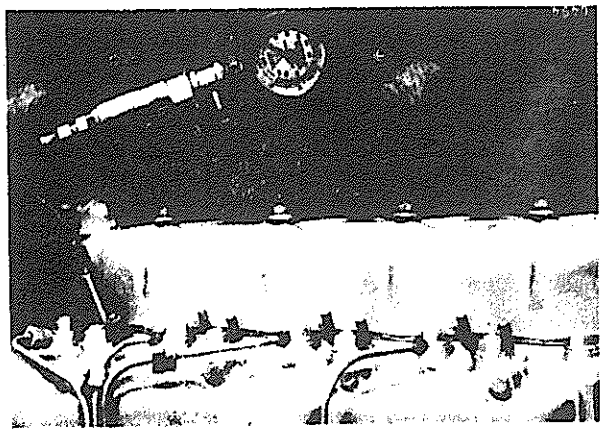
If this equipment is not available check as shown below.

Fuel System

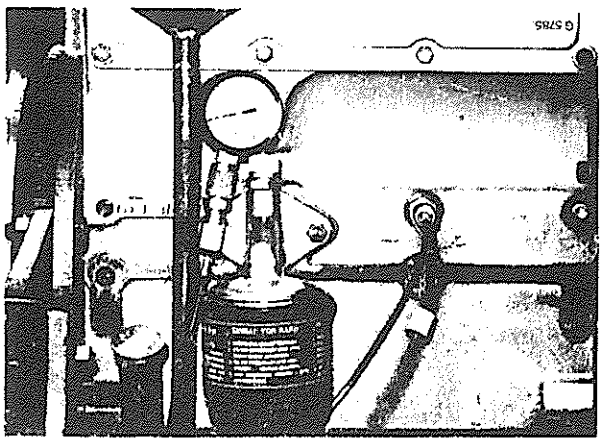
Refer to checks and adjustments as outlined under "Fuel System".

Compression

It is good practice to check compression before and after a repair to obtain comparative values.



Illust. 446
Checking Compression



Illust. 447
Checking Lubricating Oil Pressure

Run engine to warm up (operating temperature). Be sure battery is fully charged.

Disconnect fuel supply and return lines.

Remove a nozzle with holder.

Connect-up compression gauge with adapter as shown in Illust. 446.

Crank the engine with the starting motor and take a compression reading.

An engine repair is recommended if:

a) Compression readings of individual cylinders differ by more than 0.25 MPa (36 PSI).

b) Compression readings are below 1.8 MPa (255 PSI).

Lubricating Oil Pressure

If the green oil pressure control lamp on the instrument panel lights up during engine operation, it is good practice to check oil pressure with a reliable pressure gauge.

Connect pressure gauge, range

0 – 1 MPa (0 – 150 PSI) to the main oil gallery.

With engine at operating temperature read the oil pressure at low idle and rated speeds.

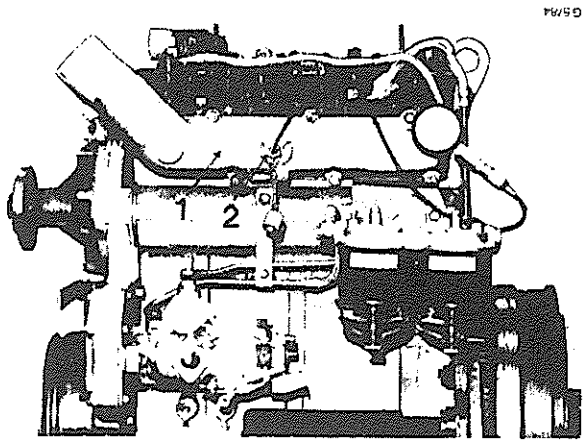
Compare readings with "Technical Data".

Probable causes for insufficient oil pressure:

Bearings excessively worn
Oil pump worn
Relief valve or relief valve spring damaged
Suction line leaking
Suction screen clogged, insufficient oil level
Diluted engine oil

Air Cleaner Restriction

Connect a vacuum gauge to the intake manifold.



Illust. 448

1 – Intake manifold
2 – Test connection

With the engine at operating temperature take a reading at rated speed.

If maximum restriction values are exceeded replace the air cleaner element.

Check service indicator, refer to "Chassis Manual".

Boost Pressure (Turbocharged Engines)

Connect pressure gauge to intake manifold.

Check boost pressure against specification listed in turbocharger section.

Causes for insufficient boost pressure:

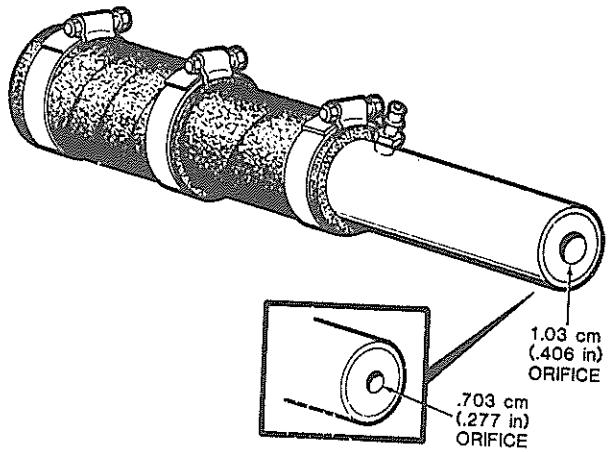
Excessive air cleaner restriction.

Intake and/or exhaust manifold leakages.

Damaged turbocharger.

Crankcase Pressure

NOTE: For measuring crankcase pressure use orifice restrictor PLT-554 for DT-358 and DT-402 engines. For all other engine models use PLT-556.



Illust. 449
Orifice Restrictor Tool

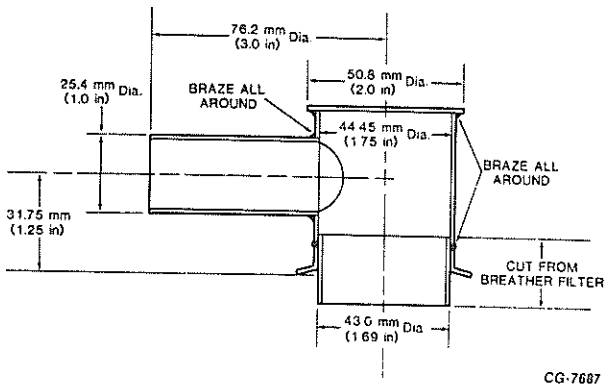
The restrictor is used to measure combustion gas flow out of the engine breather and is used with water manometer PLT-302-8.

Follow the procedure below to check crankcase pressure, then refer to crankcase pressure chart in Technical Data to interpret readings.

NOTE: Refer to Operator's Manual for proper servicing intervals of breather element.

Operating Instructions

1. Park vehicle on level ground.
2. Breather tube must be free of obstructions and element free of sludge.
3. Engine oil level must not be above full mark.
4. MACHINES WITH HAT-TYPE BREATHER: Remove the breather. Install the adapter tool (Illust. 450) using the O-ring and clamp to insure that all blow-by gas passes through the adapter.
5. Attach crankcase breather restrictor to breather outlet or adapter.
6. Connect one leg of water manometer to pressure tap of restrictor assembly with other end open to atmosphere.
7. Operate engine to establish normal coolant operating temperature 76.7° – 93°C (170° – 200°F).



Illust. 450
Adapter for use with engines equipped with Flat-Type Breathers (make locally)

8. Operate engine at HIGH IDLE SPEED, NO LOAD.
9. Observe manometer reading for approximately two minutes and record average reading (manometer reading will fluctuate).

Engine Run-In Schedule

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

The first few operating hours after a re-ringing or re-sleeving job are crucial for the service life of new parts, efficiency of the engine and economy in oil consumption.

The following steps as detailed below should be observed:

Start

Prior to starting make sure that:

a) all bearings are pre-lubricated (see below).

b) the crankcase is filled with specified engine oil.

c) the cooling system is filled to correct level.

d) Precautions for alternator operation are observed.

Priming Lubricating System

NOTE: Diesel engines must not be rotated when priming with oil; otherwise, they are likely to start running.

When assembling the overhauled engine, it is necessary to thoroughly lubricate the various running parts with clean engine oil to assure initial lubrication when engine is first started. However, to further make certain that complete initial lubrication is available, the engine lubricating system should be pressure primed or charged

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with oil. Attach the line from a priming device to a suitable fitting located in the main oil gallery, filter header or oil cooler of the engine and inject sufficient oil into the engine to fill the oil filters and charge the entire system. Use only clean engine oil in accordance with Operator's Manual. New or overhauled engines that have been in storage over an extended period should also be primed in a similar manner.

After the priming procedure is completed, make certain that the oil level is checked before the engine is put into service. Do not overfill the engine; neither should the engine be short of oil as a result of using the pressure priming procedure.

Priming the engine will minimize the possibility of scuffing or heat build-up in the running components which could lead to immediate or low mileage failures.

Run-in

1. Start and run the engine at 3/4 rated engine speed with no load, until operating temperature (80 – 85°C) is reached, cover the radiator if necessary. DO NOT run for over 10 minutes.

2. Retorque cylinder head bolts.

IMPORTANT

DO NOT run the engine longer than 15 minutes before retorquing cylinder head bolts.

3. Continue according to the following chart.

With Dynamometer

Engine RPM	Load %	Time minute
1000	40	5
2000	50	5
rated speed	80	10
100 below rated speed	50	10

Without Dynamometer

Engine RPM	Load	Time
3/4 of rated	none	1st hour
3/4 of rated	light	2nd hour
		3rd hour
Medium	full	4th hour

After Running-in

Retighten manifold bolts and/or stud nuts.

Check valve clearance and readjust as necessary.

Handing Over the Engine

In the presence of the operator check engine oil level and coolant level. Test run the engine. Point out to the operator that the overhauled engine is to be treated in the same was as a new one.

In the presence of the operator check engine oil level and coolant level. Test run the engine. Point out to the operator that the overhauled engine is to be treated in the same way as a new one.

NOTE: Re-torquing of cylinder head bolts in the field is not necessary when the new "Maintenance-free" cylinder head gasket has been installed. This new gasket can easily be identified by its red plastic borders around the oil and water sealing faces; refer to Illust. 60.

General

Engines of our present tractor line are equipped with the Bosch alternator G1–14V28A22.
This machine has a piggy-back mounted transistorized voltage regulator (12) and is protected by a load dump "Zener" diode (42) Illust. 451.

Previously tractor engines were equipped either:

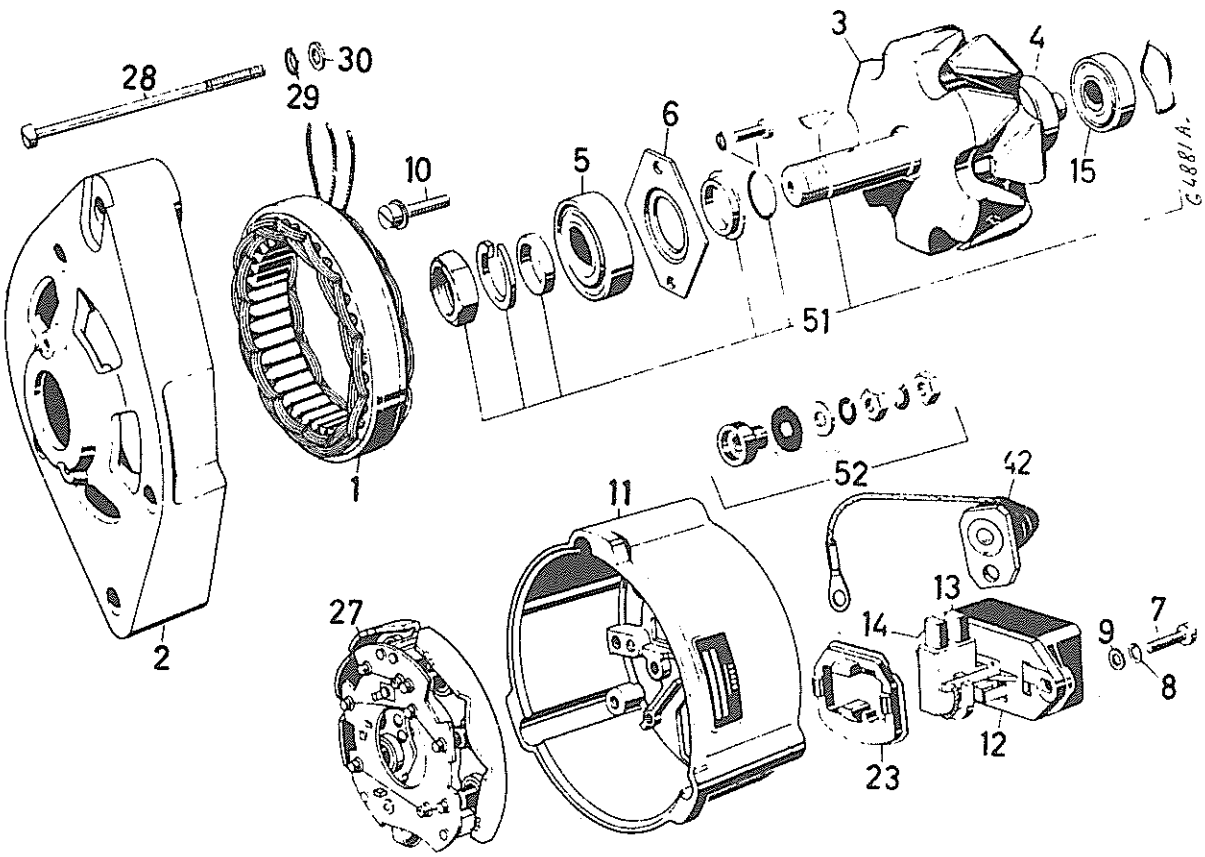
a) with the same alternator as above but using a separate, mechanical type voltage regulator and no load dump device.

b) with D.C. generators having 11, 16 or 20 Amps output.

Alternators used on construction equipment are usually of the K1–14V35A20 model or, where high power requirements demand, the K1–14V55A20 model, using a separate mechanical type voltage regulator.

The starting motor is normally of the Bosch type JD12V giving 3 kW output.

Some of the earlier 3- and 4-cylinder engines used the 1.8 kW Bosch starting motor especially in warmer climates.



Illust. 451
"G1" alternator, with piggy-back voltage regulator and load dump diode

1 – Stator
2 – Drive end frame
3 – Rotor
4 – Slip rings
5 – Ball bearing
6 – Retainer plate
7 – Screw
8 – Lock washer
9 – Washer
10 – Screw
11 – Slip ring end frame
12 – Piggy-back voltage regulator assy
13 – Brush set
14 – Brush holder
15 – Ball bearing
23 – Gasket
27 – Diode plate
28 – Screw
29 – Lock washer
30 – Washer
42 – Load dump diode
51 – Rotor parts, set
52 – Terminal parts, set

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General

The following alternator and regulator assemblies have been fitted to meet power requirements with various engine applications.

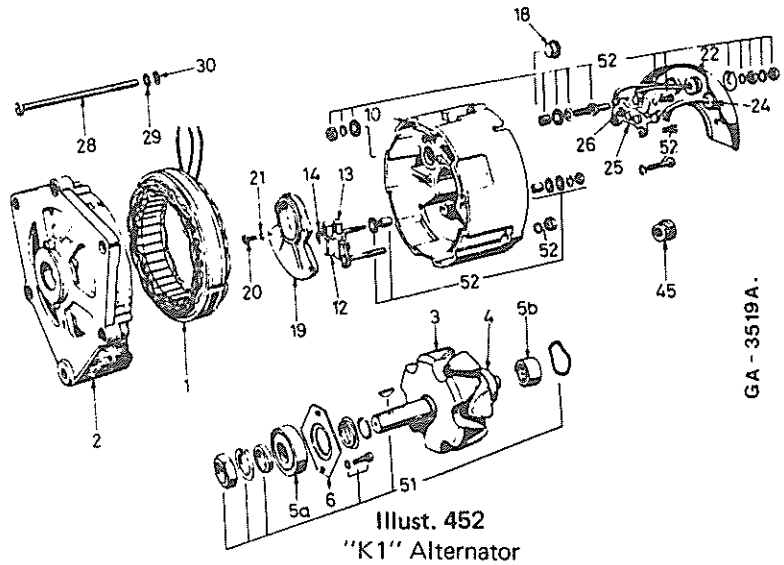
*1)	G1-14V 28A 22	3 144 924 R91
*1)	G1-14V 28A 22	3 144 907 R91
*1)	G1-14V 33A 27	3 218 239 R91
*1)	G1-14V 33A 27	3 218 577 R91
*2)	K1-14V 35A 20	3 136 412 R91
*2)	K1-14V 55A 20	3 139 172 R91
*3)	K1-14V 55A 20	3 218 544 R91
*3)	K1-28V 27A 23	3 218 884 R91
*4)	K1-28V 27A 23	3 144 930 R92
*3)	K1-28V 45A 27	3 144 988 R92

*1) With piggy-back transistorized voltage regulator and load dump diode (system protection).

*2) With separate one-element-two contact voltage regulator.

*3) With piggy-back transistorized voltage regulator and capacitor.

*4) With piggy-back transistorized voltage regulator.



Illust. 452
"K1" Alternator

1 – Stator
2 – Drive end frame
3 – Rotor
4 – Slip rings
5a – Ball bearing
5b – Ball bearing
6 – Retainer plate
10 – Slip ring end frame
12-14 – Brush holder assy.
13 – Brush, set
14 – Brush spring
18 – Diode (– load current)
19 – Cover
20 – Screw
21 – Spring washer
22 – Heat sink, assy.
24 – Diode (+ load current)
25-26 – Diode plate (exciter current)
26 – Exciter diode
28 – Screw
29 – Spring washer
30 – Washer
45 – Plug
51 – Rotor parts, set
52 – Terminal parts, set

Operating Instructions

"G1" Alternator with Piggy-back Voltage Regulator

1. When the alternator is running do not short alternator terminals B+ and D+ across or to ground (not even by touching).

2. Start the engine only with specified power supply.

3. Before starting with an ***external*** battery, disconnect the cable from alternator terminals B+ and D+ to avoid diode failure due to possible mistaking of positive and negative battery posts.

4. When quick-charging with connected vehicle light system tighten battery clamps. Couple negative with negative and positive connections.

5. During welding operations on vehicles attach the ground terminal of the welding machine directly to that part of the vehicle, which is to be welded.

6. Take care for negative earth return of battery and alternator.

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"G1" and "K1" Alternators with separate Voltage Regulator.

1. To protect the alternator and the electrical system during operation without battery, remove the cables from the regulator prior to starting the engine.

   Also remove the cables from regulator before starting, if a non operative dry-precharged or defective battery is installed.

2. Do not separate or connect cables between regulator, alternator and battery during operation.

3. When alternator is running, avoid any short circuiting (even by touching) of connections on regulator and alternator and to ground.

4. When quick-charging with connected vehicle light system tighten battery clamps. Couple negative with negative and positive with positive connections.

5. During welding operations on vehicles attach the ground terminal of the welding machine directly to that part of the vehicle, which is to be welded.

6. When starting the engine with dry-pre-charged battery, made operative beforehand by filling in acid, reconnect alternator and regulator.

7. Take care for negative earth return of battery and alternator.

8. When starting by means of a rectifier, during test runs, no connection must exist between alternator and regulator.

Preventive Maintenance.

The alternator requires very little maintenance; however, making the following checks of the alternator charging system will avoid many problems that might otherwise develop:

1. Check belt tension. Refer to your Operator's Manual for proper belt tension.

   Note: Do not over tighten – damage to bearings may result.

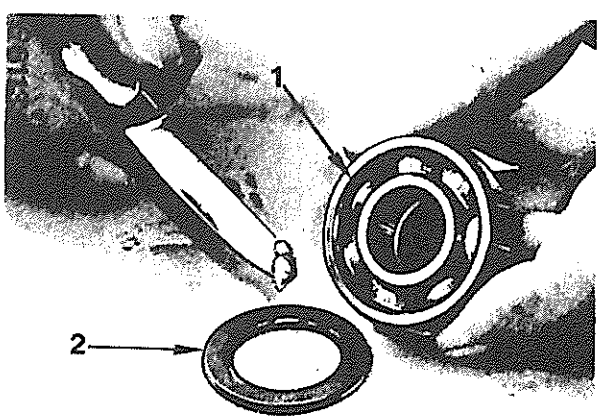
2. Keep pulley nut tight. See "Specifications".

3. Check alternator B+ and D+ terminals and cable connections for good condition, secure fastening and freedom from corrosion.

4. Check battery cables and connections for good condition, secure fastening and freedom from corrosion.

5. Check electrolyte level in battery. Add water if needed. Check battery condition and charge level. If low, charge battery. If battery will not take an adequate charge, or is otherwise unsatisfactory, replace battery.

6. Replace ball bearings after 4000 hours of operation or earlier if the unit is disassembled.



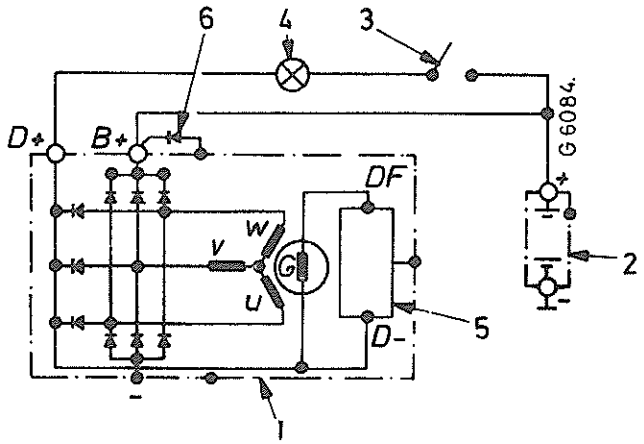
Illust. 453

1 – Ball bearing, drive end side
2 – Cover washer

7. Fill only one side of the ball bearing with high melting-point grease "Bosch F1 v 34" or equivalent.

   Over-lubrication may result in oxidation of the slip rings.

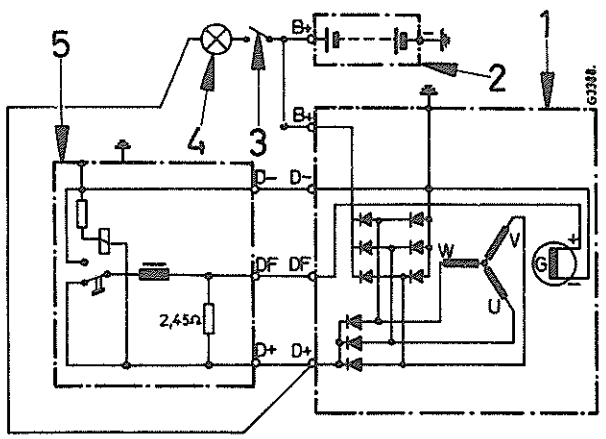
Principle of Operation



Illust. 454
Circuit diagram "G1" alternator with transistorized piggy-back voltage regulator

1 – Alternator
2 – Battery
3 – Light switch
4 – Charge control lamp, 2W
5 – Voltage regulator
6 – Load dump diode

G – Field coil (rotor)
U,V,W – Windings (stator)



Illust. 455
Circuit diagram
Alternator with separate, mechanical voltage regulator (12 V system)

1 – Alternator
2 – Battery
3 – Light switch
4 – Charge control lamp, 2 W
5 – Regulator
G – Field coil (rotor)
U,V,W – Windings (stator)

NOTE: With 24V system and separate voltage regulator a four-lead cable with space type connectors is used between regulator and alternator terminals (D+, 61, DF, D–), terminal 61 being the ground connection.

