MITSUI-MAN B&W

MC(MC-C) ENGINES

INSTRUCTION BOOK

VOLUME 2

MAINTENANCE

三井造船株式会社
MITSUI ENGINEERING & SHIPBUILDING CO.,LTD.

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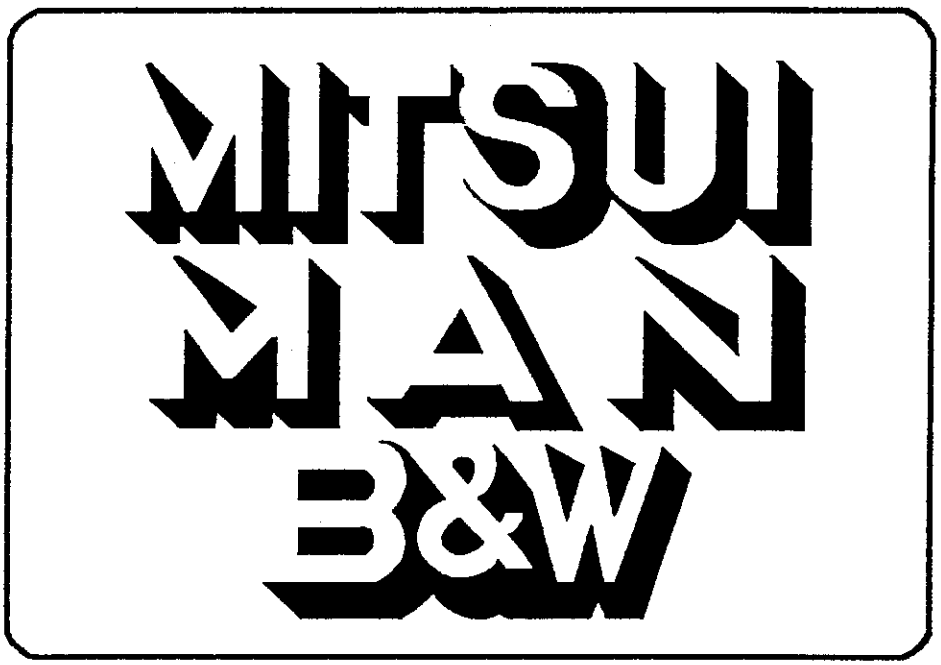


4E-91302

S50MC-C

VOLUME 2
MAINTENANCE

INSTRUCTION BOOK FOR MAINTENANCE

In view of the continued development of our diesel engines, these instruction books have been made to apply to our engines of the type S50MC-C.

The purpose of these books in the first place to describe the maintenance of the engine.

取　扱　説　明　書

保　守（解放）

ディーゼル機関のたゆまない進歩発展にかんがみ、本取扱説明書はＳ５０ＭＣ－Ｃ形機関に対し、機関の解放についてのべたものである。

4E-91302

Label of safety precaution

The following symbol marks are used in this instruction manual and for the safety precaution labels of engine.

1. Safety sign, Signal word

!	「Danger」	It shows an imminent danger that no avoidance causes death and serious injury. It is not applied for items regarding damage of machinery.
!	「Warning」	It shows that no avoidance may cause death and serious injury. It is not applied for items regarding damage of machinery.
!	「Caution」	It shows that no avoidance may cause slight injury. It is applied for items regarding damage of machinery.
	「Notice」	It shows caution items to avoid the damage of machinery.

2. Symbols for safety marks

a) Caution mark

	General caution		
	Inflammable	→	Fire
	Explosive	→	Explosion
	Corrosive	→	Corrosion
	Poisonous	→	Poisoning
	Electric	→	Electric shock
	High temperature	→	Skin burn
	Movable part	→	Rolled in
	Sharp edge	→	Cut
	High pressure fluid	→	External injury
	Slipping		
	Falling		

b) Prohibition mark

- General prohibition
- No smoking
- Naked flames prohibited
- No touching

c) Duty mark

- Wear eye protector･･･Protective glass etc.
- Wear head protector･･･Helmet etc.
- Wear hearing protector･･･Earplugs etc.
- Wear hand protector･･･Gloves etc.
- Wear foot protector･･･Safety shoes etc.

d) The others

- Refer to separate paper

Cautions during Overhauling, Maintenance, Assembling

- Before overhauling, maintenance and assembling of engine, read this book, study the structure and details of the work in question, and think out procedure beforehand and decide work.
  The insufficient prior examination cases accidents and damages of engine.
- Be sure to exchange the damaged parts as a result of inspection or wear parts which comes up to the exchange limit.
- If it is difficult to take measurement or there is no spare parts on board (on site), contact with our service division or service agency.

1. Caution items for safety

(1) Do not open the crankcase doors for more than 30 minutes until the engine is cooled down sufficiently after stop of the engine. There is a risk of explosion by mixing oil mist with fresh air in case the engine is overheated.

(2) There is a serious risk of severe personal injury if the engine is turned during overhauling and inspection.

- Before the work, ensure that control handle is on "STOP" position and the valves of starting air line are closed.
- When turning the engine, ensure there is no contact of rotational part and no risk of surrounding persons. Give a signal to surrounding persons.
- In case of overhauling or inspection of moving parts, make sure turning gear is "ENGAGED" position.

(3) For lifting the engine components during overhauling/assembling, eye-bolts supplied from engine builder (tool no. 13A20) must be used.

(4) While at work, wear suitable protectors. (Glass, Helmet, Safety shoes, Protective glass)

- Specially, it is very hot around exhaust pipe, indicator valve, turbocharger and cylinder head during running and immediately after stopping the engine. Wear the protective glove while at work to avoid skin burn.
- The floor of engine room and the engine are slippery because of oil. During work, wipe off oil on the floor and bottom of shoes. Specially, working at high position, be careful for fallen down.

(5) Before releasing some pipe systems, ensure that all valves are "CLOSE" position, and loosen the dearating plug slowly to release the pressure.
There is a risk of blowout of high temperature oil and water, when releasing the joint of filters and pipes just after engine stop by remained pressure.

(6) There is a risk of jumping out of springs when releasing valves and devices which springs are used for.

(7) Do not lift up the heavy loads by manpower. Use chain-block. Keep away below crane with load.

(8) Cut the power supply when dealing with electric parts.

(9) Keep strictly below items when dealing with liquid.

- fuel oil, lubrication oil=inflammable
  ---Naked flames prohibited

· fresh water inhibition · anti-freeze agent of fresh water · battery liquid =inflammable, poisonous

···Naked flames prohibited · Do not drink. — Wash when adhesion.

· mercury (of thermometer)=poisonous

···Do not drink. — Wash when adhesion.

2 . Caution items in during overhauling, maintenance and assembling

△ (1) Prepare beforehand tools and parts for exchange.

Use specified tools, regular designated parts.

△ (2) Cover the open space with tapes or clean cloths and so on. Do not forget to remove them when remounting.

△ (3) Keep the overhauled parts in order, to avoid injury and loss and to assemble efficiently.

△ (4) Assemble the parts which have stamps or scratch marks (ex. cylinder number or bearing number) in original position. And make the same marks on exchanged as the same position of old parts.

⚠ (5) Remount protective cover and insulating cover which was removed.

3 . Confirmation items after overhauling, maintenance and assembling

△ (1) Confirm that all bolts and nuts are tightened and secured certainly. Specially, take care of inner parts of engine which can not be seen during running.

⚠ (2) Confirm that there is no abnormality of each engine parts, by turning and priming.

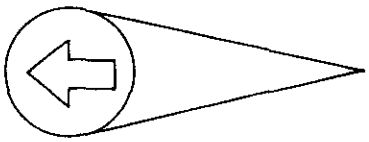
◇! (3) Confirm that the position of turning gear is "DISENGAGED" .

(4) Record in working diary the details of work and exchanged parts.

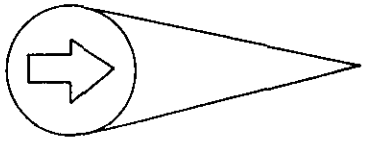
4. Caution in case of turning the main engine after standstill for a long period.

⚠ The lubricating in each bearing shell should be done certainly at least five(5) minutes with running the L.O. pump before turning the main engine in order to prevent the damage on bearing running surface from such as scratches and/or seizures due to lack of L.O..

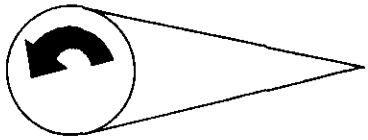
SYMBOLS — シンボルマーク



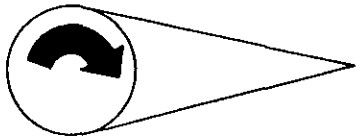
DISMANTLE, REMOVE, WITHDRAW
分解する。取りはずす。取り去る。



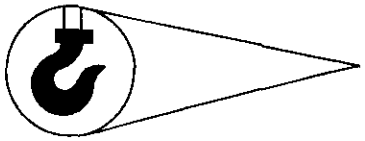
MOUNT, CONNECT, FIT
組立てる。結合する。取付ける。



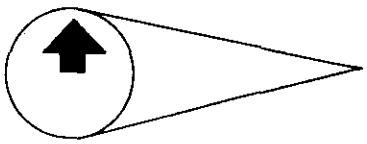
UNSCREW, LOOSEN, TURN IN DIRECTION OF ARROW
ねじをゆるめる。ゆるめる。矢印の方向に回す。



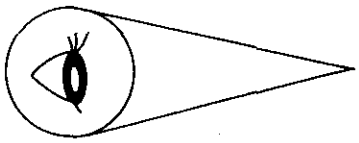
SCREW ON, TIGHTEN, TURN IN DIRECTION OF ARROW
ねじを締める。締める。矢印の方向に回す。



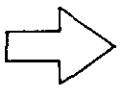
CONNECTION OF CRANE
クレーンにつなぐ。



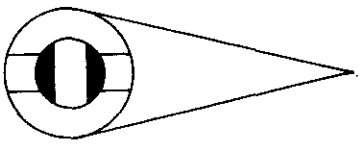
LOOSEN - TIGHTEN WITH HYDRAULIC TOOLS
油圧要具による締付およびゆるめ。



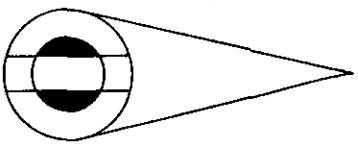
PAY ATTENTION, CHECK
注意せよ。チェックせよ。



INDICATES DIRECTION, SHOWS DETALL
方向指示。詳細を見よ。

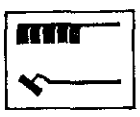


CLOSE VALVE, COCK
閉弁する。



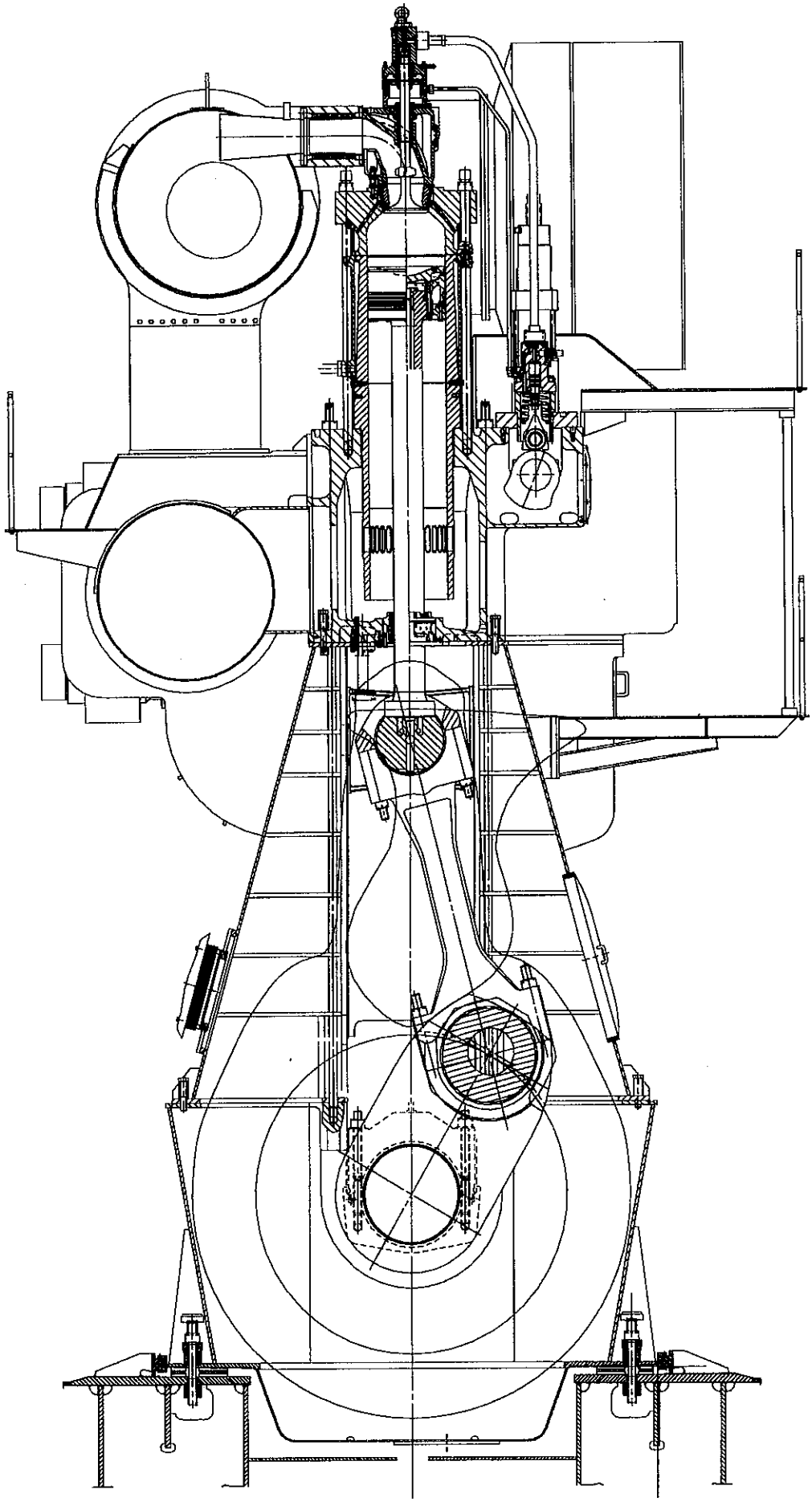
OPEN VALVE, COCK
開弁する。

LUBRICATE WITH PRESCRIBED LUBRICANT
指定の潤滑剤で潤滑する。



CLEAN
掃除する。

Cross Section through Engine



The Checking and Maintenance Programme indicates the intervals at which it is deemed appropriate to inspect the individual components of the engine and to carry out overhauls, if necessary, based on the engine condition or on time criteria.

The procedures contained in the instruction book are arranged in a logical order, and the following Checking and Maintenance Programme can be used as a table of contents.

The stated 'Normal hours of service' are only to be used as a guidance, as difference in the actual service conditions, the quality of the fuel oil, lubricating oil, treatment of cooling water, etc. will decisively influence the actual service results, and thus the intervals between necessary overhauling.

Design modifications may necessitate a revision of the instructions, and in that case the revised instructions and changed overhauling intervals, if any, will apply and supersede those originally issued (*see e.g our Service Letters*).

The procedures are divided into three categories:

A. Condition checking procedures,
marked under the heading 'Normal hours of service' by **C**, deal with the service condition of a number of engine components, and form the basis for estimating whether further overhauling is necessary. In a number of cases the condition checking procedures refer to Volume I, OPERATION, in which more detailed descriptions and working procedures can be found.

Where a procedure number is stated under the heading 'Related procedure', it will be appropriate to carry out this procedure at the same time.

B. Condition-based overhauling procedures
are those procedures which under the heading 'Normal hours of service' are marked by **O**, and opposite which, under the heading 'Overhaul to be based on procedure No.', a procedure number is stated.

This procedure number normally refers to one of the above condition checking procedures which form the basis of the overhaul. For this reason, the intervals stated are for guidance only.

Where several procedures are to be carried out on the same estimation basis, and these belong together with regard to the work, this is stated under the heading 'Related procedure'.

C. Time-based overhauling procedures,
also marked by **O** under the headings 'Normal hours of service' or 'Based on observations', are the procedures where an actual basis for estimation is lacking. It is recommended, therefore, to carry out these procedures at the overhauling intervals stated as a basis.

Where a symbol **O** or **C** is indicated under the heading 'Based on observations', this is due to the fact that special service conditions may make checking or overhauling necessary beyond the actual programme.

No.	PROCEDURE	Overhaul to be based on procedure No.: or to refer to:	Check new/overhauled parts after 500 - 1500 hours	Normal hours of service: 2000 hours	4000 hours	6000 hours	8000 hours	16000 hours	4 years (survey)	Based on observations	Related procedure
901	**CYLINDER COVER**										
-1	Cylinder cover										
-1.2	*Dismantling*									O	
-1.3	Overhaul										
-1.4	Mounting										
902	**PISTON WITH ROD AND STUFFING BOX**										
-1	Piston	901-1									
-1.1	Checking	*)	C	C							
-1.2	Dismantling										901-1
-1.3	Overhaul	***)					O	O			
-1.4	Mounting										
-2	Stuffing box										
-2.1	*Checking*						C				
-2.2	Dismantling	902-1									
-2.3	Overhaul						O				
-2.4	Mounting										
903	**CYLINDER LINER AND LUBRICATION**										
-1	Cylinder liner	901-1									
-1.1	Checking	***)	C	C							902-1
-1.2	Dismantling										
-1.3	Overhaul						O			O	
-1.4	Mounting										
-2	*Cylinder lubricators*										
-2.1	Checking	*(**)								O	
904	**CROSSHEAD WITH CONNECTING ROD**										
-1	Crosshead bearings										904-4
-1.1	*Checking*						C				905-2
-1.2	Dismantling								C	O	
-1.4	Mounting										
-2	Crosshead										
-2.2	Dismantling									O	
-2.4	Mounting										
-3	Reciprocating parts										
-3.1	Checking									O	

*) : See Vol. I Operation
**) : See maker's instructions
***) : See special notes
C : Check the condition
O : Overhaul to be carried out
A : Adjustment to be carried out

No.	PROCEDURE	Overhaul to be based on procedure No.: or to refer to:	Check new/overhauled parts after 500 - 1500 hours	Normal hours of service: 2000 hours	4000 hours	6000 hours	8000 hours	16000 hours	4 years (survey)	Based on observations	Related procedure
-4	Crankpin bearings										904-1
-4.1	Checking		C				C				905-2
-4.2	Dismantling										
-4.4	Mounting										
-5	Connecting rod										
-5.2	Dismantling									O	904-1
-5.4	Mounting										
905	**CRANKSHAFT, THRUST BEARING AND TURNING GEAR**										
-1	Deflection of Crankshaft										
-1.1	Checking	*)	C				C				
-2	Main bearings										904-1
-2.1	Checking	905-1	C				C				904-4
-2.2	Dismantling								C	C	
-2.4	Mounting									A	
-3	Thrust bearings										
-3.1	Checking		C				C				
-3.2	Dismantling								C		
-3.4	Mounting										
-5	Axial vibration damper										
-5.1	Checking									C	
-5.2	Dismantling										
-5.3	*Overhaul*									O	
-5.4	Mounting										
906	**MECHANICAL CONTROL GEAR**										
-1	Chains										
-1.1	Checking	*)	C				C				
-1.2	Dismantling										
-1.4	Mounting										
-2	Chain tightener										
-2.2	Adjustment									A	
-3	Camshaft										
-3.1	Checking		C				C			C	
-3.3	Adjustment									A	

*) : See Vol. I Operation
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C : Check the condition
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No.	PROCEDURE	Overhaul to be based on procerure No.: or to refer to:	Check new/overhauled parts after 500-1500 hours	Normal hours of service: 2000 hours	4000 hours	6000 hours	8000 hours	16000 hours	4 years (survey)	Based on observations	Related procedure
-4	Camshaft bearings								C		
-4.1	Checking										
-4.2	Dismantling										
-4.4	Mounting										
-5	Moment compensator										
-5.1	Checking									C	
-5.3	Adjustment									A	
907	**STARTING AIR SYSTEM**										
-1	Starting air distributor										
-1.1	Checking		C				C				
-1.3	Adjustment									A	
-2	Starting air valve										
-2.2	Dismantling										
-2.3	Overhaul						O				
-2.4	Mounting										
908	**EXHAUST VALVE**										
-1	High-pressure pipe										
-1.2	Dismantling										
-1.3	Overhaul									O	
-1.4	Mounting										
-2	Exhaust valve										
-2.1	Checking					C					
-2.2	Dismantling										
-2.3	Overhaul - Nimonic valve spindle					C*_)		O			
	- valve spindle with hard facing					O					
	*_) When new exhaust valve is fitted										
-2.4	Mounting										
-3	Exhaust valve actuator										
-3.1	Checking										
-3.2	Dismantling										
-3.3	Overhaul							O			
-3.4	Mounting										
-4	Exhaust valve roller guide										
-4.1	Checking	*)	C					C			
-4.2	Dismantling										
-4.3	Overhaul									O	
-4.4	Mounting										

*) : See Vol. I Operation
**) : See maker's instructions
***) : See special notes
C : Check the condition
O : Overhaul to be carried out
A : Adjustment to be carried out

No.	PROCEDURE	Overhaul to be based on procerure No.: or to refer to:	Check new/overhauled parts after 500-1500 hours	Normal hours of service: 2000 hours	4000 hours	6000 hours	8000 hours	16000 hours	4 years (survey)	Based on observations	Related procedure
-5	Exhaust valve cam										
-5.1	Checking									C	
-7	Exhaust valve emergency running									C	
909	**FUEL OIL SYSTEM**										
-1	Fuel pump lead										
-1.1	Checking	*)								C	
-1.3	Adjustment									A	
-3	Fuel pump cam										
-3.2	Adjustment	909-1								A	
-4	Fuel pump										
-4.2	Dismantling										
-4.3	Overhaul									O	
-4.4	Mounting										
-5	Fuel pump top cover										
-5.2	Dismantling										
-5.3	Overhaul									O	
-5.4	Mounting										
-6	Fuel pump barrel assembly										
-6.2	Dismantling										
-6.3	Overhaul									O	
-6.4	Mounting										
-7	Fuel pump suction valve										
-7.3	Overhaul				C		O				909-5
-8	Fuel pump puncture valve										
-8.3	Overhaul				C		O				909-5
-9	Fuel pump shock absorber										
-9.1	Checking						C				
-9.3	Overhaul									O	

*) : See Vol. I Operation
**) : See maker's instructions
***) : See special notes
C : Check the condition
O : Overhaul to be carried out
A : Adjustment to be carried out

No.	PROCEDURE	Overhaul to be based on procerure No.: or to refer to:	Check new/overhauled parts after 500-1500 hours	Normal hours of service: 2000 hours	4000 hours	6000 hours	8000 hours	16000 hours	4 years (survey)	Based on observations	Related procedure
-11	Fuel valve										
-11.1	Checking		C		C						
-11.2	Dismantling										
-11.3	Overhaul						O				
-11.4	Mounting										
-12	Spindle guide										
-12.3	Overhaul						O				
-13	Fuel valve non-return valve										
-13.3	Overhaul						O				
-14	Fuel oil high-pressure pipe										
-14.3	Overhaul									O	909-5
-15	Reversing mechanism										
-15.1	Checking									C	
-15.2	Dismantling										
-15.3	Overhaul									O	
-15.4	Mounting										
-16	Fuel pump emergency running									O	
910	**TURBOCHAGER SYSTEM**										
-1	Air cooler element	*)									
-1.1	Checking										
-1.2	Dismantling										
-1.3	Overhaul				O					O	
-1.4	Mounting										
-2	Non-return valve										
-2.3	Overhaul		C							O	
-3	Auxiliary blower										
-3.3	Overhaul									O	
-6	Watermist catcher										
-6.2	Dismantling										910-1
-6.4	Mounting										

MITSUI MAN B&W

S50MC-C

CHECKING AND MAINTENANCE PROGRAMME

*) : See Vol. I Operation
**) : See maker's instructions
***) : See special motes
C : Check the condition
O : Overhaul to be carried out
A : Adjustment to be carried out

No.	PROCEDURE	Overhaul to be based on procerure No.: or to refer to:	Check new/overhauled parts after 500-1500 hours	Normal hours of service: 2000 hours	4000 hours	6000 hours	8000 hours	16000 hours	4 years (survey)	Based on observations	Related procedure
911	**SAFETY EQUIPMENT**										
-1	Safety valve										
-1.2	Dismantling										
-1.3	Overhaul						C			O	
-1.4	Mounting										
-2	Relief valve										
-2.1	Checking								C	O	
912	**ASSEMBLY OF LARGE PARTS**										
-1	Holding down bolts and end chock bolts, cast iron										
-1.1	Checking		C				C				
-2	Holding down bolts and end chock bolts, epoxy										
-2.1	Checking		C				C				
-3	Stay bolts										
-3.1	Checking		C				C				
913	**GENERAL TOOLS**										
-1	Hydraulic tools										
-5	Torque spanner										
-6	Tightening gauge										
-7	Screws and nuts - locking										
-11	Lubricating procedures										

SPECIAL NOTES

Piston overhaul - Section 902:
8000 h piston rings only
16000 h piston complete

Cylinder liner - Section 903:
1000 + 2000 h inspection through scavenge ports
8000 h measuring inside liner

INDEX

CYLINDER COVER

PISTON WITH ROD AND STUFFING BOX

CYLINDER LINER AND
CYLINDER LUBRICATION

CROSSHEAD WITH CONNECTING ROD

CRANKSHAFT, THRUST BEARING
AND TURNING GEAR

MECANICAL CONTROL GEAR

STARTING AIR SYSTEM

EXHAUST VALVE

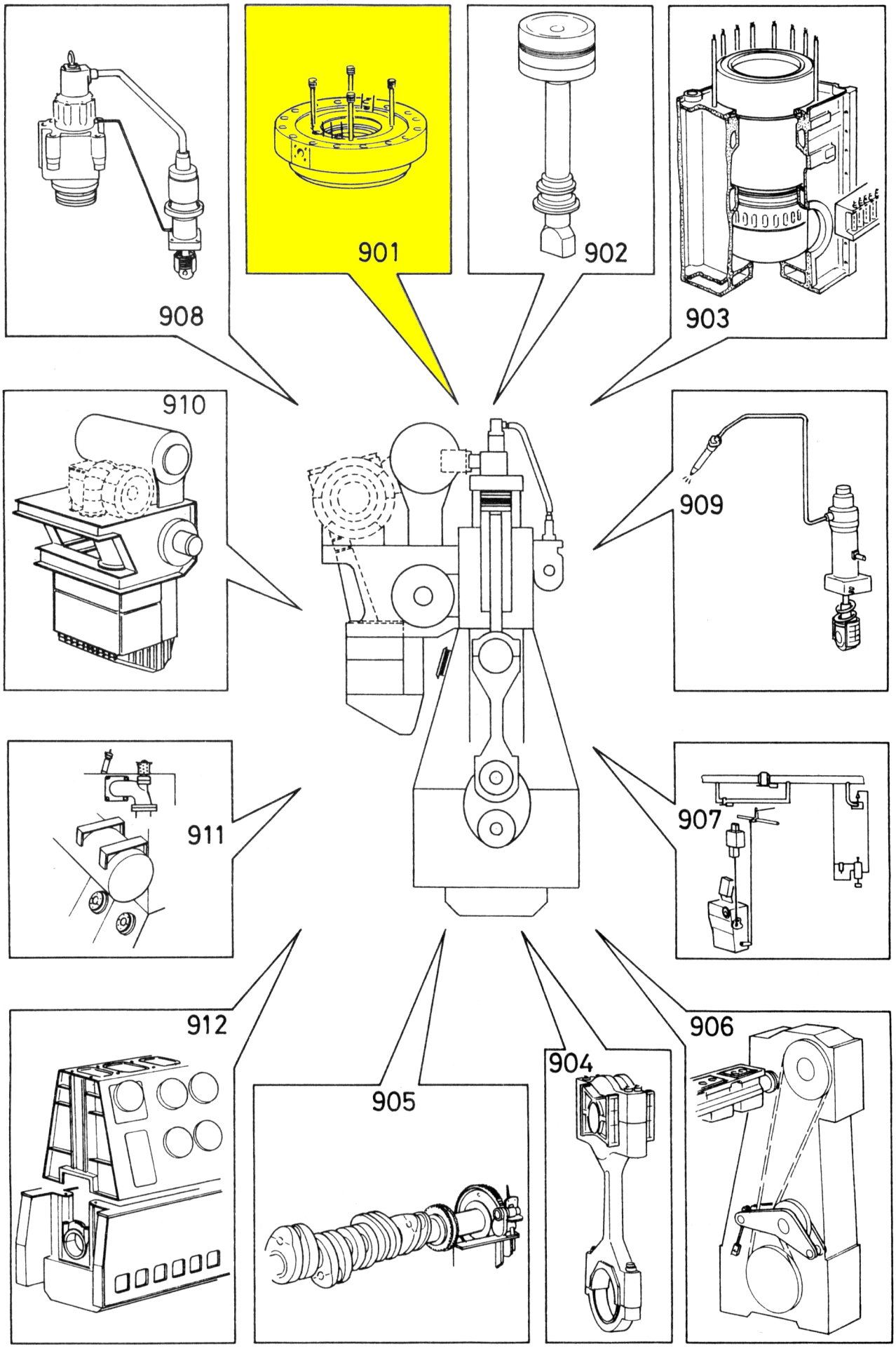
FUEL OIL SYSTEM

TURBOCHARGER SYSTEM

SAFETY EQUIPMENT

ASSEMBLY OF LARGE PARTS

GENERAL TOOLS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SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of high pressure oil
X	Block the starting mechanism	Risk of hot surface
X	Shut off starting air supply	Do not enter area when over head lifting is being carried out
X	Engage turning gear	Turning prohibited while at work (while some valves being opened)
X	Shut off cooling water	
X	Shut off fuel oil	
	Shut off lubricating oil	
X	Lock turbocharger rotors	

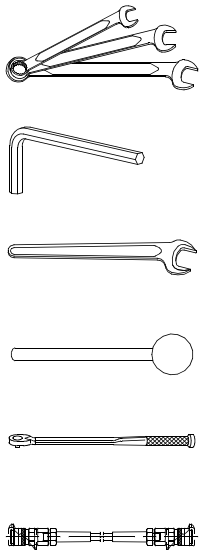
Data

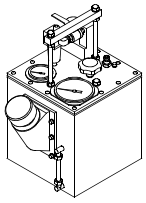
Ref.	Description	Value	Unit
D-1	Weight of exhaust valve stud	8	kg
D-2	Weight of cyl. cover compl.	1670	kg
D-3	Weight of cooling jacket	39	kg
D-4	Exhaust valve studs - screwing-in torque	200	Nm
D-5	Starting valve studs - screwing-in torque	145±20	Nm
D-6	Fuel valve studs - screwing-in torque	140±20	Nm
D-7	Weight of high-pressure pipe (exhaust valve)	34	kg
D-8	Hydraulic pressure for cylinder cover: - tightening	150 MPa (1500 bar)	
	- dismantling	150-165 MPa (1500-1650 bar)	

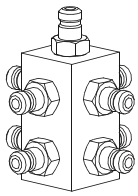
Note!
Permit to Max. 165 MPa (1650 bar) only in a short time.

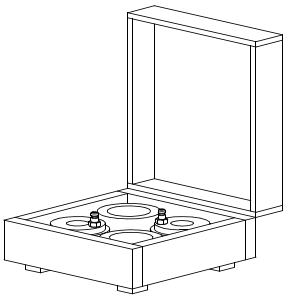
D-9	Fuel oil high-pressure pipe (fuel pump/fuel valve) - tightening torque	100	Nm
D-10	High-pressure pipe (exhaust valve) - tightening torque	36	Nm
D-11	Weight of fuel oil high-pressure pipes	7	kg

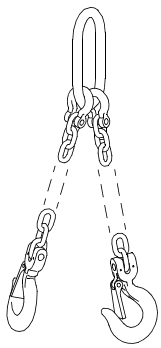
Standard Tools: See Section 913

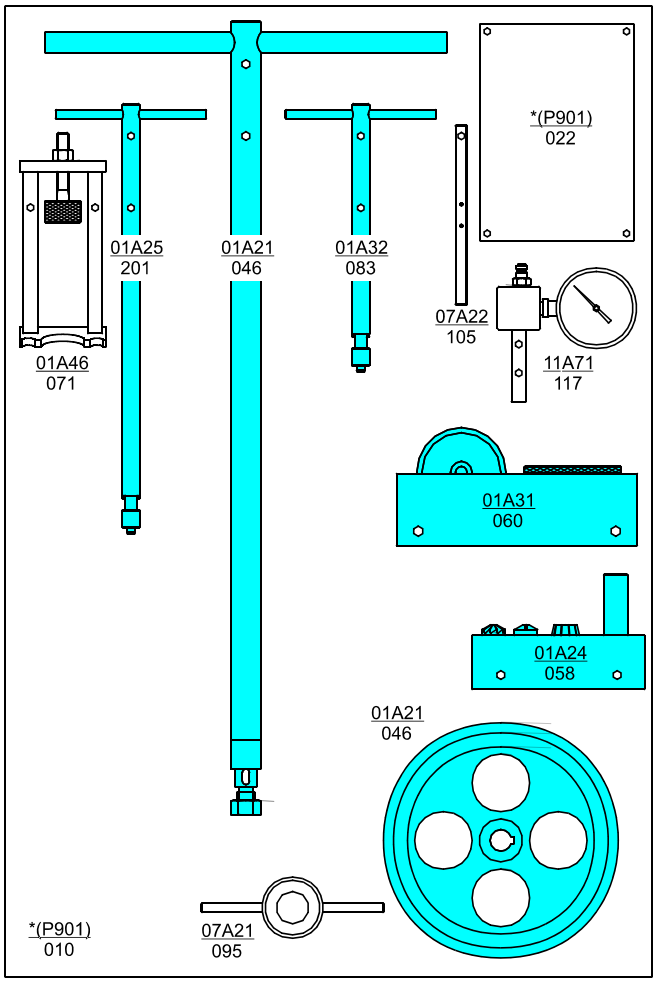








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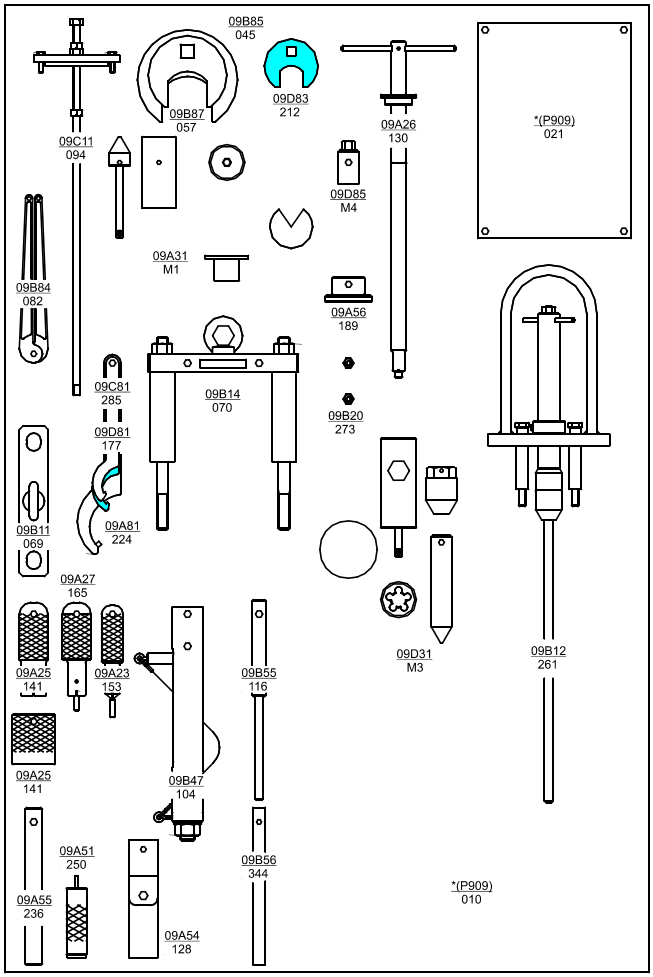
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1. Set the blocking device **A** on the main starting valve in the BLOCKED position.

   Engage the gear **B**.

   Close the fuel oil inlet valve **C**.

   Close the cooling water inlet valve **D**.

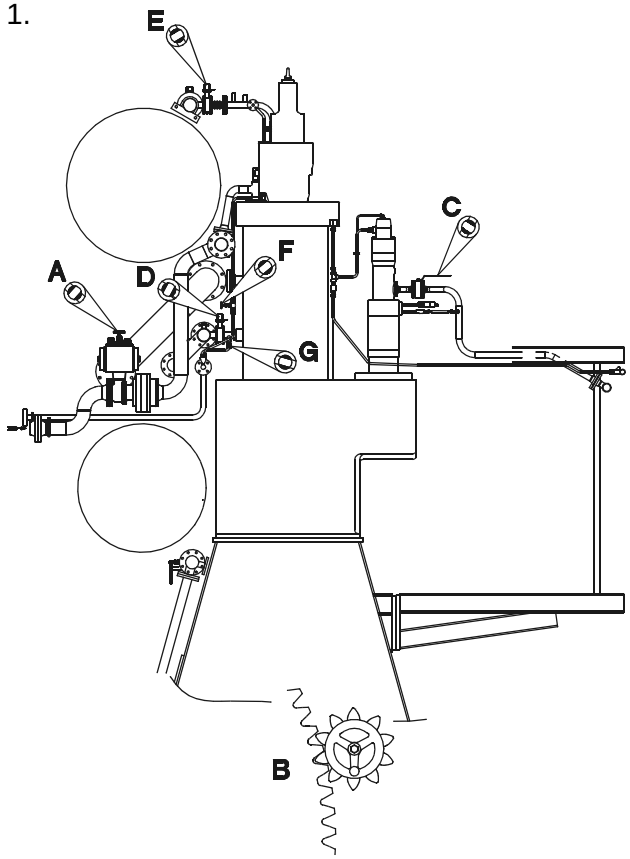
   Close the cooling water outlet valve **E**.

   Open the cooling water drain cocks **F** and **G**.

   Shut off the control air and safety air supply. Vent the manoeuvring system through the ball valve.

   Also shut off the air supply on the reduction unit for the hydraulic/pneumatic exhaust valve, and vent the system.

1.



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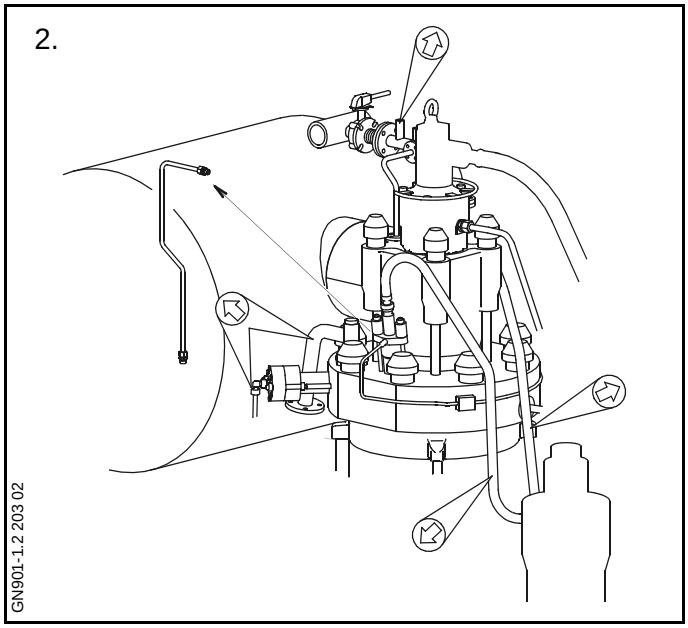
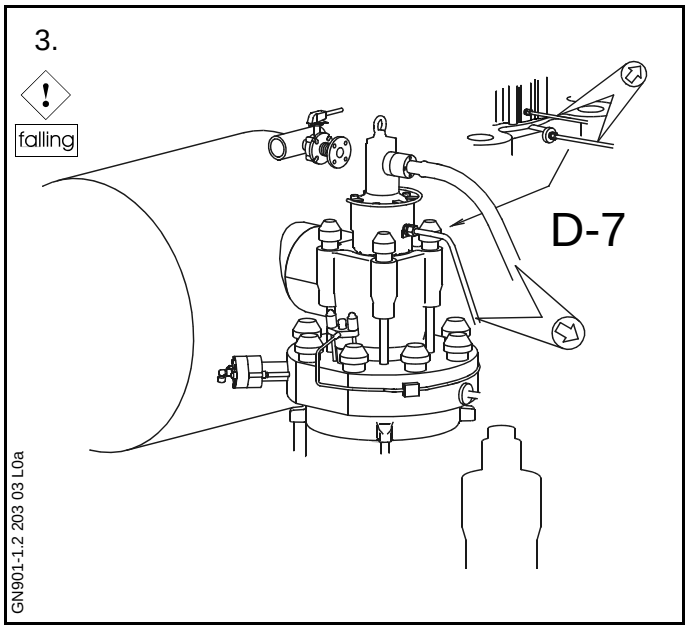
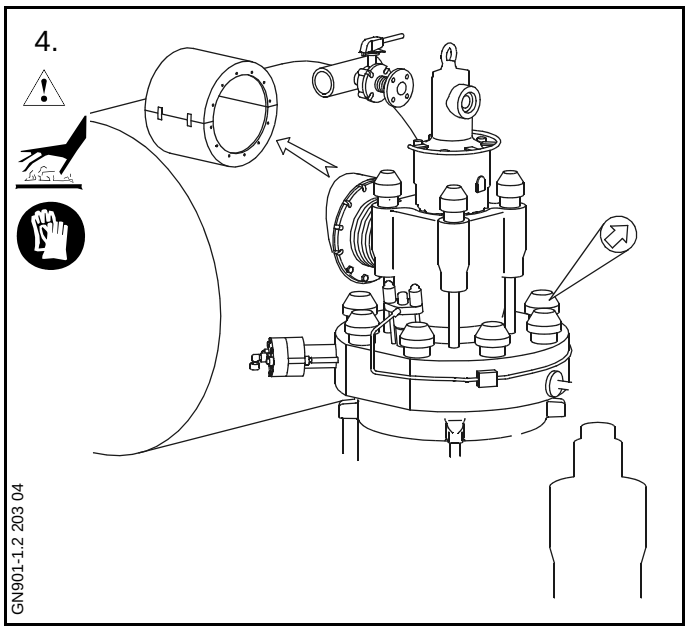






2. Remove the cooling water inlet and outlet pipes from the exhaust valve and cylinder cover.

   Remove the drain pipe from the intermediate pipe between the cylinder cover and the exhaust valve.

   Dismount the fuel oil high-pressure pipes between the fuel valves and pump.

   Dismount the control air pipe from the starting valve.

   Remove the starting air pipe.

3. Remove the screws which fasten the high-pressure pipe to the oil cylinder on the exhaust valve and the hydraulic activator, and lift the high-pressure pipe away.

