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ISSUED FEB. 25, 2008

MITSUBISHI-SULZER

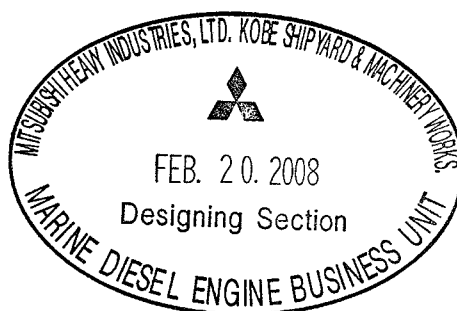
RT-flex96C

FINAL PLAN

S.No.2228

MITSUBISHI-SULZER

Maintenance Manual



MITSUBISHI HEAVY INDUSTRIES, LTD.
KOBE SHIPYARD & MACHINERY WORKS

Group 0

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For Particular Attention

1. This manual is put at the disposal of recipient solely for use in connection with corresponding MITSUBISHI-SULZER type Diesel engines. It has always to be treated confidentially by its owners.

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5. This manual is primarily intended for use by the engine operating and maintenance personnel. It is assumed that it will always be at the disposal of such personnel for the operation of the engines and/or for the required maintenance work.
6. This manual has been prepared on the assumption that operation and maintenance of the engines concerned will always be carried out by personnel having the special knowledge and skills needed to handle in a workman-like manner Diesel engines of the corresponding size, the pertaining auxiliary equipment, as well as fuel and other operating media. Therefore, generally applicable rules, which may also concern such items as protection against danger, are specified in this manual in exceptional cases only, i.e. when it must be assumed that the operating personnel qualified as above should not be familiar with the rules concerned.
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MITSUBISHI HEAVY INDUSTRIES, LTD.
KOBE SHIPYARD & MACHINERY WORKS
KOBE, JAPAN

Preface

1. This booklet is "Operating Manual" of the Instruction Book for handling of MITSUBISHI-SULZER RT-flex96C type Diesel Engine describing important instruction for maintenance, inspection and adjustment of main parts for maintaining good condition of engine for long time to the engineers who are qualified to operate and maintain engines
2. The engineers who operate and maintain this engine are requested to read this booklet before handling the engine, to grasp the engine characteristics sufficiently, and to manage engine handling without mistakes for safety operation and maintenance.

The parts indicated with symbols   in this booklet describe important matters; therefore, pay special attention to the descriptions.



: This symbol indicates that the operator must strictly follow the guidelines preventing danger to the engine operator during engine operation and/or maintenance.



: This symbol indicates that the operator must take certain measures to avoid undesirable conditions and damages to equipment during engine operation and/or maintenance.



Remark

: Related information on the engine operation and/or maintenance and useful information for improving the sufficiency of the engine operator are provided.

3. For operation and construction, please refer to a separate volume "Operating Manual".
4. In addition to the numerical instruction applied only to MITSUBISHI-SULZER RT-flex96C type Diesel Engine, this booklet also indicates the most important explanation of the general character about the operation diesel engine. We recommended that the engineers should study this booklet well and it should be always referred to. Since we think that the engineers are already familiar with what is necessary for the safety operation of diesel engine, for simplification, this booklet does not indicate in detail.
5. As for the engine accessories such as turbocharger, air cooler, governor, cylinder lubricator and auxiliary blower, please refer to the separate Instruction Book.
6. This booklet must be always stored at the fixed place and must be usable at any time by the people in charge of engine operation and maintenance.
7. It is absolutely forbidden that engine is used with being different from proper purposes and conditions in specifications or handled with being against the described contents in this booklet, because it comes to the causes of the troubles and breakdowns.

The republication of this instruction book by reproduction or extraction is prohibited. And the contents of this book have no relation to the warranty articles of the contract, but describe general guidelines for this engine.

MITSUBISHI HEAVY INDUSTRIES, LTD.
KOBE SHIPYARD & MACHINERY WORKS

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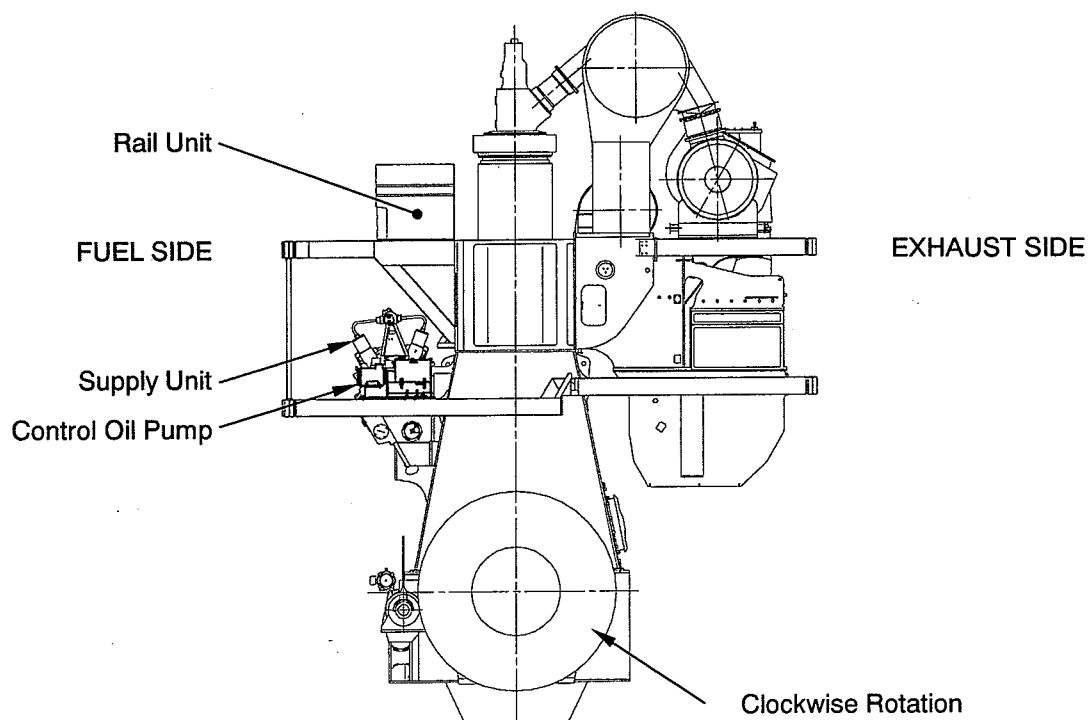
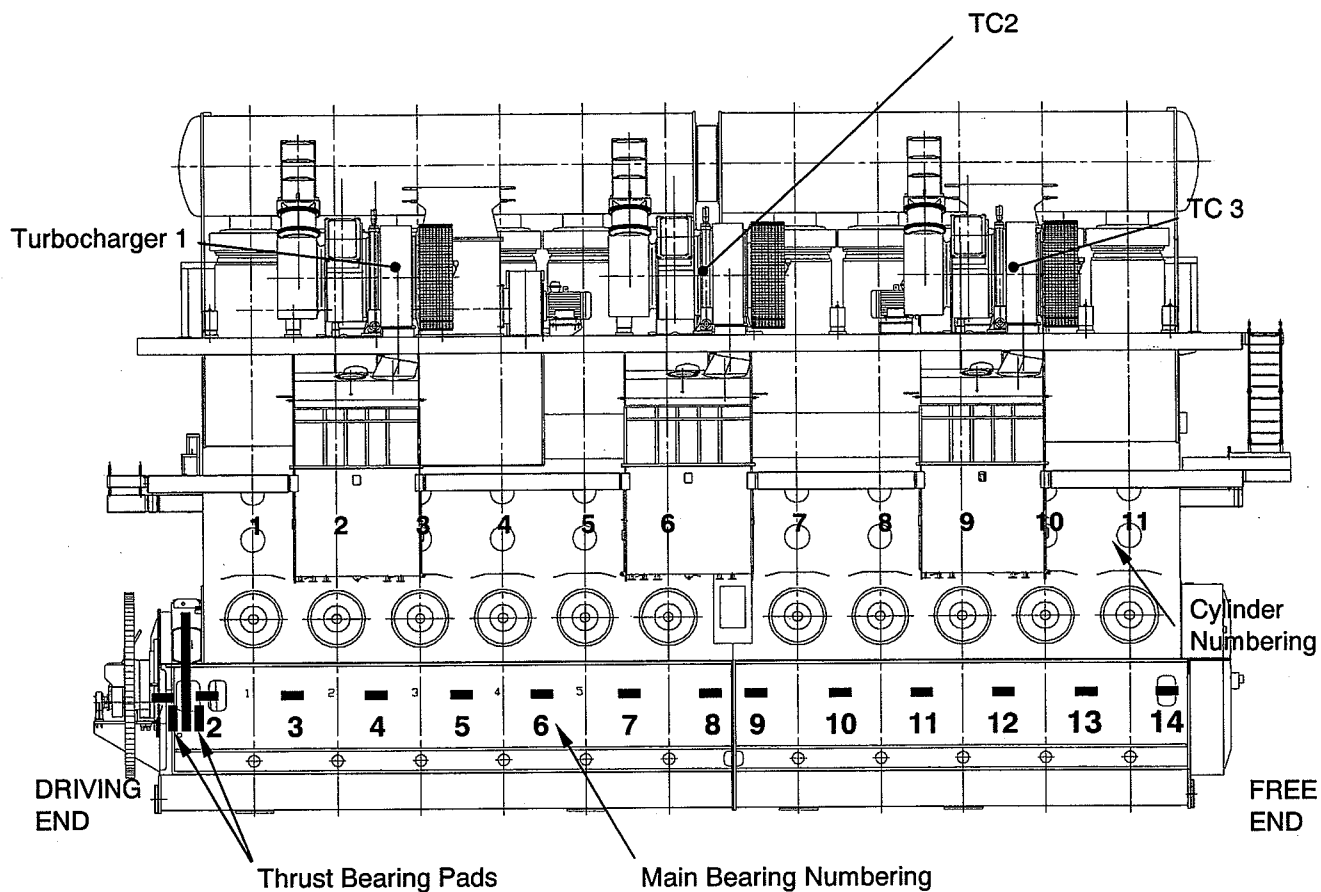
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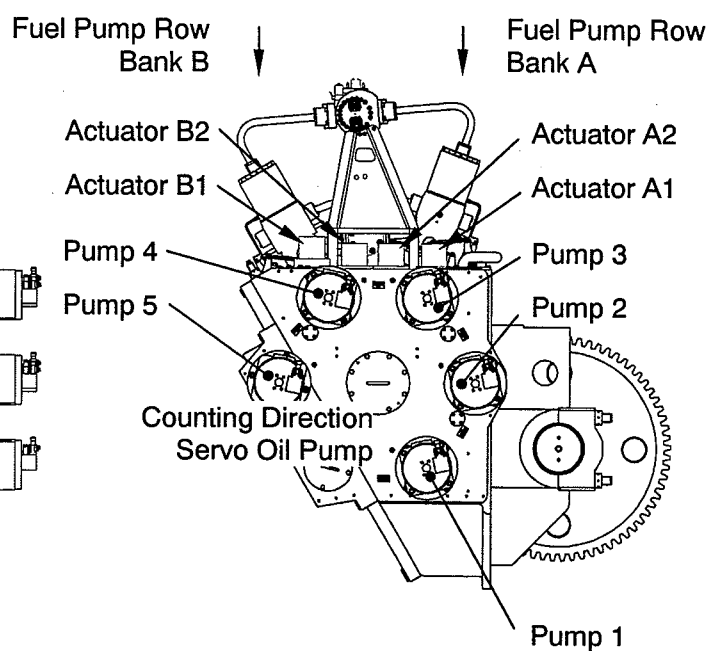
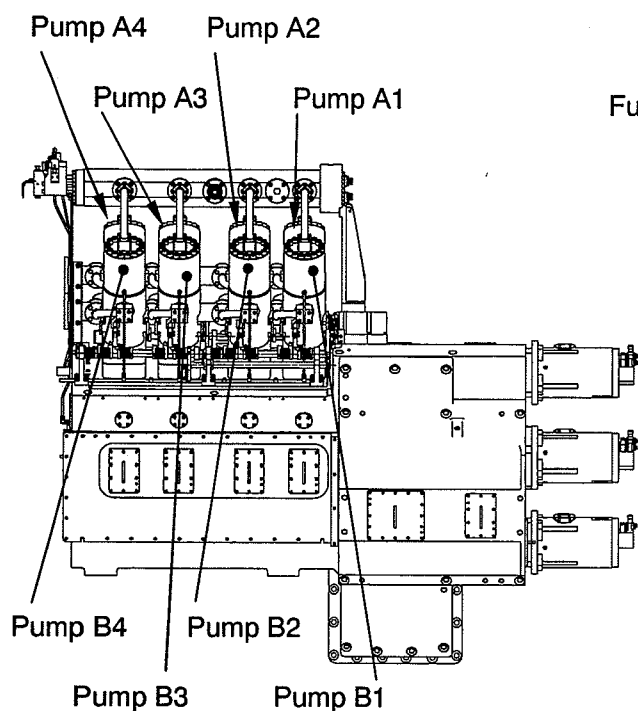
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Engine Numbering and Designations

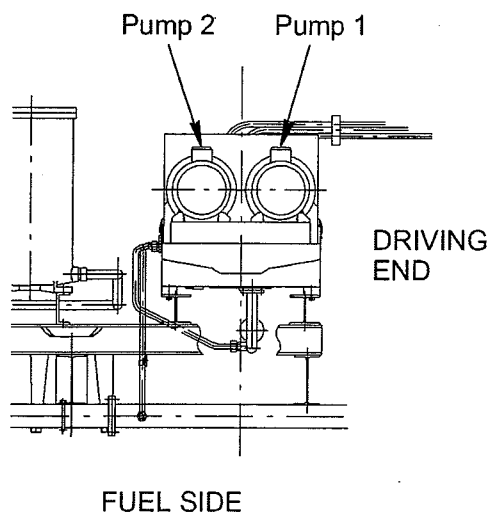


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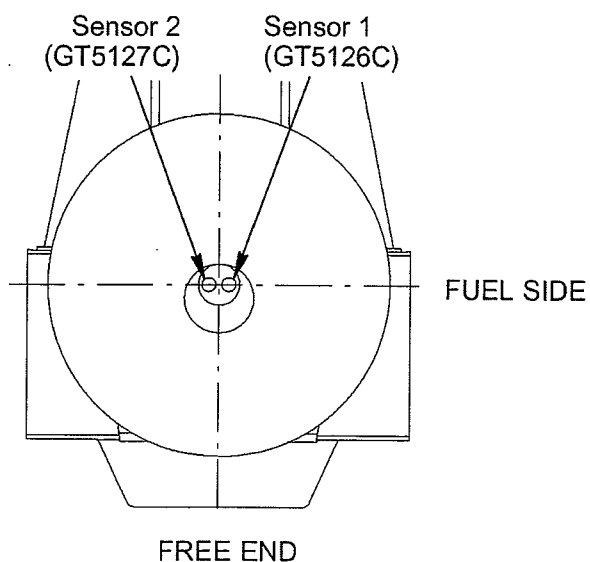
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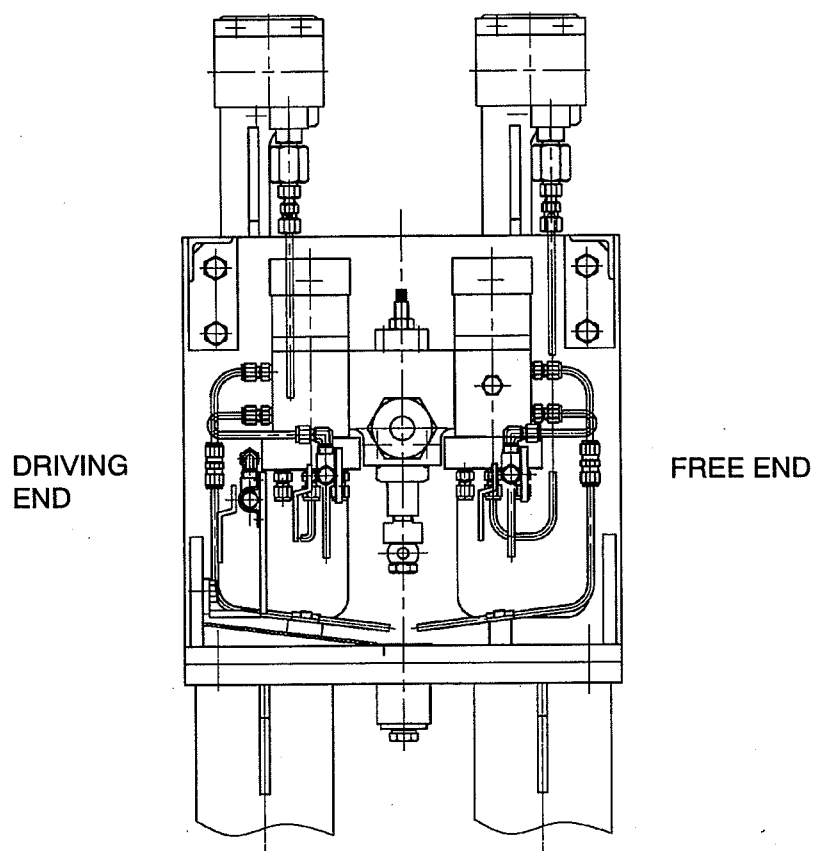
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Engine Numbering and Designations

ECL Distributor unit

System A

System B



Operation

General Matters that Demand Special Attention on Maintenance

1. General

Engine maintenance items and maintenance schedule after entering service are mentioned in the maintenance manual 0380 as guidelines. Engine maintenance schedule should be suitably determined by judging engine service condition (running output, using fuel oil and lubricating oil, etc.) together with engine circumstances which is understood on the base of experienced knowledge getting from the forementioned engine condition and many other conditions in order to maintain good conditions in order to maintain good condition of the for long time.

When doing engine maintenance and inspection work, read the "Maintenance Manual" and "Operating Manual" beforehand, grasp the structure of the parts in question and the contents of work, study working procedure sufficiently, and then set to work. If the work is done with insufficient preparatory study, not only it spends wasteful labor but also it is connected with an accident due to miss-assembly and engine damage.

The parts which damage is detected and using limit has been reached and will be reached until next inspection as the result of inspection must be replaced with the designated regular parts. If it is difficult to take measures against troubles on board or on the spot, communicate with the engine maker service department and take suitable measures.

2. Precautionary measures before beginning of maintenance work

Before starting any maintenance work on the engine (particularly on the running gear), take the following precautionary measures:

- ⇒ Close the shut-off valves on the starting air bottles.
- ⇒ Close all the shut-off valves in the control air supply unit, and open the drains on both air bottles until it is depressurized.
- ⇒ Close by hand the (automatic) shut-off valve for starting air and open the vent and drain valve to the main starting air piping on the engine as well as the vent valves on the shut-off valve starting air, and leave them in this position until maintenance work is completed.
- ⇒ Open all indicator cokes on the cylinder covers and leave them in this position until maintenance work is completed.
- ⇒ Engage turning gear (gear pinion must be in engaged position) and lock the lever.
- Where the engine has been stopped due to overheated running gear or bearings, wait a least 20 minutes before opening the crankcase doors.
- **The crankcase doors must always be locked with all the clamps whenever the engine is running**, even if this is only for a short time in order to make temperature checks (e.g. after changing bearing during an overhaul, etc.).
- In the case of a fire in the engine having been extinguished by means of CO₂, the spaces affected must be well ventilated before work can be carried out within them.



When performing electric welding near or on the engine, electromagnetic fields or peak voltage may occur, which may damage the electronic components of the WECS-9520 engine control and monitoring system.

Operation**General Matters that Demand Special Attention on Maintenance**

Prior to performing electric welding in the vicinity of WECS-9520 the following precautions must be taken:

- Stop the engine if it is operation.
- Power off the electronic system and wait one minute.
- If the welding point is within a radius of two metres from an electronic module FCM-20 and/or a sensor, disconnect the modules and/or sensors.
- Close the covers of all electric boxes and protect cables, sensors, etc. against sparking and heat.
- Shield the check and control units with a conductive material and connect them to earth.
- Run the welding cable from the welding apparatus directly to the welding point without any unnecessary loops; also, avoid leading the welding cable parallel to cables of the electronic control unit.

3. Attention to safety

- Do not open the crankcase door and each inspection door for 20 minutes after stopping engine to prevent crankcase explosion.
- When the temperature of the crankcase door is abnormally high even after 20 minutes passing, do not open the crankcase door and each inspection door.



For 20 minutes after stopping engine and being abnormally high temperature on the crankcase door, anyone must be distance from the crankcase safety valve and its blowing direction to avoid accidents arising from blowing off of the safety valve.

- Do not open the crankcase door until the engine has cooled down sufficiently.
- If fresh air flows into the crankcase when the engine is overheated, there is the possibility that oil mist catch fire and explode.



If CO₂ extinguishing system has been used, there is the possibility of suffocation and very dangerous.

- If a fire takes place in the engine room or the engine and CO₂ extinguishing system is used, ventilate the related area and remove the fire extinguisher completely.



When maintenance or inspection work is carried out, put on the protecting aids such as gloves, helmet, safety shoes, protecting glasses, safety belt and protective mask.

- There is high temperature on the engine in running and right after stopping, especially, on the parts such as exhaust pipes, turbocharger, indicator valves, and parts around cylinder covers.
Put on cloth gloves so as no to get burnt in the hand and then set to work.

Operation

General Matters that Demand Special Attention on Maintenance



When maintenance or inspection works, watch your steps carefully so that a falling-down accident and a fall accident which is working at a height cannot happen.



At all times when somebody is inside the engine casing another person must stand by in order that he can give the necessary aid if something unexpected happens to the person inside the engine. The person who is inside the engine casing must be equipped with all safety gears which are required to prevent suffocation within the limited space and atmospheric conditions. Moreover an antifall guard must be carried at dangerous places!

- The floor in the engine room and the engine are slippery with oil adhering to them. When work is carried out, wipe oil on floor and the sole of shoes and watch your steps carefully so that a falling-down and a fall accident cannot happen.
- When taking out the parts, especially, exhaust valve, cylinder cover, and piston, install an adequate cover at the opening.
- When the work is carried out inside the engine, install steady foot steps as occasion demands.



When overhauling each pipe system, keep all valves connected to engine outside "closed" and release the pressure by loosening air vent plugs, etc. gradually.

- If strainers and pipe joint parts are overhauled right after engine stopping, there is a possibility that temperature oil and water spout due to remaining pressure.



If the engine is turned during maintenance and inspection work, it is very dangerous due to the accident being caught in the engine.

- Before working, return the engine control position to "REMOTE CONTROL" position, keep the valves of starting air system and automatic starting air stop valve "closed" surely, and the lever of the turning gear is "engaging" position. Set to work after confirming that the engine is not turned.
- When the crankshaft is turned, be sure to carry it out while giving signals, after confirming whether rotating parts are out of contact with other parts and workmen and surrounding people get into danger by turning the crankshaft.
- During turning the engine, do not touch moving parts.



When the devices of the engine are overhauled, it is very dangerous since there is a possibility of spring dashing out.

- When overhauling various valves and devices which are used with springs, the take care since there is a possibility of spring dashing out.

Operation

General Matters that Demand Special Attention on Maintenance



Lift up overhauled heavy parts by using the chain block.

- Be sure to lift up overhauled heavy parts by using the lifting tool such as chain block without lifting by human power.
- Do not approach under lifting parts.



Before using tools, make sure that there is no damage on them.

- Check the hydraulic jack before using since there is the possibility that high pressure oil spout out at the time of using tool if there is a crack in the hydraulic jack and damage such as cut on the hose.
- If In particular, if there is a crack in the lifting tool, do not use the tool since there is the possibility that the lifting parts fall down.



Before maintenance around electric and electronic components, especially FCM-20, with welding, keep power source "OFF". If do it, electric and electronic components have possibilities to be occurred.
Communication abnormal due to noise



Before handling electric parts for maintenance and inspection, be sure to keep power source "OFF".

- Before handling electric parts for maintenance and inspection, do it after keeping main power source and the power source of handling electric parts "OFF" due to danger of getting an electric shock.



Do not bring a light or a fire close to fuel oil, oil, anti-corrosive agent, cleaning agent, etc.

- There is the possibility of catching fire if a light or a fire is brought close to fuel oil, oil, ant-corrosive agent, cleaning agent, etc. When handling liquids, keep the following things strictly.



- | | | | |
|--|---------------|---|---|
| • Fuel oil, Lubricating oil | : Combustible | ← | The lighting of fire is prohibited. |
| • Cooling water anti-corrosive Agent, Cleaning agent | : Combustible | ← | The lighting of fire is prohibited.
Not to drink |
| | Poisonous | | |
| • Mercury (Thermometer) | : Poisonous | ← | Not to drink |
- Put on gloves and protective glasses when handling liquid and fully wash liquids with cold fresh water when it has adhered to you skin mistake.
Furthermore, consult a doctor immediately when it has adhered to your eyes or drinking it by mistake.
- When using other liquids, chemical products, etc. , follow the instruction book of each product maker.

Operation

General Matters that Demand Special Attention on Maintenance

4. Attention during maintenance and inspection



Install adequate covers at the pipes and joints removed at connecting parts or at the opening of removed parts so as not to admit foreign matters such as dust.



Change the parts which damage is detected and using limit has been reached and will be reached until next inspection with the designated regular parts.

5. Attention at the time of ending maintenance and inspection



Ascertain that bolts and nuts are tightened and locked without forgetting.

- When tightening bolts and nuts, take care so as not to damage the thread part and tighten them after making close contact (to do metal touch) of tightening surface surely. Besides, for tightening main bolts, refer to Maintenance Manual 0352-1.
- Carry out locking securely at the parts of where it needs.



Restore the protecting cover removed at maintenance and inspection as it was before.



Make sure that used tools are not left inside and around the engine.

- If the engine is turned by leaving tools inside the engine, there is the possibility of giving damage on the engine.
- Do not leave tools on the floor plate, passages, parts, etc.



After assembling parts, make sure that there is in good order at each part of the engine by turning and priming.

- During engine turning, keep all indicator valves on cylinder covers "open".
- At engine starting, keep all indicator valves on cylinder covers "closed".



Make sure that all kinds of valves, cocks, etc. in pipe systems are set at the regular position.



Close the crankcase doors and tighten them securely.

- During engines operation, lock the crankcase doors surely.
- Keep from using the impact wrench as there is the possibility that the gasket is damaged.

Clearance Table

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1. General

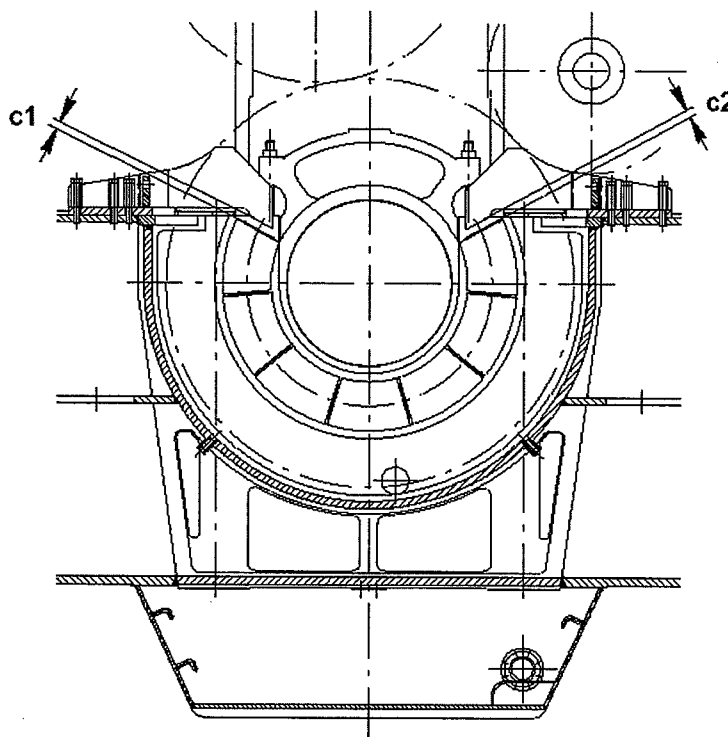
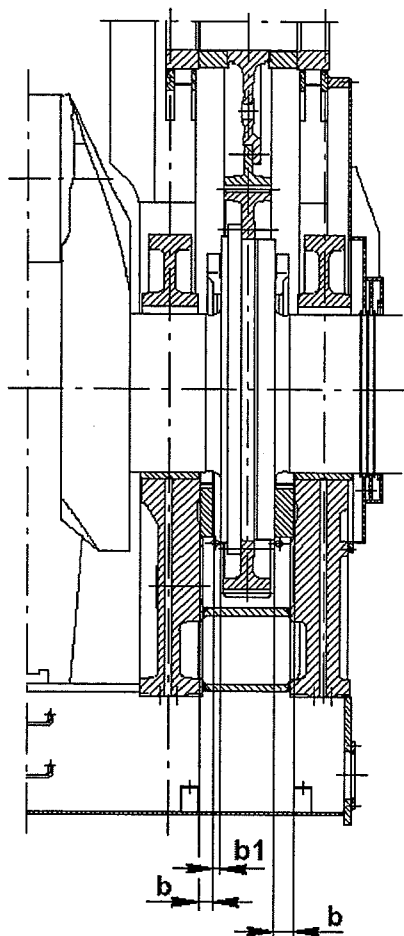
The clearances listed in the column 'Nominal dimension' of the following table correspond to design and manufacturing values or to the settings on the new engine.

The values listed in the column 'Maximum clearance, dimension' are such values as may be reached after a lengthy operating period, which however may not be allowed to be exceeded or fall below. On components where the clearance is adjustable by modifying the thickness of shims, discs, spacers etc. the value given as 'Normal Clearance' should always be arrived at, or striven to attain. Where this is not possible, worn parts must be replaced by standard new ones or reconditioned by suitable material buildup.

If, during an overhaul, clearances are measured which have almost reached the permissible limit, it must be left to individual judgment to decide whether a component part should be replaced or remain fitted till the next overhaul. This depends for example on the duration of the next operation period till the next overhaul and what wear has to be expected based on experience gained.

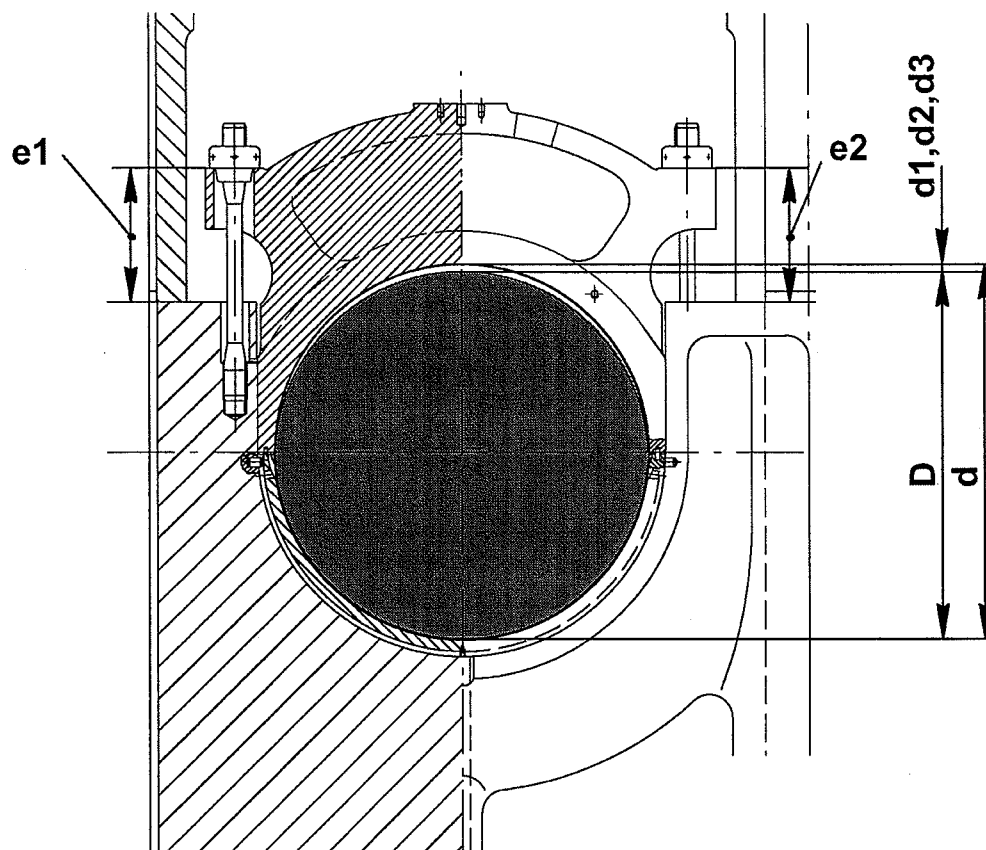
Clearance Table

Crankshaft and Thrust Bearing



Group	Key No.	Description	Measuring direction (method of measuring)	Normal dimension (normal, new) [mm]	Maximum clearance dimension (due to wear) [mm]
1203 1224		Thrust bearing			
	b	Thrust bearing pad	thickness	120 - 0.50 - 0.60	
	b ₁	Thrust bearing clearance	axial (total)	0.8 ~ 1.3	2.50
	c ₁ +c ₂	Thrust bearing pad, lateral clearance	total	6 (max. abt. 3mm per side)	

Clearance Table
Crankshaft and Main bearing

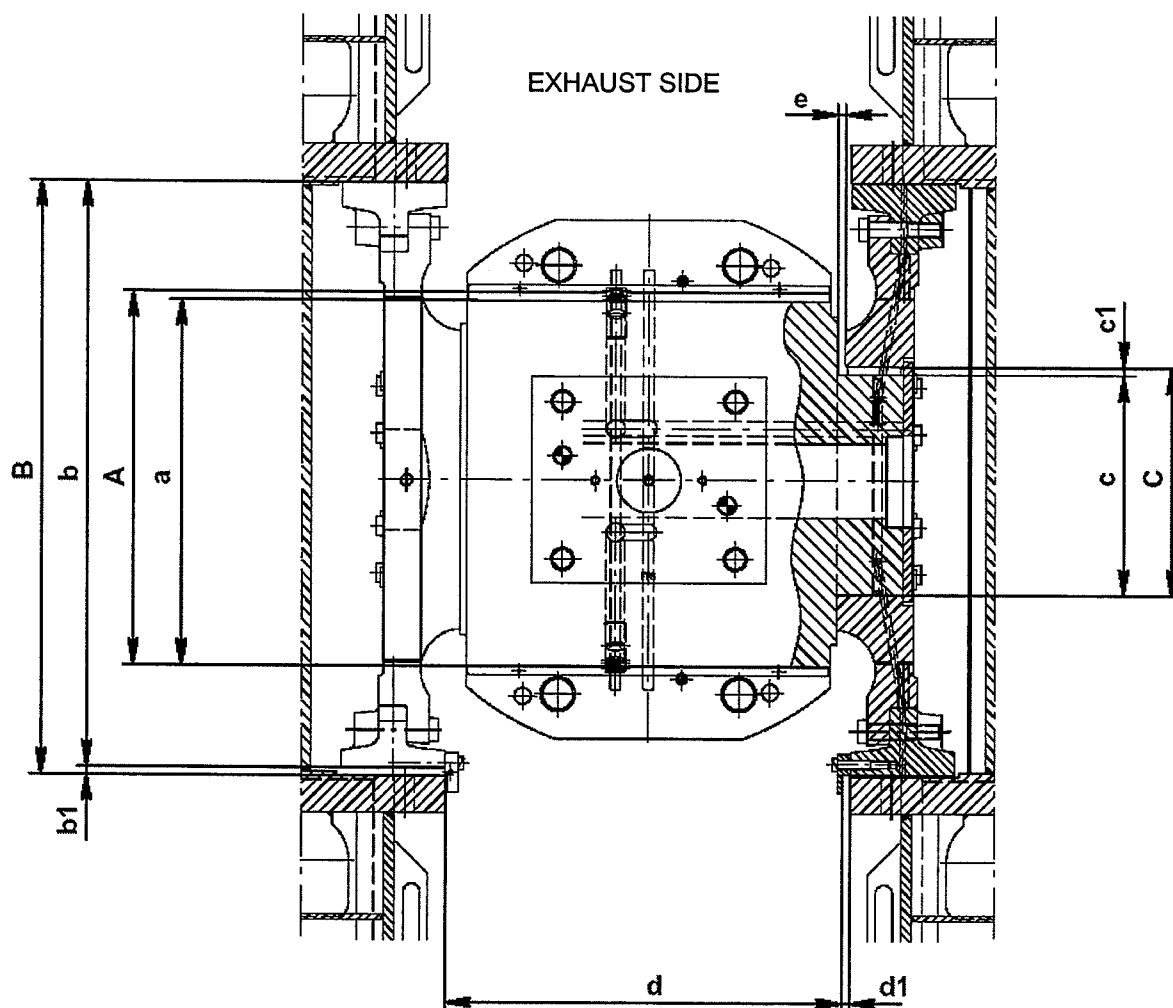


All main bearing clearances are only valid with tie rods and main bearing studs tightened.

** The difference between the two values (positional tolerance) must not be greater than 0.3 mm

Group	Key No.	Description	Measuring direction (method of measuring)	Normal dimension (normal, new) [mm]	Maximum clearance dimension (due to wear) [mm]
1132		Main bearing			
	D	Crank shaft	outer <i>F</i>	990 $\begin{smallmatrix} 0 \\ -0.10 \end{smallmatrix}$	
	d	Main bearing	inner <i>F</i>	990	
	d ₁	Bearing clearance (#1 bearing)	vertical	0.80 ~ 1.10	1.25
	d ₂	Bearing clearance (#2 bearing)	vertical	0.39 ~ 0.45	0.60
	d ₃	Bearing clearance (#3 bearing and followings)	vertical	0.40 ~ 0.50	0.65
	**e ₁ -e ₂	Positional tolerance (bearing cover)	vertical	max. 0.30	

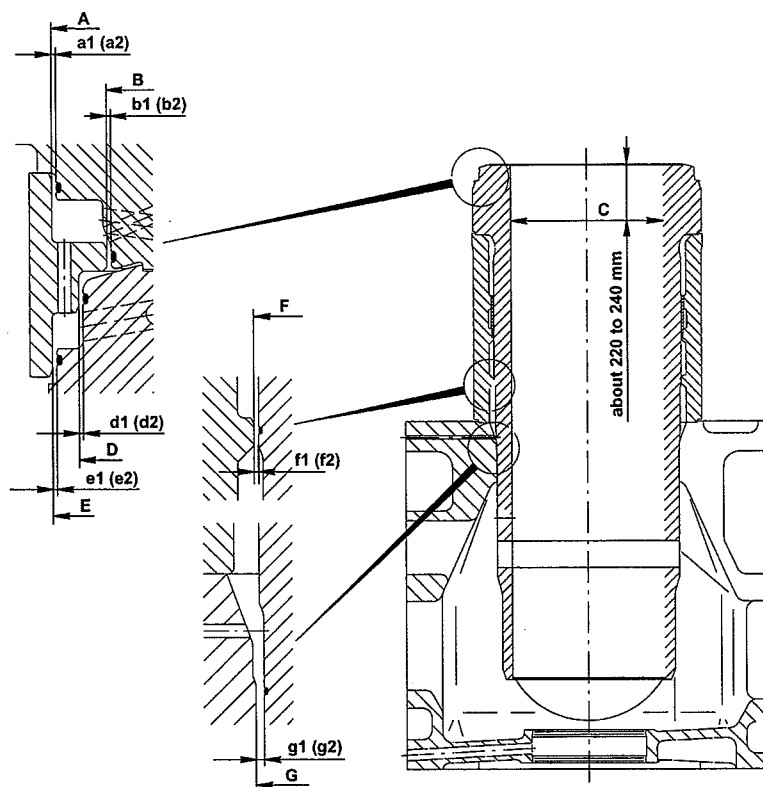
Clearance Table
Crosshead Guide



Group	Key No.	Description	Measuring direction (method of measuring)	Normal dimension (normal, new) [mm]	Maximum clearance dimension (due to wear) [mm]
3326		Crosshead guide			
	A	Connecting rod top bearing	inner F	900	
	a	Crosshead pin	outer F	900 ⁰ _{-0.10}	
	B	Guide way (column)	transverse	1430	
	b	Guide shoe	transverse	1430 ^{-0.20} _{-0.35}	
	b ₁	Guide shoe clearance		0.20 ~ 1.10	1.40
	C	Guide shoe, bearing bore	inner F	550 ^{+0.07} ₀	
	c	Guide shoe, bearing pin	outer F	550 ^{-0.05} _{-0.10}	
	c ₁	Bearing clearance	radial (total)	0.05 ~ 0.17	0.30
	d	Guide rail	longitudinal	978.30~979.30	
	d ₁	Guide rail, lateral clearance	total	0.30 ~ 1.80	2.20
	e	Guide shoe, lateral clearance	longitudinal	0.20 ~ 0.40	

* Clearance b₁ are only valid with tie rods tightened.

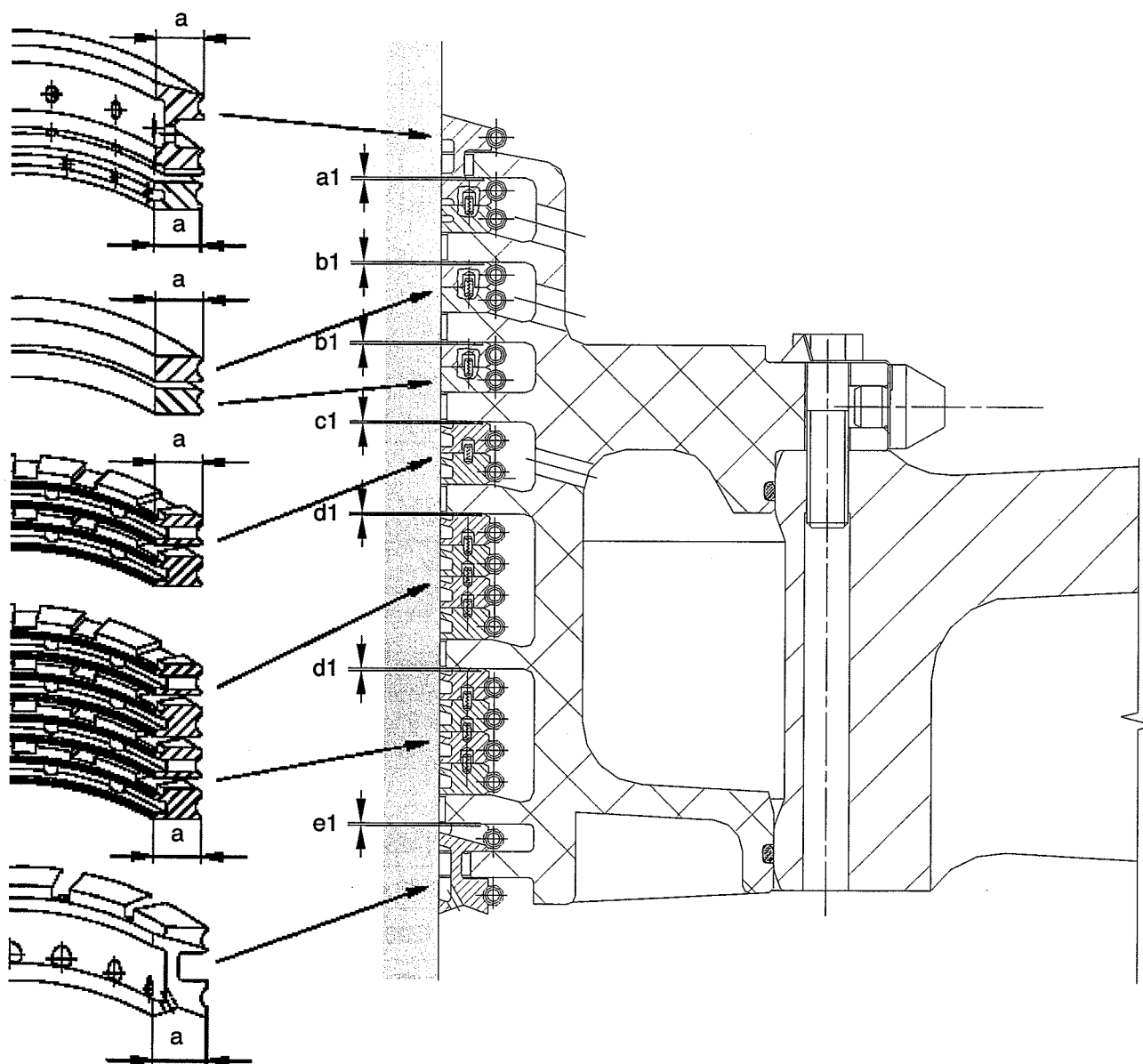
Clearance Table
Cylinder Liner



Group	Key No.	Description	Measuring direction (method of measuring)	Normal dimension (normal, new) [mm]	Maximum clearance dimension (due to wear) [mm]
2124		Water guide jacket on cylinder cover			
	A	Water guide jacket	F	1425 $\begin{smallmatrix} +0.70 \\ +0.50 \end{smallmatrix}$	
	a ₁ +a ₂	Clearance	total	0.80 ~ 1.20	
	B	Water guide jacket	F	1290 $\begin{smallmatrix} +0.70 \\ +0.50 \end{smallmatrix}$	
	b ₁ +b ₂	Clearance	total	0.80 ~ 1.20	
	D	Water guide jacket	F	1360 $\begin{smallmatrix} +0.70 \\ +0.50 \end{smallmatrix}$	
	d ₁ +d ₂	Clearance	total	0.70 ~ 1.10	
	E	Water guide jacket	F	1425 $\begin{smallmatrix} +0.70 \\ +0.50 \end{smallmatrix}$	
	e ₁ +e ₂	Clearance	total	0.70 ~ 1.10	
2124		Supporting ring for cylinder liner			
	F	Supporting ring	F	1181.50 $\begin{smallmatrix} +0.20 \\ 0 \end{smallmatrix}$	
	f ₁ +f ₂	Clearance	total	1.00 ~ 1.40	
2124		Cylinder block			
	G	Cylinder block	F	1150 $\begin{smallmatrix} +0.20 \\ 0 \end{smallmatrix}$	
	g ₁ +g ₂	Clearance	total	2.20 ~ 2.60	
2124		Cylinder liner			
	*C	Cylinder liner bore	radial	960	966.70

* Pay attention to measuring point!

Clearance Table
Piston Rod Gland Box



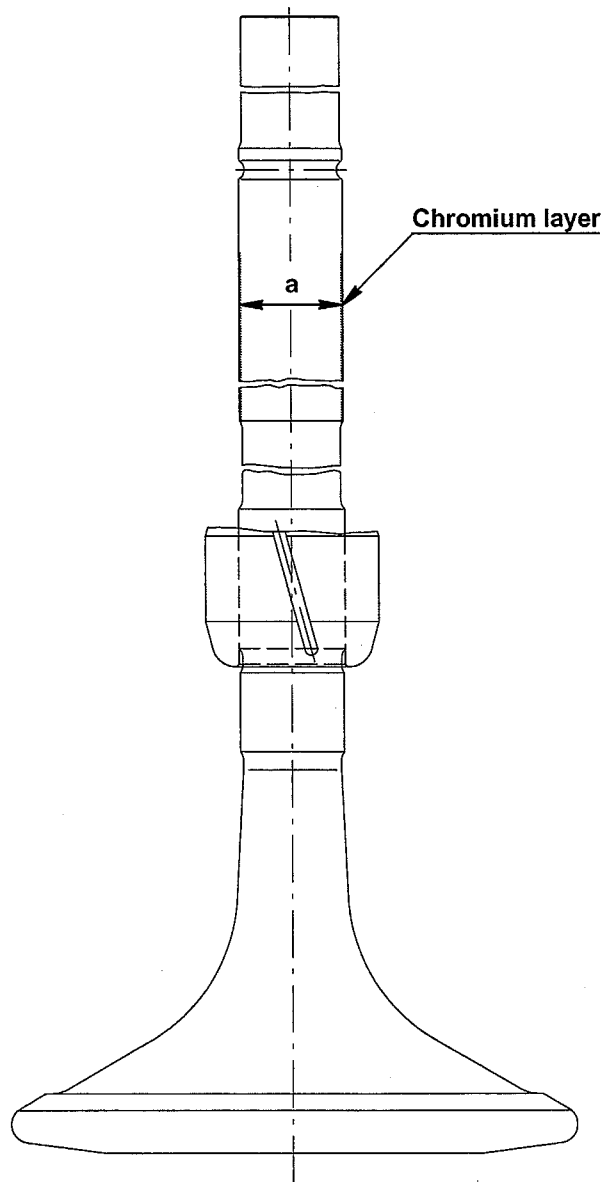
Group	Key No.	Description	Measuring direction (method of measuring)	Normal dimension (normal, new) [mm]	Maximum clearance dimension (due to wear) [mm]
2303		Piston rod gland box			
	*a	Ring width	radial	25.00	20.00
	a ₁	Ring clearance	axial	0.10 ~ 0.28	0.50
	b ₁	Ring clearance	axial	0.04 ~ 0.20	0.40
	c ₁	Ring clearance	axial	0.10 ~ 0.28	0.50
	d ₁	Ring clearance	axial	0.10 ~ 0.36	0.55
	e ₁	Ring clearance	axial	0.10 ~ 0.24	0.45

* **Ring wear**

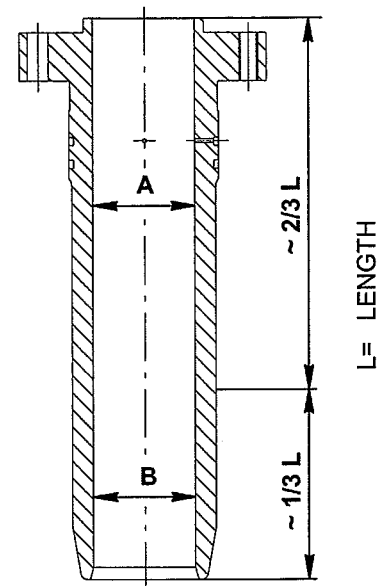
The differential value between nominal dimension and max. wear is equal for all rings, i.e. also for undersize rings.

Clearance Table
Exhaust Valve

VALVE SPINDLE



GUIDE BUSH

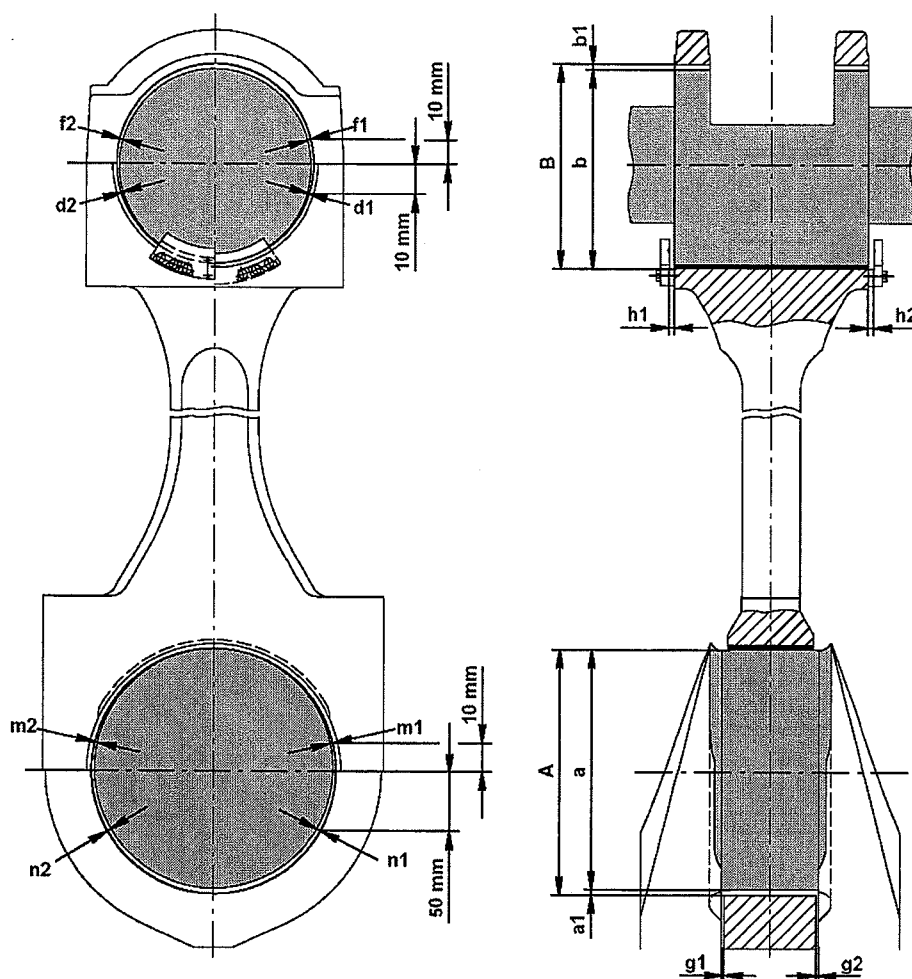


Group	Key No.	Description	Measuring direction (method of measuring)	Normal dimension (normal, new) [mm]	Maximum clearance dimension (due to wear) [mm]
2751		Valve spindle			
	a	Spindle	outer <i>F</i>	95 $\begin{smallmatrix} -0.26 \\ -0.31 \end{smallmatrix}$	94.50
2751		Guide bush			
	*A	Bore	inner <i>F</i>	95 $\begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$	95.50
	*B	Bore	inner <i>F</i>	95 $\begin{smallmatrix} +0.035 \\ 0 \end{smallmatrix}$	96.50

* Pay attention to measuring point!

Clearance Table

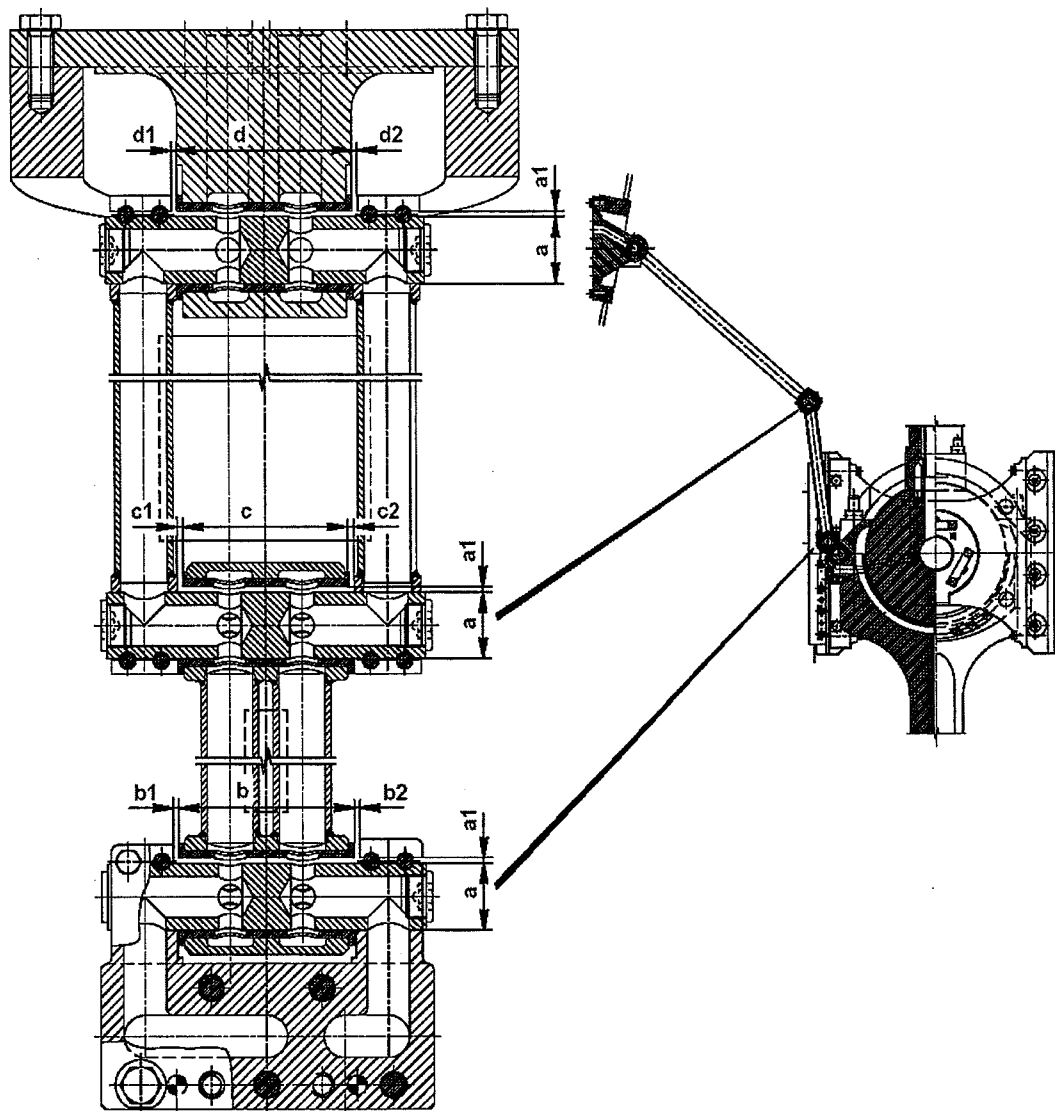
Top and Bottom End Bearings to Connecting Rod



Group	Key No.	Description	Measuring direction (method of measuring)	Normal dimension (normal, new) [mm]	Maximum clearance dimension (due to wear) [mm]
3303 3326		Top end bearing			
	B	Crosshead pin	outer <i>F</i>	900 ⁰ _{-0.10}	
	b	Bearing	inner <i>F</i>	900	
	b ₁	Bearing clearance	vertical	0.50 ~ 0.90	1.05
	*d ₁ +d ₂	Lateral clearance	total	0.60 ~ 0.85	
	*f ₁ +f ₂	Lateral clearance	total	0.75 ~ 1.05	
	h ₁ +h ₂	Axial clearance	total	0.40 ~ 0.80	1.20
3303		Bottom end bearing			
	A	Crankshaft	outer <i>F</i>	990 ⁰ _{-0.10}	
	a	Bearing	inner <i>F</i>	990	
	a ₁	Bearing clearance	vertical	0.50 ~ 0.80	0.95
	*m ₁ +m ₂	Lateral clearance	total	0.52 ~ 0.74	
	n ₁ +n ₂	Lateral clearance	total	0.75 ~ 1.00	
	g ₁ +g ₂	Axial clearance	total	34	

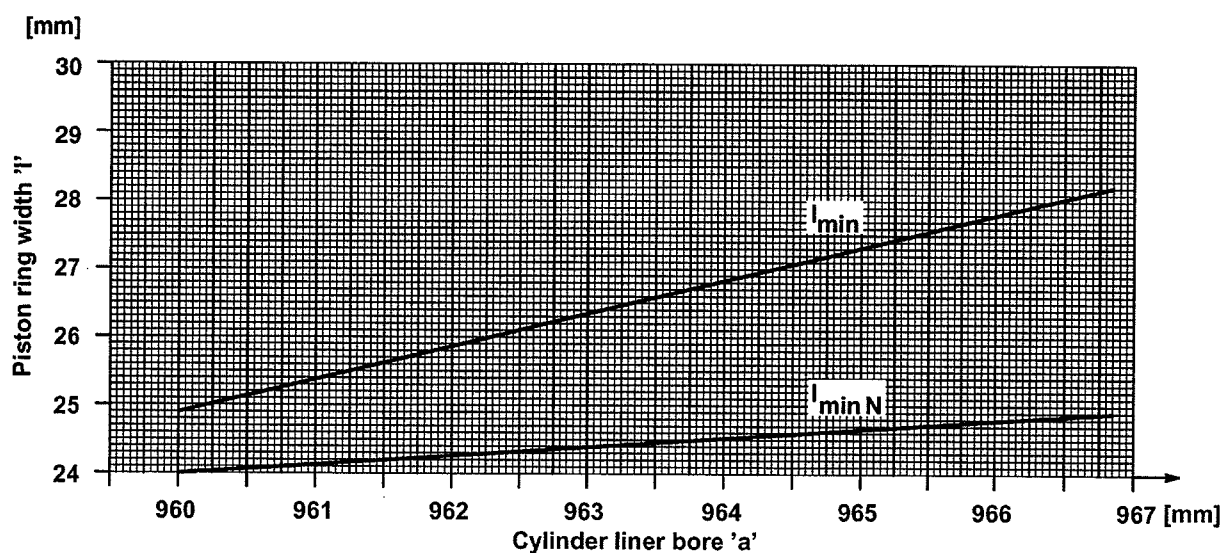
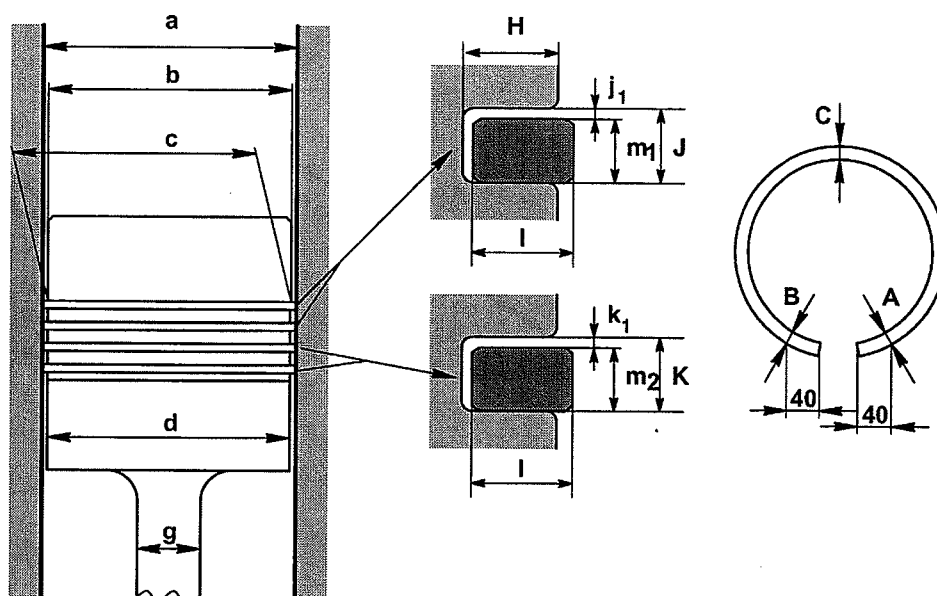
* Pay attention to measuring point!

Clearance Table
Piston Cooling and Crosshead Lubricating Link



Group	Key No.	Description	Measuring direction (method of measuring)	Normal dimension (normal, new) [mm]	Maximum clearance dimension (due to wear) [mm]
		Piston cooling and crosshead lubricating link			
	a	Pin	outer F	72	0.20
	a ₁	Bearing clearance	radial (total)	0.03 ~ 0.09	
	b, c	Bearing	width	173	
	d	Bearing	width	172	
	b ₁ +b ₂	Lateral clearance	total	min. 2.00 (min. 1.0mm per side)	
	c ₁ +c ₂	Lateral clearance	total	min. 1.00 (min. 0.5mm per side)	
	d ₁ +d ₂	Lateral clearance	total	min. 2.00 (min. 1.0mm per side)	

Clearance Table
Piston and Piston Rings



Clearance Table
Piston and Piston Rings

Group	Key No.	Description	Measuring direction (method of measuring)	Normal dimension (normal, new) [mm]	Maximum clearance dimension (due to wear) [mm]
3403		Piston crown			
	a	Cylinder liner	inner <i>F</i>	960	
	b	Crown	outer <i>F</i>	954.80	
	c	Crown	outer <i>F</i>	957.80	
3403		Piston Skirt			
	d	Skirt	outer <i>F</i>	958.70 $\begin{smallmatrix} 0 \\ - 0.20 \end{smallmatrix}$	min. 957
3403 3425		Piston ring grooves			
	J	Height of the two uppermost grooves	vertical	20 $\begin{smallmatrix} + 0.50 \\ + 0.45 \end{smallmatrix}$	
	K	Height of the two lowermost grooves	vertical	20 $\begin{smallmatrix} + 0.40 \\ + 0.35 \end{smallmatrix}$	
	H	Groove depth	radial	31	
3425		Piston rings			
	m ₁	Ring height	vertical	19.94 $\begin{smallmatrix} 0 \\ - 0.025 \end{smallmatrix}$	
	m ₂	Ring height	vertical	20.00 $\begin{smallmatrix} 0 \\ - 0.025 \end{smallmatrix}$	
	j ₁	Ring clearance	vertical	0.510 ~ 0.585	0.81
	k ₁	Ring clearance	vertical	0.350 ~ 0.425	0.65
	l	*Ring width	radial	30 ± 0.20	see diagram
3403		Piston rod			
	g	rod	outer <i>F</i>	370 $\begin{smallmatrix} - 0.062 \\ - 0.119 \end{smallmatrix}$	min. 368.80

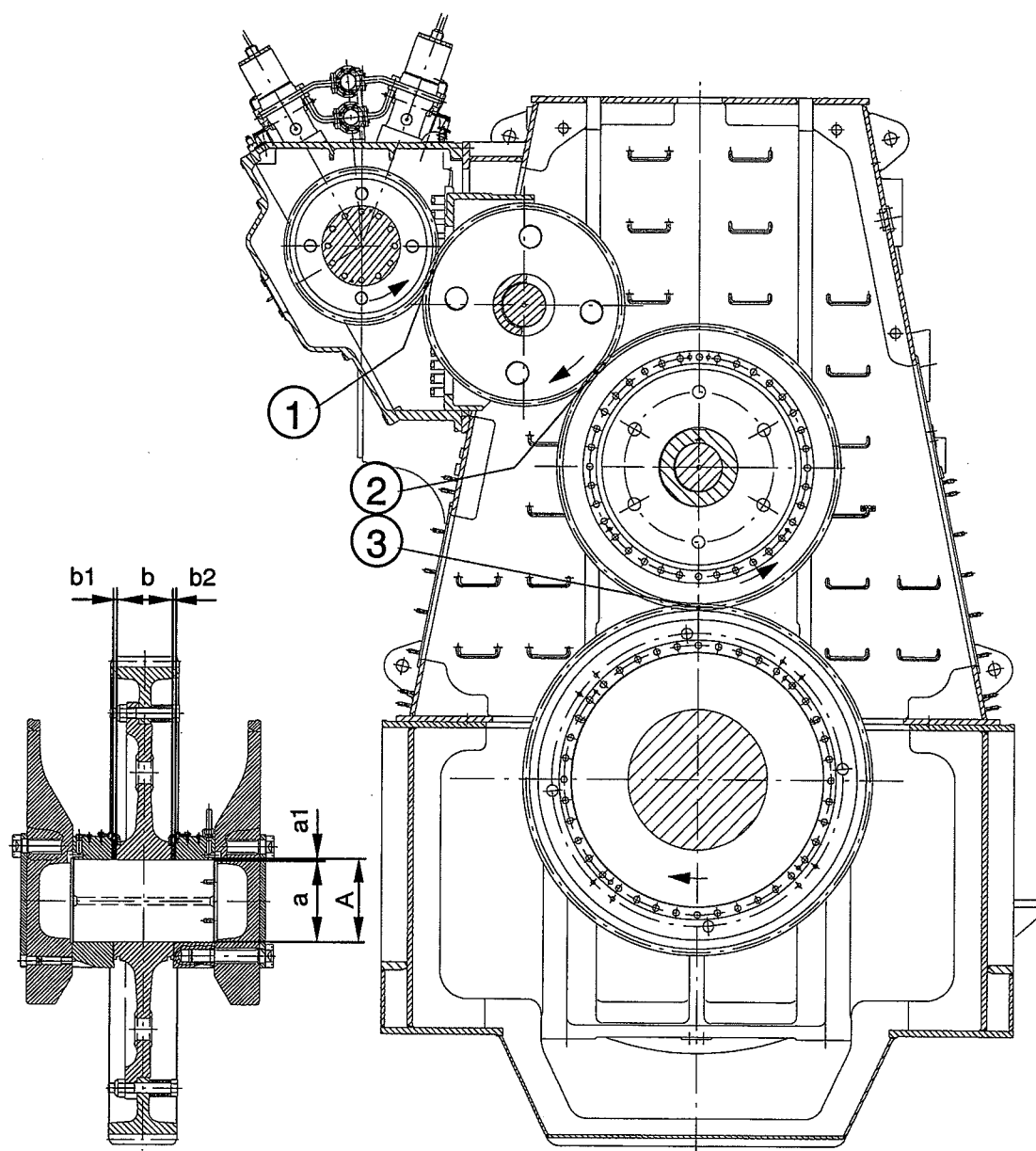
The ring width at the positions A, B and C is the decisive criterion for re-fitting of used piston ring.

Used piston rings may be re-fitted if they will keep within their min. ring width till the next overhaul (for judging and re-using the piston rings see also 3425-1).

* Pay attention to measuring point!

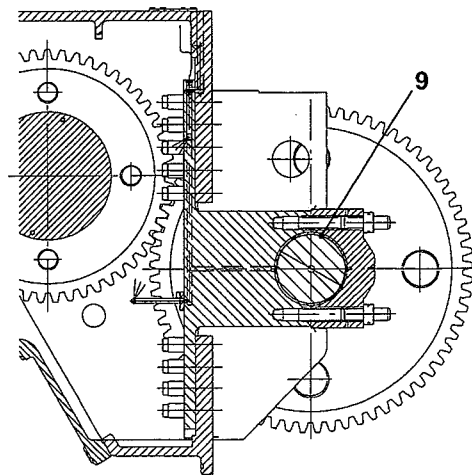
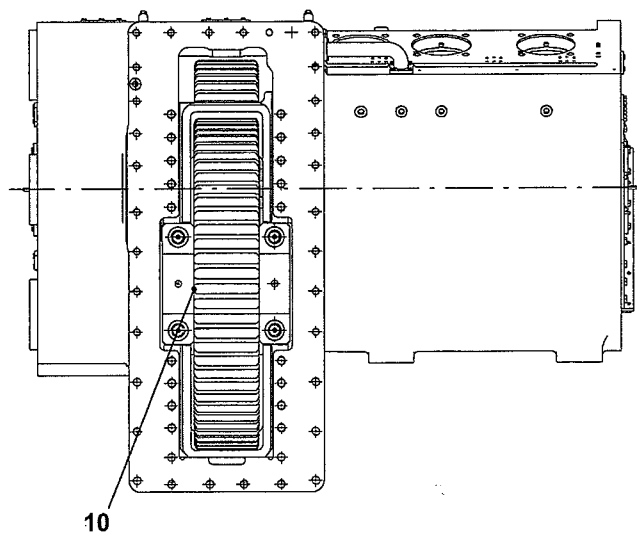
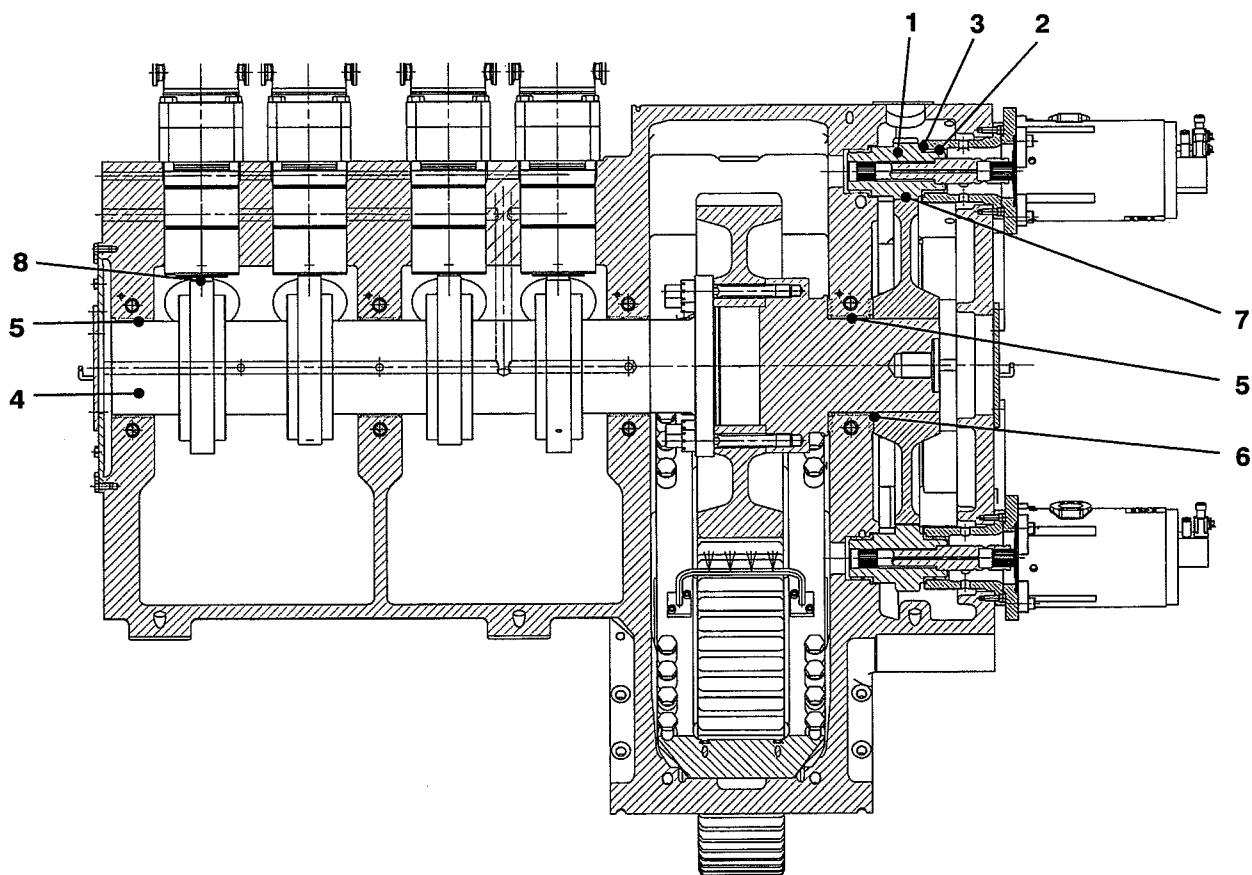
Clearance Table

Drive Wheels for Supply Unit



Group	Key No.	Description	Measuring direction (method of measuring)	Normal dimension (normal, new) [mm]	Maximum clearance dimension (due to wear) [mm]
4103		Intermediate wheel			
	A	Bearing	inner F	340	
	a	Shaft	outer F	340	
	a ₁	Bearing clearance	vertical	0.182 ~ 0.288	0.40
	b	Wheel width	width	246	
	b ₁ +b ₂	Axial clearance	total	0.60 ~ 1.10	1.50
	①	Tooth backlash		0.40 ~ 0.59	0.80
	②	Tooth backlash		0.31 ~ 0.64	0.85
	③	Tooth backlash		0.38 ~ 0.78	1.00

Clearance Table
Supply Unit



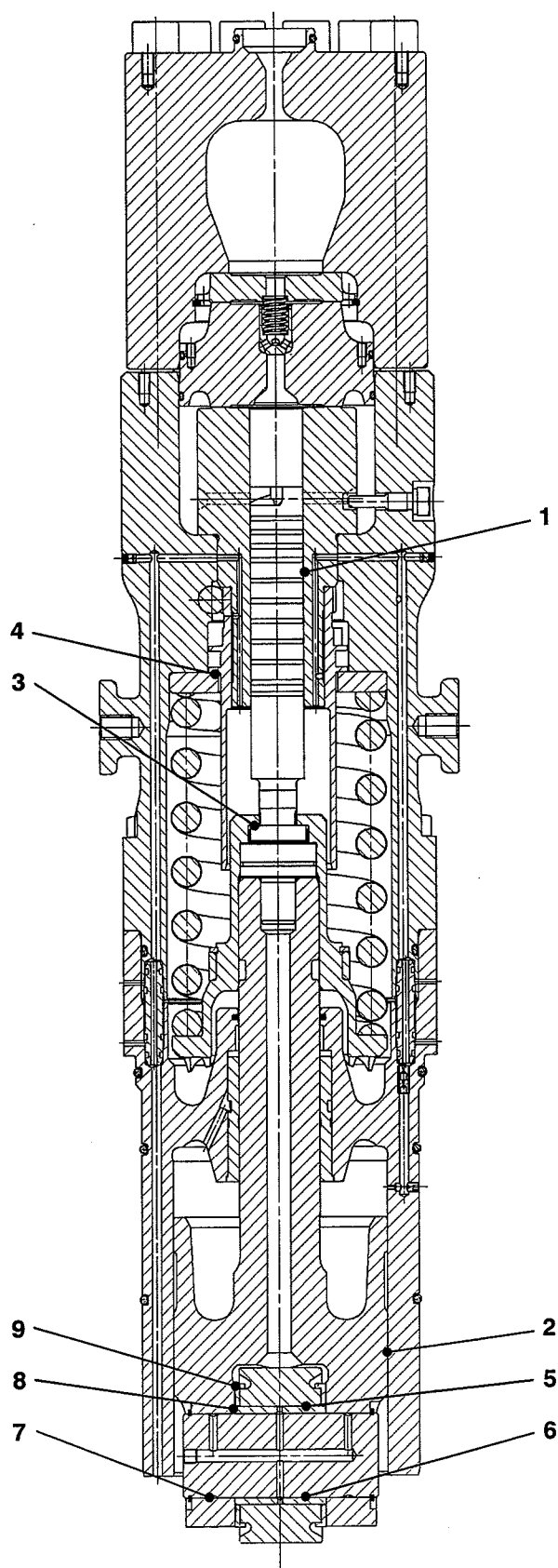
Clearance Table

Supply Unit

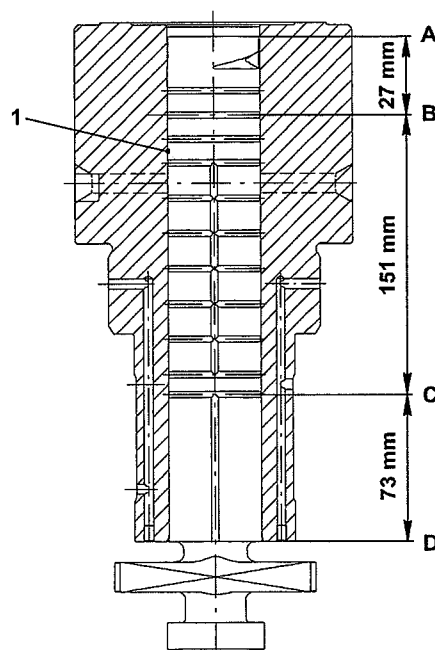
Group	Key No.	Description	Measuring direction (method of measuring)	Normal dimension (normal, new) [mm]	Maximum clearance dimension (due to wear) [mm]
5552		Supply Unit			
	1	Pinion	outer <i>F</i>	120 $\begin{smallmatrix} 0 \\ - 0.022 \end{smallmatrix}$	
		Bearing (fitted)	inner <i>F</i>	120 $\begin{smallmatrix} + 0.23 \\ + 0.14 \end{smallmatrix}$	
	2	Bearing clearance	radial	0.14 ~ 0.252	
	3	Axial clearance	total	0.25 ~ 0.54	0.70
5552		Camshaft Unit			
	4	Cam shaft	outer <i>F</i>	300 $\begin{smallmatrix} 0 \\ - 0.032 \end{smallmatrix}$	
	5	Bearing clearance	radial	0.22 ~ 0.34	
	6	Axial clearance	total	0.30 ~ 0.60	0.80
	7	Tooth backlash		0.16 ~ 0.29	
	*8	Minimum clearance		3	
5552		Intermediate wheel			
	9	Bearing clearance	radial	0.22 ~ 0.34	
	10	Axial clearance	total	0.30 ~ 0.60	0.80

* Minimum clearance between cam and roller with fuel pump cut out.

Clearance Table
Fuel Pump



PLUNGER & CYLINDER



Clearance Table

Fuel Pump

Group	Key No.	Description	Measuring direction (method of measuring)	Normal dimension (normal, new) [mm]	Maximum clearance dimension (due to wear) [mm]
5556		Fuel pump			
	1	Clearance (plunger / cylinder) A - B	radial	0.035 ~ 0.038	0.045
		Clearance (plunger / cylinder) B - C	radial	0.025 ~ 0.028	0.035
		Clearance (plunger / cylinder) C - D	radial	0.040 ~ 0.043	0.050
	2	Guide piston	outer <i>F</i>	200	
		Lower housing	inner <i>F</i>	200	
		Clearance	radial	0.195 ~ 0.230	0.254
	3	Piston / lower spring carrier	axial	0.03 ~ 0.07	0.09
	4	Regulating sleeve / upper spring carrier	axial	0.20 ~ 0.40	0.50
5556		Roller guide			
	5	Bush	outer <i>F</i>	112	
		Roller	inner <i>F</i>	112	
		Clearance	radial	0.080 ~ 0.125	0.135
	6	Pin	outer <i>F</i>	100	
		Bush	inner <i>F</i>	100	
		Clearance	radial	0.063 ~ 0.108	0.128
	7	Pin	outer <i>F</i>	100	
		Guide piston (bore)	inner <i>F</i>	100	
		Clearance	radial	0.020 ~ 0.058	0.088
	8	Axial clearance of bush	total	0.36 ~ 0.64	0.74
	9	Total clearance between guide piston and roller with pressure disc	axial	0.26 ~ 0.54	0.70

* Plunger conically machined in range 'C'-'D'; i.e. clearance increases in diameter of 0.015 mm.

Tightening Instructions
Tightening Values Important Screwed Connections

Group	Description	Thread	Tightening values			Lubricant
			Hydraulic pretension [MPa]	Tightening torque [Nm]	Tightening angle or elongation [° / mm]	
1 1106	* ① Bedplate parting faces, screw	M36		2090		Oil
	* ② Bedplate parting faces, screw	M56		5639		MOLYKOTE G
	1112-1 ③ Foundation bolts (metal and synthetic chock)	M64	100 1 st step 60 MPa			MOLYKOTE G
	1132-1 ④ Main bearing, nut for waisted stud	M64x6	100		(130°)	Oil
1715-1	⑤ Engine stays (friction type)	M64	26.3			MOLYKOTE G
1903-1	⑥ Tie rod	M180x6	100 1 st step 10 MPa 2 nd step 60 MPa 3 rd step 100 MPa			MOLYKOTE G
2 2106	* ⑦ Cylinder jacket bolting-up / bolt	M64	Elongation 0.55±0.04 mm			Oil
	* ⑦ Cylinder jacket bolting-up / fitted bolt	M64	Elongation 0.45±0.04 mm			Oil
2124-2	⑪ Supporting ring, screw	M24		150		See details in 2124-2
2708	* ⑫ Indicator valve, screws	M20		80		Never-Seez NSBT-8
2708-2	⑬ Cylinder cover, nut for waisted stud	M110x6	100		(390°)	Oil
2722-1	⑭ Injection valve, screwed connection with cylinder cover (see instructions in 2722-1)	M12	50 Nm 1 st step 25 Nm 2 nd step 50Nm } Equally tighten			Never-Seez NSBT-8
	⑮ Injection valve, retaining nut, nozzle body – nozzle holder (see instructions in 2722-1)	M65x1.5	1 st step 100 Nm 1 st step to 2 nd step 30° (loosen retaining nut after initial assembly and then repeat tightening procedure)			Never-Seez NSBT-8
2728-1	⑯ Starting valve spindle, nut (spindle thread not to be lubricated in the region of locking ring)	M36x3		(1215)	50°	MOLYKOTE G
	⑰ Starting valve, nut for waisted stud	M33		(1340)	85°	Never-Seez NSBT-8
2751-1	⑱ Exhaust valve cage, nut for waisted stud	M110x6	100		(230°)	Oil
2751-2	⑲ Exhaust valve, screw for grooved valve cone piece	M20	250 Nm 1 st step 25Nm 2 nd step 50Nm 3 rd step 250Nm } Equally tighten			Oil
	⑳ Exhaust valve, screw for lower housing – valve cage	M36	1 st step 130 Nm 2 nd step 30°			Oil

- When using other hydraulic jacks, the required pressure in MPa must be calculated in relation to the effective jack piston surfacel
- The numbers in ○ refer to the illustrations on pages 6 to 13.
- The values in parentheses (...) are for information only, to be used for reference.
- Screwed connections must be tightened in accordance with values not in parentheses.
- Respective lubricant has to be applied to threads and seating surfaces, if no other instructions are mentioned.
- Bostik Findley Inc. (USA) is manufacturer of Never-Seez NSBT-8.
- * Tightening procedure is not mentioned in this manual

Tightening Instructions
Tightening Values Important Screwed Connections

Group	Description	Thread	Tightening values			Lubricant
			Hydraulic pretension [MPa]	Tightening torque [Nm]	Tightening angle or elongation [°; mm]	
3						
3103 *	②② Flywheel, nut for coupling bolt	M56			20°	MOLYKOTE G
	②③ Crankshaft division, nut for coupling bolt	M85x4			50°	No additional Lubricant required
3130-2 *	②⑤ Crankshaft – vibration damper, nut for coupling bolt (standard flange)	M85x4			40°	MOLYKOTE G
	②⑥ Crankshaft – counterweight, nut for coupling bolt	M85x4			35°	MOLYKOTE G
3146-1	②⑦ Axial damper – bedplate, fixing bolt	M36		(2300)	50°	MOLYKOTE G
3206-1	②⑧ Turning gear, screwed connection	M52	100 1 st step 60 MPa 2 nd step 100 MPa		(60°)	Oil
3303-1	②⑨ Connecting rod, stud for top end bearing Check: 1 st step to 2 nd step	M80x6	100 1 st step 60 MPa (gap = 0) 2 nd step 100 MPa		(30°)	Oil
	③⑩ Connecting rod, stud for bottom end bearing Check: 1 st step to 2 nd step	M110x6	100 1 st step 30 MPa (gap = 0) 2 nd step 100 MPa		(80°)	Oil
3326-1	③① Middle piece of crosshead – guide shoe, screwed connection	M36		(2000)	60°	MOLYKOTE G
3403-1	③② Piston rod – crosshead, nut to waisted stud	M52	100 1 st step 60 MPa 2 nd step 100 MPa		(60°)	Oil
3403-3	③③ Piston rod – piston crown, nut to waisted stud	M48x3	100		(115°)	Oil
	③④ Spraying plate – piston rod, waisted screw	M20	1 st step 60 Nm 1 st step to 2 nd step	40°		No additional Lubricant required
4						
4103-2	③⑤ Intermediate wheel bearing, waisted screw	M56			50°	MOLYKOTE G
	③⑥ Gear rim – hub of intermediate wheel, screwed connection (nut secured with LOCTITE No. 262)	M42x3			80°	see details in 4103-2
4103-3	③⑧ Gear wheel on crankshaft, nut for waisted bolt to flanged connection (nut secured with LOCTITE No. 262)	M42x3		(4400)	80°	No additional Lubricant required

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Tightening Instructions
Tightening Values Important Screwed Connections

Group	Description	Thread	Tightening values			Lubricant
			Hydraulic pretension [MPa]	Tightening torque [Nm]	Tightening angle or elongation [°; mm]	
5						
5552-1	③⑨ Servo oil pump, screw	M24		600		Oil
5552-2	④⑩ Supply unit, waisted bolt	M42	100			Oil
5552-3	④① Camshaft wheel, waisted bolt	M42	100			Oil
5552-4	④② Supply unit – housing of intermediate wheel, screw	M16		170		Oil
	④③ Supply unit – housing of intermediate wheel, screw	M36		(2100)	47°	Oil
	④④ Bearing cover of intermediate wheel to camshaft, waisted bolt	M56	100			Oil
5553 *	④⑤ Supply unit – support, waisted screw	M42		(2850)	60°	Oil
5556-1	④⑥ Fuel pump cover – upper housing, screw	M24		320		Never-Seez NSBT-8
		M27		480		
	④⑦ Fuel pump – supply unit, screw	M30		(1250)	64°	Oil
	④⑧ Fuel pump cover – fuel pipe, screw	M12		70		Never-Seez NSBT-8
5562 *	④⑨ Non-return valve	M36x2		450		Never-Seez NSBT-8
	* ⑤⑩ Nipple	M36x2		400		Never-Seez NSBT-8
	* ⑤① Screw plug	M27x2		300		Never-Seez NSBT-8
	* ⑤② Transition nipple to pressure transmitter	M27x2		300		Never-Seez NSBT-8
	* ⑤③ Pressure transmitter	M14x1.5		25		Never-Seez NSBT-8
	* ⑤④ Cover – fuel pipe, screw	M16		190		Never-Seez NSBT-8
	* ⑤⑤ Valve block – cover, screw	M16		150		Never-Seez NSBT-8
	* ⑤⑥ Stop valve in valve block, screw	M10		35		Never-Seez NSBT-8
5564 *	⑤⑧ Fuel quantity sensor – fuel quantity housing, screw	M8		20		Never-Seez NSBT-8
	* ⑤⑨ Fuel quantity housing – intermediate flange, screw	M10		25		Never-Seez NSBT-8
	* ⑥⑩ Fuel quantity sensor – fuel quantity housing, screw	M12		75		Never-Seez NSBT-8
	* ⑥① Flange – injection control block, screw	M14		145		Never-Seez NSBT-8
5564-1	⑥② Injection control unit – fuel pipe, screw	M16		110		Never-Seez NSBT-8
	⑥③ Rail valve, screw	M4		2.5		Oil
	⑥④ Injection control unit – connection piece	M42x2		700		Never-Seez NSBT-8
	⑥⑤ Connection nipple	M42x2		350		Never-Seez NSBT-8

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- * Tightening procedure is **not** mentioned in this manual

Tightening Instructions
Tightening Values Important Screwed Connections

Group		Description	Thread	Tightening values			Lubricant
				Hydraulic pretension [MPa]	Tightening torque [Nm]	Tightening angle or elongation [° / mm]	
5566	*	66 Safety valve block, screw	M10		35		Oil
	*	67 Safety valve block – safety valve	M24x1.5		60		Oil
	*	68 Drain screw	M24x2		200		Oil
	*	69 Transmitter	G 1/4		25		Oil
	*	70 Valve block, screw	M10		35		Oil
	*	71 Shut-off valve, valve block, screw	M18x1.5		70		Oil
	*	72 Nipple	M30x2		200		Oil
5571	*	73 Shut-off valve – valve block, screw	M18x1.5		70		Oil
	*	74 Drain screw	M24x2		200		Oil
	*	75 Distributor block – pressure relief valve	M22x1.5		80		Oil
	*	76 Distributor block – pressure relief valve	M28x1.5		120		Oil
5610	*	77 Connection piece – 3/2-way valve, screw	M16		170		Oil
	*	78 Connection Piece – connecting element, screw	M16		130		Oil
	*	79 Connection piece – closing piece, screw	M16		130		Oil
	*	80 Valve block – servo oil rail, screw	M20		260		Oil
	*	81 Waisted screw to flanges	M16		170		Oil
	*	82 Pressure transmitter and screw plug	G 1/4		25		Oil
	*	83 Stop valve on valve block, screw	M16		130		Oil
5612-1		84 Connection piece – 3/2-way valve, screw	M16		170		Oil
		85 Connection piece, nut	M12		60		Oil
		86 Housing pipe holder, screw	M20		350		Oil
		87 Non-return valve – cover	G 3/4		60		Oil
		88 3/2-way valve – housing, screw	M20		350		Oil

- When using other hydraulic jacks, the required pressure in MPa must be calculated in relation to the effective jack piston surface!

- The numbers in ○ refer to the illustrations on pages 6 to 13.

- The values in parentheses (...) are for information only, to be used for reference.

- Screwed connections must be tightened in accordance with values not in parentheses.

Respective lubricant has to be applied to threads and seating surfaces, if no other instructions are mentioned.

- Bostik Findley Inc. (USA) is manufacturer of Never-Seez NSBT-8.

* Tightening procedure is not mentioned in this manual

Tightening Instructions
Tightening Values Important Screwed Connections

Group	Description	Thread	Tightening values			Lubricant
			Hydraulic pretension [MPa]	Tightening torque [Nm]	Tightening angle or elongation [° Δ; mm]	
8						
8447 *	⑧⑨ Stop valve on valve block, screw	M16		130		Oil
8447-1	⑨⑩ Servo oil piping, screw	M16		170		Oil
	⑨⑪ Spindle to shut-off valve	M30x2		200		Oil
	⑨⑫ Non-return valve	G 3/4		80		see detail in 8447-1
8733-1	⑨⑬ Fuel pressure piping, screw	M12		40		Never-Seez NSBT-8
	⑨⑭ Pressure control valve, screw	M16		190		Never-Seez NSBT-8
	⑨⑮ Flange and end flange, screw	M16		190		Never-Seez NSBT-8
	⑨⑯ Stop valve in end flange, screw	M10		35		Never-Seez NSBT-8
	⑨⑰ Flange with relief valve, screws	M16		190		Never-Seez NSBT-8
	⑨⑱ Flange of fuel pressure piping, screw	M16		190		Never-Seez NSBT-8
8751-1	⑨⑲ Relief valve	M30x2		300		Never-Seez NSBT-8
8752-1	⑩① Fuel pressure piping, screw	M12		60		Never-Seez NSBT-8
	⑩② Spindle to shut-off valve	M20		100		Never-Seez NSBT-8
	⑩③ Non-return valve	G 3/4		80		See detail in 8752-1
9						
9223 *	⑩④ Connecting unit, adjusting disc – coupling disc, screw	M10		35		MOLYKOTE G
9223-1	⑩⑤ Nut to waisted screw	M16		140		MOLYKOTE G
	⑩⑥ Shaft nut	M40x1.5		25		MOLYKOTE G
	⑩⑦ Shaft nut	M35x1.5		25		MOLYKOTE G
	⑩⑧ Screw to shaft encoder – bearing housing	M8		16		MOLYKOTE G
	⑩⑨ Screw to distance piece	M12		60		MOLYKOTE G
	⑩⑪ Screw to connecting unit – driving wheel	M12		60		MOLYKOTE G
	⑩⑫ Screw to spring tensioner – coupling disc	M12		60		MOLYKOTE G
	⑩⑬ Screw to spring tensioner	M10		35		MOLYKOTE G
*	Tools					
	⑩⑭ Screw plug 94585	M36x2		270		Never-Seez NSBT-8
	⑩⑮ Tie rod, clamp screw for anti-vibration	M24		100		MOLYKOTE G

- When using other hydraulic jacks, the required pressure in MPa must be calculated in relation to the effective jack piston surface!

- The numbers in ○ refer to the illustrations on pages 6 to 13.

- The values in parentheses (...) are for information only, to be used for reference.

- Screwed connections must be tightened in accordance with values not in parentheses.

Respective lubricant has to be applied to threads and seating surfaces, if no other instructions are mentioned.

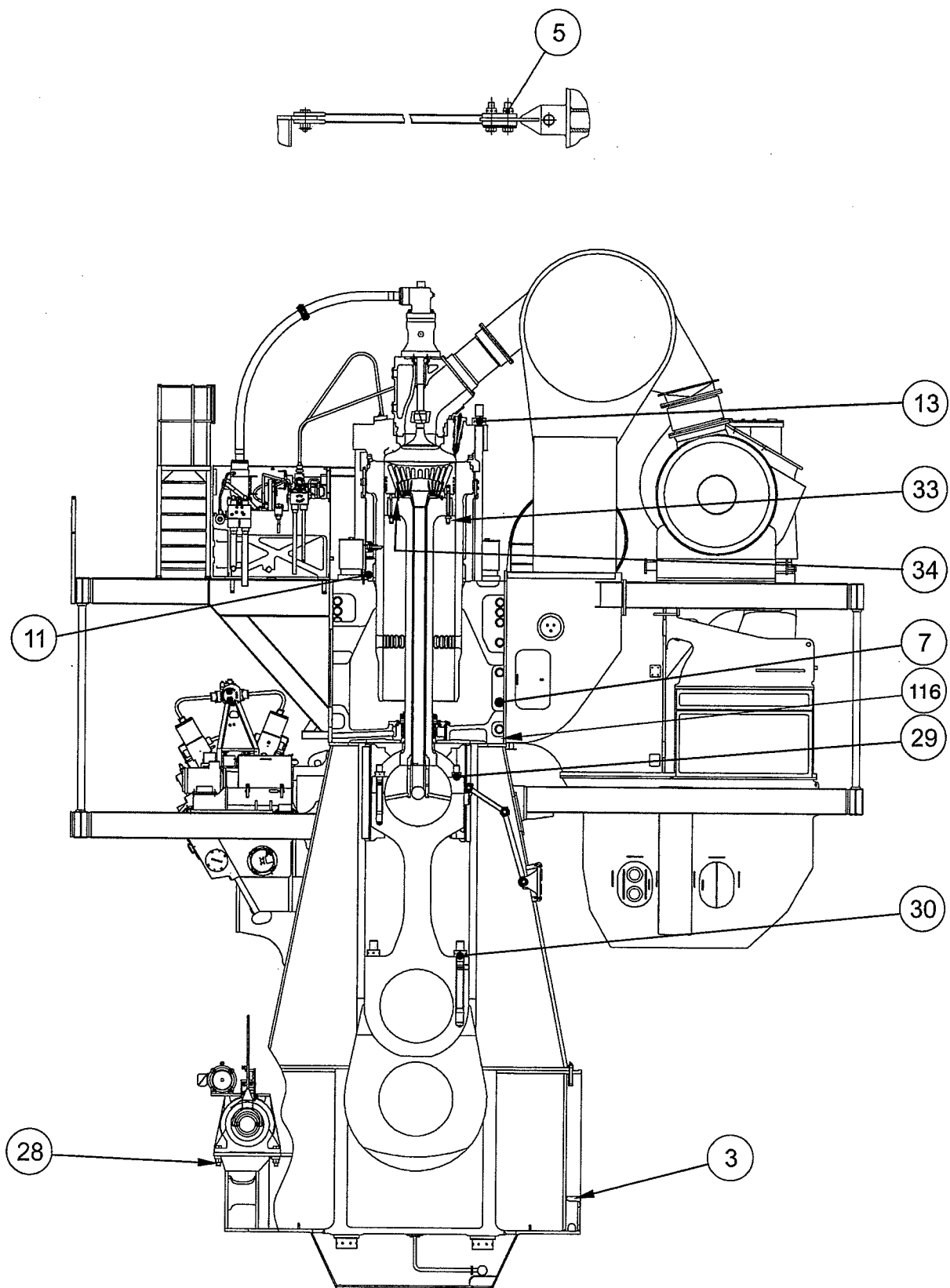
- Bostik Findley Inc. (USA) is manufacturer of Never-Seez NSBT-8.

* Tightening procedure is **not** mentioned in this manual

Tightening Instructions

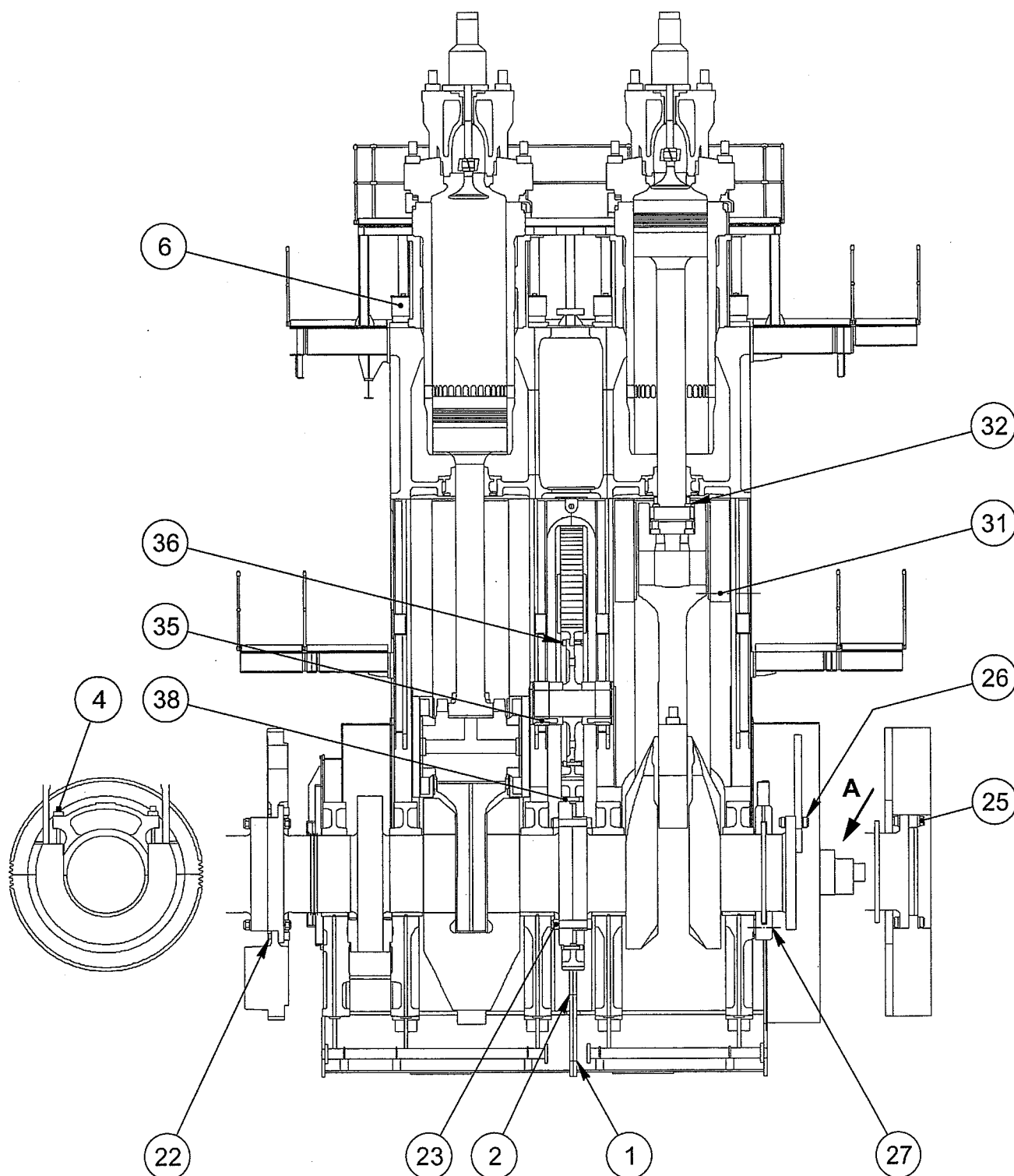
Tightening Values Important Screwed Connections

**ENGINE STAY
(FRICTION TYPE)**



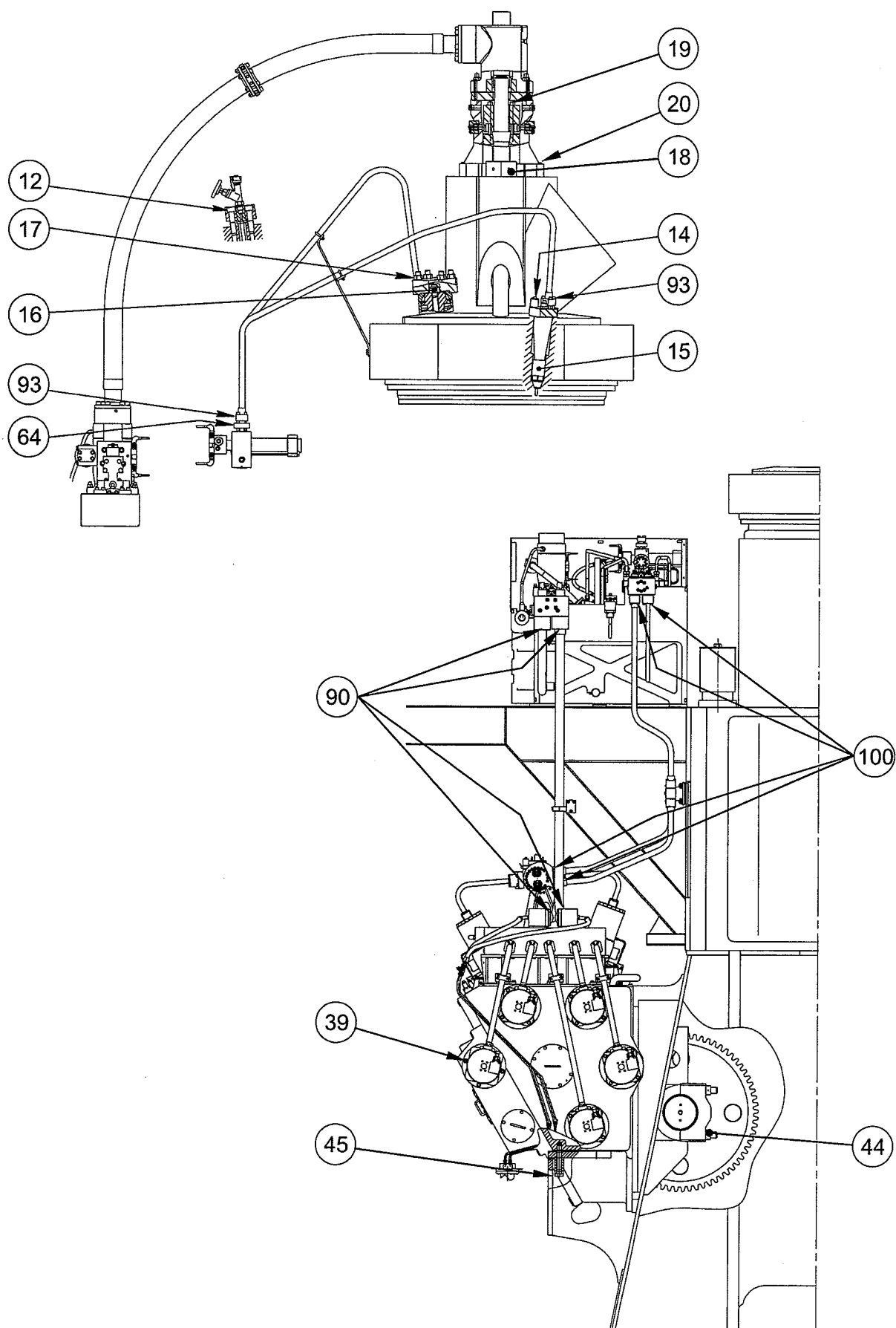
Tightening Instructions

Tightening Values Important Screwed Connections



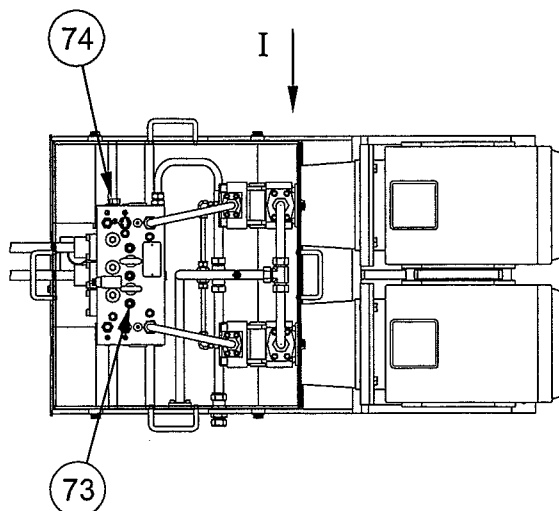
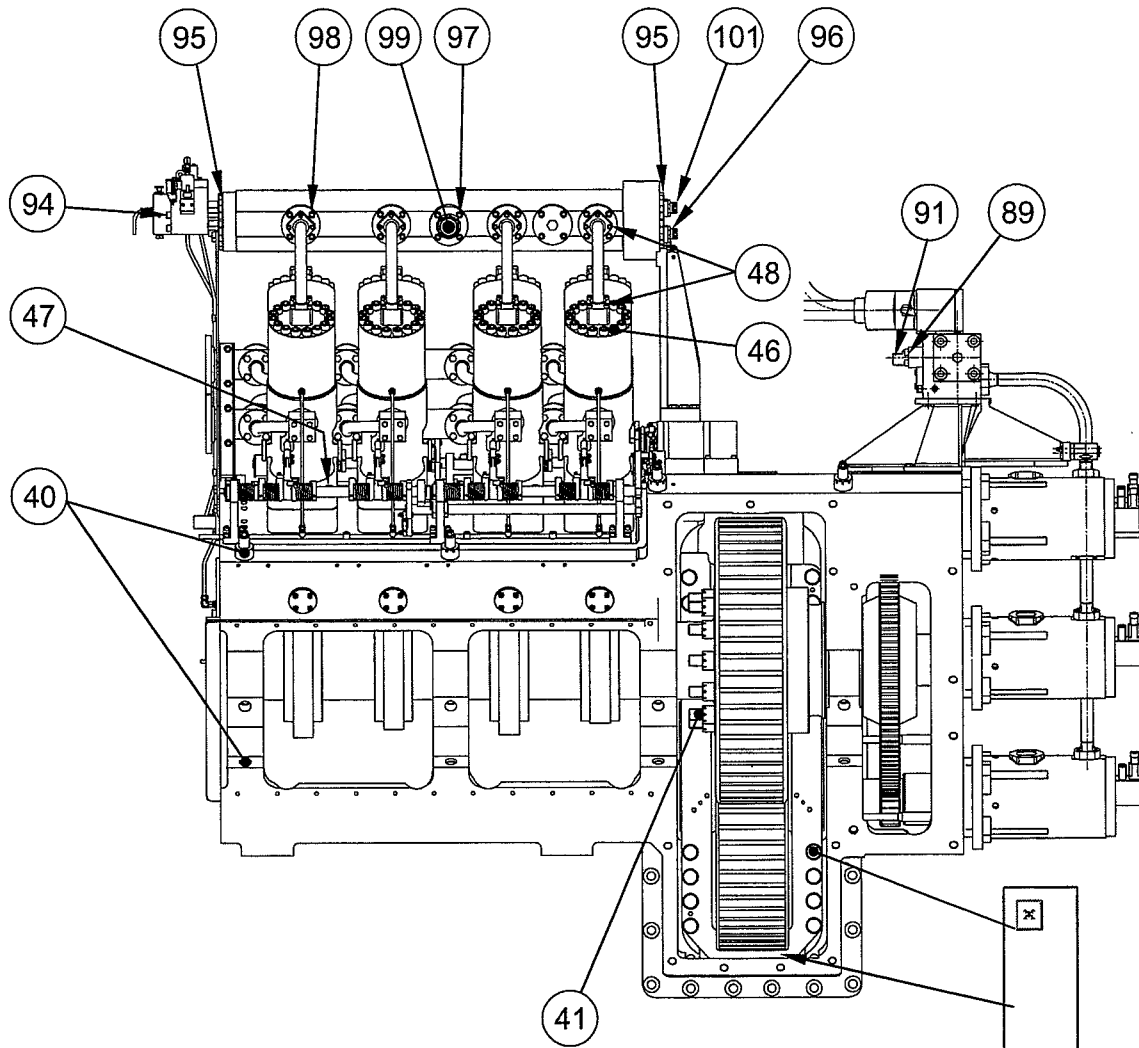
Tightening Instructions

Tightening Values Important Screwed Connections

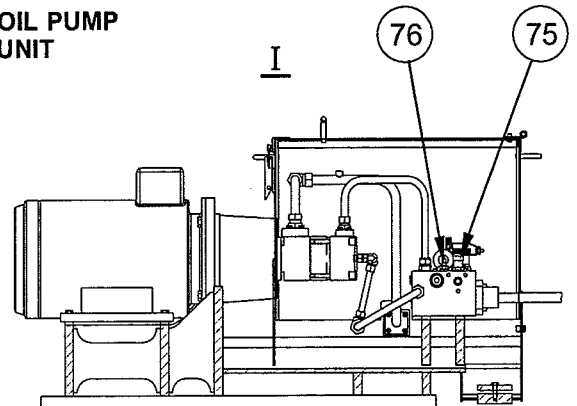


Tightening Instructions

Tightening Values Important Screwed Connections



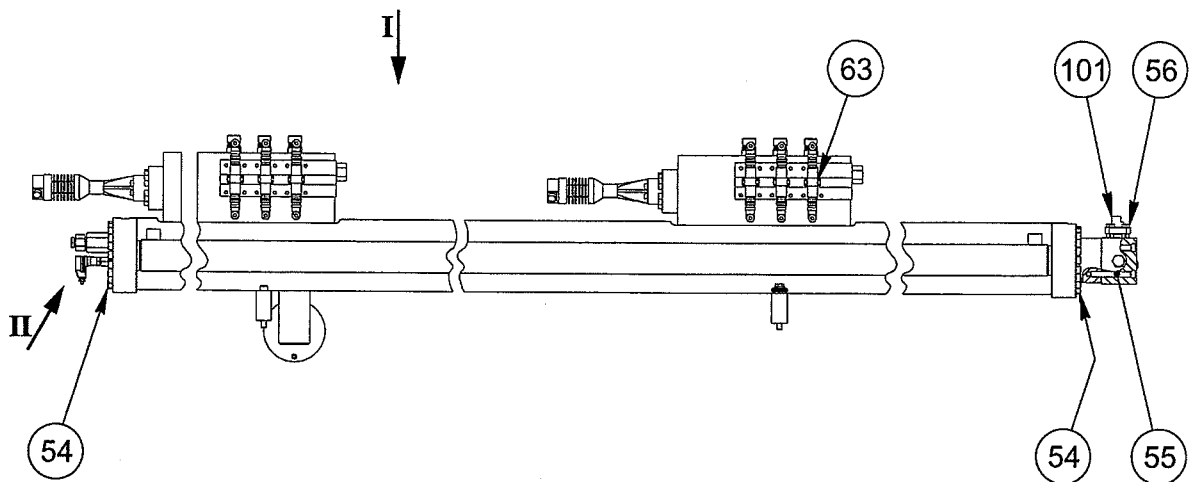
**CONTROL OIL PUMP
RAIL UNIT**



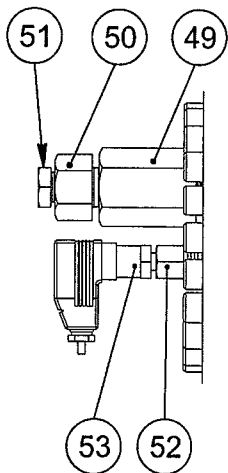
Tightening Instructions

Tightening Values Important Screwed Connections

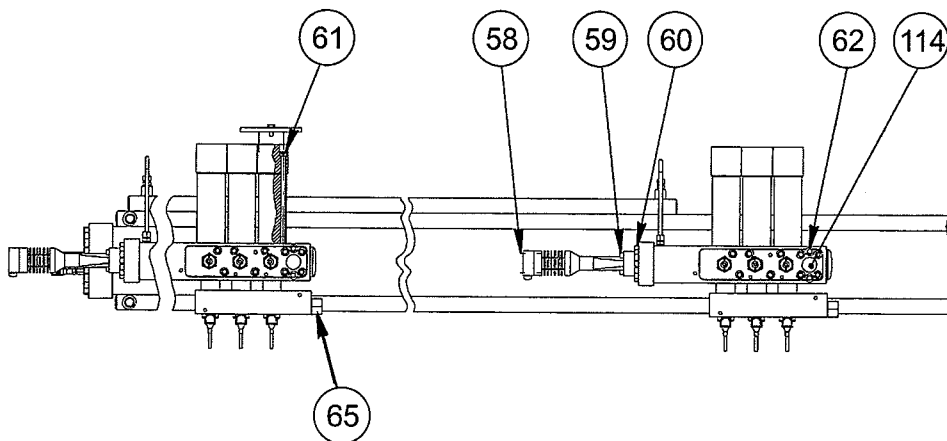
FUEL RAIL



II



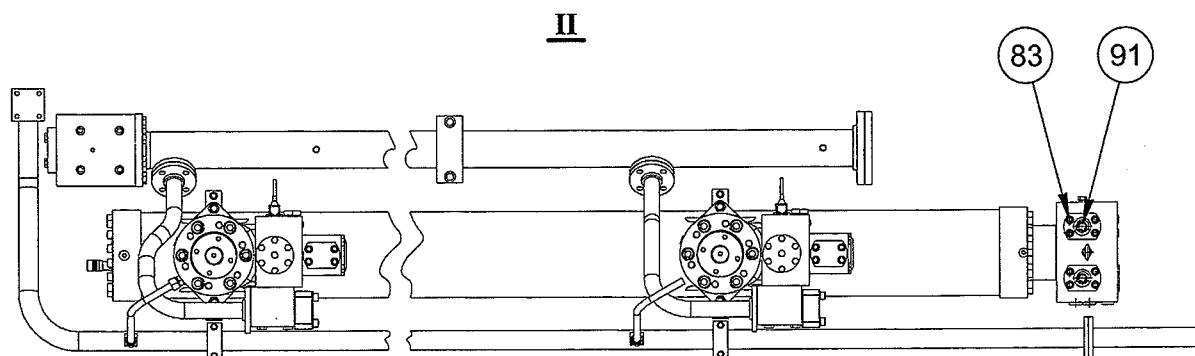
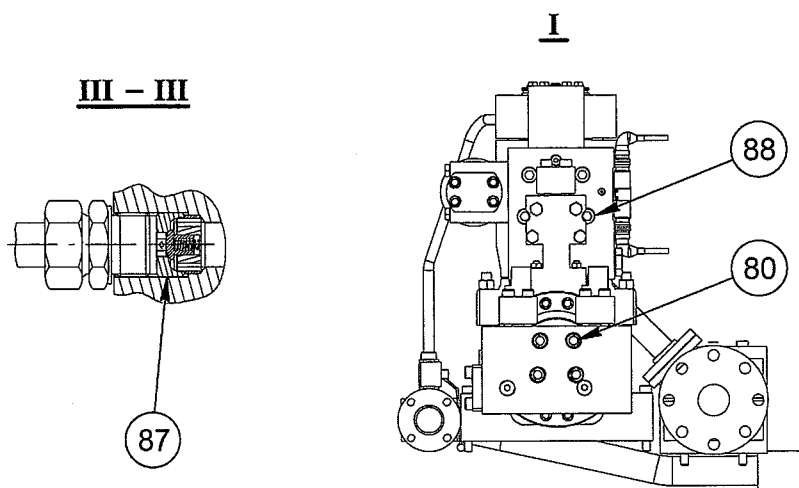
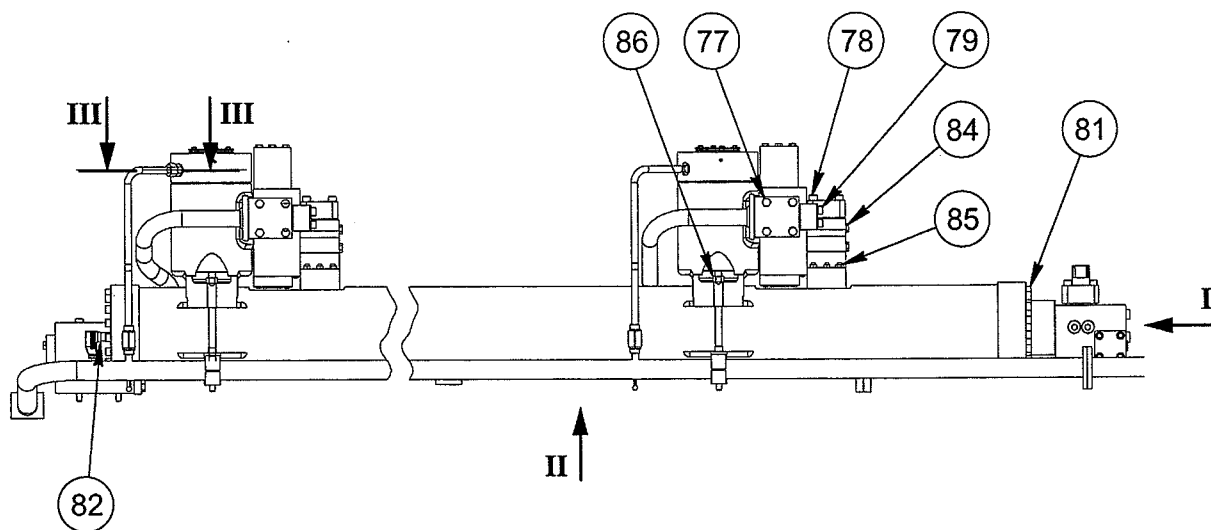
I



Tightening Instructions

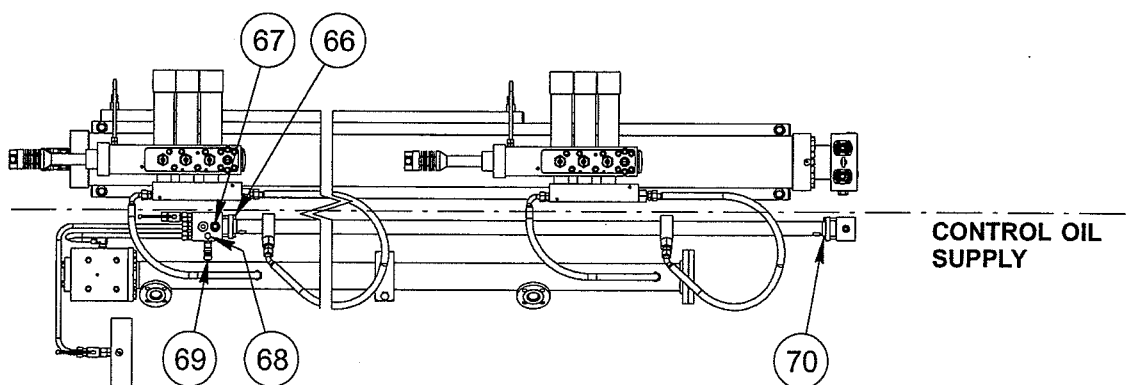
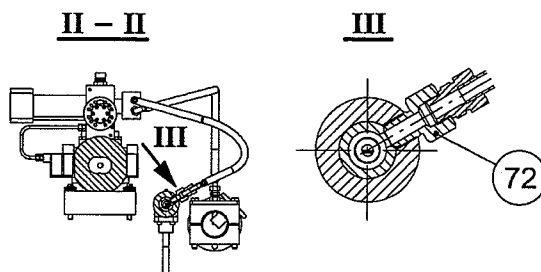
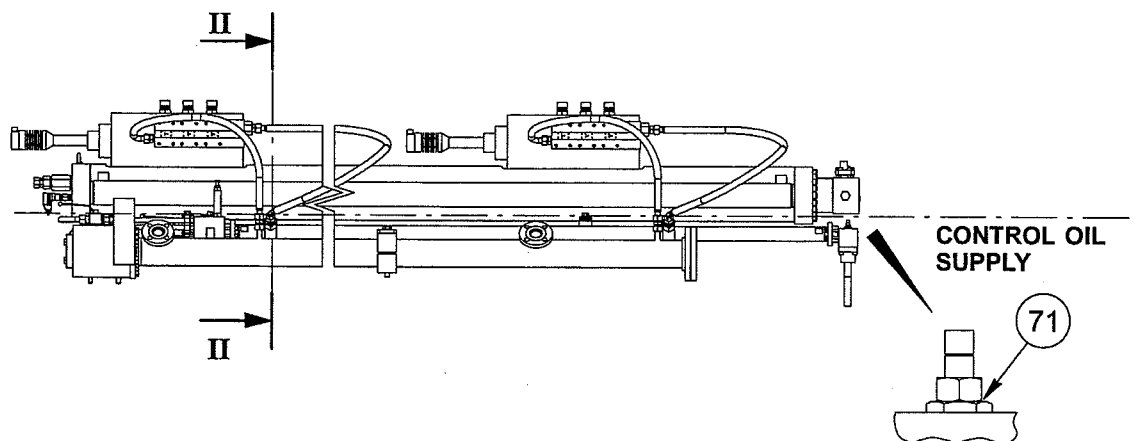
Tightening Values Important Screwed Connections

SERVO OIL RAIL



Tightening Instructions

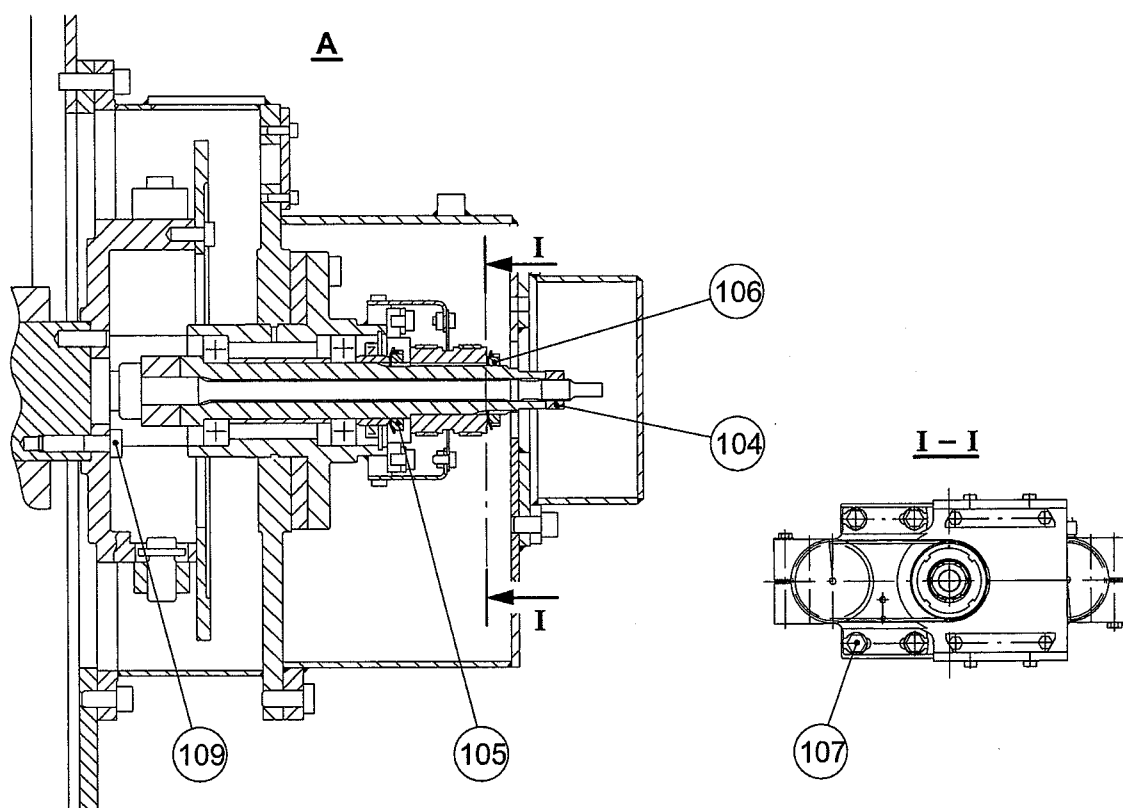
Tightening Values Important Screwed Connections



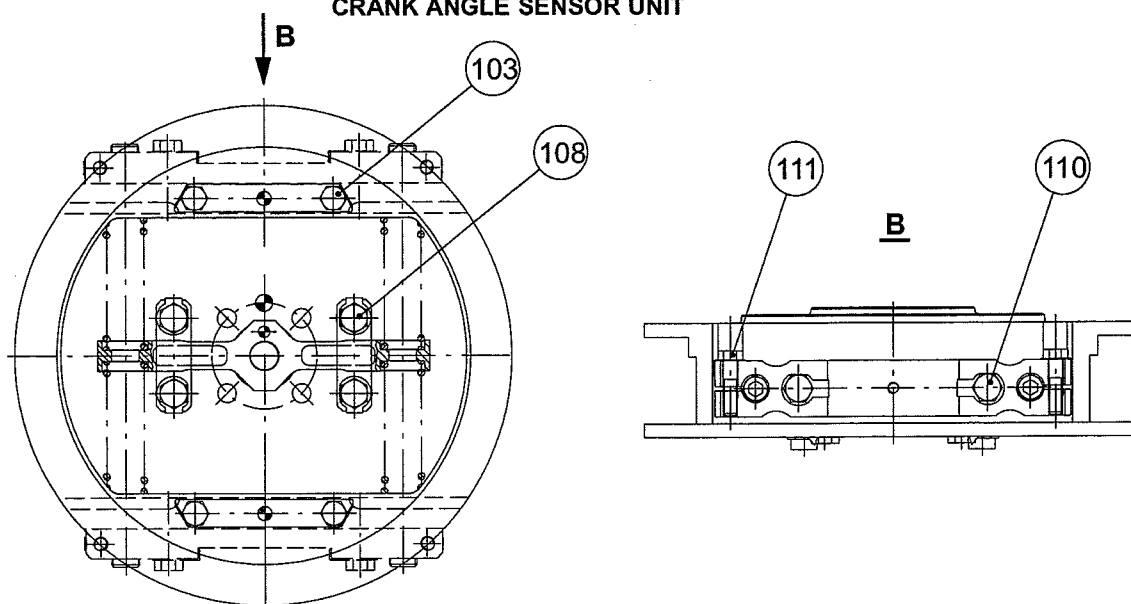
Tightening Instructions

Tightening Values Important Screwed Connections

CRANK ANGLE SENSOR UNIT



**CONNECTING UNIT TO
CRANK ANGLE SENSOR UNIT**



Maintenance Schedule
Tightening Instruction for Standard Screwed Connections
1. Standard screws

This table is valid for all screws that are not considered in 0352-1 for reference.

It is recommended to lubricate the threads for screws which come into contact with hot parts like exhaust pipings, expansion pieces, etc. with a heat-resisting lubricant, e.g. THREAD GARD.



These tightening instructions are available only if:
— threads have been lubricated with oil

Screw thread	Tightening torque Nm
M8	20
M10	40
M12	70
M14	110
M16	170
M18	250
M20	350
M22	450
M24	600
M27	900
M30	1200
M33	1600
M36	2100
M39	2500
M42	2900
M45	3300
M48	3700
M52	4100
M56	4600
M60	5200

Maintenance Schedule

Tightening Instruction for Standard Screwed Connections

2. Waisted studs

Waisted studs must be tightened according to the values in the following diagram.

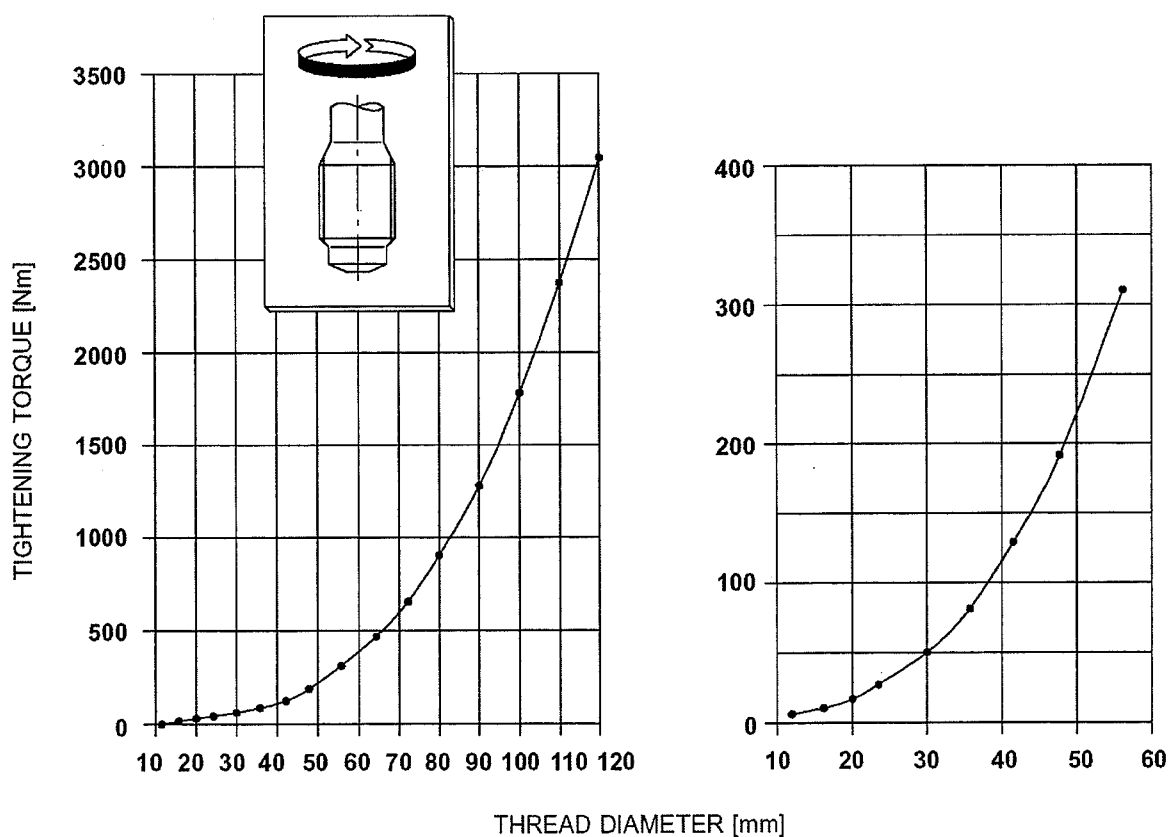
- Before fitting a waisted stud clean its thread and corresponding tap hole. The sealing faces must be degreased (e.g. using white spirit) and subsequently primed.
- Screw in the waisted stud without lubricant on the thread right to the bottom of the tap hole, and tighten. Always utilize a stud driver or two nuts.



Tools like a pipe wrench etc. which would damage the stud shank must never be used.

- For the protection of the waisted stud in the cylinder jacket and cylinder cover, fill the annular space above the thread with a non-hardening jointing compound (see 2751-1).

TIGHTENING TORQUE FOR WAISTED STUDS



Maintenance Schedule
Inspection and Overhaul Interval (Guidelines)

Group	Component	Work to be carried out	Intervals (operating hours)											
			Daily	1,000	1,500	1,500 ~ 3,000	3,000	4 ~ 6,000	6 ~ 8,000	12,000	18,000	18 ~ 20,000	24 ~ 36,000	36,000 as required
0														
0900-1	Lubricating oil	— Laboratory analysis	●											
	Cooling water	— Check concentration of inhibitor (as per supplier's instruction)												
1														
1112-1	Bedplate	— Check pre-tension of foundation bolts, first time after 1,500 operating hour								●				
	Crankcase	— Visual examination 100 Op. after overhaul works			●									
1132-1	Main bearing	— Check pre-tension waisted stud, if necessary re-tension (first time after one year)	15,000 ~ 20,000 Op. hr											
1132-2		— Remove bearing upper half for inspection	according to classification society											
1132-2		— Remove bottom bearing shell for inspection	acc. to class. society											
1203-1	Thrust bearing	— Check axial and radial clearance							●					
1203-1		— Check bottom drain for free passage							●					
1224-1		— Remove thrust bearing pads for inspection	acc. to class. society											
1715-1	Engine stays with friction shims	— Check pre-tension of waisted studs, first time after sea trial							●					
1715-1	Hydraulic engine stays: option	— Check oil pressure hydraulic cylinder, First time after sea trial (if necessary correct pressure)							●					
1903-1	Tie rod	— Check pre-tension, first time after one year (if necessary re-tension)											●	
2														
2124-1	Cylinder liner	— Establish wear in bore (in fitted condition)	at every piston removal											
2124-2		— Remove cylinder liner												●
2124-2		— Replace O-rings	at every removal											
2124-2		— Replace (soft iron) joint ring between cylinder liner and cylinder cover	at every piston removal											
2124-2		— Water guide jacket, replace O-rings	at every piston removal											
2143-3		— Grind off wear ridge in bore	at every piston removal											
2143-3		— Clean scavenge ports and refinish their edges												●

Maintenance Schedule
Inspection and Overhaul Interval (Guidelines)

Group	Component	Work to be carried out	Intervals (operating hours)											
			Daily	1,000	1,500	1,500 ~ 3,000	3,000	4 ~ 6,000	6 ~ 8,000	12,000	18,000	18 ~ 20,000	24 ~ 36,000	36,000 as required
2136-1	ECL-SIP valve	Refer to 0380-2												
2303-1	Piston rod gland box	— Clean rings, establish wear												
2708-1	Cylinder cover	— Check combustion space for damage and wear												
2722-1	Injection valve	— Check externally for tightness												
		— Check spray pressure, tightness and condition of nozzle tip, readjust opening pressure (life time of nozzle tip about 6,000 Op. h)												
2728-1	Starting valve	— Check piping before the valve during operation, if piping is too hot dismantle starting valve — Remove and dismantle one starting valve at random. From its condition determine time of overhaul for remaining valves — Solenoid valve, random check — Solenoid valve, overhaul												
2740-1	Relief valve to cylinder cover	— Check, dismantle, assemble and set												
2751-1 to 2751-4	Exhaust valve	— General inspection of valve housing, valve spindle and valve seat (without dismantling of exhaust valve) — Valve spindle, check condition and wear (if necessary regrind seat by machining) — Check piston seal ring / air spring & rod seal ring / guide bush — Check condition and wear of valve seat (if necessary regrind seat by machining) — Random check of valve drive, outside and inside pistons, damper, thrust piece — Random check of screwed connection to measuring cone												
3 3103-1	Crankshaft	— Measure crank deflection (always in case of grounding of the ship as well as before and after every docking)												
3130-1	Torsional vibration damper : if installed as option	— Take a silicon oil sample from viscous vibration damper (based on results of 1 st sample, interval for taking further samples will be decided)												
3130-2		— Inspection interval and dismantling of GEISLINGER damper												

Maintenance Schedule
Inspection and Overhaul Interval (Guidelines)

Group	Component	Work to be carried out	Intervals (operating hours)											
			Daily	1,000	1,500	1,500 ~ 3,000	3,000	4 ~ 6,000	6 ~ 8,000	12,000	18,000	18 ~ 20,000	24 ~ 36,000	36,000 as required
3146-1	Axial damper	– Dismantling and inspection	36,000 ~ 48,000 Op. h											
3206-1	Turning gear	– Inspection interval – Check screwed connections, first time after one year (if necessary re-tighten)	acc. to instruction of turn. gear manufacturer											
3303-1	Connecting rod bearings	– Check bearing clearance							●					
3303-2		– Inspect bottom end bearing (life time of shell 60,000 ~ 72,000 Op. h)	30,000 ~ 36,000 Op. h or acc. to class. society											
3303-3		– Inspect top end bearing	30,000 ~ 36,000 Op. h or acc. to class. society											
3326-1	Guide shoe, Crosshead pin	– Check clearance							●					
3326-2		– Remove crosshead												●
3403-1	Piston	– Remove, clean and measure ring grooves	after refitting											
		– Check tightness on piston in situ with running oil pump, visual check through scavenge ports												
3403-3		– Dismantling and assembling (open cooling space & clean same, min. one piston every two years)												●
3403-4		– Check condition of the piston top surface – Visual check through scavenge ports to piston, piston rings and cylinder liner (rotate crankshaft with turning gear)	at every piston removal											
	Piston underside	– Check condition of space and clean it as required			●									
		– Check drains for free passage			●									
3425-1	Piston ring	– Remove, clean and establish wear rate, if necessary fit new rings – Replace uppermost piston ring	at every piston removal											
4	Start interlock	– Check electric and pneumatic interlock (see Operating Manual 4003-1)	quarterly											
4103-1														
4325-1	Starting air shut-off valve	– Vent	after each manoeuvring period											
		– Dismantle, clean and check (particularly seat, springs and seal rings)										●		
4325-1	Control air filter	– Functional check		●										
		– Drain filter – Clean filter	weekly 6,000 Op. h											

Maintenance Schedule
Inspection and Overhaul Interval (Guidelines)

Group	Component	Work to be carried out	Intervals (operating hours)											
			Daily	1,000	1,500	1,500 ~ 3,000	3,000	4 ~ 6,000	6 ~ 8,000	12,000	18,000	18 ~ 20,000	24 ~ 36,000	36,000 as required
5														
5552-1	Supply unit	— Replace servo oil pump either with new one or a pump overhauled by a Wärtsilä workshop	24,000 Op. h											
		— Check pinion and driving wheels to servo oil pump drive				●								
5552-2		— Check bearing bushes to pinion	24,000 Op. h											
		— Camshaft, check bearing clearances at random								●				
	5552-5	— Camshaft, check thrust bearing clearances											●	
		— Check cams, rollers, roller guides, casing, non return valves in the fuel pump covers & connecting flanges of the intermediate fuel accumulator	After each sea passage											
5556-1	Fuel pump	— Overhaul, check wear of pump plunger and pump cylinder									●			
		— Random visual check of plunger & cylinder, roller and roller guide									●			
5564-1	Injection control unit	— Replace unit (incl. rail valves) either with new one or a unit overhauled by a Wärtsilä workshop											●	
		— Replace filter									●			
5564	Fuel pressure control valve	— Replace filter (control oil)									●			
5571	Control oil pump	— Check coupling, adjust working pressure according to instruction of manufacturer									●			
		— Replace ball-bearing on electric motor											●	
		— Replace pump element on HP gear pumps according to instruction of pump manufacturer											●	
	Distributor block	— Replace safety valve (control oil) (see Operating Manual 5571-1)											●	
5610	Servo oil rail	— Replace hoses	18,000 ~ 30,000 Op. h											
5612-1	Exhaust valve drive	— Random check of piston and slide rod									●			
		— Replace rail valve											●	
		— Replace filter											●	
5801-1	Regulating linkage	— Check for free movement, lubricate all movable parts				●								

Maintenance Schedule
Inspection and Overhaul Interval (Guidelines)

Group	Component	Work to be carried out	Intervals (operating hours)												
			Daily	1,000	1,500	1,500 ~ 3,000	3,000	4 ~ 6,000	6 ~ 8,000	12,000	18,000	18 ~ 20,000	24 ~ 36,000	36,000	as required
6 6420-1	Scavenge air receiver	- Check and clean air flaps - Clean receiver - Check water drain piping for free passage				●		●							
	Exhaust gas turbocharger	- Cleaning of blower - Cleaning of turbine - Air filter cleaning (ΔP max. 200 mm WG) : MET turbocharger	(see Operating Manual 6510-1) (see Operating Manual 6510-1)												
6545-1	Auxiliary blower	- Clean impeller and casing - Replace ball bearing										●	●		
6606-1	Scavenge air cooler	- Cleaning of scavenge air cooler (air side) at standstill, if ΔP (pressure drop through SAC) reaches 50 mbar (for further instructions see Operating Manual) - Cleaning of heater (air side) on engine at standstill - Watch permanent drainage (outlet either air or mixture of air / water) - Check scavenge air cooler sealing - Vent - Remove scavenge air cooler and heater for general overhaul	●											●	
			quarterly	●										●	
6708-1	Water separator	- Watch permanent drainage (outlet either air or - Check water separator elements if necessary clean them) - Check drains for free passage - Remove water separator for general overhaul	●			●								●	
						●									
7 7218	ECL system	Refer to 0380-2													

Maintenance Schedule
Inspection and Overhaul Interval (Guidelines)

Group	Component	Work to be carried out	Intervals (operating hours)											
			Daily	1,000	1,500	1,500 ~ 3,000	3,000	4 ~ 6,000	6 ~ 8,000	12,000	18,000	18 ~ 20,000	24 ~ 36,000	36,000 as required
8	Servo oil automatic filter	— Follow manufacturer's instruction												
8447	Collector block	— Replace safety valve (servo oil)												●
	Servo oil system	— Check spindle of shut-off valve for free movement	6,000 Op. h											
8447-1	Servo oil piping	— Regrind sealing faces												●
8460-1	Hydraulic piping to exhaust valve	— Regrind sealing faces												●
	Starting air piping	— Drain (de-water)	Before and after every manoeuvring period											
	Pressure gauge and pyrometers	— Compare and calibrate to master instruments						●						
	Servo oil filters	— Clean or replace filter elements (depending on make, follow special maintenance by manufacturer)												●
8733-1	Fuel pressure piping (on cylinder cover)	— Regrind sealing faces												●
8750	Intermediate fuel accumulator	— Random check of no-return valves									●			
8750-1	Relief valve (fuel overpressure safety valve)	— Function check on test bench									●			
8750-2	Fuel pressure control valve	— Check shut-down function (see Operating Manual 4003-1) — Function check (see Operating Manual 5556-1) — General overhaul	6,000 Op. h											
8752-1	Fuel pressure piping	— Regrind sealing faces												●
9														
9223-1	Crank angle sensor	— Check pre-tension of tooth belt, if necessary re-tension (first time after five Op. h on new engines or after replacing tooth belt) — Replace toothed belt — Visual lube oil check — Overhaul drive (ball-bearing, sealing ring etc.) — Replace crank angle sensor			●									●
	Oil mist detector	— Follow manufacturer's instructions	half yearly											
	WECS electronic components	— Replace FCM-20 module (see Operating Manual 4002-4) — Check cabling	36,000 ~ 50,000 Op. h quarterly											

Maintenance Schedule
Inspection and Overhaul Interval (Guidelines)

The indicated maintenance intervals must be taken as **guidance** and may vary depending on the installation. The proper intervals are subject to the points mentioned below. Experience will show whether these intervals can be extended or must be shortened.

- Environmental and operating conditions
- Heavy fuel oil and lubricating oil qualities (see Operating Manual 0710-1 and 0750-1)
- Engine load
- Fuel, lubricating oil and cooling water care (see Operating Manual 0720-1 and 0760-1)
- Overhaul according to Maintenance Manual
- Genuine spare parts used
- Engine monitoring
- Engines according to specifications of MITSUBISHI HEAVY INDUSTRIES, Ltd.

On the engine sectional drawings 0803-1, those parts are marked with group numbers, as they are found in the Maintenance Manual.

Engine Control System WECS-9520

Control works in the WECS-9520 (Wärtsilä Engine Control System) are described in the following groups of the Operating Manual:

- Regular checks and recommendation settings for WECS-9520 4002-4
- Engine control 4003-1

Maintenance Schedule of ECL system
Inspection and Overhaul Interval (Guidelines)

The indicated maintenance intervals must be taken as lower **guidelines** and may vary depending on the installation. Experience will show whether these intervals can be extended or must be shortened.

Table 1 Maintenance Schedule of ECL system (Guidelines)

Group	Component	Work to be carried out	Intervals (operating hours)							
			Daily	500	1500	3000	6 ~ 8000	15 ~ 20,000	35 ~ 40,000	as required
2	ECL-SIP valve	– Check function and tightness – Replace O-rings – Overhaul and recondition of ECL-SIP valve								
2136-5			at every piston removal and every exhaust valve removal at every liner removal at every 5 years							
7	ECL system	– Priming – Visual inspection of injection condition from piston underside – Visual inspection of injection condition from top of cylinder liner – Tactile inspection of Distributor unit – Dismantling and checking of Distributor unit								
7218-1 to 7218-5			When starting after long term shut down at every piston removal and every exhaust valve removal							
	Supply unit	– Checking of differential pressure between low pressure filter – Checking of differential pressure between middle pressure filter – Checking of pressure and temperature of system – Cleaning or exchange of filter element	●							
			●							●
	Control system	– Checking of middle pressure pump – Maintenance of Control panel – Maintenance of Solenoid valve driver box – Maintenance of Crank angle detector	●							
			●							●
			Every starting							
			Refer to Table 2							
			Refer to Table 3							
			Refer to Table 4							

Maintenance Schedule of ECL system

Inspection and Overhaul Interval (Guidelines)

Table 2 CONTROL PANEL

Maintain the device according to "CONTROL PANEL Electric Devices Maintenance Standards".

CONTROL PANEL Electric Devices Maintenance Standards						⊙ . . . Adjust / Test ○ . . . Check / Repair × . . . Change △ . . . Change after checking the progress
Name	Intervals (year)					Inspection / Test, Adjustment, Repair, and / or Change
	.5	1	3	5		
Switch			⊙	○	△	⊙ . . Check for looseness of screws. ○ . . Clean dirt and dust. △ . . If there is no problem on contacts, postpone schedule and then check them every 6 months.
AC/DC Converter DC/DC Converter					△	△ . . After output voltage is checked at 5 years, if there is the abnormality, do the renewal. If there is no problem on contacts, postpone schedule and then check them every 6 months.
Fan of AC/DC Converter		○			△	○ . . Clean dirt and dust. △ . . If there is noise, repair or renew.
Terminal board		○				○ . . Tighten screws.
Printed Circuit Board				⊙		⊙ . . Check for looseness of connector or dust. (After the operation by the service staff is confirmed at ten years, renew if necessary.)
Noise Filter			○			○ . . Check for looseness of terminals.
Amplifier			○			○ . . Check for looseness of screws.

Table 3 SOLENOID VALVE DRIVER BOX

Maintain the device according to "SOLENOID VALVE DRIVER BOX Electric Devices Maintenance Standards".

SOLENOID VALVE DRIVER BOX Electric Devices Maintenance Standards						⊙ . . . Adjust / Test ○ . . . Check / Repair × . . . Change △ . . . Change after checking the progress
Name	Intervals (year)					Inspection / Test, Adjustment, Repair, and / or Change
	.5	1	3	5		
Printed Circuit Board				⊙		⊙ . . Check for looseness of connector or dust. (After the operation by the service staff is confirmed at ten years, renew if necessary.)
Smoothing Capacitor					×	× . . Renew every 5 years.
Noise Filter			○			○ . . Check for looseness of terminals.

Table 4 CRANK ANGLE DETECTOR

Maintain the device according to "CRANK ANGLE DETECTOR Electric Devices Maintenance Standards".

CRANK ANGLE DETECTOR Electric Devices Maintenance Standards						⊙ . . . Adjust / Test ○ . . . Check / Repair × . . . Change △ . . . Change after checking the progress
Name	Intervals (year)					Inspection / Test, Adjustment, Repair, and / or Change
	.5	1	3	5		
Proximity Switch		⊙				⊙ . . Clean sensor head. Check and adjust the clearance.

Engine's Record Book (IMO-NOx compliant)

In IMO-NOx compliant engine, when the parameter check method is selected at the periodic inspection, the exchange record (exchanged data, ID-number or adjusted value, and sign) of the parts must be entered in the attached "Engine's Record Book"

ENGINE'S RECORD BOOK OF ENGINE PARAMETERS

FOR

ON-BOARD VERIFICATION FOR CONTROL OF NO_x EMISSION

Engine Manufacturer	Model Number	Engine Serial Number	Test Cycle(s)	Rated Power Rated Speed
Mitsubishi Heavy Industries, Ltd.	11RT-flex96C	3925	E3	62,920kW 102 min ⁻¹

This record book, based on Technical File:WSS-0911, is used for parameter check method for on-board NO_x verification.

All changes of engine parameters which influence exhaust emission, including adjustments, parts replacements and modifications to engine parts, shall be recorded chronologically in this record book.

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-------------------------------	----

CONTENT		REMARKS Economy mode	PURCHASER	ORDER No.	DATE	DEISEL ENGINE DESIGNING SECTION	
DESCRIPTION	PAGE			ITEM No.	REFERENCE	MARINE DIESEL ENGINE BUSSINESS UNIT DEPARTMENT	
FIGURE	SHEET			911		APPROVED BY	
Total	18 (Incl. Cover)					CHECKED BY	
						DESIGNED BY	
		DRAWN BY					
				ISSUE			
				DATE	Nov. 8, 2006		
FACTORY				DWG.No.		Rev.No.	
				WSS-1005			

1.1 Flex Control Module

Sheet No.	1.1 -
-----------	-------

Date	Cyl. No.	Allowed ID-Number	Installed ID-number	Signature of person responsible for ship / engine	Remarks
18-Aug-2006	From 1 through 11	Wärtsilä FCM-20	Wärtsilä FCM-20		Shop test
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			
	From 1 through 11	Wärtsilä FCM-20			

SAMPLE

1.2 Software Package

Sheet No.	1.2 -
-----------	-------

Date	Cyl. No.	Allowed ID-Number	Installed ID-number	Signature of person responsible for ship / engine	Remarks
18-Aug-2006		LN-BE9801	LN-BE9801		Shop test
		LN-BE9801			
		LN-BE9801			
		LN-BE9801			
		LN-BE9801			
		LN-BE9801			
		LN-BE9801			
		LN-BE9801			
		LN-BE9801			
		LN-BE9801			
		LN-BE9801			
		LN-BE9801			

SAMPLE

1.3 IMO Relevant Parameters

Sheet No. 1.3 -

.3 IMO Relevant Parameters						
Date	Check-value	Allowed ID-Number	Installed ID-number	Signature of person responsible for ship / engine	Remarks	
18-Aug-2006	CRC value	0xC26B	0xC26B		Shop test	
	Data length	736	736			
	CRC value	0xC26B				
	Data length	736				
	CRC value	0xC26B				
	Data length	736				
	CRC value	0xC26B				
	Data length	736				
	CRC value	0xC26B				
	Data length	736				
	CRC value	0xC26B				
	Data length	736				
	CRC value	0xC26B				
	Data length	736				
	CRC value	0xC26B				
	Data length	736				
	CRC value	0xC26B				
	Data length	736				
	CRC value	0xC26B				
	Data length	736				
	CRC value	0xC26B				
	Data length	736				
	CRC value	0xC26B				
	Data length	736				

1.4 Low NOx Mode

Sheet No. 1.4 -

SAMPLE

Date	Check-value	Allowed value	Installed value	Signature of person responsible for ship / engine	Remarks
18-Aug-2006	OFF or ON	OFF or ON	OFF		Shop test
	OFF or ON	OFF or ON			
	OFF or ON	OFF or ON			
	OFF or ON	OFF or ON			
	OFF or ON	OFF or ON			
	OFF or ON	OFF or ON			
	OFF or ON	OFF or ON			
	OFF or ON	OFF or ON			
	OFF or ON	OFF or ON			
	OFF or ON	OFF or ON			
	OFF or ON	OFF or ON			
	OFF or ON	OFF or ON			
	OFF or ON	OFF or ON			

2.1 Injection Nozzle

Sheet No.	2.1 -
-----------	-------

Date	Cyl. No.	Allowed ID-Number	Installed ID-number	Signature of person responsible for ship / engine	Remarks
18-Aug-2006	From 1 through 11	MF959M	MF959M		Shop test
	From 1 through 11	MF959M			
	From 1 through 11	MF959M			
	From 1 through 11	MF959M			
	From 1 through 11	MF959M			
	From 1 through 11	MF959M			
	From 1 through 11	MF959M			
	From 1 through 11	MF959M			
	From 1 through 11	MF959M			
	From 1 through 11	MF959M			
	From 1 through 11	MF959M			
	From 1 through 11	MF959M			

SAMPLE

2.2 Injection Control Block

Sheet No. 2.2 -

Date	Cyl. No.	Allowed ID-Number	Installed ID-number	Signature of person responsible for ship / engine	Remarks
18-Aug-2006	From 1 through 11	LN-BF5500	LN-BF5500		Shop test
	From 1 through 11	LN-BF5500			
	From 1 through 11	LN-BF5500			
	From 1 through 11	LN-BF5500			
	From 1 through 11	LN-BF5500			
	From 1 through 11	LN-BF5500			
	From 1 through 11	LN-BF5500			
	From 1 through 11	LN-BF5500			
	From 1 through 11	LN-BF5500			
	From 1 through 11	LN-BF5500			
	From 1 through 11	LN-BF5500			
	From 1 through 11	LN-BF5500			
	From 1 through 11	LN-BF5500			

2.3 Firing Pressure (Average)

Sheet No.	2.3 -
-----------	-------

Date	Check-item	Allowed value	Checked value	Signature of person responsible for ship / engine	Remarks
18-Aug-2006	Pmax at 100%Load	14.53 barG or less	14.53 barG		Shop test
	Pmax at 100%Load	14.53 barG or less			
	Pmax at 100%Load	14.53 barG or less			
	Pmax at 100%Load	14.53 barG or less			
	Pmax at 100%Load	14.53 barG or less			
	Pmax at 100%Load	14.53 barG or less			
	Pmax at 100%Load	14.53 barG or less			
	Pmax at 100%Load	14.53 barG or less			
	Pmax at 100%Load	14.53 barG or less			
	Pmax at 100%Load	14.53 barG or less			
	Pmax at 100%Load	14.53 barG or less			
	Pmax at 100%Load	14.53 barG or less			
	Pmax at 100%Load	14.53 barG or less			
	Pmax at 100%Load	14.53 barG or less			

SAMPLE

3.1 Piston Head

Sheet No. 3.1 -

Date	Cyl. No.	Allowed ID-Number	Installed ID-number	Signature of person responsible for ship / engine	Remarks
18-Aug-2006	From 1 through 11	M9PH-1 or LN-AH3000	M9PH-1		Shop test
	From 1 through 11	M9PH-1 or LN-AH3000			
	From 1 through 11	M9PH-1 or LN-AH3000			
	From 1 through 11	M9PH-1 or LN-AH3000			
	From 1 through 11	M9PH-1 or LN-AH3000			
	From 1 through 11	M9PH-1 or LN-AH3000			
	From 1 through 11	M9PH-1 or LN-AH3000			
	From 1 through 11	M9PH-1 or LN-AH3000			
	From 1 through 11	M9PH-1 or LN-AH3000			
	From 1 through 11	M9PH-1 or LN-AH3000			
	From 1 through 11	M9PH-1 or LN-AH3000			
	From 1 through 11	M9PH-1 or LN-AH3000			
	From 1 through 11	M9PH-1 or LN-AH3000			
	From 1 through 11	M9PH-1 or LN-AH3000			

3.2 Piston Rod

[illegible]

3.3 Cylinder Cover

Sheet No. 3.3 -

Date	Cyl. No.	Allowed ID-Number	Installed ID-number	Signature of person responsible for ship / engine	Remarks
18-Aug-2006	From 1 through 11	M9CC-1 or LN-BF2000	M9CC-1		Shop test
	From 1 through 11	M9CC-1 or LN-BF2000			
	From 1 through 11	M9CC-1 or LN-BF2000			
	From 1 through 11	M9CC-1 or LN-BF2000			
	From 1 through 11	M9CC-1 or LN-BF2000			
	From 1 through 11	M9CC-1 or LN-BF2000			
	From 1 through 11	M9CC-1 or LN-BF2000			
	From 1 through 11	M9CC-1 or LN-BF2000			
	From 1 through 11	M9CC-1 or LN-BF2000			
	From 1 through 11	M9CC-1 or LN-BF2000			
	From 1 through 11	M9CC-1 or LN-BF2000			
	From 1 through 11	M9CC-1 or LN-BF2000			
	From 1 through 11	M9CC-1 or LN-BF2000			
	From 1 through 11	M9CC-1 or LN-BF2000			

3.4 Cylinder Liner

Date	Cyl. No.	Allowed ID-Number	Installed ID-number	Signature of person responsible for ship / engine	Remarks
18-Aug-2006	From 1 through 11	M9CL-1 or LN-AH2100	M9CL-1		Shop test
	From 1 through 11	M9CL-1 or LN-AH2100			
	From 1 through 11	M9CL-1 or LN-AH2100			
	From 1 through 11	M9CL-1 or LN-AH2100			
	From 1 through 11	M9CL-1 or LN-AH2100			
	From 1 through 11	M9CL-1 or LN-AH2100			
	From 1 through 11	M9CL-1 or LN-AH2100			
	From 1 through 11	M9CL-1 or LN-AH2100			
	From 1 through 11	M9CL-1 or LN-AH2100			
	From 1 through 11	M9CL-1 or LN-AH2100			
	From 1 through 11	M9CL-1 or LN-AH2100			
	From 1 through 11	M9CL-1 or LN-AH2100			
	From 1 through 11	M9CL-1 or LN-AH2100			

3.5 Compression Shim Thickness

[illegible]

3.6 Housing of Partition device

Sheet No.	3.6 -
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Date	Cyl. No.	Allowed ID-Number	Installed ID-number	Signature of person responsible for ship / engine	Remarks
18-Aug-2006	From 1 through 11	LN-BF5600	LN-BF5600		Shop test
	From 1 through 11	LN-BF5600			
	From 1 through 11	LN-BF5600			
	From 1 through 11	LN-BF5600			
	From 1 through 11	LN-BF5600			
	From 1 through 11	LN-BF5600			
	From 1 through 11	LN-BF5600			
	From 1 through 11	LN-BF5600			
	From 1 through 11	LN-BF5600			
	From 1 through 11	LN-BF5600			
	From 1 through 11	LN-BF5600			
	From 1 through 11	LN-BF5600			

SAMPLE

3.7 Exhaust Valve Upper Housing

Sheet No. 3.7 -

Date	Cyl. No.	Allowed ID-Number	Installed ID-number	Signature of person responsible for ship / engine	Remarks
18-Aug-2006	From 1 through 11	M9UH-1 or LN-BF2700	M9UH-1		Shop test
	From 1 through 11	M9UH-1 or LN-BF2700			
	From 1 through 11	M9UH-1 or LN-BF2700			
	From 1 through 11	M9UH-1 or LN-BF2700			
	From 1 through 11	M9UH-1 or LN-BF2700			
	From 1 through 11	M9UH-1 or LN-BF2700			
	From 1 through 11	M9UH-1 or LN-BF2700			
	From 1 through 11	M9UH-1 or LN-BF2700			
	From 1 through 11	M9UH-1 or LN-BF2700			
	From 1 through 11	M9UH-1 or LN-BF2700			
	From 1 through 11	M9UH-1 or LN-BF2700			
	From 1 through 11	M9UH-1 or LN-BF2700			
	From 1 through 11	M9UH-1 or LN-BF2700			
	From 1 through 11	M9UH-1 or LN-BF2700			

3.8 Exhaust Valve Housing

Sheet No.	3.8 -
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Date	Cyl. No.	Allowed ID-Number	Installed ID-number	Signature of person responsible for ship / engine	Remarks
18-Aug-2006	From 1 through 11	M9EV-1 or LN-BF2710	M9EV-1		Shop test
	From 1 through 11	M9EV-1 or LN-BF2710			
	From 1 through 11	M9EV-1 or LN-BF2710			
	From 1 through 11	M9EV-1 or LN-BF2710			
	From 1 through 11	M9EV-1 or LN-BF2710			
	From 1 through 11	M9EV-1 or LN-BF2710			
	From 1 through 11	M9EV-1 or LN-BF2710			
	From 1 through 11	M9EV-1 or LN-BF2710			
	From 1 through 11	M9EV-1 or LN-BF2710			
	From 1 through 11	M9EV-1 or LN-BF2710			
	From 1 through 11	M9EV-1 or LN-BF2710			
	From 1 through 11	M9EV-1 or LN-BF2710			
	From 1 through 11	M9EV-1 or LN-BF2710			

SAMPLE

4.1 Turbocharger

Date	Turbocharger No.	Allowed ID-Number	Installed ID-number	Signature of person responsible for ship / engine	Remarks
18-Aug-2006	Form 1 through 3	MET83SE II or MET83MA	MET83SE II		Shop test
	Form 1 through 3	MET83SE II or MET83MA			
	Form 1 through 3	MET83SE II or MET83MA			
	Form 1 through 3	MET83SE II or MET83MA			
	Form 1 through 3	MET83SE II or MET83MA			
	Form 1 through 3	MET83SE II or MET83MA			
	Form 1 through 3	MET83SE II or MET83MA			
	Form 1 through 3	MET83SE II or MET83MA			
	Form 1 through 3	MET83SE II or MET83MA			
	Form 1 through 3	MET83SE II or MET83MA			
	Form 1 through 3	MET83SE II or MET83MA			
	Form 1 through 3	MET83SE II or MET83MA			
	Form 1 through 3	MET83SE II or MET83MA			
	Form 1 through 3	MET83SE II or MET83MA			

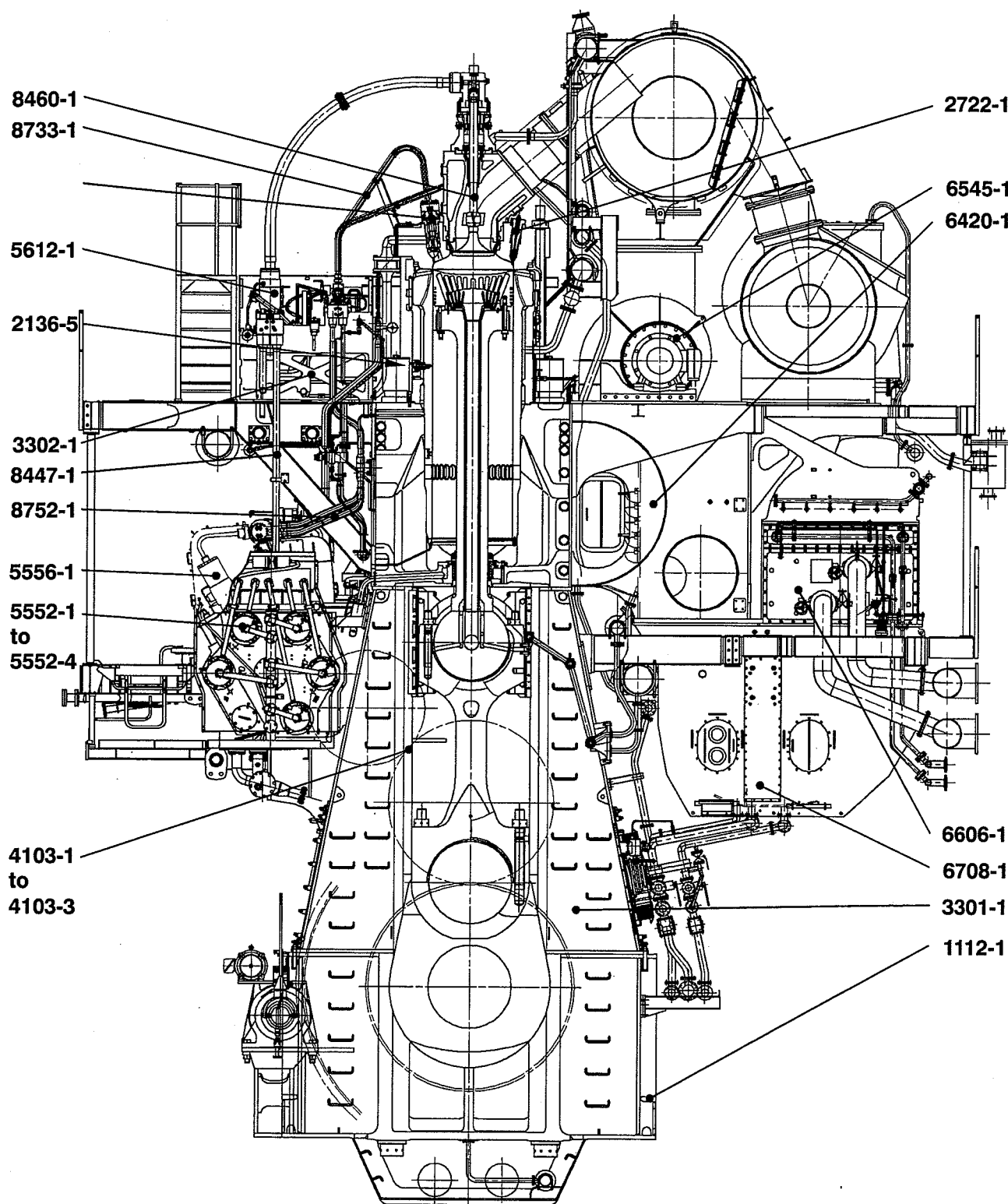
5.1 Scavenge Air Cooler

[illegible]

RT-flex96C

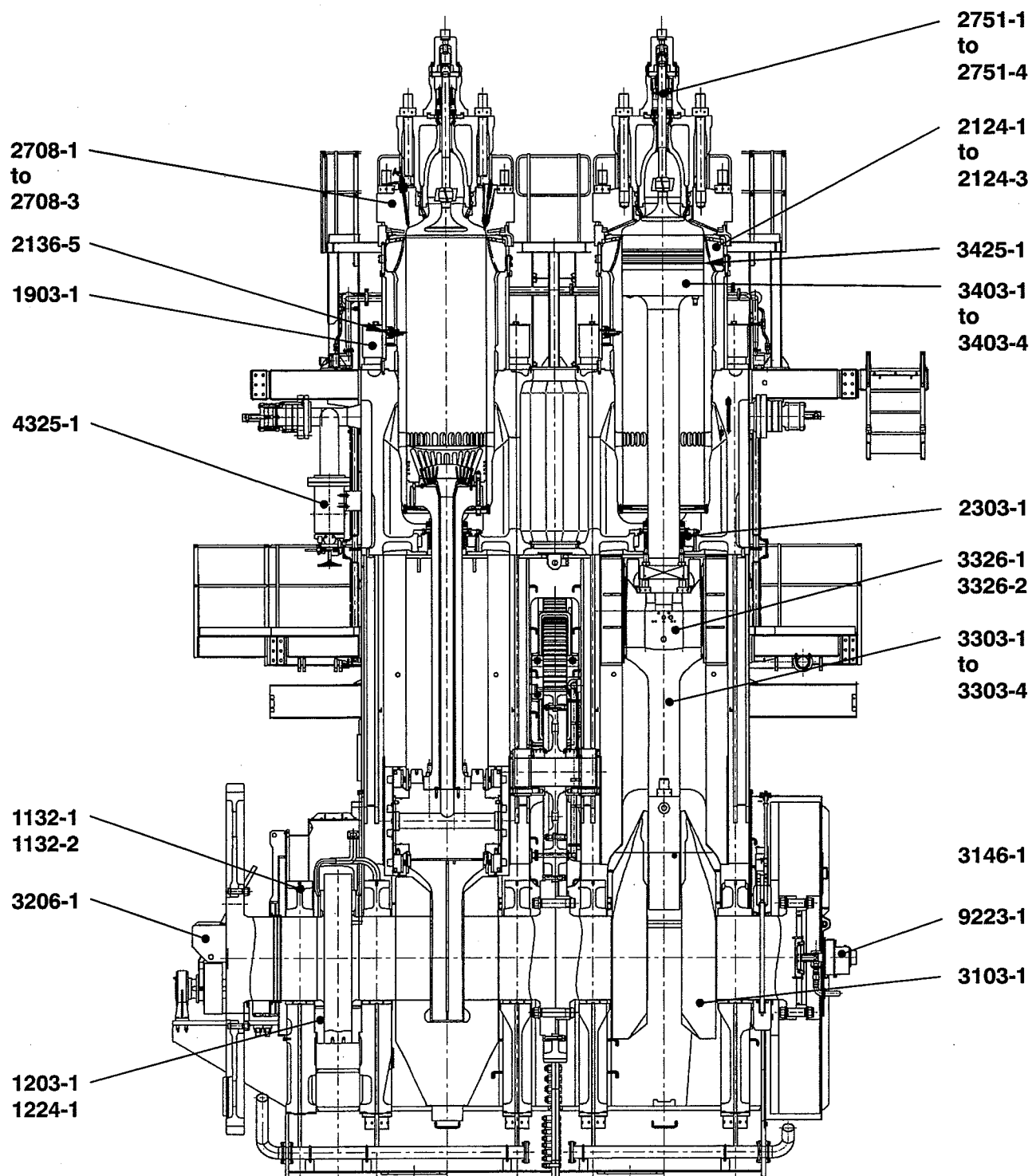
Engine Cross Section and Longitudinal Section

Cross Section:



Engine Cross Section and Longitudinal Section

Longitudinal Section:



Taking Engine Oil Samples for Laboratory Analysis

1. Standard screws

At intervals of approx. **3000** operating hours a sample should be taken of the engine oil and sent to a laboratory for an analysis.

With the oil pump running and the engine oil at operating temperature drain a small quantity of oil from a cock in the lubricating system to flush out any dirt accumulated in this cock.

Following this take an oil sample in a clean glass for the test.

The receptacle with the sample of oil must be marked with the following information for the laboratory:

- Ship's name or name of plant
- Engine type
- Engine serial number
- Date of sampling
- Operating hours of oil and of engine
- Oil brand and quality

Oil inspection

The condition of the lubricating oil charge or its alteration during operation can be assessed on the basis of some analysis data. With regular checks a deterioration can be detected at an early stage and remedial measures taken.

The following indications for limiting values are to be taken as guiding ones, which should not be exceeded in service, and in the case of the flash point not fall below.

Parameter	Unit	Limit
Viscosity	cSt at 40 °C	+ 30 %
(Change % of the new oil)		- 10 % (max. 160 cSt)
Flash point	°C	min. 190
Water	vol. %	max. 0.2
Solvent insolubles	wt. %	advice be sought from the oil supplier
Total base number	KOH mg/g	min. 2.0
SAN		none

If one of the limits is reached appropriate remedial action should be considered to correct the situation. Such action may be intensified purification (reduction of throughput, adjustment of temperatures), treating in a renovating tank or partial exchange of the oil charge.

These limits are set out as a guidance. The quality condition of the oil in circulation, however, cannot be fully judged by a single parameter. Other oil parameters as well must be used in context to be able to find the cause of the problem and the appropriate remedy for correction.

Experience shows that with correctly designed installations and carefully performed oil care measures, **generally a sufficient safety margin to the above values can be maintained.**

Group 1

1

Bedplate and Thrust Bearing: Checking the Foundation Bolts 1112-1/A1

▽ **Main Bearing**

- Loosening and Tensioning of Waisted Studs 1132-1/A1
- Removal and Fitting of a Main Bearing 1132-2/A1

▽ **Thrust Bearing**

- Checking the Axial Clearance 1203-1/A1
- Removal and Fitting the Thrust Bearing Pads 1224-1/A1

Engine Stays with Friction Shims:

Checking the Pre-tension of the Waisted Studs 1715-1/A1

Tie Rod: Checking the Pre-tension and Tensioning the Tie Rods 1903-1/A1

Bedplate and Thrust Bearing Checking the Foundation Bolts

Tools :

1 Feeler gauge	94122
1 Pre-tensioning jack	94145
1 Pressure gauge	94932a
1 Connection piece	94934
1 HP hose	94935
1 HP hose	94935a
1 Hydraulic unit	94942

Key to Illustrations :

1 Pin	11 Chock
2 Vent screw	12 Ship's foundation plate
3 Cylinder	13 Nut
4 Piston	14 Conical socket
5 Sealing ring	EV Relief valve
6 Nut	KO Slot
7 Bedplate	PP Closing piece
8 Foundation bolt	RS Round bar
9 Foundation fitted stud	SA Gap
10 Sleeve	

1. General

The pre-tension of the foundation bolts (holding down studs) must be checked at longer intervals e.g. during overhauls (see 0380-1).

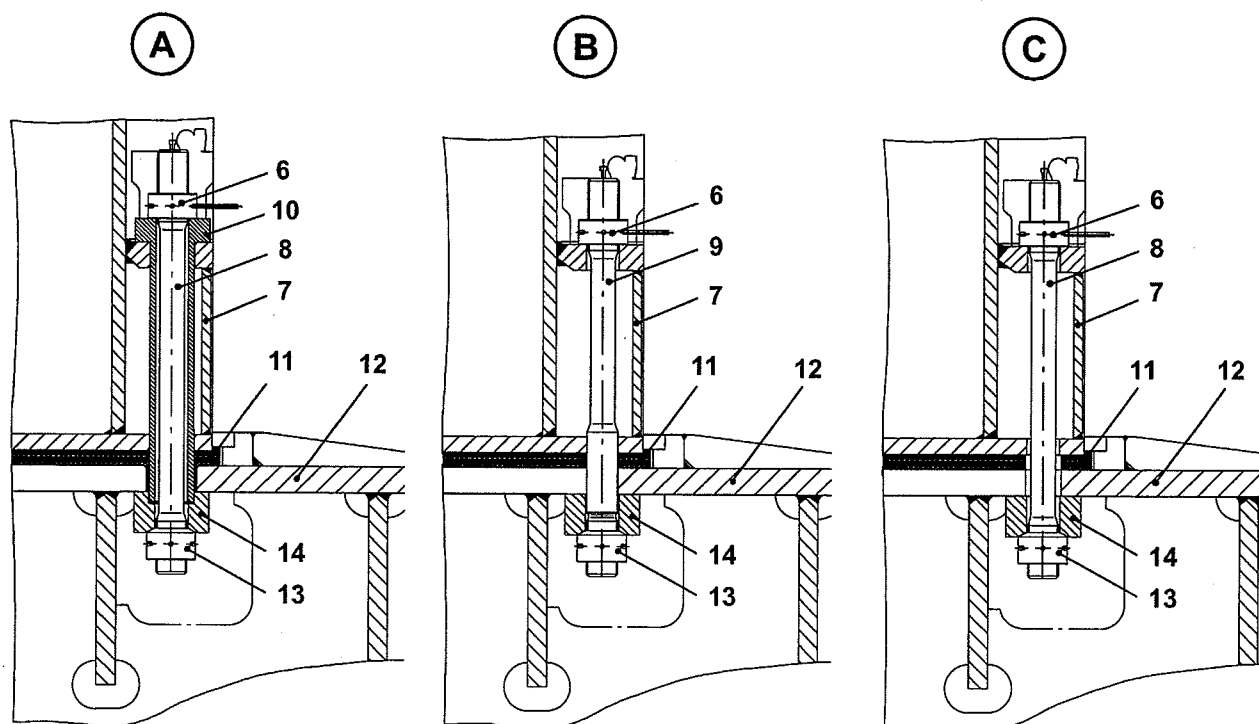
In the area of the thrust bearing the foundation may be fastened with foundation bolt and sleeve (Fig. 'A'), or with a foundation fitted stud (Fig. 'B').

The remaining area is fastened with foundation bolts without sleeves (Fig. 'C').



Remark

: Pay attention to the General Application Instructions 9403-4 for the hydraulic pre-tensioning jacks.



Bedplate and Thrust Bearing
Checking the Foundation Bolts

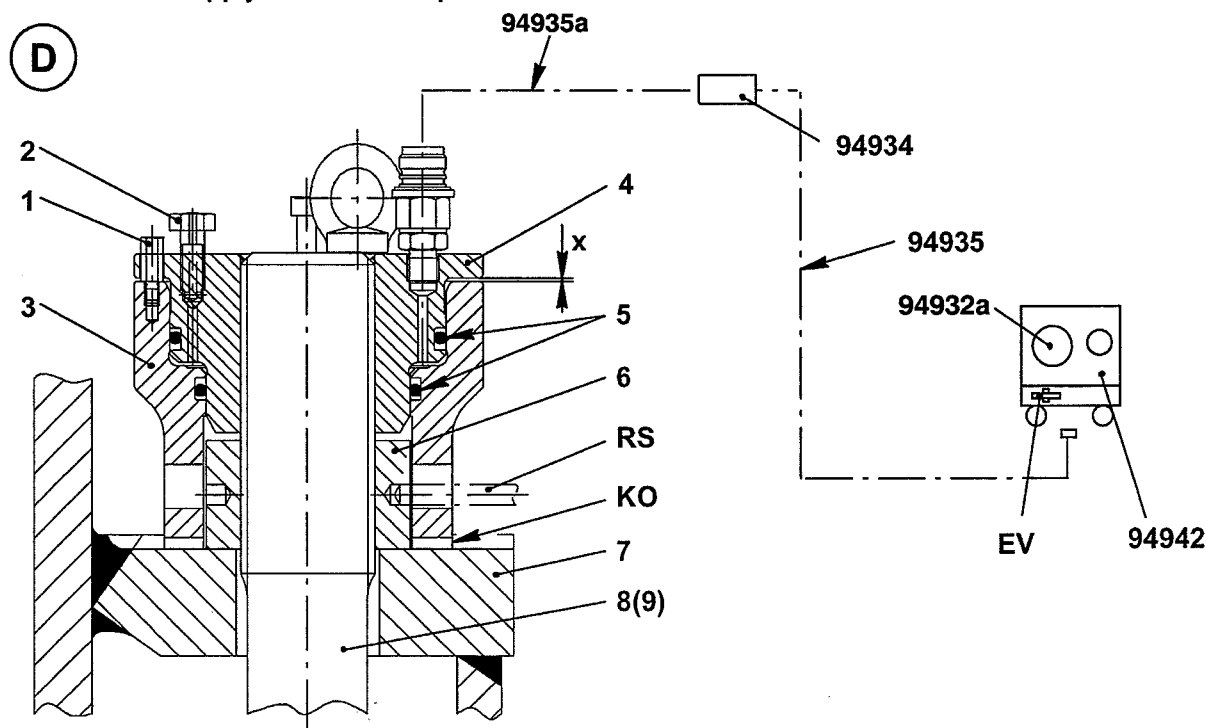
2. Checking of the pre-tension

- ⇒ Clean the threads of the foundation bolts and the seating surfaces.
- ⇒ Place the pre-tensioning jack (94145) on the foundation bolt (8) or fitted stud (9) to be checked, and screw it completely down with the vent screw (2) open until there is only little or no clearance at 'x' (Fig. 'D').
- ⇒ Connect the pre-tensioning jack (94145) with the hydraulic unit (94942) as shown in Fig. 'D', whereby one side of the connection piece (94934) must be plugged with closing piece "PP".
- ⇒ Shut relief valve "EV" at the hydraulic unit. Actuate hydraulic unit till oil flows bubble-free at the vent screw (2).
- ⇒ Close vent screw (2), tension the foundation bolt with **100 MPa** and keep pressure constant.
- Attention should be paid to ensure that the pin (1) always protrudes slightly compared with the piston (4) on the pre-tensioning jack!

CHECK

Check with feeler gauge through the slot "KO" if there is any clearance between the nut (6) and its seating.

- ⇒ If there is no clearance, this means that the tightening condition of the foundation bolt has remained unchanged since the last check. The pressure can be released to zero with relief valve "EV" and the pre-tensioning jack removed. Should a clearance be found, the nut (6) must be tightened down onto its seating with round bar "RS" while the pressure is kept at **100 MPa** (check with feeler gauge). Subsequently lower the pressure to zero.
- ⇒ Apply MOLYKOTE paste to the threads of the foundation bolts.



Remark

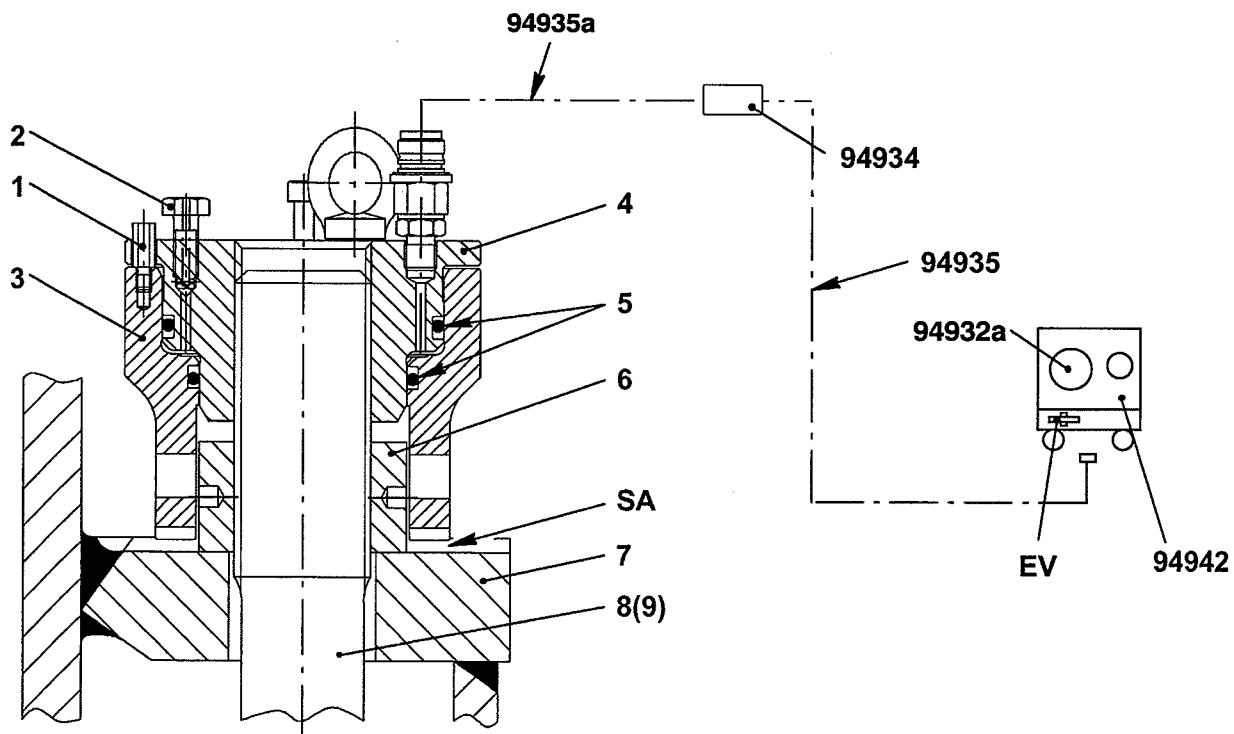
If the foundation bolts have completely loosened and have to be tensioned again, then all foundation bolts have to be pre-tensioned first with **60 MPa (1st step)**. Subsequently all foundation bolts are to be tensioned with **100 MPa (2nd step)**.

Bedplate and Thrust Bearing
Checking the Foundation Bolts

3. Loosening of the foundation bolts

- ⇒ First screw down the pre-tensioning jack (94145) as for checking the pre-tension, then turn back by ½ turn (gap "SA" in Fig. 'E').
- Connect the pre-tensioning jack to the HP oil pump (94942) according to Fig. 'E'.
- ⇒ Shut relief valve "EV" at the hydraulic unit. Actuate hydraulic unit till oil flows bubble-free at the vent screw (2).
- ⇒ Close the vent screw (2) and pump until a pressure of **102 MPa** has been reached.
- Attention should be paid to ensure that the pin (1) always protrudes slightly compared with the piston (4) on the pre-tensioning jack!
- ⇒ Turn back nut (6) by one turn, and release the pressure to '0'.
- Remove the pre-tensioning jack.

E



4. Tensioning of the foundation bolts

- Tensioning of the foundation bolts must be carried out in two steps without exception, for both metal and synthetic chocks, i.e. tension all foundation bolts first with **60 MPa (1st step)**, then finish tensioning with **100 MPa (2nd step)**.
- Tensioning must be carried out as described above, in 'Checking of the pretension'.
- Attention should be paid to ensure that the pin (1) always protrudes slightly compared with the piston (4) on the pre-tensioning jack!

Main Bearing**Loosening and Tensioning of Waisted Studs**

Tools :

2	Double pre-tensioning jacks	94114
1	Feeler gauge	94238
1	Depth gauge	94126
1	Pressure gauge	94932a
1	Connection piece	94934
1	Connection piece	94934a
1	HP hose	94935
3	HP hose	94935a
1	Hydraulic unit	94942

Key to Illustrations :

1	Waisted stud
2	Main bearing cover
3	Nut
4	Nut
5	Piston
6	Cylinder
7	Cover
8	Tension sleeve
9	Distance sleeve
10	Main bearing girder

KO Slot
RS Round bar

1. General

The double pre-tensioning jacks (94114) must always be used for loosening as well as for tensioning the waisted studs (1) for the main bearing.

Prior to screwing the nuts onto the waisted studs, threads and the nut seating surfaces must be clean. Apply oil to the threads. Pay attention to the free movement of the nuts.

2. Loosening the waisted studs

- ⇒ Screw tension sleeves (8) onto waisted studs (1) (Fig. 'B').
- ⇒ Place distance sleeve (9).
- ⇒ Place both cylinders (6) with pistons (5) onto the distance sleeves.
- ⇒ Connect both double pre-tensioning jacks (94114) by HP hoses (94935), (94935a) and connection pieces (94934) and (94934a) with hydraulic unit (94942) (arrangement see Fig. 'C').
- ⇒ Screw on round nuts (4) of the double pre-tensioning jacks till pistons (5) fully seat on cylinders (6) (Fig. 'B').

CHECK

The pistons are fully down on the cylinders when distance 'L₁' is about 16 mm, measured from the top of the piston to the upper edge of cover (7). Check the oil level in hydraulic unit (94942).

- ⇒ Subsequently loosen all round nuts (4) by about ¾ to 1 turn.
 - ⇒ Raise the pressure to **102 MPa** at the hydraulic unit.
 - ⇒ Unscrew nuts (3) by one turn with round bar "RS".
 - ⇒ Release the pressure to zero at the hydraulic unit and then remove both double pre-tensioning jacks.
-

Main Bearing

Loosening and Tensioning of Waisted Studs

3. Tensioning the waisted studs

- ⇒ Fit the main bearing cover as described in 1132-2.
- ⇒ Tighten nuts (3) with round bar 'RS' till firmly seated and mark these against the bearing cover =1st step (Fig. 'A').

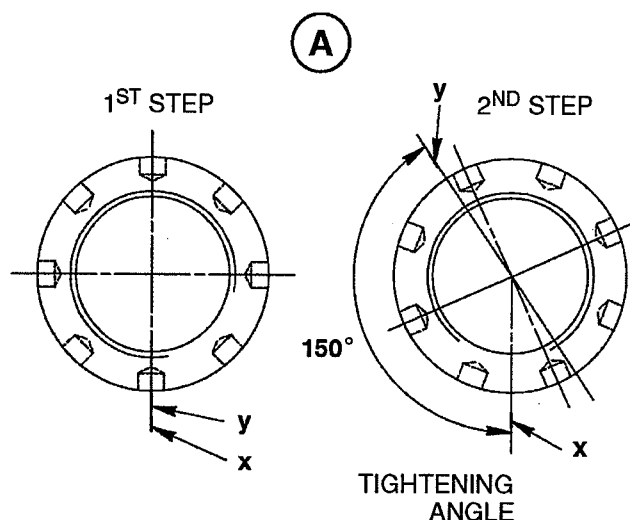
CHECK

Establish with depth gauge (94126) distances a_1 and a_2 . The difference between the two values **must not be greater than 0.3 mm**. If necessary adjust the bearing cover correspondingly by loosening and tensioning nuts (3) (Fig. 'C').

- ⇒ Place both double pre-tensioning jacks (94114) onto waisted studs (1) for the main bearing as described under section (2) (Fig. 'C').
- ⇒ Connect both double pre-tensioning jacks by HP hoses (94935), (94935a) and connection pieces (94934) and (94934a) with the hydraulic unit (94942) (arrangement see Fig. 'C').
- ⇒ Open vent screw (11).
- ⇒ Screw on round nuts (4) of the double pre-tensioning jacks till piston (5) fully seat on cylinders (6) (Fig. 'B').

CHECK

The pistons are fully down on the cylinders when distance ' L_1 ' is about 16 mm, measured from the top of the piston to the upper edge of cover (7). Check the oil level in the hydraulic unit (94942).



- ⇒ Actuate the hydraulic unit, adjust the pressure to **100 MPa** and keep it constant.
- ⇒ Tighten all nuts (3) with round bar "RS" till firmly seated.

CHECK

Using feeler gauge (94238) inserted in slot "KO", check if there is no clearance at hand between the nuts and the seating surfaces (**2nd step**).

- ⇒ Release pressure to zero at the hydraulic unit and then remove both double pre-tensioning jacks (94114).

CHECK

Check if **all the nuts** have been turned by about the same value, i.e. the **tightening angle should be 150° between the 1st and 2nd step** (Fig. 'A'). If bigger differences occur the tensioning procedure must be repeated.

