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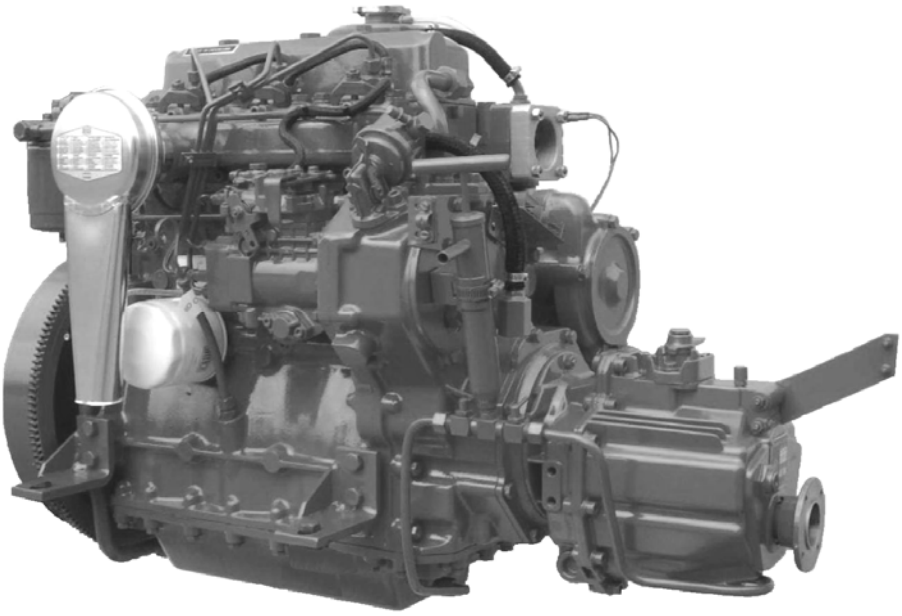
Work shop Manual
for
BUKH diesel engine
TYPE DV36/48



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SECTION A

INTRODUCTION AND TECHNICAL DATA

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Introduction

BUKH DV36 is a 3-cylinder, water cooled, 4-stroke diesel engine with direct injection, giving an easy start at low temperatures, a low consumption of fuel and a low thermic load of the cylinder head.

The engines are specially designed to comply with the heavy demands made on stability, safety and environment now.

The technical structure of the engine with components and systems appears from the individual sections of this workshop manual and therefore this introduction contains no descriptions of this.

DV36 is designed with small installation dimensions compared to corresponding engine outputs on the market. This applies to both height, length and width. At the same time the weight of the engine is comparatively low and the proportion weight/horse power is in fact only 7.36 compared to corresponding engine outputs on the market with a corresponding factor of 8.28 and 8.48.

Being a 3-cylinder engine, DV36 is a naturally low level of vibration compared to 1- and 2-cylinder engines, but in order to obtain a further improvement of the vibration level, the rotating weight system has been continued on DV36 as it is known with great success from DV10 and DV20. DV36 with the anti-vibration system is thus free from unpleasant vibrations and may correctly be described as the less vibrating engine on the market.

DV36 is supplied either with sail-drive (type DV36SME) or with BW7 gear (type DV36ME). The type description S = saildrive, M = marine gear and E = with electric start.

The temperature of the exhaust gas is for DV36 max. 550°C, which is about 100°C below corresponding engine outputs on the market.

DV36 is delivered as standard with direct seawater cooling but may be alternatively be delivered with heat exchanger built integral with water cooled exhaust, keel cooler or radiator cooler.

TECHNICAL MAIN DATA

WORKING PRINCIPLE		4-STROKE
BORE/STROKE		85 mm / 85 mm
CYLINDER VOLUME		1.447 Litres
COMPRESSION RATIO		18,5:1
COMPRESSION PRESSURE	at 1800-3600 rpm	46 Bar
OUTPUT, CONTINOUS RATING	at 2400 rpm	29.8 BHP - 21.9 kW
ACCORDING TO ISO 3046	at 3000 rpm	34.5 BHP – 25.4 kW
	at 3600 rpm	36.0 BHP - 26.5 kW
OUTPUT, INTERMITENT RATING BHP	at 4000 rpm	39.3 BHP – 28.9 kW
MAX. TORQUE Kp*m	at 1800 rpm	9.2 Kpm – 90 Nm
MAX. AIR CONSUMPTION		2214 Litres/min.
ENGINE ROTATING, LOOKING AT FLYWHEEL		CLOCWISE
IDLING SPEED		800 – 1000 RPM
MAX INCLINATION, FORE AND AFT		15°
HEEL, MAX. CONTINOUS		30°
NET WEIGHT INCL. ZF MARINEGEAR		265 Kg
NET WEIGHT INCL. SAILDRIVE		290 Kg
LOCATION OF ENGINE SERIAL NUMBER		ON CRANKCASE NEAR FUEL THE PUMP
EXHAUST TEMP. MAX / NORMAL		600°C – 580°C

VALVE TIMING AND INJECTION POINT

FLYWHEEL DIAMETER		370 mm
INLET VALVE OPENS	BEFORE TDC	32° (arc measure: 103 mm)
INLET VALVE CLOSES	AFTER BDC	64° (arc measure: 207 mm)
EXHAUST VALVE OPENS	BEFORE BDC	64° (arc measure: 207 mm)
EXHAUST VALVE CLOSES	AFTER TDC	32° (arc measure: 103 mm)
INJECTION STARTS	BEFORE TDC	6.2° (arc measure: 20 mm)
VALVE CLEARANCES (COLD ENGINE) INLET/EXHAUST		0.30 mm

FUEL SYSTEM		DIRECT INJECTION
INJECTOR OPENING PRESSURE		210 Bar
INJECTION TIMING		AUTOMATIC VARIABLE
FUEL LIFT PUMP		CAM SHAFT DRIVEN DIAPHRAGM PUMP
STATIC PRESSURE OF FUEL LIFT PUMP		153 - 285 mBar
FUEL FILTER		THROW AWAY FILTER INSERT
FUEL QUALITY GAS OIL		BS 2869 CLASS A

LUBRICATING SYSTEM

TYPE OF LUBRICATING OIL PUMP		ROTARY VANE PUMP
LUBRICATING OIL PRESSURE: WARM ENGINE / MINIMUM		2-4.5 Bar / 1 Bar
LUBRICATING OIL QUALITY		SERVICE CC or CD
LUBRICATING OIL VISCOSITY	BELOW +5°C	SAE 10 or SAE 10W-30
	BETWEEN +5°c and +25°C	SAE 20 or SAE 15W-40
	ABOVE +25°C	SAE 30 or SAE 15W-40
LUBRICATING OIL CONTENT INCL. FILTER		4.9 Litres
LUBRICATING OIL FILTER		THROW AWAY FILTER INSERT

ZF BW7 MARINEGEAR

LUBRICATING OIL QUALITY		API CC or CD, MILL-L-46152
LUBRICATING OIL VISCOSITY		SAE 30 or SAE 15W-40
LUBRICATING OIL TEMPERATURE		MAX. 120°C
LUBRICATING OIL CONTENT		1.1 Litres

NEWAGE PRM120 MARINEGEAR

LUBRICATING OIL QUALITY		Automatic Transmission Fluid (ATF)
LUBRICATING OIL TEMPERATURE		MAX. 120°C
LUBRICATING OIL CONTENT		0.8 Litres

BAYSAN M60 MARINEGEAR

LUBRICATING OIL QUALITY	Automatic Transmission Fluid (ATF)
LUBRICATING OIL TEMPERATURE	MAX. 120°C
LUBRICATING OIL CONTENT	0.5 Litres
STERN TUBE (FLEXIBLE) LUBRICANT	OUTBOARD GEAR OIL

COOLING WATER SYSTEM – DIRECT SEAWATER COOLING

COOLING WATER TEMPERATURE	50 – 65°C
TYPE OF CIRCULATING PUMP / CAPACITY AT 3600 rpm	CENTRIFUGAL / 24-30 Litres/min
CAM HEIGHT	2.0 mm
MAX. PUMP COUNTER PRESSURE	0.6 Bar
MAX. PUMP SUCTION PRESSURE	0.3 Bar

COOLING WATER SYSTEM – INDIRECT COOLING WITH FRESHWATER

COOLING WATER TEMPERATURE	70 – 95°C
TYPE OF FRESHWATER PUMP / CAPACITY AT 3600 rpm	CENTRIFUGAL / 135 Litres/min
PUMP PRESSURE	1.1 Bar
TYPE OF SEAWTAER PUMP / CAPACITY AT 3600 rpm	CENTRIFUGAL / 36-42 Litres/min
CAM HEIGHT	3.1 mm
MAX. PUMP COUNTER PRESSURE	0.6 Bar
MAX. PUMP SUCTION PRESSURE	0.3 Bar

ELECTRICAL SYSTEM

BATTERY VOLTAGE / CAPACITY	12 VOLT / 88 Ah
STARTER TYPE / OUTPUT	GEAR DRIVEN / 1.0 KW
ALTERNATOR TYPE/ OUTPUT	BELT DRIVEN / 700 W
ENGINE STOP	SOLONOID / MANUAL
RELAY	ELECTRONIC, BUILT ON

TORQUES

CYLINDER HEAD BOLTS/BEARING TOP SECTION	118 +/- 5 Nm (12 +/- 0.5 Kpm)
CONNECTING ROD BOLTS	69 +/- 3 Nm (7 +/- 0.3 Kpm)
FLYWHEEL/COUNTERWEIGHTS	147 +/- 7 Nm (15 +/- 0.7 Kpm)
FLEX. COUPLING	61 +/- 3 Nm (6.3 +/- 0.3 Kpm)
ASSEMBLY OF FUEL VALVE	59 +/- 3 Nm (6.0 +/- 0.3 Kpm)
BRACKET FOR ENGINE SUPPORTS	69 +/- 3 Nm (7 +/- 0.3 Kpm)
GEARBOX	25 +/- 5 Nm (2.5 +/- 0.5 Kpm)

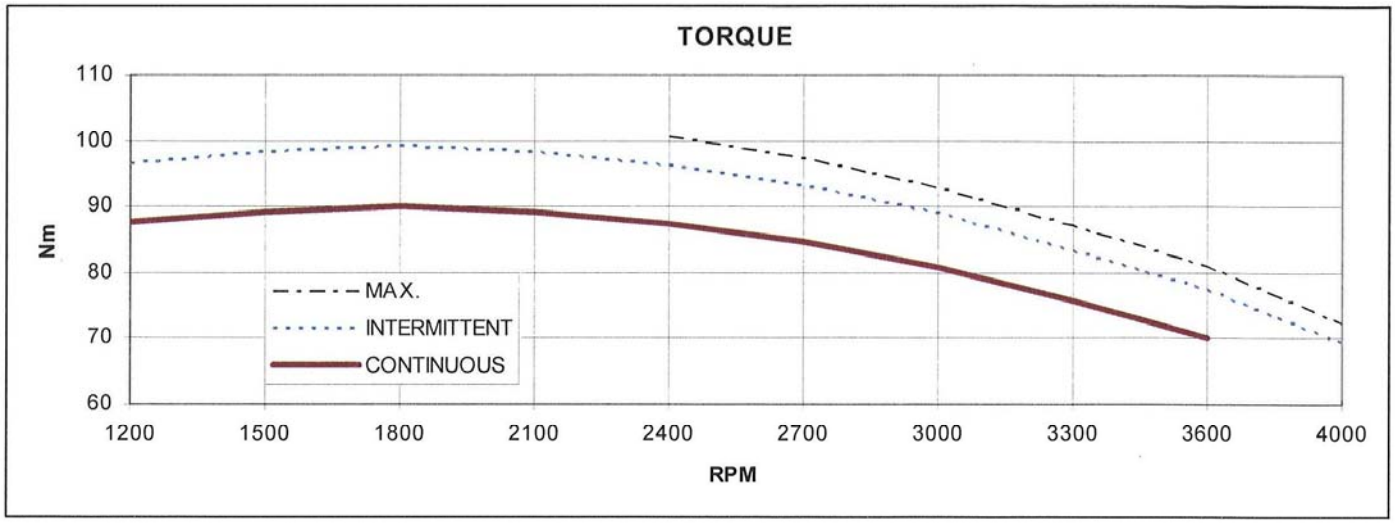
Spare Part Numbers for Service Parts

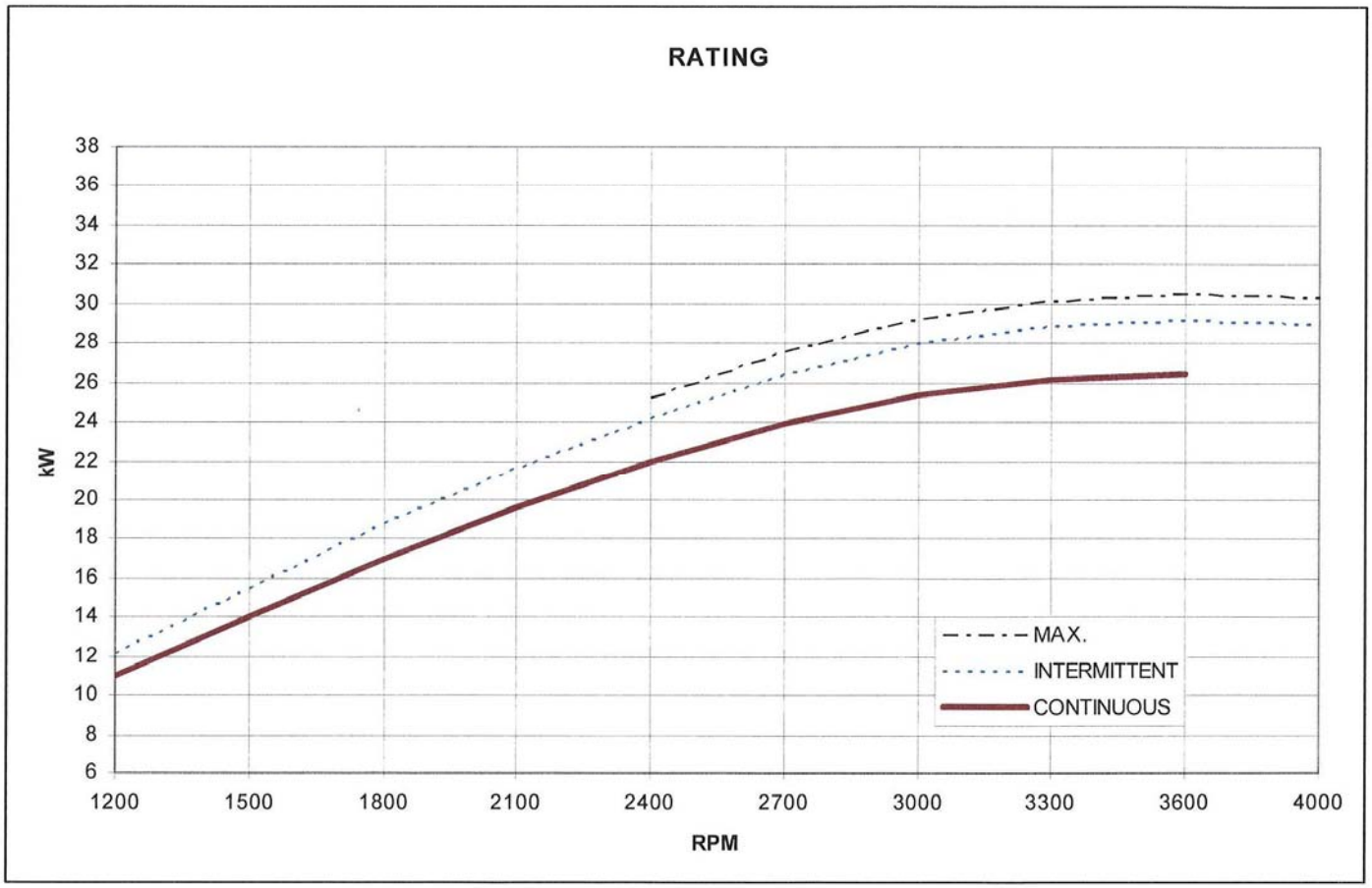
In this manual we have maintained on the drawings some numbers which are also spare part numbers. However, this manual is not to be regarded as a spare parts catalogue but only as helping guidance for correct identification of parts.

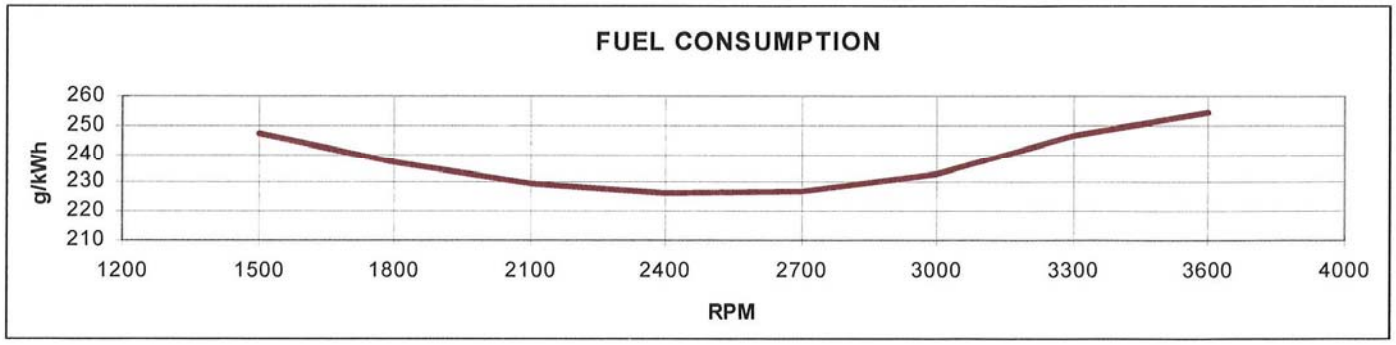
In the daily service work, some of the parts must be replaced after the number of hours stated in the owner´s manual and in this book, and therefore we have made the following table:

610J0200	Lubricating oil filter
610D0201	Fuel filter
020D4326	Air filter
000E0450	Sacrificial zinc anode
610G0506	Impeller
542A0602	V-belt 10*1035 (seawater cooling)
542A0609	V-belt 10*1100 (freshwater cooling)

TORQUE-, RATING- AND FUEL CONSUMPTIONS CURVE for DV36







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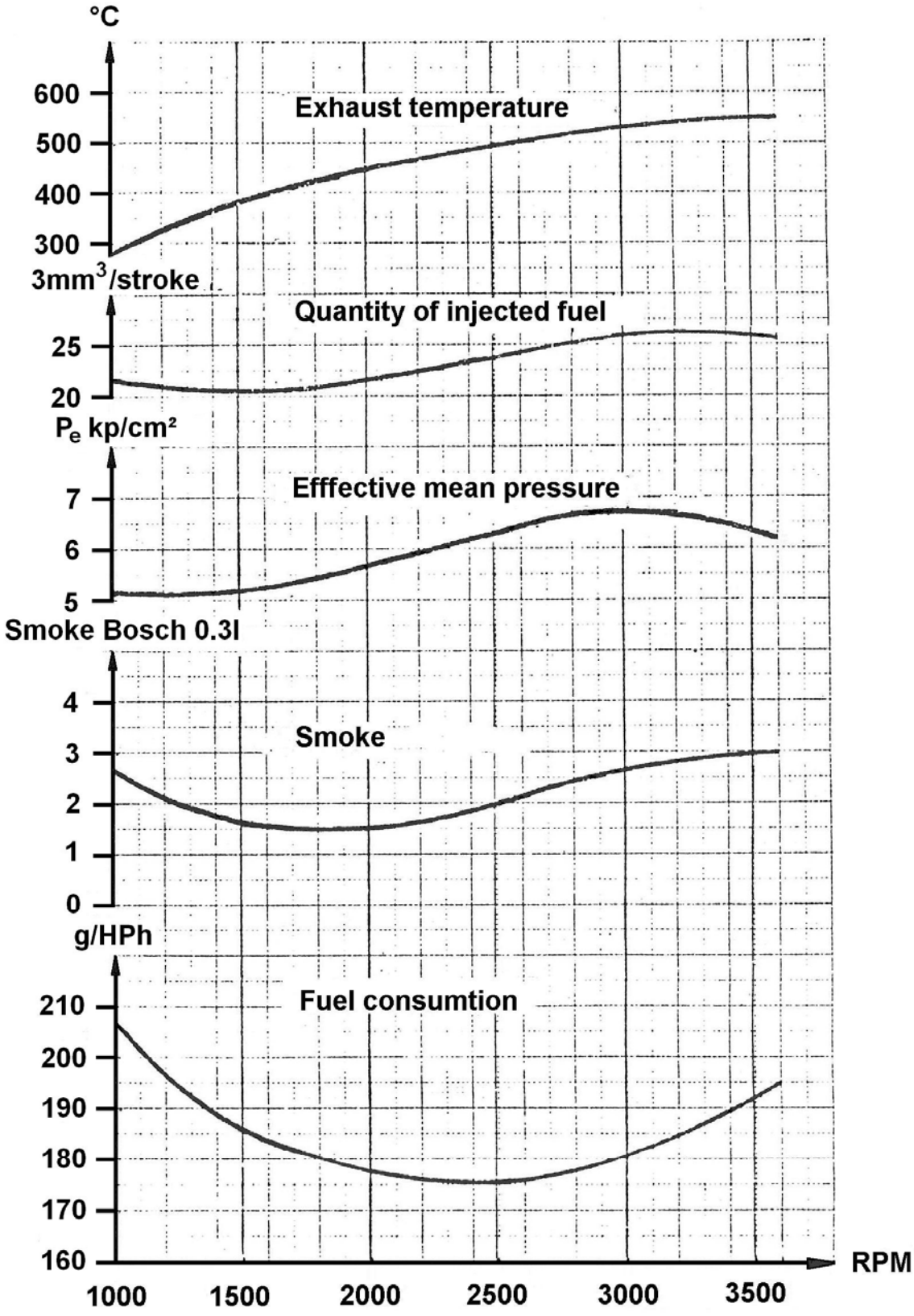
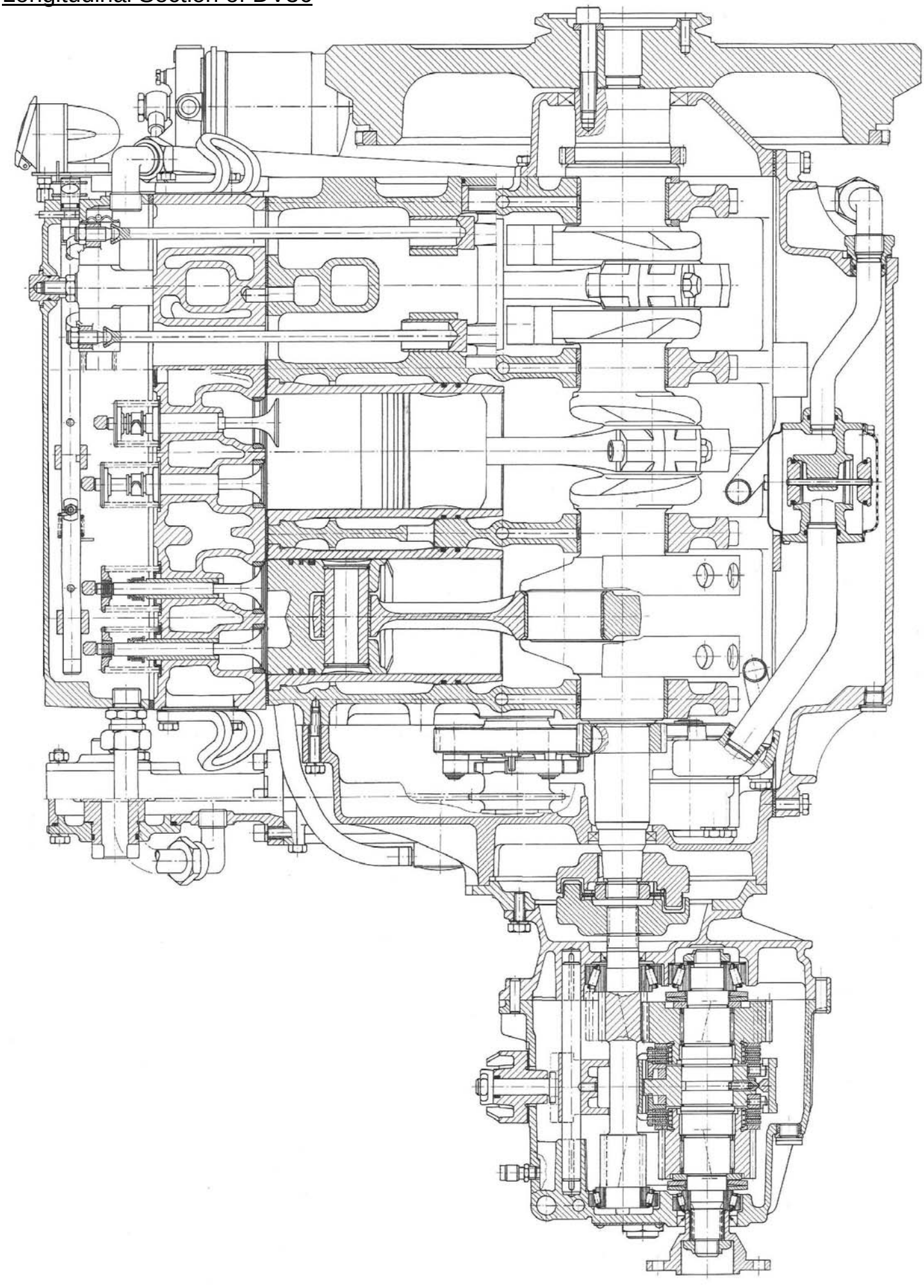
Results of Measurement

The below curves indicate results of measurements at 762 mm Hg and a room temperature of 26 °C.



Longitudinal Section of DV36



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Cross Section of DV36

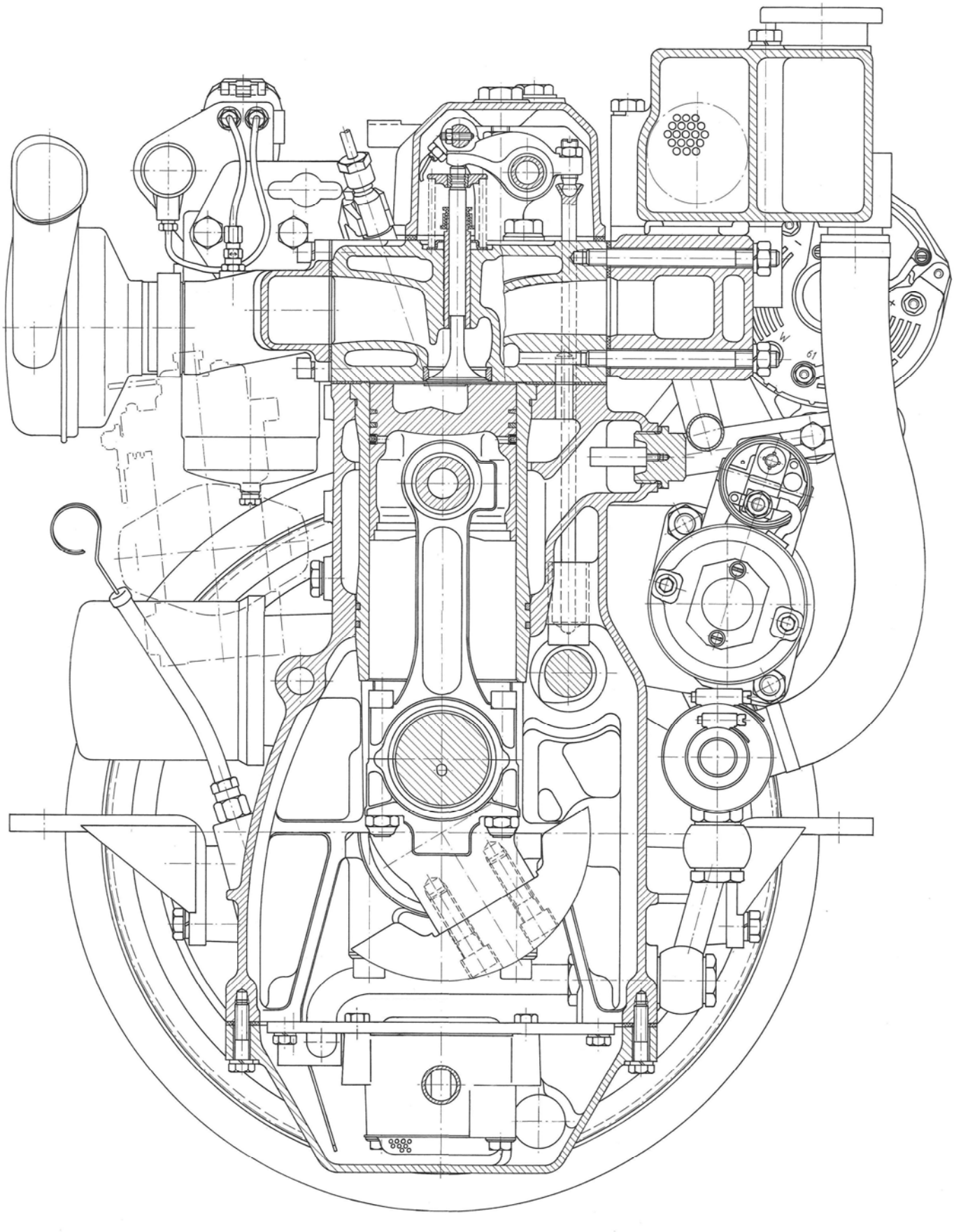
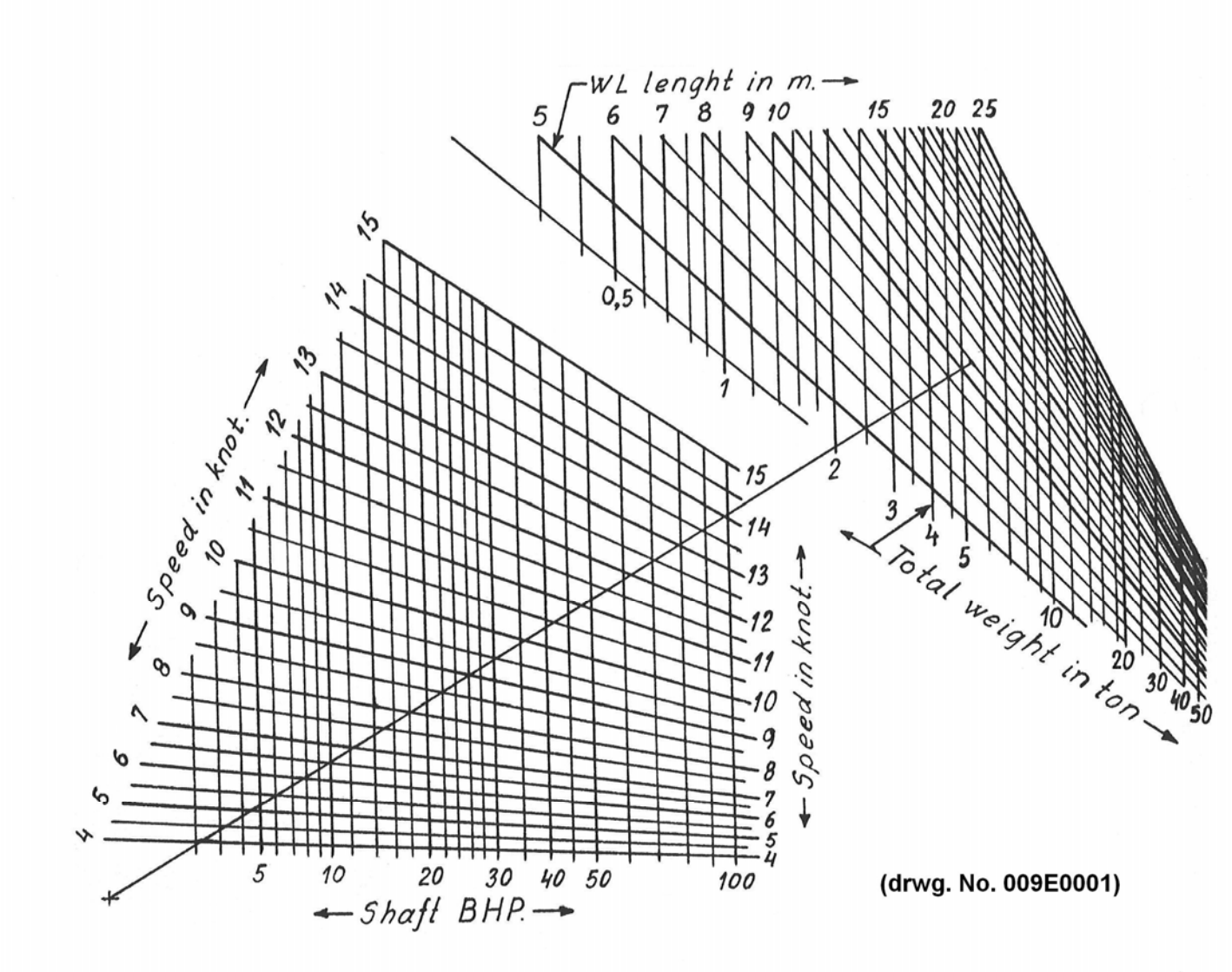


Diagram of the Relation between the Total Weight, Speed and Horse Power of the boat

The below diagram is normative and not binding in any way as many different circumstances influence the result, especially the type and shape of the boat, the propeller and its placing as well as the horse power of the engine.



Seek the scheme to the right of the intersection between the actual length in the waterline of the ship and the total weight.

Draw a straight line between this point (the intersection) and the fixed point in the bottom left corner.

Where the line of the desired speed crosses the straight line, you can read the required horse power vertically below.

If you know three of the specifications, you can by means of these schemes find the fourth one.

SECTION B

LIST OF TOOLS

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Tools for repairs on DV36

The below mentioned tools are necessary to make the engine repairs described in this manual.

Part of the tools are special tools which can be ordered from the spare parts department at BUKH.

We have indicated the fields of application for the special tools in this manual.

Designation of tools	Fields of application	Spare part No.
Slip-on ring for mounting of pistons	Section IJ	
Puller for cylinder liner	Section IJ	009P2235
Punch for rear seal ring	Section G	009P3177
Punch for front seal ring	Section E	009P3178
Punch for mounting of camshaft bearing in block	Section M and L	009P3179
Punch for journal for intermediate wheel	Section G	009P3180
Punch for journal for front and rear rotating weight	Section E and G	009P3181
Punch for mounting of valve guide	Section C	009P3175
Punch for mounting of inlet valve seat	Section C	009P3173
Punch for mounting of exhaust valve seat	Section C	009P3174
Punch for mounting of expan-sion discs in the cylinder head	Section C	009P3176

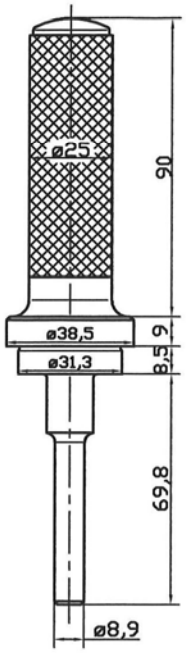
Designation of tools	Fields of application	Spare part No.
36 mm socket spanner		
19 mm socket spanner for fastening of cylinder head	Section C	
19 mm crowfoot wrench for tightening up of cyl. head	Section C	009P3225
10 mm Allen top for faste-ning of bearing top section	Section L	
5 mm Allen key	-	
6 mm Allen key	-	
7 mm Allen key	-	
Open-end spanner/ring spanner, 8/10/12/13/14/15/17/19/22/24/27 30 and 32 mm	-	
Dismantling tool for valve springs	Section C	009P3115
Tachometer	Generally	009P3106
Testing set for fuel nozzles	Section H	009P3100
Cleaning for fuel nozzles	Section H	009P3101
Bosch dial indicator for adjustment of fuel pump	Section H	
Bosch dial indicator “holder with extension” for adjustment of the fuel pump (KDEP1085)	Section H	529W0002

Designation of tools	Fields of application	Spare part No.
Flanging tools for nozzle holder insert	Section C	009P2565
Torque wrench (Stahlwille 73/6 1.5-6.5)	Generally	009P3108
Torque wrench (Stahlwille 73/25 8-26)	Generally Section C, D, IJ and L	009P3109
Circlip tongs (external) A1, 10-28 mm	-	
Circlip tongs (internal) J2, 19-75 mm	-	
Puller for gear wheel (Kukko 20/10)	Generally	
Puller for flexible coupling	Section R	T 41069
Compression gauge	Section C	529W0000
Adapter for compression gauge	Section C	009P3123

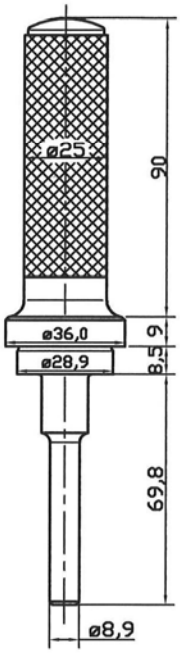
Part of the mentioned special tools can be manufactured without too much trouble at the dealer´s workshopin periods outside the boat season. Therefore we have made sketches at page B6 of each individual mounting punch with dimensions.

Slip-on ring for mounting of pistons is not illustrated but is manufactured of a worn out cylinder liner or another piece of work pipe. Cut the cylinder liner so that you get a piece being about 100 mm high, the turn it conical inside the liner or pipe.

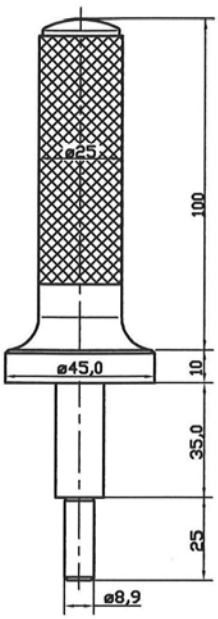
Inlet valve seat
000P3173



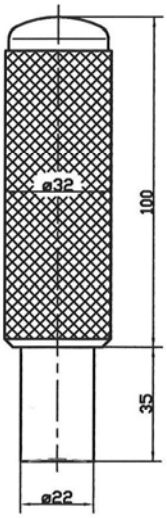
Exhaust valve seat
000P3174



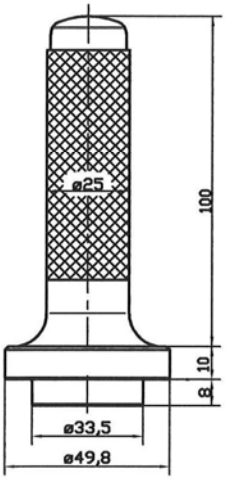
Valve guide
000P3175



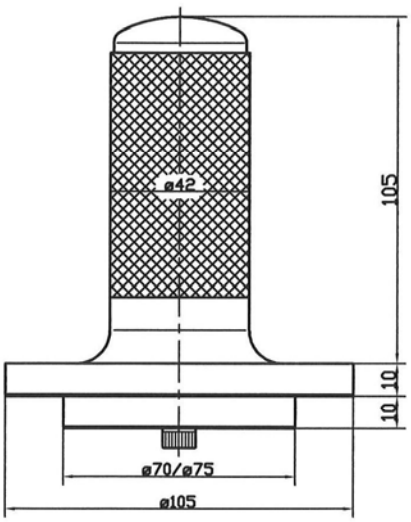
Expansion disc
000P3176



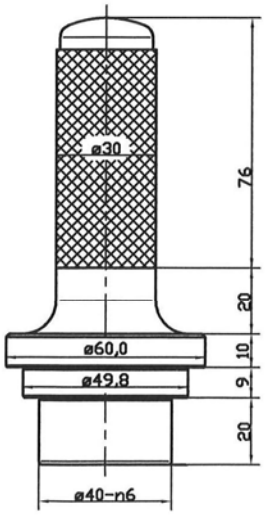
Seal ring, rear end cover
000P3177



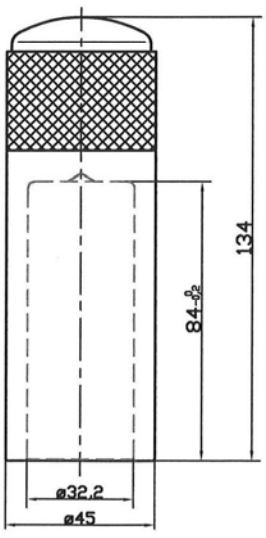
Seal ring, front end cover
000P3178



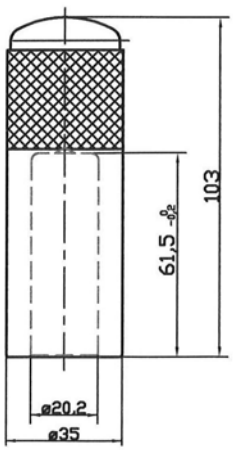
Camshaft bearing
000P3179



Journal for intermediate wheel
000P3180



Journal for rotating weight
000P3181



SECTION C

CYLINDER HEAD

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Replacement of rocker arm or rocker shaft ..... page C 6

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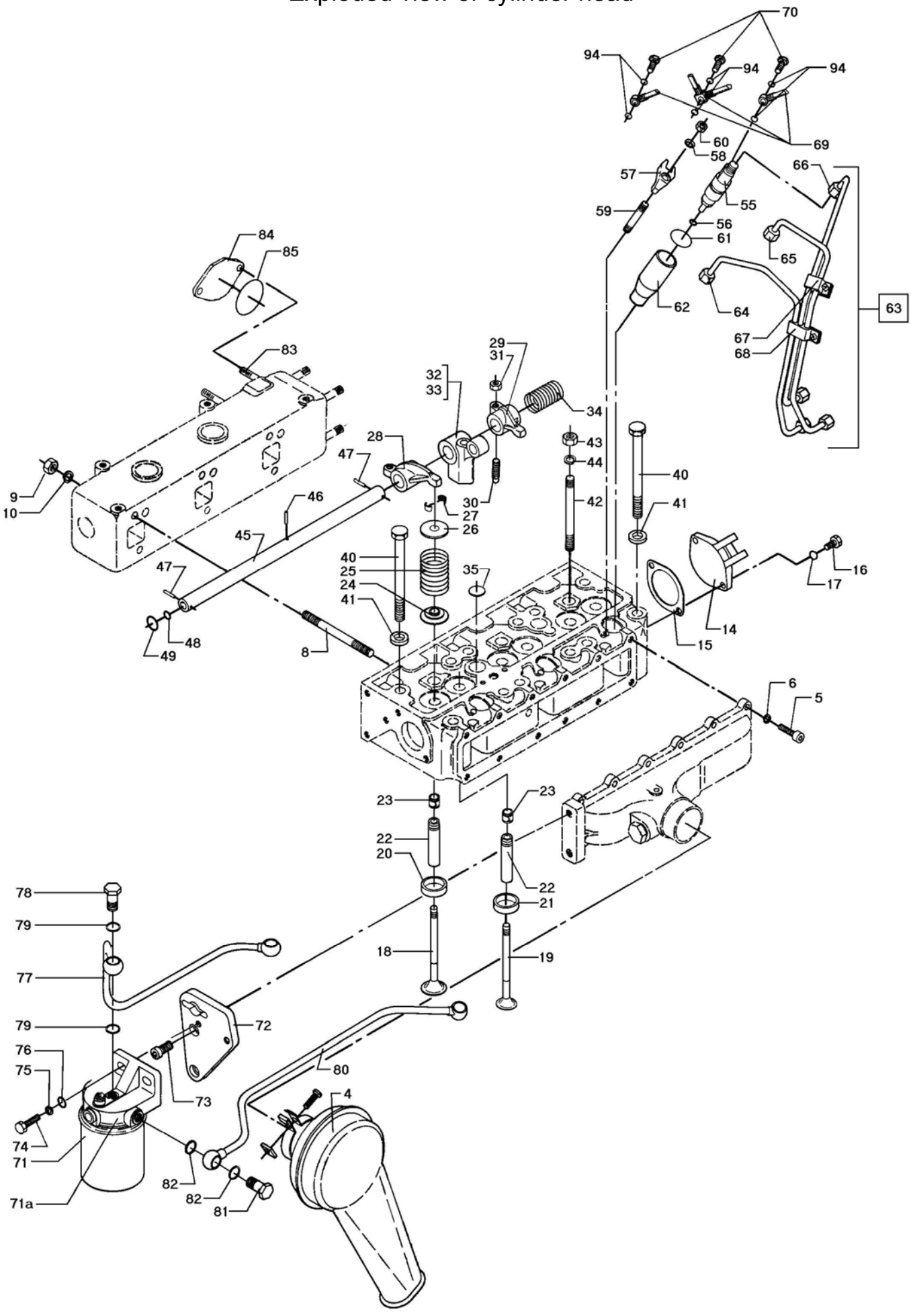
Exploded view of cylinder head



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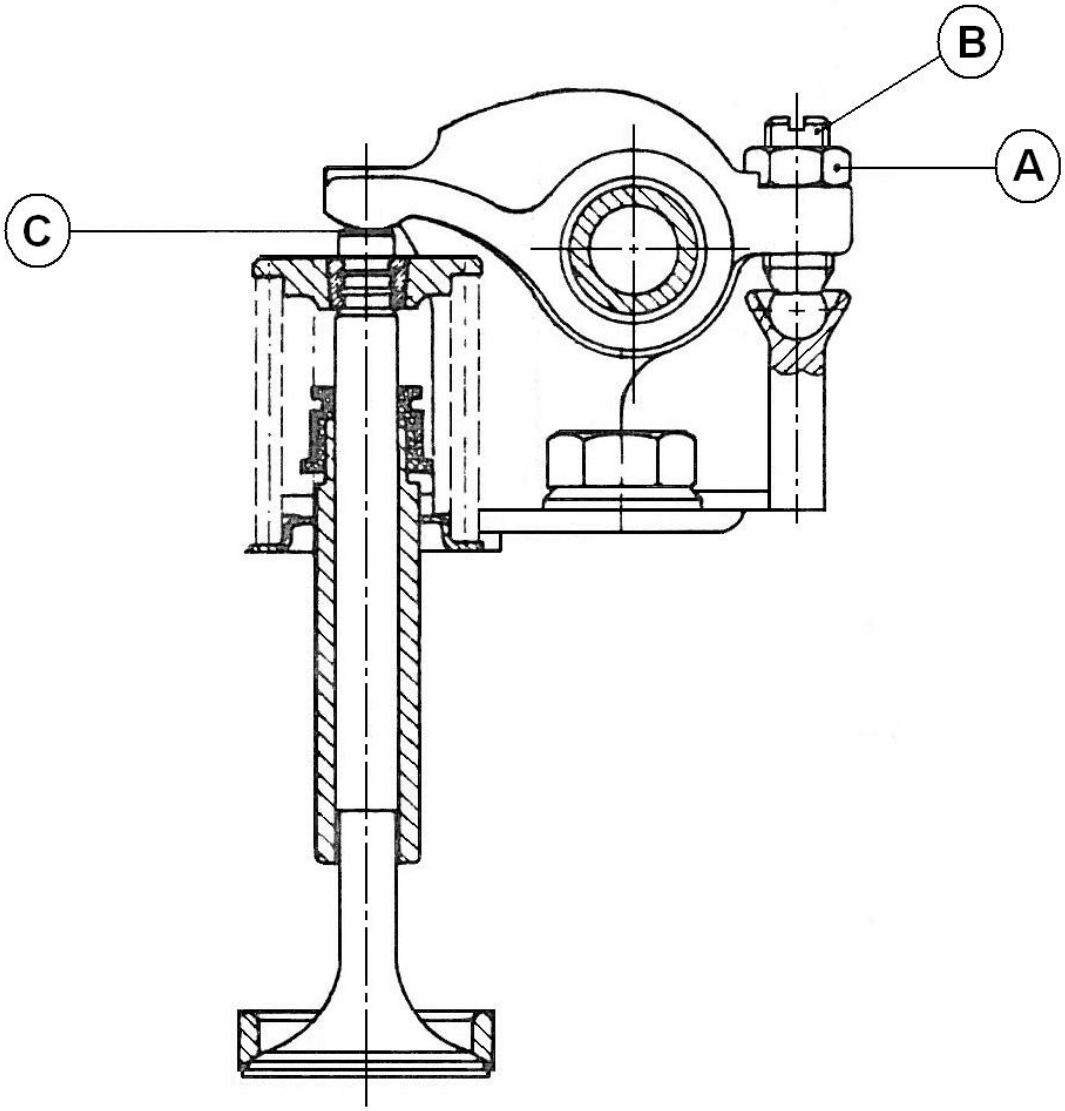
Valve adjustment

The clearance of the inlet and exhaust valves should be adjusted at **0.3 mm** when the engine is **cold** and the clearance of the valves should always be checked after tightening-up of the cylinder head. The valves are adjusted when the pistons are alternately at their highest point in the working stroke.

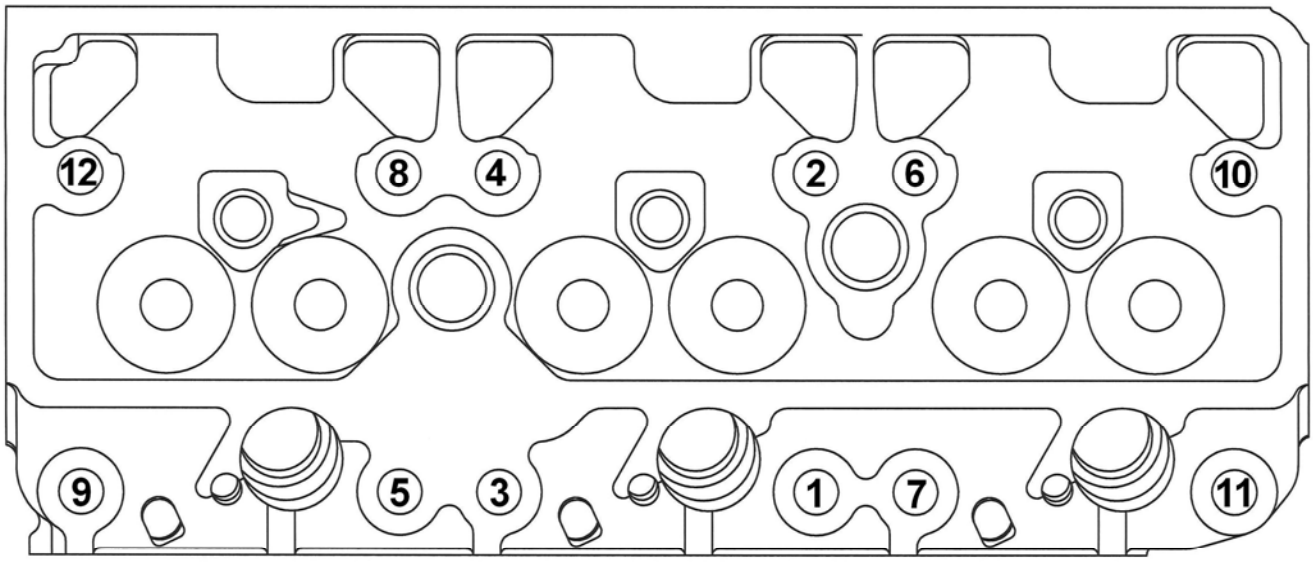
Adjust the valves by loosening the counter nut **A** which makes it possible to adjust the clearance by means of the adjusting screw **B**.

Measure the clearance with a feeler gauge at **C**.



Removal and refitment of cylinder head

1. Drain off the cooling water.
2. Remove the top cover.
3. Remove valve rocker arms.
4. Remove the inlet and return pipes of the fuel valves.
5. Remove the charging alternator.
6. Remove the exhaust and inlet manifold.
7. Loosen the top bolts, after which the cylinder head can be lifted out of the engine block.
8. Refitment of the cylinder head is made in reverse order and the bolts are tightened evenly at a torque of **118±5 Nm (12±0.5 kpm)**. Tighten in the order shown on the skeleton diagram below.



Replacement of rocker arm or rocker shaft

For each cylinder, a rocker arm column wit h two rocker arms for inlet valve and exhaust valve, respectively, is fitted on a common shaft with corresponding rocker arm columns and rocker arms for the two other cylinders.

1. Remove the top cover.

2. Unscrew the three central nuts on the rocker arm columns.

3. Lift off the shaft arrangement.

4. Knock out the tube pin and washer in one of the shaft ends.

5. Then the rocker arms and the intermediate springs can be taken out.

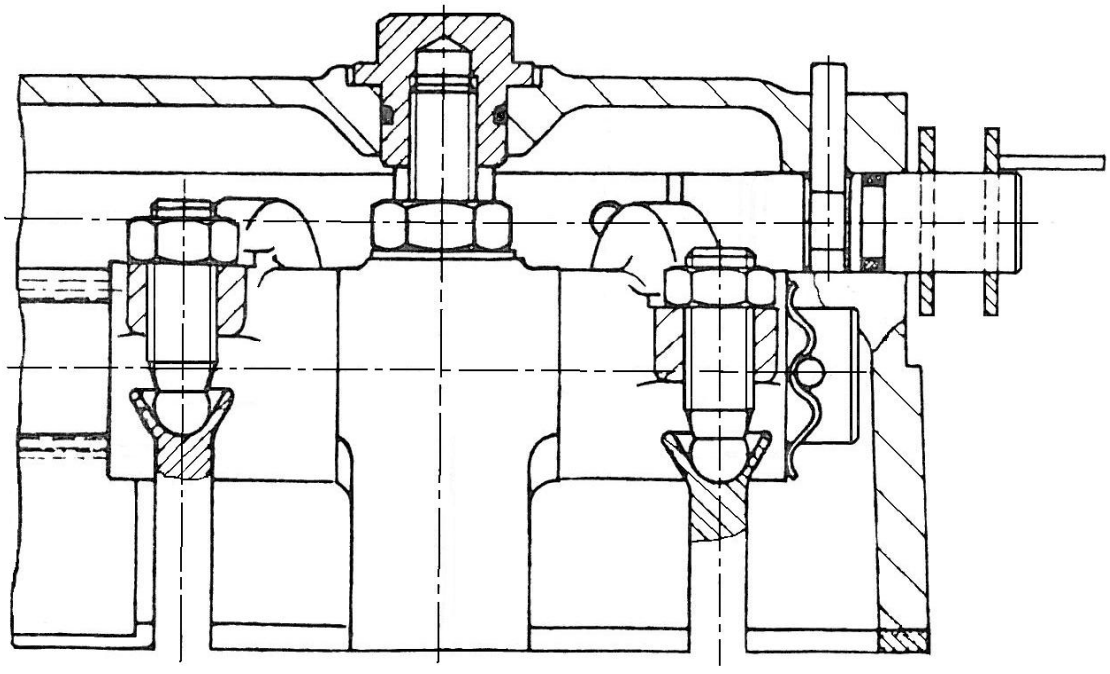
Reassembly is a reversal of the dismantling procedure.

Adjustment of valve lifter arrangement

Furthermore, a common shaft for decompression is fitted on the three rocker arm columns.
For a possible removal of the shaft, remove first the pins going down on the rocker arms at decompression, after which the shaft can be pulled out.

When adjusting, adjust the pins so that you faintly see a single groove of the pin thread (about 1.5 mm free pin) just on the side facing the rocker arms.

When fitting the top cover, ensure that the slot in the decompression handle in the top cover mesh with the corresponding pin on the decompression shaft.



Replacement of rocker arm bushing

1. Remove the rocker arm as indicated on page C5 and check it as to wear and tear as well as fracture.

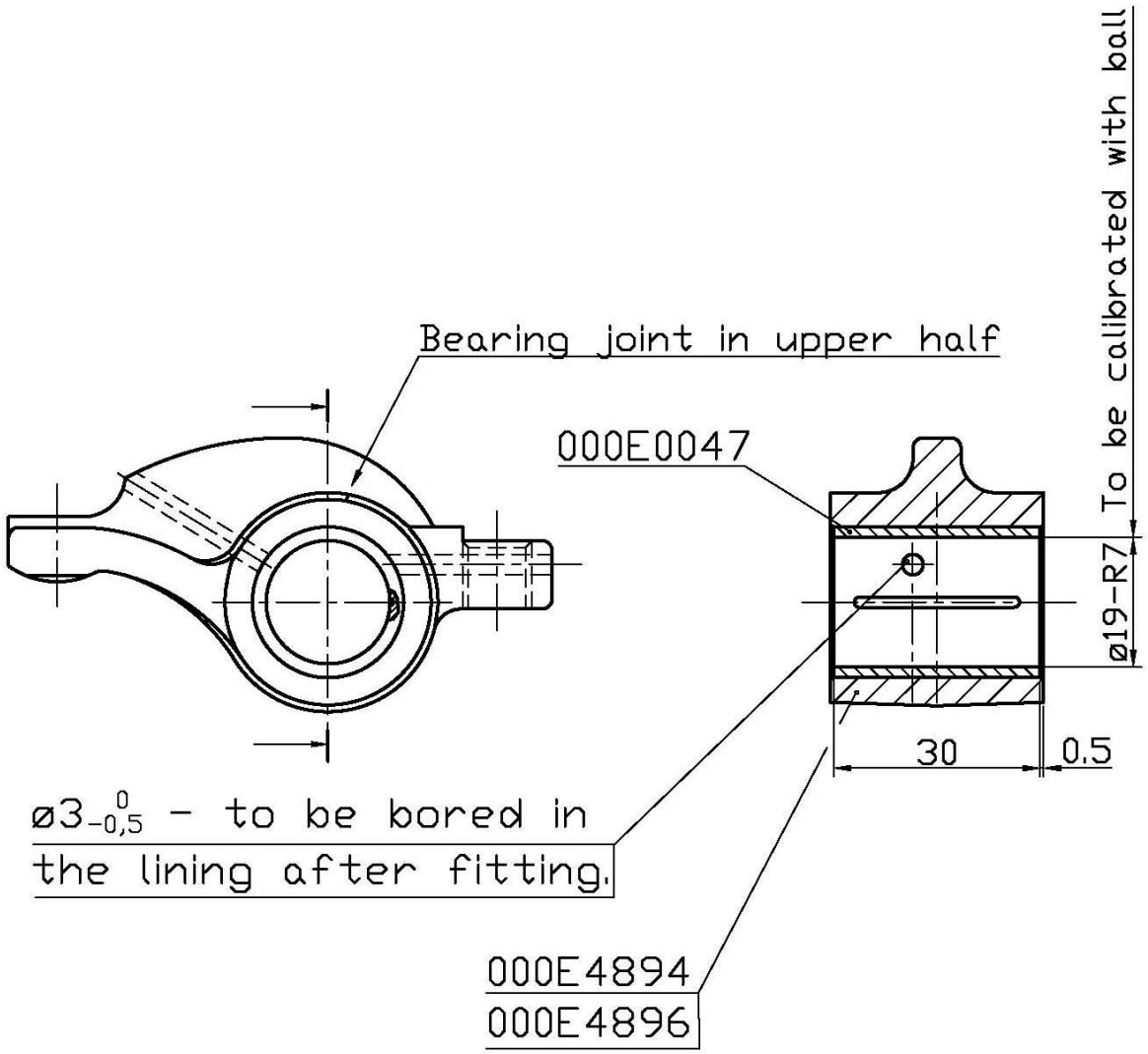
2. Press out the defective bushing with an adequate tool.

3. Fit the new bushing as shown below paying special attention to the position of the bearing joint and the oil grooves.

4. When fitted, calibrate the bearing bush so that the tolerance ø19-R7 is observed. Do this either with a calibration ball or with a reamer having the mentioned tolerance.