   Dismount the drain oil pipe between the exhaust valve and the hydraulic activator, the air pipe for the pneumatic exhaust valve, and the pipes for the seal air.

4. Remove the protective jacket enclosing the intermediate pipe between the exhaust receiver and the exhaust valve.

   Dismount the screws in the flange between the intermediate pipe and the exhaust receiver. The four lowermost screws need not be dismantled, just loosened.

   Remove the protective caps from the cylinder cover nuts.

5. Place eight spacer rings over the nuts, and screw the eight hydraulic jacks onto the studs.

   Connect the high-pressure pump to the jacks by means of the distributor block and the high-pressure hoses.

   Using the vent screws of the hydraulic nuts, vent the system and increase the pressure as stated in Data.
   For operation of the hydraulic tools, see Chapter 913.

   Loosen the nuts by applying the tommy bar through the slots in the spacer rings.

   Relieve the system of pressure.

   Disconnect the high-pressure hoses from the jacks.

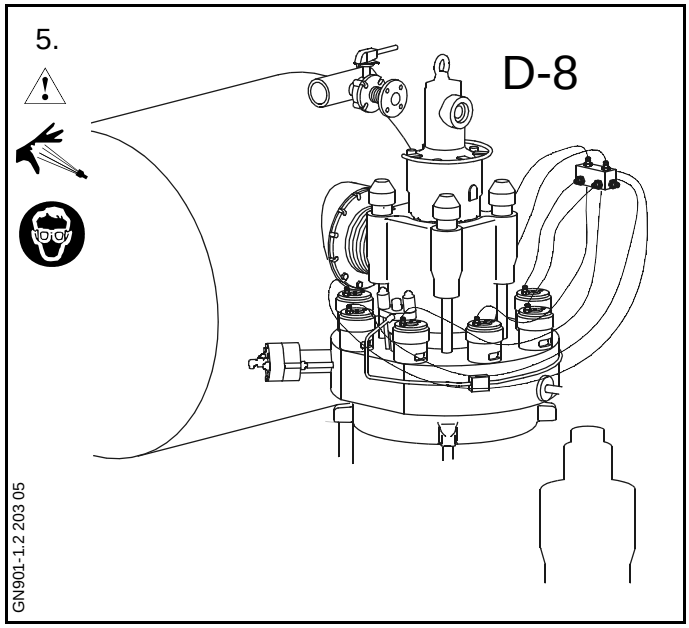
   Finally, remove the hydraulic jacks and spacer rings, and unscrew the nuts.

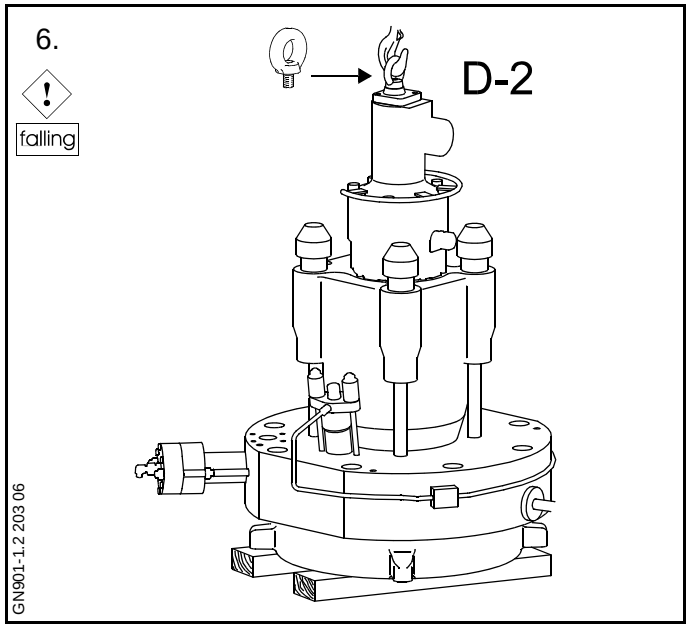
6. Mount the eye screw in the lifting tool on top of the exhaust valve.

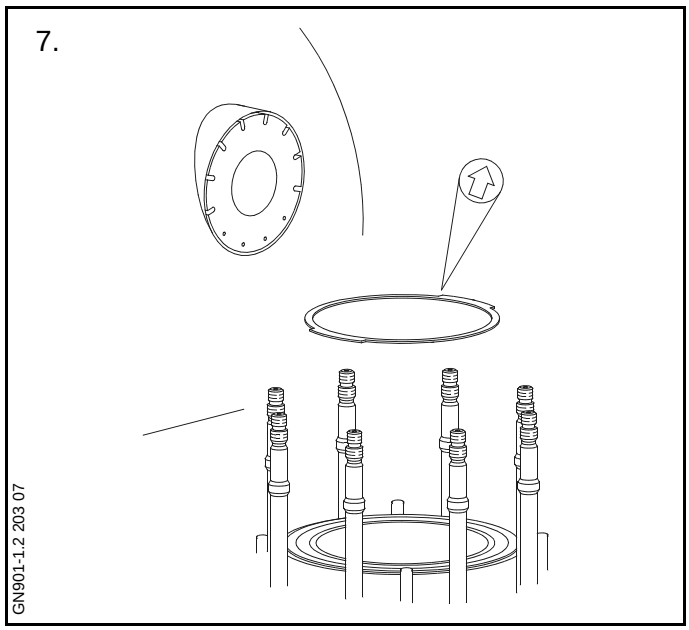
   Hook the engine room crane on to the lifting attachment on top of the exhaust valve.

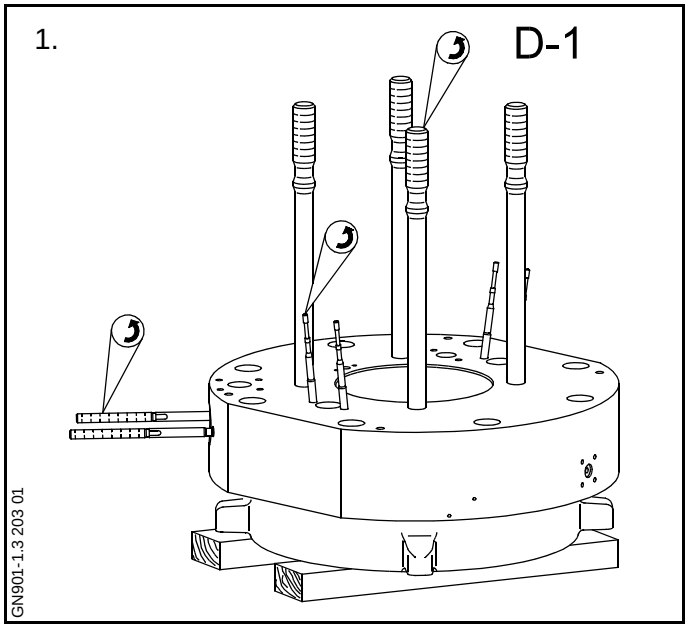
   Lift away the cylinder cover complete, and land it on a couple of wooden planks.

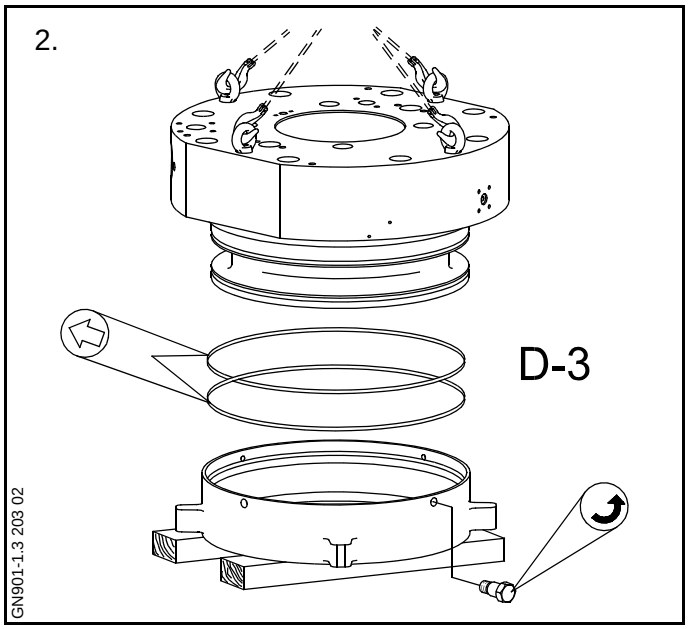
7. Remove and discard the seal ring between cylinder cover and cylinder liner.

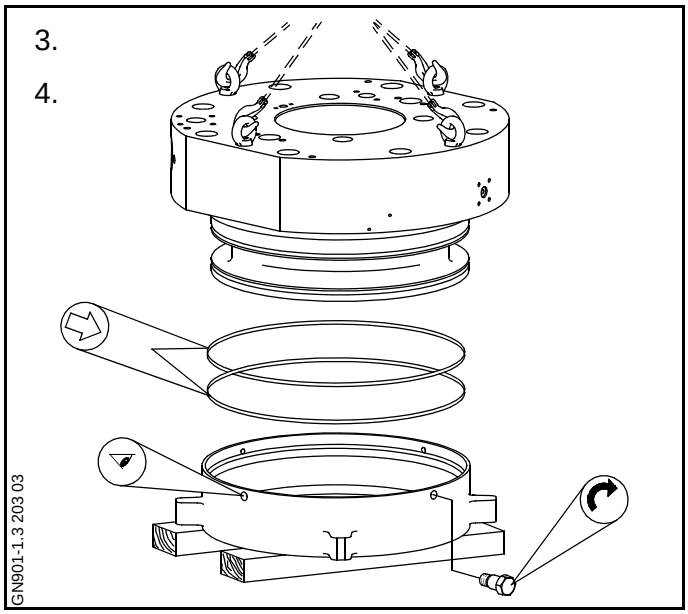












1. Dismount all valves and pipes on the cylinder cover.

   Dismount all studs on the top of the cylinder cover.

2. Unscrew the four screws which secure the cooling jacket to the cylinder cover.

   Lift the cylinder cover free of the cooling jacket and land it on a couple of planks.

   If the cooling jacket sticks, use dismantling screws to force the jacket/cover apart.

3. Remove and discard the O-rings from the cover, and carefully clean the cooling jacket and the cylinder cover.

   Provide the cylinder cover with new O-rings, well lubricated with oil.

4. Lift the cylinder cover and guide the jacket/ cover into position, using the guide pin as reference (camshaft side).

   Mount and tighten the screws for the cooling jacket.

5. Recondition the valve bores as follows:

Fuel valve bore

6. The tool consists of a common spindle with handle, and of a guide, a carbon cutter, a seating face cutter, and a grinding mandrel.

   Clean the fuel valve bores, using the carbon cutter. If required, recondition the fuel valve seating with the appropriate cutter.

   Grind the seating with the grinding mandrel and a grinding compound (e.g. Carborundum No. 200).

   After the milling/grinding, clean the bore and seating carefully, and check that the seating is not damaged.

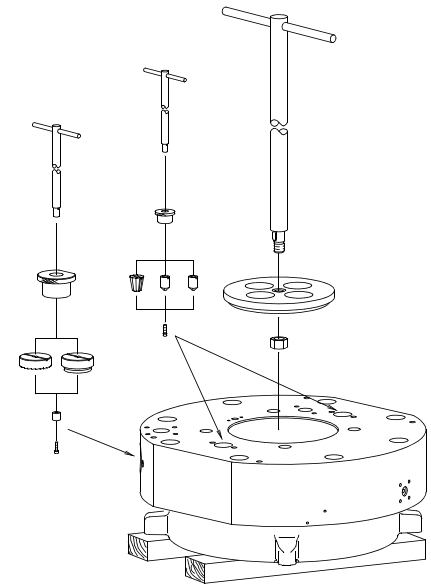
Exhaust valve bore

7. The tool consists of a spindle with handle and a grinding disc.

   After cleaning the valve bore and seating, grind the seating with the grinding disc and a grinding compound (e.g. Carborundum No. 200).

   After the grinding, clean the bore and seating carefully, and check that the seating is not damaged.

5.



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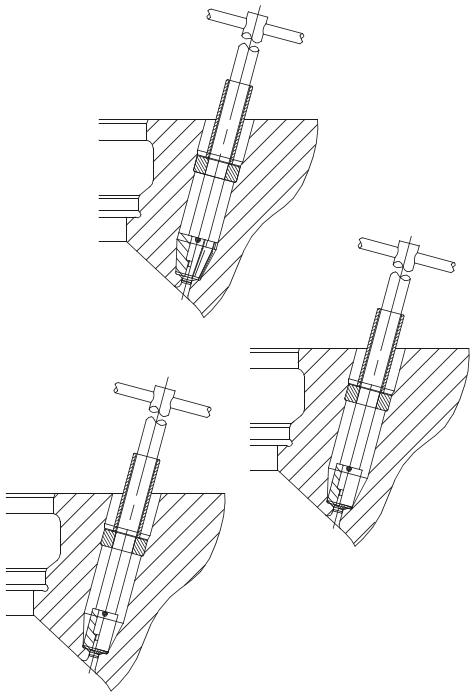

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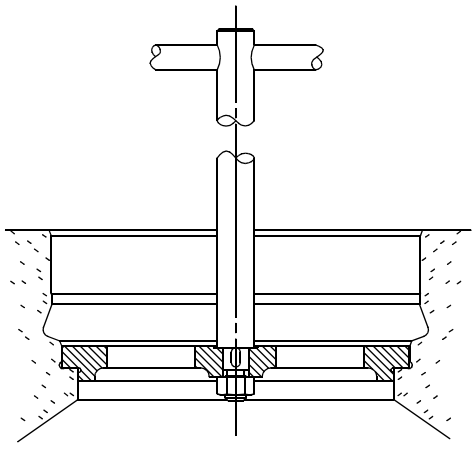

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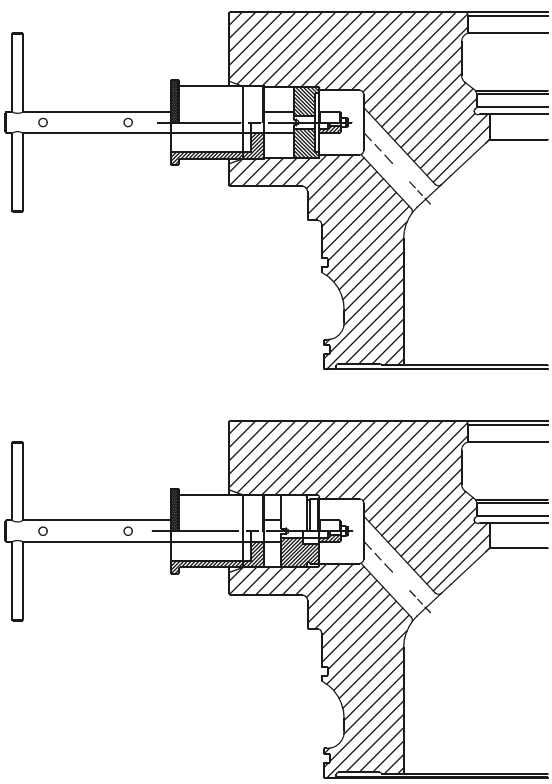

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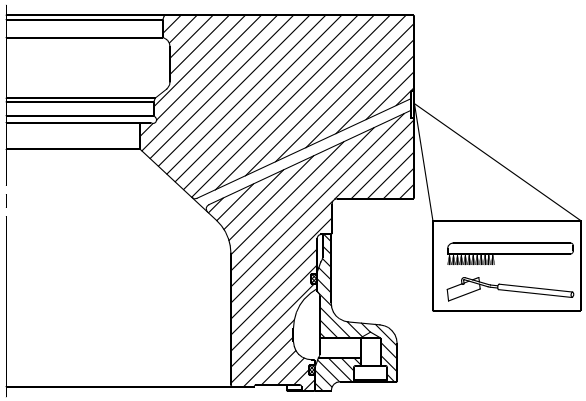

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Starting valve bore

8. The tool consists of a guide, a cutter, and a grinding disc.

   Recondition the starting valve bore and seating in the same way as described for the fuel valve bore.

   When replacing valves on a cylinder cover that is mounted on the engine, recondition the valve bores/seating in the same way as described here, but without dismounting the studs.

9. Clean the bores for safety valve/indicator cock.

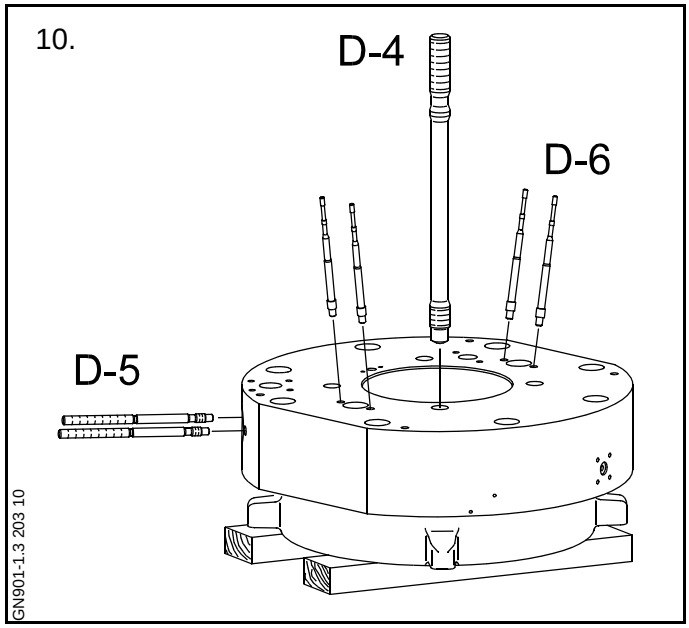
10. Lubricate the threads with ‘Never Seize' or Molybdenum Disulphide (MoS_2) and mount the valve studs.

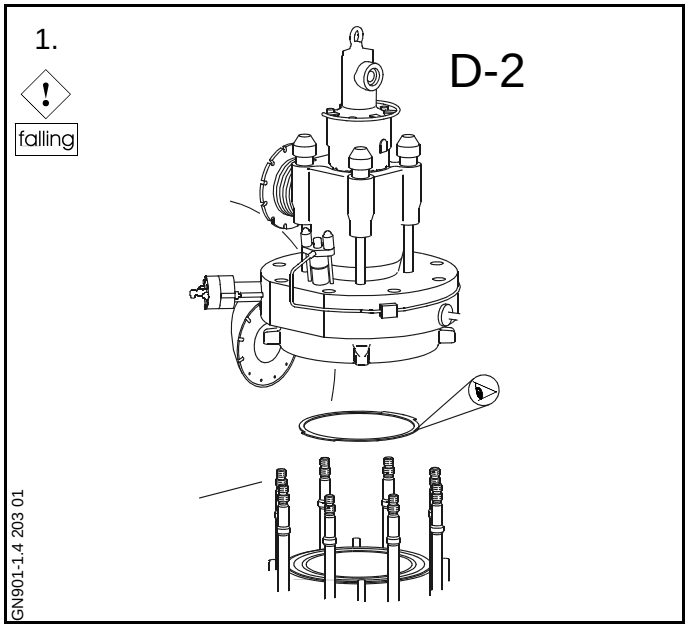
    Tighten up the studs in accordance with the screwing-in torque stated on the data sheet.

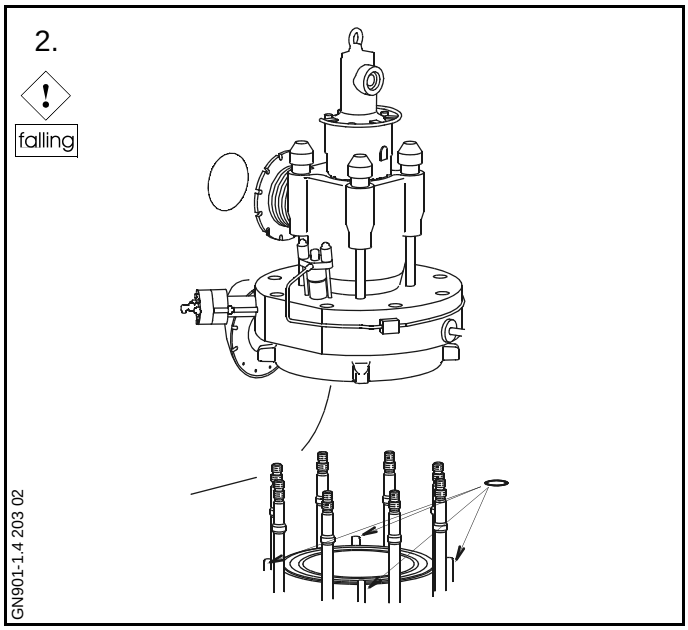
    Fill up the grooves between the valve studs and the bores for the valve studs with permatex to prevent water or oil from entering the bores during operation of the engine.

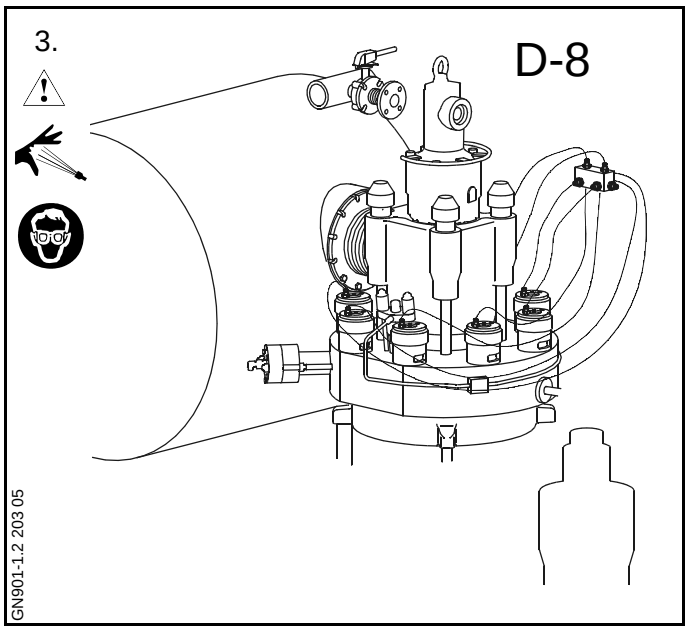
    Provide the water connection flanges with new gaskets, and keep the cylinder cover ready for replacement.

    Always fit new or overhauled valves before a cylinder cover is mounted on the engine.









1. Place a new seal ring on top of the cylinder liner with the guide tabs in the fore and aft direction.

   This is to ensure that the tabs fit into the two gas blow-out grooves milled in the cylinder cover guide recess.

2. Lift the cylinder cover by means of the crane and **carefully** wipe the contact surface which faces the cylinder liner.

   Provide the cooling water connecting pipes with new O-rings and lubricate them with grease or soft soap.

   Mount a new 'klinger' seal ring in the groove of the flange of the intermediate pipe.

   Lower the cover **carefully** into position.

   During the landing, **carefully** check that the cooling water connecting pipes engage correctly with the holes in the cooling jacket.

3. Mount the cover nuts on the studs and screw down.

   Place eight spacer rings, one around each nut, and mount the eight hydraulic jacks on the studs.

   Connect the high-pressure pump to the jacks by means of the distributor block and the high-pressure hoses.

   Use the vent screws of the hydraulic nuts to vent the system, and then increase the pressure as stated in Data.
   For operation of the hydraulic tools, see Chapter 913.

   Tighten the nuts by applying the tommy bar through the slots in the spacer rings.

   Relieve the system of pressure.

   Finally, remove the hydraulic jacks and spacer rings from the nuts.

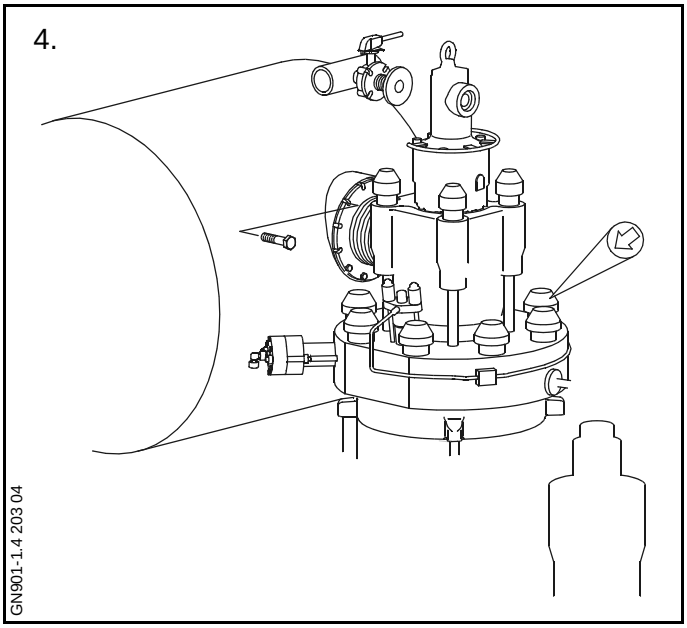
4. Mount the protective caps on the cylinder cover studs.

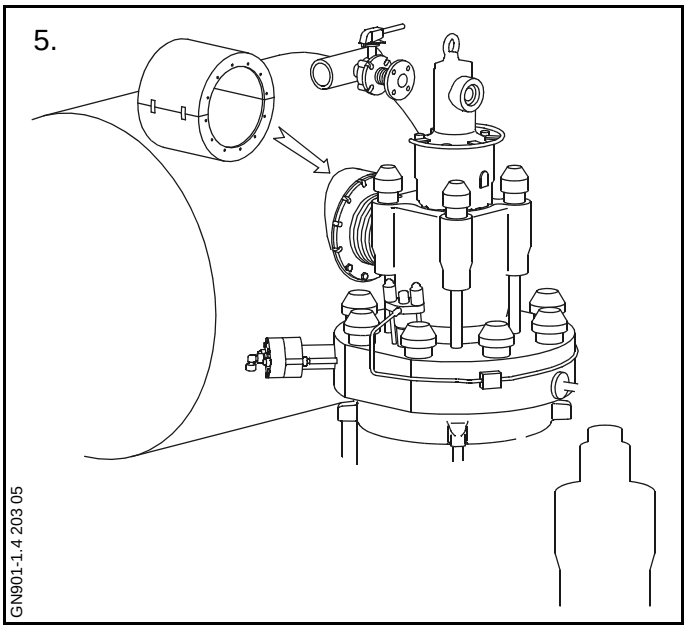
   Align the intermediate pipe so that the holes in the flange of the intermediate pipe are in line with the threaded holes in the exhaust valve.

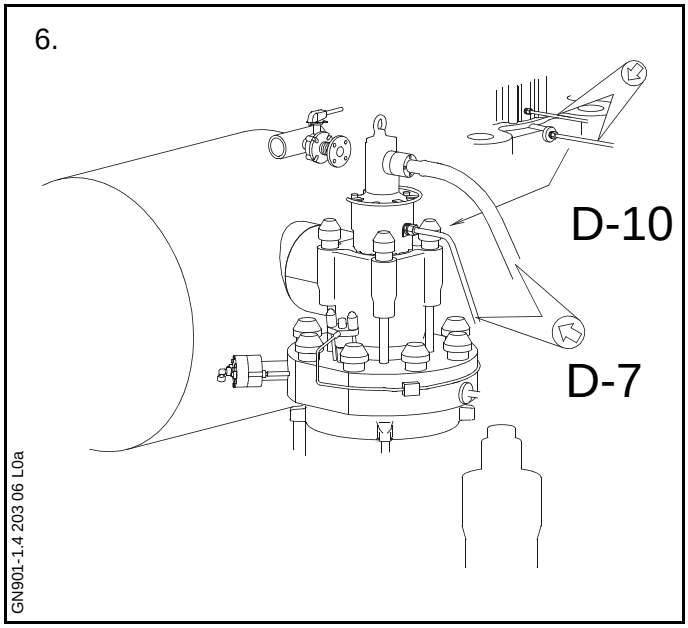
   Mount the screws of the flange between the intermediate pipe and the exhaust receiver.

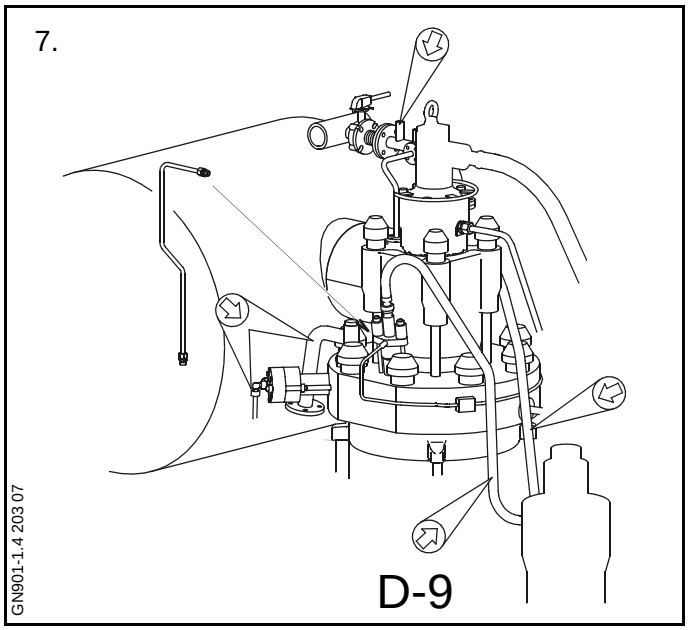
Note!
Lubricate the screws with 'Never Seize' or Molybdenum Disulphide (MoS_2) before mounting.

5. Mount the insulating jacket around the intermediate pipe.









6. Mount the return oil pipe, the seal air pipe and the air pipe for pneumatic closing of the exhaust valve.

   Mount the high-pressure pipe for the hydraulic valve gear.
   See Procedure 908-1.3.

7. Mount the starting air pipe and control air pipe for the starting valve.

   Mount the cooling water inlet and outlet pipes on the exhaust valve.

   Mount the drain pipe on the intermediate pipe between the exhaust valve and the cylinder cover.

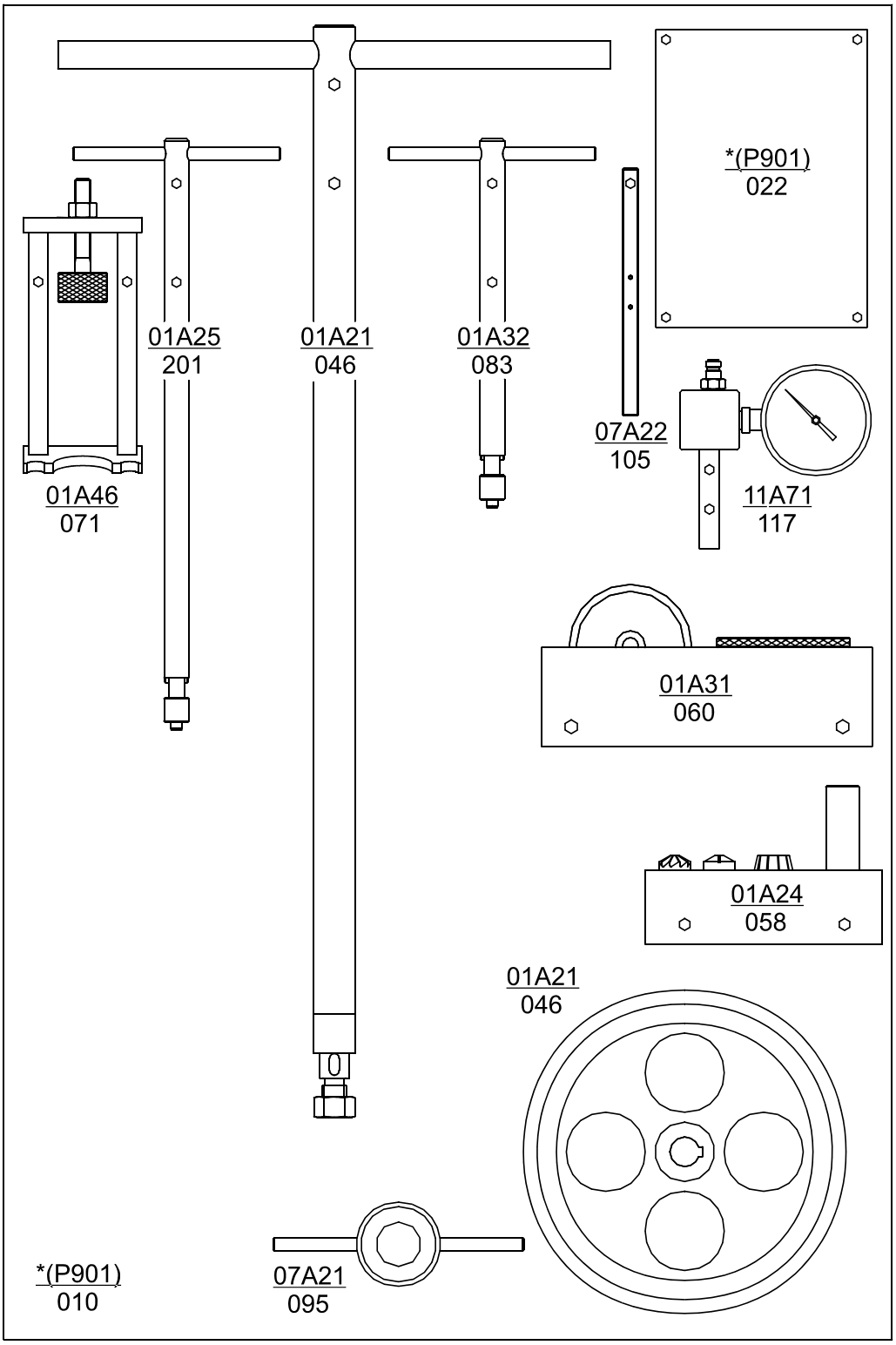
   Using a crowfoot wrench and torque spanner, mount the fuel oil high-pressure pipes between the fuel pump and the fuel valves (checking that the pipes fit properly at the seats and that all parts are clean and provided with new O-rings).
   See Procedure 909-13.4.

   Connect the outlet pipe from the return oil pipe on the fuel valves.

   Shut the drain valves and open the cooling water inlet. After venting the cylinder section, shut the vent cocks and open the cooling water outlet valve.

   Open the fuel oil, lubricating oil and air supplies to the alarm system.

Caution !
The air supply to the exhaust valve must always be connected **before** starting the camshaft oil pumps. This is **very** important, because otherwise the valve will open more than normal.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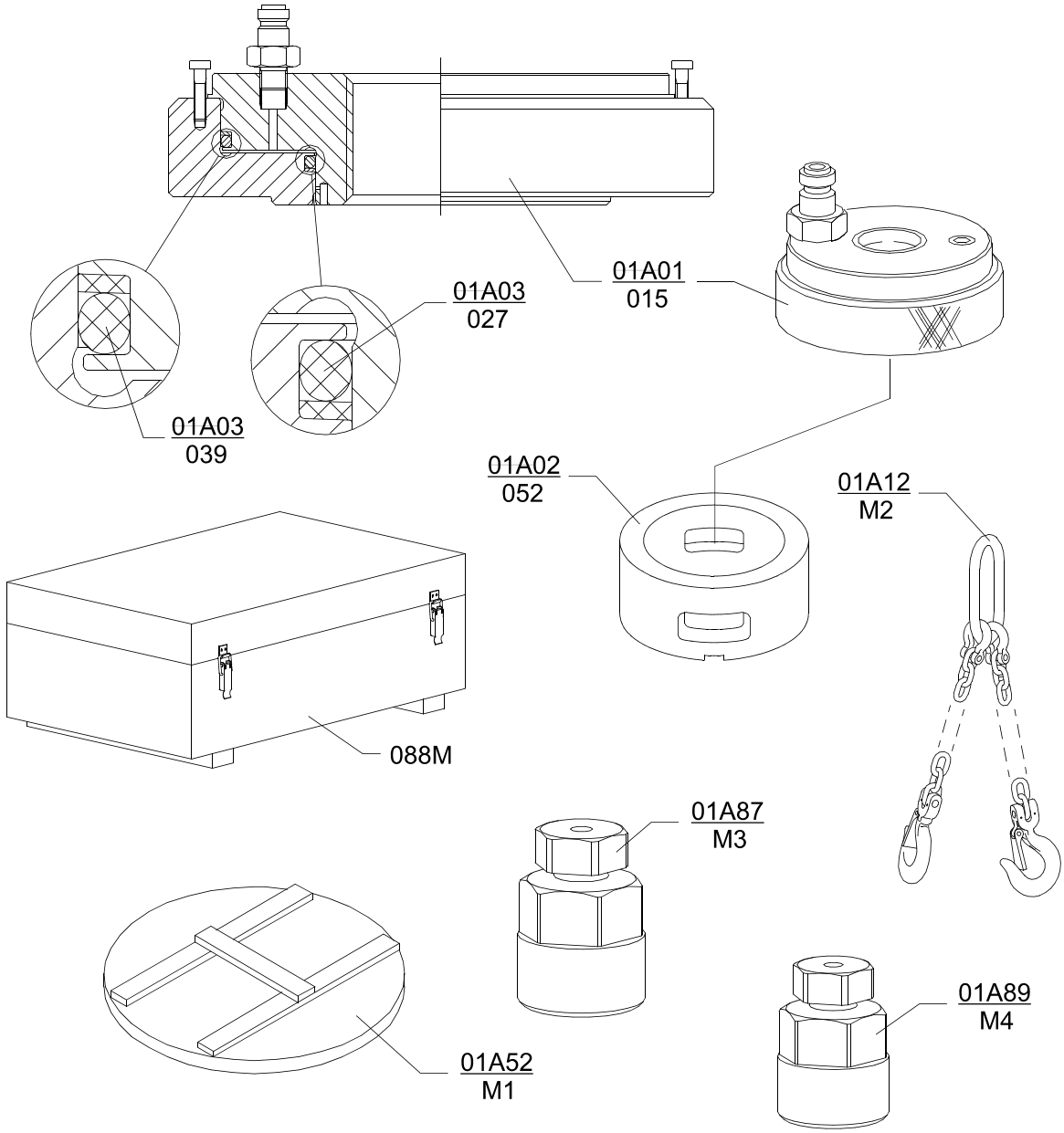
Item No.	Part Description	MES Tools No.	
010	Tool panel *)	(P901)	
022	Name plate *)	(P901)	
046	Grinding tool	01A21	
058	Milling and grinding tool for fuel valve seat	01A24	
060	Milling and grinding tool for starting valve seat	01A31	
071	Dismantling lever for fuel valve	01A46	
083	Handle for cutting and grinding tool	01A32	
095	Grinding ring for starting valve	07A21	
105	Grinding handle	07A22	
117	Pressure tester	11A71	
201	Handle for cutting and grinding tool	01A25	
010-201	*) Tool panel, complete with tools	-	
	*) Optional extras		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01A52
M1

Item No.	Part Description	MES Tools No.	
015	Hydraulic jack	01A01	
027	O-ring with back-up ring	01A03	
039	O-ring with back-up ring	01A03	
052	Spacer ring for cylinder cover	01A02	
088M	Hydraulic tools for cylinder cover	-	
M1	Cover for valve bore/stuffing box hole	01A52	
M2	Lifting chain	01A12	
M3	Studd setter for cylinder cover stud	01A87	
M4	Studd setter for exhaust valve stud	01A89	

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CYLINDER COVER

PISTON WITH ROD AND STUFFING BOX

CYLINDER LINER AND
CYLINDER LUBRICATION

CROSSHEAD WITH CONNECTING ROD

CRANKSHAFT, THRUST BEARING
AND TURNING GEAR

MECANICAL CONTROL GEAR

STARTING AIR SYSTEM

EXHAUST VALVE

FUEL OIL SYSTEM

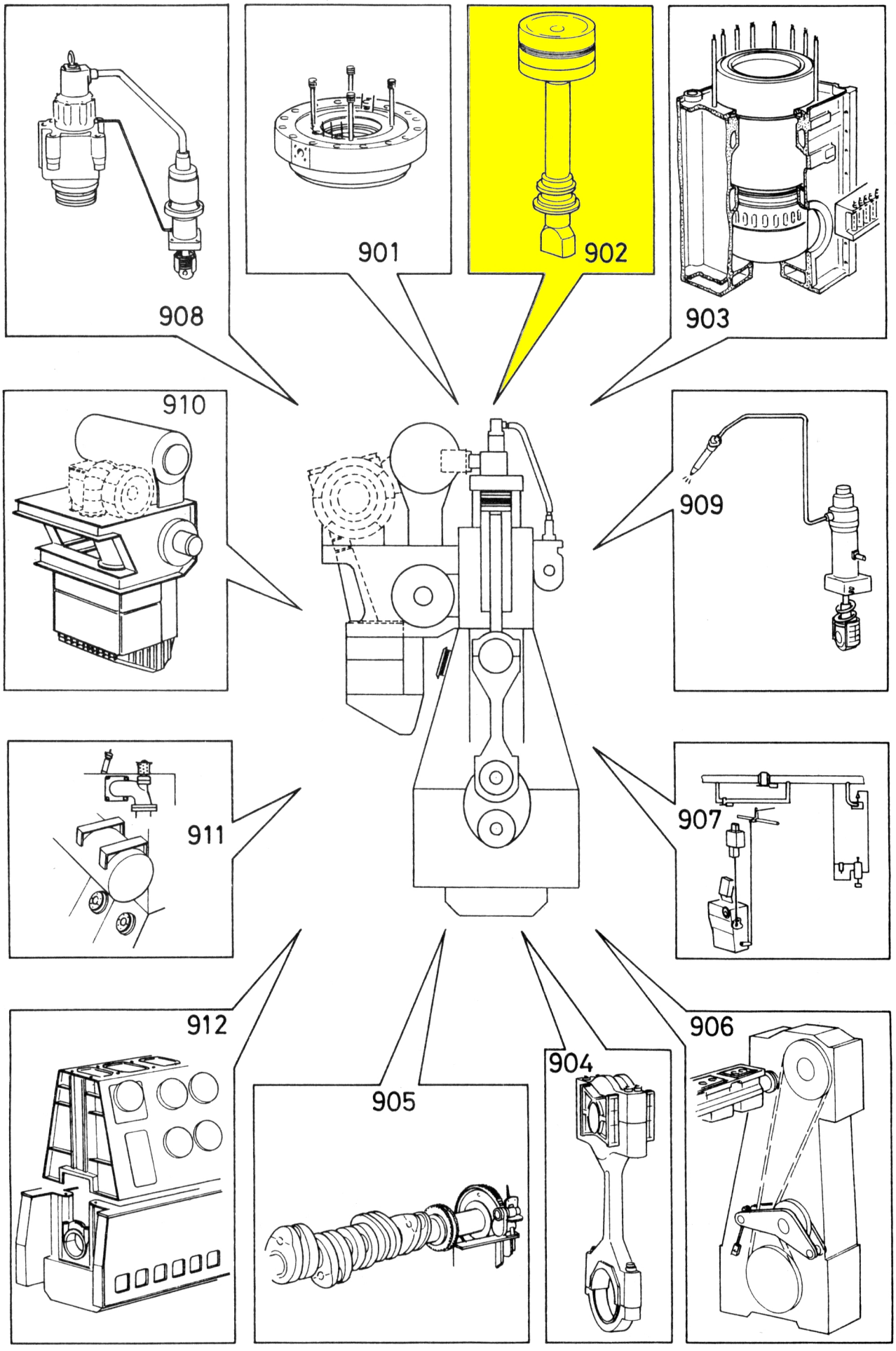
TURBOCHARGER SYSTEM

SAFETY EQUIPMENT

ASSEMBLY OF LARGE PARTS

GENERAL TOOLS

MITSUI
MAN
B&W

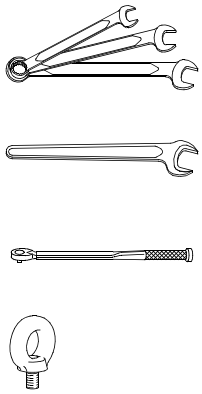


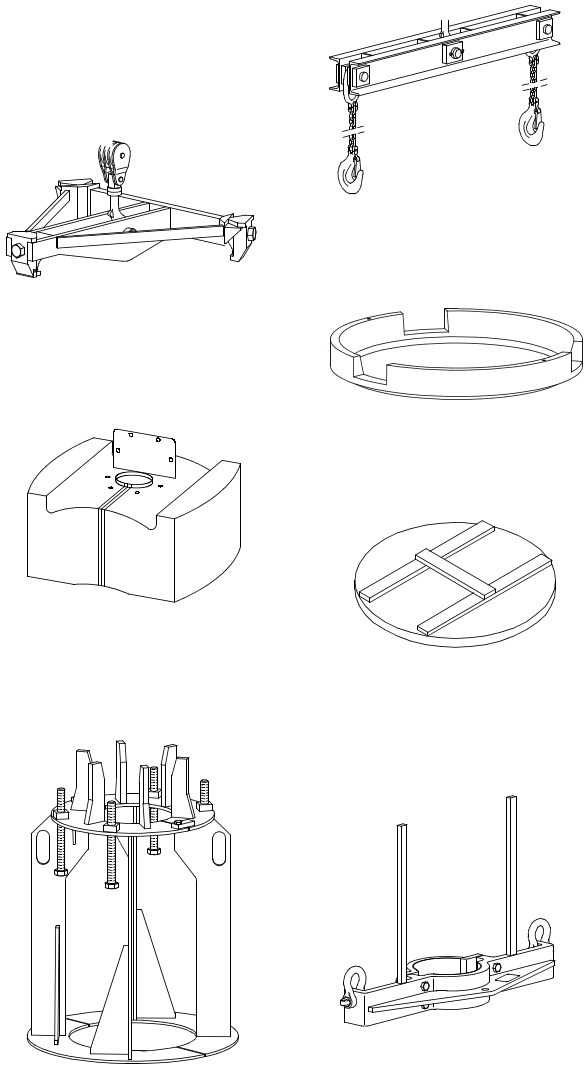
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Do not enter area when over head
X	Block the starting mechanism	lifting is being carried out
X	Shut off starting air supply	
X	Engage turning gear	
X	Shut off cooling water	
X	Shut off fuel oil	
X	Shut off lubrication oil	
	Lock turbocharger rotors	