Pre-excitement

With engine shut off, the remanent magnetism in the rotor is very weak. To provide instand power the alternator is pre-excited as follows:

With light switch (3) on, current taken from the batteries (2) flows via charge control lamp (4) and regulator, via field coil (G) to ground, Illust. 455. With the transistorized regulator (5) Illust. 454 the exciter current is passing through the regulator to ground.

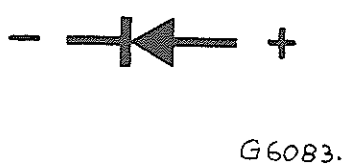
While passing the field coil, a magnetic field round the rotor is built up.

Therefore, if the engine is started, the alternator will give output at once.

With rising engine speed, the charging voltage will reach battery voltage value, so the control lamp goes out to indicate that the charging circuit works properly.

Note: A charge control lamp of min. 2 Watt is mandatory for proper pre-excitation (12V charging system).

Rectifier Diodes



Illust. 456
Symbol of rectifier diode

\+ side – conventional current passing through
– side – conventional current blocked

A diode is an electrical device which rectifies alternating current to direct current by allowing current to pass through it freely in one direction but not in the other, Illust. 456.

Therefore, the alternating current output from the stator windings, U, V, W is applied

a) to an insulated three phase full wave bridge rectifier which provides direct current to the battery and to the electrical accessories of the vehicle, while return flow is established by three negative rectifier diodes,
and

b) to a positive three phase full wave bridge rectifier which provides direct current (exciter current) to the regulator and rotor, see Illust. 454.

The six positive and the three negative rectifier diodes of the "G1" alternator are imbedded in a circular mounting plate, located inside the alternator, see Illust. 466.

On "K1" alternator models, there are three positive rectifier diodes integrated in the heat sink which are providing direct current to the battery and to the accessories.

Return flow is established by three negative rectifier diodes, imbedded in the slip ring end frame, see (3) Illust. 488.

Direct current for alternator excitement is provided by a three phase full wave bridge rectifier, which is mounted inside the alternator, see Illust. 455 and also (4) Illust. 485.

For details, see "Servicing".

Voltage Regulators

Both voltage regulator types, the transistorized piggy-back type and the separately mounted mechanical contact type, are operating on the same basic principle, i.e. exciter current is limited to a pre-determined value resulting in the required voltage of the output current.

This voltage control operates effectively at fluctuating engine speeds and changing load requirements. Both regulators are not serviceable and must be replaced if they fail.

Voltage Peaks

a) On G1 alternators with piggy-back type regulator a load dump or Zener diode (6) Illust. 454 is connected between output terminal B+ and ground. This diode blocks current flow to the ground under normal operating conditions. If, however, voltage should rise above 22 – 30 volts due to some failure in the wiring etc. the diode will dump the excessive load to the ground and protect alternator, diodes and circuit.

Caution: The Zener diode will not protect the alternator and electrical circuit, if positive and negative posts of an external or booster battery are mixed up.

b) K1 alternator models are protected against voltage peak loads either by a capacitor or a peak load resistant regulator.

Specifications

Alternator (RH Rotation)	*Performance Test*		*Resistance*	
	Alternator speed RPM	Adjusting load A	Stator 1) Ohm + 10%	Rotor Ohm + 10%
G1 – 14V 28A 22	1500 2200 7000	10 18 28	0.4	6.5 2)
G1 – 14V 33A 27	1600 2700 7000	10 22 33	0.3	4.0 2)
K1 – 14V 35A 20	1300 2000 6000	10 23 35	0.26	4.0 2)
K1 – 14V 55A 20	1200 2000 2350 3) 6000	10 36 40 55	0.14	4.0
K1 – 28V 27A 23	1315 2300 6000	5 18 27	0.4	8.7
K1 – 28V 45A 27	1750 2750 6000	10 30 45	0.22	9.0

*) Alternator (with regulator) 60° warm
1) Between Coil ends
2) With piggy-back regulator 3.4 Ohm
3) Do not exceed this value if R. Bosch test bench EFAW 275 is used.

Voltage Regulation 12V System:

Mechanical Contact Type Regulator - 13.8 ÷ 14.8 V
Transistorized Regulator = 13.9 ÷ 14V

24V System:

Transistorized Regulator = 27.3 ÷ 28.3 V

NOTE: Take voltage readings at 4000 alternator revolutions with regulator cold.

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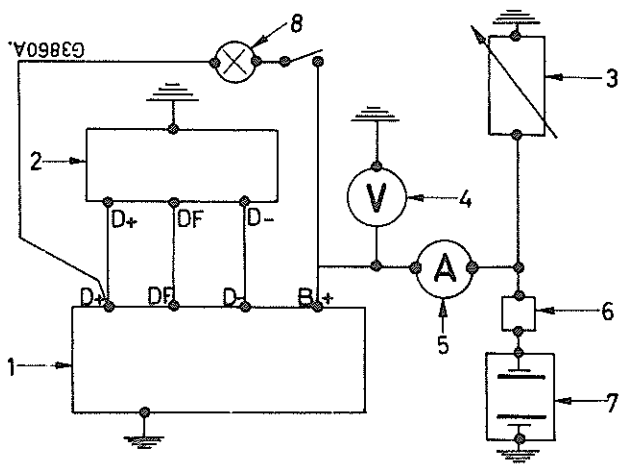
Technical Data

Alternator		*G1–14 V 28A 22*	*K1–14V 35A 20*	*K1–14V 55A 20*
Run-out of slip rings, max.	mm (inch)	0.03 (.0012)	0.03 (.0012)	0.03 (.0012)
Run-out of rotor, max.	mm (inch)	0.05 (.00197)	0.05 (.00197)	0.05 (.00197)
Minimum diameter of slip rings	mm (inch)	26.8 (1.055)	31.5 (1.240)	31.5 (1.240)
Minimum length of carbon brushes	mm (inch)	–	14.0 (.55)	14.0 (.55)
Minimum protruding length of brushes	mm (inch)	5.0 (.197)	–	–
Maximum protruding length of brushes	mm (inch)	10.0 (.394)	–	–
Brush spring pressure	gr (OZ)	–	300-400 (10.7-14.1)	300-400 (10.7-14.1)
Resistance of stator winding	Ohm + 10%	0.4	0.25	0.14
Resistance of exciter winding (rotor)	Ohm + 10%	(piggy-back regul.) 3.4 (separate regulat.) 4.0	4.0	4.0
Tightening torque of fan belt pulley nut	daNm(ft.lbs)	3.5-4.5 (25-33)	3.5-4.5 (25-33)	3.5-4.5 (25-33)

Test Instructions



Illust. 457
Electrical hook up for test bench checks

1 – Alternator
2 – Regulator
3 – Rheostat
4 – Voltmeter
5 – Ammeter
6 – Protective resistor
7 – Battery
8 – Lamp (2 Watt)

Alternator Removed

To check alternator output and its regulating voltage make a hook up as shown in Illust. 457.

To avoid dangerous voltage peaks, test the alternator and regulator only with shunt connected battery.

Connect negative battery post to the alternator frame.

Connect protective resistor (6) to battery (7) in series and rheostat (3) to battery shunt.

Switch off the rheostat only with battery connected.

Disconnect the battery only, when the alternator is not operating.

With alternator warm (60°C = 140°F) check for specified output, see "Specifications".

Adjust the load rheostat (3) if necessary to obtain desired output.

Voltage must remain within specified limits under varying load conditions.

Note: The output test given above is basic and can be performed with a minimum of test equipment.

Where a "IH Diagnostic Center" is available checks can be performed more conveniently with the alternator in position, see below.

Alternator in Position

To check alternator condition, the use of the "IH Diagnostic Center" is recommended. Consult "Operator's Manual GER 17 C/E" when using this equipment.

As an alternative method proceed as follows:

Connect a suitable ammeter between alternator output terminal B+ and the charging cable.

With alternator warm, run the engine at rated speed and take a reading.

If a half discharged battery is installed and if some accessories (heating pipe etc.) are switched on, the amps reading should approach the specified maximum value.

Note: An alternator output up to 10% below Specifications is still considered acceptable.

If test results are not satisfactory, disassemble and repair the alternator.

Trouble Shooting (G1 and K1 Models)

Behaviour of the charge control lamp, with light switch "On".	*Hints to locate a fault*	*Problem*
Charge control lamp does not light, while engine is shut down.	a) Test lamp, connected to alternator terminals B+ and D+, lights brightly	a) Charge control lamp defective or an open in the control lamp circuit.
	b) Test lamp, as above connected, does not light.	b) Short in one plus load current diode. At once disconnect charging cable from B+, otherwise battery will discharge with engine shut down.
	c) Test lamp, connected to D+ and ground glows. Also the charge control lamp glows. In this case, pull off the plug from the regulator and connect an ammeter to terminal B+ and DF. The ammeter reads 0 amps.	c) Carbon brushes excessively worn. Oxidation on slip rings. Open field winding. Defective regulator or an open in the cable from regulator to alternator.
With engine shut down or running, the charge control lamp lights constantly bright.	Disconnect the plug from the regulator when engine is shut down.	
	a) Charge control lamp still lights. The charge control lamp does not light. In this case reconnect the plug on regulator and connect an ammeter between alternator terminals B+ and D+.	a) Cable, control lamp to terminal D+ is shorted.
	b) The ammeter reading is less than 2 amps.	b) Regulator defective.
	c) The ammeter reading is more than 2.5 amps.	c) Field winding or cable to DF shorted.
While engine is shut down the charge control lamp lights brightly. At running engine, however, the lamp does not go out, it goes dim or just glows.	Connect a test lamp to terminal B+ and D+ while engine is running.	
	a) Test lamp does not light.	a) Serious electrical resistance in the charge circuit due to loose, cracked and corroded cables.
	b) Test lamp glows.	b) Regulator defective (danger of battery overcharging) or Alternator defective (unsatisfactory battery charging).
	With engine shut down, replace the regulator with a new one. Start engine and again connect a test lamp to terminal B+ and D+.	
	c) Test lamp does not light.	c) Removed regulator is defective.
	d) Test lamp glows.	d) Alternator defective.

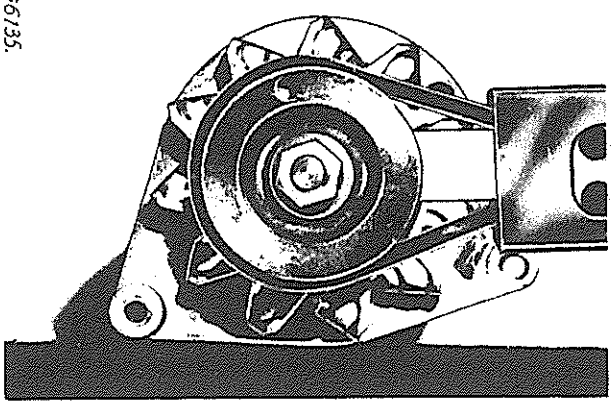
Note: Nearly all of the failures, occuring in the charging circuit, will be indicated by the behaviour of the charge control lamp.

Servicing "G1" Alternator

The following illustrations show the "G1" alternator operating with piggy-back transistorized voltage regulator.

Disassembly

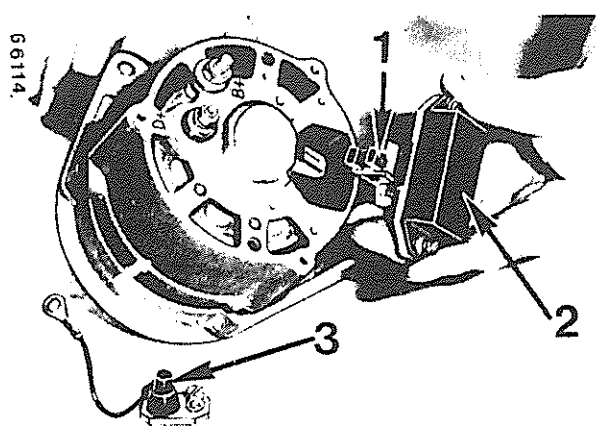
G6135.



Illust. 458

Use a special tool when loosening or tightening the pulley nut. Illust. 458.

G6114.

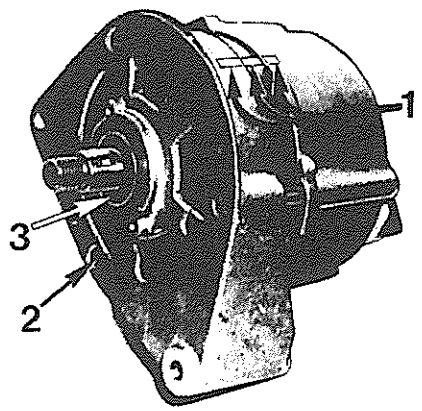


Illust. 459

1 – Brush holder assy.
2 – Transistorized voltage regulator
3 – Zener diode

Remove brush holder assembly (1+2) and Zener diode (3).

G 6115.



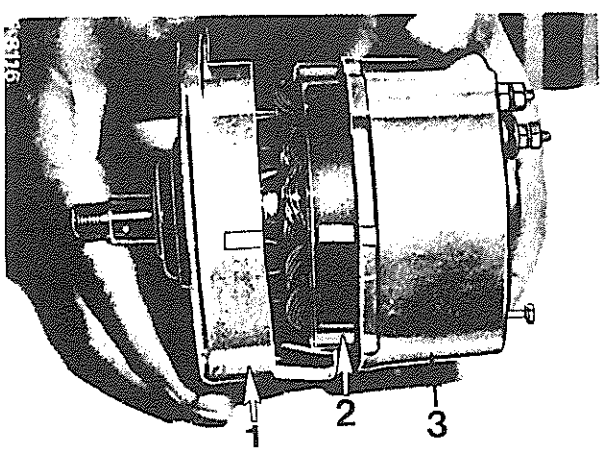
Illust. 460

1 – Marks
2 – Through bolts
3 – Spacer ring

To facilitate reassembly mark the stator, drive end and slip ring end frame (1).

Remove through bolts (2).

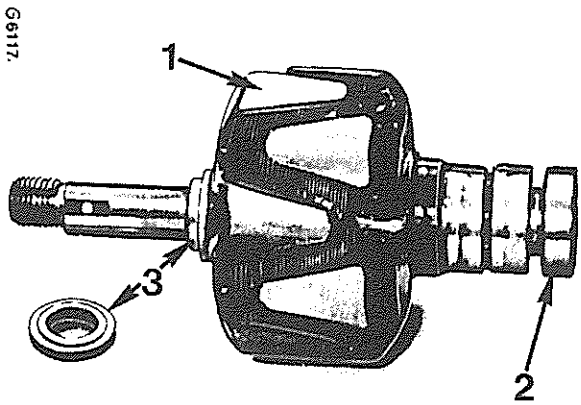
G 6116.



Illust. 461

1 – Drive end frame
2 – Stator
3 – Slip ring end frame

Pull off drive end frame (1) with rotor.

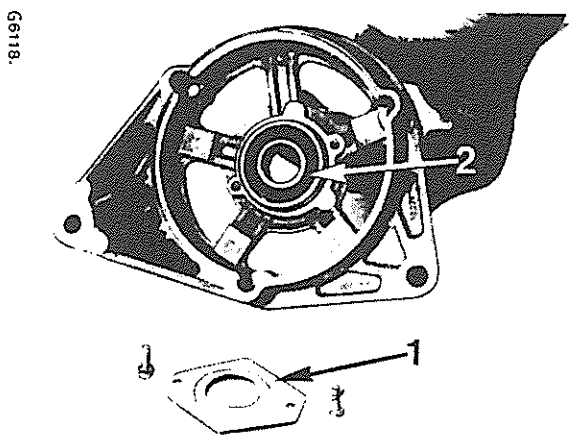


Illust. 462

1 – Rotor
2 – Ball bearing
3 – Spacer rings

Use an arbor press to separate the rotor from the drive end frame bearing.

Remove ball bearing (2).



Illust. 463

1 – Retainer plate
2 – Ball bearing

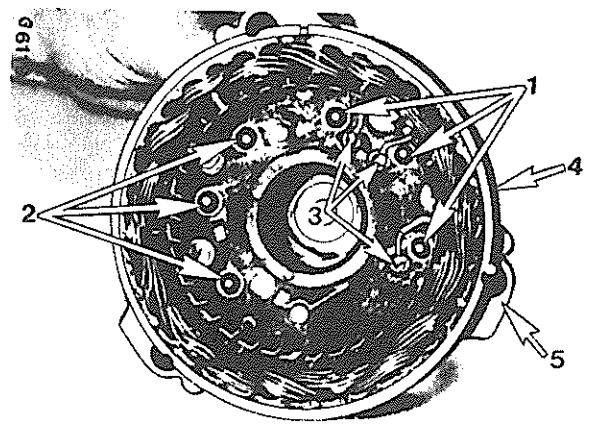
Remove retainer plate (1) and ball bearing (2).

Cleaning, Inspection and Repair

Clean alternator components with a lintfree petrol moistened cloth.

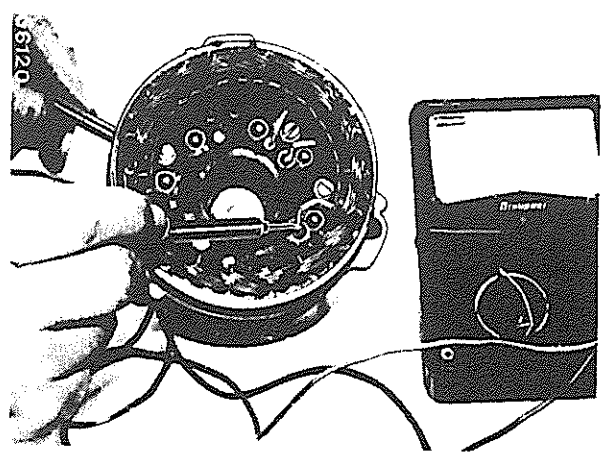
Diodes

Check load dump diode (1) Illust. 482 with a rising voltage. The diode must be blocked at normal operating voltage and permit free flow it the threshold voltage of 22–30 V is exceeded.



Illust. 464

1 – Charging current rectifier diodes, positive
2 – Charging current rectifier diodes, negative
3 – Exciter current rectifier diodes
4 – Stator
5 – Slip ring end frame



Illust. 465
Checking diodes with stator in place, using an ammeter

Check individual diodes for shorts or opens.

The simplest method for checking diodes is to use a test lamp of not more than 12 Volts.

To check diodes (1) Illust. 464 connect one lead of the test lamp to B+ and the other in turn to the individual diodes.

Note, whether the lamp lights or not. Now reverse the leads and note whether the lamp lights or not.

If the lamp lights in both checks, the diode is shorted, or if the lamp fails to light for either check, the diode is open.

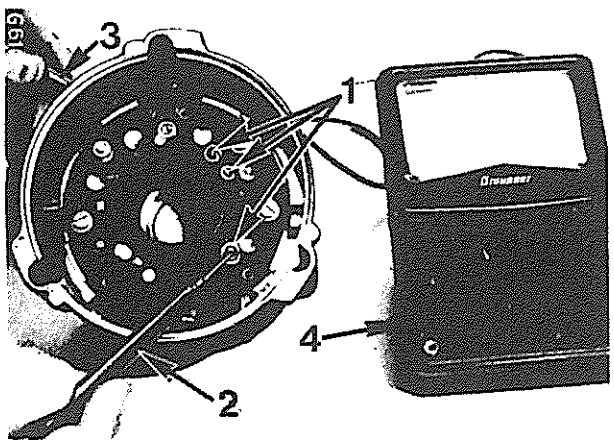
A good diode will light in one of the two checks only.

Check the remaining diodes in the same manner. However, connect one test lamp lead to D+ when checking diodes (3) and connect one test lamp lead to ground when checking diodes (2).

Note 1: If tests on charging and exciter current rectifier diodes are unsatisfactory, the stator winding may be shorted.
Unsolder stator winding ends and remove the stator.
Repeat diode checks as shown in Illusts. **466 to 468.**

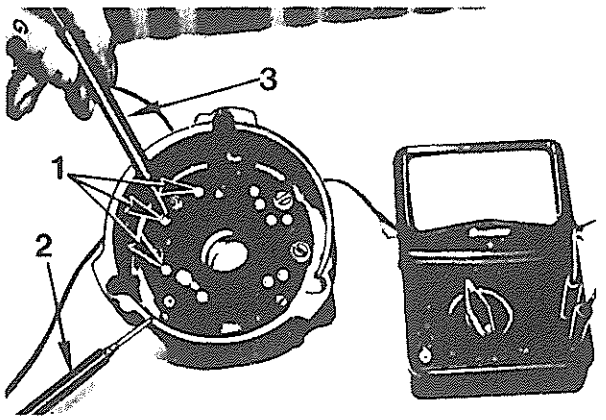
Note 2: An alternative method for checking diodes is to use an ohmmeter. Hereby, the lowest range scale on the ohmmeter should be used and the ohmmeter should have a 1-1/2 Volt cell.
To check diodes, hold the ohmmeter probes on the diodes as described for test with test lamp.
If both readings are very low, or if both readings are very high, the diode is defective.
A good diode will give one low and one high (infinite) ohm reading.

Note 3: If a special diode tester, as "Bosch tester EF AW 192" is available, all of the diodes may be checked with the stator in place. To check diodes with this tester consult manufacturer's instructions.



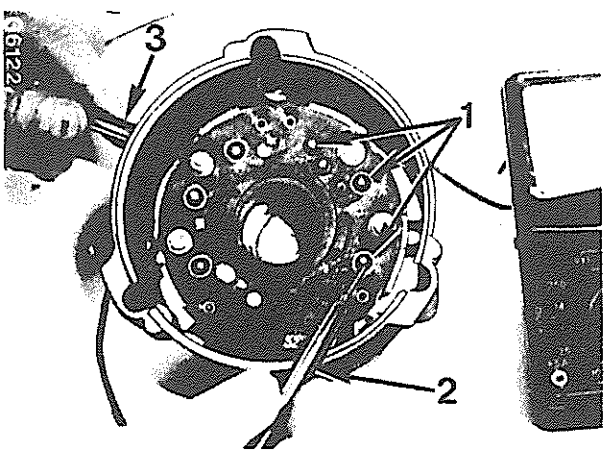
Illust. 466
Testing exciter current rectifier diodes

1 – Exciter current rectifier diodes
2 – Probe, on diode
3 – Probe, on D+
4 – Ohmmeter



Illust. 467
Testing negative charging current rectifier diodes

1 – Negative charging current rectifier diodes
2 – Probe on ground
3 – Probe on diode

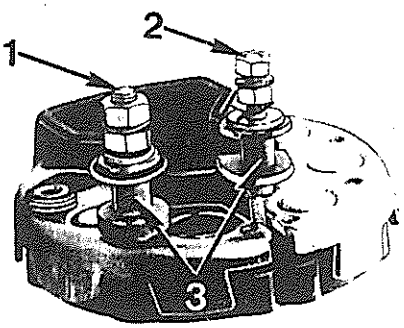


Illust. 468
Testing positive charging current rectifier diodes

1 – Positive charging current rectifier diodes
2 – Probe on diode
3 – Probe on B+

With the stator removed, test the individual diodes as shown in Illusts. 466 to 468, using methods as outlined above.

G6124.