5. After refitting the rocker arm, check the axial play with a feeler gauge. The axial play may be 0.1 – 0.2 mm.

6. Finish refitting the rocker arm arrangement.



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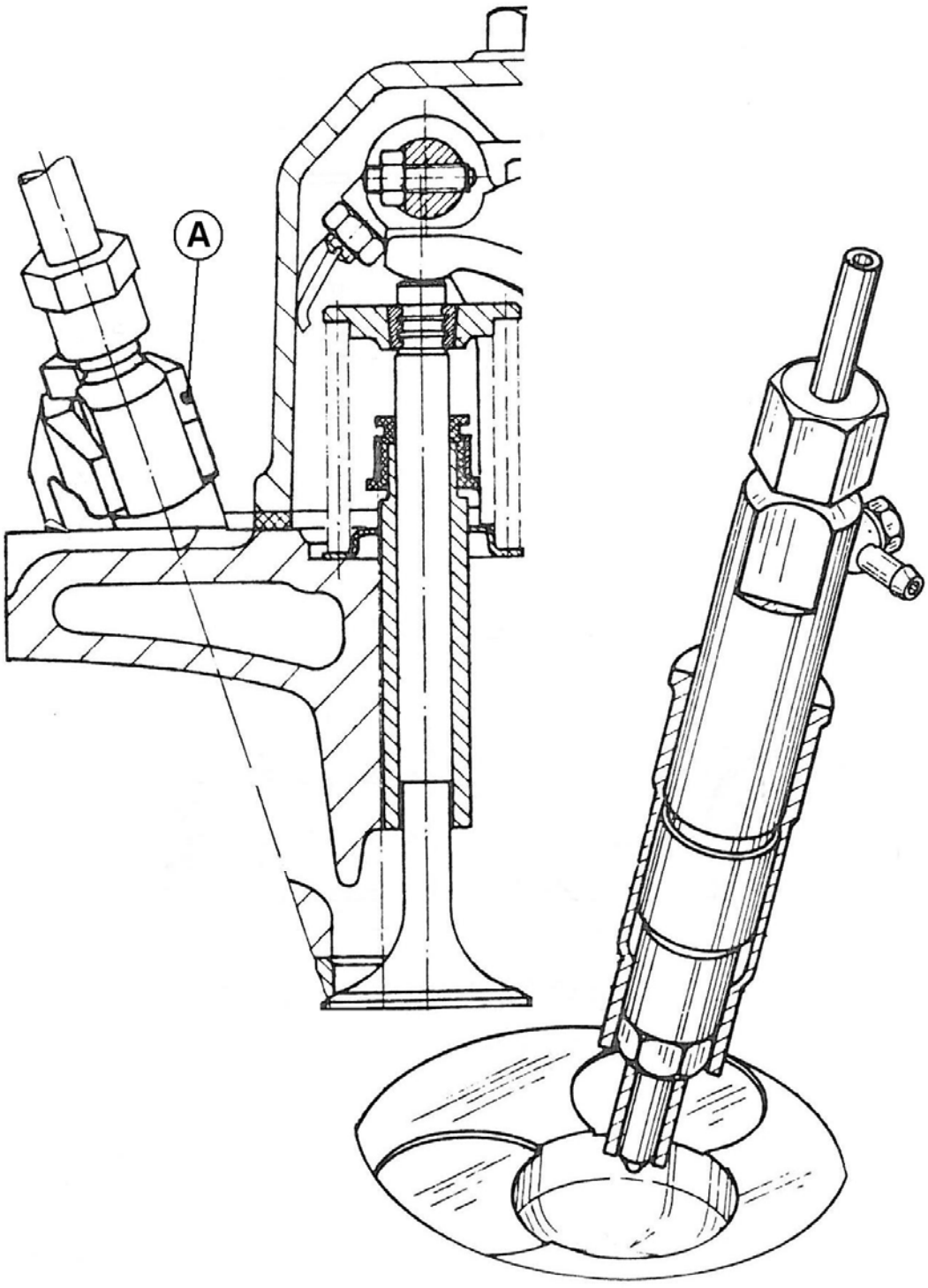
Removal of fuel valves

The fuel valves are removed by loosening the clamping nuts for the flanges **A** as indicated on the sketch below after removal of the inlet and return pipes of the fuel valves.

The drawing at the bottom right-hand side indicates the placing of the fuel valve in proportion to the piston.

For repair of the fuel valves, we refer to section H.



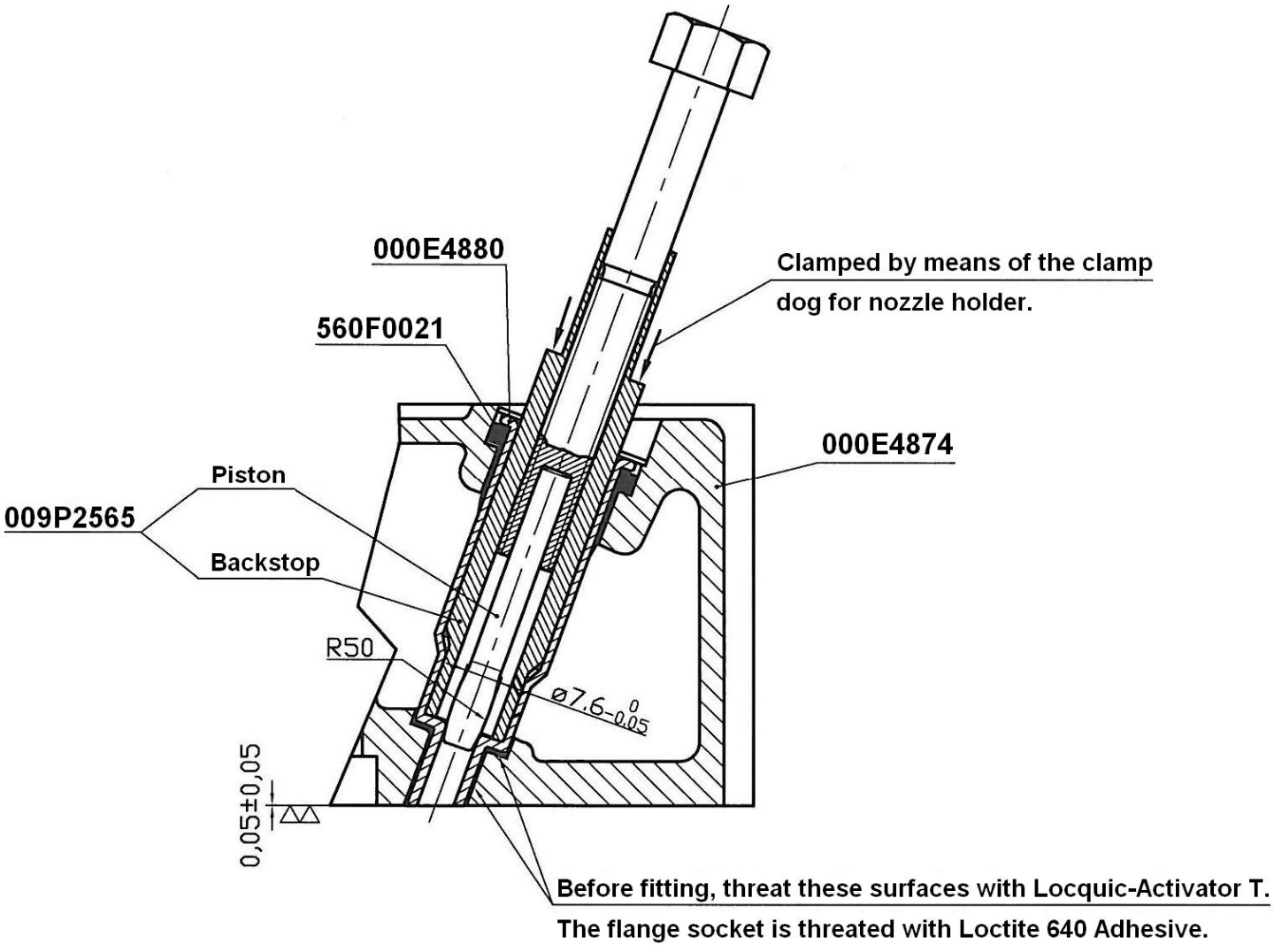
Nozzle holder insert

The nozzle holder inserts are placed in the cylinder head and form – a the name indicates – an insert for the placing of the fuel valves in the cylinder head.

The nozzle holder inserts can be replaced, which demands that the special tools below for flanging (piston and backstop) are used and that the surfaces are treated as indicated on the drawing.

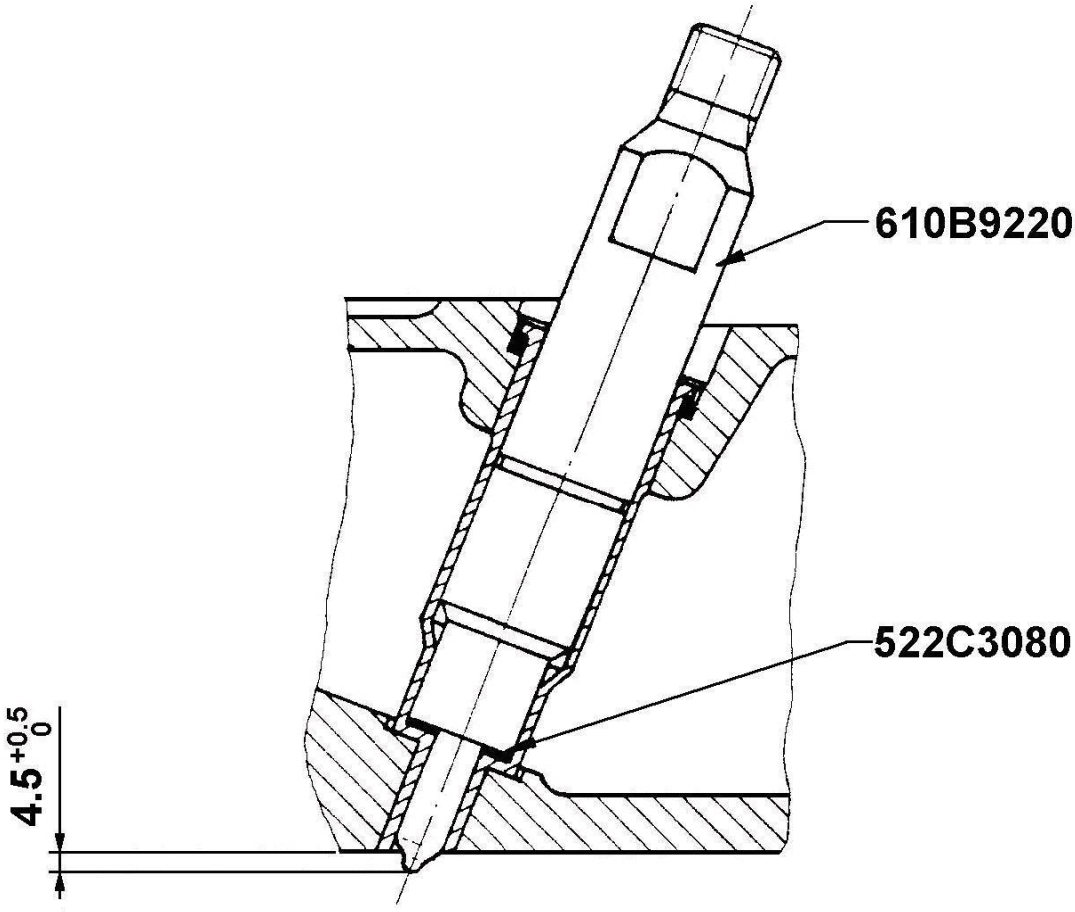
Remove the old nozzle holder inserts by boring-up the flanged end of the nozzle holder inserts with a ø8 – ø9 mm drill, and then knock out the nozzle holder inserts with a 10 mm punch.

After having fitted the new nozzle holder inserts, test the cylinder head for pressure with water in order to check the flanged seals.



drwg. No. 008E4881

Fitting measurements for the fuel nozzle into insert.



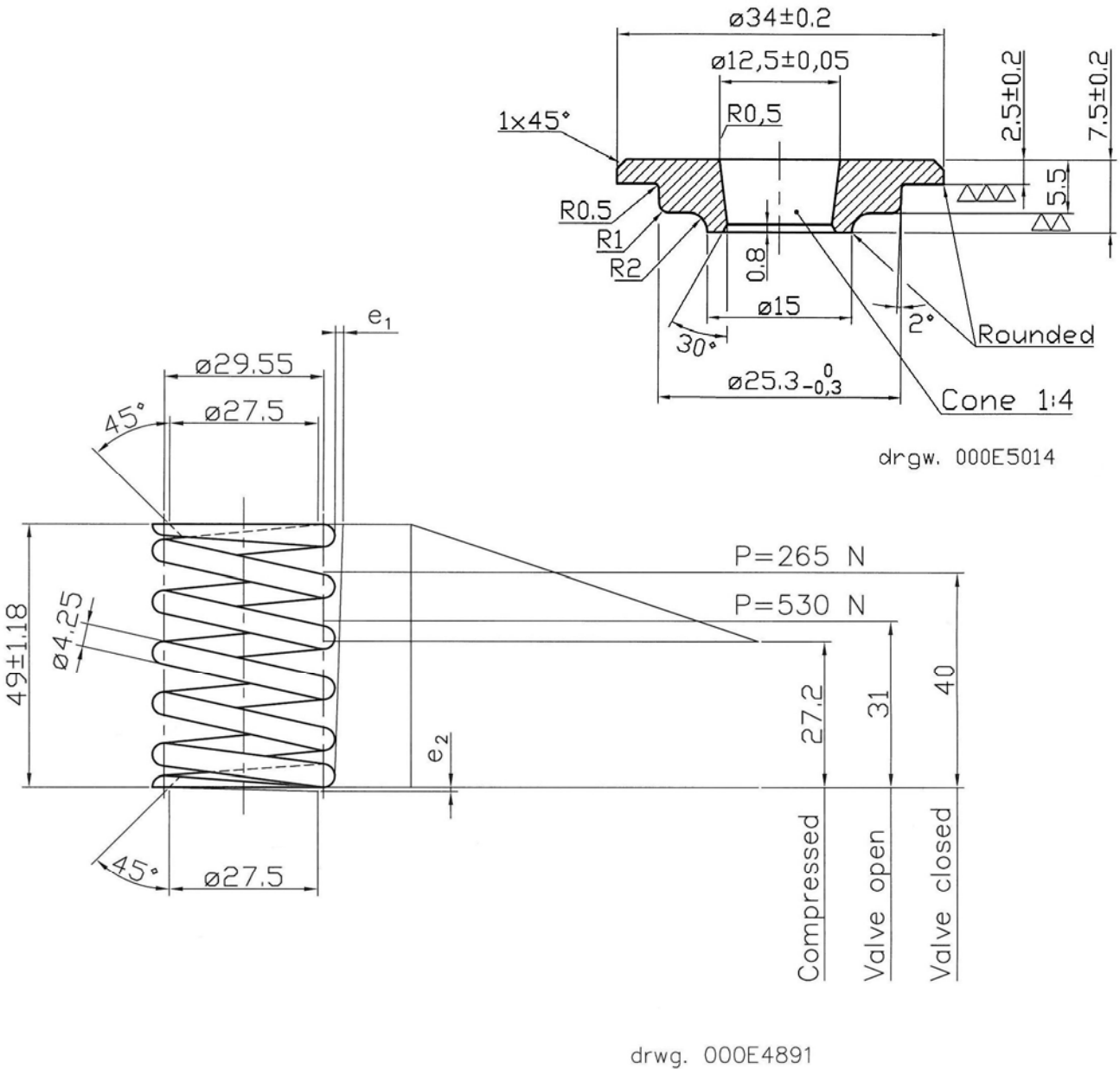
Valve springs

Six identical springs for inlet and exhaust valves, respectively, are fitted in the cylinder head. The springs are identical in both ends, and therefore fitting up or down is of no importance.

The springs are locked in their position in proportion to the valve stems by means of two conical halves for each valve spring and guided by a guide for valve spring and a corresponding disc, respectively.

The valve springs are removed by compressing the valve springs and removing the conical locking halves with special tools or the like so the valves are cut off from following the movement of the springs.

When refitting the valve springs, make sure that the conical locking halves are correctly placed in their trace on the valve stems. This can be done by knocking gently with a plastic hammer on top of the valve stem while the cylinder head is lifted from the file bench so that the valve heads can move so as to be clear of the valve seats.

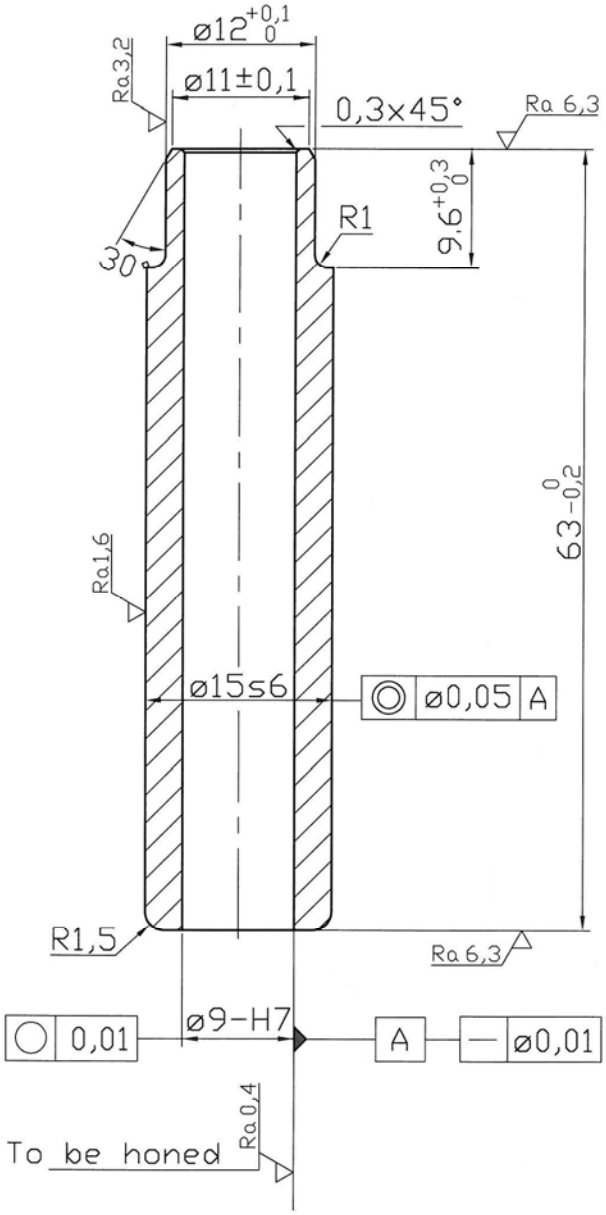


Replacement of valve guides

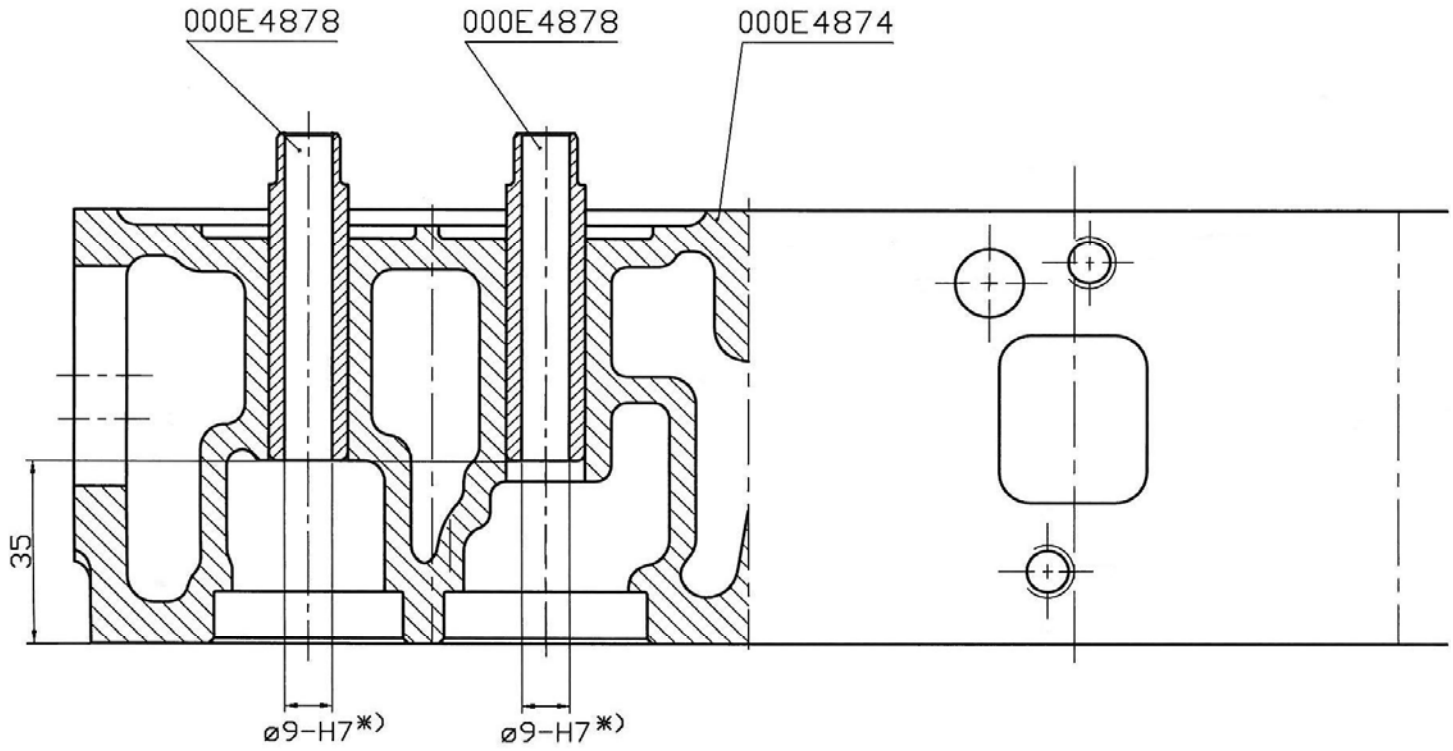
Replace the valve guides whic h are pressed into the cylinder head if the tolerance is exceeded because of wear and tear by 0.05 mm. Check the measure with a ø9 – H7 internal gauge according to the drawing below of the valve guide.

Fit new valve guides according to the drawing on page C13. Before fitment, heat the cylinder head in an oven or heat it in boiling water and cool down t he valve guides in a deep freezer or otherwise.

After fitment of new valve guides, broach the bore of the valve guides with a broach in order to remove possible ups ettings from the fitti ng. Use a broach ø 9 – H7 for the broaching.



Pressing-in dimensions for valve guide.



*) The valve guides tolerance after fitting

drgw.no. 008E4879

Valve guide stuffing box

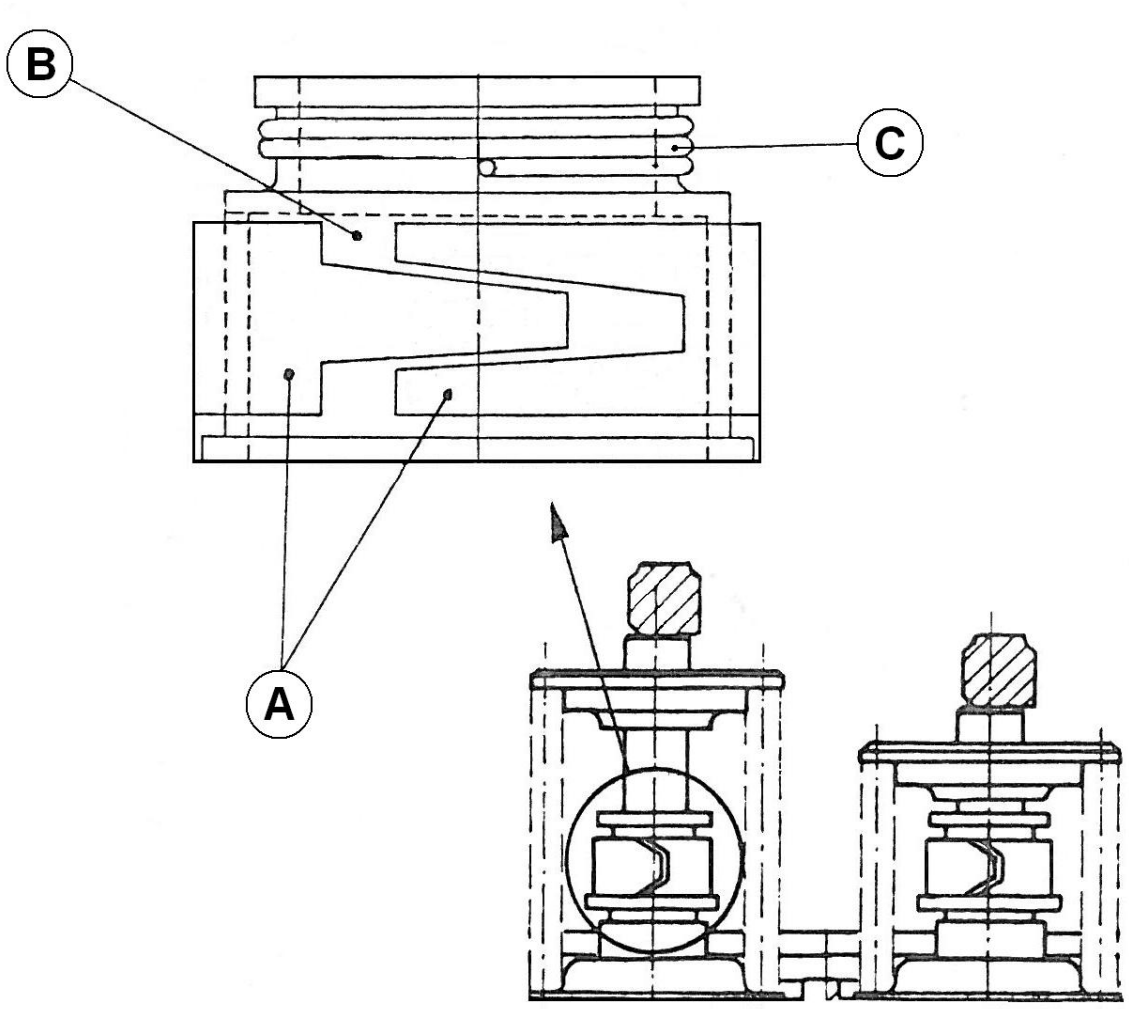
In order to avoid lubricating oil consumption because of lubricating oil passing between valve guide and valve stem causing the valves to be burnt or to be carbonized, a stuffing box has been mounted on the upper end of the valve guides.

The stuffing box is as shown schematically on the drawing below and consists of:

A: Metal spring coat
B: Plastic bushing
C: Spring wire

The stuffing box compensates for wear and tear of the valve guides so that the lubricating oil consumption because of leaky valve guides is reduced to a minimum.

The stuffing box cannot be repaired but has to be replaced if necessary.



Repair or replacement of inlet and exhaust valves

1. Remove the cylinder head from the engine (page C5).

2. Then place the cylinder head on a file bench or the like with the valve seats at the bottom.

3. Compress the valve springs with a special tool or the like and remove the conical valve locking halves.

4. Then place the cylinder head upright and remove the valves from the cylinder head.

Refitment is a reversal of removal procedure.
Note! Refit the valves in the same valve guides again.

Replace the valves if they are so damaged that a refacing with special tools and subsequent grinding are impossible without exceeding the tolerances indicated on page C18 and C19.

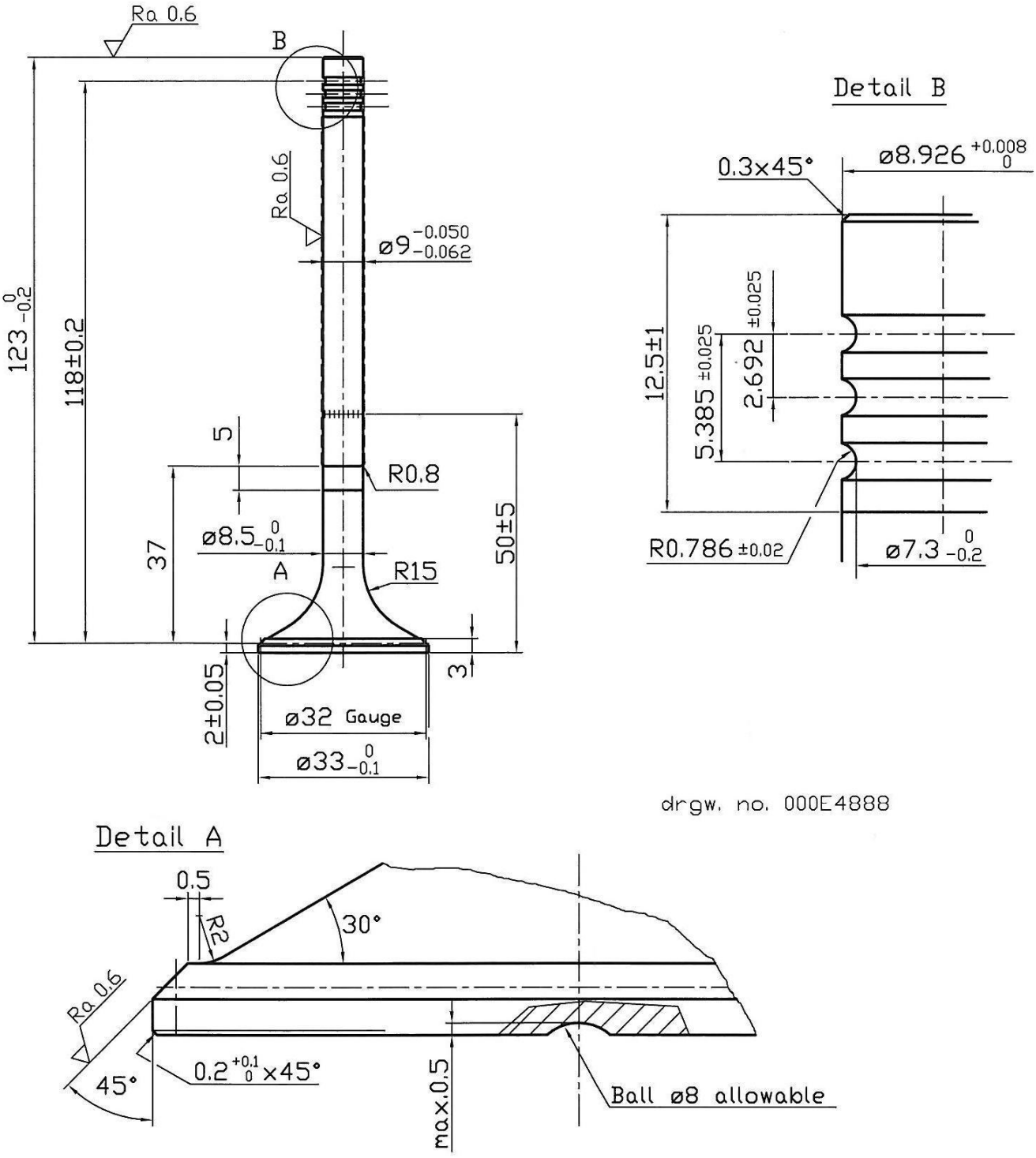
A refacing of the valve seats with fixed guide should always be made if the valve does not function satisfactorily.

After replacement of valve or valve seat, grind together with abrasive compound seat and valve so that total tightness is obtained. It is an indispensable condition for the compression of the engine that this work is performed carefully.

Grinding of valves is made as described on page C18.

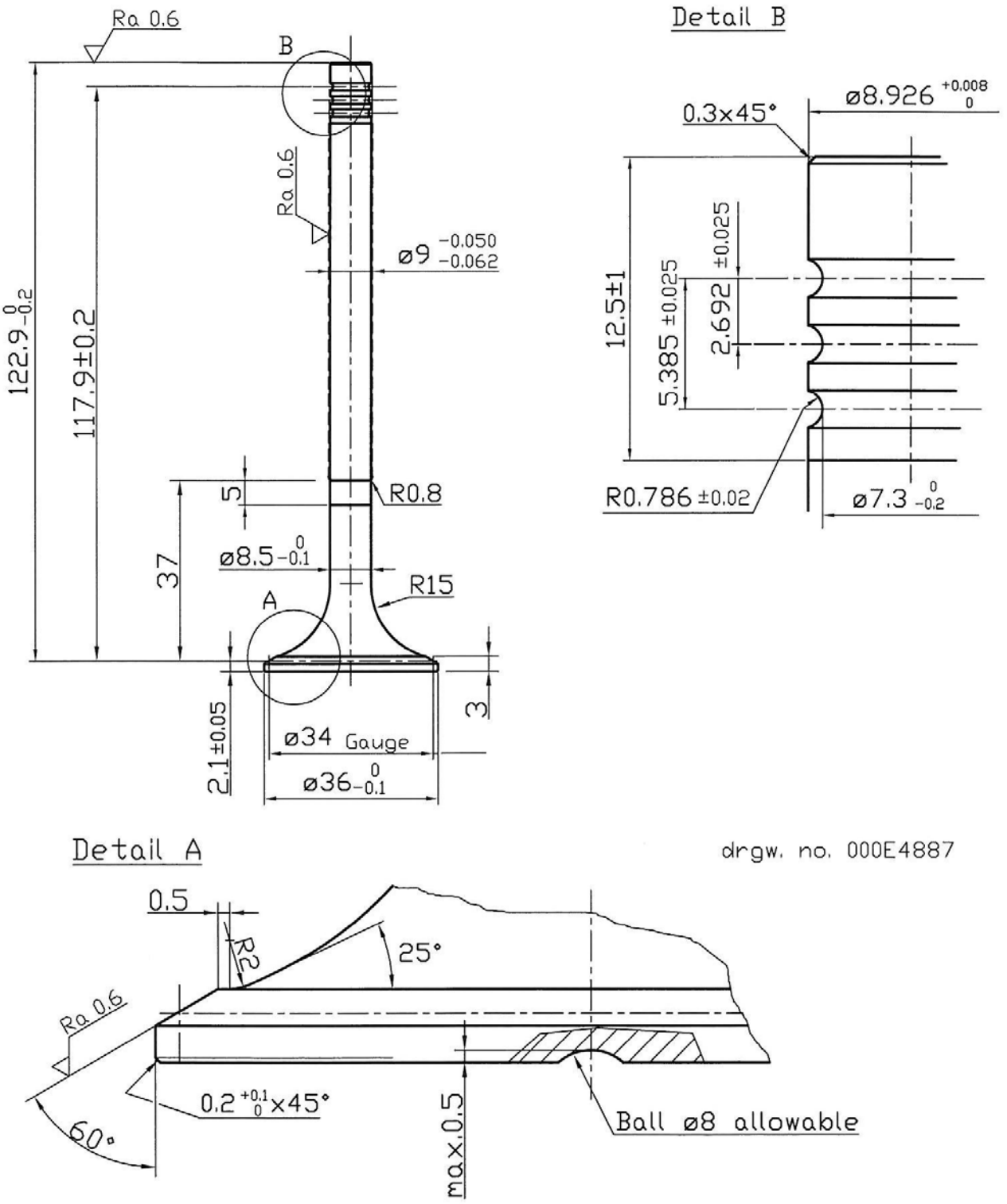
Exhaust valve

Tolerances and repair measures.



Inlet valve

Tolerances and repair measures.



Grinding of valves

1. Place the cylinder head with the valve seats upwards. Block the cylinder head so that the valves fit tightly against the seats and can be turned freely by means of a rubber suction disc or the like.

2. Apply abrasive compound to valve and seat, after which grinding can take place.

3. When grinding, turn the valve by means of the rubber suction disc in various directions while fitting it at the same time with an equal pressure against the seat. When grinding, lift frequently the valve and spread all over the seat the abrasive compound applied.

4. You can check whether the valve is tight by cleaning off the abrasive compound carefully by for example cleaning liquid. Then make 4 pencil marks staggered 90 degrees from each other on the contact face of the valve. Insert the valve and turn it about 20 degrees. If the valve is tight, the marks will have disappeared.

5. Before refitment in the cylinder head, clean the valve carefully for abrasive compound and apply a thin coat of oil to it. Do the same with regard to the valve seat.

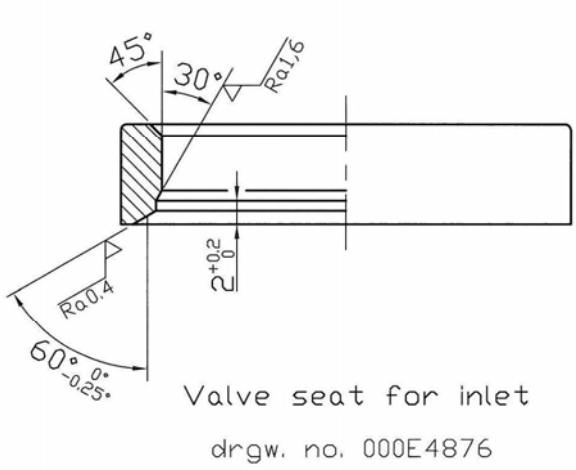
Measures for new valves

Valve stem diameter ..... ø9 $^{-0.050 / -0.062}$

Valve guide bore ..... ø9 – H7

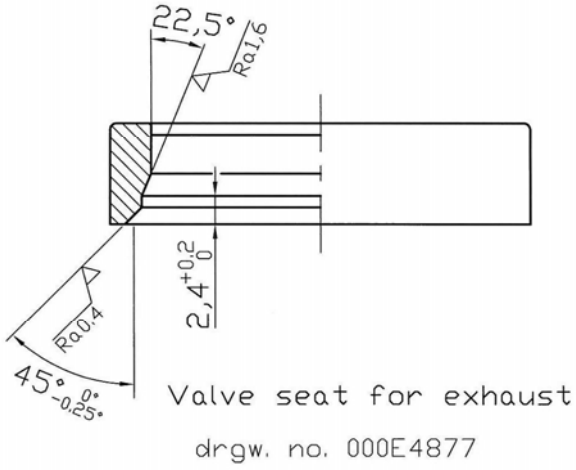
Clearance between valve stem and valve guide ..... 0.050 – 0.077 mm

The valve stems have been specially treated and therefore they must not be ground.



Valve seat for inlet

drgw. no. 000E4876



Valve seat for exhaust

drgw. no. 000E4877

Replacement of valve seats

The valve seat rings should be replaced when, after repeated millings and grindings, they have been milled so far down that the valve heads are more than 0.3 mm below the face of joint of the cylinder head (see the sketch below).

1. Remove the valve springs and valves as indicated previously in this section.

2. Place a lead plate or an annealed copper plate between the cylinder head and a bent chisel and knock out the valve seat ring with this (crowbar principle) by sticking one end of the chisel under the rear edge of the valve seat ring.

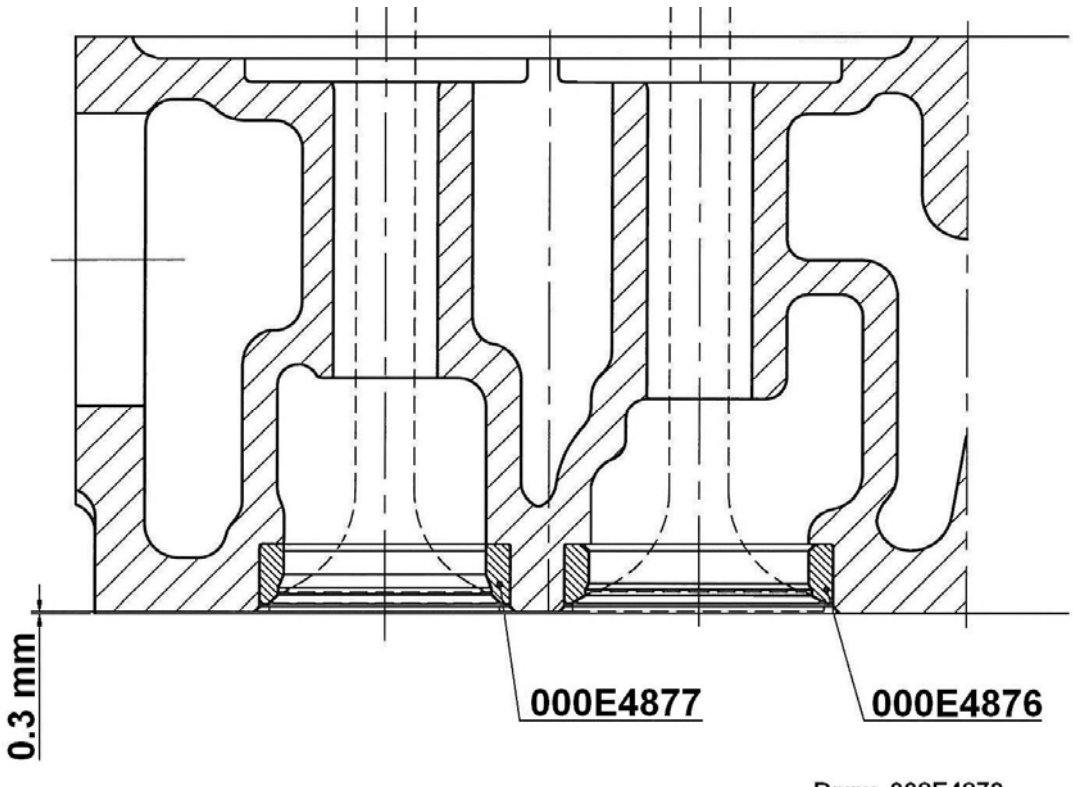
IT IS IMPORTANT THAT THE FILLING PIECE IS USED BETWEEN CYLINDER HEAD AND CHISEL IN ORDER TO AVOID DAMAGING THE CYLINDER HEAD.

Before fitting new valve seat rings, clean the bores in the cylinder head for same and check that the holes are not oval.

Then warm up the cylinder head in hot water to about 100° C (212° F), after which fit, by means of a punch, the valve seat rings having been cooled down beforehand in nitrogen or carbon dioxide.

When fitting the valve seat rings, the difference of temperature between cylinder head and valve seat ring is to be 220 – 250° C (430 – 480° F).

DO NOT KNOCK IN THE VALVE SEAT RING VIOLENTLY. ONLY ACTIVATE THE PUNCH WITH A RATHER GENTLE BLOW IN ORDER TO FIT THE VALVE SEAT RING.



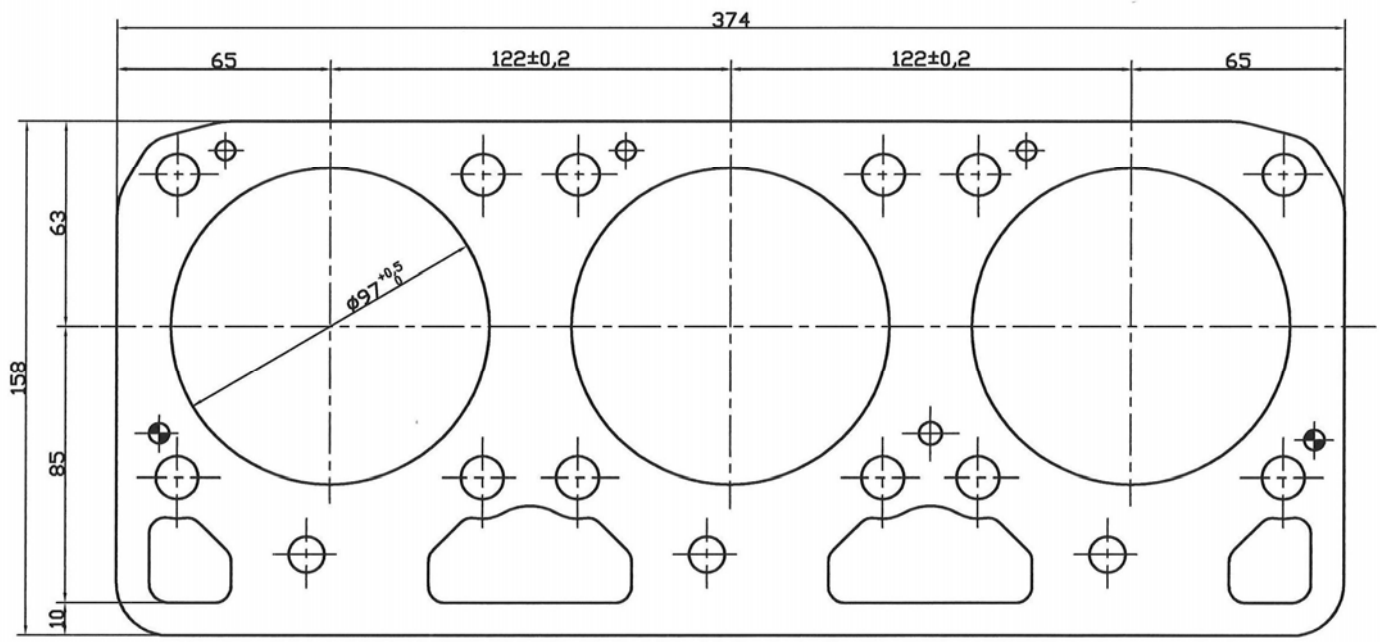
Drgw. 008E4873

Cylinder head gasket

The cylinder head gasket is made from “Grafos eal” (Asbestos free) which is an expanded graphite which is strengthened with a special 0.2 mm carbon steel inlay.

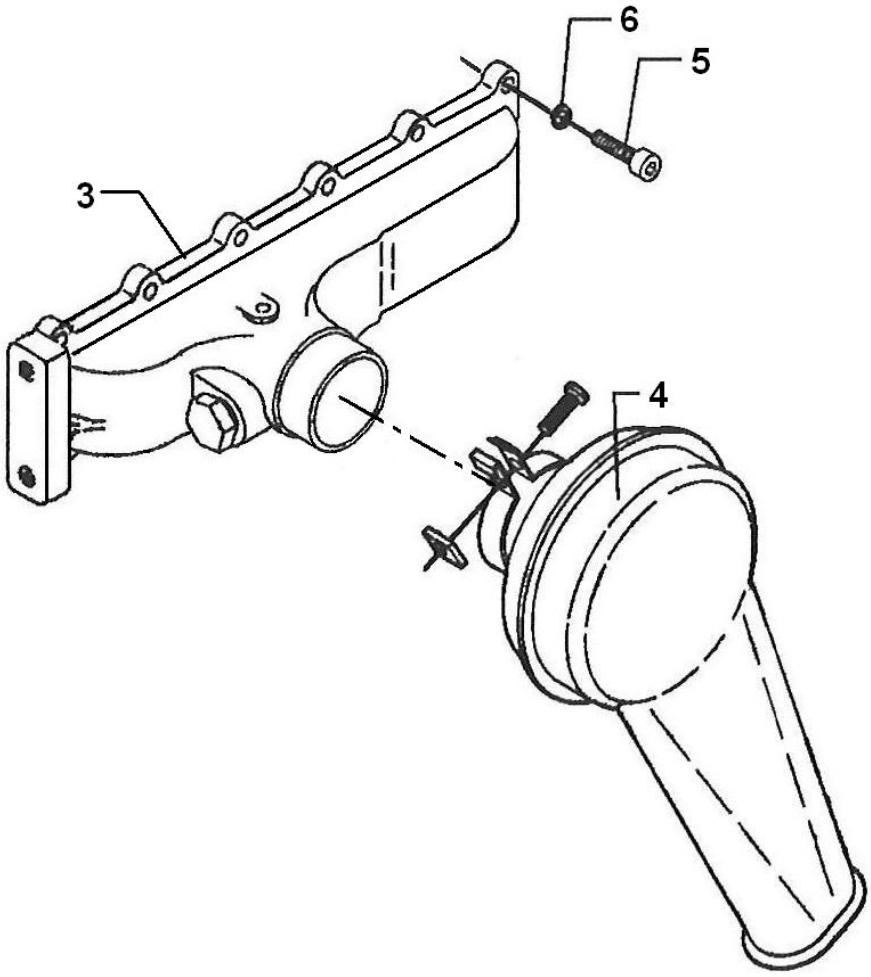
When replacing the cylinder head gasket, the grooves in the cylinder head must be completely clean to obtain tightness.

If the cylinder head has been removed several time s, the metal around the studs may have risen which can be checked by m eans of a straight-edge. If the me tal has risen, it must be planned.



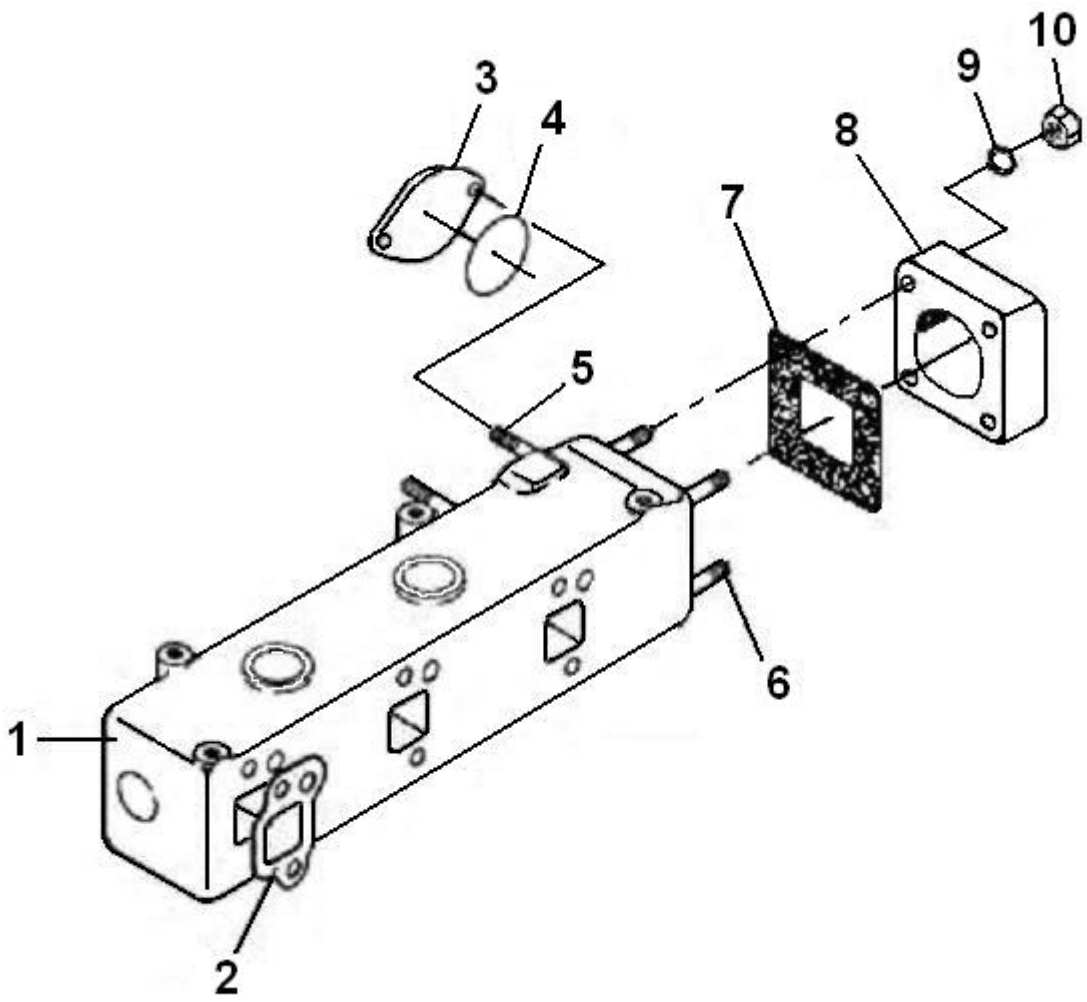
Drwg. 000E4789

Air inlet manifold arrangement.



Pos.	Part No.	Qty.	Beskrivelse	Description	Benennung
3	000E4923	1	Indsugningsmanifold	Inlet manifold	Einlasssammelrohr
4	008E7310	1	Luftfilter	Air filter	Luftfilter
5	501A2363	12	Cylinderskrue	Unbraco screw	Unbracoschraube
6	522E0521	12	Låseskive	Locking washer	Arretierungsscheibe

Exhaust manifold arrangement.



Pos.	Part No.	Qty.	Beskrivelse	Description	Benennung
1	000E7434	1	Vandkølet udstødningsmanifold	Water-cooled exhaust manifold	Wassergekühltes Auspuffsammelrohr
2	000E5028	3	Pakning for udstødningsmanifold	Gasket for exhaust manifold	Dichtung für Auspuffsammelrohr
3	008E9239	1	Flange	Flange	Flansch
4	560F1031	1	O-ring	O-ring	Abdichtung
5	500C2363	2	Sætskrue M8x20	Set screw M8x20	Setzschraube M8x20
6	503N2367	2	Tapskrue M8x35	Stud M8x35	Stiftschraube M8x35
7	000E5360	1	Udstødningspakning	Exhaust gasket	Auspuffdichtung
8	000E7788	1	Udstødningsflange	Exhaust flange	Auspuffflansch
9	522F1020	4	Fjederskive	Spring washer	Federscheibe
10	510A3208	4	Møtrik M8	Nut M8	Mutter M8

SECTION D

FLYWHEEL

CONTENTS

Removal and refitment of flywheel ..... page D 3

V-belt pulley fitted on flywheel ..... page D 3

Replacement of gear rim ..... page D 4

Removal and refitment of flywheel

1. Mark the flywheel in proportion to the crankshaft out of consideration for the other marking of the outer diameter of the flywheel.
2. Slacken the V-belt for the charging alternator and take it clear of the V-belt pulley of the flywheel.
3. Remove the six bolts securing the flywheel to the crankshaft.
4. Lift off the flywheel.

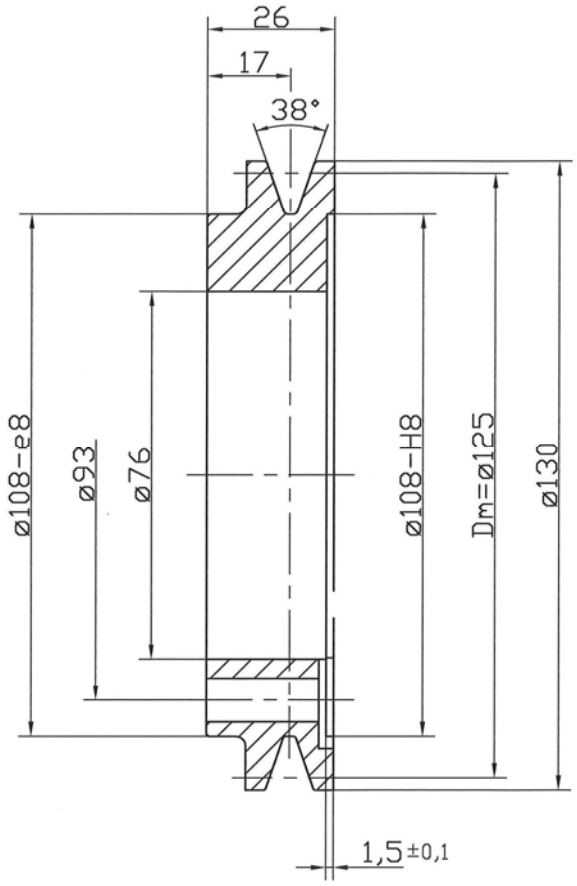
Refitment is to be carried out in reverse order. Smear the bolts with some Loctite or something similar and tighten them with a torque of 147±7 Nm (15.0±0.7 kpm).

When dismounting the flywheel please note to fit the flywheel in the same position as before. This only due to the timing marks on the flywheel and not due to the balance of the flywheel.

V-belt pulley fitted on flywheel.

A V-belt pulley, as indicated on the drawing below, is fitted on the front end of the flywheel. This V-belt pulley can be replaced by three "A" grooves and diameter 125 mm for operation of e.g. bilge pump, winch or the like. However, only max. 10 HP must be loaded from the front of the engine.

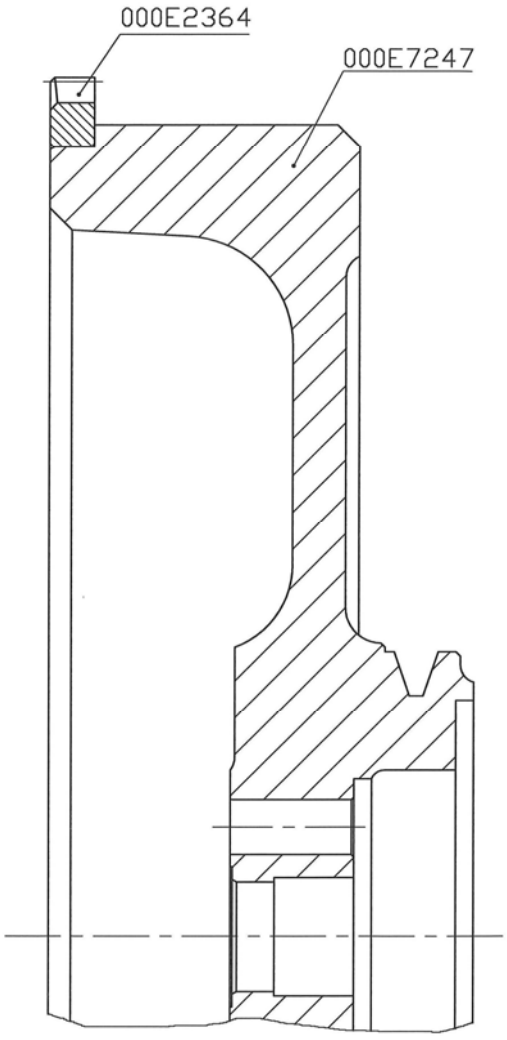
The V-belt pulley may be ordered against number 023D2801.



Drwg. 000E4931

Replacement of gear rim

1. Remove the flywheel.
2. Saw with a hacksaw as far int o the gear rim as possible without damaging the flywheel.
3. Split the gear rim in the sawed slot with a chisel.
4. Clean the recess on the flywheel.
5. Heat the new gear rim gradually to about 225°C (dark blue) and fit it. Make sure at the fitting that the gear rim lies true against th e recess and that the chamfered edge turns towards the starter engine.



Drwg. 008E7312

SECTION E

FRONT END COVER

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Dismounting of front end cover..... page E 3

Mounting of front end cover..... page E 3

Front rotating weight..... page E 3

Replacement of front oil seal ring..... page E 4

Replacement of bushes in the front rotating weight..... page E 4

Dismounting of front end cover

1. Dismount the flywheel (see page D3).

2. Slacken the attachment of the end cover in engine block as well as in oil sump.

3. Dismount the tightening arrangement for shaft for rotating weight.
   The tightening consists of two washers of different thickness and a fibre washer assembled by a 8 mm screw.

4. Remove the end cover considering the guide spindles of the cover.

.

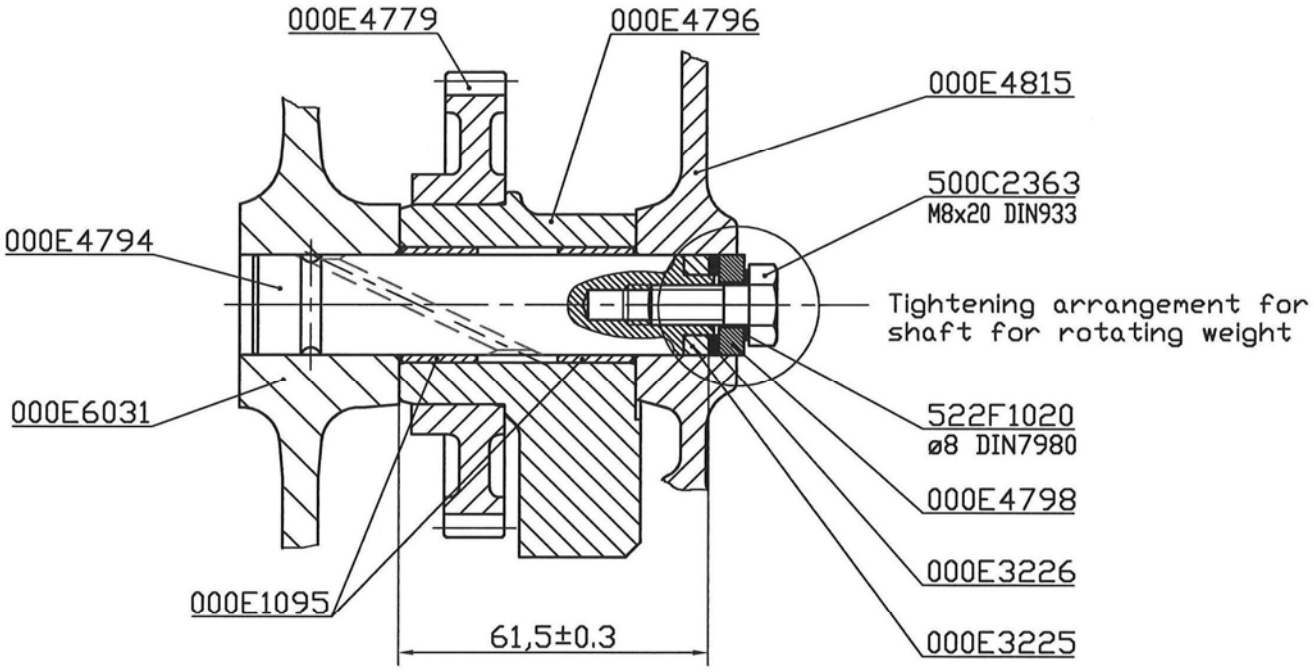
Mounting of front end cover

The mounting is carried out in reverse order of the dismounting, i.e. the tightening arrangement for shaft for rotating weight is to be mounted last.