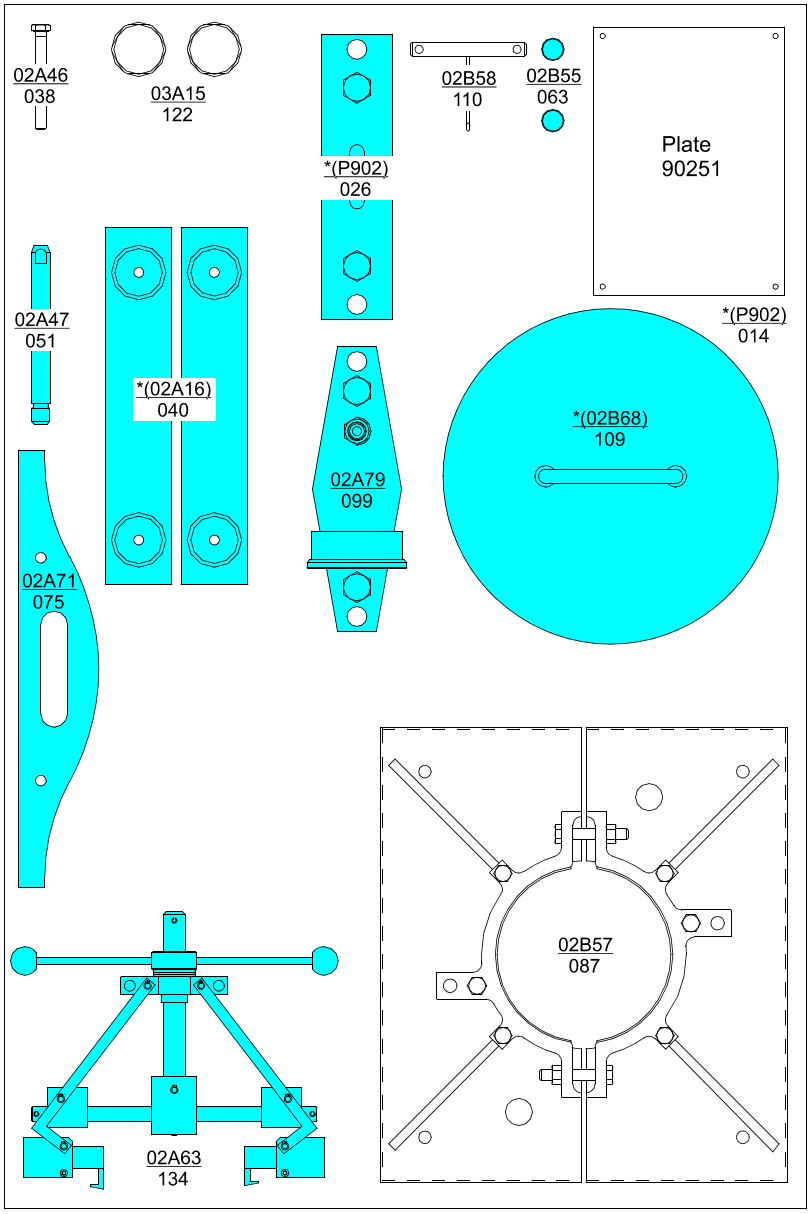
Data

Ref.	Description	Value	Unit
D-1	Radial width:		
	- new piston ring	17	mm
	- worn piston ring	14	mm
D-2	Maximum vertical height:		
	- groove of nominal height:		
	12.5 mm rings	13.1	mm
	9.5 mm rings	10.1	mm
D-3	Max. permissible burn-away:		
	- standard piston top	15	mm
	- Inconel piston top	8	mm
D-4	Nominal height:		
	- ring groove	12.5	mm
	- ring groove	9.5	mm
	- piston ring	12.5	mm
	- piston ring	9.5	mm
D-5	Minimum ring gap	3.5	mm
D-6	Vertical clearance	0.35-0.45	mm
D-7	Piston complete	957	kg
D-8	Piston crown	210	kg
D-9	Piston skirt	57	kg
D-10	Piston skirt		
	- tightening torque	80	Nm
D-11	Piston cooling pipe	23	kg
D-12	Cooling pipe		
	- tightening torque	80	Nm
D-13	Piston rod	555	kg
D-14	Piston crown/rod		
	- tightening torque	300	Nm
D-15	Test pressure	0.7 (7	MPa bar)
D-16	Cyl. cover with exhaust valve	1670	kg
D-18	Tightening torque of piston	430	Nm
D-19	Stuffing box		
	- tightening torque	80	Nm

Standard Tools: See Section 913



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*(P902)
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051
*(02A16)
040
02A79
099
*(02B68)
109
02A71
075
02B57
087
02A63
134

Scavenge port inspection

To detect possible leakages from the piston or cylinder cover, keep the cooling water and cooling oil circulating during the scavenge port inspection.

1. Remove the inspection covers on the camshaft side of the cylinder frame.

Note!
The scavenge port inspection can also be carried out from within the scavenge air receiver.

Clean the openings.

Begin the inspection at the cylinder whose piston is nearest **BDC**.

2. With the piston in **BDC**, inspect the piston crown and the cylinder wall.

Note down the results.
See Vol. 1 “Operation & Data” Chapter 707.

3. Turn the engine. While the piston is passing the scavenge air ports, inspect the piston rings, the ringlands and the piston skirt.

Check the movability and the tension of the piston rings, by pressing against them with a wooden stick.

Note down the results.

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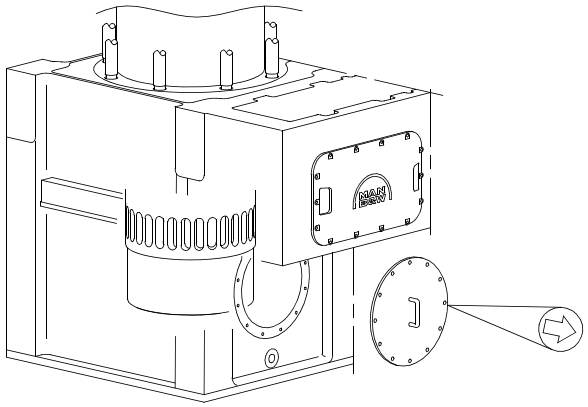

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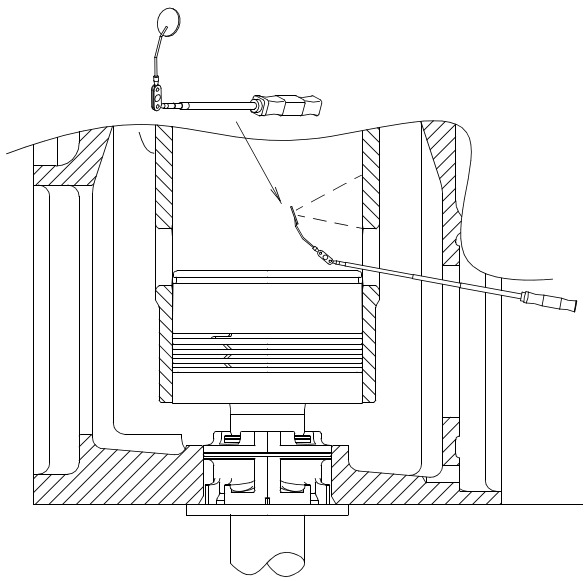

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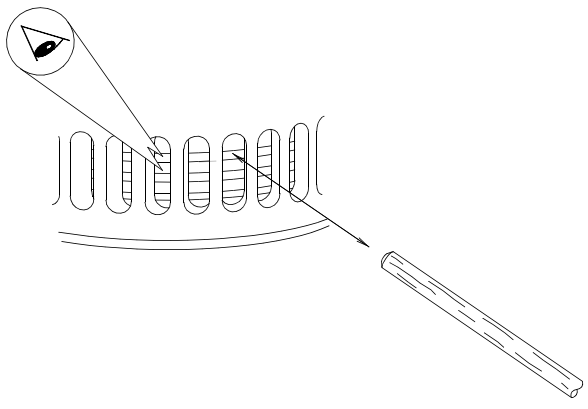

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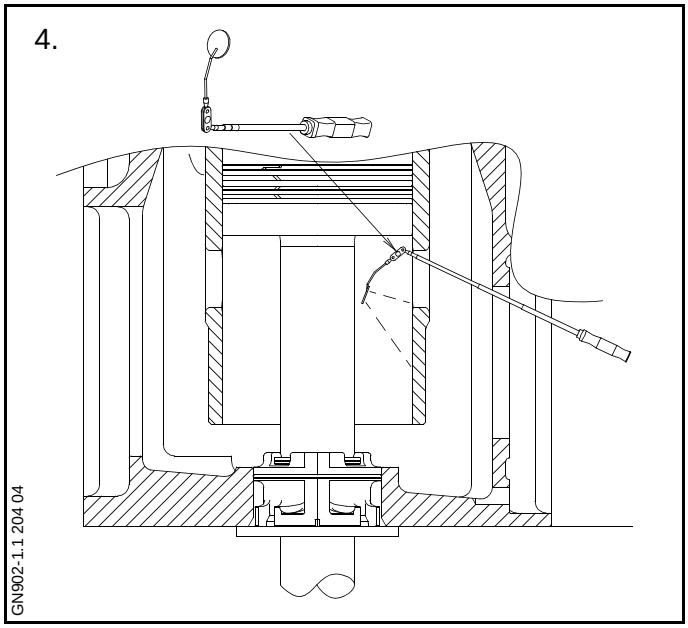
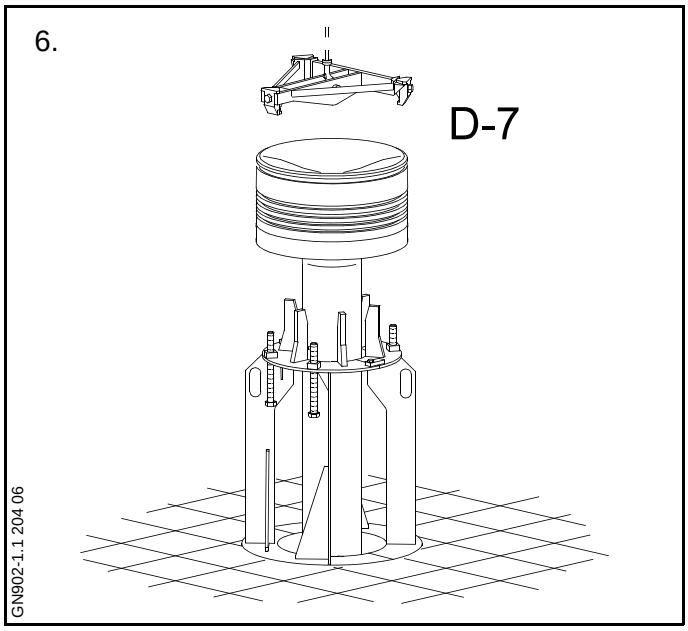




4. After turning the piston upwards, past the scavenge air ports, inspect the piston rod and the lower part of the cylinder wall.

   Note down the results.

5. Re-mount the inspection covers on the cylinder frame. If necessary, replace the gaskets.

Piston rings and piston crown

6. Remove the piston from the cylinder and place it on the piston support.
   See Procedure 902-1.2.

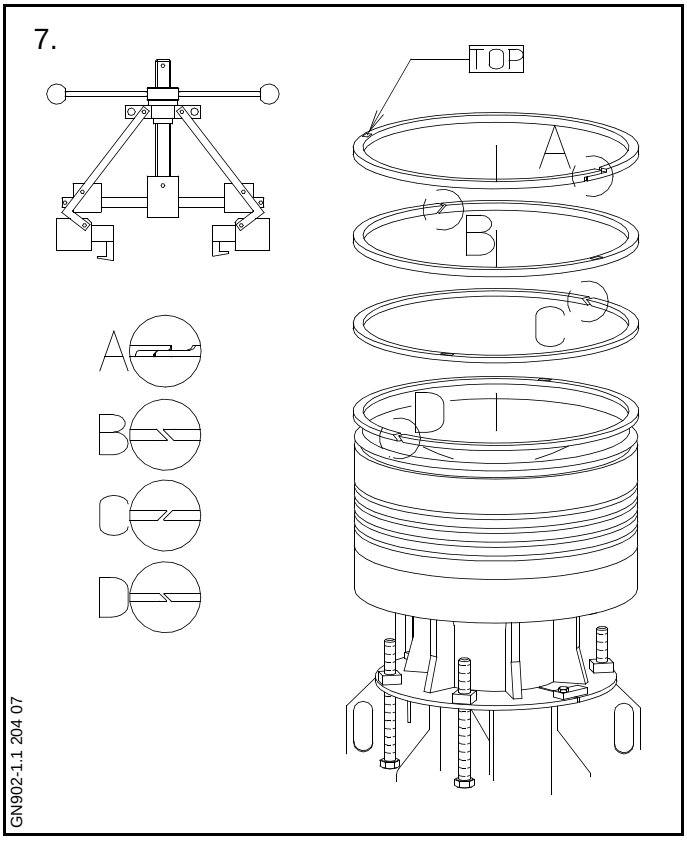
7. Take off the piston rings by means of the ring expander.

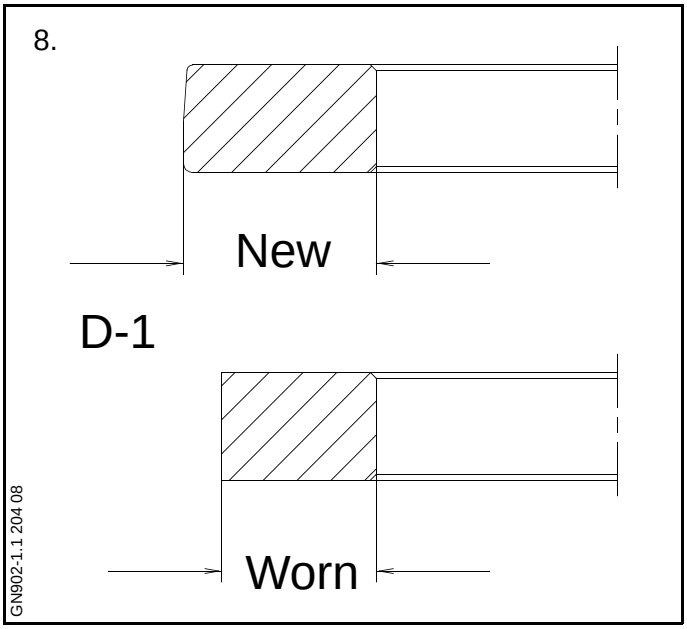
   Clean and inspect the rings.

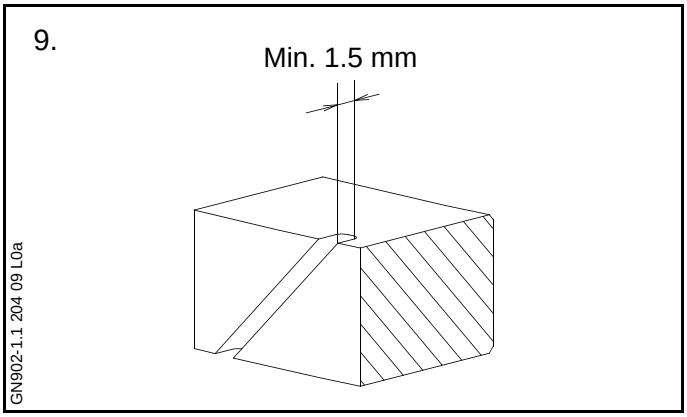
8. Measure and record the radial width and the height of the rings.
   See Vol. 1 "Operation & Data" Chapter 707.

   Worn rings must be replaced if the radial width is less than stated in Data.

9. Piston rings with milled pressure relief grooves must be replaced if the radial depth of the grooves has worn down to less than 1.5 mm.







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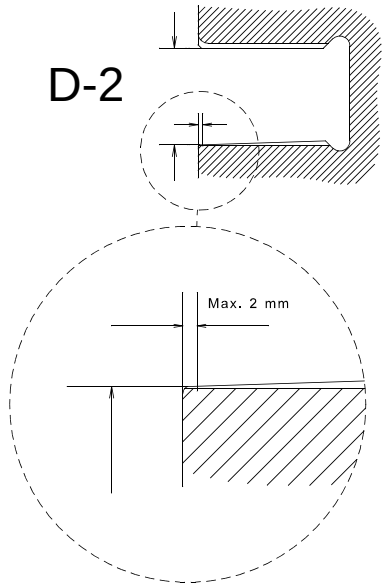

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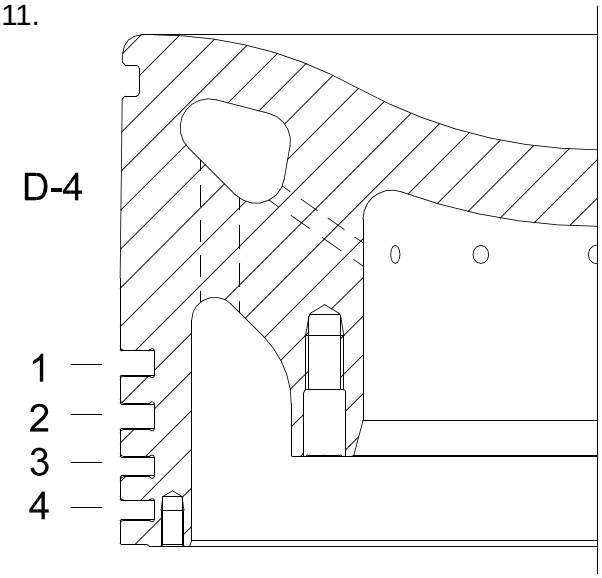

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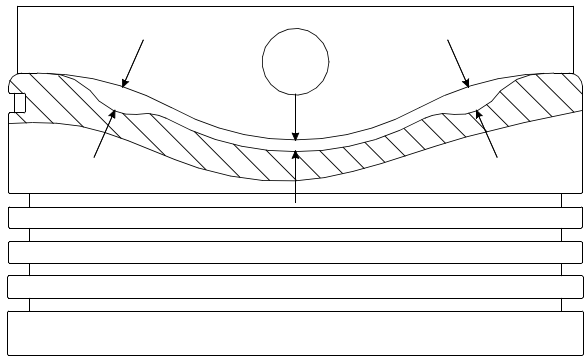

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10. Clean the ring grooves and check them for burn marks or other deformation.

    Measure the ring grooves with a caliper gauge.

    Clearance in piston ring grooves:

    The maximum vertical height in a worn ring groove **must not** exceed the value stated in Data.

    The groove is also worn out if there is no chromium layer.

11. The nominal heights of ring grooves and piston rings are as stated in Data. And, nominal height of each piston rings, *see Vol. 1 "Operation & Data"*.

12. Clean the piston crown and check the burn-away by means of the template.
    For maximum permissible burn-away value, see Data.

    Check the burn-away on the whole circumference of the piston crown.

13. Before mounting a new piston ring, measure the piston ring gap.

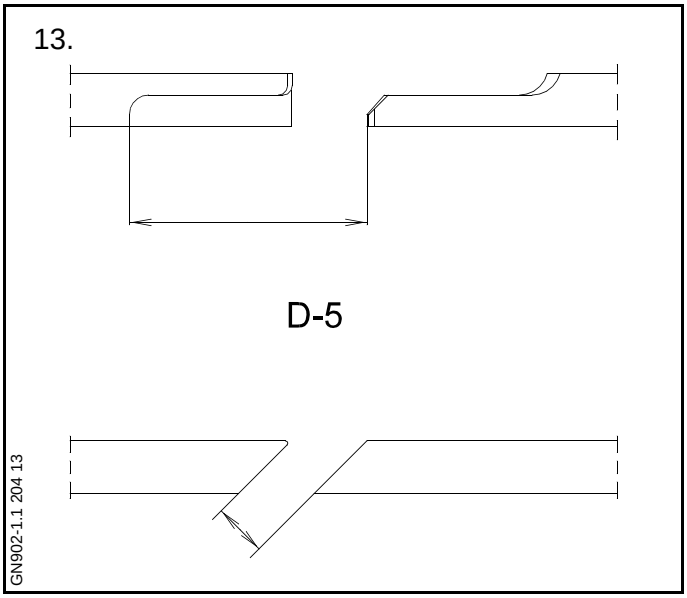
    Insert the piston ring in either a new cylinder liner or in the bottom of a used cylinder (below the ring travel zone) during the measuring.

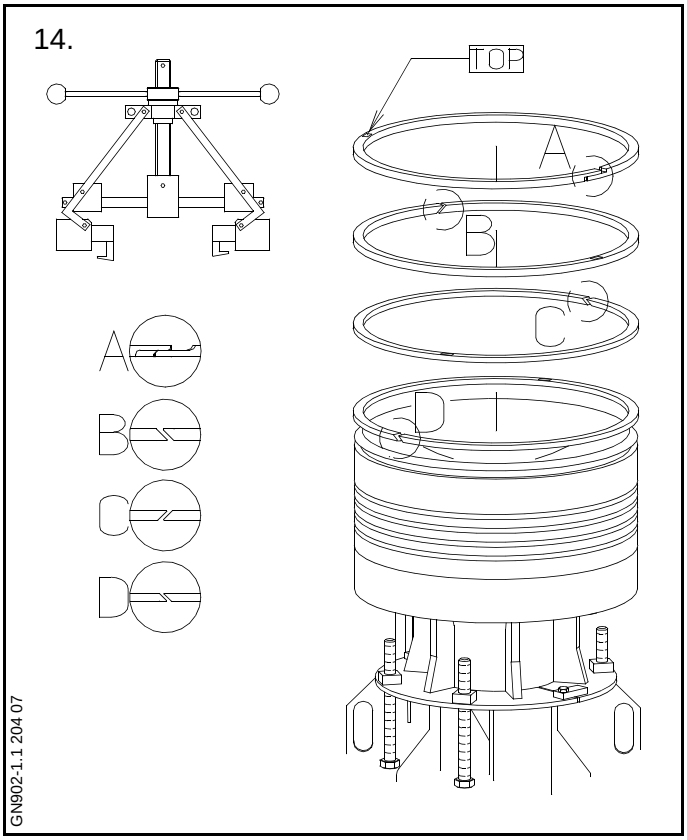
    For minimum ring gap, see Data.

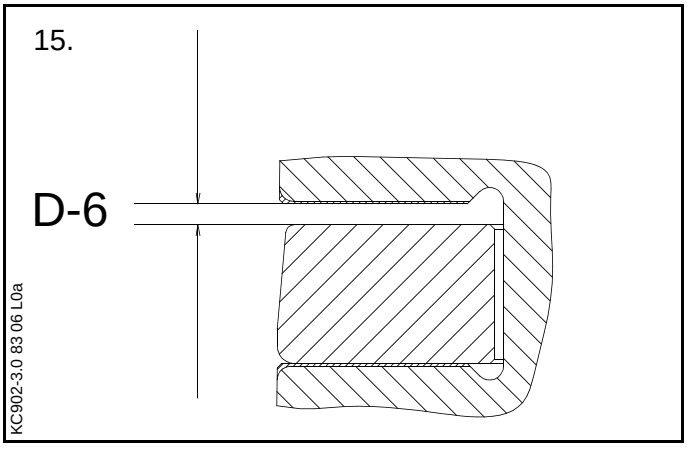
14. Fit the piston rings (alternately right-hand and left-hand cuts with the ring gaps staggered 180° and with the TOP mark upwards) by means of the ring expander.

    The ring expander prevents unintended deformation of the rings.

15. Check the vertical clearance between the new piston ring and the new or reconditioned ring groove with a feeler gauge. *See Data.*







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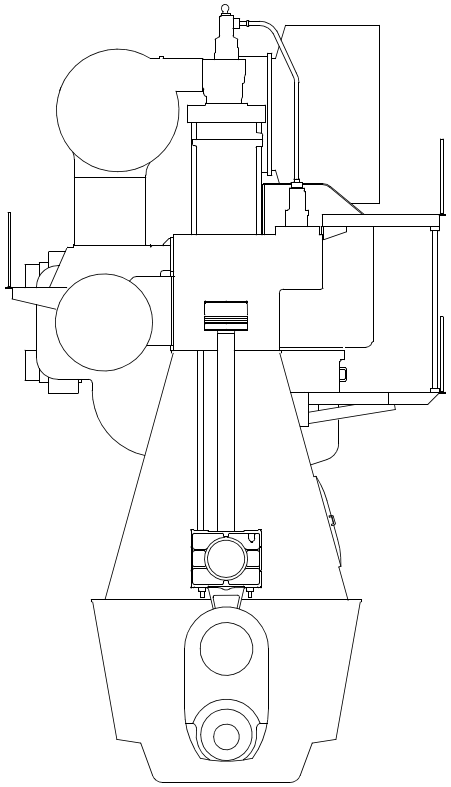

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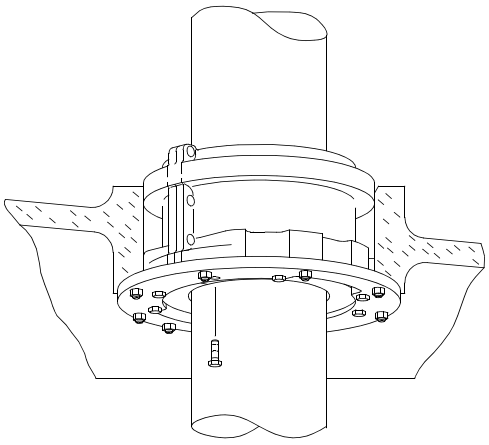

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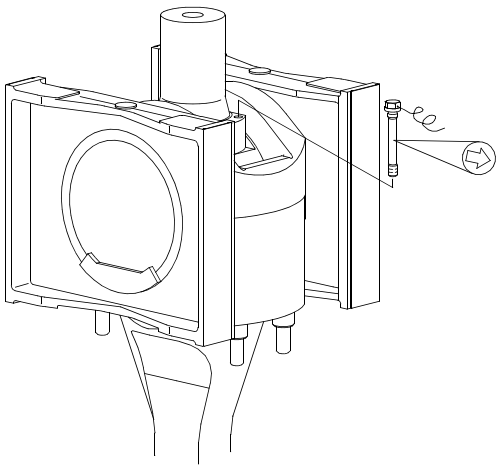

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1. Turn the crosshead down far enough to give access to the piston rod stuffing box, the tightening screws for the piston rod, and to the telescopic pipe.

2. Release the stuffing box by removing the innermost screws from the stuffing box flange.

Note!
Do **NOT** remove the outermost screws from the flange.

3. Remove the screws from the piston rod.

4. Mount the two distance pieces on the piston rod foot to protect the lower scraper ring and to guide the stuffing box.

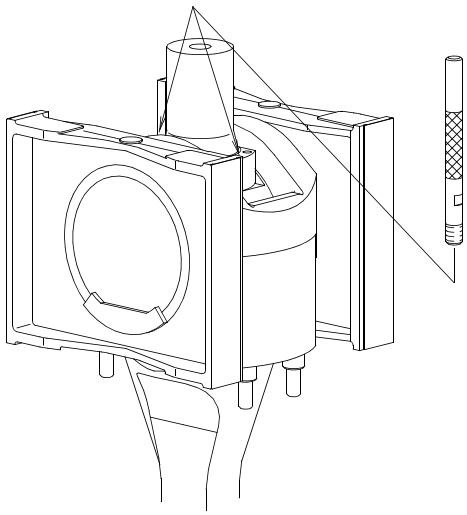
5. Dismount the cylinder cover.
   See Procedure 901-1.3.

   Remove the piston cleaning ring from the cylinder liner. *See Procedure 901-1.1.*

   Carefully smooth out any wear ridges at the top of the cylinder liner by using a hand grinder.
   See Procedure 903-1.2.

6. Turn the crosshead to **TDC**, while checking that the guide pins of the distance pieces enter the holes in the stuffing box.

4.



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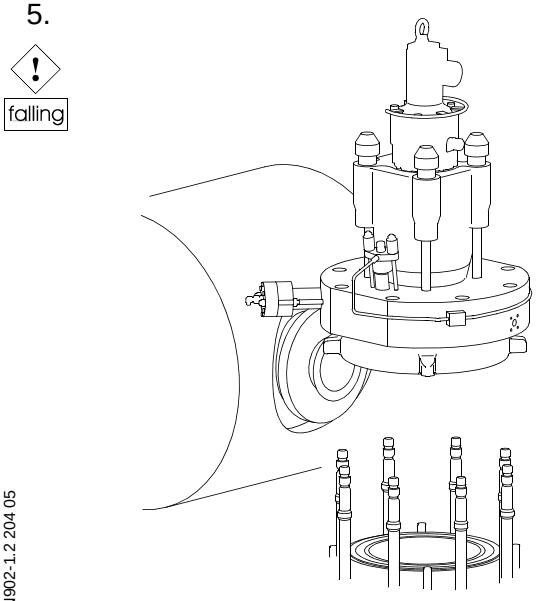

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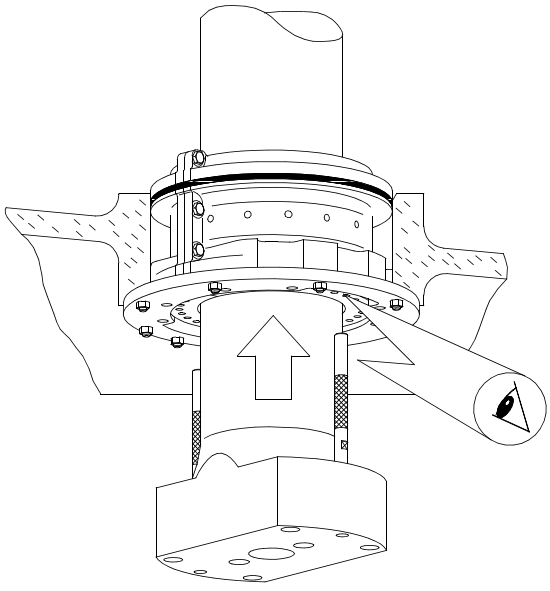

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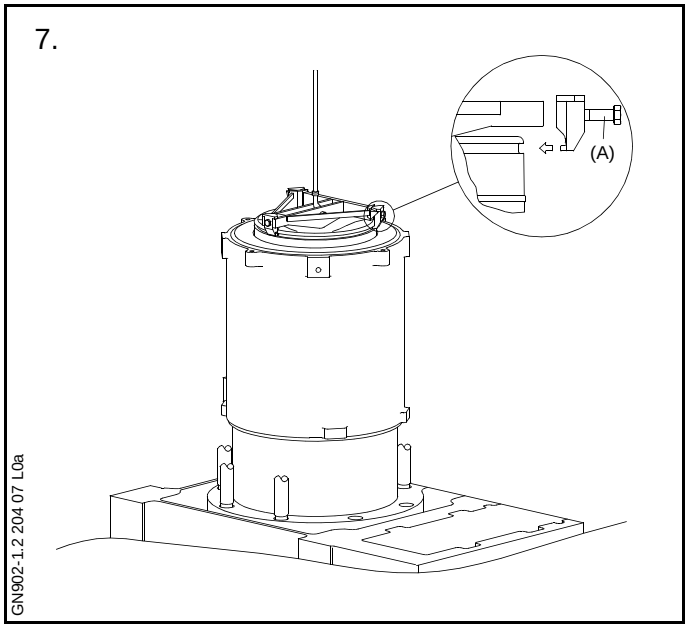
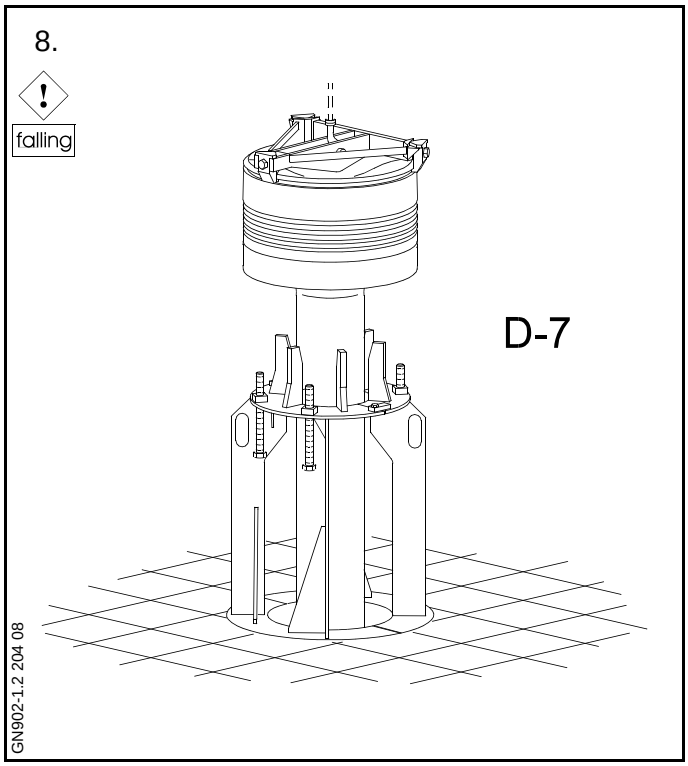


7. The top of the piston is now free of the cylinder liner.

   If necessary, remove one or two cylinder cover studs, using a stud setter.

   Clean the lifting groove of the piston crown and mount the lifting tool in such a manner that the two 'fixed' claws of the tool fit into the lifting groove of the piston.

   Fit the third, adjustable, claw of the tool to the lifting groove and tighten it up against the stop of the tool.



Note!
The bolt (A), which is provided specially for the purpose of tightening the removable claw, must be firmly tightened.

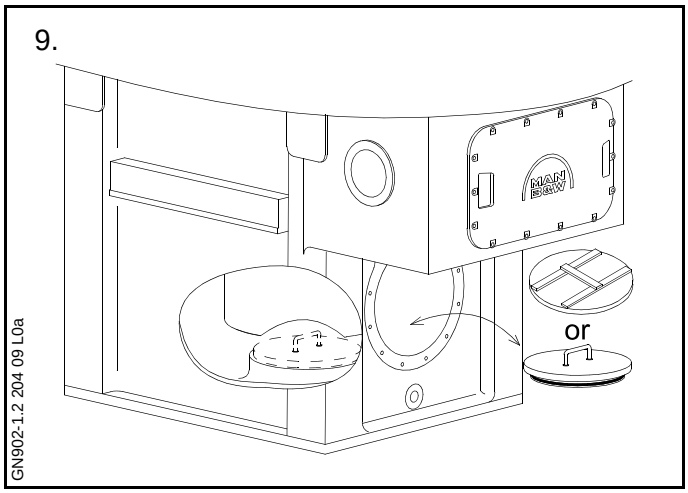
8. Place the two halves of the support around one of the openings in the platform.

   Lift the piston out of the cylinder and lower the piston rod foot and stuffing box through the opening in the platform.

   Place the two halves of the support around the piston rod and secure the two halves with screws.

9. Place a cover over the opening for the piston rod stuffing box in the bottom of the cylinder unit.

   Clean, measure and recondition the cylinder liner.
   See Procedure 903-2.1.



10. Turn the crosshead down far enough to permit mounting of the protective rubber cover on the crosshead bearing cap.

    The protective cover should remain in place to protect the crosshead bearing journal from impurities until the piston is remounted.

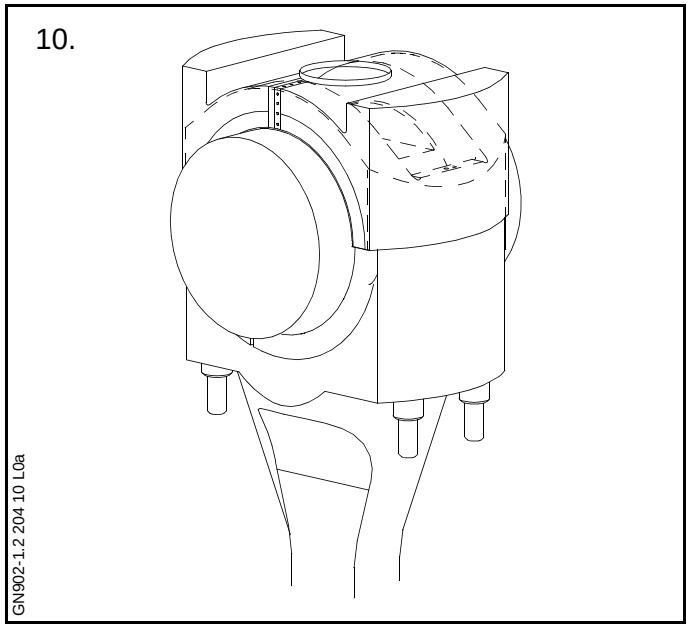
Low lifting height

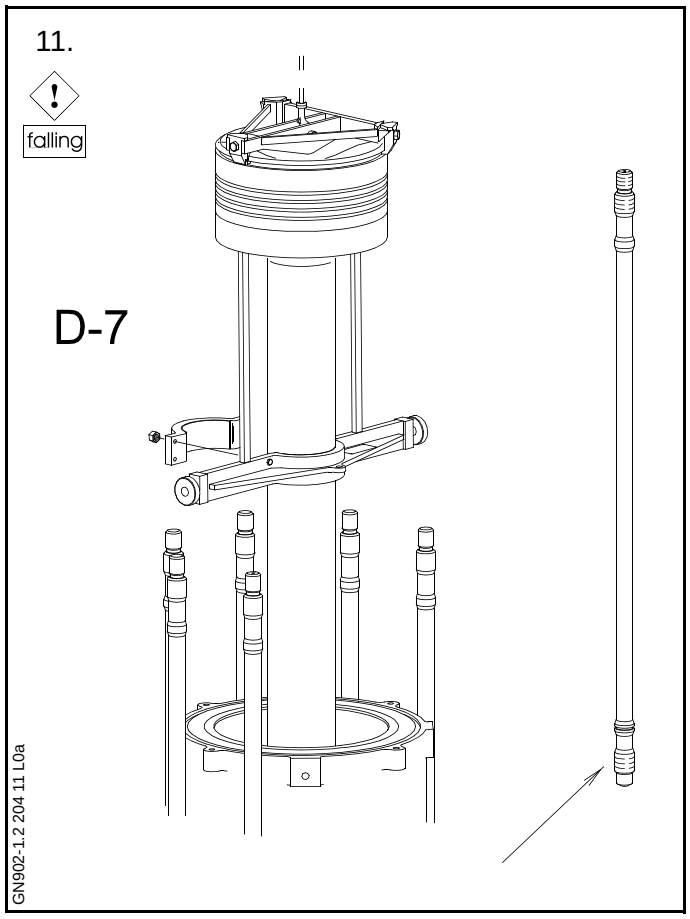
If the space conditions above the engine make it impossible to remove the piston in the normal way, the piston can be removed as follows:

11. Remove one or two cylinder cover studs, using the stud setter.

    Lift the piston high enough to give ample room over the cylinder cover studs.

    Mount the clamp on the piston rod so that the distance piece of the clamp lies true against the piston.





