



General

Diesel Engines

D5
DS5
D7
D8
D10
DS10
D11
DS11

The engines described here are constructed on the same general lines, and the majority of their corresponding components are of the same design. As a rule, therefore, it is possible to employ the same methods in maintenance work. For this reason these engines are dealt with in common in this section of the Service Master Manual.

In identifying or ordering spare parts, please refer to the spare parts list for the type of engine concerned.

SCANIA  **VABIS**

General	A
Cylinder Heads	B
Cylinder Block	C
Crankshaft and Reciprocating Components	D
Timing Gears	E
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Cooling System	G
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Turbocharger	J
Specifications Adjustment Values and	

For U. S. equivalents of valve clearance, crankshaft end play, and torque values, use the following listing and the following torque conversion chart:

	D317D	F475D	F673D	H866DS
Valve – Int.	.014"	.014"	.014"	.014"
Clearance – Exh. (* .028" for D317DS and F475DS)	*.018"	*.018"	.028"	.028"
Crankshaft End Play	.002" – .010"	.002" – .010"	.0035" .0115"	.0035" .0115"
Torque values –				
Cylinder head	123 ft. lbs.	123 ft. lbs.	174 ft. lbs.	159 ft. lbs.
Main bearings	152 ft. lbs.	152 ft. lbs.	210 ft. lbs.	304 ft. lbs.
Main bearing				101 ft. lbs.
Transverse bolts				101 ft. lbs.
Rod bearings	80 ft. lbs.	80 ft. lbs.	80 ft. lbs.	80 ft. lbs.
Flywheel	137 ft. lbs.	137 ft. lbs.	137 ft. lbs.	188 ft. lbs.
Vibration damper	80 ft. lbs.	80 ft. lbs.	80 ft. lbs.	80 ft. lbs.
Vibration damper hub	542 ft. lbs.	542 ft. lbs.	542 ft. lbs.	542 ft. lbs.
Oil pan	36 ft. lbs.	36 ft. lbs.	36 ft. lbs.	36 ft. lbs.
Flywheel housing	43 ft. lbs.	43 ft. lbs.	62 ft. lbs.	62 ft. lbs.
Injectors	7 ft. lbs.	7 ft. lbs.	7 ft. lbs.	36 ft. lbs.
Injection tubing nuts	11–14 ft. lbs.	11–14 ft. lbs.	11–14 ft. lbs.	11–14 ft. lbs.
Rocker arm shaft retaining screws	34 ft. lbs.	34 ft. lbs.	61 ft. lbs.	

TORQUE CONVERSION CHART

kgm	ft. lbs. equiv.	kgm	ft. lbs. equiv.	kgm	ft. lbs. equiv.
.7	5	4.1	30	15	108
.8	6	4.7	34	17	123
1	7	5	36	19	137
1.4	10	6	43	20	145
1.5	11	6.2	45	21	152
1.6	12	6.7	48	22	159
2	14	8.4	61	24	174
2.1	15	8.5	62	26	188
2.4	17	11	80	29	210
2.5	18	13	94	42	304
2.8	20	14	101	75	542

S A F E T Y P R E C A U T I O N S

The exhaust products of an internal combustion engine are toxic and may cause injury to health or death if inhaled. All engine installations, especially those within a closed shelter, or building, should be equipped and maintained with an exhaust discharge pipe so that exhaust gases are delivered into the open air.

All internal combustion engine fuels are highly combustible and may explode under certain conditions. Fuels must be conducted to the engine with secure piping, free from leaks, properly designed to resist breakage from vibration.

All engine installations should be equipped with a means of positive fuel shutoff for emergency use when fuel is conducted to the engine from a remote source. In addition, fuels under pressure such as natural gas or liquified petroleum gas, should be controlled by a positive shutoff valve, preferably automatic, other than those integral with the carburetor or gas pressure regulation equipment. It shall be the final responsibility of the engine owner to ensure that the installation is free from fuel or exhaust leakage.

Gas used to energize starters must be discharged away from the engine into a harmless area. Ignition connections and electrical equipment on engines expose to potentially explosive ambient atmospheres should be specially equipped to minimize spark hazard and it is the responsibility of the engine owner to specify or provide such connections and equipment.

Internal combustion engines must be properly provided with guards against hazard to persons or structures in close proximity to rotating or heated parts and it is the responsibility of the engine owner to specify or provide such protection.

INTRODUCTION

The Waukesha Motor Company supplies this publication for use with Waukesha-Scania diesel engines. Scania and Waukesha identify these Waukesha marketed diesel engine models as follows:

Scania Basic Designations	Waukesha Basic Designations
D5 and DS5	D317D and D317DS
D8 and DS8	F475D and F475DS
D11 and DS11	F673D and F673DS
DS14	H866DS

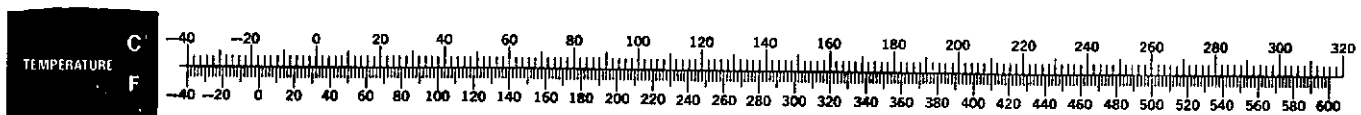
The Scania basic designation indicates D for diesel, S for turbocharged, and the numerical designation, (5, 8, 11, or 14) is the approximate displacement in litres. The Waukesha basic designation indicates the number of cylinders (D is 4, F is 6, and H is 8), the displacement in cubic inches (317, 475, 673, and 866), D for diesel, and S for turbocharged. When a U is added to the basic designation it indicates an industrial unit. When an M is added to the basic designation it indicates a marine application. Only one of these models is available with an intercooler and this model is designated as F673-DSIM.

All spare parts for Waukesha-Scania engines are stocked under the applicable Scania part number plus a WS prefix. The WS prefix is used to avoid confusion of duplicate Waukesha and Scania part numbers. All Waukesha-Scania parts orders and correspondence must include this WS prefix.

CONVERSION FACTORS

In order to convert the metric data provided in these publications, use the following conversion factors.

TO CONVERT:	TO:	MULTIPLY BY:	TO CONVERT:	TO:	MULTIPLY BY:
mm	inches	.03937	litres	gallons	.2642
m	feet	3.281	kg	pounds	2.2046
mm ²	sq. inches	.00155	kgm	foot - pounds	7.233
dm ²	sq. inches	15.5	kg/cm ²	psi	14.22
cm ³	fluid oz.	.0338	kcal	BTU	3.968
m ³	cu. ft.	35.31			



For direct conversion of .1 to 25.4 millimeters (mm) into inches, use the following chart:

CONVERSION CHART SHOWING MILLIMETER SIZES, FRACTIONAL AND DECIMAL INCH SIZES AND NUMBER DRILL SIZES

Milli-Meter	Dec. Equiv.	Frac-Tional	Num-ber	Milli-Meter	Dec. Equiv.	Frac-tional	Num-ber	Milli-Meter	Dec. Equiv.	Frac-tional	Num-ber	Milli-Meter	Dec. Equiv.	Frac-tional	Num-ber	Milli-Meter	Dec. Equiv.	Frac-tional
.1	.0039			1.75	.0689			....	.1570		22	6.8	.2677			10.72	.4219	27/64
.15	.0059			....	.0700		50	4.0	.1575			6.9	.2716			11.0	.4330	
.2	.0079			1.8	.0709			....	.1590		21	....	.2720	I		11.11	.4375	7/16
.25	.0098			1.85	.0728			....	.1610		20	7.0	.2756			11.5	.4528	
.3	.0118			....	.0730		49	4.1	.1614			....	.2770	J		11.51	.4531	29/64
....	.0135		80	1.9	.0748			4.2	.1654			7.1	.2795			11.91	.4637	15/32
.35	.0138			....	.0760		48	....	.1660		19	....	.2811	K		12.0	.4724	
....	.0145		79	1.95	.0767			4.25	.1673			7.14	.2812	....		12.30	.4843	31/64
.39	.0156	1/64	....	1.98	.0781	5/64	....	4.3	.1693			7.2	.2835			12.5	.4921	
.4	.0157			....	.0785		47	....	.1695			7.25	.2854			12.7	.5000	1/2
....	.0160		78	2.0	.0787			4.37	.1719	11/64	....	7.3	.2874			13.0	.5118	
.45	.0177			2.05	.0807			....	.1730		17	....	.2900	L		13.10	.5156	33/64
....	.0180		77	....	.0810		46	4.4	.1732			7.4	.2913			13.49	.5312	17/32
.5	.0197			....	.0820		45	....	.1770		16	....	.2950	M		13.5	.5315	
....	.0200		76	2.1	.0827			4.5	.1771			7.5	.2953			13.89	.5469	35/64
....	.0210		75	2.15	.0846			....	.1800		15	7.54	.2968	....		14.0	.5512	
.55	.0217			....	.0860		44	4.6	.1811			7.6	.2992	19/64		14.29	.5625	9/16
....	.0225		74	2.2	.0866			....	.1820		14	....	.3020	N		14.5	.5709	
.6	.0236			2.25	.0885			4.7	.1850		13	7.7	.3031			14.68	.5781	37/64
....	.0240		73	....	.0890		43	4.75	.1870			7.75	.3051			15.0	.5906	
....	.0250		72	2.3	.0905			4.76	.1875	3/16	....	7.8	.3071			15.08	.5937	19/32
.65	.0256			2.35	.0925			4.8	.1890		12	7.9	.3110			15.48	.6094	39/64
....	.0260		71	....	.0935		42	....	.1910		11	7.94	.3125	5/16	....	15.5	.6102	
....	.0280		70	2.38	.0937	3/32	....	4.9	.1929			8.0	.3150			15.88	.6250	5/8
.7	.0276			2.4	.0945			....	.1935		10	....	.3160			16.0	.6299	
....	.0292		69	....	.0960		41	....	.1960		9	8.1	.3189		O	16.27	.6406	41/64
.75	.0295			2.45	.0964			5.0	.1968			8.2	.3228			16.5	.6496	
....	.0310		68	....	.0980		40	....	.1990		8	....	.3230	P		16.67	.6562	21/32
.79	.0312	1/32	....	2.5	.0984			5.1	.2008			8.25	.3248			17.0	.6693	
.8	.0315			....	.0995		39	....	.2010		7	8.3	.3268			17.06	.6719	43/64
....	.0320		67	....	.1015		38	5.16	.2031	13/64	....	8.33	.3281	21/64	....	17.46	.6875	11/16
....	.0330		66	2.6	.1024			....	.2040		6	8.4	.3307			17.5	.6890	
.85	.0335			....	.1040		37	5.2	.2047			....	.3320	Q		17.86	.7031	45/64
....	.0350		65	2.7	.1063			....	.2055		5	8.5	.3346			18.0	.7087	
.9	.0354			....	.1065		36	5.25	.2067			8.6	.3386			18.26	.7187	23/32
....	.0360		64	2.75	.1082			5.3	.2086			....	.3390	R		18.5	.7283	
....	.0370		63	2.78	.1094	1/4	....	....	.2090		4	8.7	.3425			18.65	.7344	47/64
.95	.0374			....	.1100		35	5.4	.2126			8.73	.3437	11/32	....	19.0	.7480	
....	.0380		62	2.8	.1102			....	.2130		3	8.75	.3445			19.05	.7500	3/4
....	.0390		61	....	.1110		34	5.5	.2165			8.8	.3465			19.45	.7656	49/64
1.0	.0394			....	.1130		33	5.56	.2187	7/32	....	....	.3480	S		19.5	.7677	
....	.0400		60	2.9	.1141			5.6	.2205			8.9	.3504			19.84	.7812	25/32
....	.0410		59	....	.1160		32	....	.2210		2	9.0	.3543			20.0	.7874	
1.05	.0413			3.0	.1181			5.7	.2244			....	.3580	T		20.24	.7969	51/64
....	.0420		58	....	.1200		31	5.75	.2263			9.1	.3583			20.5	.8071	
....	.0430		57	3.1	.1220			....	.2280		1	9.13	.3594	23/64	....	20.64	.8125	19/16
1.1	.0433			3.18	.1250	1/8	....	5.8	.2283			9.2	.3622			21.0	.8268	
1.15	.0452			3.2	.1260			5.9	.2323			9.25	.3641			21.03	.8281	53/64
....	.0465		56	3.25	.1279			....	.2340		A	9.3	.3661			21.43	.8437	21/32
1.19	.0469	3/64	....	....	.1285		30	5.95	.2344	15/64	....	....	.3680	U		21.5	.8465	
1.2	.0472			3.3	.1299			6.0	.2362			9.4	.3701			21.83	.8594	55/64
1.25	.0492			3.4	.1338			....	.2380		B	9.5	.3740			22.0	.8661	
1.3	.0512			....	.1360		29	6.1	.2401			9.53	.3750	3/8		22.23	.8750	3/8
....	.0520		55	3.5	.1378			....	.2420		C	....	.3770		V	22.5	.8858	
1.35	.0531			....	.1405		28	6.2	.2441			9.6	.3780			22.62	.8906	57/64
....	.0550		54	3.57	.1406	9/64	....	6.25	.2460			9.7	.3819			23.0	.9055	
1.4	.0551			....	.1417			6.3	.2480			9.75	.3838			23.02	.9062	29/32
1.45	.0570			....	.1440		27	6.35	.2500	1/4		9.8	.3858			23.42	.9219	59/64
1.5	.0591			3.7	.1457			6.4	.2520			....	.3860			23.5	.9252	
....	.0595		53	....	.1470		26	6.5	.2559			9.9	.3898		W	23.81	.9375	15/16
1.55	.0610			3.75	.1476			....	.2570			9.92	.3906	25/64	....	24.0	.9449	
1.59	.0625	1/16	....	....	.1495		25	6.6	.2598			10.0	.3937			24.21	.9531	61/64
1.6	.0629			....	.1496			....	.2610			....	.3970		X	24.5	.9646	
....	.0635		52	....	.1520		24	6.7	.2638			....	.4040		Y	24.61	.9687	31/32
1.65	.0649			3.9	.1535			6.75	.2657	17/64	....	10.32	.4062	13/32	....	25.0	.9843	
1.7	.0669			....	.1540		23	6.75	.2657			....	.4130		Z	25.03	.9844	63/64
....	.0670		51	3.97	.1562	5/32	....	....	.2660			10.5	.4134			25.4	1.0000	1

Service Master Manual Section
Diesel Engines

DIESEL ENGINES

D5, DS5, D8, D88, D11, DS11

Specification
Adjustment Values and
Tightening Torques

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Specifications

General	D5	DS5	D8	DS8	D11	DS11	DS11 ¹⁾
Number of cylinders	4	4	6	6	6	6	6
Cylinder bore mm	115	115	115	115	127	127	127
Stroke mm	125	125	125	125	145	145	145
Displacement litres	5:19	5:19	7.79	7.79	11.02	11.02	11.02
Compression ratio	16.5:1	15.5:1	16.5:1	15.5:1	16:1	16:1	15:1
Firing order	1-2-4-3	1-2-4-3	1-5-6-2-4	1-5-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4
Working principle	4-stroke	4-stroke	4-stroke	4-stroke	4-stroke	4-stroke	4-stroke
Injection method	direct	direct	direct	direct	direct	direct	direct
Weight kg	approx. 518	approx. 530	approx. 695	approx. 730	approx. 875	approx. 890	approx. 890

Max. speed, output and torque: see the operator's manual or service card for the engine in question.
DS11 with higher output (DS11A)

The Truck version is exclusive of compressor, hydraulic pump, coolant and oil.

Cylinder Heads

	D5 ²⁾ DS5 ²⁾	D8 ²⁾	DS8 ²⁾	D11 DS11	DS11 ¹⁾
Intake valve timing	opens 11° closes 41°	11° 41°	28° 24°	13° 43°	30° 26°
Exhaust valve timing	opens 43° closes 7°	43° 7°	62° 26°	46° 10°	64° 28°
Intake valve diameter, head	50 mm	50 mm	54 mm	54 mm	54 mm
Exhaust valve diameter, head	42 mm	42 mm	44 mm	44 mm	44 mm
Position of intake-valve seat insert	Depth 11.20-11.30 mm	Sharp corner	Sharp corner	Sharp corner	Sharp corner
Position of exhaust-valve seat	Depth 11.20-11.30 mm	Sharp corner	Sharp corner	Sharp corner	Sharp corner

DS5²) DS8²) DS11¹)
 DS5²) DS8²) DS11

valve, guide, I.D.	Intake valve	11.00-11.02 mm	11.00-11.02 mm
	Exhaust valve	11.00-11.02 mm	11.00-11.02 mm
valve springs	Number per valve	2	2
rocker-arm shaft	Outside diameter	21.99-21.98 mm	24.99-24.98 mm
pushrods	Diameter	14 mm	14 mm

DS11 with higher output (DS11A)
 More information about engine cylinder head given on engine service card or corresponding instruction

C. Cylinder Block

Cylinder liners	Type	Wet, renewable	Wet, renewable
	Cylinder bore	115.000-115.020 mm	127.000-127.025 mm
	Shims, thickness	0.10, 0.15, 0.20, 0.25, 0.30 0.50, 0.75 mm	0.10, 0.15, 0.20, 0.25, 0.30 0.50, 0.75 mm

D. Crankshaft and Reciprocating Components
 Pistons 1)

Material	Light metal	Light metal
Compression rings	3	3
Scrapper rings	2 Alt. 1	2 Alt. 1

Crankshaft

Thrust washers	Thickness	3.429-3.378 mm	3.429-3.378 mm
	Standard	3.505-3.454 mm	3.505-3.454 mm
	Oversize 1	3.556-3.505 mm	3.556-3.505 mm
	Oversize 2		

1) More information about engine parts given on engine service card or corresponding instruction

D5, DS5,
D8, DS8

D11, DS11

Oversize 3	3.683-3.632 mm
Oversize 4	3.937-3.886 mm

3.683-3.632 mm
4.191-4.140 mm

bearing journals

Diameter		
Standard	85.000-84.978 mm	101.598-101.620 mm
Undersize 1 (ground down by 0.25 mm)	84.750-84.728 mm	101.349-101.371 mm
Undersize 2 (ground down by 0.50 mm)	84.500-84.478 mm	101.097-101.120 mm
Undersize 3 (ground down by 0.75 mm)	84.250-84.228 mm	100.849-100.871 mm
Undersize 4 (ground down by 1.00 mm)	84.000-83.978 mm	100.597-100.620 mm
Undersize 5 (ground down by 1.25 mm)	83.750-83.728 mm	100.348-100.371 mm
Undersize 6 (ground down by 1.50 mm)	83.500-83.478 mm	100.096-100.119 mm
Fillet radius	4.7-4.3 mm	5.2-4.8 mm
Profile depth of bearing surface	1 μm	1 μm

Width

Journal without axial guide (No. 1, 2, 3, 5 and 6)	-	47.00-47.20 mm
Journal without axial guide (No. 4)	-	51.80-52.00 mm
Journal without axial guide (No. 1-6)	42.00-42.20 mm	-
Journal with axial guide (No. 7)	42.20-42.25 mm	47.20-47.25 mm

blns

Diameter		
Standard	75.000-74.981 mm	81.233-81.255 mm
Undersize 1 (ground down by 0.25 mm)	74.750-74.731 mm	83.985-84.005 mm
Undersize 2 (ground down by 0.50 mm)	74.500-74.481 mm	83.734-83.754 mm
Undersize 3 (ground down by 0.75 mm)	74.250-74.231 mm	83.485-83.505 mm
Undersize 4 (ground down by 1.00 mm)	74.000-73.981 mm	83.233-83.254 mm
Undersize 5 (ground down by 1.25 mm)	73.750-73.731 mm	83.383-83.005 mm
Undersize 6 (ground down by 1.50 mm)	73.500-73.481 mm	82.733-82.753 mm
Undersize 7 (ground down by 1.75 mm)	73.250-73.231 mm	-
Undersize 8 (ground down by 2.00 mm)	73.000-72.981 mm	82.235-82.255 mm

D5, DS5,
D8, DS8

DL1, DS11

5.2-4.8 mm

1 µm

59.0-59.1 mm

4.7-4.3 mm

1 µm

52.0-52.1 mm

Fillet radius
Profile depth of bearing surface

Width

fuel System 1)

D5

DS5

D8

CAV

CAV

CAV

Injection pump
Automatic governor
Centrifugal governor
pump
Timing
Injector
Nozzle
Rudder
filter
pressure relief valve
tag order

See type plate on the pump
See type plate on the governor
See type plate on the governor
DFP 3E/64
Direct flange
Bosch DLLA 150S 494
Bosch KBAL 97S 19/4
CAV FS 5836150
CAV 7019/239 C
1-2-4-3

DFP 3E/64
CAV FDC 6248240
CAV BDLA 150S 6438
CAV BKBL 97S 5275S
Alt. CAV BKBL 97S 5340B
CAV ZFS 5845080
CAV 7019/239 C
1-5-3-6-2-4

DS3

DS8

DL1

DS11

CAV

Bosch

Bosch

Bosch

Injection pump
Automatic governor
centrifugal governor

See type plate on the pump
See type plate on the governor
See type plate on the governor

DFP 3E/64
CAV FDC 6248240
Bosch DLLA 150S 494
Bosch KBAL 97S 19/4
CAV ZFS 5845080

pump
Timing
Injector
Nozzle
Rudder
filter

FP/K22 P6
Bosch EPKG 1 R 22
Bosch DLLA 150S 494
Bosch KBAL 97S 19/4
Bosch FJ 63L FJ/D51 W6x2/1

FP/K22 P6
Bosch ZKG 25 2 4
Bosch DLLA 150S 496
Alt. Bosch DLLA 150S 549
Bosch KBL 112 S28/13
setting "e"
Bosch FJ/DL11 W11 A116
Alt. Bosch FJ/DB 1W6x2/1

FP/K22 P6
Bosch ZKG 25 2 4
Bosch DLLA 150S 495
Alt. Bosch DLLA 150S 548
Bosch KBL 112 S28/13
setting "g"
Bosch FJ/DL11 W11 A116
Alt. Bosch FJ/DB 1W6x2/1

For more information about engine fuel system governor, see engine service card or corresponding information.

	DS8	DS11	DS11
Pressure relief valve	CAV 7019/239C 1-5-3-6-2-4	CAV 7019/239 C 1-5-3-5-2-4	CAV 7019/239C 1-5-3-6-2-4
Timing order			

	DS5	DS11
Turbocharger		
Valve ring marked	"140"	"224"

Adjustment Values and Tightening Torques

	DS5, DS8, DS, DS8	DS11, DS11
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Tighten the cylinder heads according to the instructions.

Valve clearance, cold engine	50% 75% full	88Nm (9 kgm) 128 Nm (13 kgm) 167Nm (17 kgm)	118Nm (12 kgm) 177 Nm (18 kgm) 236Nm (24 kgm)
Intake valve		0.35 mm	0.35 mm
Exhaust valve		0.45 mm	0.70 mm
Intake valve		29.5°	29.5°
Exhaust valve		29.5°	29.5°
Intake valve (dimension D)		49 mm	53 mm
Exhaust valve (dimension D)		41 mm	43 mm
Intake valve		30°	30°
Exhaust valve		30°	30°
Intake valve (dimension A)		1.2-1.5 mm	1.2-1.5 mm
Exhaust valve (dimension A)		1.2-1.5 mm	1.2-1.5 mm

Distance between face plane of cylinder head and valve head (dimension B)

min. 0.7 mm

min. 0.7 mm

approx. -80°C

approx. -80°C

Applies to DS5

D5, DS5,
D8, DS8

D11, DS11

max. 0.14 mm

max. 0.14 mm

25⁺-0.25 mm

25⁺-0.25 mm

Distance between valve stem and guide

Height of valve guides above seating level of valve springs

There is an inside conical recess of the exhaust-valve guide should face the valve head

Valve springs

Outer:

66 mm

66 mm

free length
length with at
least 470N (48 kg) load

36 mm

36 mm

Inner:

59 mm

59 mm

free length
length with at
least 200N (20.5 kg) load

32 mm

32 mm

more closely wound end of the outer valve spring should face the cylinder head

Outside diameter of rocker-arm bushing (after pressing in)

22.00-22.02 mm

25.00-25.02 mm

File depth of bearing surface

4 μm

4 μm

Holes for the oil passages must be drilled in the rocker-arm bushing

Tightening torque rocker-arm shaft retaining screws

46Nm (4,7 kgm)

83Nm (8,4 kgm)

Cylinder Block

All liners with the marking turned to face the front of the engine

Height above level of cylinder block by repairing

0.05-0.07 mm

0.05-0.10 mm

Permissible difference between dimensions read off at diametrically opposite points transverse to the engine

0.02 mm

0.02 mm

Permissible height difference for liners belonging to same cylinder head

0.03 mm

0.03 mm

D5, DS5,
D8, DS8

D11, DS11

permissible deviation from parallelism in the cylinder-
flange

0.02 mm 0.02 mm

max. 0.35 mm max. 0.35 mm

y (with cylinder head fitted)

max. 0.05 mm max. 0.05 mm

Crankshaft and Reciprocating Components

removing or fitting piston pin, piston must be
1 to

100°C

100°C

piston rings must be fitted with the marked side up

r-ring gap

Top compression ring

0.6-0.8 mm

Second and third compression rings

0.05-0.7 mm

0.5-0.7 mm

play, piston ring

max. 0.25 mm

max. 0.25 mm

Fitting Rods

from 1 to 6, alternatively 1 to 4

connecting rods must be fitted so that the numeral
ings can be read from the same direction as the
all markings in the cylinder block

nd bolts

Tightening torque

108Nm (11 kgm) 108Nm (11 kgm)

r-pin bushing

Inside diameter (when pressed in)

47.031-47.043 mm

Profile depth of bearing surface

2.5 μ m

D5, DS5, DS11, DS11
 D8, DS8

play (adjusted with thrust washers at main bearing 7)

0.05-0.25 mm 0.03-0.29 mm

ing play (radial)

0.053-0.112 mm
 0.044-0.094 mm

0.058-0.126 mm
 0.050-0.106 mm

bearing nuts

206Nm (21 kgm)

284Nm (29 kgm)

eeel bolts

186Nm (19 kgm)

186Nm (19 kgm)

re fitting, flywheel ring gear must be heated to

250°C

250°C

ation-damper

108Nm (11 kgm)

108Nm (11 kgm)

for vibration-
 er hub at front
 of crankshaft

735Nm (75 kgm)

735Nm (75 kgm)

for flywheel
 ang

59Nm (6 kgm)

84Nm (8.5 kgm)

ming Gears

shaft

Bearing play
 Axial
 Radial bearing 1
 Radial bearings 2-4

0.10-0.25 mm
 0.045-0.083 mm
 0.030-0.079 mm

shaft bushings
 a pressed in)

Inside diameter
 Bearing 1
 Bearing 2
 Bearing 3
 Bearing 4
 Profile depth of bearing surface

68.200-68.230 mm
 68.100-68.130 mm
 68.000-68.030 mm
 60.000-60.030 mm
 2.5 μm

re fitting, camshaft gearwheel must be heated to

100°C

100°C

re fitting, crankshaft gearwheel must be heated to

100°C

100°C

oes not apply to D5, DS5

D5, D65,
D8, D88

D11, D811

play (new engine)

0.03-0.09 mm 0.03-0.09 mm

Timing screws for cooling fan LB80, LB85

23.5Nm (2.5 kgm)

between retaining ring and injection pump bracket before opening the sealing-ring holder of the driving shaft of the injection pump

0.2 mm 0.2 mm

Clearance of shims for the adjustment above

0.10, 0.25, 0.50 mm 0.10, 0.25, 0.50 mm

lubricating System

Pressure

1.5-4.9 bar (1.5-5 kg/cm²) 1.5-4.9 bar (1.5-5 kg/cm²)

Injection valve to be set to 4.9 bar (5 kg/cm²) with engine warm and running at

2.400 r.p.m. 2.200 r.p.m.

Oil for rotor cover of centrifugal cleaner (applies to centrifugal-cleaner housing with divided rotor)

First make finger-tight, then give half-turn with wrench

Spanner bolts

4.9Nm (5 kgm)

4.9Nm (5 kgm)

Pump bushings

Bearing 1

19.075-19.100 mm

19.075-19.100 mm

Washer of Eaton-type.

Bearing 2

19.075-19.100 mm

19.075-19.100 mm

Washer: inner diameter

Bearing surface profile depth

2 μm

Washer: outer diameter

Bearing 1

4 μm

Washer: fitted bushings

Bearing 2

4 μm

Pump bushings in pump of gear wheel type

gear wheel shaft journal

22.222-22.235 mm

housing bushing diameter

22.265-22.286 mm

Clearance between pump gear wheel centre lines

47.68-47.72 mm

gear wheel outer diameter

56.970-56.951 mm

gear wheel recess diameter in the pump housing

57.030-57.060 mm

housing bushing finish

0.6 Ra

Wrenching torque for

locking screw, pump housing cover

19.6 Nm (2,0 kgm)

locking screw, intermediate gear wheel

locking nut, pump gear wheel

137 Nm (14 kgm)

D5, D55,
D6, D58

D11, D511

cooler test pressure
on side
side

4 kp/cm² 4 bar
10 kp/cm² 9,8 bar

Cooling System

Liquid
thermostat

Wax
thermostat

Liquid
thermostat

Wax
thermostat

74°C
77°C
88°C

74°C
77°C
88°C

79°C
94°C

79°C
94°C

thermostat

79°C
94°C

Distance between plane of pump housing and impeller (new pump)

0.3-1.2 mm

0.3-1.2 mm

When belts are correctly tensioned, moderate force between generator and fan should be suffice to deflect them

approx. 10 mm

approx. 10 mm

1-freeze

See directions in operator's manual or service instructions

portion of emulsifying cutting oil added to coolant
Cutting oil must not be added to the anti-freeze

2-3%

2-3%

icon oil for fan with temperature controlled speed and
coupling (available as spare part)

Dow Corning 210 viscosity 12.500 cSt at + 25°C

Fuel System

Injection Pump

Setting on engine (timing)
Control-rod opening, max. mm

D5, D6

D55

1 } 25° B.T.D.C.
2 }

See indicated value on engine
See the figure stamped on the pump or the appropriate Service Bulletin

D5, D8

D85

pressure (measured in fuel chamber of injection pump)	bar ($\frac{kg}{cm^2}$)	0.6-0.8 min. 0.2 approx. 0.5	0.6-0.8 min. 0.2 approx. 0.5
pressure relief valve	bar ($\frac{kg}{cm^2}$)		
inlet pipes	mm	1.7	1.7
inlet nuts	Nm (kgm)	15-20 (1.5-2)	15-20 (1.5-2)
inlet valves	Opening pressure on inspection		
	bar ($\frac{kg}{cm^2}$)	132-142 (135-145)	196-205 (200-210)
	bar ($\frac{kg}{cm^2}$)	137-142 (140-145)	201-205 (205-210)
needle	mm	0.29-0.31	0.29-0.30
needle lift	mm	0.25-0.30	0.25-0.30
Solex B	mm w.g.	210-240	200-230
inlet nuts	Tightening torque	10 (1.0)	10 (1.0)
rpm of engine	No-load idling	500-550	500-550
	High no-load	2650 (2)	2650
	Max. load	2400	2400
injection pump	Setting on engine (timing)		
	Control-rod opening, max. mm	D38	D11
		1) 28° B.T.D.C.	25° B.T.D.C.
		3) 3)	3)
retaining	Retaining screws		
	Tightening torque		
mark when using Bosch coupling (marked on coupling)		6R	6R
pressure (measured in fuel chamber of injection pump)	bar ($\frac{kg}{cm^2}$)	0.6-0.8 min. 0.3 approx. 0.5	0.6-0.8 min. 0.3 approx. 0.5
pressure relief valve	bar ($\frac{kg}{cm^2}$)		
inlet pipes	mm	2	2
inlet nuts	Tightening torque	15 (1.5)	15 (1.5)
indicated value on engine			
the figure stamped on the pump or the appropriate Service Bulletin			
		2) With the damper device cut of action.	

K11

	DS8	DS11	DS11	DS11
Factors	196-205 (200-210)	132-142 (135-145)	196-205 (200-210)	132-142 (135-145)
	201-205 (205-210)	137-142 (140-145)	201-205 (205-210)	137-142 (140-145)
Opening pressure on inspection when setting	bar (kg/cm ²)	bar (kg/cm ²)	bar (kg/cm ²)	bar (kg/cm ²)
Hole diameter	mm	mm	mm	mm
Needle lift	mm	mm	mm	mm
Soler B	mm w.g.	mm w.g.	mm w.g.	mm w.g.
Tightening nuts	Tm (kgm)	Tm (kgm)	Tm (kgm)	Tm (kgm)
No. of engine	150-500	450-500	450-500	450-500
No-load idling	r.p.m.	r.p.m.	r.p.m.	r.p.m.
High no-load	2650	2450	2450	2450
Max. load	2400	2200	2200	2200

With the damper device out of action see the appropriate Service Bulletin

turbocharger

Clearances and Tightening Torque

turbocharger type 3LD (engines DS5 and DS8)

See Service Bulletin Group 282 No. 1004

turbocharger type 4LE (engines DS11 and DS111)

See Service Bulletin Group 282 No. 1006

Charging Pressure

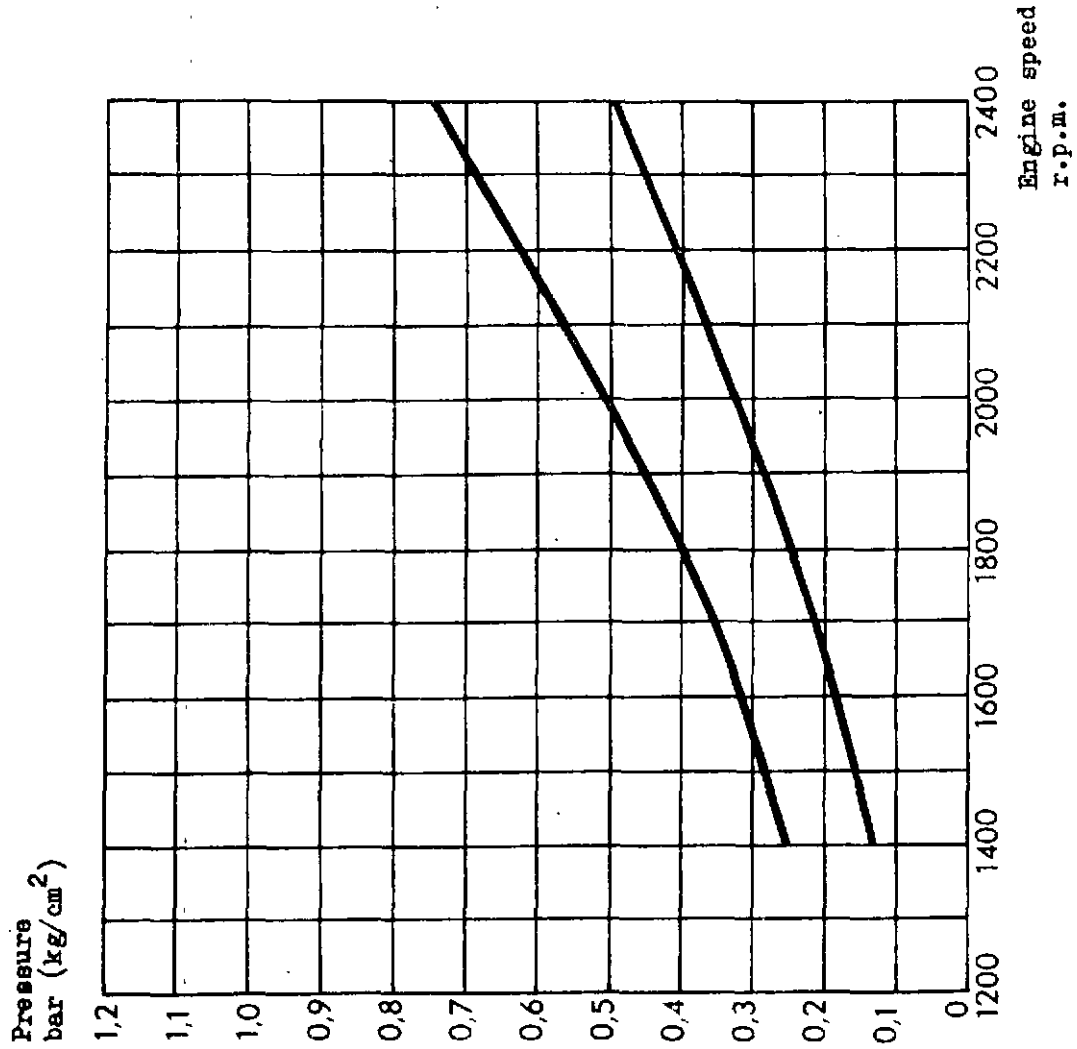
Correction table for measurement of charging pressure with consideration to the temperature of the intake air in °C. (The corrected values refer to an intake air temperature of +25°C and are to be compared with the current charging pressure diagram).

Charging Pressure Measured Below Bar (kg/cm ²)	Temperature of Air Sucked in °C (Ambient Temperature)											
	-20	-15	-10	-5	0	+5	+10	+15	+20	+25	+30	+35
0,20 (0,20)	0,16	0,16	0,17	0,17	0,18	0,18	0,19	0,19	0,20	0,20	0,21	0,22
0,30 (0,31)	0,23	0,24	0,25	0,26	0,27	0,27	0,28	0,29	0,30	0,30	0,31	0,32
0,40 (0,41)	0,31	0,32	0,33	0,34	0,35	0,36	0,37	0,38	0,39	0,40	0,41	0,42
0,50 (0,51)	0,39	0,40	0,41	0,42	0,44	0,45	0,46	0,47	0,49	0,50	0,51	0,52
0,60 (0,61)	0,46	0,48	0,50	0,51	0,52	0,54	0,55	0,57	0,58	0,60	0,62	0,63
0,70 (0,71)	0,54	0,56	0,58	0,59	0,61	0,63	0,65	0,66	0,68	0,70	0,72	0,73
0,80 (0,82)	0,62	0,64	0,66	0,68	0,70	0,72	0,74	0,76	0,78	0,80	0,82	0,84
0,90 (0,92)	0,70	0,72	0,74	0,76	0,79	0,81	0,83	0,85	0,88	0,90	0,92	0,94
1,00 (1,02)	0,77	0,80	0,82	0,85	0,87	0,90	0,92	0,95	0,97	1,00	1,02	1,05
1,10 (1,12)	0,85	0,88	0,91	0,94	0,96	0,99	1,02	1,05	1,07	1,10	1,13	1,16
1,20 (1,22)	0,93	0,96	0,99	1,02	1,05	1,08	1,11	1,14	1,17	1,20	1,23	1,26

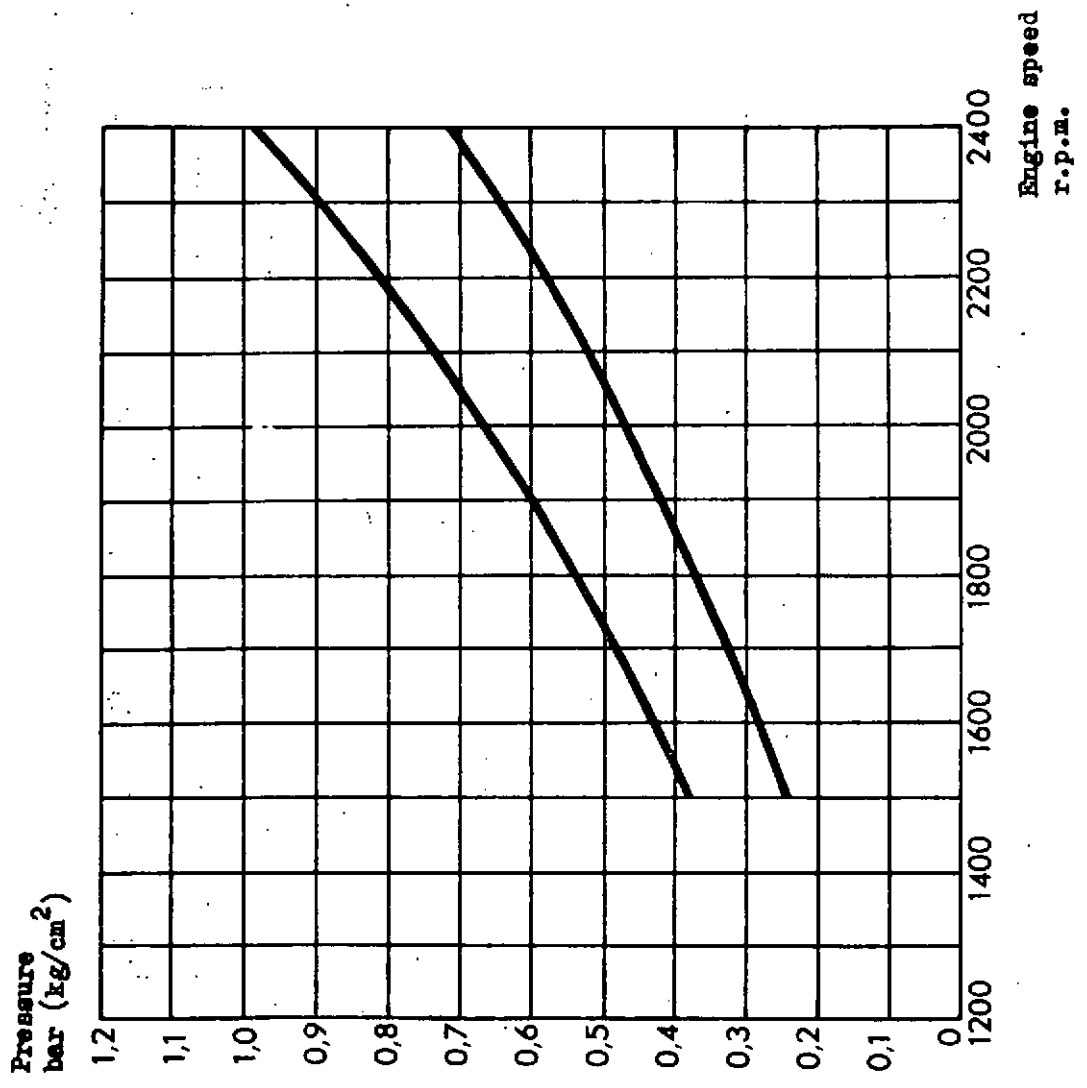
Example: A charging pressure of 1.0 bar (1.02 kg/cm²) measured at -15°C corresponds to 0.90 bar at +25°C.

A charging pressure of 0.50 bar (0.51 kg/cm²) measured at +35°C should at +25°C have been 0.52 bar etc.

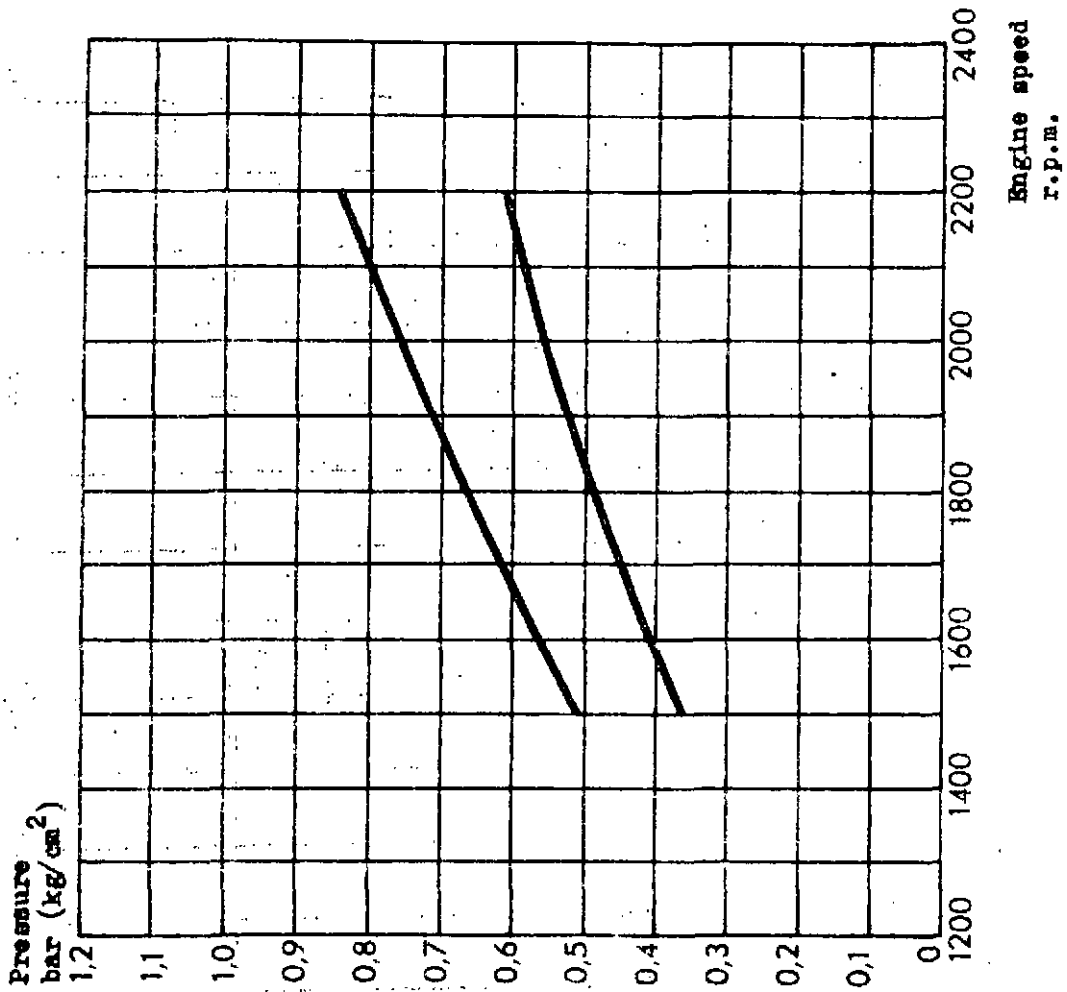
Limits of corrected charging
pressure for engines DS5
continuous duty air-cooled
exhaust pipe



Limits of corrected charging
pressure for engines D88
continuous duty air-cooled
exhaust pipe



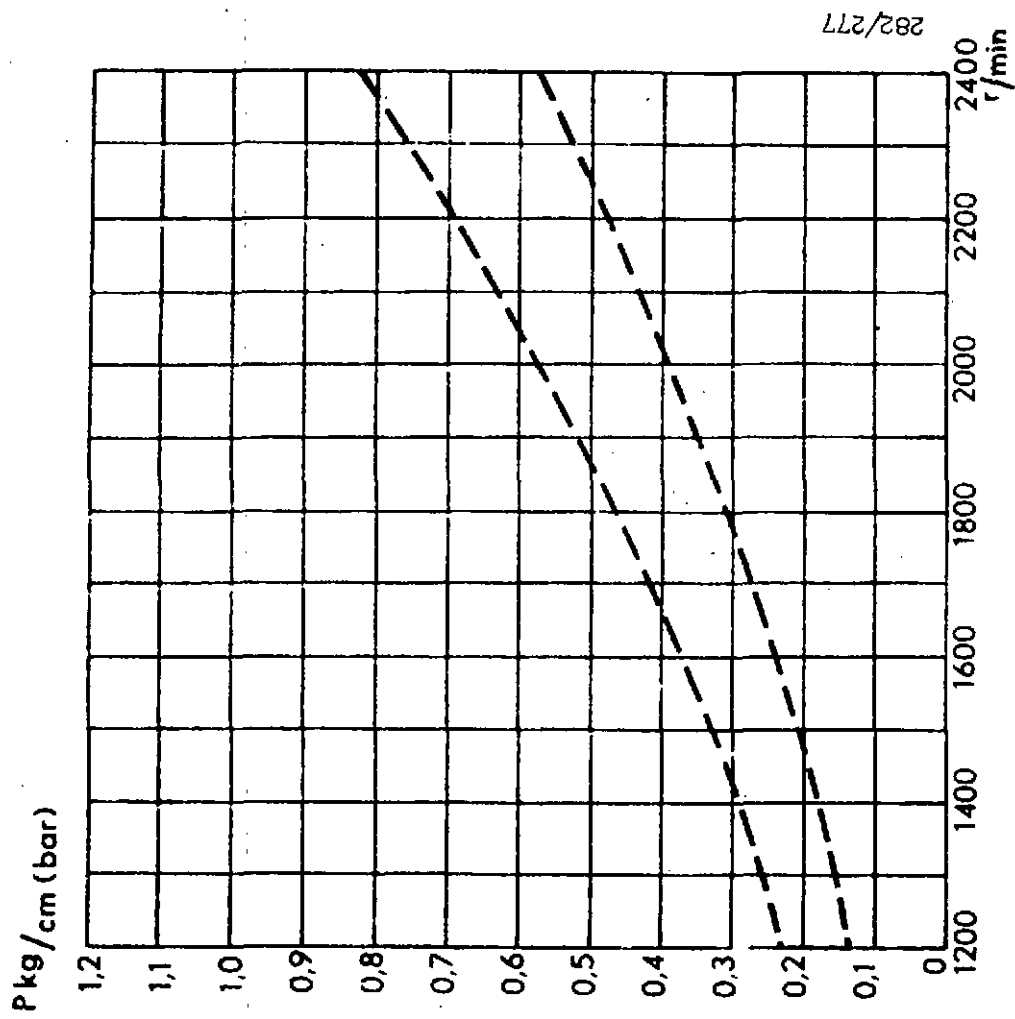
Limits of corrected charging
pressure for engines IS11A
260 hp SMMT continuous duty
air-cooled exhaust pipe



Limits of corrected charging pressure for engines IS111R82A with turbocharger type 4LE

Engine output hp SMMT	Engine speed r.p.m.	
	1400	1800
250	max. 0,55 min. 0.46	max. 0,70 min. 0,56
	bar (kg/cm ²) bar (kg/cm ²)	
230	max. 0.49 min. 0.36	max. 0.64 min. 0.46
	bar (kg/cm ²) bar (kg/cm ²)	

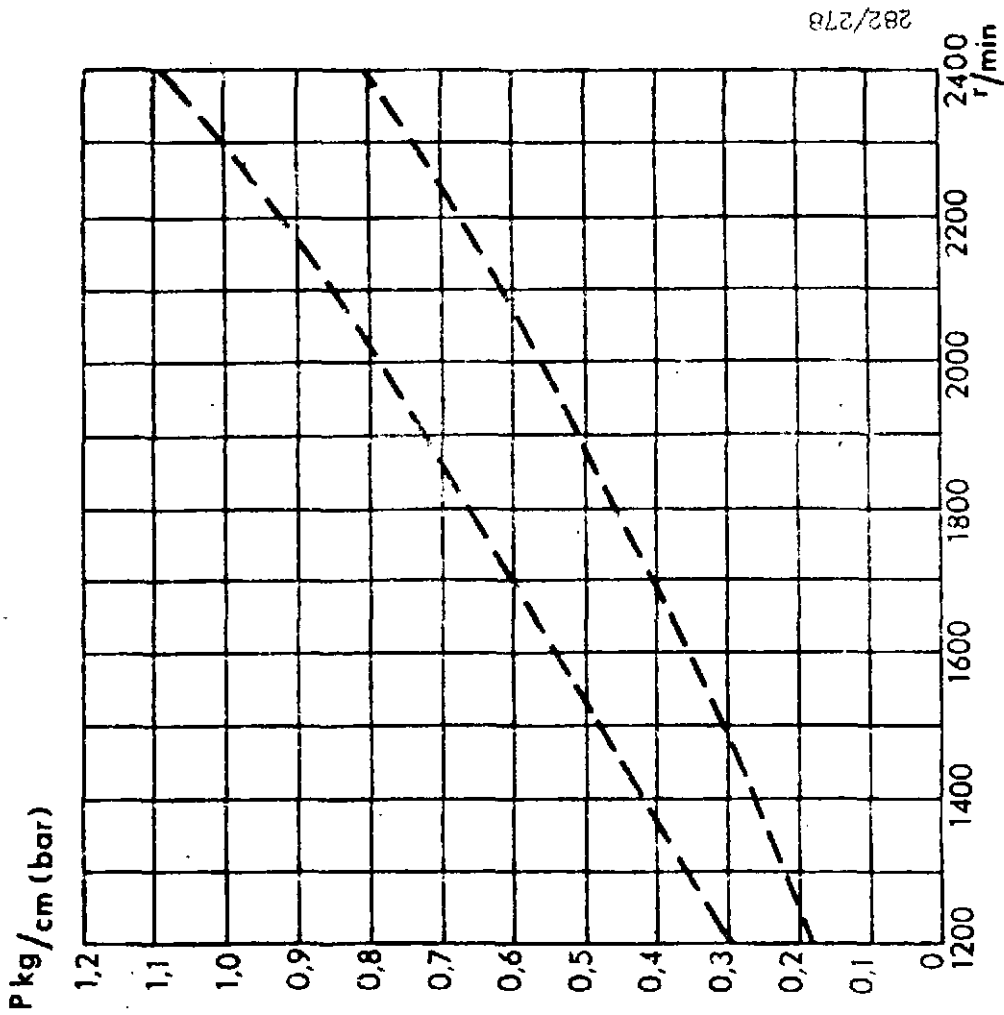
Limits of corrected charging
pressure for engines DS5
intermittent duty



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Diagram 1

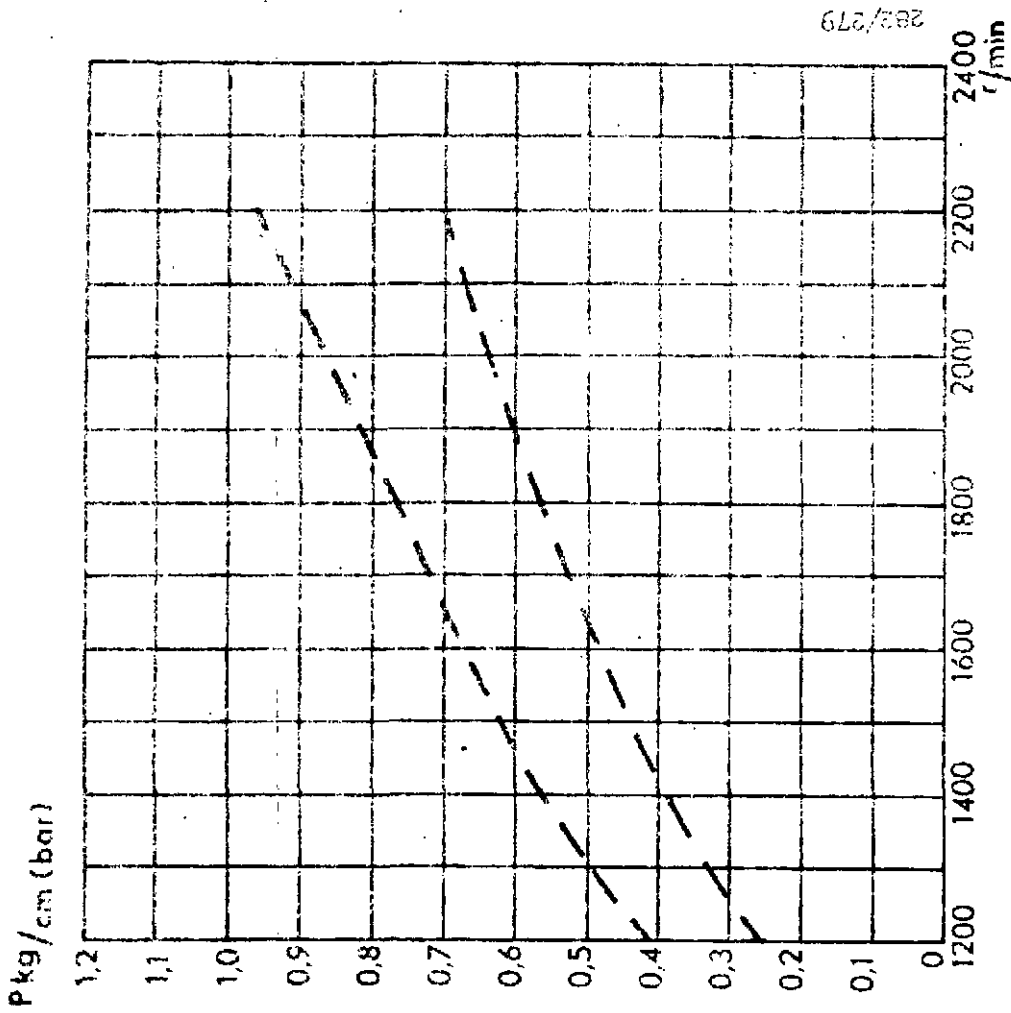
Limits of corrected charging
pressure for engines D68
intermittent duty



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Limits of corrected charging
pressure for engines IS11R01A
intermittent duty



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IS11R01A

Limits of corrected charging
pressure for engines DS11R06
intermittent duty

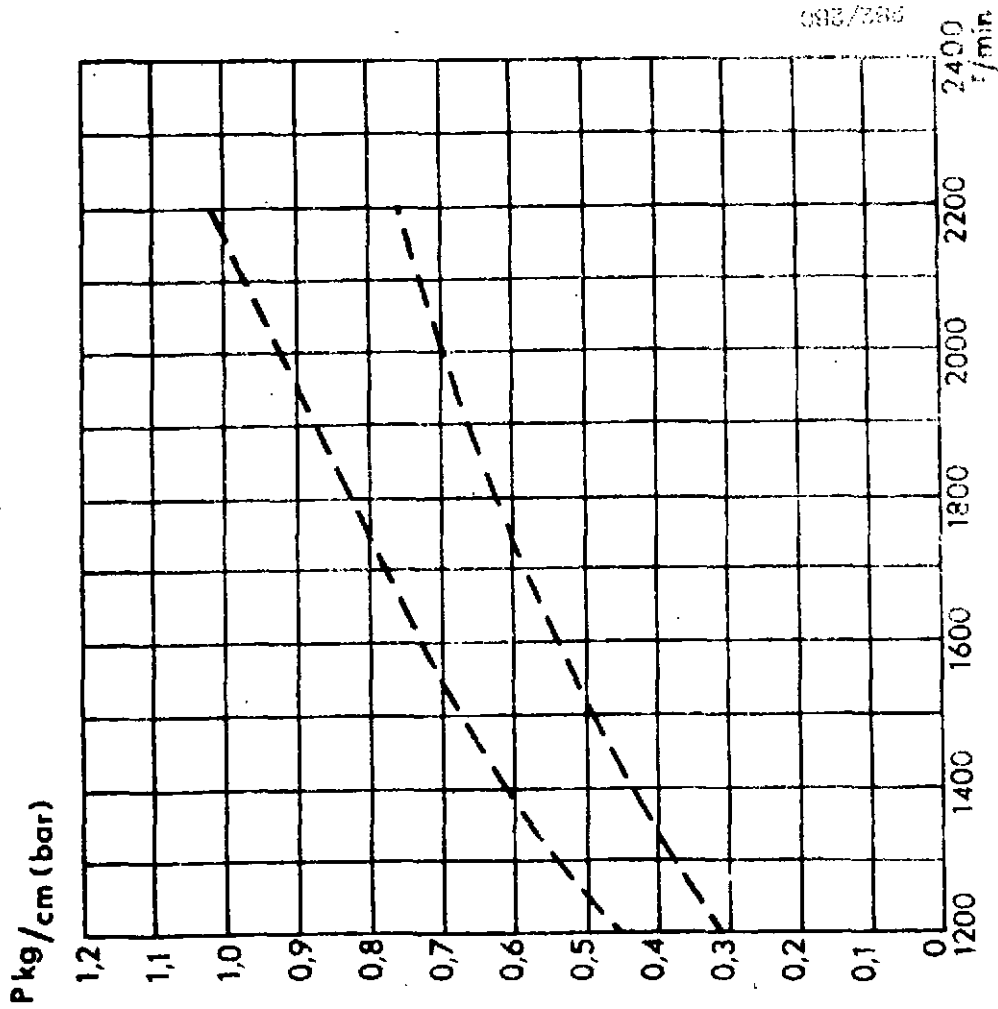


Diagram 2



Explanation of Engine Type References

Example: DS11R40

The engine type reference DS11R40 indicates the main particulars of the engine in code form.

D=diesel engine

S=engine equipped with turbocharger

I=engine equipped with intercooler

The number 11 indicates that the displacement of the engine is approximately 11 litres.

The following letter R (or L) indicates the siting of the injection pump:

R=engine with injection pump on right-hand side

L=engine with injection pump on left-hand side

The last two numerals indicate the class of installation:

01—19 engines for trucks

20—39 engines for buses

40—59 separate engines for general use

60—79 engines for power packs and generating sets

80—99 engines for marine applications

References for Classified Marine Engines

Example: DS11R80-LR

To ensure as far as possible that classified engines are fitted with classified spare parts, the engine type reference, carried on the engine name plate, is extended by two letters indicating the classification society in which the engine is classified.

The classification societies are denoted as follows:

LR=Lloyd's Register of Shipping

NV=Det Norske Veritas

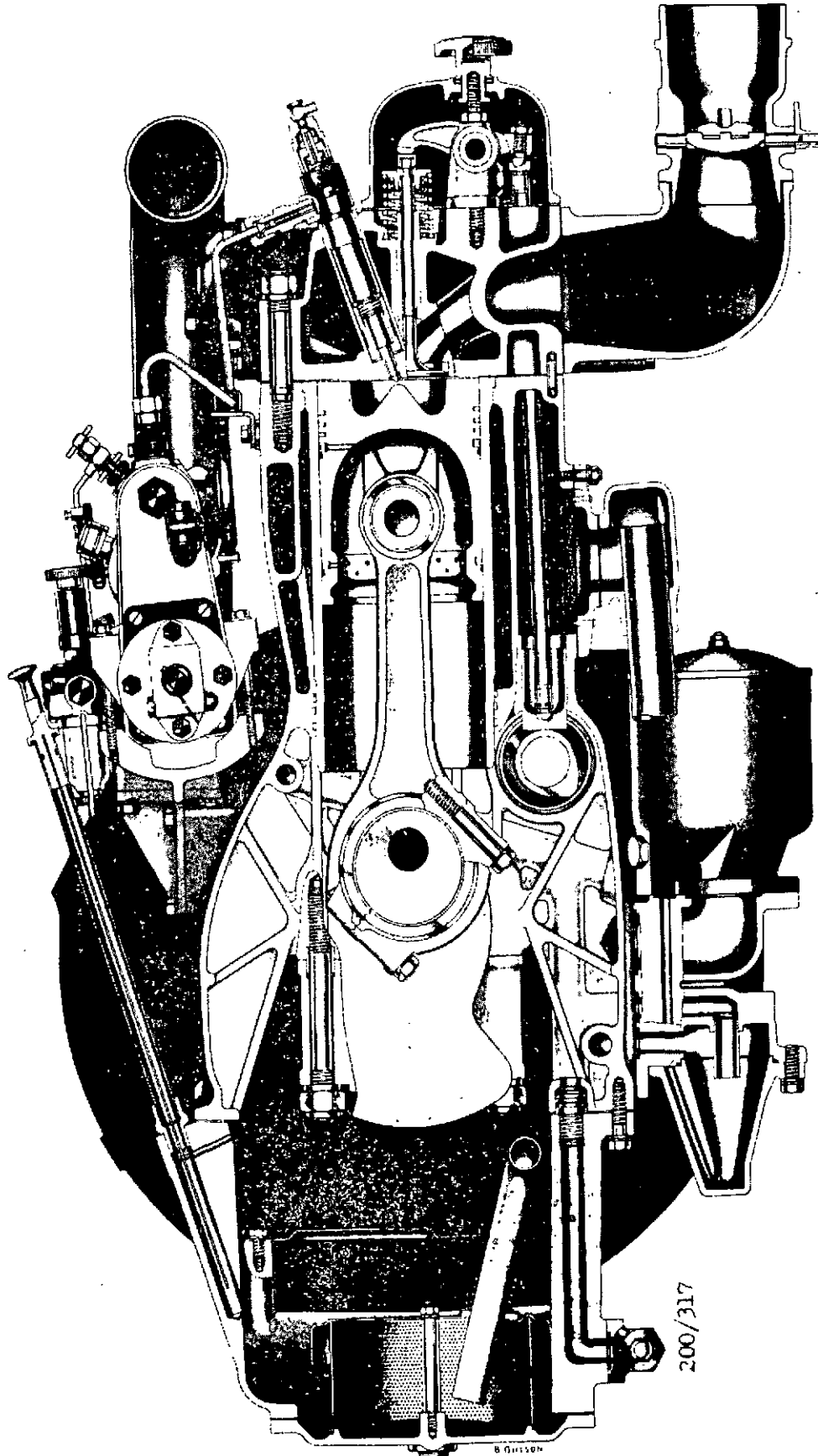
BV=Bureau Veritas

GL=Germanischer Lloyd

SF=Statens Fartygsinspektion (The National Swedish Ship's Inspectorate), Stockholm

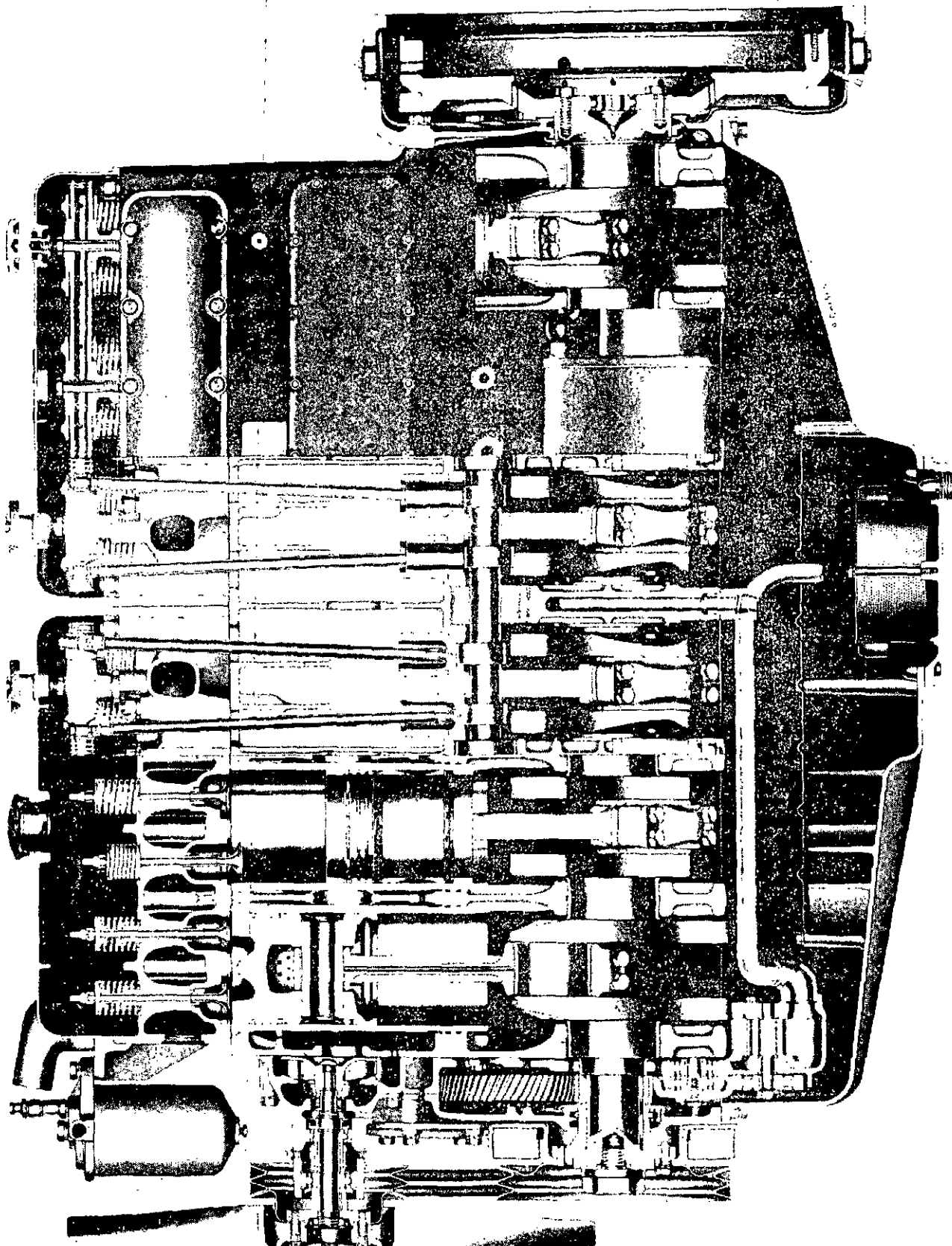
Thus the reference DS11R80-LR denotes a marine engine with a turbocharger and an intercooler, certificated by Lloyd's Register of Shipping.

Besides the engine number the complete engine type reference should always be



Diesel engine
Transverse section

17-1007



Diesel engine
Lengthwise section



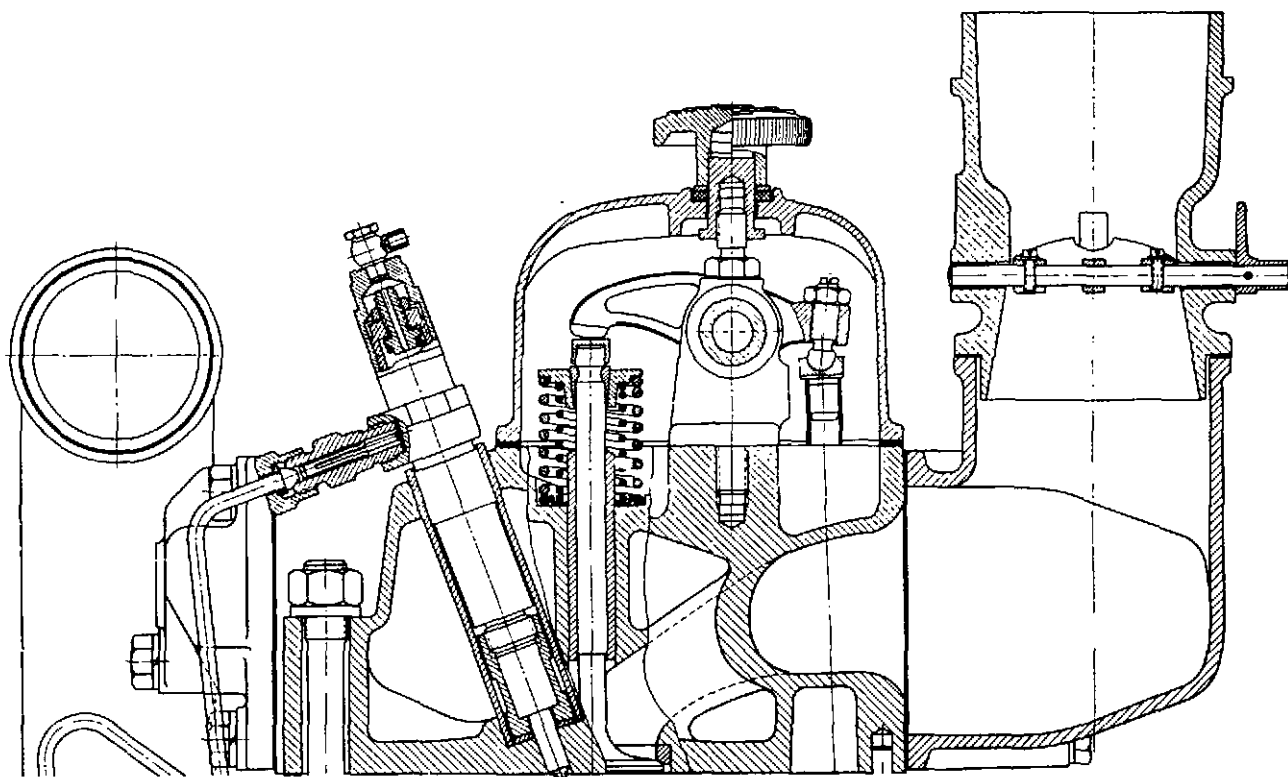
Cylinder Heads

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Inspecting Cylinder Heads	B3
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Fitting a Valve Guide	B3
Changing Valve Seat Inserts and Injector Sleeves	B4
Grinding Valve Seats	B4
Grinding Valves	B5
Checking Valve Springs and Fitting Valves	B6
Reconditioning the Valve Mechanism	B6
Fitting Cylinder Heads	B7
Adjusting the Valve Clearance	B8
Advancing the Cylinder-head Nuts	B8



Cylinder Heads



Cross-section of cylinder head

General

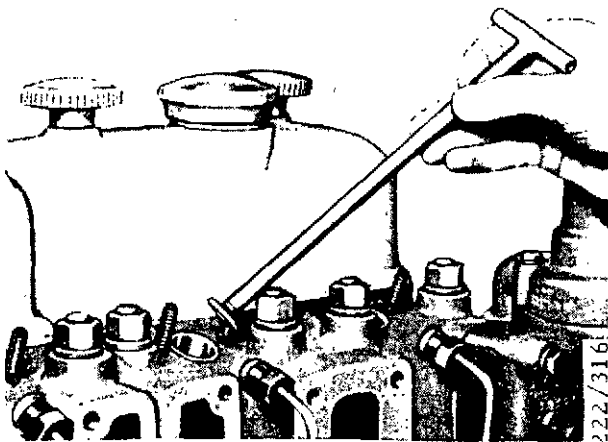
The cylinder heads are fitted with pressed-in valve seat inserts made of a special alloy. In each cylinder head there are also pressed-in stainless steel sleeves in which the injectors are mounted. These steel sleeves are in direct contact with the circulating coolant, which thus cools the injectors effectively.

The intake and exhaust valves are made of heat-

resistant steel with a satellite coating on the valve heads and with hard-chromium-plated valve stems. The valves are fitted with renewable hardened steel caps, against which the rocker arms bear. This keeps wear on the top end of the valve stems down to negligible proportions. The valve stems run in valve guides made of cast-iron.

Removing Cylinder Heads

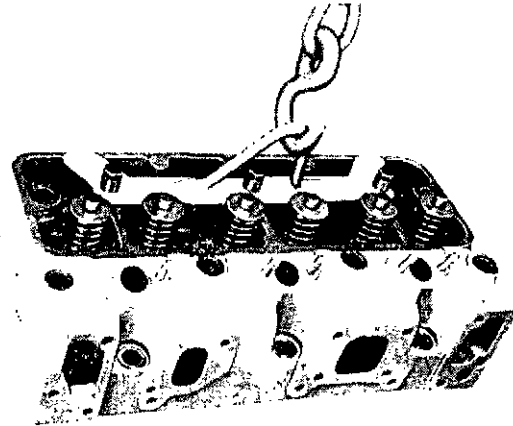
1. Drain off the coolant.
2. Remove the air cleaner and the vacuum pipes, undo the link rod of the throttle control at the throttle housing and remove the intake manifold.
3. Remove the exhaust manifold from the cylinder heads.
4. Carefully unscrew the metal sleeve of the coolant thermometer and remove the water-passage flange.
5. Disconnect the leak-off tube at the injectors. Fit protective plugs.
6. Remove the pressure pipes. Fit protective plugs at both ends of the pressure pipes and protective caps on the injection pump and injectors.
7. Remove the injectors. If the sealing washers do not come up with them, remove these washers using the extractor.
8. Remove the valve covers.
9. On engines with a lubricating-oil pipe running to the rocker-arm mechanism, disconnect the banjo connection of this pipe at the bearing bracket.



Take up the sealing washer of the injector

10. Undo the screws of the bearing brackets of the valve mechanism. Check that the gaskets beneath the bearing brackets do not fall down into the holes for the pushrods while the valve mechanism is being lifted clear.
11. Remove the pushrods carefully so that the valve lifters do not come with them.

12. Screw off the cylinder-head nuts. See that none of the nuts fall into the holes for the pushrods. Should this happen, the nut can be recovered by taking off the corresponding side cover.
13. Lift off the cylinder head with the lifting tool.



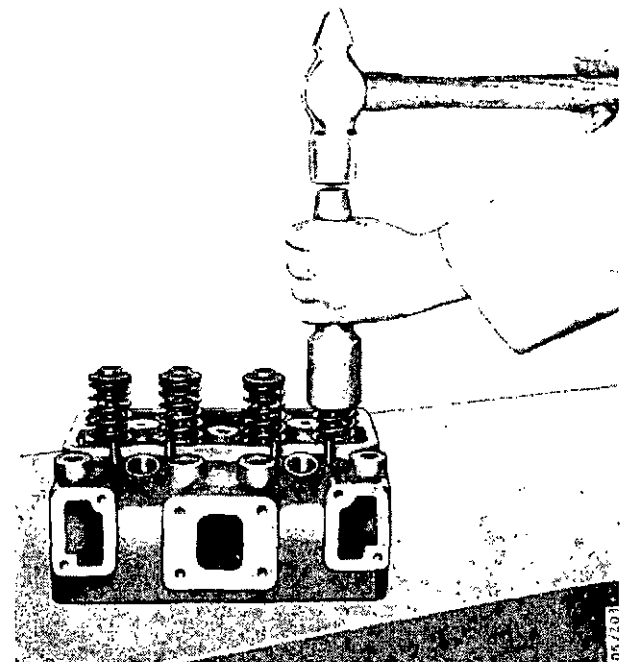
Lift off the cylinder heads

Reconditioning Cylinder Heads

Removing the Valves

Lift off the valve caps and remove the valves. The valve-stem keys can be removed with the aid of the drift, which is placed on the upper guide washer of the valve.

A heavy blow on the drift will compress the springs and release the keys.



Remove the valve-stem keys



The valve-spring compressor, which is actually designed for use in fitting the valve-stem keys, can also be used to remove them.

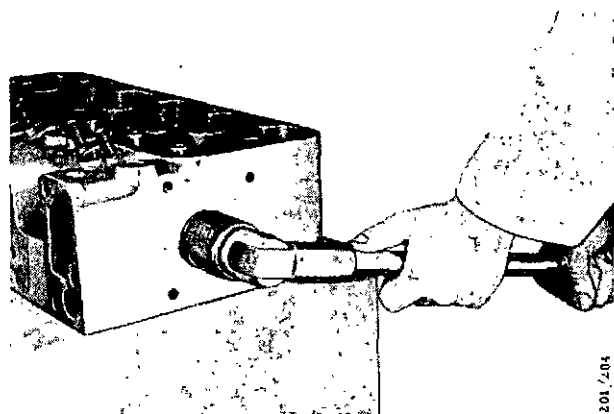
Put the valves into a valve stand in their correct order, which will make it easier to put them back into their original places during reassembly.

Inspecting Cylinder Heads

Examine each cylinder head for cracks and other defects. The underside of the cylinder head must be absolutely plane. The easiest and best way to check this is to use a surface plate smeared with marking blue. Marking blue adhering to the cylinder head indicates the points of unevenness. Small unevennesses can be corrected with a scraper. The cylinder head must then be checked again with the surface plate. The correction of greater unevennesses calls for machining.

While the cylinder head is out of the engine the coolant passages should be scraped clean and then blown through with compressed air.

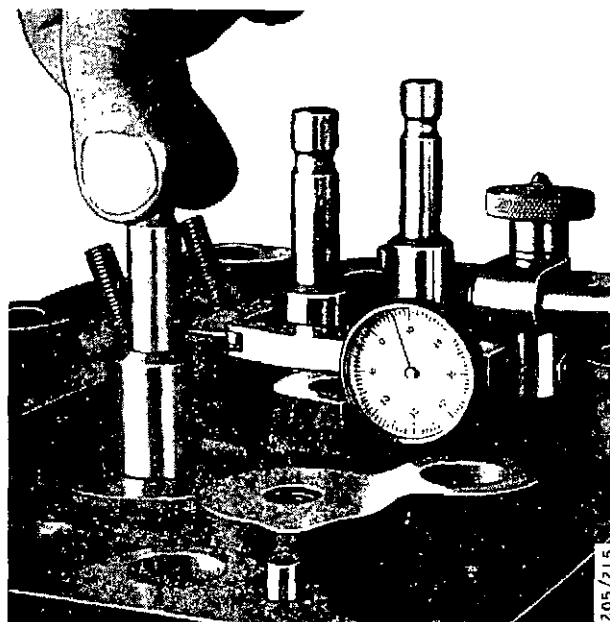
Examine the sealing plugs in the cylinder heads for damages. Check that the threads of the sealing plugs and cylinder heads are clean. If required, replace the sealing plugs by new ones with oversize threads. Fit new sealing rings. Smear self-hardening plastic on the threads. Tighten the sealing plugs using the stud wrench.



Fit the sealing plugs

If the clearance between valve stems and valve guides is excessive, the guides should be replaced by new ones. Excessive clearance between valve and guide results in poor valve sealing and increases the oil consumption, since more oil passes through the guides of the intake valves than is needed for lubrication.

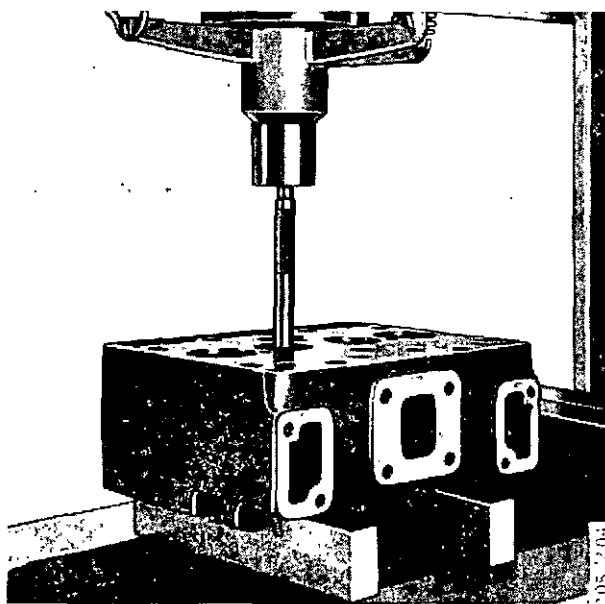
The clearance is best checked by using a dial



Check the clearance between the valve stem and valve guide

Removing a Valve Guide

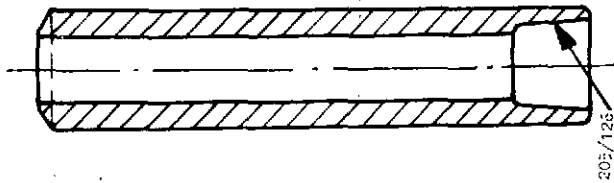
The old valve guides are removed with a drift, by means of which they are pressed out towards the top of the cylinder head.



Press out the valve guides

Fitting a Valve Guide

Oil the valve guides before fitting them. The guides of the intake and exhaust valves differ in design. It is therefore important to fit them into the right holes. The lower end of the exhaust valve guide has a recess intended to prevent deposits of coke which would make the valve stick. If this guide is not renewed, the recess should be scraped



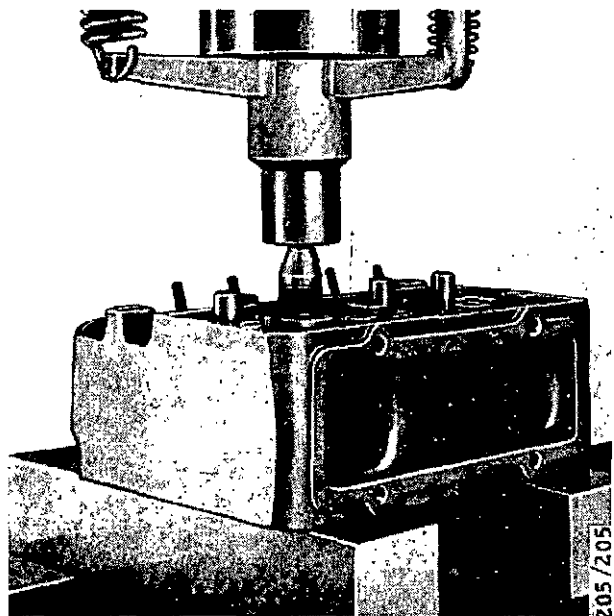
Exhaust valve guide

1. The valve guide has a recess which must be turned towards the valve head

To ensure that the valve guide is correctly positioned and is not damaged while being pressed in, the appropriate drift should be used.

This automatically gives the correct distance from the upper edge of the guide to the seating plane of the springs when the drift is pressed down against the cylinder head. After the guide has been pressed in, its inside diameter will be correct and will not need any subsequent treatment. The guide should, however, be checked with a gauge or a new valve.

Always use a press in fitting a guide. If the guide is driven in with a hammer it can easily be upset, rendering additional treatment necessary.



Press in the valve guides

Changing Valve Seat Inserts and Injector Sleeves

Valve seat inserts whose seating surface, as a result of repeated grinding, has acquired an outer diameter (dimension D) greater than the stated figures must be changed.

Also, of course, damaged and loose valve seat inserts must be renewed. Pay particular attention to the seats of the exhaust valves.

Proceed as follows in removing valve seat inserts.

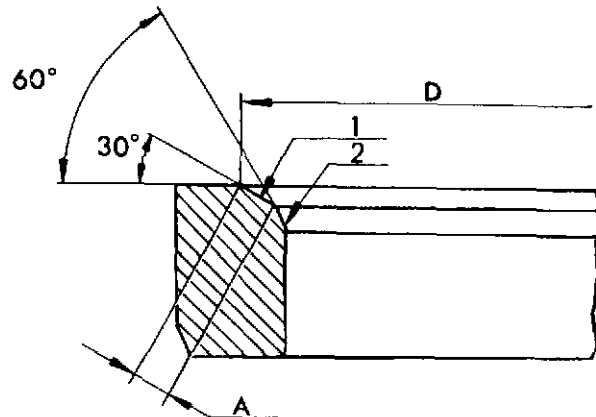
1. If no suitable puller is available, a mounted grinding wheel can be used to grind two diametrically opposite grooves in the insert, after which the two halves can be levered out.

2. Wash the cylinder head.
3. Give the cylinder head a pressure test if water leaks are suspected, and change the injector sleeves if necessary. If the sleeves are leaky the injectors will usually be found to be corroded. In this case, cut a suitable thread in the upper part of the sleeve to provide a hold for a puller.
4. In fitting the injector sleeves, oil them and press them down into the cylinder head.
5. Smear the valve seat recesses with a suitable carbon solvent. The cylinder heads can also be laid with the recesses downwards in a container holding enough solvent to ensure that the recesses come into contact with the liquid.
6. Clean the valve-seat recesses.
7. Before being pressed in, the valve seats, and also the drifts, must be chilled to the stated temperature, for example using carbon dioxide snow in a heat-insulated container. Inserts to be cooled should be in close contact with the snow for at least 15 minutes. The pressing in of the valve seat inserts must be done very quickly, since the insert warms up almost at once when it comes into contact with the recess in the cylinder head. To prevent excessive heat transfer from the drift to the insert the drift must also be chilled. If liquid air is available we recommend it as a cooling agent. In this case, however, the drift need not be chilled.

N.B. Take care in handling the above-mentioned cooling agents and items chilled with them, since frostbite is a very real hazard.

Machining Valve Seats

1. After the inserts have been pressed in, the seats must be very carefully adjusted in relation to the valve guides. Use for this purpose the appropriate milling tool with a locating spindle screwed with moderate force into the valve guide.
2. Turn the milling head with the 30° milling angle side facing the valve seat and put the milling head over the locating spindle, using the T-wrench. Turn with as much uniform force and speed as possible until the sealing surface attains the width A. If the sealing surface should be

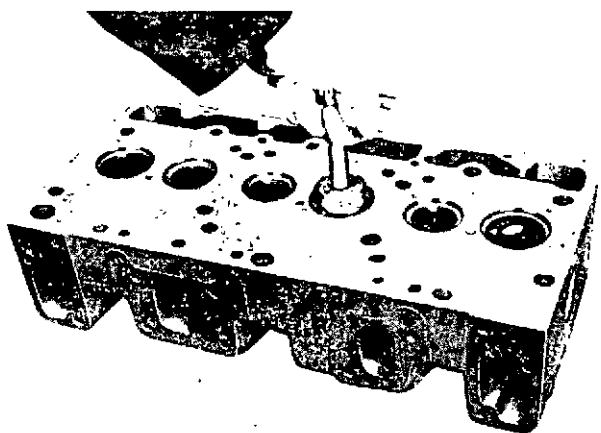


Valve seat insert

1. Sealing surface
2. Bevel

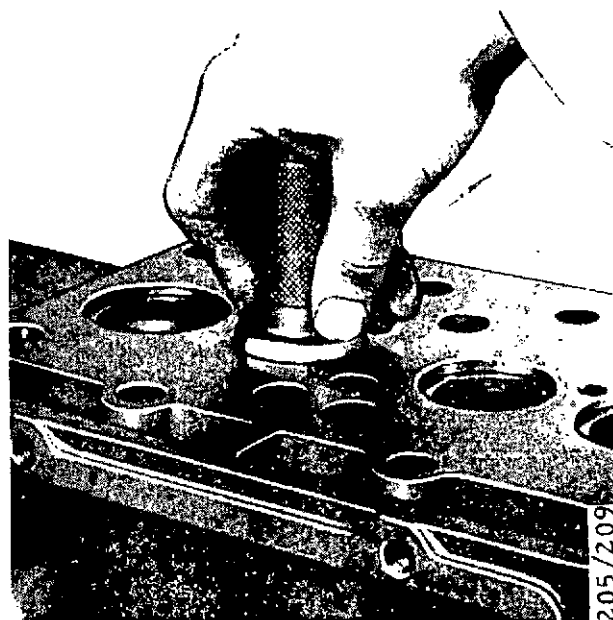


wider, which may easily occur on re-milling the valve seat. mill at 60° the inner edge of the valve seat until the width of the sealing surface does not exceed the maximum permitted value.



Machine the valve seats

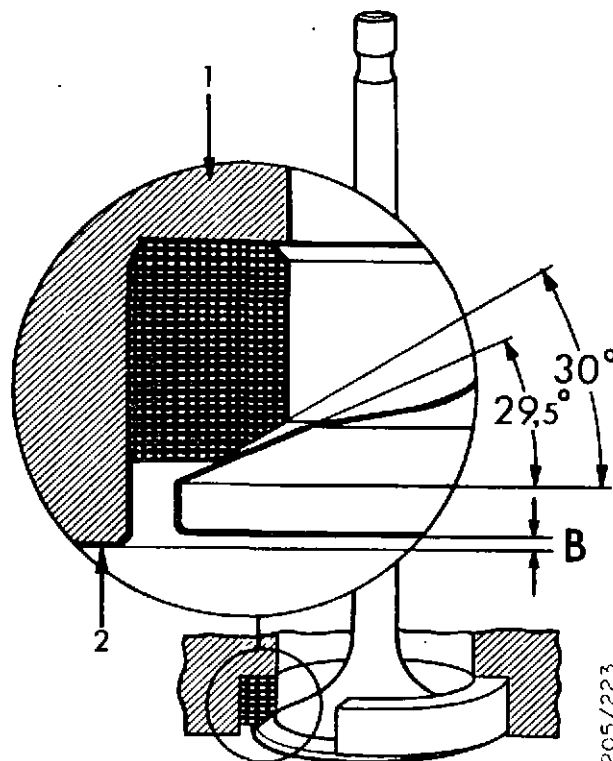
3. Smear the sealing surface with a thin layer of marking blue. Put the valve seat gauge into the valve guide, press it lightly against the valve seat and turn it to and fro. The marking blue will show whether the valve seat has the correct angle. If that is not so, find out the cause and take the measures required. Mill then once more and check.



Check the sealing surface of the valve seat

Grinding Valves

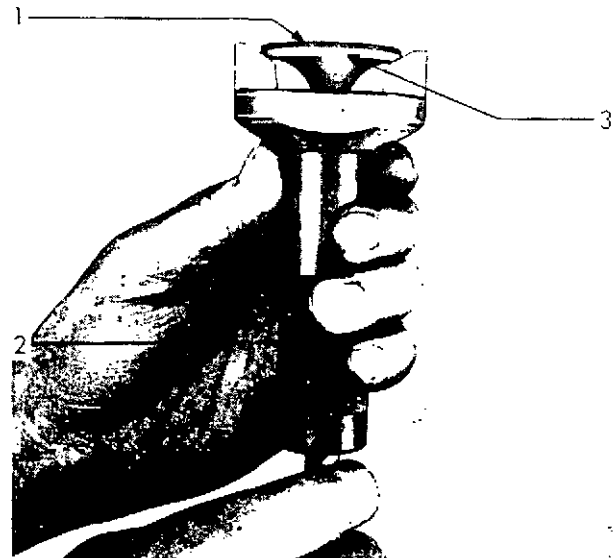
In order to make the sealing between the valve and seat as effective as possible, the sealing surfaces have been given a special shape. Thus the valve seat has an angle of 30° , while the corresponding angle on the valve is 29.5° . This arrangement produces a very narrow sealing surface, which during the bedding-in period gives better sealing than a



Valve and valve seat insert

1. Cylinder head
2. Underside of cylinder head

1. If the sealing surfaces of the valve heads are defective, the valves must be reground by machine. Set the grinding machine to 29.5° . The grinding wheel should be a ceramic-bonded aluminium oxide wheel, grain size 70 or possibly 80, and hardness M-N with a structure of 8. Check the angle of the grinding wheel before grinding, and correct it, if necessary, using a diamond. Do not grind away more metal than is absolutely necessary to give a clean contact surface. After grinding, check the angle of the sealing surface with the valve gauge.

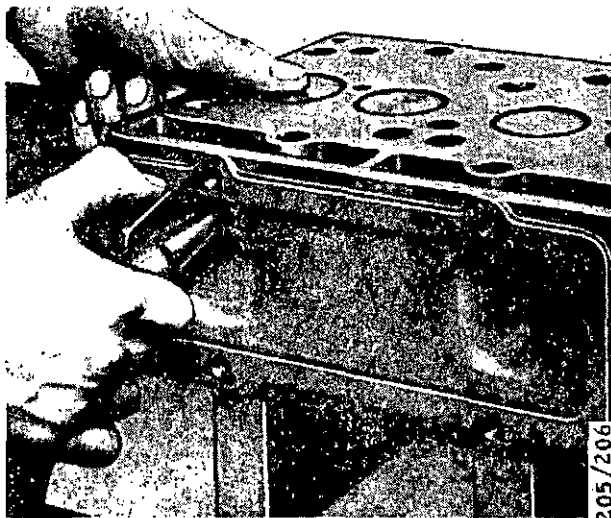


Check the sealing surface of the valve

205/223

205/209

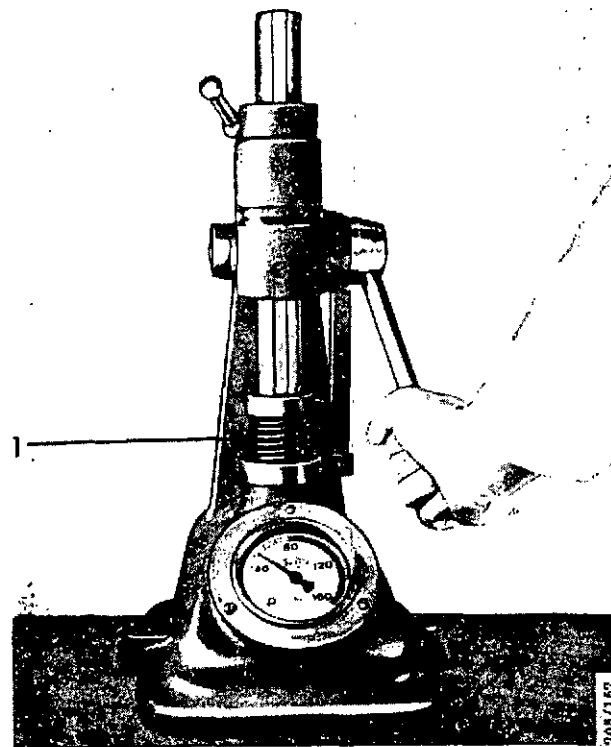
2. Check the sealing of the valve as follows: Fit the valve into the cylinder head and pour a little liquid onto the valve head. Press the valve against the seat and blow compressed air in from below. If the valve is leaky, air bubbles will appear around the valve head. But the blast of compressed air must not be so powerful that the valve is lifted by the air pressure. If the valve *does not seal, machine the valve seat (not the valve) once more using the milling tool. Then clean the valve seat and test it afresh with the valve.*
3. Blow the head and seat of the valve clean with compressed air and check the dimension B.



Check that the valve seals properly

Checking Valve Springs and Fitting Valves

1. Before the valve springs are fitted they should

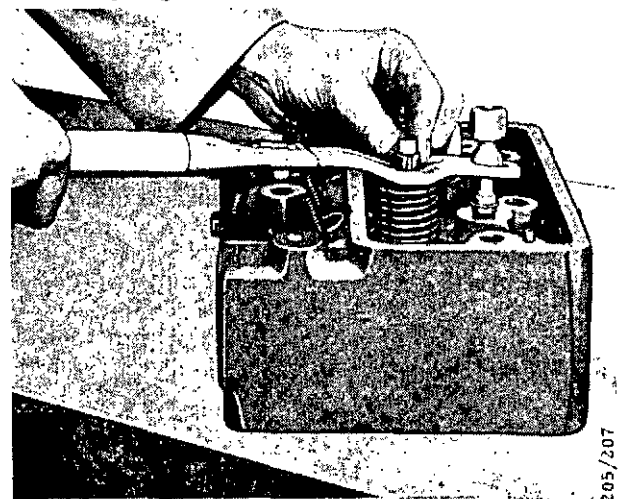


Test valve springs

be checked individually in a spring testing apparatus with respect both to their free length and their length under a given load.

2. Check also that there are no cracks or other defects in the springs.
3. Oil the valve stems with engine oil and fit the valves into the guides.
4. In fitting the valve springs, first put the guide washers into place and then fit, in the following order, the inner spring, the outer spring, and the washer above the springs. The valve springs are made with a pitch increasing towards one end. The more tightly wound end of the spring must be turned to face the cylinder head. The way to find out which end is the more closely wound is to see how far a conical implement (e.g. a pencil point) can be inserted between the first and second turns of wire opposite the ends of the spiral.

Using the valve-spring compressor, compress the springs and fit the valve-stem keys.



Fit the valve-stem keys

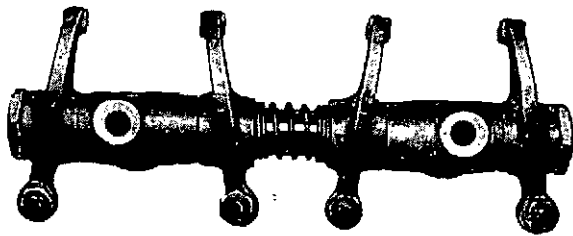
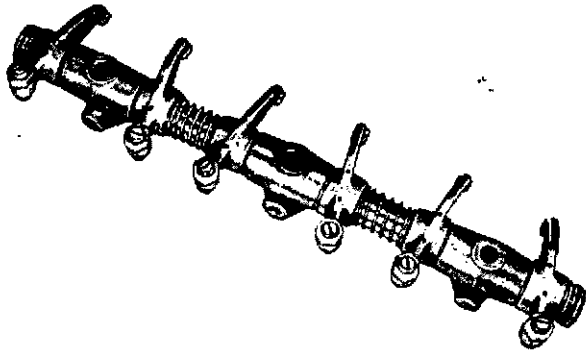
5. Fit the valve caps. *These caps must be free to rotate easily on the valve stems.*

Reconditioning the Valve Mechanism

1. In engine reconditioning, the whole of the valve mechanism should be stripped down and checked. First examine the valve lifters. The surface at which the valve lifters contact the camshaft must not show any depressions or other damage. Defective valve lifters must be renewed.
2. Check that the pushrods are straight by rolling them on a surface plate. Against a light background it is very easy to see whether they are straight or not. If the deviations are not excessive the pushrods can be straightened out using a rubber mallet. See that the balls and ball cups have not worked loose in the rods. Examine the balls and ball cups. Remember that the ball cups, too, are subject to wear. The length of the pushrods should also be checked. The simplest way to do this is to compare them with a new pushrod.
3. Strip the rocker-arm mechanism down.
4. Wash all components.

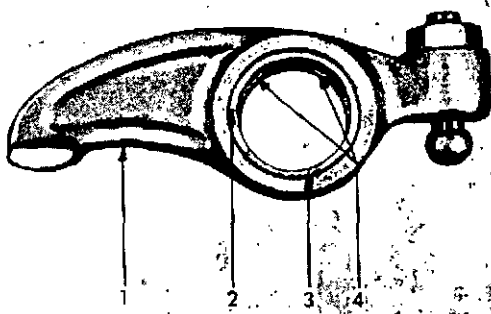


shaft are clean, and that the shaft is undamaged.



Rocker-arm mechanisms

6. Check that the ball stud on the rocker arms has not worked loose or become damaged.
7. Check the surface at which the rocker arms contact the valve caps. In mild cases of wear the surface can be corrected in a grinding machine.
8. A rocker-arm bushing which has become worn oval must be changed. It is pressed in and out using the drift. The bushing must be pressed in so that the slit comes in the position shown in the figure. The bushing must be flush with that side of the rocker arm that bears against the bearing bracket.



Rocker arm with bushing

1. Rocker arm 3. Bushing

N.B. Two holes for the oil passages must be drilled in the bushing.

The bushing must then be reamed to bring the clearance to the correct figure.

Clean up thoroughly.

9. Clean the oil passages in the rocker arms.
10. In assembling the rocker-arm mechanism, first oil the shaft and then fit the various components in order. Note that the rocker arms are of two different designs, being arranged in opposite pairs.

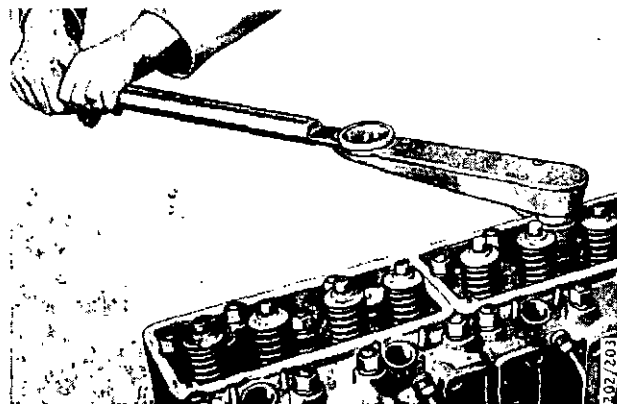
For the fitting of the rocker-arm mechanism onto the cylinder head, see points 5 and 6 under the heading "Fitting Cylinder Heads".

Fitting Cylinder Heads

The order of assembly of the cylinder head and its various components is the reverse of that of removal.

Before putting the cylinder heads on, check that the studs that take the cylinder-head nuts are really tight.

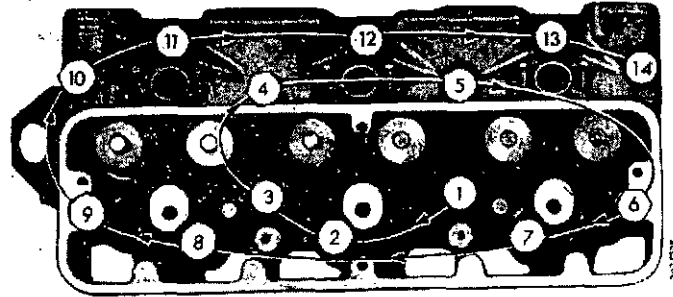
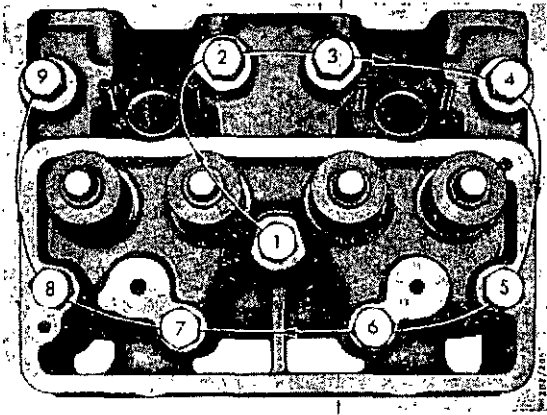
1. Besides this, make a thorough check to see that the sealing surfaces on the cylinder block, the liners, the cylinder head and the gasket are undamaged and absolutely free from coke deposits and other impurities. The stud holes in the cylinder head should also be cleaned. The reason for this is that high working pressures in the engine make it extremely important for the various components to seal perfectly against each other. The cylinder-head gasket must always be renewed. Turn the gasket so that the part number faces upwards, towards the cylinder head. Be careful not to damage the gasket in threading it over the studs.
2. Lift the cylinder head into place and check that it fits properly onto the locating pins.
3. Smear the washers of the cylinder-head nuts, and the threads of the studs, with engine oil.



Always tighten the cylinder-head nuts with a torque wrench

4. Tighten the cylinder-head nuts in the order shown in the figure, working in three stages as follows:

First tighten all the nuts to 50 % of full torque, then once to 75 % of full torque, and finally once to full torque.



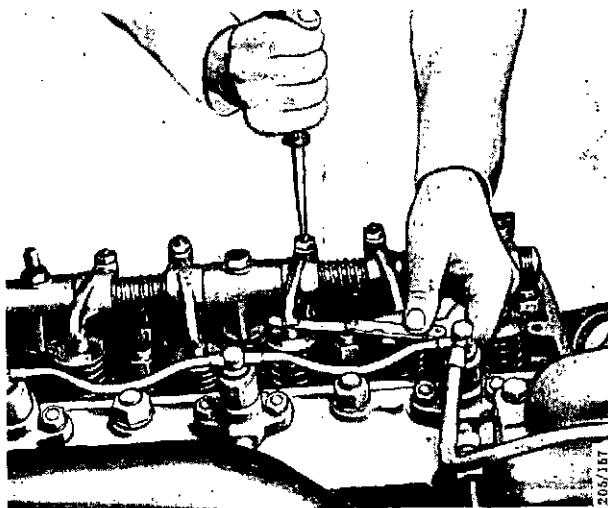
The cylinder-head nuts should be tightened in the order shown here

5. On engines having a lubricating-oil pipe running to the rocker-arm mechanism, fit this pipe.
6. Check that no sealing washers have been left down in the injector sleeves. Always fit new washers.
7. The nuts of the injectors must be tightened to the stated torque. This torque is obtained automatically if the job is done with the appropriate torque wrench.

Adjusting the Valve Clearance

After the cylinder heads have been fitted the valve clearance must be adjusted. It is simplest to adjust the valve for one cylinder at a time, taking them in the firing order. The piston in the cylinder whose valves are to be adjusted must be at T.D.C. on its compression stroke. The simplest way to bring this about is to bar the engine to the position at which both the valves are slightly open (dead centre after the exhaust stroke) in the cylinder whose piston occupies the same position as that for which the valves are being adjusted.

Adjust the clearance by means of the adjusting screw at one end of the rocker arm. When the



Adjust the valve clearance

clearance is correct, lock the adjusting screw with the locknut. The engine need not be quite cold while the valve adjustment is being carried out. But do not adjust immediately after a run; give the engine at least half an hour to cool down before starting work.

Check that oil reaching the rocker-arm mechanism.

The valves should not be adjusted with the engine running.

Advancing the Cylinder-head Nuts

After running the engine up to its working temperature, the cylinder-head nuts must be advanced while the engine warm.

1. Follow points 8—10 under the heading "Removing Cylinder Heads".
On engines with cylinder-head nuts beneath the pressure pipes, these pipes must be detached from the injectors to enable the cylinder-head nuts to be tightened with the appropriate wrench.
2. Follow points 3—5 under the heading "Fitting Cylinder Heads".
3. Give the engine at least half an hour to cool down and check the valve clearance according to the instructions given under "Adjusting the Valve Clearance".

When the engine has been run for some 50 hours or 2,500 km, advance once more the cylinder nuts.

Follow the instructions under "Advancing the Cylinder-head Nuts", except for point 2 where in this case the following measures are to be taken:

2. Loosen by four turns each cylinder head nut, lubricate with motor oil the washer and the stud threads and tighten immediately the nut to the indicated (full) torque. Tighten in this way all the nuts in the order shown by the figure.



Cylinder Block

C

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Cylinder Block

General

The cylinder block and the upper half of the crankcase are a one-piece casting of alloy cast-iron. The main bearing caps are steel forgings. The cylinder block has renewable cylinder liners of the wet type, by which is meant that the liners are in direct contact with the circulating cooling water. The sealing between each liner and the cylinder block at the lower end of the liner is provided by three rubber rings seated in grooves in the cylinder block. The sealing at the upper end of the liner is effected by the cylinder-head gasket, which presses the collar on the liner down against a seating surface located in a recess in the block. Between the two lower O-ring grooves at each cylinder there is a drilled "tell-tale" hole through the wall in the cylinder block. If coolant or lubricating oil runs out of any of these holes on the outside of the block the affected cylinder seals should be renewed before more serious damage occurs.

Cylinder Block

When the engine is stripped down for complete reconditioning the cylinder block must be cleaned. Wash off oil deposits in the crankcase with a suitable solvent. Then blow everything clean with compressed air. Carefully remove all remnants of old gaskets.

If the crankshaft is not to be removed, the oil passages in the crankpins must be protected against the entry of dirt immediately after the removal of

the pistons and connecting rods. Wrap cellophane tape or insulating tape round the crankpin so as to cover the lubricating passages. Apply the tape with the sticky side out so as to make it easier to remove in due course.

Measuring Cylinder Wear

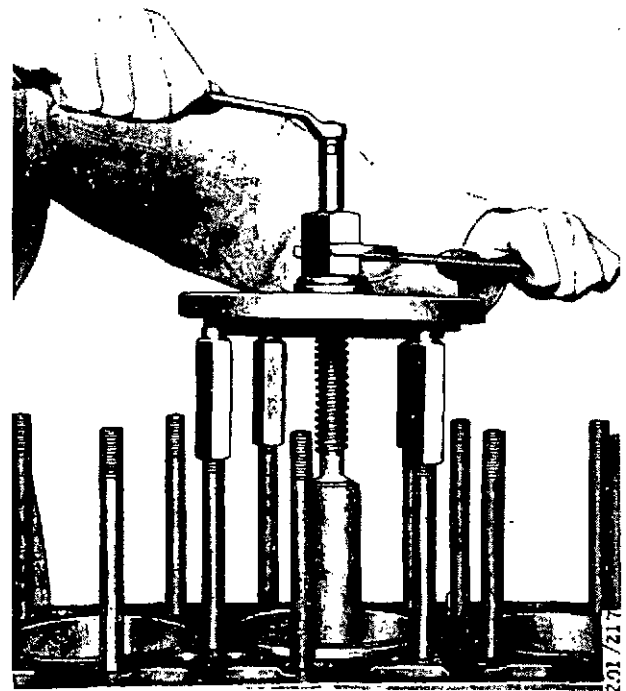
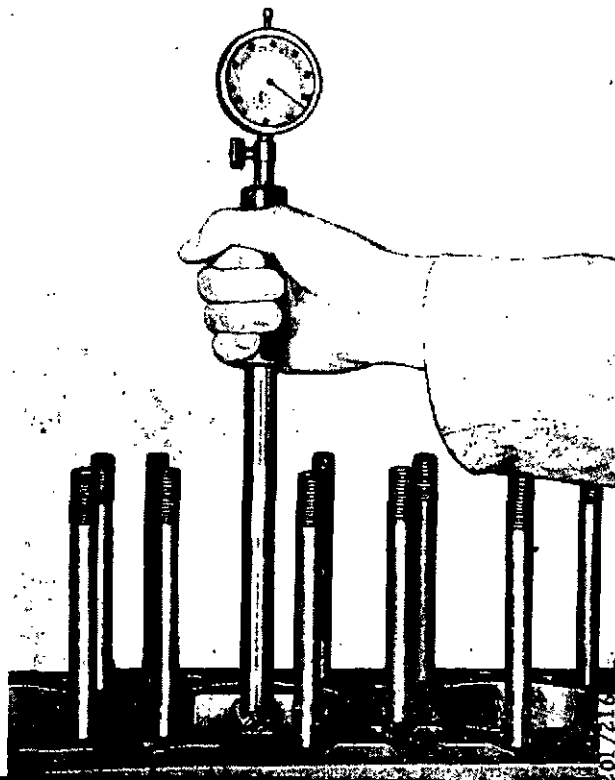
Wipe out the cylinder bores thoroughly before taking any measurements. The work of measurement is done with a cylinder dial gauge, which can be zeroed using, for example, a new cylinder liner or a micrometer.