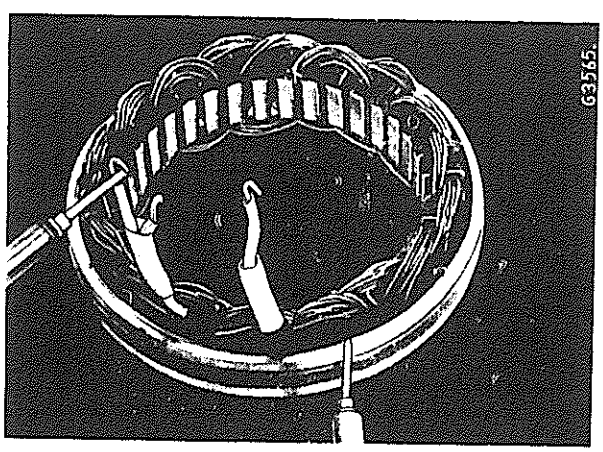
Illust. 469
Diode plate (heat sink)

1 – B+ stud
2 – D+ stud
3 – Insulating parts

If one of the nine diodes, imbedded in the plate (Illust. 469) fails, the plate must be replaced.

Take care all insulating parts (3) are installed when replacing this plate.

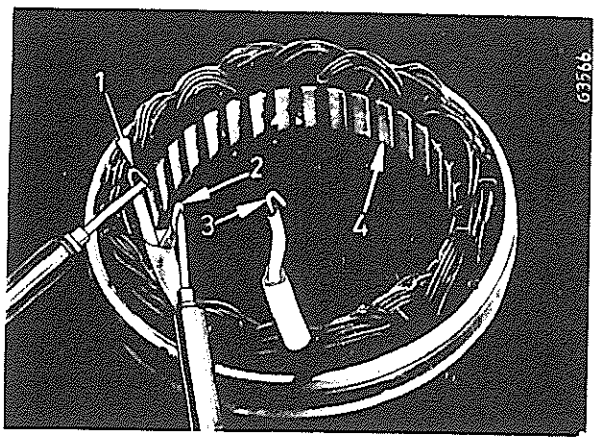
Stator



Illust. 470
Testing stator winding for ground

Hold one lead of a 40 Volt test lamp or one probe of an ohmmeter on one winding end and the other to the stator.

The lamp must not light up. The ohm reading must be infinite.



Illust. 471
Testing stator winding for opens and short circuit

1-3 – Winding ends
4 – Stator

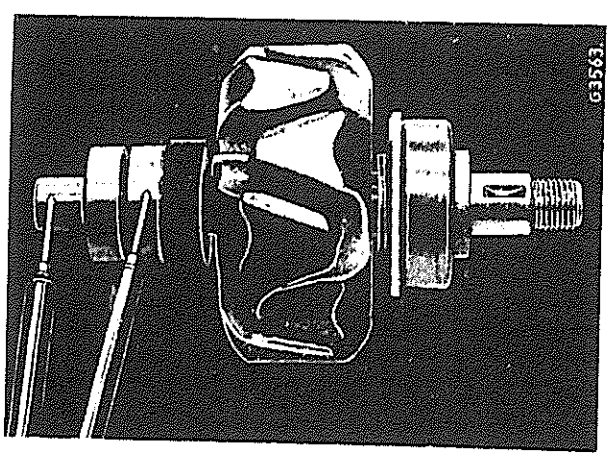
To check stator windings for opens, hold the leads of a 40 Volt test lamp to the winding ends in the following order: End (1) and (2), end (1) and (3), end (2) and (3). In either check the test lamp must light up.

To check stator windings for short circuits hold the probes of an ohmmeter on the end of the windings as mentioned above.

All windings must have the same resistance readings and be within "Specifications".

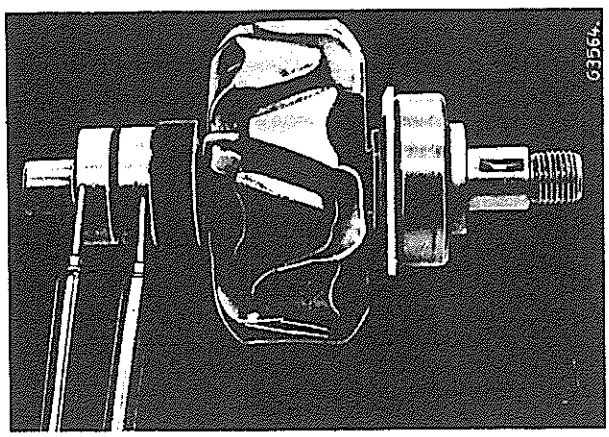
Replace the stator with new one, if any winding is found to be defective.

Rotor



Illust. 472
Testing field winding for ground

Hold the leads of a 40 Volt test lamp or the probes of an ohmmeter on the rotor as shown in Illust. 472. The test lamp must not light up or the ohm reading must be infinite.



Illust. 473
Testing field winding for opens and short circuits

To check the field winding for opens, hold the leads of a 40 Volt test lamp on both slip rings, Illust. 473. The test lamp must light up.

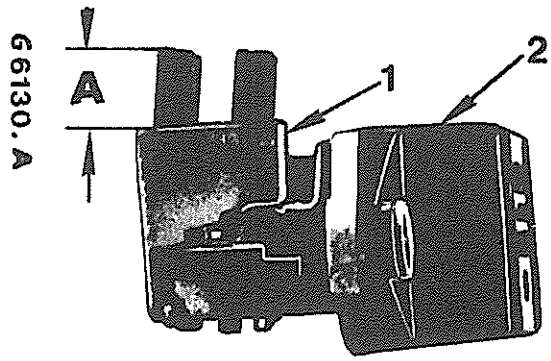
To check the field winding for short circuits, hold the probes of an ohmmeter on the slip rings, Illust. 473. The ohm reading must be within "Specifications". Note, a lower ohm reading will shown a short circuit.

Replace the rotor with new one if the winding is found to be defective.

Slip rings may be given a polish-over if necessary.

Note: Slip rings may be turned up in a lathe. Strictly observe the dimensions given in "Technical Data" when reconditioning these rings.
Finish with 400 grain or finer polishing cloth and blow away all dust.

Brush Holder Assembly



Illust. 474

1 – Brush holder assembly
2 – Piggy-back transistorized voltage regulator

A – 10 mm (.4"), brushes new
A – 5 mm (.2"), brushes worn to max. limit

Check protrusion of carbon brushes, see "A" Illust. 474.

When replacing brushes observe the following:

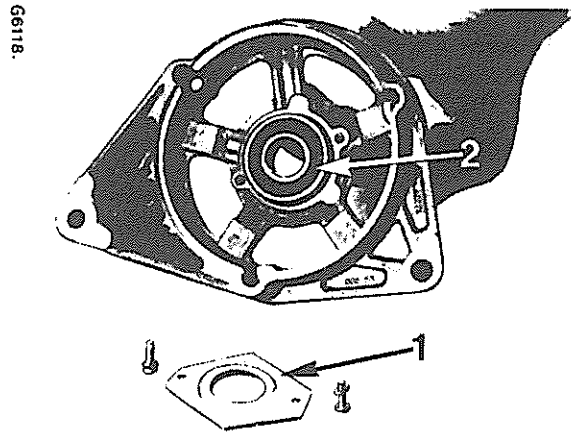
Use only compound soldering tin material of good quality.

Take care that tin material does not penetrate into copper leads to ensure maximum flexibility.

Check protrusion "A". Secure insulating hoses close to the soldered connection.

When in place, carbon brushes should be inclined towards the regulator to facilitate installation, see Illust. 474.

Reassembly



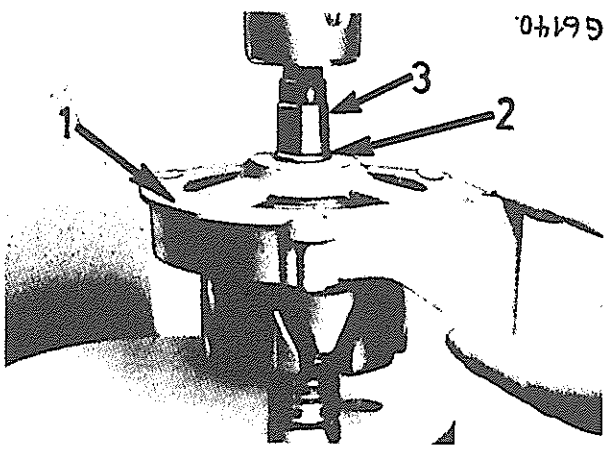
Illust. 475

1 — Retainer plate
2 — Ball bearing, drive end side

Whenever the alternator needs overhauling both ball bearings should be replaced with new ones.

To avoid oxidation of the slip rings due to overgreasing, fill only one side of the bearings with specified ball bearing grease.

Secure ball bearing (2) Illust. 475 with retainer plate (1). Secure plate screws by caulking. Install ball bearing (2), Illust. 462.

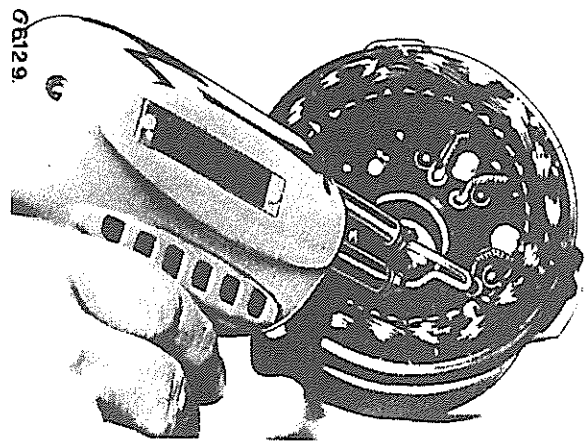


Illust. 476

1 — Drive end frame
2 — Outer spacer ring
3 — Installing sleeve

Slide the inner spacer ring (3) Illust. 462 over the rotor shaft before installing the drive end frame (1) Illust. 476.

Take care, sleeve (3) contacts only the outer spacer ring (2) when pressing frame (1) in place.



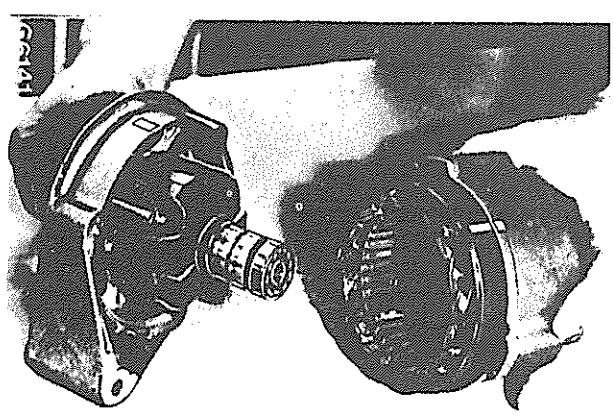
Illust. 477
Soldering of stator winding ends

Use a 100 Watt solder gun and resinated core stick 60 % tin, 40 % lead solder for reconnecting stator winding ends.

Caution: Do not heat excessively and do not bend or move the diode stem as this may damage the diode.

Remove all traces of tin spatter.

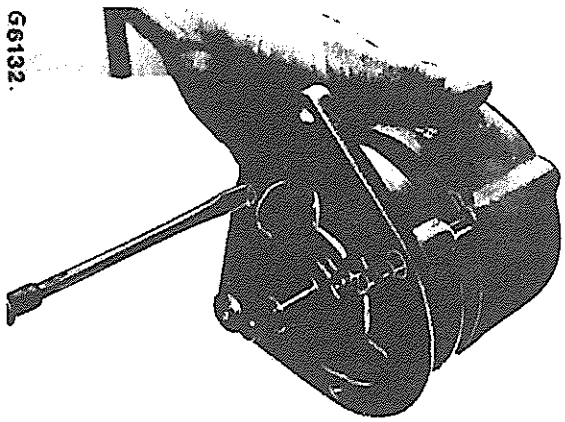
After soldering recheck diodes for opens or short circuits.



Illust. 478

Place the spring washer (as found on disassembling) into the counter bore of the slip ring end frame and fill a small amount of special grease into the counter bore before sliding the rotor assembly into place, Illust. 478.

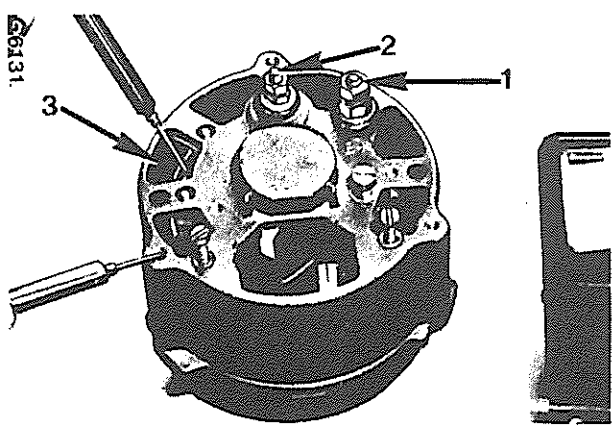
Be sure, point marks are in line.



Illust. 479

Install the three retainer screws with washer and lock washer.

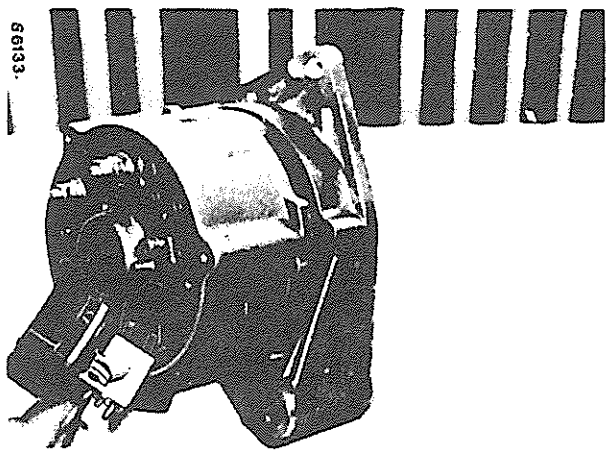
Tighten up alternately and evenly.



Illust. 480

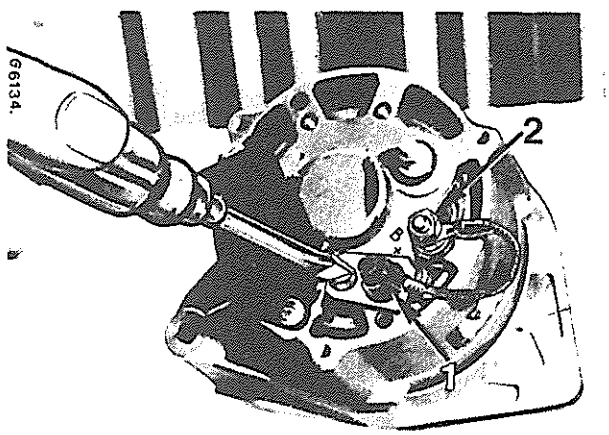
1 – Terminal B+
2 – Terminal D+
3 – Negative heat sinkt

Using a test lamp, check the negative heat sink for good ground conditon.



Illust. 481

Carefully insert and install the brush holder/voltage regulator assembly.



Illust. 482

1 – Load dump
2 – Terminal B+

Install load dump as shown in Illust. 482.

Finally install fan, woodruff key and V-belt pulley.

Use a clamping tool (Illust. 458) and tighten pulley nut to specified torque.

Check the overhauled alternator in a test bench for proper output and voltage regulation. See "Specifications".

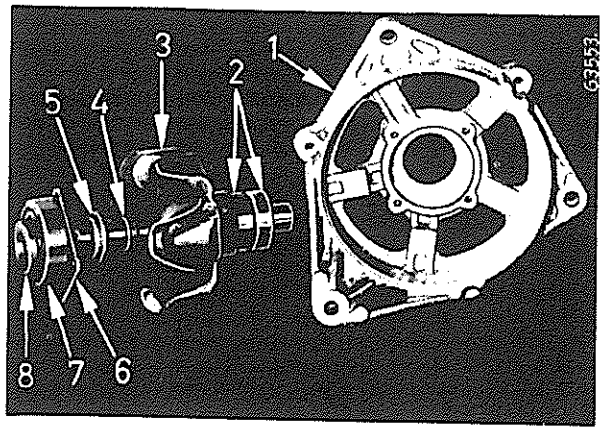
Installation

Install and connect the alternator according to diagram, Illust. 454.

Before starting the engine, make sure to observe "Operating Instructions".

Watch the charge control lamp during start up to make sure the charging circuit is in order.

If a new V-belt is used, readjust its tension after 20 hour of operation.



Illust. 484

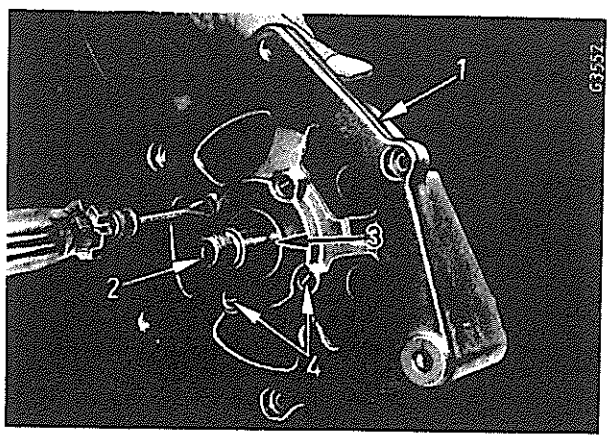
1 – Drive end frame
2 – Slip rings
3 – Rotor
4 – Snap ring
5 – Stepped stop ring
6 – Retainer plate
7 – Ball bearing
8 – Spacer ring

Servicing "K1" Alternator

Disassembly

Disassemble as outlined for "G1" alternator, Illusts. 458 to 461.

Proceed as follows:



Illust. 483

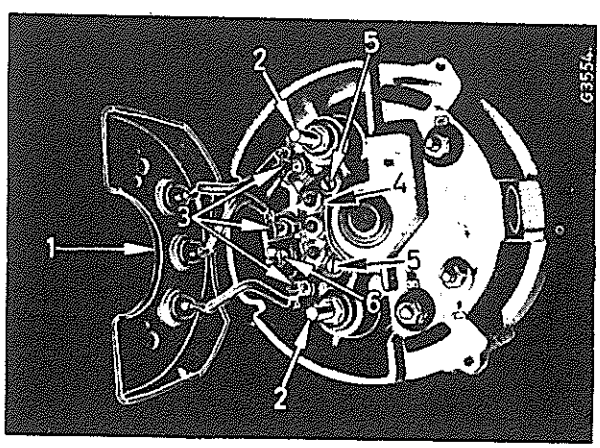
1 – Drive end frame
2 – Rotor shaft
3 – Spacer ring, outer
4 – Retainer plate screws

Remove screws (4) Illust. 483.

Take off the drive end frame, taking care spacer ring (3) does not drop.

Remove ball bearings from the rotor shaft.

Remove retainer plate (6) and stop ring (5). Do not remove snap ring (4).



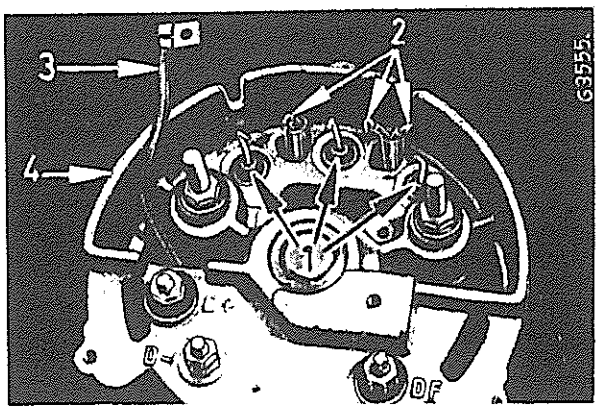
Illust 485

1 – Heat sink, positive diodes
2 – Terminals B+
3 – Insulated tongues
4 – Heat sink, exciter diodes
5 – Screws
6 – Screw (D+ lead)

Unscrew the nuts from both terminals B+, and take off heat sink (1).

Now, all diodes are accessible for testing. Also tongues (3) are accessible.

If necessary, unscrew screw (6), to disconnect D+ lead.



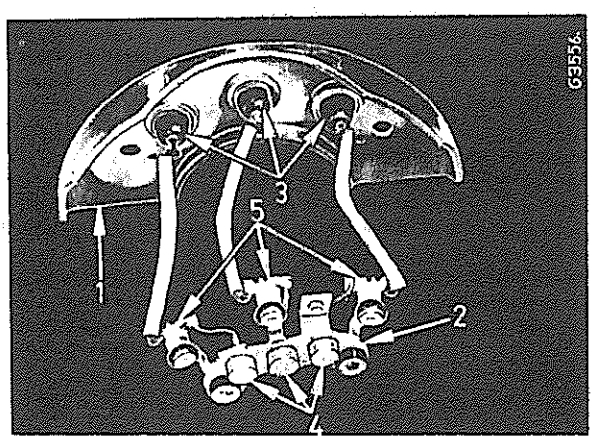
Illust. 486

1 – Negative diodes
2 – Ends of stator winding
3 – D+ lead
4 – Slip ring end frame

Using a solder gun and a flat nose pliers (heat sink), unsolder the ends of the stator winding (2) Illust. 486, also unsolder negative diodes (1).

Unscrew exciter diodes heat sink (4) Illust. 485 and remove it together with positive diode heat sink (1);

Thereafter separate the stator from slip ring end frame.

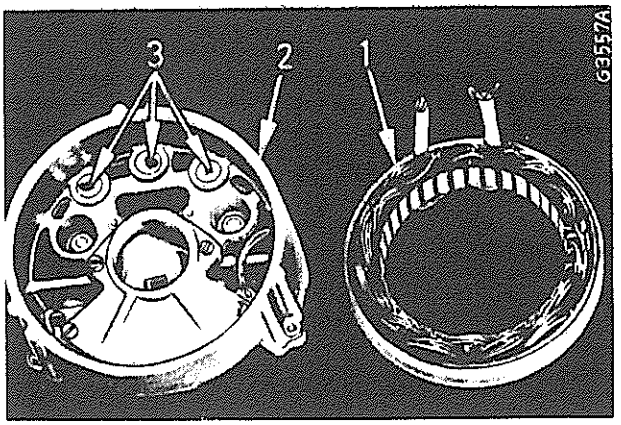


Illust. 487
Heat sinks, disconnected

1 – Positive heat sink
2 – Exciter heat sink
3 – Positive diodes
4 – Exciter diodes
5 – Insulated tongues

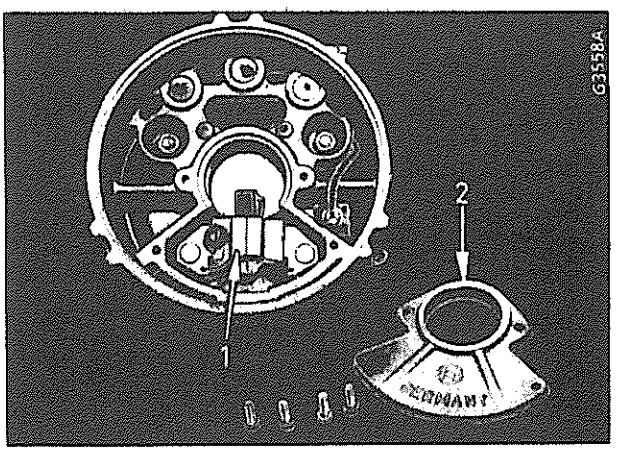
Separate heat sink (1) and (2) Illust. 487 by unsoldering the leads from the tongues (5).

Removing diodes: Refer to "Inspection and Repair".



Illust. 488
Stator and slip ring end frame, separated

1 – Stator
2 – Slip ring end frame
3 – Negative diodes



Illust. 489

1 – Brush holder assembly
2 – Cover

To remove brush holder assembly (1) Illust. 489, remove cover (2) and nuts of terminals D- and DF.

While sliding out the brush holder take care its insulating parts do not drop.