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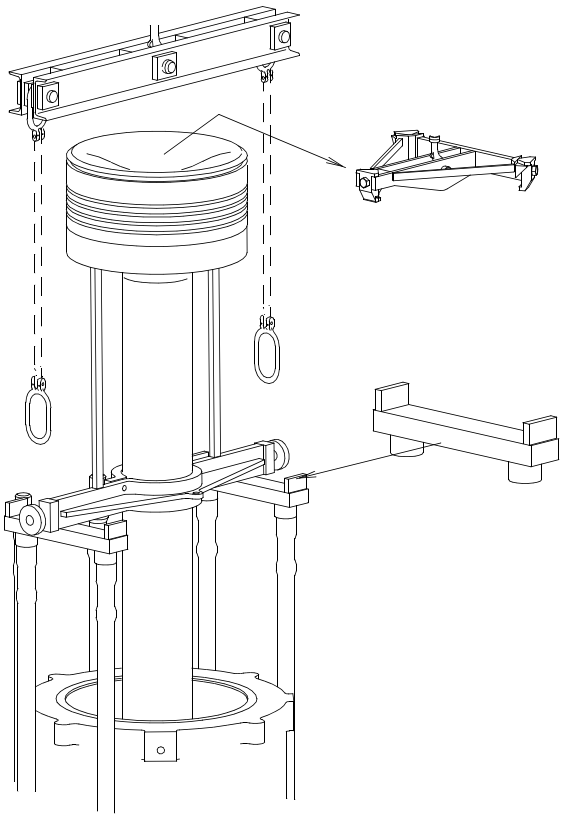

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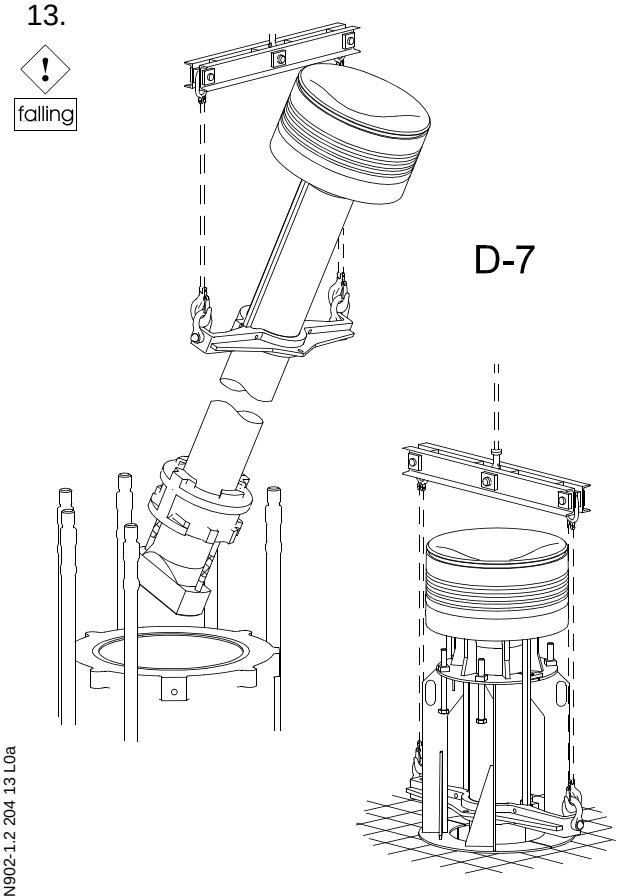

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12. Place the supporting tools on the cylinder cover studs and lower the piston until the clamp rests on the tools.

    Remove the lifting tool from the piston.

    Hook the transverse piece on to the crane and attach it to the clamp for tilting the piston.

13. Lift the piston to the maximum crane height. Run the crane athwartship and, at the same time, tilt the piston.

    Keep the piston rod clear of the cylinder liner and studs while carrying out the tilting.

    When space conditions permit, straighten up the piston and lead it over to the cut-out in the platform for overhauling the piston.

    When the piston is at a suitable height above the platform cut-out, position the piston support around the piston rod and clamp.

    Now lower the piston while guiding the support to the platform cut-out.

    After landing the piston and ensuring that it rests correctly on the support, remove the tilting tool.

Note!
On engines with extremely low lifting height, use the engine room double-jib crane instead of the transverse piece.

1. Position new O-rings on the platform around the piston overhaul cut-out.

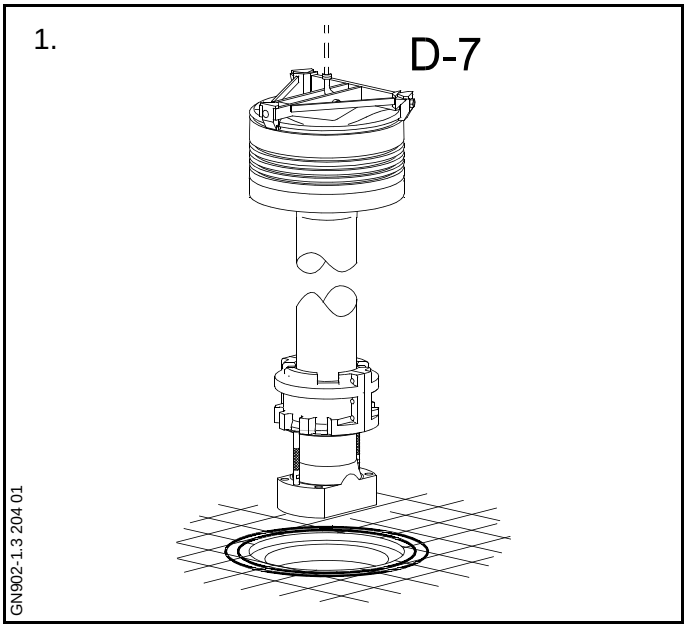
2. Ease the piston down so that the stuffing box is below the floor.

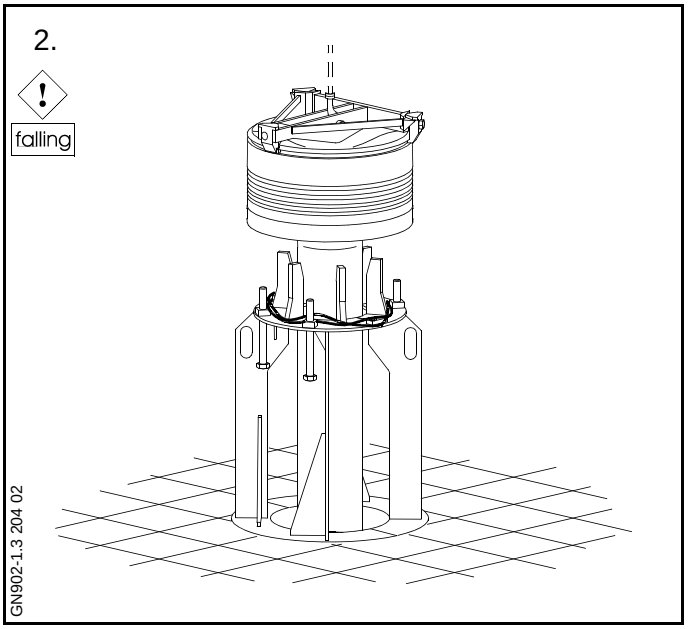
   Lift the O-rings and assemble the two valves of the piston support around the piston rod.

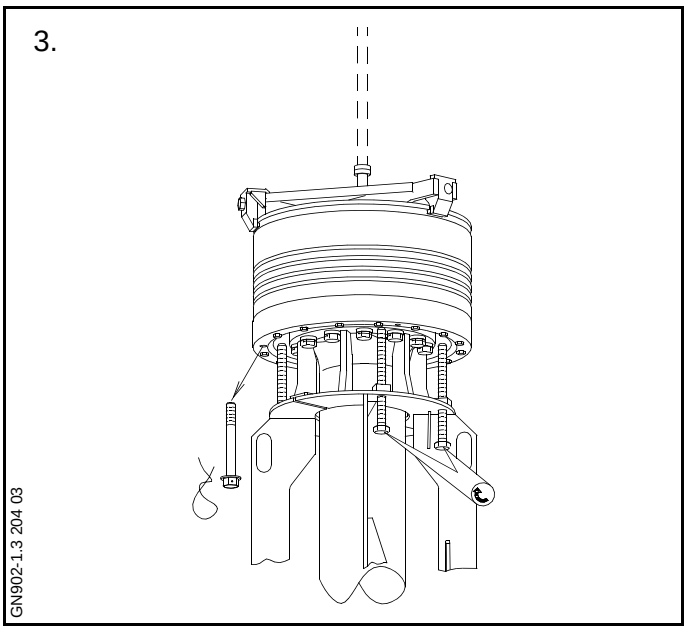
   Position the O-rings on the piston support.

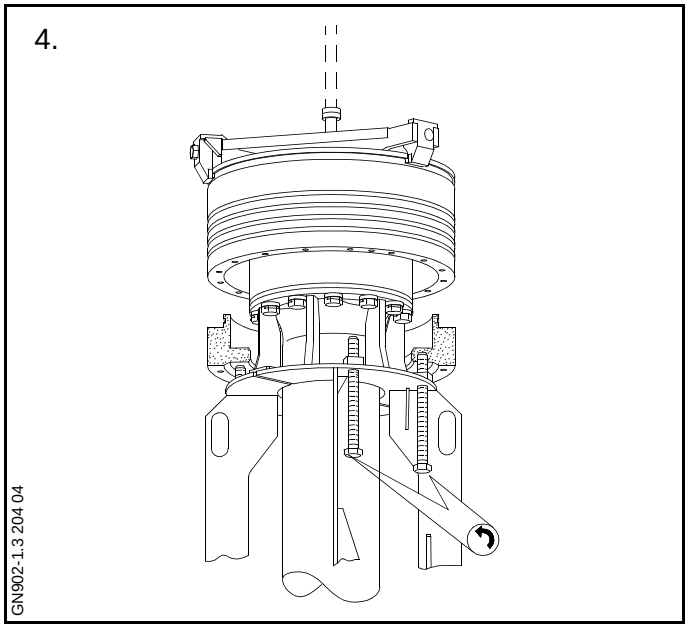
3. Dismount the locking wire and screw up the support screws of the piston support to a position just below the piston skirt.

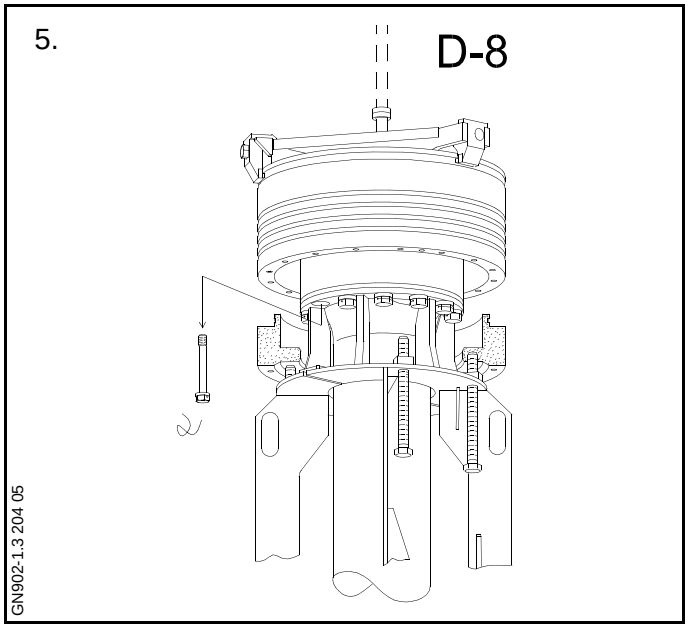
   Remove the piston skirt screws.

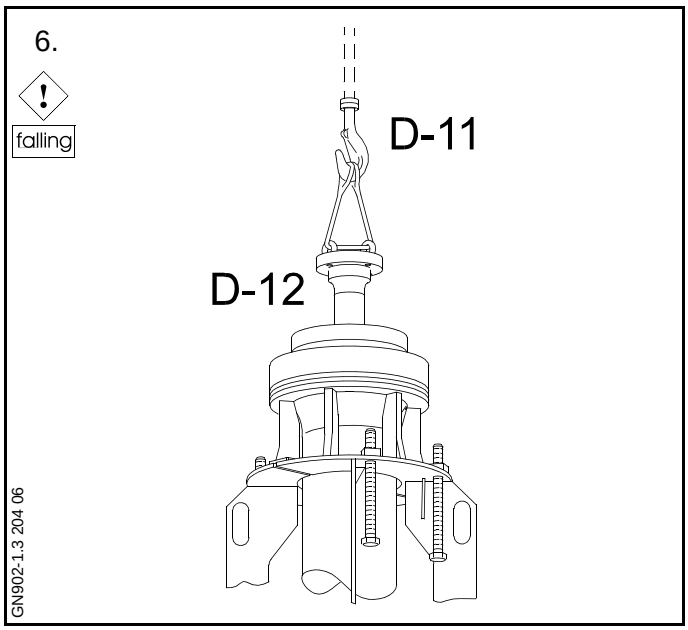












4. Screw the four screws of the support downwards until the skirt rests on the support.

   If the skirt will not budge, free it by means of two dismantling screws.

5. Dismount the locking wire and the innermost screws between the rod and the piston crown.

   Lift away the piston crown.

6. Dismount the screws of the cooling oil pipe flange.

   Mount the eye screws and lift out the cooling oil pipe.

Alternatively, the piston can be dismantled in the following way:

Note!
Tilting of the piston must only take place with the piston rod stuffing box mounted on the piston rod.

7. While the complete piston is hanging from the lifting tool, mount the collar round the piston rod so that the distance pieces of the collar obtain contact with the piston.

   Lower the piston so that the collar rests on the platform.

   Remove the lifting tools from the top of the piston crown.

   Hook the engine room crane on to the lifting crossbar and hook the chains of the lifting crossbar on to the shackles of the collar.

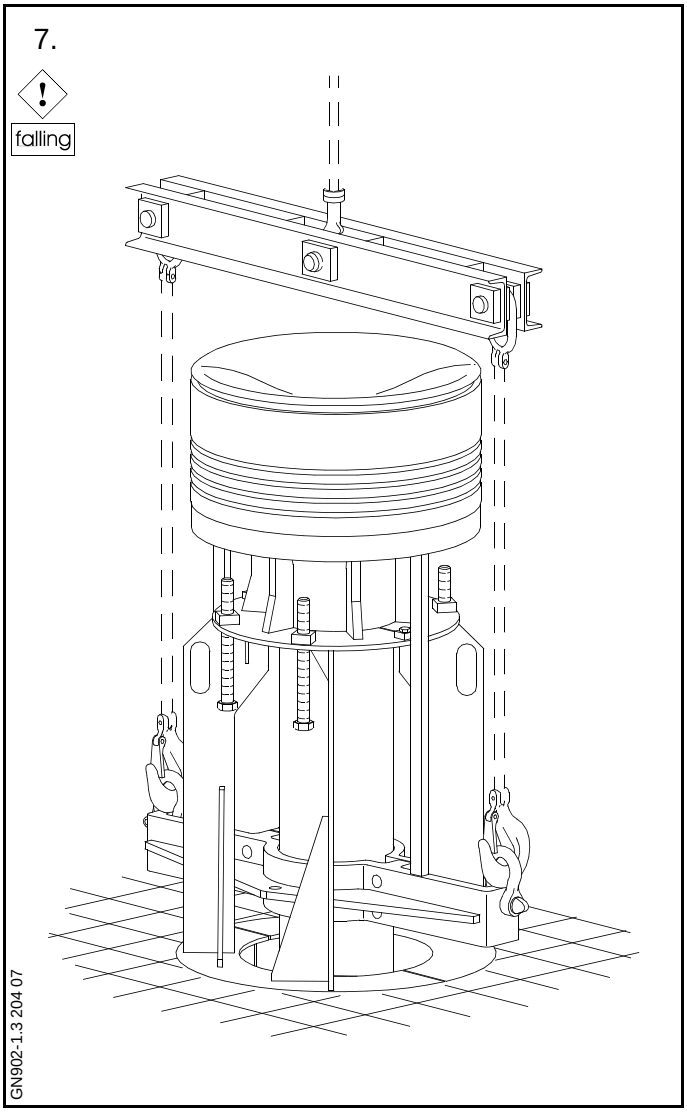
8. Lift the piston, tilt it to the horizontal position, and land it in this position on a couple of wooden blocks. Remove the lifting crossbar and chains from the collar.

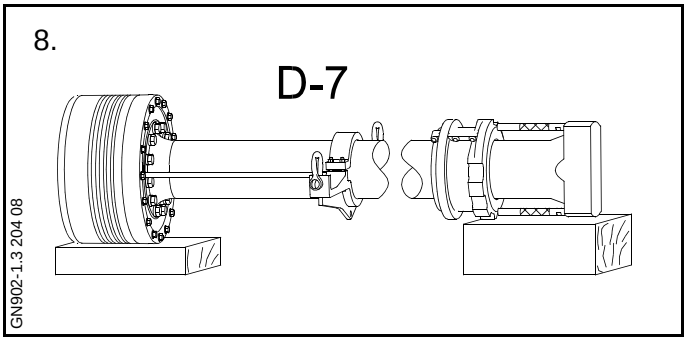
9. Attach the lifting tool to the bottom of the piston rod foot. Hook the crane on to the lifting tool.

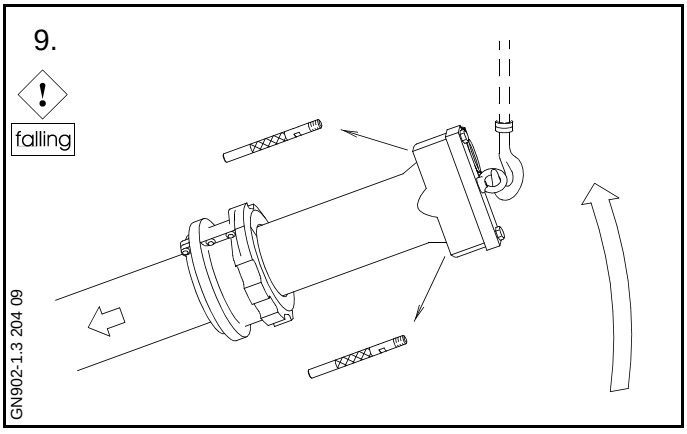
   Lift the foot of the piston rod clear of the wooden block. Move the piston rod stuffing box up the piston rod until it is in contact with the collar. Remove the two distance pieces from the piston rod foot.

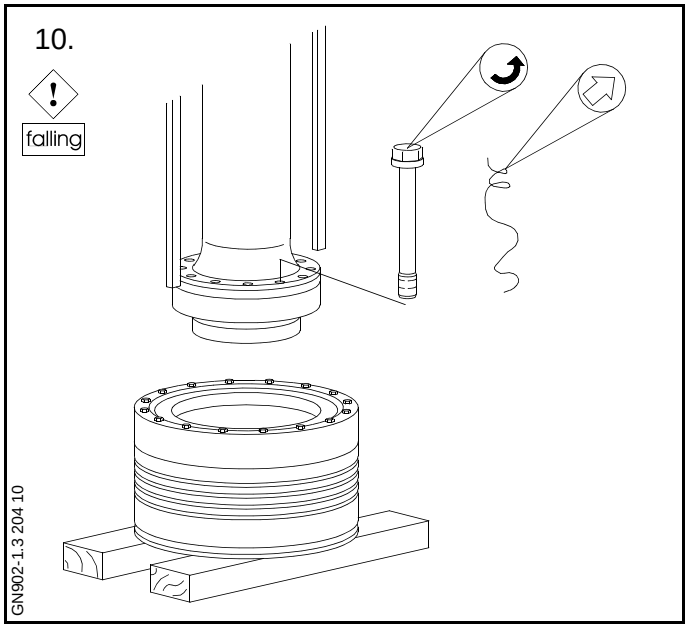
Note!
During the lift, follow with the crane to keep the crane positioned vertically above the foot of the piston rod.

Keep lifting until the piston rod is in a vertical position.









10. Place the piston in an upright position with the piston crown resting on wooden blocks.

    Dismount the locking wire and the innermost screws between the rod and the piston crown. Lift the piston rod away and land it in a horizontal position on a couple of wooden blocks.

11. Remove the locking wire and the screws in the skirt and mount two eye bolts in the holes intended for dismantling screws. Lift the skirt and land it on a couple of planks.

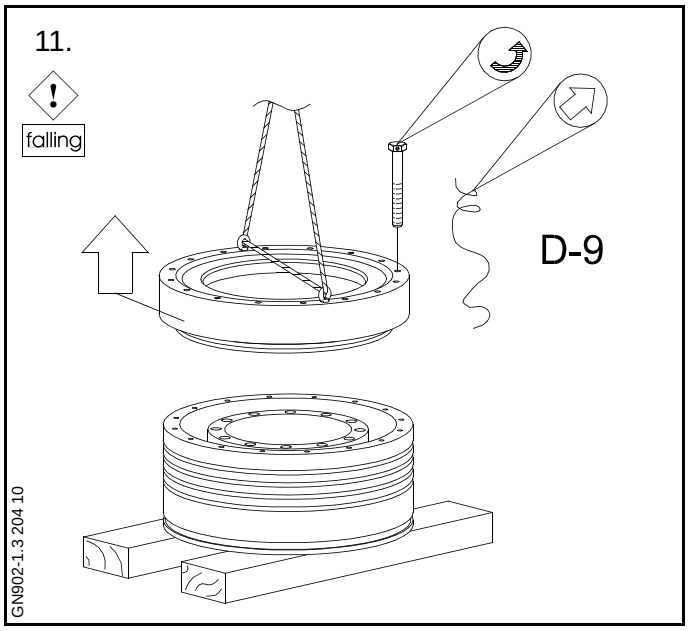
12. Thoroughly clean and inspect all parts of the piston.
    Regarding check of the piston crown, see Procedure 902-1.1.

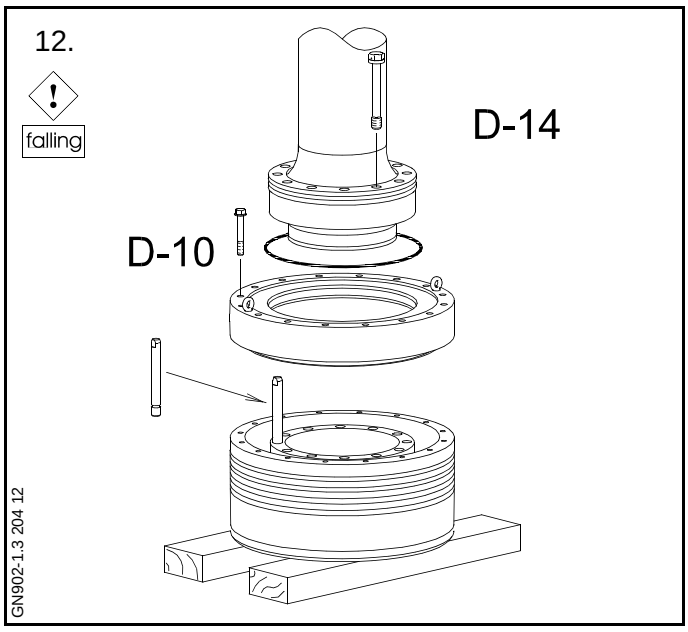
    Replace all sealing rings of the piston. All the new sealing rings must be coated with lubricating oil before the piston is assembled.

    Coat all screws with Molybdenum Disulphide (MoS_2).

    Assemble the piston in the reverse order to disassembly. Use the guide screw to ensure the correct positioning of the piston rod in relation to the piston crown.

    Tighten all the screws diagonally to the torque stated in Data.





13. Lock all the screws with locking wire.

    Mount the locking wire in such a way that the wire is tightened if one of the screws works loose.
    See Procedure 913-7.

14. Mount the pressure-testing tool around the base of the piston rod.

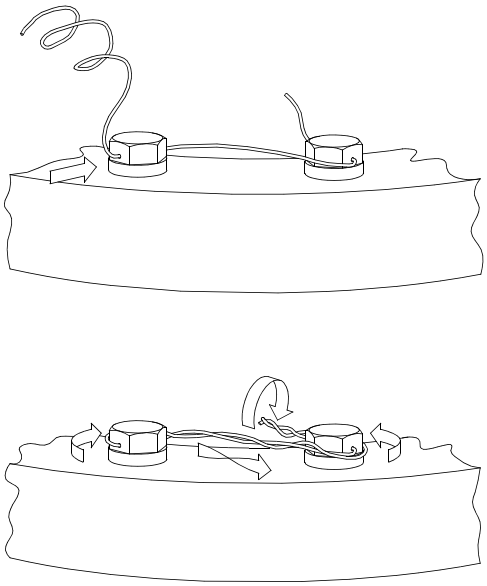
    Pressure-test the piston at the pressure stated on the data sheet.

    Check the contact surfaces of the piston and the sealing rings for tightness.

    Check the tightness using soap liquid without bubble.

    Check that there are no cracks in the piston crown.

13.



GN902-1.3 204 13

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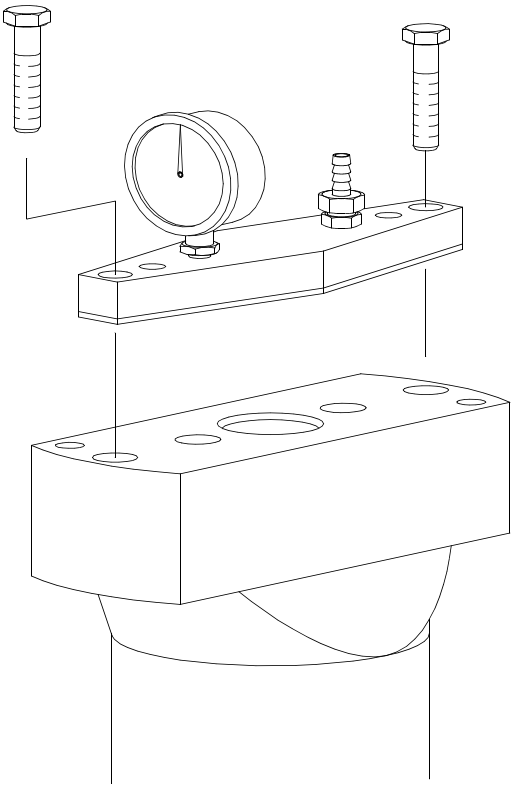

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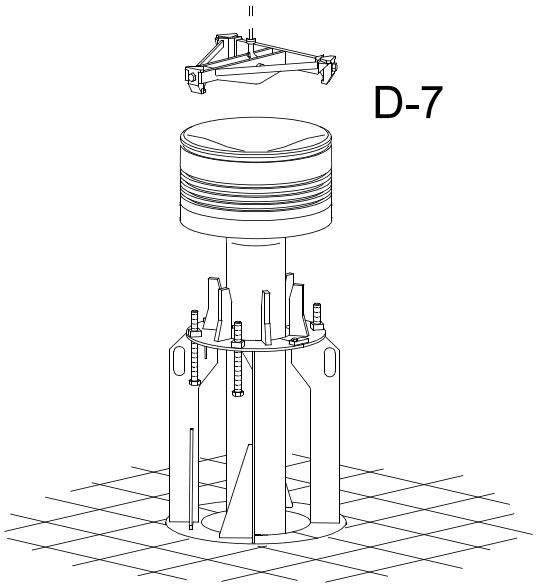

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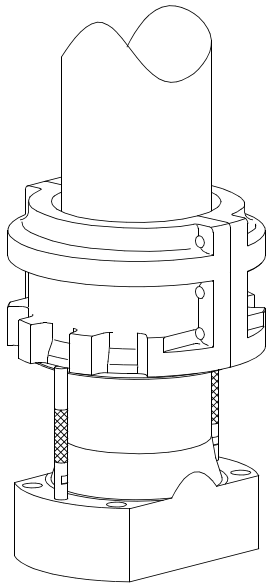

GN902-1.4 204 03 L0a

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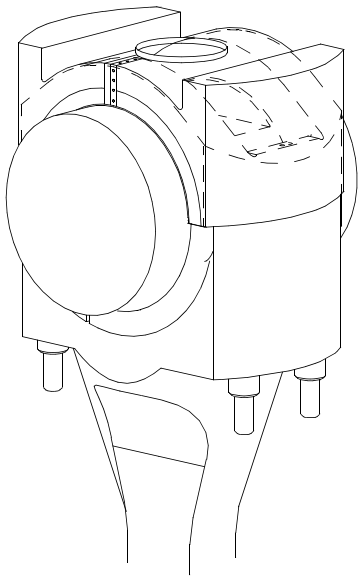


GN902-1.2 204 10 L0a

1. Check the piston rings and piston crown in accordance with Procedure 902-1.1.

   Coat the piston rings, piston rod and cylinder liner with lubricating oil.

2. Mount the lifting tool on the piston crown.

3. Ensure that the stuffing box is correctly positioned over the guide pins in the distance pieces mounted on the piston rod foot.

   Coat the O-rings of the stuffing box with oil.

4. Remove the protective cover from the crosshead.

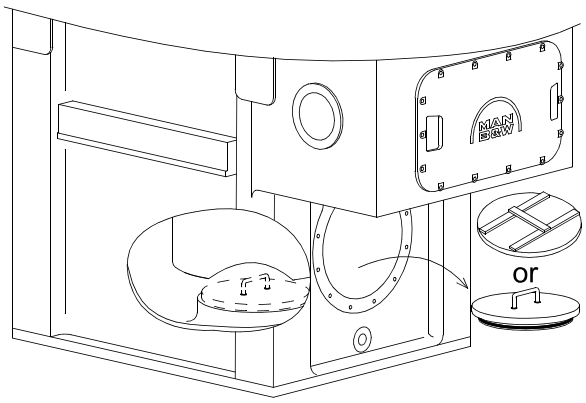
5. Remove the cover from the piston rod stuffing box opening in the bottom of the cylinder unit.

6. Turn the crosshead to a position 45° from **TDC**.

   Mount the guide ring for piston rings on the cylinder liner.

7. Lower the piston into the cylinder liner - while guiding the piston rod foot through the cut-out in the stuffing box flange - until the piston rings are inside the liner, corresponding to the lifting tool lacking about 30 mm in landing on the guide ring.

5.



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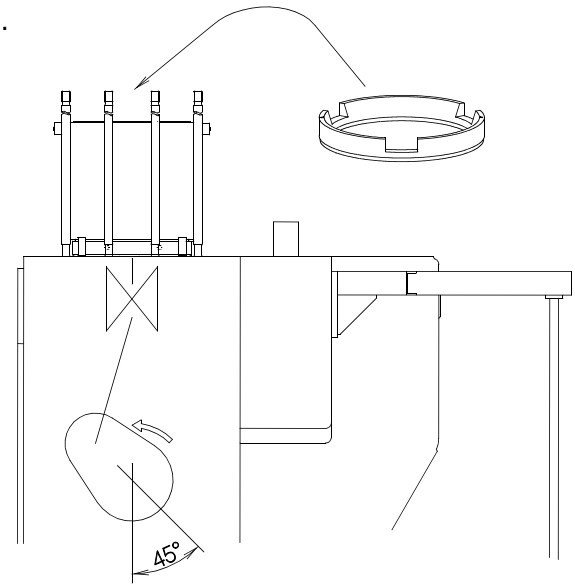

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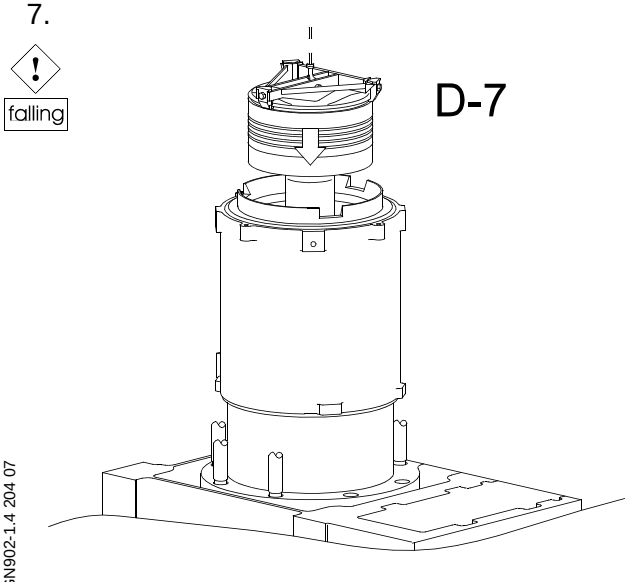

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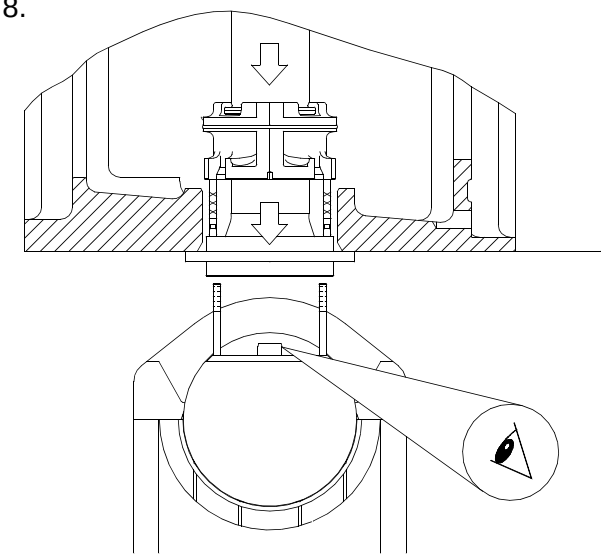

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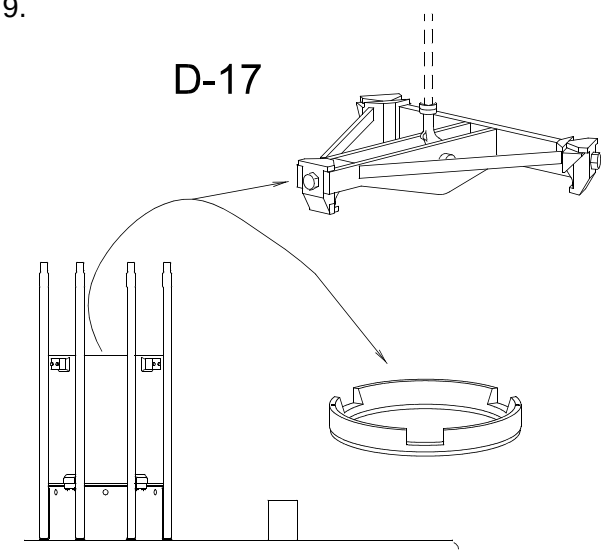

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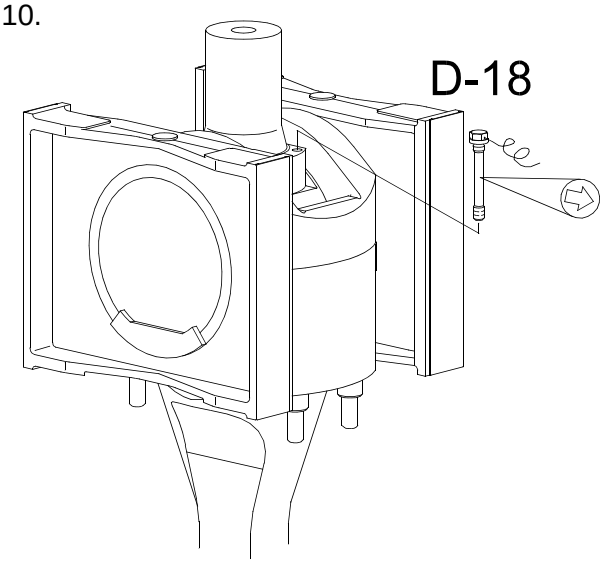


GN902-1.4 204 10

8. Turn the crosshead to **TDC** while checking that the guide ring of the crosshead enters the centre hole in the piston rod.

9. After turning the piston fully to **TDC**, unscrew the adjustable claw of the lifting tool and pull the lifting tool free of the lifting groove in the piston

   Remove the lifting tool and the guide ring for piston rings.

   Turn the crosshead with the piston rod and the telescopic pipe down far enough to permit tightening of the piston rod screws.

10. Remove the distance pieces from the piston rod foot.

    Mount and tighten the piston rod screws. *See Data.*

    Lock the screws with locking wire.

    Mount the locking wire in such a way that the wire is tightened if one of the screws works loose.
    See Procedure 913-7.

11. Tighten down the piston rod stuffing box by means of the screws through the inner holes in the stuffing box flange. *See Data.*

12. Mount the cylinder cover studs with the stud setter.

    Carefully clean the surfaces around the base of the mounted studs and refill the roots properly with Permatex 3.

Note!
The studs should not be fully screwed-in. Instead the stud should only be screwed-in until the edge on the stud is 2.0-2.5 mm above the cylinder frame, *see the sketch.*

    Mount the piston cleaning ring on the cylinder liner.

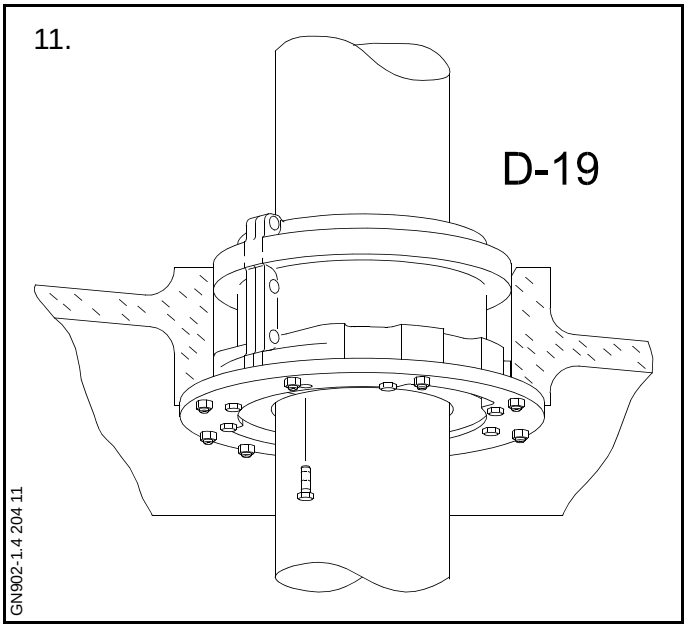
OBS!
Check that TOP, CAM SIDE mark on the ring face upwards and TOP, CAM SIDE mark set the camshaft side when mounting.

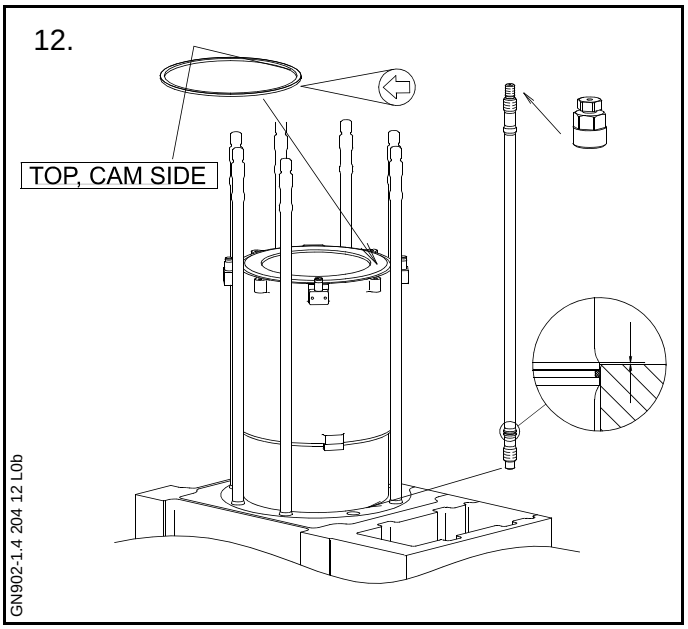
13. Smear the piston rod with molybdenum disulphide, and turn the crankshaft a couple of revolutions.

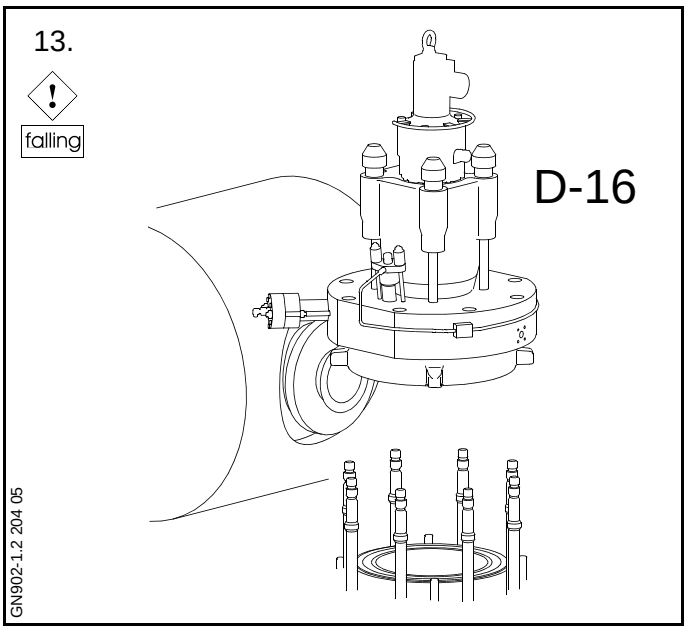
    Mount the cylinder cover.
    See Procedure 901-1.4.

14. Start the engine and keep it running for about 15 minutes at a number of revolutions corresponding to very slow.

    Then stop the engine and inspect the piston rod and stuffing box.