Front rotating weight

The front rotating weight is mounted below the front end cover, as shown on the drawing below and overleaf.

As will appear from the drawing overleaf the weight is marked in relation to a corresponding mark on the gear wheel of the crank.



Drwg. No. 008E4799

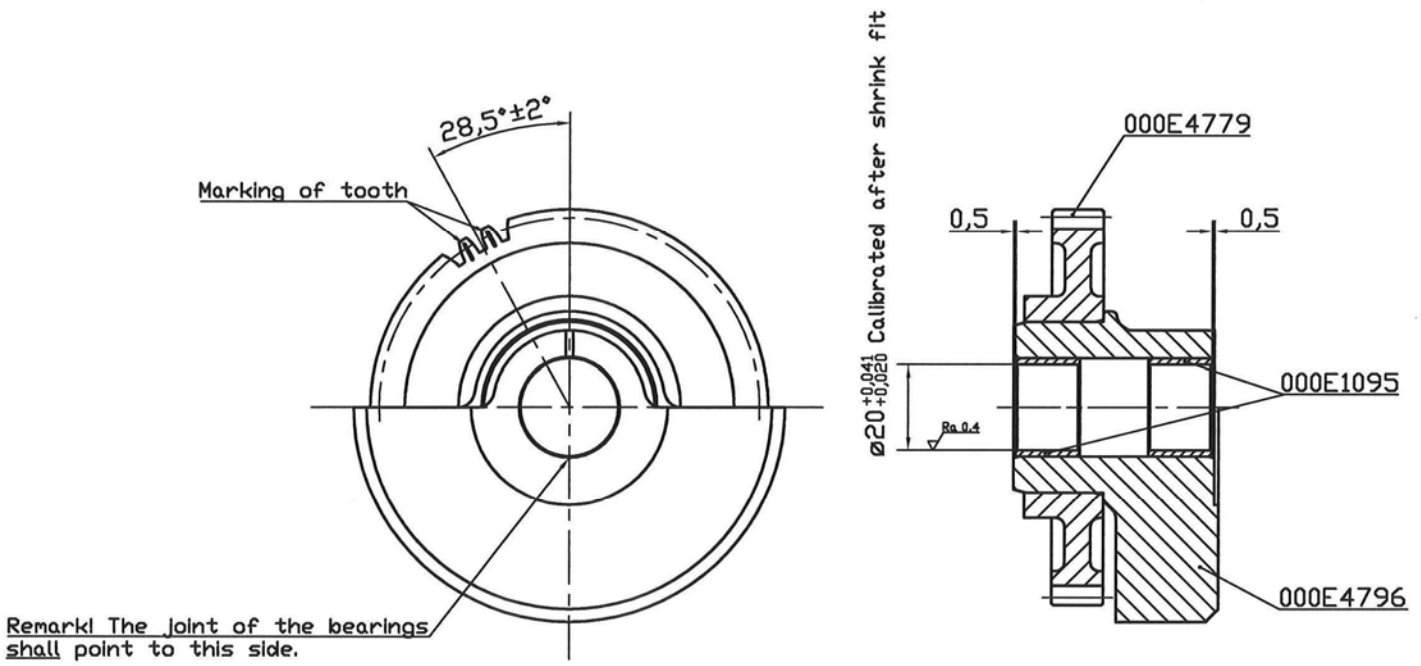
Replacement of front seal ring

A seal ring is mounted in the front end cover in order to avoid lubricating oil waste at the end of the crank through the front end cover.

The seal ring can be replaced without dismounting the front end cover. It is, however, necessary to dismount the flywheel.

Replacement of bushes in the front rotating weight

When replacing the bushes in the front rotating weight the new bushes must be calibrated with a ball or reamed, with clearance and measures as indicated on the drawing.



Drwg. No. 008E4800

SECTION G

REAR END COVER AND HAND START

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Rear end cover ..... page G 3

Dismounting of rear end cover ..... page G 3

Mounting of intermediate wheel and chain wheel ..... page G 4

Tightening for shaft for intermediate wheel ..... page G 4

Intermediate wheel ..... page G 5

Rear of rotating weight (drawing) ..... page G 6

Mounting of rear of rotating weight ..... page G 7

Replacement of bush in the rear rotating weight and intermediate wheel ..... page G 8

Replacement of seal ring in rear end cover ..... page G 8

Mounting of the rear end cover ..... page G 8

Chain adjuster ..... page G 9

Hand start ..... page G 10

Rear end cover

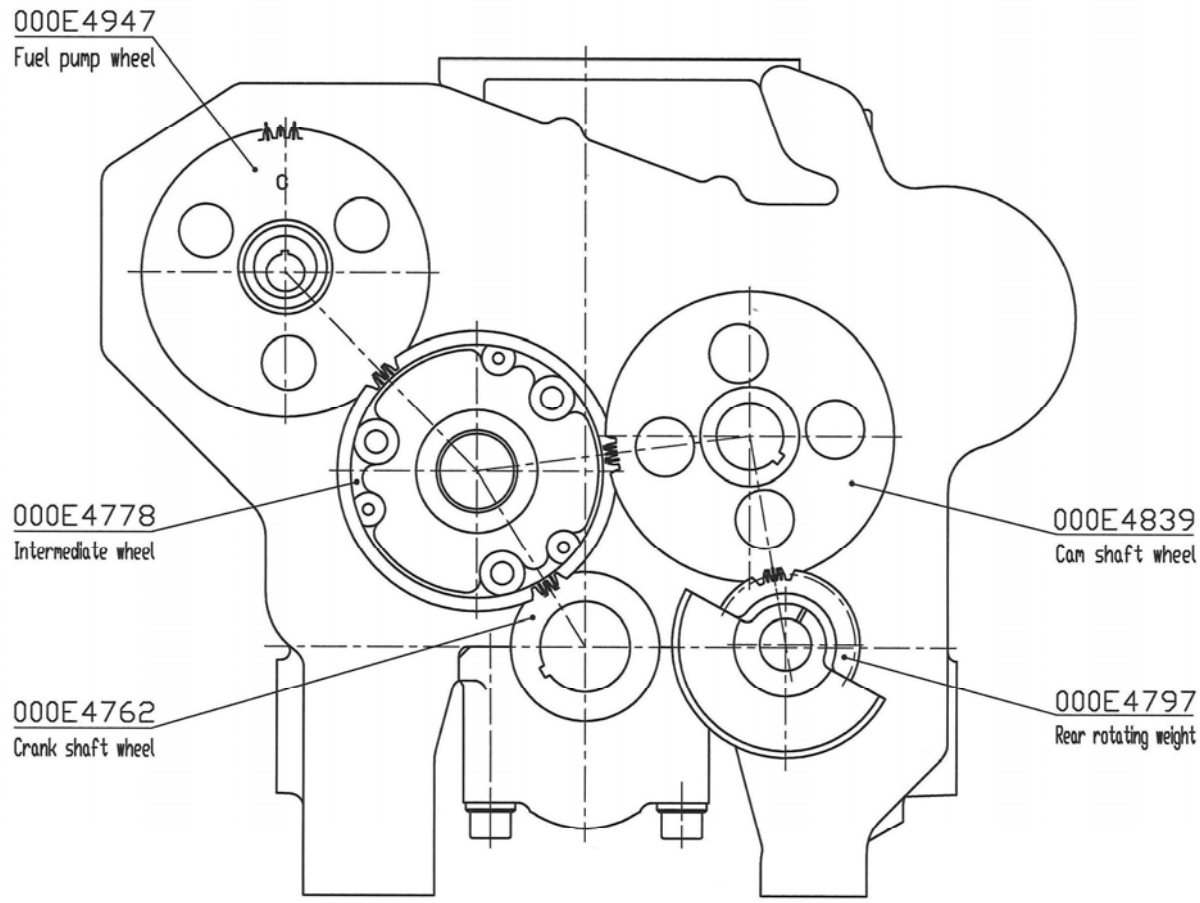
The rear end cover contains gear-wheel for crank, cam shaft, fuel pump,hand start, lubricating oil pump, cooling water pump and rear rotating weight.

The gear-wheels are in the gear with each other through an intermediate wheel. The sketch below indicates the marking of the gear-wheels which have been marked in relation to each other so that their position to each other may easily be observed when being repared.

Dismounting of rear end cover

1. Dismount the gear from the engine.
2. Dismount the flexible coupling half on the crank.
3. Slacken the attachment of the end cover on engine block and oil sump.
4. Dismount the hand start and lower the chain into the end cover (see page G10).
5. Slacken the shaft seals for intermediate wheel and rear rotating weight and remove the end cover.

Simplified sketch of tooth markings for gear wheels in the rear end cover



Drwg. No. 008E6192

Mounting of intermediate wheel and chain wheel

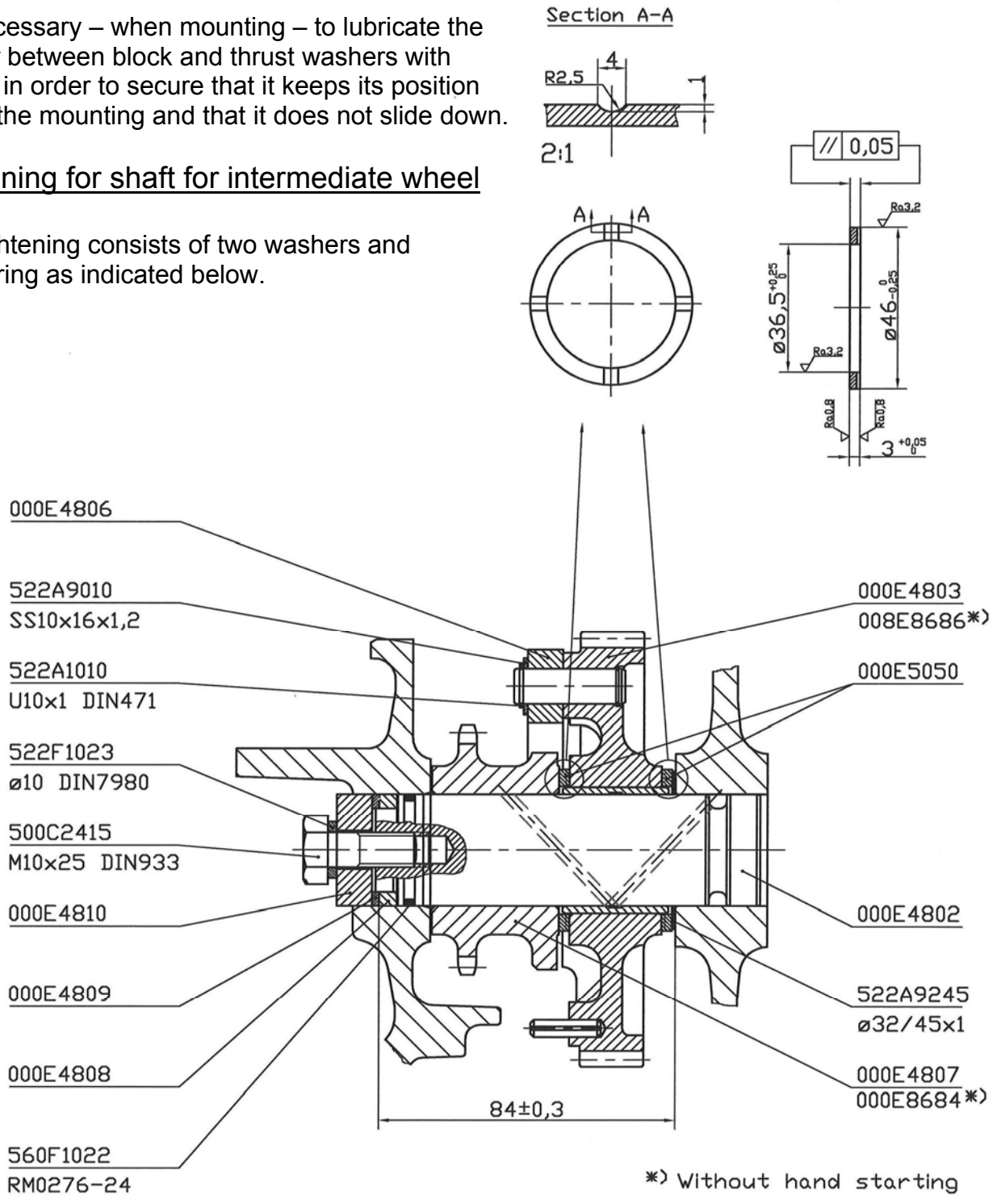
After the intermediate wheel has been placed on the shaft, and after the timing marks – as indicated overleaf – have been adapted for the corresponding marks, the chain wheel for hand start should be mounted on the same shaft.

The two thrust collars shown form part of the arrangement.

It is necessary – when mounting – to lubricate the washer between block and thrust washers with grease in order to secure that it keeps its position during the mounting and that it does not slide down.

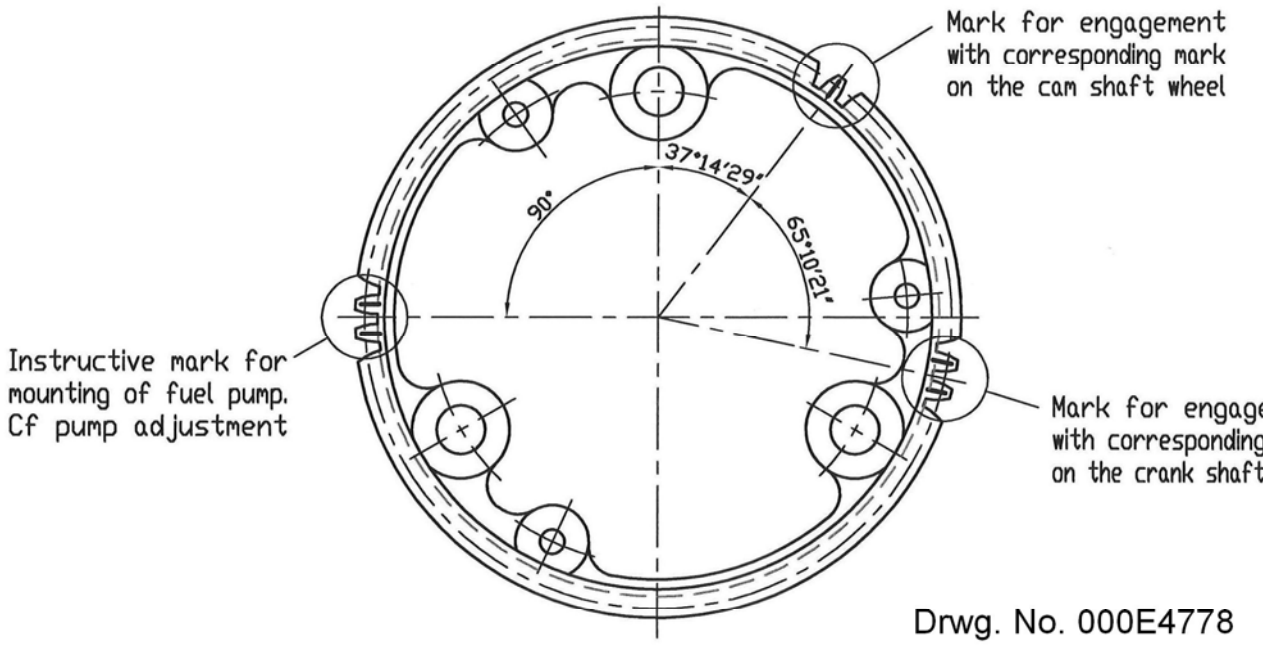
Tightening for shaft for intermediate wheel

The tightening consists of two washers and a fibre ring as indicated below.

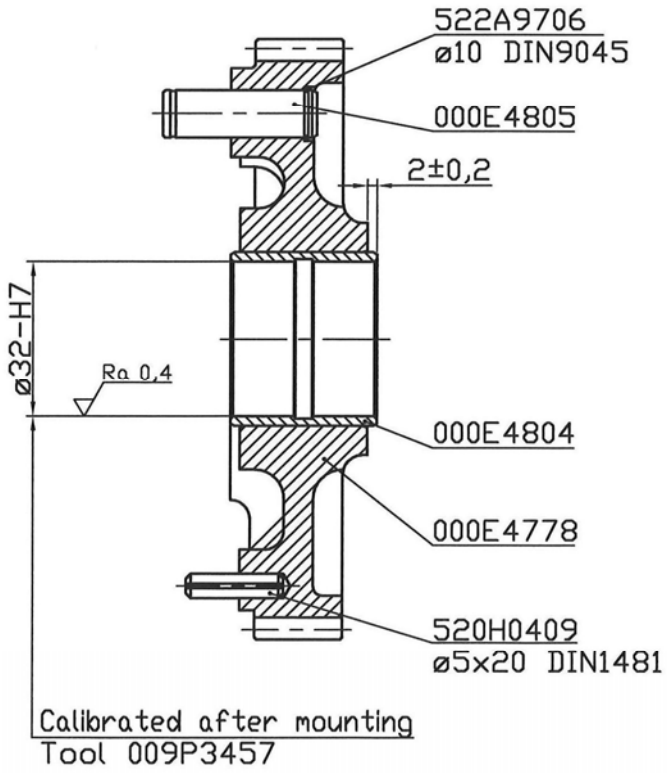


Drwg. No. 008E4801

Intermediate Wheel

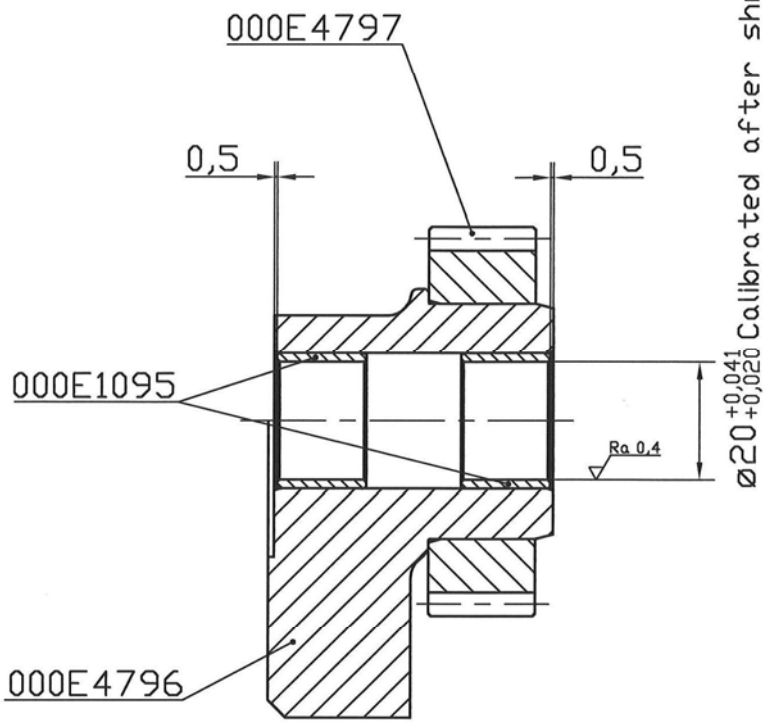


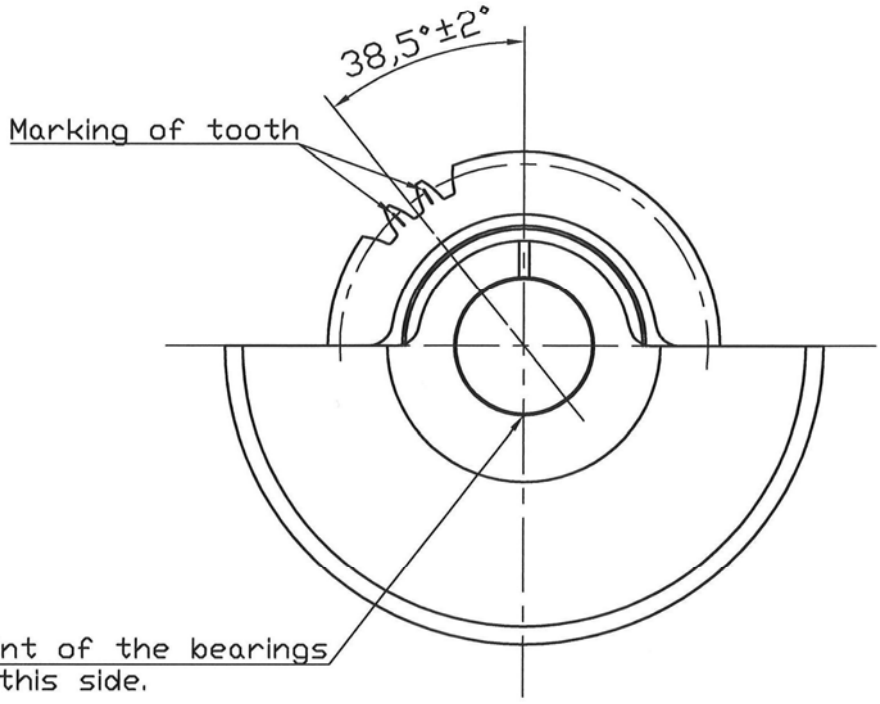
Drwg. No. 000E4778



Drwg. No. 008E4803

Rear Rotating Weight





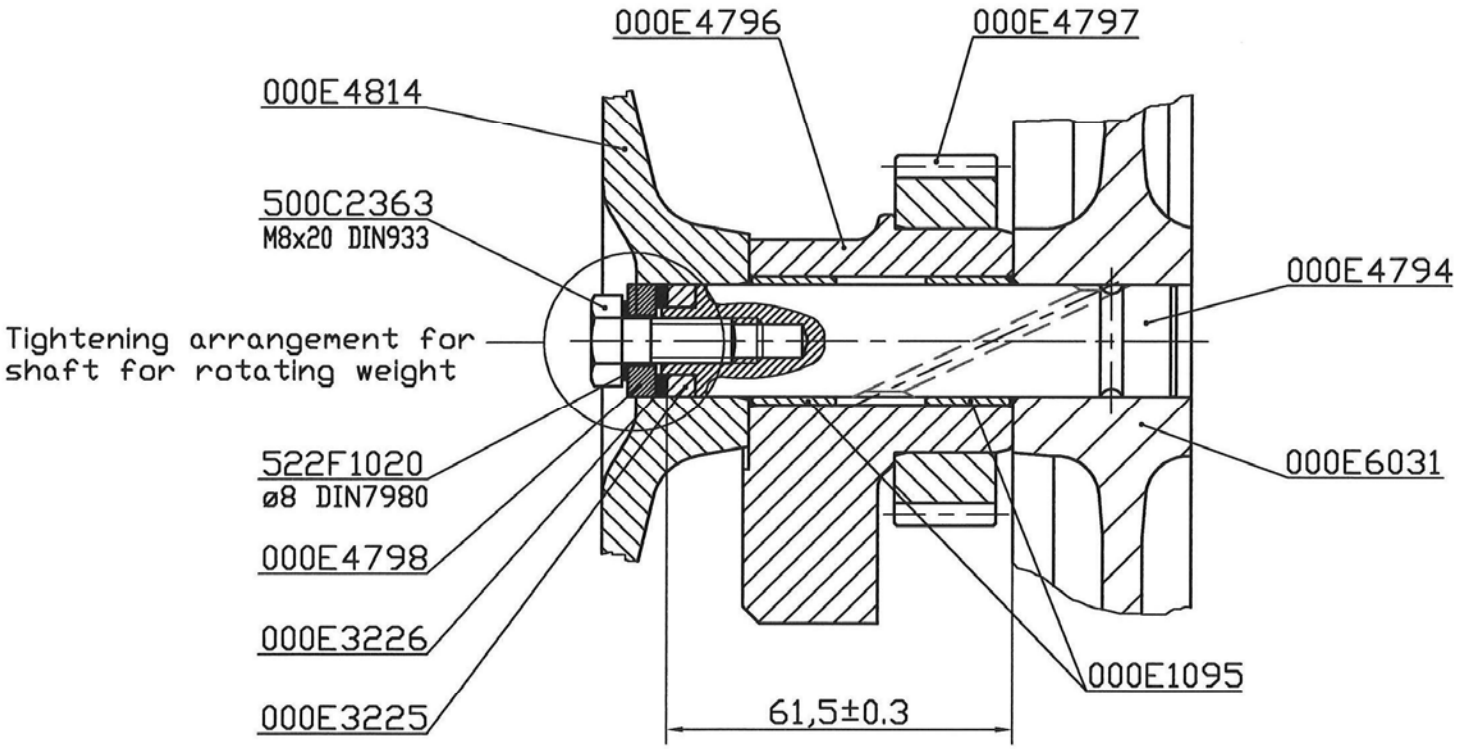
Drwg. No. 008E4795

Mounting of the rear rotating weight

Mount the rotating weight on the shaft pressed into the engine block and the tooth marking in relation to the intermediate wheel should be observed.

After the end cover has been mounted, the tightening for shaft should be mounted in accordance with the drawing below.

The tightening consists of two washers of different thickness and a fibre ring.



Drwg. No. 008E4793

Replacement of bush in the rear rotating weight and intermediate wheel

Bushes have been mounted in both rear rotating weights as well as in the intermediate wheel. These bushes can be replaced in case of wear and tear.

After the new bushes have been pressed in these should be calibrated with a ball or be reamed with the correct measures and clearances as indicated on the drawings on page G5 and G6 for rear rotating weight and intermediate wheel respectively.

Replacement of seal ring in rear end cover

A seal ring is mounted in the rear end cover in order to avoid leak of lubricating oil at the outlet of the crank through the rear end cover.

It is possible to replace the seal ring without dismounting the end cover after the gearbox with intermediate guard has been dismounted.

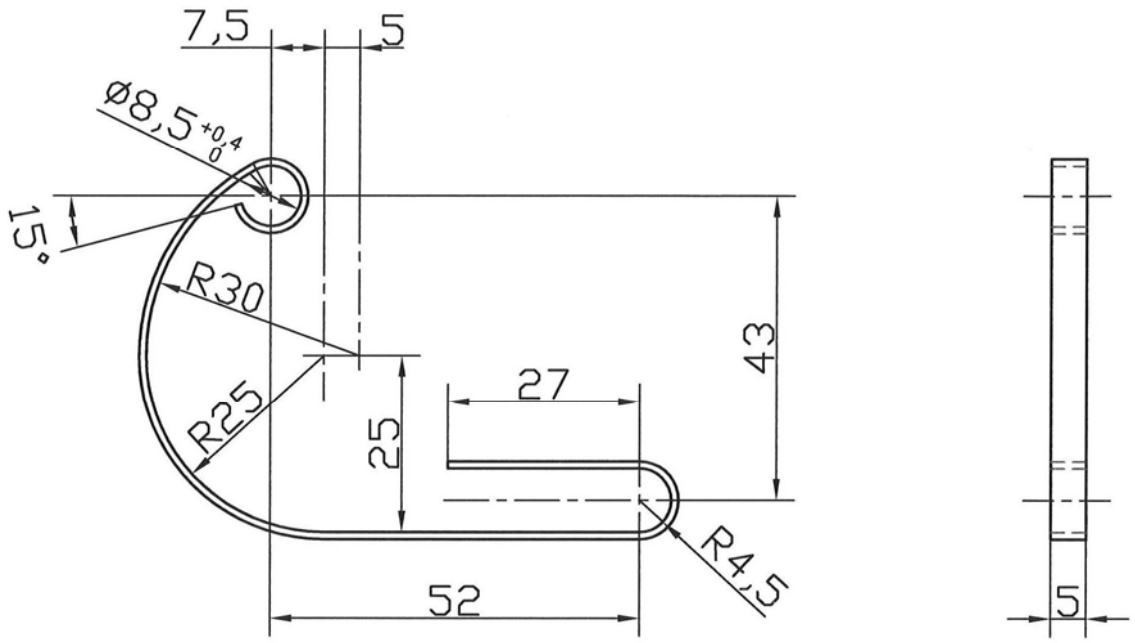
Mounting of the rear end cover

The mounting is carried out in reverse order of the dismounting, as the chain for hand start is to be mounted on the chain wheel and then to be pulled up through the hole in the end cover with a piece of string or the like, and here the hand start is to be ready-mounted later.

Chain adjuster

The chain adjuster is mounted on two pins in the engine block.

The chain adjuster is self-adjusting and thus it does not require any adjustments in connection with repairs in the end cover during which the chain is to be dismounted.



Drwg. No. 000E4813

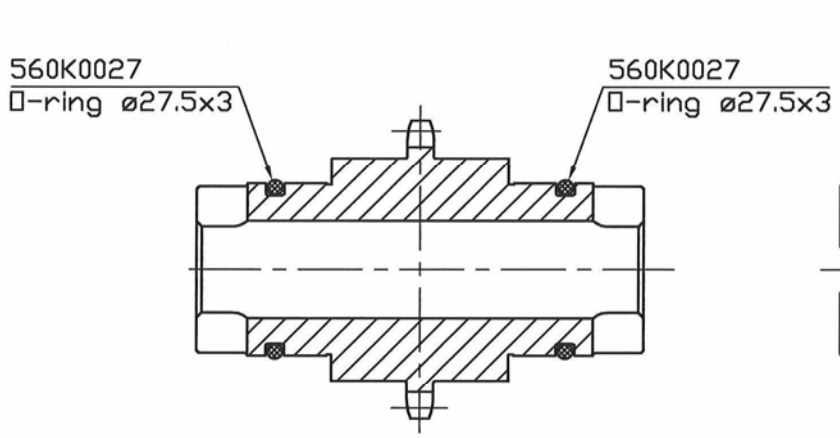
Hand start

The chain case is bolted on to the rear end cover, as indicated on the drawing below.

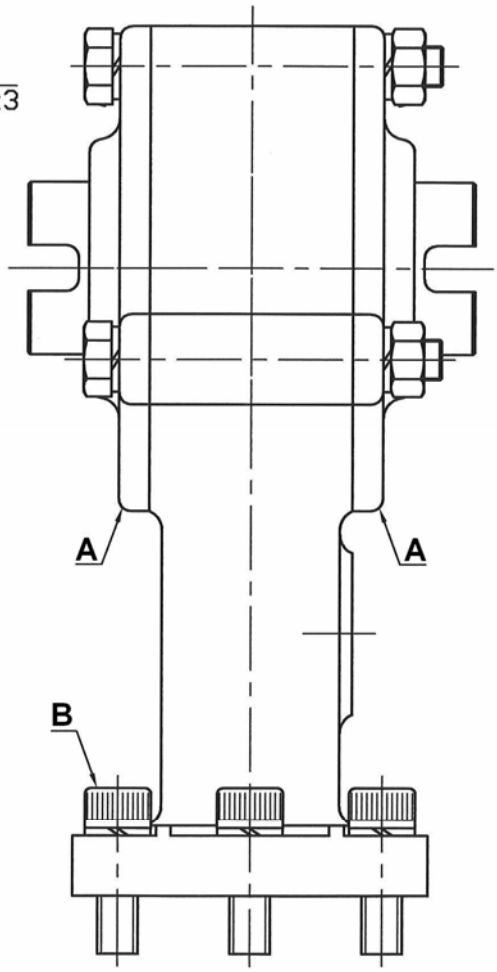
When dismounting remove the covers “**A**”, and this results in the chain being slackened and then the chain wheel and shaft can be taken out.

Mounting is carried out in reverse order and it should be taken care that the O-rings for oil-tightness are correctly placed in the grooves on the chain wheel shaft.

Dismount the chain case from the end cover by removing the bolts “**B**”.



Drwg. No. 000E5100



SECTION H

FUEL SYSTEM

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Dismounting of the fuel pump ..... page H 3

Mounting and Adjustment for fuel pump ..... page H 4

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Fuel System ..... page H 7

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Fuel Lift Pump ..... page H10

Fuel Filter ..... page H11

Fuel Valve ..... page H12

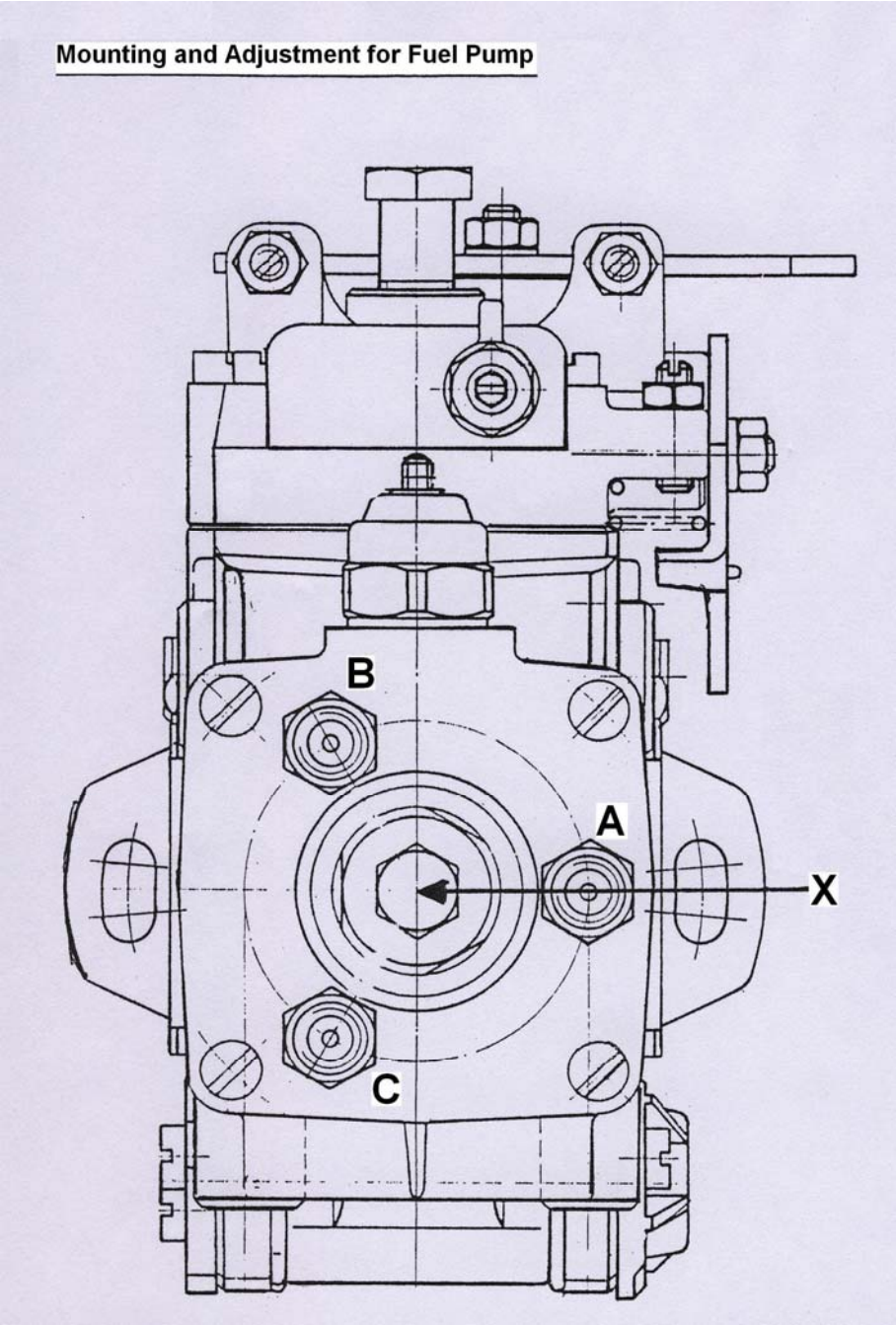
Causes and Remedies of the Fuel Pump ..... page H13

Dismounting of the fuel pump

1. Dismount the bilge pump for lubricating oil from engine and gear.
2. Dismount the flange opposite of the fuel pump.
3. Take off the gear-wheel of the pump by slackening the clamping nut on the shaft of the pump and pull off the gear-wheel.
4. Slacken the nuts in the flange of the pump and take out the pump.

REPAIRS OF THE PUMP SHOULD ONLY BE CARRIED OUT BY AUTHORIZED BOSCH WORKSHOPS

H4



1. Turn piston No. 3 (rear) to TOP in the working stroke.

2. Mark the flywheel in this position in relation to the arrow mounted on the front edge of the engine.

3. Measure 86 mm. arc measure from the TOP mark (to the right, when the flywheel faces you).

4. The pump should be adjusted for correct injection timing:

   a. Adjust the key on the conical shaft of the pump so that it flushes with the outlet hole **B** to the fuel valve for cylinder No. 3.

   b. Remove the screw **X** and mount a dial indicator with a special sensing element instead by means of a special holder for dial indicator.

   c. Push in the dial indicator 2.0 mm.

   d. Mount the flywheel for the pump loosely and turn it to the left, seen from the gear-wheel side until the dial just indicates within the range of 0.01 mm.

5. Mount the pump on the engine by means of two nuts with washers and spring washers so that the nuts are placed about the middle of the oblong holes in the flange of the pump.

6. Mount the gear-wheel for the pump through the hole on the opposite side of the pump. Fasten the gear-wheel on the conical pump shaft by means of a nut.

7. Mount the flange above the hole for mounting of the gear-wheel of the pump.

8. Mount the dial indicator again at the same place and in the same way and push it 2.0 mm in.

9. Turn the flywheel back from the 86 mm arc measure to 6 mm[*)] arc measure before the TOP mark. The indicator is then to show 1.0 mm variation (1 turn).

   If this is not so, fine-adjust either by moving the gear-wheel one tooth in relation to the intermediate wheel (when indicating more than 0.7 mm) or by adjusting the placing of the clamping nuts in the oblong holes in the flange of the pump (when indicating less than 0.7 mm).

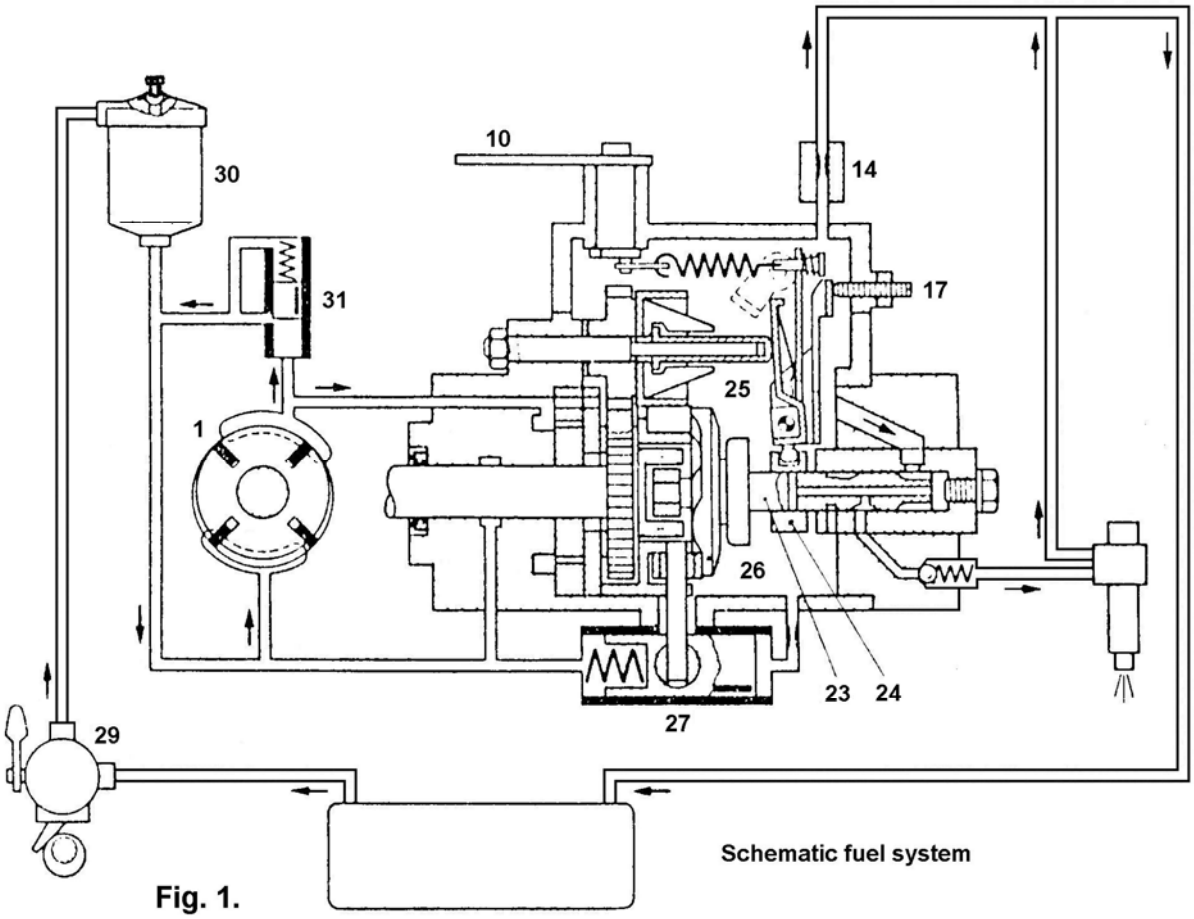
   [*)] According to the Service information SI0601, the arc measure has been changed from **6** mm. to **20** mm. from engine no. 8395.

Specification of Numbers to Fig. 1 and 2

1. Feed pump
2. Drive shaft
3. Gear-wheel
4. Thrust washer
5. Governor shaft
6. Governor bush
7. Holder
8. Governor weight
9. Governor spring
10. Timing lever
11. Adjusting screw (idling)
12. Adjusting screw (max. r.p.m.)
13. Stop lever
14. Overflow throttle
15. Correcting lever
16. Bolt
17. Adjusting screw (full load)
18. Idle spring
19. Clamping arm
20. Starter spring
21. Starting lever
22. Delivery valve holder
23. Distributor piston
24. Governor slide
25. Fuel chamber
26. Cam disc
27. Injection timing piston
28. Roller cage
29. Lift pump
30. Fine filter
31. Pressure control valve

Fuel System

The fuel is pumped by a lift pump (29 from the tank via a fine filter (30) to the internal wing feed pump. This feed pump gives a constant quantity/revolution.



Schematic fuel system

Fig. 1.

Through the pressure control valve (31), after the feed pump, a pressure is produced. Most of the fuel flows through the pressure control valve back to the suction side. The remaining part of the fuel flows through the inner chamber of the pump (fuel chamber) (25) to the high pressure chamber of the distributor head and then it is led to cooling and bleeding and then back to the tank through the overflow throttle (14).

The distributor piston (23) is activated by the drive shaft (2). By means of the cam disc (26) and the rollers in the roller cage (28) the piston obtains an axial motion besides the rotary motion.

The delivery (high pressure) takes place by means of the axial motion of the piston. The distribution to the individual outlets (22) is through a slit in the distributor piston.

The injection stops when the governor slide (24) disengages the transversing hole in the distributor piston. The fuel flows back into the fuel chamber of the pump (25).

The governor slide (24) is controlled by the centrifugal governor.

Centrifugal Governor

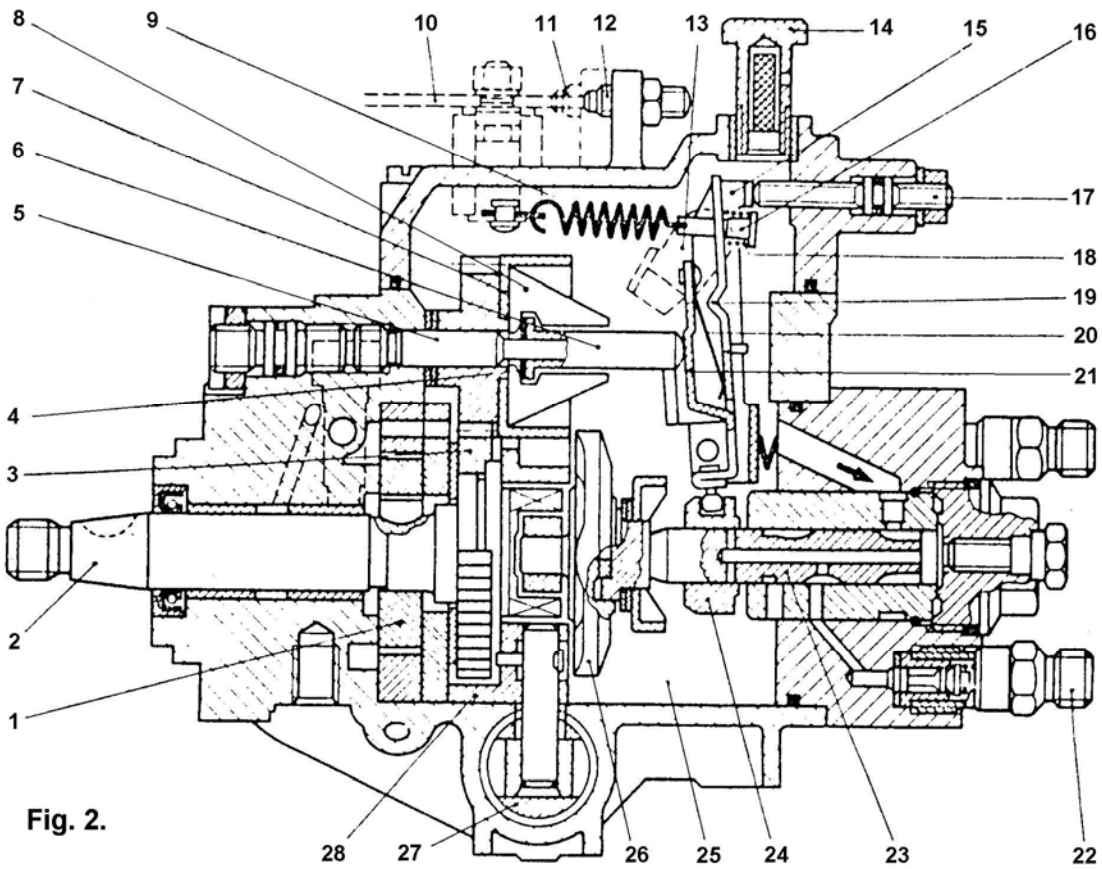


Fig. 2.

The centrifugal governor is placed in the upper part of the fuel pump.

The holder (7) with gear-wheel is placed on the governor shaft (5) and is driven by the drive shaft (2) via the gear-wheel (3) and a rubber shock absorber (vibration damper).

Four weights (8) are mounted in the centrifugal weight holder. They press on the axially displaceable governor bush (6) via a thrust washer (4) with their pressure arms.

The governor arm group consists of starting lever (21), clamping arm (19) and correcting lever (15). Starting lever and clamping arm are placed in the pump housing. In this way it is possible to adjust the full load quantity by the adjusting screw (17) without influencing th adjustment of the revolutions.

A leaf spring is placed on the starting lever (21) and it works as a starter spring. An axially displaceable bolt (16) with idle spring (18) is placed in the upper part of the clamping arm (19). The governor spring (9) is fixed in this bolt. The tension of the governor spring can be changed by the timing lever (10). The starting lever (21) has a ball in the lower part connected with the governor slide (24).

Injection Timing

On the under side of the fuel pump, at right angles in proportion to the longitudinal axis, the spring-loaded injection timing piston (27) is. The roller cage (28) is turned influenced by the feed pump pressure and via a mechanism. The injection timing is thus adjusted depending on the revolutions.

Function of the Centrifugal Governor

The revolutions of the engine are transmitted by the drive shaft (2) through gear-wheel to the governor weights (8) and are transformed into centrifugal force there.

With stopped fuel pump, the starting lever (21) and the governor slide (24) are pressed into start position by the starter spring (20). Through this automatic ful volume, when starting, is obtained.

When the r.p.m. of the engine goes up after start the function of the weak starter spring (20) is taken over by the pressure from the governor bush (6). By this the starting lever (21) is pressed against the clamping arm (19) and the starting volume is automatically declutched as the governor slide (24) is displaced.

At low idling the governor spring (9) is not working.
The regulation is controlled by the idle spring (18).

By setting the governor spring (9) more or less with the timing lever (10) a lower or higher r.p.m. is adjusted. The idle spring is pressed together.

The idling volume is adjusted by the adjusting screw (11) and the full load volume by the adjusting screw (17).

Max. r.p.m. is adjusted by the adjusting screw (12).

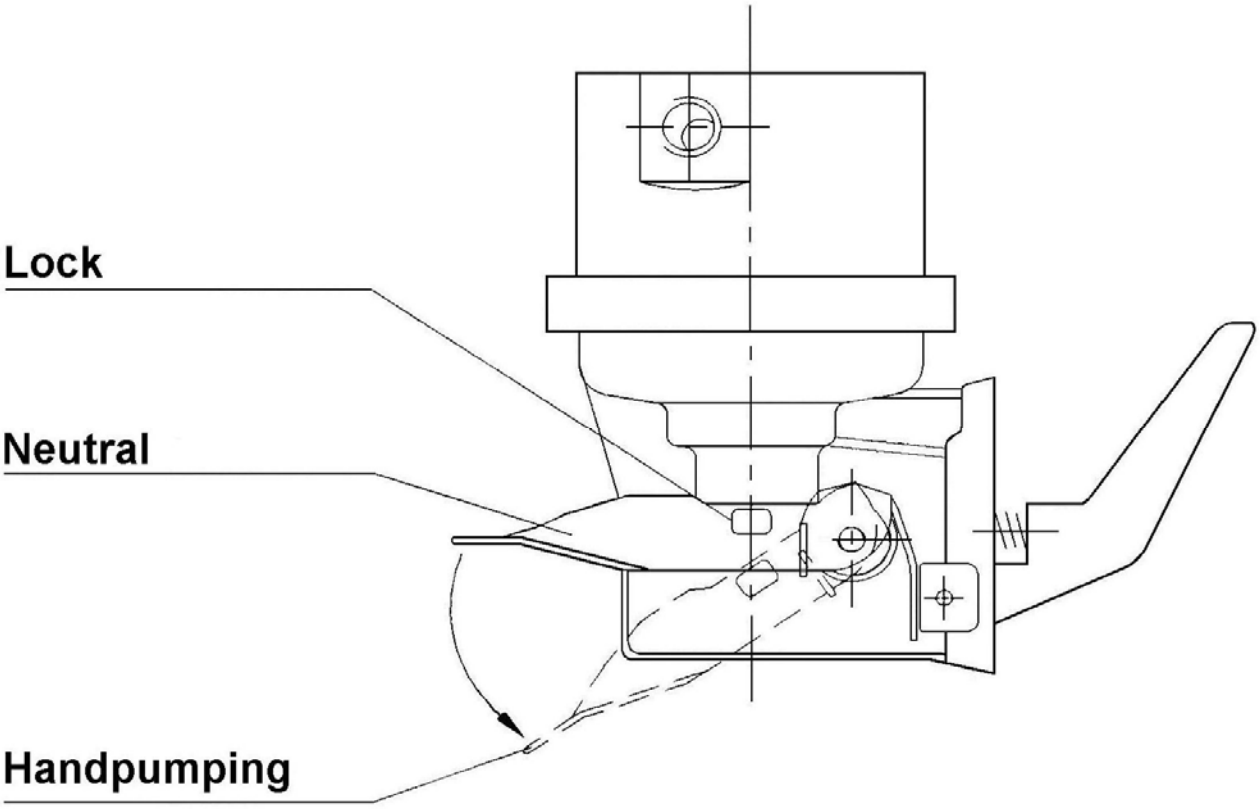
The pump is stopped by means of a stop magnet built on to the fuel pump (not shown on the sketch). This magnet closes the inlet port to the high pressure chamber in the distributor head at electrical activation resulting in a dead stop magnet.

Fuel Lift Pump

The fuel lift pump is a diaphragm type and is placed at the upper side of the rear end cover. The pump is sealed and cannot be dismantled for repair or cleaning. It is driven by the camshaft.

Workpressure is 35 – 55 kPa.

A hand pump is fitted, which can be used for priming and bleeding by standing engine. **After priming the lever must be put in neutral position, where it is locked.** If priming not is effective, it may be caused by the driving cam being in top position. The engine must be turned to bring the cam in bottom position.



Fuel Filter

The fuel filter used is a Bosch disposable one mounted to the port side on the front of the engine.

The filter cannot be cleaned, but has to be changed every 300 operating hours, or if water contamination is suspected.

Unscrew the filter casing by hand after the filter casing has been emtied for fuel via the drain screw in the bottom of the filter casing.

Before fitting of a new filter the sealing surface of the filter casing should be cleaned. The filter casing should now be filled with clea fuel before it is screwed on and tightened about half a turn after the sealing surface fits tightly.

After changing the filter bleed the fuel system by actuating the manual handle on the fuel lift pump and pump until the fuel, free from bubbles, runs out at the vent screw on the top of the fuel filter. Tighten the screw and loosen the fuel pressure pipes at their connection on the fuel valves and pump again with the fuel lift pump until fuel, free from bubbles, runs out from the fuel pressure pipes.

The fuel valves are mounted in the cylinder head and are secured here with tightening bars which are loosened when dismounting the fuel valves.

Disassemble the fuel valves after the sketch beside and so the nozzle can be exchanged and the pressure can be adjusted at the washers (541).

Adjust the fuel valves by means of a pressure test apparatus at 184 Kp/cm² *) opening pressure.

When using Bosch pressure testapparatus for nozzles you are referred to Bosch infor-mation WPP 320/2 DK (500.8.76) and this states test procedure and measures in detail.

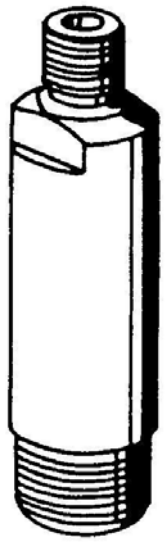
The nozzle (548) is a Bosch nozzle DLLA 150P 34 combined with a nozzle holder KBEL 78P 10/13 and this combination makes the fuel valve (Item no. 610B9120) *).

The adjusting filling pieces for injection pressure are obtainable from 1 mm to 1.975 mm thickness with 0.05 mm from washer to washer.

When exchanging the nozzle the new nozzle has to be cleaned in petrol as it has been prepared with a protective oil. Both nozzle needle and nozzle housing should be carefully cleaned.

When assembling the fuel valve tighten with 6 – 8 Kpm.

*) According to Service information SI0601 the fuel valve has been changed from 610B9120 (opening pressure 184 Bar) to 610B9250 (opening pressure 230 Bar) from engine no. 8395 and again changed according to SI1102 from 610B9250 (opening pressure 230 Bar) to 610B9220 (opening pressure 210 Bar) from engine no. 8845.



541

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548

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SYMPTOMS

1 Either the engine will not start at all or it is difficult to start when warm
2 Either the engine will not start at all or it is difficult to start when cold
3 The engine "saws" when idling
4 Irregular idling when the engine is warm
5 Engine misfires when running
6 The output is not satisfactory
7 The fuel consumption is too high
8 The engine cannot be stopped
9 Heavy engine running, black exhaust gas in the full load range, and perhaps reduction of the output
10 Foggy exhaust gas in th full load range (white)
11 Wrong revolutions
12 No increase of the r.p.m. in cold condotion
13 The distributor pump gets unusually warm

1	2	3	4	5	6	7	8	9	10	11	12	13	CAUSES	REMEDIES
X	X			X	X				X		X		Empty tank, tank bleeding choked	Fill the tank, bleed the system, check the tank bleeding
X	X		X	X					X		X		Air in fuel system	Bleed the fuel system, tighten the system
X	X						X						Solenoid valve without voltage or defective	Try electrical connections or repair the pump
				X	X				X		X		Fuel filter choked	Replace the filter box
				X	X				X				Pressure pipes choked (constricted)	Check all pipes - repair or replace
				X	X				X				Fuel supply pipes choked (constricted)	Check all pipes - repair or replace
X	X			X	X								Loose connections, pipes leaky, broken	Tighten the connection, repair the leak
	X												Heavy paraffin separation in the filter	Change filter box, use winter fuel
X	X			X		X		X	X		X		Wrong start of fuel feed	Adjust start of fuel feed, correct adjustment engine/pump
			X										Defective nozzle	Replace
					X			X					Choked engine air filter	Change filter element
X	X		X		X	X		X					Injection order does not correspond to firing order	Fit the pressure pipes in proper order
					X					X			Max. r.p.m. is wrong	Adjust max. r.p.m.
		X		X	X				X	X	X		Banjo bolts of delivery and return pipes have been mixed up	Fit the banjo bolts correctly
												X	Overflow throttle choked	Clean the overflow throttle
											X		Cold start accelerator is not working	Work the cold start accelerator and inform the customer
X	X		X								X		Compression of engine too low or irregular	Repair
X	X	X	X	X	X	X	X	X	X	X	X		Distributor pump defective or out of adjustment	New adjustment, or repair
										X			Idling r.p.m. wrong	Adjust idling (adjusting screws on the distributor pump)

SECTION IJ

PISTON, CONNECTING ROD AND CYLINDER LINER

CONTENTS

Disassembling of pistons and connecting rods..... page IJ 3

Assembling of pistons and connecting rods ..... page IJ 3

Exchange of pistons ..... page IJ 4

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Exchange of piston pin bearing in connecting rod ..... page IJ 9

Arrangement of connecting rod (drawing) ..... page IJ 10

Connecting rod bearings ..... page IJ 11

Cylinder liner ..... page IJ 12

Measuring of cylinder wear..... page IJ 12

Dismounting of cylinder liner ..... page IJ 12

Mounting of cylinder liner..... page IJ 12

Test measurement of cylinder liner (drawing)..... page IJ 13

Disassembling of Pistons and Connecting Rods

1. Drain off the cooling water and the lubricating oil from the engine.
2. Dismount the cylinder head (see section C).
3. Remove any wear or soot edge which may be at the top of the cylinder liner with a scraper.
4. Turn the engine “upside down”.
5. Remove the oil pan.
6. Unscrew the connecting rod nuts and remove the bearing cap from the connecting rod.
7. Fit the connecting rod bolts with protective caps (soft plastic hose or the like) in order to avoid the crank being damaged.
8. Turn the piston in top position and press out the piston and the connecting rod of the cylinder liner. The crank must be in the exact top position.

   Note! On later engines the connecting rod nuts have been replaced by unbraco screws and therefore item 7 can be omitted.

Assembling of Pistons and Connecting Rods

1. Put a slip ring over the cylinder liner.
   (The slip ring may be made from a worn out cylinder liner , of which 2/3 should be removed and the remaining 1/3 should be turned weakly conical in the top end wanted.)

2. Place the crank in the top position.

3. Fit the connecting rod bolts with protective caps.

4. Lower the piston and the connecting rod down into the cylinder liner by means of the slip ring and do observe that the piston ring gaps are staggered. It should further be checked that the recess in the piston head is turned towards the fuel valve. Before fitting the pistons and connecting rods lubricate the crank journals abundantly with lubricating oil.