Finally check the vertical clearances by means of feeler gauge (94238) or depth gauge (94126) (see Clearance Table 0330-1 'Crankshaft and main bearing').

Recheck distances a_1 and a_2 . If the difference exceed 0.3 mm, loosen the waisted studs, adjust the bearing cover correspondingly and repeat the tensioning procedure.



Remark

: All main bearing clearance values are valid only with tightened tie rods and waisted studs.

Loosening and Tensioning of Waisted Studs



Main Bearing

Removal and Fitting of a Main Bearing

Tools:

1	Lifting tool	94116
1	Roller support	94117
1	Turning-out device	94118
1	Turning-out device	94118a
1	Lifting eye bolt	94120a
2	Wire rope (L=350 (L=700×1/2))	94120b
2	Wire rope (L=500 (L=1000×1/2))	94120c
2	Wire ropes (L=700)	94120d
2	Wire ropes (L=1000)	94120e
1	Wire rope (L=1250)	94120f
2	Wire ropes (L=1500)	94120g
1	Wire rope (L=2100)	94120h
1	Wire rope (L=2600)	94120i
2	Wire rope (L=5000)	94120j
1	Feeler gauge	94238
1	Depth gauge	94124
1	Support	94141
1	Jack support	94141a
1	Working platform	94142
18	Shackles (BC20)	
1	Connecting piece	94934
1	Connecting piece	94934a
1	HP hose	94935
3	HP hoses	94935a
2	Hydraulic jacks	94936
1	Hydraulic unit	94942

Key to Illustrations:

1	Crankshaft
2	Main bearing cover
3	Main bearing shell
4	Locating pin
5	Groove
6	Locating pin
7	Flywheel
8	Main bearing girder
9	Guide shoe middle part
10	Support
11	Waisted stud
12	Nut
13	Vibration damper
14	Support
15	Intermediate wheel
16	Crosshead pin
17	Connecting rod
18	Blank flange
19	Hydraulic jack
20	Support
21	Cover
22	Casing, upper part
23	Oil baffle, upper part
24	Shim
25	Shim
26	Shim (for fine tuning)
27	Screw

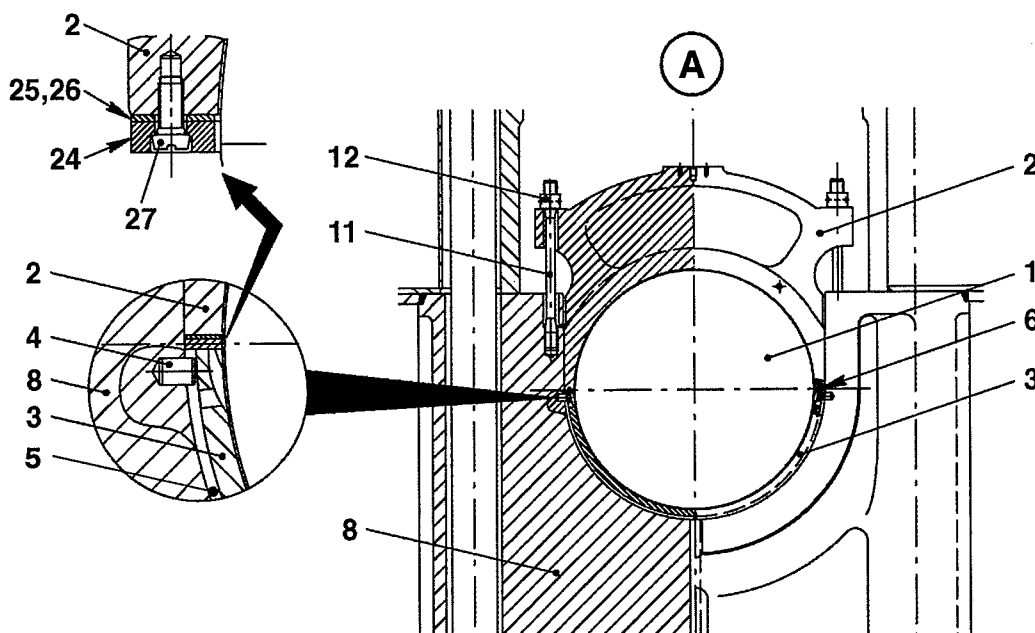
HO	Wooden board
HZ	Chain block
H ₁ ...	Chain blocks
OB	Oil bore
RC	Eye bolt M30
RC1	Eye bolt M20
RC2	Eye bolt M12

Overview

1.	Arrangement and characteristics of the main bearing	2/26
2.	Removal of No.1 main bearing cover	3/26
3.	Removal of No.2 main bearing cover	4/26
4.	Removal of intermediate main bearing cover	8/26
5.	Removal of main bearing cover next to gear wheel on crankshaft	9/26
6.	Removal of main bearing cover at free end	13/26
7.	Removal of main bearing shells	15/20
8.	Fitting of main bearing shell and main bearing cover	23/26

Main Bearing
Removal and Fitting of a Main Bearing

Cross section of main bearing:



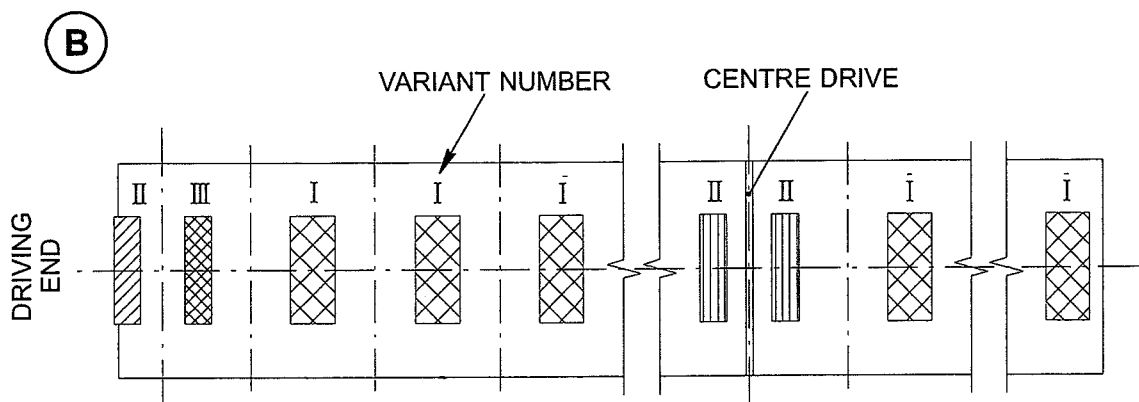
1. Arrangement and characteristics of the main bearings

Variation of the main bearings

Type "I": Broad bearing shell and cover (for intermediate main bearings)

Type "II": Narrow bearing shell and cover (for main bearing on driving end and either side of driving gear)

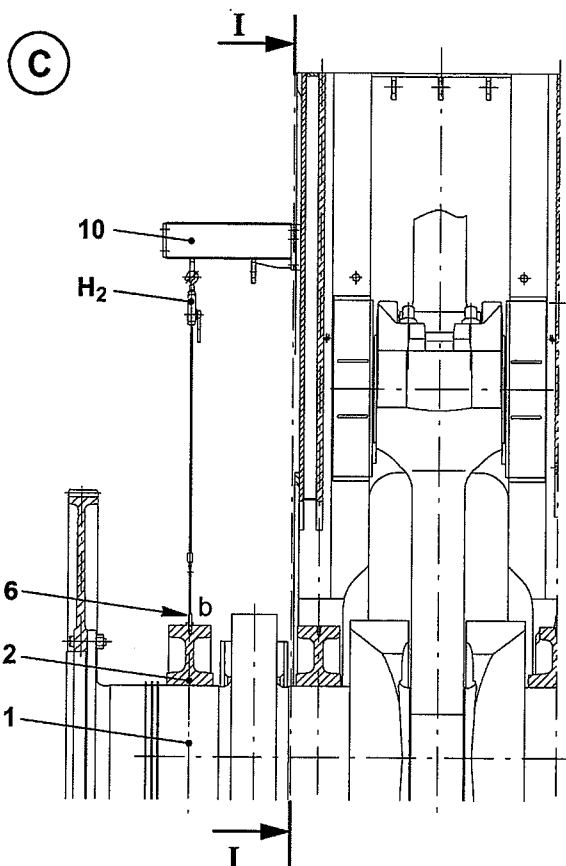
Type "III": Middle width bearing shell and cover (for No.2 main bearing, see 0008-1)



Main Bearing

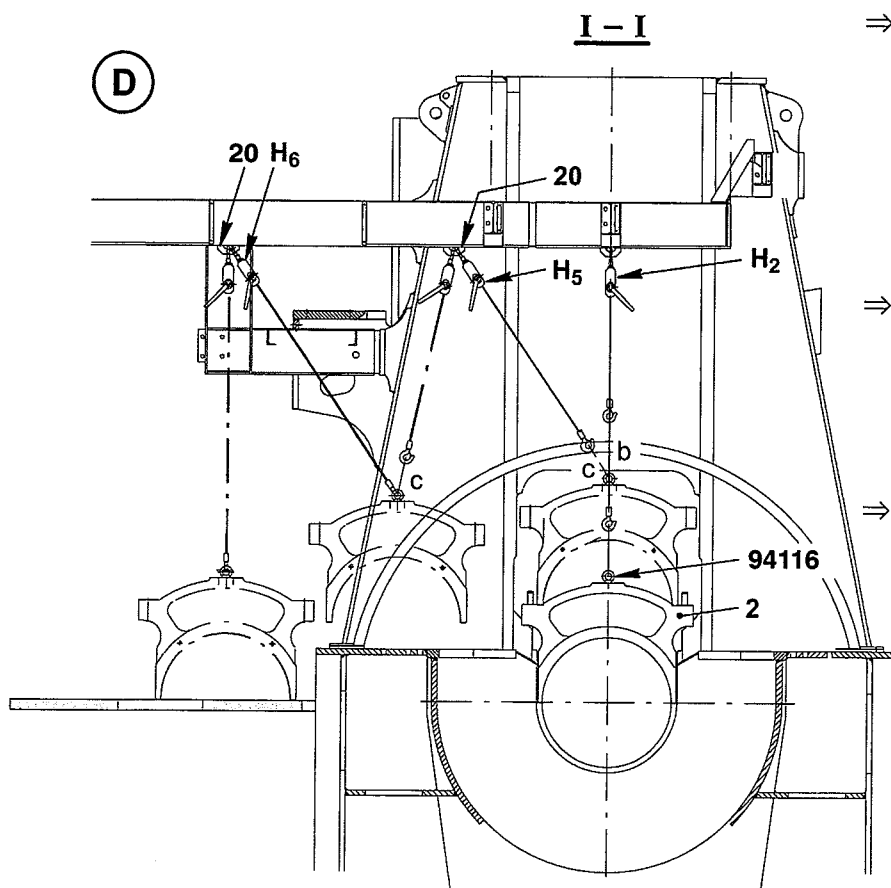
Removal and Fitting of a Main Bearing

2. Removal of No.1 main bearing cover



The crankshaft must not be turned by turning gear when workmen are in crankcase.

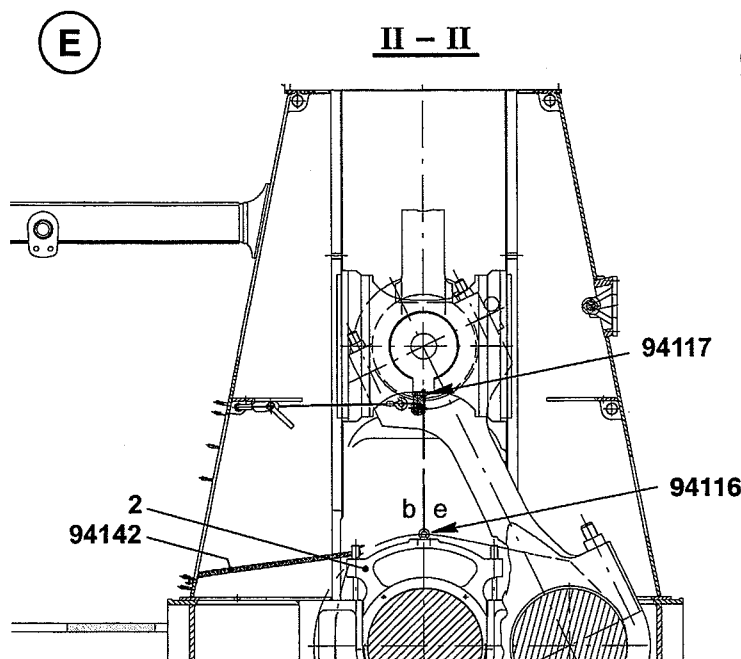
- ⇒ Turn crank (1) to exhaust side approx. 100° after T.D.C.
- ⇒ Remove upper parts of oil baffle and casing at the driving end.
- ⇒ Remove oil piping from thrust bearing.
- ⇒ Loosen nuts (12) for waisted studs (11) (Fig. 'A') hydraulically (see 1132-1).
- ⇒ Screw down lifting tool (94116) to main bearing cover (2).
- ⇒ Connect wire rope 'b' (94120b) with the lifting tool (94116), chain block H₂ and shackle which is fastened to the outer eye of support (10) and lift bearing cover.



- ⇒ Fasten chain block "H₅" to suspension eye (20) together with shackle (BC20) and connect wire rope 'c' (94120b) with bearing cover (2), and subsequently swing it towards fuel side with wire ropes 'b' and 'c'.
- ⇒ Fasten chain block "H₆" to suspension eye (20) together with shackle (BC20) and connect it to bearing cover (2) and then swing the latter fully towards fuel side.
- ⇒ Remove wire rope 'c'.

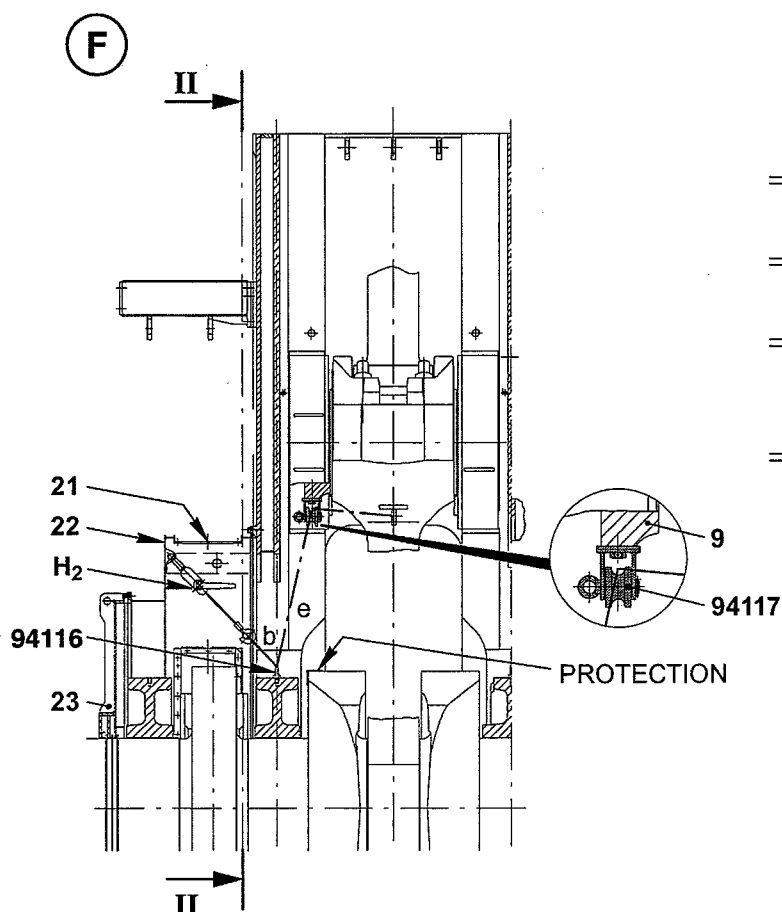
Main Bearing
Removal and Fitting of a Main Bearing

3. Removal of No.2 main bearing cover



The crankshaft must not be turned by turning gear when workmen are in crankcase.

- ⇒ Turn No.1 crank to exhaust side approx. 90° after T.D.C.
- ⇒ Install working platform (94142).
- ⇒ Remove oil piping from thrust bearing.
- ⇒ Loosen nuts (12) for waisted studs (11) (Fig. 'A') hydraulically (see 1132-1).
- ⇒ Fasten roller support (94117) to guide shoe middle parts (9) (Fig. 'F').
- ⇒ Screw down lifting tool (94116).
- ⇒ Connect wire rope 'e' (94120f) with lifting tool (94116) and chain block "H₁" with a shackle (BC20) via roller support as shown in Fig. 'E' and 'F'.

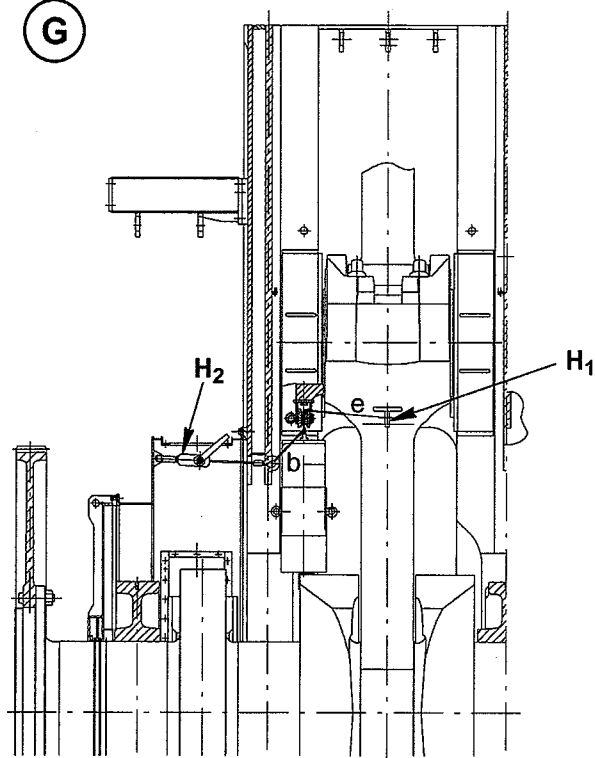


- ⇒ Remove cover (21) from casing upper part (22).
- ⇒ Fasten chain block "H₂" with shackle to the inner side of the casing upper part.
- ⇒ Connect wire rope 'b' (94120b) with chain block "H₂", shackle and lifting tool (94116).
- ⇒ Provide protection for the crank web.

Main Bearing

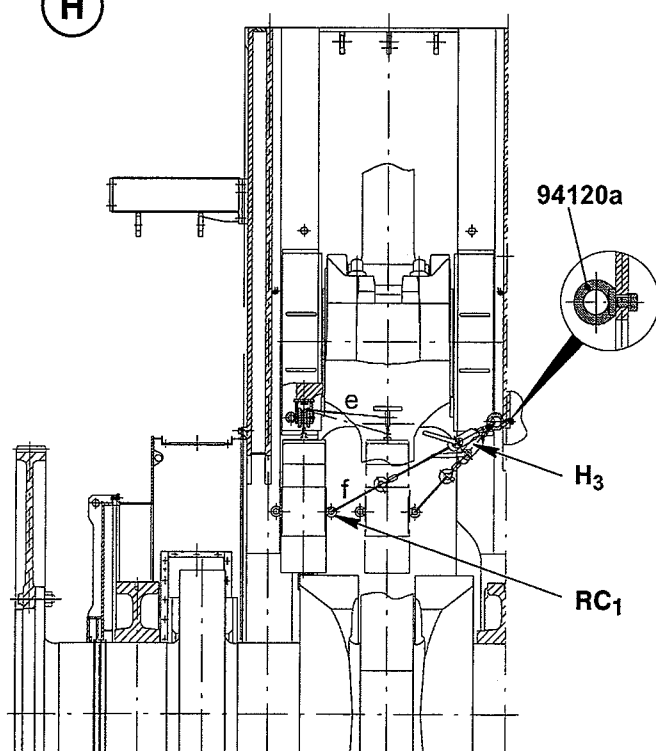
Removal and Fitting of a Main Bearing

G



- ⇒ Lift the bearing cover carefully over the crank web with wire ropes 'b' and 'e'.
- ⇒ Remove wire rope 'b'.

H



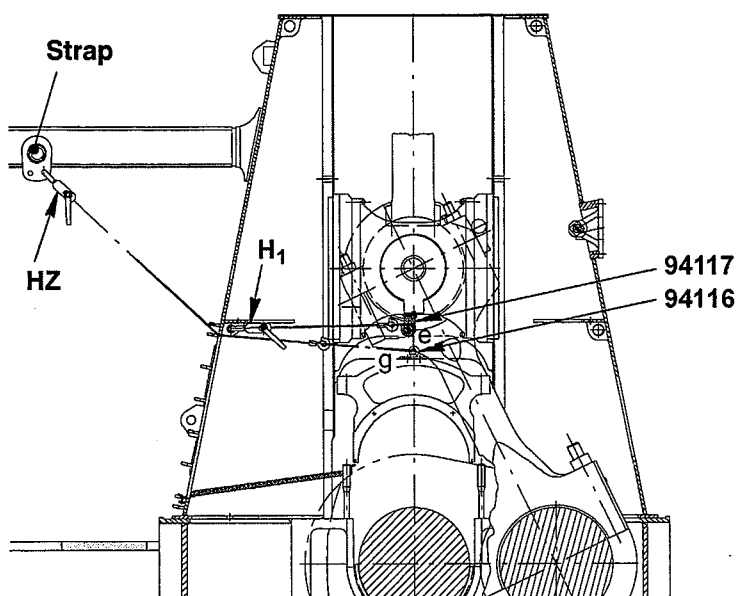
- ⇒ Screw two eye bolt "RC₁" laterally in to the bearing cover.
- ⇒ Fasten lifting eye bolt (94120a) to the column
- ⇒ Connect wire rope 'f' (94120d) with eye bolts "RC₁", chain block "H₃" and a shackle (BC20).

The further removal of the bearing cover is carried out analogously as described for Fig. 'I' ~ 'L'.

Main Bearing

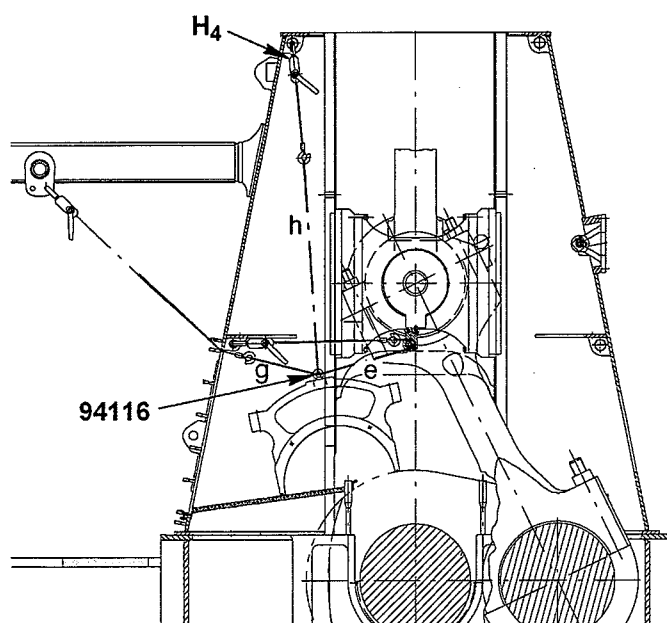
Removal and Fitting of a Main Bearing

I



- ⇒ Fasten chain block "HZ" with shackle to strap.
- ⇒ Connect wire rope 'g' (94120b) with lifting tool (94116), chain block "HZ" and shackle (BC20).
- ⇒ Lift the bearing cover carefully over the crank web with wire rope 'e' and 'f' towards middle of cylinder (Fig. 'H') and pull it with wire rope 'g' (Fig. 'K') to fuel side at the same time.

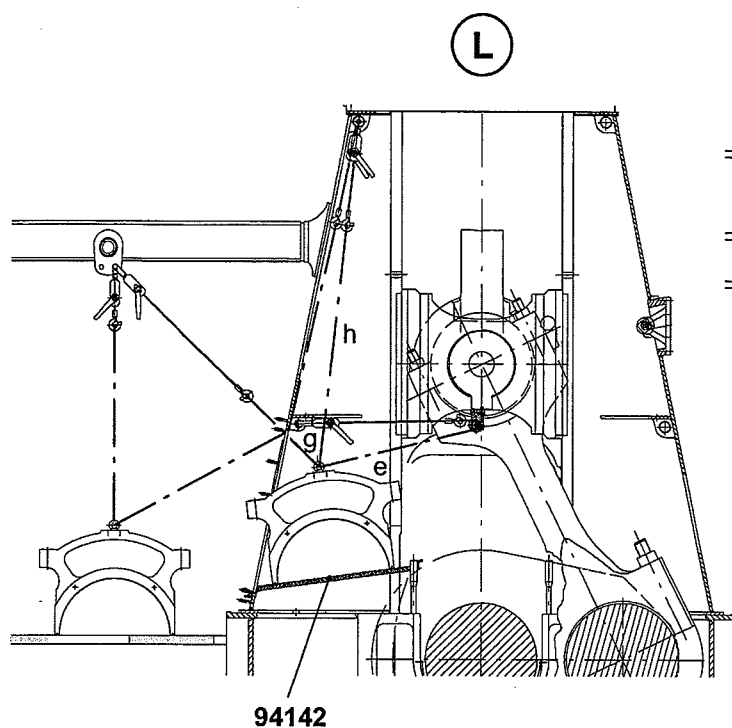
K



- ⇒ Guide the bearing cover to fuel side with wire rope 'g' and 'e' until 'h' (94120g) can be connected with chain block "H4", shackle (BC20) and lifting tool (94116).

Main Bearing

Removal and Fitting of a Main Bearing



- ⇒ Place the main bearing cover (2) on working platform (94142).
- ⇒ Remove wire rope 'e' (94120f).
- ⇒ Lift the main bearing cover (2) out of the crankcase using chain blocks "HZ" and "H₄" with shackles (BC20).

Main Bearing

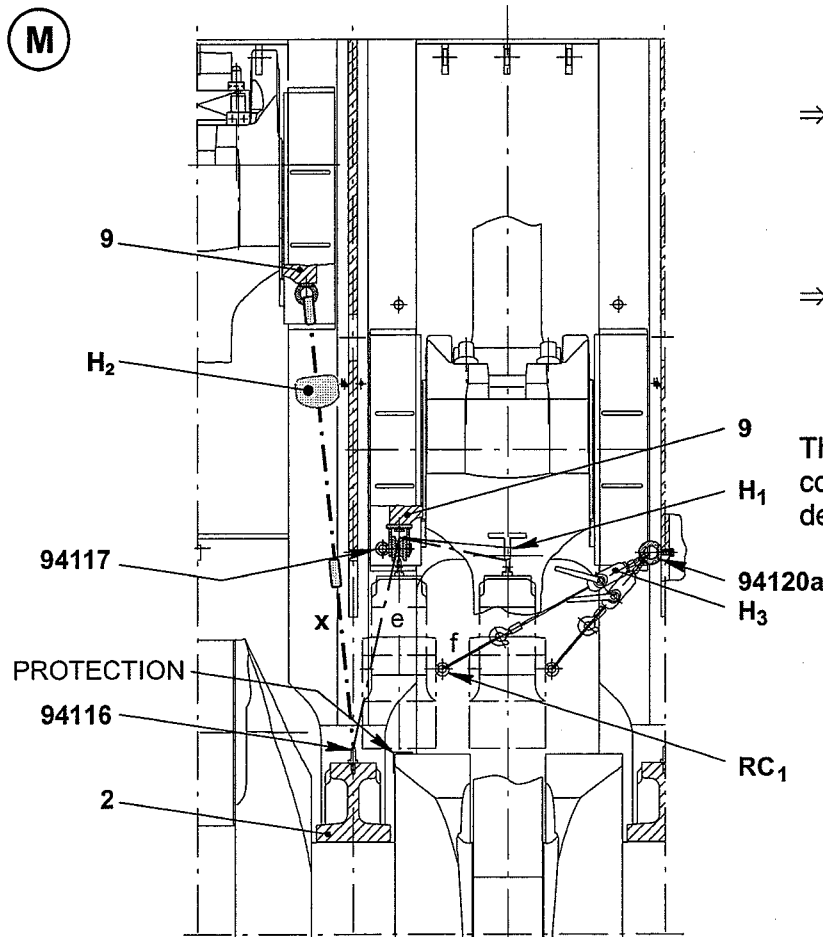
Removal and Fitting of a Main Bearing

4. Removal of intermediate main bearing cover



Turn crank shaft must not be turned by turning gear when workmen are in crankcase

- ⇒ Turn corresponding crank to exhaust side approx. 90° after T.D.C. (Fig. 'E').
- ⇒ Install working platform (94142) (Fig. 'E').
- ⇒ Loosen nuts (12) for waisted studs (11) (Fig. 'A') hydraulically (see 1132-1).
- ⇒ Screw a roller support (94117) onto guide shoe middle part (9) (see detail concerned in Fig. 'F').
- ⇒ Fasten lifting eyebolt (94120a) with nut to the column (see detail concerned in Fig. 'H').
- ⇒ Screw down lifting tool (94116) to main bearing cover (2) with two shackles (BC20).
- ⇒ Connect wire rope 'e' (94120f) with shackle to lifting tool (94116) and chain block "H₁" via roller support (94117) as shown in Fig. 'M' and 'E'.
- ⇒ Screw an eye bolt "RC" onto the neighbouring guide shoe middle part (9).
- ⇒ Connect wire rope 'x' with lifting tool (94116), chain block "H₂" and shackle (BC20) (rope 'x' differ in lengths depending on the position of the guide shoe).
- ⇒ Provide protection for the crank web.



- ⇒ Lift the main bearing cover (2) carefully over the crank web with wire ropes 'x' and 'e' and detach wire rope 'x'.
- ⇒ Screw two eye bolts "RC₁" laterally into the main bearing cover (2) and connect them with wire rope 'f' (94120d) with two shackles (BC20) and chain block "H₃".
- ⇒ Pull the main bearing cover (2) with wire rope 'e' and 'f' towards middle of cylinder using chain blocks "H₁" and "H₃".

The further removal of the main bearing cover (2) is carried out analogously as described for Fig. 'I' ~ 'L'.

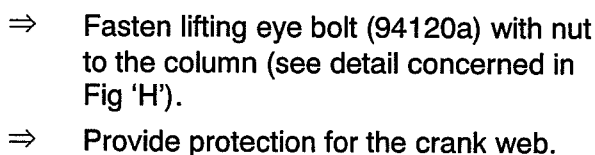
Removal and Fitting of a Main Bearing

5. Removal of main bearing cover next to the gear wheel on crankshaft

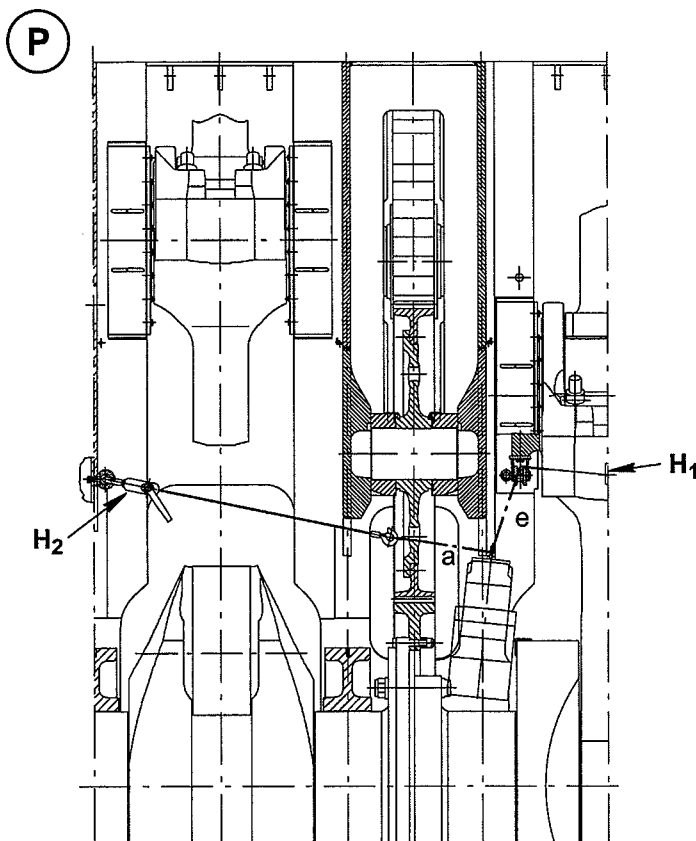


The crankshaft must not be turned by turning gear when workmen are in crankcase.

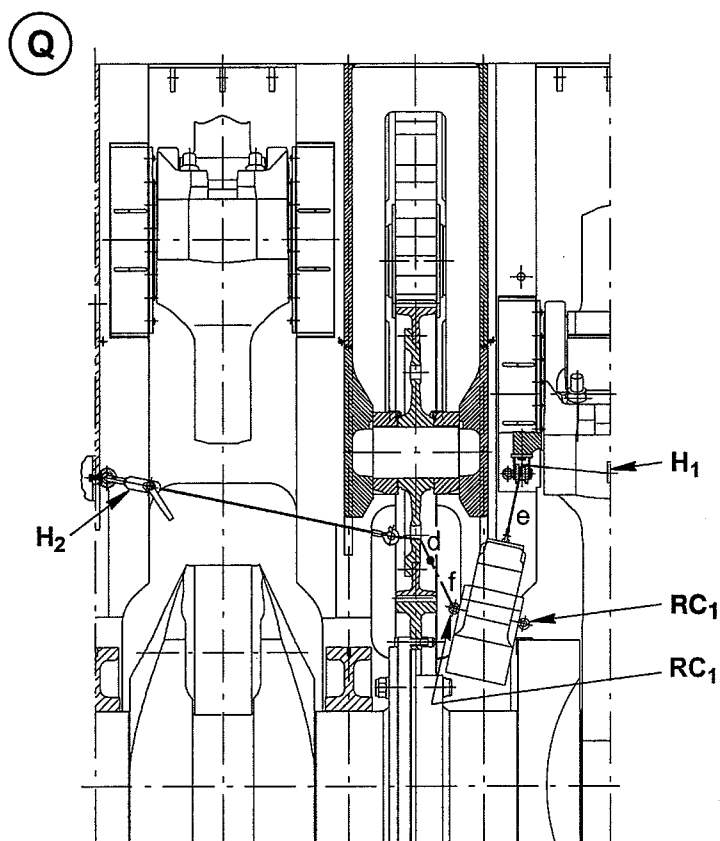
- ⇒ Turn the corresponding crank to exhaust side approx. 90° after T.D.C.
- ⇒ Install working platform (94142).
- ⇒ Loosen nuts (12) for waisted studs (11) (Fig. 'A') hydraulically (see 1132-1).
- ⇒ Fasten roller support (94117) to guide shoe middle part (9) as shown in Fig. 'N', 'O' and detail concerned in Fig. 'F'.
- ⇒ Screw down lifting tool (94116) to the main bearing cover (2) with two shackles (BC20).
- ⇒ Connect wire rope 'e' (94120f) with lifting tool (94146), chain block "H₁" and shackle (BC20) via roller support (94147) as shown in Fig. 'N' and 'O'.
- ⇒ Pull wire rope 'a' (94120e) through a hole in intermediate gear wheel (15) and connect it with lifting tool (94146), chain block "H₂" and shackle (BC20).



Main Bearing
Removal and Fitting of a Main Bearing



- ⇒ Lift the main bearing cover (2) using chain blocks "H₁" and "H₂".
- ⇒ Loosen wire rope 'a' until main bearing cover lies at the crank web.
- ⇒ Instead of wire rope 'a', connect wire rope 'd' (94120e) with chain block "H₂" and shackle (BC20) as shown in Fig. 'Q'.

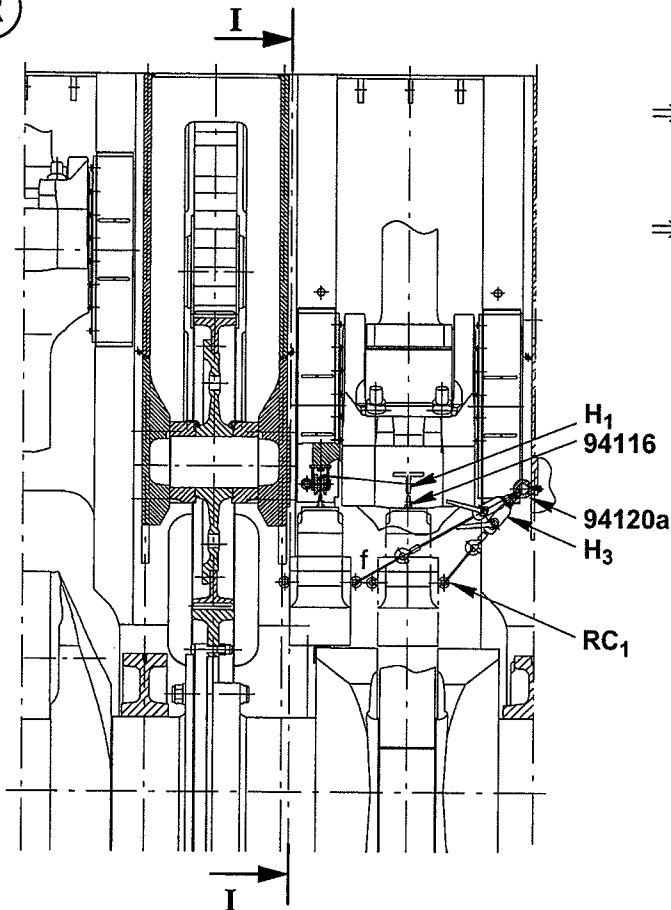


- ⇒ Screw two eye bolts "RC₁" with shackles (BC20) laterally into the main bearing cover.
- ⇒ Connect wire rope 'f' (94120d) with eye bolts "RC₁", wire rope 'd' and shackle (BC20).
- ⇒ Lift the bearing cover carefully onto the crank web using chain blocks "H₁" and "H₂".
- ⇒ Subsequently remove wire ropes 'd' and 'f'.

Main Bearing

Removal and Fitting of a Main Bearing

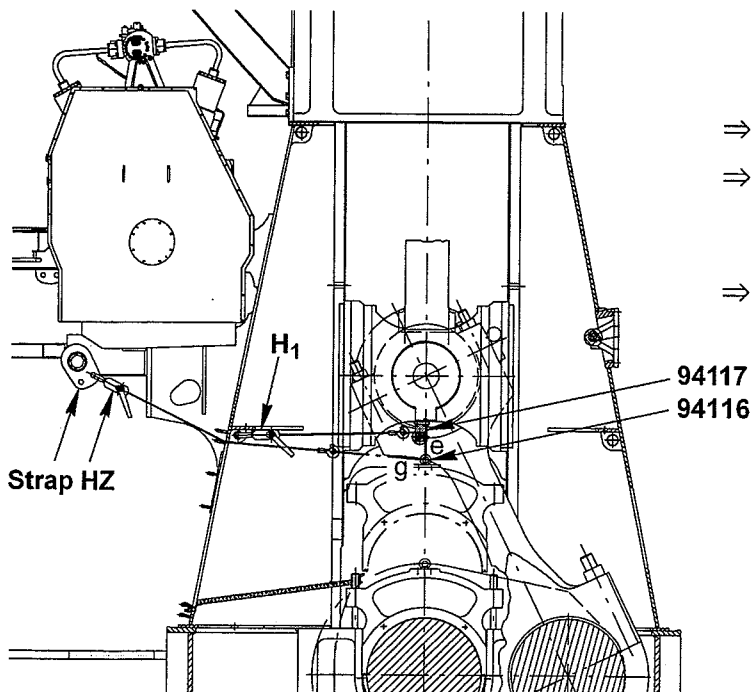
(R)



- ⇒ Fasten lifting eye bolt (94120a) with nut to the column (see detail concerned in Fig. 'H').
- ⇒ Connect wire rope 'f' (94120d) with eye bolt "RC₁", chain block "H₃" and shackle (BC20).

(S)

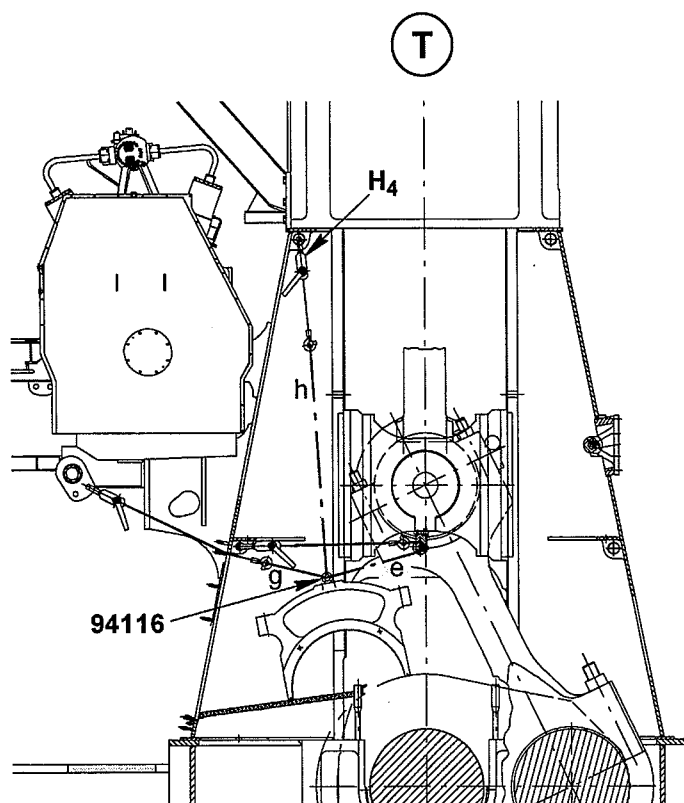
I - I



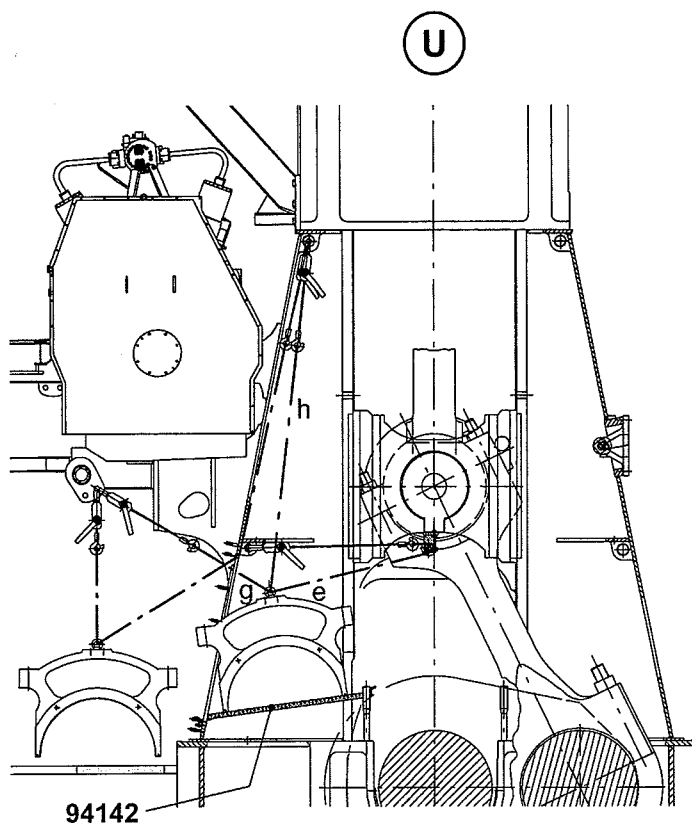
- ⇒ Fasten chain block "HZ" to strap.
- ⇒ Connect wire rope 'g' (94120c) with lifting tool (94116), chain block "HZ" and shackle (BC20).
- ⇒ Lift the main bearing cover carefully over the crank web using chain blocks "H₁" and "H₃" towards middle of cylinder (Fig. 'R') and pull it using chain block "HZ" to fuel side at the same time (Fig. 'S').

Main Bearing

Removal and Fitting of a Main Bearing



⇒ Guide the main bearing cover to fuel side with wire ropes 'g' and 'e' until wire rope 'h' (94120f) can be connected with chain block "H4", lifting tool (94116) and shackle (BC20).



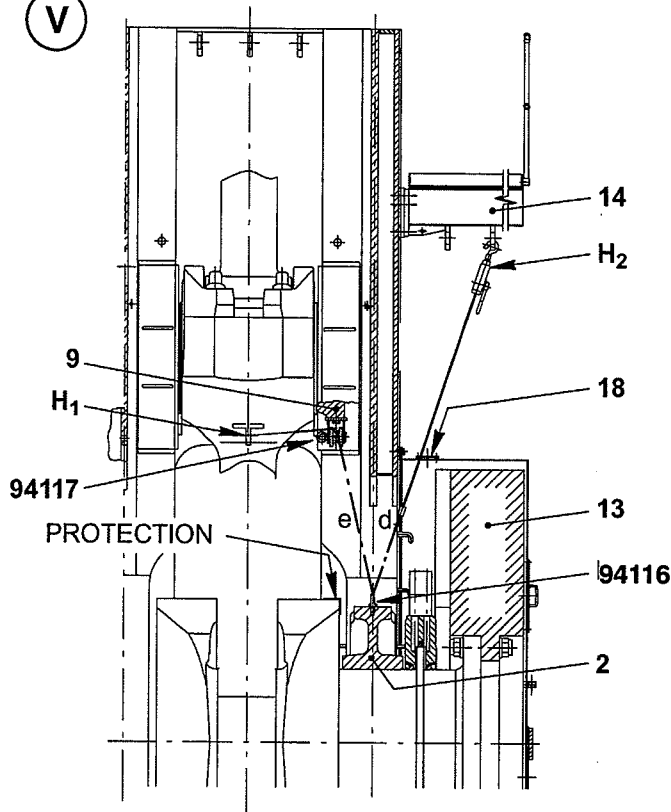
⇒ Place the main bearing cover on working platform (94142).
⇒ Remove wire rope 'e'.
⇒ Lift the main bearing cover out of the crankcase using chain blocks.

Main Bearing

Removal and Fitting of a Main Bearing

6. Removal of main bearing cover at free end

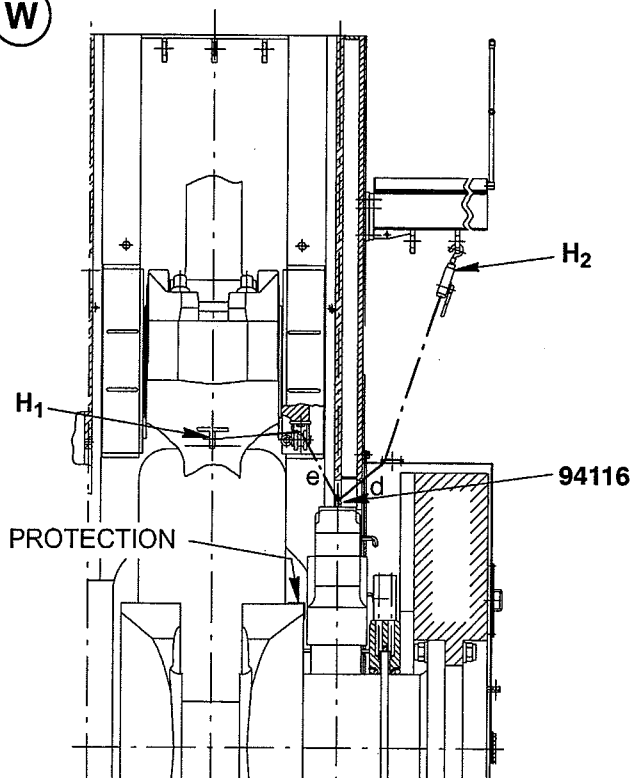
V



The crankshaft must not be turned by turning gear when workmen are in crankcase.

- ⇒ Turn crank of the last cylinder to exhaust side approx. 90° after T.D.C. (Fig. 'E').
- ⇒ Install working platform (94142) (Fig. 'E').
- ⇒ Loosen nuts (12) for waisted studs (11) (Fig. 'A') hydraulically (see 1132-1).
- ⇒ Screw down lifting tool (94116) with two shackles (BC20) to the main bearing cover.
- ⇒ Remove blank flange (18) from casing upper part.
- ⇒ Fasten chain block "H₂" to support (14) and connect wire rope 'd' (94120c) with shackle (BC20) on lifting tool (94116).
- ⇒ Fasten roller support (94117) to guide shoe middle part (9) (see detail concerned in Fig. 'F')
- ⇒ Connect wire rope 'e' (94120f) with lifting tool (94116), chain block "H₁" and shackle (BC20) via roller support (94117) as shown in Fig. 'E' and 'V'.
- ⇒ Provide protection for the crank web.

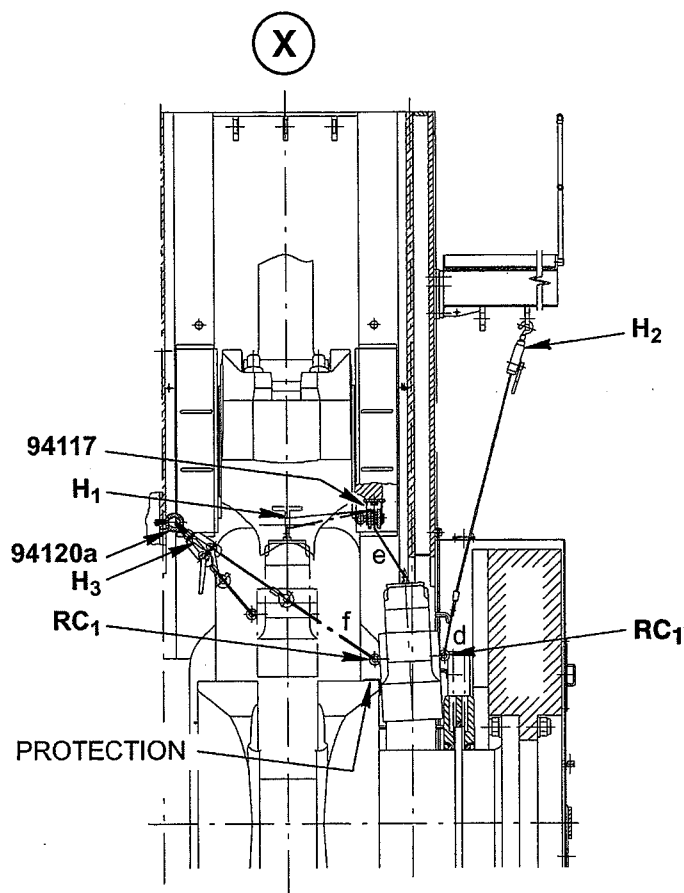
W



- ⇒ Lift the main bearing cover carefully as much as possible using chain block "H₁" and "H₂", and detach wire rope 'd' from lifting tool (94116).

Main Bearing

Removal and Fitting of a Main Bearing



- ⇒ Screw two eye bolts "RC₁" with shackles (BC20) laterally into the main bearing cover.
- ⇒ Fasten lifting eye bolt (94120a) with nut to the column (see detail concerned in Fig. 'H').
- ⇒ Connect wire rope 'd' with eye bolt "RC₁", chain block "H₂" and shackles (BC20).
- ⇒ Connect wire rope 'f' (94120d) with eye bolt "RC₁", chain block "H₃" and shackles (BC20).
- ⇒ Lift the main bearing cover carefully over the crank web using chain blocks "H₁" and "H₃" towards middle of cylinder.

The further removal of the main bearing cover is carried out analogously as described for Fig. 'I' ~ 'L'.

Main Bearing

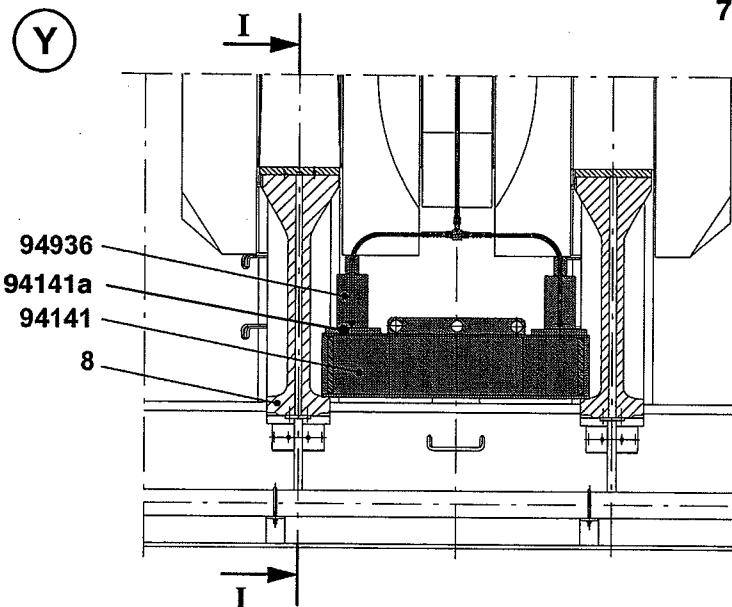
Removal and Fitting of a Main Bearing

7. Removal of main bearing shells



Never remove two neighbouring bearing shells at the same time.

- The same lifting tackles are used for the removal of the corresponding bearing shells as for the removal of the corresponding bearing covers.
- For the removal of bearing shells No. 1 and 2 the flywheel must also be pressed up with the non-standard hydraulic jack (19). To protect the flywheel toothing, put a copper or aluminium plate between the hydraulic jack and the flywheel (Fig. 'D₁').

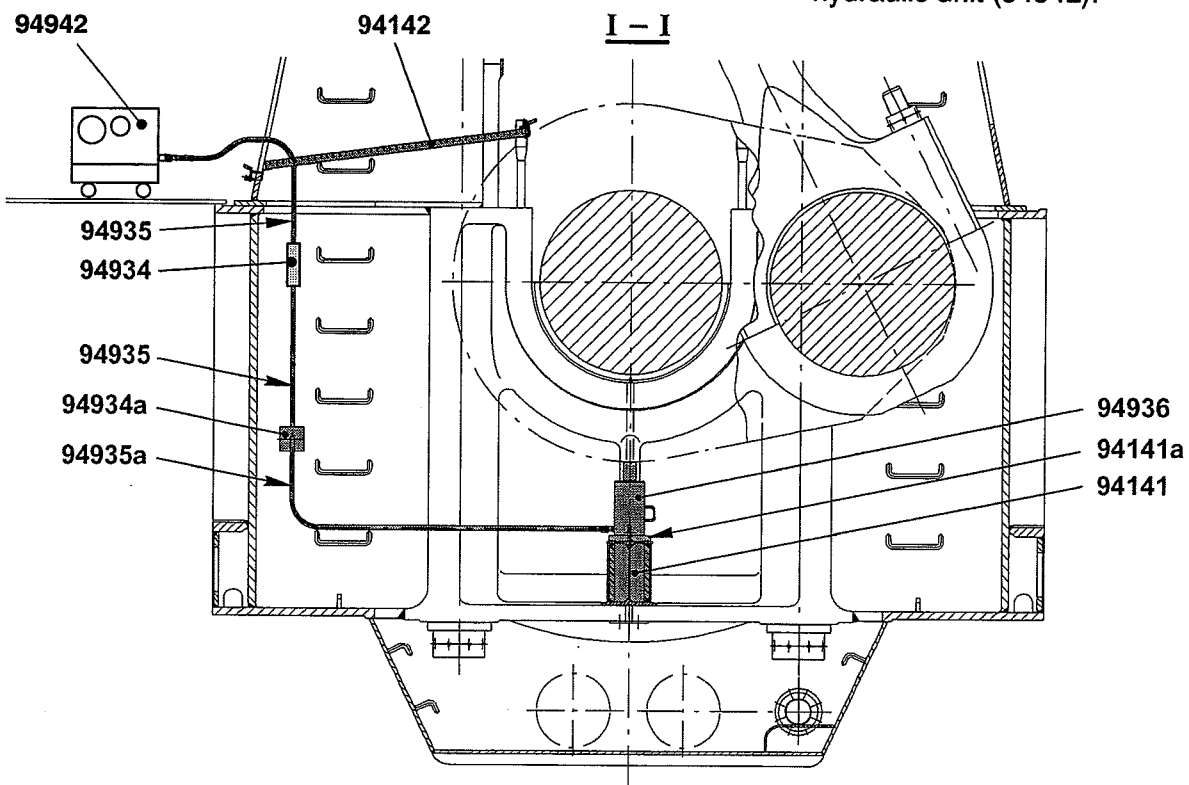


7.1 Fitting the hydraulic jacks



The crankshaft must not be turned by turning gear when workmen are in crankcase.

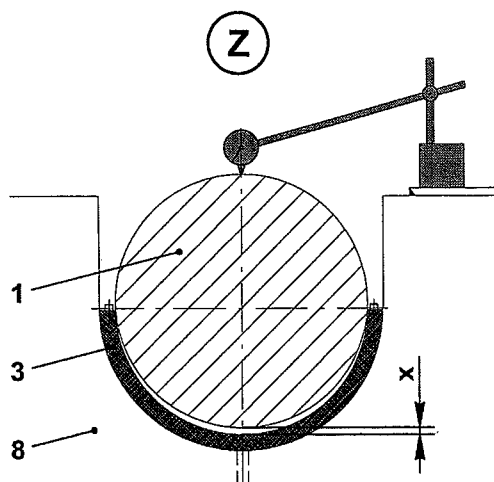
- ⇒ Turn crankshaft (1) to exhaust side approx. 90° after T.D.C.
- ⇒ Put support (94141) on two main bearing girders (8) parallel to the engine axis.
- ⇒ Place hydraulic jacks (94936) with jacking support (94141a) on support (94141).
- ⇒ Connect the hydraulic jacks (94936) with HP hoses (94935) and (94935a), as well as connecting pieces (94934) and (94934a) to hydraulic unit (94942).



Main Bearing

Removal and Fitting of a Main Bearing

7.2 Lifting the crankshaft



⇒ Using hydraulic jacks (94936) and lift the crankshaft at the bearing to be removed by value 'x' = 0.4 ~ 0.5 mm.



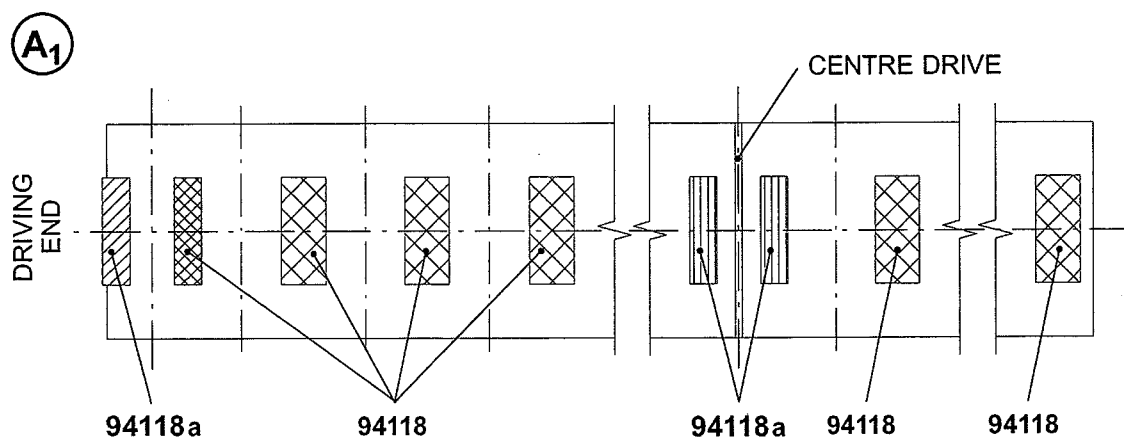
Lift the crankshaft max. to the point where the neighbouring main bearings show vertically no clearance any more between the main bearing cover and crankshaft.

CHECK

Check this procedure with a dial gauge installed above the crankshaft, and verify the bearing clearance at the neighbouring main bearings using special feeler gauge (94123).

7.3 Turning out the main bearing shell

- The same wire ropes are used for turning out and lifting of the bearing shells, and their arrangements are illustrated as follows:
 - Fig. 'D₁' for No.1 main bearing
 - Fig. 'E₁' for No.2 main bearing
 - Fig. 'C₁' for intermediate main bearing
 - Fig. 'F₁' for main bearing next to gear wheel on crankshaft
 - Fig. 'G₁' for main bearing at free end
- The turning-out procedure is the same for all bearing shell as described for Fig. 'B₁'.
- Turning-out devices (94118) and (94118a) are provided depending on the location of the main bearing shell as shown in Fig. 'A₁'.

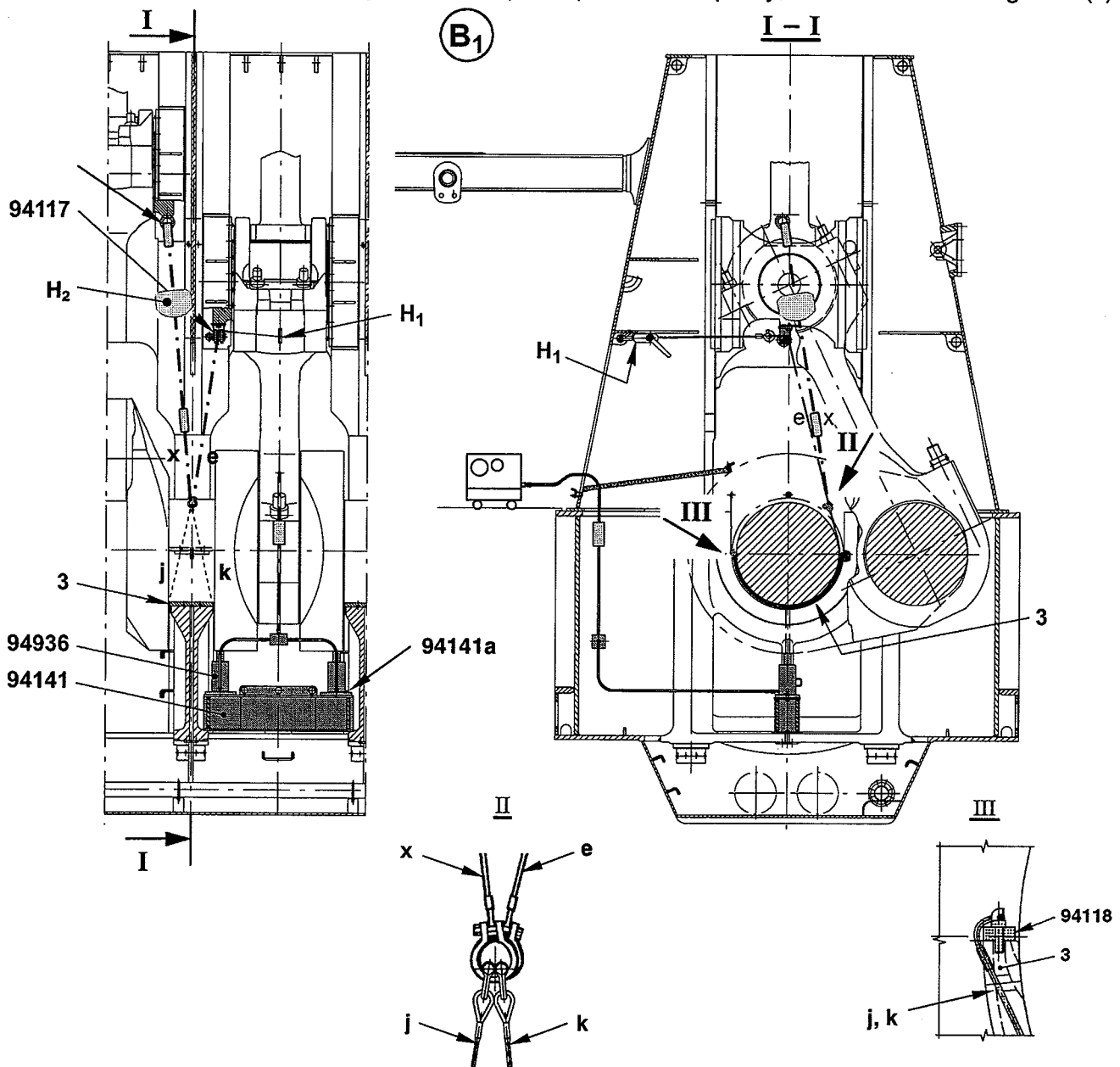


Main Bearing

Removal and Fitting of a Main Bearing

7.3.1 Turning out No.8 main bearing shell : (example of intermediate main bearing)

- ⇒ Fasten turning-out device (94118) on the joint face of the bearing shell of fuel pump side utilizing screws (M12) (view III).
- ⇒ Connect wire ropes 'j' and 'k' (94120j) with hook on turning-out device (94118). Lead both ropes along the lateral edges of main bearing shell (3) to the other side. Connect shackle (BC20) with the end of each rope.
- ⇒ Fasten chain block "H₁" with shackle (BC20) to eye plate at fuel pump side in column. Connect wire rope 'e' (94120g) with both shackles at the end of ropes together with shackle (BC20) (view II). Connect the latter with the chain block "H₁" via roller support (94117).
- ⇒ Fasten chain block "H₂" with eye bolt "RC" and shackle (BC20) on the neighbouring guide shoe middle part (9). Connect wire rope 'x' with both shackles at the end of wire ropes together with shackle (BC20). Connect the latter with chain block "H₂".
- ⇒ Pull main bearing shell (3) using chain blocks "H₁" and "H₂".
- ⇒ Remove turning-out device (94118) and wire ropes 'j', 'k' from main bearing shell (3).



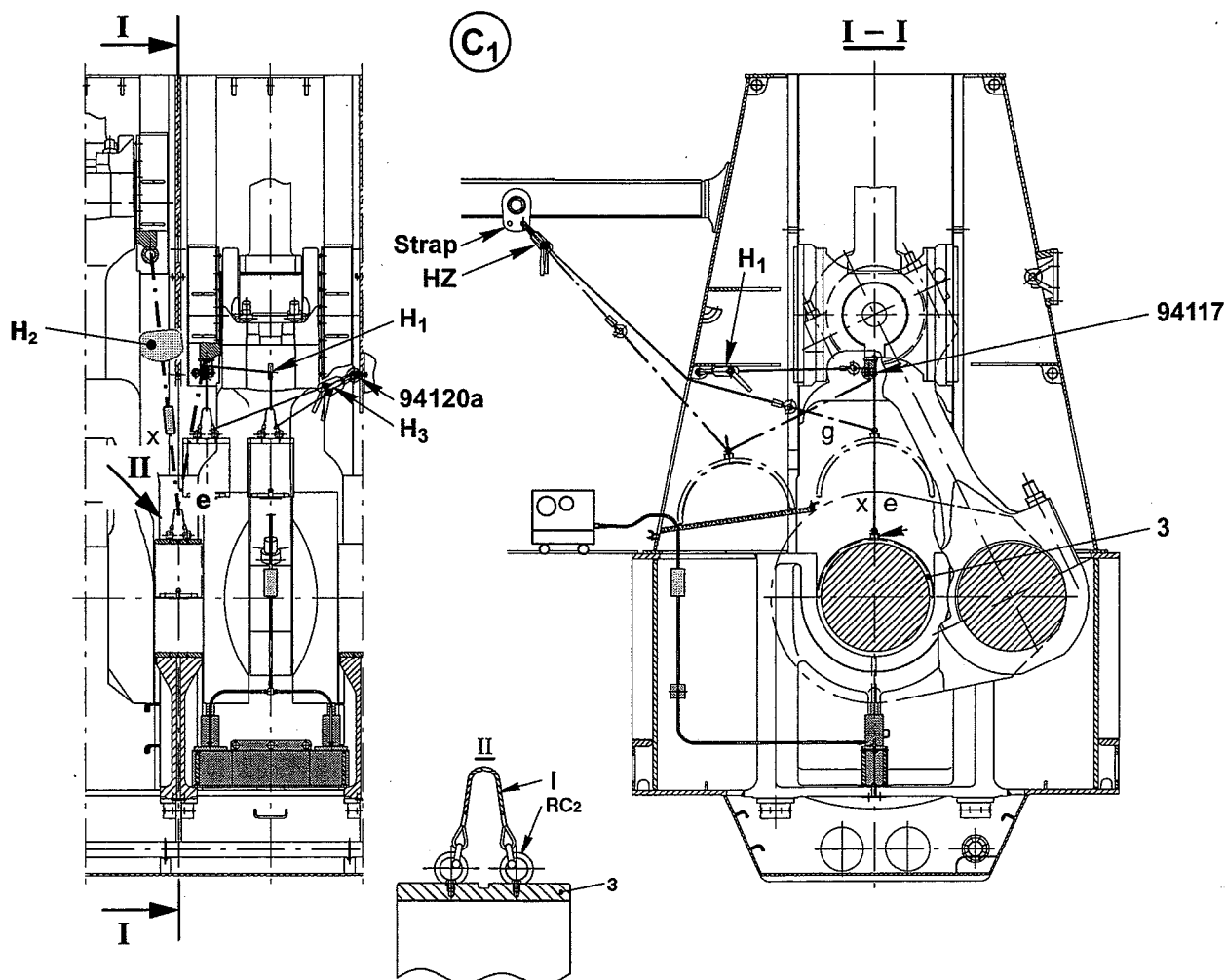
Main Bearing

Removal and Fitting of a Main Bearing

7.4 Removal of No.8 main bearing shell : example of intermediate main bearin

- ⇒ Screw two eye bolts "RC₂" to the main bearing shell (3) and connect it with wire rope 'I' (94120b), eyebolts and shackles as shown in view II.
- ⇒ Connect wire rope 'x' (94120c) on chain block "H₂" with the wire rope 'I' (94120b) eye bolt "RC₂" together with shackle (BC20). Connect the wire rope 'e' (94120g) with eye bolt "RC₂" same as the above.
- ⇒ Lift the main bearing shell (3) toward under roller support (94117) using chain blocks "H₁" and "H₂". Then, remove wire rope 'x' on chain block "H₂".
- ⇒ Fasten lifting eyebolt (94120a) with nut to partition of column. Fasten chain block "H₃" with shackle (BC20) to lifting eyebolt (Fig. "K").
- ⇒ Hook chain block "H₃" to wire rope 'I' (94120b) on the main bearing shell.
- ⇒ Lift the main bearing shell (3) toward middle of cylinder using the chain blocks "H₁" and "H₃".
- ⇒ Fasten chain block "HZ" to strap. Connect wire rope 'g' (94120b) with wire rope 'I' (94120a) on the main bearing shell together with shackle (BC20). Connect the latter with chain block "HZ".
- ⇒ Pull the main bearing shell together with chain blocks "H₁", "H₃" and "HZ" to fuel side (view I-I).

The further procedure is carried out analogously as shown in Fig. 'K' and 'L' (Removal of main bearing cover).

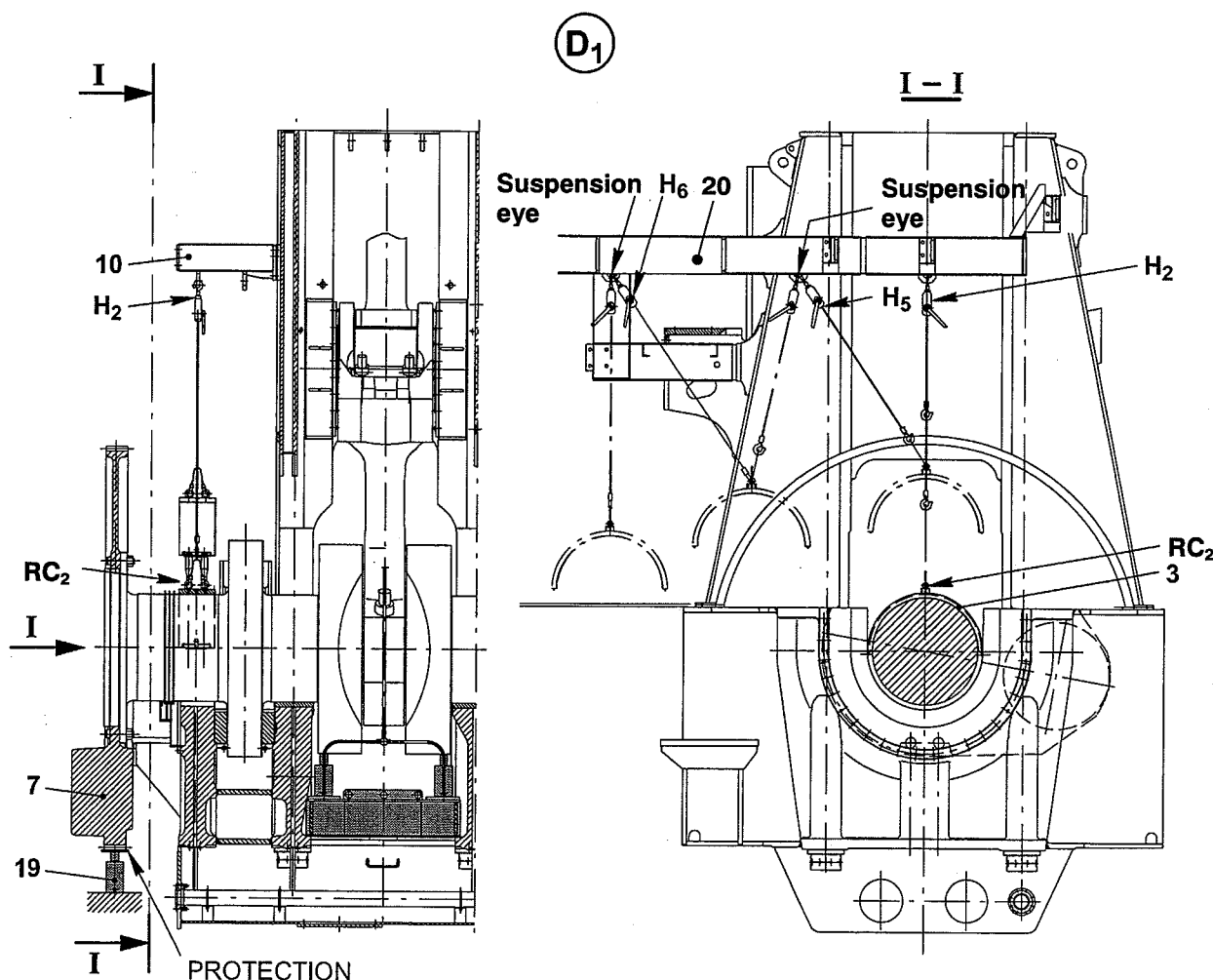


Main Bearing

Removal and Fitting of a Main Bearing

7.5 Removal of No.1 main bearing shell

- ⇒ Screw two eye bolts "RC₂" to the main bearing shell (3) and connect it with wire rope 'I' (94120b), eyebolts and shackles (Fig. 'C₁' view II).
- ⇒ Fasten chain block "H₂" with shackles (BC20) to suspension eye on support (10). Hook wire rope 'I' on the main bearing shell to chain block "H₂".
- ⇒ Fasten chain block "H₅" with shackle (BC20) to suspension eye on support (20). Hook wire rope 'I' (94120b) on the main bearing shell to chain block "H₅".
- ⇒ Swing the main bearing shell under support (20) using the chain blocks "H₂" and "H₅". Then, remove the chain block "H₂".
- ⇒ Fasten chain block "H₆" with shackle (BC20) to support of fuel pump side. Hook wire rope 'I' on the main bearing shell to chain block "H₆" and swing it out of crankcase using chain blocks "H₅" and "H₆".
- ⇒ Remove chain block "H₅".



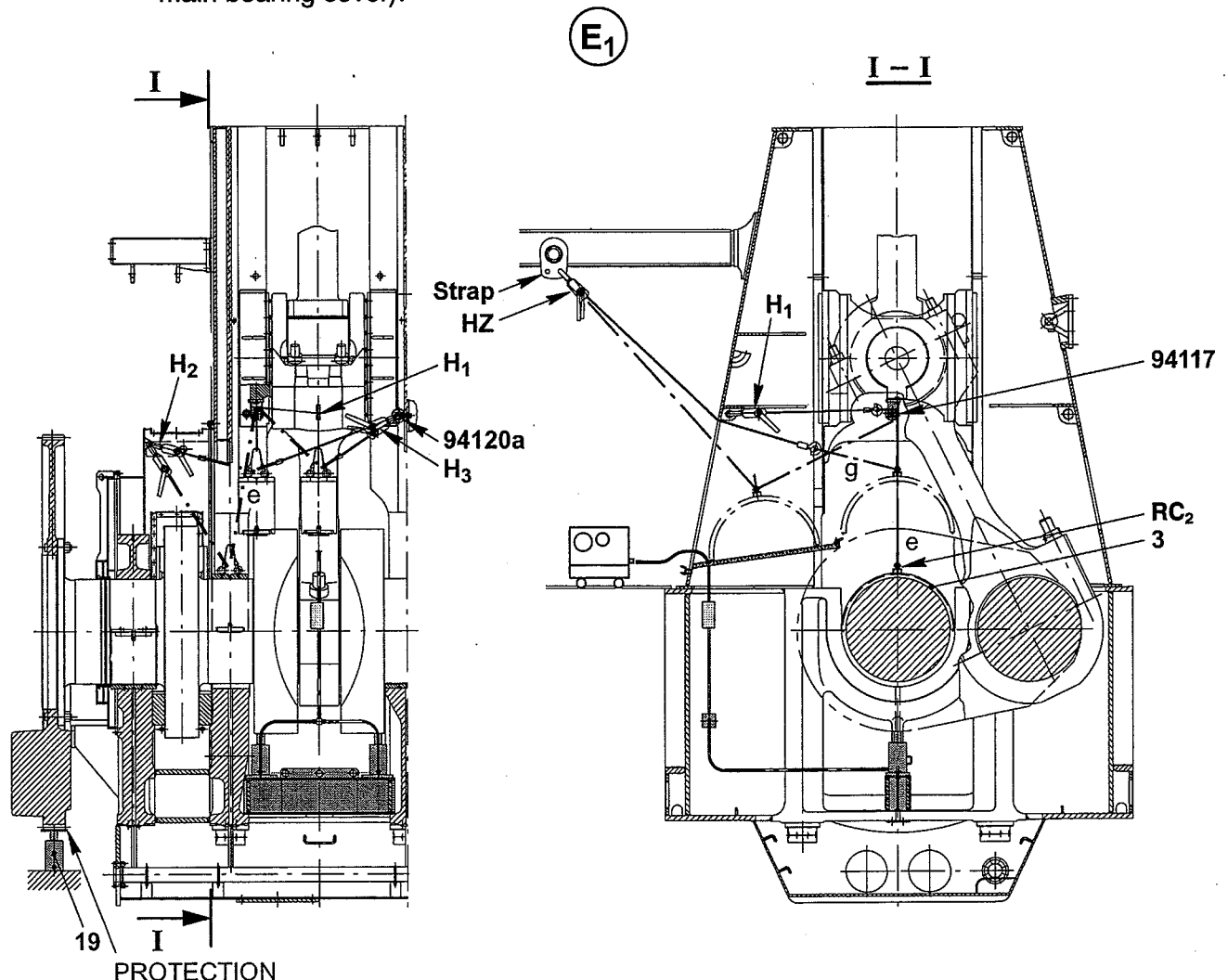
Main Bearing

Removal and Fitting of a Main Bearing

7.6 Removal of No.2 main bearing shell

- ⇒ Screw two eye bolts "RC₂" to the main bearing shell (3) and connect it with wire rope 'I' (94120b), eyebolts and shackles (Fig. 'C₁' view II).
- ⇒ Fasten chain block "H₁" with shackle (BC20) to eye plate at fuel pump side in column. Connect wire rope 'e' (94120g) with chain block "H₁". Connect the latter with wire rope 'I' on the main bearing shell via roller support (94117).
- ⇒ Fasten chain block "H₂" with shackle (BC20) and connect chain block "H₂" with wire rope 'I' on the main bearing shell together with shackle (BC20) as shown in Fig. 'E₁'.
- ⇒ Lift the main bearing shell under the roller support (94117) using the chain blocks "H₁" and "H₂". Then, remove chain block "H₂" from wire rope 'I'.
- ⇒ Fasten lifting eye bolt (94120a) with nut to partition of column. Fasten chain block "H₃" with shackle (BC20) to the lifting eye bolt. Hook wire rope 'I' to chain block "H₃".
- ⇒ Lift the main bearing shell toward middle of cylinder using chain blocks "H₁" and "H₃".
- ⇒ Fasten chain block "HZ" to strap and connect wire rope 'g' (94120c) together with shackle (BC20) wire rope 'I' on the main bearing cover. Connect the latter to chain block "HZ".
- ⇒ Pull the main bearing shell together with chain blocks "H₁", "H₃" and "HZ" to fuel side (view I-I).

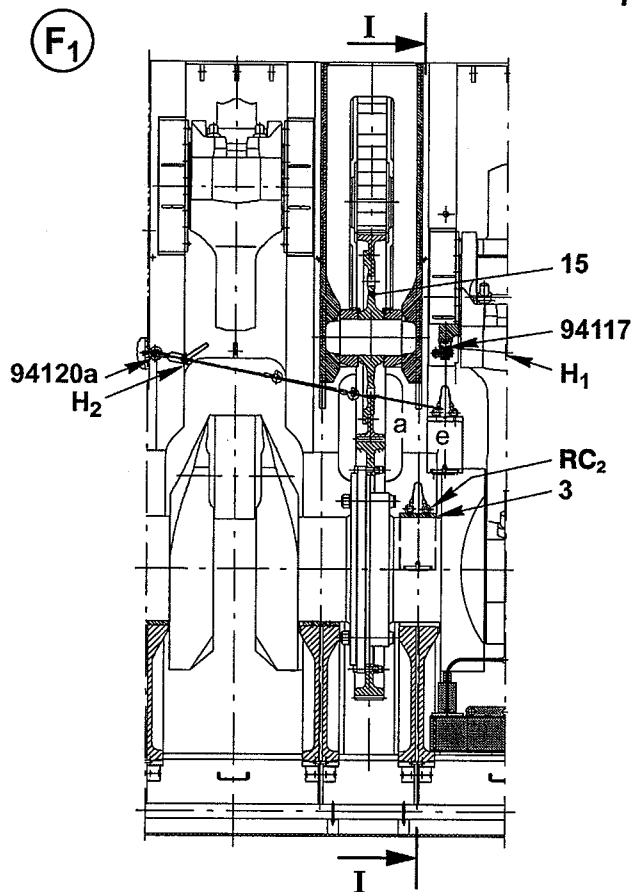
The further procedure is carried out analogously as shown in Fig. 'K' and 'L' (Removal of main bearing cover).



Main Bearing

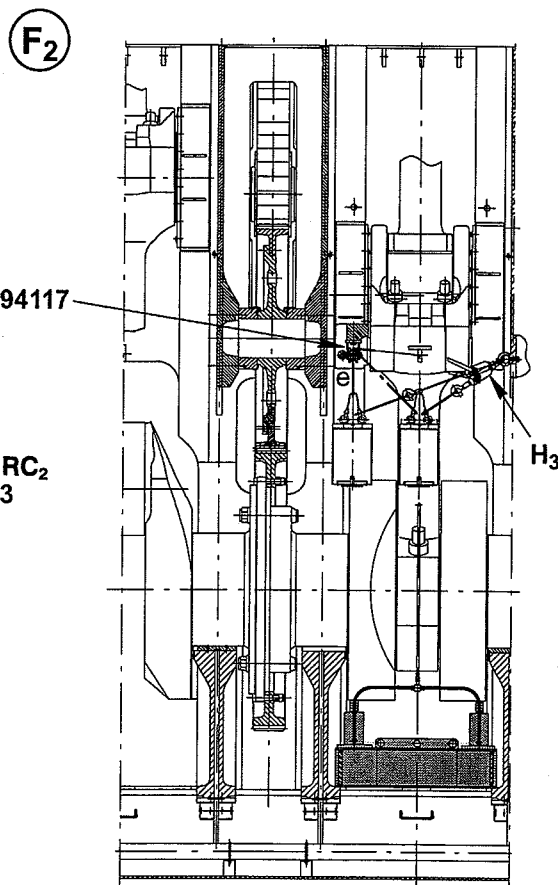
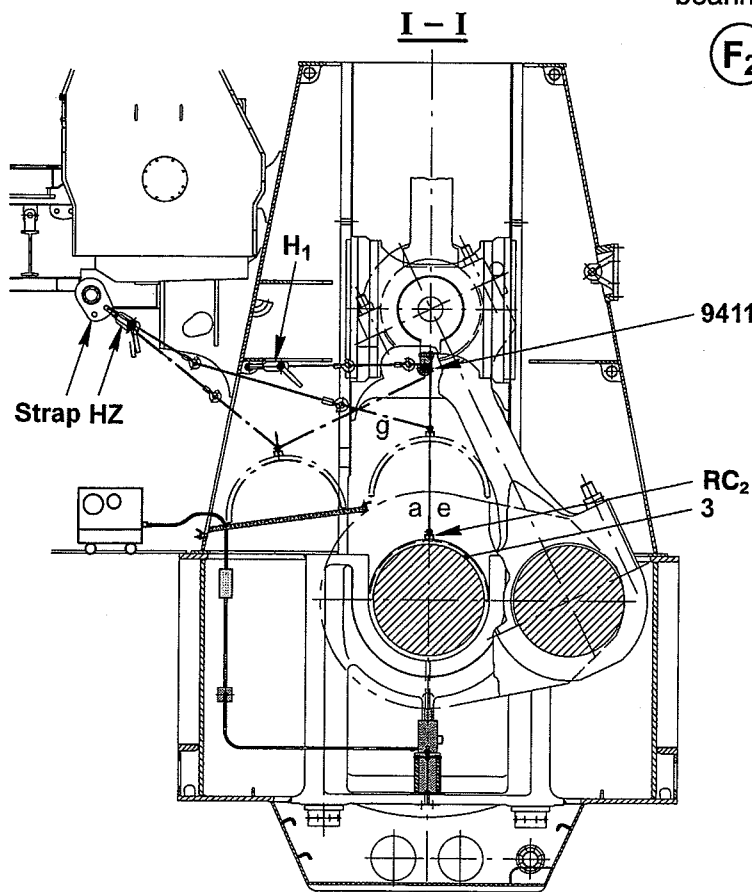
Removal and Fitting of a Main Bearing

7.7 Removal of main bearing shell next to gear wheel on crankshaft



- ⇒ Screw two eyebolts "RC₂" and attach it with shackles and wire rope 'I' (94120b) (Fig. 'C₁' view II).
- ⇒ Lead wire rope 'e' (94120g) over roller support (94117) and connect it with chain block "H₁", wire rope 'I' and shackle.
- ⇒ Pull wire rope 'a' (94120f) through a hole in intermediate wheel (15) and connect it with chain block "H₂", wire rope 'I' and shackle.
- ⇒ Lift the main bearing shell carefully over the crank web with chain blocks "H₁" and "H₂" (Fig. 'F₁').
- ⇒ Remove wire rope 'a', lifting eye bolt (94120a), chain block "H₂" and shackle.
- ⇒ Connect chain block "H₃" directly to wire rope 'I' and pull the main bearing shell together with wire rope 'e' towards middle of cylinder as shown in Fig. 'F₂'.
- ⇒ Fasten chain block "HZ" to strap.
- ⇒ Connect wire rope 'g' (94120c) with chain block "HZ", wire rope 'I' and shackle, and then pull the bearing shell to fuel side (view I-I).

The further procedure is carried out analogously as shown in Fig. 'S' and 'U' (Removal of main bearing cover).



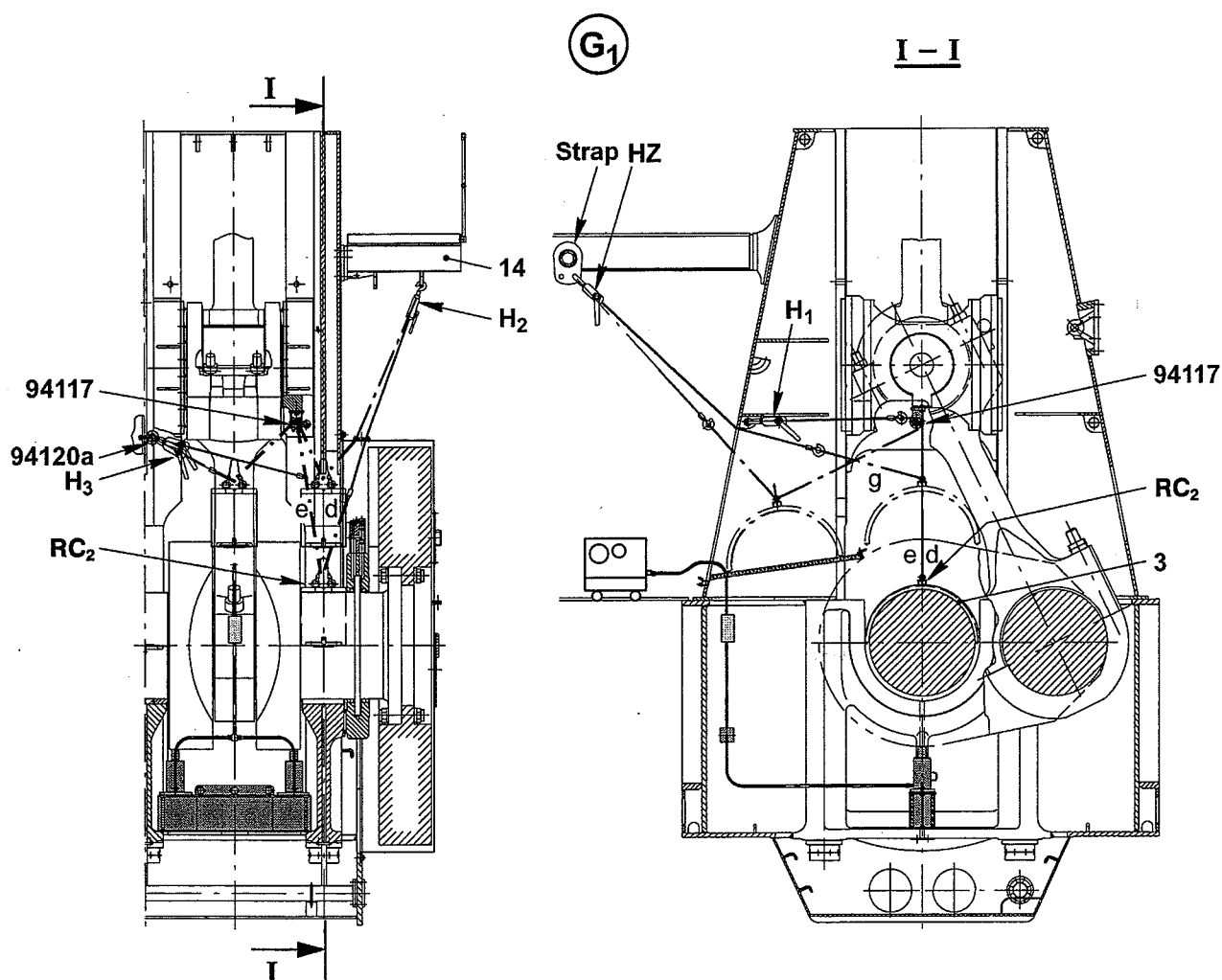
Main Bearing

Removal and Fitting of a Main Bearing

7.8 Removal of main bearing shell at free end

- ⇒ Screw two eyebolts "RC₂" and attach it with shackles and wire rope 'I' (94120b) (Fig. 'C₁' view II).
- ⇒ Lead wire rope 'e' (94120c) over roller support (94117) and connect it with chain block "H₁", wire rope 'I' and shackle.
- ⇒ Connect wire rope 'd' (94120g) with wire rope 'I', chain block "H₁" and shackle.
- ⇒ Lift the main bearing shell carefully over the crank web with chain blocks "H₁" and "H₂".
- ⇒ Remove wire rope 'd', and chain block "H₂".
- ⇒ Connect chain block "H₃" directly to wire rope 'I' and pull the main bearing shell together with wire rope 'e' towards middle of cylinder.
- ⇒ Fasten chain block "HZ" to strap.
- ⇒ Connect wire rope 'g' (94120c) with chain block "HZ", wire rope 'I' and shackle, And then pull the main bearing shell together with chain blocks "H₁", "H₃" and "HZ".

The further procedure is carried out analogously as shown in Fig. 'L' and 'M' (Removal of main bearing cover).



Main Bearing

Removal and Fitting of a Main Bearing

8. Fitting of main bearing shell and main bearing cover

- Prior to fitting the main bearing shell or main bearing cover pay attention to 'Arrangement and characteristics of the main bearings' on page 2/26.



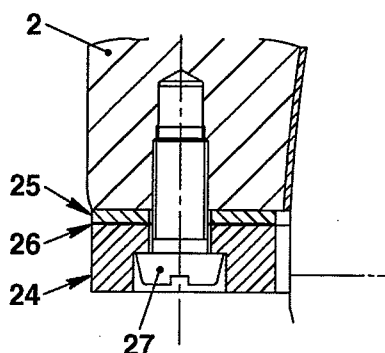
The main bearing shell and cover must not be interchanged!

- All main bearing shells are marked on their faces with DRIVE END. All main bearing covers are marked on their upper faces with "S" (exhaust gas side) and "P" (fuel pump side). Therefore, they must be fitted correspondingly.

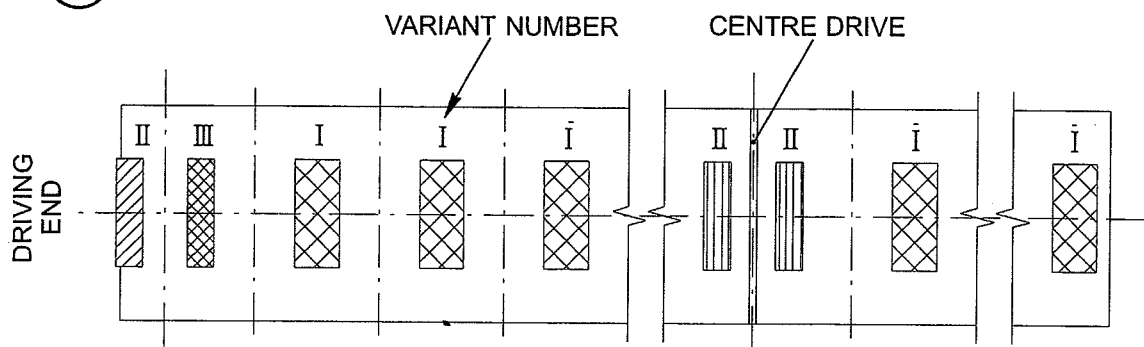


Take care not to get the top and bottom of shims (24), (25) and (26) mixed up. According to the type of main bearings 'I', 'II' and 'III' shims must be fitted correspondingly.

H_1



I_1

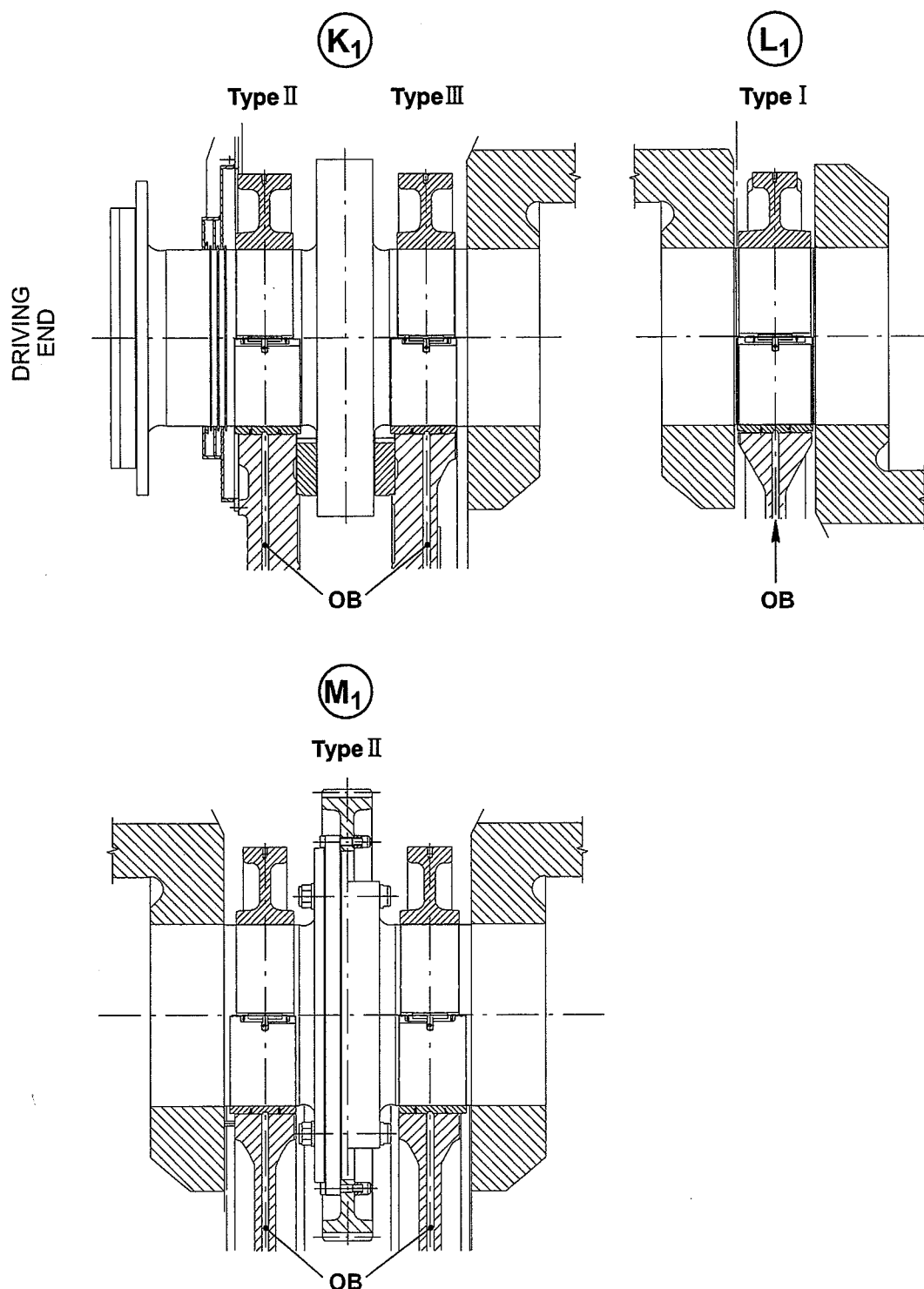


Main Bearing

Removal and Fitting of a Main Bearing

- Bearing shell and bearing cover should be fitted into the main bearing girder in their original position.
- Oil bore "OB" in the main bearing girder must be clean and without particles of white metal.
- Crankshaft journal, girder bore for main bearing and all parts to be fitted must be clean and undamaged!

Crosshead section of main bearings (numbering):



Main Bearing

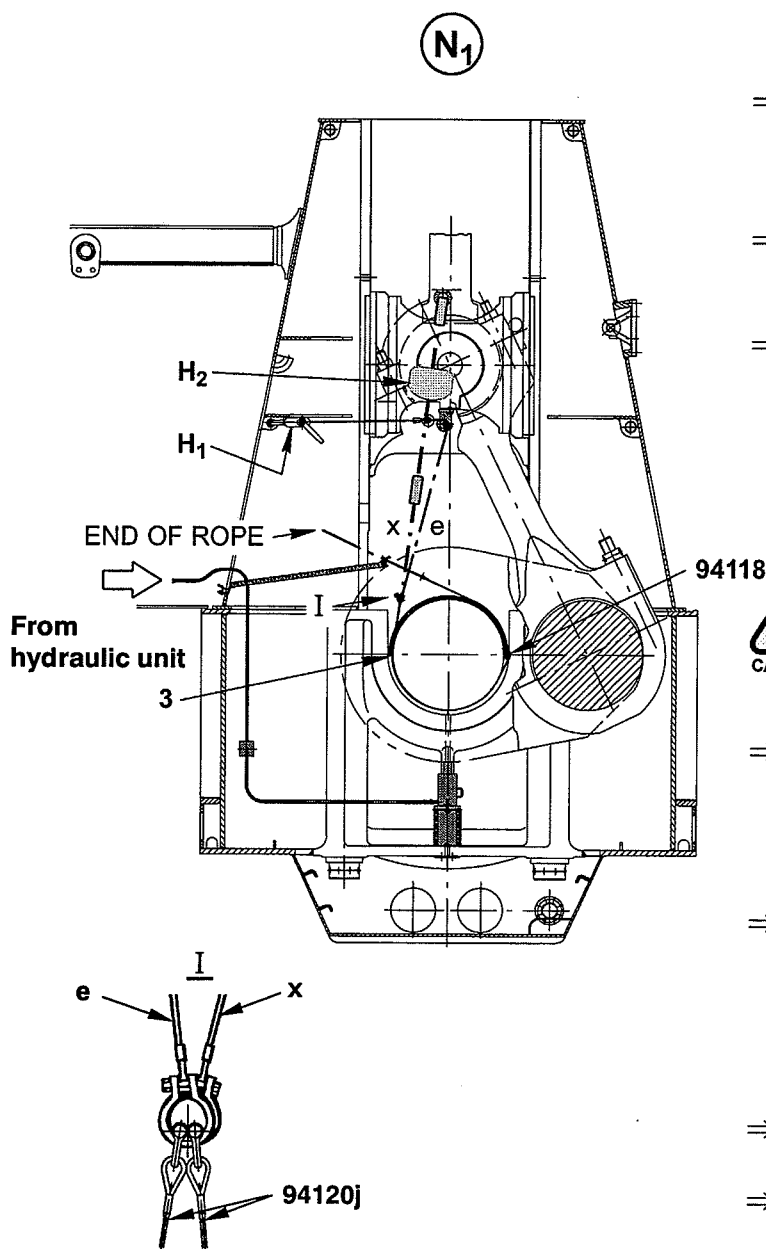
Removal and Fitting of a Main Bearing

They fitting of main bearing shell and cover is carried out analogously but in reverse sequence to the removal

- ⇒ **Directly before fitting (turning in)** main bearing shell apply a **very thin** layer of MOLYKOTE paste G to the back of it.
- ⇒ The crankshaft journal and the running surface of the main bearing shell must be thoroughly lubricated with clean engine.

8.1 Turning in the main bearing

(see Fig. 'N₁' as an example for main bearing No.8)



- ⇒ Connect wire rope 'x' with chain block "H₂" and connect wire rope 'e' (94120g) with chain block H₁" as shown in Fig. 'B₁'.
- ⇒ Connect wire rope 'e' with two ropes via roller support (94117) together with shackle (view I).
- ⇒ Fasten turning-out device (94118) on the joint face of the main bearing shell. Lead two ropes along the lateral edges of the main bearing shell (3). Connect two ropes with turning-out device (94118). The end of ropes must be led to fuel pump side as show in Fig. 'N₁'.



So that main bearing shell does not glide jerkily, it must be held and guided slowly into the bearing girder.

- ⇒ Pull the main bearing shell using chain blocks "H₁" and "H₂" until the surfaces between the main bearing shell and cover become level (Check depth using depth gauge).
- ⇒ Release the pressure at the hydraulic unit (94942). Remove turning-out device (94117) from the main bearing shell. Fit the main bearing cover (1) analogously but in reverse sequence to the removal.
- ⇒ Tighten nut (12) for waisted studs (11) following the instructions in 1132-1.
- ⇒ Remove all the tools from the engine.

CHECK

The bearing clearances and the crank deflection must be measured after a new bearing shell has been fitted and the bearing cover has been tightened (see 0330-1 and 3103-1).
After assembly, check if lubricating oil is supplied to the main bearing with the oil pump in operation.

Thrust Bearing
Checking the Axial Clearance
Tools :

1	Inside micrometer	94101a
1	Feeler gauge	94238
1	Dial gauge with magnetic base	

4, 4a

Key to Illustrations :

1	Coupling flange	7	Thrust bearing pads for ASTERN
2	Oil baffle, upper part		
3	Oil baffle, lower part	7a	Thrust bearing pads for AHEAD
4, 4a	Holder		
5	Thrust flange	8	Cover
6	Crankshaft	9	Screw plug

1. Measuring method 1

The total displacement which results from pushing the crankshaft axially both ways until it contacts the thrust bearing pads AHEAD and ASTERN, is measured with a dial gauge. This is then checked against the figure marked on the sheet 'Check Dimensions' in the engine documents supplied (see also Clearance Table 0330-1 'Crankshaft and main bearing').

An increase compared with the nominal figure signifies wear of the thrust bearing pads.

2. Measuring method 2

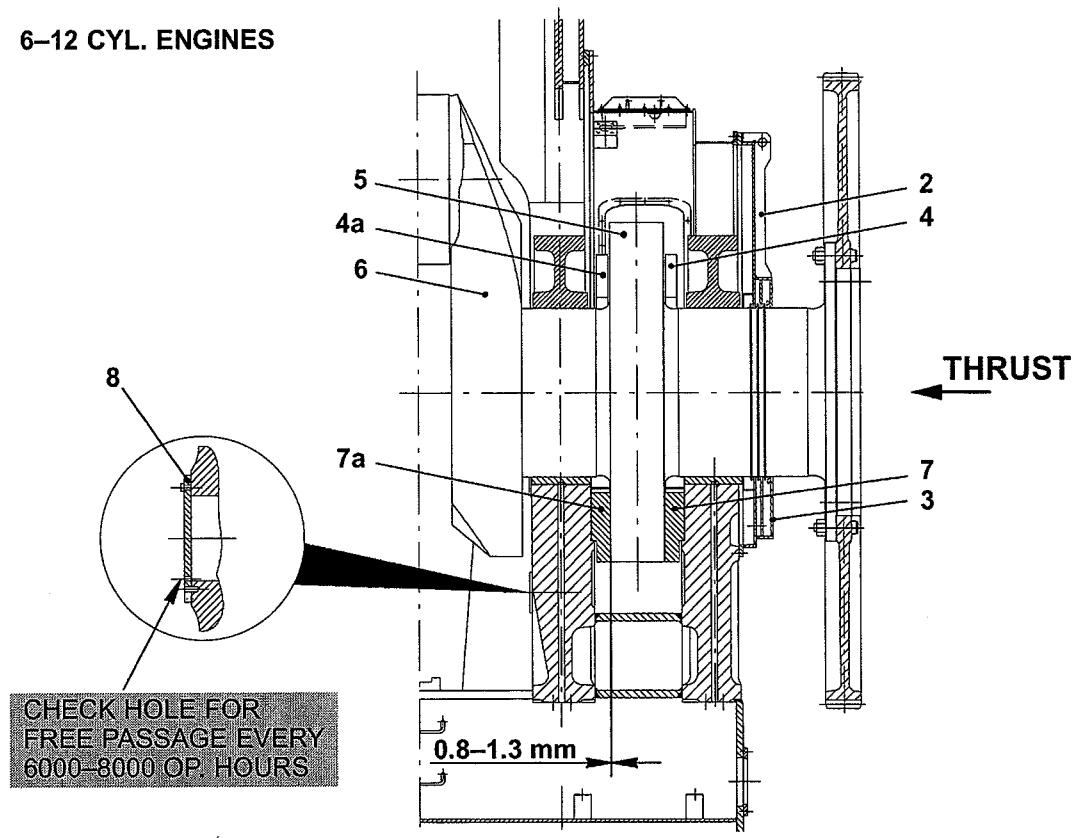
- ⇒ Displace the crankshaft axially until it rests on the engine side thrust bearing pads (AHEAD) and then fix it in this position.
- ⇒ Measure the distance between the coupling flange and the upper part of the oil baffle with the inside micrometer (94101a) at the position indicated (see Fig. 'C'). The amount by which the distance 'X' is smaller than that given on the sheet 'Check Dimensions' corresponds to the wear of the engine side thrust bearing pads (AHEAD).
- ⇒ Displace the crankshaft axially until it rests on the thrust bearing pads for ASTERN. Determine the total axial clearance with the inside micrometer.


Remark

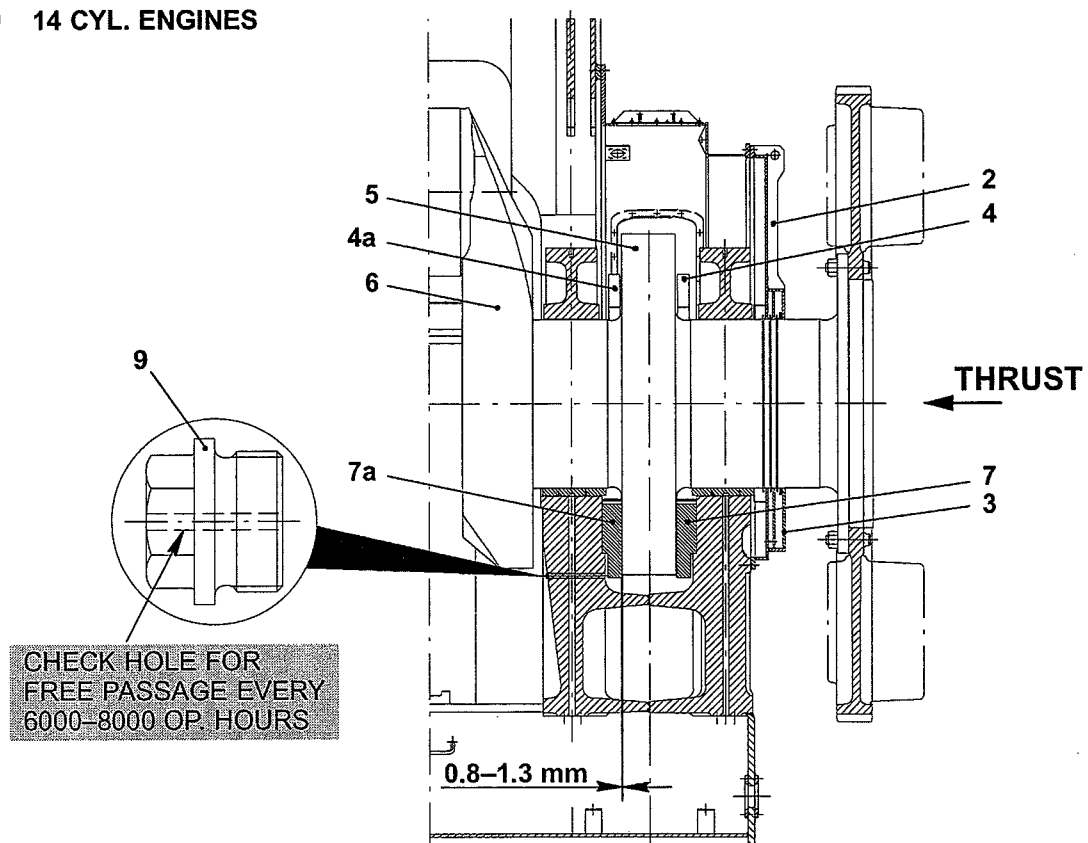
: If during checking or repair work any objects should fall into the thrust bearing housing, they can be removed after dismantling cover (8). After major works have been carried out in the thrust bearing space dismantle cover (8) for a check-up on the thrust bearing housing. Remove any foreign matters through the opening.

Thrust Bearing
Checking the Axial Clearance

(A) 6-12 CYL. ENGINES

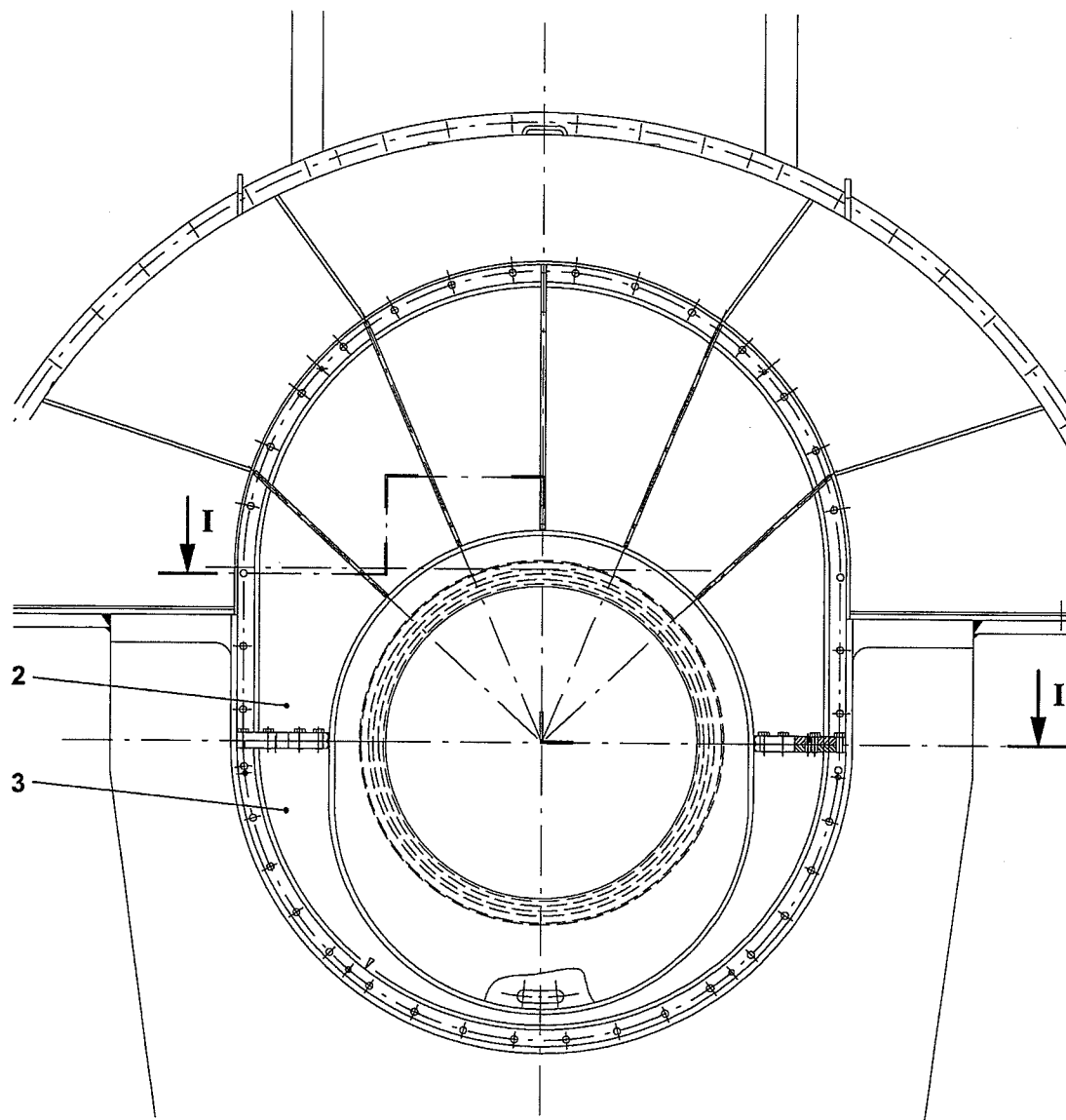


(B) 14 CYL. ENGINES

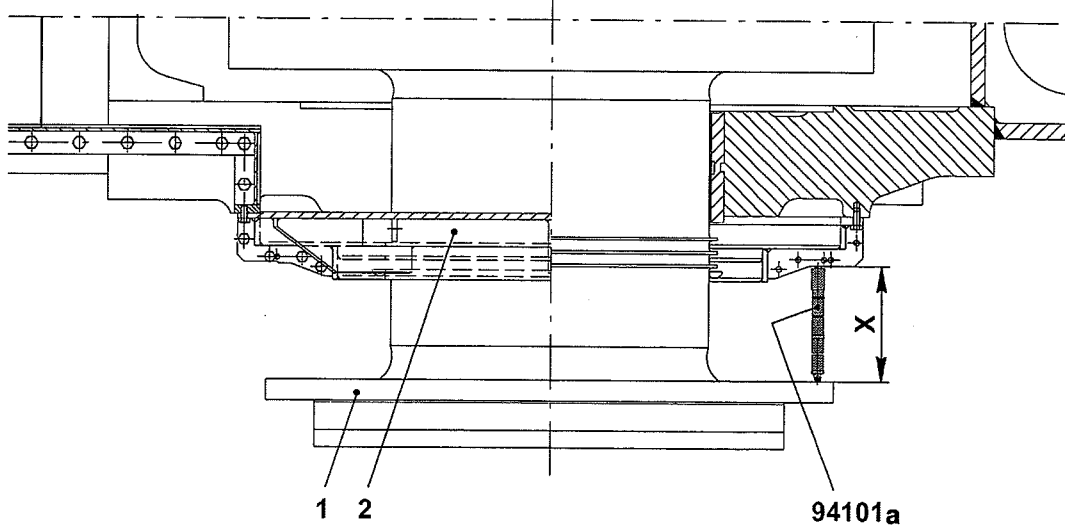


Thrust Bearing
 Checking the Axial Clearance

(C)



I - I



Thrust Bearing

Removal and Fitting the Thrust Bearing Pads

Tools :

- | | | |
|---|---|--------|
| 1 | Turning-out device
for 6 and 7 Cyl. engines,
with 1-part gear wheel | 94155 |
| 1 | Turning-out device
for 6 and 7 Cyl. engines,
with 2-part gear wheel | 94155a |
| 1 | Turning-out device
for 8 – 12 Cyl. engines | 94155b |

- 1 Eye bolt M16

Key to Illustrations :

- | | |
|-------|----------------------------|
| 1 | Thrust bearing flange |
| 2, 2a | Thrust bearing pads |
| 3 | Gear wheel |
| 4 | Holder |
| 5 | Screw with distance sleeve |
| 6 | Bearing cover |
| 7 | Oil baffle, upper part |

1. Removal

- ⇒ Remove the screws (5) to both holders (4) (Fig. 'A' and 'C').
- ⇒ In addition, to ensure a better access for the removal of thrust bearing pads (2) (ASTERN operation), the upper part of oil baffle (7) (Fig. 'B' and 'D') is also to be removed (see 1132-2).
- ⇒ Insert and laterally fasten turning-out device (94155) or (94155a) or (94155b) respectively to the gear wheel or the thrust bearing flange as illustrated on Fig. 'B' or 'D'.



The crankshaft must not be turned by turning gear when workmen are in crankcase.

- ⇒ The crankshaft is then to be turned with the turning gear until an eye bolt M16 can be screwed into a pad which can then be lifted up and removed one by one.



Remark : When only a few thrust bearing pads of a row are to be removed the crankshaft is located in its axial position by the remaining pads. When all thrust bearing pads must be removed then the crankshaft must be prevented from sliding axially. Therefore, insert a piece of hardwood of the same thickness in place of the thrust bearing pad.

Thrust Bearing
Removal and Fitting the Thrust Bearing Pads

2. Fitting

- Make absolutely sure that all the thrust bearing pads are meticulously clean and smeared with fresh engine oil; the thrust bearing pads must all be re-placed in their original position. Note the numbering of the individual pads! Also refer to the following pages for the arrangement of thrust bearing pads on engines with fixed pitch propellers (F.P.P.) and controllable pitch propellers (C.P.P.) respectively.
- For fitting the thrust bearing pads tool (94155) or (94155a) or (94155b) respectively can also be utilized. Note in this respect that the first pad, when pushed in, rests against the tool. The following thrust bearing pads can then be fitted one after the other while simultaneously turning the crankshaft. The thrust bearing pads should slide in without effort to their end position.



After fitting the thrust bearing pads immediately remove tool (94155) or (94155a) or (94155b) respectively.

CHECK

With all the thrust bearing pads in position the distances from the outermost pads on the fuel side and on the exhaust side to the upper edge of the bedplate must be equal. The holders (4) can now be refitted. Subsequently check the clearance between holder and thrust bearing pads (2) and (2a) (see Clearance Table 0330-1 'Crankshaft and thrust bearing').

- Prior to fitting screws (5) clean threads, tap holes and coat screw threads with LOCTITE No. 222.

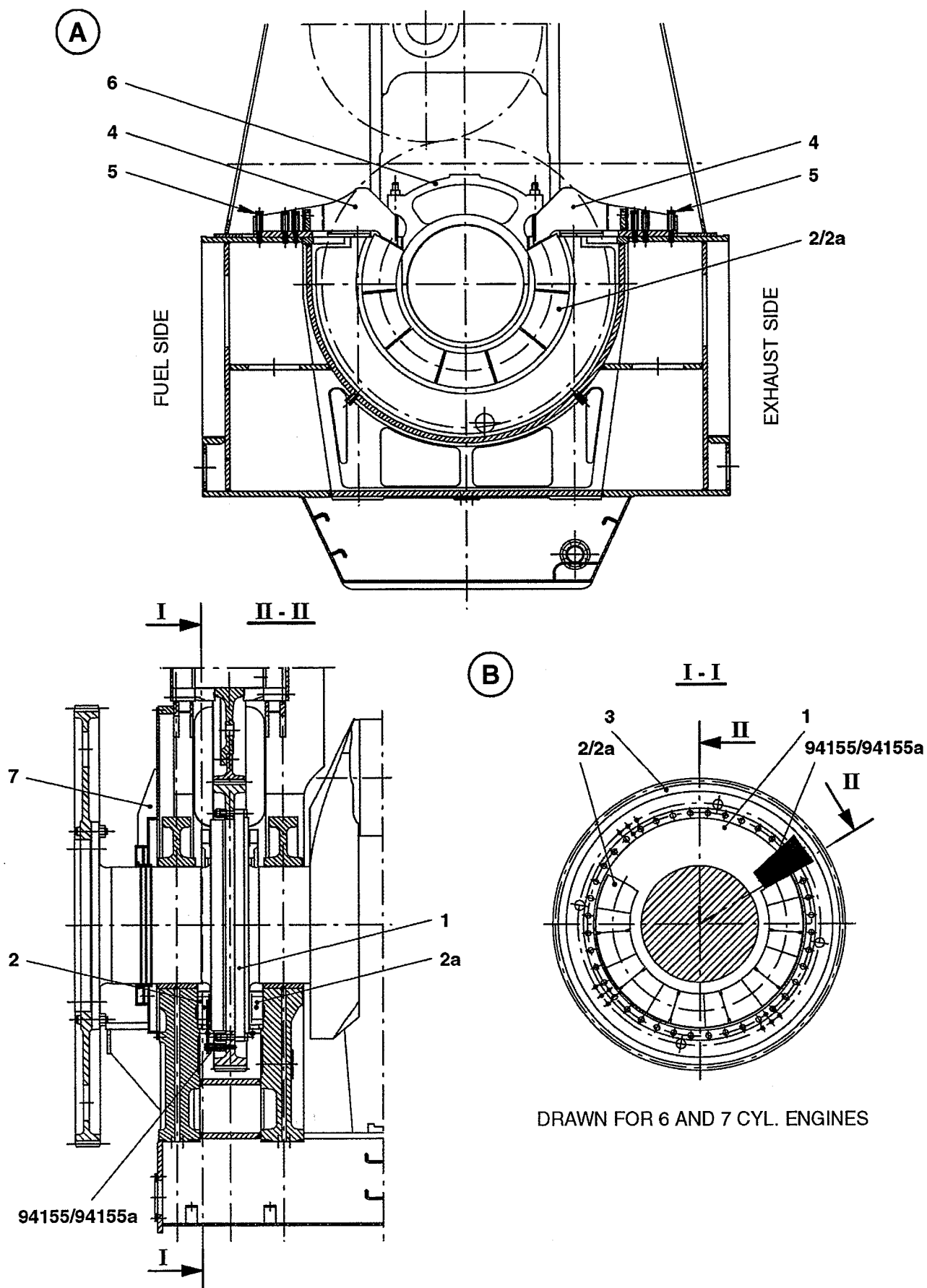

Remark

: When fitting new or remetalled thrust bearing pads, care must be taken that their thickness (final dimension) corresponds exactly with the neighbouring pads.

When replacing a complete row of new or remetalled thrust bearing pads the clearance must be adjusted to the original values (see Clearance Table 0330-1 'Crank-shaft and thrust bearing' and 1203-1).

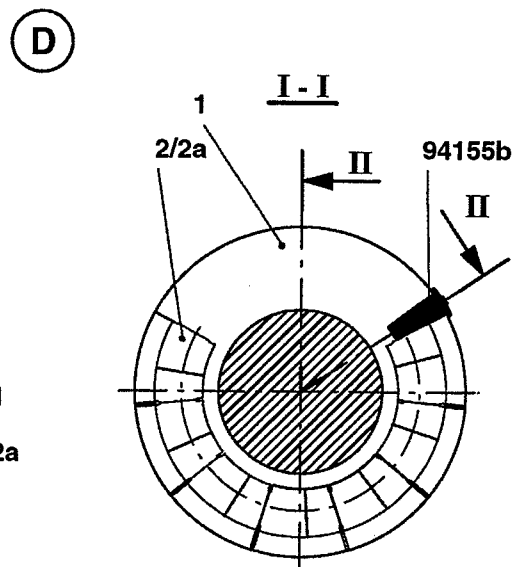
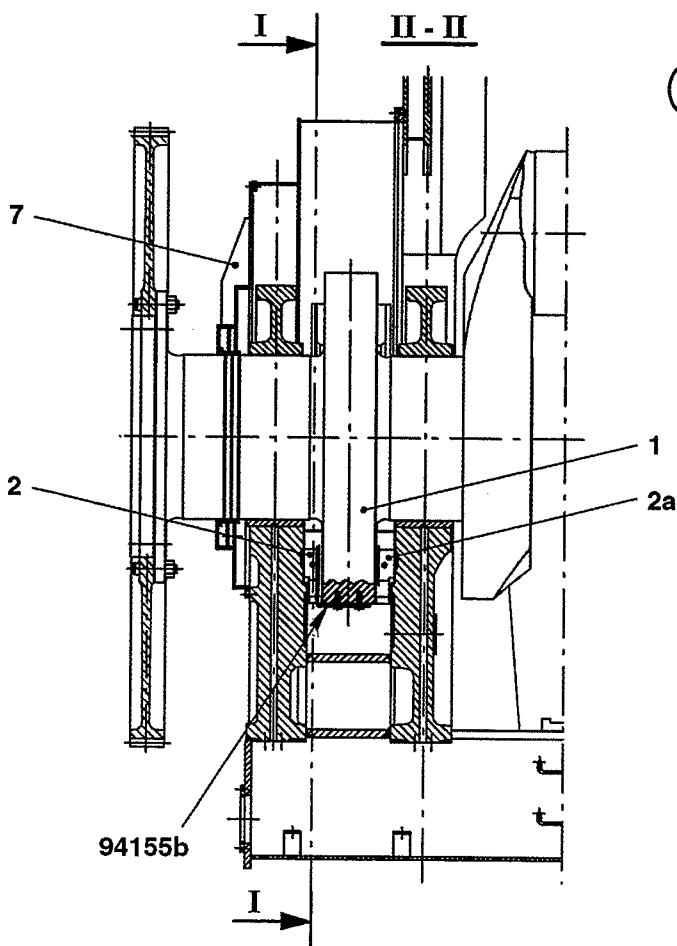
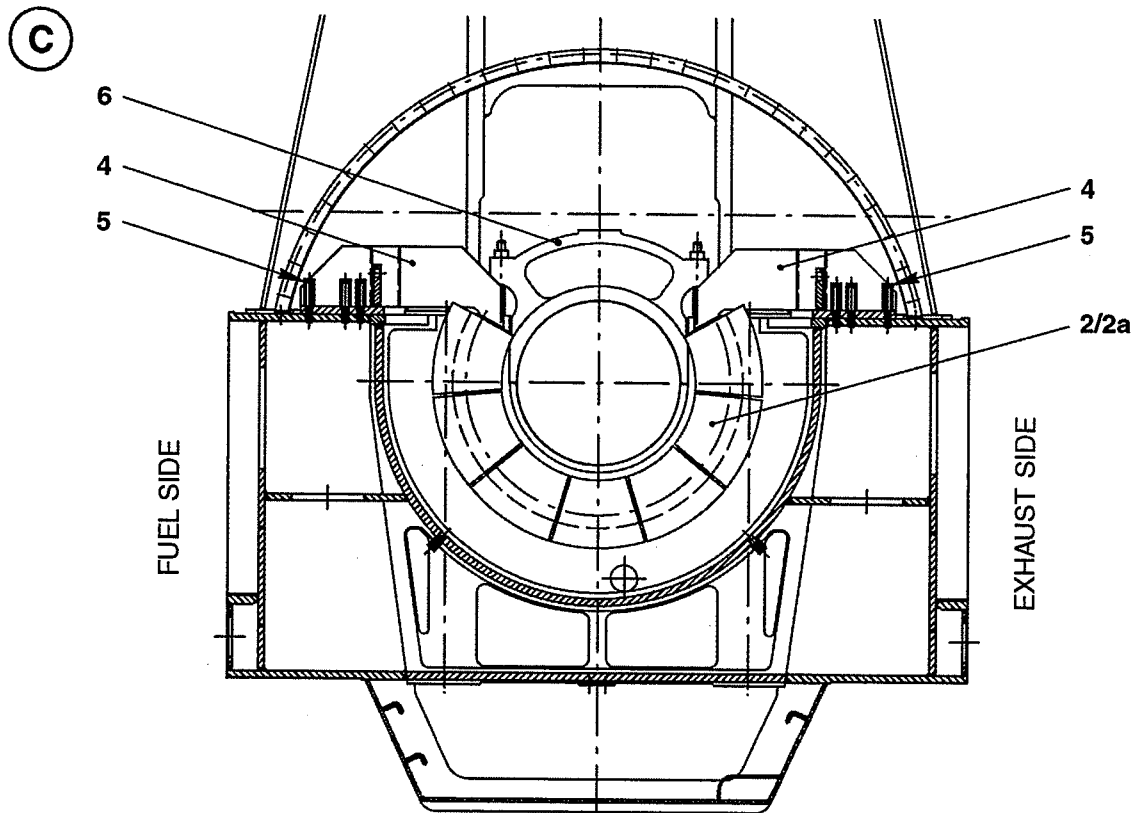
Thrust Bearing

Removal and Fitting the Thrust Bearing Pads



Thrust Bearing

Removal and Fitting the Thrust Bearing Pads

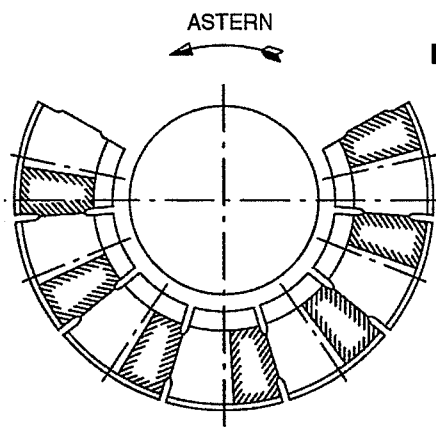


DRAWN FOR 8-12 CYL. ENGINES

Thrust Bearing

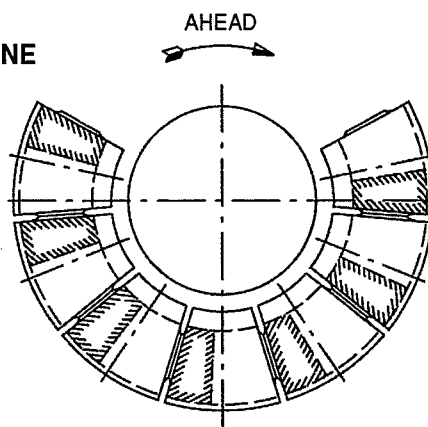
Removal and Fitting the Thrust Bearing Pads

**ARRANGEMENT OF THRUST BEARING PADS
FOR ENGINES WITH FIXED PITCH PROPELLER**

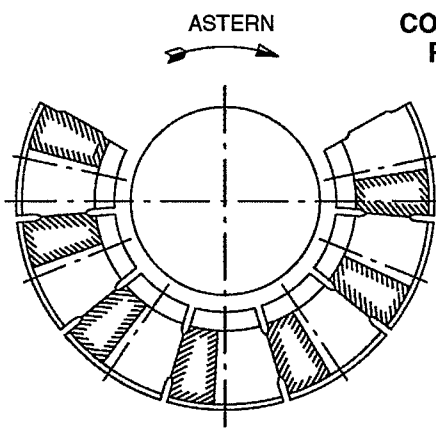


VIEW FROM DRIVING END
PADS AT DRIVING END

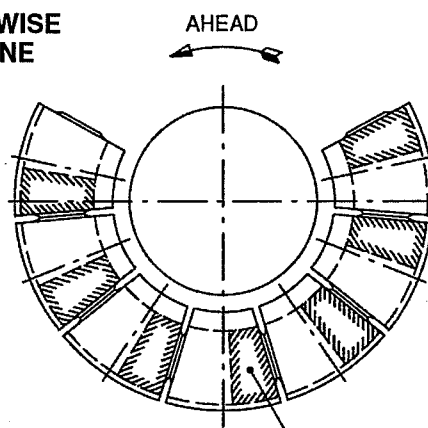
**CLOCKWISE
ROTATING ENGINE**



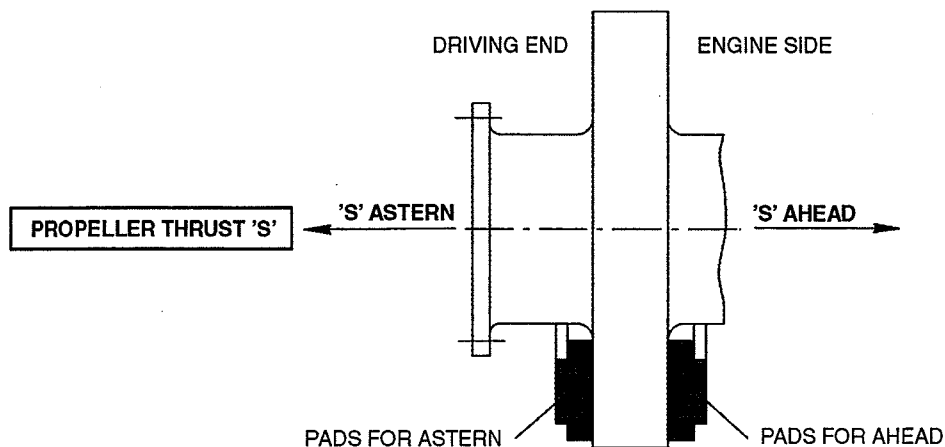
VIEW FROM DRIVING END
PADS ON ENGINE SIDE



**COUNTER-CLOCKWISE
ROTATING ENGINE**



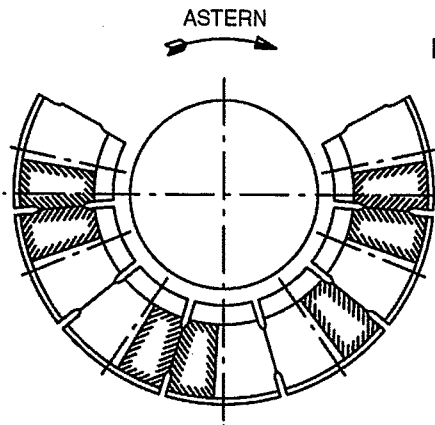
SUPPORT SURFACE



Thrust Bearing

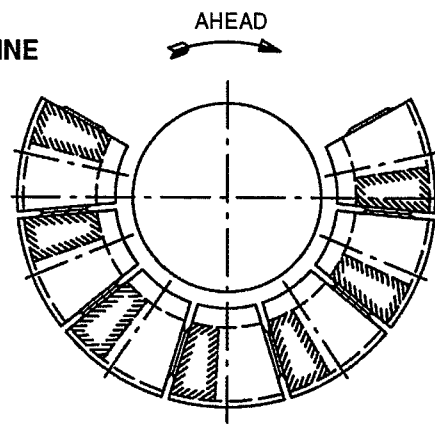
Removal and Fitting the Thrust Bearing Pads

ARRANGEMENT OF THRUST BEARING PADS FOR ENGINES WITH CONTROLLABLE PITCH PROPELLER

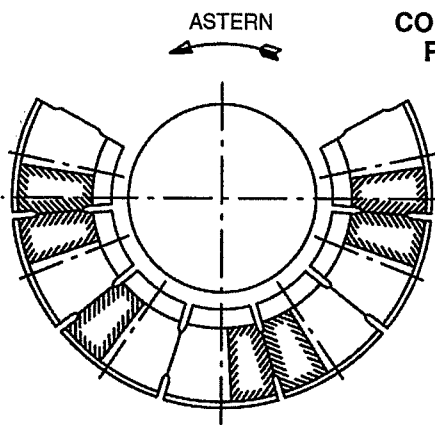


VIEW FROM DRIVING END
PADS AT DRIVING END

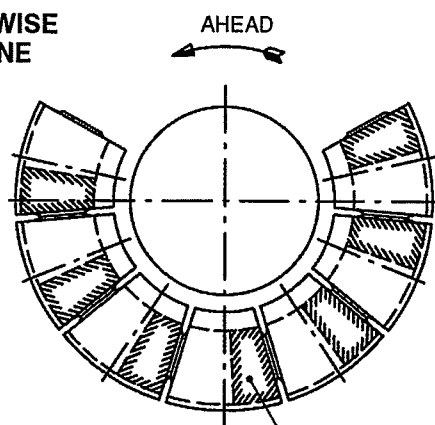
CLOCKWISE ROTATING ENGINE



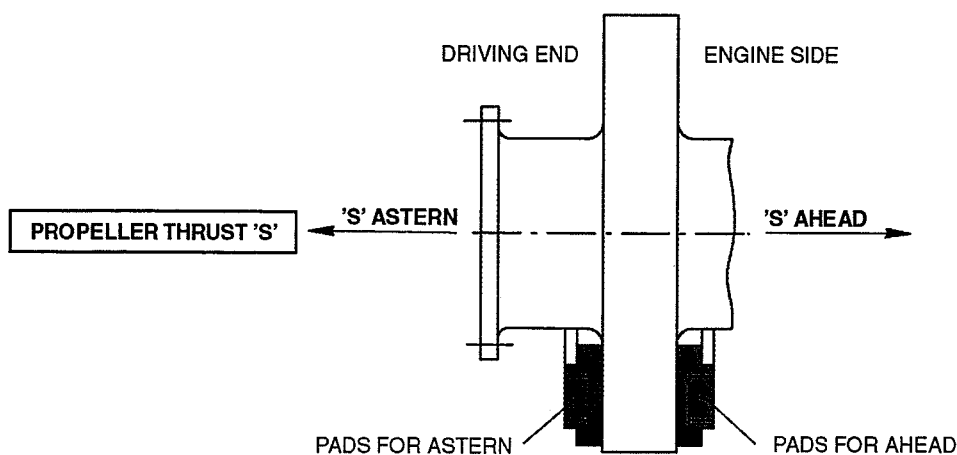
VIEW FROM DRIVING END
PADS ON ENGINE SIDE



COUNTER-CLOCKWISE ROTATING ENGINE



SUPPORT SURFACE



Engine Stays with Friction Shims
Checking the Pre-tension of the Waisted Studs

Tools:

1	Feeler gauge	94122
1	Pre-tensioning jack	94145
1	HP oil pump	94931
1	Pressure gauge	94932
1	Connection piece	94934
2	HP hose	94935a

Key to Illustrations:

1	Engine stays	9	Cylinder
2	Friction shims	10	Sealing ring
3	Screw		
4	Nut		
5	Disc spring	EV	Relief valve
6	Vent screw	KO	Slot
7	Pin	PP	Closing piece
8	Piston	RS	Round bar

1. General

Four friction type stays (1) are installed on the exhaust side of the engine (Fig. 'A').

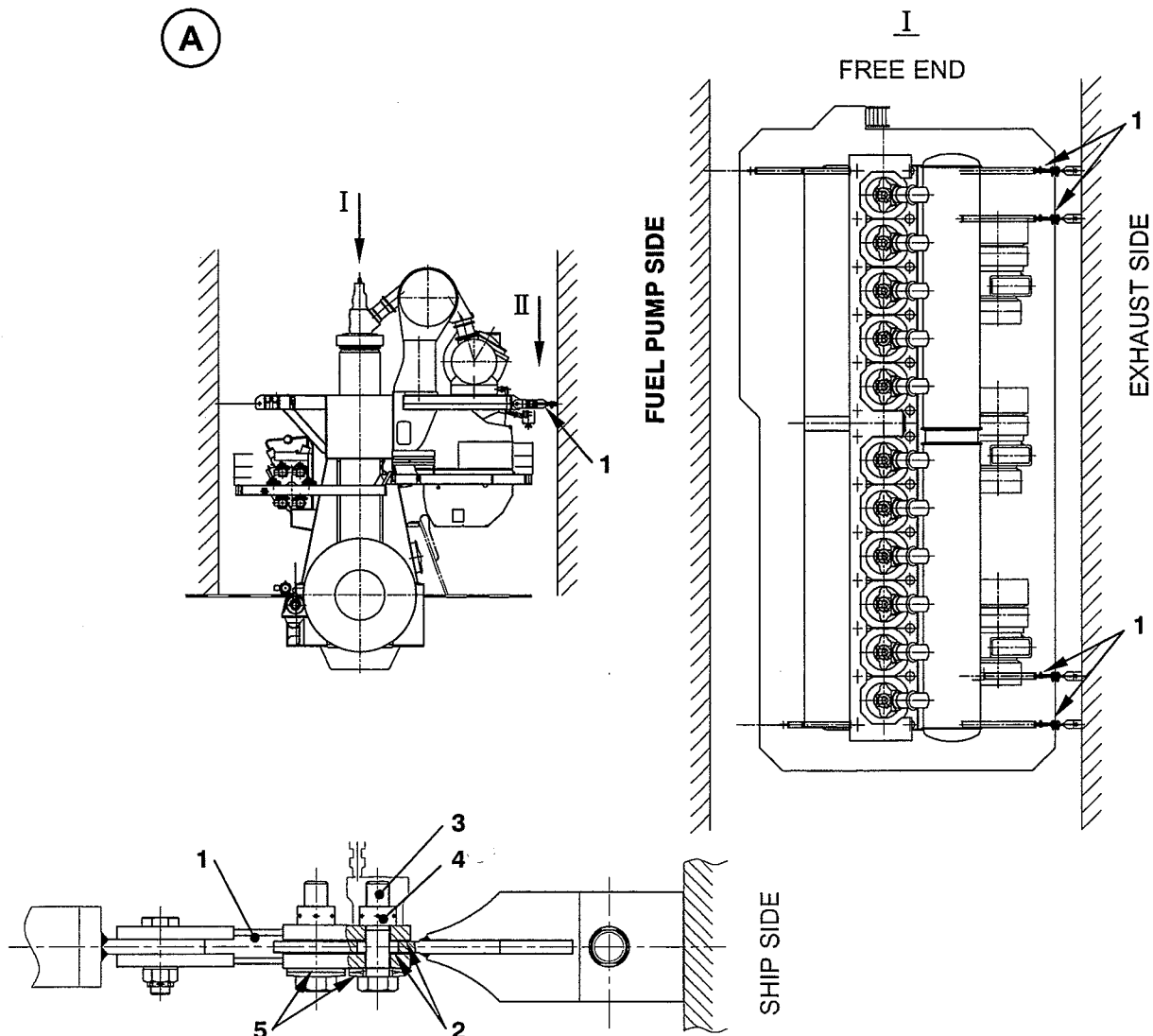
CHECK

*The pre-tension of screws (3) must be checked at specified intervals (see 0380-1).



Remark

: Pay attention to General Application Instructions 9403-4 for hydraulic pre-tensioning jacks.



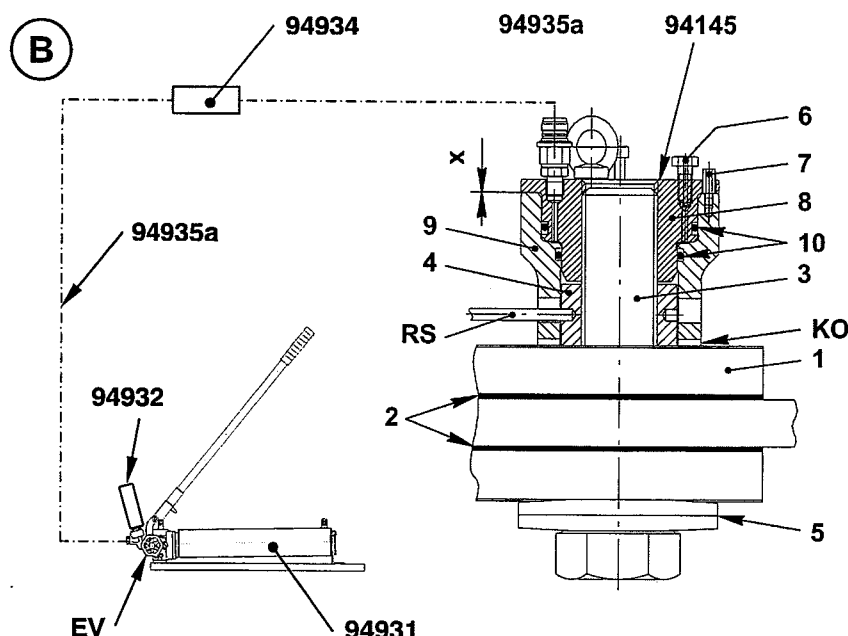
Engine Stays with Friction Shims
Checking the Pre-tension of the Waisted Studs
2. Checking the pre-tension

- ⇒ Clean the screw thread and the seating surface. Subsequently apply MOLYKOTE G paste to the thread.
- ⇒ Place pre-tensioning jack (94145) on the screw to be checked, and screw it completely down with vent screw (6) open until there is only little or no clearance at 'x' (Fig. 'B').
- ⇒ Connect pre-tensioning jack (94145) with HP oil pump (94931) as shown in Fig. 'B'.
- ⇒ Close relief valve "EV" at the HP oil pump, then actuate the HP oil pump until the oil comes out without bubbles from opened vent screw (6).
- ⇒ Close vent screw (6), tension the screw with **26.3 MPa** and keep the pressure constant.

CHECK

Check with feeler gauge through slot "KO" if there is any clearance between nut (4) and its seating.

- ⇒ If there is no clearance, this means that the tensioning condition of the screw has remained unchanged since the last check. The pressure can be released to zero and the pre-tensioning jack removed. Should a clearance be found, nut (4) must be tightened down onto its seating with round bar "RS" while the pressure is kept at **26.3 MPa** (check with feeler gauge). Subsequently lower the pressure to zero.


3. Loosening the screws

If the screws must be loosened, first screw on pre-tensioning jack (94145) completely, then loosen it by about ½ turn. Afterwards tension the screw with **27.3 MPa**, and turn nut (4) back by one turn.



Attention should be paid to ensure that pin (7) always protrudes slightly compared with piston (8) on the pre-tensioning jack!

Tie Rod

Checking the Pre-tension and Tensioning the Tie Rods

Tools :			Key to Illustrations :			
2	Pre-tensioning jacks	94180	1	Cylinder jacket	12	Clamp screw
1	Pressure gauge	94932a	2	Intermediate ring	13	Column
1	Connection piece	94934	3	Upper tie rod nut	14	Bedplate
1	Connection piece	94934a	4	Cylinder	15	O-ring
1	HP hose	94935	5	Piston	16	Lower backing ring
3	HP hoses	94935a	6	Sealing ring	17	Lower tie rod nut
1	Hydraulic unit	94942	7	Round bar	18	Bush
			8	Vent screw		
			9	Tie rod	AN	Drain slot
			10	Screw	KO	Slot
			11	Protection cap	MS	Measuring place

1. General

We recommend that about one year (6,000 ~ 8,000 operating hours) after commissioning the engine all the tie rods are checked for their correct pre-tensioning and if necessary to tension them to the specified value. Later it is sufficient to make random checks during major over-hauls, or the pre-tension of all tie rods has to be checked within 4 years.

 **Remark** : For such checks it is not required to loosen the waisted studs of the main bearings nor the clamp screws (12) of the tie rods.

2. Checking the pre-tension of tie rods

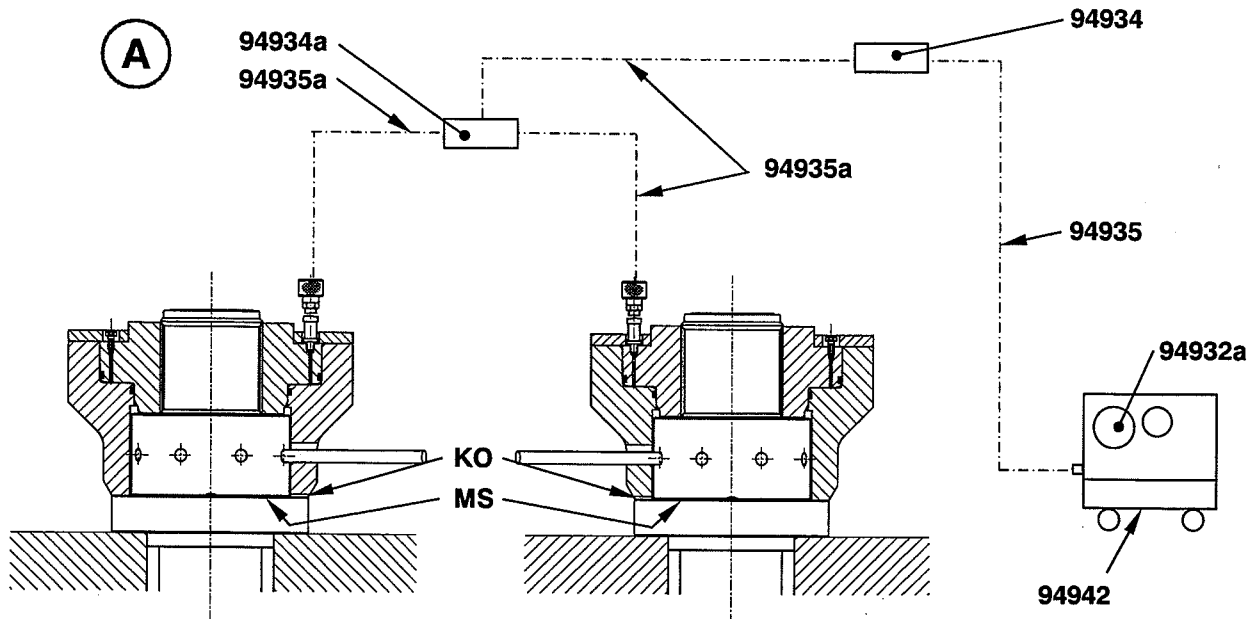
- ⇒ Remove thread protection cap (11) from all tie rods and clean the contact face of intermediate ring (2).
- ⇒ Screw both pre-tensioning jacks (94180) onto two tie rods lying opposite each other until cylinder (4) rests on intermediate ring (2), i.e. there is only little or no clearance at 'x' (Fig. 'A'). If necessary, turn the pre-tensioning jack back a little so that the holes in the tie rod nuts (3) are accessible. Slightly slacken vent screws (8).
- ⇒ Connect both pre-tensioning jacks (94180) with hydraulic unit (94942) according to Fig. 'A'.
- ⇒ Actuate the hydraulic unit till bubble-free oil flows out through vent screws (8). Close vent screws.
- ⇒ Operate hydraulic unit up to **100 MPa** and maintain this pressure.
- Attention should be paid to ensure that pins (8) protrude slightly compared with pistons (5) on the pre-tensioning jacks.

CHECK

Using a feeler gauge inserted through slot "KO", check at "MS" if there is any clearance between tie rod nut (3) and intermediate ring (2).

Tie Rod

Checking the Pre-tension and Tensioning the Tie Rods



- ⇒ If any clearance does exist, tighten the tie rod nut with round bar (7) until it rests firmly on the intermediate ring (check with feeler gauge). Subsequently re-lease the pressure to zero at the hydraulic unit. If no clearance exists, the pressure can immediately be released and the pre-tensioning jacks removed. Check all the tie rods in this manner and, wherever necessary, tighten the tie rod nut.
- ⇒ The tie rod threads have to be protected against corrosion by coating them with MOLYKOTE grease after checking has been completed. The protection cap must then be screwed on tightly.

3. Loosening and tightening the tie rods

Should tie rods have to be removed or fitted, the following points have to be care-fully observed:

- ⇒ Remove clamp screws (14) (Fig. 'D').
- Tensioning has to be carried out in three steps. The order in which the tie rods are to be loosened or tensioned is shown in schematic illustration (Fig. 'C'), i.e. in pairs, first tie rods a/a, then b/b, etc.
- If the tie rods have been newly tightened, then the waisted studs of the main bearings also have to be checked for correct pre-tensioning (see 1132-1).

Tie Rod
Checking the Pre-tension and Tensioning the Tie Rods

3.1 Loosening

The procedure for loosening the tie rods is the same as the one described above for checking the pretension, except that the pre-tensioning jacks must be released by 1 ½ turns after being completely screwed down. At this starting point (Fig. 'A') connect the jacks with the hydraulic unit and operate it until a pressure of **102 MPa** is reached. The tie rod nuts are now loose and can be unscrewed with round bar (7) until they touch piston (5).

Before releasing the hydraulic pressure to zero, it is of advantage to place a hardwood wedge under the lower tie rod nut (17) in the bed plate, whereby the wedge will take the full weight of the tie rod.

The pre-tensioning jacks can now be removed.

3.2 Tensioning
Preliminary works:

- Clamp screws (12) must not be tightened up.
- Lower nut (17) of the tie rod is screwed on.
- ⇒ Clean the seating surface for intermediate ring (2) and upper nut (3) and smear them with MOLYKOTE paste G.
- ⇒ Smear the tie rod thread for upper nut (3) lavishly with MOLYKOTE paste G and screw the nut on (check for easy threading).
- ⇒ Screw ring screw into the tie rod and lift carefully till the lower tie rod nut rests snugly against the bearing girder.



Use a chain block hooked onto the crane, with which the tie rod can be lifted manually till the lower nut is snug on its seating, as with the crane alone the landing of the nut cannot easily be felt and the rope might break.

- ⇒ In this position tighten the upper tie rod nut with round bar (7) till firmly seated on the intermediate ring, and separate the chain block from the tie rod.

CHECK

There must now be no clearance between bearing girder and lower tie rod nut and the lower tie rod nut must be flush with the tie rod end.

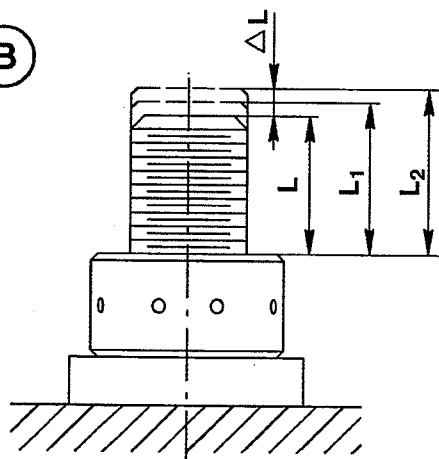
3.2.1 Working sequence for tensioning

- ⇒ If all the preliminary work has been carried out, then pre-tensioning jacks (94180) with loosened vent screws (8) have to be screwed onto both tie rods a/a (Fig. 'C'). Attention should be paid to easy access to one of the slotted apertures to tighten upper tie rod nuts (3).
- ⇒ Connect pre-tensioning jacks with hydraulic unit (94942) as shown in Fig. 'A'.
- ⇒ Actuate the hydraulic unit till oil flows out bubble-free at the vent screws (9) , then tighten these.
- ⇒ Actuate the hydraulic unit and raise a pressure of **10 MPa (1st step)**, keep pressure constant till the two upper tie rod nuts (3) have been tightened down firmly with round bar (7). Then release pressure to zero at the hydraulic unit.

Tie Rod

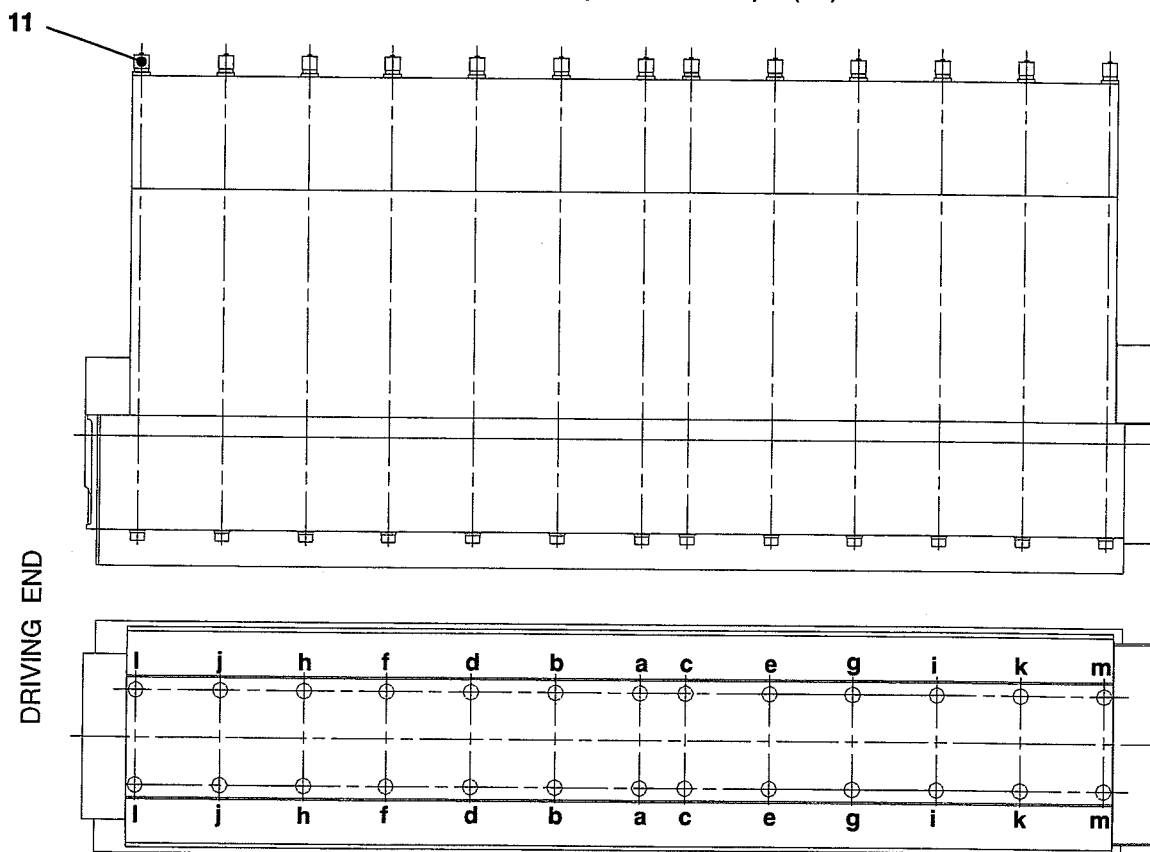
Checking the Pre-tension and Tensioning the Tie Rods

(B)



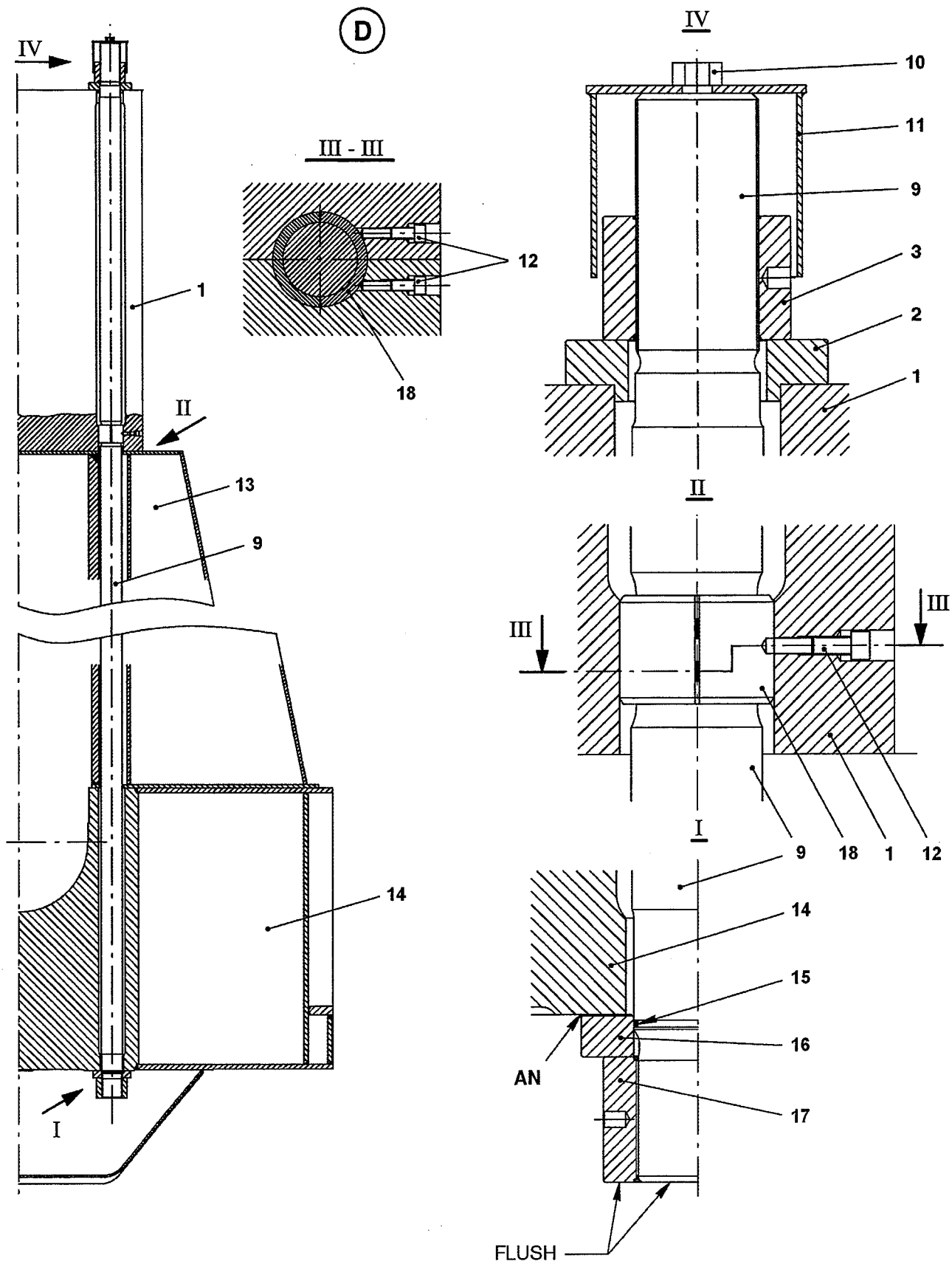
- ⇒ Measure and record distance 'L' (Fig. 'B') (initial position).
- ⇒ Repeat the procedure, but raise the pressure to **60 MPa (2nd step)**.
- ⇒ Measure again distance 'L' and record it as 'L₁'. The tie rods are correctly tensioned when with a pressure of **60 MPa** the following reference value is measured:
'L₁' - 'L' = about 6.4 mm.
- ⇒ In this manner tension all tie rods in the sequence as described above.
- ⇒ After all tie rods have been pre-tensioned with 60 MPa, these are to be tensioned with **100 MPa** in the same sequence (**3rd step**). Measure again distance 'L' and record it as 'L₂'. The tie rods are correctly tensioned when with a pressure of **100 MPa** the following reference value is measured:
total elongation
 $\Delta L = \text{about } 11.5 \text{ mm ('L}_2\text{' - 'L')}$.
- ⇒ After completing the tensioning, smear the protruding thread portions of all the tie rods lavishly with MOLYKOTE grease and fit protection caps (11).

(C)



Tie Rod

Checking the Pre-tension and Tensioning the Tie Rods



Group 2

2

▽ Cylinder Liner

- Measuring Bore Wear.....2124-1/A1
- Removal and Fitting.....2124-2/A1
- Removing the Wear Ridge, Re-dressing Lubricating Grooves.....2124-3/A1
and Scavenge Ports
- ECL-SIP Valve: Function Check, Removal and Fitting.....2136-5/A1
- Piston Rod Gland Box: Dismantling and Assembling, Measuring the Wear2303-1/A1

▽ Cylinder Cover

- Removal and Fitting of the Cylinder Cover and Water Guide Jacket.....2708-1/A1
- Hydraulic Loosening and Tensioning of Cylinder Cover Waisted Studs....2708-2/A1
- Machining of Sealing Face for the Injection Valve.....2708-3/A1
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- Relief Valve for Cylinder Cover: Dismantling, Assembling and Testing2740-1/A1

▽ Exhaust Valve

- Removal and Fitting of.....2751-1/A1
the Exhaust Valve, Replacing of the Waisted Studs
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- Replacing and Grinding the Valve Seat.....2751-3/A1
- Grinding the Seating Surface on the Valve Head2751-4/A1

Cylinder Liner

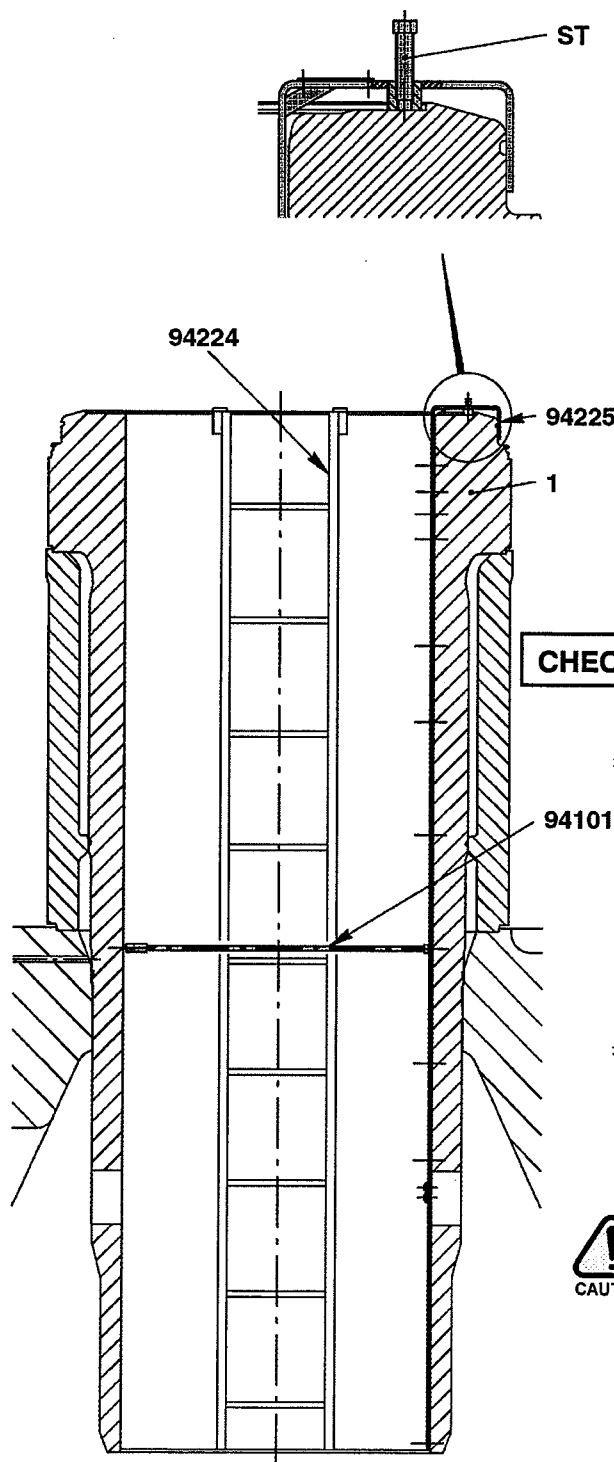
Measuring Bore Wear

Tools :

- 1 Inside micrometer 94101
- 1 Ladder 94224
- 1 Measuring gauge 94225
- 1 Standard gauge for inside micrometer
- 1 Cover for gland box bore

Key to Illustrations :

- 1 Cylinder liner
- ST Setting screw



- ⇒ The wear of the cylinder liners should be checked after every piston removal. Always measure cylinder liners in fitted position.
- ⇒ To permit comparisons with measures previous always carry out measuring in the same place and note down the values on a log sheet.
- ⇒ To this end always use measuring gauge (94225). It is so designed that it can simply be hooked over the top face of the liner.
- ⇒ The measurements have to be taken in longitudinal and transversal directions to the engine axis by putting inside micrometer (94101) into the holes provided for this purpose in the measuring gauge.

CHECK

For maximum permissible inside diameter refer to Clearance Table 0330-1 'Cylinder liner'.

- ⇒ Should the thickness of the compression shims be altered after putting the engine into operation, then the length of setting screw 'ST' has to be adjusted accordingly on measuring gauge (94225). By this the measuring bores of the gauge are again brought to the original setting relative to the position of the piston.
- ⇒ The ridge formed during the course of operation at the top of the cylinder bore has to be removed carefully without damaging the running surface for the piston rings (see 2124-3).



The gland box bore must be covered with the cover for gland box bore whenever a cylinder liner is being inspected.

Cylinder Liner
Removal and Fitting

Tools :

1	Suspension bridge beam	94202
2	Wedges	
2	Suspension straps	94206
2	Screws to 94206	94207
1	Hydraulic Unit	94942
1	Pressure gauge	94932a
1	Connection piece	94934a
3	HP hose	94935
2	HP hoses	94935a
2	Hydr. jacks	94936

Key to Illustrations :

1	Screw	10	Cylinder cover
2	Water guide jacket	11	O-ring
3	Supporting ring	12	O-ring
4	Cylinder liner		
5	Cylinder jacket		
6	Allen screw		
7	Centring pin		
8	O-ring	AF	Seating surface
8a	O-ring		
9	Centring pin	HU	Wooden underlay

Overview

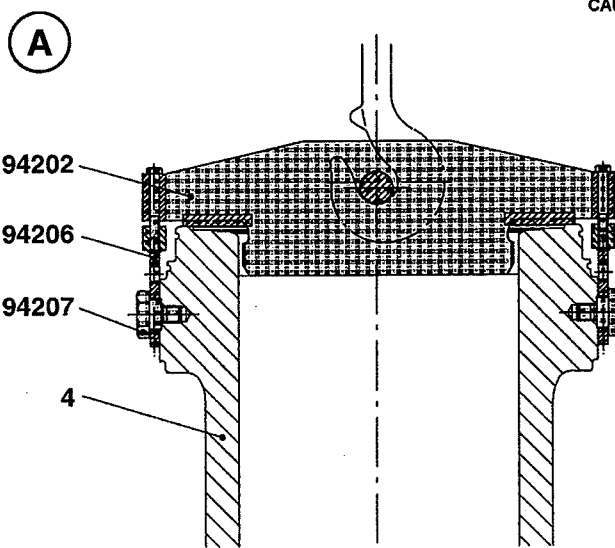
1. Preparations for the removal of a cylinder liner	1/5
1.1 Removal	1/5
1.2 Removal of a jammed cylinder liner	2/5
2. Removal and fitting of a supporting ring	3/5
3. Preparations for fitting a cylinder liner	3/5
3.1 Fitting	3/5
4. Righting and laying down a cylinder liner	5/5

1. Preparations for the removal of a cylinder liner

- ⇒ Drain cylinder cooling water from the respective cylinder, and remove cylinder cover (see 2708-1).
- ⇒ Remove piston together with piston rod gland box (see 3403-1 and 2303-1).
- ⇒ The **two screws (1)** fastening supporting ring (3) with cylinder liner (4) **must be loosened and removed** (Fig. 'E') .



Separate all piping connections for cylinder oil from the ECL-SIP valves. **All the ECL-SIP valves as well as their protecting bushes must be removed** whenever a cylinder liner is being pulled out.



1.1 Removal (Fig. 'A')

A cylinder liner can be removed normally by crane and suspension bridge beam, whereby the following must be observed:

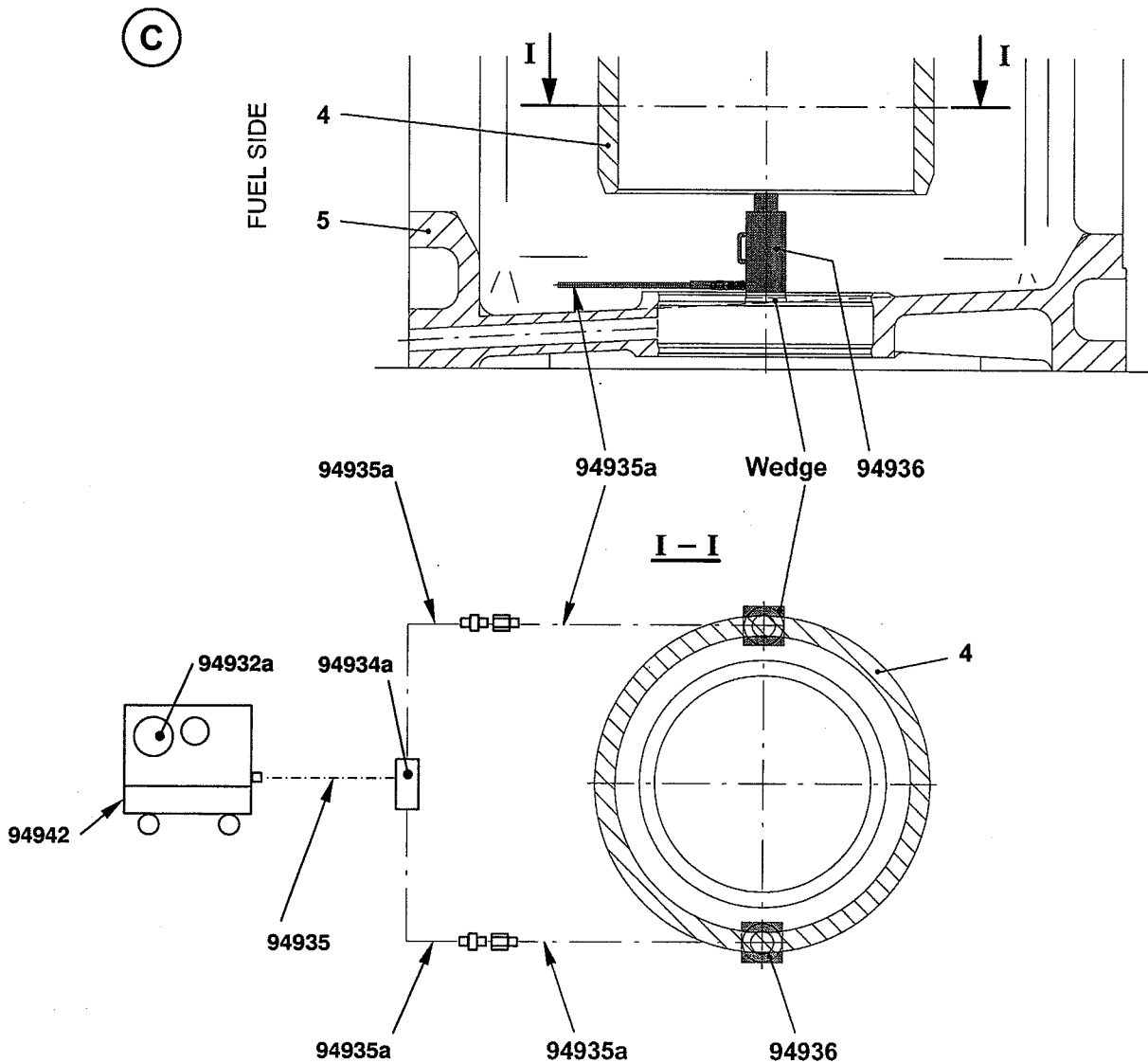
- ⇒ Mount suspension bridge beam (94202) and screw fasten it together with the suspension straps (94206) and screws (94207).
- ⇒ Pull cylinder liner fully out.

Cylinder Liner
Removal and Fitting

1.2 Removal of a jammed cylinder liner (Fig. 'B')

If a cylinder liner jam in the cylinder jacket bore, proceed as follows:

- ⇒ Place both wedges at the bottom of cylinder jacket (5) as shown in Fig. 'B'.
Thereby the bigger end of the wedges must point towards fuel side.
- ⇒ Place both hydr. jacks (94936) on wedges and push them against the cylinder liner.
- ⇒ Connect hydr. jacks by HP hoses (94935), (94935a) as well as connection piece (94934a) to hydraulic unit (94942).
- ⇒ Jack out the cylinder liner (4) of its guide portion by slowly pumping.



Cylinder Liner Removal and Fitting

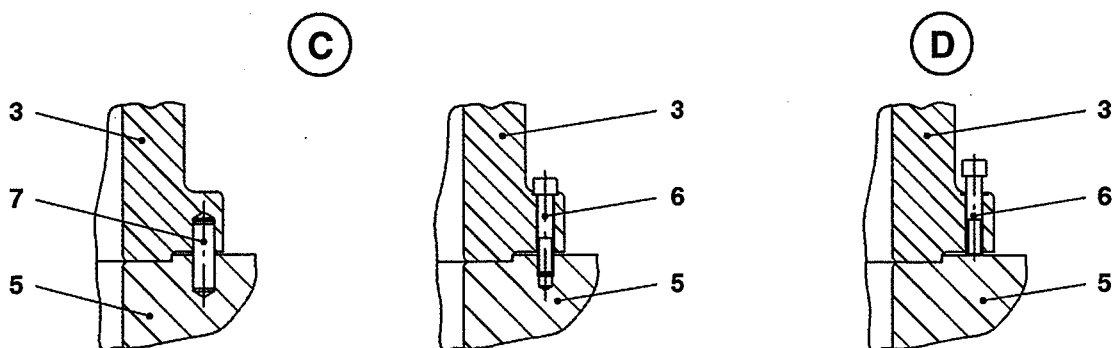
2. Removal and fitting of a supporting ring

2.1 Removal

Supporting ring (3) (Fig. 'C' and 'E') is fastened with three Allen screws (6) to cylinder jacket (5) and located on fuel side by centring pin (7). For the removal of the supporting ring the three Allen screws (6) can be used as jacking screws (see Fig. 'D').

2.2 Fitting

- ⇒ The sealing surfaces on supporting ring and cylinder jacket must be cleaned and then smeared with a non-hardening sealing compound (e.g. silicone).
- ⇒ Place supporting ring.
- ⇒ Apply LOCTITE 245 to screws (6) and tighten them with a torque of **150 Nm**.



3. Preparations for fitting a cylinder liner

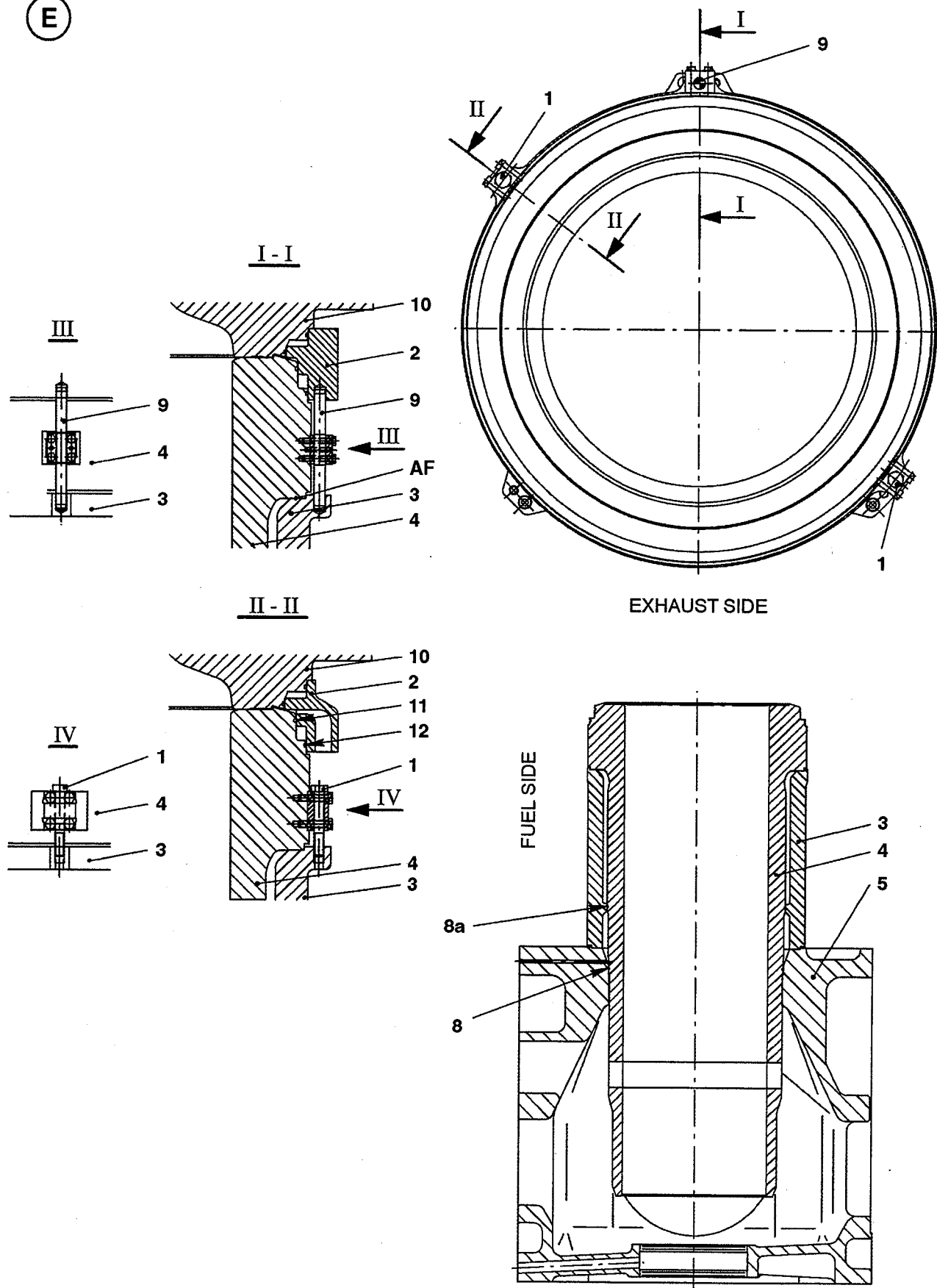
- ⇒ Clean all guide areas and sealing surfaces on cylinder liner (4) and cylinder jacket (5) as well as on supporting ring (3).
- ⇒ Place O-rings (8) and (8a) of the specified quality and dimension into the grooves on the cylinder liner.
- ⇒ Smear O-rings and guide areas of cylinder liner, cylinder jacket and supporting ring with grease.
- ⇒ Clean seating surfaces 'AF' of supporting ring (3) and cylinder liner (4) carefully.

3.1 Fitting

- ⇒ Mount suspension bridge beam (94202) and screw fasten it together with the suspension straps (94206), and screws (94207) according to Fig. 'A'.
- ⇒ Move the cylinder liner hanging on the crane above the supporting ring (3).
- ⇒ Lower the cylinder liner and apply a non-hardening sealing compound to the seating surfaces "AF" (Fig. 'E' section I-I) evenly.
- ⇒ Turn cylinder liner and align the centring pin (9) with the centring holes of the supporting ring and cylinder liner. Lower cylinder liner.
- ⇒ Fit screws (1) and tighten them firmly for locking the cylinder liner onto the supporting ring (Fig. 'E' section II-II).

Cylinder Liner
Removal and Fitting

(E)



Cylinder Liner
Removal and Fitting

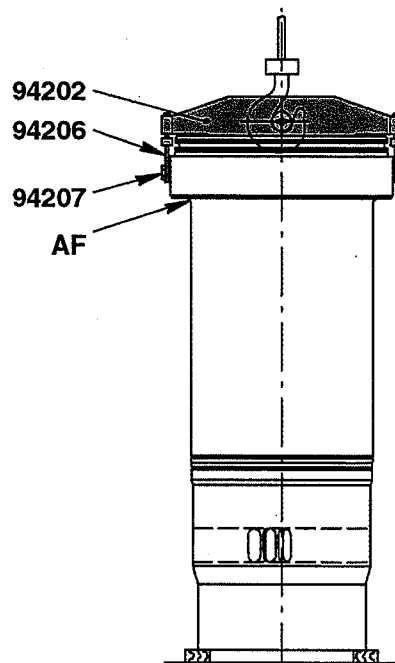
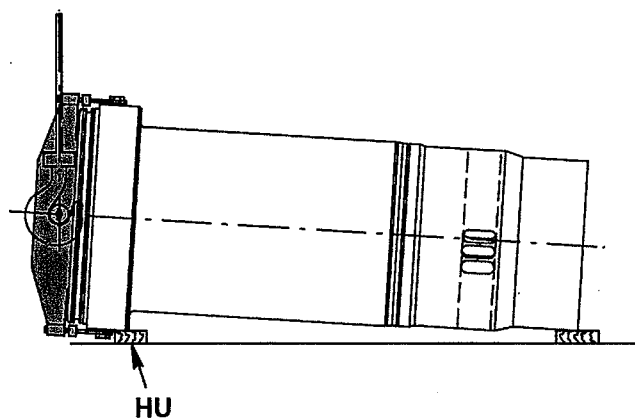
4. Righting and laying down a cylinder liner

Righting and laying down respectively has to be done with the aid of the suspension bridge beam (94202), the suspension straps (94206) and screws (94207).



Risk of accident! Raising and laying down a cylinder liner **must not be done in any other way than as shown in the figure**, i.e. in the longitudinal direction of the suspension cross beam (94202)!

F



Cylinder Liner

Removing the Wear Ridge, Re-dressing Lubricating Grooves and Scavenge Ports

Tools :

- 1 Portable handy grinder
- Emery cloth
- Assorted files
- Fine grain carborundum
- 1 Cover for gland box bore
- Oil stone

Key to Illustrations :

- SI Scavenge port
- SN ECL-SIP Lubricating grooves

1. General

Due to wear in the cylinder liner a ridge is formed on top to where the piston rings do not reach during the course of operation. By that also the lubricating grooves in the cylinder liner lose their depth, and the corner radii of the scavenge port edges become smaller.



After every piston removal measure the bore of the cylinder liner (see 2124-1) and remedy any irregularities. For that the following points are of importance:

- The gland box bore must be covered with the cover for gland box bore.
- After completing the reconditioning clean the bore of the cylinder liner thoroughly. (particularly the ECL-SIP lubricating grooves and Lubricating grooves)
- Remove waste particles which may have passed into the scavenge space through the ports.
- Execute the priming of ECL system until oil flows from all the lubricating points, thereby flushing away any metal dust.

2. Removing the wear ridge



When grinding away the wear ridge with portable handy grinder and fine grain carborundum take greatest care not to damage the running surface. (see Mitsubishi Service Information MSI-0103E)

3. Re-dressing the lubricating grooves

If the depth of the ECL-SIP lubricating grooves (Fig. 'A') has worn to less than 5 mm (new depth 6 mm) re-dress them to their original depth and slightly round their edges with the file or oil stone. If the ECL-SIP lubricating grooves has been re-dressed renew the taper washer on the seating surface of ECL-SIP valves (see 2136-5).

4. Re-dressing the edges on the scavenge ports

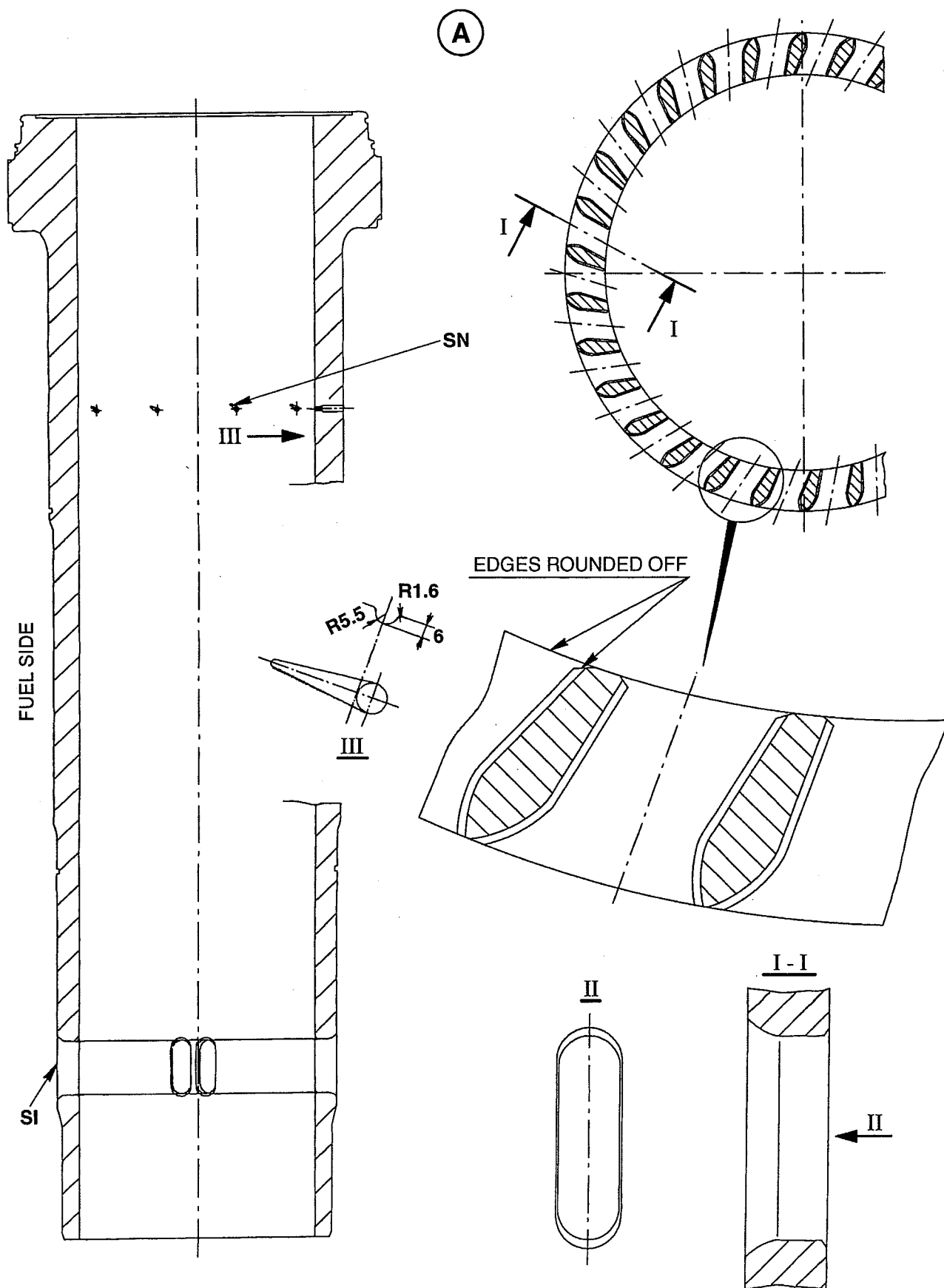
The shape of the scavenge ports shown in Fig. 'A' corresponds to new cylinder liners. When reconditioning (depending on the degree of wear or damage) aim at matching these shapes with portable handy grinder and Fine grain carborundum. Polish (round) the passages into the running surface with emery cloth.



Take care not to damage the running surface in the cylinder liner bore!