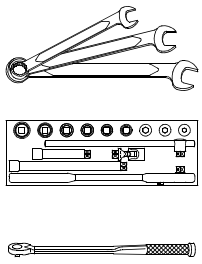
SAFETY PRECAUTIONS

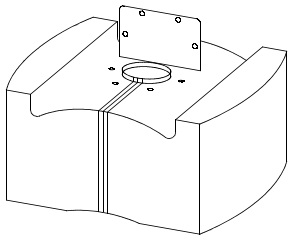
X	Stopped engine
X	Block the starting mechanism
X	Shut off starting air supply
X	Engage turning gear
X	Shut off cooling water
X	Shut off fuel oil
X	Shut off lubrication oil
	Lock turbocharger rotors

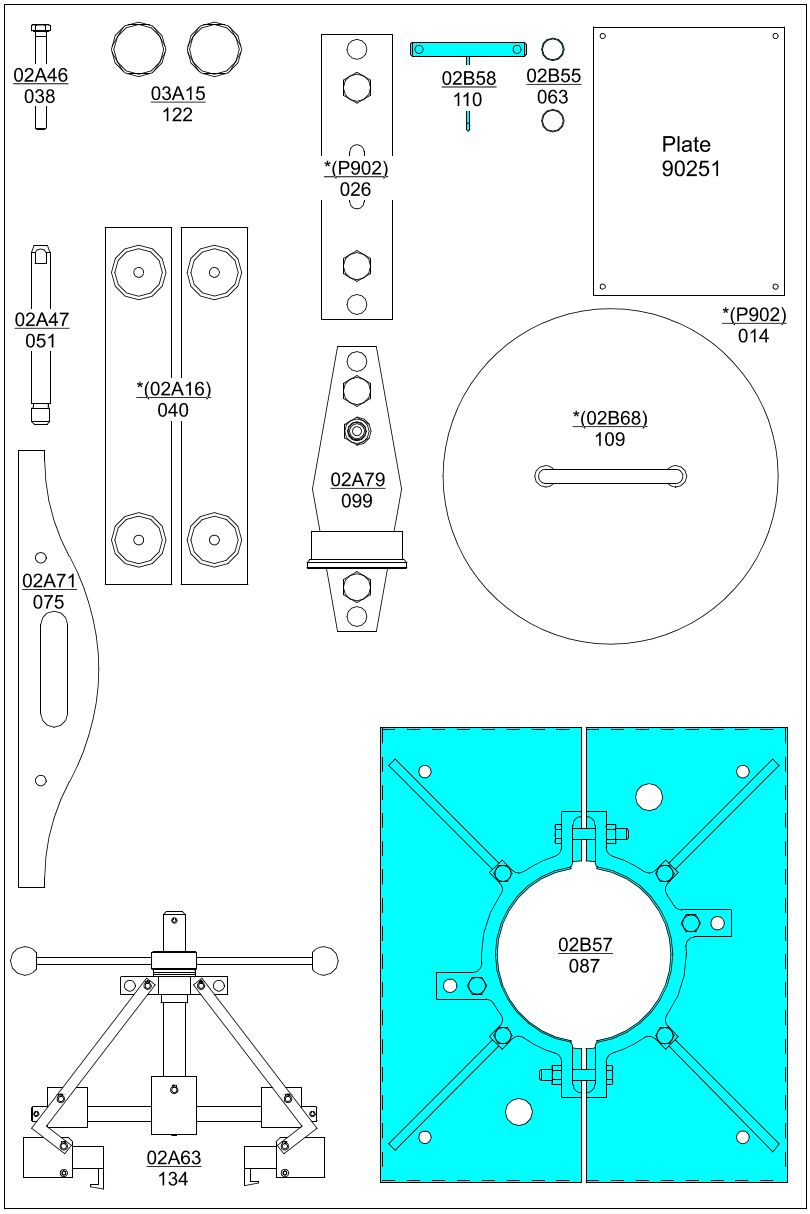
Data

Ref.	Description	Value	Unit
D-1	Stuffing box complete	57	kg
D-2	Stuffing box half	22	kg
D-3	Tightening torque for stuffing box halves	80	Nm
D-4	Tightening torque for stuffing box flanges	80	Nm
D-5	Tightening torque for inner screws	80	Nm
D-6	Uppermost rings - vertical clearance	0.085-0.152	mm
D-7	Middle rings - vertical clearance	0.100-0.167	mm
D-8	Lowermost rings - vertical clearance	0.082-0.127	mm
D-9	Uppermost ring (upper) - ring-end clearances	3 x 3	mm
D-10	Uppermost ring (lower) - ring-end clearances	3 x 6	mm
D-11	Lowermost rings - ring-end clearances	3 x 3	mm
D-12	Check length for upper scraper ring springs:		
	- F_0 = 0 N.....L_0 =	645.5	mm
	- F_1 = 86.3 +/– 8N..... L_1 =	702.5	mm
D-13	Check length for uppermost sealing ring and sealing ring springs(protecting rings/seat rings.)		
	- F_0 = 0 N..... L_0 =	662.5	mm
	- F_1 = 86.3 +/– 8N..... L_1 =	749	mm
D-14	Check length for the scraper ring springs		
	L_0 .. 0 N ..... Check length	496	mm
	L_1 .. 80 +/– 3N... Check length	646	mm
	L_1 ..117 +/– 7N.. Check length	714	mm

Standard Tools: See Section 913



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038
03A15
122
*(P902)
026
02B58
110
02B55
063
Plate
90251
*(P902)
014
02A47
051
*(02A16)
040
02A79
099
*(02B68)
109
02A71
075
02B57
087
02A63
134

1. After the piston rod stuffing box has been dismantled, checkthe following clearances: *See Procedure 902-2.2.*

   Uppermost scraper ring and seal rings

   Vertical clearance between seal ring section and groove. (**D-6**)

   Clearance at ring ends (scraper ring).
   Total clearance (scraper ring). (**D-9**)

   Clearance at ring ends (seal rings).
   Total clearance (seal rings). (**D-9**)

   Middle seal rings

   Vertical clearance between seal ring and groove. (**D-7**)

   Clearance at ring ends.
   Total clearance. (**D-10**)

   Lowermost scraper rings

   Vertical clearances between seal ring and groove. (**D-8**)

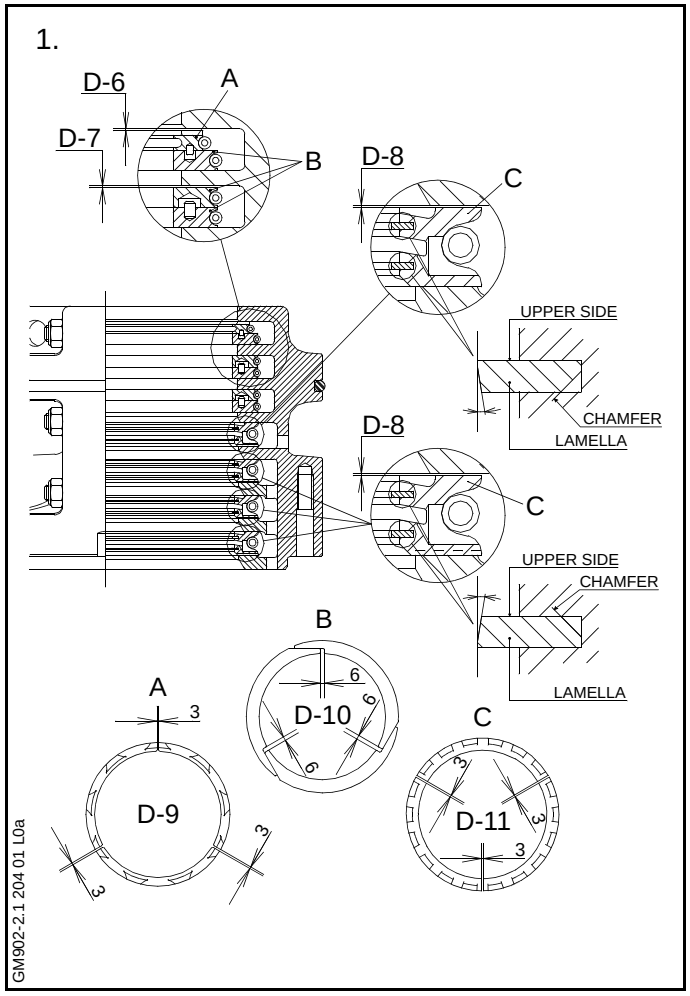
   Clearance at ring ends.
   Total clearance. (**D-11**)

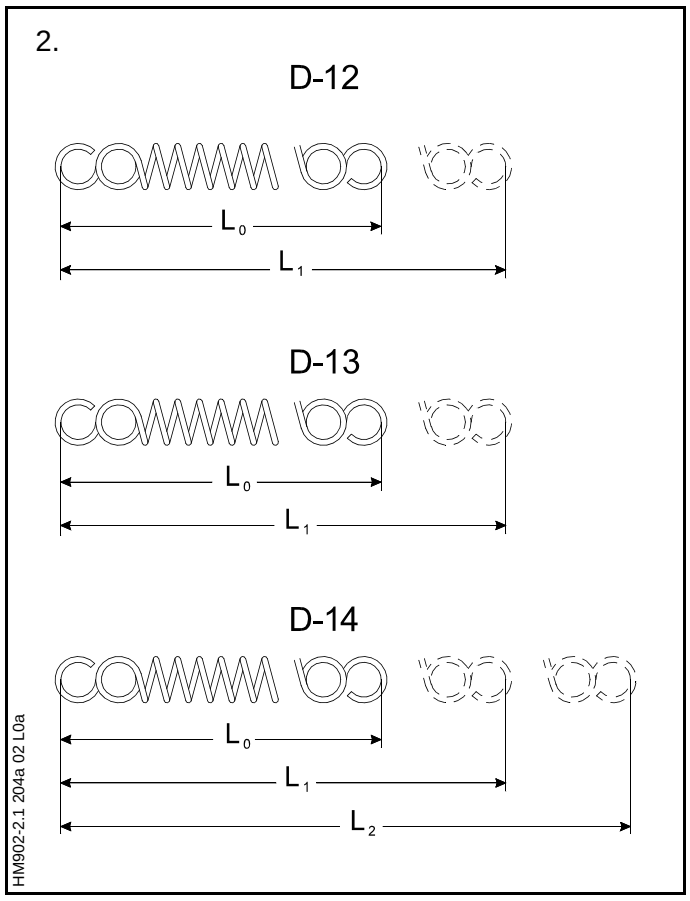
   The ring clearances stated in Data apply to new rings.

   As a general guide, it is recommended- depending on the overhauling intervals and one's own experience-to replace seal rings and scraper rings when the specified clearance values **D-9**, **D-10** and **D-11** has been halved.

2. Check the length of the springs at different loads. Adjust the loads to achieve the lengths stated in Data.

   If the loads necessary are outside the limits stated in Data, the springs must be discarded.





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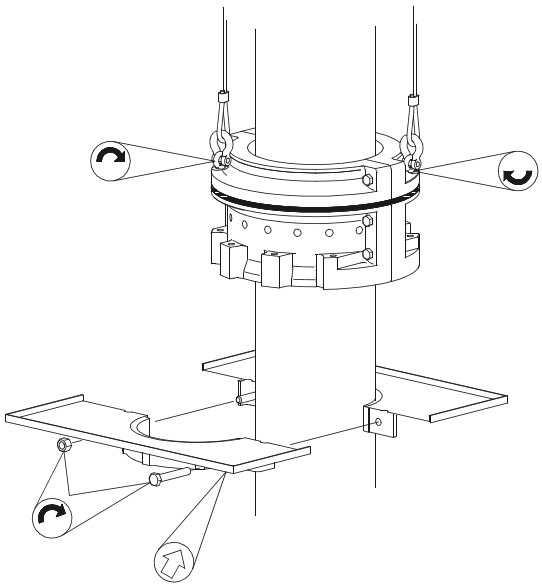

GN902-2.3 204 01 L0a

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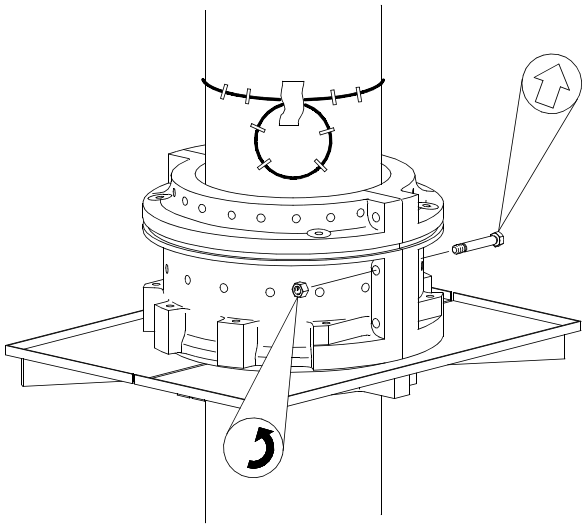

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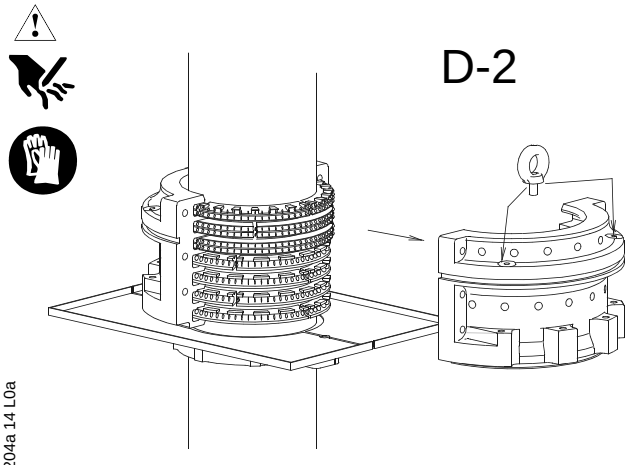

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Outside the engine

Normally, overhaul of the piston rod stuffing box is carried out by routine methods in connection with dismantling (pulling) of the pistons.
See Procedure 902-1.2.

During such overhauls the piston rests on a support placed over one of the cut-outs in the top platform.

Work on the stuffing box is then carried out from the platform below.

1. Mount two eye screws in the stuffing box flange, and hook on two tackles.

   Then lift the stuffing box a little up the piston rod, and mount the worktable round the piston rod at a suitable working height.

   Land the stuffing box on the worktable, and remove the tackles and screws.

2. Remove the O-ring of the stuffing box. If the O-ring is intact and is to be used again, move it up the piston rod and secure it in this position, for example with tape.

   If the overhaul is carried out inside engine the O-ring has to be reused.

   Remove the nuts from the stuffing box assembling bolts.

3. Take out the six bolts, and pull away one stuffing box half.

   Mount two eye screws in the stuffing box half and remove it from the worktable.

Inside the engine

If, in the period between piston overhauls, it becomes necessary to inspect the piston rod stuffing box, proceed as follows:

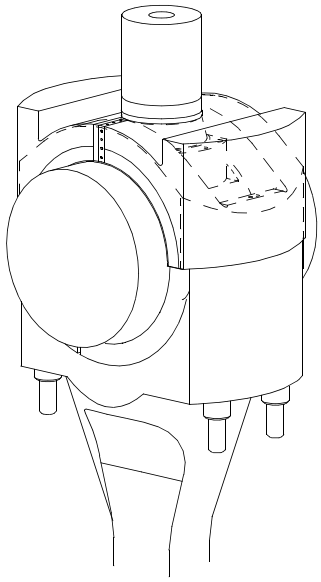
1. Turn the crankthrow to about 90° from **TDC**.

   Mount the protecting cover around the piston rod to protect the crosshead bearing from impurities.

2. Remove the drain oil pipe and all innermost screws and all outer screws except for two screws placed diametrically opposite in the stuffing box flange, longitudinally to the engine.

3. Mount the worktable round the piston rod so that the two remaining screws can be loosened through the worktable holes.

1.



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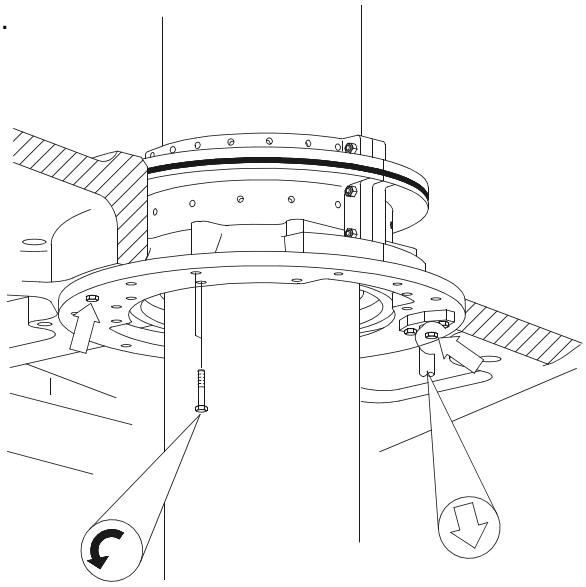

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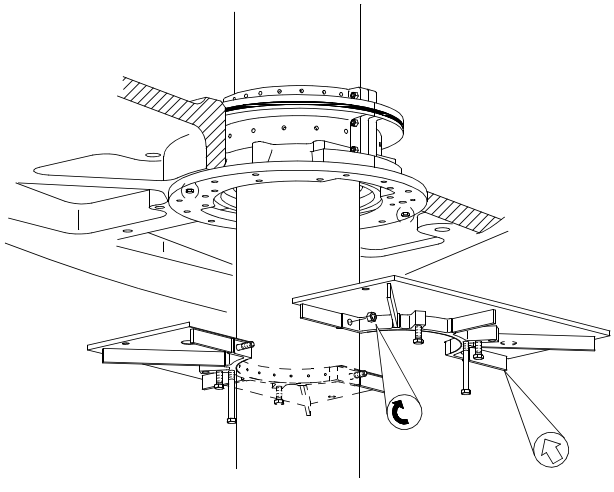

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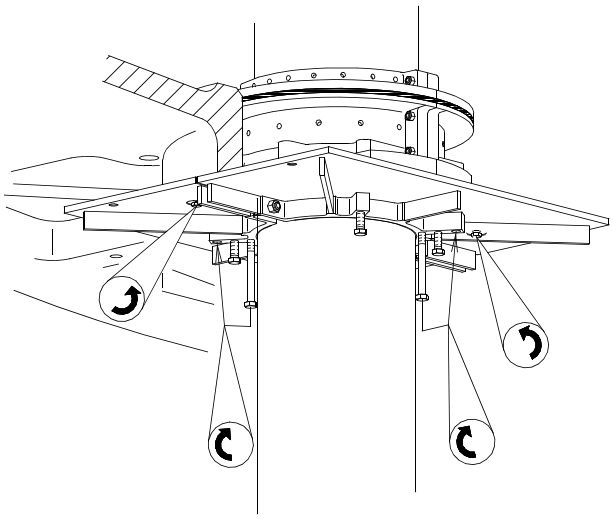


MB902-5.2 94 04 L0a

4. Remove the two long screws from the worktable.

   Mount them in the stuffing box through the holes in the worktable.

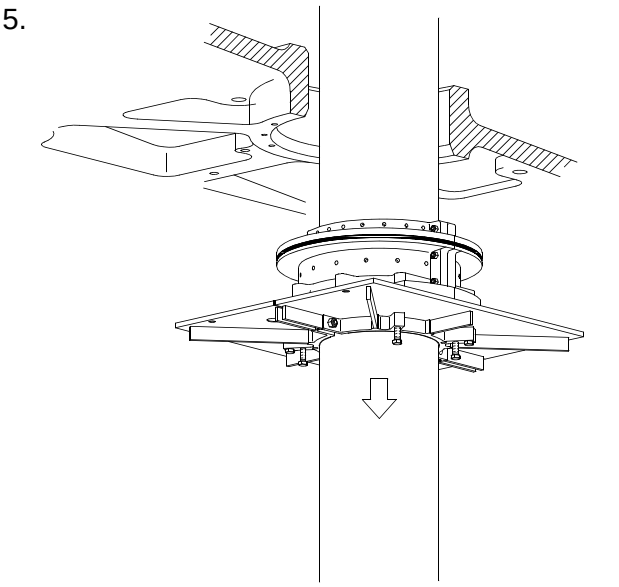
   Remove the remaining two screws from the stuffing box.

5. Turn the piston to **BDC**, thereby withdrawing the stuffing box from the cylinder frame bottom.

   Remove the two long dismantling screws from the stuffing box and mount them in the worktable.

6. By means of the four short screws in the worktable, press the stuffing box out of the flange.
   For overhauling the stuffing box, see Procedure 902-2.3.

5.



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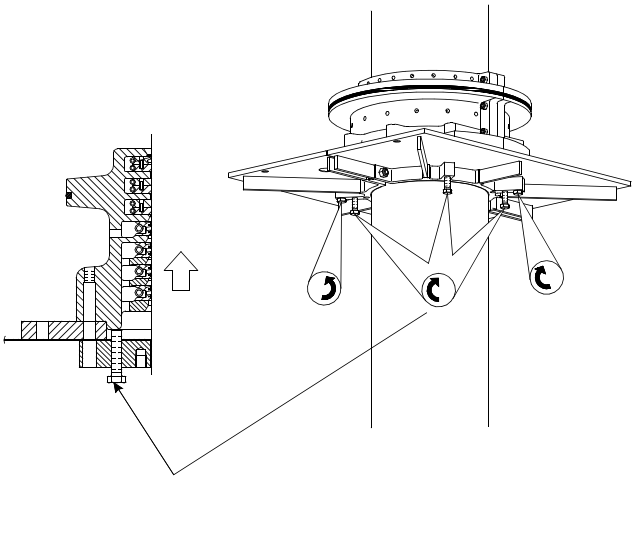


MB902-5.2 94a 06 L0a

1. Remove the remaining stuffing box half and press all seal rings and scraper rings down against the worktable.
   See Procedure 902-2.1.

2. Measure the ring end clearance (**D-9**, **D-10** and **D-11**) between the ring segments to determine whether replacement is necessary.
   See Procedure 902-2.1.

Note!
Dismantle and stack the rings in the same order as when fitted in the stuffing box.

Carefully clean all the ring segments.

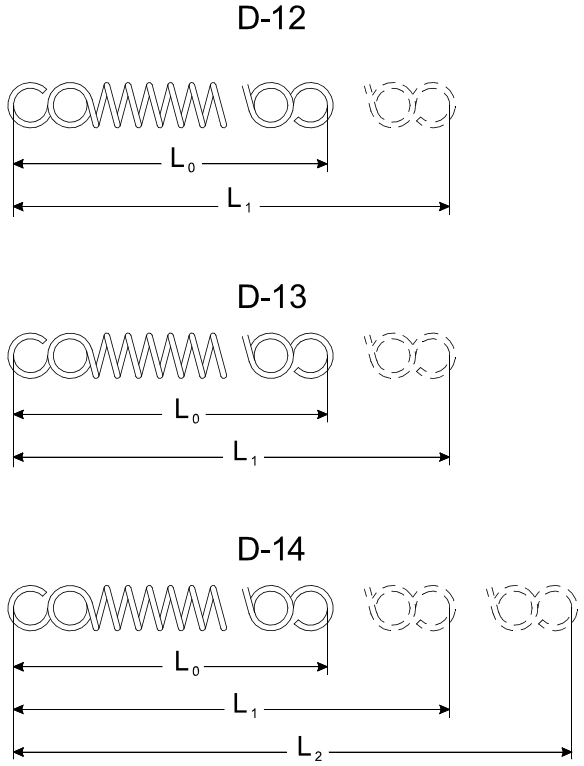
Inspect and assess the surface quality of the seal rings. If their sliding surfaces have scratches or marks, replace the rings.

3. Check the lengths of the springs.
   See Procedure 902-2.1.

4. Inspect the surface of the piston rod. If small longitudinal scratches have occurred (caused by poorly adapted stuffing box rings), smooth the piston rod surface carefully with a fine grained carborundum stone. In the case of coarse scratches, it may prove necessary to machine-grind the surface in a workshop.

5. Clean the halves of the stuffing box housing.

3.



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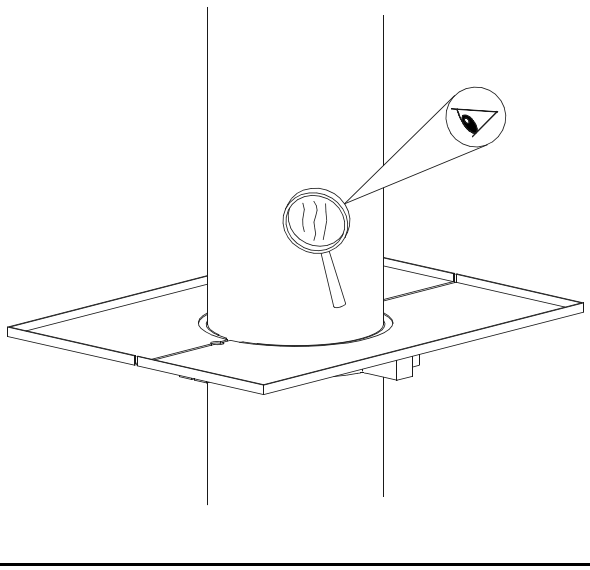

GN902-2.3 204 19

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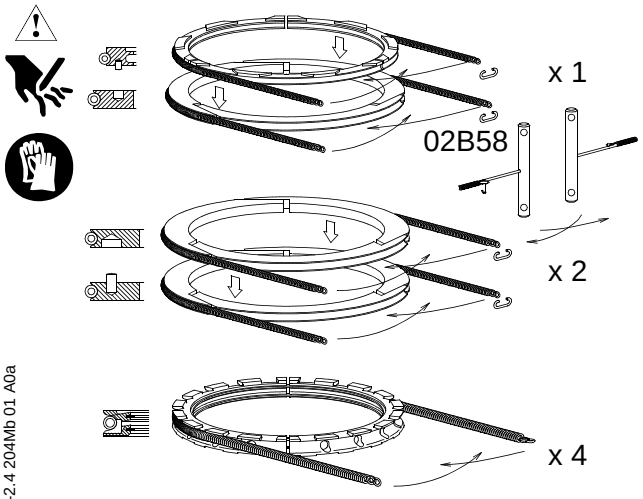

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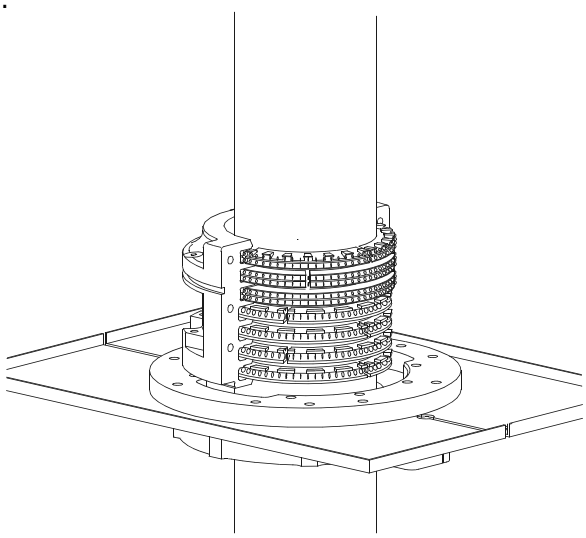

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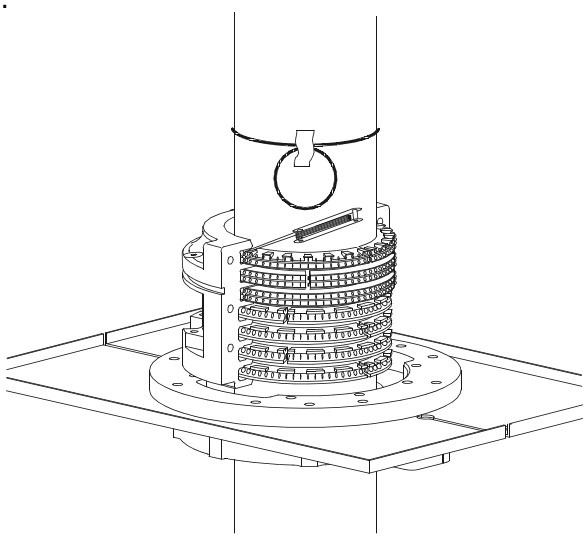


GN902-2.3 204a 10 L0a

1. Lubricate the piston rod (in the area where all the ring units in the stuffing box will be positioned) with molybdenum disulphide (MoS_2).

   Assemble all the stuffing box ring units round the piston rod, on the worktable, in the following way:

   Assemble the four scraper ring units (consisting of 3 part).
   Place the segments (3 part) for the scraper ring unit on the working table.

Note!
Be careful not to set the lamellas for scraper rings up side down. *See the sketch in 902-2.1-1*.

   Place the spring round the segments and, by means of two hooks, pull both spring ends, and assemble the spring.

   Repeat this procedure for the remaining scraper rings.

   On top of the scraper ring unit, assemble the two seal ring units (consisting of under side : 3 part with the guide pin and upper side : 3 part with the pin hole).

   Finally, assemble the uppermost ring unit (consisting of under side : 3 part seal ring with the pin hole and upper side : 3 part scraper ring with th eguide pin).

2. The height of all the assembled ring units on the piston rod until the ring units are opposite the corresponding grooves in the stuffing box housing. Subsequently, push the stuffing box half into contact with the piston rod, round the ring units.

3. Using a feeler gauge, measure the horizontal clearance of the rings.
   See Procedure 902-2.1.

4. Then place the other half of the stuffing box housing on the worktable, pushing it into place round the rings.

   Mount and tighten up the fitted bolts to the torque specified on the Data Sheet.

Outside the engine

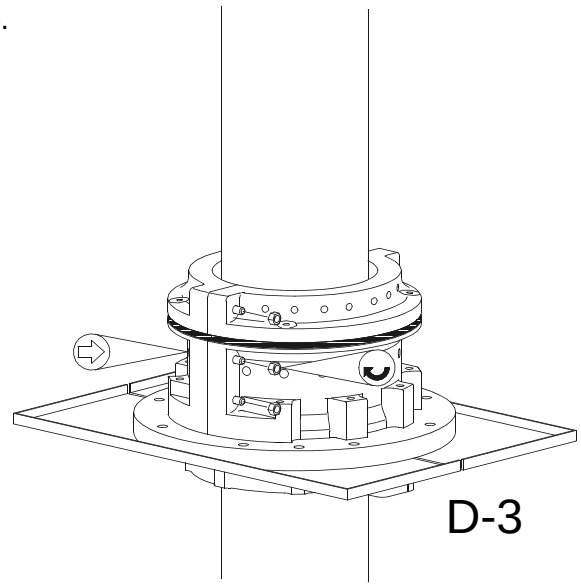
5. Mount eye screws and wire ropes, and lift the stuffing box a little. Remove the worktable.

6. Remove the worktable and lower the stuffing box until it rests against the distance pieces on the piston rod foot.

   Mount a new O-ring in the stuffing box groove.

   Remove wire ropes and screws.
   For mounting of the stuffing box and the piston, see Procedure 902-1.4.

4.



GN902-2.3 204 11 L0a

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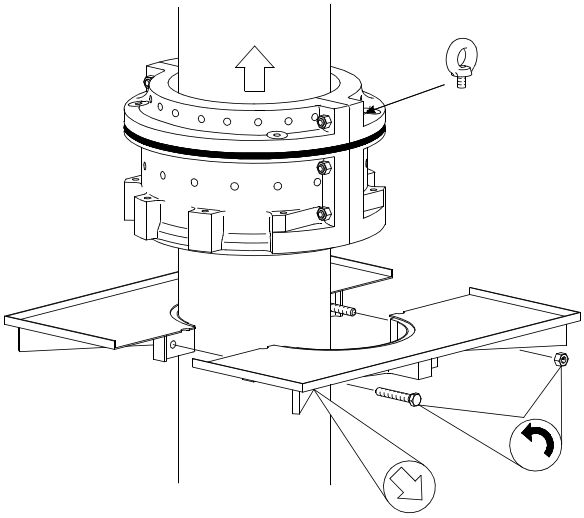

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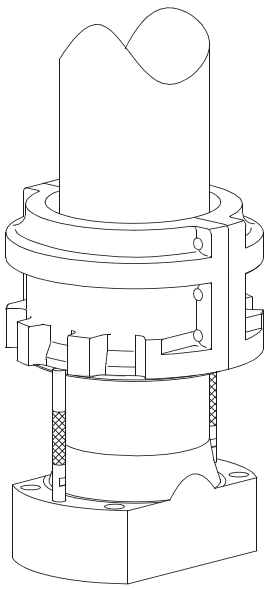

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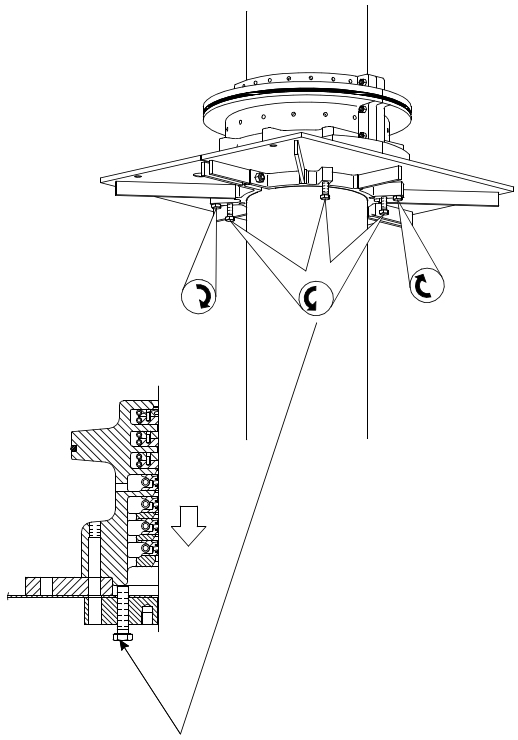

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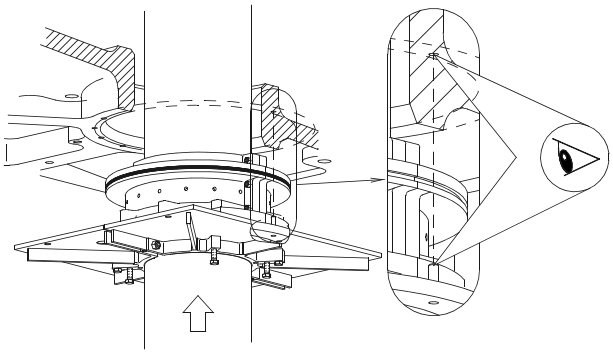

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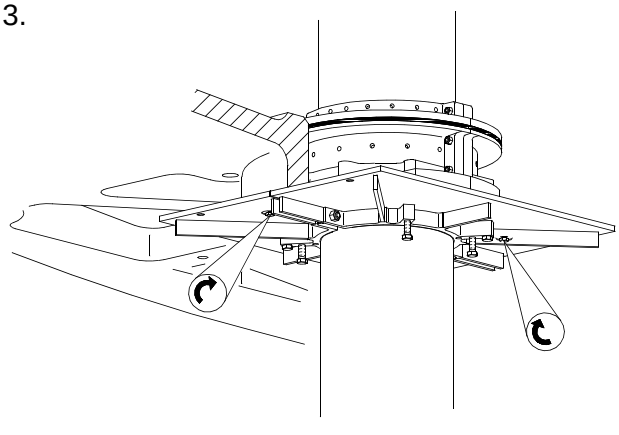


MB902-5.2 94 09 L0a

Inside the engine

1. After overhauling, support the stuffing box halves on top of the four screws.

   Mount the two long screws from the worktable in the stuffing box.

   Unscrew the short screws so that the stuffing box lands on the flange.

2. Turn the piston upwards until the stuffing box is in place in the cylinder frame.

Note!
Make sure that the two guide pins in the flange enter the guide holes in the bottom of the cylinder frame.

3. Mount two screws in the flange through the holes in the worktable.

4. Remove the long screws from the stuffing box and mount them in the worktable.

   Remove the worktable from the piston rod.

5. Mount and tighten all the inner and outer screws for the stuffing box. *See Data*.

6. Remove the protecting cover from the piston rod/crosshead.

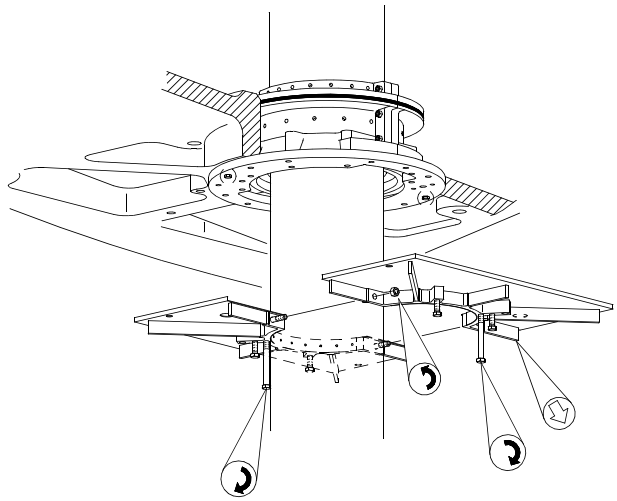
   Smear the piston rod with molybdenum disulphide.

   Then turn the crankshaft a couple of revolutions.

   Start up the engine and keep it running for approx. fifteen minutes at a number of revolutions corresponding to very slow or idle speed.

   Then stop the engine and inspect the piston rod and stuffing box.

4.



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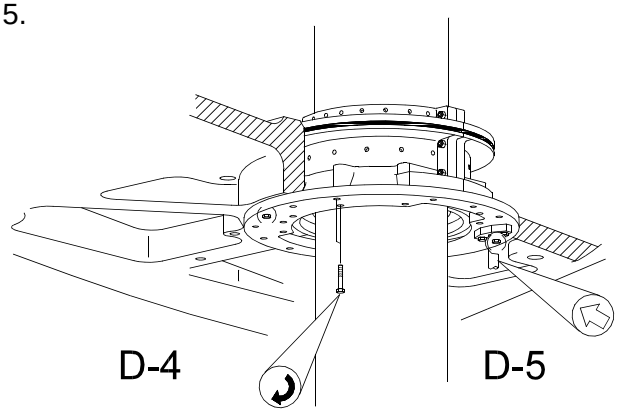

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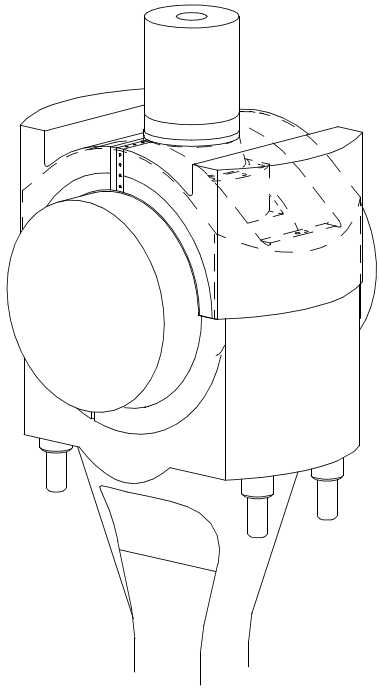

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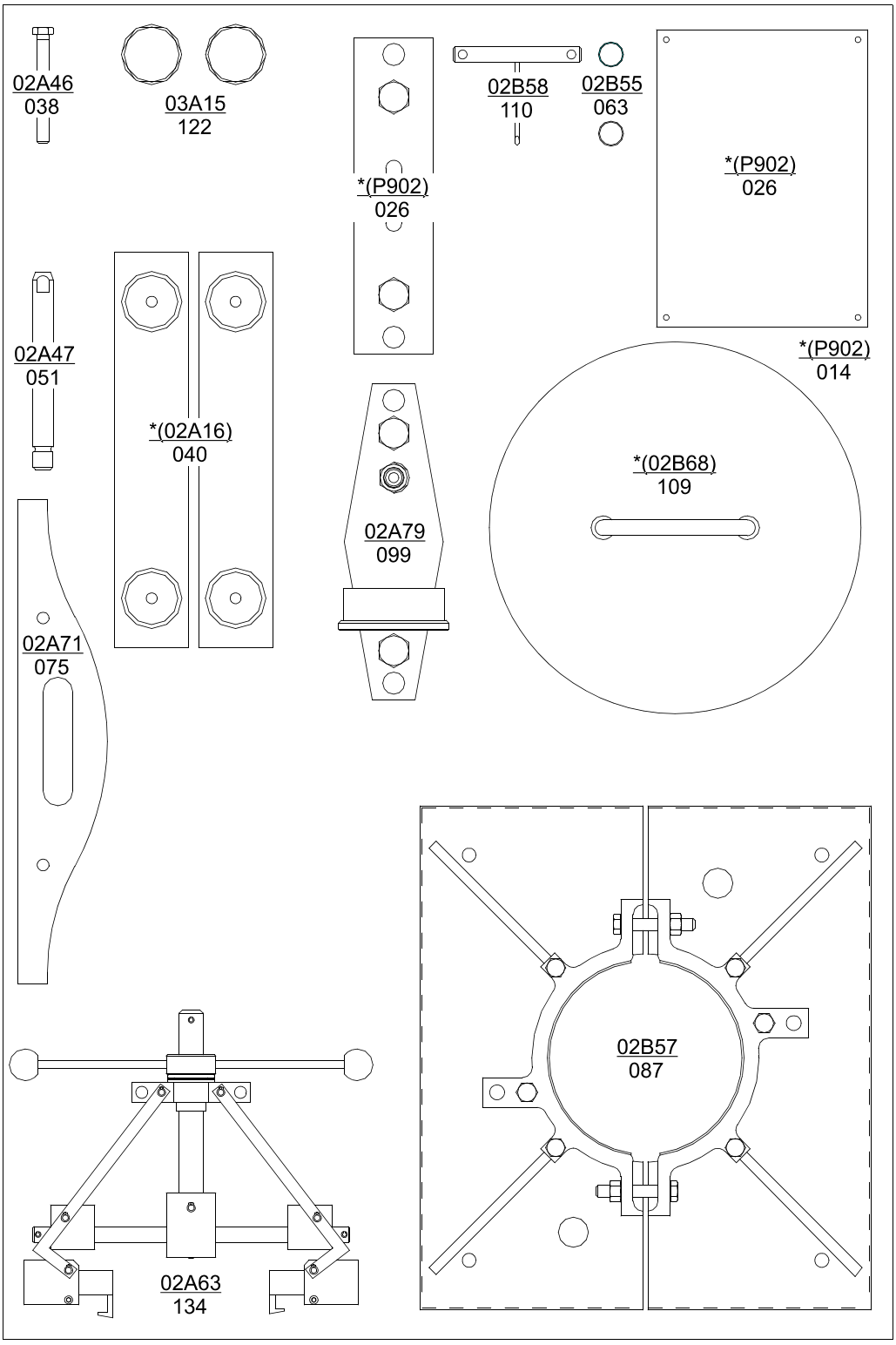
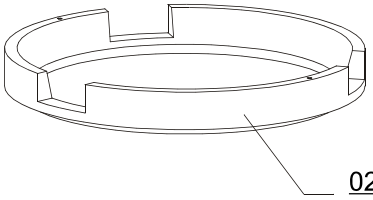

02A46
038
03A15
122
*(P902)
026
02B58
110
02B55
063
*(P902)
026
*(P902)
014
02A47
051
*(02A16)
040
02A79
099
*(02B68)
109
02A71
075
02B57
087
02A63
134

Item No.	Part Description	MES Tools No.	
014	Tool panel *)	(P902)	
026	Name plate *)	(P902)	
038	Dismntling screw	02A46	
040	Support for tilting tool *)	(02A16)	
051	Guide screw for piston crown	02A47	
063	Distance piece	02B55	
075	Template	02A71	
087	Worktable	02B57	
099	Pressure testing device	02A79	
109	Cover	(02B68)	
110	Hook for mounting of spring *)	02B58	
122	Lifting and tilting screw	03A15	
134	Piston ring expander	02A63	
014-134	Tool panel, complete with tools *)	-	
	*) Optional extras		



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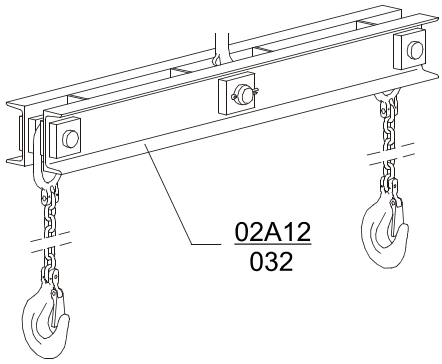

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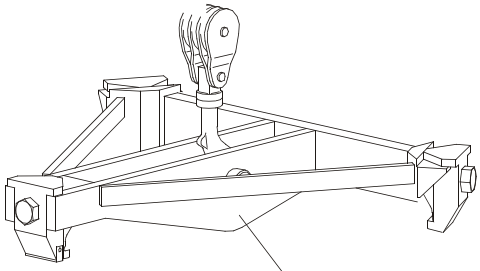

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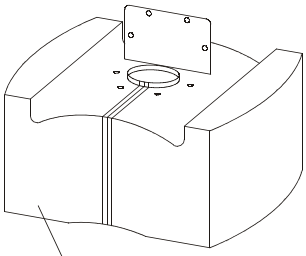
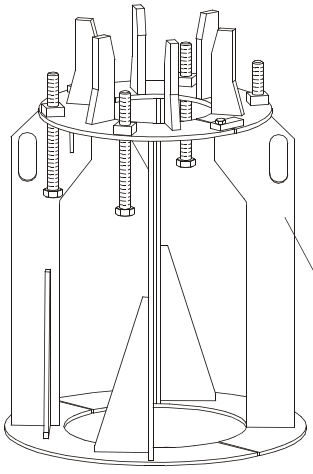
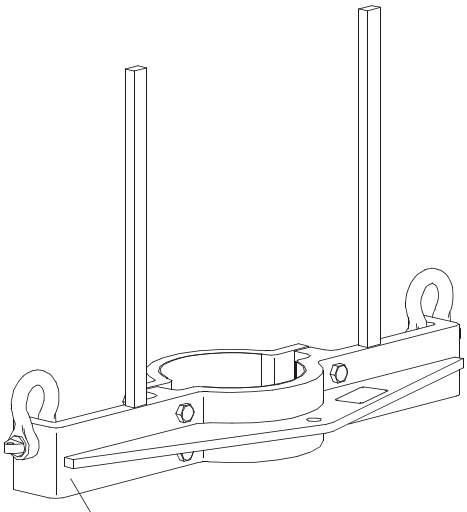