5. Place the engine on the side or turn it “upside down”.

6. Remove the protective caps.

7. Fit the bearing cap with the bottom bearing shells.

8. Tighten the connecting rod nuts with a torque of 69 +/- 3 Nm (7 +/- 0.3 kpm). Use self-locking nylon nuts for the connecting rod bolts and replace the nuts after each disassembling of the connecting rod.

   Note! The numbers on the connecting rod must be placed as before the disassembling of the engine and the numbers on the connecting rod and bearing cap must fit.
   The bearing cap and the connecting rod are guided by two balls which you must have in mind when assembling.

Exchange of Pistons

If the pistons are scored or very worn, exchange them for new ones.

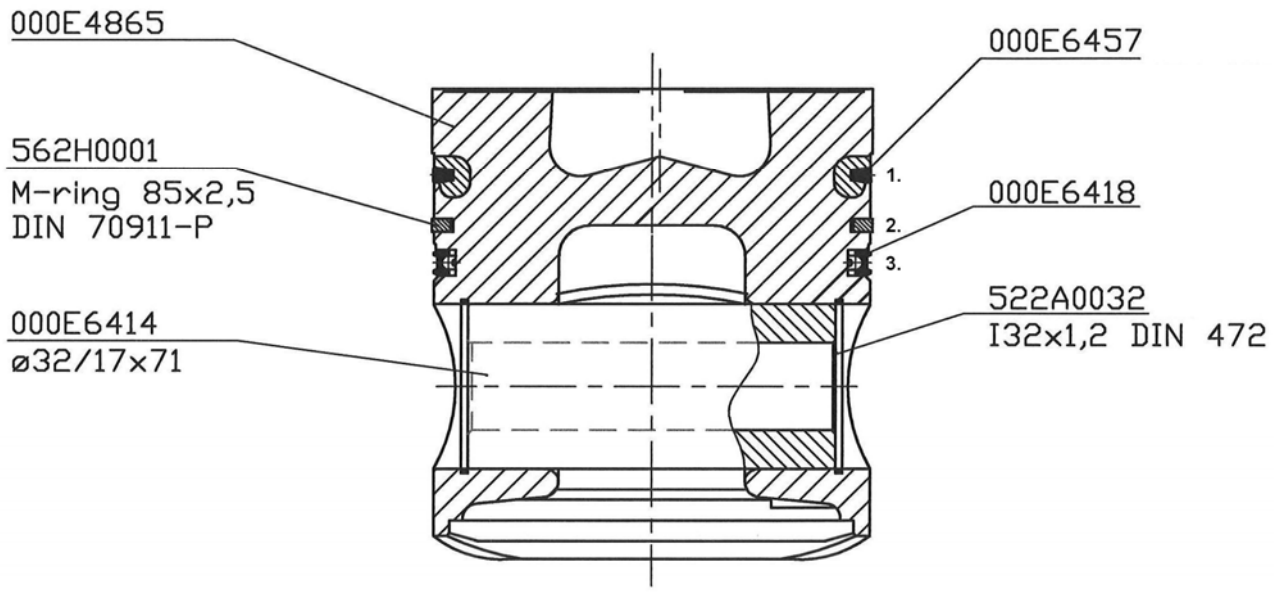
This is carried out as follows:

1. Remove the pistons with connecting rods as stated on page IJ 3.
2. Take off one of the locking rings at the gudgeon pin.
3. Knock out the gudgeon pin with a punch.
4. Place the new pistons upside down. Pour a little spirit into them and light it.
   The heating can also take place on a boiling plate.
5. When the piston has reached a temperature of about 100°C, smother the fire. Place the connecting rod in the piston before the oiled gudgeon pin is pushed in.

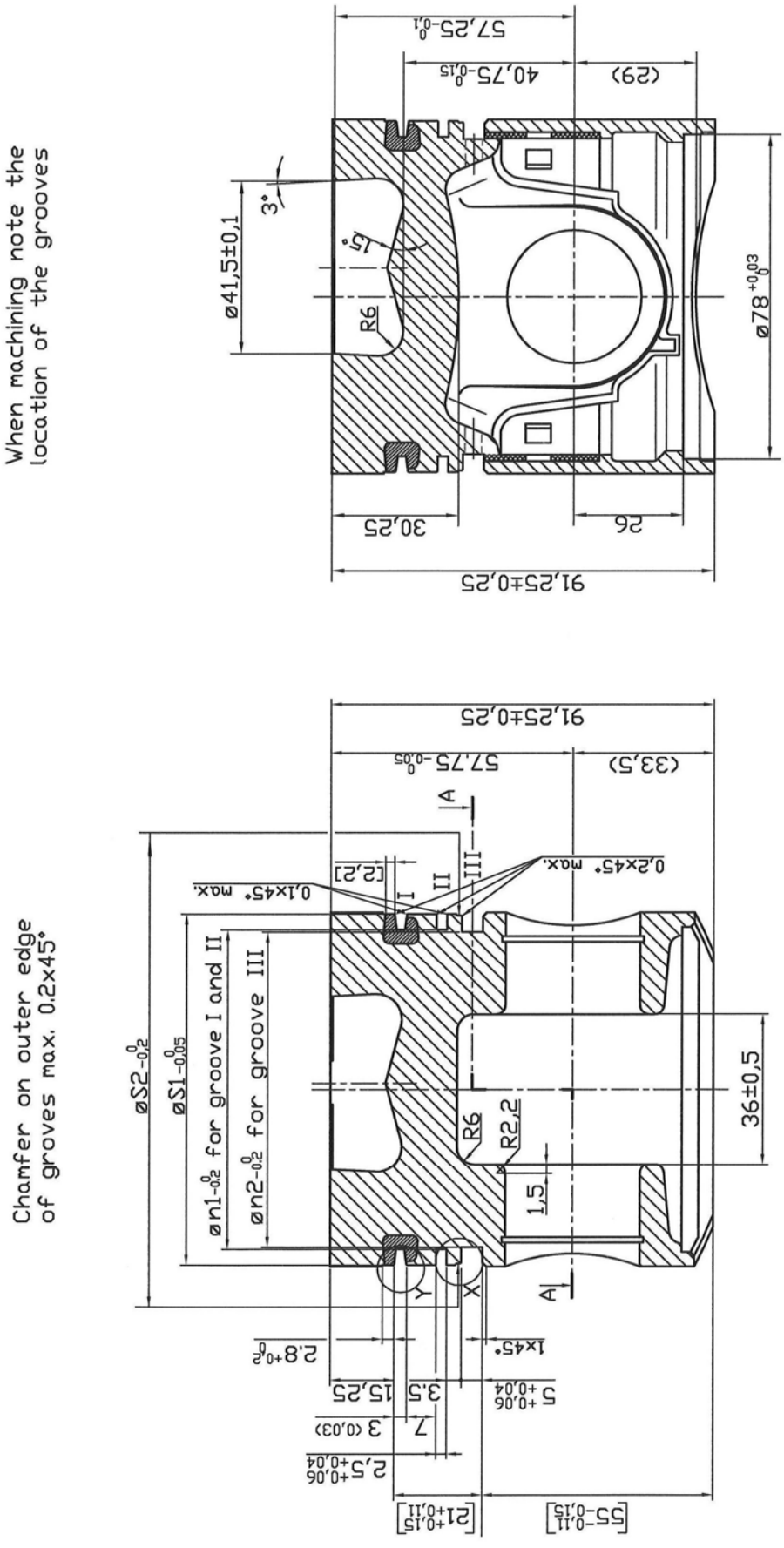
   It is recommended to cool down the gudgeon pin first, e.g. in a deep freezer or by means of nitrogen or carbonic acid, if it is possible.
6. Relock the gudgeon pin with the locking ring.

Carefully observe that the piston is placed correctly in proportion to the numbering on the connecting rod.

Weight of piston complete: 1,088 grams ± 7 grams.



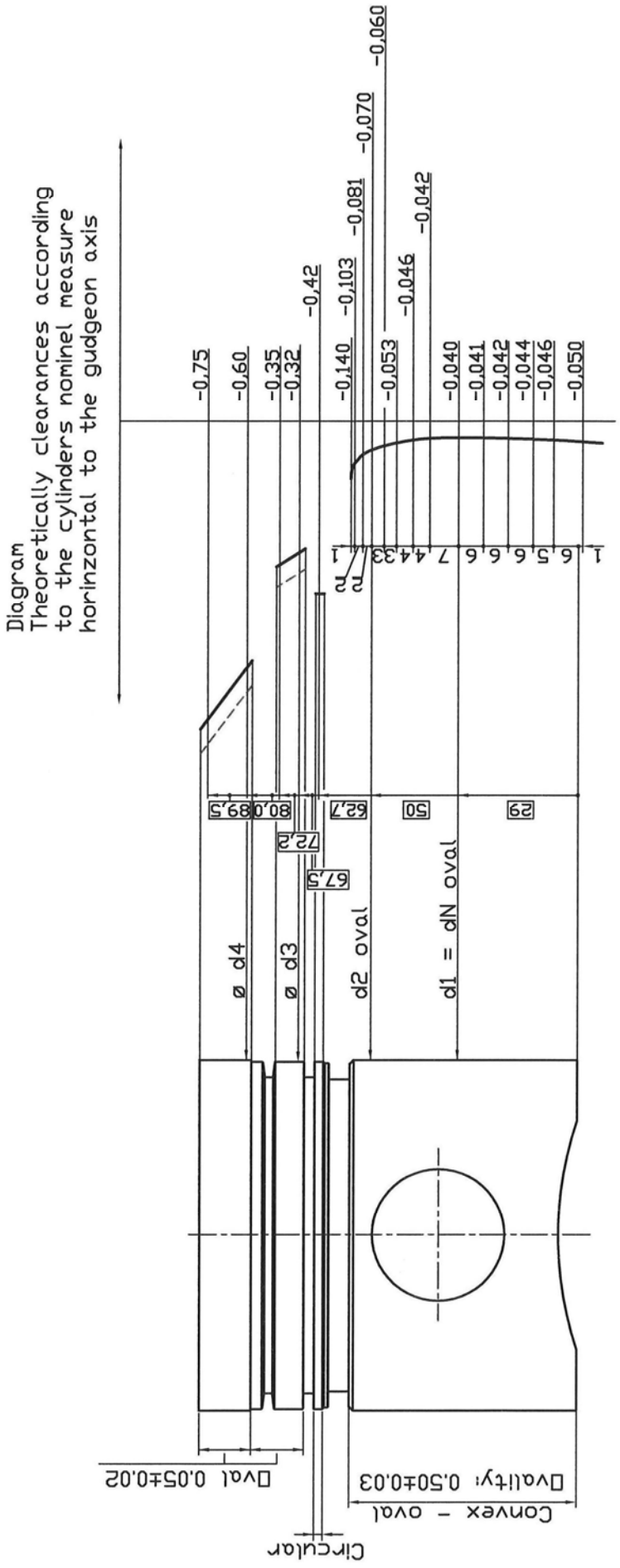
Measurements for Piston



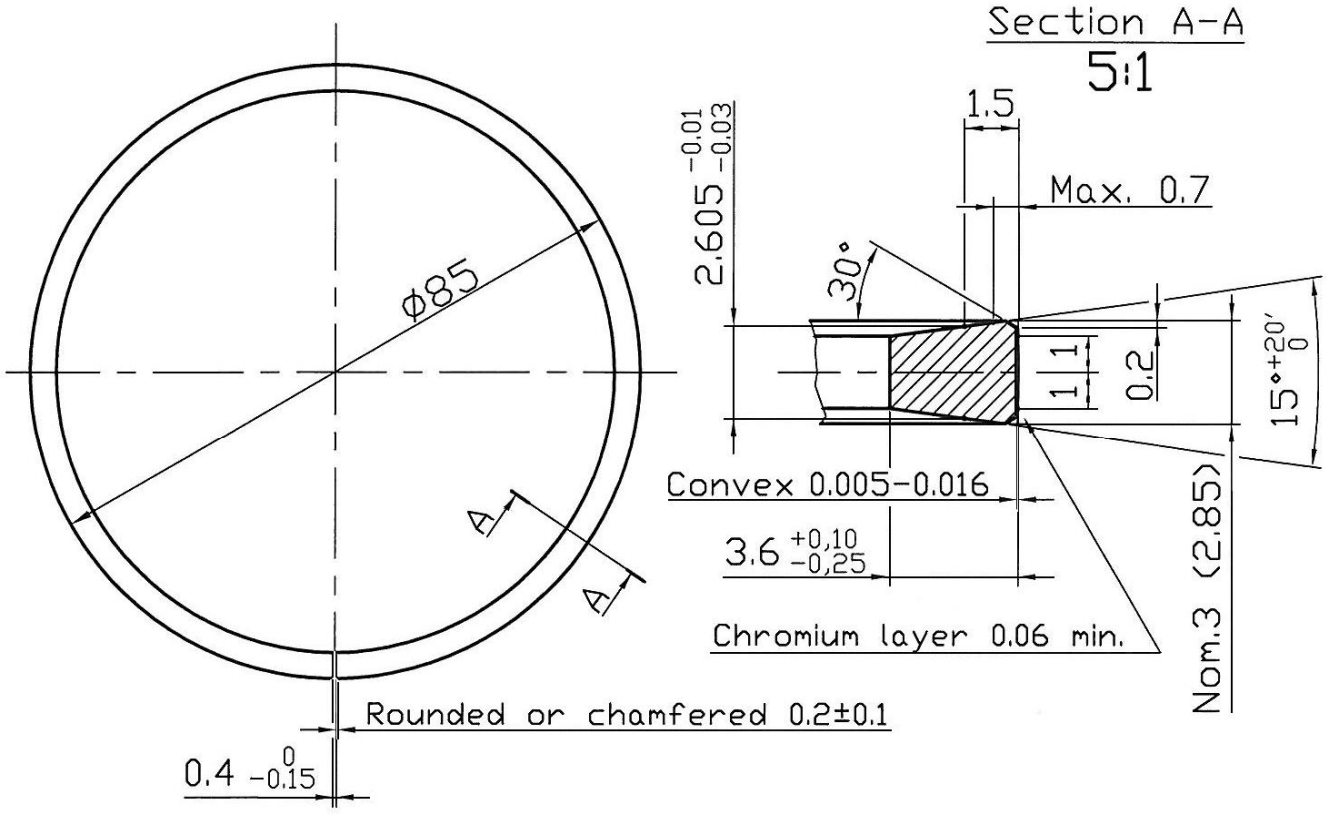
IJ6

Piston sign	Cyl. ø	dN	n1	n2	B	S1	S2
Grade							
Std.	85,0	84,96	76,7	75,7	82,0	84,25	83,5

d1 = dN ±0,009
d2 = (dN eff −0,03) ±0,007
d3 = (dN eff −0,38) ±0,012
d4 = (dN eff −0,56) ±0,012



Piston Ring 1 (Please note page IJ4)



1. Material: Cast iron (TP□1301)
   (1) Analysis (%):

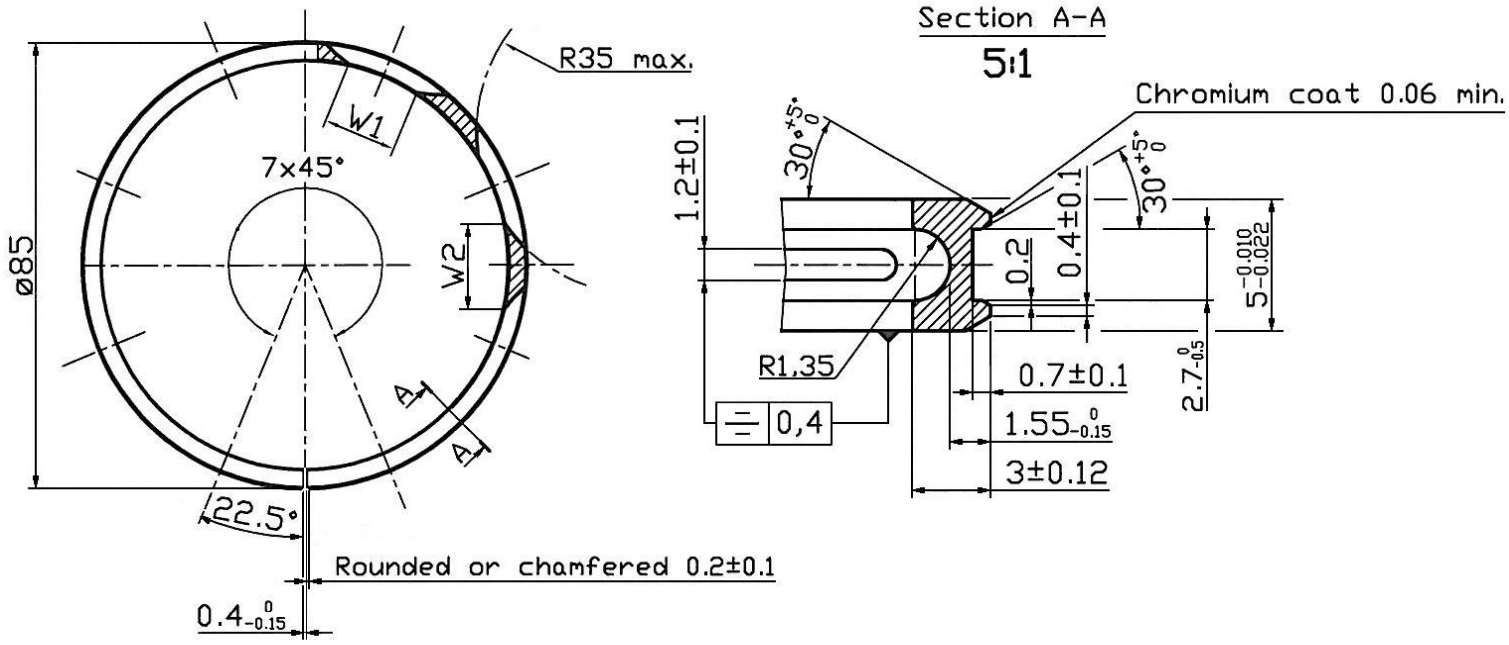
T.C	Si	Mn	P	S
3.3 ~4.1	2.0 ~3.2	0.2 ~0.6	0.15 Max.	0.03 Max.

   (2) Modulus of elasticity: Min. 14000 kp/mm^2
   (3) Ultimate strength: Min. 55 kp/mm^2
   (4) Hardness: 100-110 HRB
2. Tangential force: 2.6±0.41 kp
3. Surface threatment: Phosphated

TP. nr.: K01-087977

Drg.no. 000E6457

Piston Ring 3 (Please note page IJ4)



1. Material: Cast iron (TP01101)
   (1) Analysis (%):

T.C	Si	Mn	P	S	Cr
3.2 ~4.0	2.1 ~3.1	0.4 ~1.0	0.2 ~0.6	Max. 0.12	Max. 0.4

   (2) Modulus of elasticity: Min. 8000 kp/mm²
   (3) Ultimate strength: Min. 25 kp/mm²
   (4) Hardness: 95-107 HRB
2. Tangential force (with spring): 4.76±0.95 kp
3. Surface treatment: Nitrated
4. Allowable diff. between W1-W2: 4 mm
5. Spring: ø2.5±0.05

TP nr. K01-089745-00

Drg.no. 000E6418

Exchange of Piston Rings

The piston ring gap is 0.3 – 0.45 mm (0.0118 - 0.0177 inch) in a new engine.

The wear of the piston rings can be seen by measuring the piston ring gap, and the piston rings must be changed when this is max. 2.0 mm (0.0787 inch).

This is done as follows:

1. Take out the piston with connecting rod as stated on page IJ 3.

2. Remove the piston rings either by a special pair of tongs or by means of two pieces of string which have been folded. With the closed ends around the ends of the piston ring, the piston ring is extended and can be lifted clear of the piston.

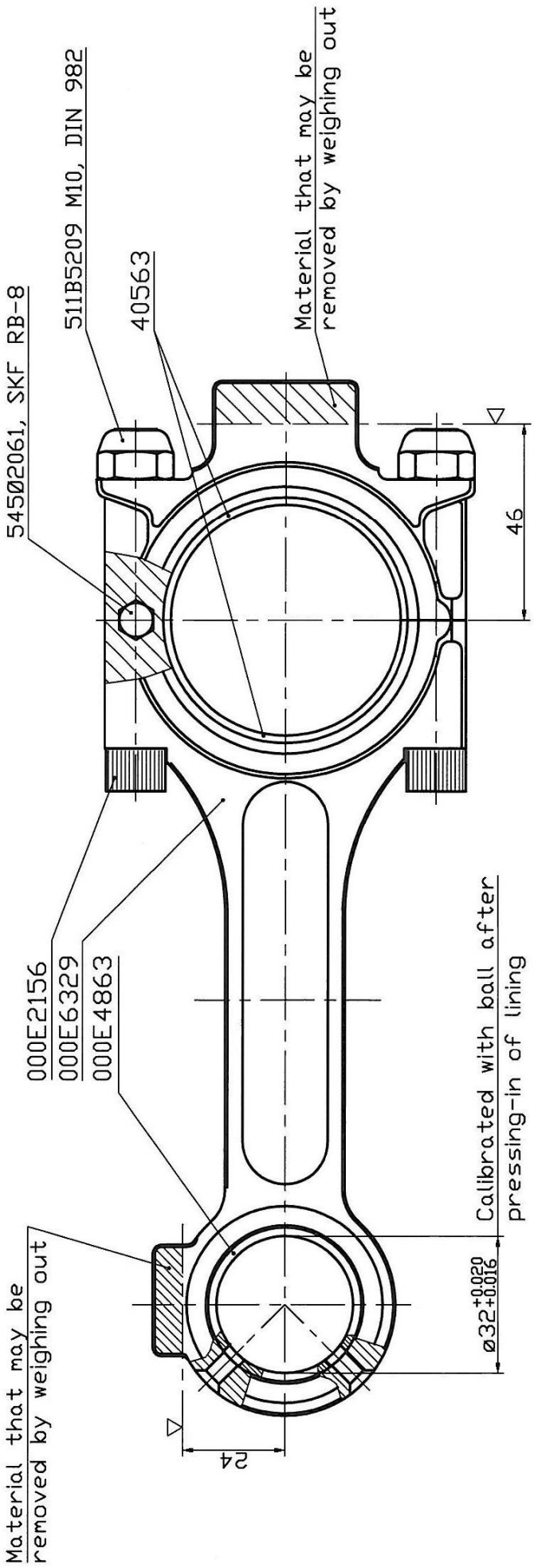
The mounting is carried out in the reverse order after the piston ring grooves have been cleaned. Rotary steel brushes or a steel scrapers should not be used as cleaning tools.

Each piston has three piston rings: two compression rings and one oil scraper ring as shown on the drawing page IJ4. The upper compression ring are shown on page IJ 7 the lower compression ring is a so called M-ring and the oil scraper ring is shown on page IJ8.

Exchange of Piston Pin Bearing in connecting rod

If heavy wear of the piston pin bearing in the connecting rod is found, it may be necessary to exchange it. Particular attention should be paid when exchanging, as the bearing must be calibrated to correct roundness and clearance after the fitting. This is either done with a calibration ball, as indicated on page IJ10, or with a reamer with the tolerance mentioned.

Arrangement of Connecting Rod



Weighing of connecting rod:

Weight of connecting rod complete:	1548 gram $^{+8}_{-20}$ g
Weight of heavy end:	1156 gram ±4g
Weight of light end:	392 gram ±4g
Weight without kush and bearings:	1430 gram ±14g

Connecting Rod Bearings

The connecting rod bearings are in two parts and consists of two steel shells in which a thin layer of bearing metal is cast.

The connecting rod bearings must be exchanged if they are scratched or if the “red” layer between the bearing metal and the steel shell can be seen faintly.

When grinding the crank journal, connecting rod bearings can be supplied in following undersize: 0.6 mm (0.02362inch) (see section L).

Cylinder liner

The bore of the cylinder liner is 85.000 – 85.020 mm (3.3464 – 3.3472 inch). The cylinder liner must be exchanged when it is worn max. 0.3 mm (0.012 inch).

Measuring of Cylinder Wear

Place a new piston ring in the upper end of the liner where this is not worn. Measure the piston ring gap with a feeler gauge. This will be e.g. 0.3 mm (0.012 inch). Place the piston ring lower in the liner where it is worn and measure the piston ring gap again which is now e.g. 0.9 mm (0.0354 inch).

The wear of the liner is then (0.9 – 0.3) / 3 = 0.2 mm. That is: Largest measure less smallest measure divided by 3 (approximate value for ¶).

The cylinder liner can also be measured with a cylinder template gauge.

Dismounting of Cylinder Liner

1. Remove the cylinder head (see section C page 7).

2. Take out the pistons (see page IJ 3).

3. Cover the connecting rod journals with a piece of oil paper or plastic.

4. Pull out the cylinder liners with a special tool or place the engine block on the side and knock out the cylinder liners carefully with a wooden block as filling piece. Knock the liners from the bottom and upwards.

Mounting of Cylinder Liner

There is no gasket between cylinder liner and the engine block at the top. The joint faces must therefore be completely clean and without burrs. Grind with abrasive compound, if required.

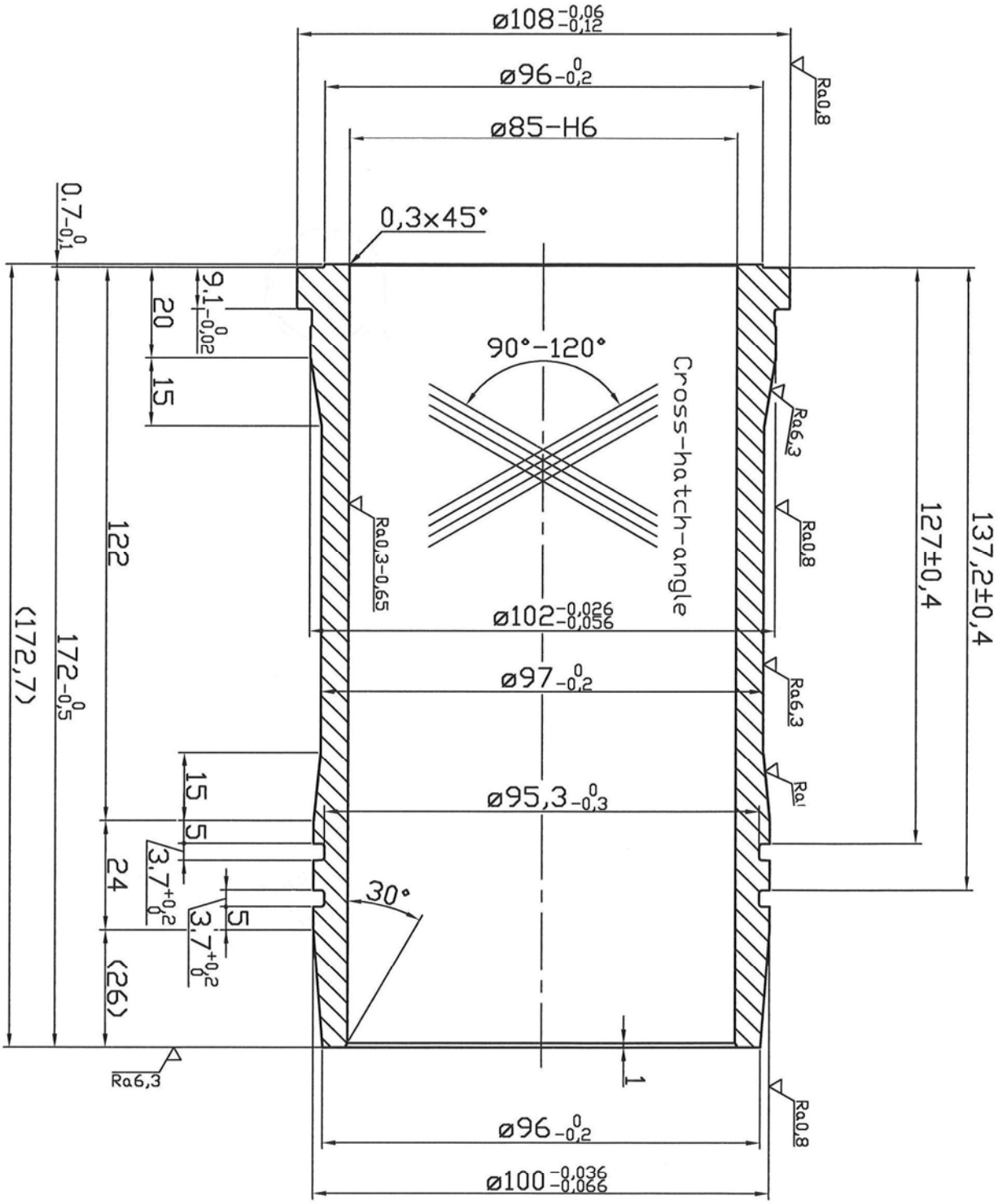
The rubber rings of the lower edge of the cylinder liner must be renewed at each disassembly and they must not be twisted when mounting.

The rubber rings and the collar may be supplied with a thin coat of jointing paste at the mounting.

When the above things are in order put back the cylinder liner in the engine block – by means of a wooden block.

After the mounting you must check the clearance of the liner above the engine block. This clearance must be 0.10 – 0.20 mm (0.0039 – 0.0079 inch).

Test Measurements of Cylinder Liner



Drwg. No. 000E4788

SECTION L

CRANKCASE, CRANKSHAFT, MAIN BEARINGS AND OIL SUMP

CONTENTS

Dismounting of crankshaft ..... page L 3

Change of main bearings ..... page L 3

Rear part of crank ..... page L 4

Rear gear-wheel and rear part of crank ..... page L 5

Marking of front gear-wheel on crank ..... page L 6

Front part of crank ..... page L 7

Repair dimensions of crakshaft ..... page L 8

Connecting rod journals ..... page L 8

Main bearing journals ..... page L 8

Main bearings ..... page L 8

Oil sump ..... page L 9

Dismounting of crankshaft

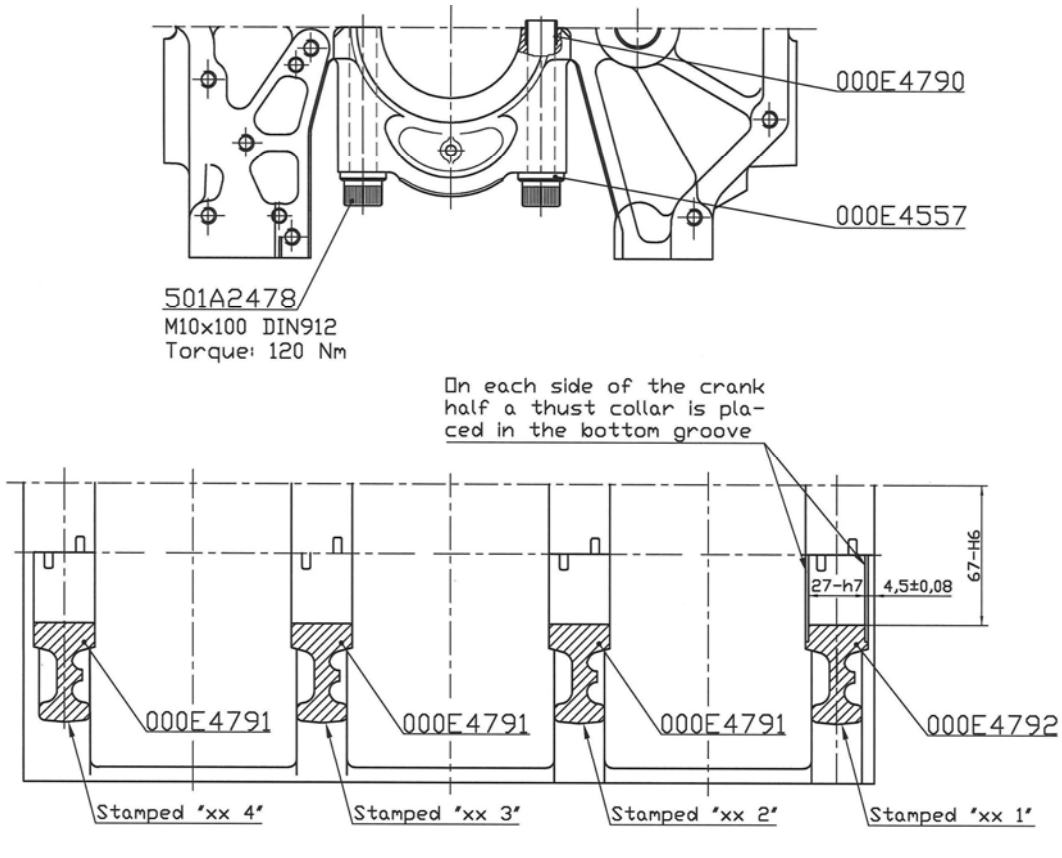
1. Remove the cylinder head with manifold (see section C page 4).
2. Dismount the flywheel (see section D page 3).
3. Dismount the gear (see section R page 3).
4. Dismount the rear end cover (see section G page 3).
5. Turn the engine upside down.
6. Remove the oil sump.
7. Dismount the pistons and the connecting rods (see section IJ page 3).
8. Dismount the front end cover (see section E page 3).
9. Remove the bearing caps and lift out the crank.

The mounting of the crankshaft takes place in reverse order, the bearing caps being fastened at a torque of **12 kpm** (86.8 ft.lbf). Further make sure that the two thrust collars are correctly fitted in accordance with the drawing below.

Change of main bearings

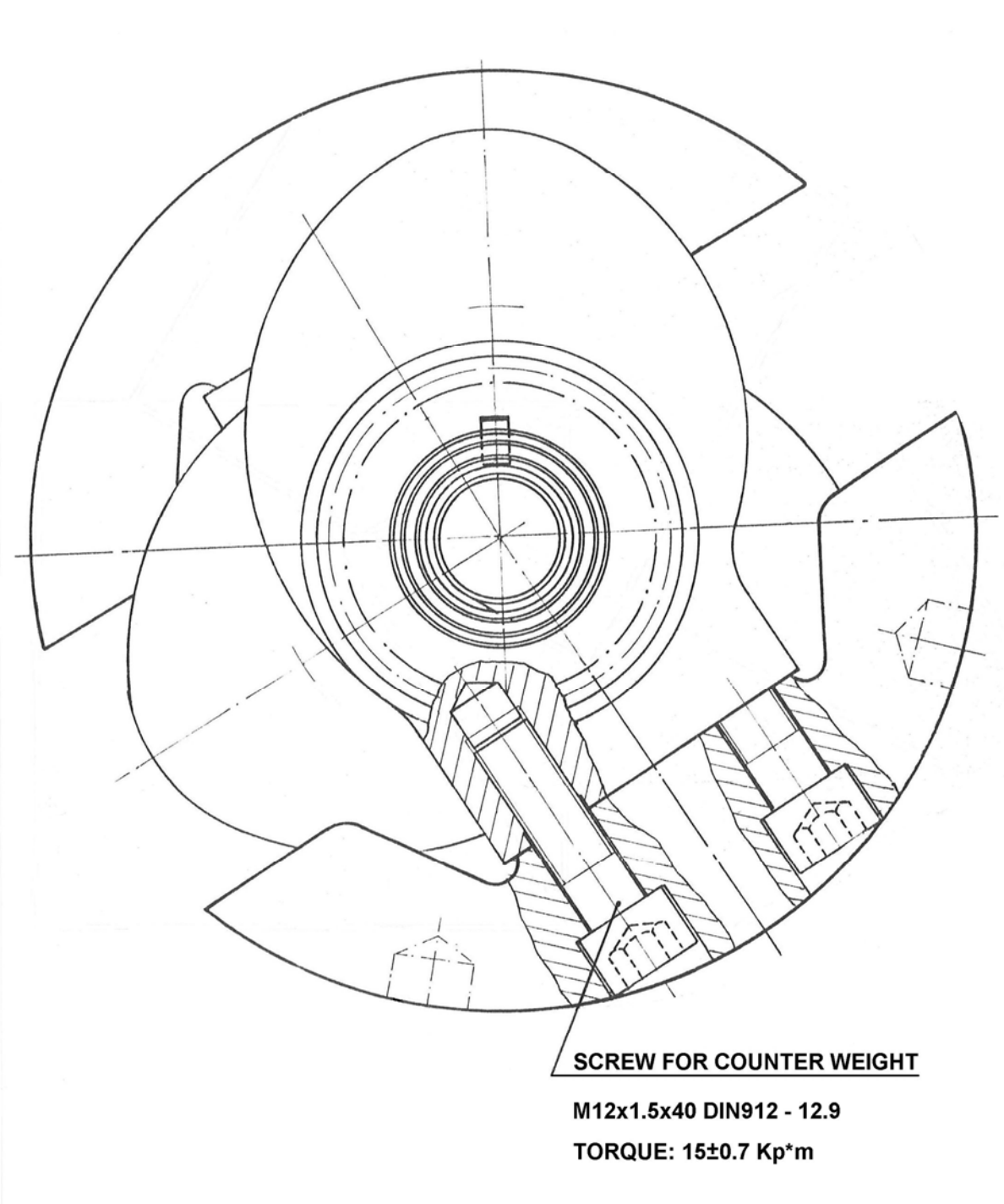
Proceed in the same way as when dismounting the crankshaft.

As will appear from the drawing below, the caps are stamped in proportion to corresponding part of the engine block. Observe this marking when disassembling.



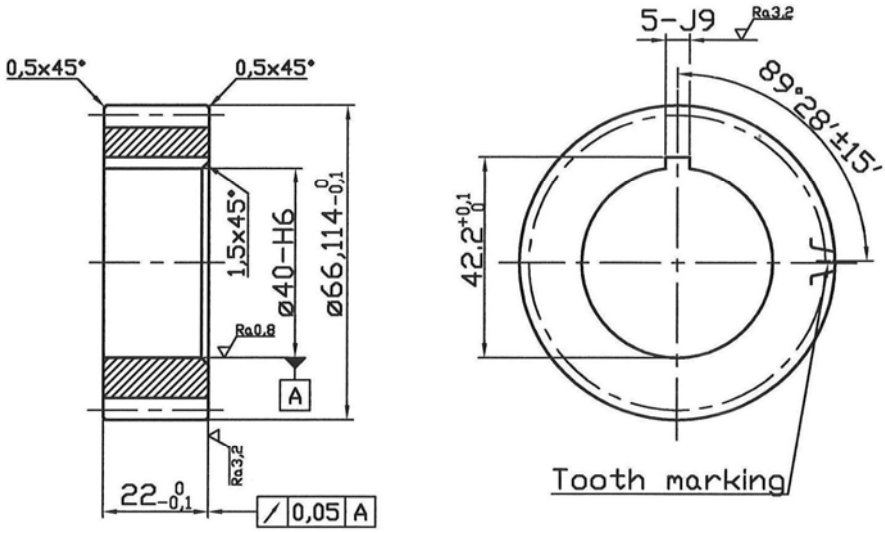
Rear part of crank

The drawing below shows the rear part of the crank with screwing-on of the counter weights of the crankshaft.



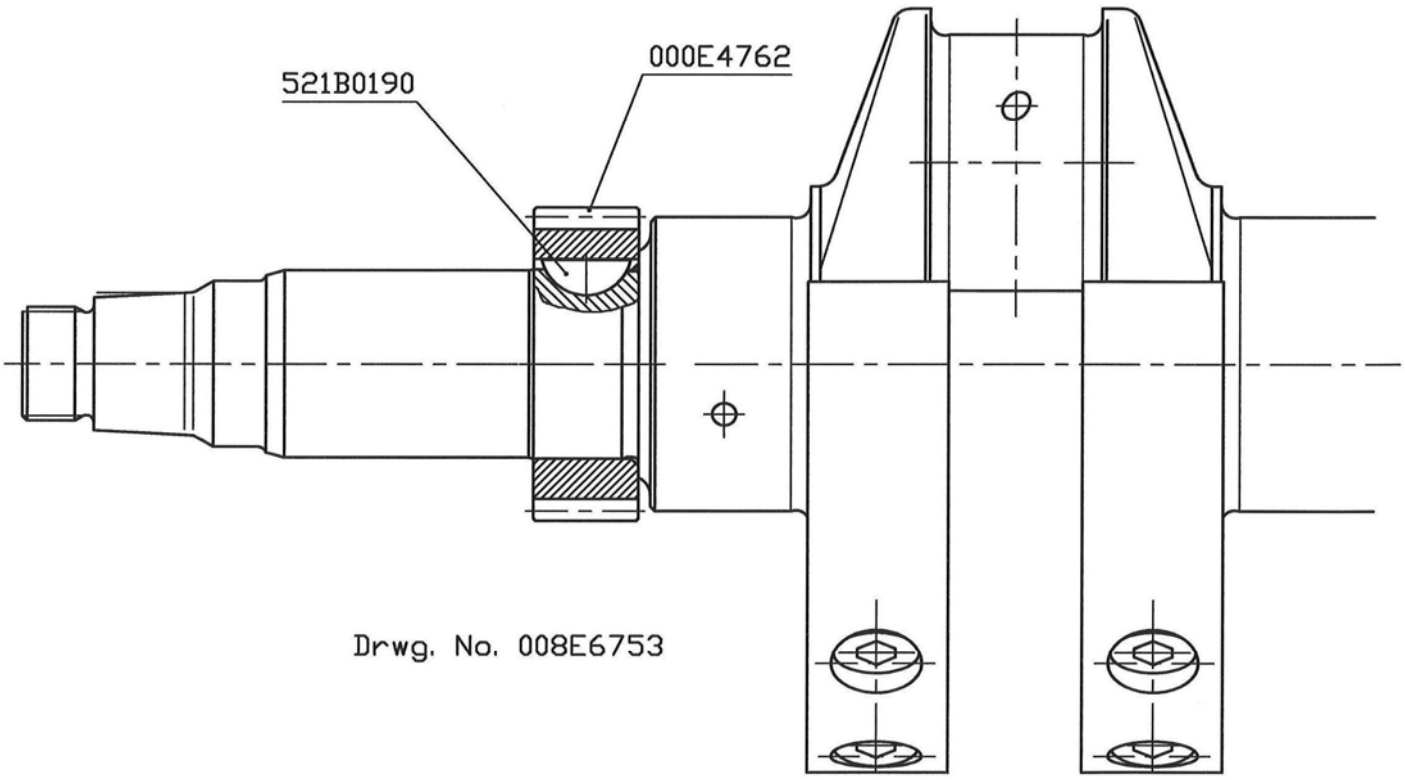
Drwg. No. 008E4757

Rear gear-wheel and rear part of crank



Drwg. No. 000E4762

When shrinking the gear wheel drwg. 000E4762 the temperatur difference (crankshaft-gear wheel) should be 230°C.



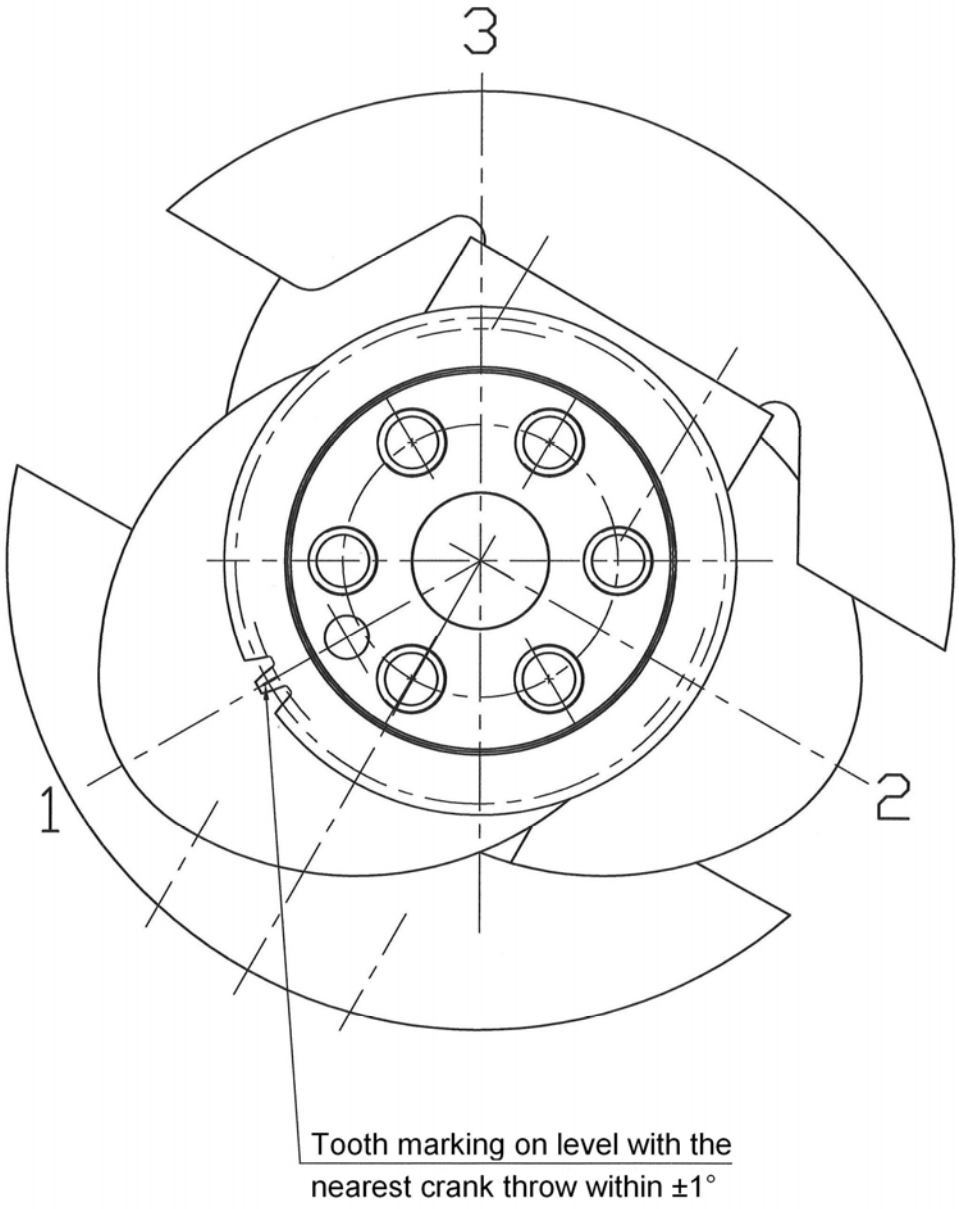
Drwg. No. 008E6753

Marking of front gear-wheel on crank

The front gear-wheel on the crank drives the front rotating weight and is marked in proportion to this and in accordance with the drawing below.

The gear-wheel has been shrinked on the shaft. When shrinking on a new gear-wheel there should be a difference of temperature between the crankshaft and the gear-wheel of 231 C.

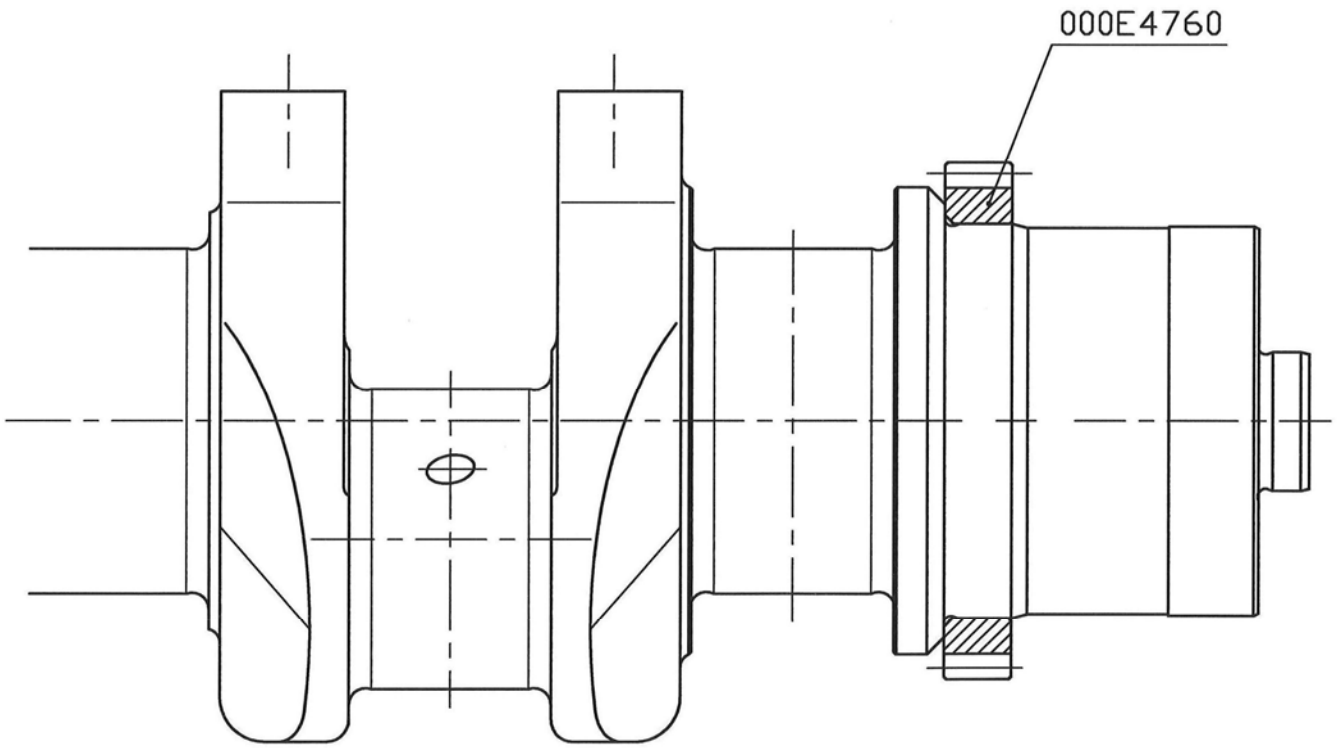
Further see the drawing overleaf.



Drwg. No. 008E6753

Front part of crank

When shrinking the gear wheel drwg. 000E4760 the tempe-
ratur difference (crankshaft-gear wheel) should be 230°C.



Drwg. No. 008E6753

Repair dimensions of crankshaft

The crankshaft is made of drop-forged, heat-treated steel. Thus it is possible to gring the crankshaft without subsequent surface treatment.

The crankshaft must never be repaired with hard chromium-plate or metal feeding, but only by grinding in accordance with the below mentioned measures and tolerances to which we supply undersize bearings.

The crankshaft should be ground, if it is oval and the smallest diameter is 0.05 mm (0.002 inch) below the diameter it had when leaving the factory.

Connecting rod journals

Standard ..... 53.987 – 54.000 mm (2.1255 – 2.1260”)

0.6 mm undersize ..... 53.387 – 53.400 mm (2.1019 – 2.1024”)

Clearance between bearing and journal……..…..0.028 – 0.068 mm (0.0011 – 0.0027”)

Main bearing journals

Standard ..... 61.981 – 62.000 mm (2.4402 – 2.4409”)

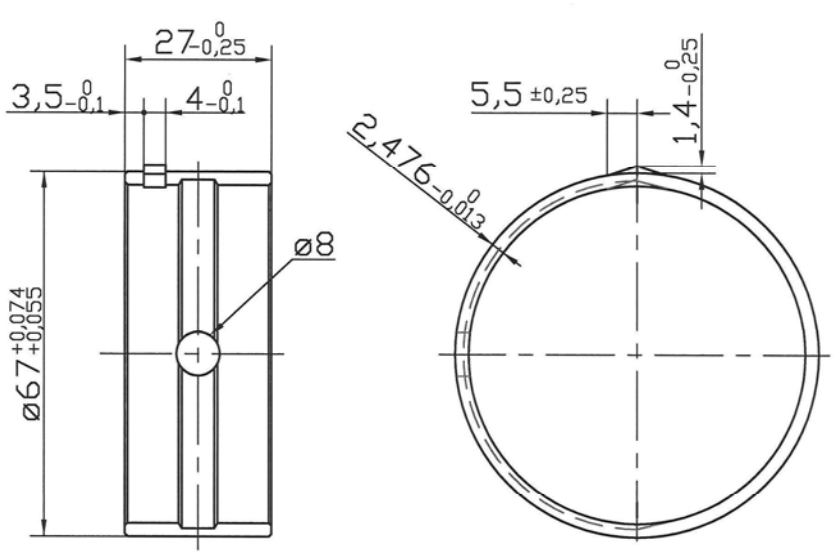
0.6 mm undersize ..... 61.381 – 61.400 mm (2.4166 – 2.4173”)

Clearance between bearing and journal ....0.048 – 0.112 mm (0.0019 – 0.0044”)

Main bearings

The engine is fitted with four two-piece main bearings as shown on the drawing below.
The bearings must be changed when the “red” layer under the bearing metal can be seen faintly, or if the bearings are much scratched.

Bearing shell: C10 2.1 mm thick
Bearing material: tin aluminium with net structure
External surface: tinned 0.001 mm thick



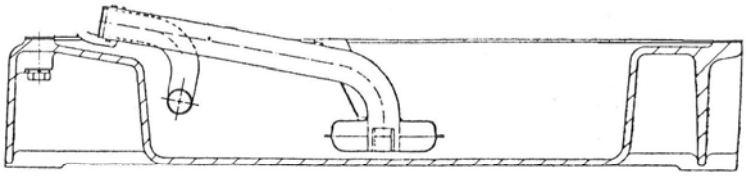
Drwg. No. 000E4765

Oil Sump

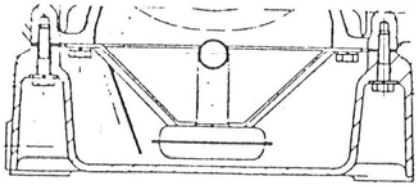
The engine is fitted with an oil sump of cast iron. The oil sump is fixed to the crankcase and is ensured correct position to this by means of guide pins.

Under the oil sump the suction strainer for the lubricating oil system is placed and pipe connections for it.

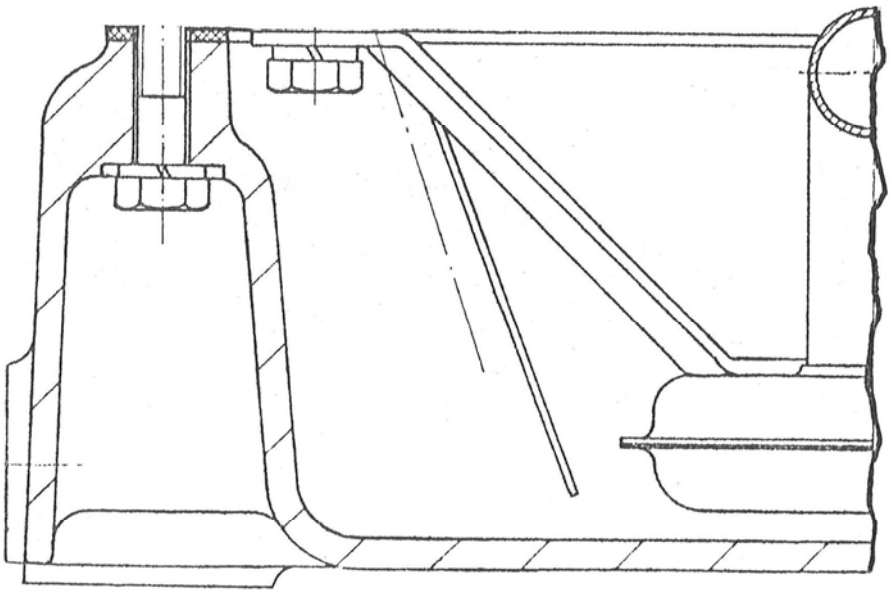
The oil sump with pipe arrangement for lubricating oil system is shown on the drawing below.



Longitudinal section



Cross section



Cross section

SECTION M

CAMSHAFT, COMPLETE

CONTENTS

Camshaft ..... page M 3

Valve timings ..... page M 4

Guide for push rod ..... page M 4

Gear-wheel of camshaft ..... page M 5

Drawing of push rod ..... page M 6

Drawing of push rod guide ..... page M 7

Camshaft

The camshaft runs in borings in the engine block, and it has been forced-lubricated through grooves bored in the engine block.

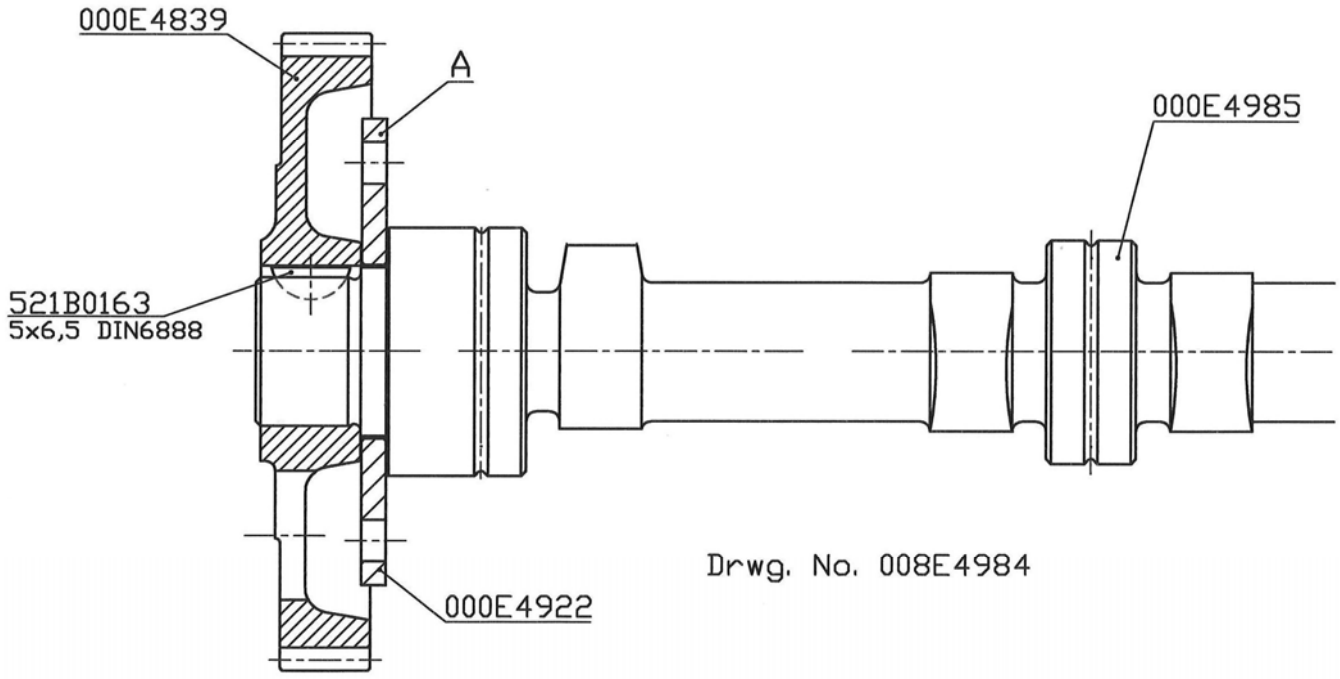
A bush for the camshaft is fitted in the front end of the engine block. There is a hole for lubricating oil inlets in this bush.

The camshaft is fixed on to the engine block at the flange **"A"** on the sketch below.

The cams which are casted together with the camshaft are made of hardened steel.

The camshaft is driven via a gear-wheel from the crankshaft.

When dismantling the camshaft remove gear and rear end cover as stated in sections R and G. Then loosen the camshaft at the flange **"A"** on the sketch below and take it out.