Cylinder Liner

Removing the Wear Ridge, Re-dressing Lubricating Grooves and Scavenge Ports



ECL-SIP Valve

Function Check, Removal and Fitting

Tools :

- 1 Nozzle testing unit
- 1 Bush tightening tool
- 1 Cleaning pin

Key to Illustrations :

- | | | |
|------------------|--------------------|------------------|
| 1 Cylinder liner | 11 Locating pin | 21 Bush |
| 2 ECL-SIP valve | 12 Valve body | 22 Spring |
| 3 Bush | 13 O-ring | 23 Spring disc |
| 4 Flange | 14 O-ring | 24 Needle |
| 5 Press plate | 15 Union | 25 Nozzle body |
| 6 Gasket | 16 Guide | 26 Gasket |
| 7 Screw | 17 Adjusting screw | 27 Gasket |
| 8 Screw | 18 Rocking nut | 28 Pointed screw |
| 9 Conical shim | 19 Screw | |
| 10 O-ring | 20 Adjusting rod | |

1. General

1.1 Check Function

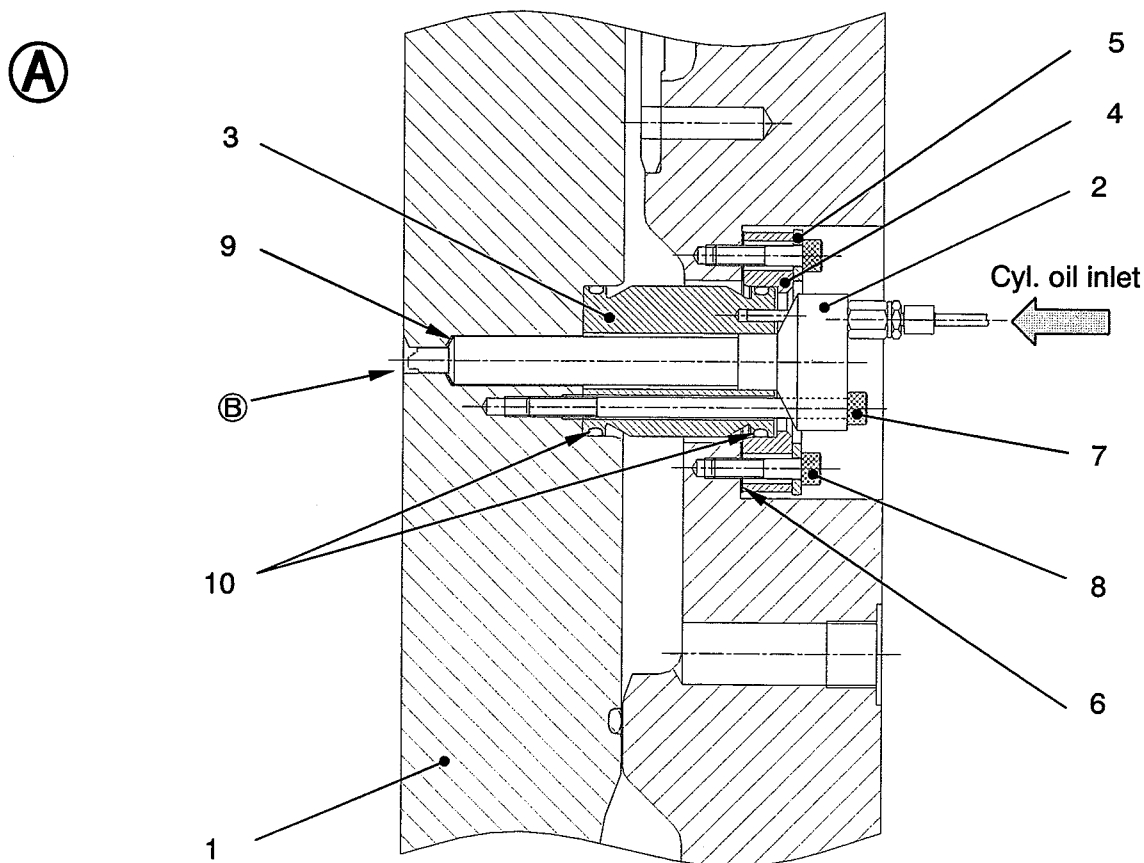
Lubricating oil injected by the ECL-SIP valves is evenly injected from all the lubricating points in the bore of the corresponding cylinder liner.

The ECL-SIP valves that do not inject lubricating oil properly must be checked.

It must be checked that the ECL-SIP valves properly inject lubricating oil when the exhaust valve or cylinder cover is removed.

The above can be visually checked when priming of cylinder lubricating oil.
 (refer to operation manual 0630-1/A1)

The above check can be checked through the scavenge air port.



ECL-SIP Valve

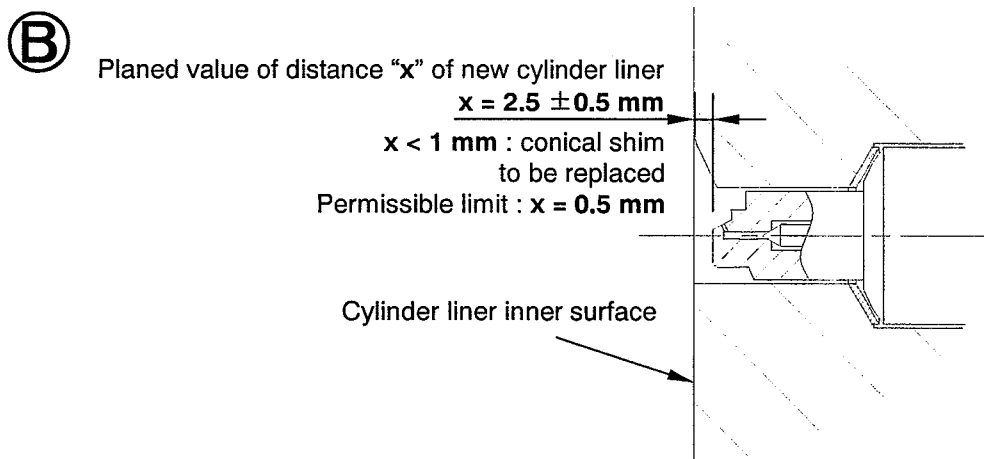
Function Check, Removal and Fitting

1.2 Check of distance "x" from ECL-SIP valve to running surface (Fig. 'B')

The distance "x" from ECL-SIP valve to running surface was adjusted to $2.5 \pm 0.5 \text{ mm}$ initially. The distance "x" does not reach zero when cylinder liner is worn until maximum permissible inside diameter under normal cylinder liner wear condition.

Therefore, in principle, the distance "x" does not need to adjust.

Renew the conical shim (9) and adjust the distance "x" if the distance "x" is reduced less than 1.0 mm (minimum thickness "x" = 0.5 mm) under abnormal cylinder liner wear condition.



1.3 Check ECL-SIP valve opening pressure

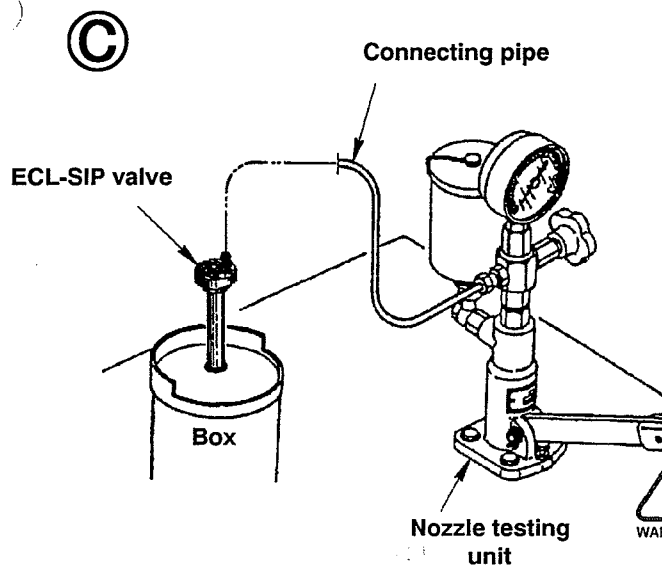
The connecting pipe must be connected with the ECL-SIP valve correctly.



The connecting pipe must be connected with nozzle testing unit and ECL-SIP valve certainly to prevent leakage.



Before commissioning the instructions and directions of the nozzle testing unit manufacturer must be observed.



During test of ECL-SIP valve lead drain to proper vessel.

ECL-SIP valve opening pressure:

$6.5 \pm 0.05 \text{ MPa}$ ($66.3 \pm 0.5 \text{ kgf/cm}^2$)

In case the pressure deviates from the specified the opening pressure should be adjusted. This can be done by loosening the locking nut (18) then adjusting the adjusting screw (17).

Turn clockwise to raise opening pressure.

Turn anti-clockwise to lower opening pressure.

Take care not to touch injected lubricating oil. Never hold finger or hands directly in front of the injection holes because injected lubricating oil is high pressure.



Remark

If the nozzle testing unit with electric motor driven pump is equipped in the work shop, refer to the instruction manual of the manufacturer.

ECL-SIP Valve

Function Check, Removal and Fitting

2. Removing and fitting



All the ECL-SIP valves and bushes must be removed whenever a cylinder liner is being pulled out.

2.1 Removing

- ⇒ Vent ECL-SIP valve return line by changing three-way valve position.
(refer to operation manual 8016-2)
- ⇒ Separate all piping connections for cylinder oil from the ECL-SIP valves.
- ⇒ Unscrew two screws (7) and remove the ECL-SIP valve and the conical shim (9).



Check: If there is no conical shim at the ECL-SIP valve head when the valve has been removed, take it out by using a wire and others from the bush (3).

- ⇒ Keep ECL-SIP valve and conical shim (9) insets.

2.2 Fitting

Fit the ECL-SIP valves into cylinder liner after testing valves.

- ⇒ Smear grease thinly on the taper part of ECL-SIP valve head and stick the conical shim (9) on it.



This is carried out for preventing the conical shim (9) from dropping off when ECL-SIP valve is inserted.

- ⇒ Insert ECL-SIP valve into the bush (3) while taking care so as not to drop off the conical shim (9).



Take care not to be upside down.

- ⇒ Tighten the fitting screw (7) with the specified torque 40 Nm evenly.

3. Fitting the ECL-SIP valve when the cylinder liner is replaced

Check the distance "x" from cylinder liner inner surface to ECL-SIP valve tip end.

- ⇒ Fit ECL-SIP valve to the cylinder liner once by using the conical shim (9) whose thickness is the same as that of the conical shim (9) used before cylinder liner replacement.
- ⇒ Tighten two screws (7) with the specified torque 40 Nm evenly. (Fig.A)
Removing and fitting procedures of ECL-SIP valve are in the same way as the above.
- ⇒ Measure and check the distance "x" from cylinder liner inner surface to ECL-SIP valve by using the depth gauge, etc.

The planed value of distance "x" is 2.5 ± 0.5 mm (Fig.B)

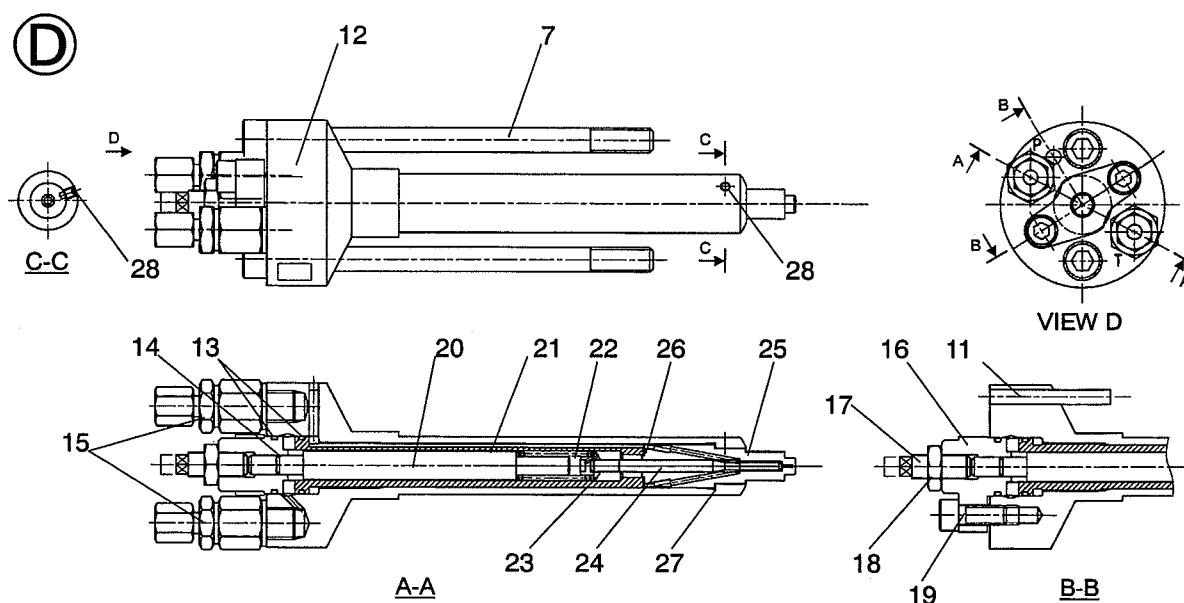
If the distance "x" varied from the initial value, adjust it with the thickness of the conical shim (9).

Carry out the above procedure again by changing the conical shim (9) thickness to the thickness so that "x" can become the planned value.

ECL-SIP Valve

Function Check, Removal and Fitting

4. Dismantling and Assembling of the ECL-SIP valve



4.1 Dismantling and Cleaning

- ⇒ Loosen and remove the locking nut (18) and the adjusting screw (17).
- ⇒ Loosen and remove two screws (19), then pull out the guide (16).
- ⇒ Pull out the adjusting rod (20).
- ⇒ Loosen and pull out the bush (21) from valve body (12) by using the bush tightening tool.
- ⇒ Remove the spring (22) and the spring disc (23).
- ⇒ Loosen the pointed screw (28) coated with LOCTITE.
- ⇒ Remove the needle (24) and the nozzle body (25) with gaskets (26), (27).
- ⇒ Wash the needle (24) and the nozzle body (25) with kerosene.
- ⇒ Clean the injection hole of nozzle body (25) by using the cleaning pin.
- ⇒ Blow-off foreign particles in injection hole in nozzle body inside direction by air, and blow-off sufficient air so that foreign particles can not remain inside nozzle body (25).
- ⇒ Wash dismantled parts with kerosene, and then clean it by blowing-off air sufficiently.
- ⇒ Check if three O-rings (13), (14) fitted at valve upper part have no damages.

ECL-SIP ValveFunction Check, Removal and Fitting

4.2 Assembling

- ⇒ When the nozzle body (25) is inserted into the valve body (12), confirm that gascket (27) is correctly fitted on valve body (12) seat and gascket (26) is correctly fitted on the nozzle body (25) upper surface.
- ⇒ Insert the nozzle body (25) with needle (24) and spring disc (23) into the valve body (12) and adjust the position of nozzle body (25) to pointed screw hole.
- ⇒ Tighten the pointed screw (28) temporarily and lightly.
- ⇒ Confirm that the gascket (26) is not shifted on nozzle body (25) upper surface, and insert the bush (21) into valve body (12).
- ⇒ Tighten the bush (21) with torque of approx. 90 Nm by using the bush tightening tool.
- ⇒ Apply LOCKTITE on the pointed screw (28) and tighten.
Take care so as not to tighten it excessively.
- ⇒ Insert the spring (22) and adjusting rod (20) into the bush (21).
- ⇒ Fit the guide (16) and tighten two screw (19) evenly.
- ⇒ Screw the adjusting screw (17) into the guide (16).
- ⇒ Screw and tighten the locking nut (18).

Piston Rod Gland Box

Dismantling and Assembling, Measuring the Wear

Tools :			Key to Illustrations :			
2	Distance holders	94345	1	Housing (2-part)	11	Screw
2	Spring tensioner	94345a	2	Scraper ring	11a	Screw
2	Gauges	94345c	2a	Scraper ring	12	Cylinder covet stud
1	Piston resting device	94350	3	Oil scraper ring	13	O-ring
			4	Sealing ring	14	Locating pin
			4a	Sealing segment	15	Hinged cover
			5	Oil scraper ring	16	Cylinder jacket
			7	Tension spring	18	Locking plate
			8	Screw	20	Guide pin
			10	Piston rod		

Overview

1. General	1/6
2. Removing a gland box	2/6
3. Dismantling a gland box	2/6
4. Assembling a gland box	3/6

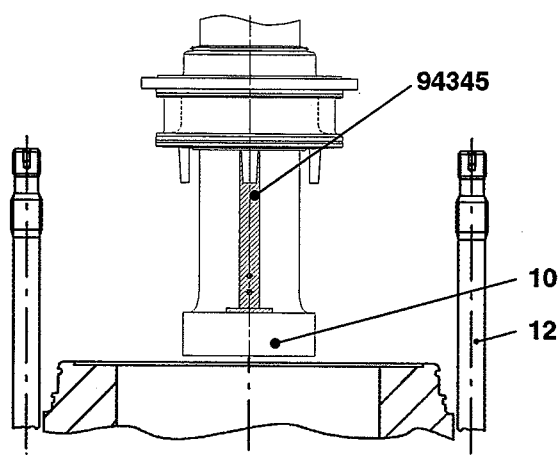
1. General

For dismantling the piston rod gland box (gland box for short) the gland box should be removed together with the piston.

At every piston overhaul, the gland box must also be dismantled and inspected.

Excessively worn or damaged parts are to be replaced.

It is important that the gland box be in perfect condition when assembled.

Piston Rod Gland Box
Dismantling and Assembling, Measuring the Wear
2. Removing a gland box
A


- ⇒ For removing the gland box, both distance holders (94345) are to be screwed on the foot of piston rod (10) (Fig. 'A')
- ⇒ Outer screws (8) (4 pieces) on 2-part housing (1) are to be loosened and removed (Fig. 'B' and 'C').
- ⇒ Removed the gland box including the piston (see 3403-1 'Removal of a piston').

3. Dismantling a gland box

- ⇒ Place and fix piston in the piston resting device (94350). For this the split housing of the gland box (1) must rest on the two hinged covers (15) of the device.
- ⇒ Loosen four screws (11) and two screws (11a) to the split housing of the gland box, and remove them.
- ⇒ Push the two gland housing halves (1) away from the piston rod.
- ⇒ Remove tension springs (7), scraper rings (2),(2a) oil scraper rings (3) and (5) as well as the seal rings (4) with the sealing segments (4a), using spring tensioner (94345a)
- ⇒ On the following parts wear has to be measured (see Fig. 'C'):
 - Scraper ring (2),(2a)
 - Oil scraper ring (3)
 - Sealing ring (4)
 - Oil scraper ring (5)
- The admissible wear on the wearable parts is indicated in Clearance Table 0330-1 'Piston rod gland box'.
- Such parts which are beyond the admissible tolerance must be replaced. Wearable parts approaching the tolerance limit should be replaced in doubtful cases, as they cannot be checked again before the next piston overhaul.

Piston Rod Gland Box**Dismantling and Assembling, Measuring the Wear**

4. Assembling a gland box (see Fig. 'D' and 'E')

- ⇒ Place piston in piston resting device (94350), its hinged covers (15) must be folded down.
- ⇒ Place scraper ring (3-parts) (2a) on the hinged covers (15) and fit tension spring using spring tensioner (94345a).
- ⇒ Tension spring (7) as well as O-ring (13) must be replaced when they are no longer in perfect condition.
- ⇒ Fit first lower scraper ring (2a), then two ring pairs (each with 4 rings) followed by ring pairs with oil scraper rings (5). In the same way fit both sealing ring packages with sealing rings (4), sealing segments (4a) and oil scraper ring (3) with upper scraper ring (2).

For the above assembly proceed as follow:

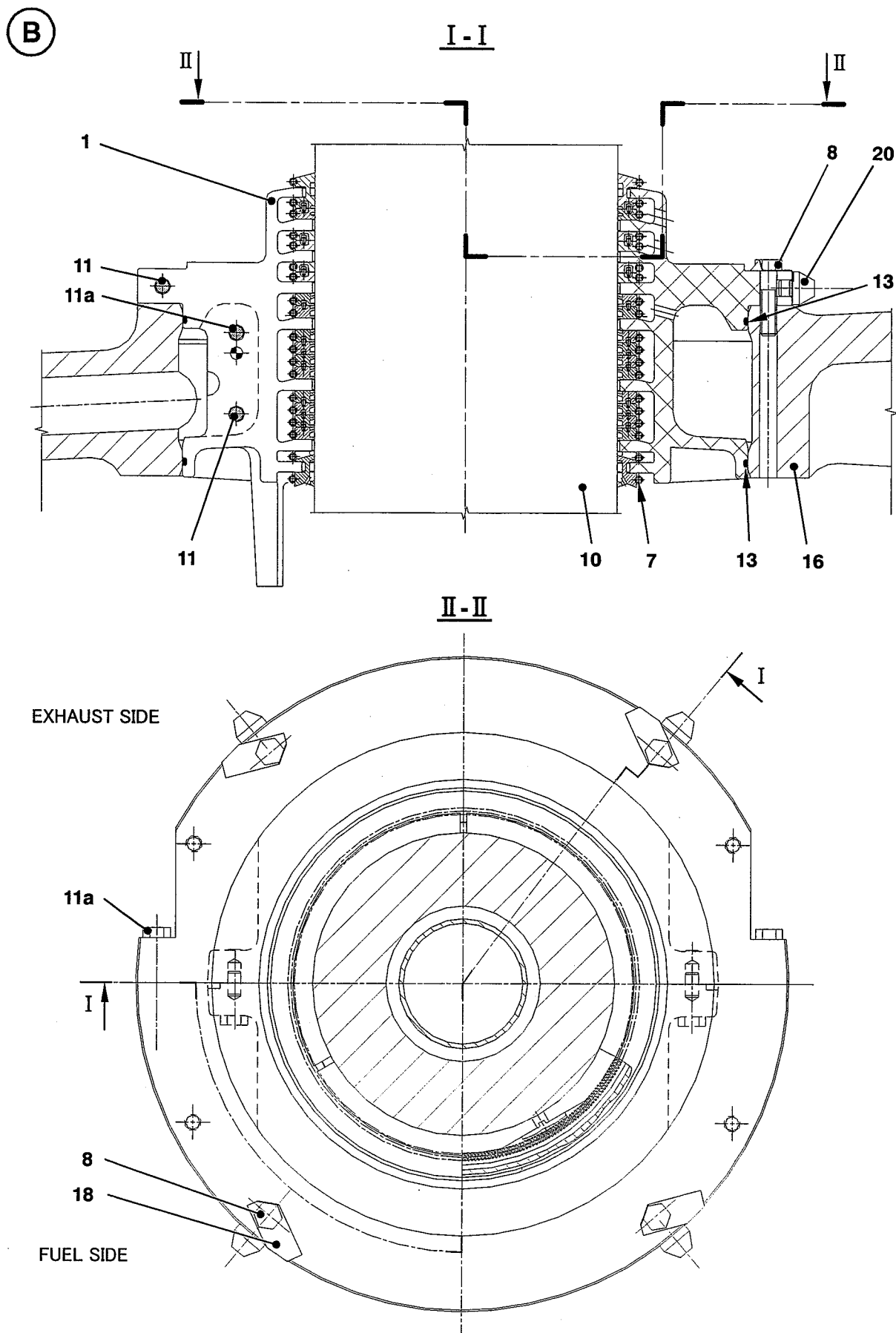
- ⇒ Fit lower scraper ring (2a) with tension springs (7) using spring tensioner (94345a).
- ⇒ Place 3-part oil scraper ring (5) with locating pin pointing upwards. This pin must always fit into oil scraper ring (5) provided with a pin hole.
- ⇒ Fit tension spring (7) into the groove in the oil scraper ring (5).
- ⇒ In the same way fit tension spring (7) for the remaining oil scraper rings. After fitting the ten oil scraper rings (5), fit four sealing rings (4) together with sealing segments (4a) and oil scraper ring (3).

CHECK

For the assembly pay attention that on the oil scraper rings and sealing rings one segment each is provided with a locating pin (14) (see Fig. 'C'). This pin must always point **upwards** and fit into the segment provided with a pin hole.

- ⇒ Fit upper scraper ring (2) with tension spring (7).
- ⇒ Utilizing two gauges (94345c) (Fig. 'E') which have been placed on two hinged covers (15) of the piston resting device, adjust scraper rings (2), (2a) and oil scraper rings (3), (5) and sealing rings (4) in such a way that each ring set comes to rest at the height of the respective ring groove in 2-part housing (1) (Fig. 'C').
- ⇒ Smear piston rod (10) as well as all rings with bearing oil. Then push both housing halves on hinged covers (15) over the ring pairs against the piston rod, then screw them together with screws (11) and screws (11a).
- ⇒ Just before the gland box is fitted with the piston, apply lubricating oil to the respective centring portions in the cylinder jacket as well as to the gland housing in the region of O-ring (13).
- When fitting the gland box into the cylinder jacket distance holders (94345) must be mounted on the foot of the piston rod as shown on Fig. 'A'. After assembling the gland box, fit screws (8) and secure these with locking plates (18).

Piston Rod Gland Box
Dismantling and Assembling, Measuring the Wear

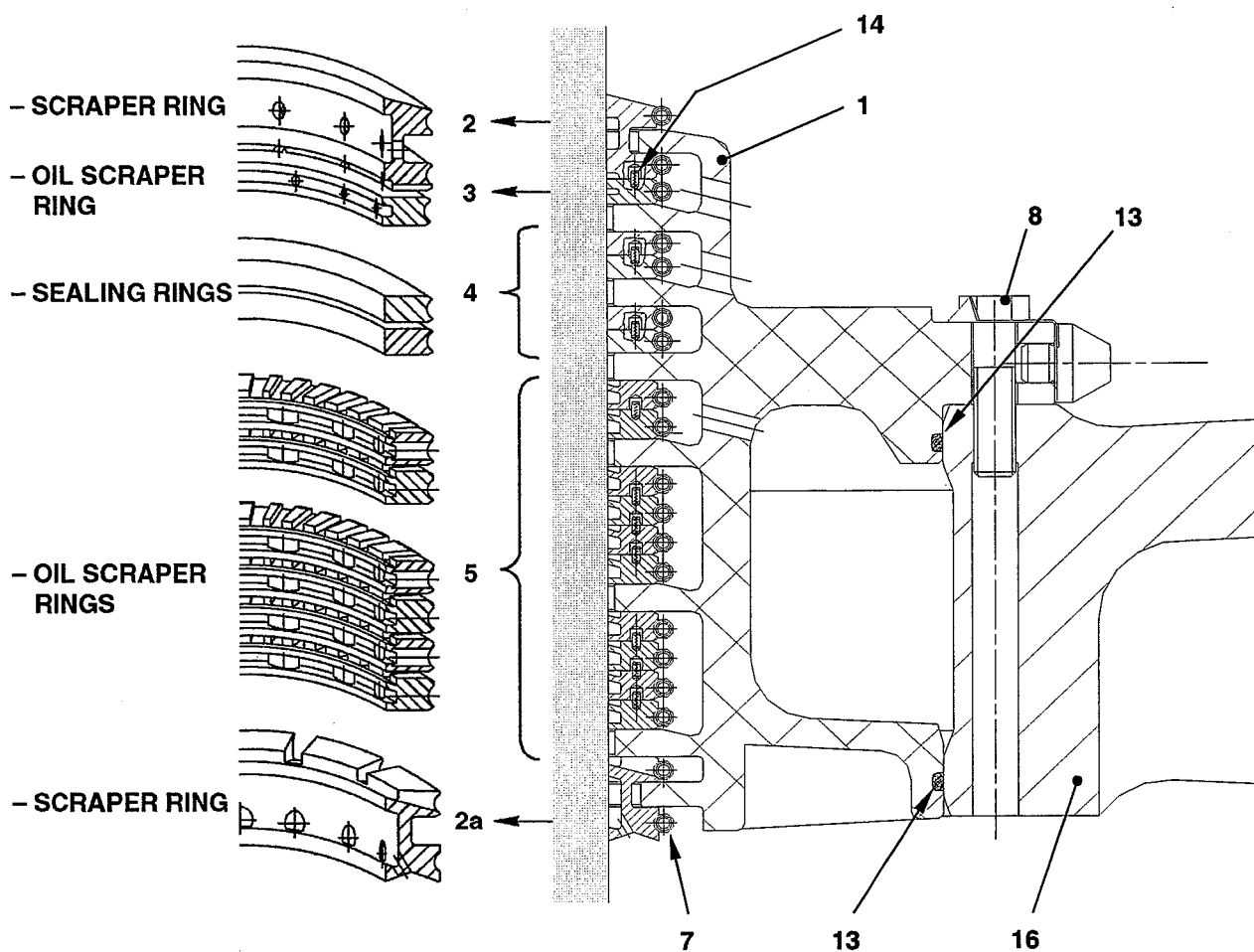


Piston Rod Gland Box

Dismantling and Assembling, Measuring the Wear

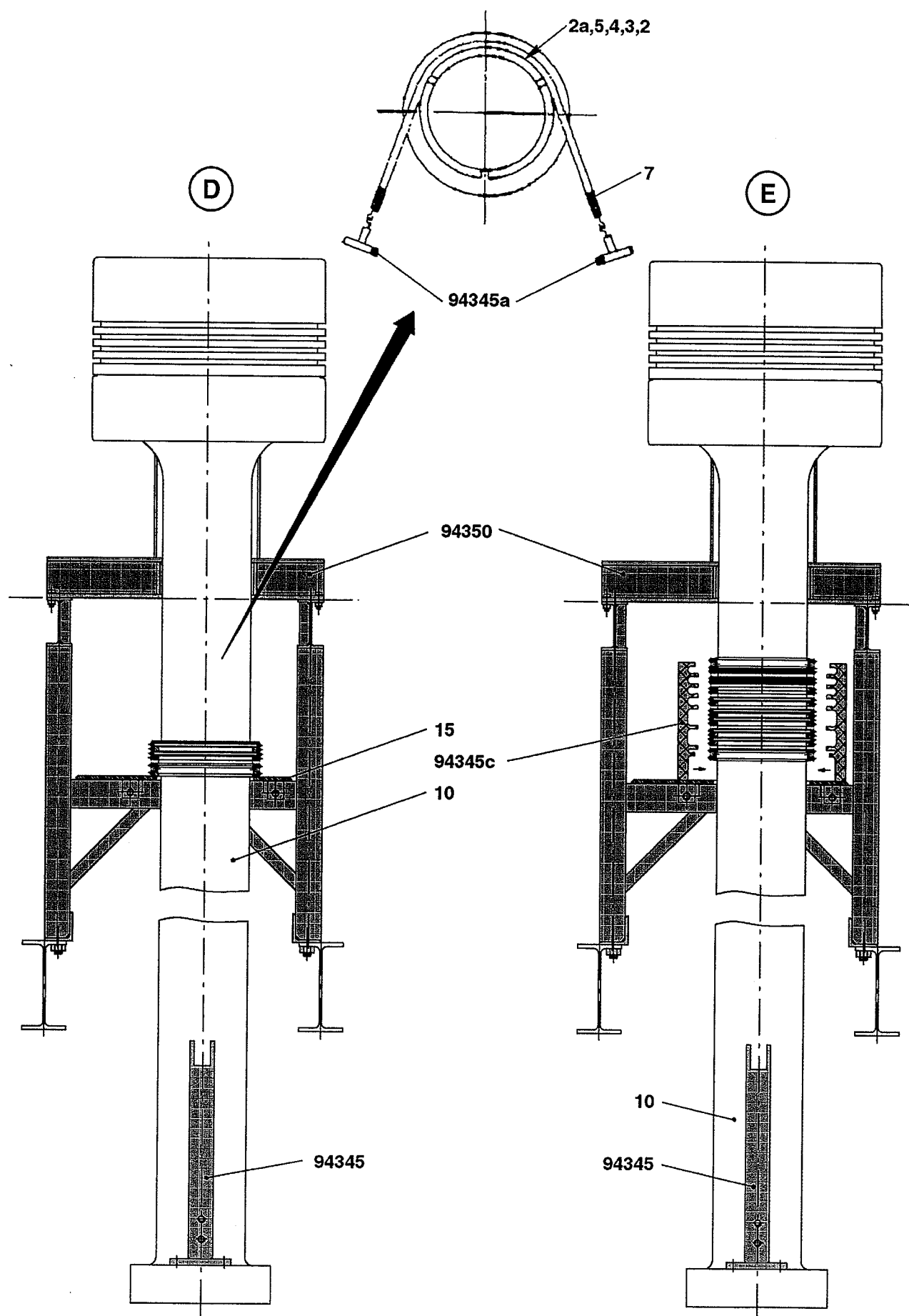
C

**ARRANGEMENT OF SCRAPER
AND SEALING RINGS**



Piston Rod Gland Box

Dismantling and Assembling, Measuring the Wear



Cylinder Cover

Removal and Fitting of the Cylinder Cover and Water Guide Jacket

Tools :

- | | | |
|---|-------------------------|--------|
| 1 | Hydr. tensioning device | 94215 |
| 1 | Suspension device | 94265 |
| 2 | Spec. eye nuts | 94265a |
| 2 | Shackle(5ton) | |

Key to Illustrations :

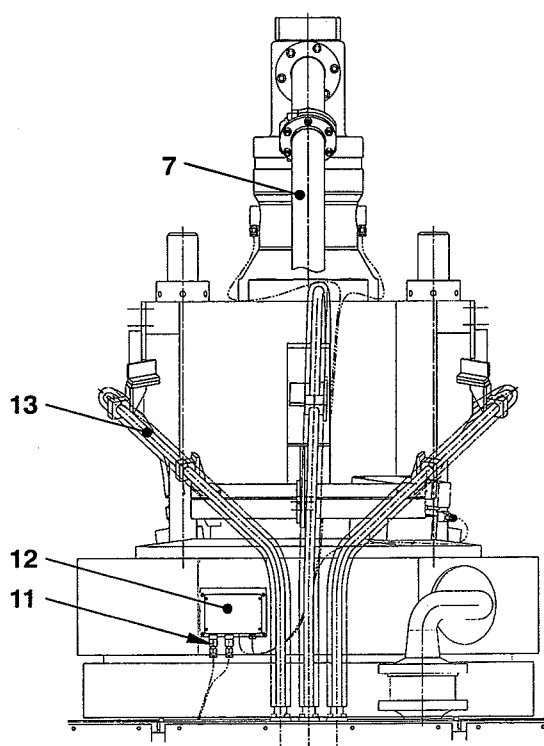
- | | | | |
|----|----------------------------|----|----------------------|
| 1 | Cylinder cover | 9 | Water guide jacket |
| 2 | Nut | 10 | Allen screw |
| 2a | Cylinder cover stud | 11 | Plug |
| 3 | Cyl. cooling water outlet | 12 | Control box |
| 4 | Leak oil outlet | 13 | Fuel pressure piping |
| 5 | Exhaust valve cage | 14 | O-ring |
| 5a | Stud of exhaust valve cage | 15 | O-ring |
| 7 | Hydraulic piping | GL | Threaded hole |
| 8 | Air inlet for valve spring | HU | Wooden underlay |

Overview

- | | | |
|----|-----------------------------------|-----|
| 1. | Removal of cylinder cover | 1/4 |
| 2. | Transport of cylinder cover | 2/4 |
| 3. | Fitting of the cylinder cover | 3/4 |
| 4. | Removal of the water guide jacket | 4/4 |
| 5. | Fitting of the water guide jacket | 4/4 |

1. Removal of the cylinder cover

A



- ⇒ Drain the cylinder cooling water from the affected cylinder, i.e. first shut the valves for cylinder cooling water inlet and outlet at the supporting ring on the exhaust side and above the cylinder cover respectively.
- ⇒ Open drain valve to the respective cylinder. This valve is situated on the exhaust side below the valve for cylinder cooling water inlet.
- ⇒ Then open the vent valve in the cylinder cooling water outlet pipe of the respective cylinder!
- ⇒ Disconnect all the connections to the cylinder cover and to the exhaust valve as well as the expansion piece between exhaust valve and exhaust manifold (see 2751-1).
- ⇒ Remove hydraulic piping (7) as described in 8460-1.
- ⇒ Remove fuel pressure piping (13) (see 8733-1).
- ⇒ Disconnect plug (11) from control box (12).
- ⇒ Clean all the thread protrusions on the cylinder cover studs.
- ⇒ Loosen the nuts of the cylinder cover studs (see 2708-2).

Cylinder Cover

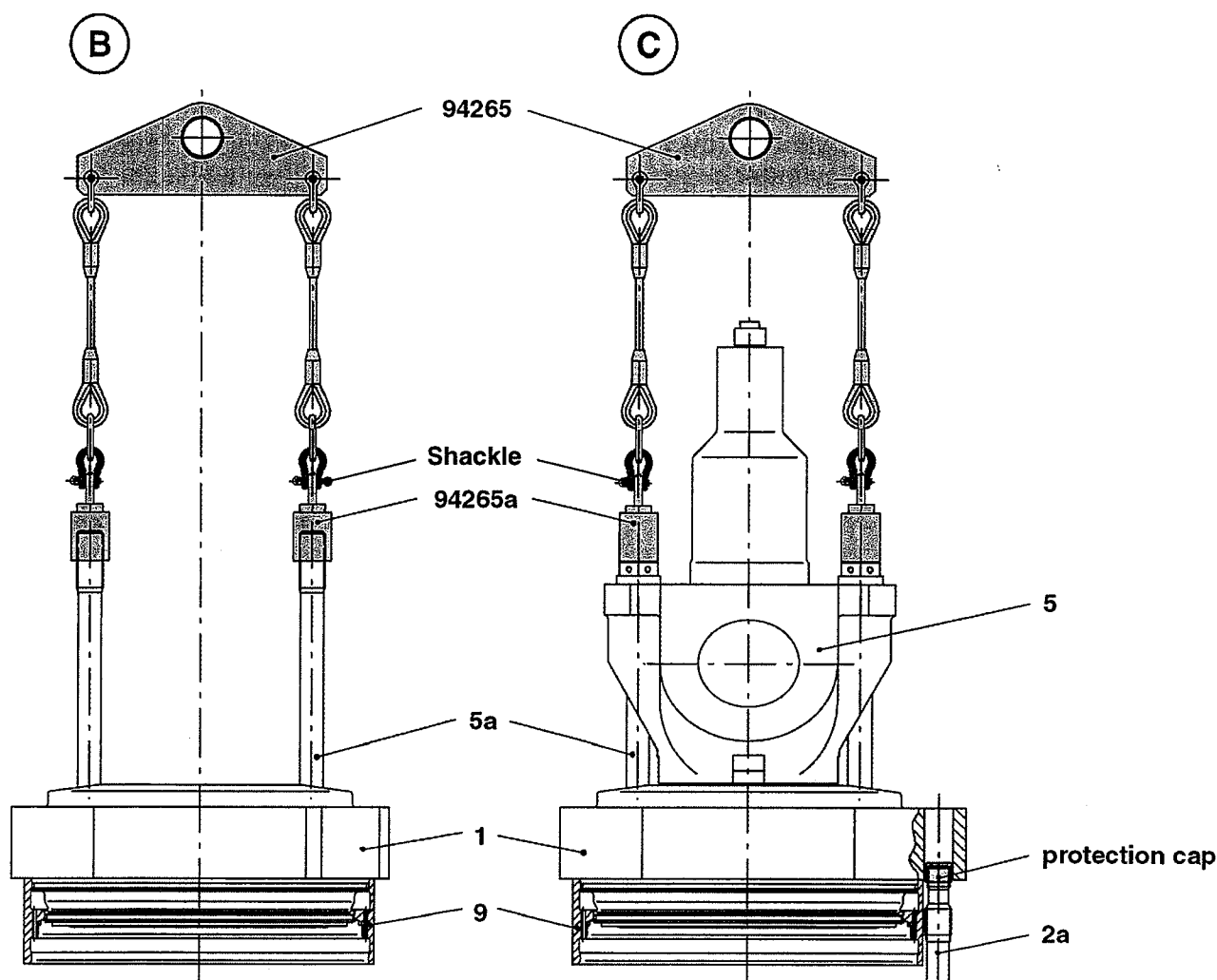
Removal and Fitting of the Cylinder Cover and Water Guide Jacket

2. Transport of cylinder cover

- ⇒ Screw the spec. eye nuts (94265a) to suspension device (94265) onto the studs (5a) of the exhaust valve cage. Insert the two hooks of the suspension device with shackles into the spec. eye nuts.
- ⇒ Lift cylinder cover (1) and water guide jacket (9) together with the crane (see Fig. 'C').



Remark : Removing and transporting the cylinder cover is the same with exhaust valve cage (5) in situ or removed from the cylinder cover (Fig. 'B' and 'C').



Cylinder Cover

Removal and Fitting of the Cylinder Cover and Water Guide Jacket

3. Fitting of the cylinder cover

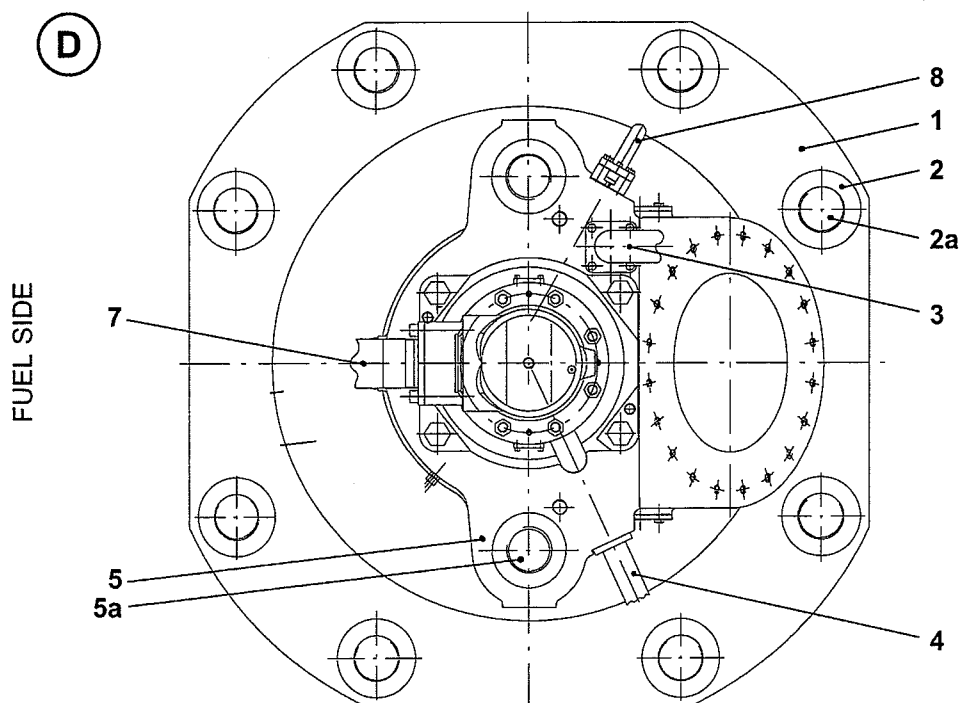
Before placing the cylinder cover in position the following points must be taken care of

- The compression space must be absolutely free of foreign particles or dirt.
- The seating surfaces on cylinder cover and cylinder liner must be clean and undamaged.
- A new soft iron joint ring 2 mm thick must be placed on the cylinder liner in such a way that it lies flat all over.
- The inner surface of water guide jacket (9) which is screw fastened to the cylinder liner as well as the respective guide surface at the collar of the cylinder liner must be clean and smeared with grease.
- Place new O-rings into the grooves of the cylinder liner and smear these with grease.
- The threads of the cylinder cover studs must be clean and smeared with MOLYKOTE paste.
- Place protection caps on cylinder cover waisted studs or wrap up the thread of the cylinder cover studs with vinyl tape (see Fig. 'C').

When these conditions are all met, lower the cylinder cover, attached to suspension device (94265), slowly over the cylinder cover studs, whereby a centring pin assures the correct position (see 2124-2).

- ⇒ Screw all the nuts by hand onto the cylinder cover studs, paying attention to easy turning.
- ⇒ Pre-tension the studs with hydraulic pre-tensioning device (94215) in accordance with 2708-2.
- ⇒ Reconnect all connections to cylinder cover and exhaust valve.
- ⇒ Finally shut drain and vent valve, and open the valves for cooling water inlet and outlet.

 **Remark** : Concerning the fitting of the expansion piece between exhaust valve and exhaust manifold see 2751-1.



Cylinder Cover

Removal and Fitting of the Cylinder Cover and Water Guide Jacket

4 Removal of the water guide jacket

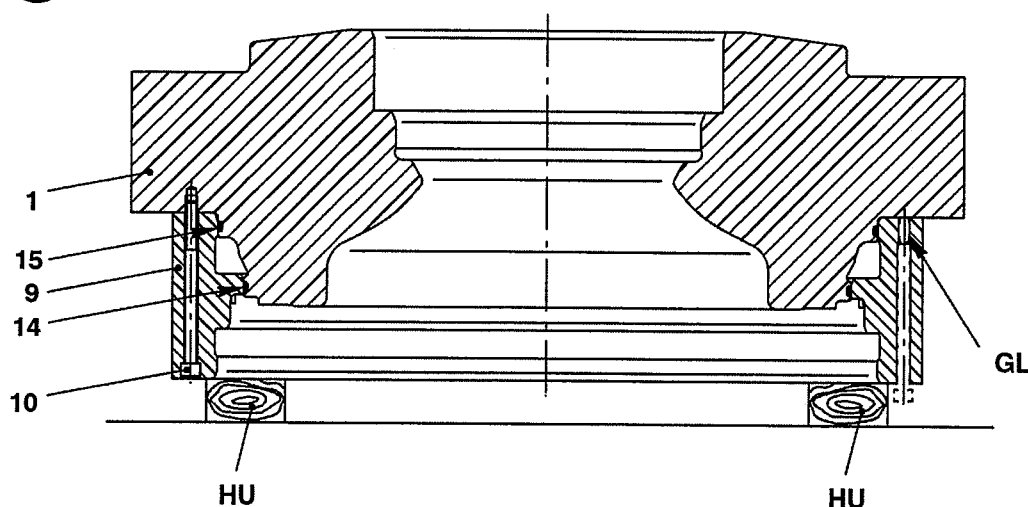
- ⇒ Place the cylinder cover with screwed-down water guide jacket on wooden underlays "HU" as shown in Fig. 'E'.
- ⇒ Unscrew Allen screws (10), and then screw them into the three threaded holes 'GL' for jacking off the water guide jacket.
- ⇒ Lift the cylinder cover slightly with the crane (10 ~ 20 mm), and continue to screw in Allen screws (10) until the water guide jacket, lying on wooden underlays "HU", is withdrawn from the cylinder cover.



Risk of accident! Never put your hand between the water guide jacket and the wooden underlays!

When the cylinder cover is lifted off, the water guide jacket must either be screwed down on it, or completely removed!

(E)



5. Fitting of the water guide jacket

- ⇒ Clean all the sealing faces and ring grooves.
- ⇒ Unscrew Allen screws (10) from threaded holes "GL" and insert them in the through holes.
- ⇒ Put the water guide jacket on wooden underlays "HU", and smear the sealing faces with grease, as well as the O-rings. Use new O-rings only!
- ⇒ Lower and align the cylinder cover above the water guide jacket as far as to allow Allen screws (10) to be screwed in the cylinder cover.
- ⇒ Screw in and tighten the Allen screws evenly.

Cylinder Cover

Hydraulic Loosening and Tensioning of Cylinder Cover Waisted Studs

Tools:

1	Hydr. tensioning device consisting of:	94215
2	Device halves each with four pre-tensioning jacks	94215a
8	HP hoses	94215b
1	Suspension device	94215c
1	Connection piece	94934
1	Connection piece	94934a
1	HP hose	94935
3	HP hoses	94935a
1	Hydraulic unit	94942
1	Pressure gauge	94932a

Key to Illustrations:

1	Cylinder cover stud	MO	Emplacement for round nuts (5) when not in use
2	Nut		
3	Vent screw	RO	Emplacement for round bars 'RS' when not in use
4	Piston		
5	Round nut	RS	Round bar
6	Cover		
7a,b	Seal and O-ring		
8a,b	Seal and O-ring		
9	Cylinder		
10	Screw		
11	Spring plate		

1. General

 **Remark** : Pay attention to General Application Instructions 9403-4 for hydraulic pre-tensioning jacks.

Should a cylinder cover stud have to be replaced, please observe the indication in 2751-1.

2. Set-up of the pre-tensioning jacks

- ⇒ Clean the threads of all cylinder cover studs (1) (Fig. 'B') as well as the area around nuts (2).
- ⇒ Mount two device halves of pre-tensioning device (94215) over the cylinder cover studs and rest them on the cylinder cover (arrangement according to Fig. 'A').
- ⇒ Open vent screws (3) (Fig. 'B') of all pre-tensioning jacks.
- ⇒ Connect the device halves to hydraulic unit (94942), using HP hoses (94935) and (94935a), as well as andconnection piece (94934),(94934a) (Fig. 'A').
- ⇒ Press piston (4) of all pre-tensioning jacks (94215a) downwards upon cylinder (9), either by screwing on round nut (5) (Fig. 'B').

CHECK When the pistons are resting on the cylinders there should be little or no clearance at 'x'.

 **Remark** : For **loosening** the waisted studs **screw back** the round nuts (5) by about two turns.
For **tensioning** the waisted studs the round nuts (5) must **lie on** piston (4).

Cylinder Cover

Hydraulic Loosening and Tensioning of Cylinder Cover Waisted Studs

3. Loosening

- ⇒ Set-up of the pre-tensioning jacks as mentioned already. Open vent screws (3) of the pre-tensioning jacks.
- ⇒ Start up hydraulic unit (94942).
- ⇒ Close vent screws (3) on the jacks as soon as oil flows bubble-free.
- ⇒ Actuate hydraulic unit until a pressure of **102 MPa** is indicated on its pressure gauge (94932a).
- Attention should be paid to ensure that pins (6) always protrude slightly compared with pistons (4) on the pre-tensioning jacks.
- ⇒ Turn all nuts (2) upwards till the stop, using round bar "RS". Store round bar "RS" in emplacement "RO" while not in use (see Fig. 'A').
- ⇒ Release pressure to zero.
- ⇒ Disconnect and remove HP hoses (94935a) from both device halves.
- ⇒ Unscrew round nuts (5) and remove them together with the pre-tensioning jacks.

4. Tensioning

- ⇒ Smear threads and seating surface of nuts (2) with MOLYKOTE paste G.

CHECK

Tighten all nuts (2) down with round bar "RS" till fully seated (check with feeler gauge).

- ⇒ Mark position of all nuts, with a line on nuts (2) and cylinder cover, with a felt-tip pen (this will serve for a later check).
- ⇒ Set-up of the pre-tensioning jacks as mentioned already. Open vent screws (3) of the pre-tensioning jacks.
- ⇒ Start up hydraulic unit (94942).
- ⇒ Shut vent screws (3) on the pre-tensioning jacks as soon as oil flows bubblefree.
- ⇒ Actuate hydraulic unit until a pressure of **100 MPa** is indicated on its pressure gauge (94932a).
- Attention should be paid to ensure that pin (6) always protrude slightly compared with piston (4) on the pre-tensioning jacks.

CHECK

While keeping this pressure constant tighten all nuts (2) with round bar "RS" till fully seated on the cylinder cover (check seating with feeler gauge), **verify while tightening that all nuts can be turned by about the same angle of 390°.**

Cylinder Cover

Hydraulic Loosening and Tensioning of Cylinder Cover Waisted Studs

- Where it is found that a nut can be turned considerably less than the others, it must be assumed that the respective cylinder cover stud has become insufficiently tensioned.

Possible causes:

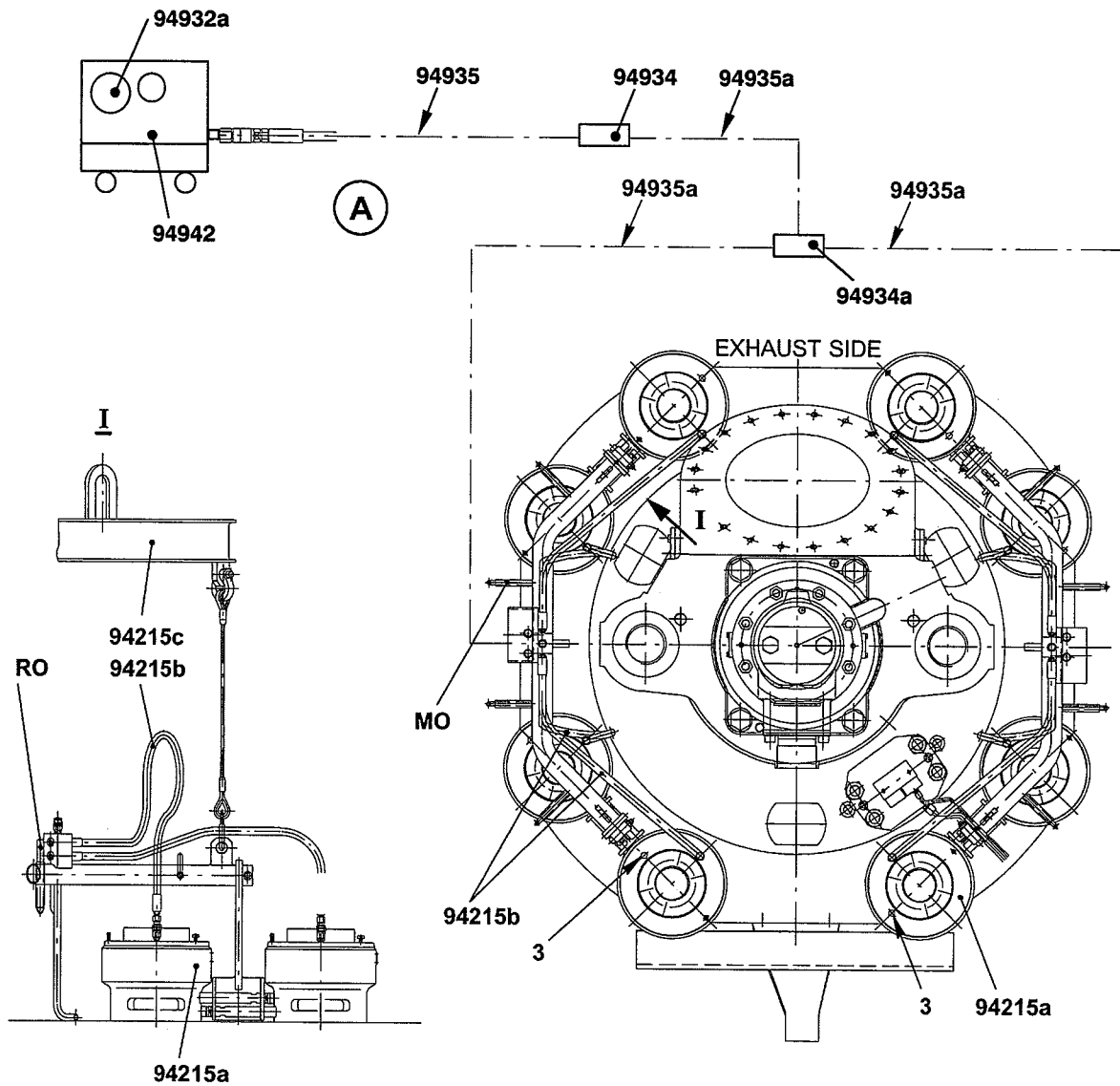
- Seal and O-rings (7a), (7b) and (8a), (8b) defective (Fig. 'B').
- Piston (4) jams.
- Connection piece of HP hoses (94215b) leaky or incorrectly connected.
- Repeat tensioning procedure after the cylinder cover studs have been loosened again.
- ⇒ When all nuts have been tightened by practically the same angle, release the oil pressure to zero.
- ⇒ Disconnect and remove HP hoses from both device halves.
- ⇒ Unscrew round nuts (5) and remove them together with the pre-tensioning jacks.

CHECK

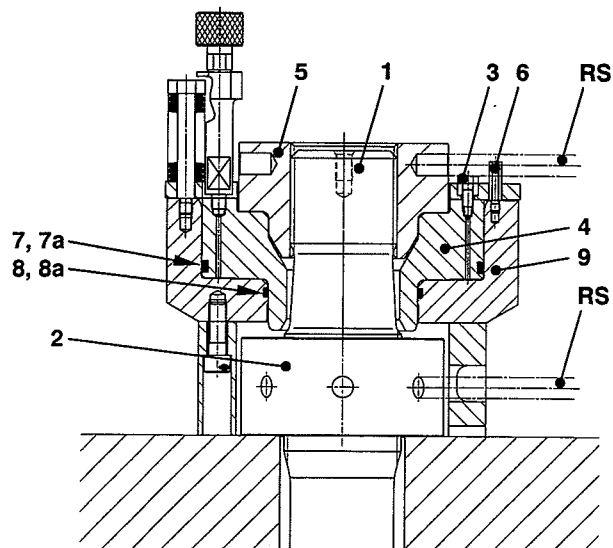
Verify by the previously applied marks that all nuts have been turned equally by an angle of about 390°.

Cylinder Cover

Hydraulic Loosening and Tensioning of Cylinder Cover Waisted Studs



(B)



Cylinder Cover
Machining of Sealing Face for the Injection Valve

Tools :

- 1 Overhauling device 94270
1 Double-ended box spanner 24×27

Key to Illustrations :

- | | |
|-------------------------|------------------------|
| 1 Cylinder cover | 6 Centring mandril |
| 2 Milling cutter holder | 7 Screw |
| 3 Guide flange | 8 Lapping tool |
| 4 Setscrews | |
| 5 Profiling cutter | * Depository for screw |

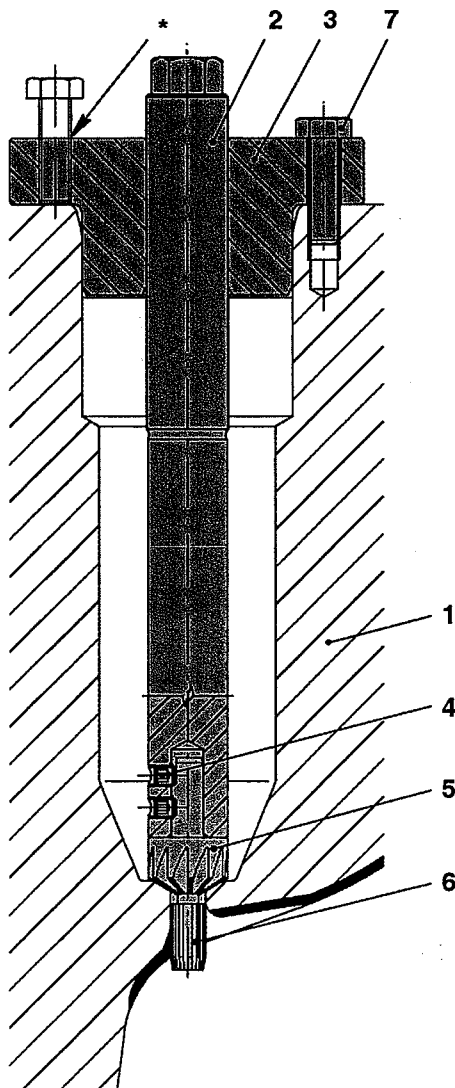
1. General

The seat sealing face in the cylinder cover must be clean and undamaged as the sealing is metallic.



Should any blow-by of combustion gases have been noticed during engine operation, the spring packets with their screws of the injection valve are not, under any circumstances, to be tightened further as a counter measure.

2. Machining of sealing face



Dirty or slightly damaged sealing faces can be re-conditioned on the spot by using overhauling device (94270).

⇒ Carefully insert the profiling cutter (5), bolted to the milling cutter holder (2), into the hole in the cylinder cover.

⇒ Fasten guide flange (3) with screws (7).

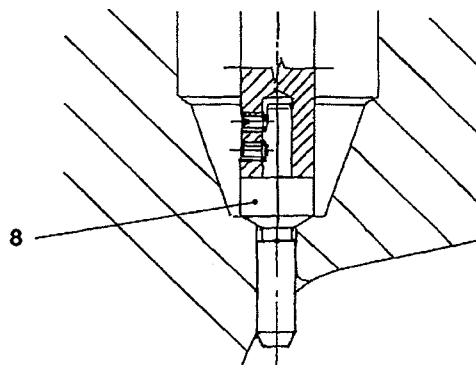
When the tool is being used, the centring mandril (6) on the profiling cutter on the one hand and the guide flange on the other, give the tool the necessary stability and direction.

⇒ Cutting is done by pressing down lightly with the hand on the milling cutter holder at the same time as turning the hexagon evenly with the other hand using the double-ended box spanner.

Try to remove as little material as possible but sufficient, however, to obtain the desired standard for the seating area.

● Putting some sticky grease on the profiling cutter will prevent any foreign matter from entering the combustion chamber during overhaul.

⇒ Exchange the profiling cutter (5) for the lapping tool (8). Spread lapping powder on the seating area and complete machining work with the lapping tool.



Injection Valve

Checking, Dismantling, Assembling and Adjusting

Tools:

1 Test bench 94271

Key to Illustrations:

1 Allen screw	13 Nozzle body
2 Spring guide	14 Retaining sleeve
3 Cup spring (spring packet)	15 Snap ring
4 Nozzle holder	16 Dowel pin
5 Collar nut	17 Dowel pin
6 Spring tensioner	18 Dowel pin
7 Nozzle tip	19 Spring cage
8 Tappet carrier	20 O-ring
9 Tappet	
10 Retaining nut	
11 Compression spring	
12 Nozzle needle	FL Leakage fuel

Overview

1. General	1/8
2. Checking an injection valve	2/8
3. Judging an injection valve	3/8
4. Dismantling an injection valve	4/8
5. Replacing a nozzle tip	5/8
6. Assembling an injection valve	7/8
7. Adjusting the opening pressure	7/8
8. Assembling a spring cage	8/8
9. Fitting an injection valve in cylinder cover	8/8

1. General

For checking, dismantling, assembling and adjusting the injection valve use test bench (94272).

Before commissioning the instructions and directions of the test bench(94272) manufacturer must be observed.

Keep the test bench in perfect condition and always put clean diesel oil (gas oil) into the fuel tank.

CHECK

From time to time check the pressure gauges of the test bench with a master pressure gauge and adjust them if necessary.



The work station must be clean; welding and grinding should not be done nearby!

Injection Valve

Checking, Dismantling, Assembling and Adjusting

2. Checking an injection valve

- ⇒ Remove combustion residues and clean injection nozzle externally with a brass wire brush.
- ⇒ Fit injection valve into rotary type test stand of test bench (94272) and fasten it.
- ⇒ Connect high pressure hose ⑳ of the test bench with fuel inlet of injection valve.
- ⇒ Start test bench following the instructions of the test bench maker's.
- ⇒ Check the atomization of the fuel first with a few short pump jerks, then with slow equal pump jerks and observe at what pressure the injection valve opens.

Injection valve specified opening pressure = **37.5 MPa**

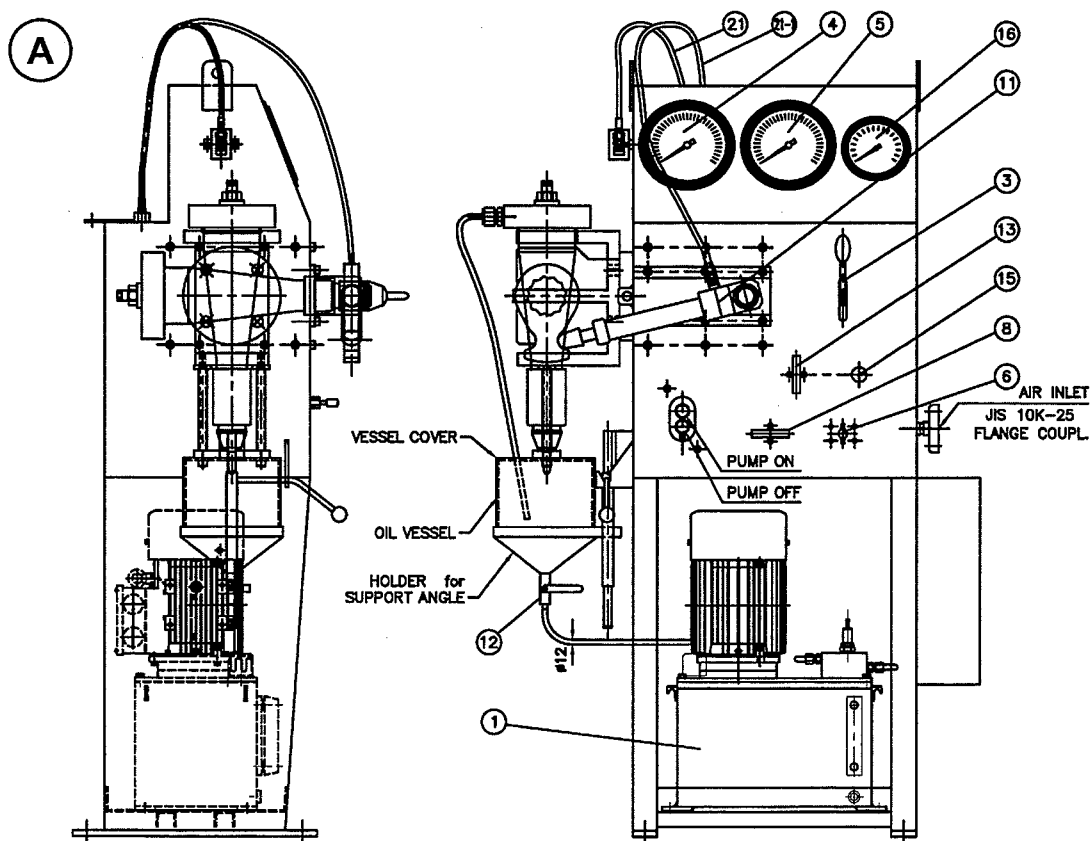


Danger of injuries!

Never hold finger or hands directly before the spray holes of the injection nozzle. Risk of bad accident.

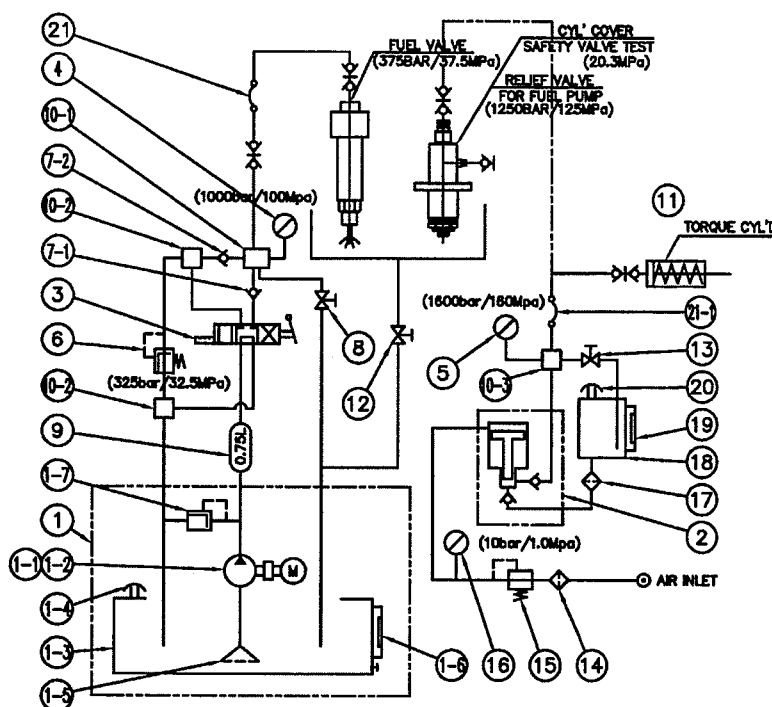
Test bench (94272) :

- | | | |
|---------------------------|--------------------------|---|
| ① Electric pump | ⑨ Booster | ⑯ Pressure gauge |
| ② Air booster pump | ⑩ Distributor | ⑰ Oil filter |
| ③ Hydraulic control valve | ⑪ Torque cylinder | ⑱ Oil tank |
| ④ Pressure gauge | ⑫ Ball valve | ⑲ Oil level gauge |
| ⑤ Pressure gauge | ⑬ Pressure release valve | ⑳ Filter cap with strainer |
| ⑥ Relief valve | ⑭ Air filter | ㉑ Hydr. hose for fuel valve |
| ⑦ Check valve | ⑮ Pressure control valve | ㉒ Hydr. hose for torque cyl./ F.O. relief valve |
| ⑧ Pressure release valve | | |



Injection Valve

Checking, Dismantling, Assembling and Adjusting



3. Judging an injection valve

For correct functioning and for a re-use of an injection valve observe the following points:

- The injection valve works properly if the fuel sprays equally and well atomized from all spray holes of the injection nozzle at the specified opening pressure. This should be not accompanied by a 'chatter', and after the end of pumping no fuel should 'dribble' from the injection nozzle.
 - The opening pressure (see 2722-1 page2/8) should be ± 0.5 MPa for **new** injection valves. A pressure reduction of 8% may be acceptable on **used** injection valves. Should a new setting of the opening pressure be necessary consult the section 7.
 - In order to test tightness between nozzle needle (12) (see Fig. 'C') and needle seat, keep the pressure constant in the test bench at 2 MPa below the opening pressure over a period of 10 seconds. During this period of time no dripping should occur at the nozzle tip.
 - The spray holes of nozzle tip (7) must not be flushed out unduly.
- ⇒ Injection valves which do not spray efficiently must be dismantled as described in section 4. Often, a thorough cleaning suffices to make them fully functional.



Remark

Injection nozzle (7) with flushed out spray holes must be replaced by new ones.
Nozzle holder (4) and nozzle body (13) (Fig. 'C') with poor sealing faces must either be replaced or repaired by the manufacturer or a special company.
As for the fuel nozzle maintenance record sheet, see Mitsubishi Service Information MSI-8906E.

Injection Valve

Checking, Dismantling, Assembling and Adjusting

4. Dismantling an injection valve

- ⇒ For dismantling, the injection valve has to be held in rotary type test stand of test bench (94272), as already mentioned.
- ⇒ Prior to dismantling an injection valve (Fig. 'C') unscrew spring tensioner (6) (after loosening collar nut (5)) till compression spring (11) is fully relaxed.



Prior to loosen retaining nut (10) spring tensioner (6) must be unscrewed (after loosening collar nut (5)) to relax compression spring (11).

- ⇒ Bring injection valve to the horizontal position with the help of the rotary type test stand.
- ⇒ Attach the spanner for retaining nut of the test bench to retaining nut (10). Connect the torque cylinder ① to the spanner and connect the high pressure hose (21-1) to the torque cylinder (Fig. 'A').
- ⇒ According to the operating instructions of the manufacturer, actuate the test bench to loosen retaining nut (10), then remove nozzle needle (12), nozzle body (13), retaining sleeve (14) and nozzle tip (7) (Fig. 'A').

CHECK

Remove spring tensioner (6) with collar nut (5), compression spring (11) and tappet (9) and inspect their condition.



Remark : If only a defective nozzle tip (7) has to be replaced, then to this end only snap ring (15) has to be removed see section 5. All other parts are not to be dismantled.



Never interchange nozzle needle (12) and nozzle body (13)! Each nozzle needle belongs to its mated nozzle body into which it has been individually fitted with greatest precision.

Injection Valve

Checking, Dismantling, Assembling and Adjusting

5. Replacing a nozzle tip

If nozzle tip (7) should be dismantled only, it is sufficient to remove tip retainer (14).

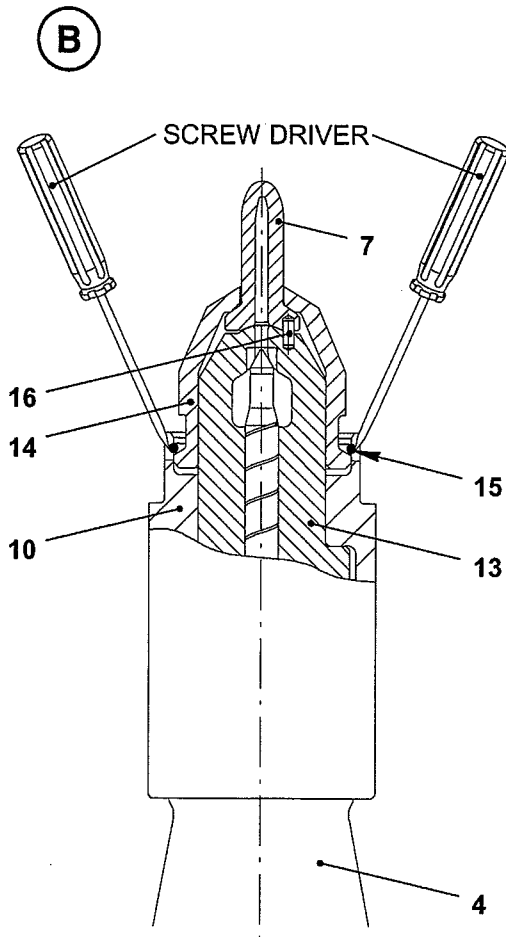
5.1 Removal

- ⇒ Using two screw drivers inserted between both recesses in retaining nut (10), press snap ring (15) out of the groove in the retaining nut, whereby the tip retainer can be withdrawn (Fig. 'B'). Watch that the snap ring does not jump off unexpectedly.
- ⇒ Remove nozzle tip.

5.2 Fitting

For fitting it is advantageous to fit the injection valve into rotary type test stand of test bench, and then proceed as follows:

- ⇒ Clean all parts with clean diesel oil or kerosine and blow them out with compressed air.
- ⇒ Place nozzle tip on the nozzle body whereby the position is assured by dowel pin (16).
- ⇒ Put retaining sleeve (14) over the nozzle tip, and press snap ring (15) into the groove of the retaining nut by means of the screw drivers.

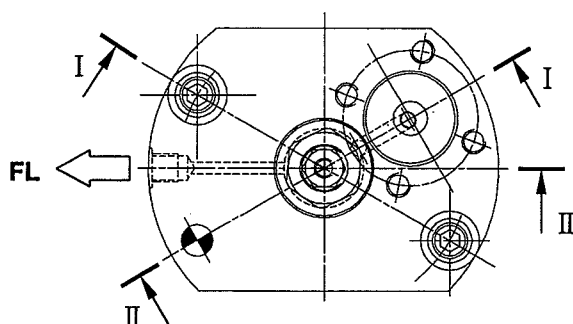
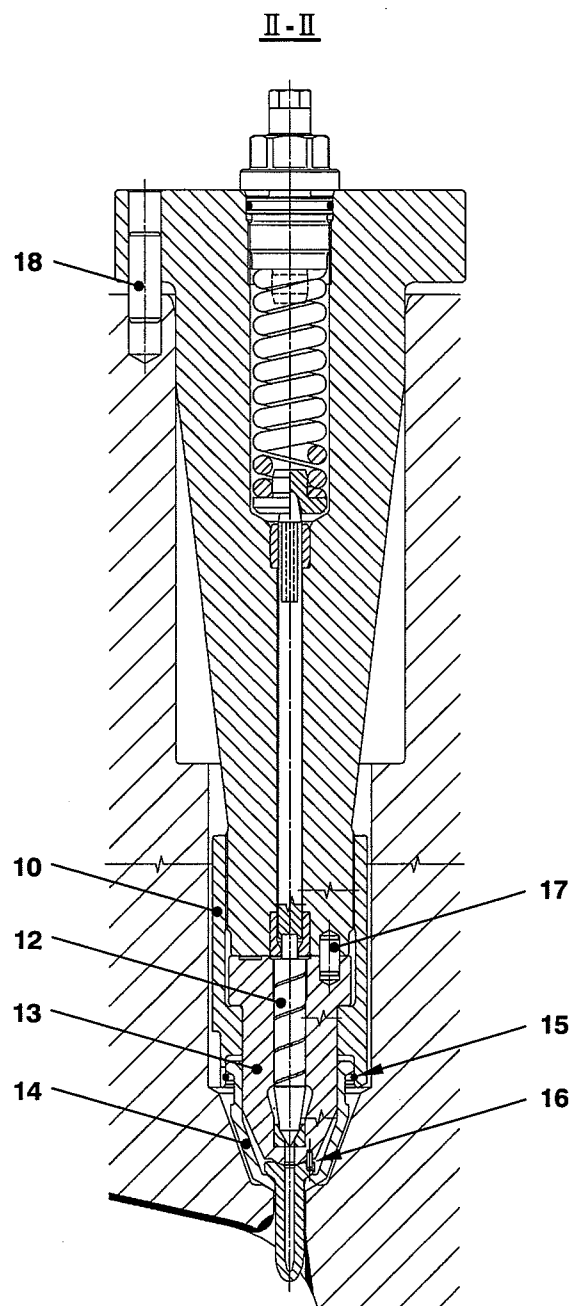
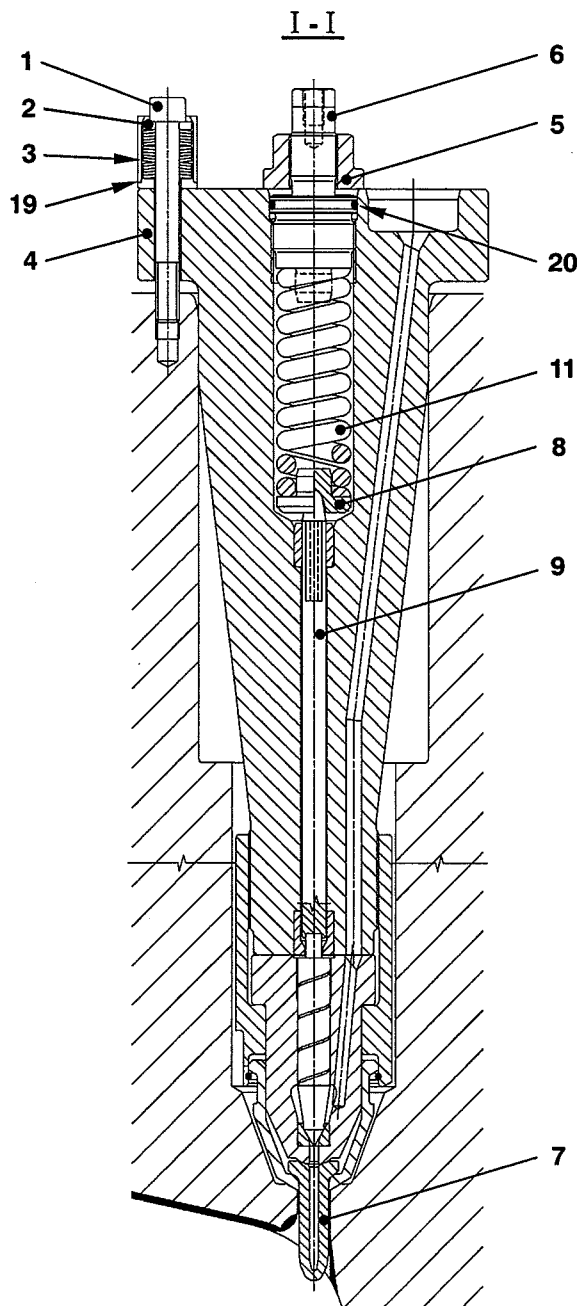


Injection Valve

Checking, Dismantling, Assembling and Adjusting

(C)

OPENING PRESSURE ADJUSTABLE
BY SPRING TENSIONER(6)



Injection Valve

Checking, Dismantling, Assembling and Adjusting

6. Assembling of an injection valve

To assemble an injection valve, follow generally the reverse sequence of the dismantling process, but note also the following points:

- To clean injection valve parts, use only clean diesel oil (gas oil) or fresh kerosene, and dry compressed air.
- When assembling nozzle tip (7) and nozzle body (13), be careful that the dowel pin (16) meshes into the corresponding bore (Fig. 'C').
- If tappet (9), tappet carrier (8), compression spring (11), and spring tensioner (6) with collar nut (5) are already fitted, the spring tensioner must be screwed by approx. one turn only, in order to prevent the compression spring from being under tension in any case.
- Apply a thin layer of Never-Seez NSBT-8 on the thread and the seating face of retaining nut (10).
- Pre-tighten retaining nut (10) to 100 Nm using the torque cylinder ⑪ provided with the test bench (94272) (Fig. 'A'). Starting from this position, tighten the retaining nut by a further angle of 30°.

Before using the complete assembly of injection valve which is supplied as spare part carry out the assembling procedure mention above after loosening collar nut (11).

7. Adjusting the opening pressure

The injection valve opening pressure is adjustable by spring tensioner (6) (Fig. 'C').

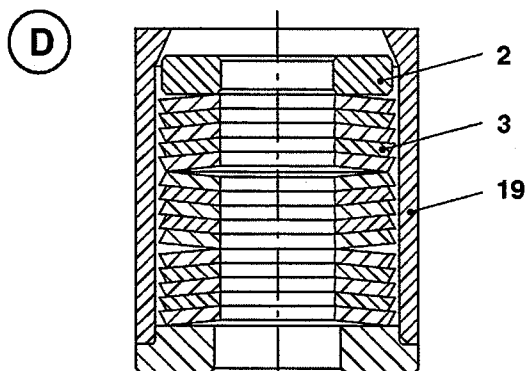
- ⇒ Install the injection valve in the test bench (Fig. 'A').
- ⇒ The opening pressure of the injection valve can be set by adjusting spring tensioner (6).
- ⇒ For adjusting the opening pressure anew, compression spring (11) must first be completely released by means of spring tensioner (6).
- ⇒ Then operate the valve test bench and tighten the spring tensioner (6) simultaneously until the required opening pressure is reached.
- ⇒ Check the injection valve as described under section 2.

 **Remark** : If the opening pressure has to be corrected, tighten collar nut (5) to fix spring tensioner (6).

Injection Valve

Checking, Dismantling, Assembling and Adjusting

8. Assembling a spring cage



- Cup springs (3) are fitted in spring cage (19).
- The spring packet consists of three packs composed of five cup springs which are arranged as shown in Fig. 'D'.

9. Fitting an injection valve in cylinder cover

CHECK

Clean the seating surface of the injection valve in the cylinder cover and check for damages.

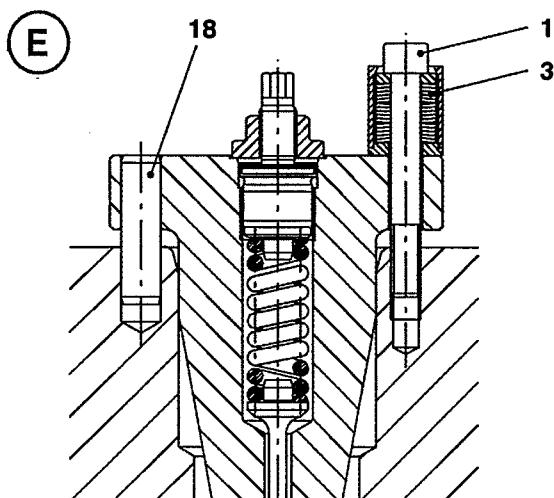
If necessary recondition the seating surface with the special tool supplied with the tools set (see 2708-3).



CAUTION

The sealing must be metal-to-metal, i.e. **no joint** must be put in between.

- ⇒ Put the injection valve carefully in the cylinder cover. Dowel pin (18) assures the correct position.



9.1 Screwing down the injection valve

- ⇒ Apply Never-Seez NSBT-8 to the threads and the seating surfaces of Allen screws.
- ⇒ Tighten two allen screw (1) to **50 Nm** evenly using torque wrench.

Starting Valve

Removal, Fitting and Dismantling, Grinding-in and Assembling

Tools:

- 2 Jacking screws
- 1 Handle
- 1 Leakage test device

Key to Illustrations:

- | | |
|-----------------------|--------------------------|
| 1 Nut | 11 Joint ring |
| 2 Cover | 12 Control valve |
| 3 Intermediate ring | 13 Connecting pipe |
| 4 Casing | 14 Piston ring |
| 4a Valve seat | 15 Spindel guide |
| 5 Cylinder cover | 16 O-ring |
| 6 Self-locking nut | 17 O-ring |
| 7 Piston | |
| 8 Valve spindle | CA Control air pipe |
| 9 Allen screw | (from starting air pipe) |
| 10 Compression spring | RC Eye bolt |

1. General

Should functional difficulties occur with the starting valves when starting, or should a starting air pipe near to the connection become noticeably hotter in operation than on the neighbouring cylinders, then the starting valve must be dismantled and reconditioned at the very next opportunity.

If no such difficulties occur it is recommended to dismantle yearly at random one starting valve for a thorough check and to overhaul the other starting valves in frequencies determined by such checking.

2. Removal from the cylinder cover

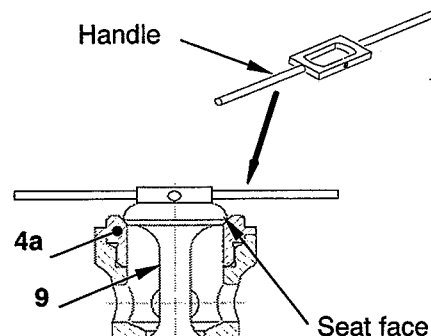
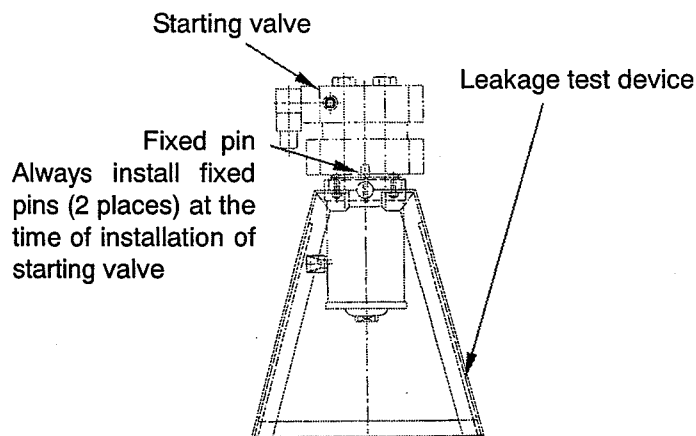
- ⇒ Loosen pipes for control air "CA".
- ⇒ Loosen and remove all four nuts (1).
- ⇒ Loosen and remove allen screws (9). Screw jacking screws into the threaded holes in casing (4) and by tightening them jack the complete starting valve from the bore in cylinder cover (5).
- ⇒ Reinsert both allen screws (9) for removing the complete valve.
- ⇒ Suspended by eye bolts "RC" lift the valve off the cylinder cover.
- When the removal is carried out with the cylinder cover fitted on the engine, the vacated opening must be immediately covered by suitable means to prevent the possibility of foreign particles entering the combustion space.

3. Dismantling a starting valve

- Dismantle a starting valve, using "Leakage test device".
- Lift cover (2) with mounted control valve (12) off casing (4). Take care that during lifting, the cover does not get jammed, whereby connecting pipe (13) risks being damaged.
- ⇒ Remove intermediate ring (3) from casing (4).
- ⇒ For further dismantling clamp the valve on the milled faces below the valve spindle head (spanner purchase) in a vice.
- ⇒ Loosen self-locking nut (6) with a socket spanner, and remove it.
- ⇒ Pull piston (7) and compression spring (10) from casing (4).
- ⇒ Lift casing (4) and valve seat (4a) up over valve spindle (8).

Starting Valve

Removal, Fitting and Dismantling, Grinding-in and Assembling



4. Grinding-in

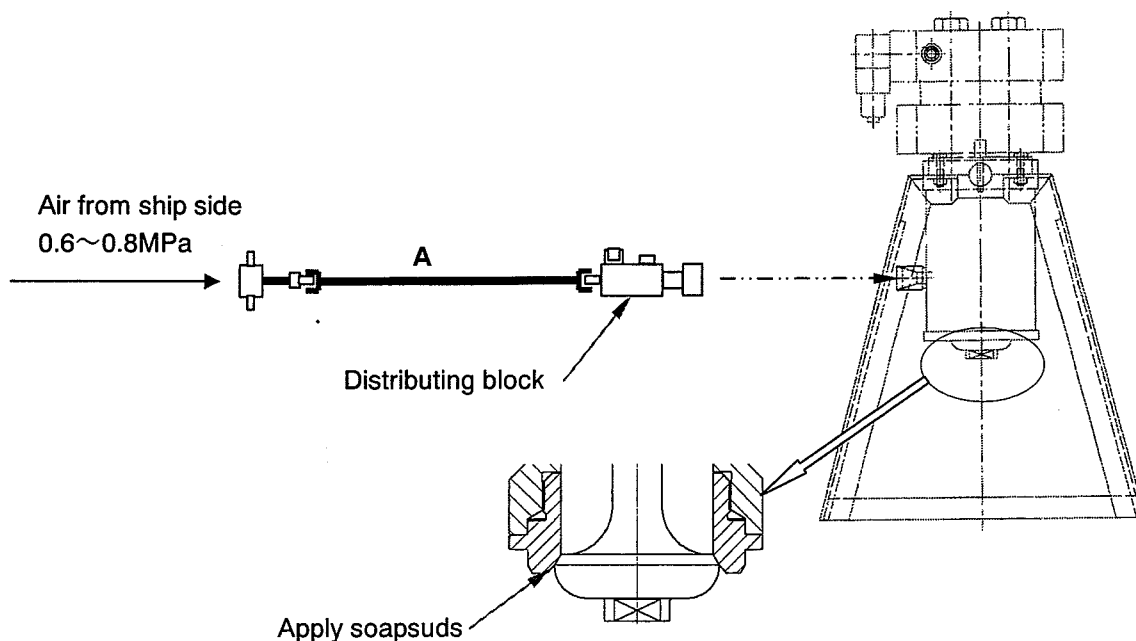
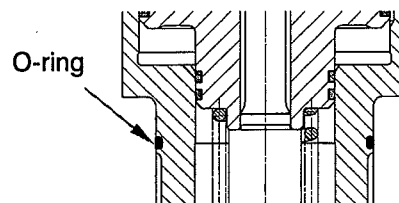
- Slightly damaged seat faces of valve seat(4a) and valve spindle(8) may be ground in (lapped) manually. Mount the handle on the
- Badly worn seat faces must first be machined and then ground in (lapped) with the handle.



Remark : The valve spindle has an angle of 61° , however, the valve seat angle amounts to 60° .

5. Leakage test

- ⇒ Install O-ring in starting valve. Then check no damage in the O-ring.
- ⇒ Connect leakage test device and the hose "A", and supply air ($0.6 \sim 0.8 \text{ MPa}$) from ship side.
- ⇒ Check no air leak from seat faces of valve seat(4a) and valve spindle(8) using soapsuds.
- ⇒ If air leak from the seat faces, valve seat (4a) and valve spindle (8) may be ground in (lapped) manually. After the adjustment, carry out leakage test again and check no air leak from seat faces.



Starting Valve

Removal, Fitting and Dismantling, Grinding-in and Assembling

6. Assembling

Assemble the valve in reverse sequence to the dismantling.

- ⇒ Clean all parts and smear them lightly with oil.
- ⇒ Apply MOLYKOTE paste G to the thread of valve spindle (8),



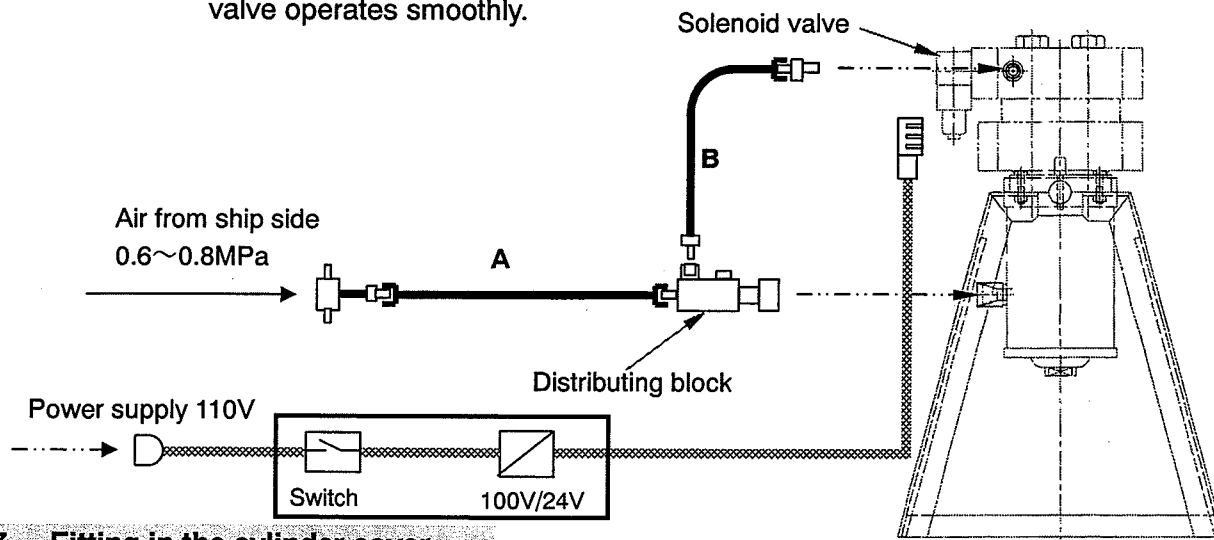
however **not** in the area of the locking ring of the self-locking nut (6).

- ⇒ Tighten the **not** greased, clean self-locking nut with **1215 Nm** or by a tightening angle of **50°**.
- ⇒ Place new, lightly oiled, O-rings (16) and (17) into the groove in casing (4) and connecting pipe (13) respectively.

CHECK

After completing the assembly (without cover 2) check the easy movement of the valve spindle by moderately tapping the upper end of the valve spindle several times with a lead block in an axial direction; the valve spindle must jump every time back on the seat.
If the valve seat have been ground/machined several times, check the clearance 'x' (see figure) with a depth gauge from the upper edge of intermediate ring (3) onto the piston (7).
Clearance 'x' must be minimum 1 mm.

- ⇒ Fit cover (2) and tighten it with Allen screws (9). Take care that when assembling cover (2), connecting pipe (13) does not interfere.
- After assembling the starting valve, airtight and operation test is possible using tool.
- ⇒ Install the hose "A", "B" into the starting valve.
- ⇒ Connect the solenoid valve with the starting valve to the ship side power.
- ⇒ Push the switch to "OPEN" and release it to "CLOSE", and check the starting valve operates smoothly.

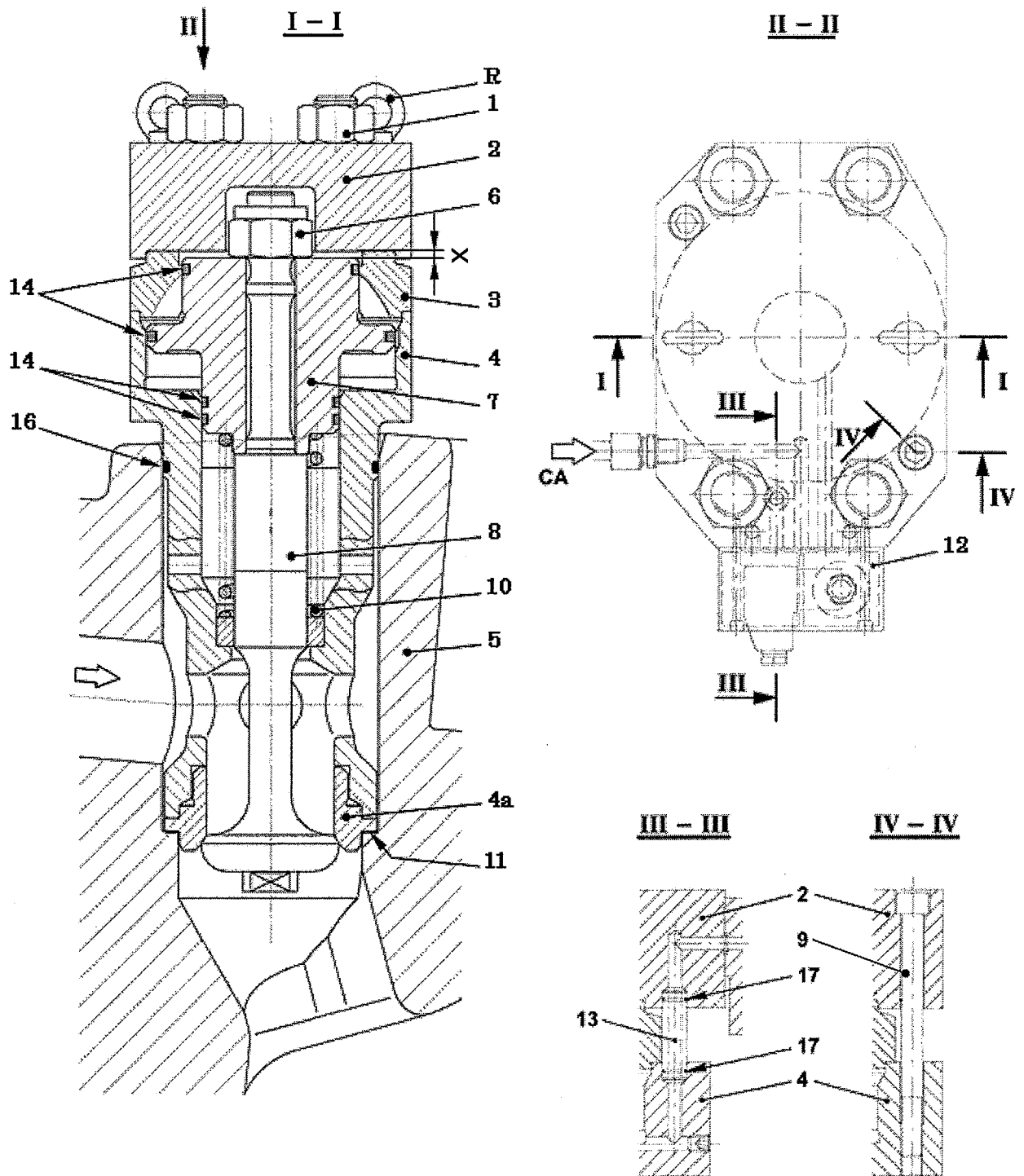


7. Fitting in the cylinder cover

- ⇒ Place a new joint ring (11) on the shoulder of the bore in cylinder cover (5).
- ⇒ Smear bore in cylinder cover lightly with oil and fit the assembled starting valve.
- ⇒ Apply Never-Seez NSBT-8 to the threads of nuts (1), fit and tighten them crosswise through an angle of **85°**.

Starting Valve

Removal, Fitting and Dismantling, Grinding-in and Assembling



Relief Valve for Cylinder Cover
Dismantling, Assembling and Testing

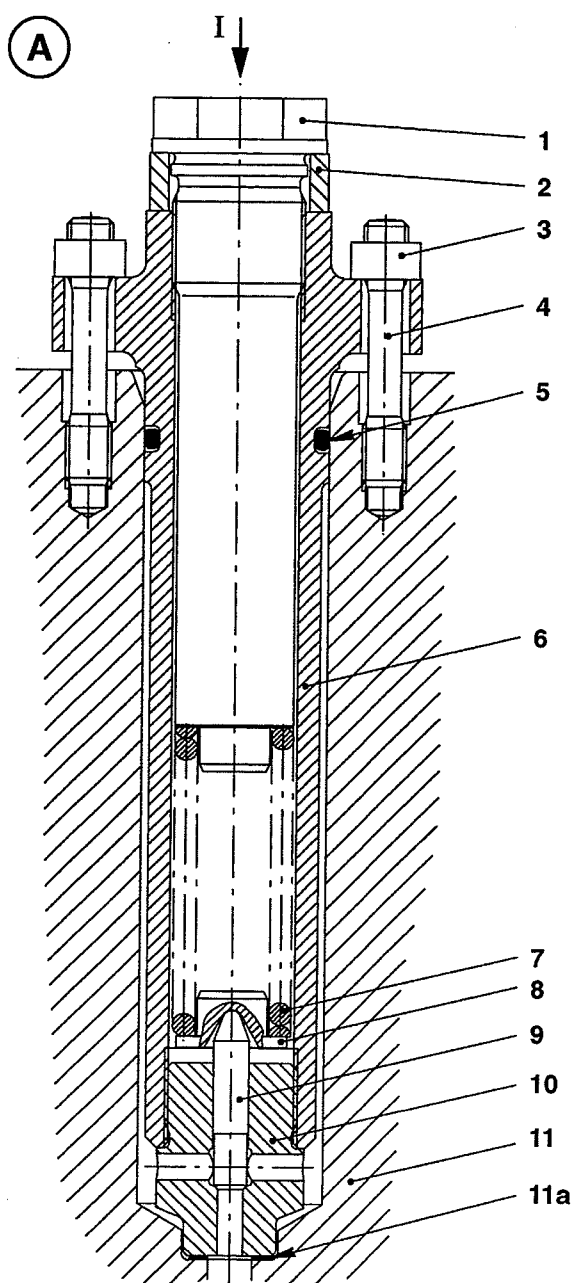
Tools :

- 1 Test bench 94272
- 2 Jacking screws M12

Key to Illustrations :

- 1 Spring tensioner
- 2 Distance ring
- 3 Nut
- 4 Stud
- 5 O-ring
- 6 Housing
- 7 Compression spring
- 8 Spring plate
- 9 Valve body
- 10 Valve seat
- 11 Cylinder cover
- 11a Copper joint

1. Removal, dismantling, grinding-in



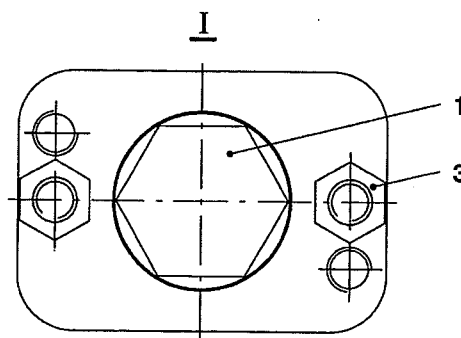
After loosening both nuts (3) the relief valve can be withdrawn from the cylinder cover using two jacking screws M12. Check relief valve for absolute tightness and correct opening pressure, with the aid of test bench (94272) (Fig. 'B').

1.1 Dismantling (Fig. 'A')

Even if the opening pressures are still correct, it is advisable to check a few relief valves at random. Depending on the condition found, possibly check the remaining relief valves too.

Remark : The correct opening pressure is marked on the flange of housing (6).

- ⇒ For dismantling clamp the relief valve at the rectangular upper part in the vice.
- ⇒ Unscrew spring tensioner (1) and remove compression spring (7) with spring plate (8) and valve body (9). Then loosen valve seat (10).
- ⇒ All components should be cleaned and checked thoroughly.



Relief Valve for Cylinder Cover
Dismantling, Assembling and Testing

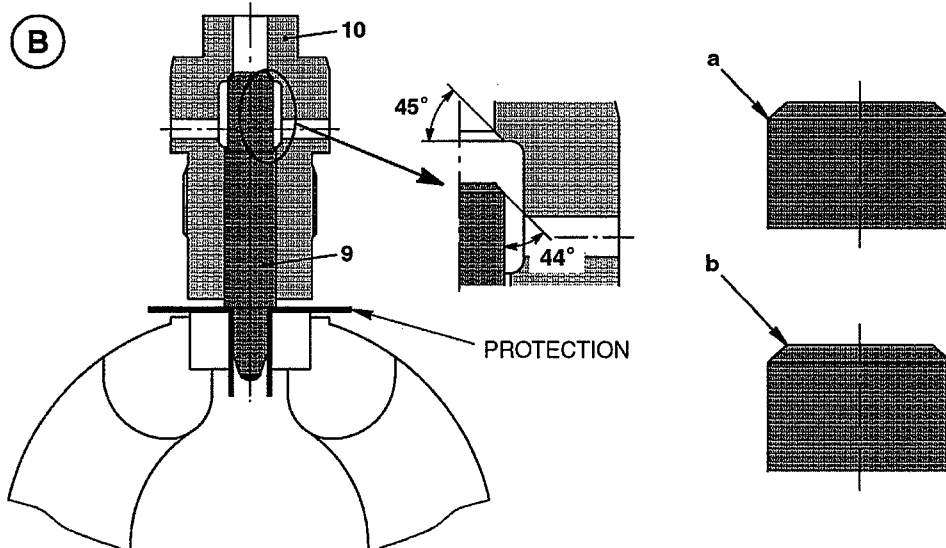
1.2 Procedure for grinding-in

Valve seats with bad sealing faces are best re-ground by machine, aiming at the following angles:

- Seat of valve body (9) = 44°
- Seat of valve seat (10) = 45°

Valve seats which are only slightly damaged, however, can be re-conditioned by grinding-in by hand. In this case follow the procedure below (Fig. 'B'):

- ⇒ Clamp valve body (9) into a bench vice (use protection).
- ⇒ Using a small pointed stick, place a few dots of grinding paste onto the seat of the valve body, towards the greater diameter (Fig. 'B', detail 'a').
- ⇒ Put valve seat (10) onto valve body (9) and turn valve seat backwards and forwards. Clean the faces several times and repeat the grinding process until a relatively narrow, shiny band - towards the smaller diameter indicates the contact area (Fig. 'B' detail 'b').
- ⇒ Finally thoroughly clean valve seat and body.



2. Assembly

- ⇒ Thoroughly clean all components and lightly oil them.
- ⇒ Apply Never-Seez NSBT-8 to valve body (9), the landing faces of compression spring (7) and the threads of spring tensioner (1).
- ⇒ Use a high temperature resistant lubricant, such as THREAD GARD or LOCTITE ANTI SEIZE COMPOUND, for coating the threads of valve seat (10).
- ⇒ Clamp the relief valve at the rectangular upper part in the vice and screw the valve seat (10) — with valve body (9) fitted — into the housing (6) and tighten firmly
- ⇒ Place the relief valve into test bench (94272) (Fig. 'C').



Prior to attach the relief valve into the test bench place the copper joint (11a) on to the seat face.

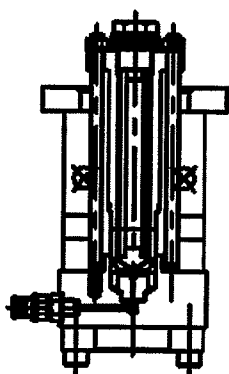
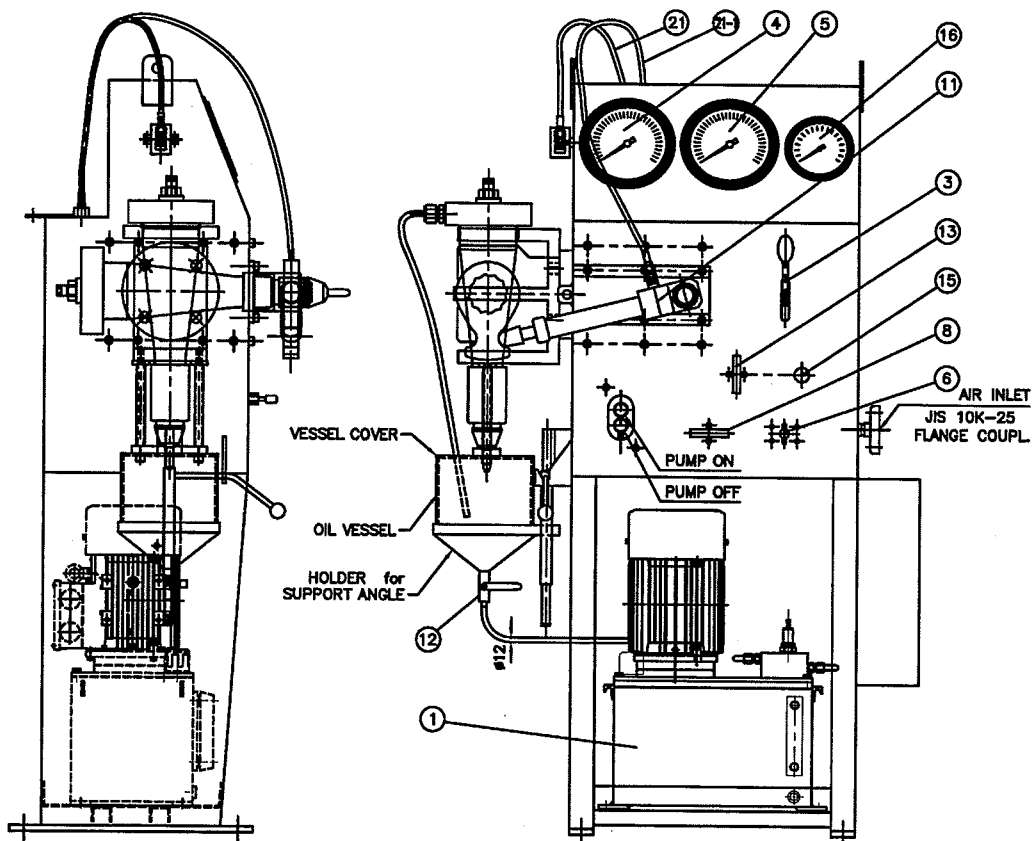
- ⇒ Fit spring plate (8) and compression spring (7) and screw in the spring tensioner (1) — at first without distance ring (2) — until the distance to the valve housing corresponds approximately to the height of the distance ring.

Relief Valve for Cylinder Cover
Dismantling, Assembling and Testing

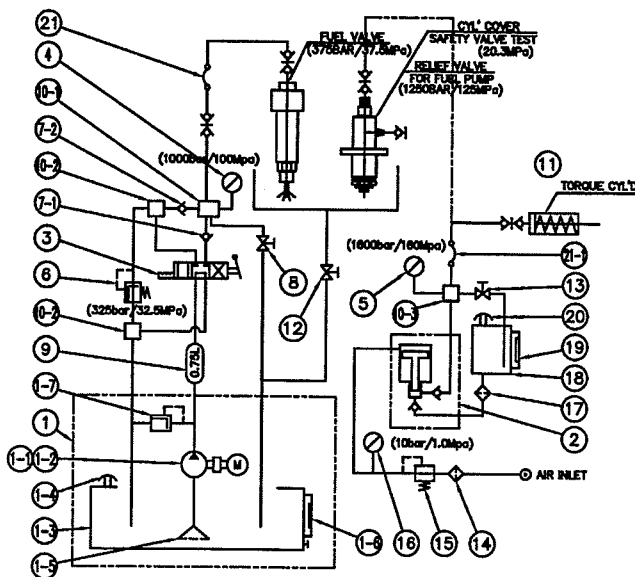
Test bench (94272) :

- | | | |
|---------------------------|--------------------------|---------------------------------|
| ① Electric pump | ⑨ Booster | ⑯ Pressure gauge |
| ② Air booster pump | ⑩ Distributor | ⑰ Oil filter |
| ③ Hydraulic control valve | ⑪ Torque cylinder | ⑱ Oil tank |
| ④ Pressure gauge | ⑫ Ball valve | ⑲ Oil level gauge |
| ⑤ Pressure gauge | ⑬ Pressure release valve | ⑳ Filter cap with strainer |
| ⑥ Relief valve | ⑭ Air filter | ㉑ Hydr. hose for fuel valve |
| ⑦ Check valve | ⑮ Pressure control valve | ㉑-1 Hydr. hose for torque cyl./ |
| ⑧ Pressure release valve | | F.O. relief valve |

(C)



Test block for
Cyl. relief valve



Relief Valve for Cylinder Cover
Dismantling, Assembling and Testing

3. Testing the relief valve

CHECK

Pay attention to the manufacturer's detailed instructions and working specifications of the test bench (Fig. 'C'), in particular prior to commissioning.

- ⇒ Depending on the opening pressure found, further tighten or loosen spring tensioner (1) until the correct opening pressure has been established.

Relief valve for cylinder cover specified opening pressure = 20.0MPa

- ⇒ Measure the distance between spring tensioner (1) and housing (6) and prepare a distance ring (2) of corresponding height.
- ⇒ Unscrew the spring tensioner and insert distance ring.
- ⇒ Tighten spring tensioner (1) once again and re-check the relief valve.

4. Fitting the relief valve (see Fig. 'A')

Before fitting the relief valve, thoroughly clean the bore and contact surface in the cylinder cover. Make sure that no foreign matter enters the combustion chamber when carrying out the work with the cylinder cover fitted.

- ⇒ Fit the relief valve with an O-ring (5) in perfect condition.
- ⇒ Place a new copper joint (11a) onto the contact surface in the cylinder cover.
- ⇒ Coat the outside of the valve housing with a little grease or oil to protect it against rust.
- ⇒ Apply Never-Seez NSBT-8 to the threads of both studs (4) and nuts (3).
- ⇒ After fitting the relief valve, firmly tighten the nuts (3) crosswise and in even stages.

Exhaust Valve

Removal and Fitting of the Exhaust Valve, Replacing of the Waisted Studs

Tools :

1	Hydr. tensioning device	94252
1	Valve protector	94262
1	Suspension device	94265
2	Eye bolt(M36)	
1	Pressure gauge	94932a
1	Connection piece	94934
1	Connection piece	94934a
1	HP hose	94935
3	HP hoses	94935a
1	Hydraulic unit	94942
1	Lifting belt for expansion piece	

Key to Illustrations :

1	Waisted stud	9	Cylinder
2	Nut	10	Valve cage
3	Vent screw	11	Valve spindle
4	Piston	12	Expansion piece
5	Round nut		
7	Sealing ring	KO	Slot
8	Sealing ring	RS	Round bar

1. General

Prior to the removal of an exhaust valve, drain first the cylinder cooling water from the respective cylinder (see 2708-1), and close the air inlet to the air spring at the control air supply.

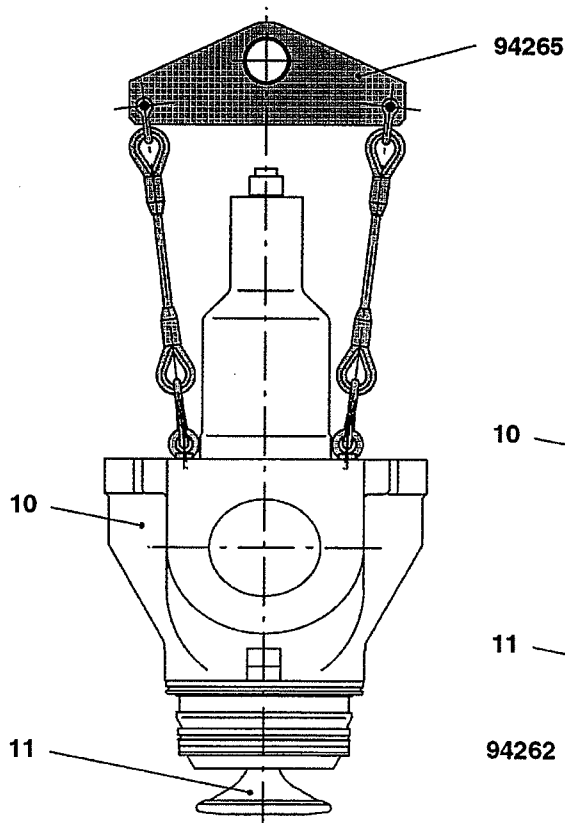
The exhaust valve can be removed from the cylinder cover or transported as whole unit (without cylinder cover) with suspension device (94265) (Fig. 'A'). The valve cage must be suspended as shown in Fig. 'A'.



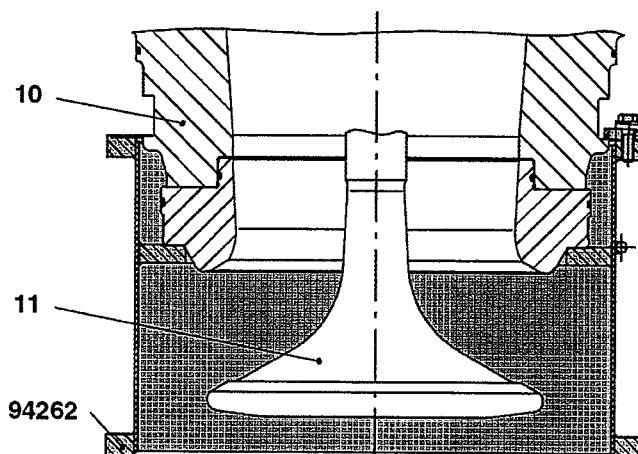
It is essential that the instructions 9403-4 referring to the application of hydraulic pre-tensioning jacks to screwed fastenings be strictly followed.

- If the exhaust valve is not to be dismantled at site immediately, mount the valve protector (94262) (Fig. 'B').

A



B



Exhaust Valve

Removal and Fitting of the Exhaust Valve, Replacing of the Waisted Studs

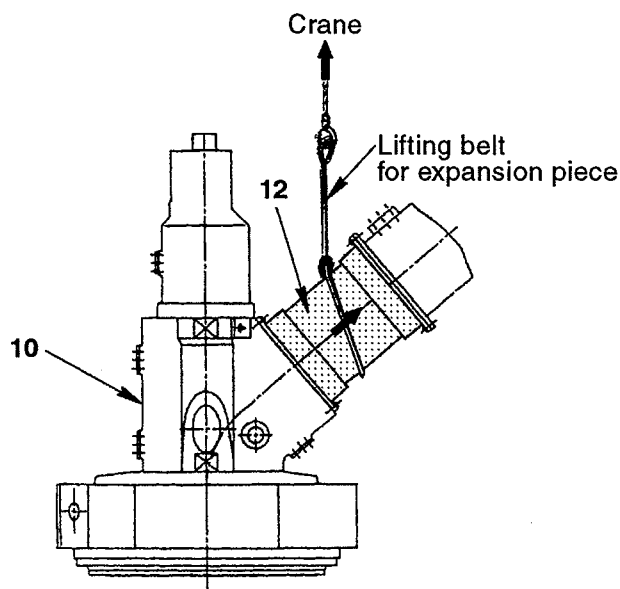
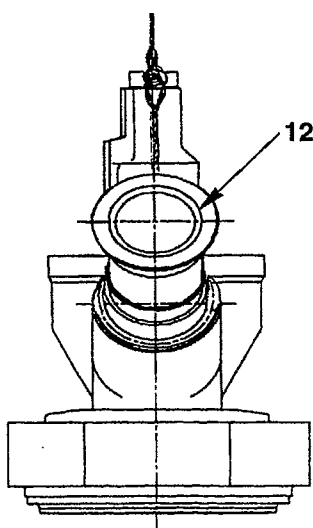
2. General



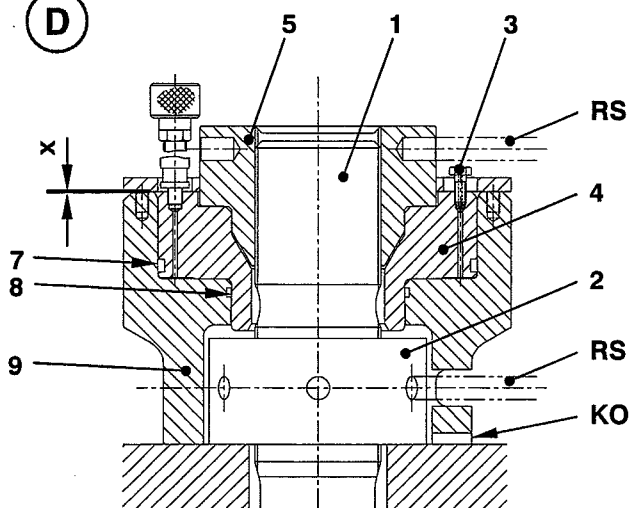
Prior to the removal of an exhaust valve immediately after stopping the engine protect your hands with leather gloves.

- ⇒ Remove all connected pipes. Remove hydraulic piping (see 8460-1).
- ⇒ Expansion piece (12) (Fig. 'C') has to be removed with the aid of lifting belt for expansion piece. After removing the connecting screws from the expansion piece flanges the expansion piece (12) can be taken out in the engine longitudinal direction.

(C)



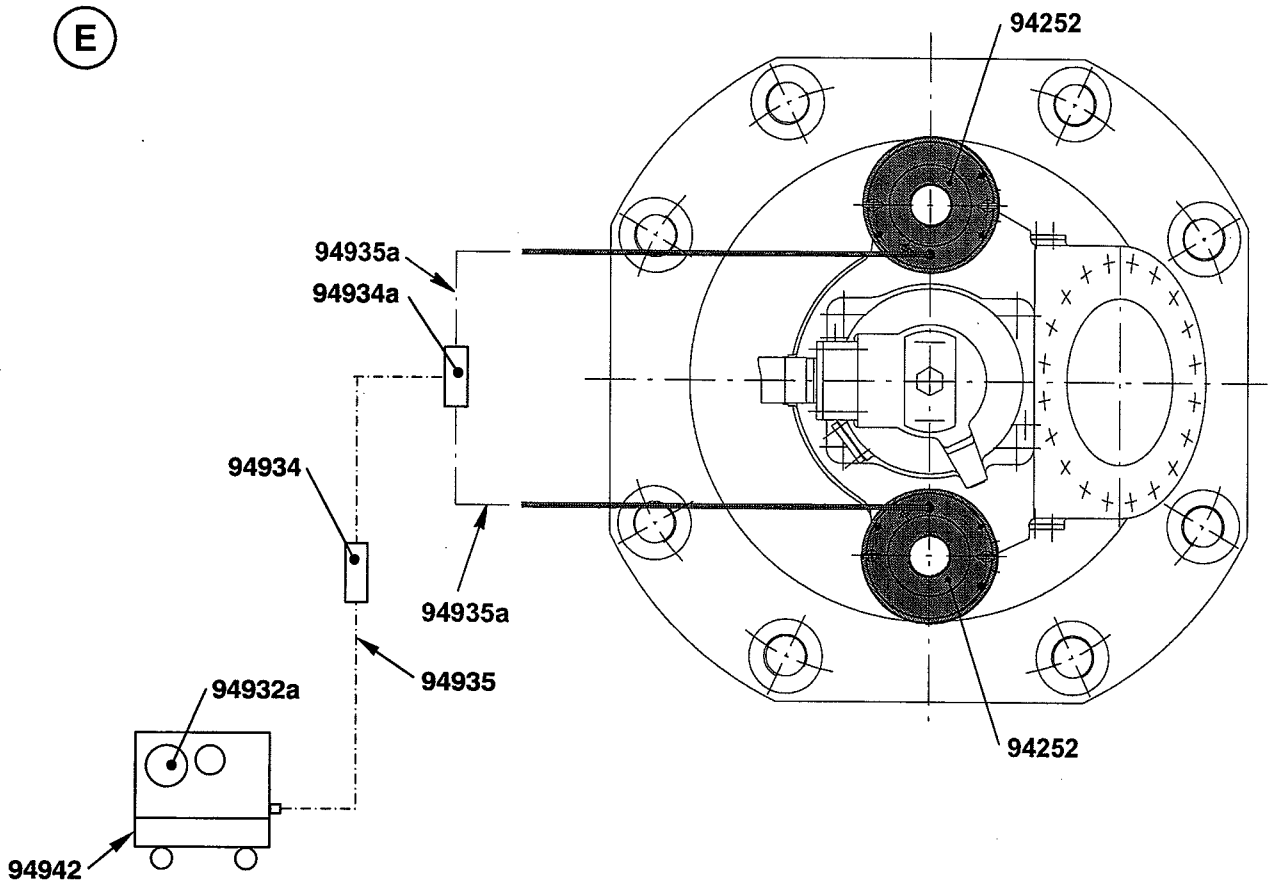
(D)



- ⇒ Clean the threads of waisted studs (1) of the valve cage as well as the area around nuts (2) (Fig. 'D').
- ⇒ Place hydr. tensioning device (94252) consisting of two pre-tensioning jacks on the two waisted studs (1) (Fig. 'D') which have to be loosened (arrangement according to Fig. 'E').
- ⇒ Open vent screw (3) of each pre-tensioning jack.
- ⇒ Screw round nuts (5) onto waisted studs (1) until there is no or very little clearance at 'x'.
- ⇒ Subsequently slacken round nuts (5) by about 1 1/2 turns (for loosening only)

Exhaust Valve

Removal and Fitting of the Exhaust Valve, Replacing of the Waisted Studs



- ⇒ Connect pre-tensioning jacks by HP hoses (94935) and (94935a) as well as connection piece (94934), (94934a) with hydraulic unit (94942) as shown in Fig. 'E'.

CHECK Verify the oil level in the hydraulic unit.

- ⇒ Actuate hydraulic unit.
- ⇒ Close vent screws (3) on the pre-tensioning jacks as soon as oil flows bubblefree.
- ⇒ Actuate hydraulic unit till a pressure of **102 MPa** is indicated on the pressure gauge (94932a) at the hydraulic unit.
- Attention should be paid to ensure that pins (6) always protrude slightly compared with pistons (4) on the pre-tensioning jacks!
- ⇒ Turn all nuts (2) upwards till the stop, using round bar "RS".
- ⇒ Release pressure to zero at the hydraulic unit.
- ⇒ Disconnect HP hoses to hydr. tensioning device (94252) and remove the latter.
- ⇒ Unscrew round nuts (5) from the waisted studs (1).
- ⇒ Suspend the hooks of suspension device (94265) (Fig. 'A') into the eye bolts of valve cage (10) and pull the complete exhaust valve out of the cylinder cover.

Exhaust Valve

Removal and Fitting of the Exhaust Valve, Replacing of the Waisted Studs

3. Fitting

- Before fitting the exhaust valve into the cylinder cover, the sealing surfaces must be checked for cleanliness and possible damage.
- Make sure that the soft iron gasket of 2 mm thickness lies flat in its recess in the cylinder cover.
- ⇒ New O-rings of the specified quality and dimension must be smeared with grease before fitting them into the grooves on the seat face of exhaust valve.
- ⇒ Fit the complete exhaust valve suspended on the suspension device (94265), taking care not to damage the thread of the waisted studs.
- The correct position of the exhaust valve cage is determined by the cylindrical dowel pin set in the cylinder cover.
- ⇒ Smear thread of waisted stud lightly with MOLYKOTE paste.

CHECK

Fit nuts (2) and tighten them firmly with round bar "RS" till fully seated before mounting the pre-tensioning jacks (check seating with feeler gauge).

- ⇒ Mark position of the nuts (2) on a corner and their position on valve cage (10) with a felt-tip pen (for later checks).
- ⇒ Place hydr. tensioning device (94252) consisting of two pre-tensioning jacks on the two waisted studs (1) (Fig. 'D') which have to be loosened (arrangement according to Fig. 'E').
- ⇒ Open vent screw (3) of each pre-tensioning jack.
- ⇒ Screw round nuts (5) onto waisted studs (1) until there is no or very little clearance at 'x'.
- ⇒ Connect the pre-tensioning jacks (94252) by HP hoses (94935) and (94935a) as well as connection piece (94934a) with hydraulic unit (94942) as shown in Fig. 'E'.

CHECK

Verify the oil level in the hydraulic unit.

- ⇒ Actuate hydraulic unit.
- ⇒ Close vent screws (3) on the pre-tensioning jacks as soon as oil flows bubblefre
- ⇒ Slowly raise the pressure to **100 MPa**.
- Attention should be paid to ensure that pins (6) always protrude slightly compared with pistons (4) on the pre-tensioning jacks!

CHECK

Keep this pressure constant and tighten nuts (2) with round bar "RS" till firmly seated on exhaust valve cage (10) (check seating with a feeler gauge through the slot "KO"). After tightening the nuts ascertain that these have been turned **by about the same angle** of 230°.

If bigger differences occur the tensioning procedure must be repeated.

- ⇒ Release pressure to zero and remove both pre-tensioning jacks.



CAUTION

When fitting expansion piece (12) smear its flange surfaces and connecting screws lightly with a heat resisting lubricant. The expansion piece has to be fitted in such a way that the expansion piece comes to lie in the flow direction, as shown in Fig. 'C'.

Exhaust Valve
Removal and Fitting of the Exhaust Valve, Replacing of the Waisted Studs
4. Replacement of waisted studs

Should waisted studs (1) (in the following text called stud for short) of the valve drive, cylinder cover, relief valve or starting valve have to be replaced, then their annular spaces must be filled with a jointing compound! Moreover the following points must be observed:

- Before fitting a stud clean its thread and corresponding tap hole. The sealing faces (Fig. 'F') must be degreased (e.g. using white spirit) and subsequently primed.
- Screw in the stud without lubricant on the thread, right to the bottom, and tighten it according to the instructions 0352-2. Always utilize a stud driver or two nuts.



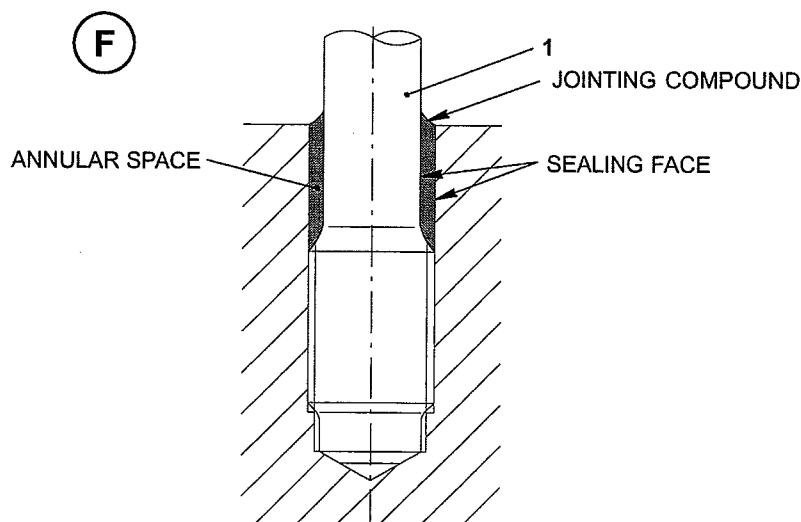
Tools like a pipe wrench etc. which would damage the stud shank must never be used.

- For the protection of the stud in the cylinder cover, fill the annular space above the thread with a well adhering, water and oil proof jointing compound (as shown in Fig. 'F'). The jointing compound must remain plastic at normal operating temperatures.

4.1 Recommended jointing compound and adhesive primers

Jointing compound	Hardener	Adhesive primer	Manufacturer
Elastosil RT 622 A	RT 622 B	G 790	Wacker-Chemie Gmbh Geschäftsbereich Silicone Hanns-Seidel-Platz 4 D-81737 München
Silcoset 105RTV	Silcoset Curing Agent A	Silcoset Primer	AMBERSIL LTD Wylds Rd Bridgwater Somerset TA6 4DD Uk-Great Britain

Equivalent products of other manufacturers may also be used.



Exhaust Valve
Dismantling and Assembling

Tools:

1	Depth gauge	94124
2	Retaining screws	94259
2	Jack screws	94263
1	Rotation device	94290
1	Torque wrench	
1	Eye bolt	M30

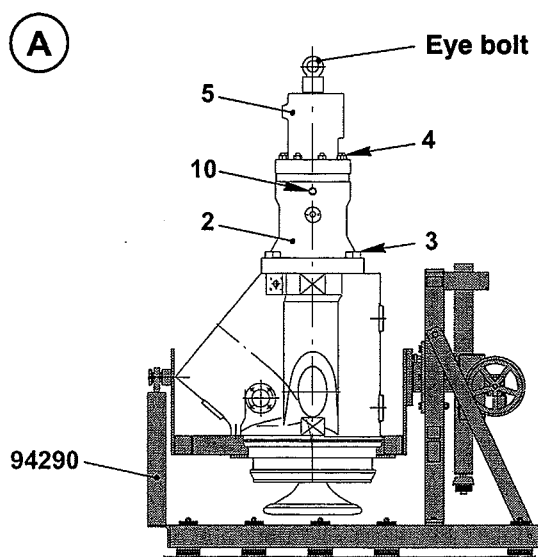
Key to Illustrations:

1	Valve cage	26	Non-return valve
2	Lower housing	27	Bush
3	Screw	28	Air pipe
4	Nut	29	Screw
5	Upper housing	30	Valve stroke sensor
6	Outside piston	31	Screw
7	Inside piston	32	Housing
8	Thrust piece	33	Spring
9	Valve spindle	34	Distance ring
10	Screw plug	35	Damper
11	Piston guide	36	Shim
12	Flange	37	O-ring
13	Screw	38	O-ring
14	Measuring cone	39	O-ring
15	Head screw	40	O-ring
16	Valve cotter	41	O-ring
17	Piston	42	O-ring
18	Piston seal ring	43	O-ring
19	Disc spring	44	O-ring
20	Distance ring	45	O-ring
21	Screw	46	O-ring
22	Guide bush		
23	Vent screw		
24	Valve seat	HH	Hydr. HP pipe
25	Rod seal ring	OB	Oil bore

Overview

1. **Dismantling of exhaust valve** 1/10
2. **Assembling of exhaust valve** 4/10
3. **Dismantling of valve drive and blocking exhaust valve** 9/10

1. Dismantling of exhaust valve



To dismantle the exhaust valve it must be fastened to the rotation device (94290) as shown in Fig. 'A'.

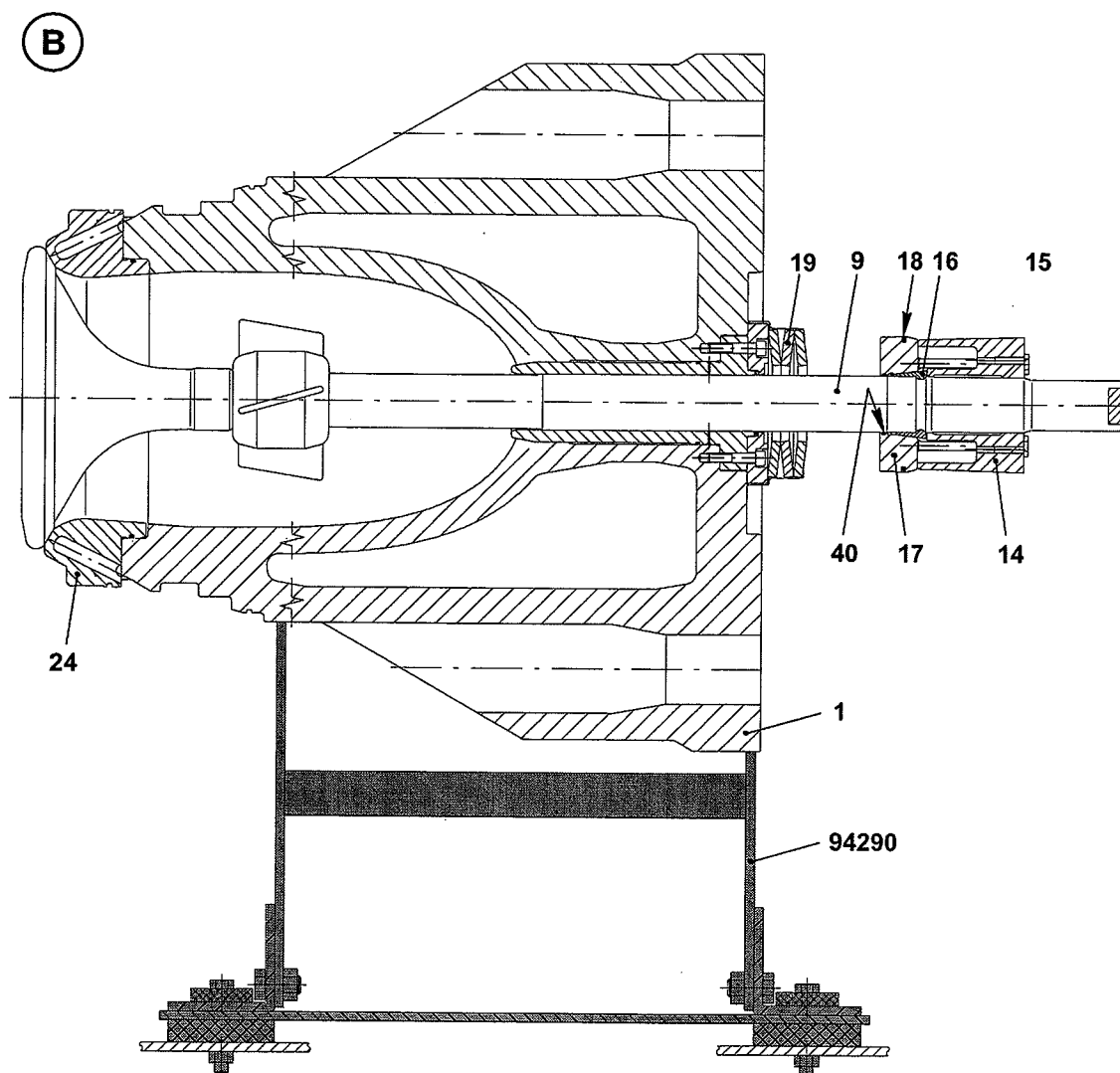
1.1 Dismantling of complete valve drive

- ⇒ Loosen and remove all nuts (4).
- ⇒ Lift the upper valve drive and remove it (Fig. 'M') using eye bolt.
- ⇒ Loosen screws (31) and remove housing (32), valve stroke sensor (30), spring (33) and distance ring (34) (Fig. 'G').
- ⇒ Remove O-ring (38).
- ⇒ Loosen and remove all screws (3).
- ⇒ Lift lower housing (2) and remove it.

Exhaust Valve
Dismantling and Assembling
1.2 Dismantling of valve spindle

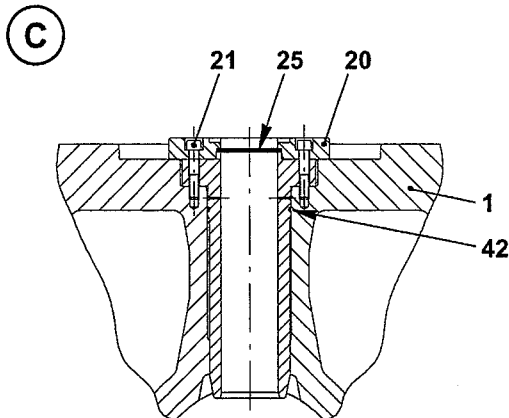
- ⇒ Bring the valve cage to horizontal position by means of the rotation device.
- ⇒ Push valve spindle (9) against valve seat (24).
- ⇒ Loosen screws (15) and remove them together with measuring cone (14).
- ⇒ Push piston (17) away from valve cotters (16), then remove the latter.
- ⇒ Withdraw the piston from the valve spindle.
- ⇒ Remove disc springs (19).
- ⇒ Dismantle the valve spindle.

The valve spindle can be dismantled in vertical or horizontal position after turning the valve cage with rotation device (94290).



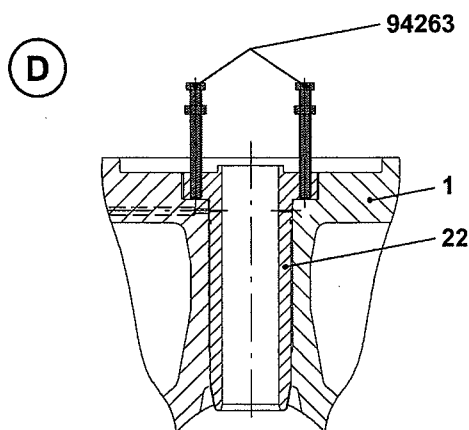
Exhaust Valve

Dismantling and Assembling



1.3 Removal of guide bush

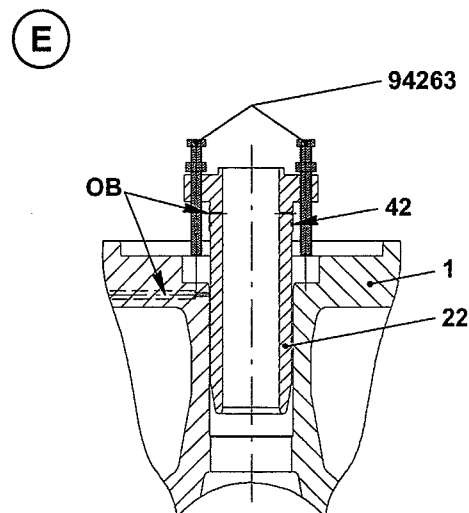
- ⇒ Turn valve cage (1) in vertical position.
- ⇒ Undo head screws (21), remove them together with distance ring (20) and rod seal ring (25).



- ⇒ Screw both jack screws (94263) into the flange of guide bush (22) until the latter can be lifted off.

CHECK

Check and measure inner diameter of the guide bush according to Clearance Table 0330-1 'Exhaust Valve'.



1.4 Assembling of guide bush

- ⇒ Clean the bore in valve cage (1) concerned.
- ⇒ Clean guide bush (22).

CHECK

Check oil bores "OB" in guide bush and valve cage for free passage.

- ⇒ Replace O-ring (42).
- ⇒ Oil guide bush and press it into the valve cage up to the stop using jack screws (94263).

Exhaust Valve
Dismantling and Assembling

2. Assembling of exhaust valve

Assembling is carried out analogously to dismantling but in reverse sequence.

CHECK

Check dimensions of valve spindle (9) according to Clearance Table 0330-1 'Exhaust Valve'.



The condition of piston seal ring (18) (Fig. 'K') is to be examined on every occasion, at the latest, however, on the occasion of an overhaul of the exhaust valve according to the maintenance schedule. A damaged piston seal ring must be replaced in any case.

⇒ Check all O-rings of the dismantled parts for damage and replace them if necessary.



Remark : If an exhaust valve is to be fitted with a new seat or spindle, in any case the valve seat must be ground beforehand in fitted condition with the available grinding tool for valve seats. Instructions are given in 2751-3.



Remark : After each overhaul vent screw (23) (Fig. 'K') must be checked and cleaned. (see Mitsubishi Service Information MSI-0106E)

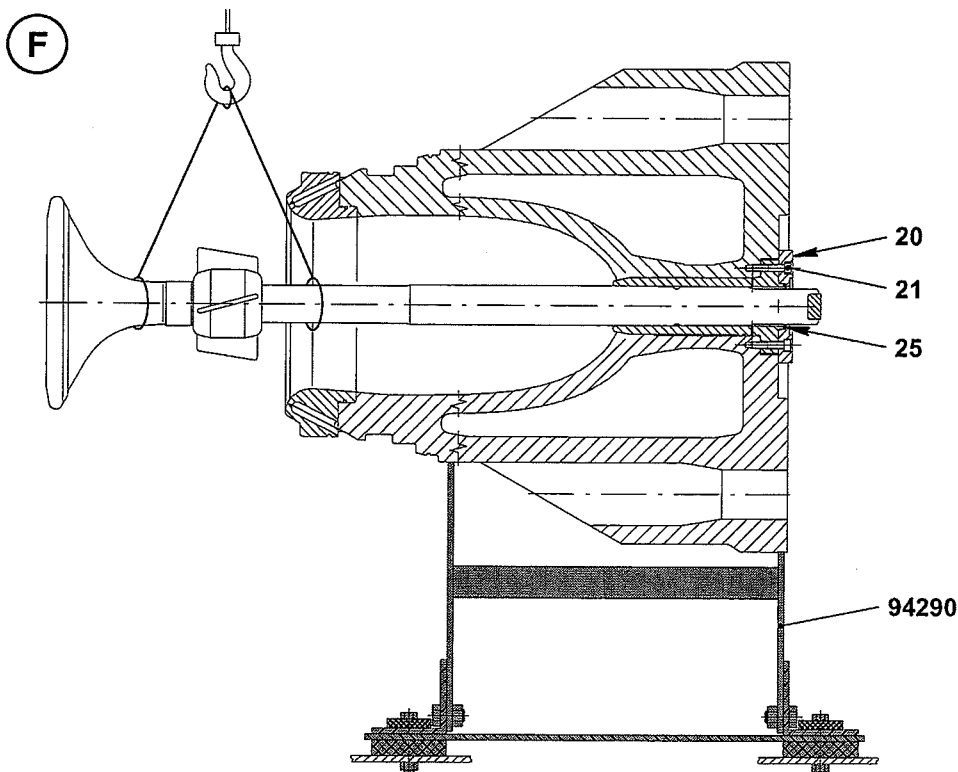
2.1 Fitting of valve spindle

⇒ Fit the valve spindle (Fig. 'F').

⇒ Fit a new rod seal ring (25), distance ring (20) and tighten them with head screws (21).



Remark : Always fit rod seal ring and distance ring only after fitting the valve spindle, otherwise the rod seal ring might be damaged.

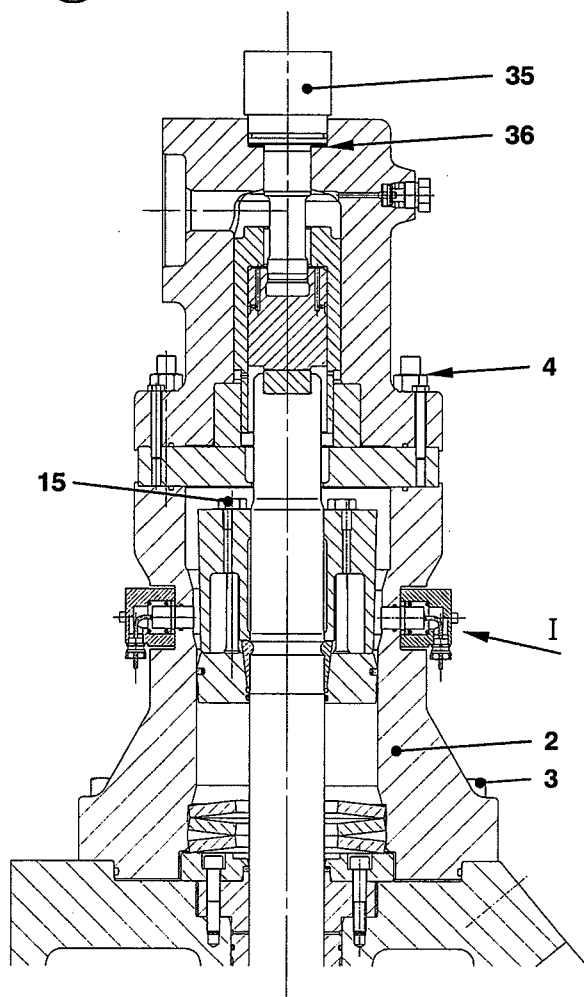


Exhaust Valve
Dismantling and Assembling

2.2 Assembling of valve drive

- ⇒ Push valve spindle (9) against the valve seat and fit disc springs (19) as shown in (Fig. 'B').
- ⇒ Fit piston (17), valve cotters (16) and measuring cone (14) (Fig. 'B').
- ⇒ Apply oil to the threads of screws (15). Fit and tighten them crosswise in following steps, i.e. with a torque of **20 Nm**, **80 Nm** and **finally up to 200 Nm**.
- ⇒ Bring the valve cage to vertical position by means of the rotation device.
- ⇒ Fit lower housing (2) (Fig. 'G').
- ⇒ Apply oil to the threads of screws (3). Fit and pre-tighten them crosswise with a torque of **130 Nm** and subsequently by a further angle of **30°**.
- Take care of bush (27) and O-ring (46) when fitting (Fig. 'I', section I-I).
- ⇒ Fit the upper valve drive and fasten it (Fig. 'M') using nuts (4).

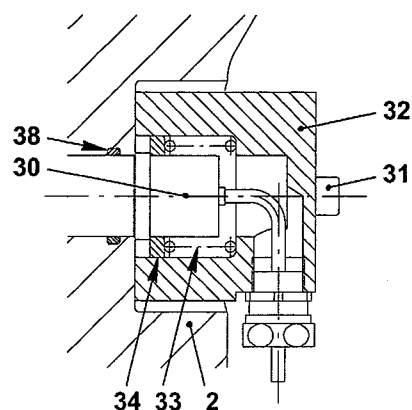
G



2.3 Assembling of valve stroke sensor

- ⇒ Oil O-ring (38) and insert it into the corresponding groove in lower housing (2).
- ⇒ Fit valve stroke sensor (30) (Fig. 'G') in such a way that spring (33) presses distance ring (34) against the collar of the valve stroke sensor.
- ⇒ Push valve stroke sensor together with housing (32) into the exhaust valve housing and tighten screws (31).

I



Exhaust Valve

Dismantling and Assembling

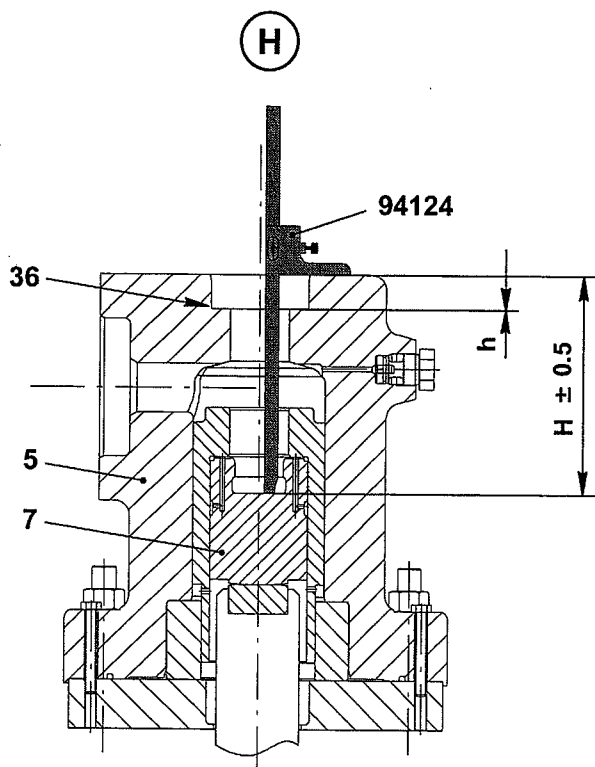
2.4 Setting of damper

Setting of damper (35) (Fig. 'G') is necessary only after a valve spindle or valve seat has been replaced, and after one of the valve seating faces has been ground.

Setting is to be carried out, after assembling of the exhaust valve as shown in Fig. 'H'.

2.5 Determining of total thickness 'h' of the shims

- ⇒ Remove damper (35) (Fig. 'G').
- ⇒ Determine with depth gauge (94124) measure 'H' from the top edge of upper housing (5) to the bottom of the damper bore in inside piston (7); for this the exhaust valve must be closed (check with feeler gauge whether the valve plate lies against the valve seat without clearance).
- The total thickness 'h' of shims (36) assigned to measure 'H' is shown in the following table:



Measure 'H' ± 0.5 mm	Total Thickness 'h'
222 mm	2 mm
221 mm	3 mm
220 mm	4 mm
219 mm	5 mm
218 mm	6 mm
217 mm	7 mm
216 mm	8 mm

- ⇒ Fit damper (35) and shims (36) with determined total thickness.

Single shim rings of 1 mm are available.

Exhaust Valve
Dismantling and Assembling

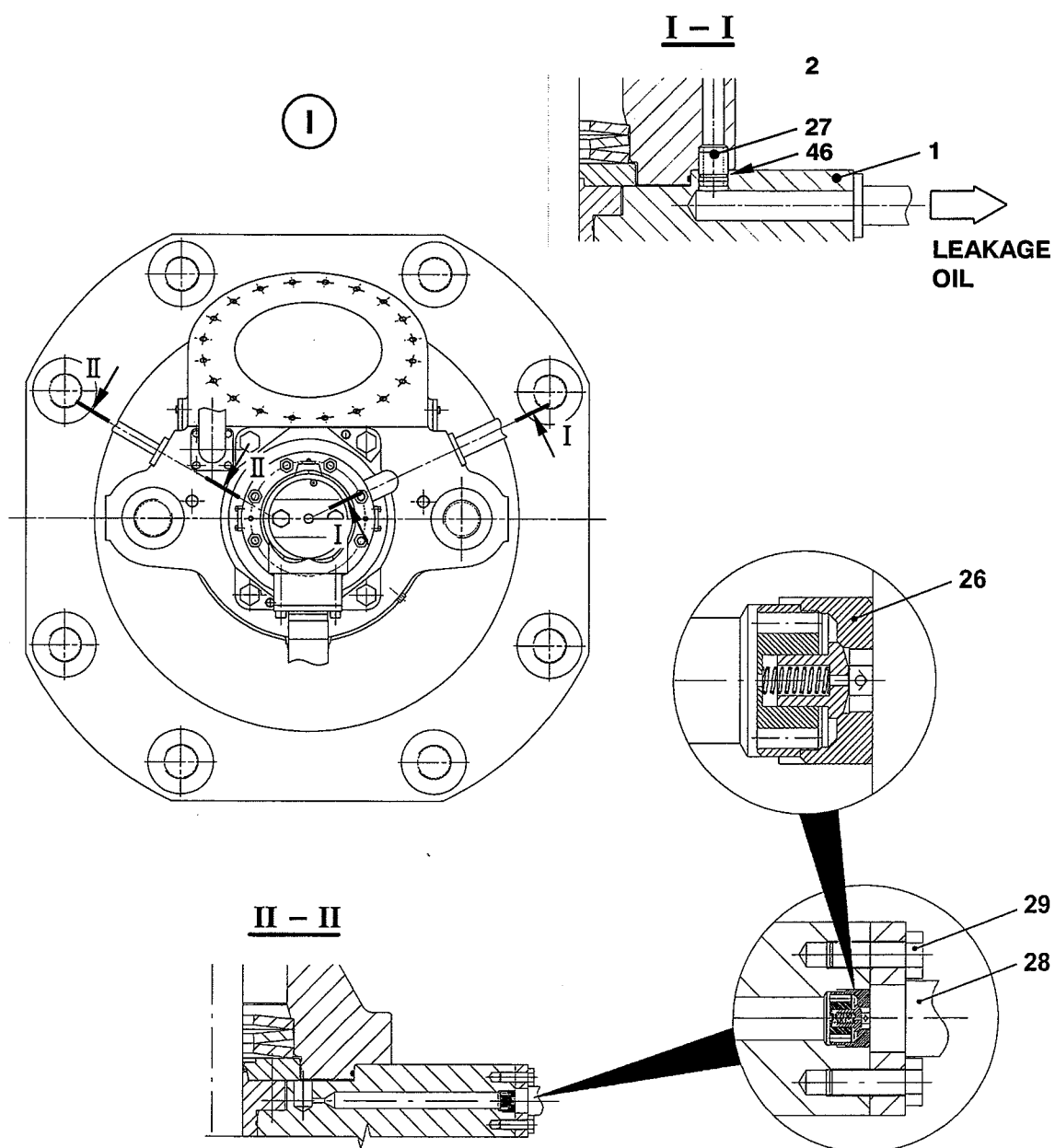
2.6 Checking vent screw

- ⇒ Remove and check vent screw (23) (detail in Fig. 'K') for cleanliness, and replace O-ring (45).

2.7 Checking non-return valve

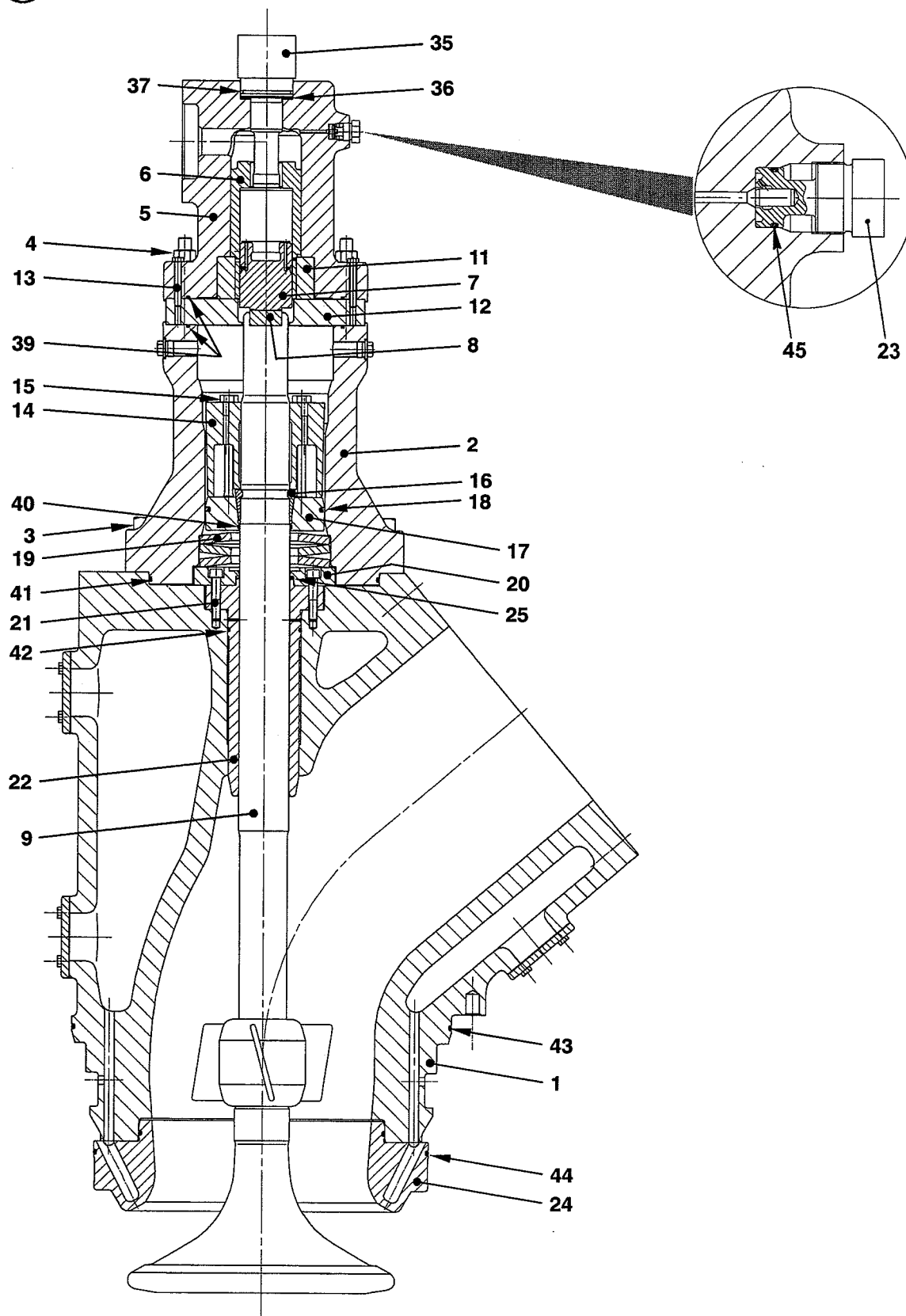
- In order to remove non-return valve (26) unscrew air pipe (28) (Fig. 'I').
- ⇒ Undo the non-return valve.

CHECK Check the non-return valve.



Exhaust Valve
Dismantling and Assembling

(K)

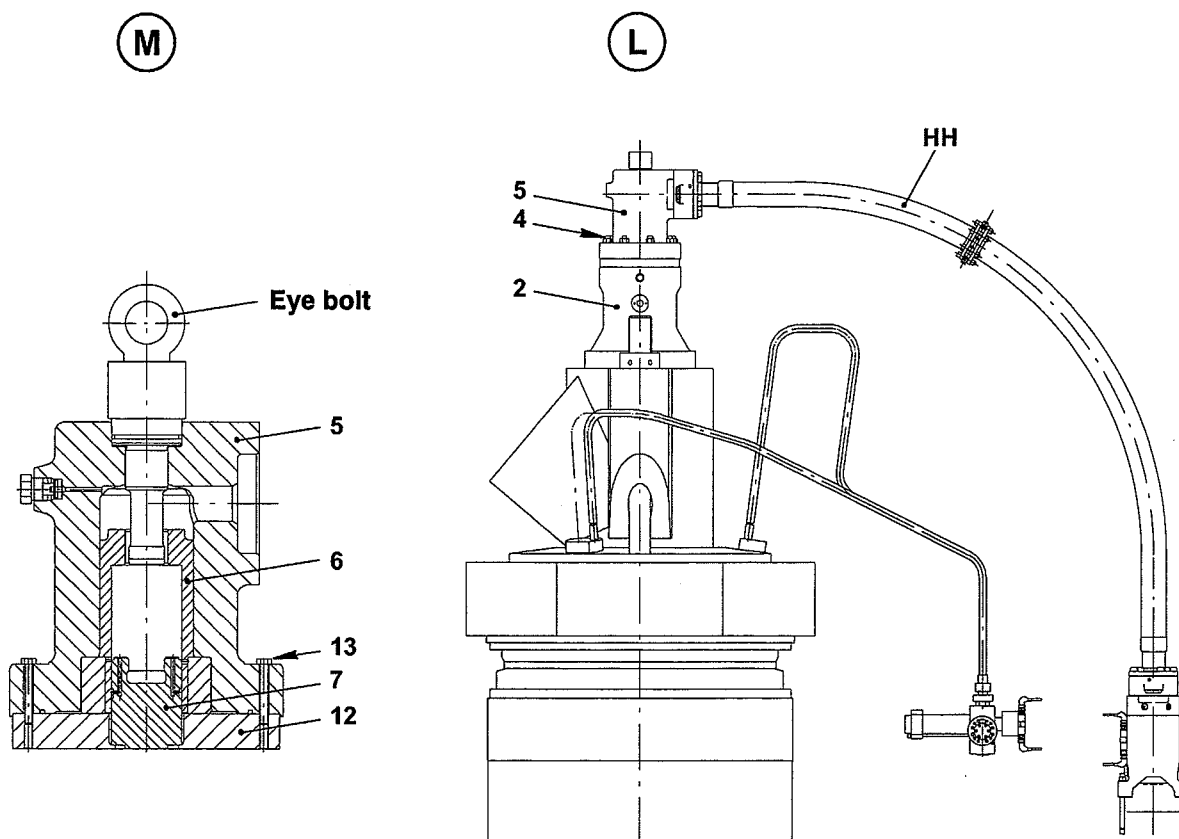


Exhaust Valve
Dismantling and Assembling**3. Dismantling of valve drive and blocking exhaust valve**

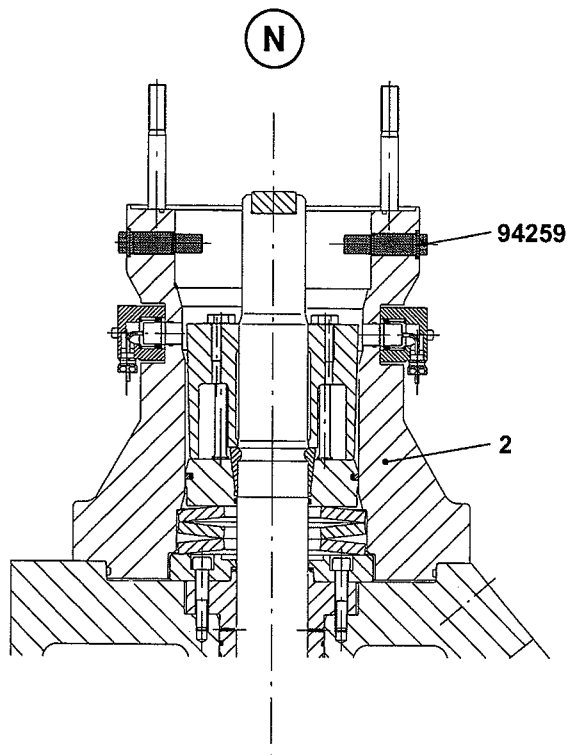
For dismantling the upper valve drive (Fig. 'M') the operation must be interrupted temporarily. The necessary measures for it are described in Operating Manual 0520-1 and must be followed strictly.

3.1 Dismantling of upper valve drive

- ⇒ Drain and dismantle hydr. HP pipe "HH" to the exhaust valve drive (see 8460-1).
- ⇒ Remove nuts (4) (Fig. 'L').
- ⇒ Attach the upper part of the valve drive to eye bolt (Fig. 'M') and lift it off.
- ⇒ Cover opening appeared above lower housing (2) to prevent dirt from entering!

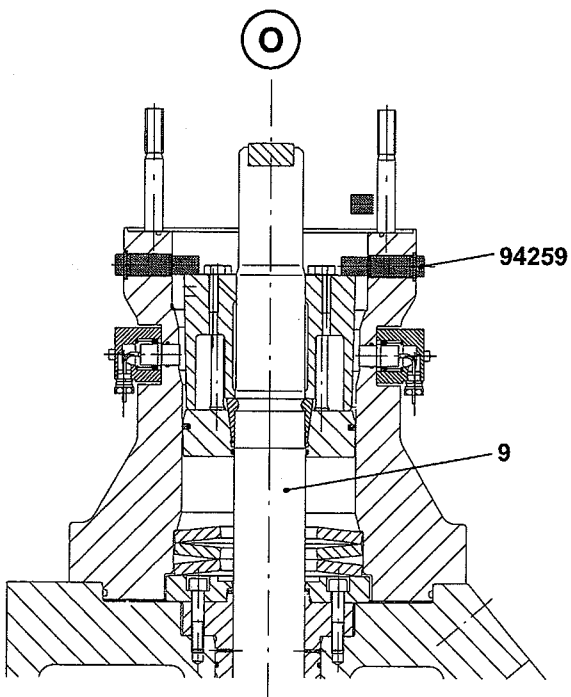


Exhaust Valve
Dismantling and Assembling



3.2 Blocking exhaust valve

⇒ Unscrew both screw plugs (10) (Fig. 'A') from lower housing (2) and screw in retaining screws (94259) instead.



3.3 Blocked exhaust valve

After screwing in retaining screws (94259) reopen the shut-off valve to the air spring supply. This locks valve spindle (9) in OPEN position (Fig. 'O').



Remark : For operation with a cylinder cut-out see Operating Manual 0520-1.

Exhaust Valve

Replacing and Grinding the Valve seat

Tools :

1	Feeler gauge	94122
1	Valve seat fitting and dismantling device	94261
1	Valve seat grinding machine	94278
1	Gauge	94279
1	Working stand	94290

Key to Illustrations :

1	Valve seat	AF	Seating face
2	Valve cage	HA	Hammer
3	O-ring	RC	Eye bolt

Overview

1. General	1/5
2. Removing the valve seat	1/5
3. Fitting the valve seat	2/5
4. Grinding the valve seat	3/5
5. Checking the valve seat	5/5

1. General

Valve seats of which the seat surfaces are badly damaged must be ground. Valve seats on which the wear limit has been reached through frequent grinding must be replaced.

The most advantageous position for replacing or grinding the valve seat is to bring the valve cage to the vertical on the working stand (94290).

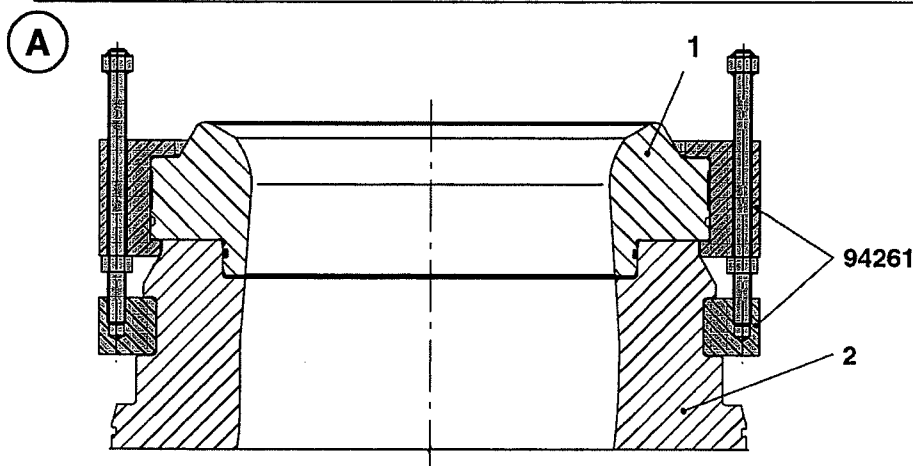
The guide bush (spindle guide) does **not** have to be removed.

2. Removing the valve seat (Fig. 'A')

- ⇒ Fit both pairs of ring halves of the valve seat fitting and dismantling device (94261) into the groove on the circumference of the valve cage (2) and valve seat (1) respectively.
- ⇒ By equal tightening of the three jack screws of the valve seat fitting and dismantling device (94261), the valve seat can be pressed out of its seating in the valve cage.



Should a used valve seat (1) be re-used, then it must be marked together with the valve cage (2) before removing. When re-fitting the valve seat the previously applied markings must be brought in line.



Exhaust Valve

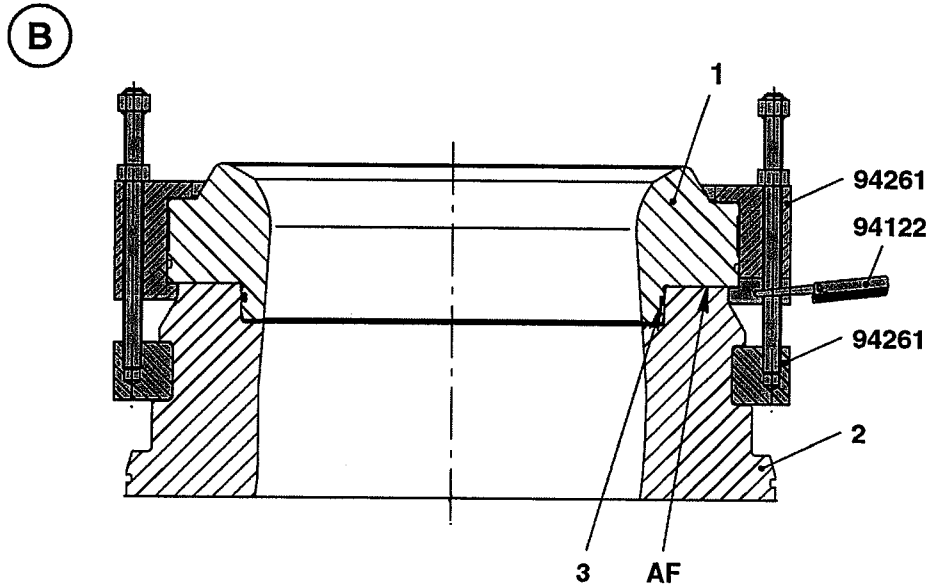
Replacing and Grinding the Valve seat

3. Fitting the valve seat (Fig. 'B')

- ⇒ Place valve cage - as for the seat removal - vertically (Fig. 'C').
- ⇒ Clean bore as well as seating shoulder at "AF" meticulously.
- ⇒ Smear the bore into which the valve seat has to fit with oil, or lubricants such as THREAD GARD, LOCTITE, ANTI-SEIZE COMPOUND etc.
- ⇒ Smear new O-ring (3) of original specification with the same lubricant.
- ⇒ Push valve seat as far as possible into the bore, then mount valve seat fitting and dismantling device' (94261) (Fig. 'B') and by equal tightening of the jack screws press the valve seat down till fully seated.

CHECK

Through the control openings in the valve seat fitting and dismantling device (94261) check with feeler gauge (94122) all around the circumference that no clearance remains at "AF". For this check the fitting device has still to be fitted fast as required for the subsequent grinding of the valve seat.

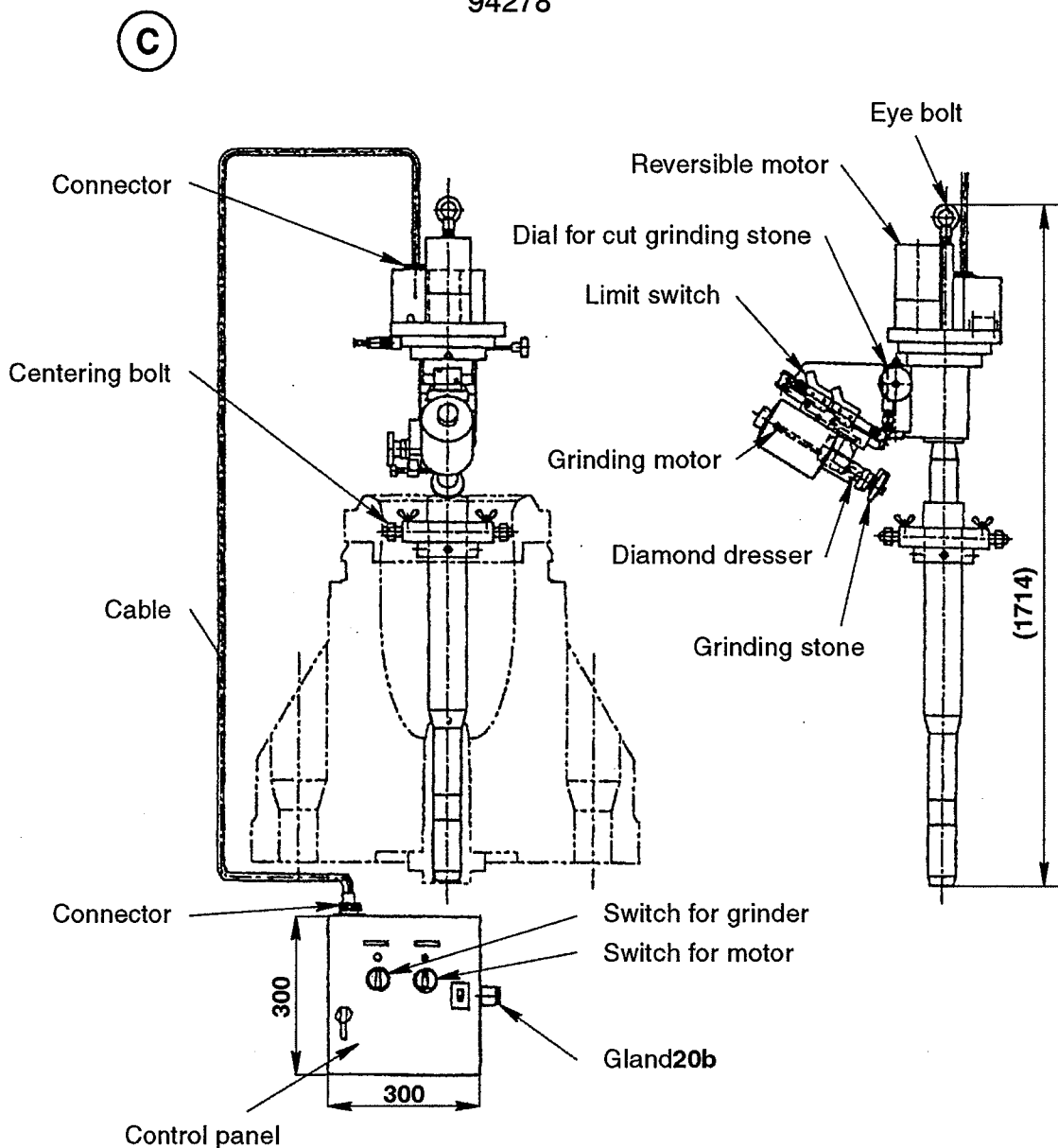


Exhaust Valve

Replacing and Grinding the Valve seat

Valve seat grinding machine

94278



4. Grinding the valve seat (Fig. 'C')

- Valve seats must be ground only with the valve seat grinding machine (94278).



Grinding in valve seats using the valve spindle with grinding paste must be avoided as a matter of principle!

When is grinding of valve seats in the valve cage indicated?

- When a valve seat is fitted to the valve cage.
- When new or reconditioned valve spindles are fitted.
- When the seat surface on the valve seat is badly damaged (impacts, corrosion scars).

Exhaust Valve

Replacing and Grinding the Valve seat

- When grinding the valve seat, take care that as little grinding dust as possible falls into the valve cage or even stays there. A thorough cleaning after completion is absolutely essential.



Regarding the operation of the grinding machine refer to the operating instructions of the manufacturer.



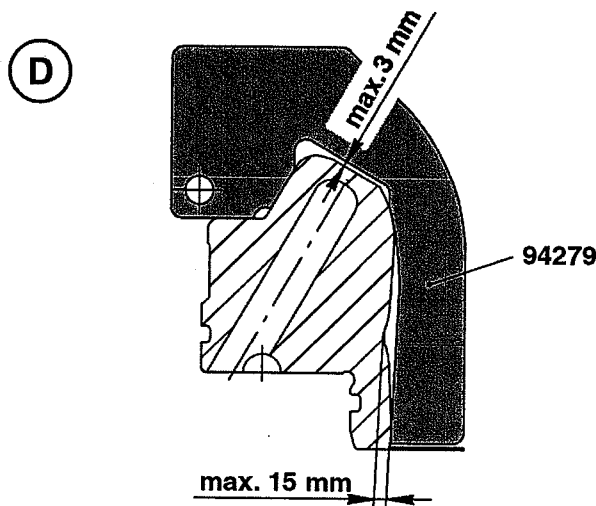
Experience has shown that when grinding valve seat surfaces 'chatter' marks are generated if vibrations are set up by engine or other machines in the vicinity. To prevent such 'chatter' marks, attach the antivibration rubber to the support of valve seat.

Valve seat angle = $30^{\circ} +2^{\circ}_0$

CHECK

The grinding allowance on the valve seat is maximum 3 mm. The wear condition can be checked efficiently with gauge (94279) in combination with feeler gauge (94122) (see Fig. 'D'). Possible burn scars at the inside of the valve seat must not exceed 15 mm. The depth of the burn scars can also be verified with the gauge (94279) as shown in Fig. 'D'.

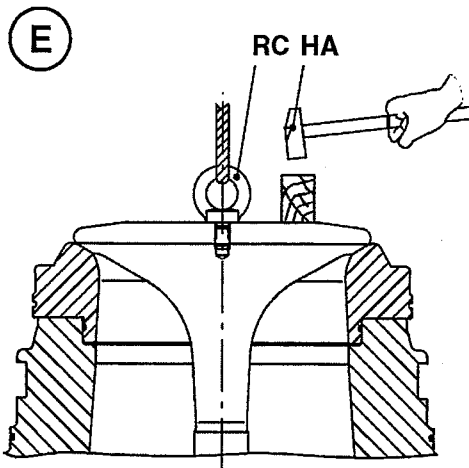
- Valve seats which exceed the above mentioned values must be replaced.



Exhaust Valve

Replacing and Grinding the Valve seat

5. Checking the valve seat

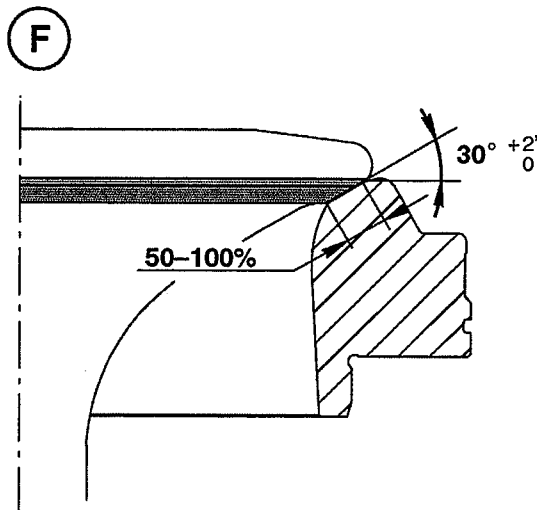


After grinding it is necessary to check whether the new or re-ground valve spindle makes correct contact with the valve seat. For this the spindle head seat face is spread with a thin coating of blueing paste, then inserted vertically into the valve guide bush.



Remark

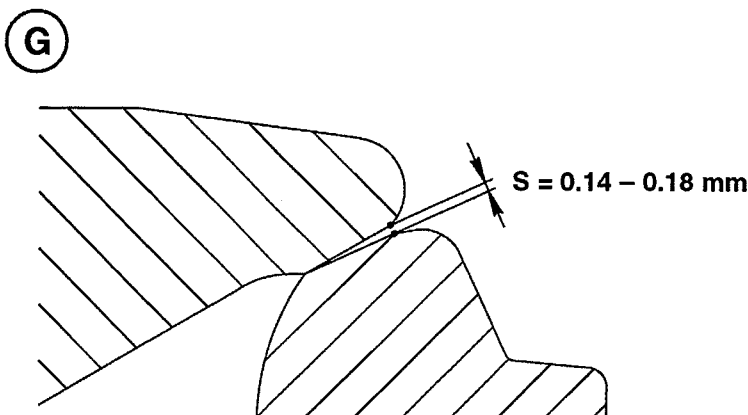
∴ The angle difference is chosen such that in the hot operating condition the valves make contact by 50 ~ 100% from the outer edge (Fig. 'F'). The blueing check should show that the cold valve makes contact only from inside around the whole circumference. The angle difference can be checked at gap 'S' on the outer edge with a feeler gauge (Fig. 'G').



⇒ The blueing on the valve seat must be checked by tapping the valve head three or four times with a hammer on a wooden block! (Fig. 'E').



Do not rotate the valve spindle on the valve seat face, as this risks seizure of the seating.



Exhaust Valve

Grinding the Seating Surface on the Valve Head

Tools :

1	Feeler gauge	94122
1	Valve grinding machine	94291
1	Gauge	94292

1. General



Grinding in a valve together with its valve seat with grinding paste is not permitted. Valves which have had the seating surfaces badly damaged by pitting or corrosion have to be reground by machine. It is strongly recommended that a suitable grinding machine (94291) be made available.



Remark : A valve spindle with missing rotation wing may not be reground. The wing hub must be shrink-fitted on the valve shaft by heating it to 480 °C. Grinding may first begin after the whole unit has cooled down.



Before commissioning the instruction and direction of the valve grinding machine manufacturer must be observed.

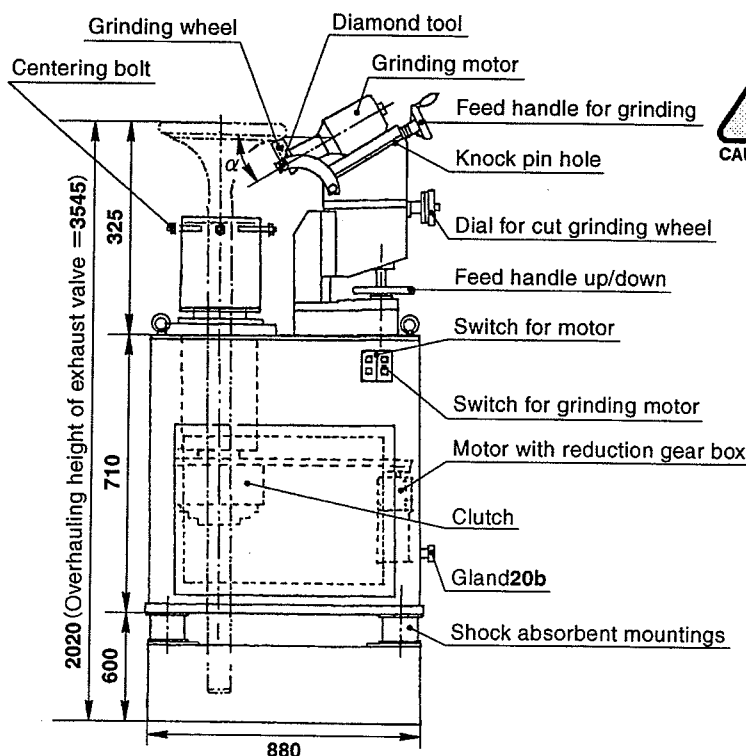
2. Grinding the seating surface

**Valve grinding machine
94291**

SEATING FACE ANGLE ON VALVE

A

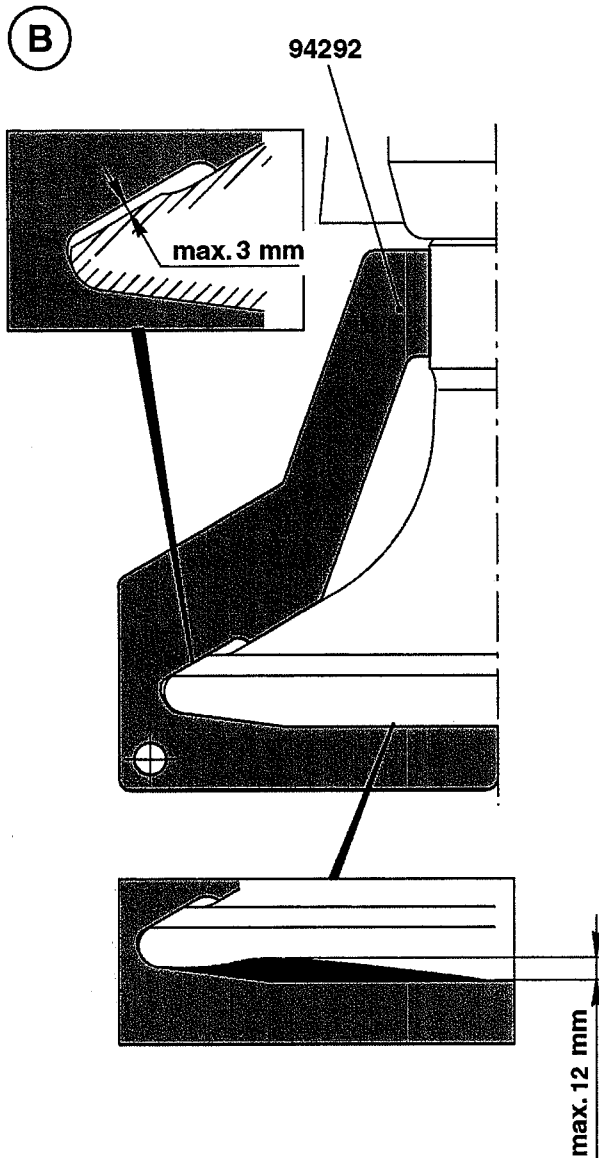
$$a = 30^{\circ} \begin{matrix} +20' \\ +18' \end{matrix}$$



In order to avoid the appearance of chatter marks on the seating surface, the grinding machine should be placed in an area which is free of vibration from running machinery or engines, etc. If necessary the grinding machine should be stood on a rubber mat.

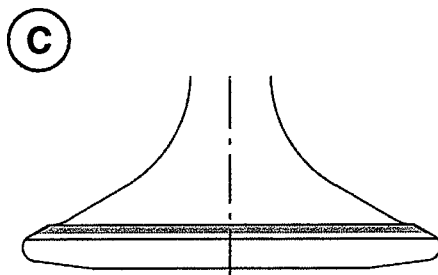
Exhaust Valve

Grinding the Seating Surface on the Valve Head



CHECK The wear condition can be checked at any time with gauge (94292) and feeler gauge (Fig. 'B').

- A maximum of 3 mm may be ground off the valve seating face.
- On engines with heavy operation duty, corrosion may form at the bottom of the valve plate, after a longer operating time. Valve plates, on which the corrosion layer is deeper than 12 mm or where the seat surface has been ground back by more than 3 mm (Fig. 'B'), can be reconditioned by build-up welding. Such a repair process may, however, only be carried out by the engine manufacturer.



- Where the precise angle required has been obtained during grinding, a check with marking blue with the valve on the reground valve seat in the valve cage will show only a line contact or a very narrow band (extent of contact) starting from the smaller diameter (Fig. 'C').

Group 3

3

Crankshaft: Measuring Crank Deflection3103-1/A1

▽ **Vibration Damper**

Vibration Damper: Inspection (GEISLINGER Vibration Damper)3130-2/A1

Axial Damper: Dismantling and Assembling3146-1/A1

Crankcase: Utilization of the Working Platform and the Ladder3301-1/A1

▽ **Connecting Rod**

— Loosening and Tensioning the Connecting Rod Studs3303-1/A1

— Inspection, Removal and Fitting of Bottom End Bearing3303-2/A1

— Inspection, Removal and Fitting of Top End Bearing3303-3/A1
with Piston in Situ

— Inspection, Removal and Fitting of Top End Bearing3303-3/A2
with Piston Removed

— Removal and Fitting3303-4/A1

▽ **Crosshead**

— Checking the Clearances and Fitting the Guide Shoes3326-1/A1

— Removal and Fitting of a Crosshead Pin3326-2/A1

▽ **Piston**

— Removal and Fitting3403-1/A1

— Dismantling and Assembling3403-3/A1

— Checking Piston Top Surface3403-4/A1

Piston Rings: Checking Piston Ring Wear3425-1/A1

Crankshaft

Measuring Crank Deflection

Tools :

1 Dial gauge 94305

Key to Illustrations :

1 Flywheel
2 Pinion

1. General

The crank deflections (crankshaft alignment) must be measured in order to ascertain whether the values of the crankshaft axis have changed.

For that dial gauge (94305) is fixed between the corresponding crank webs. When turning the crankshaft, the change in distance between the crank webs can be read from the dial gauge as it indicates any opening or closing up. The smaller the variations the better the position of the shaft.



The crankshaft must not be turned by turning gear when workmen are in crankcase.

2. Checking crank deflection

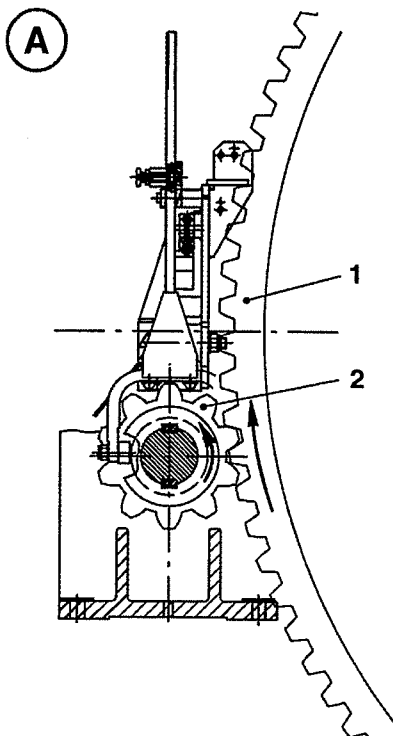
- Under normal circumstances, once a year.
- In case the ship has touched ground.
- After replacing main bearing shells and again after approx. 100 service hours.
- By signs of damage to the main bearings.

3. Conditions for measuring

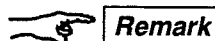
- Indicator valves must be open.
- The ship must be floating freely and lying straight in the water.
- The crankshaft must rest perfectly on all the main bearings.

3.1 Influences on measuring

- Engine cold or at service temperature.
- Loaded condition of the ship.
- Differing air and water temperatures.
- Strong sunshine.
- Temporary deformation of the hull and/or the engine.