Cleaning, Inspection and Repair

Clean alternator components with a lintfree, petrol moistened cloth.

Stator and Rotor

Check stator and field windings for shorts, opens and ground contact as outlined for "G1" alternator.

Replace the stator or the rotor with new one if any winding defects are detected.

True up or polish slip rings as necessary. Replace both ball bearings with new ones. Observe greasing instructions for ball bearings.

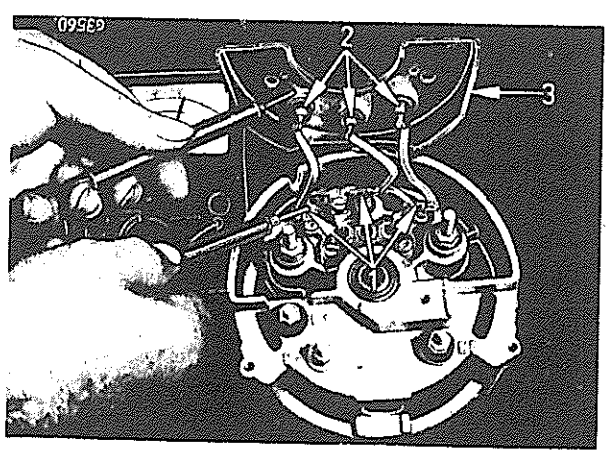
Diodes

Check each of the nine rectifier diodes for a shorted or opened condition.

Use testing methods as outlined for "G1" alternator diodes.

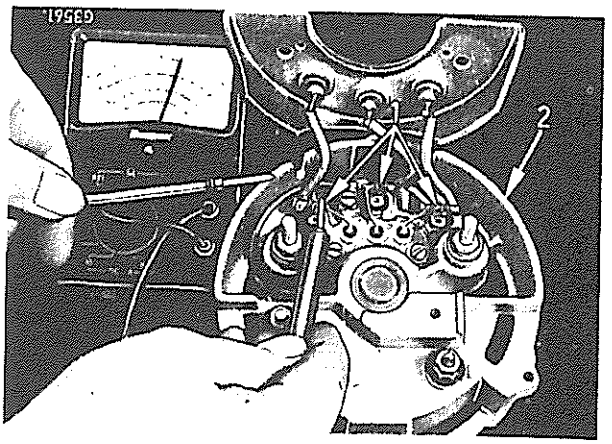
For individual tests, see Illusts. 490 to 492.

Make sure, heat sink (3) Illust 490 will not touch the slip ring end frame, when testing diodes.



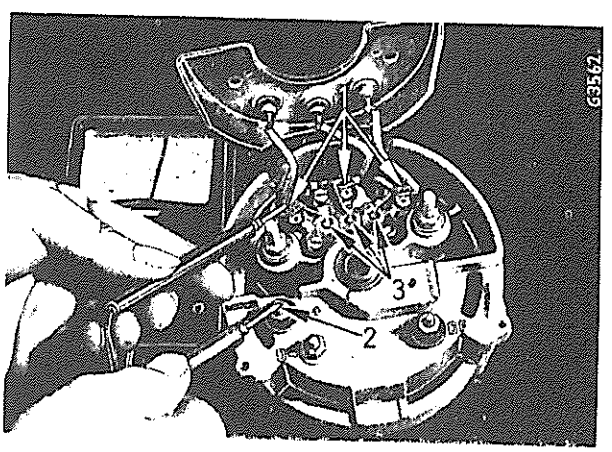
Illust. 490
Testing positive charging current rectifier diodes

1 – Insulation tongues
2 – Positive diodes
3 – Heat sink



Illust. 491
Testing negative charging current rectifier diodes

1 – Insulation tongues
2 – Slip ring end frame



Illust. 492
Testing exciter current rectifier diodes

1 – Insulated diodes
2 – Terminal DF
3 – Exciter diodes

Replacing Diodes

It is recommended to replace diodes preferably complete with their heat sink plates.

When replacing individual diodes, the use of the special tool set "Robert Bosch EFT 057" is strongly recommended.

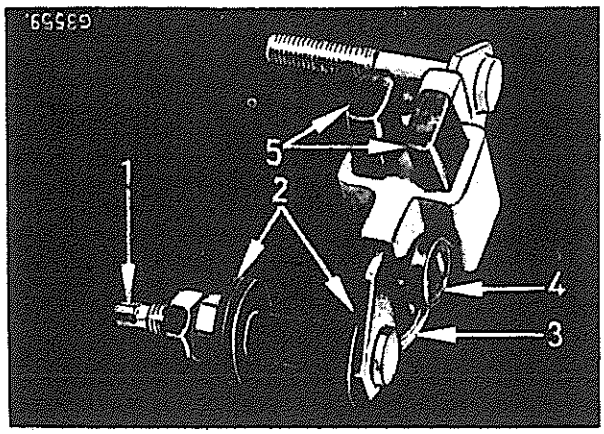
The tool set is provided to work with an arbor press. Never try to replace diodes with hammer blows. This may destroy other, still operative diodes.

Reset the diode fit before installation.

Smear diode seat with SILICON oil "63v2" before diodes are being pressed in place.

After fitting, test diode for proper operation.

Brush Holder



Illust. 493
Brush holder assembly

1 – DF Terminal
2 – Insulating parts
3 – Flexible lead
4 – Brush spring
5 – Carbon brushes

Check brushes (5) Illust. 493 for wear, also check tension and condition of spring (4). See "Technical Data".

Check to see lead (3) is well soldered and not cracked.

A faulty holder should be replaced with a new one.

Reassembly

Reassembling the alternator is a reversal of the disassembly procedure.

The following points must be observed:

Do not overhead diodes when soldering. Use a pair of flat nose pliers for heat sink. Retest diodes after soldering.

When installing the rotor, make sure slip rings and carbon brushes are absolutely clean and dry.

Do not overlook to install the V-belt pulley key.

Secure screws (4) Illust. 483 after tightening by caulking.

Note: Since the inner race of the ball bearing and the fan are fastened by friction only, be sure the V-belt pulley nut is tightened with specified torque.

Installation

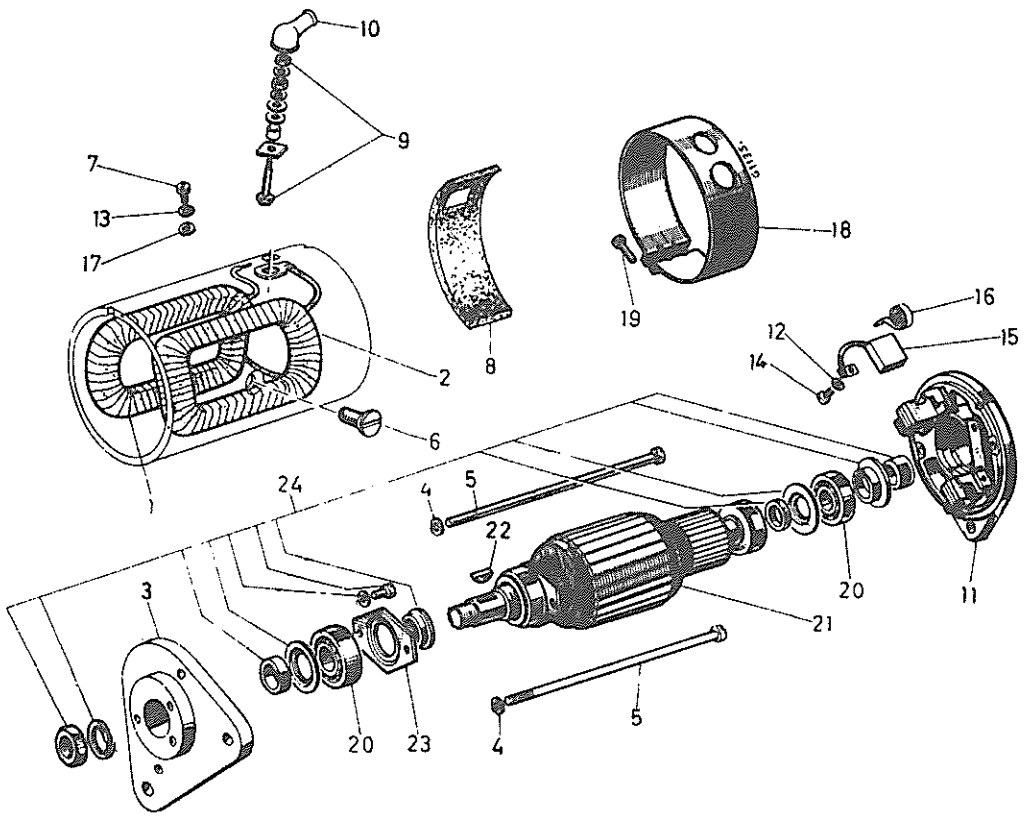
Install the alternator and adjust V-belt tension.

With engine shut down and operative battery installed, connect regulator and alternator according to Illust. 455.

Connect battery ground cable.

Start the engine and watch the charge control lamp to see the charging circuit is in order.

If a new V-belt is used, readjust its tension after 20 hours of operation.



Illust. 494
Exploded view of the "Bosch Generator JA14V20A16

1 – Field coil
2 – Field coil
3 – Drive end bracket
4 – Lock washer
5 – Through bolt
6 – Bolt, pole shoe
7 – Bolt
8 – Insulating strip
9 – Terminal assembly
10 – Boot
11 – Commutator end bracket
12 – Lock washer
13 – Lock washer
14 – Bolt
15 – Brush
16 – Brush spring
17 – Washer
18 – Cover band
19 – Bolt
20 – Ball bearings
21 – Armature
22 – Woodruff key
23 – Retainer
24 – Small stock set for armature

General

According to application, the engines may be fitted with an 11, 16 or 20 amps generator.

The following Illustrations show the JA (R) 14V 20A 16 generator, excepting Illusts. 359 and 365.

The inspection and procedure of overhaul of the above generator types is nearly equal. However, each generator type has its special Test-Specifications and operates with a special regulator. Refer to "Specifications".

The generators are shunt-wound, two-pole machines with the field coils connected in series and with one common connection for the field and armature.

The generators are designed for use with a "Bosch" or "Wehrle" regulator which varies the generator output in accordance with the state of charge of the battery and the load in the circuit. Output is independent of variations in generator speed above the initial speed at which maximum output is generated. The regulator cuts the circuit if generator voltage is less than battery voltage.

Should trouble develop in the current supply system, check to determine whether the generator or the regulator is at fault.

Note: A defective regulator cannot be repaired. Replace with a new one.

Mechanical Data

	JA(R) 14V 20A 16	*G(R) 14V 16A 21*	*EH(R) 14V 11A 19*
Armature Permissible out-of-round	0.05 mm = .002"	0.05 mm = .002"	0.05 mm = .002"
Commutator Permissible out-of-round Permissible diameter after rework	0.03 mm = .0012" 39 mm = 1.54 "	0.03 mm = .0012" 35.5 mm = 1.40 "	0.03 mm = .0012" 32 mm = 1.26 "
Brushes Min. length	17.0 mm = .67"	16.0 mm = .63"	13.0 mm = .51"
Housing diameter	116 mm = 4.57"	102 mm = 4.02"	90 mm = 3.55"
Pulley nut torque	3.5–4.5 daNm = 25–32.5 lbs.ft.	3.5–4.5 daNm = 25–32.5 lbs.ft.	3.5–4.5 daNm = 25–32.5 lbs.ft.

Specifications, Generator *(Housing temperature 60°C = 140°F)*

Generator	*no output* *Generator rpm*	*2/3 output* *Rated Generator rpm/amps.*	*max. output* *Generator rpm/amps.*
EN(R) 14V 11A 19	1450	1900 / 7.3	2200 / 11
G(R) 14V 16A 21	1650	2100 / 10.6	2350 / 16
JA(R) 14V 20A 16	1250	1600 / 13.2	1850 / 20

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Specifications, Regulator

Generator	Regulator	Charging Voltage	max. charging current	Switch setting value		1) Regulator Setting value			Commencement of current regulation	
				Cut-in	Return current at 12-12.2 V	Regulating voltage at			Load at double rated speed of generator	
						2) Idle speed	3) Load	3) Load current	cold	warm
		Volt	AMP	Volt	AMP	Volt	Volt	AMP	AMP	AMP
EH(R) 14V 11A 19	VA 14V 11A	14	11	12.4-13.1	2.5- 9.5	13.8-14.8	12.7-13.7	16.5	–	–
EH(R) 14V 11A 19	UA 14V 11A	14	11	12.5-13.5	5 -11.5	13.5-14.5	–	–	10.5-13	9 -12
G(R) 14V 16A 21	VA 14V 16A	14	16	12.4-13.1	2.5- 9.5	13.8-14.8	13.1-14	25	–	–
G(R) 14V 16A 21	UA 14V 16A	14	16	12.5-13.2	5 -11.5	13.5-14.5	–	–	15 -19	14 -18
JA(R) 14V 20A 16	UA 14V 20A	14	20	12.5-13.2	5 -11.5	13.5-14.5	–	–	19 -23	17.5-22
EH(R) 14V 11A 19	W 101 KB	14	11	12.4-12.8	5.5- 6.5	13.2-14.4	–	–	10.5-11.5	
G(R) 14V 16A 21	W 103 KB	14	16	12.4-12.8	5.5- 6.5	13.2-14.4	–	–	15.5-16.5	

1) Measure at cold generator and regulator

2) Increase speed of generator and thereby determine maximum exciter current. Increase speed further till exciter current has dropped to half its max. value (Regulator with PTC-Resistance 2/3 exciter current) and then measure "No-Load" Voltage.

3) Drive the generator at 5500 RPM.

Maintenance

Inspect the generator after every six months of operation to ensure long life.

The commutator should be smooth and polished with even colouring and there should be no signs of solder thrown from the commutator connections.

Brushes must be polished over the whole face, be free in their boxes and should be checked for wear. If badly, worn, replace them with new ones.

Check brush spring pressure with the fingers to see if they appear adequate.

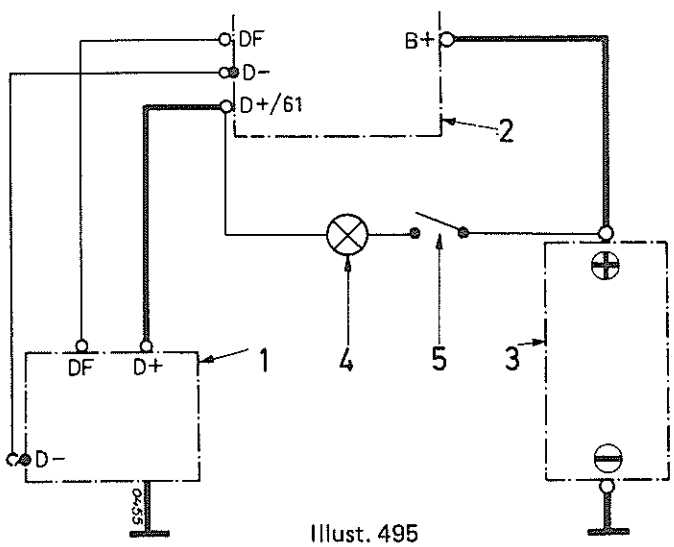
All parts should be free from dust and all connections be clean and tight.

Testing in Position to Locate a Fault

Before proceeding to test the generator check:

That the drive belt is serviceable and that the tension is correct.

That the generator is correctly connected to the regulator and that the ground connections is correct. See Illust. 495.



Illust. 495

1 — Generator
2 — Voltage regulator
3 — Storage battery
4 — Charge control lamp
5 — Light switch

Checking the Generator

Switch off all lights and accessories, then disconnect the cables from the generator and link the two generator terminals with a length of wire.

Connect the plus lead of a voltmeter (0-20 volts range) to the linked generator terminals and the other lead to a good earth on the generator body.

Start the engine and gradually increase the engine speed. The voltmeter reading should rise without fluctuation.

Warning: Do not allow the voltmeter reading to reach 20 Volts.

Do not race the engine in an attempt to increase the voltage. It is sufficient to run the engine up to 800-1000 rpm. Carry out this test as brief as possible to avoid damage to the field coils.

If there is no reading, check the brush wear.

If there is a low reading of approximately 1/2-1 volt, the field winding may be at fault.

If there is a reading of approximately half the normal voltage, the armature winding may be at fault.

Note: Excessive sparking at the commutator in the above test indicates a defective armature which should be replaced. Sparking can be seen when cover band (18) Illust. 494 is removed.

Slacken the driving belt and check the bearings for free-running by spinning the pulley by hand. If the armature fails to spin freely, with the brushes raised from the commutator, the generator should be disassembled and the bearings examined.

If the generator is in good order, remove the link wire and restore the original connections, then proceed to test the regulator.

Checking the Regulator

Note: Test must be made after the generator has completed a run of several hours. If the engine has been shut down after a run, operating temperature may be re-established by operating the regulator at normal to full load for a period equal to the down time (up to 30 minutes).

Testing the Switch (Return Current Switch)

1. Cut-in voltage

   Disconnect the cable from regulator terminal B+ and make sure the bared end of the loose cable will not contact any of the metal parts.

   Connect a test lamp 12V across terminal B+ and earth.

   Connect a voltmeter to generator terminal D+ and earth.

   Start the engine and observe the voltmeter.

   With rising engine speed the test lamp must light up.

   Voltage reading at this moment is the cut-in voltage. Refer to "Specifications".

2. Return current

   Connect an ammeter with charge and discharge ranges (20 amps) between regulator terminal B+ and a half discharged and properly earthed 12 volt battery.

   Start the engine and slowly increase engine speed up to rated rpm.

   Then slowly decrease engine speed to low idle and observe the ammeter. Now, the pointer of the ammeter will fall in the discharge range and then go back to zero.

   At this very moment the switch has cut-off the circuit due to return current flux.

   The return current value must be within "Specifications".

Testing the Voltage Regulator

Note: This test must be made with generator cold, without batteries and load.

Connect an ammeter to generator terminal DF and regulator terminal DF.

Slowly increase engine speed and watch the ammeter.

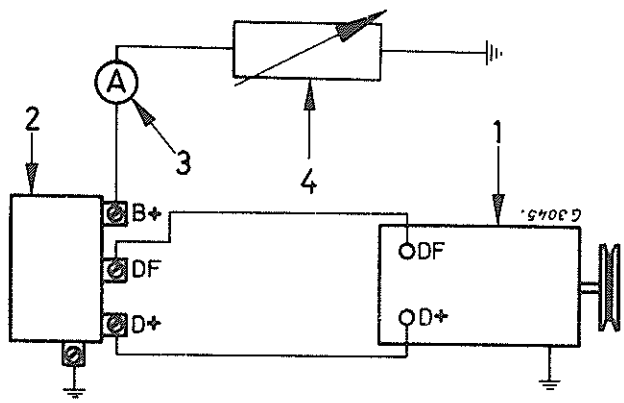
Note, when maximum ammeter reading is reached.

At further increasing engine speed, the ammeter reading will drop.

Stop increasing engine speed as soon as ammeter reading has dropped to half of its former max. value, or has dropped to 2/3 of its former value if a PTC-resistance regulator is installed.

Now read the voltage at generator terminal B+. Refer to figure two of "Specifications". A deviation of -0.1 to +0.4 volt is permissible.

Testing Current Regulation



Illust. 496

Hook-up for checking current regulation

1 – Generator	3 – Ammeter
2 – Regulator	4 – Rheostat

Connect up ammeter (3) and rheostat (4) as shown in Illust. 496.

Run the generator at double rated rpm, see figure (3) and column "Commencement of current regulation" of specifications, respectively. Then adjust the rheostat so the ammeter will read specified current value.

With the specified load still on and increasing engine speed, the load current must remain in its former value.

Replace the regulator when its voltage- or current regulation or its switch are at fault.

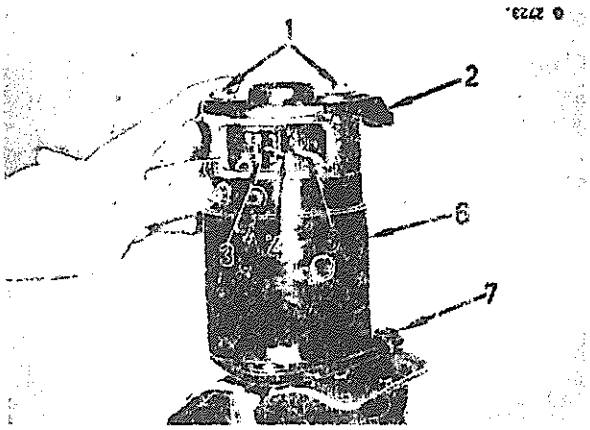
Removal and Disassembly

Disconnect battery ground cables and cables at generator terminals. Remove the generator and clean it externally.

Clamp the generator in a vice, using soft metal jaws.

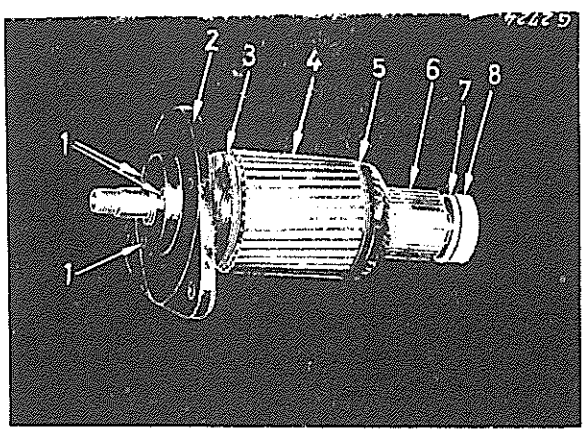
Take off cover band, disconnect flexible connector (4) and lead (5), lift the brush springs and remove brushes (3).

Unscrew the two through bolts (1), then separate commutator end bracket (2) and yoke (6) from the armature.



Illust. 497

1 – Through bolt
2 – Commutator end bracket
3 – Brush
4 – Field coil connector
5 – Lead to terminal D+
6 – Yoke
7 – Drive end bracket

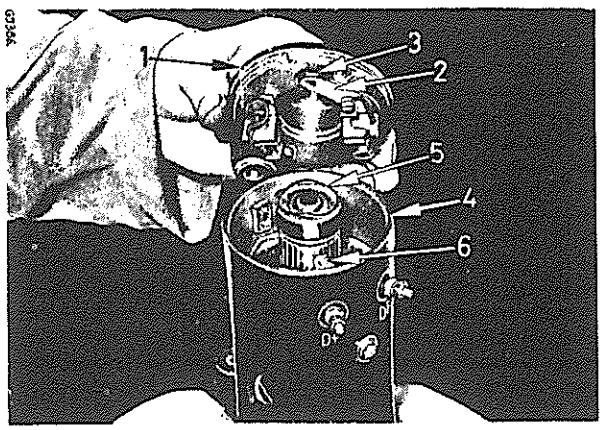


Illust. 498

1 – Retaining screws
2 – Drive end bracket
3 – Coil end band
4 – Armature core
5 – Coil end band
6 – Commutator
7 – Retaining plate
8 – Ball bearing

Remove retaining screws (1) Illust. 498 and separate the drive end bracket (2) from the bearing.

If necessary pull the two ball bearings from the armature shaft, using a suitable puller tool.



Illust. 499

11 amps Generator

1 – Commutator end bracket
2 – Terminal
3 – Access hole
4 – Yoke
5 – Spring washer
6 – Terminal D+

Disassemble 11 amps generator, Illust. 499, as follows:

Remove the two through bolts.

Work out the rubber plug from access hole (3) and remove the screw from terminal (6). Lift off the commutator end bracket (1), taking care spring washer (5) does not drop. Take off yoke (4) from the armature.