Valve timings and injection point

Flywheel diameter ..... 370 mm

Inlet valve opens ..... before TDC: 32° (arc measure: 103 mm (4.07”))

Inlet valve closes..... after BDC: 64° (arc measure: 207 mm (8.14”))

Exhaust valve opens ..... before BDC: 64° (arc measure: 207 mm (8.14”))

Exhaust valve closes..... after TDC: 32° (arc measure: 103 mm (4.07”))

Injection starts..... before TDC: 6.2° (arc measure 20 mm (0.79”))

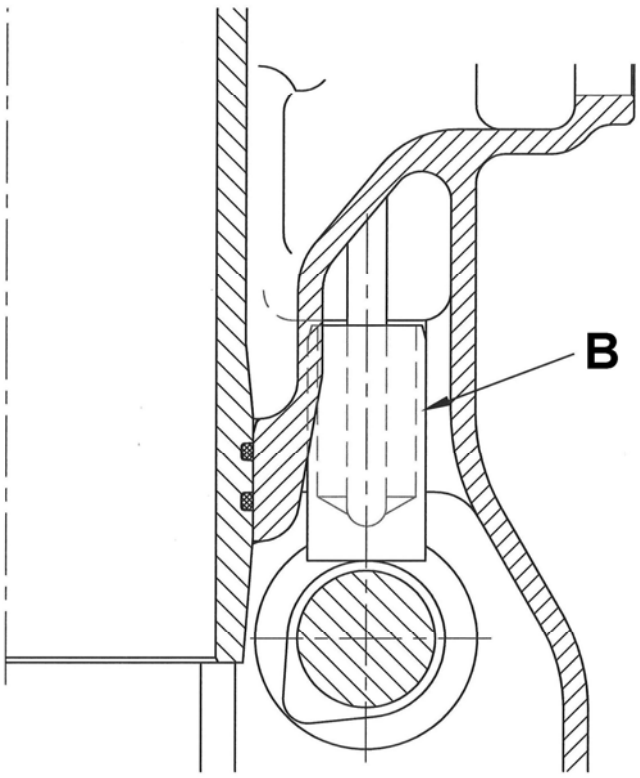
Valve clearances (cold engine).. inlet: 0.30 mm (0.01180”)

exhaust: 0.30 mm (0.01180”)

Guide for push rod

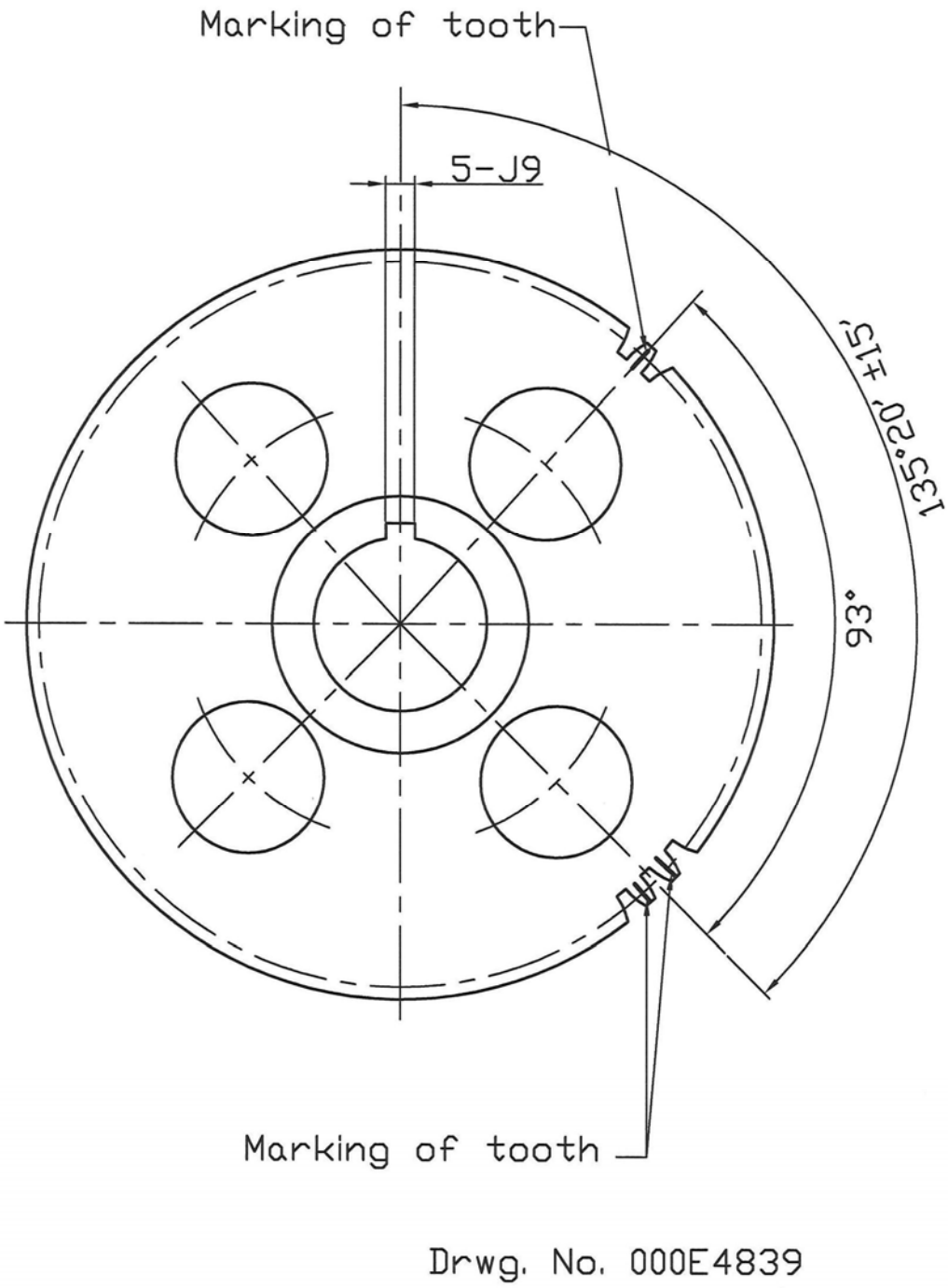
On the picture below the guide for push rod is shown in position **“B”**.
When removing the camshaft the guide for push rod should be kept up in its pilot hole in the engine block by means of grease or by means of magnets.

The guides for push rod may be fitted from under side or from top side of the engine block.

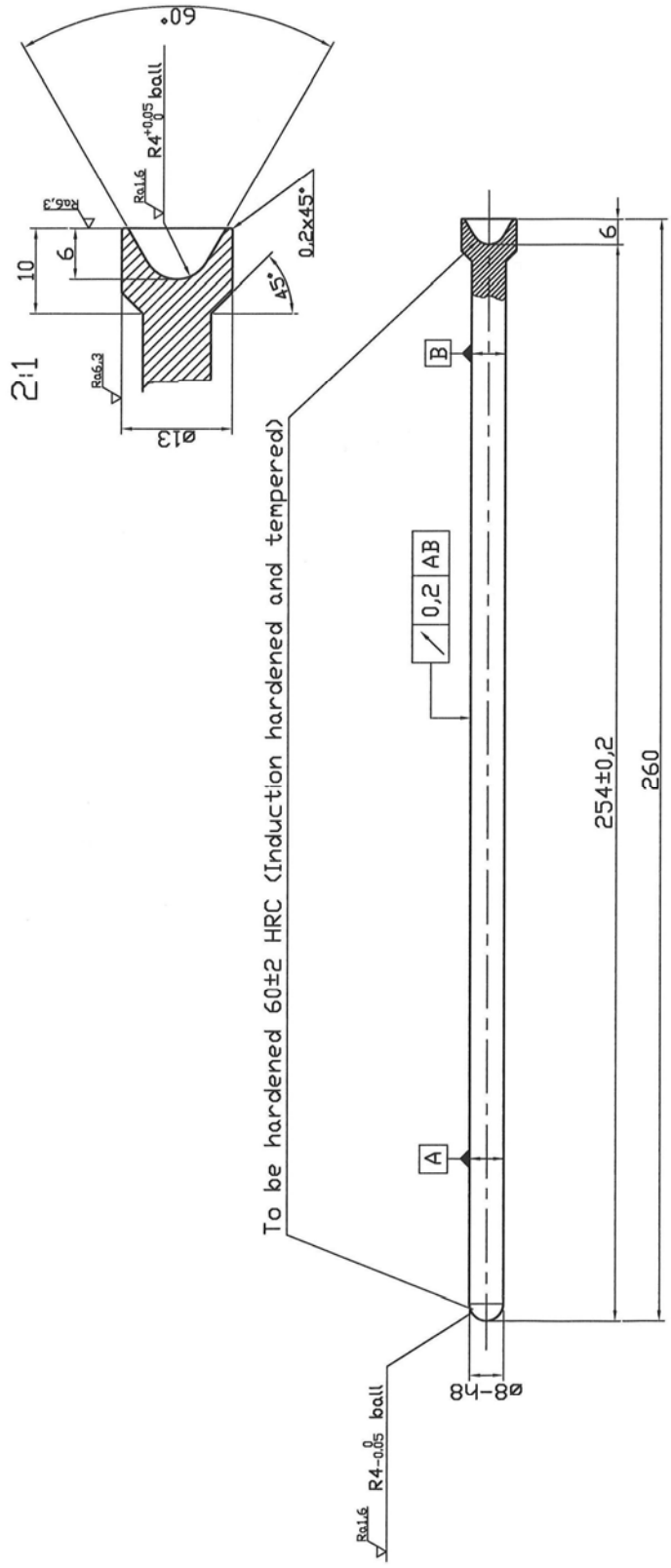


Gear-wheel of camshaft

The camshaft gear-wheel is equipped with a single mark for its correct position in relation to the rear rotating weight and a double mark in relation to intermediate wheel (see instructions in section G page 3).

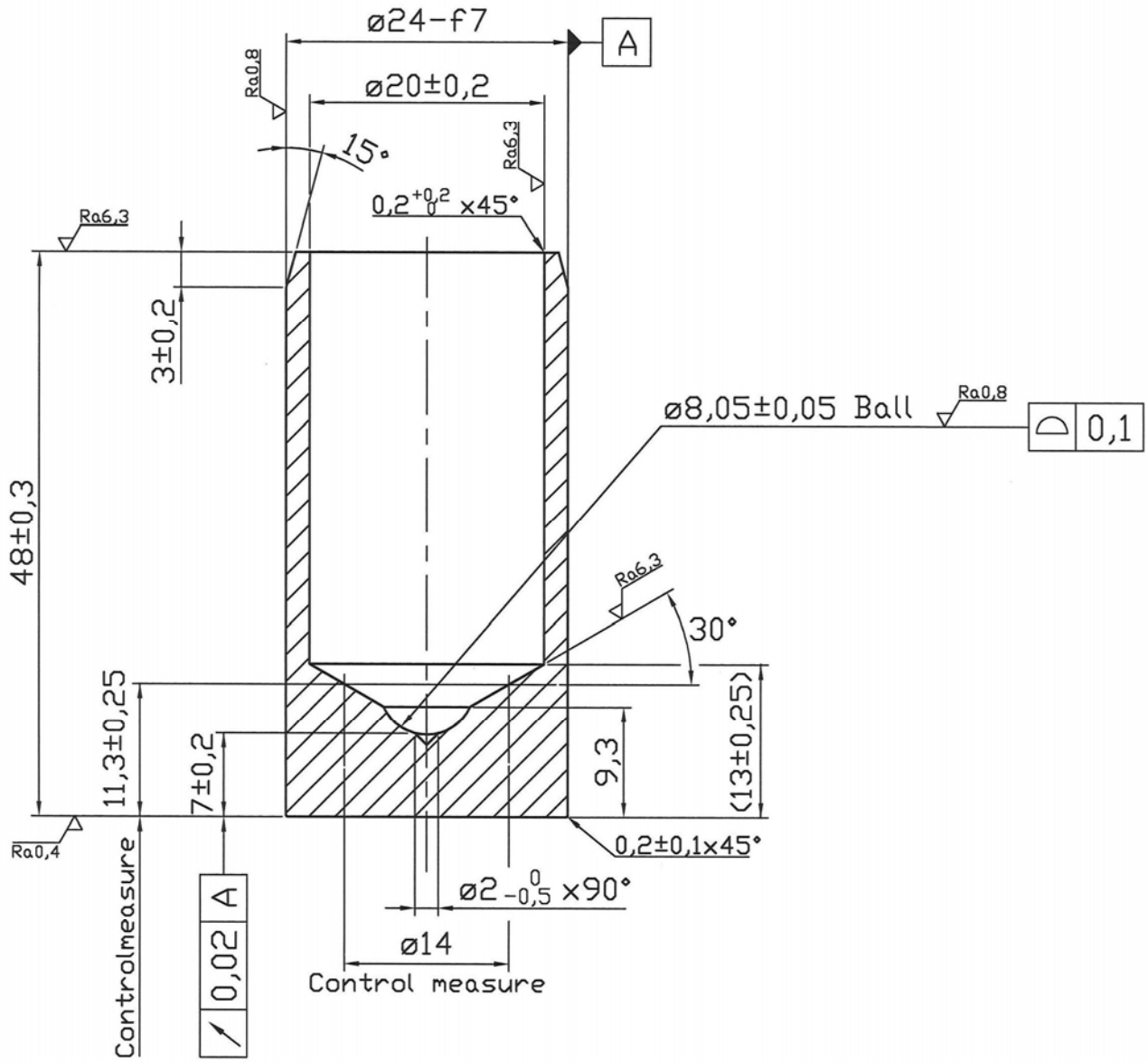


Drawing of pushrod



Drwg. No. 000E9455

Drawing of push rod guide



SECTION N

LUBRICATING OIL SYSTEM

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Pressure relief valve ..... page N 3

Fitting of dip stick ..... page N 4

Pipe connections in oil sump ..... page N 5

Lubricating oil pump ..... page N 6

Removal of lubricating oil pump ..... page N 6

Lubricating oil cooler ..... page N 7

Removal of lubricating oil cooler ..... page N 7

Change and quality of lubricating oil ..... page N 8

Lubricating oil filter ..... page N 9

Lubricating oil system

The engine is lubricated through a pressure lubrication system. The lubricating pump driven by the camshaft sucks oil from the oil sump through a strainer. From the lubricating pump the oil is pressed through a fine filter to the respective lubricating points through oil ducts bored in the goods. A reduction valve in the lubricating system secures that the oil pressure is kept between **2.0** and **4.0 Bar** at hot engine and max. revolutions.

Pressure relief valve

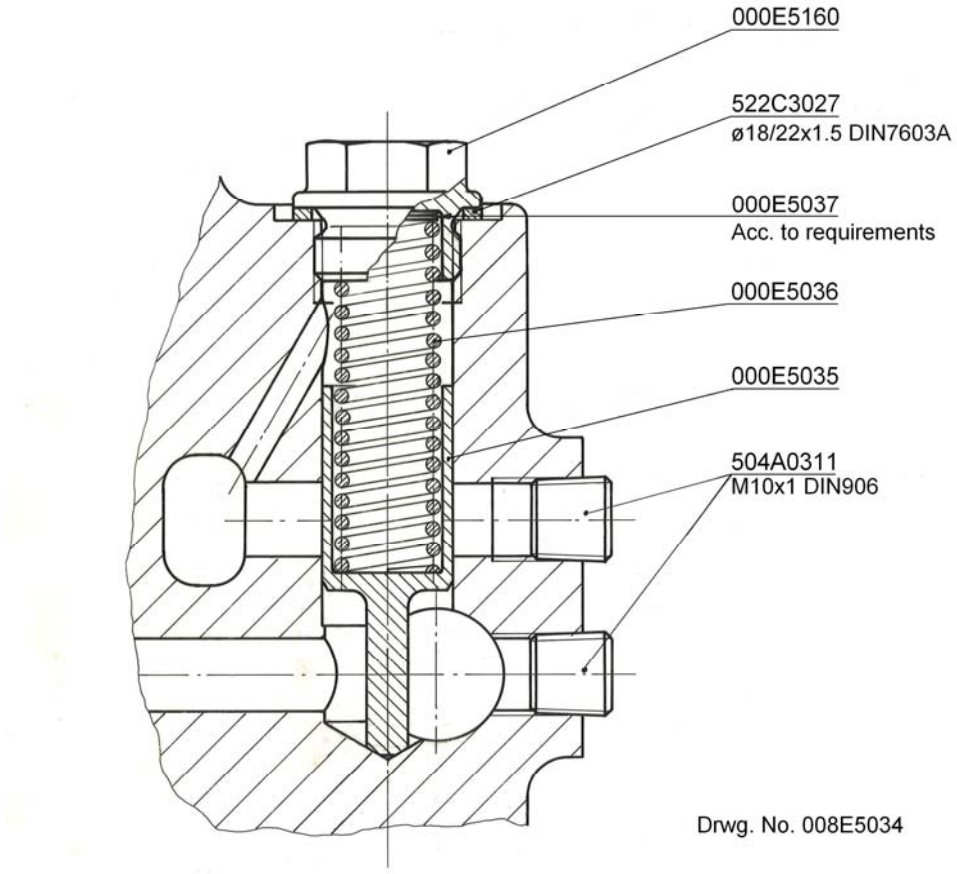
The pressure relief valve is fitted on the front of the engine in bore in the engine block in vertical position in the same side as the lubricating oil filter. The valve is built up as shown on the drawing below, and the purpose of this valve is to reduce the lubricating oil pressure to 2-4 Bar before this goes out into the system.

Min. lubricating oil pressure at idling and with warm engine is 1.0 Bar.

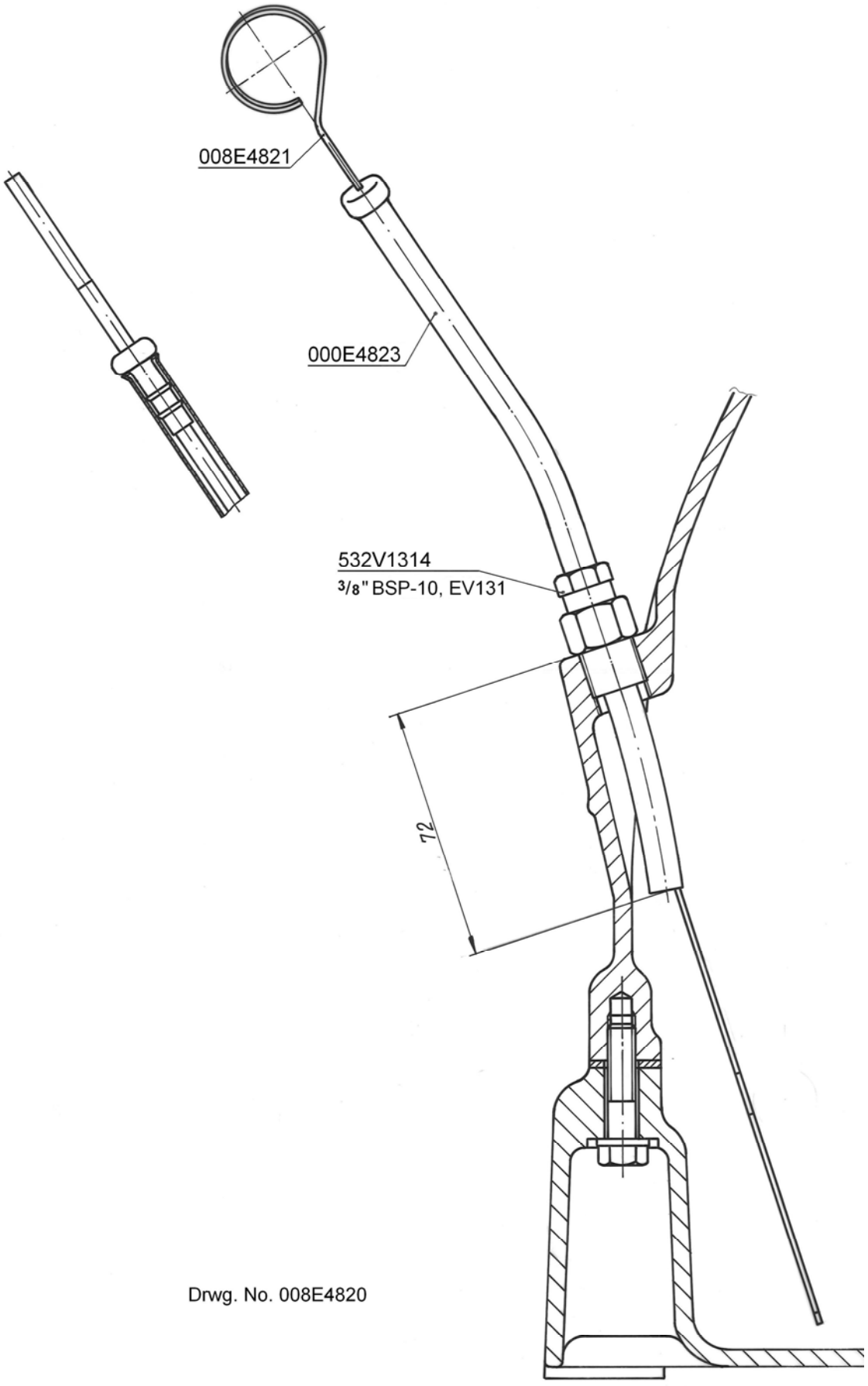
The lubricating oil pressure can be adjusted by means of intermediate washers as shown on the drawing.

Removal of washers gives lower lubricating oil pressure.

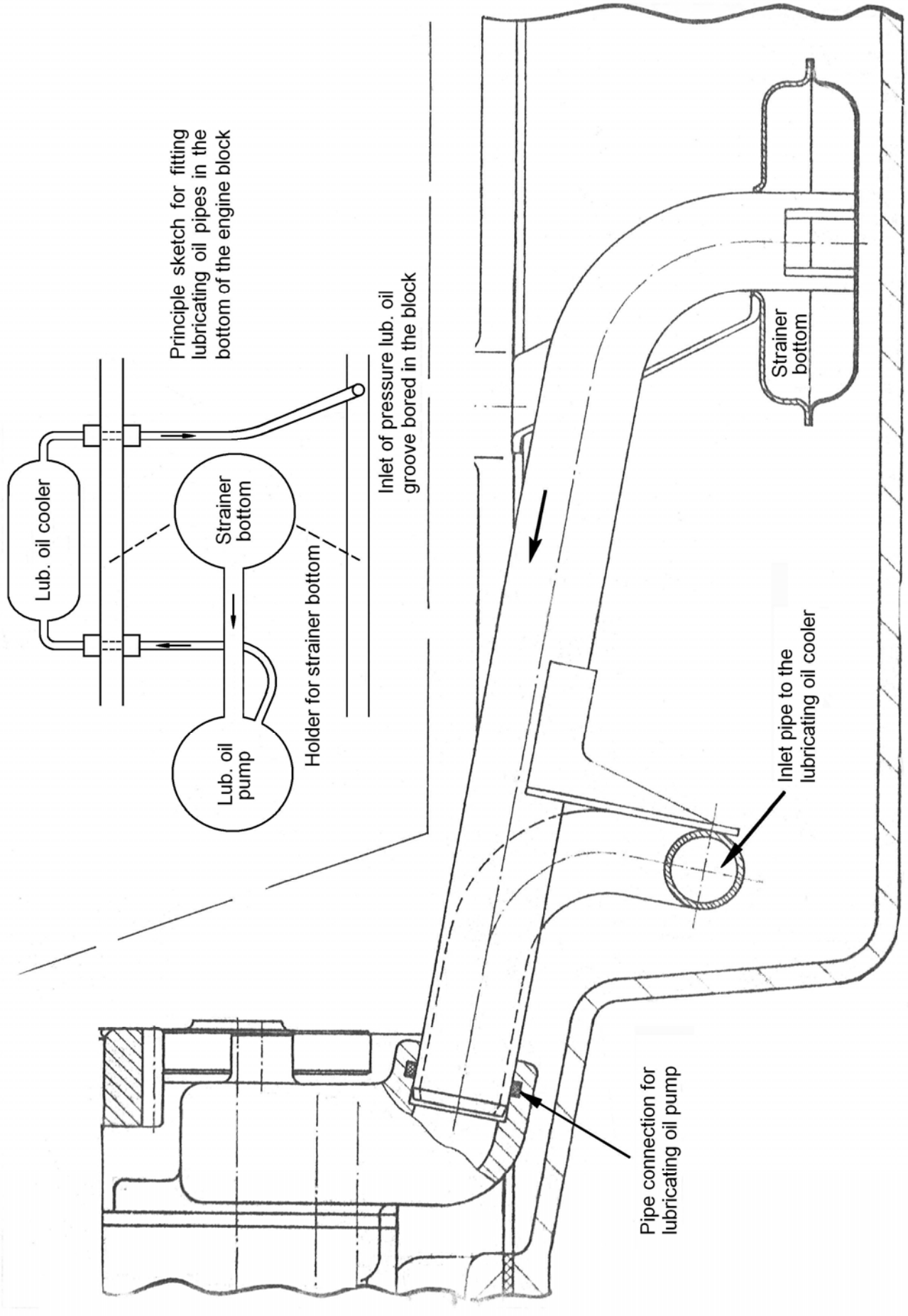
Dirt in the pressure relief valve may result in a low lubricating oil pressure and thus the piston 000E5035 should be taken out and cleaned if necessary.



Fitting of dip stick



Pipe connections in oil sump



Lubricating oil pump

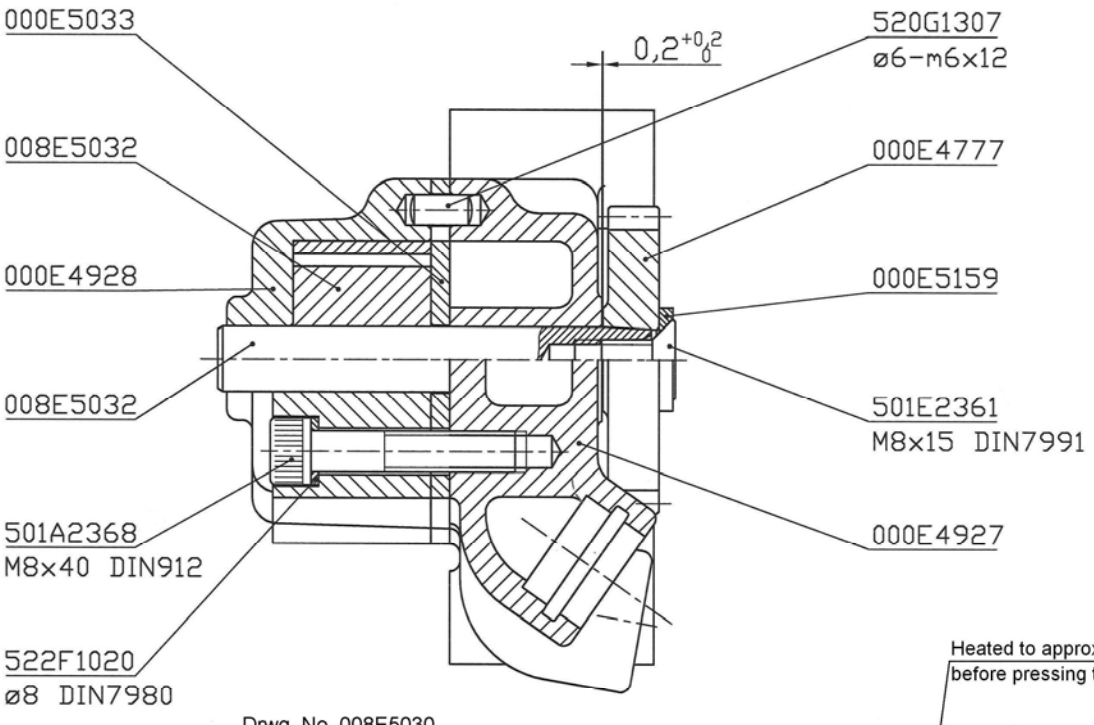
The lubricating oil pump is placed below the rear end cover and actuated via the rear gear-wheel of the crank and a gear-wheel fixed to the shaft of the pump.

The pump is an Eaton pump with star rotor and life ring.

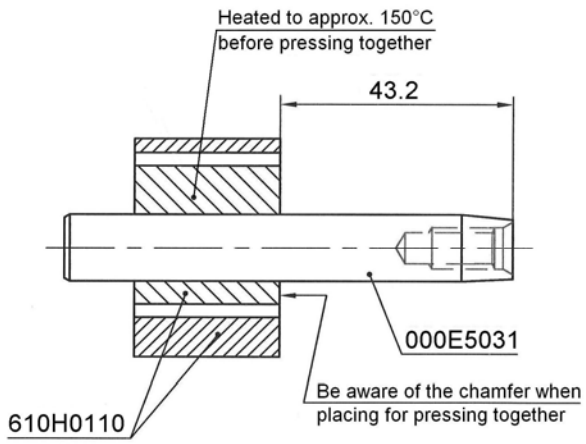
When the engine runs at full speed, the pump runs 4000 r.p.m. and thus supplies 33.15 litres lubricating oil per minute to the lubricating oil system.

Removal of lubricating oil pump

1. Remove the gear (see section R page 8).
2. Remove the rear end cover (see section G page 3).
3. Loosen the three fixing bolts of the lub. oil pump frfom the engine block.
4. Pull the free lub. oil pump from the pipe connections in the oil sump and lift it clear.
5. Loosen the bolts on the front cover of the lub. oil pump and then it can be dismantled.



Drwg. No. 008E5030



Drwg. No. 008E5032

Lubricating oil cooler

The standard engine is equipped with a lubricating oil cooler, fitted as shown on the drawing below.

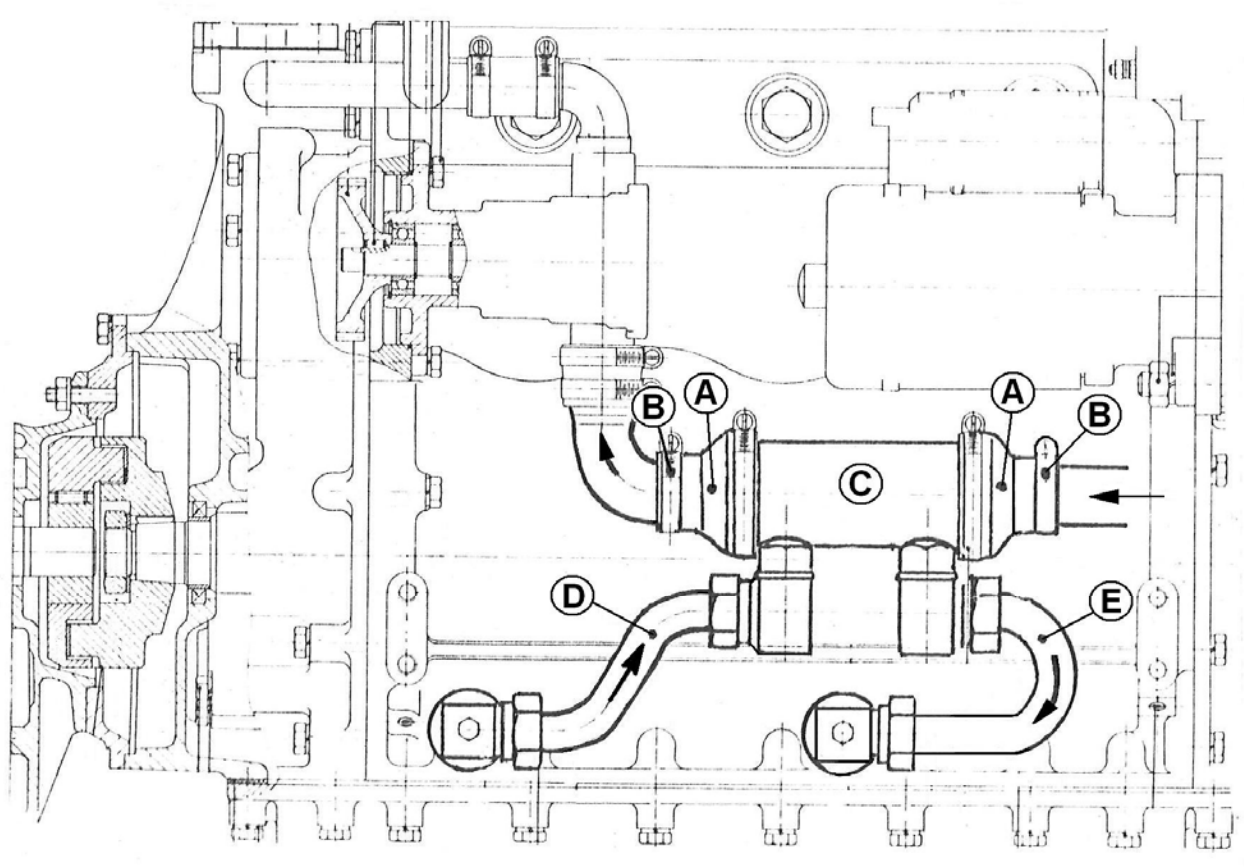
On the water side the cooler is connected between the cooling water pump and the cooling water suction hose, and on the oil side it is connected to the outlet of the lubricating oil pump to the lubricating oil system.

The end pieces **"A"** of the cooler consists of two profile-cast rubber tubes fastened to the cooler and the cooling water pipes with clips **"B"**. The cooler **"C"** consists of a nest of pipes through which the cooling water passes, whereas the lubricating oil runs round the pipes.

As the lubricating oil pressure is higher than the cooling water pressure, the cooler should be examined by pressure testing and inspected for corrosions in case of loss of lubricating oil without external visible leaks.

Removal of lubricating oil cooler

1. Remove the lub. oil pipes **"D"** and **"E"**..
2. Loosen the cooler from its attachment to the engine block.
3. Loosen the clips **"B"** on the inlet and outlet water pipes of the oil cooler.
4. Take off the cooler and dismantle it further by removing the profile-cast end pieces fastened by clips.



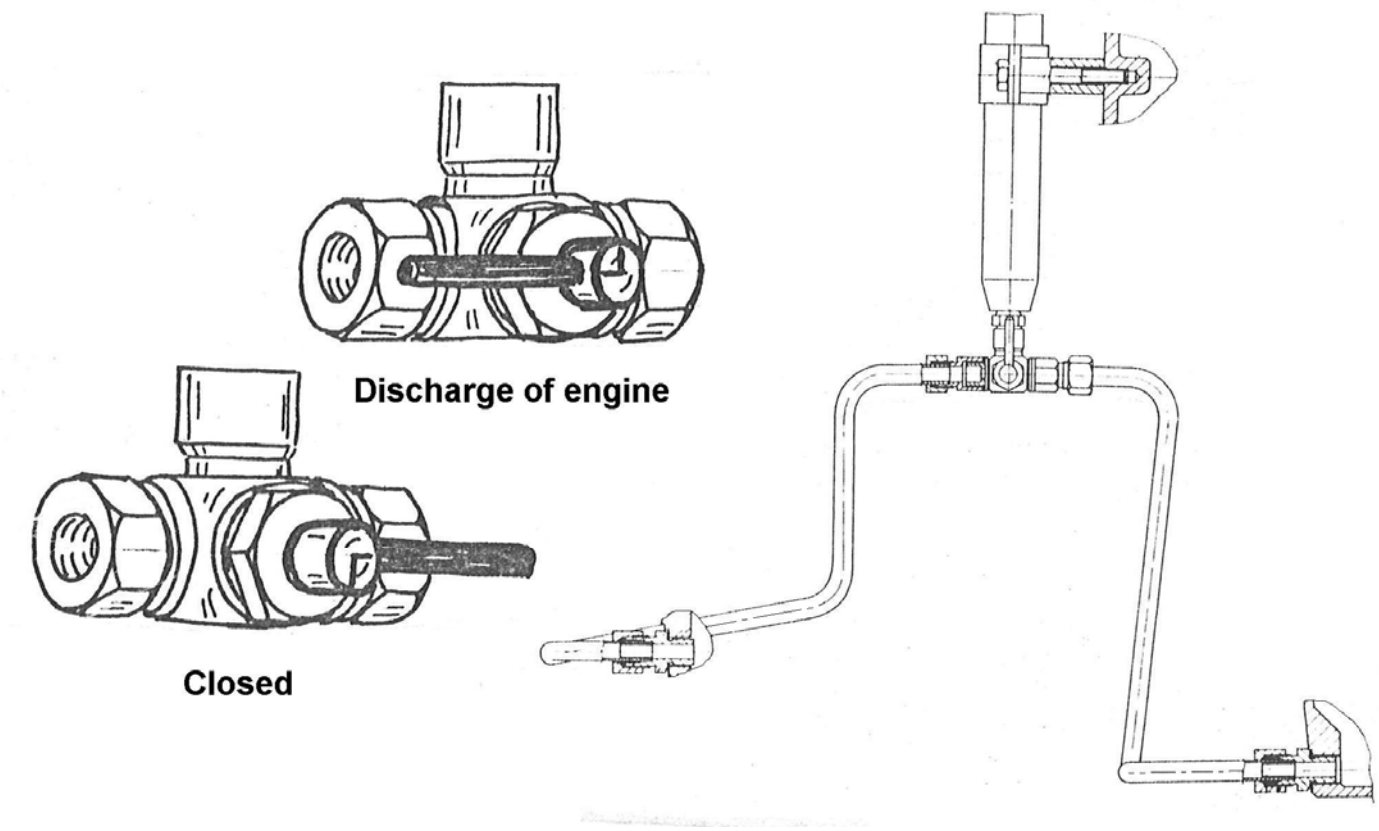
Change and quality of lubricating oil

Exchange the lub. oil every 150 operating hours or once a year.

This is done with a bilge pump, fitted on the engine. This pump can be set for emptying the engine or gearbox of lub. oil by means of the three-way cock.

Lub. oil content inclusive of filter is 4.9 Litres.

Pour fresh oil through the filling hole in the top cover.



Normally a lubricating oil quality mark “Service CC” must be used, but for operation under difficult conditions, i.e. frequent cold starting, short working periods, very varying load, quality marked “Service CD” must be used.

Besides, quality marked “Service CD” must be used if the sulphur content of the fuel is higher than 1 per cent.

The chosen viscosity of oil depends on the air temperature at the engine.

In air temperatures at the engine below 5°C viscosity SAE 10 is used or 5W/30 multigrade.

In air temperatures at the engine between 5°C and 25°C viscosity SAE 20 is used or 10W/30 multigrade.

In air temperatures at the engine above 25°C viscosity SAE 30 is used or 15W/40 multigrade.

As many lubricating oils today are multigrade the above should be used as a guidance for choosing an oil with the correct spectrum of viscosity.

For lifeboat engines where cold start is required down to minus 15°C within 2 minutes MOBIL OIL NO 1 or similar must be used for the engine as well as for the gearbox.

Lubricating oil filter

The lubricating oil filter is a disposable one which cannot be cleaned.

Exchange the filter every 150 operating hours or once a year.

Remove the filter by hand and discard it.

Tighten the new filter by hand too.

When changing the filter clean the sealing surface on the engine block, if necessary, and lubricate the rubber gasket of the filter with a little clean oil.

After changing the filter start up and check that the filter and the sealing surface towards the engine are tight.

A difference valve is fitted in the filter, and this valve shuts out the lubricating oil from the filter so that the oil is not cleaned any longer if the difference pressure is getting too high over the filter.

Various makes of oil filters can be used as e.g. the motor-car industry uses the filter type used, as standard.

The BUKH filter used is of make Mann & Hummel type W9.30.

SECTION O

COOLING WATER SYSTEM

CONTENTS

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Dismantling of intermediate housing ..... page O 4

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Refitment of pump ..... page O 5

Circulation pump for freshwater..... page O 6

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Thermostate ..... page O 9

Header tank and heat exchanger ..... page O 10

Dismantling of heat exchanger ..... page O 10

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Keel cooler arrangement ..... page O 12

The engine can be c ooled by direct seawater cooling which is supplied as standard cooling system. Alternatively freshwater cooling can be supplied as extra equipment and this c an be arranged in three different ways: either with heat exchanger, keel cooler or with radiator cooling. However, the latter will n ot be of i mmediate importance when using the engine as marine engine and therefore it is not dealt with separately in this section.

Generally the basic design of engine as a marine engine does that indirect cooling will not be benefitial unless the engine is us ed for more than 500 hours of r unning per year. However other circumstances like use in proluted rive r and narrow waters can do that i.e. a keel cooling system is recommended. Keel cooling is always used for Lifebo at Engines due to SOLAS requirements.

In case of direct seawater cooling the seawater is drawn through the external strainer and the lubricating oil cooler to the cooling water pump (Johnson type F5B9) from where the water is fed through the cooling jackets of the engine before it – via the thermostate – is lead overboard through the exhaust system.

In case of freshwater cooling with heat exchanger the engine is cooled by the freshwater which is circulating in a closed system. The freshwater is cooled in the heat exchanger by seawater. With freshwater cooling with heat exchanger it is necessary – out of considerationfor the capacity of the seawater pump – to equip the exhaust system with a by-pass hose, as stated in section Y, pages 8 and 9.

In case of freshwater cooling with keel cooler the freshwater also circulates in a closed system. The freshwater is cooled by the freshwater cooling pipes being led out somewhere through the bottom of the boat and fitted on the outside of the hull. Thus the pipes are cooled by the seawater.

The seawater is always circulated by a Johnson pump type F5B9, whereas the freshwater is always circulated by a circulation pump with metal rotor. The Johnson pump must never be used for circulating the freshwater as the temperature can be considerably higher when using freshwater cooling than in case of seawater cooling. This causes braking down of and damage to the impeller of the Johnson pump, the impeller being made from neoprene.

The advantages of freshwater cooling are:

A higher operating temperature can be reached, having the effect that the running parts of the engine will be less worn.

The engine has a somewhat better economy.

The engine block is not exposed to the corrosive actions of the seawater.

It is possible to add an anti-freeze solution to the freshwater in winter periods where you want to use the engine.

The reason why the engine is not run at a higher temperature when seawater cooled is that the salt in the seawater starts crystallizing at 70°C and this salt will settle in the engine block round the cylinder liners and result in bad heat conduction and corrosions.

Johnson cooling water pump type F5B9

The cooling water pump is used for direct seawater cooling with a cam height 0f 2.0 mm and for freshwater cooling with heat exchanger to the seawater side with a cam height of 3.1 mm (see technical data page A5).

Removal of the pump

1. Loosen the three screws in the flange marked **A**.
2. Remove the cooling water pipes going to and from the pump.
3. Lift the pump free in one piece from its attachment in the engine block.

Dismantling of the pump

1. Loosen the three screws marked **B** in the front cover of the pump and remove the front cover.
2. Withdraw the neoprene impeller which is fitted on a multiple spline shaft.
3. The cam determining the characteristic of the pump can be exchanged now by loosening the screw marked **C**.
4. Take out the washer and locking ring behind the impeller. Then loosen the bolt **D** in the mounting flange.
5. Press the pump free of the cast intermediate housing (610G0250) with two screwdrivers in the gap **E**. Take out the carbon ring stuffing box in the pump.

Dismantling of the intermediate housing

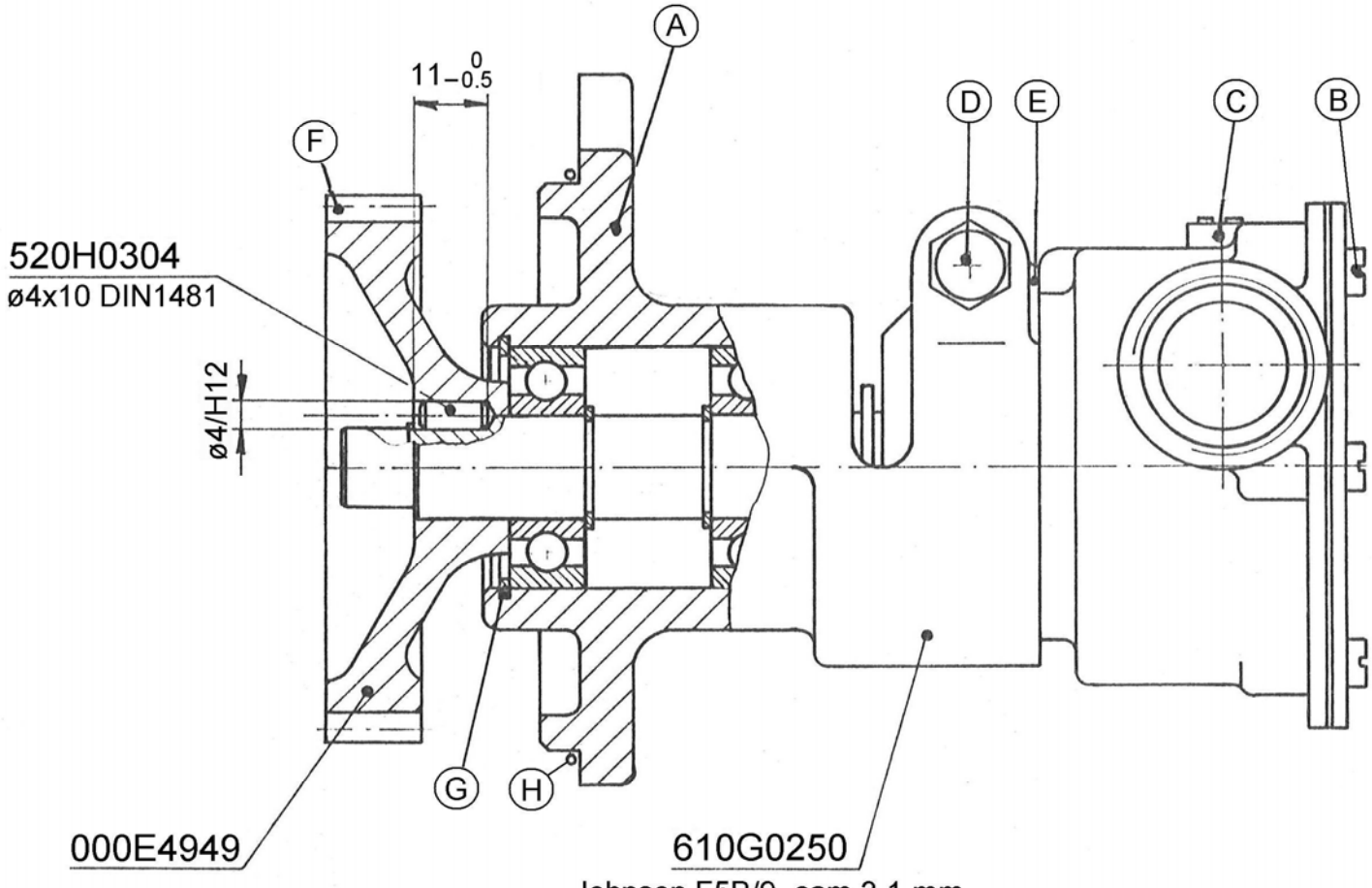
1. Proceed as when dismantling the pump.
2. Pull out the gear-wheel **F** with a special tool. The gear-wheel is shrinked onto the shaft and secured by a drilled-in tube pin. When fitting a new gear-wheel the diference of temperature should be in accordance with the drawing overleaf. Bore in thethe tube pin after fitting of the gear-wheel.
3. Remove the locking ring marked **G**.
4. Knock out the shaft with ball bearings facing the gear-wheel side with a punch or a wooden block as intermediate piece. Now the ball bearings and the seal ring in the bottom of the intermediate housing can be exchanged.

Reassembly of pump

The pump should be assembled in the reverse order of the dismantling. Observe that the ball bearings of the intermediate housing are filled with grease free from acid.

Refitment of the pump

Fit the pump in the reverse order of the removal and check that the rubber gasket ring marked **H** fits tightly.



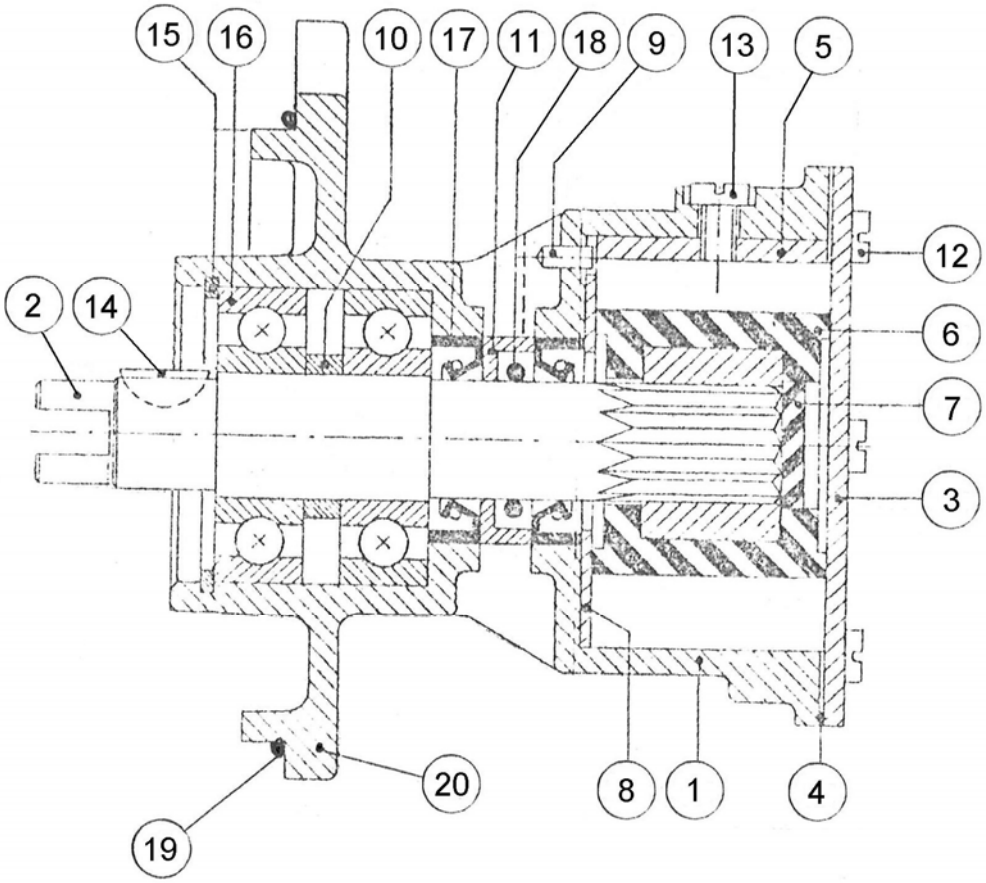
Drwg. No. 008E5184

When fitting the gear/wheel, the difference of temperature (gear/wheel/shaft) should be 236°C

Johnson cooling water pump:

After DV36 serial No. 1051 the outer dimensi ons of the Johnson cooling water pump have been changed and the pump has been par tly simplified at the same ti me, as e.g. the carbon ring stuffing box has been left out.

The type and the technical data of the pum p and height of the cam in ca se of direct seawater cooling and indirect freshwater cooling respectively are the same for the new pump as for the one previously used. Further the impeller is the same as t hat used on the previous pu mp. The new pump can be used by excha nging the previous one if the pipe connections are changed too.



1. Pump housing
2. Pump shaft
3. Pump cover
4. Gasket
5. Adjusting cam
6. Impeller
7. Neoprene washer
8. Wear washer
9. Pin
10. Distance ring
11. Washer
12. Screw
13. Screw for cam
14. Key/pin
15. Locking ring
16. Ball bearing
17. Sealing ring
18. O-ring
19. O-ring gasket
20. Pump flange

Removal of the pump

4. Loosen the three screws in the flange marked **20**.
5. Remove the cooling water pipes going to and from the pump.
6. Lift the pump free in one piece from its attachment in the engine block.

Dismantling of the pump

5. Loosen the three screws marked **12** in the front cover and remove the front cover marked **3**.
6. Withdraw the neoprene impeller which is mounted on a multiple spline shaft.
7. The cam marked **5** determining the characteristic of the pump can be exchanged now by loosening the screw marked **13**.
8. Remove the wear washer marked **8**.
9. Remove the locking ring marked **15**.
10. Press out the pump shaft marked **2** of the pump housing with ball bearings marked **16** and gear-wheel.
11. Now the sealing rings marked **17** and the O-ring marked **18** and the washer marked **11** can be exchanged/removed.

Dismantling and reassembly of gear-wheel

For operation of the pump a gear-wheel ha s been shrinked ont o the pump shaft. The gear-wheel is secured by key and tongue.

The gear-wheel can be pulled off the shaft by means of a special tool.

When fitting a gear-wheel there s hould be a difference of temper ature between the shaft and gear-wheel of 236°C.

Reassembly of pump

The pump is assembled in the reverse order of the dismantling.

Refitment of the pump

To be carried out in the reverse order of the dismantling and it should be checked that the rubber ring marked **19** fits tightly aga inst the be aring surface of the flange marked **20**.

Circulation pump for freshwater

The circulation pump shown on page O7 is used for freshwater cooling, both when cooled by heat exchanger and by keel cooling.

Removal of circulation pump

1. Remove the inlet and outlet pipes from the pump.
2. Loosen the pump from its fixing on the rear end cover and lift it out.

Dismantling of circulation pump

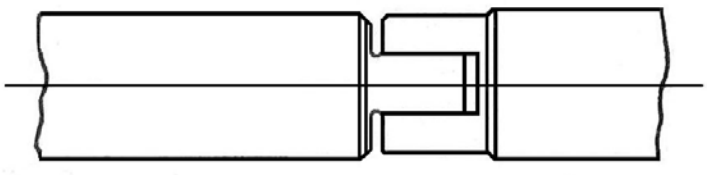
1. Loosen the screws 500C2363 in the cover 000E4934 of the pump and remove the cover and gasket 560K1119.
2. Pull out the circulation wheel 000E4933 with a special tool and now the washer 530Q9973 and the stuffing box 530Q9972 can be changed. The flexible stuffing box cannot be repaired but has to be exchanged, if the contact face shows signs of scratches or fractures.
3. Remove the locking ring 522A0042.
4. Take out the washer 522A9022.
5. Press out the shaft 000E5283 towards the open side. Now the individual ball bearings and the seal ring 561B0201 can be changed.

Reassembly of circulation pump

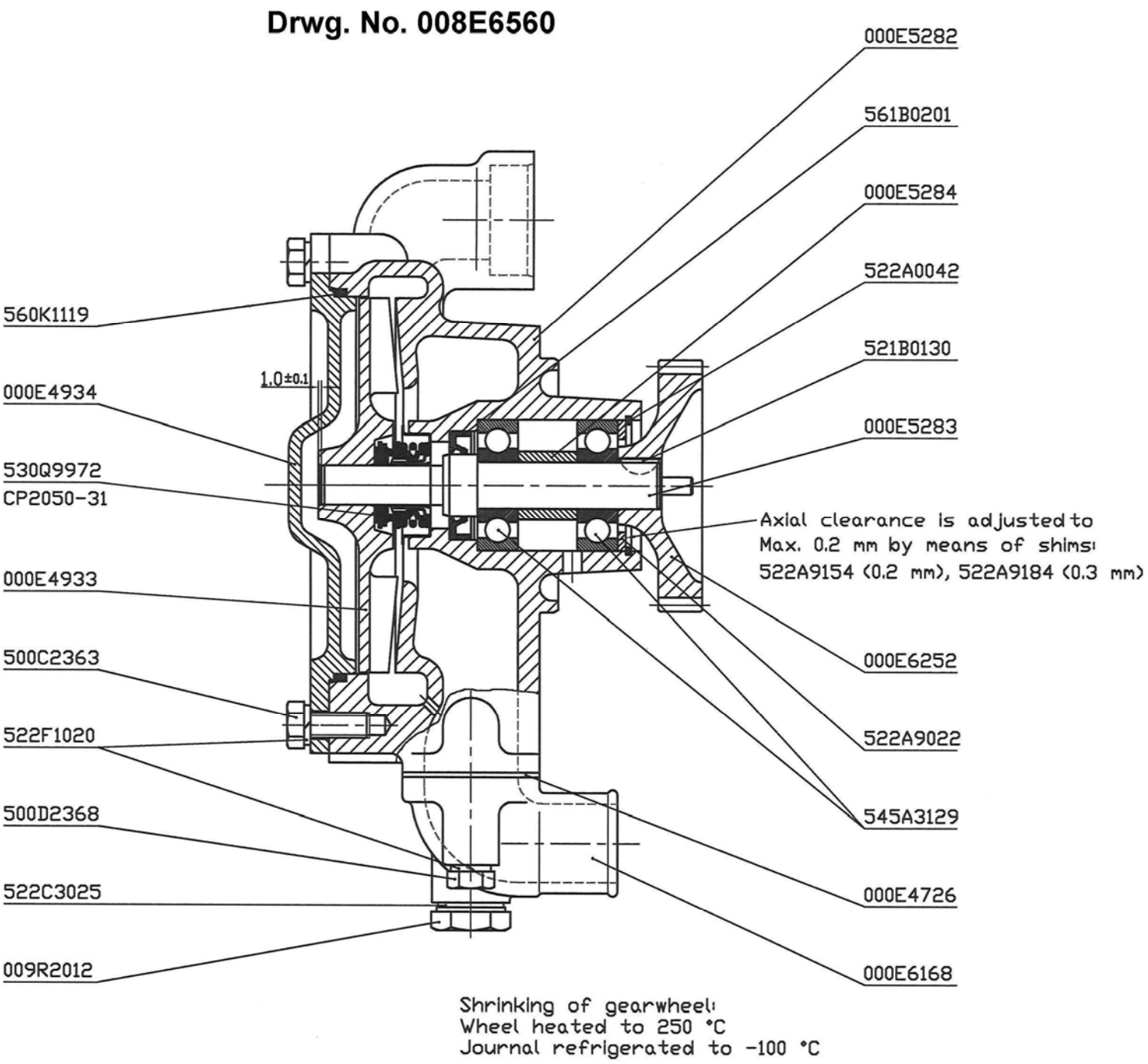
Assemble the pump in the reverse order of the dismantling.
Fill the ball bearings with grease free from acid.
When assembling and fitting the circulating pump there must only be used original gaskets.

The plug in the bottom of the pump is intended for draining off the water in the pump and the pipes in case of periods of frost.

The pump is driven through connection with the shaft end from the Johnson pump.



Circulation pump

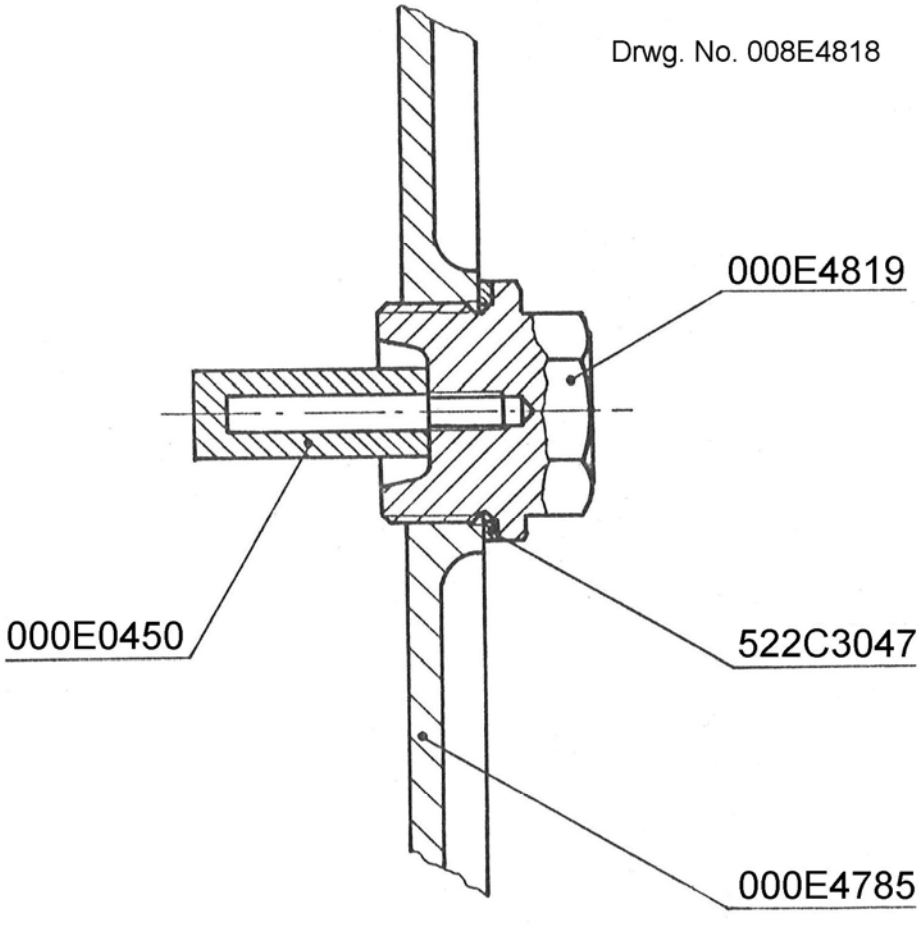


Zinc rod protection

For seawater-cooled engines it is necessary to fit zinc anodes in the cooling water system in order to protect against corrosion of the engine block.