4. Procedure of measuring

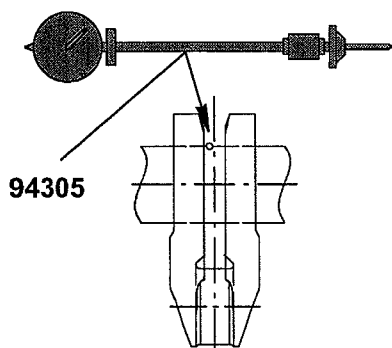
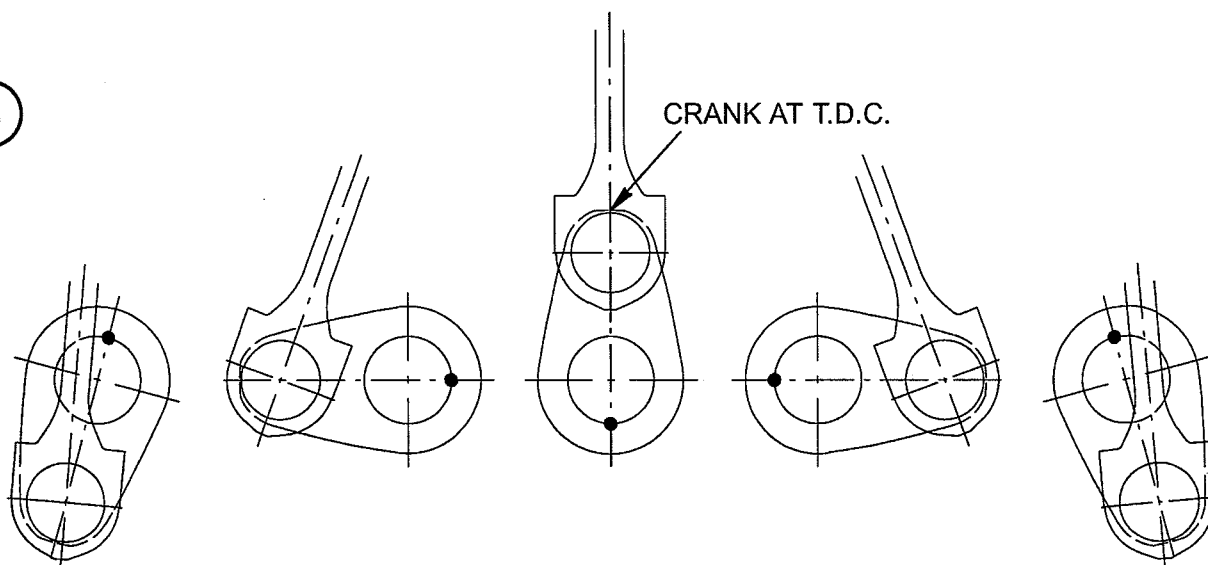


Remark : To measure the crank deflection the crankshaft must always be turned in such a manner - despite the ordinary rotation direction of the engine - that flywheel (1) and pinion (2) of the turning gear are rotating as indicated by the arrow (see Fig. 'A').

- With the running gear in place, the crank to be measured has to be turned towards (before or after) B.D.C. until the dial gauge can be fitted next to the connecting rod at the position indicated. (see Fig. 'B').

Crankshaft
Measuring Crank Deflection

B



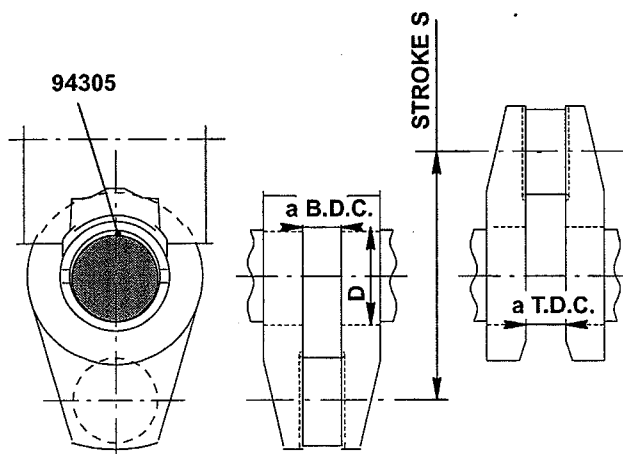
- ⇒ Pretension the dial gauge slightly and set it to zero (see Fig. 'B').
- ⇒ Turn the crankshaft with the turning gear, reading the dial gauge in the crank positions which are indicated in Fig. 'B' and noting down the values at B.D.C. - FUEL SIDE - T.D.C. - EXHAUST SIDE - B.D.C.
- The last value at B.D.C. is for checking; if everything has been carried out correctly it should be nearly zero.

5. Judging the measuring

The difference (Δa) between the indicated values at B.D.C. and T.D.C. shows the amount of crank deflection during one revolution (see Fig. 'B').

Where values are measured which lie above the maximum permissible limits, the cause has to be found and the necessary remedial measures taken (defective main bearing, engine stay altered due to hull deformation, loose holding-down bolts, defective propeller shaft bearings, etc.).

The values of Δa given below are valid for all conditions independent of outside influences.



Difference	$\Delta a = a \text{ T.D.C.} - a \text{ B.D.C.}$
Good values	$\Delta a = 0 - 0.33 \text{ mm}$
Values still admissible	$\Delta a = 0.33 - 0.66 \text{ mm}$

Vibration Damper

Inspection (GEISLINGER Vibration Damper)

Key to Illustrations:

1	Damper casing	6	Coupling bolt
2	Vent nozzles	7	Coupling disc
3	Sealing rings		(crank angle sensor unit)
4	Oil supply piping	8	Vibration damper
5	Crankshaft	9	Sealing ring

1. General

Depending on the design execution of an engine, a vibration damper of GEISLINGER make may be mounted at the free end of the crankshaft.

The service life of a vibration damper depends largely on the speed range in which the engine is operated. Water, in particular sea-water, in the lubricating oil leads to increased wear and loss of damping action.

2. Check

- The engine filters should regularly be checked for steel or bronze chippings. If such chippings are found also in the damper housing, the damper supplier is to be informed accordingly.



Until the reasons for such findings are not clarified and rectified, it is not allowed to put the damper back into service.

- Should the oil pressure drop below 0.1 MPa, it may not be corrected by adjustment of the adjustable throttle in the supply piping. Instead, the cause of the pressure drop must be investigated (defective oil supply piping (4)).
- Should damage be noticed on the engine bearings which is due to water contamination of the lubricating oil, then the vibration damper must also be inspected for possible damage at the very earliest opportunity.
- To check the inner spring tips and groove flanks the inspection cover on the face of damper casing (1) (Fig. 'B') can be removed (with stopped engine). For wear limits refer to the manual of the damper manufacturer.
- Dismantling of a vibration damper should only take place if there is a reasonable suspicion that the damper is damaged or wear rates have exceeded their limits. In this case contact the damper manufacturer for further instructions.



Adjustments on the vibration damper may only be carried out by a specialist, with simultaneous torsional vibration measurements.

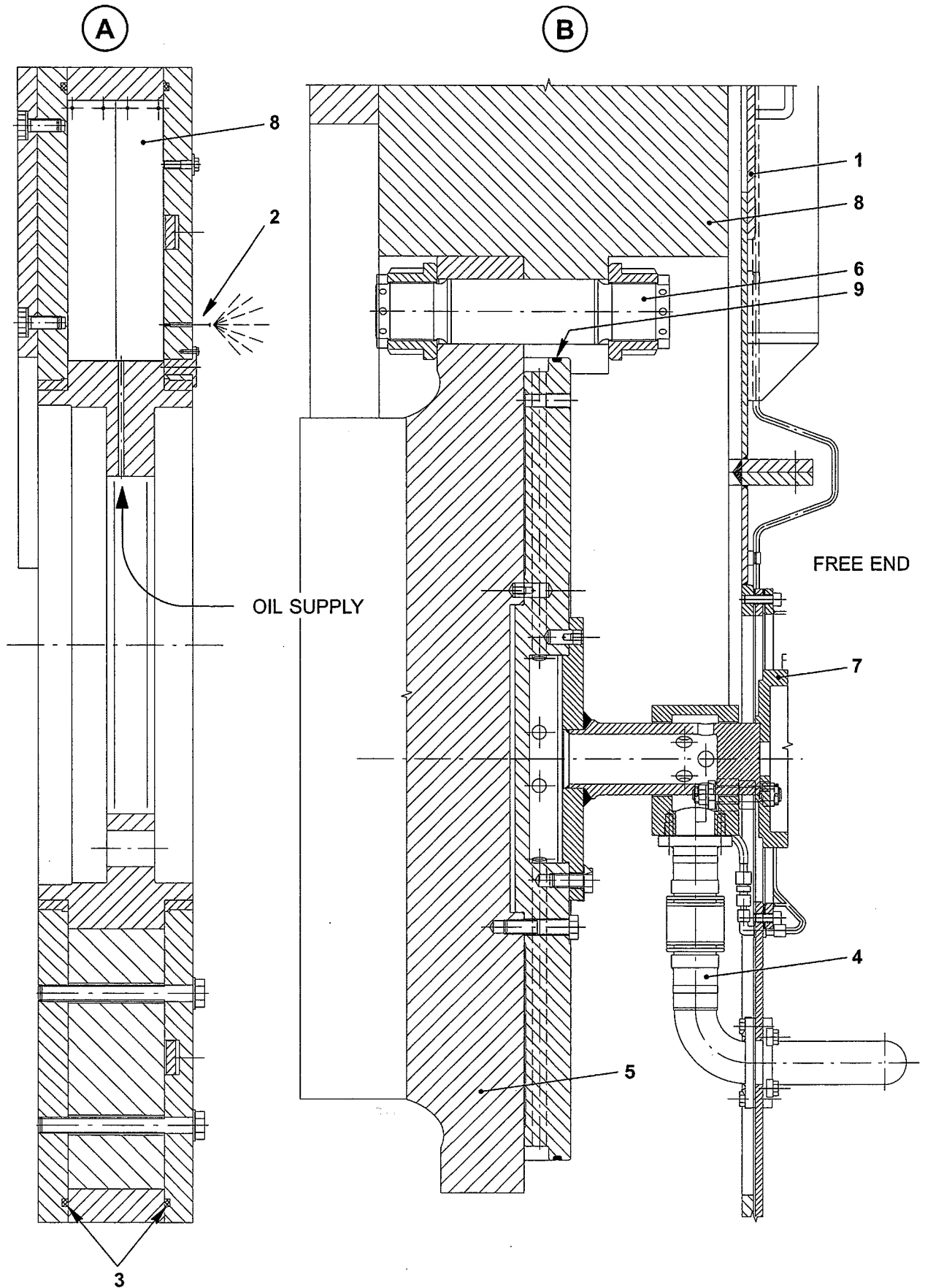
Prior to removing a vibration damper and balance weight mark their positions with reference to the crankshaft.

- For tightening values of coupling bolts (6) see 0352-1.



Remark : For the test run after the first commissioning, as well as the normal checking and servicing intervals, refer to the manual of the damper manufacturer.

Vibration Damper
Inspection (GEISLINGER Vibration Damper)



Axial Damper

Dismantling and Assembling

Tools :

- 2 Eye bolt M30

Key to Illustrations :

- | | |
|--------------------------|-----------------------|
| 1 Upper part of cylinder | 12 Locking screw |
| 2 Lower part of cylinder | 13 Locking plate |
| 3 Screw | 14 Diaphragms |
| 4 Screw | 15 Oil inlet pipe |
| 5 Screw | 16 Main bearing cover |
| 6 Large seal ring | 17 Crankshaft |
| 7 Small seal ring | 18 Main bearing shell |
| 8 Self-locking nut | |
| 9 Allen screw | |
| 10 Throttling valve | HZ Chain block |
| 11 Spindle | RC Eye bolt |

1. Dismantling

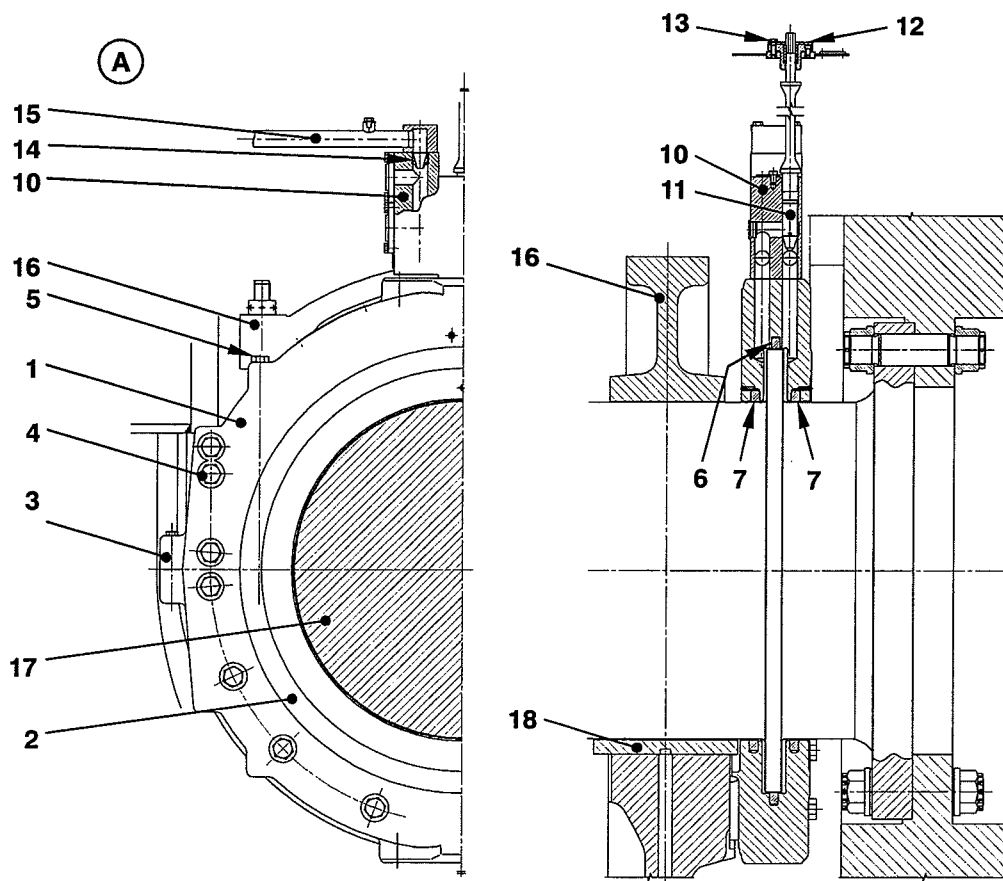
Prior to any overhaul work being started on an axial damper, switch off the bearing oil pump. Then remove the upper half of the two-piece crankshaft casing at the free end.

⇒ Remove oil inlet pipe (15).

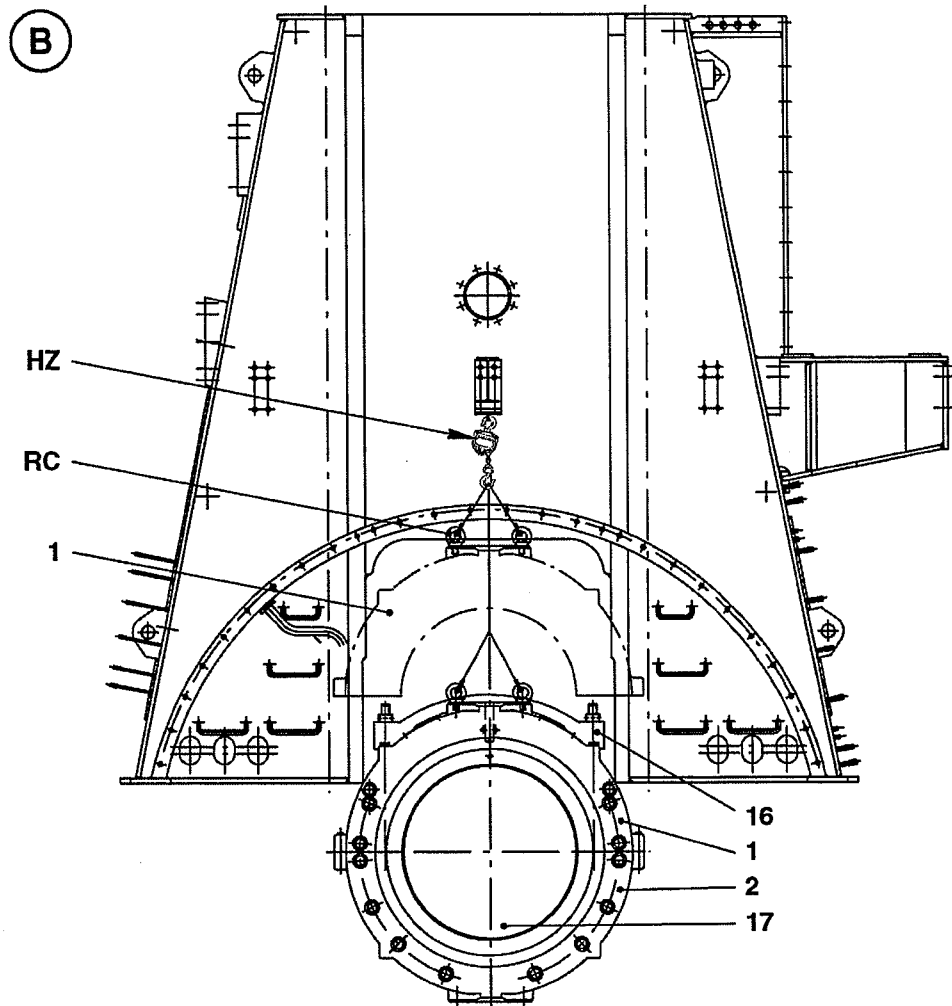
⇒ Pull out both taper pins locating the upper and lower part of cylinder (2) and (1) respectively. For this purpose the taper pins have been provided with respective threads.

⇒ Loosen and remove all screws (3) and (5) (Fig. 'A').

⇒ Loosen screws (4) to the upper part of cylinder (1) and pull them out as far as possible.



Axial Damper
Dismantling and Assembling



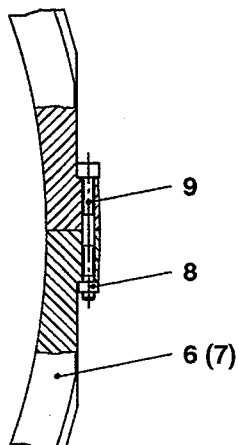
- Screw in two eye bolts “RC” (Fig. 'B') into the upper part of cylinder and fit chain block “HZ” on the platform support at the free end. Join the eye bolts by steel ropes and the chain block.



CAUTION

Using lifting tackle **carefully** raise upper part of cylinder. Make absolutely sure that the upper part of the cylinder **slides out of the seal rings (6) and (7) without jamming**, as otherwise the seal rings risk being damaged.

C

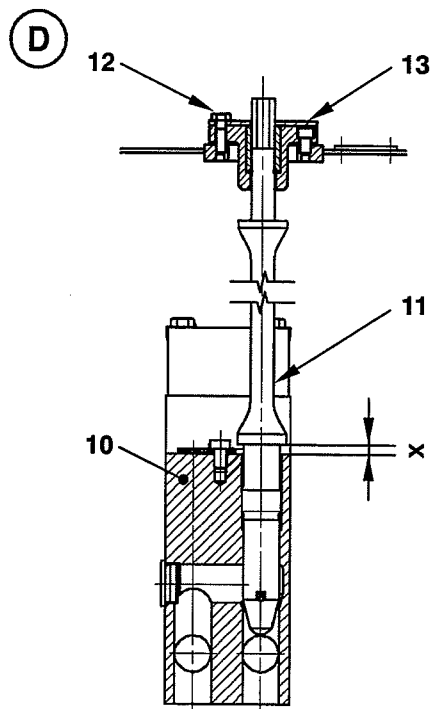


- For removal of two-part seal rings (6) and (7), loosen first self-locking nuts (8) and remove Allen screws (9). The sealing rings can then be turned their grooves in the lower part of cylinder (2) without any problems.

Axial Damper

Dismantling and Assembling

2. Checking the throttling valve



- When overhauling the axial damper check also the condition of throttling valve (10). The spindle position has been locked by locking screw (12) and a locking plate (13).



Changing the position of the throttling valve is forbidden.

- For pre-setting spindle (11) has to be turned back by about four turns starting from the closed position. 'X' = 12 mm.
- This adjustment must be verified on the basis of vibration measurements during sea trial; otherwise the spindle must be readjusted. The final adjustment has to be engraved in the name plate fitted to the upper part of cylinder (1).



If it becomes necessary to unscrew or replace a spindle for any reason, then the distance 'x' must be measured first (Fig. D'). The spindle has to be adjusted to the same distance on reassembling. The spindle must not be turned back by more than 16 turns, that corresponds to a stroke of $x = 48$ mm.

- When the above check brings to light any defect of throttling valve (10) then diaphragms (14) (Fig. 'A') screwed into the throttling valve must also be checked for possible damage and replaced if necessary.



The engine must **not** be operated with spindle (11) removed or with the oil supply to the axial damper interrupted!

3. Assembling

- Badly worn or damaged seal rings (6) and (7) must be replaced. The seal rings are fastened by two Allen screws (9) and self-locking nuts (8). Immediately before fitting the seal rings smear them with clean engine oil.
- Newly fitted seal rings must allow radial movement when fitted.
- The assembling of the axial damper is done analogously to dismantling but in reverse sequence. Pay the utmost attention when lowering upper part of cylinder (1) into place, to prevent seal rings (6) and (7) from being damaged.
- Before tightening screws (3) as well as (4) and (5) fit the taper pins for the upper part and lower part of the cylinder.



Remark : Apply MOLYKOTE and tighten screw (4) between axial damper and bedplate with a tightening angle of 50° (see also 0352-1).

Crankcase

Utilization of the Working Platform and the Ladder

Tools :

- | | | |
|---|------------------|-------|
| 2 | Working platform | 94142 |
| 2 | Working supports | 94143 |

Key to Illustrations :

- | | |
|---|--------------------------|
| 1 | Engine longitudinal beam |
| 2 | Crank web |
| 3 | Step |

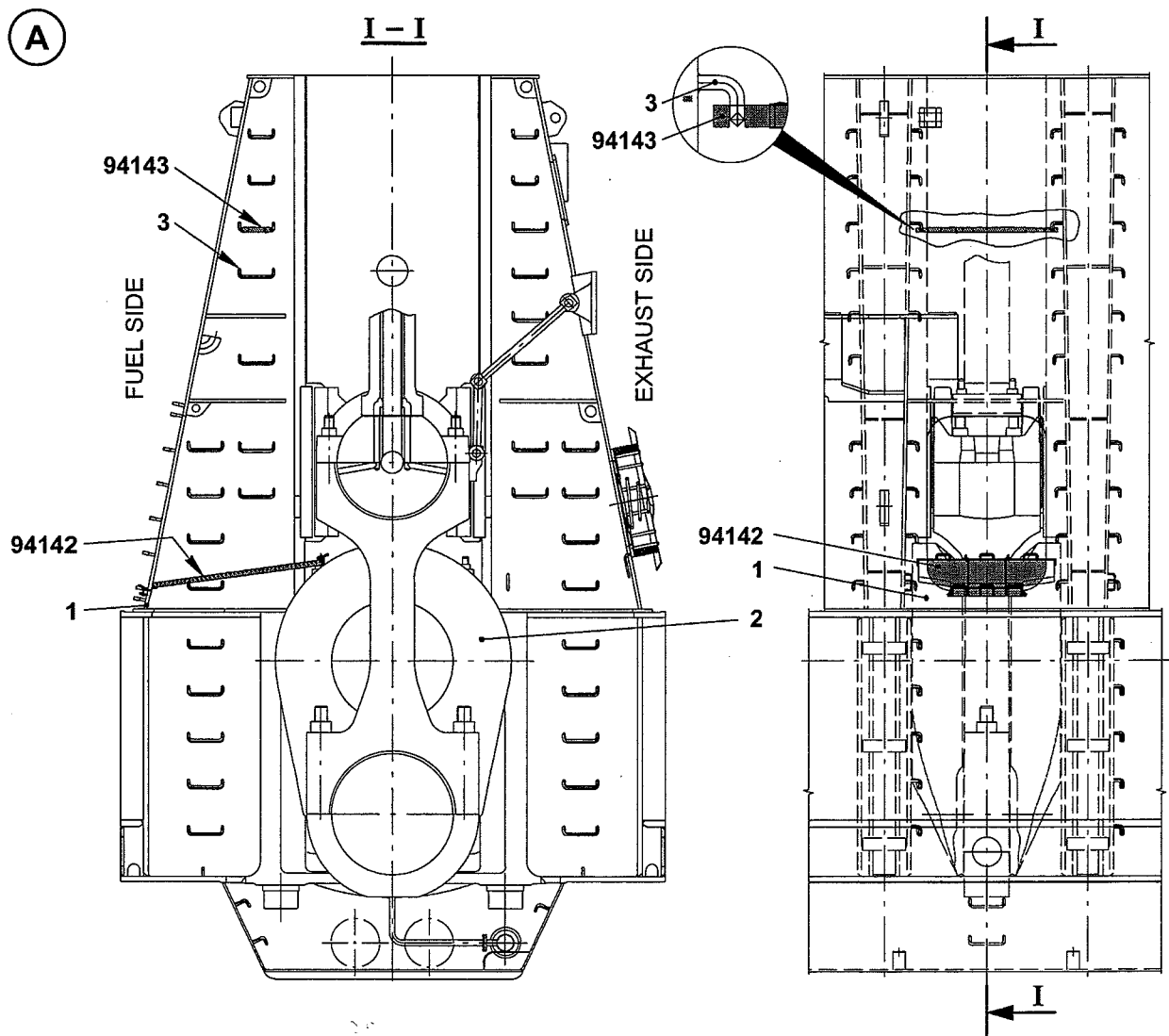
1. Dismantling

To avoid accidents, the grids of working platform (94142) and working supports (94143) should be used for inspections or work in the crankcase. The grids must always be fitted in such a way that their U-profiles come to lie between engine longitudinal beam (1) and that the opposite end rests on crank web (2), as shown in Fig. 'A'.

Working support (94143) can be fitted between the columns at the desired height, on steps (3).



Never rotate the crankshaft while working supports in position.



Connecting Rod
Loosening and Tensioning the Connecting Rod Studs
Tools :

1	Feeler gauge	94122
2	Pre-tension jacks	94314
2	Pre-tension jacks	94315
1	Pressure gauge	94932a
1	Connection piece	94934
1	Connection piece	94934a
1	HP hose	94935
3	HP hoses	94935a
1	Hydraulic unit	94942

Key to Illustrations :

1	Connecting rod stud	8	Bottom end bearing
2	Nut	9	Top end bearing
3	Pin		
4	Vent screw		
5	Piston	KO	Slot
6	Cylinder	RS	Round bar
7	Sealing ring	SA	Gap

Overview

1. General	1/5
2. Loosening the stud of the bottom end bearing	2/5
3. Tensioning the stud of the bottom end bearing	2/5
4. Loosening the stud of the top end bearing	4/5
5. Tensioning the stud of the top end bearing	5/5

1. General

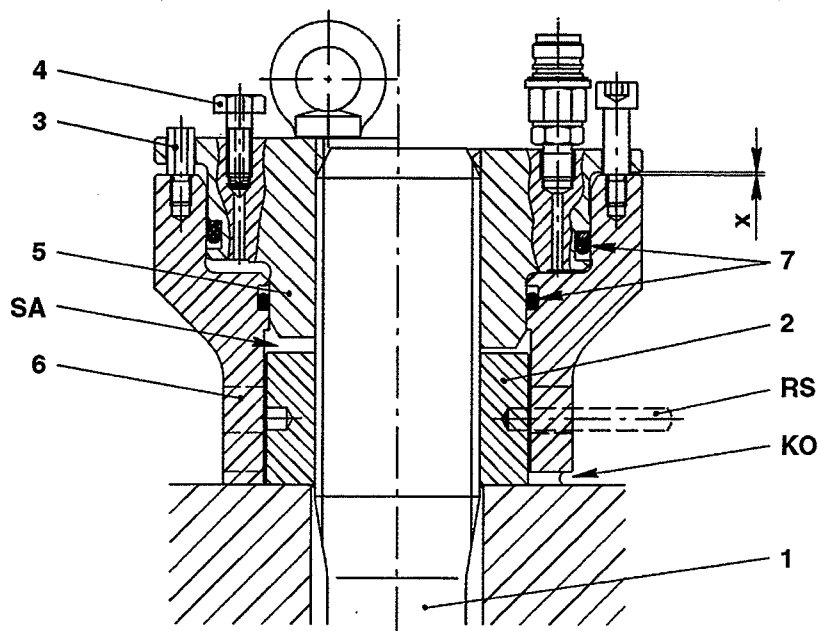
⇒ For loosening and tensioning clean the threads of connecting rod studs (1) and the area around nuts (2) and lubricate the thread

CHECK

Check that the nuts turn freely on the threads.
Always check the oil level before using the hydraulic unit.



- The crankshaft must not be turned by turning gear when workmen are in crankcase
- Never turn the crankshaft (with the turning gear) as long as the pre-tensioning jacks are mounted on the connecting rod studs!

A
**PRE-TENSIONING JACK
PLACED FOR LOOSENING**
**PRE-TENSIONING JACK
PLACED FOR TENSIONING**


Connecting Rod

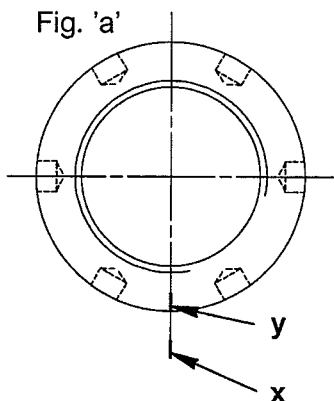
Loosening and Tensioning the Connecting Rod Studs

3. Tensioning the connecting rod stud of the bottom end bearing

- Consider the previously mentioned directions.
- ⇒ Tighten the nuts first with round bar "RS" by hand with a smart jerk.
- CHECK** Check whether the nuts rest flush on the connecting rod shank.
- ⇒ Equally distribute the clearance between the bearing halves (bearing projection).
- ⇒ Screw pre-tensioning jacks (94314) onto connecting rod studs (1) until these rest against the connecting rod shank. Moreover, open slightly vent screws (4) so that pistons (5) can slide back to their initial position, i.e. there is no or little clearance at 'x' (Fig. 'A').
- ⇒ Connect the pre-tensioning jacks to hydraulic unit (94942) as shown in Fig. 'B'.
- ⇒ Actuate the hydraulic unit and set pressure to **30 MPa** (1st step) and keep pressure constant.
- ⇒ Start up hydraulic unit till bubble-free oil flows out through vent screws (4). Shut the vent screws.
- Attention should be paid to ensure that pins (3) always protrude slightly compared with pistons (5) on the pre-tensioning jacks!

CHECK Tighten the nuts with round bar 'RS' and check with the feeler gauge through slot "KO" (Fig. 'A') that no clearance remains between nut and supporting surface.
Check with the feeler gauge that no clearance remains between bearing cover and connecting rod shank.
(Should clearance remain, loosen the fastening and compare the bearing projection with the nominal value as indicated in 3303-2).

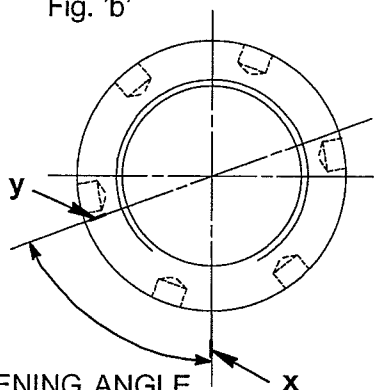
Fig. 'a'



- ⇒ After tensioning to the 1st step mark the position of the nuts against connecting rod as shown in Fig. 'a'.
- ⇒ Raise the pressure to **100 MPa** (2nd step) and keep constant.

CHECK Tighten nuts down and check correct seating with the feeler gauge. Check from the markings applied by how much the nuts were turned after pre-tightening (1st step).
Tightening angle to be about **80°** (Fig. 'b').

Fig. 'b'



- ⇒ Should considerable differences to these nominal values be encountered then repeat the tensioning process.
- ⇒ Release pressure to zero at the hydraulic unit and then remove pre-tensioning jacks.

CHECK Finally check the vertical bearing clearance (see Clearance Table 0330-1 'Top and bottom end bearings to connecting rod').

TIGHTENING ANGLE

Connecting Rod

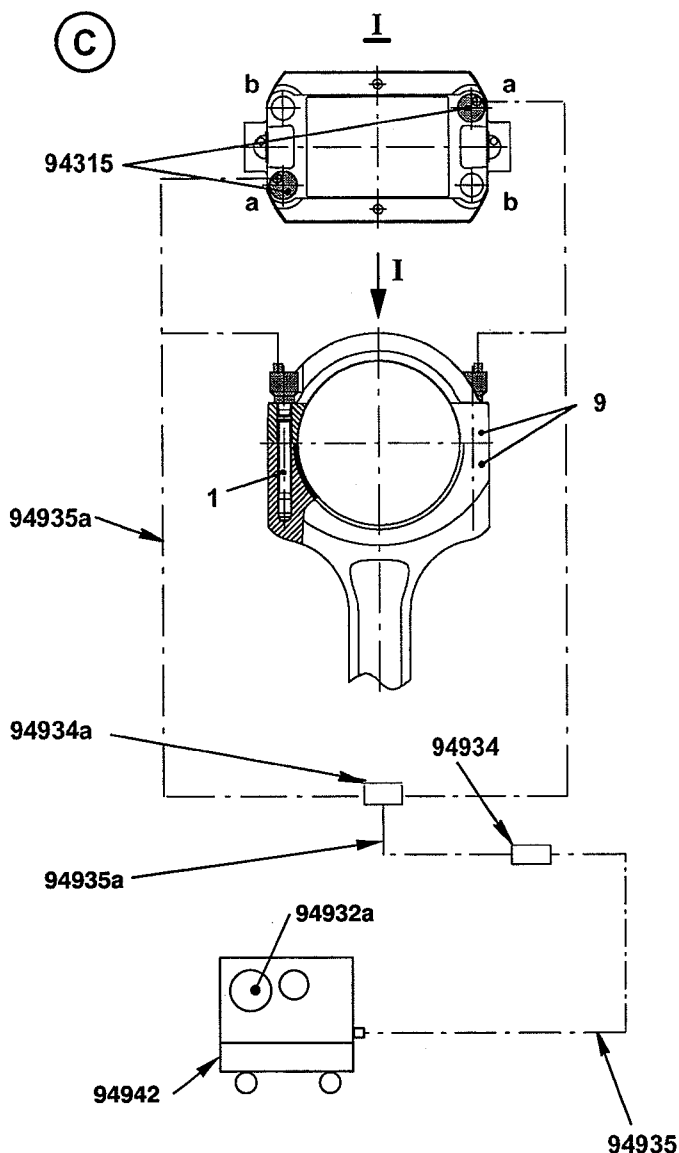
Loosening and Tensioning the Connecting Rod Studs

4. Loosening the connecting rod stud of the top end bearing



Remark

: For loosening the studs **always** follow the sequence shown in Fig. 'C' i.e. a+a and b+b.



Place pre-tensioning jacks (94315) diagonally on connecting rod studs (1) (Fig. 'C') and completely screw them on with opened vent screw (4) (Fig. 'A').

The pre-tensioning jacks are to be loosened by about $\frac{1}{2}$ turn (gap "SA" in Fig. 'A').

Connect the pre-tensioning jacks with hydraulic unit (94942) as shown in Fig. 'C'.

Actuate hydraulic unit.

Close vent screws (4) on the pre-tensioning jacks as soon as oil flows bubble-free.

Actuate hydraulic unit till a pressure of **102 MPa** is indicated on pressure gauge (94932a) and on the pressure gauge at the hydraulic unit.

Attention should be paid to ensure that pins (3) always protrude slightly compared with pistons (5) on the pre-tensioning jacks!

Turn back nuts (2) by one turn, using round bar "RS".

Release pressure to zero at the hydraulic unit and then remove pre-tensioning jacks.

Proceed in the same manner for the second pair of connecting rod studs.

Connecting Rod

Loosening and Tensioning the Connecting Rod Studs

5. Tensioning the connecting rod stud of the top end bearing

 **Remark** : For tensioning the studs **always** follow the sequence shown in Fig. 'C' i.e. a+a and b+b for **each** step.

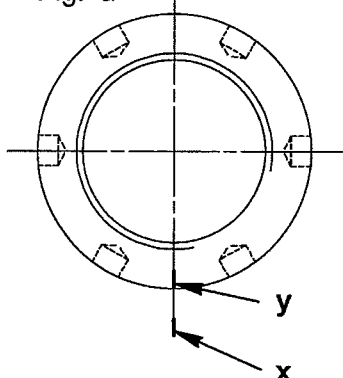
- Consider the previously mentioned directions.
- ⇒ Tighten the nuts first with round bar "RS" by hand with a smart jerk.

CHECK Check whether the nuts rest flush on the bearing cover.

- ⇒ Equally distribute the clearance between the bearing halves (bearing projection).
- ⇒ Screw pre-tensioning jacks (94315) diagonally onto two connecting rod studs (1) until these rest against the bearing cover. Moreover, open slightly vent screws (4) so that pistons (5) can slide back to their initial position, i.e. there is no or little clearance at 'x' (Fig. 'A').
- ⇒ Connect the pre-tensioning jacks to hydraulic unit (94942) as shown in Fig. 'C'.
- ⇒ Start up hydraulic unit till bubble-free oil flows out through vent screws (4). Shut the vent screws.
- ⇒ Actuate the hydraulic unit and set pressure to **60 MPa** (1st step) and keep pressure constant.
- Attention should be paid to ensure that pins (3) always protrude slightly compared with pistons (5) on the pre-tensioning jacks!

CHECK Tighten the nuts with round bar "RS" and check with the feeler gauge through slot "KO" (Fig. 'A') that no clearance remains between nut and supporting surface.
Check with the feeler gauge that no clearance remains between bearing cover and connecting rod shank.
(Should clearance remain, loosen the fastening and compare the bearing projection with the nominal value as indicated in 3303-3).

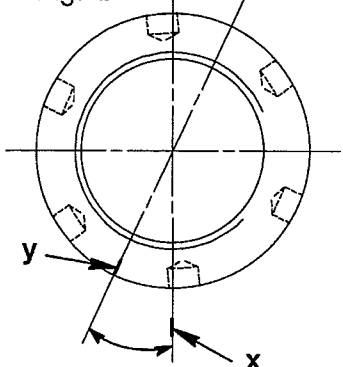
Fig. 'a'



- ⇒ Proceed in the same manner for the second pair of connecting rod studs.
- ⇒ After tensioning to the 1st step mark the position of the nuts against bearing cover as shown in Fig. 'a'.
- ⇒ Raise the pressure to **100 MPa** (2nd step) and keep constant.

CHECK Tighten nuts down and check correct seating with the feeler gauge.
Check from the markings applied by how much the nuts were turned after pre-tightening (1st step).
Tightening angle to be about **30°** (Fig. 'b').

Fig. 'b'



- ⇒ Should considerable differences to these nominal values be encountered then repeat the tensioning process.
- ⇒ Release pressure to zero at the hydraulic unit and remove pre-tensioning jacks.

CHECK Finally check the vertical bearing clearance (see Clearance Table 0330-1 'Top and bottom end bearings to connecting rod').

TIGHTENING ANGLE

Connecting Rod

Inspection, Removal Fitting of Bottom End Bearing

Tools :

- | | | |
|---|---------------------------------|-------|
| 1 | Working platform | 94122 |
| 2 | Wooden boards | 94314 |
| 4 | Retaining pin | 94315 |
| | Hydr. tools according to 3303-1 | |

Key to Illustrations :

- | | | | |
|---|---------------------|----|------------------------------|
| 1 | Connecting rod stud | 8 | Guide way |
| 2 | Nut | 9 | Threaded holes for eye bolts |
| 3 | Crank | 10 | Bearing shell |
| 4 | Toggle lever | 11 | Allen screw |
| 5 | Support | 12 | Cylindrical pin |
| 6 | Bearig cover | | |
| 7 | Connecting rod | | |

1. General

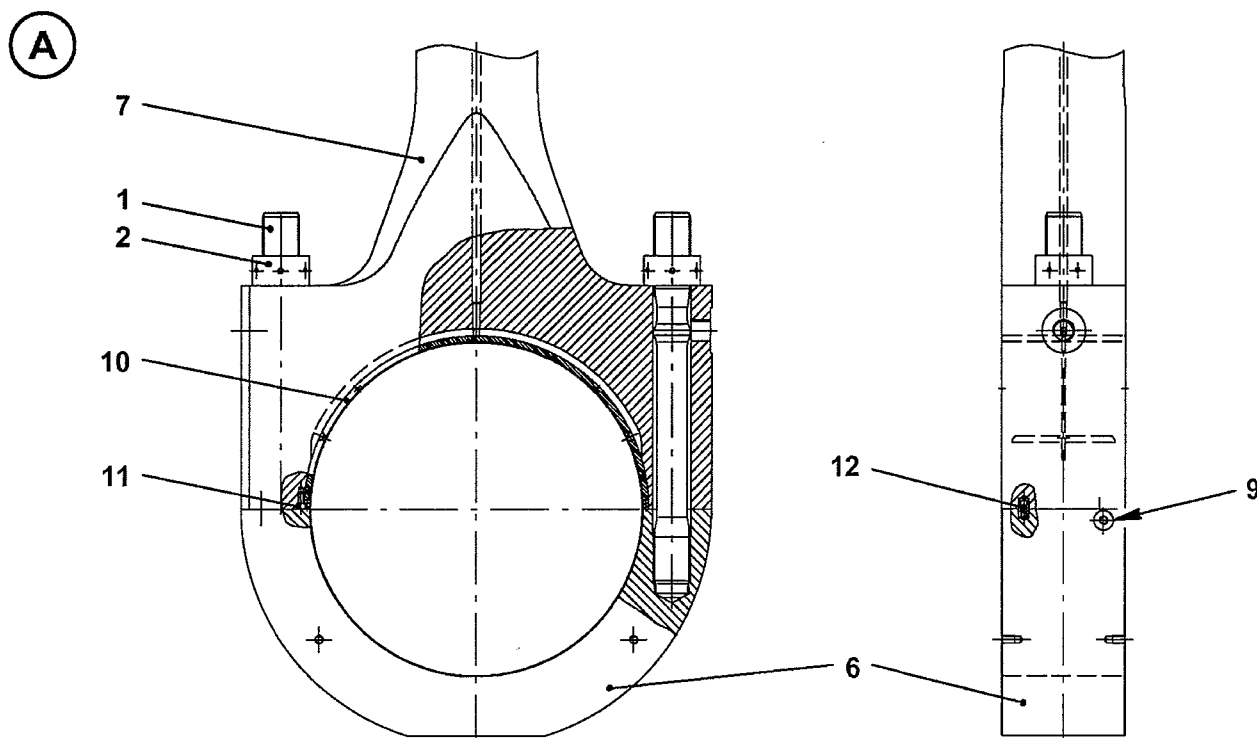
When a **bottom end bearing** has to be inspected or removed, nuts (2) of the connecting rod studs (1) (Fig. 'A') have to be loosened hydraulically as per 3303-1, for which the respective crank must be approximately 60° before T.D.C.



- The crankshaft must not be turning gear when workmen are in crankcase.
- Never turn the crankshaft as long as the pre-tensioning jacks are screwed onto the connecting rod studs.

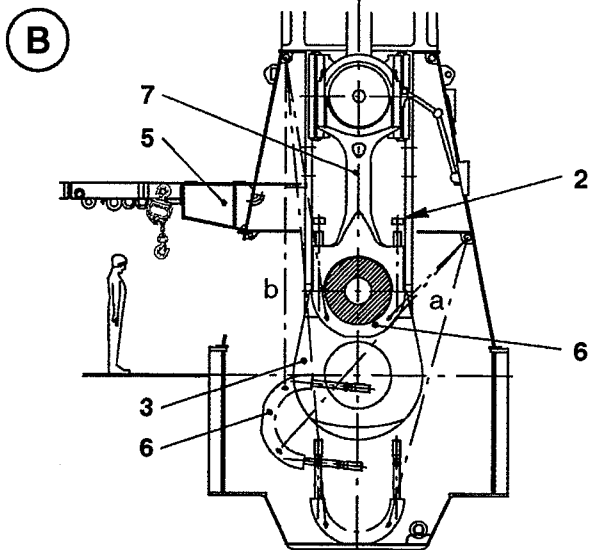
2. Inspection and removal

- ⇒ Fit an eye bolt on each side of bearing cover (6) immediately below the bearing separation.
- ⇒ Secure bearing cover with two wire ropes 'a' and 'b' and suitable chain block. (Fig. 'B')
- ⇒ Remove nuts (2).



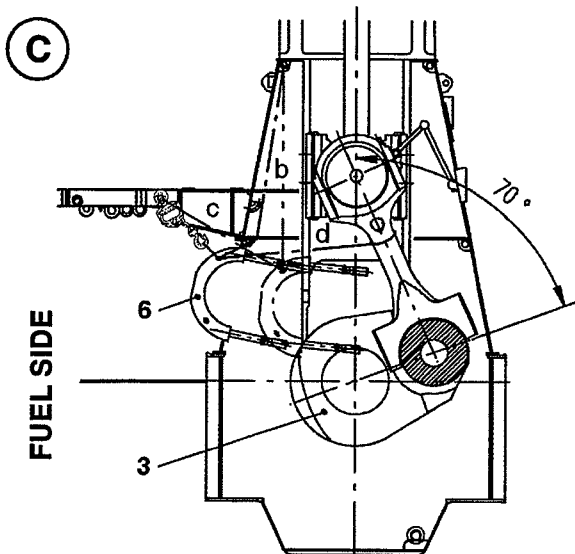
Connecting Rod

Inspection, Removal Fitting of Bottom End Bearing



- ⇒ Carefully lower the bearing cover (6) while taking care that the threads of the connecting rod studs as well as the surface of the crankpin are not damaged (Fig. 'B').
- ⇒ After lowering the bearing cover, turn the crankshaft towards exhaust side by about 70° after T.D.C. for the following removal of the bearing cover (Fig. 'C').
- ⇒ Remove the bearing cover together with the connecting rod studs with the aid of ropes "b", "c" and "d", whereby rope "d" must be winded onto connecting rod (7).

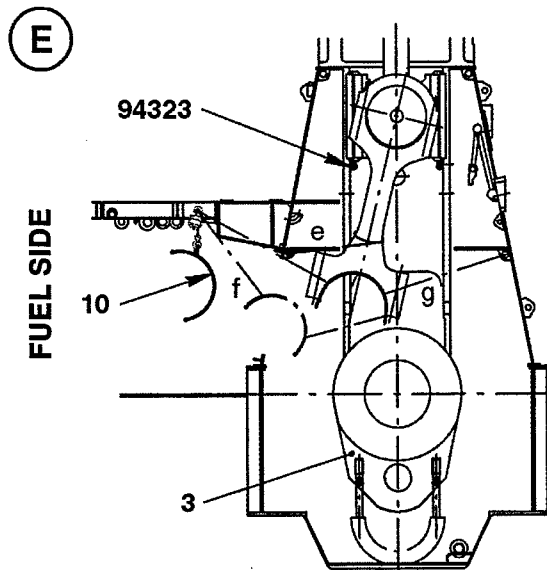
Should the running surface of upper bearing shell (10) have to be inspected or the bearing shell have to be removed, proceed as follows:



- ⇒ Loosen and remove the screws fastening toggle lever (4) of piston cooling and crosshead lubrication and separate toggle lever from connecting rod (7). Suspend toggle lever with lifting wire rope the crankcase as shown in Fig. 'D'.
- ⇒ Turn the crankshaft to T.D.C. and place four retaining pins (94323) into guide ways (8), thereby the retaining pins with their eccentrics are to be turned in such a way that they touch the guide shoes.
- ⇒ Secure the connecting rod with rope 'c' and lifting tackle on the fuel side (Fig. 'D').
- ⇒ Turn crankshaft carefully towards fuel side while pulling the lower part of the connecting rod with rope "e" and lifting tackle so far outwards until the connecting rod bearing is no longer engaged with the crankpin.

Connecting Rod

Inspection, Removal Fitting of Bottom End Bearing



- ⇒ For the removal of bearing shell (10) Fig. 'E', but **before** loosening Allen screws (11) (Fig. 'A'), first screw in two eye bolts into the front faces of bearing shell (10).
- ⇒ After Allen screws (11) have been loosened, the bearing shell can be lowered and then lifted out of the crankcase (Fig. 'E') with the aid of ropes "f" and "g".

3. Fitting

The fitting of bearing shell (10) and bearing cover (6) is carried out analogous to removal but in reverse sequence.

- The running surfaces have to be lavishly smeared with clean bearing oil.
- The tensioning of the connecting rod studs must be carried out according to the instructions in 3303-1.



Always fit toggle lever (4) in such a way that its curvature stands upwards.
After completing the work the retaining pins (94323) must be removed without fail.

Connecting Rod

Inspection, Removal Fitting of Bottom End Bearing

4. Fitting of a bearing shell

- For fitting a **bearing shell to the bottom end bearing**, the surface of the crankpin must be in perfect condition.



While fitting a bearing shell pay attention to prevent dirt or foreign particles from entering between the shell rear surface and its seating! The contact surfaces of the shell rear side and the bearing bore must be free from any damage.

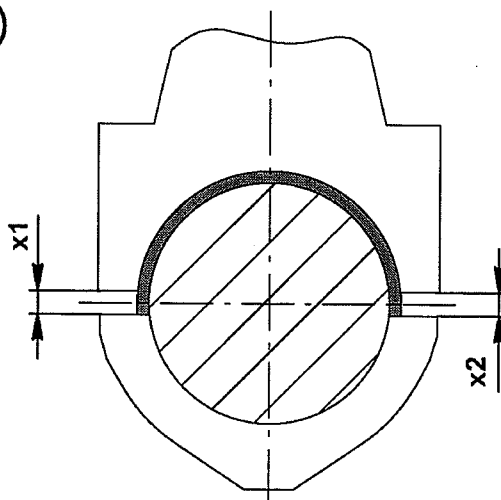
Immediately before inserting the bearing shells they have to be wiped with a **slightly oily hand**, so that a **trace** of oil is on them.

- The bearing shell should be placed in the connecting rod head such that it protrudes by the same distance at both ends of the separating face.



This protrusion is a must and under no circumstances may the separating face of the bearing shell be filed to reduce it!

F



Protrusion of a new bottom end bearing shell:

$X1 + X2 = \text{approx. } 0.56 \sim 0.64 \text{ mm}$



Remark : Above measuring checks must be carried out when fitting new bearing shells. For this the bearing shells are placed in position the bearing cover fitted and the nuts tightened by hand with a round bar.

Prior to final assembly smear the running surfaces lavishly with clean bearing oil. Should, however, the engine have to be frequently turned after the fitting of the bearing, or should a re-start of the engine not be immediately planned, then instead of bearing oil a mixture of 2/3 steam-engine cylinder oil and 1/3 normal bearing oil should be used. Special oils suited to this purpose are also available from reliable suppliers.

In order to further reduce the risk of dry running on newly fitted bearing shells, the latter can be post-lubricated by means of a lubricating pump (see 3303-3).

Connecting Rod

Inspection, Removal and Fitting of Top End Bearing with Piston in Situ

Tools:

1	Working platform	94142
4	Retaining pins	94323
2	Roller supports	94331
1	Carrying roller	94332
2	Suspension straps	94333a
2	Wire rope sling with hook	94333b
2	Eye bolts	94333c
1	Connecting flange	

Key to Illustrations:

1	Crankshaft	13	Guide shoe
2	Toggle lever	14	Guide segment
3	Connecting rod	15	Bolt with nut
4	Guide way	16	Supporting sheet
5	Crosshead pin	17	Piston rod foot
6	Nut		
7	Connecting rod stud		
8	Threaded hole for eye bolt	TR	Trolley
9	Cylindrical pin	DL	Oil pressure pipe
10	Bearing shell	HZ	Chain block
11	Allen shell	H1...	Chain blocks
12	Bearing cover	OP	Lubricating pump
		RC	Eye bolt

Overview

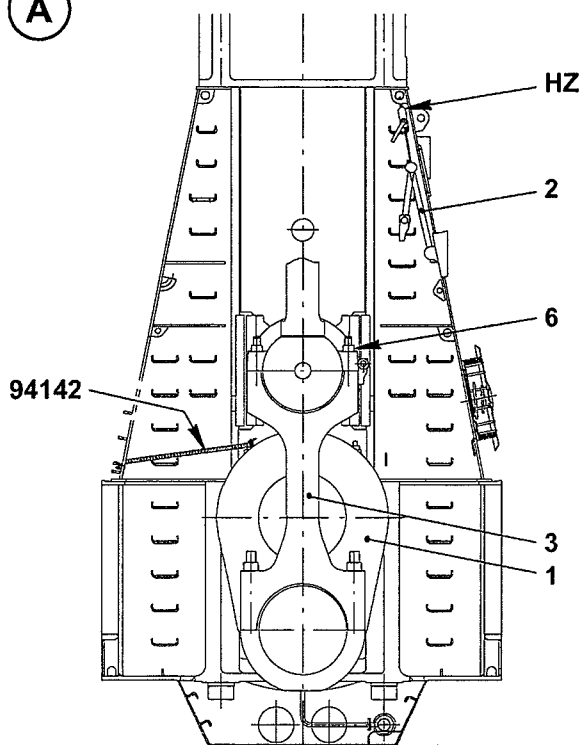
1.	Inspection of bearing shell	1/9
2.	Remove of bearing shell	3/9
3.	Fitting the bearing shell	5/9
4.	Removal of bearing cover	7/9
5.	Fitting the bearing cover	9/9

1. Inspection of bearing shell



The crankshaft must not be turned by turning gear when workmen are in crankcase.

A



- ⇒ Turn crank of the corresponding cylinder to B.D.C.
- ⇒ Install working platform (94142).
- ⇒ Loosen and remove all nuts (6) of connecting rod studs (7) to top end bearing as instructed 3303-1.
- ⇒ Loosen the screws fastening toggle lever (2) of the crosshead lubrication and piston cooling, and separate the toggle lever from connecting rod (3).
- ⇒ Suspend toggle lever with chain block "HZ" inside the crankcase.
- ⇒ Remove the working platform from the crankcase.

Connecting Rod

Inspection, Removal and Fitting of Top End Bearing with Piston in Situ

- ⇒ Turn crank to T.D.C.
- ⇒ Place two retaining pins (94323) into guide ways (4) on exhaust side.
Pay attention to detail in Fig. 'B'!
- ⇒ Fix two roller supports (94331) on guide ways (4) on fuel side, using bolts and nuts (15) belonging to the roller support.
- ⇒ Carrying roller (94332) is to be fitted to the front face of connecting rod (3) on fuel side, using eye bolt "RC" (M64) screwed into threaded hole (8) (Fig. 'G').
Thereby, supporting sheet (16) to carrying roller must rest below the connecting rod head (Fig. 'B').
- ⇒ Turn crankshaft (1) carefully downwards to exhaust side till the connecting rod studs are free (i.e. out of bearing cover (12)), and guide shoes (13) seat on both retaining pins (94323). Otherwise the latter have to be turned so that their eccentrics contact the guide shoes.



CAUTION

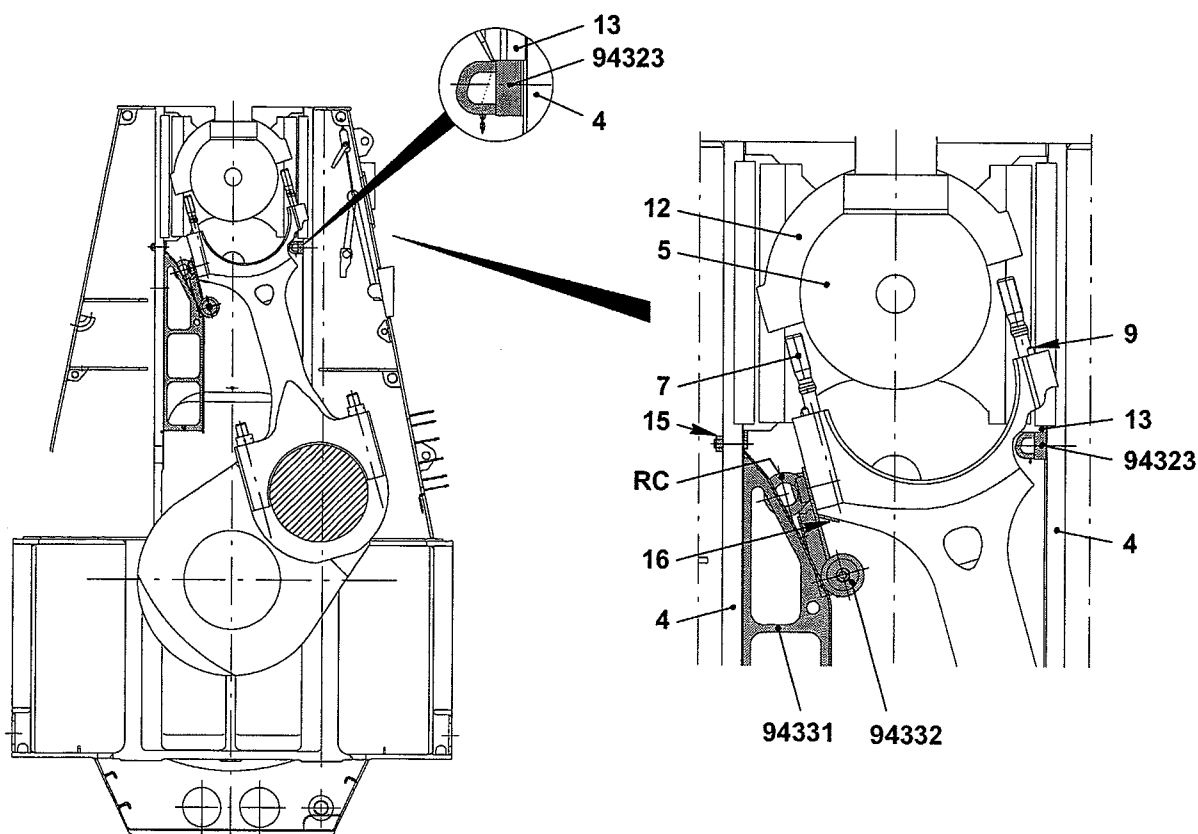
Take care that cylindrical pins (9) and connecting rod studs (7) slide out through the bores without jamming!



WARNING

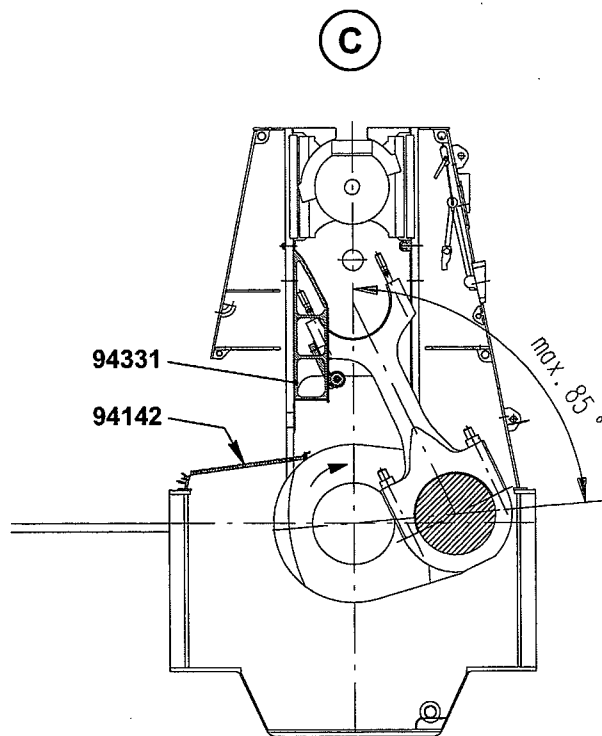
Risk of accident! The piston may not be removed in this position without securing the bearing cover against falling down.

B



Connecting Rod

Inspection, Removal and Fitting of Top End Bearing with Piston in Situ



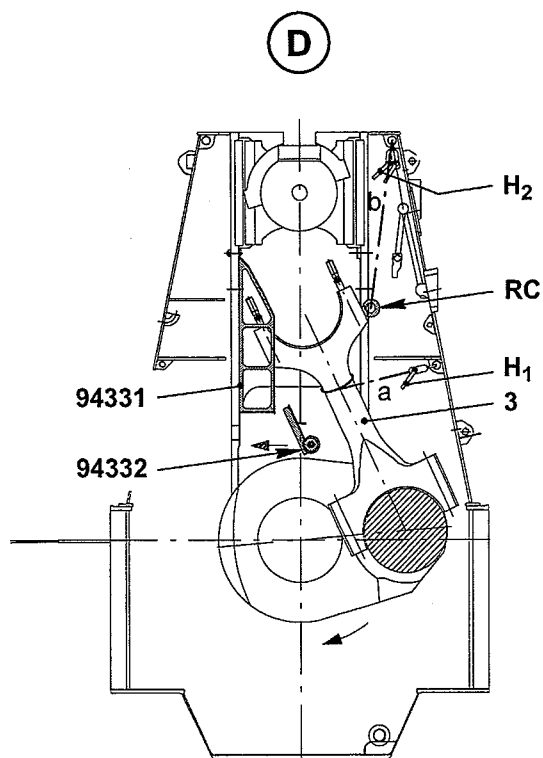
⇒ Turn the crank to max. 85° after T.D.C. as shown in Fig. 'C'.

⇒ Install working platform (94142).

CHECK

Examine bearing shell.

2. Removal of bearing shell



⇒ Mark lateral guide segments (14) (Fig. 'G') and remove them.



Remark: The lateral guide segments must be marked to ensure that they are refitted to the connecting rod head in the same place!

⇒ Sling rope 'a' (lifting capacity 3000 kg) around connecting rod (3).

⇒ Connect rope 'a' with chain block H₁ (lifting capacity 3000 kg each) and tighten it till carrying roller (94332) is lifted slightly from roller support (94331).

⇒ Remove carrying roller.

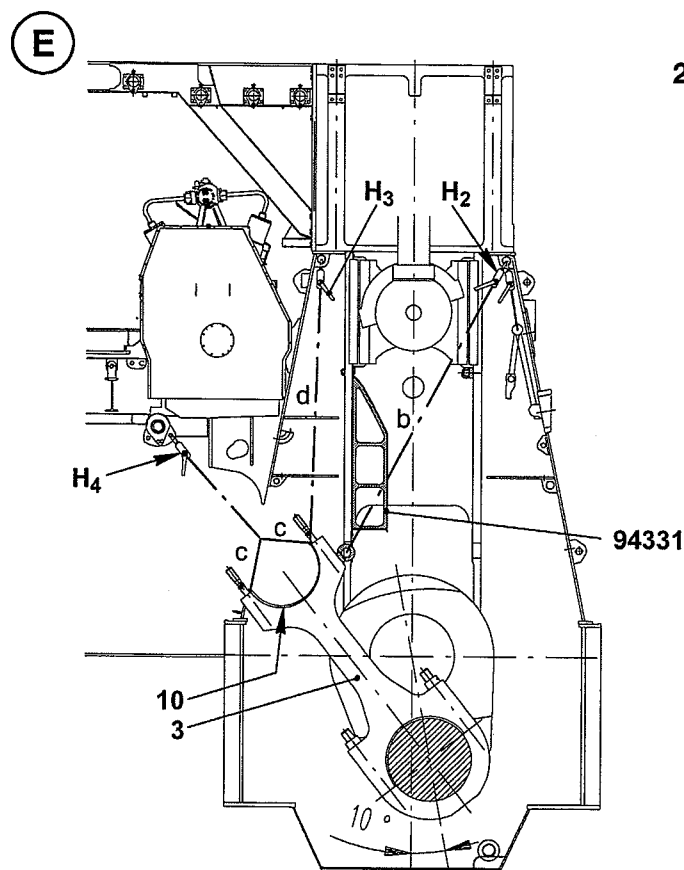
⇒ Screw eye bolt "RC" (M64) into the connecting rod head.

⇒ Attach chain block H₂, connect rope 'b' (lifting capacity 4000 kg each) with eye bolt "RC" and tighten it.

⇒ Remove rope 'a'.

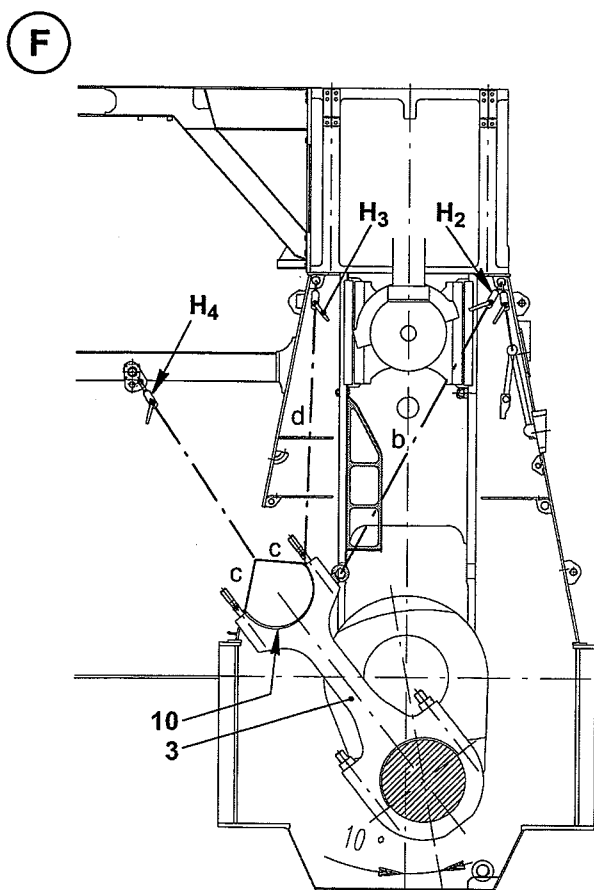
Connecting Rod

Inspection, Removal and Fitting of Top End Bearing with Piston in Situ



2.1 Removal of bearing shell below supply unit

- ⇒ Turn the crank to 10° before B.D.C. while evenly tightening rope 'b'.
- ⇒ Swing out the connecting rod as shown in Fig. 'F'.
- ⇒ Fit two eye bolts (M8) each into the front faces of the bearing shell.
- ⇒ Loosen Allen screws (11) (Fig. 'G').
- ⇒ Attach chain block H₃ and connect rope 'd' (lifting capacity 500 kg each) with the eye bolts fitted in the bearing shell.
- ⇒ Attach chain block H₄ and connect rope 'c' (lifting capacity 500 kg each) with the eye bolts fitted in the bearing shell.
- ⇒ Remove the bearing shell from the connecting rod using ropes 'c' and 'd'.



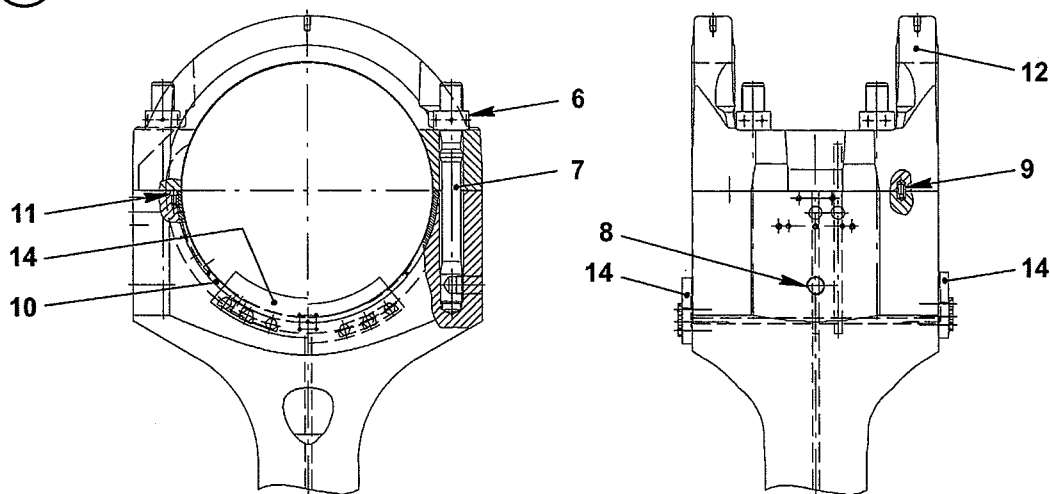
2.2 Removal of bearing shell outside the area of supply unit

- ⇒ Turn the crank to 10° before B.D.C. while evenly tightening rope 'b'.
- ⇒ Swing out the connecting rod as shown in Fig. 'F'.
- ⇒ Fit two eye bolts (M8) each into the front faces of the bearing shell.
- ⇒ Loosen Allen screws (11) (Fig. 'G').
- ⇒ Attach chain block H₃ and connect rope 'd' (lifting capacity 500 kg each) with the eye bolts fitted in the bearing shell.
- ⇒ Attach chain block H₄ and connect rope 'c' (lifting capacity 500 kg each) with the eye bolts fitted in the bearing shell.
- ⇒ Remove the bearing shell from the connecting rod using ropes 'c' and 'd'.

Connecting Rod

Inspection, Removal and Fitting of Top End Bearing with Piston in Situ

(G)



3. Fitting the bearing shell

The fitting of bearing shell (10) and bearing cover (12) is carried out analogously but in reverse sequence to the removal, whereby the following points require special attention:

- Lateral guide segments (14) (Fig. 'G') must be refitted to connecting rod head in the same place as before!

CHECK

Check whether the surface of the crosshead pin is in perfect condition before fitting the bearing shell.



CAUTION

While fitting a bearing shell pay attention to prevent dirt or foreign particles from entering between the shell rear surface and its seating! The contact surfaces of the shell rear side and the bearing bore must be free from any damage. Immediately before inserting the bearing shell they have to be wiped with a **slightly oily hand**, so that a **trace** of oil is on them.

- The bearing shell should be placed in the connecting rod head such that it protrudes by the same distance at both ends of the separating face (Fig. 'H').



WARNING

This protrusion is a must and under no circumstances may the separating face of the bearing shell be filed to reduce it!

Prior to final assembly smear the running surfaces lavishly with clean bearing oil. Should, however, the engine have to be frequently turned after the fitting of the bearing, or should a restart of the engine not be immediately planned, then instead of bearing oil a mixture of 2/3 steam-engine cylinder oil and 1/3 normal bearing oil should be used. Special oils suited to this purpose are also available from reliable suppliers.

- The tensioning of the connecting rod studs must be carried out as instructed in 3303-1.
- When fitting the bearing shell, as well as the crosshead pin, pay attention not to damage the white metal of the two guide segments (14) (Fig. 'G').

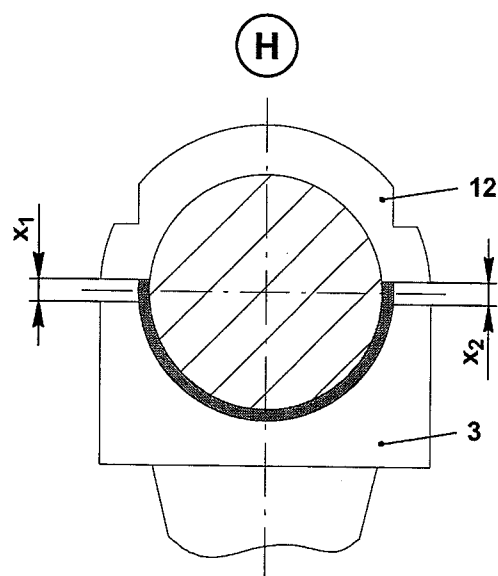


CAUTION

Always fit toggle lever (2) in such a way that its curvature stands upwards. Retaining pins (94323), roller supports (94331) and carrying roller (94332) must be removed immediately after completing the work.

Connecting Rod

Inspection, Removal and Fitting of Top End Bearing with Piston in Situ



3.1 Fitting a new top end bearing shell

⇒ Proceed as described in section 3, however protrusion $x_1 + x_2$ must be measured prior to tension connecting rod studs (7).

3.1.2 Measuring the protrusion

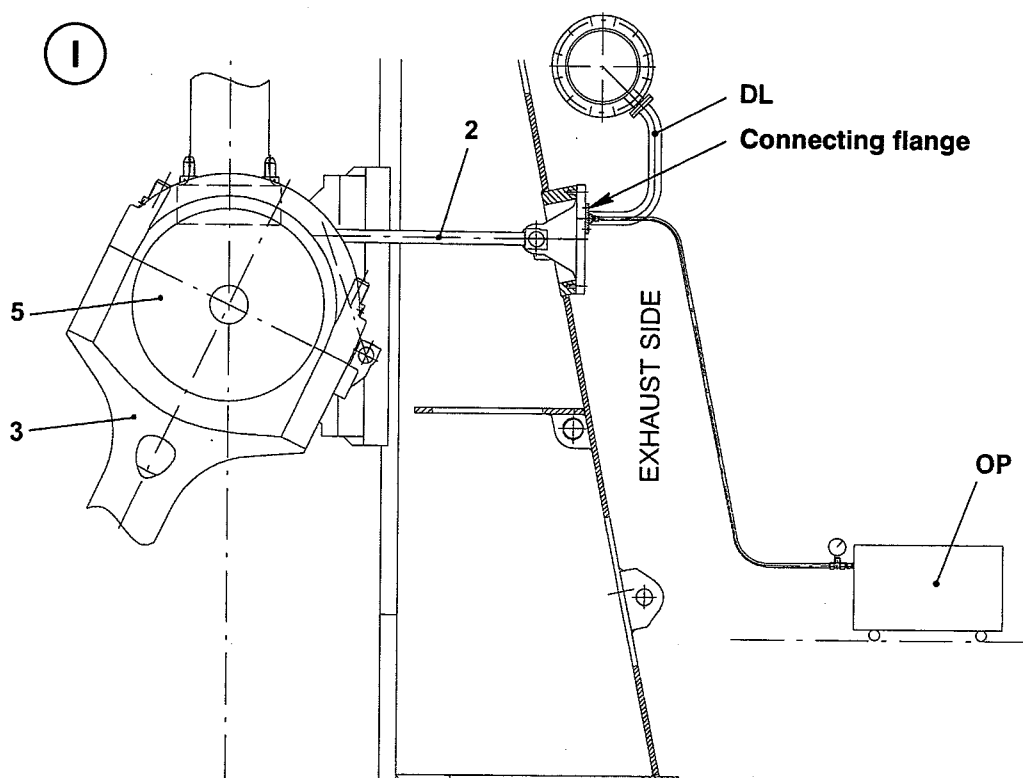
⇒ Hand-tighten nuts (6) (Fig. 'G') with a round bar and measure the protrusion (of a new bearing shell):

$$x_1 + x_2 = \text{approx. } 0.64 \sim 0.72 \text{ mm}$$

3.2 Post lubrication of connecting rod bearing

In order to further reduce the risk of dry running on newly fitted bearing shells, a connecting flange can be fitted after removing the oil pressure pipe "DL" to the crosshead bearing as shown in Fig. 'I'. The connecting flange has to be connected via an oil pressure hose to a lubricating pump "OP".

The pump has to be filled with the mentioned oil mixture (steam-engine cylinder oil) or special oil. The lubricating pump has to be operated from time to time, until oil is pouring out from the bearing side faces. Before the engine is put back into operation, the oil pressure pipe "DL" must be refitted. The remainder of the above mentioned special oil or oil mixture may remain in the engine oil system.

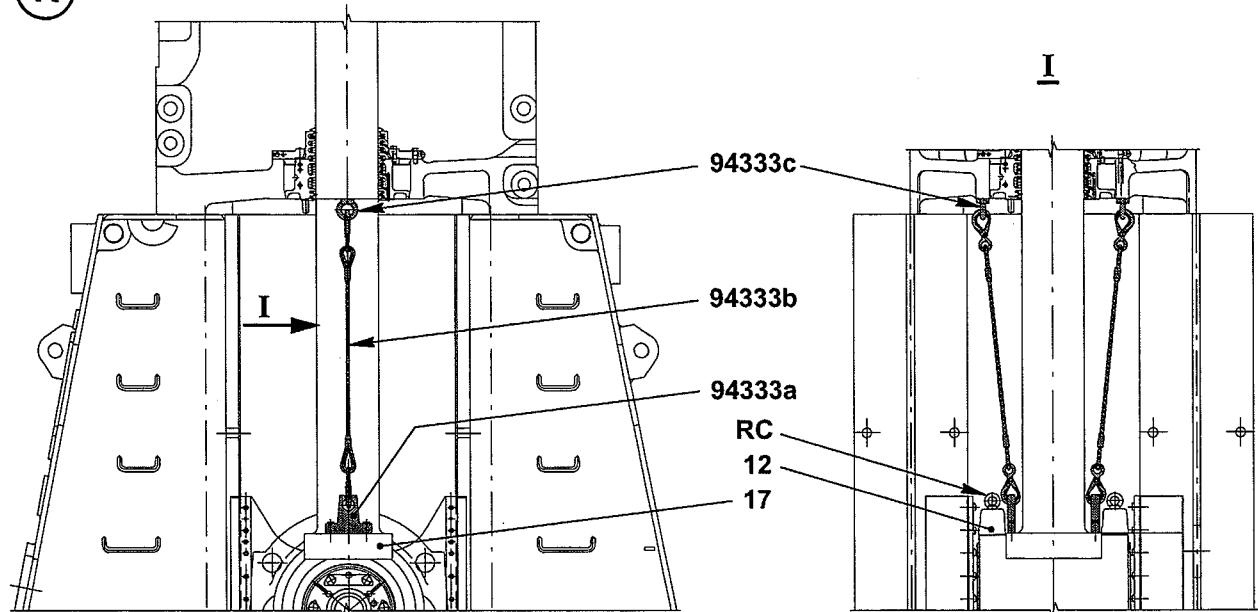


Connecting Rod

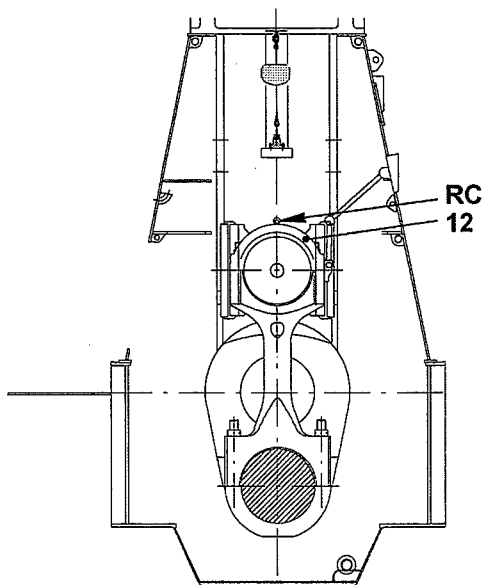
Inspection, Removal and Fitting of Top End Bearing with Piston in Situ

4. Removal of bearing cover

(K)



(L)



- ⇒ Turn crank to B.D.C.
- ⇒ Loosen and remove all nuts (6) (Fig. 'A') to connecting rod studs (7) (see 3303-1).
- ⇒ Remove the nuts for the connection of crosshead pin (5) and piston rod foot (17) (see also 3403-1).
- ⇒ Screw down both suspension straps (94333a) (Fig. 'K') onto the piston rod foot.
- ⇒ Fit two eye bolts (94333c) to the underside of the cylinder jacket.
- ⇒ Turn crank of the corresponding cylinder towards T.D.C. till both wire rope sling (94333b) can be attached to the eye bolts and the two suspension straps.



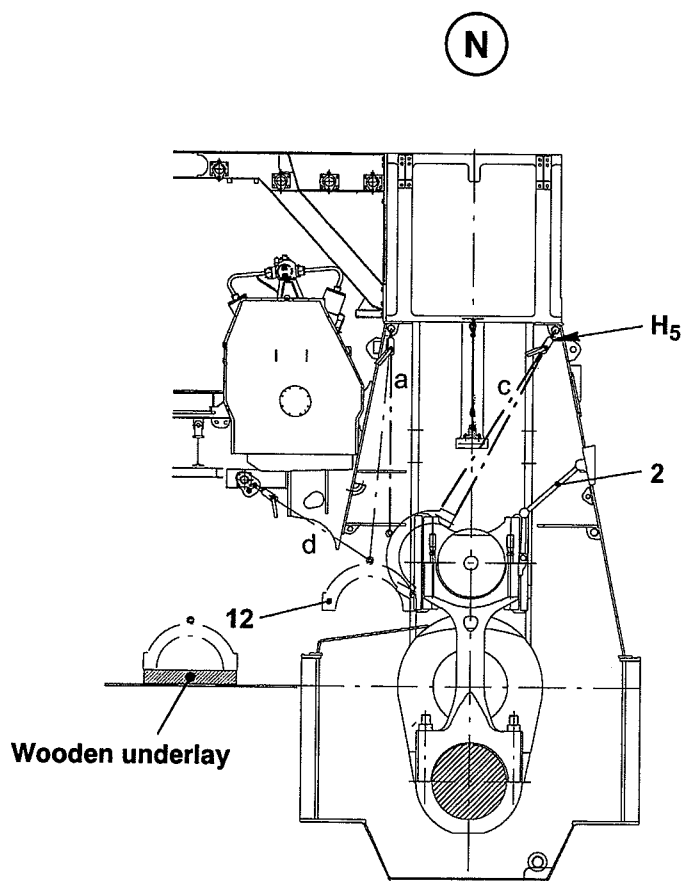
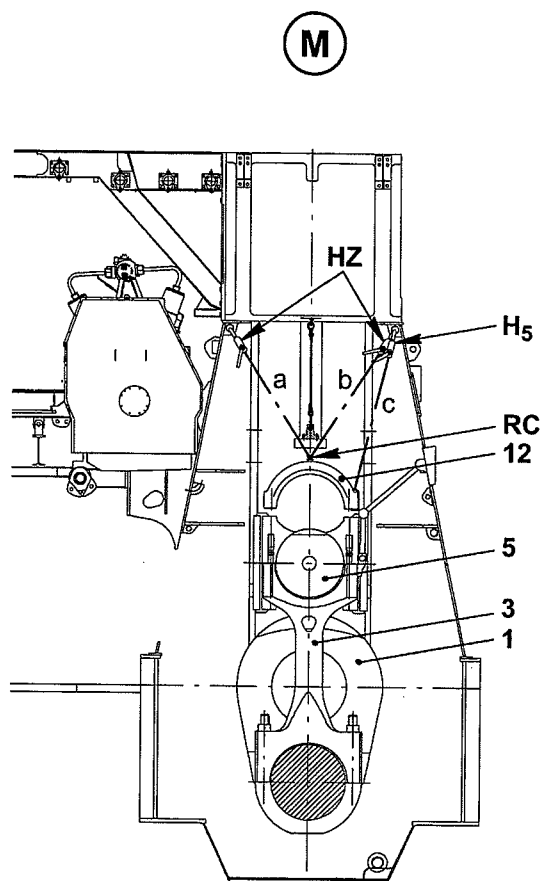
CAUTION

Turn the crankshaft **slowly** towards B.D.C. (Fig. L). Piston rod foot must slide out through the waisted studs in crosshead pin (5) **without jamming**.

- ⇒ Screw eye bolts "RC" (M24) into bearing cover (12).

Connecting Rod
Inspection, Removal and Fitting of Top End Bearing with Piston in Situ
4.1 Removal of bearing cover below supply unit

- ⇒ Attach chain blocks "HZ" and connect ropes 'a' and 'b' (lifting capacity 1000 kg each) with eye bolt "RC" and then lift up bearing cover (12).
- ⇒ Attach chain block H₅ and connect rope 'c' (lifting capacity 1000 kg each) with the bearing cover as shown in Fig. 'M'.
- ⇒ Remove rope 'b'.
- ⇒ Lift out the bearing cover by means of ropes 'a', 'c' and 'd' as shown in Fig. 'N'.
- ⇒ Protect the crosshead pin against dirt and damage.

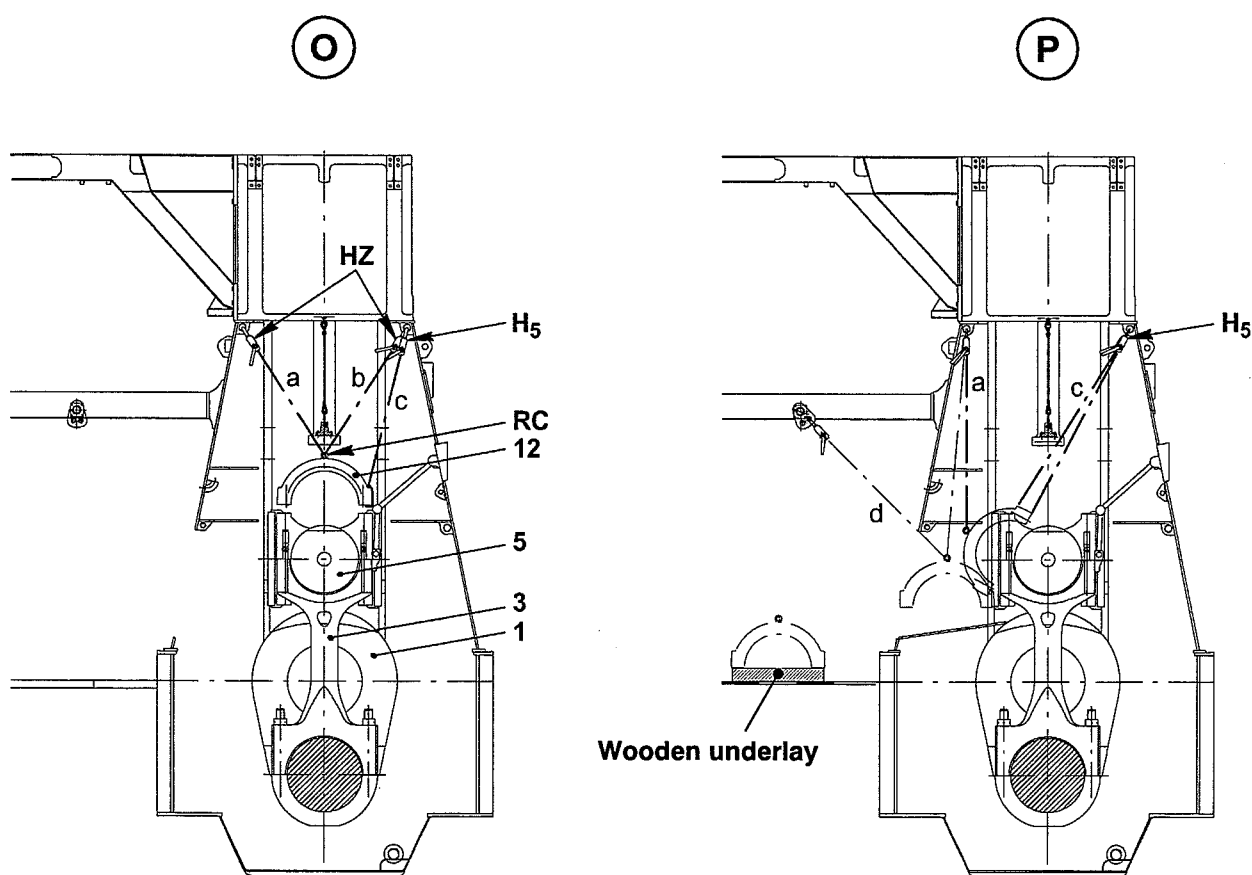


Connecting Rod

Inspection, Removal and Fitting of Top End Bearing with Piston in Situ

4.2 Removal of bearing cover outside the area of supply unit

- ⇒ Attach chain blocks "HZ" and connect ropes 'a' and 'b' (lifting capacity 1000 kg each) with eye bolt "RC" and then lift up bearing cover (12).
- ⇒ Attach chain block H₅ and connect rope 'c' (lifting capacity 1000 kg each) with the bearing cover as shown in Fig. 'O'.
- ⇒ Remove rope 'b'.
- ⇒ Lift out the bearing cover by means of ropes 'a', 'c' and 'd' as shown in Fig. 'P'.
- ⇒ Protect the crosshead pin against dirt and damage.



5. Fitting the bearing cover

The fitting of bearing cover (12) is carried out analogously but in reverse sequence to the removal, whereby the following points require special attention:

- Before fitting smear the running surfaces lavishly with clean bearing oil.
- Tightening of nuts (6) (Fig. 'G'), see 3303-1.
- Tightening of the nuts for the connection of crosshead pin (5) and piston rod foot (17), see 3403-1.

Connecting Rod

Inspection, Removal and Fitting of Top End Bearing with Piston Removed

Tools:

1	Working platform	94142
4	Retaining pins	94323
1	Lifting plate	94324
2	Eye bolts	
1	Connecting flange	

Key to Illustrations:

1	Crankshaft	13	Guide segment
2	Toggle lever	14	Bolt with nut
3	Connecting rod	15	Piston rod foot
4	Guide way	16	Waisted stud
5	Crosshead pin	17	Nut
6	Nut		
7	Connecting rod stud		
8	Cylindrical pin	DL	Oil pressure pipe
9	Bearing shell	HZ	Chain block
10	Allen shell	H1...	Chain blocks
11	Bearing cover	OP	Lubricating pump
12	Guide shoe	RC	Eye bolt

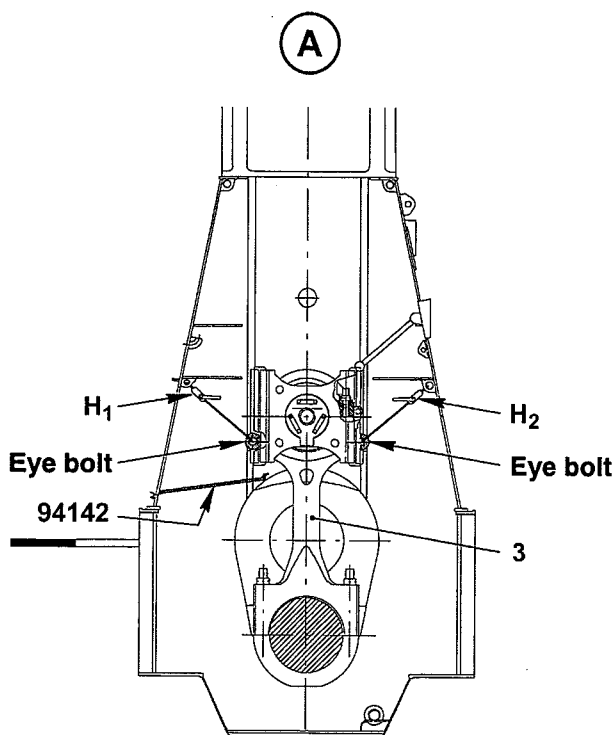
Overview

1.	Inspection of bearing shell	1/8
2.	Remove of bearing shell	3/8
3.	Fitting the bearing shell	5/8
4.	Removal of bearing cover	7/8
5.	Fitting the bearing cover	8/8

1. Inspection of bearing shell



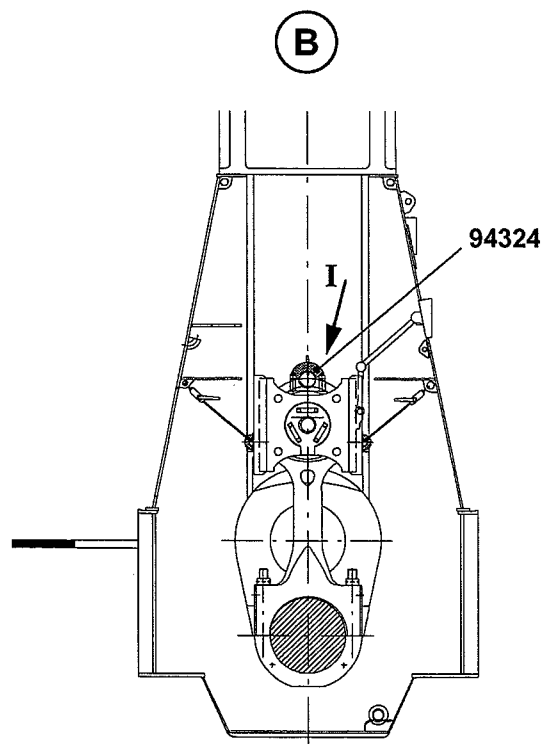
The crankshaft must not be turned by turning gear when workmen are in crankcase.



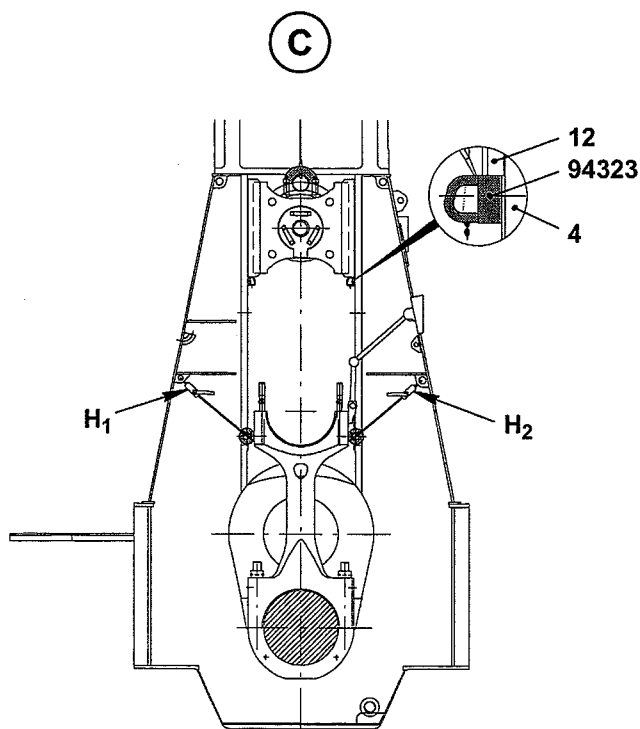
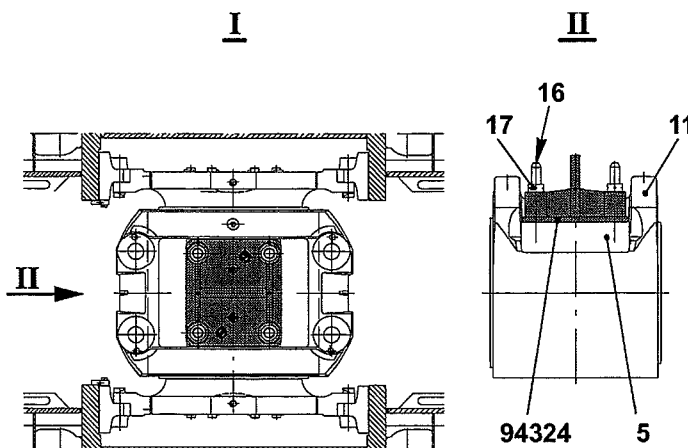
- ⇒ Turn crank of the corresponding cylinder to B.D.C.
- ⇒ Install working platform (94142).
- ⇒ Loosen and remove all nuts (6) of connecting rod studs (7) to top end bearing as instructed 3303-1.
- ⇒ Screw in eye bolts (M64) on either side of the connecting rod head.
- ⇒ Connect chain blocks H₁ and H₂ (lifting capacity 4000 kg each) with eye bolts and column straps.

Connecting Rod

Inspection, Removal and Fitting of Top End Bearing with Piston Removed



⇒ Fasten lifting plate (94324) with nuts (17) of waisted studs (16) to crosshead pin (5).



⇒ Connect a lifting tackle with 10000 kg lifting capacity to lifting plate (94324) and engine crane.



WARNING

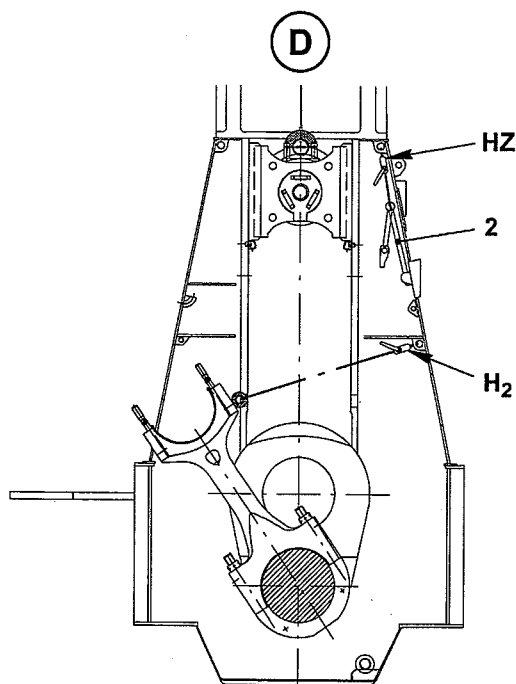
For safety reasons the crosshead shall not be lifted directly with the engine crane, but with the chain block connected between!

- ⇒ Lift crosshead up over the bores provided for retaining pins in the guide ways.
- ⇒ Place four retaining pins (94323) into guide ways (4), and pay attention to detail in Fig. 'C'!
- ⇒ Lower crosshead onto retaining pins.
- ⇒ Turn retaining pins so that their eccentrics contact the guide shoes (12).

Connecting Rod

Inspection, Removal and Fitting of Top End Bearing with Piston Removed

2. Removal of bearing shell

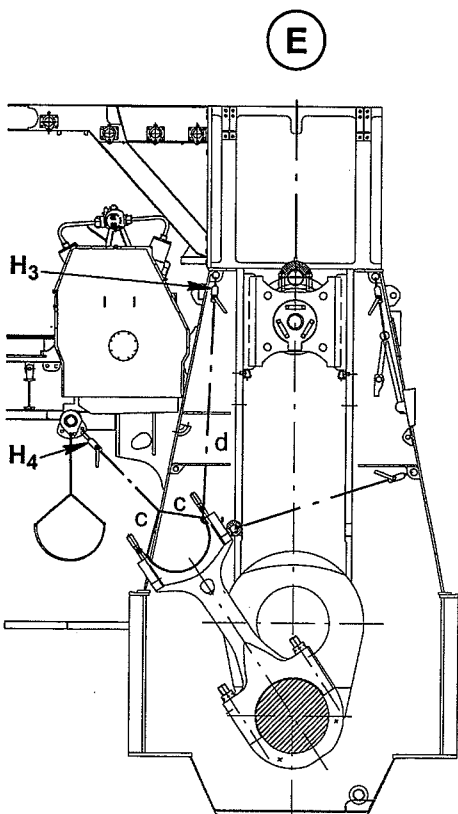


- ⇒ Loosen the screws fastening toggle lever (2) of the crosshead lubrication and piston cooling, and separate the toggle lever from connecting rod (3).
- ⇒ Suspend toggle lever with chain block "HZ" inside the crankcase.
- ⇒ Mark lateral guide segments (13) (Fig. 'G') and remove them.



Remark: The lateral guide segments must be marked to ensure that they are refitted to the connecting rod head in the same place!

- ⇒ By means of chain blocks H₁ and H₂ (Fig. 'C') swing connecting rod to fuel side ensuring that it can not tilt back to exhaust side.
- ⇒ Remove chain block H₁ and swing connecting rod in that position as shown in Fig. 'D'.

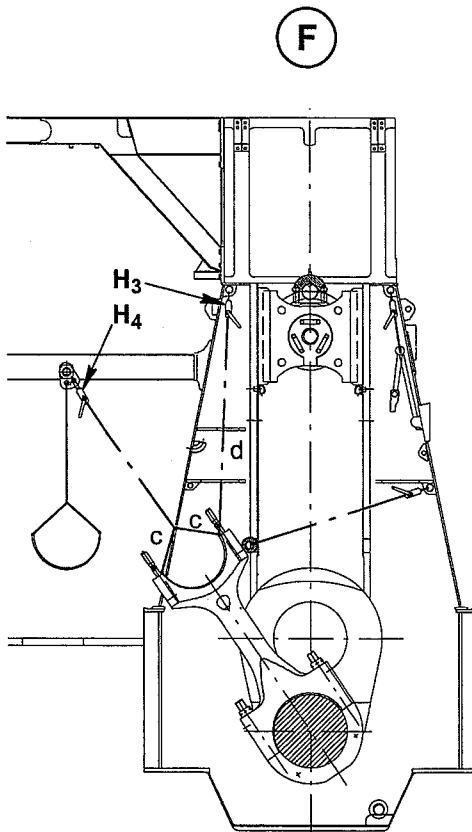


2.1 Removal of bearing shell below supply unit

- ⇒ Fit two eye bolts (M8) each into the front faces of the bearing shell.
- ⇒ Loosen Allen screws (10) (Fig. 'G').
- ⇒ Place chain block H₃ and connect rope 'd' (lifting capacity 500 kg each) with the eye bolts fitted in the bearing shell.
- ⇒ Place chain block H₄ and connect rope 'c' (lifting capacity 500 kg each) with the eye bolts fitted in the bearing shell.
- ⇒ Lift the bearing shell out of the crankcase using ropes 'c', 'd' and chain block H₄.

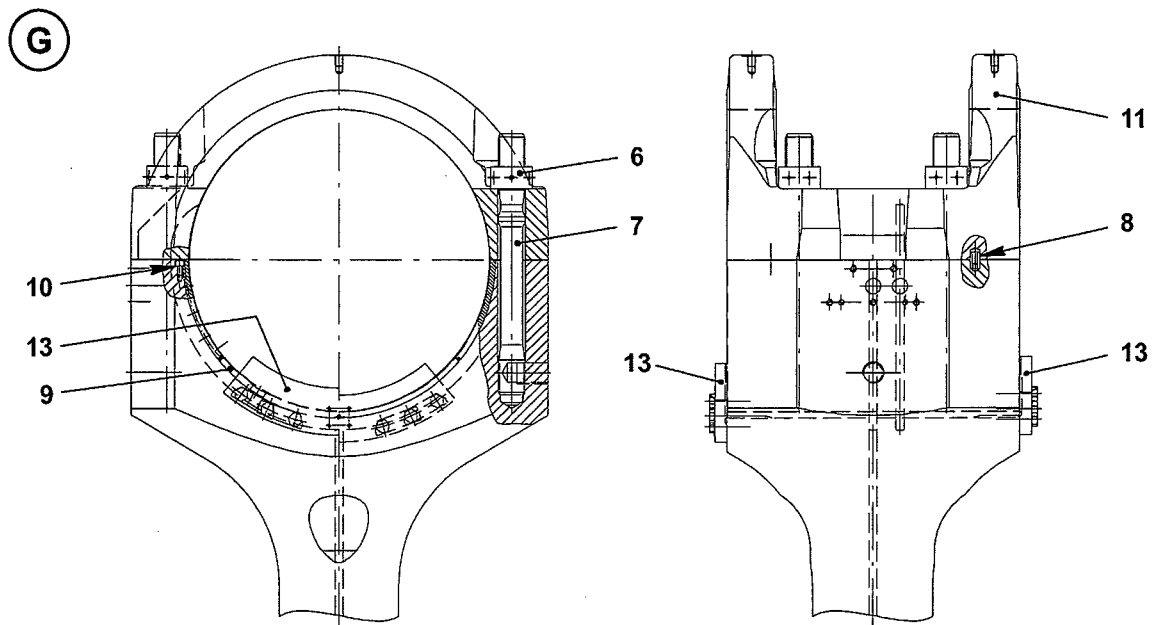
Connecting Rod

Inspection, Removal and Fitting of Top End Bearing with Piston Removed



2.2 Removal of bearing shell outside the area of supply unit

- ⇒ Fit two eye bolts (M8) each into the front faces of the bearing shell.
- ⇒ Loosen Allen screws (10) (Fig. 'G').
- ⇒ Place chain block H₃ and connect rope 'd' (lifting capacity 500 kg each) with the eye bolts fitted in the bearing shell.
- ⇒ Place chain block H₄ and connect rope 'c' (lifting capacity 500 kg each) with the eye bolts fitted in the bearing shell.
- ⇒ Lift the bearing shell out of the crankcase using ropes 'c', 'd' and chain block H₄.



Connecting Rod

Inspection, Removal and Fitting of Top End Bearing with Piston Removed

3. Fitting the bearing shell

The fitting of bearing shell (9) and bearing cover (11) is carried out analogously but in reverse sequence to the removal, whereby the following points require special attention:

CHECK

Check whether the surface of the crosshead pin is in perfect condition before fitting the bearing shell.



While fitting a bearing shell pay attention to prevent dirt or foreign particles from entering between the shell rear surface and its seating! The contact surfaces of the shell rear side and the bearing bore must be free from any damage. Immediately before inserting the bearing shell they have to be wiped with a **slightly oily hand**, so that a **trace** of oil is on them.

- The bearing shell should be placed in the connecting rod head such that it protrudes by the same distance at both ends of the separating face (Fig. 'H').



This protrusion is a must and under no circumstances may the separating face of the bearing shell be filed to reduce it!

Prior to final assembly smear the running surfaces lavishly with clean bearing oil. Should, however, the engine have to be frequently turned after the fitting of the bearing, or should a restart of the engine not be immediately planned, then instead of bearing oil a mixture of 2/3 steam-engine cylinder oil and 1/3 normal bearing oil should be used. Special oils suited to this purpose are also available from reliable suppliers.

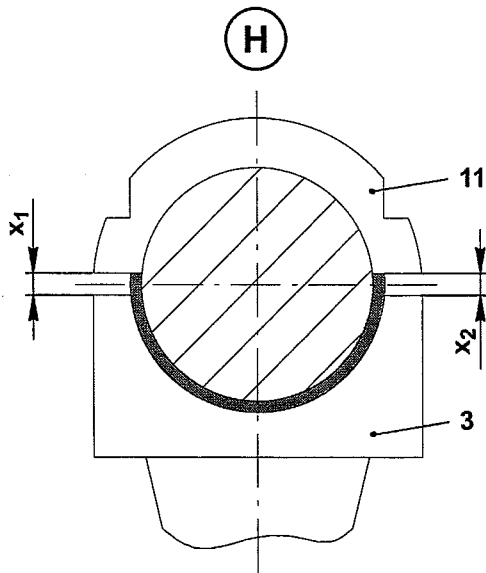
- The tensioning of the connecting rod studs must be carried out as instructed in 3303-1.
- When fitting the bearing shell, as well as the crosshead pin, pay attention not to damage the white metal of the two guide segments (13) (Fig. 'G').



Always fit toggle lever (2) in such a way that its curvature stands upwards.

Connecting Rod

Inspection, Removal and Fitting of Top End Bearing with Piston Removed



3.1 Fitting a new top end bearing shell

⇒ Proceed as described in section 3, however protrusion $x_1 + x_2$ must be measured prior to tension connecting rod studs (7).

3.1.2 Measuring the protrusion

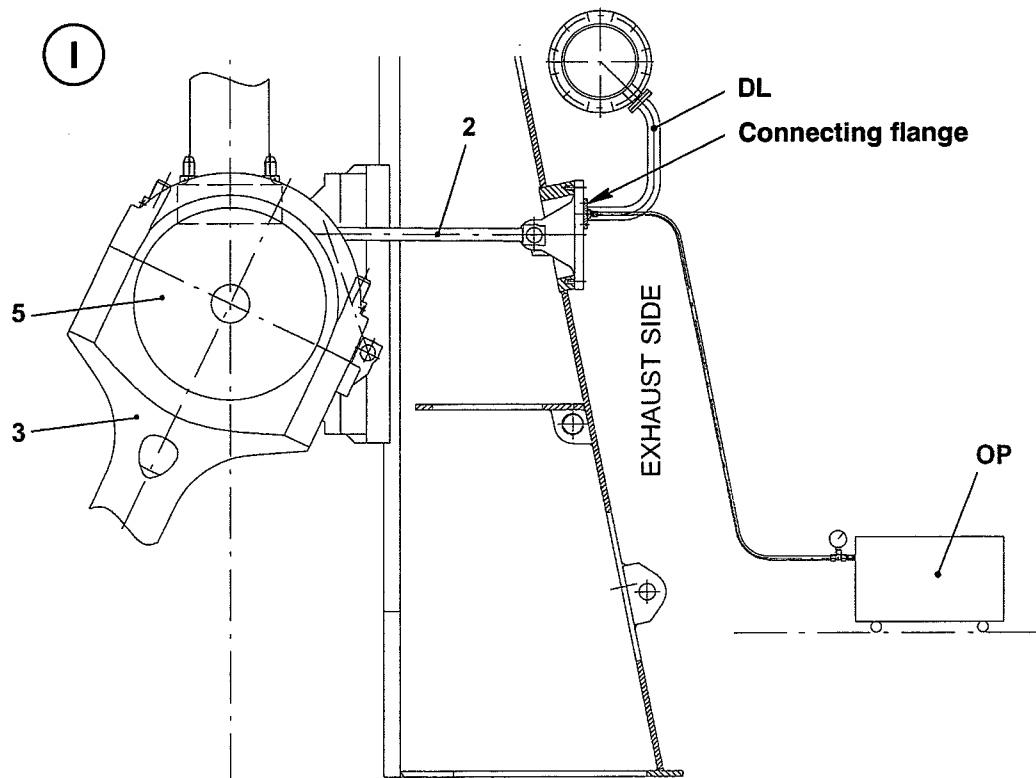
⇒ Hand-tighten nuts (6) (Fig. 'G') with a round bar and measure the protrusion (of a new bearing shell):

$$x_1 + x_2 = \text{approx. } 0.64 \sim 0.72 \text{ mm}$$

3.2 Post lubrication of connecting rod bearing

In order to further reduce the risk of dry running on newly fitted bearing shells, a connecting flange can be fitted after removing the oil pressure pipe "DL" to the crosshead bearing as shown in Fig. 'I'. The connecting flange has to be connected via an oil pressure hose to a lubricating pump "OP".

The pump has to be filled with the mentioned oil mixture (steam-engine cylinder oil) or special oil. The lubricating pump has to be operated from time to time, until oil is pouring out from the bearing side faces. Before the engine is put back into operation, the oil pressure pipe "DL" must be refitted. The remainder of the above mentioned special oil or oil mixture may remain in the engine oil system.



Connecting Rod

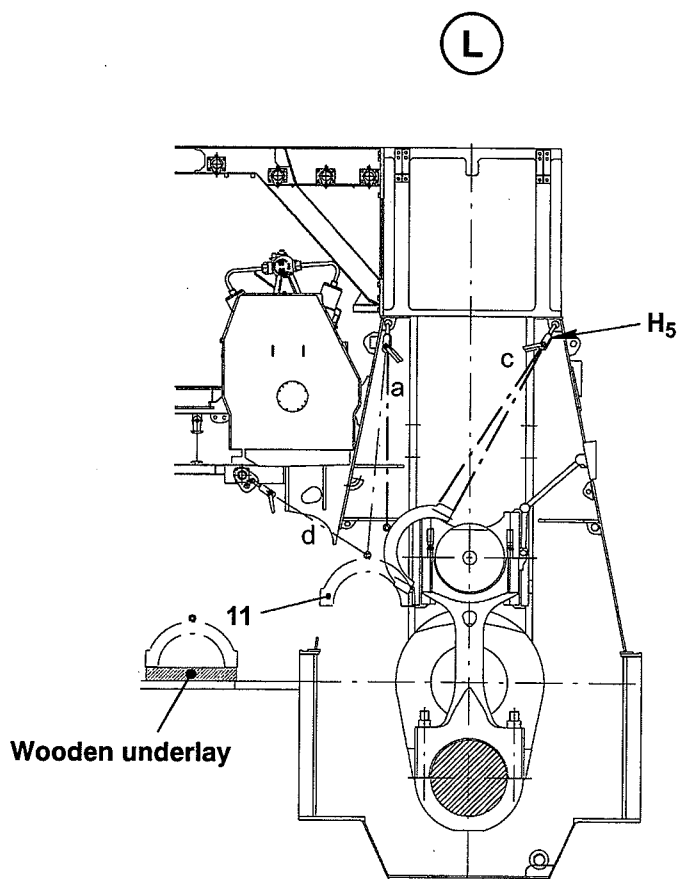
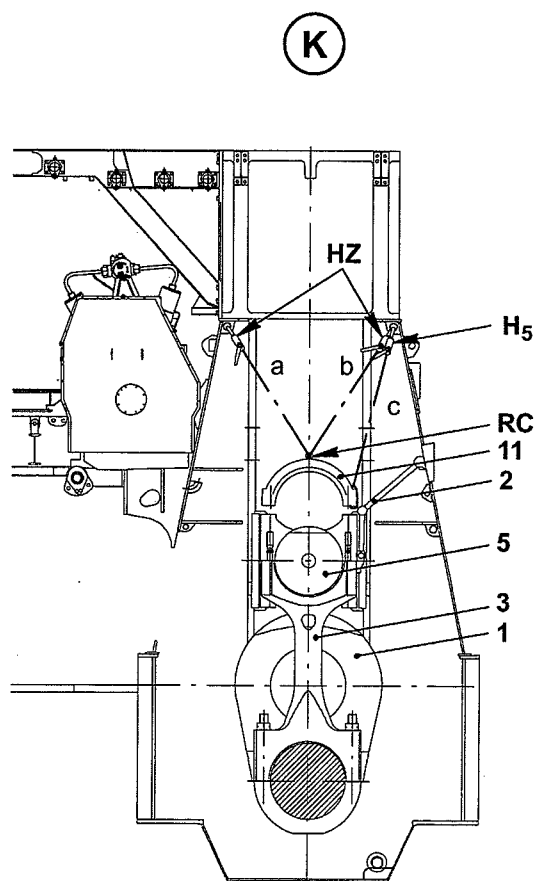
Inspection, Removal and Fitting of Top End Bearing with Piston Removed

4. Removal of bearing cover

- ⇒ Turn crank to B.D.C.
- ⇒ Loosen and remove all nuts (6) (Fig. 'A') to connecting rod studs (7) to top end bearing as instructed in 3303-1.

4.1 Removal of bearing cover below supply unit

- ⇒ Attach chain blocks "HZ" and connect ropes 'a' and 'b' (lifting capacity 1000 kg each) with eye bolt "RC" and then lift up bearing cover (12).
- ⇒ Attach chain block H₅ and connect rope 'c' (lifting capacity 1000 kg each) with the bearing cover as shown in Fig. 'K'.
- ⇒ Remove rope 'b'.
- ⇒ Lift out the bearing cover by means of ropes 'a', 'c' and 'd' as shown in Fig. 'L'.
- ⇒ Protect the crosshead pin against dirt and damage.

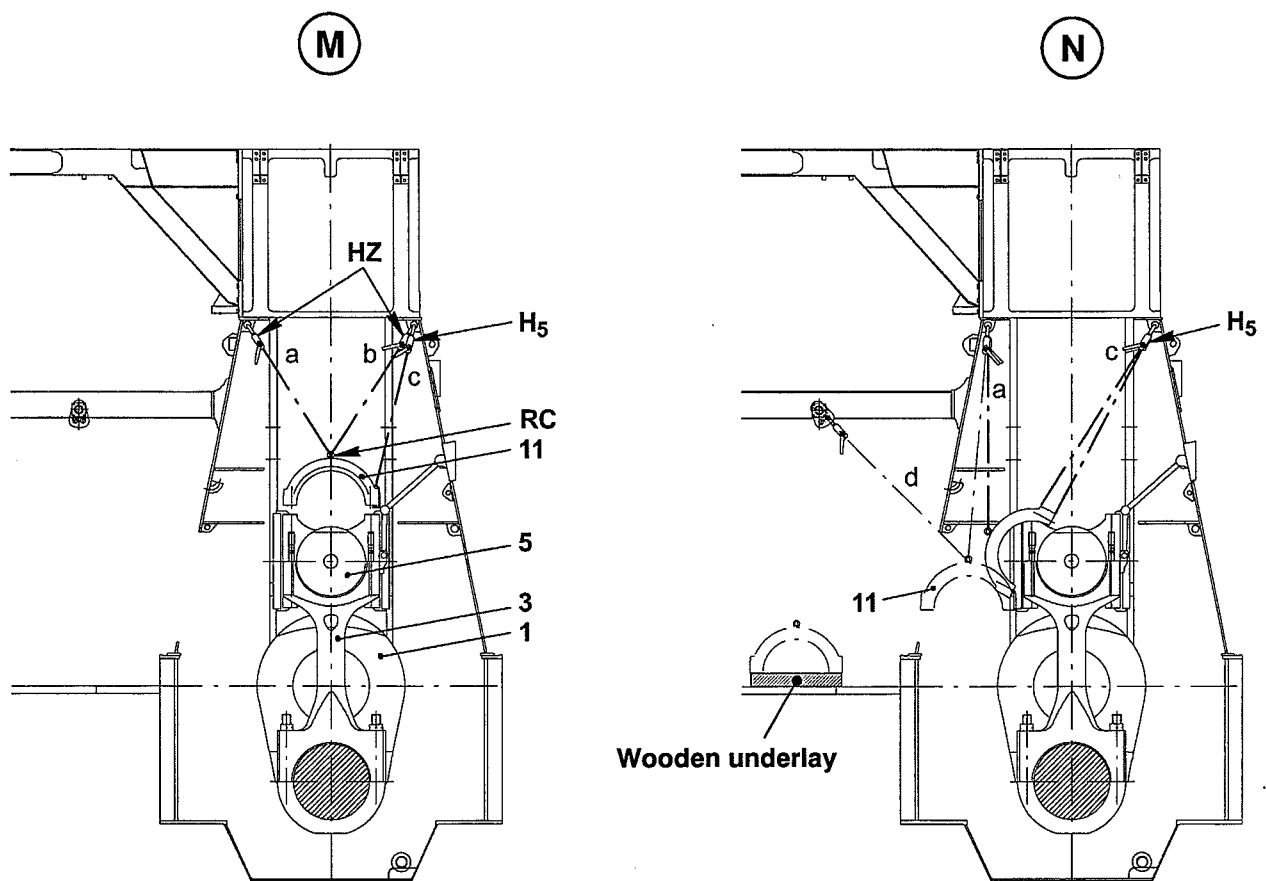


Connecting Rod

Inspection, Removal and Fitting of Top End Bearing with Piston Removed

4.2 Removal of bearing cover outside the area of supply unit

- ⇒ Attach chain blocks "HZ" and connect ropes 'a' and 'b' (lifting capacity 1000 kg each) with eye bolt "RC" and then lift up bearing cover (11).
- ⇒ Attach chain block H₅ and connect rope 'c' (lifting capacity 1000 kg each) with the bearing cover as shown in Fig. 'M'.
- ⇒ Remove rope 'b'.
- ⇒ Lift out the bearing cover by means of ropes 'a', 'c' and 'd' as shown in Fig. 'N'.
- ⇒ Protect the crosshead pin against dirt and damage.



5. Fitting the bearing cover

The fitting of bearing cover (11) is carried out analogously but in reverse sequence to the removal, whereby the following points require special attention:

- Before fitting smear the running surfaces lavishly with clean bearing oil.
- Tightening of nuts (6) (Fig. 'G'), see 3303-1.

**Connecting Rod
Removal and Fitting**

Tools:

1	Working platform	94142
2	Retaining pins	94323
1	Lifting device	94330
2	Roller supports	94331
1	Carrying roller	94332

Key to Illustrations:

1	Crankshaft	11	Waisted stud
2	Toggle lever	12	Suspension beam
3	Connecting rod		
4	Support	14	Upper platform
5	Guide way	15	Lower plat form
6	Crosshead pin		
7	Bearing cover		
8	Guide shoe	HZ	Chain block
9	Nut	H1...	Chain blocks
10	Guide segment	RC	Eye bolt

1. General

A connecting rod can be removed from or fitted to the engine without removing the piston and crosshead pin.

- The bearing cover for the bottom end bearing must be removed (see 3303-2).

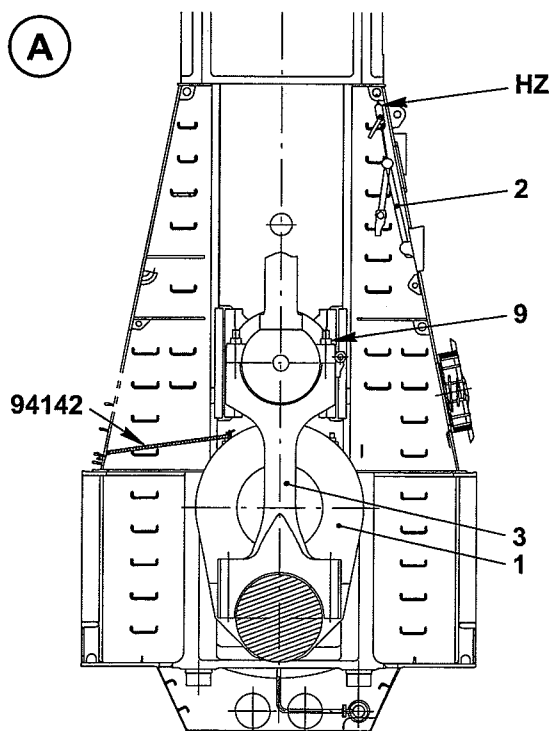


Risk of accident! Should the piston have been removed prior to the removal of the connecting rod then lifting plate (94324) for the crosshead pin (see 3326-2) must be installed or bearing cover (7) secured by steel ropes. In this way the bearing cover of the top end bearing is prevented from turning around and dropping down after lowering the connecting rod.

2. Removal



The crankshaft must not be turned by turning gear when workmen are in crankcase.



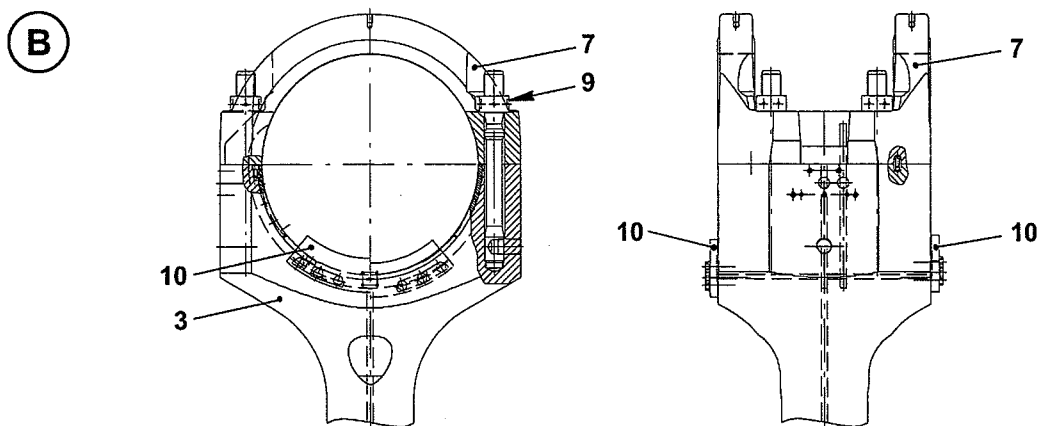
- ⇒ Turn crank of the corresponding cylinder to B.D.C.
- ⇒ Install working platform (94142).
- ⇒ Loosen and remove all nuts (6) of connecting rod studs (7) to top end bearing as instructed 3303-1.
- ⇒ Loosen the screws fastening toggle lever (2) of the crosshead lubrication and piston cooling, and separate the toggle lever from connecting rod (3).
- ⇒ Suspend toggle lever with chain block "HZ" inside the crankcase.
- ⇒ Mark lateral guide segments (10) (Fig. 'B') and then remove them.



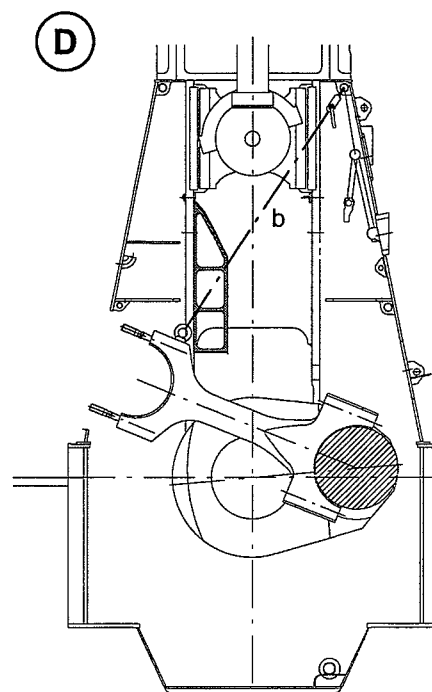
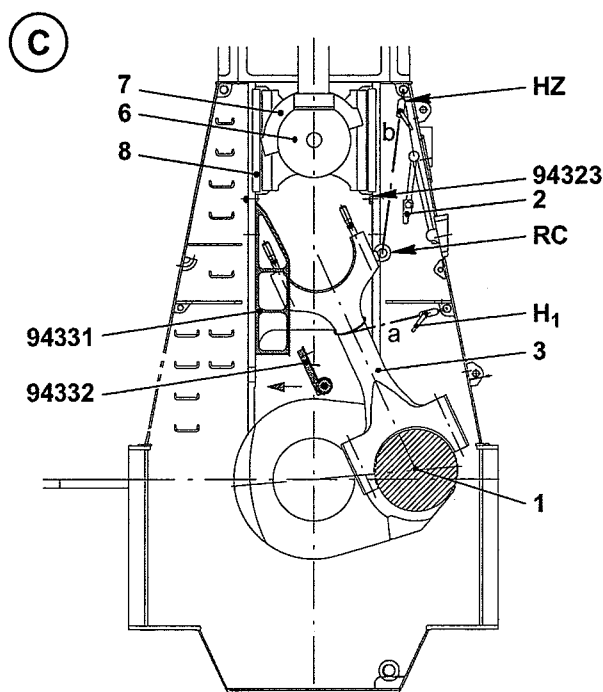
Remark : The lateral guide segments must be marked to ensure that they are refitted in the same place!

- ⇒ Remove the working platform.
- ⇒ Turn crank to T.D.C.

Connecting Rod
Removal and Fitting

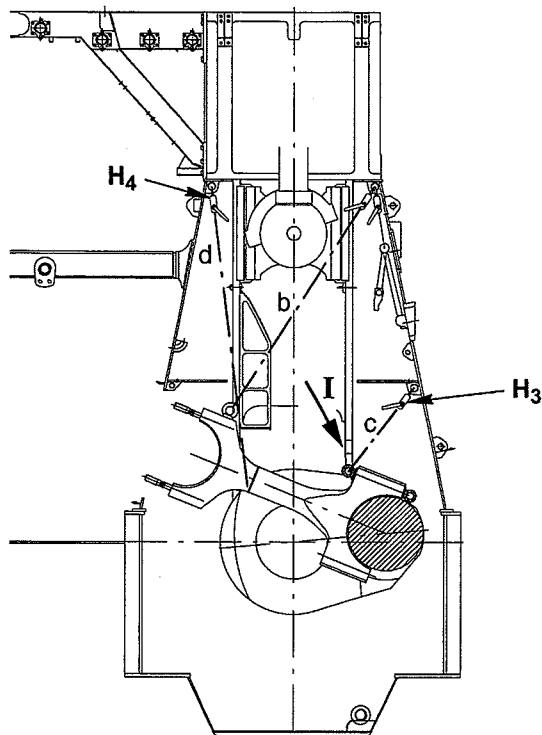


- ⇒ Fit two retaining pins (94323) and roller supports (94331), as well as the carrying roller (94332) in the same manner as described for Inspection, Removing and Fitting of Top End Bearing 3303-3.
- ⇒ Turn crankshaft carefully max. 85° after T.D.C. towards exhaust side (Fig. 'C'). Follow instructions in 3303-3.
- ⇒ Attach chain block H₁ and rope 'a' (lifting capacity 3000 kg each) and sling the latter around the connecting rod (Fig. 'C').
- ⇒ Tighten rope 'a' till the carrying roller is slightly lifted off the roller support.
- ⇒ Dismantle carrying roller (94332).
- ⇒ Attach chain block H₂ and rope 'b' (lifting capacity 4000 kg each), screwing eye bolt 'RC' into the connecting rod head. Tighten rope 'b' and remove rope 'a'.
- ⇒ Lower the connecting rod head till column opening, using rope 'b' (Fig. 'D').
- Be careful that crosshead pin (6) is not damaged!

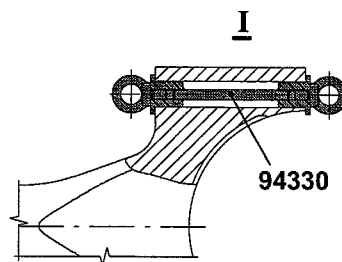


**Connecting Rod
Removal and Fitting**

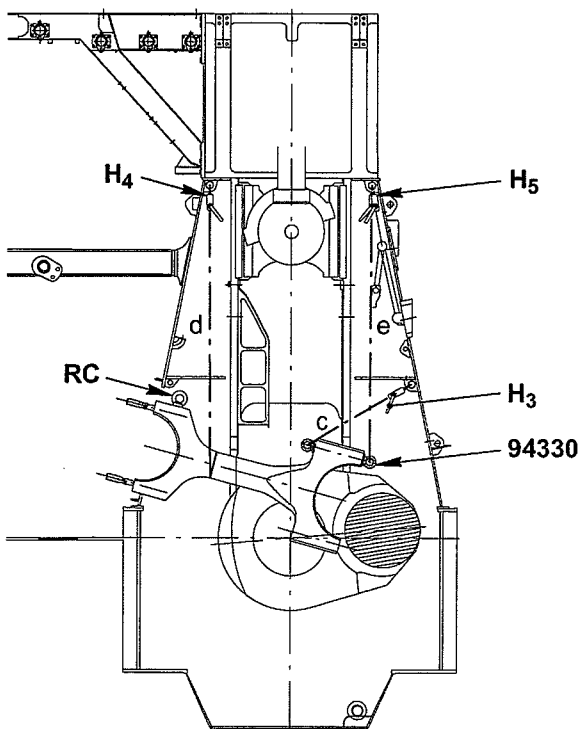
E



- ⇒ Fit lifting device (94330) as shown in view I.
- ⇒ Attach chain block H₃ and rope 'c' (lifting capacity 3000 kg each), connect it to the lifting device and tighten it.
- ⇒ Attach chain block H₄, sling rope 'd' (lifting capacity 4000 kg each) around the connecting rod and tighten it.
- ⇒ Remove rope 'b'.



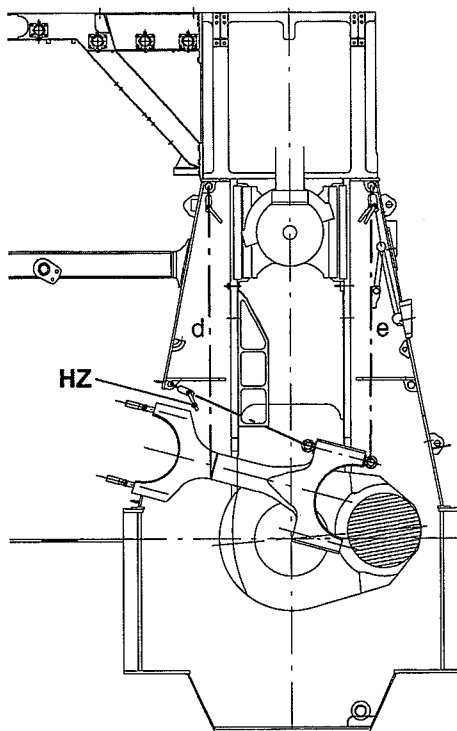
F



- ⇒ Attach chain block H₅ and rope 'e' (lifting capacity 4000 kg each) and connect it to lifting device (94330).
- ⇒ Carefully separate the bearing part from the crankpin by slackening rope 'c' while lifting the connecting rod with rope 'e'.
- ⇒ Remove rope 'c'.
- ⇒ Remove eye bolt "RC".

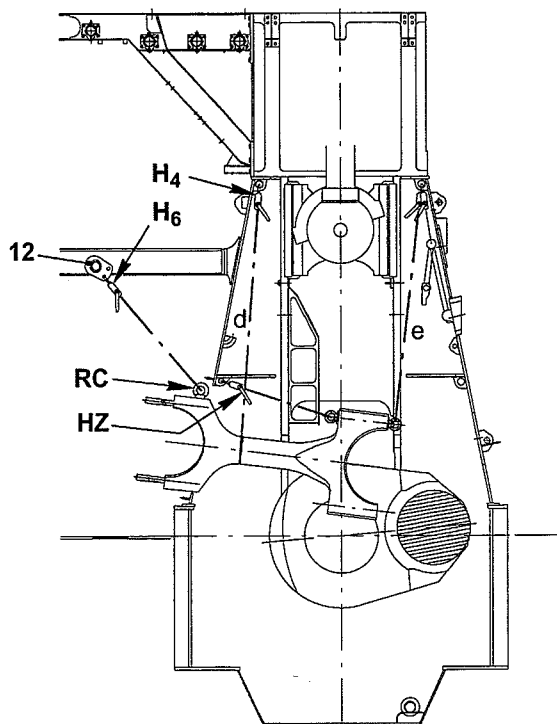
Connecting Rod
Removal and Fitting

G



⇒ Attach chain block "HZ" (lifting capacity 3000 kg) and connect it to lifting device (94330).

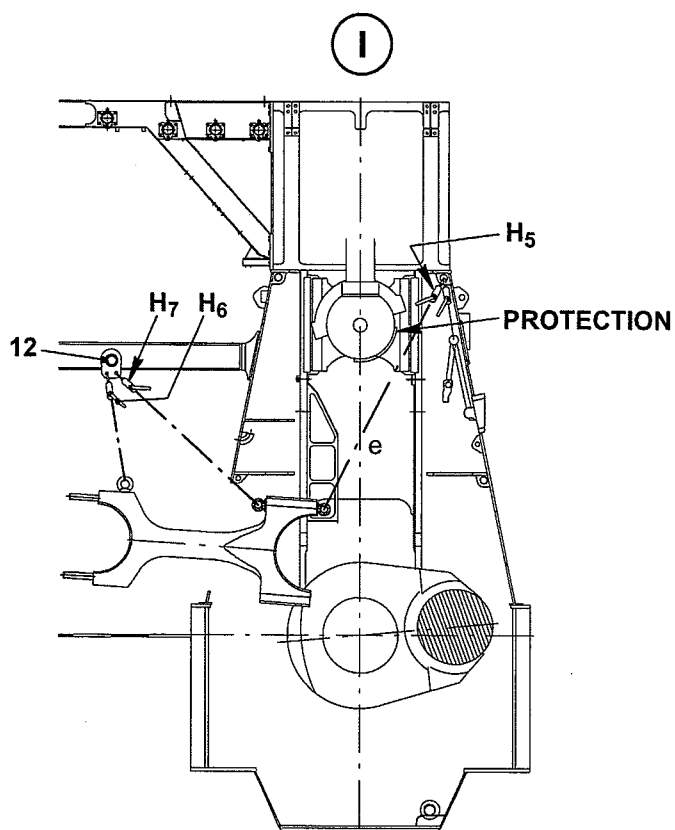
H



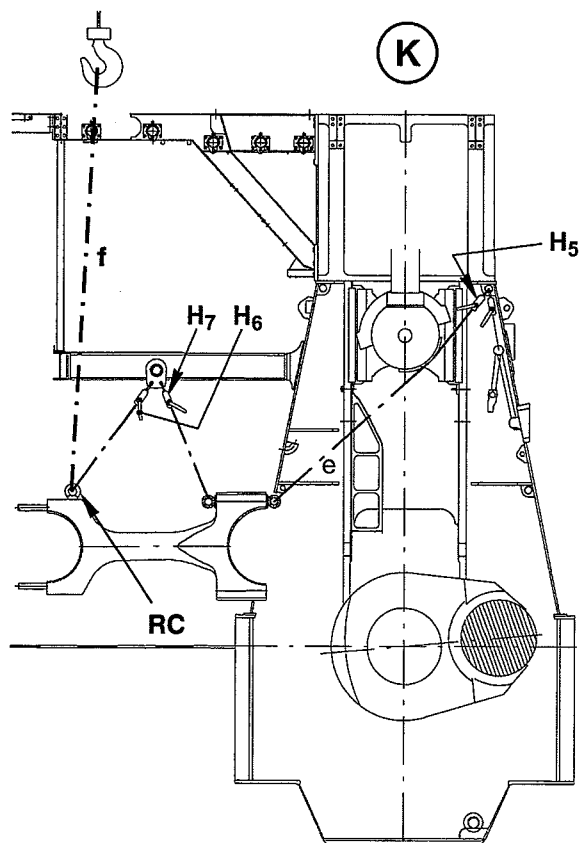
2.1 Removal of connecting rod outside the area of supply unit

- ⇒ Pull connecting rod head through the column door by means of chain block "HZ" while following up with ropes 'e' and 'd'.
- ⇒ Screw eye bolt into the connecting rod head.
- ⇒ Attach chain block H₆ (lifting capacity 4000 kg) to the outer hole on suspension beam (12), connect it to eye bolt "RC" and then tighten it.
- ⇒ Remove rope 'd' and chain block "HZ".

Connecting Rod Removal and Fitting

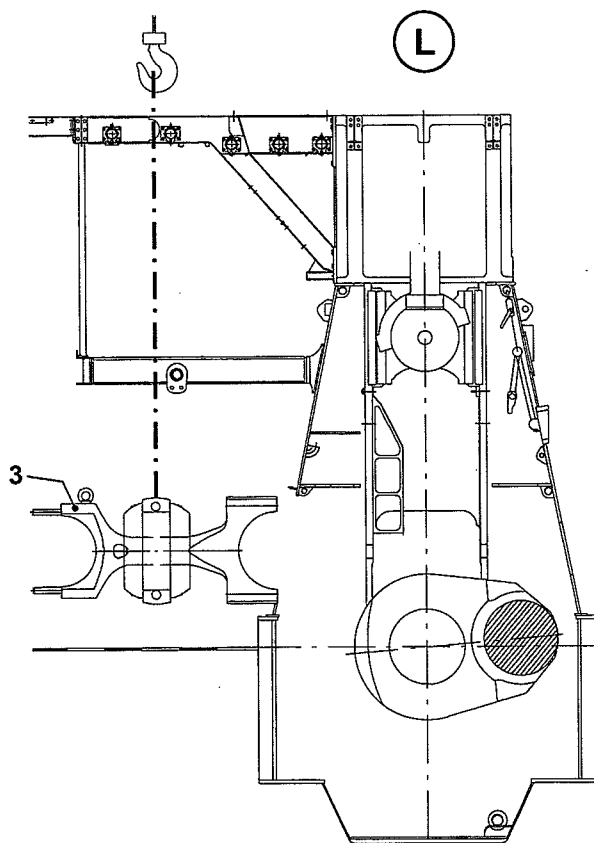


- ⇒ Attach chain block H₇ (lifting capacity 4000 kg) to the inner hole on suspension beam (12) and connect it to lifting device (94330).
- Be careful that crosshead pin (6) is not damaged!
- ⇒ Pull the connecting rod out from the crankcase by means of chain blocks H₆, H₇ and rope 'e'.

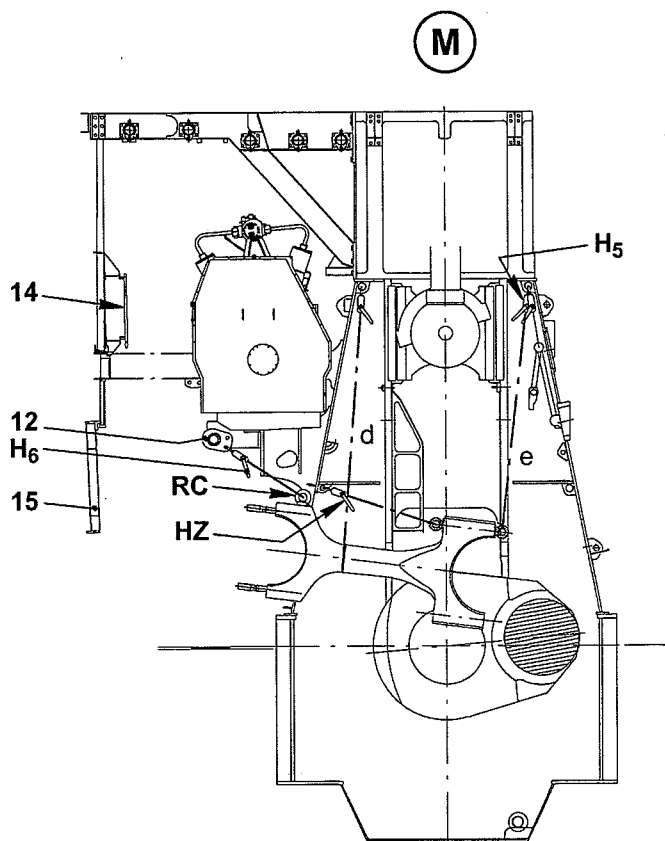


- ⇒ Remove supports in upper and lower platform.
- ⇒ Connect rope 'f' with engine crane to eye bolt "RC" and tighten it.
- ⇒ Remove rope 'e'.
- ⇒ Remove chain block H₅.

**Connecting Rod
Removal and Fitting**



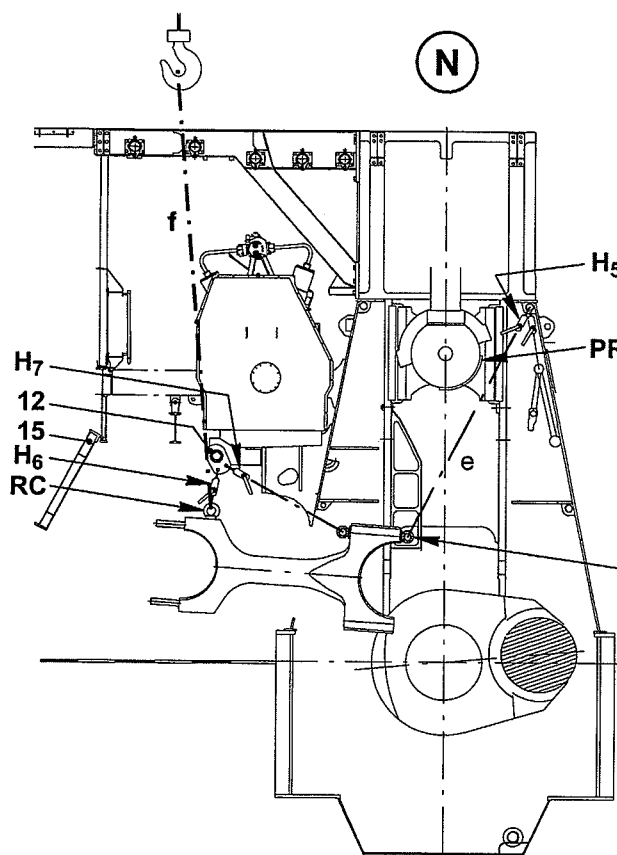
⇒ Move connecting rod (3) in such a position that it can be taken over by the engine crane.



**2.2 Removal of connecting rod
below supply unit**

- ⇒ Pull connecting rod head through the column door by means of chain block "HZ" while following up with ropes 'e' and 'd'.
- ⇒ Screw eye bolt "RC" into the connecting rod head.
- ⇒ Attach chain block H6 (lifting capacity 4000 kg) to the outer hole on the suspension beam (12), connect it to eye bolt "RC" and tighten it.
- ⇒ Remove rope 'd' and chain block "HZ".
- ⇒ Open upper and lower platforms (14) and (15)
- ⇒ Remove supports in corresponding platforms.

**Connecting Rod
Removal and Fitting**



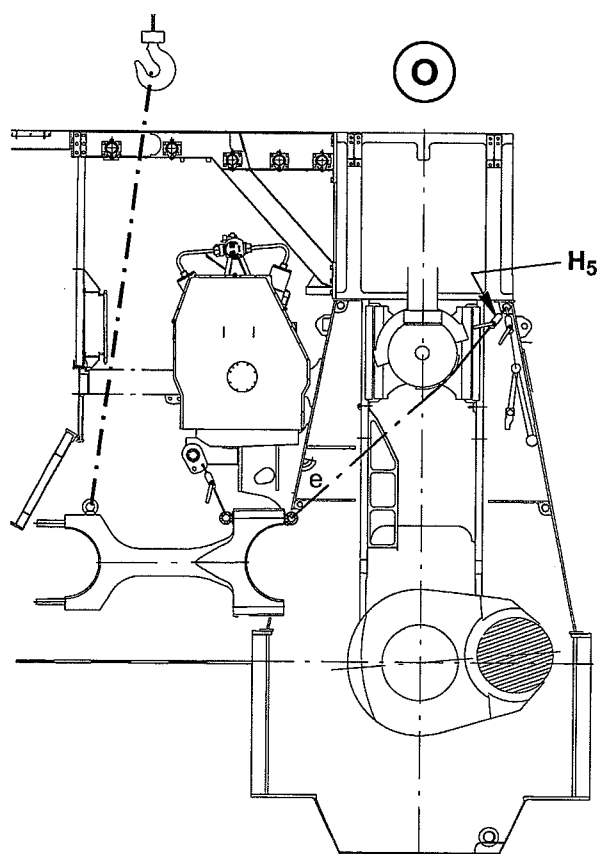
⇒ Attach chain block H7 (lifting capacity 4000 kg) to the inner hole on suspension beam (12) and connect it to lifting device (94330).

● Be careful that crosshead pin (6) is not damaged!

⇒ Pull the connecting rod out from the crankcase by means of lifting tackles H6, H7 and rope 'e'.

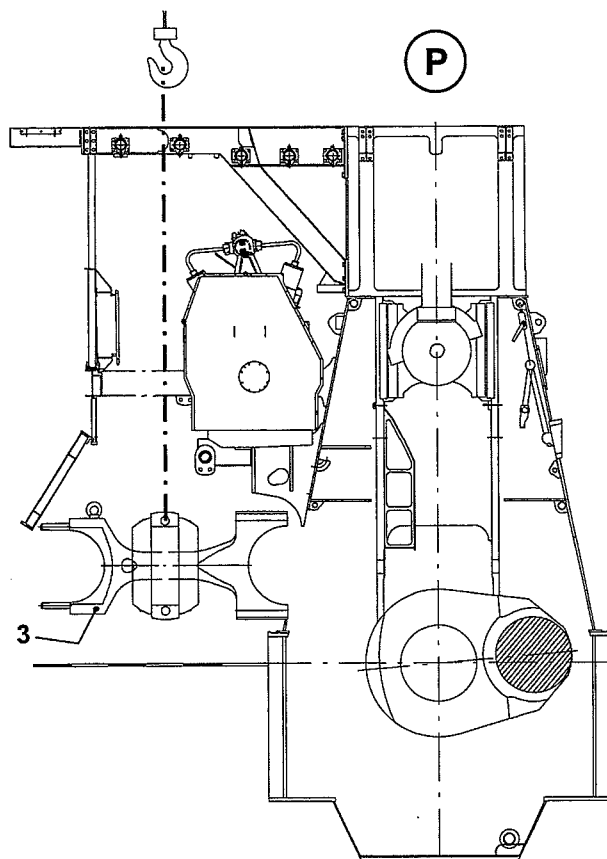
⇒ Swing lower platform (15) slightly up.

⇒ Connect rope 'f' with the engine crane and eye bolt "RC".



⇒ Remove rope 'e'.

Connecting Rod
Removal and Fitting



⇒ Move connecting rod (3) in such a position that it can be taken over by the engine crane.

3. Fitting

Fitting the connecting rod is carried out analogously to the removal but in reverse sequence, whereby attention must be paid to instructions 3303-1 to 3303-3.

For the assembly bearings and bearing pins must be in perfect condition. They must be smeared lavishly with fresh bearing oil.



Remark : When fitting the crosshead pin, pay attention not to damage the two guide segments (10) to the crosshead pin (see Fig. 'B') if they are already fitted. The two white metal lined guide segments are fitted to the front sides of the connecting rod head.



Always fit toggle lever (2) in such a way that its curvature stands upwards. After completing the work retaining pins (94323), roller support (94331) and carrying roller (94332) must be removed immediately.

Crosshead

Checking the Clearances and Fitting the Guide Shoes

Tools :

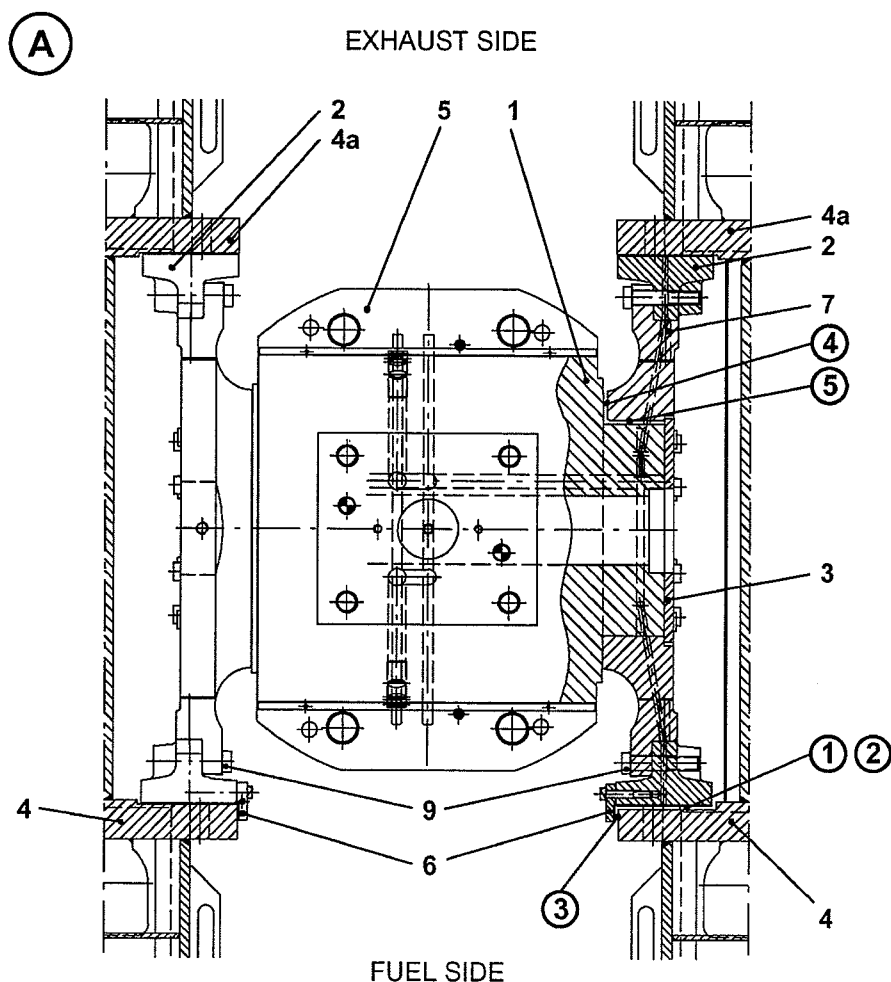
- 1 Feeler gauge 94238
- 1 Wrench (SW 50)
- 1 Socket (SW 55)

Key to Illustrations :

- 1 Crosshead pin
- 2 Guide shoe
- 3 Retaining cover
- 4 Guide way in engine column (on fuel side)
- 4a Guide way in engine column (on exhaust side)
- 5 Top end bearing
- 6 Guide rail
- 7 Middle part
- 8 Screw
- 9 Screw

1. General

On the occasion of an overhaul or when a crosshead has been removed, the opportunity should be taken to measure the various running clearances and to compare them with the values found in the Clearance Table 0330-1, so that possible wear may be discovered.



Crosshead**Checking the Clearances and Fitting the Guide Shoes****2. Checking the clearances****Clearances ① ② Clearances between guide shoes (2) and guide ways (4):**

The corresponding crankpin must stand towards fuel side.

In this position guide shoes (2) lie on the guide ways on exhaust side (Fig. 'B').

Clearance ③**Axial clearance of crosshead between the columns:**

In order to establish correct measurement the complete crosshead must be pressed axially to the side with suitable hardwood wedges or similar aids. The side pressure must be exerted onto the guide shoe or the middle part (7) and not onto the crosshead pin.

Clearance ④

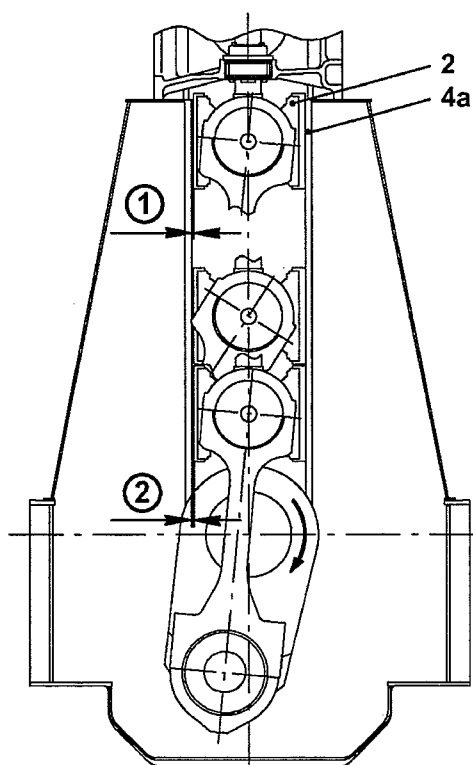
Push the corresponding middle part to the stop of the retaining cover (3) in the above mentioned position.

Clearance ⑤**Radial clearance between crosshead pin and guide shoe bore:**

This clearance is very difficult to establish inside the engine. It is therefore best to measure and calculate this clearance on the removed crosshead. For this the pin diameter and the bore in the middle part (7) have to be measured with micrometers.

(B)

FUEL SIDE



Crosshead

Checking the Clearances and Fitting the Guide Shoes

3. Removal and assembly of a guide shoe

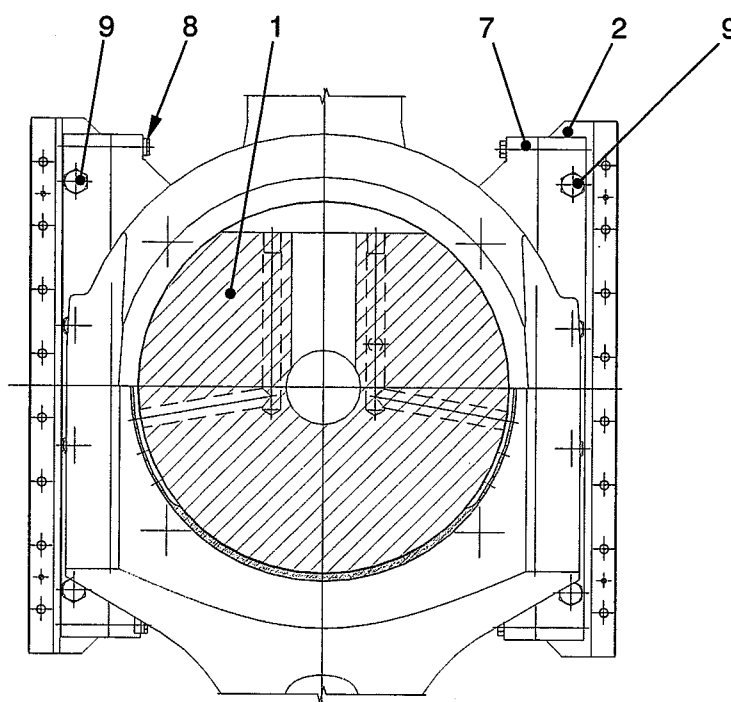
For dismantling as well as for assembling guide shoe (2) to middle part (7), use the wrench to loosen or tighten screws (9) (Fig. 'C').

 **Remark** : When using the HYTORC torque machine, observe also the instructions of the manufacturer.

⇒ Loosen all screws (9) with the socket and the wrench, then remove screws (8).

⇒ Dismantle guide shoe (2).

(C)



CAUTION

Attention must be paid when mounting guide shoe (2) onto middle part (7) so that the middle part bears the guide shoe with no clearance whatsoever. For this purpose, screws (8) are first to be tightened slightly. Then screws (9) are to be tightened slightly by hand and subsequently tightened and secured with tightening angle 60° (2000 Nm (about 60 MPa) when using HYTORC torque machine).

⇒ Tighten and secure screws (8).

CHECK

with feeler gauge (94238) that there is no clearance between the surfaces of guide shoe (2) and middle part (7).

- Guide rails (6) are screwed on fuel side only!

Crosshead

Removal and Fitting of a Crosshead Pin

Tools:

1	Working platform	94142
2	Retaining pins	94323
1	Lifting plate	94324
2	Holder	94325
2	Guide pieces	94325a
2	Roller supports	94331

Key to Illustrations:

1	Crosshead pin	11	Suspension girder
2	Guide shoe	12	Support
3	Retaining cover	13	Upper platform
4	Screw	14	Lower platform
5	Guide way		
6	Guide rail		
7	Middle part		
8	Screw	HZ	chain block
9	Crank	H1...	Chain blocks
10	Neighbouring cylinder	RC	Eye bolt

1. General

If a crosshead pin has to be removed, the piston of the cylinder concerned must first be pulled out (see 3403-1).

In addition, the covers for top & bottom end bearings and the connecting rod must be removed from the crankcase. Follow the instructions in 3303-2 to 3303-4.



Remark

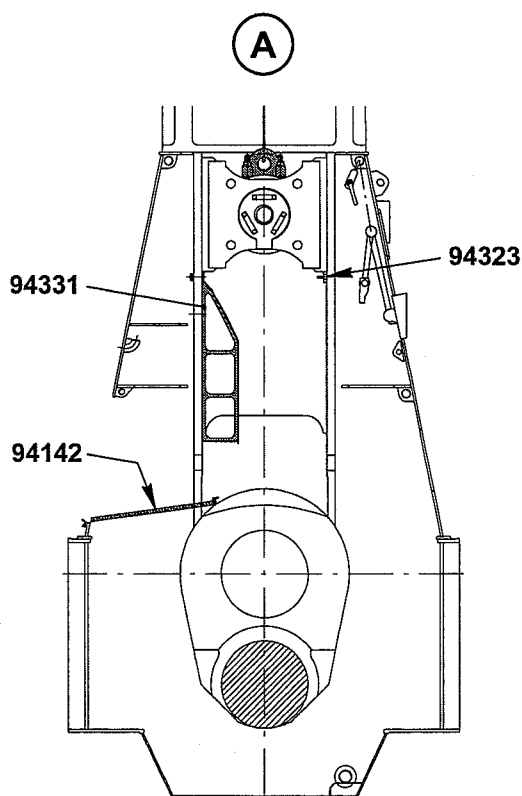
: Pay attention to:

- Utilization of Working Platform and Ladder 3301-1.

2. Preparation



The crankshaft must not be turned by turning gear when workmen are in crankcase.



- Turn crankshaft to such a position, that crank (9) of the neighbouring cylinder stands at 90° or at 270° after T.D.C. respectively. The correct crank position (ideal position) of the neighbouring cylinder (10) is shown in the table Fig. 'B'. This ideal position of the crank is important to ensure the accessibility for the removal of the respective crosshead pin (1).



Remark

: Always start the removal of the guide shoes (2) and middle parts (7) on the corresponding side of the neighbouring cylinder.

- ⇒ Lift the crosshead pin slightly with the engine crane and remove roller supports (94331) and retaining pins (94323) used for the removal of the connecting rod (Fig. 'A').

Crosshead
Removal and Fitting of a Crosshead Pin

Table with ideal crank positions of neighbouring cylinders:

B

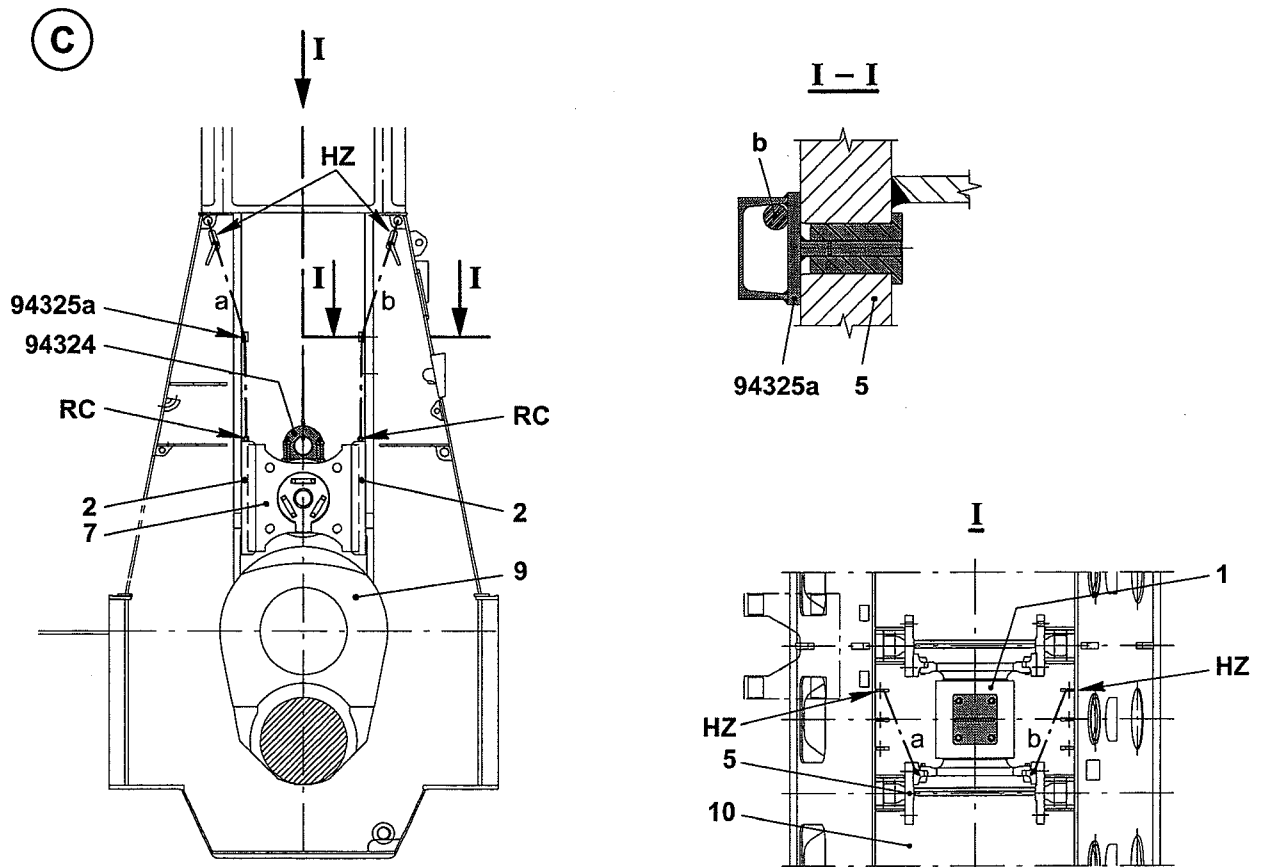
6 Cyl. ENGINE	NEIGHBOURING CYL.	CRANK ANGLE AFTER TDC	7 Cyl. ENGINE	NEIGHBOURING CYL.	CRANK ANGLE AFTER TDC
1	2	270°	1	2	270°
2	1	90°	2	1	90°
3	2	90°	3	2	90°
4	3	270°	4	5	90°
5	4	90°	5	4	270°
6	5	90°	6	5	90°
			7	6	90°
8 Cyl. ENGINE	NEIGHBOURING CYL.	CRANK ANGLE AFTER TDC	9 Cyl. ENGINE	NEIGHBOURING CYL.	CRANK ANGLE AFTER TDC
1	2	270°	1	2	90°
2	1	90°	2	3	90°
3	2	90°	3	4	270°
4	5	90°	4	3	90°
5	6	90°	5	4	90°
6	5	270°	6	5	90°
7	6	90°	7	8	90°
8	7	90°	8	9	90°
			9	8	270°
10 Cyl. ENGINE	NEIGHBOURING CYL.	CRANK ANGLE AFTER TDC	11 Cyl. ENGINE	NEIGHBOURING CYL.	CRANK ANGLE AFTER TDC
1	2	270°	1	2	270°
2	1	90°	2	1	90°
3	2	90°	3	2	90°
4	3	90°	4	3	90°
5	4	90°	5	6	90°
6	5	90°	6	7	90°
7	6	90°	7	8	90°
8	7	90°	8	9	270°
9	8	90°	9	8	90°
10	9	90°	10	9	90°
			11	10	90°
12 Cyl. ENGINE	NEIGHBOURING CYL.	CRANK ANGLE AFTER TDC	14 Cyl. ENGINE	NEIGHBOURING CYL.	CRANK ANGLE AFTER TDC
1	2	270°	1	2	90°
2	1	90°	2	1	270°
3	2	90°	3	2	270°
4	3	90°	4	5	270°
5	4	90°	5	4	90°
6	5	90°	6	7	270°
7	8	270°	7	6	90°
8	7	90°	8	9	90°
9	8	90°	9	8	90°
10	11	270°	10	9	270°
11	10	90°	11	12	270°
12	11	90°	12	13	90°
			13	12	270°
			14	13	270°

Crosshead
Removal and Fitting of a Crosshead Pin

3. Removal

3.1 Removal of guide shoes

- ⇒ Lower the crosshead pin to the position shown in figure below with the engine crane.
- ⇒ Remove guide rails (6) (Fig. 'F').
- ⇒ Fit guide pieces (94325a), which are used for deviating ropes 'a' and 'b', into both guide ways (5) on exhaust and fuel sides (Fig. 'C').
- ⇒ Screw an eye bolt "RC" into each end of guide shoes (2).
- ⇒ Place chain blocks "HZ" (lifting capacity 1000 kg each).
- ⇒ Guide ropes 'a' and 'b' (lifting capacity 1000 kg each) through the eye pieces of guide pieces (94325a) and connect them to eye bolts "RC" (view I-I).
- ⇒ Tighten both ropes.
- ⇒ Loosen the screwed connections of guide shoes (2) to middle parts (7) (Fig. 'C') as described in 3326-1 'Removal and assembly of a guide shoe'. Remove the screws concerned.



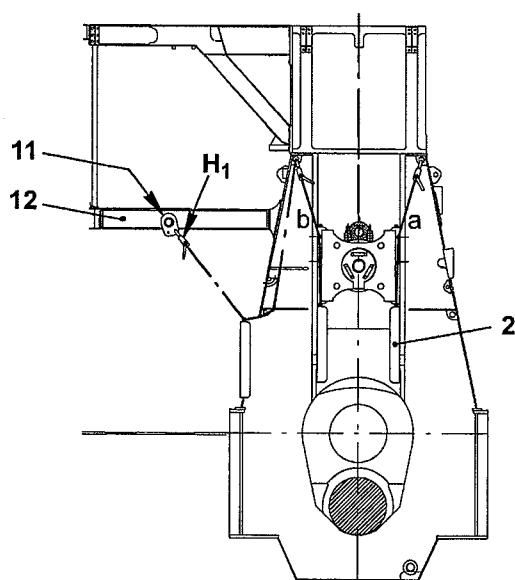
Crosshead

Removal and Fitting of a Crosshead Pin

- ⇒ Lift the crosshead pin carefully with the engine crane until both guide shoes (2) are no longer in gear (Fig. 'D' and 'E').
- ⇒ Place chain block H₁ (lifting capacity 1000 kg) on suspension girder (11) of the corresponding support (12) and then remove the guide shoes from the crankcase together with ropes 'a' and 'b'.
- The removing process for the two other guide shoes is the same as described above.

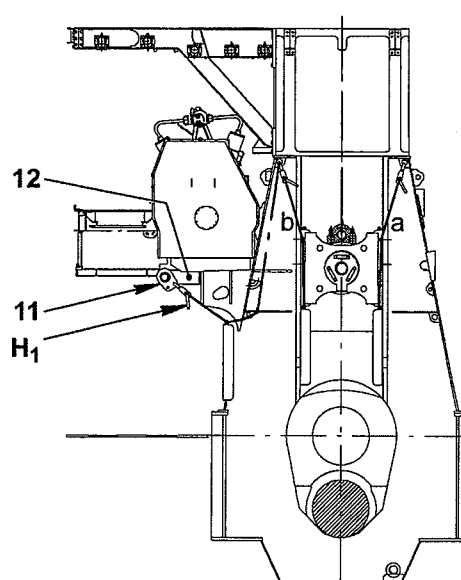
(D)

REMOVAL OUTSIDE OF
AREA OF SUPPLY UNIT

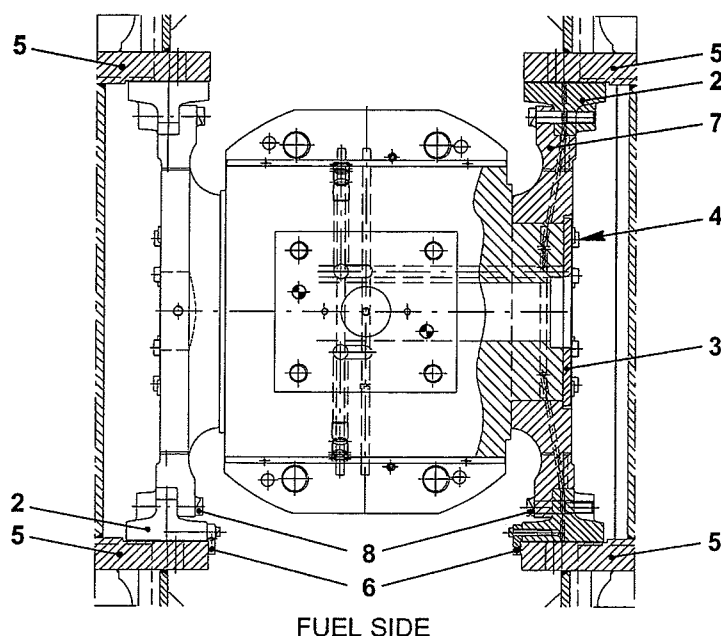


(E)

REMOVAL BELOW
SUPPLY UNIT



(F)

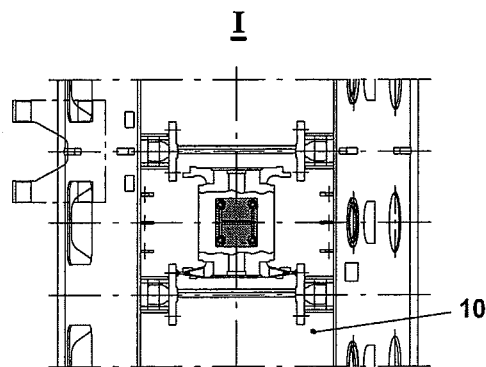
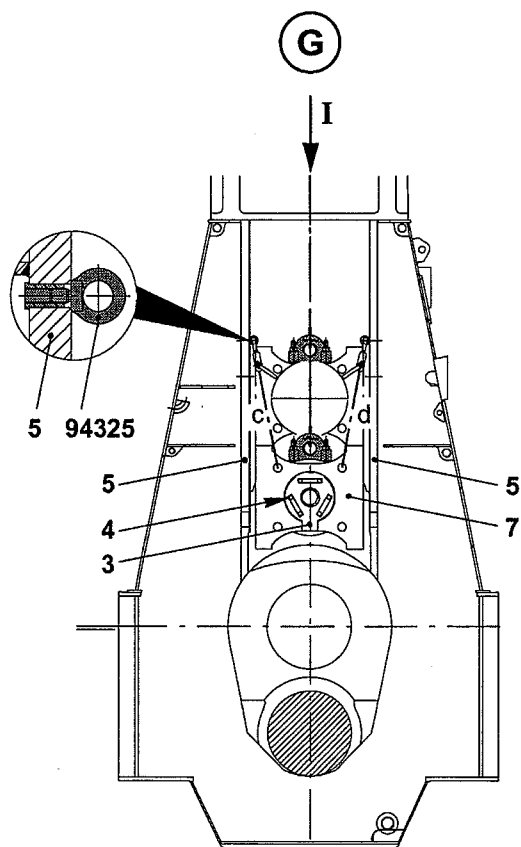


Crosshead

Removal and Fitting of a Crosshead Pin

3.2 Removal of middle pieces

- ⇒ Lower crosshead pin (1) till screws (4) to retaining cover (3) are accessible from the neighbouring cylinder.
- ⇒ Remove guide pieces (94325a) from guide ways (5) and fit holders (94325) instead (Fig. 'G').
- ⇒ Place chain blocks "HZ" (lifting capacity 1000 kg) on the holders.
- ⇒ Connect ropes 'c' and 'd' (lifting capacity 1000 kg each) to chain blocks "HZ" and the holders, and tighten them.
- ⇒ Loosen screws (4) and remove the retaining cover (38 kg).
- ⇒ Using the engine crane, draw the crosshead pin out of the bearing of middle part (7) in longitudinal direction of the engine.
- ⇒ Remove the middle part.
- ⇒ The dismantling process for middle part (7) on the opposite side of neighbouring cylinder (10) is the same as described above. However, shift the crosshead pin as near as possible to the neighbouring cylinder, gaining thereby better access for dismantling retaining cover (3).



Crosshead

Removal and Fitting of a Crosshead Pin

3.3 Removal of crosshead pin

- ⇒ After dismantling the middle parts, revolve the crosshead pin by 90° around its own axis.
- ⇒ Place chain blocks "HZ" and connect ropes 'e' and 'f' (lifting capacity 5000 kg each) to lifting plate (94324), and tighten them.
- ⇒ Disconnect the engine crane.
- ⇒ Move the crosshead pin to fuel side (Fig. 'H' and 'I') by means of ropes 'e' and 'f'. Subsequently remove rope 'f'.
- ⇒ Place chain block H₂ (lifting capacity 5000 kg) on suspension girder (11) of the corresponding support (12) and connect it to lifting plate (94324) (Fig. 'H' and 'I').
- ⇒ Remove the crosshead pin from the crankcase by means of chain block H₂ and rope 'e'.



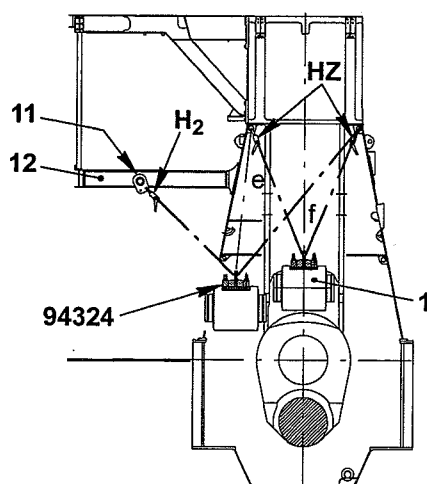
Remark : After opening upper and lower platforms (13) resp. (14) (see 3301-2), the crosshead pin can be lifted up by means of the engine crane (Fig. 'K').



When removing and fitting a crosshead pin it is absolutely necessary to protect it from being damaged.

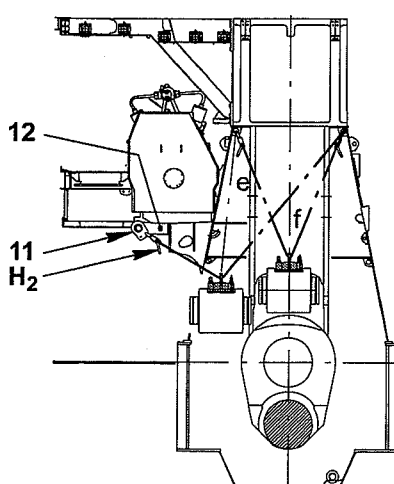
(H)

REMOVAL OUTSIDE OF
AREA OF SUPPLY UNIT

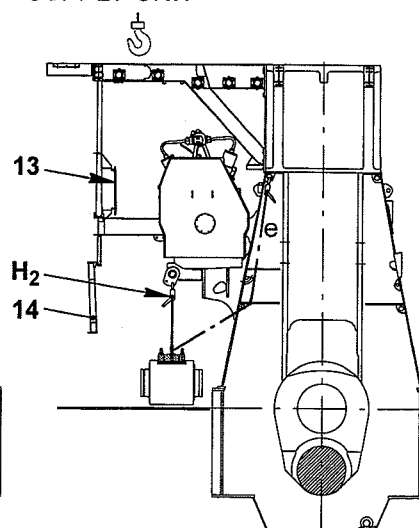


(I)

REMOVAL BELOW
SUPPLY UNIT



(K)



Crosshead

Removal and Fitting of a Crosshead Pin

4. Fitting

Fitting procedure is analogous to the removal, but in reverse sequence.

- **Fit only crosshead pins which have a perfect, undamaged running surface.**
- Before fitting the crosshead pin clean all guide and bearing surfaces carefully and smear them lavishly with bearing oil.
- Lock screws (4) to retaining covers (3).



Always fit toggle lever to crosshead lubrication and piston cooling in such a way that its curvature stands upwards.

CHECK

After completing the work check that all tools and foreign bodies are removed from the crankcase, and that all the screwed fastenings are tightened to specification and locked accordingly.

Check crosshead clearances according to Clearance Table 0330-1 'Crosshead Guide'.

Check with lubricating oil pump running that crosshead and connecting rod bottom end bearings are lavishly supplied with oil.

Piston
Removal and Fitting
Tools :

1	Piston ring expander	94338
2	Pre-tensioning jacks	94340
1	Suspension device	94341
1	Insertion funnel	94342
2	Distance holders	94345
1	Cover plate	94345d
1	Tap	94348
1	Piston supporting device	94350
1	Pressure gauge	94932a
1	Connection piece	94934
1	Connection piece	94934a
1	HP hose	94935
3	HP hoses	94935a
1	Hydraulic unit	94942

Key to Illustrations :

1	Piston rod	11	Piston rod gland box
2	Crosshead pin		
3	Waisted stud	13	Screw connection
4	Nut	14	Centring pin
5	Vent screw		
6	Pin	16	Cylinder liner
7	Piston		
8	Platform support	KO	Slot
9	Support	RS	Round bar
10	Hinged cover	SA	Gap

Overview

1.	General	1/7
2.	Loosening the waisted studs of piston foot fastening	1/7
3.	Tensioning the waisted studs of piston foot fastening	3/7
4.	Removal of the piston	4/7
5.	Fitting the piston	6/7
5.1	Fitting	7/7
6.	Leak test	7/7

1. General


The crankshaft must not be turned by turning gear when workmen are in crankcase.

We recommend to follow the instructions (9403-4) referring to the application of hydraulic pre-tensioning jacks to screwed connections. Regarding draining cylinder cooling water and removal of a cylinder cover refer to 2708-1.

- Remove wear ridge in the cylinder liner at every piston removal (see 2124-3).



The piston may not be transported with built-on piston rod gland box (11) (gland box for short).



Attention! The supporting device (94350) can be used for piston overhauling work at calm sea only, however, in no case this may serve as storage place during the voyage!
Moreover, always bear in mind, that the passage between engine and supporting device is limited (e.g. as possible escape route) on the platform.

2. Loosening the waisted studs of the piston foot fastening

- ⇒ Turn piston to B.D.C.
- ⇒ Clean the threads of waisted studs (3) and the area around nuts (4) (Fig. 'A').
- ⇒ Place both pre-tensioning jacks (94340) crosswise on the waisted studs to be loosened, and completely screw them on (arrangement according to Fig. 'A') with opened vent screw (5) (Fig. 'B').
- ⇒ Both pre-tensioning jacks are to be loosened by approx. ½ turn (gap "SA" in Fig. 'B').

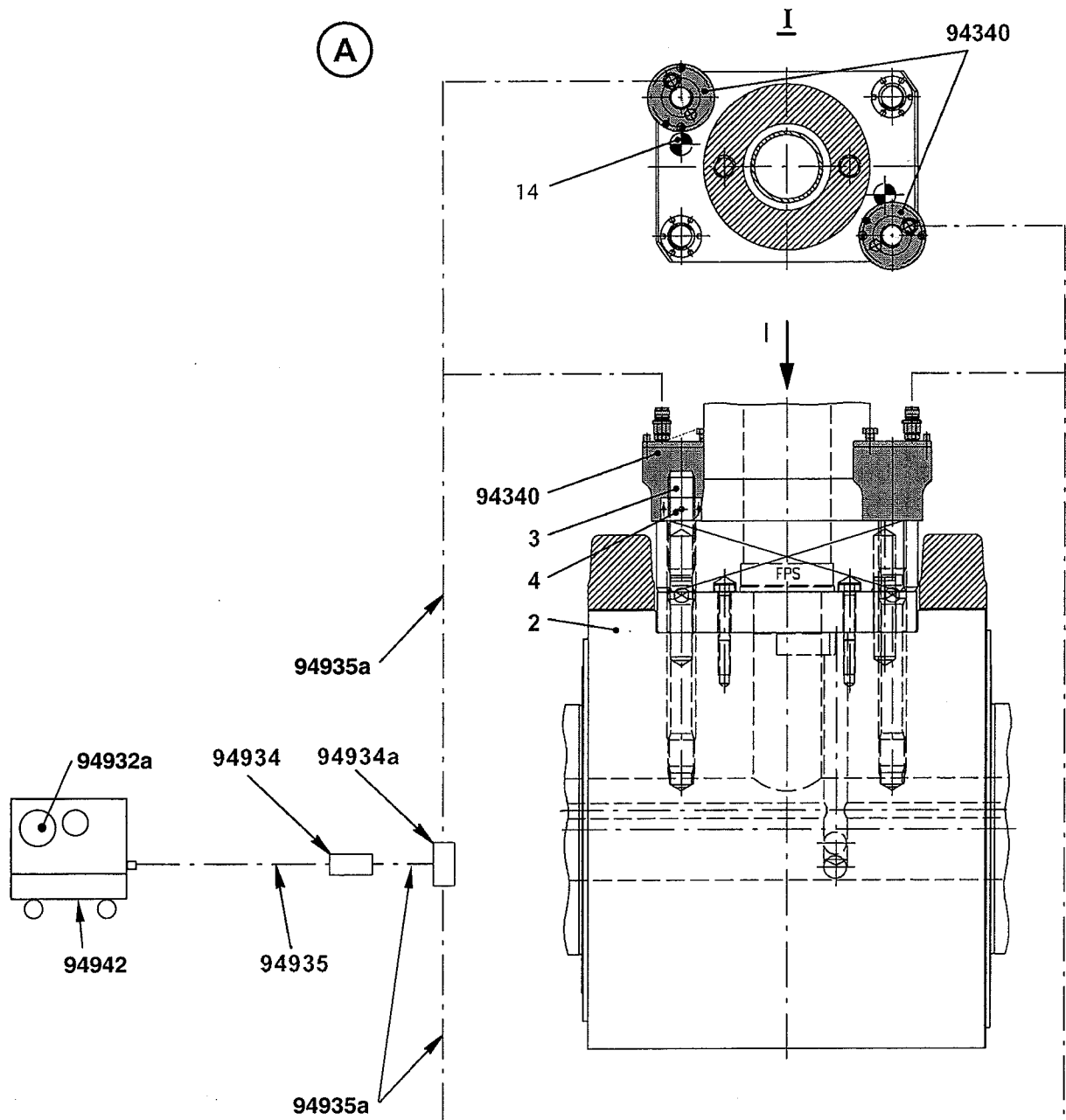
Piston

Removal and Fitting

- ⇒ Connect both pre-tensioning jacks to hydraulic unit (94942) with HP hoses (94935), (94935a) and connection piece (94934), (94934a) as shown in Fig. 'A'.

CHECK Check the oil level in hydraulic unit (94942).

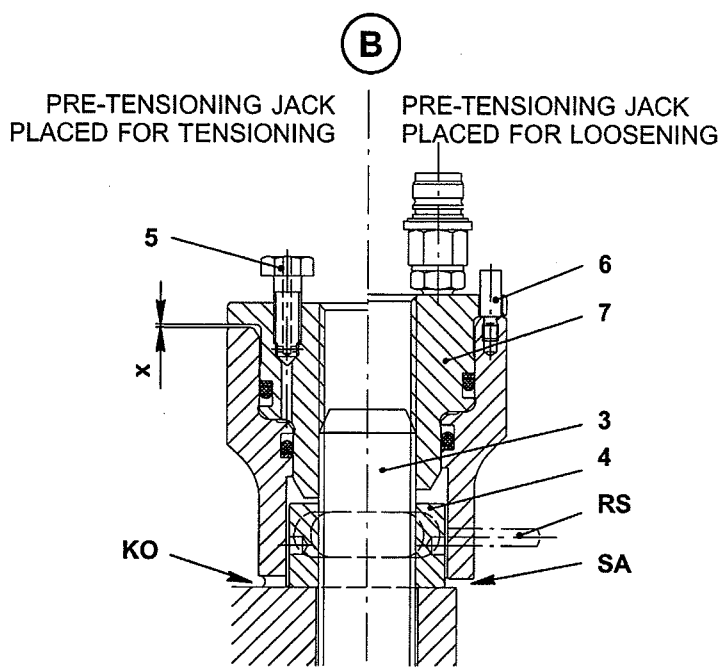
- ⇒ Start up the hydraulic unit and at the same time open vent screws (5) of the pre-tensioning jacks till oil flows out bubble-free. Close the vent screws.
- ⇒ At a pressure of **102 MPa** unscrew nuts (4) by one turn with round bar "RS".
- Attention should be paid to ensure that pins (6) always protrude slightly compared with pistons (7) on the pre-tensioning jacks!
- ⇒ Release pressure to zero at the hydraulic unit and then remove pre-tensioning jacks and the nuts (4).
- The same procedure is to be applied for loosening the other two waisted studs.



Piston

Removal and Fitting

3. Tensioning the waisted studs of the piston foot fastening

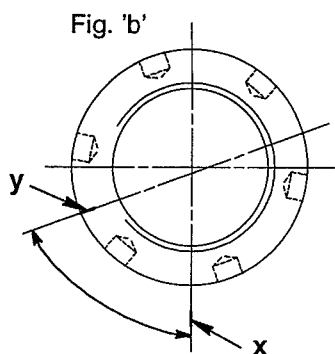
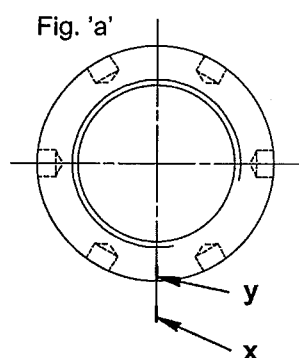


- ⇒ Clean the threads of waisted studs (3) and the area around nuts (4) (Fig. 'A').
- ⇒ Apply oil to the threads of the waisted studs and screw on the nuts.
- ⇒ Tighten the nuts (4) with round bar "RS" (Fig. 'B') by hand.

CHECK

Using a feeler gauge, check whether the nuts rest flush on the piston foot.

- ⇒ Mark position of nuts to seating surface with a felt tipped pen (Fig. 'a').
- ⇒ Completely screw the pre-tensioning jacks diagonally onto waisted studs (3) (Fig. 'A'). Moreover, vent screws (5) are to be opened slightly so that pistons (7) can slide back to their initial position i.e. there is no or very little clearance at "x" (Fig. 'B').
- ⇒ Connect both pre-tensioning jacks to hydraulic unit (94942) with HP hoses (94935), (94935a) and connection pieces (94934), (94934a) as shown in Fig. 'A'.



TIGHTENING ANGLE

- ⇒ Start up the hydraulic unit till bubble-free oil flows out through vent screws (5). Shut the vent screws.
- ⇒ Slowly raise the pressure to **60 MPa (1st step)**.
 - Attention should be paid to ensure that pins (6) always protrude slightly compared with pistons (7) on the pre-tensioning jacks!
- ⇒ Keep the pressure of 60 MPa constant and tighten nuts (4) with round bar "RS" till firmly seated.
- ⇒ Release pressure to zero at the hydraulic unit and then screw the pre-tensioning jacks onto the other two waisted studs. These are to be tensioned in the same sequence as described above.
- ⇒ Subsequently the waisted studs are to be tensioned again diagonally with **100 MPa (2nd step)**.

CHECK

After tensioning the nuts (6) check

- their seatings with a feeler gauge through slot "KO".
- whether these have been turned **by about the same angle i.e. about 60°** compared with the marks previously made (Fig. 'b').

Piston
Removal and Fitting

4. Removal of the piston

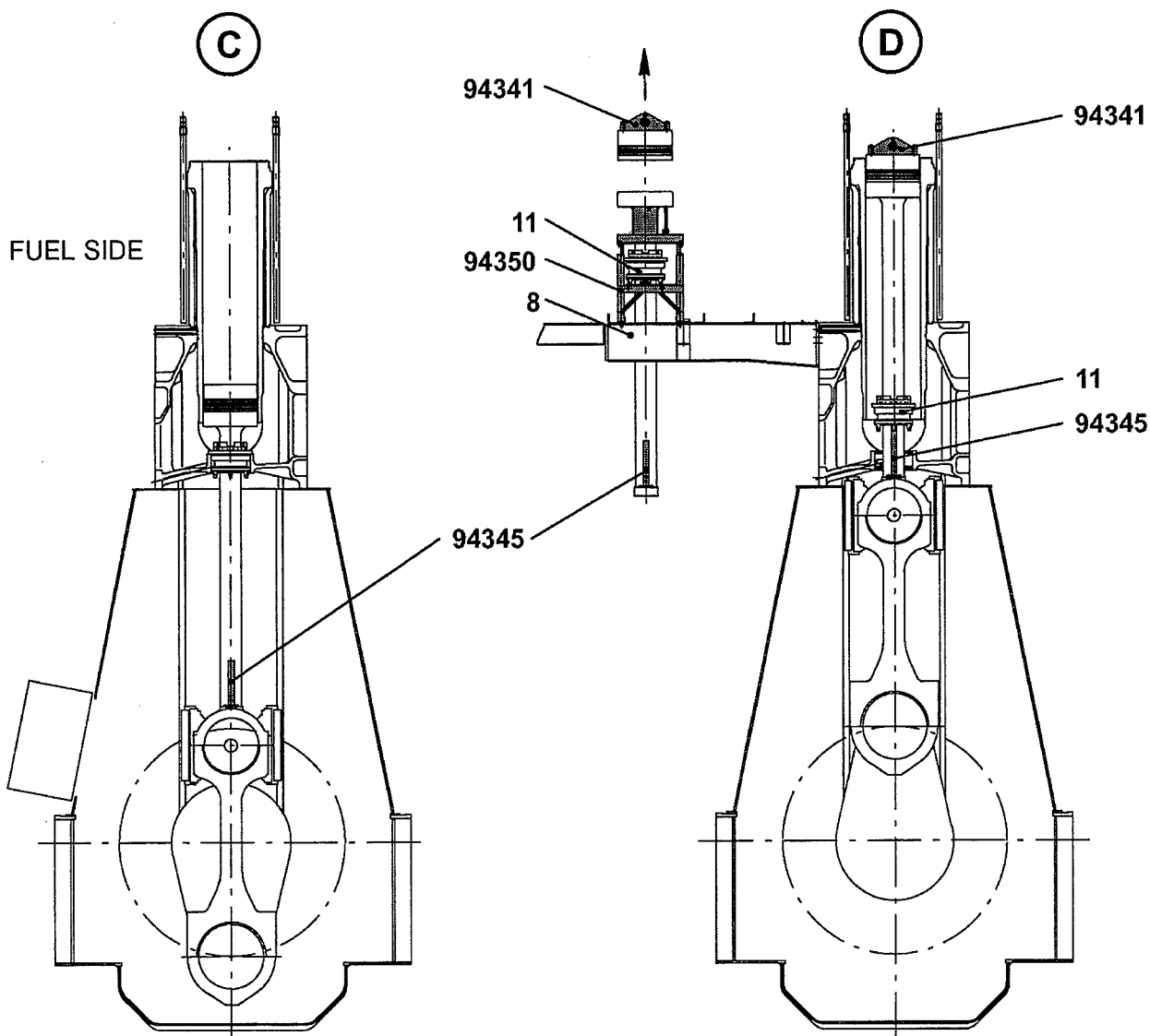
 **Remark** : Loosen and remove all screws for the screwing gland box / cylinder jacket (see 2303-1).

If the cylinder liner at the top of the collar is provided with an antipolishing ring, it must be removed as described in 2124-2.

- ⇒ Screw fasten both distance holders (94345) to the piston foot (Fig. 'C').
- ⇒ Turn crank to T.D.C. whereby the gland box is pushed out of its seating in the cylinder jacket by distance holders (94345) (Fig. 'D').
- ⇒ Use tap (94348) to clean threaded holes of combustion residue in the piston crown.
- ⇒ Mount suspension device (94341) to the piston crown.