If oil consumption is high and wear exceeds the stated figure a change of cylinder liner should be considered, if a temporary repair is wanted. When complete engine reconditioning is being carried out we recommend changing the liner if this degree of wear is found.

Changing a Cylinder Liner

Removing the Cylinder Liner

1. Remove pistons and connecting rods: see the section entitled "Crankshaft and Reciprocating components".
2. Remove the cylinder liner using an extractor. Put on the stud extensions. Introduce the extractor through the cylinder liner and bring the plate to bear on the studs. Turn the crosspiece so that the liner is positioned to bear against the shoulder during extraction. Then screw down the extractor nut until the liner comes away. To prevent the rod from rotating with the nut, apply a suitable tool to the four-square flats at the upper end of the rod.

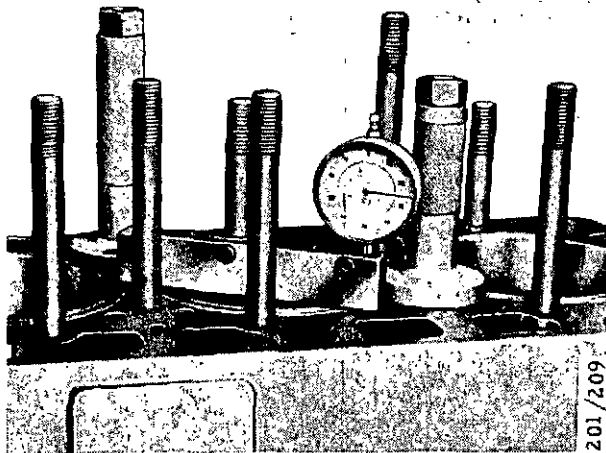


Inspecting the Cylinder Block and Cylinder Liners

1. If there is an excessive amount of scale in the block it must be removed, since cooling would otherwise be jeopardized. The coolant comes from the coolant pump through a passage along one side of the block and goes out through holes in the walls of the passage up into the cylinder head and also towards the liners. When these holes have been cleaned it will be possible to see whether the distribution gallery is choked up. If it is, the plugs on the outside of the block must be removed and the gallery cleaned out. Investigate the sealing plugs in the cylinder block for damages. Check that the threads on the sealing plugs and in the cylinder block are clean. If required, replace the sealing plugs by new ones with oversize threads. Fit new sealing rings. Smear self-hardening plastic on the threads. Tighten the sealing plugs using the stud wrench.
2. Check that the seating surface of the cylinder liner on the block is clean and free from defects. If the surface is damaged it may be necessary to use the facing tool. But this method should be resorted to only when it is absolutely necessary. Great accuracy must be observed to ensure that the seating surface is not made crooked.

The least possible amount of metal should be removed; it is best if the surfaces are merely scraped clean.

3. Give new cylinder liners a thorough inspection. Defects may arise during transport and through careless handling. Damaged edges, etc., are easy to spot but a crack is not so readily detected. The best way to detect cracks in the liner is by "ringing" it. If it is sound a clear bell-like tone will be heard, whereas a cracked liner will produce a "creaked" sound. Clean the upper and lower locating surfaces and the seating surface, and the grooves for the sealing rings.



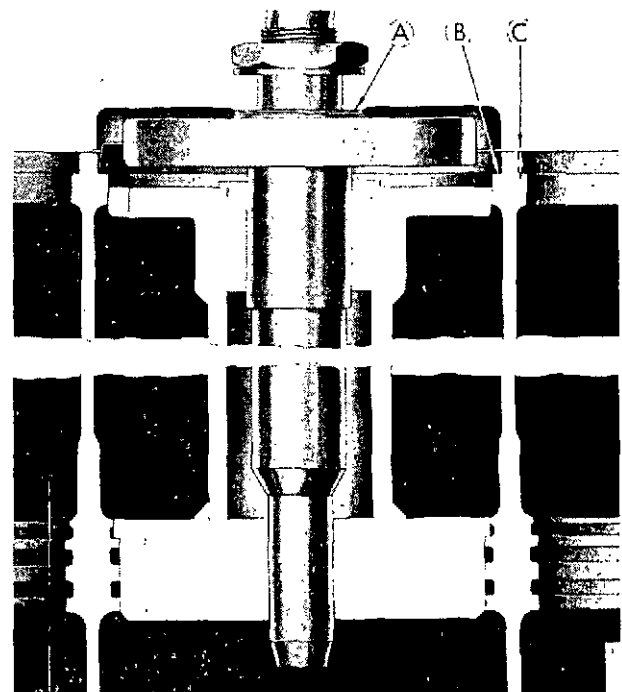
Measure the height of the cylinder liner above the cylinder block

Measuring and Adjusting the Height of the Cylinder Liner above the Cylinder Block

Before the liner is finally fitted into place its position in relation to the upper face of the cylinder block must be checked as follows:

1. Use a micrometer to check the flange on the cylinder liner in respect of parallelism between the seating surfaces.
2. Position the liner, without its rubber rings.
3. Press the liner down with the aid of two sleeves on the studs.
4. Measure the height of the cylinder liner above the cylinder block. Each liner must be measured at two diametrically opposite points sited transversely across the engine. Find the difference between the two readings. If the difference is greater than that stated, the sealing will be below standard. It is also important to see that the cylinder liners belonging to the same cylinder head will as far as possible be at the same height above the cylinder block. The height difference for liners belonging to the same cylinder head must not exceed the stated figure. On engines with cylinder heads covering three cylinders the middle liner under each cylinder head must not be sited lower than the neighbouring cylinder liners.

It is of the utmost importance that the surfaces against which the measurements are taken really are clean. The same thing applies to the surfaces against which the straight edge is applied. We should also like to point out that the reading can also be upset by local minor unevennesses and burrs. This means that if you get readings outside the stated limits you should not scrap any component without undertaking the requisite check. If the liner is too low its vertical position can be adjusted in the first



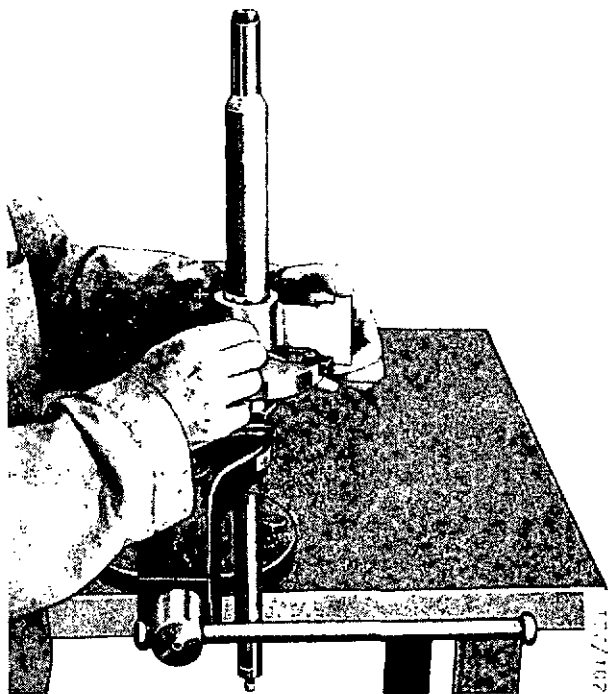
Positioning the facing tool in the liner seat



resort with shims. The shims should be placed on the seating surface between the liner and the block. Measure the liner height again.

If the stated measurement is not complied with, the liner seats should be reamed and shims fitted to the required extent as follows.

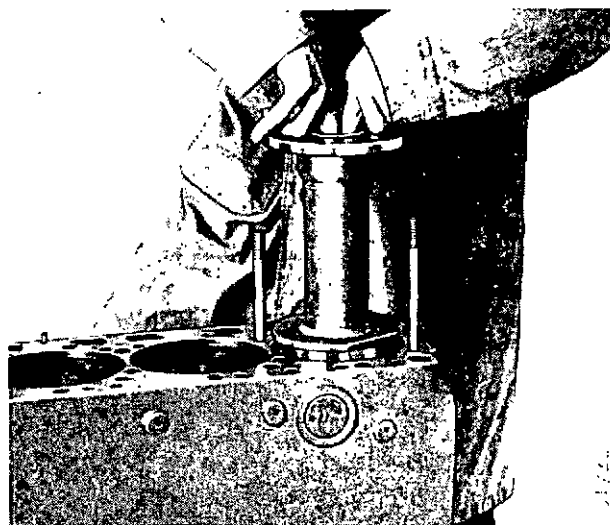
5. Choose a shim, or a set of shims, which, in relation to the desired liner height, will require the least possible amount of reaming in the liner seat. Check the shims and polish off any burrs on their edges.
6. Measure the thickness of the shim with a micrometer.
7. Calculate the difference between the thickness of the shim and the amount by which it is desired to raise the cylinder height. The difference will be the thickness of the layer that will have to be removed with the facing tool.



Adjust the cutting radius of the facing tool using the setting gauge

8. This point applies only to facing tools with an adjustable cutter.

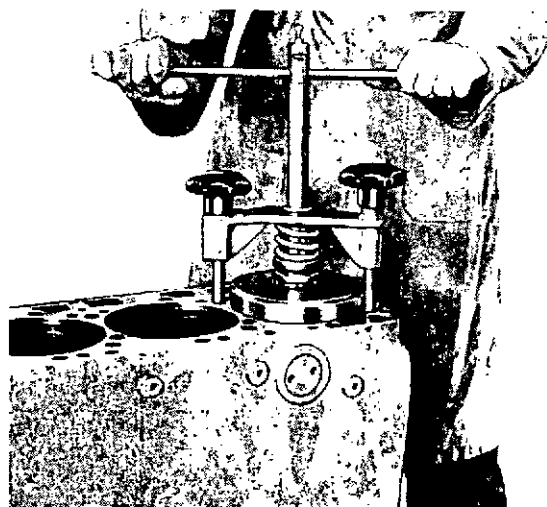
Adjust the cutting radius of the tool for the type of engine you are working on using the setting gauge, which is pushed up onto the upper locating surface of the tool spindle. On the setting gauge are lugs, marked with the engine type reference, against which the cutter can be set. The cutter can be shifted by undoing the locking screw in the locking wedge which clamps the cutter in place. In some cases it will be necessary to pry the wedge carefully loose, using a screwdriver for example, in order to be able to move the cutter. Adjust the tool to the correct cutting radius by using the adjusting screw to shift the cutter towards a larger radius. Just before the correct cutting radius is reached, tighten the locking screw lightly so as to make



Place the locating device in the cylinder-liner seat

In changing the cutter, put the new one in right way round, so that its cutting direction agrees with the direction of rotation of the tools, as marked by an arrow on the stop disc. Check also that the flat surface of the cutter which is turned towards the bottom face of the cutting head bears firmly against it, and that there are no particles of dirt between any of the contact faces.

9. If the facing tool has a separate locating device, put the latter into the cylinder-liner seat.
10. Smear the ground guide surfaces of the tool with engine oil to make it work easily. Place the tool in the cylinder-liner seat. Check that the cutter of the tool bears against the seat (B).
11. The distance (C) between the stop disc of the facing tool and the plane of the cylinder block must be equal to the measurement obtained according to point 7. Measure the distance using feeler gauges and adjust as needed using shims (A) between the cutting head and the stop disc. Make sure there are no particles of dirt on any of the contact faces. Make the locknut really tight.



12. If you have a feed attachment for your facing tool, slip it down over the spindle of the tool and over two of the studs in the block, sited opposite each other. The two knobs belonging to the attachment should then be screwed onto these studs and tightened enough to produce a degree of resistance which feels just about right when the tool is turned.
 13. Put a few drops of oil between the stop disc of the tool and the cylinder block so as to prevent damage to the contact faces.
 14. Keep working on the liner seat with the tool until the stop disc bears against the cylinder block.
- Never turn the tool backwards.*
15. Clean the liner seat very thoroughly.
 16. Fit the shim and the cylinder liner.
 17. Press the cylinder liner down with the help of the studs and check the height of the liner according to the instructions given under point 4.

Fitting the Cylinder Liner

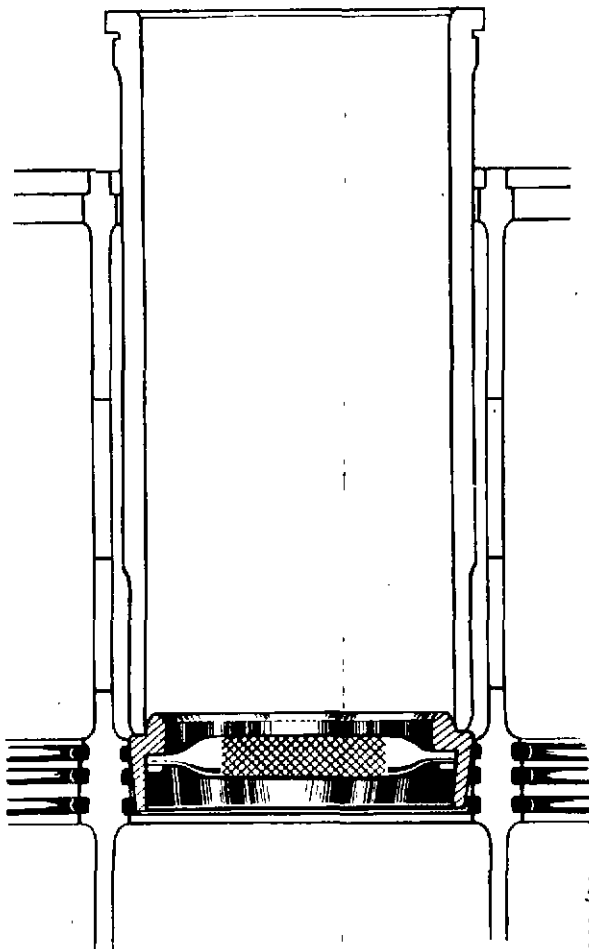
1. When the vertical position of the liner has been settled, fit new rubber rings in the block before fitting the liner into place. To facilitate the

fitting of the liner, the rubber rings and the lower locating surface of the liner should be smeared with ordinary engine oil.

2. Always fit the liners with the drill mark in their top edge turned to face the front of the engine.
3. Press the liner down into position in the block. To prevent the sealing rings from dropping out of their grooves in the cylinder block as the liner is being pushed down, use the assembly tool, which should be smeared with engine oil. Place this tool on the side of the liner in the lower liner seat and then push it down with the cylinder liner. The tool keeps the rings in position while the liner is being pressed down.
4. If the crankshaft has been taken out, the liner can be pushed down into place at one stroke. If the crankshaft is in place in the engine it must be turned so that the crankpin of the cylinder in question is halfway between T.D.C. and B.D.C. In this case the liner must be pushed down only sufficiently for the assembly tool to pass the lowermost sealing ring and come loose. Then raise the tool on edge and take it down past the crankshaft. The liner can then be pushed down into its position.

If the liner cannot be pushed down by hand, it must on no account be knocked down. Pull it up instead and find out why it is binding.

5. This step is carried out in special cases only: After the liner has been fitted its ovality can be checked as follows: Fit the cylinder head with its gasket and tighten the cylinder-head nuts. Measure the inside diameter of the liner. The ovality found should not be greater than the value stated. Measurement with the cylinder head removed does not give a reliable result.



Fit the cylinder liners



Crankshaft and Reciprocating Components

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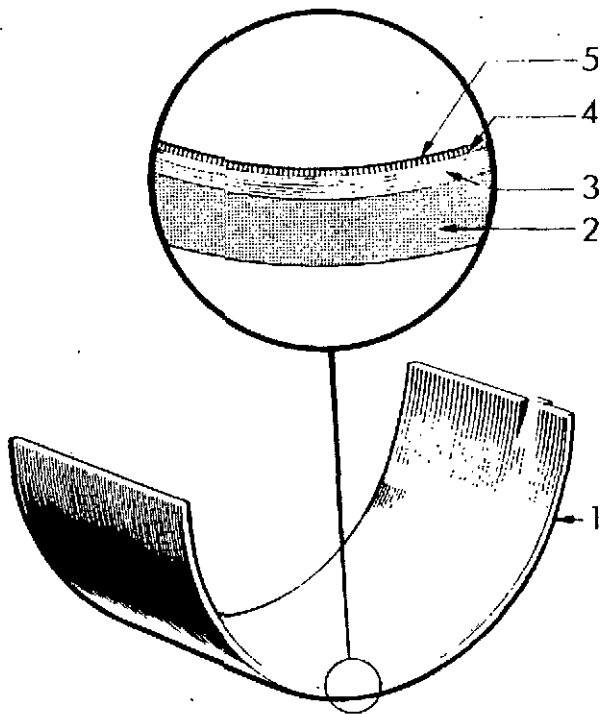
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Crankshaft and Reciprocating Components

General

The crankshaft is drop-forged of alloy steel and is statically and dynamically balanced. It is carried in force-lubricated main bearings with renewable bearing shells. The bearing shells are built up with lead-bronze on a steel body. On the friction surface there is a thin layer of lead and indium.



Cross-section of a bearing shell

- | | |
|------------------|-----------|
| 1. Bearing shell | 4. Lead |
| 2. Steel body | 5. Indium |
| 3. Lead-bronze | |

The lead-indium layer is softer than the actual bearing metal, and is there for the purpose of assisting running-in. No risk is therefore entailed if, after a period in service, this layer is worn away. The bearing surfaces of the crankshaft are hardened and fine-polished, giving long life. The axial thrust is taken up by washers at the rearmost main bearing.

The rear end of the crankshaft is in the form of a flange to which the flywheel is bolted. The ring gear for the starting motor is shrunk onto the flywheel.

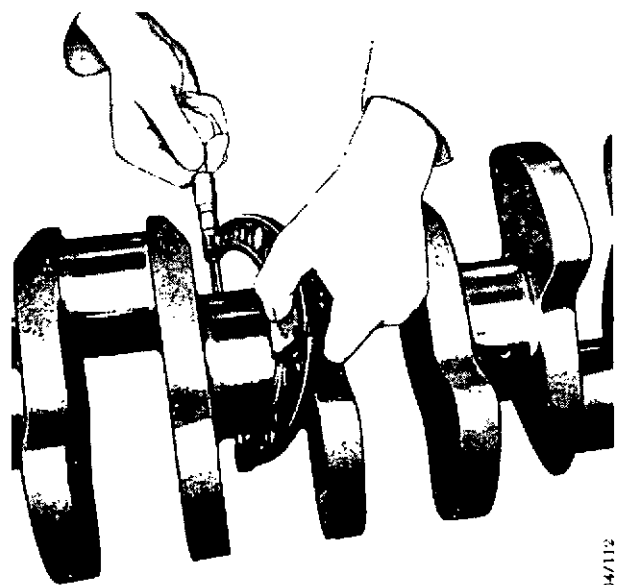
Crankshaft

Removing the Crankshaft

3. Remove the engine.
3. Remove the oil pan; see the section headed "Lubricating System".
4. Remove the oil pump with the suction pipe for the engine oil.
5. Remove the timing-gear casing; see the section headed "Timing Gear".
6. Remove the clutch.
7. Remove the flywheel.
8. Remove the flywheel casing.
9. Screw off the bearing caps on the connecting rods.
10. Screw off the nuts which hold the main bearing caps and lift off the caps.
11. The crankshaft can now be raised. The safest way to do this is to use some form of hoist and a rope sling or a suitably shaped yoke.

Overhauling the Crankshaft

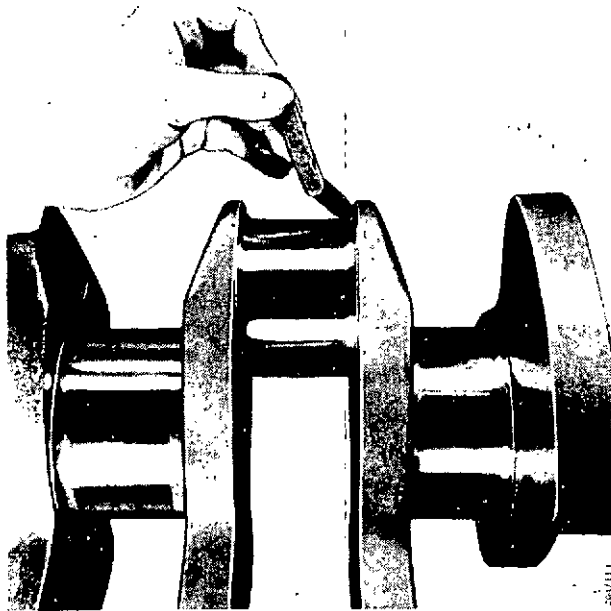
1. After removing the crankshaft, clean it thoroughly. Clean the oil passages carefully.
2. Examine the wear. If it exceeds the stated figure, the regrinding of the crankshaft should be considered. The oil pressure should also be taken into account.



Measure the wear

In regrinding, the stated undersizes must be adhered to. Finished bearing shells are available for these sizes.

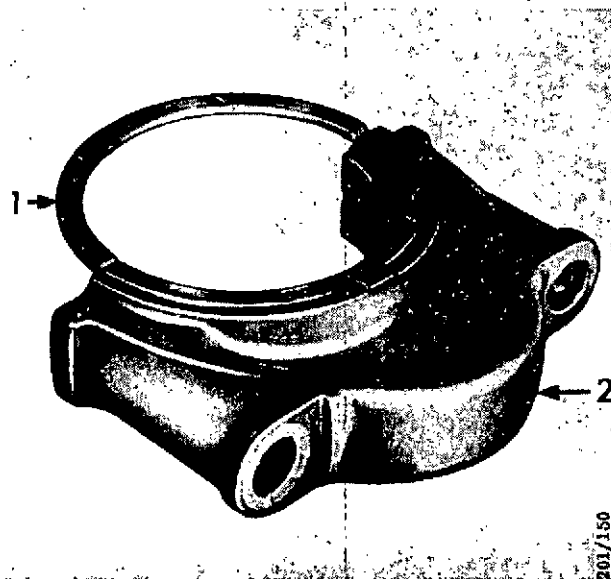
4. In grinding the crankshaft it is of the utmost importance to preserve the correct fillet radius on the journals and crankpins. These fillets must have smooth transitions to the plane and the



Measure the fillet radius with a radius gauge

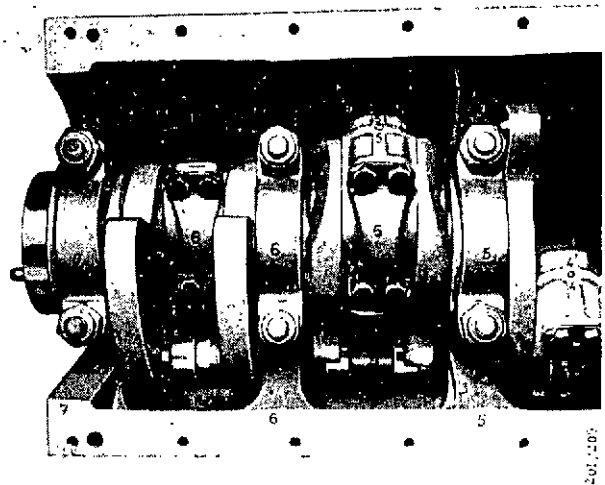
Fitting the Crankshaft

1. Carefully clean all oil passages and seating surfaces on bearing shells, cylinder block, caps and crankshaft.
2. Put the bearing shells into place in the block and in the bearing caps. See that they are correctly positioned, and that neither bearing shells, bearings nor caps show upsets or burrs.
3. Lubricate the journals and crankpins with clean engine oil and carefully position the crankshaft in the block.
4. Fit the thrust washers on both sides of the rear main bearing. The oil grooves must face outwards towards the bearing surface of the thrust washers on the crankshaft.
5. Fit the caps so that the stamped figure on each cap can be read the same way up as the corresponding figure on the block.



Main-bearing cap with thrust washer

1. Thrust washer



Markings of the crankshaft bearings

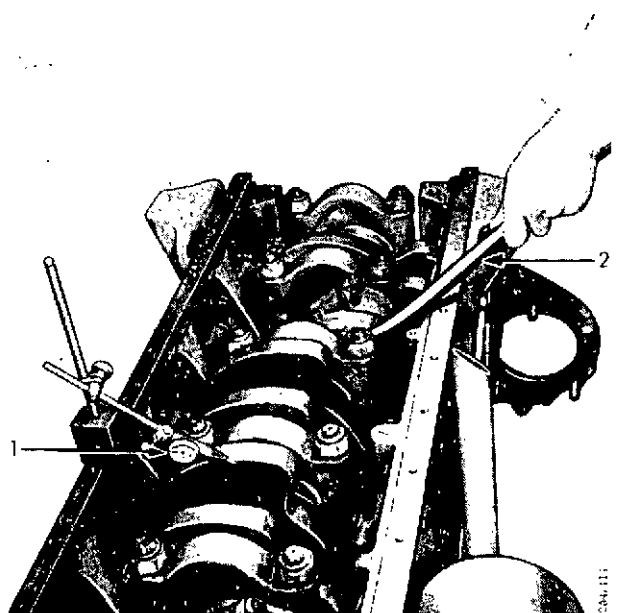
6. The nuts of the main-bearing caps are of a self-locking type. Oil the threads before screwing the nuts on. Tighten them to the stated torque.

The bearing shells must on no account be scraped; nor may they be tightened by filing the bearing caps.

7. Check the axial play of the crankshaft. It can be adjusted by changing thrust washers, which are available in various thicknesses.

Changing the Rear Oil Deflector

If the oil deflector has been removed (because it is damaged or to permit grinding of the crankshaft) a new oil deflector must always be fitted. Use the assembly tool.



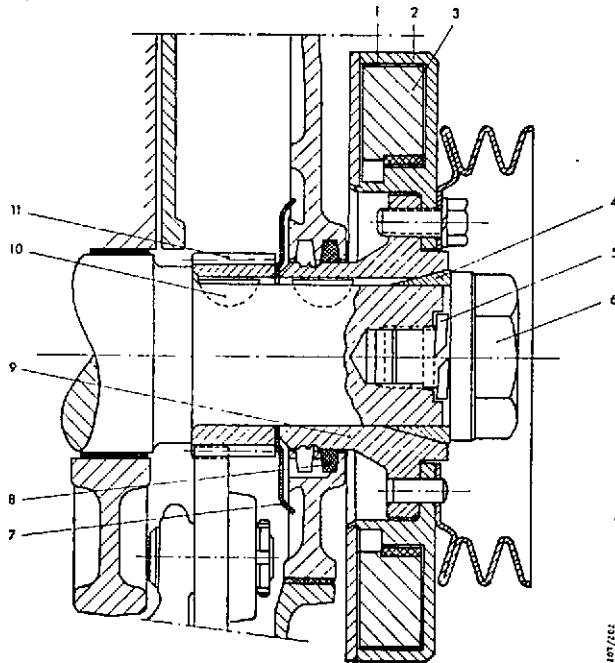
Check the axial play of the crankshaft

1. Dial Gauge



Vibration Damper

The vibration damper consists of a hermetically sealed housing. The housing encloses a steel damper ring of rectangular cross-section. The space between the damper ring and the housing forms a narrow gap which is filled with liquid. The liquid has a high viscosity and a high viscosity index, the latter indicating that the viscosity is relatively unaffected by temperature changes.



Vibration damper

- | | |
|---|------------------------------------|
| 1. Gap between damper ring and housing. The space is filled with liquid | 6. Bolt securing hub to crankshaft |
| 2. Hermetically sealed housing | 7. Oil deflector |
| 3. Damper ring | 8. Felt ring |
| 4. Expanding cone | 9. Hub |
| 5. Spring washer | 10. Key |
| | 11. Crankshaft gearwheel |

The housing, which is fixed to the crankshaft, takes part in the movements of the crankshaft. The damper ring, which is not directly secured to the housing, attempts, by its inertia, to go on rotating at the same speed. The occurrence of torsional vibration in the crankshaft will give rise to a difference in speed, of alternating direction, between the damper ring and the housing. The resistance offered by the liquid serves to equalize the speeds of the damper ring and the housing. Since the housing is fixed to the crankshaft, this speed equalization means that the vibration of the crankshaft will be damped down.

The damper requires no adjustment, oil replenishment or other maintenance.

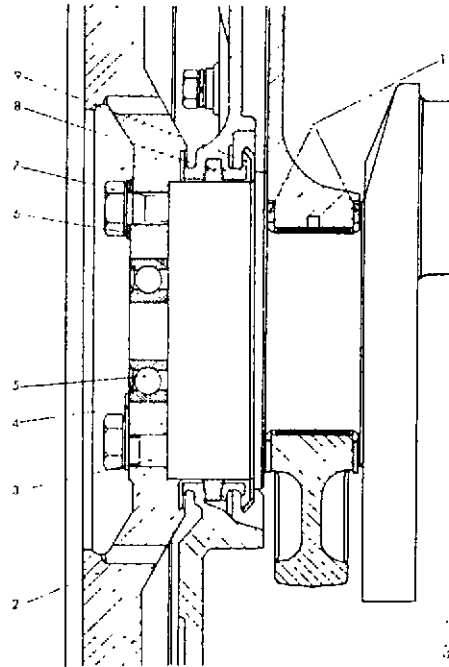
Great care must be observed in handling and transporting the vibration damper. The slightest deformation of the housing can immobilize the damper ring and put the vibration damper out of action, which in its turn can lead to crankshaft failure. The housing of the vibration damper is located by two dowels on the hub of the vibration

Removing and Replacing the Vibration Damper

See the section on "Timing Gears".

Flywheel

The flywheel is attached to the rear end of the crankshaft with bolts locked by tab washers. It is located by three asymmetrically sited dowels, so that the wheel can be fitted in one way only.

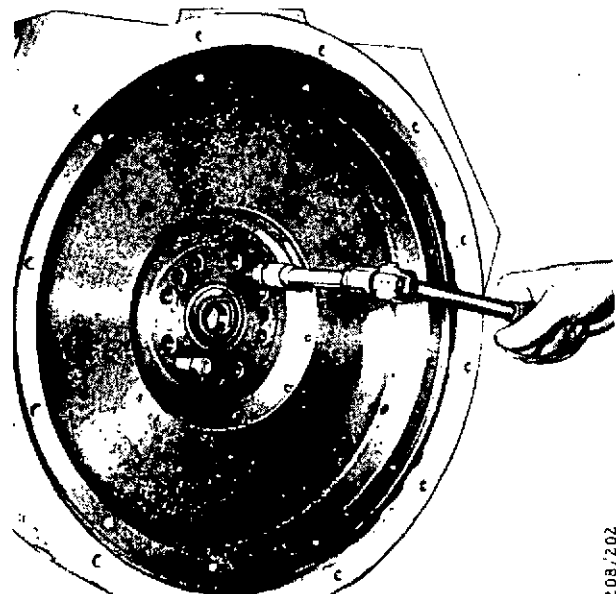


Flywheel

- | | |
|--|---|
| 1. Thrust washer | 6. Lock washer for bolt |
| 2. Flywheel | 7. Bolt securing flywheel to crankshaft |
| 3. Dowel | 8. Felt ring |
| 4. Lock washer for bolt and ball bearing | 9. Oil deflector |
| 5. Ball bearing | |

Removing the Flywheel

1. Turn down the tabs of the lock washers and screw out the bolts.
2. Pull the flywheel off the crankshaft using two puller screws.



Changing the Ring Gear on the Flywheel

Change the ring gear on the flywheel if the teeth have become so badly worn that the starting-motor pinion has difficulty in engaging. Make the change as follows:

1. Grind as deep a groove as possible in the ring gear and split it with a cold chisel, then remove the ring from the flywheel.
2. Clean the seating surface on the flywheel, a steel-wire brush being suitable for this job.
3. Heat the new ring gear so that it is evenly warmed all round to the stated temperature. In order to be able to see when this temperature is reached, two bright spots should first be ground at different points on the ring. Heating should be discontinued at the latest when these surfaces begin to show blue coloration. If heating is continued beyond this point there is a risk that the ring gear will lose its temper.
4. Drive the heated ring gear onto the flywheel so that the bevelling on the teeth faces towards the starting motor. See that the ring gear beds down firmly onto the flywheel.
5. The ring gear must not be cooled with water or similar means, but must be allowed to cool freely in air.

Removing and Replacing the Flywheel Casing

1. The flywheel casing is bolted to the engine block. Screw out these bolts. If necessary, tap the casing with a fibre mallet to loosen it.
2. A felt ring, located in the flywheel casing, bears against a sealing surface on the crankshaft. Change this ring. Soak the new felt ring thoroughly in engine oil before fitting it.
3. Place the assembly tool on the dowels on the end of the crankshaft so as to provide a flush transition between the outsides of the tool and the shaft flange.
4. Fit a new gasket between the flywheel casing and the engine block after removing the remains of the old gasket.
5. Fit the flywheel casing.

Fitting the Flywheel

1. Oil the locating surfaces of the flywheel and position the flywheel on the shaft so that the dowels on the crankshaft fit into the appropriate holes in the flywheel.
2. Fit the bolts, with new lock washers.
N.B. On certain types of flywheel, one of the bolt lock washers also serves to retain the ball bearing in the flywheel.
3. Tighten the bolts to the stated torque and lock them by turning up the tabs of the lock washers.

Connecting Rods

General

The big-end bearings are of the same type as the main bearings, having renewable bearing shells of lead-bronze.

The piston-pin bushing is made of lead-bronze on a steel body like the other bearings, but has no

Removing a Piston with Connecting Rod

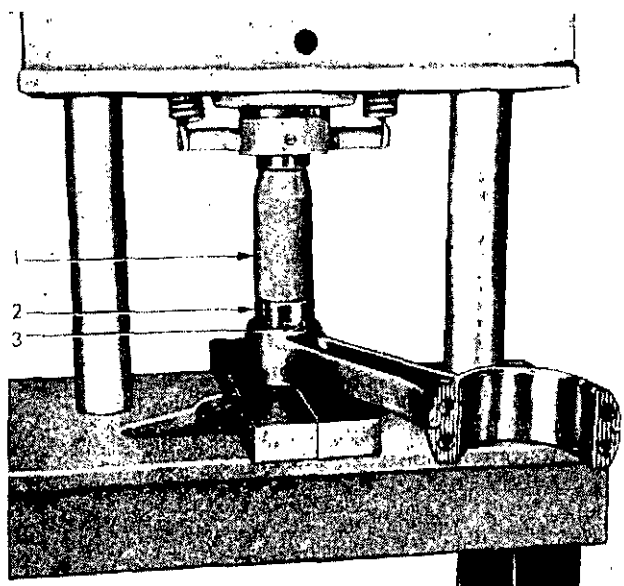
1. Remove the cylinder head; see the section "Cylinder Heads".
2. Remove the oil sump; see the section "Lubricating System".
3. Scrape away the edge of the carbon in the cylinder liner. Level off the "step" at the upper limit of piston travel with a scraper if it is sharply marked. Do not damage the wearing surface in the liner.
4. Remove the bearing caps and bearing shells in both connecting-rod and cap.
5. Press the piston and connecting rod up out of the cylinder using a piece of wood.
6. If the bearing shells are not to be renewed they should be laid out so that in reassembly they can be put back into their original places.
7. If the crankshaft is not to be removed, the bearing surfaces and oil passages must be protected by wrapping insulating tape or cellophane tape round the pin with the sticky side out.
8. The piston and connecting rod can then be washed as a unit.

Removing a Piston Pin

1. Take off the retaining rings of the piston pin using a pair of retaining-ring pliers.
2. Heat the piston on a hotplate to the stated temperature. The piston pin can be pressed out by hand when the piston has reached this temperature. Use the drift. The piston pin must not be knocked or pressed out while the piston is cold. When cold the piston pin is too tight a fit in the piston, and the piston would be deformed. Occasionally, the tolerances may happen to be such that the piston pin is fairly loose in the piston even while it is cold.

Changing a Piston Pin Bushing

1. Press out the bushing in a press using the drift.
2. Check that the oil passage is clean and the bearing seat undamaged.



Press the piston-pin bushing in



3. Press in the new bushing using the same drift. See that the oil hole in the bushing coincides with the corresponding hole in the connecting rod.
4. After being pressed in, the bushing must be reamed or better still precision-drilled to the stated size.
5. If the fit between the piston pin and the piston-pin bushing is correct, it should be possible to feel a slight play when the parts are dry. With oil on the bearing surfaces the play should no longer be perceptible.

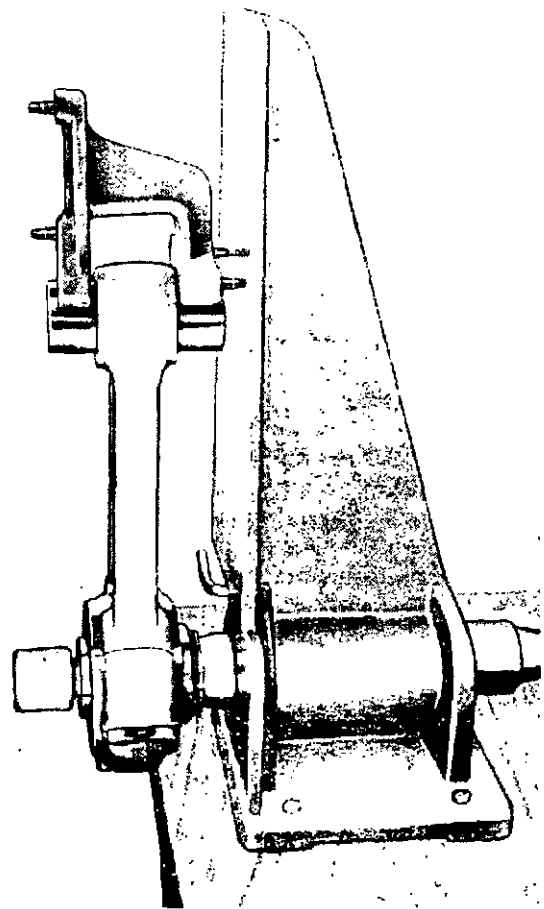
Checking a Connecting Rod

Check the connecting rods in the appropriate tool. The method is as follows:

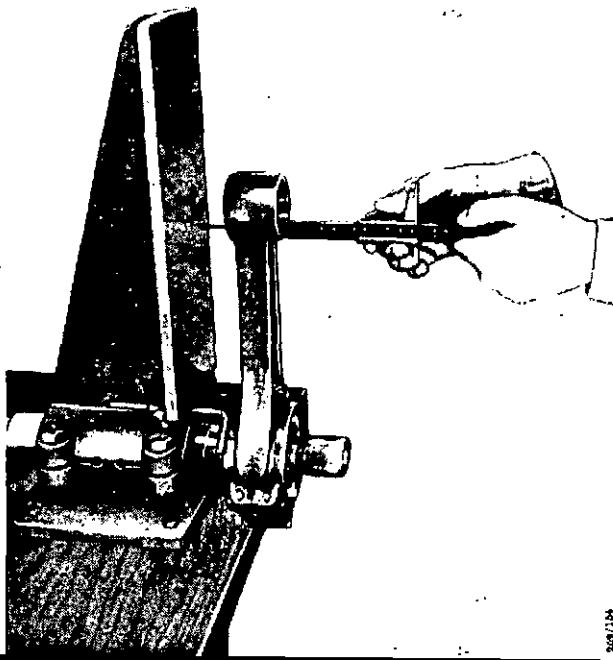
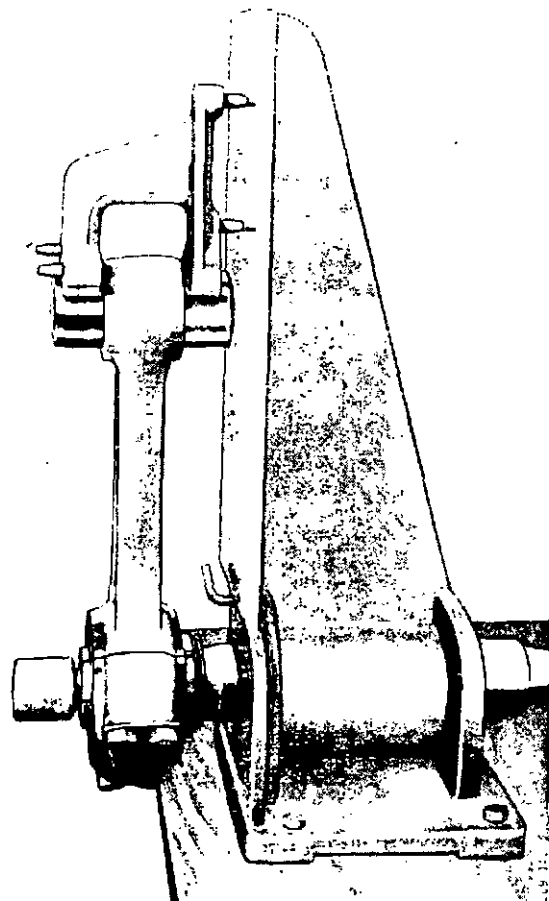
1. After checking and if necessary renewing the piston-pin bushing, fit the bearing cap according to the marking and tighten the nuts.
2. Set the connecting rod up in the tool using the expander, and put the piston pin belonging to it into the piston-pin bushing. Then set the gauge on the piston pin.
With the gauge tips horizontal, check whether the connecting rod is twisted.
With the gauge tips vertical, check whether the connecting rod is bent.
3. Check also to see whether the connecting rod is bent in the form of an S. Do this by measuring the distance between the outer side of the piston-pin bushing and the plane surface of the tool. Reverse the connecting rod and take the corresponding measurement. The difference must not be more than 0.6 mm.

It is inadvisable to straighten connecting rods. Defective connecting rods should therefore be changed.

Important. Concerning the fitting of the piston pin and the fitting of the piston with connecting rod, see "Pistons and Piston Rings".



Use the gauge to check whether the connecting rod is twisted



Pistons and Piston Rings

General

The pistons are made of an aluminium-silicon alloy. Each piston has three compression rings and two scraper rings. The top compression ring has a chromium-plated wearing surface.

Taper-face piston rings must be fitted with the marked side up.

The piston pins are made of case-hardened chromium steel. At normal working temperatures they are fully floating, i.e. free to move in both piston and connecting rod.

The fit between the piston pin and the piston-pin hole in the piston must be kept within quite narrow limits, so that every piston and piston pin is classified. The classification principle is that the items are grouped by tolerance, each group being denoted by a particular colour. Thus when a new piston is being fitted, a piston pin with the same marking as the piston must be used. For this reason, new pistons are supplied with selected piston pins. A used piston pin must not be fitted into a new piston.

The piston-pin hole is offset to one side in the piston (but not on the D7), and it is therefore important that the pistons are always fitted into the engine with the marking facing forwards. Since the connecting rods, too, may only be fitted one way round it is necessary to see that this marking faces the proper way right from the beginning when the piston is being fitted onto the connecting rod.

Changing Piston Rings

Normally speaking, re-ringing has not shown itself to be necessary as a maintenance measure. As a rule, the need does not arise until the engine as a whole is worn.

New piston rings, the top ring being chromium-plated, should be fitted only in the cases given below, provided that the running-in can be effected carefully according to our instructions.

1. On the simultaneous replacement of piston and cylinder liner.
2. If the mileage covered by the vehicle to which the engine is fitted is less than 100,000 km.

This is because the effect of the chromium plating is to make it relatively hard for the piston rings to bed in against the surface of the cylinder liner.

More detailed directions are given as appropriate in separate instructions.

1. Remove the old piston rings. Use a pair of piston-ring tongs so as not to scratch the sides of the piston.
2. Clean the pistons and connecting rods. The piston-ring grooves can best be cleaned with a special scraper. Be careful of the sides of the grooves, so that the scraper does not remove stock from the piston but only the impurities. This is because it is important that the piston rings seal properly against the sides of the grooves. Clean out the oil holes inside and below the scraper rings using suitable drills, turning the drills by hand.
3. Check the axial play of the new rings with the

4. Before putting new piston rings onto the piston the piston-ring gap must be checked. Use the piston-ring compressor. It has the same inside dimension as a new cylinder liner. Push the piston ring down using a piston until the piston-



Check the axial play of the piston rings



Check the piston-ring gap

ring gap is opposite the hole in the side of the piston-ring compressor.

Check the piston-ring gap using the gauge. If the gap is too small, correct it with a piston-ring file.

5. The easiest way to fit piston rings is to use a pair of piston-ring tongs. With other methods it is easy to damage the rings. The compression rings have different gaps, so be careful to put the right ring into the right groove.

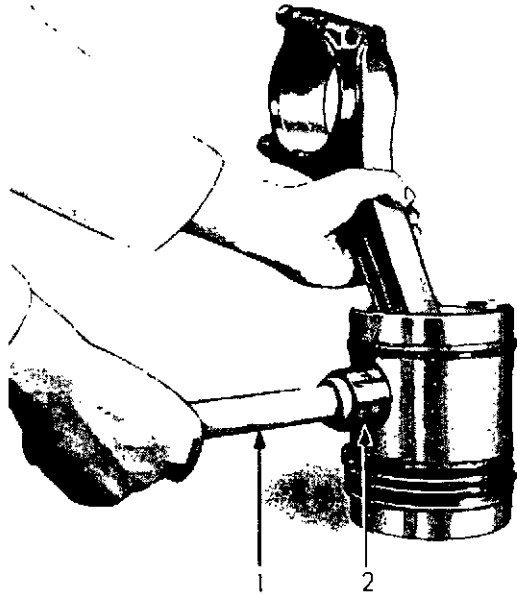
N.B. After re-ringing the engine must be run



fully run in. A good way is first to run the engine for an hour off load at a good speed, about 1200 r.p.m., and then to drive the vehicle quietly for the first 10 hours (500 km).

Fitting a Piston Pin

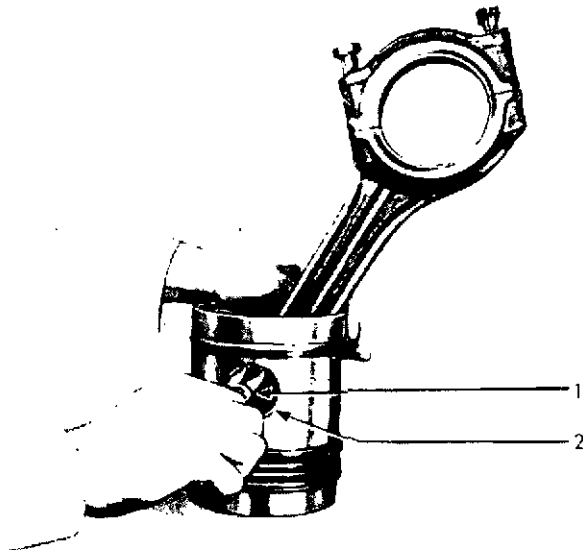
When the piston pin is to be fitted the piston must be heated to the stated temperature. Note that the piston pin must not be knocked in; it must be possible to push it in by hand using moderate force.



Fit the piston pin with the drift

1. Drift 2. Piston pin

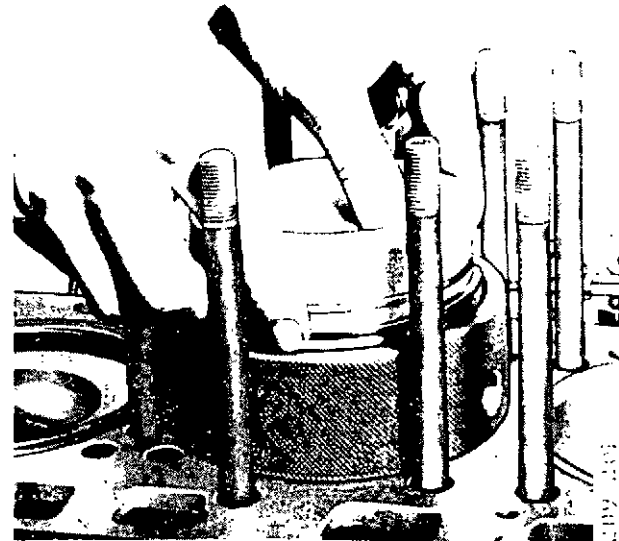
1. Heat the piston to the stated temperature.
2. Get the piston and connecting rod the right way round in relation to each other.
3. Fit the piston pin using the drift.
4. Fit the retaining rings of the piston pin.



Fit the retaining rings of the piston pin

Fitting a Piston with Connecting Rod

1. Liberally oil the piston, piston rings, cylinder liner and piston-ring compressor with engine oil.
2. Spread the ring gaps round the piston so that they do not come directly one above the other.
3. Remove the protective coverings from the crankpins.
4. Fit the piston with connecting rod into the cylinder, using the piston-ring compressor which will squeeze the piston rings together as the piston is being pushed down into the cylinder. Turn the connecting rod the right way round as shown in the figure under the heading "Fitting the Crankshaft".



Fit the piston with connecting rod into the cylinder

5. Put the bearing shells into place in the connecting rod and cap. See that they are the right way round, so that the lugs drop properly into their grooves. Lubricate the crankpin with engine oil.
6. Fit the cap and put new lock washers under the bolts, which must be well oiled. Take great care in tightening the bolts. Tighten them to the stated torque and lock them by turning up the tabs of the lock washers.

Special Instructions for Engine Type D7

Measure the length of the big-end bolt before making it tight.

See that the nuts are fitted to the same bolts as they originally belonged to.

When the nuts have been tightened to the marking, i.e. when the punch pops on the nut and bearing cap are opposite each other, measure the length of the bolts again.

Lock the nuts with new split pins, which must fill the holes up properly since they would otherwise be liable to shake loose.

If the split-pin hole does not line up, even though the stated measurements were duly found beforehand after tightening, another nut must be tried. Never grind off a nut to make it fit unless you



Timing Gears

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Removing the Idler Gear and Stub Shaft	E4
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Fitting the Compressor	E6
Fitting the Hydraulic Pump of the Power Steering	E6



Timing Gears

General

The timing gears comprise cylindrical gearwheels with helical teeth.

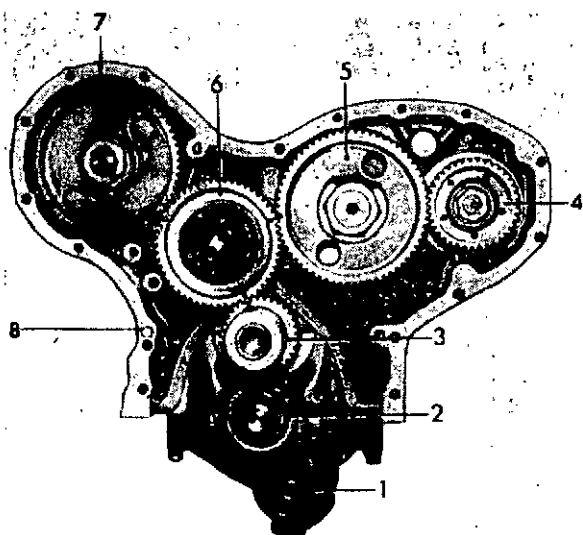
The drive is taken from the crankshaft.

The injection pump and camshaft are driven through an idler gear.

The compressor is driven through the camshaft gearwheel.

The hydraulic pump is driven through a rubber coupling direct from the compressor gearwheel.

The lubricating-oil pump is driven by the crankshaft through an idler gear.



Timing Gears

- | | |
|---|-------------------------|
| 1. Driving wheel for lubricating-oil pump | 4. Compressor gearwheel |
| 2. Idler gear for lubricating-oil pump | 5. Camshaft gearwheel |
| 3. Crankshaft with gearwheel | 6. Idler gear |
| | 7. Pump-shaft gearwheel |
| | 8. Dowel |

The timing gears are protected by a timing-gear casing and a timing-gear housing. The timing-gear housing is bolted to the cylinder block. In its turn, the casing is bolted to the timing-gear housing.

The lubricating-oil pump with its idler gear is sited partly down in the oil pan. The pan is bolted to the timing-gear casing, the timing-gear housing, the cylinder block and the flywheel casing.

Dismantling the Timing Gears

Removing the Hydraulic Pump of the Power Steering

1. Drain off the hydraulic fluid.
2. Undo the hose connections at the pump and the two nuts that secure the pump to the timing-gear casing.
Fit protective plugs.
3. Pull out the pump. See that the five rubber bushings on the driver pins come out with it.

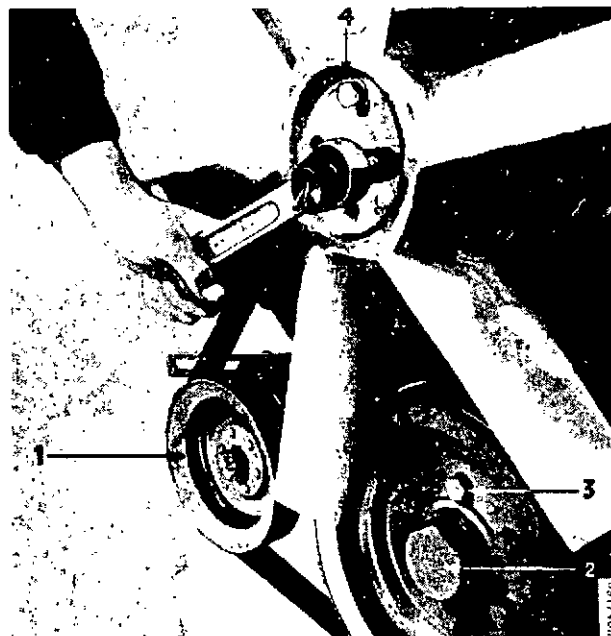
between the shaft and the driver breaks when the hydraulic pump is subjected to abnormal overloads, caused for instance by impurities in the hydraulic fluid. On some hydraulic pumps there is a spring with a ball, which is held in position by a metal washer in the centre of the driver and which thrusts the broken surfaces apart. The engine can still be run and the vehicle can also be steered, although the steering gear will now function as a purely mechanical unit.

A hydraulic pump whose shaft is thus broken must be removed with great care, since the spring and ball might otherwise drop into the engine. If this should occur, the lost parts must of course be recovered to prevent damage to the engine.

When the hydraulic pump is being removed and replaced the rubber bushings on the driver pins must be changed.

Removing the Vibration Damper

1. Reduce the belt tension by slackening the retaining screws of the generator and the screw in the generator support. On engines equipped with a tensioning pulley, undo the nut in the centre of the pulley.

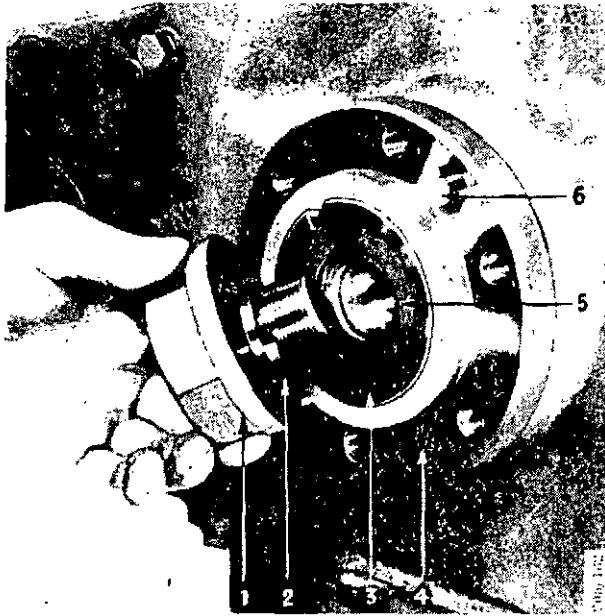


Remove the fan and the pulley

- | | |
|--|--|
| 1. Bolt pulley for generator | 4. Bolts securing fan and pulley to the flange on the coolant-pump shaft |
| 2. Bolt for hub of pulley and vibration damper | |
| 3. Bolts securing the pulley and vibration damper to the hub | |
2. Undo the bolts in the fan hub and lift off the fan, the belt pulley and the fan belts.
 3. Remove the coolant pipe and the drain pipe connected to the compressor.
 4. Undo the retaining screws of the large belt

Lay the vibration damper where it cannot be subjected to any damage, since the slightest deformation of the damper housing may put the vibration damper out of action, which can result in crankshaft failure.

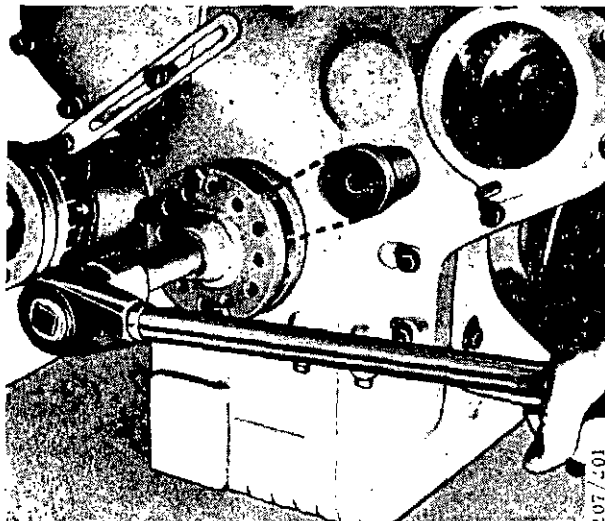
5. Undo the screw on the crankshaft using the socket wrench.



Attaching the hub

- | | |
|-------------------------|----------------------|
| 1. Screw | 4. Hub |
| 2. Spring washer | 5. End of crankshaft |
| 3. Split conical sleeve | 6. Dowel |

6. Take out the conical sleeve.
7. Place the thrust plug in the end of the crankshaft.
8. Pull the hub of the vibration damper off using the puller.



Pull off the hub of the vibration damper

Removing the Timing-gear Casing

1. Undo the screws round the timing-gear casing and the oil pan.
2. Take off the oil deflector. In order to get at the lubricating-oil pump the oil pan must be com-

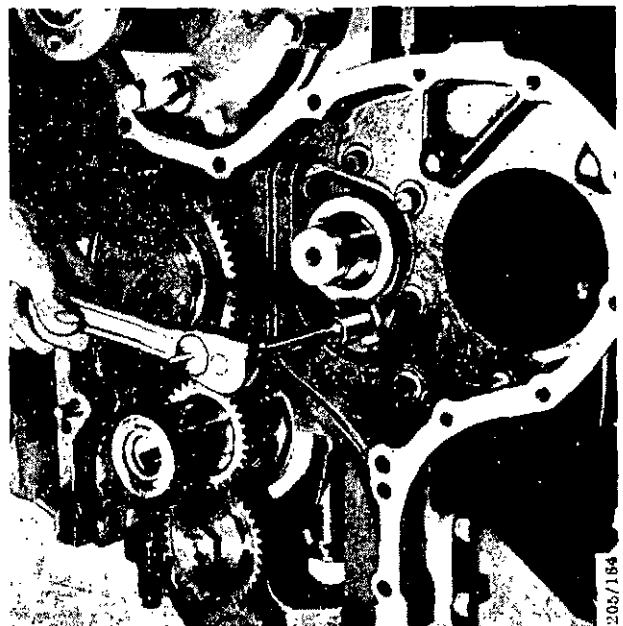
Removing the Compressor

1. If the driving wheel of the compressor is to be detached from the compressor shaft, first remove the driver plate of the hydraulic pump and then the centre nut.
2. Remove the water hose between the coolant pump and the lower part of the radiator.
3. Detach: lubricating-oil pipe to compressor, hose clip on line for return coolant, pressure-regulator pipe, cooling coil for compressor air, connection for incoming coolant, hose from anti-freeze bottle, and nuts that secure compressor to timing-gear housing.
4. Lift off the compressor and make sure of the rubber ring sited inside the attachment flange.

Removing the Camshaft with the Camshaft Gearwheel

It is not necessary to take the camshaft gearwheel off the camshaft in order to be able remove the camshaft from the engine. But the following steps must be taken:

1. Take off the valve covers.
2. Detach the rocker-arm mechanism. Note that the lubricating-oil pipe, which is fitted to certain types of engine, must be detached first.
3. Lift out the pushrods.
4. Undo the screws holding the side covers and take the covers off.
5. Lift the valve lifters out and place them in order, e.g. in a drilled board.
6. Rotate the camshaft until one of the screws for the locating flange behind the camshaft gearwheel becomes visible. Undo and remove the screw and rotate the camshaft so that the other screw can be removed.
7. Pull the camshaft straight out so as not to damage the bearings.

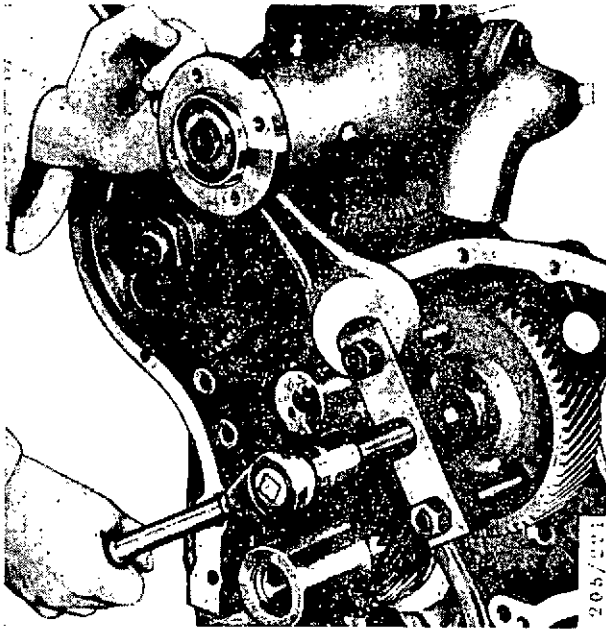


Undo the screws of the camshaft locating flange. If the wheel is still on the camshaft, undo the screws through holes in the



Removing the Camshaft Gearwheel

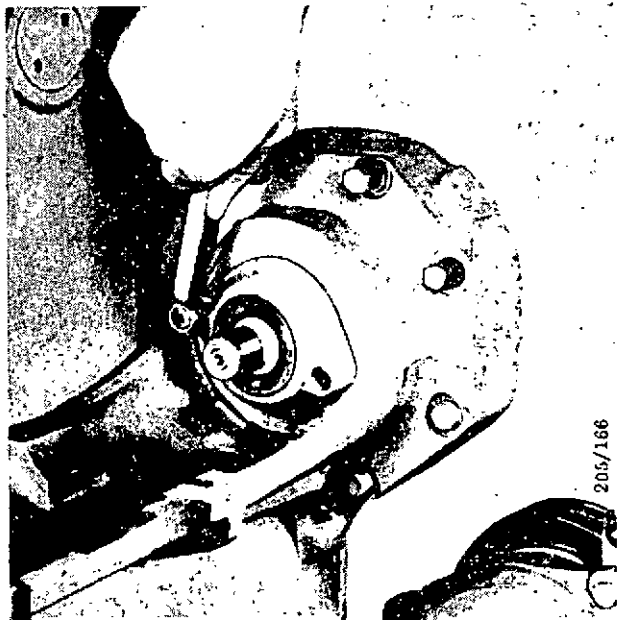
1. Knock down the lock washer and undo the nut.
2. Pull the wheel off using the puller.



Remove the camshaft gearwheel

Removing the Driving Shaft of the Injection Pump

1. Remove the injection pump according to the instructions given in the section headed "Fuel System".
2. Undo the screws of the sealing-ring holder and pull it off the end of the shaft.

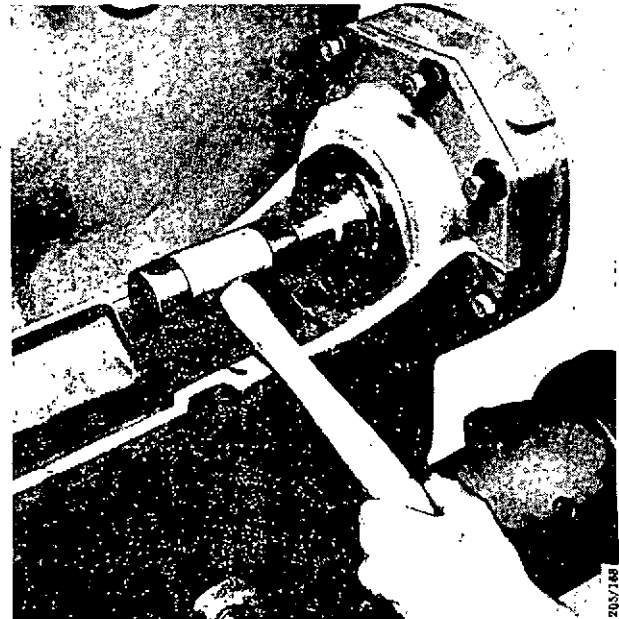


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Remove the retaining ring in the rear bearing of the driving shaft

3. Remove the retaining ring in the outer ring of the rear ball bearing.
4. If the gearwheel or the front bearing is to be changed, undo the nut.
5. Knock the driving shaft out to the front using a fibre mallet.



Knock the driving shaft out to the front with a fibre mallet

Removing and Fitting the Pump-shaft Gearwheel

The nut of the wheel can best be undone while the driving shaft is still in place in the engine and the wheel is locked (see above).

Press off the gearwheel, the bearing and the

Removing the Idler Gear and Stub Shaft

1. Undo the two screws securing the washer to the shaft of the idler gear. Remove the washer.
2. Take off the front thrust washer, the idler gear and the rear thrust washer.
3. To remove the stub shaft, undo the two screws in the shaft flange. Pull out the stub shaft.

Removing the Crankshaft Gearwheel

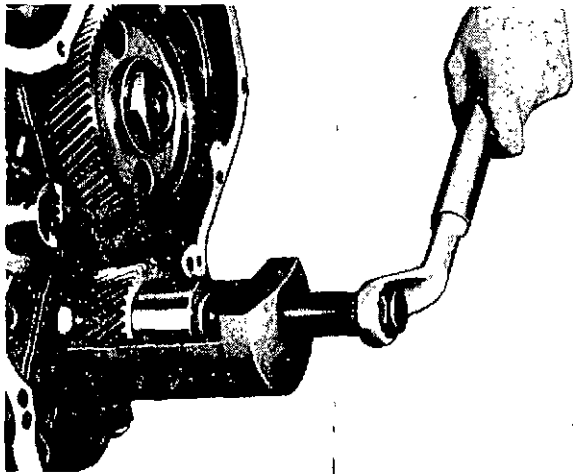
The gearwheel need only be removed if it is damaged or worn.

Remove the oil pan; see the section headed "Lubricating System"¹⁾.

Remove the oil pump; see the section headed "Lubricating System"¹⁾.

Remove the key of the vibration-damper hub.

Put on the puller of the crankshaft gearwheel, and the thrust pad, and pull off the gearwheel.



Pull the crankshaft gearwheel off with the puller

Removing the Lubricating-oil Pump with Idler Gear

See the section headed "Lubricating System".

Changing Camshaft Bushings

The camshaft and the camshaft bushings suffer only negligible wear, and it is extremely rare for these items to require any attention. But in carrying out engine reconditioning, check that the bearing surfaces and the cams are not abnormally worn. If any bushing has been damaged, all bushings should be changed.

Press the new bushings in so that the oil holes come in line with the oil passages in the engine block.

After being pressed in the bushings must be machined to the stated dimensions. The use of a boring machine must be available if this work is to give

Assembling the Timing Gears

Fitting the Crankshaft Gearwheel

1. Fit the key and check that it is not too high.
2. Warm the wheel in a water bath. Turn the marking (0) to face forwards, and push the wheel into position on the stub shaft.

Fitting the Driving Shaft with the Pump-shaft Gearwheel

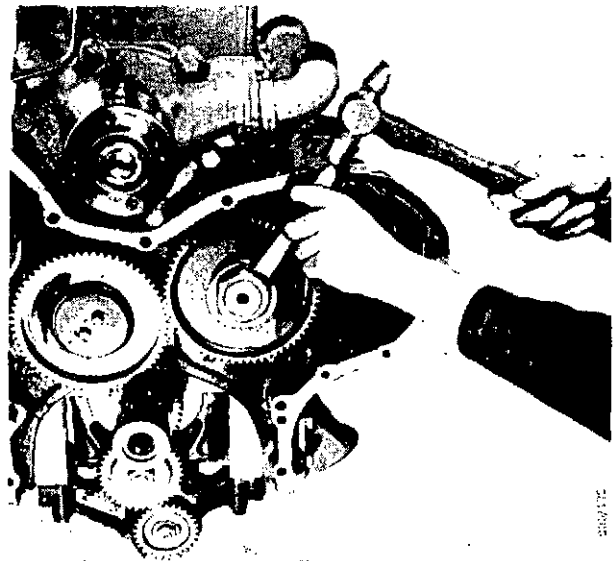
1. Drive the shaft in from the front with a fibre mallet, and match the two teeth so that a marked tooth fits into a marked tooth space on the idler gear.
2. Put the retaining ring into its groove in the outer ring of the rear bearing.
3. Fit the sealing-ring holder. Make quite sure that the lip in the sealing ring has assumed its correct position. Then make the sealing-ring holder tight.
4. Fit the injection pump; see the section headed "Fuel System".

Fitting the Camshaft and Camshaft Gearwheel

When the camshaft is being pushed into its bearings, take great care so as not to damage the bearing surfaces. If the oil pan has been taken out, it is a good plan to support the camshaft with one hand in the crank chamber.

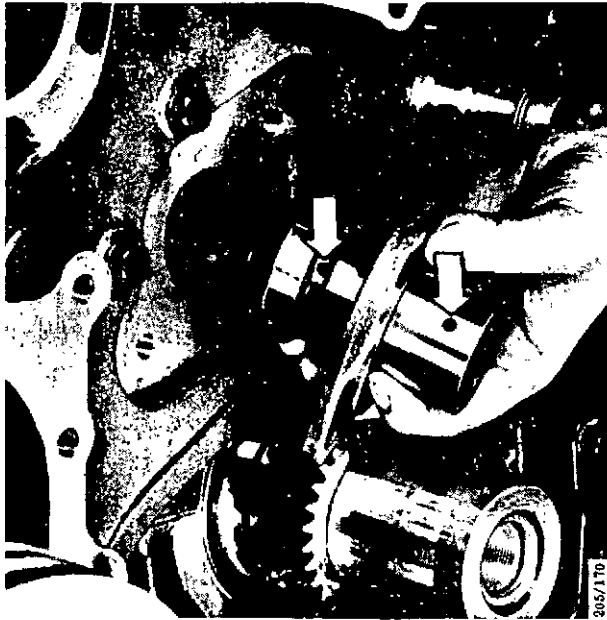
Put on the locating flange, make it tight with the two screws and lock it.

Warm the wheel in water and push it onto the end of the shaft so that a marked tooth fits into a marked tooth space on the idler gear (see the figure). Do not drive the cold wheel onto the shaft with a drift and a hammer, since this could leave the shaft crooked or otherwise damaged. Make the nut tight and lock it with a lock washer.



Lock the nut of the camshaft

The wheel can also be fitted onto the camshaft while it is out of the engine. In this case, do not forget to begin by putting on the locating flange.

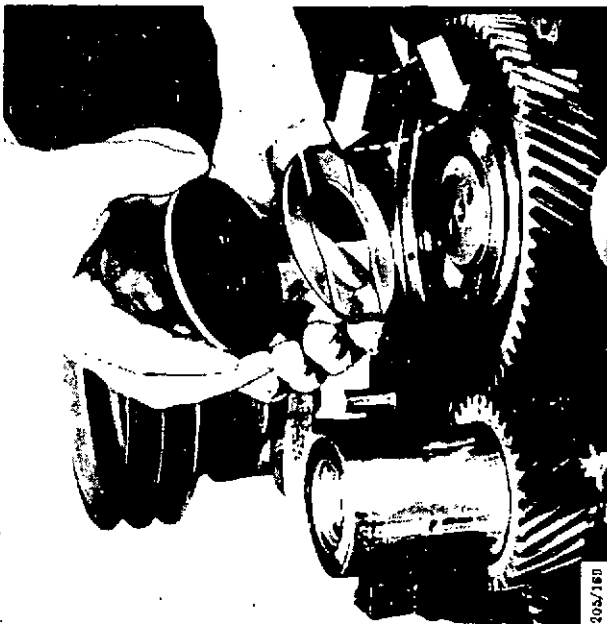


Recess and oil passages in shaft for idler gear

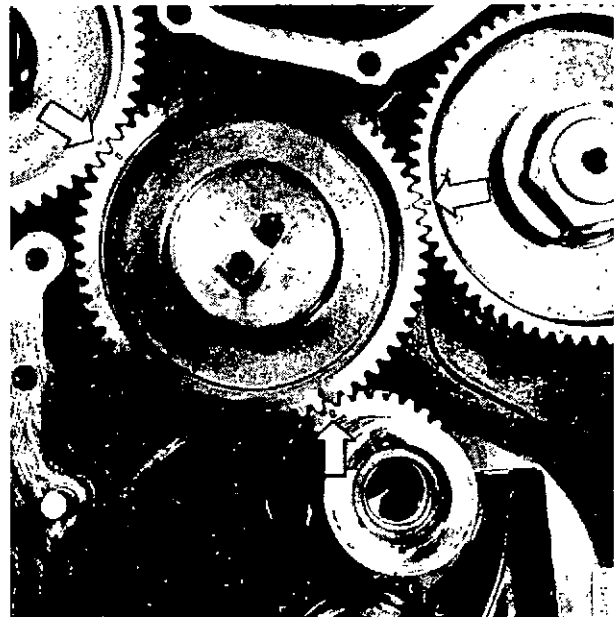
Fitting the Stub Shaft and Idler Gear

In the seat that takes the stub shaft in the cylinder block there is an oil passage. It is in communication with the recess and oil passage in the stub shaft. Oil is forced from the lubricating system of the engine through the stub shaft to the journal bearings and thrust washers of the idler gear. The oil that leaks through splashes out through the holes between the teeth and lubricates the whole timing-gear assembly. It is therefore very important to see that the idler gear and the thrust washers are fitted according to the directions given in points 2, 3 and 4.

1. Fit the stub shaft for the idler gear and check that there is nothing to prevent the oil from the oil passage in the cylinder block from passing through the stub shaft out to the bearing end on the shaft. There must be no gasket beneath the flange.



2. Fit the inner thrust washer so that the oil grooves face the wheel.
3. Turn the idler gear so that the radially drilled holes face forwards. This means that the stamped marks will also face forwards. Push the idler gear on so that the marked tooth spaces fit round a marked tooth on the crankshaft gearwheel, the camshaft gearwheel and the pumpshaft gearwheel respectively. At the same time check the tooth play in the timing gears: see under the heading "Checking the Tooth Play in the Timing Gears".
4. Fit the outer thrust washer with the oil grooves facing the wheel.
5. Fit the outermost washer. Do not lock the screws until the final check on the tooth play has been made.
6. Check that the outer thrust washer is not being pinched. It should be possible to move it slightly by hand.



The markings on the timing gears

Checking the Tooth Play of the Timing Gears

Check the tooth play in the timing gears. The play is normal when it is possible, with all gearwheels fitted, to push the idler gear in on its stub shaft by hand using moderate force.

If the idler gear cannot be pushed in this way, it must not be driven in; the reason for the tight fit must be eliminated.

In the event of excessive play and noise in the timing gears, worn gearwheels should be changed.

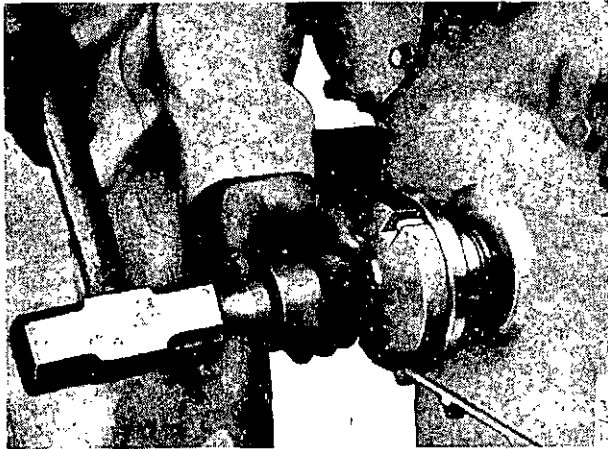
Fitting the Timing-gear Casing

Change the felt ring in the timing-gear casing. Thoroughly soak the new felt ring in engine oil before putting it into the groove.

Fitting the Vibration Damper

Drive the hub on with the drift.

Tighten the bolts of the vibration damper and the screw in the front end of the crankshaft to the stated torque.



Drive the hub on with the drift

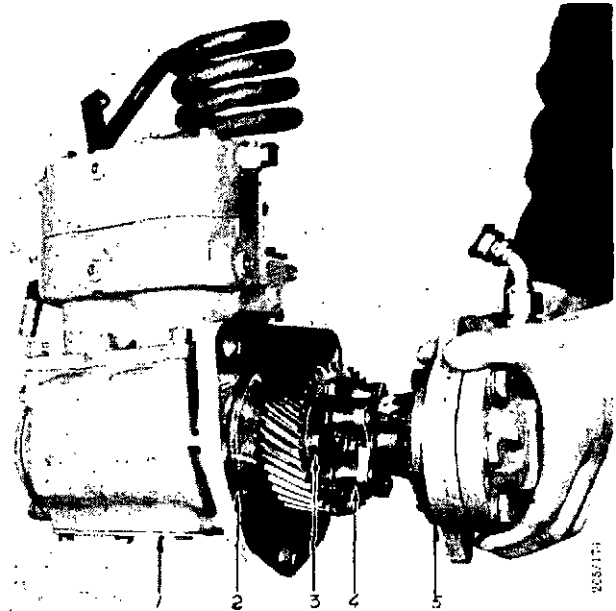
Fitting the Compressor

Fit the compressor after first fitting a new rubber ring into its groove ahead of the attached flange. Make the compressor tight and connect up the pipes that were disconnected in removing it.

Fitting the Hydraulic Pump of the Power Steering

Fit the pump so that the rubber bushings on the driver pins fit into the corresponding holes in the driver plate in the driving wheel of the compressor. Make the nuts tight.

Remove the protective plugs and connect up the hose couplings. Fill up with hydraulic fluid.



Hydraulic pump and compressor

- | | |
|-----------------|--------------------------------|
| 1. Compressor | 4. Driver with rubber bushings |
| 2. Rubber ring | 5. Hydraulic pump |
| 3. Driver plate | |



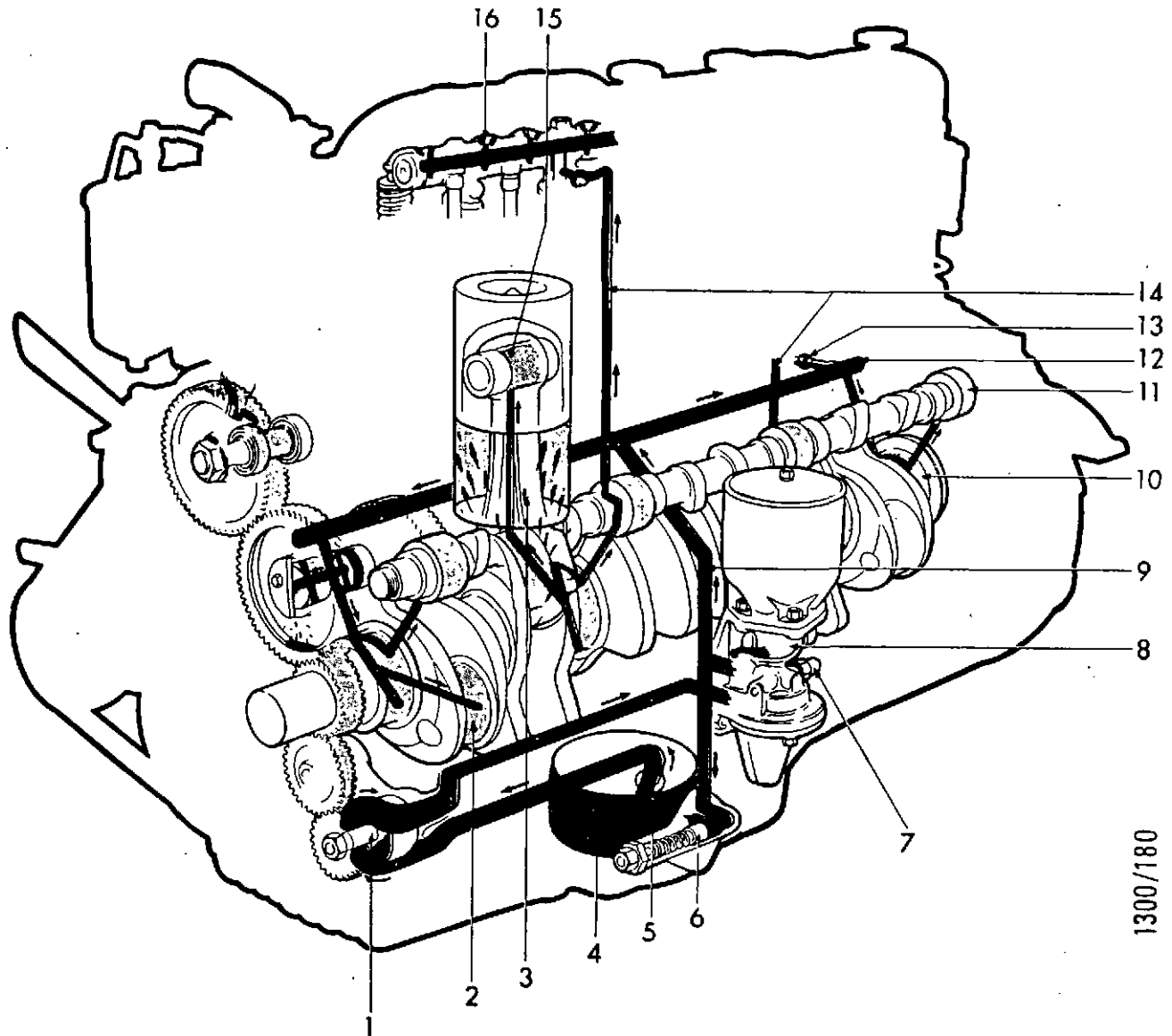
Lubricating System

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Lubricating-oil Pump	F3
General	F3
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Fitting	F4
Cleaning the Centrifugal Cleaner	F4
Relief Valve	F4



Lubricating System



1300/180

Lubricating System

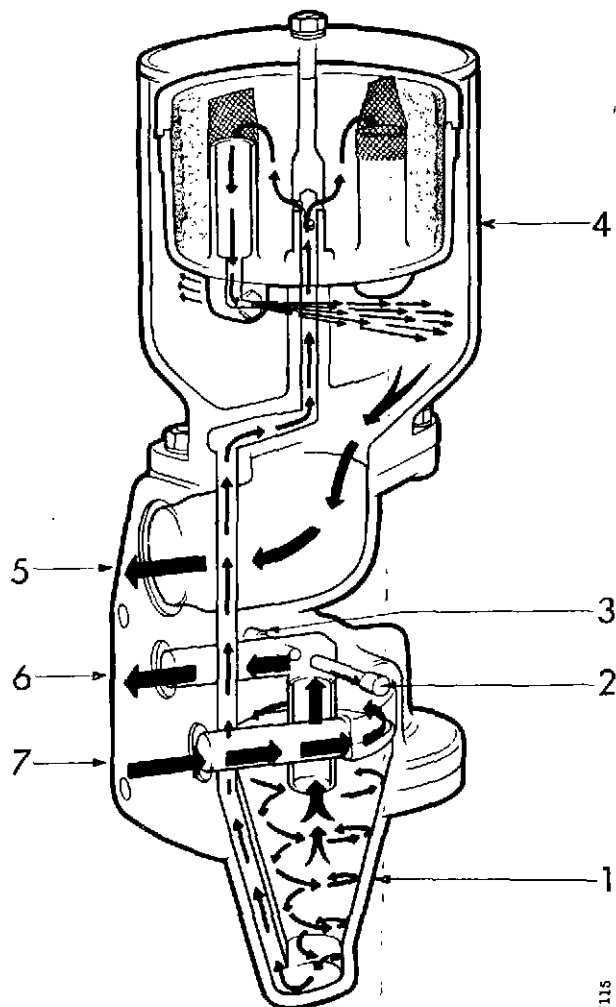
- | | |
|---|--|
| 1. Oil pump | 10. Main bearing |
| 2. Big-end bearing | 11. Camshaft bearings |
| 3. Splash lubrication for cylinder bores | 12. Distribution oilway |
| 4. Oil strainer mounted in pan | 13. Connection for oil-pressure gauge |
| 5. Suction pipe for oil from pan to pump | 14. Oilway for lubricating oil to rocker-arm mechanism |
| 6. Relief valve for oil pressure | 15. Piston pin |
| 7. Oil-pressure monitor | 16. Rocker-arm mechanism |
| 8. Lubricating-oil cleaner | |
| 9. Oilway between cyclone and distribution oilway | |

General

The engine has a force-lubrication system, which means that the oil is forced round to the various lubricating points by an oil pump.

The oil pump, which is located at the front end of the oil pan, draws oil from the pan via an oil strainer. The oil strainer removes any coarse particles which may be present in the oil before it is drawn up out of the pan. The oil pump then feeds the oil under pressure into a lubricating-oil cleaner in which it is cleaned.

The lubricating-oil cleaner consists of a cyclone (1) and a centrifugal cleaner (4). The oil is first forced into the cyclone, where the impurities, by reason of their greater weight, are thrown out against the walls and are then driven downwards by the current of following oil. The dirty oil is next forced through the oilway in the housing of the oil cleaner up into the rotor section of the centrifugal cleaner. This is made to rotate at high speed by the reaction of the oil squirting out of the two nozzles.



Lubricating oil cleaner

1. Cyclone
2. Outlet for lubricating oil to compressor
3. Connection for oil-pressure monitor
4. Centrifugal-cleaner housing with rotor
5. Return line to oil pan
6. Oilway from cyclone to distribution oilway

The centrifugal force throws foreign particles in the oil out against walls of the rotor, where they are deposited in the form of a black, rubbery mass. The clean oil flows through the line (5) back down into the oil pan.

The oil in the centre of the cyclone is free from impurities, and is taken through the oilway (6) to the distribution oilway (12), from which the oil is taken by oilways in the block to the main bearings (10), the camshaft bearings (11), and the timing gears. From the main bearings the oil goes through oilways in the crankshaft to the big-end bearings (2), and from there by oilways in the connecting rods to the piston pins (15). Through oilways in the camshaft the oil is forced intermittently to the rocker-arm mechanism (16). The oil running back from the rocker arm mechanism lubricates the valve lifters.

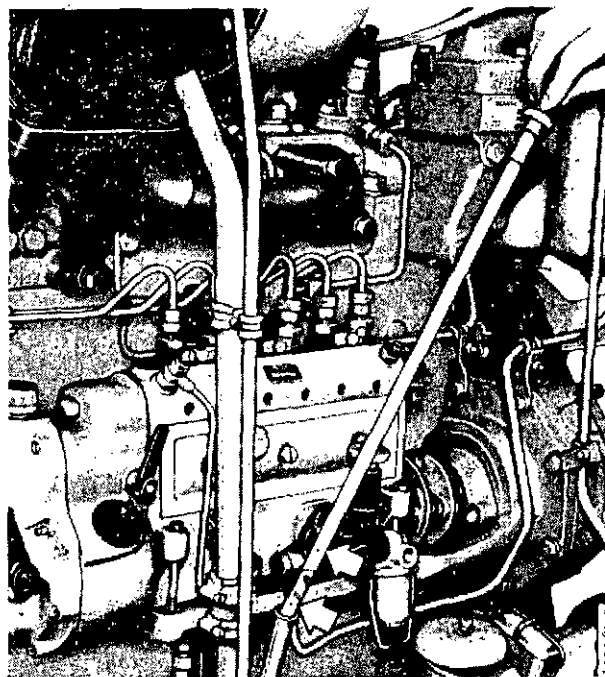
The pistons, the cylinder bores and the cams on the camshaft are lubricated by oil splashed about by the crankshaft.

The oil pressure is controlled by an externally sited plunger-type relief valve (6).

An oil-pressure gauge, which is sited on the instrument panel, is connected by a pipe (13) to the distribution oilway of the engine. The lubricating system is also provided with an electric contact for a warning lamp (7). The lamp, which is sited on the instrument panel, lights when the oil pressure goes too low.

The oil level in the engine is checked by means of an oil dipstick located in the oil pan on the right-hand side of the engine. The oil level must be between the marks on the dipstick. The oil need not be topped up until the level has fallen to the lower marking.

To prevent the occurrence of overpressure in the crankcase the engine is provided with a special



Check the oil level

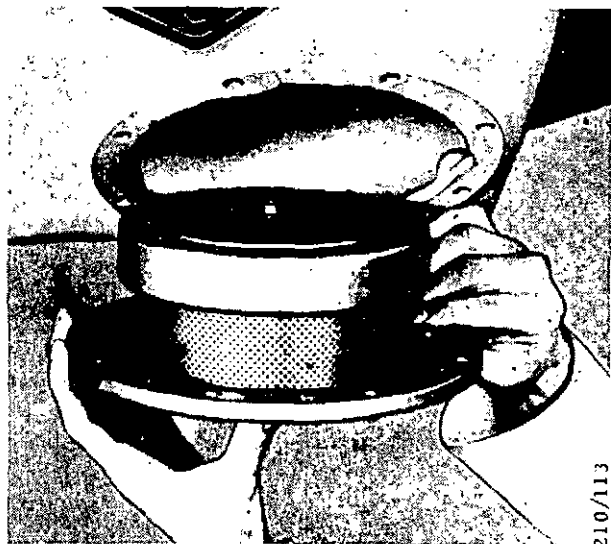
1. Oil dipstick



breather pipe mounted on one of the side covers. Inside the cover is a filter which extracts the oil from the crankcase gases before they leave the engine.

Oil Pan

The oil pan is a silumin casting and is provided with a cylindrical oil strainer. The pan is so shaped that the return oil from the lubricating points of the engine runs down on the outside of the strainer. The suction line of the oil pump is therefore located inside the strainer. The drain plug for the engine oil is fitted with a magnetic plug. The magnetic plug collects all particles of magnetic material out of the oil. Certain engines have a special bottom cover with a sludge pocket round the oil strainer.



Bottom cover with oil strainer

Removing the Oil Pan

1. Drain off the engine oil by screwing out the drain plug.
2. Screw out the screws of the oil pan.
3. Lift down the pan, take out the baffle plate and relief valve and clean the parts.

Fitting the Oil Pan

In fitting the oil pan a new gasket and a new O-ring at the sealing sleeve in the passage to the relief valve must be used.

To ensure adequate sealing it is important that the gasket and all sealing surfaces are absolutely dry and clean when the gasket joint is put together. If the gasket is smeared with any kind of sealing compound it may be spoiled by plastic deformation when the screws are being made tight.

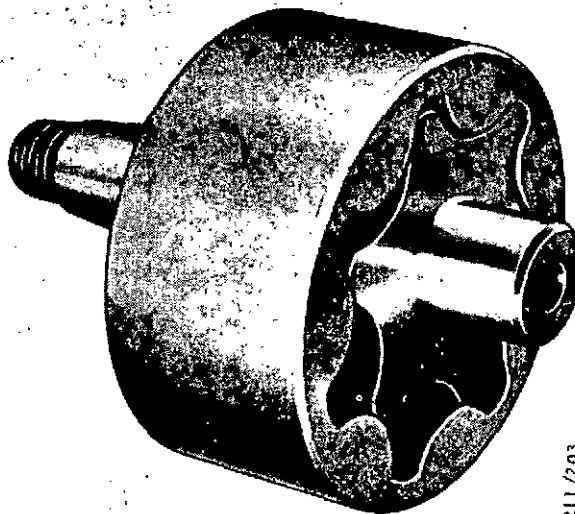
1. Lift the oil pan into place. See that the gasket is correctly positioned.
2. The screws must be tightened evenly and to the correct torque. Excessive tightening may deform the seating surface of the oil pan against the gasket and render it uneven.
3. Put in fresh oil and check the oil level and oil

Lubricating-oil Pump

General

The lubricating-oil pump is a rotor pump of Eaton type and is mounted on the engine block at the first main bearing. The moving parts consist of an inner and an outer rotor. The outer rotor, which has internal arc-shaped teeth, runs eccentrically in relation to the inner rotor. The outer rotor rotates freely in the pump housing.

The number of teeth on the inner rotor is one less than the number of tooth spaces in the outer, and the inner rotor is so shaped that it is in constant contact with the outer rotor.



Rotor set

The inner rotor is made integrally with the driving shaft, which is carried in the pump housing and cover with readily renewable bearing bushings. The pump is driven by the crankshaft gearwheel via an idler gear.

The bearing stub for the idler gear is also pressed into the pump housing. The idler gear is carried on this stub with two ball bearings.

The oil is drawn via the oil strainer and suction pipe through passages in the lower part of the pump housing in between the rotors. These rotors then force the oil up into the passage leading to the lubricating-oil cleaner.

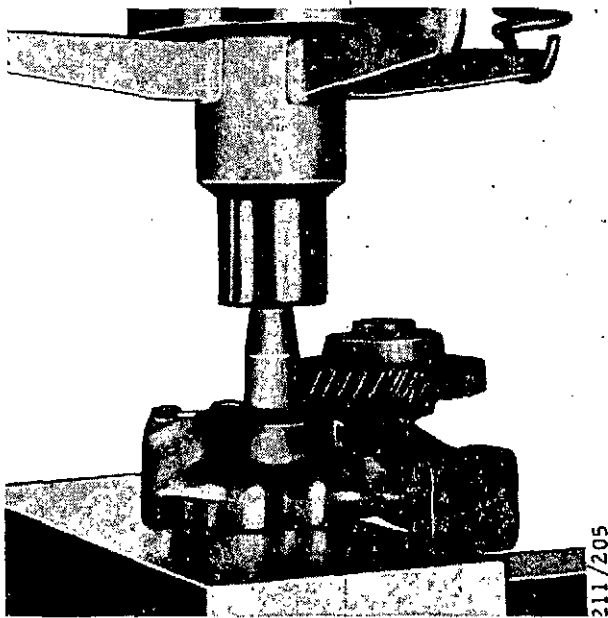
Removal

To remove the lubricating-oil pump and its idler gear only, it is merely necessary to drop the oil pan.

1. Remove the suction pipe.
2. Remove the screws that secure the pump and its bracket to the cylinder block on either side of the front main bearing.

Inspection and Reconditioning

1. Dismantle the pump. Do not forget to remove the key of the pump wheel before the inner rotor is taken out the pump housing.
2. Thoroughly clean all parts.
3. Inspect the pump. Change worn bearings and wheels. Ream the bushings for the rotor shaft after pressing them in. If necessary, grind the pump cover flat.



Press in the bushings for the rotor shaft

4. Inspect the rotor set and replace it by a new one if it is worn.
5. Assemble the pump, using new O-rings.
6. Check that it runs easily.

Fitting

Fitting is carried out in the reverse order to removal. Always fit a new O-ring at the pressure passage.

After fitting the pump, always check that there is a clearance between the studs of the main bearing caps and the pump bracket.

Put in oil, give the engine a test run and set the oil pressure to the correct figure by means of the relief valve.

Cleaning the Centrifugal Cleaner

1. Screw off the nut holding the top cover of the cleaner and remove this cover.
2. Lift out the rotor and screw off the two nuts. Take off the cover.
3. Scrape the deposits off the walls of the rotor with a knife or similar implement.

on the cover of the rotor agrees with the marking on the rotor itself.

5. Press the cover firmly down against the rotor so that the cover bottoms against it.
6. Make the nuts of the cover finger-tight, then give them *half a turn* with a wrench. Check that the rotor runs easily on the shaft by spinning it with the fingers.
7. After fitting the cover of the centrifugal cleaner, check also that the rotor runs easily, as follows: Start the engine and run it until the oil is reasonably warm. Stop the engine.

Check by putting your ear close to the cleaner that the rotor is spinning. It makes an unmistakable humming noise. Normally it should rotate for at least one minute after the engine is stopped.



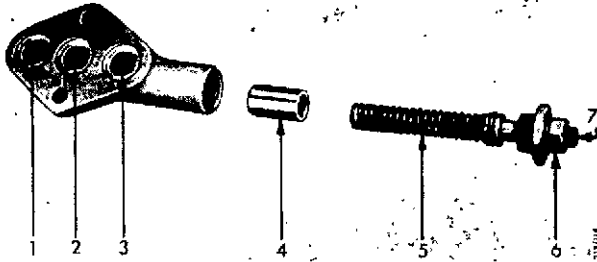
Fit the rotor of the centrifugal cleaner

Should it become necessary to remove the central section of the lubricating-oil cleaner, this is done by unscrewing the four retaining screws. Before the screws are undone the pipe connection for the lubricating oil to the compressor and the line to the oil warning lamp must be disconnected.

N.B. Always fit new O-rings at the passages in the assembly flange.

Relief Valve

The relief valve controls the oil pressure. It is located on the left-hand side of the oil pan. It consists of a valve body, a valve plunger, a compression spring and an adjusting screw. The relief valve

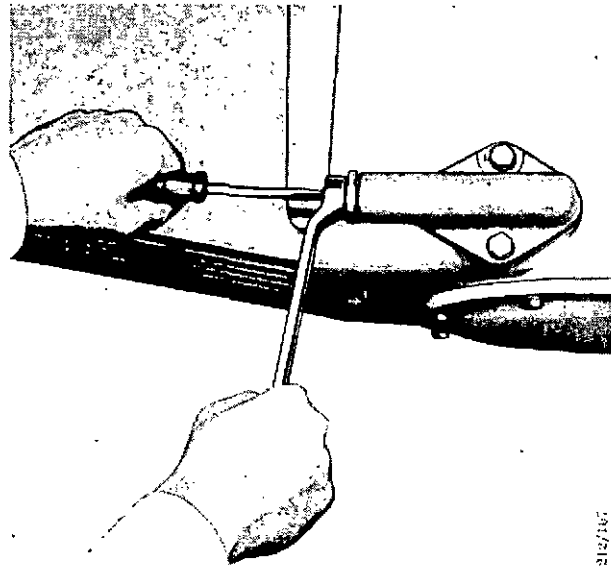


Relief valve

- | | |
|--|-----------------------|
| 1. Intake hole | 4. Plunger |
| 2. Outlet hole | 5. Compression spring |
| 3. Outlet hole for oil
leaking past plunger | 6. Locknut |
| | 7. Adjusting screw |

The valve body has an intake hole and an outlet hole. The outlet hole is closed by the valve plunger as long as the oil pressure is less than the maximum. When the oil pressure has reached this figure the spring is compressed and the outlet hole is uncovered, so that the pressure is prevented from rising further.

If the oil pressure in an engine has fallen too low, and normal pressure cannot be restored by adjusting the relief valve, the reason for the pressure drop may be that the valve is worn. Since it is often difficult to judge from the appearance of a relief valve whether it is worn or not, it should be removed and replaced by a new valve, after which the oil pressure in the engine should be checked afresh. This check should be made with the engine warm and running at the stated r.p.m. Adjust the spring loading in the relief valve with the adjusting screw



Setting the maximum oil pressure

to bring the oil pressure to the maximum permissible. The screw is screwed inwards to increase the oil pressure and outwards to reduce it.

If the pressure is still too low even with the new valve, this points to some other fault. For example, the oil pump may be worn or there may be a leak in the piping. When the oil pump is being checked the suction pipe should also be examined for leaks.

If the engine is badly worn, the trouble is very likely due to excessive bearing slackness, which has a strong tendency to reduce the oil pressure.

N.B. Fit new O-rings beneath the assembly flange of the relief valve every time the valve has been taken out.



Cooling System

Contents

	Page
General	G1
Coolant Pump	G2
Disassembly	G4
Inspection	G4
Assembly	G4
Fan and Fan Belts	G5
Thermostat	G6
Coolant Temperature Gauge	G6
Radiator	G6
Temperature-controlled Fan	G7



Cooling System

General

The coolant is made to circulate by the coolant pump (2), which pumps the liquid through the engine and radiator. The pump draws the coolant from the lower part of the radiator and forces it into the distribution gallery of the engine block. From the distribution gallery the coolant is forced on into the engine block where it flows round the cylinder liners and then rises up into the cylinder heads (9). From the distribution gallery the coolant is also forced direct up into the cylinder heads through passages which are so directed that the coolant flows round the sleeves of the injectors.

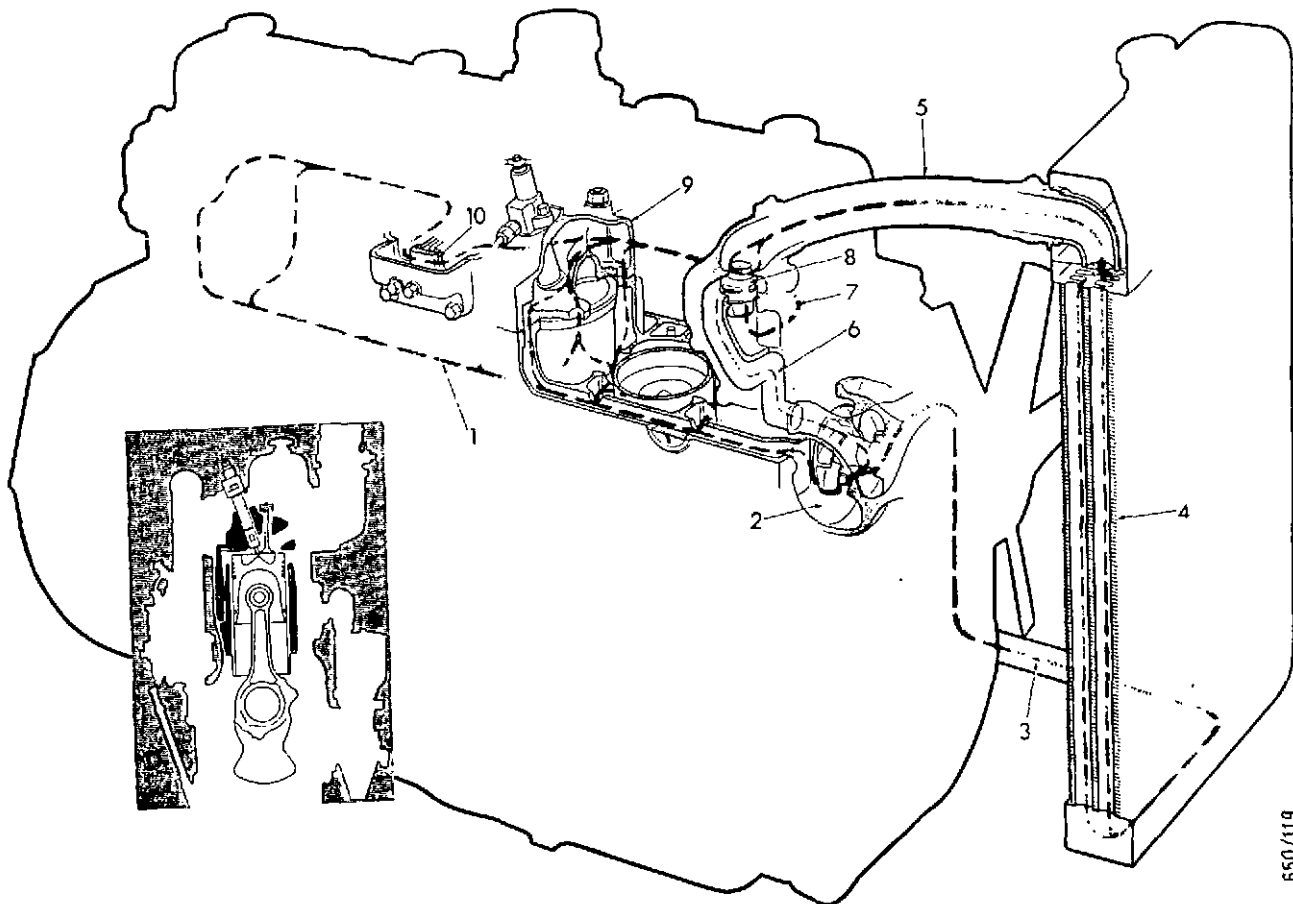
From the rear cylinder head the coolant passes through a communicating passage (10) to the front cylinder head which is in communication with the thermostat housing through a passage (7).

The task of the thermostat is to keep the engine at as constant a working temperature as possible. It

consists of a valve for controlling the flow of coolant through the radiator and a bellows which regulates the valve. The thermostat bellows is made of thin corrugated sheet metal, so that it is able to expand and contract. Inside the bellows is a volatile liquid. When the bellows is heated this liquid vaporizes, increasing the pressure and causing the bellows to expand. The controlling action of the thermostat is based on this principle.

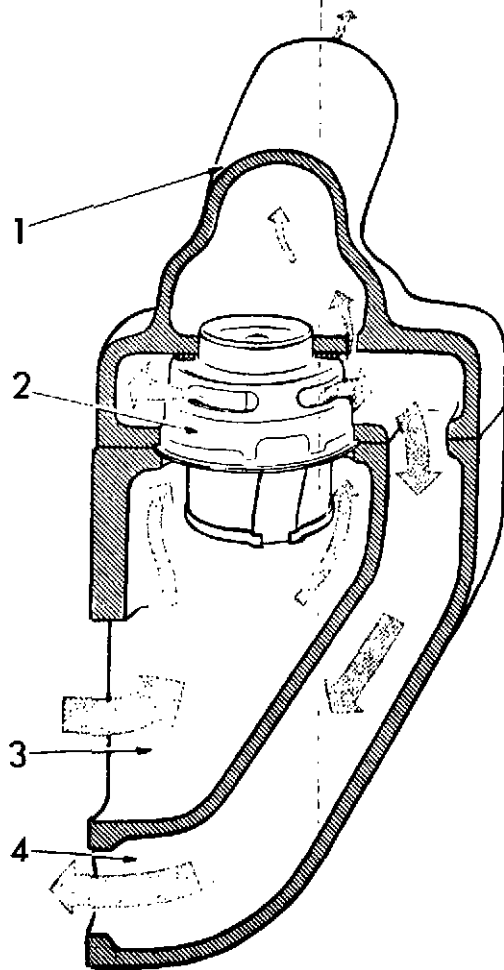
The figure shows the thermostat in the half-open position, i.e. the temperature of the engine coolant is within the control range of the thermostat. In this position some of the coolant will flow through a theurn line (6) direct to the coolant pump (2). The rest of the coolant flows through the half-open thermostat and on through the upper coolant hose (5) and into the radiator (4) where it is cooled down.

If the coolant temperature in the engine is lower than the opening setting of the thermostat, almost



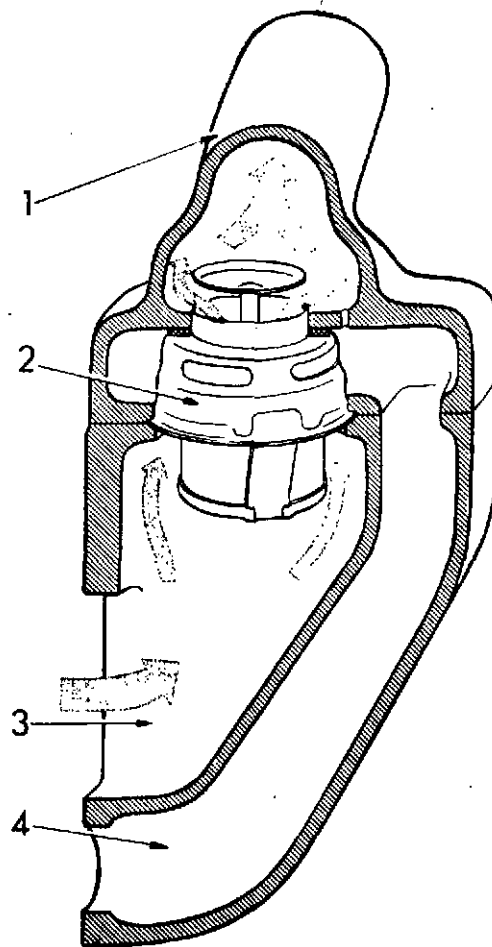
Cooling system

- | | |
|---------------------------------|---|
| 1. Coolant distribution gallery | 7. Inlet passage from cylinder head to thermostat housing |
| 2. Coolant pump | 8. Thermostat |
| 3. Lower radiator hose | 9. Cylinder head |
| 4. Radiator | |



650/120

A. Fully closed thermostat



650/121

B. Fully open thermostat

Thermostat housing

1. Upper coolant pipe
2. Thermostat
3. Inlet passage from cylinder head
4. Return line to coolant pump

all the coolant will flow through the return line (4) (see the figure above) straight to the coolant pump. However, a small quantity of coolant will still flow through a hole drilled in the thermostat housing and on through the upper coolant pipe (1) to the radiator. This slight flow through the radiator prevents the coolant in the radiator from freezing when the vehicle is driven in low ambient temperatures.

If the coolant temperature in the engine is above the temperature at which the thermostat is fully open, all coolant will flow through the open thermostat (2) out into the radiator for cooling.

On its way down through the radiator the coolant is cooled by the air stream through the radiator. This air stream is created partly by the motion of the vehicle and partly by the fan. The quantity of air passing through can be controlled by means of a radiator blind.

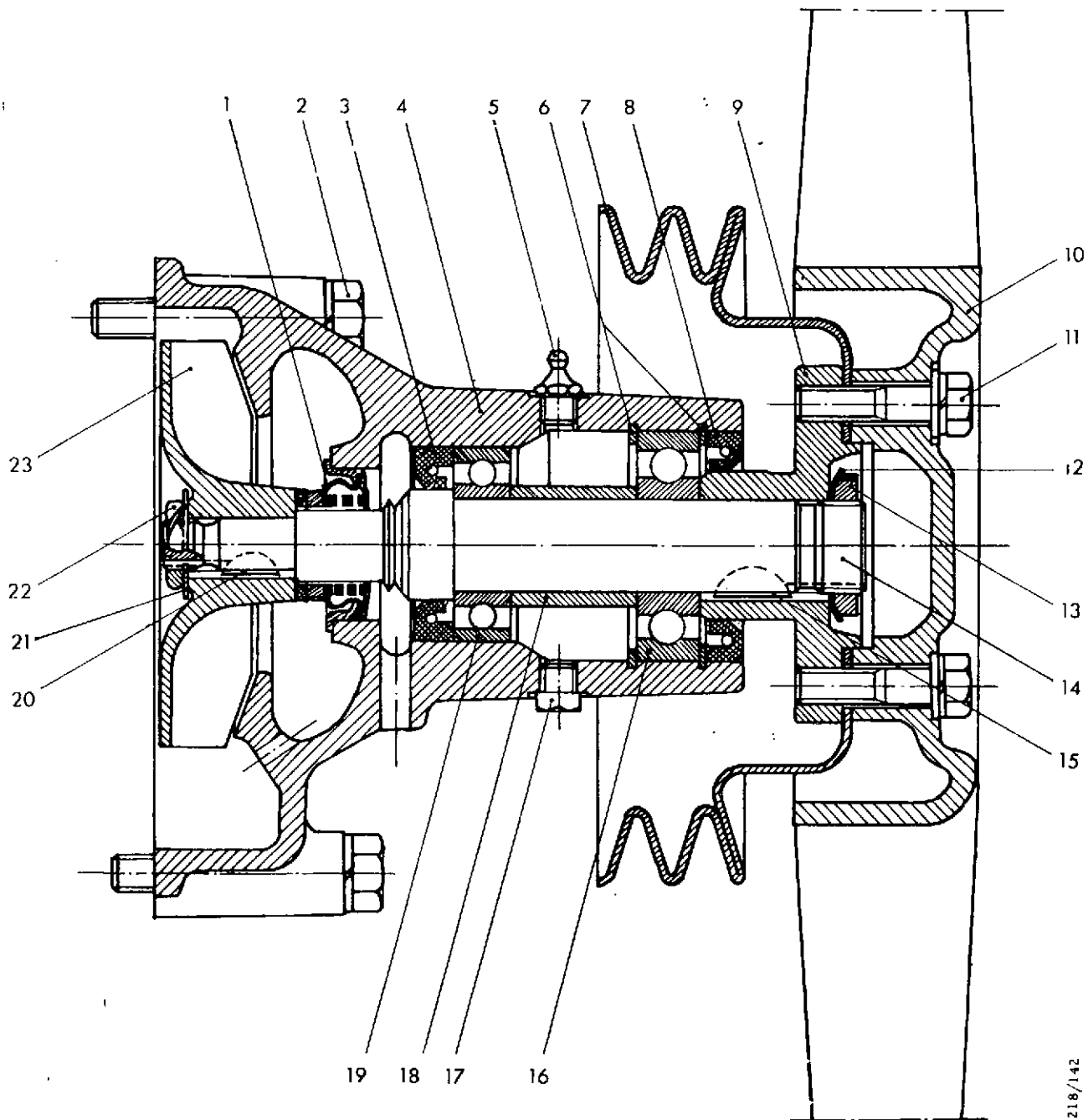
To indicate the temperature of the engine there

is a thermometer giving a continuous reading of the coolant temperature. It consists of a dial instrument and a closed metal sleeve, joined by a connecting tube of very fine bore. The dial instrument is built into the combination instrument on the instrument panel while the detector is mounted in one of the communicating passages and is in direct contact with the coolant.