On the starboard side of the engine under the exhaust manifold there therefore are three mounting holes for zinc anodes. As standard for seawater cooling zinc anodes have been screwed into the two back holes as shown on the drawing below. There is no zinc anode in the third hole as – due to the placing of the starter – there is no easy access to this plug during the day-to-day running.

Change the zinc anodes as according to requirements which are influenced by the water in which you are normally sailing. Usually it will be necessary to change the zinc anodes once a year just before the first spring sail.



It is not necessary to exchange the plug as the zinc anode is screwed on to this.

Thermostate

For controlling the cooling water temperature the cooling water system is fitted with a thermostate.

Dependent on the cooling principle the thermostate has different opening temperatures.

In case of direct seawater cooling the thermostate has an opening temperature of 50°C.

In case of freshwater cooling the thermostate has an opening temperature of 80°C.

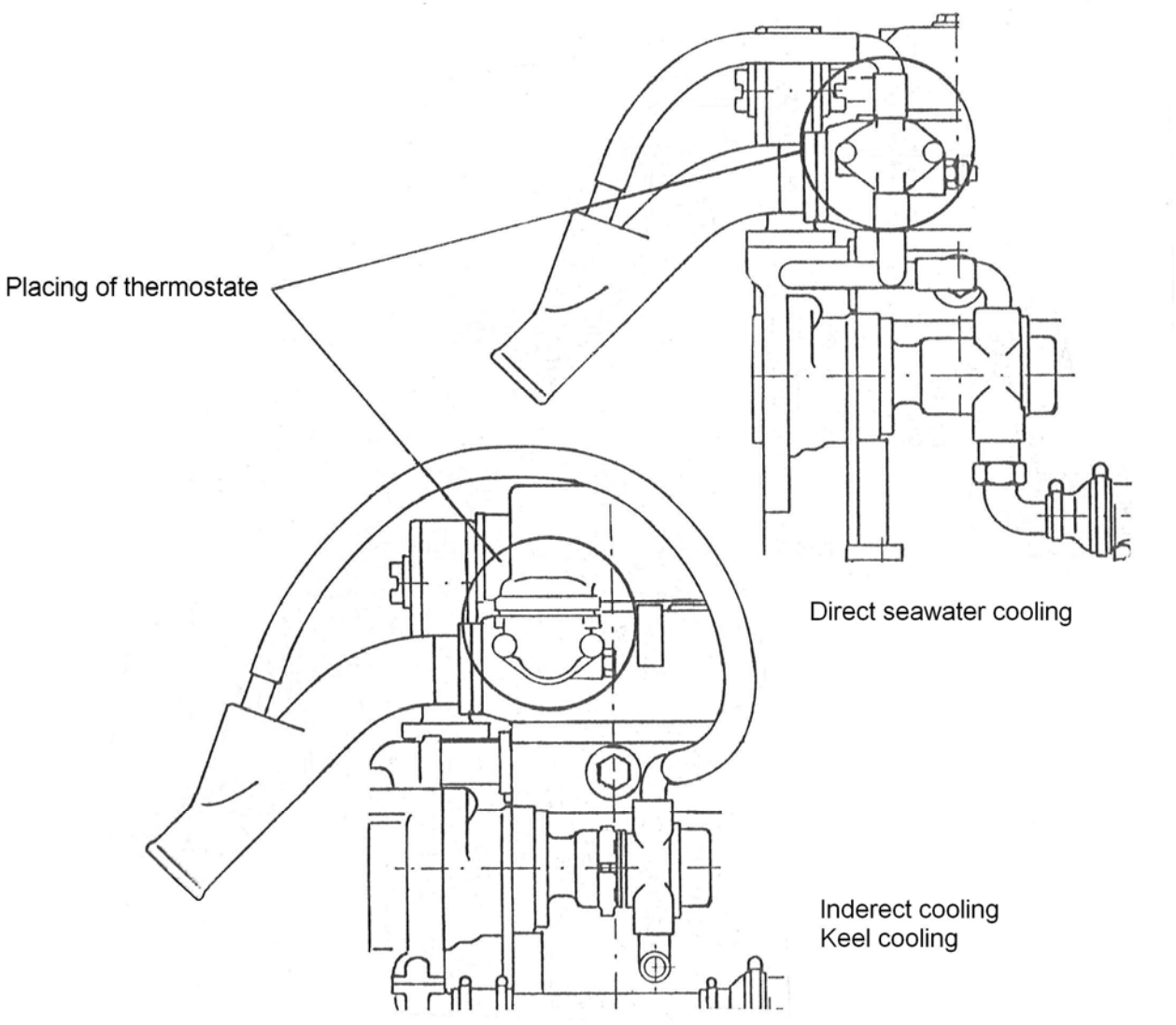
In case of freshwater cooling with keel cooler the thermostate has an opening temperature of 80°C.

Direct seawater cooling thermostate No. 008E6587.

Freshwater cooling with heat exchanger thermostate No. 033D1202.

Freshwater cooling with keel cooler thermostate No. 030G6601.

In all three cases the thermostate is placed at the exhaust manifold astern in starboard side of the engine.



Header tank and heat exchanger

The arrangement of header tank and heat exchanger fitted on the top of the water cooled exhaust manifold is shown on page O11.

In case of keel cooling the arrangement only serves as header tank and from the factory it has been prepared for this by changes in proportion to the use as heat exchanger/ header tank, and directly it will not be possible to change the function from keel cooling into heat exchanger cooling without buying a new header tank or heat exchanger/header tank prepared for the purpose.

Dismantling of heat exchanger

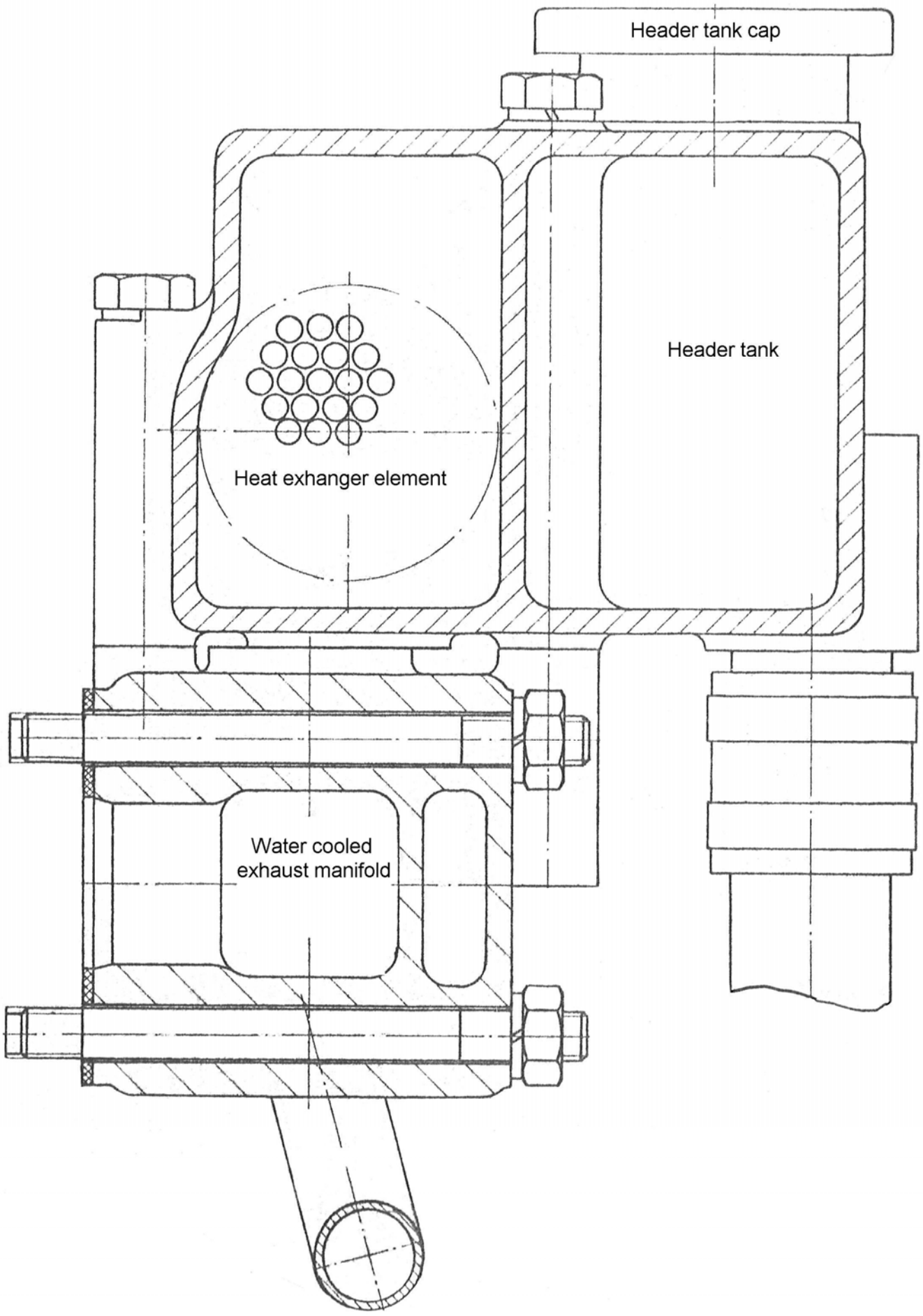
In order to clean the heat exchanger element or in order to test it for pressure, remove the profile-cast rubber tubes on the inlet and outlet side of the seawater connection and take out the element.

Further, exchange the element in case of corrosion or leaks, as it can not be recommended to plug leaky pipes because of reduced heat conductivity.

Filling of anti-freeze solution

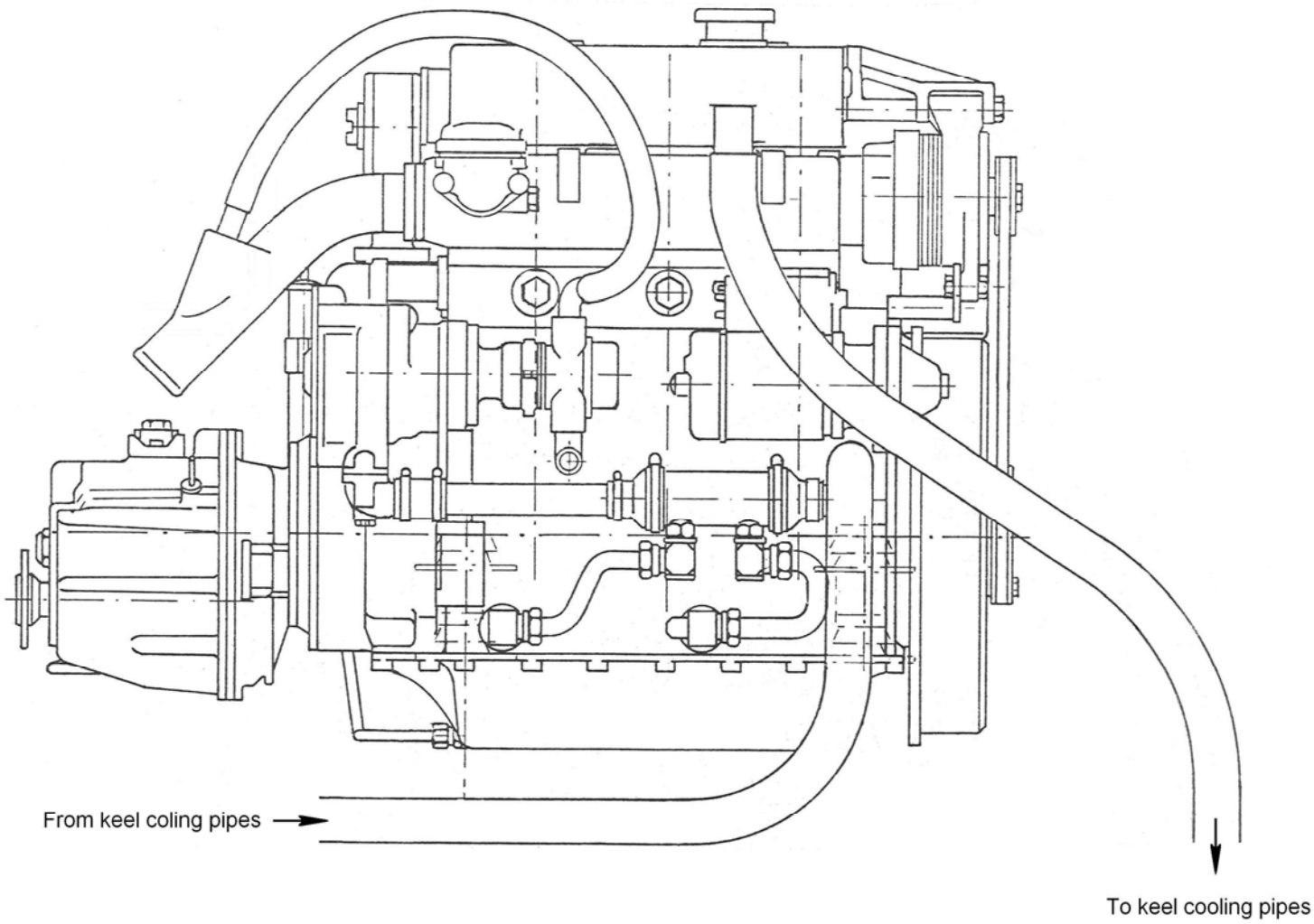
If you want to continue to use the boat in periods of frost pour water/anti-freeze solution through the cap of the header tank, depending on what temperature you want protection against.

Before doing so drain off the freshwater from the engine through the drain plug in the crankcase and through the drain plug of the circulation pump.



009W2329-R01

Keel cooler arrangement



SECTION P

ELECTRICAL SYSTEM

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Wiring diagram (key switch) – 2 battery starting system..... page P 4

Wiring diagram (push button) ..... page P 5

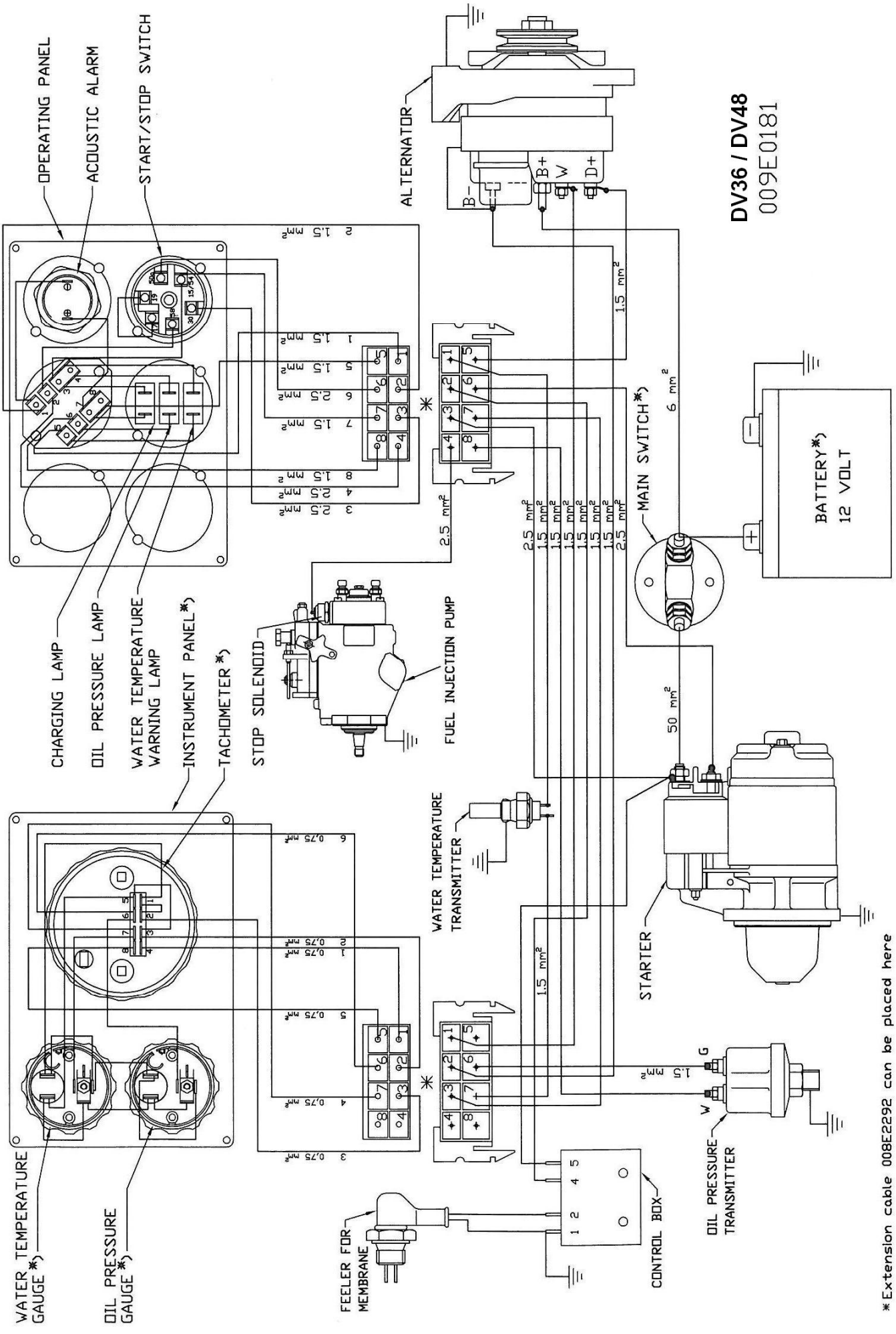
Wiring diagram (push button) – 2 battery starting system ..... page P 6

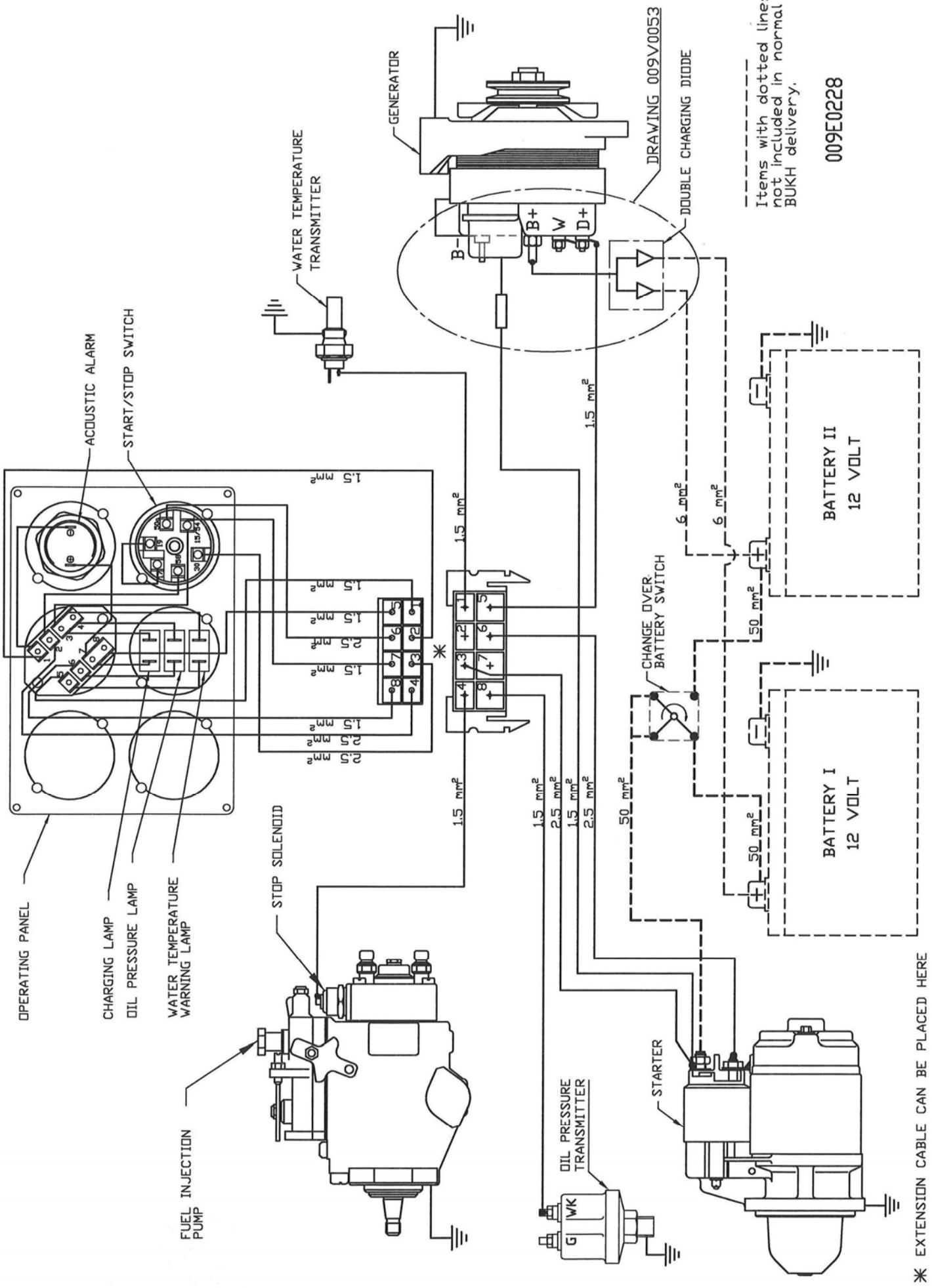
Generator with double charging diodes ..... page P 7

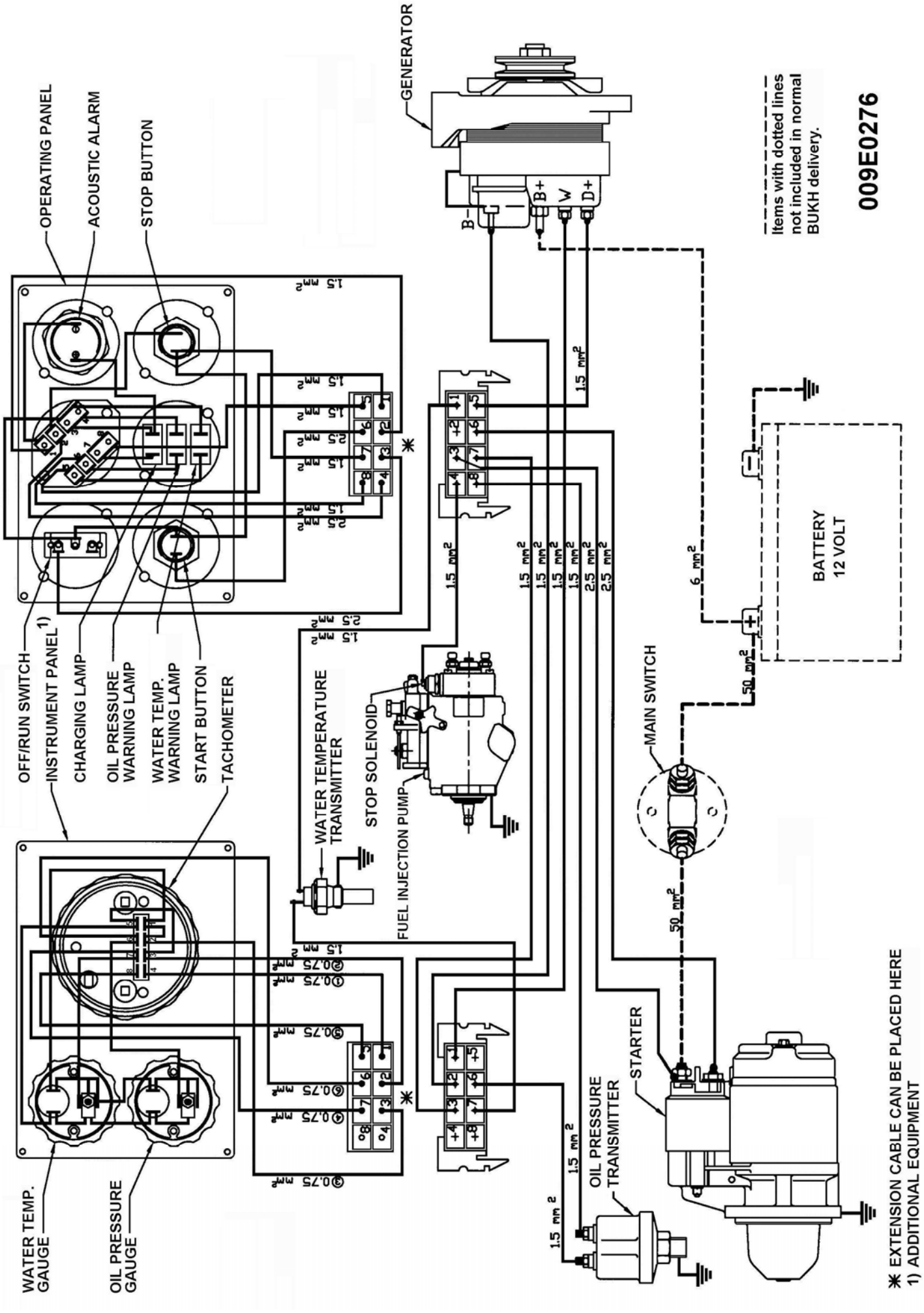
Key switch start panel ..... page P 8

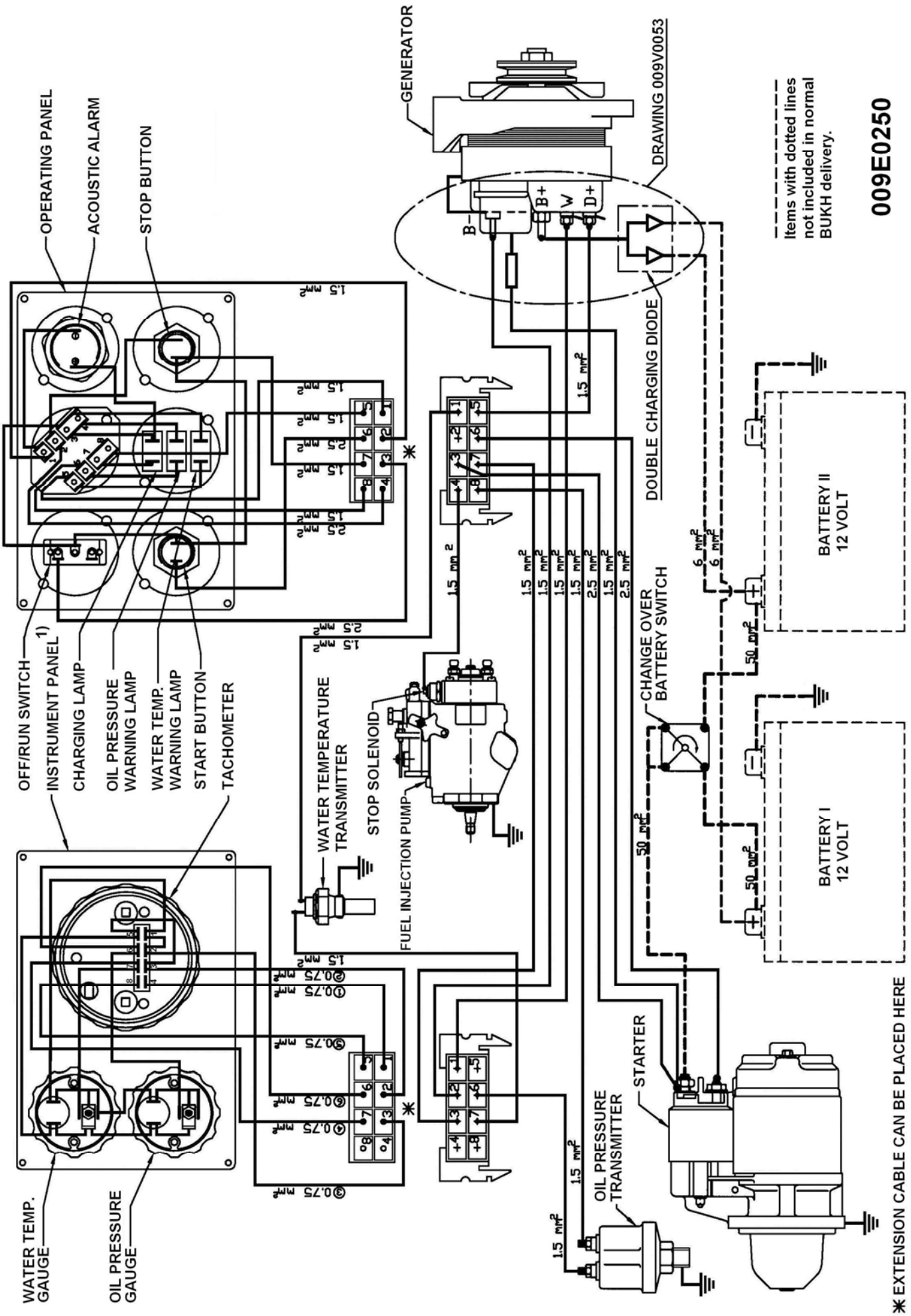
Push button start panel ..... page P 9

Instrument panel..... page P 10

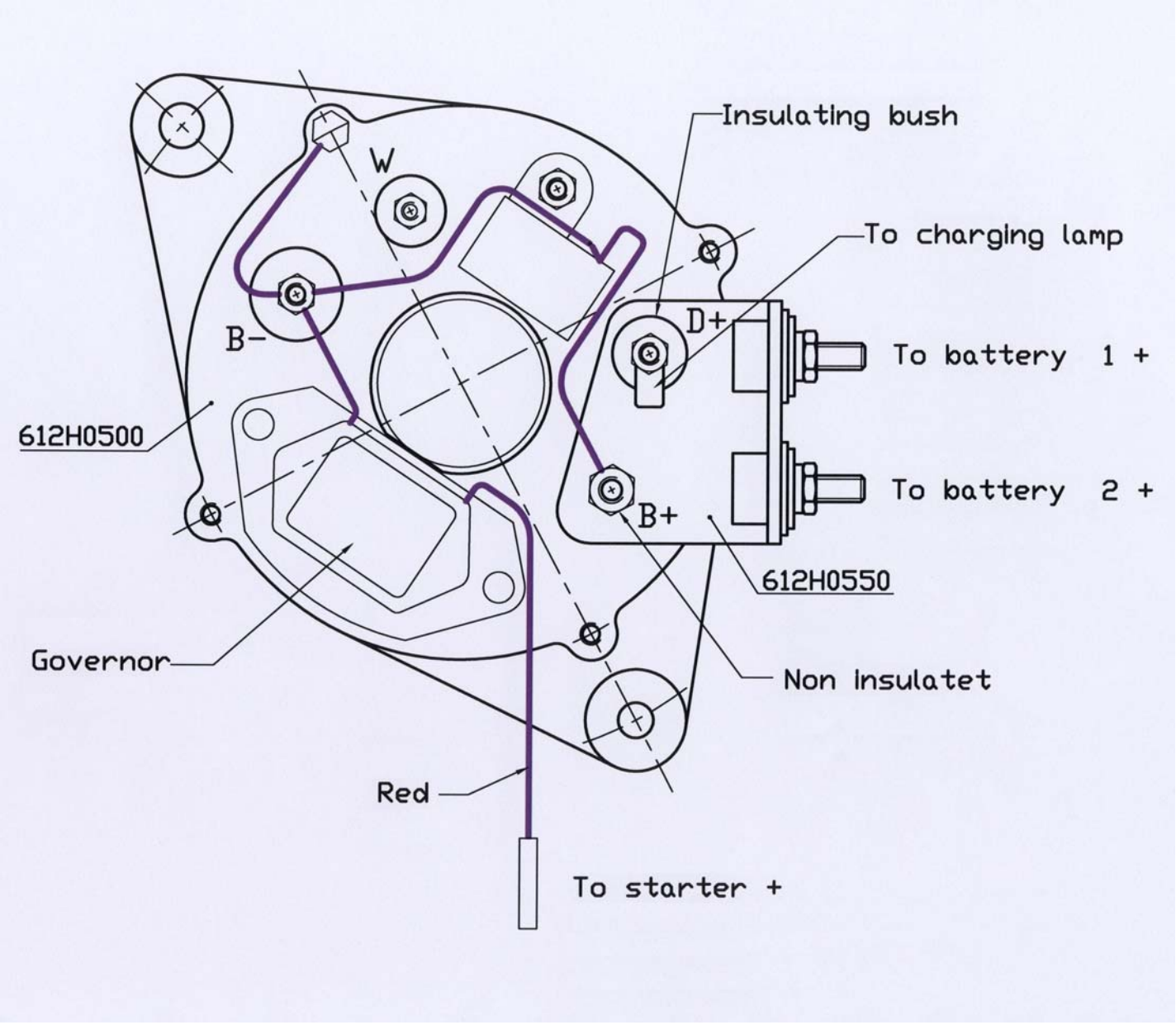

DV36 / DV48
009E0181
OPERATING PANEL
ACOUSTIC ALARM
START/STOP SWITCH
ALTERNATOR
B+
W
D+
B-
CHARGING LAMP
OIL PRESSURE LAMP
WATER TEMPERATURE WARNING LAMP
INSTRUMENT PANEL*)
TACHOMETER*)
STOP SOLENOID
FUEL INJECTION PUMP
MAIN SWITCH*)
BATTERY*)
12 VOLT
WATER TEMPERATURE TRANSMITTER
STARTER
WATER TEMPERATURE GAUGE*)
OIL PRESSURE GAUGE*)
FEELER FOR MEMBRANE
CONTROL BOX
OIL PRESSURE TRANSMITTER
2.5 mm²
1.5 mm²
6 mm²
50 mm²
*Extension cable 008E2292 can be placed here


009E0228
Items with dotted lines not included in normal BUKH delivery.
GENERATOR
DRAWING 009V0053
DOUBLE CHARGING DIODE
B-
B+
W
D+
WATER TEMPERATURE TRANSMITTER
ACOUSTIC ALARM
START/STOP SWITCH
OPERATING PANEL
CHARGING LAMP
OIL PRESSURE LAMP
WATER TEMPERATURE WARNING LAMP
STOP SOLENOID
FUEL INJECTION PUMP
OIL PRESSURE TRANSMITTER
G
WK
STARTER
CHANGE OVER BATTERY SWITCH
BATTERY II 12 VOLT
BATTERY I 12 VOLT
1.5 mm²
2.5 mm²
6 mm²
50 mm²
✳ EXTENSION CABLE CAN BE PLACED HERE

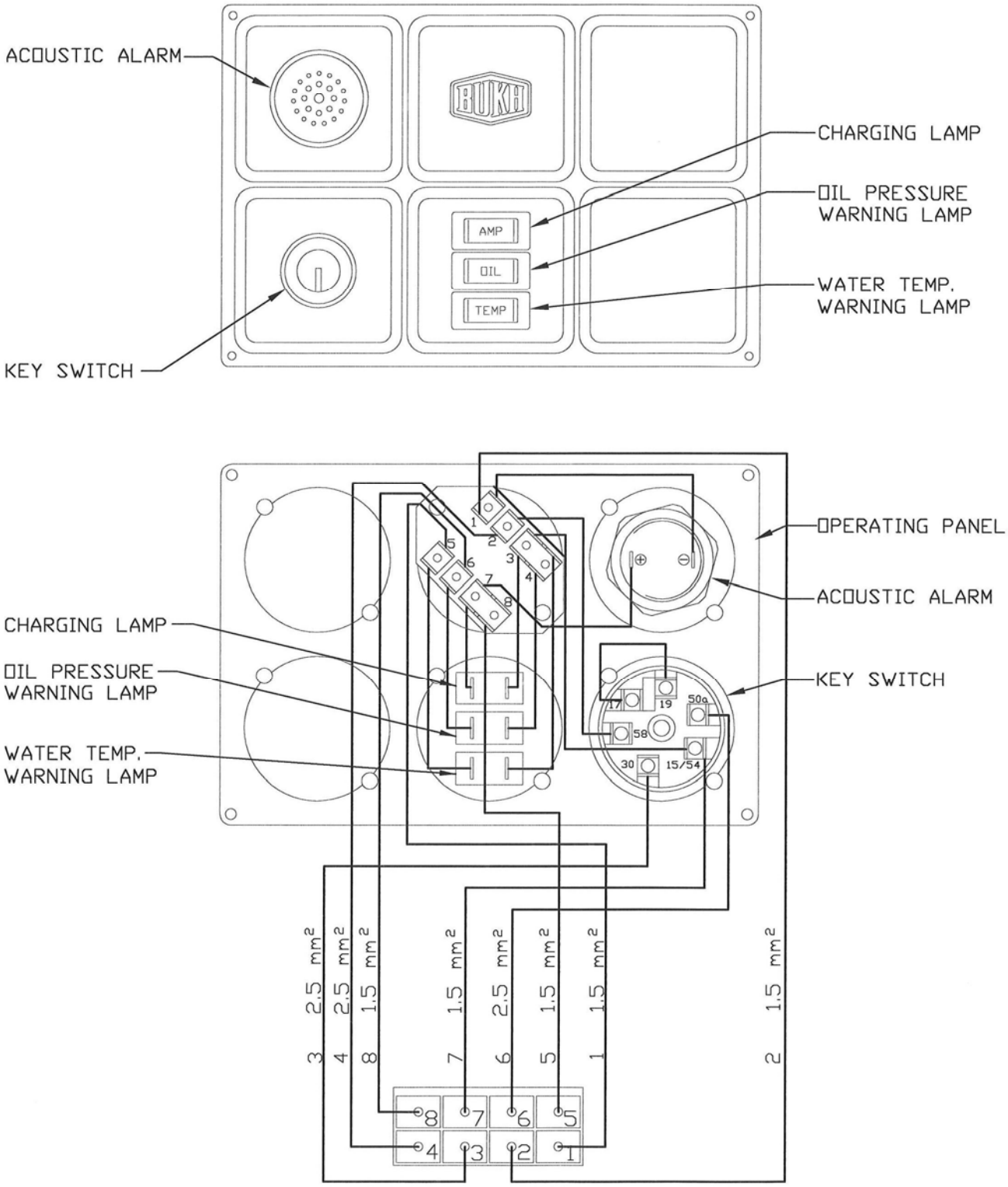

009E0276
Items with dotted lines not included in normal BUKH delivery.
GENERATOR
B-
B+
W
D+
OPERATING PANEL
ACOUSTIC ALARM
STOP BUTTON
OFF/RUN SWITCH
INSTRUMENT PANEL 1)
CHARGING LAMP
OIL PRESSURE WARNING LAMP
WATER TEMP. WARNING LAMP
START BUTTON
TACHOMETER
WATER TEMPERATURE TRANSMITTER
STOP SOLENOID
FUEL INJECTION PUMP
MAIN SWITCH
BATTERY 12 VOLT
STARTER
OIL PRESSURE TRANSMITTER
WATER TEMP. GAUGE
OIL PRESSURE GAUGE
1.5 mm²
2.5 mm²
6 mm²
50 mm²
0.75 mm²
* EXTENSION CABLE CAN BE PLACED HERE
1) ADDITIONAL EQUIPMENT


009E0250
GENERATOR
DRAWING 009V0053
B-
B+
W
D+
DOUBLE CHARGING DIODE
Items with dotted lines not included in normal BUKH delivery.
OPERATING PANEL
ACOUSTIC ALARM
STOP BUTTON
OFF/RUN SWITCH
INSTRUMENT PANEL 1)
CHARGING LAMP
OIL PRESSURE WARNING LAMP
WATER TEMP. WARNING LAMP
START BUTTON
TACHOMETER
WATER TEMPERATURE TRANSMITTER
STOP SOLENOID
FUEL INJECTION PUMP
CHANGE OVER BATTERY SWITCH
BATTERY II 12 VOLT
BATTERY I 12 VOLT
STARTER
OIL PRESSURE TRANSMITTER
WATER TEMP. GAUGE
OIL PRESSURE GAUGE
* EXTENSION CABLE CAN BE PLACED HERE
1) ADDITIONAL EQUIPMENT

Generator with double charging diodes



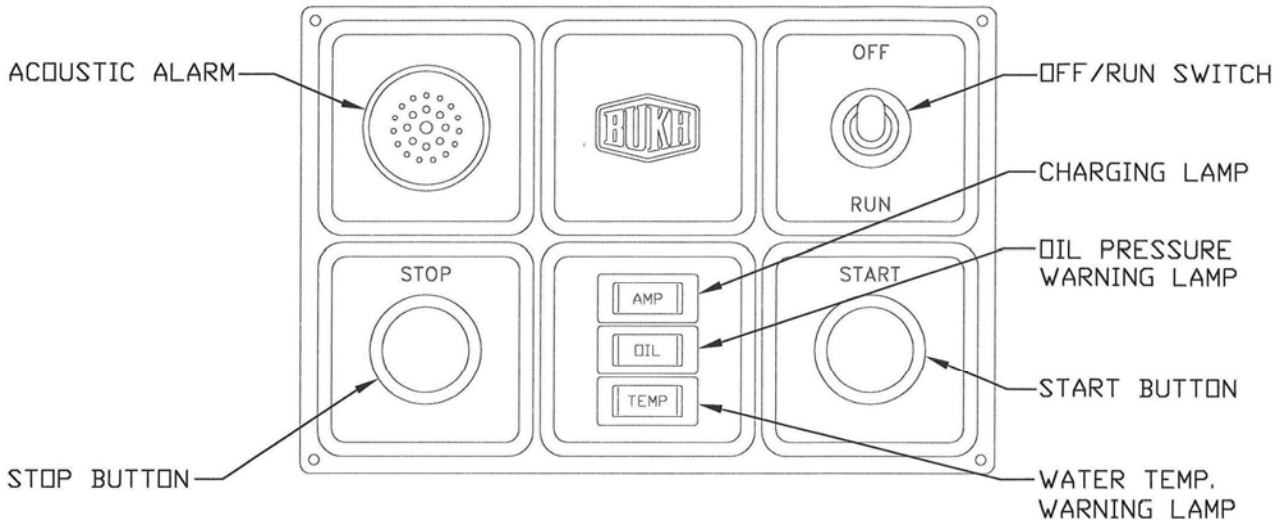
Drg.no. 009V0053

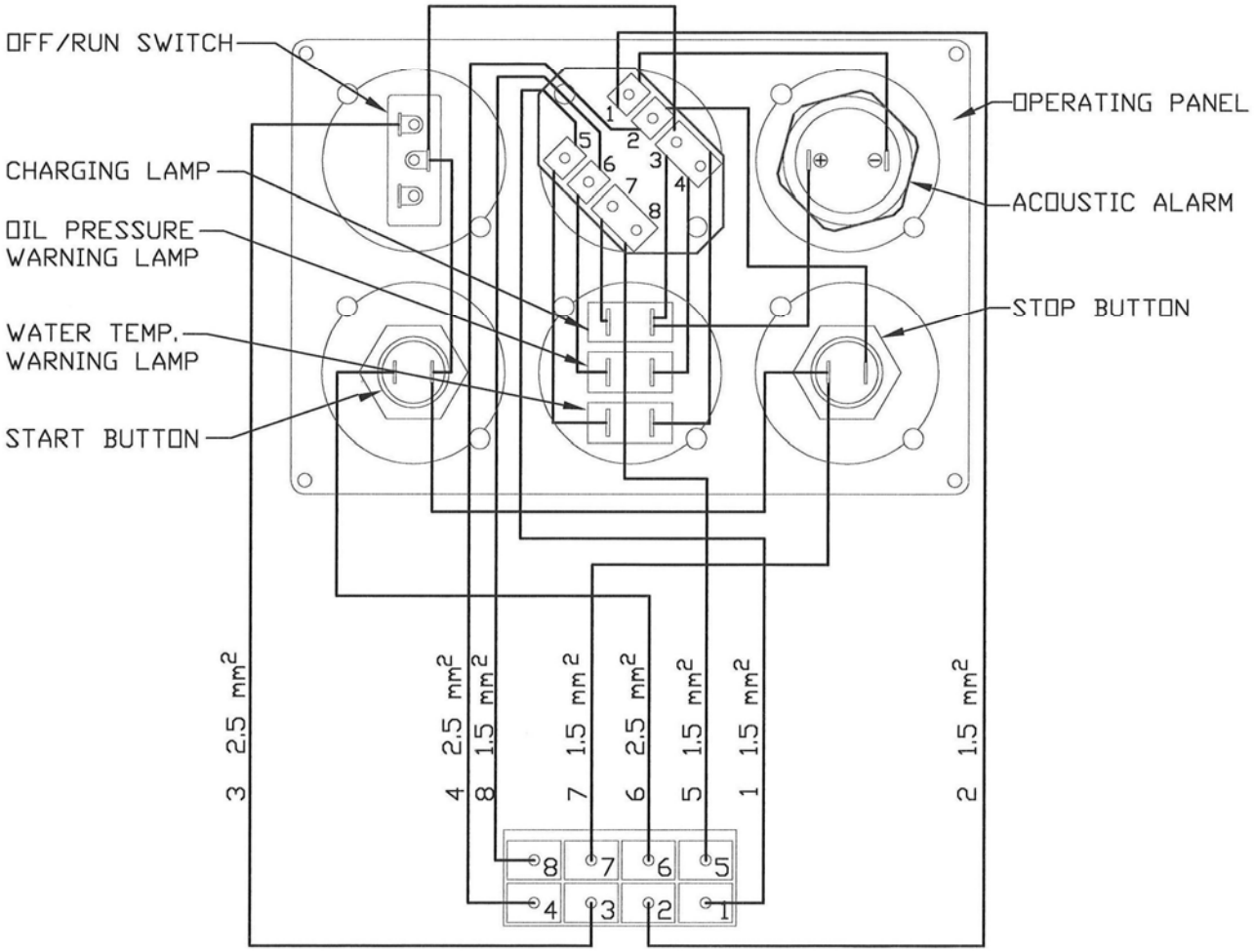


BUKH powering marine safety

ELECTRIC CIRCUIT DIAGRAM

Key Switch Starter Panel			
A4	Kontrolleret	Tegnet 070817 NL	009E0296

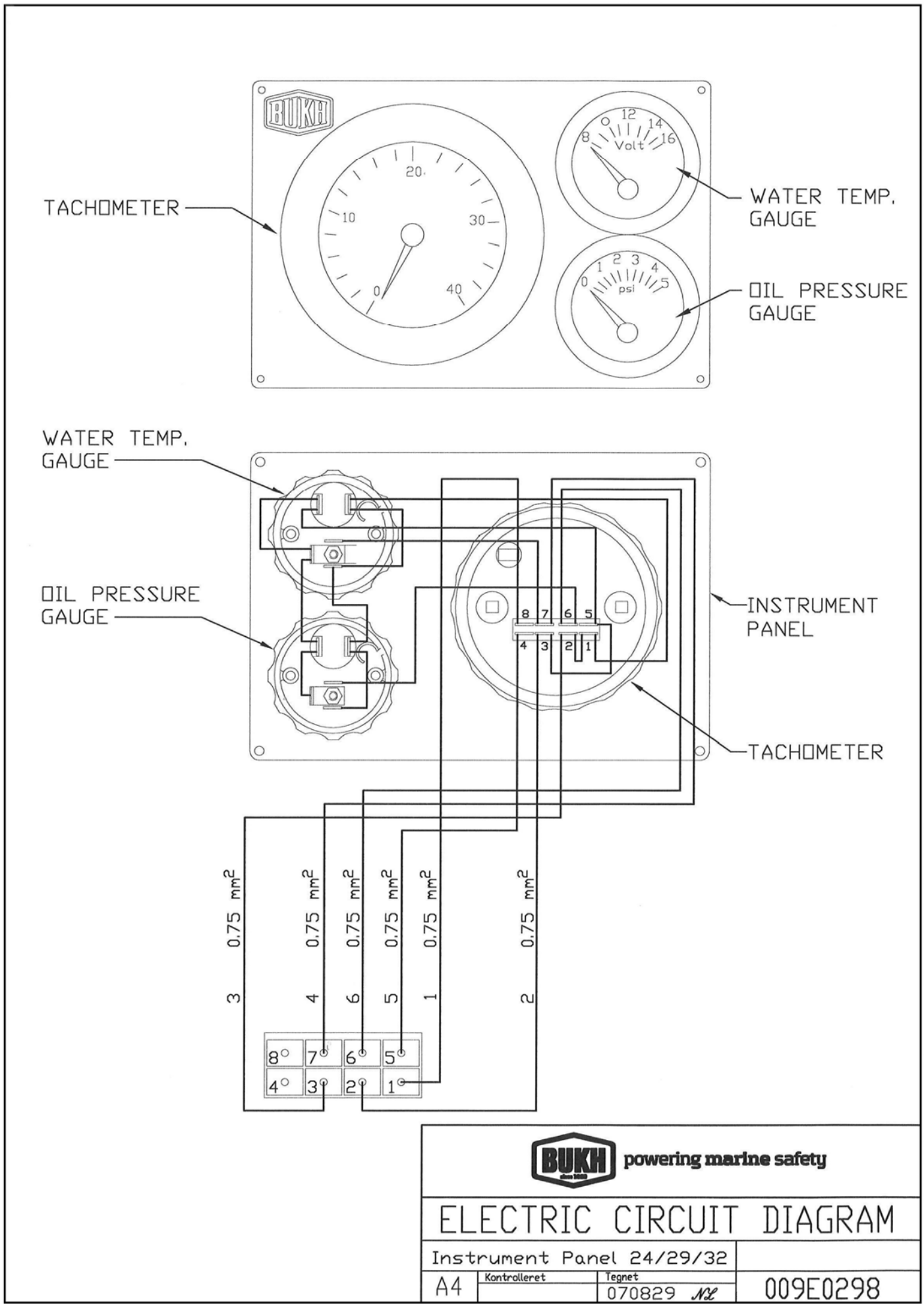




powering marine safety

ELECTRIC CIRCUIT DIAGRAM

Push Button Starter Panel			
A4	Kontrolleret	Tegnet 070817 NL	009E0297


TACHOMETER
WATER TEMP. GAUGE
OIL PRESSURE GAUGE
WATER TEMP. GAUGE
OIL PRESSURE GAUGE
INSTRUMENT PANEL
TACHOMETER
0.75 mm²
3
4
6
5
1
2
8 7 6 5
4 3 2 1
powering marine safety
ELECTRIC CIRCUIT DIAGRAM
Instrument Panel 24/29/32
A4
Kontrolleret
Tegnet
070829
009E0298

SECTION R

ZF GEAR – BW7

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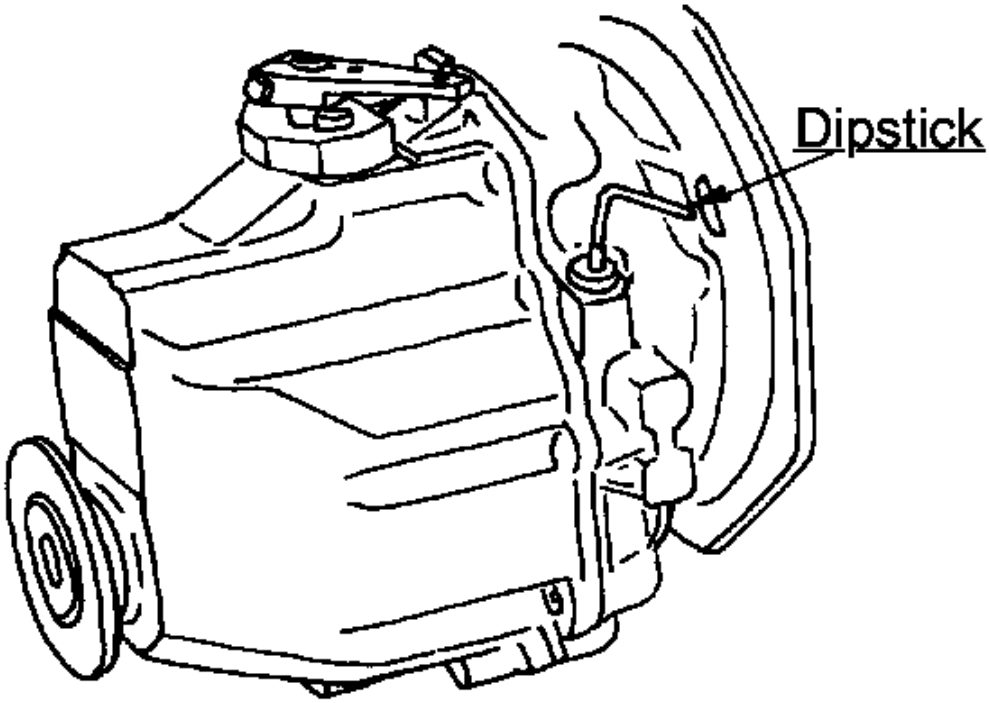
Supplement to fitting of shaft seal rings ..... page R 31

Gear Ratio

The BW7 gear which is used on DV36 has normally a reduction ratio of 3.0:1 for AHEAD and 2.36:1 for REVERSE.

For special purposes it can be delivered with a reduction ratio of 2.47:1 for AHEAD and 2.36:1 for REVERSE.



Oil Change

The gear will need no other attendance than regular change of oil. This to be carried out after the first 25 hours of operation and then every 150 hours or once a year.

The oil change is carried out by means of the hand bilge pump which is delivered together with the tools for the engine.

Refill fresh oil to the quantity of 1.1 litres.

Quality of lubricating oil marked Service CC or CD with a viscosity of SAE 30 or SAE15W-40 is used. Oils covering more viscosity numbers must not be used.

R4

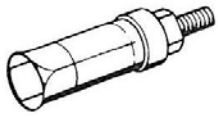
Special Tools

Order No. 009P3187

Mounting punch for seal ring 25x33x6 at input shaft

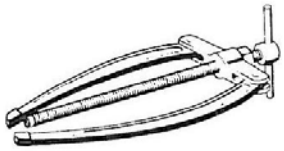
Order No. 009P3188

Internal puller for tapered roller bearings / outer ring



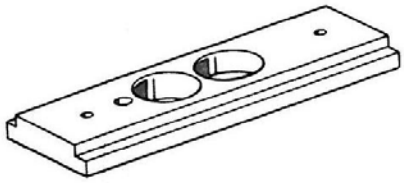
Order No. 009P3189

For fitting of tapered roller bearings / outer ring in connection with 009P3188



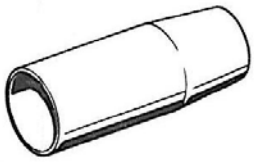
Order No. 009P3190

Measuring instrument for adjustment of tapered roller bearings



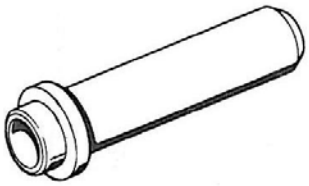
Order No. 009P3191

Protective sleeve for seal ring 25x33x6 at input shaft



Order No. 009P3192

Mounting punch for seal ring 32x45x7 at output shaft



Order No. 009P3193

Bush for stiffening of disc springs “AHEAD”

Order No. 009P3193

Bush for stiffening of disc springs “ASTERN”

Adjusting Measures and Torques for BW7

Designition	Statement of dimensions	Gauge	Remarks
Axial tightening of tapered roller bearings on input and output shafts	0.03 – 0.08 mm With a load of 30 N (3 Kp)	Dial indicator or Depth micrometer	Adjusted by means of washer (s) under bearing outer ring in the housing. The bearings are fitted with Loctite 601
Axial clearance Sliding sleeve in shifting fork	0.1 – 0.4 mm	Feeler gauge	New gear
Axial clearance Sliding sleeve in shifting fork incl. permissible wear	Max. 0.8 mm	Feeler gauge	Clearance + wear limit
Axial clearance “AHEAD” and “ASTERN” wheels	0.1 – 0.4 mm	Depth measure	“AHEAD”: Clearance appears when fitting and is examined at control. “ASTERN”: Clearance can be Adjusted by means of a thrust washer
Disc / plate clearance per disc clutch	0.9 – 1.0 mm	Feeler gauge	To be measured two places opposite one another. To be adjusted by washer
Disc / plate clearance per disc clutch with max. wear	1.5 mm	Feeler gauge	To be measured two places opposite one another. To be adjusted by washer
Tightening of disc springs	Min. 1.1 mm	Depth measure	Measured on disc springs when slack on the output shaft
Testing indication for pressure spring 0732 041 225 in star bolts	L = 15.5 mm P = 38.9±2.4 N (3.89±0.24 Kp)	Depth measure Weight	L = length of loaded spring P = spring power

Adjusting Measures and Torques for BW7

Designition	Statement of dimensions	Gauge	Remarks
Testing indication for pressure spring 0732 041 008 for shift pins	L = 11.4 mm P = 46±5 N (4.6±0.5 Kp)	Depth measure Weight	L = length of loaded spring P = spring power
Torque of hexagon nut M20x1.5 on output shaft on the output side	100 Nm (10 Kpm)	Torque wrench	Secure after having packed with liquid jointing on the contact face
Torque of hexagon nut M20x1.5 on output shaft on the input side	100 Nm (10 Kpm)	Torque wrench	Secure after tightening
Torque of hexagon nut M20x1.5 on the gear-wheel bolts	50 Nm (5 Kpm)	Torque wrench	Secure after having packed with liquid jointing on the contact face
Torque of M8 screws in the halves of the gearbox	17 Nm (1.7 Kpm)	Torque wrench	Add U-washers
Torque of M8x25 screws at the gear wheel bolts	17 Nm (1.7 Kpm)	Torque wrench	Secure with Loctite 241
Torque of vent valve	10 Nm (1.0 Kpm)	Depth measure	
Seal ring for input shaft: Depth of compression	Binding with surface of casting of half of gearbox	Ruler	Shaft seal rings inserted with sealing compound (unhardening)
Output shaft seal ring Depth of compression Measured from front of output shaft to front of shaft seal ring	22.5±0.5 mm	Depth measure	Shaft seal ring inserted with sealing compound (unhardening)

General Information for Work with the Gear

Show cleanliness when repairing the gear and before the gear is opened it must be carefully cleaned.

Use special tools as stated earlier in this section when removing and fitting the gear.

The seal face between the two parts of the housing is tightened with liquid jointing.

When dismantling the halves of the gearbox from each other, loosen the screws in the flanged joint first and push/press back the fitting pins.

Press the two halves of the gearbox from each other by means of two rods or the like. Do not use chisels.

Use special tools for loosening parts fixed to the shafts such as bearings, gear-wheels etc.

When assembling the gear and fitting the bearings it is necessary to heat the cylinder bearings in oil bath before fitting them. The temperature must not exceed 120°C.

When fitting the bearing outer rings the housing should be heated and the bearing outer rings should be fitted with Loctite.

Removal of Gear from Engine

Before the gear can be dismantled it must be removed from the engine:

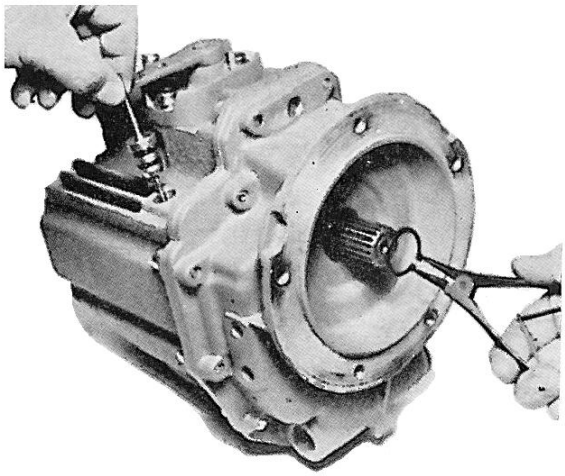
1. Loosen the propeller shaft flange and push the propeller shaft a little backwards.
2. Loosen the gear from the engine by removing the bolts of the intermediate flange between the engine and gear.
3. Lift clear the gear of the engine.
4. Dismantle the flexible coupling by loosening the central nut and pulling off the coupling half from the input shaft of the gear with special tool No. T 41069.