04A68
M1



02A55
056



*(02A13)
044

Item No.	Part Description	MES Tools No.	
019	Guide ring for piston	02A53	
020	Lifting tool for piston	02A11	
032	Lifting crossbar	02A12	
044	Lifting collar *)	(02A13)	
056	Support for piston	02A55	
M1	Cover for crosshead	04A68	
	*) Optional extra		

INDEX

CYLINDER COVER

PISTON WITH ROD AND STUFFING BOX

CYLINDER LINER AND
CYLINDER LUBRICATION

CROSSHEAD WITH CONNECTING ROD

CRANKSHAFT, THRUST BEARING
AND TURNING GEAR

MECANICAL CONTROL GEAR

STARTING AIR SYSTEM

EXHAUST VALVE

FUEL OIL SYSTEM

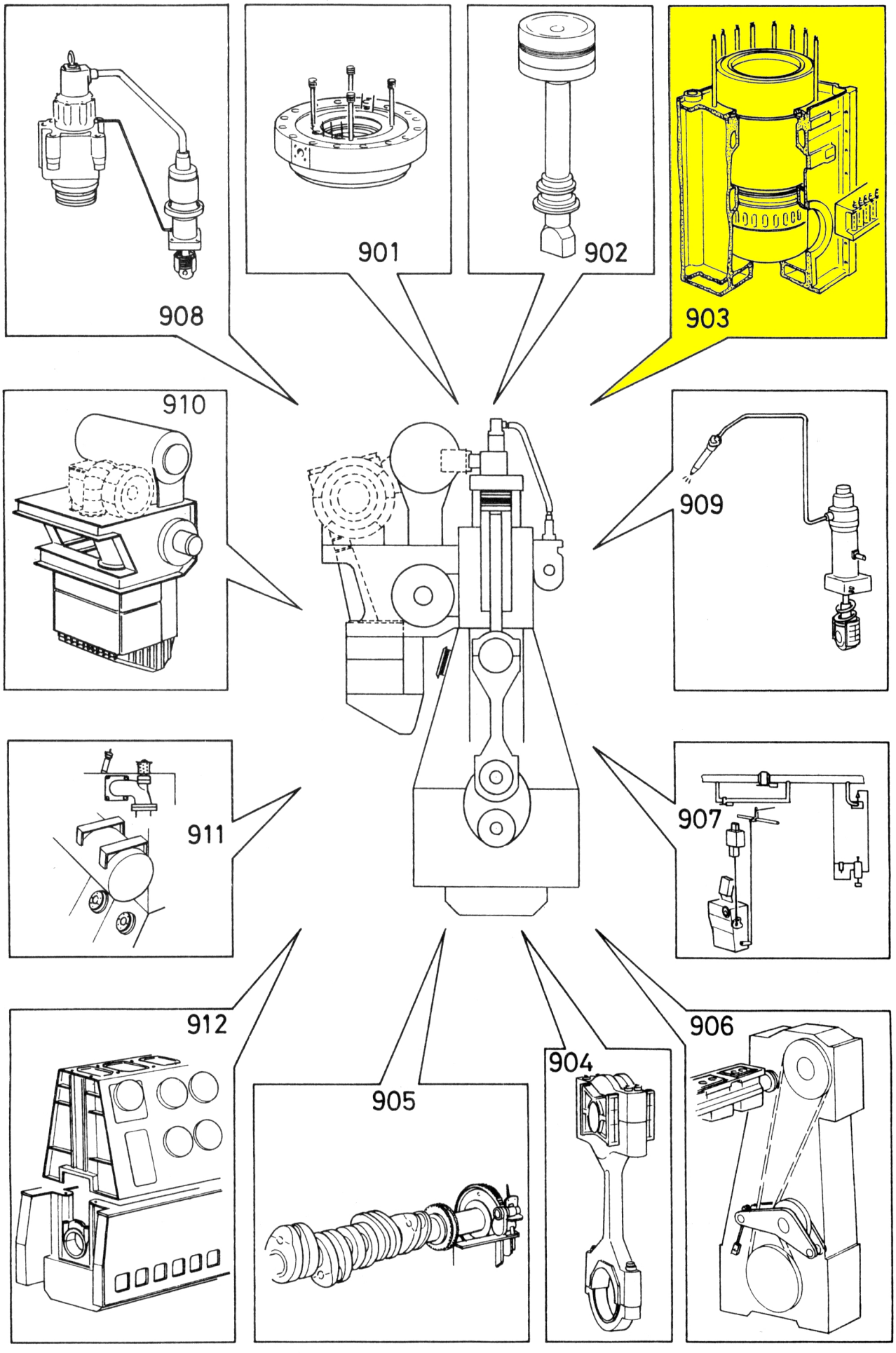
TURBOCHARGER SYSTEM

SAFETY EQUIPMENT

ASSEMBLY OF LARGE PARTS

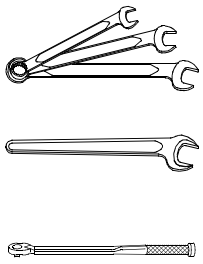
GENERAL TOOLS

MITSUI
MAN
B&W



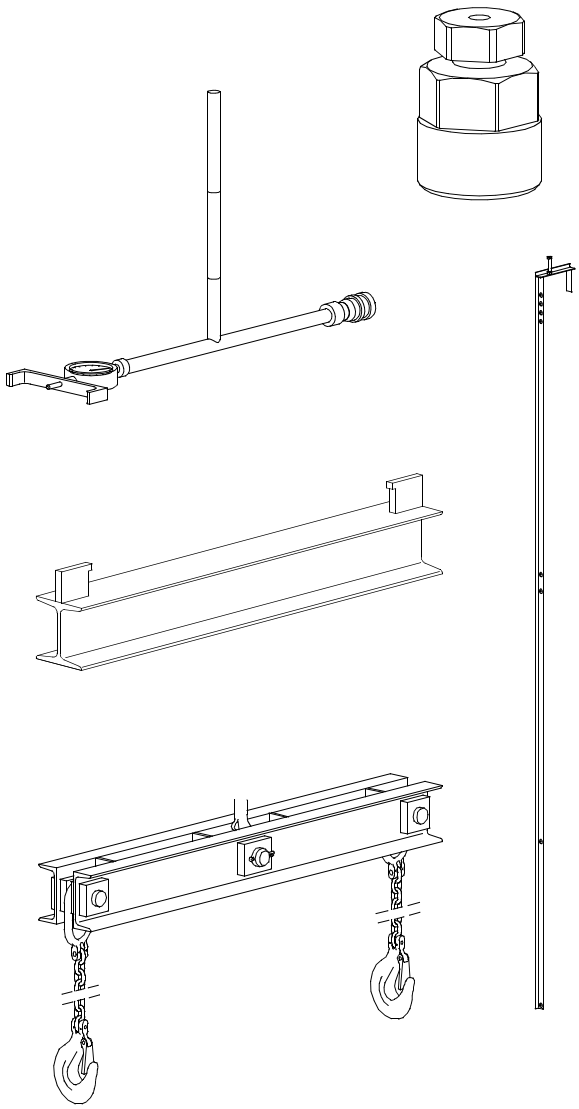
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of falling
X	Block the starting mechanism	Do not enter area when over head lifting is being carried out
X	Shut off starting air supply	
X	Engage turning gear	
X	Shut off cooling water	
X	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

Standard Tools: See Section 913



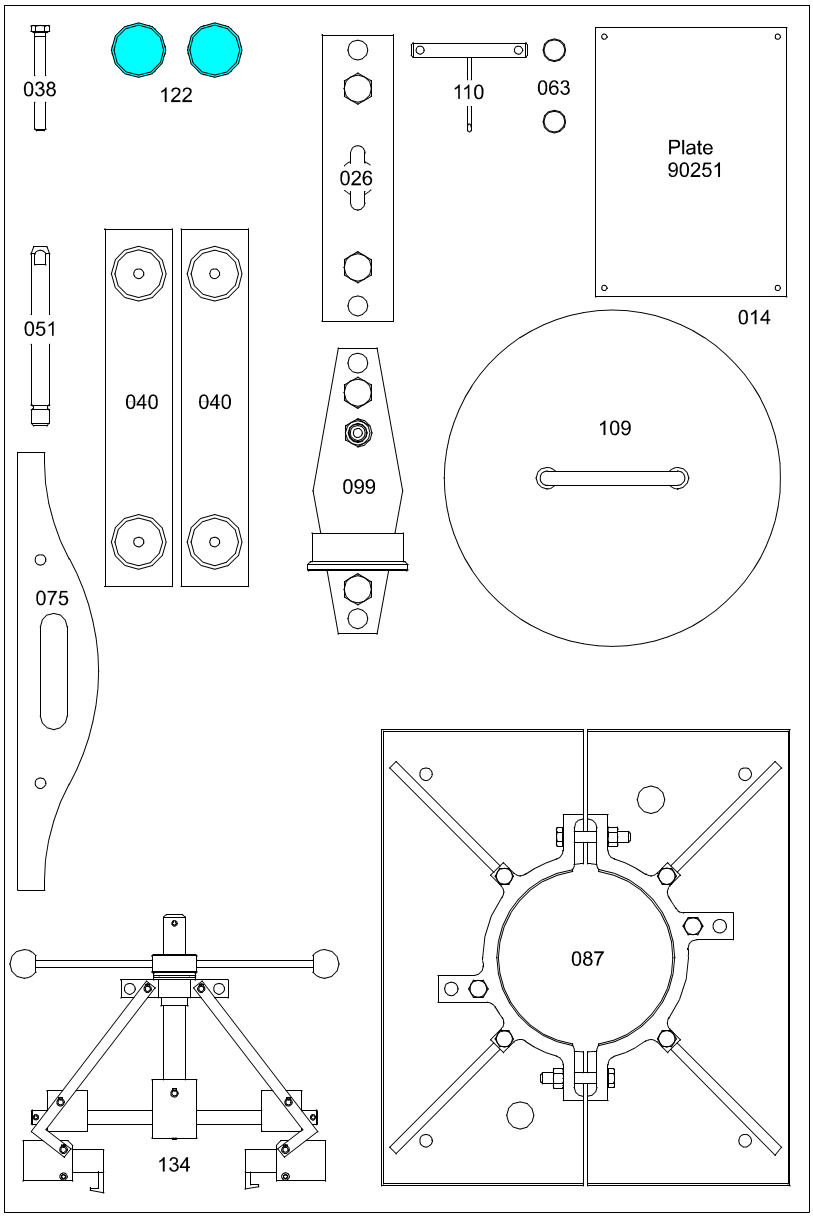
Data

Ref.	Description	Value	Unit
D-1	Cylinder diameter, new	500	mm
D-2	Cylinder liner, complete	1680	kg
D-3	Cooling jacket	178	kg
D-4	Cylinder cover studs - screwing-in torque	500	Nm
D-5	Cylinder cover stud	27	kg
D-6	Piston cleaning ring diameter, new	498.3	mm
D-7	Piston cleaning ring thickness, new	38.85	mm



The cylinder liner should be renewed if wear exceeds 0.4-0.8 % of the cylinder diameter.

When the cylinder liner is replaced, the new piston cleaning ring should be used at the same time.


038
122
110
063
026
Plate
90251
014
051
040
040
099
109
075
087
134

1. Dismount the cylinder cover.
See Procedure 901-1.2.

   Discard the mild steel ring between the cylinder liner and the cylinder cover.

   Remove the piston cleaning ring from the cylinder liner and clean it. Especially the inclined grooves on the inside must be cleaned carefully.

   If the piston cleaning ring looks normaly, it way be remounted. However, if it is damaged or gets abnormal wear contact MITSUI ENGINEERING & SHIPBUILDING CO., LTD. for advise.

   Dismount the piston.
See Procedure 902-1.2.

   Clean the cylinder liner and scavenge air ports.

2. Position the cylinder liner measuring rod to the cylinder liner.

   Measure the cylinder liner according to the points indicated on the measuring rod. *See Data.*

3. Take measurements in the fore-and-aft and athwartship directions.

4. Check and evaluate the condition of the cylinder liner according to the description given in Vol. 1, Chapter 707.

   Carefully grind away any scores or marks on (or wear ridge in the bottom of) the cylinder liner running surface by means of a grind stone.

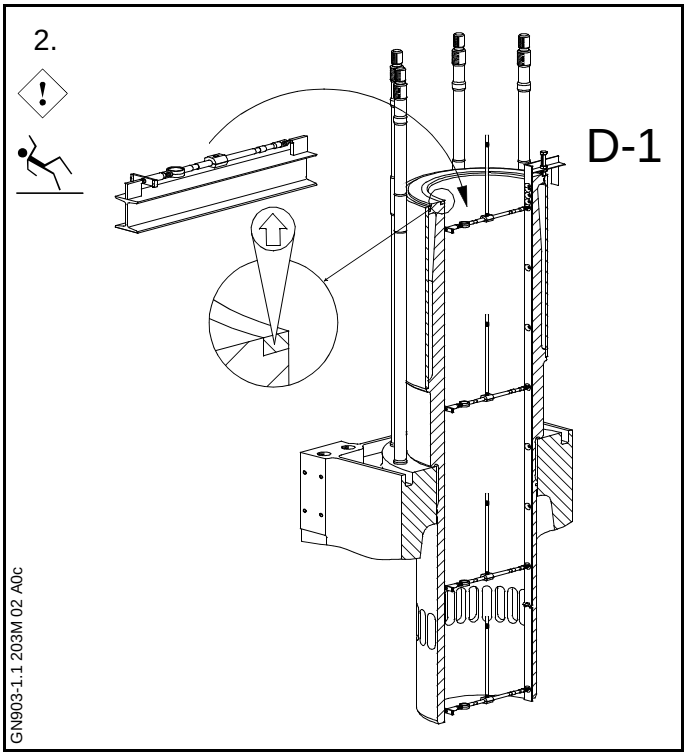
   Check the lubricating points of the cylinder by manually pumping cylinder oil to each individual lubricating point.

   Clean any blocked lubricating duct.

   Mount the piston and cylinder cover.
See Procedures 902-1.4 and 901-1.4.

Note!
In cases where shims have been mounted between the piston rod and the crosshead, the length of the measuring rod must be adjusted in accordance with the thickness of the shims.

2.



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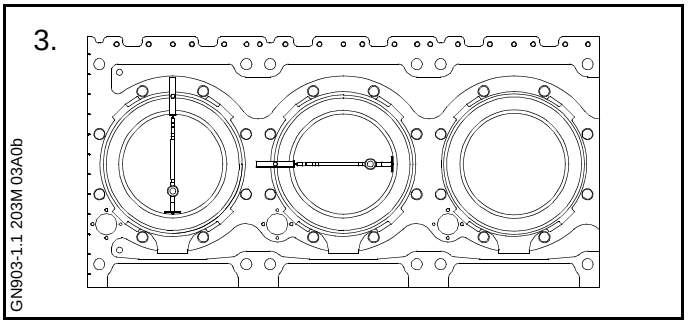

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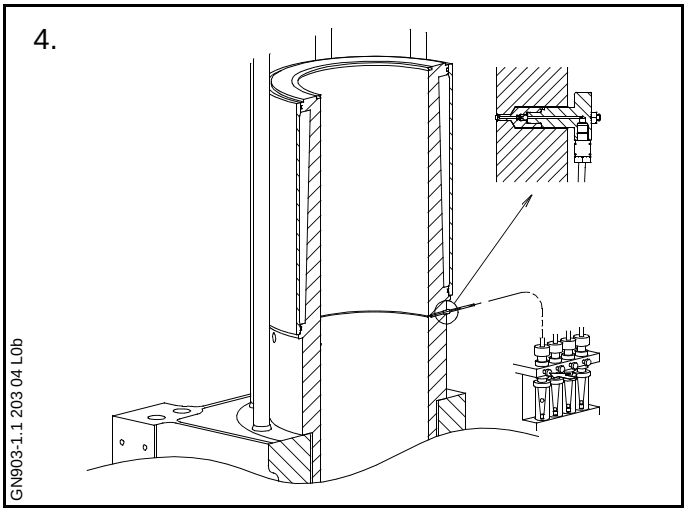
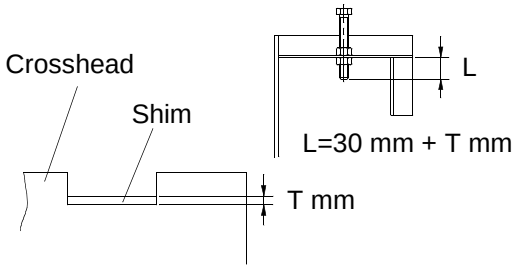
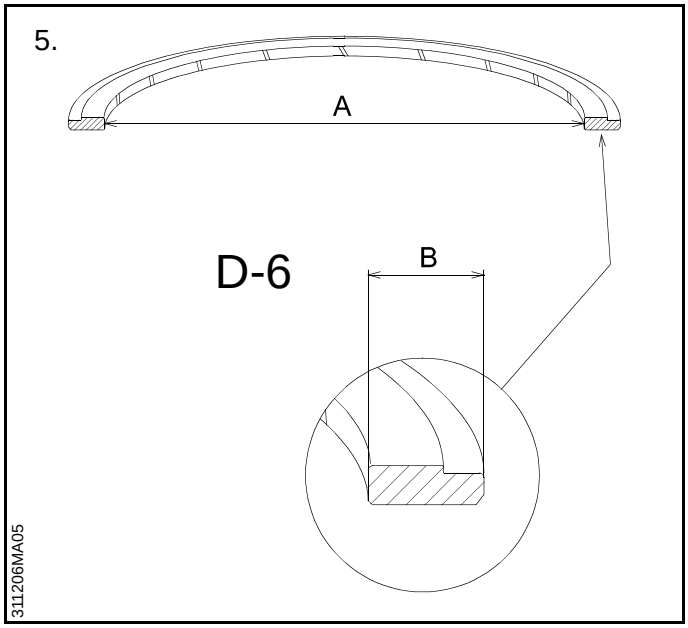






5. Compare the measured diameter of cylinder liner at the position No.5 marked “PC” on the measuring tool with that of the new cylinder liner to calculate the wear amount, *see data.*

   If the wear of cylinder liner at “PC” in diameter is below 0.6 mm then re-use the overhauled piston cleaning ring.

   If the wear of cylinder liner at “PC“ in diameter is below 0.6 mm or over, and below 1.2 mm then install the oversized piston cleaning ring by 0.6 mm diameter. (to be ordered as a spare parts.)

   If the wear of cylinder liner at “PC“ in diameter is below 1.2 mm or over, then install the oversized piston cleaning ring by 1.2 mm in diameter. (to be ordered as a spare parts.)

   Measure the inside diameter A of the piston cleaning ring in the **FORE**-and-**AFT** and athwartship direction with an inside micrometer. Compare the measured dismeter **A** with the original one, *see Data(**D-6**)*, to calculate the wear of piston cleaning ring in diameter.

   If the significant wear amount of piston cleaning ring in diameter is measured, contact MITSUI ENGINEERING & SHIPBUILDING CO., LTD. for further action.

   Measure the thickness B of piston cleaning ring at **PORT** side, **FORE** side, **STARBOARD** side, and **AFT** side. Compare the measured thickness **B** with the original one, *see Data(**D-7**)*, to calculate the wear of piston cleaning ring in radius.

   If the significant deviation of wear in radius is measured, contact with engine builder for further action.

   Further more, in case of the metallic contact between piston crown top land and piston cleaning ring, check the wear of piston skirt.

1. Dismount the cylinder cover.
   See Procedure 901-1.2.

   Discard the seal ring from the top of the cylinder liner.

   Remove the piston cleaning ring from the cylinder liner.

   Turn the piston down far enough to make it possible to grind away the wear ridges at the top of the liner with a hand-grinder.
   See Procedure 903-1.3.

   Dismount the piston.
   See Procedure 902-1.2.

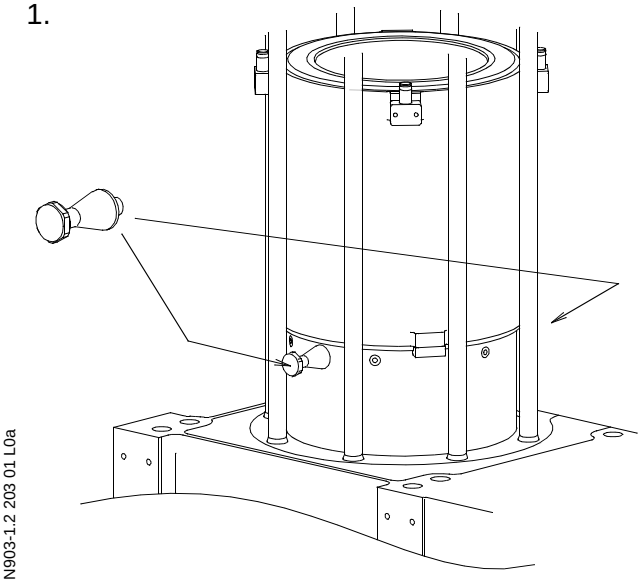
   Mount the two lifting screws in the cylinder liner.

Caution!
Tighten firmly the lifting tools against the contact surface of the cylinder liner, (tightening torque:approx. 150 Nm). Other wise the lifting tools might be damged.

2. Disconnect - at the exhaust side of cylinder - the oil pipes leading from the cylinder lubricator to the junction box.

   Dismount the four cooling water pipes - between the cooling jacket and cylinder cover - and clean them carefully.

1.



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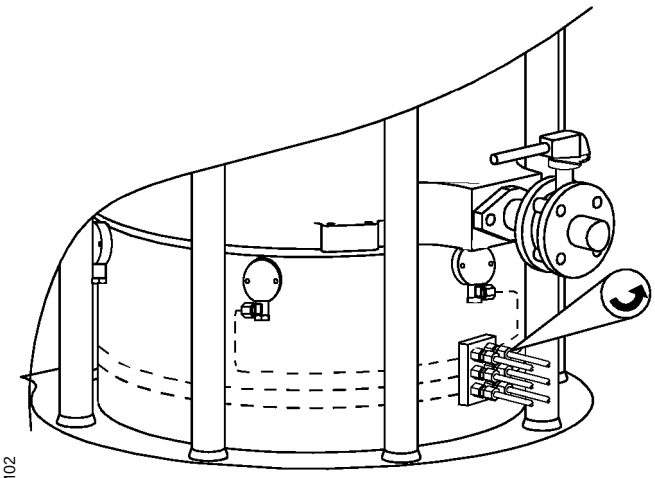

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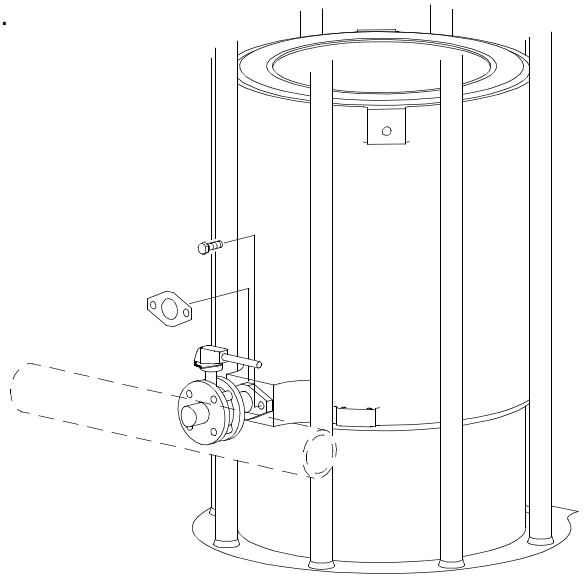

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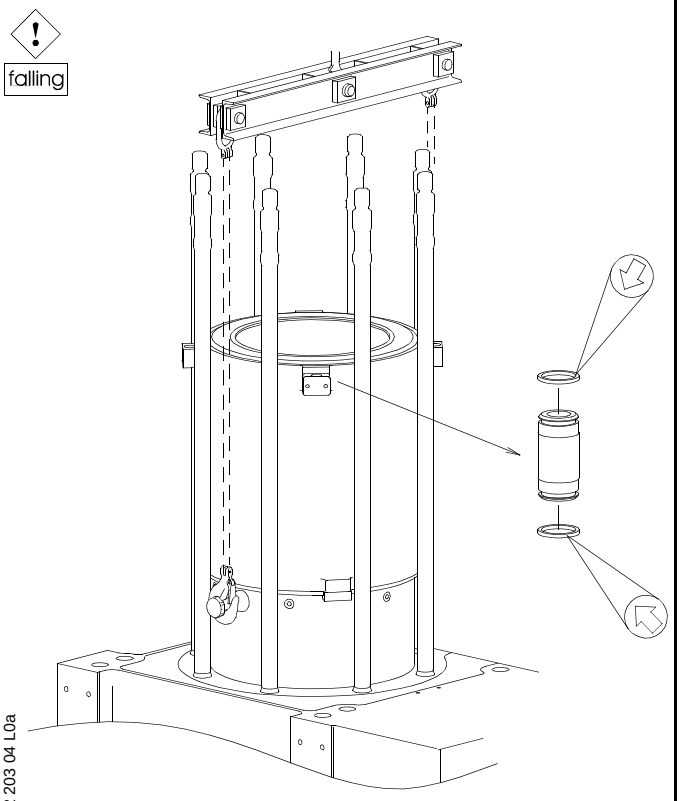

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3. Remove the screws of the cooling water inlet pipe.

4. Attach the crane to the lifting tool.

   Hook the chains from the lifting crossbar on to the lifting screws and lift the cylinder liner with the cooling jacket out of the cylinder frame.

Note!
Low lifting height in the engine room may require the removal of one or more cylinder cover studs before dismantling the cylinder liner.

Land the cylinder liner vertically on, for instance, a couple of planks.

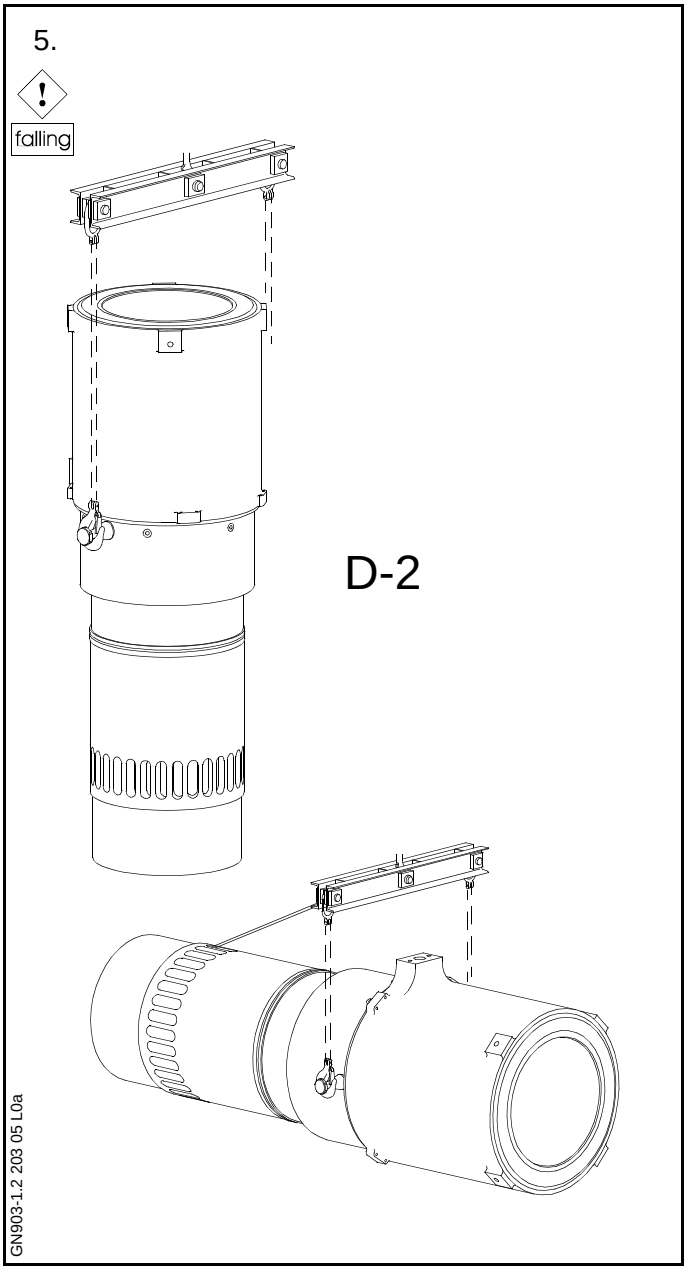
Clean the cylinder frame internally, paying special attention to the contact surfaces for the cylinder liner at the top of the cylinder frame.

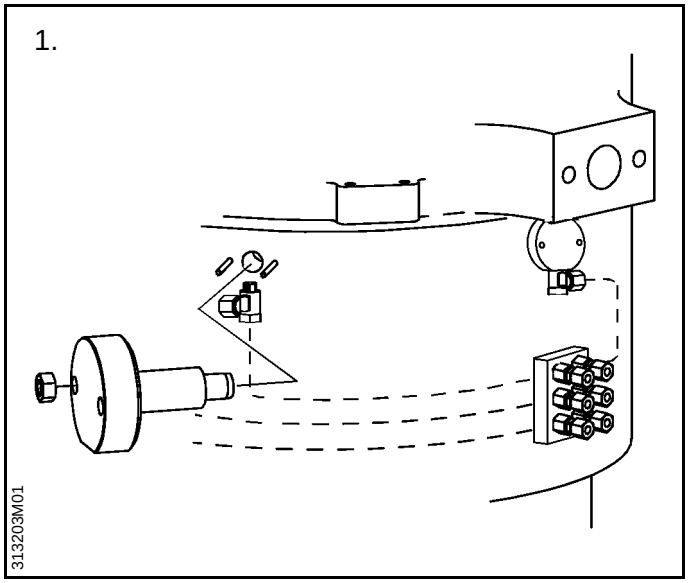
Discard the O-rings on the cooling water pipes.

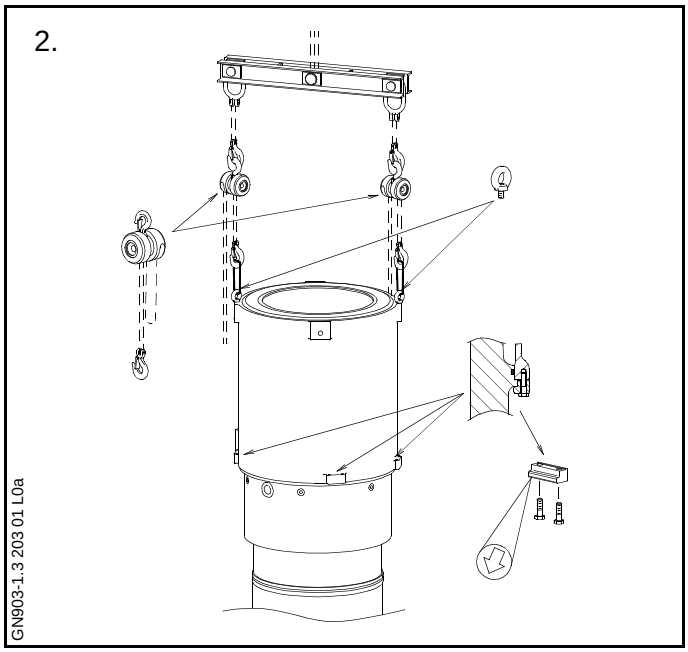
Clean the pipes carefully.

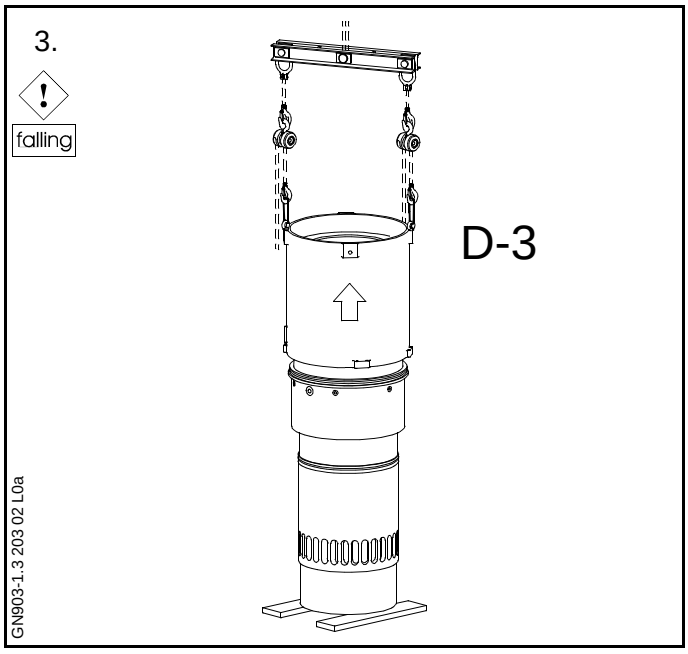
5. The lifting screws are also used for transporting of the cylinder liner.

Note!
The cylinder liner **is not** in balance, even with the cooling jacket mounted. To keep the liner in a horizontal position during transportation, use e.g. a wire rope connected from the scavenge ports to the traverse as shown on the sketch.









1. Unscrew the nuts on the non-return valves and remove the valves.

   Clean and inspect the non-return valves.

2. Attach two tackles to the crossbar, as shown.

   Mount two lifting screws in the cooling jacket.

   Hook the tackles on to the lifting screws on the cooling jacket and haul tight.

   Remove the two lifting screws in the cylinder liner.

   Remove the four clamps which fix the cooling jacket to the cylinder liner.

3. Lift away the cooling jacket by means of the tackles and land it on the wooden planks.

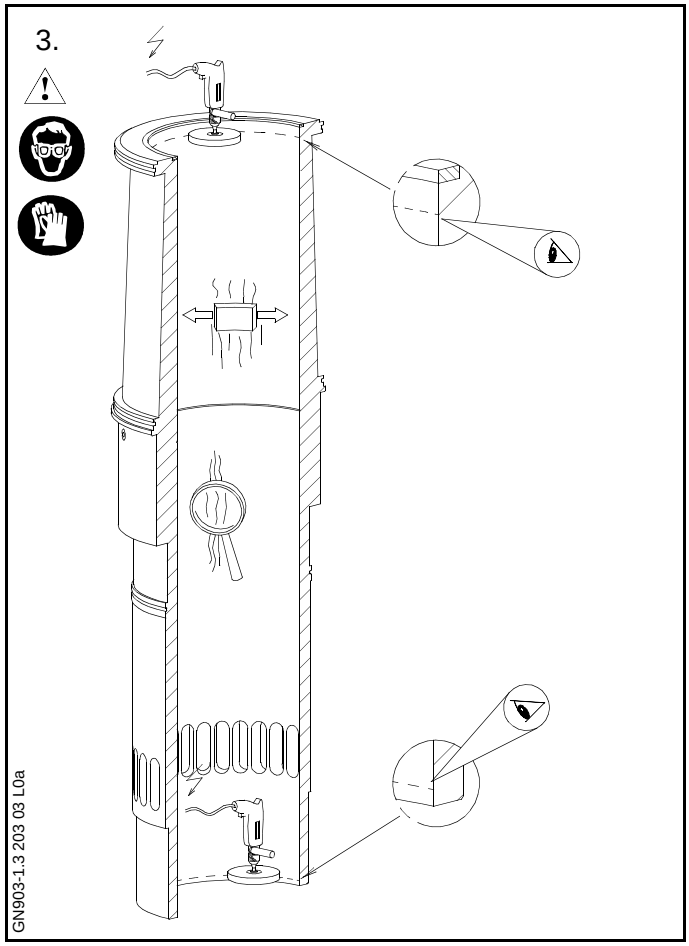
4. Check and assess the condition of the cylinder liner according to the description given in Vol. 1, Chapter 707.

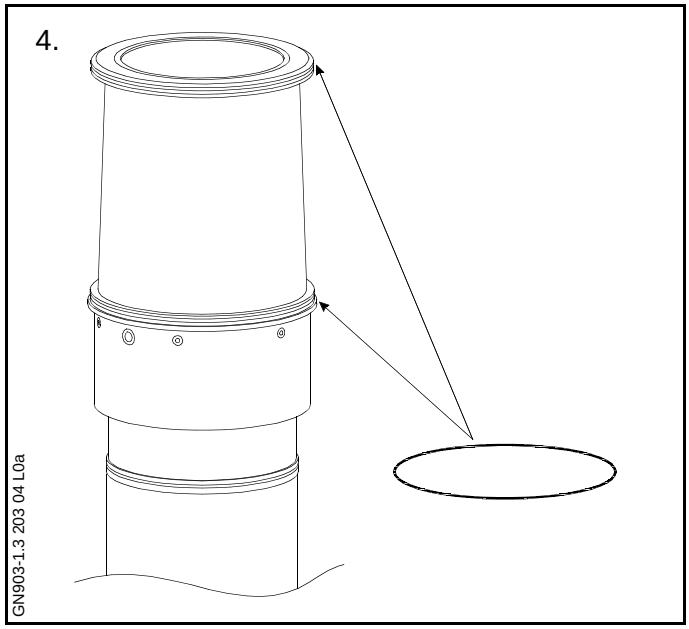
   Carefully grind away any scores or marks on the cylinder liner running surface, by means of a grindstone held in the hand.

   Using a grinding machine, remove the wear ridges at the top and bottom of the cylinder liner (where the piston rings reverse direction), so that a smooth transition is formed.

   Clean the cylinder liner and the cooling jacket both internally and externally. Pay special attention to the O-ring grooves and lubricating ducts.

5. Replace the two uppermost O-rings on the cylinder liner.





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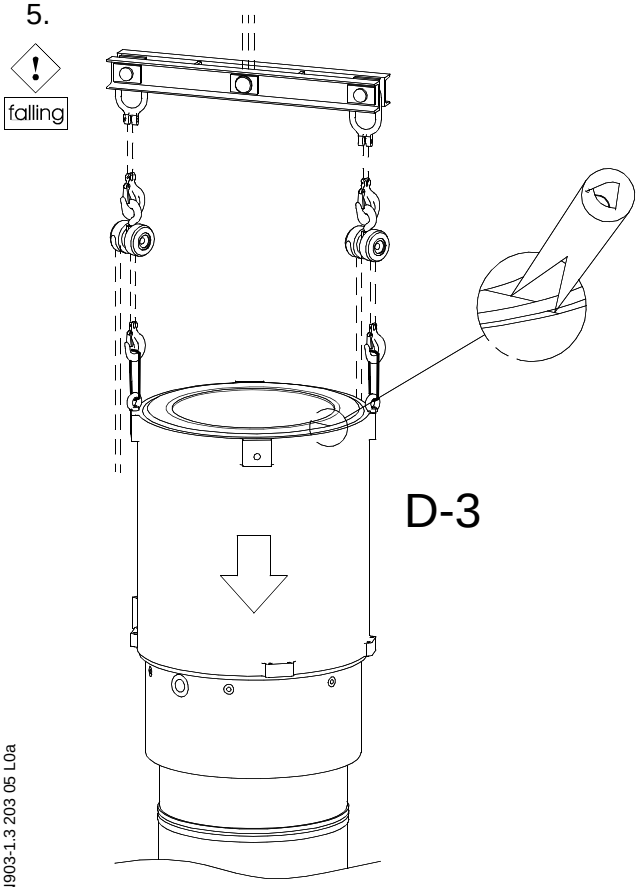

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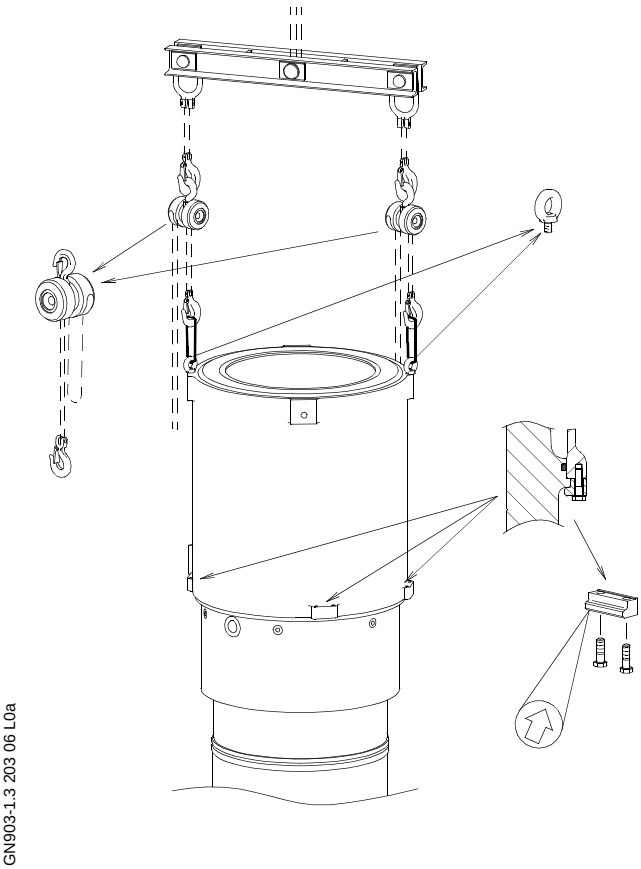


GN903-1.3 203 06 L0a

6. Lower the cooling jacket on to the cylinder liner.

Note!
Make sure that the scratch marks in the camshaft side of the cylinder liner and cooling jacket coincide.

7. Mount the four clamps in the groove of the liner, and tighten the screws.

   Remove the tackles from the lifting crossbar and the cooling jacket lifting screws.

8. Mount the non-return valves for cylinder lubrication. Tighten the nuts and connect the lubricating oil pipes.

1. Loosen the water connections on the cooling jacket.

   Mount the two lifting screws in the cylinder liner.

Caution!
Tighten firmly the lifting tools against the contact surface of the cylinder liner, (tightening torque:approx. 150 Nm). Other wise the lifting tools might be damged.

   Hook the chains from the lifting crossbar on to the lifting screws, and lift the jacket/liner assembly.