The metal sleeve contains a certain quantity of a volatile liquid, which vaporizes when the coolant in the engine warms up. The vapour pressure is communicated through the connecting tube to the pressure-gauge spring. The effect of this is that the spring attempts to straighten out. It is connected to the pointer by a lever, which transmits its movement to the pointer.

Coolant Pump

The coolant pump is mounted on the front end of the engine and is driven by vee belts from a belt



Coolant pump, complete, with belt pulley and fan

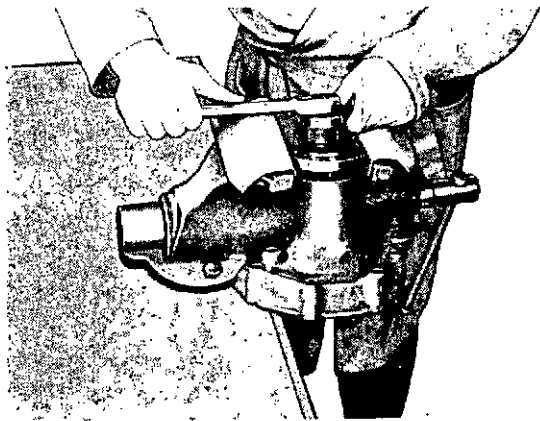
- | | | |
|-----------------------------|------------------------------|--------------------|
| 1. Sealing ring for coolant | 9. Fan hub | 17. Relief valve |
| 2. Screw with spring washer | 10. Fan | 18. Spacer sleeve |
| 3. Sealing ring for grease | 11. Screw with spring washer | 19. Ball bearing |
| 4. Pump housing | 12. Lock washer | 20. Key |
| 5. Lubricating nipple | 13. Nut | 21. Lock washer |
| 6. Retaining nipple | 14. Pump shaft | 22. Nut |
| 7. Belt pulley | 15. Key | 23. Impeller blade |
| 8. Sealing ring for grease | 16. Ball bearing | |

with an impeller of phosphor-bronze and a shaft of stainless steel. The shaft runs in ball bearings and the pump is fitted with a resilient seal which bears against a ceramic ring on the impeller.

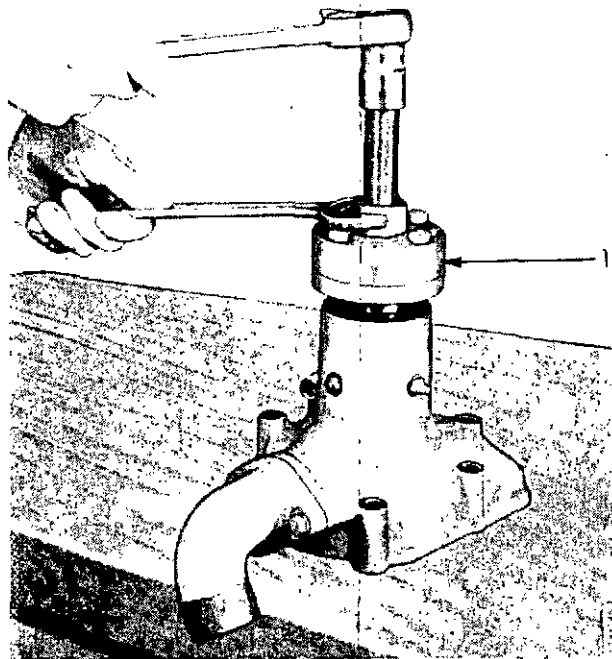
housing, but to eliminate the risk of burst sealing rings the pump is fitted with a relief valve (17). This valve opens when the bearing housing is full of grease. Lubricate with a hand grease gun until

Disassembly

1. Detach the fan and belt pulley by unscrewing the screws (11).
2. Unscrew the shaft nut (22) of the impeller wheel, after first turning down the lock washer. While doing this job, have the hub clamped in a vice to prevent the pump shaft from rotating.
3. In the same way, detach the shaft nut (13) of the hub using the keyed socket.



Remove the shaft nut



Remove the hub using the puller

1. Puller

4. Remove the hub using the puller. Make the screws of the puller thoroughly tight.
5. Remove the sealing ring inside the hub using a suitable tool.
6. Remove the outer retaining ring (6) with a pair

7. Detach the impeller using the puller.



Detach the impeller using the puller

8. Press the shaft with bearings out of the pump housing, working towards the driving flange.
9. Remove the coolant sealing ring and the inner grease sealing ring.

Inspection

Clean all parts thoroughly in a cleaning liquid.

Examine the pump housing. Among other things, make sure that all bearing and contact surfaces are free of defects. If water leakage has occurred at the sealing surface against the engine block, this surface should be checked with a surface plate. Check that the drain hole of the pump housing is clear. Inspect the remaining parts of the pump. If the ceramic washer on the impeller is too badly worn or otherwise defective, the impeller must be changed. The pump shaft and hub should be changed if, for example, the contact surfaces for the sealing rings are appreciably worn. If necessary, the bearings of the pump shaft can be changed in the usual way using a press. In fitting the smaller bearing, check that it is made to bear against its shoulder on the pump shaft. The position of the larger bearing is then determined by the spacer sleeve between the bearings. If the bearings are incorrectly positioned, there will be a corresponding inaccuracy in the position of the impeller after assembly, which may make it necessary to take the pump shaft out again.

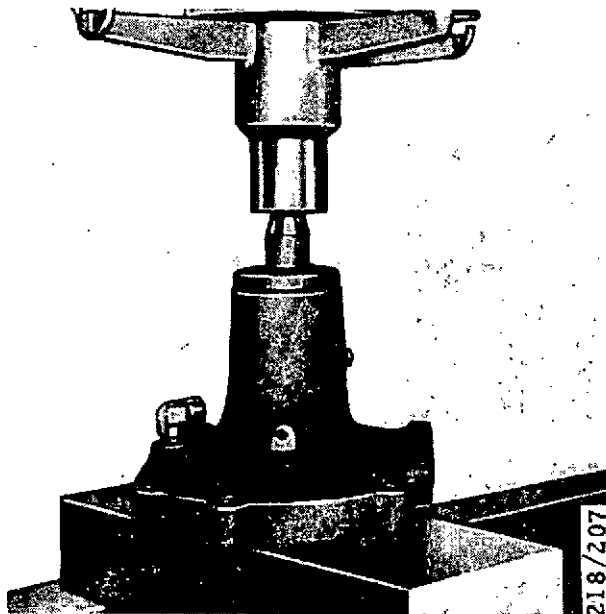
All sealing rings should be renewed, even if they do not appear to be worn or defective.

Assembly

1. See that the inner retaining ring (6) of the outer bearing is firmly seated in its groove in

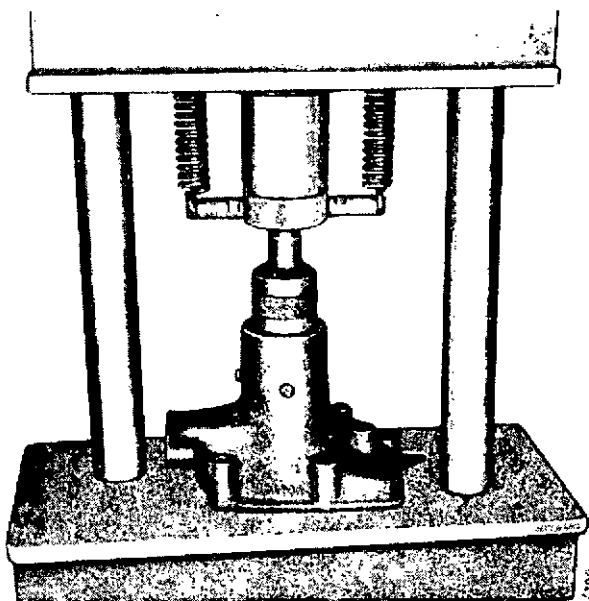


2. Press the inner sealing ring (3) into its position. Use the drift, which will prevent the sealing ring being pressed in too far.
3. Press in the coolant sealing ring. Use the drift.

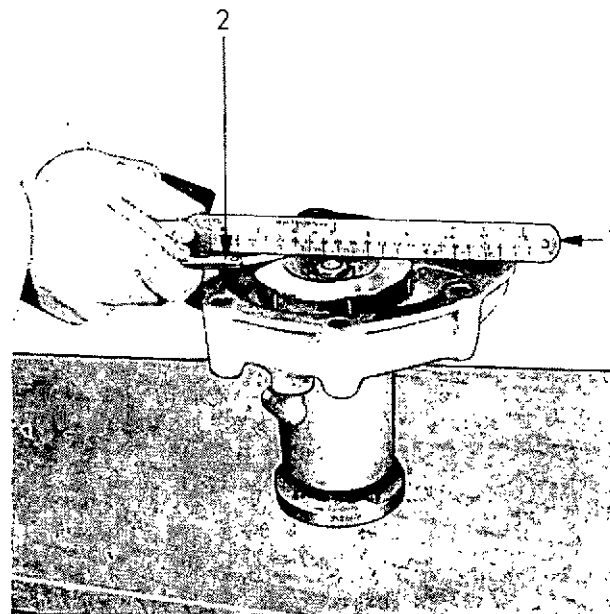


Press the inner sealing ring into its position

4. Press the bearings and the spacer sleeve into place on the shaft.
5. Grease the bearings and the surface at which the sealing ring (3) contacts the shaft with rolling-bearing grease.
6. Then press the shaft, carrying the bearings, into the bearing housing. The press force should be applied to a tubular drift covering the outer and inner rings of the front bearing.



7. Fit the retaining ring outside the front bearing and press the sealing ring (8) in with the drift. The open side must be turned to face the bearing.
8. Fit the key. Lubricate the sealing surface of the hub with rolling-bearing grease and fit the hub.
9. Fit the nut with a new lock washer. The conical side of the nut must be turned to face the hub washer. Tighten the nut and lock it.
10. Fit the key of the impeller and then the impeller itself. Lock the nut with a new lock washer.
11. Check the position of the impeller in relation to the face of the pump housing. Use a suitable straightedge and feeler gauge. If assembly has been correctly performed the distance will be somewhere between the stated figures.



Check the position of the impeller

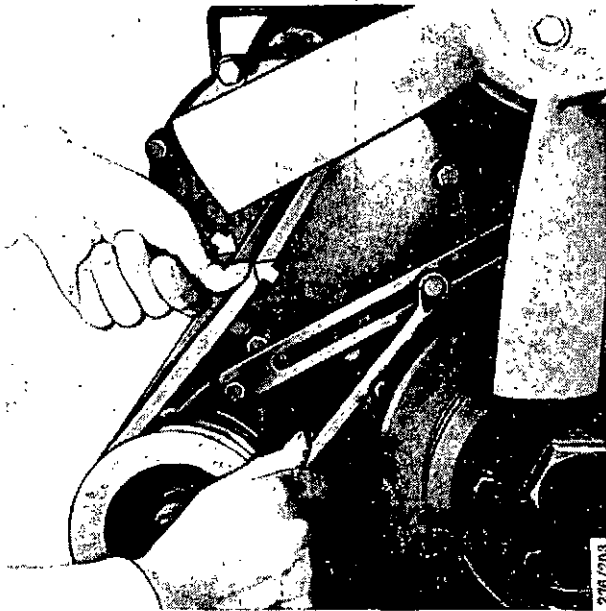
1. Straightedge
2. Feeler gauge

12. Fit the pump. Use a new gasket.
13. Lubricate the pump with rolling-bearing grease and check that the relief valve is in working order.
14. Fit the belt pulley and the fan. Use new lock washers.

Fan and Fan Belts

The fan is made of light metal and is mounted on the shaft of the coolant pump. The fan, coolant pump and generator are driven by vee belts. It is of great importance for the operation of the vee belts that they are as nearly equal in length as possible. If a belt is damaged it is often good policy to change the whole set of which it is a part. After the change the belts that work together must have the same tension.

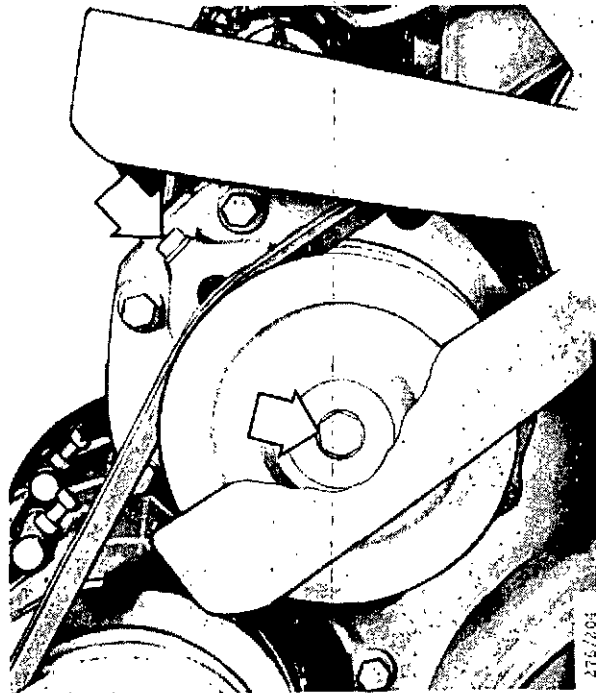
If the belts are correctly tensioned it should be



Check the tension of the vee belts

Adjust the belt tension as follows:

1. Slacken the retaining screws of the generator a few turns.
2. Shift the generator out until the belt tension is correct.
3. Tighten the retaining screws and check that the correct belt tension has been obtained.



Tensioning pulley

On engines equipped with a tensioning pulley, first slacken the nut in the centre of the pulley. Then adjust the belt tension by means of the setting

Under winter conditions, when the air temperature is too low that the coolant does not reach normal working temperature, it may be advisable to remove the fan.

Thermostat

The thermostat has a very important function in the cooling system. It should therefore be checked now and then to ensure that it is functioning satisfactorily.

This check is carried out according to the instructions below:

1. Take the thermostat out of the thermostat housing, immerse it in a vessel of water and let it hang so that it does not touch the sides or bottom of the vessel.
2. Heat the water slowly and check the temperature with a thermometer. Stir the water and do not let the thermometer rest against the bottom of the vessel.
3. The thermostat must begin to open and must reach full opening at the stated temperatures. When it is open, the elongated holes round the thermostat must be covered by the inner valve ring. If the thermostat valve sticks or if it begins to open at too high or too low a temperature, the thermostat must be changed.
4. Before the thermostat is fitted into the thermostat housing the later must be cleaned and inspected to ensure that there is nothing to upset the function of the thermostat.

Coolant Temperature Gauge

The coolant temperature gauge can easily be checked by screwing out the metal sleeve from the engine and immersing it in a vessel of water which is heated and stirred at the same time. Take the temperature of the water with an ordinary thermometer, and compare its reading with that of the dial instrument.

In taking out the metal sleeve, be careful to see that the tube does not accompany the nut.

See that the thermostat tube is free from sharp bends and that it does not chafe against the engine. Nor must the tube be so tightly stretched that it can be pulled apart by the movements of the engine.

Radiator

The radiator consists of an upper and a lower tank, connected by a large number of vertical, thin-walled pipes. To increase the heat-dissipating capacity of the radiator, the pipes are threaded through a large number of thin metal strips. The upper radiator tank is provided with a filler pipe with a cap and also with a coolant tailpiece which is connected by a rubber hose to the thermostat housing on the engine. On the lower tank there is an outlet which is connected to the suction side of the coolant pump.

The radiator is secured in the radiator support



To prevent overpressure or underpressure in the cooling system, a tell-tale pipe is connected to the filler pipe of the radiator. The tell-tale pipe opens in the lower part of the radiator.

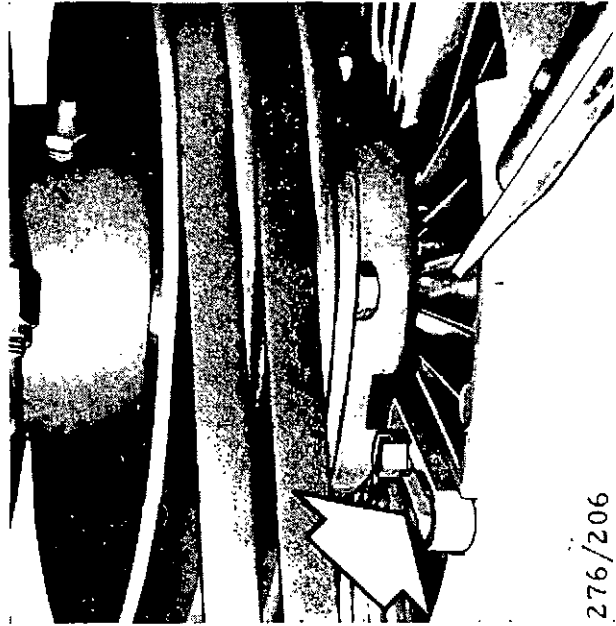
Temperature-controlled Fan

The temperature regulator adapts automatically the r.p.m. of the fan in relation to the temperature of the air which has passed through the radiator.

If the coolant temperature becomes too high and the defect cannot be traced elsewhere, the fan can be locked to the belt pulley:

1. Turn the fan so that one of the keys comes opposite one of the recesses in the belt pulley (see figure).
2. Loosen the screw retaining the key and push it in.
3. Tighten the screw.

Keeping the stop control in pulled-out position, use the starting motor to run the engine so that the fan turns half a turn. Lock the fan also by means of the other key as per 2 and 3.



Temperature-controlled fan

276/206



Fuel System

Contents

General
Injection Pump
Pneumatic Governor
Fuel Filter
Injectors
Trouble Shooting



General

Maintenance work on the injection equipment should be carried out only by specially trained personnel with access to the necessary tools and testing equipment.

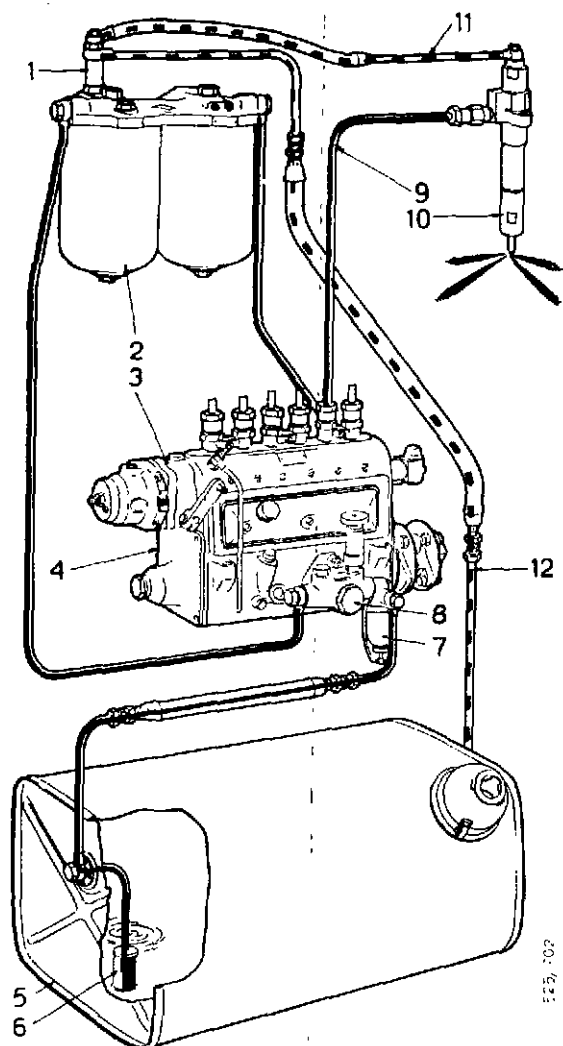
The settings of maximum output and maximum speed that are made at the factory have been carefully worked out and tested and must not be changed, since this would entail a risk of damage to the engine. For this reason, the injection equipment has lead seals at a number of points.

If the seals are broken by an unauthorized person, the factory's guarantee on the engine, and in certain cases that on the drive line as well, will be wholly invalidated.

Observe the greatest care and cleanliness in all work on the fuel system.

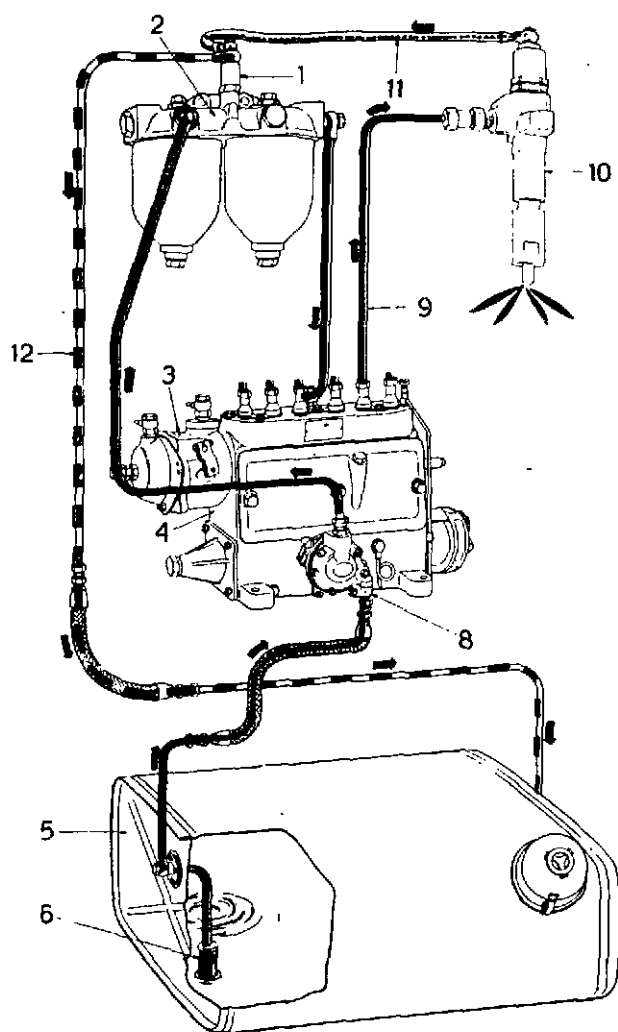
Store protective caps and plugs so that they do not get dirty.

Special tools for injection equipment, such as cleaning tools for injectors, are available from the agent representing the maker of the injection equipment.



Fuel system, Bosch

1. Pressure relief valve
2. Main filter
3. Governor
4. Injection pump
5. Fuel tank
6. Tank filter



Fuel system, CAV

7. Prefilter
8. Feed pump
9. Pressure pipe
10. Injector
11. Leak-off pipe
12. Return line to fuel tank

The feed pump (8) draws fuel oil from the fuel tank (5) through the tank filter (6) and pumps fuel oil through the main filter into the fuel chamber of the injection pump at a certain overpressure in order to give effective filling of the pump elements. The Bosch injection equipment also has a prefilter (7) on the feed pump. Separate pump elements in the injection pump — one for each engine cylinder — then force the fuel on through the pressure pipes (9) into the injectors (10). From this point the fuel is sprayed through four holes into the engine cylinders in a finely divided state.

The filter (6) consists of strainer gauze that takes the coarser impurities out of the fuel before it passes on up to the main filter (2). This item consists of two filter elements which are series-connected in the Bosch injection equipment and par-

filter takes out the remaining solid particles, so that the fuel is effectively purified when it enters the injection pump (4).

The pressure pipes are connected to the injectors (10) through connection studs that are provided with edge filters. These filters serve as a check filter for such impurities as may enter the pipes while they are disconnected from the engine.

The injectors spray the fuel, in a finely divided condition, into the engine cylinders. Leak-off oil from the injectors is collected in a special pipe which is connected to the main filter. The surplus fuel is taken back to the tank through the pressure relief valve (7), the purpose of which is to limit the overpressure produced by the feed pump. The main filter is continuously bled by the current of fuel oil passing through the pressure relief valve back to



Injection Pump

General

The task of the injection pump is to distribute fuel to the various cylinders at the right time and in amounts corresponding to the load on the engine. For this purpose the injection pump is fitted with a camshaft driven from one of the timing gears at the front of the engine. The camshaft acts on the pump elements. The position of the cams, and with it the moment of injection, is always in a certain relation to the position of the crankshaft. Each pump element consists of a plunger and a barrel. These two components are very accurately mated and belong together as a unit.

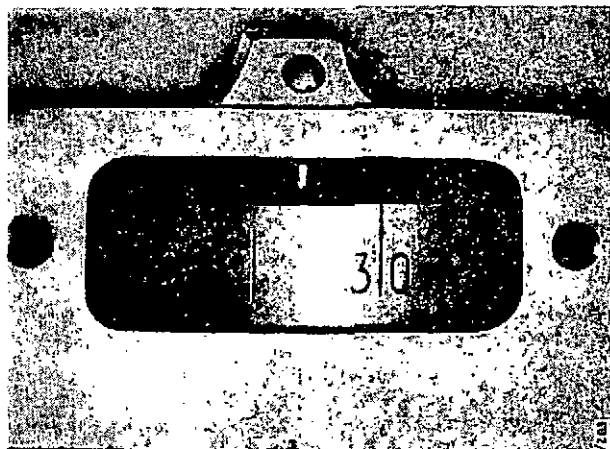
To permit regulation of the fuel charge the plunger is rotatable and has a control helix. The plunger is rotated in the pump barrel by means of a control rod, which derives its motion from the governor. During the upward movement of the pump plungers the fuel is forced out into the individual pressure pipes to the injectors.

Removing the Steel Disc Coupling Injection Pump

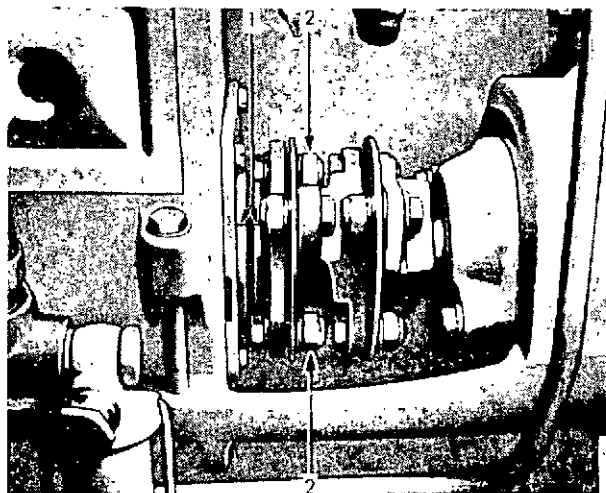
1. Wash the injection pump and the adjacent surfaces of the engine and also all the pipe connections to the pump. Do this carefully!
2. Loosen all the pipe connections and controls fitted to the pump.
3. Put protective caps on all the loosened connections.
4. Loosen the bolts retaining the pump to the pump support.
5. Loosen and remove the bolt keeping the pump coupling fixed to the drive shaft. Lift away the pump and pump coupling assembly, without dismantling the pump coupling. Take care of the key of the drive shaft.

Fitting and Setting the Steel Disc Coupling Injection Pump

1. Open the inspection cover on the flywheel casing, so as to permit the reading of the flywheel graduation.

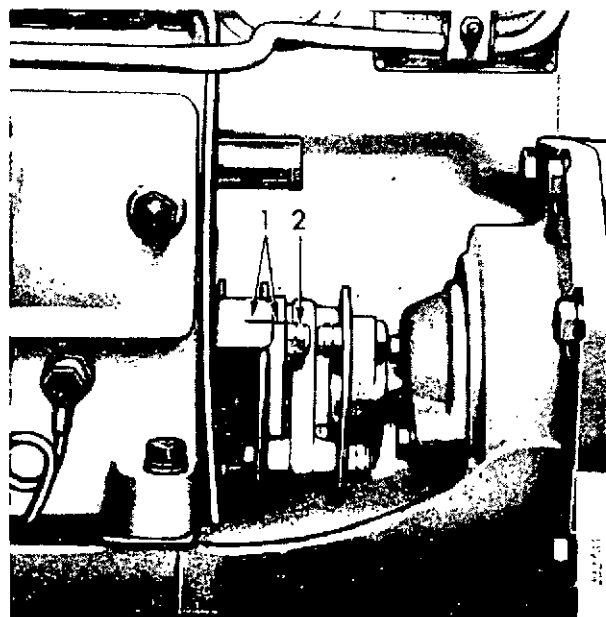


2. Remove the front valve cover and turn the crankshaft until the two valves of cylinder 1 are closed (compression stroke). Turn clockwise, viewed from in front. Go on turning the crankshaft to the number of degrees indicated on the flywheel. The mentioned number must be opposite the point of the index pin in the flywheel casing. If the pin is viewed from one side, an erroneous deviation of several degrees may occur.
3. Place the injection pump on its bracket, and turn the drive coupling of the pump until the index mark on the coupling boss is in line with the corresponding mark on the end cover of the pump (Bosch) or on the plate fitted on the pump (CAV).



Setting the coupling of the injection pump (Bosch)

1. Index marks
2. Adjusting screws



Setting the coupling of the injection pump (CAV)

5. Tighten the pump retaining screws and the coupling locking bolt.
6. If the drive coupling, while being fitted according to point 4, has to be turned a little to line up the spline on the drive shaft and the keyway in the coupling boss, the pump setting will have to be adjusted correspondingly. This is effected by undoing the adjusting screws, after which the coupling boss of the pump can be turned until the index marks once more coincide. Then make the adjusting screws tight again.
7. Turn the crankshaft anti-clockwise about 1/8 turn. Then turn slowly back to the indicated number of degrees. When the flywheel is in this position, the marking on the pump coupling must coincide with the marking on the pump end cover (Bosch) or the plate mark (CAV). Otherwise, adjust on the pump coupling.
8. Injection pumps with connection to the engine lubricating system:
Put oil into the injection pump until it flows out at the connection of the oil outlet line, and then connect up both the oil lines.
Other injection pumps:
Put oil into the injection pump and, where stated, into the centrifugal governor as well, and check the oil level.
9. Fit all the loosened pipe connections and controls.
10. Bleed the fuel system.
N.B. If the injection pump has been removed from the engine, the setting must always be checked on the flywheel scale when the pump is put back again.

Removing the Flange-fitted Injection Pump

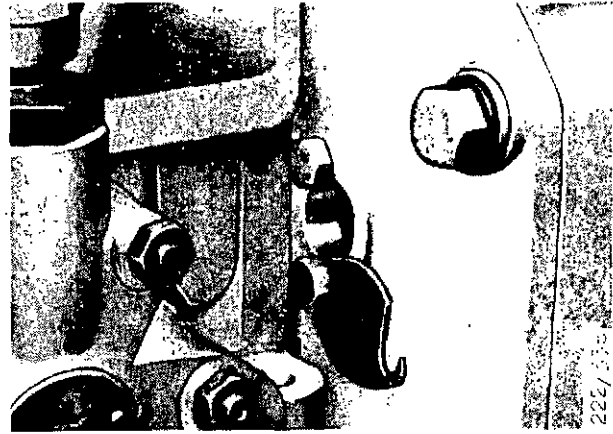
1. See "Removing the Steel Disc Coupling Injection Pump", points 1—4.
2. Remove the cover facing the pump shaft gearwheel on the timing gear casing.
3. Loosen the three bolts retaining the pump shaft gearwheel to the pump hub. Be careful so as to avoid the washers dropping into the timing gear. If this should occur, remove the washers before starting the engine.
4. Loosen the bolts retaining the pump end to the timing gear casing. Lift the pump away.

Fitting and Setting the Flange-fitted Injection Pump

1. See "Fitting and Setting the Steel Disc Coupling Injection Pump", points 1—2.
2. Put the pump back on the engine. Check that the O-ring on the pump flange is faultless and smear it with engine oil!
3. Turn the pump hub clockwise, viewed from in front, until its marking is opposite the marking on the pump end. The markings are visible

through an opening in the pump end, using a looking glass.

4. Tighten the screws retaining the pump in the timing gear casing.



Inspection window

5. Loosen the bolts retaining the pump bracket to the engine block.
6. Tighten the screws retaining the pump to the pump bracket.
7. Tighten the screws retaining the pump bracket to the engine block. The points 5—7 are important and must be kept carefully. Otherwise, stresses can arise in the pump housing.
8. Put the pump shaft gearwheel back. Note that the pitch between the oblong retaining holes is not equal. Make sure that the screw holes in the pump hub come in the middle of the oblong retaining holes. If that should not be the case, move the pump shaft gearwheel one tooth or two. Tighten the screws securing the pump shaft gearwheel.
9. Turn the crankshaft about 1/8 turn anti-clockwise. Then turn slowly back to the indicated number of degrees. When the flywheel is in this position, the marking of the pump hub must be in line with that of the pump end. Otherwise, loosen the pump shaft gearwheel screws and turn the hub until the markings are in line. The adjustment range is $\pm 10^\circ$ on the pump, corresponding to $\pm 20^\circ$ on the flywheel.
10. Fit all the loosened connections and controls. Screw the cover to the timing gear casing.
11. See "Fitting and Setting the Steel Disc Coupling Injection Pump", points 8—10.

Checking the Opening of the Control Rod for Maximum Delivery

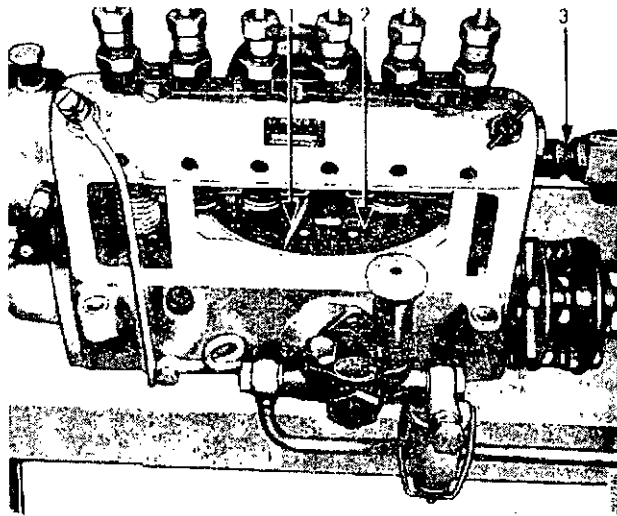
Checking the control rod opening is effected using different check tools.

Bosch B-design Pump and CAV Pump

1. Remove the side cover of the injection pump and screw on the scale as shown in the figure and so that it does not bear against any pump element and obstruct its action.

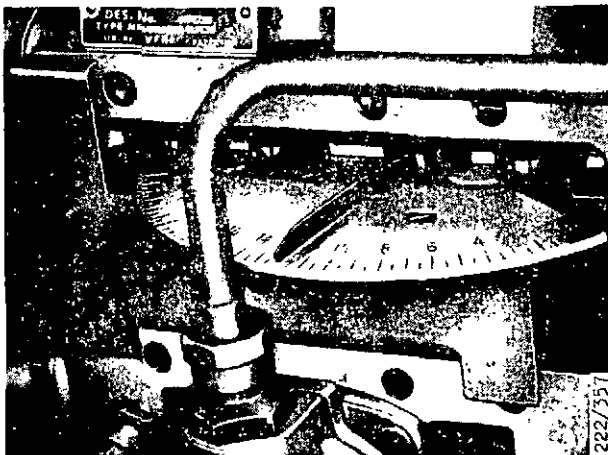


- Attach the pointer to the pump element and zero the scale by turning it. While this is being done the control rod must be held in its stop position. With some injection pumps it may be found that the pump housing gets in the way of the scale when it is turned so that the pointer cannot be zeroed. In this event, set the scale to line up with one of the nearest following graduations.



Checking the control-rod opening (Bosch)

- Pointer
- Scale
- Adjusting device



Checking the control-rod opening (CAV)

- Now move the control rod over to the maximum-delivery position, reading off the number of graduations passed on the scale. Each graduation on the scale corresponds to a control-rod movement of one millimetre.
- On Bosch injection pumps and certain CAV injection pumps, correction of the control-rod opening can be effected by means of the adjusting device on the cold-start control.

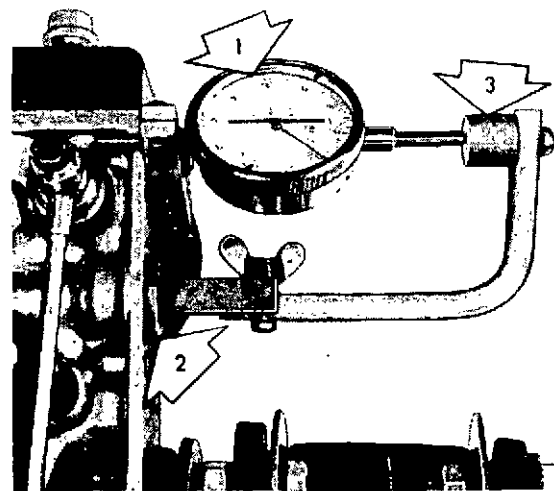
ing is sited under the protective cover on one of the pipe connections on the governor housing.

Put on a new lead seal after making the setting.

Bosch P-design Pump (without Smoke Limiter) for separate engines

Use the dial indicator with retainer and magnet of the check tool for control rod opening on the Bosch P-design pump with smoke limiter.

- Remove the sleeve over the control rod.
- Screw in the bushing retainer instead of the sleeve.
- Screw the lever of the tool, together with the magnet, to the control rod.
- Remove the washer from the magnet of the tool.
- Screw the dial indicator retainer to the end of the injection pump. Lock the dial indicator to the retainer so that the measuring point bears against the magnet.
- Turn the scale to zero the dial indicator.



Checking the opening of the control rod (Bosch P-design)

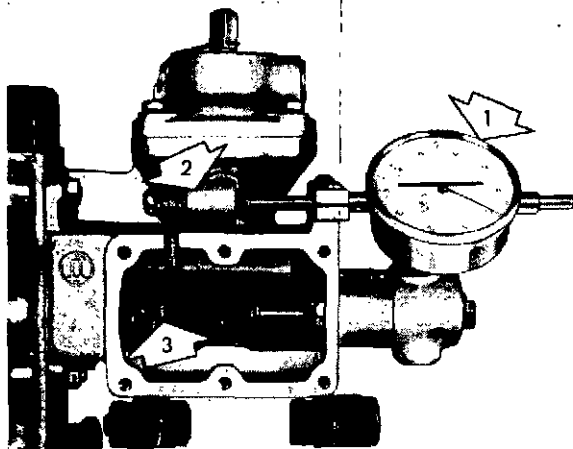
- Dial indicator
- Bushing retainer
- Magnet

- Move the control rod to the full-load position and read off the deflection of the dial indicator pointer.
- Make any correction of the control rod opening by means of the full-load stop screw of the control rod, which will be accessible after removing the scaled cover of the governor housing.

Re-seal the cover.

Bosch P-design Pump (with Smoke Limiter)

- Remove the side cover of the smoke limiter and the plug on the end of the smoke limiter.



Checking the opening of the control rod (Bosch P-design with smoke limiter)

1. Dial indicator
2. Magnet
3. Full-load stop screw

3. Remove the protective washer from the magnet of the tool.
4. Screw the retainer of the dial indicator to the housing of the smoke limiter. Lock the dial indicator to the retainer so that the measuring point bears against the magnet.
5. Turn the scale to zero the dial indicator.

6. Move the control rod to the full-load position and read off the deflection of the dial indicator pointer.
7. Make any correction of the control rod opening by means of the full-load stop screw of the control rod. Use a U-wrench to retain the front end of the control rod so as to prevent the control rod from turning while the stop nut is being loosened or tightened.

Re-seal the side cover of the smoke limiter.

Smoke Limiter

The smoke limiter prevents embarrassing exhaust smoke at low engine r.p.m. The injected fuel quantity is adapted automatically in relation to the available air quantity.

The diaphragm housing is connected through a pipe line to the intake manifold of the engine. When the engine is loaded, the r.p.m. of the turbo-charger will increase. As a result, the chamber above the diaphragm. The latter is pressed down, influencing through the diaphragm rod and the cam disc the maximum opening of the control rod. As a result, an increasing quantity of fuel can be injected.

The maximum control rod opening is not obtained until a certain set loading pressure is reached. This loading pressure is attained at an engine speed of some 1,200 r.p.m.



Pneumatic Governor

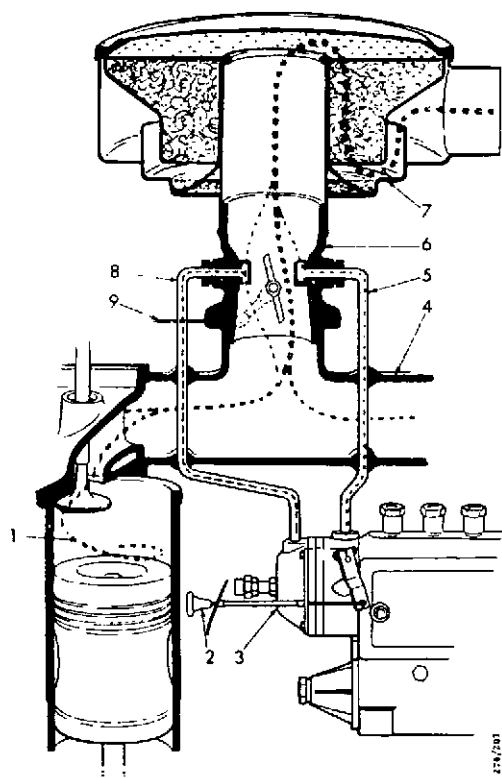
General

The pneumatic governor consists of a housing divided by a leather diaphragm into two chambers, an outer and an inner chamber. The control rod of the injection pump is connected to the diaphragm, and a diaphragm spring presses it towards the position giving maximum fuel delivery. The two chambers are connected by pipes to the throttle housing. The task of the pneumatic governor is to vary the fuel delivery in such a way that every position of the throttle corresponds to a definite engine speed range. The throttle controls the flow of air through the venturi tube and with it the degree of vacuum in the outer chamber.

With the engine stationary the pressure in the governor will be atmospheric. The diaphragm spring will then press the diaphragm and with it the control rod towards the maximum-delivery position. When the engine is running with the throttle wide open there will be a low underpressure in the pipe and consequently in the outer chamber at speeds below the maximum permissible. Under these circumstances the diaphragm spring will hold the control rod in the position for maximum fuel delivery. If the throttle is closed more there will be an increase in the air velocity and with it the vacuum in the outer chamber. The difference in pressure thus set up between the chambers will be so great that the resistance of the diaphragm spring will be overcome, and the diaphragm, and with it the control rod, will be shifted to give a smaller injection delivery.

If the power requirements are increased without any alteration in the position of the butterfly valve, the speed will fall. A fall in speed leads to a reduction in the underpressure in the outer chamber. The diaphragm spring will then cause the control rod to move in such a way that the injection delivery is increased and a new equilibrium is reached. If the load falls, on the other hand, the speed will rise, whereupon the underpressure rises also. The consequence of this is that the control rod will be shifted towards the idling position, with a corresponding decrease in the fuel delivery, causing the speed to fall.

When the engine is idling, the butterfly valve is very nearly closed. To ensure that the engine will idle smoothly the governor is provided with a damper device mounted in the outer chamber. It is set so that it bears against the control rod when the engine is idling.



Intake system

1. Cylinder bore
2. Stop button
3. Pneumatic governor
4. Intake manifold
5. Pressure pipe
6. Throttle housing
7. Air cleaner
8. Vacuum pipe

Idling Stabiliser

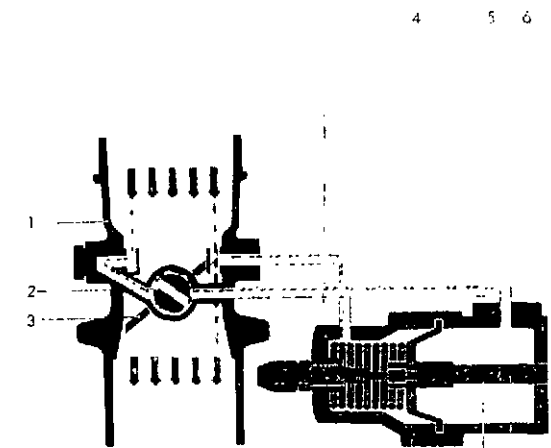
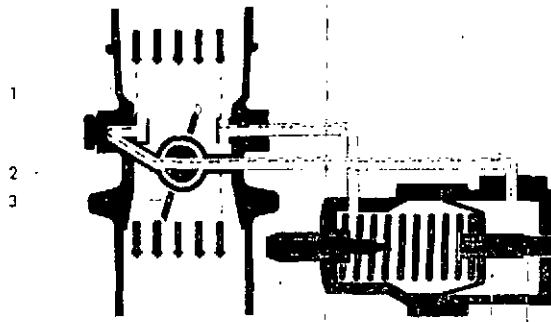
The idling stabiliser prevents the speed of the engine from "hunting" at low r.p.m.

On passing to and from the inner chamber of the governor housing on the injection pump, the air flows through a hole in the throttle shaft.

When the throttle is open, the connection between the inner chamber and the throttle housing is open.

On closing the throttle, the connection is choked.

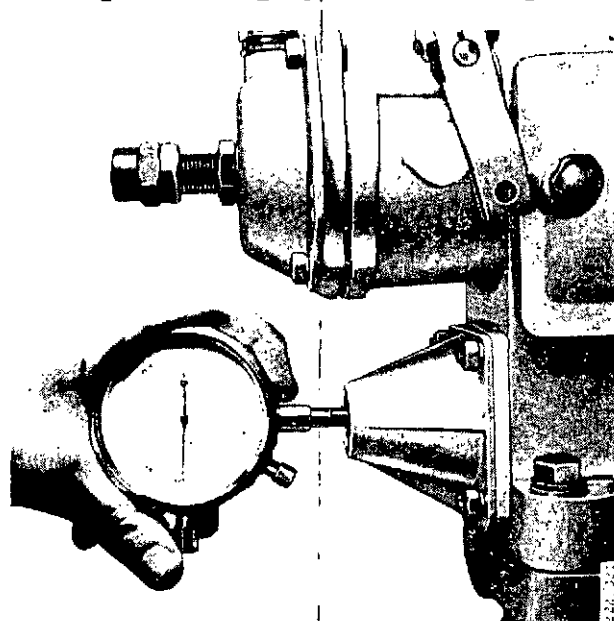
As a result, the movement of the control rod is damped, impeding thus the "hunting" tendency of



Idling stabiliser with opened and closed throttle

1. Throttle housing
2. Throttle shaft
3. Throttle
4. Governor housing on injection pump
5. Inner chamber of governor housing
6. Control rod

Setting the Idling Speed of the Engine

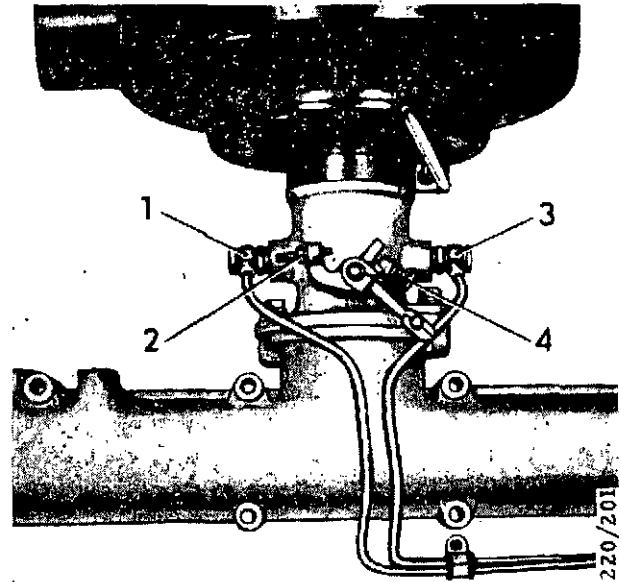


Check the engine speed

N.B. The pump shaft rotates at half the engine speed

The engine should be run thoroughly warm before setting is carried out.

The speed can be checked using a tachometer connected to the rear end of the shaft of the injection pump. This shaft end becomes accessible once the plug on the protective cover has been screwed out. Remember that the engine rotates at a speed twice that of the injection pump.



1. Pressure pipe
2. Stop screw for the high no-load speed
3. Vacuum pipe
4. Adjusting screw for the low no-load speed

The difference between the maximum permissible speed with the engine off load (the high no-load speed) and with the engine on full load constitutes the speed range (known as the cut-out range) within which the pneumatic governor operates at a constant maximum throttle position.

Before adjusting the r.p.m. of the engine, make the damper device of the control rod inoperative. For this purpose, screw out completely the damper device and then screw it in 3-4 turns so that it seals but still is inoperative. N.B. on the pneumatic governor type Bosch EP/MZ80BA104, turn the adjusting screw clockwise to put the damper device out of operation. As to the other types, turn the adjusting screw anti-clockwise to obtain the same result.

Adjust then the high no-load r.p.m. to the stated value, by turning the sealed stop screw on the throttle housing. After setting, seal the screw.

Setting the Low No-load Speed of the Engine

Check the low no-load speed and, if necessary, adjust it to the stated value. Carry out this adjustment using the adjusting screw on the throttle housing. Screw then in the damper device so that it only just acts on the control rod and impedes any "hunting". Do not screw the damper device in too far. The high no-load speed can be too high, entailing risk of damages.

When the damper device is put in operation, the engine must not be run off load at the high no-load speed.



Fuel Filter

General

The feed pump, which is driven from the injection-pump camshaft, draws fuel oil from the fuel tank through the tank filter (and in Bosch injection equipment also through a prefilter on the feed pump) and then pumps it on to the main filter.

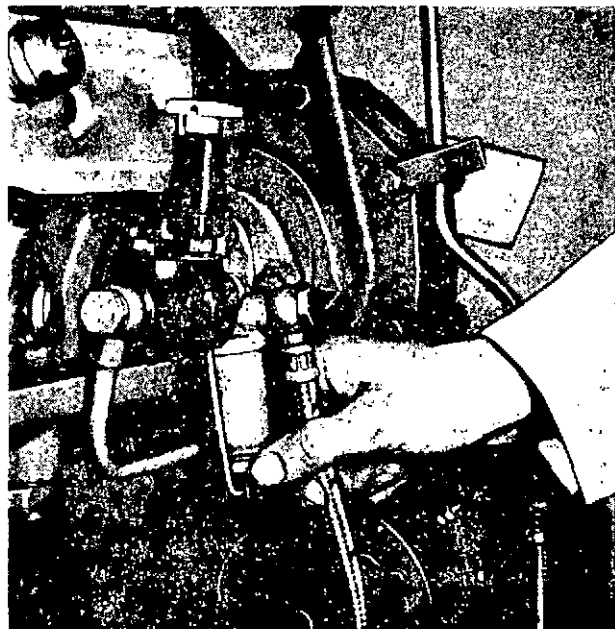
The main filter takes the smaller impurities out of the fuel and thus prevents the vulnerable precision components in the injection pump and injectors from being damaged or prematurely worn by foreign particles.

From the main filter the fuel oil is taken to the fuel chamber of the injection pump.

The feed pump is so designed that it delivers considerably more fuel than is needed to run the engine. The surplus fuel is taken back to the fuel tank, via the pressure relief valve and a return line connected to it. Thus the fuel system will be continuously bled while the engine is running.

Cleaning the Prefilter on the Feed Pump (Bosch)

Undo the knurled nut, turn the bail out and take out the filter housing. The wire gauze is washed in gasoline or diesel fuel oil. With time the sealing ring becomes so hard that it is of no further use. It must therefore be renewed in good time to prevent air from penetrating into the fuel system.



Detaching the prefilter of the feed pump (Bosch)

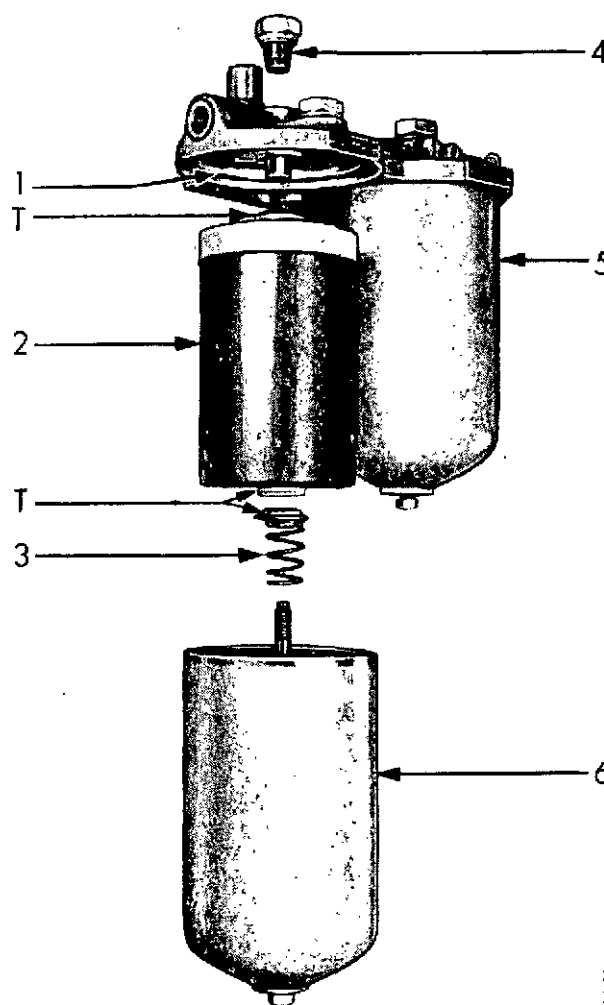
Changing Elements in the Main Filter

Bosch Main Filter

The prefilter (Vorfilter) and the fine filter (Fein-

fuel will therefore for the most part be separated out in the prefilter. In changing its element, proceed as follows:

1. Clean the outside of the filter housings and the cover.
2. Drain the fuel out of the filter housings by screwing out the drain plugs.
3. Disassemble the prefilter by undoing the screw (4).



Main filter (Bosch)

- | | |
|-------------------|--------------------------|
| 1. Gasket | 3. Spring |
| T. Felt seals | 4. Screw |
| 2. Filter element | 5 and 6. Filter housings |

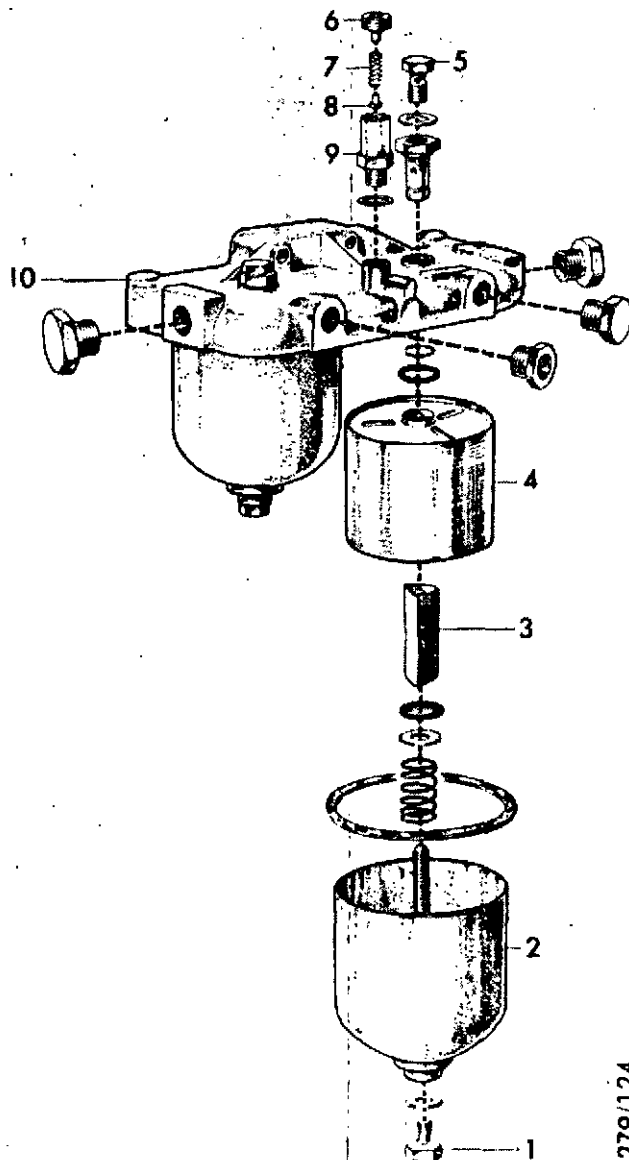
4. Clean the filter housing in clean fuel oil.
5. Put the new filter element into the filter housing. Examine the felt seals (T), and the spring (3), to see that they are effective, since otherwise fuel oil will be able to pass the filter without being cleaned. Check also that the gasket (1) is sound and that there is a copper washer on the screw (4) when it is screwed in.
6. Tighten the drain plugs.

element in the lead-sealed fine filter as well, this job can be done in corresponding fashion. In this case, a fresh lead seal must be put on this filter after the insert has been fitted.

CAV Type F (Earlier Design)

The filter is a parallel-connected duplex filter. The filter elements consist of glued and specially impregnated paper wound in a spiral round a tubular core. This assembly is enclosed in a thin metal canister.

1. Clean the outside of the filter housings and the cover.
2. Drain the fuel out of the filter housings by screwing out the drain plugs.
3. Undo the retaining nuts and take out the filter housings with the filter elements. Do not lose the locating sleeve.



Main filter (CAV)

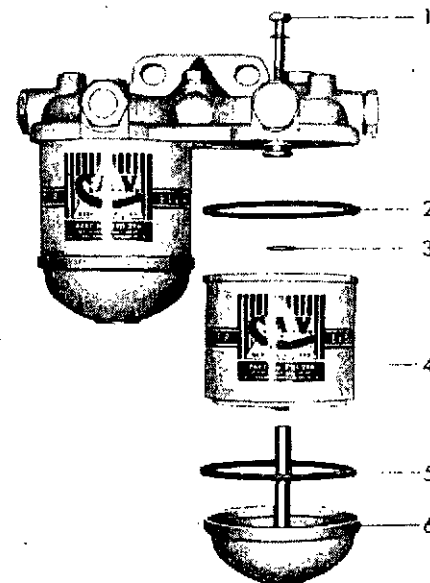
- | | |
|------------------------------------|--------------------------|
| 1. Drain plug | 6. Clamp screw |
| 2. Filter housing with centre bolt | 7. Spring |
| 3. Locating sleeve | 8. Valve cone |
| 4. Filter element | 9. Valve housing |
| 5. Vent screw | 10. Filter-housing cover |

4. Clean the filter housings thoroughly on the inside. See that the four small drain holes in the bottom of the housings are free from sludge. Check particularly that the "clean" side of the filter housing, i.e. the centre bolt above the lower sealing ring, is free from dirt deposits. Be careful not to wash dirt over to the clean side.
5. Fit the new filter elements and sealing rings. Do not forget to fit the locating sleeve! A sealing ring is supplied with every filter element. Check that it is sound and that it goes into the correct position.
6. Fit the filter housings and secure them with the retaining nuts.
7. Screw in the drain plugs.
8. Finally, bleed the whole fuel system.

CAV Type FC (Later Design)

The filter has either a single-connected or a parallel-connected design. The element is fitted between the filter cover and the lower part.

1. Shut off the fuel supply (the tank is located higher than the filter).
2. Clean the filter externally, using for instance diesel fuel oil.



Main filter (CAV type FS)

- | | |
|----------------|-------------------|
| 1. Centre bolt | 4. Filter element |
| 2. Gasket | 5. Gasket |
| 3. O-ring | 6. Lower part |

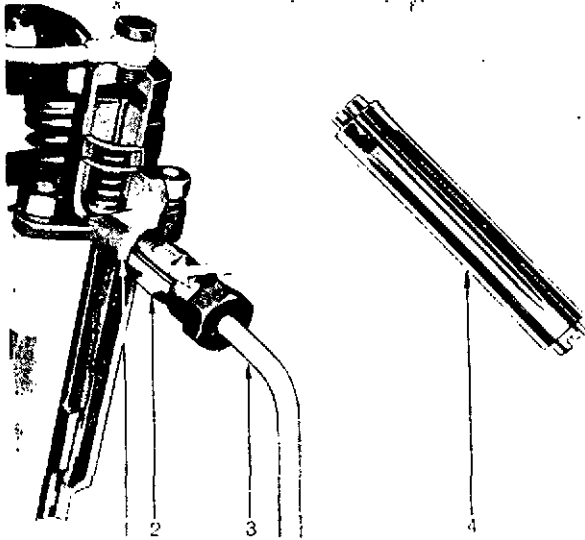
3. Loosen the centre bolt on the top of the filter and remove the lower part.
4. While turning the filter element, pull it downwards.
5. Fit new gaskets into the filter cover and the lower part. Replace also the O-ring sealing between the filter element and the filter cover. This O-ring is a sealing between the filtered and contaminated fuel.
6. Fit the new filter element, the lower part and the centre bolt. Tighten it moderately.
7. Open the fuel supply and bleed the system.



Injectors

General

From the injection pump the fuel is fed through the pressure pipes to the injectors. The pipe connection on the injector is in the form of an edge filter. This is a safety filter that prevents any dirt which may have got into the pressure pipes, e.g. after disassembly, from accompanying the fuel into the injectors.



Injection and edge filter

- | | |
|----------------|------------------|
| 1. Injector | 3. Pressure pipe |
| 2. Edge filter | 4. Filter rod |

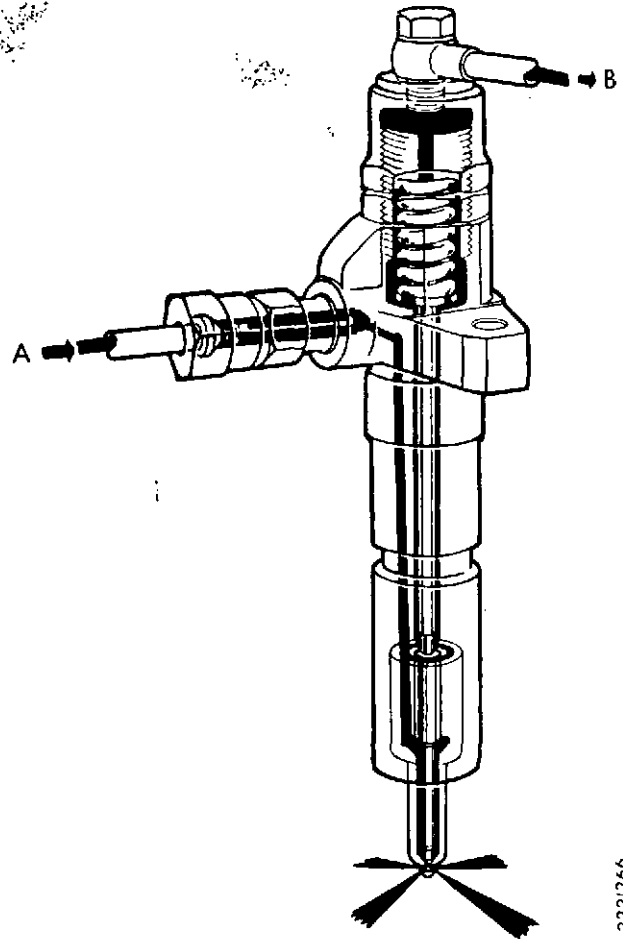
The filter consists of a steel rod, with lengthwise grooves running from both ends. These grooves do not, however, run right through; the fuel is forced to pass through a narrow gap between the actual rod and the wall of the filter housing in which it is placed. Any solid particles will be trapped in this narrow passage.

When the fuel passes the edge filter and enters the injector, it is led through a passage on the side of the valve spindle down to the nozzle; see the figure.

When the opening pressure for the particular type of injector has been reached, the opposition of the compression spring is overcome and the needle is lifted from its seat. The fuel then issues through four holes in the nozzle into the combustion chamber. The hole diameter is only a few tenths of a millimetre, and this, combined with the high pressure, causes the fuel to enter the chamber as a fine mist and mix with the swirling air in the combustion chamber.

Even though the fit of the nozzle needle in the nozzle is very fine, some fuel will still get past the needle and penetrate up into the passage in the centre of the injector. The amount of leak-off oil is very little, but it must still be led away. Each injector is therefore provided with a special leak-off pipe.

The leak-off oil from all injectors is taken

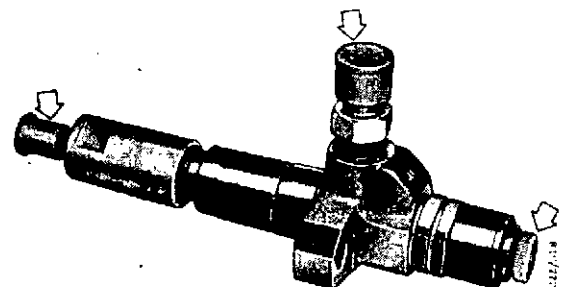


The path of the fuel through the injector

filter and on down to the nozzle, which distributes it in four jets. The leak-off oil comes out at B and is piped back to the tank.

Removing an Injector

Always put protective caps on injectors and pressure pipes, and in the sleeve in the cylinder head, as soon as an injector is removed from the engine.



Injector with protective caps

If the sealing washers do not come up with the

Injector Maintenance

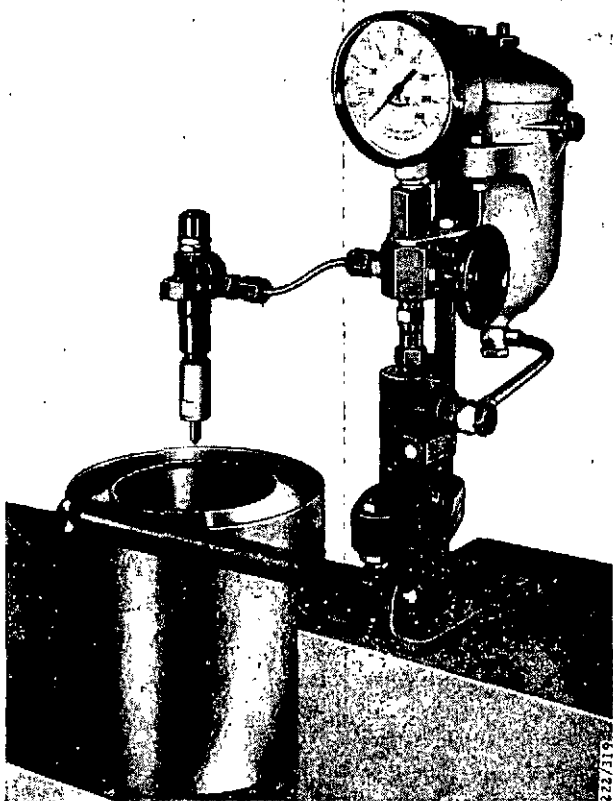
In testing injectors, great care must be taken to keep the hands out of the way of the spray, which has great penetrating force and can produce blood poisoning.

Checking

Clean the outside of the injector before testing and disassembling it. This is best done with a liquid cleaning agent — gasoline, kerosine or white spirit — and a stiff brush. Never use a knife or similar implement to remove coke or carbon from the nozzle.



Clean the outside of the injector

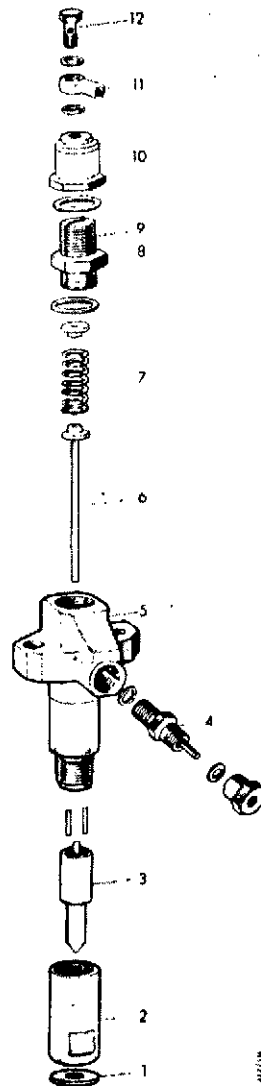


Before dismantling an injector, place it in a nozzle-testing outfit to be checked according to the following points:

1. A check on the opening pressure of the injector.
2. A check on the pressure drop.
3. A check on the sealing of the valve needle against its seat.
4. A check on the spray form.
5. A check to see that the valve needle is working properly.

For testing instructions, see under the heading "Checking and Setting".

Use a carefully filtered test oil — we suggest Esso Mentor 28 or Shell Fusus Oil — in the testing outfit.

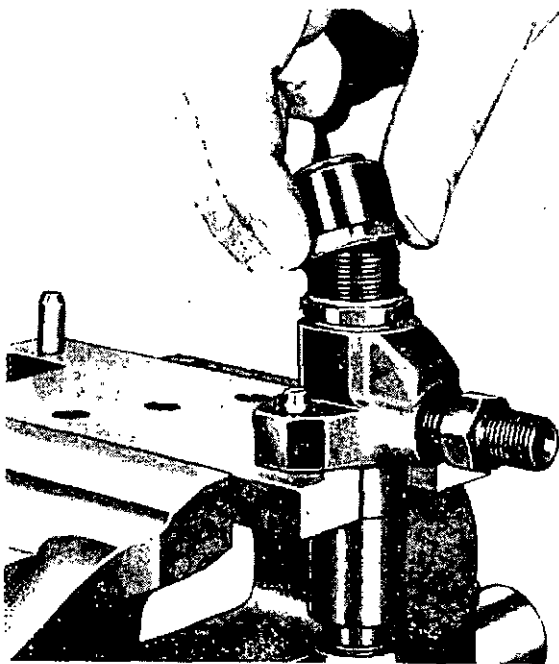


Injector

- | | |
|----------------------------------|--|
| 1. Washer | 7. Valve spring |
| 2. Nozzle cap nut | 8. Locknut |
| 3. Nozzle body with valve needle | 9. Set screw |
| 4. Edge filter | 10. Cap nut |
| 5. Nozzle-holder body | 11. Banjo connection for leak-off pipe |

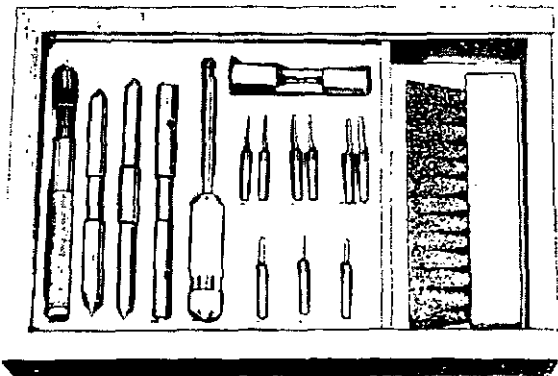


If the injector does not function as it should, it must be taken apart and cleaned. Set the injector up in a fixture with the nozzle body downwards. Take off the cap nut, the copper gasket, the locknut, the second copper gasket, the set screw, the valve spring and the valve spindle. Then reverse the injector in the fixture and take out the nozzle cap nut and the nozzle body with the valve needle.



222 326

It is most important to unload the valve spring before undoing the nozzle cap nut. Otherwise damage may be done.

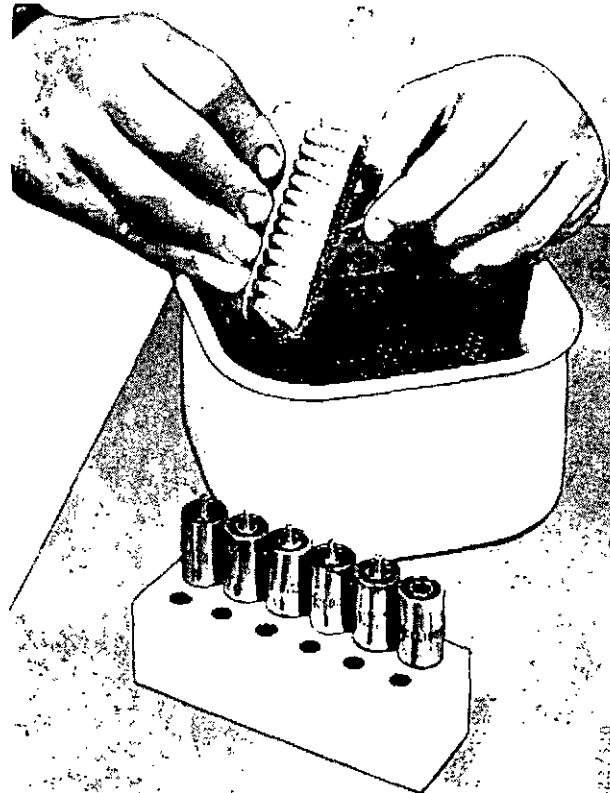


Cleaning tools for injectors (CAV)

Cleaning

Clean the valve needle with a brush and a liquid cleaning agent. If it is difficult to get the valve

needle quite clean, a special resin solvent should be used. *Be careful to see that each valve needle is fitted into the right nozzle body. These items are accurately mated.*



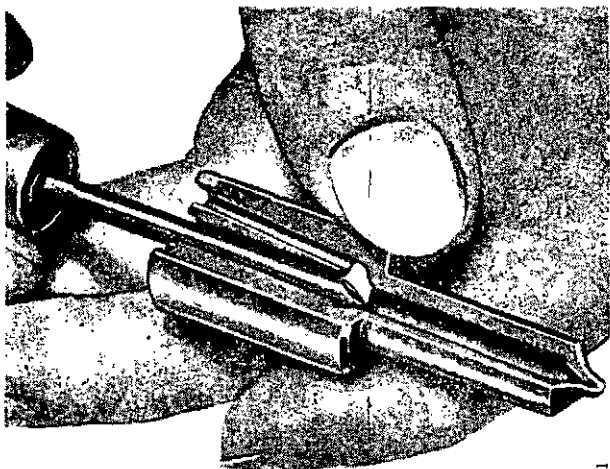
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To avoid confusion, the nozzles should be placed in a nozzle rack.

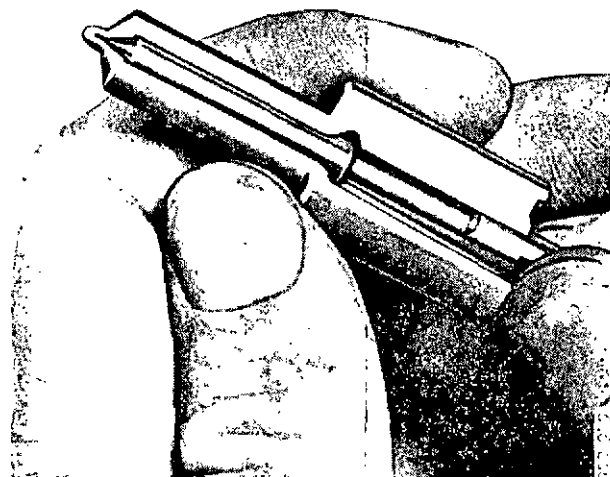


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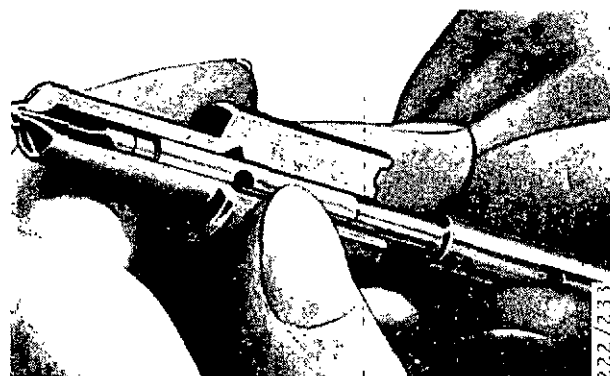
Clean the inside of the nozzle body with brushes and a liquid cleaning agent. Use a resin solvent if required.



Clean the fuel gallery with a special groove scraper. Rotate the scraper in the gallery and at the same time press hard against the sides of the cavity to scrape off all deposits. When inserting the scraper into the nozzle body be careful not to scratch the locating surfaces.

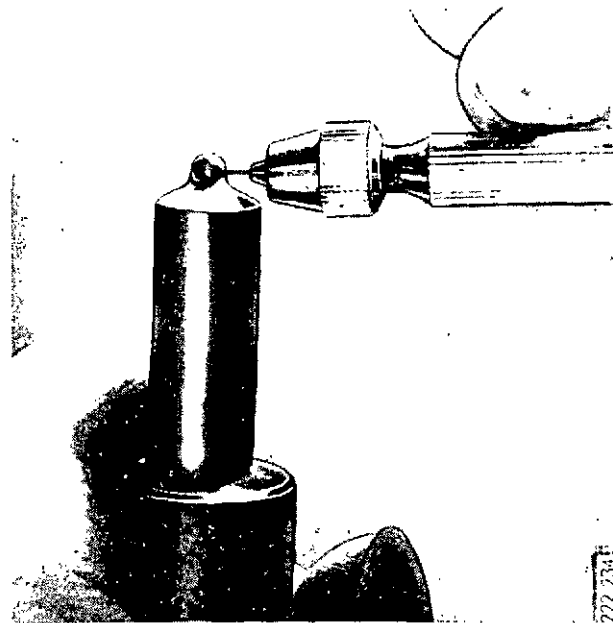


Clean the seat of the needle valve. Use the conical seat scraper, rotating it while pressing it against the seat.



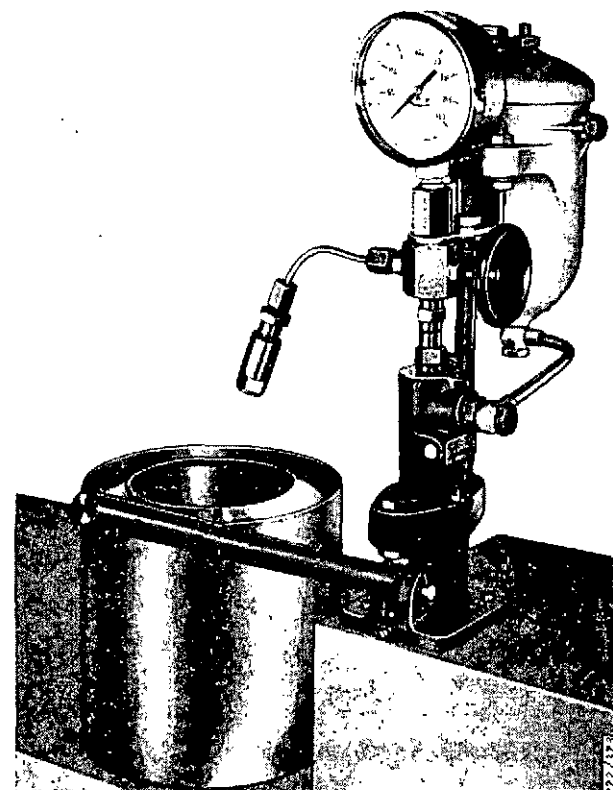
Clean the annular cavity between the seat and needle of the nozzle. Introduce the scraper until it bottoms and then rotate it.

Scrape away any soot in the tip of the nozzle body.



Clean the nozzle holes. Check that there are no burrs on the cleaning wire. Polish it on a hone stone. To avoid damage to the nozzle holes during cleaning, the diameter of the cleaning wire should be 0.02—0.03 mm less than the hole diameter.

Then flush the nozzle in white spirit and blow it dry with compressed air.



Flush out the nozzle body. For this purpose there is a special flushing tool which is connected to the nozzle-testing outfit. Fit the nozzle body into the flushing tool and connect the latter to the testing outfit. Disconnect the pressure gauge and pump vigorously.



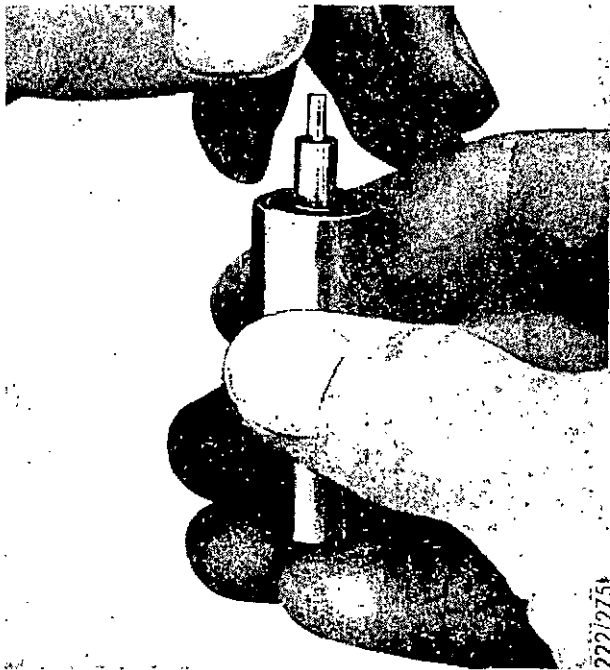
The edge filter in the delivery connection stud of the pressure pipe is cleaned as follows:

Detach the delivery connection stud from the injector. Shut off the pressure gauge of the nozzle-testing outfit. Connect the delivery connection stud to the testing outfit using the flushing tool. Give a few vigorous strokes of the pump lever, which will wash out by the back way any dirt that may be in the edge filter.

N.B. The rod in the filter should never be taken out of the delivery connection stud.

Check the fit of the valve needle in the nozzle body. This check is carried out as follows:

Flush the valve needle and nozzle body thoroughly in kerosine or an equivalent, and blow them dry with compressed air. Then dip the valve needle into well-filtered diesel fuel oil and push it into the guide of the nozzle body. If the clearance in the guide is correct, and if the parts are thoroughly cleaned, the needle should slide easily without the slightest tendency to stick. If the nozzle is held vertically and the needle is lifted up about 10 mm and then released, it should slip down into the body by its own weight.



Test this a number of times and rotate the valve needle each time so that it is brought to a new position. If the needle shows a tendency to stick, dip it again in diesel fuel oil and then rub it in the nozzle body. Then clean the needle and body and blow them dry, dip the needle in diesel fuel oil and test the fit in the same way as before.

Nozzle maintenance over and above that described in the foregoing must not be attempted.

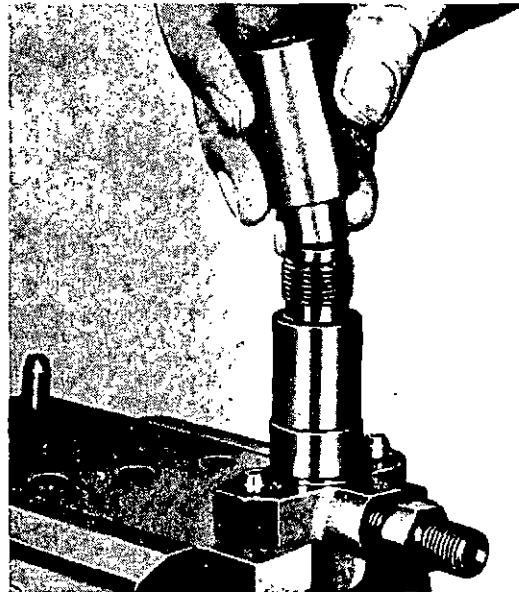
Assembly

Before the injector is assembled the nozzle body and other components should be thoroughly rinsed in a cleaning liquid and inspected for defects on the pressure faces and threads. Discard defective components.

First place the nozzle-holder body in the fixture

Then reverse the nozzle holder in the fixture and fit the valve spindle, valve spring, set screw, gasket and locknut.

Always use open-ended wrenches.



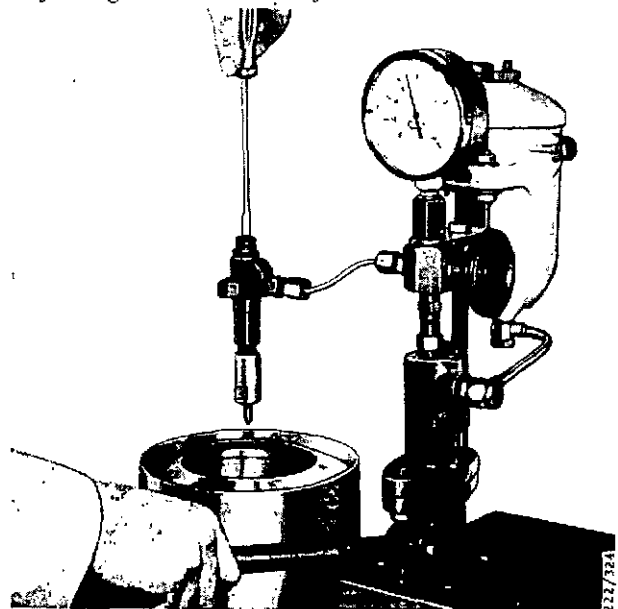
Always fit the nozzle and nozzle cap nut first

Checking and Setting

Connect the injector to the nozzle-testing outfit and go through the following check list. Note the results on a test sheet.

1. Setting the Opening Pressure of the Injector

First open the valve to the pressure gauge and then adjust the spring loading by screwing in the adjusting screw on the injector.



While the set screw is being screwed in, work the hand pump and check the opening pressure. When the injector is correctly adjusted the needle valve should open at the stated pressure. Then lock the set screw with the locknut.

2. Checking the Pressure Drop

Pump up the pressure in the same way as in

pressure to fall. Read off the time taken for the pressure to drop from 100 to 75 kg/cm². The permissible time is 6–25 seconds for the nozzles.

If the time is too short it indicates that the clearance between the valve needle and the nozzle body is too large or that the needle does not seal tightly against the seat, thus allowing too much leakoff oil to pass this way.

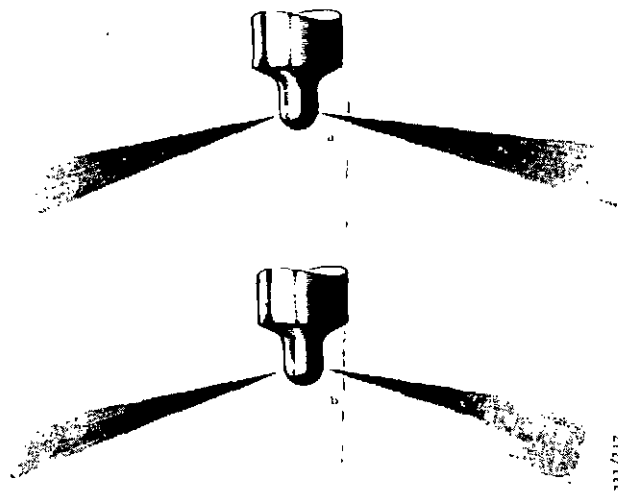
N.B. See that the screwed connections are tight and that the valves of the nozzle-testing outfit are in good condition, since the test will otherwise be misleading.

3. Checking the Sealing of the Valve Needle against the Seat

Before this test is performed the nozzle tip should be blown thoroughly dry with compressed air. Then pump the pressure up slowly to about 10 kg/cm² below the opening pressure. Keep the pressure close to this value, e.g. by light strokes or by slowly depressing the pump lever of the testing outfit over about ten seconds. During this time, not more than a faint dampness can be allowed to appear round the nozzle holes. If the nozzle does not satisfy this test, the needle can be gently rubbed in against its seat after being dipped in clean diesel fuel oil. Grinding or lapping paste must not be used.

4. Checking the Spray Form

Connect the injector to the nozzle-testing outfit and shut off the pressure gauge. Slacken the set screw on the injector enough to remove the spring thrust against the valve spindle and valve needle. Give a few gentle, long strokes of the pump (with the pump lever going right to the bottom). A nozzle in good condition has a spray form like that shown in Fig. a. There must be no streaks. A faulty spray form is shown in Fig. b.



5. Checking the Valve Needle for Correct Function

When the pump lever of the nozzle-testing outfit is worked slowly the needle will open and shut at a relatively high frequency during the pump strokes, which may produce a "creaking" sound. But it is not necessary for the injector to "creak".

To see whether the valve needle is functioning properly, work the pump slowly and check at the same time that the fuel spray is cut off sharply

Fitting an Injector into the Cylinder Head

Check that none of the sealing washers has been overlooked down in the injector sleeve. Always fit new washers.

When the injector has been placed in the sleeve the nuts must be tightened to the stated torque. This tightening torque is obtained automatically if the appropriate torque wrench is used.

N.B. Overtightened nuts may cause the valve needle to stick in the nozzle body.

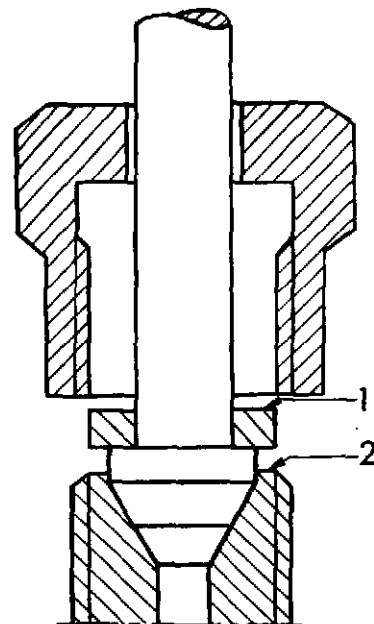


Always use a torque wrench in tightening the injectors

Fitting the Pressure Pipe

Be careful to see that the cones of the pressure pipes fit properly into the connection studs. If the pressure pipes are at an angle when the cap nuts are made tight the result will be to deform the cones and leakage will appear.

The clamps for the pressure pipes are intended to damp down the vibrations in the pipes, thereby reducing the risk of their cracking. So do not forget to screw these clamps into place.



Pressure pipe and cap nut on injection pump or injector



Trouble Shooting

Exhaust Appearance

When the exhaust gases of a diesel engine become too dark, the reason is incomplete combustion of the fuel. The cause of this, in its turn, is either that the fuel is not sufficiently finely divided or that there is an excess of fuel in relation to the amount of air drawn in. Dark exhaust gases can also be due to high compression losses.

If the engine begins to smoke, action must be taken immediately. If the engine is correctly adjusted no appreciable exhaust smoke should be visible even on full throttle.

It is very uneconomical to run the engine with a smoky exhaust, for the following reasons:

1. The engine quickly becomes covered with carbon.
2. The lubricating oil becomes dirty more quickly than normally.
3. Pistons and valves will more readily coke up.
4. The engine may be overloaded, involving a risk of piston seizure.
5. The cooling losses increase.
6. The load on the cooling system increases.
7. The fuel consumption increases.

In other words:

The life of the engine is shortened and repair costs rise sharply.

Lower Output and Smoky Exhaust

If the engine is not delivering full output, uses more fuel than normal and produces smoky exhaust gases, the reason may be:

1. The air cleaner is choked.
2. A fault in the injection pump or its setting.
3. Injector faults.

If a fault is suspected in any of the injectors it is often possible to find which injector is affected by undoing the pressure-pipe nut on each injector in turn. While the engine is running at low no-load speed, put your ear to each of the other cylinders; it will then often be possible to find out which injector is defective. If there is any reason to suspect functioning in the injectors, they should be removed and tested in a nozzle-testing outfit.

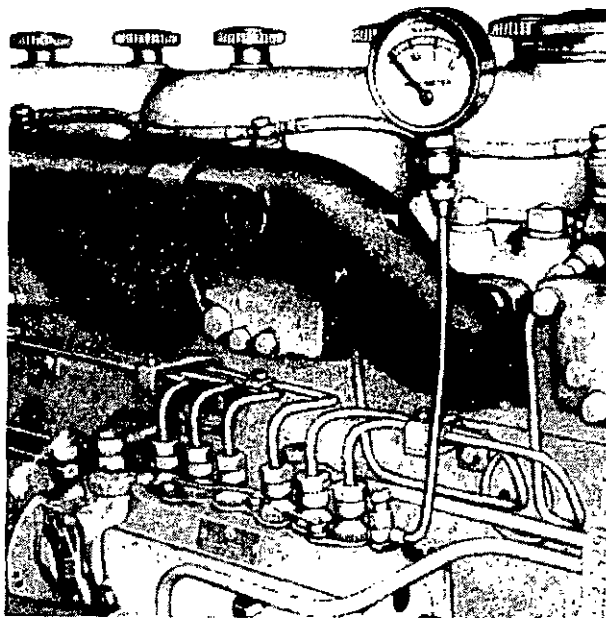
4. A fault in the turbocharger or leakage in the intake system.

Lower Output

If the engine does not deliver full output, the reason may be:

1. The air cleaner is choked.
2. Leaky pressure pipes.
3. A fault in the injection pump or its setting.
4. Injector faults (see point 3 above).
5. Insufficient feed pressure.

Connect a low-pressure gauge to the vent screw of the injection pump and check the feed pressure.



A low-pressure gauge mounted on the vent screw of the injection pump

Insufficient Feed Pressure

If the feed pressure in the fuel chamber of the injection pump is lower than that stated, the cause may be:

1. Choked or leaky fuel lines and screwed joints.
2. A fault in the pressure relief valve.
3. The main filter is choked.
4. A fault in the feed pump.

These sources of trouble should be investigated in the order given according to the following directions.

A. Checking the Pressure Relief Valve

If the feed pressure has been checked as above and has been found to be too low, the opening pressure of the pressure relief valve should be investigated.

1. Work the pump by hand until the pressure relief valve opens. Read off the opening pressure.
2. If the valve is leaky it should be renewed.

B. Checking the Main Filter

If the feed pressure is still too low after the pressure relief valve has been examined, the extent to which the main filter is choked should be investigated.

It is not possible to check for choking in the filters by measuring pressures while the engine is idling, since in this case the amount of fuel passing through the filters will be too small for the pressure drop to be measureable.

The extent to which the filters are choked must

on full load at maximum speed. This can be done, for example, by driving up a hill on which a speed corresponding to the maximum engine r.p.m. can be obtained by driving in a suitable gear with the engine on load. The highest possible gear should be chosen, since it is important to obtain full loading at the same time.

For this test the pressure gauge is set up in the cab. If the pressure in the fuel chamber of the pump is less than the stated value for the above running conditions, the filter elements should be changed.

C. Checking the Feed Pump

1. Undo the pipe connection at the pressure relief valve. Shut off the opening from the filter; a finger will do for this.
2. Have the engine started and then read off the pressure shown by the gauge at low no-load speed.
3. If the pressure is too low, check the suction line from the tank for leaks.
4. If the pressure is still too low, check the valves of the feed pump, and change them if they are damaged or leaky.
5. If the fault has still not been cured, the pump should be taken apart and thoroughly inspected.
6. Give the feed pump a pressure test. Plug it on the outlet side with a suitable screwed connection. Couple a supply of compressed air at about 2 kg/cm^2 to the suction side of the pump. Immerse the pump in a suitable liquid, e.g. fuel oil or lamp oil. Seal any leaks that are found.

Difficult Starting

If the engine proves difficult to start after standing unused overnight for example, this may be due to a leakage pressure relief valve coupled with a slight leak in the injection pump or the line between the injection pump and the filters.

Racing

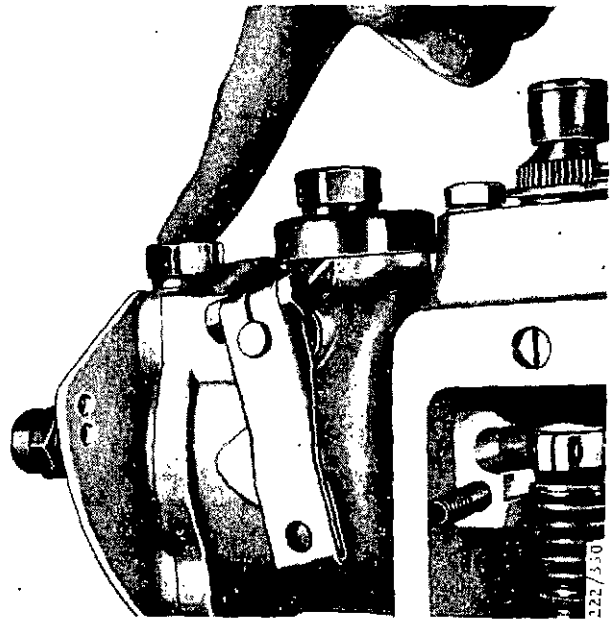
If the highest speed of the engine is too high, the reason may be:

1. Stop-screw for throttle or control rod incorrectly set.
2. Governor not functioning properly.
3. Vacuum pipe or screwed connection leaky.
4. Diaphragm in pneumatic governor leaky.

Checking the Diaphragm in Pneumatic Governor

If it is suspected that the diaphragm is leaky it should be checked as follows:

1. Take off the inspection cover on the pump, the stop control and the two pipe connections on the pneumatic governor.
2. Press the stop arm against the stop position and



Test the diaphragm

3. Release the stop arm. If the diaphragm is free from leaks the control rod will not go right back. If it is leaky, the rod is forced back by the spring. On the primary side (the vacuum pipe) there must be no leakage. On the secondary side (pressure pipe) a leakage time of at least five seconds can be tolerated.
4. If the diaphragm needs lubricating a vegetable oil must be used. The nuts holding the governor housing together must be lead-sealed.



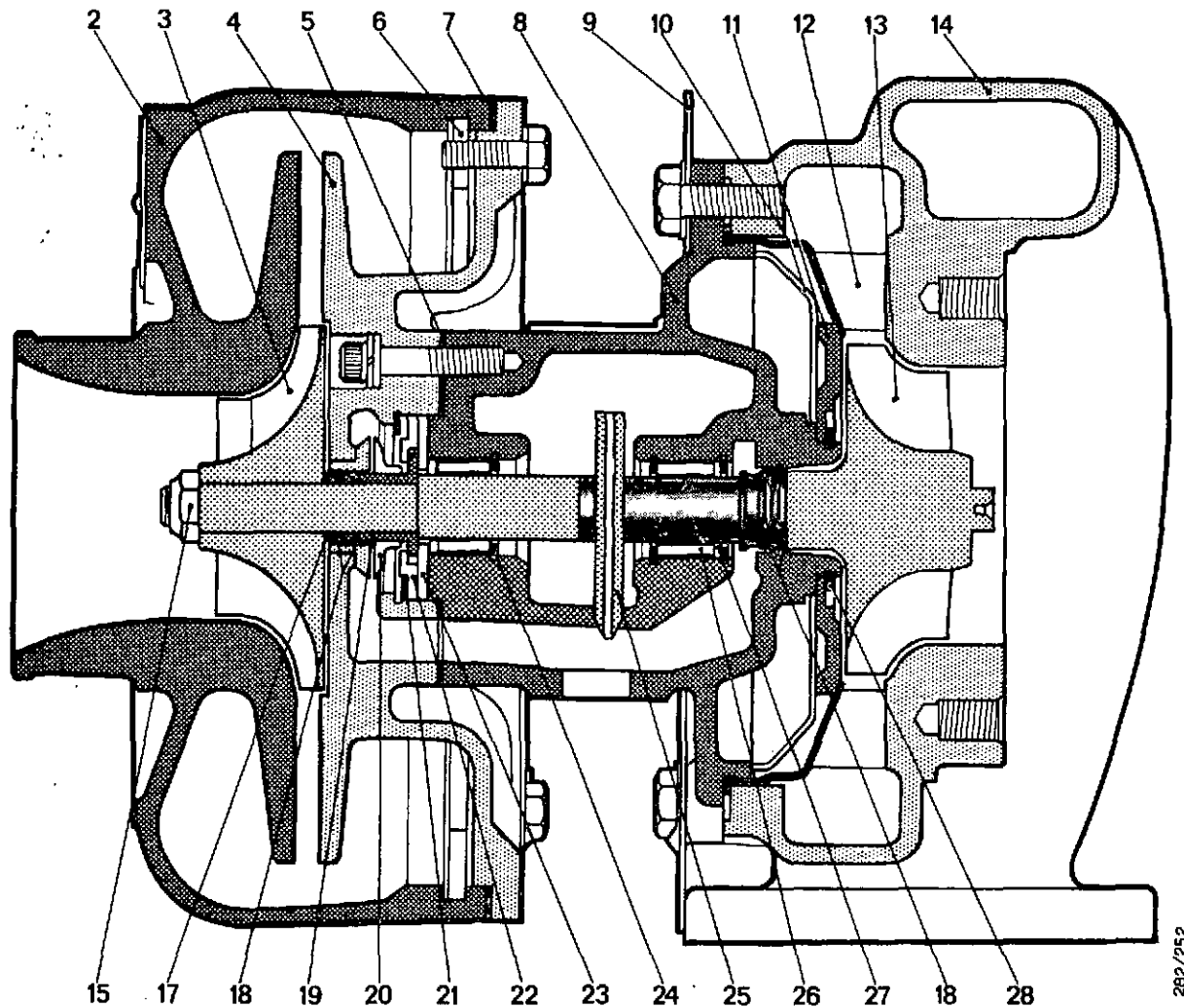
Turbocharger

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Turbocharger



Turbocharger, model 3, No. 173738

- | | | | |
|-----------------------|------------------------------|--------------------|---------------------|
| 2. Compressor cover | 9. Outer shield | 17. Shims | 23. Thrust washer |
| 3. Compressor wheel | 10. Inner shield | 18. Sealing rings | 24. Lock ring |
| 4. Compressor housing | 11. Support plate | 19. Thrust bearing | 25. Check pipe |
| 5. Gasket | 12. Nozzle ring | 20. Sleeve | 26. Sliding bearing |
| 6. Lock ring | 13. Turbine wheel with shaft | 21. Spring | 27. Thrust plate |
| 7. Gasket | 14. Turbine housing | 22. Bearing flange | 28. Lock ring |
| 8. Bearing housing | 15. Lock nut | | |

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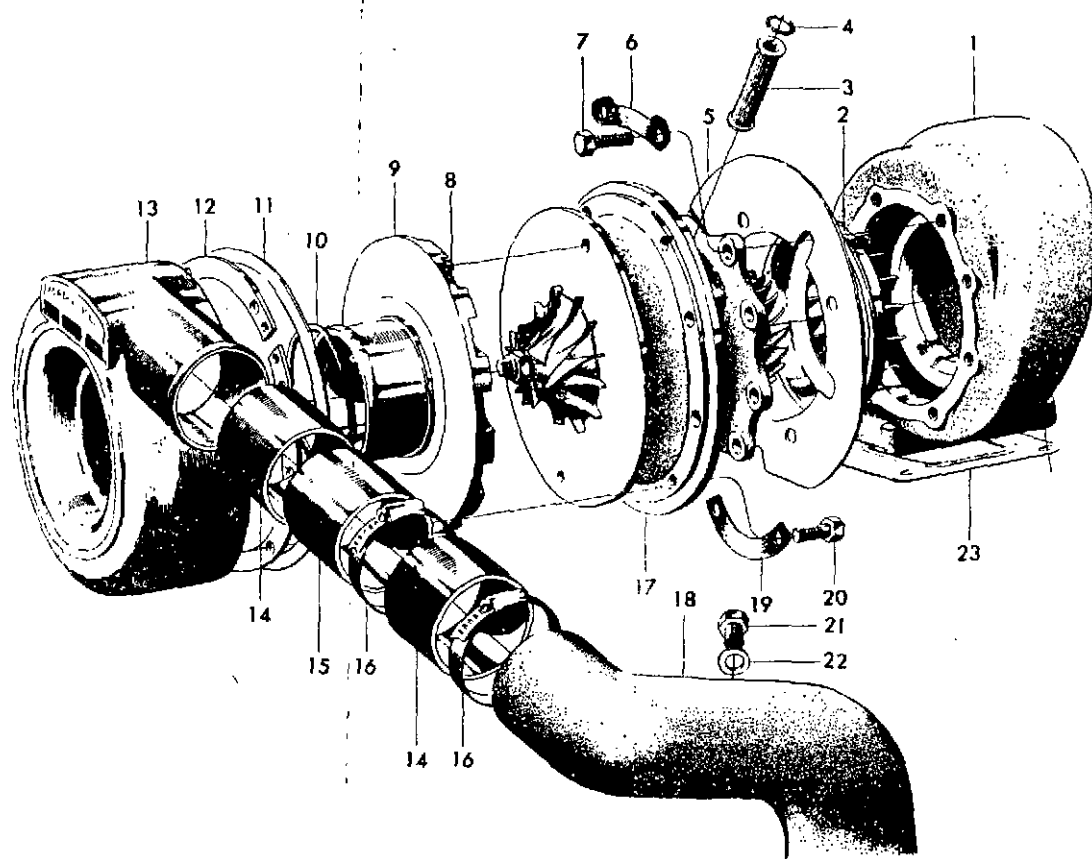
General

The task of the turbocharger is to increase the air supply to the cylinders of the engine. This increase in the supply of air enables the engine to burn more fuel per piston stroke than a naturally aspirated engine, so that a greater power output becomes possible.

The turbocharger consists of the following main sub-assemblies: Exhaust turbine, bearing housing and compressor. The turbine and the compressor are mounted one on each side of the bearing housing, the turbine wheel and compressor wheel being united by a common shaft. The shaft runs in the bearing housing in "floating" sliding bearings.

contained in the hot exhaust gas. The exhaust gas goes straight from the exhaust manifold of the engine into the turbine housing. Inside the housing the gas first passes a nozzle ring to give it a greater velocity before it reaches the turbine wheel. The energy of the exhaust gas is converted by the turbine wheel into kinetic energy. The turbine wheel drives the compressor wheel, which is of the centrifugal type.

The air is drawn in at the centre of the compressor wheel and is forced out radially into the compressor housing through a diffuser. From the outlet of the compressor cover it is then forced into



Turbocharger, model 4

- | | | | |
|--------------------|------------------|-------------------------------|----------------|
| 1. Turbine housing | 7. Screw | 13. Compressor cover | 19. Lock plate |
| 2. Nozzle ring | 8. Dowel pin | 14. Rubber hose | 20. Screw |
| 3. Oil strainer | 9. Diffuser ring | 15. Connecting tube | 21. Plug |
| 4. Lock ring | 10. O-ring | 16. Clip | 22. Washer |
| 5. External shield | 11. Gasket | 17. Replacement core assembly | 23. Gasket |
| 6. Lock plate | 12. Lock ring | 18. Air tube | |

Since the turbine is driven by the engine exhaust gas, the speed of the turbocharger will automatically adjust itself to the load and speed of the engine.

The lubrication of the bearings and the cooling of the bearing housing is effected by oil from the engine lubricating system. Before entering the bearing housing the oil first passes through a separate filter mounted on the right-hand side of the engine and then goes through an oil strainer situated in the connection of the oil inlet line on the bearing housing.

The turbocharger is mounted directly on the exhaust manifold of the engine with a screwed fastening in the intake flange of the turbine. It is extremely important that this fastening alone should take the weight of the turbocharger and that no pipe connections or joints are too stiff, or they are liable to exert constraining forces on the unit and in such a condition could soon lead to trouble. For this reason, the exhaust pipe from the turbine is fitted with a special connection which takes up the movements that occur.

Repair Instructions

Checks

In all work on turbochargers the utmost cleanliness must be observed. Any dirt or other foreign matter that gets into the bearing housing will soon cause serious damage. The need for cleanliness is just as great as in the case of the injection pump.

Air and Exhaust Leaks

Start the engine. Check the connections between

the intake manifold and the engine, between the outer air intake and the air cleaner, and between the air cleaner and the turbocharger. Check that all gaskets are whole. Make a careful check of the exhaust system, particularly with regard to its connection to the turbocharger and its connections to the cylinder heads. After correcting any faults, or if faults, or if nothing abnormal is found, continue checking according to the instructions given



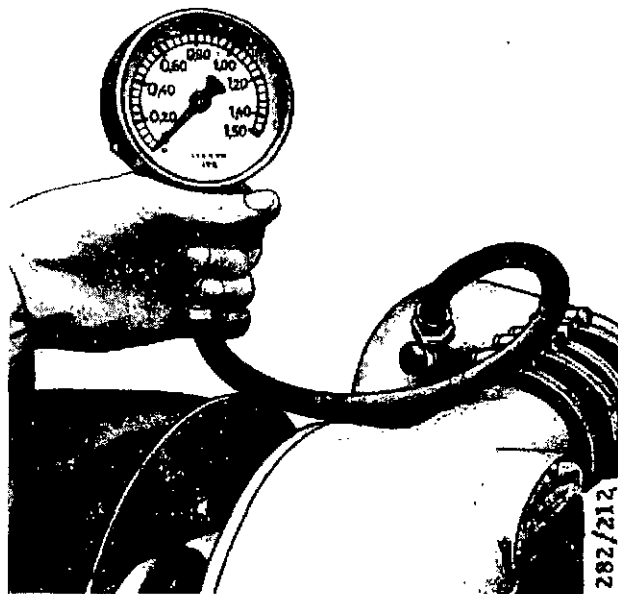
Charging Pressure

The check on the charging pressure should be preceded by a check on the high no-load speed of the engine.

Then connect a pressure gauge to the air pipe between the compressor discharge and the intake manifold. At maximum engine speed and load the pressure must agree with the values given in the graphs. Measure the charging pressure at maximum load and r.p.m. It is important to keep the engine loaded at the maximum r.p.m. long enough for the pressure to be built up in the intake manifold and for steady conditions to be established. When the reading is being taken for an engine fitted in a truck, it is a good plan to run the engine at full load and full throttle uphill while the engine speed reaches the maximum r.p.m. for maximum load relatively slowly.

The graphs indicate the charging pressure at 25°C, and the measured charging pressure must thus be corrected, if the intake air does not have this temperature when the reading is taken. Corrected values corresponding to the temperature and charging pressure readings can be obtained from a table. If the corrected charging pressure is not within the limits indicated by the graphs, the reason can for instance be that the air cleaner is clogged up or the compressor unit of the turbo-charger is dirty.

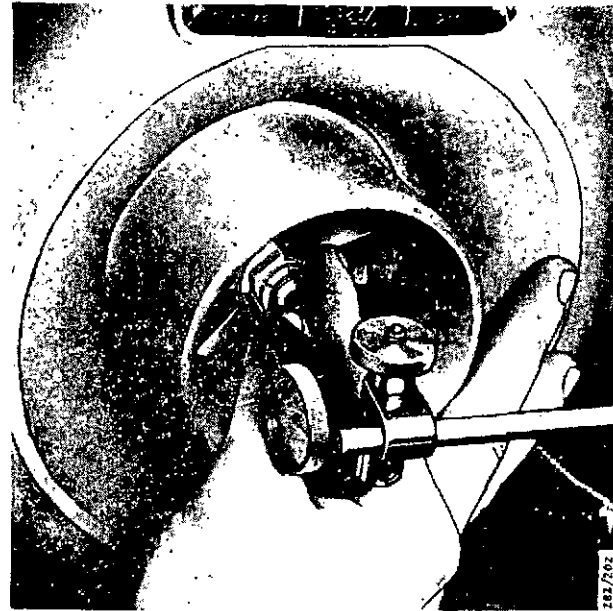
Note! The setting of the injection pump must not be altered under any circumstances beyond the prescribed values in order to adjust the charging pressure.