Before pulling the piston out, the crosshead pin and the top end bearing must be protected, so that entry of dirt into the top end bearing is absolutely prevented.



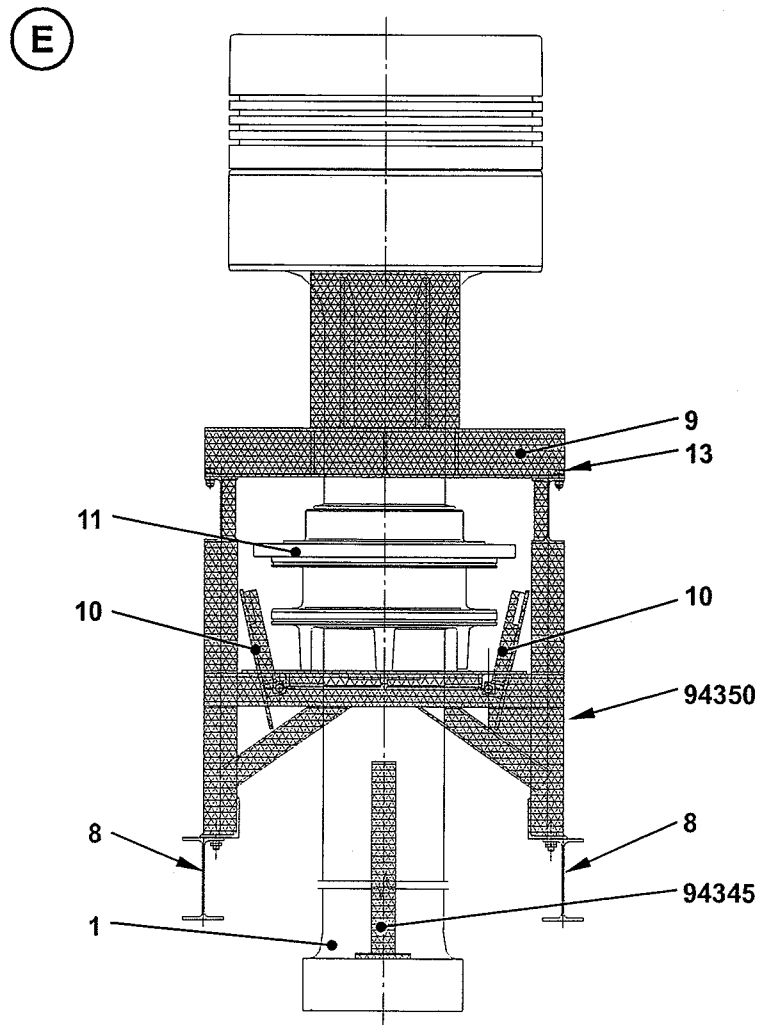
Piston

Removal and Fitting

- ⇒ Fasten piston supporting device (94350) to platform supports (8) designed for this on the cylinder cover platform (Fig. 'D' and 'E').
- ⇒ Pull piston by crane out of cylinder liner.
- ⇒ Loosen screw connection (13) and push supports (9) of piston supporting device (94350) completely outwards and turn up hinged covers (10) (Fig. 'E').
- ⇒ Lower piston on crane into the supporting device until the piston foot protrudes below the supporting device.
- ⇒ Turn the two hinged covers (10) down and lower the piston until gland box (11) rests on the two hinged covers. Push the two supports (9) together and firmly tighten screwed connection (13).
- ⇒ Lower piston further till the piston rod head rests on support (9).



For dismantling the piston it must be secured against turning by fastening the locking screws of the waisted bolts to straps (12), see 3403-3.



Piston
Removal and Fitting

5. Fitting the piston

Prior to fitting the piston, the following works must be carried out:

- ⇒ Remove piston rings with ring expander (94338) (see 3425-1) and clean piston exterior thoroughly. (Use no tool which could scratch or otherwise damage the surface!).

CHECK

Determine the height of the piston ring grooves (see Clearance Table 0330-1 "Piston and piston rings").

- ⇒ Clean piston rings and measure them.



For re-fitting of used and new piston rings, follow strictly the instructions in 3425-1.

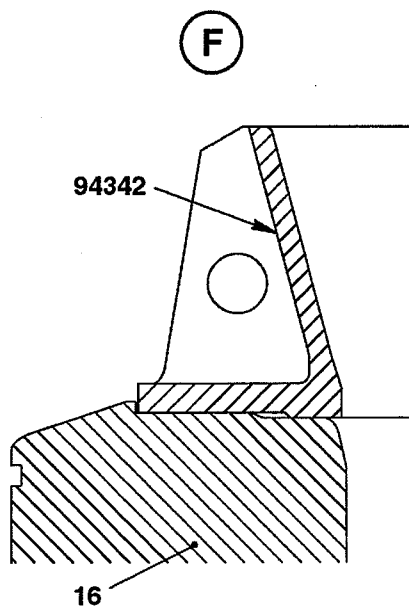
- **When re-fitting used piston rings** be sure to fit them in the **same grooves as before**.
- **Fit the piston rings in such a manner that their marking TOP is on top.**

CHECK

Check the piston top surface (see 3403-4).

Measure bore of cylinder liner (see 2124-1) and carry out any needed reconditioning to scavenge ports and lubricating grooves (see 2124-3).

- ⇒ Actuate the cylinder lubrication of the respective cylinder until oil flows from all the lubricating points.
- Gland box and both distance holders (94345) must be mounted on the piston rod (see 2303-1).



- ⇒ Insertion funnel (94342) for the piston rings must be placed on the cylinder liner as shown in Fig. 'G'.

- Suspension device (94341) must be fastened to the top of the piston crown.

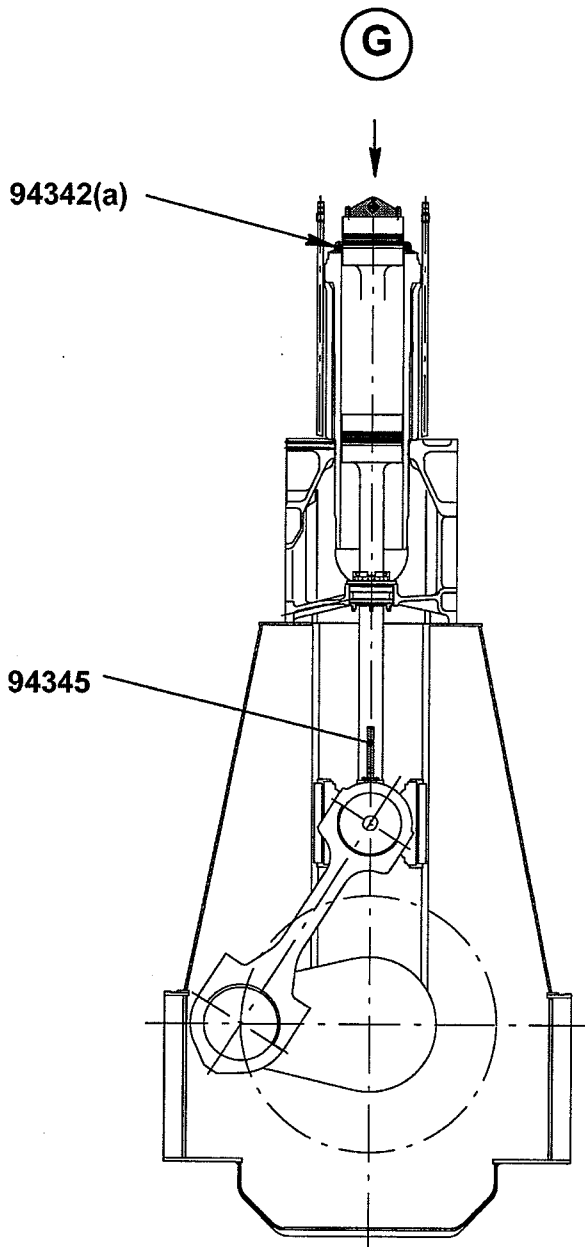
- ⇒ Smear piston rings, piston skirt, piston rod and running surface in cylinder liner lavishly with bearing oil.



Remove the locking screws which were perhaps used to secure the piston in the piston supporting device, and screw them again into the piston rod for locking of the waisted screws.

Piston
Removal and Fitting

5.1 Fitting



- ⇒ Slightly lift piston by crane. Loosen screw connection (13) of supports (9) (Fig. 'E') and push both supports outwards. Then lift the piston including gland box (11) so far that the two hinged covers (10) can be turned up.
- ⇒ Lift piston out of supporting device and bring it above cylinder liner, lower it slowly into it (Fig. 'G').
- When the piston is lowered into the cylinder liner until the lowest piston ring is at the upper level of the insertion funnel, arrange the piston rings so that their gaps alternate by 180° to each other. See instructions in 3425-1.
- ⇒ Slowly lower the piston further till its piston rod foot has arrived just above the crosshead pin. While one person directs the further lowering of the piston from the top, another directs the piston rod progress from the engine interior and how it must be turned to guide the piston rod foot, without jamming, into the centring pins (14) (Fig. 'A') in the crosshead pin.
- ⇒ Slacken the crane rope a bit and remove the suspension device.
- ⇒ Turn piston to B.D.C. (loosen crane correspondingly) and direct the insertion of the gland box into its seating bore in the cylinder jacket (see 2303-1).
- ⇒ Loosen and remove both distance holders (94345) from the piston foot.
- ⇒ Firmly tighten all screws fastening the gland box housing.
- ⇒ Tension the waisted studs for the piston foot fastening as described above.

6. Leak test

A leak test must be carried out after every fitting of a piston in the cylinder. For this, start the bearing lubrication pump and set the bearing lubricating pressure. Check through the scavenge space on the fuel side in the cylinder jacket (piston underside) whether cylinder liner running surface and piston rod remain dry.

Any increase in the dirty oil level in the scavenge air space may be caused by a faulty O-ring in the piston.

Piston

Dismantling and Assembling

Tools :

1	Suspension device	94341
2	Pre-tensioning jacks	94346
1	Piston supporting device	94350
2	Jacking screws	94363
2	Jacking screws	94364
1	Connection piece	94934
1	Connection piece	94934a
1	HP hose	94935
3	HP hoses	94935a
1	Hydraulic unit	94942
1	Torque wrench	

Key to Illustrations :

1	Piston crown	12	Locating pin
2	Spraying plate with oil pipe	13	Locating pin
2a	Nozzle to spraying plate	14	Waisted screw
3	Vent screw	15	O-ring
4	Piston	16	O-ring
5	Cylinder	17	O-ring
6	Nut		
7	Waisted stud	BN	Limiting groove
8	Piston rod	EV	Relief valve
9	Piston skirt	KO	Slot
10	Centering pin	RS	Round bar
11	Elastic screw	SA	Gap

Overview

1.	General	1/6
2.	Loosening the waisted studs of piston crown	2/6
3.	Tensioning the waisted studs of piston crown	3/6
4.	Dismantling of a piston	4/6
5.	Assembling of a piston	6/6

1. General

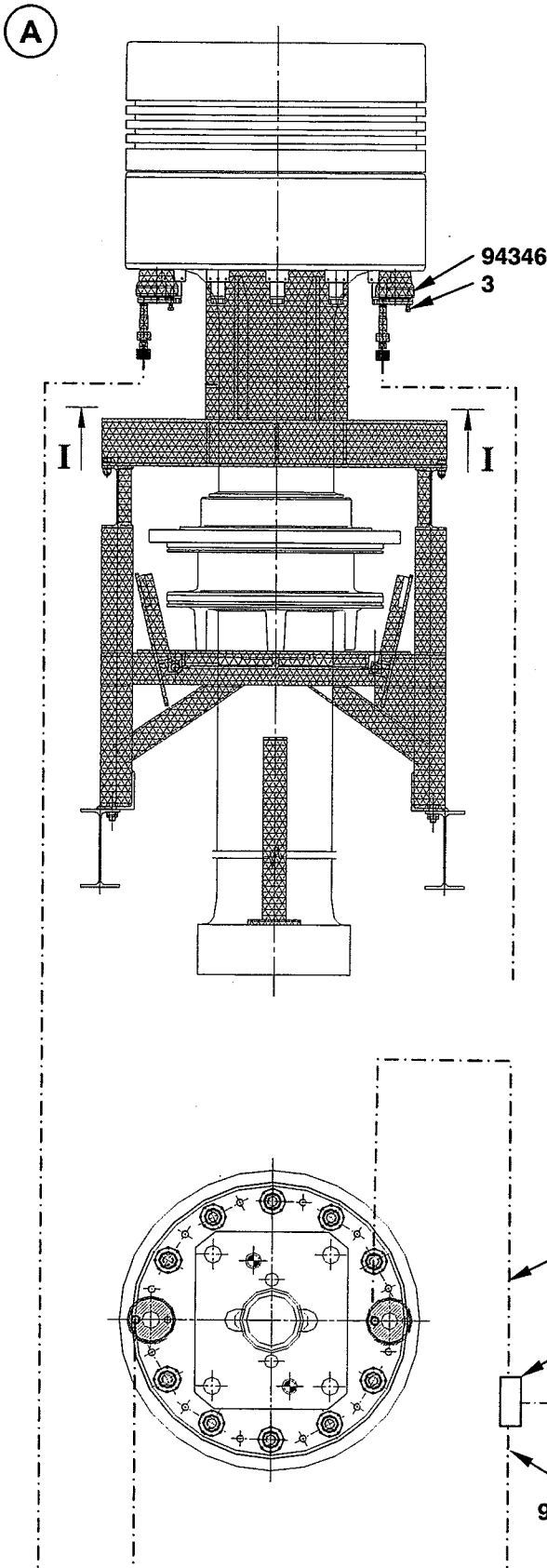
Should the dismantling of a piston become necessary (cleaning the cooling chamber, reconditioning the ring grooves etc.), then this can be carried out as described below. For this purpose the piston is to be placed in the piston supporting device (94350) according to 3403-1.



When dismantling or assembling a piston take particular care that the nozzles to spraying plate (2a) are not damaged.

Piston
Dismantling and Assembling

2. Loosening the waisted studs of piston crown

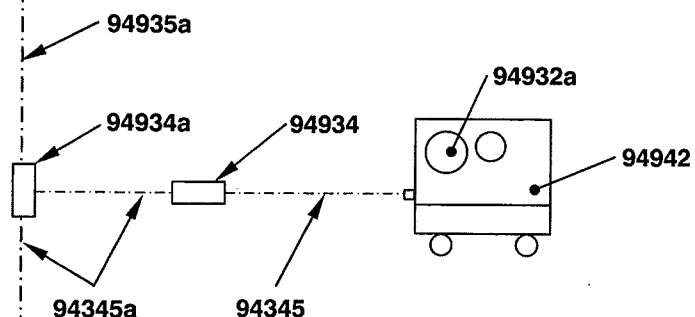


- ⇒ Clean the threads of waisted studs (7) and the area around nuts (5)
- ⇒ place the two pre-tensioning jacks (94346) crosswise on the waisted studs as shown in Fig 'C', and completely screw them on with opened vent screw (3) till there is a clearance at 'x' of approx. 1 mm (Fig. 'B').
- ⇒ The pre-tensioning jacks are to be loosened by approx. 1/2 turn (gap "SA" in Fig. 'B').
- ⇒ Connect all pre-tensioning jacks to hydraulic unit (94942) as shown in Fig. 'A'.
- ⇒ Start up hydraulic unit (94942).
- ⇒ Close vent screw (3) of the pre-tensioning jacks as soon as oil flows out bubble-free.
- ⇒ Operate the hydraulic unit (94942) till a pressure of about **103 MPa** is reached.
- ⇒ Unscrew nuts (6) by one turn (Fig. 'B').



Piston (4) of the pre-tensioning jacks (94346) must **never** exceed the red limiting groove 'BN' (Fig. 'B').

- ⇒ Release pressure to zero.
- ⇒ Remove pre-tensioning jacks (94346).
- ⇒ Always the same procedure is to be applied crosswise according to the sequence in Fig. 'C' for loosening the remaining waisted studs (7).



Piston
Dismantling and Assembling

3. Tensioning the waisted studs of the piston foot fastening

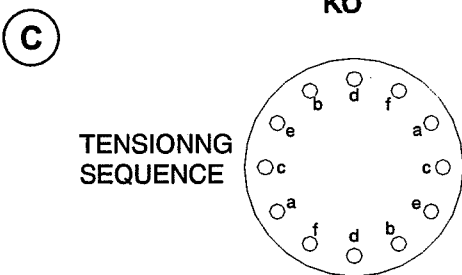
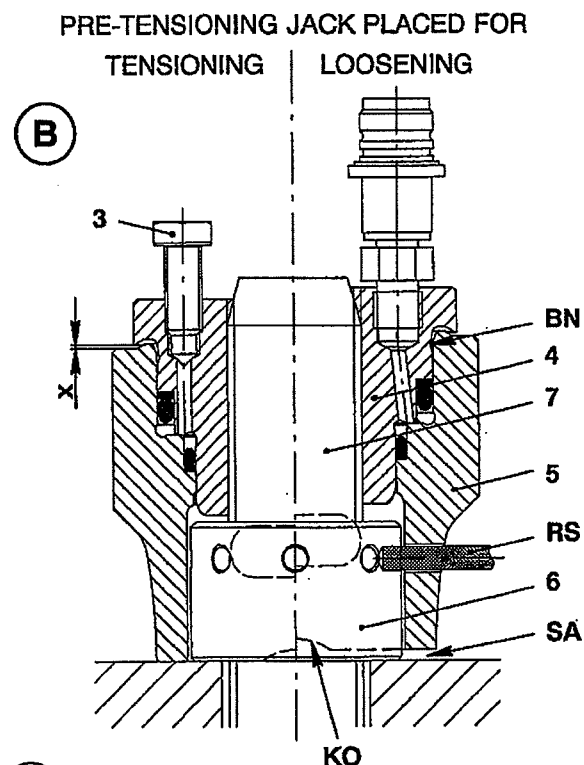


Fig. 'a'

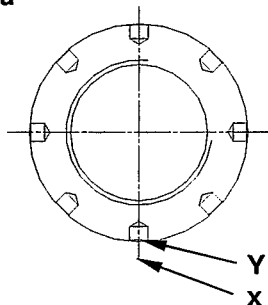
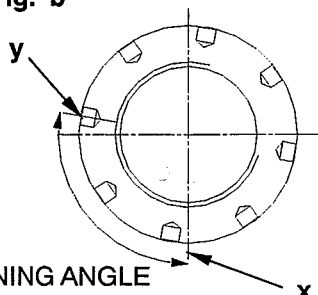


Fig. 'b'



- ⇒ Clean the threads of waisted studs (7) and the area around nuts (6) (Fig. 'A').
- ⇒ Apply oil to the threads of the waisted studs and screw on the nuts (6).
- ⇒ Tighten the nuts (6) with round bar "RS" (Fig. 'B') by hand.

CHECK

Using a feeler gauge, check whether the nuts rest without clearance.

- ⇒ Mark position of nuts to seating surface with a felt tipped pen (Fig. 'a').
- ⇒ Place the two pre-tensioning jacks (94346) crosswise on the waisted stud (7) as shown in Fig. 'C', and completely screw them on with opened vent screws (3) till there is a clearance at 'x' of approx. 1 mm.
- ⇒ Connect the pre-tensioning jacks to the hydraulic unit (94942) as shown with HP hoses (94935), (94935a) and connection pieces (94934), (94934a) as shown in Fig. 'A'.

- ⇒ Start up the hydraulic unit (94942).
- ⇒ Close vent screw (3) of the pre tensioning jacks as soon as oil flows out bubble-free.
- ⇒ Operate the hydraulic unit (94942) till pressure of 100 MPa is reached.



Piston (4) of the pre-tensioning jacks (94346) must **never** exceed the red limiting groove 'BN' (Fig. 'B').

- ⇒ Keep the pressure of **100 MPa** constant and tighten nuts (6) with round bar "RS" till firmly seated.

CHECK

After tensioning the nuts (6) check their seatings with a feeler gauge through slot "KO".

- ⇒ Always the same procedure is to be applied crosswise according to the sequence in Fig. 'C' for tensioning the remaining waisted studs (7).
- ⇒ Remove pre-tensioning jacks (94346).

CHECK

After tensioning the nuts (6) check if these have been turned **by about the same angle, i.e. approx. 115°** compared with the marks previously made (Fig. 'b').

Piston
Dismantling and Assembling

4. dismantling of a piston

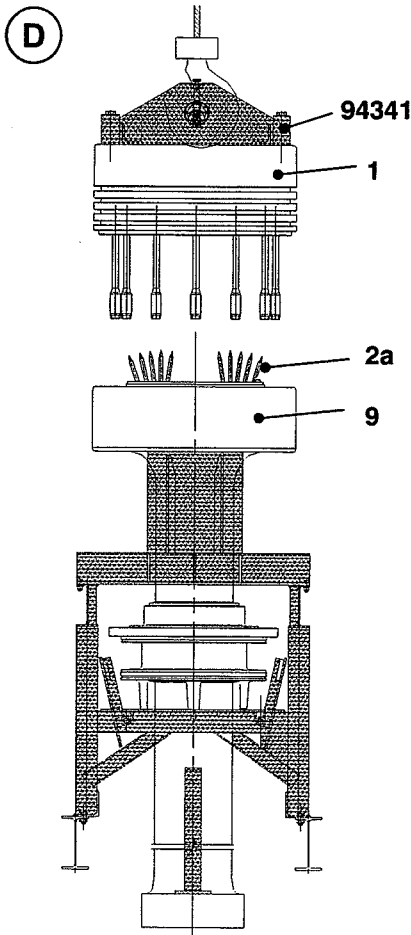
- ⇒ Insert both jacking screws (94363) into the two opposite bores for centering pins (10) in the piston rod head (Fig. 'G'), and drive them in till they press against the centering pins (10). (Fig. 'E').
- ⇒ Equally tighten the two jacking screws (94363) in small steps, till the piston crown (1) is separated from the piston rod (8).
- ⇒ Lift piston crown (1) by care and take particular care not to damage nozzles (2a) of spraying plate (2).
- ⇒ Remove both jacking screws (94963) from piston rod head.

Following the removal of piston crown (1) separate piston skirt (9) from piston rod (8) as described below:

- ⇒ Loosen and remove both elastic screws (11) (Fig. 'G').
- ⇒ Using two jacking screws (94634) (Fig. 'F') the piston skirt (9) can be separated from the piston rod (8).



While raising the piston skirt (9) pay attention that locating pin (12) does not jam.

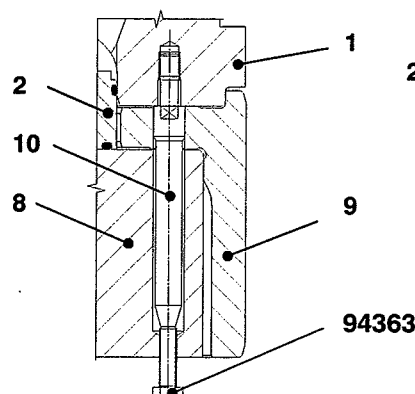


For the removal of spraying plate with oil pipe (2) (Fig. 'G') loosen and removal first waisted stud screws (14) with locking plates. The spraying plate with oil pipe (2) can then be pulled as a complete unit from piston rod (8).

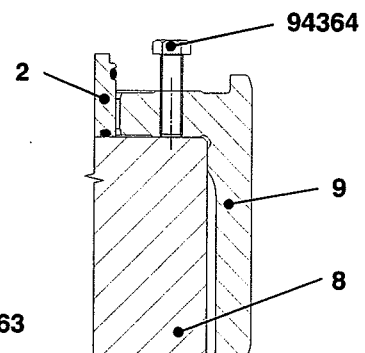


Do not damage nozzles to spraying plate (2a) !

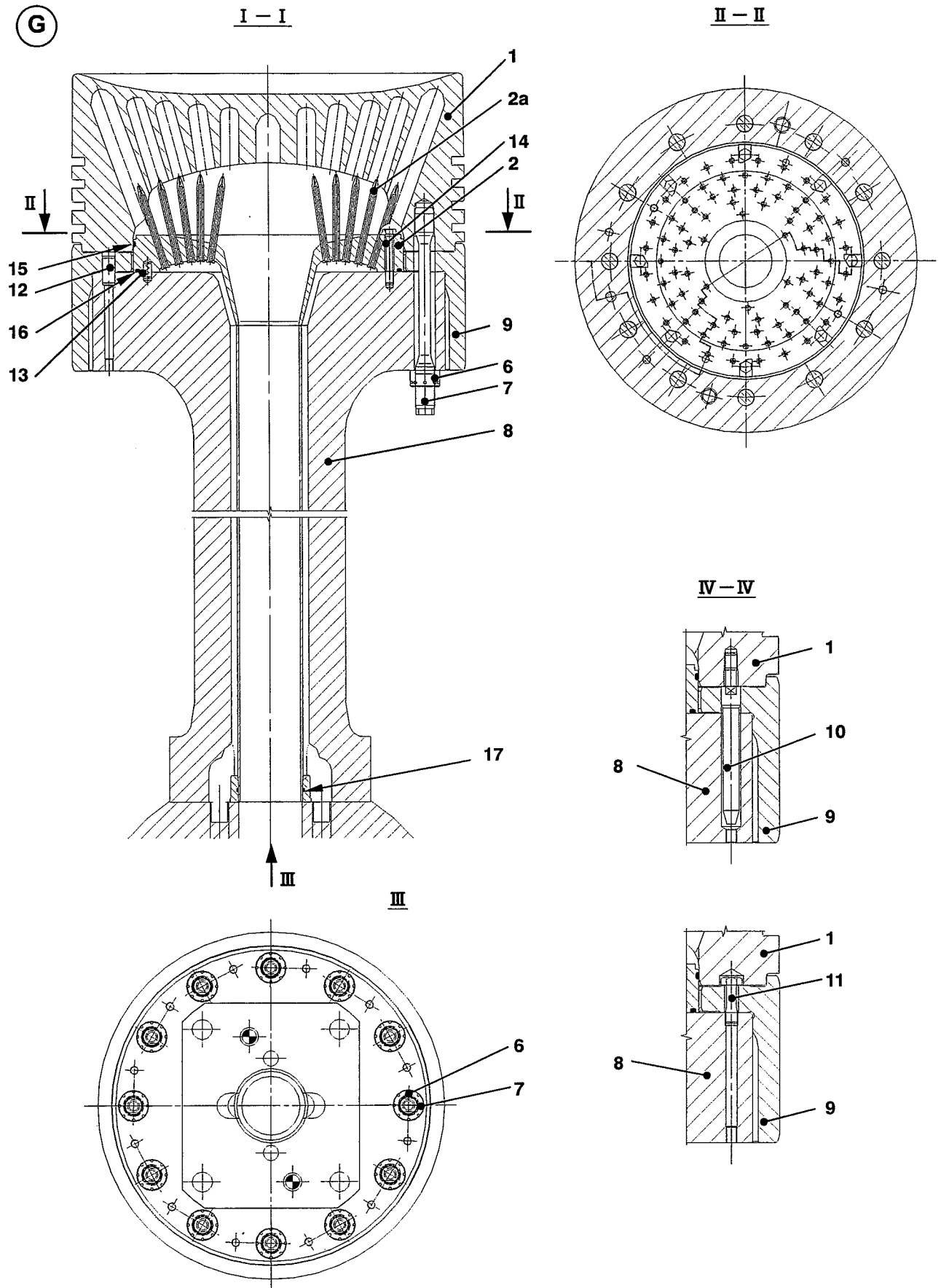
(E)
SEPARATION OF
PISTON CROWN



(F)
SEPARATION OF
PISTON SKIRT



Piston
Dismantling and Assembling



Piston

Dismantling and Assembling

5. Assembling of a piston

For assembling the piston the following points must be observed:

- Damaged nozzle to spraying plate (2a) may under no circumstances be refitted.
- Whenever possible always use new O-rings, they must conform in dimensions and quality to our specifications (see 0370-1).
- All cylindrical **guide portions** as well as **O-rings, screw head seatings and threads** of the waisted screws must be smeared with **MOLYKOTE paste G** before fitting.
- **No additional lubricant** must be applied to the threads of screws (14).

CHECK

Pre-tighten screws (14) to the spraying plate with oil pipe (2) with **60 Nm** using a torque wrench then tighten to an angle of **40°** and finally secure with a locking plate.

- Attention must be paid to locating pin (12) when assembling a piston skirt (9) with a piston rod (8).
- ⇒ Insert and tighten both screws (11).
- For the assembly of piston crown (1) to piston rod (8) make sure that the two centring pins (10) (Fig. 'G'), serving also as guides, mate with the corresponding bores in the piston skirt (9) and the piston rod (8).
 - Tension waisted studs (7) according to section 3.

Piston

Checking Piston Top Surface

Tools :

1	Feeler gauge	94122
1	Template	94366
1	Template	94366a

CHECK

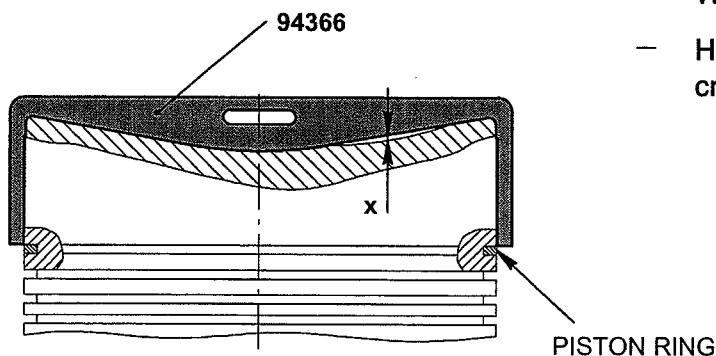
Every time a piston is pulled the piston top surface contour must be checked with the checking template (94366) and with feeler gauge (94122). The template is placed on the topmost piston ring and rotated around the piston axis (see Fig. 'A').

- Where burn scars are only slight it is sufficient to grind over them and to smooth sharp edged zones with emery cloth. Where, however, burn scars exceed $x = 10$ mm the original material thickness must be restored by surface welding. This entails the removal of the piston crown.

Before re-starting the engine, the reason for such heavy burns should be established. The causes must be remedied.

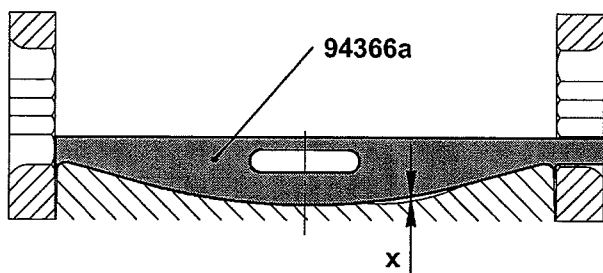
Causes of heavy burn scars may be:

(A)



- Poor combustion
- Worn nozzles
- Heavy local carbon deposits on top of the crown etc.

(B)



The template (94366a) should be used if the shape of the crown top of a piston in situ has to be checked. As shown in Fig. 'B', the template is to be pushed through one of the scavenge ports of the cylinder liner and placed on top of the piston crown.

Piston Rings

Checking Piston Ring Wear

Tools :

- | | | |
|---|-------------------------------|-------|
| 1 | Feeler gauge | 94122 |
| 1 | Piston ring tensioning device | 94338 |
| 1 | Inside micrometer | |

Key to Illustrations :

- | | |
|---|-------------|
| 1 | Piston ring |
|---|-------------|

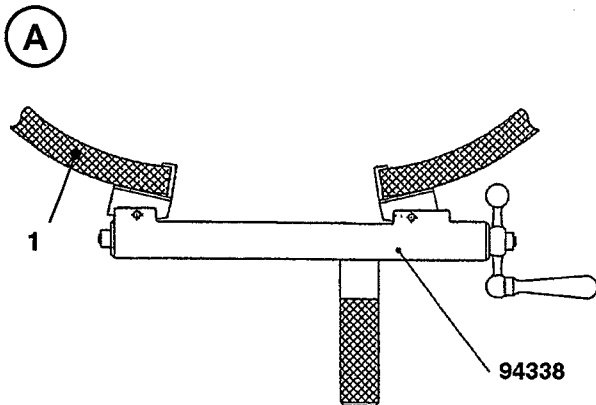
Overview

- | | |
|--|-----|
| 1. General | 1/4 |
| 2. Removing piston rings..... | 1/4 |
| 3. Measuring piston rings and piston ring grooves..... | 1/4 |
| 4. Reuse of piston rings..... | 2/4 |
| 5. Fitting of piston rings | 4/4 |

1. Inspection and removal

In the course of a piston overhaul the following work has to be done depending on the requirement.

2. Removing piston rings



- Always use piston ring tensioning device (94338) (Fig. 'A') to remove rings from piston ring grooves. Expand the rings only sufficiently to allow removal over the piston crown. **Avoid unnecessary strain (overstrain, while fitting or removing).**

⇒ Thoroughly clean piston, piston rings and piston ring grooves.

⇒ Use a steel wire brush to remove carbon and lacquer residue.

3. Measuring piston and piston ring grooves

Check all dimensions and record them (see Clearance Table 0330-1 'Piston and piston rings'). These records are important for later evaluation of the running gear. They should encompass all dimensions, the date of overhaul and operating hours of the various components and of the engine itself.

⇒ Measure the vertical piston ring clearance with the feeler gauge (94122). For that the piston ring must be fitted and pressed right into the groove at the measuring point (see Fig. 'B').

 **Remark** : If an inspection reveals much wear of the chrome layers (Fig. 'B'), then a new chrome plating is indicated. Instructions for reconditioning work of piston ring grooves can be requested from the engine maker.

Piston Rings**Checking Piston Ring Wear****3.1 Ring gap**

The current piston ring wear can roughly be determined – without having to dismantle the piston – by means of the ring gap.

- When the piston is assembled the piston rings must be turned such that the ring gaps of all or at least the two topmost piston rings are staggered by 180° and point in the direction of a scavenge port.

CHECK

After assembling the piston it must be moved until the piston rings appear at the level of the scavenge ports. In this position measure and record the ring gap (S_1).

3.2 Determining the wear of the piston rings

In order to determine the piston ring wear, some time or other – approximately 3000 running hours after the last piston overhaul – the ring gaps (S_2) are measured where accessible and recorded.

The piston ring wear can be determined with the formula

$\frac{S_2 - S_1}{2 \times 3.14}$

$\frac{S_2 - S_1}{2 \times 3.14}$

CHECK

Later regular optical checking of the piston rings through the scavenge ports provides a reliable judgement of the piston ring condition. Depending on the position of the topmost piston ring, its ring gap can be measured through the ports (see Mitsubishi Service Information MSI-8706E). The ring gap measured during such an inspection also permits a determination of the next piston overhaul.



Should the gap of the topmost piston ring be in an inconvenient position, do not turn it by using any sort of tool. In this case carry out the measurement of the ring gap at a later opportunity.

4. Reuse of piston rings

Pull one piston after about 2000 operating hours, to establish the wear rate of the cylinder liner and the piston rings.

With the aid of the diagram in Clearance Table 0330-1 'Piston and piston rings' the approximate service life of a piston ring can be estimated.

At the same time the replacement date for the piston ring can be estimated.

4.1 Examples (see also the diagram)**Case one*****New cylinder liner, new piston rings:***

- Piston pulled after 2000 operating hours.
Wear was established as:
- Cylinder liner 0.14 mm = 0.07 mm / 1000 h point 1
- Piston ring 1.00 mm = 0.50 mm / 1000 h point 1
- If all piston rings are otherwise in good condition they can be refitted. However, consider that refitted piston rings may only be used till limiting line I min.

Case two***First piston overhaul after total 9000 operating hours:***

- Total wear of cylinder liner 0.63 mm = 0.07 mm / 1000 h point 2
- Total wear of piston ring 4.50 mm = 0.50 mm / 1000 h point 2

Piston Rings

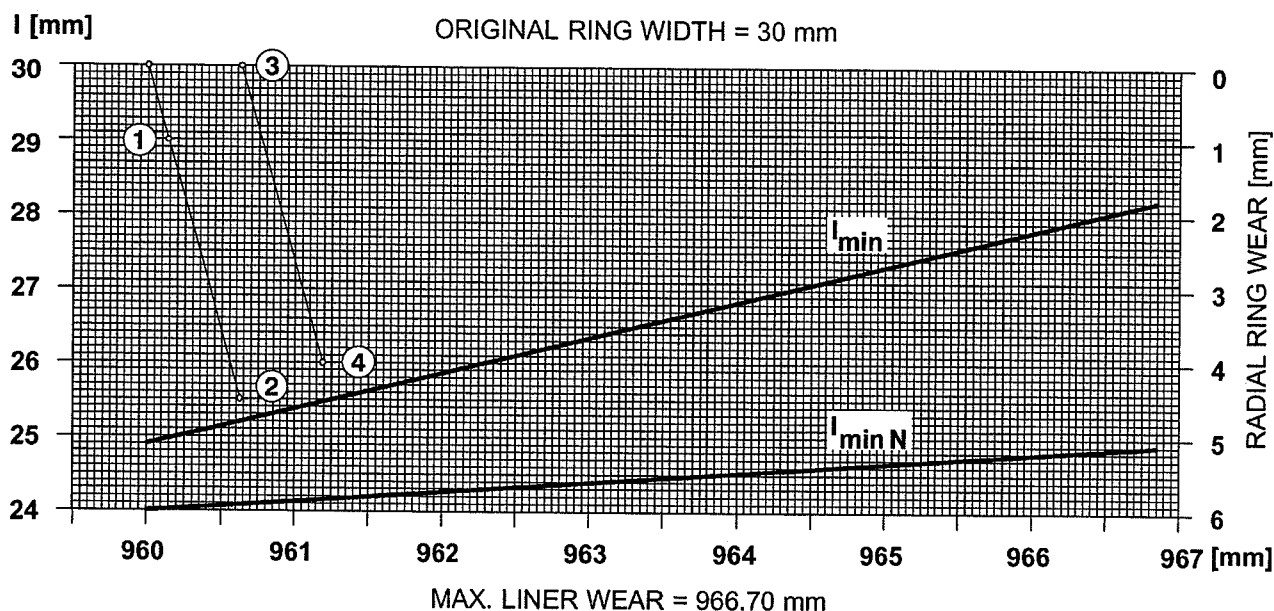
Checking Piston Ring Wear

- Point 2 lies above line I min. Therefore, it is not recommended to refit the piston ring as its service life is limited by line I min.

Case three

Second piston overhaul after total 17 000 operating hours of the engine:

- Wear of cylinder liner 0.56 mm since first overhaul = 0.07 mm / 1000 h point 4
- Wear of piston ring 4.00 mm since first overhaul = 0.50 mm / 1000 h point 4
- Point 4 lies above line I min. Therefore, it is not worth while to refit the piston ring.



Line I min = for old reused piston rings

Line I min N = for new piston rings

- When fitting piston rings, note down whether they are new ones or used ones.
- To ensure good sealing of the whole piston ring set, the diagram must be followed without fail. When piston rings are worn too much, an optimum seal of the piston ring set is no longer ensured.
- Experience has shown that used and refitted piston rings seal rather less well in operation than newly fitted ones. For this reason the limit for total wear of old reused piston rings (I min) has been set somewhat higher than for new piston rings (I min N).

Piston Rings
Checking Piston Ring Wear

5. Fitting of piston rings

- When reusing old piston rings, only such rings may be fitted which are in undamaged, good condition. The piston rings must be fitted with the marking **TOP upwards**.
- ⇒ Reused old piston rings with sharp edges must be rounded off with radii according to Fig. 'B'. The edges of the ring gap must be rounded off with a radius of 0.4 mm.

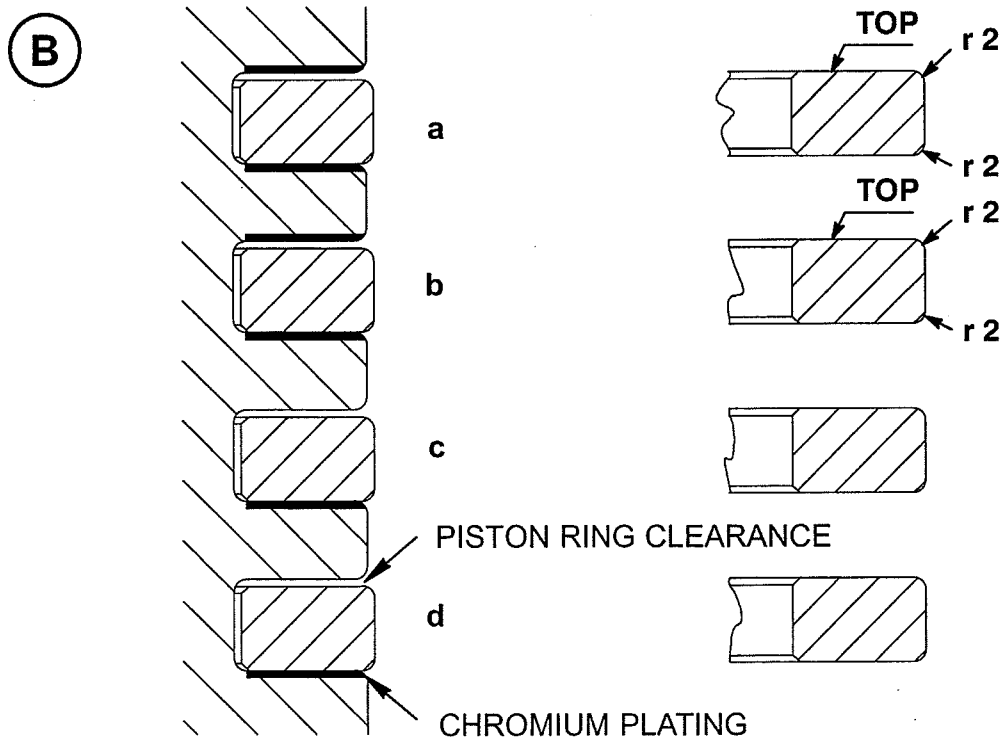
Reused piston rings must be refitted in the same ring grooves and in the Same position (TOP) as removed.



Newly fitted piston rings have to be run-in according to the relevant indications in the Operating Manual 0410-1.

5.1 Piston ring equipment for cylinder liner

Ring position		Ring type (marking)
Top	"a"	KOB, R9VMA
2 nd	"b"	
3 rd	"c"	KOB, R7
4 th	"d"	



Group 4

▽ Driving Wheels

- Checking the Running and Backlash Clearances4103-1/A1
and Condition of the Teeth
- Removal and Fitting of Intermediate Wheel4103-2/A1

Shut-off Valve for Starting Air: Cleaning and Function Check4325-1/A1

Driving Wheel
Checking the Running Backlash Clearances and Condition of the Teeth
Tools :

1	Feeler gauge	94122
1	Micrometer	
1	Dial gauge	
1	Lead wire Φ 1.5 mm	

Key to Illustrations :

0 ~ 6	Tooth profile
a, b, c	Lead wires
TF	Driving flanks

1. General

Gear wheels of new engines have to be checked visually during the running-in period after about 1 ~ 2 operating hours. The same applies to old engines which have been equipped with new gear wheels.

2. Check

- ⇒ Rotate crankshaft with the turning gear until all the teeth have been inspected.
- ⇒ Check with running lubricating oil pump, whether all the spray nozzles are delivering oil freely.
- ⇒ Check whether all the screws are correctly locked, and whether any irregularities can be detected.
- ⇒ After the running-in period check the gear wheels periodically every 3 months in the manner described above. Should in this time faults appear, then these can in certain cases be remedied by an experienced engineer.
- Should noises be heard in the region of the gear train, search for its cause. Replace defective gear wheels as soon as ever possible, to prevent damage to the mating gear wheels.
- When the gear wheels have run well for an initial running period of 6000 ~ 8000 hours the above-mentioned inspection may be carried out annually.
- For the checking of clearances and tooth impressions the tie rods and the waisted studs of the main bearings must be tightened.

3. Checking the gear tooth backlash

Information concerning the gear tooth backlash values can be found in the table of clearances (see 0330-1). The backlash can be determined in several ways. Depending on the possibilities, the following methods of measurement can be used:

3.1 With feeler gauge 94122

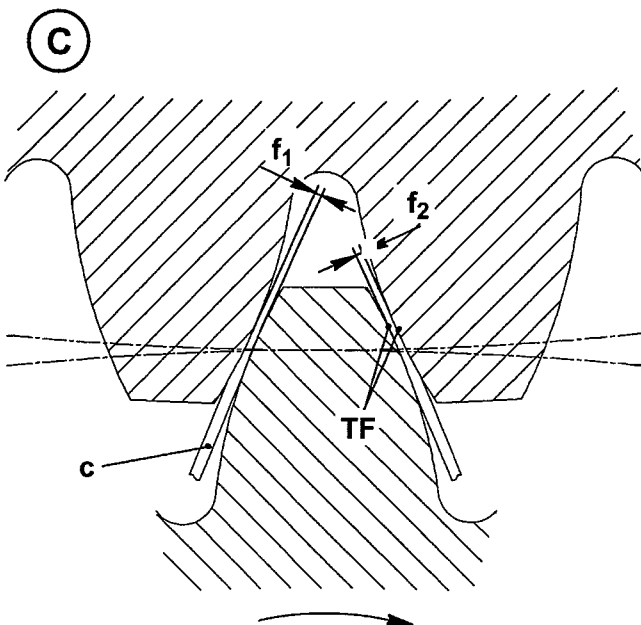
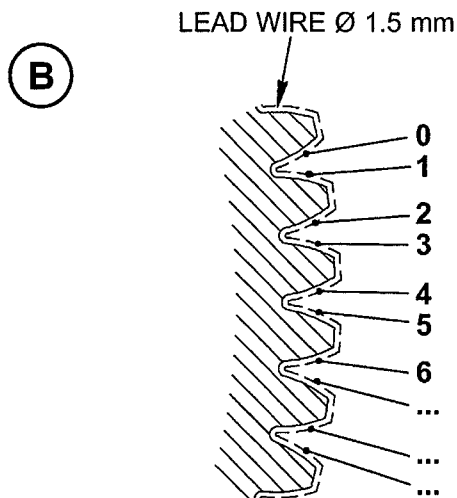
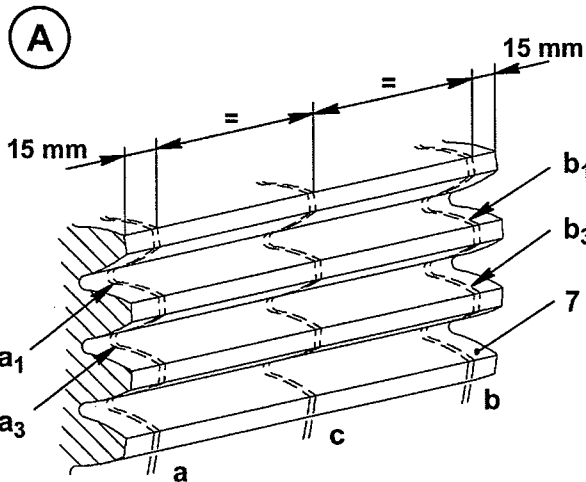
Measure the gap between the teeth flanks by using different thicknesses of feelers. Repeat the measurement at a minimum of four points on the circumference of the gear wheel.

3.2 With dial gauge

Mount the dial gauge in such a way that the turning movement can be read off in mm. The gear wheel is turned in such a way that the tooth profile of one tooth moves from one side to the other. When using this method of measuring care must be taken since the drive wheel must not be allowed to turn.

Driving Wheel

Checking the Running Backlash Clearances and Condition of the Teeth



3.3 Measuring tooth backlash with lead wire

- Use a fresh piece of lead wire Pb 99.9 fine of **1.5 mm diameter** for each measurement.
- Always use lead wires of the same diameter and quality.
- ⇒ Place three lead wire pieces a, b, c of about 200 mm length around the tooth profile and attach them with scotch tape (see Fig. 'A' and 'B').
- ⇒ Number the tooth profiles in accordance with Fig. 'B'.
- The middle lead wire 'c' (Fig. 'A') serves to verify the total tooth backlash 'f' (Fig. 'C'). With the two outer lead wires 'a' and 'b' (Fig. 'A') the tooth profile parallelity is checked.
- ⇒ Turn the lead wires only **once** through the teeth meshing.
- The total tooth backlash 'f' (Fig. 'C') composes of f_1 and f_2 (thickness of lead wire) $f = f_1 + f_2$.
- Obliquity ' Δf ' is calculated from the difference in thickness of the squashed lead wires along **driving flanks TF** (Fig. 'A'):
 $\Delta f = a_1 - b_1$ or $a_3 - b_3$ etc.
- The admissible deviation of tooth profile parallelity amounts to max. 0.2 ‰ across the width of the tooth.

4. Checking the running performance

To enable judging the running performance of the gear train after re-commissioning, three teeth each of the gear wheels are smeared with a thin coat of oil resisting marking blue (ink) equally spread. This check is necessary in order to verify the mating appearance of the teeth. One brand of oil resisting marking blue is, for example, Dykem Layout Red Dx-296.

Driving Wheel

Removal and Fitting of Intermediate Wheel

Tools:

- | | | |
|---|--------------------|-------|
| 1 | Feeler gauge | 94122 |
| 6 | Adjusting devices | |
| | Withdrawing device | |
| | for taper pins | |

Key to Illustrations:

- | | | | |
|----|--------------------------|--------------------|----------------------|
| 1 | Intermediate wheel | 13 | Locking strap |
| 2 | Cover | 14 | Double column |
| 3 | Cover | 15 | Wheel hub |
| 4 | Pipe bend | 16 | Gear rim |
| 5 | Support | 17 | Lubricating oil pipe |
| 6 | Gear wheel on crankshaft | 18 | Self-locking nut |
| 7 | Waisted screw | 19 | Strap |
| 8 | Cover | 20 | Strap |
| 9 | Screw plug for taper pin | 21 | Underslung separate |
| 9a | Screw plug | | |
| 10 | Taper pin | | |
| 11 | Bearing | HZ | Chain block |
| 12 | Bearing journal | H ₁ ... | Chain blocks |

Overview

- | | | |
|----|---|-----|
| 1. | General | 1/6 |
| 2. | Removal | 2/6 |
| 3. | Fitting | 4/6 |
| 4. | Adjustment of the intermediate wheel | 5/6 |
| 5. | Replacement of a gear rim | 6/6 |

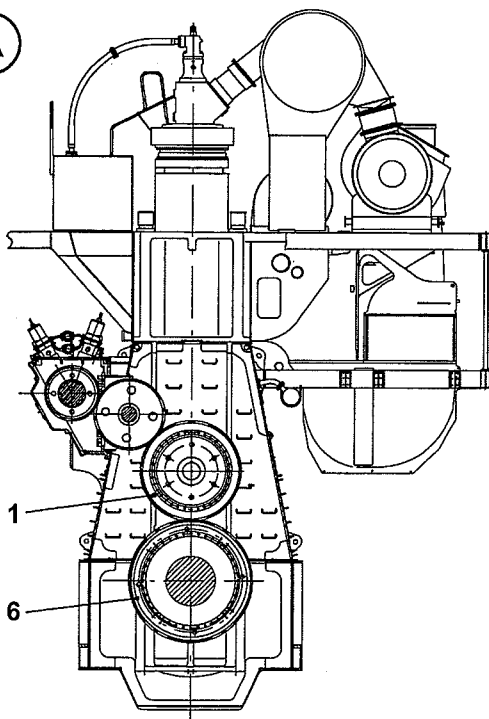
1. General



The crankshaft must not be turned by turning gear when workmen are in crankcase.

- The turning gear must be engaged.

A

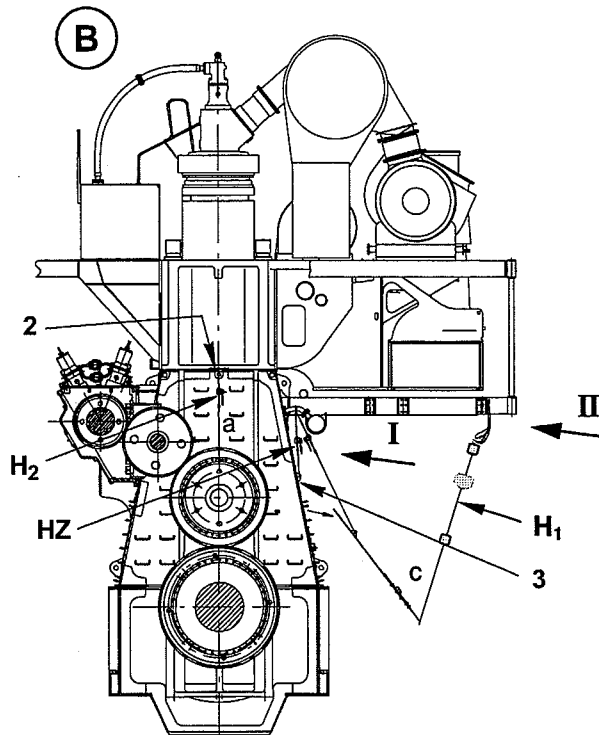


Precautions must be taken that, while removal work is in progress, the running gear can on no account be put into motion.

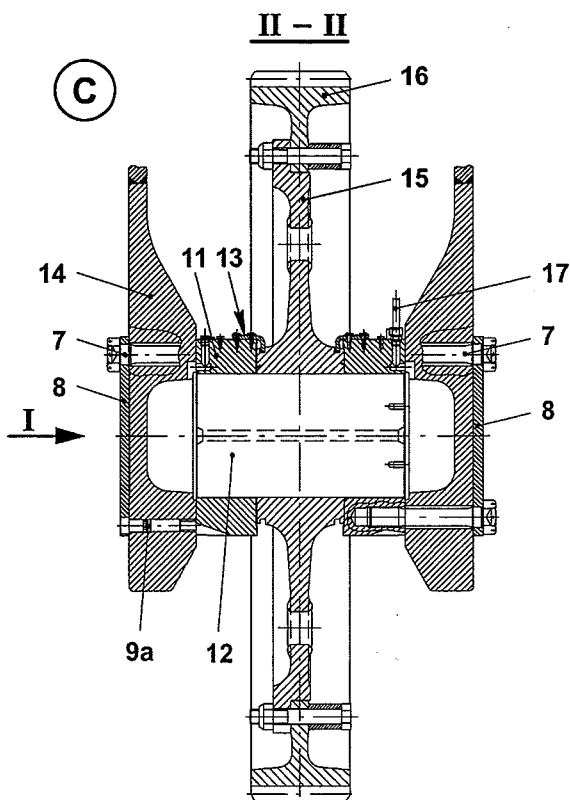
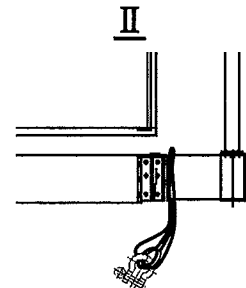
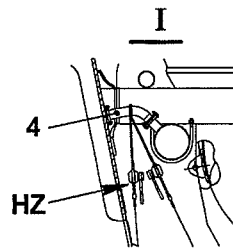
Driving Wheel

Removal and Fitting of Intermediate Wheel

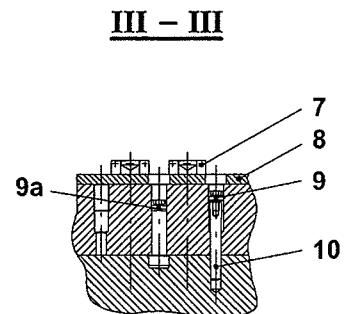
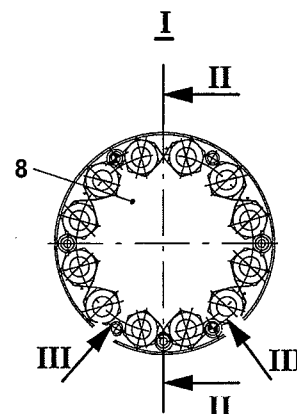
2. Removal



- ⇒ Remove cover plate and support in middle platform.
- ⇒ Remove No.2 underslung separate (21).
- ⇒ Fasten wire rope and shackle to support of middle platform (Fig. 'B' view II).
- ⇒ Connect chain block "H₁" to shackle and connect it and wire rope 'c' to cover.
- ⇒ Loosen and remove the cover.
- ⇒ Remove lubricating oil pipe (17) to intermediate wheel (1), where necessary.
- ⇒ Fasten chain block "H₂" to cover (2).
- ⇒ Connect one wire rope 'a' with intermediate wheel and chain block "H₂".
- ⇒ Pull wire rope 'a' taut.

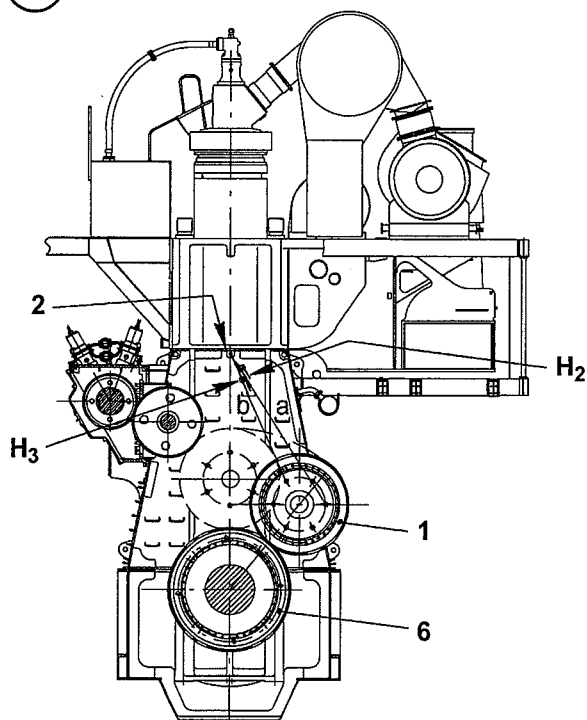


- ⇒ Loosen and remove waisted screws (7) on both sides of taper pins (10).
- ⇒ Remove screw plugs (9) (Fig. 'C') and then loosen taper pins (10) for the bearing location using a withdrawing device.
- ⇒ Loosen remaining waisted screws (Fig. 'C') of the intermediate wheel and remove them together with cover (8).



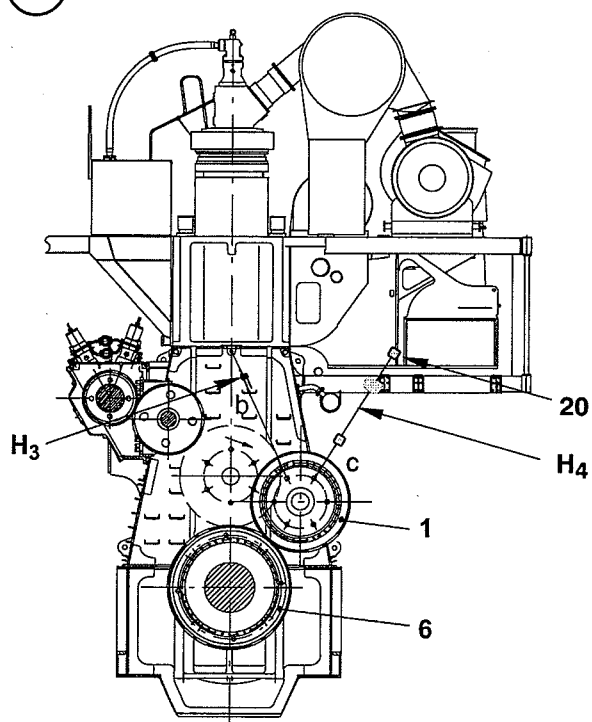
Driving Wheel
Removal and Fitting of Intermediate Wheel

D



- ⇒ Fasten chain block "H₃" to cover (2).
- ⇒ Connect wire rope 'b' with intermediate wheel and chain block "H₃".
- ⇒ Lower intermediate wheel (1) completely onto the gear wheel on crankshaft (6) by means of wire rope 'a', and turn it out to exhaust side while following up with wire rope 'b'.
- ⇒ Remove wire rope 'a'.

E

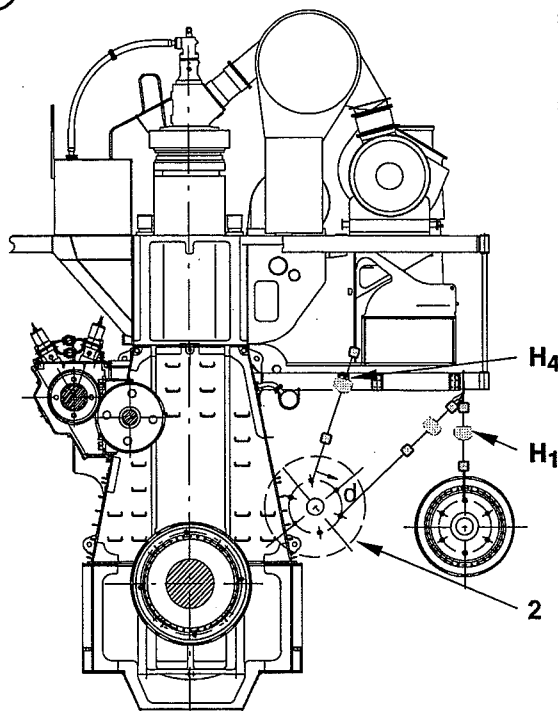


- ⇒ Fasten chain block "H₄" to straps (20) at free end side and connect chain block "H₄" and wire rope 'c' to intermediate wheel (2).
- ⇒ Lift the intermediate wheel out of the double column with wire rope 'a', 'b' and chain block "H₃", "H₄".

Driving Wheel

Removal and Fitting of Intermediate Wheel

F



- ⇒ Connect wire rope and shackles to support of middle platform as shown in Fig. 'B' view II.
- ⇒ Connect chain block "H₁" and wire rope 'd' with intermediate wheel (2).
- ⇒ Pull out the intermediate wheel by means of chain block "H₁" and "H₄", and then remove chain block "H₄".
- After having removed locking straps (13) with screws and locking plates, they can be pulled off bearing journal (Fig. 'C').

3. Fitting

Fitting the intermediate wheel is carried out analogously to the removal but in reverse sequence, whereby attention must be paid as follows:



Remark

: When fitting bearings (11) they must first be lavishly smeared with bearing oil. Both bearings are basically equal, they may, however, only be refitted in their original place, as their position has been dowelled with taper pins (10) when building the engine.

- Fit intermediate wheel so that marking DRIVING END appears when viewed from the driving end of the engine.
- Intermediate wheel may be fitted arbitrarily with respect to the tooth position.
- ⇒ Before the final assembly of the intermediate wheel, apply a non-hardening sealing compound on the joint face of covers (8); afterwards fit it with three waisted screws (7) (lubricated with MOLYKOTE G paste) on double column (14).
- ⇒ Tighten the waisted screws only as much as bearings (11) can still be moved.
- ⇒ Align the bearings so that the bores of the pinholes in the double column correspond exactly with those in the bearings.
- ⇒ Drive home the taper pins to both of the bearings, using a copper rod and a hammer.

Driving Wheel

Removal and Fitting of Intermediate Wheel

- ⇒ Screw in the remaining waisted screws and tighten them all slightly and evenly by hand with a wrench.
- ⇒ In this position mark the screws with a line and tighten them crosswise until an angle of 50° is obtained.

CHECK

As a safeguard check the tooth backlash between the gear wheels (see also Clearance Table 0330-1 'Driving Wheels for Supply Unit').

- ⇒ Fit screw plugs (9) with LOCTITE No. 0222 and screw them in till the stop at the taper pins.
- ⇒ Lock all waisted screws (7) in pairs with locking wire.

4. Adjustment of the intermediate wheel

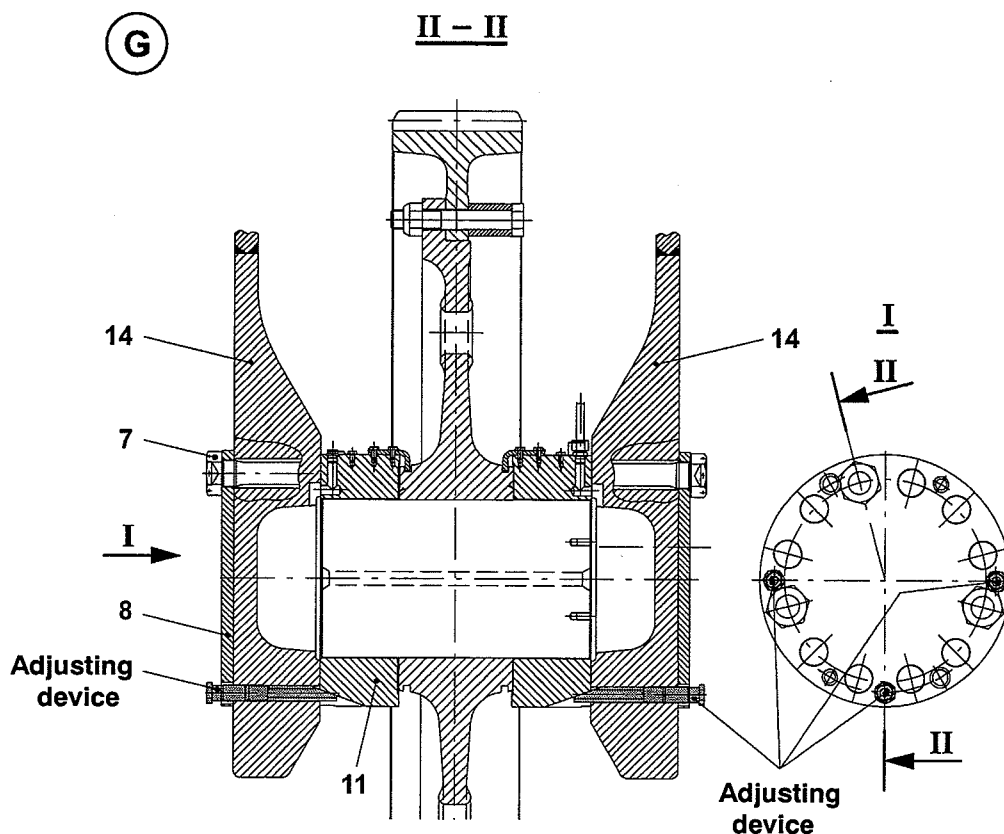
Should it be necessary to replace one bearing (11), the opposite bearing must be replaced at the same time, as new bearings are always manufactured in pairs. When fitting them an exact adjustment of the intermediate wheel is essential.

- For a new adjustment of the intermediate wheel, adjusting devices must be used as shown in Fig. 'G'.

CHECK

After a new adjustment of the intermediate wheel the tooth backlash (see Clearance Table 0330-1 'Driving Wheels for Supply Unit'), as well as the tooth flank contact pattern have to be checked (see 4103-1).

- If a new adjustment of the bearings is required, the pin holes pre-bored in the column must be used.



Driving Wheel

Removal and Fitting of Intermediate Wheel

5. Replacement of a gear rim

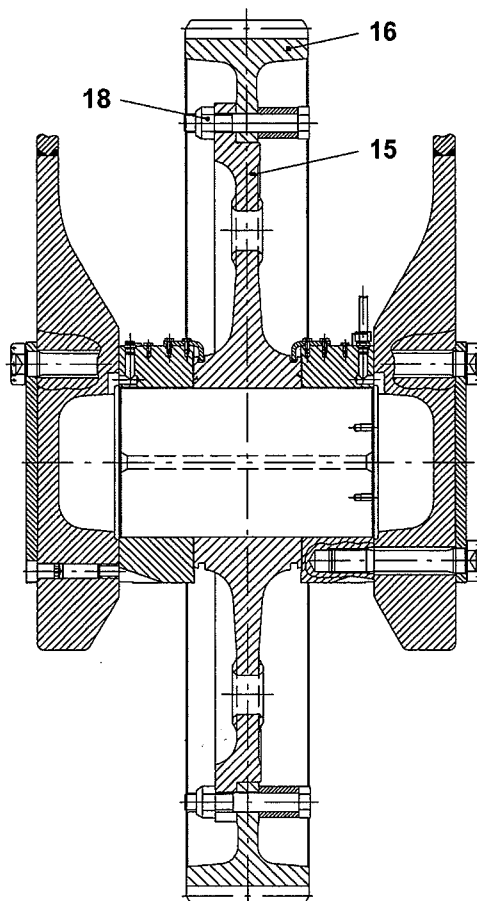
- The replacement of a damaged 2-part gear wheel may only be done in exchange for a complete gear wheel i.e. gear rim (16) must be screw fastened to wheel hub (15) and the bearing journal fitted.
- This is necessary as the final machining of the gear teeth has been carried out in this mounted condition at the maker's works and guarantees the required perfect true running of the complete gear wheel.
For this reason a split design gear wheel may only be installed if the final machining of the teeth had been carried out with assembled hub / gear rim.



After the final machining of the teeth the gear rim may not be separated from the wheel hub.

- Should the damage be limited to the toothing (gear rim), then the hub may be reused, provided a new rim, on which the teeth are not finish-machined, is fitted to the hub, screw-fastened and dowelled. Then its teeth can be finish-machined.
- Apply LOCTITE 262 and then tighten self-locking nuts (18) until an angle of 80° is obtained.

(H)



Shut-off Valve for Starting Air

Cleaning and Function Check

Key to Illustrations :

1	Valve seat	18	Spindle
2	Cover	19	Spindle guide
3	Spring	20	Handwheel
4	Valve body	21	Locking lever
5	Valve seat	22	Common start valve
6	Spindle guide	23	O-ring
7	Spring	24	O-ring
8	Valve body		
9	Control valve	DT*	To instrument panel and pressure transmitter PT4301C
10	Piston seal ring	EB*	Equalizing bore
11	Piston	EV*	To venting valve 2.21
12	Valve body	SL*	Control air
13	Screw plug	TV*	To (drain and) test valve 2.06
14	Spring		
15	Screw plug		
16	Liner bush	*	See Control Diagram 4003-2 in the Operating Manual
17	Screw		

1. General

The shut-off valve must be dismantled, cleaned and inspected according to Maintenance Schedule 0380-1.



Remark : To avoid accumulation of water in the main starting air piping open for a short time water drain pipe on the main starting air piping after each starting operation.



Before starting work on the shut-off valve for starting air it is essential to manually close the stop valves on the starting air receivers. The turning gear must be engaged.
The venting valve (2.21) to connection "EV" as well as the valve (2.27) must be open for venting and draining the main starting air piping on the engine (see Control Diagram 4003-2 in the Operating Manual).

2. Dismantling and assembly

2.1 Dismantling

- ⇒ If the valve seat (1) is to be grind in, first loosen the screws to cover (2).
- ⇒ Withdraw spring (3) together with valve body (4) and spindle (18) as an unit.
- ⇒ Unscrew spindle guide (19) and remove the valve body from the spindle.
- ⇒ If valve seat (5) of the non-return valve is to be grind in, then the shut-off valve must be completely dismantled.
- ⇒ After dismantling valve guide (6) and spring (7) remove valve body (8) of the non-return valve.
- When the above mentioned items are being checked, control valve (9) has also to be dismantled and cleaned.

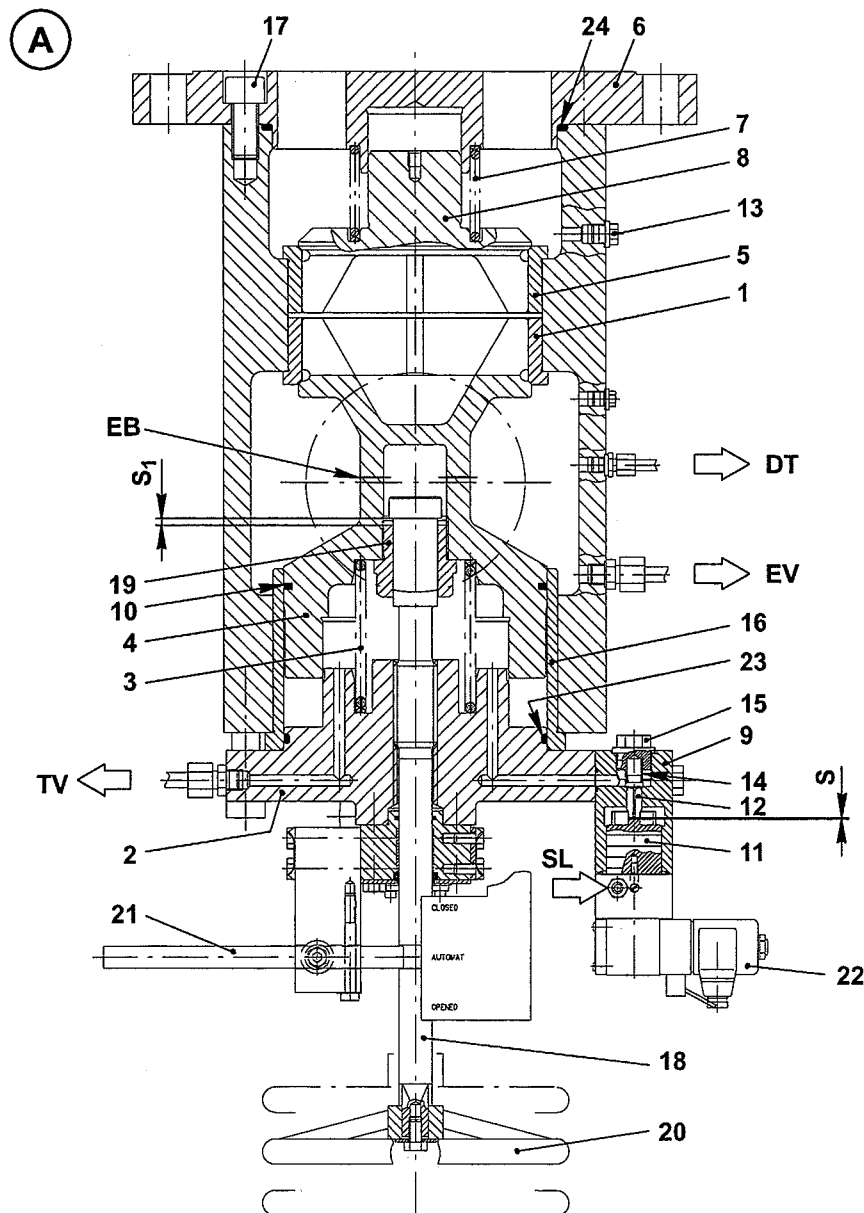
Shut-off Valve for Starting Air Cleaning and Function Check

2.2 Assembly

- ⇒ Before reassembling all items replace corroded springs by new ones.
- ⇒ Replace damaged or much worn piston seal ring (10).
- ⇒ Check equalizing bores “EB” for free passage.
- ⇒ Before reassembling spindle (18), the threads in valve body (4) and spindle guide (19) are to be thoroughly degreased and then smeared with LOCTITE. Insert the spindle and fully tighten the spindle guide.
- ⇒ For the assembly smear all the parts lightly with MOLYKOTE paste.

CHECK

Check to ascertain that the clearance "S" between piston (11) and valve body (12) of control valve (9) amounts to about 1 mm.



Shut-off Valve for Starting Air

Cleaning and Function Check

3. Function check

After completing the assembly carry out a function check, for which the following precautions have to be taken:

3.1 Initial position

- The stop valves of the starting air receivers must still be closed.
- Screw plug (13) of the shut-off valve has to be removed.
- Shut-off valve for starting air is in position "CLOSED" (closed by hand).
- Venting valve 2.21 to connection "EV" must be closed.
- **The engine has to be completely assembled, ready to start and the turning gear must be in the disengaged position.**



The area of flywheel, propeller shaft and propeller must be free of persons or objects.



During the functional check the reversing must remain in position "STOP" and "START" **may not be actuated** under any circumstances.

3.2 Tightness

- ⇒ Close venting valve (2.27) in the main starting pipe.
- ⇒ Open the stop valve of a starting air receiver **slowly**.

CHECK

Check whether the automatic shut-off valve is airtight, i.e. verify that no air escapes from the bore of screw plug (14).

3.3 Manual opening

- ⇒ Open the shut-off valve **slowly** with the help of handwheel (20) till locking lever (21) is in the position "OPENED" (by hand). The discharging air at the bore for screw plug (13) indicates that valve bodies (4) and (8) of both the shut-off valve and the non-return valve are open.



Great care must be taken for this operation. To prevent accidents from compressed air suddenly escaping out of the bore for screw plug (14) a sufficient distance has to be kept.

3.4 Automatic closing

- ⇒ Turn handwheel (20) to position "CLOSED" till locking lever (21) engages in position "AUTOMATIC".
- In this position the shut-off valve should, through the spring resistance, be automatically closed. No more air should come out at the bore for screw plug (13).
- In this position, the valve closes positively only if there is a clearance "S₁" (in new condition min. 2 mm ~ max. 5 mm) between spindle (18) and spindle guide (19).

Shut-off Valve for Starting Air

Cleaning and Function Check

CHECK

By turning the spindle carefully to position "OPENED", the contact with Spindle guide (19) can be felt. The clearance "S₁" can thus be determined externally and it shall be min. 2 mm corresponds to 1/3 turn of the spindle.

- Should virtually no clearance exist after frequent reconditioning of valve seat and valve body, these parts have to be replaced during the next overhaul.

3.5 Automatic opening

- Locking lever (21) is in position "AUTOMATIC".
- By opening test valve (2.06), which is fitted in piping "TV", the same effect is obtained as when actuating control valve (9).
- Upon opening test valve (2.06) the shut-off valve opens automatically. The air now escaping at the bore for screw plug (13) indicates that the two valve bodies (4) and (8) of the shut-off valve and of the non-return valve have opened.



Great care must be taken for this operation. To prevent accidents from compressed air suddenly escaping out of the bore for screw plug (13a) sufficient distance has to be kept to the shut-off valve.

- After shutting test valve (2.06) no air must escape from bore for screw plug (13).
- ⇒ After completing these checks fit and tighten screw plug (13), and close the shut-off valve with handwheel (20) to position "CLOSED" (by hand).

Group 5

▽ Supply Unit

- Removal and Fitting of Servo Oil Pump and Servo Oil Pump Drive 5552-1/A2
- Removal and Fitting of Camshaft and Bearing Shells 5552-2/A1
- Removing and Fitting the Fuel Cams and 5552-3/A1
Gear Wheels on Camshaft
- Removal and Fitting of Intermediate Wheel to Camshaft 5552-4/A1
- Periodic Inspection of Supply Unit Cams and Rollers 5552-5/A1

▽ Fuel Pump

- Dismantling and Assembling 5556-1/A2
- Removal of a Jammed Pump Plunger 5556-2/A1

Injection Control Unit: Removal and Fitting 5564-1/A1

Exhaust Valve Drive: Removal, Fitting, Dismantling and Assembling 5612-1/A1

Regulating Linkage: Adjusting 5801-1/A1

Supply Unit

Removal and Fitting of Servo Oil Pump and Servo Oil Pump Drive

Tools:

1	Device	94561
1	Pump cutting tool ;	
1	plug	94561k
1	cover	94561l
1	blank flange	94561m
1	blank flange	94561n

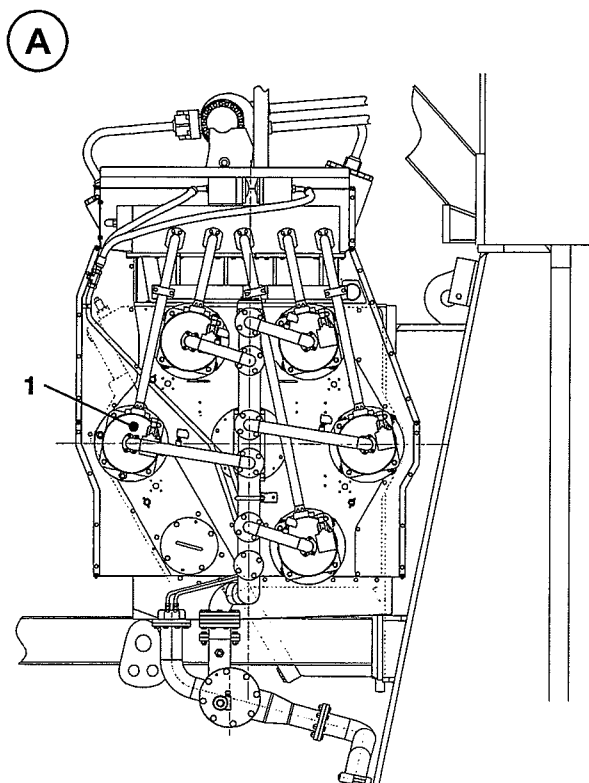
Key to Illustrations:

1	Servo oil pump	20	Guide
2	Flange	21	Flange
3	Screw	22	Screw
4	Pump support	23	Flange
5	Snap ring	24	Screw
6	Pinion	25	Wing nut
7	Shaft	26	Shut-off valve
8	Gear wheel	27	Collector block
9	Intermediate wheel	28	Screw
10	Bearing bush	29	Drain screw
11	Housing	30	Screw
12	Spray nozzle	31	O-ring
13	Spray nozzle	32	O-ring
14	Screw	33	O-ring
15	Screw		
16	Cover		
17	Guide bush	HZ	Chain block
18	Stop rod	MA	Mark
19	Foot	RC	Eye bolt

1. General

Concerning the maintenance of the servo oil pump observe the instructions from the manufacturer. The servo oil pump drive must be checked in accordance with the Maintenance Schedule 0380-1 'Supply Unit'.

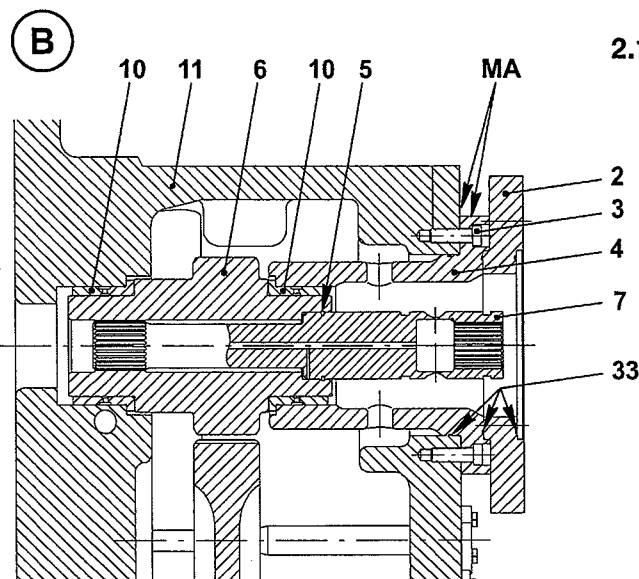
2. Removal of servo oil pump



- ⇒ Stop the engine.
- ⇒ Shut the stop valve before automatic filter (see 5551-1 in the Operating Manual).
- ⇒ Remove the casing as far as necessary.
- ⇒ Disconnect the electrical connections from servo oil pump (1) to be removed.
- ⇒ Open drain screw (29) (Fig. 'J').
- ⇒ Remove the corresponding pipings.
- ⇒ Close shut-off valves (26) to collector block (27) (Fig. 'J').
- ⇒ Connect servo oil pump (1) (227 kg) with a chain block, loosen and remove it in horizontal direction.

Supply Unit

Removal and Fitting of Servo Oil Pump and Servo Oil Pump Drive



2.1 Removal of pinion

Device (94561) is used for removing pinion (6) as shown in Fig. 'F' and its application is illustrated in Fig. 'C' to 'F'.

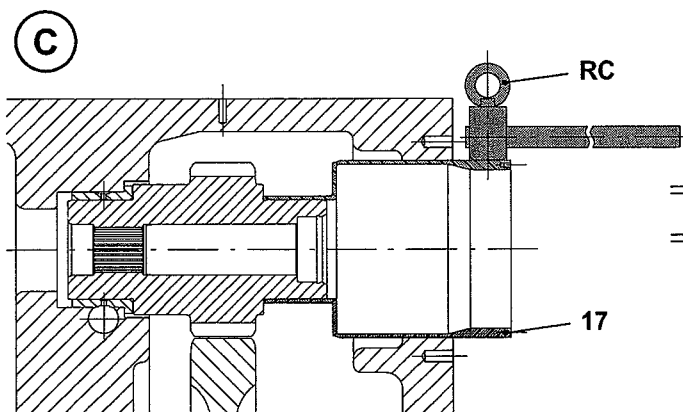
⇒ Loosen and remove flange (2) (30 kg).

⇒ **Remark** : Please note there are also supply units without flange (2).

⇒ Withdraw and remove shaft (7).

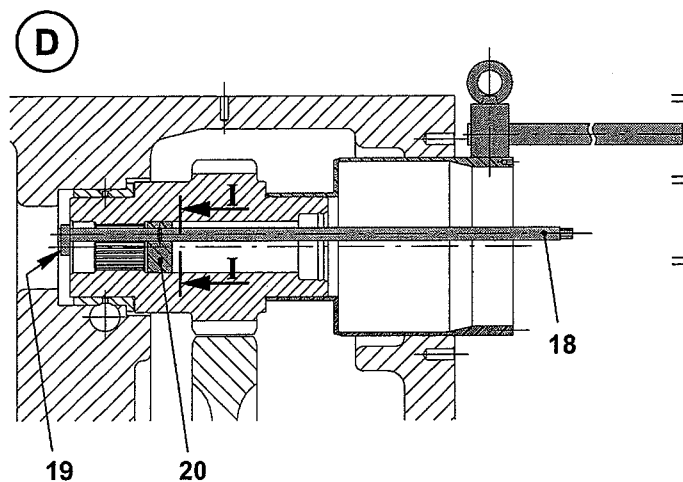
⇒ Remove screws (3) and fit threaded rods M16 instead.

⇒ Withdraw pump support (4) from housing (11) using two screws (3) and then remove the pump support.



⇒ Fit guide bush (17) as shown in Fig. 'C'.

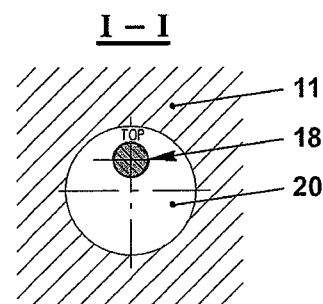
⇒ Fit eye bolts "RC".



⇒ Turn stop rod (18) till its foot (19) pointing vertically downwards.

⇒ Turn guide (20) till its mark TOP pointing upwards.

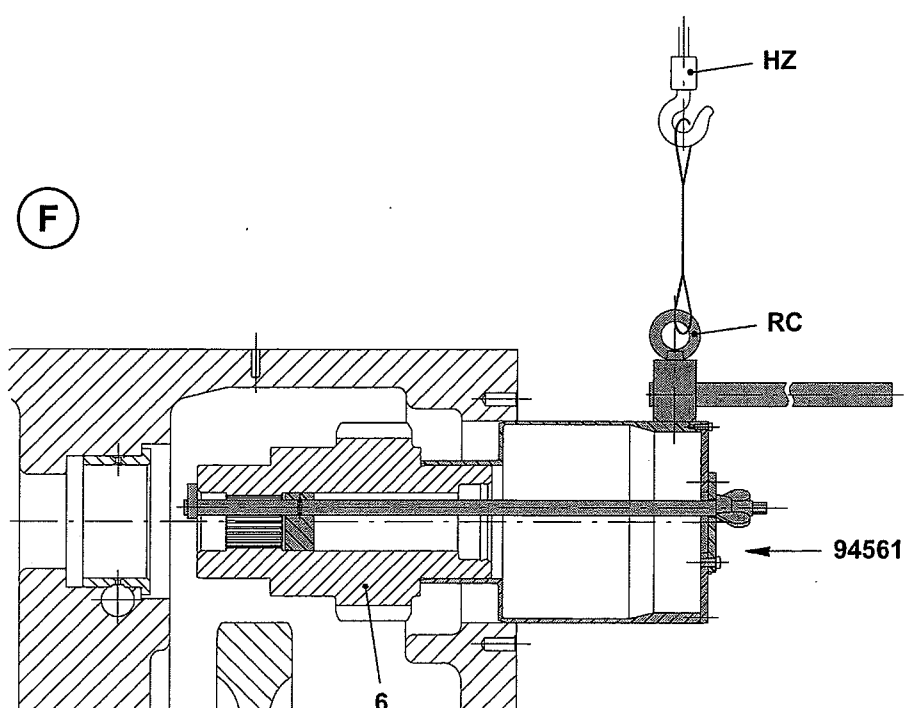
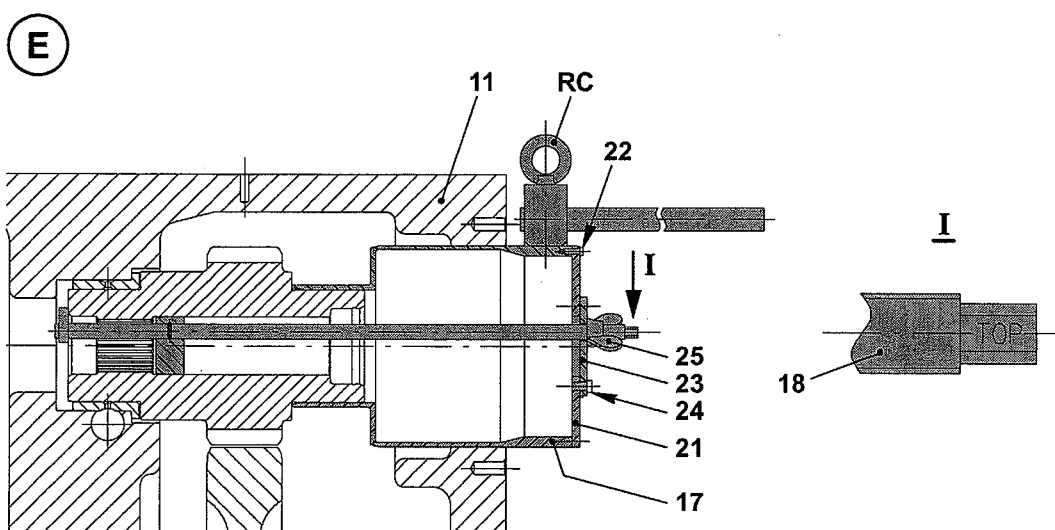
⇒ Insert stop rod as shown in Fig. 'D'.



Supply Unit

Removal and Fitting of Servo Oil Pump and Servo Oil Pump Drive

- ⇒ Turn stop rod (18) till its mark TOP pointing upwards (view I).
- ⇒ Fasten flanges (23) to flange (21) by means of screws (24).
- ⇒ Push flange (21) (mark TOP pointing upwards) over stop rod (18) to guide bush (17) and fasten it by means of screws (22).
- ⇒ Fit and tighten wing nut (25) to the stop rod.
- ⇒ Connect lifting tackle "HZ" with eye bolt "RC" and remove pinion (6) (see Fig. 'F').



Supply Unit

Removal and Fitting of Servo Oil Pump and Servo Oil Pump Drive

3. Fitting and Removal of pump cutting tool

Operating the engine cutting a serve oil pump, pump cutting tool must be installed after removal of pinion (6).

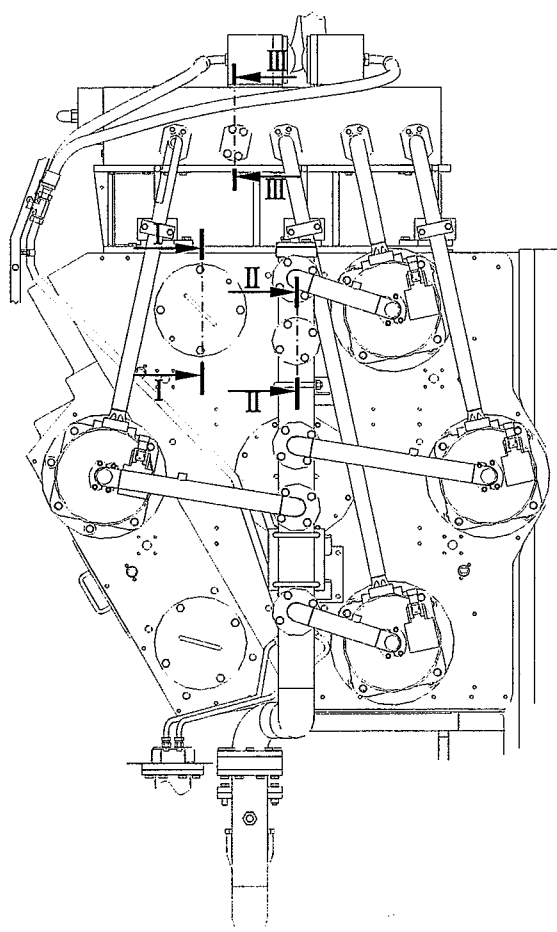
3.1 Fitting of pump cutting tool

- Install the plug (94561k) to bearing bush (10).
- Fasten cover (94561l) by means of screws (3) (view I).
- Fasten blank flange (94561m) and seal by means of screws (view II).
- Fasten blank flange (94561n) with O-ring by means of screws (view III).

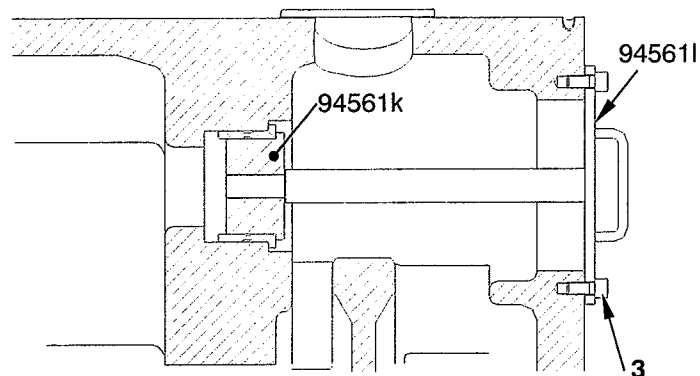
3.2 Removal of pump cutting tool

Removal is carried out analogously to the fitting but in reverse sequence.

G

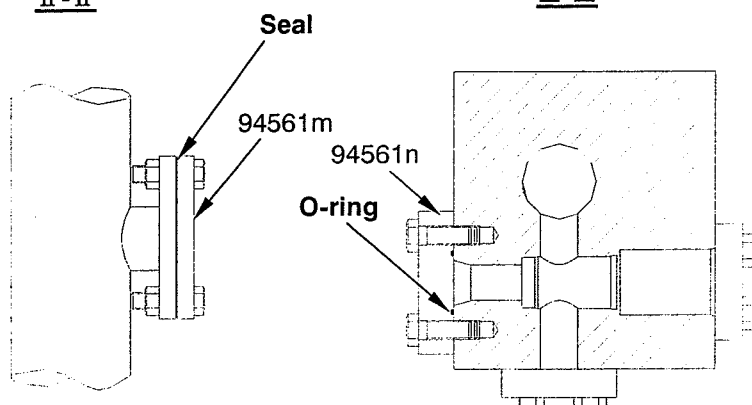


I - I



II - II

III - III



Supply Unit

Removal and Fitting of Servo Oil Pump and Servo Oil Pump Drive

4. Spray nozzles

Two spray nozzles (12) are provided for each pinion; they are located in such a manner that oil is sprayed between pinion (6) and gear wheel (8).

The tap holes in the housing of the supply unit are properly arranged ensuring correct fitting of the spray nozzles.

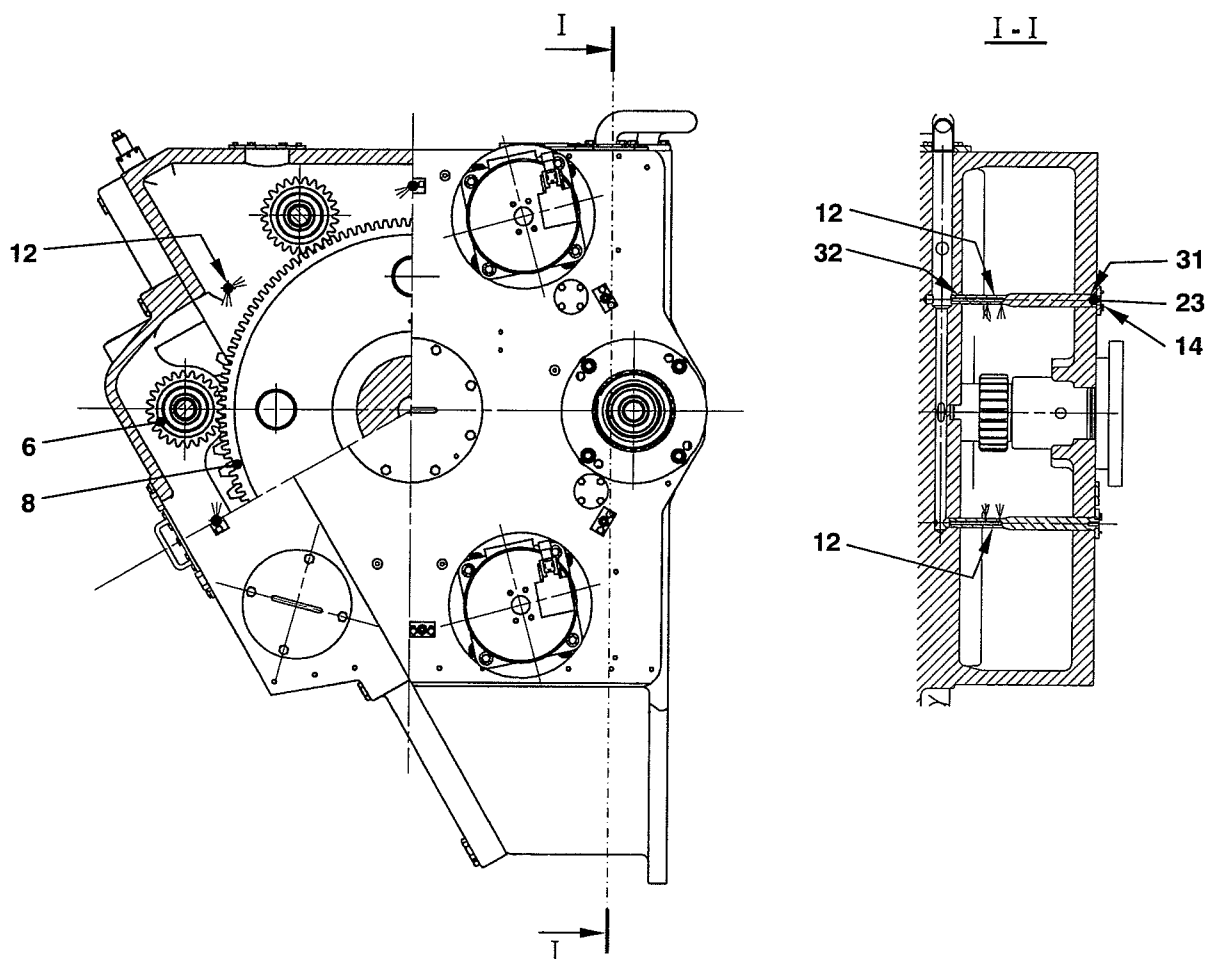
The spray nozzles can be removed each time the engine and the lubricating pump are stopped.

4.1 Removal of spray nozzles

- Spray nozzle (12) can be removed after loosening screw (14).
- Spray nozzle (13) for intermediate wheel (9) can only be unscrewed after removal of cover (16) (Fig. 'I').
- For the removal of cover (16) see 5552-2.

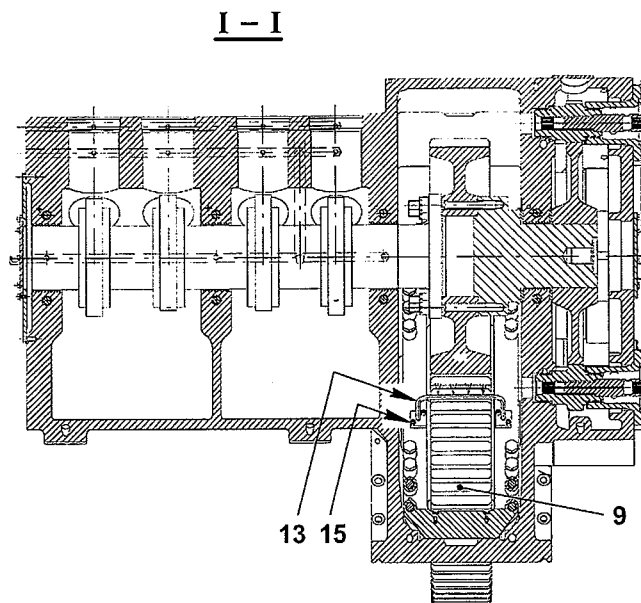
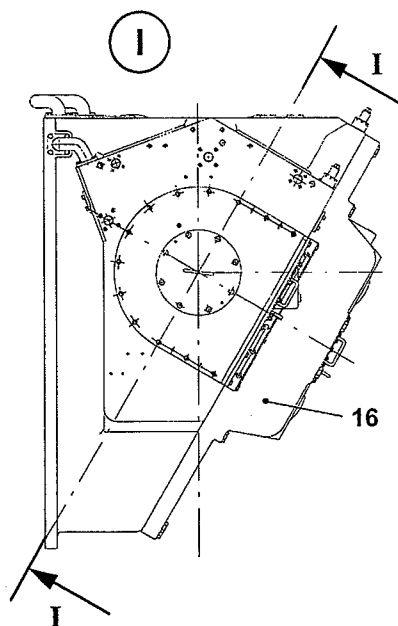
CHECK Check spray nozzles for free passage.

H



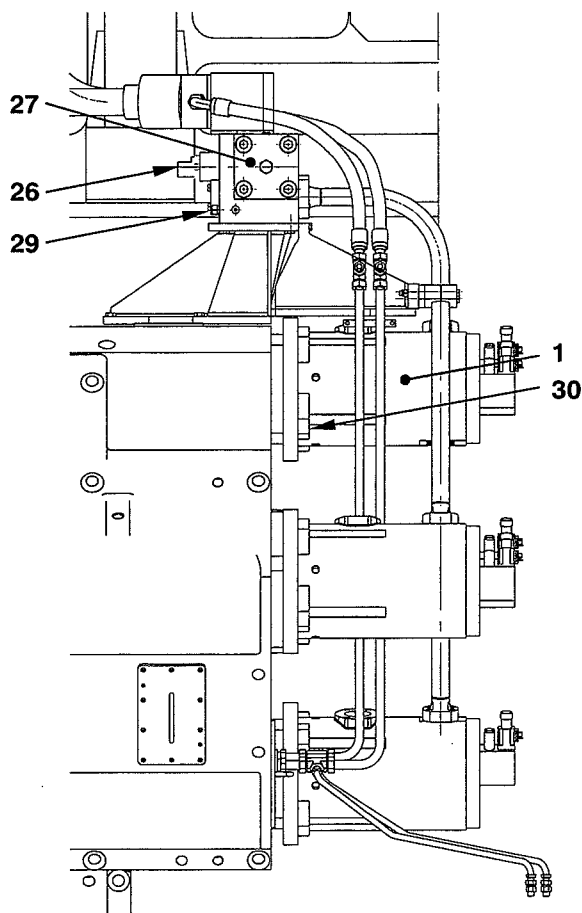
Supply Unit

Removal and Fitting of Servo Oil Pump and Servo Oil Pump Drive



5. Fitting

J



Fitting is carried out analogously to the removal but in reverse sequence, whereby attention must be paid to the following:

- O-rings (31) and (32) of spray nozzles (12) must be replaced.
- Screws (15) for fastening spray nozzles (13) (Fig. 'I') must be secured with LOCTITE 0243.
- O-rings (33) in pump support (4) and flange (2) must be replaced by new ones.

Remark : Bores for bearing bushes (10) in housing (11) and pump support (4) are machined together and marked accordingly. Therefore, never interchange the pump supports and take special care of marks "MA" on assembly!

- Apply oil to screws (30) and tighten them with a torque of **600 Nm**.

CHECK

During fitting the clearances are to be determined in accordance with Clearance Table 0330-1 'Supply Unit'.

- ⇒ Open shut-off valves (26) and tighten their spindles with **200 Nm**.

Supply Unit
Removal and Fitting of Camshaft and Bearing Shells
Tools:

Devices	94430
(depending on number of cylinders)	
1 Lifting support	94553
1 Lifting support	94553a
1 Lifting support	94553b
1 Fork lever consisting of:	94554
1 Face plate	94554a
1 Rocker arm	94554b
1 Nut	94554c
1 Bolt	94554d
1 Web	94554e
2 Pre-tensioning jacks	94557
2 Sleeves	94558
1 Socket wrench	94559
2 Round bars	94560
2 Supports	94566
2 Tension nuts	94566a
1 Assembly template	94567
1 Pipe	94567a
1 Pressure gauge	94932a
1 Connection piece	94934a
1 HP hose	94935
2 HP hoses	94935a
1 Hydraulic unit	94942

Key to Illustrations:

1 Servo oil pump	18 Gear wheel
2 Cover	19 Push rod
3 Fuel pump	20 Nut
4 Cover	21, 21a Bolt
5 Cover	22 Guide
6, 6a Waisted bolt	23 Dowel pin
7, 7a Nut	24 Flange
8 Vent screw	25 Distance plate
9 Cylinder	26 O-ring
10 Piston	
11 Housing	
12 Bearing cover	
13 Dowel pin	BN Limiting groove
14 Camshaft	BO Bore
15 Thrust bearing ring half	HK Wooden wedge
16 Screw	HZ Chain block
17 Lower bearing shell	H1... Chain block
17a Upper bearing shell	SA Gap

Overview

1. Preparation	1/16
2. Removal of camshaft bearings	5/16
3. Removal of camshaft	11/16
4. Fitting of bearings and camshaft	13/16

1. Preparation

- ⇒ Stop the engine and main lubricating pump.
- ⇒ Remove the casing plates from servo oil pumps.
- ⇒ Cut out fuel pumps (3) (Fig. 'A' or 'D') by means of devices (94430) (see 5556-2 in the Operating Manual).
- ⇒ Remove servo oil pumps (1) which are placed in front of camshaft wheel and the corresponding pinions (see 5552-1).

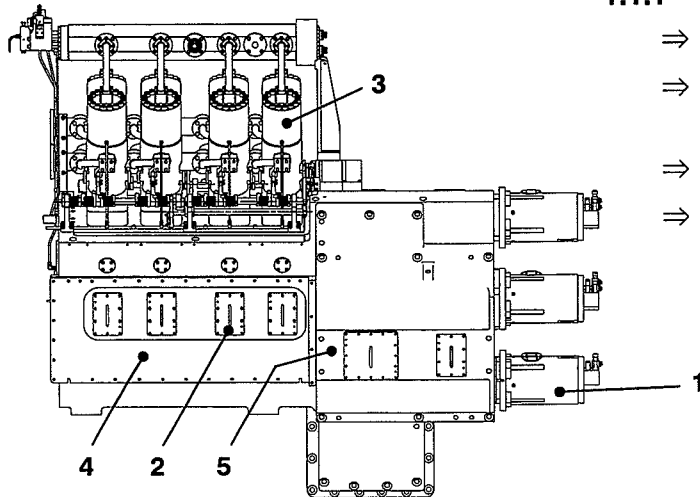

Remark : Pay attention to:

- General Application Instructions 9403-4 for hydraulic pre-tensioning jacks.

Supply Unit

Removal and Fitting of Camshaft and Bearing Shells

A

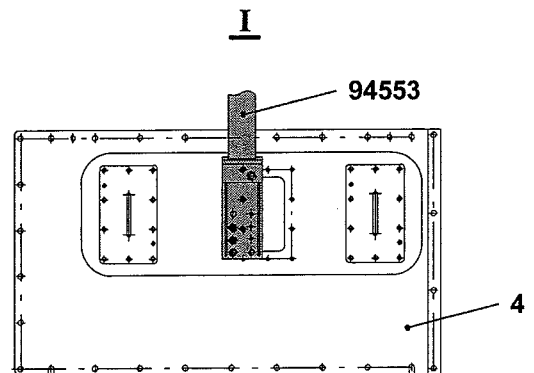
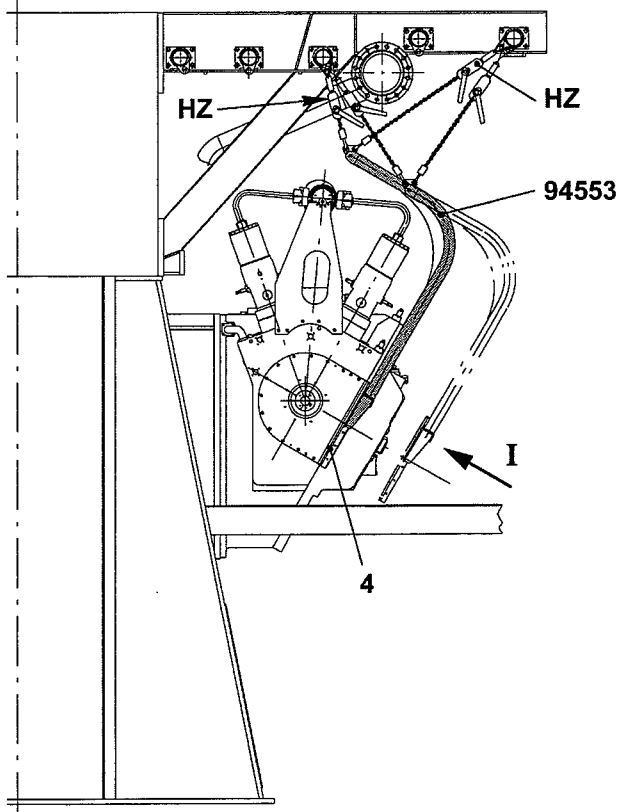


**1.1 Removal of covers
(8 to 14 Cyl. engines)**

1.1.1 Removal of cover 4

- ⇒ Remove cover (2).
- ⇒ Connect chain block "HZ" with lifting support (94553) as shown in Fig. 'B'.
- ⇒ Fasten lifting support (94553) to cover (4).
- ⇒ Remove cover (4).

B

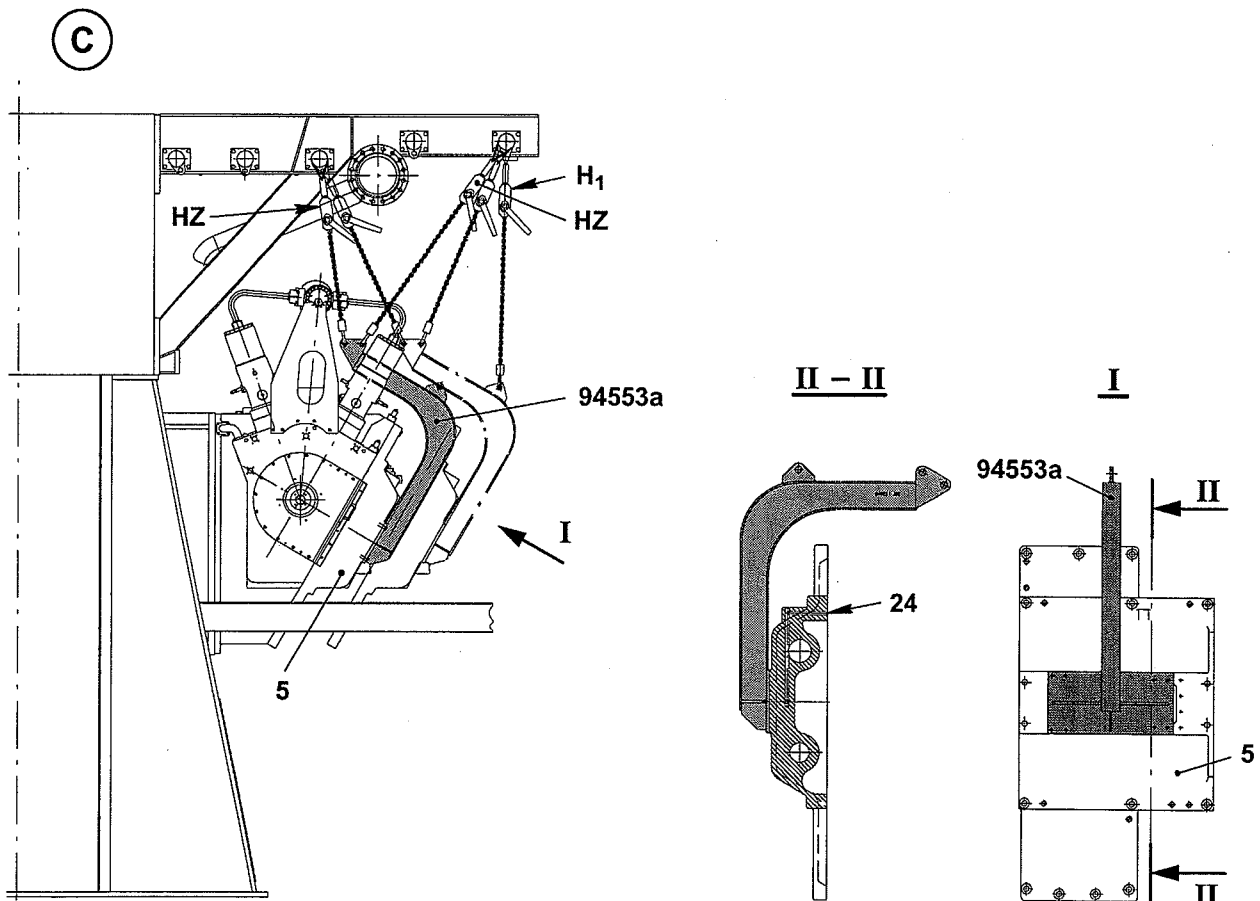


Supply Unit

Removal and Fitting of Camshaft and Bearing Shells

1.1.2 Removal of cover (5)

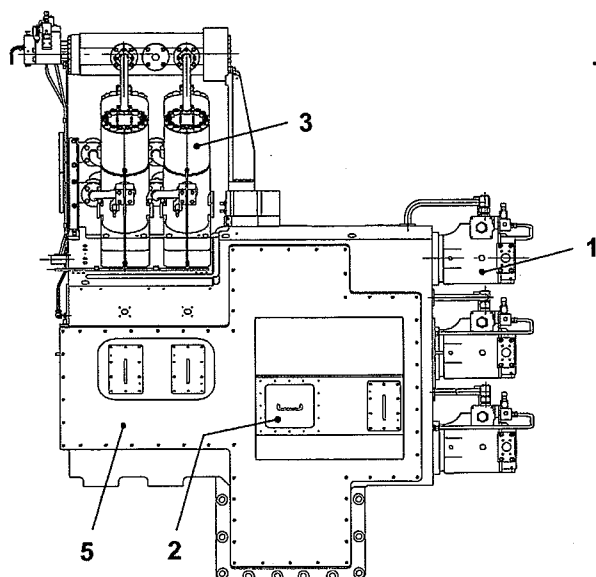
- ⇒ Connect chain block "HZ" with lifting support (94553a) as shown in Fig. 'C'.
- ⇒ Fasten lifting support (94553a) to cover (5).
- ⇒ Remove cover (5).
- ⇒ Connect the lifting support with chain block H₁ for the further transport of the cover.



Supply Unit

Removal and Fitting of Camshaft and Bearing Shells

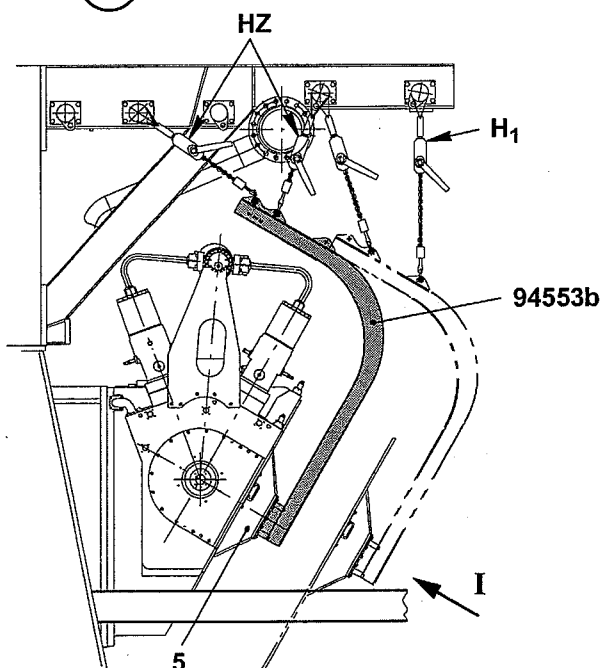
D



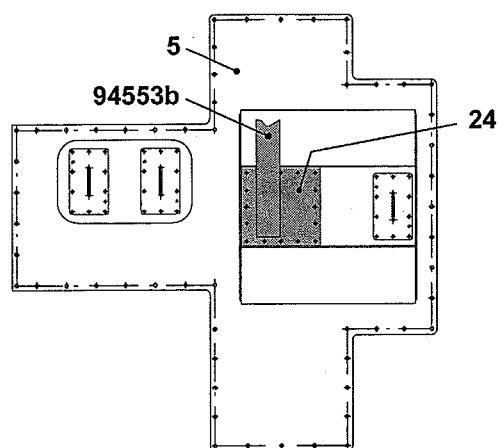
**1.2 Removal of cover (5)
(6 and 7 Cyl. engines)**

- ⇒ Remove cover (2).
- ⇒ Install flange (24) to lifting support (94553b).
- ⇒ Connect chain block "HZ" with lifting support (94553b) as shown in Fig. 'E'.
- ⇒ Fasten lifting support (94553b) to cover (5).
- ⇒ Remove cover (5).
- ⇒ Connect the lifting support with chain block H_1 for the further transport of the cover.

E



I



Supply Unit

Removal and Fitting of Camshaft and Bearing Shells

2. Removal of bearing shells

2.1 Loosening and removal of waisted bolts

 **Remark** : Always two waisted bolts can be loosened at the same time.

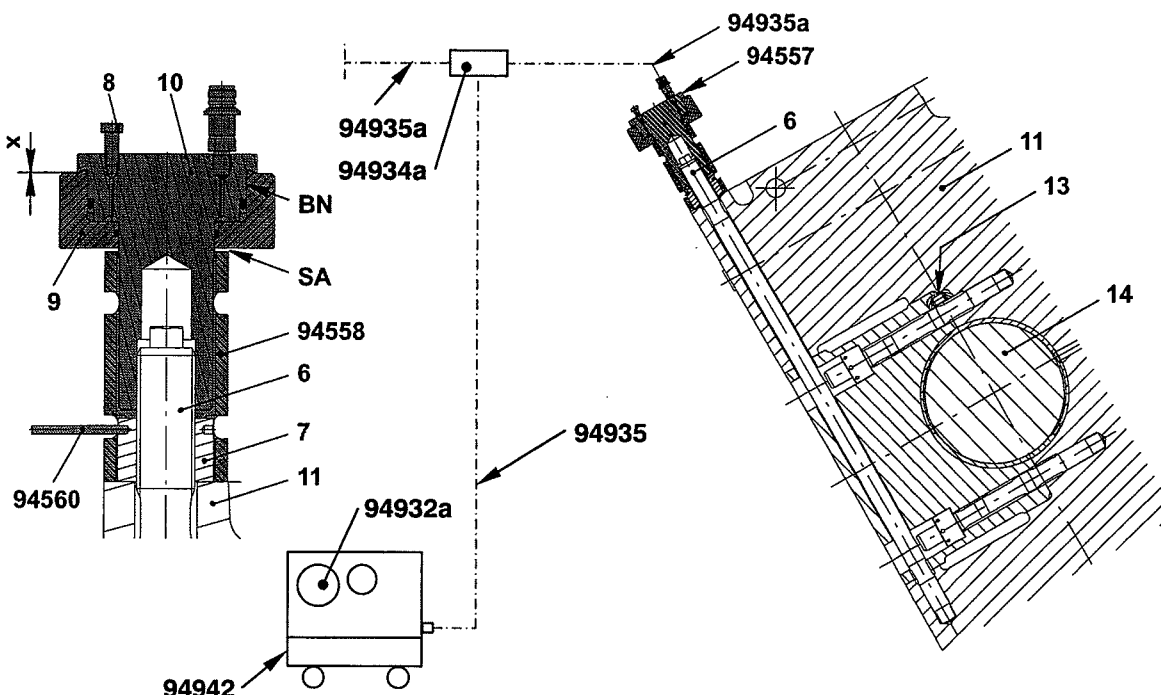
- ⇒ Clean the threads of waisted bolts (6) and the area around nuts (7) and oil the threads.
- ⇒ Put sleeves (94558) over the nuts.
- ⇒ With vent screws (8) open, screw pre-tensioning jacks (94557) on waisted bolts (6) till they seat on the sleeves and there is little or no clearance at 'x'.
- ⇒ Then unscrew the pre-tensioning jacks by 1½ turns (gap "SA" in Fig. 'F').
- ⇒ Connect the pre-tensioning jacks to hydraulic unit (94942) as shown in Fig. 'F'.
- ⇒ Actuate hydraulic unit, and close vent screws as soon as oil flows bubble-free.
- ⇒ Operate hydraulic unit till a pressure of approx. **102 MPa** is reached.



Pistons (10) of the pre-tensioning jacks must **never** exceed the red limiting grooves "BN".

- ⇒ Turn back nuts (7) with round bar (94560) till they are almost touching the pistons of the pre-tensioning jacks.
- ⇒ Release pressure to zero and remove the pre-tensioning jacks and sleeves.
- ⇒ Remove the nuts and waisted bolts.

F



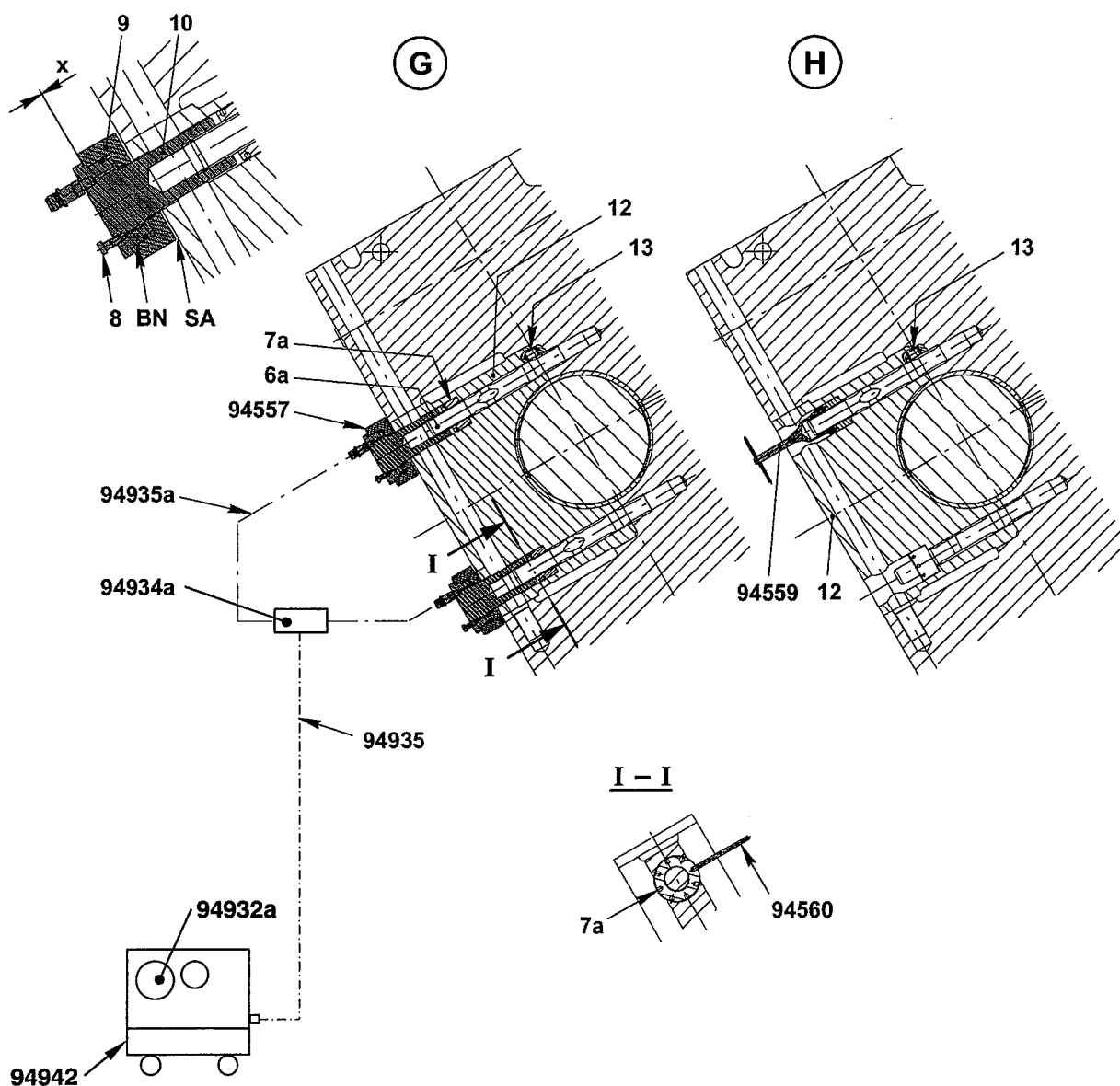
Supply Unit

Removal and Fitting of Camshaft and Bearing Shells

2.2 Loosening of waisted bolts 6a

- ⇒ With vent screws (8) open, screw pre-tensioning jacks (94557) on waisted bolts (6a) till they seat on bearing cover (12) and there is little or no clearance at 'x' (Fig. 'G').
- Till the removal of pre-tensioning jacks the further procedure is the same as described in paragraph 2.1.
- Nuts (7a) are turned out with socket wrench (94559) as shown in Fig. 'H'.

 **Remark** : For safety reasons do not unscrew nuts (7a) before the corresponding bearing cover will be removed!



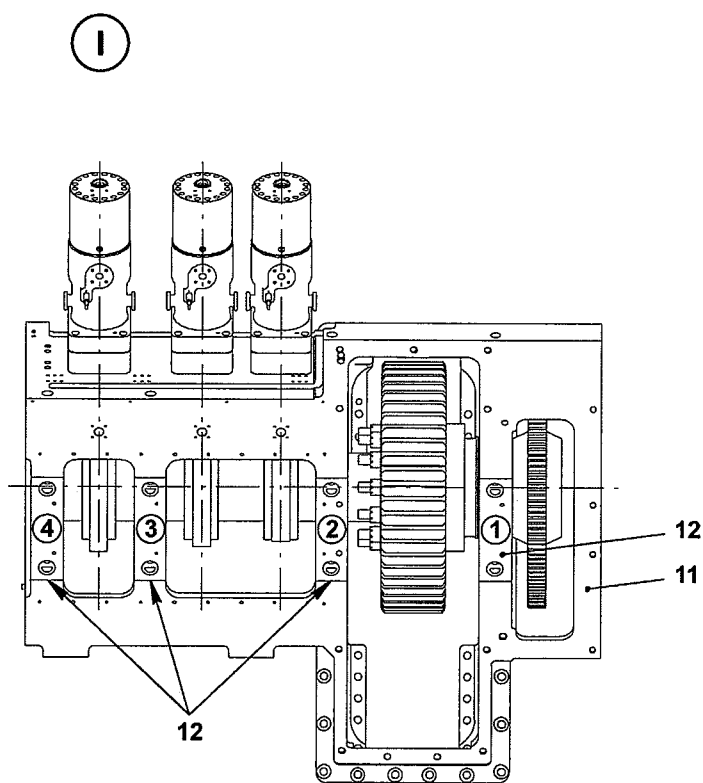
Supply Unit

Removal and Fitting of Camshaft and Bearing Shells

2.3 Numbering of bearings

Bearing No. ① is designed as thrust bearing.

 **Remark** : All bearing covers (12) are machined together with housing (11), therefore never interchange them! They must be marked accordingly before their removal.

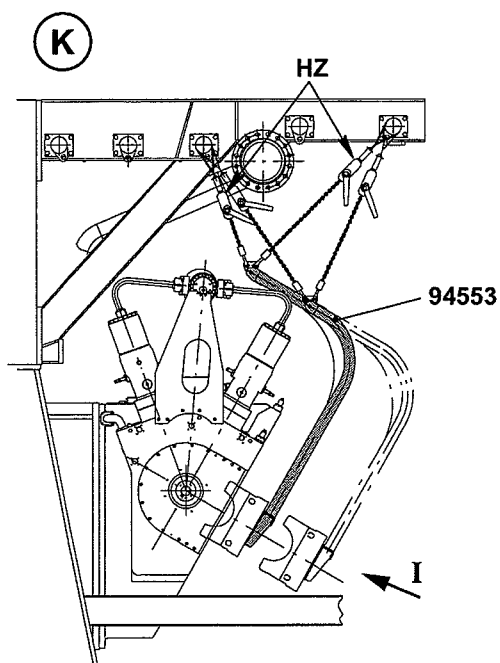


Supply Unit

Removal and Fitting of Camshaft and Bearing Shells

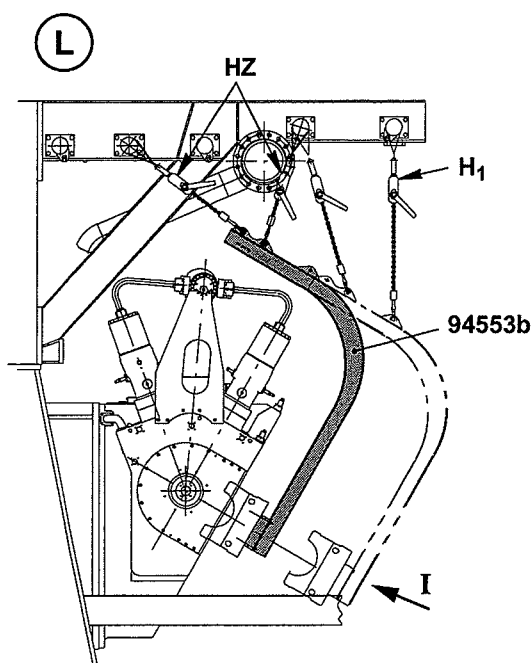
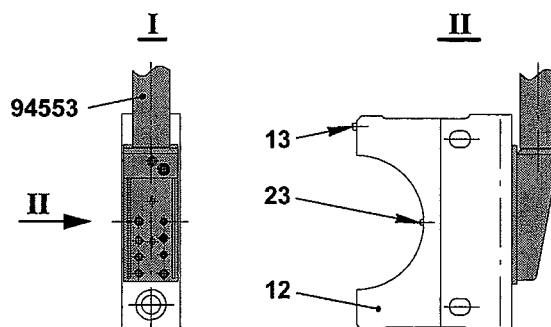
2.4 Removal of bearing shells

Start with the removal of bearing No. ① (Fig. 'I'). The other bearing covers may be removed after the respective bearing shells have been removed and support (94566) has been installed.



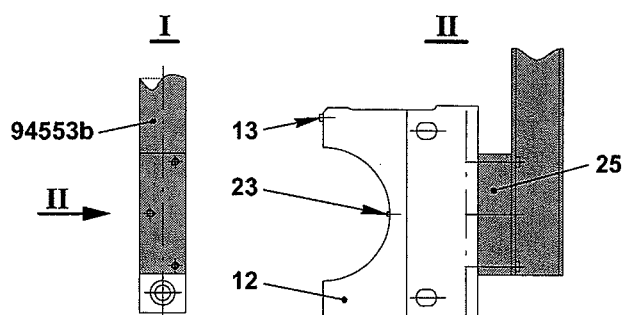
2.4.1 Removal of bearing covers (8 to 14 Cyl. engines)

- ⇒ Fasten lifting support (94553) to bearing cover (12).
- For bearing covers (12) the removal procedure is the same as described for cover (4) in paragraph 1.1.1.



2.4.2 Removal of bearing covers (6 and 7 Cyl. engines)

- ⇒ Install distance plate (25) to lifting support (94553b).
- ⇒ Fasten lifting support to bearing cover.
- For bearing covers (12) the removal procedure is the same as described for cover (5) in paragraph 1.2.



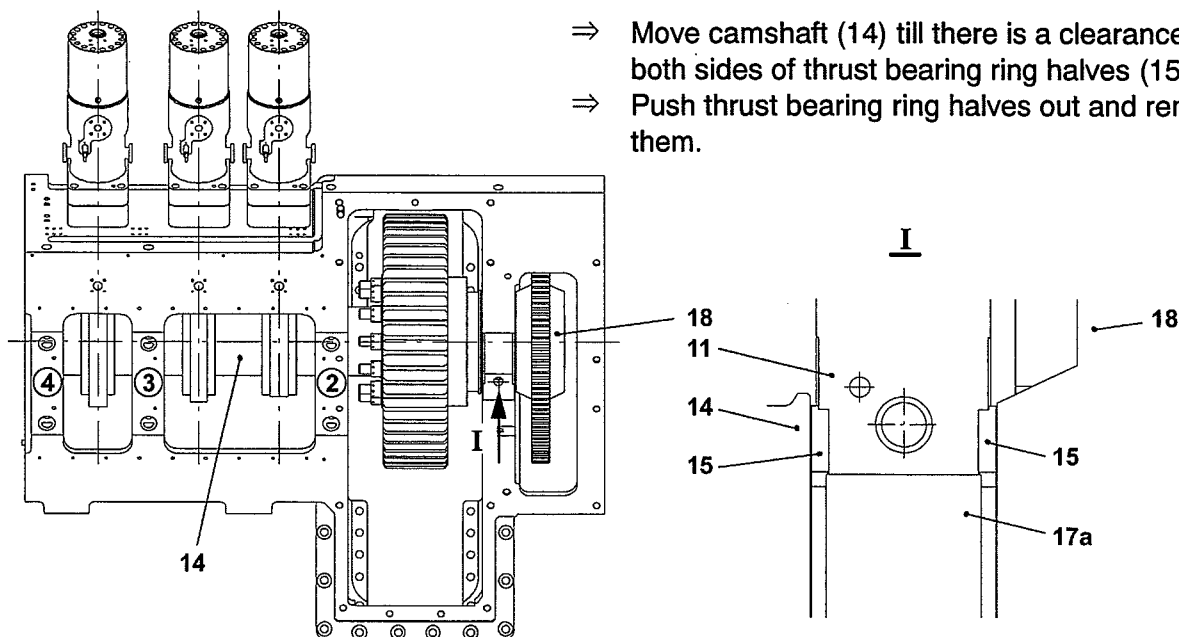
Supply Unit

Removal and Fitting of Camshaft and Bearing Shells

(M)

2.4.3 Removal of bearing shell No. ①

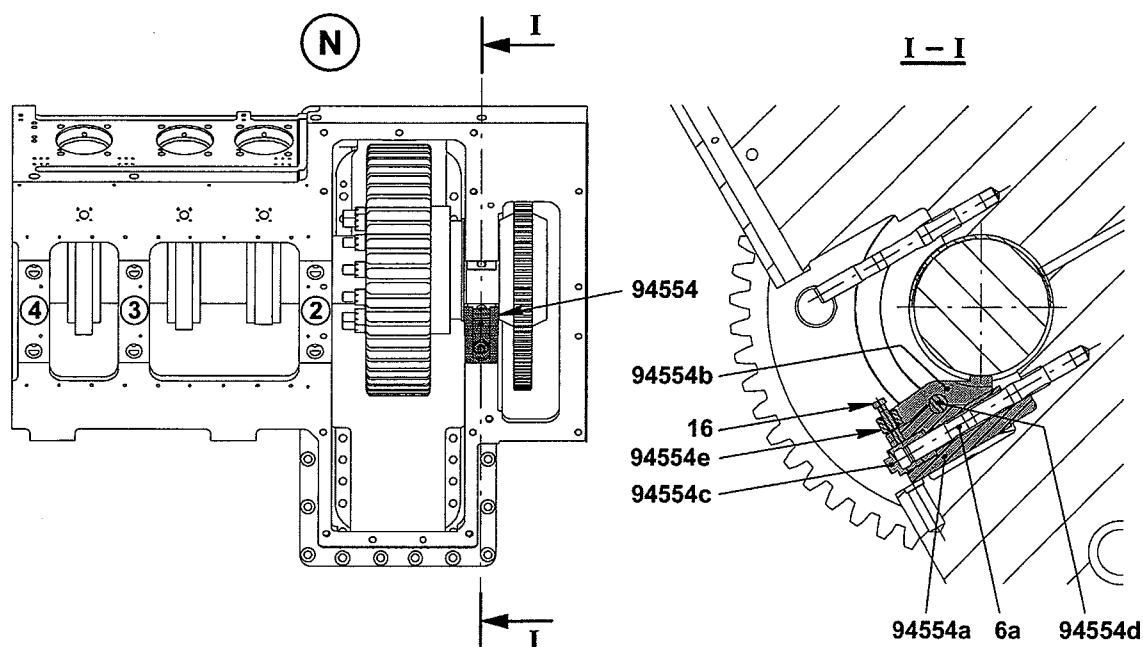
- ⇒ Move camshaft (14) till there is a clearance on both sides of thrust bearing ring halves (15).
- ⇒ Push thrust bearing ring halves out and remove them.



2.4.4 Turning out the bearing shells

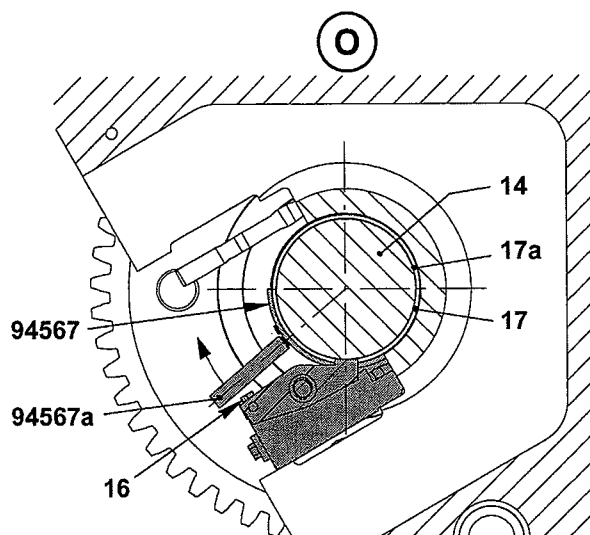
- ⇒ Loosen screw (16) so far till web (94554e) is fastened only.
- ⇒ Push fork lever (94554) over waisted bolt (6a) and fasten it with nut (94554c) as shown in Fig. 'N'.

(N)

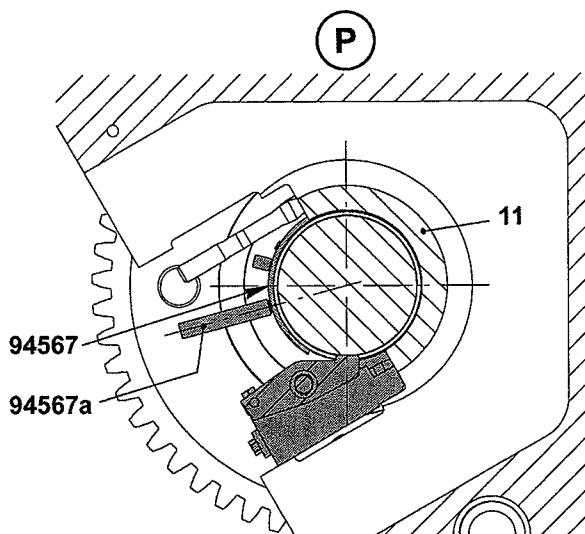


Supply Unit

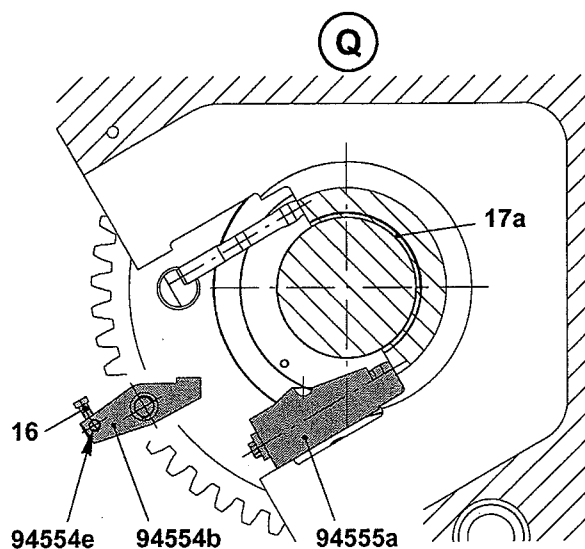
Removal and Fitting of Camshaft and Bearing Shells



- ⇒ Place assembly template (94567) on lower bearing shell (17), so that its pin fits into the corresponding bore of the bearing shell.
- ⇒ Put pipe (94567a) on the assembly template and pull it in arrow direction, push camshaft (14) up by tightening screw (16) till the bearing shells can be turned at the same time.
- ⇒ Turn lower bearing shell (17) upwards as far as possible.



- ⇒ Insert pipe (94567a) into the other pin and turn lower bearing shell upwards till assembly template stops at housing (11).
- ⇒ Remove assembly template.



- ⇒ Turn screw (16) out of gear with face plate (94554a), lift and remove rocker arm (94554b).
- ⇒ Remove lower bearing shell.

Remark : Lower bearing shells (17) which are reused must be marked properly with the bearing number and LOWER in order to fit these in the same place as before.

- ⇒ Remove face plate (94554a).

Supply Unit

Removal and Fitting of Camshaft and Bearing Shells

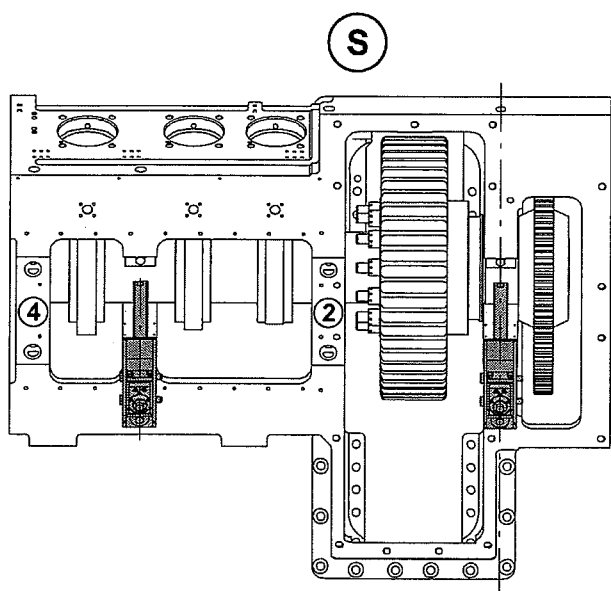
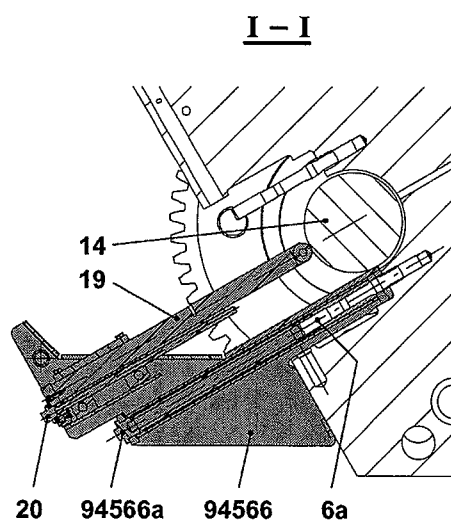
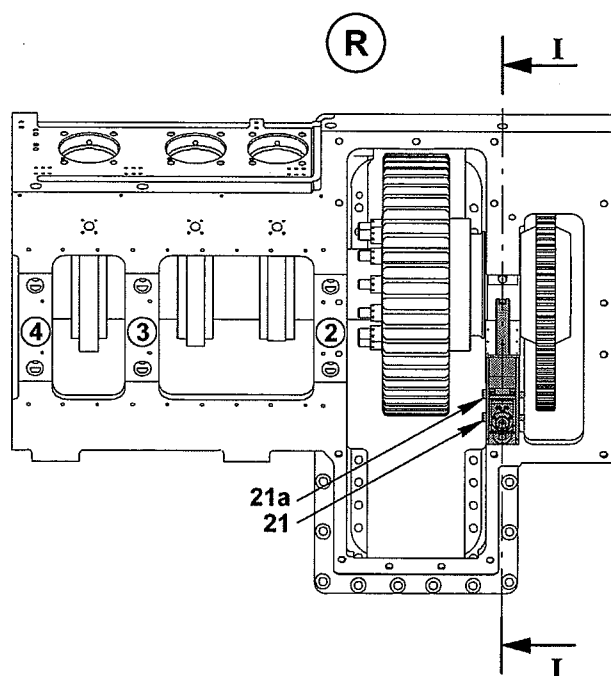
3. Removal of camshaft

- ⇒ Push support (94566) over waisted bolt (6a) and fasten it with tension nut (94566a) as shown in Fig. 'R'.



Heads of bolts (21) and (21a) must point towards the free end when fitting support (94566) as shown in Fig. 'R'.

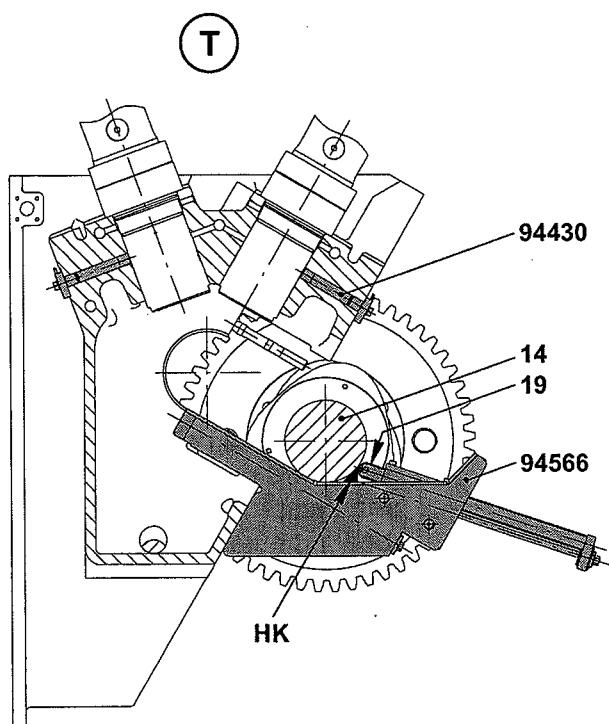
- ⇒ By means of turning nut (20), extend push rod (19) till it touches camshaft (14).



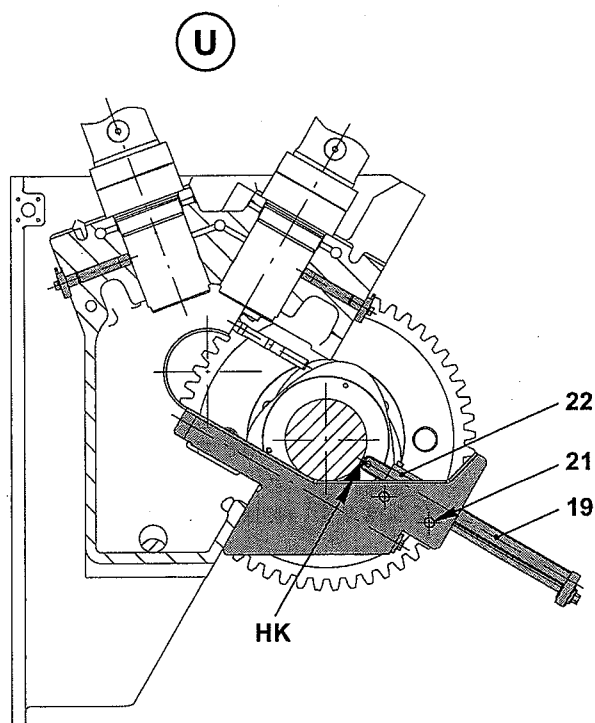
- ⇒ Screw the bearing cover and bearing shell down to bearing No. 3 as described in paragraph 2.4.4.
- ⇒ Fit support (94566) and extend push rod (19) as described for Fig. 'R'.
- ⇒ Remove the bearing covers and lower bearing shells (17) from the remaining bearings.

Supply Unit

Removal and Fitting of Camshaft and Bearing Shells



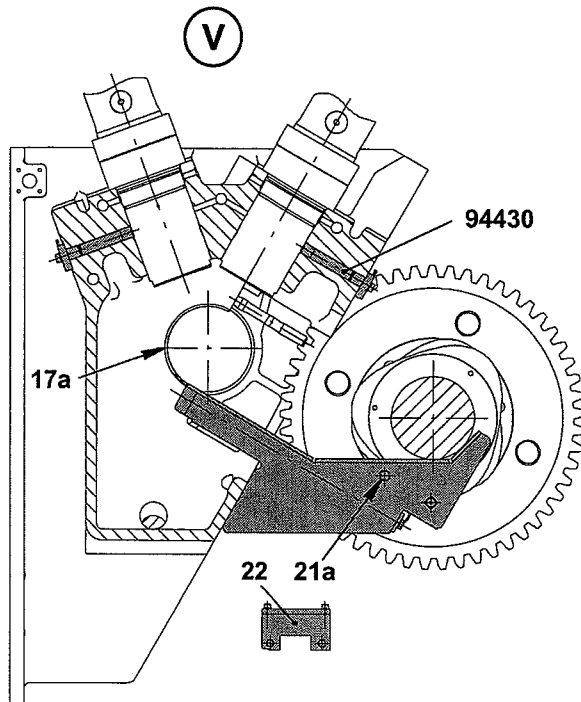
- ⇒ Equally retract push rods (19) till camshaft (14) is seated horizontally on supports (94566). Take care that rear bearing shells do not fall out.
- ⇒ Secure the camshaft with wooden wedge "HK".



- ⇒ Pull out bolt (21) and lift push rod (19) together with guide (22).
- ⇒ Reinsert the bolt and put the guide (22) on it as shown in Fig. 'U'.
- ⇒ Remove the push rod (19) from the guide (22).

Supply Unit

Removal and Fitting of Camshaft and Bearing Shells



- ⇒ Pull out bolt (21a). Lift and remove guide (22).
- ⇒ Reinsert the bolt.
- ⇒ Remove wooden wedge "HK" (Fig. 'U') and roll camshaft (14) till the stop.
- ⇒ Upper bearing shells (17a) can now be removed.

 **Remark:** Upper bearing shells (17a) which are reused must be marked properly with the bearing number in order to fit these in the same place as before.

4. Fitting of bearings and camshaft

The fitting of bearings and camshaft is carried out analogously but in reverse sequence to the removal, whereby the following points require special attention:

The camshaft can be installed in every position, however:

- all parts to be fitted must be clean and undamaged!
- for the assembly smear bearing shells, thrust bearing ring halves and camshaft with oil.
- take care of the designations of reused bearing shells.
- fit bearing shells, so that their bores provided for dowel pins (23) in the bearing covers point to the same side (Fig. 'K' or 'L').
Align bearing shells laterally and their mating surfaces with housing (11).
- fit lower bearing shell (17) laterally aligned with upper bearing shell (17a).
- take care of the bearing cover numberings and meshing of dowel pins (13) and (23) (Fig. 'K').
- apply oil to the threads of nuts (7), (7a) and tighten nuts (7a) with socket wrench (94559) till there is no clearance at 'y' (Fig. 'W').

Supply Unit

Removal and Fitting of Camshaft and Bearing Shells

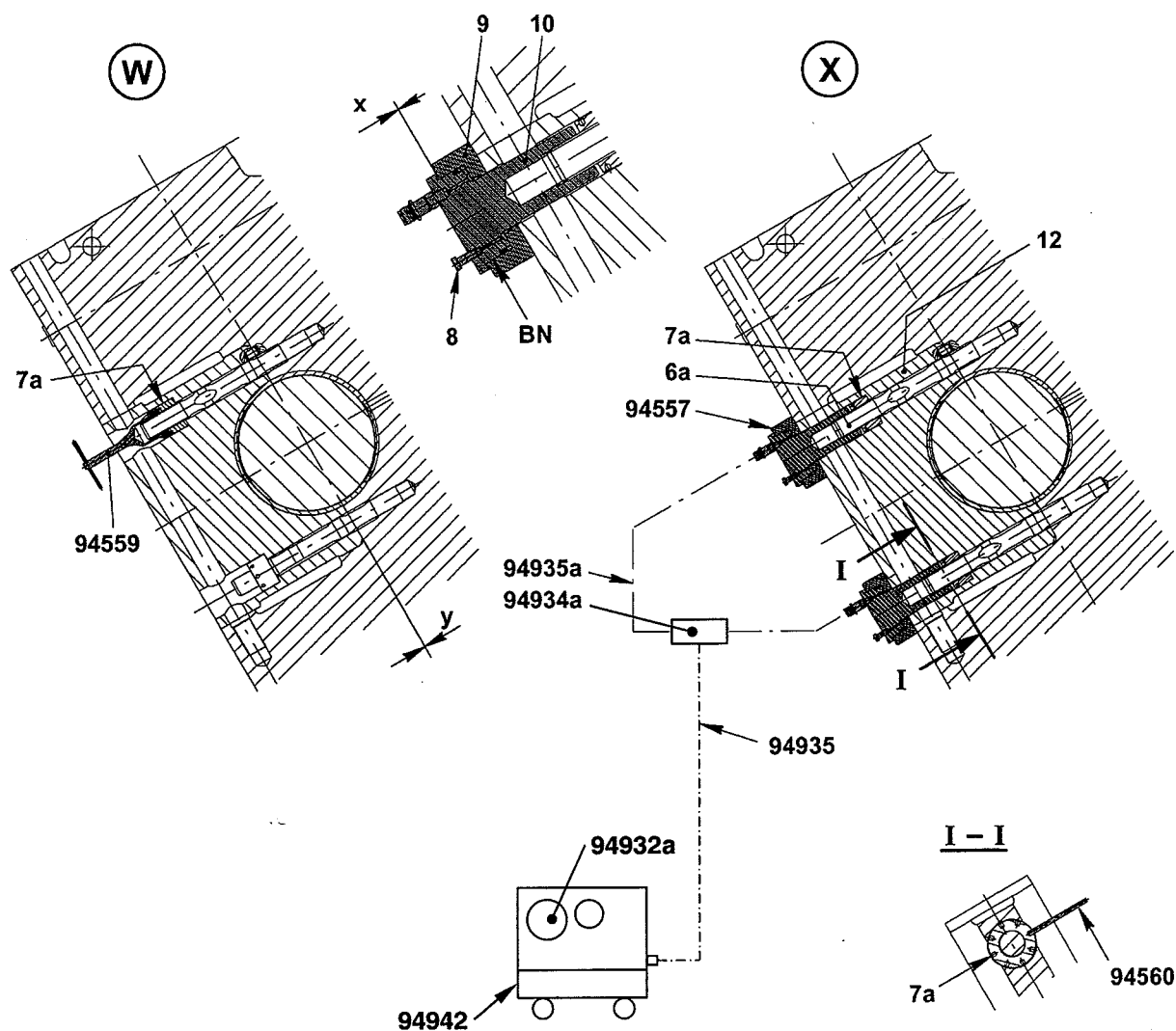
4.1 Tensioning of waisted bolts 6

- ⇒ With vent screws (8) open, screw pre-tensioning jacks (94557) on waisted bolts (6a) till they seat on the sleeves and there is little or no clearance at 'x'.
- ⇒ Connect the pre-tensioning jacks to hydraulic unit (94942) as shown in Fig. 'W'.
- ⇒ Actuate hydraulic unit, and close vent screws as soon as oil flows bubble-free.
- ⇒ Operate hydraulic unit till a pressure of **100 MPa** is reached.



Pistons (10) of the pre-tensioning jacks must **never** exceed the red limiting grooves 'BN'.

- ⇒ Keep pressure constant and tighten nuts (7a) with round bar (94560) till firmly seated.
- ⇒ Release pressure to zero and remove the pre-tensioning jacks.



Supply Unit

Removal and Fitting of Camshaft and Bearing Shells

4.2 Tensioning of waisted bolts 6

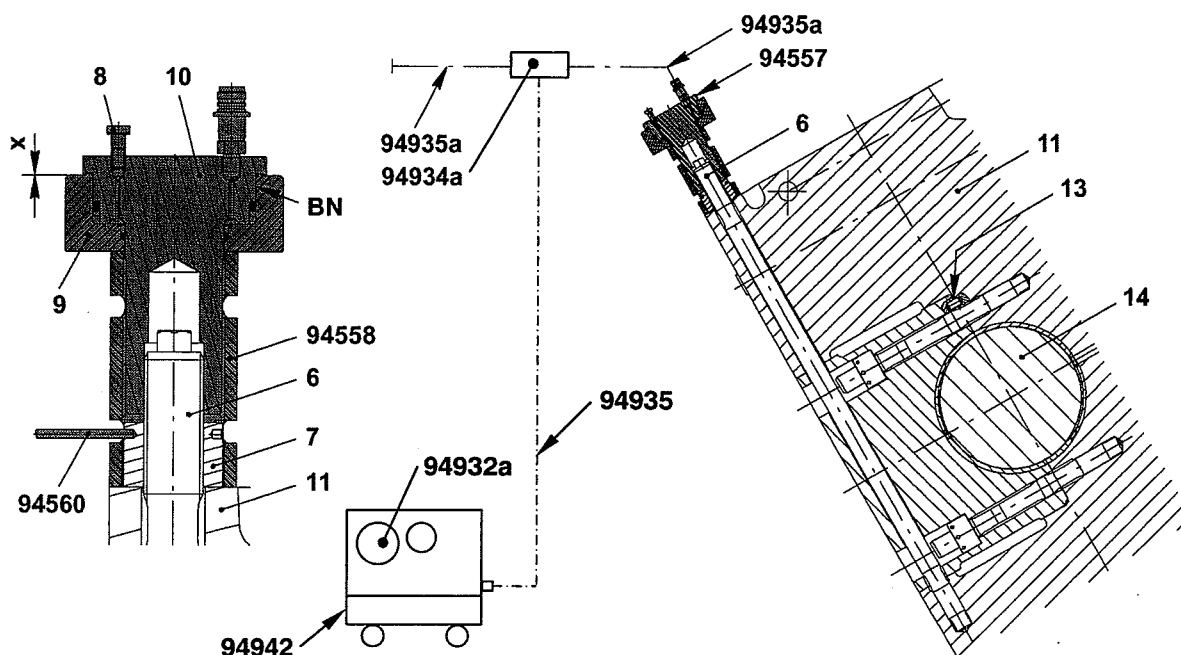
- ⇒ Clean and oil the threads of waisted bolts (6).
- ⇒ Fit and tighten the waisted bolts.
- ⇒ Clean the area around nuts (7).
- ⇒ Screw on and tighten the nuts by hand with round bar (94560).
- ⇒ Put sleeves (94558) over the nuts.
- ⇒ With vent screws (8) open, screw pre-tensioning jacks (94557) on waisted bolts (6) till they seat on the sleeves and there is little or no clearance at 'x'.
- ⇒ Connect the pre-tensioning jacks to hydraulic unit (94942) as shown in Fig. 'Y'.
- ⇒ Actuate hydraulic unit, and close vent screws as soon as oil flows bubble-free.
- ⇒ Operate the hydraulic unit till a pressure of **100 MPa** is reached.



Pistons (10) of the pre-tensioning jacks must **never** exceed the red limiting grooves 'BN'.

- ⇒ Keep pressure constant and tighten nuts (7) with round bar (94560) till firmly seated.
- ⇒ Release pressure to zero and remove the pre-tensioning jacks and sleeves.

Y



Supply Unit
Removal and Fitting of Camshaft and Bearing Shells

4.3 Final assembly
CHECK

Determine radial and axial clearances, see clearance table 0330-1 'Supply Unit'.

- ⇒ Put O-ring (26) in cover (5) (Fig. 'C').
- ⇒ Apply sealing compound to sealing faces of covers (4), (5) and fit the latter.
- ⇒ Fit servo oil pumps (see 5552-1).
- ⇒ Install all pipings.
- ⇒ Cut in the fuel pumps and remove tools (94430) (see 5556-2 in the Operating Manual).

CHECK

After assembly, turn the engine and check if lubricating oil is supplied to all lubricating points and bearings with the oil pump in operation!



Prior to commissioning or after maintenance works and exchange of servo oil pumps, they must be filled up with system oil (see 5552-1 'Fitting').

Supply Unit
Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft
Tools:

1	Hydr. jacking tool	94424
1	Connection piece	94426
2	Pre-tensioning jacks	94557
2	Sleeves	94558
1	Round bar	94560
1	Cam adjusting gear	94562
consisting of:		
1	Angle rail	94562a
1	Regulating shaft	94562b
1	Regulating shaft	94562c
1	Flat head screw	94562d
1	Distance holder	94563
1	Distance holder	94563a
1	Distance holder	94563b
1	Positioning unit	94564
1	HP oil pump	94931
1	Pressure gauge	94932
1	Pressure gauge	94932a
1	Connection piece	94934a
1	HP hose	94935
2	HP hoses	94935a
1	Hydraulic unit	94942

Key to Illustrations:

1	Camshaft	19	Adjusting nut
2	Fuel cam	20	Guide tube
3	Nut	21	Bush
4	Vent screw	22	Screw
5	Cylinder	23	Vent screw
6	Piston	24	Ring piece
7	Shaft	25	Piston supporting plate
8	Gear wheel	26	Piston
9	Camshaft wheel	27	Shaft
10	Waisted bolt		
11	Nut		
12	Withdrawing screw	BN	Limiting groove
13	Spacer	EV	Relief valve
14	Washer	GL	Taphole
15	Fitted bolt	HU	Wooden underlay
16	Stop bolt	HZ	Chain block
17	Lock nut	RS	Round bar
18	Allen screw	SA	Gap

Overview

1.	General	1/25
2.	Repositioning the 1-part fuel cam	2/25
3.	Fitting the 2-part fuel cam	12/25
4.	Removing the 2-part fuel cam	21/25
5.	Removing the camshaft wheel	22/25
6.	Fitting the camshaft wheel	24/25

1. General

1-part fuel cams are shrunk into position on the camshaft by the engine builder. Setting their positioning angle and distance to each other is described in section 2.



Remark : If, however, 1-part fuel cams must be replaced for any reasons, they must be cut and then 2-part fuel cams (i.e. cams with bush) are fitted.

The camshaft must be removed from the supply unit for removing and fitting the fuel cams and gear wheels on the camshaft (see 5552-2). To be able to work appropriately, it is recommended to put the camshaft on suitable pedestals.

Prior to repositioning or fitting the fuel cams, it must be ensured that the fuel cams, bushes and camshaft are absolutely clean and in perfect condition.

HP oil pump (94931) and hydraulic unit (94942) have to be filled with engine oil having a viscosity of SAE30 to SAE40 before starting them up. In exceptional cases hydraulic unit (94942) may be filled with cylinder lubricating oil.



Remark : Pay attention to:
 – General Application Instructions 9403-4 for hydraulic pre-tensioning jacks.

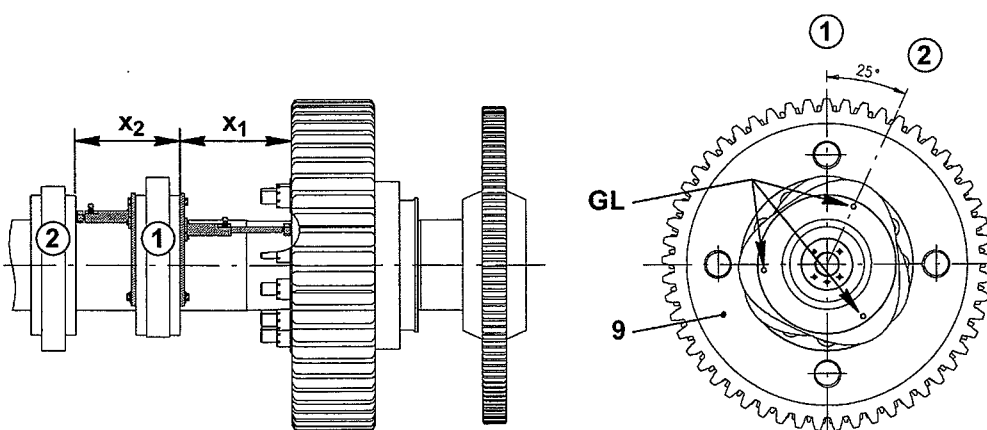
Supply Unit**Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft****2. Repositioning the 1-part fuel cam**

If a 2-part fuel cam has been newly fitted, repositioning of the remaining 1-part fuel cam(s) becomes necessary.

The 1-part fuel cam to be replaced (e.g. No. ①) must be cut and removed from the camshaft. Subsequently the following fuel cam(s) must be shifted accordingly, i.e. by one place towards the camshaft wheel, as the spare 2-part fuel cam is always placed in the last position.

2.1 Numbering, distances and positioning angle of fuel cam

- The numbering starts with fuel cam No. ①, which is next to the camshaft wheel (9).
- Setting of the distances and positioning angles of the fuel cams to each other is carried out with the aid of cam adjusting gear (94562).
The appropriate tool is delivered for each engine.
 - Distance ' x_1 ' = 365 ± 0.2 mm
 - Distance ' x_2 ' = 200 ± 0.2 mm
 - Distance ' x_3 ' = 300 ± 0.2 mm
- The positioning angles of the fuel cams to the camshaft wheel is undefined.
- All fuel cams are identical, independent of the number of cylinders.

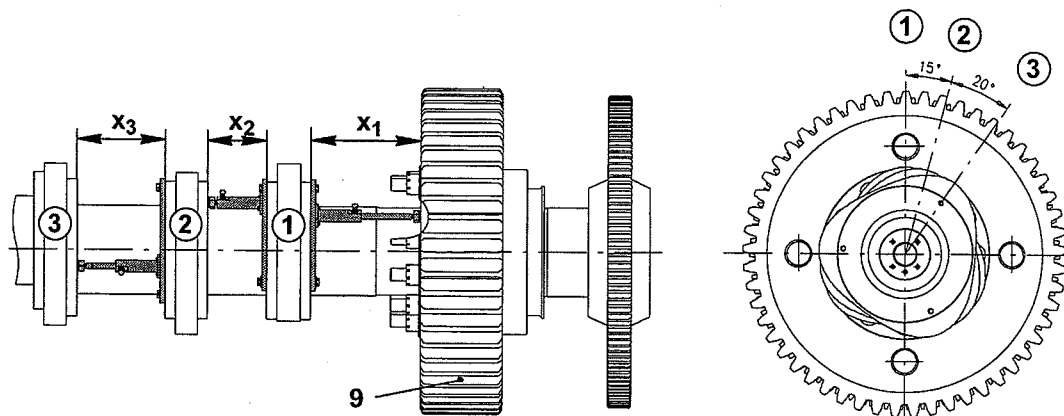
A**6 – 7 CYLINDERS**

Supply Unit

Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

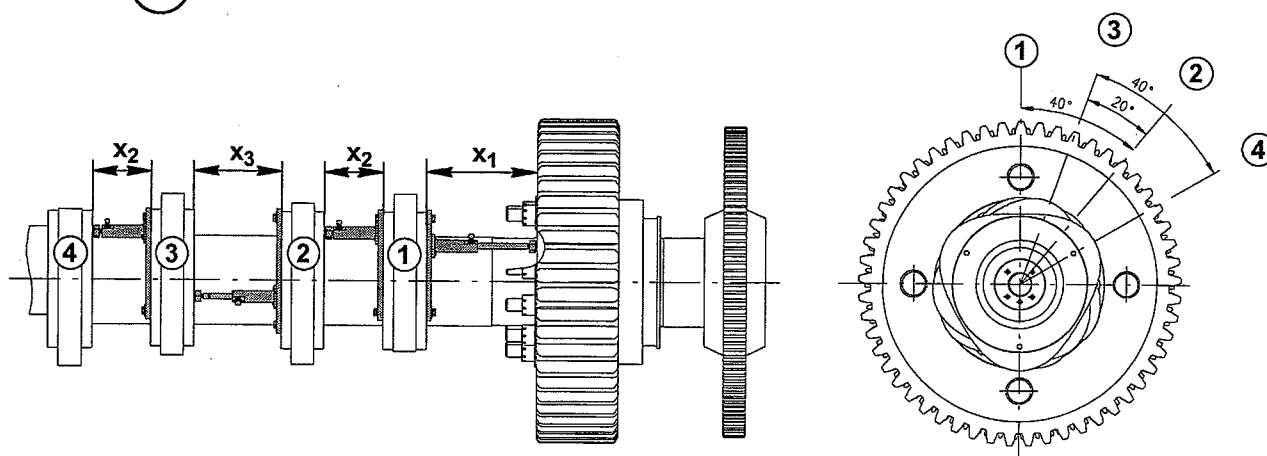
(B)

8 – 10 CYLINDERS



(C)

11 – 14 CYLINDERS

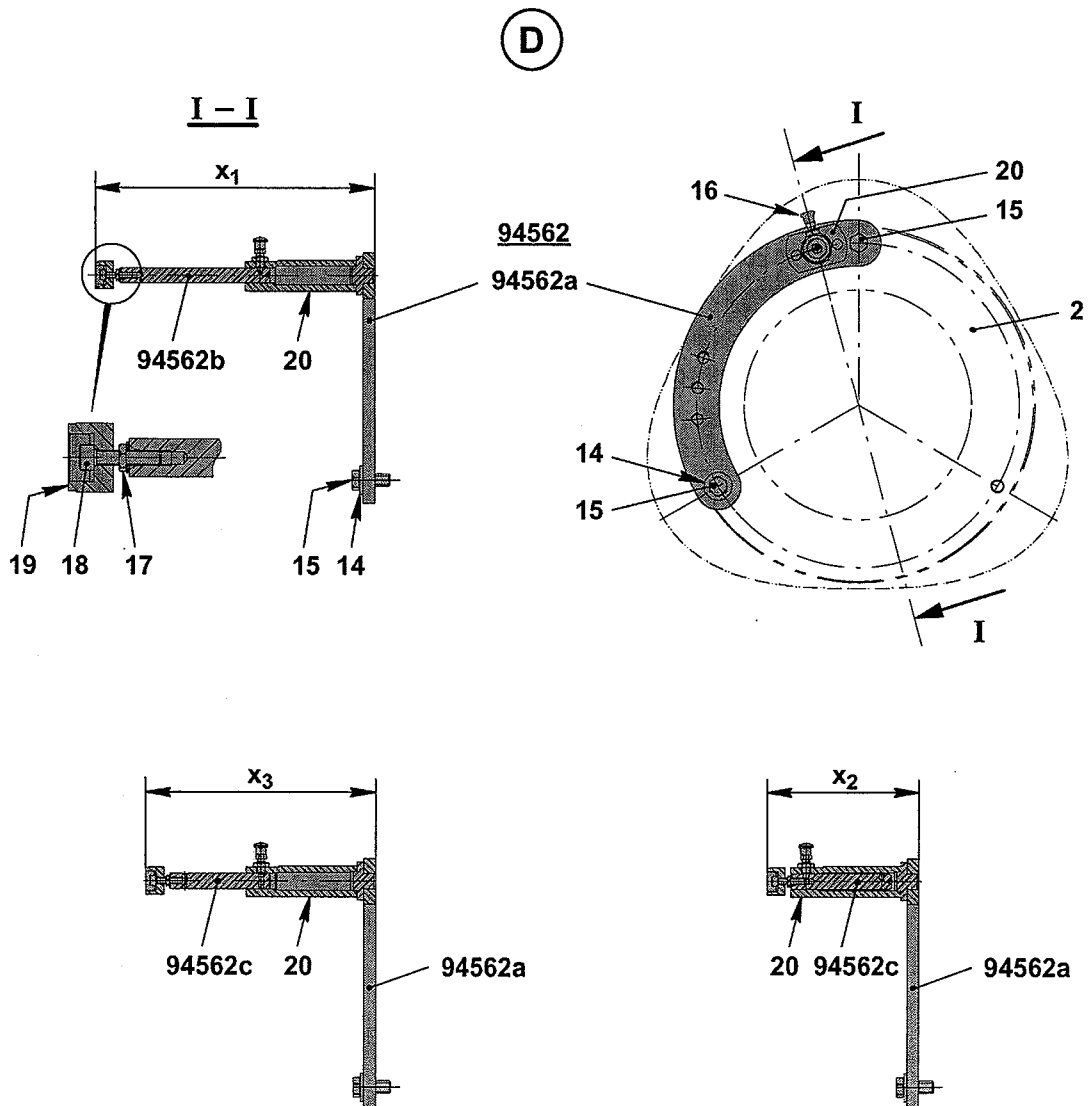


Supply Unit

Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

2.2 Setting the cam adjusting gears

- Distances ' x_1 ', ' x_2 ' and ' x_3 ' (see paragraph 2.1) must be set for cam adjusting gear (94562) using the appropriate regulating shafts as follows:
 - Regulating shaft (94562b) for distance ' x_1 '
 - Regulating shaft (94562c) for distances ' x_2 ' and ' x_3 '.
- ⇒ Lock regulating shaft (94562b) or (94562c) with stop bolt (16) in proper position.
- ⇒ Loosen lock nut (17) and adjust Allen screw (18) correspondingly. For measuring the distance, adjusting nut (19) must be in contact with the head of Allen screw and lock nut tightened.

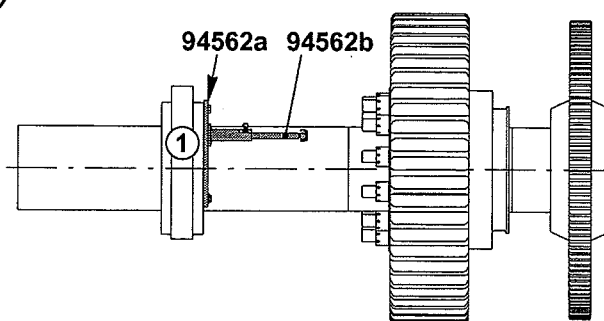


Supply Unit
Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft
2.3 Setting the fuel cam No.①

 **Remark** : The position of fuel cam No.① is identical on all engines.

- Cam adjusting gear must be set to distance ' x_1 ' as described in paragraph 2.2.
- ⇒ Fasten cam adjusting gear (94562) consisting of angle rail (94562a) and regulating shaft (94562b) to the fuel cam using fitted bolts (15) and washer (14) (Fig. 'D').

E

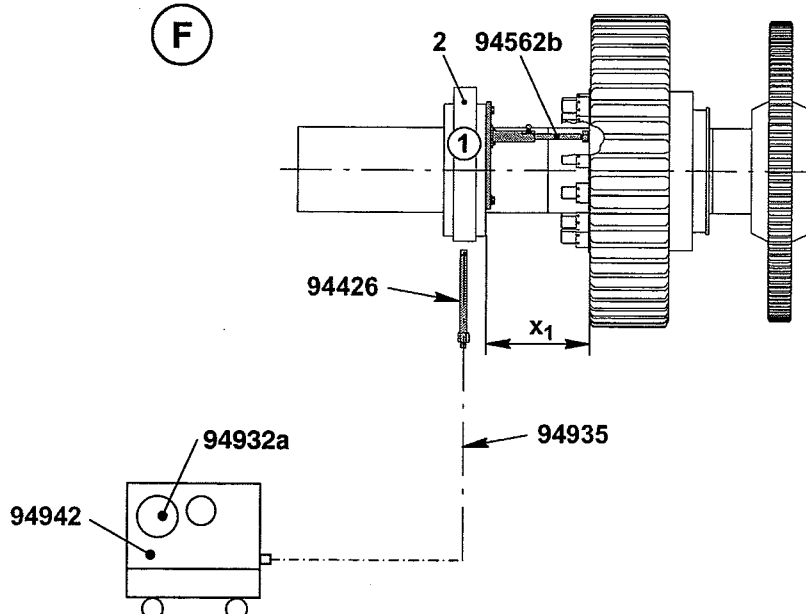


- ⇒ Screw connection piece (94426) into fuel cam (2) and connect it to hydraulic unit (94942) as shown in Fig. 'F'.
- ⇒ Operate the hydraulic unit till oil squeezes out on both sides of the fuel cam on the whole circumference.
- ⇒ Shift the fuel cam till regulating shaft (94562b) touches the flange of the camshaft (Fig. 'F').
- ⇒ Release pressure to zero.

CHECK Check distance ' x_1 ' (see paragraph 2.1).

- ⇒ Remove connection piece (94426) and cam adjusting gear (94562).

F



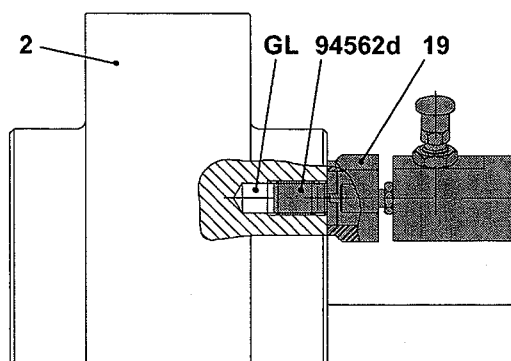
Supply Unit

Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

2.4 Setting the fuel cam No. ② (6 and 7 Cyl. engines)

- Cam adjusting gear must be set to distance ' x_2 ' as described in paragraph 2.2.
- ⇒ Fasten cam adjusting gear (94562) consisting of angle rail (94562a) and regulating shaft (94562c) to fuel cam No. ① using fitted bolts (15) and washer (14) (Fig. 'D' and 'G').
- ⇒ Turn flat head screw (94562d) into one of tapholes "GL" in fuel cam No. ①.
- ⇒ Screw connection piece (94426) into fuel cam (2) and connect it to hydraulic unit (94942) as shown in Fig. 'G'.
- ⇒ Operate the hydraulic unit till oil squeezes out on both sides of the fuel cam on the whole circumference.

II



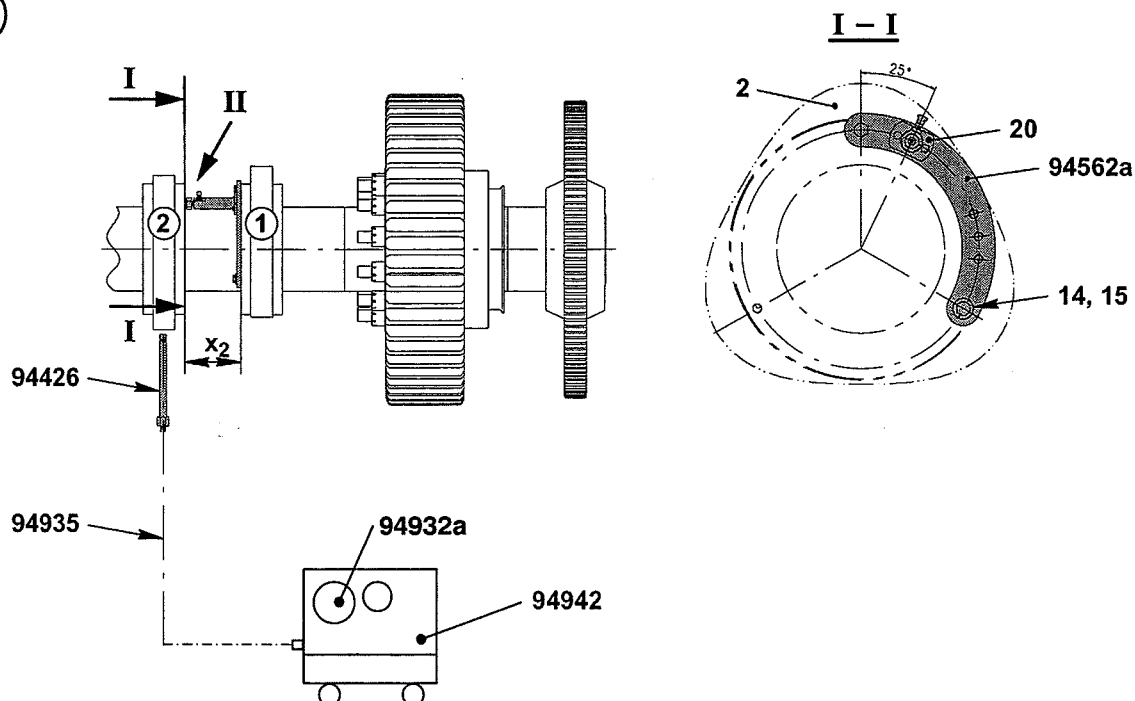
- ⇒ Shift the fuel cam till flat head screw (94562d) rests in adjusting nut (19) (view II).
- ⇒ Release pressure to zero.

CHECK

Check distance ' x_2 ' (see paragraph 2.1).

- ⇒ Remove connection piece (94426), cam adjusting gear (94562) and flat head screw (94562d).

G

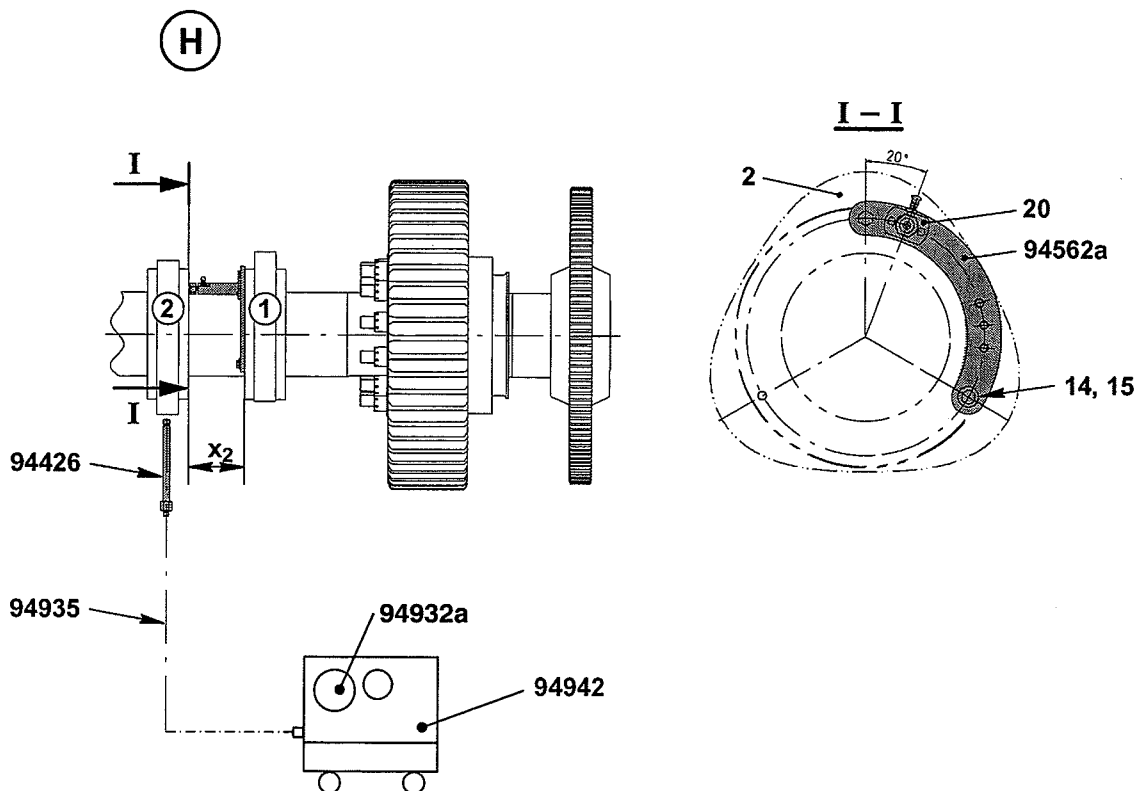


Supply Unit
Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft
2.5 Setting the fuel cam No. ② (8 to 10 Cyl. engines)

- Cam adjusting gear must be set to distance ' x_2 ' as described in paragraph 2.2.
- ⇒ Fasten cam adjusting gear (94562) consisting of angle rail (94562a) and regulating shaft (94562c) to fuel cam No. ① using fitted bolts (15) and washer (14) (Fig. 'D' and 'H').
- ⇒ Turn flat head screw (94562d) into one of tapholes "GL" in fuel cam No. ② as shown in Fig. 'G' view II.
- ⇒ Screw connection piece (94426) into fuel cam (2) and connect it to hydraulic unit (94942) as shown in Fig. 'H'.
- ⇒ Operate the hydraulic unit till oil squeezes out on both sides of the fuel cam on the whole circumference.
- ⇒ Shift the fuel cam till flat head screw (94562d) rests in adjusting nut (19) (Fig. 'G' view II).
- ⇒ Release pressure to zero.

CHECK Check distance ' x_2 ' (see paragraph 2.1).

- ⇒ Remove connection piece 94426, cam adjusting gear (94562) and flat head screw (94562d).



Supply Unit

Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

2.6 Setting the fuel cam No. ② (11 to 14 Cyl. engines)

- Cam adjusting gear must be set to distance ' x_2 ' as described in paragraph 2.2.
- ⇒ Fasten cam adjusting gear (94562) consisting of angle rail (94562a) and regulating shaft (94562c) to fuel cam No. ① using fitted bolts (15) and washer (14) (Fig. 'D' and 'I').



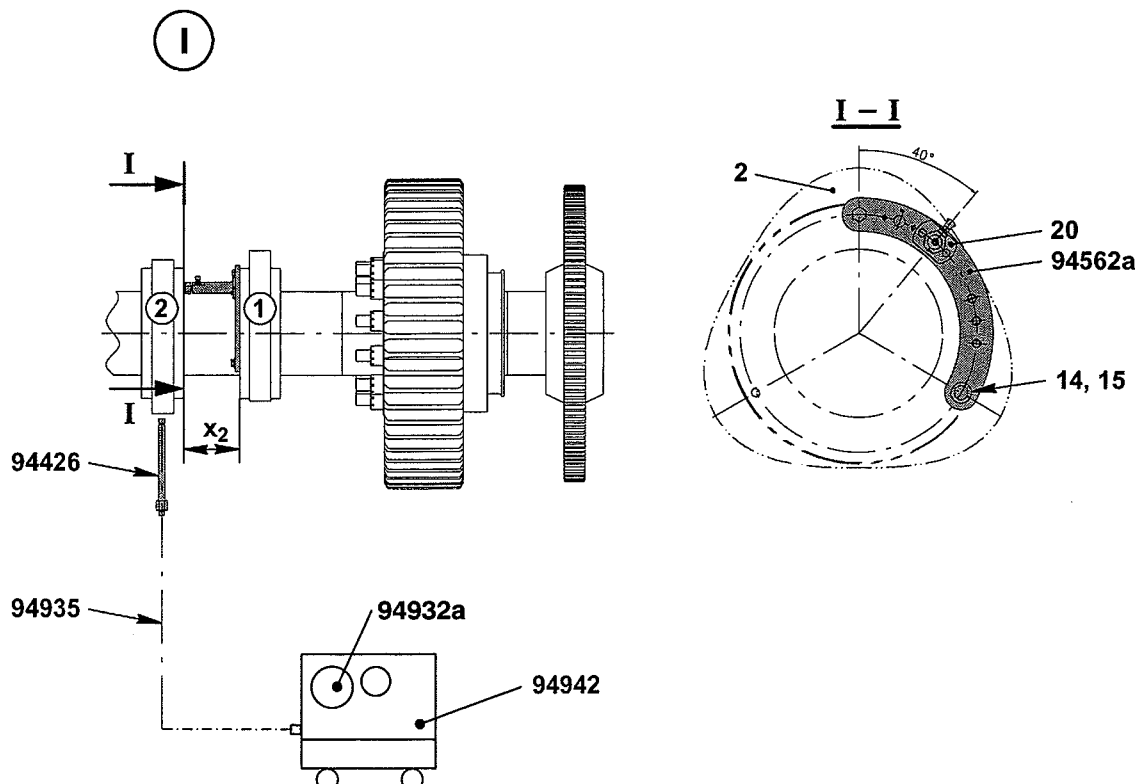
Pay attention that guide tube (20) is fastened at 40° mark of angle rail (94562a).

- Turn flat head screw 94562d into one of tapholes "GL" in fuel cam No. ② as shown in Fig. 'G' view II.
- ⇒ Screw connection piece (94426) into fuel cam (2) and connect it to hydraulic unit (94942) as shown in Fig. 'I'.
- ⇒ Operate the hydraulic unit till oil squeezes out on both sides of the fuel cam on the whole circumference.
- ⇒ Shift the fuel cam till flat head screw (94562d) rests in adjusting nut (19) (Fig. 'G' view II).
- ⇒ Release pressure to zero.

CHECK

Check distance ' x_2 ' (see paragraph 2.1).

- ⇒ Remove connection piece (94426), cam adjusting gear (94562) and flat head screw (94562d).



Supply Unit

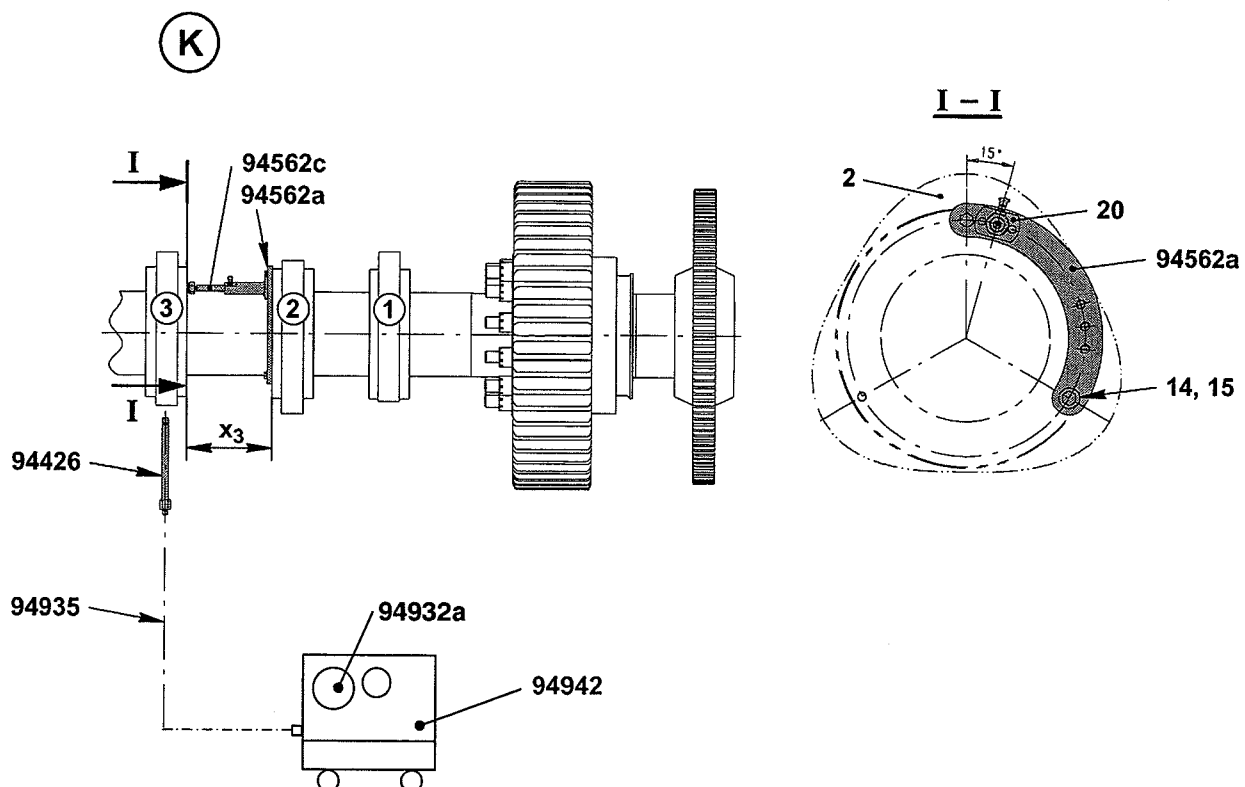
Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

2.7 Setting the fuel cam No. ③ (8 to 10 Cyl. engines)

- Cam adjusting gear must be set to distance ' x_3 ' as described in paragraph 2.2.
- ⇒ Fasten cam adjusting gear (94562) consisting of angle rail (94562a) and regulating shaft (94562c) to fuel cam No. ② using fitted bolts (15) and washer (14) (Fig. 'D' and 'K').
- ⇒ Turn flat head screw (94562d) into one of tapholes "GL" in fuel cam No. ③ as shown in Fig. 'G' view II.
- ⇒ Screw connection piece (94426) into fuel cam (2) and connect it to hydraulic unit (94942) as shown in Fig. 'K'.
- ⇒ Operate the hydraulic unit till oil squeezes out on both sides of the fuel cam on the whole circumference.
- ⇒ Shift the fuel cam till flat head screw (94562d) rests in adjusting nut (19) (Fig. 'G' view II).
- ⇒ Release pressure to zero.