Dismantling of BW7 Gear

Pull the dip stick of the housing.

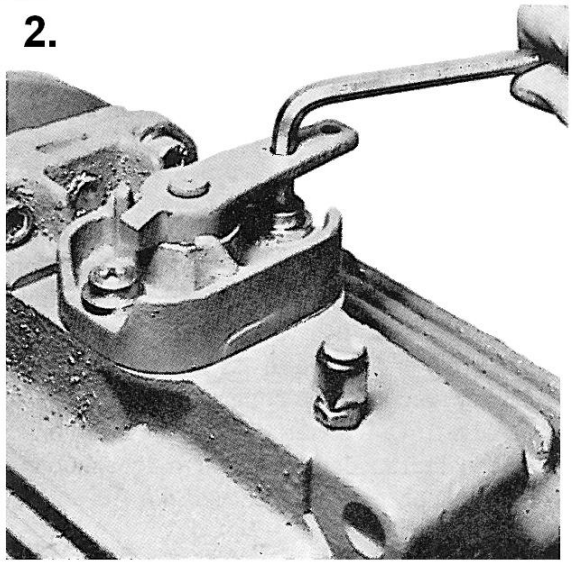
Remove the locking ring on the input shaft.

1.



Remove the shifting arrangement with gasket.

2.

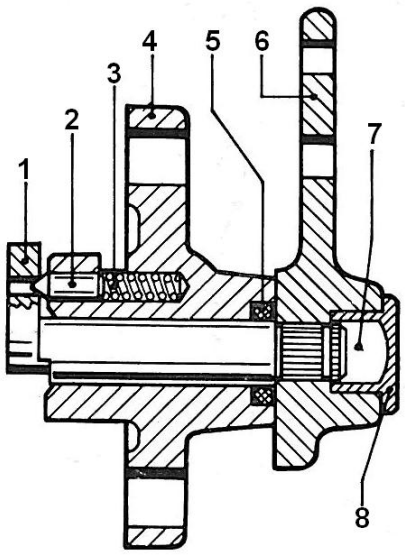


There are two different shifting levers which, however, can be built in without any problems in either cases.

Press the shifting lever out of the shifter shaft and take out the O-ring 12x2.4 and the pin and the pressure spring.

Before the shifting lever is pressed out it should be marked in proportion to the shaft out of consideration for the later assembling of the arrangement.

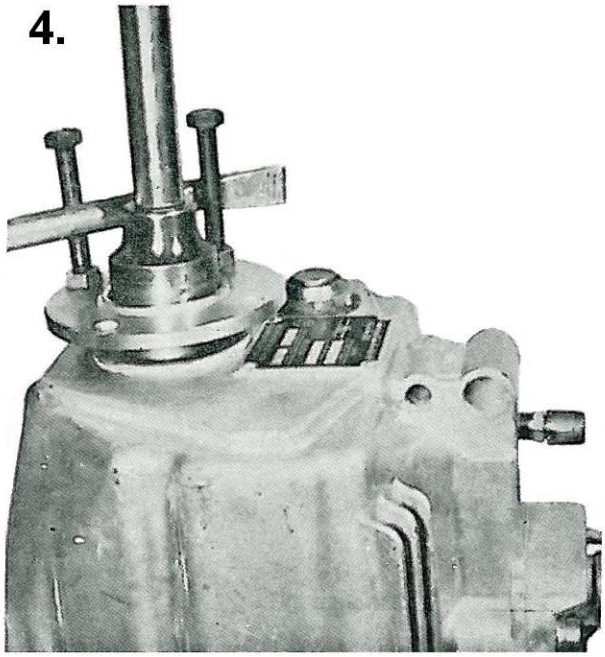
3.



1. Shifter shaft
2. Pin
3. Pressure spring
4. Shifting housing
5. O-ring
6. Shifting lever
7. Grease lubricating
8. Screw cap

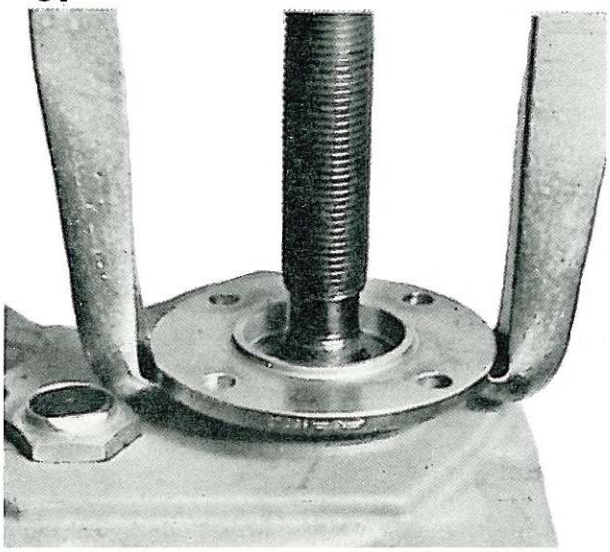
Unscrew the nut of the output shaft flange.

4.



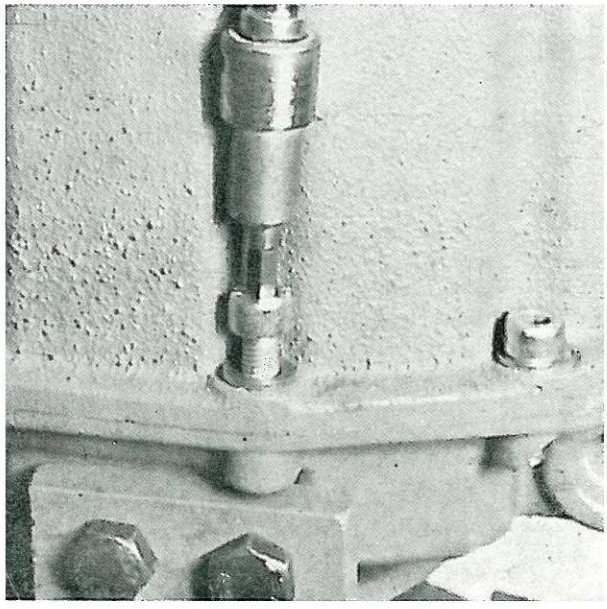
Pull off the output shaft flange.

5.



Screw off the fixing screws which hold the halves of the gearbox together.

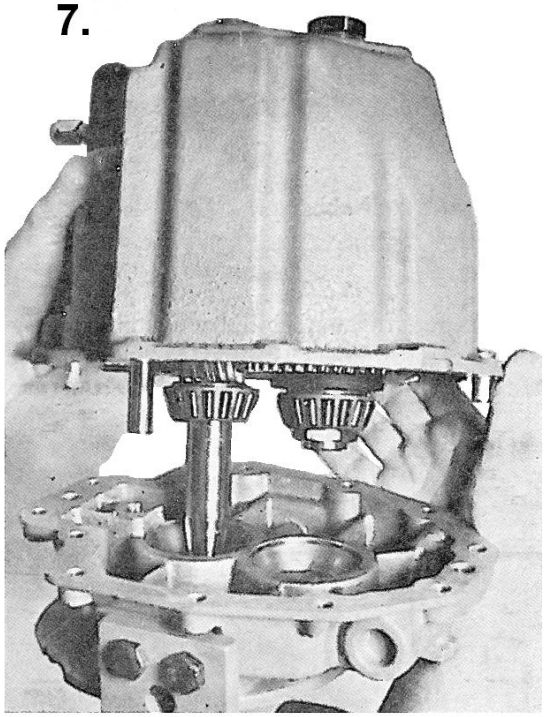
6.



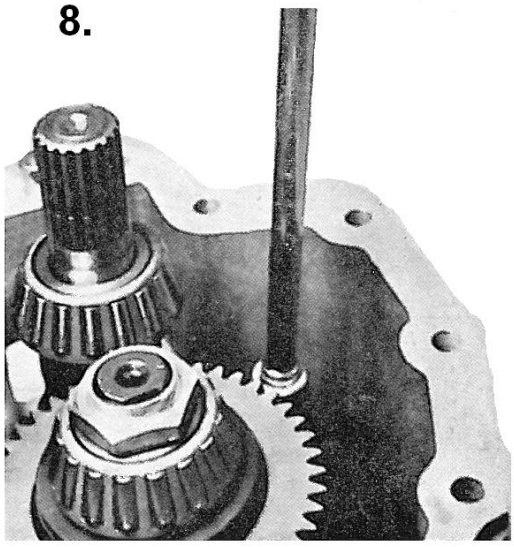
Drive back the fitting pins 2 – 3 mm in the gearbox and lift one gearbox half with reversing shaft, input and output shafts free of the other gearbox half.

Protective sleeve 1 x 56 136 992 may be fitted on the input shaft before the dismantling.

7.



8.



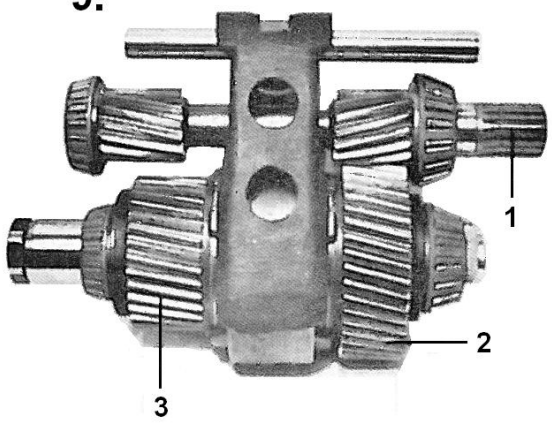
Removal of Input and Output Shaft

ProTake out the screws M8x25 and the gear-wheel bolts and remove the washer plate.

At the fitting the screws have been smeared with Loctite and consequently it may be necessary to heat before they are loosened.

Loctite No. 241 has been used.

9.



Lift the complete arrangement with input and output shafts and shifting fork out of the housing.

Now the arrangement can be lifted free of each other.

1. Input shaft
2. Wheel “ASTERN”
3. Wheel “AHEAD”

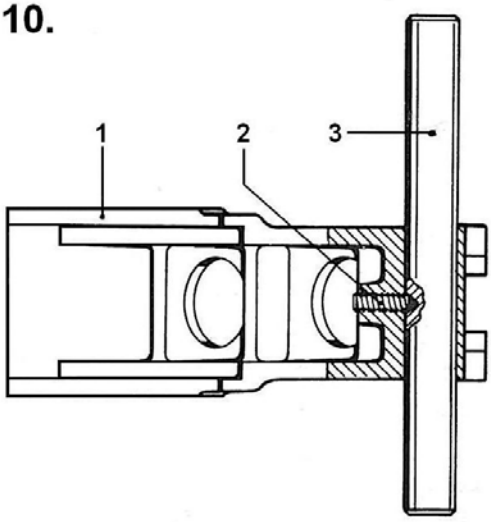
Dismantling of Shifting Fork

Screw out the pin M6x12 of the shifting fork and press out the reversing shaft of the shifting fork.

At the fitting the threaded pin has been smeared with Loctite No. 241 and so it may be necessary to heat.

1. Shifting fork
2. Threaded pin
3. Reversing shaft

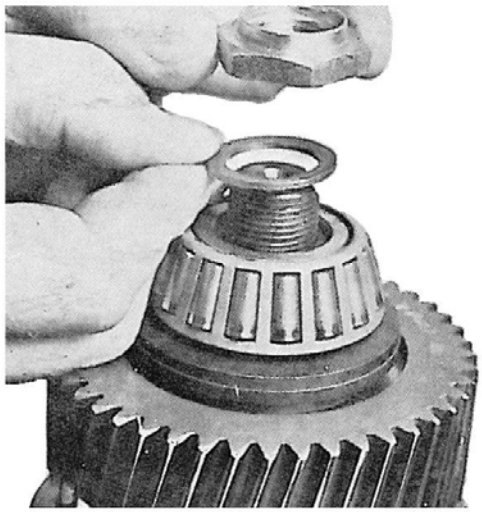
10.



Dismantling of Output Shaft

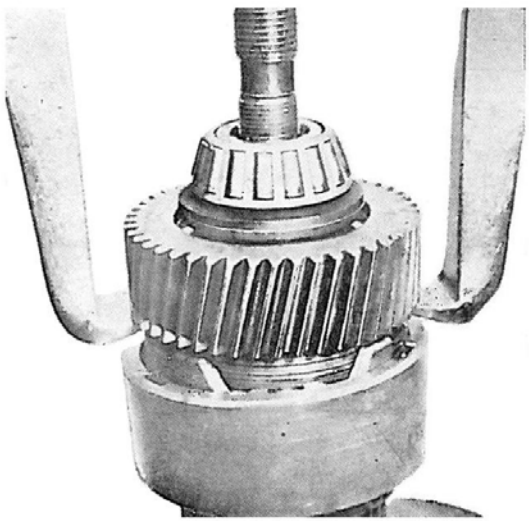
Remove nut with washer “ASTERN”

11.



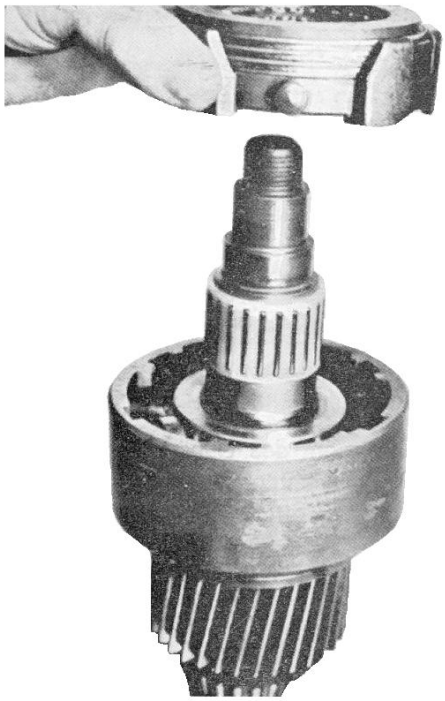
Pull off the wheel “ASTERN” with a special tool and take up washer, disc springs and tapered roller bearing inner collar.

12.



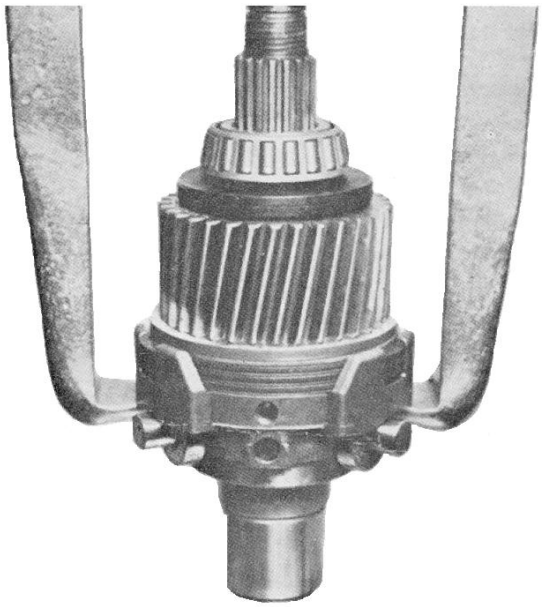
13.

Remove the thrust collar wuth bolts and washers together wuth needle bearing bushing, sliding sleeve and pressure spring.



14.

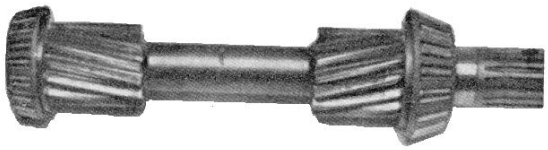
Remove the wheel “AHEAD” with a special tool and take off all parts “AHEAD”.



Dismantling of Input Shaft

Squeeze off the tapered roller bearing inner collar.

15.



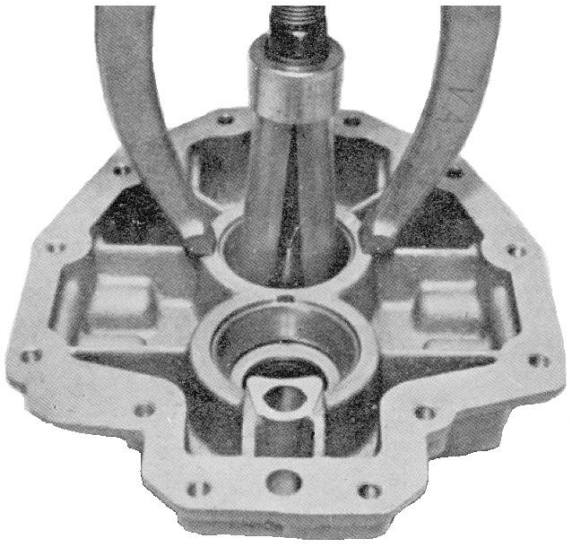
Dismantling of Lower Gearbox Half

Pull out the tapered roller bearing outer collars of the lower gearbox with an inner puller No. 1 x 56 122 208 and auxiliary tool No. 1 x 56 122 227 and take up the washers.

At the fitting the tapered roller bearing outer collars have been smeared with Loctite 601 and so heating may be necessary.

At the dismantling: Mark the adjusting washer(s) which lie below the bearing rings in proportion to the bore.

16.



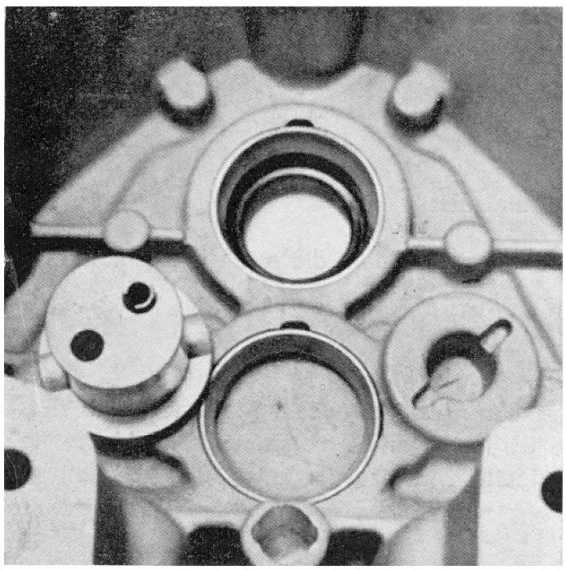
Dismantling of Upper Gearbox Half

Pull off the tapered roller bearings outer collars as described under picture No. 16 above.

Loosen the nuts at the wheel and press out the bolt of the housing.

Remove slotted pin and washer.

17.



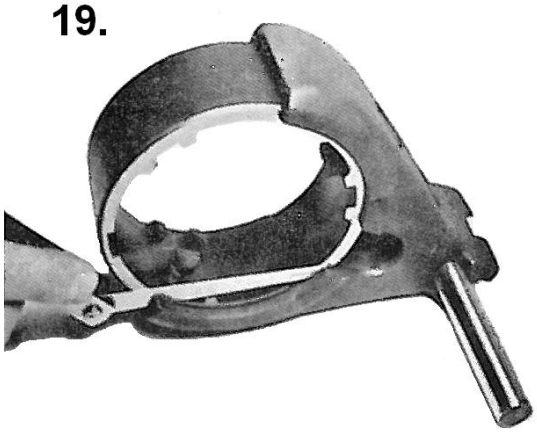
Refitment of BW7 Gear

Before refitment of the gear examine the different components for cracks and wear.

In the following description only the fitting of output shaft for “AHEAD” is described as the fitting for “ASTERN” is chiefly corresponding.

If it is necessary reference will be made to the paragraph marked “Note”.

19.



Picture 19

Insert the sliding sleeve in the shifting fork and measure the axial clearance of the sliding sleeve.

The axial clearance below the wear limit must be 0.1 – 0.4 mm.

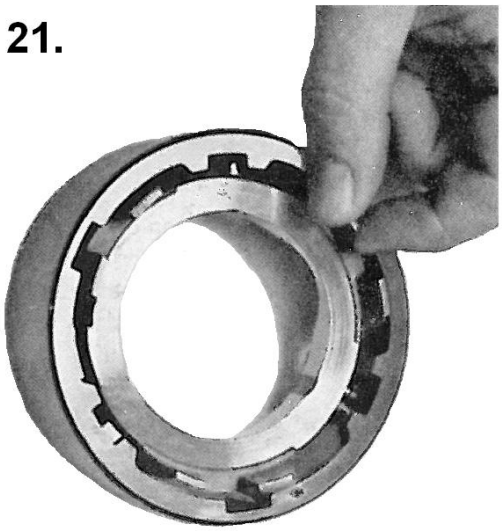
20.

Picture 20

Insert the locking bolt in the thrust collar. The locking bolt should be able to turn easily in its bore in the thrust collar.

The head of the locking bolt must adjoin the thrust collar.

21.



Picture 21

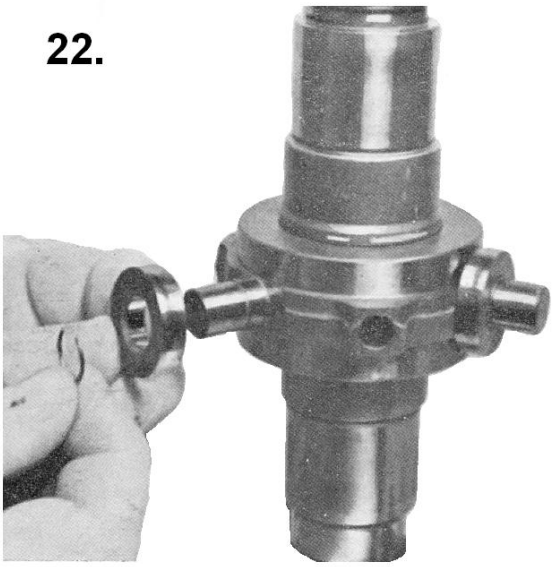
Insert thrust collar with locking bolt in sliding sleeve.

Check torsion in sliding sleeve.
The locking bolts must not pinch by this.

Fit the tension rollers on the shafts for suspension by rollers.

“Note”: The tension rollers must be placed so that the big surface lies outwards.

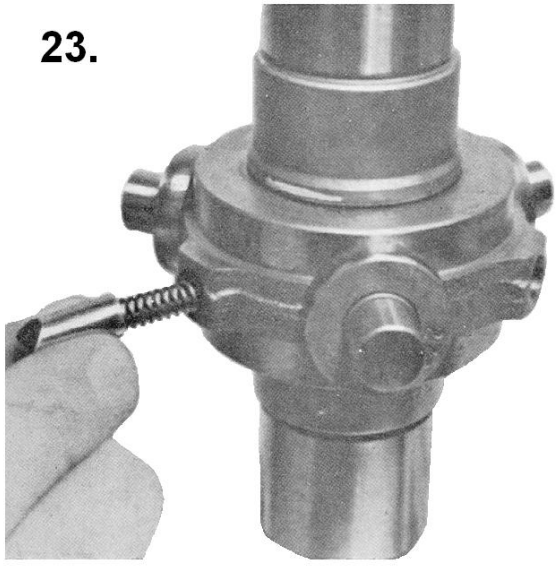
22.



Fit the pressure springs in the check bolts. Fit the check bolts in the corresponding bores.

The point of the check bolts should turn so that it is horizontal.

23.

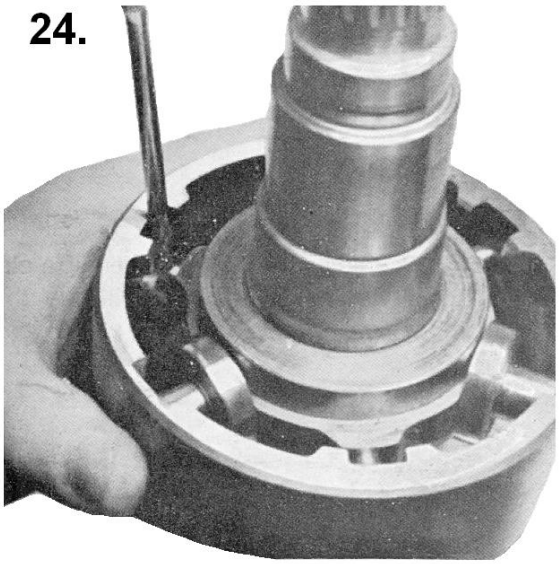


Press the sliding sleeve from the bottom against the check bolts.

Press the check bolts back with a screw-driver and at the same time press the sliding sleeve upwards.

The bolts should rest in the points of rest of the sliding sleeve.

24.

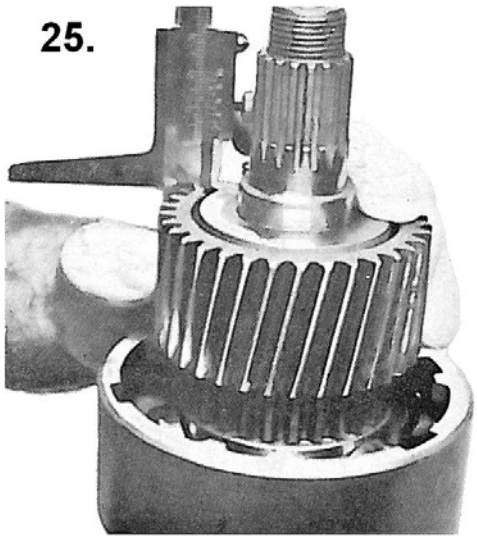


Fit needle bearing housing, wheel for “AHEAD” and washer.

Check the axial clearance of wheel for “AHEAD”. It should be 0.1 – 0.4 mm.

“Note”: For “ASTERN” the axial clearance can be adjusted by fitting an intermediate washer (thrust washer).

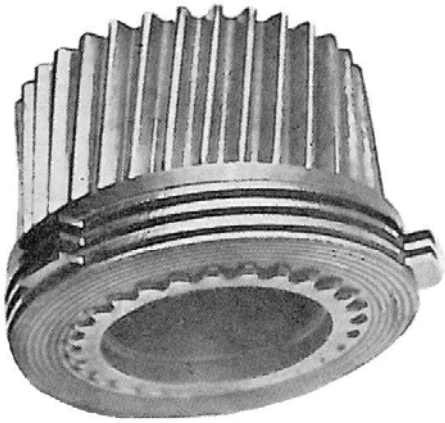
25.



First fit a washer. Then fit an inner disc and the an outer disc.

Fit 4 inner and 3 outer discs in this order.

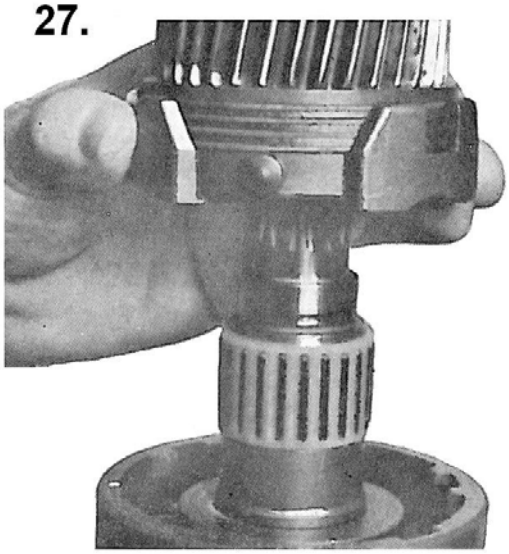
26.



Fit wheel for “AHEAD” with clutch discs on the thrust collar.

First fir the driving pins through the thrust collar and the fit the thrust collar with clutch discs and wheel for “AHEAD” over the needle case on the input shaft in the sliding sleeve.

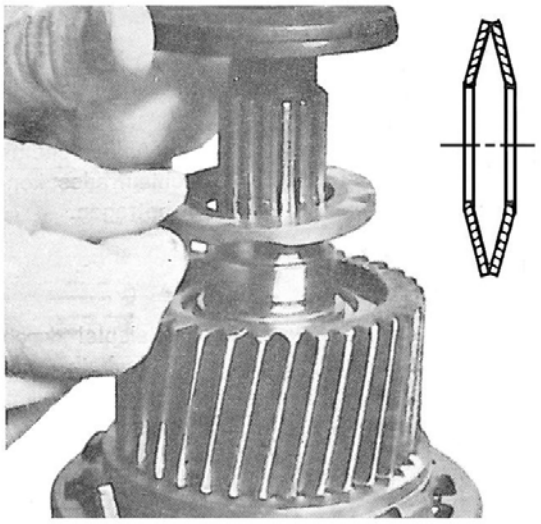
27.



Fit thrust washer, the oil pockets of which should turn towards the wheel for “AHEAD”.

Fit the disc springs which should touch with the outside diameter.

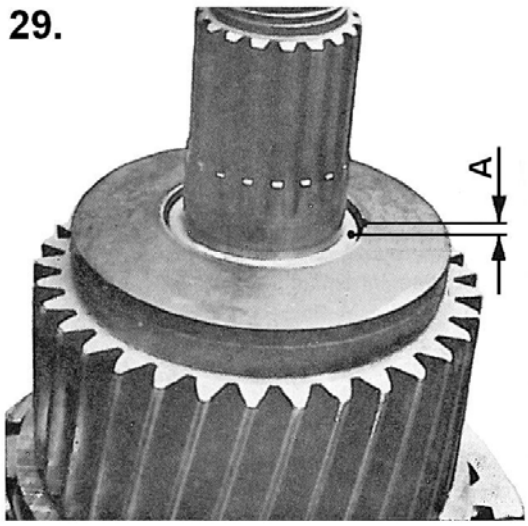
28.



Check the tightening of the disc springs.

The inside diameter of the disc springs must, when slack, in proportion to the front be min. 1.1 mm (measure A).

29.



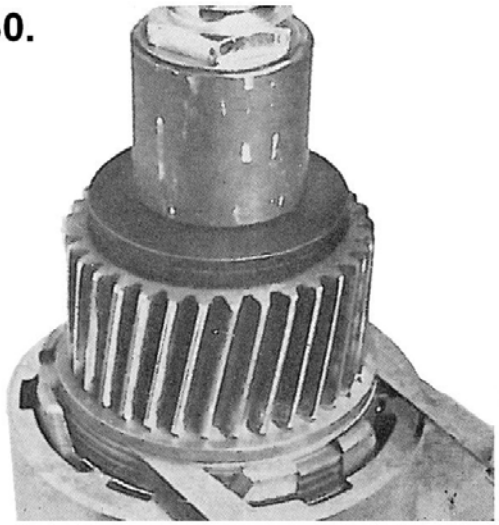
Tighten the disc springs with bush 1 x 56 136 994. Measure disc clearance between inner disc and washer with a feeler gauge in two places which are opposite one another.

The disc clearance to be 0.75 – 0.85 mm.

Deviations should be adjusted with washer available in different thicknesses.

“Note”: Tighten the disc springs on the side for “ASTERN” with bush No. 1 x 56 136 995.

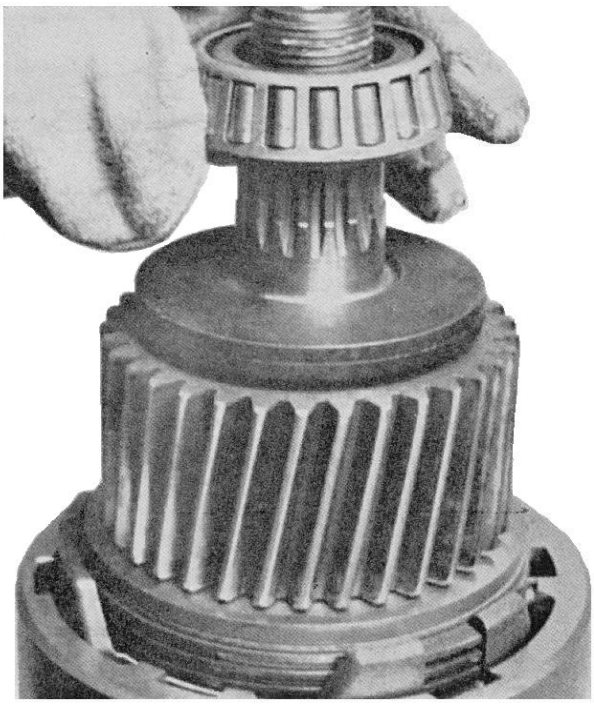
30.



Heat the tapered roller bearing inner collar to about 85°C and fit it with the thin end of the taper roller facing the shaft end of the output shaft until it fits tightly against the disc springs.

Tighten the tapered roller bearing with bush No. 1 x 56 136 995 and original hexagon nut until it fits tightly against the shaft assembly. See picture No. 33 overleaf too).

31.

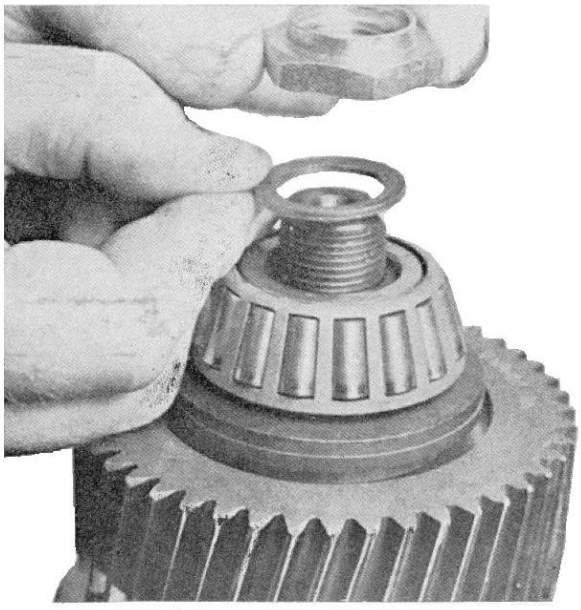


"Note": Fix the tapered roller bearing for "ASTERN" with supporting washer and original hexagon nut.

The torque of the nut is 100 Nm (10.0 kpm).

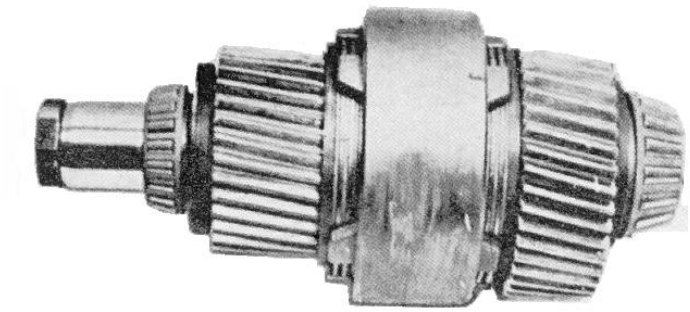
Secure the nut.

32.



The picture shows the ready-mounted output shaft.

33.

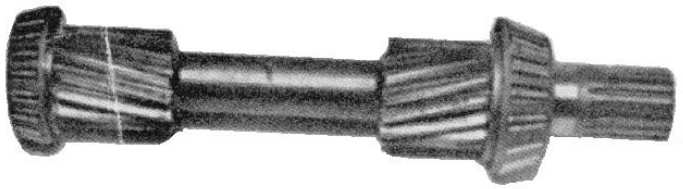


Fitting of Input Shaft

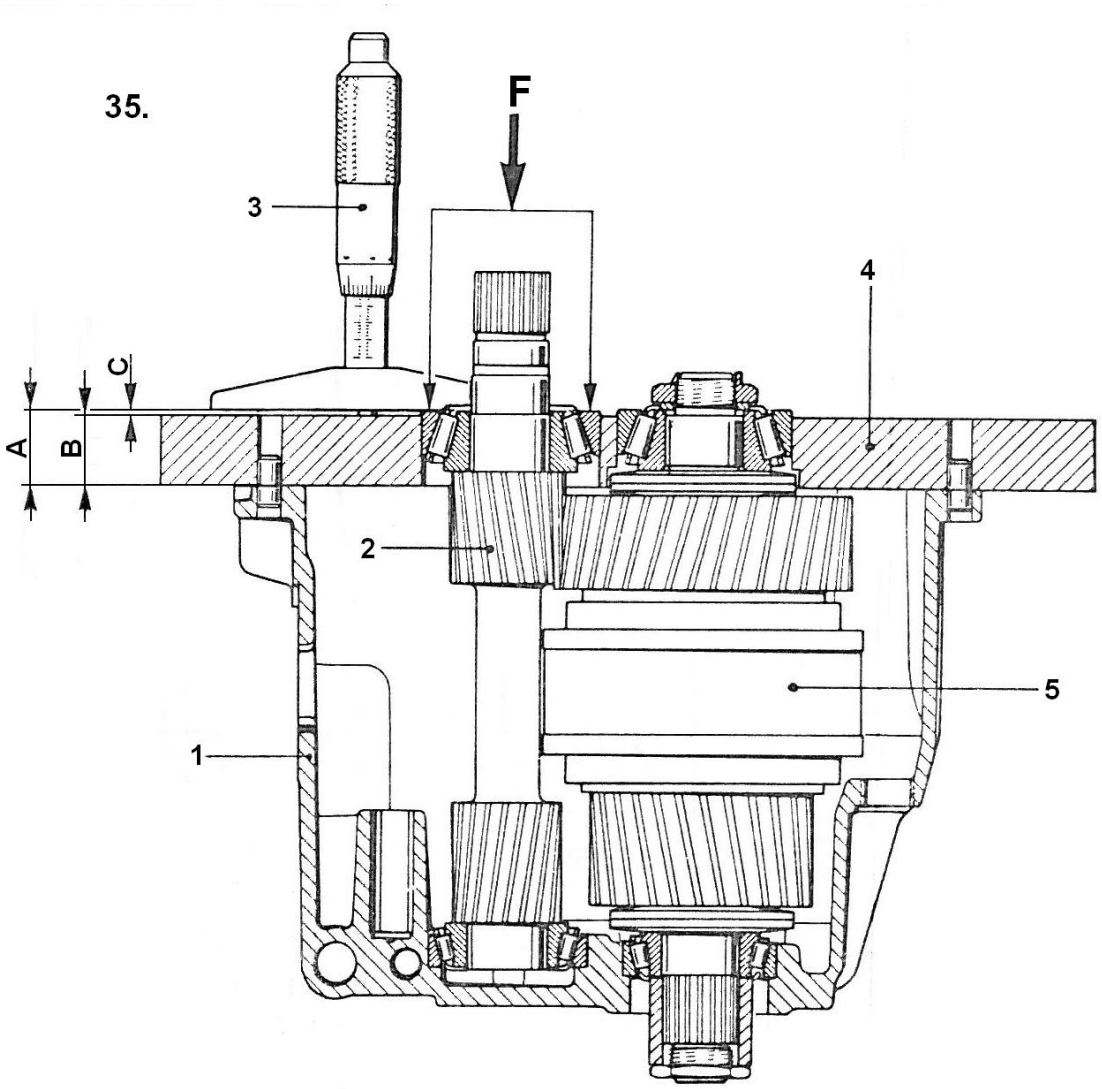
Heat the tapered roller bearing inner collars to about 85°C and fit it with the thin end of the bearings towards the shaft ends.

“NOTE”: Fit wide tapered roller bearing on the input side.

34.



Measuring of Tightening of Tapered Roller Bearing on Input and Output Shafts with Measuring Gauge.



1 = Housing
2 = Input shaft
3 = Depth micrometer
4 = Measuring gauge 1 x 56 136 978
5 = Output shaft

Heat the bearing bores in the housing to about 85°C and fit the tapered bearing outer collars with Loctite No. 601.

Build in the tapered roller bearings of input and output shafts with the tightening of 0.03 to 0.08 mm after the cooling.

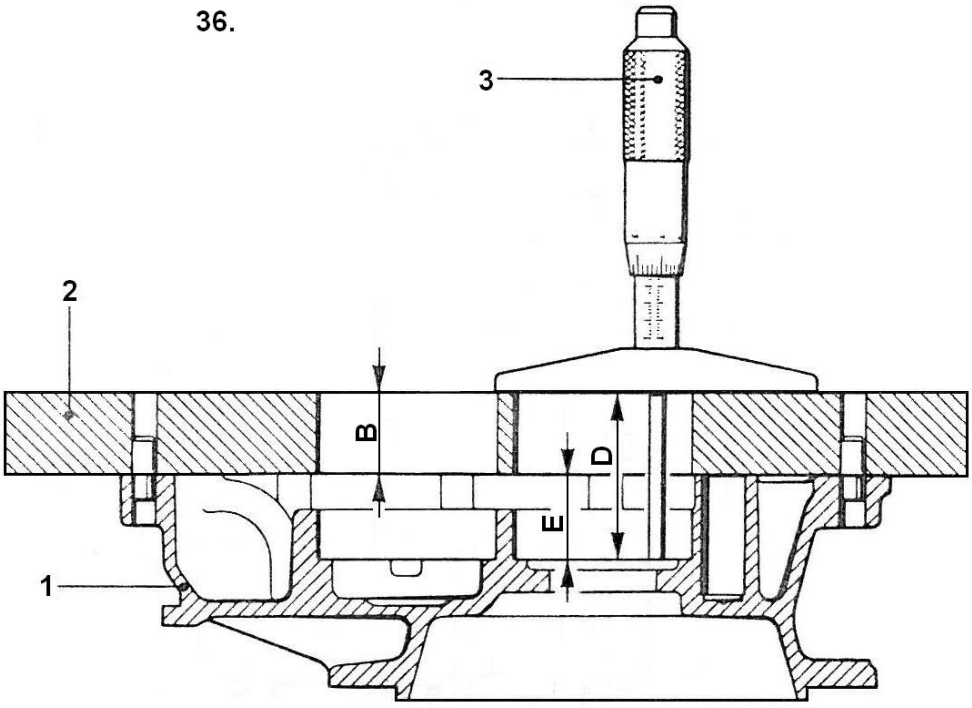
Measure the tightening as shown on the pictures 35, 36 and 37 and adjust it with adjusting washers (measure G). Measure G: measure F (difference measure) plus tightening.

Fit the input and output shafts in the housing and fit the measuring gauge on the housing by means of the pins.

Fit the tapered roller bearing outer collars in the measuring gauge until they fit tightly against the tapered rollers while constantly turning the input and output shafts with a pressure of F = 30 N (3.0 kp) on the bearing outer collars.

Measure A = B + C, B = thickness of measuring gauge, C = bearing outer collar above measuring gauge.

36.



1 = Bearing bushing
2 = Measuring gauge
3 = Depth micrometer

Fit the measuring gauge on lower gearbox half.

Calculate the thickness of the intermediate washer G as follows:

Establish measure E as D minus B (thickness of measuring gauge).

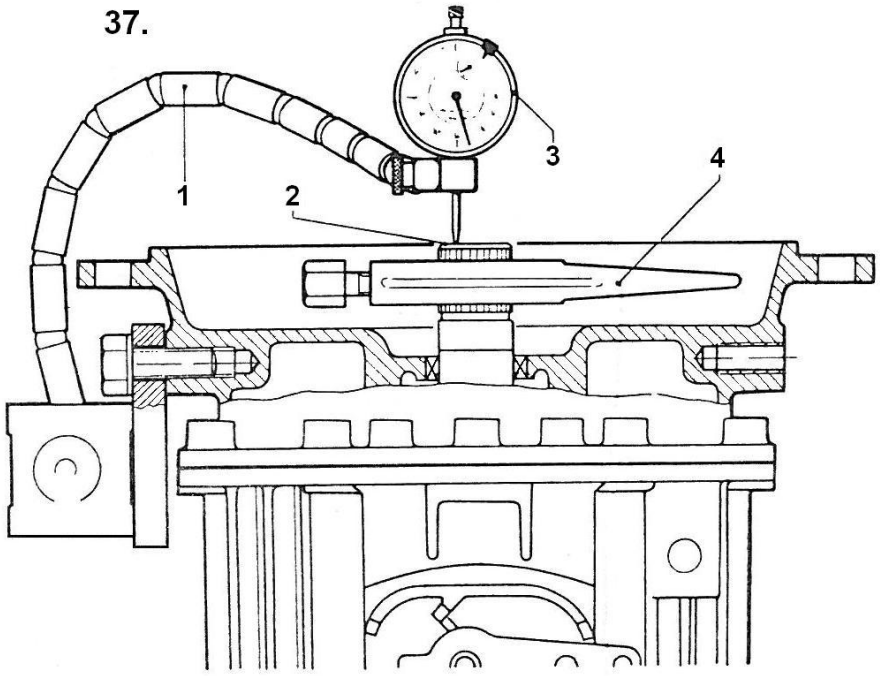
Calculate the difference measure F as E minus A (See picture No. 35 on last page).

Calculate intermediate washer G for the input shaft as F plus tightening 0.03 – 0.08 mm.

At the calculations the thickness of the liquid jointing, when compressed, should be included and an empirical value of 0.02 mm should be considered.

Then fit the necessary intermediate washers in the bearing bores (max. 2 washers per bore) and heat the bearing bores to about 85°C and fit the roller bearing outer collars with Loctite No. 601.

Measuring of Tapered Roller Bearing tightening on Input and Output Shafts without Measuring Gauge.



1 = Dial indicator holder 2 = Input shaft 3 = Dial indicator 4 = Driving arrangement

It would be an advantage, if the input shaft and the output shaft are measured individually for the adjusting of the tapered roller bearing tightening. The measuring procedure is the same both for input as well as for output. However, only the procedure for the input shaft is described here. When measuring the output shaft it should be as described at picture no. 31.

Turn the shafts when measuring in order to compensate for possible deviations, and a fixed point of measuring should be chosen for marking of the axial clearance.

Heat the bearing bore to about 85°C and fit the outer collar of the tapered roller bearing with Loctite no. 601.

In order to be able to adjust the tightening of the roller bearing it is necessary that the shafts show axial clearance. This is obtained by fitting intermediate washers which are 0.2 mm thinner than those which were removed and marked as described at picture no. 16.

Heat the bearing bore to about 85°C and fit the bearing outer collar without Loctite in the bore.

Place the input shaft in the housing after the cooling and fit the lower gearbox half without any packing and drive in the guide pins.

Fit the contact point of the dial micrometer on the front of the input shaft and turn the shaft backwards and forwards. During this the shaft should show axial clearance.

If there is no clearance shown. fit thinner washers under the bearing outer collar.

Add the roller bearing tightening of 0.03 – 0.08 mm plus further 0.02 mm (liquid jointing compressed) to the measured axial clearance and thus we get the thickness of the intermediate washer.

Picture No. 37 continued

Measuring example:

Thickness of intermediate washer during the measuring procedure:	0.60 mm
Measured axial clearance of shaft:	0.08 mm
Correct tightening 0.03 – 0.08 mm (average value):	0.055 mm
Thickness of compressed liquid jointing:	0.02 mm
Theoretical thickness of intermediate washer:	0.755 mm

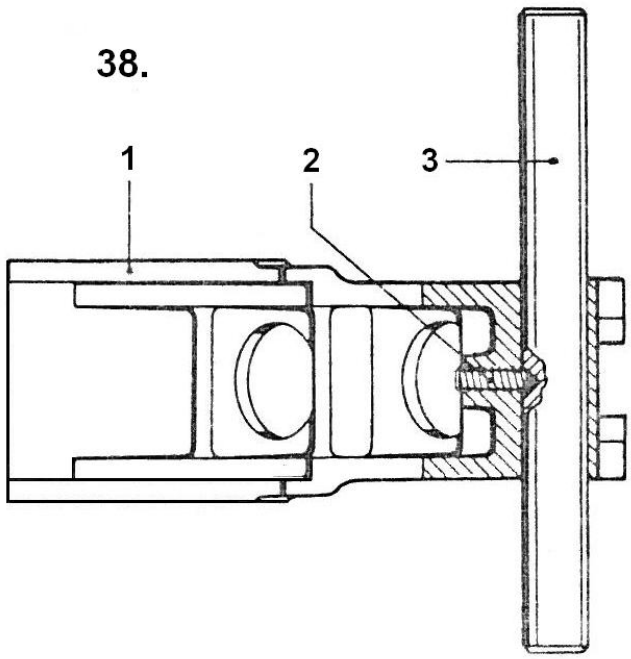
In practice the intermediate washer will be 0.73 – 0.78 mm.

Then insert the correct intermediate washers in the bores (max. 2 washers in each bore) and fit the bearing outer collars after heating with Loctite No. 601.

Pre-Mounting of Shifting Fork.

Place the reversing shaft in the shifting fork and secure it with the threaded pin and smear it with Loctite No. 241.

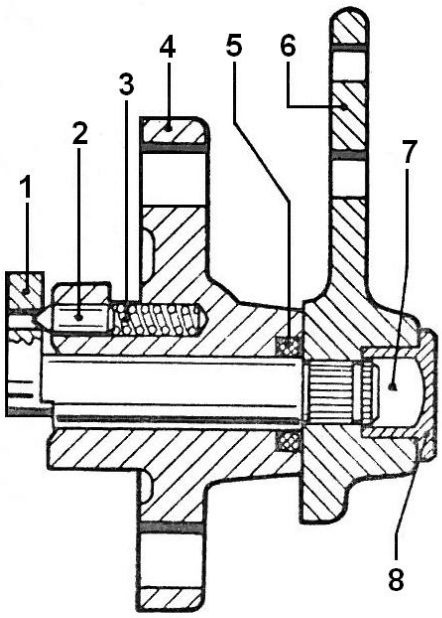
“NOTE”: the long side of the reversing shaft points to the left when the position of the shifting fork is as shown on the drawing.



1 = Shifter shaft
2 = Shift pin
3 = Pressure spring
4 = Gearbox
5 = O-ring
6 = Shift control lever
7 = Grease lubrication
8 = Screw cap

Insert pressure spring, shift pin, oiled shifter shaft and O-ring in the gearbox.

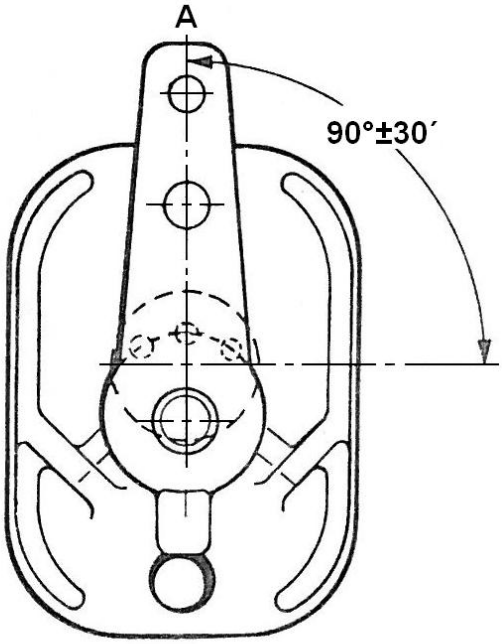
39.



Press the shift control lever on to theshifter shaft so tha t shift control leveris placed in neutral position at 90°±30'to the gear shaft length.

Fit the screw cap with grease lubrica-ting after the pressing on.

40.



Fitting of Bolts in Gearbox

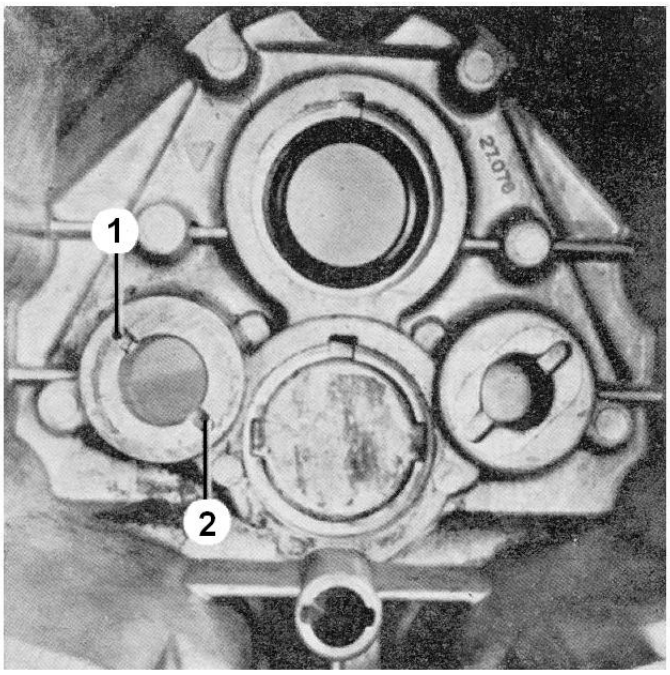
Drive in t he slotted pins 4x16 in thebolts and fit the washers on the bolts so that the lubricating groove in them point to the wheel.

"NOTE": The bolt must be fitted in pos. 1 or 2 all depending on the transmission.

Transmission:

GLL = AHEAD
GGL = ASTERN

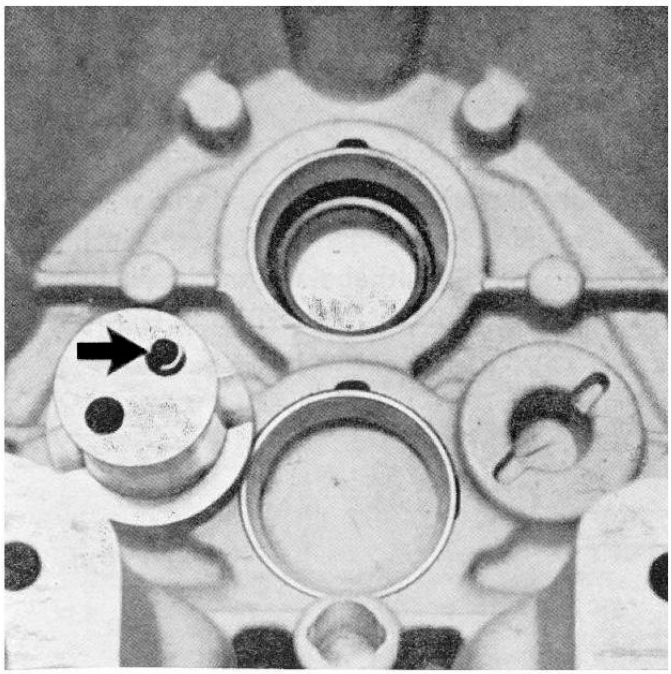
41.



Heat the gearbox and fit the bolts with slotted pins in pos. 1 or 2 all depending on the transmission.

Fit the hexagon nut and tight en it with 100 Nm (10 kpm).
Fit the sleeve in the bolt bore nearest the centre of the gear (s ee the arrow).
Smear the hexagon nut with unhardening packing material before the fitting.

42.

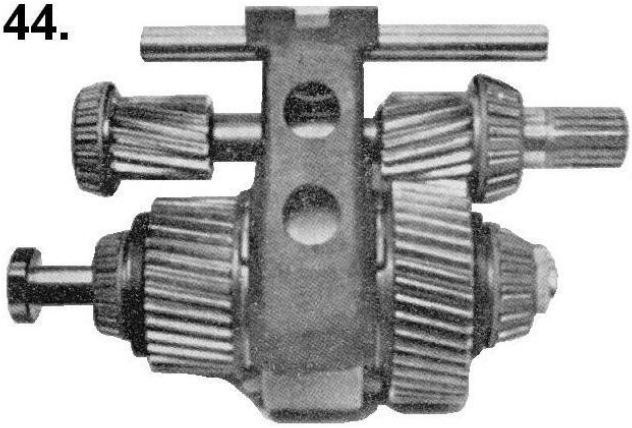


Fitting of Input and Output Shafts with Shifting Fork in Gearbox

Place the shaft arrangement as shown on the picture.

"NOTE": The long side of the reversing shaft faces the input side.

44.

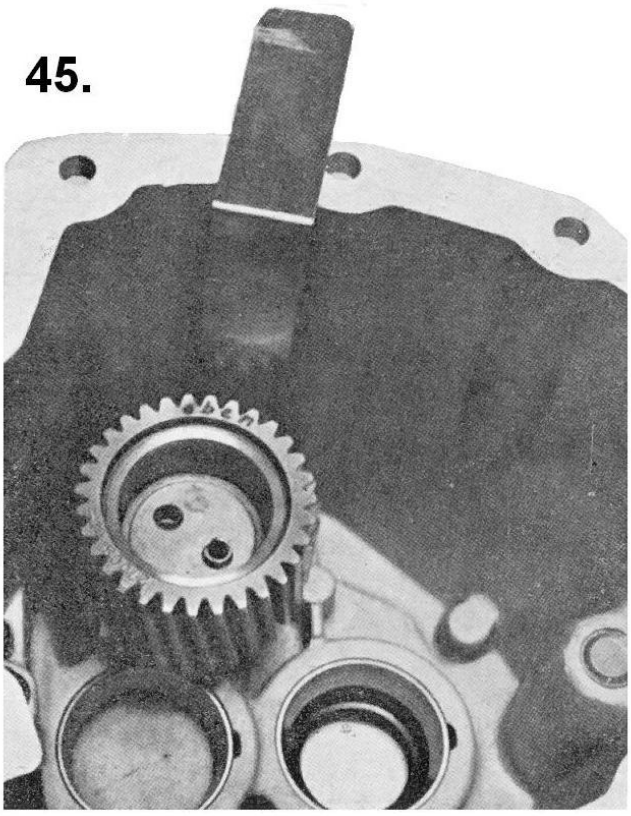


Fit the intermediate wheel and needle bearing.

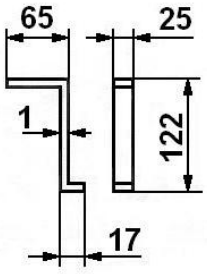
Lift intermediate wheel with s top plate (see illustration).

The intermediate wheel should be lifted about 25 mm, otherwise fitting is not possible.

45.



Sketch of Stop Plate



measures in mm

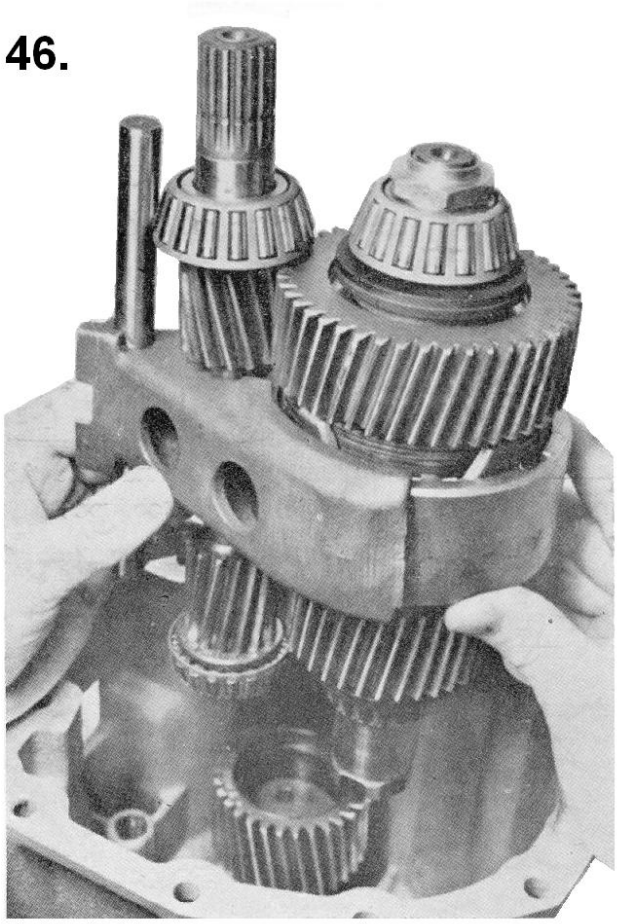
Place the housing so that the opening of it turns upwards.

Oil the roller bearings and reversing shaft and fit them together in the housing.

Remove the stop plate.

"NOTE": The long side of the reversing shaft points upwards to the input side.