Measure the charging pressure

Radial and Axial Clearance

When measuring radial and axial clearance use the dial indicator in accordance with the directions below



The position of the contact point of the dial gauge in measuring the radial clearance of the compressor end

Radial Clearance of Compressor End

Apply the contact point of the dial gauge to the centre of one side of the locknut of the compressor wheel. Push the compressor wheel against the contact point and push the turbine wheel in the other direction at the same time. Rotate the wheels slowly to and fro until the lowest gauge reading is obtained and note this reading or set the gauge at zero. Then push the wheels in the opposite direction, rotate the wheels again as just described, and note the lowest reading.

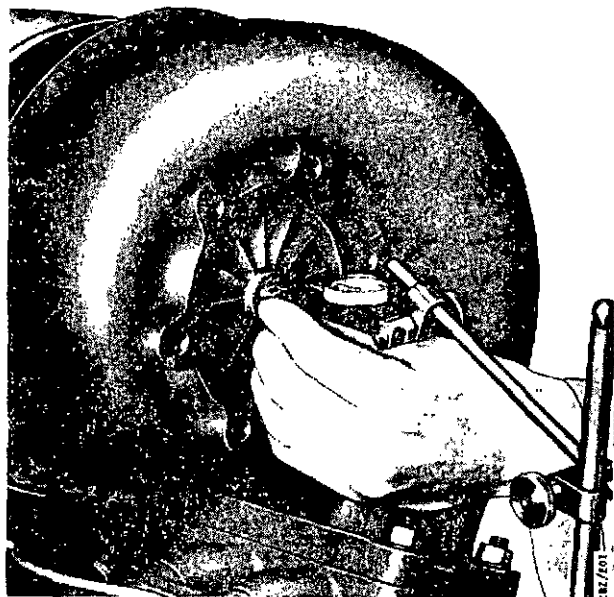
The difference between the two readings is the total radial movement of the compressor wheel. Repeat the procedure several times before accepting a final result.



Measure the axial clearance of the compressor end

Radial Clearance of Turbine End

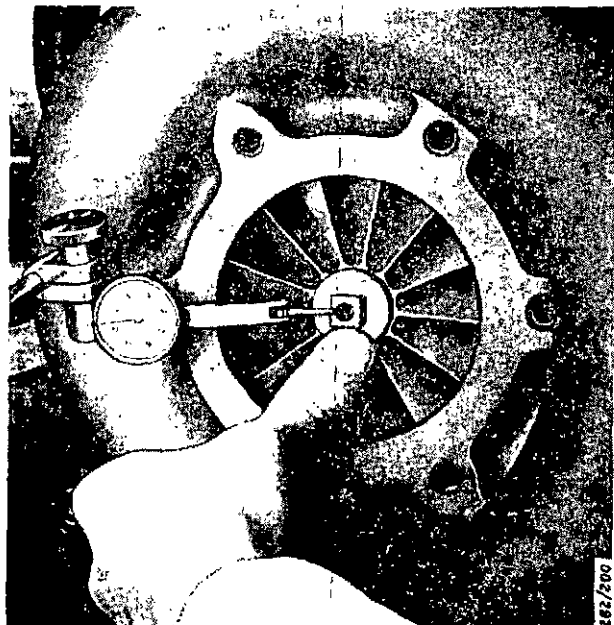
Apply the contact point of the dial gauge to the centre of one of the sides of the square extension on the turbine wheel. Then proceed in the same way as when checking the radial clearance of the compressor end.



Position of the contact point of the dial gauge in measuring the radial clearance of the turbine end

Axial Clearance of Shaft

Apply the contact point of the dial gauge to the end of the shaft on the turbine side. Push the shaft towards the dial gauge as far as possible, read the gauge and note the reading or set the instrument at zero. Then push the shaft towards the compressor



Position of the contact point of the dial gauge in

side as far as possible, read the gauge and note the reading.

The difference between the two readings gives the axial clearance of the shaft.

Cleaning the Compressor Unit with the Turbocharger in Place on the Engine

If the corrected charging pressure is lower than that indicated in the graph, even though the turbocharger has been passed free of faults during the above checks, the reason may be that the compressor unit is dirty.

With the turbocharger remaining on the engine the compressor unit can be cleaned as follows:

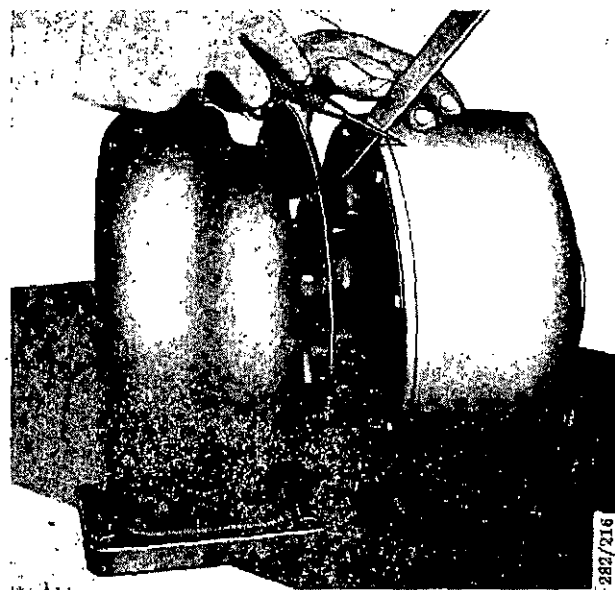
Take the compressor cover and the inlet cone out of the turbocharger according to the instructions given under the heading "Dismantling and Clean-in".

Clean the parts in white spirit or a similar detergent fluid.

Put the parts back and measure the charging pressure again according to the instruction under "Checks".

Dismantling and Cleaning

When the turbocharger has been taken out of the engine it is extremely important to protect the connections for the oil inlet and oil outlet. Use protective plugs.



Mark the compressor housing

Preparations

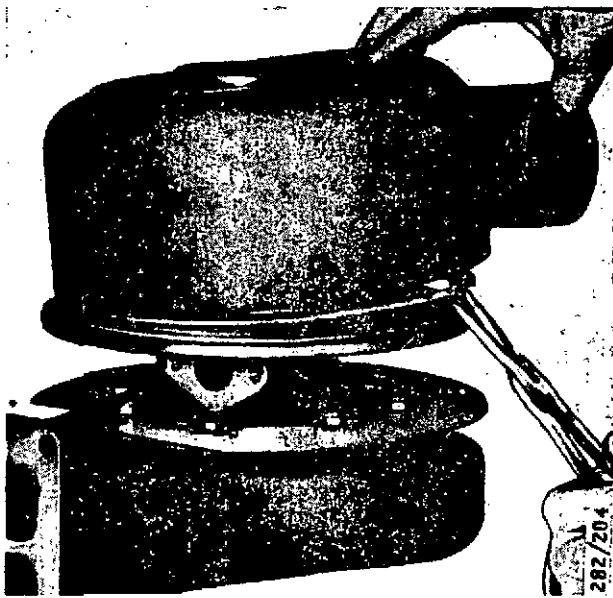
Clamp the turbocharger in a vice with the turbine side down. Lubricate the eight screws of the turbine housing with penetrating oil or diesel fuel



Put the long side of a ruler flush on the oil inlet flange of the replacement core assembly and mark the compressor cover at the lower edge of the ruler. Then mark the external shield and the turbine housing just opposite the marking on the compressor cover.

Compressor Cover

The compressor cover is secured with screws which are locked with lock plates. Knock down the tabs of the lock plates and screw out the screws. Then raise the compressor cover and apply a pair of lock-ring pliers to the two end holes of the lock ring. Compress the lock ring and remove it from its groove.



Remove the compressor cover, the lock ring and the gasket

Diffuser Ring

Model 3 No. 169300 (inlet cone and compressor cover in two units).

Remove the compressor cover. Remove the O-ring, spacer ring and O-ring from the inlet cone. Lift the inlet cone and locating washer up. Remove the locating washer from the inlet cone. Remove the lock ring and the gasket.

Model 3 No. 173738 (inlet cone built integral with the compressor cover).

Remove the compressor cover including the inlet cone. Remove the lock ring and the gasket.

Model 4.

Remove the compressor cover. Remove the O-ring from the inlet cone. Lift the inlet cone up. If it is

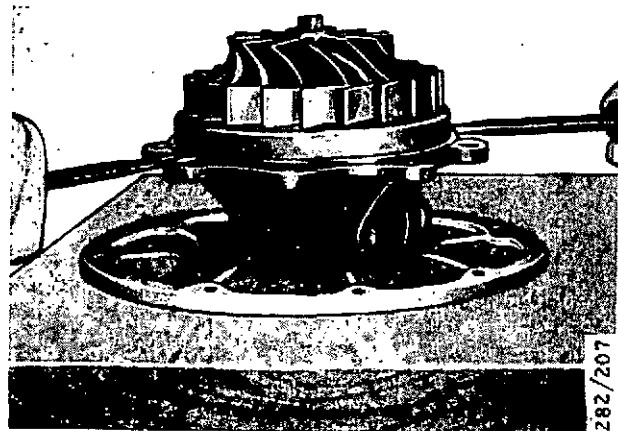
serting them under the inlet cone by the side of the dowel pins. Pry gently with the screwdrivers until the inlet cone comes loose.

Turbine Housing

Knock down the tabs of the lock plates and screw out the screws. Lift the bearing housing, with the shaft, wheels and nozzle ring, straight up. If it is tight, two screwdrivers can be inserted, one from each side, between the bearing housing and the turbine housing and used to pry the bearing housing gently free from the turbine housing. Then remove the external shield.

Nozzle Ring

If the nozzle ring is tight on the bearing housing, a knifeblade or similar implement can be inserted between the ring and the housing at various points and used to pry the ring gently loose. When the gap between the ring and the housing is big enough, the knife-blade is replaced by two screwdrivers. Apply them on opposite sides and pry gently, shifting the screwdrivers round the periphery of the ring to prevent it being distorted.

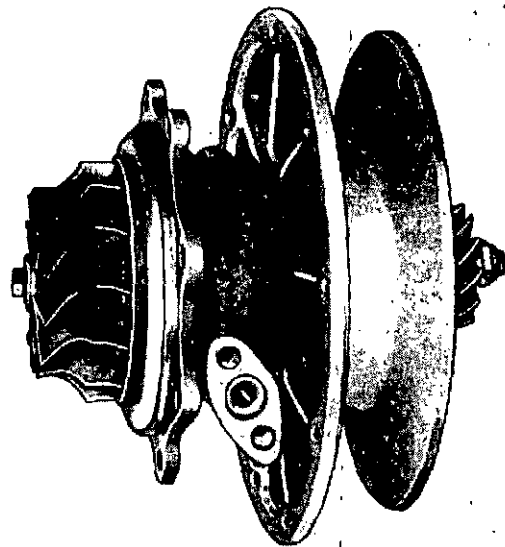


Carefully detach the nozzle ring

Replacement Core Assembly

The item which now remains undismantled is known as the replacement core assembly. If the replacement core assembly requires repair, it can be repaired or changed. On repairing the replacement core assembly, see "Reconditioning of the Replacement Core Assembly".

If the replacement core assembly is to be changed, it is necessary to pack it carefully. The transport container in which the new replacement core assembly is delivered is also to be used for the



Replacement Core Assembly

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Cleaning

Never use corrosive cleaning detergents. Be careful not to get cleaning agent into the bearing housing.

Wash and clean thoroughly all parts. Remove softened deposits with a soft brush, plastic scraper or compressed air.

Never use a steel-wire brush or steel scraper. Make quite sure that the wheels do not knock against anything and suffer damage. Check carefully that all the wheel vanes are thoroughly cleaned, since deposits left on them will upset balance.

When cleaning the nozzle ring, check that it is undamaged and that the vanes are not bent, so that the openings between them have changed.

A nozzle ring with damaged vanes or with vane spacings that are too small must be changed.

Remove the oil strainer of the bearing housing and inspect it. Take great care not to get impurities into the bearing housing. If the strainer is contaminated, this is a sign of a fault in the filter system. Change the filter insert in the oil filter of the turbo-charger.

Assembly

Nozzle Ring

Clamp the turbine housing in a vice and put the nozzle ring into the turbine housing by pressing it straight down. If the flange of the ring is lightly deformed, it may be carefully corrected. If there is much deformation, the correction must not be carried out in the turbine housing; the nozzle ring

Turbine Housing

Position the external shield. Press the replacement core assembly down into the turbine housing.

Use a ruler in the same way as when the marking was carried out and check that the lower edge of the ruler registers with the markings on the external shield and the turbine housing.

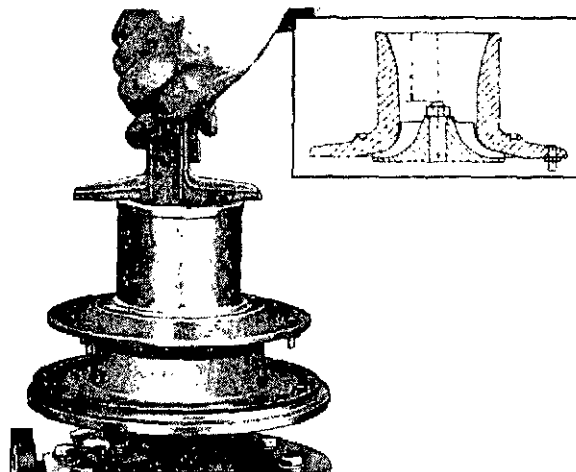
Use new lock plates and secure the bearing housing to the turbine housing.

Then lock the screws with the lock plates.

Diffuser Ring

Model 3 No. 169300 (inlet cone and compressor cover in two units).

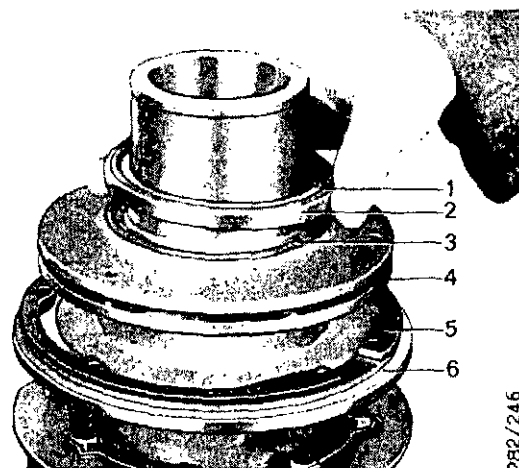
Put the inlet cone carefully on the compressor wheel and measure the distance from the end of the inlet cone to the shaft end. See Fig. 282/245. Note the value, because it will be used later on.



Measure the distance between the end of the inlet cone and the shaft end

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Fit a new gasket, 0.38 mm (0.015") thick on the compressor housing and fit the lock ring. Fit the locating washer and the inlet cone. Make sure that the dowel pins come into their holes. Put a new O-ring into the inlet cone and fit the spacer ring, which must also be provided with a new O-ring. See Fig. 282/246.



Fit the inlet cone

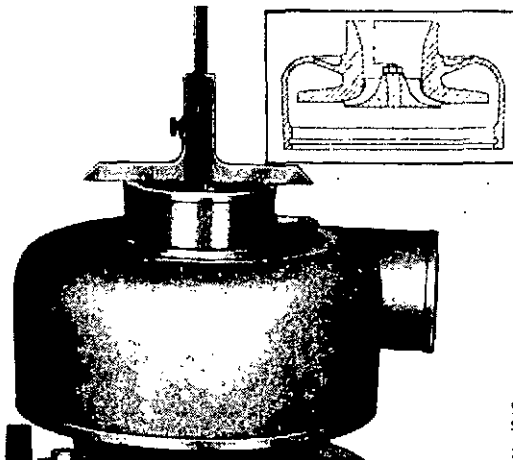
- 1. O-ring
- 2. Gasket
- 3. Lock ring
- 4. Guide washer
- 5. Spacer ring
- 6. Inlet cone

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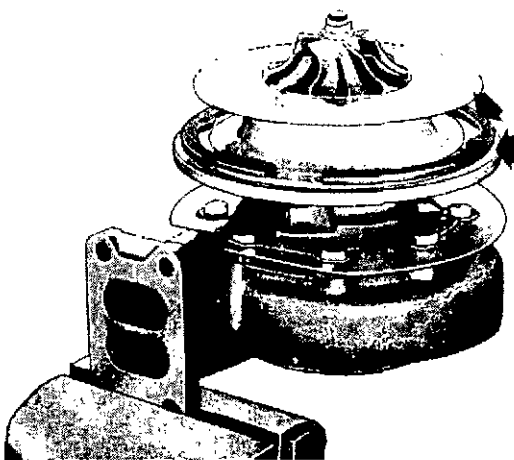
Model 3 No. 173738 (inlet cone built integral with the compressor cover).

Put gently the compressor cover, including the inlet cone, on the compressor wheel and measure the distance between the end of the inlet cone to the shaft end. N.B. When measuring this distance, there must be no gasket between the compressor housing and the compressor cover. See Fig. 282/247. Note the value, because it will be used later on.



Measure the distance between the end of the inlet cone and the shaft end.

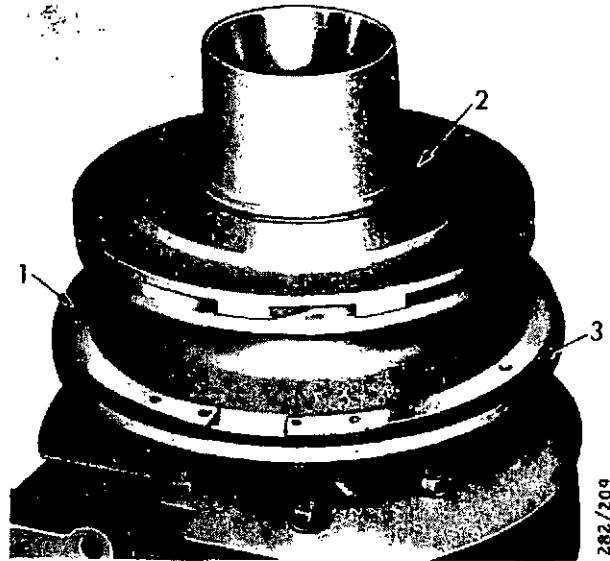
Fit a new gasket, 0.89 mm (0.035") thick, on the compressor housing and fit the lock ring. See Fig. 282/248.



Fit the gasket and the lock ring

Model 4

Fit a new gasket on the compressor housing and put the lock ring into position. Fit the inlet cone. Make sure that the dowel pins come into their holes. Put a new O-ring into its groove on the inlet



Fit the diffuser ring

- 1. Lock ring
- 2. O-ring
- 3. Gasket

Compressor Cover

Models 3 and 4

Fit the compressor cover and put the lock ring into its groove. Put the screws and the lock plates into position, without tightening the screws. Put the long side of a ruler on the oil inlet flange of the replacement core assembly and turn the compressor cover so that its marking (made during dismantling) registers exactly with the edge of the ruler. Secure the compressor housing.

Model 3

Measure the distance between the end of the inlet cone and the shaft end. Work out the difference between the value obtained and that obtained under the heading "Diffuser Ring". Check that the difference lies within the stated value.

Models 3 and 4

Secure the compressor cover. Then lock the screws with the lock plates, and place the turbocharger on a bench with the shaft horizontal. Rotate the wheels by hand and check that they run freely.

Fitting the Turbocharger onto the Engine

Check the intake line from the air cleaner and replace it, if it is deformed or damaged.

Check that the intake system is free from foreign particles.

Check that the engine exhaust system is free from

Check that the oil outlet and oil inlet lines are not deformed.

Check that the connection face of the turbocharger to the exhaust manifold on the engine is flat. Fit a new gasket on this connection.

Fit the turbocharger onto the engine.

Connect up the oil inlet line but not the oil outlet line.

Connect the intake line from the air cleaner and check all connections.

Connect the exhaust manifold to the turbine

housing. Use a new gasket and check that there are no remaining traces of the old one.

Check that there are no restraining forces at work on the turbocharger.

Turn the engine over with the starting motor without starting it until a steady stream of oil flows out of the oil outlet. Connect up the oil outlet line.

Start the engine, observing the starting instructions applying to engines with turbochargers, and check that all connections are tight.

Reconditioning of the Replacement Core Assembly.

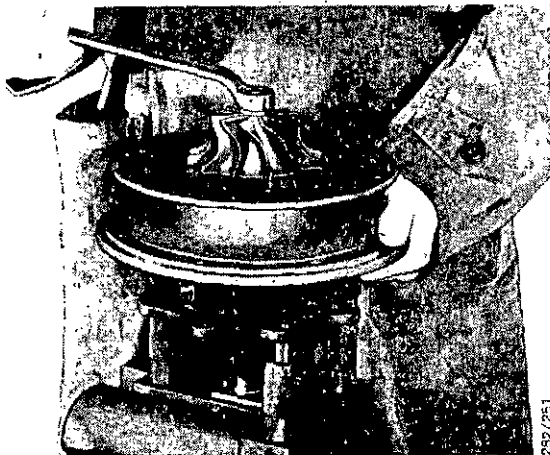
Reconditioning of the Replacement

Dismantling

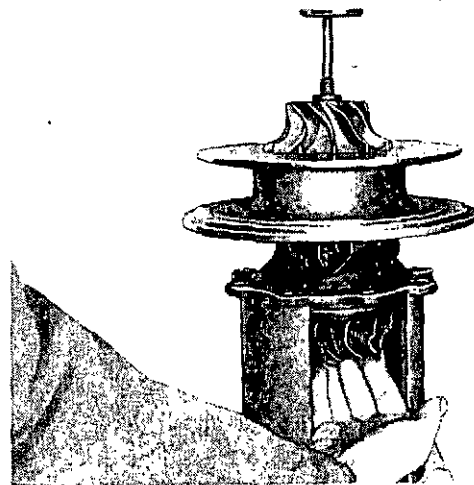
Before reconditioning the replacement core assembly, check the radial and axial clearance. See "Checks". Note down these clearance values, because they may be used later on when determining the wear.

Compressor Wheel

Put the replacement core assembly into the fixture 87032. Undo the locknut (15, Fig. 282/236).



Undo the locknut of the compressor wheel



Press the shaft out

Compressor Housing



Put the pressing tool 87031 into the press. Place the replacement core assembly, the turbine end facing down, in the pressing tool. Use the press drift 87035 to press the shaft out. Hold the turbine wheel with one hand and press the shaft out. Remove the shaft and compressor wheel. Take care



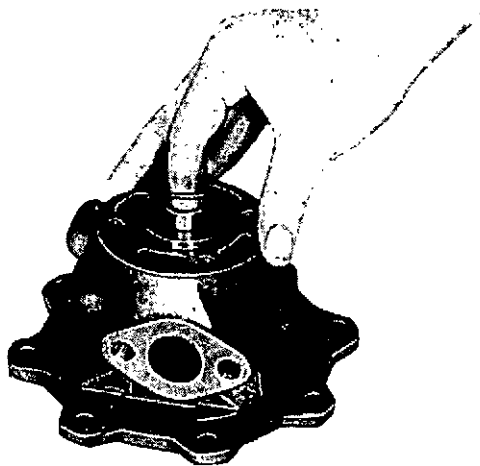
Put the replacement core assembly back again into the fixture 87032. Loosen and remove the screws retaining the compressor housing. Remove the compressor housing. Push with one finger the pressure flange out of the compressor housing. Remove the spring (21) from the recess in the compressor housing. Remove the thrust washer (23) and the gasket from the bearing housing.

Thrust Flange

Remove the sealing rings (18) from the thrust bearing.

Sliding Bearings and Thrust Washer

Put a finger through the thrust washer into the sliding bearing and pull the two parts out of the housing.



Remove the thrust washer and the sliding bearing

Place the bearing housing on the bench. Remove the outer lock ring retaining the sliding bearing of the turbine end. Use the lock-ring pliers 87030. Lift up the sliding bearing and the thrust washer, if the sealing recess in the bearing housing is not coated with carbon. If that is the case, remove the two inner lock rings, the sliding bearing and the thrust washer from the compressor end.

Remove the sealing rings (18) from the shaft.

Support Plate of Nossle Ring

Remove the lock ring retaining the support plate (11) and the internal shield (10). Lift the support plate and the internal shield. In certain cases, these



Remove the lock ring for the support plate of the nozzle ring

Oil Strainer

Remove the lock ring, using a screwdriver, and pull the oil strainer out.

Cleaning

Wash all the parts in an appropriate cleaning fluid. Never use corrosive solutions. Make sure in particular that the parts do not knock against each other. Use only a soft brush, plastic scraper or compressed air to remove deposits. A steel-wire brush or steel scraper must not be employed for this purpose. Make sure that all the vanes are cleaned carefully, because any remaining deposits will affect the balancing. Clean carefully all the inner cavities in the bearing housing, using compressed air. See to it that the check pipe (25, Fig. 282/236) is well cleaned.

Inspection

Compressor Wheel

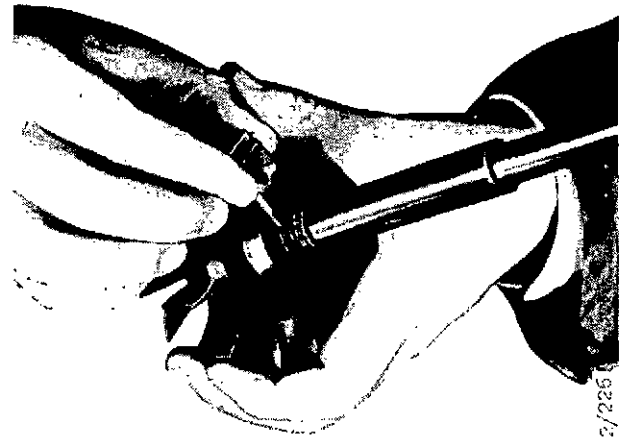
Always replace a damaged compressor wheel. If a vane has been distorted, the wheel is unbalanced and must not be used. When the vane profile has fouled the diffuser ring, this can be due to worn sliding bearings or too much dirt accumulation in the diffuser ring. If the inlet edges of the vanes are

into the turbocharger. Wear of the compressor wheel rear side may have been caused by too much dirt or wear on the thrust washer and on the sliding bearings.

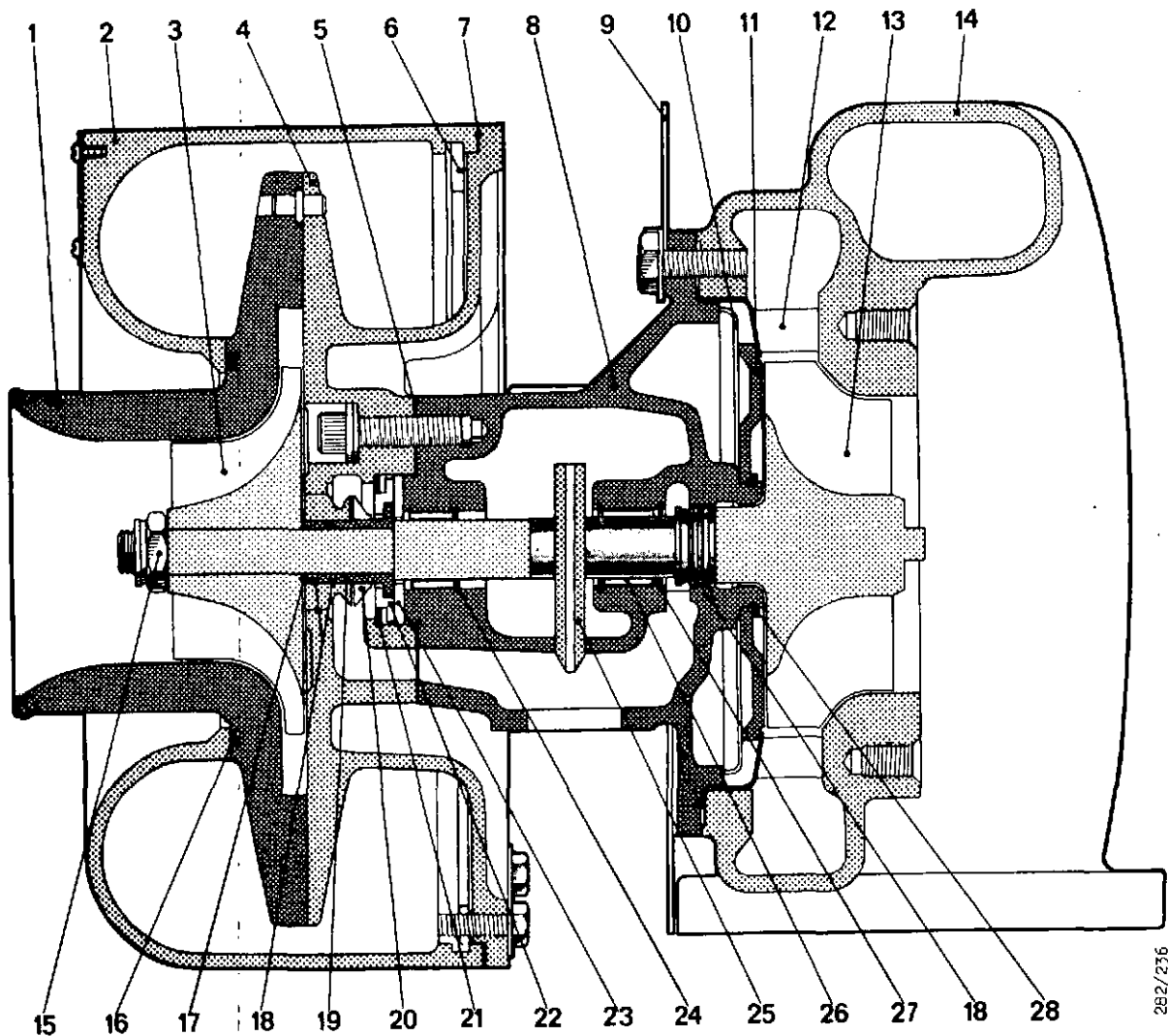
Turbine Wheel including the Shaft

Check that the sealing ring grooves are clean and that the sides of the grooves are parallel. Check the width of the grooves using the measuring tool 87063.

In case of excessive wear of the sliding bearings, the turbine wheel can foul the turbine housing, causing damage to the vanes. The same cause can also result in the shaft fouling the bearing housing. If such damages are found, replace the turbine wheel, including the shaft.



Check the sealing ring grooves



- 1. Inlet cone with diffuser ring
- 2. Compressor cover
- 3. Compressor wheel
- 4. Compressor housing
- 5. Gasket
- 6. Lock ring
- 7. Gasket

- 8. Bearing house
- 9. Outer shield
- 10. Inner shield
- 11. Support plate
- 12. Nozzle ring
- 13. Turbine wheel with shaft
- 14. Turbine housing

- 15. Lock nut
- 16. O-ring
- 17. Shims
- 18. Sealing rings
- 19. Thrust bearings
- 20. Sleeve
- 21. Spring

- 22. Bearing flange
- 23. Thrust washer
- 24. Lock ring
- 25. Check pipe
- 26. Sliding bearings
- 27. Thrust plate
- 28. Lock ring

282/236

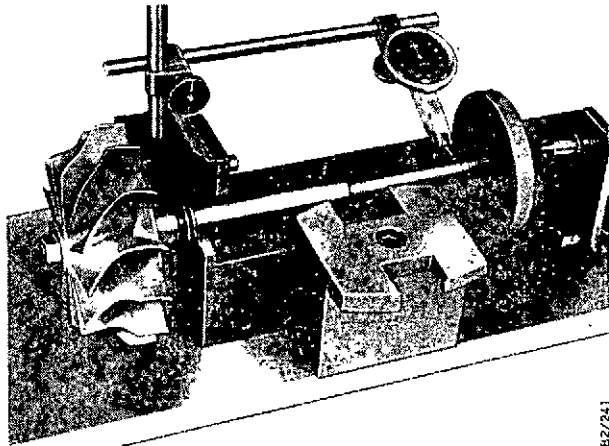
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The operational disturbances which occur most often in respect of the turbine wheel, are caused by particles, e.g. valve fragments or bits from the exhaust ducts, which penetrate into the turbine. As soon as such damage, presents itself, a thorough, investigation of these parts will be made necessary.

When the shaft diameter has attained through wear the minimum value, or when deep scratches appear in the bearing surface, replace the shaft.

Check the runout of the shaft in the indicator 87028. See Fig. 282/241.



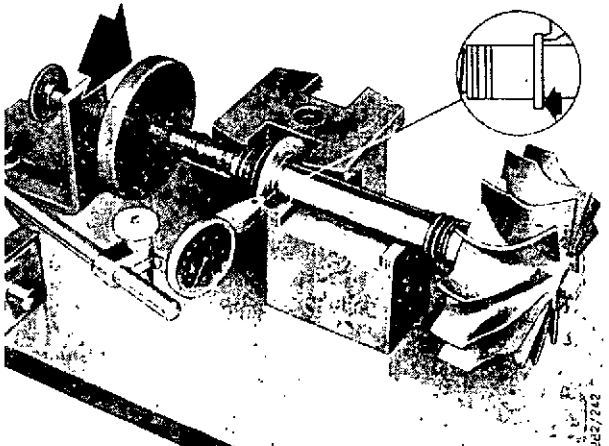
Check the runout of the shaft at the compressor

Thrust Flange and Thrust Washer

Wear on the thrust flange assembly and the thrust washer (23, Fig. 282/236) appears when the axial clearance has become excessive.

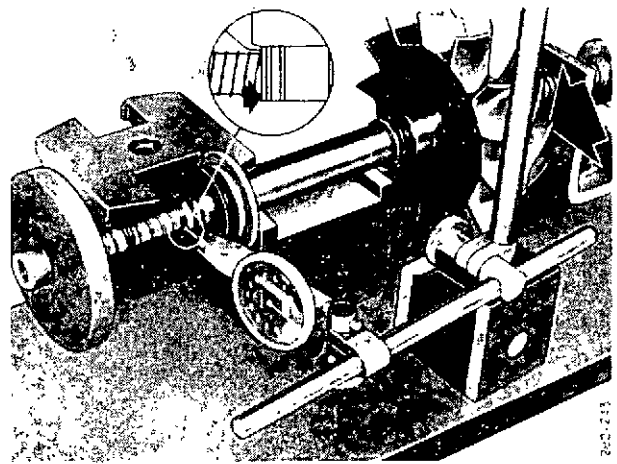
In case of extensive wear of the sliding bearings, the thrust bearing (19) may have fouled the compressor housing. On discovering scratches on the thrust bearing, replace it. Check that the grooves of the sealing rings in the thrust bearing are clean and that the sides of the grooves are parallel. Use the measuring tool 87063 to check the width of the grooves. If the tin layer of the bearing flange (22) has worn off, the bearing flange should be replaced. If the thrust flange assembly is to be dismantled, it will be necessary to balance the rotor unit.

Fit the thrust flange to the shaft and place the unit into the indicator 87028. Check the flange runout of the thrust bearing. See Fig. 282/242.



Check the flange runout of the thrust bearing

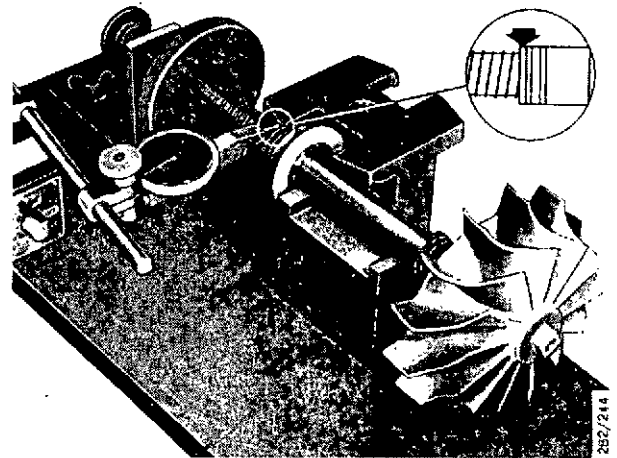
Check the end runout of the thrust bearing. See



Check the end runout of the thrust bearing

N.B. When measuring the Thrust bearing flange and end runout, the reading is twice the actual value.

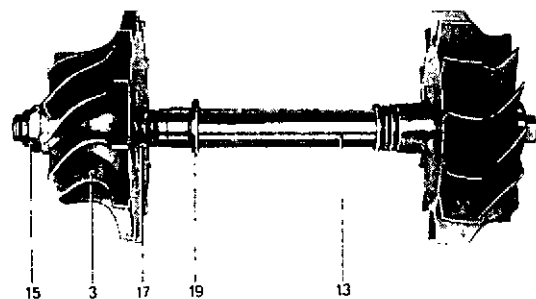
If oil leaks have been found at the compressor end, check the radial runout of the thrust bearing at the grooves of the sealing rings. See Fig. 282/244.



Check the radial runout of the thrust bearing at the grooves of the sealing rings

Rotor Unit

The rotor unit consists of locknut (15, Fig. 282/225), compressor wheel (3), turbine wheel and shaft assembly (13) and thrust bearing (19). All these



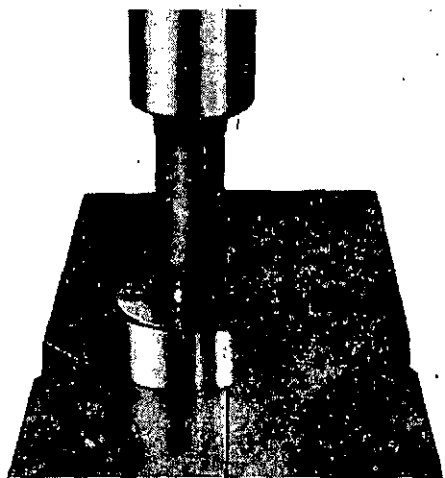
Rotor unit

- 3. Compressor wheel
- 13. Turbine wheel with shaft
- 17. Shims
- 19. Thrust bearing

parts have been balanced together, and if one of these parts is to be replaced, the whole rotor unit must therefore be balanced.

On balancing the rotor unit, remove the bearing flange (22, Fig. 282/236) and the sleeve (20) from the thrust bearing.

Use the removing tool 87040 or 87041 to press the sleeve off. Put the two halves of the removing tool under the sleeve (20). Place the unit in the annular reinforcement of the removing tool and press on the end of the thrust bearing until the sleeve comes free. See Fig. 282/222.



Press off the sleeve from the thrust bearing

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Fit the thrust bearing, the shims and the compressor wheel. Make sure that the marking on the flange of the thrust bearing and on the front edge of the compressor wheel point in the same direction as the marking on the shaft end. The setting is important, and it must be carried out as accurately as possible. Tighten the locknut to the torque stated. The rotor unit can then be balanced.

Sliding Bearings

On dismantling the replacement core assembly, the sliding bearings should always be changed. The condition of the sliding bearings gives some indications about, among other things, the quality of the lubrication. Wear of bearing inner diameter and shaft discolouration are normally due to insufficient oil pressure. Dirty oil generally entails the greatest wear on the outer diameter of the bearings. The outward end of the bearings, which is pressed by the oil pressure against the thrust washer (27, Fig. 282/236), will lose its tin plating even after a short period of operation. If there should be tin on this front side, this is due to insufficient oil pressure. The tin plating on the inner end of the sliding bearing will last normally for a limited time. When this layer has worn off,

Bearing Housing

Bearing housing wear can be due to poor lubrication of the sliding bearings. This can be ascertained by measuring the diameter of the hole. If the bore is too large, replace the bearing housing. Check the surface of the sealing hole. If the hole has scratches or if the hole is too large, replace the bearing housing.

Compressor Housing

Check whether there is any damage in the hole for the sealing rings. If scratches are found, and if there are big scratches in the front side behind the compressor wheel, replace the housing. Check also the sealing ring hole for ovality. Put a fault free sealing ring into the hole. Cover the ring hole, and raise the housing towards the light. If any light gap is then visible between the sealing ring and the compressor housing, replace the housing.

Sealing Rings

Always replace the sealing rings.

Assembly

Observe the greatest possible cleanliness on assembling the replacement core assembly. Always use new sealing rings and gaskets. The rotor unit must always be re-balanced, if one of the rotor unit parts has been replaced or if the inspection has indicated that some parts are out of balance.

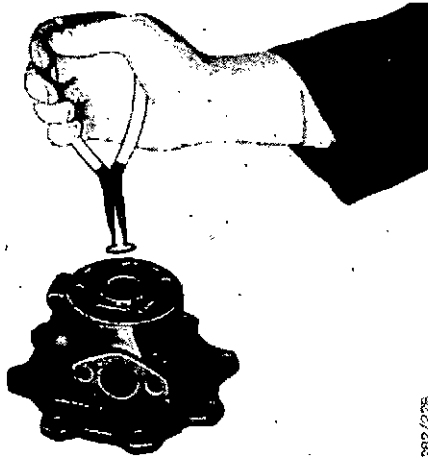
Sealing Rings (at the Turbine End)

Put the sealing rings into the grooves without extending them more than necessary.

Bearing Housing

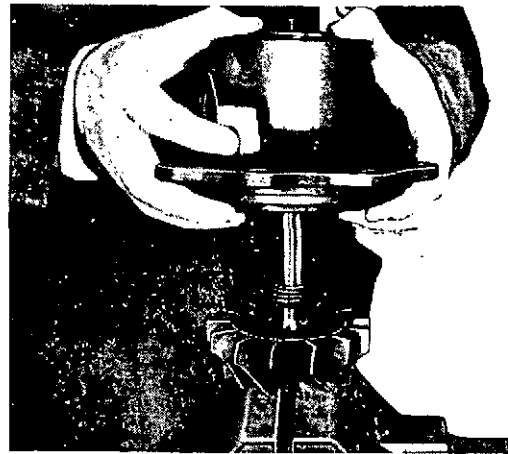
Use compressed air to clean thoroughly the bearing housing. See that the check pipe is completely free of impurities. Fit the two inner lock rings (24, Fig. 282/236) without fouling the hole surfaces. Make sure that the smooth face of the lock ring faces outwards. Check that they are in the correct position.

Oil the sliding bearing of the turbine end and fit it with the grooved end facing outwards. Fit the thrust plate (27). Fit the lock ring with the smooth



Fit the lock rings

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Lower gently the bearing housing over the sealing rings on the shaft

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Fit the inner shield (10), the support plate (11) and the lock ring.



Fit the support plate and the lock ring

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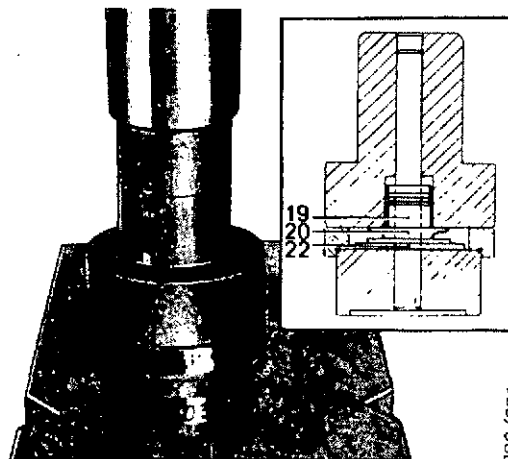
Remove the unit from the vice and place it in the assembly fixture. Make sure that the shaft does not drop out of the bearing housing.

Oil the sliding bearing of the compressor end and push it over the shaft into the bearing housing, with the grooved end facing outwards. Oil the thrust washer and place it over the sliding bearing. Put the thrust washer over the shaft so that its smooth face bears on the bearing housing. Lubricate lightly the thrust washer.

Thrust Flange

When the thrust flange assembly has been dismantled, use the assembly tool 87033 to fit the sleeve (20). This will ensure that the sleeve gets into the correct position. Always use a new sleeve.

Put the bearing flange over the thrust bearing with the flange facing downwards. Place the unit into the assembly tool 87033. Make sure that the intermediate ring of the assembly tool is located correctly. Fit the sleeve (20) with the flat face turned upwards. Fit the top of the assembly tool and press the units together.



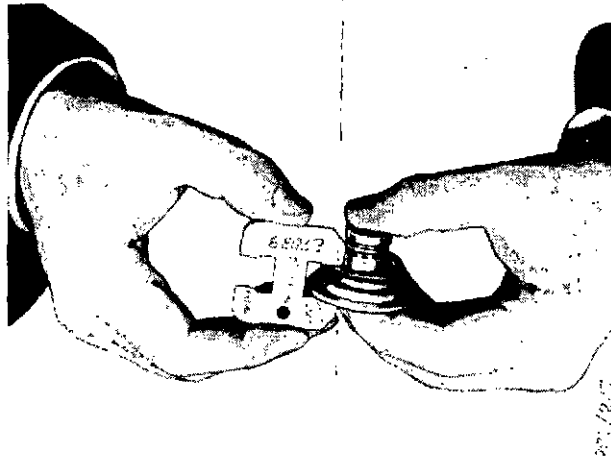
Press the thrust flange assembly together

282/231

Fit the oil strainer and the lock ring

Secure gently the shaft in a vice. Provide the shaft and the rings with a thin oil layer. Set the sealing rings so as to obtain a half-turn spacing between the ring gaps. Centre the rings. Place the bearing housing (with the support plate of the nozzle ring facing downwards) over the shaft. Do not use excessive force. If the sealing rings do not

Use the snap gauge 87038 or 87039 to check round the sleeve that it has got into the correct position.

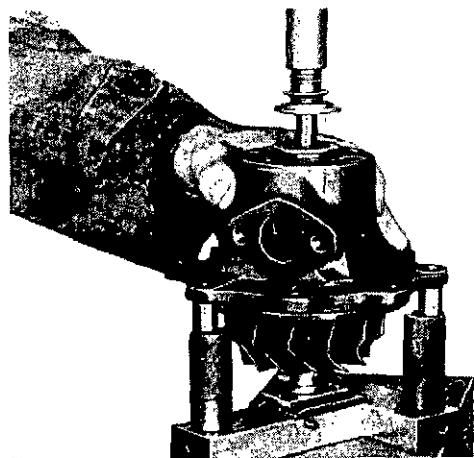


Check the position of the sleeve

Fit the sealing rings without extending them more than necessary.

Put the thrust flange assembly on the shaft and set it according to the punched-in markings on the collar of the thrust flange and the shaft end. Normally, it is possible to push by hand the thrust bearing onto the shaft. However, under certain circumstances it will be necessary to use a press, press drift 87036 or 87037 and support yoke 87034.

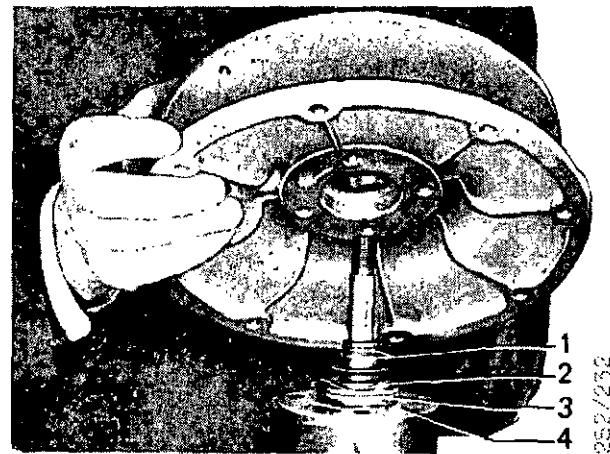
Raise the bearing housing just enough to allow the support yoke to be pushed in under the lock washer and the assembly fixture. Place the whole unit in the press. Press the thrust flange on, using the press drift.



Press the thrust flange assembly on

Compressor Housing

Lubricate the sealing rings on the thrust bearing and make sure that there is a half-turn spacing between the gaps. Put the spring (21) over the bearing flange (22). Place the gasket (5) on the bearing housing so that the hole in the gasket registers with the oil outlet hole. Centre the sealing rings. Fit the compressor housing so as to register with the oil outlet hole and the bolt holes. Make sure that the sealing rings do not creep out of their grooves.



Fit the compressor housing

- | | |
|------------------|------------------|
| 1. Sealing rings | 3. Thrust washer |
| 2. Spring | 4. Gasket |

N. B. It is essential that the compressor housing is not turned after having pushed it over the thrust bearing, if the thrust bearing is of a loose fit on the shaft. If that is so, displace the thrust bearing in relation to the shaft.

Put the washers and the spring washers into the four countersunk holes in the compressor housing. Insert the screws and tighten them evenly to the torque stated.

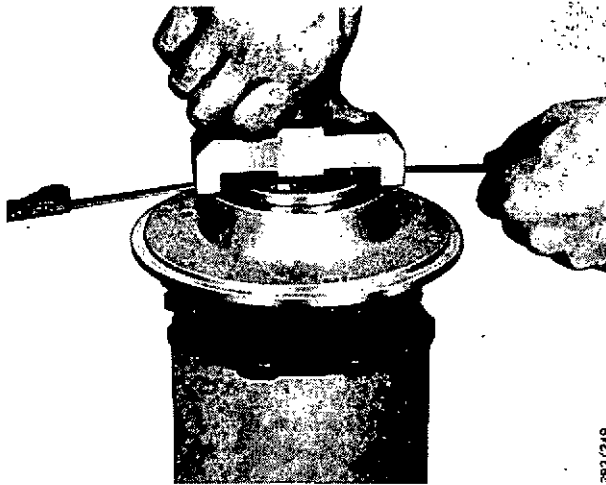
Compressor Wheel

Before fitting the compressor wheel check and, if necessary, adjust the position of the compressor wheel on the shaft. Use shims (17) to carry out any adjustment required.

Model 3

Put the shims over the shaft and fit wheel spacer block 79025 or 79020 over the shaft. Screw the locknut in and tighten it to the torque stated.

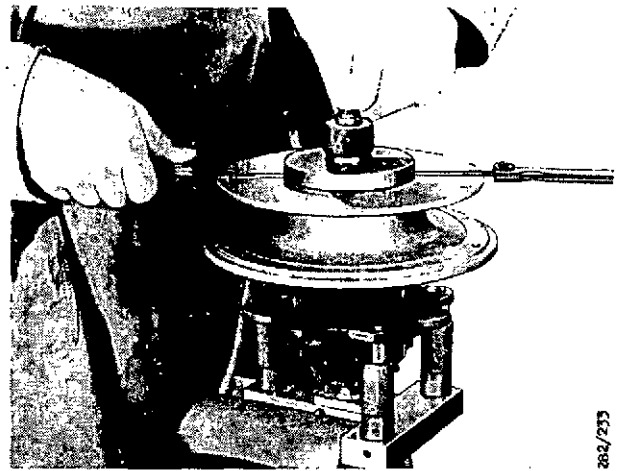
Measure by means of a feeler gauge on both sides, as shown by Fig. 282/249 or 282/250. On measuring, press the shaft against the turbine end.



282/249

Modell 3, No. 169300

Check the distance between the wheel spacer block 79025 and the compressor housing

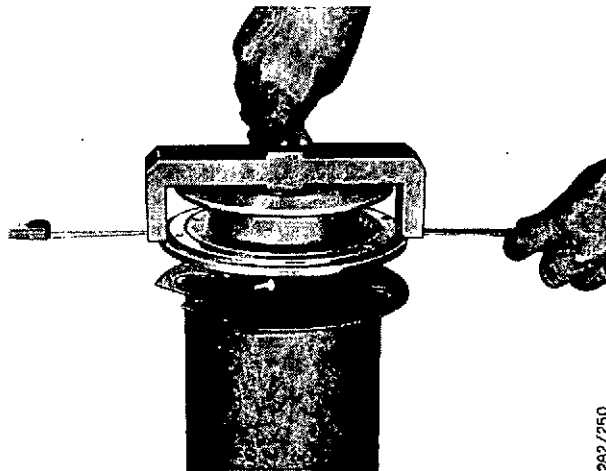


282/233

Modell 4

Check the distance between the wheel spacer block and the compressor wheel

Use shims to adjust the distance, if required. Remove the wheel spacer block.



282/250

Modell 3, No. 173738

Check the distance between the wheel spacer block 79020 and the compressor housing

If required, adjust the distance by means of shims. Remove the wheel a spacer block.

Model 4

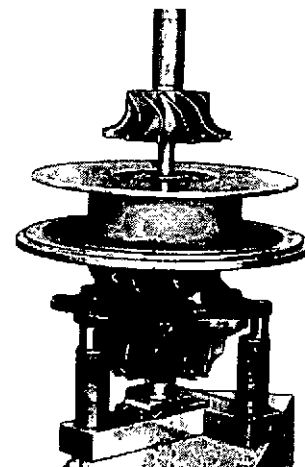
Put the shims over the shaft and fit the wheel spacer block 87061. Screw on the locknut and tighten it to the torque stated. Measure on either side, as shown by Fig. 282/233. On measuring, press

Models 3 and 4

Press lightly the compressor wheel onto the shaft and check that the marking at the shaft end and on the compressor wheel point in the same direction.

Raise the unit just enough to allow the support yoke to be pushed in under the lock washer and the assembly fixture.

Place the whole unit into the press. Press the compressor wheel on, using the press drift 87036 or 87037.



282/234

Press the compressor wheel on

Put the unit back again into the vice and remove the support yoke.



Tighten the locknut

Check that the axial and radial clearance is within the admissible limits. See "Checks".

For further assembly, see under "Repair Instructions".

Factors affecting the Service Life of the Turbocharger

Foreign Particles

The size of the vane spacings in the nozzle ring determines the velocity of the exhaust gas, which in its turn determines the speed at which the turbine wheel runs. Trials have shown that one particular vane spacing gives the best results. It is therefore very important not to change the vane spacing.

The nozzle ring is designed to be able to withstand the pressure of the engine exhaust. However, it cannot be made strong enough to withstand foreign particles passing through the turbine wheel. Even very small particles have a hammering effect on the vanes, which can result in the reduction of the spacing.

This reduction increases the velocity of the exhaust gas and with it the speed of the turbine wheel. Overspeeding of the turbine wheel increases bearing wear, and with excessive bearing slackness the turbine wheel scrapes against the housing. This tears metal from the vanes and results in a loss of balance.

When the turbocharger has been taken out of the engine for any reason, the whole exhaust system must be checked over, including the exhaust ports in the cylinder heads. Remove all particles which might loosen and get into the turbine.

Check the air intake system to see that it is free

Air Cleaner and Intake System

A choked air cleaner or deformed intake line may cause oil to be sucked past the seals and into the compressor.

A smaller quantity of air may also be caused by a choked air cleaner or intake system. This raises the exhaust temperature and may cause cracking of the turbine housing and bearing housing and overheating of the bearings.

Oil which penetrates into the compressor collects on the walls and, together with dust, builds up a thick coating. This also reduces the air supply to the engine.

Lubricating Oil

The turbocharger runs at high speed, which makes a good supply of lubricating oil to the bearings very important.

The grade of lubricating oil and oil changing are dealt with in the maintenance section of the appropriate operator's manual.

If the oil filter of the turbocharger becomes clogged, the oil reaching the unit will not have received any special cleaning, in consequence of which the unit may be put out of function within a short time. This risk is particularly serious, if the main cleaner of the engine, the centrifugal cleaner, should be out of action for any reason. The sludge which will then appear in the engine will be sufficient to clog the turbocharger filler very quickly, with bearing damage as a result. It is therefore extremely important to look after both oil cleaning units according to the maintenance instructions.

Overheating

Excessive exhaust-gas temperature may be due to excessive fuel supply and to the conditions mentioned in the section headed "Fuel System".

Alteration of the fuel supply with the object of obtaining greater power entails a great risk of both engine and turbocharger breakdown. Extra power obtained in this way can be very expensive.

Oil Leakage

Sealing rings of piston-ring type are used to prevent oil from leaking out of the bearing housing. These sealing rings do not seal against oil under pressure. However, owing to the fact that the oil outlet line is of relatively large diameter, the oil that passes the bearings can run back to the crankcase without the occurrence of overpressure between the bearings and the sealing rings. If the outlet line is choked, the oil collects in the bearing housing and is forced past the sealing rings. It is therefore very important to keep the outlet line



If the air cleaner or the intake lines should become choked, the engine does not get sufficient air. This sets up an underpressure in the compressor housing, and oil is sucked past the sealing rings and into this housing.

If the engine is run idle or with sharp accelerations for a prolonged period, a certain amount of oil may leak past the sealing rings. This has no appreciable effect on the oil consumption of the engine but is nevertheless noticeable in the line between the turbocharger and the intake manifold. This is quite normal and should not be regarded as oil leakage in the ordinary sense of the term.

Air and Exhaust Leaks

Even very small leaks in the line between the air cleaner and the turbocharger can give rise to heavy dirt accumulations in the compressor housing. They reduce the supply of air to the engine and affect its performance. They also contribute to a rise in exhaust-gas temperature, causing overheating of both turbocharger and engine.

If the exhaust gases leak out before they pass the turbine, the turbine wheel runs at a lower speed. This in turn means that the compressor wheel also runs more slowly, reducing the supply of air to the engine.

In view of this, check thoroughly to see that all gaskets are tight.

Excessive Fuel Consumption

A supercharged engine usually operates with a large excess of air. When the fuel supply is in-

creased, the speed of the turbocharger increases, and with it the air supply. This also increases the power developed by the engine. However, the fuel supply must not be increased, since a greater fuel supply results in a higher exhaust temperature. Excessive exhaust temperature not only causes damage to the turbocharger but also leads to engine damage, such as piston seizure, burned valves and cracks in the cylinder heads. The increased combustion pressure in the cylinders which results from increased fuel supply may cause purely mechanical faults, such as failure of the connecting rods and crankshaft.

Scheduled Maintenance to be Carried Out by Specially Trained Personnel

Every 1,200 hours (60,000 km)

- Check the charging pressure.
- Clean the compressor sub-assembly.¹⁾
- Check for air, exhaust and oil leakage.
- Repeat the check of the charging pressure.

Every 3,600 hours (180,000 km)

- Complete reconditioning of the core replacement unit.

¹⁾ N. B. This work should be done without the



Specification Adjustment Values and Tightening Torques Tools

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Specifications

A. General	D 5	DS 5	D 7	D 8	D 10	DS 10	D 11	DS 11
Number of cylinders	4	4	6	6	6	6	6	6
Cylinder bore	mm 115	115	115	115	127	127	127	127
Stroke	mm 125	125	115	125	135	135	145	145
Displacement	litres 5:19	5:19	7.17	7.79	10.26	10.26	11.02	11.02
Compression ratio	16:1	16:1	17:1	17:1	16:1	16:1	16:1	16:1
Firing order	1-2-4-3	1-2-4-3	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4
Working principle	4-stroke	4-stroke	4-stroke	4-stroke	4-stroke	4-stroke	4-stroke	4-stroke
Injection	direct	direct	direct	direct	direct	direct	direct	direct
Weight ¹	kg approx. 518	approx. 530	approx. 685	approx. 695	approx. 860	approx. 875	approx. 875	approx. 896

Max. speed, output and torque: see the operator's manual or service card for the engine in question.

¹The R01 version is exclusive of compressor, hydraulic pump, coolant and oil.

B. Cylinder Heads		D 5 DS 5	D 7 D 8	D 10, DS 10, D 11, DS 11
Valve timing	Intake valve	opens	11° B.T.D.C.	10° B.T.D.C.
		closes	41° A.B.D.C.	40° A.B.D.C.
	Exhaust valve	opens	43° B.B.D.C.	46° B.B.D.C.
		closes	7° A.T.D.C.	10° A.T.D.C.
Diameter, head	Intake valve		50 mm	54 mm
	Exhaust valve		42 mm	44 mm
Position of intake-valve seat insert	Depth		11.20—11.30 mm	11.25—11.35 mm
	Fillet radius		Sharp corner	Sharp corner
Recess for exhaust-valve seat	Depth		11.20—11.30 mm	11.25—11.35 mm
	Fillet radius		Sharp corner	Sharp corner
Valve guide, I.D.	Intake valve		11.00—11.02 mm	11.00—11.02 mm
	Exhaust valve		11.00—11.02 mm	11.00—11.02 mm
Valve springs	Number per valve		2	2
Rocker-arm shaft	Outside diameter		21.99—21.98 mm	24.99—24.98 mm
Pushrods	Diameter		14 mm	14 mm

C. Cylinder Block

Cylinder liners	Type	Wet, renewable	Wet, renewable
	Cylinder bore	115.000—115.020 mm	127.000—127.025 mm
	Shims, thickness	0.20, 0.25, 0.30	0.20, 0.25, 0.30
		0.50, 0.75 mm	0.50, 0.75 mm

D. Crankshaft and Reciprocating Components

Pistons		D5, DS 5, D 7, D 8	D 10, DS 10, D 11, DS 11
Material		Light metal	Light metal
Compression rings	Number per piston	3	3
Scraper rings	Number per piston	2	2

Crankshaft

Thrust washers	Thickness		
	Standard	3.429—3.378 mm	3.429—3.378 mm
	Oversize 1	3.505—3.454 mm	3.505—3.454 mm
	Oversize 2	3.556—3.505 mm	3.556—3.505 mm
	Oversize 3	3.683—3.632 mm	3.683—3.632 mm
	Oversize 4	3.937—3.886 mm	4.191—4.140 mm

Main-bearing journals	Diameter		
	Standard	85.000—84.978 mm	101.598—101.620 mm
	Undersize 1 (ground down by 0.25 mm)	84.750—84.728 mm	101.349—101.371 mm
	Undersize 2 (ground down by 0.50 mm)	84.500—84.478 mm	101.097—101.120 mm
	Undersize 3 (ground down by 0.75 mm)	84.250—84.228 mm	100.848—100.871 mm
	Undersize 4 (ground down by 1.00 mm)	84.000—83.978 mm	100.597—100.620 mm
	Undersize 5 (ground down by 1.25 mm)	83.750—83.728 mm	100.348—100.371 mm
	Undersize 6 (ground down by 1.50 mm)	83.500—83.478 mm	100.096—100.119 mm
	Fillet radius	4.7—4.3 mm	5.2—4.8 mm
	Profile depth of bearing surface	1 μm	1 μm
	Width		
	Journal without axial guide (No. 1, 2, 3, 5 and 6)	—	47.00—47.20 mm
	Journal without axial guide (No. 4)	—	61.80—62.00 mm
	Journal without axial guide (No. 1—6)	42.00—42.20 mm	—
	Journal with axial guide (No. 7)	42.20—42.25 mm	47.20—47.25 mm

Crankpins	Diameter		
	Standard	75.000—74.981 mm	84.233—84.255 mm
	Undersize 1 (ground down by 0.25 mm)	74.750—74.731 mm	83.985—84.005 mm
	Undersize 2 (ground down by 0.50 mm)	74.500—74.481 mm	83.734—83.754 mm
	Undersize 3 (ground down by 0.75 mm)	74.250—74.231 mm	83.485—83.505 mm
	Undersize 4 (ground down by 1.00 mm)	74.000—73.981 mm	83.233—83.254 mm
	Undersize 5 (ground down by 1.25 mm)	73.750—73.731 mm	83.983—83.005 mm
	Undersize 6 (ground down by 1.50 mm)	73.500—73.481 mm	82.733—82.753 mm
	Undersize 7 (ground down by 1.75 mm)	73.250—73.231 mm	—
	Undersize 8 (ground down by 2.00 mm)	73.000—72.981 mm	82.235—82.255 mm
	Fillet radius	4.7—4.3 mm	5.2—4.8 mm
	Profile depth of bearing surface	1 μm	1 μm
	Width	52.0—52.1 mm	59.0—59.1 mm



H. Fuel System		D 7	D 10	DS 10
Make		CAV	Bosch	Bosch
Injection jump	Alt. I	NR 6G 75/206	PE6 B80 E410 RS1274/11	PE6 B95 E410 RS1389/11
	Alt. II	—	PE6 B80 E410 RS1434/11	PE6 B95 E410 RS1475/11
Pneumatic governor	Alt. I	GLIPE 27	EP/MZ 80 BA104	—
	Alt. I	—	EP/MZ 80 BA114	—
	Alt. II	—	EP/MZ 80 BA117	—
Centrifugal governor	Alt. I	—	—	RQV 250—1100 B 338
	Alt. II	—	—	RQV 250—1100 B 367
Feed pump		DFP 3/7 S	FP/K22 BC209/2	FP/K22 BC209/2
Coupling		FDC 6248240	ZKG 25 Z 4	ZKG 25 Z 4
Injector				
Nozzle		BDLL 150S 6072B	DLA 150 S111	DLA 150 S138
Holder		BKBL 97S 661B	KBL 112 S38/13	KBL 112 S28/13s
Fuel filter		2F 3A/12 R	FJ/DW11 W11 A116	FJ/DWLL W11 A116
Pressure relief valve		7019/239 C	PVE 53 S 8Z	PVE 53 S 8Z
Alternatively		—	CAV 7019/239 C	CAV 7019/239 C
Firing order		1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4

	D 8	D 11	DS 11
Make	CAV	Bosch	Bosch
Injection pump	See type plate on the pump		
Pneumatic governor	See type plate on the governor		
Centrifugal governor	See type plate on the governor		RQV 250—1100 B 378
Feed pump	DFP 3/7 S	FP/K22 BC209/2	FP/K22 BC209/2
Coupling	FDC 6248240	ZKG 25 Z 4	ZKG 25 Z 4
Injector			
Nozzle	BDLL 150S 6403	DLA 150 S204	DLA 150 S138
Holder	BKBL 97S 661B	KBL 112 S28/13	KBL 112 S28/13
Fuel filter	2FS 584	FJ/DW11 W11 A116	FJ/DWLL W11 A116
Pressure relief valve	7019/239 C	PVE 53 S 8Z	PVE 53 S 8Z
Alternatively	—	CAV 7019/239 C	CAV 7019/239 C
Firing order	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4

	D 5	DS 5
Make	CAV	CAV
Injection pump	See type plate on the pump	
Pneumatic governor	See type plate on the governor	
Centrifugal governor	See type plate on the governor	
Feed pump	DFP 3/63	DFP 3/64
Coupling	Direct flange	Direct flange
Injector		
Nozzle	BDLL 150S 6403	BDLL 150SX 4960M
Holder	BKBL 97S 661B	BKBL 97S 661
Fuel filter	FS 583	FS 583
Pressure relief valve	7019/239 C	7019/239 C
Firing order	1-2-4-3	1-2-4-3

J. Turbocharger	DS 5	DS 10	DS 11
Nozzle ring marked	"140"	"210"	"224"

Adjustment Values and Tightening Torques

B. Cylinder Heads		D5, DS 5, D 7, D 8	D 10, DS 10, D 11, DS 11
Tighten the cylinder heads according to the instructions.			
Torque	50 %	10 ¹⁾	9 kgm
	75 %	15 ¹⁾	13 kgm
	full	19 ¹⁾	17 kgm
Valve clearance, cold engine	Intake valve	0.35 ²⁾	0.35 mm
	Exhaust valve	0.70 ²⁾	0.45 mm
Angle of valve head	Intake valve	29.5°	29.5°
	Exhaust valve	29.5°	29.5°
Diameter of valve seat	Intake valve (dimension D)	49 mm	53 mm
	Exhaust valve (dimension D)	41 mm	43 mm
Angle of valve seat	Intake valve	30°	30°
	Exhaust valve	30°	30°
Width of valve seat	Intake valve (dimension A)	1.2—1.5 mm	1.2—1.5 mm
	Exhaust valve (dimension A)	1.2—1.5 mm	1.2—1.5 mm
Distance between face plane of cylinder head and valve head (dimension B)		min. 0.7 mm	min. 0.7 mm
Chilling temperature for valve seat inserts and insertion drifts before the inserts are pressed in		approx. —80°C	approx. —80°C
Clearance between valve stem and guide		max. 0.14 mm	max. 0.14 mm
Height of valve guides above seating level of valve springs		25±0.25 mm	25±0.25 mm
The inside conical recess of the exhaust-valve guide should face the valve head			
Valve springs			
Outer:	free length	66 mm	66 mm
	length with at least 48 kg load	36 mm	36 mm
Inner:	free length	59 mm	59 mm
	length with at least 20.5 kg load	32 mm	32 mm
The more closely wound end of the outer valve spring should face the cylinder head			
Inside diameter of rocker-arm bushing (after pressing in)		22.00—22.02 mm	25.00—25.02 mm
Profile depth of bearing surface		4 μ	4 μ
Two holes for the oil passages must be drilled in the rocker-arm bushing			
C. Cylinder Block			
Fit all liners with the marking turned to face the front of the engine			
Height above level of cylinder block		0.03—0.07 mm	0.05—0.10 mm
Max. permissible difference between dimensions read off at two diametrically opposite points transverse to the engine		0.02 mm	0.02 mm
Max. permissible height difference for liners belonging to the same cylinder head		0.03 mm	0.03 mm

¹⁾ Applies to D5—DS5—D8 with stud of harder material.

²⁾ Applies to D5—DS5.



	D5, DS 5, D 7, D 8	D 10, DS 10, D 11, DS 11
Max. permissible deviation from parallelism in the cylinder-liner flange	0.02 mm	0.02 mm
Wear	max. 0.35 mm	max. 0.35 mm
Ovality (with cylinder head fitted)	max. 0.05 mm	max. 0.05 mm

D. Crankshaft and Reciprocating Components

Pistons

Before removing or fitting piston pin, piston must be heated to	100°C	100°C	
Taper piston rings must be fitted with the marked side up			
Piston-ring gap	Top compression ring	0.5—0.7 mm	0.6—0.8 mm
	Second and third compression rings	0.3—0.6 mm	0.5—0.7 mm
Axial play, piston ring	max. 0.25 mm	max. 0.25 mm	

Connecting Rods

Marked from 1 to 6, alternatively 1 to 4

The connecting rods must be fitted so that the numeral markings can be read from the same direction as the numeral markings in the cylinder block

Big-end bolts	Length before tightening ¹⁾	107.00—107.03 mm	—
	Length after tightening ¹⁾	107.22—107.25 mm	—
	Tightening torque	11 kgm	11 kgm
Piston-pin bushing	Inside diameter (when pressed in)	42.051—42.058 mm	47.031—47.043 mm
	Profile depth of bearing surface	2.5 μm	2.5 μm

¹⁾ Applies to D 7

Crankshaft

Axial play (adjusted with thrust washers at main bearing 7)		0.05—0.25 mm	0.09—0.29 mm
Bearing play (radial)	Main bearings	0.053—0.112 mm	0.058—0.126 mm
	Big-end bearings	0.044—0.094 mm	0.050—0.106 mm
Main-bearing nuts	Tightening torque	21 kgm	29 kgm
Flywheel bolts	Tightening torque	19 kgm	19 kgm
Before fitting, flywheel ring gear must be heated to		250°C	250°C
Vibration-damper screws	Tightening torque	11 kgm	11 kgm
Screw for vibration-damper hub at front end of crankshaft	Tightening torque	75 kgm	75 kgm
Screw for flywheel casting	Tightening torque	6 kgm	8.5 kgm

E. Timing Gears			D5, DS 5, D 7, D 8	D 10, DS 10, D 11, DS 11
			Camshaft	Bearing play	Axial	0.10—0.25 mm	0.10—0.25 mm
		Radial bearing 1	0.045—0.083 mm	0.045—0.094 mm
		Radial bearings 2—4	0.030—0.079 mm	0.030—0.079 mm
Camshaft bushings (when pressed in)	Inside diameter	Bearing 1	68.200—68.230 mm	68.200—68.230 mm
		Bearing 2	68.100—68.130 mm	68.100—68.130 mm
		Bearing 3 ¹⁾	68.000—68.030 mm	68.000—68.030 mm
		Bearing 4	60.000—60.030 mm	60.000—60.030 mm
	Profile depth of bearing surface		2.5 μ m	2.5 μ m
Before fitting, camshaft gearwheel must be heated to			100°C	100°C
Before fitting, crankshaft gearwheel must be heated to			100°C	100°C
Tooth play (new engine)			0.03—0.09 mm	0.03—0.09 mm
F. Lubricating System				
Oil pressure			1.5—5 kg/cm ²	1.5—5 kg/cm ²
Relief valve to be set to 5 kg/cm ² with engine warm and running at			2,400 r.p.m.	2,200 r.p.m.
Nuts for rotor cover of centrifugal cleaner			First make finger-tight, then give half-turn with wrench	First make finger-tight, then give half-turn with wrench
Oil-pan bolts	Tightening torque		5 kgm	5 kgm
Oil pump bushings (pressed in)	Inner diameter	Bearing 1	19.075—19.100 mm	19.075—19.100 mm
		Bearing 2	19.075—19.100 mm	19.075—19.100 mm
	Bearing surface profile depth	Bearing 1	4 μ m	2 μ m
		Bearing 2	4 μ m	4 μ m
G. Cooling System				
Thermostat	Must be completely closed at		74°C	74°C
	Must begin to open at max.		77°C	77°C
	Must be completely open at		88°C	88°C
Water pump	Distance between plane of pump housing and impeller (new pump)		0.3—1.2 mm	0.3—1.2 mm
Fan belts	When belts are correctly tensioned, moderate force between generator and fan should be suffice to deflect them		approx. 10 mm	approx. 10 mm
Anti-freeze			See directions in operator's manual or service instructions	See directions in operator's manual or service instructions
Proportion of emulsifying cutting oil added to coolant			2—3 %	2—3 %
N.B. Cutting oil must not be added to the anti-freeze				

¹⁾ Does not apply to D5, DS5.

**H. Fuel System**

			D 7	D 10	DS 10
Injection pump	Setting		33° B.T.D.C. 1)		25° B.T.D.C.
	Control-rod opening, max.	mm	12±0.5	2)	2)
Coupling	Retaining screws			2.0—2.5	2.0—2.5
	Tightening torque	kgm			
Feed pressure (measured in fuel chamber of injection pump)		kg/cm ²	0.6—0.8	0.6—0.8	0.6—0.8
	at max. r.p.m. and load	kg/cm ²	min. 0.2	min. 0.2	min. 0.2
Pressure relief valve	Opening pressure	kg/cm ²	aprox. 0.5	aprox. 0.5	aprox. 0.5
Pressure pipes	Inside diameter	mm	2	1.7	2
Cap nuts	Tightening torque	kgm	1.5—2	1.5—2	1.5—2
Injectors	Opening pressure on inspection	kg/cm ²	175—185	175—185	200—210
	when setting	kg/cm ²	180—185	180—185	205—210
Nozzle	Hole diameter	mm	0.29—0.31	0.28—0.30	0.34—0.36
	Needle lift	mm	0.25—0.30	0.20—0.28	0.35—0.43
Retaining nuts	Solex B	mm w.g.	200—230	215—245	140—160
	Tightening torque	kgm	1.0	1.0	1.0
R.p.m. of engine	No-load idling	r.p.m.	450—500	450—500	450—500
	High no-load	r.p.m.	2650 3)	2450 3)	2450
	Max. load	r.p.m.	2400	2200	2200

			D 8	D 11	DS 11
Injection pump	Setting	mm	30° B.T.D.C.	28° B.T.D.C.	25° B.T.D.C.
	Control-rod opening, max.		1)	1)	1)
Coupling	Retaining screws	kgm		2.0—2.5	2.0—2.5
	Tightening torque				
Feed pressure (measured in fuel chamber of injection pump)		kg/cm ²	0.6—0.8	0.6—0.8	0.6—0.8
	at max. r.p.m. and load	kg/cm ²	min. 0.2	min. 0.2	min. 0.2
Pressure relief valve	Opening pressure	kg/cm ²	aprox. 0.5	aprox. 0.5	aprox. 0.5
Pressure pipes	Inside diameter	mm	1.7	1.7	2
Cap nuts	Tightening torque	kgm	1.5—2	1.5—2	1.5—2
Injectors	Opening pressure on inspection	Kg/cm ²	135—145	135—145	200—210
	when setting	Kg/cm ²	140—145	140—145	205—210
Nozzle	Hole diameter	mm	0.29—0.31	0.32—0.34	0.34—0.36
	Needle lift	mm	0.25—0.30	0.35—0.43	0.35—0.43
Retaining nuts	Solex B	mm w.g.	200—230	215—245	140—160
	Tightening torque	kgm	1.0	1.0	1.0
r.p.m. of engine	No-load idling	r.p.m.	450—500	450—500	450—500
	High no-load	r.p.m.	2650 3)	2450 3)	2450
	Max. load	r.p.m.	2400	2200	2200

1) Bosch PE6 B80 E410 RS1274/11 28° B.T.D.C.
Bosch PE6 B80 E410 RS1434/11 30° B.T.D.C.

2) See the figure stamped on the pump or the appropriate Service Bulletin.

3) With the damper device out of action.

			D 5	DS 5
Injection pump	Setting		30° B.T.D.C.	25° B.T.D.C.
	Control-rod opening, max.	mm	1) ¹⁾	1) ¹⁾
Feed pressure (measured in fuel chamber of injection pump)	at max. r.p.m. and load	kg/cm ²	0.6—0.8	0.6—0.8
Pressure relief valve	Opening pressure	kg/cm ²	min. 0.2 approx. 0.5	min. 0.2 approx. 0.5
Pressure pipes	Inside diameter	mm	1.7	1.7
Cap nuts	Tightening torque	kgm	1.5—2	1.5—2
Injectors	Opening pressure on inspection	kg/cm ²	135—145	135—145
	when setting	kg/cm ²	140—145	140—145
Nozzle	Hole diameter	mm	0.29—0.31	0.29—0.30
	Needle lift	mm	0.25—0.30	0.25—0.30
	Solex B	mm w.g.	210—240	200—230
Retaining nuts	Tightening torque	kgm	1.0	1.0
R.p.m. of engine	No-load idling	r.p.m.	500—550	
	High no-load	r.p.m.	2650 ²⁾	2650
	Max. load	r.p.m.	2400	2400

1) See the figure stamped on the pump and the appropriate Service Bulletin.

2) With the damper device out of action.

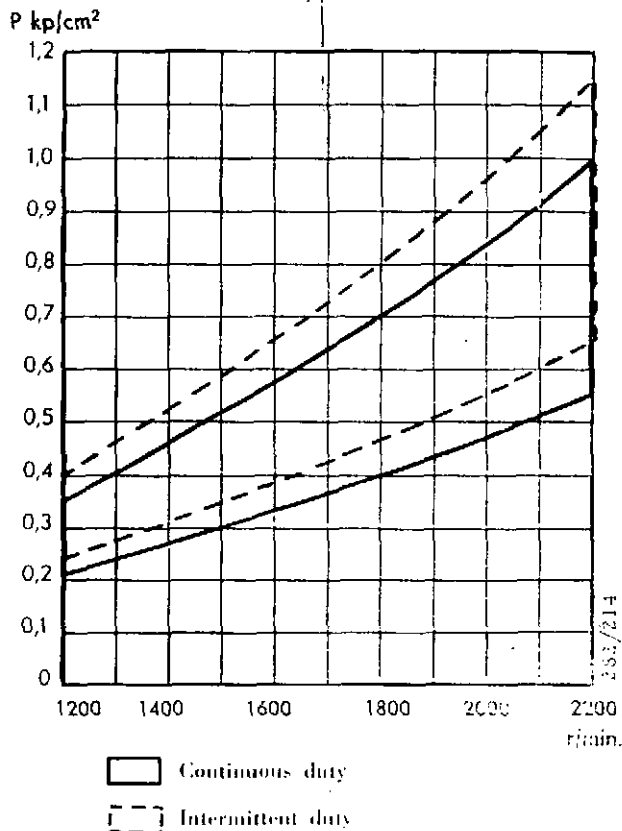
J. Turbocharger			DS 5	DS 10, DS 11
Charging pressure			as per diagram	as per diagram
Wear limits	Radial clearance of turbine wheel	mm	max. 0.53	max. 0.58
	Radial clearance of compressor wheel	mm	max. 0.53	max. 0.58
	Shaft axial clearance	mm	0.10—0.15	0.10—0.15
	Total shaft runout in V-block	mm	max. 0.010	max. 0.020
	Thrust bearing			
	Axial runout on flange	mm	max. 0.005	max. 0.005
	Axial runout on the opposite end	mm	max. 0.005	max. 0.005
	Radial runout at sealing ring grooves	mm	max. 0.012	max. 0.012
	Bearing housing hole at bearing positions	mm	max. 19.10	max. 22.28
	Shaft diameter at bearing positions	mm	min. 14.252	min. 17.425
Setting values	Distance between wheel spacer block and compressor housing	mm	1.0	0.46—0.56
	Distance between inlet cone and compressor wheel:			
	Turbocharger No. 169300	mm	0.43—0.79	
	Turbocharger No. 173738	mm	0.35—0.66	
	Admissible unbalance	gmm	max. 1.44	max. 1.44
Tightening torques	Screws for compressor housing	kgm	2.8	2.8
	Screws for compressor cap	kgm	0.8	0.8
	Screws for turbine housing	kgm	1.6	1.6
	Lock nut for compressor wheel	kgm	2.1	4.1



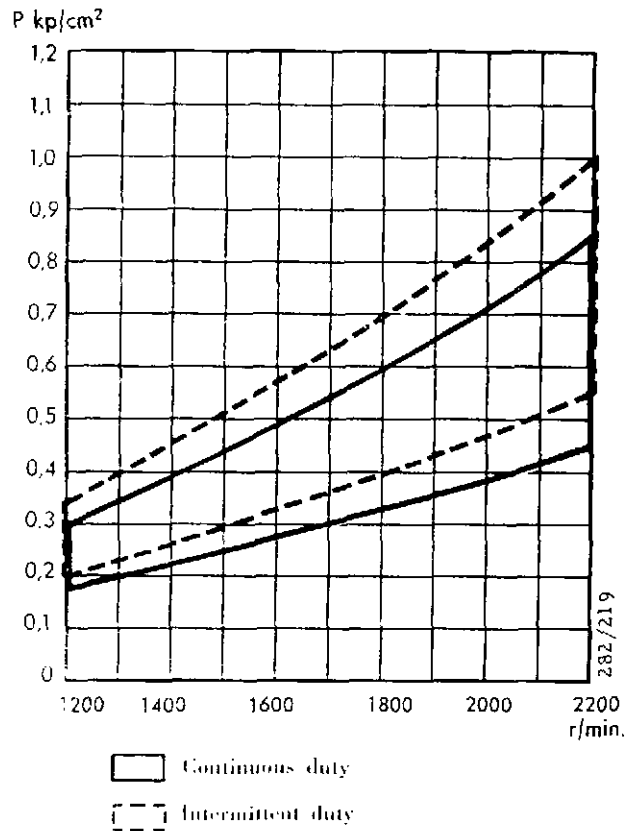
Corrected charging pressure (p) based on measured charging pressure and temperature of intake air.

Measured charging pressure	Temperature of intake air in °C											
	-20	-15	-10	-5	0	+5	+10	+15	+20	+25	+30	+35
0.20	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.19	0.20	0.20	0.21	0.22
0.30	0.23	0.24	0.25	0.26	0.27	0.27	0.28	0.29	0.30	0.30	0.31	0.32
0.40	0.31	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.41	0.42
0.50	0.39	0.40	0.41	0.42	0.44	0.45	0.46	0.47	0.49	0.50	0.51	0.52
0.60	0.46	0.48	0.50	0.51	0.52	0.54	0.55	0.57	0.58	0.60	0.62	0.63
0.70	0.54	0.56	0.58	0.59	0.61	0.63	0.65	0.66	0.68	0.70	0.72	0.73
0.80	0.62	0.64	0.66	0.68	0.70	0.72	0.74	0.76	0.78	0.80	0.82	0.84
0.90	0.70	0.72	0.74	0.76	0.79	0.81	0.83	0.85	0.88	0.90	0.92	0.94
1.00	0.77	0.80	0.82	0.85	0.87	0.90	0.92	0.95	0.97	1.00	1.02	1.05
1.10	0.85	0.88	0.91	0.94	0.96	0.99	1.02	1.05	1.07	1.10	1.13	1.16
1.20	0.93	0.96	0.99	1.02	1.05	1.08	1.11	1.14	1.17	1.20	1.23	1.26

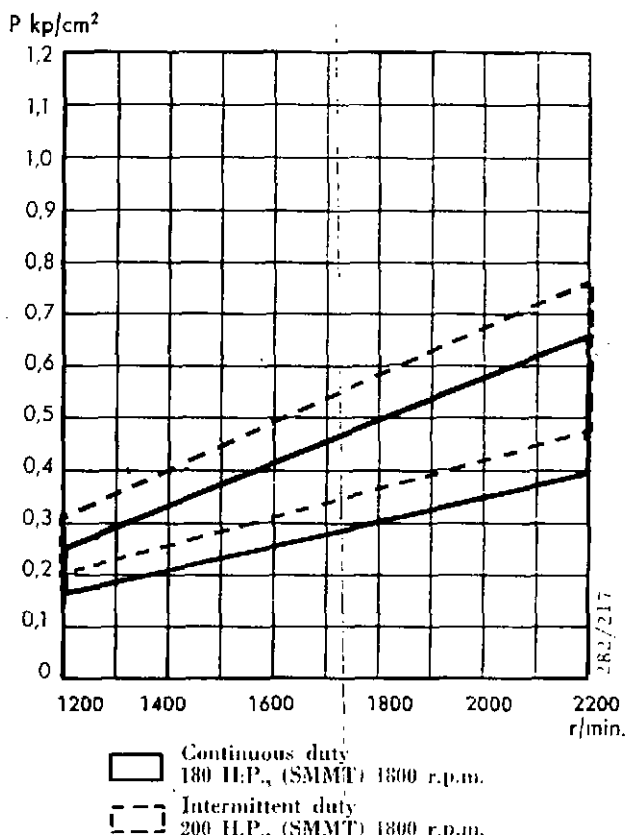
Limits for corrected charging pressure (p) for Type DS10 and DS11 engines with P-pump
Intake air temperature +25°C



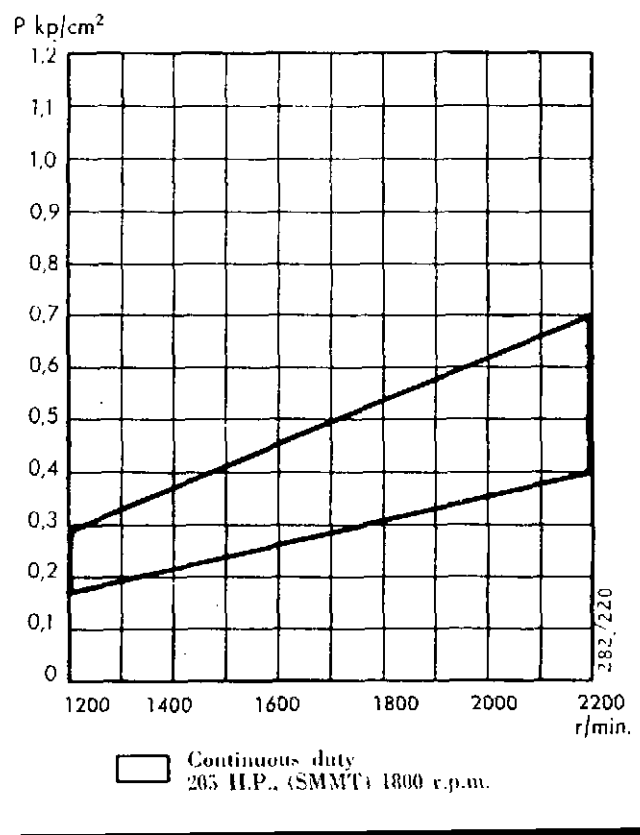
Limits for corrected charging pressure (p) for Type DS11 engines with B-pump
Intake air temperature +25°C



Limits for corrected charging pressure (p) for Type DS10 engines (with intercooler)
Intake air temperature +25°C

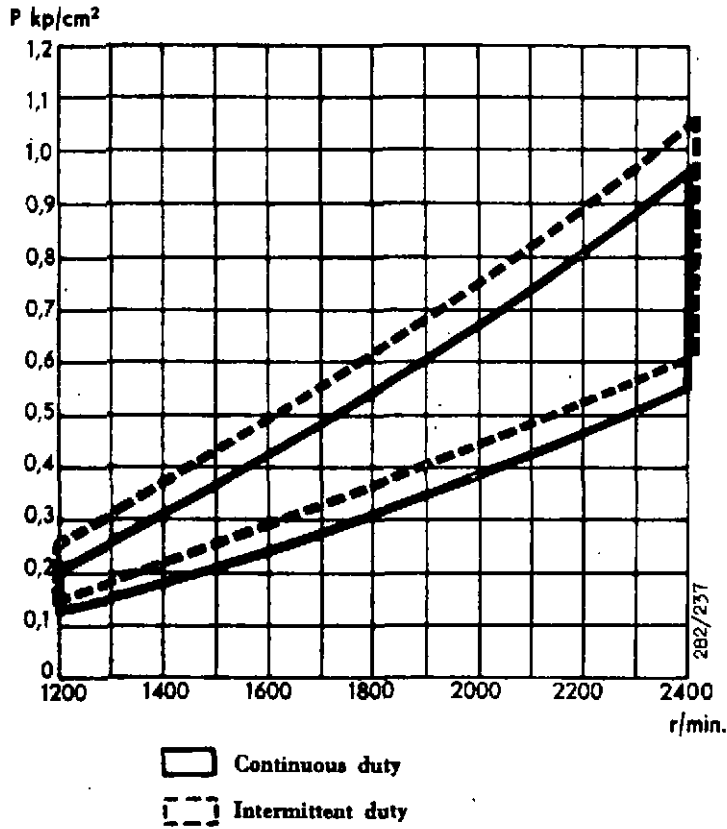


Limits for corrected charging pressure (p) for Type DS11 engines (with intercooler)
Intake air temperature +25°C





Limits for corrected charging pressure (p) for
Type DS5 engines
Intake air temperature +25°C





Tools

Tools Generally Used at the Vehicle Repair Place

Located in fixed places in the Workshop

A. General

Hoisting tool for engine D5, DS5
Hoisting tool for engine
Fixture for removing and fitting the starting motor
Fixture for removing and fitting the engine on LB vehicles
Starting motor wrench (24 mm gap) for L75, L76 and LB76
Starting motor wrench (24 mm gap) for L75 and L 76

**D5, DS 5,
D 7, D 8**

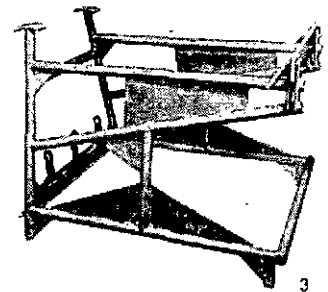
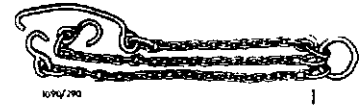
No. Pos. No.

87065 —
87910 1

**D 10, DS 10,
D 11, DS 11**

No. Pos. No. Class

— — 1
87910 1 3
87395 2 3
87135 3 3
87140 4 2
87146 5 3



B. Cylinder Head

Polygon wrench for advancing the cylinder head nuts below injectors (24 mm gap)
Polygon wrench for advancing all the cylinder head nuts (21 mm gap)

87132 6

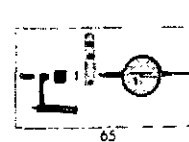
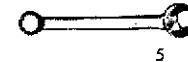
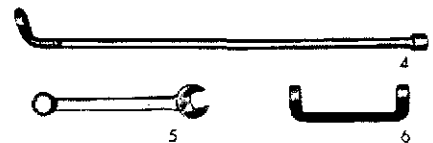
87171²⁾ 6 2
— — 2

H. Fuel System

Check tool for control rod opening, CAV pump, ass.
Check tool for control rod opening, Bosch pump of B design, ass.
Check tool for control rod opening, Bosch pump of P design with smoke limiter, ass.
Check tool for control rod opening, Bosch pump of P design without smoke limiter (for combination with 79005) ..
Drive roller for tachometer (centrifugal governors)

87165²⁾ 7

— — 2
—¹⁾ 4) 8 2
79005²⁾ 65 1
79000²⁾ 73 1
87241 9 1

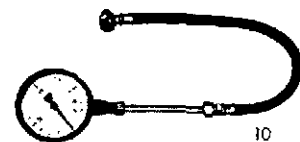


J. Turbocharger

Air pressure gauge with connecting pipe for measuring the charging pressure on DS engines

— —

87226 10 3



Tools Used in Unit Repair Room Only

Located at Fixed Places in the Unit Repair Room

A. General

"Surte" trestle (made by Surte Mek. Verkstade AB, Surte Sweden)
Fixture for "Surte" trestle

—¹⁾ 11
—¹⁾ 12

—¹⁾ 11 —
—¹⁾ 12 —

- ¹⁾ We do not supply the actual tool.
- ²⁾ The tool is new and has not previously been recommended for work at any other unit.
- ³⁾ The tool is supplied against special order only.



J. Turbocharger

These tools are new and have not been recommended previously for work at any other unit

Tool set for turbocharger, including Nos. 87027—87041, complete
 Packing for tool set, turbocharger
 Indicating tool, turbocharger
 Detail drawing for 87028
 Lock ring pliers, turbocharger, models 3 and 4
 Assembly fixture, turbocharger, models 3 and 4
 Supporting yoke, turbocharger, models 3 and 4
 Pressing tool, turbocharger, models 3 and 4
 Assembly tool, pressure flange sleeve on turbocharger, models 3 and 4
 Pressing drift, dismantling of turbocharger, models 3 and 4
 Pressing drift, pressure flange of turbocharger, model 3
 Pressing drift, pressure flange of turbocharger, model 4
 Snap gauge, turbocharger, model 3
 Snap gauge, turbocharger, model 4
 Dismantling tool, pressure flange sleeve of turbocharger, model 3
 Dismantling tool, pressure flange sleeve of turbocharger, model 4
 Wheel spacer block, turbocharger, model 3 of earlier design
 Wheel spacer block, turbocharger, model 3 of later design
 Wheel spacer block, turbocharger, model 4
 Measuring tool, piston ring grooves in turbocharger, models 3 and 4

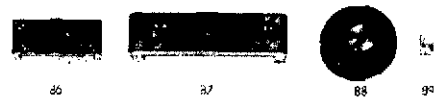
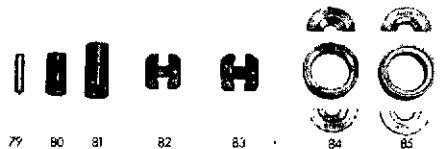
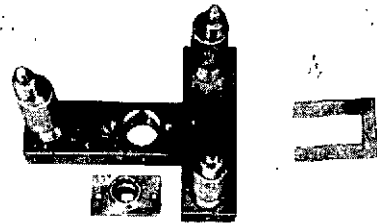
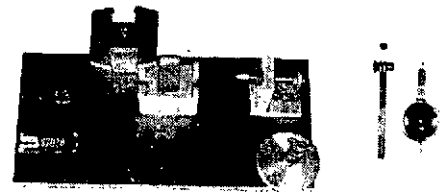
DS 5

No. Pos. No.

DS 10, DS 11

No. Pos. No. Class

87026	—	87026	—	—
87027	—	87027	—	—
87028	74	87028	74	1
87029	—	87029	—	—
87030	—	87030	—	—
87032	75	87032	75	1
87034	76	87034	76	1
87031	77	87031	77	1
87033	78	87033	78	1
87035	79	87035	79	1
87036	80	—	—	1
—	—	87037	81	1
87038	82	—	—	1
—	—	87039	83	1
87040	84	—	—	1
—	—	87041	85	1
79025	86	—	—	1
79020	87	—	—	1
—	—	87061	88	1
87063	89	87063	89	1



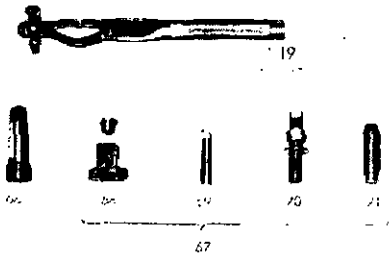
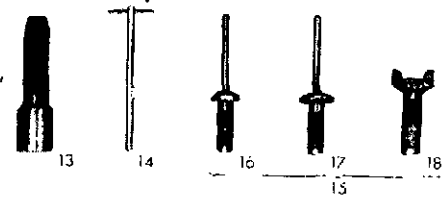


located on Tool Panel at Work
Bench in Unit Repair Room

**D5, D5 5,
D 7, D 8** **D 10, DS 10,
D 11, DS 11**

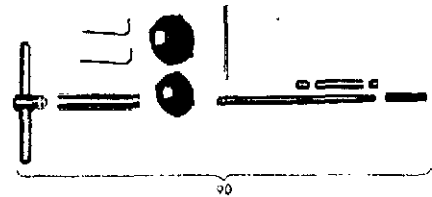
B. Cylinder Head

Drift for removing valve stem keys	87736	13	87736	13	3
Scraping tool for valve guide (exhaust)	88287	14	88287	14	2
Valve and valve seat gauges, set	87905	15	87616	15	1
Valve seat gauge (exhaust)	87931	16	87617	16	—
Valve seat gauge (intake)	87940	17	87618	17	—
Valve gauge	87941	18	87619	18	—
Valve spring compressor	87407	19	87506	19	2
Thread-cutting taps, sealing plugs with oversize M46×1.5, M52×1.0	2) 3)	66	2) 3)	66	—
Tool, replacement of injection sleeves, set	87059 ²⁾	67	87059 ²⁾	67	1
Thread-cutting tap, M28×1.5	87050	69	87050	69	—
Puller body and guide bushing	87057	68	87057	68	—
Screw, nut and washer	87058	70	87058	70	—
Fitting drift	87056	71	87056	71	—
Milling tool for valve seat, set	1) 2)	90	1) 2)	90	—



**D. Crankshaft and Reciprocating
Components**

Drift for fitting piston pin	87822	20	87362	20	3
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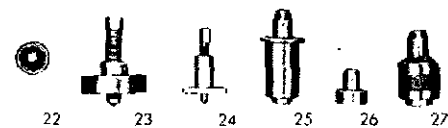
F. Lubricating System

Sleeve for nut of oil pump idler gear- wheel stub-shaft	87360	21	87360	21	1
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G. Cooling System

Grooved sleeve for shaft nut	87531	22	87531	22	1
Puller for fan hub	87527	23	87527	23	2
Puller for impeller	87501	24	87501	24	1
Drift for fitting inner sealing ring	87402	25	87402	25	1
Drift for fitting coolant sealing ring ...	88248	26	88248	26	2
Drift for fitting outer sealing ring	87526	27	87526	27	2

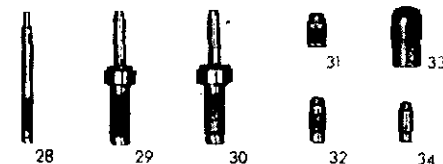


**Tools Generally Used at
Unit Repair Room Press**

Located on Tool Panel close to the
Unit Repair Room Press

B. Cylinder Head

Drift for removing valve guide	87961	28	87961	28	3
Drift for fitting valve seat insert (exhaust)	87341	29	87343	29	1
Drift for fitting valve seat insert (in- take)	87342	30	87344	30	1
Drift for fitting valve guide	87423	31	87620	31	1
Drift for fitting rocker arm bushing ...	88091	32	87474	32	3



1) The tool is supplied by AB AGB, Luntmakargatan 25,
Stockholm, Sweden, No. 8-227-SV.

2) The tool is new and has not previously been
recommended for work at any other unit.

D. Crankshaft and Reciprocating Components

Drift for fitting piston pin pushing	88121	33	87475	33	1
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F. Lubricating System

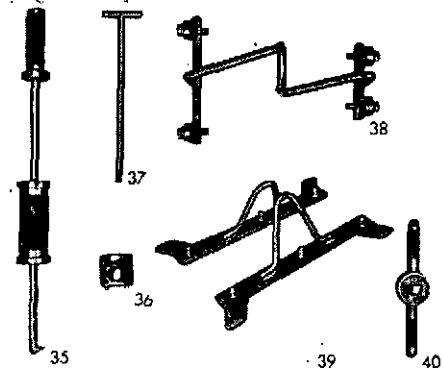
Drift for fitting oil pump bushing	87361	34	87361	34	3
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Tools Used both at Vehicle Repair Place and in Unit Repair Room

Located on Tool Trolley

A. General

Tool for removing sealing rings and bearings	87596	35	87596	35	2
Stud wrench for sealing plugs	87536	36	87536	36	1



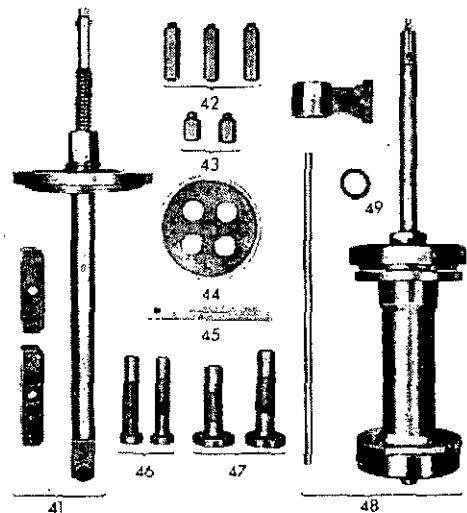
B. Cylinder Head

Puller for injector sealing washer	87125	37	87125	37	2
Hoisting tool for cylinder head	87401	38	87060	39	3
Hoisting tool for cylinder head, D5, DS5					
Torque wrench for injectors	87529	40	87529	40	2



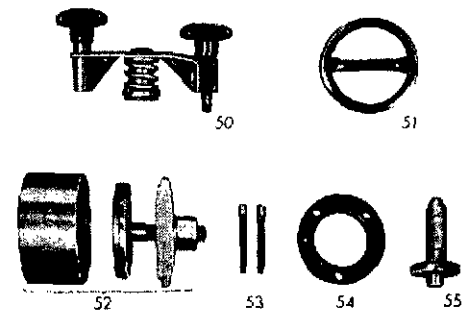
C. Cylinder Block

Puller for cylinder liner	87627	41	87627	41	1
Spare yoke for 87627	—	—	87151	—	—
Stud extension	87372 ¹⁾	42	87499 ²⁾	43	1
Check tool for cylinder liner seat	—	—	87210	44	1
Straightedge for dial indicator	87198	45	87198	45	2
Sleeves for pressing down cylinder liners, set (87493 comprises one 87494 and one 87626)	87415 ¹⁾	46	87493	47	1
Adjusting reamer for cylinder liner seat, ass., excluding feeding tool	87392	48	87175	48	1
Spare knife for 87175	—	—	87179	—	—
Shims for adjusting reamers, set of 20 shims (0.03, 0.05, 0.10, and 0.20 mm) ..	87207	49	87207 ³⁾	49	1
Feeding tool for adjusting reamers	—	—	87185	50	1
Assembly tool for cylinder liners	87424	51	87521	51	1



D. Crankshaft and Reciprocating Components

Assembly tool for, rear oil deflector ..	87290	52	87290	52	1
Puller screws for flywheel	87368 ²⁾	53	87368 ²⁾	53	2
Assembly tool for flywheel casing	87508	54	87508	54	1
Drift for fitting flywheel ball bearing ..	87510	55	87510	55	3
Piston ring compressor	87718	56	87629	56	1
Gauge for piston ring gap, set (0.3, 0.5, 0.6, 0.7 and 0.8 mm)	87147	57	87147	57	2



¹⁾ The tool No. comprises the tool quantity required.

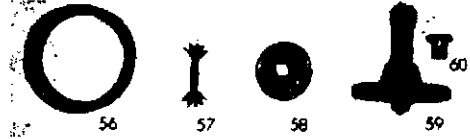
²⁾ The tool No. comprises one tool only.

³⁾ One set of shims is included in No. 87175.



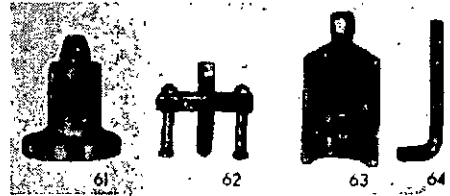
E. Timing Gear

Sleeve for screw of vibration damper hub	87519	58	87519	58	2
Puller for vibration damper hub	87665	59	87665	59	1
Thrust pad for 87665 and 87358	87663	60	87663	60	2
Drift for fitting vibration damper hub	87509	61	87509	61	1
Puller for camshaft and pump shaft					
Gearwheels (only camshaft for D5, DS5)	87359	62	87359	62	1
Tools for maintenance of the pump gear wheel D5, DS5	87019	—	—	—	1
Tools for maintenance of the pump gearwheel	87019	—	—	—	1
Puller for crankshaft gearwheel	87358	63	87358	63	1



F. Lubricating System

Wrench for oil plug (18 mm gap)	87823	64	87823	64	—
Wrench for oil plug (19 mm gap)	87202	64	87202	64	—



Maintenance instructions for diesel engines

Types D5, DS5, D8, DS8, D11, DS11 and DSI 11

These instructions deal with operation and maintenance of engines. Special instructions are also valid for marine engines and generator sets which are to be found in the corresponding engine manual section. If you follow them, and carefully study the directions given, your personal attention will ensure that the engines are always in good condition.

AB Scania-Vabis has an extensive network of service workshops, which from the trade expert aspect can take care of your engine. The personnel at the Scania workshops have received a thorough basic training through service master manuals, films, service bulletins, special instructions and through our service school.

Therefore in case of need always seek the advice of an authorized Scania-workshop when your engine requires servicing or repair. Here will be found the necessary special tools and original spare parts. These workshops have considerable interest in carrying out first rate work for you.

The design data and specifications contained in this manual are not binding, and we reserve the right to make without notice any alteration we consider advisable.

AB SCANIA-VABIS

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General

Type Reference

For information concerning engine references and Classification Society please see Service Master Manual Section "Diesel Engines". In all correspondence state the type of engine and the engine manufacturing number.

Generator Set

The type reference of a diesel engine contains the most important data.
Example: GAS111-05. The significance of this is:

- GAS = Generator set with supercharging
- I = Intercooler
- 11 = Displacement, litres
- 05 = The set design according to the following:
 - 01 = With sheet-steel canopy
 - 02 = Without sheet-steel canopy
 - 03 = Stand-By Set
 - 04 = Transportable
 - 05 = Marine
 - 06 = Marine emergency design
 - 07 = Auxiliary power plant for 1000 hours operation without maintenance.

Running instructions

Running-in Period

When the engine is put into use, and when it has been run for about 50 hours, there are a number of checks and adjustments to be carried out in addition to the normal periodical maintenance. One reason for this is that gaskets will give somewhat after a period in service. Accordingly, these steps should also be carried out after the engine has been reconditioned. (See the section headed "Maintenance").

Running a Diesel Engine Indoors

If the pack is to be run indoors, due attention must be paid to our instructions concerning such matters as air intake, exhaust pipes and the temperature in the machine room.

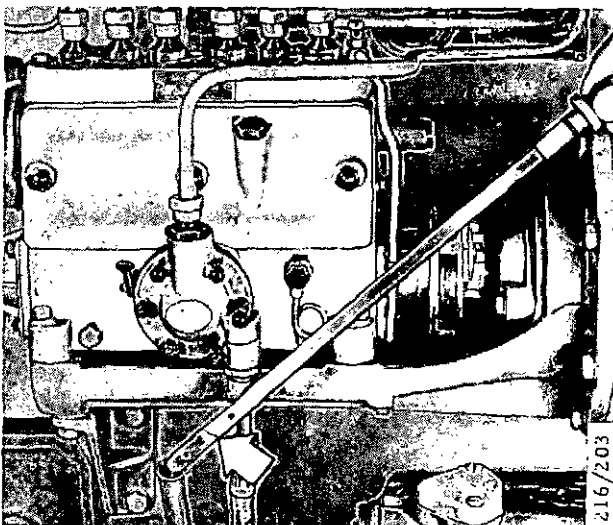
Running at a Site High Above Sea Level

When the engine is dispatched from Scania-Vabis the injection pump is set in such a manner that the maximum fuel charge delivered corresponds to the air supply at a particular air pressure, as a rule the normal air pressure for places up to 500 metres above sea level.

For places higher up, which have a lower nominal pressure, the setting of the injection pump will need to be altered. This alteration must be carried out by diesel-trained personnel.

Daily Inspection before Running

Oil Level



Check the engine oil level with the dipstick on the right-hand side of the engine (looking from the flywheel end). The oil level must be between the level marks on the dipstick. If the oil level is below the lower mark, oil must be added. Always use oil of the same type and viscosity as that already present in the engine. (See "Periodical Maintenance", point 2).

Coolant Level

Screw off the radiator cap (heat exchanger) and check the coolant level. Only pure water containing glycol or cutting oil should be used. After topping up with water, the glycol content or soluble-oil content should be tested and if necessary adjusted. (See "Periodical Maintenance", point 4).

Fuel Supply

Top up diesel fuel as required.

Starting and Stopping the Engine

When starting the generator set see also "Supplementary to Maintenance Instructions".

1. Disengage the engine if it has clutch or reverse gear.
2. Open the cock between the fuel tank and the engine, if there is one. If the tank is sited lower than the injection pump and the engine has at any time been difficult to start after a period of disuse, this can usually be cured by bleeding the fuel system. (See "Periodical Maintenance" point 5.)
3. Turn on the main switch of the electrical system. The main switch must not afterwards be turned off before the engine has stopped as damages can occur to rectifiers and regulator.
4. Engine with marine cooling system: Open the sea-water circuit bottom valve.
5. Put the switch on the instrument panel in position "On".
6. Check that the warning lamps on the instrument panel light up.
7. Starting the engine:

Engine without starting interlocking button:

Depress the starting button and release it when the engine starts.

Engine with starting interlocking button:

Depress the starting button and interlocking button until the engine starts. Release the starting button. Keep the interlocking button depressed until the engine lubricating oil pressure

Warming Up the Engine

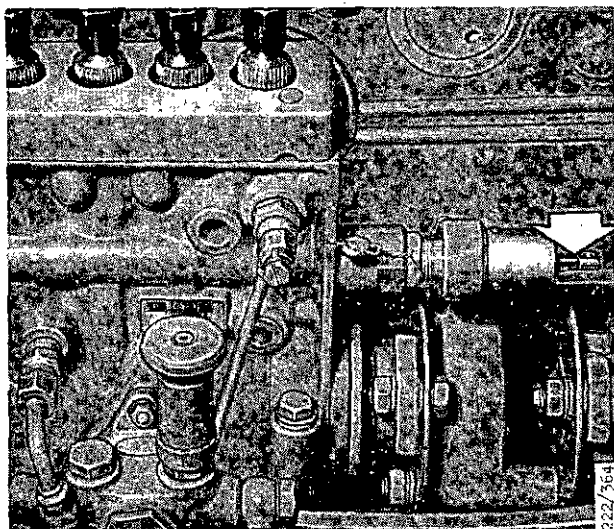
Allow the engine if possible to idle at a moderate speed for a few minutes. After running with low load at a moderate speed for a minute or so, let the engine work under a light load and a moderate speed until it has reached its normal running temperature (70—90°C). Make use of the radiator blind or curtain if available.

The generator set should never be operated at a speed below low idling 700 rev/min. The coupling between the engine and generator may then be damaged.

Starting in Cold Weather

In cold weather, starting can be facilitated if the cold start device is engaged after full throttle has been made.

1. On Bosch injection pump it is located on the front end and is engaged by the loop provided lever arm being folded to one side.