CHECK Check distance ' x_3 ' (see paragraph 2.1).

- ⇒ Remove connection piece (94426), cam adjusting gear (94562) and flat head screw (94562d).



Supply Unit

Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

2.8 Setting the fuel cam No. ③ (11 to 14 Cyl. engines)

- Cam adjusting gear must be set to distance 'x₃' as described in paragraph 2.2.
- ⇒ Fasten cam adjusting gear (94562) consisting of angle rail (94562a) and regulating shaft (94562c) to fuel cam No. ② using fitted bolts (15) and washer (14) (Fig. 'D' and 'L').



Pay attention that guide tube (20) is fastened on the back side of 20° mark of angle rail (94562a).

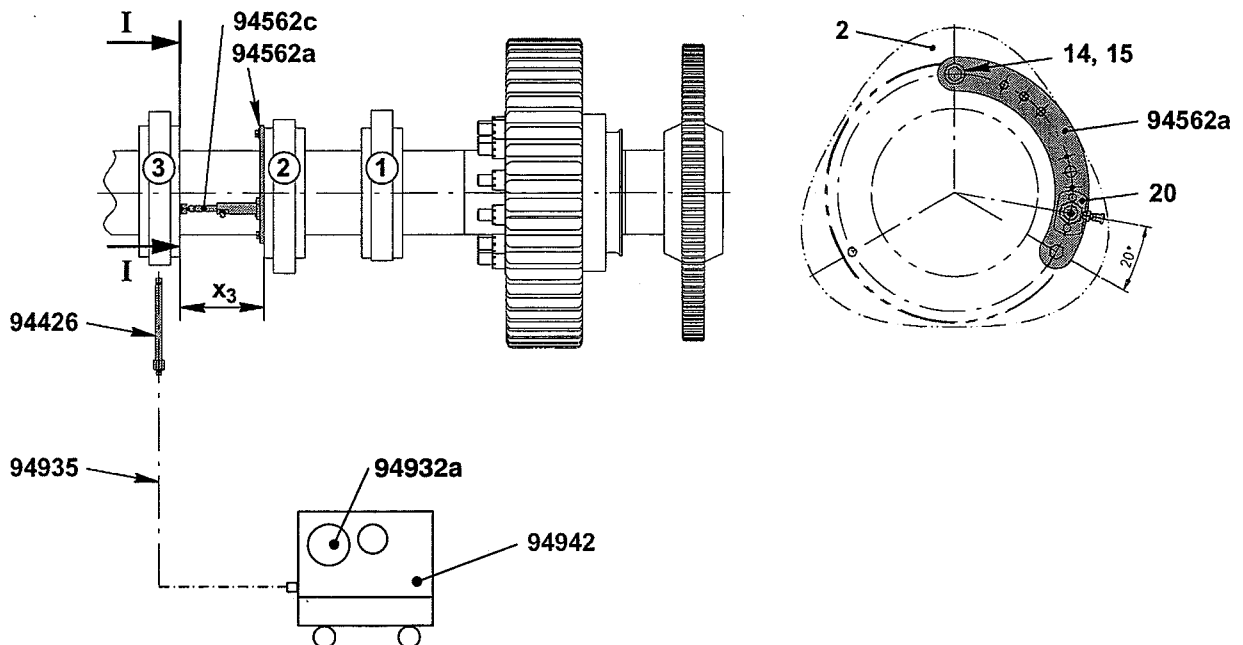
- Turn flat head screw (94562d) into one of tapholes "GL" in fuel cam No. ③ as shown in Fig. 'G' view II.
- ⇒ Screw connection piece (94426) into fuel cam (2) and connect it to hydraulic unit (94942) as shown in Fig. 'L'.
- ⇒ Operate the hydraulic unit till oil squeezes out on both sides of the fuel cam on the whole circumference.
- ⇒ Shift the fuel cam till flat head screw (94562d) rests in adjusting nut (19) (Fig. 'G' view II).
- ⇒ Release pressure to zero.

CHECK

Check distance 'x₃' (see paragraph 2.1).

- ⇒ Remove connection piece (94426), cam adjusting gear (94562) and flat head screw (94562d).

L



Supply Unit
Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft
2.9 Setting the fuel cam No. ④ (11 to 14 Cyl. engines)

- Cam adjusting gear must be set to distance ' x_2 ' as described in paragraph 2.2.
- ⇒ Fasten cam adjusting gear (94562) consisting of angle rail (94562a) and regulating shaft (94562c) to fuel cam No. ③ using fitted bolts (15) and washer (14) (Fig. 'D' and 'M').



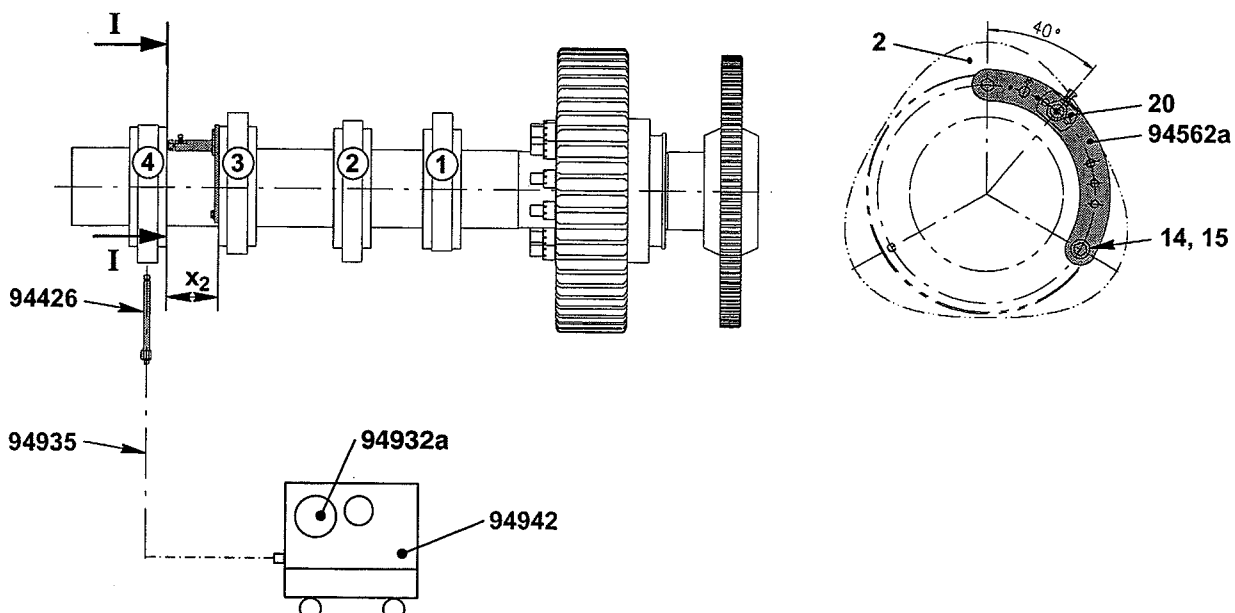
Pay attention that guide tube (20) is fastened at 40° mark of angle rail (94562a).

- Turn flat head screw (94562d) into one of tapholes "GL" in fuel cam No. ④ as shown in Fig. 'G' view II.
- ⇒ Screw connection piece (94426) into fuel cam (2) and connect it to hydraulic unit (94942) as shown in Fig. 'M'.
- ⇒ Operate the hydraulic unit till oil squeezes out on both sides of the fuel cam on the whole circumference.
- ⇒ Shift the fuel cam till flat head screw (94562d) rests in adjusting nut (19) (Fig. 'G' view II).
- ⇒ Release pressure to zero.

CHECK

 Check distance ' x_2 ' (see paragraph 2.1).

- ⇒ Remove connection piece (94426), cam adjusting gear (94562) and flat head screw (94562d).

M


Supply Unit
Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

3. Fitting the 2-part fuel cam

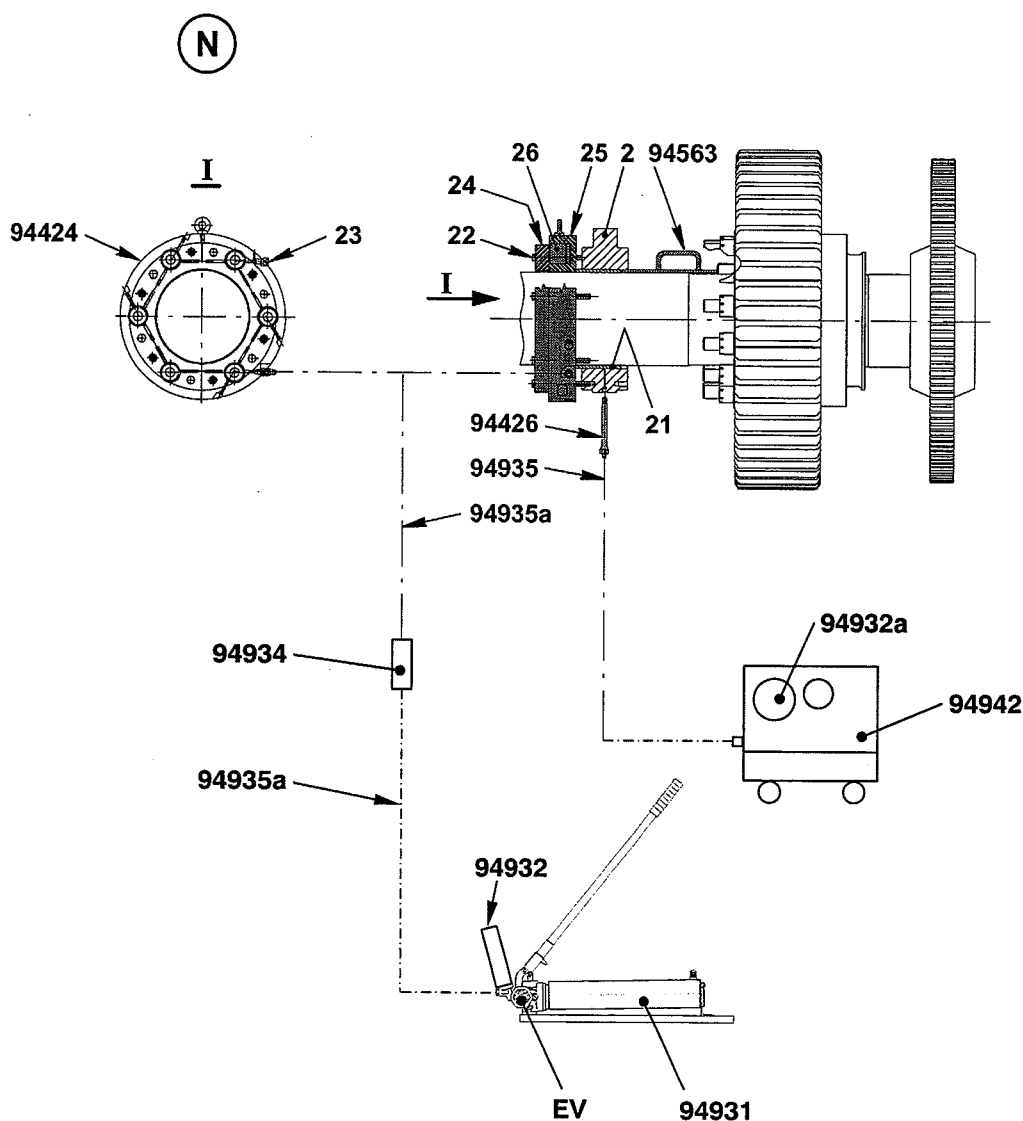
- The numbering, distances 'x₁', 'x₂' and 'x₃' and positioning angles of the 2-part fuel cams (i.e. cam and bush) are identical to the 1-part fuel cams as described in paragraph 2.1.
- Setting the distances of the fuel cams to each other is carried out with the aid of distance holders (94563), (94563a) and (94563b).
- Setting the positioning angles of the fuel cams to each other is carried out with the aid of cam adjusting gear (94562) and positioning unit (94564).


Remark

: A 2-part fuel cam and its bush form one unit and must not be interchanged! If necessary, both parts must therefore be replaced at the same time; moreover they are only supplied together.

Supply Unit
Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft
3.1 Fitting the fuel cam No. ①

- ⇒ Put distance holder (94563) onto the camshaft and push it against the camshaft flange.
- ⇒ Push fuel cam (2) together with bush (21) onto the oiled camshaft till the bush rests on the distance holder.
- ⇒ Push hydr. jacking tool (94424) on bush (21) and fasten it to the fuel cam using six screws (22) as shown in Fig. 'N' (evenly tighten screws slightly by hand only).
- ⇒ Connect the hydr. jacking tool to HP oil pump (94931).
- ⇒ Open vent screw (23) and relief valve "EV".
- ⇒ Tighten screws (22) evenly by hand till ring piece (24) rests on piston supporting plate (25).
- ⇒ Close relief valve "EV".
- ⇒ Screw connection piece (94426) into fuel cam (2) and connect it to hydraulic unit (94942) as shown in Fig. 'N'.



Supply Unit

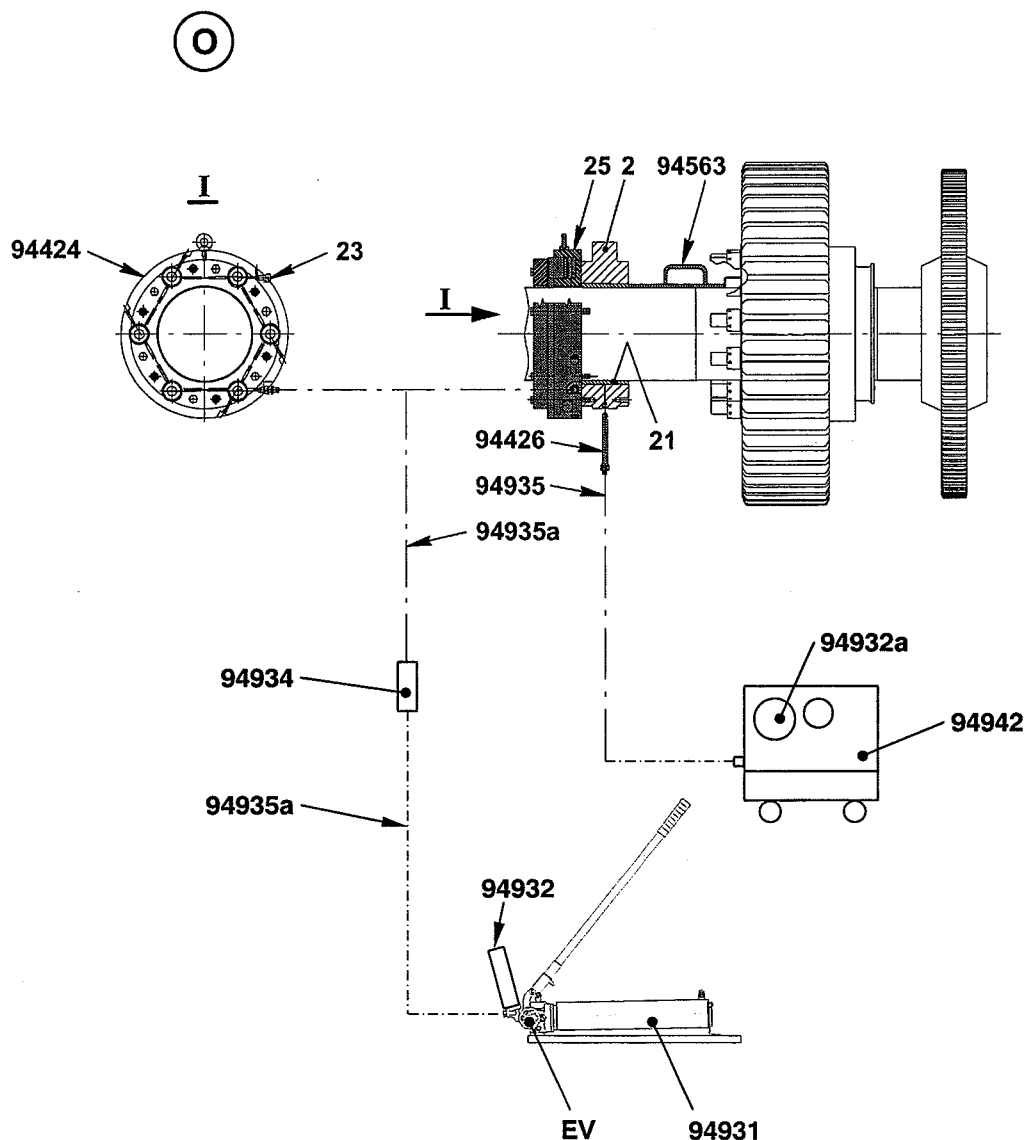
Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

- ⇒ Actuate HP oil pump (94931) till oil flows bubble-free at vent screw (23); then close the latter.
- ⇒ Actuate hydraulic unit (94942), and when oil is squeezing out on the whole circumference between bush (21) and fuel cam (2), operate also the HP oil pump.
- ⇒ Pull the fuel cam onto the bush by means of the HP oil pump while keeping the hydraulic unit running. During this process pay attention that oil is continuously squeezing out between bush and fuel cam.



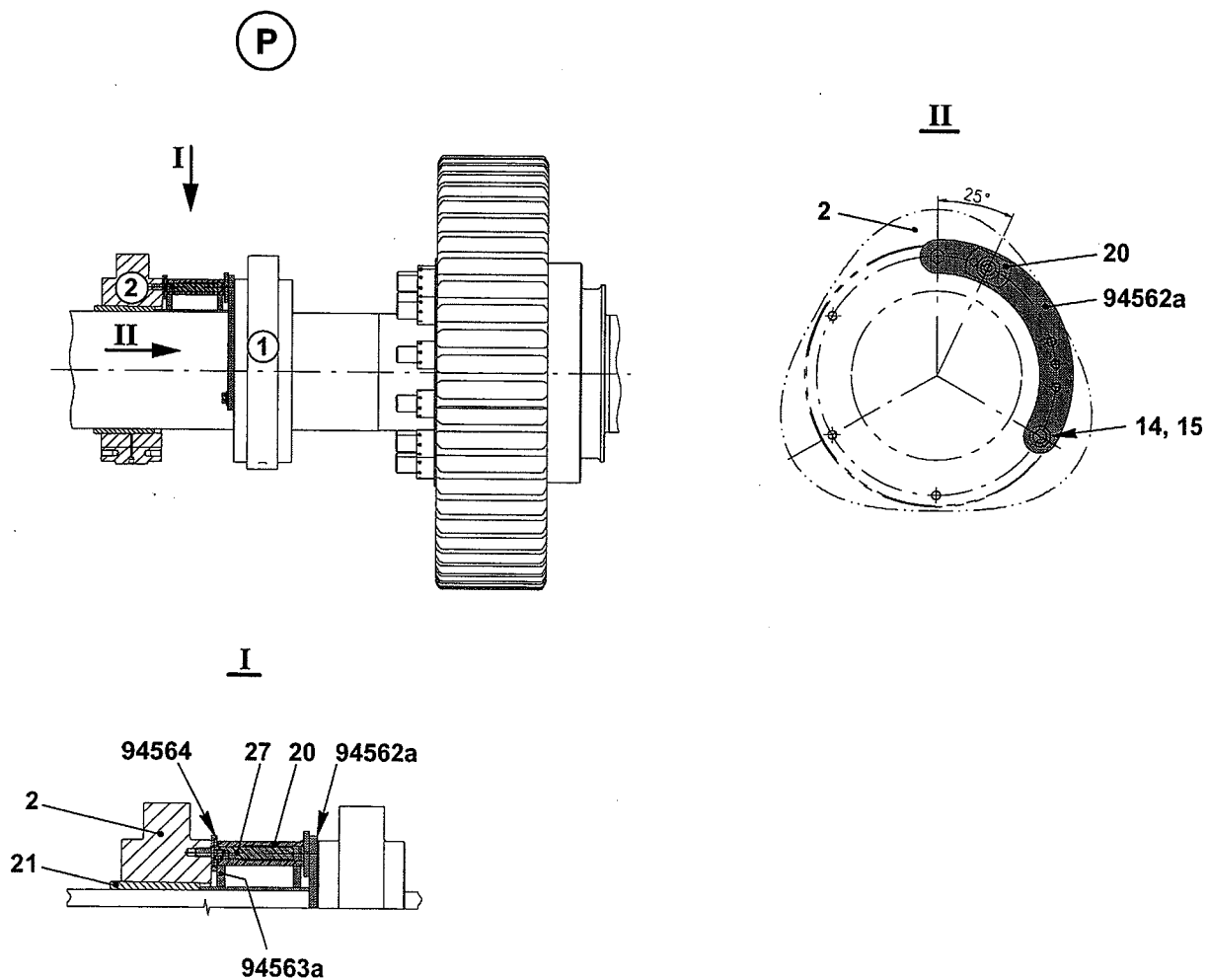
The oil pressure in hydr. jacking tool (94424) may **not exceed 25.0 MPa**.

- ⇒ When the fuel cam is flush with piston supporting plate (25) as shown in Fig. 'O', release the pressure to zero at the hydraulic unit and approx. 30 seconds later also at the HP oil pump.
- ⇒ Remove all tools.



Supply Unit
Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft
3.2 Fitting the fuel cam No. ② (6 and 7 Cyl. engines)
3.2.1 Preparation

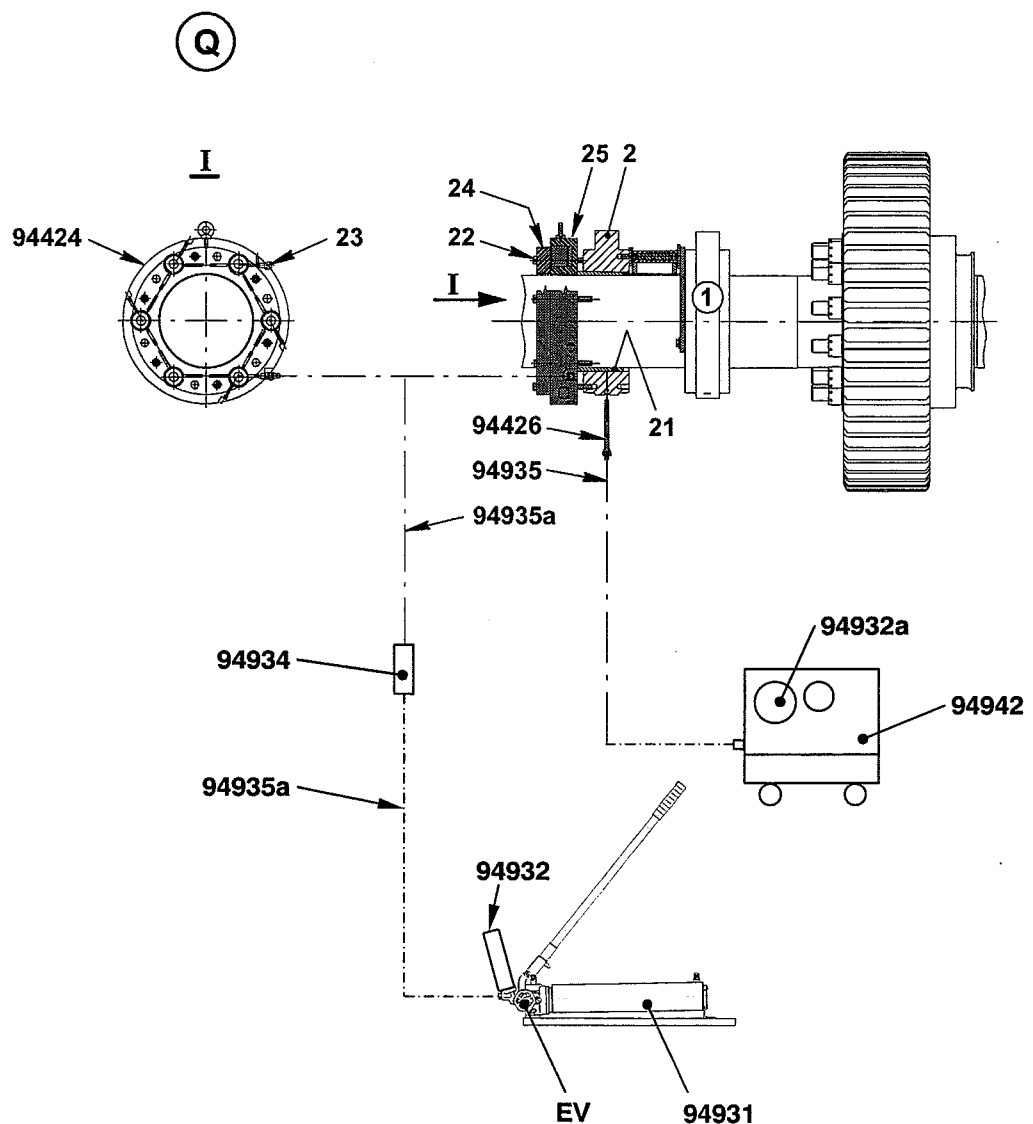
- ⇒ Unscrew stop bolt (16) (Fig. 'D') from guide tube (20) and remove regulating shafts (94562b), (94562c).
- ⇒ Fasten angle rail (94562a) with fitted bolts (15) and washers (14) to fuel cam No. ① as shown in Fig. 'P'.
- ⇒ Push bush (21) together with fuel cam No. ② onto the oiled camshaft.
- ⇒ Complete positioning unit (94564) with its shaft (27) and fit them into one of the three tapholes on the relevant side of fuel cam No. ②.
- ⇒ Put distance holder (94563a) onto the camshaft and push it against fuel cam No. ①.
- ⇒ Push and turn the bush with fuel cam so that shaft (27) meshes in guide tube (20).



Supply Unit

Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

- ⇒ Push fuel cam (2) together with bush (21) onto the oiled camshaft till the bush rests on distance holder (94563a).
- ⇒ Push hydr. jacking tool (94424) on bush (21) and fasten it to the fuel cam using six screws (22) as shown in Fig. 'Q' (evenly tighten screws slightly by hand only).
- ⇒ Connect the hydr. jacking tool to HP oil pump (94931).
- ⇒ Open vent screw (23) and relief valve "EV".
- ⇒ Tighten screws (22) evenly by hand till ring piece (24) rests on piston supporting plate (25).
- ⇒ Close relief valve "EV".
- ⇒ Screw connection piece (94426) into fuel cam (2) and connect it to hydraulic unit (94942) as shown in Fig. 'Q'.



Supply Unit
Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft
3.2.2 Fitting the fuel cam

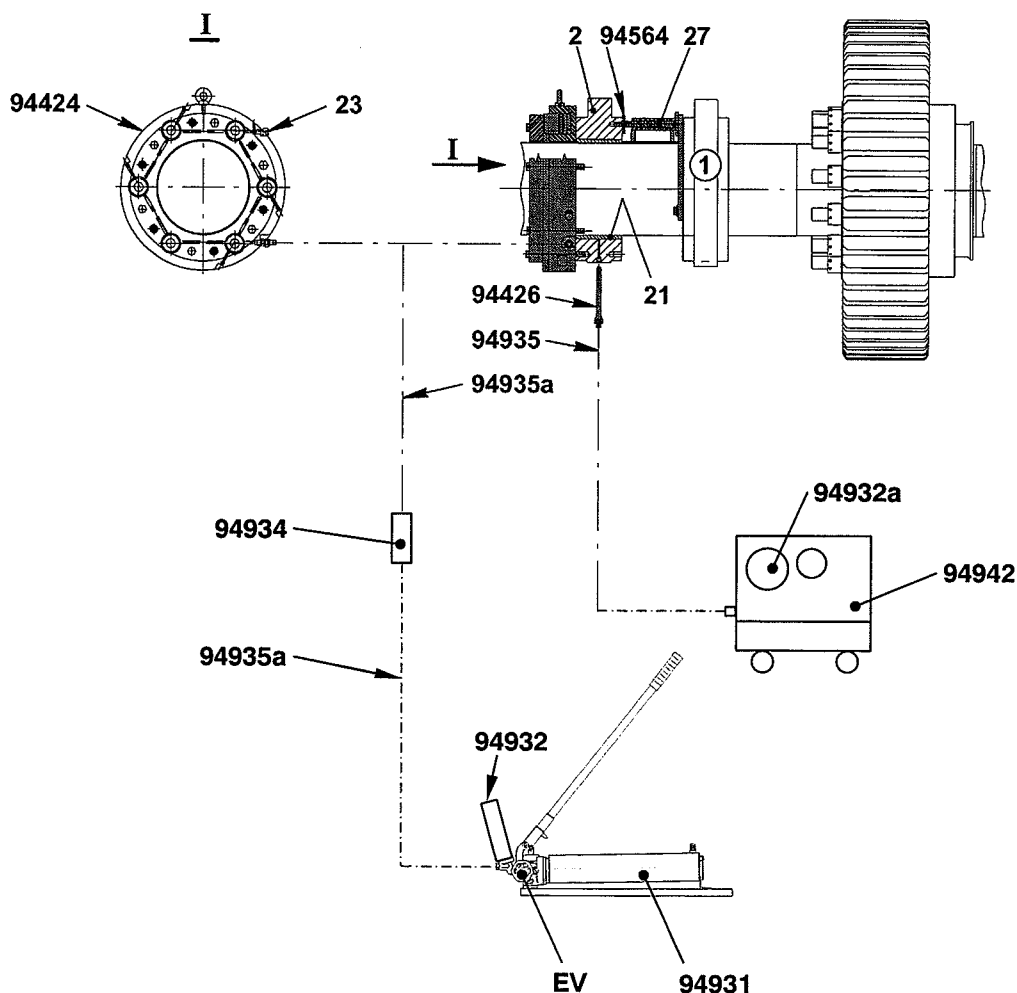
- ⇒ Actuate HP oil pump (94931) till oil flows bubble-free at vent screw (23); then close the latter.
- ⇒ Actuate hydraulic unit (94942), and when oil is squeezing out on the whole circumference between bush (21) and fuel cam (2), operate also the HP oil pump.
- ⇒ Pull the fuel cam onto the bush by means of the HP oil pump while keeping the hydraulic unit running. During this process pay attention that oil is continuously squeezing out between bush and fuel cam.



The oil pressure in hydr. jacking tool (94424) may **not exceed 25.0 MPa**.

- ⇒ When the fuel cam is flush with piston supporting plate (25) as shown in Fig. 'R', release the pressure to zero at the hydraulic unit and approx. 30 seconds later also at the HP oil pump.
- ⇒ Remove shaft (27) from positioning unit (94564) and subsequently remove the angle rail.
- ⇒ Remove all remaining tools.

(R)

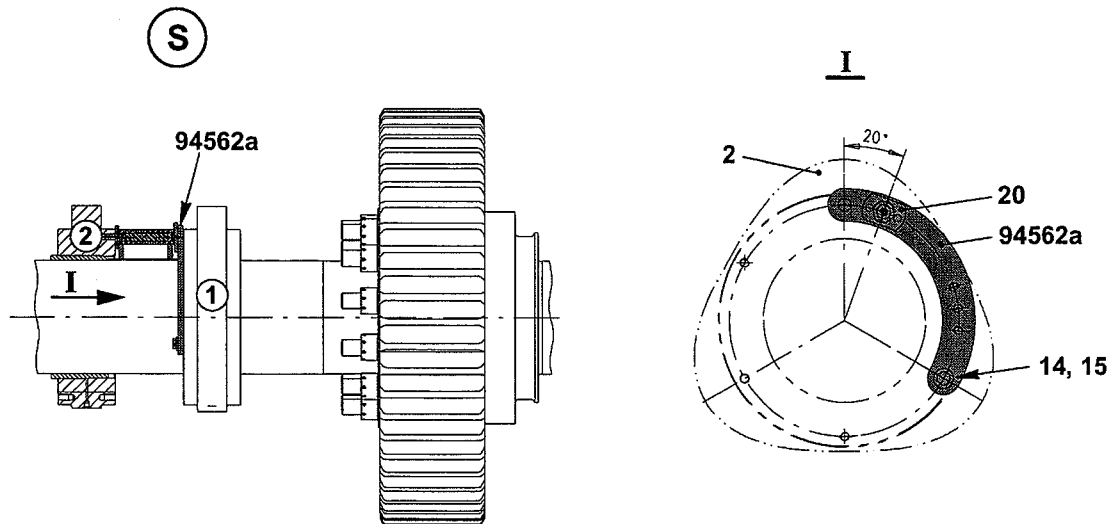


Supply Unit

Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

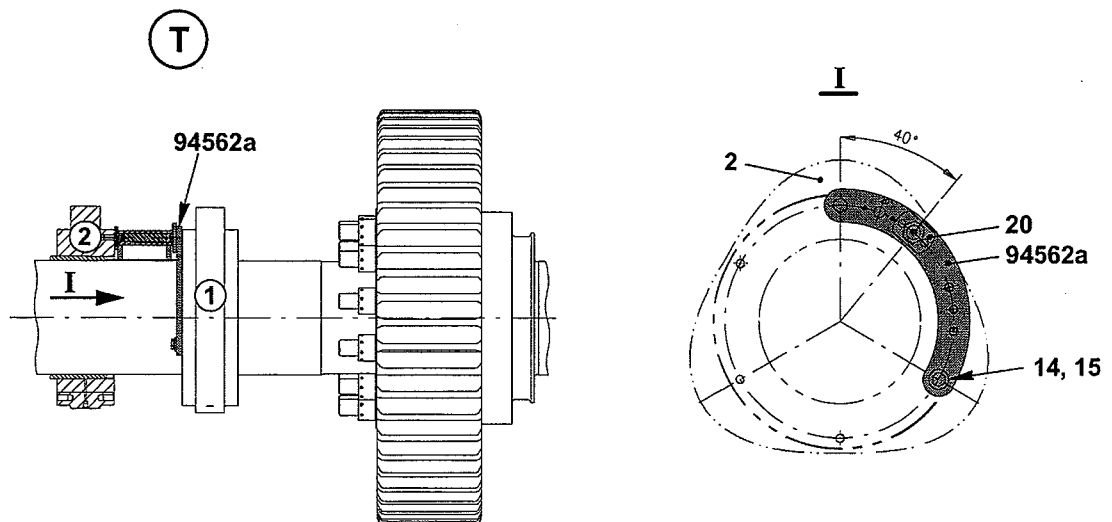
3.3 Fitting the fuel cam No. ② (8 to 10 Cyl. engines)

⇒ The preparation and fitting procedures for fuel cam No. ② are the same as described in paragraphs 3.2.1 and 3.2.2, however, angel rail (94562a) with a turning angle of 20° must be fastened to fuel cam No. ①.



3.4 Fitting the fuel cam No. ② (11 to 14 Cyl. engines)

⇒ The preparation and fitting procedures for fuel cam No. ② are the same as described in paragraphs 3.2.1 and 3.2.2, however, angel rail (94562a) with a turning angle of 40° must be fastened to fuel cam No. ①.

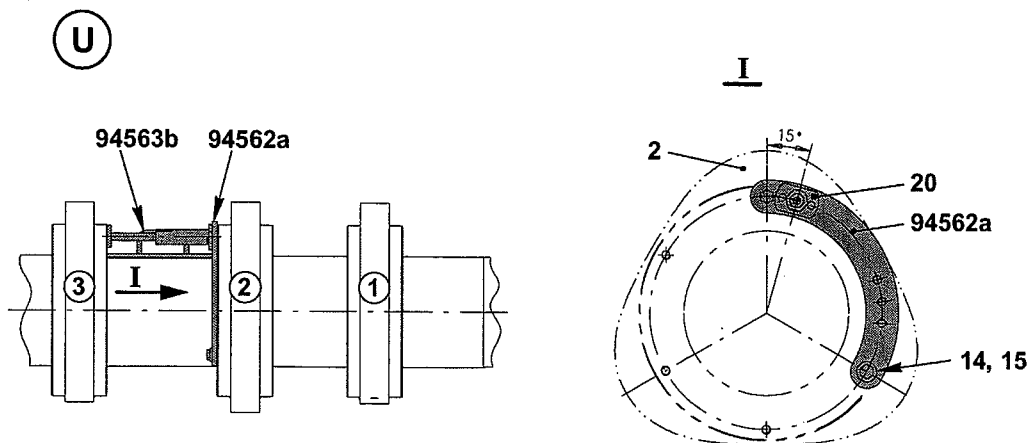


Supply Unit

Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

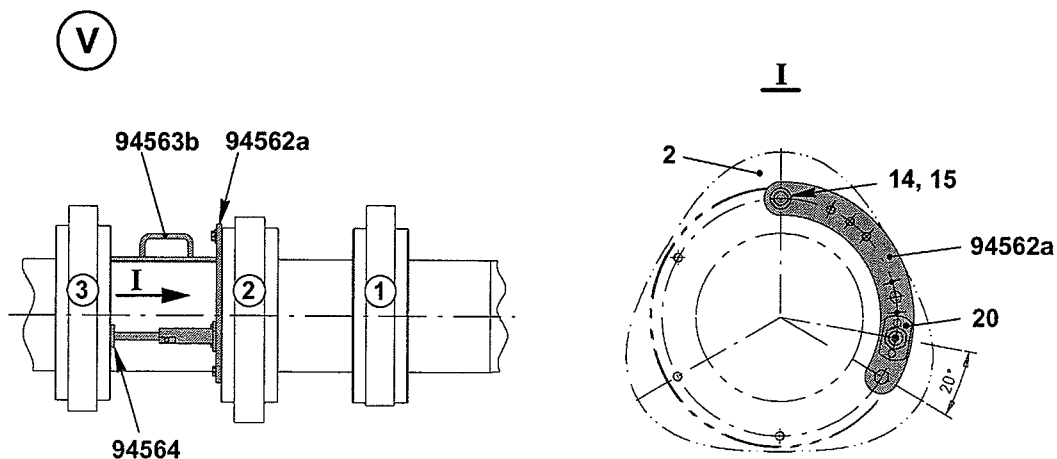
3.5 Fitting the fuel cam No.③ (8 to 10 Cyl. engines)

- ⇒ The preparation and fitting procedures for fuel cam No.③ are the same as described in paragraphs 3.2.1 and 3.2.2, however, angel rail (94562a) with a turning angle of 15° must be fastened to, and distance holder (94563b) must be pushed against fuel cam No.②.



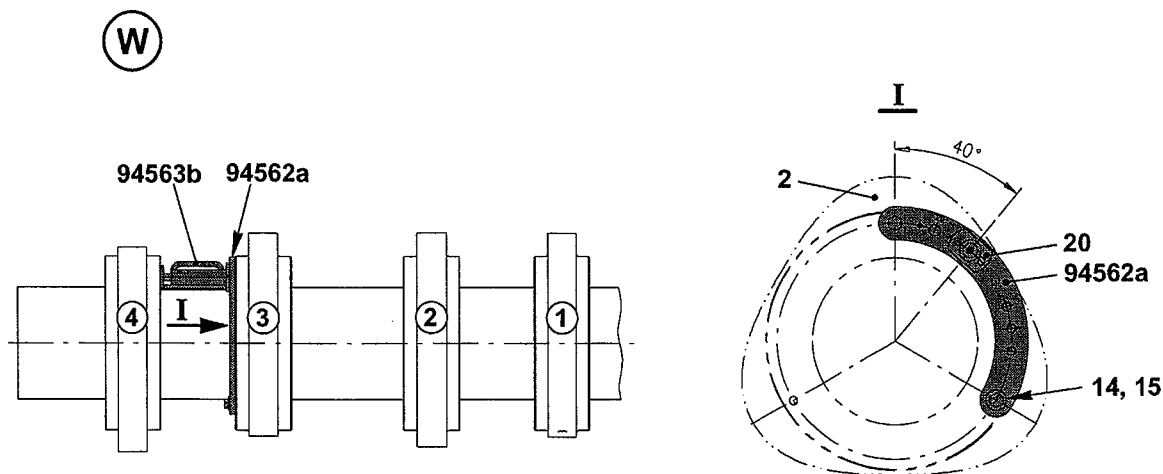
3.6 Fitting the fuel cam No.③ (11 to 14 Cyl. engines)

- ⇒ The preparation and fitting procedures for fuel cam No.③ are the same as described in paragraphs 3.2.1 and 3.2.2, however, guide tube (20) is fastened on the back side of 20° mark of angle rail (94562a) and distance holder (94563b) is pushed against fuel cam No.②.



Supply Unit**Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft****3.7 Fitting the fuel cam No. ④ (11 to 14 Cyl. engines)**

⇒ The preparation and fitting procedures for fuel cam No. ④ are the same as described in paragraphs 3.2.1 and 3.2.2, however, guide tube (20) is fastened at 40° mark of angle rail (94562a).



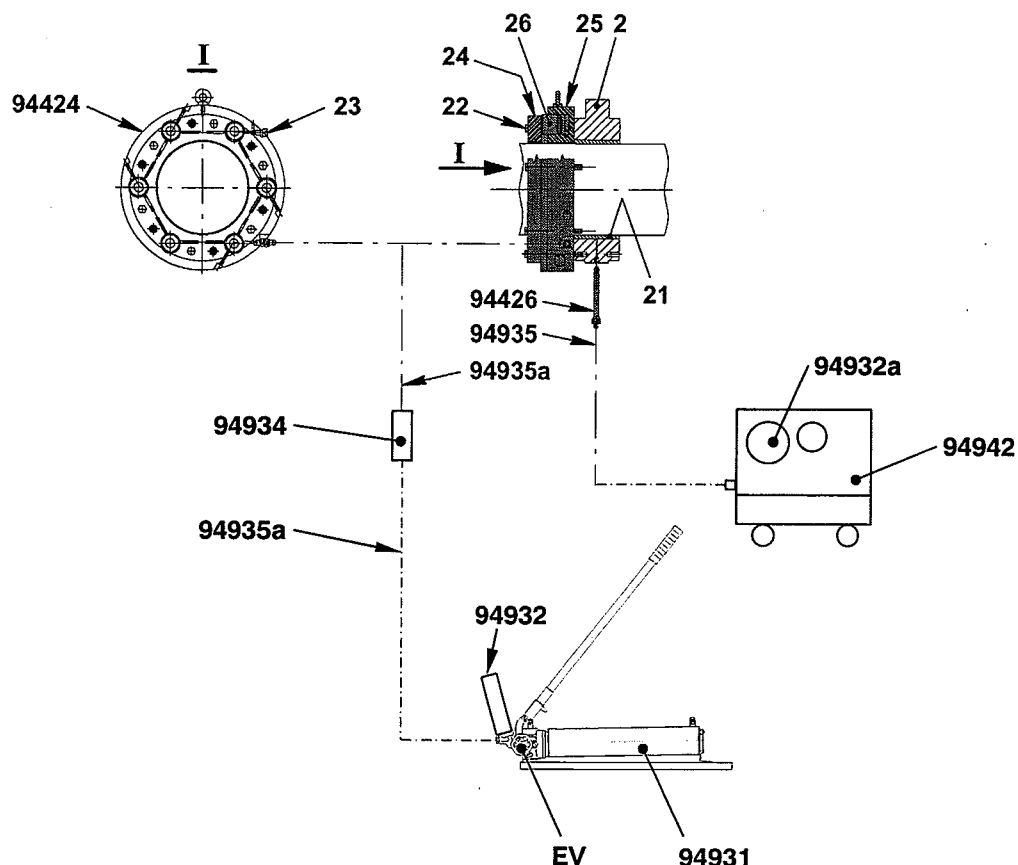
Supply Unit
Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft
4. Removing the 2-part fuel cam

- ⇒ Screw connection piece (94426) into fuel cam (2) to be removed and connect it to hydraulic unit (94942) as shown in Fig. 'X'.
- ⇒ Push hydr. jacking tool (94424) on fuel cam and fasten it using six screws (22) (evenly tighten screws slightly by hand only).
- ⇒ Connect the hydr. jacking tool to HP oil pump (94931).
- ⇒ Close relief valve "EV" and open vent screw (23).
- ⇒ Actuate HP oil pump (94931) and close the vent screw as soon as oil flows bubble-free, and continue pumping till all pistons (26) are drawn out.
- ⇒ Evenly tighten screws (22).



The following order of actuating HP oil pump and hydraulic unit **must** be followed!
 The oil pressure in the hydr. jacking tool (94424) may **not exceed 25.0 MPa**.

- ⇒ Actuate HP oil pump (94931) till the pressure in the hydr. jacking tool reaches approx. 9.0 MPa.
- ⇒ Actuate hydraulic unit (94942) till oil is squeezing out on the whole circumference between bush (21) and fuel cam (2). While keeping the hydraulic unit running, the oil pressure in the hydr. jacking tool may slowly be reduced with relief valve "EV" at HP oil pump (94931), whereupon the fuel cam will loosen.
- ⇒ Dismantle all tools and remove bush and fuel cam.



Supply Unit

Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

5. Removing the camshaft wheel

Prior to dismantling camshaft wheel (9), waisted bolts (10) must be loosened and shaft (7) with gear wheel (8) removed.

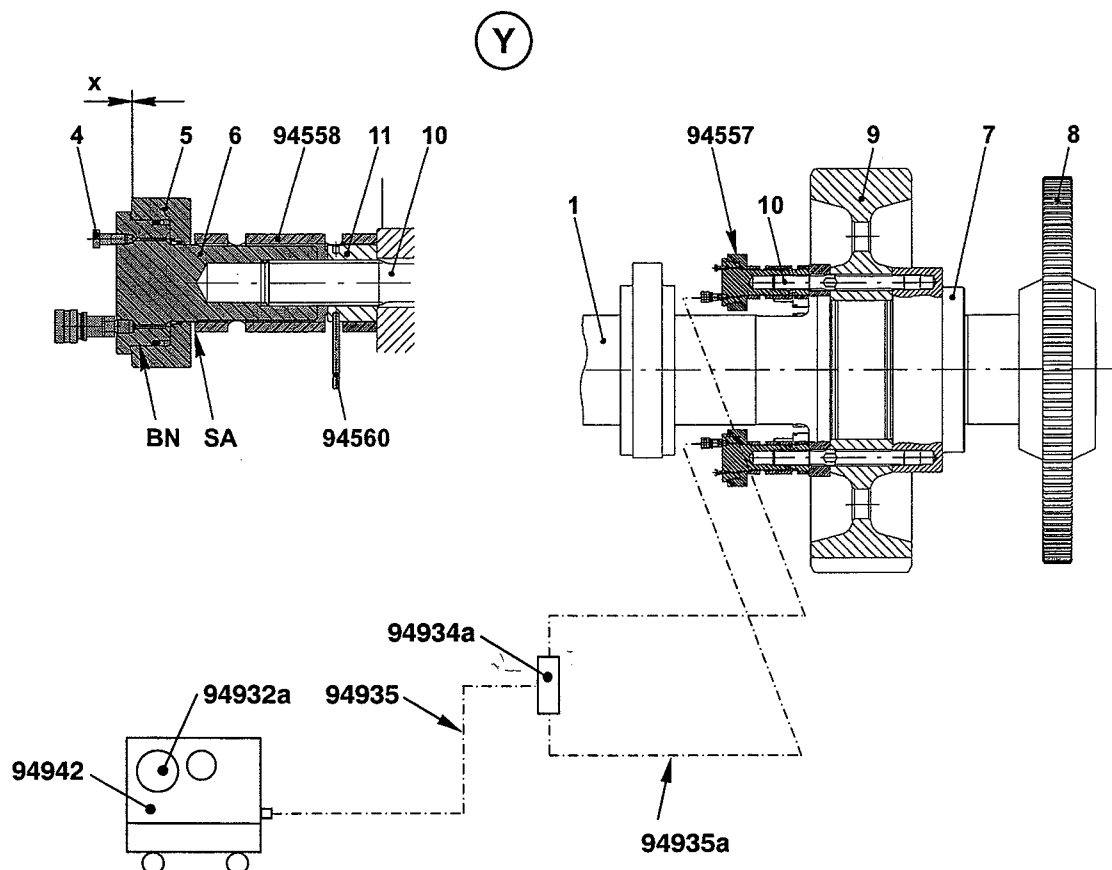
5.1 Loosening the waisted bolts

- ⇒ Clean the threads of waisted bolts (10) and the areas around nuts (11) and oil the threads.
- ⇒ Put sleeves (94558) over the nuts.
- ⇒ With vent screws (4) open, screw pre-tensioning jacks (94557) on waisted bolts till they seat on the sleeves and there is little or no clearance at 'x'.
- ⇒ Unscrew the pre-tensioning jacks by 1½ turns (gap "SA" in Fig. 'Y').
- ⇒ Connect the pre-tensioning jacks to hydraulic unit (94942) as shown in Fig. 'Y'.
- ⇒ Actuate hydraulic unit, and close vent screws as soon as oil flows bubble-free.
- ⇒ Operate the hydraulic unit till a pressure of approx. **103 MPa** is reached.



Pistons (6) of the pre-tensioning jacks must **never** exceed the red limiting grooves "BN".

- ⇒ Turn back nuts (11) with round bar (94560) till they are almost touching the pistons of the pre-tensioning jacks.
- ⇒ Release pressure to zero and remove the pre-tensioning jacks and sleeves.



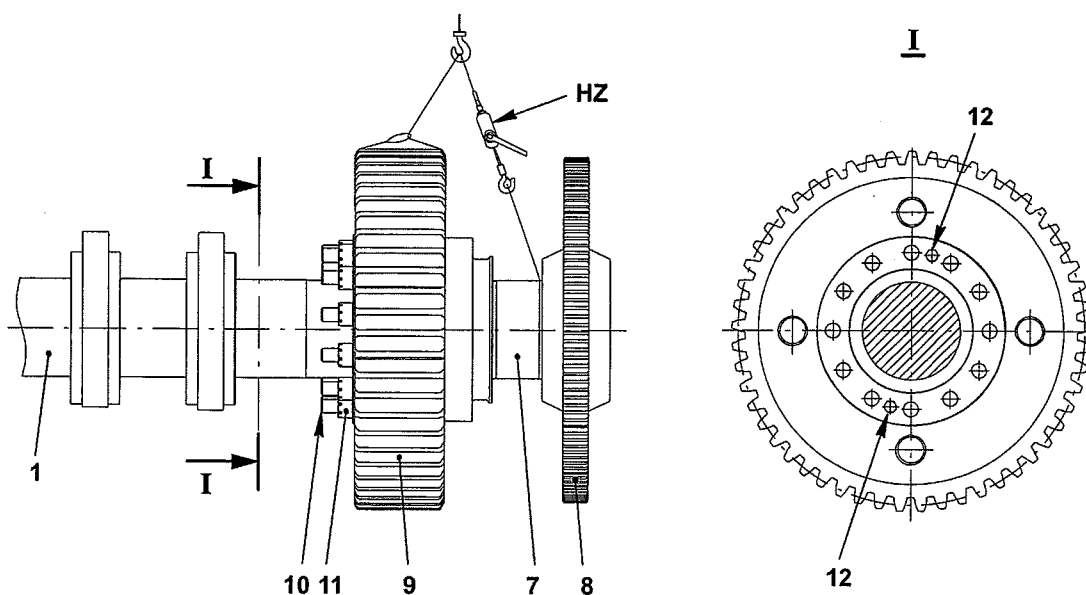
Supply Unit

Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

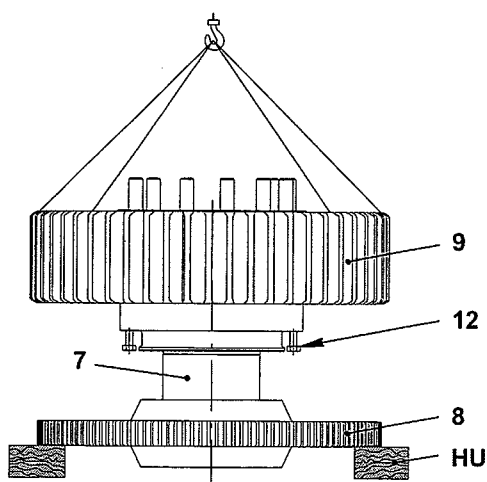
5.2 Removing the camshaft wheel

- ⇒ Connect shaft (7) and camshaft wheel (9) with the crane and chain block "HZ" as shown in Fig. 'Z'.
- ⇒ Remove nuts (11).
- ⇒ Turn withdrawing screws (12) (M16) into the flange of camshaft (1) in order to loosen and separate the camshaft wheel.
- ⇒ Carry away the whole unit (consisting of camshaft wheel (9), shaft (7) and gear wheel (8)) by means of the crane.

Z



A₁



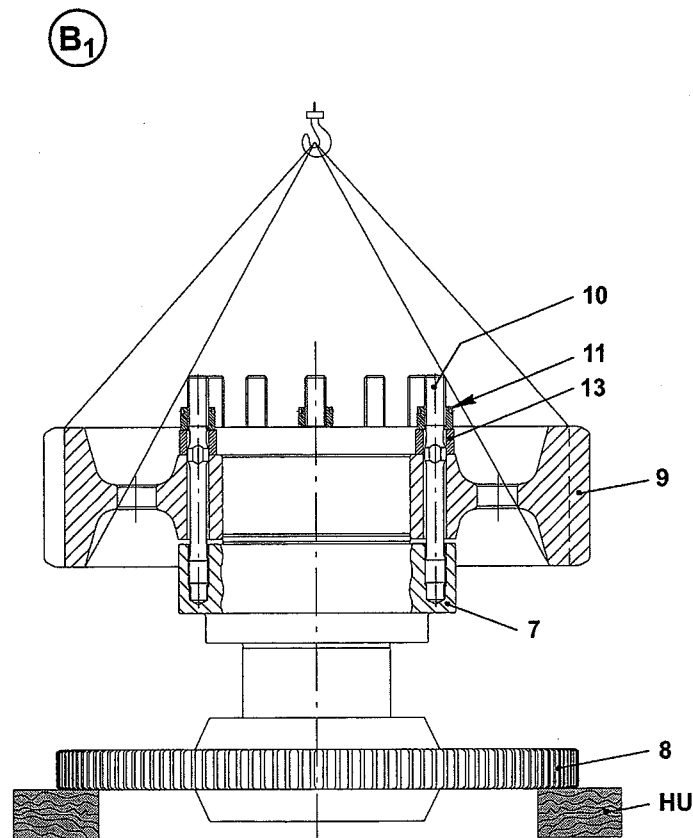
- ⇒ Hold camshaft wheel (9) with two nuts (11) (Fig. 'Z') provisionally on the shaft (7).
- ⇒ Place the unit on wooden underlays "HU".
- ⇒ Remove nuts (11).
- ⇒ Turn withdrawing screws (12) (M16) into the flange of shaft (7) in order to loosen and separate the camshaft wheel.
- ⇒ Lift and move the camshaft wheel away.

Supply Unit

Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

6. Fitting the camshaft wheel

- ⇒ Lower camshaft wheel (9) over the flange of shaft (7).
- ⇒ Clean and oil the threads of waisted bolts (10).
- ⇒ Equally press camshaft wheel into the flange of shaft (7) by means of spacers (13) and nuts (11) (Fig. 'B₁').
- ⇒ Hang the unit consisting of camshaft wheel, shaft and gear wheel (8) on the crane as shown in Fig. 'Z'.
- ⇒ Remove the spacers and nuts.
- ⇒ Fit the unit onto the camshaft and tighten it with nuts (11).



Supply Unit

Removing and Fitting the Fuel Cams and Gear Wheels on Camshaft

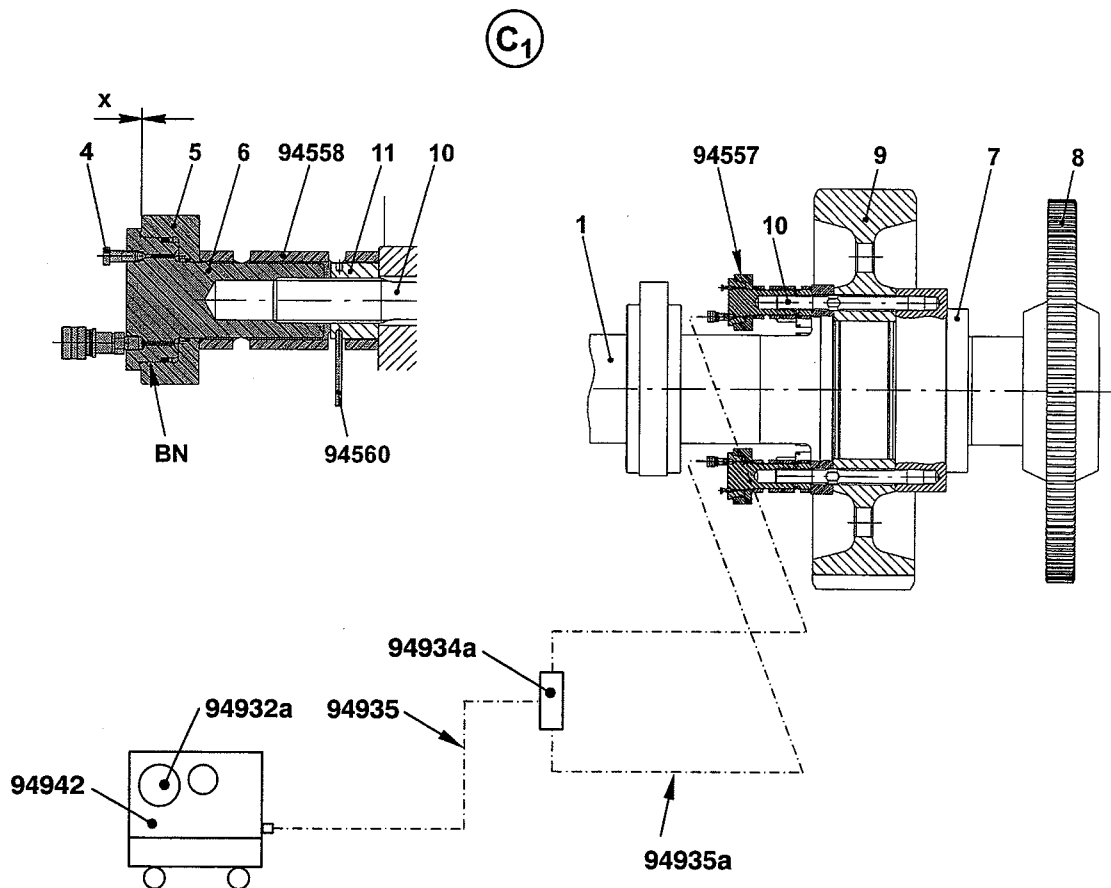
6.1 Tensioning the waisted bolts

- ⇒ Clean the areas around nuts (11).
- ⇒ Put sleeves (94558) over the nuts.
- ⇒ With vent screws (4) open, screw pre-tensioning jacks (94557) on waisted bolts (10) till they seat on the sleeves and there is little or no clearance at 'x'.
- ⇒ Connect the pre-tensioning jacks to hydraulic unit (94942) as shown in Fig. 'C₁'.
- ⇒ Actuate hydraulic unit, and close vent screws as soon as oil flows bubble-free.
- ⇒ Operate the hydraulic unit till a pressure of **100 MPa** is reached.



Pistons (6) of the pre-tensioning jacks must **never** exceed the red limiting grooves "BN".

- ⇒ Keep pressure constant and tighten nuts (11) with round bar (94560) till firmly seated.
- ⇒ Release pressure to zero and remove the pre-tensioning jacks and sleeves.



Supply Unit

Removal and Fitting of Intermediate Wheel to Camshaft

Tools:

1	Feeler gauge	94122
2	Pre-tensioning jacks	94556
1	Assembly template	94567
1	Pipe	94567a
1	Rail	94571
2	Screws	94571a
2	Washers	94571b
1	Carriage	94571c
8	Screws	94571d
1	Pressure gauge	94932a
1	Connection piece	94934a
1	HP hose	94935
2	HP hoses	94935a
1	Hydraulic unit	94942

Key to Illustrations:

1	Intermediate wheel	18	Pin
2	Housing	19	Bearing cover
3	Intermediate shaft	20	Jack
4	Cover	21	Lower bearing shell
5	Screw plug	21a	Upper bearing shell
6	Screw	22	Locating pin
7	Spray nozzle	23	Locating pin
8	Housing	24	Thrust bearing ring halves
9	Screw	25	Bearing pin
10	Bush		
11	Screw	AF	Seating face
12	Securing bolt	BO	Bore
13	Waisted bolt	HU	Wooden underlay
14	Nut	RC	Eye bolt M10
15	Vent screw	RS	Round bar
16	Cylinder	SA	Gap
17	Piston	ZA	Pin

Overview

1.	General	1/9
2.	Removal of housing with intermediate wheel	2/9
3.	Removal of bearing shell and intermediate wheel	6/9
4.	Fitting bearing shell and intermediate wheel	7/9
5.	Fitting housing with intermediate wheel	9/9

1. General

Removing intermediate wheel (1) is only possible after the camshaft has been removed too (see 5552-2).

The intermediate wheel must be removed together with its housing. After that the intermediate wheel itself can be removed.

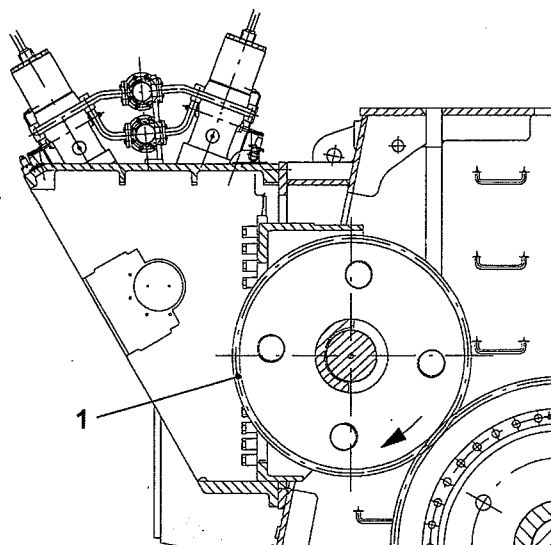


Remark

: Pay attention to:

- General Application Instructions 9403-4 for hydraulic pre-tensioning jacks.

A

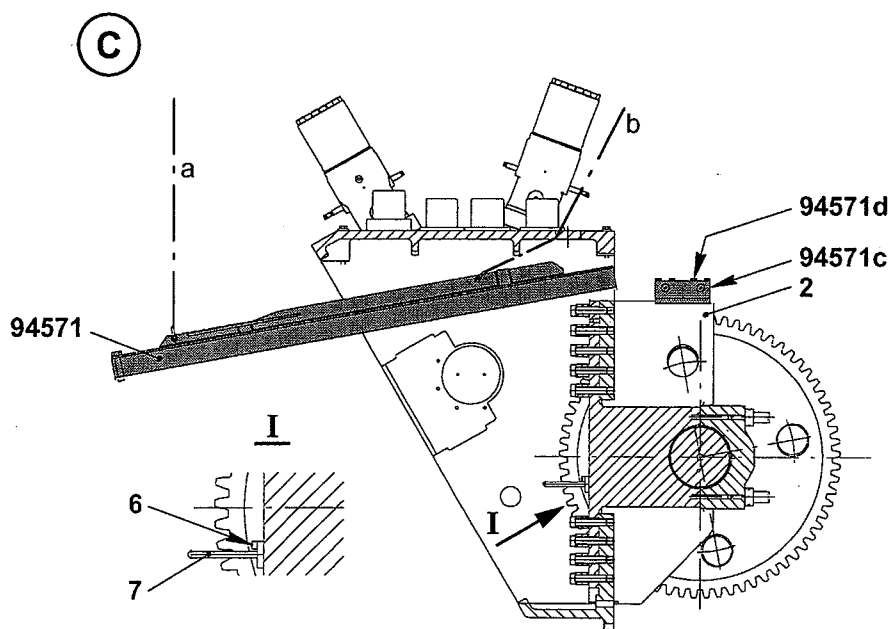
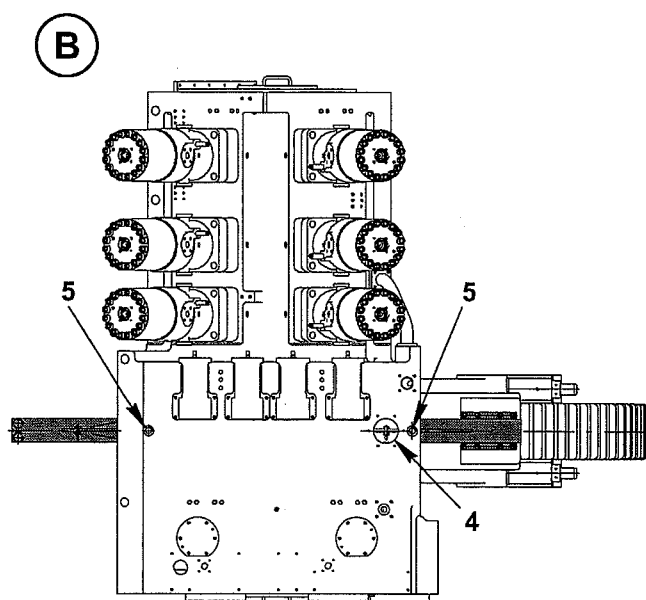


Supply Unit

Removal and Fitting of Intermediate Wheel to Camshaft

2. Removal of housing with intermediate wheel

- ⇒ Remove cover (4) and screw plugs (5) (Fig. 'B').
- ⇒ Loosen screws (6) and remove spray nozzle (7).
- ⇒ Fasten carriage (94571c) with screws (94571d) to housing (2).
- ⇒ Connect rail (94571) to ropes 'a', 'b' and chain blocks. Rope 'b' is guided through the opening which appears after removing cover (4).
- ⇒ Insert rail into carriage (94571c) according to Fig. 'C' and 'D'.



Supply Unit

Removal and Fitting of Intermediate Wheel to Camshaft

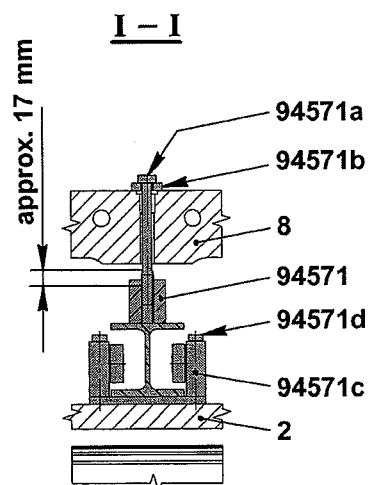
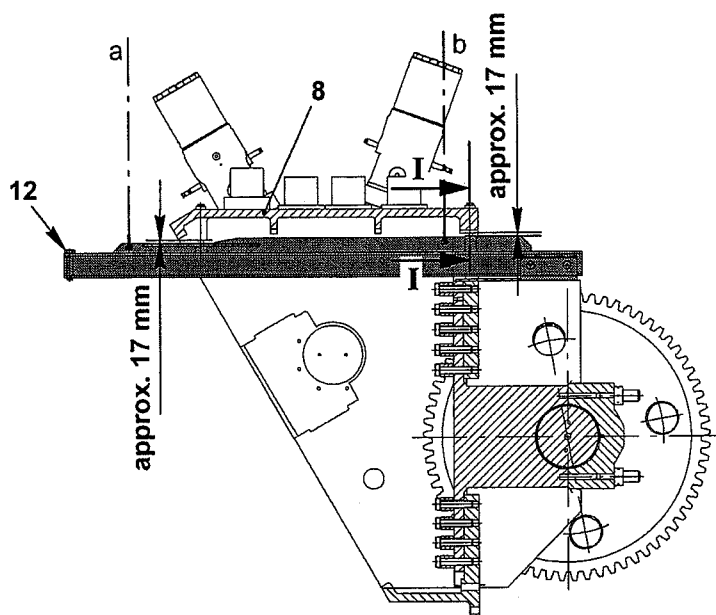
- ⇒ Instead of screw plugs (5) (Fig. 'B'), insert screws (94571a) with washers (94571b) into housing (8) and fasten them to rail (94571).



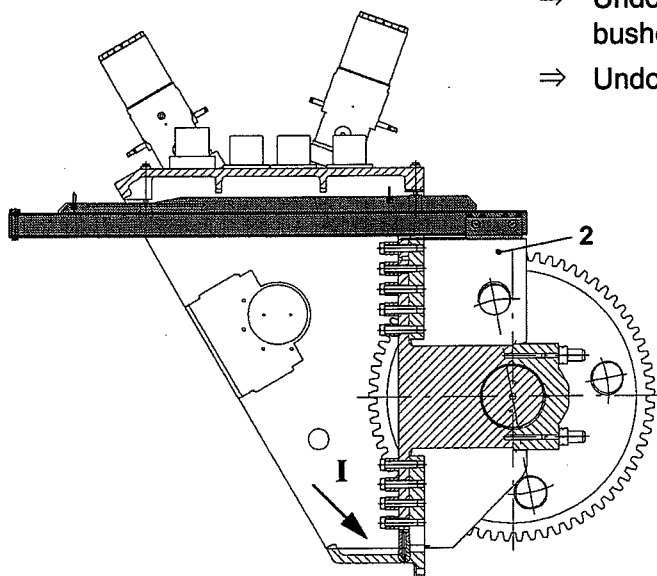
Always fit securing bolt (12) in the rail!

- ⇒ Tighten screws (94571a) till there is a clearance of approx. 26 mm between rail and housing (8).
⇒ Remove rope 'a' and 'b'.

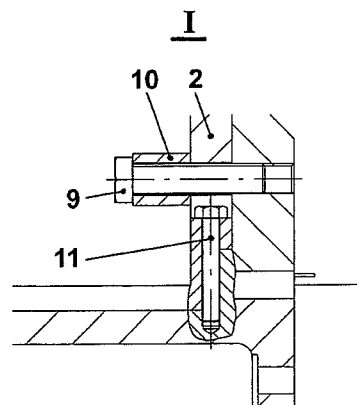
D



E

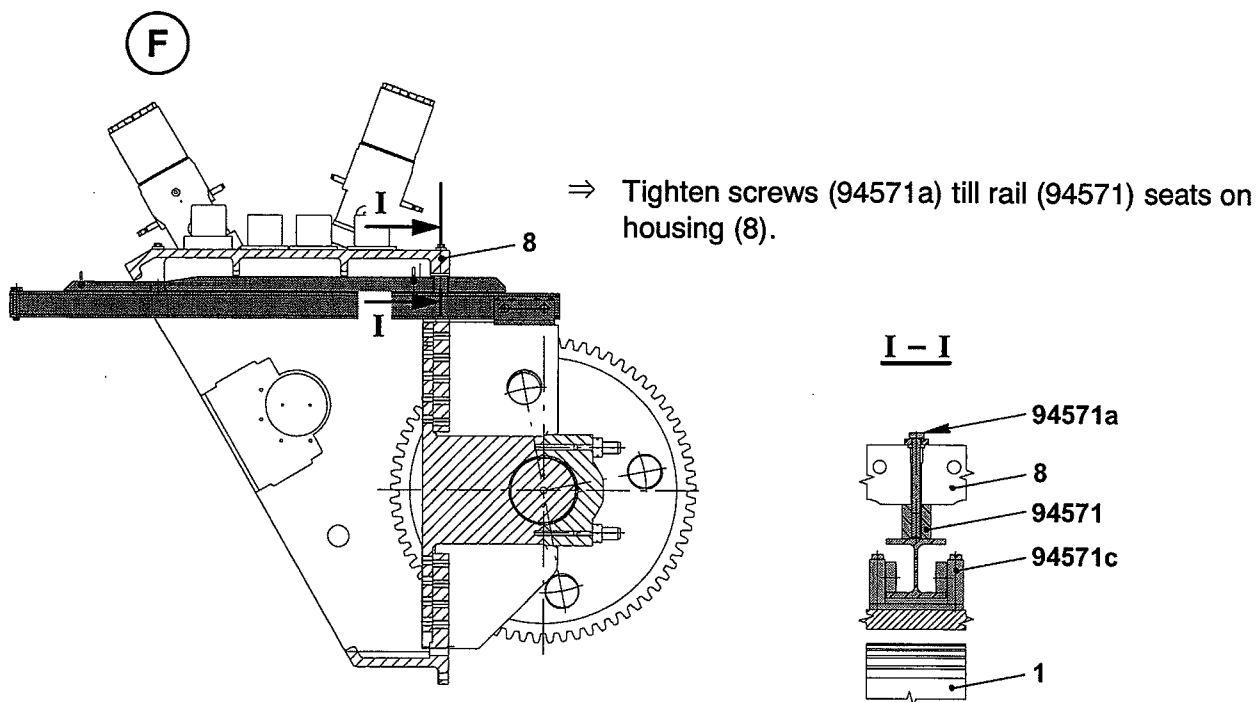


- ⇒ Undo screws (9) and remove them together with bushes (10).
⇒ Undo screws (11).



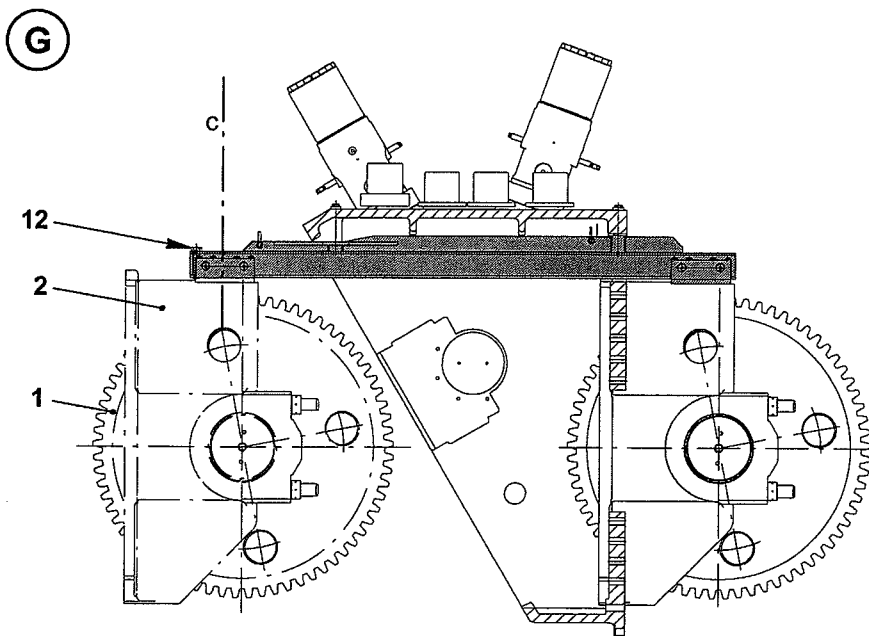
Supply Unit

Removal and Fitting of Intermediate Wheel to Camshaft



- ⇒ Pull housing (2) with intermediate wheel (1) back till securing bolt (12) as shown in Fig. 'G'.
- ⇒ Connect rope 'c' (lifting capacity 3000 kg) through the holes in housing (2) and intermediate wheel (1) with the chain block and tighten rope.
- ⇒ Loosen securing bolt and then remove the housing with intermediate wheel and place them on wooden underlays "HU" as shown in Fig. 'H'.

Remark : Wooden underlays "HU" must be high enough so that a jack can be underlaid afterward as shown in Fig. 'K'.

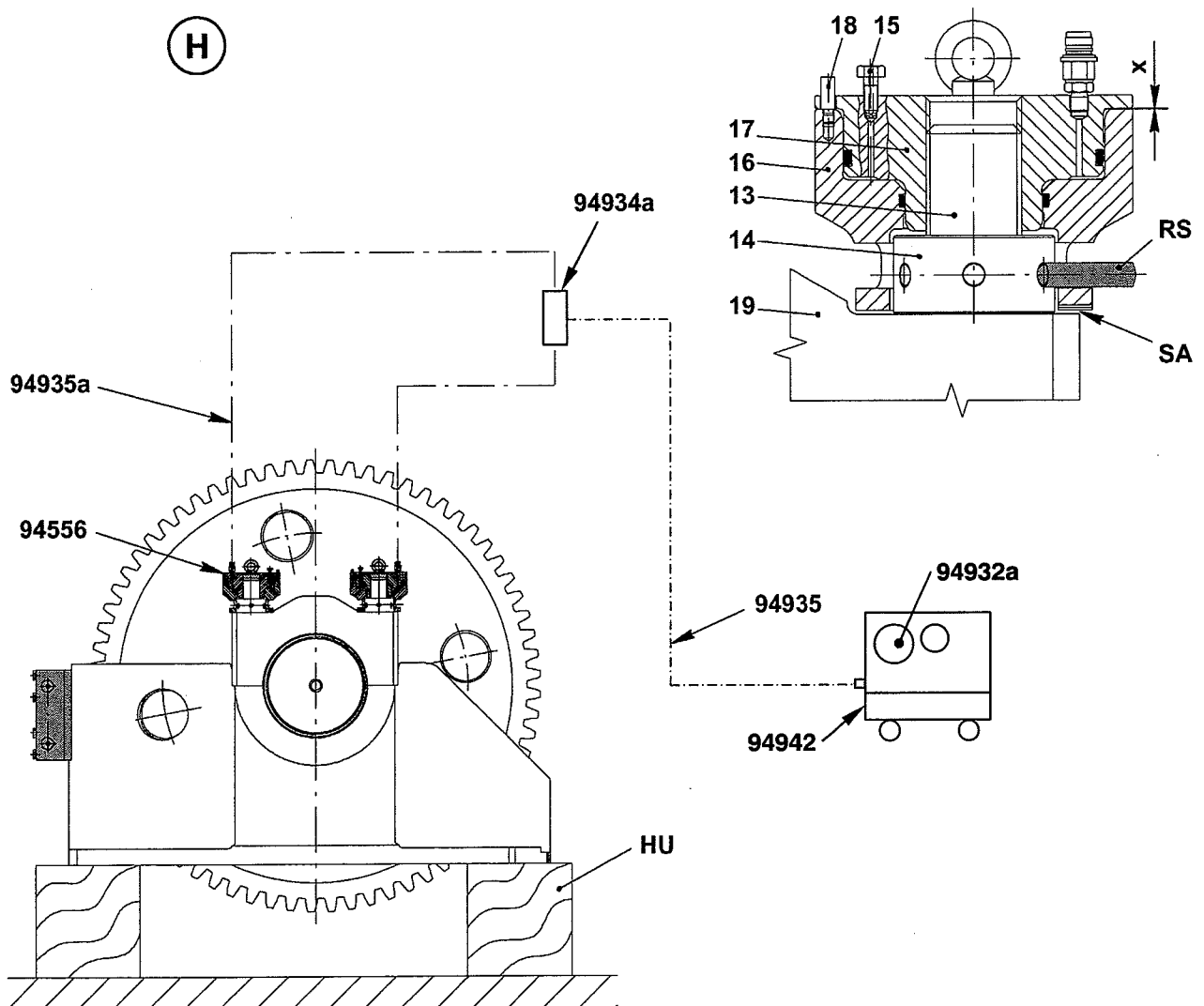


Supply Unit

Removal and Fitting of Intermediate Wheel to Camshaft

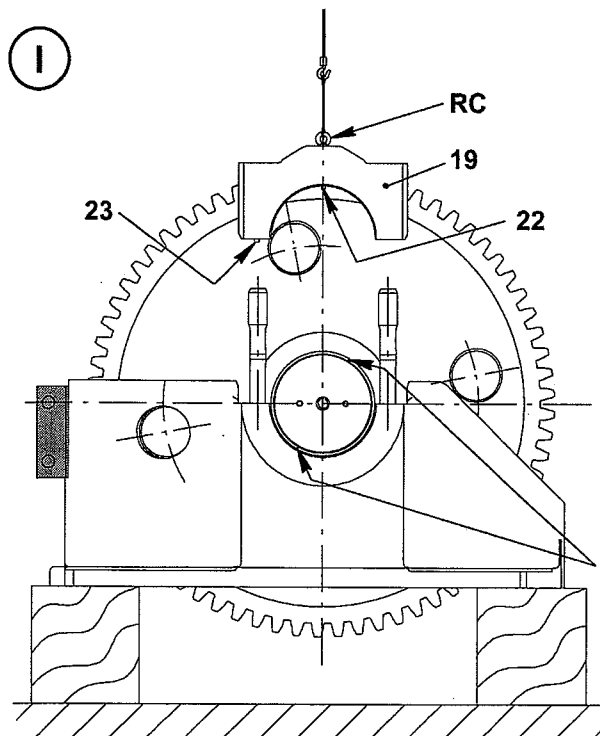
2.3 Loosening waisted bolts

- ⇒ With vent screws (15) open, screw pre-tensioning jacks (94556) on waisted bolts (13) till they seat on bearing cover (19) and there is little or no clearance at 'x'.
- ⇒ Unscrew the pre-tensioning jacks by $\frac{3}{4}$ turns (gap "SA" in Fig. 'H').
- ⇒ Connect the pre-tensioning jacks to hydraulic unit (94942) as shown in Fig. 'H'.
- ⇒ Actuate hydraulic unit, and close vent screws as soon as oil flows bubble-free.
- ⇒ Operate hydraulic unit till a pressure of approx. **103 MPa** is reached.
- Attention should be paid to ensure that pins (18) always protrude slightly compared with pistons (17) on the pre-tensioning jacks!
- ⇒ Turn back nuts (14) with round bar "RS" till they are almost touching the pistons of the pre-tensioning jacks.
- ⇒ Release pressure to zero and remove the pre-tensioning jacks and nuts.



Supply Unit

Removal and Fitting of Intermediate Wheel to Camshaft

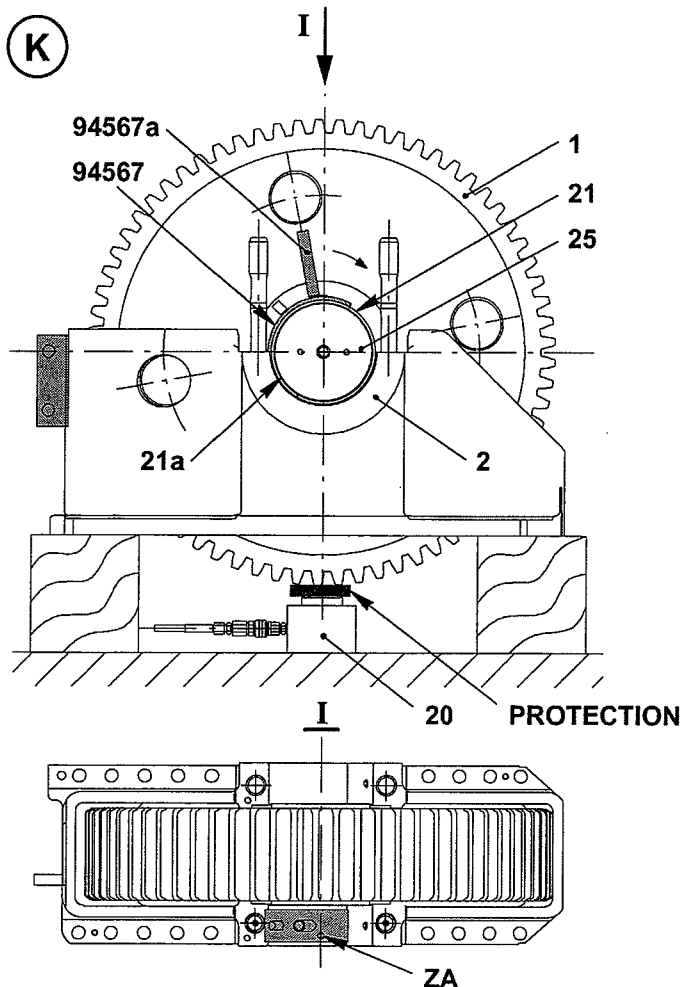


3. Removal of bearing shells



Remark: All bearing covers (19) are machined together with housing (2), therefore never interchange them! They must be marked accordingly before their removal.

⇒ Fit eye bolt "RC" into bearing cover (19), lift and remove the latter by means of the crane.



In order to be able to remove bearing shells (21) and (21a), jack (20) with a protection (AI or Cu plate) is used to lift intermediate wheel (1) as shown in Fig. 'K'.

⇒ Lift intermediate wheel as much as necessary till a clearance of approx. 0.10 mm around bearing pin (25) can be measured with feeler gauge (94122).

⇒ Place assembly template (94567) on upper bearing shell (21a), so that its pin "ZA" fits into the corresponding bore of the bearing shell.

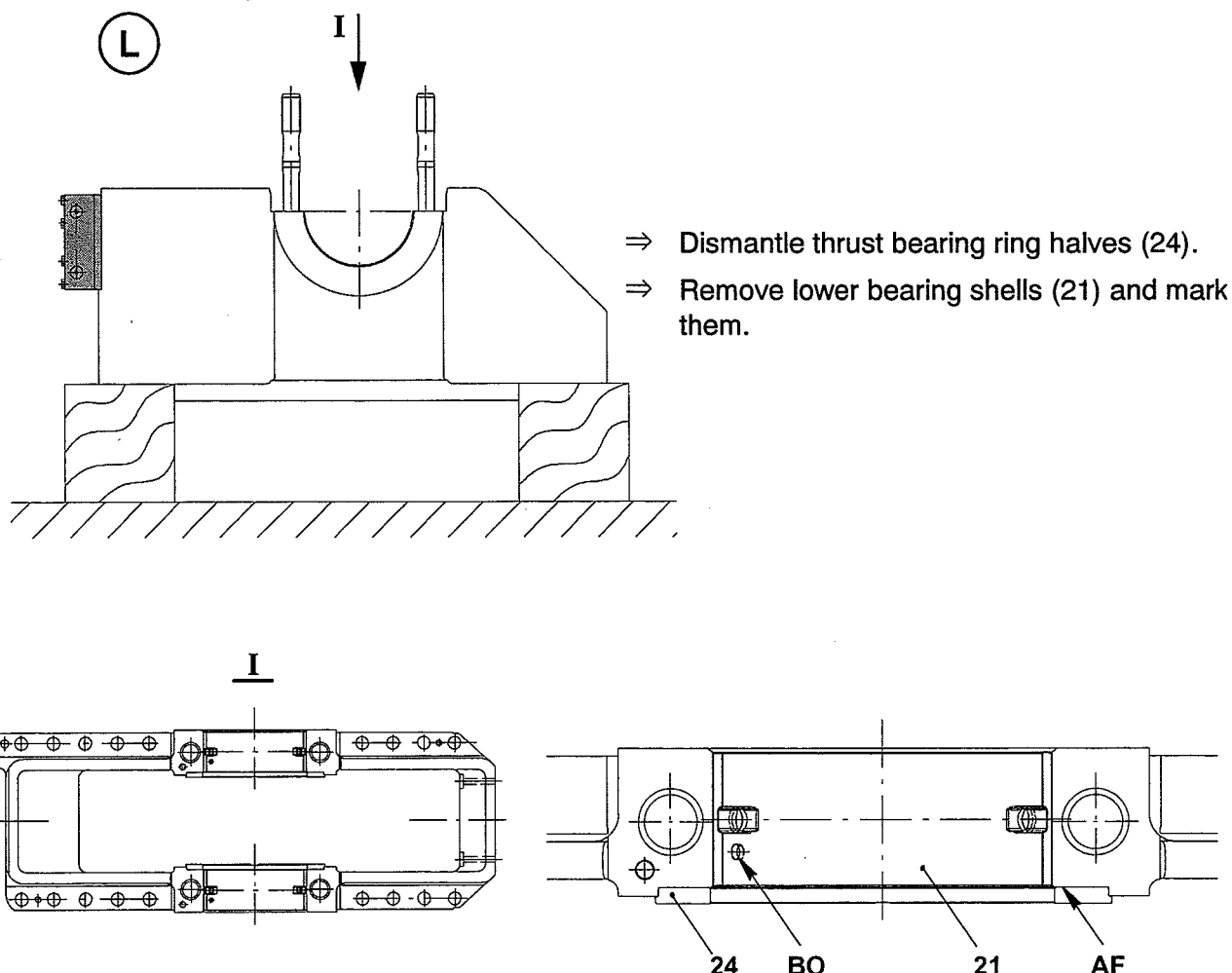
⇒ Insert pipe (94567a) into the other pin and turn assembly template in arrow direction till it stops at housing (2).

● Remove assembly template and upper bearing shell.

⇒ Lift and remove the intermediate wheel.

Supply Unit

Removal and Fitting of Intermediate Wheel to Camshaft



4. Fitting bearing shell and intermediate wheel

The fitting of bearing shells and intermediate shaft is carried out analogously but in reverse

sequence to the removal, whereby the following points require special attention:

- All parts to be fitted must be clean and undamaged!
 - For the assembly smear bearing shells and thrust bearing ring halves with oil.
 - Take care of the designations of reused bearing shells.
 - Fit bearing shells, so that their bores "BO" provided for locating pins (22) in the bearing covers (Fig. 'I') point to the same side (Fig. 'L').
Moreover align bearing shells laterally (they must not protrude in any case!) with seating faces "AF" of thrust bearing ring halves (24).
 - Take care of the designations and meshing of locating pins (22) and (23) when fitting the bearing covers.
- ⇒ Apply oil to the threads of nuts (14) and tighten them with round bar "RS" till there is no clearance at 'y' (Fig. 'M').
- Carry out tensioning of waisted bolts (13) as described in paragraph 4.1.

CHECK

After tensioning of waisted bolts determine radial and axial clearances, see clearance table 0330-1 'Supply Unit'.

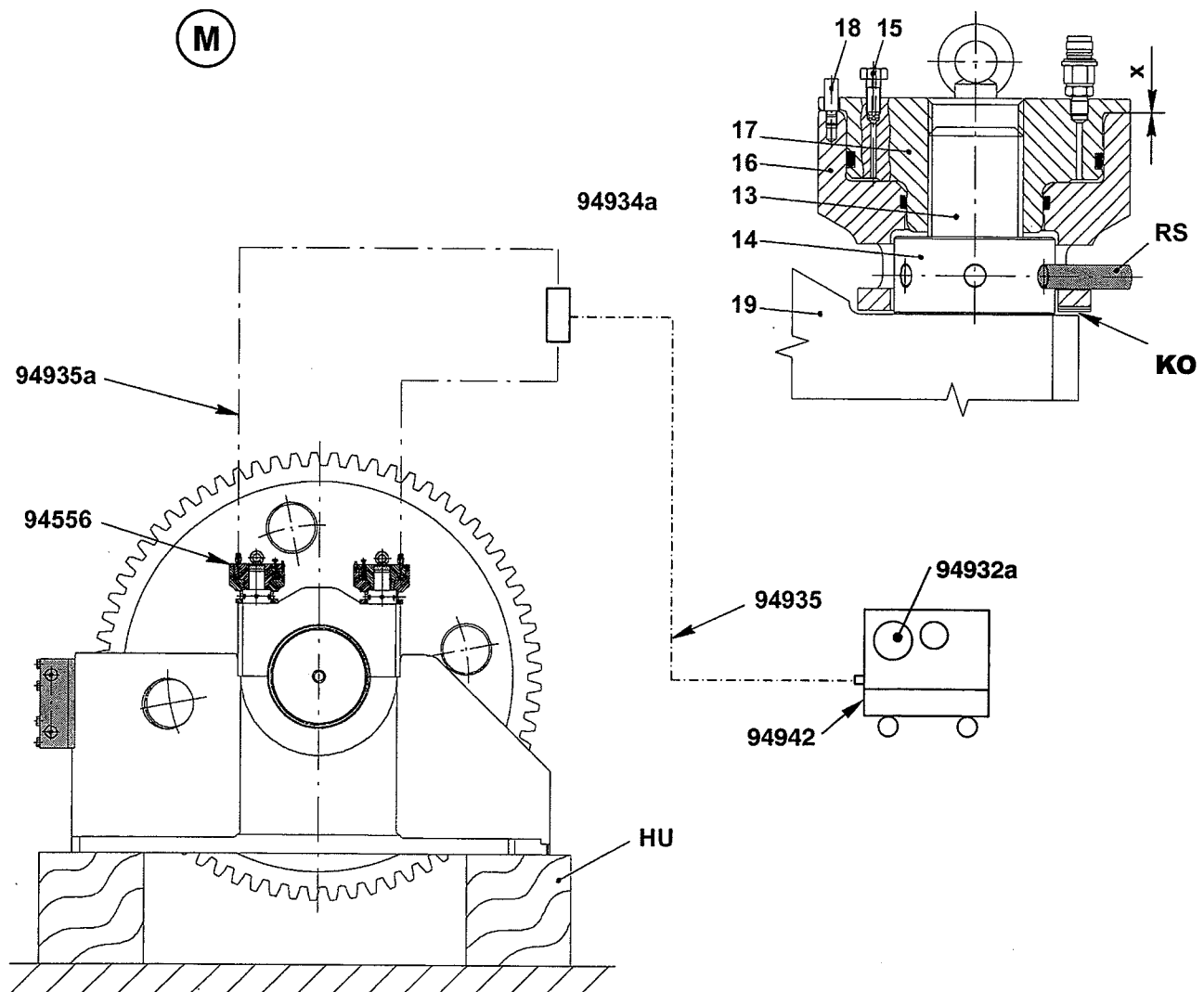
Supply Unit
Removal and Fitting of Intermediate Wheel to Camshaft
4.1 Tensioning waisted bolts

- ⇒ With vent screws (15) open, screw pre-tensioning jacks (94556) on waisted bolts (13) till they seat on bearing cover (19) and there is little or no clearance at 'x'.
- ⇒ Connect the pre-tensioning jacks to hydraulic unit (94942) as shown in Fig. 'M'.
- ⇒ Actuate hydraulic unit, and close vent screws as soon as oil flows bubble-free.
- ⇒ Operate hydraulic unit till a pressure of approx. **100 MPa** is reached.
- Attention should be paid to ensure that pins (18) always protrude slightly compared with pistons (17) on the pre-tensioning jacks!
- ⇒ Keep pressure constant and tighten nuts (14) with round bar "RS" till firmly seated.

CHECK

Using feeler gauge inserted through slot "KO" (Fig. 'M'), check whether the nuts rest on bearing cover without any clearance.

- ⇒ Release pressure to zero and remove the pre-tensioning jacks.



Supply Unit**Removal and Fitting of Intermediate Wheel to Camshaft****5. Fitting housing with intermediate wheel**

The fitting of housing with intermediate wheel is carried out analogously but in reverse sequence to the removal.

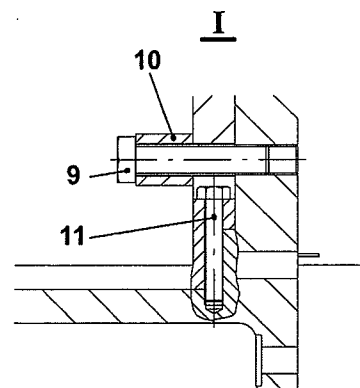
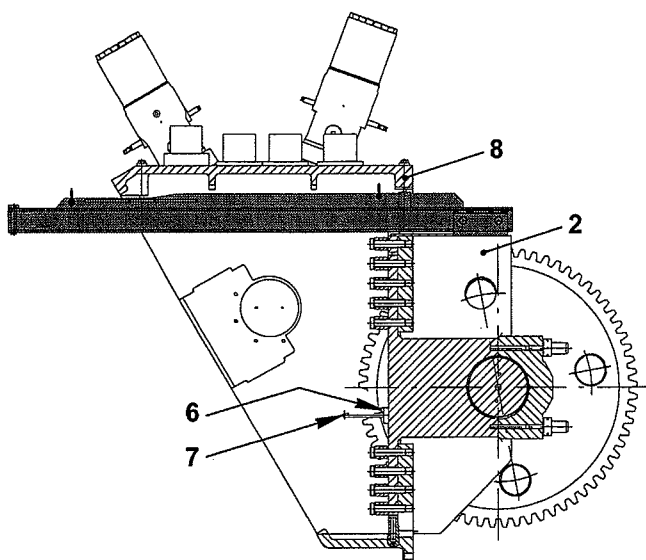
Fastening housing (2) to housing (8) is carried out as follows:

- ⇒ Apply oil to the threads of screws (9) and (11).
- ⇒ Fit screws (9) and bush (10).
- ⇒ Tighten screws (9) till housing (2) seats on housing (8).
- ⇒ Fit and tighten screws (11) with a torque of **170 Nm** using a torque wrench.
- ⇒ Lightly tighten screws (9) manually in small steps using a wrench. Starting from this position, tighten the screws by a further angle of **47°**.

CHECK

Check tooth backlash, see clearance table 0330-1 'Driving Wheels for Supply Unit'.

- ⇒ Remove all tools.

**5.1 Fitting spray nozzle****CHECK**

Check spray nozzle (7) for free passage!

- Screws (6) must be secured with LOCTITE 0243!

Supply Unit
Periodic Inspection of Supply Unit Cams and Rollers
Tools:

1 Tool 94430

Key to Illustrations:

1 Fuel cam	3 Guide piston
2 Roller	4 Non-return valve

1. General

Occasionally damage occurs on the fuel cams (1), rollers (2) or guide pistons (3) of fuel supply units that could have been avoided by regular inspection. This section gives a list of points that should be periodically checked to determine abnormalities that could lead to damage.

2. Check List

The following checks can easily be done through the inspection covers and are recommended to be carried out regularly e.g. after each sea passage.

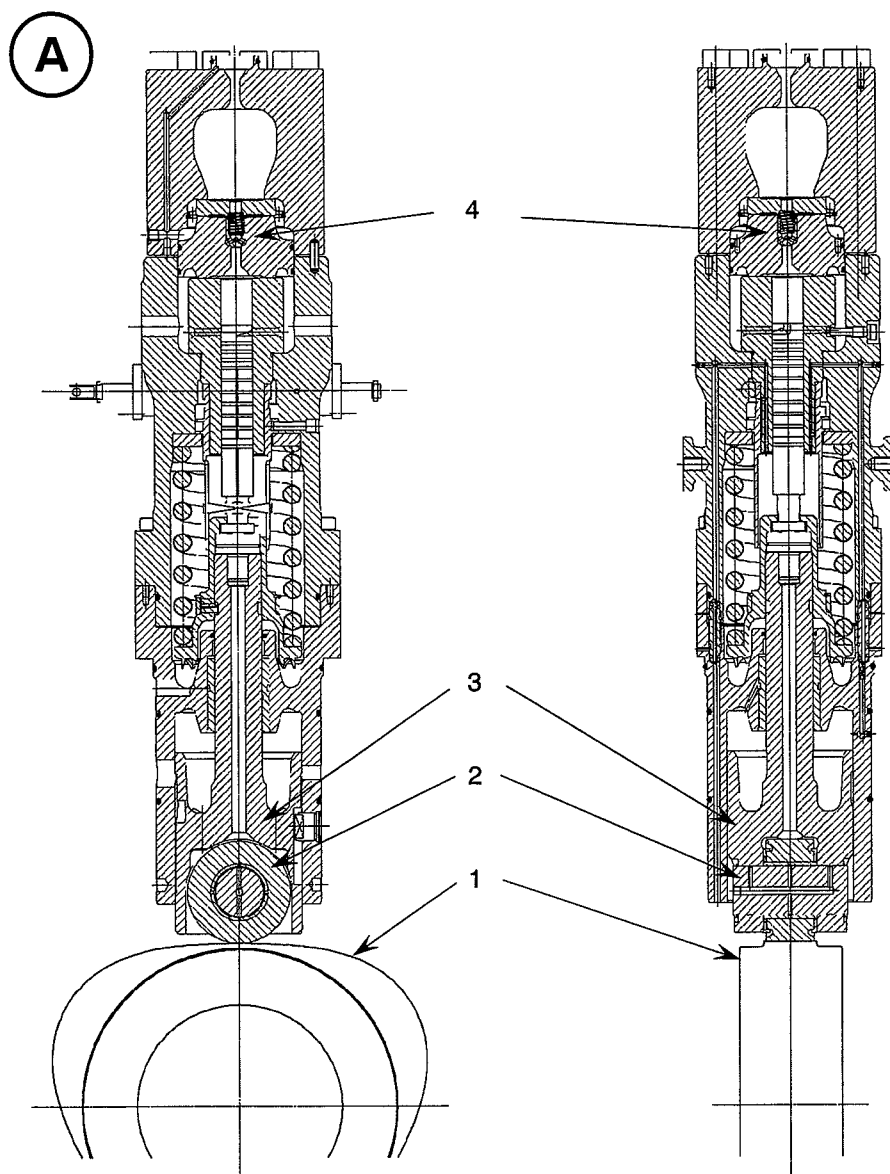
1. The running surface of cams (1) and rollers (2) should be carefully checked for abnormal running marks, discoloration, scratches etc.
2. With the roller (2) on the cam base circle, the visible part of the guide piston (3) running surface should be carefully checked for abnormal running marks.
3. Lift the fuel pump using the cut-out device (tool 94430).
(See 5556-2 in operating manual)
The roller (2) should now be able to rotate smoothly by hand. The axial clearance between the roller (2) and guide piston (3) should be between 0.26 and 0.54 mm.
(See 0330-1 in maintenance manual)
4. Check the casing for debris.
5. Check the fuel rail pressure after engine stop. There should not be a significant pressure drop in the first 5 minutes after stopping the engine. If there is, the non return valves (4) in the fuel pump covers and in the connecting flanges of the intermediate fuel accumulator should be checked.
In general, be familiar with the sound of a normal running unit so that suspicious noise like knocking attracts attention.

3. Reporting

In case of any signs of abnormal running conditions, please inform engine manufacturer soonest. Damages should be clearly documented with photographs. The rising and falling sides of the cams as well as the cam's TDC should be indicated with a white marker on both sides of the cam (1).

Supply Unit

Periodic Inspection of Supply Unit Cams and Rollers



Fuel Pump
Dismantling and Assembling

Tool:			Key to Illustrations:		
1	Feeler gauge	94122	1	Intermediate fuel accumulator	26
1	Rotation device	94290	2	Fuel pipe	27
1	Carrier	94290b	3	Screw	28
1	Fitting & dismantling device	94551	4	Pump cover	29
1	Cover	94552	5	Upper housing	30
1	Spacer	94555	6	Lower housing	31
1	Assembly tool	94581	7	Guide piston	32
2	Guide screws	94581a	8	Roller	33, 33a
2	Steel wires	94581b	9	Guide pin	34
1	Assembling device	94593	10	Pin	35
consisting of:			11	Circlip	36
1	Tool half	94593a	12	Pressure disc	37
1	Tool half	94593b	13	Bush	38
2	Flat bars	94593c	14	Piston seal ring	39
1	Metal sheet	94593d	15	Pin	40
4	Screws	94593e	16	Circlip	41, 41a
1	Mandrel	94597	17	Retaining ring	42
1	Impact wrench	94598	18	Connecting pin	43
2	Extensions	94598a	19	Adapter piece	44 ~49
1	Socket spanner insert	94598b	20	Allen screw	50
1	Protection tool	94599k	21	Lower spring carrier	51
			22	Pump plunger	DS
			23	Pump cylinder	GS
			24	Compression spring	H1...
			25	Guide pin	RC
				Regulating sleeve	
				Upper spring carrier	
				Screw	
				Flange	
				Regulating (toothed) rack	
				Circlip	
				Stop ring	
				Head screws	
				Valve block	
				Valve body	
				Compression spring	
				Holding screw & Cu-ring	
				Intermediate disc	
				Circlip	
				Screw	
				Bushes	
				Spindle	
				Rod seal ring	
				O-rings	
				Screw	
				Blank flange	
				Pressure piece	
				Handle screw M6	
				Chain blocks	
				Eye bolt M8	

Overview

1.	General	1/20
2.	Removal of a fuel pump	2/20
3.	Identification of fuel pump design	7/20
4.	Dismantling of a fuel pump	8/20
5.	Assembling of a fuel pump	13/20
6.	Fitting of a fuel pump	20/20
7.	Preserving	20/20

1. General

The fuel pumps must be removed only with the engine at standstill, and the fuel and the oil supply pump cut out.

Non-return valves are fitted between intermediate fuel accumulator (1) and fuel pipes (2). They allow removing the fuel pipes without draining the intermediate fuel accumulator. However, the shut-off valves to the fuel inlet and outlet pipes must be closed (see Operating Manual 0720-1).

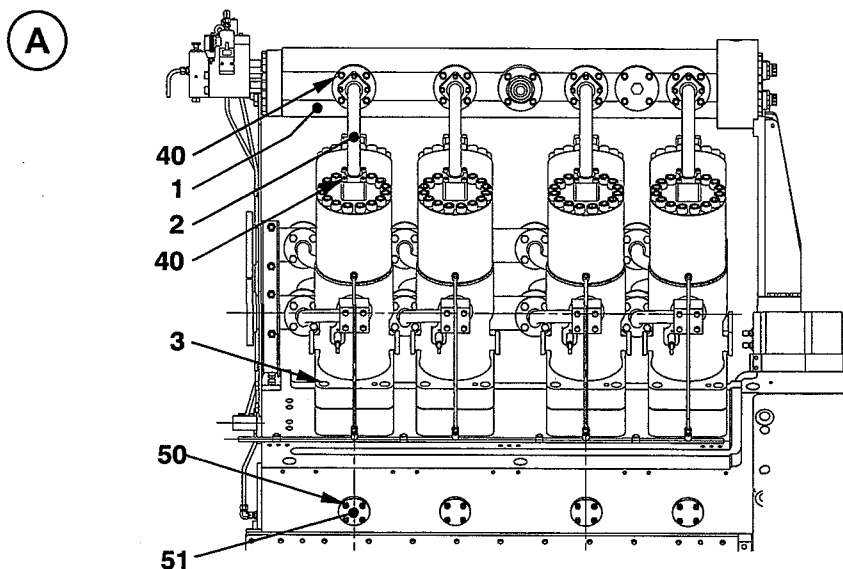
There are different designs of fuel pumps which, however, can not be differentiated externally.

As the fuel pumps are to be dismantled properly, an identification of the design must first be carried out as described in section 3.

Dismantle and assemble the fuel pumps in a clean room which should be as dustfree as possible (grinding dust, etc.).

Fuel Pump

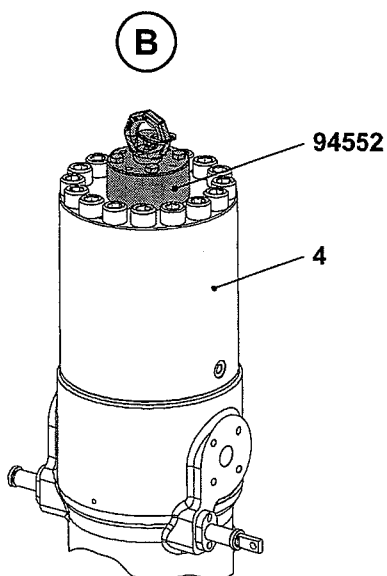
Dismantling and Assembling



2. Removal of a fuel pump

2.1 Preparation

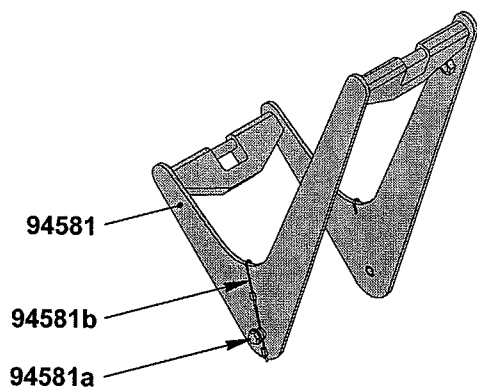
- ⇒ Turn the engine till roller (8) rests on the cam base circle (Fig. 'Q').
- ⇒ Remove the casing as far as necessary, and screw off the pipings fastened to the fuel pump.
- ⇒ Remove all screws (3) (see also Fig. 'O₁').
- ⇒ Using a jacking screw M16, lift the fuel pump till the locating pin is no longer meshing.
- ⇒ Fit cover (94552) onto pump cover (4).



Fuel Pump

Dismantling and Assembling

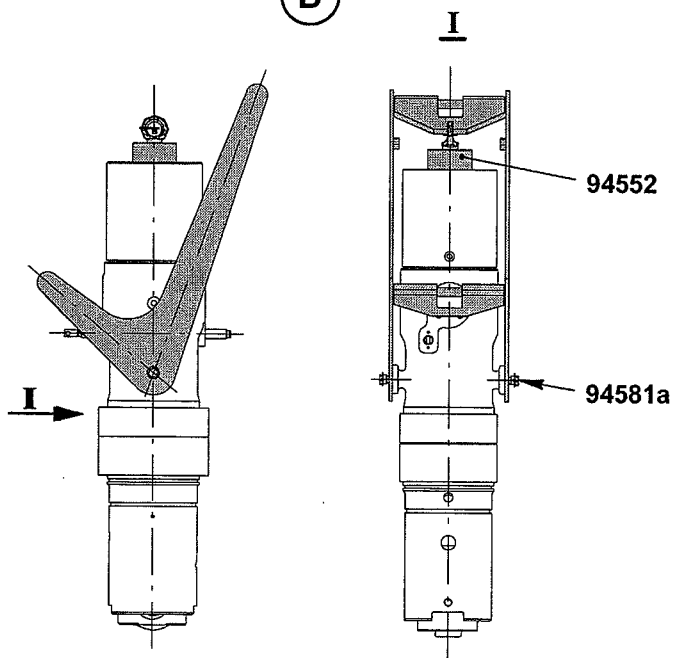
(C)



2.2 Fitting assembly tool

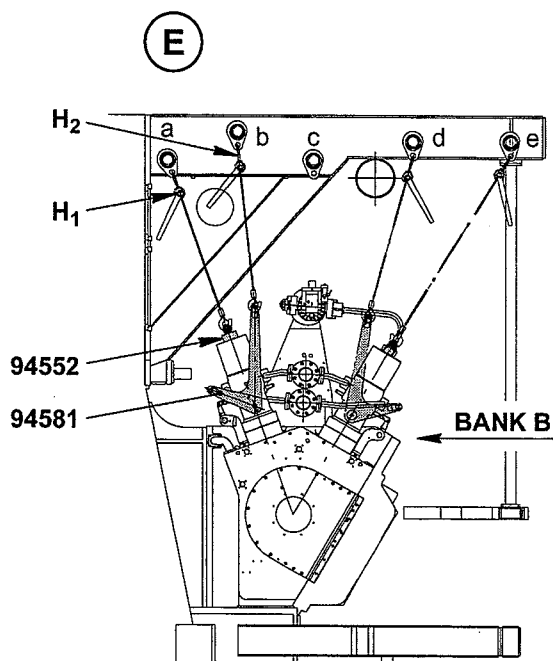
- ⇒ Insert guide screws (94581a) into the corresponding bores of assembly tool (94581) and secure them by means of steel wires (94581b).

(D)



- ⇒ Align assembly tool to the height of the tapholes in the fuel pump housing provided for guide screws (94581a).
- ⇒ Extract steel wires (94581b).
- ⇒ Drive guide screws into the tapholes till the stop.

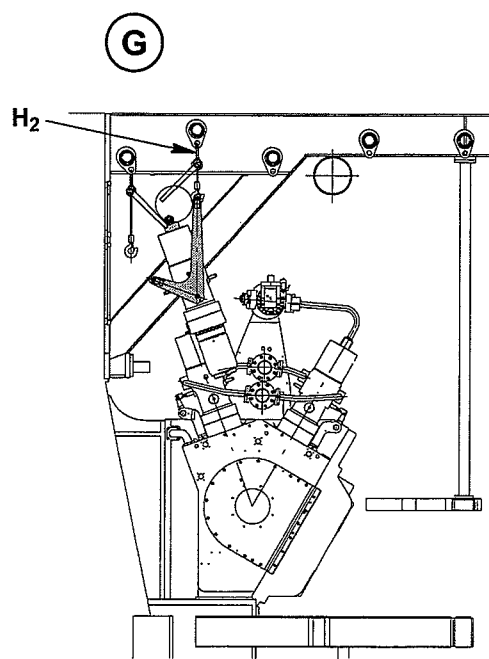
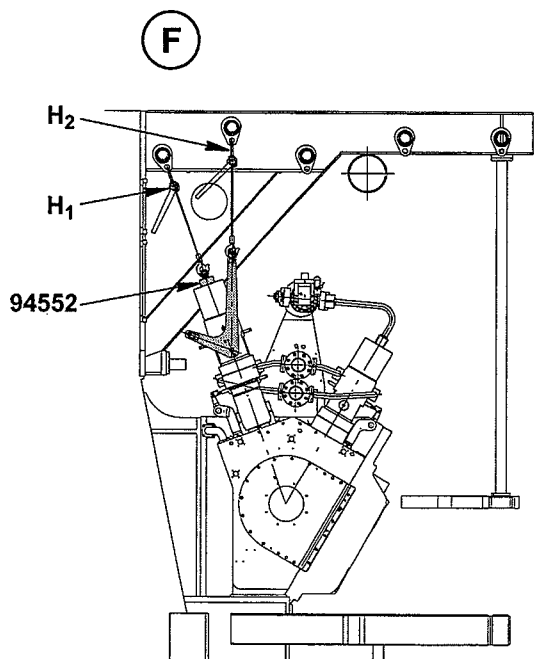
Fuel Pump
Dismantling and Assembling



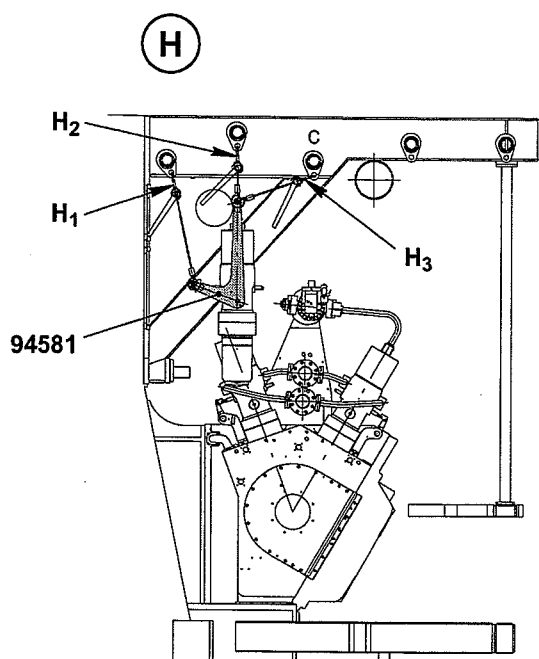
2.3 Removal

- ⇒ Connect chain block H₁ with lifting lug 'a' and cover (94552).
- ⇒ Connect chain block H₂ with lifting lug 'b' and assembly tool (94581).
- For the removal of the fuel pumps of BANK B the tools are used as drawn with interrupted lines, however only lifting lugs 'd' and 'e' are necessary.

- ⇒ Carefully pull the fuel pump out of the supply unit housing by means of chain blocks H₁ and H₂ (Fig. 'F').
- ⇒ Remove chain block H₁ from cover (94552) and then lift the fuel pump as high as possible with chain block H₂ (Fig. 'G').

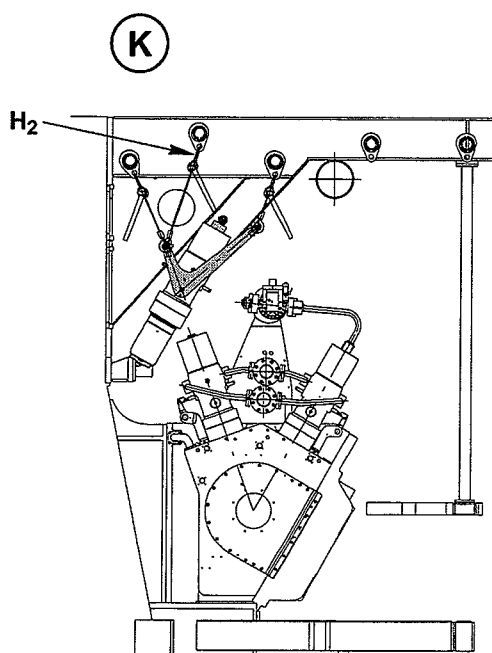
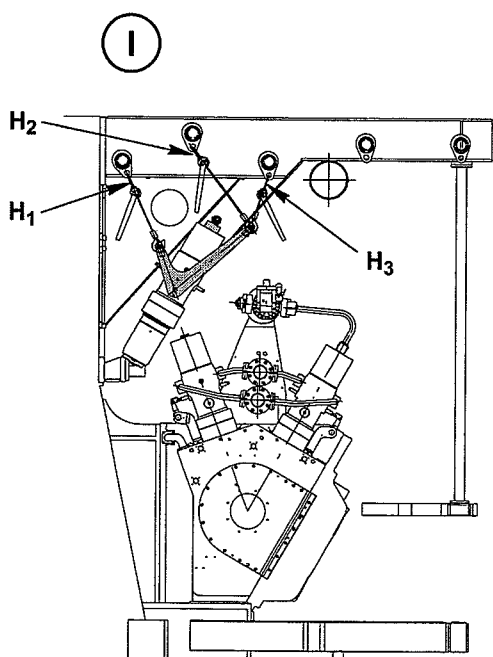


Fuel Pump
Dismantling and Assembling

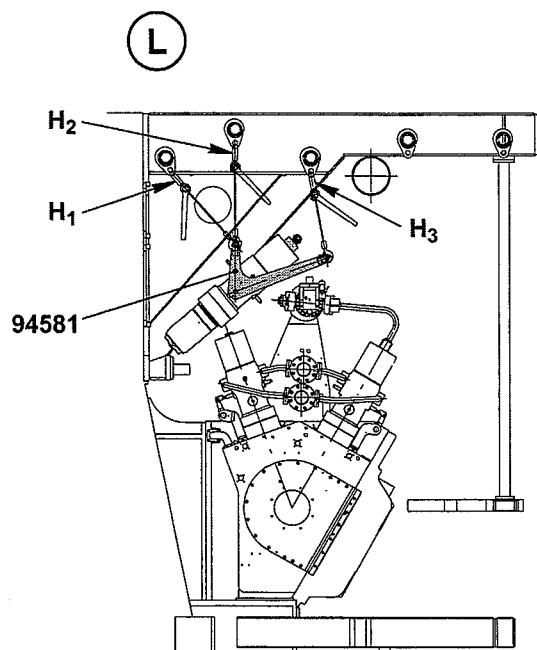


- ⇒ Connect chain block H₁ with the short lever of assembly tool (94581).
- ⇒ Connect chain block H₃ with lifting lug 'c' and the long lever of the assembly tool.

- ⇒ Move the fuel pump towards chain block H₃ as far as possible by means of chain blocks H₁, H₂ and H₃ (Fig. 'I').
- ⇒ Disconnect chain block H₂ from the long lever and connect it with the short lever of the assembly tool (Fig. 'K').

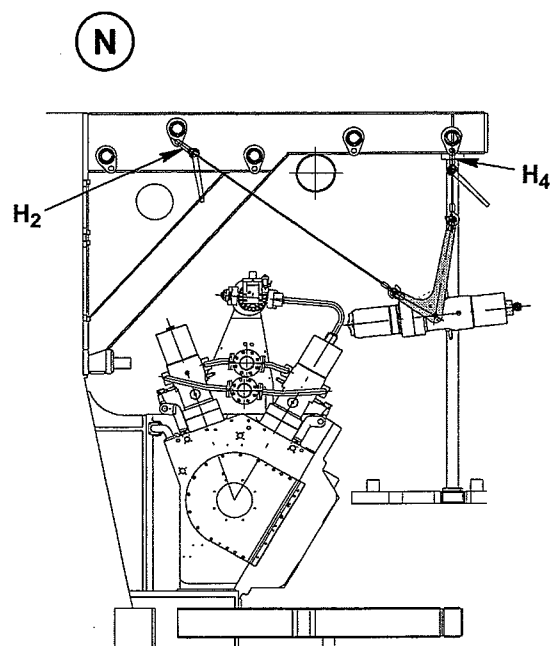
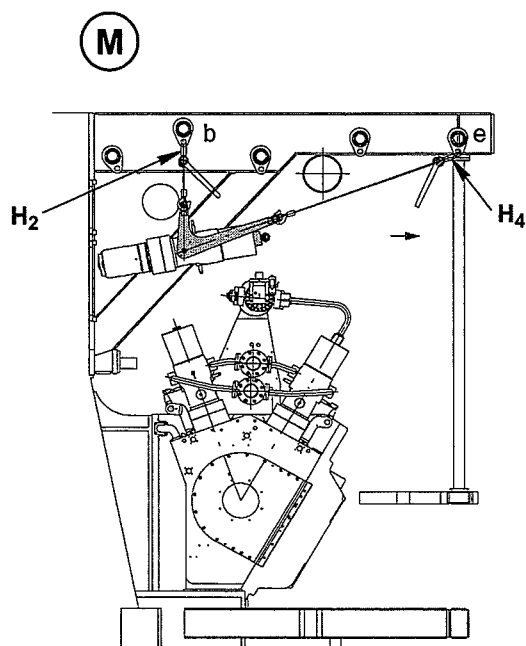


Fuel Pump
Dismantling and Assembling



- ⇒ Move the fuel pump by means of chain blocks H1, H2 and H3, i.e. till it hangs as shown in Fig. 'L' with the short lever of assembly tool (94581) now in vertical position.
- ⇒ Remove chain blocks H1 and H3.

- ⇒ Connect chain block H₄ with lifting lug 'e' and the long lever of the assembly tool.
- ⇒ Move the fuel pump over the supply unit by means of chain blocks H₂ and H₄ as shown in Fig. 'N'.



Fuel Pump

Dismantling and Assembling

3. Identification of fuel pump design

 **Remark** : All fuel pumps may be fitted into holding angle (94290a) or carrier (94290b) for identification of the design.

Fuel pumps provided with connecting pins, however, can only be dismantled in carrier (94290b).

- ⇒ Fasten carrier (94290b) to rotation device (94290).
- ⇒ Fit fuel pump into the carrier (Fig. 'P') and subsequently bring it to the required position by means of the rotation device as shown in Fig. 'O'.
- ⇒ Remove guide pin (9) from lower housing (6) (see paragraph 4.2).
- ⇒ Loosen equally Allen screws (20) (Fig. 'T') and then refit them by approx. five turns.

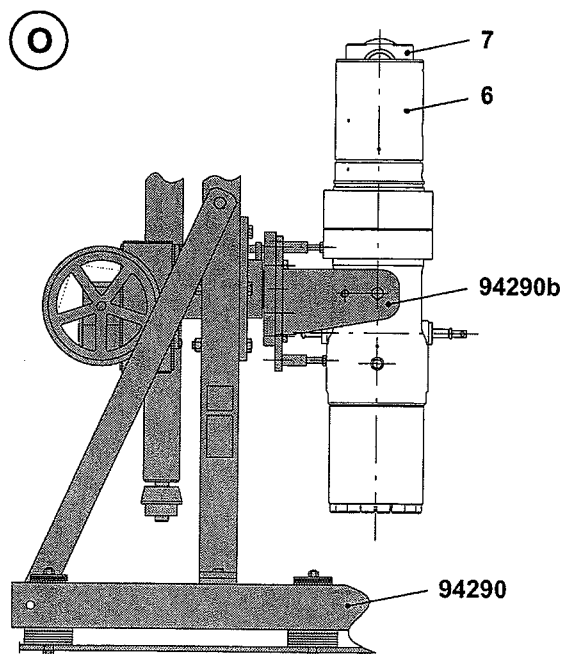


Always use a spur-gearred chain block hooked onto the crane and operate only these without exception for all the following works requiring a crane!

- ⇒ Screw two eye bolts "RC" (M8) into guide piston (7) (Fig. 'V') and connect it to a chain block. Carefully lift now the guide piston in order to observe the following details:
 - **If only the guide piston is lifted off, i.e. it concerns a fuel pump without connecting pin**, and the instructions about dismantling must be carried out according to 5556-1/A1.
 - **If the guide piston and lower housing are lifted off together, i.e. it concerns a fuel pump with connecting pin (18).**
The guide piston must be lowered again and the works can be continued according to the instructions on hand (5556-1/A2).



Remark : When the execution is established, it is recommended marking the fuel pumps accordingly, e.g. WITH CONNECTING PIN or WITHOUT CONNECTING PIN.

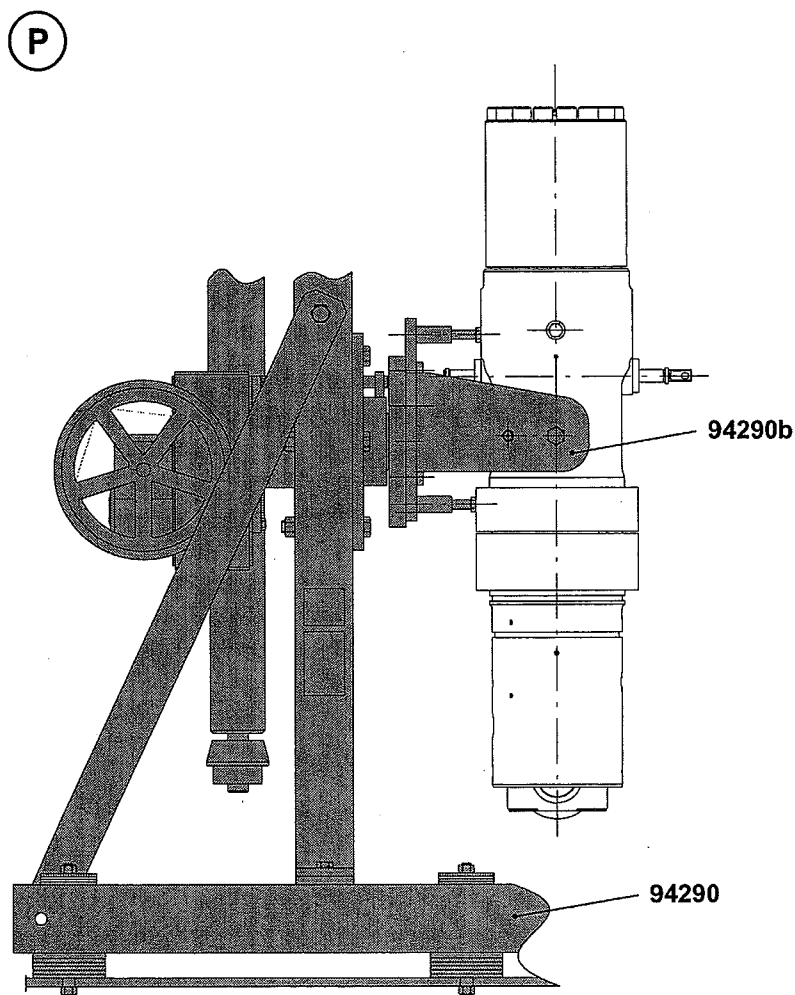


Fuel Pump
Dismantling and Assembling

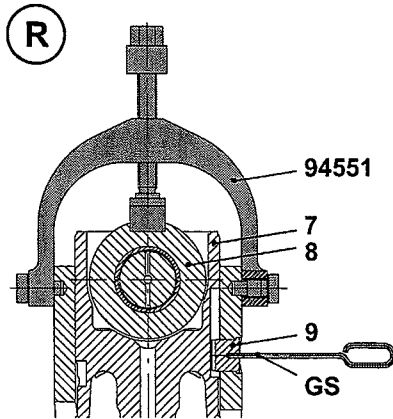
4. Dismantling of a fuel pump

4.1 Fitting a fuel pump into carrier

- ⇒ Fasten carrier (94290b) to rotation device (94290).
- ⇒ Fit fuel pump into the carrier as shown below.



Fuel Pump
Dismantling and Assembling

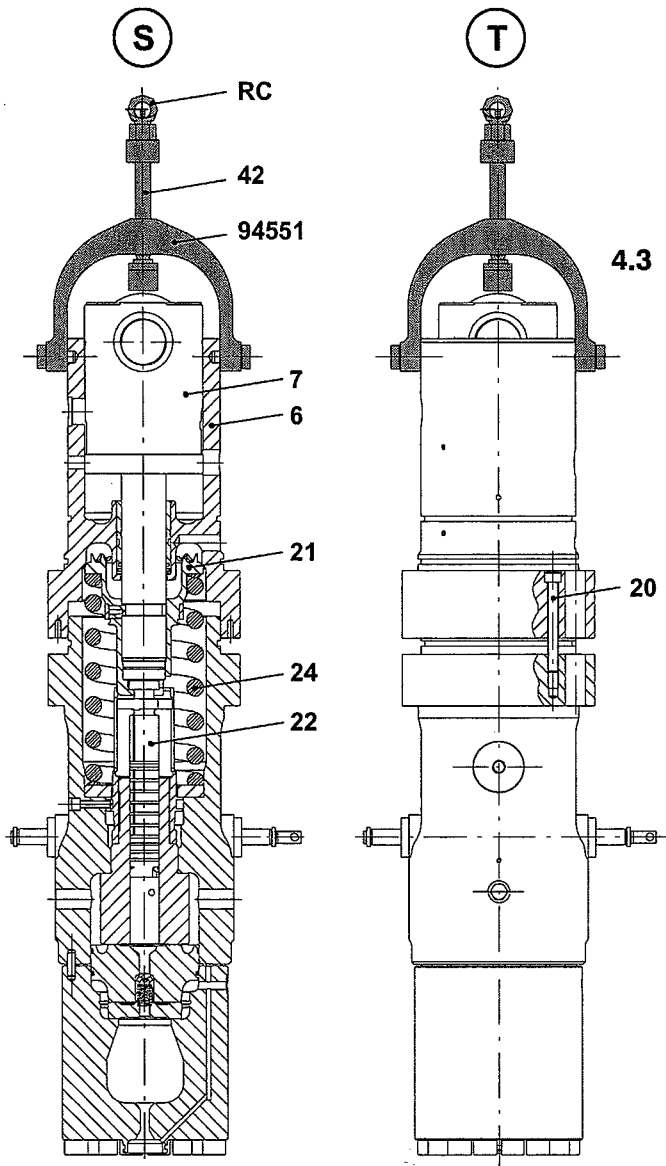


4.2 Removal of guide pin



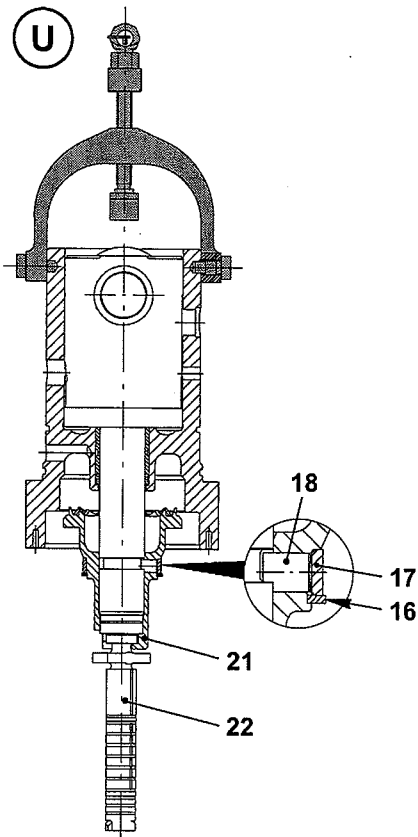
Guide pin (9) must only be removed with fitting & dismantling device (94551)!

- ⇒ Turn rotation device (94290) till roller (8) of the fuel pump points upwards.
- ⇒ Mount fitting & dismantling device according to Fig. 'R', and press guide piston (7) inwards by turning the spindle of the device till guide pin (9) allows to be withdrawn by means of handle screw "GS".

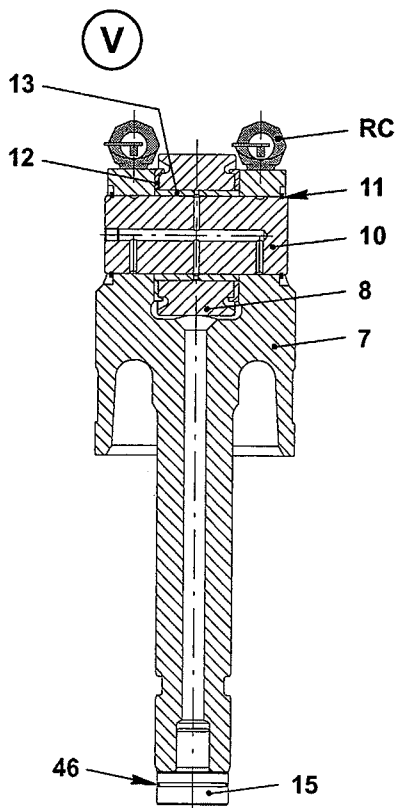


4.3 Removal of guide piston

- ⇒ Screw eye bolt "RC" into the hexagon of tool (94551).
- ⇒ Turn back spindle (42) (Fig. 'S').
- ⇒ Loosen equally Allen screws (20) and remove them.
- ⇒ Carefully lift now lower housing (6) together with guide piston (7), lower spring carrier (21) and pump plunger (22) by means of eye bolt "RC".
- ⇒ Remove compression spring (24).

Fuel Pump
Dismantling and Assembling


- ⇒ Push pump plunger (22) out from lower spring carrier (21).
Store pump plunger in a manner not to damage it.
- ⇒ Remove circlip (16) and push retaining ring (17) downwards.
- ⇒ Withdraw connecting pin (18) by means of a handle screw (M8) and remove lower spring carrier.

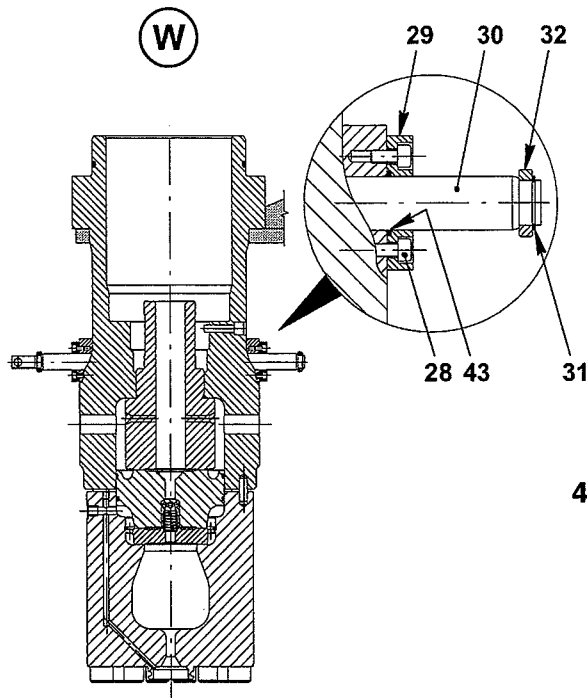


- ⇒ Screw two eye bolts "RC" (M8) into guide piston (7), and withdraw the latter from the housing.

4.4 Removal of roller

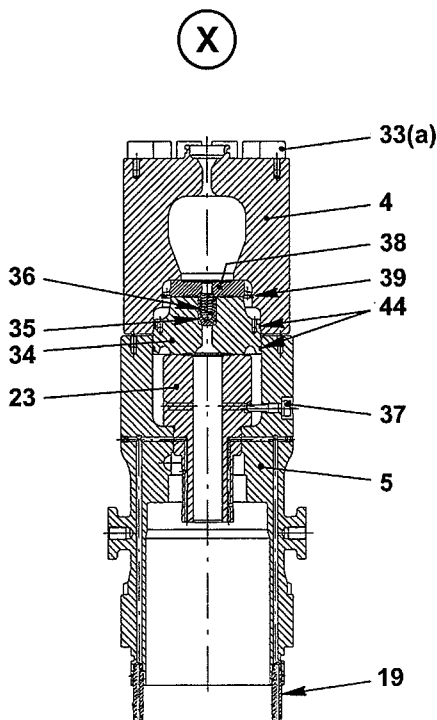
- ⇒ Remove circlip (11).
- ⇒ Press out pin (10), and remove roller (8) together with pressure discs (12) and bush (13).

Fuel Pump
Dismantling and Assembling



4.5 Removal of regulating rack

- ⇒ Unscrew all screws (28).
- ⇒ Remove circlip (31) and stop ring (32).
- ⇒ Remove flange (29), and push out regulating rack (30).



4.6 Removal of pump cylinder

- ⇒ Turn fuel pump till pump cover (4) points upwards.
- ⇒ Unscrew head screws (33),(33a) crosswise in equal steps.
- ⇒ Remove pump cover (4), valve block (34), valve body (35) and compression spring (36). For removing intermediate disc (38) loosen circlip (39).
- ⇒ Remove holding screw (37) and pump cylinder (23).



Remark : Pump cylinder (23) and pump plunger (22) form a single unit and must not be interchanged. Therefore, they are also not delivered separately.

4.7 Removal of adapter piece

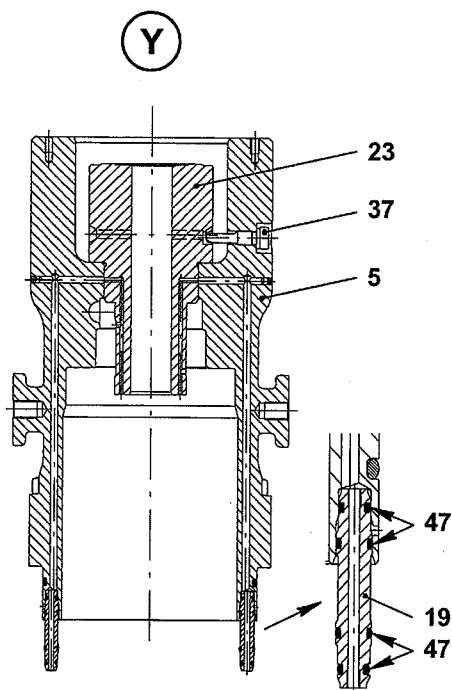
- ⇒ Withdraw adapter piece (19) from upper housing (5) by means of a screw M6.



Remark : Please note there are also fuel pumps without adapter pieces.

Fuel Pump
Dismantling and Assembling
5. Assembling of a fuel pump
5.1 Preparation

- ⇒ Clean all parts and check their condition.
Damaged parts must be replaced.
- ⇒ Replace all O-rings, piston and rod seal rings.
- ⇒ Check the lubricating oil bores in the housings and in pump cylinder (23) for free passage using compressed air.
- ⇒ Oil and fit adapter piece (19) with its O-rings (47).


5.2 Fitting the pump cylinder

- ⇒ Fasten upper housing (5) in vertical position to carrier (94290b).
- ⇒ Carefully fit pump cylinder (23), aligning the groove in the pump cylinder precisely with the bore provided for holding screw (37) in the upper housing.
- ⇒ Screw in and tighten the holding screw together with the Cu-ring.


Remark

There must be a clearance between holding screw (37) and the groove base!

5.3 Fitting the pump cover

Remark

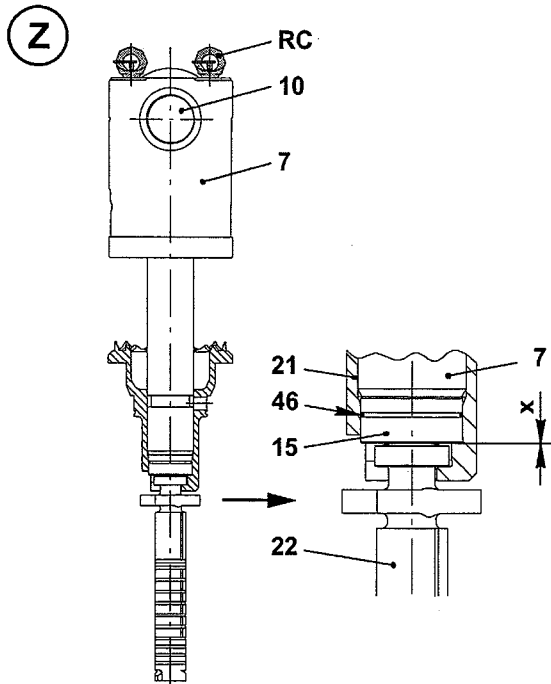
Thoroughly check the sealing surfaces for cleanness when fitting the valve block and the pump cover (Fig. 'X').

- Depending on design of pump cover (4) and upper housing (5), head screws (33) or (33a) are used.
- ⇒ Fit valve block (34) with the mounted and oiled O-rings (44) in upper housing (5). Then fit valve body (35) and compression spring (36) in the valve block.
- ⇒ Fit intermediate disc (38) with circlip (39) into the pump cover.
- ⇒ Fit pump cover (4).
- ⇒ Apply Never-Seez NSBT-8 to the threads and head seating surfaces of the head screws and tighten them crosswise in equal steps:
 - head screws (33) (M24) with a total torque of **320 Nm**
 - head screws (33a) (M27) with a total torque of **480 Nm**.

CHECK

Recheck all head screws (33) or (33a), i.e by applying the corresponding torque again!

Fuel Pump
Dismantling and Assembling



5.4 Assembling the guide piston

- ⇒ Clean and oil all bores and parts.
- ⇒ Press pin (15) into guide piston (7) and insert O-ring (46).
- ⇒ Fit roller (8), bush (13), pressure disc (12) and pin (10) in guide piston (7) (Fig. 'V').

5.5 Checking axial clearance of pump piston

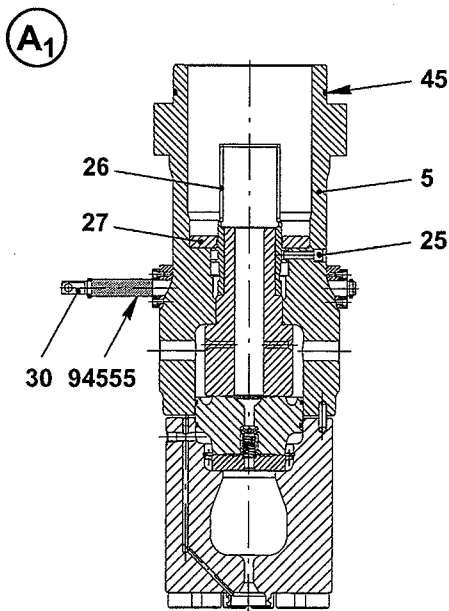
- ⇒ Suspend guide piston on eye bolt "RC".
- ⇒ Fit pump plunger (22) in lower spring carrier (21).
- ⇒ Push lower spring carrier together with pump plunger over guide piston (7). Press lower spring carrier by hand against pin (15), checking whether there results a clearance of $x = 0.03 \sim 0.07$ mm.
- ⇒ Remove lower spring carrier and pump plunger.

5.6 Fitting the regulating rack

- ⇒ Turn rotation device (94290) till the pump cover points downwards.
- ⇒ Fit regulating rack (30) according to Fig. 'W'.

CHECK Check regulating rack for easy movement.

- ⇒ Place rod seal ring (43) in both flanges (29).
- ⇒ Push both flanges onto the regulating rack and screw them up with the upper housing.
- ⇒ Fit stop rings (32) and circlips (31).



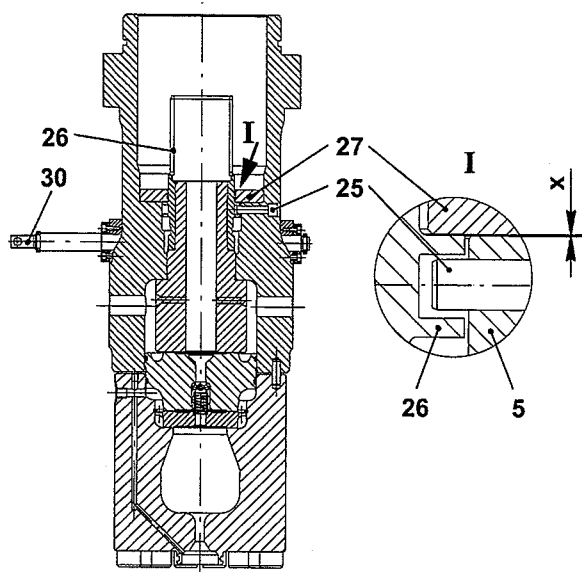
5.7 Fitting the regulating sleeve

- ⇒ Bring regulating rack (30) to the position shown in Fig. 'A1' and place spacer (94555).
- ⇒ Fit guide pin (25).
- ⇒ Fit regulating sleeve (26) in the upper housing, the toothed rim turned to the bottom and the groove of 12 mm width being flush with guide pin (25).
- ⇒ Fit upper spring carrier (27).

CHECK Remove spacer (94555) and check that regulating rack moves freely over the entire regulating travel.

Fuel Pump
Dismantling and Assembling

B₁



5.8 Checking axial clearance of regulating sleeve

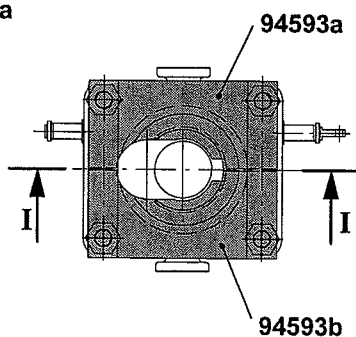
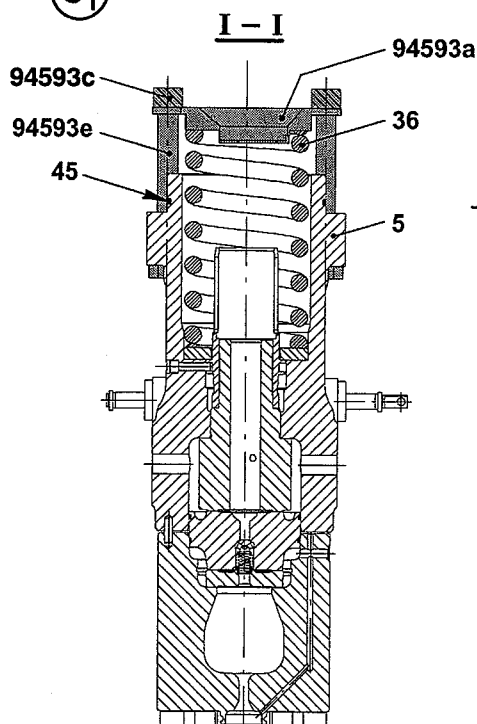
CHECK

Press upper spring carrier (27) against upper housing (5), checking whether regulating sleeve (26) can be moved axially (clearance $x = 0.2 \sim 0.4$ mm).

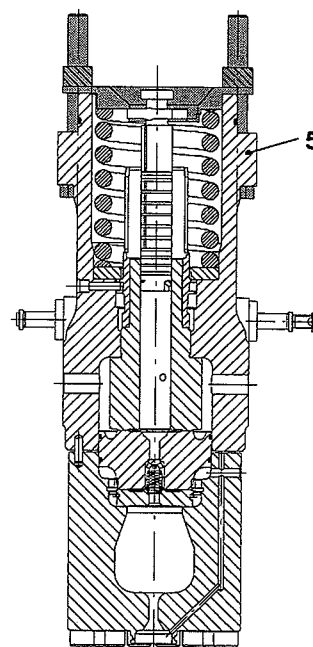
5.9 Fitting the spring carrier

- ⇒ Insert O-ring (45) and fit compression spring (36).
- ⇒ Place tool halves (94593a), (94593b) and flat bars (94593c) as shown in Fig. 'C₁'.
- ⇒ Tighten screws (94593e) till the tool halves rest on upper housing (5) (Fig. 'D₁').

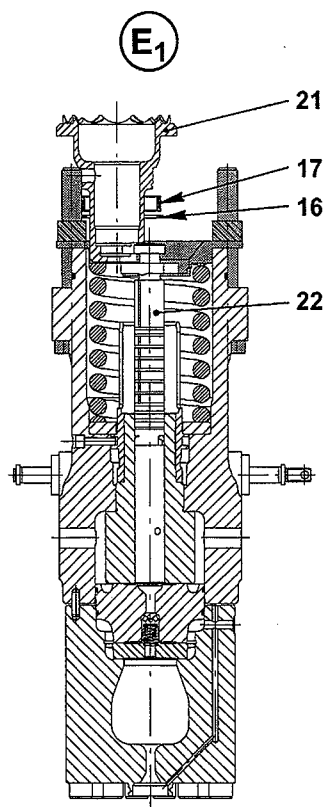
C₁



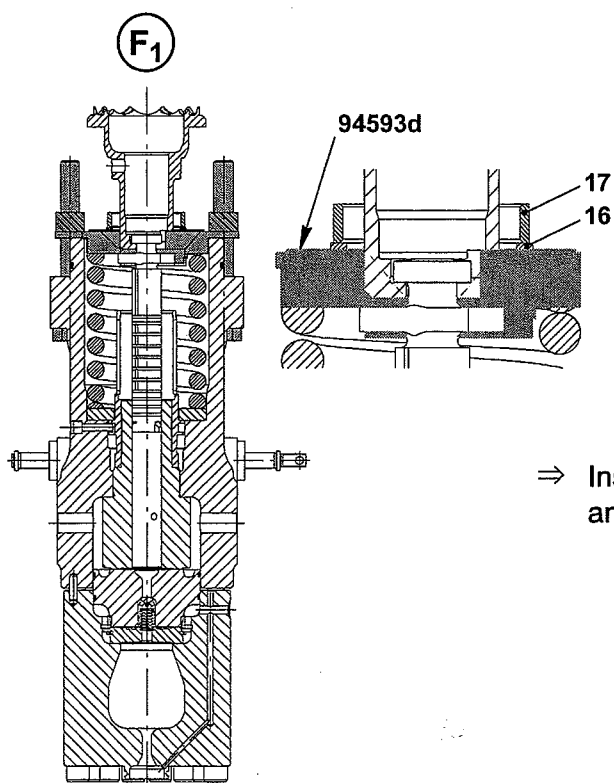
D₁



Fuel Pump
Dismantling and Assembling



- ⇒ Oil pump plunger (22), sliding carefully into pump cylinder (23) and rest it on tool halves.
- ⇒ Guide retaining ring (17) and circlip (16) over lower spring carrier (21) and push them onto the pump plunger.



- ⇒ Install metal sheet (94593d) on the tool halves and place circlip (16) and retaining ring (17).

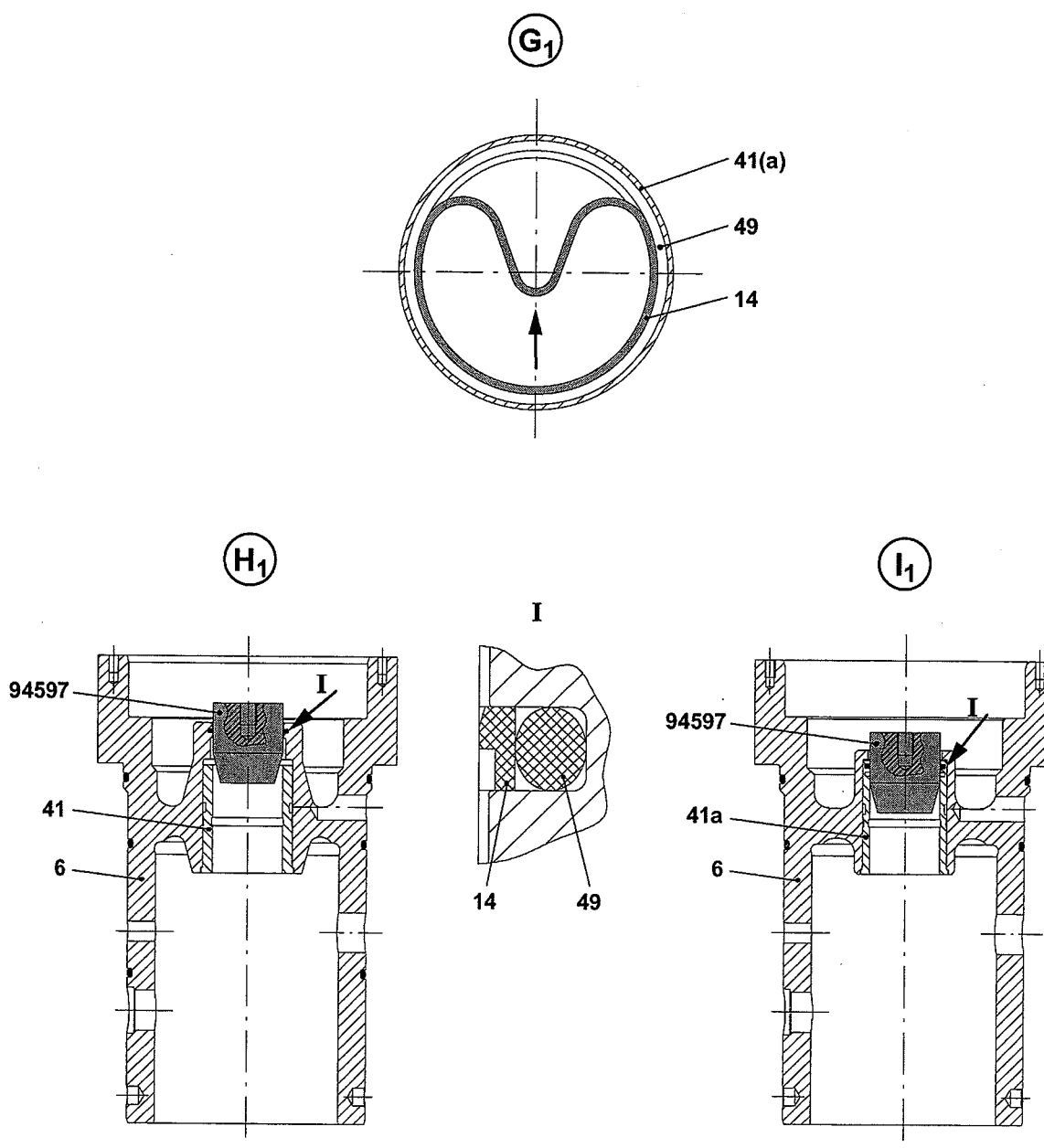
Fuel Pump

Dismantling and Assembling

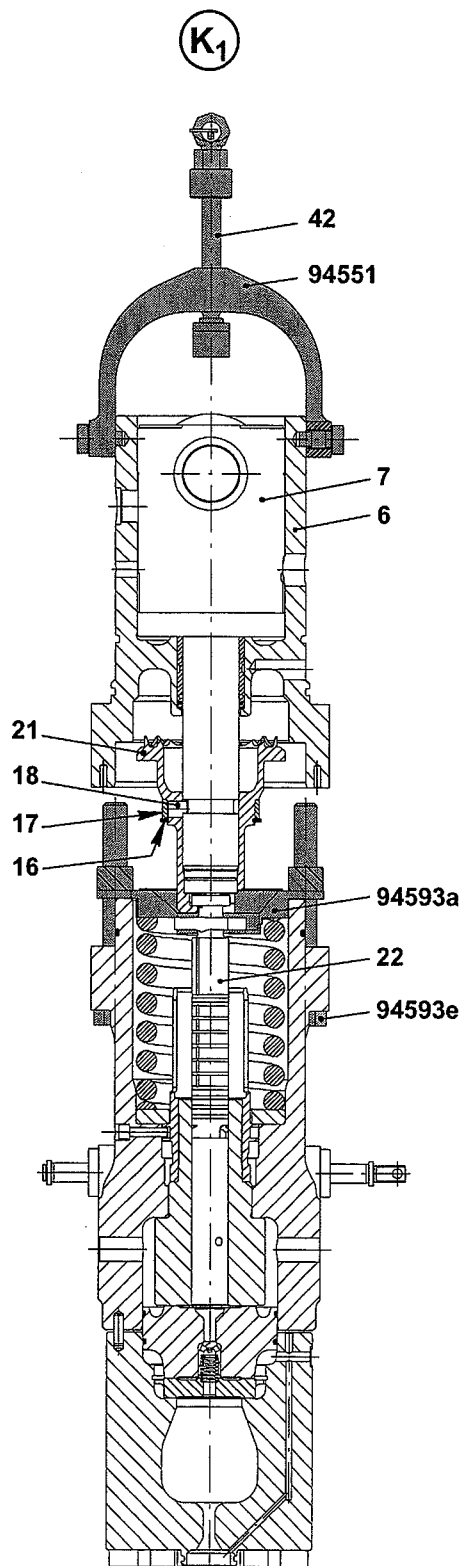
5.10 Fitting the piston seal ring

 **Remark**: There are different designs/arrangements of the piston seal ring (14), i.e. it can either be fitted into lower housing (6) (Fig. 'H₁') or into bush (41a) (Fig. 'I₁').

- ⇒ Insert O-ring (49) of the piston seal ring into the groove.
- ⇒ Deform piston seal ring "kidney-shaped", insert it into the groove and pay attention to its fitting position as shown in view I below.
- ⇒ Press piston seal ring into the groove in direction of arrow.
- ⇒ Press mandrel (94597) through bush (41)/(41a) calibrating the piston seal ring after fitting (Fig. 'H₁' and 'I₁').



Fuel Pump
Dismantling and Assembling

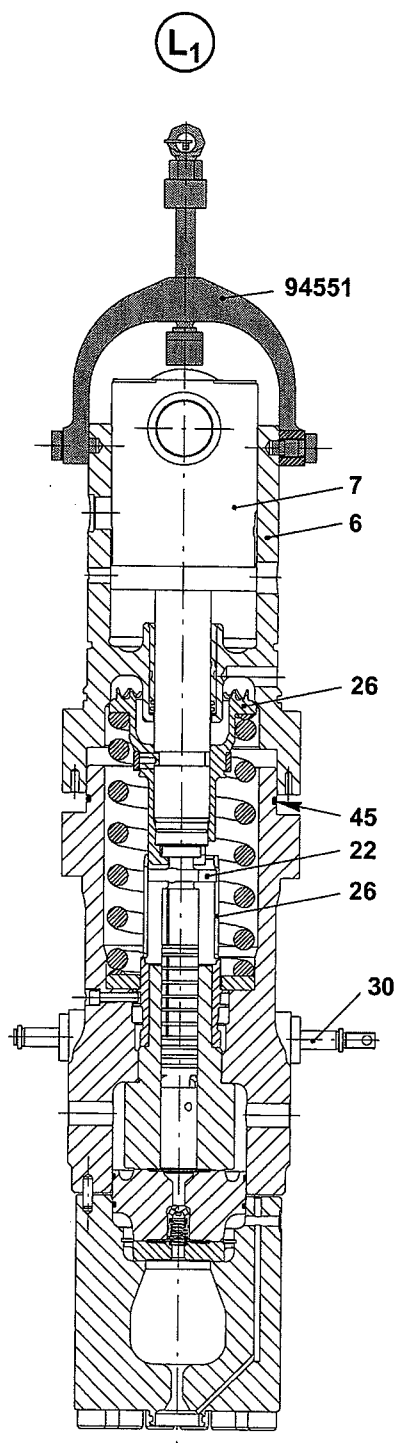


5.11 Final assembly

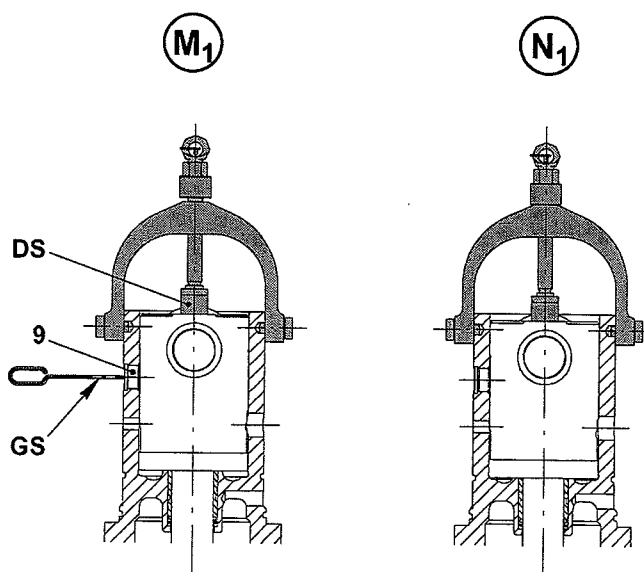
- ⇒ Oil guide piston (7) and fit it into lower housing (6).
- ⇒ Install fitting & dismantling device (94551) on the lower housing.
- ⇒ Turn back spindle (42).
- ⇒ Lower down carefully lower housing together with guide piston into lower spring carrier (21) and insert pin (18).
- ⇒ Push up retaining ring (17) and fit circlip (16).
- ⇒ Turn pump plunger (22) till both drivers fit into the recesses of tool halves (94593a) and (94593b).
- ⇒ Loosen equally screws (94593e) and remove the tool halves.

 **Remark**: When loosening screws (94593e), make sure that the pump plunger is not pushed up too!

Fuel Pump
Dismantling and Assembling



- ⇒ Lower down carefully lower housing (6) together with guide piston (7), ensuring that the drivers of pump plunger (22) fit into the slot (guide) of regulating sleeve (26) (Fig. 'L₁'). Should this not be possible, the regulating sleeve must be properly turned by means of regulating rack (30).
- ⇒ Fit the lower housing to the upper housing with the two Allen screws (20) (Fig. 'T').
- ⇒ Preload compression spring (24) with fitting & dismantling device (94551) till guide pin (9) can be inserted into the lower housing and guide piston with handle screw "GS". Should this not be possible, the groove in the guide piston must be aligned turning pressure piece "DS" in the required direction.
- ⇒ Press the pump plunger into T.D.C. using fitting & dismantling device (94551) as shown in Fig. 'N1', and check regulating rack (30) (Fig. 'L₁') for easy movement.
- ⇒ Release fitting & dismantling device and remove it.



Fuel Pump
Dismantling and Assembling

6. Fitting of a fuel pump

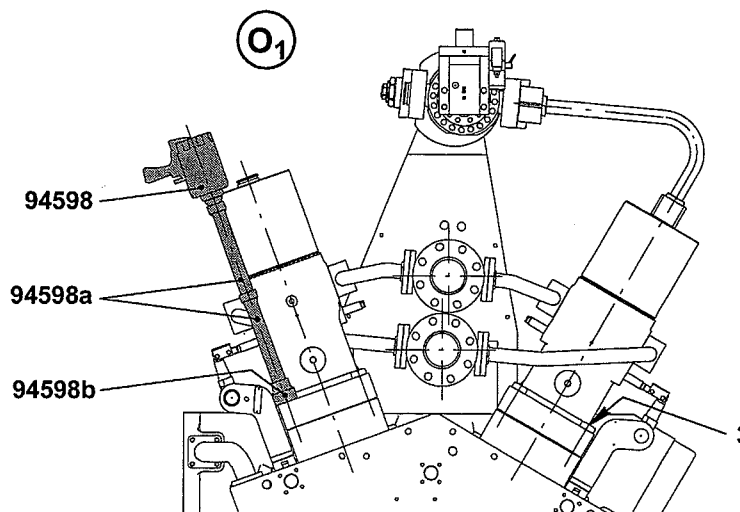
- ⇒ Turn the engine till the cam belonging to the fuel pump concerned is on the base circle (Fig. 'Q').

CHECK Check whether the seating surfaces as well as the guide parts of the supply unit housing and fuel pump are in a faultless condition.

- ⇒ Fit remaining O-rings (45) (Fig. 'Q').
- ⇒ Loosen screw(50) and remove them together with blank flange (51) and its gasket. Push Protection tool (94599k) till the stop and tighten protection tool with screw (50) (Fig. 'A').
- ⇒ Oil the guide parts and fit the fuel pump, taking care of the locating pin and the regulating shaft (do **not** use any jointing agent).
- ⇒ Fit screws (3) with oiled threads and head seating surfaces.
- ⇒ Tighten screws (3) to an angle of **64°** using socket spanner insert (94598b), extensions (94598a) and impact wrench (94598) as shown in Fig. 'O₁'.

CHECK Check the setting of the regulating linkage (see 5801-1).

- ⇒ Loosen and remove screw(50), and withdraw protection tool (94599k). Fit blank flange (51) (with gasket) and tighten it with screw (50).
- ⇒ Fit all pipings. Apply Never-Seez NSBT-8 to threads and head seating surfaces of screws (40) (Fig. 'A') and tighten them crosswise in equal steps with a total value of **70 Nm**.
- ⇒ When putting the fuel pump into operation, watch for possible leakages or abnormal temperature rise. Fit the casing when everything is in order.



7. Preserving

If a fuel pump has to be stored over a long period of time, the spaces carrying fuel oil must be filled with Vaseline oil/ rust preventive oil and plugged with plastic stoppers. Furthermore, oil the fuel pump and protect it against humidity and soiling by wrapping it suitably.

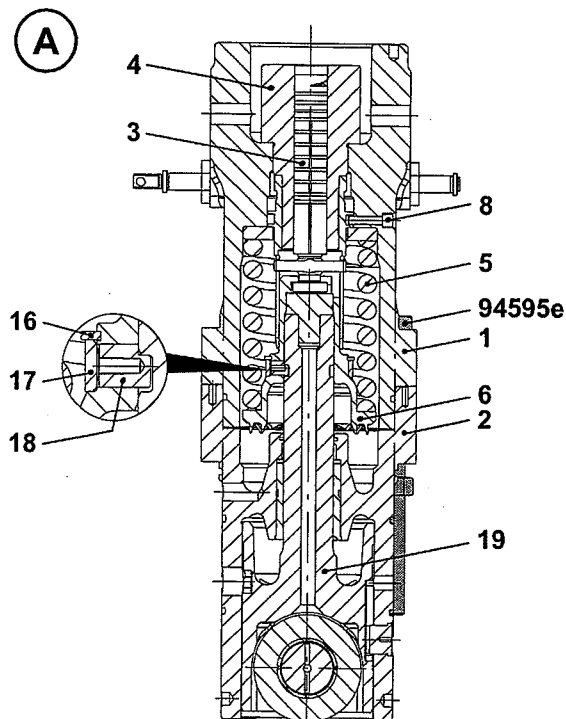
The fuel pumps must be stored in upright position.

Fuel Pump
Removal of a Jammed Pump Plunger
Tool:

1	Rotation device	94290
1	Jack (for 12 holes)	94595
1	Jack (for 16 holes)	94595a
1	Short tappet	94595b
1	Long tappet	94595c
1	Piston reset tool	94595d
2	Screws	94595e
1	HP oil pump	94931
1	Pressure gauge	94932
1	HP hose	94935a

Key to Illustrations:

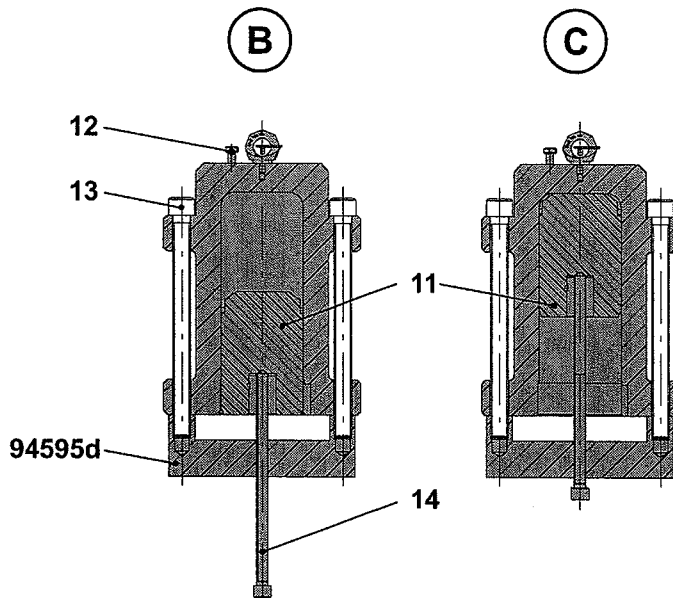
1	Upper housing	12	Vent screw
2	Lower housing	13	Head screw
3	Pump plunger	14	Spindle
4	Pump cylinder	15	Indicator
5	Compression spring	16	Circlip
6	Lower spring carrier	17	Retaining ring
7	Regulating sleeve	18	Connecting pin
8	Guide pin	19	Guide piston
9	Head screw		
10	Nut		
11	Piston	EV	Relief valve

1. Preparation (F.P. with connecting pin 18)


⇒ Remove the fuel pump from the supply unit. Place it into rotation device (94290) and dismantle the fuel pump (see 5556-1/A2) till the condition is reached as shown in Fig. 'A'.

Fuel Pump

Removal of a Jammed Pump Plunger

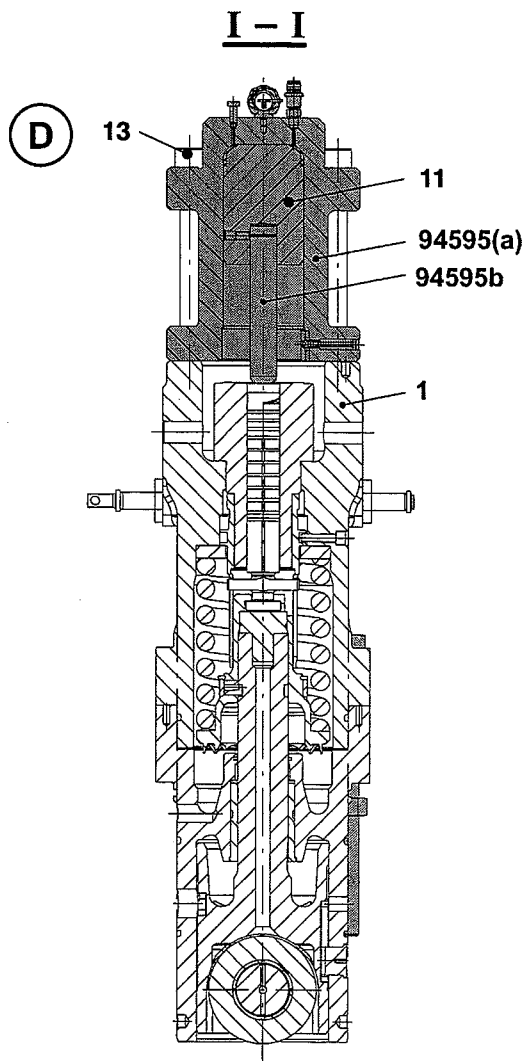


2. Preparation of jack 94595/94595a

- ⇒ Remove tappet (94595b) or (94595c) from piston (11) (Fig. 'D').
- ⇒ Fasten piston reset tool (94595d) to jack (94595)/(94595a) by means of head screws (13) which are used for fastening the fuel pump cover.
- ⇒ Open vent screw (12).
- ⇒ Push piston (11) fully back into initial position by means of spindle (14) (Fig. 'C').
- ⇒ Remove the piston reset tool.

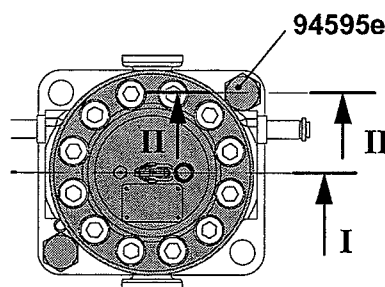


Lower housing (2) must be secured against falling down!

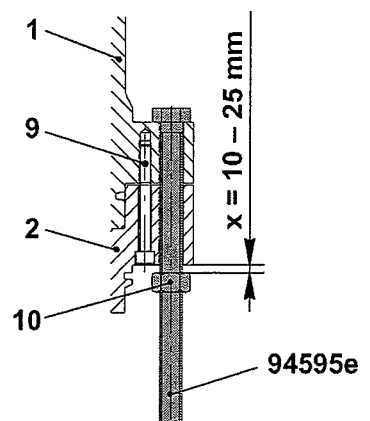


3. Placing the jack 94595/94595a

- ⇒ Insert short tappet (94595b) into piston (11).
- ⇒ Fasten jack (94595)/(94595a) onto upper housing (1) by means of head screws (13).
- ⇒ Insert screws (94595e) through flange bore of the lower and upper housings in diagonal direction.
- ⇒ loosen nuts (10) till a minimum clearance of $x = 10 \sim 25 \text{ mm}$ is reached (see section II-II).
- ⇒ Remove head screws (9).



II - II

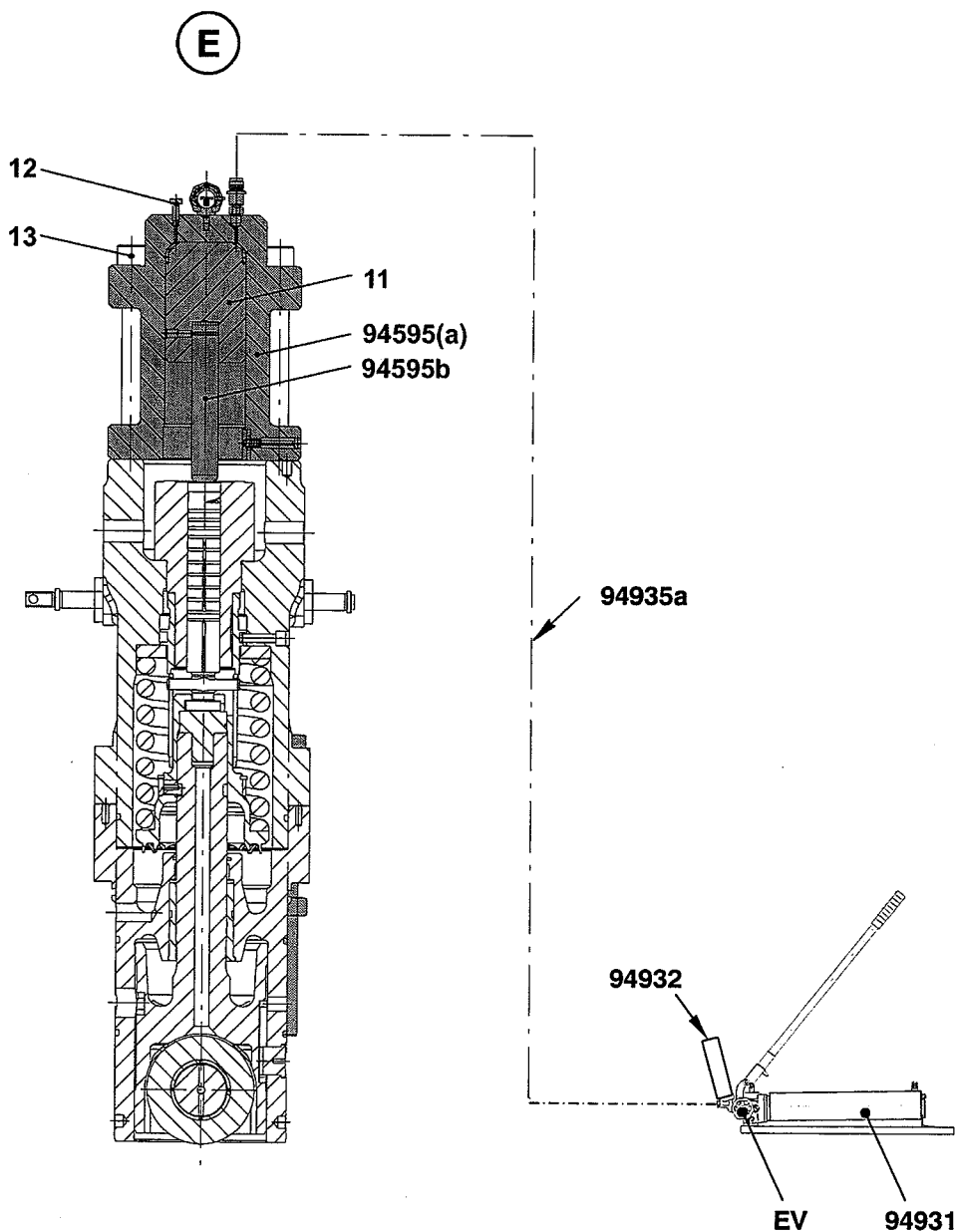


Fuel Pump

Removal of a Jammed Pump Plunger

4. Jacking-out the plunger

- ⇒ Connect jack (94595)/(94595a) with HP oil pump (94931) as shown in Fig. 'E'.
- ⇒ Shut relief valve "EV" and actuate HP oil pump till oil flows bubble-free at vent screw (12).
- ⇒ Close the vent screw.



Fuel Pump

Removal of a Jammed Pump Plunger

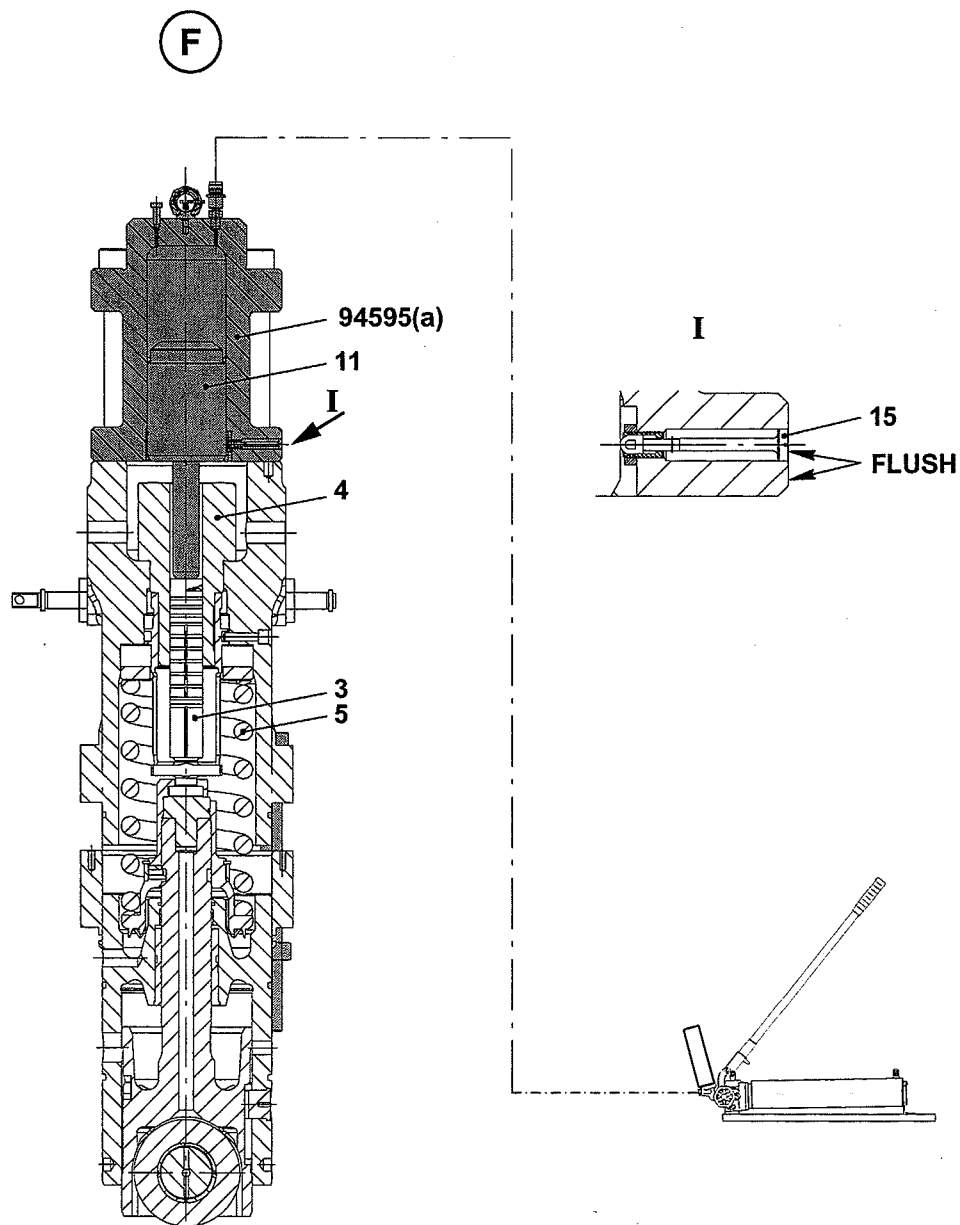
4.1 Jacking-out 1st stage

- ⇒ Pump slowly till plunger (3) is either jacked out from pump cylinder (4) by the force of compression spring (5) or till indicator (15) shows the stroke end of piston (11), i.e. the indicator is flush with the housing.



During pumping procedure, i.e. till the plunger is loose, follow correspondingly with nuts (10) keeping always a clearance of $x = 10 \sim 25 \text{ mm}$ (Fig. 'D' section II-II).

- If the plunger can now be taken out, remove jack (94595)/(94595a) and the remaining disassembly of the fuel pump can be carried out according to 5556-1/A2.
- However, in case the plunger is still not loose, proceed as described in the following paragraph 4.2 (jacking-out 2nd stage).

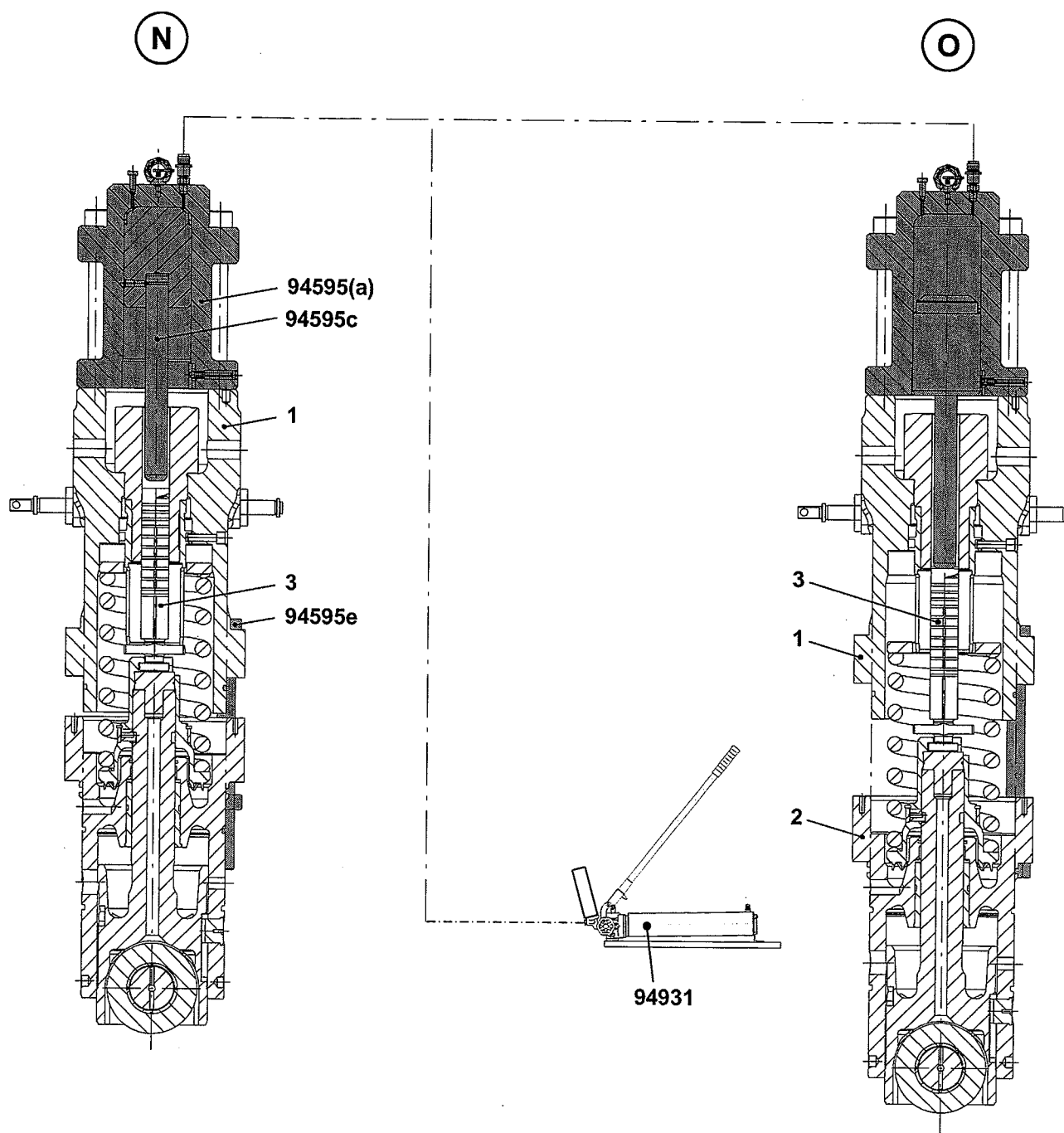


Fuel Pump

Removal of a Jammed Pump Plunger

4.2 Jacking-out 2nd stage

- ⇒ Remove jack (94595)/(94595a) from upper housing (1).
- ⇒ Reset piston (11) using tool (94595d), see section 2.
- ⇒ Remove short tappet (94595b) and replace it with long tappet (94595c).
- ⇒ Place jack again onto the upper housing and connect it with HP oil pump (94931).
- ⇒ Proceed as described in paragraph 4.1 till the plunger is loose.



Injection Control Unit
Removal and Fitting

Tools:

- | | | |
|---|-------------------|-------|
| 1 | Lifting plate | 94584 |
| 2 | Withdrawing tools | 94589 |

Key to Illustrations:

- | | | | |
|----|------------------------|----|--------------------|
| 1 | Control oil inlet | 8 | Rail valve |
| 2 | Control oil outlet | 9 | Screw |
| 3 | Fuel leakage return | 10 | Intermediate plate |
| 4 | Fuel rail | 11 | Lip seal |
| 5 | Connection piece | 12 | Position sensor |
| 6 | Injection control unit | 13 | Countersunk screw |
| 7 | Screw | 14 | O-ring |
| 7a | Screw | | |

1. General

When working on an injection control unit in principle the engine has to be stopped and the control oil pump switched off.



Pipings to control oil inlet (1) and outlet (2), fuel leakage return (3) and fuel rail (4) must be pressureless!
The corresponding injection control unit must be shut off (Fig. 'A').
Follow the detailed instructions in 0510-1 of the Operating Manual without fail!



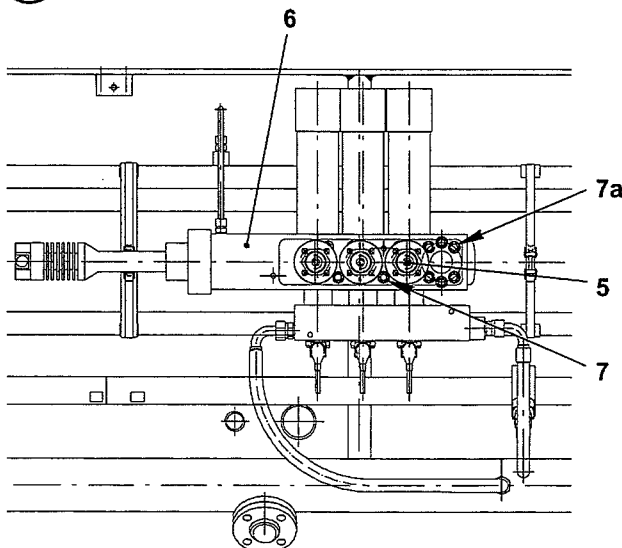
Maintenance works on the injection control unit may be carried out only by the manufacturer as a matter of principle. However, if troubles have been detected on the injection control unit during operation, it must be replaced by a revised unit, following the instruction below.



Remark : No maintenance work is provided for rail valve (8). If necessary it must be replaced as a whole unit!

2. Removal

A



- ⇒ Remove fuel pressure pipings and their connection pieces (5) from injection control unit (6) according to 8733-1 (the connection pieces are screwed into the spare injection control unit).
- ⇒ Remove screws (7) and (7a).

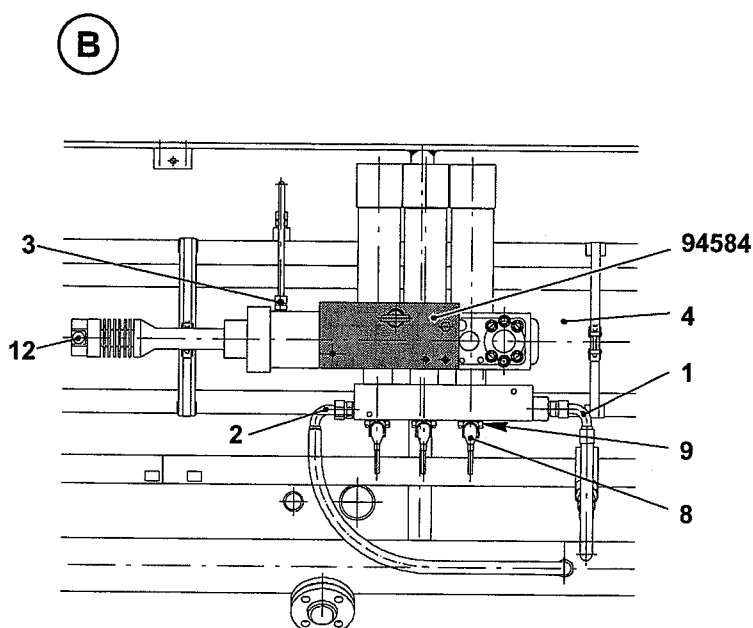
Injection Control Unit

Removal and Fitting

- ⇒ Fasten lifting plate (94584) onto injection control unit (6).
- ⇒ Remove cable plugs from rail valves (8) and position sensor (12).
- ⇒ Loosen screws (9) and remove them together with rail valves (Fig. 'B').
- ⇒ Lift up the injection control unit.

 **Remark** : Immediately cover the appearing opening in fuel rail (4) to prevent dirt from entering in any circumstance!

- ⇒ Lip seal (11) (Fig. 'C') can be removed (if necessary) with one of withdrawing tools (94589).