Cleaning, Inspection and Repair

Clean generator components with compressed air and a lint-free petrol moistened cloth.

Brushes

Check for wear and see that connectors are well soldered. Replace worn brushes when their lenght is less than specified.

A new brush set does not need "bedding" but check to see that new brushes move freely in their guides.

Brush Springs

Check the brush springs for pressure and examine for corrosion, freedom of movement and that they bear squarely on top of the brushes. Replace fatigued, bent or corroded springs as complete sets.

Bearings

Clean the bearings thoroughly in spirit and examine for pitting of the balls and races and test for free and smooth rotation.

Repack the bearings with high melting-point grease for HALF the circumference of the cage.

Warning: On no account should ordinary grease be used as this will melt when warm, find its way out of the bearings and penetrate the commutator.

Armature

The binding bands (3) and (5) Illust. 498 should be examined for sign of loosening.

If the commutator has been neglected and is in very bad condition, it should be set up in a lathe and skimmed, using a diamond tool for preference. It is of great importance that after skimming, the commutator surface should be concentric with the bearing diameters.

Only a very light cut should be taken, and the tool should be sufficiently keen to leave a smooth surface.

The insulators between the commutator segments should be undercut to a depth of 0.8 mm = 1/32".

Use a hacksaw blade ground to the thickness of the insulator and ensure that all the insulator is removed at the sides of the slots.

Finally, again mount the armature in a lathe and take a polish cut of about 0.03 mm = .001".

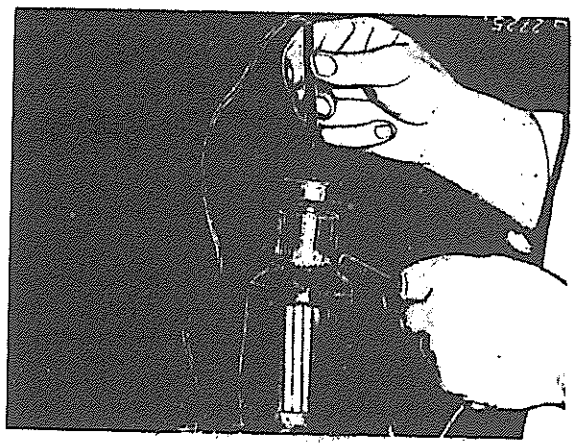
The slots between the segments should be cleared of turnings and the undercutting of the micas should be maintained at about 0.8 mm = 1/32". Care must be taken to see that no mica is left level with or projecting above the surface of the copper segments.

Warning: No attempt should be made to machine the armature core or to true up a distorted armature shaft.

Connect the probes of an ohmmeter to the armature shaft and to any segment as shown in Illust. 500.

Low or zero ohm readings indicate a short.

If a short in the windings is suspected the armature should be tested by means of a "growler". If during this test a hacksaw blade is rested on the core laminations whilst the armature is rotated, a short is indicated when the blade is attracted to the core.



Illust.500
Testing commutator insulation

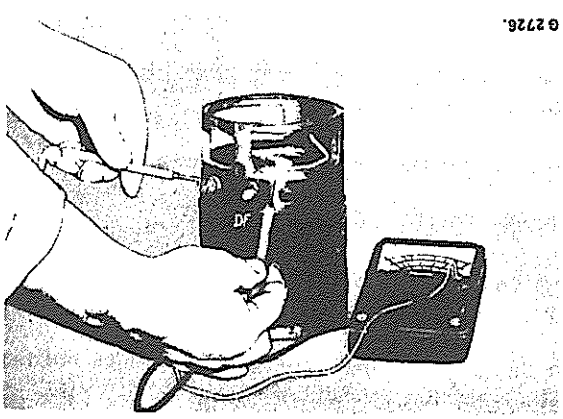
The armature coils should be tested for continuity by passing current from a battery through the armature via two brushes (set at 180 degrees) pressing on to the commutator, and noting on a milli-volt meter the voltage drop between every adjacent pair of segments. A variable resistance should be incorporated in the circuit to limit the voltage passing through at about 2 volts. As the armature is slowly rotated, the voltage drop indicated on the meter should be substantially the same for any pair of adjacent segments.

A low reading, or none at all, would indicate a partially shorted coil or commutator segment, and a high reading, a high resistance in the coil circuit, probable a badly soldered joint at the commutator riser.

Faulty armatures must be replaced.

Field Coils

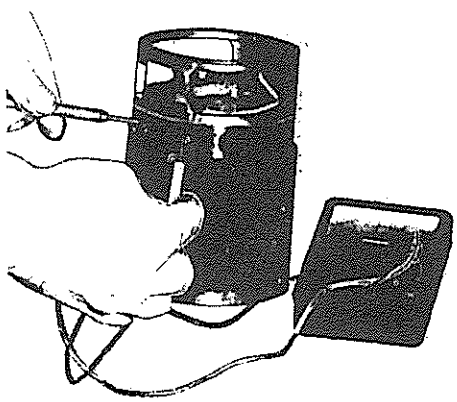
The field coils must be maintained clean and free from dust and moisture. The flexible lead should show no signs of abrasion and the tangs should be clean and well soldered.



Illust. 501
Testing the field coil insulation

Connect one probe of an ohmmeter to terminal D+ and the other to a clean part of the yoke as shown in Illust. 361.

Low or zero ohm readings indicate that the coil is shorted to the yoke.



Illust. 502
Testing the field coil for open circuit

Connect the two probes of an ohmmeter to the terminal as shown in Illust. 502. The field resistance should be 3.5-3.9 ohms. An "infinite" ohm reading indicates a break in the field coils.

Field Coil Short

An ammeter in series with the coil will indicate, by a high reading, if a short between turns is present. In the latter event, individual coils should be isolated and tested for resistance until the fault is discovered.

Note: In case of a short circuit, break or coil short, the field coil must be replaced.

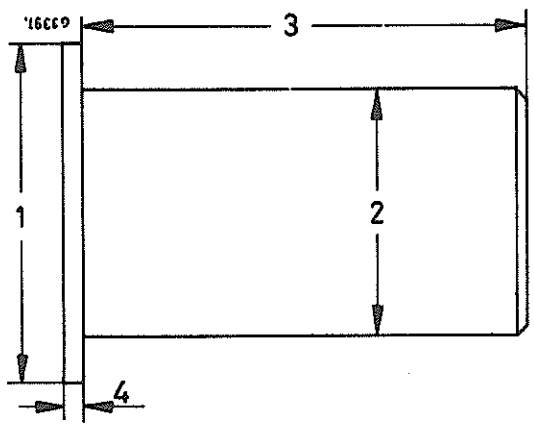
Replace a defective field coil as follows:

Unsolder the coil connections.

Unscrew the fixing screws and separate pole shoes and coil.

Fit the new field coils over the pole shoes and place them in position inside the yoke.

Locate the pole shoes by lightly tightening the fixing screws.

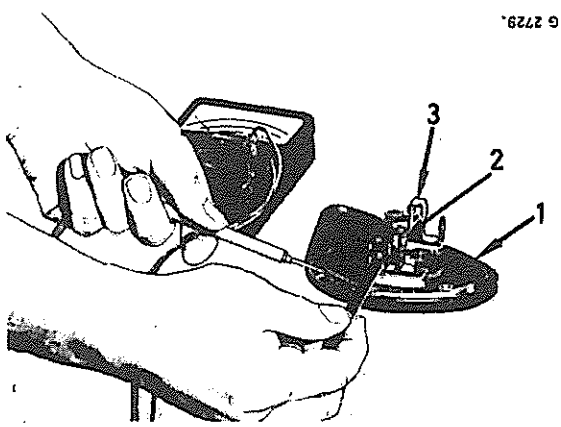


Illust. 503
Shaft for pole shoe mounting

1 – Outer yoke diameter
2 – Armature diameter
+0.35–0.40 mm = .014"–.016"
3 – Yoke length
4 – 5 mm = 3/16"

For proper alignment, slide the shaft Illust. 503 into the yoke. Tighten the pole shoe screws fully and lock them by caulking.

Replace the insulation piece between field coil connection and yoke, then re-solder the connection.



Illust. 504
Testing brush guide insulation

1 – Commutator end bracket
2 – Insulated brush guide
3 – Earthed brush guide

Test the insulation of brush guide (2) Illust. 504 by means of an ohmmeter.

An "infinite" ohm reading indicates the insulation is in order.

Note: For this test, the end bracket must be free of brush dust and dry.

Replace the end bracket, if insulation is poor.

Polarizing the Generator

The Bosch generator has sufficient remanent magnetism and therefore needs no polarizing on new or replacement unit. However, if the unit has been disassembled and field coils are tested or replaced, polarize the generator as follows:

Install the generator and connect cables in accordance with the wiring diagram.

With V-belt off, bridge regulator terminals B+ and D+ with a jumper lead for one second.

The momentary surge through the generator will run the generator as a motor and polarize it.

Warning: Do not run the overhauled generator without polarizing it or the regulator will be damaged.

Assembly

Assembling the generator is a reversal of the disassembling procedure.

The following points must be observed.

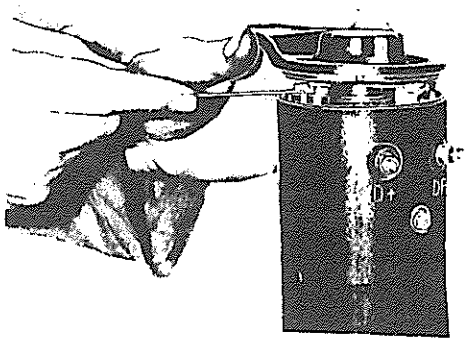
Observe strict cleanliness.

Be sure the locating tangs of the yoke engage in the recesses of both end brackets.

Make sure the Woodruff key seats properly and tighten the pulley nut to specified torque.

Replace the cover band ensuring that the gasket effectively seals the yoke ports.

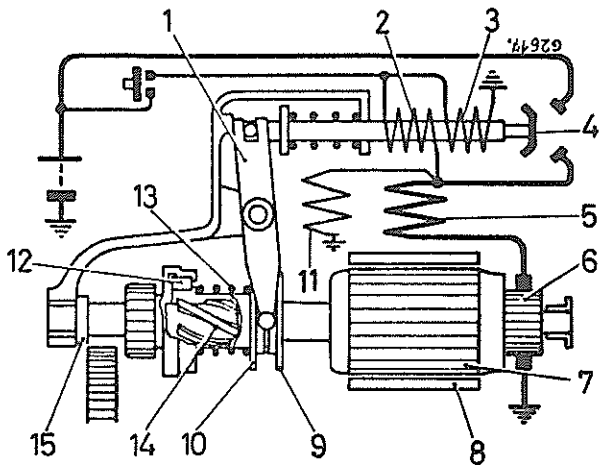
After assembling the generator, spin the armature by hand to ensure free rotation and at the same time listen for any indication if the armature may be fouling the pole shoes.



Illust. 505
11 amps Generator
Installing commutator end bracket

Unhook both brush springs and withdraw the carbon brushes, then slide the commutator end bracket on the armature.

Place the brush springs in working position, using a suitable hook. Check to see the brushes move freely in their guides.



Illust. 506
Schematic view of the "Bosch" starting motor JD 12V 3kW (4HP)

1 – Shift lever
2 – Closing coil
3 – Holding coil
4 – Solenoid plunger
5 – Field coil
6 – Commutator
7 – Armature
8 – Pole shoe
9-10- Shifter rings
11 – Shunt coil
12 – Overrunning clutch (drive assembly)
13 – Spring
14 – Spiral splines
15 – Pinion stop

General

The starting motor is an electric motor of a highly specialized design. It is capable of producing high horsepower and tremendous torque despite its small size.

It is a four brush, earth return machine with series parallel connected field coils and operates off a 12 or 24 volt system.

A solenoid-operated drive assembly (12) Illust. 366 is carried on the spiral armature shaft which ensures positive engagement of the pinion with the ring gear before the motor is energized due to main current.

The shift lever (1) actuated by the solenoid (4) slides the overrunning clutch and drive pinion assembly along the spiral splined armature shaft to engage or disengage the pinion.

The engagement of the pinion and flywheel ring gear is supported by the screwing effect of the spiral splines (14). On occasions of tooth to tooth abutment, whilst axial movement of the pinion stops, the plunger of the solenoid continues to move, loading spring (13) and also closing the solenoid contact.

When the switch is closed the main current from the batteries begins to rotate the armature (7) and the pinion.

As soon as the teeth of the pinion become aligned, the combination of spring pressure and screwing effect slide the pinion into mesh with the flywheel ring gear. Torque is not transmitted by the overrunning clutch (12) from the starter to the flywheel to crank the engine.

To protect the armature from excessive speeds when the engine starts, the clutch is designed to "overrun" or turn faster than the armature which permits the pinion to disengage itself in a short time.

The pinion will not be permitted to disengage until the solenoid circuit is cut.

The armature brake stops the motor as power is cut.

Here are three design stages as follows:

a) Shunt coil (11) Illust. **506** (displaced)

b) Mechanical spring frictional brake (displaced)

c) Reinforced brush springs

When trouble develops in the starting motor system and the motor cranks the engine slowly or not at all, checks should be made to determine whether the trouble is in the starting motor, batteries, connecting wiring or elsewhere.

Note: Starting motors differ in design and output. See "Electrical Specifications" and "Mechanical Specifications".

When ordering parts observe manufacturers code plate and date given in the parts catalog.

Preventive Maintenance

After every 1000 hours of operation or once a year remove cover (2) Illust. **513** and carry out following inspection.

Note: Replace bolts (1) Illust. **513** after the cover is removed.

Check that the brushes move freely in their holders by holding back the brush springs and pulling gently on the flexible connectors.

If the movement is sluggish, remove the brush from its holder and clean its sides with a fluffless petrol moistened cloth. Replace the brush in its original position. Brushes which are worn must be replaces as a set.

Check the tension of the brush springs using a spring balance. Spring tensions are given in "Specifications". If the tension is low, fit new springs as a set.

The commutator must have a smooth blue/grey appearance. It may be cleaned by pressing a fine dry cloth against it while the motor is turned. If the commutator is very dirty or oil contaminated, moisten the cloth with petrol.

Check that all electrical connections are clean and tight. Any that are dirty or corroded must be cleaned and the contacting surfaces lightly smeared with petroleum jelly.

Ensure that the starting motor mounting bolts are tight at all times. A loose mounting will cause pinion and ring gear wear.

Check the cables for chafing or for cracking, particularly at the point where the cable enters the terminal lug.

Approx. every two years disassemble the motor. Clean and lubricate the motor with a special high melting point grease.

Lubrication

New bushings should be soaked in "Bosch oil 1v13" for 1/2 to 1 hour before installation.

Using "Bosch Ft 2v3" grease, lubricate the following points lightly:

Journals and spiral splines of armature shaft. Shifter lever fork and shifter rings.

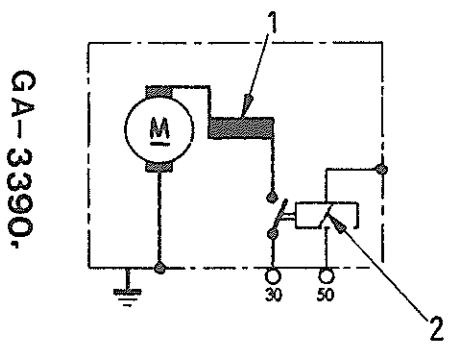
Shims on commutator end.

Washer on armature drive end.

Spring and pinion of the overrunning clutch.

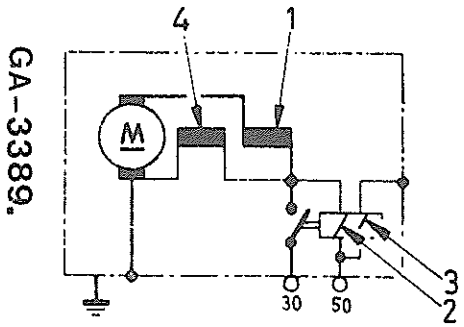
Pivot pin of the shift lever (lubricate more liberally).

Diagrams



Illust. 507
Bosch Number 0 001 354
(1.8 kW Starting Motor)

1 – Field coil/winding 2 – Closing and holding coil

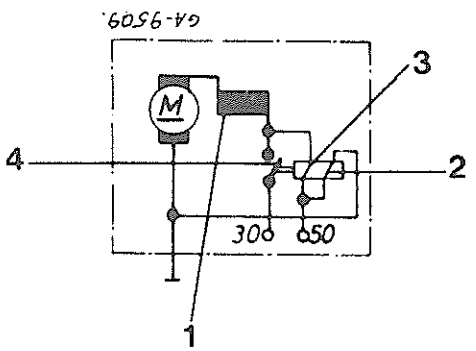


Illust. 508
Diagram, 3kW starting motors,

R. Bosch Number 0 001 359 014
" 035
" 019
" 029
0 001 360 029
0 001 364 029

1 – Field winding
2 – Closing coil (solenoid)
3 – Holding coil (solenoid)
4 – Shunt coil (*

(* = Not used for 3 kW starting motors,
R. Bosch Number 0 001 359 058
" 059
" 074
" 075



Illust. 508a

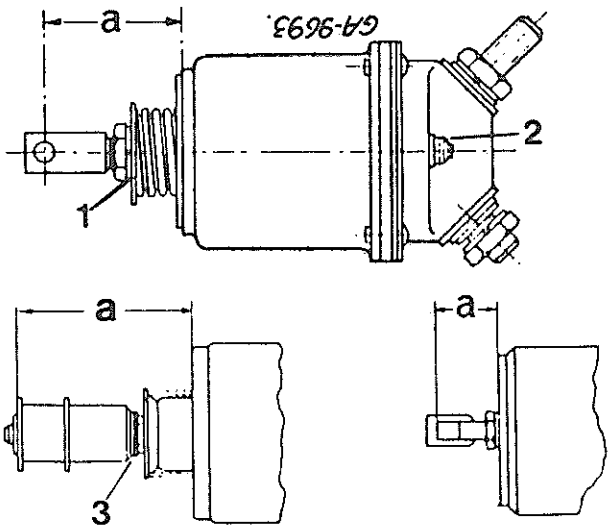
Bosch Number B 001 816 ...
. ..... 362 ...
. ..... 367 ...

1 – Field coil/winding
2 – Closing coil (solenoid)
3 – Holding coil (solenoid)
4 – Starter switch

Solenoid Switch:

Before fitting the solenoid switch, adjust dimension "a" as shown on next page.

If dimension "a" is not adjustable, inspect the actuating slot in the switch rod for wear. Replace solenoid switch if necessary.



Illust. 508b

Dimension "a" (in pull-in position)

Starting motor 0 001 354 ... = 33.8 – 34.2 mm
(1.33 – 1.35")
Starting Motor 0 001 364 ... = 34.0 – 34.2 mm
(1.34 – 1.35")

1 – Secure here (with a spot of paint)
2 – Seal here
3 – Shims

Draw-in voltage

12V-system = 8 V min.
24V-system = 15 V min.

Electrical Specifications

Bosch Order-No.	Starting Motor	Light running test (idling)			Lock Test			Min. Switch-on Voltage at Terminal 50	Starting Switch Amperage	
		V	< A	> RPM	V	A	Torque min.daNm	V	Closing and Holding Coil A	Holding Coil Only A
0 001 354 080	JD-12V1.8kW	11.5	75	5000	6.5	580-700	3.7	7.5	20	–
0.001 359 075 074	JD-12V3 kW	11.5	90	4800	4	760-900	4.6	8	67	13
0 001 360 001	JD-24V 4kW	23.5	50	5500	14	760-880	6.2	18	38	8
0 001 364 103 105	JD-24V4.8kW	23	85	6500	12	970-1170	7	18	24	6

NOTE: Test Specifications are based on a battery rating similar to regular application. Electrolyte temperature must be + 20°C (68°F) and a supply cable of adequate cross section (low resistance) should be used.

Mechanical Specifications

Starting Motor		JD-12V 1.8 kW	JD-12V 3 kW	JD-24V 4 kW	JD-24V 4.8 kW
Brush spring pressure	daNm	1 – 1.3	2.6 – 2.8	2.8 – 3.8 from 11.75 and up 3.8 – 4.0	2.8 – 3.8
Starting switch, dimension "a",	mm	34.8 – 35.0	–	–	–
Switch, permissible contact wear,	mm	1 – 2	1 – 2	0.7 – 1.3	0.7 – 1.3
Armature end play	mm	0.1 – 0.3	0.1 – 0.3	0.1 – 0.4	0.1 – 0.4
Armature breaking torque,	Ncm	4.5 – 75	45 – 75	4 – 5.5	4.5 – 7.5
Overrunning clutch torque,	Ncm	26 – 32	40 – 55	4 – 5.5	4.5 – 7.5
Commutator, Dia. new,	mm	42	42	42	42
Commutator, minimum Dia.	mm	39.5	39.5	39.5	39.5
Commutator, max. run out,	mm	0.05	0.05	0.05	0.05
Armature, max. run out,	mm	0.10	0.10	0.10	0.10
Carbon brushes, min. length,	mm	15.5	15.5	15.5	15.5
Armature, shaft, running clearance,	mm	0.095 – 0.14			

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Electrical Specifications

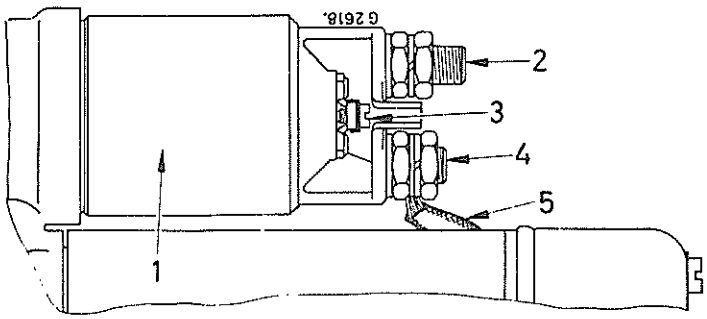
Starting motor	1.8 kW				3 kW				3 kW			
Bosch Designation	0 001 354 094 " 084 " 080 " 029				0 001 359 014 " 035 " 019 " 029				0 001 359 074 " 075 " 058 " 059			
	RPM	Volt	Amp.	Torque daNm (ft.lbs.)	RPM	Volt	Amp.	Torque daNm (ft.lbs.)	RPM	Volt	Amp.	Torque daNm (ft.lbs.)
Light running test (idling)	5000-7000	11.5	< 75	–	4800-6800	11.5	<90	--	6500-8500	11.5	<130	–
Partial load test	1500	10.0	350	1.4 (10.1)	1190	8.2	800	2.6 (18.8)	1300	8.5	800	2.6 (18.8)
Lock test	–	6.5	580-700	3.7 (26.7)	–	5.8	1300	4.8 (34.7)	–	4.0	850-1050	4.6 (33.3)
Ampereage at clamp 50 (nominal voltage)	1.8 kW starting motor Closing and holding coil 20 Amp.				3 kW starting motor 0 001 359 074 " 075 Closing and holding coil 60 Amp. Holding coil only 12 Amp.				3 kW starting motor 0 001 359 029 0 001 359 059 " 058 " 014 " 035 " 019 Closing and holding coil 67 Amp. Holding coil only 13 Amp.			

Note: Test Specifications are based on a fully charged 110 Ah battery for 1.8 kW and a 143 Ah battery for 3 kW starting motors. Electrolyte temperature must be + 20°C (68°F) and resistance of supply circuit 1 Ohm per m (yd.).