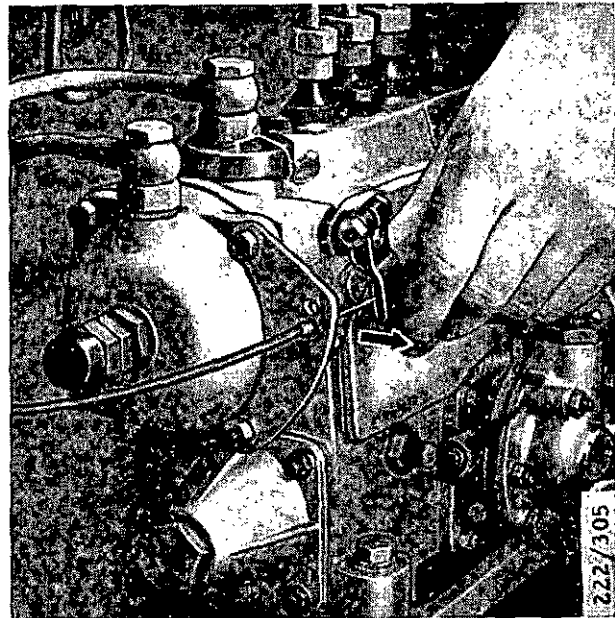


Cold Start Bosch

2. On CAV injection pump it is engaged when the stop arm is pulled out.

On engines with automatic monitoring connected to the stop magnet the interlocking button shall be kept depressed when the cold start is engaged.

If the engine is provided with cold start magnet the cold start device is engaged automatically when



Cold Start CAV

N.B. If the engine is equipped with turbocharger the engine speed should not exceed 1200 rev/min during the first 30 seconds after the engine has started. By doing so it is assured that the turbocharger receives sufficient lubrication before it is brought up to high speed.

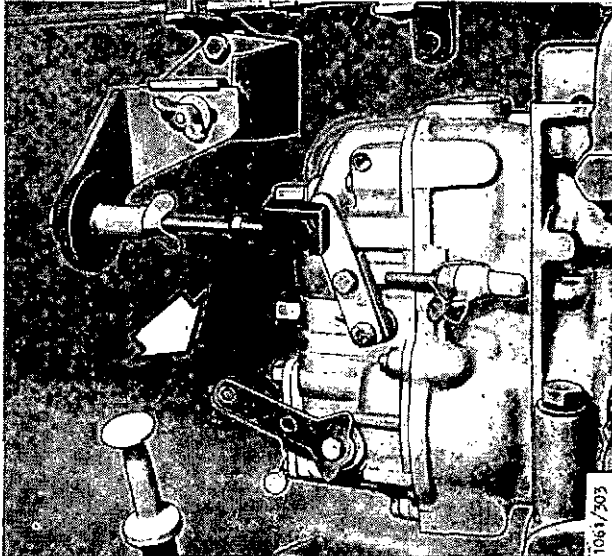
The starter motor and batteries should not be overloaded. If the engine does not start at the first attempt, wait for a minute or so before trying again. This pause between attempts at starting is necessary to prevent the starter motor from becoming too hot and to give the batteries a chance to "get their breath back".

Stopping the Engine

Let the engine run without load for a few minutes to ensure cooling. Stop the engine by pulling out the stop lever. The lever must be left in "stop" position until the next start. Put the "On-off" switch in the "Off" position. If the engine is fitted with a stop magneto, the engine is stopped by putting the "On-Off" Stop switch in the "Stop" position. When the engine has stopped the selector is released, whereupon it will automatically return to the "Off" position where it should be left until the

If automatic monitoring is fitted the engine is stopped by depressing the stop button.

If, for example, battery voltage should not be available for stopping with the stop magnet, emergency stopping can be effected by moving the stop lever on the injection pump to the rear.



Emergency stop lever

Turn off the main switch.
Shut the fuel valve if such valve is available.

Automatic Monitoring

If the engine develops a failure so that the alarm bell begins to sound or the engine stops, one of the following monitors may have closed the circuit to the alarm bell or stop magneto.

1. The temperature monitor closes if the temperature of the coolant rises to approx. 93°C or approx. 100°C if cooling system has pressure cap. The monitor returns automatically to operating position when the coolant assumes operating temperature. The monitor is screwed into the rear right-hand part of the rear cylinder head.
2. The oil-pressure monitor closes if the oil pressure in the engine lubricating system goes below 1 kg/cm². The monitor returns automatically to operating position when the oil pressure goes above the value just mentioned. The monitor is located on the central section of the lubricating oil cleaner.
3. Speed monitor.

For monitors in the generator set electrical system see also "Supplement to Maintenance Instructions".

Operation

Keep the Instruments under Observation

While the unit is running, check the instruments now and then to make sure that everything is working.

With the engine warm the oil pressure must be max. 5 kg/cm² and min. 1.5 kg/cm². If the oil pressure goes below 1.5 kg/cm² while the unit is running, the engine must be stopped at once and the cause investigated. But there is no risk if the oil pressure goes below 1.5 kg/cm² at speeds below 800 rev/min. as long as the pressure rises above 1.5 kg/cm² when this speed is exceeded.

The oil-pressure warning lamp comes on when the oil pressure goes below 1 kg/cm² and is intended as a warning signal if the oil pressure should suddenly disappear.

Check the ammeter to see that the generator is charging. If the discharge warning lamp comes on while running, the cause should be investigated and the fault put right as soon as possible.

The coolant temperature must be between 70 and 90°C.

The temperature is controlled automatically by a thermostat. If the temperature does not remain within the stated limits, this should be corrected without delay.

On engines equipped with intercoolers there is a small hole (0.2 mm) drilled in the lower rear section of the intercooler. Check that the water does not leak out through this hole down in the small cup which is placed beneath the hole. If this is the case the cooling assembly of the intercooler must be investigated for leakage. If leakage is revealed the cooling assembly must be replaced immediately.

Operating the Friction Clutch

Operate the friction clutch with the control lever. When the lever is in the forward position the clutch is engaged: when it is in the rearward position the clutch is disengaged. Operate the clutch with firm movements. The engine speed should be below 800 r.p.m. when the clutch is operated.

Check that there is a relatively powerful resistance in the control lever when the clutch is moved towards the engagement position.

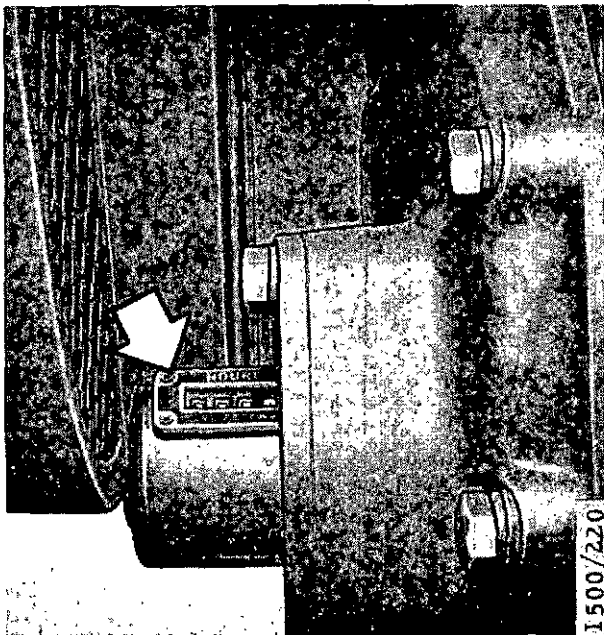
When the clutch goes in mesh a distinct click should be heard. If the control lever moves too easily the clutch must be adjusted. (See "periodical maintenance" point 18). For Operation of Marine engine see also "Supplement to Maintenance Instructions".

Action after Operation

(For marine engine and generator set see also "Supplement to Maintenance Instructions").

Fill up with diesel fuel, but first wipe off the area round the filler hole. Use a funnel with a filter, and rinse it out first. If there is a risk of freezing the cooling system should be drained, unless it is filled with anti-freeze coolant. (See "Periodical Maintenance", point 8).

For checking the running time of the engine or power pack there is an hour-meter mounted on the left-hand side of the timing-gear casing.

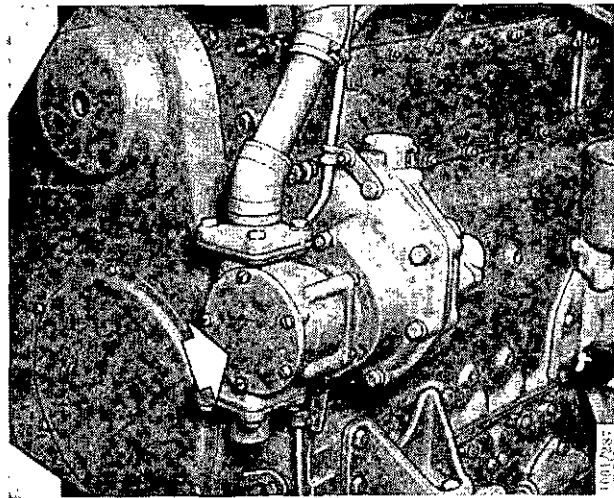


Hour-meter

For engine with marine cooling system also applies

Close the bottom valve of the sea-water circuit.

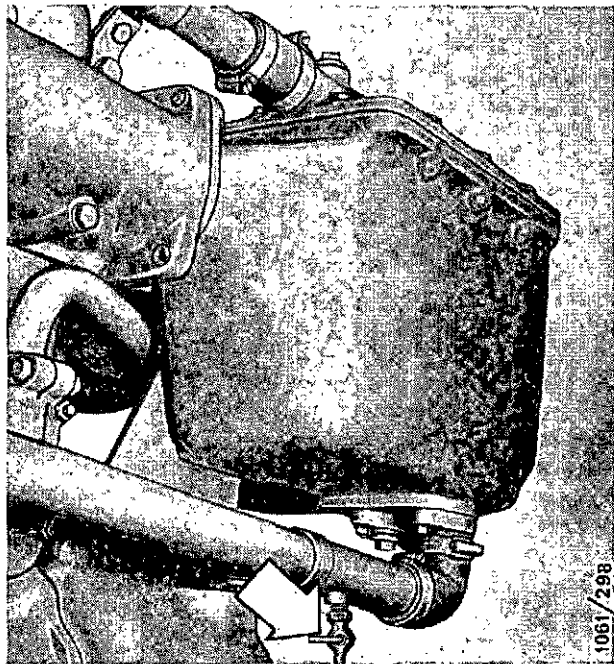
Freezing risk: Open the drain cock in the sea-water circuit. Loosen the screws that hold the cover securely on the sea-water pump a couple of turns, so that the water remaining between the vanes on the impeller flows out. Otherwise the water in the pump may freeze and cause fractures on the vanes when the engine is started.



Sea-Water Pump

Engine with intercooler:

Empty the intercooler of sea-water by opening the drain cock which is located on the sea-water piping straight under the intercooler.



The Drain Cock of the Intercooler

Important: Reverse Running

The operating principle of the diesel engine is such that reverse running can occur in certain circumstances. If the engine is loaded in such a way that the speed is forced considerably below the normal low idling speed and then disengaged, there is a risk that the engine may reverse its rotation.

Should reverse running occur, stop the engine at once as follows:

If the engine is equipped with a stop magneto and an "On-Off" stop switch, put this switch in the "Stop" position and keep it there until the engine has stopped.

The engine must not be given any throttle while it is being stopped.

Maintenance

For Maintenance of Marine Engine and Generator Sets see also "Supplement to Maintenance Instructions".

Running-in Period

On engines that are ready to go into service as delivered, the maintenance points listed below are all that need be done during the running-in period. For other engines, it is necessary to see in addition that instructions in "General Instructions for Installation of Scania Engines" are observed. Some caution should be observed during the first 100 hours after the engine has gone into service. The operator should avoid using the full output or running the engine at excessively high speeds, and above all he should avoid heavy and continuous loading. It is also important to let the engine reach running temperature (70—90°C) by running it at moderate speed under a light load, if it is started from cold.

A certain amount of care for a further 100 hours period is always advisable.

Oil Changes during the Running-in Period

AFTER 10 RUNNING HOURS

Change the engine oil. (See "Periodical Maintenance", point 2).

AFTER 50 RUNNING HOURS

Change engine oil. (See "Periodical Maintenance", point 2).

Servicing after 50 Running Hours

Engine.

Check the tensioning of the fan belts. (See "Periodical Maintenance", point 1).

Tighten the cylinder-head nuts.

Adjust the valve clearance.

Clean the centrifugal cleaner. (See "Periodical Maintenance", point 6).

Clean the air cleaner. (See "Periodical Maintenance", point 3).

Check that the engine suspension is in good condition. Check and if necessary tighten the retaining screws of the engine suspension.

Tighten the retaining screws of the injection pump and the screws of the pump coupling.

Tighten the screws of the intake and exhaust manifolds.

Tighten all nuts and screws belonging to side covers and casings.

Tighten the screws of the oil pan.

Check the oil cooler for tightness.

Check and if necessary tighten screwed connections and hose clips, and check the lines listed below for leakage and damage:

Lubricating-oil lines

Coolant lines

Fuel lines

Intake system

Exhaust system

Engine oil pan

Injection pump and regulator sea-water lines (Marine Cooling System)

Check the content of soluble oil or ethylene glycol in the engine cooling system. (See "Periodical Maintenance", point 4).

Drain the bottom sludge out of the main filter. Clean the prefilter and bleed the fuel system. (See "Periodical Maintenance", point 5).

Change the oil filter of the turbocharger. (See "Periodical Maintenance", point 12).

Check the charge of the batteries, the level of the electrolyte, and the cable connections on the batteries to see that they are properly greased. (See "Periodical Maintenance", point 14 and 15).

Check that the instrument lighting and all switches are in working order.

Check the corrosion safety bars (Marine Cooling System). (See "Periodical Maintenance", point 9).

Check the high idling speed.

Check the low idling speed.

Check the stop and speed levers.

FRICION CLUTCH

Grease the bearings of the clutch and the moving parts of the clutch mechanism. (See "Periodical Maintenance", points 16 and 17).

Check that the clutch plates do not slip and that the lever remains in the engaged position.

Periodical Maintenance which can be Carried Out by the Operator

The daily inspection which the operator must carry out before, during and after running is described as part of the running instructions. For maintenance of marine and generator sets see also "Supplement to Maintenance Instructions".

See point		Every 50 hours	Every 100 hours	Every 200 hours	Every 600 hours	Every 1200 hours
	Engine					
1	Check and if necessary adjust the vee-belt tension		• ¹⁾	•		
2	Change oil in the engine		•			
3	Clean the air cleaner					
4	Check and if necessary adjust the soluble-oil or ethylene glycol content			•		
	Drain the bottom sludge out of the main filter (Bosch), clean the prefilter and bleed the fuel system			•		
6	Clean the centrifugal filter			•		
7	Lubricate the coolant pump (fresh water circuit)			•		
8	Flush the cooling system (fresh water circuit)				• ²⁾	
9	Check the corrosion safety bars (Marine cooling system)			•		
10	Clean the sea-water circuit (Marine cooling system)					• ³⁾
11	Lubricate the compressed air start motor (alt. equipment)	4)				
	Tighten the hose clamps on cooling, heating and intake system			•		
	Tighten the exhaust pipe screws			•		
	Tighten the injection pump fixing screws				•	
	Tighten the screws to drive coupling in the injection pump				•	
	Tighten screws and nuts to engine mounting				•	
	Turbocharger					
12	Change the oil filter of the turbocharger			•		
13	Make a check for air, exhaust and oil leakages			•		
	Engine electrical equipment					
14	Check the electrolyte level in the batteries	•				
15	Clean the batteries, cables and cable terminals and check the state of charge			•		
	Friction clutch					
16	Lubricate the release bearing ⁵⁾	•				
17	Lubricate the locating and support bearings of the clutch and the moving parts of the clutch mechanism ⁵⁾⁶⁾	•			7)	
18	Adjust the clutch	4)				

¹⁾ If the engine oil sump (capacity 31 litres) has side covers the oil exchange period can be extended to 200 hrs. If the engine has oil sump and separate lubricating oil tank (common capacity approx. 180 litres) the oil exchange period can be extended to 1,000 hrs.

²⁾ Or every six months.

³⁾ Or every year.

⁴⁾ The interval is adapted according to operating conditions and circumstances.

⁵⁾ Do not use grease containing molybdenum disulphide.

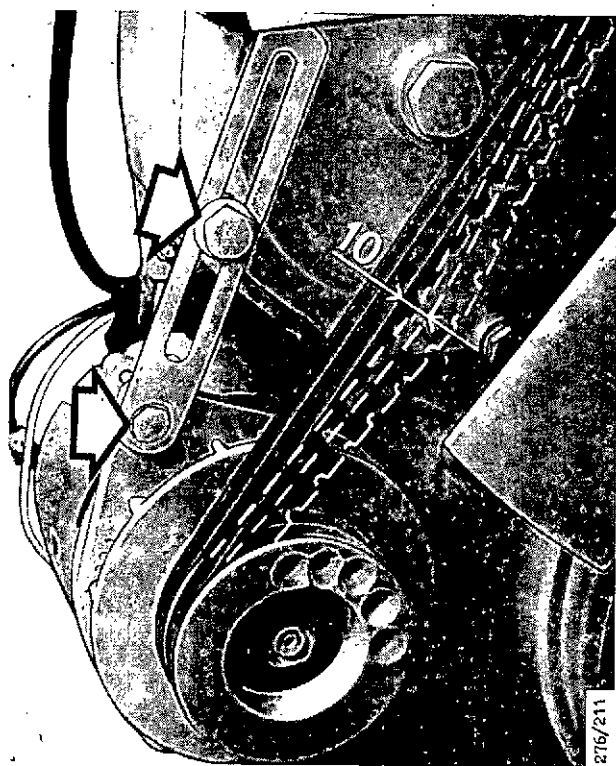
⁶⁾ If the clutch support bearings do not have a special lubricating nipple they do not require maintenance.

⁷⁾ Applies to support bearings on marine engine installations.

Engine

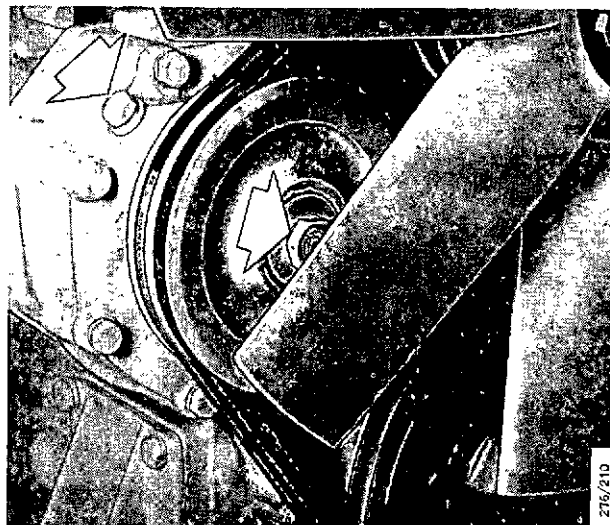
1. Check and if necessary adjust the vee-belt tension

If the vee-belts are properly tensioned it should be easy to push them in about 10 mm. If adjustment is required the finger guard must be removed and the generator unfastened. Tension the vee-belts by moving the generator outwards. When the belts are correctly adjusted, make the generator tight and replace the finger guard.



Checking the vee-belt tension

If the engine is equipped with a large generator, the vee-belt tension must be adjusted by means of the tensioning pulley. First slacken the nut in the centre of the tensioning pulley. Then adjust the belt tension with the setting screw. Then tighten the nut in the centre of the tensioning pulley.



Separate tensioning pulley device

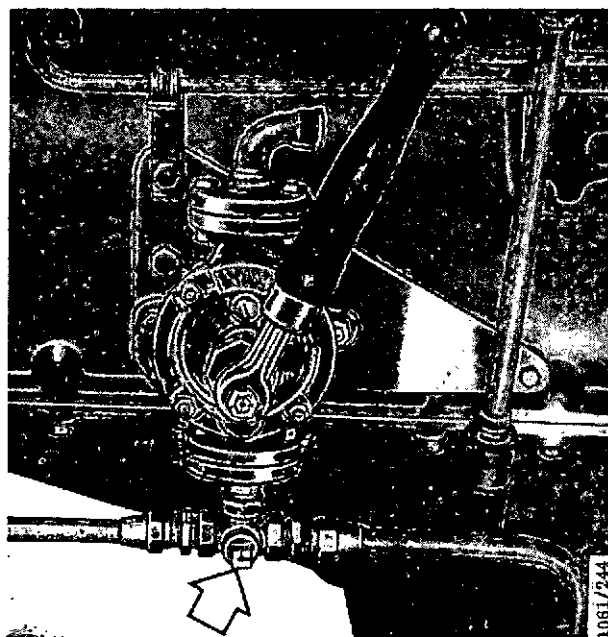
2. Change oil in the engine

The oil is drained out from the bottom of the oil pan. It is advantageous if the oil can be drained off immediately after operation, when it is hot and easy-flowing.

The drain plug, which is fitted with a magneto, must be cleaned at the time of an oil change.

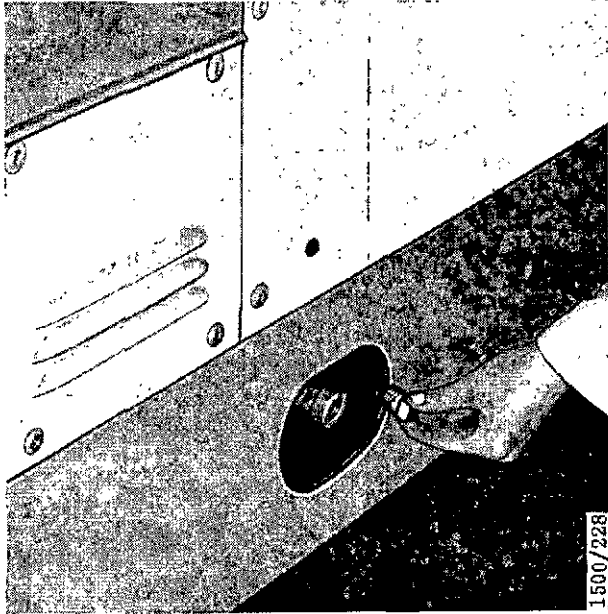
Engine equipped with oil main pump:

Pump out the old oil with the hand pump on right-hand side of engine. The two-way cock shall be turned so that the marking faces opposite the hand pump and the line from the engine oil sump.

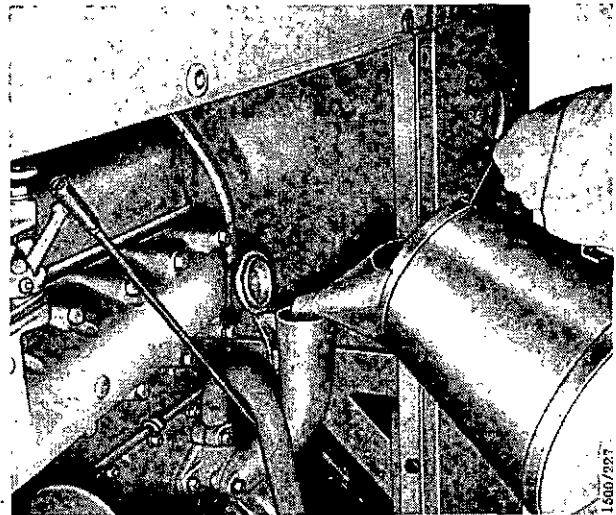


Metal covered unit

Drain the oil out through the extension pipe on right-hand side of unit.



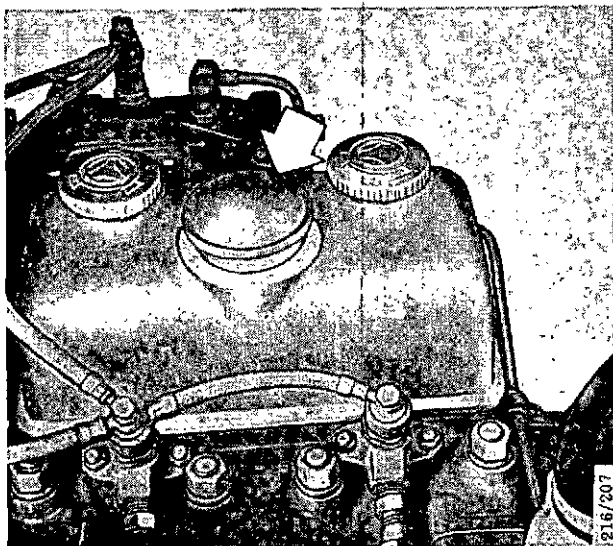
Extension pipe



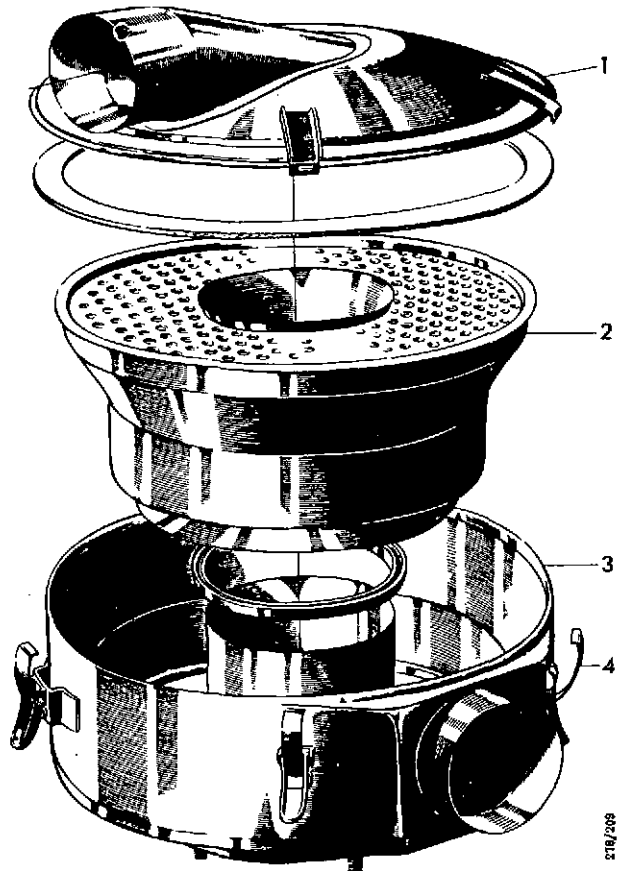
Filling pipe

Filling:

Fill up with oil through the filling hole in one of the valve covers or through the oil filling pipe on the engine crankcase ventilating pipe.



3 *Clean out the air cleaner*



Air cleaner of oil bath type

- 1. Cover
- 3. Oil reservoir

Release the snap catches (4) and lift off the cover (1), and take out the filter insert (2). Discard the old oil and the dirt. Wash the oil reservoir (3) out with diesel fuel.

Wash the filter insert clean. Allow it to furn out and then if possible blow it clean with compressed air. Direct the air jet against the underside of the insert, since the dirt would otherwise be blown farther into the filter insert. Fill the oil reservoir with oil up to the level mark. See that gaskets under the cover and under the insert are sound.

The oil reservoir must not be filled with oil above the level mark.

Use oil of the same type and viscosity as in the engine.

Never detach the cover of the air cleaner while the engine is running.

4. *Check and if necessary adjust the soluble-oil or ethylene glycol content*

We recommend the addition to the coolant of 2—3% of a soluble oil, which gives good protection against corrosion.

This recommendation does not apply if anti-freeze (glycol) is used. The soluble-oil content is checked as follows:

- a. Drain off about half a litre of coolant from the warm cooling system and pour 98 cm³ into a 100 cm³ measuring cylinder.
- b. Add one teaspoonful of common salt and shake the measuring cylinder well to dissolve as much salt in the liquid as possible.
- c. Let the solution stand for 15—30 minutes at room temperature so that the oil is completely separated from the water.
- d. The quantity of oil above water surface, measure in cm³, gives the oil content as a percentage.
- e. Throw away the test coolant from the measuring cylinder, and top up the cooling system as required with water and soluble oil.

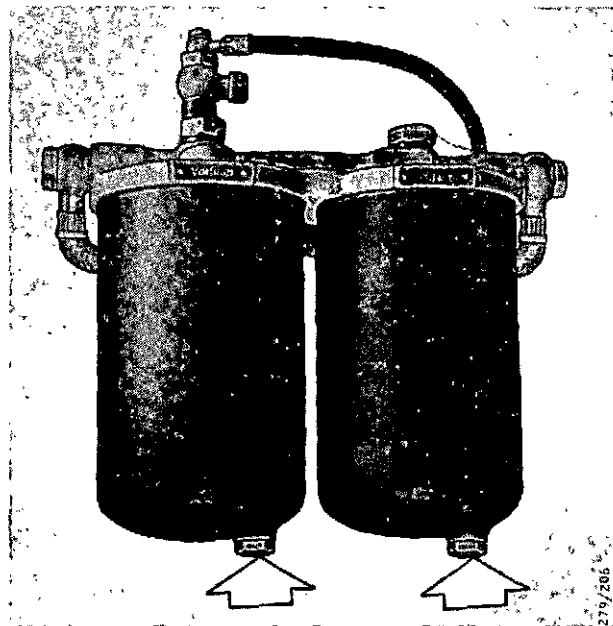
- f. If the soluble-oil content is found to be low without any obvious cause (water losses, etc.), it may be that the cooling water has properties which break down the emulsion. Check through the filter tailpiece of the radiator that the water surface is not covered with a thick layer of separated oil. If it is, the coolant must be changed.

Concerning grades of soluble oil, see section headed "Diesel Fuel, Lubricating Oil and Coolant".

5. *Drain the bottom sludge out of the main filters (Bosch). Clean the prefilter (Bosch). Empty the sludge from the fuel tank and bleed the fuel system.*

Main Fuel Filter (Bosch)

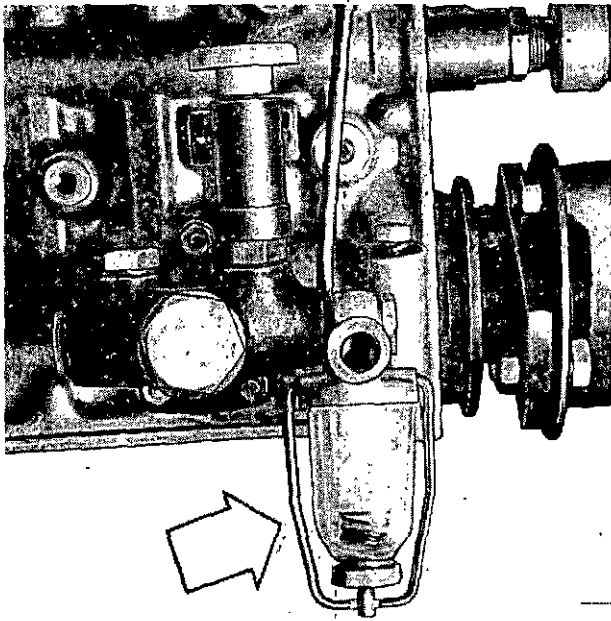
The dirt collected by the filter inserts is shaken down by the engine vibration and accumulates in the lower part of the filter housings. It is removed by screwing out the drain plugs in the bottom of the housings. The fuel in the main filters will then flush out most of the deposited dirt.



Drain plugs on main fuel filter

Fuel Prefilter (Bosch)

To clean the prefilter, which is mounted on the feed pump, undo the knurled nut, swing the bail aside and take the filter canister out downwards. Wash the wire gauze in diesel fuel. In time the gasket, which provides the sealing between the filter canister and the pump housing, becomes so hard that it no longer seals properly. It must therefore be changed in good time so as to prevent air from penetrating the fuel system.



Prefilter on feed pump

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Fuel Tank

When the strainer in the fuel tank is to be cleaned the amount of fuel remaining in the tank should be so little that it can be discarded when drained off. Screw out and clean the drain plug with the tank filter.

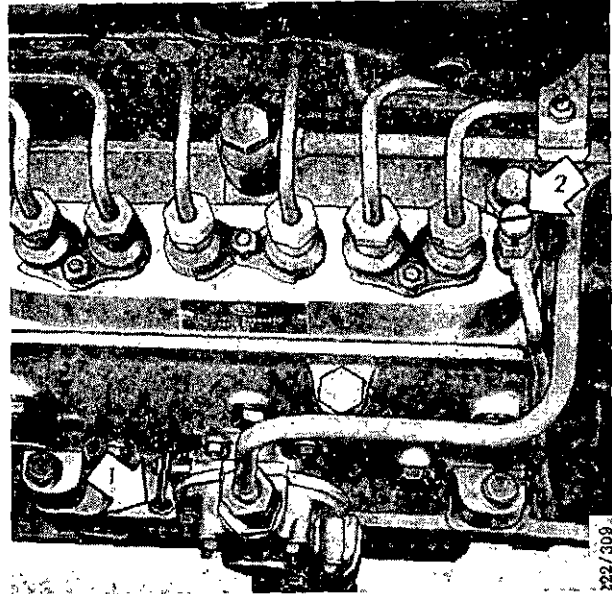
Bleeding

When the above service points have been attended to, the fuel tank must be filled and the fuel system bled. Bleeding is important, since air bubbles in the diesel fuel can upset operation and make starting impossible. Bleed the system as follows:

CAV

1. Open one of the bleeder screws on one of the parallel connected main filters and work the hand pump of the feed pump until bubble-free fuel flows out at the bleeder screws.

2. Then bleed the injection pump by opening the bleeder screw on the pump and working the hand pump of the feed pump until bubble-free fuel flows out. Close the bleeder screw.



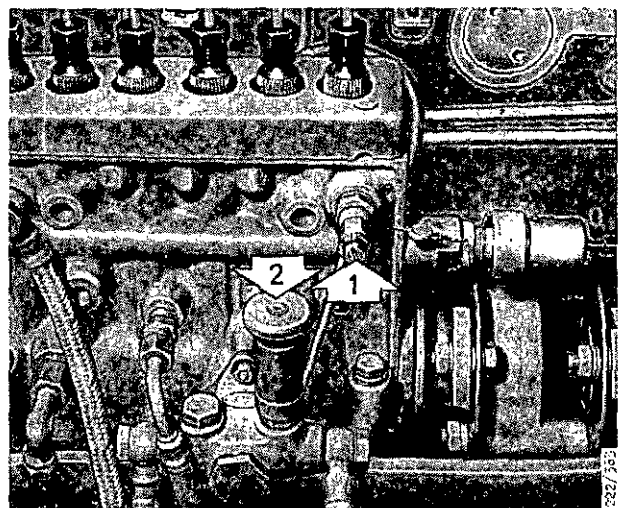
CAV injection pump

1. Bleeder screw
2. Feed pump

BOSCH

Unscrew the knurled handle on the feed pump. Pull the handle up and down, by doing so the pump will begin to operate.

Bleed the injection pump according to point 2 above. Screw on the feed pump handle. N.B. The handle must only be tightened by hand.

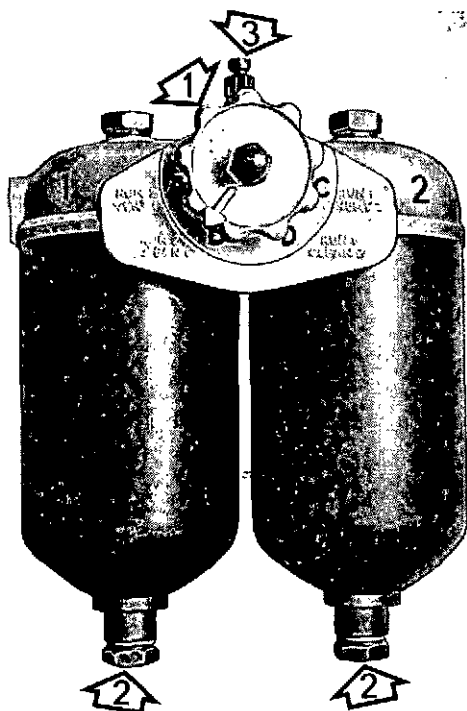


Bosch injection pump

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Reversible Fuel Filter (Additional Equipment)



1. Reverse turn
2. Draining plugs
3. Bleeder valve

Only one filter is connected according to the following:

- Position A: Filter 2 connected
filter 1 can be bled
- Position B: Filter 2 connected
filter 1 can be cleaned
- Position C: Filter 1 connected
filter 2 can be bled
- Position D: Filter 1 connected
filter 2 can be cleaned

Regularly remove dirt and water by screwing out the filter draining plugs. Change the filter inserts according to the interval which operating conditions allow.

If operating disturbances occur during function carry out the following:

1. Connect the unused filter by putting the reverse turn in position "cleaning" for the filter used.
2. Change the insert in the filter used.
3. Put the reverse turn in position "bleeding" for the exchanged filter. Bleed the filter by opening the bleeder valve on the upper side of the filter holder. Close the valve when bubble free fuel flows out.

N.B. Bleed the filters regularly so that they are always ready to be put in service.

6. Clean the centrifugal cleaner



Centrifugal filter

Screw off the nut that secures the top cover of the cleaner and remove the cover. Then lift out the rotor assembly. Carefully scrape off the deposits on the rotor walls using a knife or similar tool. If the layer of dirt becomes more than 10 mm thick between each period of cleaning we recommend cleaning more often. Wash the rotor in diesel fuel.

Change the sealing rings, if necessary.

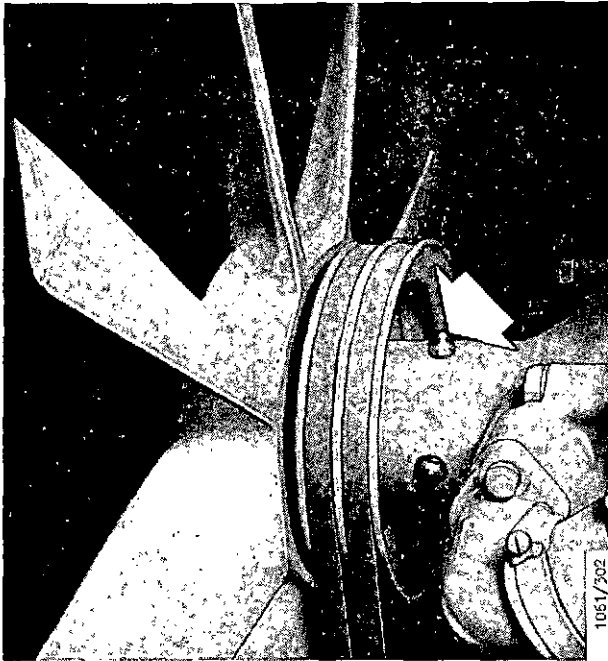
Put the sealing rings in their correct positions. Turn the cover of the rotor assembly until its marking arrow comes opposite the corresponding marking on the rotor housing.

The cover is then pressed down firmly against the housing and the nuts tightened with the fingers as far as possible. Afterwards tighten the nuts additionally by giving them half a turn with wrench.

After fitting the rotor assembly and the cover of the centrifugal cleaner, check to see that the rotor assembly runs easily, as follows: Start the engine, run it until the oil is reasonably warm and then stop it. Check at once, by listening with your ear close to the cleaner, that the rotor assembly is spinning — it produces an unmistakable humming noise. The rotor assembly should normally rotate for at least one minute after the engine is stopped.

7. Lubricate the coolant pump

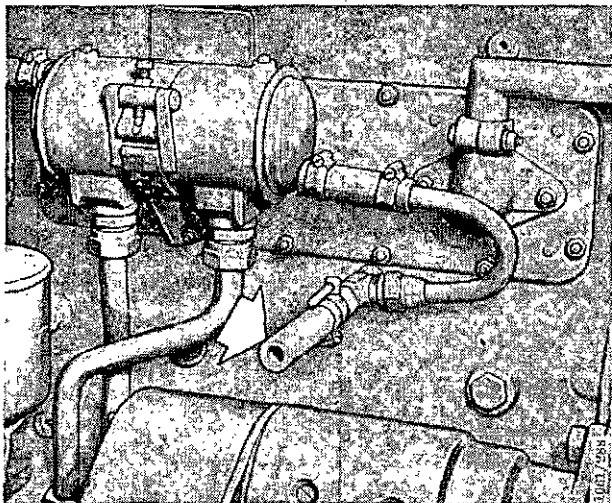
Lubricate with roller-bearing grease. Avoid using excessive quantities or applying the grease with excessive pressure, since this would entail a risk of damaging the sealing rings in the pump.



Lubricating nipple of coolant pump

8. Flush the cooling system

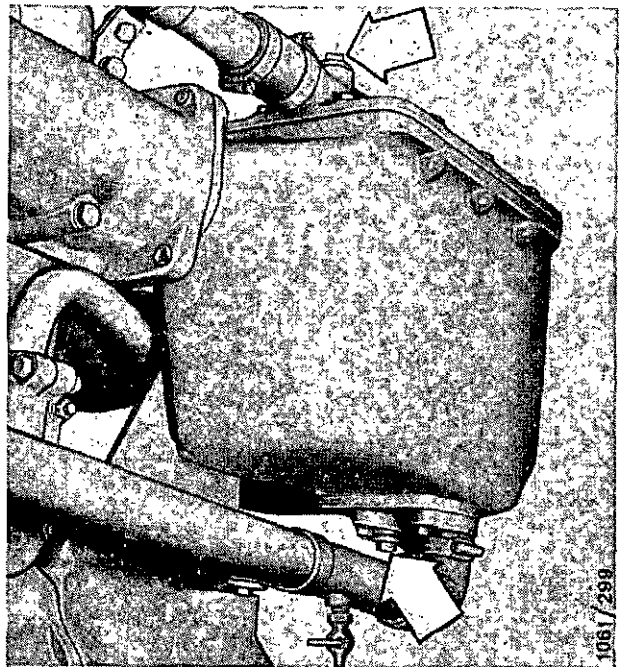
If glycol is used in winter, it is good practice to flush out the cooling system of the engine, when putting in and draining off the glycol. The cooling system is provided with a drain cock located in the lower part of the radiator or in the engine block above the starter motor.



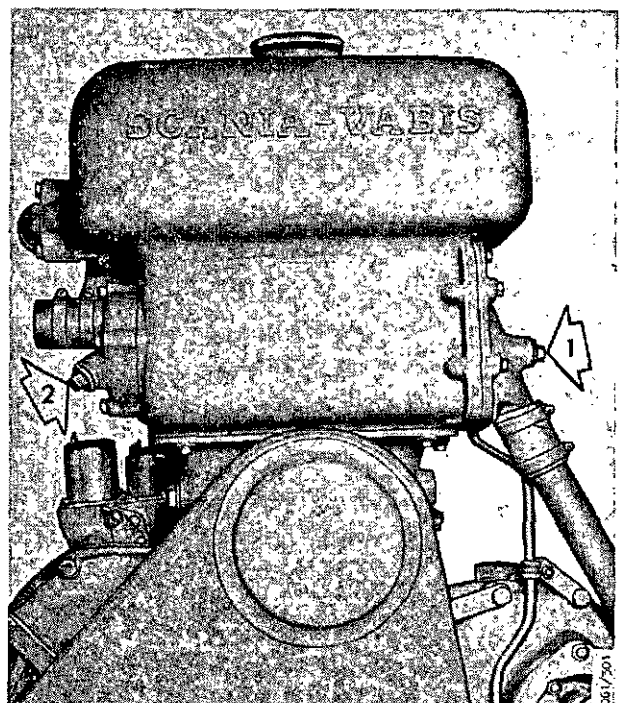
After draining out the coolant, flush the system until nothing but pure water emerges from the drain cock or cocks.

9. Check the anti-corrosion anodes (marine cooling system)

In the sea-water circuit there are anti-corrosion anodes located. They prevent galvanic currents from attacking the material in the heat exchangers and intercooler.



Anti-corrosion anodes in heat exchanger



Before the anodes are screwed out for check the bottom valve of the sea-water circuit shall be closed and the water drained out from the sea-water circuit. Screw off the anodes and examine them by carefully scraping them with a knife or by gently tapping them with a hammer. If they crack or are deformed new shall be put in. If rusting on the anodes is allowed to go too far a small hole is exposed in the plug which the anode is screwed in. Through this hole water will then seep out.

10. Clean the sea-water circuit (marine cooling system)

Preparation:

1. Close the bottom valve.
2. Empty the sea-water circuit (See "Measures after Driving".)
3. Empty the fresh-water circuit (See point 8)

Heat Exchanger

Remove the heat exchanger from the engine. Screw off the anticorrosion anodes and put plugs in the holes. Seal the outlet opening on the heat exchanger. Afterwards place the heat exchanger on right edge and fill it with a solution of 20 percentage by weight caustic soda (sodium hydroxide) and water. Allow the heat exchanger to stand two days with this solution, flush it clean afterwards with water and/or steam.

Intercooler

Screw off the anti-corrosion anodes and put a plug in the hole for the lower anode. Screw off the feed and exhaust pipes. Seal the inlet opening on the intercooler. Fill up with a solution of 20 percentage by weight caustic soda and water. Allow the intercooler to stand two days with this solution. Flush it clean afterwards with water and/or steam.

11. Lubricate the compressed air starter motor (optional equipment)

The compressed air starting motor has three lubricating nipples. Lubricate regularly with nonfreezing lubricant.

Turbocharger

12. Change the oil filter of the turbocharger

Remove the old filter. Then fit by hand the new filter as follows:

Oil slightly the rubber gasket of the filter. Tighten by hand the filter until the gasket leans on the contact surfaces.

Tighten further the filter half a turn.

Start the engine.

Check that the filter is tight.



Oil filter of turbocharger

13. Make a check for air, exhaust and oil leakages

Start the engine. Check the connections between the turbocharger and the intake manifold, between the intake manifold and the engine, and between the air cleaners and the turbocharger. Check that all gaskets are sound. Make a careful check on the exhaust system, particularly in respect of the connection to the turbocharger and the connections to the cylinder heads. Check that no oil has got out into the compressor cover or into the compressor wheel. Check that the connections are tight at the oil inlet and outlet of the turbocharger.

Engine Electrical Equipment

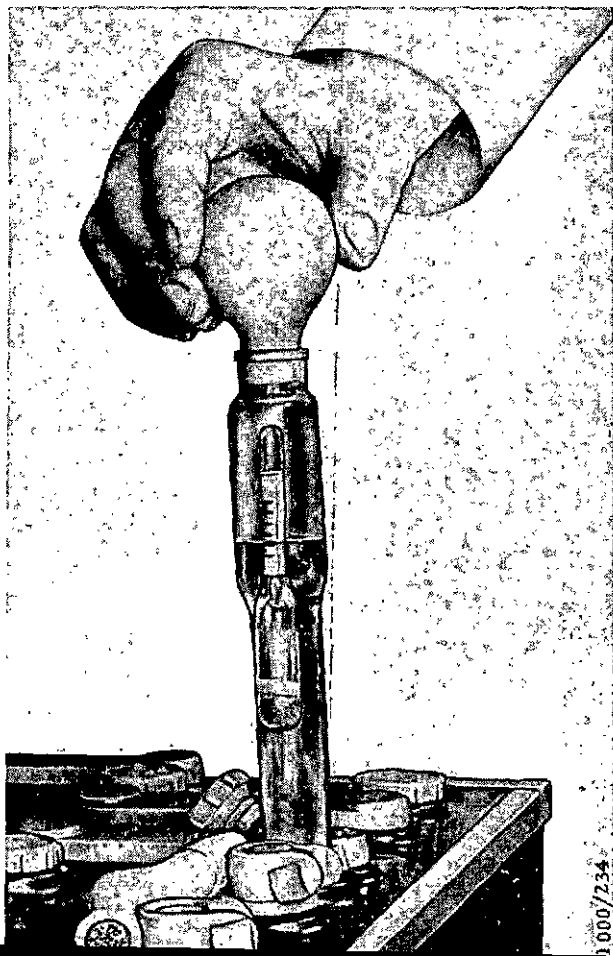
N.B. Never loosen the battery cables when the engine is in motion and never connect them up incorrectly.

14. Check the electrolyte level in the batteries

Screw out the plugs and check the level of the electrolyte in all cells. Top up with distilled water so that the level is 10—15 mm above the plates.

15. Clean the batteries, cables and cable terminals and check the state of charge

Clean the cable terminals and the terminal bolts and check that the terminals are securely tightened. Then smear them with vaseline or an equivalent. Check that state of charge of the batteries using a hydrometer. In a fully charged battery the density of the electrolyte will be 1.28. If it has fallen to 1.20 the battery must be sent for recharging. Normally, however, the engine's own generator should keep the batteries sufficiently charged.



Special care must be taken in winter to see that the batteries do not become discharged. Even -20°C or so is enough to freeze the electrolyte in a flat battery, which is thereby ruined.

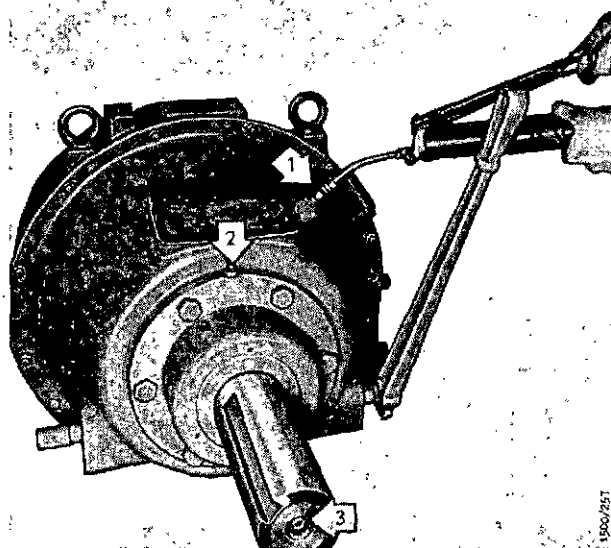
Friction Clutch

16. Lubricate the release bearing

Lubricate the release bearing with heat-resistant roller-bearing grease through the front lubricating nipple on the outside of the clutch casing.

17. Lubricate the locating and support bearings of the clutch and the moving parts of the clutch mechanism.

Lubricate these bearings with heat-resistant roller-bearing grease through the rear lubricating nipple on the shaft stub. This nipple is located either behind the bearing housing on the shaft or in the end of the shaft.



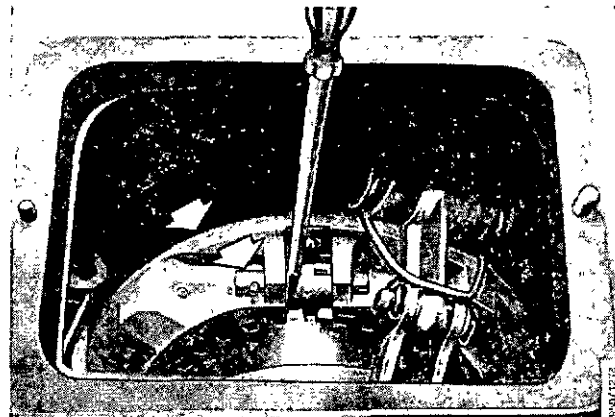
Lubricating nipples of friction clutch

1. Lubricating nipple of release bearing
2. Lubricating nipple of locating bearing

The need for lubricating the support bearing varies depending on operating conditions. The support bearing does not function during operation but only when the clutch is released. A 3 cm³ quantity of grease is in general sufficient at each lubrication. If a longer period of idling occurs often with the clutch released, a larger quantity of grease should be applied.

Do not use too much grease. If grease gets in onto the friction discs the ability of the clutch to transmit the drive is impaired and the friction discs will have to be changed.

On certain clutches, the lubricating nipple in the free shaft stub is replaced by a lubricator. Screw the threaded top of the lubricator inwards. This forces grease to the bearing. Replenish the lubricator with grease as necessary. Grease also, when necessary, the bearings of the release shaft in the release fork. Lubricate the moving parts of the clutch mechanism with a few drops of oil.



Adjustment for the clutch

A new clutch needs several adjustments before the clutch plates are worn in. It is thus quite normal to have to adjust the clutch two or three times at frequent intervals when it is new or when new clutch plates have been fitted.

18. Adjust the clutch

If the clutch slips or runs hot or if the lever will not remain in the engaged position the clutch needs adjustment. It should be carried out as follows:

1. Remove the inspection cover.
2. Expose the clutch.
3. Turn the clutch until the retainer of the adjusting ring can be released.
4. Turn the adjusting ring clockwise, seen from behind, until the lever encounters strong resistance when it is moved towards the engaged position. If the adjusting ring cannot be screwed in far enough to make the clutch pull properly, the clutch plates are worn and will need to be changed.
5. Put the clutch in neutral and check by turning the driven shaft, that no snatching or jerking can be felt.
6. Put the inspection cover back on and run the unit to check that the clutch is correctly adjusted.

Electrical Welding on or by Engine

N.B. When carrying out electrical welding on or close to the engine all cables on the charging regulator and the battery cable terminals must be disconnected.

Periodical Maintenance which should be carried out by diesel-trained personnel

Every 600 hours or once every six months, whichever is the earlier

Check the charging pressure of the turbocharger. This applies only when the crankcase ventilation discharges next to the air filter.

Check the feed pressure and change the filter inserts if necessary (Bosch).

Change the main filter inserts of the fuel system (CAV).

Check the injection pump setting.

Check before the winter season that the control rod goes into cold start position.

Check and adjust if necessary low and high idling speed.

Check the temperature and oil-pressure monitors.

Every 1200 hours or once a year, whichever is the earlier

Check and clean the turbocharger according to the current recommendations.

Clean the oil strainer in the oil pan.

Check the valve clearance:

Check the injectors.

Check the injection pump and governor.

Check the starter motor, generator and charging regulator.

Check the thermostat and the coolant thermometer.

Every 3600 hours

Recondition completely the turbocharger.

Diesel Fuel, Lubricating Oil and Coolant

Diesel Fuel

Characteristics	Requirements	Test method ¹⁾
Solid impurities	none	ocular inspection
Water content	Max. 0.05% by vol.	ASTM D 95
Sediment content	Max. 0.01% by weight	ASTM D 473
Density at +20°C	0.82—0.86 grams per cm ³	ASTM D 1298
Cetane number	Min. 45	ASTM D 613
Flash point (Pensky-Martens)	min. +40°C ²⁾	ASTM D 93
Viscosity at +20°C	2.0—6 cSt	ASTM D 445
Pour point	Summer max. —10°C Winter max. —25°C	ASTM D 97
Distillation:		
Temperature giving 90% distillate by volume	Max. +340°C	ASTM D 86
Carbon residue, Ramsbottom (10 % distillation residue)	Max. 0.2% by weight	ASTM D 524
Ash content	Max. 0.01% by weight	ASTM D 482
Sulphur content	Max. 0.7% by weight	ASTM D 129
Corrosion	Not more than 1 on the corrosion scale	ASTM D 130

¹⁾ Latest issue applies

²⁾ To classified vessels the flash point shall be minimum +65,6°C, whereby higher values of the minimum liquid temperatures can be permitted.

Lubricating Oil

Always use oil of an established brand.

Under normal operating conditions we recommend oil designated "Supplement 1".

Under exceptionally severe operating conditions, where this oil does not give satisfactory operating results, oil designated "Series 3" should be used.

For engines with a turbocharger, "Series 3" lubricating oil must always be used.

The oil must also have a suitable viscosity, which should be chosen with regard to the ambient tem-

Use SAE 10 W	in temperatures below —10°C
Use SAE 20 (SAE 20W)	in temperatures between —10°C and +10°C
Use SAE 30	in temperatures above +10°C

Never use flushing oil in the engine. This is because of the risk that this oil may fail to withstand the high bearing pressures in the engine leading to the breakdown of the oil film and the destruction

Oil Capacities

D5, DS5	11 litres
D8, DS8	16.5 litres
D11, DS11, DSI11	20 litres

If the engine has an oil pan with side covers, the pan will hold 31 litres. If the engine has oil pan but separate lubricating oil reservoir it will hold approx. 180 litres.

Coolant

Adding Cutting Oil

The conditions in the engine cooling system are such that there is a risk of rust and cavitation attacks. This is because the coolant readily attacks the metals it comes into contact with, and in some cases it can cause severe damage within a short time. For this reason it is necessary to reduce the severity of the attacks as far as possible by adding an anti-corrosion agent to the coolant. Protection against corrosion is obtained by adding 2—3% by volume of an soluble oil.

Some suitable grades of soluble oil are given below.

BP	Energol SB 40
Caltex	Radiatortex
Esso	Kutwell 40
Gulf	Gulfeut 51 A
Mobil Oil	Solvac 2
Nynäs	Skärolja AK 85 X
Shell	Donax C
Castrol	Cooledge

Adding Ethylene Glycol

During the cold season we recommend the use of Ethylene glycol as an anti-freeze in the engine cooling system. When glycol is used as anti-freeze, cutting oil must not be used as an anti-corrosion additive, since foaming would otherwise be liable to occur. To suppress corrosion the glycol must contain anticorrosion additives (inhibitors) of the type laid down by the British Standards Institution in B.S. 3151, which gives the most effective protection against the various types of corrosion which occur in the cooling system of a diesel engine.

We advise most strongly against the use of methylated spirit, mixtures with lower boiling point than 100°C, pure glycol, or glycol containing inhibitors other than those specified in B.S. 3151 in the cooling system of our diesel engines.

The coolant must contain at least 25% anti-freeze by volume to give sure protection against corrosion. This applies even when a lower concentration would be sufficient to give adequate protection against frost damage.

Maximum depression of freezing point is obtained with a mixture containing 60% ethylene glycol and 40% water. There is therefore no point in further increasing the glycol content.

Freezing points of mixtures of ethylene glycol and water

Percentage of ethylene	Freezing point °C
25	—10
35	—20
40	—25
45	—30
50	—35
55	—43

COOLANT CAPACITIES, APPROX.

Engine Type	Marine Engine	Generator Unit
D5	22 litres	25 litres
DS5	22 litres	—
D8	28 litres	32 litres
DS8	28 litres	—
D11	35 litres	41 litres
DS11	35 litres	41 litres
DSI11	35 litres	41 litres

Mothballing

Mothballing the Engine

When engines are to be laid up for a prolonged period (6 months), the first consideration is to protect the cylinder bores, bearing, injection equipment and other vital parts of the engine from the attack of rust.

To avoid deterioration of this kind the following "mothballing" procedure should be employed.

1. Run the engine until warm, and then drain off the oil from the crankcase.
2. Fill the crankcase with preservative oil to the lower level mark on the dipstick. Most oil companies supply a suitable oil, e.g. Esso Rust-Ban 623 or Shell Ensis Oil 10 W or 20 W.
3. Empty the main filters of the fuel system.
4. Connect the suction side of the feed pump and the return line for leak-off oil to a drum containing one of the following mixtures:
 - a) Esso Rust-Ban 623 and diesel fuel in proportion 1:2
 - b) Esso Rust-Ban 623 and kerosene (paraffin) (e.g. Esso Blá) in proportion 1:2
 - c) Shell Calibration Fluid B 1:2
 - d) Shell Ensis Oil 10W and white spirit in proportion 1:1
5. Bleed the fuel system.
6. Check that soluble oil is present in the cooling system. A 10% concentration of soluble oil is suitable for mothballing.
7. Start the engine and run it for 10—15 minutes at low no-load speed 800—1000 rev/min.
8. While the engine is running, apply rust-inhibiting oil liberally to the valves and pushrods.
9. Stop the engine.
10. Remove the injectors and spray about 20 cm³ (2 centilitres) of preservative oil into each cylinder. Use the same oil in the engine crankcase. Then bar the engine a few revolutions. After this, put the injectors back into place.
11. Drain the preservative oil out off the engine crankcase.
Once these measures have been completed the engine should not be barred.
12. Reconnect the fuel lines in their original positions. Do not work the feed pump by hand nor carry out any bleeding operation until the engine is to be put back into service.
13. Drain the cooling system. Let the radiator stand for a while with the radiator cap off so that the water vapour can disperse. Then screw the radiator cap back on and close the drain cocks.
14. Lubricate the water pump with roller-bearing grease.
15. Treat external unpainted surfaces with a suitable rust preventive e.g. Esso Rust-Ban 392 or 395, Shell Ensis Fluid 256 or corresponding products of other brands. If it is uncertain whether the surfaces to be treated are absolutely dry, they should first be treated with a water-repellent oil, e.g. Esso Rust-Ban 392. These rust pre-

spraying is preferable. Use plenty of rust-preventives round the injectors so that it penetrates down between the nozzle holders and the sleeves in the cylinder head.

Remember that certain of these preventives intended for external use, have a relatively low flash point and should therefore be used with caution. Certain volatile liquids, such as Esso Rust-Ban 392, are also dangerous to breathe, so that a gas mask should be worn while spraying.

16. Cover the air filter to protect it from dust and dirt.
17. Mark the engine clearly with the date on which it was mothballed, and with a prohibition against running or barring it, since this would make it necessary to repeat the mothballing process.
18. Indicate also at a conspicuous place that oil and cooling water have been drained off.

For engines that are to be laid up for a shorter period (1—2 months), it will normally be sufficient to carry out points 6, 10 and 13 above. Point 13 can also be omitted provided that, if in winter, the cooling system is filled with antifreeze in accordance with our recommendations: see the section headed "Periodical Maintenance". Normally, moreover, the injection of rust-preservative oil according to point 10 can be dispensed with if the engine is to be started now and then and run warm.

Demothballing the engine

1. Fill the cooling system with water and soluble oil, if required, with water and glycol. (See "Coolant").
2. Put oil into the engine. Important. So-called flushing oil must not be used.
3. Bar the engine a few turns with the injectors removed. At the same time, liberally oil the valve mechanism including the pushrods and tappets.
4. If the engine is equipped with a turbocharger, detach the lower connection of oil line at the turbocharger and check that oil flows through the bearing housing of the turbocharger when the engine-rotates according to item 3.
5. Drain the rust-preservative oil out of the main filters of the fuel system. Bleed the fuel system.
6. Wash off the rust preventive from the outside of the engine. Cotton waste wrung out of white spirit can be used.

Batteries

Remove the batteries for attention at a charging station. They should be kept fully charged, since if this is neglected the plates of the batteries may be damaged and in time completely ruined by sulphating. But this does not apply to batteries which, according to the maker, do not require maintenance charging.

Even if lay-up time is only about one month the same action should be taken, unless the engine is

SAAB-SCANIA SÖDERTÄLJE

SERVICE

SERVICEAVDELNINGEN/SERVICE DEPARTMENT

Engine Manual

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GENERAL INSTRUCTIONS FOR THE INSTALLATION OF SCANIA

ENGINES TYPE D5, DS5, D8, DS8, D11, DS11A, DSI11A

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- B Exhaust System
- C Cooling System
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- E Electrical System - Compressed Air System
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- G Operating Control
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- J Multi-engine Installation
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A Intake System - Engine Room Ventilation

1 Air Intake to the Engine Room

Always make the air intake opening large enough so as to avoid negative pressure in the engine room. Also make quite sure that the air intake cannot be shut off inadvertently (Fig. A1).

The minimum permissible opening section for air intakes to engine rooms of the engine types specified below is as follows:

D5: 2 dm² D8: 3 dm² D11: 4 dm²
 DS5: 3 dm² DS8: 4 dm² DS11-DSI11: 5 dm²

Should several engines be operated in the same engine room, the air intake section shall be increased correspondingly.

2 Air Consumption (in m³/h)

Engine r.p.m.	D5	DS5	D8	DS8	D11	DS11R40A DS11R60A	DS11R82A	DSI11R82A
1500	200	260	300	390	430	600	540	600
1800	240	330	360	510	510	760	710	780

If other equipment, such as heating boiler, requiring oxygen for their operation, should be installed in the engine room, it will be necessary to take their air consumption into consideration also. A heating boiler operated with kerosene or equivalent fuel consumes approx. 16 m³ air per litre of fuel.

3 Temperature in the Engine Room

The temperature of the intake air for the engine should not exceed 35°C. The maximum permissible temperature of the intake air is 40°C.

This requires in general, when engine installations with inside air intake, i.e. the intake air for the engine is taken direct from the engine room, that the engine room is provided with a ventilation system (ventilation fan). The ventilation fan capacity can be calculated with the help of the particulars below.

Specific radiating heat at maximum permissible output and 25°C air temperature.

	kcal/h.p.h. Ws/kWh.	
D11, DS11 and DSI11 with water-cooled exhaust manifold and heat exchanger	50	(285000)
D5, D8 and D11 with neither exhaust manifold cooling nor heat exchanger	80	(455000)
DS5 with neither exhaust manifold cooling nor heat exchanger	90	(510000)
DS8 and DS11 with neither exhaust manifold cooling nor heat exchanger	100	(570000)

Consideration must also be taken to the radiating heat from the exhaust line extending from the engine. The amount of this heat depends on how much of the line is located in the engine room and if the line is insulated.

In general, efficiency losses are converted by the driven units into quantities of heat which can be considerable.

4 Air Intake for Engine

It is worthwhile providing the engine with a fresh air intake, i.e. the intake air is taken outside the engine room and conducted straight through to the

temperature of the air introduced in the engine is automatically obtained. The engine room temperature may then rise to maximum 60°C without the engine suffering damage. If the air temperature exceeds this value, there is risk, in the first place, of functional disturbances on the alternator, the charging regulator, and the magnetic cut-out. This means that in special cases a ventilation fan is required even for engine installations with fresh air intake.

5 Location of Air Intake

The air intake should be located in such a way as to eliminate any risk of the engine exhaust gas being sucked into the intake air system. In addition, it must be so arranged that the intake air is kept as pure as possible. As a rule, this implies that the air intake must be located as high as possible. The air intake should be protected so as to prevent water, snow and other impurities from entering.

6 Resistance in the Engine Intake Line

If the engine has been provided with a line for the intake air, the pressure drop in this line shall be measured. This check, however, is not required, if the inner diameter of the intake pipe is minimum 150 mm for DS11-DSI11, 100 mm for DS5-D8-D11 and 90 mm for D5 and if the length of line does not exceed 5 metres, provided that the line is not fitted in sharp bends. If the line dimensions are more unfavourable, the pressure drop shall be checked. Maximum permissible pressure drop is 300 mm water column (0.03 kg/cm²) covering also the resistance of the air cleaner used. If the pressure drop is excessive, there may be risk of insufficient air supply to the engine. In case a hose is used, this should be reinforced to prevent it from caving in.

7 Ventilation of the Crankcase

The gases from the engine crankcase should preferably be conducted out of the engine room through a separate line. However, on non-turbo-charged engines they can also be conveyed straight to the engine air filter provided that this is of the oil bath type.

With turbocharged engines it should always be endeavoured to conduct the crankcase gases out of the engine room. The condensate from the gases contaminate the intake system (turbocharger etc), which has a detrimental effect on its efficiency. In the case of installation where this would imply a very long ventilation line and expensive fitting, it is possible however, even with a turbocharged engine, to conduct the gases to the air filter of oil bath type, but then the turbocharger unit must be cleaned more often than usual. See the applicable maintenance instructions.

It is advisable to use for the crankcase ventilation line a pipe or a plastic hose connected to the engine breather pipe. The inner diameter of this line should be at least 24 mm up to a length of 5 metres. In the case of longer lines a proportionally larger diameter should be selected. The outlet of the crankcase ventilation line outside the engine room is to be protected in such a way as to prevent impurities from entering into the crankcase. If a pipe is used, the junction between the engine and the pipe must consist of a flexible hose absorbin, the movements of the engine. If a plastic hose is used, make sure that it is secured with clips in a proper way and that there are no sharp folds or bends. The line leading from the engine through the engine room out into the atmosphere must slope upwards all the way from the engine. If the line is installed in such a way as to form a droop, oil condensate may remain there, causing excessive pressure in the crankcase. Abnormally great pressure in the crankcase can entail lubricating oil leaks.

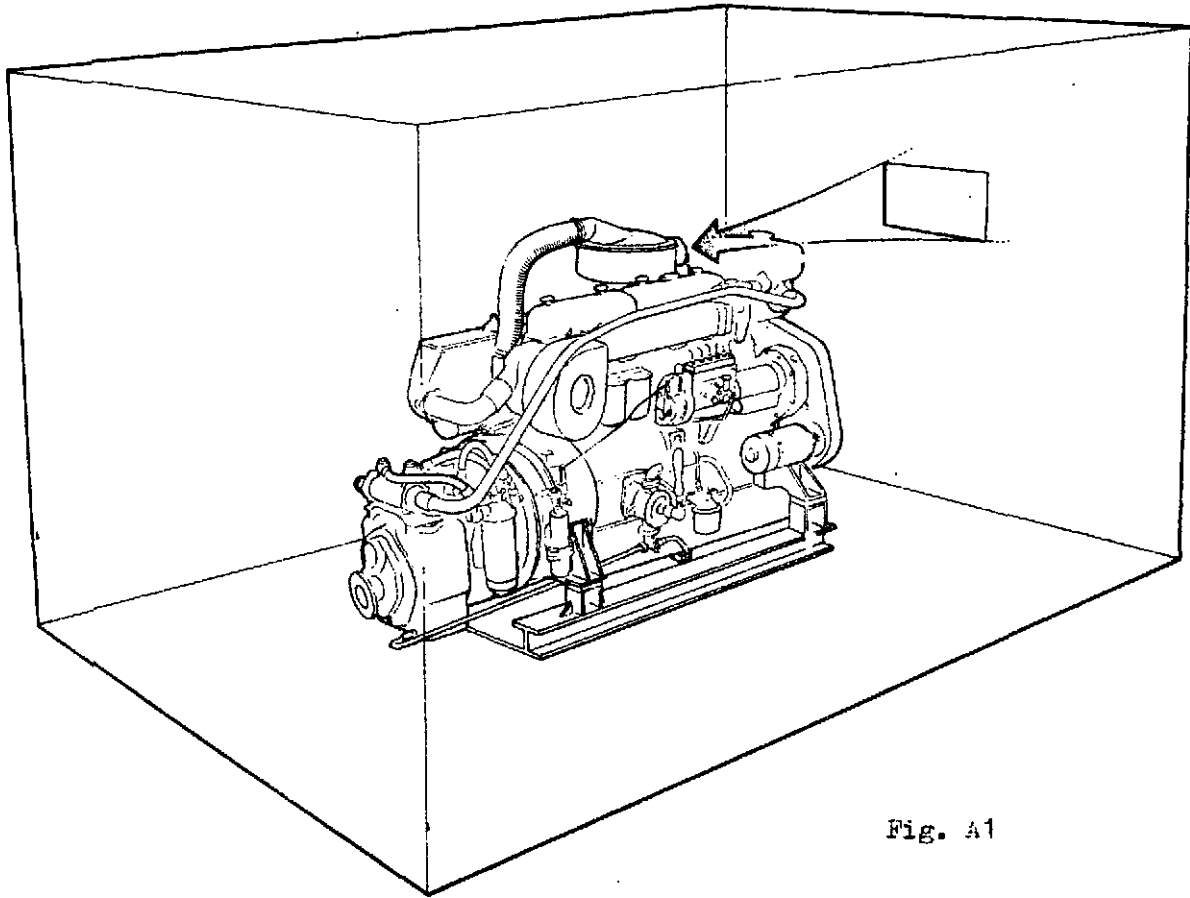


Fig. A1

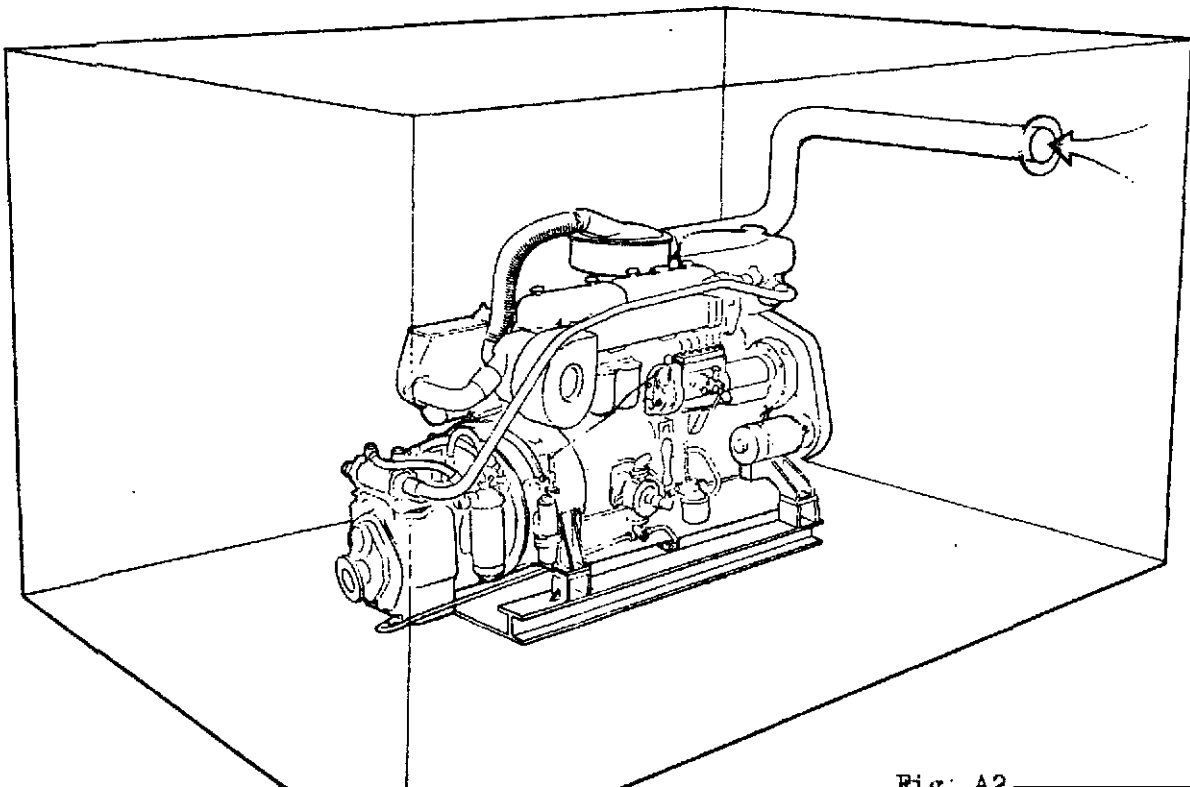


Fig. A2

B Exhaust System

1 Sound Damping

Mufflers are used at the majority of engine installations.

However, the need for mufflers must be judged from case to case with consideration being given to acceptable noise level, exhaust line length, the position of the exhaust line opening, etc. Heat insulation of the exhaust line also has an effect on the noise level in such a way that, with an insulated line, the exhaust noise will be greater than with a line which is not insulated.

As an alternative to mufflers on marine engine installations there is also used quite often a sea-water-cooled exhaust line, i.e. the exhaust gases are cooled down with help of sea water, which is an effective way to reduce the exhaust noise.

When particularly big demands are placed on low noise level, e.g. at a hospital, a sound insulation cell for the exhaust gases can be built. More detailed instructions about this can be obtained through the Engine Sales Department at AB Scania-Vabis.

2 Dimensioning of the Exhaust Line

The diameter of the exhaust line is calculated in the following manner:

- a) Measure the length of the planned exhaust line.
- b) Calculate how many 90° pipe elbows are to be included in the exhaust line. Two 45° pipe elbows are equivalent to one 90° pipe elbow etc.
- c) Determine a preliminary inner diameter (Dp) for the exhaust line from the table below.

Exhaust Line Inner Diameter, mm

Engine r.p.m.		1500					1800					Muffler part No.
Exhaust line length, m		5	10	20	30	40	5	10	20	30	40	
Exhaust line inner diameter, mm	D5R40, 60	66	66	66	66	66	66	66	66	67	71	135210
	DS5R40, 60	66	68	78	85	90	73	84	96	105	111	
	D8R40, 60	66	66	66	71	76	66	66	72	78	86	163383
	DS8R40, 60	68	79	92	98	105	80	94	106	115	122	or
	D11R40, 60	66	69	80	87	92	68	78	90	98	104	190160
	D11R80	66	68	78	85	90	66	76	87	95	100	
	DS11R40A, 60A	90	104	119	130	138	113	129	148	162	171	165169
	DS11R82A	87	95	109	119	126	102	117	134	146	155	or
	DSI11R82A	89	102	117	128	135	114	130	150	163	173	190163
	DSI11R40A, 60A	82	92	106	115	122	88	101	116	126	133	
	DSI11R82A	82	87	100	109	116	85	97	112	121	129	188155
DSI11R82A	82	91	105	114	121	88	121	116	126	133		

- d) With help of the preliminary diameter Dp and the quantity of 90° pipe elbows, which are converted calculatoryly into straight pipes with the same total resistance value, an additional length is determined (L_t) from the diagram (Fig. B1).

With the additional length, consideration is taken to the resistance in pipe elbows and the discharge resistance in the line opening. N.B. It will be necessary to calculate with an additional length, even if the exhaust line has no pipe elbows.

- e) Add the estimated additional length (L_t) to the length measured (L_u) and then read with guidance from this total length (L_{tot}) the final inner diameter in the table. Select the next larger standard diameter.

Example: Engine type: DS11R60A
Operating r.p.m.: 1500
Muffler: Part No. 165169

- 1) Measured length (L_u) = 12 m
- 2) Number of pipe elbows: 3 parts 90° + 4 parts 45° = 5 parts
- 3) Preliminary inner diameter (D_p) = $104 + \frac{2}{10} (119-104) = 107$ mm
- 4) Additional length (L_t) = 9 m
- 5) $L_u + L_t = L_{tot} = 12 + 9 = 21$ m
- 6) Definite inner diameter = $119 + \frac{1}{10} (130-119) = 120$ mm

The pipe elbows on the exhaust line shall be designed with large radius.

The estimated inner diameter according to the above implies that the exhaust line is insulated; that is the reason why any increase of the inner diameter is unnecessary because of this.

3 Exhaust Line Connection and Location

With regarding to the engine movements when this is rubber suspended and to the lateral changes which occur in the exhaust line as a result of changes in temperature in the line, where must be some sort of flexible connection between the exhaust pipe and the engine. This is particularly important for engines equipped with turbochargers in order to prevent the unit from being damaged. AB Scania-Vabis supplies two types of flexible connections, viz.:

Flexible Exhaust Hose

Exhaust Line with Compensator

- a) The Flexible Exhaust Hose should be used in connection with installations with flexible rubber suspension, since the hose will absorb the lateral movements sometimes occurring, e.g. when starting or stopping the engine. However, this hose cannot absorb any appreciable movements in the longitudinal direction. Thus, this design will fit most generating sets and separate engines with flexible suspension.
- b) The Exhaust Line with Compensator is of a sturdier design than the exhaust hose. The compensator, consisting of several layers of deeply corrugated stainless steel sheets, will absorb both lateral and longitudinal movements (Fig. B2).

A maximum displacement laterally of 8 mm and longitudinally of ± 10 mm is permitted simultaneously for compensator No. 161058. A maximum displacement laterally of 10 mm and longitudinally of ± 15 mm is permitted simultaneously for compressor No. 157941. If it is only a question of a longitudinal movement, a displacement of ± 50 mm can be permitted. These flexible connections are specially suitable for rigid engine suspension, thus frequently marine engine installations. Due consideration should be taken to the longitudinal expansion of the pipe between cold and hot temperatures so that the motion-absorbing capacity limits of the compensator according to the above are not exceeded. In case the compensator No. 157941 is to be insulated, there is an insulating cover No. 163223 available, which is easy to install.

A bracket or similar should be fitted direct after the exhaust hose or compensator so that the exhaust line weight does not load the flexible connection.

In those cases where a muffler is to be fitted, this should be located as far away from the engine as possible. However, it should not be placed in the end of the exhaust line but roughly one metre from the opening. If, because of limited space, the muffler cannot be placed close to the exhaust opening, it should be put as near to the engine as possible. It is often advisable to fit in a booster muffler close to the exhaust opening, whereby possible resonance vibrations in the exhaust line following the muffler at the engine will be absorbed.

Choice of muffler is suitably done in consultation with the Engine Sales Department at AB Scania-Vabis.

4 Insulation

The necessity of insulating the exhaust line must be judged from case to case. With internal air intake for the engine, the exhaust line should be insulated particularly well in order to reduce the engine room temperature. One other reason for insulating is e.g. to reduce the risk of the machine personnel contracting burns and to diminish expenses for ventilation. Be particularly careful about the insulation when fitting the line through or in the vicinity of inflammable material.

5 Protection against the Penetration of Water

Rain or condensation water which penetrates into the engine can cause corrosion damages. Therefore, the exhaust line should be protected in order to prevent this.

Long exhaust lines should be provided with a condensation water separator to be located after the flexible connection, although not too far from the engine. A cleanable water trap should be attached to the condensation water separator. Even with short exhaust lines the condensation water separator may be justified, if there is a risk of water penetration. This risk, as illustration B3 shows, can be eliminated by using a self-closing cover over the exhaust line.

Text for Fig. B3

Exhaust pipe with compensator, condensation water separator and protection cover.

- | | |
|--------------------------|-----------------------------------|
| 1 Elbow | 6 Protection cover (self-closing) |
| 2 Pipe 1" | 7 Gasket |
| 3 Plug R $\frac{1}{2}$ " | 8 Condensation water separator |
| 4 Muffler | 9 Flexible connection |
| 5 Flange | 10 Engine |

A = 1700 mm for non-turbocharged engines

600 mm for turbocharged engines

6 Multi-engine Installation

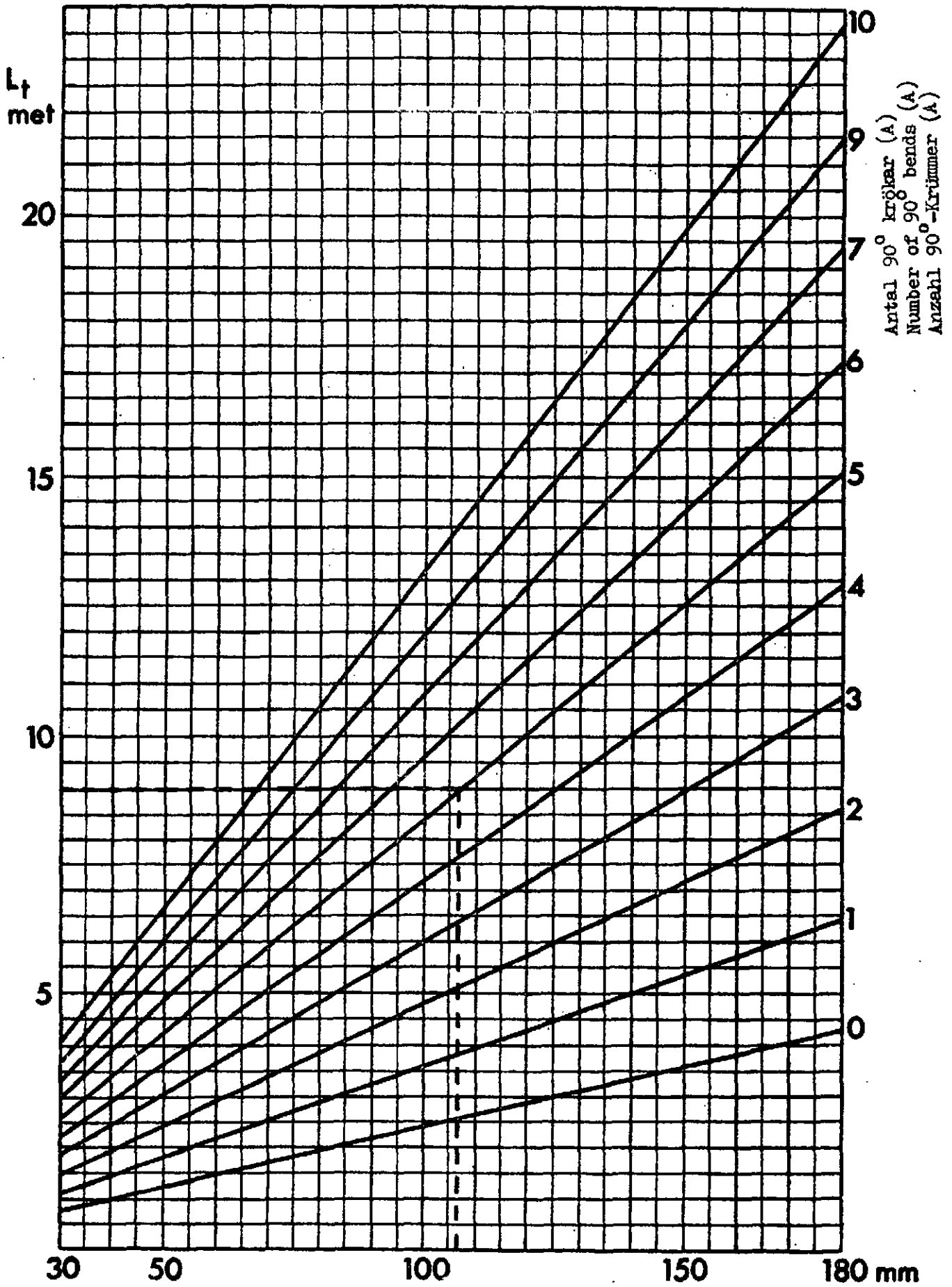
With multi-engine installations a separate exhaust line for each engine should be provided if possible. In those cases where the exhaust lines from several engines are joined to a common exhaust line, the same dimensioning principles are applicable for every branch line as for the exhaust line of the single engine installation according to the above. The common exhaust line section will be finally dependent on its length, but it shall at least correspond to the total section of the branch lines.

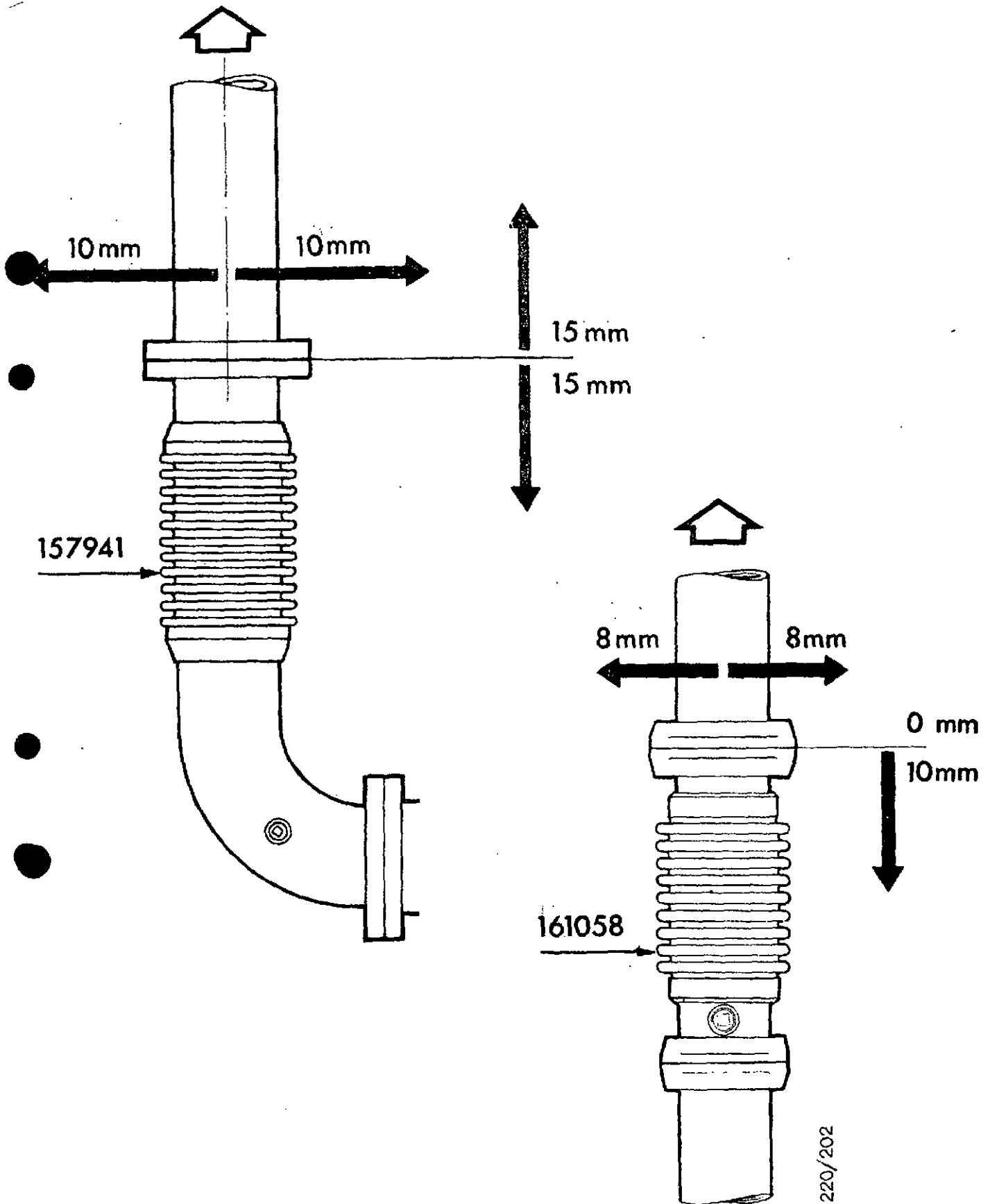
In those cases where several engines are connected to a common exhaust line, there should be an easily operated and effective shut off device in each branch line. This is very important, as the exhaust gases from the engines which are in operation can otherwise penetrate into an engine which is not in operation and cause, among other things, corrosion damages.

7 Back Pressure in the Exhaust Line

After installation the back pressure in the exhaust line should always be checked. The values shown in the table below indicate the maximum permissible back pressure. Measure the pressure adjacent to the connection between the exhaust line and the engine. Run the engine with maximum load and at maximum r.p.m. when measuring.

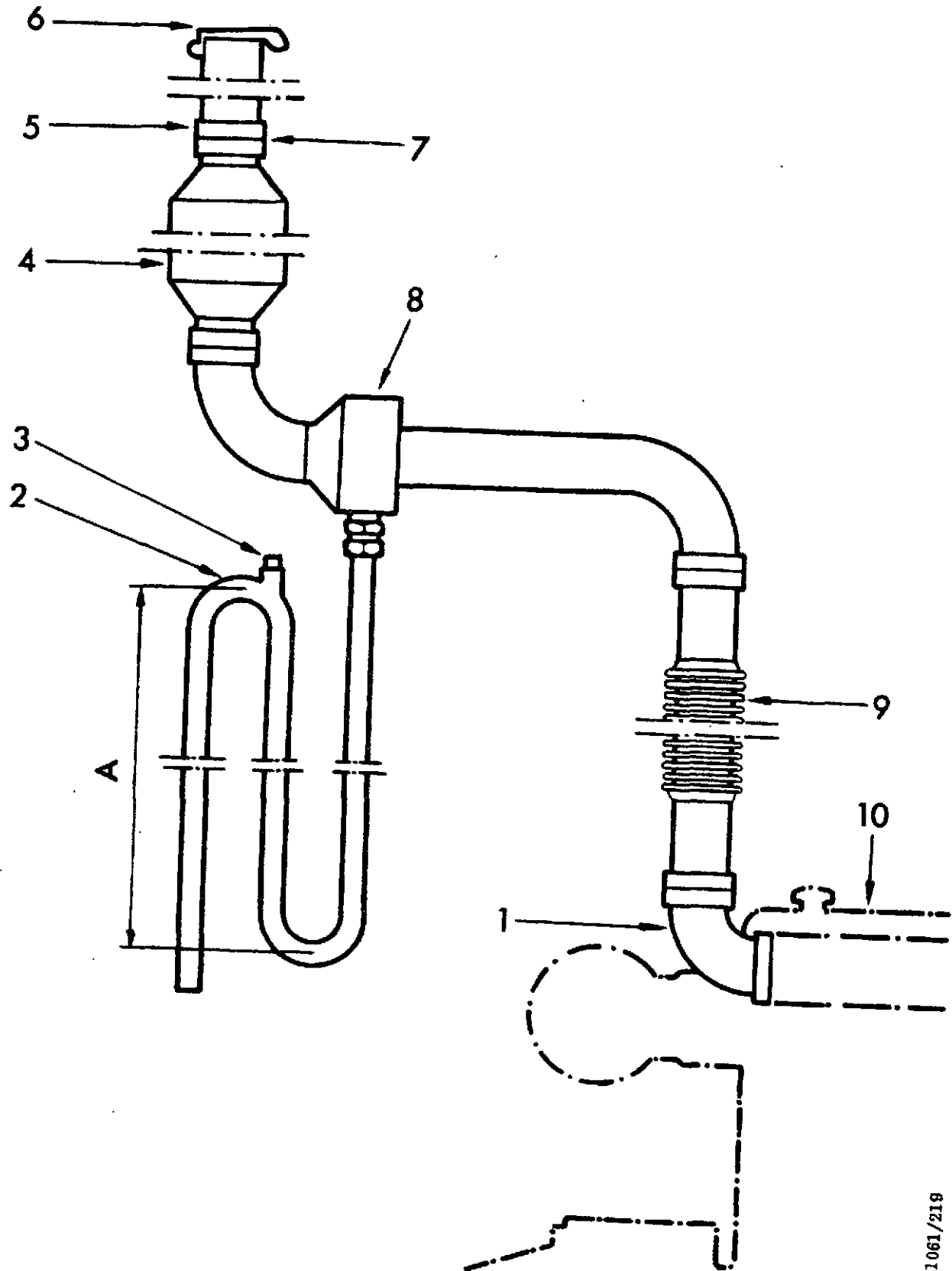
Maximum permissible back pressure	mm water column
Non-turbocharged engines	1600
Turbocharged engines	500





220/202

3121
5.68



1061/218

C Cooling System

1 System Cooled with Sea Water

The design of the marine cooling system for engine type DSI11 is shown by the figures C1 and C2.

This engine in standard design is equipped with sea water pump of make Jabsco. The static height of suction for this pump must not exceed 2.5 metres. In addition, with consideration to the risk of detrimental dry running period for the pump impeller, the suction line volume between the sea water level and sea water pump should not exceed 3 litres. With larger volumes or in case there is risk of air coming in, measures should be taken to use a more effective and non-sensitive pump arrangement. In that case the exhaust line must also be designed so that the air can easily be evacuated.

The sea water inlet of the vessel shall be so located that the risk of air coming in at heavy sea is prevented as far as possible.

The coolant lines of the sea water circuit shall be carefully planned so as to reduce to a minimum the pipe length and the number of elbows. The inner diameter of the coolant lines for the undermentioned engines, as a rule, should be at least 45 mm (2"). If the combined length of line exceeds 8 m or if a number of elbows and valves are introduced on the sea water lines, the diameter must be increased, otherwise the flow resistance will be excessive. The total flow resistance in the inlet and outlet lines as well as the resistance corresponding to the total geometrical lifting height of the sea water system for engine equipped with Jabsco pump and intercooler should not exceed 0.6 kg/cm² (0.59 bar) with a cooling water delivery Q = 160 litres/min. The equivalent value with Jabsco pump but without intercooler is 1.4 kg/cm² (1.38 bar) with Q = 150 litres/min. For marine propeller engine equipped with oil cooler on the reversing gear the equivalent resistance values are reduced to 0.3 kg/cm² (0.29 bar) and 1.0 kg/cm² (0.98 bar), respectively.

When using a certain type of centrifugal pump the resistance values mentioned can be permitted up to 1.4 (1.37) and 2.0 (1.96), respectively, for engine only and 1.0 (0.98) and 1.6 (1.57), respectively, for engine with reverse gear. These values are limited by reason of the maximum permitted water pressure in the engine sea water system, i.e. 2 kg/cm² (1.96 bar).

The measuring of the pressure is carried out immediately before and after the sea water pump.

When hesitating about choice of sea water pump, please get into contact with the Engine Sales Department, AB Scania-Vabis, for further particulars.

The minimum permissible sea water delivery, expressed in litres/min., through the heat exchanger in continuous operation and with full load is shown in the table.1. The temperature of the sea water shall be below 20°C in order that the values be valid. Furthermore, it is implied that the water in the engine fresh water system is mixed with the recommended concentration of cutting oil. Glycol, which is recommended in order to prevent freezing during the winter, shall not be used during the warmer seasons of the year, as glycol/water mixture reduces the cooling capacity of the system.

Table 1

Engine r.p.m. r.p.m.	Water delivery in litres/min. for engine types		
	D11	DS11	DSI11 (230 h.p./1800 r.p.m.)
1200	105	110	115
1500	120	130	135
1800	140	150	155

Sea Water Filter

Sea water filter of reversible type - with hole size of ϕ 2 mm - normally gives an excellent protection against dirt penetrating into the engine heat exchanger, etc.

The resistance in the filter must not be so great that critical depression values arise in the inlet system, in respect of steam pressure. In cases where demands for great operating safety occur, the sea water system should be provided with the possibility of supervision.

In very dirty waters where sea water filters of normal size are quickly clogged up, the keel-cooling system is very often the most appropriate. This means that the engine fresh water system is connected up with cooling water pipes situated on the outside of the boat's hull, by means of which the sea water flushing round the line cools the fresh water. In certain cases, as an alternative, a large fresh water tank can be installed and connected to the engine fresh water circuit. However, one condition for this is that the tank makes good contact with a large part of the hull surface facing the sea water, so that the heat is easily carried off from the fresh water tank via the hull and out into the sea water.

2 Air-cooled System

The inner diameter of the cooling water lines should be at least 45 mm (2") for all engine types. If the total line length exceeds 8 m or a number of pipe elbows and valves are introduced on the coolant lines, the diameter should be increased in order that the flow resistance shall not be too great. The pressure loss in the cooling system connected to the engine must not exceed the values indicated in table 2.

Table 2

Maximum loss of pressure in the cooling system connected up to the engine, in kg/cm² (bar), permitting sufficient cooling water circulation, is shown below:

Engine r.p.m.	Engine type					
	D5	DS5	D8	DS8	D11	DS11
1500	0.40 (0.39)	0.35 (0.34)	0.30 (0.29)	0.30 (0.29)	0.40 (0.39)	0.30 (0.29)
1800	0.55 (0.54)	0.48 (0.47)	0.43 (0.42)	0.35 (0.34)	0.60 (0.59)	0.40 (0.39)

Should it become desirable to check the pressure loss in the outer circuit, the thermostat is to be removed, and the return duct from the thermostat housing to the suction side of the coolant pump must be plugged so that the entire coolant flow from the coolant pump is conducted through the outer circuit.

The measuring of the pressure loss is carried out at the inlet and outlet of the engine.

At the same time as this test is made, it is advisable to measure the temperature of the coolant at the inlet of the coolant pump, when the engine develops the intended maximum butput. The temperature there will give an idea about the cooling capacity margin. Should the temperature be as high as 65°C, this means that the cooling system is insufficient during conditions which are more unfavourable than those prevailing during the test.

Table 3

The required delivery of water flowing through the system at full load (maximum load and continuous operation) is indicated in litres per minute in the table below.

Engine r.p.m.	Engine type					
	D5	DS5	D8	DS8	D11	DS11
1500	66	81	95	112	137	176
1800	75	97	111	133	160	215

The values indicated in table 2 apply provided that the water pump r.p.m. = 1.185 x the engine r.p.m. on engines of series D5 and D8 and 1.48 x engine r.p.m. on D11-series engines.

In certain installations an increase of fan and water pump r.p.m. can be made. Gear ratios of 1.63 and 1.86 x the engine r.p.m. can then be applied.

The cooling system must always be so arranged that the coolant has the possibility of expanding. The connection between engine and expansion vessel shall be carried out with even rise so that risk of air or steam pockets is eliminated. A shut-off valve must not be located on this line. The expansion tank shall be placed somewhat higher than the highest part in the remaining cooling system and must be provided with level and ventilation pipes and filler opening with cover.

The thermostats normally supplied with the engines are designed for a maximum static pressure of 2.5 m water column, i.e. the highest coolant level must not be higher than 2.5 m above the engine thermostat housing.

Table 4

Thermostat No.	Static pressure, m water column	Opening temperature at atmospheric pressure,	
		°C	°F
77744	0 - 2.5	77	170
136133	2.5 - 7.5	66	150
136134	7.5 - 12.5	55	130

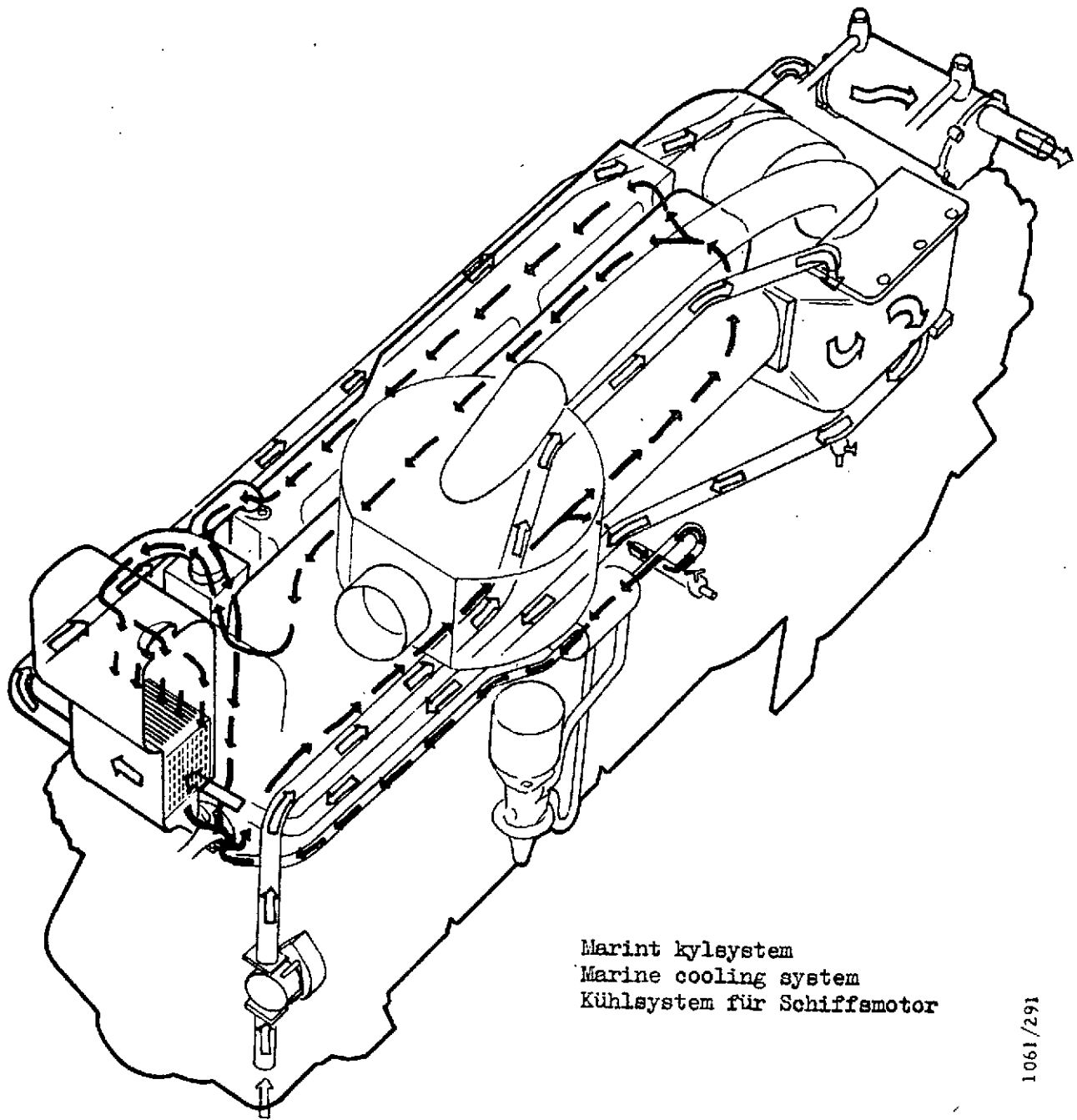
The above thermostats with the low opening temperatures (55 and 66°C, respectively) will, when installed, have an opening temperature corresponding to 77°C. The opening temperature, expressed in °F, is punched on the thermostat.

3 Heat Content of the Coolant

The heat to be carried off from the engine by the cooling system is indicated in table 5. The quantity of heat is indicated in kcal/h (kW), and the values apply to maximum load and continuous operation.

Table 5

Engine r.p.m.	Engine type						
	D5	DS5	D8	DS8	D11	DS11	DSI11
1500	27.500 (32)	34.000 (40)	40.000 (47)	47.000 (55)	57.500 (67)	74.000 (86)	100.000 (116)
1800	31.500 (37)	40.500 (47)	47.000 (55)	56.000 (65)	67.500 (78)	90.000 (104)	120.000 (140)

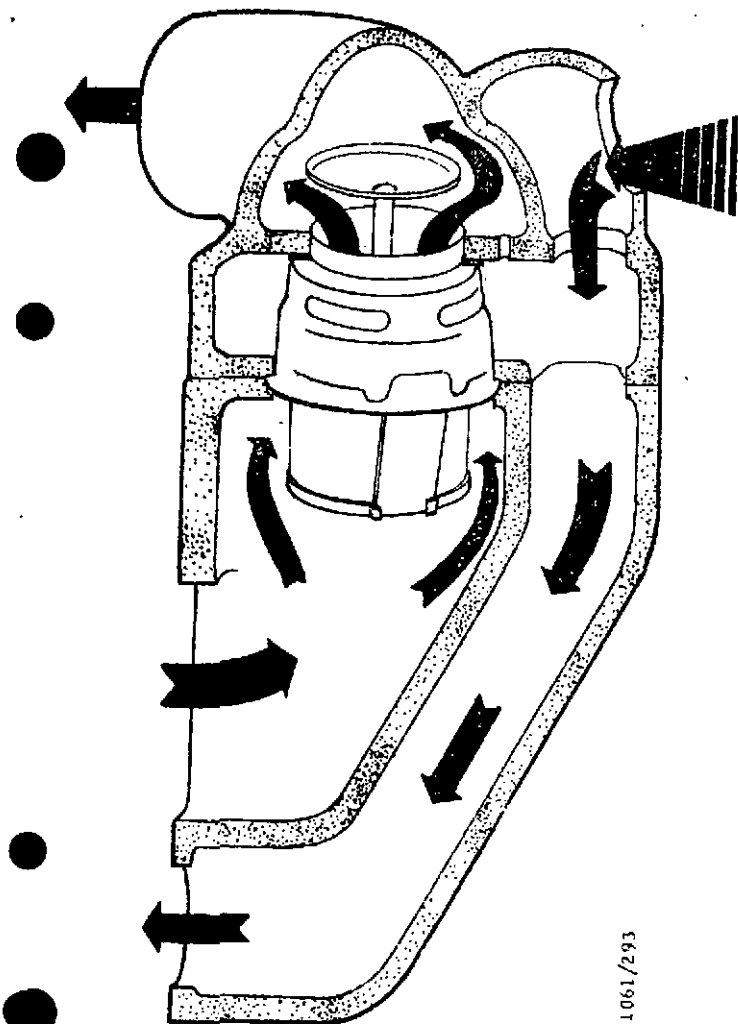


Marint kylsystem
Marine cooling system
Kühlsystem für Schiffsmotor

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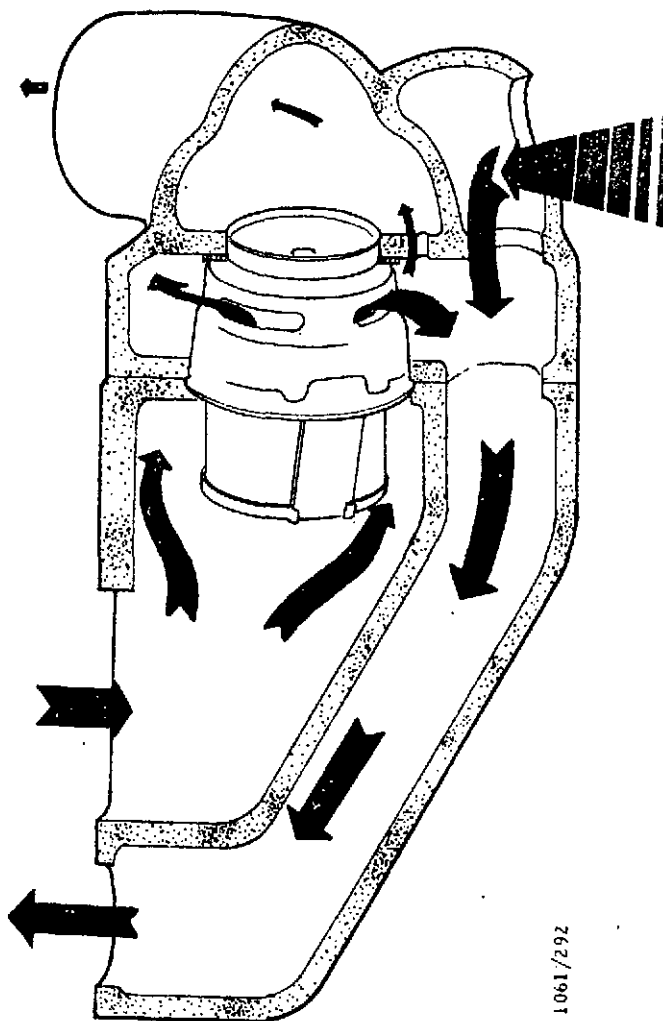
← = färskvattenkrets
fresh water circuit
Frischwasserkreis

⇐ = sjövattnenkrets
sea water circuit
Meerwasserkreis



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Termostat öppen
Thermostat open
Thermostat geöffnet



1061/292

Termostat stängd
Thermostat closed
Thermostat geschlossen

Fig. C2

D Fuel System

1 General

The depression in the suction line of the feed pump, caused by static suction height, flow resistance in the fuel line and possible extra fuel filters must not exceed 0.2 kg/cm^2 (0.2 bar), which must be checked when full output is taken from the engine. On the other hand, if the fuel tank is located higher than the engine injection pump, a shut-off valve should be provided in the fuel line to the feed pump; the line should be closed when the operation is interrupted. The maximum fuel level in relation to the feed pump must not exceed 3.5 m. In those cases where a greater difference in level may be required for technical installation reasons, the circumstances should first be discussed with AB Scania-Vabis, Engine Sales Department. The fuel pipes should, if possible, consist of steel tubes, connected to the engine with flexible couplings to prevent the fuel pipes from being exposed to breaking stresses. This applies particularly to flexible engine suspension. AB Scania-Vabis supply flexible hoses for this purpose. Such a hose of classed design, part No. 171238, is a tight folded steel hose braided with steel wire. It must not be bent more than 90° , and the bending radius must not be less than 115 mm. The fuel supply line to the engine should have an inner diameter of at least 8 mm with lengths up to 8 metres. Should the suction line be longer, a proportionally larger dimension is required. The fuel supply line should be placed in such a way that the fuel is not heated up noticeable by sources of radiation which may exist in the engine room.

In cases of operation where there is risk of water getting into the fuel, a water separating fuel filter should be fitted. When the demand for operational safety is particularly great (e.g. in marine installations), it is advisable in addition to fit extra fuel filters of reversible type to be connected in the line between the water separating filter and engine. On engine installations liable to be subjected to low ambient temperatures an extra fuel filter should, if possible, be fitted in the neighbourhood of the engine so that radiation heat from the engine will warm up the filter somewhat and prevent the risk of freezing in it. N.B. The fuel filters fitted as standard on the engine are not replaced by the above mentioned extra fuel filters. The return line from the overflow valve should be drawn to the fuel tank and must not be connected up to the suction line. The return line should have the same dimension as the suction line.

The fuel tanks should be manufactured of steel plate. The tanks shall be welded and, if so required, provided with baffle plates. Moreover, they should be provided with sludge and water separators with drain cock so that sludge and water which has sunk to the bottom of the fuel tank can be drained away. The fuel line from the tank should project up roughly 5 cm above the bottom of the tank, and in the upper part of the tank there should be a connection to outer air, e.g. through a special ventilation pipe or through a ventilation hole in the filler cap. Large tanks should be provided with openings in order to make it possible to carry out inside cleaning.

After manufacture the tanks shall be carefully cleaned and, if necessary, pressure tested. Afterwards, it is advisable to anti-rust-treat the tanks on the inside with a water repellent oil. An appropriate oil is supplied by the majority of oil Companies. Comply with the Oil Company recommendations when applying the oil. The tanks should be painted on the outside with a protective colour. N.B. The tanks must not be painted on the inside. They must not be galvanized either.

E Electrical System

1 General

The electrical system must always be of bipolar design for marine engines. There is a great deal of risk of galvanic damages etc. when unipolar design is used. The nominal voltage of the system is 24 V. The operating voltage may amount to 28 V making it necessary to use bulbs designed for this voltage.