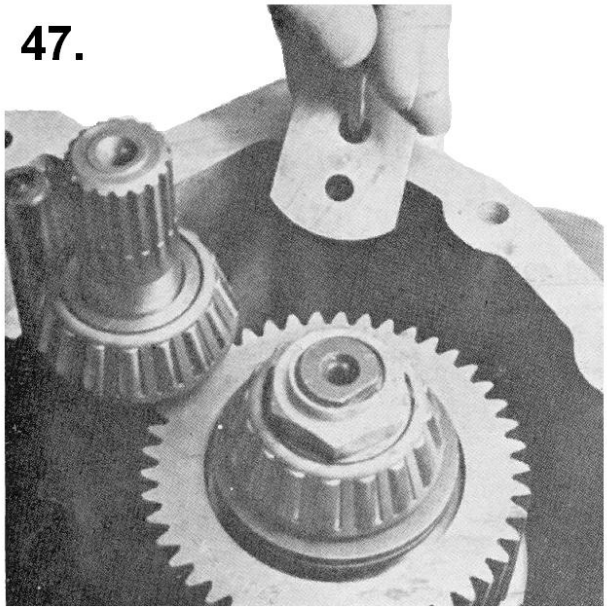
46.



Fit retaining plate for intermediate wheel and before that smear the screws M8x25 with Loctite No. 241.

Torque: 17 Nm (1.7 Kpm).

47.

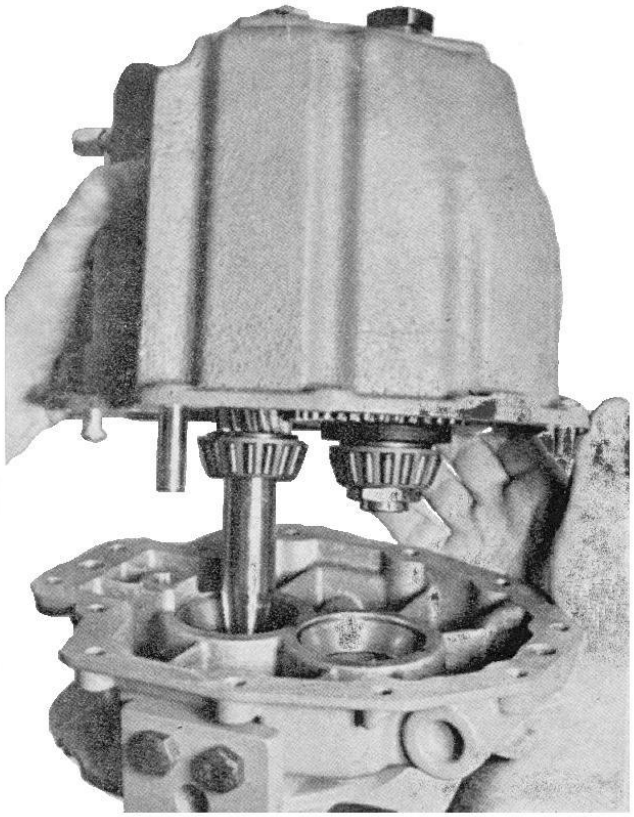


Smear the seal f aces of the gearbox halves wit h permanently plastic liquid jointing.

Oil the bearings on the input and output shafts.

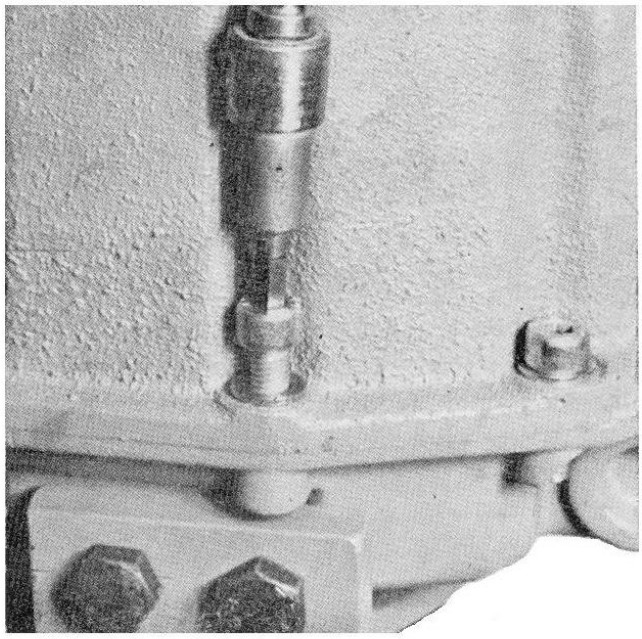
Assemble the gearbox and drive in the guide pins.

48.



Tighten the screws M8x25 with a torque of 17 Nm (1.7 Kpm).

49.

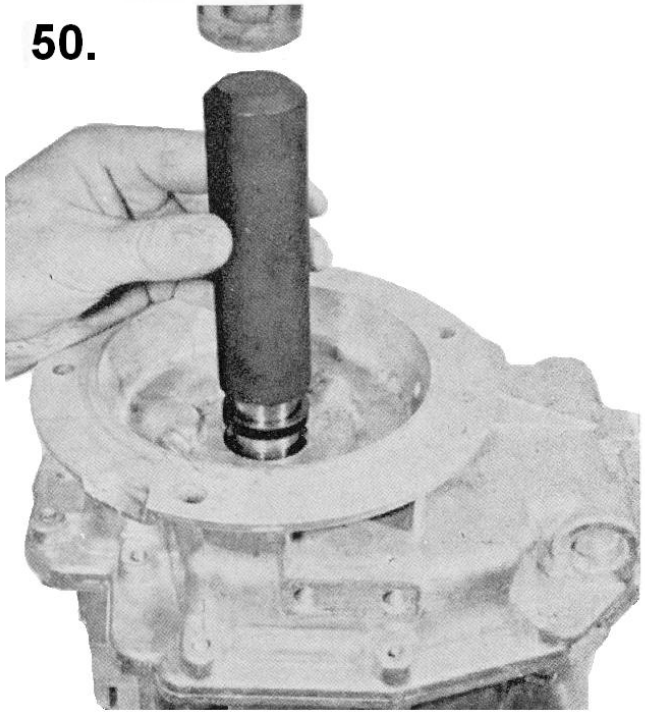


Fitting of Shaft Seal Rings

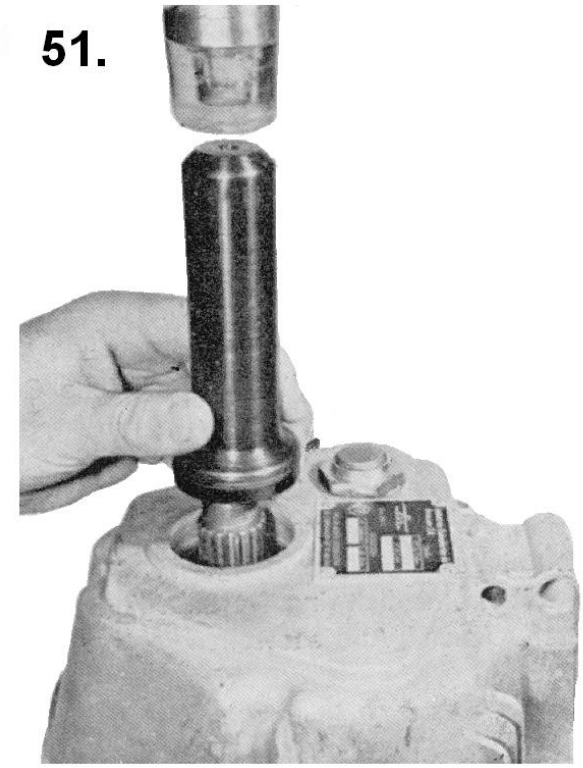
Fit the protective cap No. 1 x 56 136 992 over the input shaft.

Smear the seal ring 25 x 33 x 6 with a thin layer of grease on the lip ring and smear with a thin lay er of plastic liquid jointing on the outside.

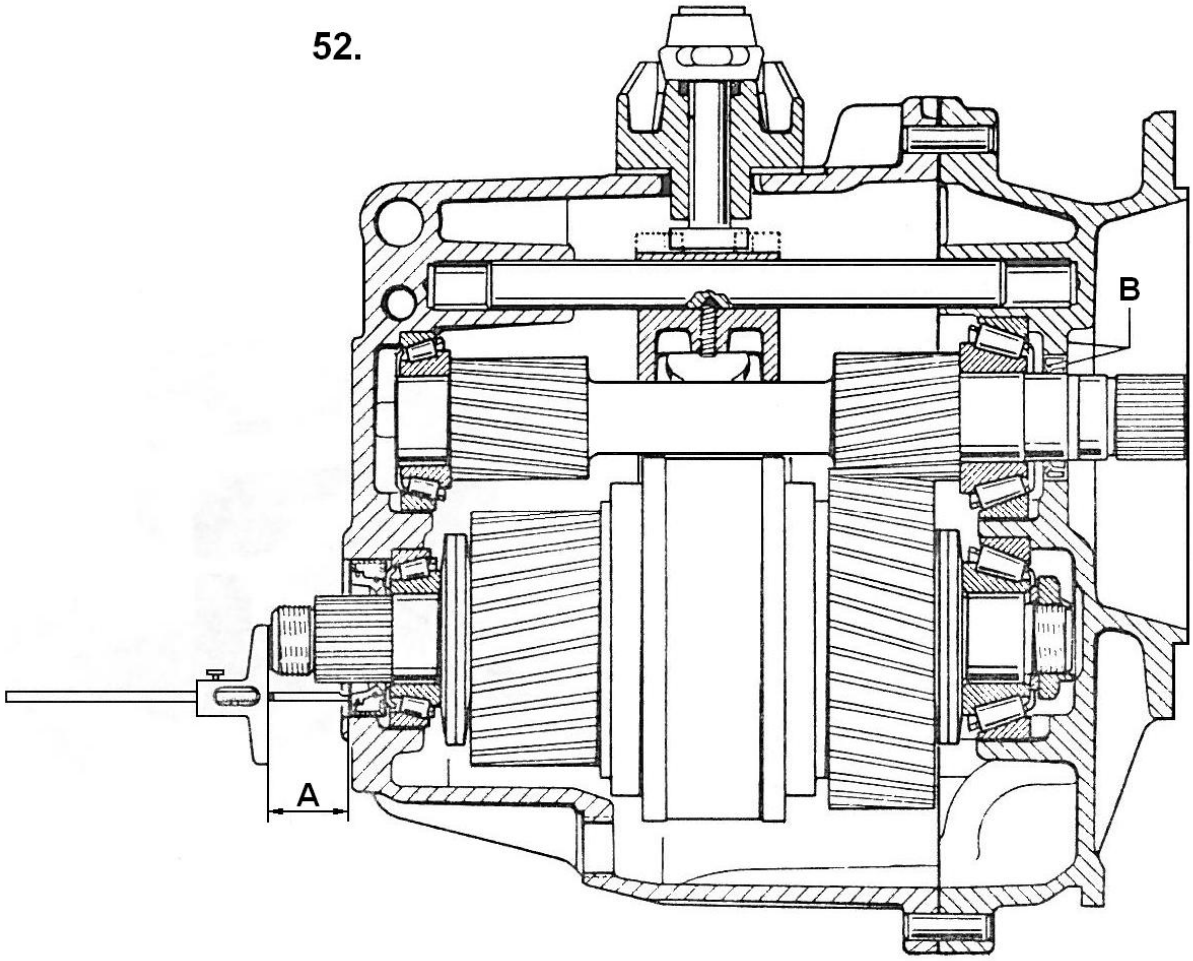
Fit the seal ring with punch No. 1 x 56 199 916 so that it fits tightly against the bore of the housing.



Smear the similar seal ring 32 x 45 x 7 for the output shaf t in the same way as the seal ring for the input shaft and fit it by means of punch No. 1 x 56 136 993 in the housing so that it fits tightly against the tapered roller bearing inner collar.



Supplement to Fitting of Shaft Seal Rings

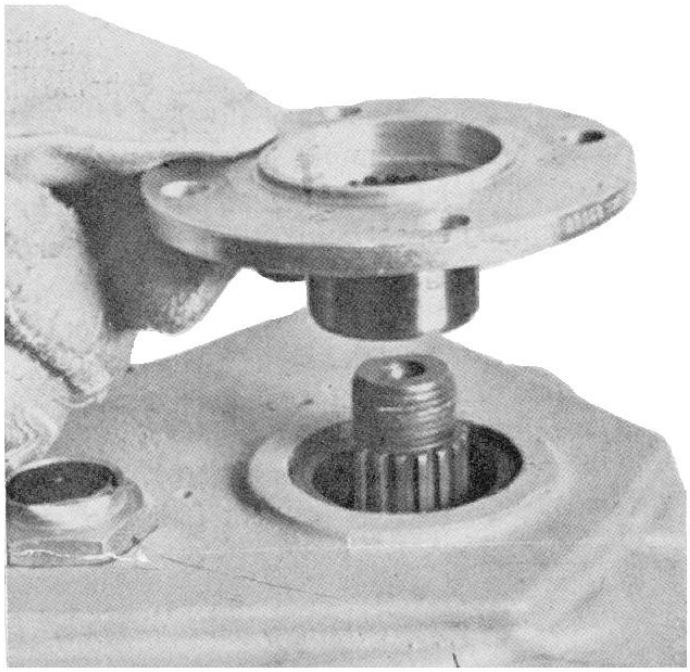


A = Distance to shaft seal ring: 22.5 ±0.5 mm.
B = Shaft seal ring binding with surface of casting on the lower gearbox half.

The picture shows the necessary mounting dimensions for the shaft seal rings on the input and output shafts.

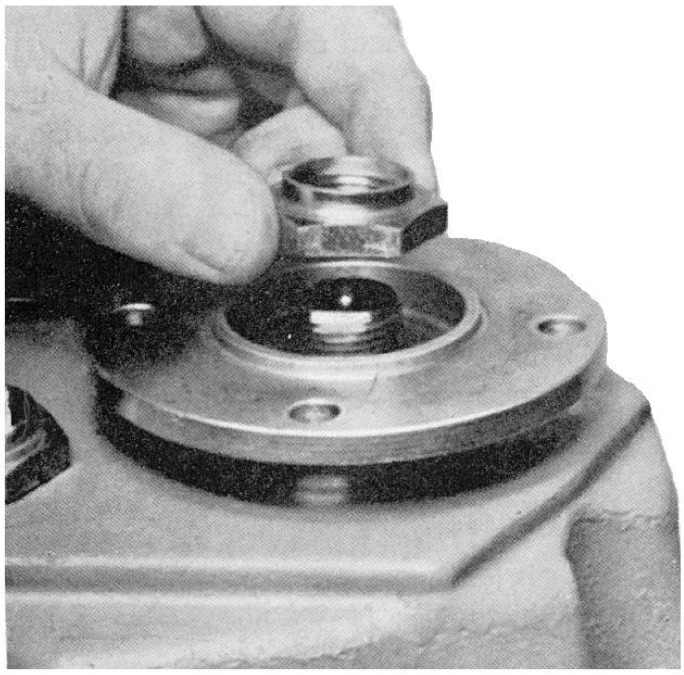
Heat the output flange to about 85°C and fit it on the output shaft.

53.



Smear the nut with permanently plastic liquid jointing and secure it with a torque of 100 Nm (10 Kpm).

54.



Picture 55

Fit the screws M8x25 with washers in the gearbox. Put the gear shift lever in "neutral" (the sliding sleev e is also in "neutral" position).

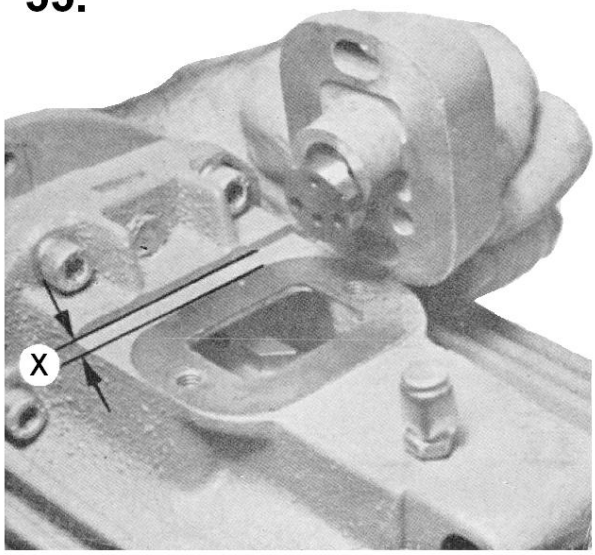
Place the gearbox with gask et in the opening of the housing and pr ess the shifting eccentric down into the shifting fork. In connection with this check at the same time with a ligh t pressure of the eccentric pointing to the assembly the axial clearance between the sliding sleeve and the shifting fork.

Secure the shifter housing in this position.

"NOTE": When checking the axial clearance it must be checked whether the fixing screws hit against the walls of the gearbo x because of the slots which may lead to wrong adjustments.

Adjustment can be c arried out by axial displacement (angle 90° m ust be maintained, see picture 40).

55.



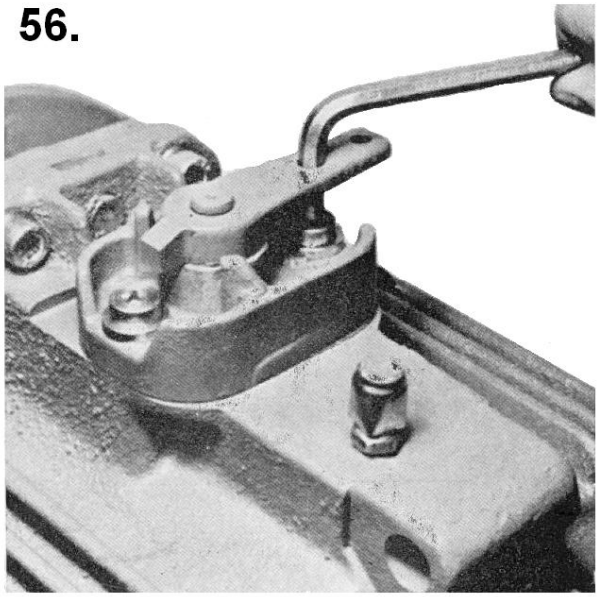
Picture 56

Tighten the shifter housing with a torque of 17 Nm (1.7 Kpm).
Shift the shift control lever in both directions and check the function of the reversing.

The sliding sleeve s hould be connected (click) in b oth directions when the angles of engagement are as equal as possible.

Besides, it must always be possible t o turn the shift control lever 37° in either direction without much resistance.

56.

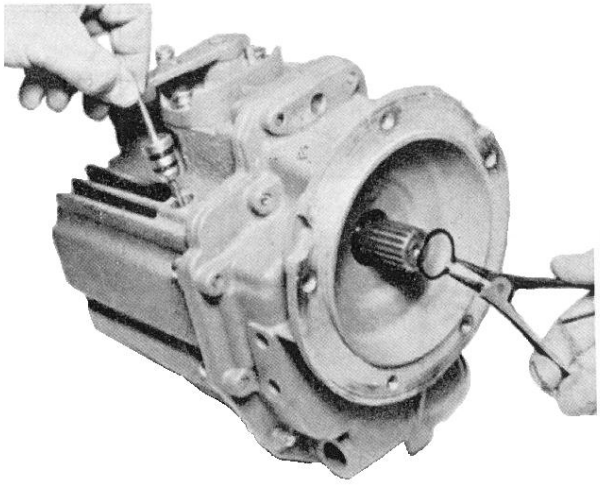


Picture 57

At last fit the dip stick and the loc king ring at the end of the input shaft when fitted.

Fill oil in the ge arbox to a quantit y corresponding to the upper mark on the dip stick.

57.



SECTION S

SAIL DRIVE TYPE Z-7

CONTENTS

Oil change and gear ratio ..... page S 3

Zinc anode..... page S 3

Outside maintenance ..... page S 3

Removal of sail drive from engine and boat ..... page S 3

Alarm function of double membrane..... page S 5

General (for assembly and dismantling of sail drive)..... page S 6

Assembling procedure for sail drive ..... page S 7

Intermediate housing and intermediate shaft (drawing)..... page S 12

Oil Change and Gear Ratio

As an alternative to the BW7 gear the DV36 can be equipped with a sail drive.

The reduction ratio is 2.25:1 for “AHEAD” and 2.25:1 for “REVERSE”.

The sail drive will need no other attendance than regular change of oil. This to be carried out after the first 25 hours of operation and then every 150 hours or once a year.

Carry out the oil change when the boat is on land by loosening the drain screw in the bottom of the sail drive enabling the oil to run out.

Refill with fresh oil through the filler hole at the top of the sail drive to a quantity of 3.3 litres corresponding to the upper mark on the dip stick.

Use the same quality of oil as for the BW7 gear.

Zinc Anode

A replaceable zinc anode is fitted at the propeller. Check this anode twice a year or as required all depending on the waters you are sailing in.

Outside Maintenance

Do not grind thoroughly when careening the boat. Damage to the surface treatment should be treated as soon as possible with special BUKH paint.

The sail drive should be coated with the same bottom paint as the rest of the bottom of the boat.

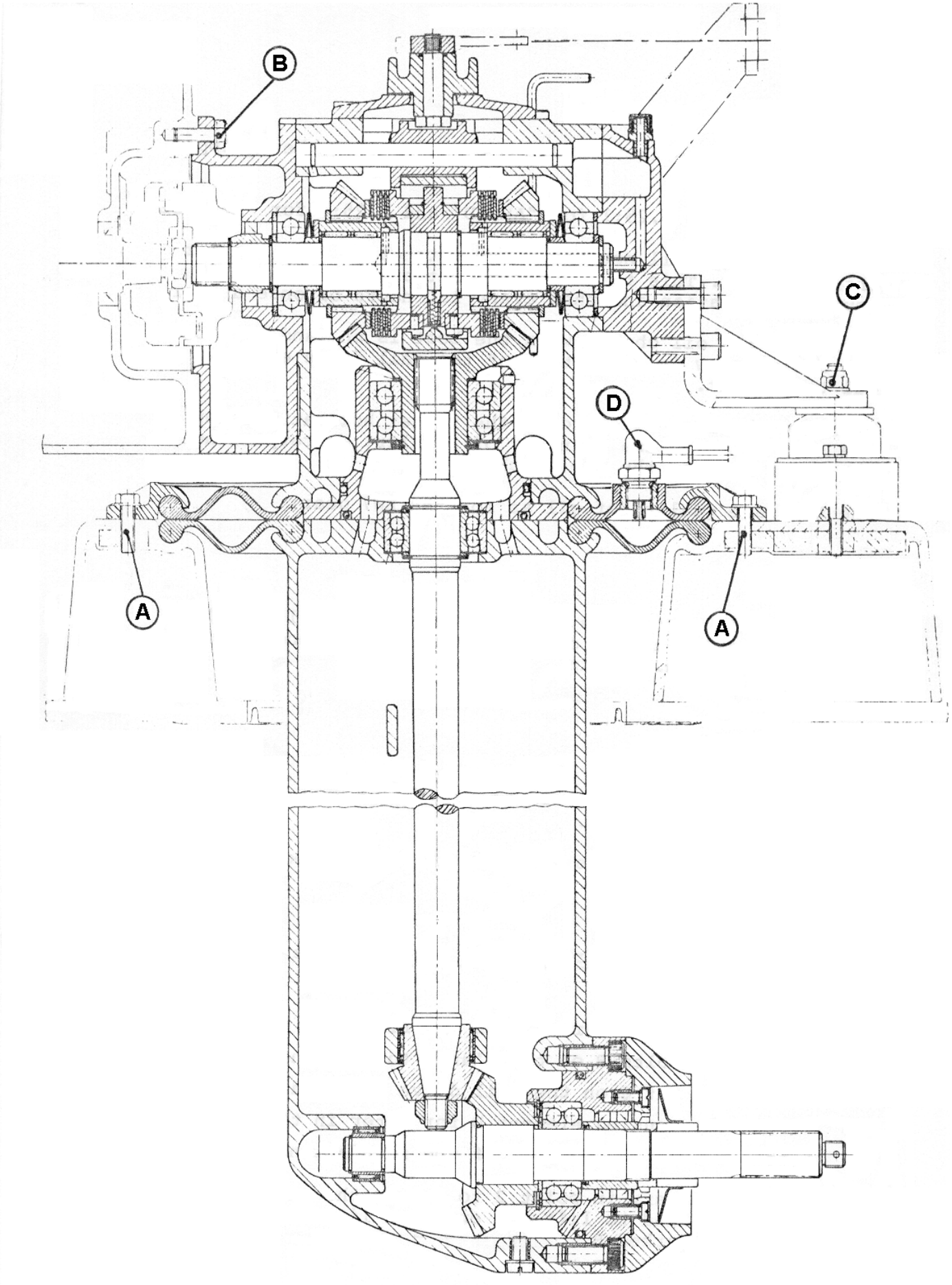
Removal of Sail Drive from Engine and Boat

(see drawing page S4)

1. Beach the boat.
2. Loosen the bolts marked **A** in the flange at the double membrane.
3. Loosen the bolts marked **B** on the flange towards the engine.
4. Loosen the sensing element marked **D** for water in the double membrane.
5. Lift the sail drive clear of the foundation.

It may be necessary in point 2 to loosen the engine mountings from the foundation and to lift the engine a little in order to loosen all the bolts marked **B**.

S4



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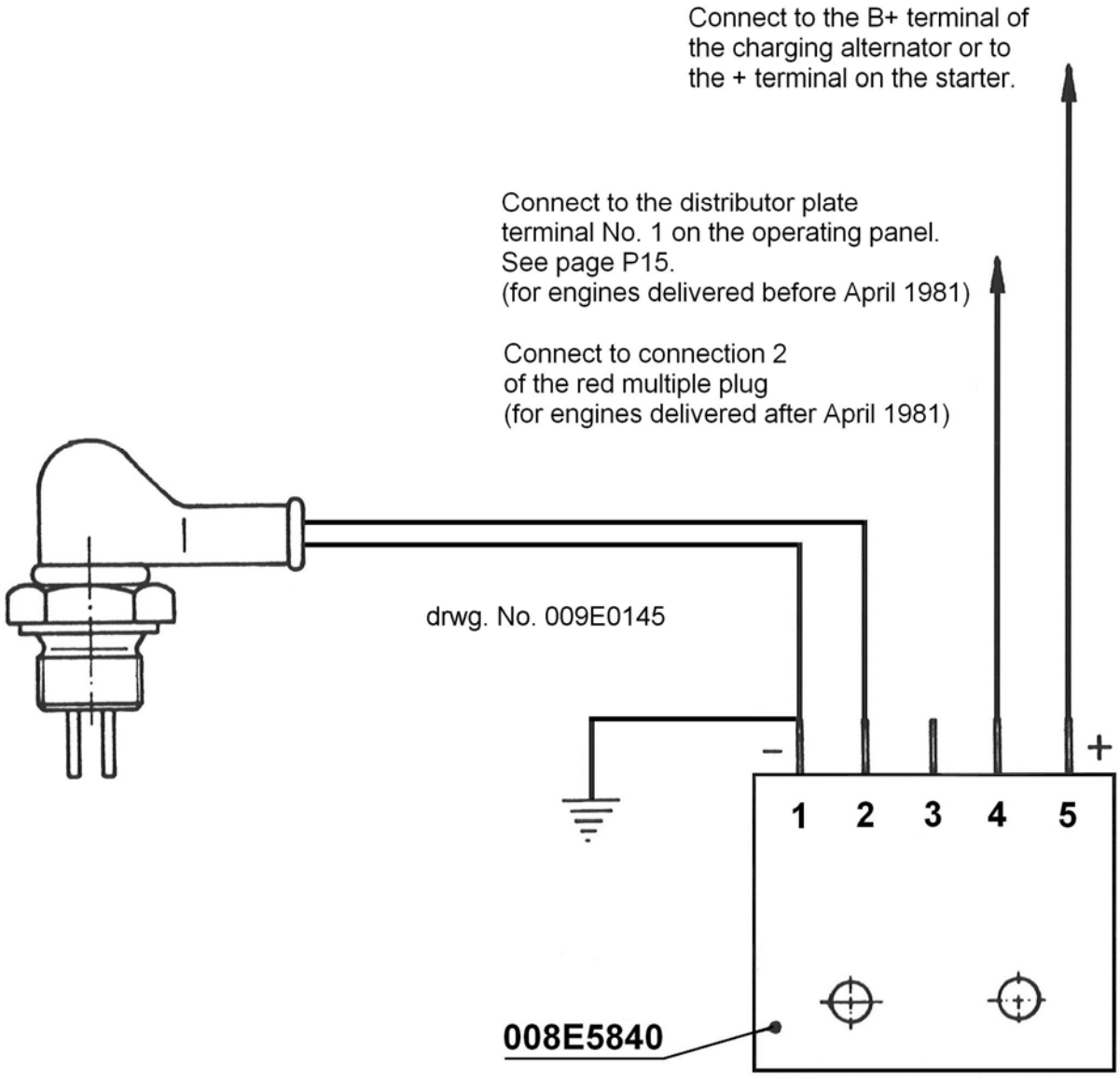
Alarm Function of Double Membrane

A sensing element is fitted in the double membrane. The element is shown on the diagram below.

The sensing element is connected to the the operating panel and if water penetrates into the double membrane it will release an acoustic alarm.

As a precaution the alarm function should be checked once or twice a year by short-circuiting the connections 1 and 2 on the plastic box No. 008E5840 placed on the engine next to the multiple plugs.



The instruction below is stated for assembling of sail drives as broadly the disassembly procedure is to be carried out in reverse order noting the thickness and the placing of the different intermediate washers.

General

At the assembly all parts must be clear, burred and free from grease.

In order to prevent wrong measuring when adjusting, the parts should normally not be oiled when being assembled.

Heat the mounting houses with a hot-air blower, an oven or the like to **80°C** when fitting the bearings in accordance with the procedure. However, the temperature must not exceed **140°C**.

When replacing gear-wheels, change them two and two, i.e. do not change one single gear-wheel, but one connected set of gear-wheels.

When replacing the coupling arrangement at the top of the sail drive, replace the whole arrangement without repairs of single components of it. This should be seen in the light of the fact that a correct repair of the coupling arrangement demands a very advanced measuring equipment which only very few have at their disposal.

The special tools mentioned in this instruction are not numbered, but can be ordered with reference to this section of the workshop manual through BUKH´s spare parts department.

Both distance measure and flange clearance are always marked on the wheels, and they apply to the wheel on which they are written.

The sail drive comprises 11 filling pieces each consisting of an intermediate washer at the least.

Assembling Procedure for Sail Drive

1. Measure the intermediate piece (between engine and clutch housing), the clutch housing and the end cover for the same, and then the "**K**" measure can be worked out.

2. Up-end the clutch shaft so that any clearance is equalized. (about 2 kg compression, if it is not possible to up-end the shaft). At the same time the gear-wheel should be engaged. Measure the "J" measure now. Measure the "**C**" measure for use later on under point 10.

3. Measure the "**H**" measure in order to find the centre of the vertical intermediate shaft. Measure the "**G**" measure as "**F**" measure + "**A**" measure, as the "**A**" measure is written on the gear-wheel.

   Measure the "**F**" measure while the shaft still stands on its edge, so that any clearance is equalized.
   Calculate the thickness of the intermediate washer "**II_v**" as: "**H**" measure minus "**G**" measure.

4. Calculate the thickness of the intermediate washer "**II_r**" as: "**K**" measure minus sum of "**J**" measure and intermediate washer "**II_v**".

5. Fit the intermediate piece on the clutch housing with liquid jointing as filling piece.

6. Fit the reversing part at the top of the clutch housing as follows:

a. Put the reversing lever in "Neutral" position and the pipe collar too.

b. Lead the reversing house with gasket into the opening of the clutch housing and press the shifting eccentric into the wedge-shaped groove of the shifting fork. In order to equalize the axial clearance between the shifting fork and the pipe collar the shifting eccentric should be fitted with the groove in the shifting fork with a light pressure.

c. Tighten the reversing house in this position.

   NOTE: The clearance of the angle between the longitudinal shaft of the gear and the one of the reversing lever must be observed. The angle is to be **90°±30`**.
   Use a reference gauge for this purpose.

   When adjusting the reversing house the fixing screws must not encounter the wall of the slots of the reversing house as this would lead to wrong adjustment.

d. Shift the reversing lever in both directions and test the shifting function. In both shifting positions the pipe collar be connected (click), when the angles of engagement measured on the reversing lever are as equal as possible.

   Besides, it must always be possible to turn the reversing lever **37°**. The adjustment is corrected by axial displacement of the reversing house, the angle of 90° being observed.

e. In order to test the function of both clutches turn the input shaft (clutch shaft) round by hand and brake the output shaft by hand when engaged.

   The upper part of the sail drive is now temporarily ready.

Measure on the intermediate wheel as follows:

7. 1.0 mm is chosen as thickness of the intermediate washer "**III**" as starting point.

8. Freeze the gear-wheel and measure the stagger between the inner collar and outer collar of the bearing. Fit the bearing with the ball filler hole facing the adjusting washer "**IV**".
   Fit the next bearing correspondingly. Punch the inner collar when fitting it to secure that the two inner collars touch each other.
   Measure the intermediate bearing housing for the measures "**D**" and "**E**".

9. Measure the "**M**" measure for use later on.

10. Calculate the thichness of the intermediate washer "**IV**" now, the intermediate washer = "**C**" measure minus the sum of "**D**" measure and "**B**" measure.
    "**B**" measure is written on the gear-wheel.

11. Measure the "**L**" measure, then calculate the thickness of the intermediate washer "**V**", this washer being = "**L**" measure minus the sum of "**E**" measure and the intermediate washer "**IV**".

12. Fit the intermediate wheel in the bearings and secure it with a Seeger circlip in accordance with the drawing for it.

13. Fit the bearing housing with intermediate wheel in the gearbox with O-rings.

14. Remove the end cover in the clutch housing together with the shifting fork arrangement for the test described in the next point (15) to be carried out.

15. Mount the clamping tools for fixing of the big gear-wheel. Mount a dial indicator on the gear-wheel of the clutch shaft through the upper opening at the reversing handle of the clutch housing, so that the indicator meets the following requirements.

    a. Point of contact about in the middle of the tooth flank and of the pitch circle.
    b. The indicator should be vertical in the longitudinal and height direction of the tooth flank.
    With the bigger gear-wheel (z=45) fastened, measure the flank clearance. Measure both the wheels of the clutch shaft in this way.
    If occasion should arise, adjust the clearance to the one stamped which is correct by changing the washers "**IV**" and "**V**".

16. Refit the end cover and the reversing arrangement as stated under point 6.

17. Measure the propeller house for "**O**" measure, "**W**" measure and "**U**" measure.

18. Fit the bottom conical gear-wheel marked "**X**" at a torque of **125 Nm±5 Nm (13 ±0.5 Kpm)** on the intermediate shaft of the propeller house.

19. The intermediate washer "**VI**" normally is 1.5 mm and must never be used smaller. Fit the intermediate washer "VI" on the shaft together with the bearing, the ball filling opening of which should turn up.

20. Measure the intermediate washer "**VII**" with a feeler gauge and fit the correct thickness together with the upper locking ring.

21. Calculate the "**T**" measure. The "**S**" measure is stamped on the gear-wheel whereas the "**R**" measure has to measure. "**T**" measure = "**S**" measure minus "**R**" measure.

22. The intermediate washer "**$VIII_B$**" should be: the sum of "**T**" measure and "**Q**" measure minus the difference of "**U**" measure and "**O**" measure.

23. Find the thickness of the intermediate washer "**$VIII_A$**" by measuring the bearing outer collar "**N**" measure, after which the washer should be: the sum of "**M**" measure and "**O**" measure minus the sum of intermediate washer "**$VIII_B$**" and "**N**" measure.

24. Having finished the measuring of the intermediate shaft remove the gear-wheel marked "**X**" again and fit the needle bearings "**Z**" and "**Y**" after the house has been heated.

25. Fit the intermediate shaft with bearings in the propeller housing.

26. Refit the gear-wheel marked "**X**" and tighten it with the same torque as indicated in point 18.

27. Check whether the distance measures of the small gear-wheel are correctly adjusted with the fitted washers ("**T**" measure) with special tools.

28. Measure the "**V**" measure.

29. Heat the bearing housing "***Æ***" and fit the bearing with the ball filling opening facing the gear-wheel side.

30. Measure the thickness of the washer "**X**" with a feeler gauge (between locking ring and outer collar of the bearing).

31. Calculate the intermediate washer "**IX**". The "**W_1**" measure is indicated on the gear-wheel. The intermediate washer = "**W**" measure minus the sum of "**V**" measure and "**W_1**" measure.
32. Fit the output shaft with gear-wheel in the cover for propeller house with seals.

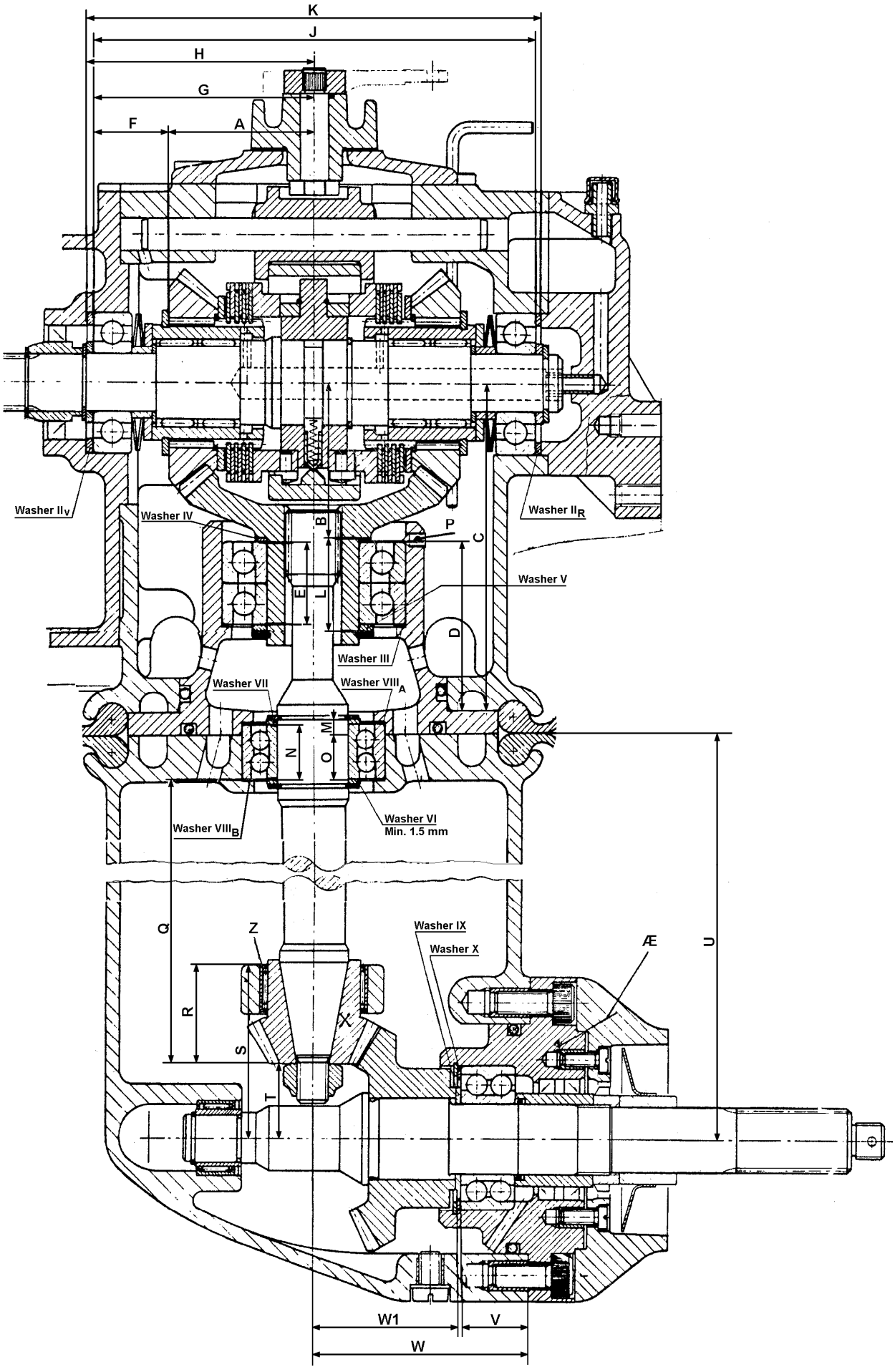
33. Fit cover with shaft and gear-wheel in the propeller housing.

34. Check the flank clearance at the output shaft.
    The intermediate shaft is blocked and on the propeller shaft a lever is placed, on which should be measured at difference radius R=40 mm. The shaft nut must be tightened.

    The correct flank clearance is indicated on the gear-wheel and is corrected at the intermediate washer "IX" if necessary.

On pages S10, S11, S12 and S13 longitudinal sections of the sail drive with places of measuring drawn in are shown, partly by a general drawing and partly by detail drawings.

S10



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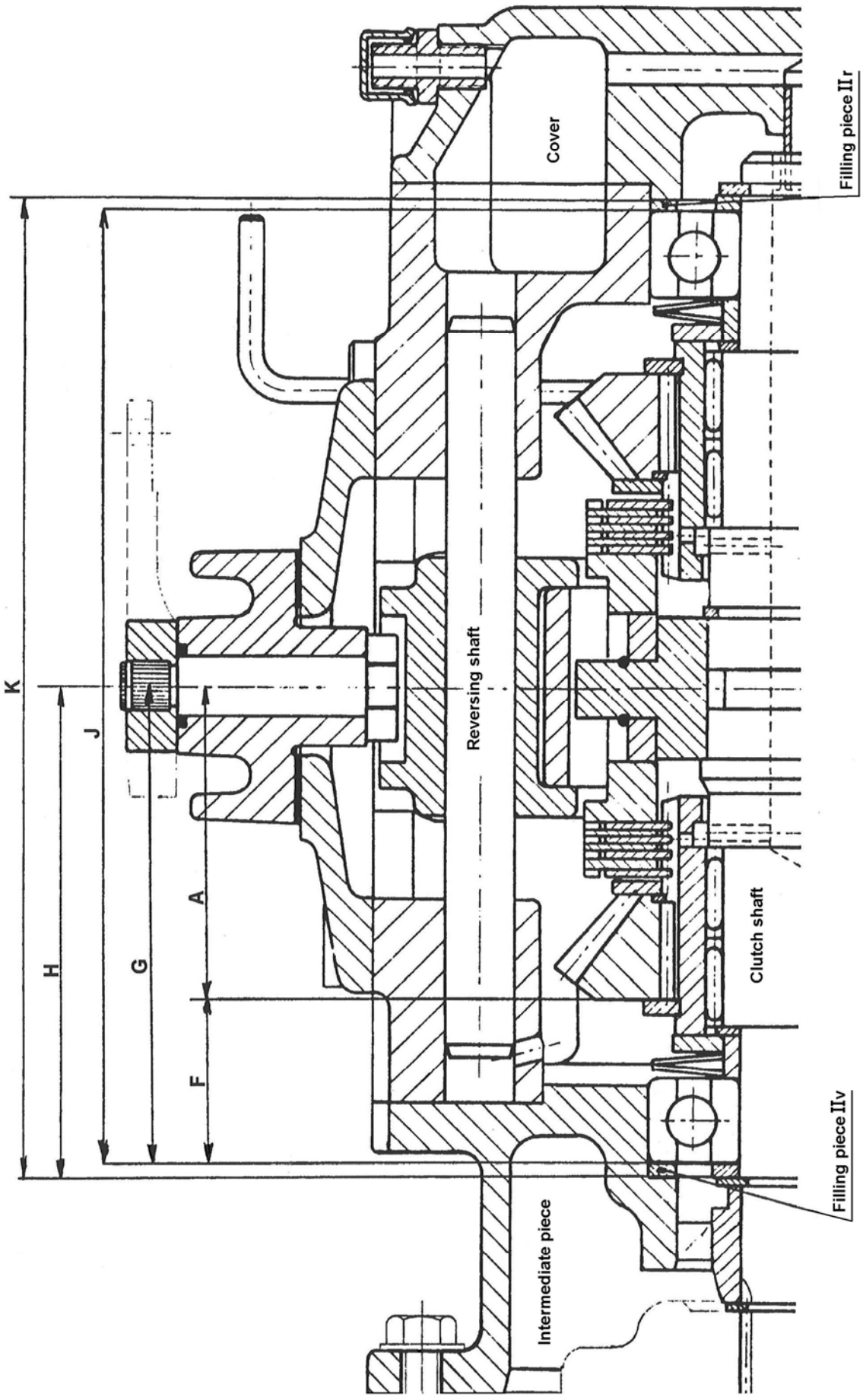

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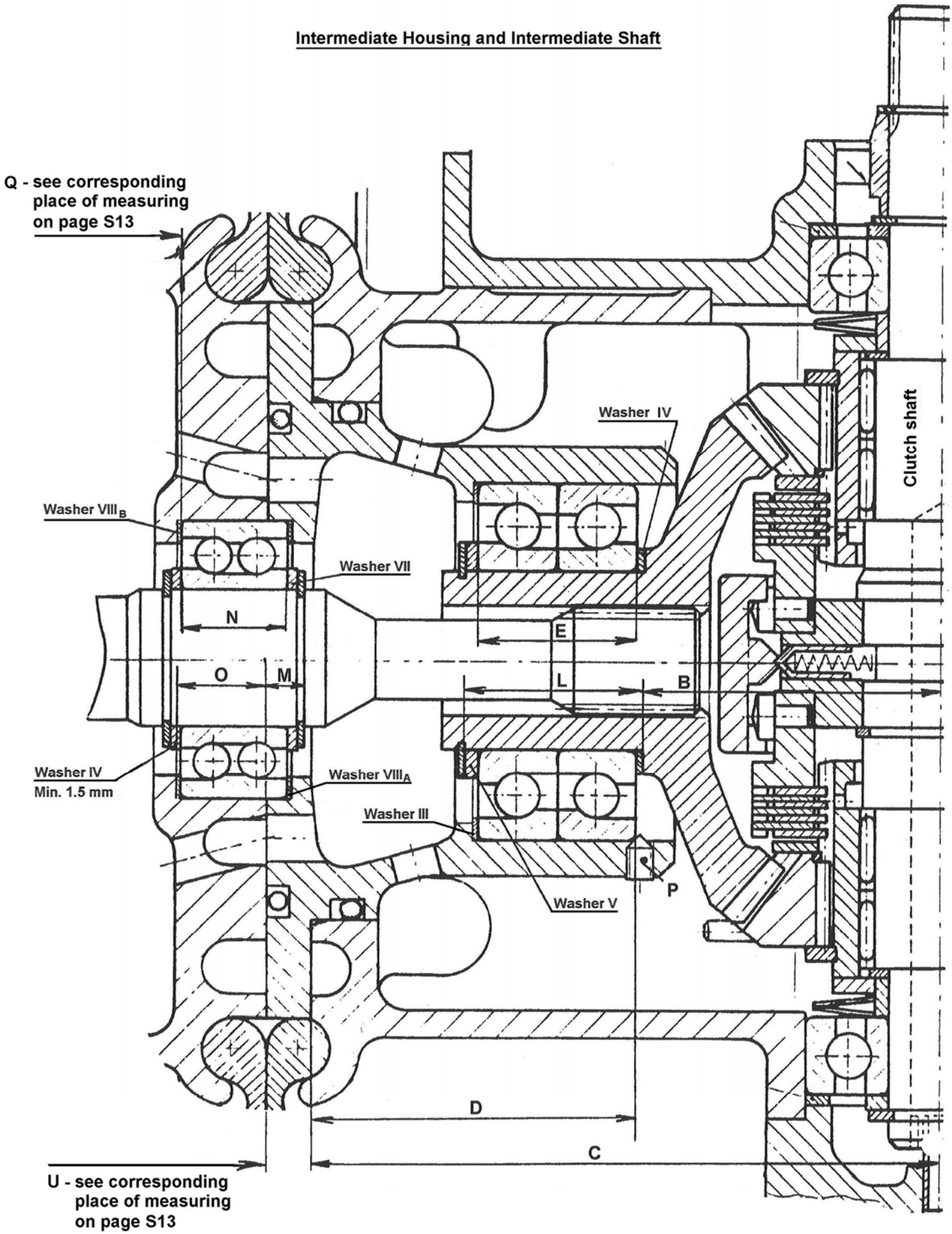
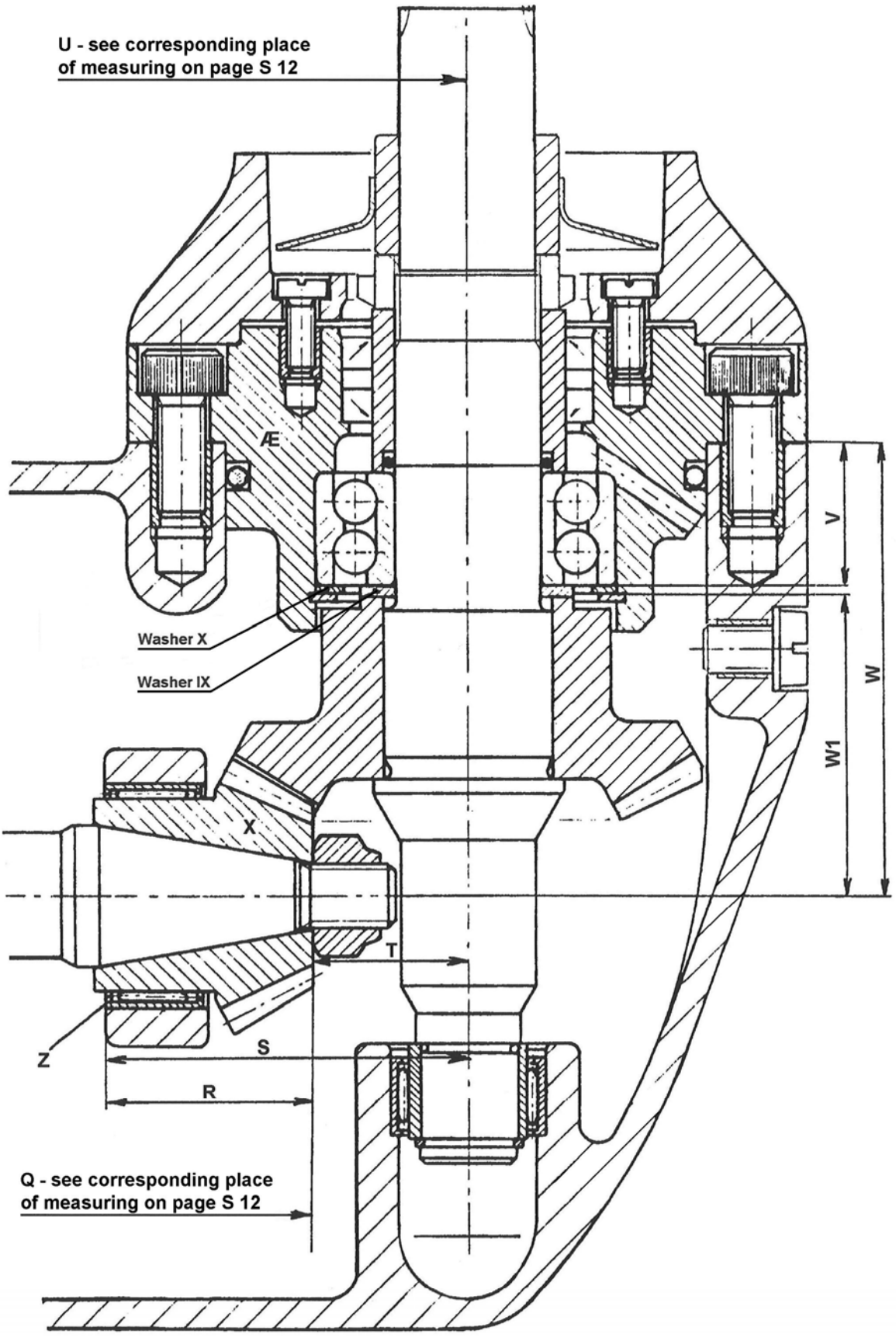
Intermediate Housing and Intermediate Shaft




U - see corresponding place
of measuring on page S 12
Æ
Washer X
Washer IX
V
W
W1
X
T
Z
S
R
Q - see corresponding place
of measuring on page S 12

SECTION T

IRREGULAR OPERATION, CAUSES AND REMEDIES

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Engine does not start ..... page T 3

The engine starts, but stops soon after ..... page T 3

The engine does not reach maximum output ..... page T 3

Knocking operation of engine ..... page T 3

Engine speed too high ..... page T 3

The engine knocks ..... page T 3

The engine smokes ..... page T 3

Excessive consumption of lubricating oil ..... page T 3

Excessive fuel oil consumption ..... page T 3

The engine gets too warm or too cold ..... page T 3

Insufficient or no lub. oil pressure ..... page T 3

1. Engine does not start

SYMPTOM	CAUSE	REMEDY
Insufficient or very little compression	Inlet and/or exhaust valves leaking	Grind or replace the valves, mill the seats
	Inlet and/or exhaust valves sticking	Grease valve stems with 2/3 gas oil and 1/3 lub. Oil. If necessary clean the valves.
	Insufficient rocker arm clearance	Adjust to 0.25 mm inlet and 0.3 mm exhaust when engine is cold (turn left)
	Piston rings stuck in grooves or are worn	Replace piston rings
	Valve springs broken or are weak	Replace springs
Insufficient or no pressure from fuel pump	Air in fuel system or nozzles sticking	Bleed or renew nozzles
Thermo start out of order	No fuel (valve leaking)	Fill up (renew thermo-start)
	Electric supply out of order	Check and/or replace switch and connections. Chech fuse
Engine does not reach normal revs	Unloaded battery or defective	Battery to be charged or renewed
Starter motor turns engine too slowly	Loose or corroded connections	Tighten or clean connections

2. The engine starts, but stops soon after

The engine starts, but stops soon after	Empty fuel tank	Refill and bleed
	Air in fuel system	Bleed
	Nozzle sticking	Replace nozzle
	Fuel filter clogged	Replace filter element. Clean the tank

3. The engine does not reach maximum output

Difficult to start	None or insufficient compression	See ”engine does not start”
The engine revs. Is reduced considerably when loaded	Fuel supply choked up. Air/water in fuel system	Check fuel system thoroughly
	Governor incorrectly adjusted or something in the system works sluggishly	Adjust the governor. Check governor system and correct the error
Hot engine (smell of heat)	Insufficient cooling water supply	Stop engine. Check cooling water pump
	Damaged cylinder liner or bearings	Check bearings, piston and cylinder, if necessary replace them

4. Knocking operation of engine

The engine runs unevenly	Air/water in fuel system Fuel filter clogged	Bleed see ”engine does not start” Replace filter element. Clean the tank

5. Engine speed too high

Governor not working properly	Governor spindle is bent or works sluggish	Repair or replace spindle
Governor not properly adjusted	Governor arm has turned on the spindle	Adjust arm
Engine runs too fast during idling	Idler spring too tight	Repair or replace spring

6. Engine knocks

Hard knocking sound at the combustion	Incorrect adjustment of the injection time	Adjust timing
Knocking sound from engine	Loose connecting rod bolts Worn or burnt bearings Piston and cylinder liner highly worn	Tighten bolts Replace bearing shells Replace piston/cylinder liner

7. The engine smokes

Black smoke	Clogged air inlet filter	Clean filter
	Insufficient compression	See ”engine does not start”
Blue smoke	The lube oil passes piston and oil rings an penetrates into combustion chamber, or vacuum valve defective	Replace oil rings and possibly the piston rings. Clean vacuum valve
Grey smoke	Thermostart valve is leaking	Replace

8. Excessive consumption of lubricating oil

Blue smoke	Oil- and piston rings are worn	Replace oil- and piston rings, if required
	Piston and cylinder liner highly worn	Replace
	Defective vacuum valve	Replace
Lub. oil leaks out of crankshaft bearings	Worn oil seal ring	Replace

9. Excessive fuel oil consumption

Lubricating oil thinned with fuel oil	Leakages at the fuel lift pump	Check lift pump and replace if necessary
	Fuel pipes or hoses leaking	Check fuel line

10. The engine gets too warm or too cold

Cooling water temperature too high (smell of heat)	Unsufficient cooling water supply caused by:defective water pump, choked strainer or a defective thermostat	Investigate pump rotor for broken wings or lost driver screw. Clean strainer. Clean or replace thermostat
Cooling water temperature too low	Defective thermostat	Clean or replace thermostat

11. Insufficient or no lubrication oil pressure

Oil warning lamp lights up. Oil pressure gauge indicates abnormally low oil pressure	Insufficient lube oil in the engine	Check and refill
	Leakage in lube oil system	Tighten and refill
	Relief valve sticking or spring too weak	Clean bore and valve, stretch or replace the spring

As to defects of the fuel pump see special section on this page H13.

SECTION V

MAINTENANCE

CONTENTS

Recommended maintenance and check list..... page V 3

RECOMMENDED MAINTENANCE AND A CHECK LIST FOR BUKH ENGINES

	CHECK	RECTIFY IF NEEDED	WEEKLY	MONTHLY	YEARLY	EVERY 5 YEARS
1. Tightness of connections through hull:						
1.1 *stern tube*	hull connection	change sealing			X	
2. Check of lubricating oil:						
2.1 a *engine*	change oil	-			X	X
2.1.b *engine*	check oil level	-	X			
2.2.a *gearbox*	change oil	-			X	
2.2.b *gearbox*	check oil level	-	X			
2.3 *lubricating oil filter*	change	-			X	
3. Check of cooling watersystem:						
3.1 *system*	system to be full	fill up	X			
3.2 *anti freeze liquid*	check for minus 25°C.	refill anti freeze liquid			X	
3.3 *cooling water connections tightness*	for leaks	renew if leaking		X		
3.4 *condition of rubber hoses*	cracks and leaks	renew				X
3.5 *V-belt* for cooling water pump	adjust or renew	-		X		
3.6 *thermostat*	renew after 5 years	-				X
4. Check of fuel system:						
4.1 *supply line*	clean water/fuel separa-tor and check line bends	repair if damaged or renew				X
4.2 *fuel tank*	drain for water	-			X	
4.3 *fuel filter*	change	-			X	
4.4 *return line*	check for bends & damages	repair if damaged or renew				X
5. Check of remote control cables:						
5.1 *cables*	check easy operation and stroke sufficient	adjust cables				X
6. Check of propeller shaft arrangement:						
6.1 *rear stern tube bearing*	check clearance for bearing insert	renew insert				X
6.2 *sufficient water flow to rear stern tube bearing*	check that water holes in bearing housing are not blocked	clean holes				X
6.3 *alignment of gear flange and prop.shaft flange*	alignment to be within 0.05-0.01mm	realign the engine				X
6.4 *stuffing box seals*	tightness	renew all three seals				X
6.5 *condition of rubber tube for stuffing box*	cracks	renew				X
6.6 *Out-Board gearoil*.	oillevel	refill		X		
6.7 *propeller*	check size and condition	renew if damaged				X
7. Starting of the engine:						
7.1 start with *electrical start*	engine start within 2 minutes	if malfunctions -the engine must be ser-viced by a mechanic	X			
7.2 start with *handstart*	same	same		X		
8. Engine maintenance						
8.1 valve clearance	clearance	adjust			X	
8.2 electric starter	rust protection of starter drive	spray rust protection spray			X	
9. Running with engine - check:						
9.1 *Idling speed* to be 900-1200 RPM	900-1200 RPM	adjust RPM	X			
9.2 *Full speed unload* / min. 3700 RPM	min. 3700 RPM	adjust RPM	X			
9.3 *Full speed loaded* with *propeller*	3300-3600 RPM	adjust RPM			X	
9.4 *Cooling water temp*. to be max. 75 degr. Celcius	max. 75°C	change termostat		X		
9.5 *Audible and visual alarms*	check function	change senders, lamps or switch			X	
9.6 *Lubricating oil pressure*	min. 1.5 kg/cm² at idling	adjust oil relief valve				X
9.7 *Gearbox change* from FW to Neutral to ASTERN	check cables	adjust	X			
10. Air supply:						
10.1 *air inlet filter*	renew	-				X
11. Bateries:						
11.1 *level of liquid*	check, refill	renew	X	X X		X
11.2 *voltage conditon*	charge	renew		X		