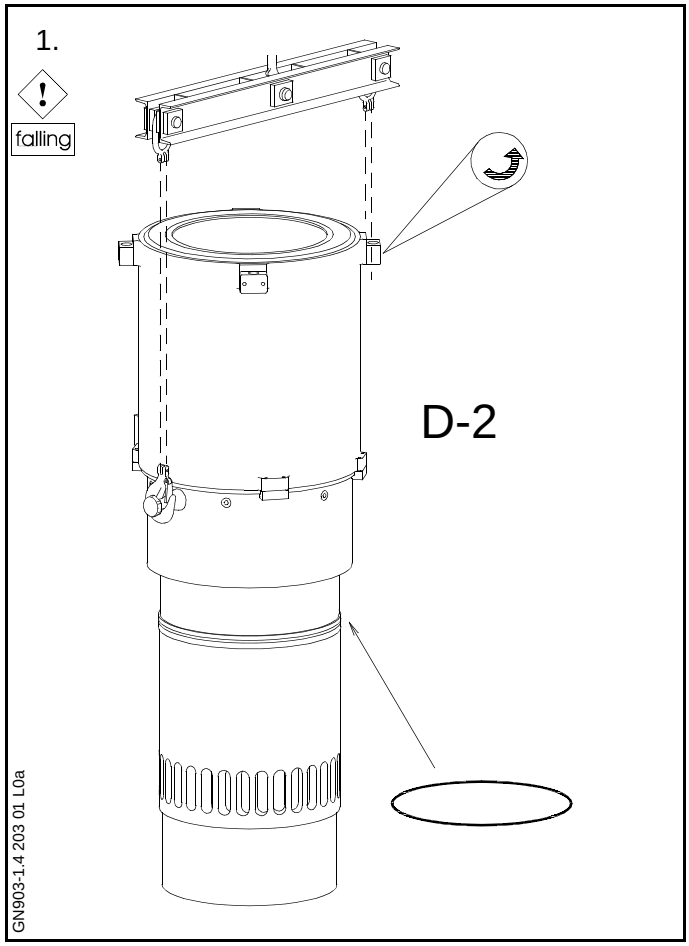
   Mount the lowermost O-ring and apply a little lubricating oil on the ring.

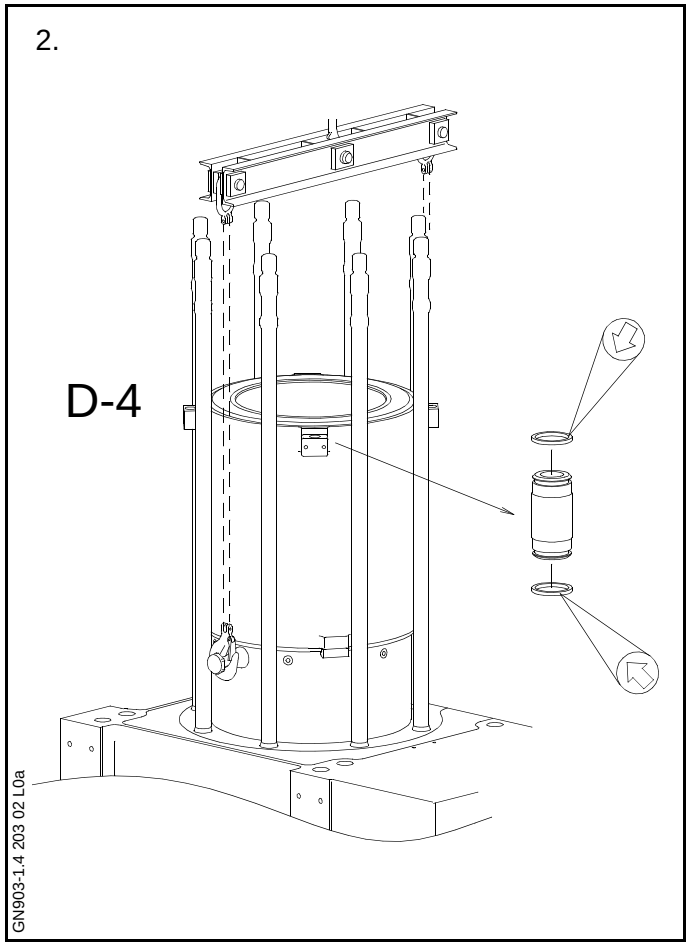
2. Check that the joint surfaces on the cylinder frame and cylinder liner are completely clean.

   Coat the joint surfaces with permatex or a similar liquid seal compound.

   Mount the cylinder liner in the cylinder frame. Replace the O-rings on the water connections and mount the water connections on the cooling jacket.

   If one or more cylinder cover studs have been removed during the dismantling of the cylinder cover, remount the studs using the stud setter and a torque wrench, *see Data*.





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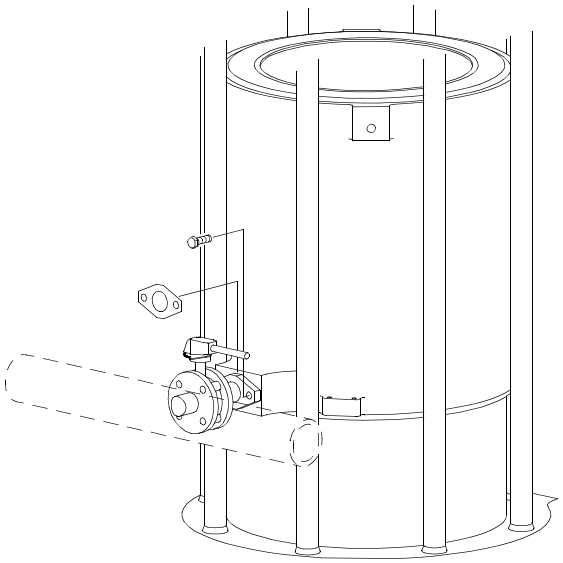


GN903-1.4 203 03 L0a

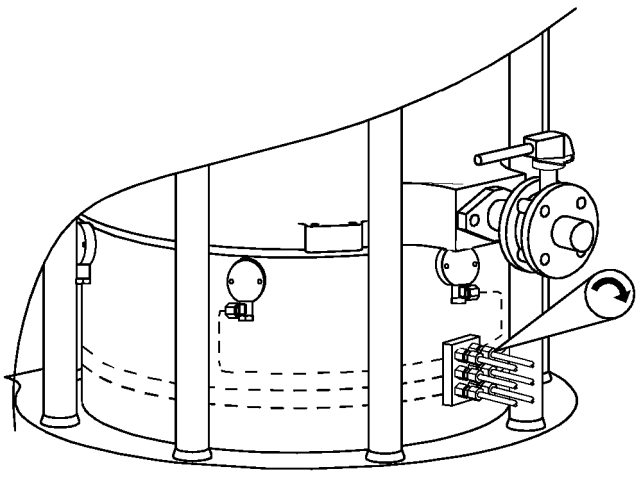
3. Fit a new gasket between the cooling water inlet pipe and the cooling jacket. Mount and tighten the screws.

4. Connect the oil pipes from the lubricator on to the junction box, but do not tighten.

   Vent the cylinder lubricating system by manually pumping each individual pipe through until oil, without air bubbles, comes out from the union pipe/non-return valve.

   When this is in order, tighten the pipes firmly on the non-return valves and again pump manually until it is certain that each individual lubricating point functions correctly.

4.



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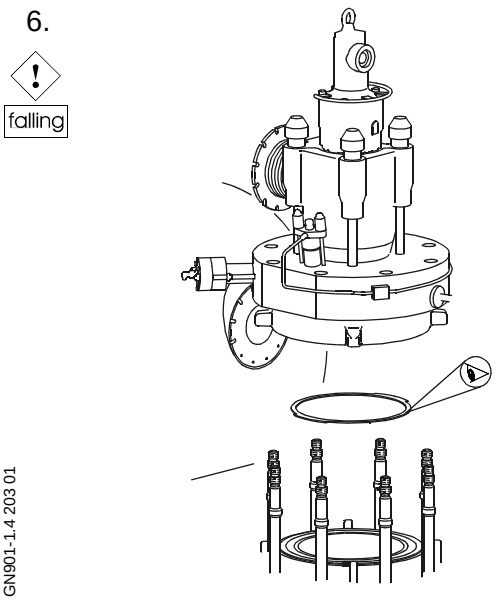
5. Lubricate the inside of the cylinder liner with cylinder lubricating oil and mount the piston.
   See Procedure 902-1.4.

6. Mount the seal ring and the cylinder cover.
   See Procedure 901-1.4.

Note!
Make sure to mount the piston cleaning ring correctly, so that the scratching marks are aligned.

Tighten the upper water connections on the cooling jacket as soon as the cylinder cover is correctly positioned.

6.



GN901-1.4 203 01

Make sure to mount the piston dean ring with marking “TOP CAMESIDE” coreetly.
Check if there is no contact between piston dean ring and piston crown by turning gear both clock and counterclockwise around **TDC**.

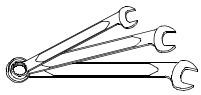
SAFETY PRECAUTIONS

X	Stopped engine
X	Block the starting mechanism
X	Shut off starting air supply
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
	Shut off lubrication oil
	Lock turbocharger rotors

Data

Ref.	Description	Value	Unit
D-1	Cylinder oil feed rate:	0.8-1.2 1.1-1.6	g/bhph g/kWh

Standard Tools: See Section 913



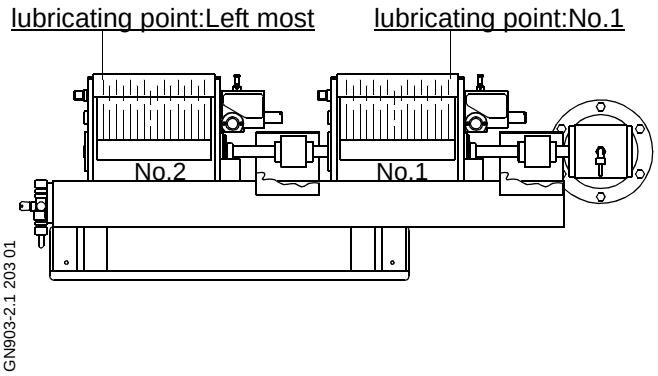
1. *Further information concerning other than nominal feed rates, feed rates for running-in and for part load operation, and recommended oil types, is given in instruction book Vol. 1 "OPERATION".*

2. The cylinder lubricators are mounted on the front end of the engine.

3. Each cylinder has six injection points. Check that the pumps of all injection points are activated during one revolution of the engine.

4. Turn the engine in AHEAD direction until the mark on the first lubricator housing is in line with the mark on the scale at the lead-in shaft. This indicates that the pump stroke is completed for lubricating point No. 1.

1.



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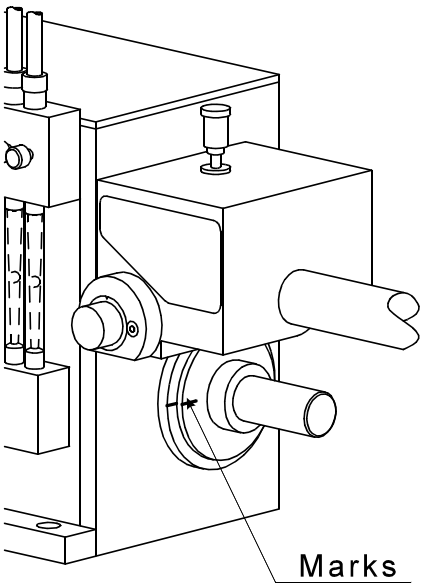
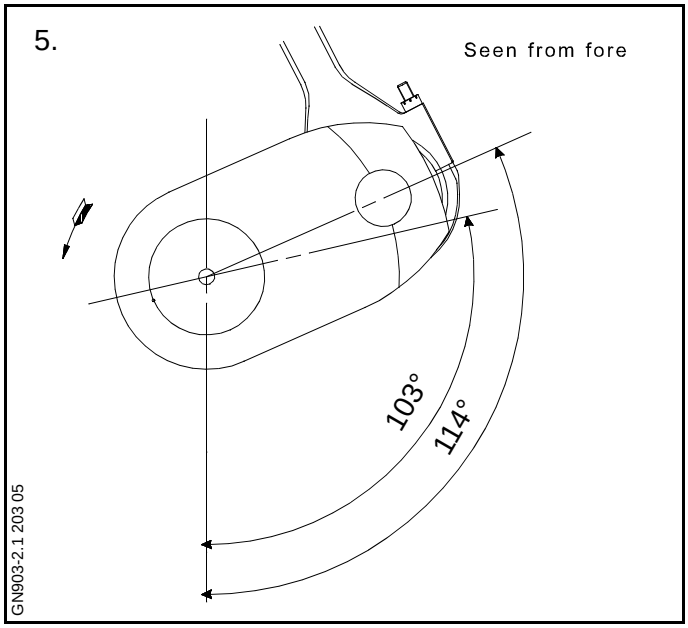
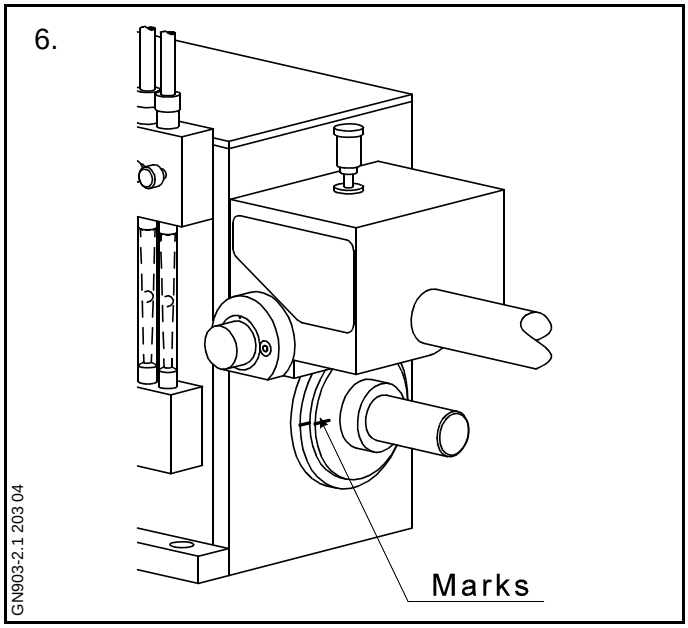
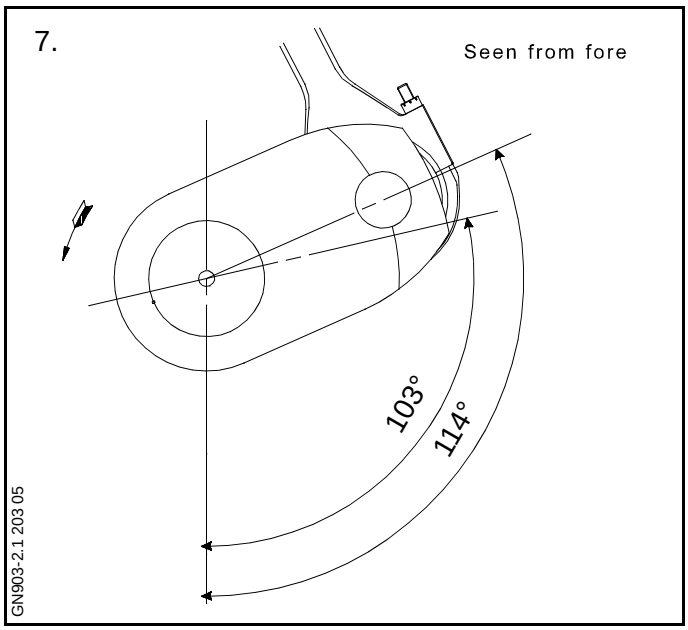








5. Check that the crankthrow for cylinder No. 1 is positioned between 103° and 114° past **BDC**.

   Use the numbers on the turning wheel to determine the exact position of the crankthrows.

6. Turn the engine further in AHEAD direction until the mark on the second lubricator housing is in line with the mark on the scale at the lead-in shaft. This indicates that the pump stroke is completed for lubricating point:Left most.

7. Check that the crankthrow for the aftmost cylinder is positioned between 103° and 114° past **BDC**.

8. If one of the crankthrows is not in the correct position, adjust the lubricators.
   See Procedure 903-2.3.

Note!
Any adjustment of lubricator No. 1 will alter the setting of lubricator No. 2. Therefore, any adjustment of lubricator No. 1 **must** be followed by a re-adjustment of lubricator No. 2.

1. Remove the guards over the couplings.

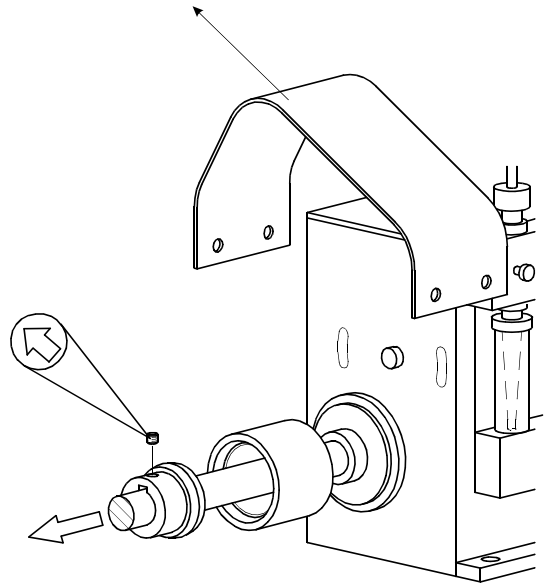
   Loosen the set screws in the couplings and pull the coupling wheels out of contact with the planet wheels.

2. For adjustment of lubricator No. 1, turn the crankshaft in AHEAD direction until the crankthrow for cylinder No. 1 is 108° past **BDC** for lubricator No. 1.

   For adjustment of lubricator No. 2, turn the crankshaft in AHEAD direction until the crankthrow for aftmost cylinder is 108° past **BDC**.

   Use the numbers on the turning wheel to determine the exact position of the crankthrows.

1.



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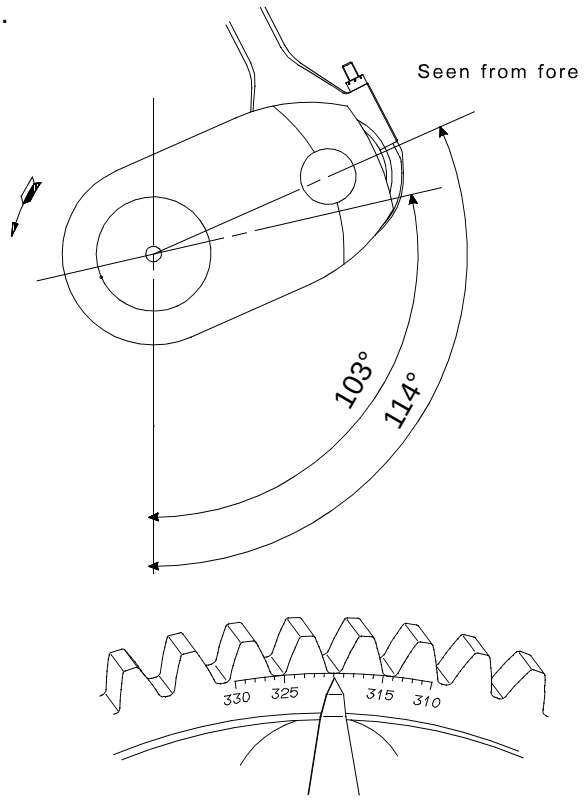

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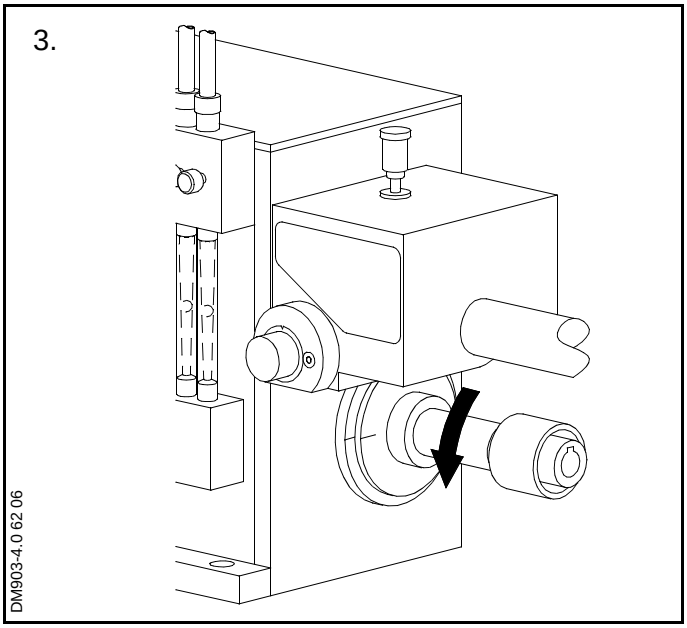

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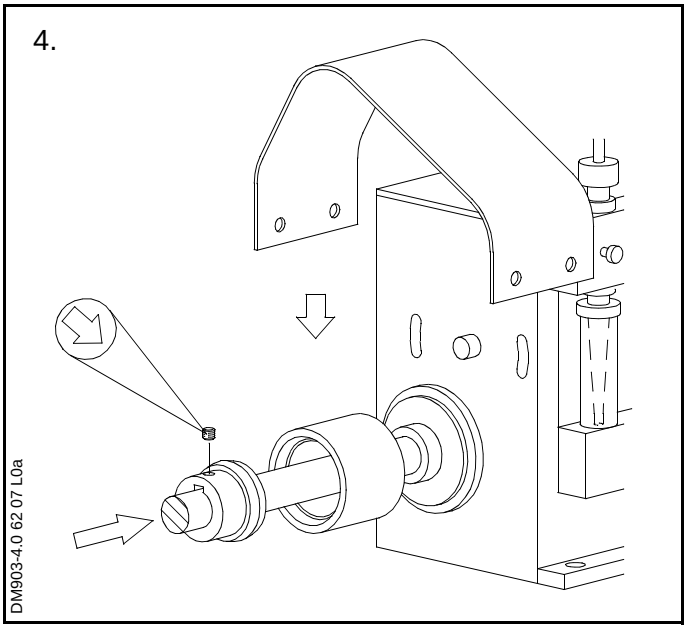

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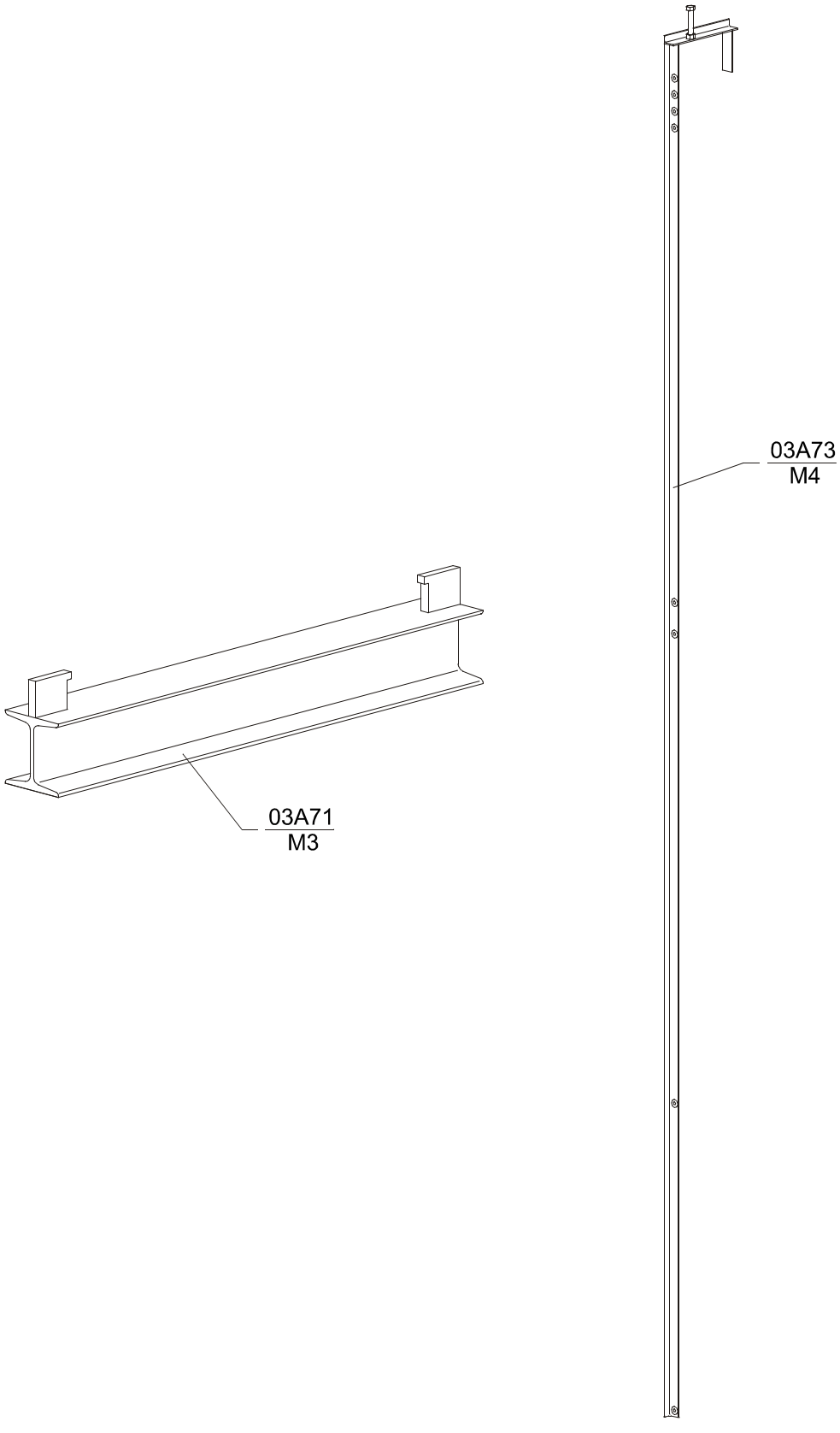
3. Turn the pump shaft slowly in AHEAD direction until the mark on the scale at the lead-in shaft is in line with the mark on the lubricator housing.

4. Re-engage the coupling wheel and tighten the set screw.

   Repeat step 1 to re-check the setting.

   Mount the guard over the coupling.


03A73
M4
03A71
M3

Item No.	Part Description	MES Tools No.	
M3	Standard gauge	03A71	
M4	Measuring rod for cylinder liner	03A73	

INDEX

CYLINDER COVER

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CYLINDER LUBRICATION

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MECANICAL CONTROL GEAR

STARTING AIR SYSTEM

EXHAUST VALVE

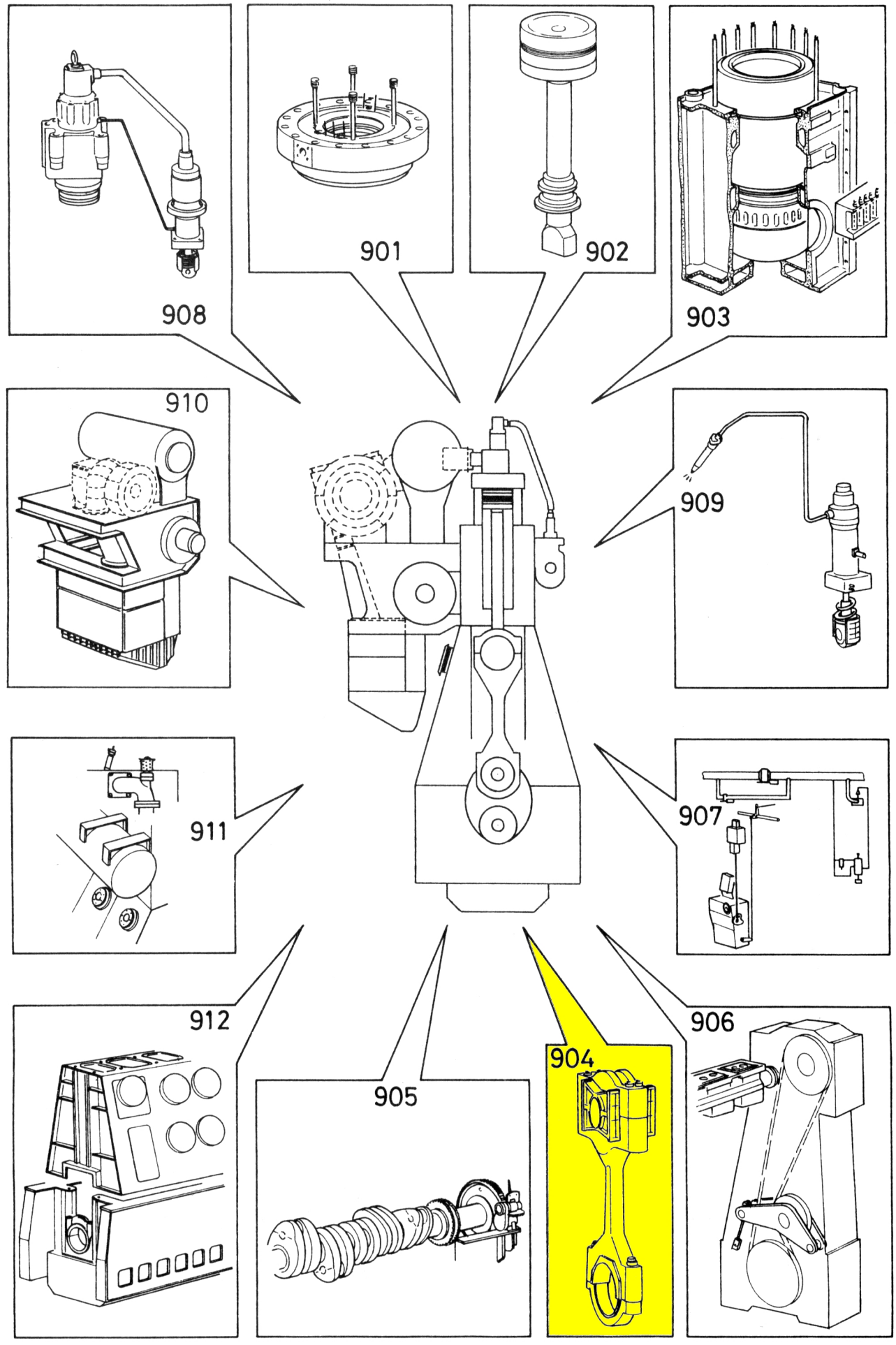
FUEL OIL SYSTEM

TURBOCHARGER SYSTEM

SAFETY EQUIPMENT

ASSEMBLY OF LARGE PARTS

GENERAL TOOLS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SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of high pressure oil
X	Block the starting mechanism	Do not enter area when over head lifting is being carried out
X	Shut off starting air supply	Slippy surfaced and risk of falling (while at work in crankcase)
X	Engage turning gear	Risk of severe personal injury (while engine being turned)
X	Shut off cooling water	
X	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

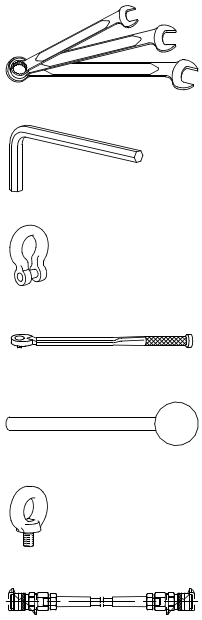
Data

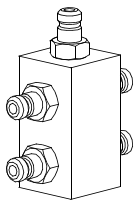
Ref.	Description	Value	Unit
D-1	Top clearance in crosshead bearing: *See Vol. 1 "Operation & Data".*		
D-2	Oil wedge length	L=10	mm
D-3	Hydraulic pressure - tightening	150 (1500 bar)	MPa
	Hydraulic pressure - dismantling	150-165 (1500-1650 bar)	MPa

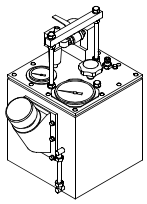
Note!
Permit to Max. 165 MPa (1650 bar) only in a short time.

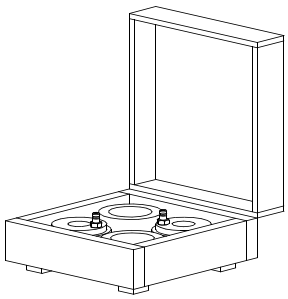
D-4	Crosshead bearing cap, complete	195	kg
D-5	Crosshead + piston complete	1940	kg
D-6	Bearing shell, lower	28	kg
D-7	Crosshead, complete	1076	kg
D-8	Piston rod - tightening torque	430	Nm
D-9	Bearing shell, upper	13	kg

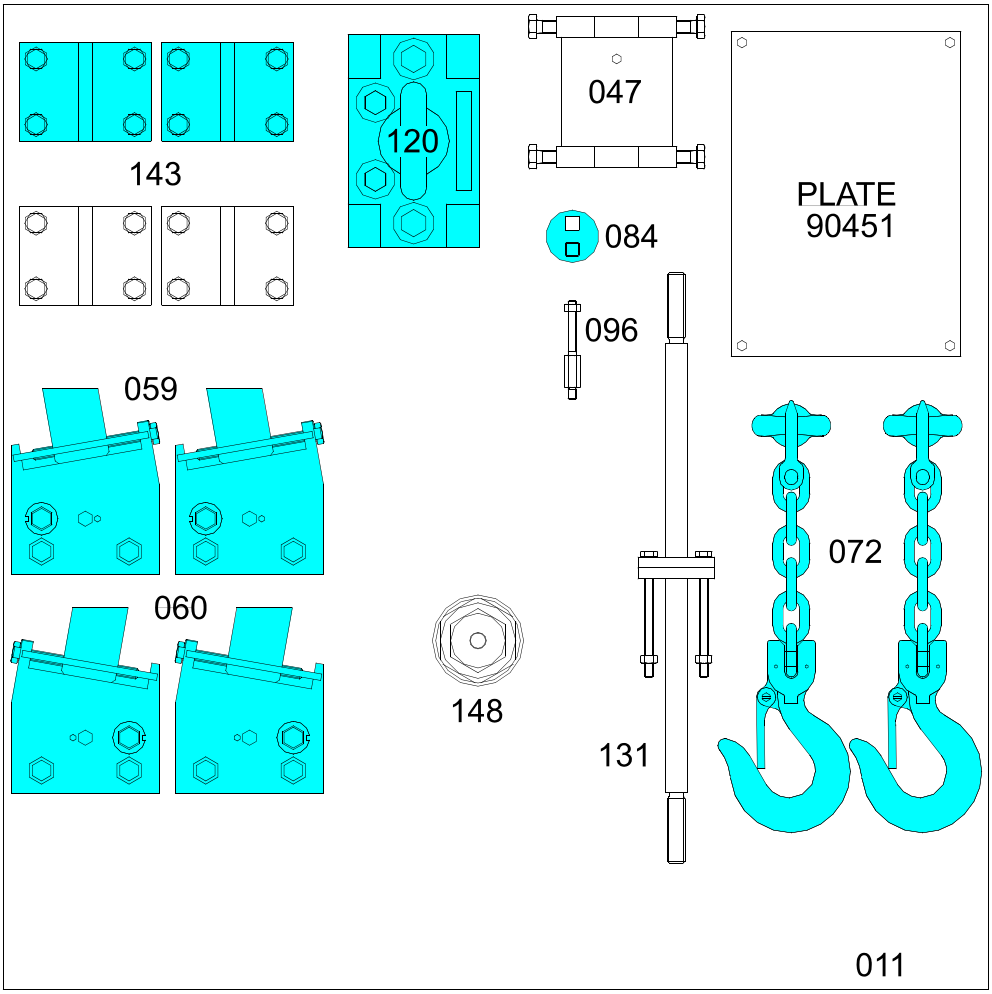
Standard Tools: See Section 913







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The top clearance between the journal and a new bearing shell is the result of a summation of the production tolerances of the bearing assemblies.

For the top clearance of a specific bearing, see the measurement in the adjustment sheet.

1. Open the crankcase door at the relevant cylinder.

2. Turn the crankthrow concerned to 90° before **BDC** on the exhaust side.

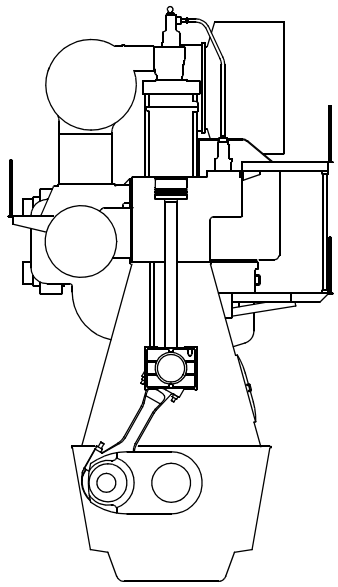
3. Measure the clearance in the crosshead bearing by inserting a feeler gauge between the bearing cap and the crosshead journal, exactly next to the landing surface for the piston rod foot. *See Data.*

4. When checking the clearances, the discrepancy between the **actual** measurements and the measurements recorded in the adjustment sheet (or the clearance noted for a new bearing installed later) **must not** exceed 0.1 mm. If so, the crosshead bearing must be disassembled for inspection.
   See Procedure 904-1.2.

5. The wear limit for a crosshead bearing shell is confined to 50% reduction of the oil wedge length (**L**). *See Data.*

6. *For further external inspection of the crosshead bearing, see Chapter 708, 'Bearings' in the instruction book, Vol. 1 "OPERATION".*

2.



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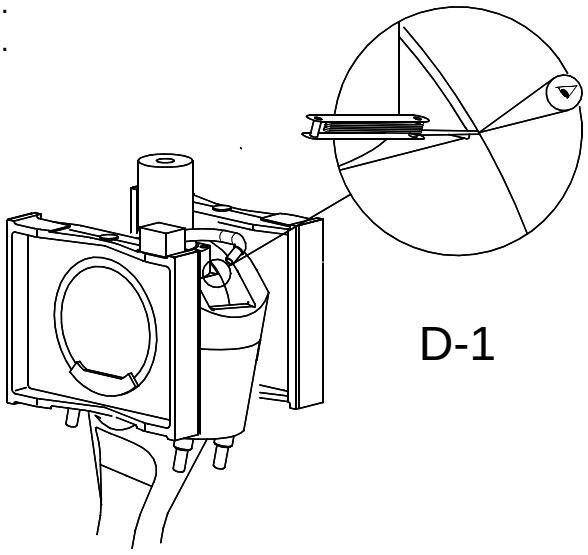
3.
4.



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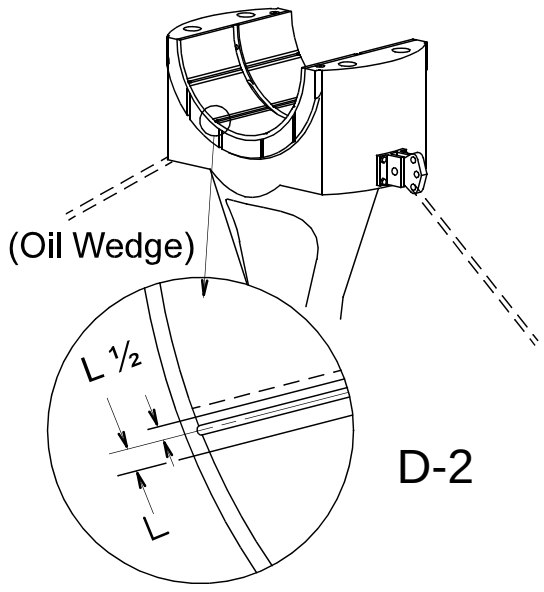

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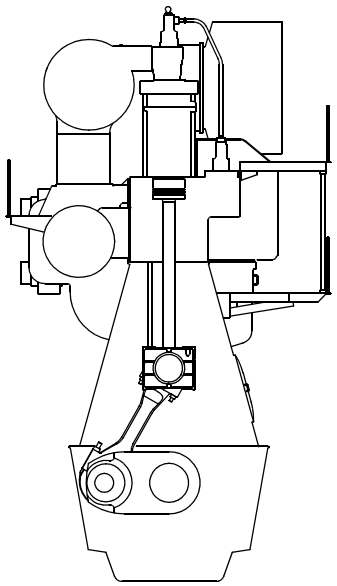

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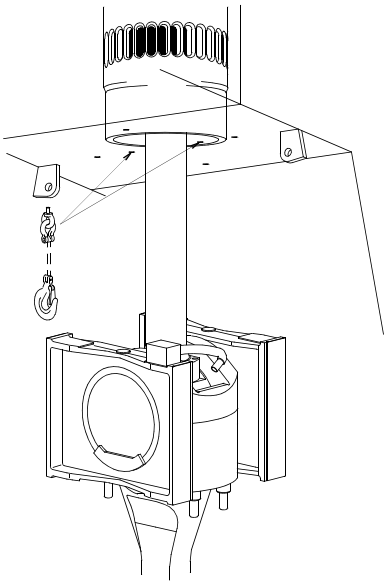

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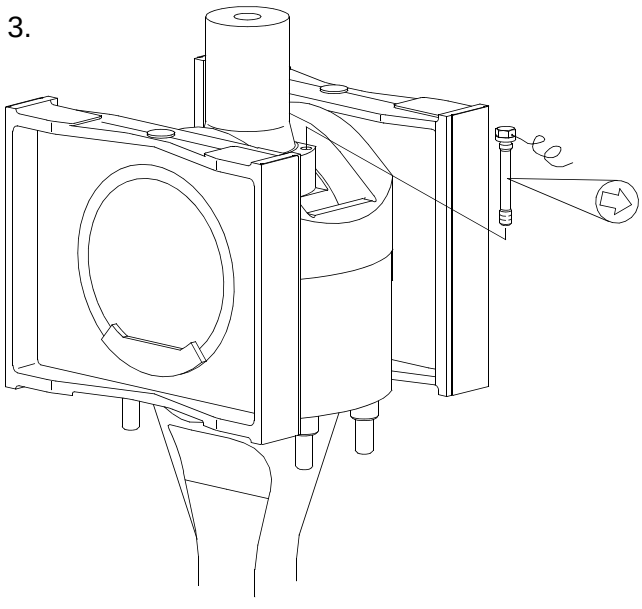


GN902-1.2 204 03

This procedure has been divided into two dismantling situations, as follows:

- with piston mounted
- with piston removed

With piston mounted:

1. Turn the crankshaft down far enough to give access to the screws on the piston rod.

2. Mount two chains in the inner screw holes in the top of the crankcase in the athwarthship direction for suspending the piston rod.

3. Loosen and remove the locking wire from the screws on the piston rod foot. Remove the screws.

4. Mount a lifting eye bolt on each side of the piston rod.

5. Turn the crosshead to **TDC**.

   Hook the chains to the lifting eye bolts in the piston rod.

   Turn the crosshead downward, and the piston rod will then remain suspended from the two chains.

With piston removed:

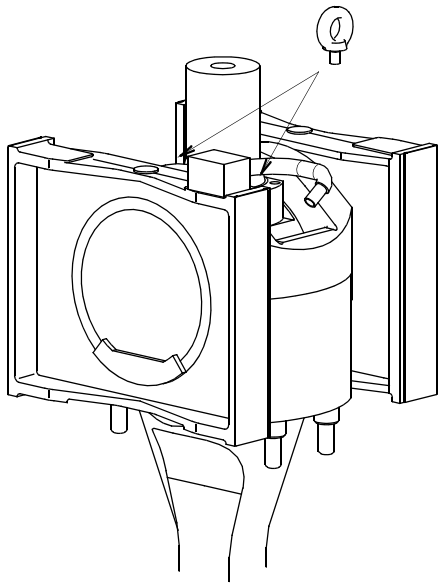
6. Turn to **BDC**.

7. Hold the spacer rings around the nuts and screw the hydraulic jacks on to the studs.

   Loosen the crosshead bearing cap nuts. *For operation of the hydraulic jacks, see Procedure 913.*

   Remove the hydraulic jacks and the spacer rings and unscrew the nuts.

4.