2 Batteries

The type of battery usually used is lead batteries of type "storage battery", which are capable of supplying considerable current intensity during a short period. In some cases, Nife batteries are installed (alkaline). If lead batteries are used, it is possible to connect two 12 V batteries in series. Nife batteries are to contain minimum 18 cells in order to supply a voltage of 24 V.

In those cases where lead batteries are to be used, we recommend that these batteries should have a minimum capacity of 133 Ah (ampere-hours) and supply a short circuit current of approximately 1000 A. This is necessary to start an engine which has been exposed to very low temperatures. If the capacity of the battery is too small, the starting power may be insufficient and the battery overloaded.

N.B. If the engine is provided with an alternator, the master switch, if any, must not be put off or the battery disconnected when the engine is in operation, as peak voltages can then occur and damage alternator parts.

3 Battery Charging Regulator

a) General

The battery charging regulator should be protected against water, oil, and other liquids as well as against mechanical damage.

b) Charging Regulator for Direct Current Generator

The charging regulator should be mounted perpendicularly and protected against vibrations (e.g. by rubber suspension). At the time of delivery the battery charging regulator is set for the charging of 12-cell lead batteries of storage battery type. If other types of batteries are to be used, e.g. Nife batteries (alkaline), the setting of the battery charging regulator must be changed. This can be executed by the nearest agent for the manufacturer of the charging regulator.

c) Charging Regulator for Bosch Alternator

The ambient temperature for this regulator must not exceed 60°C. This means that it must not be fitted on the engine block or in any other place where the heat from the engine can be transmitted to the regulator. Take particular care when connecting up, because a faulty connection or short circuit can damage the regulator.

The battery charging regulator is set for charging 12-cell lead batteries of storage battery type, and for charging 18-cell Nife (alkaline) batteries. If batteries with a different voltage are used, a special battery charging regulator must be ordered from Robert Bosch GMBH, Stuttgart, Germany.

d) Battery Charging Regulator for Special Engine Installations

In certain installations, where the batteries are only used for starting, instrument lighting and similar, the batteries can easily be overcharged. In order to prevent this from happening a battery charging regulator for D.C. generator can be modified by the nearest agent for the battery regulator manufacturer so that the generator will give lower voltage.

regulator for Bosch alternator cannot be modified in the corresponding manner; therefore, in such cases, two or several 35 W bulbs must be connected in behind the master switch. A convenient connection point is at position 10 in Fig. E2. The bulbs must not be connected in on the lines between regulator and generator.

4 Starting Block Relay

In multi-engine plants where the engines are started up from a control position outside the engine room, or where for instance on account of other machine noise it is difficult to decide whether an engine is operating or not, one should, in order to obtain increased safety, fit a starter blocking relay, which makes it impossible to engage the starting motor to an engine that is already in motion.

5 Wires

All wires except those of the starting motor and the generator should be joined to one terminal block. From the terminal block, which should be mounted in a location protected against water and oil, the wires are to be mounted together and marked. Secure the wires by means of clips in a proper manner. Furthermore, the wires should be led over from the engine at the bottom where the movements of the engine are smallest. This is specially important in connection with flexible rubber suspension.

The starting motor wire section in mm² is shown by the table below. Note that it is the total length of positive and negative wires that is to be considered when deciding the cable section. The minimum permissible wire section is 50 mm².

Length, m	Section, mm ²
up to 2	50
" " 3,5	70
" " 5	95
" " 7	120
" " 9	2 x 70
" " 12	2 x 95
" " 17	2 x 120

Locate the wires so that they are not subjected to wear or damages of any other sort.

6 Master Switches and Fuses

Between the batteries and starting motor a master switch should in general be fitted. With a bipolar electrical system two isolating switches are required: one on the positive cable and the other on the negative cable. With a unipolar electrical system one master switch is required, which is conveniently connected up on the negative cable. Furthermore, the electrical system shall be protected by fuses (regarding alternator, compare the section about "Fusing up Charging Circuits"). Both the master switches and main fuses, if any, must be fitted as close to the battery as possible. Fig. E1 and E2 show basically how the wiring should be carried out. A detailed wiring diagram will accompany each separately delivered engine.

7 Radio Interference Suppression of Electrical Equipment for Marine Engines

Of the electrical equipment which usually follows with our engines it is only the direct current generator and its charging regulator that are responsible for generating such disturbances that measures must be taken in order to

screen sleeves etc. in suitable places or also by taking both these measures simultaneously.

Bosch alternator is as standard provided with an interference suppression condenser, and for this reason it is only necessary in exceptional cases to take additional precautions.

8 Parallel Operation with Electrical Generators

Very often with multi-engine plants it is desirable to make the charging generators on two or more engines charge one and the same battery. With the Bosch alternators and charging regulators which are usually used there is no need for any additional arrangement to be made. With direct current generators it is necessary to check the following:

a) Generators with the Same Output

I The Generators are to be Loaded as Evenly as Possible

This is attained by using charging regulators with compensating windings and interconnecting these compensating windings on charging regulators for the generators which shall charge the same battery. The compensating winding connections are on Bosch regulators marked 44, and on C.A.V. regulators, BAL. The wires from the charging regulator connections B+ and B- to the battery are conveniently drawn to two connection joints near the battery. These connection joints must be located from the electrical point of view, exactly symmetrical, in relation to respective charging regulators, so that the resistance will be equal in all the positive wires in relation to one another. In order that satisfactory compensating effect shall be attained the positive wires must in addition (from B+ on the charging regulator to the connection joint) be so finely dimensioned that a voltage drop of at least 1% is obtained at nominal charging current, but the total voltage drop in the wires from the charging regulator via the connection joint to the battery and back again must not exceed 0.6 V with nominal charging current.

II Possible Disconnection of a Stationary Generator

The best way to carry out disconnection of a stationary generator is by connecting in a standstill switch in the circuit. This switch is as a rule built into the charging regulator.

b) Generators with Different Output

Different-size generators can also be used in parallel operation if the same method is utilized as in parallel operation with equally large generators. It is then essential that the voltage drop in all positive wires is the same and amounts to at least 1% (=0.24 V) with nominal charging current. This implies that the respective wire resistance must be inversely proportional to the nominal charging current intensity of the attached generators.

9 Electrical Welding

When carrying out electrical welding close to an engine with alternator the wires between alternator and battery, and between alternator and charging regulator, should be disconnected.

10 Protection Equipment for Bosch Alternators

As shown, the alternator must only be operated with charging regulator and battery connected, otherwise damages can occur on rectifiers and regulator. Involuntary interruption, in certain circuits, through cable fractures, loose cable terminals etc. have the same effect; therefore the alternator manufacturer has produced protection equipment which can be used when judged to be desirable:

a) Protection against Excess Voltages

The alternating current plant is sensitive to high excess voltages; there is then risk of damages occurring on transistors and rectifier diodes. Already under normal conditions, for instance when electrical users of an inductive type (e.g. relays) are connected or disconnected, inductive voltage peaks arise in the system which may result in damages to the diodes and transistors. Because of this the standard-delivered alternator of make Bosch is equipped with a condense as protection against such voltage peaks. The condense, in addition, serves to suppress radio interference.

The total capacity of the condense is however insufficient for high voltage peaks, which may appear if for instance the master switch should cut out or a cable break so that the alternator becomes separated from the battery during operation. The same conditions will occur if the user should be connected and disconnected at a relatively high load and high alternator speed without the battery being joined to the circuit. Excess voltages of this size are however damped down to a non-dangerous level, if an excess voltage protector Bosch type RS7/1H3 (ordering No. Bosch 0 192 900 001, SV 197809) is connected to the alternator. The wiring shall be carried out according to diagram E3. The connection circuits between the protection unit and alternator shall be as short as possible, and the cable section should be maximum $1\frac{1}{2}$ mm². For the cable joints to D+ and D- on the excess voltage protector a flat plug box is required (ordering No. Bosch 2 124 485 400, SV 197810) together with two flat plug sleeves (ordering No. Bosch 1 351 355 810, SV 179847).

b) Protection against Disconnection of Battery during Operation

In order to prevent the battery from becoming disconnected with the engine functioning an auxiliary relay can be connected up (ordering No. Bosch 0 332 003 012, SV 137691) via the master switch according to diagram E4. The relay coil is energized as soon as the alternator charges, so that the circuit from 30/51 to 87 is closed and the battery is consequently connected to the alternator even if the master switch is cut out. In a bipolar system with isolating switches in both positive and negative circuits a relay is connected via each isolating switch section, and the relay terminal 85 is connected to terminal B-/D- on the alternator. Instead of two relays of the type indicated, it is possible to use one relay with two closing contacts with corresponding loading capacity.

c) Protection against Polarity Faults

If the battery in conjunction with fitting, is connected up incorrectly, so that the battery cables are mixed up, there is also risk of damages. However, this risk can be prevented through installation of a polarity protector. In a plant with an ordinary battery master switch a special type quickly reacting fuse can be used, which shall be connected up in series on the positive cable close to the terminal B+ on the alternator and which is fixed on an insulated base. The fuse has SV part No. 197815 for the 35 A alternator and SV part No. 197816 for the 60 A alternator. See also under heading "Electromagnetic Master Switch" below.

d) Electromagnetic Master Switch

Instead of battery master switches of conventional type, a battery relay can be used. This is best characterized as an electromagnetic master switch which permits, instead of "the polarity fusing", to connect up a blocking diode as polarity protection. The battery relay is operated with the switch for instrumentation and supervision so that the battery is disconnected as soon as the switch is set in the off-position. The connecting up of the battery relay in a unipolar system shall be carried out accor-

Bosch O 332 003 012, SV 137691) which prevents the battery being disconnected while the alternator is still charging. The blocking diode has ordering No. Bosch 1 337 320 001, SV 197812.

In a bipolar system, where the demand is both for positive and negative connections on the battery to be disconnected a doubling up of the equipment will be necessary, i.e. two battery relays (ordering No. Bosch O 333 301 009, SV 197811), two blocking diodes (ordering No. Bosch 1 337 320 001, SV 197812), and two relays (ordering No. Bosch O 332 003 012, SV 137691). The latter can be replaced by a relay with two closing contacts. The wiring will be as shown in diagram E6.

In the coil of the battery relay the amperage of the working current is 4.5 A, and that of holding current, 0.3 A. The main contacts can be loaded with 200 A continuously and 2.500 A during one second.

In the operating circuit, to terminal 86 on the battery relay, the voltage drop must not exceed 0.5 V; for this reason the cable section must be at least 0.47 l mm^2 , when the cable length is $l \text{ m}$.

11 Fusing up Charging Circuits

For fusing up the circuits where an interruption would lead to such consequences as dwelt upon above, Bosch advise against the use of ordinary fuses of motor vehicle type, which are secured with spring force. Instead, Bosch have produced special fuse boxes which contain two fuses of leaf type which are screwed up. Other fuse types where the fuse is screwed up, e.g. Diazed fuses, can also naturally be used.

The Bosch fuse box with two 50 A fuses, which are suitable for 35 A generator has type reference VM 30/1D34 (ordering No. Bosch O 354 120 004, SV 197813), inclusive of fuses. The corresponding box with two 80 A fuses for 60 A generator has type reference VM 30/1D30 (ordering No. Bosch O 354 120 005, SV 197814). The spare fuses have ordering No. 1 191 017 005 (SV 193538) for 50 A and 1 191 017 003 (SV 192616) for 80 A.

Text for Figs. to E1, E2, E3, E4, E5, and E6

1 Generator	7 Discharge warning lamp	12 To instruments
2 Charging regulator	8 Battery relay	13 To ammeter, if any
3 Battery	9 Block diode	14 Overvoltage protection
4 Master switch	10 To extra current user	15 Main fuses
5 Starting motor	11 Starting switch	16 Fuses
6 Relay		17 Operational selector switch

Remarks: On illustration E3 the master switch is not drawn.

Compressed Air System

The need of compressed air for the engine installation arises in the first place where the compressed air starting motor and/or pneumatic operation of speed control and declutching in power transmission is used. As conditions for these requirements can vary considerably for different installations, contact should be made from case to case with AB Scania-Vabis Engine Sales Department for closer information about size required, design and location of compressed air receiver, operating cylinders, pressure reducing valves, cut-off valves, condensation water separator etc.

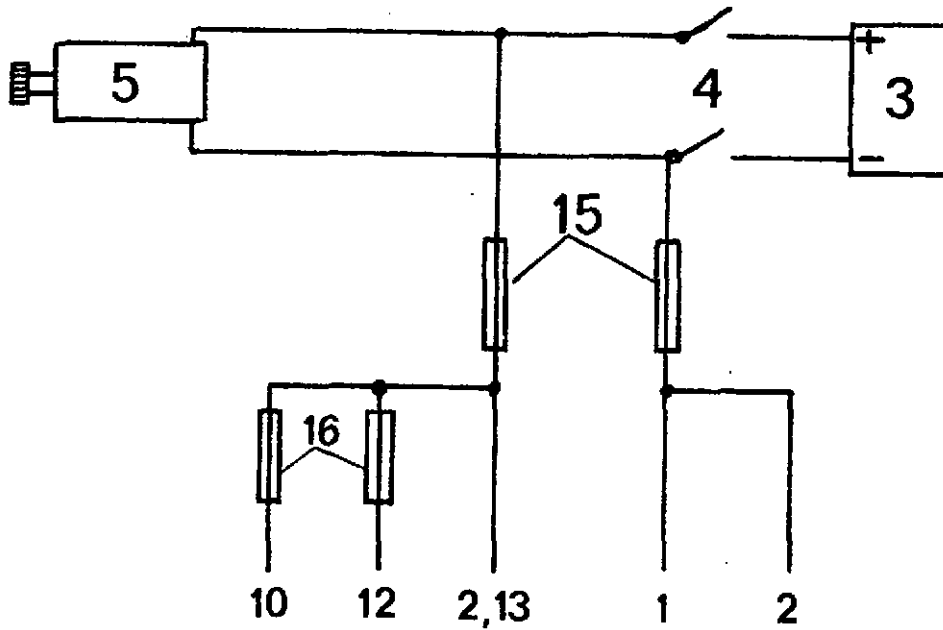


Fig. E1

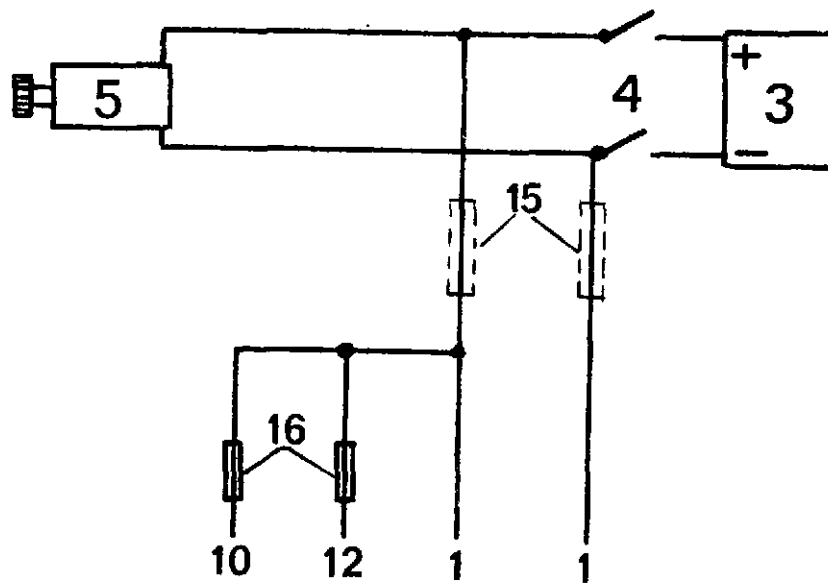


Fig. E2

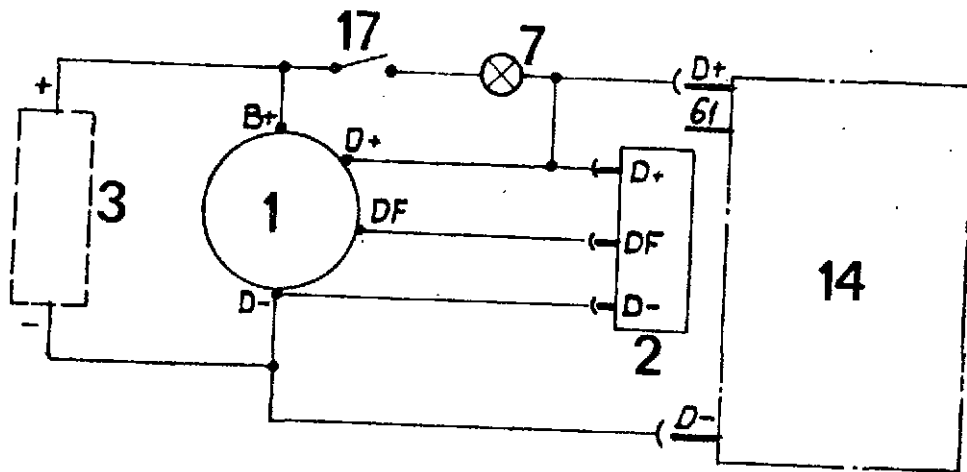


Fig. E3

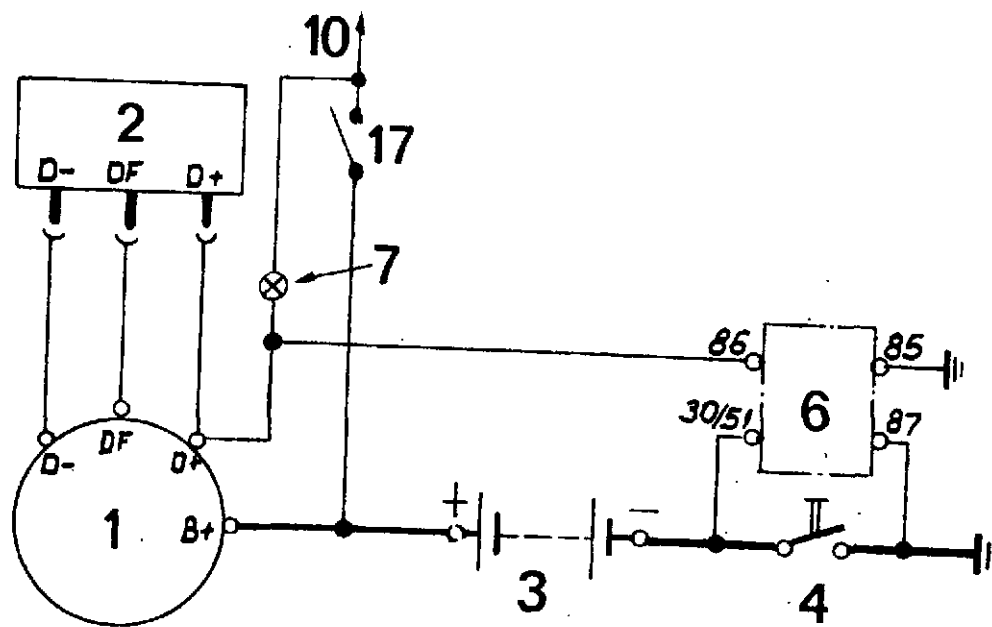


Fig. E4

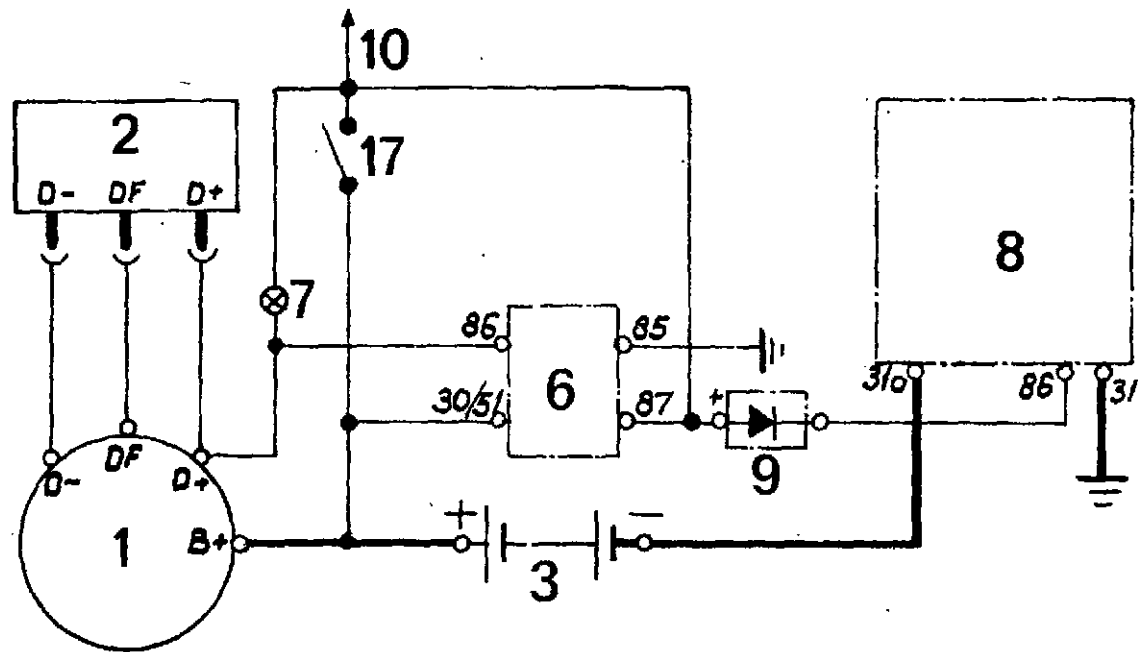
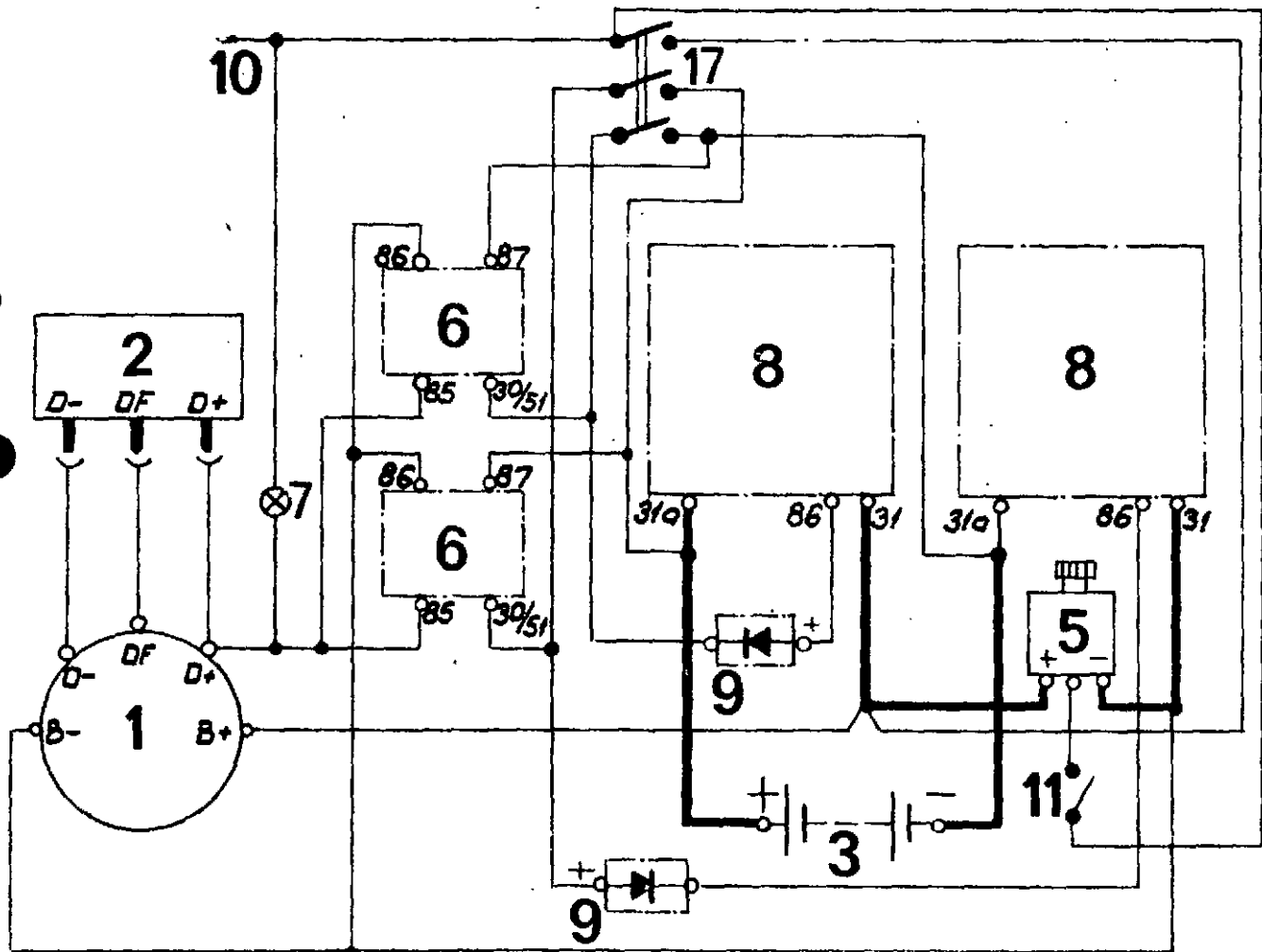


Fig. 35



F Engine Suspension

The appropriate design of engine suspension varies for different engine installations. However, generally speaking the following requirements shall be noted:

- 1 The engine suspension shall be designed for the forces, both continuous and instantaneous, it is subjected to during operation, i.e. reaction forces from the torque transmitted, in certain cases acceleration and retardation forces, reactional forces in the longitudinal direction of the engine (e.g. from propellers in marine operation where the propeller thrust is not taken up in any other way), etc.
- 2 The engine suspension and the engine bed shall be so designed that resonance vibrations do not arise within the engine r.p.m. range. They must also be so constituted that troublesome vibrations from the engine are not transmitted to the surrounding area.
- 3 The engine suspension shall be adjustable where great demands are placed on centring between engine and the unit coupled to the engine (e.g. propeller shaft).
- 4 The engine suspension and engine bed must be designed with consideration to permissible sloping angles of the engine. Max. permissible sloping in longitudinal direction for D5 and the D8 series is 12° and for the D11-series, 10° .
- 5 The engine suspension and engine bed must be designed with consideration to accessibility for service work to come (free space for e.g. oil sump removal must be available). See the section "Engine installation from the Service Point of View".

AB Scania-Vabis supply as standard three different designs of engine suspensions mentioned below:

- a) Flexible Rubber Suspension
- b) Hard Rubber Suspension
- c) Rigid Suspension

- a) Flexible Rubber Suspension gives effective vibration dampening. It can to a certain extent take up the forces in the longitudinal and transverse directions but does not permit accurate alignment of the engine. It has with these characteristics been used considerably in vehicle installations, generating sets and corresponding applications. Fig. F1.
- b) Hard Rubber Suspension dampens the vibrations to a smaller extent than the flexible suspension, but cannot on the other hand absorb great forces in the longitudinal and transverse directions of the engine. It is therefore used quite often for instance in marine operation with medium reaction forces from the propeller (corresponding reductions down to 3:1 in reverse gear and reduction gears). Fig. F2.
- c) Rigid Suspension can absorb greater forces in all directions. It permits a very accurate alignment of the engine and does not place any appreciable demands on the flexibility of the conduits and controls connected to the engine. It should only be used when circumstances make such a suspension desirable and if the vibrations do not cause any greater inconveniences. However, the vibrations can be relatively small even on a rigid suspension, if the mass represented by the engine bed and direct attached parts is large in relation to that of the engine (ratio 20:1 and above). Fig. F3.

Text for Fig. F3

A = Spacer for alignment of engine

Engine Alignment

1 General

Considerable attention should be devoted to the alignment of the engine in order that costly operational disturbances shall be avoided. On propeller engine installations alignment can take place even if the boat is ashore. However the alignment should be checked after the launching of the vessel; at the beginning of operation, for instance running in high sea can cause such settlements in the vessel that the previous alignment must be altered. In more special operational cases, it may be advisable, even in future, to check the alignment from time to time.

As means of assistance when aligning, a dial indicator, feeler gauge, set-squares and rules, can be used.

2 Alignment of Drive Shaft with Rigid Coupling

When carrying out alignment the best rule is to proceed from the driven shaft. However, first of all check to see that the shaft is straight. The best way to make sure of this is to use a dial indicator.

Check the relative positions of driving and driven shafts:

If the shafts are provided with flanges, this check is conveniently carried out by putting the flanges in contact with one another so that the guide edge of one flange fits in the corresponding guide hole of the other flange. After this, a dial indicator is fixed onto one of the flanges and the indicator applied against the other flange as fig. F4 shows. When checking, the shafts shall be rotated simultaneously. (This is simplified, if, by way of suggestion a retaining screw is screwed in through a screw hole in the flanges; however, the screw must not be tightened up). When afterwards the shafts are rotated, the total deflection is read off on the dial indicator, the value of which shows maximum deviation. Afterwards, apply the dial indicator as illustration F5 shows and repeat the measuring procedure in the same way.

Text for Figs. F4 and F5

1 Flanges 2 Dial indicator

If it is a question of a relatively long shaft, consideration must be taken to the deflection of the shaft on account of its own weight.

The mentioned check of the angle deviation between the shaft centre lines, can also be carried out with the aid of feeler gauge, with which the distance is measured between the flange surfaces on the outer edge.

If a split coupling is used and both the shaft ends are free when alignment is made, this can also be carried out with aid of dial indicator which is applied as fig. F6 shows. The dial indicator should be applied and a check made in two different places with at least a 200 mm space from one another. Both the shafts are rotated simultaneously when the total deflection on the indicator is read off.

This check can also be carried out with aid of set-squares, feeler gauge, gauge blocks and rules (Fig. F7).

Permissible deviations:

The required accuracy of the alignment varies, depending on the design of the installation, in respect of power transmission, propeller shaft, etc. However, generally speaking as great accuracy as possible should be aimed at. As a rule, a greater total indicator deflection should not be permitted, when measuring according to the illustrations F4, F5 or F7, than 0.10 mm.

3 Alignment of Driving Shaft with Flexible Coupling

When aligning the shafts, proceed in the same manner as described under "2 Alignment of Drive Shaft with Rigid Coupling".

Permissible deviations for single flexible coupling, type Layrub, "two four series":

Maximum permanent angel between driving and the driven shaft	3.5°
Maximum instantaneous angle between driving and the driven shaft	8.0°
Maximum permanent axial displacement at maximum permanent angle	3.17 mm
Maximum instantaneous axial displacement at maximum instantaneous angle	7.90 mm
Maximum permanent radial displacement	0.38 mm

Where the subject coupling is in double design, the above mentioned limits must be multiplied by two.

N.B. Notwithstanding the fact that relatively large deviations are permissible according to the above, it is still advisable to aim at as great an accuracy of alignment as is reasonable, which has a favourable influence on the life of the coupling.

Remarks: After aligning the engine, it is recommended to lock its position with aid of guide pins. Holes for guide pins are to be drilled through two diametrically opposed engine brackets and suspension brackets. Appropriate diameter of guide pin is approx. 9 mm.

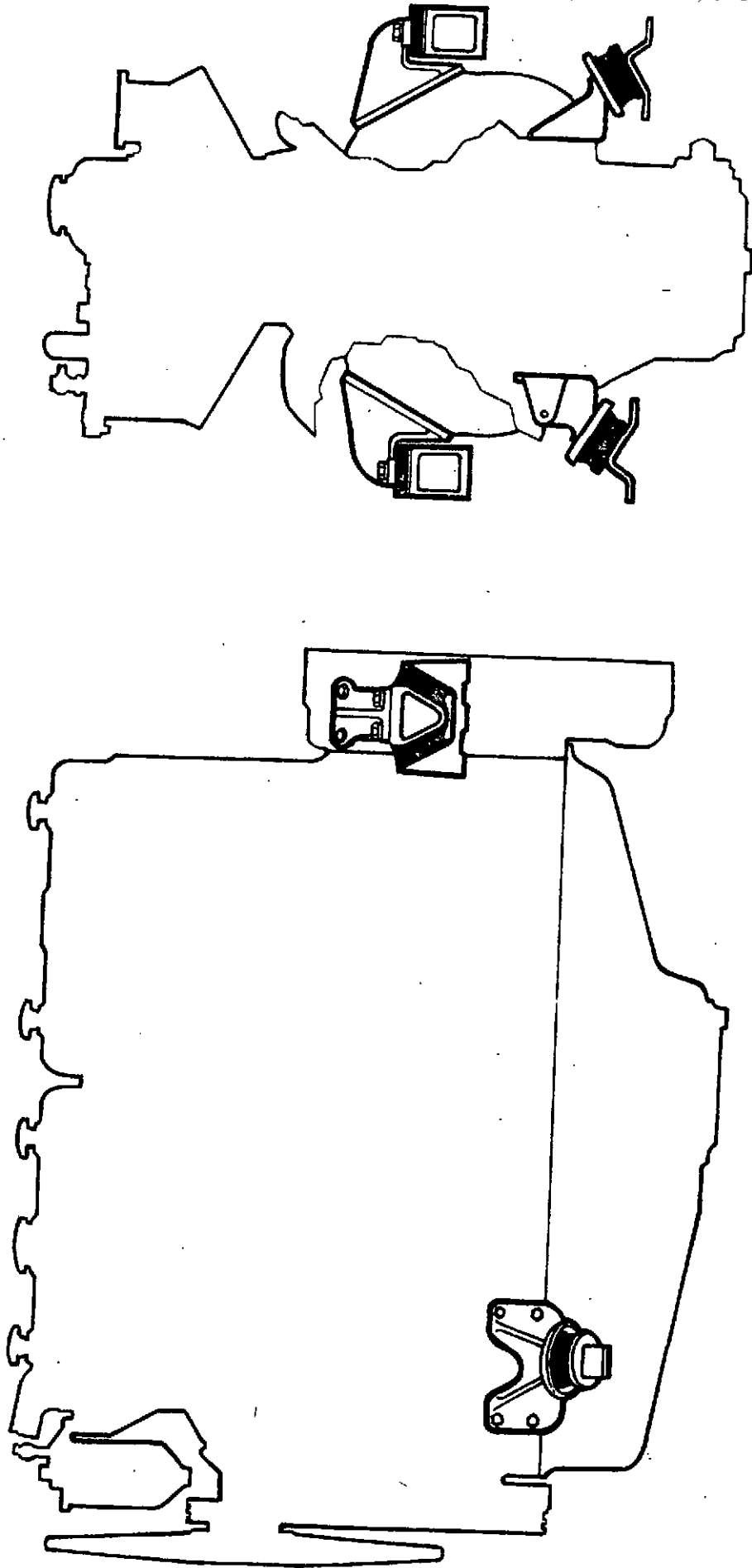


Fig. P1

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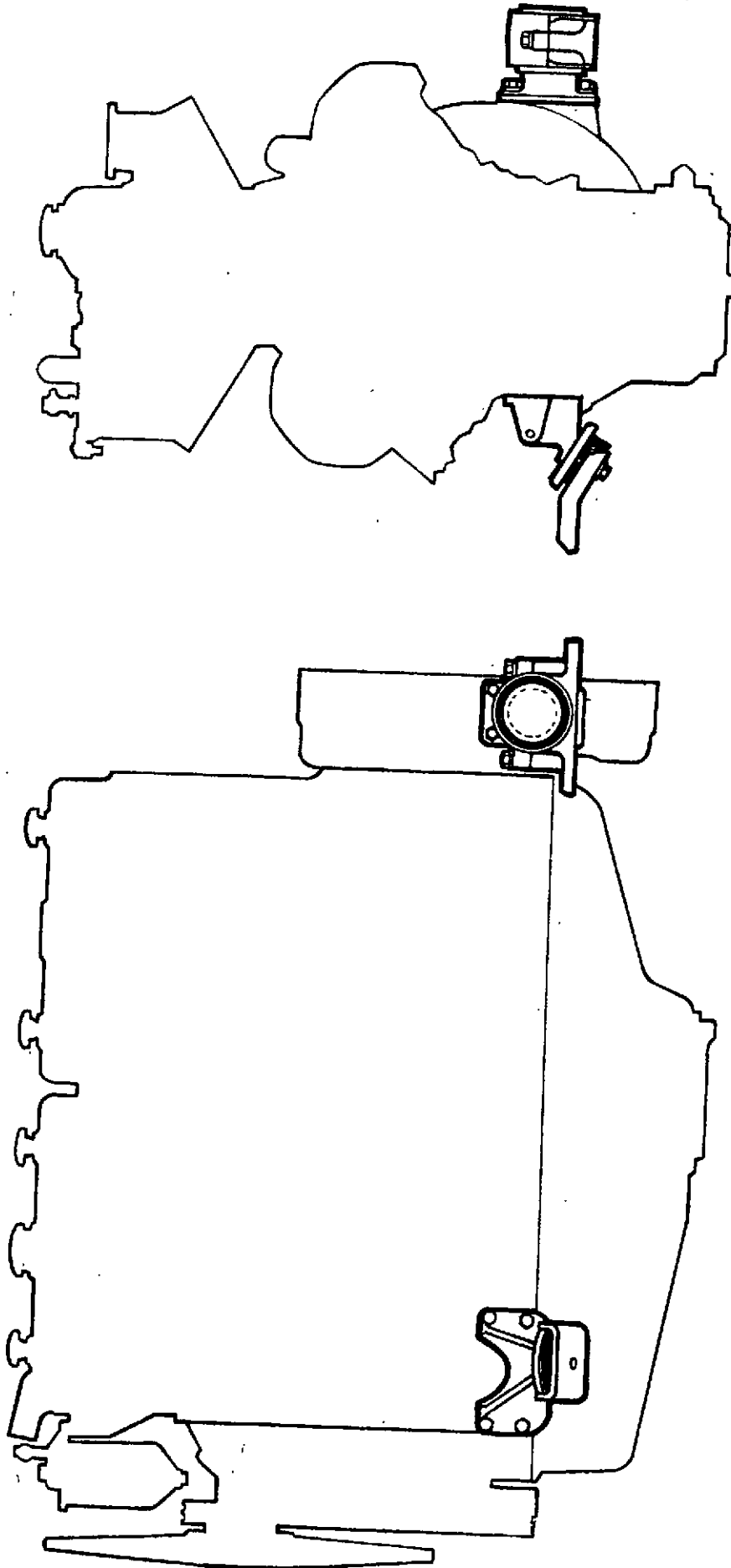
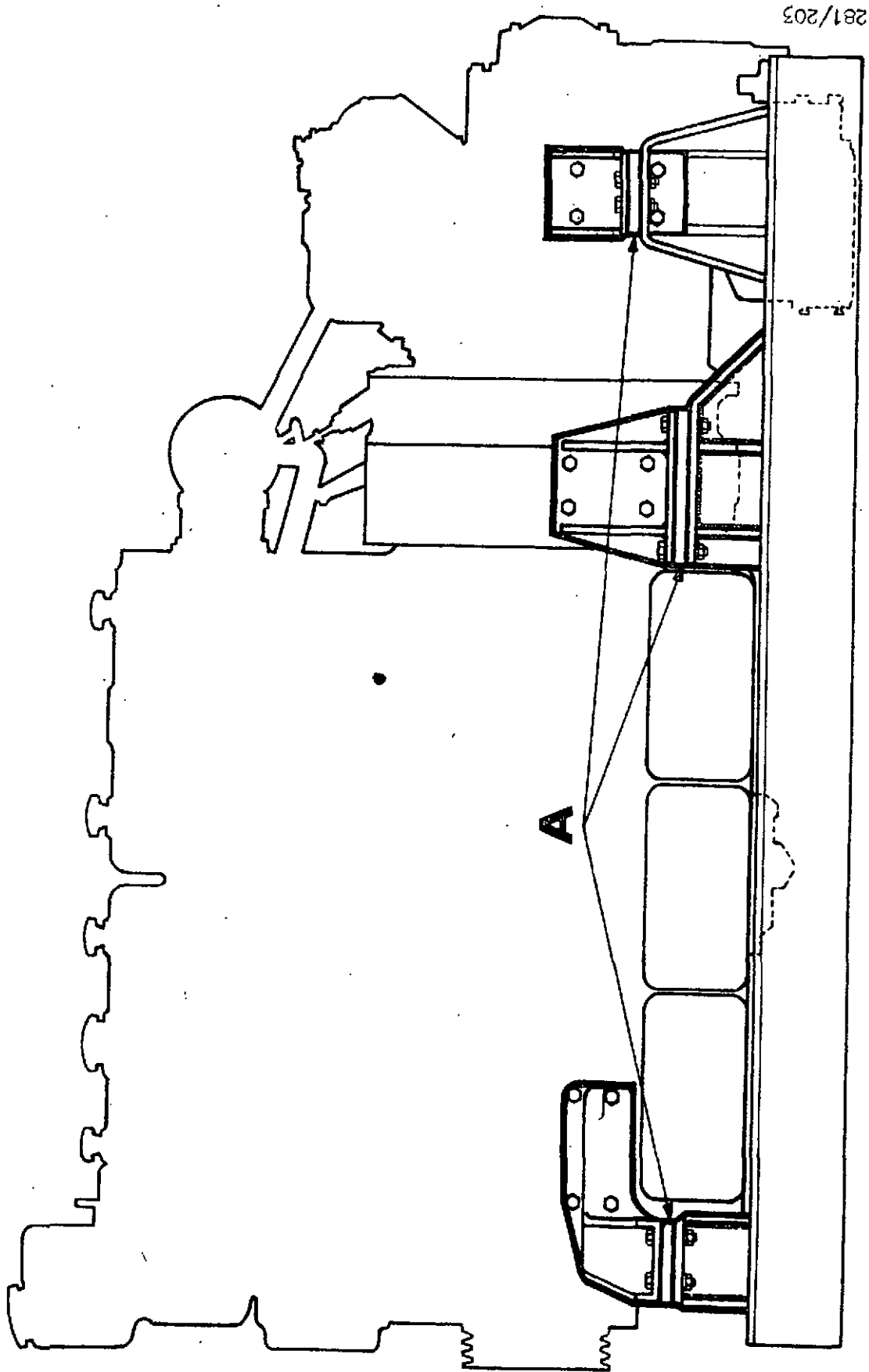


FIG. P2



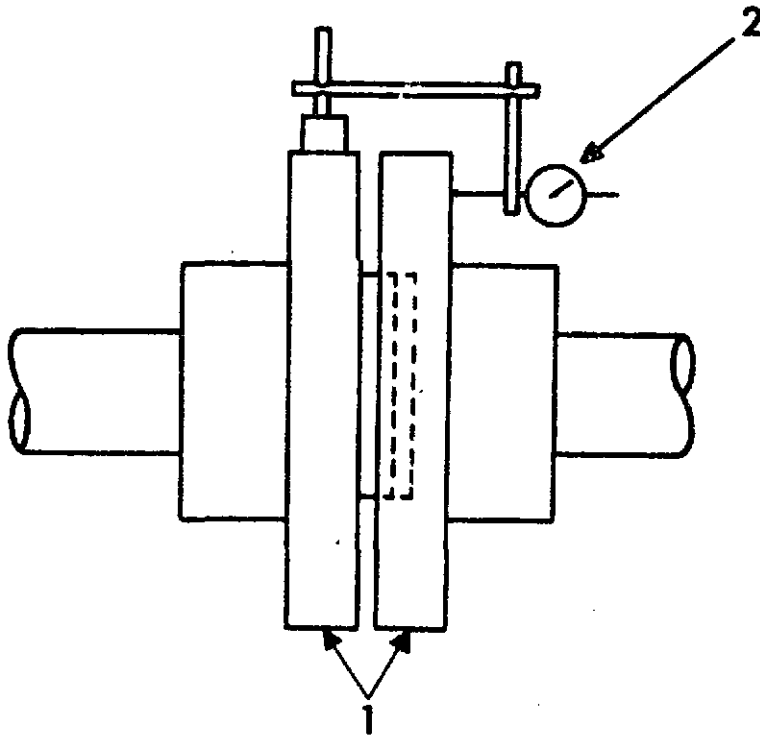


Fig. F4

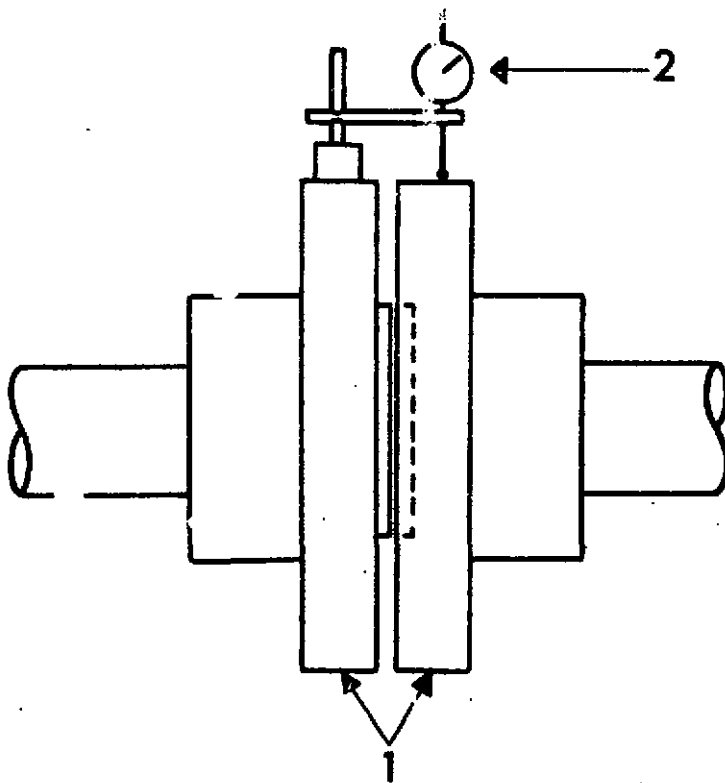


Fig. F5

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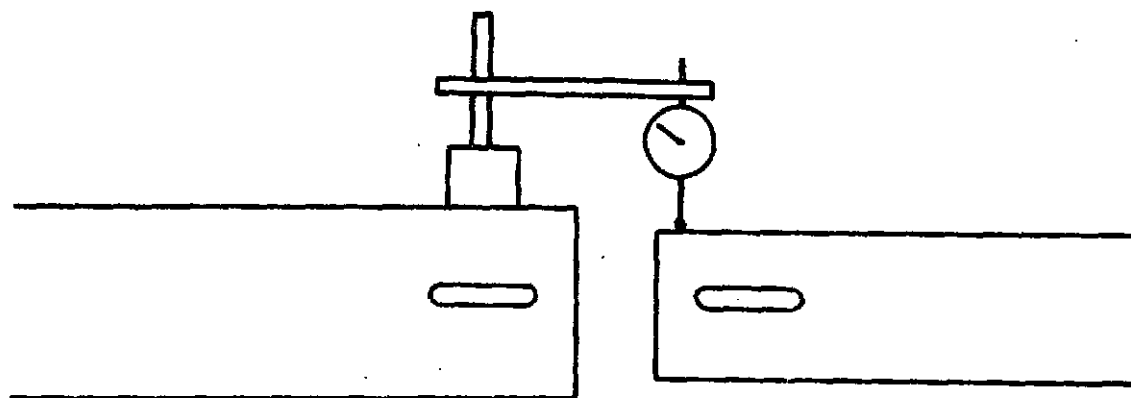


Fig. F6

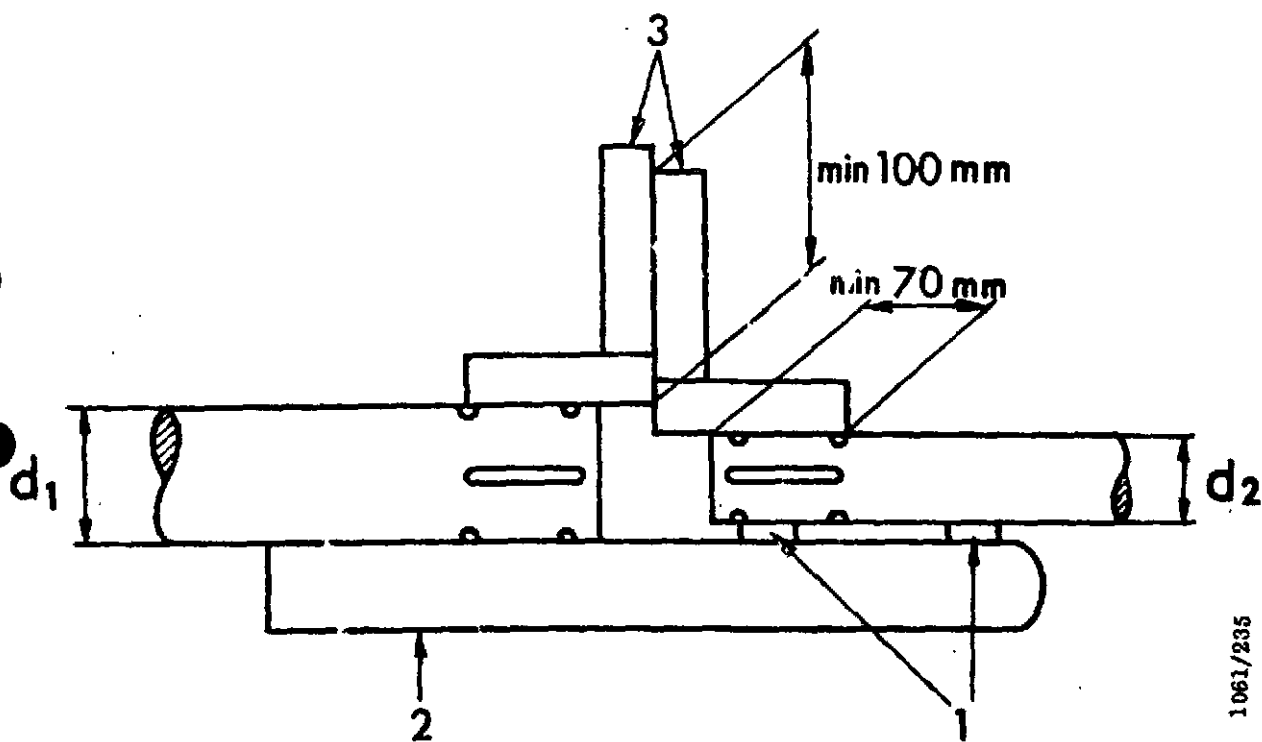


Fig. F7

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G Operating Control

The operating and r.p.m. controls should be of a reliable and simple design and permit accurate operation, so that the set control arm position is not altered by clearance, wear or the possible movements of engine in the suspension. The control lever movement stroke should be somewhat greater than that of the control arm. The resulting excess movement of the control lever should be taken up by a spring loaded link yoke in both the directions. The link yoke and possible remaining links should be adjustable in both the directions.

The angle between link yoke and control arm, in its centre position of movement stroke should be approx. 90° . Where the conditions do not permit such an angle with the standard control arm fitted, this can be provided with a plate as illustration G1 shows and the link connected to an appropriate hole in the plate.

The control designs normally used are:

- a) Teleflex control
 - b) Mechanical link age
 - c) Mechanical-hydraulic control
 - d) Electromechanical control (Billman control motor)
 - e) Pneumatic control
- a) Teleflex control can be used for all kinds of engine suspensions and is particularly well suited on flexible rubber suspension. Suitable dimension is $5/16"$, and the length of the installation can with the mentioned dimension amount to 40 metres. Detailed assembly instructions accompany each Teleflex control delivered.
- b) Mechanical link age is used on hard rubber suspension or rigid suspension. The operation links must not be bent and should be completely free from vibrations with aid of bearing points. These should preferably permit lubrication and, should be located as far away as possible from exhaust pipe and other sources of radiation, so that seizure is avoided. In order to obtain a somewhat larger movement stroke of the control lever than that of the control arm, the angle arms can be constructed with adjustable radii (see illustration G2). These angle arms also permit synchronization of the control setting on e.g. installations with two or more engines.
- c) "Sequent Control", which is included in a design of mechanical-hydraulic control, is used on marine engines with hydraulic reverse gear of make S.C.G. The advantages with this, among other things, is that it is possible to operate the machinery, i.e. clutch and r.p.m. setting, with one control only, e.g. of Teleflex type. The device mentioned, which is fitted on the reverse gear, consists of two parts; a hydraulic valve and an operating cylinder. The hydraulic valve which is actuated by the control power from the bridge, distributes oil from the reverse gear, which is under pressure, to either forward, neutral or reverse clutches in the reverse gear so that the desired clutch is applied. At the same time the oil is distributed to the operating cylinder which in turn actuates the control arm on the injection pump via a link rod.
- d) Electricomechanical control (Billman control motor) is sometimes used on generating set installations for remote control of the r.p.m. (the frequency) and synchronization of generating units in parallel operation, respectively. The control motor, which is fitted on a bracket onto the flywheel housing, is operated by means of electricity and actuates the control arm on the injection pump via a rack and a link rod. The control motor is intended for an operating voltage of 24 V, frequency 50 Hz.
- e) Pneumatic control has shown itself to be particularly advantageous on certain

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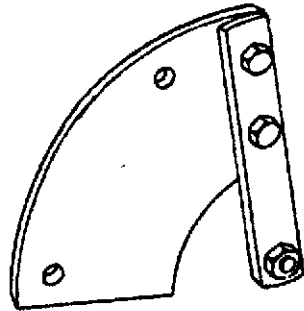


Fig. G1

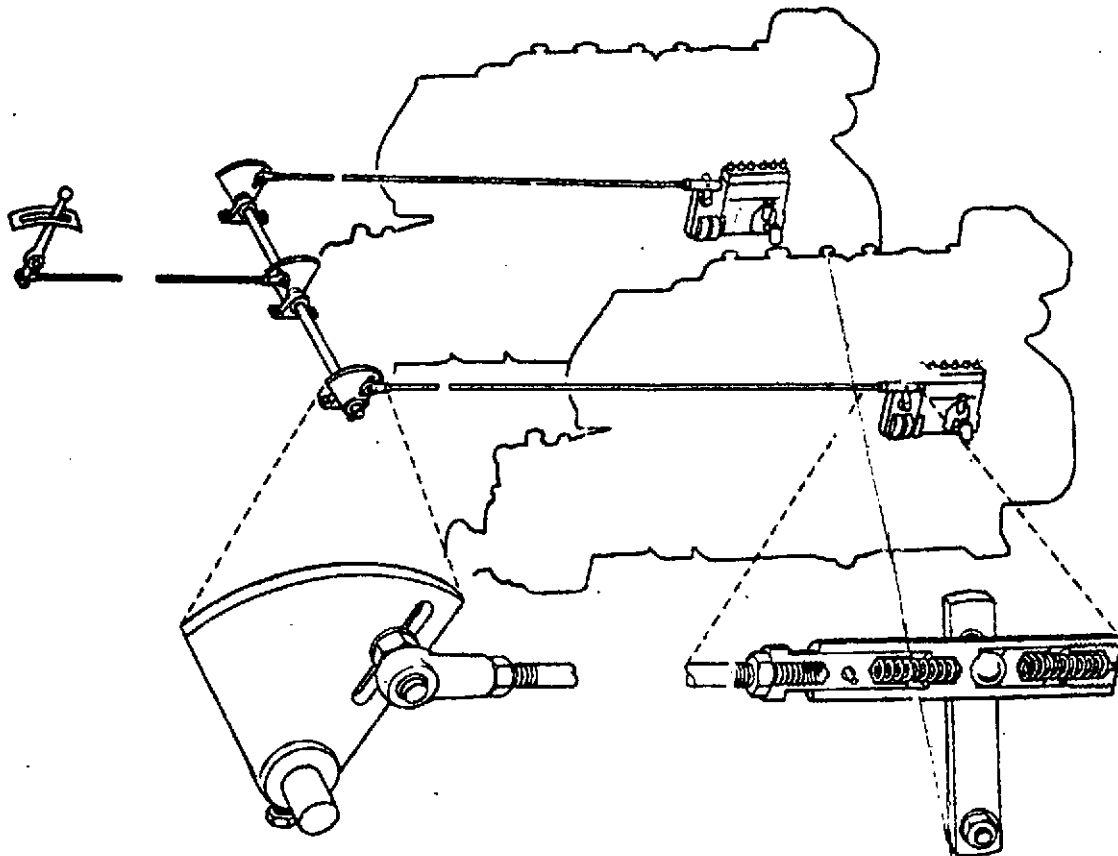


Fig. G2

H Power Transmission - Power Take-off

1 Power Transmission

The transmission of the engine torque takes place via a friction clutch which is fitted on the engine (with the exception of generating sets). For this type of clutch different designs of power transmissions can be coupled up, depending on the need in the case of operation concerned.

Friction Clutches

Two different designs of friction clutches are available as standard; partly a vehicle clutch with single friction disc and partly an industrial clutch. They vary in the first place by the industrial clutch having larger capacity (dimensioned in order to convert more friction work) than the vehicle clutch. The demand for larger clutch capacity arises with great torque of starting for the power transmission (transmission shafts and V-belt pulleys with considerable inertia moment. Thus, in conjunction with such installations the relation between clutch capacity and starting up work for the driven components coupled to the power transmission shall be judged against the background of clutch operation frequency, clutch life, etc.

The vehicle clutch will ordinarily be used on engines where a stepped-gear transmission of conventional type is used. The industrial clutch is mainly used on marine propeller engines and industrial engines.

In installations where clutch designs other than those mentioned are used, e.g. hydrodynamic clutch (fluid Clutch), possible additional instructions for the installation should be obtained from the clutch supplier.

Flexible Drive Coupling

The use of flexible coupling with coupling flange on the output drive shaft, should be considered in cases where increased flexibility in the power transmission is necessary for balancing out variations in the engine torque. The flexible coupling will often only be motivated as a means of assistance to compensate torsional vibrations in the power transmission. Therefore, the flexible coupling design recommended on account of torsional vibration calculation must not be replaced by a coupling with any other torsion spring constant.

A further advantage with this coupling is that the need for alignment accuracy between driving and the driven shaft is reduced.

Power Transmission Types

Mechanical power transmissions, such as stepped-gear transmission, reduction gear reverse gear etc., are mostly used for single engine installations. Choice of such power transmission is made firstly against the background of maximum engine torque and type of operation. For multi-engine installations, especially in respect of propeller engines in vessels or ferries, where two or several engines drive a common propeller shaft, V-belt drives have been put to considerable use during recent years.

The advantage with the V-belt drive is that it is very simple to adapt for suitable gear ratio and, it functions to a certain extent as an flexible coupling, has a quiet action and long life and requires, apart from check of belt tension and alignment, no special attention or maintenance.

For V-belt drive different types of V-belt are available, such as single V-belts and multiple V-belts consisting of 2, 3 or more V-belts joined on a cord band. Choice of V-belt type will be dependent on a number of factors. Closer details about this and assistance when calculating can be obtained

after applying to AB Scania-Vabis Engine Sales Department. On making enquiries about V-belt drives the following particulars should be enclosed:

- a) Output required.
- b) Kind of operation and r.p.m. (e.g. propeller machinery with 375 r.p.m. centrifugal pump with 3,500 r.p.m., 2-cylinder piston compressor with 1,250 r.p.m., etc).
- c) Operational hours per day.
- d) Centre distance required between shafts.
- e) Limits for centre distance between shafts.
- f) Type and size on possible existing pulleys.
- g) Maximum permissible dimension on the large pulley.
- h) Driving shaft journal diameter, length and V-groove dimensions.
- j) The driven shaft journal diameter length and V-groove dimensions.
- k) Conditions which can influence the V-belt life, e.g. oil, dirt and dust, high temperatures, etc.

When manufacturing V-belt pulleys, the requirements of the V-belt supplier for roundness and V-groove tolerances shall be adhered to.

In addition to V-belt of the type mentioned, there is also V-belt of the notched type. An equivalent to V-belt drives is the flatbelt and chain drive.

Torsional Vibrations

The power transmission should be made the subject for calculation of vibrations in those cases where hesitation as to whether such vibrations can arise with the power transmission used. The need for torsional calculation applies especially in marine installations of classed design, because the Classification Societies in general prescribe torsional calculation.

Where the hydrodynamic clutch is used, the engine vibrations are not usually transmitted through it to the power transmission, entailing thus no torsional vibrations.

Assistance with calculation of vibrations can be obtained after applying to AB Scania-Vabis Engine Sales Department. The following basic data for calculation should be sent:

- a) Inertial or vibrational moment for large vibrational masses included in power transmission.
- b) Torsion spring constant for shafts between large vibrational masses (e.g. V-belt pulleys).

Remarks: If replies to the questions 1 and 2 are not available, the power transmission component dimensions and material should be stated.

- c) The ratio on possible speed raising or reduction in relation to the engine r.p.m.
- d) Short description of the driven unit. When this consists of e.g. compressor, propeller or similar, the number of cylinders and number of blades must also be indicated.

Cooling the Transmission Oil

Where there is need to dispose of the excess heat from the power transmission, this must not be realized via the engine cooling system without its being adapted for this purpose. For certain operating conditions, this quantity of heat can be relatively great and will partly motivate consideration being

partly when connecting the power transmission cooling system to the cooling system of the engine.

AB Scania-Vabis will forward in such cases detailed instructions from case to case after application to the Engine Sales Department.

Fitting an Engine provided with Power Transmission Build-up

In those cases where for instance heavy hydraulic power transmission is built on engine before installation, the lifting equipment, when hoisting the unit, should be coupled both to engine and the hydraulic power transmission simultaneously. Otherwise, the engine flywheel housing may be subjected to harmful breaking efforts and the alignment of engine and transmission in the engine foundation is then as a result liable to become defective.

2 Power Take-offs

The engines can be delivered with three different types of power take-offs for driving subsidiary or auxiliary units:

Crankshaft belt pulley with three additional V-grooves at the front end of engine.

Side-fitted power take-off with two connecting possibilities.

Direct connection to the front end of crankshaft.

Crankshaft Belt Pulley with Three Additional V-grooves

The V-grooves in the above mentioned belt pulley are suitable for 12.5 mm (0.5") narrow V-belt, but V-belt of A-profile can also be used. With the V-belt types now available, the V-belts power transmission capacity will be decisive for how much power can be obtained. Follow the V-belt manufacturer's instructions when calculating the transmittable power.

Side-fitted Power Take-offs

This power take-off is located to the left-hand side of the engine, at the front. On the front side of the timing gear housing a hydraulic pump or sea water pump of standard design can then be fitted, the driving from the timing gear taking place via a rubber bushing coupling, and on the rear side of timing gear housing a special bearing housing with power take-off shaft can be fitted (in case the engine in question is not provided with air compressor of standard design). The total available torque and the output forwards and backwards, respectively, amount to:

Maximum Permissible Torque Available, kgm (Nm)

Continuous	10	(98)
Intermittent	15	(147)

Corresponding Output at Engine r.p.m.

	At 1500 r.p.m. h.p. (kW)	At 1800 r.p.m. h.p. (kW)
Continuous	18 (13)	22 (16)
Intermittent	28 (21)	34 (25)

Direct Connection to the Front End of Crankshaft

The transmittable torque and output respectively, when coupling direct to the front end of crankshaft are primarily dependent on which type of engine is used and the type of joint between crankshaft and V-belt pulley to which the driven shaft must be connected.

Torque and Output

Joint between crankshaft and V-belt pulley	Clamp cone joint			Polygon joint
	D5-DS5	D8-DS8	D11-DS11	
Engine type				D11-DS11
Torque, kgm (Nm)	40 (392)	20 (196)	15 (147)	65 (637)
Corresponding output at 1500 r.p.m., h.p. (kW)	84 (62)	42 (31)	31 (23)	135 (100)
Corresponding output at 1800 r.p.m., h.p. (kW)	100 (74)	50 (37)	37 (27)	162 (119)

The limit values presented above imply that it is a matter of driving machines with relatively even torque, e.g. generators, centrifugal, gearwheel or wing pumps, etc. For machines with powerful pulsating torques, e.g. piston pumps or piston compressors with one or two cylinders, a reduction of the permissible torque values, should generally occur in accordance with the corresponding reductions indicated by the manufacturer of V-belted and flexible couplings.

Moreover, it should always be judged to what extent the machines connected will have affect on the torsional vibration characteristics of the crankshaft and the whole of the shaft system. See the previous section regarding calculation of torsional vibrations.

J Multi-engine Installations

The need for a large amount of output is often satisfied by combining several engines in multi-drive. Advantages are thereby obtained in respect of operational safety, service preparedness etc.

When installing the engines it will be, especially in cases where considerable operational safety is required, important to see that the connections of the various engine parts are made as independent of one another as possible so that possible functional defects on one engine do not disturb the operation of the remainder. The instructions given for single engine installations are valid even here to applicable degree. In addition the points of view stated below must in general be observed.

1 Engine Bed

With V-belt drive the engines should be located on guide bars provided with adjusting screws so that they can be moved both laterally as well as longitudinally for alignment and adjustment of the belt tension.

Connections of controls, exhaust lines, coolant lines, fuel lines, etc., must be so designed that they allow the necessary displacement required by V-belt adjustment.

2 Fuel Lines and Cooling Water Lines

Separate fuel lines to the engines must be installed. Additional fuel filter is fitted between fuel tank and engine, and separate fuel filter for each engine is used. In certain cases the possibility of supervising the fuel pressure is to be recommended.

Separate sea water lines to and from the engines should be installed. If it is necessary to have long lines, it may be appropriate to provide a main line, which must then be very carefully made, so that cracks or other defects do not appear in it. When installing sea water cooling a nonreturn valve must sometimes (with low flow resistance) be installed at the sea water outlet for each engine, so that cooling water from an engine in operation cannot circulate through the sea water system of a stationary engine. Separate sea water filter for each engine should be installed. In certain cases the possibility of supervising the sea water pressure is to be recommended. Regarding sea water pump, see section C.

3 Exhaust Line

A separate exhaust line for each engine should be installed. In those cases where this is not possible without the exhaust lines from several engines being combined to a common line, the same recommendations apply in respect of the dimensioning of each branch line as indicated for the exhaust line of single engine installations. The common exhaust line section will be finally dependent on line length, but it shall obviously at least correspond to the total section of the branch lines. A common exhaust line requires an easily operated and effective shut-off device to be fitted in each branch line. This is important in order that exhaust gas from the engine in operation shall not penetrate into a stationary engine and cause corrosion damages, etc.

4 Checking the Degree of Engine Load

Possible output failure with an engine in multi-drive does not make itself known by speed drop of this engine in relation to remaining engines. However, the supervision of the degree of engine load is best obtained through installation for instance of an exhaust temperature gauge. Such supervision possibly can, however, be superfluous on generating sets where the electrical output for each engine is registered.

5 Automatic Monitoring

Automatic monitor for oil pressure and possibly for fresh water temperature should be connected up, in addition to the engine cut-out coil, to the friction clutch engaging and disengaging device, in those cases where the design permits this.

6 Operating Control

The control shall be so designed, that the engine r.p.m. setting can be synchronized, etc. See the section "Operating Control".

7 Classification Regulations

On marine multi-engine installations, a classification certificate shall in general be available for each engine. Such a certificate is also required for all parts included in the power transmission, for instance V-belt pulleys, shafts, clutches, couplings, etc. See "General Classification Regulations".

K General Classification Regulations

If the vessel is to be classed, contact shall be made with the Classification Society or Institution which shall inspect the vessel before the installation work commences. By doing this the risk of costly reconstruction work is avoided.

Classed engines are delivered from the AB Scania-Vabis factory, the engine type reference on the engine type plate being provided with two letters which indicate the Classification Society by whom the engine has been classed. The following references apply:

LR = Lloyd's Register of Shipping

NV = Det Norske Veritas

BV = Bureau Veritas

GL = Germanischer Lloyd

In addition, Statens Fartygsinspektion (SF) is included. This is a Swedish State Inspection Authority in matters concerning sea safety. In those cases where it is necessary that the vessel shall be classed, such classification shall be made by a Classification Society whose inspection of the vessel is approved by Statens Fartygsinspektion.

The classification implies from the technical aspect that a representative from the Classification Society examines in detail vital parts included in the engine. Where it concerns for instance crankshaft and connecting rods, these are first inspected at the semi-finished stage and afterwards in the finished state. Parts such as cylinder blocks, water pump housings, cylinder liners, and exhaust pipes will be subjected to pressure tests, etc.

The representative for the Classification Society is present when testing the engine both at the factory and after the installation in the vessel.

The classification implies that the Classification Society has drawn up a kind of quality certificate for the installation on which at a later date the insurance of the vessel is based. It is the owner of the vessel who chooses the Classification Society and who orders classification.

For classed installations the Classification Society requires as a rule that torsional vibrations for the complete power transmission, inclusive of propeller plant, be calculated. Assistance with such calculation can be obtained from AB Scania-Vabis, see the section about "Power Transmission".

L Engine Installation from the Service Point of View

- 1 According to special instructions the engine installation is to be inspected by personnel from the AB Scania-Vabis Service Organization

To be able to maintain and repair the engine and its components after the installation in a satisfactory manner, certain accessibility requirements shall be taken into consideration. The items to be observed are the following:

The removal and fitting of the engine without unnecessary waste of time require that the build-up and other components obstructive to this work are designed in such a way that they can be readily removed to the extent necessary.

To remove a reverse gear, it shall be possible to displace the propeller shaft back by at least 200 mm.

It should be possible to remove cylinder heads, valve covers and push rods and to fit them again without removing the engine. In order to achieve this a clearance of at least 400 mm is required vertically, counted from the cylinder block top surface.

The injection pump, injectors and fuel filter should be accessible for replacement and for bleeding of the fuel system. It should be possible to read the graduation of the flywheel in connection with the setting of the injection pump.

To make it possible to replace cylinder liners or pistons without removing the engine, enough space must be provided below the engine to enable the oil sump to be removed. The minimum clearance required to remove the oil sump is 210 mm for the D11 series and 110 mm for the D8 series.

Make sure that the filling and draining of oil can be executed in a simple manner and that the dipstick is readily accessible. The same thing applies to the filling and draining of coolant.

The engine air filter and the anti-freeze jar of the air compressor should be located in such a way as to make them readily accessible for changing oil and topping up anti-freeze, respectively.

Attention should also be paid to satisfactory accessibility of the following engine components:

- Lubricating oil filter for the turbocharger
- Turbocharger
- Starting motor
- Generator
- Water pump and cooling fan
- Hydraulic pump
- Radiator
- Disconnecting device at the engine flywheel
- Batteries

Text for Fig. L1

- | | |
|--------------------------------------|-----------------|
| A = min. 110 mm for series D5 and D8 | C = min. 500 mm |
| min. 210 mm for series D11 | D = min. 500 mm |
| B = min. 150 mm | E = min. 200 mm |

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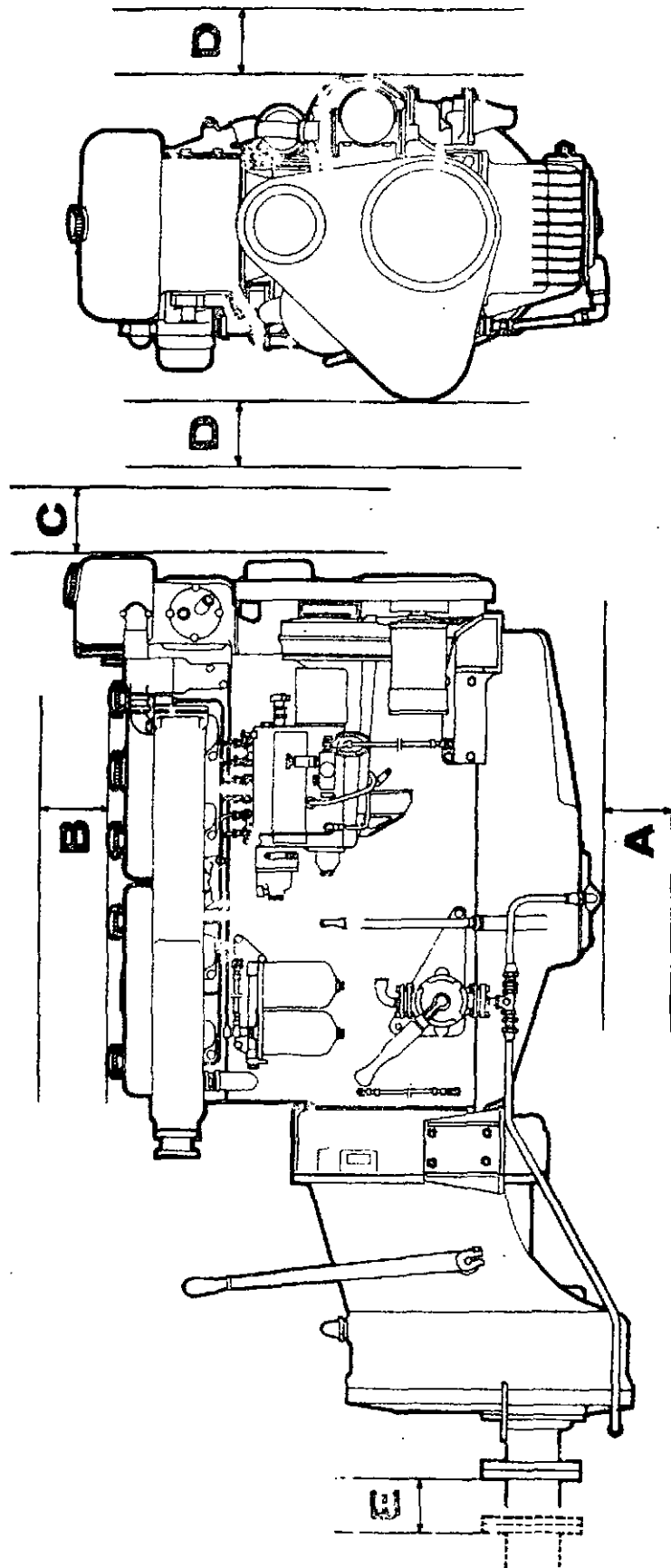


FIG. L1

SERVICE SCANIA PRODUCTS

grupp/group

2a

Function Description

nummer/number

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datum/date
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best. nr/order nr
502a E

2 Cooling System

a D5, DS5, D8, DS8, D11, DS11

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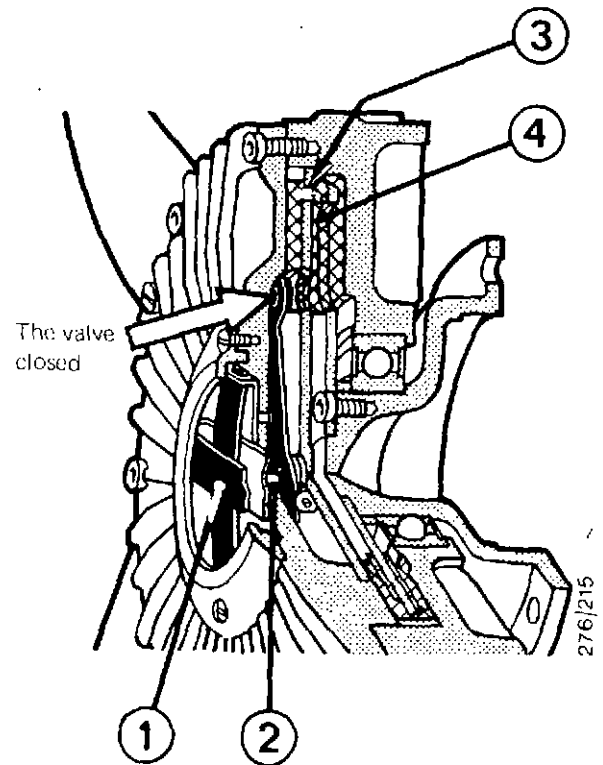
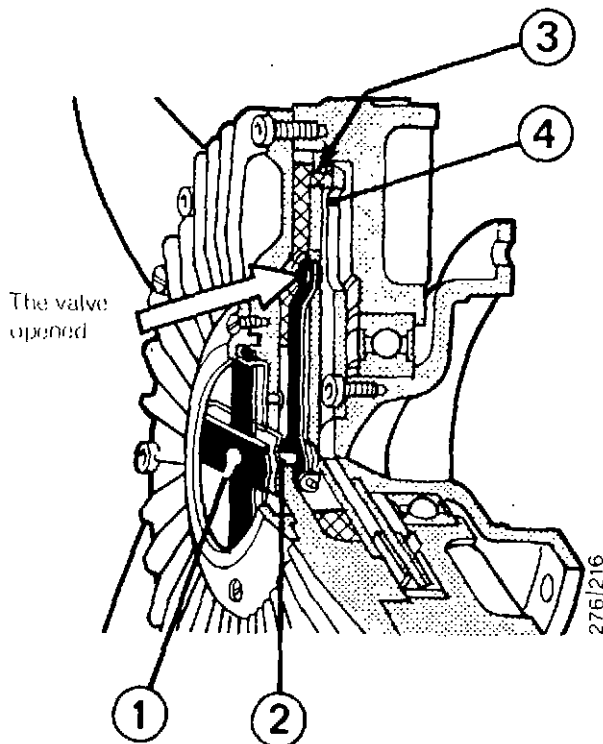
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TEMPERATURE CONTROLLED FAN

The object of the temperature controlled fan is to adapt the speed of the fan automatically to the temperature of the air which has passed the radiator.

The advantages with this automatic temperature control is, firstly, to obtain a quicker heating up of the engine coolant, which implies less engine wear and less fuel consumption. Other advantages are a lower drop in output for operating the fan and a lower noise level.

The speed of the fan is controlled by bimetal springs (1) which via a control rod (2) activate the valve. The valve regulates the amount of oil in the fans viscous clutch (4) and consequently the fan speed.



When the cooling air, which has continuously circulated round the bimetal springs reaches a temperature of $+40^{\circ}\text{C}$ the bimetal springs begin to bend. This degree of bending will be more pronounced the warmer the cooling air is, and the valve with rising temperature will let in a higher proportion of oil in the fans viscous clutch. The resistance in the clutch will thereby increase and the speed of the fan will in consequence increase with rising cooling air temperature.

By reason of the disc plate rotating in the fans viscous clutch, as soon as the engine has started, the oil in this section of the fan housing will be continuously forced out through the duct (3). When the cooling air has a lower temperature than $+40^{\circ}\text{C}$ the valve will remain closed, which implies that the viscous section of the clutch will be emptied of oil and the fan will only rotate very slowly.

Beginning with a cooling air temperature of $+60^{\circ}\text{C}$ and upwards max. fan operation is achieved. At cooling temperatures below $+40^{\circ}\text{C}$, the automatic thermostatic control is not in function and the fan rotates at relatively low speed. Between the temperature limits mentioned fan operation will be in relation to the cooling air temperature.

2 Cooling System

a D5, DS5, D8, DS8, D11, DS11

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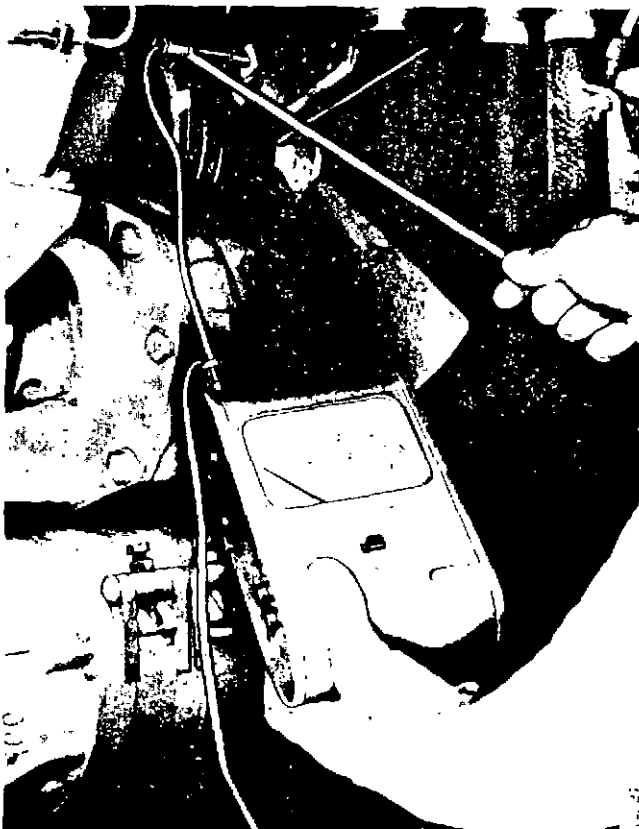
TEMPERATURE CONTROLLED FAN

Functional Check of Fan Installed on Engine

Aid and Preparation

1. A suitable electronic tachometer (Moviport) is used for speed recording. A special holder is thereby recommended for the sending unit so that risk of personal injury occurring by rotating fan is prevented. The holder for the sending unit is provided with a support trestle and the sending unit fixed on in such a way so that it cannot come into forward contact with the fan blades and be damaged by these.

(Tachometers of mechanical design, e.g. type Hassler can, on certain vehicles, also be used for recording the fan speed, provided that effective protective screening is fitted in the first place in front of the fan. Compare points of view under the heading "Caution").



2. A thin metal plate, size 20 x 40 mm with slotted grooves is fixed on the fan screw for one of the fan locking heads. The metal plate is painted white before fitting and against this the tachometer sending unit is aligned. A corresponding marking is made on the fan shaft pulley belt with a white chalk line.
3. Check the tension of the fan belt.
4. Make quite sure that the engine coolant temperature gauge is true.
5. Prepare the later arrangement of the idling speed to 2,200 rev/min. This is suitably done by replacing the adjusting screw for idling speed on throttle housing in exchange for a slotted screw M6 x,30 mm, with which the test speed of 2,299 rev/min. can be adjusted.

Check

1. Drive the vehicle until the engine has reached a temperature of 80°C.
2. Stop the vehicle.
 - a) Adjust the engine idling speed to 2200 rev/min. This normally corresponds to a speed of 3000 rev/min on the fan shaft.
 - b) Provided of course that the fan shaft speed is 3000 rev/min, measure up the speed of the fan and keep the test result in mind.
 - c) Measure in consecutive sequence, the speed of the fan again in order to check that the fan shaft speed does not alter during test 2b).

Judge the slipping of the fan. Normal slipping is $95 \pm 2\%$ of fan shaft speed, i.e. at a fan shaft speed of 3000 rev/min the fan shaft speed should normally be 2800–2900 rev/min.

3. If the fan speed is too low this may be caused by an insufficient amount of oil in the fan clutch (oil leakage) or defects arising in the automatic control. If one or other type defects should occur these can be determined according to test 4 below. However, the

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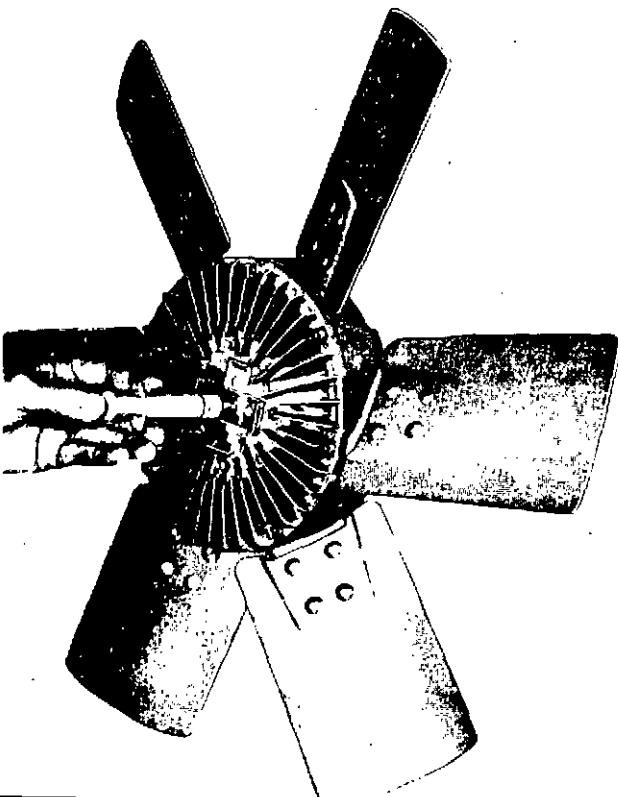
fan should in the first place be checked externally to make certain that no damage has occurred, if so, it may be necessary to replace it.

4. a) Undo the four fixing screws for the cover in the middle of the fan hub and take it off.
- b) Mark up the position of the bimetal springs located inside the cover and then remove them by pressing them inwards and towards the side. Very carefully remove the springs so that they do not become deformed. Pull out the control rod against which the bimetal springs function. By doing this the automatic control mechanism is put out of action.
- c) Start the engine and repeat the test according to 2 above (the engine does not then require normal operating temperature). If there is still too much speed slip this may be due to lack of oil on account of oil leaking out from the fan housing. If the oil leakage is slight it may be suitable to subsequently fill up with oil in order to use the fan for a further period before replacing it. The procedure to be carried out is contained under the heading "Subsequent Filling of Silicone Oil".

If, during this test, a normal fan speed is obtained by removing the bimetal springs only, then defects exist in the control mechanism and the fan should be replaced for a factory checked one.

Subsequent Filling of Silicone Oil

Put silicone oil in a hyperdermic syringe (suitably of a plastic material size 5-10 cm³, usually sold by Chemists



or Ironsmongers) and inject the oil into the fan via the pin control hole, figure 2. Inject a small quantity of oil at a time 1.3 cm³ depending upon the size of speed slip and check the result of this by repeating the speed control according to 2 above, whereby the engine does not need to be warmed up.

N.B. Avoid filling up with too much oil as the automatic control qualities of the fan will then be put out of action and the fan deprived of its desired qualities.

Refit the pin control, the bimetal springs and protective cover to their original positions.

Check again to be sure, according to 2 above, that normal fan operation is obtained at normal operating temperature.

Remaining Checks and Servicing of the Fan

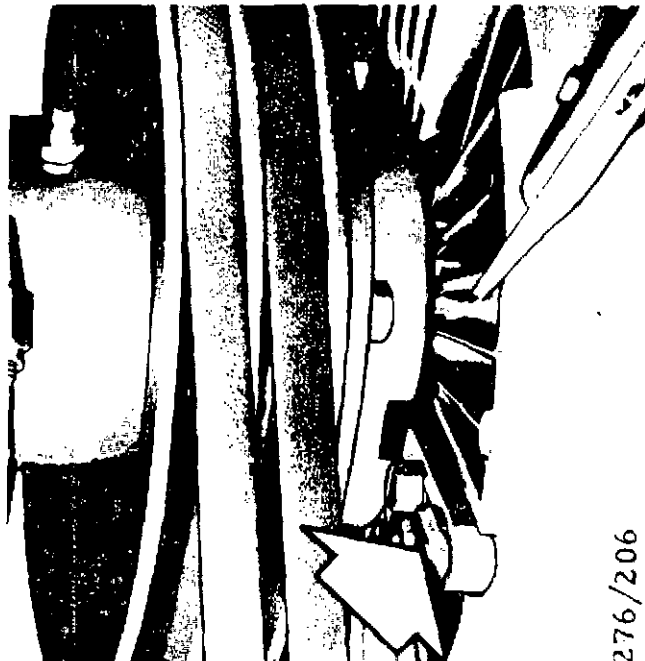
In order to check, among other things, the automatic speed control mechanism of the fan, it is necessary to have expensive testing equipment available. Therefore, the centralization of service on the fan and the replacement system have been found to be very suitable for the purpose. A defective fan should always be changed for a replacement unit.

Faulty Function

Secure Locking of the Fan

If the coolant temperature is too high and it is impossible to trace the fault the fan can be locked at the pulley.

1. Turn the fan so that one of the splines faces one of the slots in the pulley (see fig.).
2. Undo the screw holding the spline in position and push it in.



3. Tighten up the screw.

Operate the engine with aid of the starter motor, while the stop control is pulled out, so that it is possible to turn half a turn. Lock the fan with the other spline according to 2 and 3.

The silicone oil recommended is of type Dow Corning 210 viscosity 11500 cst

The silicone oil recommended is of type Dow Corning 210 viscosity 12500 cst and is supplied by our Spare Parts Department under Order No. 561072 in half litre containers.

Caution

On certain vehicles where masking with radiator is fixed on hinges and can easily be opened so as to uncover the fan, the radiator masking should be shut during tests for safety reasons in order to avoid personal injury occurring through rotating fan. Otherwise, an effective protective screen must be fitted up immediately in front of the fan so that it covers the radiator opening.

SERVICE SCANIA PRODUCTS

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2 Cooling System

a D5, DS5, D8, DS8, D11, DS11

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General

Water pump

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FAN FOR LB80, LB85 AND LB140

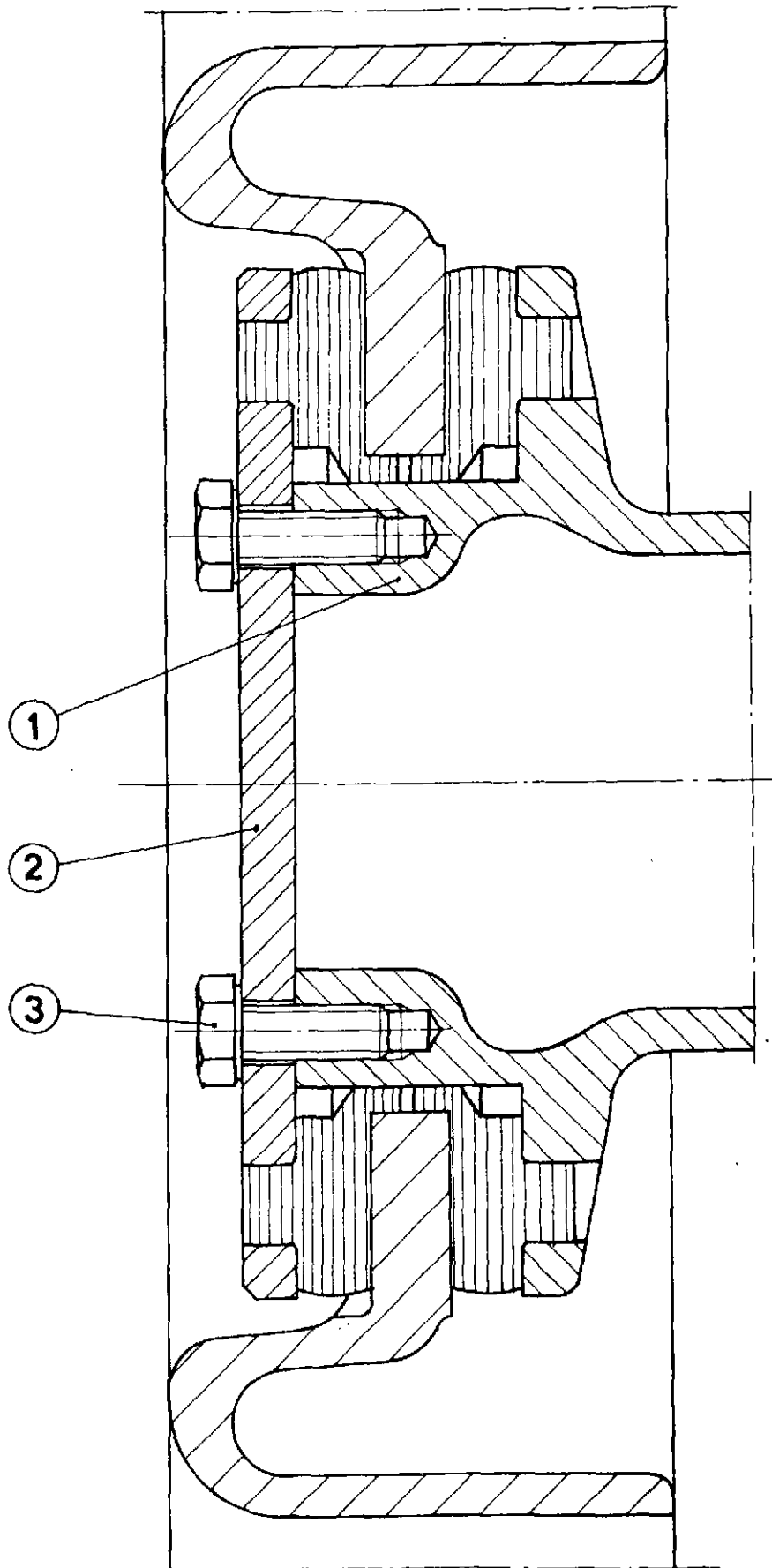
On LB80, LB85 and LB140, the fan is fitted between rubber cushions. In mounting the fan, these rubber cushions are compressed when the screws (3) are tightened (see figure), but there is a certain amount of risk that the screws will not be tightened sufficiently, and as a result the washer (2) will not rest properly against the fan hub (1). If this occurs, the screws will be subjected to excessive stresses which, after a time, can lead to fatigue failure.

Consequently, it is extremely important for the washer (2) to be tightened with all the screws in course of mounting so that it rests properly against the fan hub. It should be observed in this connection that the screws must be tightened half a turn at a time so that the washer does not get inclined excessively when the rubber cushions are compressed. The screws must be finally tightened to a torque of 2.4 kgm.

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CONNECTION OF ENGINE HEATER TO ENGINE TYPES DS11 AND DS14

(This instruction is generally speaking applicable for D11 engines as well. For engine types D5, DS5, and DS8 reference is made to Service Bulletin, Group 226 No. 2 dated March 5, 1969).

In order to get the correct distribution of temperature in the engine block and for effective utilization of engine heater, it is very important to connect this to the engine in accordance with the instruction given below. For further guidance reference is made to the assembly instructions issued by the engine heater supplier.

Note: Inlet and outlet lines for the engine heater shall be provided with shut-off cocks, which should be located as close to the engine as possible. These cocks should only remain open when the engine heater is in function!

Engine Type DS11

1. The warm water **from** the engine heater is supplied to the engine via water transfer flange part No. 178863 on the cylinder heads, see fig. 1 and 2. If necessary, drill and thread holes in the flange for connection nipple with inside diameter \varnothing 16 mm and outside diameter suitable for hose with \varnothing 19 mm inside diameter, see fig. 2. (All permissible hole locations with normal size dimensions have been drawn, as the requirements in respect of connection holes vary for different engine installations). The hose in question must not be placed too near the exhaust pipe as risk of damage by fire is likely.
2. The cold water from the engine **to** the engine heater is taken out at the outlet for oil cooler, see fig. 3 pos. 1 and 2. T-nipple part No. 156056 fitted as standard, is then replaced by nipple 203523 pos. 2, which in addition to the connections of the T-nipple is completed with connection for hose with \varnothing 19 mm inside diameter.

Engine Type DS14

1. The warm water **from** the engine heater is supplied to both the engine block halves via blind cover part No. 170626 see fig. 6 pos. 1 to which elbow nipple pos. 2 is securely soldered (brazing) in accordance with the fig. indicated. This design which is intended for the left-hand side of engine shall be the same for the right-hand side of engine, i.e. the opening of nipple shall be turned forwards - upwards. If there is no suitable nipple available, nipple with part No. 189256, compare subsection 2 below, can be used since one of the nipple connections has been cut off and joined through brazing in a satisfactory manner.

2. The cold water from engine **to** engine heater is taken out:

- a) through blind cover part No. 170918, fig. 6 pos. 3 (left-hand side) and 170914 (right-hand side).

On the cover 170918 nipple 189256 is securely soldered fig. 6 pos. 4 in accordance with the fig. shown. When air compressor is fitted a brass pipe 5 is soldered on for connection to the compressor cooling system. The nipple outlet 6 is intended for the oil cooler.

On cover 170914, nipple 189256 is also securely soldered; one of which nipple connections is used when connecting up the cab heater.

- b) from the coolant outlet in timing gear housing to the engine block halves on the right and left-hand sides respectively, in those cases where the timing gear housing is specially designed for such connection.

Through outlet to engine heater from the coolant passages in timing gear housing, which are dotted in and marked with arrows in fig. 5, the most effective method of heating is obtained.

Size of Engine Heater

The recommendations issued by the engine heater manufacturer should be closely adhered to when determining the capacity of the engine heater, in which case the coolant volume among other things should be paid considerable attention. Thus for a complete engine DS14LB01, this would amount to approx. 50 litres (i.e. exclusive coolant volume in radiators, cooling fans, etc.).

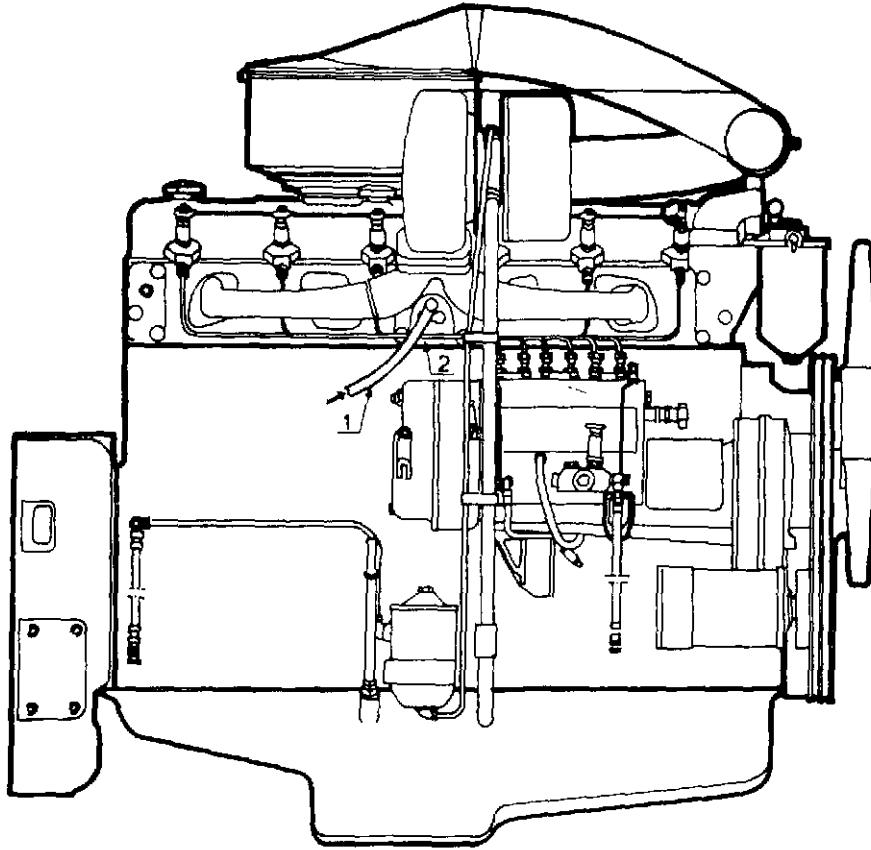


Fig. 1

Connecting up the warm water side of heater

- 1. Hose
- 2. Water transfer flange

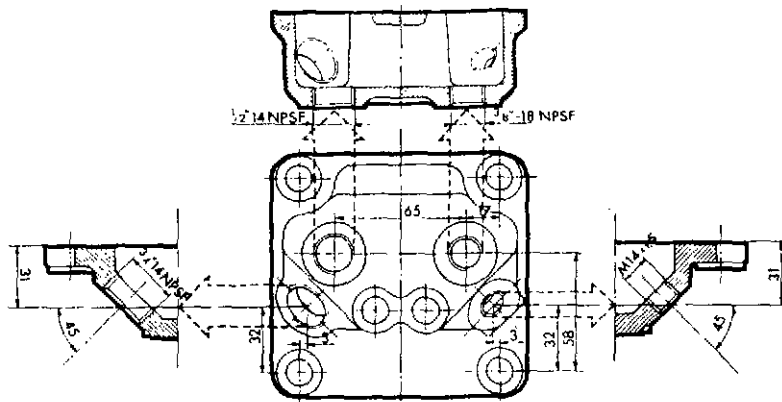


Fig. 2

Water transfer flange with different hole locations drawn

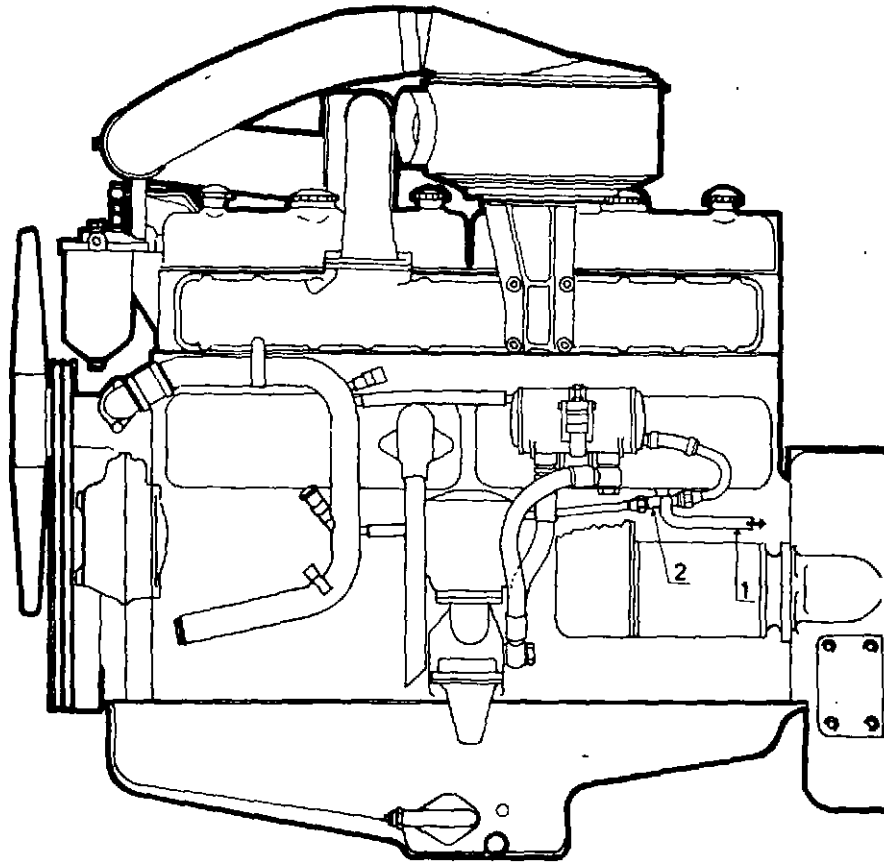


Fig. 3

Connecting up the cold water side of heater

- 1. Hose
- 2. Nipple

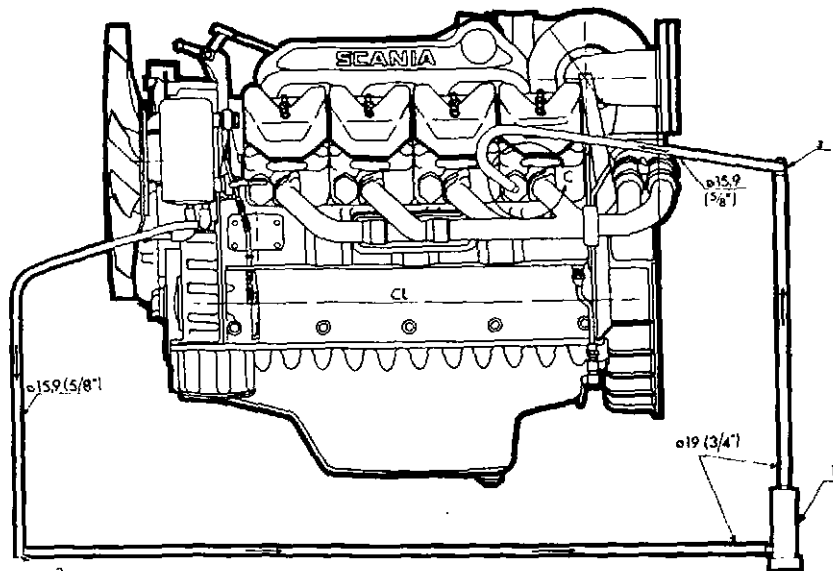


Fig. 4

Schematic connecting up of the warm water side of heater.
The hose dimensions indicated refer to inside diameter. The shut-off and draw-off cocks are not drawn

- 1. Engine heater
- 2. T-nipple
- 3. T-nipple

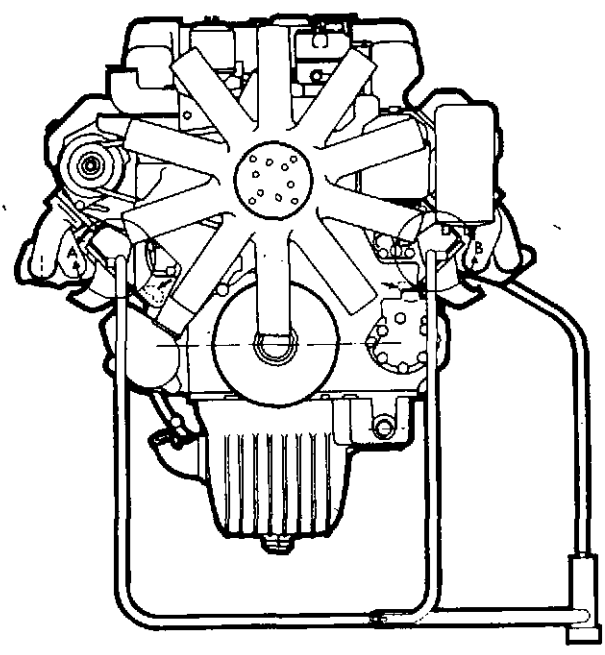


Fig. 5

Schematic connecting up of the cold water side of heater

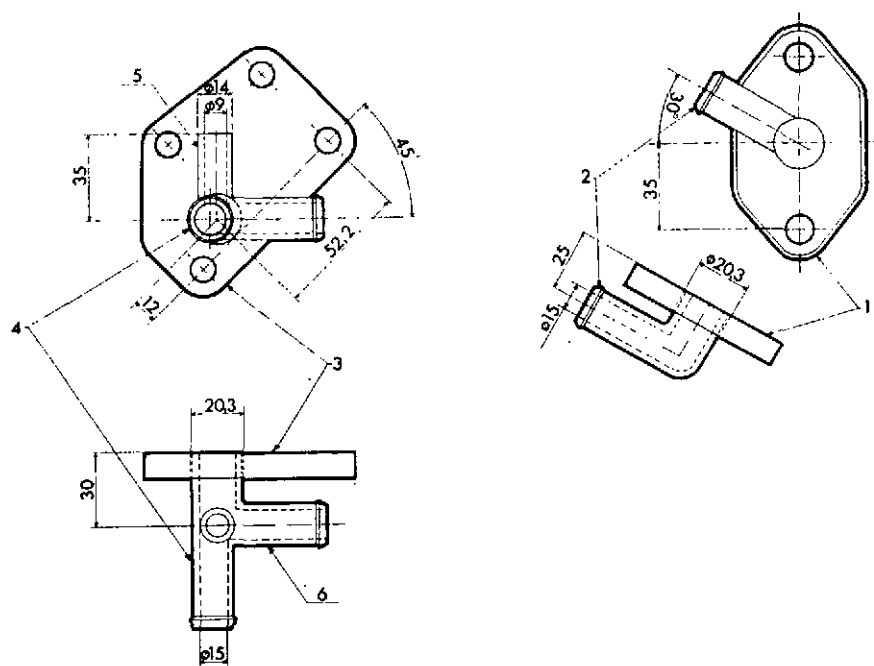


Fig. 6

Designs of Connections

- 1. Part magnification of cover C fig. 4
- 2. Nipple
- 3. Part magnification A and B fig. 5
- 4. Nipple
- 5. For compressor
- 6. For oil cooler

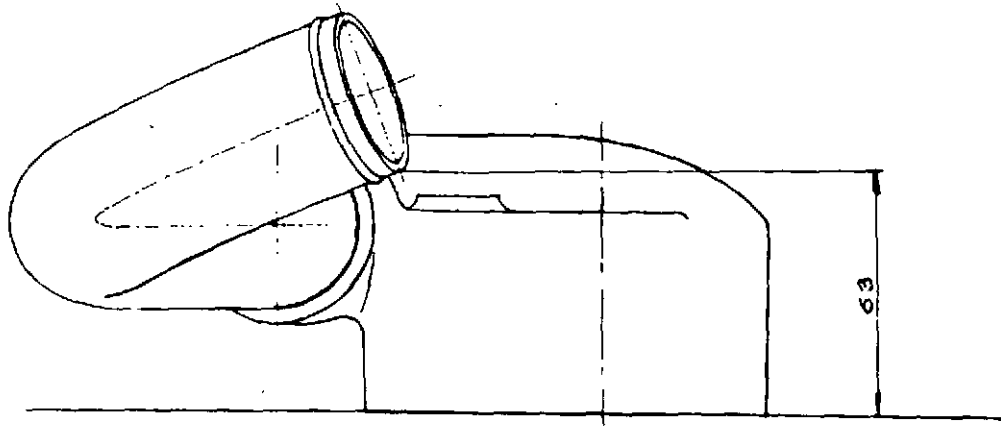
BADLY CHAFED RADIATOR HOSES

Cases have occurred where the top radiator hose on LB110-vehicles has been badly chafed against the fan housing.

In order to increase the space between hose and fan housing the engines in production have now been provided with a thermostat housing upper half of new design.

On trucks already delivered the alteration can be carried out in the following way:

1. Remove the thermostat housing upper half from the engine.
2. Heat it evenly with a gas flame until the solder joint between pipe and casting loosens.
3. Clean the parts from old soldering material and afterwards place the connection tube in the thermostat housing upper half as the figure shows.
4. Solder the tube securely with silver solder, e.g. AGA Silco 610 and AGA Silcoflux RS or Castolin 1802.
5. Check to see that the same is tight and afterwards fit the part on the engine.



1 Engines

a D5, DS5, D8, DS8, D11, DS11

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TURBOCHARGER

General

The task of the turbocharger is to increase the air supply to the cylinders of the engine. This increase in the supply of air enables the engine to burn more fuel per piston stroke than a naturally aspirated engine, so that a greater power output becomes possible.

The turbocharger consists of the following main sub-assemblies: Exhaust turbine, bearing housing and compressor. The turbine and the compressor are mounted one on each side of the bearing housing; the turbine wheel and compressor wheel being united by a common shaft. The shaft runs in the bearing housing in "floating" sliding bearings.

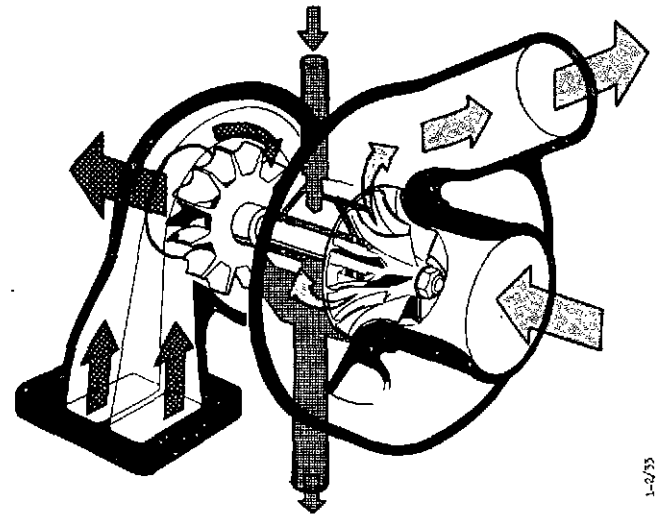
The turbine makes use of some of the energy contained in the hot exhaust gas. The exhaust gas goes straight from the exhaust manifold of the engine into the turbine housing. The energy of the exhaust gas is converted by the turbine wheel into kinetic energy. The turbine wheel drives the compressor wheel, which is of the centrifugal type.

The air is drawn in at the centre of the compressor wheel and is forced out radially into the compressor housing through a diffuser. From the outlet of the compressor cover it is then forced into the engine intake manifold.

Since the turbine is driven by the engine exhaust gas, the speed of the turbocharger will automatically adjust itself to the load and speed of the engine.

The lubrication of the bearings and the cooling of the bearing housing is effected by oil from the engine lubricating system. Before entering the bearing housing the oil first passes through a separate filter mounted on the right-hand side of the engine.