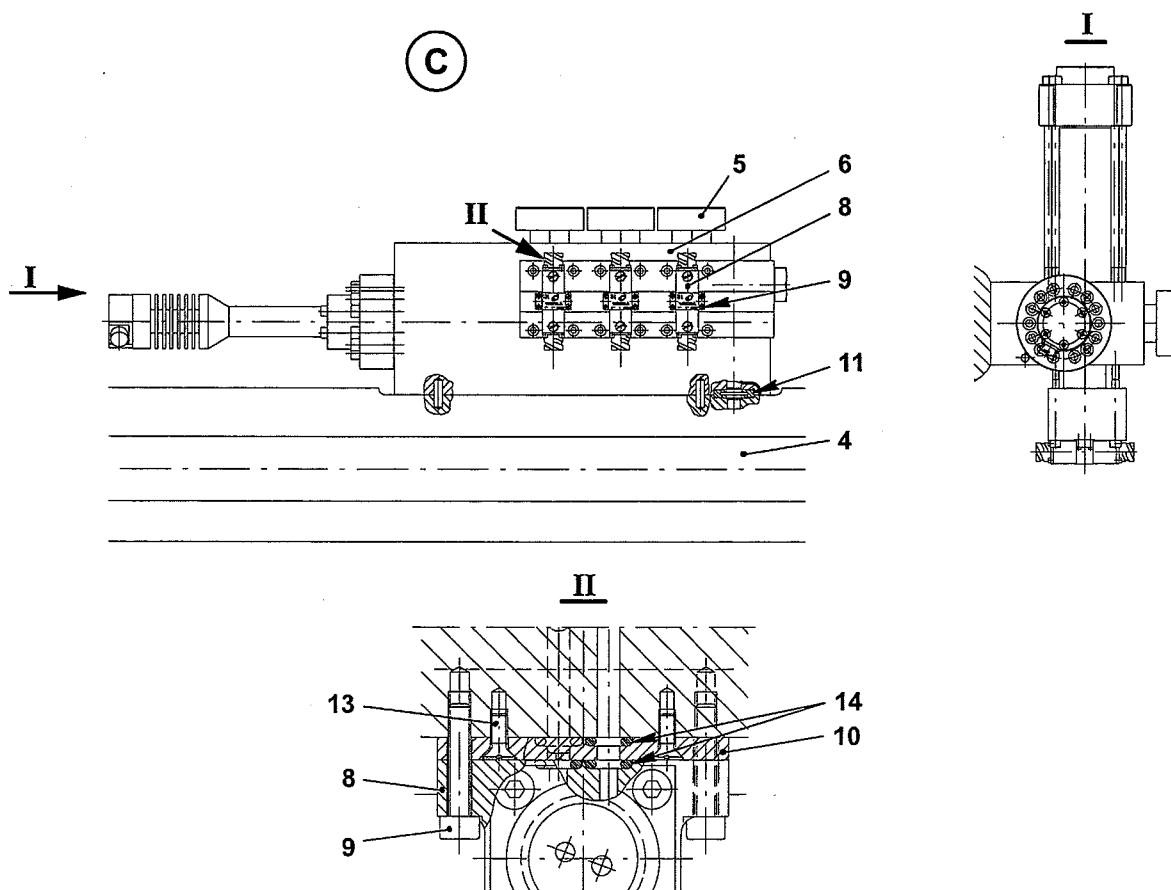


Injection Control Unit

Removal and Fitting

3. Fitting

- ⇒ Insert lip seal (11).
- ⇒ Lower injection control unit (6) carefully onto the fuel rail and remove the lifting plate.
- ⇒ Apply Never-Seez NSBT-8 to the threads of screws (7) and (7a) (Fig. 'A').
- ⇒ First tighten screws (7a) crosswise with a torque of **110 Nm** and subsequently screws (7).
- ⇒ Replace O-rings (14), if necessary.
- ⇒ Apply oil to screws (9) and fasten rail valve (8) to injection control unit (6) with them.
- ⇒ Tighten screws (9) with a torque of **2.5 Nm**.
- ⇒ Apply Never-Seez NSBT-8 to the threads of connection pieces (5) and tighten the latter with a torque of **700 Nm**.
- ⇒ Install pipings.
- For fitting the fuel pressure pipings see 8733-1.
- For restarting the injection see instructions 0510-1 in the Operating Manual!



Exhaust Valve Drive

Removal, Fitting, Dismantling and Assembling

Key to Illustrations:

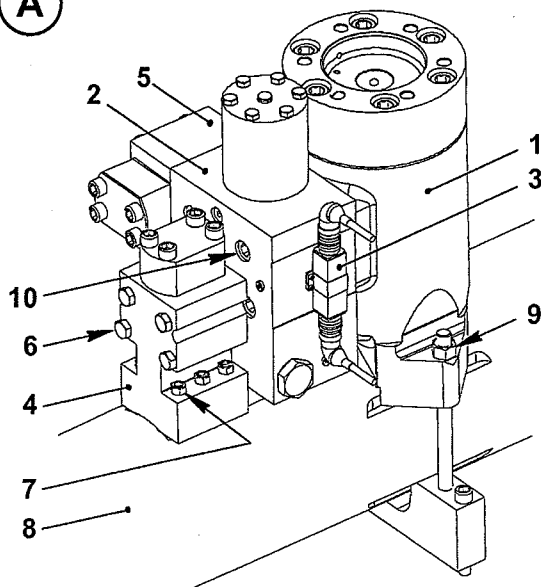
1	Housing	22	Screw plug
2	3/2-way valve	23	Screw plug
3	Rail valve	24	Filter
4	Connecting element	25	Closing piece
5	Connecting piece	26	Gasket
6	Screw	27	Screw
7	Nut	28	Non-return valve
8	Servo oil rail	29	Nipple
9	Nut	30	Screw
10	Screw	31	Screw
11	Stud	32	O-ring
12	Screw	33	O-ring
13	Cover	34	O-ring
14	Piston	35	O-ring
15	Spring housing	36	O-ring
16	Spring guide	37	O-ring
17	Compression spring	38	O-ring
18	Spring carrier		
19	Slide rod		
20	Lower cover	KO	Slot
21	Piston	OE	Oil inlet

1. General

When working on the exhaust valve drive in principle the engine has to be stopped and the control oil pump switched off.



Pipings for servo and control oil must be pressureless.
Follow the instruction in 0520-1 of the Operating Manual without fail!

2. Removal
2.1 Removal
A


⇒ For the removal of the exhaust valve drive, first remove the hydraulic piping from the exhaust valve drive (see 8460-1).

⇒ Remove piping.

⇒ Remove rail valve (3).

⇒ Loosen screws (6).

⇒ Remove nut (7).

⇒ Dismantle connecting element (4).



Remark : Immediately cover the appearing opening to prevent dirt from entering in any circumstance!

⇒ Loosen screws (9) and lift the complete exhaust valve drive by means of the board crane.

Exhaust Valve Drive

Removal, Fitting, Dismantling and Assembling

3. Fitting

It is recommended to pre-assemble the exhaust valve drive outside the rail unit.

The work station must be clean; welding and grinding should not be done nearby!

3.1 Pre-assembly



Remark: The threads of all screws must be oiled prior to their fitting.

All O-rings must be replaced by new ones.

⇒ Assemble partition device (1), 3/2-way valve (2) and connecting element (4) together that they have metallic contact, but still can be moved, however.

3.2 Fitting on servo oil rail

- ⇒ Apply grease to O-ring (37) and place it into the inner groove of connecting element (4) (Fig. 'B', view II).
- ⇒ Lower the exhaust valve drive onto servo oil rail (8) as shown in Fig. 'B'.
- ⇒ Apply oil to studs (11), screw on nuts (7) (Fig. 'A') and tighten them with a torque of **60 Nm**.

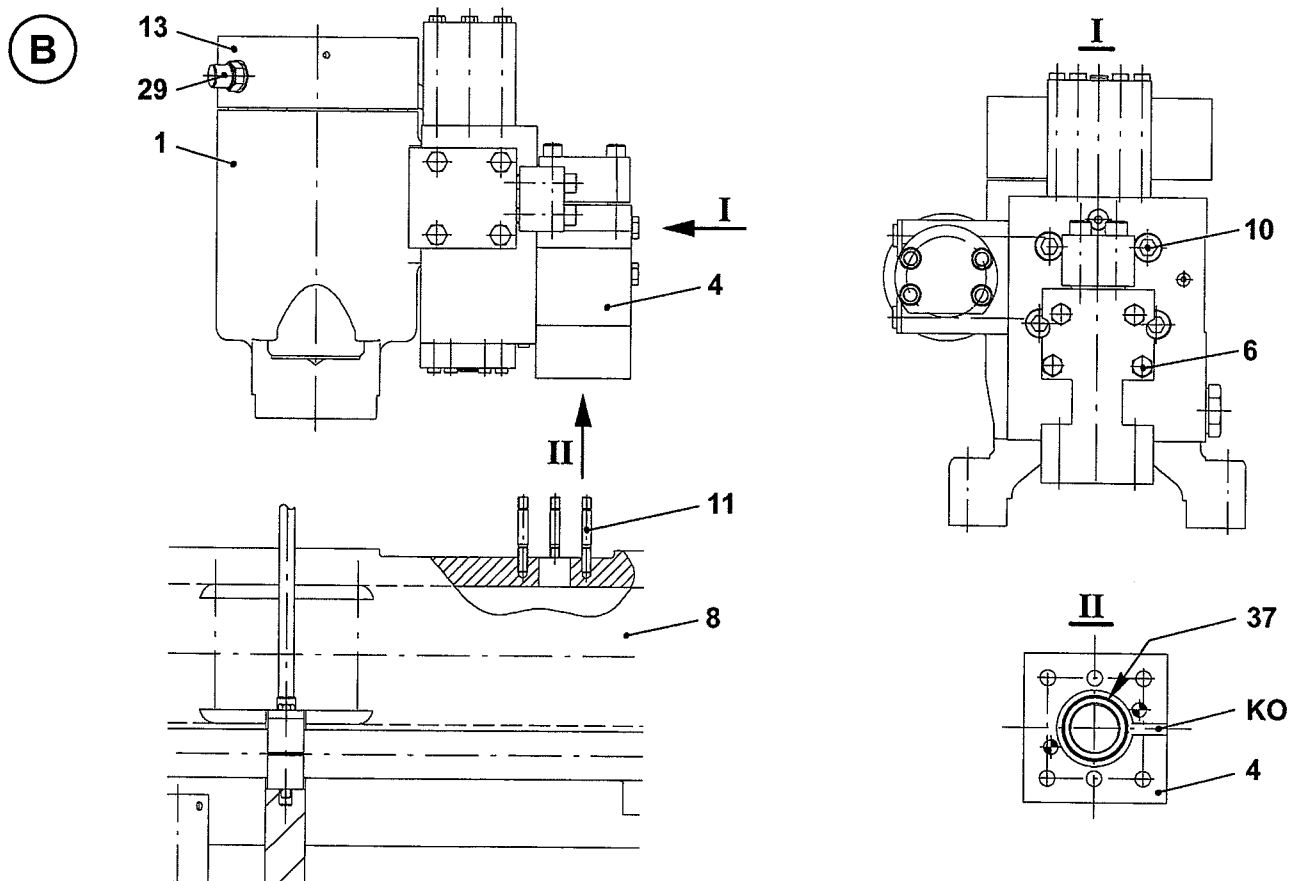
CHECK

The housing must seat on servo oil rail without clearance.

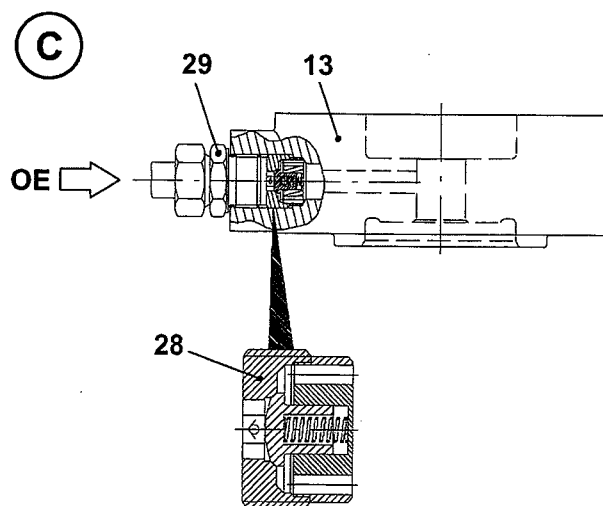
- ⇒ Tighten screws (6) with a torque of **170 Nm**.
- ⇒ Tighten screws (10).
- ⇒ Apply oil to nuts (9) (Fig. 'A') screw on and tighten them with a torque of **350 Nm**.
- ⇒ Fit rail valve (3) (Fig. 'A' and 'D') with screws (27) and tighten them with a torque of **2.5 Nm**.
- ⇒ Insert gasket (26) (Fig. 'D'), place cover (13) and fasten it equally with screws (12).
- ⇒ Install piping.
- For fitting the hydraulic piping to the exhaust valve drive see 8460-1.

Exhaust Valve Drive

Removal, Fitting, Dismantling and Assembling



4. Removal and fitting of non-return valve



4.1 Removal

- ⇒ Screw off nipple (29) (Fig. 'B' and 'C').
- ⇒ Unscrew non-return valve (28).

4.2 Fitting

- ⇒ Check non-return valve (28).
- ⇒ Oil the non-return valve, fit and tighten it with a torque of **60 Nm**.
- ⇒ Screw nipple (29) sleeve into cover (13).

Exhaust Valve Drive

Removal, Fitting, Dismantling and Assembling

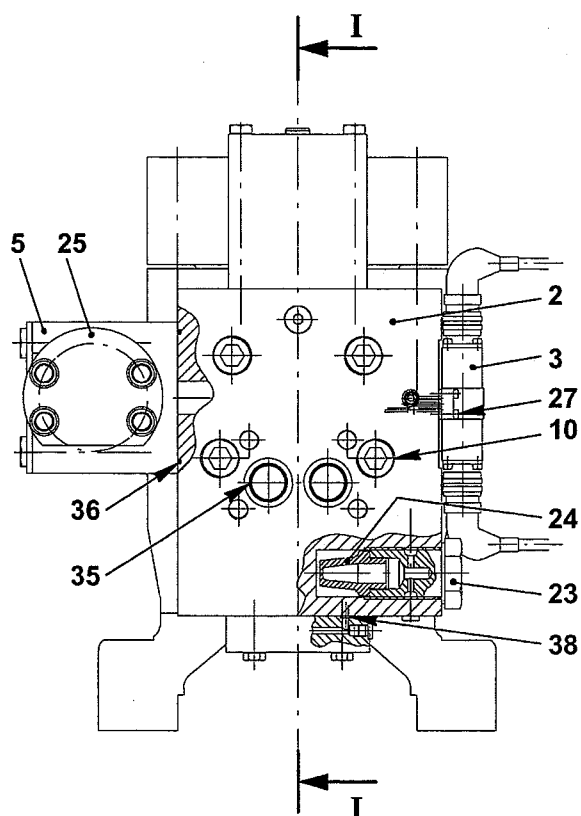
5. Removal and fitting of 3/2-way valve

 **Remark** : The complete 3/2-way valve (2) and lower cover (20) with its O-ring (34) can only be removed and fitted after the removal of the exhaust valve drive according to section 2.

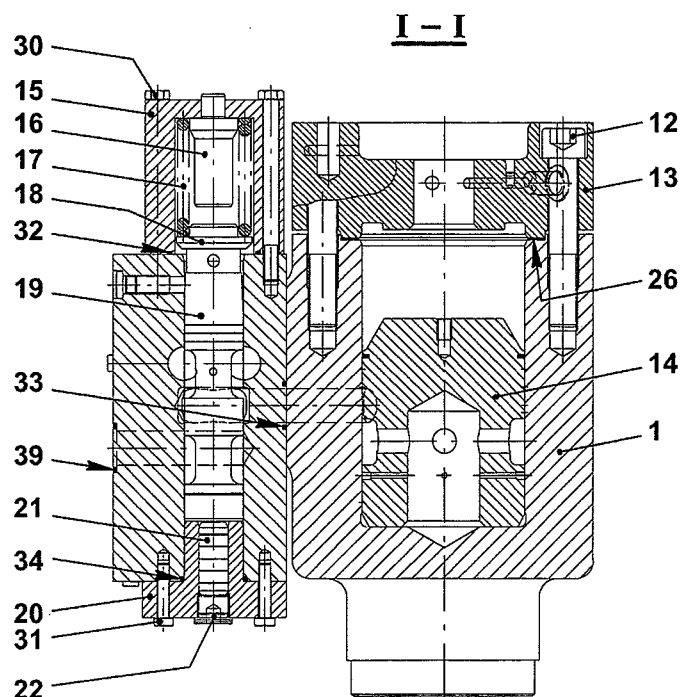
- Apply oil to the threads of screws (10) (Fig. 'A') and tighten them with a torque of **350 Nm**.
- The movable parts can be removed and fitted after removing the spring housing (15).

6. Removal and fitting of piston

- ⇒ Remove cover (13) and withdraw piston (14) using a threaded rod M12.
- ⇒ After fitting piston (14), insert gasket (26), place cover (13) and tighten the latter equally with screws (12).



D



Regulating Linkage

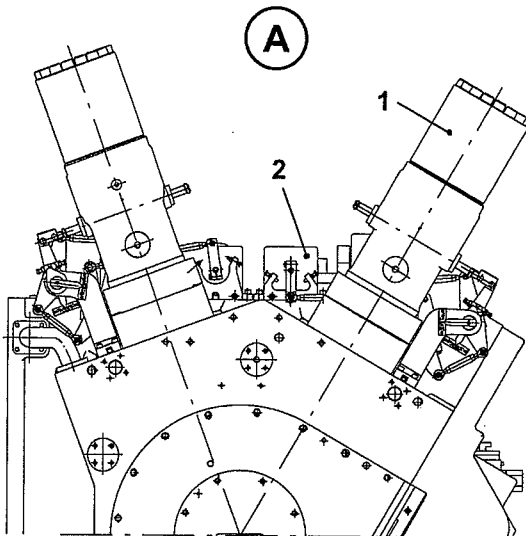
Adjusting

Key to Illustrations:

1	Fuel pump	11	Flange
2	Actuator	12	Holder
3	Forked lever	13a ~ e	Connecting rods
4	Torsion spring	14a, b	Stop screws
5	Pin	15	Actuator lever
6	Adjusting screw	16	Actuator shaft
7	Limit lever	17	Regulating shaft
8	DU bush	18	Intermediate wheel
9	Regulating (toothed) rack	19	Pointer
10	Stop ring		

1. General

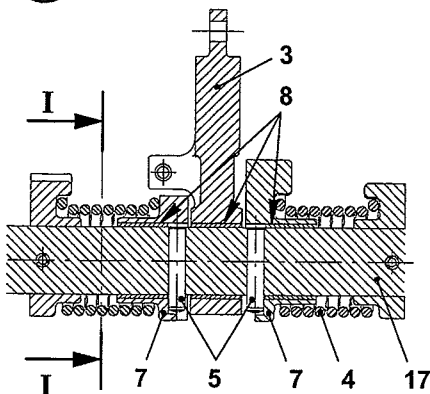
After overhauling the linkage or the fuel pumps, as well as after fitting a new fuel pump or a new actuator, the setting of the linkage must be checked and, if necessary, adjusted.



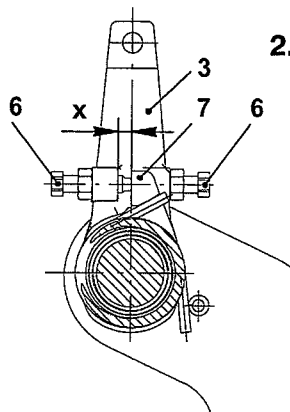
The power to the actuators (2) must be interrupted first, before they are connected from the regulating linkage (see 9362-1 in the Operating Manual).

2. Adjusting of regulating linkage

B



I - I



2.1 Pre-adjusting of forked levers

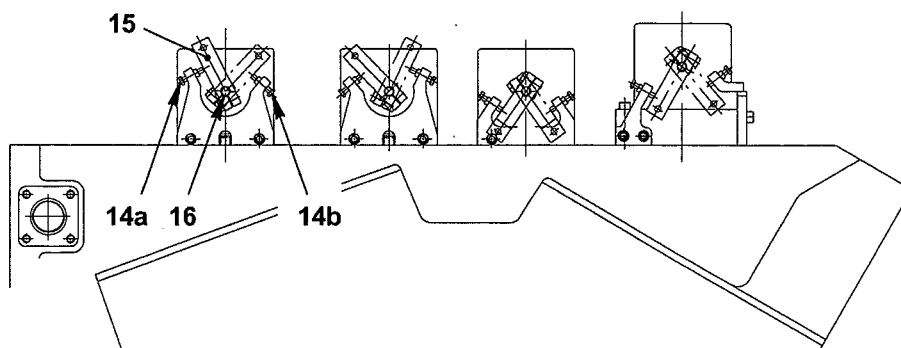
⇒ Adjust clearance 'x' = 8 mm between all limit levers (7) and forked levers (3) by means of adjusting screws (6).

Regulating Linkage
Adjusting**2.2 Adjustment of mechanical minimum – maximum limiters on actuator**

- The connecting rods (Fig. 'E') must not be connected with actuator levers (15).

2.2.1 Adjustment of mechanical minimum limiter

- ⇒ Turn back all stop screws (14a).
- ⇒ Rotate actuator shaft (16) in counter-clockwise direction till the stop inside the actuator.
In this position push the actuator lever onto the actuator shaft and place it at the corresponding stop screw (14a) as near as possible.
- ⇒ Screw in stop screw (14a) till it rests on actuator lever. Then turn stop screw by further 1/4 turn.
- ⇒ Secure stop screws with lock nuts.

(C)**2.2.2 Adjustment of mechanical maximum limiter**

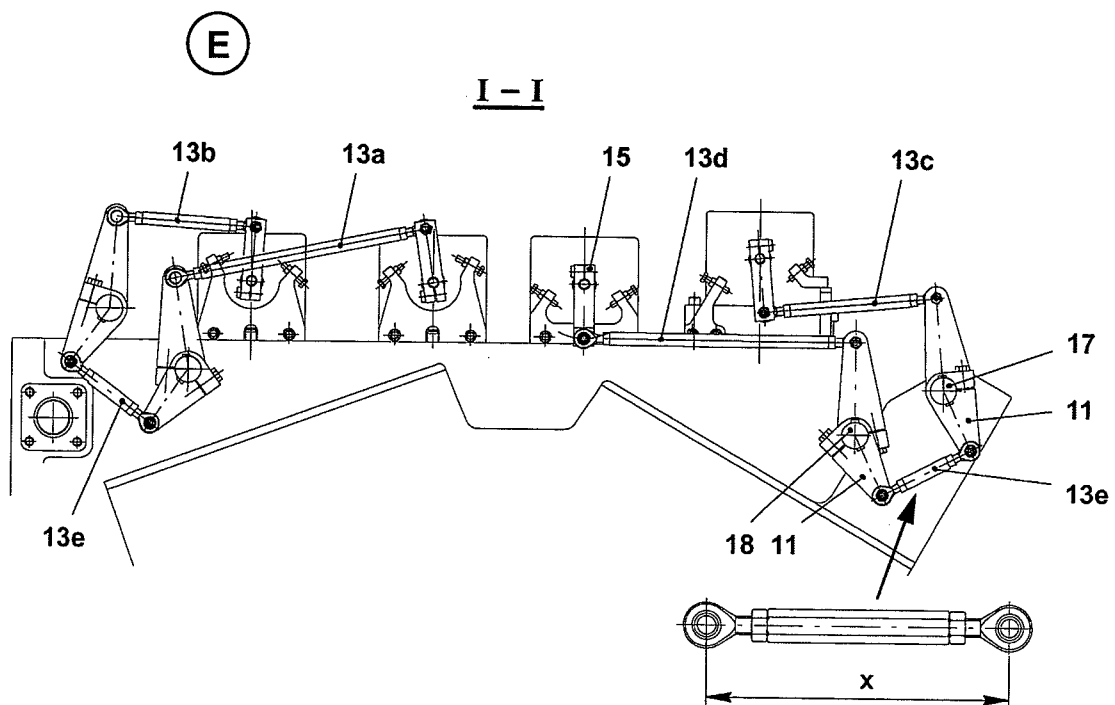
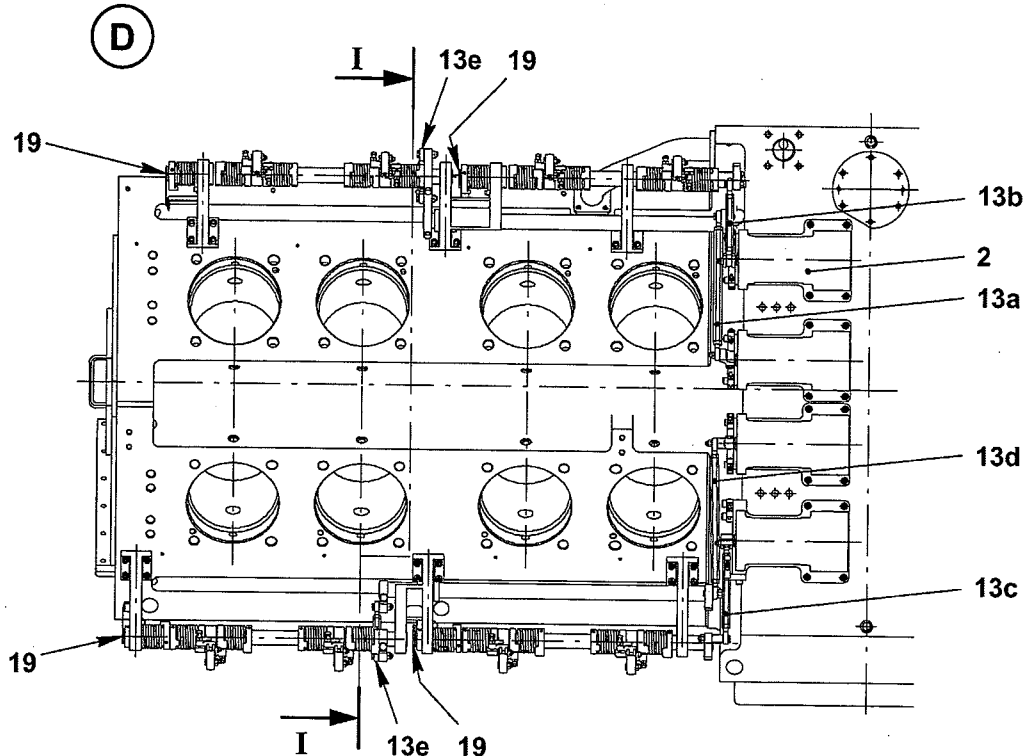
- ⇒ Turn back all stop screws (14b).
- ⇒ Rotate actuator shaft (16) in clockwise direction till the stop inside the actuator.
In this position push the actuator lever onto the actuator shaft and place it at the corresponding stop screw (14b) as near as possible.
- ⇒ Screw in stop screw (14b) till it rests on actuator lever. Then turn stop screw by one further turn.
- ⇒ Secure stop screws with lock nuts.

Regulating Linkage

Adjusting

2.3 Fitting of connecting rods

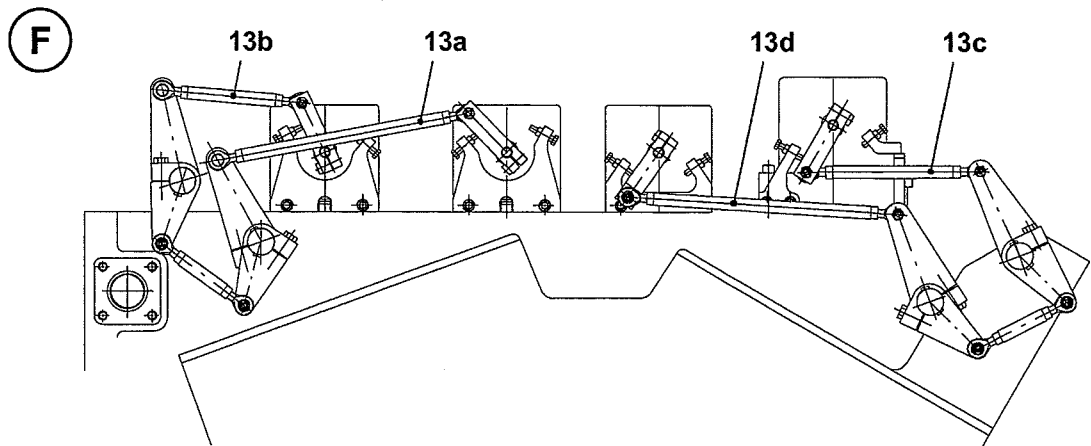
- ⇒ Adjust the length of connecting rods (13e) (Fig. 'E') to 'x' = 151.1 mm and connect them with levers (11).
- (there are connecting rods (13e) for 11, 12 and 14 cylinder engines only)
- ⇒ Install connecting rods (13a ~ d) as shown in Fig. 'D' and 'E'.



Regulating Linkage
Adjusting

2.4 Adjustment of connecting rods

- ⇒ Set all actuator levers to the mechanical minimum limiters (Pos. '0') as shown in Fig. 'F'.
- ⇒ Set pointers (19) to Pos. '0' by means of adjusting the length of the corresponding connecting rods (13a ~ d).



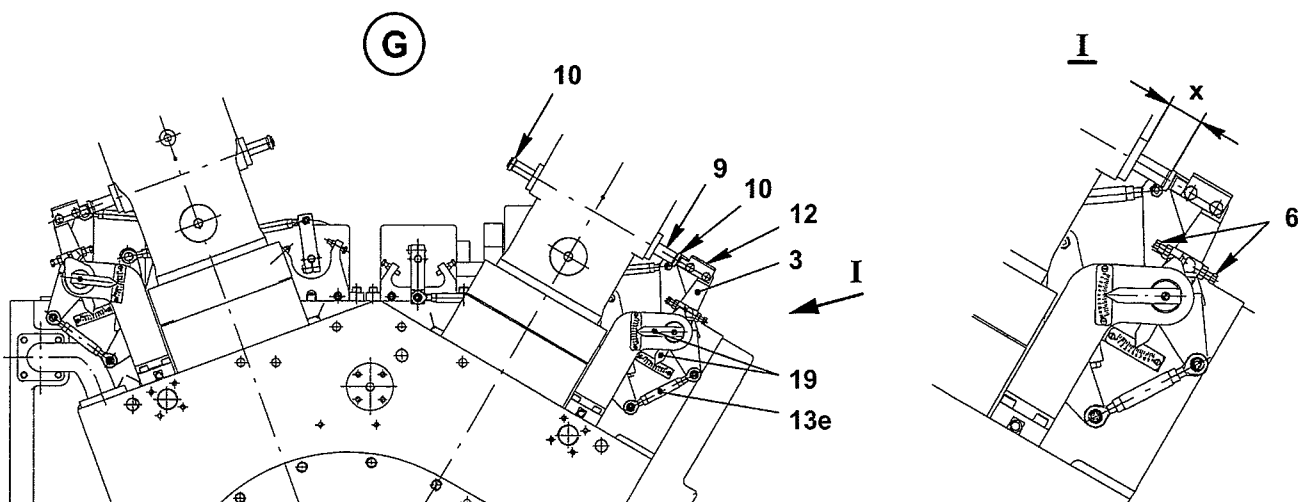
2.5 Adjustment of fuel pumps

- ⇒ Set regulating linkage to Pos. '5'.
- ⇒ Fit toothed racks 9 and holders 12 with forked levers 3 (Fig. 'G').
- ⇒ Adjust the toothed racks to dimension 'x' = 48 mm by means of adjusting screws (6).
Always screw in one adjusting screw while unscrewing the other by the same amount.
- The admissible deviation between the individual fuel pumps is ± 0.1 mm.

CHECK

Rotate the actuator shafts while checking whether the fuel regulating linkages are freely moveable over the whole regulating range.

Stop rings (10) must not touch the fuel pump housing in any of the end positions. A possible correction can be carried out by adjusting screws (6).



Group 6

Scavenge Air Receiver and Auxiliary Blower

Group 6

Checking the Air Flaps and Cleaning the Scavenge Air Receiver6420-1/A1

Auxiliary Blower: Maintenance.....6545-1/A1

▽ Scavenge Air Cooler

— Removal and Fitting of Cooler Element and Heater Element.....6606-1/A1

— Cleaning of the Scavenge Air Cooler at Standstill6606-2/A1

Water Separator: Removal and Fitting of Water Separator6708-1/A1

Scavenge Air Receiver
Checking the Air Flaps and Cleaning the Scavenge Air Receiver
Key to Illustrations:

1	Scavenge air receiver	9	Screw (M12×55)
2	Suction space	9a	Screw (M12×120)
3	Air flap	10	Locking plate
3a	Air flap	11	Distance ring
4	Door	12	Stop bar
5	Auxiliary blower	13	Pin
6	Cover	14	Drain
7		15	Relief valve
8			

1. General

Depending on number of cylinders air flaps are arranged either as shown in Fig. 'B' or Fig 'C' or there are both arrangements fitted in the same engine.

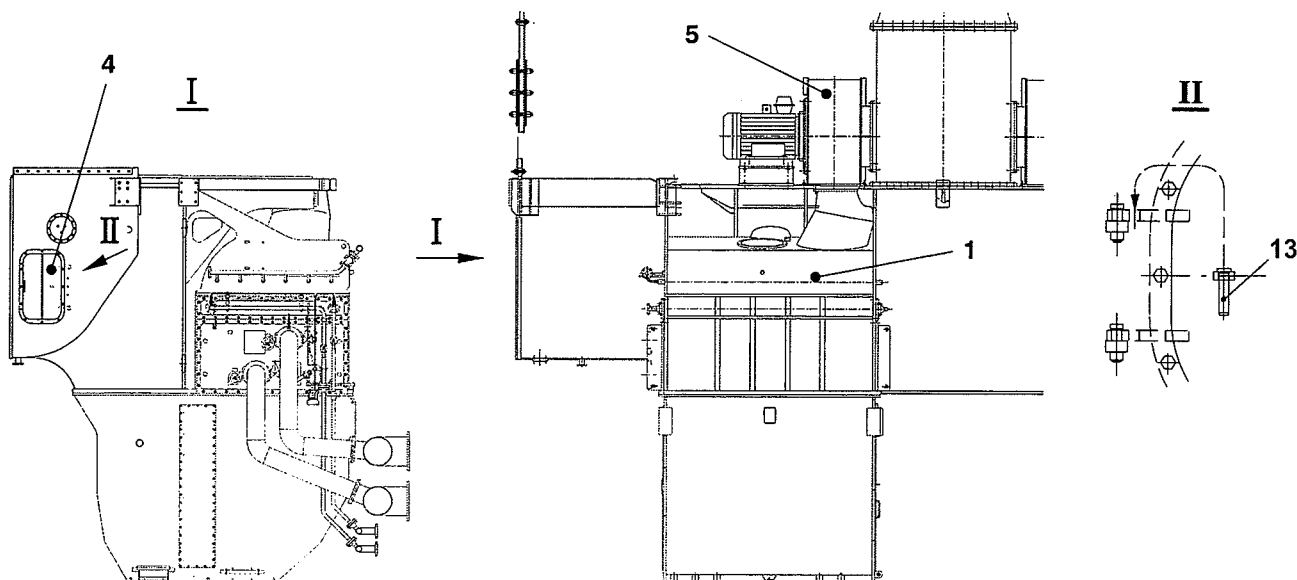
2. Inspection of air flaps
CHECK

In the course of periodic cleaning of the scavenge air receiver, air flaps (3) (Fig. 'B' and 'C') must be checked for damage, movability and fouling.

To check air flaps in scavenge air receiver (1), the two doors (4) arranged at the end are to be opened and locked with pins (13) on the inner sides (Fig. 'A' view II).

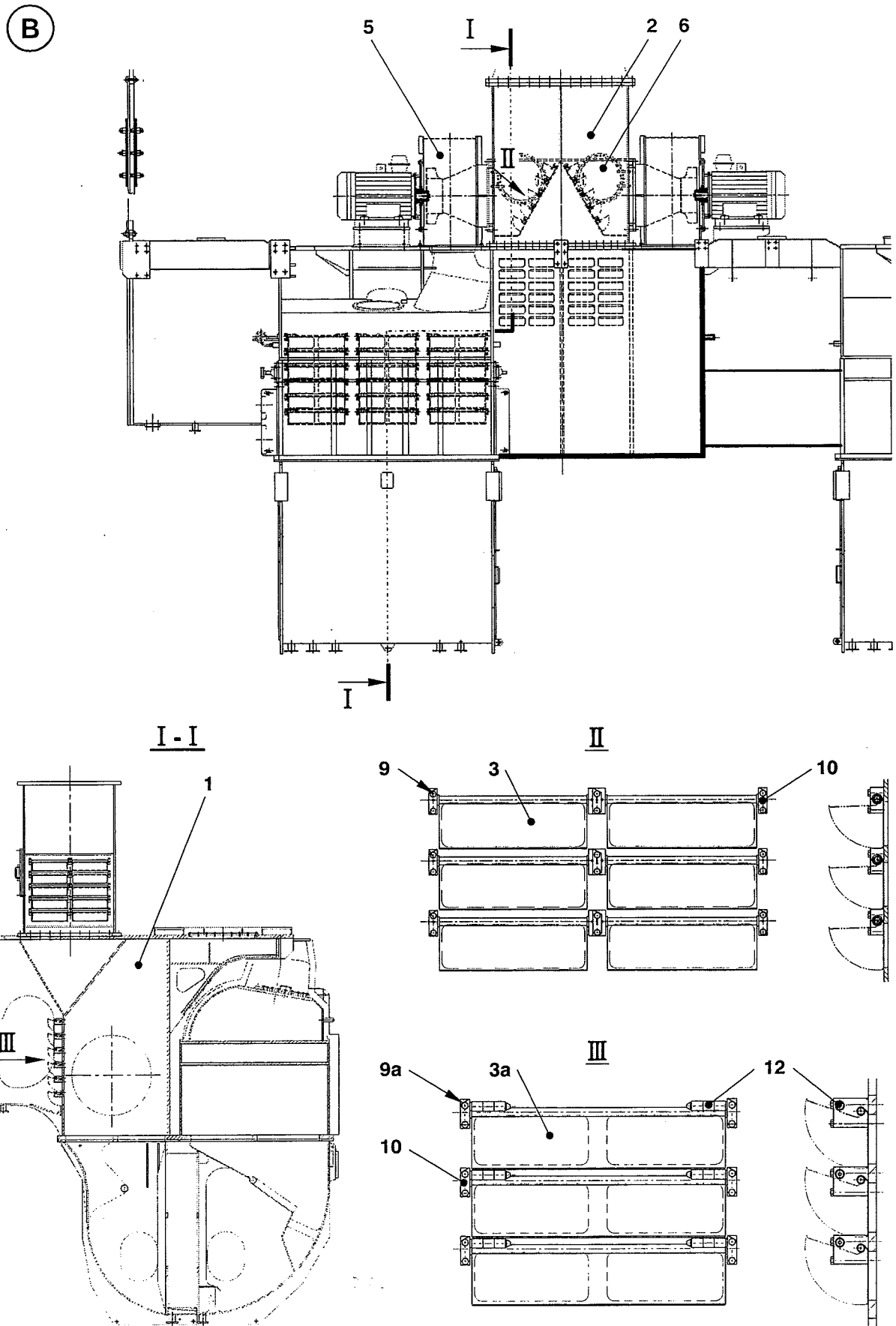
To check air flaps for auxiliary blowers (5), cover (6) on suction space (2) is to be opened (Fig. 'B').

- For the removal of several air flaps, first screws (9), (9a) and their locking plates (10) as well as stop bar must be removed as shown in Fig. 'B'. Subsequently the air flaps can be removed as single unit.

A


Scavenge Air Receiver

Checking the Air Flaps and Cleaning the Scavenge Air Receiver



Scavenge Air Receiver

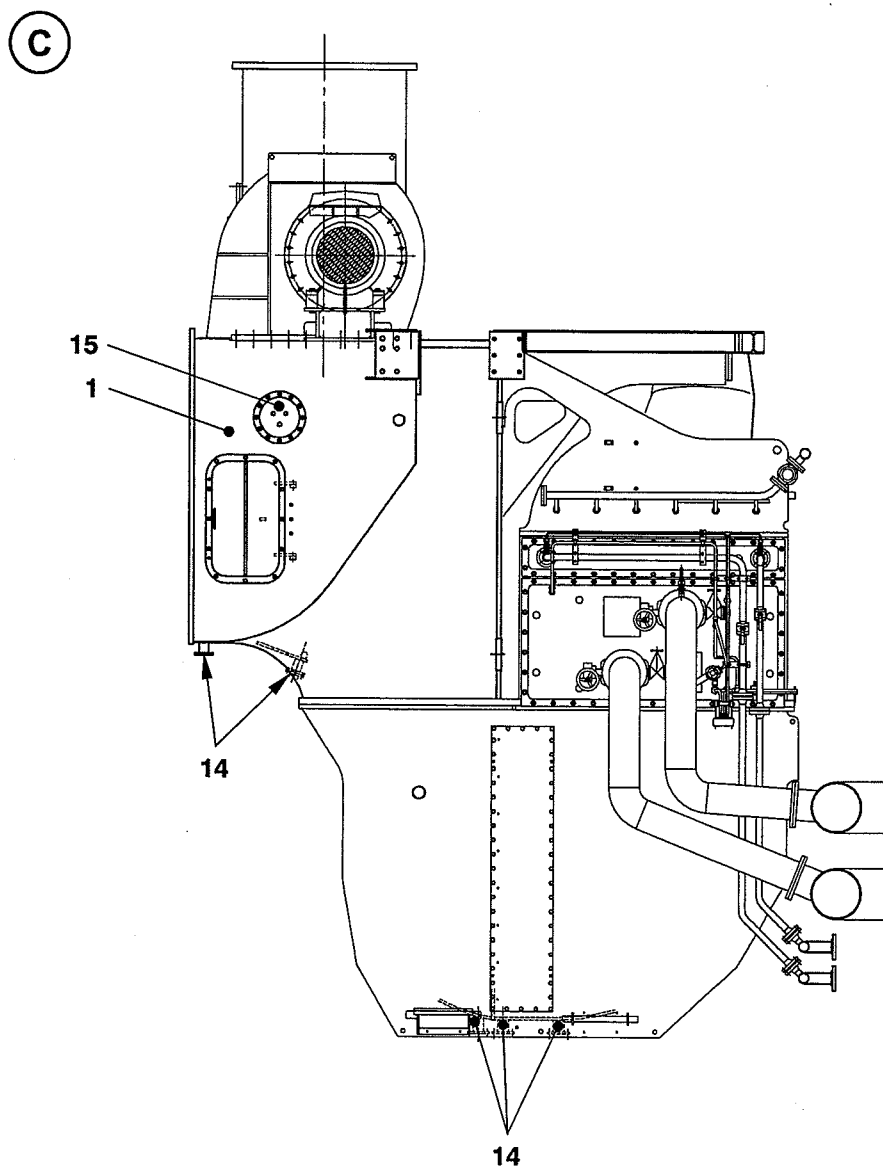
Checking the Air Flaps and Cleaning the Scavenge Air Receiver

3. Cleaning the scavenge air receiver

Cleaning and checking of the scavenge air receiver must always be carried out after a piston overhaul. The inside of the scavenge air receiver has to be cleaned at regular intervals.

CHECK

At this opportunity check whether drains (14) are not clogged, so that their function is assured during operation (Fig. 'C').

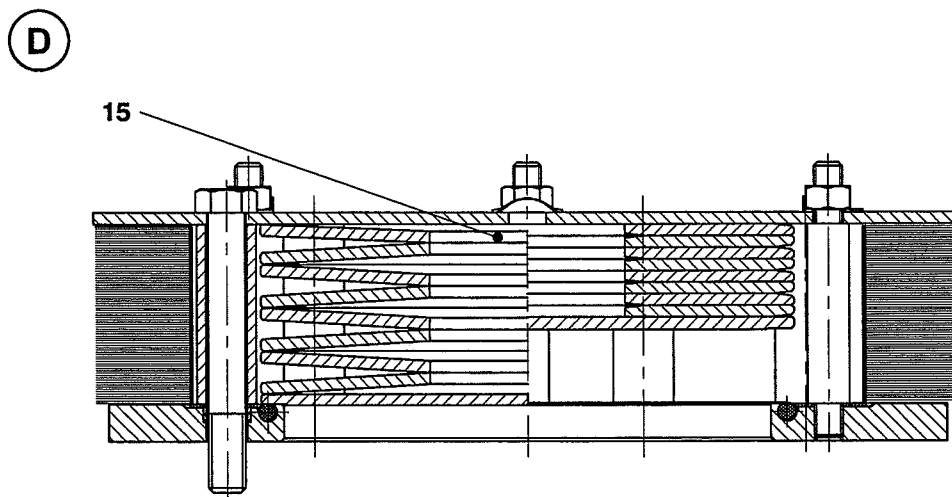


Scavenge Air Receiver

Checking the Air Flaps and Cleaning the Scavenge Air Receiver

CHECK

During a major overhaul relief valves (15) fitted on scavenge air receiver (1) (Fig. 'C' and 'D') must be checked. The valves are set to an opening pressure of 0.34 ~ 0.38 MPa.



Auxiliary Blower

Maintenance

Tools:

1	Dismantling device	94651
	Consist of:	
1	Carriage	94651a
1	Rail	94651b
1	Trolley	94651c
1	Trolley rail	94651d
1	Trolley rail	94651e
1	Trolley rail	94651f
4	Connecting plate	94651g
32	Screw and spring washer (M12)	94651h
48	Screw (M16×1.5)	94651i
2	Wire rope sling with shackle* *(hereafter called wire rope)	94651j
2	Centring studs	94652
1	Impeller extraction device	

Key to Illustrations:

1	Electric motor	16	Support
2	Motor plate	17	Shim
3	Spiral casing	18	Screw
4	Impeller	19	Screw
5	Screw	20	Engine crane
6	Washer		
7	Lock plate		
8	Motor shaft		
9	Set screw		
10	Screw		
11	Labyrinth packing		
12	Screw		
13	Washer		
14	Screw		
15	Exhaust manifold	HZ	Chain block

Overview

1.	General	1/5
2.	Support of electric motor	1/5
3.	Removal	2/5
4.	Dismantling and assembling	4/5
5.	Fitting	4/5

1. General

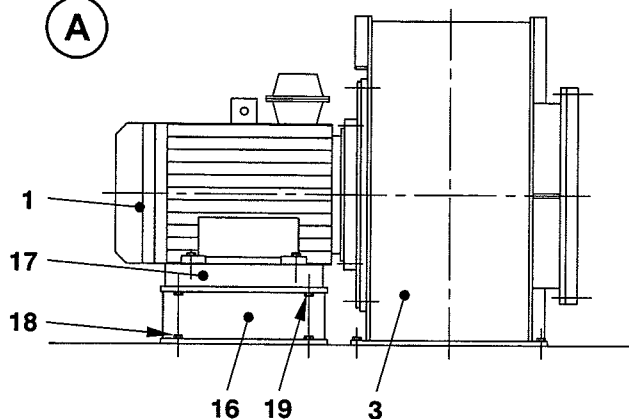


Remark

Auxiliary blower which are out of service for a longer period should be started up for a short time twice a month. Where this is not feasible, the impeller should be turned by hand by several turns. This is necessary to protect the bearing from corrosion damage.

The following instruction always also be referred to the Manufacturer instruction at the same time.

A



2. Support of electric motor

A support (16) is used for electric motor (1). Level difference are compensated with fitted shims (17). The shims have to be marked prior to dismantling!

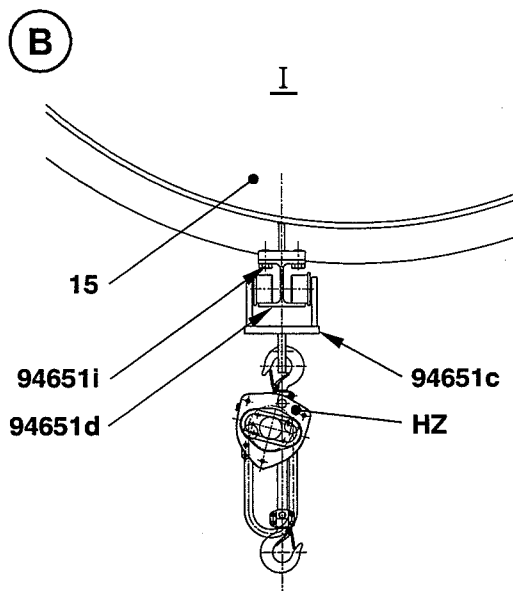
Auxiliary Blower
Maintenance

3. Removal

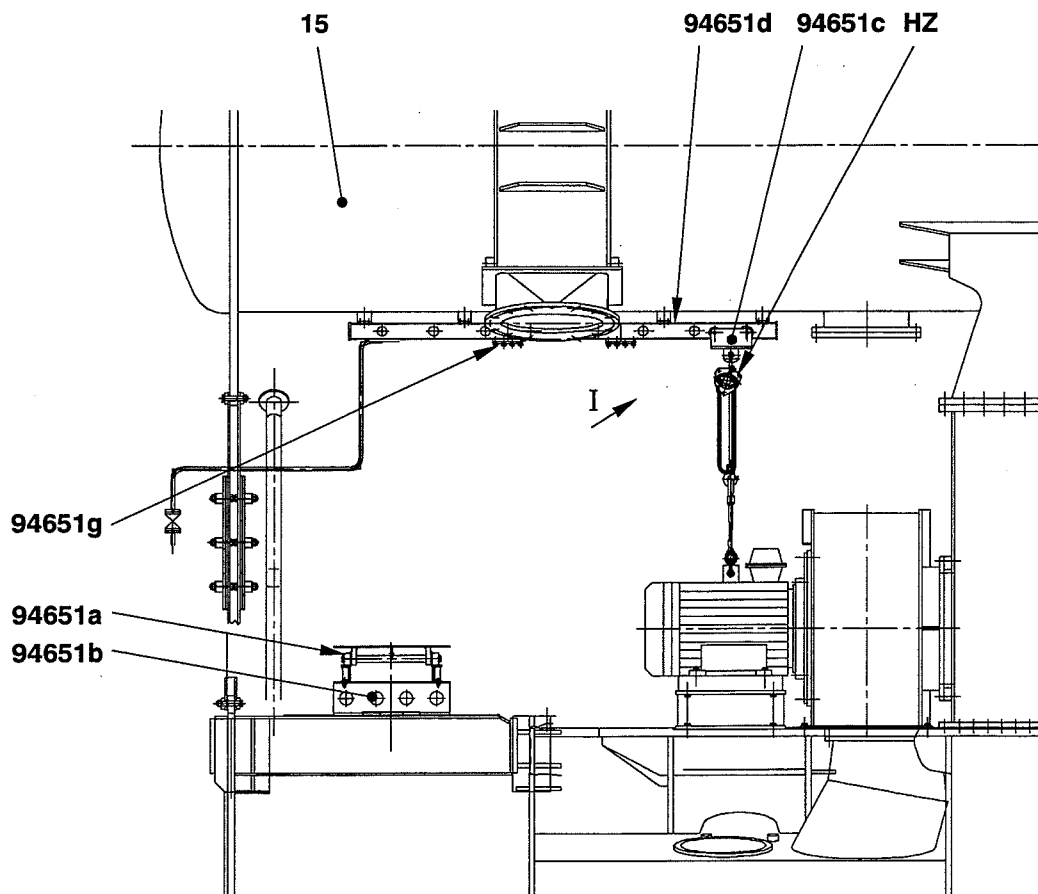


For safety reason, switch the electric motor (1) off. If possible, the switch of starter must be locked.

3.1 Preparation works



- ⇒ Separate electric leads from electric motor (1).
- ⇒ Remove screw (18).
- On 10 and more cylinder engines, some support (16) are welded on the receiver. Therefore, screws (19) must be removed.
- ⇒ Fasten trolley rail (94651d) with screws (94651i) to support of exhaust manifold (15).
- ⇒ Install trolley (94651c) and chain block "HZ" on trolley rail (94651d), (94651e) or (94651f) as shown in Fig. 'B'.
- ⇒ Lay the rail (94651b) on the correct place, and put carriage (94651a) on the rail.



No.1 auxiliary blower

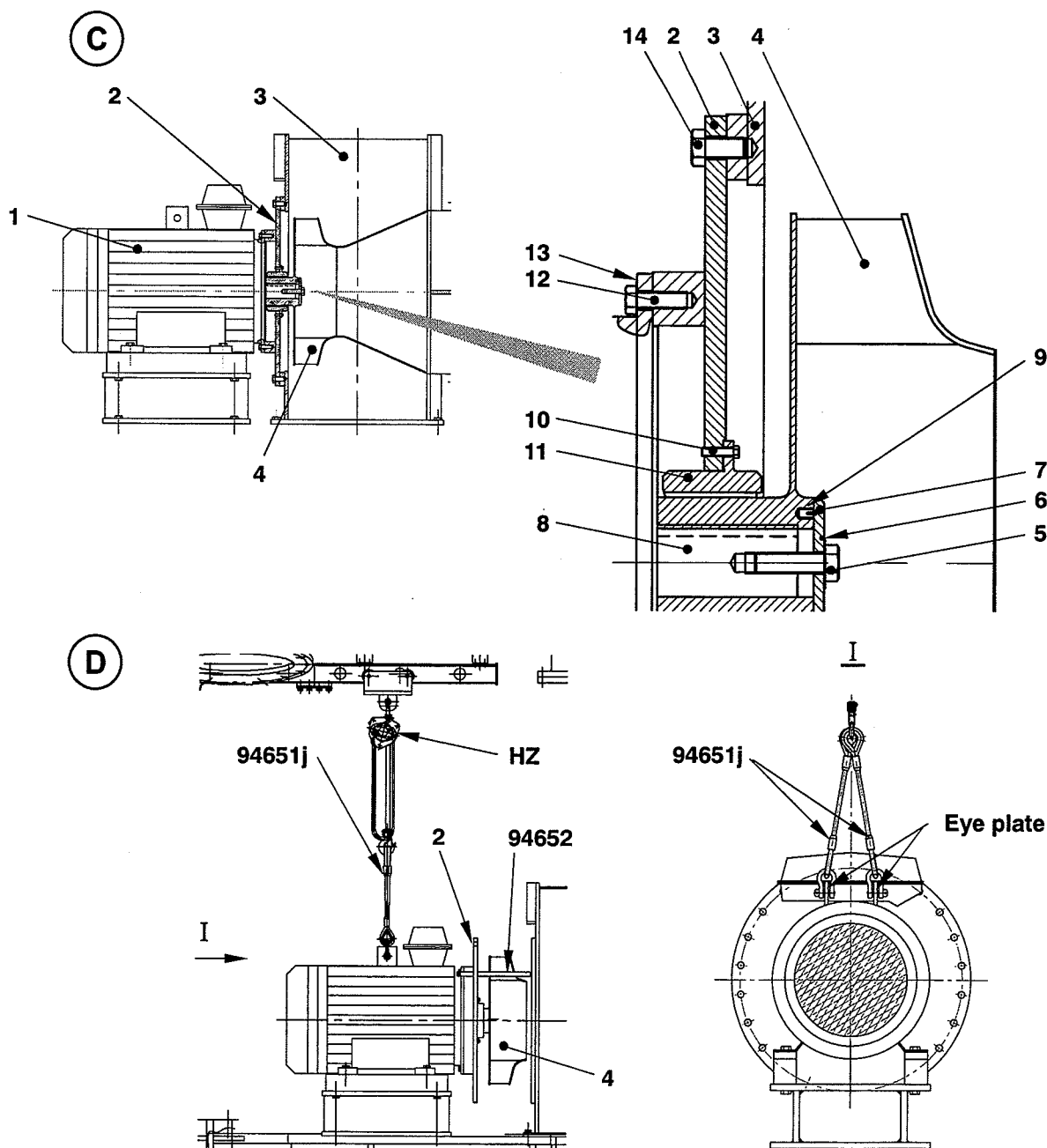
**Auxiliary Blower
Maintenance**

3.2 Removal of No.1 auxiliary blower motor

- ⇒ Remove two screws (14) and screw two centring studs (94652) instead.
- ⇒ Connect chain block "HZ" and wire ropes (94651j) with eye plate of electric motor.
- ⇒ Unscrew the remaining screws (14) of the motor plate (2).
- ⇒ Separate the motor plate (2) from the spiral casing with guiding by two centring studs (94652).
- ⇒ Extract electric motor with plate and impeller (4) from spiral casing in horizontal direction.

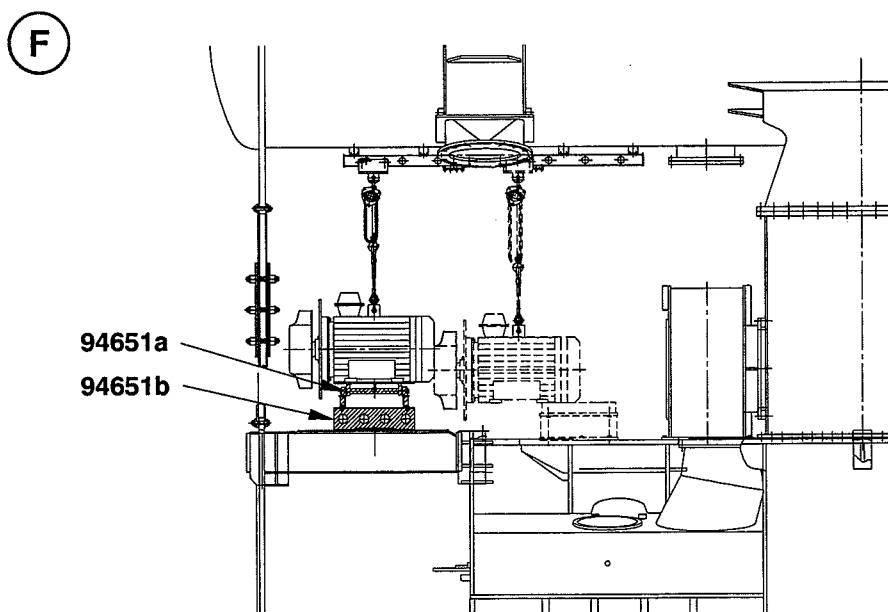
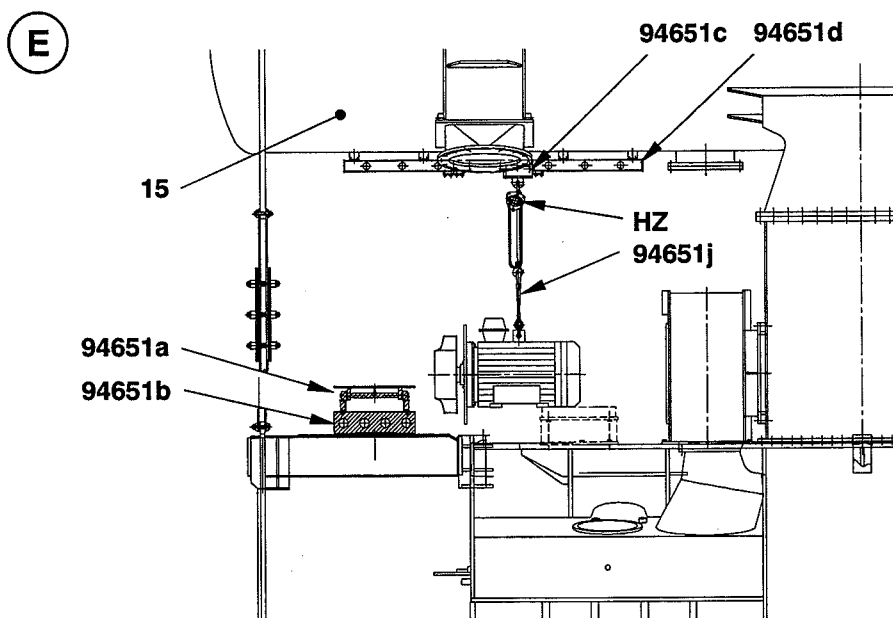


When removing take care not to damage the impeller.

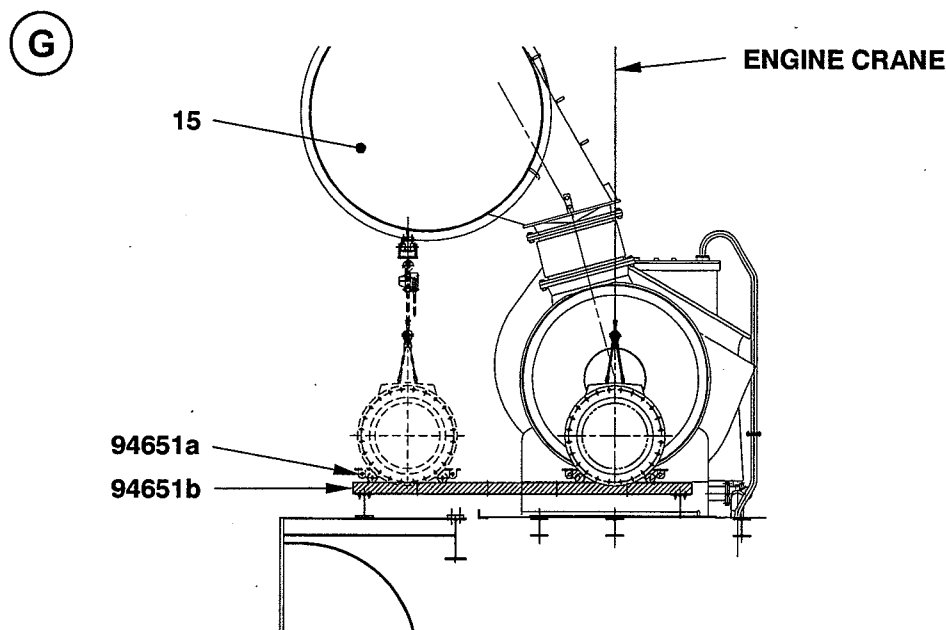


**Auxiliary Blower
Maintenance**

- ⇒ Put electric motor and impeller on scavenge air receiver, and remove support (16) and shim (17) (Fig. 'E').
- ⇒ Lift electric motor and impeller up, and move electric motor and impeller in horizontal direction with turning them by 180°.
- ⇒ Put electric motor and impeller on carriage (94651a), and move them to open space (Fig. 'F' and 'G').
- ⇒ Remove all tools.



**Auxiliary Blower
Maintenance**



3.3 Removal of No.2 and No.3 auxiliary blower motors

- The removal procedures of No.2 and No.3 auxiliary blower motor and impeller are the same as one of No.1 auxiliary blower motor and impeller (see Fig. 'E', 'F' and 'G').
However, trolley rails have different spec., depending on auxiliary blower position.
Therefore, pay attention to trolley rail specifications as below table.

No. of auxiliary blower	Trolley rail spec.	
No.1 auxiliary blower	Trolley rail 94651d	Total length = approx. 2580 mm
No.2 auxiliary blower	Trolley rail 94651e	Total length = approx. 1400 mm
No.3 auxiliary blower	Trolley rail 94651f	Total length = approx. 1980 mm

4. Dismantling and assembling

- For the dismantling and assembling of the auxiliary blower, the instruction of auxiliary blower manufacturer must be observed
- For maintenance of the ball bearing in the electric motor, please comply with the instruction of the manufacturer.

5. Fitting

The fitting procedure is the reverse sequence for the removal procedure.
Refer to the section 3 and pay attention to tools for each auxiliary blower.

CHECK

Check direction of rotation.

Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

Tools:			Key to Illustrations:			
1	Lifting device	94660	1	Butterfly valve	19	Air cooler
1	Lifting device	94660a	2	Cooling water inlet	20	Rail
2	Lifting device	94660b	3	Cooling water outlet	21	Roller
12	Lifting device	94660c	4	Drain pipe for SAC	22	Stud (M20×50)
2	Shaft	94660d	5	Vent pipe for SAC	23	Nut
1	Roller plate	94662	6	Stop valve	24	Screw (M20×50)
1	Roller plate	94662a	7	Feed water inlet	25	O-ring for SAC
1	Support	94663	8	Feed water outlet	26	O-ring for FWH
1	Guide support	94663a			27	Gasket for SAC
7	Shackle (BC18)		10	Vent pipe for FWH	28	Gasket for FWH
5	Shackle (BC22)		11	Cover for SAC (fixed side)		
2	Shackle (BC32)		12	Cover for FWH (fixed side)	DF	Sealing surface
4	Wire ropes with shackle* 94666a		13	Cover for SAC (floating side)	WL	Wooden underlay
	(L=960, BC14)		14	Cover for FWH (floating side)	AH	Stopper
2	Wire rope with shackle* 94666b		15	Flange for SAC	H1...	Chain blocks
	(L=4400, BC14)		16	Flange for FWH	RC1	Eye bolt (M30)
*	(hereafter called wire rope)		17	Receiver	RC2	Eye bolt (M20)
			18	Feed water heater	ST	Set screw

Overview

1.	General	1/23
2.	Preliminary works	2/23
3.	Removal of cooler element	3/23
4.	Fitting of cooler element	11/23
5.	Removal of heater element	14/23
6.	Fitting of heater element	22/23

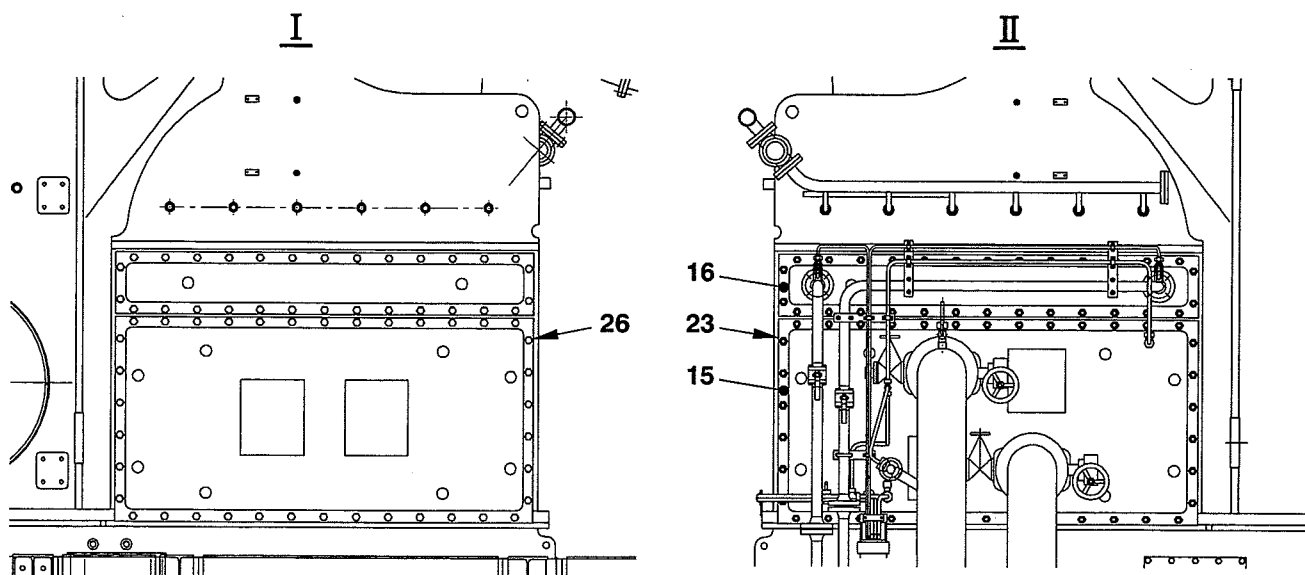
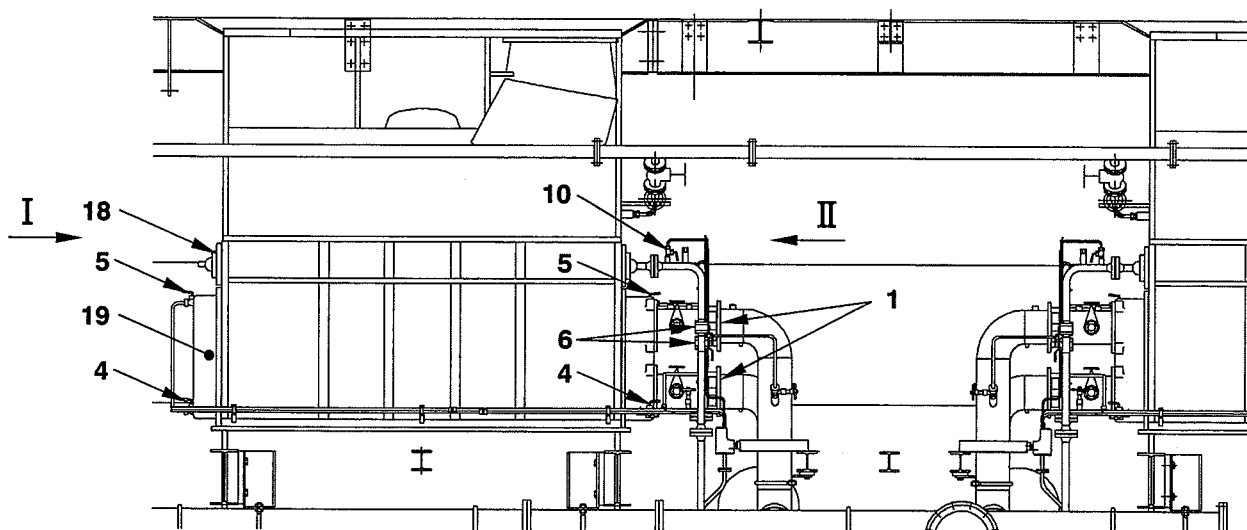
1. General


Either only the feed water heater alone or the cooler element may be removed.

Depending on the manner in which the cooler element or feed water heater after their removal are carried away, parts concerned must be removed from the upper or lower platform.

Scavenge Air Cooler
Removal and Fitting of Cooler Element and Heater Element
2. Preliminary works

- ⇒ Stop the cooling water pump and feed water pump. Close butterfly valves (1) and stop valve (6).
- ⇒ Open vent valves (5), (10) and drain valves (4). Drain air coolers (Drain may be checked at drain hopper).
- ⇒ Remove cooling water inlet and outlet pipes between air coolers (19) and butterfly valves (1).
- ⇒ Remove feed water inlet and outlet pipes between feed water heaters (18) and stop valves (5).
- ⇒ Depending on the place required, cooling water inlet and outlet pipes to the opposite cooler must also be removed.
- ⇒ Remove all the vent pipes and drain pipes which interfere to remove air coolers (19) and feed water heaters (18).

A


Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

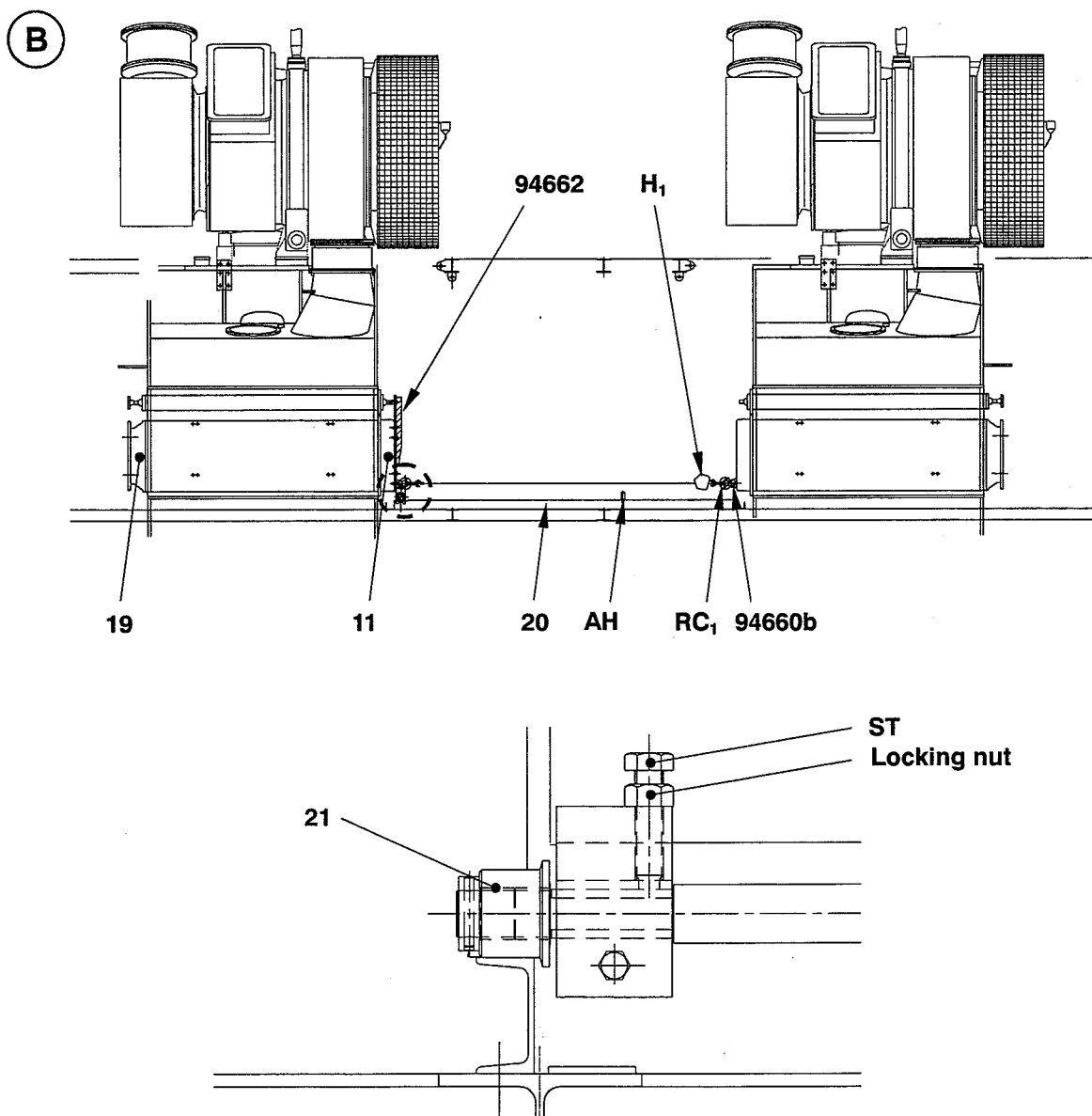
3. Removal of cooler element

3.1 Removal of No.1 air cooler

- ⇒ Remove all the screws (26).
- ⇒ Fasten roller plate (94662) with eight screws (M20×40) to cover (11) of No.1 air cooler (19).
- ⇒ Align roller (21) of roller plate (94662) with rail (20) on middle platform using set screw "ST" and locking nut.
- ⇒ Fasten lifting device (94660b), eye bolt "RC₁" and shackle to cover (11) of No.2 air cooler as shown in Fig. 'B'. And then, connect chain block "H₁" to roller plate (94662) and lifting device (94660b) (see Fig. 'B')
- ⇒ Loosen nuts (23) and remove flange (15) of No.1 air cooler (Fig. 'A').



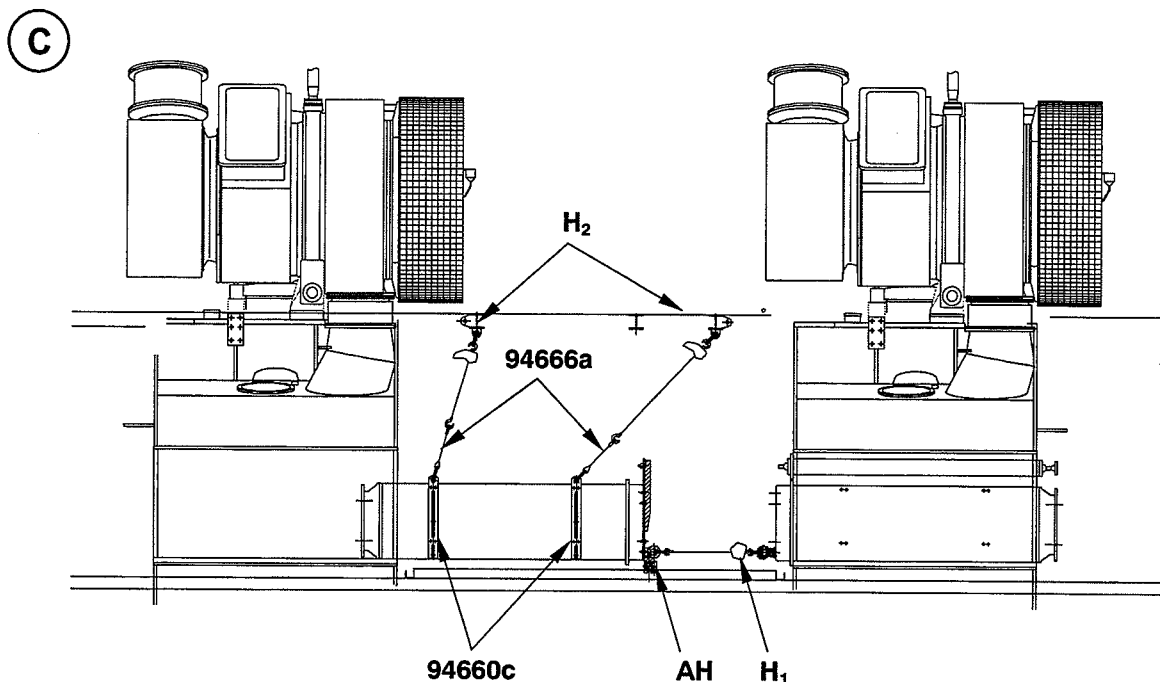
For safety reason, stopper "AH" must be set to the rail before removal works.



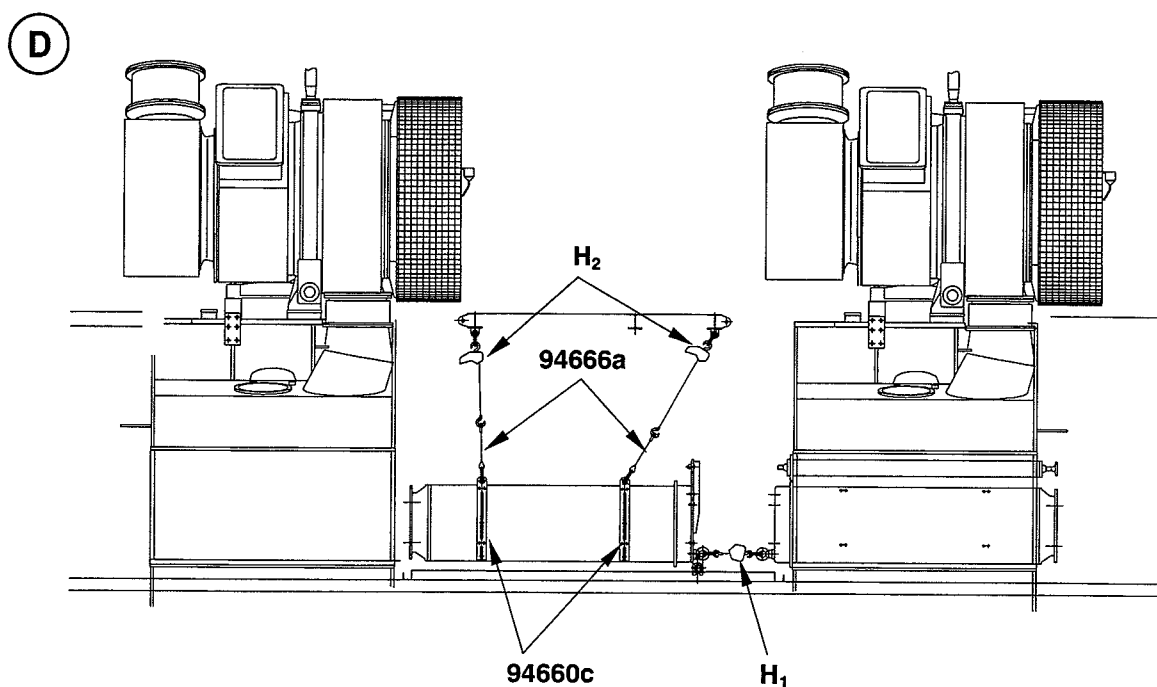
Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

- ⇒ Pull out No.1 air cooler with chain block "H₁" until it stop at stopper (see Fig. 'C').
- ⇒ Remove stopper "AH" and connect lifting devices (94660c) with No.1 air cooler.



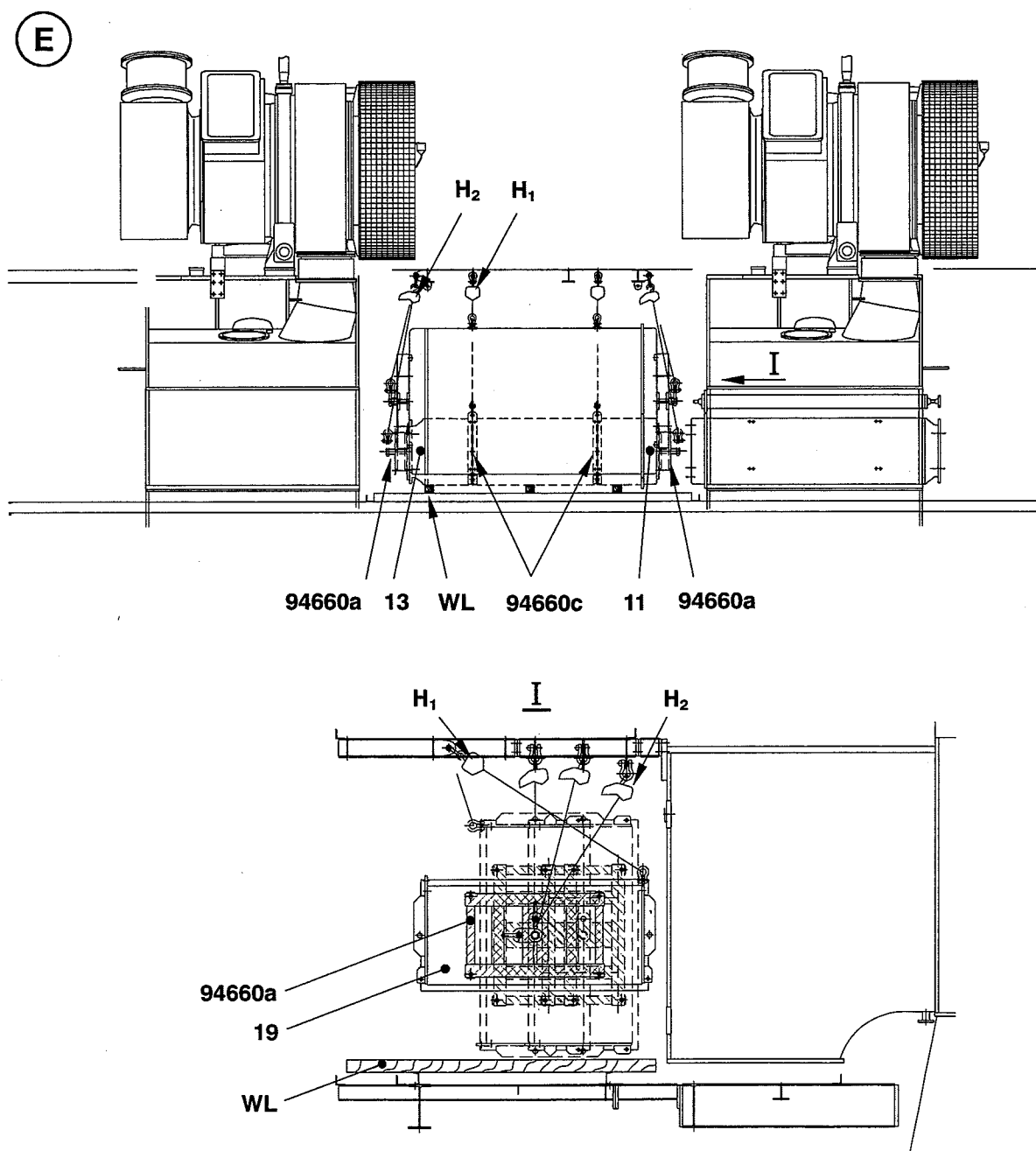
- ⇒ Fasten chain blocks "H₂" to eye plate under upper platform and connect it and wire ropes (94666a) to lifting device (94660c) (Fig. 'C'). And then, pull out No.1 air cooler completely using chain blocks "H₁" and "H₂" (Fig. 'D').



Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

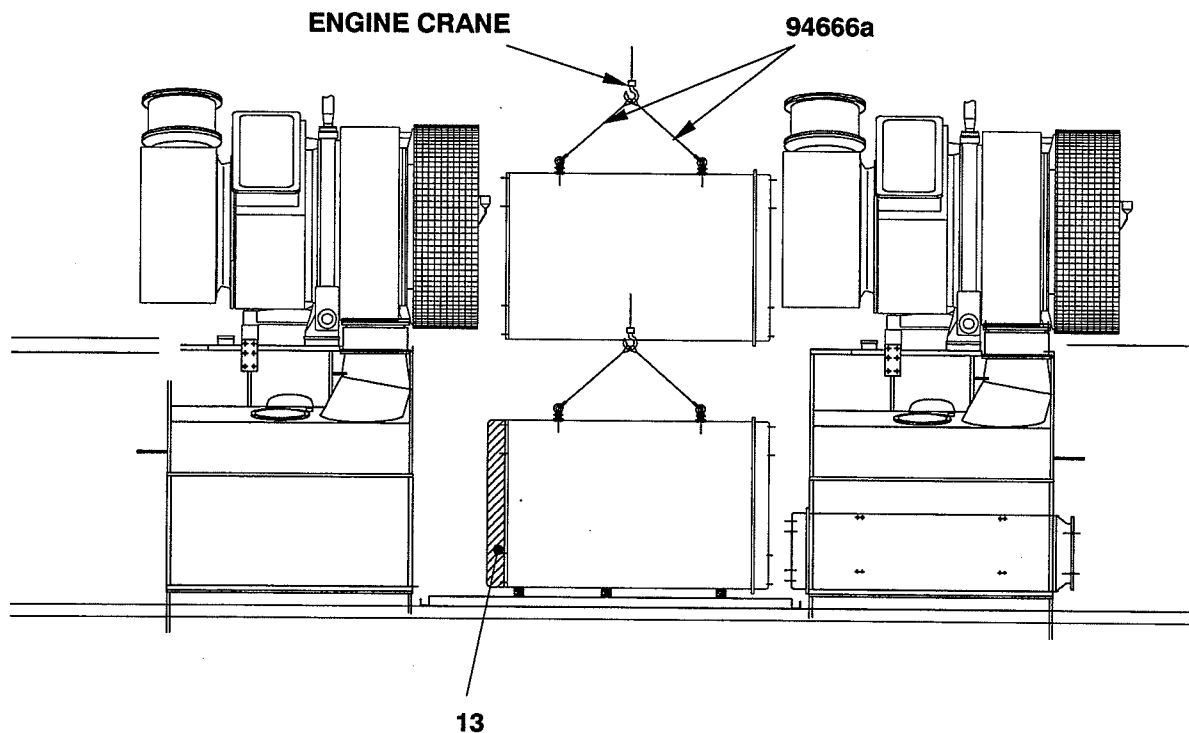
- ⇒ Remove roller plate (94662), lifting device (94660b) and chain block "H₁".
- ⇒ Lay out wooden underlay "WL" on rail (20) and put No.1 air cooler on wooden underlay using chain block "H₂" (Fig. 'E').
- ⇒ Fasten lifting devices (94660a) with four screws (M20×55) to cover (11) and (13) of No.1 air cooler, and connect shackles (BC18) and (BC22) with lifting devices (94660a).
- ⇒ Re-connect chain block "H₂" and wire rope (94666a) from lifting device (94660c) to lifting device (94660a), and connect chain block "H₁" directly to lifting device (94660c) and eye plate under upper platform as shown in Fig. 'E'.
- ⇒ Lift up and turn No.1 air cooler by 90° using chain blocks "H₁" and "H₂" (see Fig. 'E'). Put No.1 air cooler on wooden underlay "WL".
- ⇒ Move No.1 air cooler to fuel side slightly using chain blocks "H₁" and "H₂" as shown in Fig. 'E' view I.



Scavenge Air Cooler
Removal and Fitting of Cooler Element and Heater Element

- ⇒ Remove chain blocks "H₁", "H₂", wire rope (94666a) and lifting device (94660a) and remove cover (13) from No.1 air cooler.
- ⇒ Connect wire rope (94666a) with the engine crane and lifting device (94660c).
- ⇒ Move No.1 air cooler towards free-end slightly and lift No.1 air cooler upwards by the engine crane.

(F)



Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

3.2 Removal of No.2 air cooler

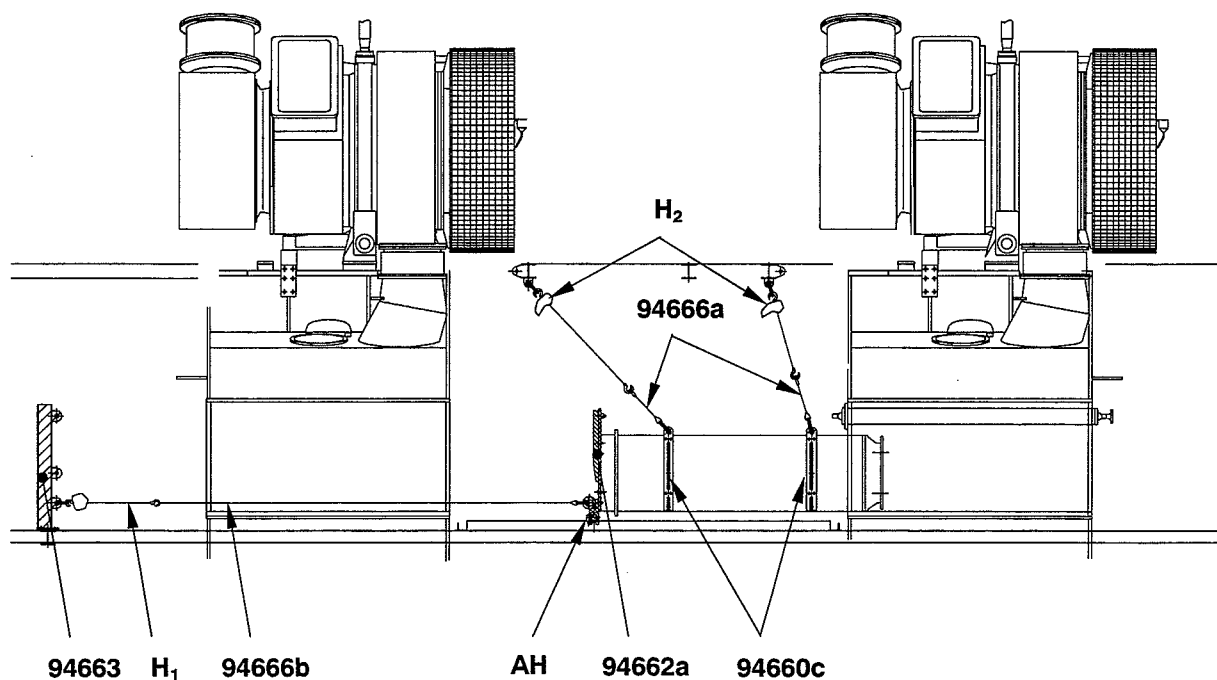
- ⇒ Remove all the screws (26).
- ⇒ Fasten roller plate (94662a) with eight screws (M20×40) to cover (11) of No.2 air cooler (19).
- ⇒ Align roller (21) of roller plate (94662a) with rail (20) on middle platform using set screw and locking nut.
- ⇒ Fasten support (94663) as shown in Fig. 'G'. And then, connect chain block "H₁" and shackles (BC18) to roller plate (94662a) and support (94663) together with wire rope (94666b) (see Fig. 'G').
- ⇒ Loosen nuts (23) and remove flange (15) of No.2 air cooler.



For safety reason, stopper "AH" must be set to the rail before removal works.

- ⇒ Pull out No.2 air cooler with chain block "H₁" until it stop at stopper (see Fig. 'G').
- ⇒ Remove stopper "AH" and connect lifting devices (94660c) with No.2 air cooler.
- ⇒ Fasten chain blocks "H₂" to eye plate under upper platform and connect it and wire ropes (94666a) with lifting device (94660c). And then, pull out No.2 air cooler completely using chain blocks "H₁" and "H₂".
- Regarding the subsequent removal works, refer to paragraph 3.1.
No.2 air cooler can be removed in the same sequence as paragraph 3.1.

G



Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

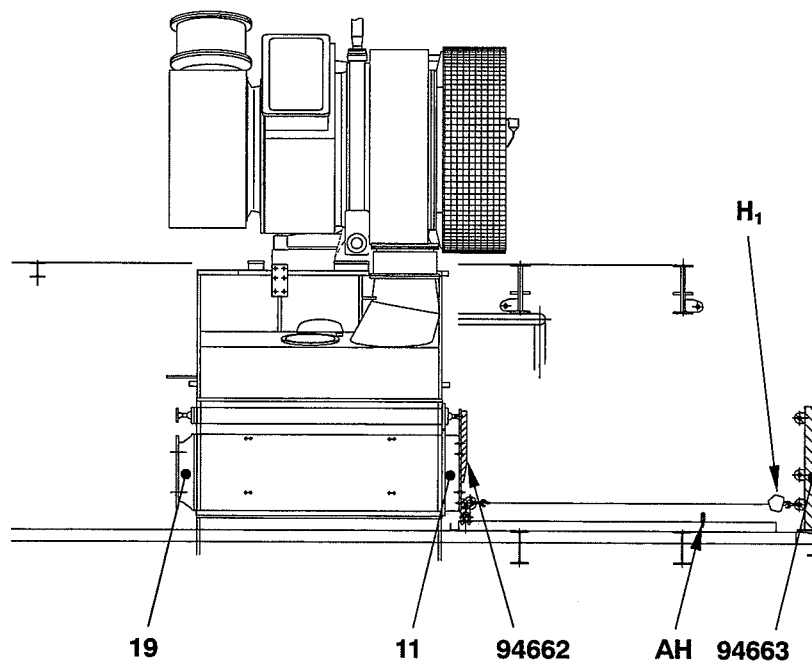
3.3 Removal of No.3 air cooler

- ⇒ Remove all the screws (26).
- ⇒ Fasten roller plate (94662) with eight screws (M20×40) to cover (11) of No.3 air cooler (19).
- ⇒ Align roller (21) of roller plate (94662) with rail (20) on middle platform using set screw and locking nut (see Fig. 'H').
- ⇒ Fasten support (94663). And then, connect chain block "H₁" and shackles (BC18) to roller plate (94662) and support (94663) (see Fig. 'H').
- ⇒ Loosen nuts (23) and remove flange (15) of No.3 air cooler (see Fig. 'A').



For safety reason, stopper "AH" must be set to the rail before removal works.

H

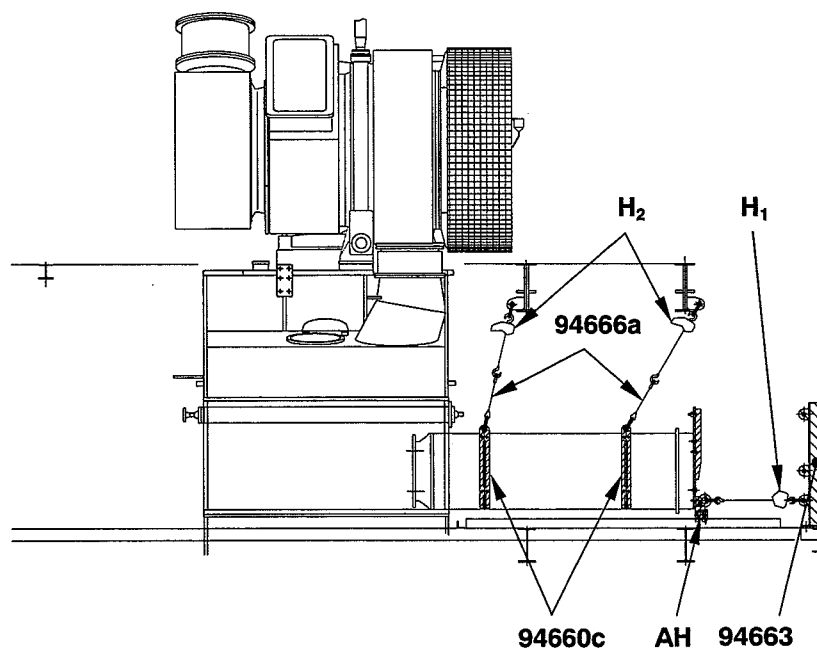


Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

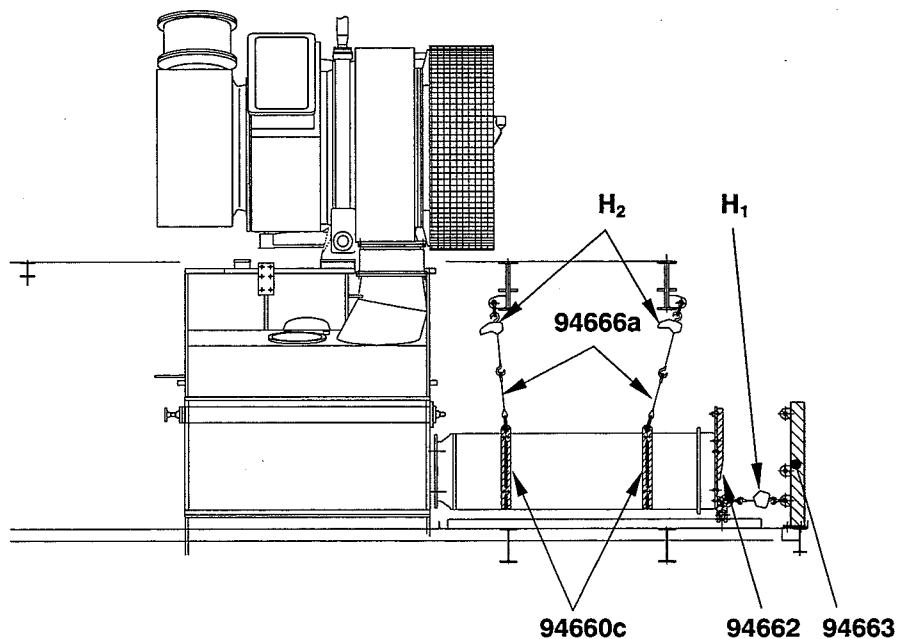
- ⇒ Pull out No.3 air cooler with chain block "H₁" until it stop at stopper (see Fig. 'I').
- ⇒ Remove stopper "AH" and connect lifting devices (94660c) with No.3 air cooler.
- ⇒ Fasten chain blocks "H₂" to eye plate under upper platform and connect it and wire ropes (94666a) with lifting device (94660c).

I



- ⇒ And then, pull out No.3 air cooler completely using chain blocks "H₁" and "H₂".
- ⇒ Remove roller plate (94662), support (94663) and chain block "H₁".

K

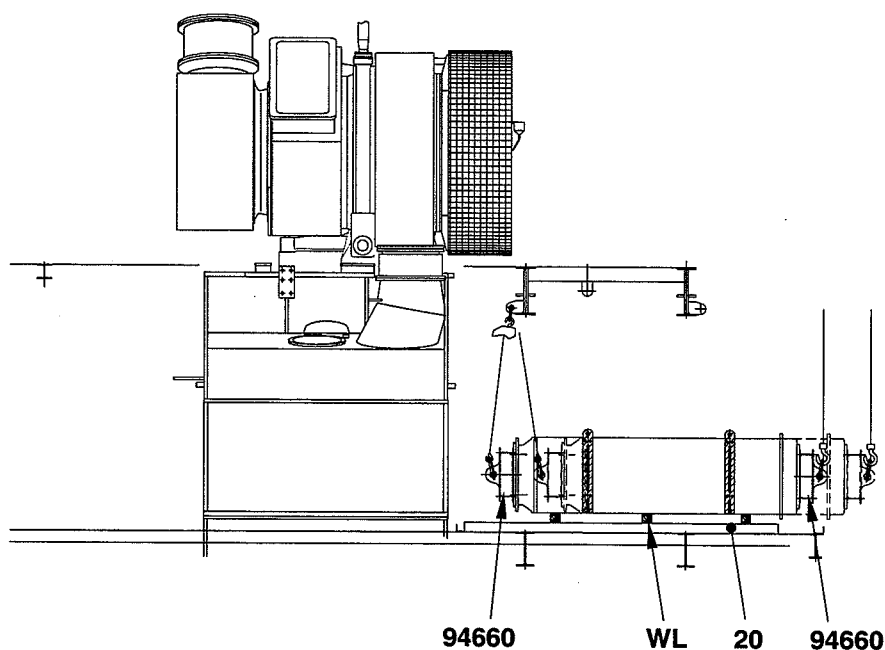


Scavenge Air Cooler

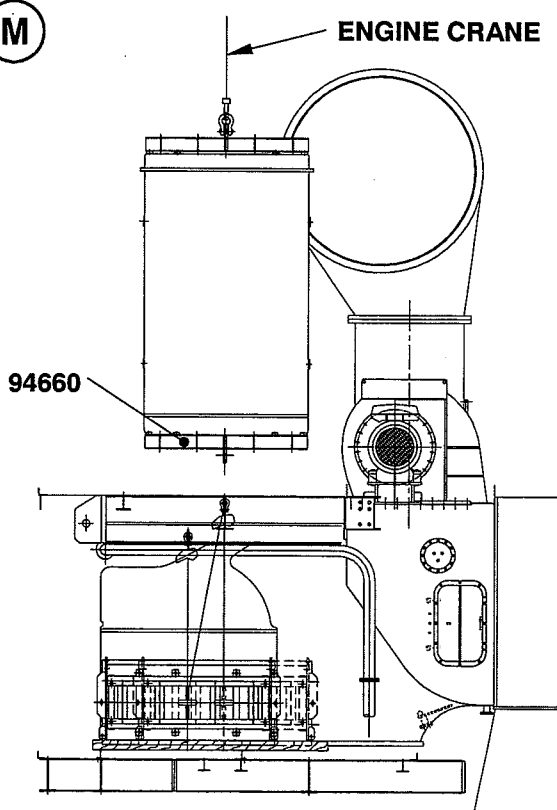
Removal and Fitting of Cooler Element and Heater Element

- ⇒ Lay out wooden underlay "WL" on rail (20) and put No.3 air cooler on wooden underlay using chain blocks "H₂".
- ⇒ Remove one chain block "H₂" and one wire rope (94666a) at free-end. Re-connect them to eye plate under upper platform as shown in Fig. 'M' and 'N'.
- ⇒ Fasten lifting devices (94660) with four screw (M20×55) and four screws (M20×45) to cover (11) and (13) of No.3 air cooler, and connect shackles (BC32) with lifting devices (94660).

L



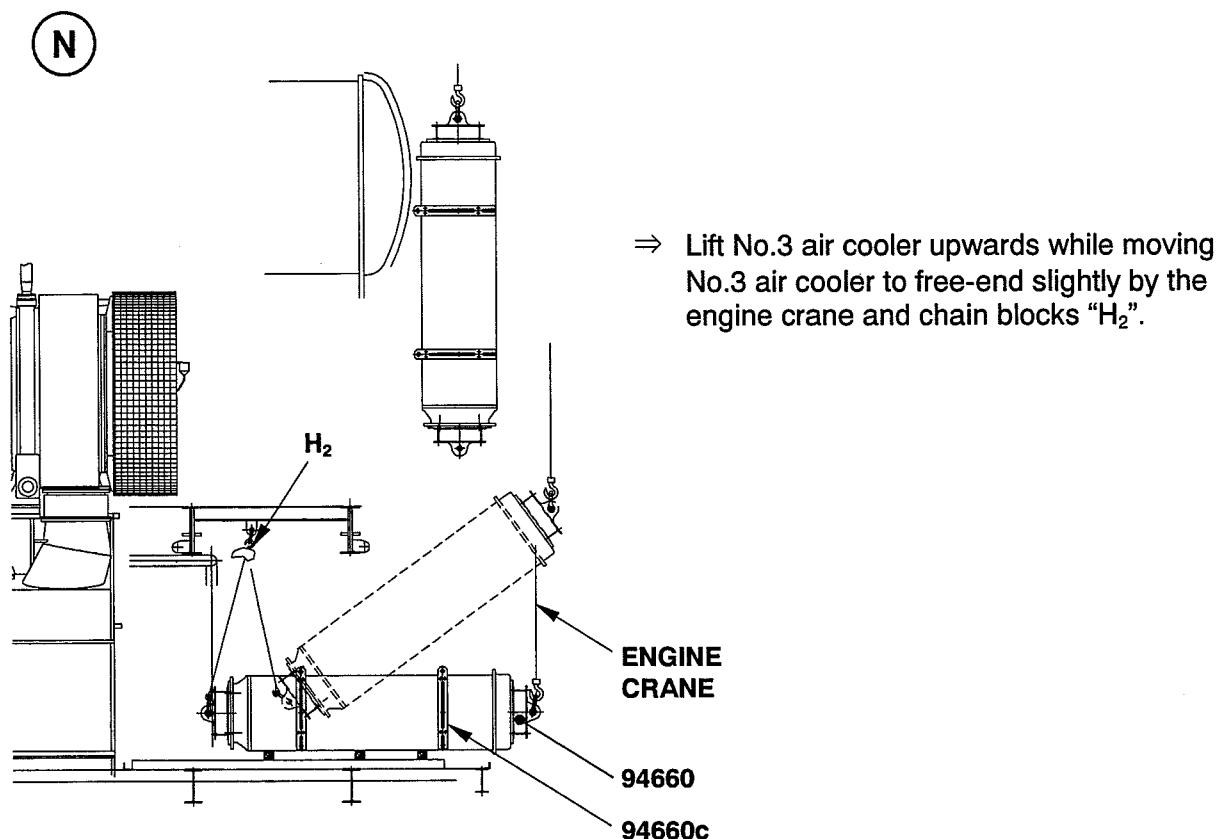
M



- ⇒ Move No.3 air cooler to fuel side slightly using the engine crane and chain blocks "H₂" as shown in Fig. 'M' and 'N'.

Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element



4. Fitting of cooler element

The fitting procedure is the reverse sequence for the removal procedure for each air cooler. Refer to the section 3 and pay attention to tools for each air cooler.

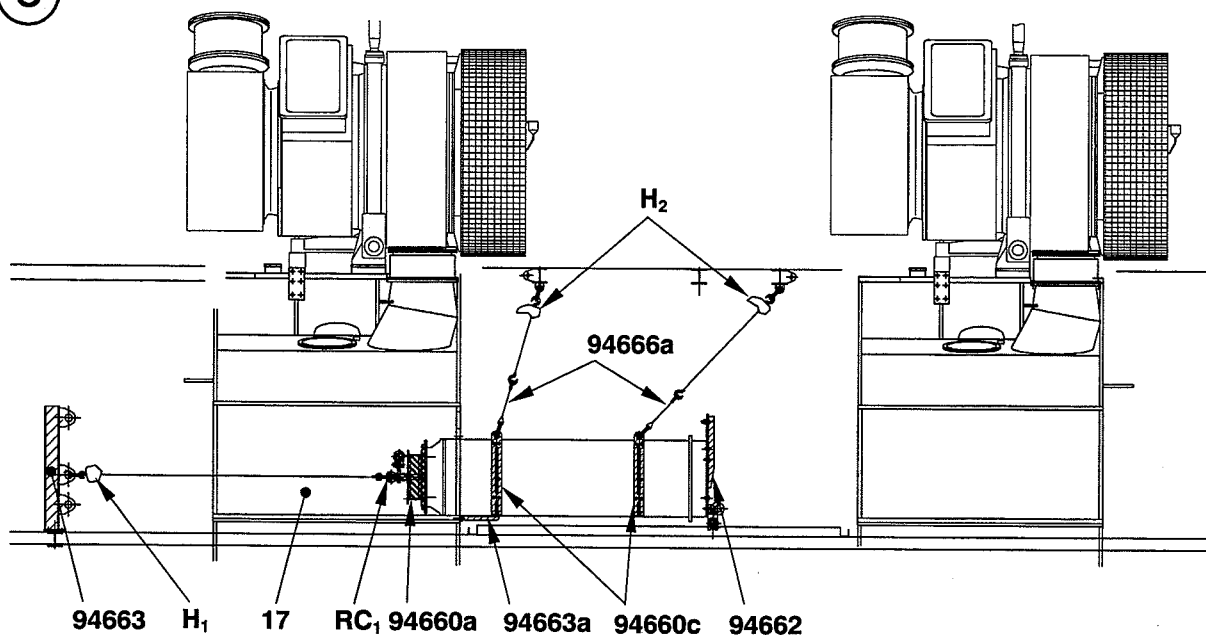
4.1 Fitting of No.1 air cooler

- ⇒ Clean sealing face "DF" of the air cooler (19) and receiver (17).
- ⇒ Move the air cooler (19) to the mounting place as shown in Fig. 'A' to 'F' for the removal but in reverse sequence, but adjust it to the mounting height.
- ⇒ Fasten support (94663) on middle platform and guide support (94663a) on receiver as shown in Fig. 'O'.
- ⇒ Connect chain blocks "H₂", wire rope (94666a) and shackle (BC22) with No.1 air cooler.
- ⇒ Connect roller plate (94662), lifting device (94660a) and eye bolt "RC₁" with No.1 air cooler. Remove lifting devices (94660c).

Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

O



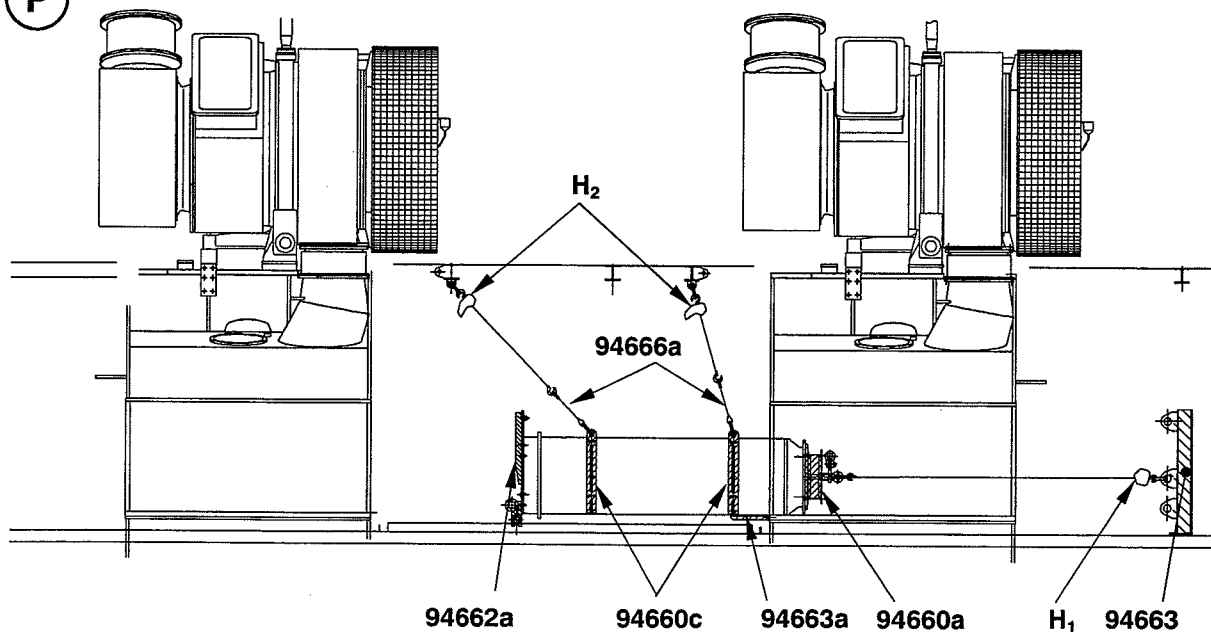
- ⇒ Connect chain block "H₁" with lifting device (94660a) and support (94663).
- ⇒ Pull the air cooler (19) into the receiver (17) using chain blocks "H₁" and "H₂".
- ⇒ Remove all tools.

4.2 Fitting of No.2 air cooler

- The fitting procedure of No.2 air cooler is the same as one of No.1 air cooler (see Fig. 'O' and 'P').

However, the roller plate (94662a), instead of the roller plate (94662), must be fastened to cover (11) of No.2 air cooler.

P



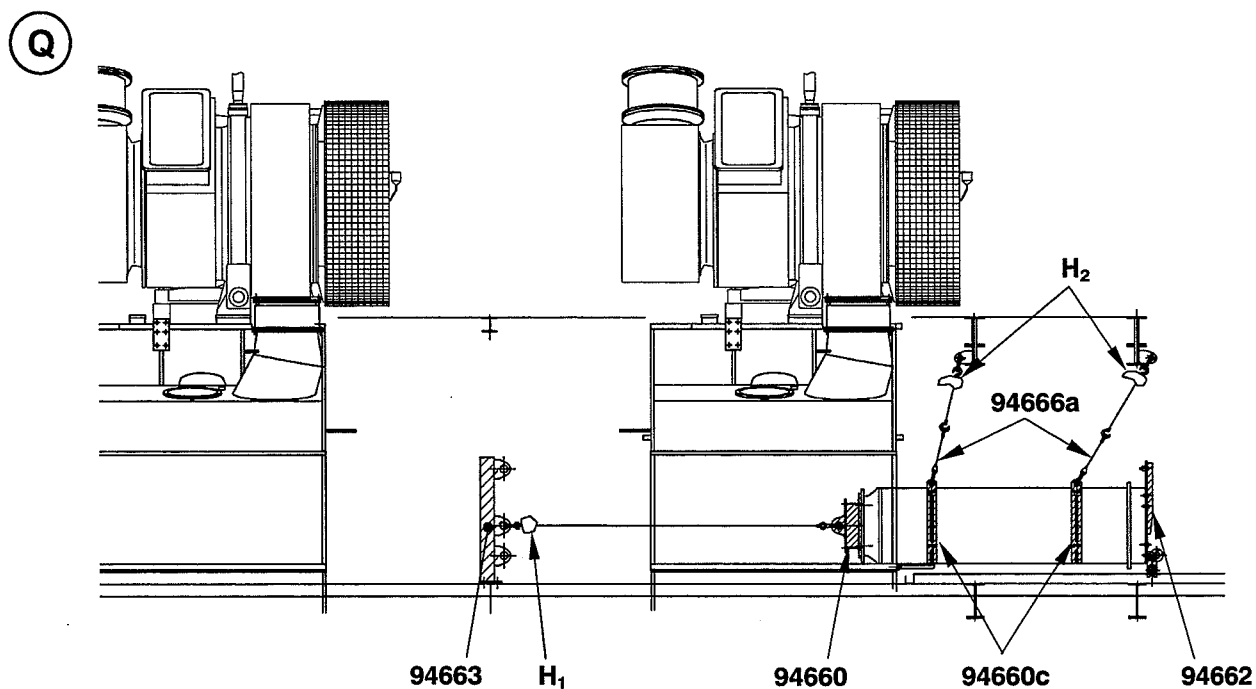
Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

4.3 Fitting of No.3 air cooler

- The fitting procedure of No.3 air cooler is the same as one of No.1 air cooler (see Fig. 'O').

However, the lifting device (94660), instead of the lifting device (94660a), must be fastened to cover (11) of No.3 air cooler.



Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

5. Removal of heater element

5.1 Removal of No.1 feed water heater

- ⇒ Remove all the screws (26).
- ⇒ Fasten roller plate (94662) with two screws (M20×70) to cover (12) of No.1 feed water heater (18).
- ⇒ Align roller (21) of roller plate (94662) with rail (20) on middle platform using set screw "ST" and locking nut (see Fig. 'B').
- ⇒ Fasten lifting device (94660b), eye bolt "RC₁" and shackle to cover (12) of No.2 feed water heater as shown in Fig. 'R'. And then, connect chain block "H₁" to roller plate (94662) and eye bolts "RC₁".
- ⇒ Loosen nuts (23) and remove flange (16) of No.1 feed water heater.

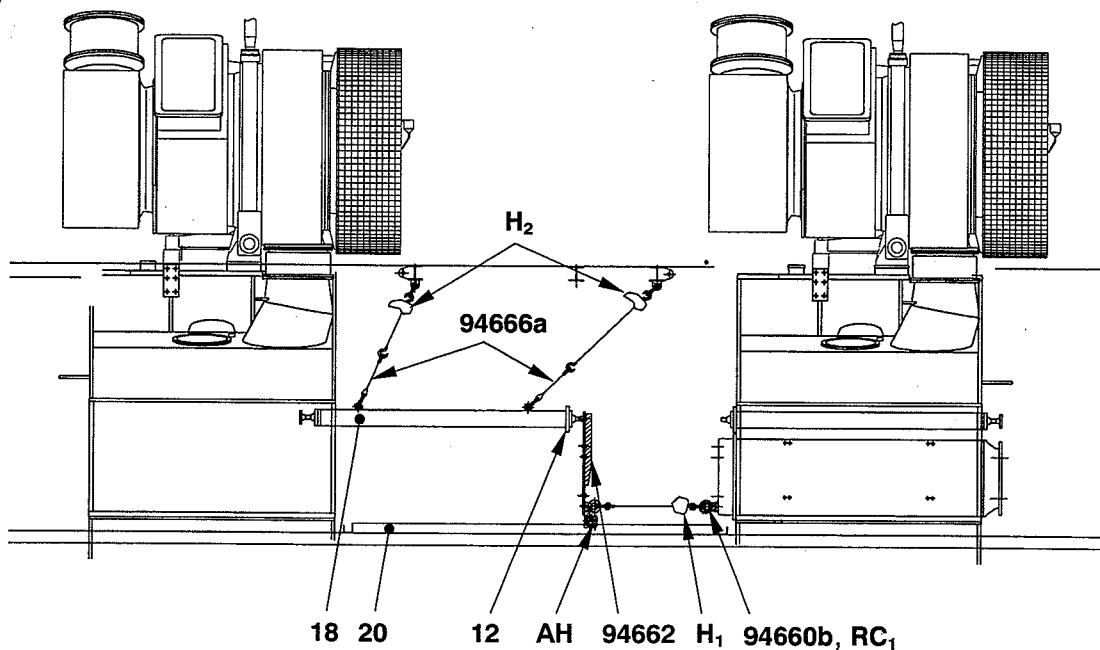


CAUTION

For safety reason, stopper "AH" must be set to the rail before removal works.

- ⇒ Pull out No.1 feed water heater with chain block "H₁" until it stop at stopper (see Fig. 'R').
- ⇒ Remove stopper "AH" and connect eye bolts "RC₂" with No.1 feed water heater.

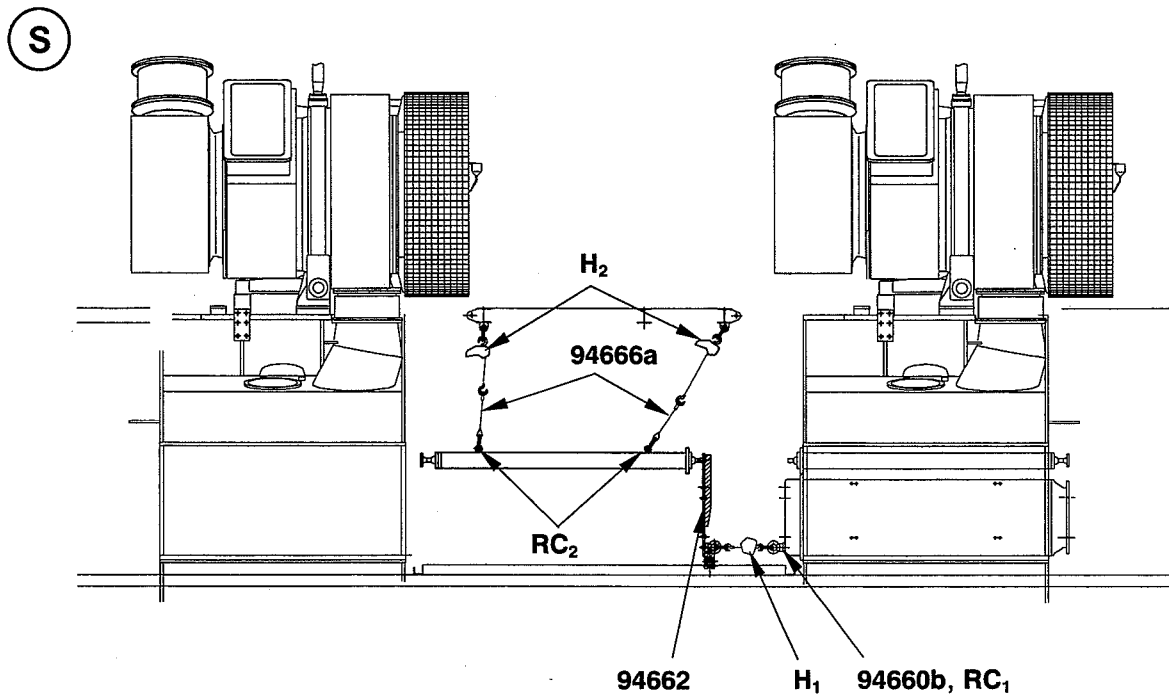
R



Scavenge Air Cooler

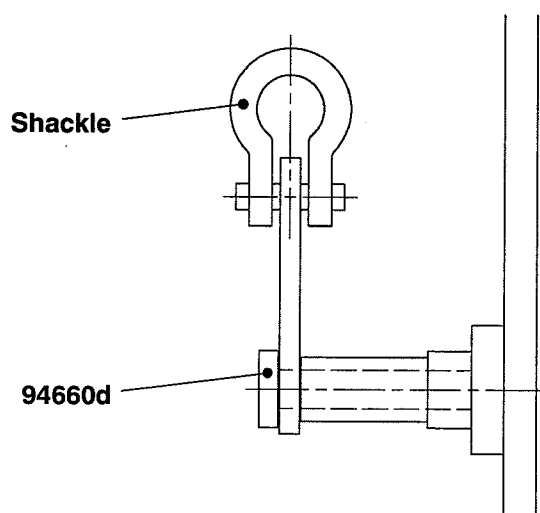
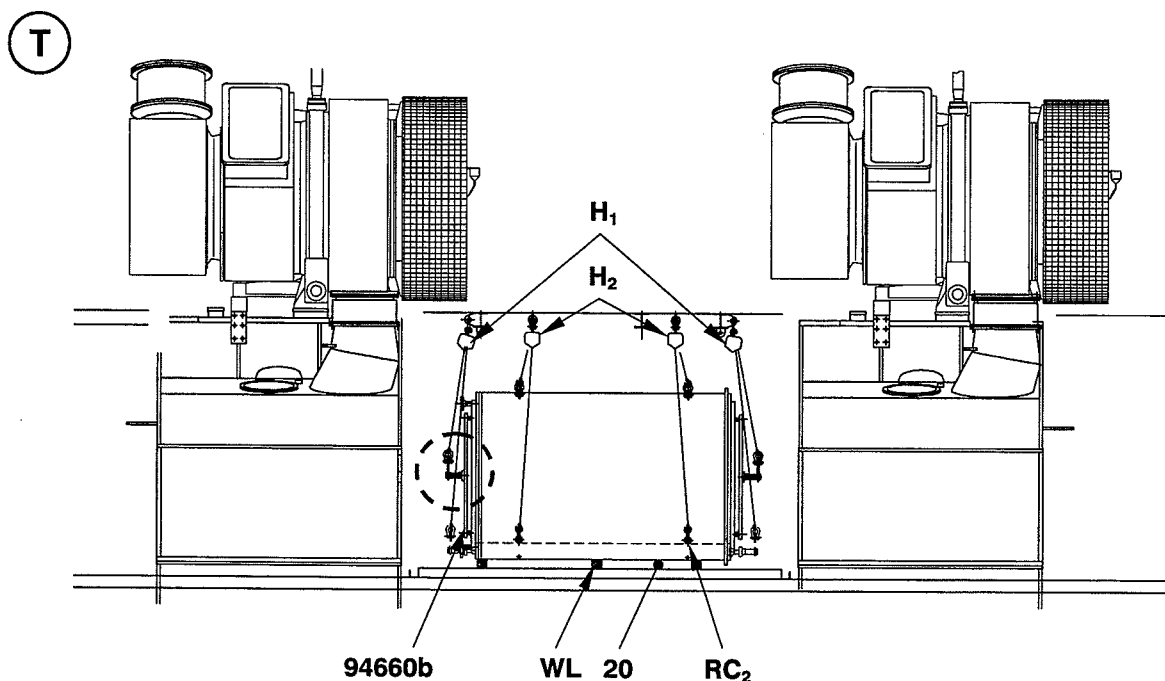
Removal and Fitting of Cooler Element and Heater Element

- ⇒ Fasten chain blocks "H₂" to eye plate under upper platform, and connect it and wire ropes (94666a) to eye bolts "RC₂". And then, pull out No.1 feed water heater completely using chain blocks "H₁" and "H₂".
- ⇒ Remove roller plate (94662), lifting device (94660b) fastened to No.2 feed water heater and chain block "H₁".



Scavenge Air Cooler
Removal and Fitting of Cooler Element and Heater Element

- ⇒ Lay out wooden underlay "WL" on rail (20) and put No.1 feed water heater on wooden underlay using chain block "H₂".
- ⇒ Fasten lifting devices (94660b) with two screws (M20×55) to cover (12) and (14) of No.1 feed water heater, and connect shaft (94660d) and shackles (BC18) with lifting devices (94660b).
- ⇒ Re-connect chain block "H₂" from eye bolt "RC₂" to shaft (94660d) on lifting device (94660b), and connect chain block "H₁" directly to shaft (94660d) and eye plate under upper platform as shown in Fig. 'T'.
- ⇒ Lift up and turn No.1 feed water heater by 90° using chain blocks "H₁" and "H₂" (see Fig. 'T'). Put No.1 air cooler on wooden underlay "WL".
- ⇒ Remove chain blocks "H₁", "H₂", lifting device (94660b) and shaft (94660d).

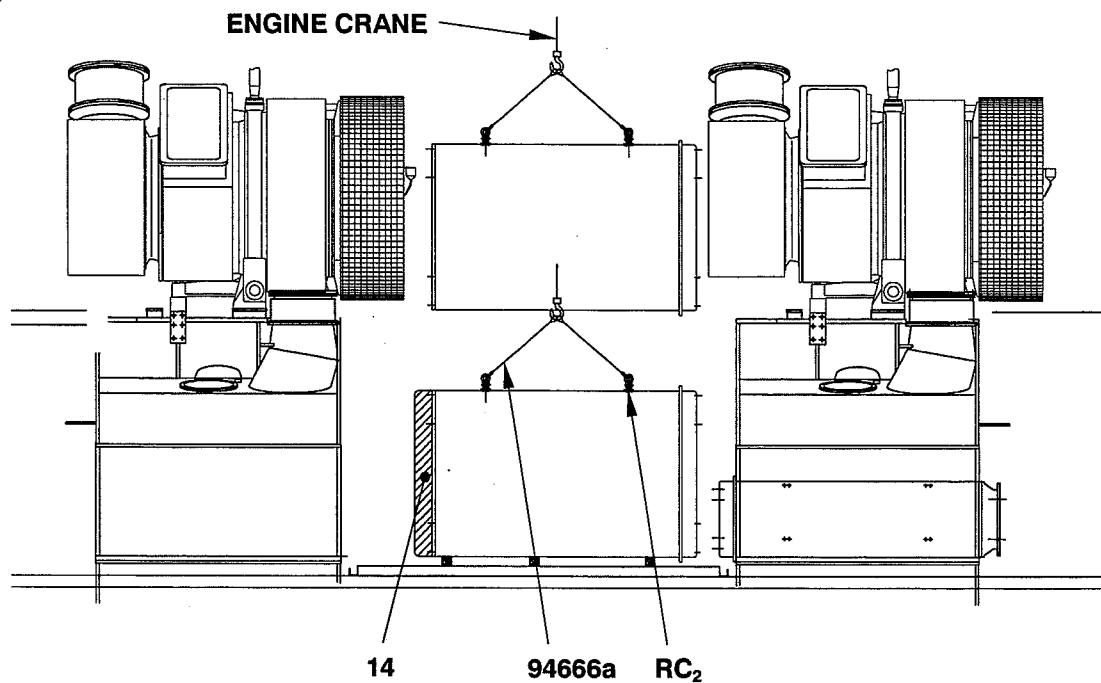


Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

- ⇒ Connect wire rope (94666a) with the engine crane and eye bolts "RC₂" and remove cover (14) from No.1 feed water heater.
- ⇒ Move No.1 feed water heater towards free-end slightly and lift No.1 feed water heater upwards by the engine crane.

U



Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

5.2 Removal of No.2 feed water heater

- ⇒ Remove all the screws (26).
- ⇒ Fasten roller plate (94662a) with two screws (M20×70) to cover (12) of No.1 feed water heater (18).
- ⇒ Align roller (21) of roller plate (94662a) with rail (20) on middle platform using set screw and locking nut (see Fig. 'B').
- ⇒ Fasten support (94663) as shown in Fig. 'V'. And then, connect chain block "H₁" and shackles (BC18) to roller plate (94662a) and eye bolts "RC₁" with wire rope (94666b) (see Fig. 'V').
- ⇒ Loosen nut (23) and remove flange (16) of No.2 feed water heater (see Fig. 'A').

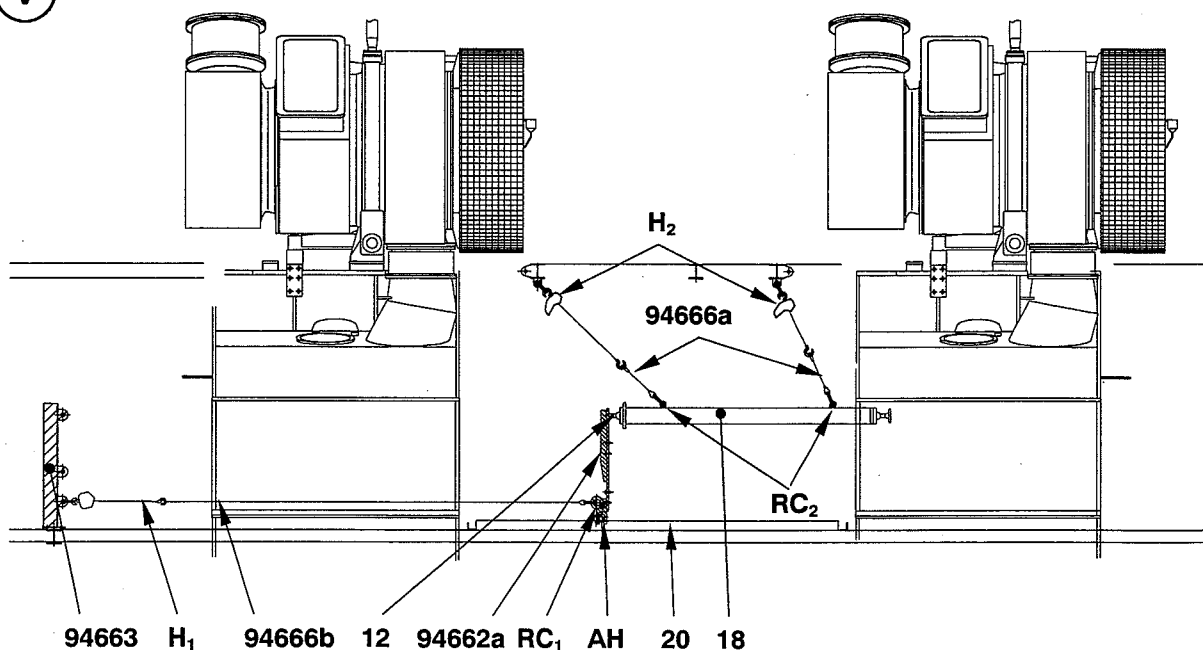


CAUTION

For safety reason, stopper "AH" must be set to the rail before removal works.

- ⇒ Pull out No.2 air cooler with chain block "H₁" until it stop at stopper (see Fig. 'V').
- ⇒ Remove stopper "AH" and connect eye bolts "RC₂" with No.2 feed water heater.
- ⇒ Fasten chain blocks "H₂" to eye plate under upper platform and connect it and wire ropes (94666a) with eye bolts "RC₂". And then, pull out No.2 feed water heater completely using chain blocks "H₁" and "H₂".
- Regarding the subsequent removal works, refer to paragraph 5.1.
No.2 air cooler can be removed in the same sequence as paragraph 5.1.

V



Scavenge Air Cooler

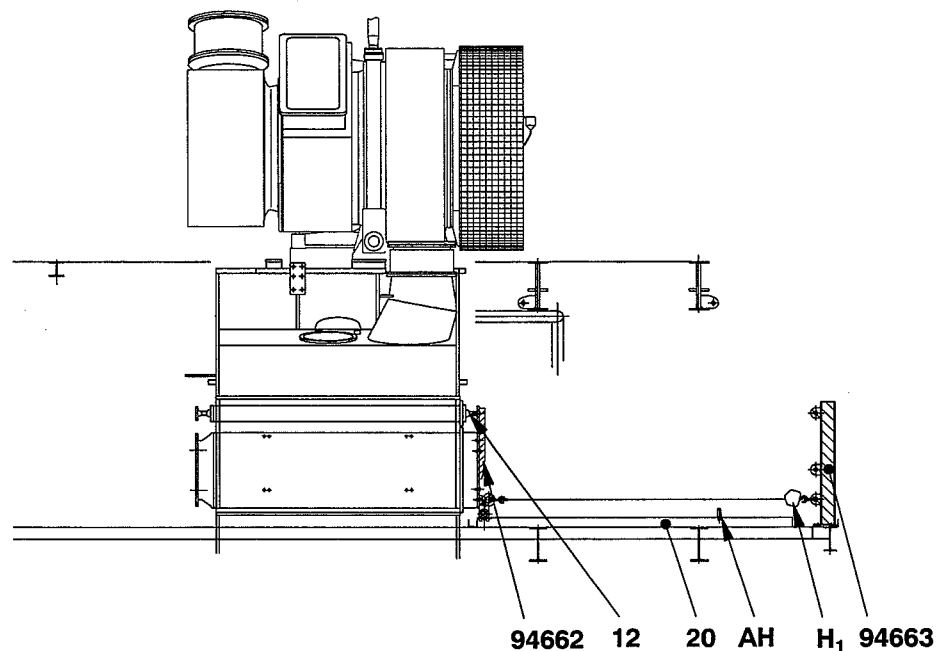
Removal and Fitting of Cooler Element and Heater Element

5.3 Removal of No.3 feed water heater

- ⇒ Remove all the screws (26).
- ⇒ Fasten roller plate (94662) with two screws (M20×70) to cover (12) of No.3 feed water heater (18).
- ⇒ Align roller (21) of roller plate (94662) with rail (20) on middle platform using set screw "ST" and locking nut (see Fig. 'B').
- ⇒ Fasten support (94663) as shown in Fig. 'W'. And then, connect chain block "H₁" and shackles (BC18) to roller plate (94662), and support (94663).
- ⇒ Loosen nuts (23) and remove flange (16) of No.3 feed water heater.



For safety reason, stopper "AH" must be set to the rail before removal works.

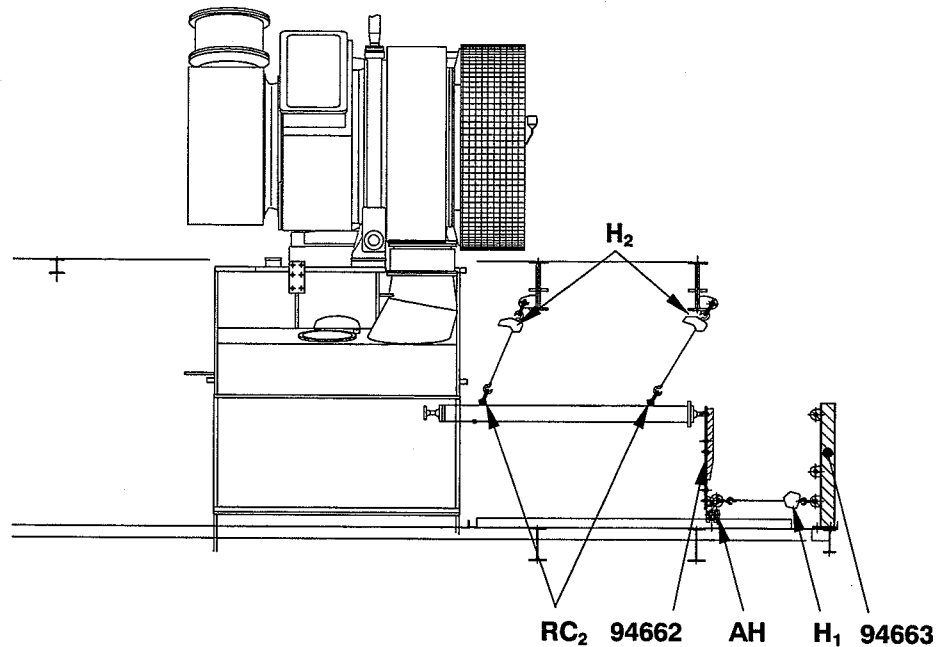


Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

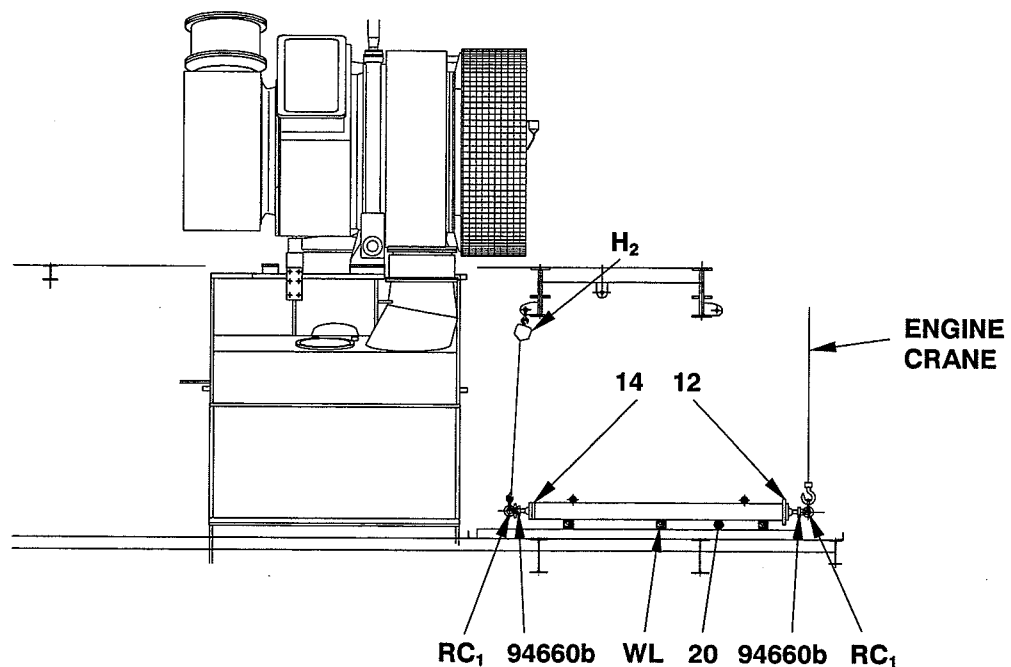
- ⇒ Pull out No.3 feed water heater with chain block "H₁" until it stop at stopper (see Fig. 'X').
- ⇒ Remove stopper "AH" and connect eye bolts "RC₂" with No.3 feed water heater.
- ⇒ Fasten chain blocks "H₂" to eye plate under upper platform and connect it with eye bolts "RC₂".

(X)



- ⇒ And then, pull out No.3 feed water heater completely using chain blocks "H₁" and "H₂".
- ⇒ Remove roller plate (94662), support (94663) and chain block "H₁".

(Y)

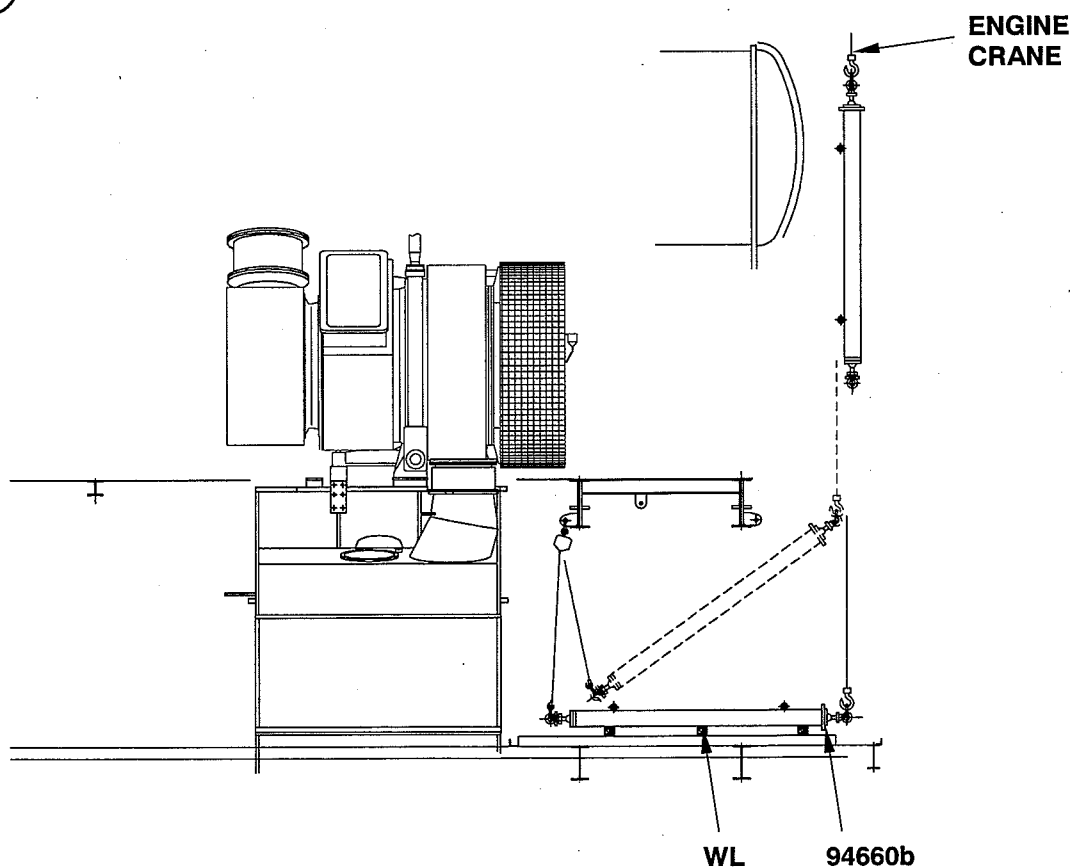


Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

- ⇒ Lay out wooden underlay "WL" on rail (20) and put No.3 feed water heater on wooden underlay using chain blocks "H₂".
- ⇒ Remove one chain block "H₂" at free-end (see Fig. 'Y'). Re-connect them to eye plate under upper platform as shown in Fig. 'Y'.
- ⇒ Fasten lifting devices (94660b) with two screws (M20×55) to cover (12) and (14) of No.3 feed water heater, and connect eye bolt "RC₁" and shackles (BC18) with lifting devices (94660b).
- ⇒ Move No.3 feed water heater to fuel side slightly using the engine crane and chain blocks "H₂".
- ⇒ Lift No.3 feed water heater upwards while moving No.3 feed water heater to free-end slightly by the engine crane and chain blocks "H₂".

Z



Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

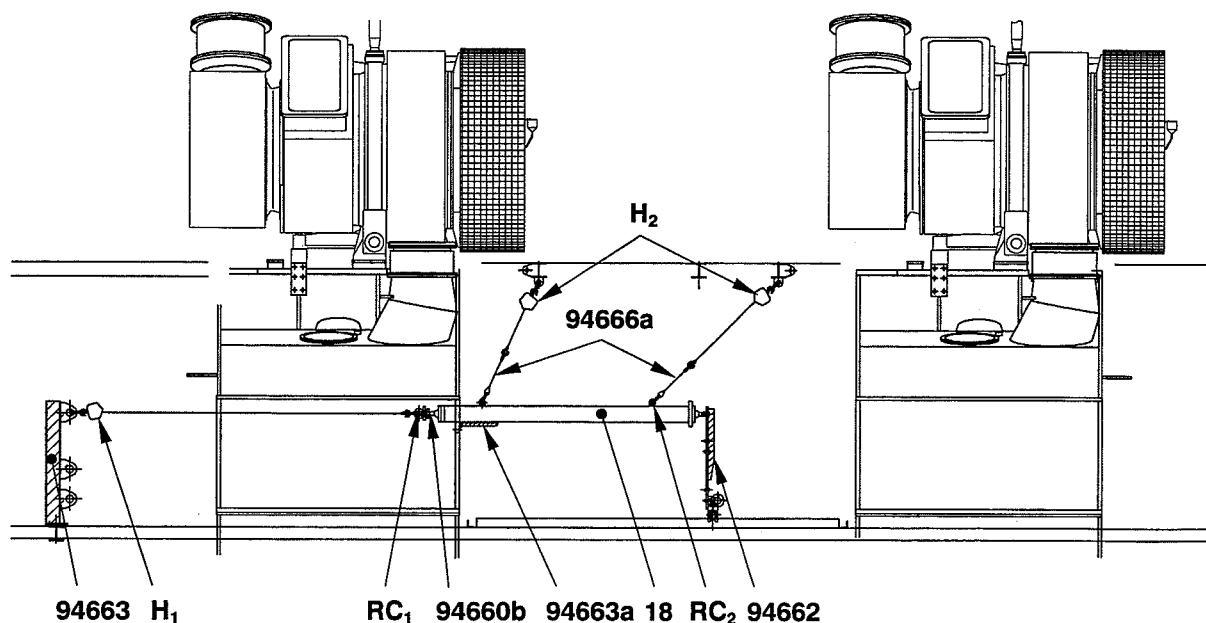
6. Fitting of heater element

The fitting procedure is the reverse sequence for the removal procedure for each air cooler. Refer to the section 5 and pay attention to tools for each air cooler.

6.1 Fitting of No.1 feed water heater

- ⇒ Clean sealing face "DF" of the feed water heater (18) and receiver (17).
- ⇒ Move the feed water heater (18) to the mounting place as shown in Fig. 'R' to 'U' for the removal but in reverse sequence, and adjust it to the mounting height.
- ⇒ Fasten support (94663) on middle platform and guide support (94663a) on receiver as shown in Fig. 'A₁'.
- ⇒ Connect chain blocks "H₂", wire rope (94666a) and shackle (BC22) with eye bolts "RC₁" attached on No.1 feed water heater.
- ⇒ Connect roller plate (94662) with No.1 feed water heater. Remove shaft (94660d) and connect eye bolt eye bolt "RC₁" on lifting device (94660b) (see Fig. 'T').
- ⇒ Connect chain block "H₁" with eye bolt "RC₁" on lifting device (94660b) and support (94663).
- ⇒ Pull the feed water heater (18) into the receiver using chain blocks "H₁" and "H₂".
- ⇒ Remove all tools.

A₁



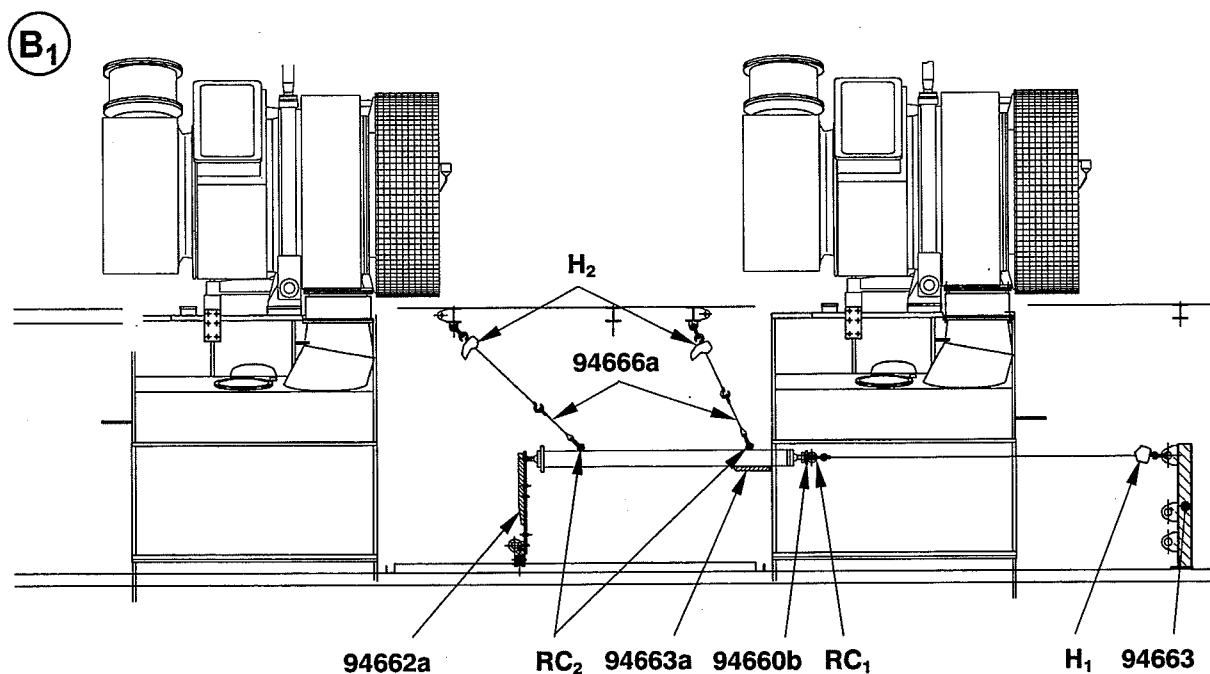
Scavenge Air Cooler

Removal and Fitting of Cooler Element and Heater Element

6.2 Fitting of No.2 feed water heater

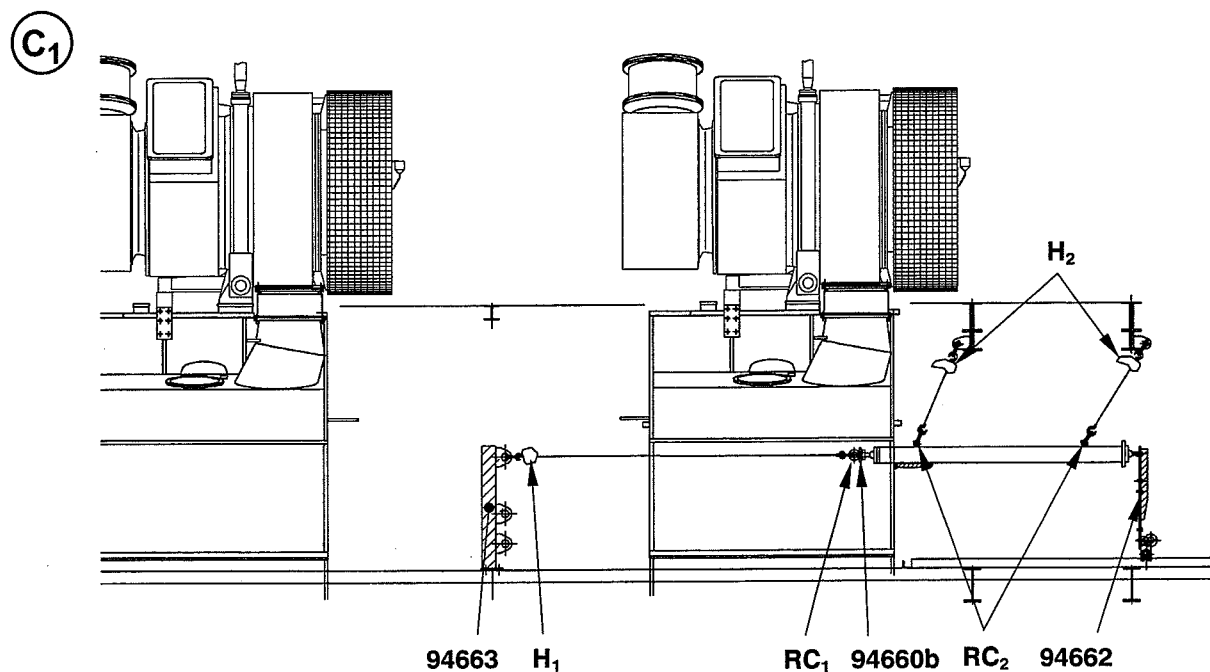
- The fitting procedure of No.2 feed water heater is the same as one of No.1 feed water heater (see Fig. 'B₁').

However, the roller plate (94662a), instead of the roller plate (94662), must be fastened to cover (12) of No.2 feed water heater.



6.3 Fitting of No.3 feed water heater

- The fitting procedure of No.3 feed water heater is the same as one of No.1 feed water heater (see Fig. 'C₁').



Scavenge Air Cooler
Cleaning of the Scavenge Air Cooler at Standstill

Key to Illustrations:

1	Feed water heater
2	Scavenge air cooler
3	Water separator
4	Turbocharger
5	Butterfly valve
6	Butterfly valve
7	Hose valve
8	Hose valve
9	Stop valve
10	Stop valve
11	Stop valve
12	Three-way valve
13	Ball valve
14	Throttle disc
15	Throttle disc
16	Sight glass
17	Cover
18	Cover
CA	Cleaning water return (air side)
CB	Cleaning water inlet (air side)
CE	Cleaning water return (cooling water side)
CF	Cleaning water inlet (cooling water side)
KA	Cooling water outlet
KE	Cooling water inlet
FA	Feed water outlet
FE	Feed water inlet
WE	Condensate water drain

1. Air side cleaning of the SAC in service

The equipment necessary for air side cleaning of the SAC is installed on the engine.

1.1 Cleaning intervals

In order to achieve the optimum cleaning effect, carry out the cooler cleaning immediately after cleaning the compressor of the turbocharger. Experience will show whether the time intervals can be extended.

The degree of SAC contamination depends to a major extent on the condition of the intake air and the maintenance of the air suction filter on the turbocharger.
(Recommended cleaning interval approx. 1000 hour)

1.2 Cleaning agent

As a rule, only products from reputable firms should be used and their instructions with regard to mixing ratio, etc. must be followed precisely.
(refer to **List of chemical agent on OPERATION MANUAL** of air cooler maker)

Scavenge Air Cooler

Cleaning of the Scavenge Air Cooler at Standstill

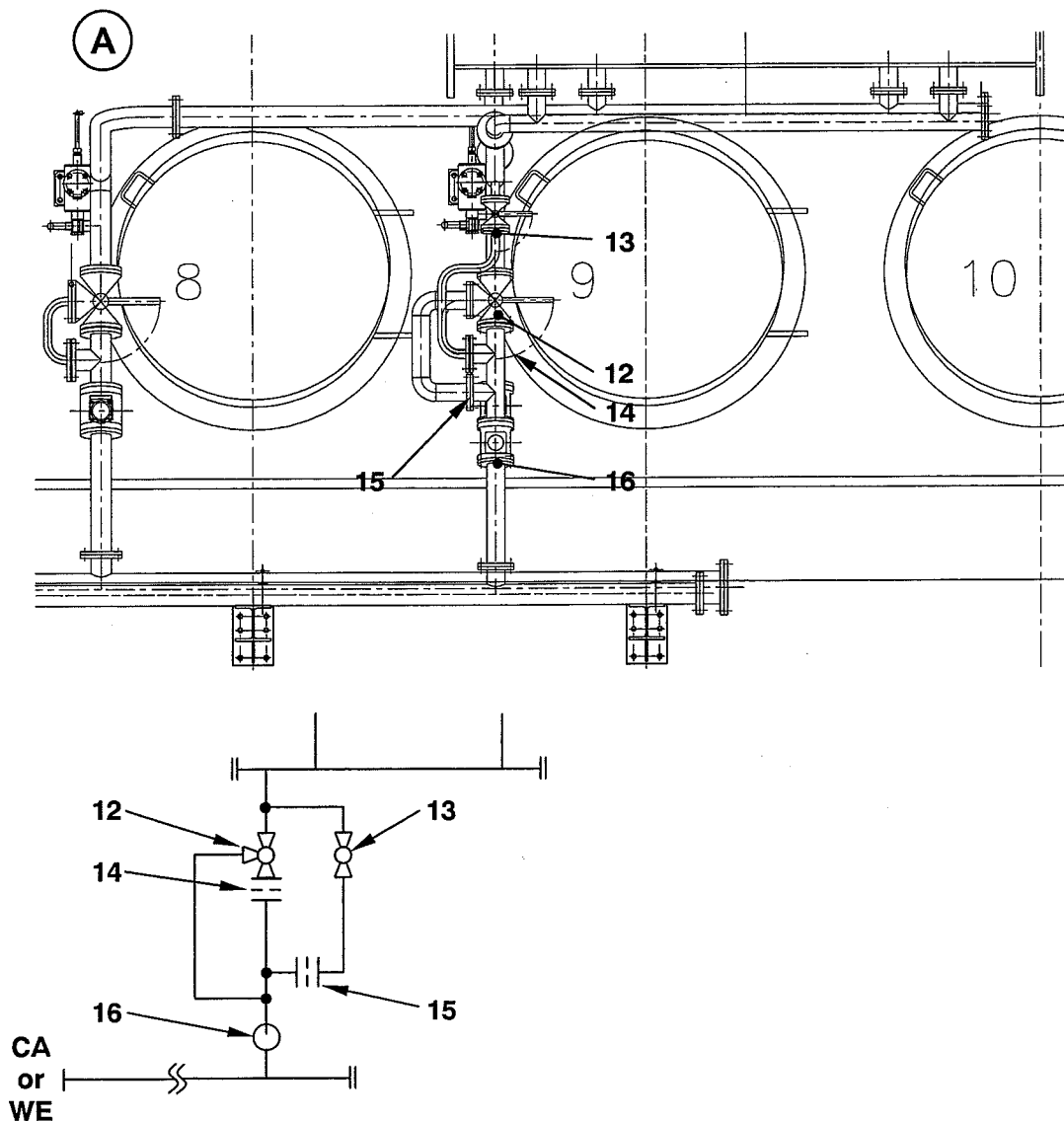
1.3 Cleaning procedure



The cleaning should be carried out at standstill.

The cleaning is ordered from cleaning maker generally or, when installing the cleaning line, the SAC is cleaned air side with circulating cleaning water through cleaning line.

- Before cleaning, check whether the throttle disc choked. If throttle disc (14) is choked, open three-way valve (12) to by-pass line.
If ball valve (13) is opened in service with heavy humidity condition, also check whether the throttle disc (15) is choked.
- ⇒ Check where the three-way valves (12) are opened to, and whether the ball valves are opened.
- ⇒ Open all the stop valves (11) (Fig. 'B').
- ⇒ Pour the cleaning agent compounded in cleaning tank fully and circulate it with pump **for approx. 1 hour**.



Piping diagram

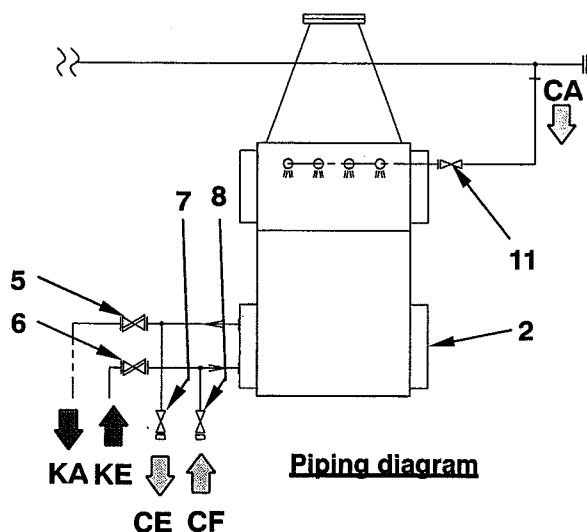
Scavenge Air Cooler

Cleaning of the Scavenge Air Cooler at Standstill

After cleaning the scavenge air coolers with chemical agent, clean them used by hot water or fresh water through the A/C cleaning piping.

Therefore, drain the cleaning water from M/E air cooler chemical cleaning tank, and then fill the clean fresh water in it.

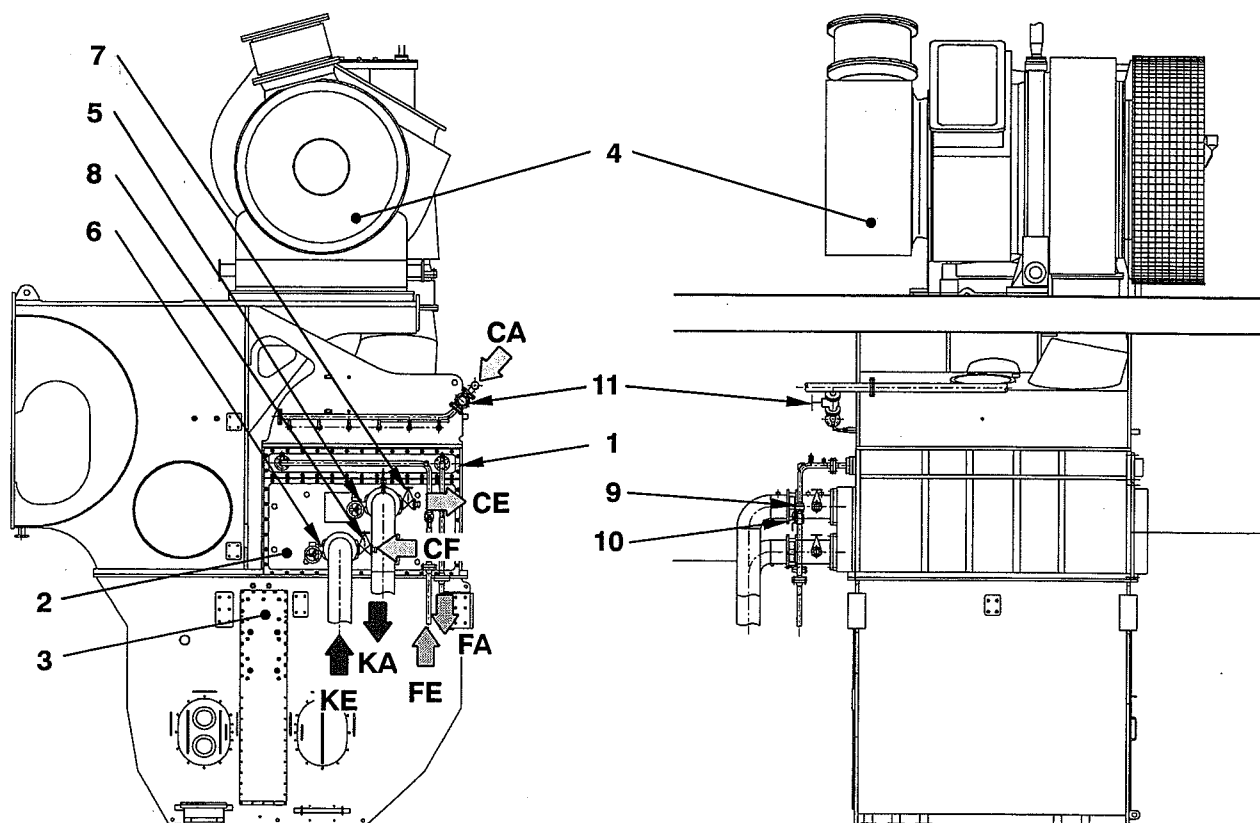
(B)



- ⇒ Circulate the fresh water through the A/C cleaning piping fully.
- ⇒ Close all the stop valves (11) (Fig. 'B').
- ⇒ Check whether three-way valves (12) is in the same position as it before cleaning and whether ball valves (13) is in the same condition as it before cleaning (Fig. 'A')



Before operating the engine, be sure to check all the stop valve (11) closed and the three-way valve (12) opened to the same position as it before cleaning **certainly**.



Scavenge Air Cooler**Cleaning of the Scavenge Air Cooler at Standstill****2. Water side cleaning of the SAC in service**

Depending on the cleanliness of the utilized cooling water, a cleaning of the cooler tubes required after a shorter or longer operating period.

The necessity to clean become evident either by measuring the pressure difference or by the temperature difference between cooling water inlet and outlet, and comparing them by the value of the clean cooler.



Put on cloth gloves so as not to get burnt in the hand at the working right after stopping.

2.1 Cleaning agent

As a rule, only products from reputable firms should be used and their instructions with regard to mixing ratio, etc. must be followed precisely.

(refer to **List of chemical agent on OPERATION MANUAL** of air cooler maker)

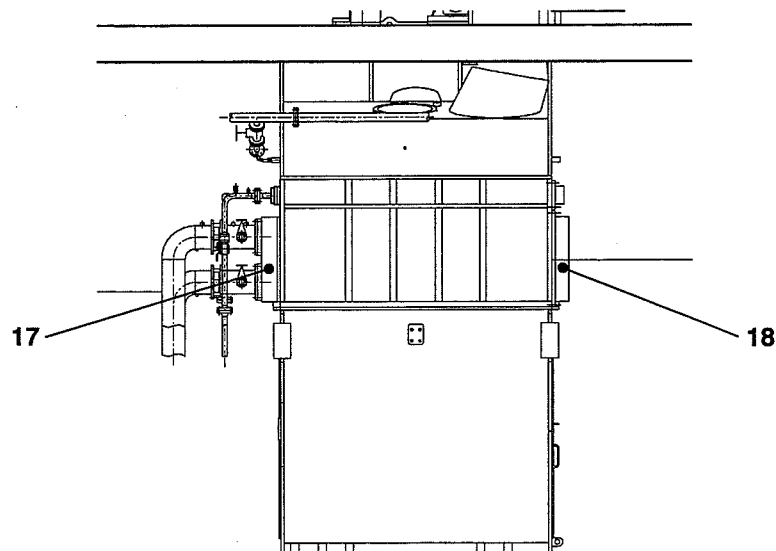
2.2 Cleaning procedure

The cooling tubes can be cleaned by mechanical and by circulating the chemical agent.

2.2.1 Mechanical cleaning in fitted condition

Before carrying out the below sequence, drain the cooling water in air cooler completely.

- ⇒ Remove the pipes connected to air cooler.
- ⇒ Remove the covers (17) and (18) (Fig. 'C').
- ⇒ The dirt, loosened by fresh water, is removed by special tube brushes.
- ⇒ Flush the tube of air cooler out.
- ⇒ Fit the covers (17) and (18), and then connect the pipe to the air cooler (Fig. 'C').
- ⇒ Before operating the engine, vent in the air cooler.

C

Scavenge Air Cooler
Cleaning of the Scavenge Air Cooler at Standstill
2.2.2 Cleaning the air cooler(water side) by circulating the clening water on fitted condition

This engine is provided with the hose valves (7) and (8) for cleaning the air cooler by circulating the the cleaning water.

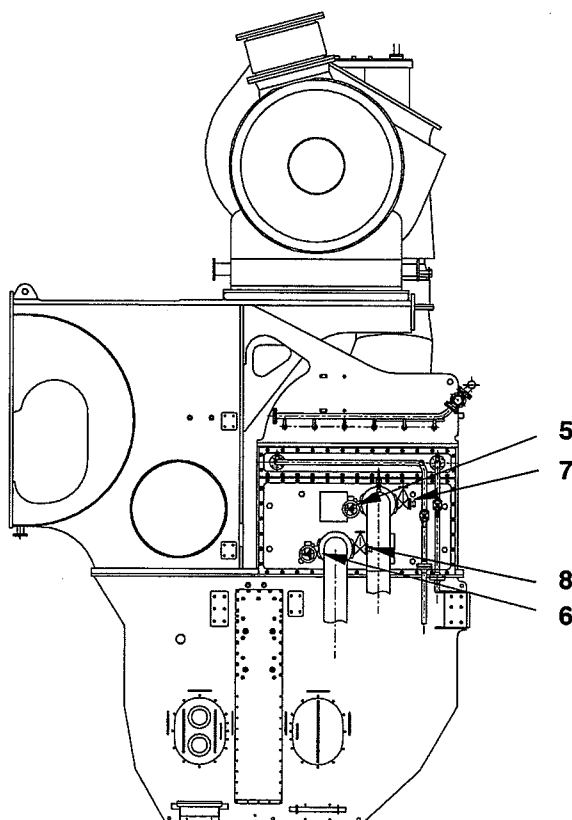
Before carrying out the below sequence, drain the cooling water in air cooler completely

- ⇒ Close the butterfly valves (5) and (6) (Fig. 'D').
- ⇒ Connect the hoses or piping to the hose valves (7) and (8), and open the hose valves (7) and (8) (Fig. 'D')
- ⇒ Circulating the cleaning water with cleaning agent, and then circulating the clean fresh water fully.
- ⇒ Open the butterfly valves (5) and (6) (Fig. 'D').
- ⇒ Before operating the engine, vent in the air cooler.



As accumulated air in the cooling water system of the scavenge air cooler can lead to operating troubles on the engine and to damage of the SAC, proper functioning of the SAC venting must be ensured.

D



Water Separator

Removal and Fitting of Water Separator

Tools:

1	Carriage	94667
1	Pulley device	94668
1	Support	94669
1	Support	94669a
1	Lifting device	94672
1	Wire rope sling*	94673
1	Wire rope sling*	94673a
*	(hereafter called wire rope)	

Key to Illustrations:

1	Door	15	Rail
2	Pin	16	Drain pipe
3	Cover	17	Gasket
4	Cover	18	Feed water outlet pipe
5	Receiver	19	Feed water inlet pipe
6	Platform support		
7	Platform support		
8	Screw		
9	Screw		
10	Jacking screw		
11	Support	RF	Sealing surface
12	Screw	HZ	Chain block
13	Spring plate	RC	Eye bolt (M30)
14	Water separator	TU	Door opening

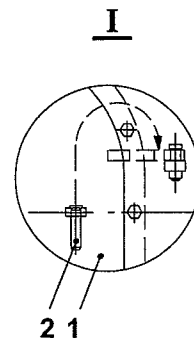
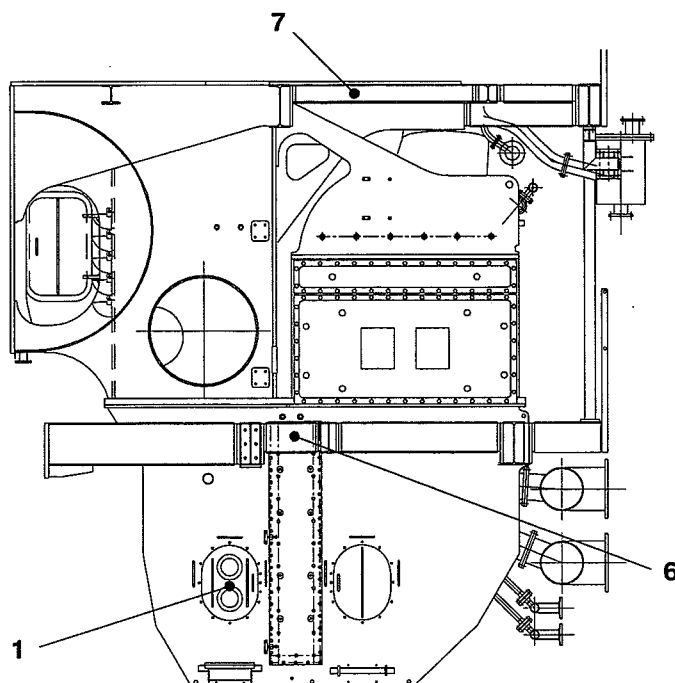
1. Preparation

- ⇒ Loosen doors (1), open up and lock it on the inside with pin (2).
- ⇒ Remove platform supports (6), (7) and the corresponding bottom plates which hinder the removal of the water separator.
- ⇒ Remove screws (8) on the corresponding cover.
- If necessary (in case of removal the No.3 water separator), remove feed water inlet pipe (18) and silencer of No.2 turbocharger.



To prevent having a fall, immediately close the openings off after removing the bottom plates!

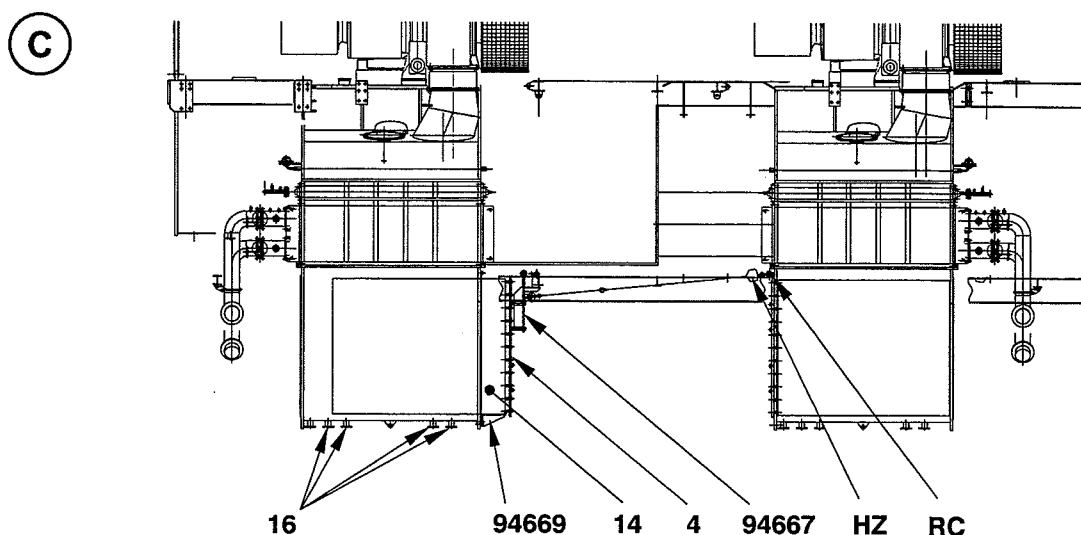
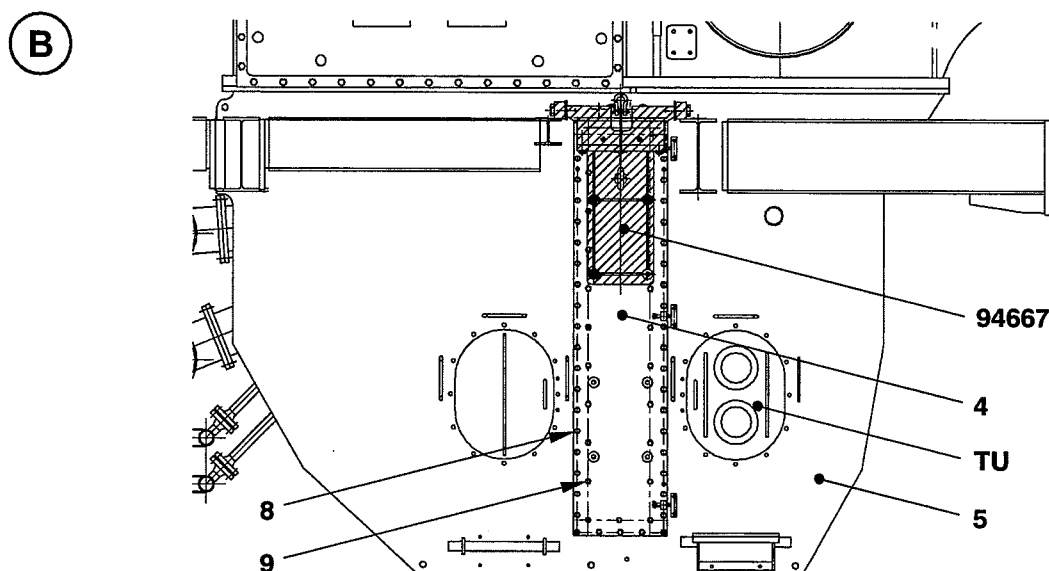
A



No.2 air receiver

Water Separator**Removal and Fitting of Water Separator****2. Removal****2.1 Removal of No.1 water separator**

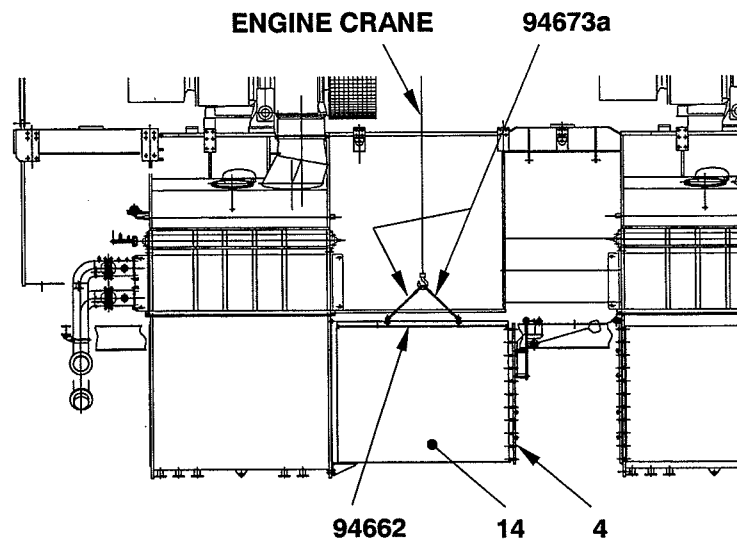
- ⇒ Removal screws (8) on cover (4).
- ⇒ Fasten carriage (94667) to cover (4) with screws (M16×170) and fasten eye bolt "RC" to receiver (5).
- ⇒ Connect chain block "HZ" with eye bolt "RC" and eye bolt on carriage (94667).
- ⇒ Pull No.1 water separator (15) slightly (approx. 400 mm) fastened with cover (4) and fasten support (94669) to receiver (Fig. 'C').
- ⇒ Pull No.1 water separator using chain block "HZ". And then, connect lifting device (94662) and wire rope (94673a) with the engine crane (Fig. 'D').
- ⇒ Lift up No.1 water separator slightly and remove carriage (94667), chain block "HZ" and eye bolt "RC".
- ⇒ Lift up No.1 water separator using the engine crane while moving it towards exhaust side.



Water Separator

Removal and Fitting of Water Separator

(D)



2.2 Removal of No.2 water separator

- The removal procedure of No.2 water separator is the same as one of No.1 water separator (see Fig. 'C' and 'D').

2.3 Removal of No.3 water separator

- The removal procedure of No.3 water separator is the same as one of No.1 water separator (see Fig. 'C', 'D' and 'F').

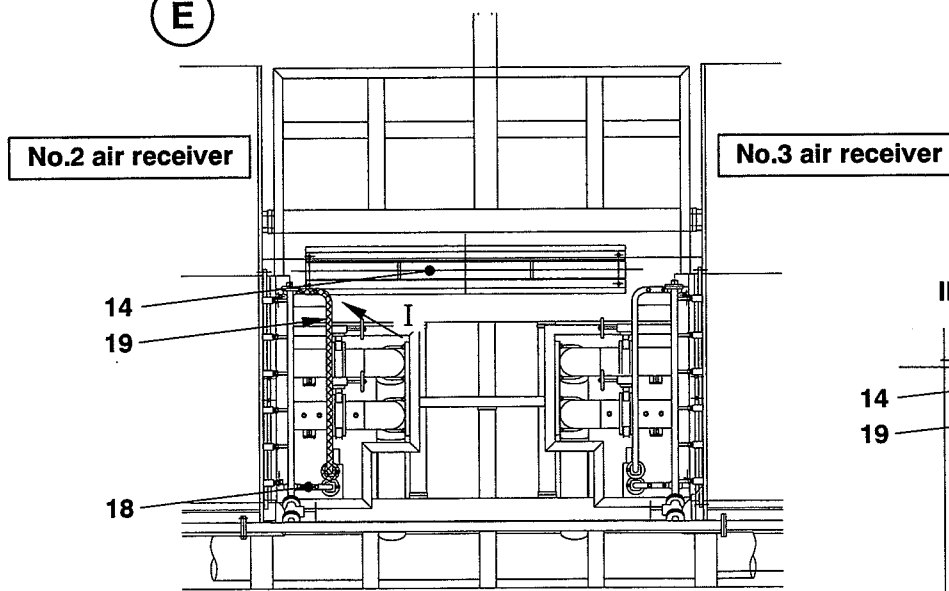
However, the support (94669a), instead of the support (94669), must be fastened to receiver (5).



CAUTION

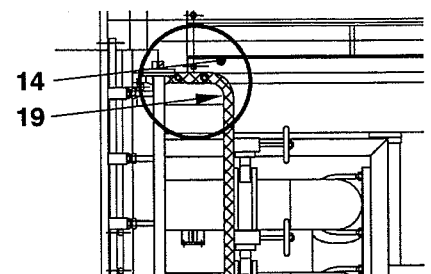
Before removing No.3 water separator, feed water inlet pipe (19) and silencer of No.2 turbocharger must be also removed (Fig. 'E' and 'F').

(E)



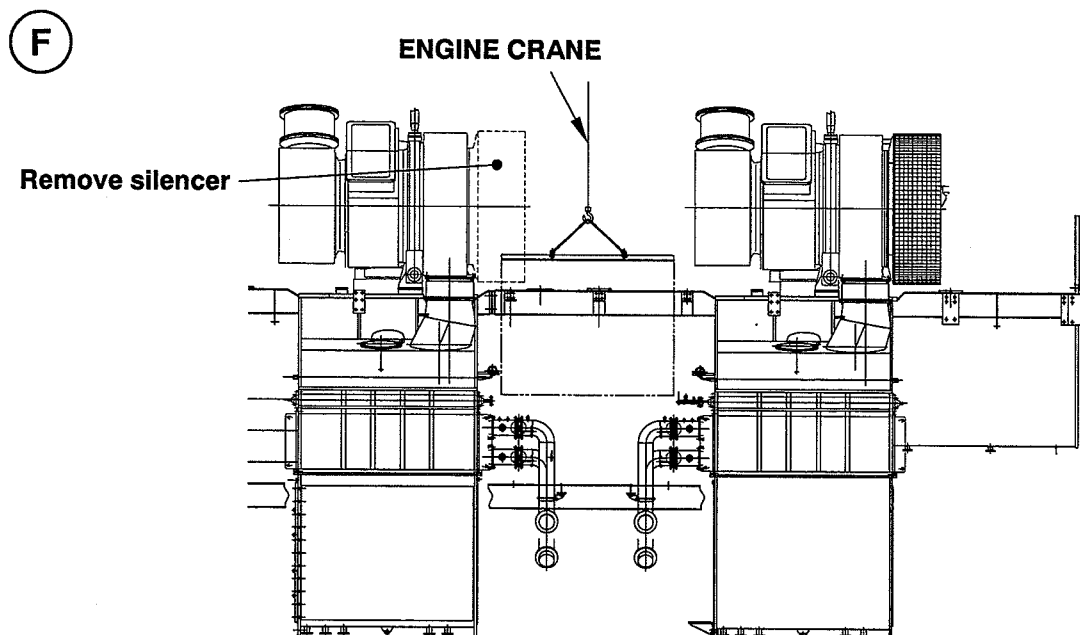
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INTERFERENCE



Water Separator

Removal and Fitting of Water Separator



3. Fitting

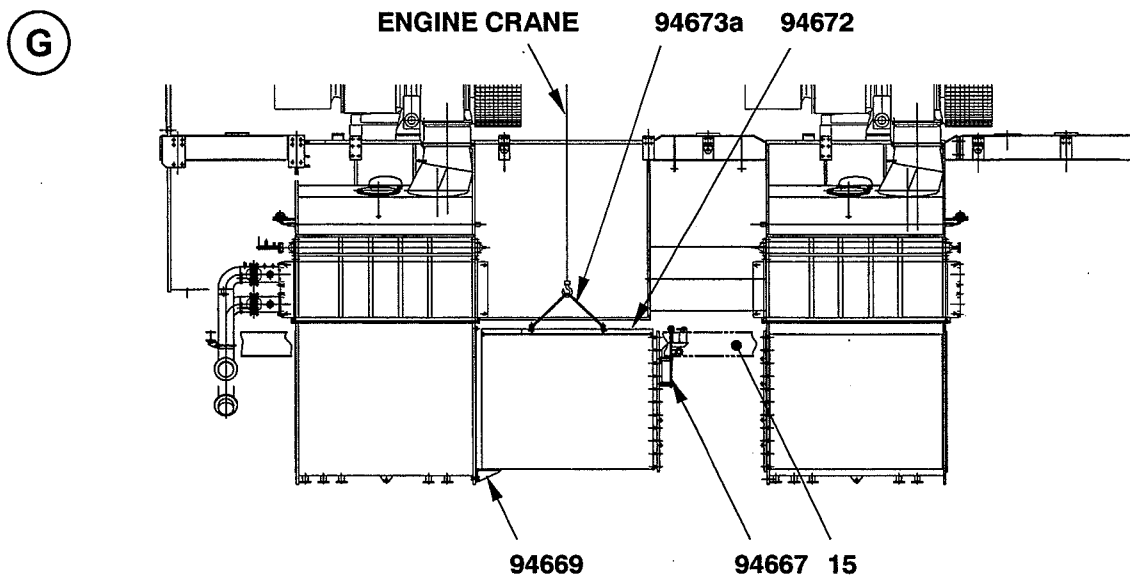
CHECK

Prior to fitting the water separator, check drain pipes (16) (Fig. 'C') for free passage.

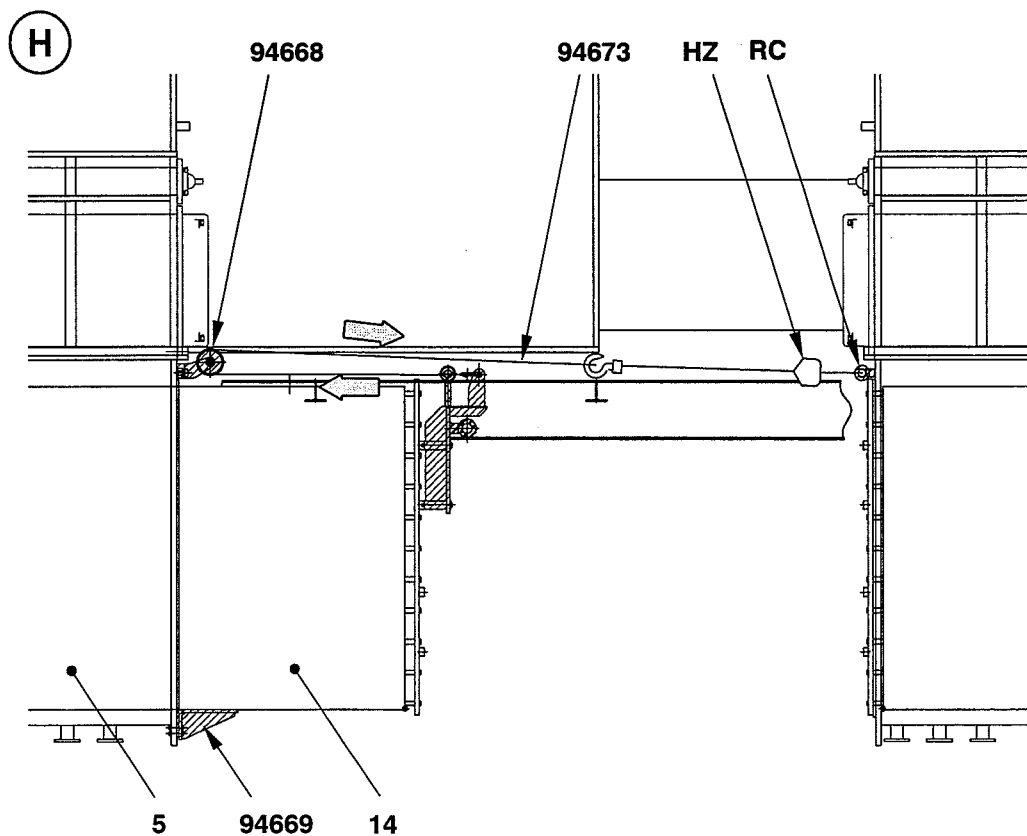
3.1 Fitting of No.1 water separator

- ⇒ Move the water separator to the mounting place as shown in Fig. 'C' and Fig. 'D' for the removal but in reverse sequence, and adjust it to the mounting height.
- ⇒ Mount support (94669) and carriage (94667).
- ⇒ Carefully lower water separator onto rails (15) and support (94669) as shown in Fig. 'G'.
- Pay attention that carriage (94667) is placed in its proper position!

Water Separator
Removal and Fitting of Water Separator



- ⇒ Remove lifting device (94672) and wire rope (94673a).
- ⇒ Fasten pulley device (94668) to receiver (5) and fasten eye bolt "RC" to the opposite receiver (Fig. 'H').
- ⇒ Connect chain block "HZ" and wire rope (94673) with pulley device (94668) and eye bolt "RC".



Water Separator

Removal and Fitting of Water Separator



Clean sealing surface "DF", and smear sealing surface "DF" with the heat-resistant silicone agent.

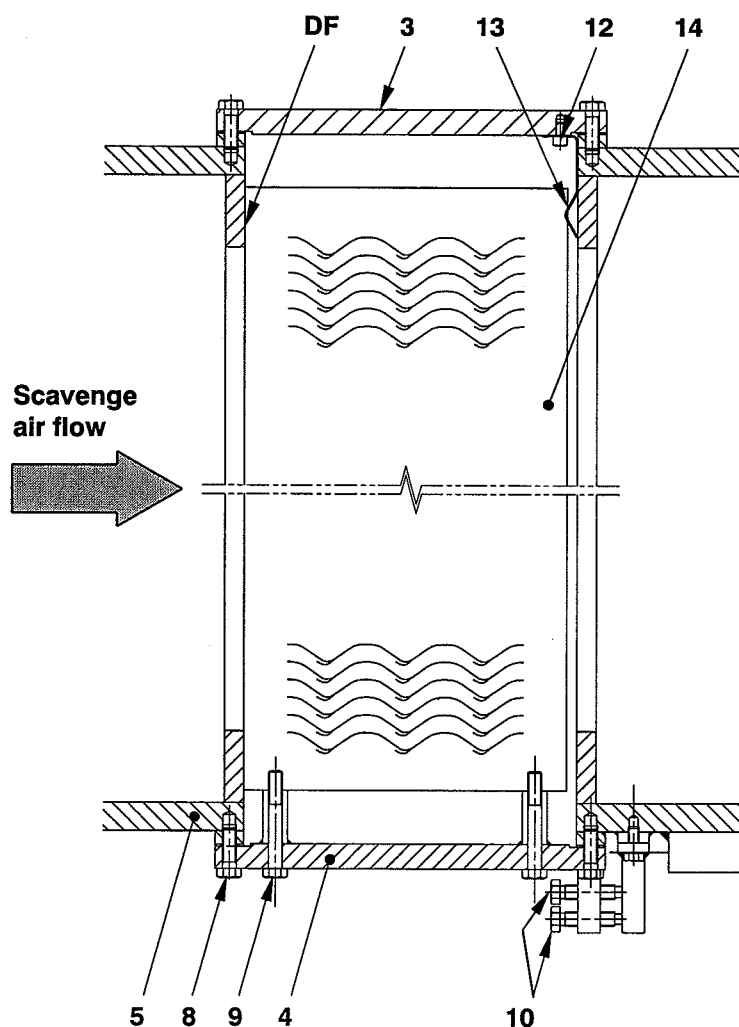
- ⇒ Pull water separator into the receiver and align it to the fitting position.
- ⇒ Push water separator to exhaust side using jacking screw (10) (Fig. 'I').
- ⇒ Fit and tighten screws (8) together with gasket (17).
- ⇒ Remove all tools.



Close and tighten up doors (1) after checking that workmen is not in receiver.

- ⇒ Reinstall platforms.

I



Water Separator

Removal and Fitting of Water Separator

3.2 Fitting of No.2 water separator

- The fitting procedure of No.2 water separator is the same as one of No.1 water separator (see Fig. 'G' and 'H').

3.3 Fitting of No.3 water separator

- The removal procedure of No.3 water separator is the same as one of No.1 water separator (see Fig. 'G' and 'H').