Mechanical Specifications

Starting motor	1.8 kW		3 kW with shunt coil or mechanical armature brake		3 kW with reinforced brush springs (present design)	
Commutator, max. run out, mm (inch)	0.03	(.0012)	0.03	(.0012)	0.03	(.0012)
Commutator minimum Dia, mm (inch)	39.5	(1.555)	39.5	(1.555)	39.5	(1.555)
Armature, max. run out, mm (inch)	0.05	(.0019)	0.05	(.0019)	0.05	(.0019)
Armature, end play, mm (inch)	0.1 - 0.3	(.004-.012)	0.1 - 0.3	((.004-.012)	0.1 - 0.3	(.004-.012)
Overrunning clutch torque, kgcm (lbs.inch)	2.6 - 3.2	(2.3-2.8)	2.6 - 3.2	(2.3-2.8)	4.0 - 5.5	(3.5-4.8)
Armature breaking torque, kgcm (lbs.inch)	4.5 - 7.5	(3.9-6.5)	4.5 - 7.5	(3.9-6.5)	4.5 - 7.5	(3.9-6.5)
Brushes, minimum length, mm (inch)	15.5	(.610)	15.5	(.610)	15.5	(.610)
Brush spring tension, kg (lbs.)	1.0 - 1.3	(2.2-2.9)	1.0 - 1.3	(2.2-2.9)	2.6 - 2.8	(5.7-6.2)
Gap between pinion and ring gear mm (inch)	1 - 5	(.04-.20)	1 - 5	(.04-.20)	1 - 5	(.04-.20)
Solenoid adjustment mm (inch)	33.8 -34.2	(1.330-1.346)	26.4 -26.8	(1.039-1.055)	———	

Testing in Position



Illust. 509

1 – Solenoid
2 – Battery terminal
3 – Switch terminal
4 – Motor terminal
5 – Cable to field coils

Starter Switch

Connect a voltmeter between terminal (3) Illust. 509 and earth and operate the starter switch.

No reading indicates a faulty switch or connection.

Check across the switch with a jumper lead to see whether the fault is in the switch or in the cable.

Solenoid

1. Connect a voltmeter between terminal (2) and earth. No reading indicates a loose or corroded cable connection.

2. Connect the voltmeter between terminal (4) and earth and operate the starter switch. No reading indicates a faulty closing or holding coil or poor solenoid contact.

Motor

Connect a voltmeter across the battery terminals (or across the terminal of two batteries connected in series) and operate the starter switch.

1. If the voltmeter records a voltage drop, current is flowing through the coils but the armature is not rotating, the motor must be disassembled for examination.

Note: When starting, voltage may fall to approx. 8 or 15 volts respectively. The actual figure recorded will depend on temperature, condition of the engine, serious electrical resistances by loose, cracked and corroded cables, poor contact or faulty commutator.

2. If the voltmeter records a slight voltage drop, current is only flowing through holding coil (3) Illust. 508, there is a break in the electrical connections or in the motor itself.

3. If the voltmeter records a voltage drop below 6 or 12 volts, but the motor works sluggish, check the condition of all batteries. If the batteries are in order, the slow action of the motor is the result of serious electrical resistance, detailed in 1 above.

Bench Testing

Whenever possible test the starting motor on a test bench, prior and after repair.

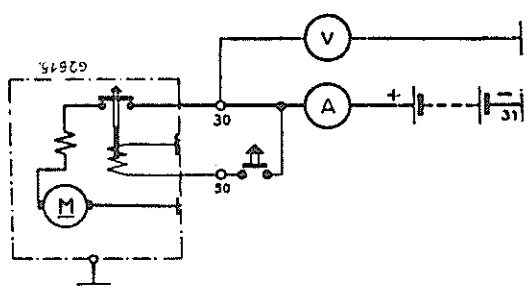
As an alternative method, the motor may be tested as outlined below.

Hereby, it is impracticable to carry out the partial load test and the lock test is not quite as accurate.

However, the light running test is best to reveal the essential fact to decide on an acceptable performance. Proceed as follows:

Secure the starting motor in a vice and connect, in series, a starter switch, an ammeter capable of carrying the specified amperage and a battery as specified. Connect a voltmeter between the motor terminal and the yoke.

Use a supply cable of specified resistance. Connect the return cable to a fixing lug on the drive end bracket.



Illust. 510
Instrument hook up for bench testing

LIGHT RUNNING TEST

To avoid accidents, cover the pinion of the overrunning clutch.

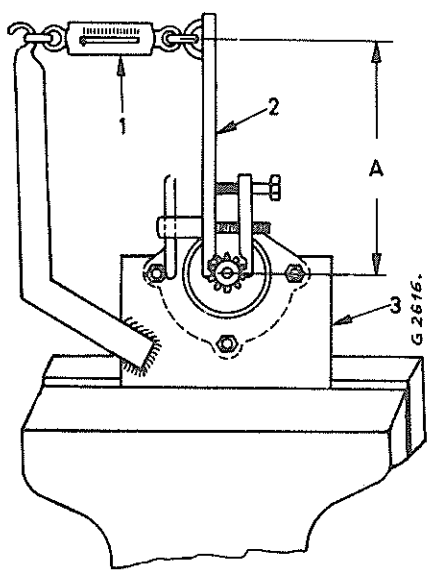
Operate the switch and note the speed of armature rotation, using a tachometer, and the readings given by the ammeter and voltmeter. These should conform with the figures given in "Specifications".

While the motor is running, examine the brush gear and check if there is any undue sparking at the commutator or excessive brush movement.

Note: A low idle speed reading indicates a higher mechanical running resistance, i.e. worn bearings etc. Usually this is accompanied by a lower voltage and a higher amperage reading.

If, on the other hand, idle speed is too high the armature brake or brush springs may be defective.

Lock Test



Illust. 511
Simple rig for measuring lock torque

1 – Spring scale
2 – Arm
3 – Holding device
A – 305 mm = 12"

With the motor firmly clamped in the vice and meters connected as shown in Illusts. 510 and 511, attach an arm to the driving pinion and connect the free end of the arm to a spring scale as shown in Illust. 511.

Operate the switch and note the current consumption, voltage and the reading on the spring scale. These readings should conform with the specified figures.

Note 1: If the arm is 305 mm = 12" long, the scale will read directly in torque. For other arm lengths, the torque can be calculated by multiplying the scale reading in pounds by tne length of the arm in feet.

Note 2: To read in daNm of torque arm A should be 1 meter. If, for practical reasons, 1/2 of a meter or 1/4 of a meter are used, spring values should be doubled or multiplied by four respectively.

Note 3: If a constant voltage busbar supply is used when carrying out the lock torque test, a higher lock voltage may be shown on the voltmeter than the value given in "Specifications". In this event, a variable resistor or rheostat of suitable current carrying capacity should be connected in the battery circuit and adjusted until the lock voltage is as specified. Readings of current and torque should be taken at this value.

Attention: Do not allow the motor to overheat. Max. permissible temperature 90°C = 194°F. Max. time of operating 1-2 sec.

Load Test

If a suitable test device and equipment are available, test the motor under load. Refer to "Specifications".

Note: To check correct engagement and disengagement of the pinion in the flywheel ring gear, pinion clearance must be as specified.

For suitable ring gear, see the "Parts Catalog".

Trouble Shooting

Trouble	*Probable Cause*
Starting motor will not operate or operates slowly.	Battery discharged or faulty. Cables or terminals are loose, corroded or brocken. Brushes worn or not seating properly. Brush spring tension too low. Commutator worn. Burned or corroded switch parts. Solenoid faulty.
Starting motor operates, but the pinion does not engage the ring gear.	Foreign matter on armature shaft. Damaged pinion or ring gear. Splines or linkage damaged. Closing coil or solenoid defective.
The pinion engages, but the starting motor does not crank the engine.	Overrunning clutch slips. Excessive voltage drop in the supply circuit. Discharged or faulty battery. Engine blocked (piston sticking). Brush spring tension too low. Solenoid defective.
Motor continues to operate after the starter switch is released.	Starter switch or solenoid faulty.
Pinion will not disengange.	Return spring of the solenoid fatigued or broken. Spiral splines rough or damaged. Shifter fork or linkage sticking.
Motor continues to rotate too long after power is cut.	Armature brake defective. Brush springs fatigued or carbon brushes worn excessively.

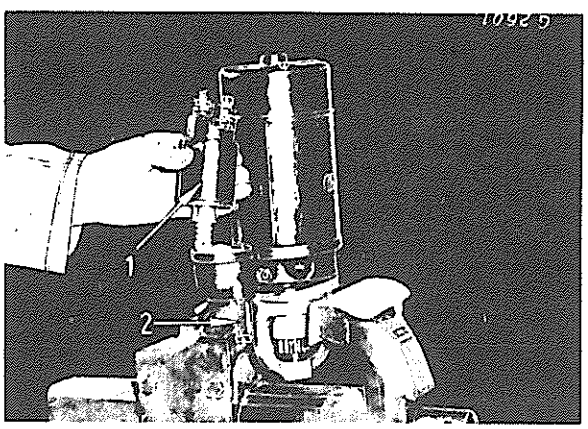
Servicing

Disconnect battery ground cables.

Loosen the cables from the terminals of the starter solenoid.

Remove the motor and clean it externally.

Disassembly (3 kW Starting Motor)



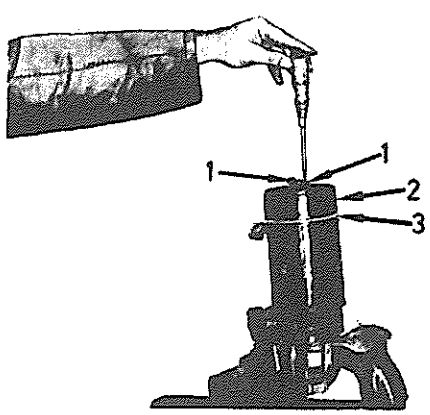
Illust. 512
1 — Solenoid
2 — Fillister head bolt

Clamp the motor in a vice, using soft metal jaws.

Remove the field lead from its terminal.

Remove bolts (2).

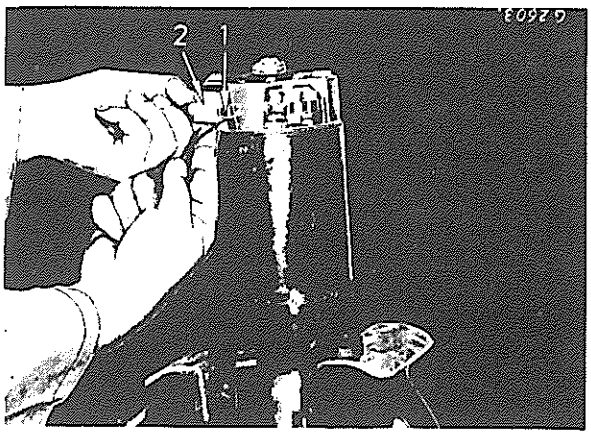
Lift the solenoid to disengage the plunger.



Illust. 513

1 — Through bolt
2 — Dust cover
3 — O-ring

Remove bolts (1) Illust. 513, cover (2) and O-ring (3).



Illust. 514

1 — Brush spring
2 — Brush

Lift the brush spring and pull out the brush as shown in Illust. 514.

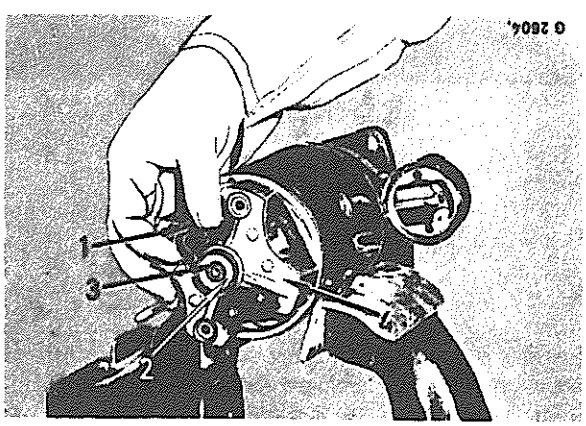
Disconnect the flexible connectors from the terminal tangs.

Remove all brushes.

Remove U-washer (1) Illust. 515. When pulling the end bracket (4) from the armature shaft (3) carefully remove shims (2) in front and behind the commutator end bracket.

Do not drop or mix up shims.

Note the thickness of each shim pack to simplify reassembly.



Illust 515

1 — U-washer
2 — Shims
3 — Armature shaft
4 — Commutator end bracket

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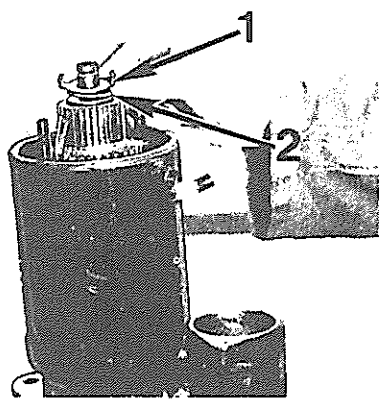
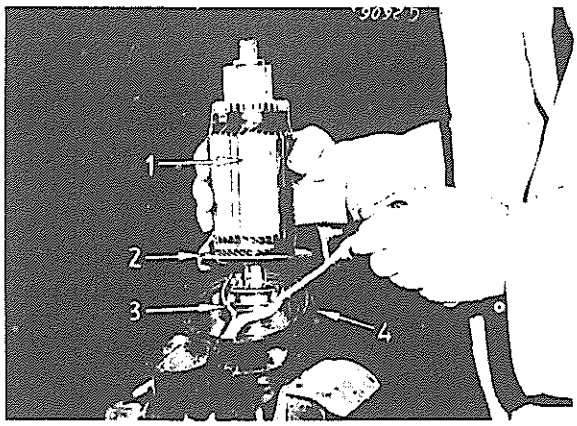


Illust. 516

1 – Brake thrust washer
2 – Brake disk

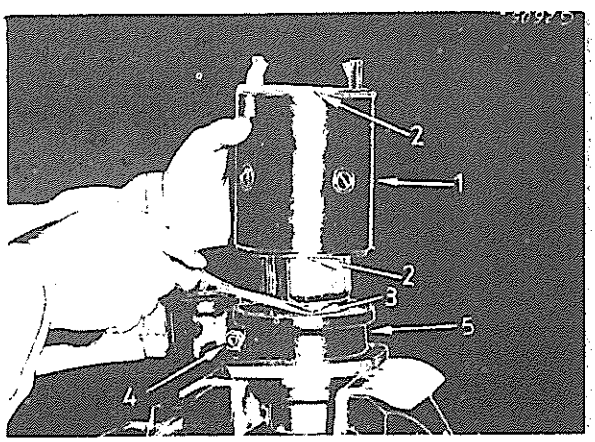
If so furnished remove washer (1) and disk (2).



Illust. 518

1 – Armature
2 – Center bearing
3 – Shift lever
4 – Drive end bracket

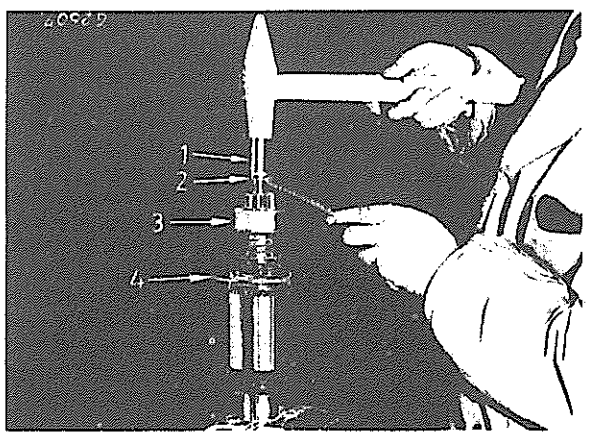
Lift the armature and the center bearing (2) as shown in Illust. 518, then disengage shift lever (3) and separate the armature from drive end bracket (4).



Illust. 517

1 – Yoke
2 – Locating tang
3 – Locating recess
4 – Shift lever pivot screw
5 – Drive end bracket

After the commutator end bracket is removed, lift off yoke (1) Illust. 517. Remove shift lever pivot screw (4).

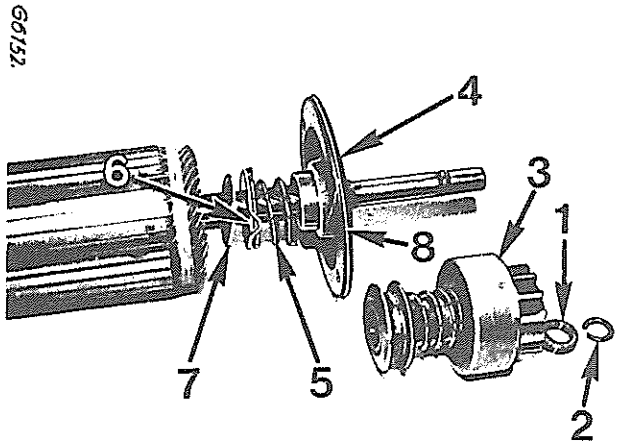


Illust. 519

1 – Hollow drift
2 – Pinion stop
3 – Overrunning clutch assembly
4 – Center bearing

Drive pinion stop (2) off the snap ring, using hollow drift (1).

Remove the snap ring and slide parts (2-4) off the shaft end.



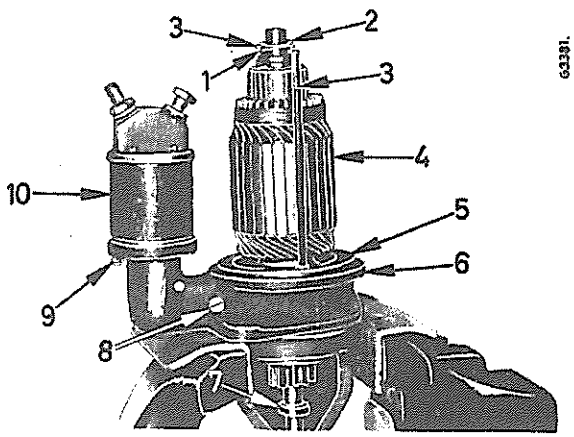
Illust. 520

1 – Pinion stop
2 – Snap ring
3 – Overrunning clutch assembly
4 – Center bearing
5 – Brake spring
6 – Thrust washer
7 – Brake disk
8 – O-ring

Remove parts (4-8) Illust. 520 from the armature shaft, if so equipped.

Disassembly (1.8 kW Starting Motor)

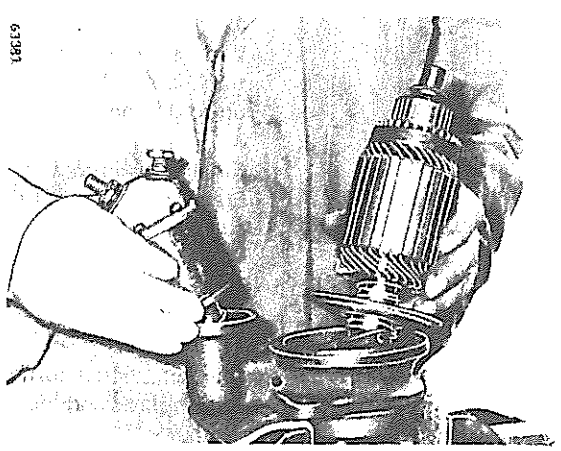
Remove dust cover.
Disconnect leads and remove brushes.
Disconnect field lead from solenoid.
Remove the two stud nuts to free the commutator end bracket.
Pull the end bracket from the armature shaft and lift off the yoke.



Illust. 521
1.8 kW starting motor, commutator end bracket and yoke removed

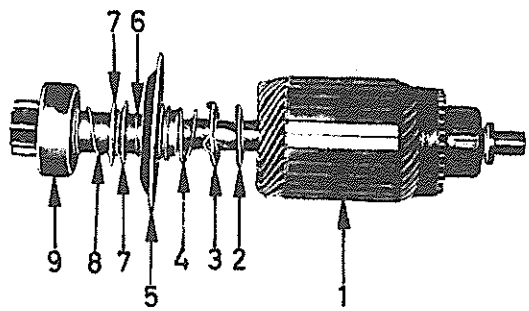
1 – Contact washer
2 – Shim(s)
3 – Studs
4 – Armature
5 – Center bearing
6 – Drive end bracket
7 – Pinion stop
8 – Shift lever pivot pin screw
9 – Through bolt
10 – Solenoid

Remove studs (3), screw (8) and bolts (9).



Illust. 522

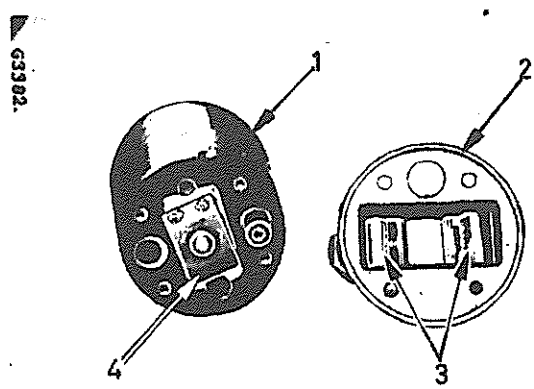
Remove armature and solenoid.



Illust. 523

1 – Armature
2 – Brake disk
3 – Thrust washer
4 – Spring
5 – Center bearing
6 – Spring
7 – Shift ring halves
8 – Spring
9 – Overrunning clutch assembly

Remove pinion stop (7) Illust. 521, slide parts (2-9) Illust. 383 from the armature shaft.



Illust. 524

1 – Solenoid
2 – Cover
3 – Contact faces
4 – Contact bridge

Remove cover (2) from solenoid (1) Illust. 384.

Cleaning, Inspection and Repair

Clean the components of the motor.

Do not wash or dip bearing bushings or overrunning clutch in a grease dissolving agent.

Brushes

Worn brushes must be replaced when the gap between their flexible connectors and guides is less than 3.9 mm (5/32").

New brushes do not need "bedding" but check to see that they move freely in their boxes.

Brush Springs

Spring tension must be checked in operating position, i.e. with the spring bearing on the brush and the brush on the commutator.

Replace the spring set when the tension of one spring is not within specifications. Be sure new springs are pressing on the center of the brushes.

Commutator

Clean the commutator with a strip of very fine "emery" cloth. Check for lifted, worn and burned segments. Carefully examine the commutator for thrown solder and high mica. If necessary, mount the armature in a lathe.

Assure the armature shaft is in line and not bent. Refer to "Specifications". Rotate at high speed and take a light cut with a very sharp (Diamond) tool. Do not remove more material than necessary. Refer to "Specifications".

With a commutator saw blade conforming with the thickness of the mica between the bars undercut evenly up to 0.8 mm (.03").

Finally, again mount the armature in a lathe and take a polish cut of about 0.03 mm (.001") ro remove undercutting burrs.

Armature

Check for loose turns in the armature windings for worn spiral splines and loose binding bands.

A damaged armature must always be replaced and not attempt should be made to machine the armature core or to true up a distorted armature shaft. An indication of a bent shaft or a loose pole shoe, may be given by scored armature laminations.

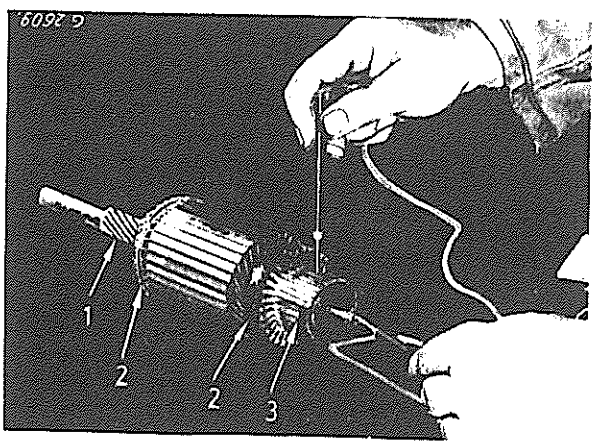
BEARING BUSHINGS

Check bearing bushings of the commutator end bracket, drive end bracket and center bearing. To prevent armature and pole shoe damage remove bushings which are excessively worn. New bushings must be pressed into their bores with a shouldered, highly polished mandrel of the same diameter as the armature shaft.