The turbocharger is mounted directly on the exhaust manifold of the engine with a screwed fastening in the intake flange of the turbine. **It is extremely important that this fastening alone should take the weight of the turbocharger and that no pipe connections or joints are too stiff, or they are liable to exert constraining forces on the unit and in such a condition could soon lead to trouble.** For this reason, the exhaust pipe from the turbine is fitted with a special connection which takes up the movements that occur.



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Types

There are two main types of turbocharger. The smaller one, type 3 LD, is available for DS8 and DS5 and the larger one, 4 LE, for DS - DSI11.

There are two variants, one being type 3 LD - 1/2.5 for DS8 with Part No. 183360 and the other type 3 LD - 12/1.6 for DS5R42 with Part No. 189141. The unit is built-up of practically the same parts as on compressor wheel, compressor cover and turbine housing. Therefore, it is of great importance to see that the different types are not confused with one another.

There are also two designs of type 4 LE. One of them has Part No. 189975 and is fitted on the engine at Södertälje. The other one is of another make and has part No. 207303 and is fitted on the engine at Zwolle in Holland. Both the complete turbochargers are interchangeable. However, it is of utmost importance to see that the parts belonging are not confused with one another.

1 ENGINES

a. D5, DS5, D8, DS8, D11, DS11

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TURBOCHARGER

Repair Instructions

Checks

In all work on turbochargers the utmost cleanliness must be observed. Any dirt or other foreign matter that gets into the bearing housing will soon cause serious damage. The need for cleanliness is just as great as in the case of the injection pump.

Air and Exhaust Leaks

Start the engine. Check the connections between the turbocharger and the intake manifold, between the intake manifold and the engine, between the outer air intake and the air cleaner, and between the air cleaner and the turbocharger. Check that all gaskets are whole. Make a careful check of the exhaust system, particularly with regard to its connection to the turbocharger and its connections to the cylinder heads. After correcting any faults, or if faults, or if nothing abnormal is found, continue checking according to the instructions given below.

Charging Pressure

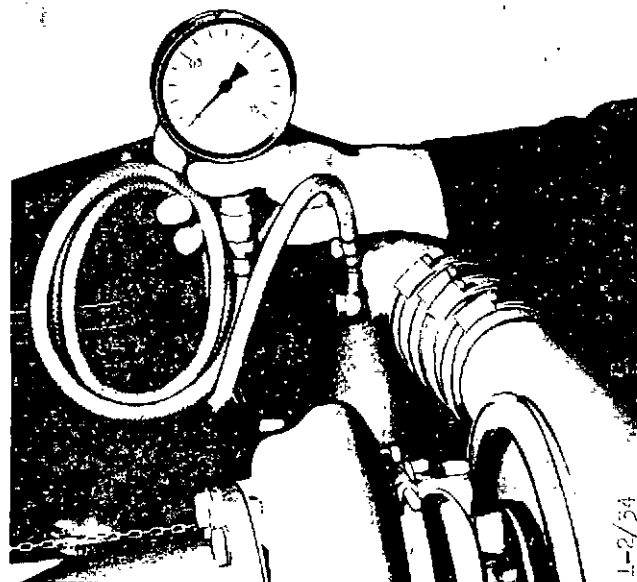
The check on the charging pressure should be preceded by a check on the high no-load speed of the engine.

Then connect a pressure gauge to the air pipe between the compressor discharge and the intake manifold. At maximum engine speed and load the pressure must agree with the values given in the graphs. Measure the charging pressure at maximum load and rev/min. It is important to keep the engine loaded at the maximum rev/min. long enough for the pressure to be built up in the intake manifold and for steady conditions to be established. When the reading is being taken for an engine fitted in a truck, it is a good plan to run the engine at full load and full throttle uphill while the engine speed reaches the maximum rev/min. for maximum load relatively slowly.

The graphs indicate the charging pressure at 25°C, and the measured charging pressure must thus be corrected, if the intake air does not have this temperature when the reading is taken. Corrected values corresponding to the temperature and charging pressure readings can be obtained from a table.

If the corrected charging pressure is not within the limits indicated by the graphs, the reason can for instance be that the air cleaner is clogged up or the compressor unit of the turbocharger is dirty.

Note! The setting of the injection pump must not be altered under any circumstances beyond the prescribed values in order to adjust the charging pressure.



Measure the charging pressure

Radial and Axial Clearance

When measuring radial and axial clearance use the dial indicator in accordance with the directions below.

Radial Clearance of Compressor End

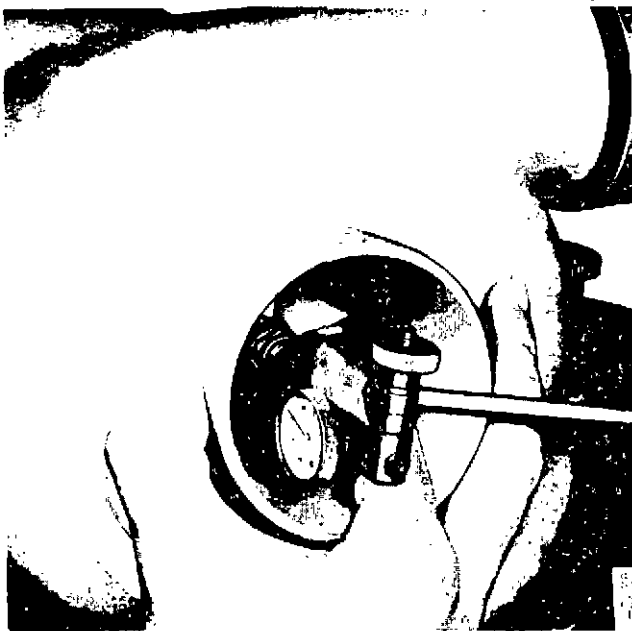
Apply the contact point of the dial gauge to the centre of one side of the locknut of the compressor wheel. Push the compressor wheel against the contact point and push the turbine wheel in the other direction at the same time. Rotate the wheels slowly to and fro until the lowest gauge reading is obtained and note this reading or set the gauge at zero. Then push the wheels in the opposite direction, rotate the wheels again as just described, and note the lowest

The difference between the two readings is the total radial movement of the compressor wheel. Repeat the procedure several times before accepting a final result.

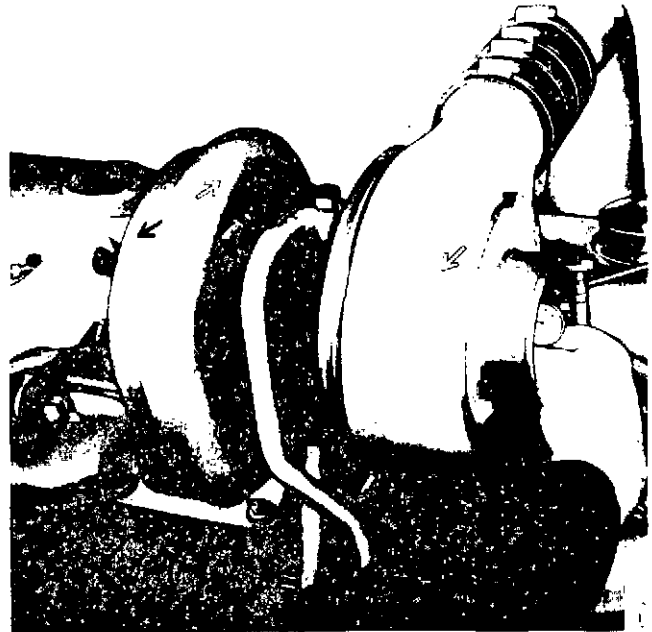
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The position of the contact point of the dial gauge in measuring the radial clearance of the compressor end



Measure the radial clearance of the compressor end

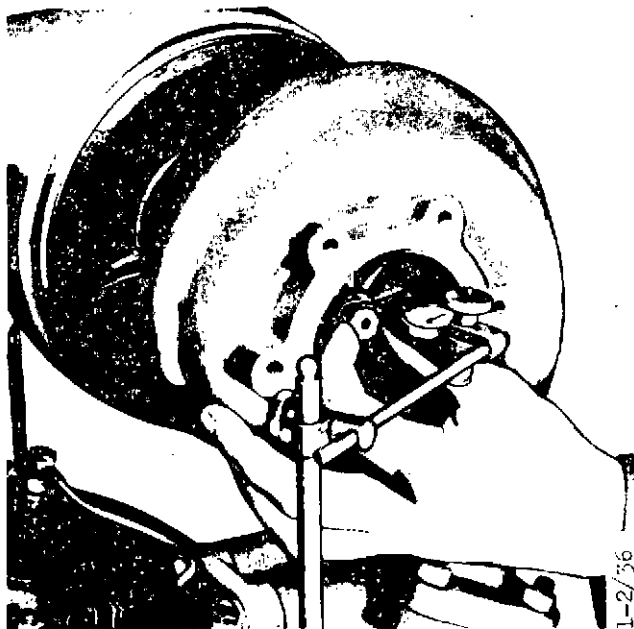
Radial Clearance of Turbine End

Apply the contact point of the dial gauge to the centre of one of the sides of the square extension on the turbine wheel. Then proceed in the same way as when checking the radial clearance of the compressor end.

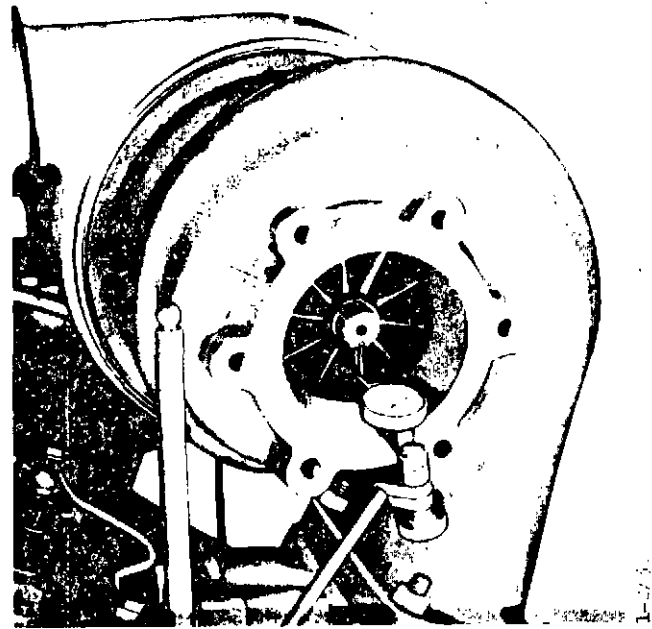
Axial Clearance of Shaft

Apply the contact point of the dial gauge to the end of the shaft on the turbine side. Push the shaft towards the dial gauge as far as possible, read the gauge and note the reading or set the instrument at zero. Then push the shaft towards the compressor side as far as possible, read the gauge and note the reading.

The different between the two readings gives the axial clearance of the shaft.



Position of the contact point of the dial gauge in measuring the radial clearance of the turbine end



Position of the contact point of the dial gauge in measuring the axial clearance of the shaft.

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Cleaning the Compressor Unit with the Turbocharger in Place on the Engine

If the corrected charging pressure is lower than that indicated in the graph, even though the turbocharger has been passed free of faults during the above checks, the reason may be that the compressor unit is dirty.

With the turbocharger remaining on the engine the compressor unit can be cleaned as follows:

Take the compressor cover and the inlet cone out of the turbocharger according to the instructions given under the heading "Dismantling and Cleaning".

Clean the parts in white spirit or a similar detergent fluid.

Put the parts back and measure the charging pressure again according to the instruction under "Checks".

Overhaul

When the turbocharger has been taken out of the engine it is extremely important to protect the connections for the oil inlet and oil outlet. Use protective plugs.

Mark the compressor housing

When overhauling the unit, i.e. cleaning including replacement of bearings, sealing rings and gaskets, no special tools are required provided that nothing abnormal has occurred. If it is discovered when making inspection that unbalance of the bearing has occurred, the compressor wheel and turbine wheel together with shaft must be rebalanced. In other respects, rotor parts are individually balanced, that is why it is possible to replace them separately, when necessary, without unbalance occurring.

Model 3LD

Dismantling

Figures within brackets refer to Appendix 1.

1. Clamp unit in turbine housing flange.
2. Mark up turbine housing (29) and compressor cover (25) positions in relation to bearing housing (8) with punch pops or scribed lines before dismantling.
3. Undo the eight screws (28) with attached lock washer (26) and washer (27) and then remove the compressor cover (25).

4. Loosen V-clamp (30) lock nut (31) and slide over the clamp on bearing housing (8). Lift "exchange unit" straight out from turbine housing. If turbine housing does not loosen, it is possible to separate bearing housing and turbine housing by using penetrating oil after which the unit should be allowed to stand and "soak" for approx. 1 hour before dismantling it.
5. Fix the turbine wheel at the shoulder in a vice with soft jaws and undo the compressor wheel lock nut (7) with an open-end wrench.
6. Pull off the compressor wheel (6) from shaft. There is a slide fit between compressor wheel and shaft, that is why the compressor wheel can be removed without force.
7. Pull out the turbine wheel together with shaft (2).
8. Remove with a finger plain bearing (9) from bearing housing.
9. Use a pair of locking ring pliers (outer) in order to remove the stop ring (14), which holds the sealing plate (13). With help of two screw drivers the plate (13) is now lifted up from bearing housing (8). Remove O-ring (12) from sealing plate.
10. The remaining parts of axial unit can now be removed in the following order:
 - a) Spacer sleeve (5), which can be pressed off with a finger from sealing plate (13).
 - b) Oil deflector (11), which is held in position by two pins.
 - c) Thrust washer (4).
 - d) Thrust disc (10).

N.B. The two pins which hold oil deflector and pressure plate have been pressed into the bearing housing and cannot be removed.

11. Remove sealing rings (3, 15) from spacer sleeve and shaft.

Cleaning

1. Use suitable cleaning fluid. Corrosive solvent, such as caustic soda, destroy certain parts and must not be used.
2. Wash the parts in the fluid until all impurities have been removed.
3. Use only a plastic scraper or bristle brush on the light alloy parts.
4. Blow clean all drilled ducts with compressed air.

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5. Check that the surfaces nearest to the wheels (compressor-turbine) are clean and do not show any deposits.

Check

1. Shaft with Turbine Wheel (2)

- a) Check the bearing surfaces in respect of scratches and wear. Slight scratches can be tolerated.
- b) Check the sides of sealing ring grooves in respect of wear. Slight scratches can be tolerated. If considerable wear is suspected, the width of ring groove can be checked with a gauge 87063.
- c) Check the turbine wheel carefully in respect of cracks and other faults, such as bent or excessively worn blades. Never attempt to straighten a crooked blade. If it is suspected that the shaft is crooked or the wheel warped, the unit can be checked in a V-block. The shaft is measured at the compressor side nearest to thread for lock nut. The wheel is measured on the back side at the radius indicated.

2. Plain bearing (9)

Replace plain bearing.

3. Bearing housing (8)

Replace housing of bearing seats or sealing ring surface are obviously scratched or worn.

4. Spacer sleeve (5)

Replace sleeve if this or sealing ring groove is damaged.

5. Thrust washer (4)

Replace thrust washer.

Thrust disc (10)

Replace thrust disc.

6. Compressor wheel (6)

Check the compressor wheel carefully in respect of cracks, bent or excessively damaged blades. Never attempt to straighten a crooked blade.

7. O-ring (12)

Replace the O-ring.

Assembly

When the turbocharger unit has been cleaned and carefully inspected and all faulty parts replaced, assembly can commence.

Assembly of the unit takes place in reverse of that when dismantling, with attention being paid to the following points, so that a satisfactory result shall be ensured:

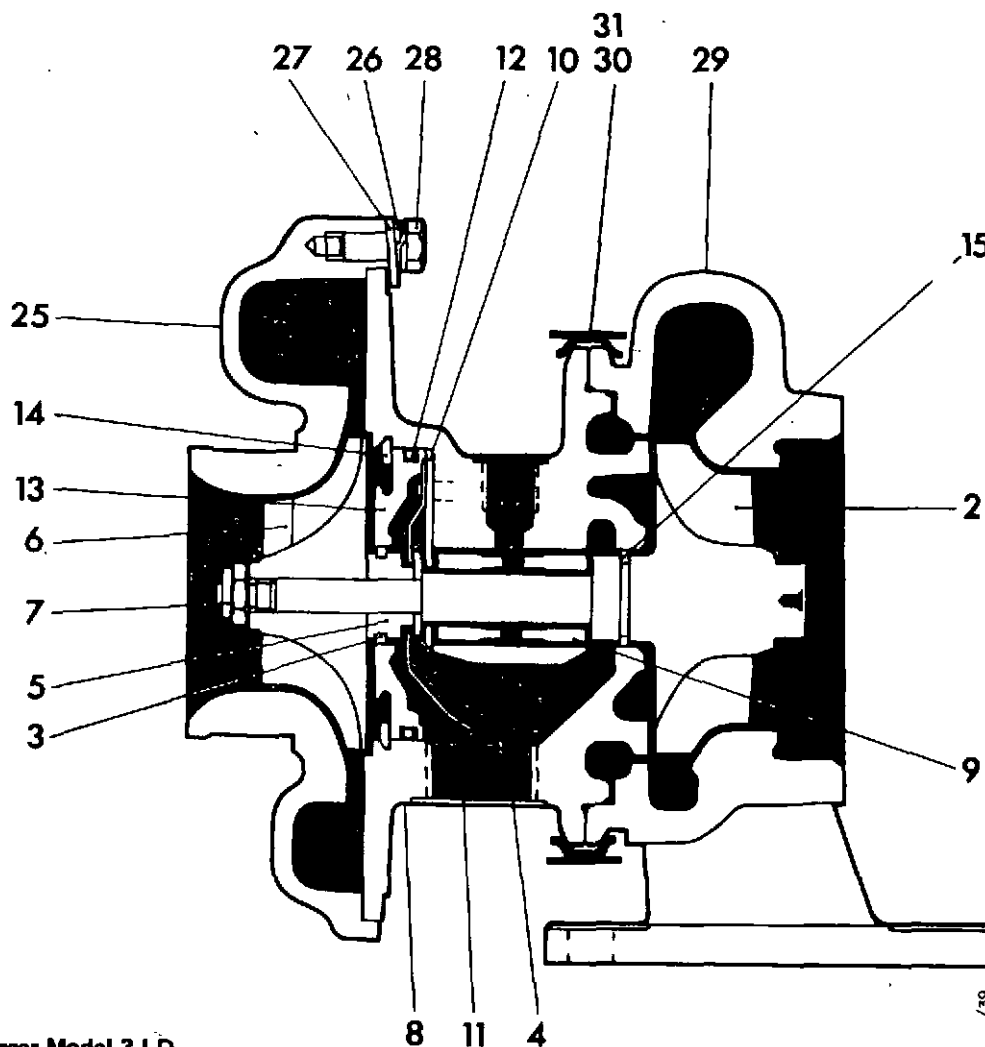
- a) Lubricate bearings, axial unit, sealing ring, O-ring and turbine shaft with pure engine oil.
- b) Make certain that the correct sealing ring is put in the right place. **Sealing ring (15) is somewhat larger than sealing ring (3)**, and it is impossible to slide it into the sealing plate. For instance, compare the ring gaps when fitting both rings in bearing housing sealing surface for **sealing ring (25) and separate in this way e.g. the smallest ring which is intended for compressor side.**

Warning: Do not extend the sealing rings too much when fitting, because this will result in a permanent elongation and the ring will break.

- c) Centre the sealing ring (3) in spacer sleeve (5) and slide unit into the sealing plate from the chamfered side (take great care). With the bearing housing compressor side turned so as to face upwards the following parts are fitted in the order quoted: Thrust disc (10) with oil grooves upwards, Thrust washer and oil deflector. After this the sealing plate together with spacer sleeve are tapped into position with a plastic mallet and locked with stop ring (24). The chamfered part of stop ring shall be facing upwards.
- d) Turn the bearing housing so that the turbine side is facing upwards and place it in a vice with open jaws so that *the compressor wheel can pass through unimpeded.*
- e) Centre thrust washer (4) with aid of a pencil or similar.
- f) Put the plain bearing (9) in bearing housing. When the turbine wheel, together with shaft (2), is inserted into the bearing housing, the sealing ring (15) shall be well centred. Do not force the ring into its seat, as a ring which is not centred properly can break, which in turn means that the shaft will get stuck. Fit the compressor wheel and tighten up the lock nut by hand.
- g) Turn the whole unit and fasten the turbine wheel shoulder in a vice, after which the compressor wheel lock nut is tightened up.
- h) Check after assembly that the rotor unit rotates freely.

Fitting on the Engine

1. Check that air inlet is clean and that no loose particles are to be found in it.
2. Check manifolds in respect of loose particles.
3. Check oil return line in respect of obstruction and deformation.
4. Check oil pressure pipe in respect of possible obstruction, deformation and leakage under pressure.
5. Check connection flange on manifold to see that no pieces of the old gasket remain.
6. Fit a new gasket between turbine housing and manifold. Make certain that the gasket does not project forward in exhaust port.
7. Put in the screws and secure turbocharger unit by tightening the screws.
8. Connect oil pressure pipe and return pipe. The return pipe is afterwards loosened at sump.
9. Connect the air hose from air filter, and connection pipe to intake manifold. Make certain that it is tight. Check also to see that the hose or pipe does not subject compressor housing to assembly stresses.
10. Operate the engine with starting motor, with stop button pulled out, until oil comes out of return pipe at oil sump.
11. Connect the oil return pipe.
12. Run the engine until it is warmed up and check that no leakage occurs.

**Turbocharger Model 3 LD**

- | | | |
|-----------------------------|-------------------|------------------------|
| 2. Shaft with turbine wheel | 9. Plain bearing | 25. Compressor cover |
| 3. Sealing ring | 10. Thrust disc | 26. Lock washer |
| 4. Thrust washer | 11. Oil deflector | 27. Washer |
| 5. Spacer sleeve | 12. O-ring | 28. Screw |
| 6. Compressor wheel | 13. Sealing plate | 29. Turbine housing |
| 7. Lock nut | 14. Stop ring | 30. V-clamp |
| 8. Bearing housing | 15. Sealing ring | 31. Lock nut for clamp |

Model 4LE

Dismantling

1. Clamp unit in turbine housing flange.
2. Mark up turbine housing (9) and compressor cover (1) positions in relation to bearing housing (14) with punch or scribed lines before dismantling.
3. Loosen Locknut of V-clamp on the compressor side and slide over the clamp on bearing housing (14) and then lift off the compressor cover (1).
4. Loosen the locknut of V-clamp on the turbine side and slide over the clamp on bearing housing (14). Lift "exchange unit" straight out from turbine housing. If turbine housing does not loosen, it is possible to separate bearing housing and turbine housing by using penetrating oil after which the unit should be allowed to stand and "soak" for approx. 1 hour before dismantling it.
5. Fix the turbine wheel at the shoulder in a vice with soft jaws and undo the compressor wheel lock nut (21) with a 5/8" open-end wrench.
6. Pull off the compressor wheel (18) from shaft. There is a slide fit between compressor wheel and shaft, that is why the compressor wheel cannot be removed without force.
7. Pull out the turbine wheel together with shaft (11).
8. Use a pair of locking ring pliers (outer) in order to remove the stop ring (2), which holds the sealing plate (23). With help of two screw drivers the plate (23) is now lifted up from bearing housing (14). Remove O-ring (5) from sealing plate.
9. The remaining parts of axial unit can now be removed in the following order:
 - a) Spacer sleeve (22), which can be pressed off with a finger from sealing plate (23).
 - b) Oil deflector (17), which is held in position by two pins.
 - c) Outer thrust washer (7).
 - d) Thrust bearing (6).
 - e) Spacer (19).
 - f) Inner thrust washer (7).

N.B. The two pins which hold oil deflector and pressure plate have been pressed into the bearing housing and cannot be removed.

10. Remove sealing rings (10, 31) from spacer sleeve and shaft.

11.

Note! When the lock rings have been removed check to see that no scratches occur in bearing seats in bearing housing.

- a) Pull out the sliding bearing with aid of one finger.
 - b) Take off the inner lock ring (16) on the compressor side.
12. Repeat the performance on the turbine side:
 - a) Outer lock ring (16)
 - b) Oil control washer (28)
 - c) Sliding bearing
 - d) Inner lock ring
 13. Take off the lock ring (30) and the turbine plate (29)

Cleaning

1. Use suitable cleaning fluid. Corrosive solvent such as caustic soda, destroy certain parts and must not be used.
2. Wash the parts in the fluid until all impurities have been removed.
3. Use only a plastic scraper or bristle brush on the light alloy parts.
4. Blow clean all drilled ducts with compressed air.
5. Check that all surfaces nearest to the wheels (compressor-turbine sides) are clean and do not show any deposits, against which the wheels are likely to scrape.

Check

1. **Shaft with Turbine Wheel (11)**
 - a) Check the bearing surfaces in respect of scratches and wear. Slight scratches can be tolerated.
 - b) Check the sides of sealing ring grooves in respect of wear. Slight scratches can be tolerated. If considerable wear is suspected, the width of the ring groove can be checked with a gauge 87063.

c) Check the turbine wheel carefully in respect of cracks and other faults, such as bent or excessively worn blades. Never attempt to straighten a crooked blade. If it is suspected that the shaft is crooked or the wheel warped, the unit can be checked in a V-block. The shaft is measured at the compressor side nearest to thread for lock nut. The wheel is measured on the back side at the radius indicated.

2. Plain bearing (15)

a) Replace sliding bearing.

3. Bearing housing (14)

Replace housing if bearing seats or sealing ring surface are obviously scratched or worn.

4. Spacer sleeve (22)

Replace sleeve if this or sealing ring groove is damaged.

5. Thrust bearing (6)

Replace thrust bearing.

6. Thrust washer (7)

Replace thrust washers if these are noticeably scratched or damaged.

7. Spacer (19)

Replace spacer if surfaces against thrust washers are damaged.

8. Compressor wheel (18)

Check the compressor wheel carefully in respect of cracks, bent or excessively damaged blades. Never attempt to straighten a crooked blade.

9. O-ring (4, 5)

Replace the O-rings.

10. Turbine housing

Check contact flange against bearing housing as regards up-set or damage from dismantling.

Assembly

When the turbocharger unit has been cleaned and carefully inspected and all faulty parts replaced, assembly can commence.

Assembly of the unit takes place in reverse of that when

dismantling, with attention being paid to the following points, so that a satisfactory result shall be ensured:

- a) Lubricate bearings, axial unit, sealing ring, O-ring and turbine shaft with pure engine oil.
- b) Make certain that the correct sealing ring is put in the right place. The turbine side **sealing ring (31) is somewhat larger than the compressor side sealing ring (10)**, and it is impossible to slide it into the sealing plate (23). For instance, compare the ring gaps when fitting both rings in bearing housing sealing surface for sealing ring (31) and separate in this way e.g. the smallest ring which is intended for compressor side.

Warning: Do not extend the sealing rings too much when fitting, because this will result in a permanent elongation and the ring will break.

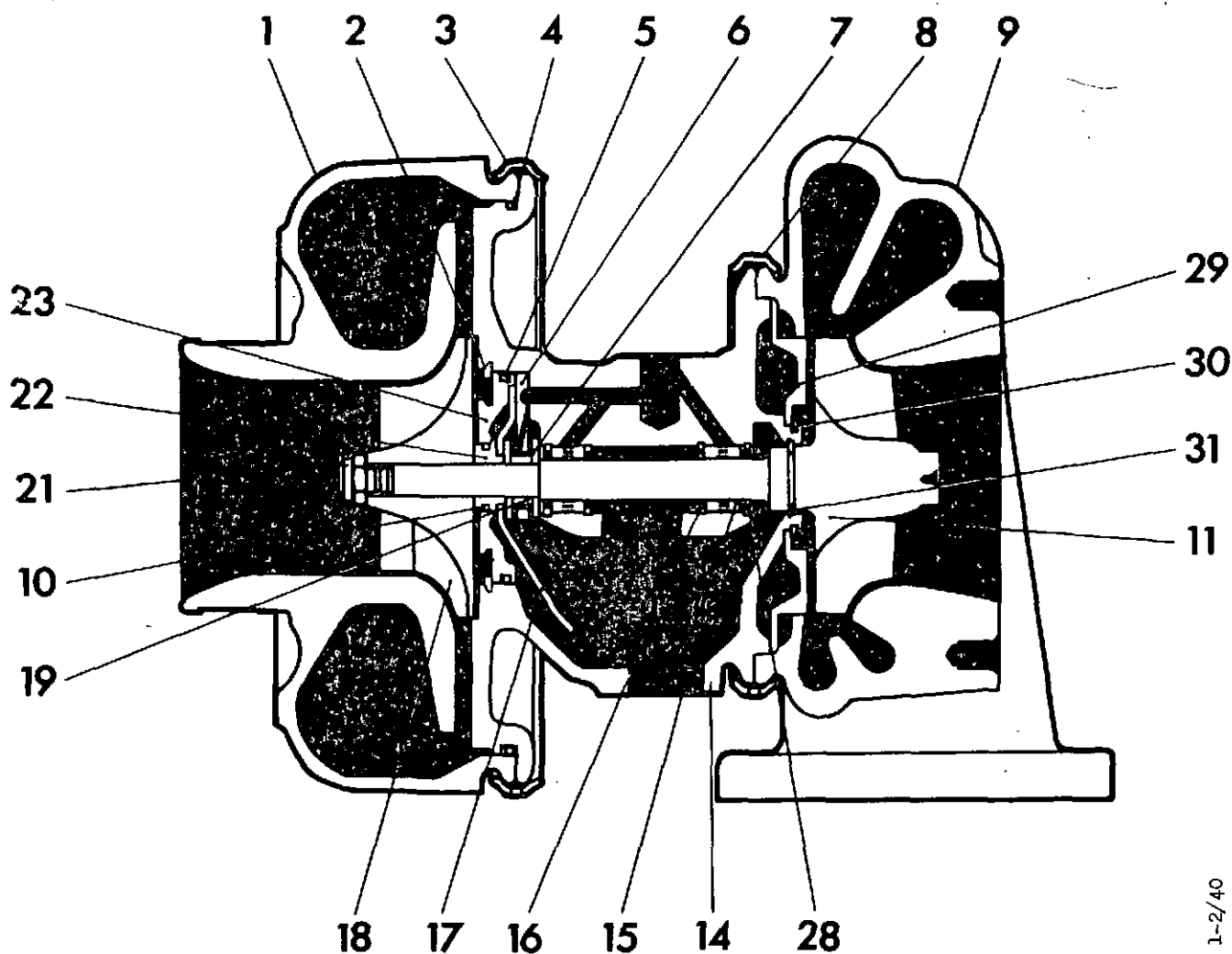
- c) The shaft with turbine wheel shall be fitted before the axial unit. Centre the sealing ring (31) well and push the shaft down carefully into the bearing housing. Do not force the shaft in, as a badly centred ring can warp or break, in which case the latter will result in oil leakage.
- d) Centre the compressor side sealing ring (10) in spacer sleeve (22) and slide unit into the sealing plate from the chamfered side (take great care).
- e) With the bearing housing compressor side turned so as to face upwards the following parts are fitted in the order quoted: Thrust washer (7) spacer (19) pressure bearings (6) thrust washer (7) and oil deflector (17). After this the sealing plate together with spacer sleeve are tapped into position with a plastic mallet and locked with stop ring (2). The chamfered part of stop ring shall be facing upwards.
- f) Check after assembly that the rotor unit rotates freely.

Fitting on the Engine

1. Check that air inlet is clean and that no loose particles are to be found in it.
2. Check manifolds in respect of loose particles.
3. Check oil return line in respect of obstruction and deformation.

1a 2 8.

4. Check oil pressure pipe in respect of possible obstruction, deformation and leakage under pressure.
5. Check connection flange on manifold to see that no pieces of the old gasket remain.
6. Fit a new gasket between turbine housing and manifold. Make certain that the gasket does not project forward in exhaust port.
7. Put in the screws and secure turbocharger unit by tightening the screws.
8. Connect oil pressure pipe and return pipe. Note that oil pressure pipe is connected with two screws, M10x35 and the return pipe with two M20x50. The return pipe is afterwards loosened at sump.
9. Connect the air hose from air filter, and connection pipe to intake manifold. Make certain that it is tight. Check also to see that the hose or pipe does not subject compressor housing to assembly stresses.
10. Operate the engine with starting motor, with stop button pulled out, until oil comes out of return pipe at oil sump.
11. Connect the oil return pipe.
12. Run the engine until it is warmed up and check that no leakage occurs.



Turbocharger Model 4 LE

- | | | |
|---------------------------|------------------------------|-------------------------|
| 1. Compressor cover | 9. Turbine housing | 19. Spacer |
| 2. Stop ring | 10. Sealing ring | 21. Lock nut |
| 3. V-clamp for compressor | 11. Shaft with turbine wheel | 22. Spacer sleeve |
| 4. O-ring-compressor | 14. Bearing housing | 23. Sealing plate |
| 5. O-ring | 15. Plain bearing | 28. Washer, oil check |
| 6. Pressure bearing | 16. Lock ring | 29. Turbine plate, rear |
| 7. Thrust washer | 17. Oil deflector | 30. Lock ring |
| 8. V-clamp for turbine | 18. Compressor wheel | 31. Sealing ring |

1. Engines

a. D5, DS5, D8, DS8, D11, DS11

List of Contents

	Number
General	0
Cylinder Head	1
Intake- and Exhaust System	2
Cylinder Block	3
Crankshaft reciprocating Components	4
Timing Gears	5
Lubricating System	6
Engine Suspension	7
Miscellaneous	9

STARTING OF ENGINES AT LOW TEMPERATURES

General pre-requisites for starting an engine:

1. The engine must be given a sufficient cranking speed on starting.
2. This cranking speed must be kept up for a certain amount of time (=a certain number of revolutions).
3. The fuel-air mixture must be in an easily ignitable state.

In view of these pre-requisites the engine must be correctly adjusted and in good condition. The storage batteries must also be in good condition and the connections between them and the starting motor thoroughly satisfactory. The capacity of the batteries should correspond to the recommendations which you will find below. The fuel system shall be free from water so that no ice crystals block the fuel filters etc.

Temperature down to about -15°C

It is possible to start normally without special equipment or special motor fuel.

A lubricating oil with viscosity recommended for the ambient temperature and a diesel fuel specified in the Service Manual are pre-requisites.

When starting at temperatures between +5°C and -0°C the cold-start device of the injection pump shall be engaged. Please see maintenance instructions.

Attempts to start at still lower ambient temperatures are to be made with the clutch pedal depressed; by so doing the work of the starting motor is facilitated.

At attempts to start the starting motor should be kept engaged without interruption until the engine starts. However, if no ignition or start occurs after a continued period of engagement for say 15 seconds the attempt to start should be interrupted. If, during this attempt the engine ignites but does not start up the attempt period may be extended up to 30 seconds after which time the attempt shall be interrupted. When the batteries have recovered sufficiently during 30 seconds a fresh attempt to start can be undertaken similar to the previous one.

Recommended battery capacities:

Engines D5, DS5, D8 and DS8: 114 ampere/hours
Saaj E 1312 Tudor 6E6, Noack 219 or corresponding

Engines D11 and DS11: 135 ampere/hours
Sääj ET1912, Noack 221, Tudor 6Ex9 or corresponding

Temperatures down to about -25°C

1. The additional conditions according to the specification below must be complied with:

- a) The lowest pour point of the fuel shall be at least 5°C below the ambient temperature.
- b) The batteries shall be of a cold-resisting type (with an increased active surface, i.e. a comparatively low internal resistance).

If the batteries are kept warm by means of a heating device such devices of a normal type can be used, too.

2. We recommend the following additional equipment:

a) ENGINE HEATER

The coolant system of the engine heater shall be connected to that of the engine according to the following instruction:

Connect the inlet hose of the heater to the suction side of the water pump.

Connect the outlet hose of the heater as far away as possible from the thermostats in the coolant system of the engine, i.e. to the cylinder head fitted at the extreme rear.

For more detailed instructions, reference is made to fitting instructions provided by suppliers of engine heaters.

N.B. The inlet and outlet hoses of the engine heater shall be provided with shut-off cocks. **These may only remain opened when the engine heater is in operation.** If a cock is left opened during operation there is danger of insufficient cooling of the engine (in an engine with lubricating oil cooler a subsequent increase of the lubricating oil temperature is then possible).

The capacity of the engine heater should be decided upon in consultation with the supplier of engine heaters. Especially the lowest possible starting temperature and other circumstances concerning the starting of the engine should be taken into consideration. The capacity required is influenced by different factors, e.g. by how well the engine and radiator are protected against wind.

As a guide when deciding upon the heater capacity we can add that at the above mentioned low starting temperature, -25°C , the heater should be constructed so as to be able to keep the coolant at a temperature of about 50° (above that of the ambient temperature, i.e. $+25^{\circ}\text{C}$).

A well wind-protected engine (and radiator) of 6 cylinders requires in this case an output of 2-3kW.

b) ETHER SPRAYER

In those cases when it is not possible to use an engine heater an "automatic starting pilot" can be fitted. Fitting Instructions for such "pilots" can be obtained from our Service Department after application. In that case, please indicate type of engine and chassis.

Temperatures down to -40°C

It is still possible to start with the help of the starting motor. Then it is a pre-requisite, however, that not only the coolant but also the lubricating oil is heated. As lubricating oil congeals slightly below -30°C , it is advisable to maintain a steady heat in order to prevent this critical temperature occurring during an interruption in operation.

1. WHEN STARTING

- a) Push in the stop control completely.
- b) Pull out the hand throttle control completely (this is now necessary for the injection pump with pneumatic governor, too, on account of the choke damper introduced in the throttle housing).
- c) Put the injection pump in cold start position by pressing in the cold start button or, on the majority of CAV pumps, by pulling out the axle of stop lever arm.
- d) **Injection Pump with Pneumatic Governor**

Push in the hand throttle control to a position corresponding to a slightly increased idling speed (approx. 600 rev/min., depress the clutch pedal (but not the accelerator) and start the engine. Let the engine warm up slightly at low speed, approx. 600 rev/min. This will give smoother ignition and less smoke formation than if the engine is operated at higher speeds.

Injection Pump with Centrifugal Governor

Depress the clutch pedal and accelerator and start the engine. Let the engine speed rise to about 1000 rev/min. and then very gently reduce the acceleration to about 600 rev/min. Allow the engine to warm up slightly at this speed. This will give smoother ignition and less smoke formation than if the engine is operated at higher speed. In certain cases, despite the above mentioned method of procedure, starting difficulties have arisen, which have been caused by one or several of the below mentioned factors.

2. In cold weather the control rod moves relatively slowly and it may, therefore, occur that it will not reach max. delivery position when the cold start device is connected in. There is risk, therefore, that the control rod will not go into the cold start position when this is engaged, which will show up by the cold start device not remaining in engaged position when it is released.
3. When the control rod has reached max. delivery position, it may occur, by reason of the slow movement of the rod, that this will only move a little way past the max. delivery position if the cold start device is released immediately after the process of engagement. The amount of friction then experienced in the cold start device, in this case, will be sufficient to prevent the rod from moving further to max. cold start position. In order to prevent this from happening, it is advisable that the cold start button and the axle of stop lever arm respectively be operated in and out several times.
4. It has occurred that with pneumatic governors of make CAV, the diaphragm has become stiff in very cold weather, which apart from other reasons can make the engagement of the cold start device very difficult.

In order to prevent this from happening the cold hardness of the diaphragm has now been improved. The new diaphragm is introduced as standard on both D5 and D8 series injection pumps with pneumatic governors beginning from pumps with the date code "XG", which is indicated on the type plate of pump in connection with serial numbers. The first letter in the code indicates the month of manufacture and the other the year of manufacture, i.e. "X" refers to October and "G" to 1965. Pumps of a later make during 1965 have the code "YG" (for November) and "ZG", (December). Pump manufactured in 1966 has designation "H" for year of manufacture.

The new diaphragm can, if necessary, also be fitted in retroactively. As the part number of the diaphragm is unchanged the improved diaphragm has been provided with an identification sign consisting of a drill mark on the front diaphragm axle end - towards the pump housing. One other difference is that the old diaphragm easily blackens when it is handled by the fingers, which the new design does not do.

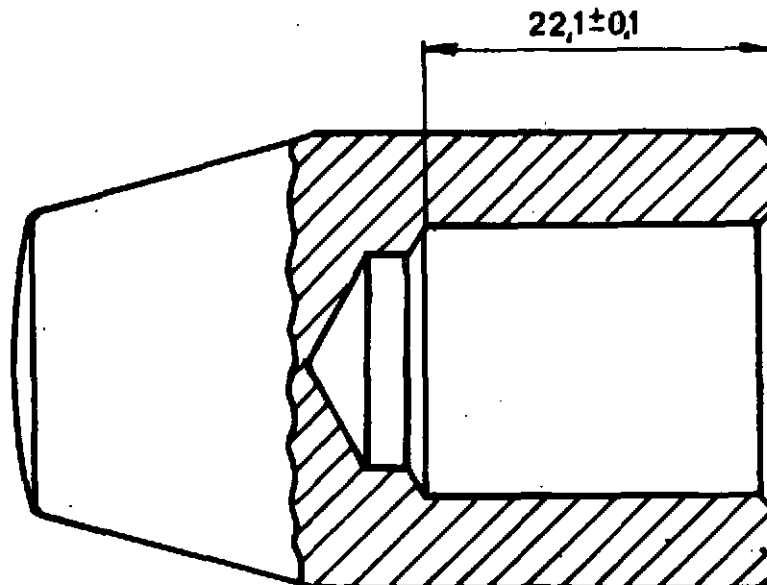
MODIFICATION OF TOOL 87423 FOR PRESSING IN OF VALVE GUIDE ON D/DS5, D7, D/DS8 AND DS14

The modification of the above-mentioned drift for pressing in of valve guides enables the tool to be used also for pressing in the valve guides on DS14.

The modification involves grinding the tool to give the dimension indicated in the figure below. At the same time, the letter "N" must be punched into the drift alongside the

tool number to indicate that the drift has been modified to the new version.

Through this modification of the drift, the nominal height of the valve guides will be 24.01 mm. This implies that the guide heights for D/DS5, D7 and D/DS8 are lowered.



PRE-LUBRICATION OF THE VALVE SPINDLE IN THE ENGINE CYLINDER HEAD

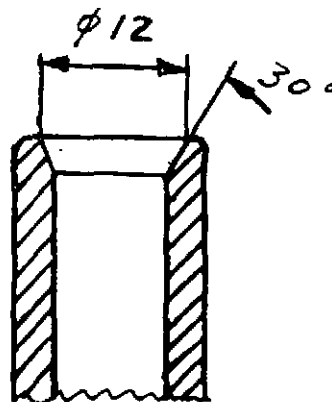
Cases have been reported of severe wear in the exhaust valve guide and on the exhaust valve spindle on account of insufficient lubrication of the valve spindle during assembly. Therefore, in order to prevent damage of this kind we recommend the following measures to be taken in conjunction with the fitting of valves:

1. Make quite sure when checking that the edge of the hole in the top guide ends does not give rise to constrictions or sharp upsetting burrs that are likely to damage the lubricating oil film on the valve spindle. The risk as far as upsetting damage is concerned is particularly great when carrying the cylinder head to D11 and DS11, if it is placed or pushed on a surface, bench or similar, with the open ends of the valve guides turned facing the bench.

Upsetting burrs can also arise if the drift is subjected to hard blows when the stop sleeves are removed on the valve spindle. If there are any signs of the defects

mentioned then the guide ends must be chamfered on the exhaust valve guides according to the figure below, but not on the intake valve guides. This only applies to exhaust valve guides Part No. 131086 on D11, DS11 and DS14.

2. Before the valves are fitted in the guides it is advisable for the spindle of both exhaust and intake valves to be carefully lubricated with a recommended engine oil.
3. The valve spindles should be lubricated just after the engine has been started - before the oil from the jet lubricating mechanism reaches forward to the valve spindle. This measure is not only recommended after the valves have been reassembled, but also in cases where the cylinder head has been removed for some other reason.



The permissible chamfer in the top end of the exhaust valve guide.
The part number of the guide is 131086

STUD BOLTS FOR ATTACHMENT OF TURBOCHARGER

It has been found that the turbocharger has been able to loosen from the exhaust manifold as a result of permanent deformation of the stud bolts. We have, therefore, introduced a better quality of stud bolts as indicated in the list below.

Type of stud bolt	Quantity
DS5, DS8	4
DS5R42	4
DS11	4

Part No.	
New	Discontinued
191892	800060
203373	800064
189259	800062

When problems of this nature are encountered, the old stud screws should be replaced by new ones as indicated above.

CRACKED FRONT OR REAR EXHAUST PIPE PARTS, PART NO. 177962 and 177963 ON DS11-SERIES ENGINES

The subject pipes - usually front - have cracked on some engines. The cause of this may be owing to the fact that the pipes have been fitted in a somewhat constricted position. The intermediate part of the exhaust manifold Part No. 176596, has to a certain extent had a dimensional error, because the contact surface of the retaining screw lugs against the cylinder heads has not been fully processed. The distance between the surface and the centre points of the pipe holes have thus been too large, causing abnormal stresses in connecting pipes when these are being tightened up.

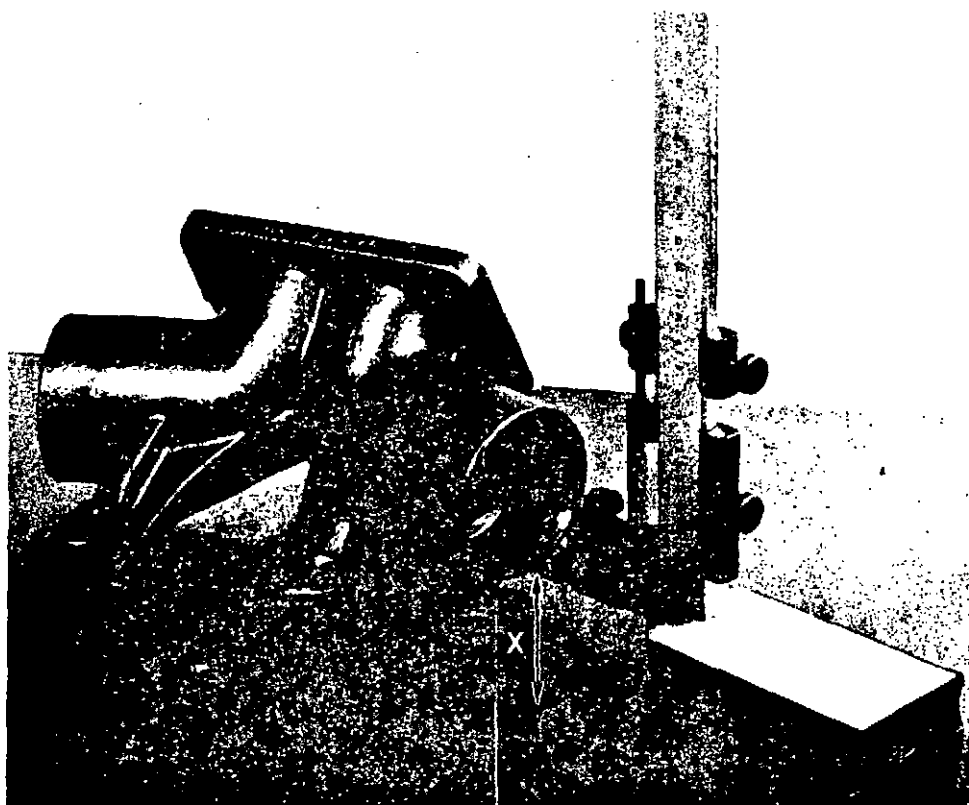
Therefore, in conjunction with replacement of cracked pipes it is necessary to check the intermediate part of the exhaust manifold. When doing so, proceed, where appropriate, in the following manner:

1. Put the intermediate pipe on a surface table and measure up very accurately the distance X mm between the pipe hole and the surface table (the accuracy of measurement, at least on tenth part mm) using vernier height gauge with vernier scale according to figure.
2. The inside diameter of the pipe hole is normally 62.0 mm. On faultless intermediate pipes the dimension $x + \frac{62}{2}$ shall amount to 50 ± 0.1 mm, i.e. X shall be

19 0.1 mm. If there is any greater distance the contact surface of screw lug against the surface table shall be processed with a suitable tool (if necessary with file) until the dimension 50 ± 0.1 mm is obtained. Make quite certain that the surface on the four lugs is processed evenly and equally as much. It will also be necessary to check the degree of processing by measuring up the height of lugs (on hole depth of the two upper lugs) before and during the processing work.

Remarks:

If the above mentioned vernier height gauge is not available, measurement can be made by using either a sliding caliper with vernier scale or an external micrometer. In such a case the intermediate pipe must be put close to one edge of the surface table, which thereby makes it possible to measure the distance to the lower side of surface table (Afterwards deduct the thickness dimension of the surface table). That part of the measuring instrument, which is flush against the surface of the hole must either be shaped as an edge or rounded off (radius less than the pipe hole) in order that an adequate contact against the surface of the hole shall be assured.



NEW SCREW JOINT FOR EXHAUST PIPE PART NO. 177962 AND 177963 ON DS11- SERIES ENGINES

In some cases retaining screws have had a tendency to come loose, as a result of which a new screw joint has been introduced as standard. This screw joint consists of a 20 mm longer retaining screw, M12x60 mm (compared with previous M12x40) and a 25 mm long spacer sleeve, which is fitted between the screw head and exhaust pipe flange.

The new screw joint should, if necessary, also be used on engines already delivered.

Thus, as the retaining screw is longer, the flexible deformation capacity of the joint increase, thereby preventing the screw from coming loose.

Therefore, when fitting screw 221362, it shall be tightened to a torque of 7 kgm or 51 lbs. The screw shall be re-tightened to the same torque after 2.500 km or 50 hours service.

Discontinued Parts	New Parts	Description
8 177634		Screw M12x40
8 803001		Washer BRB 12x22
	8 221362	Screw M12x60
	8 216247	Spacer sleeve (inner diameter Ø 12.9, Outer diameter Ø 18.0 mm)

The modification concerns the following type engines in production: DS11RO1A, DS11RO2A, DS11RO6, DS11RO7, DS11CO1, DS11CO2, DS11R40.

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datum/date 1.9.71	best. nr/order nr 6201a:3-1 E	

LEAKING DRAIN PLUGS IN CYLINDER BLOCK AND CYLINDER HEAD

Because of complaints about leakage occurring at the drain plugs in the cylinder head and cylinder block, a replacement convex sealing plate is now available from our Spare Parts Department.

The oversized, threaded plugs are still available also, e.g. for cases where the engine cooling water outlet is situated on the plug in the rear end of the cylinder block.

Convex Sealing Plate Installation

Clean the hole thoroughly and cover its surface outside the threads with sealing compound - order No. 761019 in the cylindrical part of the hole.

Install the sealing plate and flatten its centre to a tight fit with a flat end punch or similar tool.

Oversized, threaded plugs

Use the same sealing compound as mentioned above to cover the threads and additionally, sealing ring No. 151225 for

oversize No. 1 and sealing ring No. 151223 for oversize No. 2.

Parts needed

The convex sealing plate is available from our Spare Parts Department as listed below:

Name of Part	Part No.
Sealing plate, convex	204541
Sealing compound	761019

Threaded plugs, oversized:

	Thread	Part No.	Sealing Ring
Standard	M44x1.5	139302	152750
No. 1 oversize	M46x1.5	138279	151225
No. 2 oversize	M52x1.0	152635	151223

LOWER SEALING RING FOR CYLINDER LINER

In certain cases, problems may be encountered with leakage, the reason being that the lower of the three sealing rings for the cylinder liner seal hardens and cracks under the influence of high temperature and the additives contained in the lubricating oils.

For this reason, the lower sealing rings are nowadays made of a material with better resistance. These sealing rings are provided with a yellow or violet field.

A sealing ring with yellow colour marking and a sealing ring with violet colour marking are of exactly the same quality and design.

In connection with removal and fitting of cylinder liners,

we wish to recommend that the new sealing ring be fitted as the lower ring.

The new sealing rings are also included in the overhaul kits for the different engine types.

Description	Discontinued	New	Engine type
Sealing ring, lower	131611	209579	D5, DS5, D7, D8, DS8
Sealing ring, lower	139237	177587	D10, DS10, D11, DS11, DS111

INCREASED CLEARANCE BETWEEN CYLINDER LINER AND CYLINDER BLOCK ON ENGINE SERIES D5, DS5, D8, DS8, D10, DS10, D11, DS11, D14 AND DS14

In order to satisfy the demands put upon the cylinder liner fastening, which may occur during extreme cooling conditions, the clearance between cylinder liner and engine block has been increased slightly in the bottom liner position. The increase in clearance has been brought about by reducing the outer diameter in the bottom part of the liner.

Therefore, with exception of liner do DS14, (Part No. 170690), new part numbers have been added according to below:

Engine Type	Discontinued Cylinder Liner Part No.	New Cylinder Liner Part No.
D5 and DS5	131612	219207
D8 and DS8	131612	219207
D11 and DS11	156000	219938

The discontinued liner 131612 and 156000 can be used on engine of type D5 and D8 (with exception of D8R03 for which special instructions apply) and engine type D11 respectively.

MODIFIED REAR CRANKSHAFT SEALING ON SEPARATE ENGINES AND D11-ENGINES IN REAR ENGINE BUSES

Separate engines and D11-engines in rear engine buses have been provided with sealing ring 178866, instead of felt ring on rear crankshaft sealing.

When replacing the sealing ring 178866, the crankshaft is to be inspected in case of possible abrasive marking occurring from the sealing lip. If there is evidence of abrasive marking, then spacer washer 209666 shall be fitted in the flywheel housing position for sealing ring.

When taking this precaution the sealing ring is to be moved axially, so that the sealing lip will work against an unused surface of the crankshaft.

If, necessary, sealing ring 178866 can also be fitted in older engines by fitting a special bracket in the flywheel housing according to the following:

For D8-engines fig. 2

1. Turn out the flywheel housing according to fig. 1.
2. Use self-hardening plastic, Part No. 761029 when fitting the bracket 181385 in the flywheel housing. In order to facilitate fitting it is advisable to place the housing on a flat surface and to use a 13 mm thick spacer with which the bracket is pressed against. Check, with a deep gauge that the bracket is straight.
3. Press the sealing ring 178866 in the bracket with the 13 mm thick spacer as support under the bracket.
4. Grind the crankshaft with a fine emery cloth, fineness of grain 220 on the contact surface of the sealing ring, so that it is given a surface evenness Ra 1.6. This is of special importance when the surface is smooth ground by a previous felt ring.
5. Take great care when the flywheel housing is being fitted that the sealing ring does not become damaged when put on the crankshaft.

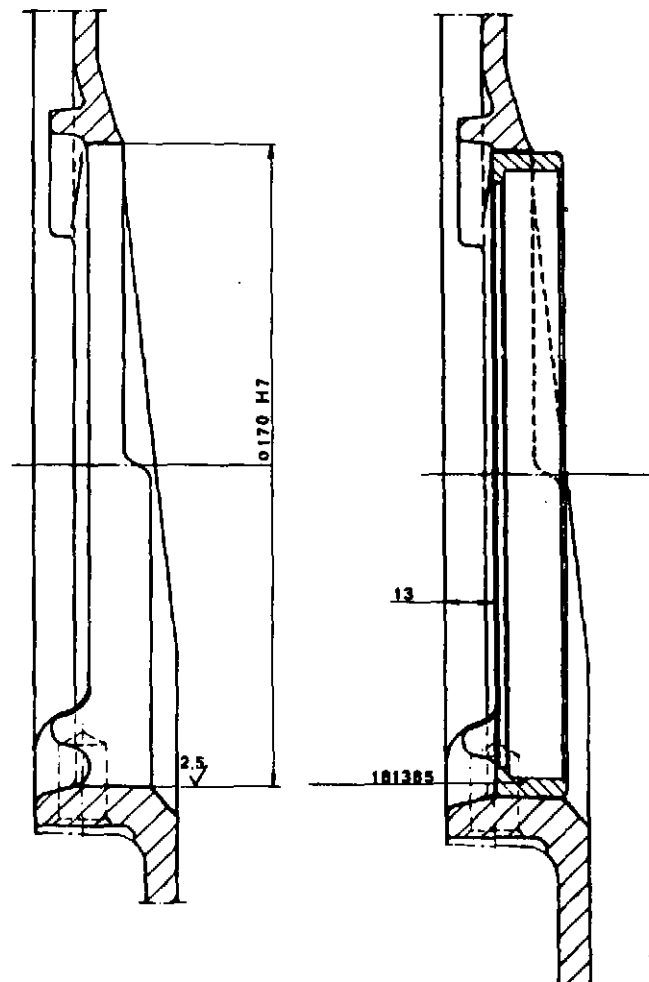


Fig 1

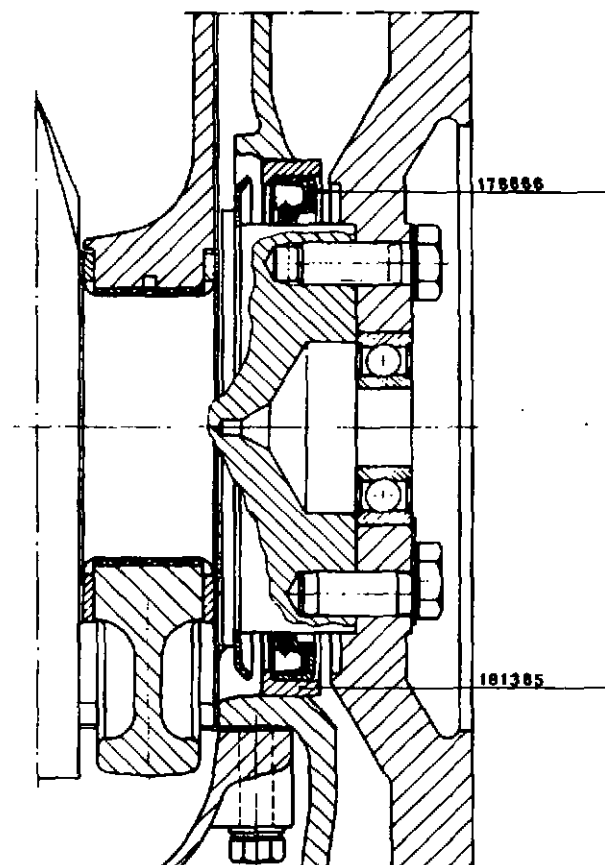


Fig 2

For D11-engines fig. 4

1. Check the flywheel housing concerning thickness of material, (see fig. 3). The thickness must be a min. of 4 mm, after turning, in order that the flywheel housing can be used.
2. Turn out the housing according to fig. 3.
3. Use self-hardening plastic, Part No. 761029 when fitting bracket 211211 in the flywheel housing. N.B. There must not be any oil or grease in the flywheel housing and bracket before coating with locking fluid. Both the bracket and the flywheel housing are to be coated.

4. Press the sealing ring 178866 in the bracket.
5. Grind the crankshaft with a fine emery cloth, fineness of grain 220 on the contact surface of the sealing ring, so that it is given a surface evenness Ra 1.6. This is of special importance when the surface is smooth ground by a previous felt ring.
6. Take great care when the flywheel housing is being fitted that the sealing ring does not become damaged when put on the crankshaft.

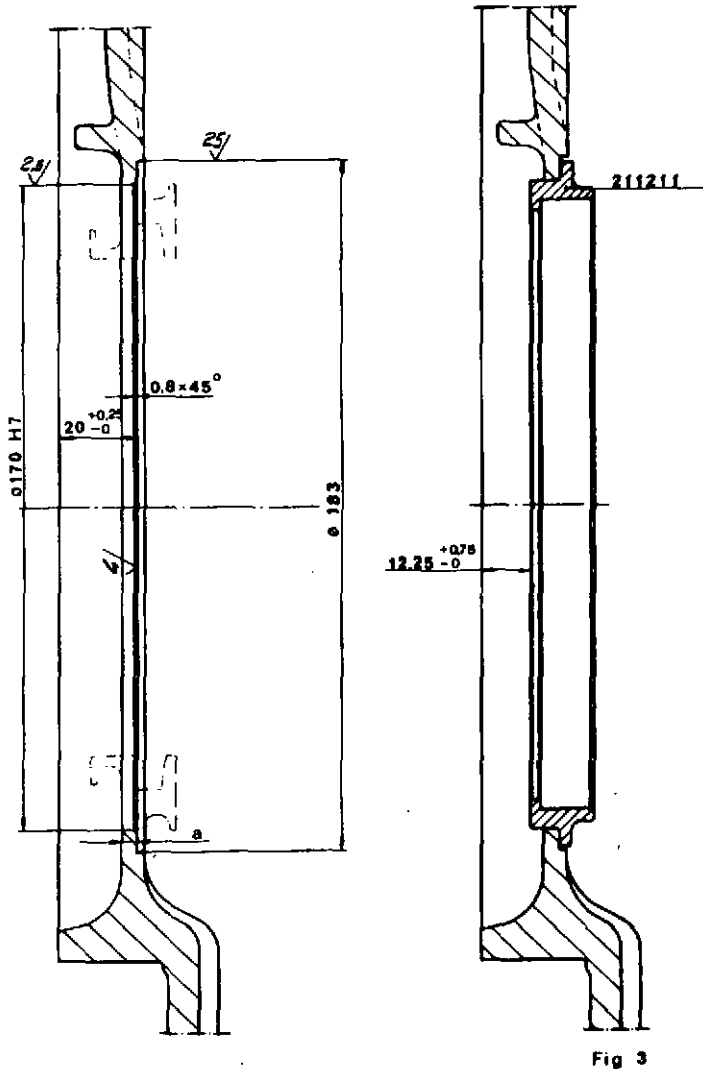


Fig 3

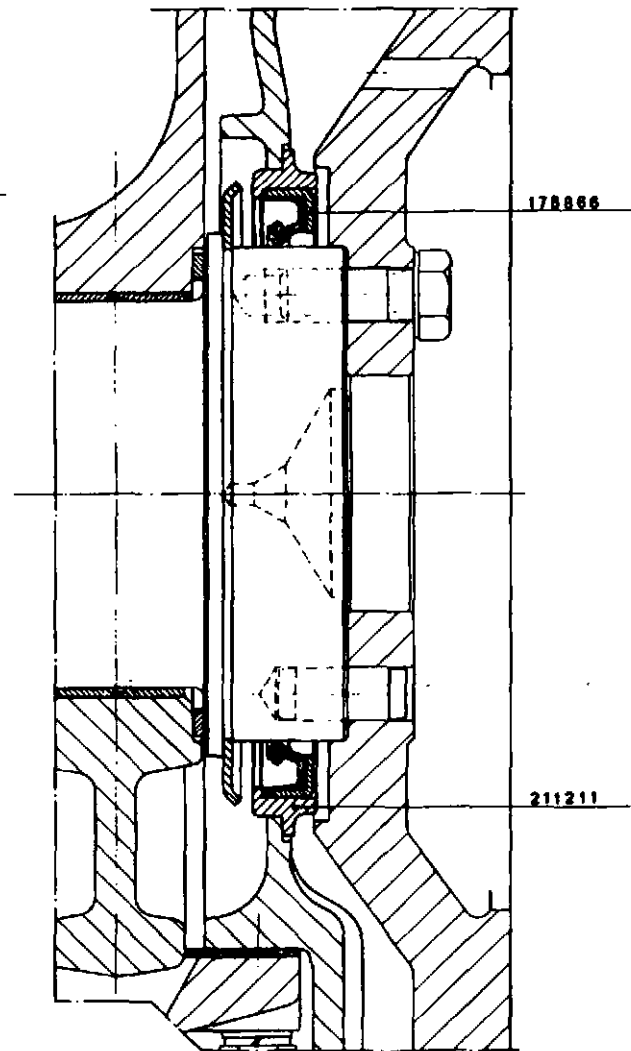


Fig 4

SERVICE SCANIA PRODUCTS

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GASKET FOR OIL SUMP

On engines D5, DS5, D8, DS8, D11 and DS11 the earlier type gaskets of fine grain cork with inserts of aluminium foil have been replaced by new gaskets of another material. Therefore, in order to facilitate handling and to make the parts less bulky the new gaskets have been made in four parts with dovetail slot joints.

The part numbers for the new gaskets are shown below.

Type	No.
D11, DS11	215242
D8, DS8	215246
D5, DS5	215248

INTAKE- AND EXHAUST SYSTEM

TURBOCHARGER MODEL 3LD AND 4LE

Wear Limits

	3LD	4LE
Radial Clearance of Rotor	Max. 0.61 mm	Max. 0.61 mm
Axial Clearance of Rotor	0.10–0.20 mm	0.80–0.15 mm
Total Shaft Run-Out in V-block	Max. 0.01	Max. 0.02 mm
The Total Distortion of Turbine Wheel Measured on Radius 30 mm	Max. 0.04 mm	-----
Measured on Radius 25 mm	-----	Max. 0.03 mm
Diameter of Bearing Housing at Bearing Positions	Max. 22.276 mm	Max. 22.268 mm
Diameter of Shaft at Bearing Positions	Min. 12.190 mm	Min. 14.251 mm

Tightening Torques

Locknut for Compressor Wheel	1.8 kgm (18 Nm)	1.9–2.2 kgm (19–22 Nm)
Locknut for V-Clamp	1.4 kgm (14 Nm)	1.4 kgm (14 Nm)
Screws for Compressor Housing	0,7 kgm (7 Nm)	-----
Applies to: DS5, DS8, DS11		SE, SF, SG, SH

Charging Pressure

Correction table for measurement of charging pressure with consideration to the temperature of the intake air in °C. (The corrected values refer to an intake air temperature of +25°C and are to be compared with the current charging pressure diagram).

Charging Pressure Measured Below bar (kg/cm ²)	Temperature of Air Sucked in °C (Ambient Temperature)											
	-20	-15	-10	-5	0	+5	+10	+15	+20	+25	+30	+35
	Corrected Values											
0,20 (0,20)	0,16	0,16	0,17	0,17	0,18	0,18	0,19	0,19	0,20	0,20	0,21	0,22
0,30 (0,31)	0,23	0,24	0,25	0,26	0,27	0,27	0,28	0,29	0,30	0,30	0,31	0,32
0,40 (0,41)	0,31	0,32	0,33	0,34	0,35	0,36	0,37	0,38	0,39	0,40	0,41	0,42
0,50 (0,51)	0,39	0,40	0,41	0,42	0,44	0,45	0,46	0,47	0,49	0,50	0,51	0,52
0,60 (0,61)	0,46	0,48	0,50	0,51	0,52	0,54	0,55	0,57	0,58	0,60	0,62	0,63
0,70 (0,71)	0,54	0,56	0,58	0,59	0,61	0,63	0,65	0,66	0,68	0,70	0,72	0,73
0,80 (0,82)	0,62	0,64	0,66	0,68	0,70	0,72	0,74	0,76	0,78	0,80	0,82	0,84
0,90 (0,92)	0,70	0,72	0,74	0,76	0,79	0,81	0,83	0,85	0,88	0,90	0,92	0,94
1,00 (1,02)	0,77	0,80	0,82	0,85	0,87	0,90	0,92	0,95	0,97	1,00	1,02	1,05
1,10 (1,12)	0,85	0,88	0,91	0,94	0,96	0,99	1,02	1,05	1,07	1,10	1,13	1,16
1,20 (1,22)	0,93	0,96	0,99	1,02	1,05	1,08	1,11	1,14	1,17	1,20	1,23	1,26

Example: A charging pressure of 1.0 bar (1.02 kg/cm²) measured at -15°C corresponds to 0.80 bar at +25°C.
 A charging pressure of 0.50 bar (0.51 kg/cm²) measured at +35°C should at +25°C have been 0.52 bar etc.

pressure
bar

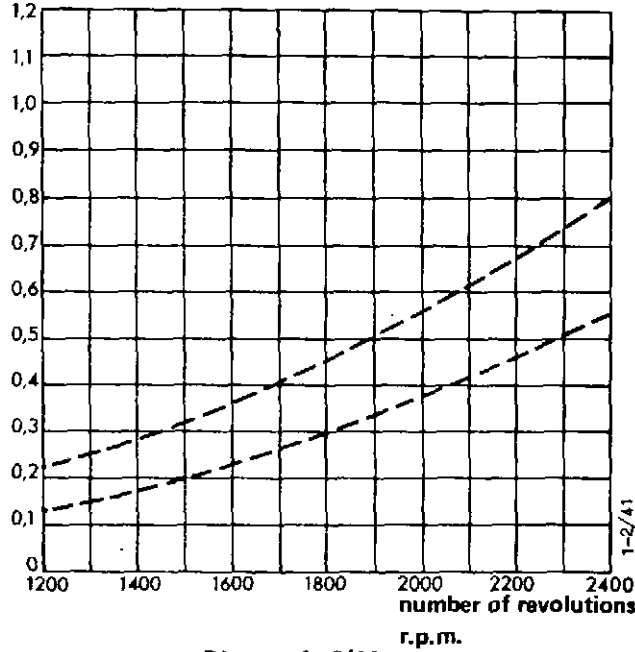


Diagram 1-2/41

Limits for corrected charging pressure for engines DS5

pressure
bar

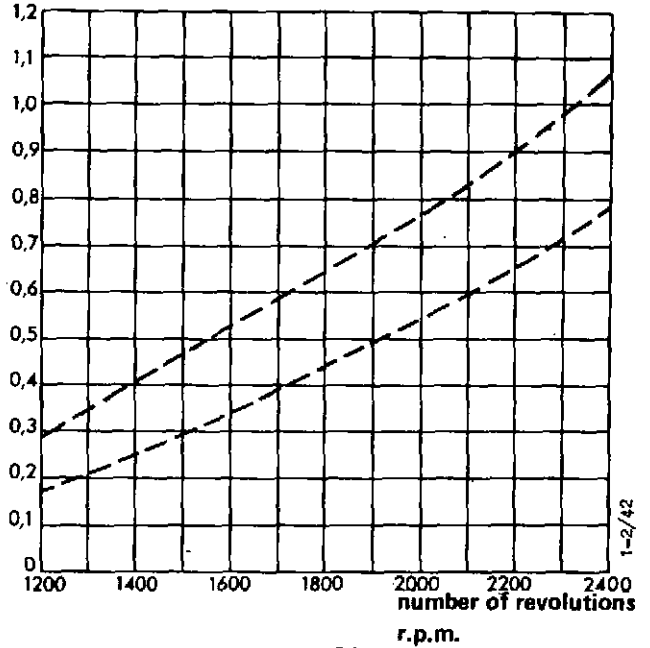


Diagram 1-2/42

Limits for corrected charging pressure for engines DS8

pressure
bar

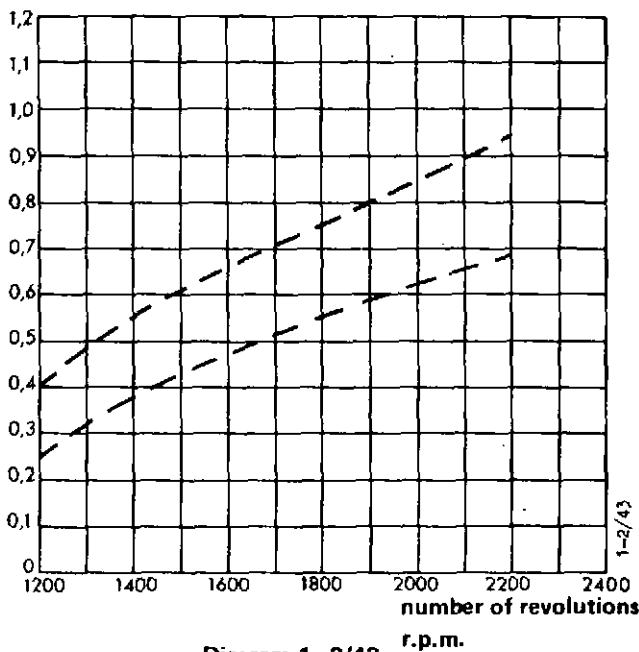


Diagram 1-2/43

Limits for corrected charging pressure for

pressure
bar

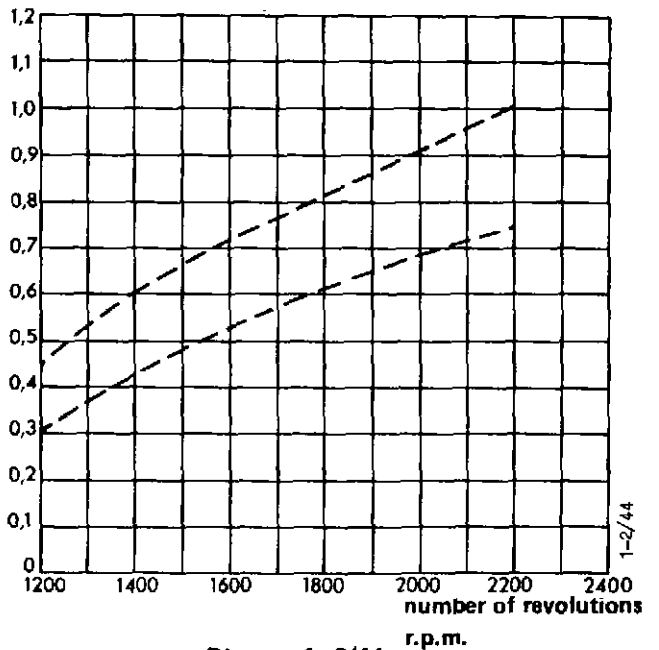


Diagram 1-2/44

Limits for corrected charging pressure for

SERVICE SCANIA PRODUCTS

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1 Engines c Separate Engines

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FITTING INSTRUCTIONS, DS14 ENGINE

A. Intake System - Engine Room Ventilation

Air Intake for Engine

It is worthwhile providing the engine with a fresh air intake, i.e. the intake air is taken outside the engine room and conducted straight through to the engine via a hose or similar. By doing this the lowest possible temperature of the air introduced in the engine is automatically obtained.

In cases where fresh air intake does not come into consideration the air intake must be located in the engine room wall, the opening of which must be adapted to the volume of air consumed in the engine room so that no appreciable underpressure in the engine room occurs. The air intake should also be designed so that it cannot shut off inadvertently.

The area of air intake should amount to 8 dm^2 where the volume of air consumption for the engine only is concerned. However, should several engines be operated in the same engine room, the air intake section shall be increased correspondingly.

The engine air consumption at maximum output:

Engine Rev/Min.	1500	1800	2100
-----------------	------	------	------

Engine Air Consumption in m^3/hrs	800	1050	1320
---	-----	------	------

Air Temperature

Temperature in the Engine Room

The temperature of the intake air for the engine should not exceed 35°C . The maximum permissible temperature of the intake air is 40°C . This requirement implies in general, on installations where the intake air for the engine is taken direct from the engine room, that the engine room is provided with a ventilation system (ventilation fan).

In the engine room with fresh air intake for engine, i.e. the intake air for this is taken direct from the outside of engine room as already mentioned. The engine room temperature may then in contrast rise to max. $+60^\circ\text{C}$ without the engine components suffering damage as a result. If the air temperature exceeds this value there is risk of functional disturbances occurring on the alternator, the charging regulator, and in the magnetic cut-out. This means that in special cases a ventilation fan is required even for engine installations with fresh air intake. The capacity of the venti-

lation fan for the engine room is estimated with support of the particulars below, which refer to the DS14-engine with non-water cooled exhaust pipe and without heat exchanger:

Engine rev/min.	1500	1800	2100
-----------------	------	------	------

Radiating heat in kW specific, at max. output and $+25^\circ\text{C}$ air temperature.

The radiating heat in kcal/hkh within brackets	0.158 (100)	0.111 (70)	0.095 (60)
--	----------------	---------------	---------------

When estimating the capacity of the fan, consideration must also be taken to the radiating heat from the exhaust line extending from the engine. The amount of this heat depends on how much of the line is located in the engine room and if the line is insulated. Furthermore, quantities of heat on account of efficiency losses also occur on driven units, which can be worthy of attention and should be taken into consideration.

Location of Air Intake and Air Filter

The air intake should be located in such a way as to eliminate any risk of the engine exhaust gas being sucked into the intake air system. In addition, it must be so arranged that the turbocharger must be cleaned more often than usual - this implies that the air intake must be located as high as possible. The air intake should be protected so as to prevent water, snow and other impurities entering.

The air filter part No. 212664, of dry filter type and parts for connecting this are supplied as standard equipment. The filter can either be fitted horizontally or in a vertical position. When placed in a horizontal position it shall be turned so that the slot inside the filter for releasing the dust is pointing upwards, see fig. A1.

Flow Resistance in the Intake Line of Engine

If the engine has fresh air intake, i.e. special line for the intake air, the drop in pressure for this line is to be measured. The maximum permissible drop in pressure is approx. 300 mm water column, the value of which also comprises the resistance of the air filter used in a clean state. If the drop in pressure is too great there is risk that the quantity of air to the engine will be insufficient or that other disturbances will occur.

The above method of control can, however, be considered superfluous if the area of the pipe line used, amounts to at

least 138 cm² (corresponding to an inner diameter of 133 mm on round section) and if the length of line does not exceed 3000 mm, provided that no sharp bends arise.

If a hose is used as air line it shall be armoured so that it cannot be sucked together.

Ventilation of Crankcase

The gases from the engine crankcase should preferably be led out from the engine room via a separate line. The condensation from the gases foul namely the intake system (turbo-charger etc.), which has a detrimental effect on its effectiveness. In cases of installation where this would mean a long ventilation line and a costly installation the crankcase ends can, however, be led to the intake system of engine between the air filter and turbocharger. However, this would imply that the turbocharger must be cleaned more of ten than usu-

al, compare Maintenance Instruction.

Crankcase gases should not be led to the engine air filter, which is of dry filter type. The crankcase ventilation line

is suitably made of a pipe or plastic hose which is connected to the ventilation pipe on the engine, see fig. F1 under "Engine Dimensions". The inside diameter of this line should be at least 35 mm up to a length of 3 m. A comparatively thicker diameter should be chosen for a longer line. The crankcase ventilation line, which opens outside the machine room shall be protected so that impurities cannot force their way down into the crankcase. The line from the engine out of the machine room must not be made with sharp creases or bends and it should rise as far as possible the whole way in direction from the engine. By doing this no oil condensation will remain in the pipe, which otherwise causes constriction and overpressure in the engine crankcase.

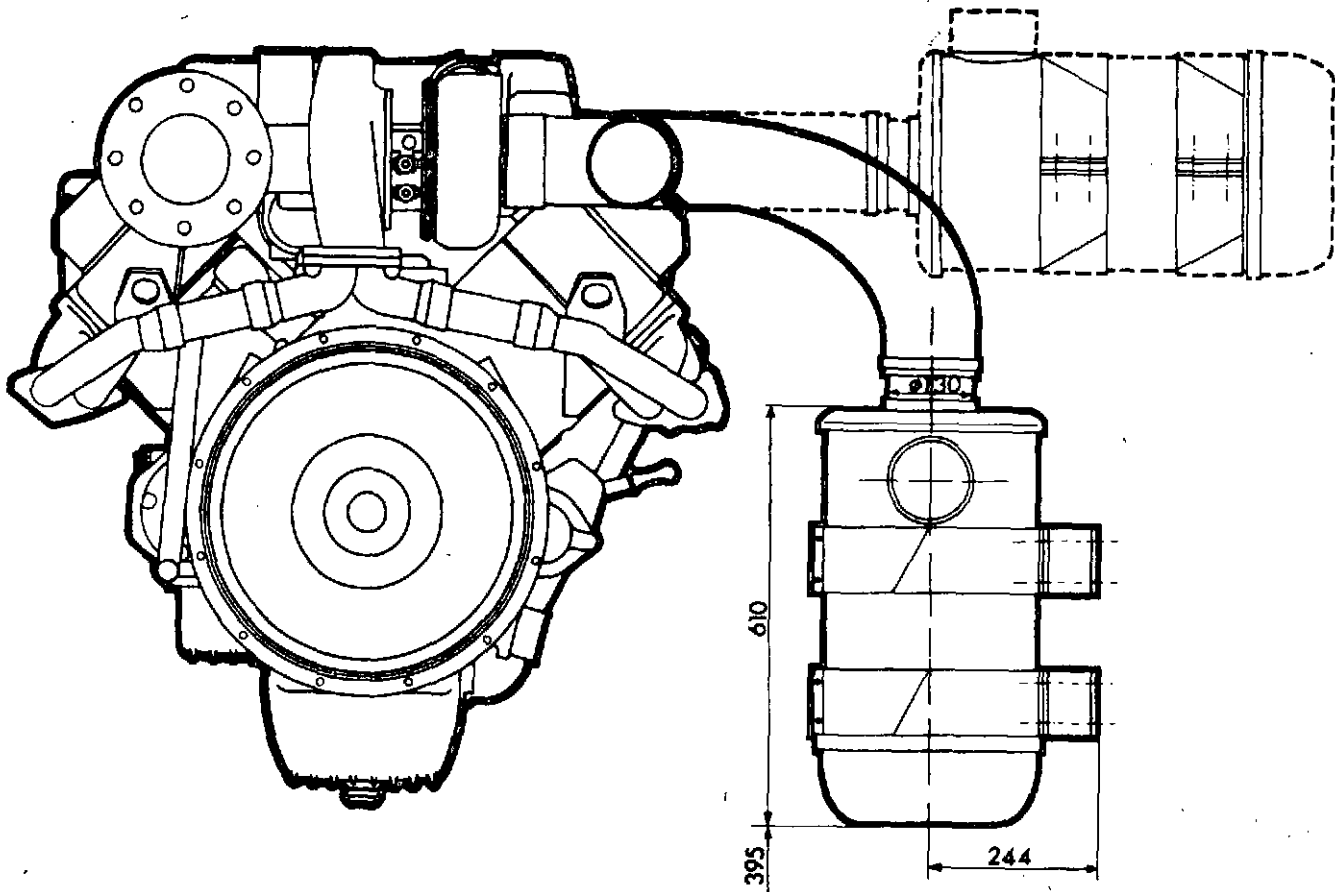


Fig. A1

Alternative installations of air filter part No. 212664. Please note when fitting horizontally, that the dust release slot inside the dust collector shall be turned facing upwards. To remove the filter insert, it is necessary to have a space of at least 395 mm available under the filter.

B Exhaust System

Sound Damping

Mufflers are used at the majority of engine installations.

However, the need for mufflers must be judged from case to case with consideration being given to acceptable noise level, exhaust line length, the position of the exhaust line opening, etc. Heat insulation of the exhaust line also has an effect on the noise level in such a way that, with an insulated line, the exhaust noise will be greater than with a line which is not insulated.

In those cases where a muffler is to be fitted, this should be located as far away from the engine as possible. However, it should not be placed in the end of the exhaust line, but roughly one metre from the opening. If, because of limited space, the muffler cannot be placed close to the exhaust opening, it should be put as near to the engine as possible. It is often advisable to fit in a booster muffler close to the exhaust opening, whereby possible resonance vibrations in the exhaust line following the muffler at the engine will be absorbed.

Choice of muffler is suitably done in consultation with the Engine Sales Department at Saab-Scania AB.

When particularly bid demands are placed on low noise level, e.g. at a hospital, a sound insulation cell for the exhaust gases can be built. More detailed instructions about this can be obtained through the Engine Sales Department at Saab-Scania AB.

Dimensioning of the Exhaust Line

The diameter of the exhaust line is calculated in the following manner:

- a) Measure the length of the planned exhaust line.
- b) Determine a preliminary inner diameter (Dp) for the exhaust line from the table below.
- c) Calculate how many 90° pipe elbows are to be included in the exhaust line. Two 45° pipe elbows are equivalent to one 90° pipe elbow etc.
- d) With help of the preliminary diameter Dp and the quantity of 90° pipe elbows, which are converted calculatively into straight pipes with the same total resistance value, an additional length is determined (L₁) from the diagram (Fig. B1).

With the additional length, consideration is taken to the resistance in pipe elbows and the discharge resistance in the line opening. N.B. It will be necessary to calculate with an additional length, even if the exhaust line has no pipe elbows (line "O" in diagram).

- e) Add the estimated additional length (L) to the length measured (L) and then read with guidance from this total length (L_{total}) the final inner diameter in the table. Select the next larger standard diameter.

Exhaust Line Inner Diameter, mm

Engine rev/min	1500					1800					2100					Muffler part No.
	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	
Exhaust line length, m																
Exhaust line inner diameter, mm	88	100	109	115	122	99	113	123	130	137	109	125	136	144	152	208306 207308

1c 8/2 4.

Example: Engine Type: DS14A01
 Operating Speed: 1500
 Muffler: Part No. 208306

- 1) Measured length (L_u) = 14 m
- 2) Preliminary inner diameter (D_p) = $100 \frac{4}{5} (109-100) = 107 \text{ mm}$
- 3) Number of pipe elbows: 3 parts 90° + 4 parts 45° = 5 parts
- 4) Additional length (L_t) = 9 m
- 5) $L_u + L_t = L_{tot} = 14 + 9 = 23 \text{ m}$
- 6) Definite inner diameter = $115 \frac{3}{5} (122-115) = 119 \text{ mm}$

The pipe elbows on the exhaust line shall be designed with large radius.

The estimated inner diameter according to the above implies that the exhaust line is insulated; that is the reason why any increase of the inner diameter is unnecessary because of this.

Exhaust Line Connection and Location

Regarding the engine movements when this is rubber suspended and to the lateral changes which occur in the exhaust line as a result of changes in temperature in the line, there must be some sort of flexible connection between the exhaust pipe and the engine. This is particularly important for engines equipped with turbochargers in order to prevent the unit from being damaged.

The Saab-Scania Engine Sales Department supplies certain designs of such compensators and parts for connection of these. The compensator with part number 208305 consists of a pipe in rustproof plating partly corrugated, see fig. B2.

The compensator can at the same time absorb the lateral and longitudinal movements indicated in the figure.

The compensator is designed to be connected to pipe elbow 208270, which in its turn is fitted on the turbocharger unit and can be connected at different angles to this. A separate bracket is also fitted to the pipe elbow, see fig. B2. Any greater demand for absorption of movement must be satisfied by fitting additional compensators of this or other design in that part of the exhaust line where the need is necessary. When it concerns the absorption of movements longitudinally, compensator 170948 may be the most objective.

Insulation

The necessity of insulating the exhaust line must be judged from case to case. With internal air intake for the engine, the exhaust line should be insulated particularly well in order to reduce the engine room temperature. One other

reason for insulating is e.g. to reduce the risk of the machine personnel contracting burns and to diminish expenses for ventilation. Be particularly careful about the insulation when fitting the line through or in the vicinity of inflammable material.

Protection against the Penetration of Water

Rain or condensation water which penetrates into the engine can cause corrosion and subsequent damage. Therefore, the exhaust line should be protected in order to prevent this.

Long exhaust lines should be provided with a condensation water separator to be located after the flexible connection, although not too far from the engine. A cleanable water trap should be attached to the condensation water separator. Even with short exhaust lines the condensation water separator may be justified if there is a risk of water penetration. This risk, can also be eliminated by using a self-closing cover over the exhaust line.

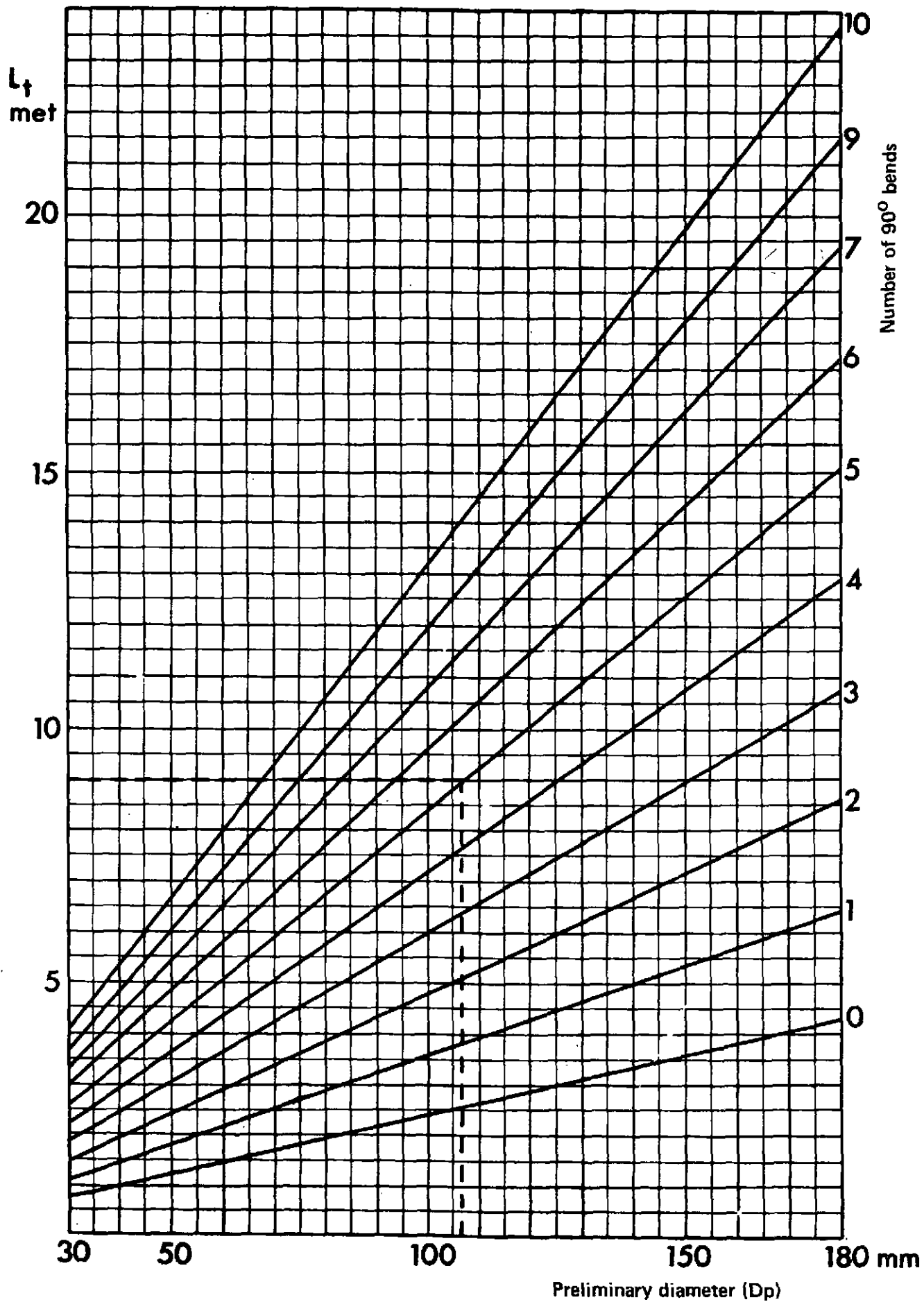
Back Pressure in the Exhaust Line

The back pressure in the exhaust line may be allowed to reach a value equivalent to max. 500 mm water column and should be checked after installation. Measure the pressure adjacent to the connection between the exhaust line and the engine. Run the engine with maximum load and at maximum rev/min. when measuring the value of a thoroughly warm exhaust system.

Multi-Engine Installations

With multi-engine installations a separate exhaust line for each engine should be provided, if possible. In those cases where the exhaust lines from several engines are joined to a common exhaust line, the same dimensioning principles are applicable for every branch line as for the exhaust line of the single engine installation according to the above. The common exhaust line section will be finally dependent on its length, but it shall at least correspond to the total section of the branch lines.

In those cases where several engines are connected to a common exhaust line, there should be an easily operated and effective shut-off device in each branch line. This is very important, as the exhaust gases from the engines which are in operation can otherwise penetrate into an engine which is not in operation and cause, among other things, corrosion damage.



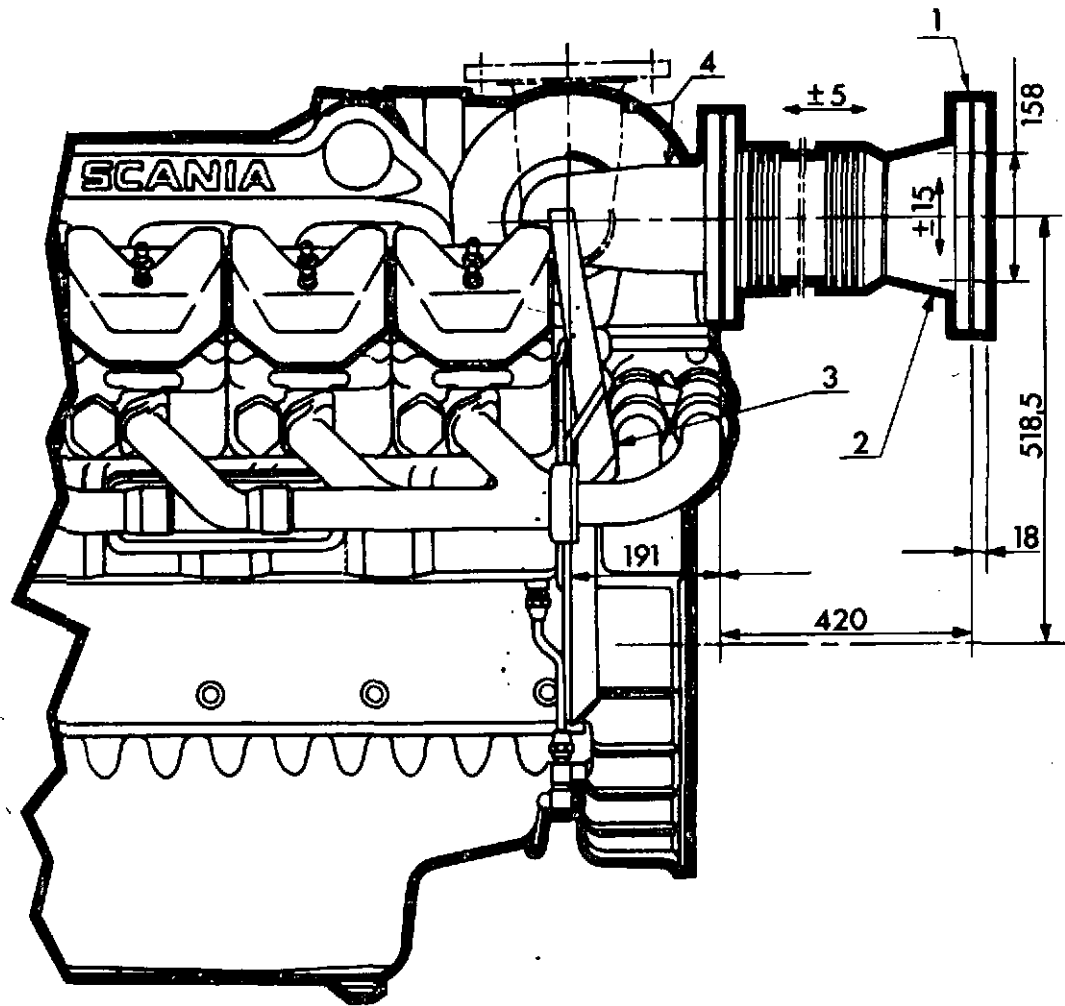


Fig. B2

Compensator connected to the turbocharger via a pipe elbow which is fixed securely to bracket 3.

1. Compensator
2. Flange with hole diameter for connecting exhaust pipe (8 bolt holes \varnothing 18 mm)
3. Bracket
4. Pipe elbow

C Cooling System

Air-Cooled Design

The cooling needs of the engine depend on the amount of output, design of the engine installation and place of operation. Experience shows that this question should be carefully considered when ordering the engine unit.

If the engine is delivered without cooling equipment from the factory, then it is necessary to find out whether the cooler to be used for the operation in question has an ample dimension. In cases where cooling of the driven unit occur via the engine cooling system, then this must obviously have a good margin for such excess of heat.

The cooling water pipes and hose connections between engine and cooler must have ample dimensions and in general be objectively designed, or otherwise there will be reduced cooling capacity. The cooler should, in case it is placed immediately in front of the engine have a convenient distance to the fan that gives effective air flow through the cooler and use of fan housing will thus give optimum flow volume.

Furthermore, it is essential to make sure that air which has already passed the cooler and is heated up does not have the opportunity to circulate through the cooler again.

Another important aspect is to make certain that no pressure losses occur on account of small inlet and outlet areas for cooling air flow in engine compartment walls or in respect of other unnecessary impediments to air flow. The engine can be equipped with a cooling fan of either suction or pressure design and in various sizes. The speed of the fan can, if necessary, be raised from 0.975 x engine speed (standard) to 1.2 x engine speed. To obtain this ratio the fan gearwheel and fan-bearing housing must be replaced by one of another design.

In doubtful cases, the pressure loss in the cooling system connected to the engine, and the quantity of coolant flowing through it should be measured. In which case the thermostats shall be removed and the return passages from the thermostat housing connected to the suction side of coolant pump, so that the entire coolant flow from coolant pump is led through the outer circuit.

The measurement of pressure loss is carried out at the inlet and outlet on the engine.

At it is the cooling capacity margin which is of final interest, it is advisable in connection with the test mentioned to measure the temperature of the coolant at the inlet on

the coolant pump, when the engine reaches the maximum output. Should the temperature in a faultless and clean cooling system be as high as 70°C, on the point mentioned; this means that the cooling system is insufficient under conditions which are more unfavourable than those prevailing during the test.

Certain guidance for judging possible loss of pressure in the connected cooling system and quantity of coolant required for providing cooling can be obtained from the table below where the values indicated refer to a vehicle installation.

The recommended values for vehicle installation with cooler Part No. 181773 cooling fan 170654.

Engine speed/min.	1500	1800	2100
Pressure rise over water pump in bar (kp/cm ²)	0.24	0.34	0.44
	0.24	0.34	0.44
Corresponding water flow litre/min.	270	330	375

Water pump speed = 1.182 x the engine speed.

The cooling system must always be so arranged that the coolant has the possibility of expanding. The connection between engine and expansion vessel shall be carried out with even rise so that risk of air or steam pockets is eliminated. A shut-off valve must not be located on this line. The expansion tank shall be placed somewhat higher than the highest part in the remaining cooling system.

The heat to be carried away via the cooling system from the engine can be calculated by guidance from the particulars below.

Engine speed/min.	1500	1800	2100
Heat content of coolant x)	0.593	0.610	0.735
	(375)	(385)	(400)

Example: Engine output 218 kW at 1800 rev/min, gives 132.132.6 kW (114000 kcal/hr)

Connections to the cooling system are shown by fig. under "Engine Dimensions".

x) in kW per kW indicated engine output (kcal per hpr and hour), specific value, of air-cooled exhaust pipe on engine.

D Fuel System

General

The depression in the suction line of the feed pump, caused by static suction height, flow resistance in the fuel line and possible extra fuel filters must not exceed 0.2 kg/cm^2 (0.2 bar), which must be checked when full output is taken from the engine. On the other hand, if the fuel tank is located higher than the engine injection pump, a shut-off valve should be provided in the fuel line to the feed pump; the line should be closed when the operation is interrupted. The maximum fuel level in relation to the feed pump must not exceed 3.5 m. In those cases where a greater difference in level may be required for technical installation reasons, the circumstances should first be discussed with Saab-Scania AB Engine Sales Department. The fuel pipes should, if possible, consist of steel tubes, connected to the engine with flexible couplings to prevent the fuel pipes from being exposed to breaking stresses. This applies particularly to flexible engine suspension. Saab-Scania AB supply flexible hoses for this purpose. Such a hose must not be bent more than 90° , and the bending radius must not be less than 115 mm. The fuel supply line to the engine should have an inner diameter of at least 10 mm with lengths up to 8 metres. Should the suction line be longer, a proportionately larger dimension is required. The fuel supply line should be placed in such a way that the fuel is not heated up noticeably by sources of radiation, which may exist in the engine room.

In cases of operation where there is risk of water getting into the fuel a water separating fuel filter should be fitted. When the demand for operational safety is particularly great (e.g. in marine installations), it is advisable in addition to fit extra fuel filters of reversible type to be connected in the line between the water separating filter and engine. On engine installations liable to be subjected to low ambient temperatures an extra fuel filter should, if possible, be fitted in the neighbourhood of the engine so that radiation heat from the engine will warm up the filter somewhat and prevent the risk of freezing in it. N.B. The fuel filters fitted as standard on the engine are not replaced by the above mentioned extra fuel filters. The return line from the overflow valve should be drawn to the fuel tank and must not be connected up to the suction line. The return line should have the same dimension as the suction line.

As regards connections of fuel system, see fig. F1B under "Engine Dimensions".

The fuel tanks should be manufactured of steel plate. The tanks shall be welded and, of so required, provided with baffle plates. Moreover they should be provided with sludge and water separators with drain cock so that sludge and water which has sunk to the bottom of the fuel tank can be drained away. The fuel line from the tank should project up roughly 5 cm above the bottom of the tank, and in the upper part of the tank there should be a connection to outer air, e.g. through a special ventilation pipe or through a ventilation hole in the filler cap. Drainage shall be arranged so that danger of fire or risk of damage to groundwater does not arise if the tank is filled up too much and overflows.

After manufacture the tanks shall be carefully cleaned and, if necessary, pressure tested. Afterwards, it is advisable to anti-rust-treat the tanks on the inside with a water repellent oil. An appropriate oil is supplied by the majority of oil companies. Comply with the Oil Company recommendations when applying the oil. The tanks shall be painted on the outside with a protective colour. N.B. The tanks must not be painted on the inside. They must not be galvanized either.

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E Electrical System

1. General

The nominal voltage of the system is 24 V. The operating voltage may amount to 28 V, thus making it necessary to use bulbs designed for this voltage.

2. Batteries

The type of battery usually used is lead batteries of type "storage battery", which are capable of supplying considerable current intensity during a short period. In some cases, NiFe batteries are installed (alkaline). If lead batteries are used, it is possible to connect two 12 V batteries in series.

In those cases where lead batteries are to be used, we recommend that these batteries should have a minimum capacity of 190 Ah (ampere-hours). This is necessary to start an engine which has been exposed to very low temperatures.

N.B. If the engine is provided with an alternator, the master switch, if any, must not be put off or the battery disconnected when the engine is in operation, as peak voltages can then occur and damage alternator parts.

3. Charging Regulator for Bosch Alternating Current Generator

The battery charging regulator should be protected against water, oil and other liquids as well as against mechanical damage.

The ambient temperature for this regulator must not exceed + 60°C. Take great care when connecting up, because a faulty connection or short circuit can damage the regulator.

The battery charging regulator is set for charging lead batteries.

4. Wires

The starting motor wire section in mm² is shown by the table below. Note that it is the total length of positive and negative wires that is to be considered when decoding the cable section. The minimum permissible wire section is 50 mm².

Length (single)	Section, mm ²
up to 2 meter	50 mm ²
up to 3,5 "	
up to 2 meter	
up to 3,5 meter	
up to 5 meter	
up to 7 meter	

up to 9 meter

up to 9 meter

up to 12 meter

70 mm²

up to 17 meter

95 mm²

Locate the wires so that they are not subjected to wear or damages of any other sort.

5. Master Switches and Fuses

Between the battery and starting motor a master switch should in general be fitted. With a bipolar electrical system two isolating switches are required: one on the positive cable and the other one on the negative cable. With a unipolar electrical system one master switch is required, which is conveniently connected up on the negative cable. Furthermore, the electrical system shall be protected by fuses (regarding alternating current generator, compare the section about "Fusing up Charging Circuits"). Both the master switches and main fuses, if any, must be fitted as close to the battery as possible. Fig. E1 shows basically how the wiring should be carried out. A detailed wiring diagram will accompany each separately delivered engine.

6. Radio Interference Suppression of Electrical Equipment for Marine Engines

The Bosch alternator is as standard provided with an interference suppression condenser, and for this reason it is only necessary in exceptional cases to take additional precautions. However, if these precautions are really necessary get into touch with our Engine Sales Department.

7. Parallel Operation with Electrical Generators

Very often with multi-engine plants it is desirable to make the charging generators on two or more engines charge one and the same battery. With the Bosch alternators and charging regulators which are usually used there is no need for any additional arrangement to be made.

8. Electrical Welding

When carrying out electrical welding
When carrying out electrical welding close to an engine with alternator the wires between alternator and battery, and between alternator and charging regulator, should be disconnected.

9. Protection Equipment for Bosch Alternators

As shown, the alternator must only be operated with charging regulator and battery connected, otherwise damages can occur on rectifiers and regulator. Involuntary interruption, in certain circuits, through cable fractures, loose cable terminals etc. have the same effect; therefore the alternator manufacturer has

produced protection equipment which can be used when judged to be desirable:

a) Protection against Excess Voltages and Connection to Alternator

The alternating current plant is sensitive to high excess voltages; there is then risk of damages occurring on transistors and rectifier diodes. Already under normal conditions, for instance when electrical users of an inductive type (e.g. relays) are connected or disconnected, inductive voltage peaks arise in the system which may result in damages to the diodes and transistors. Because of this the standard-delivered alternator of make Bosch is equipped with a condenser as protection against such voltage peaks. The condenser, in addition, serves to suppress radio interference.

The total capacity of the condenser is, however, insufficient for high voltage peaks, which may arise if for instance the master switch should cut-out or a cable break so that the alternator becomes separated from the battery during operation. The same conditions will occur if the user should be connected and disconnected at a relatively high load and high alternator speed without the battery being joined to the circuit. Excess voltages of this size are however damped down to a non-dangerous level, if an excess voltage protection is used. If necessary, get into touch with the Engine Sales Department.

b) Protection against Disconnection of Battery during Operation

(This protection is not required if the plant is equipped with special excess voltage protection). In order to prevent the battery from becoming disconnected during operation (e.g. if the master switch is unintentionally disconnected with the engine in function) it is possible to connect up an auxiliary relay (Order No. Bosch 0 332 003 012, SV 137691) via the master switch according to diagram E2. The relay coil is energized as soon as the alternator charges, so that the circuit from 30/51 to 87 is closed and the battery is consequently connected to the alternator, even if the master switch is cut out. In a bipolar system with isolating switches in both positive and negative circuits a relay is connected via each isolating switch section and the relay terminal 85 is connected to terminal B-/D- on the alternator. Instead of two relays of the type indicated, it is possible to use one relay with two closing contacts with corresponding loading capacity.

c) Protection against Polarity Faults

If the battery in conjunction with fitting, is connected up incorrectly, so that the battery cables are mix-

ed up, there is also risk of damage. However, this risk can be prevented through installation of a polarity protector.

d) Electromagnetic Master Switch

Instead of battery master switches of conventional type, a battery relay can be used. This is best described as an electromagnetic master switch which permits, instead of "the polarity fusing", the connecting up of a blocking diode as polarity protection. The battery relay is operated with the switch for instrumentation and supervision so that the battery is disconnected as soon as the switch is set in the off-position. The connecting up of the battery relay in a unipolar system shall be carried out according to diagram E3. Here, a relay has also been included (Ordering No. Bosch 0 332 003 012, SV 137691) which prevents the battery being disconnected while the alternator is still charging. The blocking diode has order No. Bosch 1 337 320 001, SV 197812.

In a bipolar system, where the demand is both for positive and negative connections on the battery to be disconnected a doubling up of the equipment will be necessary, i.e. two battery relays (Ordering No. Bosch 0 333 301 009, SV 197811), two blocking diodes (Ordering No. Bosch 1 337 320 001, SV 197812), and two relays (Ordering No. Bosch 0 332 003 012, SV 137691). The latter can be replaced by a relay with two closing contacts. The wiring will be as shown in diagram E4.

In the coil of the battery relay the amperage of the working current is 4,5 A, and that of holding current, 0,3 A. The main contacts can be loaded with 200 A continuously and 2.500 A during one second.

In the operating circuit, to terminal 86 on the battery relay, the voltage drop must not exceed 0,5 V; for this reason the cable section must be at least $0.16 L \text{ mm}^2$, when the cable length is L m.

10. Fusing up Charging Circuits

When fusing up the circuits where an interruption would lead to such consequences as dwelt upon above, Bosch advise against the use of ordinary fuses of motor vehicle type, which are secured with spring force. Instead Bosch have produced special fuse boxes which contain two fuses of leaf type which are screwed up. Other fuse types where the fuse is screwed up, e.g. Diazed fuses, can also naturally be used.

The Bosch fuse box with two 50 A fuses, which are suitable for 35 A generator has type reference VM 30/1D34 (Ordering No. Bosch 0 354 120 004, SV 197813), inclusive of fuses. The corresponding box with two 80 A fuses for 60 A generator has type reference VM 30/1D30

(Ordering No. Bosch 0 354 120 005, SV 197814. The spare fuses have ordering No. 1 191 017 005 (SV 193538) for 50 A and 1 191 017 003 (SV 192616) for 80 A.