However, the support (94669a), instead of the support (94669), must be fastened to receiver (5).



After fitting No.3 water separator, feed water inlet pipe (19) and silencer of No.2 turbocharger must be fitted.

Group 7

▽ ECL system

- Removal and Fitting of Cooler Element and Heater Element.....7218-1/A1
- Inspection and Adjusting of Supply Unit.....7218-2/A1

ECL System
Inspection, Removal and Fitting of Distributor
Tools :

- 1 Distributor dismantling tool
(A8-08632-01)

Key to Illustrations :

- | | | |
|------------------------|----------------------|-----------------------|
| 1 Pressure transmitter | 9 Empty screw | 19 Shim |
| 2 Three-way valve | 10 Base | 20 Armature |
| 3 Orifice | 11 Distributor block | 21 Screw |
| 4 Solenoid | 12 Bush | 22 Locating pin |
| 5 Distance ring | 13 Lifter | 23 Distributing piece |
| 6 Locking nut | 14 Spring | 24 Screw |
| 6a Valve bonnet | 15 Valve seat | 25 Empty screw |
| 6b Screw | 16 Valve spindle | |
| 7 Shut off valve | 17 Spring | |
| 8 Screw | 18 Screw cap | BL Bore |

1. General


If the alarms of **"Distributor Out of Work"**, **"Mulfuction of Distributor Valve Seat"** or **"Abnormal Operation of Distributor"** occur in the control panel, the distributor must be inspected or exchanged. (Refer to Operating Manual 7218-5/A1)

2. Removal of Distributor

- ⇒ Loosen the locking nut (6).
- Close the shut off valve (7) of the relevant distributor.



The distributor located on the main engine driving end is called **"System A"**, the distributor located on the main engine free end is called **"System B"**.

- ⇒ Vent the return line from ECL-SIP valve and distributors using three-way valve (2) (Refer to Instruction Manual: 8016-2/A1).
- ⇒ Separate all lubricating piping connections and detection piping of pressure transmitter (1) for the distributor.
- ⇒ Remove the solenoid (4) with the terminal box (30) and the distance ring (5) on the top of distributor. (refer to Section 6)
- ⇒ Loosen and remove four screws (8) which fasten the distributor block (11) to the base (10).

3. Dismantling and Inspection of Flow Limiter

- ⇒ Pull out the bush (12) with lifter (13) and spring (14) from the base (10).
- ⇒ Pull out the lifter (13) and spring (14) from the bush (12).
- ⇒ Clean all parts using marine diesel oil or gas oil.

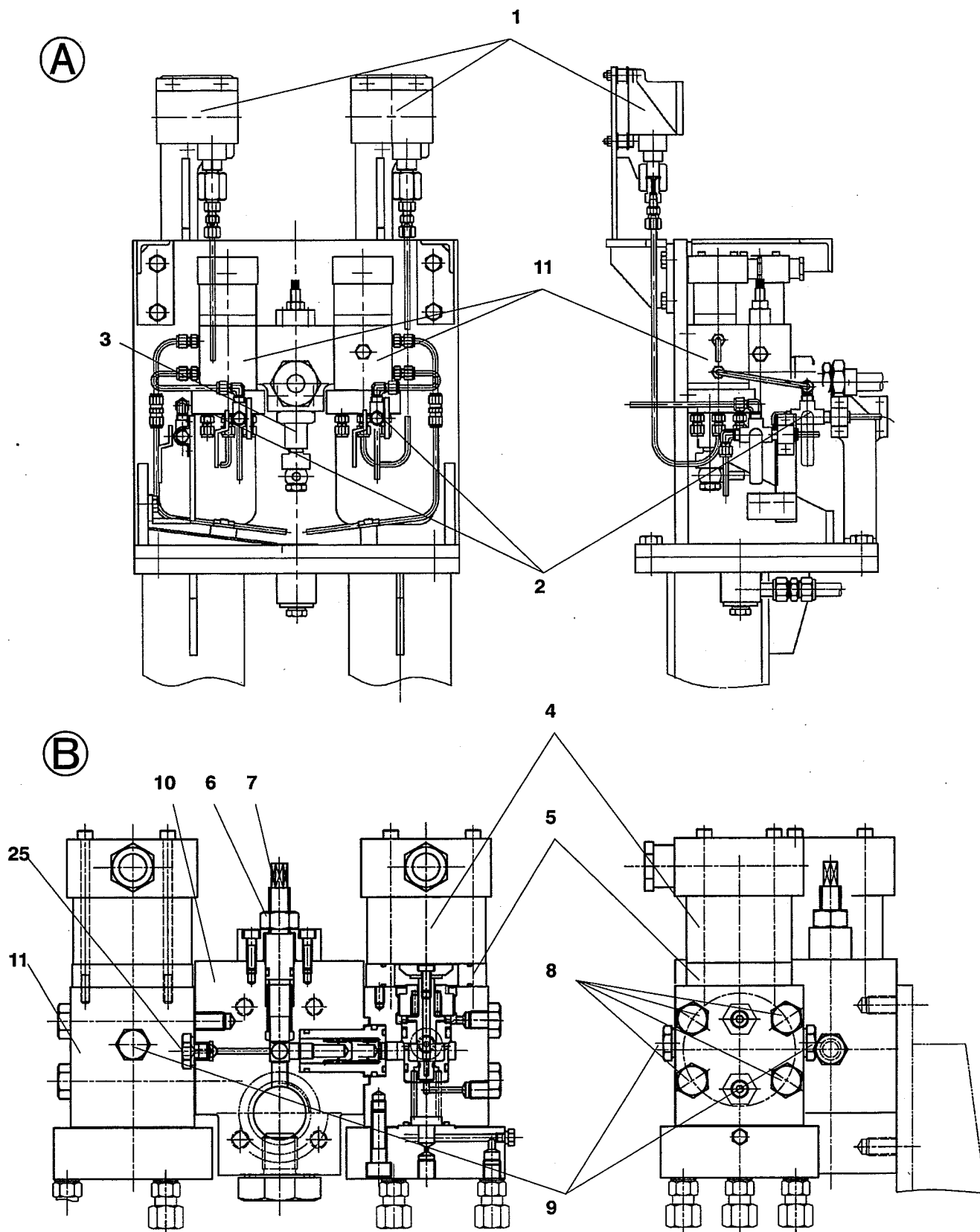


Wear protection glove.

- ⇒ Inspect whether the sliding surface and seating surface of all part are not defective.
- ⇒ Inspect whether two holes (BL) of the lifter is not choked.
- ⇒ Exchange O-rings with the new one.
- ⇒ Insert the spring (14) and the lifter (13) into the bush (12) and insert the bush (12) into the base (10).

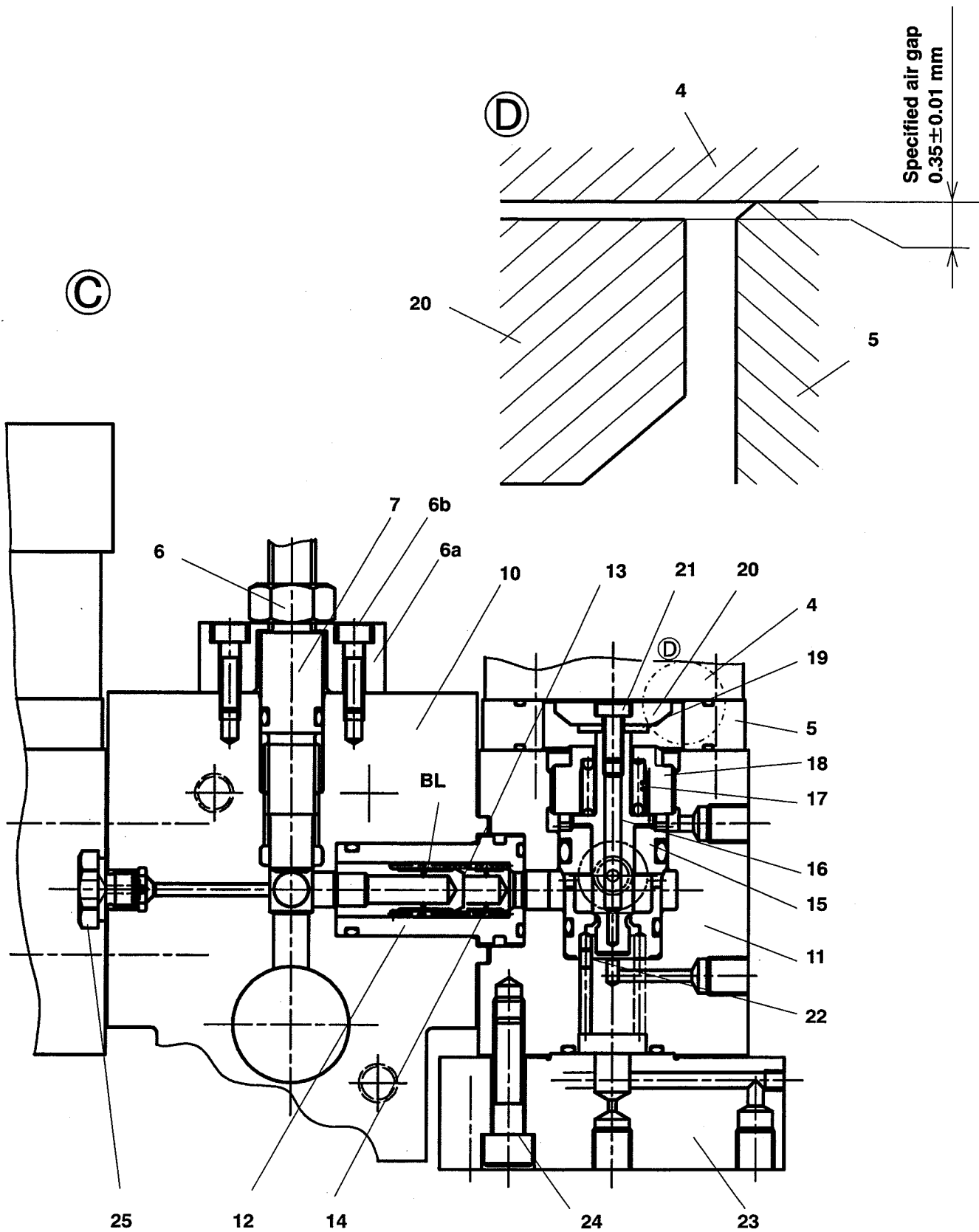
ECL System

Inspection, Removal and Fitting of Distributor



ECL System

Inspection, Removal and Fitting of Distributor



ECL System
Inspection, Removal and Fitting of Distributor
4. Dismantling and Inspection of Distributor

- ⇒ Prior to dismantling and inspecting of the distributor, measure the air gap using depth gauge (see Fig. D).
- ⇒ Loosen and remove the screw (21) which fasten the armature (20) to valve spindle (16). Remove the armature (20) and the shim (19).
- ⇒ Remove the screw cap (18) and the spring (17).
- ⇒ Pull out the valve spindle (16) from valve seat (15).
- ⇒ Pull out the valve seat (15) from distributor block (11) using the distributor dismantling tool (A8-08632-01).



Do not damage the sliding surface of the seat.

- ⇒ Loosen and remove six screws (24) which fasten the distributing piece (23) to the distributor block (11).
- ⇒ Clean all parts using marine diesel oil or gas oil.



Wear protection glove.

- ⇒ Inspect whether the sliding surface and seating surface of all part are not defective. Inspect whether all bores are not choked.
- ⇒ Exchange all O-rings and the backup rings which are installed in the valve seat (15) with new ones.
Exchange the O ring between the distributor and the distributing piece (23) with new one.
- ⇒ Fasten the distributing piece (23) with six screws (24).
- ⇒ Insert the valve seat (15) into the bottom of the distributor block (11) slowly and certainly. The fitting position of valve seat is given by two locating pins (22).
- ⇒ Insert the valve spindle (16) and spring (17) into the seat (15).
- ⇒ Smear thread of the cap screw (18) with MOLYKOTE paste.
Tighten the cap screw (18) up to a torque of $78 \pm 1 \text{ Nm}$ ($8 \pm 0.1 \text{ kgfm}$).
- ⇒ Put the shim (19) and the armature (20) on the valve spindle (16).
Lubricate thread of the screw (21) with lubricants.
Tighten the screw (21) up to a torque of 4 to 4.5 Nm (0.4 to 0.45 kgfm).
- ⇒ Put the distance ring (5) on the distributor.
Measure the air gap using depth gauge (see Fig. D).

Specified air gap : $0.35 \pm 0.01 \text{ mm}$

ECL System
Inspection, Removal and Fitting of Distributor

5. Fitting of Distributor

- ⇒ Fit the distributor block (11) to the base (10). Tighten four screws (8) equally up to a torque of 30 Nm.
- ⇒ Restore all lubricating piping and the detection piping of the pressure transmitter (1).
- ⇒ Put the distance ring (5) and the solenoid (4) with the terminal box (30) on the top of the distributor. (refer to Section 6)
- ⇒ Connect the return line from ECL-SIP valve and distributors to the low pressure return pipe(Refer to Instruction Manual: 8016-2/A1).
- ⇒ Open the shut off valve (7) of the relevant distributor.
Fasten the locking nut (6).
- ⇒ Unscrew the empty plug (25) until oil flows bubble free.
- ⇒ Unscrew the empty plug (9) until oil flows bubble free.



Unscrew the empty plug (9) very slowly. Otherwise the flow limiter may work and shut off the lubricating oil.

- ⇒ Restore three-way valve (2) (Refer to Instruction Manual: 8016-2/A1).
- ⇒ Separate a lubricating piping connections for distributor.
Execute the priming (Refer to Operating Manual: 0630-1/A1).
After checking of injection, restore the lubricating piping connection for distributor.

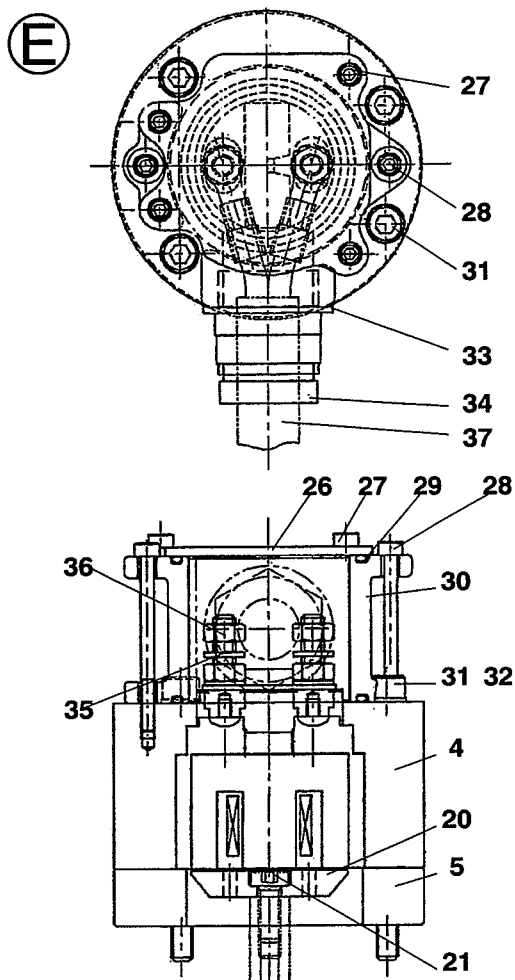
ECL System

Inspection, Removal and Fitting of Distributor

6. Removal and Fitting of Solenoid

Key to Illustrations:

26	Cover	30	Terminal box	34	Cable grand
27	Screw (M3 x 40)	31	Screw (M5 x 60)	35	Washer
28	Screw (same as 27)	32	Washer	36	Nut
29	O-ring	33	Packing ring	37	Cable



6.1 Removal of Solenoid

- ⇒ Loosen screws (31) and remove the solenoid (4) with the terminal box (30) and distance ring (5).

6.2 Fitting of Solenoid

- ⇒ Put the distance ring (5) on the distributor block (11).
- ⇒ Put the solenoid (4) with the terminal box (30) on the distance ring (5).
- ⇒ Fit and tighten screws (31) up to a torque of 4 to 5 Nm.

ECL System
Inspection, Removal and Fitting of Distributor

7. Restoration of Flow Limiter

A safety device (hereinafter call flow limiter) is equipped between distributor and base block to stop lubrication forcibly when excessive quantity of lubricating oil was delivered.

If the alarm of "**Distributor Out of Work**" occurs, prior to inspection of distributor, the following work should be executed.

7.1 Check of state of flow limiter (see Fig. B)

- ⇒ Check whether the pressure of main pipe is specified range 7.4 to 8.5 MPa.
- ⇒ Check whether the LED on the top of the relevant distributor is not emitting.
- ⇒ Check whether the shut off valve (7) of the relevant distributor is opened.
- ⇒ Loosen empty screw (9) slowly.
 - If the cylinder lubricating oil flows from empty screw (9) continuously, the flow limiter does not work.
Accordingly, the removal and inspection of distributor should be executed.
 - If the cylinder lubricating oil does not flow from empty screw (9), the flow limiter shuts off cylinder lubricating oil.
Accordingly, the restration of flow limiter should be executed as below.

7.2 Restoration of Flow Limiter (see Fig. B & C)
State of main engine stopping

- ⇒ Lower the pressure of main pipe below 0.05MPa.
- ⇒ Push "RESET" push button on the operation panel.

State of main engine running

- ⇒ Close the shut off valve (7) of the relevant distributor.
- ⇒ Loosen the empty screw (25) slowly.
- ⇒ After a few minutes, tighten the empty screw (25) and open the shut off valve (7).
- ⇒ Loosen the empty screw (9) slowly until oil flows bubble free and tigthen the empty screw (9).
- ⇒ Push "RESET" push button on the operation panel.

ECL System
Inspection and Adjusting of Supply Unit
1. Preparation before Starting after a Prolonged Shut-down Period

After initial installation, draining of main pipes completely or drydock, prior to restarting ECL system, the following works should be executed.

⇒ Open all valves except the valve at supply line in supply unit.

Open all air vent valves which are installed in the inlet of oil heater, the outlet of low pressure filters, the inlet of middle pressure pumps, the outlet of the middle pressure filter, main pipe and low pressure return pipe.



The shut off valve of each distributor should be closed fully.
The bypass valve of the pressure retaining valve should be opened.
Do not change the setting of the pressure retaining valve.

⇒ When oil flows bubble free from the air vent valve, shut off the air vent valves except the air vent valves for main pipe and low pressure return pipe.

⇒ After checking whether oil flows bubble free from the air vent valve, close the air vent valve and start middle pressure pump.



All stop valves which is located on the inlet and outlet of middle pressure pump must be opened.

⇒ After checking whether the set value of control thermostat is 55 degrees C and the set value of safety thermostat is 70 degrees C, push the button of "ON" on the heater control panel.

⇒ When oil flows bubble free from the air vent valve for main pipe and low pressure return pipe, shut off the air vent valve.

⇒ Keep circulating of lubricating oil for four hours in order to clean system.
If the pressure of main pipe exceed 4 MPa, check whether the bypass valve of the pressure retaining valve is fully opened.

⇒ After the above work, open the air vent valve until oil flows bubble free.



If the contaminations might be mixed to ECL system, it is recommended to keep circulating of lubricating oil for more than 8 hours in order to clean system.

⇒ After opening the shut off valve of each distributor, unscrew the empty screw until oil flows bubble free.



Unscrew the empty screw very slowly. Otherwise the flow limiter may work and shut off the lubricating oil. (Refer to Maintenance Manual 7218-1/A1)

⇒ After checking whether the set value of thermostat of oil cooler is specified value of 55 degrees C, close the bypass valve of the pressure retaining valve.

Check the pressure of the main pipe becomes 8MPa.

Keep circulating of lubricating oil for four hours in order to clean system under the below condition.

Main pipe pressure : 8.0 ± 0.1 MPa

Main pipe temperature : 45 – 60 degrees C



Adjusting of pressure retaining valve should be done when only one pump is running.
If two pumps are running, stop one pump. (Refer to section 5)

⇒ After the above work, execute the priming. (Refer to Operating Manual 0630-1/A1)

Regarding the cylinder oil piping diagram, refer to Operating Manual 8016-2/A1.

ECL System

Inspection and Adjusting of Supply Unit

2. Removal and Fitting of Middle Pressure Pump

Prior to removal or fitting of the middle pressure pump, close the inlet and outlet valves of the middle pressure pump.

Regarding more detail instructions of the middle pressure pump, refer to the instruction manual of the middle pressure pump manufacturer.



Do not change the setting of the safety valve at the outlet of middle pressure pump. The setting of safety valve should be executed and locked by the locking nut at the initial installation.



Except when inspecting the middle pressure pump, all the inlet and outlet valves of the middle pressure pump should be opened. The middle pressure pump should not be operated when all inlet and outlet valves of pumps are closed. If the outlet valve of the pump is closed, the safety valve at the outlet of the middle pressure pump is opened, and the lubricating oil is not supplied to the main pipe. If the inlet valve of the pump is closed, inlet pressure of the middle pressure pump becomes vacuum and the middle pressure pump must be damaged.



When removal or fitting of the middle pressure pump, turn off the main power of the middle pressure pump.

3. Cleaning of Filter Element of Low Pressure Filter

Three low pressure filters are arranged in a line. Two low pressure filters are normally operating and the other one is on stand by. Therefore, the inlet and outlet valves of the low pressure filter which is on stand by must be closed.

Plugging up of the filter element can be checked by the indicator which is located on the top of filter. When the indicator shows red, open the inlet and outlet valves of the low pressure filter on stand by. In this case, main engine can continue operation. And, clean the filter element at the next time of the main engine shutdown.

Removal of filter element

- ⇒ Close the inlet and outlet valves of respective low pressure filter.
- ⇒ Open air vent valve of the relevant filter.
- ⇒ Loosen the drain plug of the casing and drain off.
- ⇒ Open the cover of the filter.
- ⇒ Pull out the filter element.

Fitting of filter element

- ⇒ Insert the filter element into the casing.
- ⇒ Close the cover of the filter.
- ⇒ Tighten the drain plug of the casing.
- ⇒ Open the inlet valve of the low pressure filter and fill with the cylinder oil.
- ⇒ When oil flows bubble free for the air vent valve, close the air vent valve and inlet valve.

Regarding instructions of the cleaning of filter element, dismantling and assembling of the low pressure filter, refer to the instruction manual of the low pressure filter manufacturer.



Although the cleaning of filter element can be executed during the main engine operation in case of emergency, it is recommended to clean the filter element during the main engine shutdown.

ECL System

Inspection and Adjusting of Supply Unit

4. Exchange of Filter Element of Middle Pressure Filter

Two middle pressure filters are arranged in parallel. One middle pressure filter is normally operating and the other one is on stand by. Therefore, the inlet and outlet valves of the middle pressure filter which is on stand by must be closed.

Plugging up of the filter element can be checked by the indicator which is located on the top of filter. When the indicator shows red, open the inlet and outlet valves of the middle pressure filter on stand by. In this case, main engine can continue operation. And, exchange the filter element at the next time of the main engine shutdown.

Removal of filter element

- ⇒ Close the inlet and outlet valves of respective middle pressure filter.
- ⇒ Open air vent valve of the relevant filter.
- ⇒ Loosen the drain plug of the casing and drain off.
- ⇒ Open the cover of the filter.
- ⇒ Pull out the filter element.

Fitting of filter element

- ⇒ Insert new filter element into the casing.
- ⇒ Close the cover of the filter.
- ⇒ Tighten the drain plug of the casing.
- ⇒ Open the oil filling valve of the low pressure filter and fill with the cylinder oil.



At this time, confirm whether the upper steam (low pressure side) of the oil filling valve is supplied with cylinder oil.

- ⇒ When oil flows bubble free from the air vent valve, close the air vent valve and oil filling valve.

Regarding instructions of dismantling and assembling of the middle pressure filter, refer to the instruction manual of the middle pressure filter manufacturer.



Prior to opening of the oil filling valve, confirm that the middle pressure filter is ventilated. While the pressure in the middle pressure filter is high, if the oil filling valve is opened, the low pressure filter may be damaged.

Prior to opening of the inlet and outlet valve of the middle pressure pump, confirm that the oil filling valve and air vent valve of middle pressure pump are closed.

While the air vent valve is opened, if the inlet or outlet valve is opened, the high pressure oil is discharged from the air vent valve. It is very DANGEROUS.

While the oil filling valve is opened, if the inlet or outlet valve is opened, the low pressure filter may be damaged.



Although the cleaning of filter element can be executed during the main engine operation in case of emergency, it is recommended to clean the filter element during the main engine shutdown.

ECL System

Inspection and Adjusting of Supply Unit

5. Re-adjusting of Pressure Retaining Valve

In general, the setting of the pressure retaining valve should not be changed.

In case that the pressure of main pipes deviates from the specified pressure of 8.0 ± 0.1 MPa, the pressure retaining valve should be re-adjusted.



The setting of pressure retaining valve should be executed under the condition that only one middle pressure pump operates. Therefore, if two middle pressure pumps operate, the pressure of main pipe may exceed specified pressure.

Prior to re-adjusting of pressure retaining valve, loosen the locking nut.

- Turn screw clockwise for increase of pressure.
- Turn screw anti-clockwise for reduction of pressure.

After re-adjusting of the pressure retaining valve, be sure to lock the locking nut of the pressure retaining valve.

When the pressure of main pipe does not stabilize, even if the main engine load is static, the pressure retaining valve should be exchanged.



The exchange of the pressure retaining valve should be executed during the main engine shutdown.

Regarding more detail instructions of the pressure retaining valve, refer to the instruction manual of the pressure retaining valve manufacturer.

6. Exchange of Heater Element of Line Heater

Regarding more detail instructions of the line heater, refer to the instruction manual of the line heater manufacturer.



The exchange of the heater element should be executed during the main engine shutdown.



After exchange of the heater element, the air should be discharge from the air vent valve at the inlet of heater and outlet of low pressure filters.



When the middle pressure pump is inspected, turn off the main power of the line heater.

7. Exchange of Oil Cooler

Removal of oil cooler

⇒ Disconnect the wiring of the fan motor.



When the wiring of the fan motor is disconnected, turn off the main power of the fan motor.

⇒ Close the inlet and outlet valves of oil cooler.

⇒ Loosen air vent plug of the oil cooler.

⇒ Disconnect the inlet and outlet pipe of the oil cooler and drain off.

⇒ Remove the oil cooler from the stand of supply unit.

ECL System
Inspection and Adjusting of Supply Unit

Fitting of oil cooler

- ⇒ Put oil cooler on the stand of supply unit.
- ⇒ Connect the inlet and outlet pipe of the oil cooler.
- ⇒ Open the inlet and outlet valve of oil cooler slowly. When oil flows bubble free from the air vent plug, tighten the air vent plug.
- ⇒ Restore the connection of the wiring of the fan motor.



After exchange of oil cooler, evacuate air from radiator completely.



Although the exchange of oil cooler can be executed during the main engine operation in case of emergency, it is recommended to clean the filter element during the main engine shutdown because of over heating of cylinder oil.

Regarding more detail instructions of the pressure oil cooler, refer to the instruction manual of the oil cooler manufacturer.

Group 8

Servo Oil Piping:	8447-1/A1
Removing, Fitting and Regrinding of Sealing Faces	
Hydraulic Piping for Exhaust Valve Drive:	8460-1/A1
Removing, Fitting and Regrinding of Sealing Faces	
Fuel Pressure Piping:	8733-1/A1
Removing, Fitting and Regrinding of Sealing Faces	
Intermediate Fuel Accumulator:	8750-1/A1
Checking and Setting of Relief Valve	
Fuel Pressure Piping:	8752-1/A1
Removing, Fitting and Regrinding of Sealing Faces	

Servo Oil Piping

Removing, Fitting and Regrinding of Sealing Faces

Tools:

1 Regrinding device 94834a

Key to Illustrations:

1 Servo oil piping

2 Servo oil piping

3 Leakage oil piping

4 Shut-off valve

5 Shut-off valve

6, 6a, 6b Screw

7 Flange

8 Screw

9 Clamp piece

10 Shim

11 Protective shell

12 Claw

14, 14a, 14b Drain screw

15 Bush

16 Lapping body

17 Non-return valve

18 Screwed sleeve

19 Valve block

20 Intermediate piece

21 Shim

22 Shim

23 Connecting piece

24 Back-up ring

25 O-ring

26 O-ring

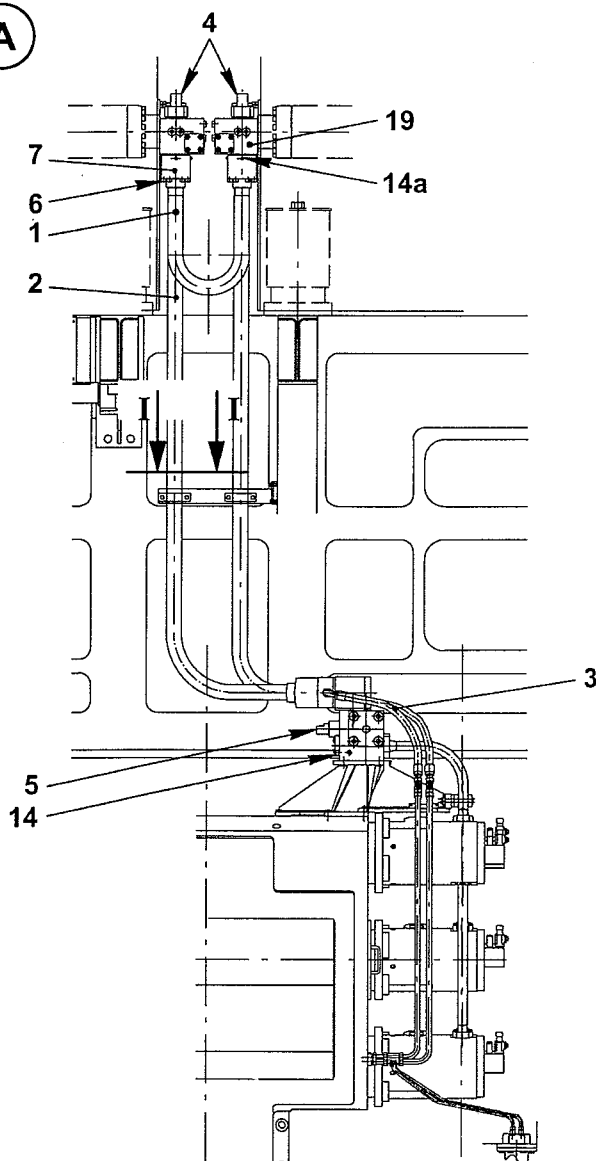
27 O-ring

28 O-ring

DF Sealing face

1. Removal

A



1.1 Preparatory works

- ⇒ Remove the casing where necessary.
- ⇒ Close shut-off valves (4) and (5) for the relevant servo oil piping.
- ⇒ Open drain screw (14)

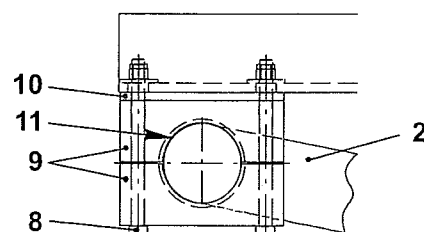


Remark The spindles of the closed shut-off valves must be tightened with **200 Nm**.

1.2 Removal of servo oil piping 1

- ⇒ Open drain screw (14a).
- ⇒ Loosen screws (6).
- ⇒ Push flanges (7) back till they are no more engaged, so that servo oil piping (1) can be removed.
- The ends of the servo oil piping must be protected from any damages.

I - I

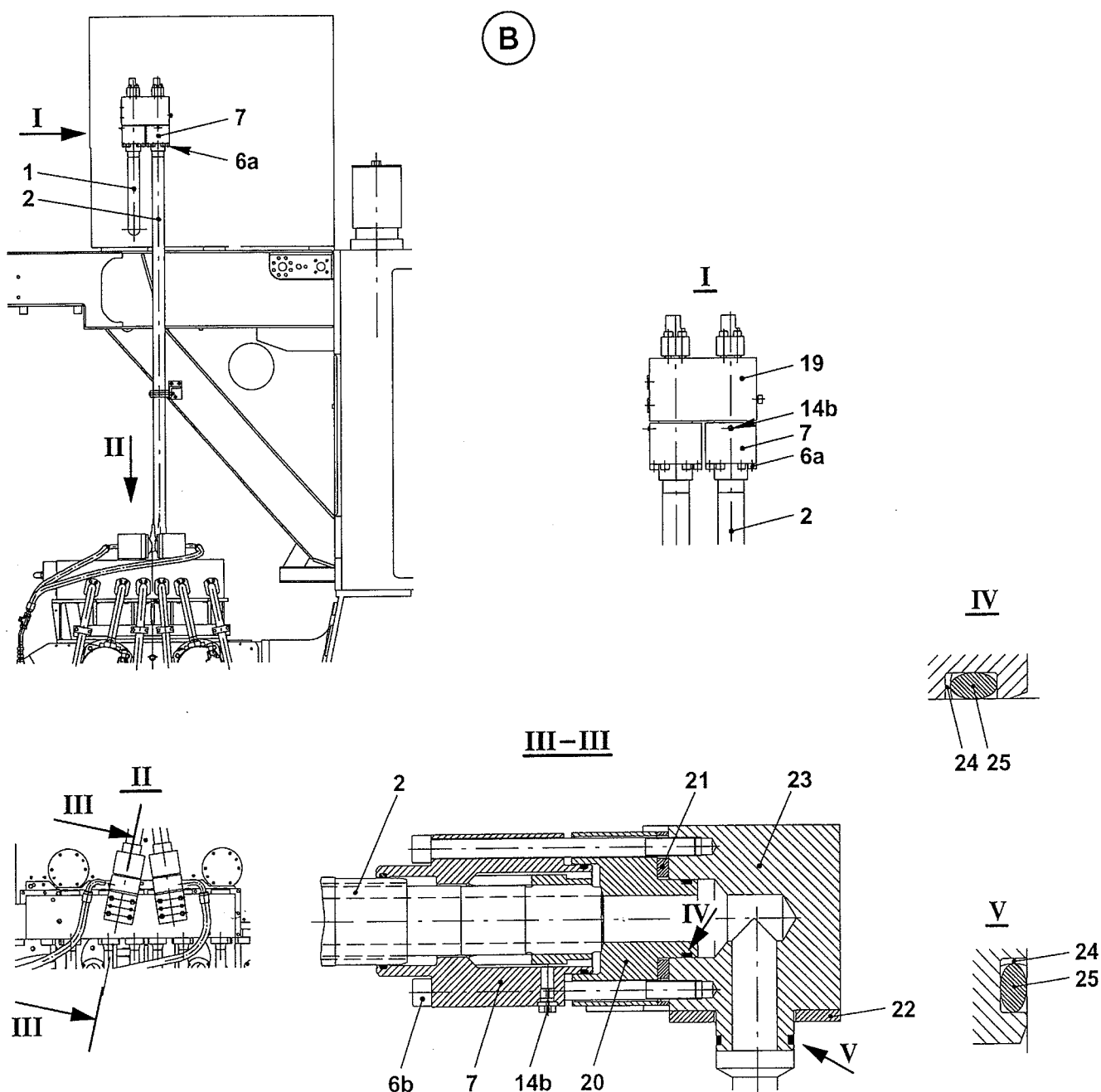


Servo Oil Piping

Removing, Fitting and Regrinding of Sealing Faces

1.3 Removal of servo oil piping 2

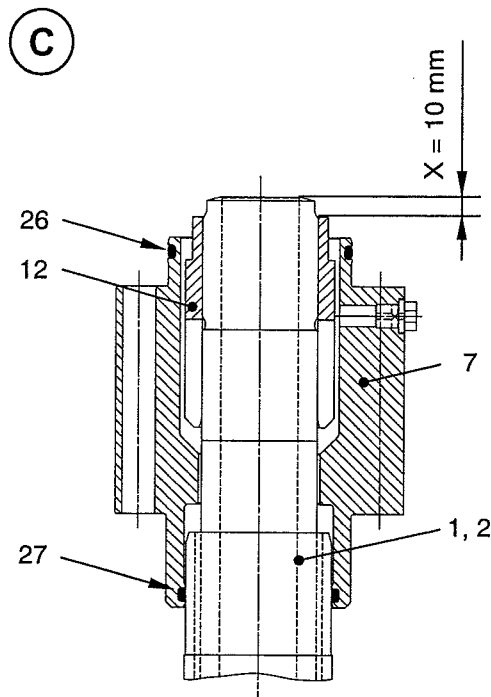
- ⇒ Open drain screws (14b)
- ⇒ Loosen screws (6a) and push flanges (7) back till they are no more engaged.
- ⇒ Mark shims (10) together with clamp pieces (9) (Fig. 'A').
- ⇒ Hold servo oil piping (65 kg) by means of a chain block.
- ⇒ Loosen and remove screws (8) (Fig. 'A').
- ⇒ Remove clamp pieces with protective shells (11) and shims (10) (Fig. 'A' view I-I).
- ⇒ Mark shims (21) and (22) together with connecting pieces (23).
- ⇒ Loosen screws (6b) and push flange (7) back.
- ⇒ Remove servo oil piping (2).



Servo Oil Piping

Removing, Fitting and Regrinding of Sealing Faces

2. Fitting



2.1 Checking the claw position

- ⇒ Before fitting the servo oil piping check whether its claws (12) are screwed on properly as shown in Fig. 'C', i.e. the servo oil piping must protrude by 'x' = 10 mm compared to the claw.
- Measure 'x' can be adjusted by turning the claw using an open-end wrench.

2.2 Fitting the servo oil pipings

Fitting is carried out analogously to the removal but in reverse sequence, whereby the following points require special attention:

- Fitting position of new back-up rings (24) (Fig. 'B' views IV and V).
- All shims must be fitted in the same place as before.
- Oil the threads of screws (6), (6a), (6b) and tighten them crosswise with a torque of **170 Nm**.
- When fitting clamp pieces (9) tighten their screws (8) **after** all servo oil pipings have been tightened!
- Close all drain screws.
- After refitting the servo oil pipings open shut-off valves (4) and (5), and tighten their spindles with **200 Nm**.

Servo Oil Piping

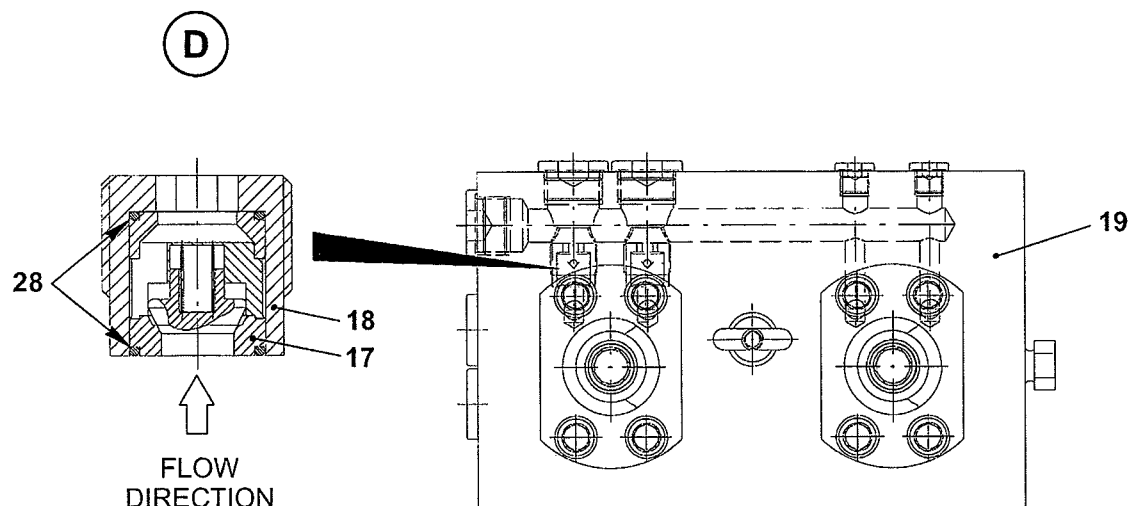
Removing, Fitting and Regrinding of Sealing Faces

3. Non-return valve

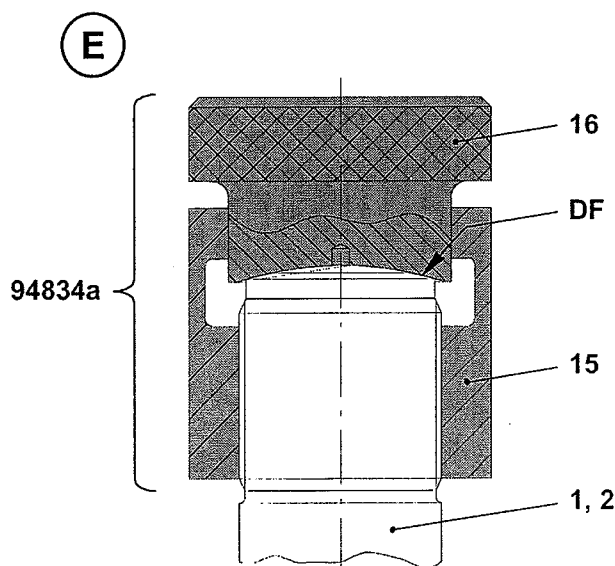
If a non-return valve (17) has been removed from valve block (19), O-rings (28) must be replaced by new ones.

The proper flow direction must be maintained when refitting the non-return valve.

⇒ Apply LOCTITE 0222 to the screwed sleeve 18 and tighten it with a torque of **80 Nm**.



4. Regrinding the sealing faces "DF"



Device (94834a) is to be used for regrinding the sealing faces "DF".

- ⇒ Unscrew corresponding claw (12) (Fig. 'C').
- ⇒ To prevent grinding compound from entering the servo oil piping, plug its openings with a piece of cloth.
- ⇒ Screw bush (15) onto the relevant thread end of the servo oil piping and regrind sealing face "DF" with lapping body (16) as shown in Fig. 'E'.
- ⇒ First rough-grind the sealing faces with grinding compound No. 200, then finish-grind them with grinding compound No. 500.
- ⇒ After grinding thoroughly clean the servo oil piping.

Hydraulic Piping for Exhaust Valve Drive

Removing, Fitting and Regrinding of Sealing Faces

Tools:

- 1 **Regrinding device 94834**

Key to Illustrations:

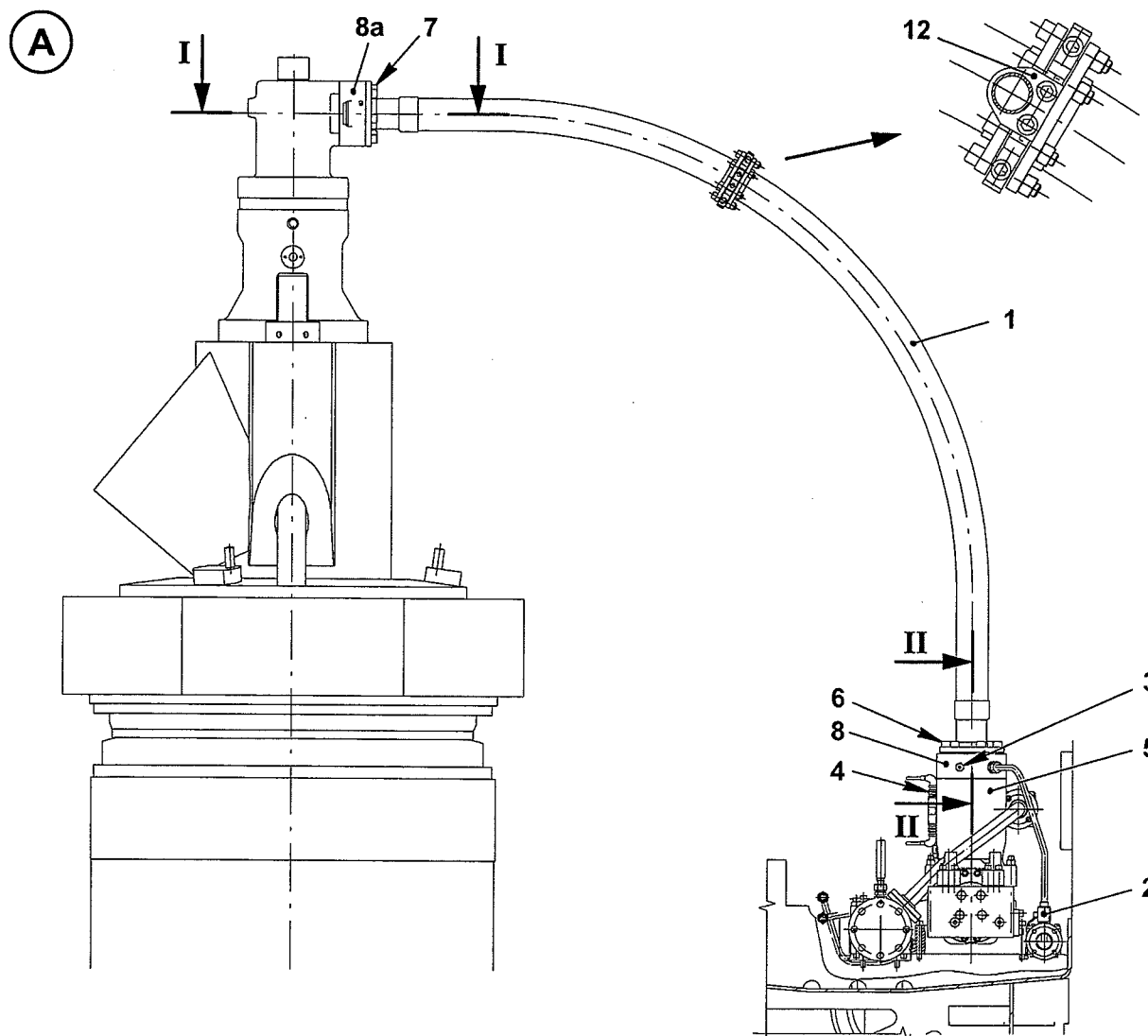
- | | | | |
|-------|------------------|----|---------------|
| 1 | Hydraulic piping | 10 | Metallic hose |
| 2 | Stop valve | 11 | Screw |
| 3 | Drain screw | 12 | Holder |
| 4 | Pilot valve | 13 | Bush |
| 5 | Partition device | 14 | Lapping body |
| 6 | Screw | 15 | O-ring |
| 7 | Screw | | |
| 8, 8a | Housing | | |
| 9 | Sealing ring | DF | Sealing face |

1. Removal

When working on a hydraulic piping 1 in principle the engine has to be stopped, and it is essential that instructions 0520-1 'Exchange of a defective hydraulic piping' in the Operating Manual be strictly followed.

CHECK

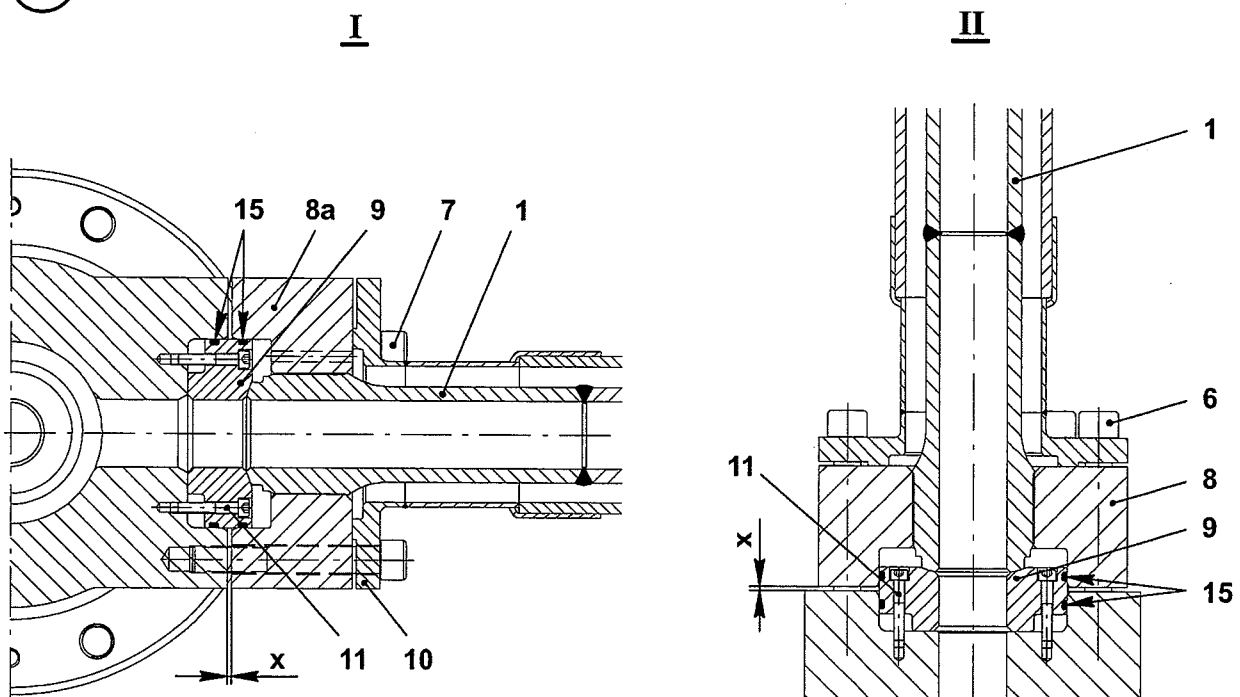
Before beginning dismantling works recheck whether stop valve (2) of the oil inlet pipe is closed and drain screw (3) is removed.



Hydraulic Piping for Exhaust Valve Drive
Removing, Fitting and Regrinding of Sealing Faces

- ⇒ Remove holder (12) (Fig. 'A').
- ⇒ Loosen screws (6) and undo screws (7).
- ⇒ Turn housing (8a) back by 2 ~ 3 turns, draw hydraulic piping (1) axially back and move it to the side.
- ⇒ Connect the hydraulic piping to the crane, undo screws (6) and remove the hydraulic piping.
- Pay attention not to damage sealing faces "DF" when removing the hydraulic piping.
- All openings must be closed off immediately after removing the connections.

B



2. Fitting

CHECK

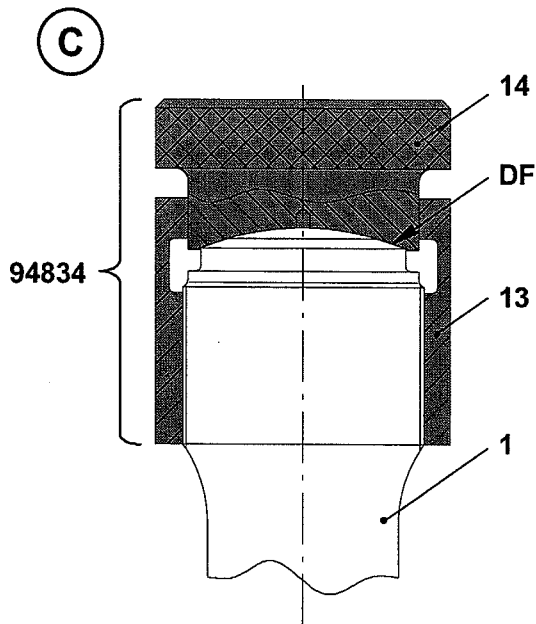
Check before assembly whether the inside of the hydraulic piping, sealing faces "DF" of the piping ends, as well as the seating surfaces of sealing rings (9) are clean and undamaged, and whether O-rings (15) are in good condition.

- Fitting together should be carried out axially, i.e. the objects to be connected must **not** be moved closer together **laterally**, in order to avoid any damaging of sealing faces "DF".
- Housing (8) or (8a) (Fig. 'B') should be screwed on hydraulic piping (1) in such a manner that after tightening screw (6) or (7) clearance 'x' is about 3 mm.
- After assembly open stop valve (2), fit and tighten drain screw (3).

Hydraulic Piping for Exhaust Valve Drive

Removing, Fitting and Regrinding of Sealing Faces

3. Regrinding the sealing faces "DF"



Regrinding device (94834) is to be used for regrinding.

- ⇒ Screw off housing (8), (8a) concerned (Fig. 'B').
- ⇒ To prevent grinding compound from entering the hydraulic piping, plug its openings with a piece of cloth.
- ⇒ Screw bush (13) onto the corresponding thread end of hydraulic piping (1) and grind sealing face "DF" with lapping body (14) as shown in Fig. 'C'.
- ⇒ First rough-grind the sealing face with grinding compound No. 200, then finish-grind it with grinding compound No. 500.
- ⇒ After grinding thoroughly clean the hydraulic piping.

Fuel Pressure Piping

Removing, Fitting and Regrinding of Sealing Faces

Tools:

- 1 Regrinding device 94872a
Torque wrench

Key to Illustrations:

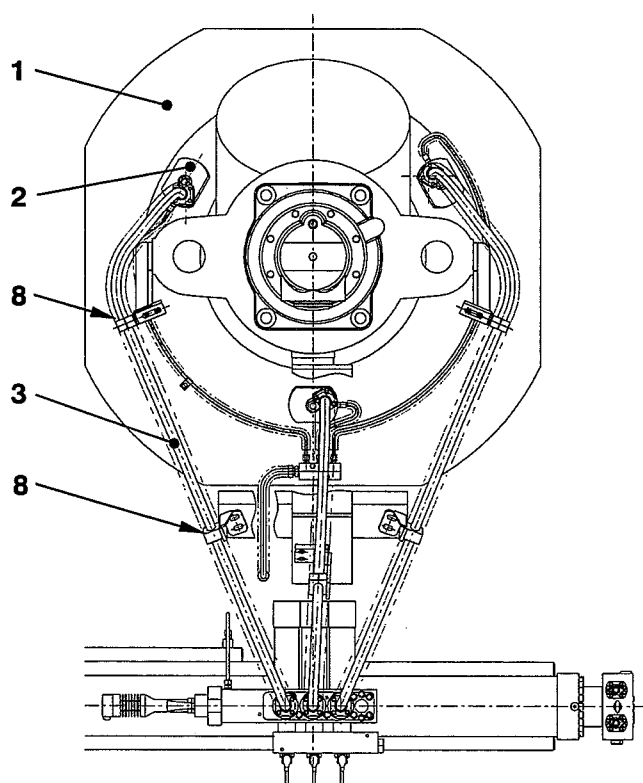
- | | |
|-----------------------------|------------------------|
| 1 Cylinder cover | 10 Connection piece |
| 2 Injection valve | 11 Drain screw |
| 3 Fuel pressure pipe | 12 O-ring |
| 4 Injection control unit | 13 O-ring |
| 5 Claw | 14 O-ring |
| 6 Head screw | |
| 7 Flange | |
| 8 Pipe bracket | BD Collar |
| 9 Thrust ring | DF Sealing face |

1. Removal

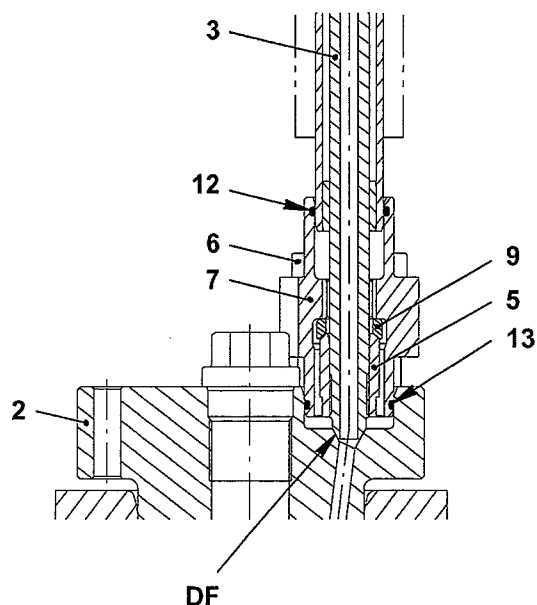
When working on a fuel pressure pipe (3) in principle the engine has to be stopped, and it is essential that instructions 0510-1 in the Operating Manual be strictly followed.

- ⇒ Remove all pipe brackets (8).
- ⇒ Remove head screws (6) from flange (7) on injection valve (2) and injection control unit (4) (Fig. 'A' and 'C').
- Pay attention not to damage sealing faces "DF" when removing fuel pressure pipes (3).
- All connections must be closed off immediately and sealing faces "DF" must be protected after removing fuel pressure pipes.

A



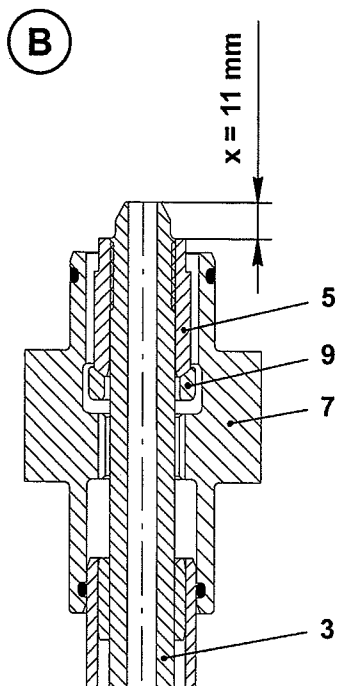
I - I



Fuel Pressure Piping

Removing, Fitting and Regrinding of Sealing Faces

2. Fitting



Fitting procedure is analogous to the removal but in reverse sequence.

CHECK

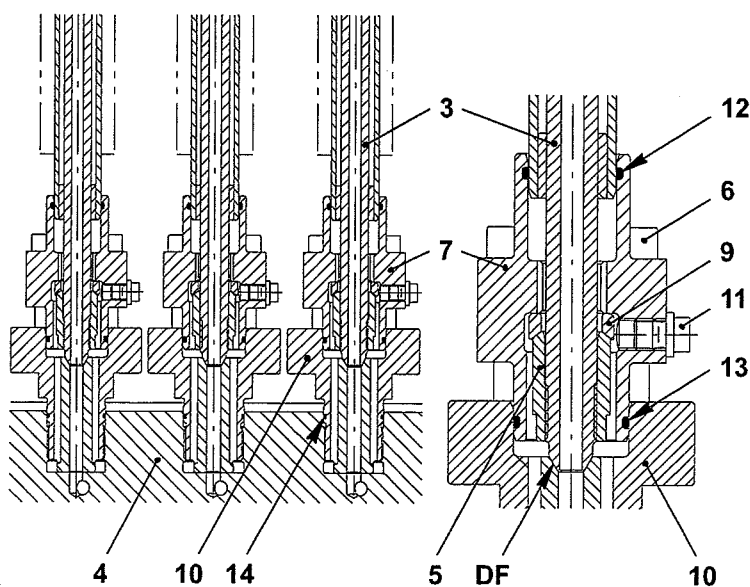
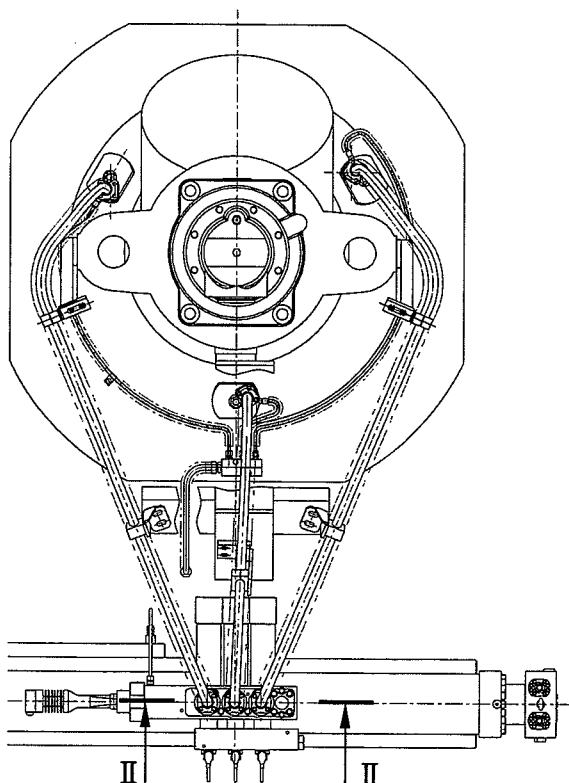
Before fitting fuel pressure pipe (3) check whether its claws (5) are screwed on properly, i.e. the fuel pressure pipe must protrude by 'x' = 11 mm compared to the claw as shown in Fig. 'B'.

Measurement 'x' can be adjusted by turning the claw using an open end spanner.

- ⇒ Fit fuel pressure pipe.
- ⇒ Apply Never-Seez NSBT-8 to threads of screws (6) and tighten them crosswise with a torque of **40 Nm**.



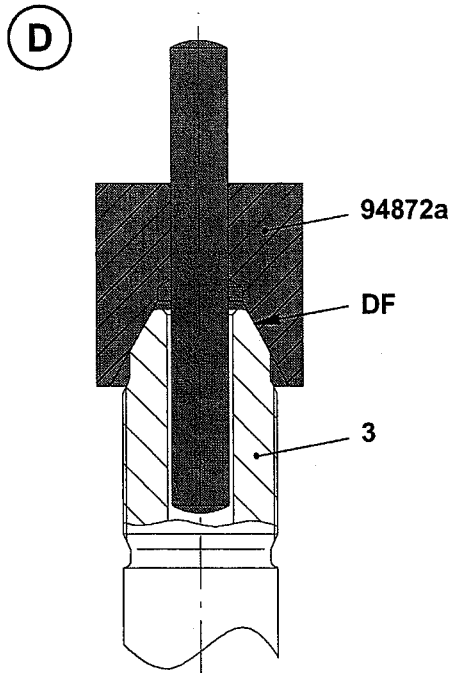
II - II



Fuel Pressure Piping

Removing, Fitting and Regrinding of Sealing Faces

3. Regrinding of sealing faces "DF"



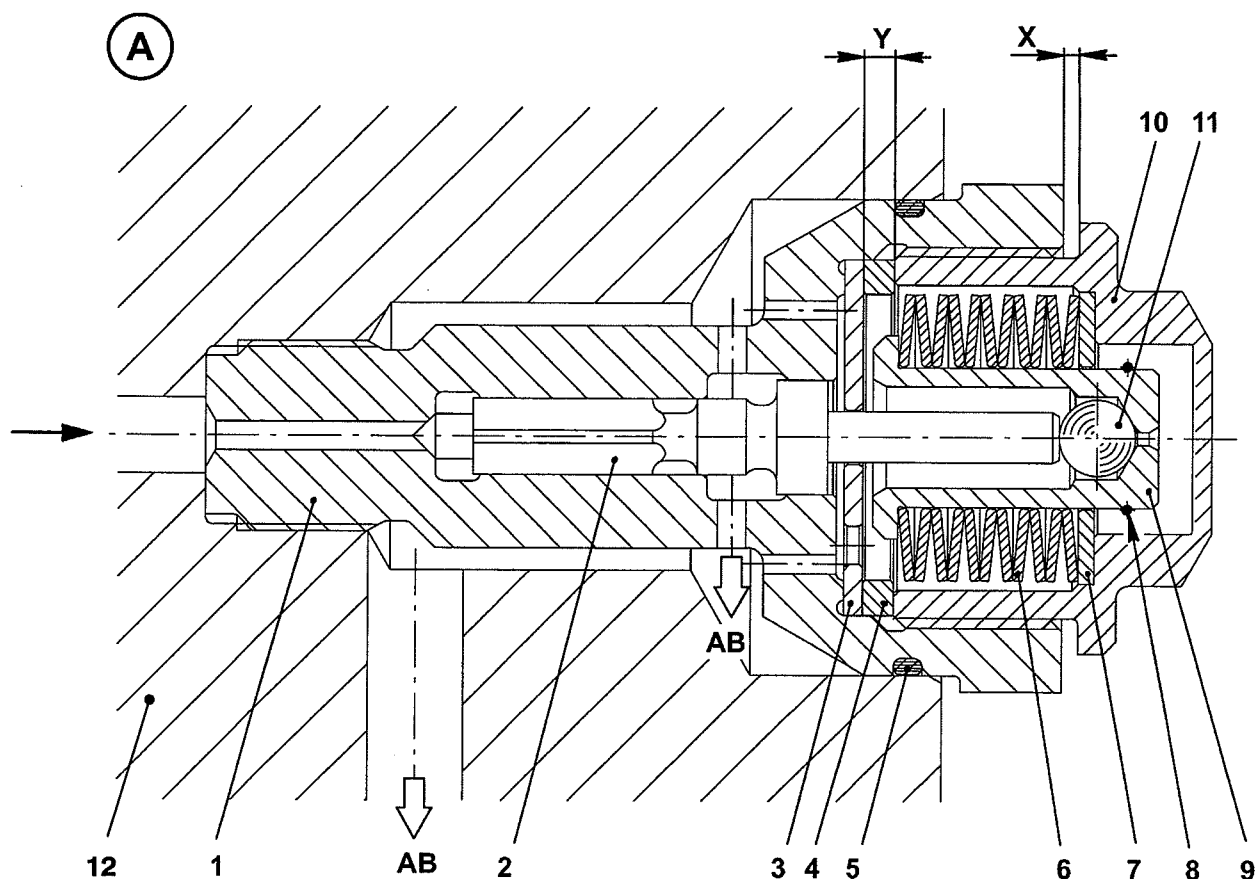
- ⇒ Remove claw (5) (Fig. 'B').
- ⇒ Place regrinding device (94872a) on sealing face "DF" as shown in Fig. 'D'.
- ⇒ First rough-grind the sealing faces with grinding compound No. 200, then finish-grind them with grinding compound No. 500.
- ⇒ After grinding thoroughly clean the fuel pressure piping.

Intermediate Fuel Accumulator
Checking and Setting of the Relief Valve
Tools:

- | | | |
|---|-------------|-------|
| 1 | Test bench | 94272 |
| 1 | Slide gauge | |

Key to Illustrations:

- | | | | |
|---|-------------------------|----|----------------|
| 1 | Valve housing | 9 | Spring carrier |
| 2 | Valve needle | 10 | Screw plug |
| 3 | Stop ring | 11 | Ball |
| 4 | Distance ring | 12 | flange |
| 5 | O-ring | | |
| 6 | Disc spring (11 pieces) | | |
| 7 | Seating washer | | |
| 8 | Snap ring | AB | Drain bore |


1. General
CHECK

Before dismantling a relief valve for overhaul (grinding in of the valve needle), distance 'X' must be measured and recorded as 'X'. For this purpose, distance ring (4) must be pressed against stop ring (3) by screw plug (10).

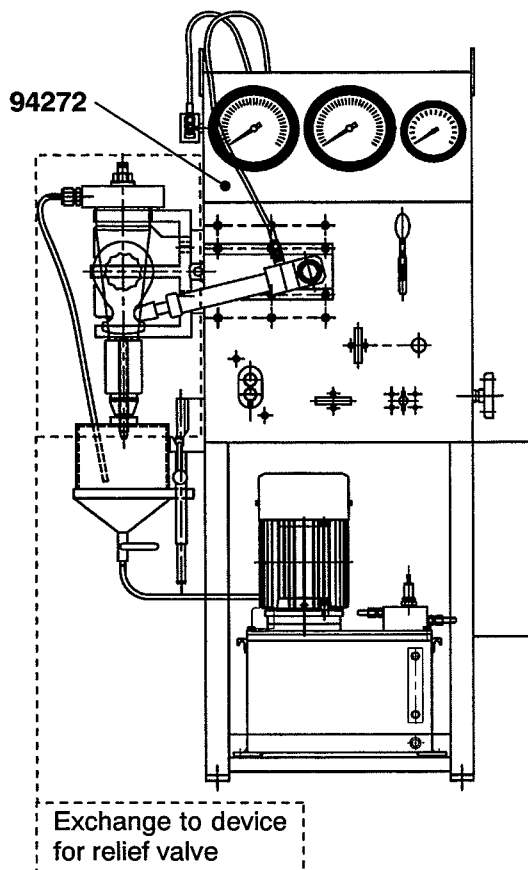
- ⇒ After grinding valve needle (2) into the seat of valve housing (1), thoroughly clean all parts, lightly oil valve needle (2) and spray parts (6), (7), (9) and (11) with MOLYBDENUM DISULPHIDE (MoS₂).
- During assembly, care must be taken that disc springs (6) are correctly positioned (see Fig. 'A').
- ⇒ Not yet fit distance ring (4).
- ⇒ Tighten screw plug (10) until distance 'X' is about the same as before dismantling.
- ⇒ For testing and setting the relief valve, use test bench (94272) (Fig. 'B').

Intermediate Fuel Accumulator

Checking and Setting of the Relief Valve

2. Setting the opening pressure

B



⇒ Place the relief valve into adapter of device for relief valve and tighten it.

● **Pay attention to the manufacturer's detailed instructions**, in particular prior to commissioning and for the operations of the test bench.

⇒ Increase the pressure on the test bench and at the same time observe the pressure gauge to see at what pressure the relief valve opens. Correct opening pressure = **125 MPa**.

CHECK

Set the required pressure by moving the closing plug (10). Measure distance 'X' and note it as 'X1' (Fig. 'A').

⇒ Reduce height 'Y' of the distance ring by the difference between distances 'X1' and 'X'.

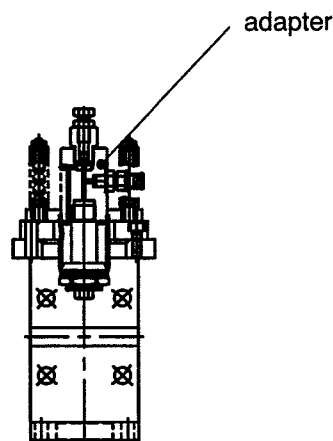
⇒ Reassemble the relief valve with distance ring (4) and tighten screw plug (10) until it is fully down on distance ring (4).

CHECK

Recheck the opening pressure on the fully assembled relief valve.

Before screwing the relief valve into flange (12), check that the sealing faces are clean since the sealing of these faces is metallic.

Check drain bore "AB" for free passage in the valve housing (1) and in the flange of the intermediate fuel accumulator.



Device for relief valve

Fuel Pressure Piping

Removing, Fitting and Regrinding of Sealing Faces

Tools:

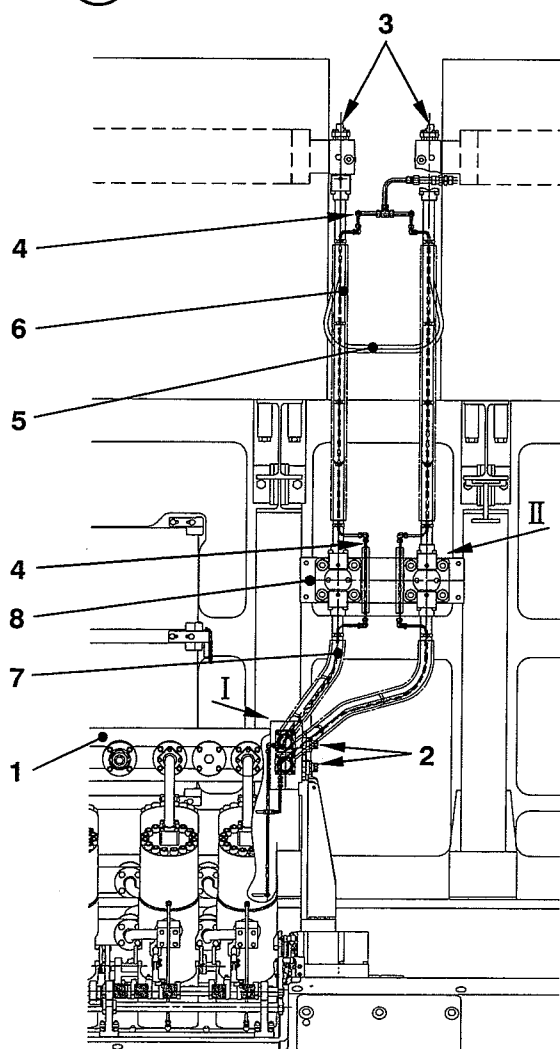
- | | | |
|---|-------------------|-------|
| 1 | Regrinding device | 94872 |
| 1 | Turnbuckle | 94873 |

Key to Illustrations:

- | | | | |
|-----------|-------------------------------|----|------------------|
| 1 | Intermediate fuel accumulator | 13 | Claw |
| 2 | Stop valve | 14 | Thrust ring |
| 3 | Stop valve | 15 | Drain screw |
| 4 | Heating pipe | 16 | Valve block |
| 5 | Fuel pressure piping | 17 | Screwed sleeve |
| 6 | Fuel pressure piping | 18 | Non-return valve |
| 7 | Fuel pressure piping | 19 | O-ring |
| 8 | Pipe bracke | 20 | O-ring |
| 9, 9a, 9b | Screw | 21 | O-ring |
| 10, 10a | Flange | | |
| 11 | Screw | | |
| 12 | Intermediate piece | DF | Sealing face |

1. Removal

A



1.1 Preparation to removal

- ⇒ Close steam supply to heating pipes (4) on plant side.
- ⇒ Remove casings where necessary.
- ⇒ Close respective stop valves (2) and (3).

Remark : The spindles of closed stop valves (2) and (3) must be tightened with **100 Nm**.

- ⇒ Open corresponding drain screws (15) (Fig. 'B' view III).

Fuel Pressure Piping

Removing, Fitting and Regrinding of Sealing Faces

1.2 Removal of fuel pressure pipings 6 and 7

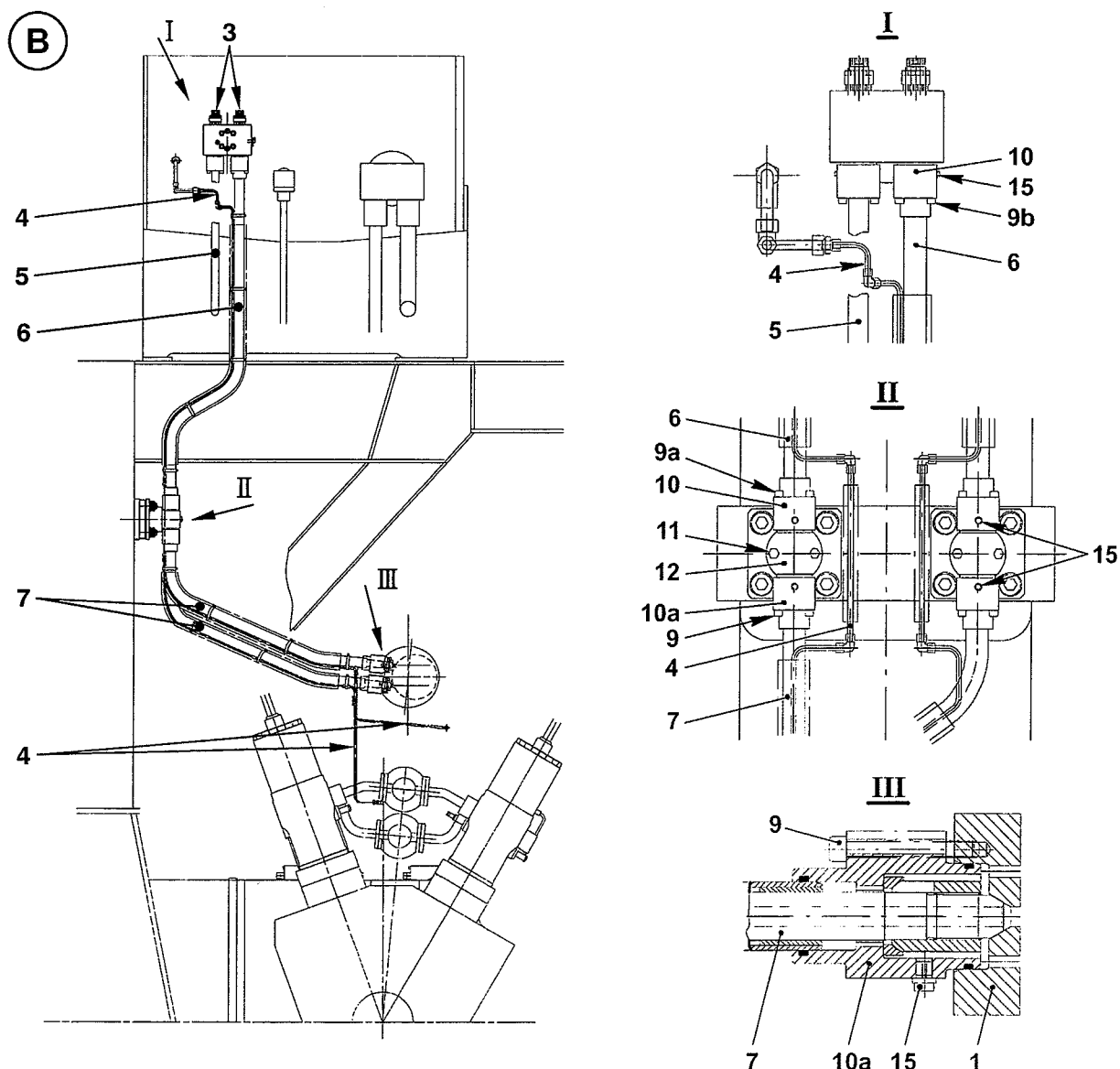
- If a fuel pressure piping (6) must be removed, first dismantle the corresponding fuel pressure piping (7).
- The sealing faces "DF" at the pipe ends must be protected from any possible damages.

1.2.1 Removal of fuel pressure piping 7

- ⇒ Loosen corresponding heating pipe (4).
- ⇒ Undo screws (9) and push flanges (10a) back till they do not mesh any more.
- ⇒ Pull fuel pressure piping (7) away and remove it from intermediate fuel accumulator (1).

1.2.2 Removal of fuel pressure piping 6

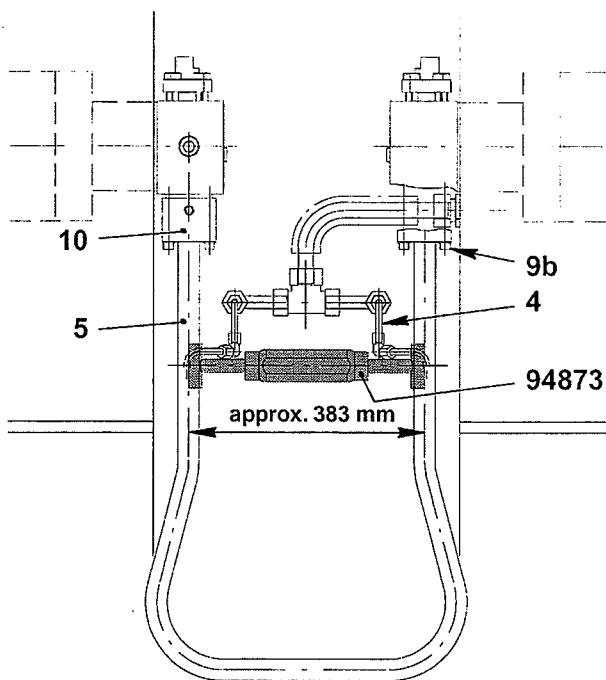
- ⇒ Undo screws (9a) and push flange (10) back.
- ⇒ Undo screws (11) and remove them together with intermediate piece (12).
- ⇒ Undo screws (9b) and remove fuel pressure piping (6).



Fuel Pressure Piping

Removing, Fitting and Regrinding of Sealing Faces

C



1.3 Removal of fuel pressure piping 5

⇒ Place turnbuckle (94873) between fuel pressure piping (5) as shown in Fig. 'C'.

 **Remark** : Tension turnbuckle (94873), so that it does not fall down.

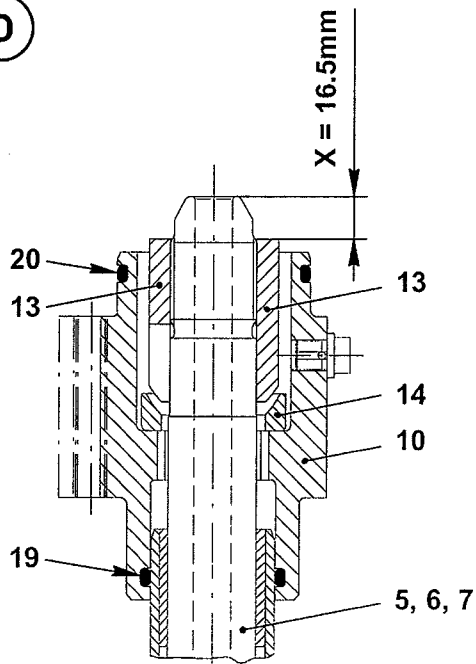
⇒ Undo screws (9b) and push flange (10) back till it does not mesh any more.

⇒ Remove fuel pressure piping (5).

● The sealing faces "DF" at the pipe ends must be protected from any possible damages.

2. Fitting

D



Fitting procedure is analogous to the removal but in reverse sequence.

CHECK

Before fitting fuel pressure pipings (5), (6) or (7), check whether their claws (13) are screwed on properly, i.e. fuel pressure pipe must protrude by 'x' = 16.5 mm compared to the claw, as shown in Fig. 'D'.

Measurement 'x' can be adjusted by turning the claw using an open end spanner.

 **Remark** : For fitting fuel pressure piping (5) must be expanded to approx. 383 mm with turnbuckle (94873) as shown in Fig. 'C'.

⇒ Apply Never-Seez NSBT-8 to threads of screws (9), (9a), (9b) and tighten them crosswise with a torque of **60 Nm**.

⇒ After refitting the fuel pressure piping open stop valves (2) and (3) and tighten their spindles with **100 Nm**.

Fuel Pressure Piping

Removing, Fitting and Regrinding of Sealing Faces

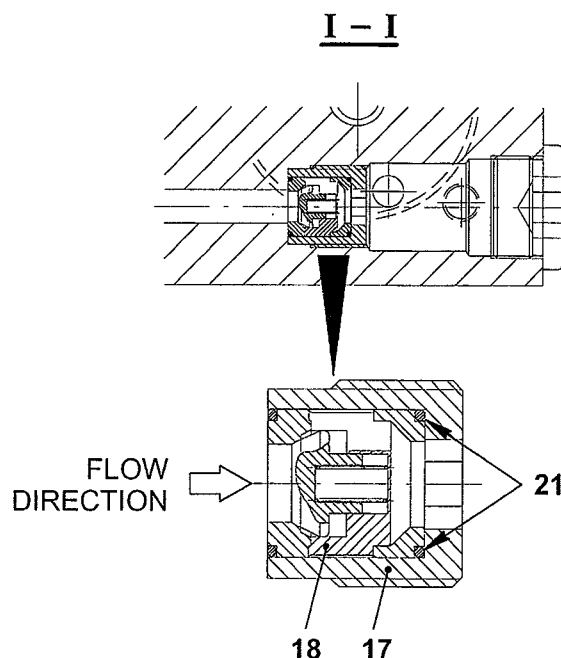
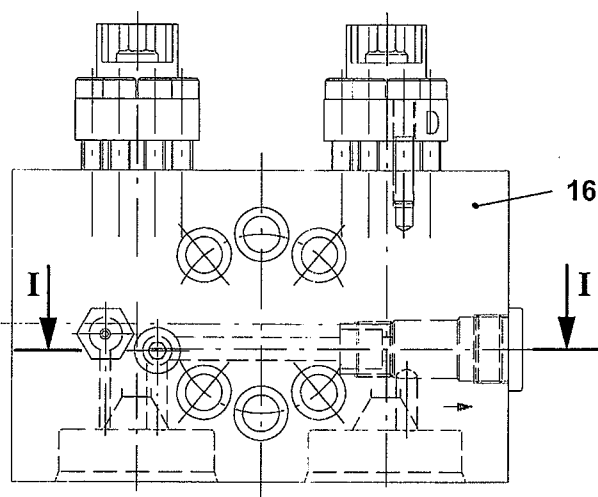
3. Non-return valve

If a non-return valve (18) has been removed from valve block (16), O-rings (21) must be replaced by new ones.

The proper flow direction (see arrow engraved in valve block) must be maintained when refitting the non-return valve (Fig. 'E').

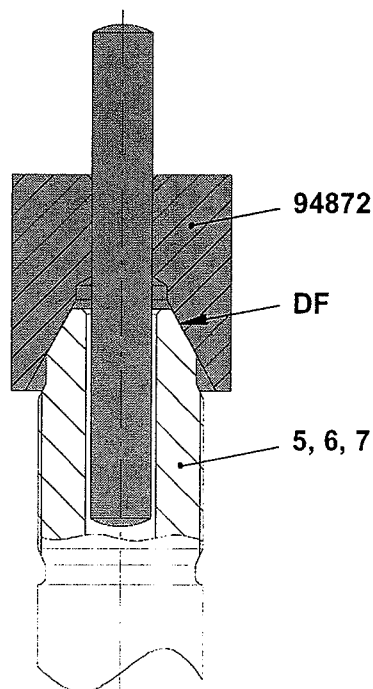
⇒ Apply LOCTITE 0222 to the screwed sleeve (17) and tighten it with a torque of 80 Nm.

E



4. Regrinding of sealing faces "DF"

F



- ⇒ Remove claw (13) (Fig. 'D').
- ⇒ Place regrinding device (94872) on sealing face "DF" as shown in Fig. 'F'.
- ⇒ First rough-grind the sealing faces with grinding compound No. 200, then finish-grind them with grinding compound No. 500.
- ⇒ After grinding thoroughly clean the fuel pressure piping.

Group 9

Crank Angle Sensor Unit:	9223-1/A1
Dismantling, Assenbling and Adjusting	
Hydraulic Jacks and Pumps: Arrangement and Application	9403-2/A1

▽ **Hydraulic Pre-tensioning Jacks**

— Storing, Servicing and Maintenance	9403-3/A1
— General Application Instructions	9403-4/A1

Crank Angle Sensor Unit
Dismantling, Assembling and Adjusting
Tools:

1	Feeler gauge	94122
1	Spring balance	94923
1	Hook spanner	94924
1	Hook spanner	94925

Key to Illustrations:

1	Protection hood	36	Circlip
2	Covering cap	37	Disc
3	Screw	38	Key
4	Nut	39	Packing ring
5	Shaft	40	Locating pin
6	Crank angle sensor	41	Inspection cover
7	Holder	42	Compression spring
8	Screw	43	Lever
9	Toothed belt	44	Screw with locking plate
10	Protection plate	45	Throttle
11	Screw with locking plate	46	Housing
12	Angle holder	47	Screw
13	outer shaft encoder	48	Screw
13a	inner shaft encoder	48a	Locking plate
14	Bearing housing	49	Connecting unit
15, 15a	Screw	50	Locating pin
16	Washer	51	Coupling disc
17	Locking plate	52	Spring tensioner
18	Gear wheel	53	Screw with locking plate
19	Gear wheel	54	Adjusting screw
20	Waisted screw	55	Clamp screw w. tab washer
21	Screw with locking plate	56	Distance piece
22	Packing ring	57	Screw with locking plate
23	Adjusting disc	58	Locating pin
24	Locking plate	59	O-ring
25	Shaft nut		
26	Locking plate		
27	Shaft nut	GL	Tap hole
28	Circlip	KD	Cable clamp
29	Retaining ring	KK	Terminal box
30	Sealing ring	MK	Mark
31	Distance ring	OE	Oil inlet
32, 32a	Ball bearing	SU	Collar
33	Distance ring	SH	Protective sleeve
34	Distance sleeve	SK	Sensor cable
35	Disc spring	SR	Protective pipe

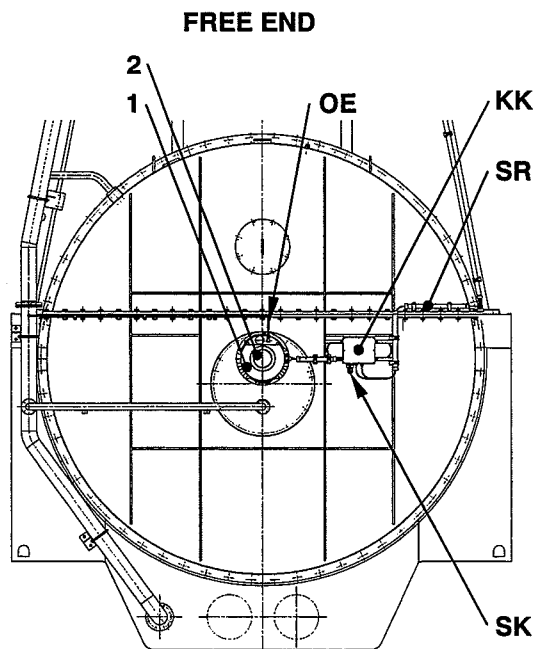
Overview

1.	Removal of shaft encoder	2/18
2.	Shaft encoder	3/18
3.	Fitting the shaft encoder	4/18
4.	Removal of crank angle sensor drive	7/18
5.	Dismantling the crank angle sensor drive	8/18
6.	Assembling the crank angle sensor drive	10/18
7.	Fitting the crank angle sensor drive	13/18
8.	Removal and fitting of compression spring	14/18
9.	Checks	17/18

Crank Angle Sensor Unit
Dismantling, Assembling and Adjusting

1. Removal of shaft encoder

A



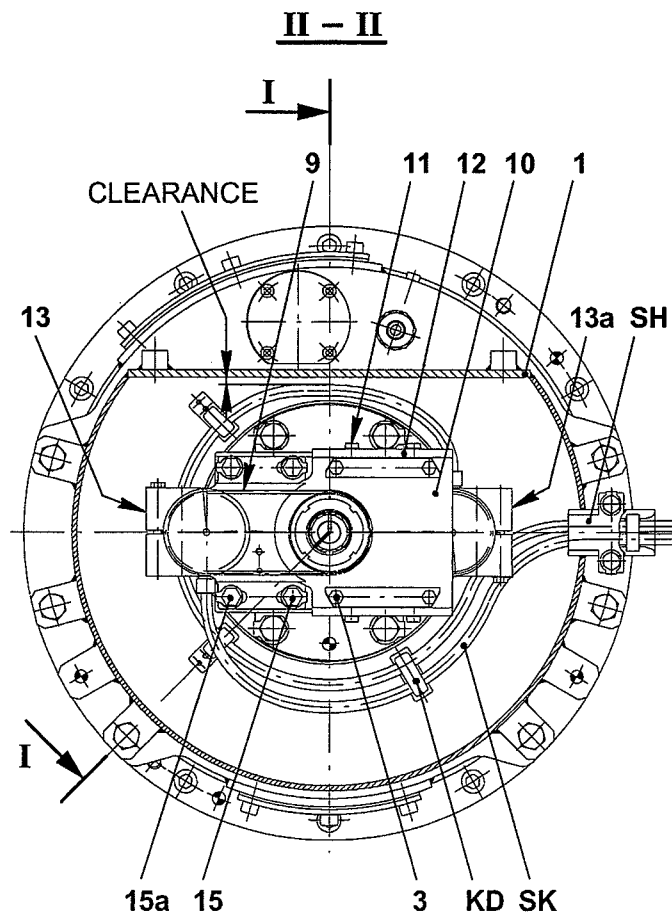
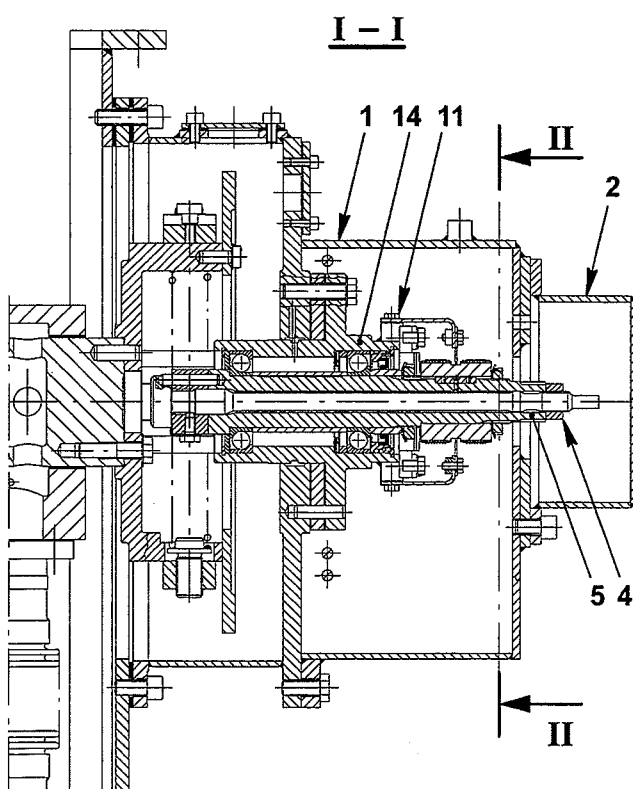
1.1 Preparation

- ⇒ Pull out plug of sensor cable "SK" at terminal box "KK" (Fig. 'A').
- ⇒ Unscrew protection hood (1) and remove it together with covering cap (2).
- ⇒ Unscrew cable clamps "KD" as well as protective sleeve "SH" and withdraw sensor cable from protective pipes "SR".

1.2 Outer shaft encoder

- ⇒ Loosen screws (3) and remove them together with protection plates (10).
- ⇒ Loosen screws (11) and remove them together with angle holder (12).
- ⇒ Loosen screws (15), (15a) and remove outer shaft encoder (13) together with toothed belt (9).

B



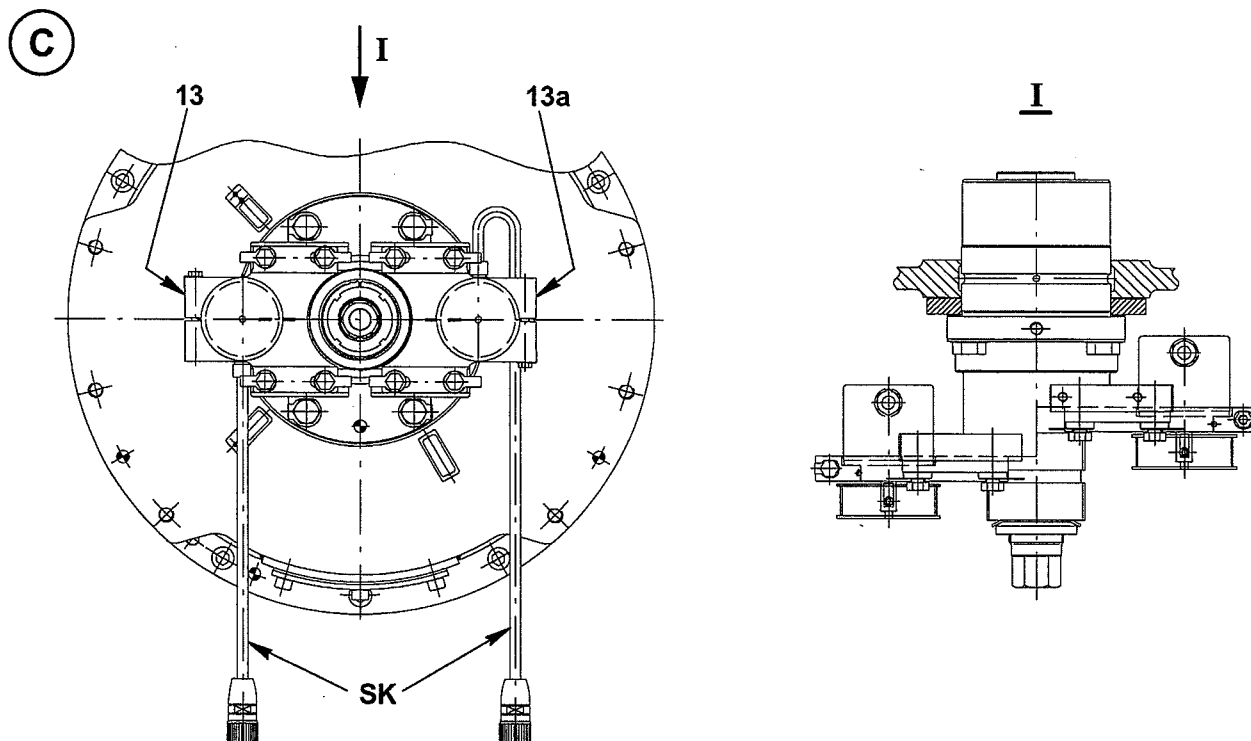
Crank Angle Sensor Unit

Dismantling, Assembling and Adjusting

1.3 Inner shaft encoder

Removing the inner shaft encoder (13a) is only possible after the toothed belt of the outer shaft encoder (13) has been removed according to paragraph 1.2.

Removal of the inner shaft encoder (13a) is carried out analogously to the outer one.

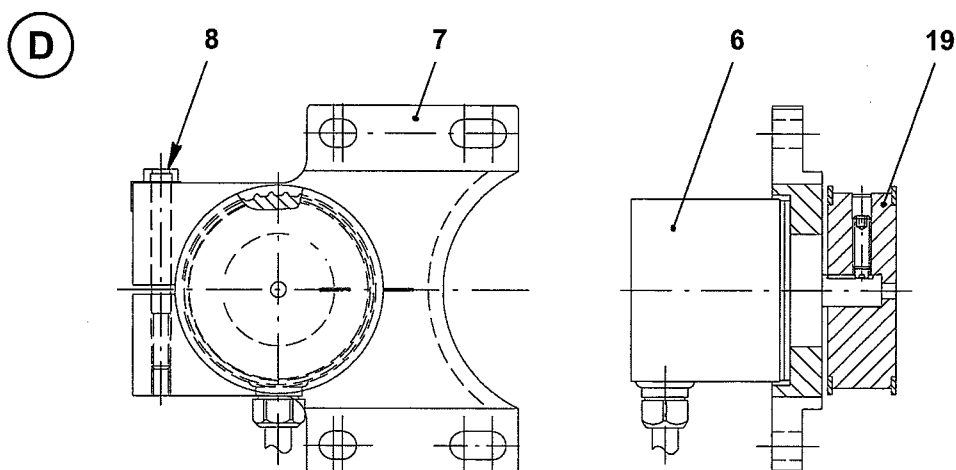


2. Shaft encoder

- Shaft encoders are only supplied complete (Fig. D'). The crank angle sensor (6) is fastened to the holder (7) and set by the manufacturer.



Never loosen screw (8)!



Crank Angle Sensor Unit
Dismantling, Assembling and Adjusting

3. Fitting the shaft encoder

3.1 Inner shaft encoder

- ⇒ Turn crankshaft to T.D.C. of Cyl. 1.
- ⇒ Mount shaft encoder (13a) (Fig. 'D' and 'E') on the guide plate of bearing housing (14) with screws (15), washers (16) and locking plates (17). Do not tighten screws (15). Apply MOLYKOTE paste G to the threads and head seatings.

CHECK

Slide shaft encoder along the guide plate to check that the shaft encoder is moving freely.

- ⇒ Push shaft encoder inwards.

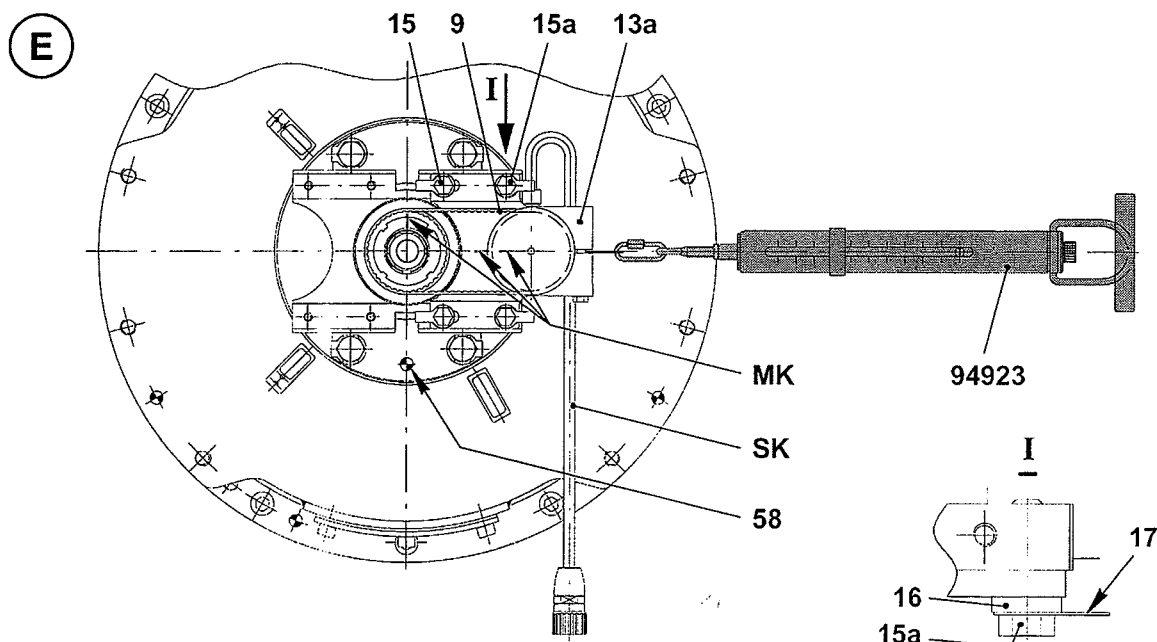
3.2 Fitting the toothed belt

- ⇒ Connect gear wheels (19) and (18) with toothed belt (9), paying attention to their marks "MK" which must coincide according to Fig. 'F' (zero position).
- ⇒ Push shaft encoder outwards till the toothed belt is lightly tensioned and meshing properly with the gear wheels. Lightly tighten screws (15). Recheck marks "MK".
- ⇒ Fit screws (15a), washers (16) and locking plates (17). Apply MOLYKOTE paste G to the threads and head seatings.
- ⇒ Align toothed belt exactly in running direction.
- ⇒ Attach spring balance (94923) to the shaft encoder and slightly preload it according to Fig. 'E'.
- ⇒ Loosen all screws (15) and (15a), paying attention that the shaft encoder can still move freely.
- ⇒ Tension toothed belt with **4.1 ~ 4.6 kg (40~45N)** indicated on spring balance, and fixate shaft encoder with screws (15) and (15a).



Remark

: Pull the spring balance exactly in tensioning direction, keeping the friction between the holder guide and screw surfaces as small as possible.



Crank Angle Sensor Unit

Dismantling, Assembling and Adjusting

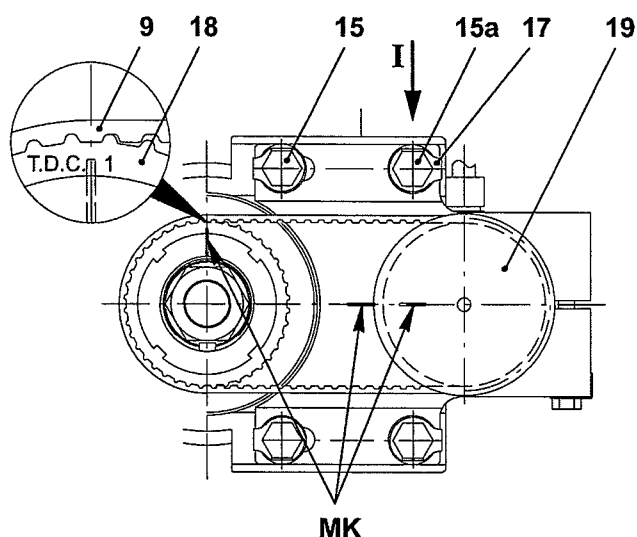
- ⇒ In order to align toothed belt (9) on its running track, turn the crankshaft one to two revolutions with the turning gear.
- ⇒ Recheck belt tension according to Fig. 'F' and 'G' as well as marks "MK". Repeat tensioning procedure if belt slackened after crankshaft has been turned or if marks "MK" are not matching.
- ⇒ Adjust and bend the long lugs of locking plates (17) according to Fig. 'F'.
- ⇒ Tighten all screws (15) and (15a) with a torque of **16 Nm** and lock them.



Always use new locking plates, bending them **once** only!

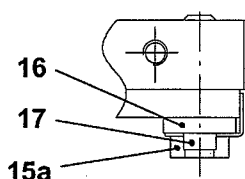
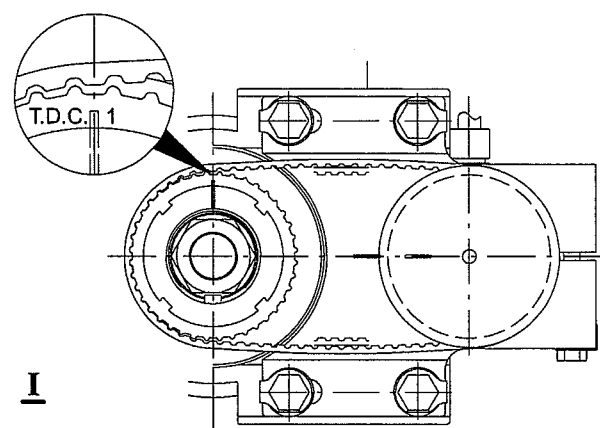
F

TOOTHED BELT TENSIONED

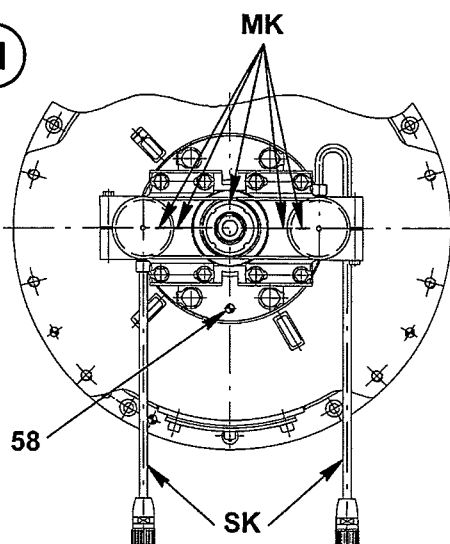


G

TOOTHED BELT LOOSE



H



3.3 Outer shaft encoder

Fitting the outer shaft encoder (13) is carried out analogously to the inner one.



When fitting shaft encoders, toothed belts or crank angle sensor drive (section 7) always pay attention to the following points:

- Crankshaft at T.D.C. of Cyl. 1.
- Bore for locating pin (58) of the crank angle sensor drive pointing downwards as shown in Fig. 'H'.
- Mark "MK" (T.D.C. 1) of gear wheel (18) pointing upwards as shown in Fig. 'F' and all other marks aligned according to Fig. 'H'.

Crank Angle Sensor Unit

Dismantling, Assembling and Adjusting

3.4 Final works

- ⇒ Fit angle holder (12) using screws (11) with their locking plates. Subsequently install protection plates (10) in such a way that they contact each other at the centre without overlapping and touching any moveable parts, using screws (3) with their locking plates.
- ⇒ Tighten and lock screws (3) and (11).
- ⇒ After assembling fit carefully the sensor cables "SK". Pay attention to the clearance which must exist between sensor cables and housing (Fig. 'B', section II).
Fit protection hood (1) together with covering cap (2).

3.5 Toothed belt change

If there should be changed only one toothed belt, proceed as follows:

- ⇒ Remove protection plate (10) and angle holder (12) (Fig. 'B').
- ⇒ Remove screws (15a) with locking plates and washers.
- ⇒ Remove screws (15), replace locking plates and loosely refit the screws.
- ⇒ Push shaft encoder inwards and replace toothed belt.
- For fitting pay attention to paragraphs 3.1 to 3.4.

3.6 Rechecking of toothed belt tension

In accordance with Maintenance Schedule 0380-1 'Crank angle sensor unit' the toothed belt tension must be visually rechecked as shown in Fig. 'F' and 'G', and by lightly tapping on the toothed belt with a finger.

If necessary or in case of doubt the toothed belt must be retensioned as described in paragraph 3.2!



CAUTION

After every loosening of a shaft encoder the toothed belt tension must be rechecked after about five operating hours!

Crank Angle Sensor Unit

Dismantling, Assembling and Adjusting

4. Removal of crank angle sensor drive

⇒ Preparation according to paragraph 1.1.

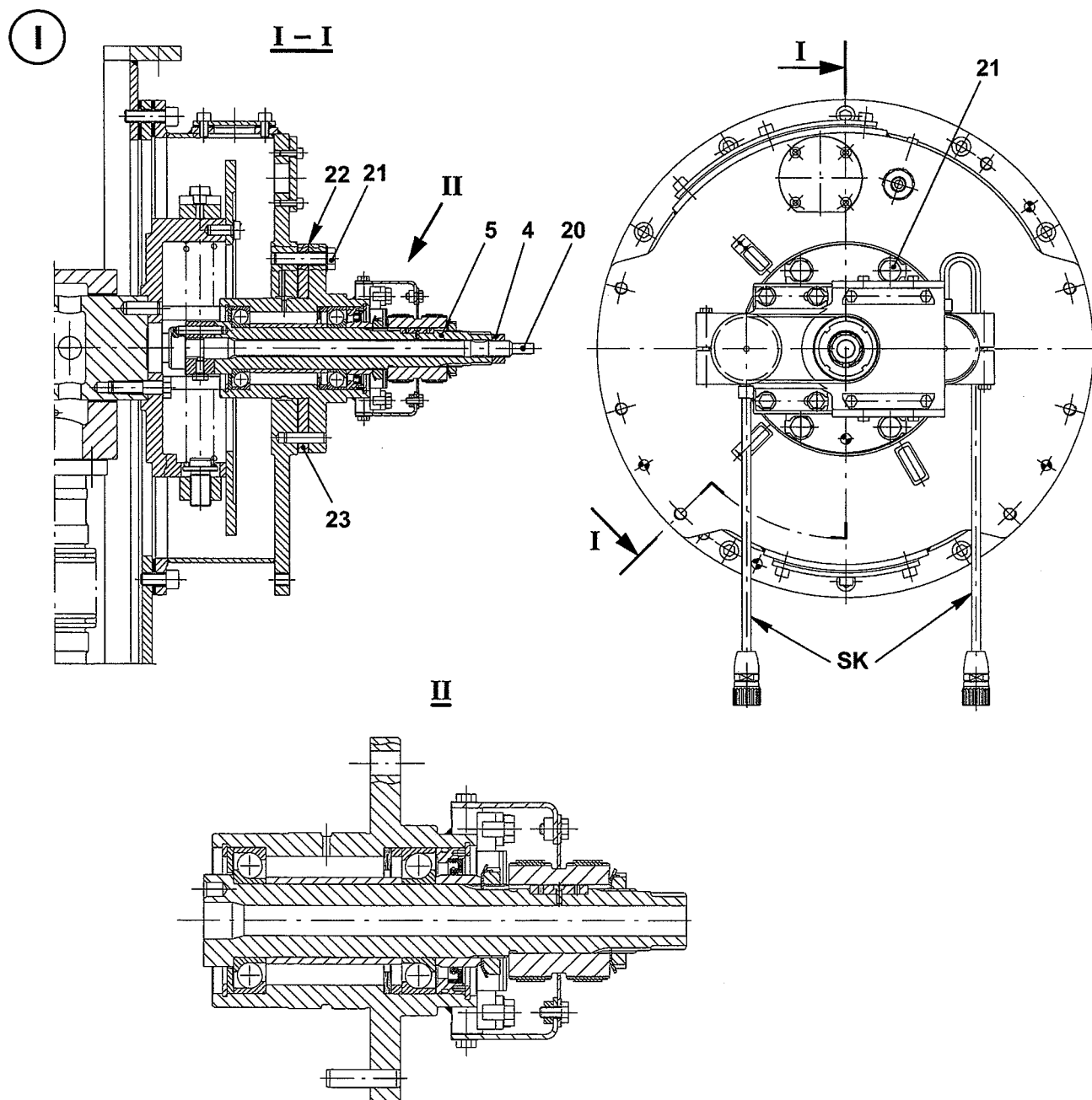
⇒ Loosen and remove nuts (4).



When loosening nut (4) **hold up** shaft (5) by means of an open end spanner AF27!

⇒ Remove screws (21) and withdraw the crank angle sensor from the waisted screw (20) (view II).

 **Remark** : Do not unscrew adjusting disc (23).

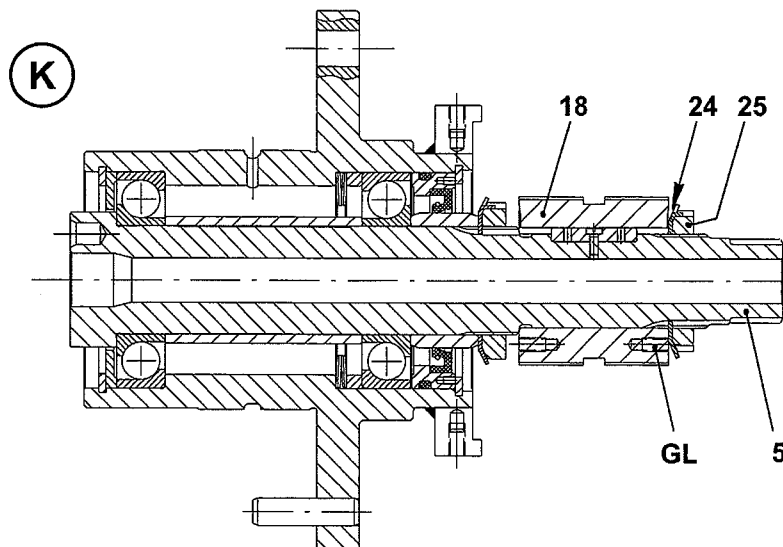


Crank Angle Sensor Unit
Dismantling, Assembling and Adjusting**5. Dismantling the crank angle sensor drive****Recommendation:**

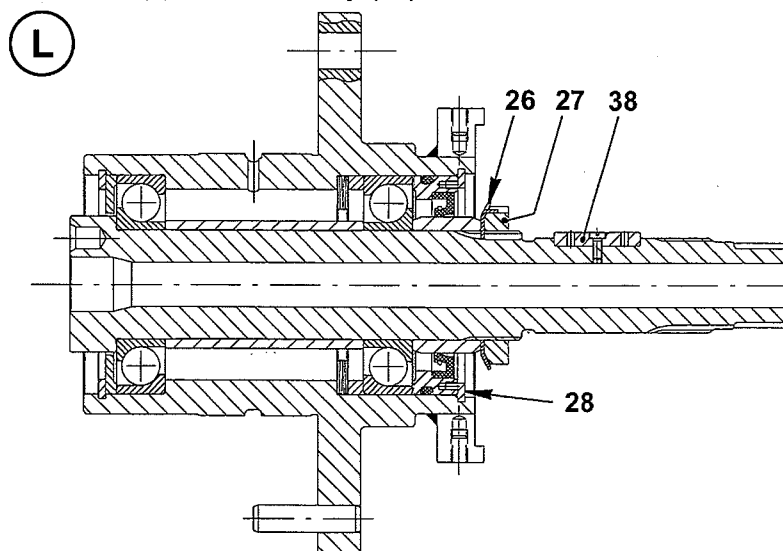
To ensure a high availability and quality standard we recommend that a complete crank angle sensor drive according to Fig. 'I', view II (including shaft encoder Fig. 'D') always be kept in stock. Maintenance works as described in sections 5 and 6 may be carried out only by qualified manufacturers as a matter of principle.

- ⇒ Remove shaft encoder according to paragraphs 1.2 and 1.3.
- ⇒ Unbend locking plate (24), loosen and remove shaft nut (25) using hook spanner (94924).
- ⇒ Withdraw gear wheel (18) from the shaft (5).

 **Remark** : If withdrawing by hand is not possible, the gear wheel must be removed by means of the two tap holes "GL" and suitable tools, however, without striking and damaging the toothing.

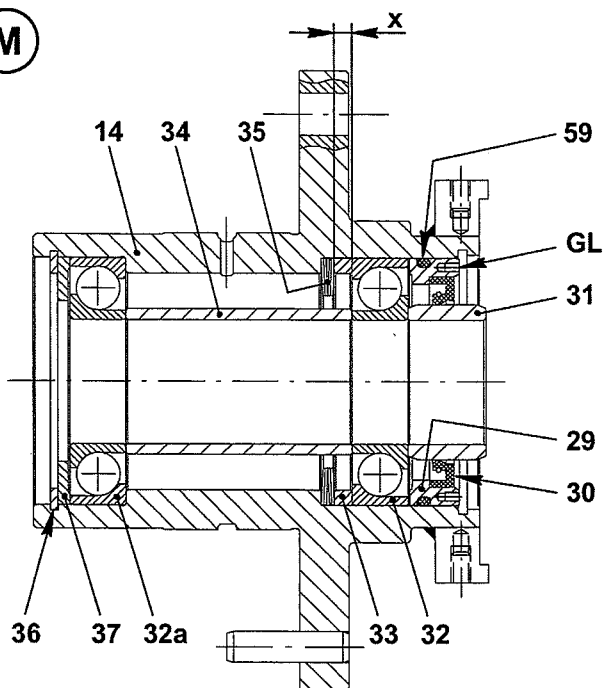


- ⇒ Remove circlip (28) using a snap ring tong.
- ⇒ Unbend locking plate (26), loosen and remove shaft nut (27) using hook spanner (94925).
- ⇒ Remove shaft (5), however, key (38) remains in situ.



Crank Angle Sensor Unit
Dismantling, Assembling and Adjusting

M



Parts to be removed in the following sequence:

- Retaining ring (29) (using tap holes “GL”) together with sealing ring (30) and O-ring (59).
- Distance ring (31).
- Ball bearing (32), distance ring (33), distance sleeve (34) and disc springs (35).
- Circlip (36).
- Disc (37) together with ball bearing (32a).

Crank Angle Sensor Unit
Dismantling, Assembling and Adjusting

6. Assembling the crank angle sensor drive

- ⇒ Clean all parts and check their conditions prior to assembling.
- ⇒ Replace sealing ring (30), ball bearings (32), (32a) and O-ring (59) (Fig. 'M').

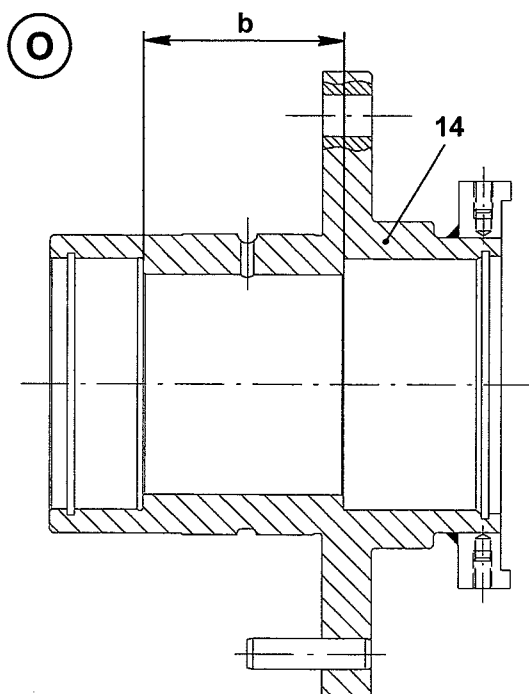
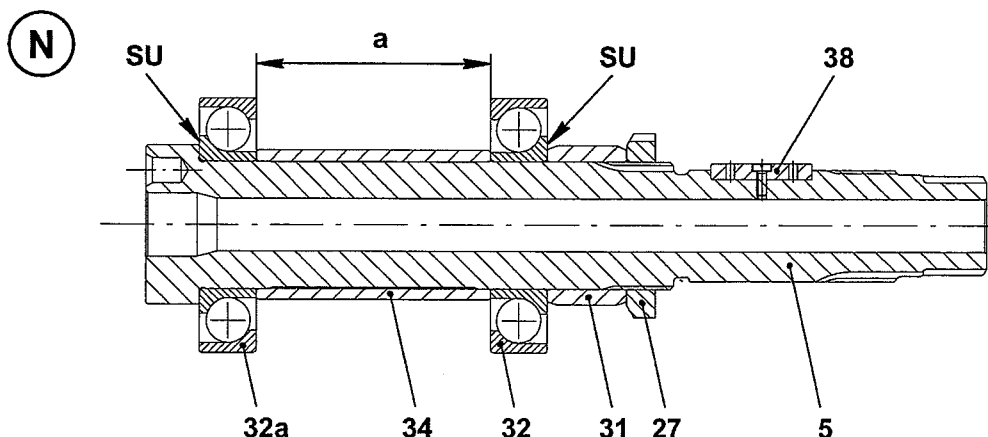
6.1 Determining of thickness 'x' of distance ring 33 (Fig. 'M')

- ⇒ Push ball bearing (32a), distance sleeve (34), ball bearing (32) and distance ring (31) onto the shaft (5) according to Fig. 'N'.



Big collar "SU" on inner ring of the ball bearings **must point outwards!**

- ⇒ Screw shaft nut (27) onto shaft (5) and lightly tighten it by means of hook spanner (94925).
- ⇒ Measure and note down distance 'a'.



- ⇒ Measure and note down distance 'b' in housing (14).

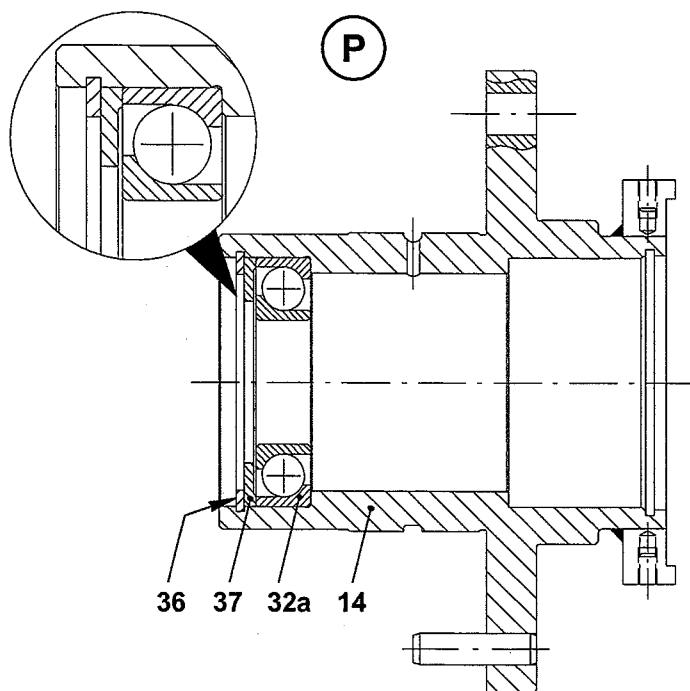
According to the following formula determine thickness 'x' for distance ring (33) to be fitted:

$$x = a - b - 4.2 \text{ mm}$$

Tolerance 'x' amounts to $\pm 0.2 \text{ mm}$.

Crank Angle Sensor Unit

Dismantling, Assembling and Adjusting

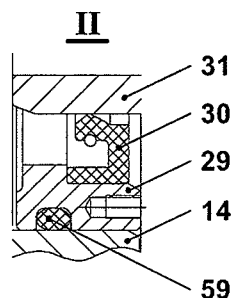
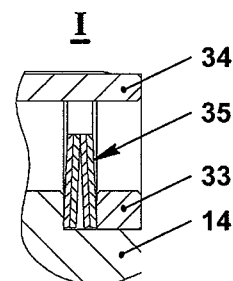
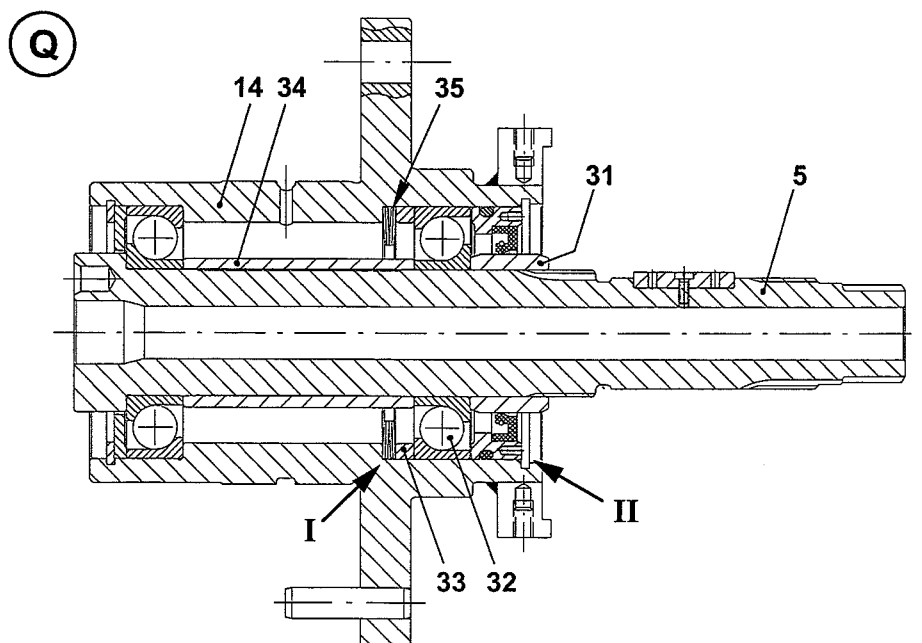


6.2 Sub-assembly of bearing housing

- ⇒ Remove the parts which are fitted on shaft (5) as shown in Fig. 'N'.
- ⇒ Oil ball bearing (32a) and insert it into housing (14). Pay attention to the fitting position in paragraph 6.1!
- ⇒ Place disc (37) with its smaller seating surface pointing to the ball bearing and fit circlip (36).

6.3 Completing of the bearing housing

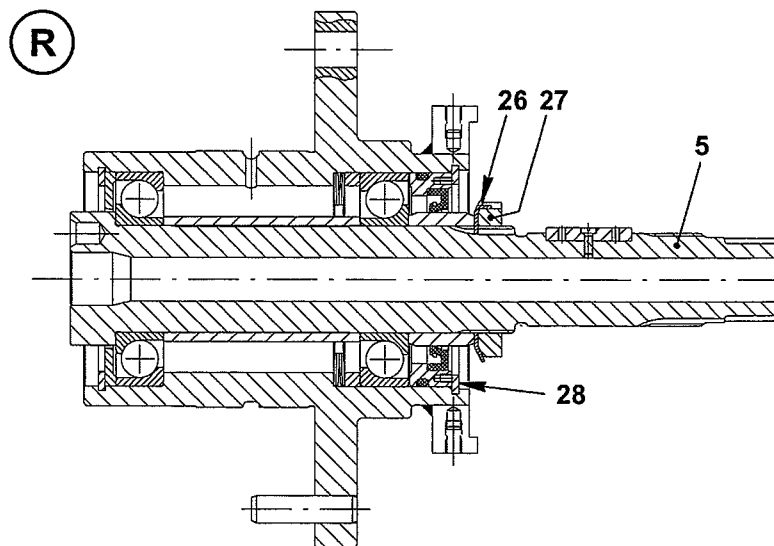
- ⇒ Oil all parts.
- ⇒ Fit shaft (5).
- ⇒ Push distance sleeve (34) onto the shaft.
- ⇒ Fit disc springs (35) according to view I.
- ⇒ Fit distance ring (33) with thickness 'x' determined under paragraph 6.1.
- ⇒ Oil ball bearing (32) and insert it into housing (14). Pay attention to the fitting position in paragraph 6.1!
- ⇒ Fit retaining ring (29) with new sealing ring (30) and O-ring (59) according to view II.
- ⇒ Fit distance ring (31).



Crank Angle Sensor Unit
Dismantling, Assembling and Adjusting

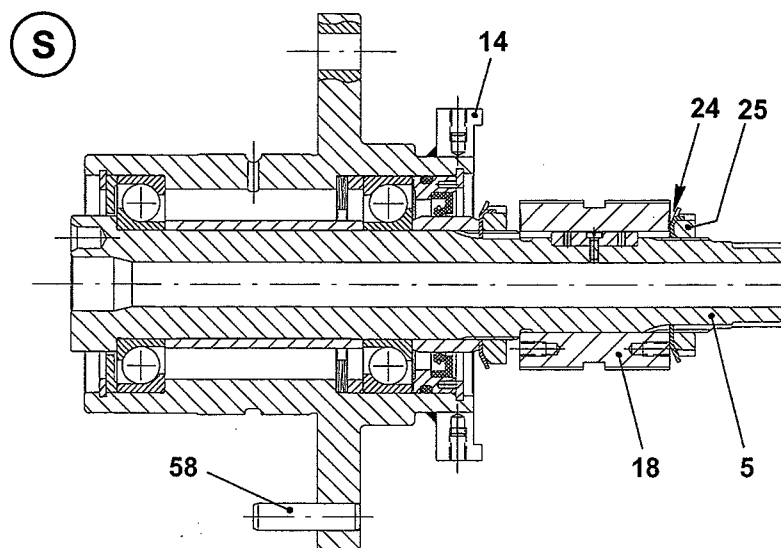
6.4 Tightening the shaft nut

- ⇒ Apply MOLYKOTE paste G to the thread and seating surface of shaft nut (27).
- ⇒ Fit locking plate (26) and screw down shaft nut.
- ⇒ Put torque wrench with socket spanner AF27 on the hexagon of shaft (5) and tighten the shaft nut with **25 Nm** using hook spanner (94925).
- ⇒ Lock shaft nut with locking plate.
- ⇒ Fit circlip (28).



6.5 Fitting gear wheel 18

- ⇒ Oil bore and push gear wheel (18) onto shaft (5) till the stop.
- ⇒ Apply MOLYKOTE paste G to the thread and seating surface of shaft nut (25).
- ⇒ Fit locking plate (24) and screw down shaft nut (25).
- ⇒ Put torque wrench with socket spanner AF27 on the hexagon of shaft (5) and tighten the shaft nut with **25 Nm** using hook spanner (94924).



Crank Angle Sensor Unit
Dismantling, Assembling and Adjusting

6.6 Fitting the shaft encoder

For the purpose of improved accessibility the shaft encoders (13) and (13a) may be fitted onto the bearing housing (14) (Fig. 'S') outside the engine. For that proceed as described under paragraphs 3.1 and 3.2 with the difference that shaft (5) must be turned several times by hand in order to adapt it to its running track.
When fitting the toothed belt pay attention to the important points in paragraph 3.2!

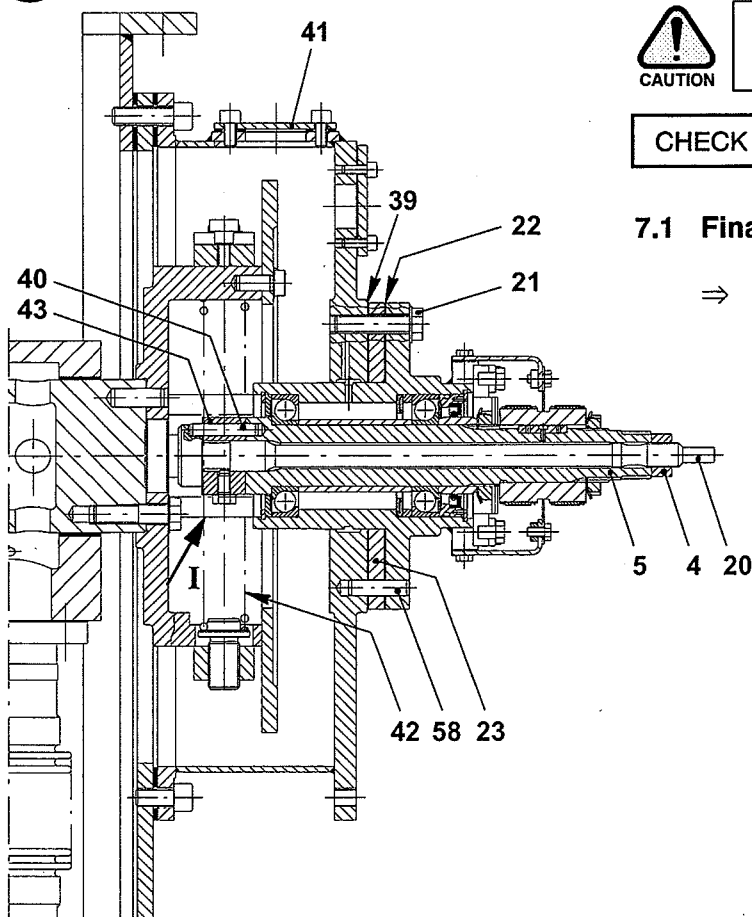
7. Fitting the crank angle sensor drive

- ⇒ Push crank angle sensor drive with packing ring (22a) little onto waisted screw (20) and turn shaft (5) in such a way that locating pin (40) and the corresponding bore in the shaft are in line.
- ⇒ Push crank angle sensor drive further till the locating pin fits into the corresponding bore in shaft (5).
- ⇒ Fasten screws (21) with their locking plates.

CHECK Turn crankshaft to an appropriate position.
Remove inspection cover (41) and check through the opening the fitting positions of:

- Compression springs (42), lever (43) and connection according to view I.
- ⇒ Apply MOLYKOTE paste G to the thread and seating surface of nut (4).
- ⇒ Screw nut onto waisted screw (20) and tighten it with a torque of **140 Nm**.

T

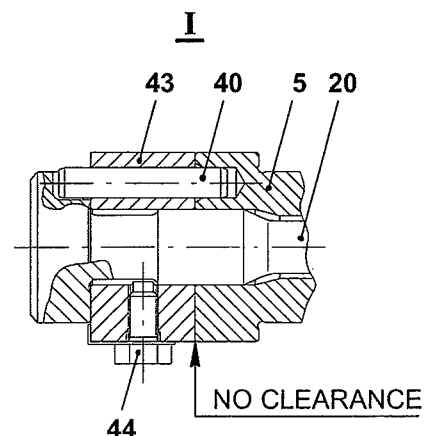


When tightening nut (4) **hold up** shaft (5) by means of an open end spanner!

CHECK Check adjustments according to paragraph 3.3.

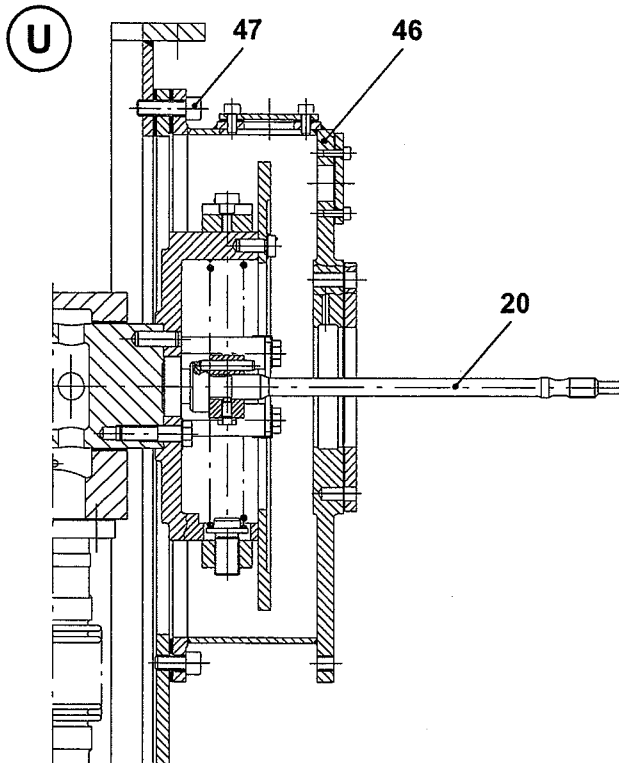
7.1 Final works

- ⇒ Carry out final works according to paragraphs 3.4 and 9.1.



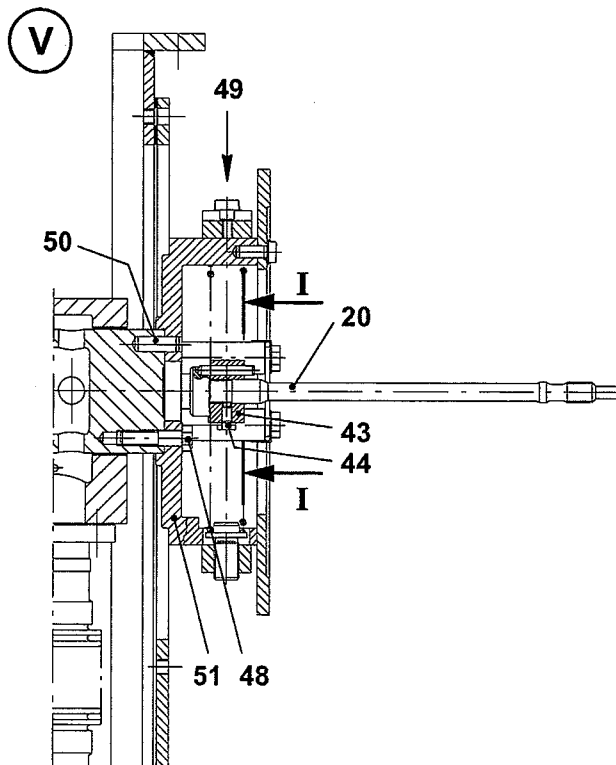
Crank Angle Sensor Unit
Dismantling, Assembling and Adjusting

8. Removal and fitting of compression spring

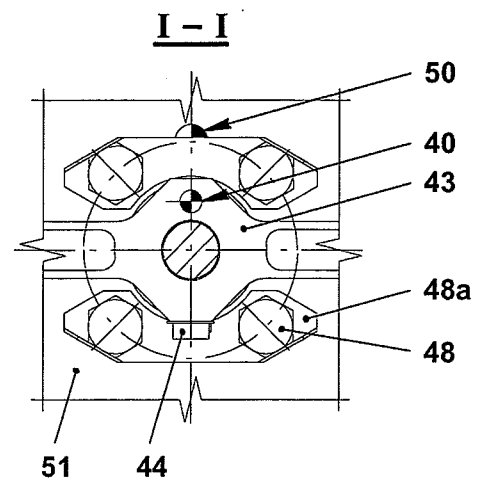


8.1 Preparation

- ⇒ Remove oil inlet "OE" (Fig. 'A').
- ⇒ Dismantle crank angle sensor drive according to section 4.
- ⇒ Remove screws (47) and housing (46).

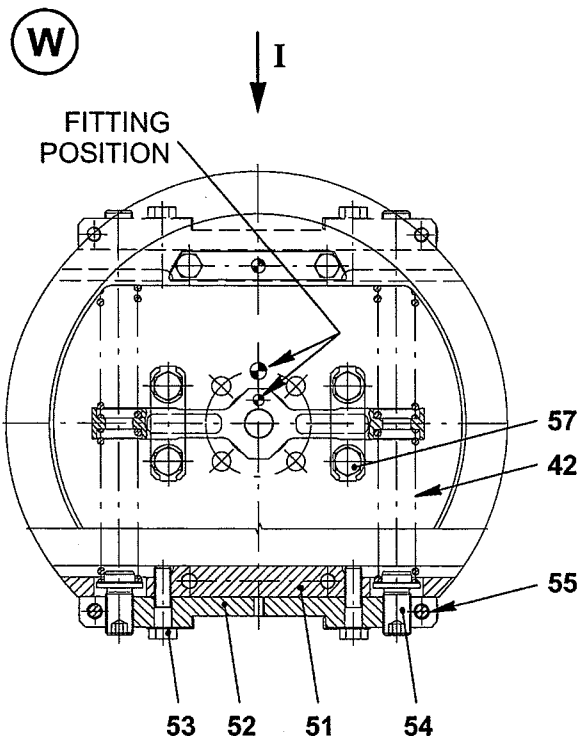


- ⇒ Remove screws (48) and connecting unit (49).
- ⇒ Remove screws (44) and withdraw waisted screw (20) from the lever (43).



Crank Angle Sensor Unit

Dismantling, Assembling and Adjusting



8.2 Removing the compression spring

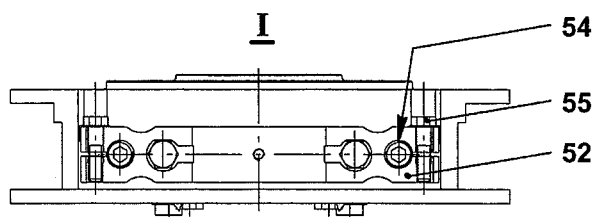
- ⇒ Loosen screws (53) and remove them together with spring tensioner (52).
- ⇒ Remove and check compression springs.



Remark : When replacing only one compression spring (42), it is recommend to remove also the second spring tensioner for carrying out further adjustments.

CHECK

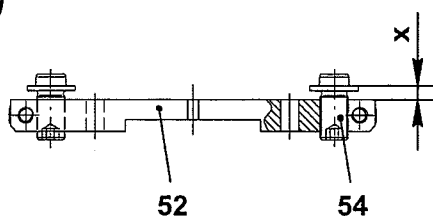
Check spring seating surface for wear.



8.3 Fitting of the lever

- ⇒ When fitting lever (43) pay attention to its fitting position (Fig. 'W').
- ⇒ Replace locking plates to screws (57).
- ⇒ Apply MOLYKOTE paste G to threads and seating surfaces of screws (57).
- ⇒ Tighten screws (57) with a torque of **60 Nm** and lock them.

(X)



8.4 Fitting the compression spring

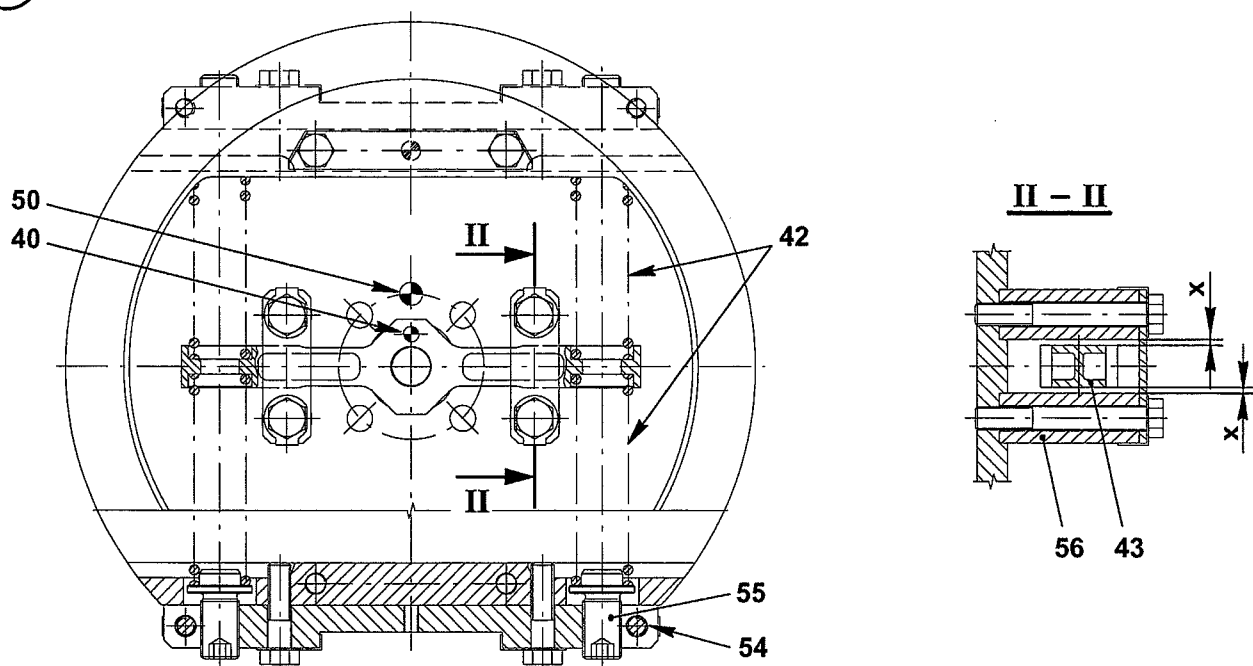
- ⇒ Loosen clamp screws (55) of spring tensioner (52) (Fig. 'W'). Replace locking plates. Apply MOLYKOTE paste G to threads and seating surfaces of screws (55) and refit them.
- ⇒ Oil and adjust all adjusting screws (54) to 'x' = 10 ± 0.10 mm (Fig. 'X').
- ⇒ Insert compression springs (42), fit spring tensioner with screws (53) and new locking plates, applying MOLYKOTE paste G to threads and seating surfaces.
- ⇒ Tighten screws (53) with a torque of **60 Nm** and lock them.

Crank Angle Sensor Unit
Dismantling, Assembling and Adjusting

8.5 Adjusting the compression spring

- ⇒ By means of synchronously adjusting screws (54) (i.e. if one of the adjusting screws is screwed-in by e.g. ½ turn, the opposite one must be screwed-out by ½ turn) move the relevant compression spring pair (42) until lever (43) shows the same distance 'x' between the stops on both sides (centering lever).
For measuring use feeler gauge (94122).
- ⇒ Tighten all clamp screws (55) with a torque of **35 Nm** and lock them.

Y



8.6 Fitting the connecting unit (Fig. 'V')

- ⇒ Fit waisted screw (20) and screw (44) with new locking plates. Tighten and lock the latter (Fig. 'T' view I).
- ⇒ **Remark** : Screw (44) must **not** press against waisted screw (20)!
- ⇒ Fit connecting unit (49) and screws (48) together with new locking plates (48a), applying MOLYKOTE paste G to threads and seating surfaces.
- ⇒ Tighten screws (48) with a torque of **60 Nm** and lock them.

CHECK

Locating pin (40) and locating pin (50) must point upwards on cylinder No. 1 at T.D.C. according to Fig. 'V' and 'Y'!

Crank Angle Sensor Unit
Dismantling, Assembling and Adjusting

8.7 Final fitting the crank angle sensor unit

- ⇒ Fit housing (46) with joint and fasten with screws (47) (Fig. 'U').
- ⇒ Fitting of the crank angle sensor drive according to section 7.
- ⇒ Carry out final works according to paragraphs 3.4 and 9.1.

9. Checks

The periodical checks **must** be carried out according to Maintenance Schedule 0380-1 'Crank angle sensor unit'.

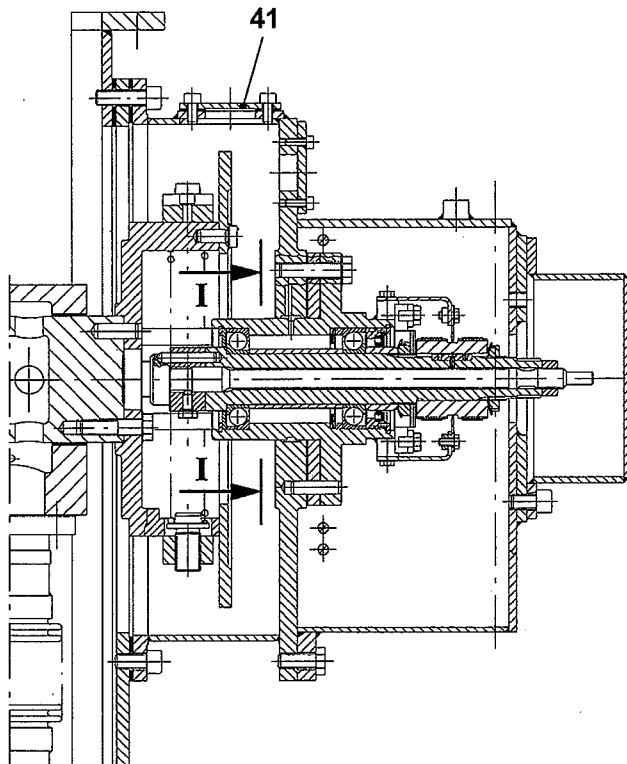
9.1 Lubricating oil flow in the crank angle sensor drive

- ⇒ Start main lubricating oil pump and adjust bearing oil pressure.
- ⇒ Remove inspection cover (41).
- ⇒ Turn crankshaft till the two oil outlets are good visible (view I-I).

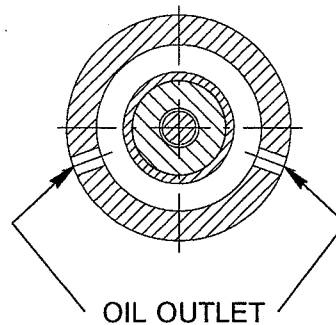
With correct oil flow at operating temperature an oil spray results according to Fig. 'A₁'. However, the oil outlets should be filled up.

- ⇒ Refit inspection cover (41).

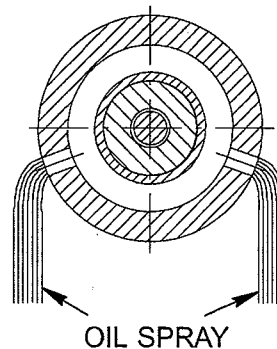
Z



I - I



A₁



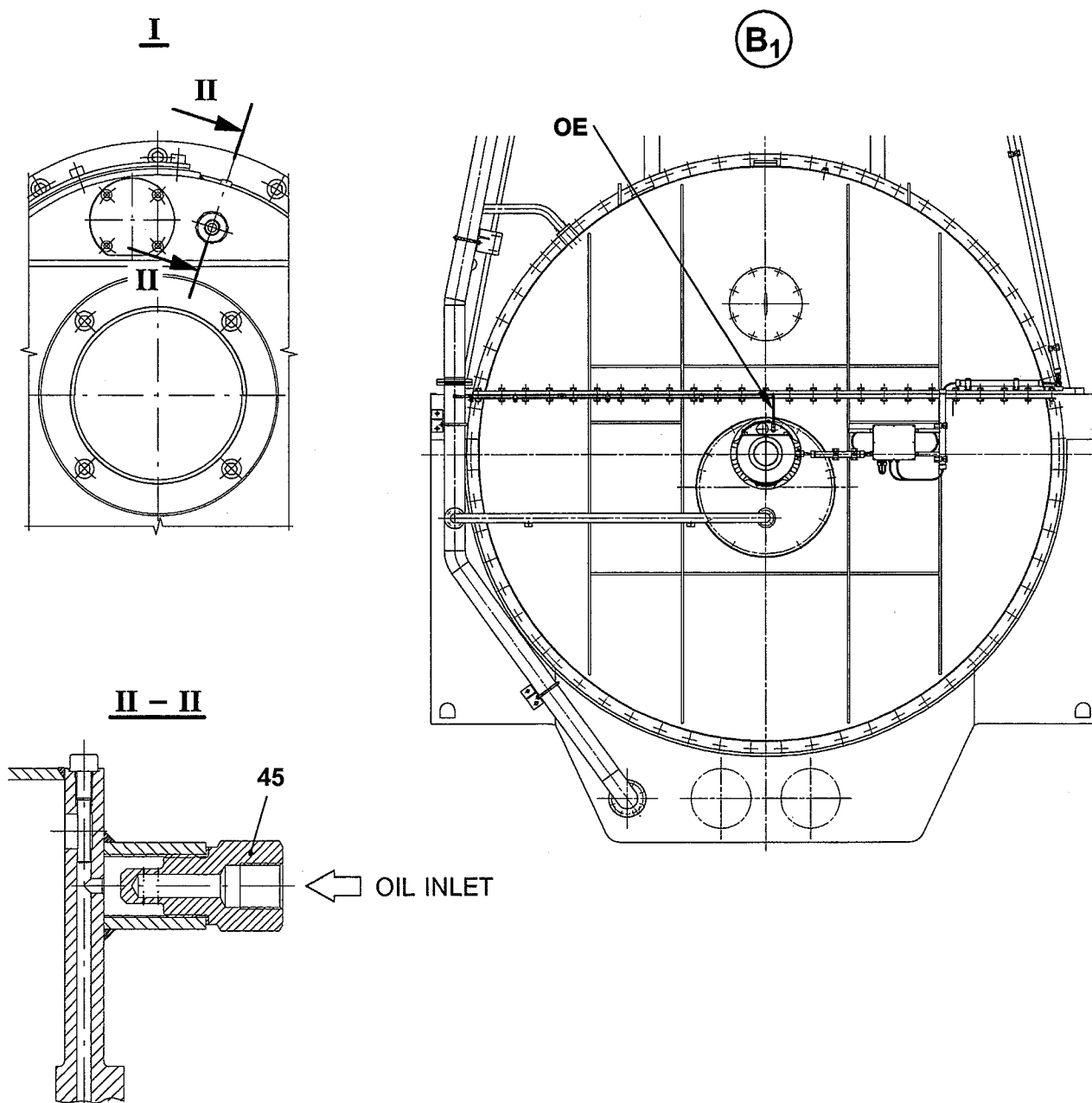
Crank Angle Sensor Unit
Dismantling, Assembling and Adjusting

9.2 Checking the throttle

Before reaching the crank angle sensor unit, the oil flows first through throttle (45), which reduces the oil quantity and also keeps back larger oil particles.

Checking the throttle is carried out as follows:

- ⇒ Stop main lubricating pump.
- ⇒ Remove oil inlet "OE" from the throttle.
- ⇒ Unscrew throttle and check its oil spray holes for free passage. Clean if necessary.
- ⇒ Reinstall all parts.

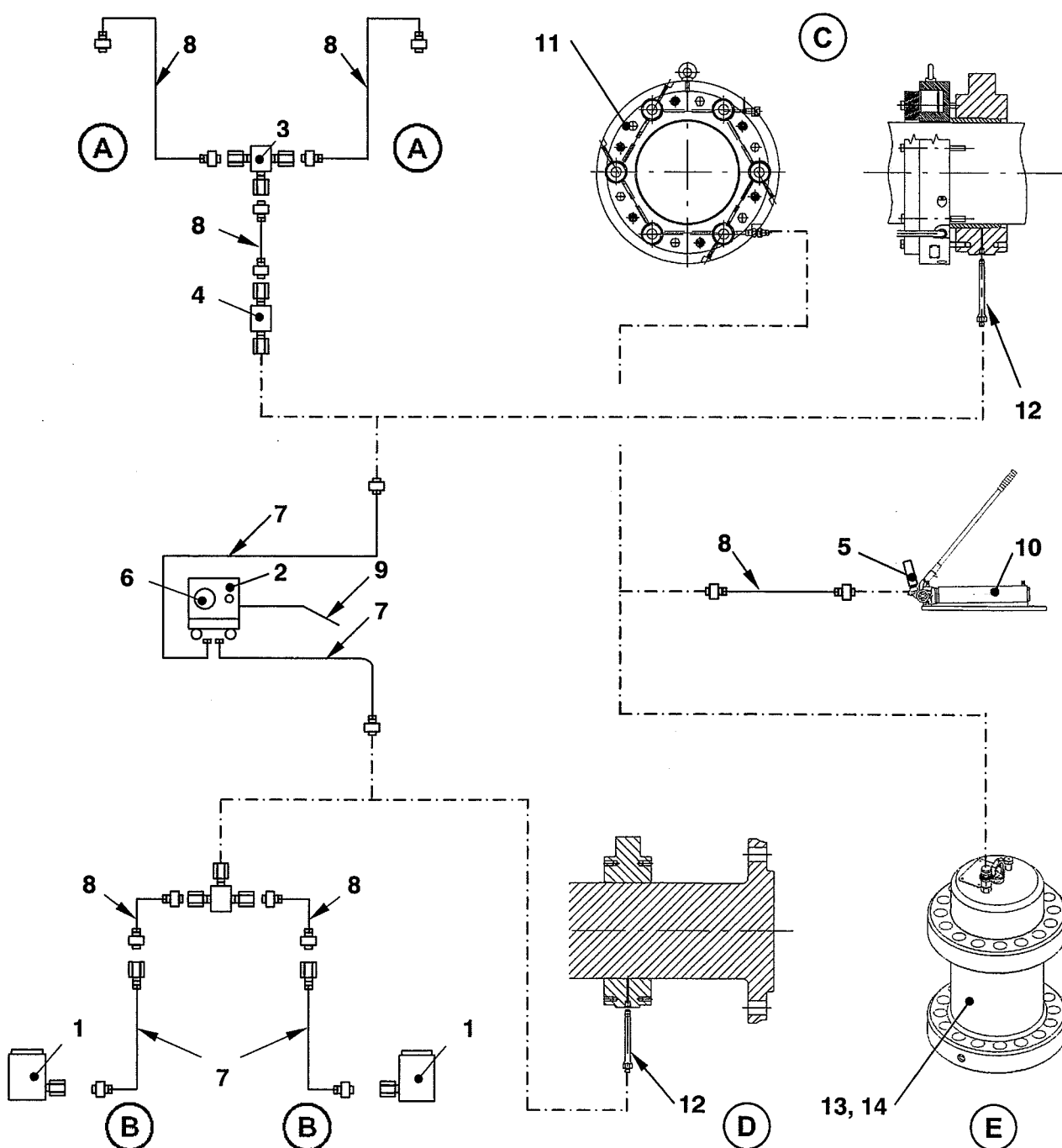


RT-flex96C

Hydraulic Jacks and Pumps
Arrangement and Application

Key to arrangement of the hydraulic jack and pumps :

1	Hydraulic jack	1000 kN (100t)	94936	8	High pressure hose	94935a
2	Hydraulic unit	150 MPa	94942	9	Rubber hose for hydraulic unit	
3	Conection piece		94934a	10	Hand pump	150 MPa 94931
4	Connection piece		94934	11	Hydr. jacking tool	94424
5	Pressure gauge on hand pump		94932	12	Connection piece	94426
6	Pressure gauge on hydr. unit		94932a	13	Jack (for 12 holes fuel pump)	94595
7	High pressure hose		94935	14	Jack (for 16 holes fuel pump)	94595a



RT-flex96C
Hydraulic Jacks and Pumps
Arrangement and Application

A = Tensioning / loosening of waisted studs to main bearings, tie rods, valve cages, top and bottom end bearings to connecting rod; piston rod foot fastening; screwed connections to turning gear; waisted bolts to camshaft and gear wheel bearings, supply unit housing cylinder cover, fundation bolts, piston crowns, .

B = Removing and fitting of main bearing shells and jacking out of cylinder liners.

C = Fitting / removing the 2-part fuel cam

D = Repositioning the 1-part fuel cam

E = Removal of a jammed fuel pump plunger


Remark

: When connecting HP hose to hydraulic unit

- ① remove couples (male) of HP hose and hydraulic unit.
Then, connect HP hose to hydraulic unit.
- ② remove couple (male) of HPhose and fit couple (female)
into HP hose. Then, connect HP hose to hydraulic unit.

Hydraulic Pre-tensioning Jacks
Storing, Servicing and Maintenance

1. General

The hydraulic pre-tensioning jacks forming part of the engine tool kit are to be stored in their tool boxes when not in use, in a clean place, where they are protected from damage (after greasing them and closing the connections with dust plugs).

We recommend to always keep in stock a sufficient number of new O-rings, supporting rings, piston seal rings and rod seal rings of the specified quality and dimensions.

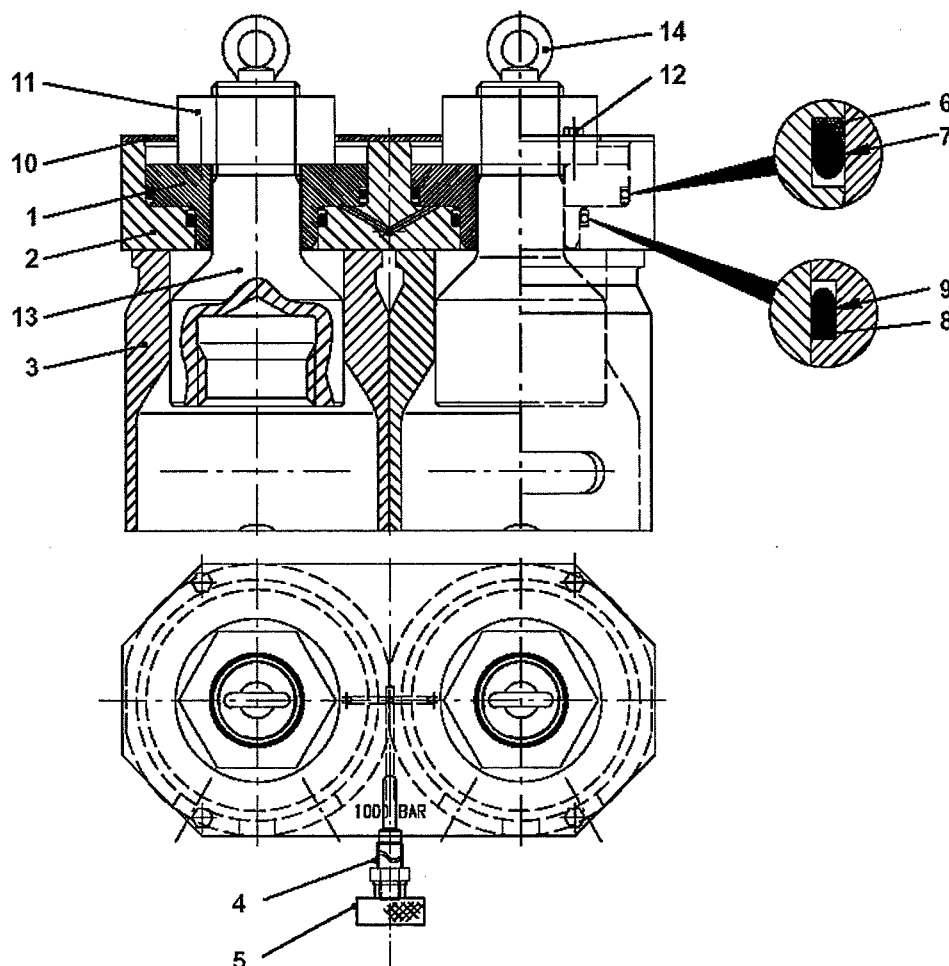


When fitting new supporting rings, piston seal rings and rod seal rings proceed with care, to avoid their damage; **do not use any sharp edged utensils** for assistance.

Heat unslit supporting and sealing rings which are used as piston seal rings in boiling water before fitting them.

Tool 94114 Double pre-tensioning jack for waisted studs to main bearing

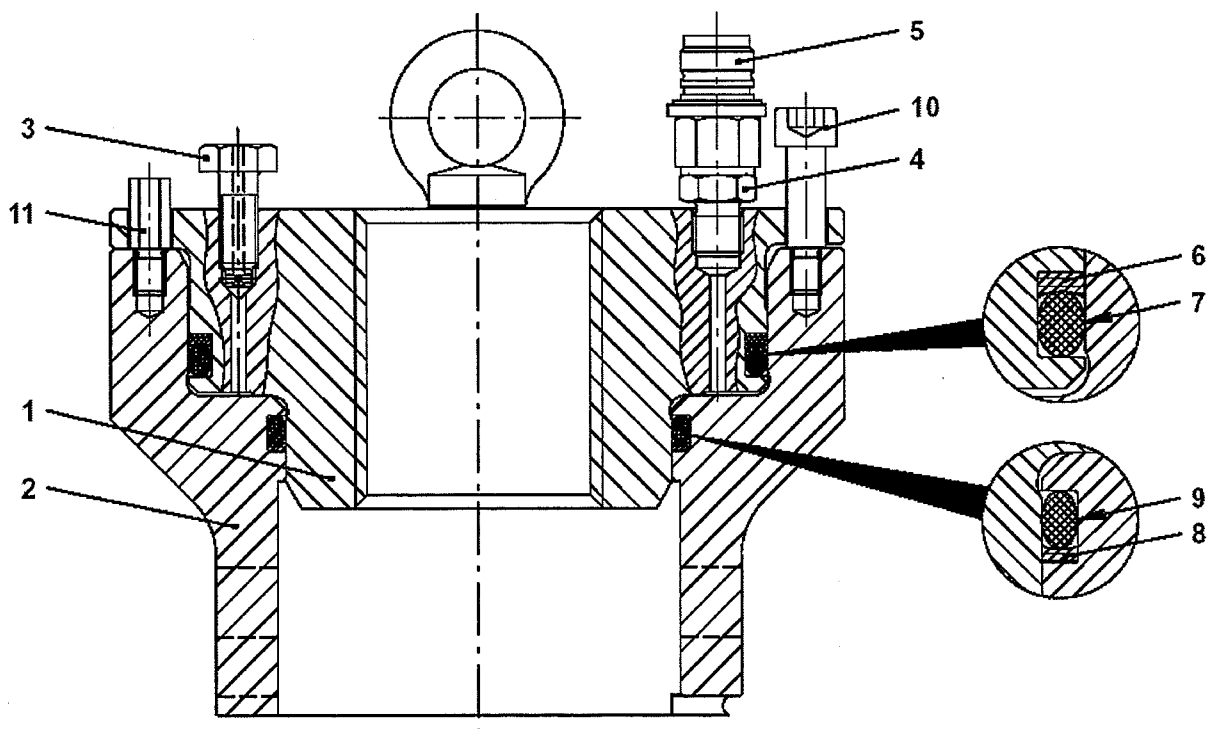
- | | | | | |
|---|------------------|----|-----------------|----------------|
| 1 | Piston | 8 | Supporting ring | } Sealing ring |
| 2 | Double cylinder | 9 | O-ring | |
| 3 | Distance sleeve | 10 | Cover | |
| 4 | Adapter | 11 | Nut | |
| 5 | Connection piece | 12 | Screw | |
| 6 | Supporting ring | 13 | Tension sleeve | |
| 7 | O-ring | 14 | Eye bolt | |



Hydraulic Pre-tensioning Jacks
 Storing, Servicing and Maintenance

- Tool 94145** Pre-tensioning jacks for engine stay
- Tool 94314** Pre-tensioning jacks for waisted studs to bottom end bearing
- Tool 94315** Pre-tensioning jacks for waisted studs to top end bearing
- Tool 94340** Pre-tensioning jacks for waisted studs to piston rod foot fastening and screwed connection to turning gear
- Tool 94556** Pre-tensioning jacks for waisted stud to bearing of intermediate wheel (supply unit)

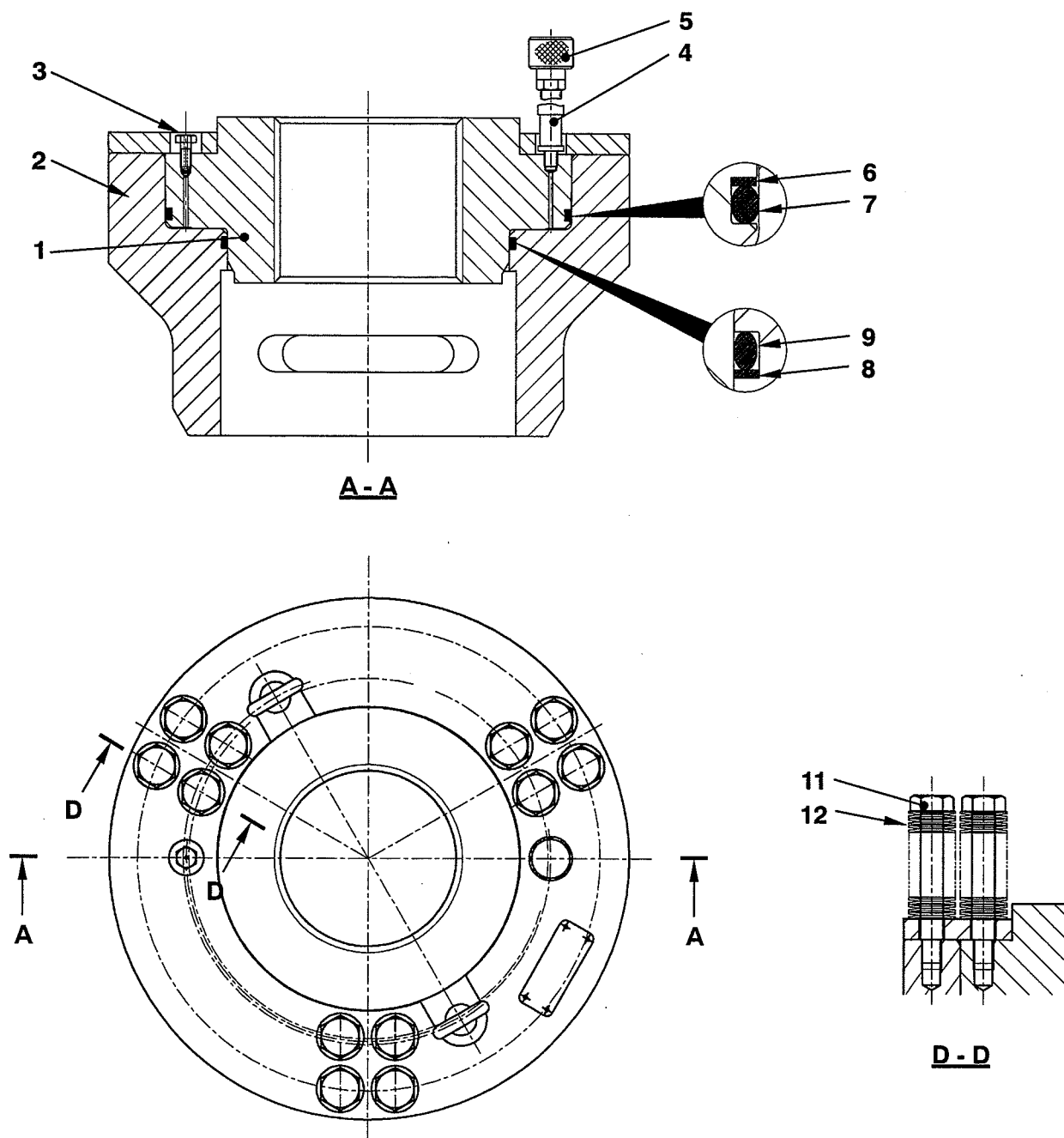
- | | | | | |
|---|------------------|----|-----------------|----------------|
| 1 | Piston | 8 | Supporting ring | } Sealing ring |
| 2 | Cylinder | 9 | O-ring | |
| 3 | Vent screw | 10 | Screw | |
| 4 | Adapter | 11 | Pin | |
| 5 | Connection piece | | | |
| 6 | Supporting ring | | | } Sealing ring |
| 7 | O-ring | | | |



Hydraulic Pre-tensioning Jacks
Storing, Servicing and Maintenance

Tool 94180 Pre-tensioning jacks for tie rod

- | | | | | |
|---|------------------|----|-----------------|----------------|
| 1 | Piston | 8 | Supporting ring | } Sealing ring |
| 2 | Cylinder | 9 | O-ring | |
| 3 | Vent screw | 10 | Screw | |
| 4 | Adapter | 11 | Tension washer | |
| 5 | Connection piece | 12 | Tension washer | |
| 6 | Support ring | | | } Sealing ring |
| 7 | O-ring | | | |

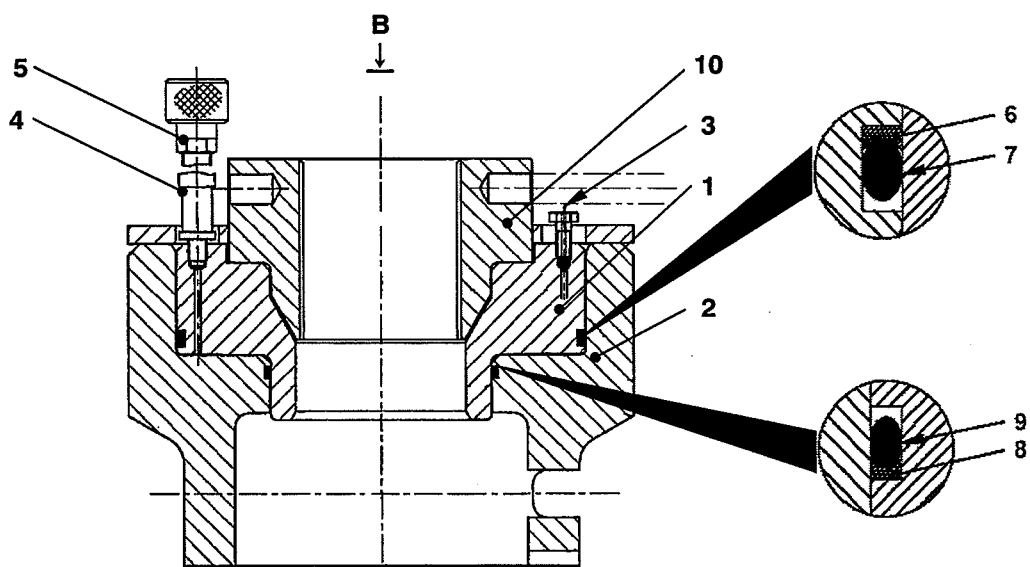


Hydraulic Pre-tensioning Jacks
Storing, Servicing and Maintenance

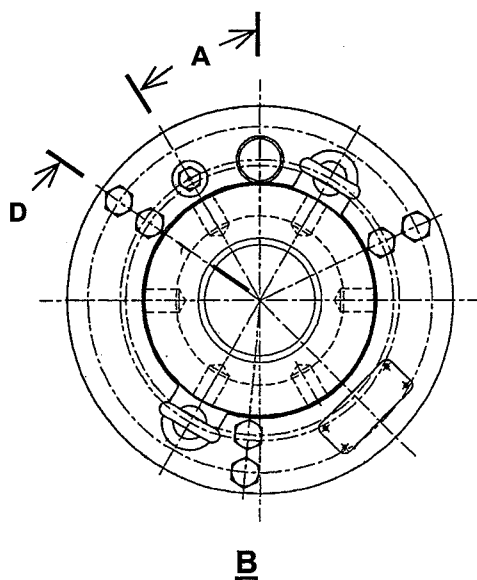
Tool 94215a Pre-tensioning jack for waisted studs to cylinder cover

Tool 94252a Pre-tensioning jacks for waisted studs to exhaust valve

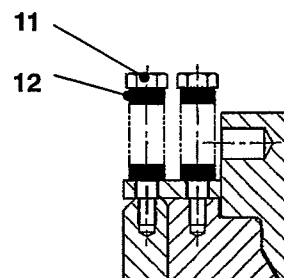
- | | | | | |
|---|------------------|----|-----------------|----------------|
| 1 | Piston | 8 | Supporting ring | } Sealing ring |
| 2 | Cylinder | 9 | O-ring | |
| 3 | Vent screw | 10 | Nut | |
| 4 | Adapter | 11 | Screw | |
| 5 | Connection piece | 12 | Tension washer | |
| 6 | Supporting ring | | | } Sealing ring |
| 7 | O-ring | | | |



A-A



B

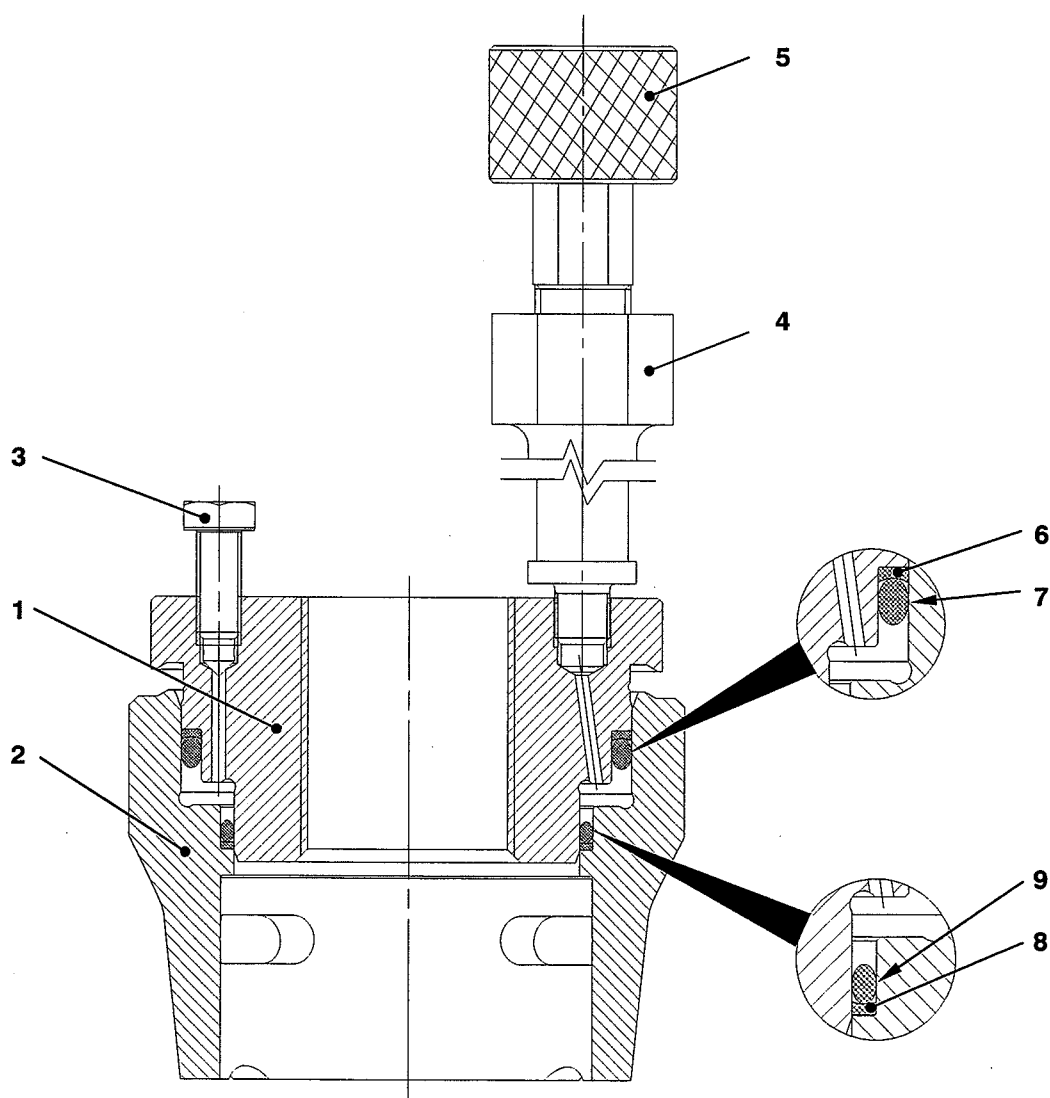


D-D

Hydraulic Pre-tensioning Jacks
 Storing, Servicing and Maintenance

Tool 94346 Pre-tensioning jacks for waisted studs to piston crown

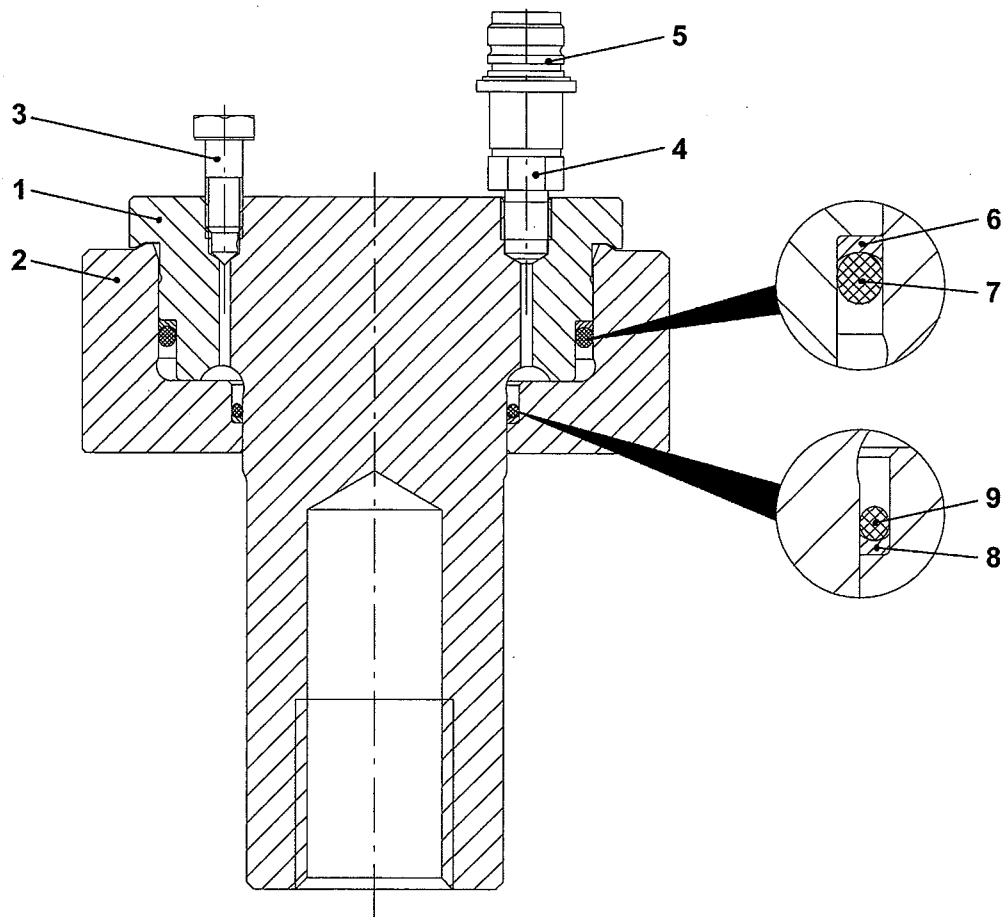
- | | | | | |
|---|------------------|---|-----------------|----------------|
| 1 | Piston | 6 | Supporting ring | } Sealing ring |
| 2 | Cylinder | 7 | O-ring | |
| 3 | Vent screw | 8 | Supporting ring | } Sealing ring |
| 4 | Adapter | 9 | O-ring | |
| 5 | Connection piece | | | |



Hydraulic Pre-tensioning Jacks
Storing, Servicing and Maintenance

Tool 94557 Pre-tensioning jacks for waisted studs to supply unit housing and camshaft bearing and gear wheel on cam shaft

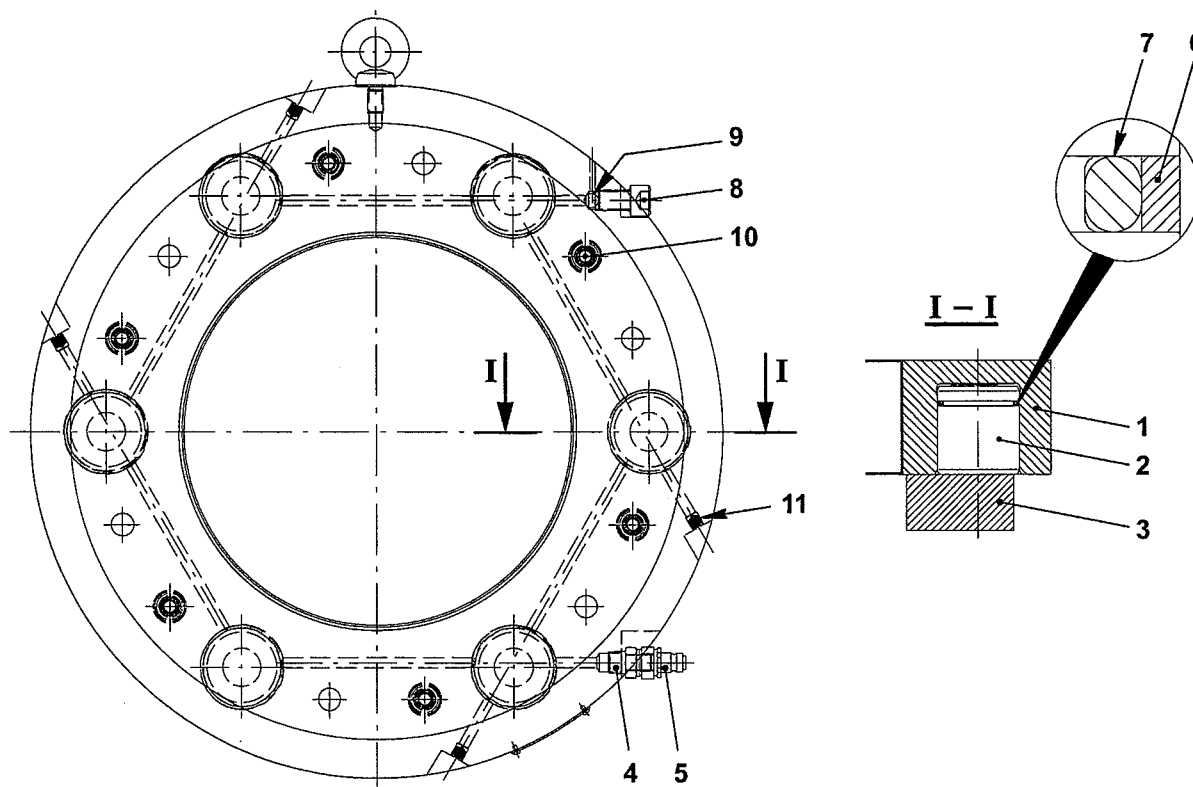
- | | | | | |
|---|------------------|---|-----------------|----------------|
| 1 | Piston | 6 | Supporting ring | } Sealing ring |
| 2 | Cylinder | 7 | O-ring | |
| 3 | Vent screw | 8 | Supporting ring | } Sealing ring |
| 4 | Adapter | 9 | O-ring | |
| 5 | Connection piece | | | |



Hydraulic Pre-tensioning Jacks
 Storing, Servicing and Maintenance

Tool 94424 Hydr. jacking tool for camshaft

- | | | | |
|---|-------------------------|----|-------------|
| 1 | Piston supporting plate | 8 | Allen screw |
| 2 | Piston | 9 | Ball |
| 3 | Ring piece | 10 | Screw |
| 4 | Adapter | 11 | Screw plug |
| 5 | Connection piece | | |
| 6 | Piston seal ring | | |
| 7 | O-ring | | |
- } Sealing ring

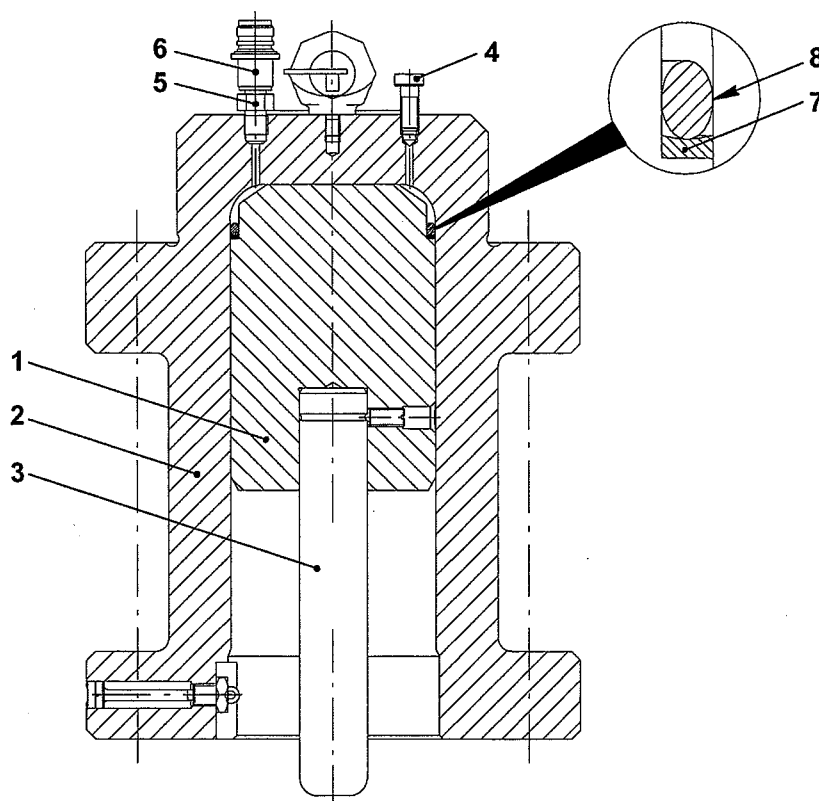


Hydraulic Pre-tensioning Jacks
 Storing, Servicing and Maintenance

Tool 94595 Jack for removal of a jammed fuel pump plunger (for 12 holes)

Tool 94595a Jack for removal of a jammed fuel pump plunger (for 16 holes)

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|---|------------|---|------------------|
| 1 | Piston | 5 | Adapter |
| 2 | Cylinder | 6 | Connection piece |
| 3 | Push rod | 7 | Back-up ring |
| 4 | Vent screw | 8 | O-ring |



Hydraulic Pre-tensioning jacks

General Application Instructions

1. General

For distinct screwed connections different designs and sizes of waisted bolts or waisted studs (bolts/studs) are used, which are pre-tensioned by hydraulic pre-tensioning jacks. The bolts/studs have threads which extend over the nut. The pre-tensioning jack is mounted on this thread end.

For each thread of the various bolts/studs a suitable pre-tensioning jack is supplied. Since the bolts/studs are pre-tensioned with the pre-tensioning jacks, the nuts are threaded-on only manually until seated.

Prior to the mounting of the pre-tensioning jacks, their threads as well as the threads of the waisted bolts/studs must be carefully cleaned. The threads must be undamaged and freely working. Concerning utilization of lubricant for screwing on nuts the instructions in 0352-1 must be followed.



Always wear safety goggles when working with hydraulic tools.

2. Working procedure for loosening

- ⇒ Thread the pre-tensioning jack by hand onto the extending thread end of the bolts/studs to be loosened until it is landed on the part and the piston on the cylinder without any clearance. On pre-tensioning jacks with round nuts these have to be slightly tightened.
- Then, depending on the design of the pre-tensioning jack, turn it or the round nut back by about $\frac{1}{2}$ to $1\frac{1}{2}$ turns. The clearance thus obtained between pre-tensioning jack and landing face of the part or piston and cylinder is essential, before starting the pre-tensioning of the bolts/studs. It enables the loosening of the nut till total relaxation of the bolts/studs in one single working sequence.
- ⇒ Connect the hydraulic unit and pre-tensioning jack with the HP hose.
- ⇒ Open the vent screw on top of the pre-tensioning jack a little.
- ⇒ Shut relief valve at the hydraulic unit and actuate it. As soon as oil flows out bubble-free close the vent screw at the pre-tensioning jack.
- When tensioning attention should be paid that the pins of the pre-tensioning jacks protrude slightly above the upper edges of the pistons (stroke limitation!).
- ⇒ Raise the pressure about 2 MPa beyond the nominal pressure (see 0352-1). The nut is now slack, loosen it with a round bar, while keeping the pressure constant.
- ⇒ Release the pressure at the hydraulic unit and remove the pre-tensioning jack.

Hydraulic Pre-tensioning jacks

General Application Instructions

3. Working procedure for tensioning

- ⇒ Use a felt pen and mark the positions of the nuts, which already have been firmly seated against their landings on the part. The marks are later a reference for judging the correct pre-tensioning.
- ⇒ Thread on by hand the pre-tensioning jack onto the protruding thread end of the bolts/studs until it is fully seated without any clearance between the jack and the part or the piston is seated on the cylinder without any clearance. On a pre-tensioning jack with round nut tighten it lightly.
- ⇒ Connect hydraulic unit and pre-tensioning jack by the HP hose.
- ⇒ Open the vent screw on top of the pre-tensioning jack a little.
- ⇒ Shut relief valve at the hydraulic unit and actuate it. As soon as oil flows out bubble-free close the vent screw at the pre-tensioning jack.
- When tensioning attention should be paid that the pins of the pre-tensioning jacks protrude slightly above the upper edges of the pistons (stroke limitation!).
- ⇒ Raise the pressure with the hydraulic unit, in accordance with the indication on the tightening of important screwed connections (see 0352-1).
- ⇒ Maintain the oil pressure constant at the adjusted value and use the round bar to tighten the nut onto its seating surface until firmly seated.

CHECK

Check with the feeler gauge whether actually no clearance remains between nut and seating.

Check with the referenced markings, whether all the nuts of a screwed connection have been turned by the same value as mentioned in 0352-1. If big differences are noted their causes have to be investigated and the tensioning procedure must be repeated.

- ⇒ Release the pressure at the hydraulic unit and remove the pre-tensioning jacks.
- For operation and maintenance of the hydraulic unit we also refer to the manufacturer's documentation.