The armature must spin freely without brushes installed.

If it does not, do not rework bushings with a reamer. Use a polished mandrel which is slightly larger in diameter than the shaft to get the necessary running clearance.

Electrical Test

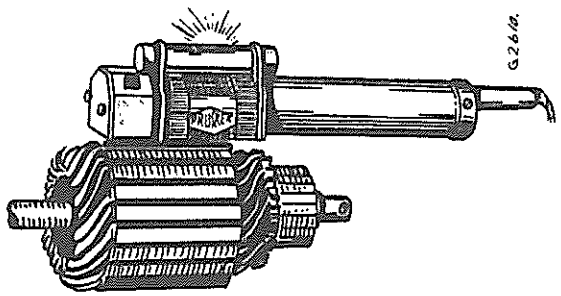


Illust. 525
Checking armature insulation

1 – Spiral splines
2 – Binding bands
3 – Commutator

To check armature insulation, use an ohmmeter or 40-volt a.c. test lamp. Infinite reading should be shown on the meter, or the test lamp should not light, when connected between the armature shaft and the commutator segments. Faulty insulation will be indicated by a low ohmic reading or by the lighting of the test lamp.

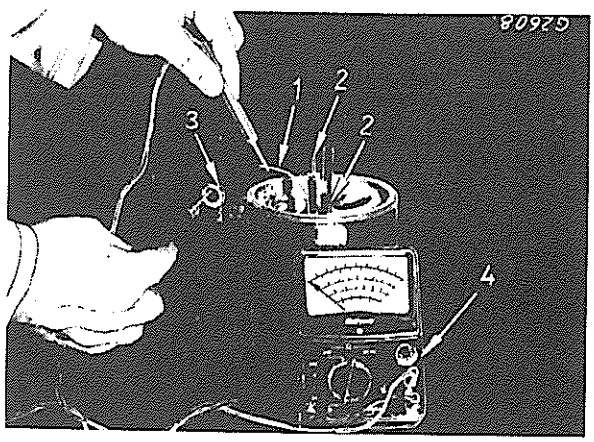
If a short circuit is suspected, check the armature on a "growler" or use a conventional testing tool as shown in Illust. 526A.



Illust. 526A
Short circuit testing tool

Note: The motor overheating may cause thrown solder to short circuit the commutator segments.

Note: If so equipped the shunt coil end (1) Illust. 526B must be unsoldered, when testing the coils.



Illust. 526B
Break test

1 – Shunt coil end (unsoldered)
2 – Field coil ends (brush connectors)
3 – Lead to solenoid
4 – Ohmmeter

Break Test

Use an ohmmeter. Connect its two probes to lead (3) and in turn to each of the coil ends (1 and 2).

If the reading is more than .003 ohm or a 12 volt test bulb connected as above does not light, there is a break in the coils.

Insulation Test

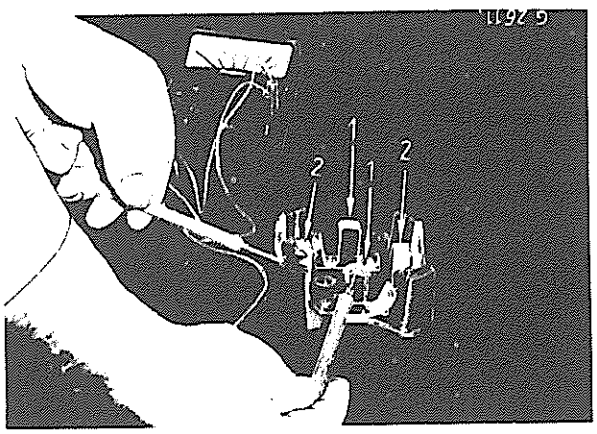
Connect an ohmmeter or a 40 volt a.c. test lamp between lead (3) and a clean part of the yoke.

Lighting of the lamp or a low ohmic reading indicates that the field coils are earthed to the yoke.

Replace the yoke assembly when tests reveal any coil damage or pole shoes are burnt and scored by the armature due to bearing failure.

Connect an ohmmeter or a 40 volt a.c. test lamp between each of the two insulated brush boxes (1) Illust. 527 on the commutator end bracket, and the end bracket itself.

Lighting of the lamp or a low ohmic reading indicates that the box is earthed to the bracket.



Illust. 527
Testing insulation of the brush boxes

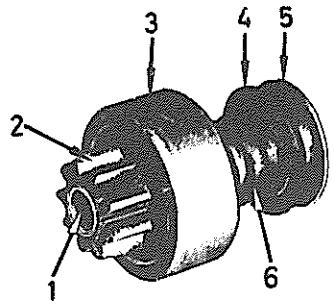
1 – Insulated brush boxes
2 – Earthed brush boxes

Note: Clean off all traces of carbon dust before making this test.

Replace the commutator end bracket, when insulation is damaged.

Overrunning Clutch Assembly

Check pinion (2) Illust. 528 for wear and damage. Slide the clutch assembly on the armature shaft to check for binding.



Illust. 528

1 – Bushing
2 – Pinion
3 – Overrunning clutch
4-5– Shift rings
6 – Pinion spring

Check the overrunning torque of the pinion, using a torque balance as shown in Illust. 530. Refer to "Specifications".

Important: If overrunning torque is insufficient the pinion slips earlier than specified, i.e. there may be no positive power-lock between the starting motor and the flywheel.

When the overrunning torque is higher than specified there is danger of over-speeding the armature, when the engine starts firing.

The clutch assembly must be replaced when parts of the clutch are worn or the overrunning torque of lock mechanism is not as specified.

Solenoid

Check to see the amperage the closing- and holding coil is within "Specifications".

Replace the solenoid with new one, if respective checks are not satisfactory.

Note: Above check should be made with solenoid in place.

Reassembly

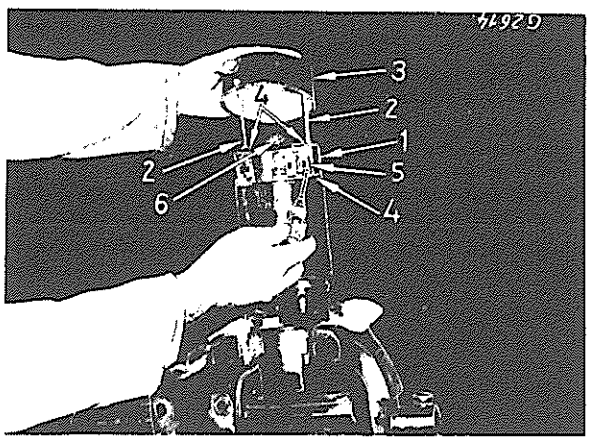
Assembly of the starting motor is reversal of the disassembling procedure. The following points must be observed:

Every component must be clean and dry.

Grease bearings, shims, spiral splines, shifter rings and the plunger of the solenoid with a long time lubricant or special starting motor grease.

Install shim packs as found in disassembly in front of and behind the commutator end bracket.

Be sure the locating tangs of the yoke engage in the recesses provided for this purpose in the drive end bracket, in the center bearing and also in the commutator end bracket.



Illust. 529

1 – Commutator end bracket
2 – Through bolts
3 – Dust cover
4 – O-rings
5 – Insulation sleeve
6 – Shims

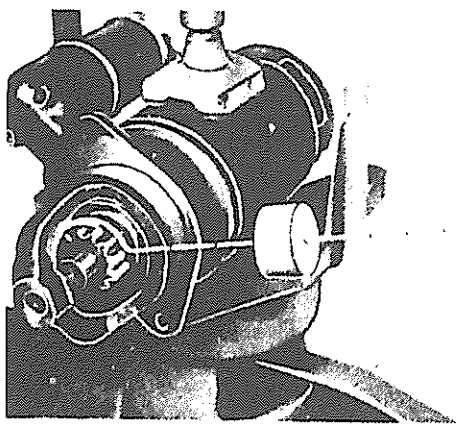
Install the two through bolts (2) Illust. 529 with dust cover off.

Install the U-washer and check the end play of the armature with a feeler gauge. Refer to "Specifications". If end play is more than specified, add shims (6) as necessary.

Check to see that the armature spins freely, then install brushes.

Install new O-rings (4). When finally installing bolts (2) be sure to fit also their insulation sleeves (5).

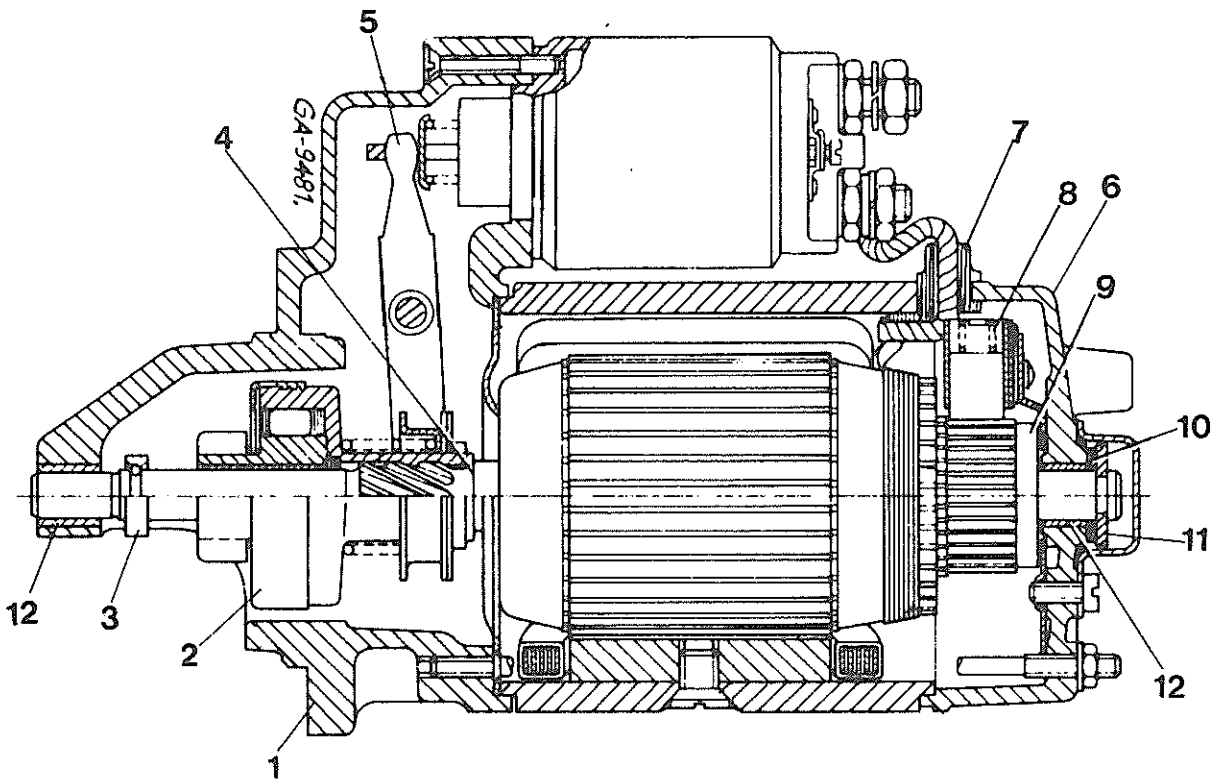
Check the breaking torque of the armature, using a torque balance. Refer to "Specifications".



Illust. 530
Checking breaking torque

If the armature does not slip within specifications, see for armature shaft binding or low brush spring tension.

STARTING MOTOR (JF-Series)



Illust. 531

Sectional view of JF starter

1 – Housing, drive end
2 – Overrunning clutch assy.
3 – Pinion stop
4 – Stop on armature
5 – Shift lever
6 – Cover commutator end
7 – Grommet
8 – Coil spring, brush
9 – Thrust collar, commutator
10 – Shims, end float
11 – U-washer
12 – Bushing, oilless

General

The JF Starting motor is designed on the same general principle as the JD model.

Main differences are as follows:

a) Six-roller overrunning clutch with self centering.

b) Shorter spiral splines with stop ring (4) on armature shaft.

c) No mechanical armature brake. Braking action is taken care of by increased brush pressure.

d) Coil type brush spring and special brush holder assy.

e) Shims for armature end float adjustment, accessible without disassembly.

Although the principle of operation is the same, assembly and disassembly procedures are somewhat different.

For Circuit Diagram, see "JD" Starting Motor.

Electrical Specifications

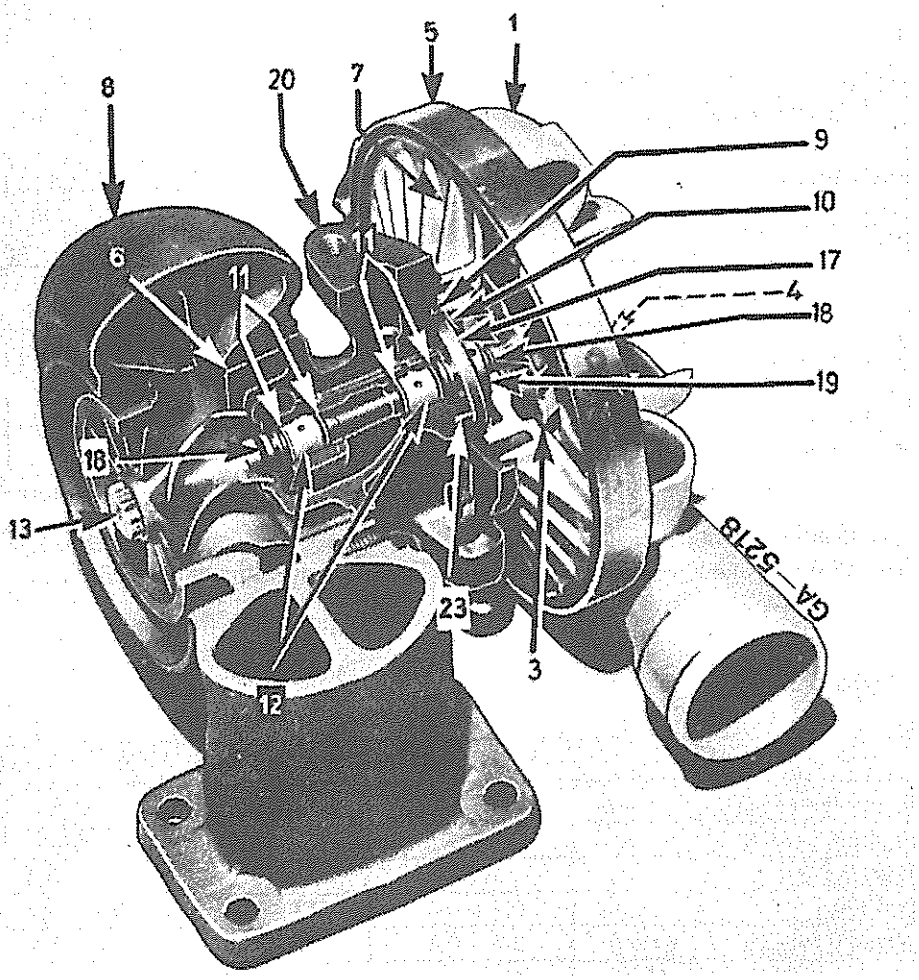
R. Bosch Order-No.	Starting Motor	Light Running Test (Idling)			Lock Test			Min. Switch-on Voltage at Terminal 50 V	Starting Switch Amperages	
		V	< A	> RPM	V	A	Torque min. daNm		Closing and Holding Coil A	Holding Coil Only A
0 001 362 064 063	JF-12V2.4kW	11.5	95	6500	4.5	700-800	3.4	7.5	60	12
0 001 362 300 301	JF-12V2.7kQ	11.5	125	7000	4.5	850-1000	3.5	7.5	60	12
0 001 367 001 . ... 002 003	JF-12V 3kW	11.5	130	7000	7.2	1150-1300	5.7	8	60	12
B 001 816 042	JF-24V 4 kW	23	85	7000	13.5	900-1050	6.5	18	24	6

NOTE: Test Specifications are based on a battery rating similar to regular application. Electrolyte temperature must be +20°C (68°F) and a supply cable of adequate cross section (low resistance) should be used.

Mechanical Specifications

Starting Motor		JF-12V 2.4 kW	JF-12V 2.7 kW	JF-12V 3 kW	JF-24V 4 kW
Commutator, minimum Dia.,	mm	42.5	42.5	42.5	42.5
Commutator, max. run out	mm	0.05	0.05	0.05	0.05
Armature, max. run out	mm	0.10	0.10	0.1 – 0.4	0.1 – 0.4
Armature, end play,	mm	0.1 – 0.4	0.1 – 0.4	0.1 – 0.4	0.1 – 0.4
Overrunning clutch torque,	daNcm	3.5 – 6.5	3.5 – 6.5	3.5 – 6.5	3.5 – 6.5
Armature breaking torque	daNcm	4.5 – 7.5	4.5 – 7.5	5.0 – 12.0	5.0 – 12.0
Brushes, min. length,	mm	8.5	8.5	8.5	8.5
Brush spring pressure,	daN	2.4	2.4	3.1	3.1
Armature shaft, running clearance in bushings mm		0.095 – 0.14			

Turbocharger (Airesearch) TO–466, TO–476, TO–4B



Illust. 532
Models TO–466 and TO–476 shown. TO–4B similar

1 – Compressor housing
3 – Compressor wheel
*4 – Diffuser
*5 – V-Clamp
6 – Shroud
7 – Back plate
8 – Turbine housing
9 – Seal ring
10 – Thrust collar spring
11 – Bearing retainer
12 – Bearing
13 – Turbine wheel and shaft
17 – Thrust washer
18 – Seal ring
19 – Thrust collar
20 – Center housing
23 – Spring pin

* Used only on Models TO–466 and TO–476

General

The turbocharger is essentially an exhaust driven blower. Its purpose is to increase diesel engine power output by supplying compressed intake air to the engine.

The turbocharger consists of a turbine wheel and a centrifugal blower impeller, or compressor wheel separately encased but mounted and rotating on a common shaft. The power to drive the turbine wheel, which in turn drives the compressor, is obtained from the energy of the exhaust gases. The rotating speed of the turbine changes as the energy level of the exhaust gases changes so the engine is supplied with enough compressed intake air to burn the fuel for its load requirements.

The large volume of oil flowing through the turbocharger bearing housing is of vital importance for cooling and lubricating the unit. Heat and its dissipation is an inherent factor in turbocharger operation. Heat originates not only on the turbine side by exhaust fumes, but also on the compressor side in the process of air compression

and frictional head due to the high speeds of the core assembly. A minimum inlet oil pressure must therefore be maintained to assure the necessary oil volume.

Carbon deposits in the bearings are also a sign of excessive heat, often resulting from disregarding basic instructions given in the Operator's Manual. If for instance a hot engine is shut-down without previous idling the oil in the bearing will burn as soon as it stops circulating, resulting in carbon deposits which reduce efficiency and in severe cases cause turbocharger failure.

All connections to the turbocharger (manifolds and piping) must be clean and free of foreign material, since serious damage to the turbocharger or engine could result. All connections must be air–tight.

Note: Air flow requirements for diesel turbocharged engines are considerably greater than for an non--turbocharged engine of the same size running at the same speed. Air inlet accessories, such as pre--cleaners, etc. must be regularly serviced to minimize the restriction at this higher air flow and to maintain performance of the turbocharger unit.

Periodically, check the boost pressure against specifications.

The engine crankcase breather must be cleaned periodically to be sure there is no restriction.

During normal operation, the turbocharger should be free from vibration or unusual noises.

The exhaust stack must be covered to prevent water from entering and damaging the turbine during shut–down periods or when the unit is being transported.

Periodically inspect the compressor wheel for soft carbon deposits, damaged blading, interference or excessive end play, see specifications.

Allow exhaust manifolds to cool before removing the turbocharger from the engine. This will prevent warping of the exhaust manifold and turbocharger mounting flanges.

To prevent premature failure of the turbocharger, check end play and running clearance of turbine and compressor shaft after every 3 000 hours of operation, refer to "Inspection and Repair".

Whenever it becomes necessary to replace either wheel due to unbalance etc., a matched set of both the turbine and compressor wheel as balanced at the factory must be used. Never attempt to repair a damaged wheel or to intermix a compressor wheel from one unit with a turbine wheel from another unit, or vice versa.

SPECIFICATIONS	METRIC	ENGLISH
Shaft Wheel Assembly:		
Running clearance	0.08-0.15 mm	.003-.006 in
End play	0.025-0.1 mm	.001-.004 in
Boost Pressure at rated RPM and load	66-80 kPa	9.6-11.6 psi
Maximum Vacuum in air suction side	6.2 kPa	1.8 in of Hg
TORQUES		
*Bolt, turbine housing/ center housing	11-15 N•m	100-130 lbF-in
Bolt, back plate/ center housing	4.5-6.7 N•m	40-60 lbF-in
**Locknut, Compressor wheel	2-2.2 N•m plus 1/4 turn	18-20 lbF-in plus 1/4 turn
Models TO-466 & TO-476		
V-clamp	4.5-9 N•m	40-80 lbF-in
V-clamp (stainless steel)	16-19 N•m	140-170 lbF-in
Models TO-4B-12-18 & 25		
Bolt, back plate/ compressor housing	12-15 N•m	110-130 lbF-in

* Threads coated with anti-seize compound.
** Threads and locknut face oiled.

Inspection Before Removing the Turbocharger

Insufficient power output of the engine may be caused by declining turbocharger efficiency.

Make sure whether the turbocharger or the engine is faulty, before removing the turbocharger.

1. Check intake and exhaust manifolds and all air ductings for leakage.
2. Check the boost pressure in the intake manifold and the vacuum pressure in the air suction hose against specifications.

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3. If boost pressure is poor, remedy all leaks, replace restricted air cleaner element with new one and repeat step 2.

4. If boost pressure remains insufficient, check for lodged foreign material in the compressor and turbine. Check for correct fuel injection pump setting.

5. Check for excessive dirt build-up in the compressor, impeller and turbine. Determine and correct the cause of build-up.

6. Check for proper oil pressure at low idle and rated rpm.

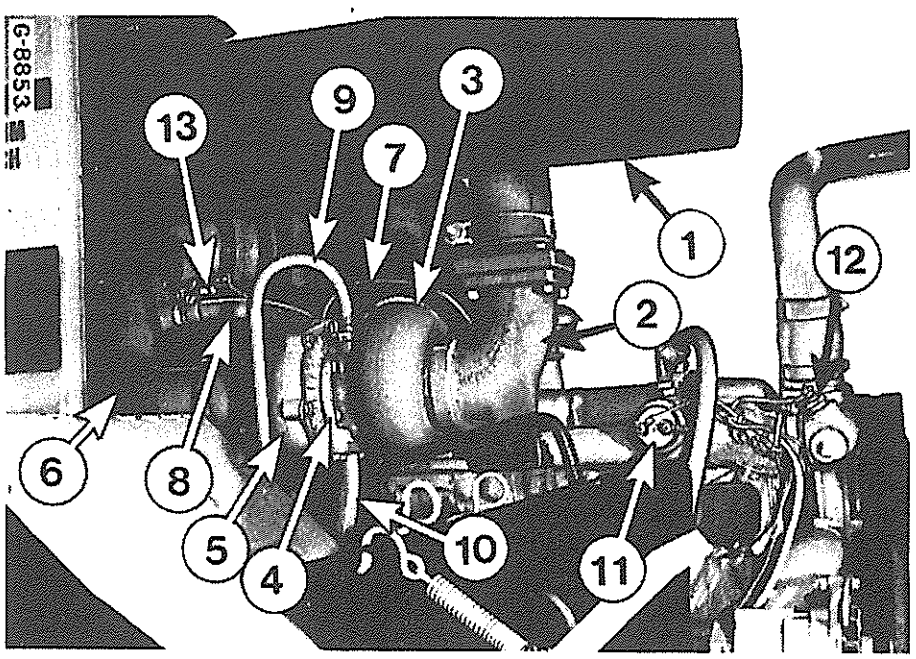
7. Check for rotating assembly bearing seizure. With the compressor housing removed, push the impeller forward the turbine wheel end and turn rotating assembly by hand. Check for binding or rubbing, listen for unusual noises.