Text for Figs. to E1, E2, E3 and E4

- | | |
|---------------------------|---------------------------------|
| 1. Generator | 9. Block diode |
| 2. Charging regulator | 10. To extra current user |
| 3. Battery | 11. Starting switch |
| 4. Master switch | 12. To instruments |
| 5. Starting motor | 13. To ammeter, if any |
| 6. Relay | 14. Main fuses |
| 7. Discharge warning lamp | 15. Fuses |
| 8. Battery relay | 16. Operational selector switch |

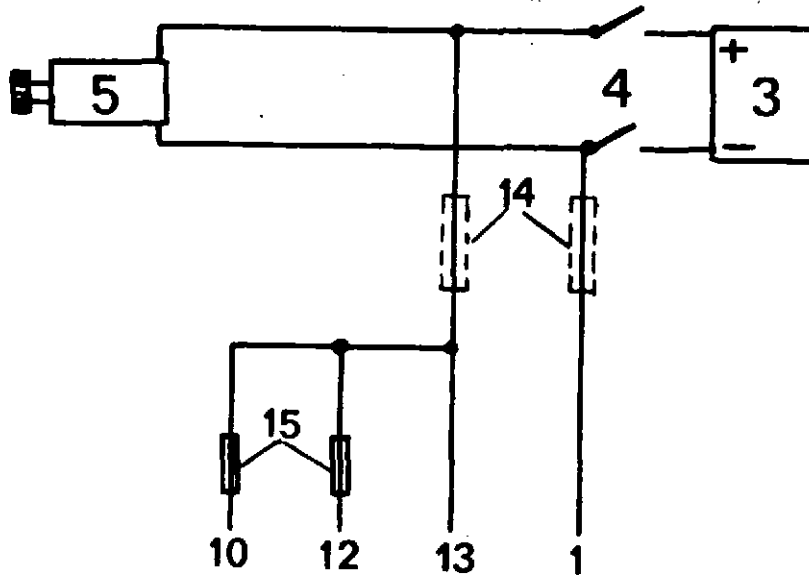


Fig. E1

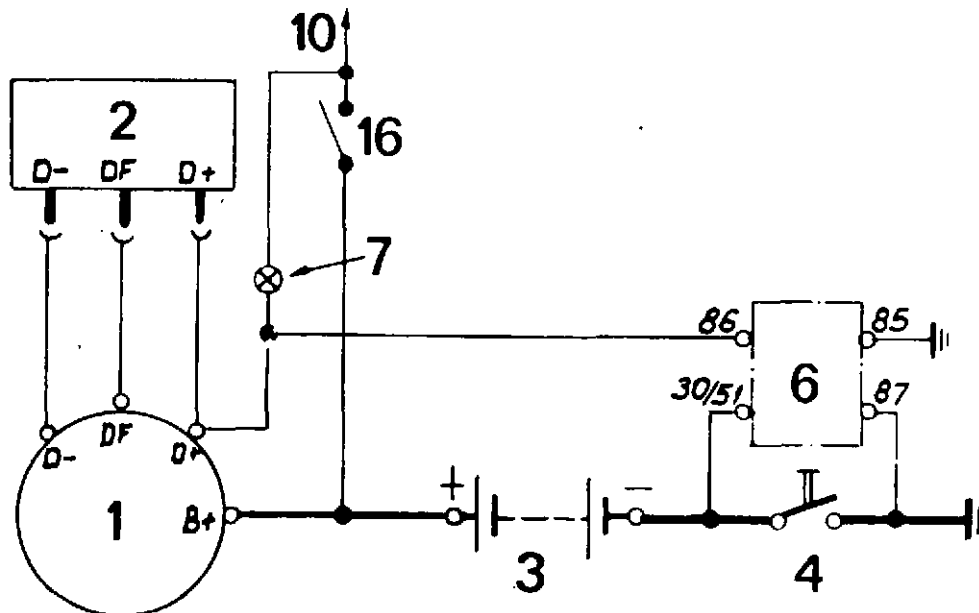


Fig. E2

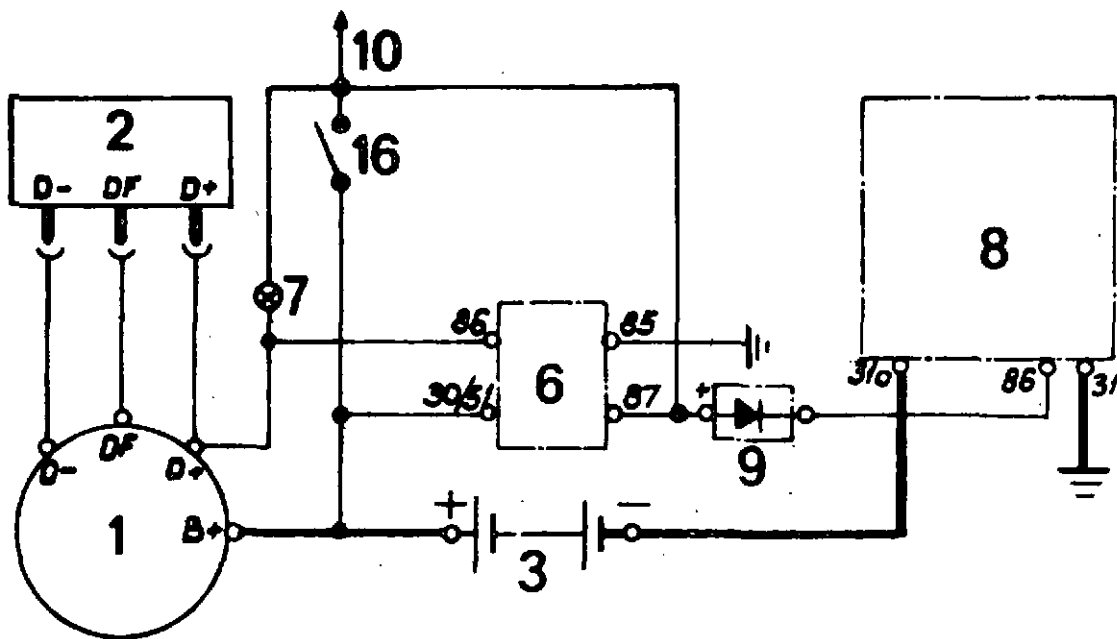


Fig. E3

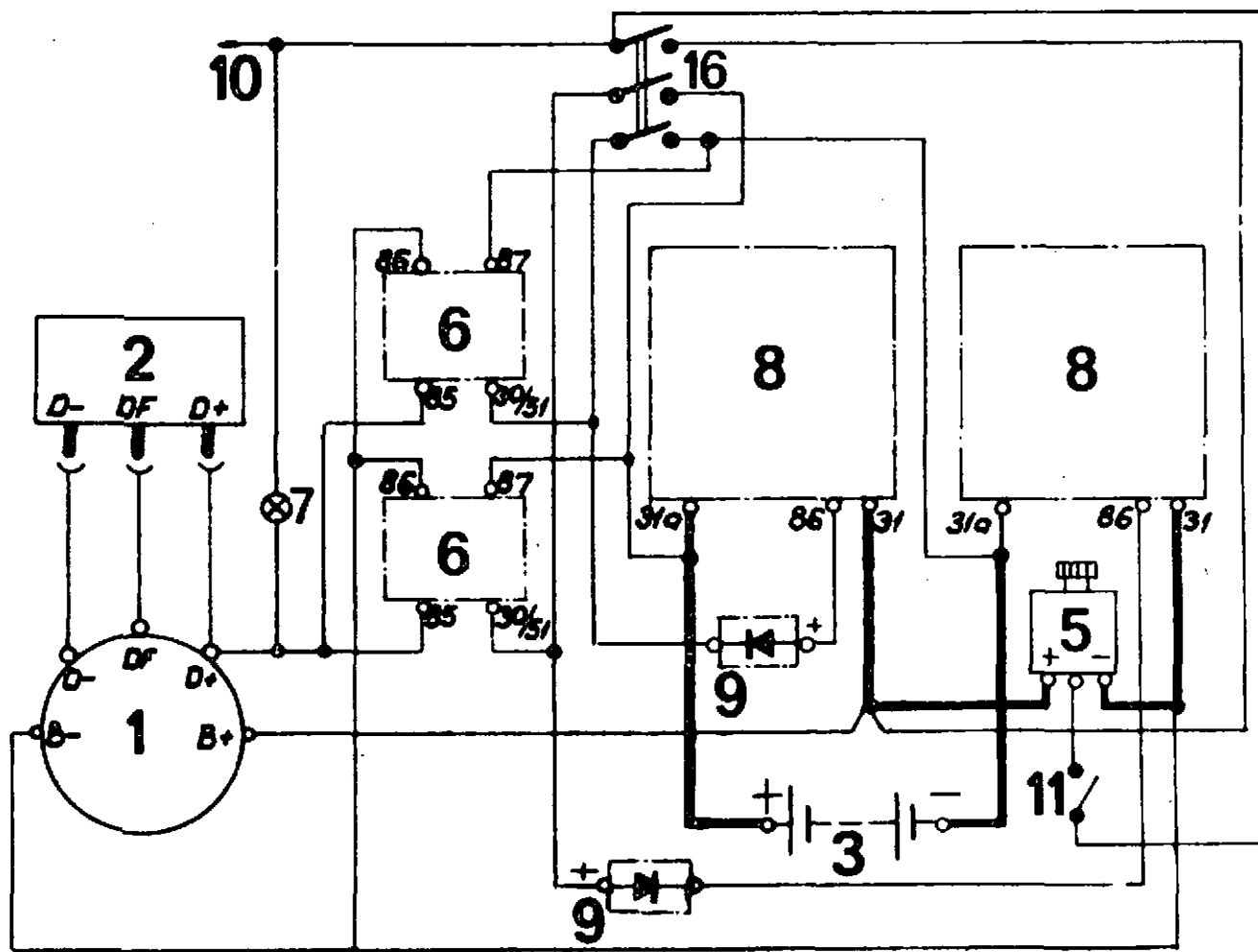


Fig. E4

Monitoring system

The description below covers the requirements, normally available of visual, or acoustic monitoring measurements on the engine.

In the event of further requirements get into touch with our Engine Sales Department.

1a) Lubricating Oil Pressure

Pressure outlet for lubricating oil pressure is located in the engine compartment near the lubricating oil outlet to turbocharger. From this point there is a pipe line drawn for connection of pressure gauge, the pipe of which branches out either at the left front end of engine pos. 6 fig. FIC under "Engine Dimensions" or at the right-hand side of engine according to fig. E5a. When connecting the oil gauge transmitter to electrical indicator, this is connected with a distributor piece No. 208310 provided with two outlets, in the oil pipe line according to fig., to which the oil pressure monitor can also be fitted in cases arising. The oil pressure monitor can also be connected to pressure outlets on the cyclone cleaner of lubricating oil filter, but the monitor must then be set specially for this measuring point.

1b) Coolant Temperature

The mechanical temperature gauge or transmitter to electrical temperature gauge is connected in cases where the temperature monitor is also connected to the cooling system on a flange which is located on the front left-hand side of the engine according to fig. E5b. The temperature monitor of closed or interrupted type is connected to the cooling system close to the thermostat housing. Temperature monitors for two different temperature levels are available for service; one design comes into operation at 93°C and the other at 100°C, the use of which usually requires a certain amount of overpressure in the cooling system (pressure cover).

1c) Engine Speed

Outlet for tachometer is located on the timing gear housing according to fig. FIA under "Engine Dimensions" to which an angle gear part No. 170832 with ratio 1,2 shall be fitted. The angle gear operation takes place via a driver pivot from the front end of compressor shaft. In cases where the compressor has not been fitted there is a corresponding loose shaft to be fitted.

Note: When removing and fitting the angle gear be very careful to see that the driver pivot does not fall down into the timing gear housing!

The mechanical tachometer is connected straight

to the angle gear. Where an electrical tachometer is concerned an electrical transmitter is connected immediately after the angle gear.

Avoid attaching the cable to a mechanical tachometer in a bent or curved condition.

1d) Revolution Counter Gauge and Hour Recorder

The revolution counter gauge is built-in the tachometer of mechanical design. The revolution counter gauge indicates the total number of revolutions rotated by the engine and it is effective for all kinds of operations, i.e. those with fixed operating speeds (e.g. generator units) and those with varying operating speeds. The connection between the number of engine revolutions and the need for maintenance will be shown in the Maintenance Instructions, the particulars of which assume that driving takes place mainly within the normal engine operating speed range of 1300 - 2300 rev/min. Idling at a speed below 1300 rev/min, for longer periods may result in alternations to be made in the Maintenance Instructions.

If the revolution counter gauge is used for installations with constant operating speed, then an approx. operating time can be obtained by dividing the engine counter amount with the operating speed indicated.

An electrical hour recorder can also be fitted. This is meant to be connected to the lubricating oil system and is controlled by the lubricating oil pressure. This instrument records the consecutive operating time regardless as to operating speed used. The electrical hour recorder can be used as an alternative to the revolution counter gauge in installations with constant operating speed (generator units). Generally speaking the hour recorder is effective in other cases of operation where definite hourly time is to be recorded.

By combining the revolution counter gauge and hour recorder in cases of operation where varying engine speeds are used, it is possible to utilize the engine to best advantage. In similar vehicle installations the hour recorder in combination with the odometer gives a basis of calculation for the average speed.

The electrical instruments described above are only available in a 2-pole design.

2. Magnetic Cut-out

Through the electrical magnetic cut-out which is connected to the stop arm of injection pump a sufficient amount of control force is obtained in order to stop the engine after the stop button has been pushed in

In conjunction with fitting of magnetic cut-out check and if necessary adjust its movement so that the cut-

or, automatically on the occasion of faults having been sensed by temperature- or oil pressure monitors. If faults occur in the electrical system the magnetic cut-out can be activated manually.

There are two designs of magnetic cut-out; one with a pulling function and one with a retaining function. In the former case the cut-out comes into operation when the current is connected up. In the latter case holding current is fed to the cut-out when the engine is in operation and the current is disrupted when the engine is to be stopped, whereby a return spring overcomes the control force required. The magnetic cut-out must not be fed with current directly over the monitors described above, but via a relay; otherwise there is risk that the monitors will be burnt out by the high amperage.

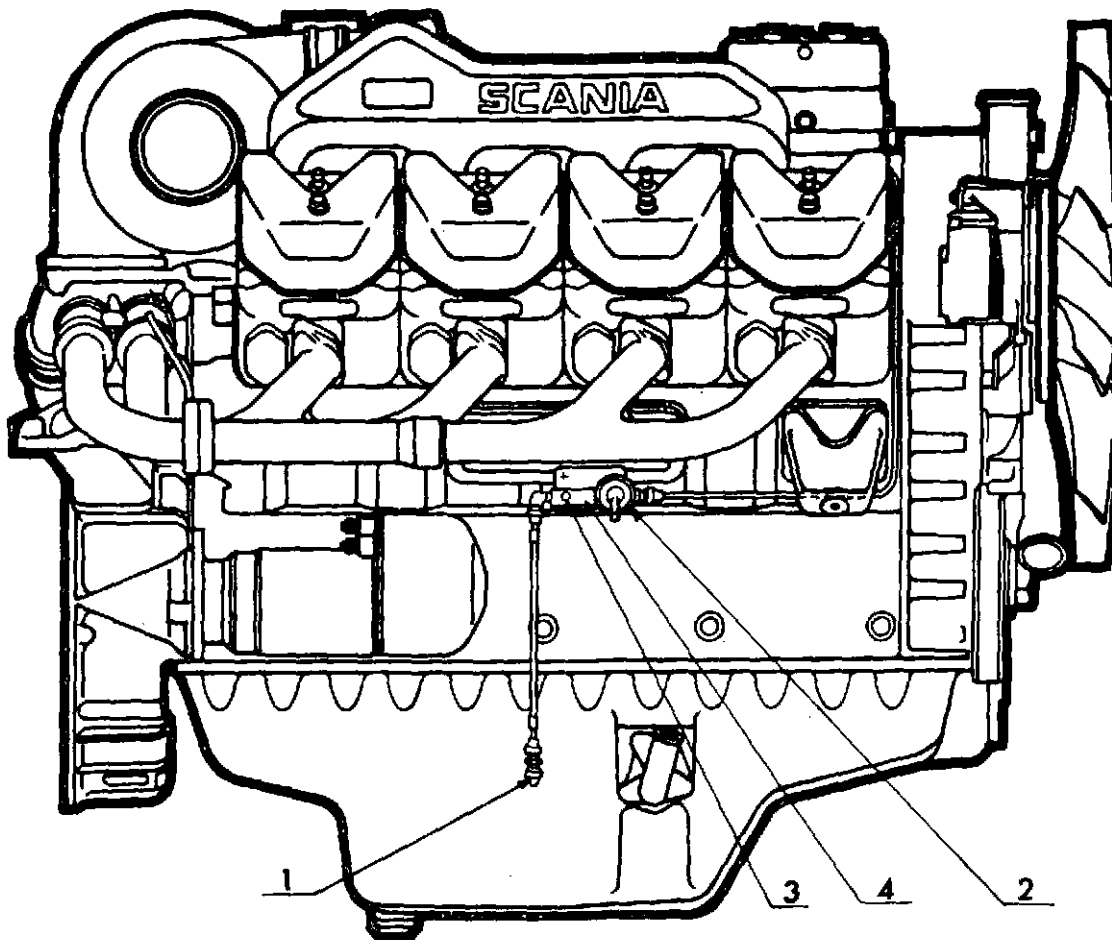


Fig. E5a

1. Pressure socket for oil pressure gauge
2. Oil pressure monitor (compare also fig. E5b)
3. Additional socket for oil pressure monitor
4. Distributor piece

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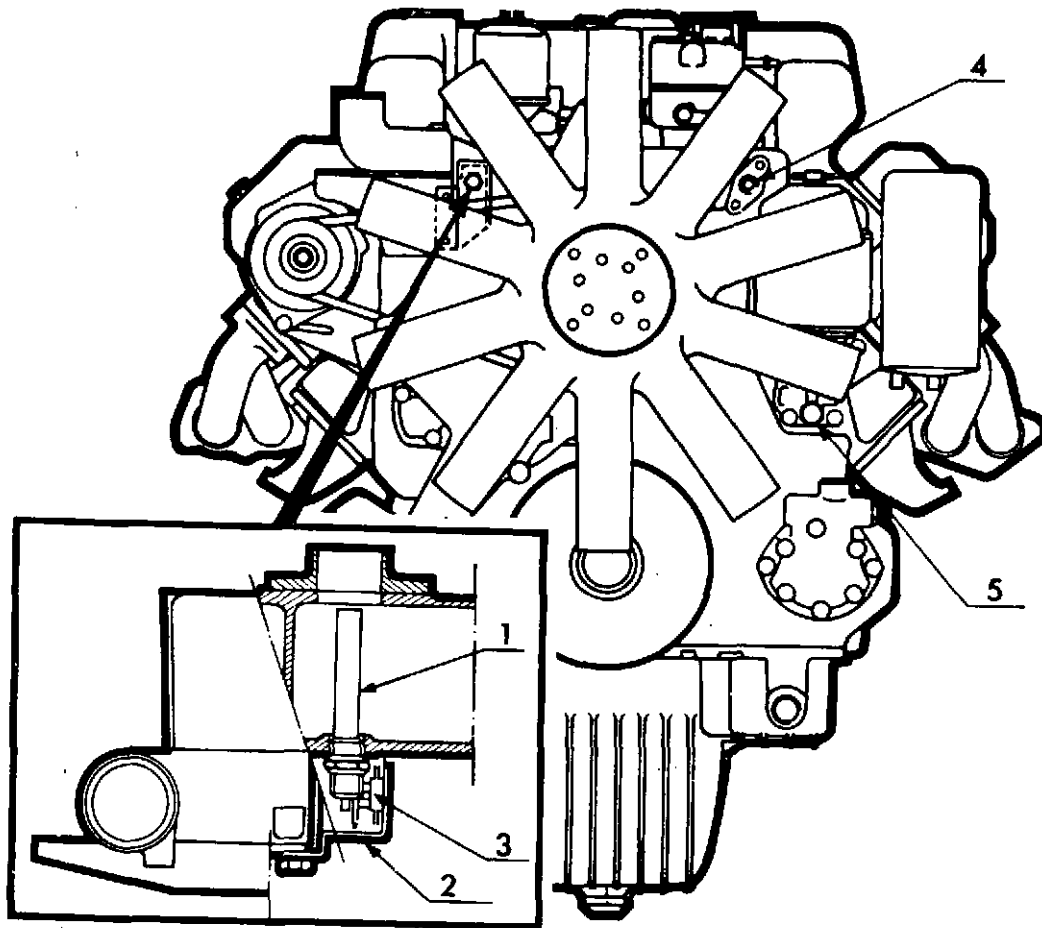


Fig. E 5b

1. Temperature monitor, fitted in thermostat housing (fig. inserted shows horizontal section through this)
2. Protective plating
3. Connecting block
4. Socket for temperature gauge hole M14 x 1,5 (this is connected at pos. 1 above when the monitor is not used)
5. Socket for oil pressure monitor of special design

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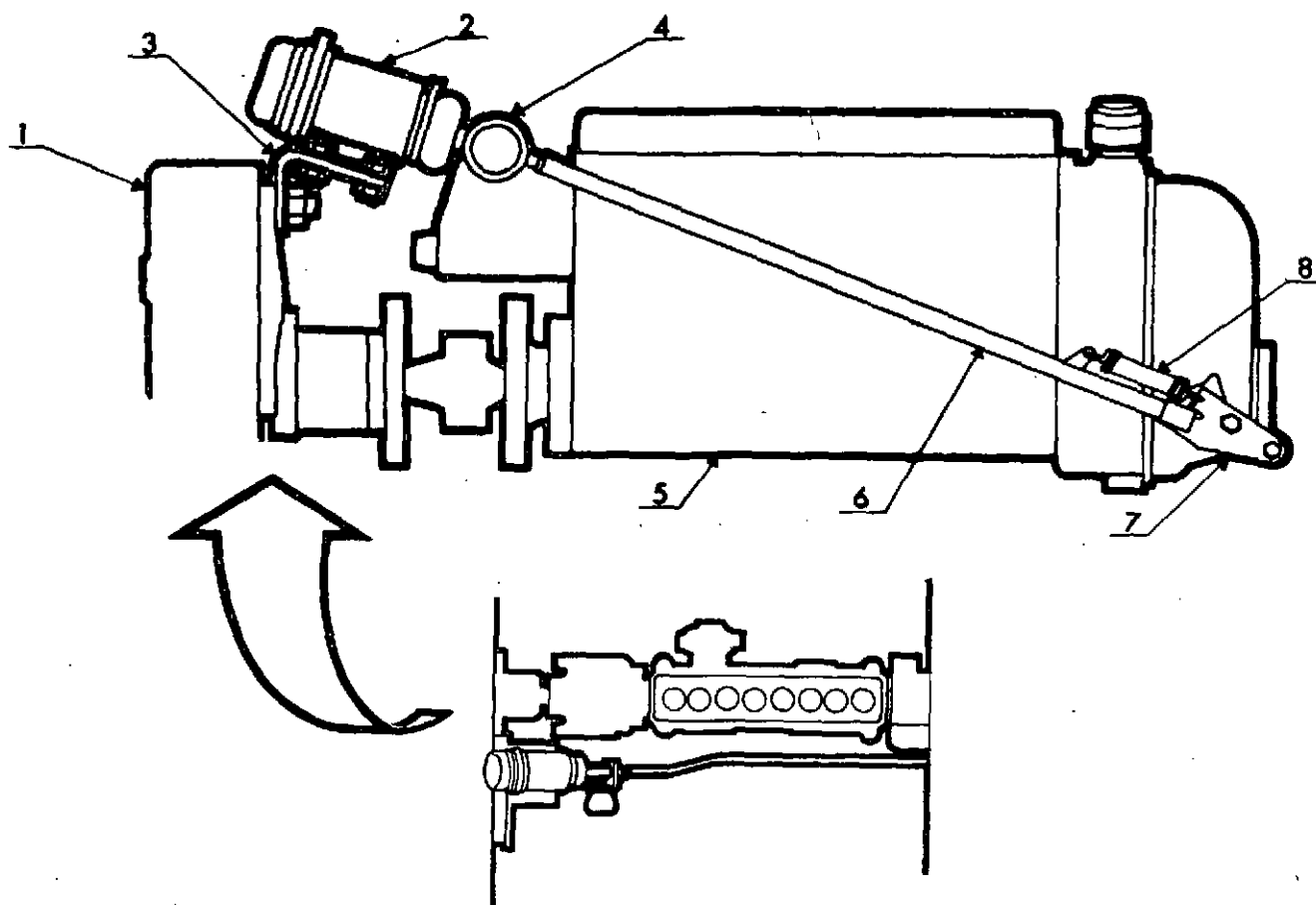


Fig. E6a

Magnetic cut-out for injection pump with RSV governor

1. Timing gear housing, upper edge
2. Magnetic cut-out
3. Bracket for magnetic cut-out
4. Handle for manual stop
5. Injection pump
6. Operating rod, the straight part is sited parallel with injection pump
7. Governor stop lever arm
8. Return spring

In conjunction with fitting of magnetic cut-out check and if necessary adjust its movement so that the cut-out stop position is reached approx. 1 mm before corresponding stop position on injection pump control rod; otherwise the cut-out control force can damage the injection pump.

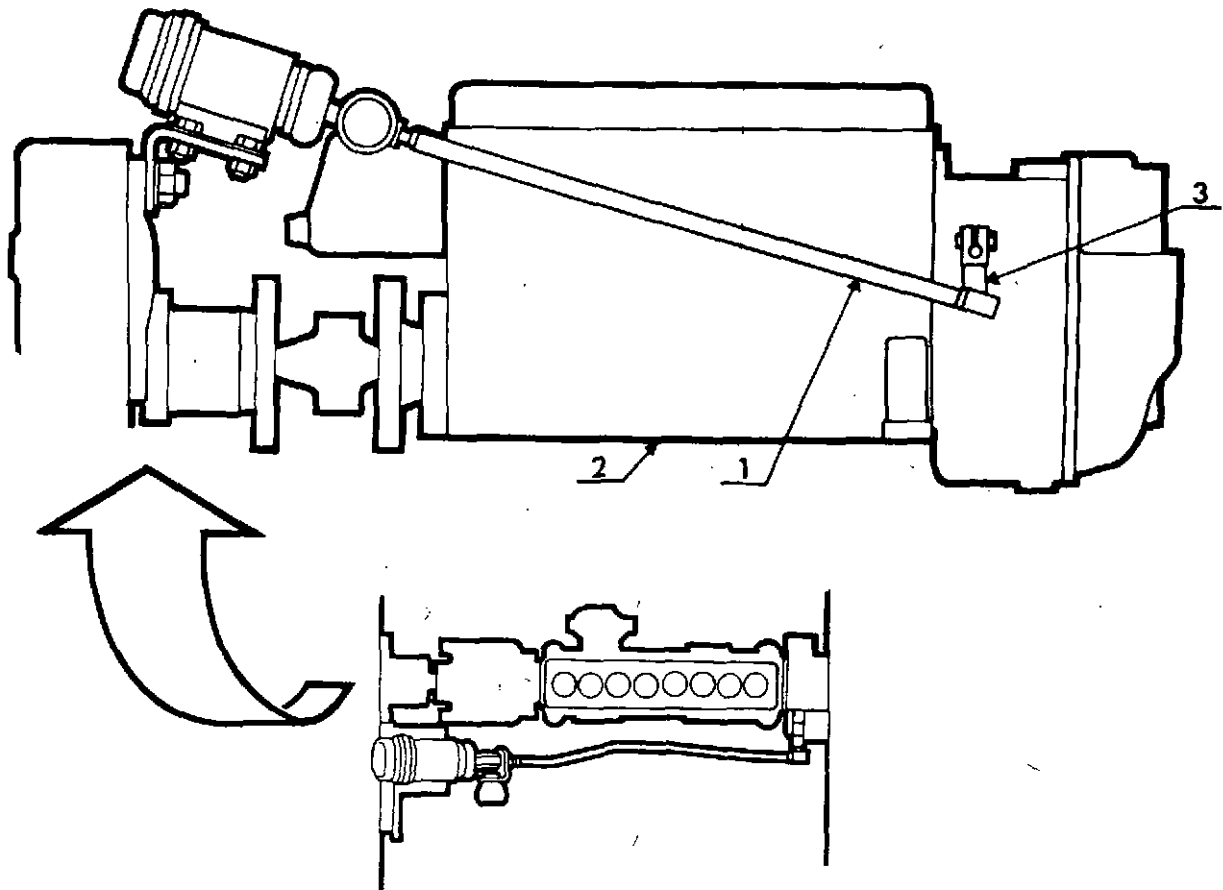


Fig. E6b

Magnetic cut-out for injection pump with RQV governor

1. Operating rod
2. Injection pump
3. Stop lever arm

In conjunction with fitting of magnetic cut-out check and if necessary adjust its movement so that the cut-out stop position is reached approx. 1 mm before corresponding stop position on injection pump control rod; otherwise the cut-out control force can damage the injection pump.

F Engine Dimensions

- | | |
|---|---|
| <ol style="list-style-type: none"> 1. Fuel inlet, steel pipe \varnothing 10 mm inside diameter. 2. Return line to fuel-tank, steel pipe \varnothing 10 mm inside diameter. 3. Water inlet 4. Water outlet 5. Socket for thermometer or monitor for cooling water temperature M14 x 1.5 6. Pressure socket for lubrication oil. 7. Cocks for water drainage. 8. Speed governor (in idling position) 9. Cooling fan Part No. 170654 10. Flange for exhaust line. 11. Air intake from air filter. 12. Plug oil drainage 13. Outlet for oil pressure monitor, specially calibrated. 14. Crankcase ventilation pipe. | <ol style="list-style-type: none"> 15. Bracket 16. Socket for cooling water thermometer when temperature monitor is fitted to connection 5). 17. Socket for tachometer. 18. Flywheel housing (Silumin) 19. Flywheel housing (cast iron) with two alternative attachment levels for engine suspension. 20. The bolt holes M14 for front engine suspension have a thread depth of 21 mm. 21. Connection flange for oil filler pipe. <p>Note: Regarding pos. 18 and 19, The dimension \varnothing 511.2 + 0.12 refers to guide edge in housing.
CL= Centre line of crankshaft.
The bolt holes M10 for driven unit and bolt holes M14 for engine suspension have a thread depth of 20 mm.</p> |
|---|---|

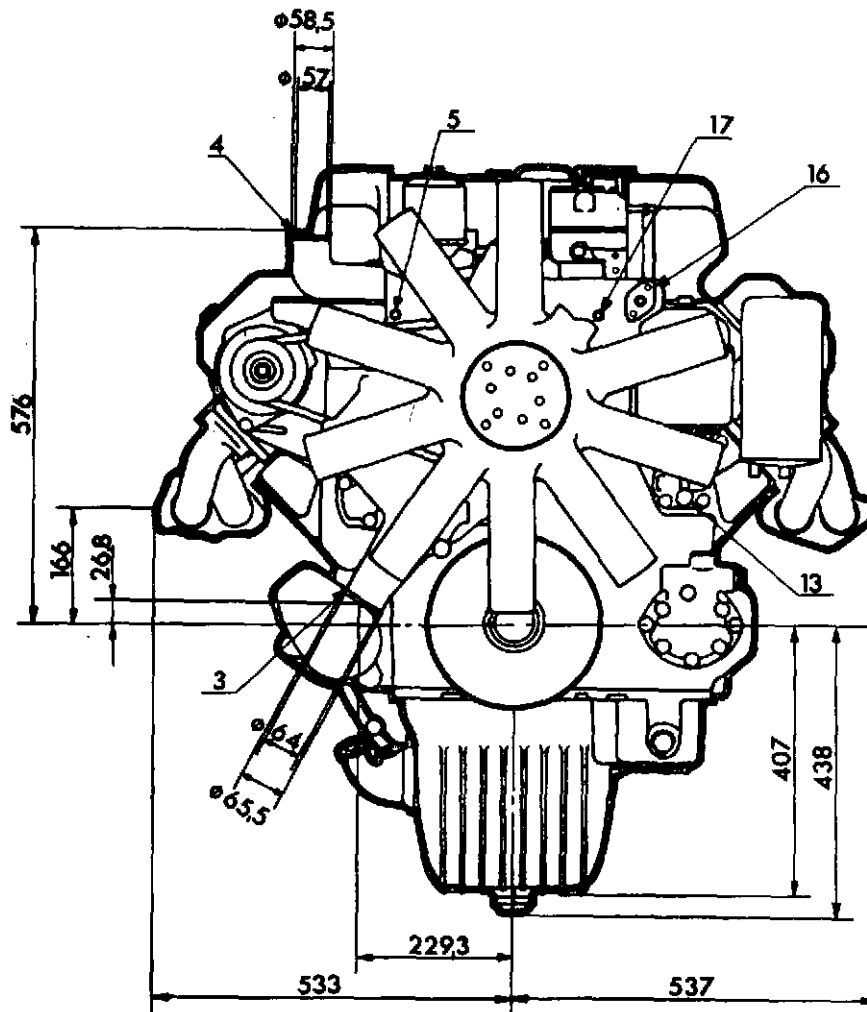


Fig. F1A

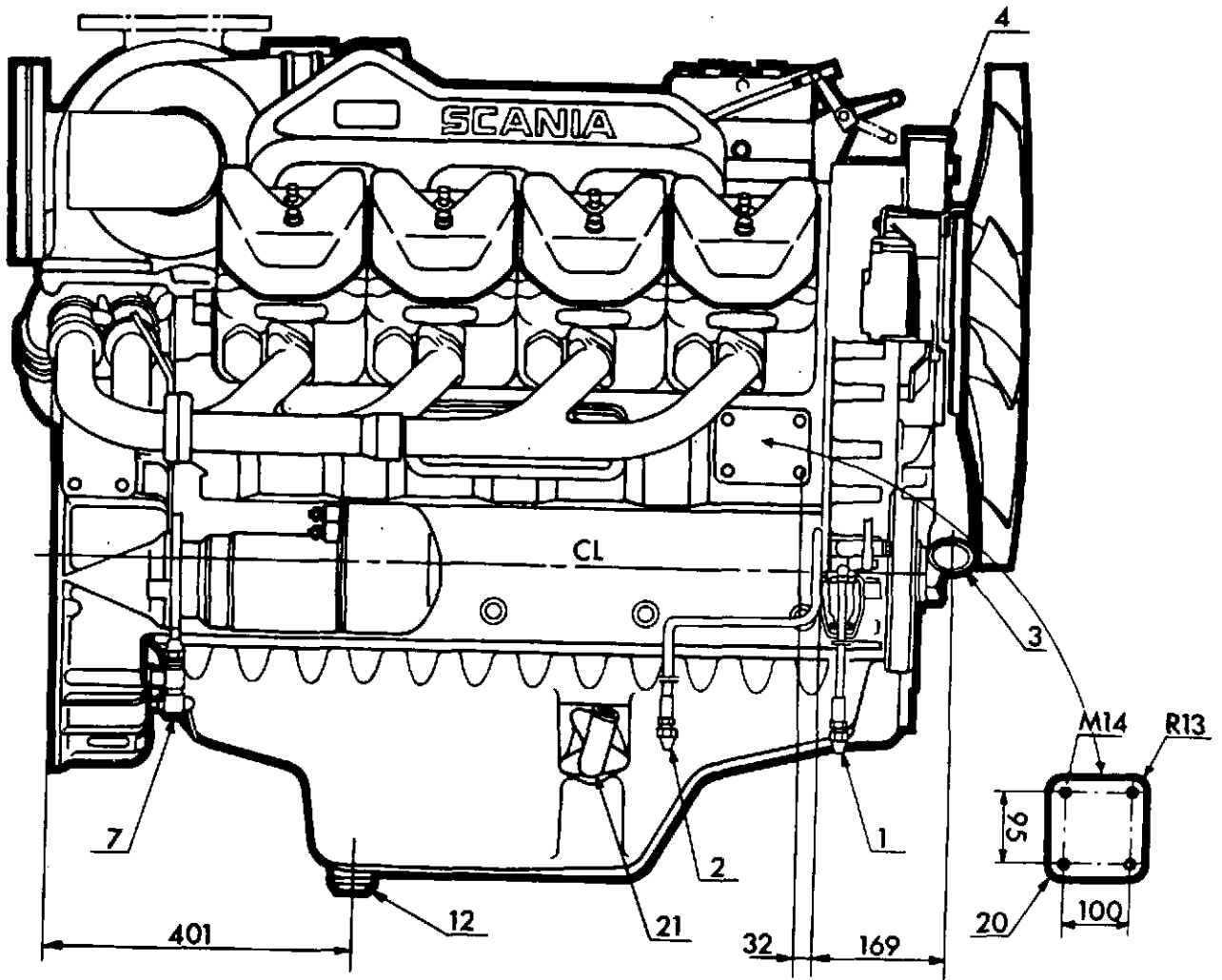


Fig. F1B

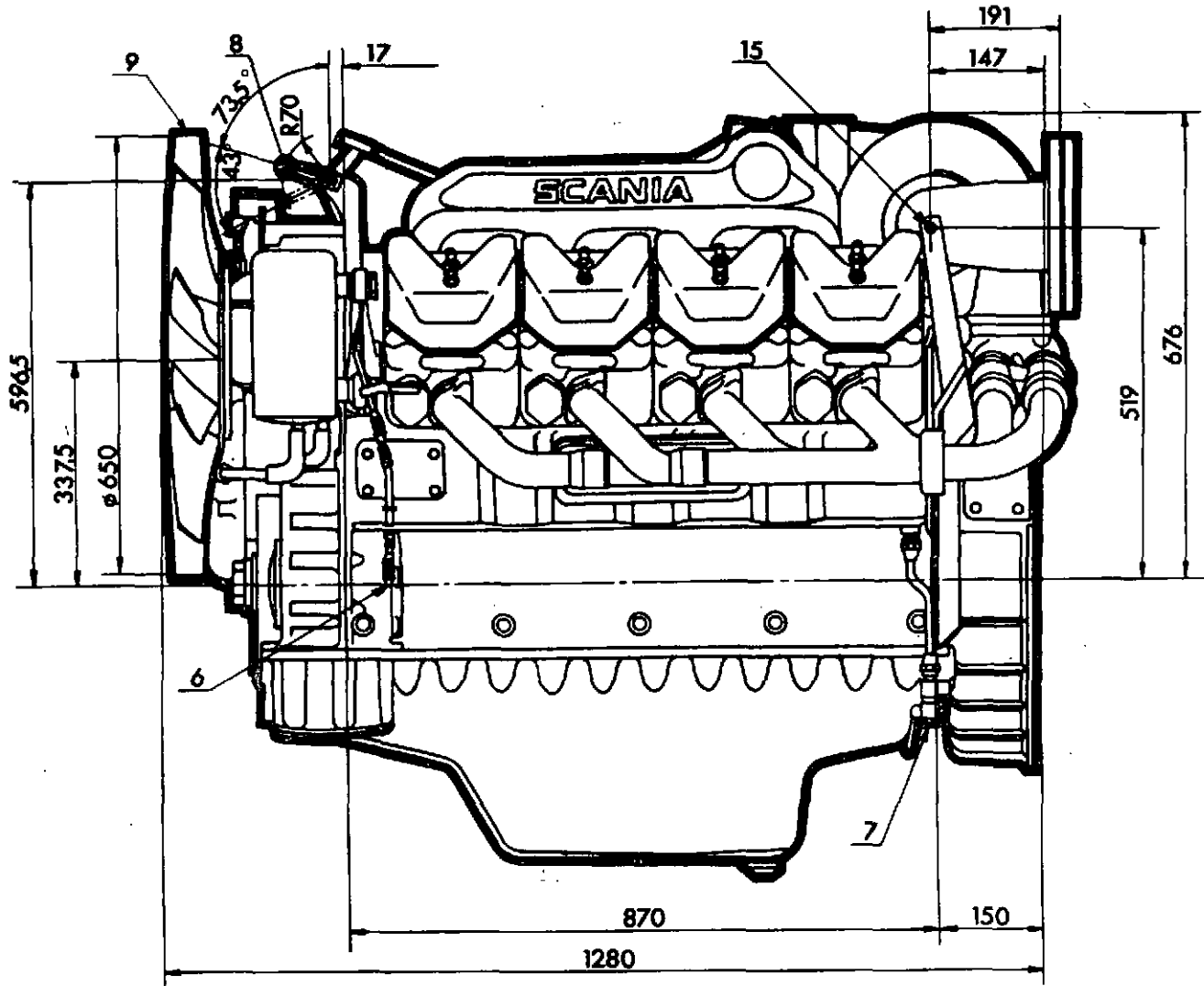


Fig. F1C

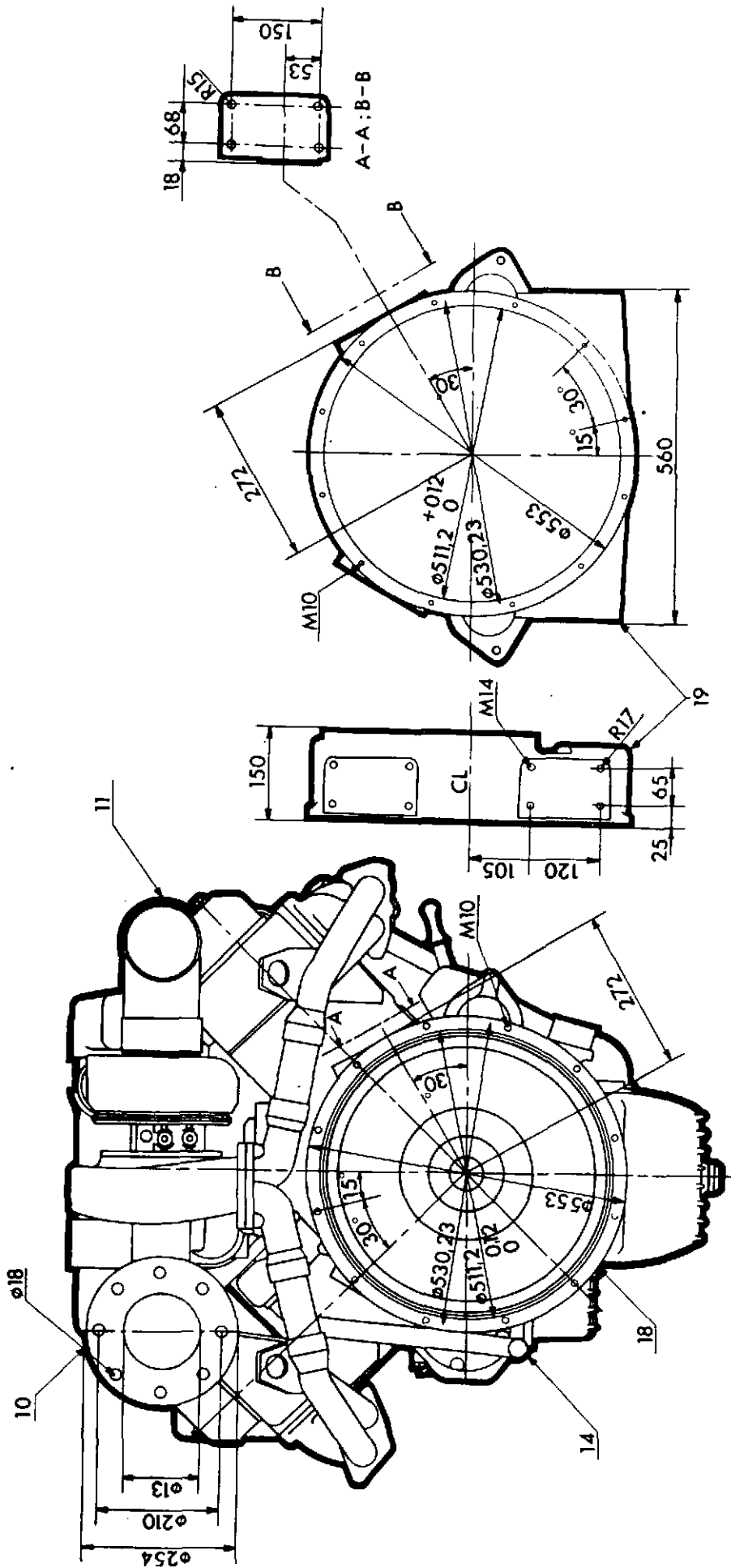


Fig. F1D

Note: Fig. F1A - F1D refers mainly to DS14 A01, but is to a certain extent applicable for other engine variants. The air compressor is not drawn in fig. F1C.

F Engine Suspension

The appropriate design of engine suspension varies for different engine installations. However, generally speaking the following requirements shall be noted:

1. The engine suspension shall be designed for the forces, both continuous and instantaneous, it is subjected to during operation, i.e. reaction forces from the torque transmitted, in certain cases acceleration and retardation forces, reactional forces in the longitudinal direction of the engine (e.g. from propellers in marine operation where the propeller thrust is not taken up in any other way), etc.
2. The engine suspension and the engine bed shall be so designed that resonance vibrations do not arise within the engine rev/min range. They must also be so constituted that troublesome vibrations from the engine are not transmitted to the surrounding area.
3. The engine suspension shall be adjustable where great demands are placed on centring between engine and the unit coupled to the engine (e.g. propeller shaft).
4. The engine suspension and engine bed must be designed with consideration to permissible sloping angles of the engine. Max. permissible sloping forwards and backwards in longitudinal direction is thus 30° and for transverse direction 30°. A special instruction applies for engine with liquid content exhaust pipe.
5. The engine suspension and engine bed must be designed with consideration to accessibility for future service work (free space for e.g. oil sump removal must be available). See the section "Engine Installation from the Service Point of View".

Saab-Scania AB supply as standard three different designs of engine suspensions mentioned below:

a) **Flexible Rubber Suspension**

b) **Hard Rubber Suspension**

c) **Rigid Suspension**

a) **Flexible Rubber Suspension** gives effective vibration dampening. It can to a certain extent take up the forces in the longitudinal and transverse directions but does not permit accurate alignment of the engine. It has with these characteristics been used considerably in vehicle installations, generating sets and corresponding applications. Fig. F2.

b) **Hard Rubber Suspension** dampens the vibrations to a smaller extent than the flexible suspension, but cannot on the other hand absorb great forces in the longitudinal and transverse directions of the engine. See fig. F3.

c) **Rigid Suspension** can absorb greater forces in all directions. It permits a very accurate alignment of the engine and does not place any appreciable demands on the flexibility of the conduits and controls connected to the engine. It should only be used when circumstances make such a suspension desirable and if the vibrations do not cause any greater inconveniences. However, the vibrations can be relatively small even on a rigid suspension, if the mass represented by the engine bed and direct attached parts is large in relation to that of the engine (ratio 20:1 and above) Fig. F4.

Text for Figs. to F2, F3 and F4:

F2: 1 and 2 flexible rubber suspension
 CL= Centre line of crankshaft
 Dimension 35 mm refers to pressure on rubber
 When the pressure on rubber is released the dimension is reduced to 30 mm at the front and 32 mm at the rear.

F3: 1 and 2 hard rubber suspension
 CL= Centre line of crankshaft

F4: 1 and 2 engine suspension of rigid design
 CL= Centre line of crankshaft

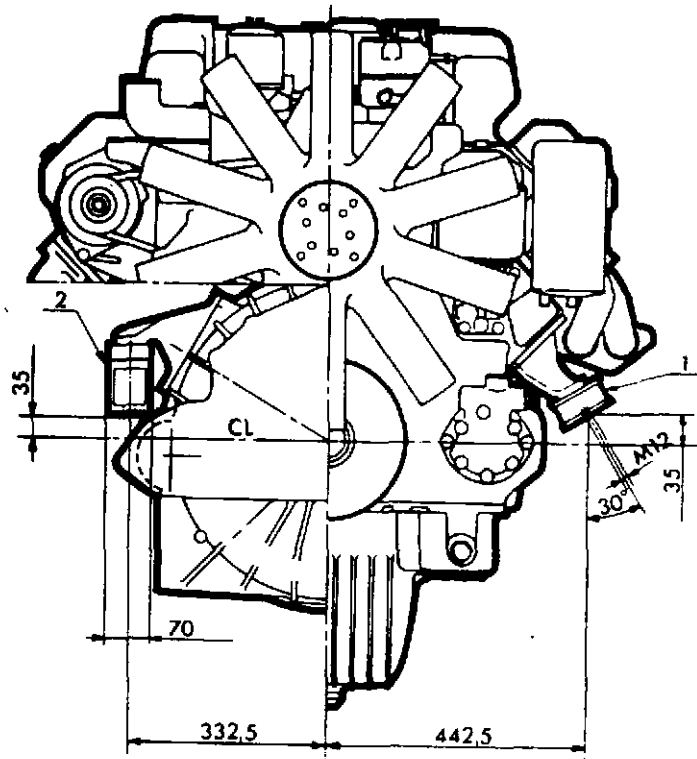


Fig. F2a

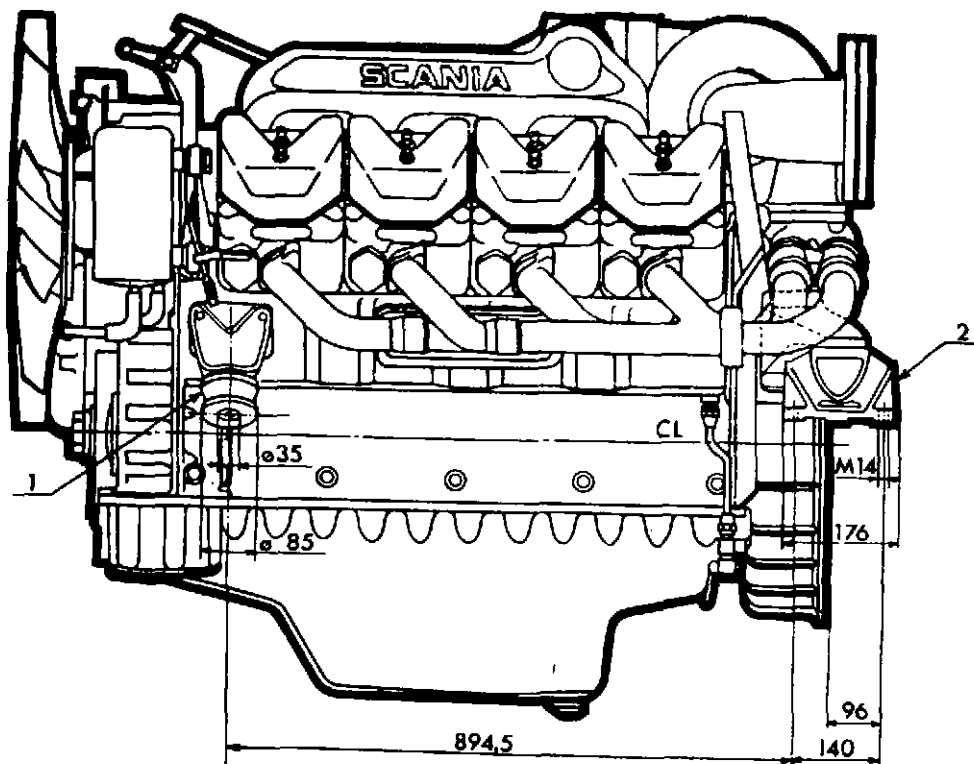


Fig. F2b

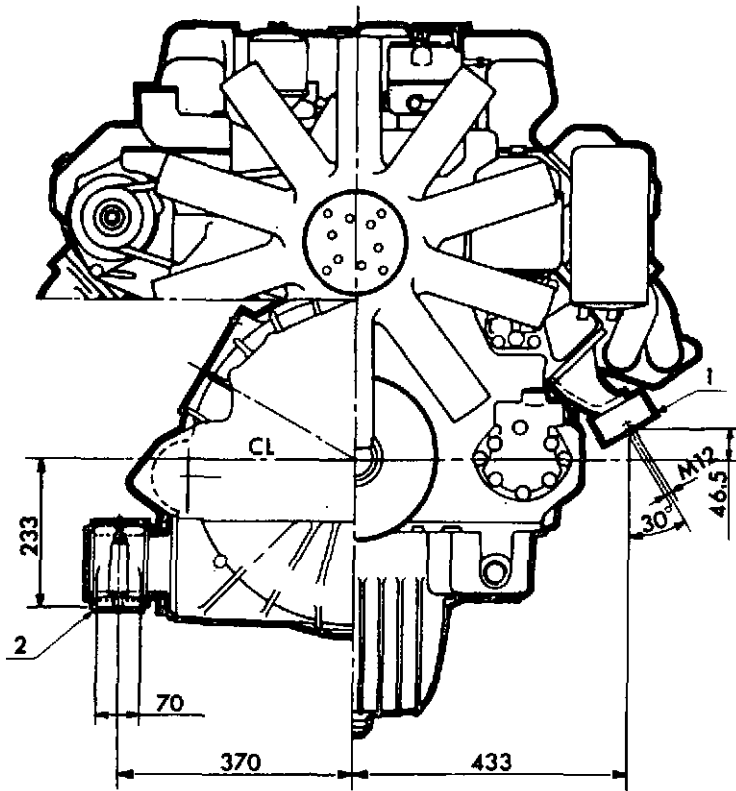


Fig. F3a

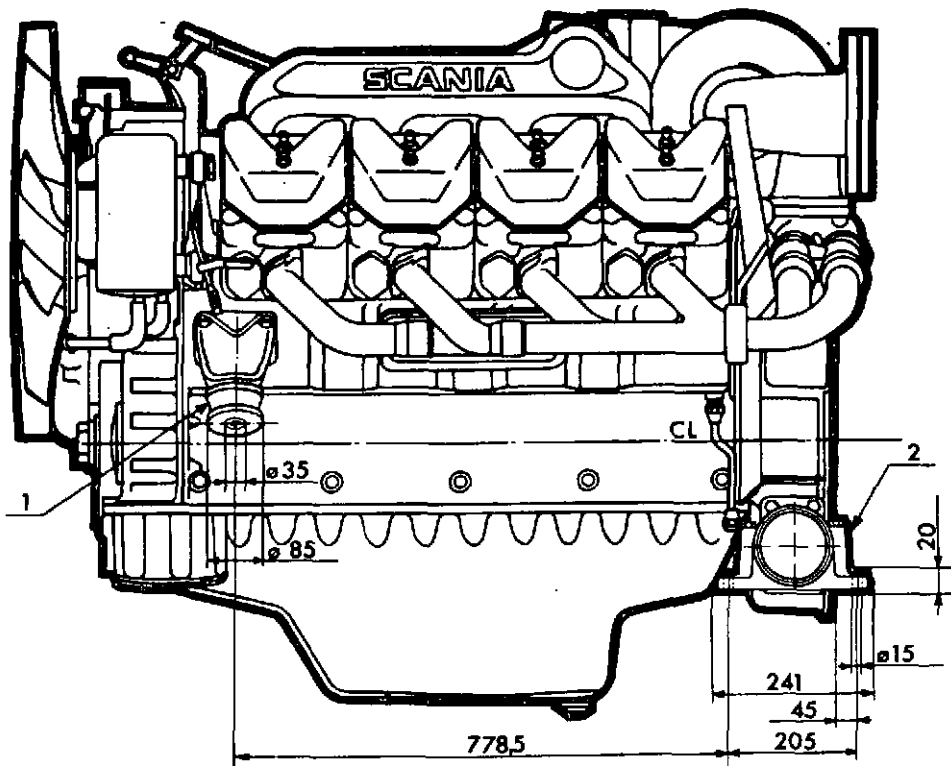


Fig. F3b

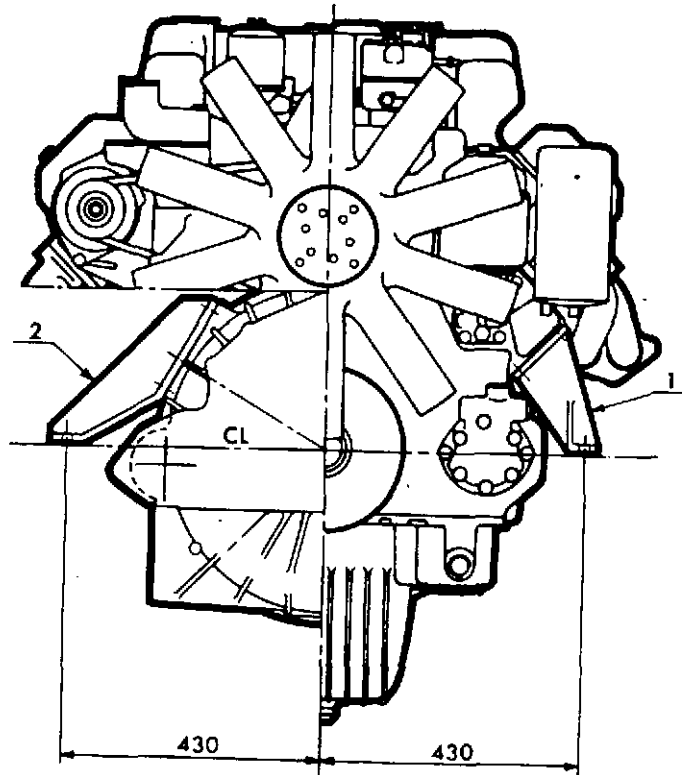


Fig. F4a

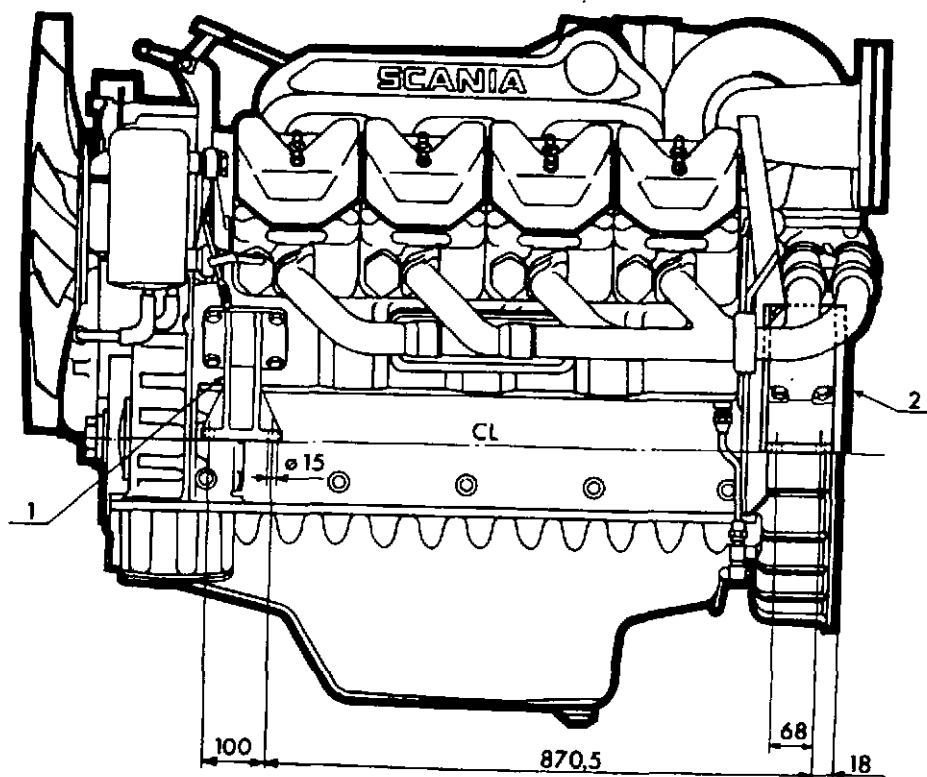


Fig. F4b

F Engine Alignment

General

Considerable attention should be devoted to the alignment of the engine in order that costly operational disturbances shall be avoided. In more special operational cases, it may be advisable, even in future, to check the alignment from time to time.

Permissible deviations:

The required accuracy of the alignment varies, depending on the design of the installation, in respect of power transmission, propeller shaft, etc. However, generally speaking efforts should be made to strive after the max. possible accuracy.

Permissible deviations for single flexible coupling, type Layrub, "two four series":

Maximum permanent angle between driving and the driven shaft	3.5°
Maximum instantaneous angle between driving and driven shaft	8.0°
Maximum permanent axial displacement at minimum permanent angle	3.17 mm
Maximum instantaneous axial displacement at maximum instantaneous angle	7.90 mm
Maximum permanent radial displacement	0.38 mm

N.B. Notwithstanding the fact that relatively large deviations are permissible according to the above, it is still advisable to aim at as much accuracy of alignment as is reasonable, which has a favourable influence on the life of the coupling.

G Operating Control for Engine Speed

The operating and rev/min. controls should be of a reliable and simple design and permit accurate operation, so that the set control arm position is not altered by clearance, wear or the possible movements of engine in the suspension. The control lever movement stroke should be somewhat greater than that of the control arm. The resulting excess movement of the control lever should be taken up by a spring loaded link yoke in both the directions. The link yoke and possible remaining links should be adjustable in both the directions.

The angle between link yoke and control arm, in its centre position of movement stroke should be approximately 90°. Where the conditions do not permit such an angle with the standard control arm fitted, this can be provided with a plate as illustration G1 shows and the link connected to an appropriate hole in the plate.

The control designs normally used are:

- a) Teleflex control
- b) Mechanical linkage system
- c) Electro-mechanical control (Billman control motor)
- d) Pneumatic control

- a) **Teleflex control** can be used for all kinds of engine suspensions and is particularly well suited on flexible rubber suspension. Suitable dimension is 5/16", and the length of the installation can with the dimension stated amount to 40 metres. Detailed assembly instructions accompany each teleflex control delivered.
- b) **Mechanical linkage system** is used on hard rubber suspension or rigid suspension. The operation links must not be bent and should be completely free from vibrations with aid of bearing points. These should preferably permit lubrication and, should be located as far away as possible from exhaust pipe and other sources of radiation, so that seizure is avoided. In order to obtain a somewhat larger movement stroke of the control lever than that of the control arm, the angle arms can be constructed with adjustable radii (see illustration G2). These angle arms also permit synchronization of the control setting on e.g. installations with two or more engines.
- c) **Electro-mechanical control** (Billman control motor) is sometimes used on generating set installations for remote control of the rev/min. (the frequency) and synchronization of generating units in parallel operation, respectively. The control motor, which is fitted on a bracket onto the flywheel housing, is operated by means of electricity and actuates the control arm on the injection pump via a rack and a link rod. The control motor is intended for an operating voltage of 24 V, frequency 50 Hz.
- d) **Pneumatic control** has shown itself to be particularly advantageous on certain multi-engine installations.

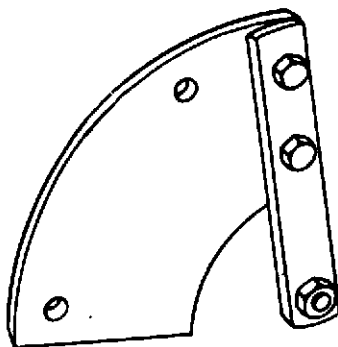


Fig. G1

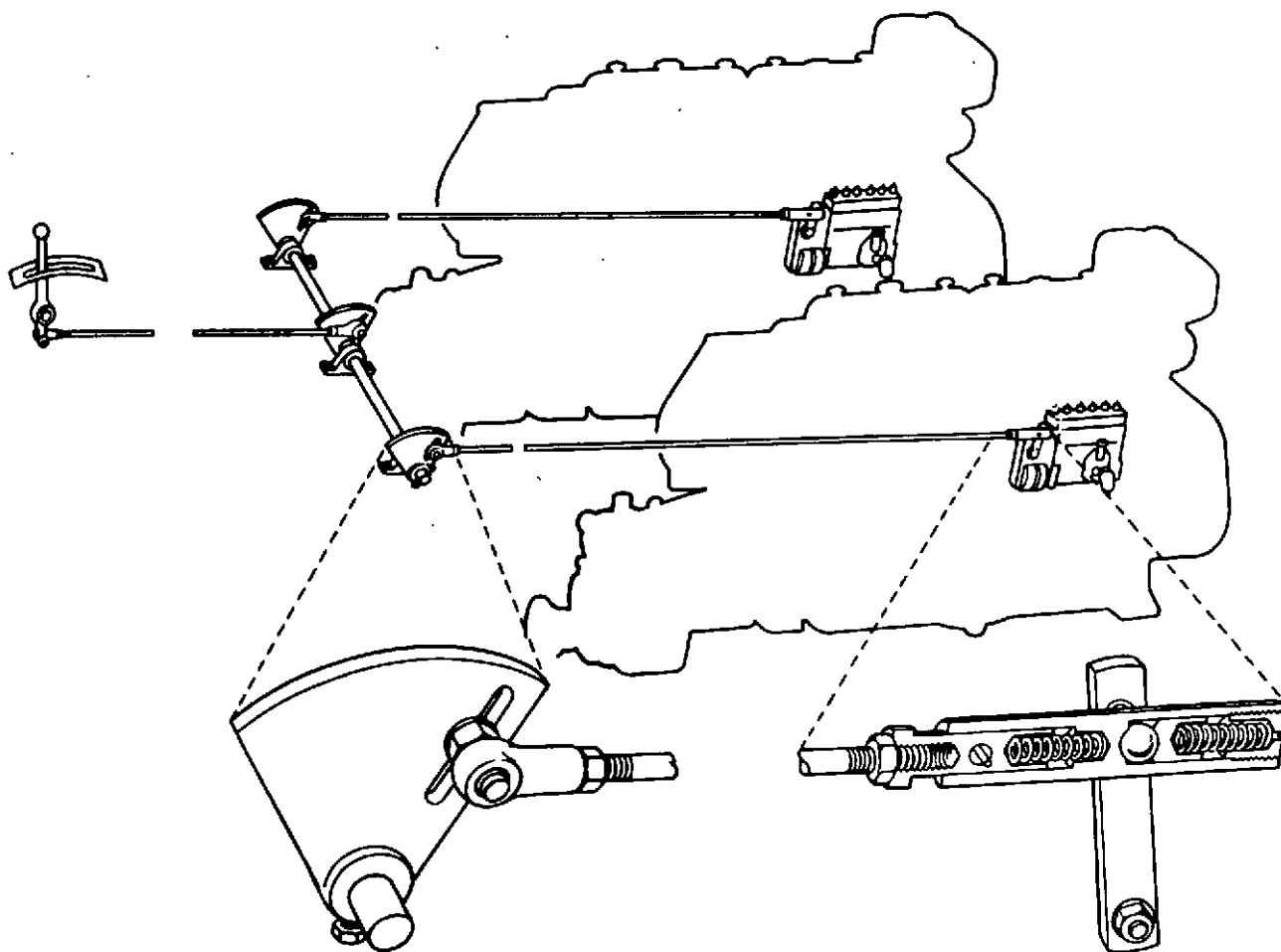


Fig. G2

H Power Transmission - Power Take-off

Power Transmission

The transmission of the engine torque takes place via a friction clutch which is fitted on the engine (with the exception of generating sets). For this type of clutch different designs of power transmissions can be coupled up, depending on the need in the case of operation concerned.

Friction Clutches

Two different designs of friction clutches are available as standard; partly a vehicle clutch with single friction disc and partly an industrial clutch. They vary in the first place by the industrial clutch having larger capacity (dimensioned in order to convert more friction work) than the vehicle clutch. The demand for larger clutch capacity arises with great torque of starting for the power transmission (transmission shafts and V-belt pulleys with considerable inertia moment. Thus, in conjunction with such installations the relation between clutch capacity and starting up work for the driven components coupled to the power transmission shall be judged against the background of clutch operation frequency, clutch life, etc.

The vehicle clutch will ordinarily be used on built-in engines where a stepped-gear transmission of conventional type is used. The industrial clutch is mainly used on marine propeller engines and industrial engines.

In installations where clutch designs other than those mentioned are used, e.g. hydrodynamic clutch (fluid Clutch), possible additional instructions for the installation should be obtained from the clutch supplier.

Flexible Drive Coupling

The use of flexible coupling with coupling flange on the output drive shaft, should be considered in cases where increased flexibility in the power transmission is necessary for balancing out variations in the engine torque. The flexible coupling will often only be motivated as a means of assistance to compensate torsional vibrations in the power transmission. Therefore, the flexible coupling design recommended on account of torsional vibration calculation must not be replaced by a coupling with any other torsion spring constant.

A further advantage with this coupling is that the need for alignment accuracy between driving and the driven shaft is reduced.

Power Transmission Types

Mechanical power transmissions, such as stepped-gear transmission, reduction gear reverse gear etc., are mostly used for single engine installations. Choice of such power transmission is made firstly against the background of maximum engine torque and type of operation. For multi-engine installations, especially in respect of propeller engines in vessels or ferries,

where two or several engines drive a common propeller shaft, V-belt drives have been put to considerable use during recent years.

The advantage with the V-belt drive is that it is very simple to adapt for suitable gear ratio and, it functions to a certain extent as a flexible coupling, has a quiet action and long life and requires, apart from check of belt tension and alignment, no special attention or maintenance.

For V-belt drive different types of V-belt are available, such as single V-belts and multiple V-belts consisting of 2, 3 or more V-belts joined on a cord band. Choice of V-belt type will be dependent on a number of factors. Closer details about this and assistance when calculating can be obtained after applying to AB Saab-Scania Engine Sales Department. On making enquiries about V-belt drives the following particulars should be enclosed:

- a) Output required.
- b) Kind of operation and r.p.m.
- c) Operational hours per day.
- d) Centre distance required between shafts.
- e) Limits for centre distance between shafts.
- f) Type and size on possible existing pulleys.
- g) Maximum permissible dimension on the large pulley.
- h) Driving shaft journal diameter, length and V-groove dimensions.
- j) The driven shaft journal diameter length and V-groove dimensions.
- k) Conditions which can influence the V-belt life, e.g. oil, dirt and dust, high temperatures, etc.

When manufacturing V-belt pulleys, the requirements of the V-belt supplier for roundness and V-groove tolerances shall be adhered to.

In addition to V-belt of the type mentioned, there is also V-belt of the notched type. An equivalent to V-belt drives is the flatbelt and chain drive.

Torsional Vibrations

The power transmission should be made the subject for calculation of vibrations in those cases where hesitation as to whether such vibrations can arise with the power transmission used. The need for torsional calculation applies especially in marine installations of classed design, because

the Classification Societies in general prescribe torsional calculation.

Where the hydrodynamic clutch is used, the engine vibrations are not usually transmitted through it to the power transmission, entailing thus no torsional vibrations.

Assistance with calculation of vibrations can be obtained after applying to AB Saab-Scania Engine Sales Department. The following basic data for calculation should be sent:

- a) Inertial or vibrational moment for large vibrational masses included in power transmission.
- b) Torsion spring constant for shafts between large vibrational masses (e.g. V-belt pulleys).

Remarks: If replies to the questions 1 and 2 are not available, the power transmission component dimensions and material should be stated.

- c) The ratio on possible speed raising or reduction in relation to the engine r.p.m.
- d) Short description of the driven unit. When this consists of e.g. compressor, propeller or similar, the number of cylinders and number of blades must also be indicated.

Cooling the Transmission Oil

Where there is need to dispose of the excess heat from the power transmission, this must not be realized via the engine cooling system without its being adapted for this purpose. For certain operating conditions, this quantity of heat can be relatively great and will partly motivate consideration being taken, when making choice of cooling parts for the engine cooling system and, partly when connection the power transmission cooling system to the cooling system of the engine.

AB Saab-Scania will forward in such cases detailed instructions from case to case after application to the Engine Sales Department.

Fitting an Engine provided with Power Transmission Build-up

In those cases where for instance heavy hydraulic power transmission is built on engine before installation, the lifting equipment, when hoisting the unit, should be coupled both to engine and the hydraulic power transmission simultaneously. Otherwise, the engine flywheel housing may be subjected to harmful breaking efforts and the alignment of engine and transmission in the engine foundation is then as a result liable to become defective.

Power Take-offs

The engines can be delivered with three different types of power take-offs for driving subsidiary or auxiliary units:

Direct Connection to the Front End of Crankshaft

The transmittable torque and output respectively, when coupling direct to the front end of crankshaft are the following:

Crankshaft belt pulley with three additional V-grooves at the front end of engine.

Side-fitted power take-off with two connecting possibilities.

Direct connection to the front end of crankshaft.

Crankshaft Belt Pulley with Three Additional V-grooves

To fit this pulley belt the mounting of the cooling fan must be moved forward. The V-grooves in the above mentioned belt pulley are suitable for 12.5 mm (0.5") narrow V-belt, but V-belt of A-profile can also be used. With the V-belt types now available, the V-belts power transmission capacity will be decisive for how much power can be obtained. Follow the V-belt manufacturer's instructions when calculating the transmittable power.

Side-fitted Power Take-offs

This power take-off is located to the left-hand side of the engine, at the front. On the front side of the timing gear housing e.g. a hydraulic pump of standard design or component with corresponding output requirement can then be fitted, the driving from the timing gear taking place via a rubber bushing coupling, and on the rear side of timing gear housing a special bearing housing with power take-off shaft can be fitted (in case the engine in question is not provided with air compressor of standard design). The total available torque and the output forwards and backwards, respectively, amount to:

147 Nm (15kgm) and 23 kW (31 hpr) respectively at 1500 rev/min and 27 kW (37 hpr) at 1800 rev/min.

44 kW (60 hpr) at a max. torque of 183 Nm (18.7 kgm).

The limit values presented above imply that it is a matter of driving machines with relatively even torque, e.g. generators, centrifugal, gearwheel or wing pumps, etc. For machines with powerful pulsating torques, e.g. piston pumps or piston compressors with one or two cylinders, a reduction of the permissible torque values, should generally occur in accordance with the corresponding reductions indicated by the manufacturer of V-belted and flexible couplings.

Moreover, it should always be judged to what extent the machines connected will have affect on the torsional vibration characteristics of the crankshaft and the whole of the shaft system. See the previous section regarding calculation of torsional vibrations.

J Multi-Engine Installations

The need for a large amount of output is often satisfied by combining several engines in multi-drive. Advantages are thereby obtained in respect of operational safety, service preparedness etc.

When installing the engines it will be, especially in cases where considerable operational safety is required, important to see that the connections of the various engine parts are made as independent of one another as possible so that possible functional defects on one engine do not disturb the operation of the remainder. The instructions given for single engine installations are valid even here to applicable degree. If further instructions are required get into touch with the Engine Sales Department at AB Saab-Scania.

K General Classification Regulations

If the vessel is to be classed, contact shall be made with the Classification Society or Institution which shall inspect the vessel before the installation work commences. By doing this the risk of costly reconstruction work is avoided.

Classed engines are delivered from the AB Saab-Scania factory, the engine type reference on the engine type plate being provided with two letters which indicate the Classification Society by whom the engine has been classed. The following references apply:

LR= Lloyd's Register of Shipping
NV= Det Norske Veritas
BV= Bureau Veritas
GL= Germanischer Lloyd

In addition, Statens Fartygsinspektion (SF) is included. This is a Swedish State Inspection Authority in matters concerning sea safety. In those cases where it is necessary that the vessel shall be classed, such classification shall be made by a Classification Society whose inspection of the vessel is approved by Statens Fartygsinspektion.

The classification implies from the technical aspect that a representative from the Classification Society examines in detail vital parts included in the engine. Where it concerns for instance crankshaft and connecting rods, these are first inspected at the semi-finished stage and afterwards in the finished state. Parts such as cylinder blocks, water pump housings, cylinder liners, and exhaust pipes will be subjected to pressure tests, etc.

The representative for the Classification Society is present when testing the engine both at the factory and after the installation in the vessel.

The classification implies that the Classification Society has drawn up a kind of quality certificate for the installation on which at a later date the insurance of the vessel is based. It is the owner of the vessel who chooses the Classification Society and who orders classification.

For classed installations the Classification Society requires as a rule that torsional vibrations for the complete power transmission, inclusive of propeller plant, be calculated. Assistance with such calculation can be obtained from AB Saab-Scania, see the section about "Power Transmission".

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31.

L Engine Installation from the Service Point of View

According to special instructions the engine installation is to be inspected by personnel from the AB Saab-Scania Service Organization.

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To be able to maintain and repair the engine and its components after the installation in a satisfactory manner, certain accessibility requirements shall be taken into consideration. The items to be observed are the following:

The removal and fitting of the engine without unnecessary waste of time require that the build-up and other components obstructive to this work are designed in such a way that they can be readily removed to the extent necessary.

The injection pump, injectors and fuel filter should be accessible for replacement and for bleeding of the fuel system. It should be possible to read the graduation of the flywheel in connection with the setting of the injection pump.

To make it possible to replace cylinder liners or pistons without removing the engine, enough space must be provided below the engine to enable the oil sump to be removed. The minimum clearance required to remove the oil sump is 275 mm.

Make sure that the filling and draining of oil can be executed in a simple manner and that the dipstick is readily accessible. The same thing applies to the filling and draining of coolant.

The engine air filter and the anti-freeze jar of the air compressor should be located in such a way as to make them readily accessible for changing oil and topping up anti-freeze, respectively.

Attention should also be paid to satisfactory accessibility of the following engine components:

- Lubricating oil filter for the turbocharger
- Turbocharger
- Starting motor
- Generator
- Water pump and cooling fan
- Hydraulic pump
- Radiator
- Disconnecting device at the engine flywheel
- Batteries

3. FUEL- AND EXHAUST SYSTEM

a. D5, DS5, D8, DS8, D11, DS11

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Test Schedule for D11	1	5, 7, 9
Test Schedule for DS8	1	11, 13
Test Schedule for D8	1	15, 17, 19, 21, 23
Test Schedule for DS5	1	25
Test Schedule for D5	1	27, 29, 31, 33
Speed Governors	2	
Injectors	3	
Fuel System, misc.	5	
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3. FUEL- AND EXHAUST SYSTEM

a. D5, DS5, D8, DS8, D11, DS11

List of Contents

	Number
General	0
Injection Pump	1
Speed Regulators	2
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INJECTION EQUIPMENT FOR SCANIA VEHICLE ENGINES (not applicable for Mack)

In consequence of the new Swedish law relating to the smoke density of exhaust gases from diesel engines which came into force on July 1st, 1969, certain modifications have been made to the injection equipment for our diesel engines.

The modifications have resulted not only in less smoke at low engine speeds but also in higher maximum torque. Certain engine types belonging to series D8 and D5 have been given an increased nominal engine rating.

All turbocharged engines as well as engines of the D11-series have been equipped with new injectors with five nozzle holes instead of four. Modifications to the injection pumps include new delivery valves and new pump elements.

The table below shows the injection equipment in all vehicle engines currently in production that are manufactured in Sweden. Both the make of the injector and its three-figure identification number are indicated in column 6. The nominal opening pressure of the injector, expressed in kg/cm^2 (with the figure in bar given in brackets), is indicated in column 9. The type designation of the pump is in some cases followed by an output code, e.g. x or z, as indicated in column 3.

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2.

Engine type	make	Injection pump		∞°	Instr.		Injector			Pressure pipe dia. mm	Remarks
		type	type		sign	make	holder type	nozzle type	opening pressure		
1	2	3	4	5	6	7	8	9	10	11	
DS14LB01	Bosch	PE6P110/920/4LS132	25	204201	Bosch 793	KBL97S86/4	DLA150S495 (five holes)	200 (196)	2.0		
DS11R01A DS11R02A DS11R06 DS11R07 DS11C01 DS11C02 DS11C03	Bosch	PE6P100/720RS145	25	204201	Bosch 795	KBL112S28/13	DLA150S495 (five holes)	200 (196)	2.0	DS11R02A has an extra long coupler.	
D11R01		PE6P90/720RS147 or 148								Pump - 147 has a v-governor Pump - 148 has a c-governor Pump - 149 has a v-governor	
D11R02		147	27	170949	Bosch 794	KBL112S28/13	DLA150S496 (five holes)	200 (196)	1.7		
D11R07	Bosch	148									
D11R21		147									
D11R27		149									
D11R28		149									
D11R29		149									
DS8R01 DS3LB01 DS8C01	Bosch CAV	PE6P100/720RS140 NNR6H90/399	24	208916	Bosch 866	KBAL97S19/4	DLA150S494 (five holes)	200 (196)	1.7	Each engine type either a Bosch or a	
DS8R01 DS8R02 DS8R20 DS8LB01 DS8LB02	CAV	NNR6H80/338 360	30	204009	CAV 135	BKBL97S52758	BDLL150S6403 (four holes)	135 (132)	1.7	Each engine type either pump - 338 (governor) or pump (centrifugal governor)	
DS3LB01 DS3LB03 DS3LB04	CAV	NNR6H90/407 408	25	213148	CAV 200	BKBL97S52758	BDLL150S6438 (four holes)	200 (196)	1.7	Increased nominal rating. Combustion dia. 58 mm. Each can have either pu (vacuum governor) 403 (centrifugal)	
DS5R01	CAV	NNL4H90/401	24	208916	Bosch 866	KBAL97S19/4	DLA150S494 (five holes)	200 (196)	1.7		
DS5R01	CAV	NNL4H80/339	30	204009	CAV 135	BKBL97S52758	BDLL150S6403 (four holes)	135 (132)	1.7	Unchanged nominal rating	
DS5L01	CAV	NNL4H90/406	25	213148	CAV 200	BKBL97S52758	BDLL150S6438 (four holes)	200 (196)	1.7	Increased nominal rating	

FITTING POSITION FOR BOSCH INJECTION PUMP TYPE P ON DS8, D11, DS11 AND DS14 SERIES ENGINES

The driving coupling of the injection pump has given, in a number of cases unsatisfactory service life and has thereby increased the need for alignment of the pump in relation to its driving shaft.

Up till now the position of the pump, when being fitted, has been carefully located at the front through the fixing screw of special design and the sleeve socket used in the front left-hand fixing hole of pump (viewed from driving side).

In order to improve the alignment of the pump at the rear the sleeve socket will also be inserted in the rear left-hand fixing hole.

Improved Production Design

Beginning from pumps with date code 028 and to a limited extent even on earlier pumps with date code 027 (equivalent to manufacturing months August and July 1970 respectively) the two left-hand fixing holes of the pump housing (viewed from driving side) will be provided with sleeve socket Bosch No. 2 410 390 000 according to fig. 1. This sleeve socket which has been used so far in the front left-hand fixing hole of the pump and is to be used in the future, shall have after being pressed in an inner diameter of 10.50 - 10.61 mm. There has not been any alteration made to the fixing screw, but the screw Part No. 178075 is used as before in the front with the sleeve socket hole provided, while screw 177913 is fitted in the other three fixing holes.

Improvements for Pumps on Engines Delivered

Pumps with date code beginning from 705 (manufacturing Month May 1967) are to be provided with additional sleeve socket, according to below, in connection with any other service measure to be taken that motivates dismantling the pump.

Sleeve socket Part No. 221651 (Bosch Part No. will not be available) is fitted in the left-hand rear fixing hole (viewed from driving side) where it is locked with lock fluid, compare figure. The inner diameter of this sleeve socket when fitted will be \varnothing 10.50 - 10.61 mm while the front sleeve socket Bosch 2 410 390 000 will have a diameter of \varnothing 10.20 - 10.30 mm. The same instruction applies to the fixing screws as was given above for the production design.

In anticipation of the production design becoming available, sleeve socket 221651 has been fitted in our production and the engines mentioned below have the injection pump provided with this changeover improvement.

Type D11, DS11	Beginning from engine number 861568
Type DS8	Beginning from engine number 744152
Type DS14	Beginning from engine number 900251

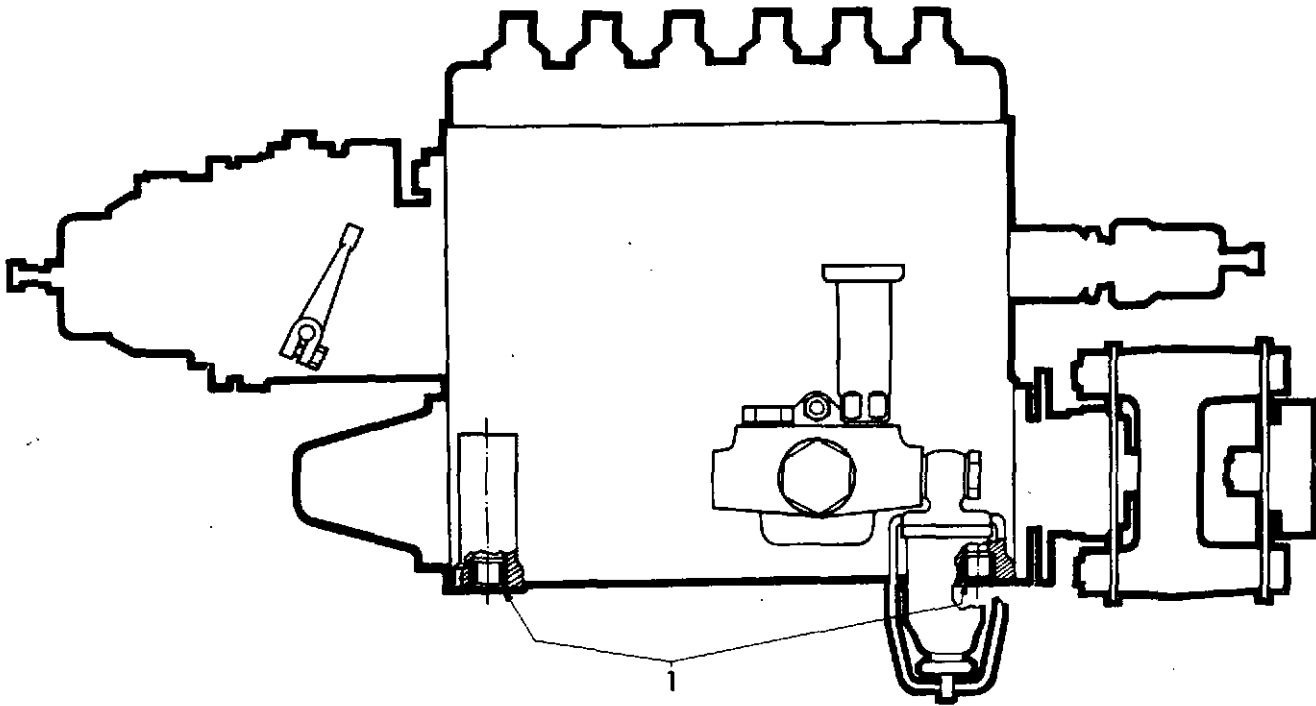


Fig. 1

Production design

1. Socket sleeve Bosch no. 2 410 390 000

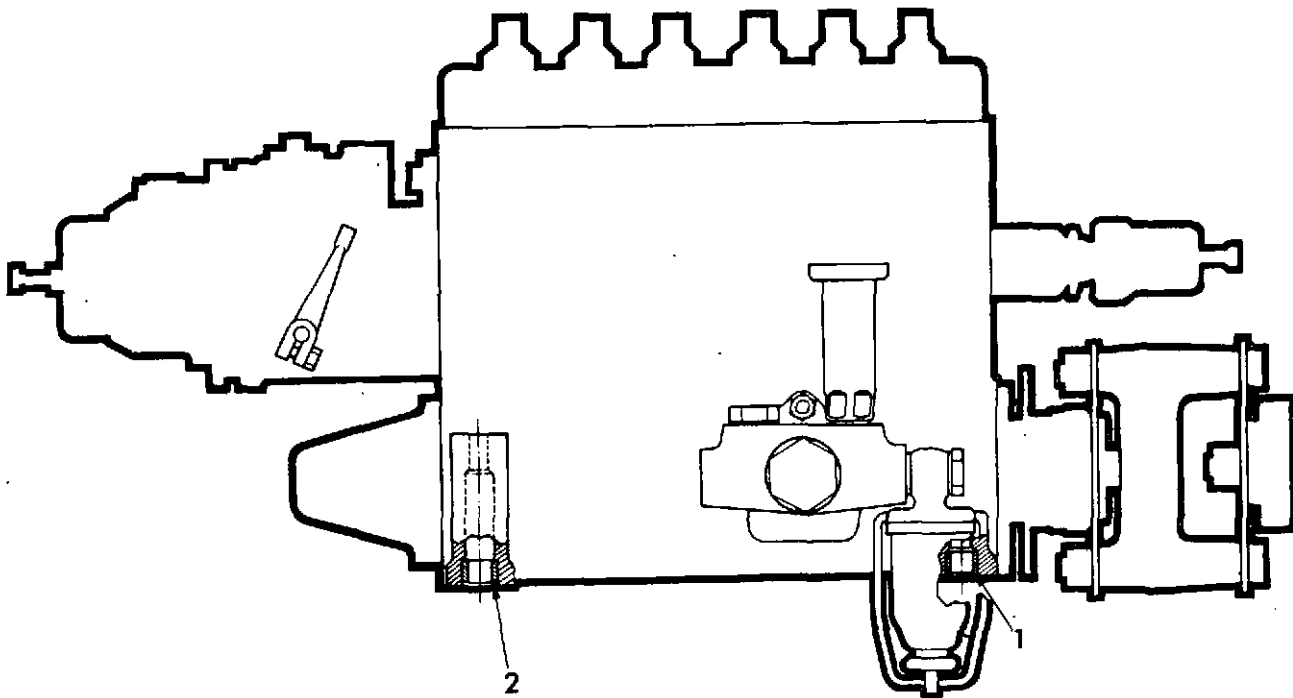


Fig. 2

For retroactive fitting on pumps of certain series

1. Socket sleeve Bosch no. 2
2. Socket sleeve 221651

FITTING OF NEW END WALLS IN FUEL TANKS

It has happened that cracks appear in the end walls of fuel tanks. For the purpose of repair, therefore, separate end walls may be obtained from our Spare Parts Department, according to the part numbers stated below.

Fitting

The existing end wall does not need to be removed but may serve as an extra baffle. Fitting of the new end wall is carried out as follows:

1. Place the tank on end and buckle in the centre of the cracked end wall.
2. Make some holes of approximately 30 mm diameter evenly distributed in the cracked end wall. This is done to prevent rust damage occurring through condensation.
3. If an end wall, in which a tank armature is mounted, has cracked, the hole for the tank armature must be enlarged so that the float is capable of free movement with due regard to the fact that the tank armature will be mounted in the new end wall.
4. Fill the tank with water up to a few centimetres below the end wall.
5. Use a wooden mallet to drive home the new end wall outside the old one. To make this possible the edges of the new end wall must be upset. After the new end wall

is in position, the edges must be made to fit the tank casing. This is made possible with the aid of wooden mallet. Secure the end wall at a few places around its perimeter.

6. Weld the whole joint by melting together the edges of the tank and the end wall.
7. Empty the tank and flush out, e.g. with a few litres of methylated spirit. At the same time check welded joint for leaks.

Material

Necessary material may be ordered from our Spare Parts Department.

Description	Part No.	Dimensions of end wall
Tank end wall with cutout for tank-armature	197492	400x400 mm
Tank end wall with cutout for tank-armature	197493	400x400 mm
Tank end wall with cutout for tank-armature	171258	500x500 mm
Tank end wall with no cutout for tank-armature	171259	500x500 mm

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3. FUEL- AND EXHAUST SYSTEM

c. Separate Engines

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	Number
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BILLMAN CONTROL MOTOR TYPE ME5V

This control motor is used in certain cases for speed control, e.g. in generating set installations with long distance between the engine and the operator's control place.

Description

The control motor consists mainly of the following parts:

Driving motor, gear, end position switches with position indicator and terminal block housing.

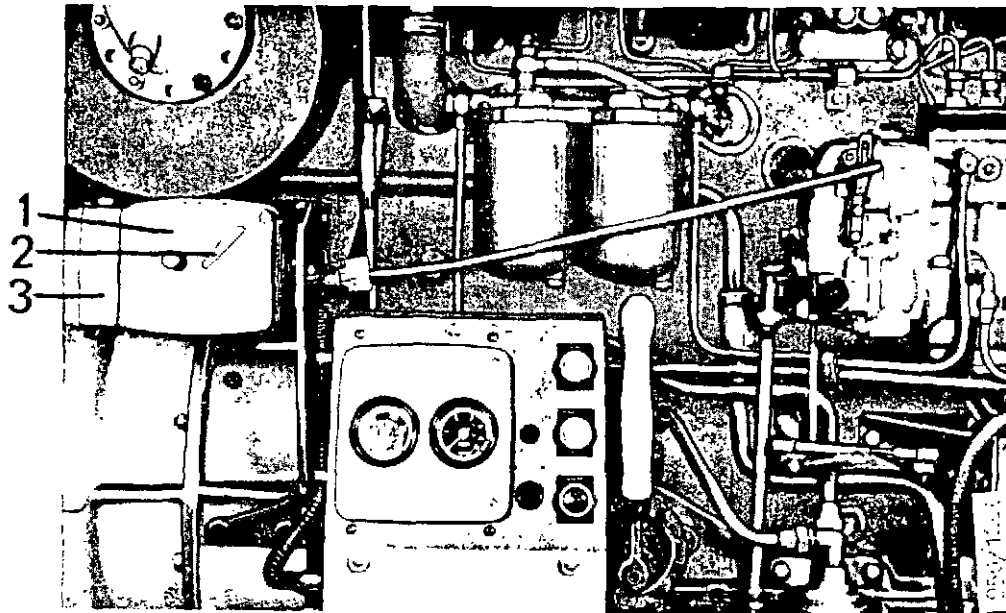


Fig. 1

Control motor

1. Cover for end position mechanism
2. Position indicator
3. Cover for terminal block housing

The driving motor is a reversible alternating current motor designed for permanent phase splitting with condenser and has a short-circuited rotor. By connecting the condenser in series with the windings of either stator half, it is possible to obtain different rotational directions. On the rotor shaft is to be found a brake device which functions when the motor current is broken. The driving motor activates a gear the driven shaft of which, on one side, drives a rack mechanism

which transmits the motor movement via a link rod to the injection pump control lever. At the other end of the shaft, beneath the removable cover (1, fig. 1), is to be found the end position mechanism and a driver arm which actuates the position indicator (2, fig. 1).

Beneath the cover (3, fig. 1) is to be found a terminal block for connecting the electrical cables.

Technical data

Operating voltage: 24V, 50 cycl.p.sec. A.C.
 Power consumption: 16 VA
 Stroke: Adjustable between 14 and 50 mm
 Max. permitted ambient temperature: + 55°C
 Running time for 25 mm stroke: 80, 160 or 320 seconds

Notes

Control motors with 80-second running time have so far in general been used for injection pump with mechanical governor of RQV (Bosch) or VW (CAV) design.

Control motors with 320 second running time have in a number of cases been used for injection pump with mechanical governor of RSV design.

In those cases where running time is not punched on the control motor rating plate, it is possible to determine it by assistance from the three-digit number, which is included in the type reference. If the first digit is a 3, the running time is 80 seconds; if it is a 4, the running time is 160 seconds; if it is a 6, the running time is 320 seconds.

The reason for control motors with various running times being used is the fact that on different governor types a certain angle alternation on the control lever results in different changes to the engine speed.

As the control motor is used first and foremost on a generating set which shall be phased together e.g. with an other generating set, it will be important, for connecting up at the right moment, that the r.p.m. does not alter too quickly. On the other hand the operation must not take place too slowly in those cases where the demand for speedy paralleling exists.

Fitting and Electrical Connection

The control motor is fitted on a bracket on the flywheel housing and connected, according to the wiring diagram shown below, to the operational voltage mentioned. To obtain this voltage it is generally necessary to install a transformer. The electrical installation shall be carried out in accordance with the applicable prescriptions for heavy current. The cables shall have a cross section of at least 1 mm².

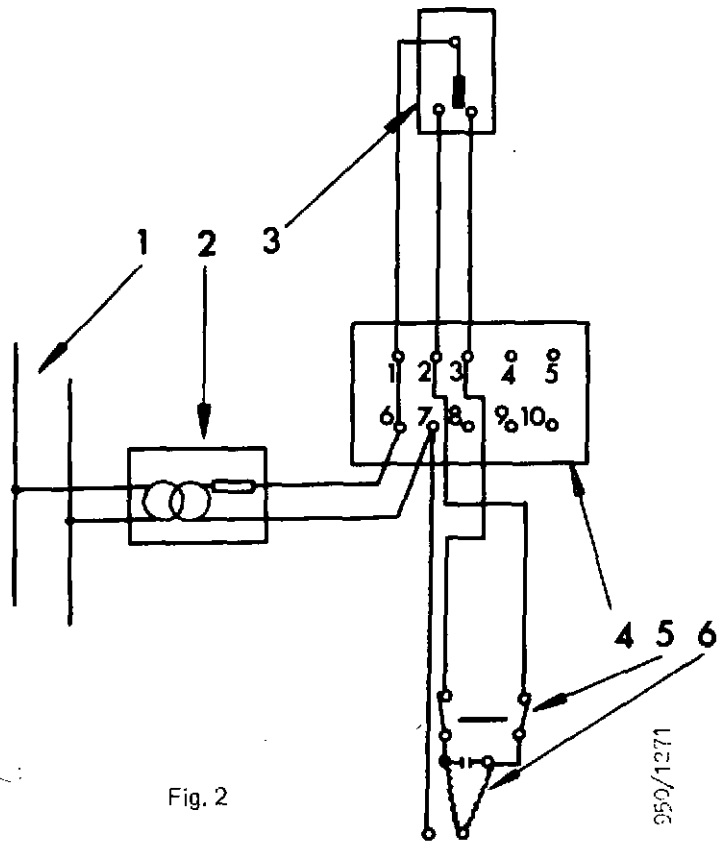


Fig. 2

Wiring diagram for control motor ME5V

1. Electrical mains (e.g. 220V, 50 cycl.p.sec.)
2. Single-phase transformer with 24V, 50 cycl.p.sec. secondary voltage
3. Control device.
4. Terminal block
5. End position switch
6. Driving motor with condenser

The setting of the control lever end positions, and thus the starting point for the possible speed control range, takes place in the following manner:

- a) Check that the knob to be found on the back of the control motor is tightened up. (Some control motors lack this knob.).
- b) Run the control motor until the rack reaches its maximum protruding position by supplying connections 2 and 7 with supply voltage.
- c) Push the control lever of the injection pump against the maximum speed stop and screw up the link rod in the rack holder (3, fig. 3).
- d) Run the control motor until the rack reaches its maximum protruding position by supplying the connections 3 and 7 with supply voltage. Adjust the stroke with the setting screw (1, fig.3) so that it corresponds to the movement between the control lever end positions. Clockwise turning gives reduced movement.

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N.B. Never re-set the contacts for the end position switch contacts (2, fig. 3). They are correctly set before delivery and must not be altered when re-setting the control motor movement.

- e) Run the control motor for testing between the end positions several times and check to see that it is absolutely stationary in both upper and lower end positions, respectively, when the current to the end position switch is broken. As a matter of fact, it may happen that the control motor moves back after the current interruption, if the buffer spring on the rack is for some reason or other compressed too much.

As a general rule, see that no permanent sparking occurs between the contact points at the movement stop end positions.

- f) Start the diesel engine and check that it is possible to govern it within the desired speed range.

Notes

During operation the majority of generating set installations only utilize a part of the control motor movement stroke for governing the diesel engine r.p.m.

Maintenance

The rack mechanism should be lubricated occasionally with ordinary ball bearing grease. By screwing in the red plug in the end of the rack housing it is easy to fill this with a little grease.

Spare Parts

The control engine and spares for this are sold in Sweden by:

Billman Regulator AB, Fack, Huddinge 1

Suitable transformer is supplied by:

Erik Sundberg Försäljningskommanditbolag, Box 68, Sollentuna

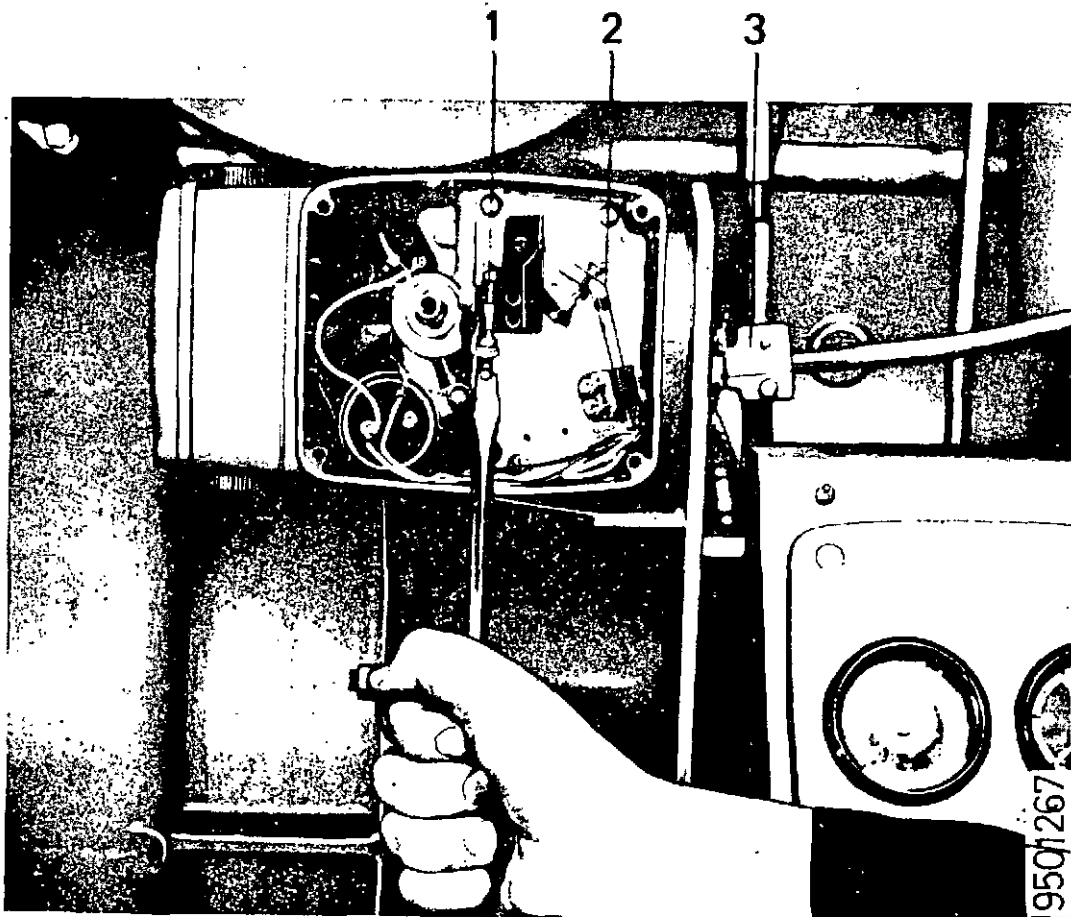


Fig. 3

Adjusting the end position mechanism

1. Setting screw
2. Contacts for the end position switches
3. Holder for link rod

BOSCH BALANCE SPRING GOVERNOR TYPE TYPE EP/RSV

General

The subject governor is now used on the D11-series engines in generating sets and multi-engine installations.

The advantage to be gained with this governor, being of the

all-speed type, is that only **one** governor weight set and **one** governor spring are necessary in order to cover the demands so far on control characteristics. This can furthermore be adjusted in a simple manner, which is of extremely great importance when operating engines in parallel. The design is shown by the figure below:

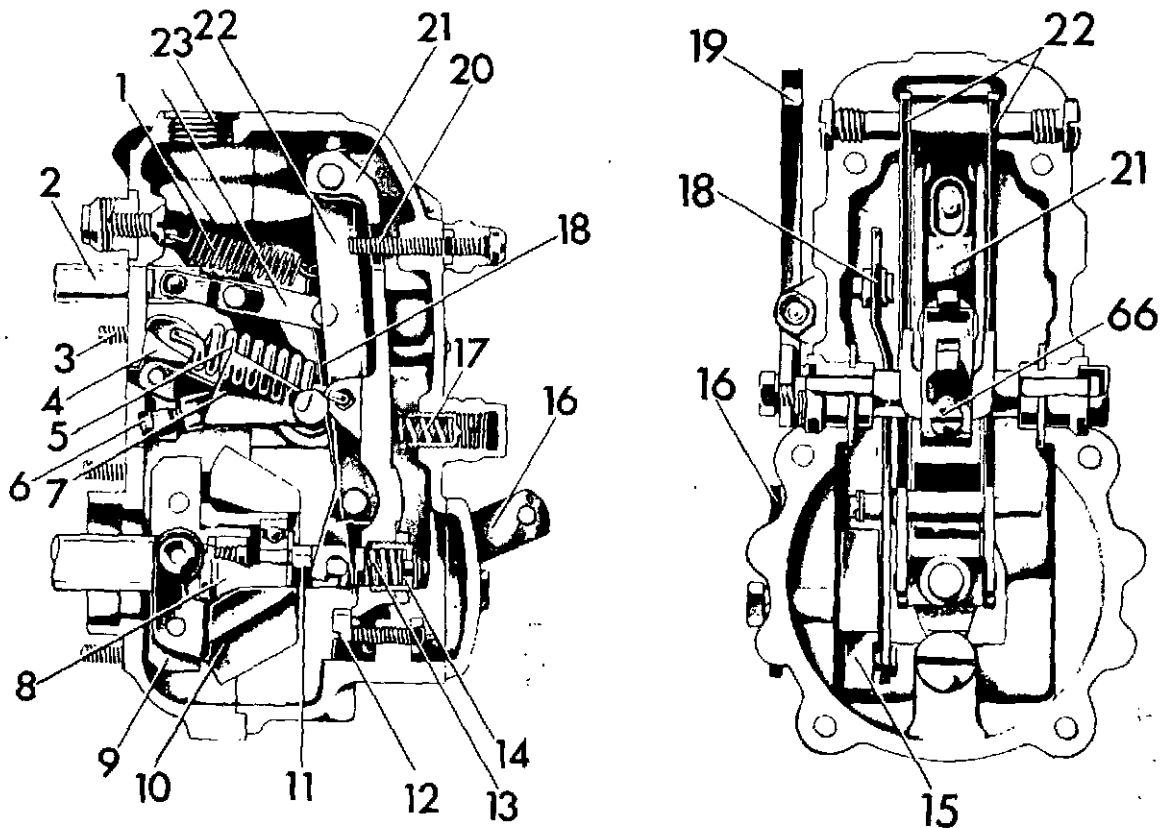


Fig. 1

Governor EP/RSV

- | | | |
|-----------------------|-----------------------------|--------------------------|
| 1. Starting Spring | 10. Governor weight | 17. Idling damper spring |
| 2. Control rod | 11. Driver pin | 18. Governor arm |
| 3. Maximum speed stop | 12. Internal full load stop | 19. Control arm |
| 4. Rocker arm | 13. Equalizer spring | 20. Idling stop |
| 5. Governor spring | 14. Adjusting washers | 21. Tension arm |
| 6. Set screw | 15. Stop device | 22. Guide arm |
| 7. Balance arm | 16. Stop lever | 23. Screw plug |
| 8. Governor sleeve | | |
| 9. Governor hub | | |

Functional Description

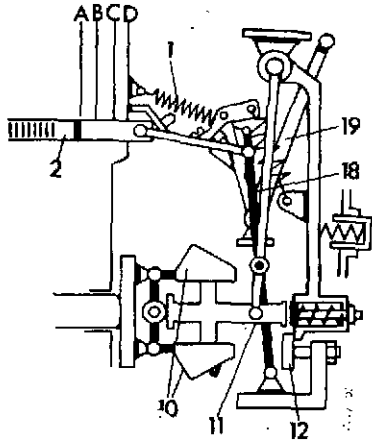


Fig. 2 Starting the engine

Starting the engine, fig. 2:

The starting spring (1) pulls the governor arm (18) and in conjunction with this, the control rod (2) towards the cold start position. When the engine has started, the governor weights (10) move outwards and push the driver pin (11) and the lower end of the guide arm to the right as in the figure. The guide arm in its turn activates the governor arm (18) and the control rod (2) so that control rod movement is reduced. N.B. when the engine is not operating, the control rod runs towards the cold start position or full load position, depending on governor type, see page 3, regardless of the position of the control arm (19).

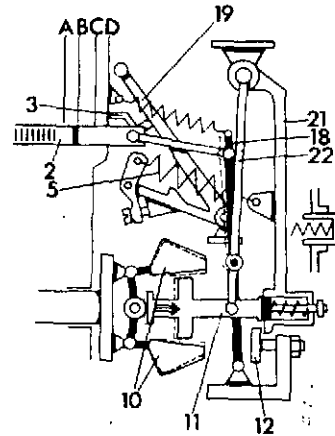


Fig. 3 Regulation at maximum full load speed

Regulation at max. full load speed, Fig. 3:

The control arm (19) then bears against the maximum speed stop (3) and pulls, through the governor spring (5), the tension arm (21) towards the full load stop (12). If the speed is now increased further, which occurs when the load is reduced, the centrifugal force of the governor weights (10) overcomes the tension force of the governor spring (5) and pushes the driver pin (11) to the right. The driver pin in its turn activates the guide arm (22), which via the governor arm (18) pushes the control rod (2) to a smaller control rod opening, whereby the engine speed is restricted.

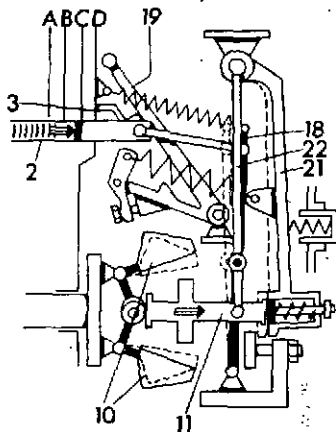


Fig. 4 High no-load speed

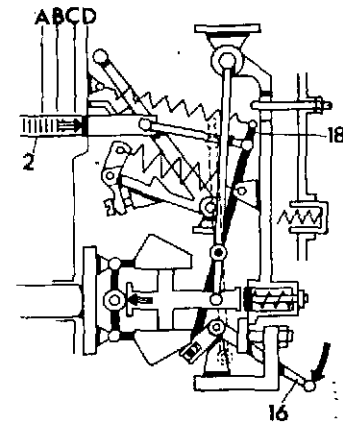


Fig. 5 Stopping the engine

High no-load speed (i.e. completely unloaded engine), Fig 4:

The control arm (19) bears against the maximum speed stop (3), and the centrifugal force from the governor weights (10) is now so great that the tension arm (21) is pushed farther to the right. The driver pin (11) activates the guide arm (22) and the governor arm (18), which pushes the control rod (2) to an even smaller control rod opening equivalent to the fuel quantity necessary in order to keep the engine rotating.

Stopping the engine, Fig. 5:

When the stop lever (16) is moved into the stop position, the governor arm (18) is activated so that its upper part moves to the right and pulls the control rod (2) towards zero. When the stop lever is released, it is moved back again by a return spring to the operating position.

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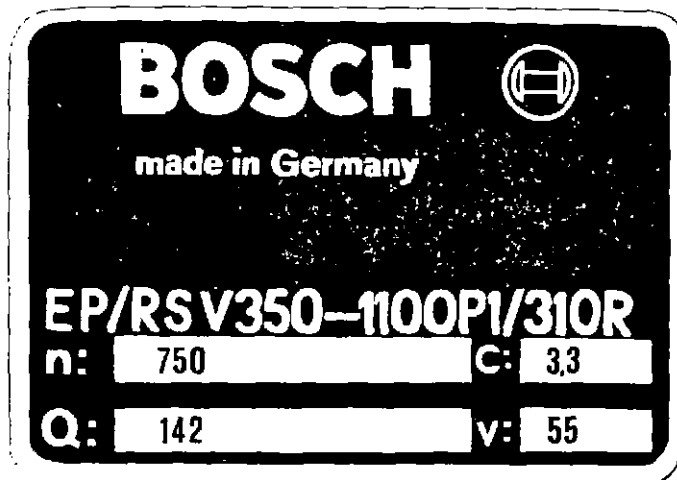
3.

Different Type Designs

The following two governor types have been used on the D11 series:

- a) EP/RSV 350-1100 P1/307R
 - b) EP/RSV 350-1100 P1/310R
- a) This governor type has so-called internal maximum load stop, i.e. the screw with which max. control rod opening is set is to be found inside the governor, see 12 in Fig. 1. This implies that the control rod always runs towards the cold start position when the engine has been stopped, see Fig. 2 and "Starting the Engine". If the "spill cut-off" method (Wilbär) is then used for setting the pump at its due degree marking, on the engine, a faulty setting will occur because of the cold start grooves in the pump elements. This can be avoided, if the stop lever is moved half way towards the stop position and kept there during the setting.
 - b) This governor type lacks the above described internal maximum load stop but has instead an external maximum load stop. The cold start device on the front edge of pump serves in this case as maximum load stop. When the weather is cold it is thus necessary to operate the cold start device.

Type Plate



On the governor casing is to be found the above plate, which in addition to the type, indicates the values which the injection pump has been set at in conjunction with engine testing.

The below mentioned example will make it quite clear what the values refer to:

- n: 750 Maximum load speed of injection pump on bench test.
- Q: 142 Fuel delivery in mm³/stroke on bench test at a certain maximum load speed.
- c: 3.3 Specific speed increase of injection pump, defined as:

The speed difference between the maximum load speed of the injection pump and the speed at which the control rod opening has decreased by 6 mm from the control rod opening at maximum load, in percent of the maximum load speed. The control arm shall bear on the maximum speed stop.

Example

The maximum load speed of the pump = 750 r.p.m.
 Maximum control rod opening equivalent to maximum load position = 13 mm.
 Speed at 7 mm (= 13-6) control rod opening = 775 r.p.m.

$$c = \frac{(775-750)}{750} \cdot 100 = 3.3\%$$

Note that the specific speed increase indicates the regulation characteristics and has no definite connection with the engine speed increase.

- V: 55 Maximum control arm angle, defined as $V = 40^\circ$ when the control arm is parallel with the parting line between the governor housing and the pump housing.

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4.

Setting and Adjustment

The necessary values for repairs or operating of governor on the test bench is shown by the Bosch repair and test instructions.

Particulars for calibrating the pump and setting maximum delivery are also indicated by us in a separate Service Bulletin.

Adjustment of the maximum load speed is effected with the maximum speed screw on the outside of governor housing.

The engine speed increase and thereby the high no-load speed are influenced foremost by the governor spring preload. The tensioning is performed by the set screw (6, Fig.1). It is possible to adjust this screw through the hole for the screw plug (23, Fig. 1), if the control arm is moved backwards, see Fig. 2. In certain cases, it will also be necessary to screw out the idling stop (20, Fig. 2).

Turning clockwise results in higher tension and smaller speed increase. The control arm angle must then be diminished to maintain the same maximum load speed. Inversely, a re-setting of the control arm position will also modify somewhat the preload of the governor spring.

The procedure when re-setting the maximum fuel delivery or maximum control rod opening is shown in the above section about different type designs.

Re-setting the maximum fuel delivery also influences somewhat the maximum load speed and the speed increase.

The idling speed is set with screw (20, Fig. 1). The idling damper spring (17, Fig. 1) prevents engine stalling and permits an even transition to low no-load speed. It must not be screwed in too far that it increases the high no-load speed.