8. Check engine under load conditions. Excessive exhaust smoke indicates improper fuel–air mixture and could be a result of either engine overloading (improper injection pump adjustment) or turbocharger malfunction.

9. Remove and disassemble the turbocharger for inspection if binding or any restriction is evident and/or running clearance or end play of the wheel shaft assembly is not within specified limits.

Note: Bearing inspection can be made while the turbocharger is still mounted on the engine. To do this remove exhaust elbow (2), air suction tube (6) **and oil drain pipe (10) Illust. 532a.**

Checking procedure, see "Inspection after Removal".



Illust. 532a

Turbocharger Model TO–4B, mounted on DT–402 Diesel Engine shown

1 – Muffler
2 – Exhaust elbow
3 – Turbine housing
4 – Center housing
5 – Compressor housing
6 – Air suction tube
7 – Air cross-over tube
8 – Air suction hose (to air compressor)
9 – Oil supply line
10 – Oil drain pipe
11 – Sender unit (coolant gauge)
12 – Switch (coolant warning light)
13 – Switch (air cleaner restriction)

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Removal

Clean the turbocharger externally.

To facilitate reassembly mark:

a) Turbine housing—to—center housing
b) Back plate—to—center housing
c) Compressor housing—to—back plate

Remove the muffler (1) and elbow (2) Illust. 2.
Remove air ductings.
Remove oil supply line (9) and drain pipe (10).
Remove turbocharger as a unit.

Note: Be careful when removing housings to prevent damage to compressor and turbine wheel.

Do not rest the unit on wheels, once damaged, they cannot be repaired.

Models TO—466 and 476:

Remove V—Band and lift off the compressor housing from the back plate. Remove the diffuser from the compressor housing.

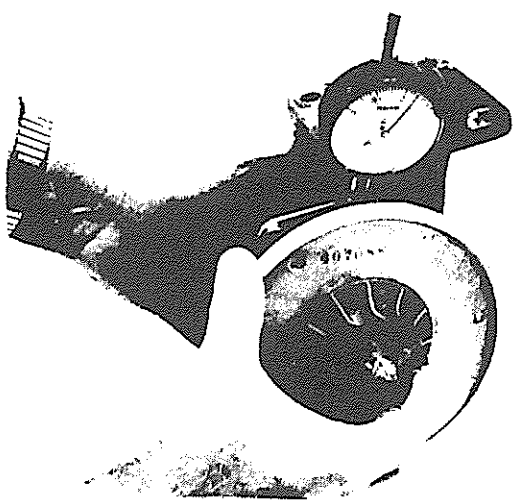
Models TO—4B

Remove bolts, clamps and lock plates which hold the compressor housing to the back plate.

Remove bolts, clamps and lock plates which hold the turbine housing to the center housing group. Tap with a soft hammer if force is needed for removal.

Inspection after Removal

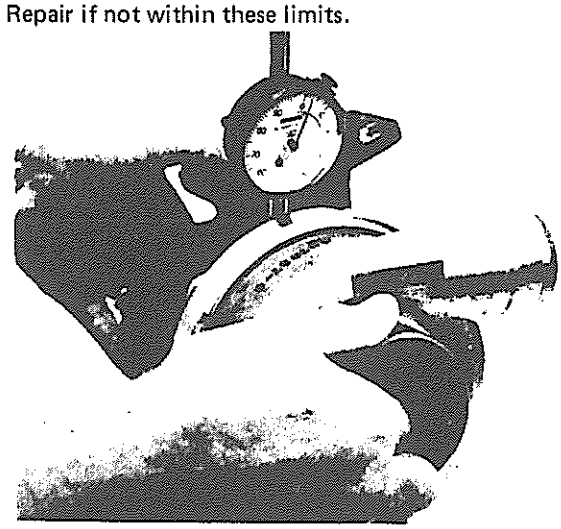
Wheel Shaft Running Clearance



Illust. 533
Set—up of the dial indicator

Fasten a dial indicator with two inch indicator extension to the oil drain hole, using a suitable mounting adapter. **Illust. 533.**
Make sure the tip of the extension rests on the center of the turbine wheel shaft.
Pre—load the dial indicator about 6 mm (.25 in) and zero the indicator.

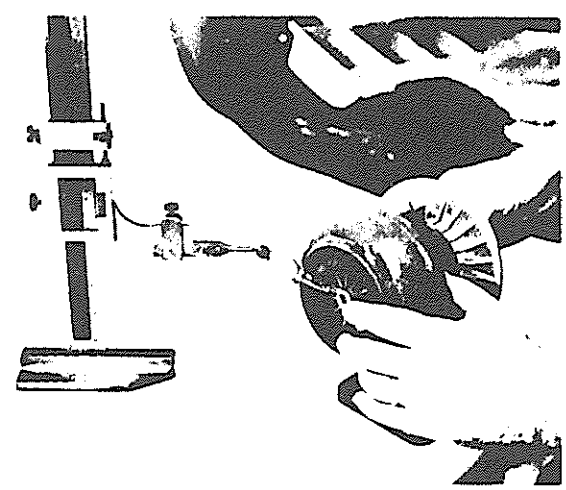
Move the turbine wheel shaft forward and away from the indicator. **Illust. 534.**
Take care to move the shaft in the same direction as the dial indicator travels. Apply equal pressure to the shaft at both ends simultaneously.
The total dial indicator displacement should not be less than 0.08 mm (.003 in) or more than 0.15 mm (.006 in). Repair if not within these limits.



Illust. 534
Checking shaft running clearance

Wheel Shaft End Play

Fasten a dial indicator to the back plate so that the indicator tip rests on the end of the shaft, or use method as shown in **Illust. 535.**



Illust. 535
Checking end play

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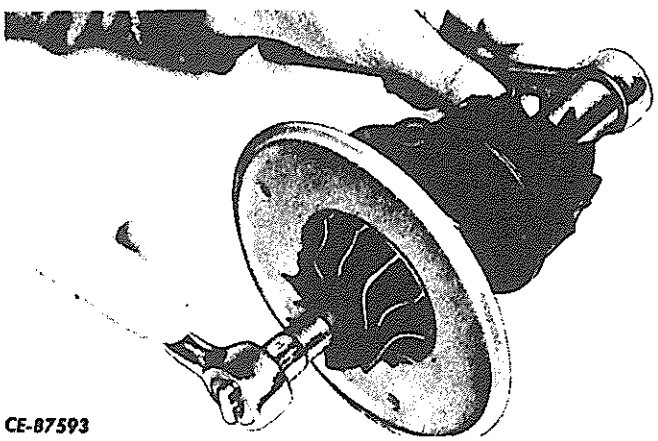
Move the shaft axially back and forth by hand. The indicator reading should not be less than 0.025 mm (.001 in) or more than 0.10 mm (.004 in). Take down for repair if not within these limits.

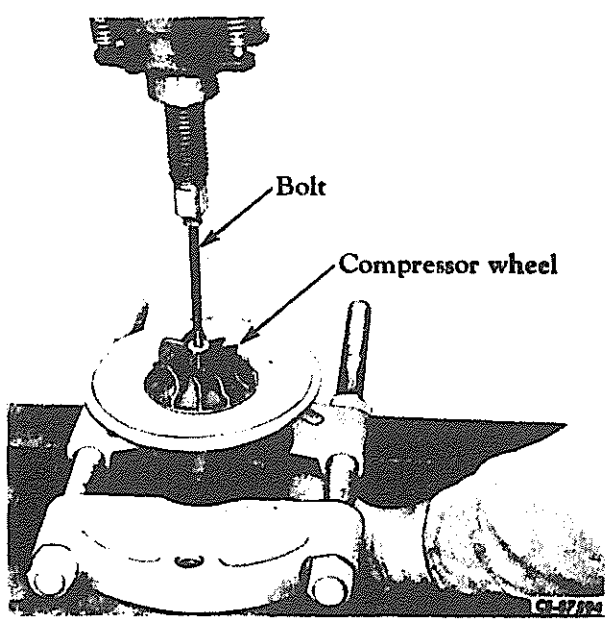
Disassembly



Illust. 536
Removing compressor wheel lock nut

Remove the lock nut. Be careful not to apply side thrust when loosening the lock nut as it is possible to bend the shaft.

Slide the compressor wheel from the shaft. If, after extended use, the wheel requires a light press to remove due to carbon build–up, the center housing must be supported on an arbor press.



Illust. 537
Removing compressor wheel

Grind a radius on the end of a 1/4 inch bolt to fit the end of the turbine shaft.

Press the shaft from the compressor wheel. In the same time hold the turbine wheel to prevent it and the shroud from dropping Illust. 537.

Remove four lock plates and bolts from back plate (15) Illust. 538 or (16) Illust. 539.

Tap back plate with soft mallet to remove it from the recess in the center housing.

Remove thrust collar and thrust bearing from the center housing.

Remove bearing and retainers from center housing.

Note 1: The turbine wheel shroud is not retained to the center housing and will fall free, when the shaft wheel is removed.

Note 2: Do not remove the two inboard retainers (22) Illust 538 or (21) Illust 539. These retainers are subject to distortion in removal and must be replaced whenever removed. However, if they appear to be damaged and worn, they must be replaced.

Cleaning

Before cleaning, inspect all parts for signs of rubbing, burning or other damage which might not be evident after cleaning.

Soak all parts in clean carbon solvent. After soaking use a stiff bristle brush and remove all dirt particles. Dry parts thoroughly.

Note: Normally a light accumulation of carbon deposits will not affect turbine operation.

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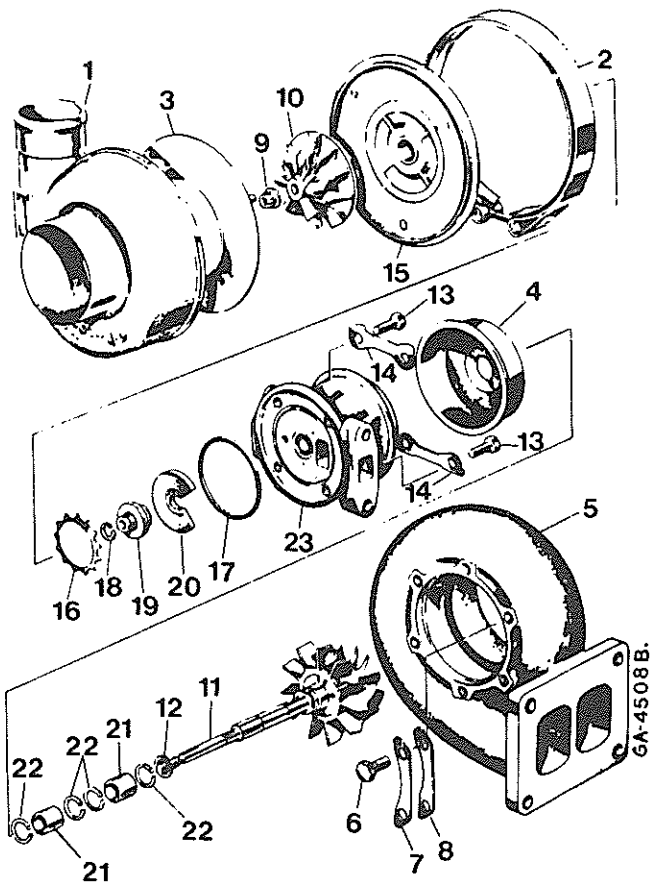
TURBOCHARGER



Illust. 538
Turbocharger, models TO–466 and TO–476

1 – Compressor housing
2 – V–Band coupling
3 – Diffuser
4 – Shroud
5 – Turbine housing
6 – Bolt
7 – Lock plate
8 – Clamp
9 – Lock nut
10 – Compressor wheel
11 – Turbine wheel and shaft
12 – Seal ring
13 – Bolt
14 – Lock plate
15 – Back plate
16 – Thrust collar spring
17 – Seal ring
18 – Piston ring
19 – Thrust collar
20 – Thrust washer
21 – Bearing
22 – Bearing retainer
23 – Center housing

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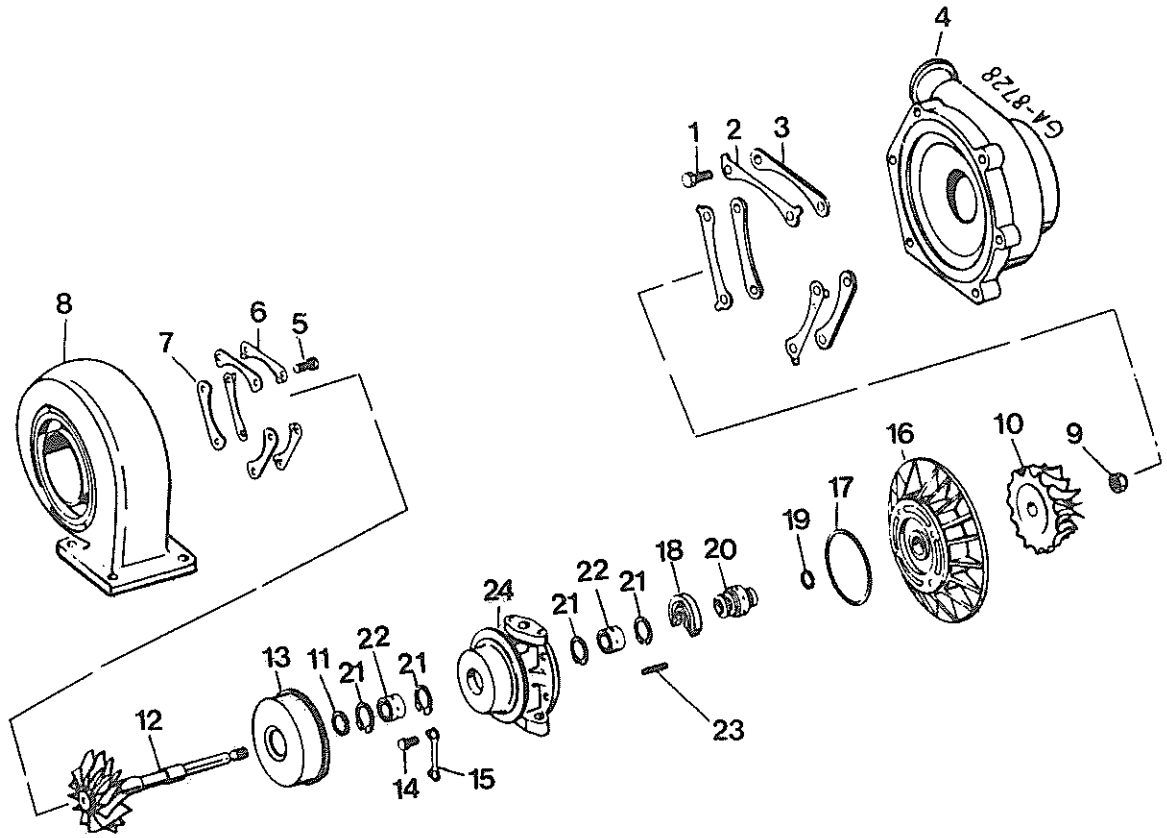
TURBOCHARGER



Illust. 539
Turbocharger, models TO–4B

1 – Bolt
2 – Lock plate
3 – Clamp
4 – Compressor housing
5 – Bolt
6 – Lock plate
7 – Clamp
8 – Turbine housing
9 – Lock nut
10 – Compressor wheel
11 – Seal ring
12 – Turbine wheel and shaft
13 – Shroud
14 – Bolt
15 – Lock plate
16 – Back plate
17 – Seal ring
18 – Thrust washer
19 – Seal ring
20 – Thrust collar
21 – Bearing retainer
22 – Bearing
23 – Spring pin
24 – Center housing

Inspection and Repair

1. Parts must not shown signs of damage, corrosion or deterioration. Threads must not be nicked, crossed or stripped.

2. Turbine wheel must show no signs of rubbing and vanes must not be torn or worn to a feather edge.

3. Impeller must show no signs of rubbing or damage from foreign material. It must be completely free of dirt or other foreign material. Impeller bore must not be galled.

4. Seal parts must not show signs of rubbing or scoring on running faces.

5. Housings must show no signs of contact with rotating parts. Oil and air passages must be clean and free of obstructions.

Replace any part which fails to meet the requirements of 1–5 above.

Replace bearing retainers and lock plates after every disassembly.

Replace damaged bolts.

Note: If bearings and thrust bearing show signs of nicks, scores, shellac deposites or foreign material imbedments or if tin plate is worn off, replace. If specified running clearance or end play is exceeded, replace bearings with new ones.

On models TO–466 and 476 inspect diffuser (3) **Illust. 538. Replace if necessary.**

Reassembly

Observe strict cleanliness and assemble as follows:

1. **With a sharp pick install new inboard bearing retainers (21) Illust. 539 or (22) Illust. 538. (If they were removed.)**

2. **Lubricate bearings with engine oil and insert. Install new outer bearing retainers.**

3. **Install seal ring (11) Illust. 539 or (12) Illust. 538 into the groove on the turbine wheel shaft.**

4. **Place the shroud over the turbine end of the center housing. Carefully insert turbine wheel and shaft through the shroud and center housing.**

5. **Install a new seal ring (19) Illust. 539 or (18) Illust. 538 onto the thrust collar.**

   Install thrust washer (18) Illust. 539 or (20) Illust. 538 onto the collar with the flat surface of the washer toward the large diameter of the collar.

6. **Install collar over the turbine wheel shaft thrust washer first and engage the holes in the washer with the anti-rotating pins in the center housing.**

7. **Install a new sealing ring (17) Illust. 538 and 539 into the groove in the compressor side of the center housing.**

8. Check to be sure the thrust collar spring is correctly seated in the back plate.

9. Align the marks (made during disassembly) on the back plate with those on the center housing and install the back plate over the shaft and thrust collar. Be careful not to damage the seal ring, when engaging the thrust collar into the bore in the back plate.

   To facilitate installation of the back plate enter the open side of the seal ring into the back plate first.

10. Install back plate bolts with lock plates. Torque bolts as specified and secure by bending the lock tabs on the lock plates against the bolt head.

11. Slip the compressor wheel onto the turbine shaft. Apply a small amount of engine oil to the threads and washer face of the lock nut.

    Install lock nut finger tight.

12. Place the assembled center housing in a vise equipped with brass jaws; clamping on the hex on the end of the turbine wheel.

13. Tighten compressor wheel lock nut using a wrench with a double universal joint so as to avoid side loads which could cause the shaft to bend.

    Tighten lock nut to specified torque then tighten an additional 1/4 of a turn.

14. Remove the assembly from the vise and spin the wheels by hand. The wheels must rotate freely.

    Check to be sure the turbine wheel does not rub against the shroud.

15. Align the marks (made during disassembly) on the center housing with those on the turbine housing.

    Install the turbine end of the center housing into the turbine housing.

16. **Coat the threads of the bolts (14) Illust.539 or (13) Illust. 538 with anti-seizing compound.**

    Install the bolts with clamps and lock plates. Torque bolts as specified and secure.

17. *Models TO—466 and 476:*

    Install diffuser (3) Illust. 538 into the compressor housing. Align the marks on the compressor housing with those on the center housing and back plate.

    Install clamp (2) and tighten clamp bolt to specified torque.

    Models TO—4B:

    Align the marks on the compressor housing with those on the center housing and back plate.

    Install the compressor housing using bolts, clamps and lock plates. Torque the bolts as specified and secure the bolts.

18. Push the turbine shaft as far as possible from the turbine end and check for binding during rotation.

    Repeat check, pushing from the compressor end. The shaft must rotate freely with no interference at either end of the turbocharger.

19. If the turbocharger is not to be installed immediately, lubricate internally and install protective covers on all openings.

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Installation

1. a) Remove and thoroughly clean the piping connecting the air cleaner to the turbocharger.

   b) Remove the air cleaner element and thoroughly clean the inside of the air cleaner housing.

   c) Install a new air cleaner element. Shaking the old element to remove embedded particles is not satisfactory as some will remain and vibrate loose during operation. These pieces can then be sucked back into the turbocharger and again damage the compressor wheel.

2. Inspect the exhaust manifold for pieces of gaskets or other foreign material. If any foreign material is evident remove the manifold and clean it.

3. Inspect the oil drain line to be sure the inside diameter has not been reduced by swelling or that the line is not clogged. Also inspect the oil supply line for dirt, clogging or deterioration.

4. Inspect the turbocharger mounting pad on the manifold for flatness. Be sure all of the old gasket has been removed.

5. Check the oil change period. If the next change period is near, it is recommended that the oil and oil filter element be changed before operating the turbocharger.

6. Install the turbocharger, using new gasket and seal. Coat the threads of the attaching bolts and the piston ring which seals the exhaust elbow, with high temperature compound.

   Install pipings in such a manner as to impose no compressive bending or torsional loads on turbocharger.

   Note: **Before connecting the oil inlet line to the turbocharger put 120-150 ml (4-5 oz.) of lubricating oil into oil inlet opening in top of turbocharger.**

   Before connecting oil drain pipe (10) Illust. 532 turn the engine until an even oil stream leaves the turbocharger.

7. Operate the engine observing the turbocharger for any of the following:

   a) Unusual turbocharger noises.
   b) Lubrication leaks.
   c) Fastening to the engine not secure.
   d) Excessive vibration.
   e) Excessive exhaust smoke.
   f) Air leaks in the air cleaner—to—turbocharger or turbocharger—to—intake manifold ducting.

   Investigate and correct any of these conditions immediately to avoid possible turbocharger or engine failure.

8. Retighten cap screws, hold down nuts, air connections, and oil connections to and from the turbocharger after the initial warm—up.

TURBOCHARGER

TROUBLE SHOOTING INFORMATION

Trouble	Probable cause	Remedy
Noisy operation or vibration.	Bearings are not being lubricated.	Supply required oil pressure. Clean or replace oil line or clean oil strainer. If trouble persists, overhaul the turbocharger.
	Leak in engine intake or exhaust manifold.	Tighten loose connections or replace manifold gaskets if necessary.
Engine will not deliver rated power.	Clogged manifold system.	Clear all ducting.
	Foreign material lodged in compressor, impeller, or turbine.	Disassemble and clean.
	Excessive dirt built–up in compressor.	Thoroughly clean compressor assembly. Clean air cleaner and check for leakage.
	Leak in engine intake or exhaust manifold.	Tighten loose connections or replace manifold gaskets as necessary.
	Rotating assembly bearing seizure.	Overhaul turbocharger.

Note: If shrill whine is heard, shut down the engine immediately. The whine indicates imminent turbocharger bearing failure.

Do not confuse the whine heard during run–down, with one which indicates a bearing failure during operation. Other unusual noises would probably result from improper clearance between turbine wheel and turbine housing. If such noises are heard, the turbocharger must be overhauled.