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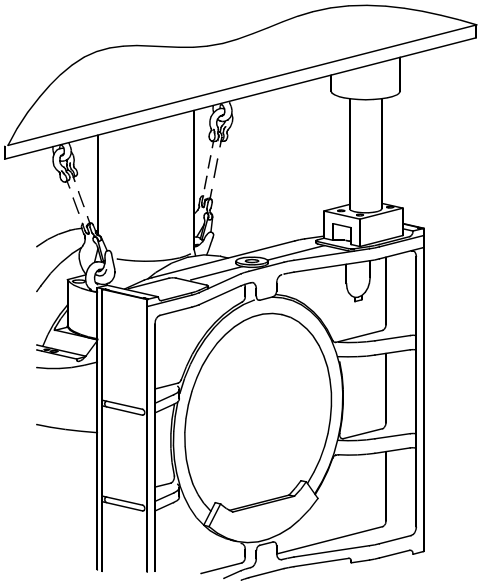

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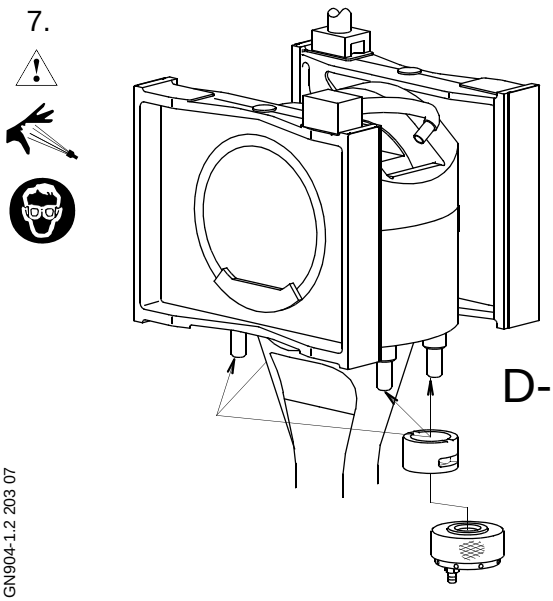

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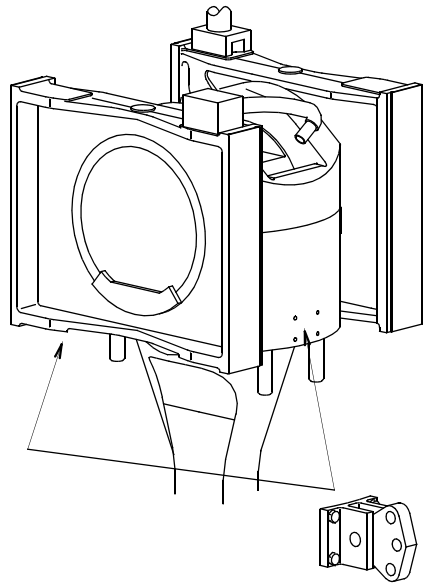
GN904-1.2 203 07

8.



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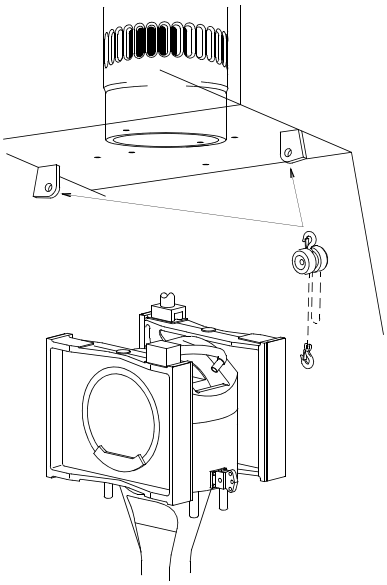

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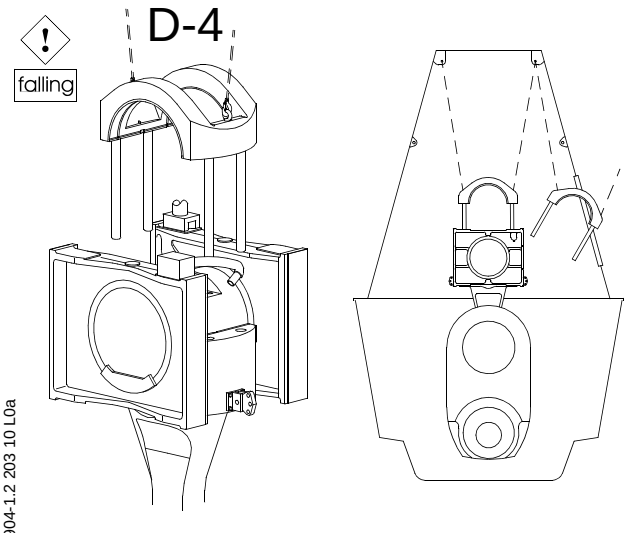


GN904-1.2 203 10 L0a

8. Mount the lifting attachments on the head of the connecting rod.

9. Suspend two tackles from the lifting brackets in the athwarthship direction.

10. Mount two eye bolts in the top of the crosshead bearing cap.

    Hook the tackles on to the eye bolts in the crosshead bearing cap and remove the cap from the engine. Check the upper part of the journal.

11. Place the bearing cap on one side on a couple of wooden planks.

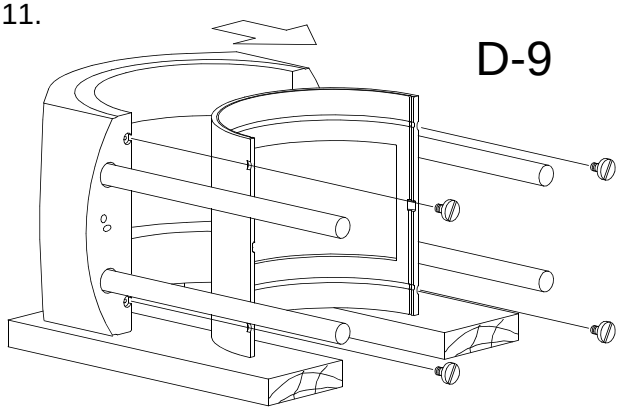
    Check the bearing shell, see Procedure 904-1.1.

12. Fasten tackles to the fixed lifting brackets on the frame box wall.

13. Turn the crosshead upwards until the piston rod lands on the crosshead. Ensure that the guide ring in the crosshead fits correctly in the centre hole of the piston rod.

    Do not remove the chains or lifting eye bolts.

11.



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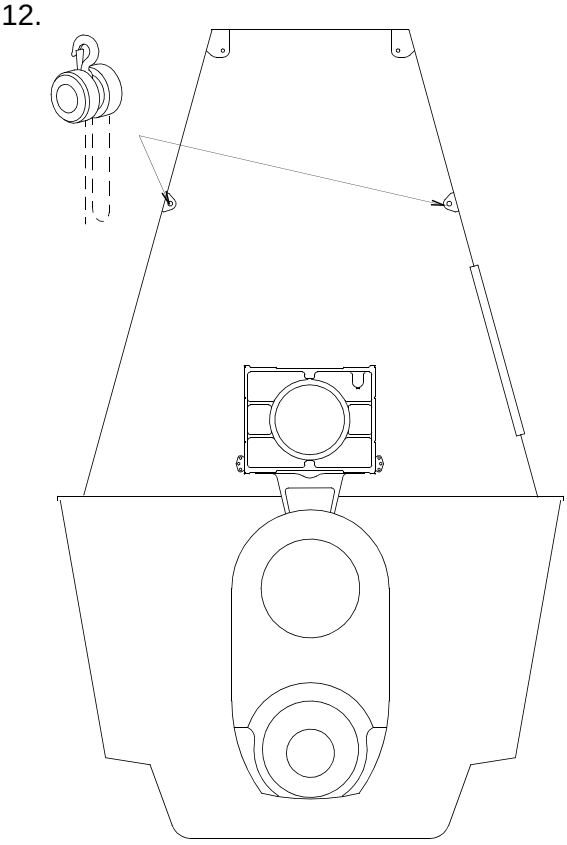

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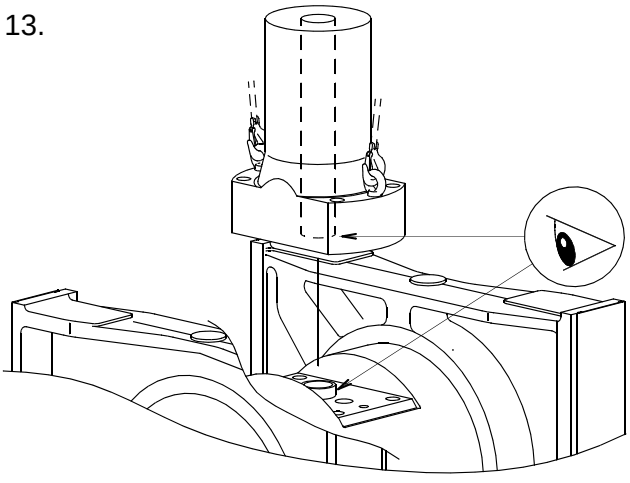

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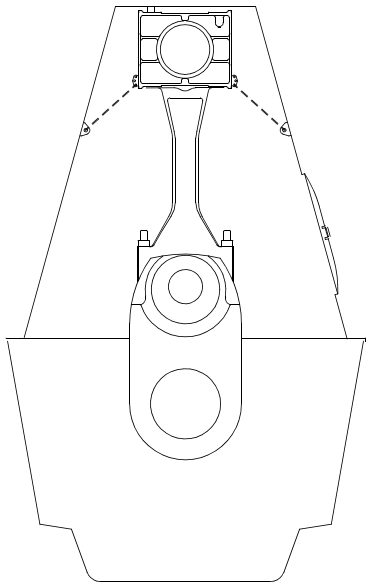

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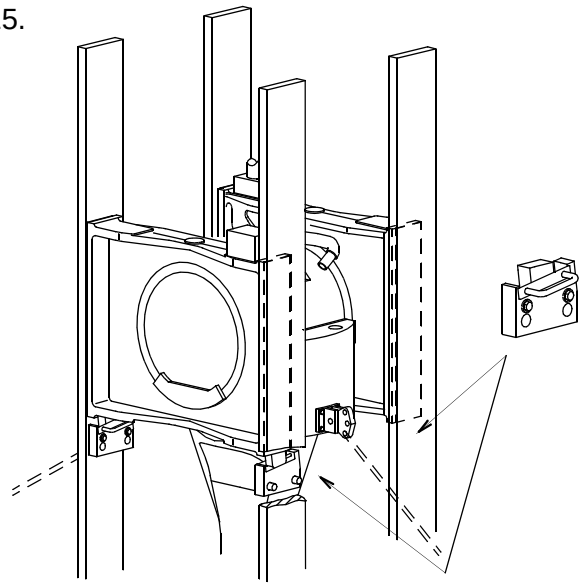

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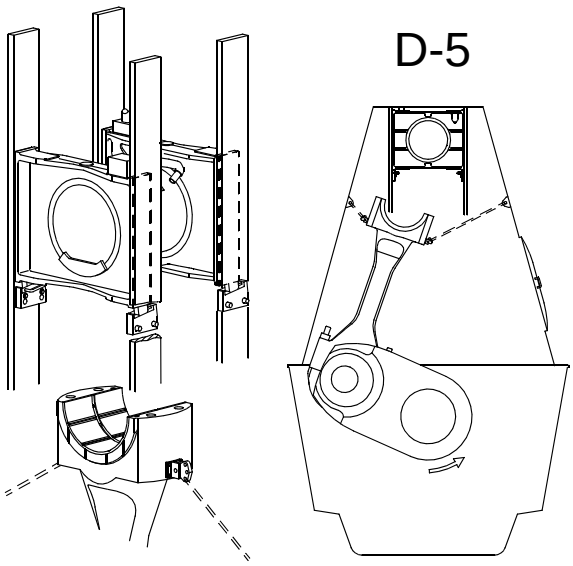

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14. Turn to **TDC** and attach the tackle hooks to the lifting attachments. Haul the tackles tight.

15. Mount the four supports for guide shoes on the crosshead guides.

    Carefully turn the crank down towards the exhaust side, until the guide shoes rest on the supports.

    Adjust the support brackets to the guide shoes so that the weight of the crosshead is evenly distributed on the four supports. Haul the tackles tight.

16. Turn the crankthrow towards **BDC** while 'following' with the tackles, thus continuously supporting the connecting rod.

17. With the crosshead resting on the supports, check the lower part of the crosshead journal and the lower bearing shell.

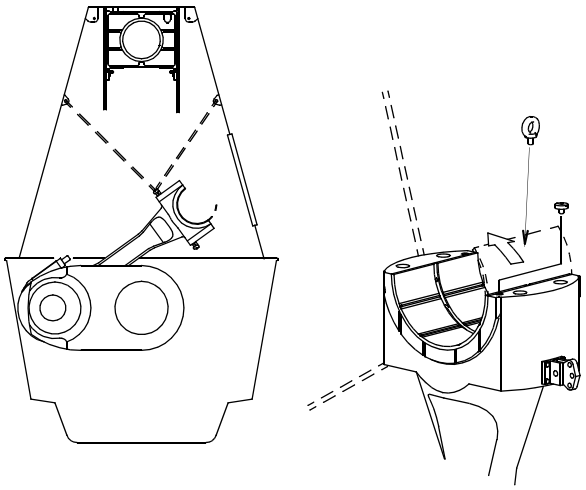
    Regarding checking of journal and bearing shells, see Vol .1 "OPERATION", Chapter 708 "Bearings".

18. In cases where it is necessary to remove the lower bearing shell, tilt the connecting rod towards the door in the camshaft side by means of the tackles.

    Dismount the locking screws, and turn the bearing shell so far up that an eye bolt can be mounted.

    Lift the bearing shell out of the engine.

18.



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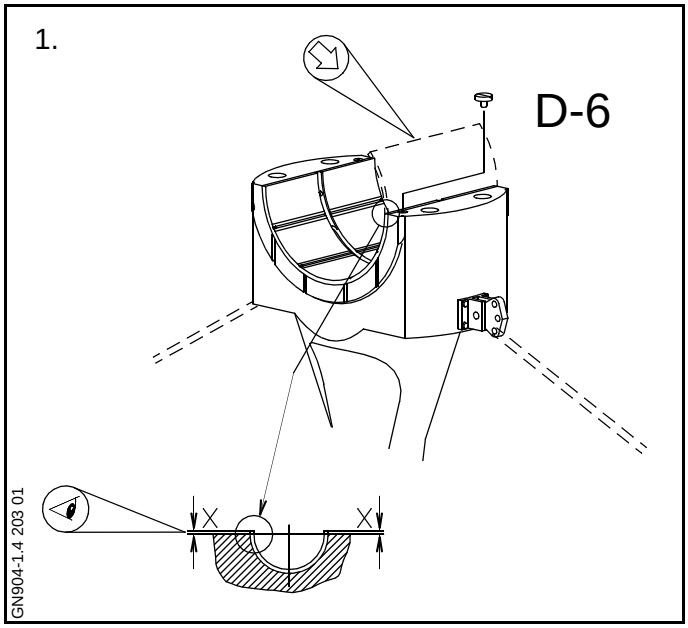
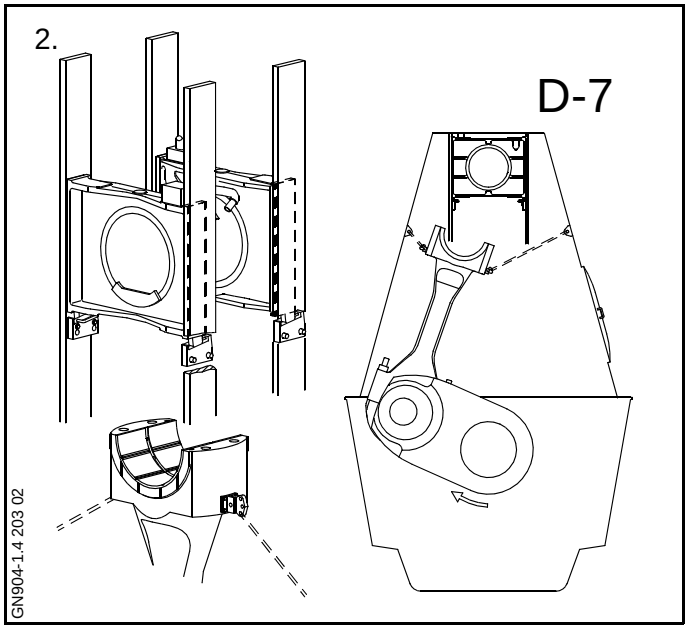
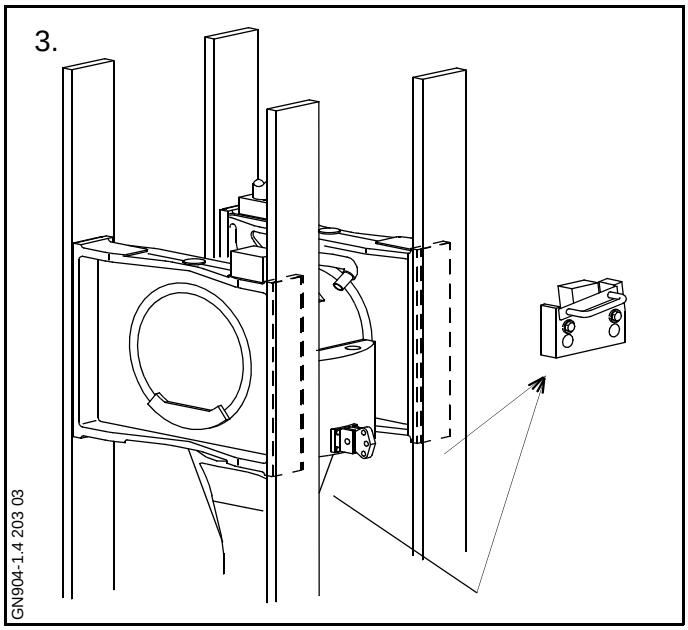






With the piston mounted/
With the piston removed:

1. Mount and secure the bearing shell in the bearing housing.

   The excess height **X** is to ensure the correct tightening-down of the bearing shell and **must not** be eliminated.

2. Raise the connecting rod to an upright position.

   Turn to **TDC** while 'following' with the tackles, for assembling the crosshead and the connecting rod.

   Take care that the guide shoes do not damage the bearing shell.

3. Remove the supports from the crosshead guides.

   Remove the tackles from the crosshead.

   Turn the crank throw to **BDC**.

   If the piston is mounted, slowly turn down until it is fully suspended from the chains.

4. Lift the bearing cap into the engine. Lower the bearing cap onto the crosshead and remove the tackles. Remove the lifting attachments from the connecting rod.

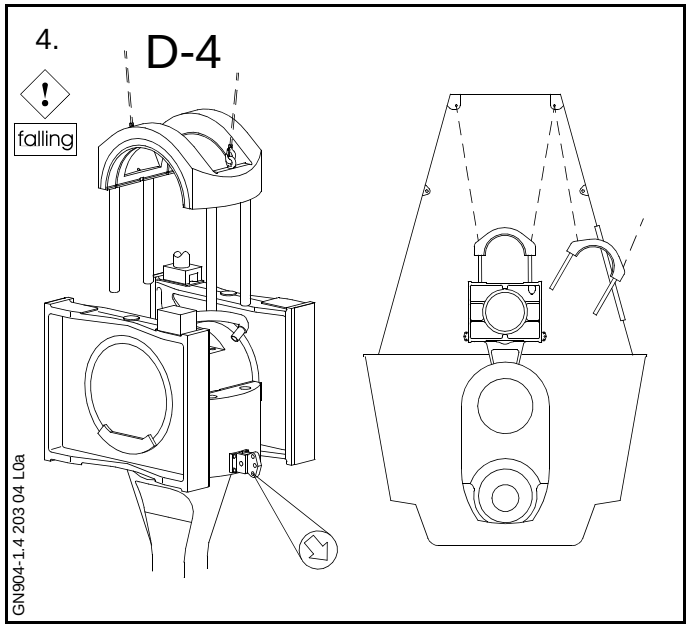
Note!
Take care that the bearing studs do not damage the crosshead.

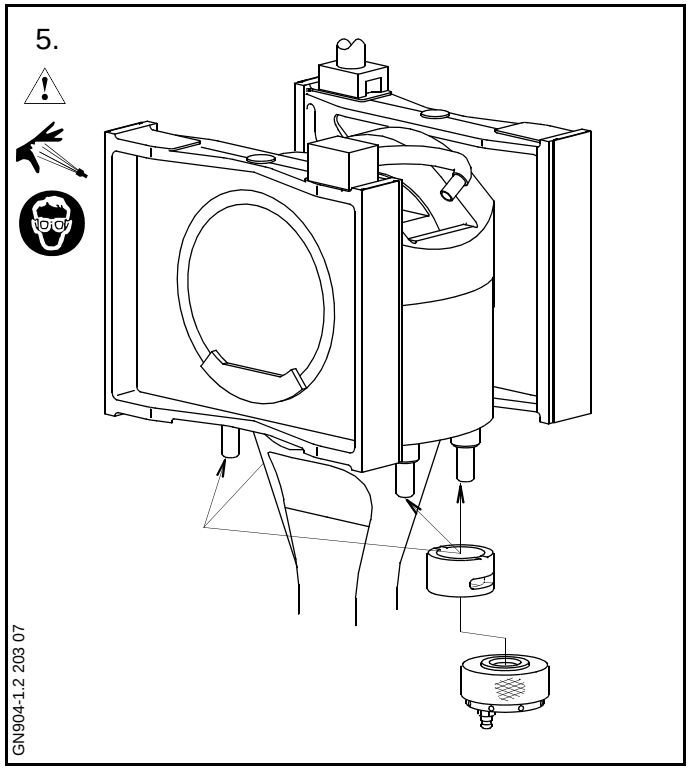
5. Tighten all four crosshead bearing cap nuts simultaneously. *See Data*.
   For operation of hydraulic jacks, see Section 913.

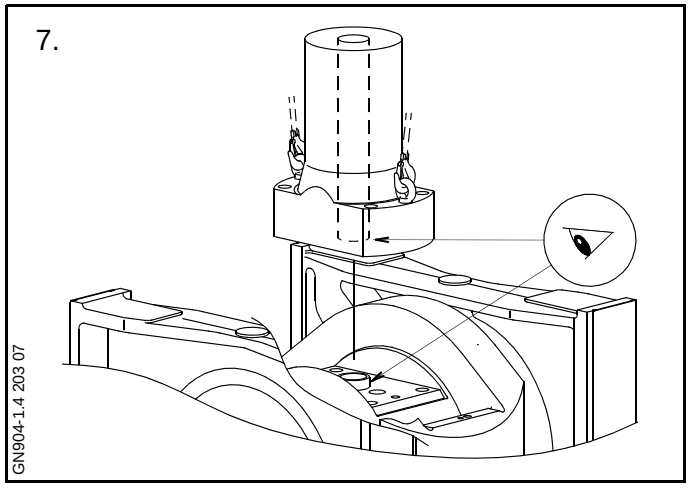
6. Mount the piston.
   See Procedure 902-1.4.

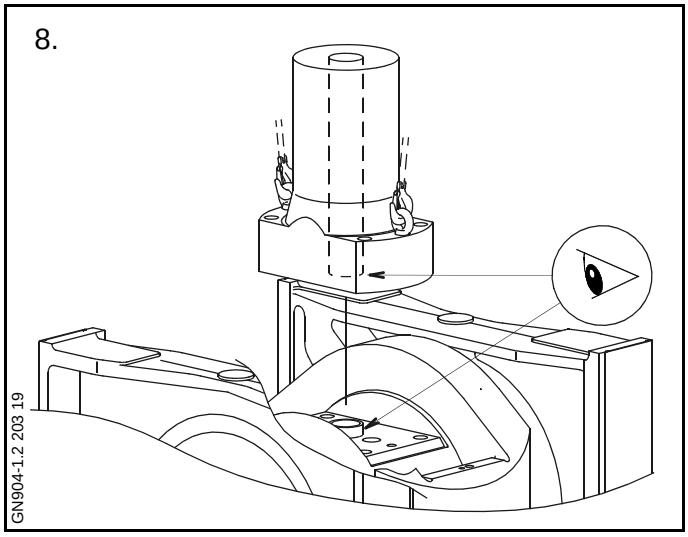
With the piston mounted:

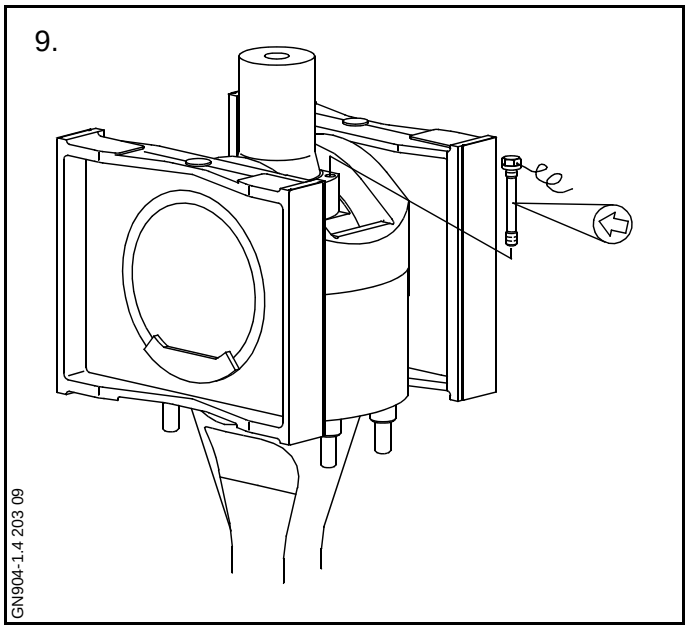
7. Turn the crosshead upwards until the piston rod lands on the crosshead. Ensure that the guide ring in the crosshead fits correctly in the centre hole of the piston rod.











8. Unhook the chains from the lifting eye bolts in the piston rod. Remove the chains and eye bolts from the top of the crankcase, from the piston rod and from the crosshead bearing cap.

9. Turn down to **BDC** and tighten the screws in the piston rod and lock by means of locking wire. *See Data.*

   Mount the locking wire in such a way that the wire is tightened if one of the screws works loose.
   See Procedure 913-7.

SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of high pressure oil
X	Block the starting mechanism	Do not enter area when over head lifting is being carried out
X	Shut off starting air supply	Slippy surfaced and risk of falling (while at work in crankcase)
X	Engage turning gear	Risk of severe personal injury (while engine being turned)
X	Shut off cooling water	
X	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

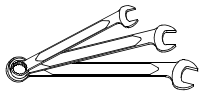
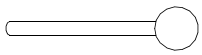
Data

Ref.	Description	Value	Unit
D-1	Hydraulic pressure - tightening	150	MPa (1500 bar)
	Hydraulic pressure - dismantling	150-165	MPa (1500-1650 bar)

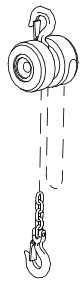
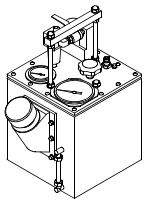
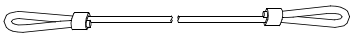
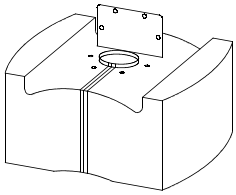
Note!
Permit to Max. 165 MPa (1650 bar) only in a short time.

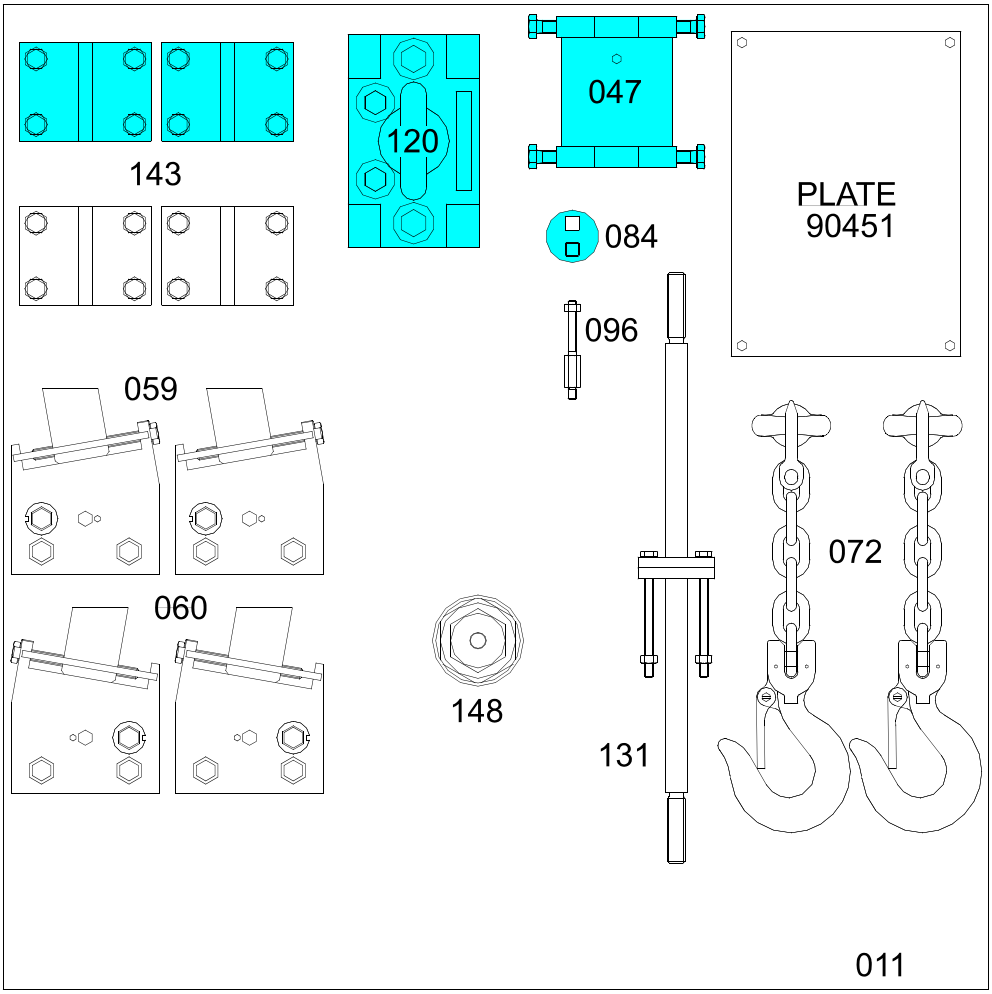
D-2	Crosshead bearing cap	191	kg
D-3	Crosshead complete	1100	kg
D-4	Connecting rod	1065	kg
D-5	Guide shoe	187	kg
D-6	Cooling oil outlet pipe	9	kg
D-7	Outlet pipe - tightening torque	80	Nm
D-8	Guide plate - tightening torque	150	Nm
D-9	Nuts on guide strips - tightening torque	150	Nm
D-10	Telescopic pipe - tightening torque	80	Nm

Standard Tools: See Section 913

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1. Dismount the piston.
   See Procedure 902-1.2.

2. Dismount the main bearing lubricating oil pipes.

3. Dismount the cooling oil outlet pipe from the guide shoe and the drain oil slotted pipe.

   Loosen and remove the screws which secure the telescopic pipe to the guide shoe.

   In order to reach the screw in the corner behind the telescopic pipe, use the offset tool along with a socket wrench.

4. Mount the retaining tool for the telescopic pipe on the stuffing box housing for the telescopic pipe.

   Turn the crosshead to **TDC**.

   Suspend the telescopic pipe by means of the tool.

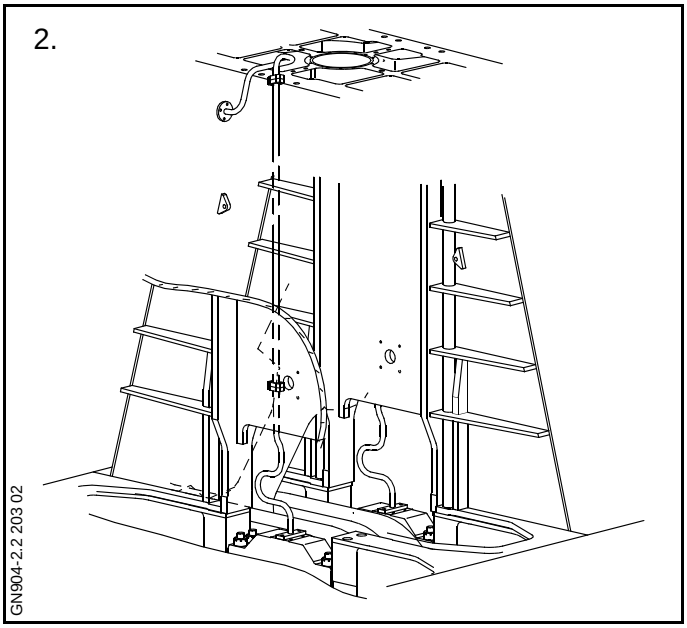
   Turn the crosshead to gain access to the nuts on the crosshead bearing studs.

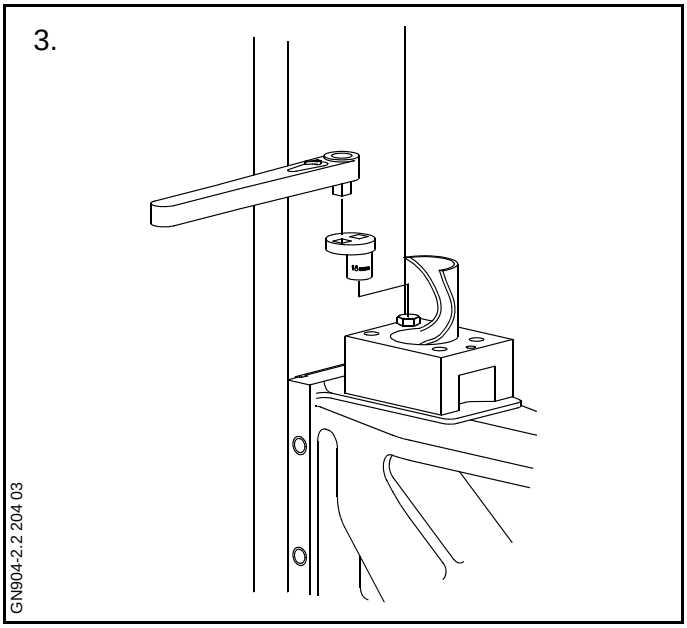
   Mount two eye screws in the top of the crankcase in the fore-and-aft direction.

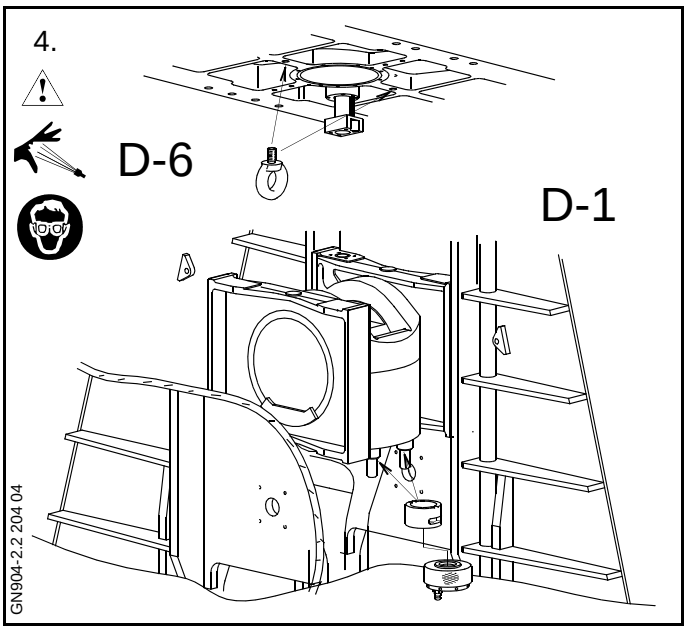
   Mount the spacer rings and the hydraulic jacks for loosening the nuts on the crosshead bearing studs.

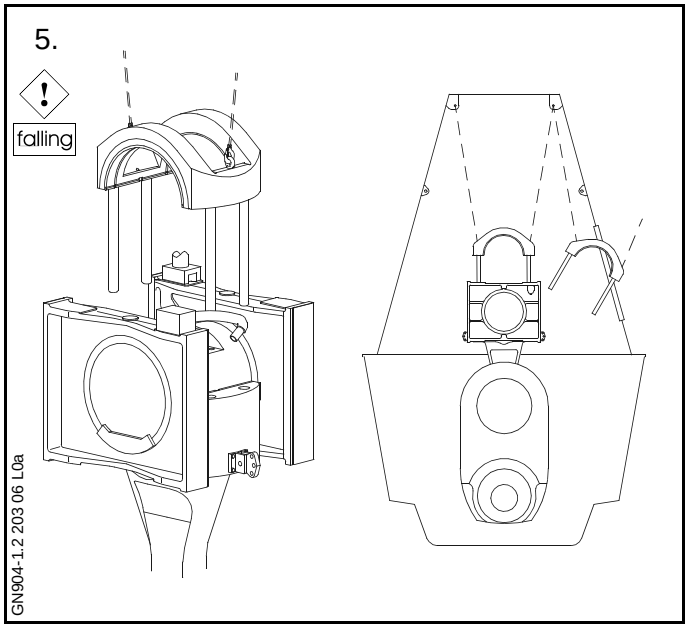
   For operation of the hydraulic tools, see Section 913.

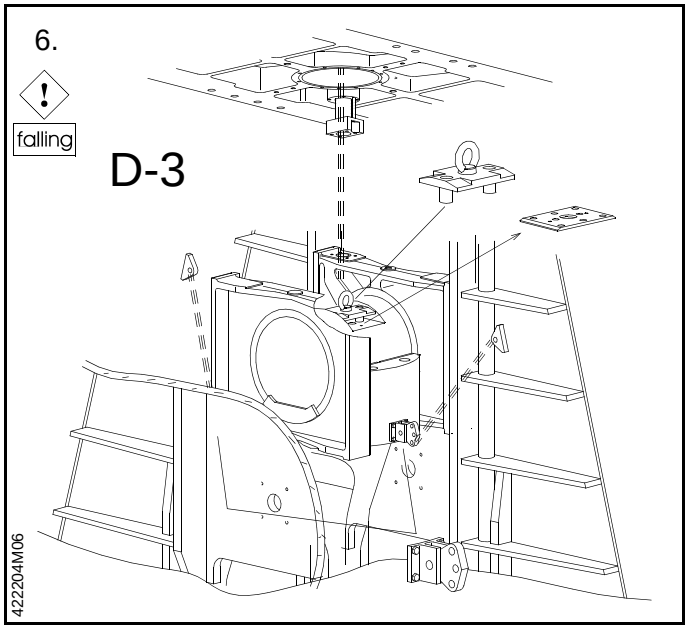
   Loosen the nuts, remove the hydraulic jacks and unscrew the nuts.

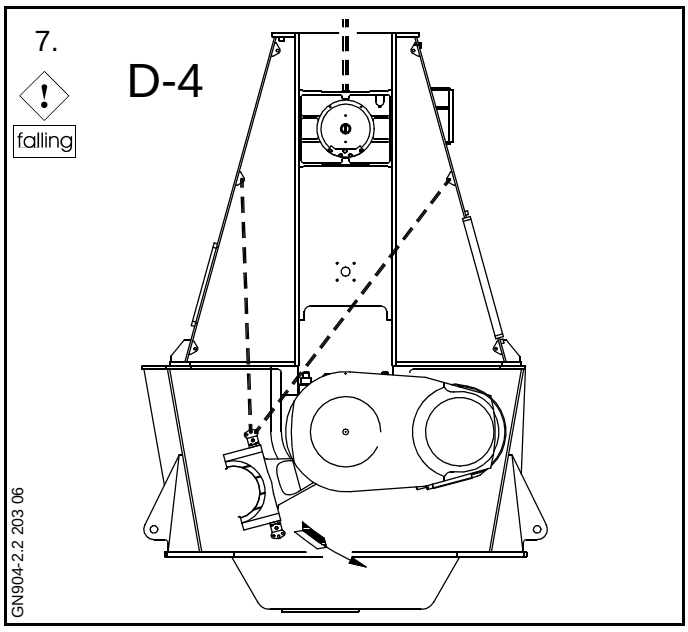












5. Mount eye screws in the crosshead bearing cap and hook the tackles on to the lifting brackets in the top of the crankcase.

   Dismount the bearing cap and lift it out of the engine.

6. Dismount the shim under piston rod.

   Mount the special lifting tool on the crosshead.

   Mount the lifting attachments for fixing the connecting rod, on the head of the connecting rod.

   Fasten tackles to the lifting brackets on the frame box wall and attach the tackle hooks to the lifting attachments. Haul the tackles tight.

   Attach the flat-plaited wire strap to the engine room crane.

   Hook the engine room crane on to the lifting tool on the crosshead, and lift the crosshead.

7. Using the tackles, tilt the connecting rod towards the exhaust side, while turning the crankthrow towards the camshaft side.

   Transfer the tackles from one lifting attachment to another as necessary.

   When the crankthrow is 90° after **BDC**, stop turning.

   By alternate use of the tackles, tilt the connecting rod until it rests against a couple of wooden planks in the bottom of the bedplate.

8. Lower the crosshead to a position just above the main bearing caps.

   Remove the guide strips and both guide plates from the guide shoes.

   Mount a lifting eye screw in one of the guide shoes, and hook on a tackle.

   Squeeze in a plank between the guide shoes.

9. Suspend two tackles from the eye screws in the top of the crankcase in the fore-and-aft direction.

   Mount an eye screw in the top of each guide shoe.

   Mount the guide shoe extractor tool on the guide shoe.

   Hook the tackles on to the eye screws in the guide shoes, haul tight and, at the same time, using the guide shoe extractor tool, pull the crosshead towards the extractor tool until it is free of the opposite guide shoe.

   Follow the movement of the crosshead with the engine room crane.

   Dismount the guide shoe extractor tool.

   Lift up the free guide shoe.

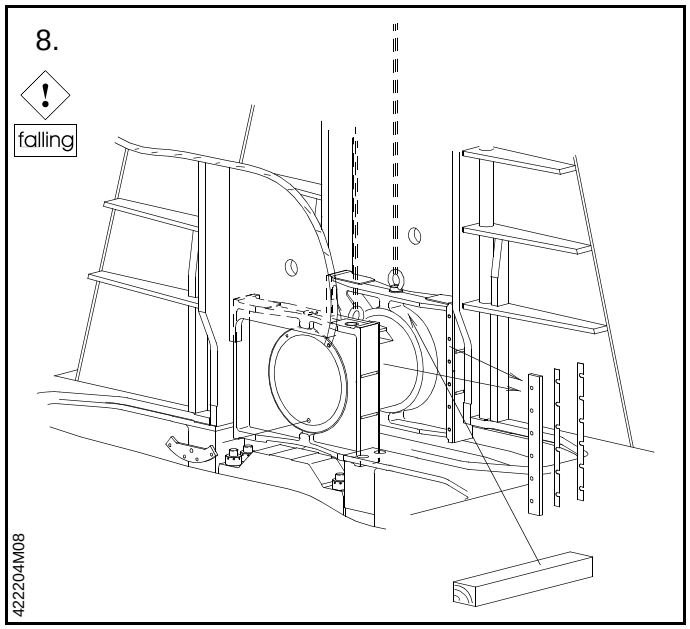
10. Mount the guide shoe extractor tool on the remaining guide shoe.

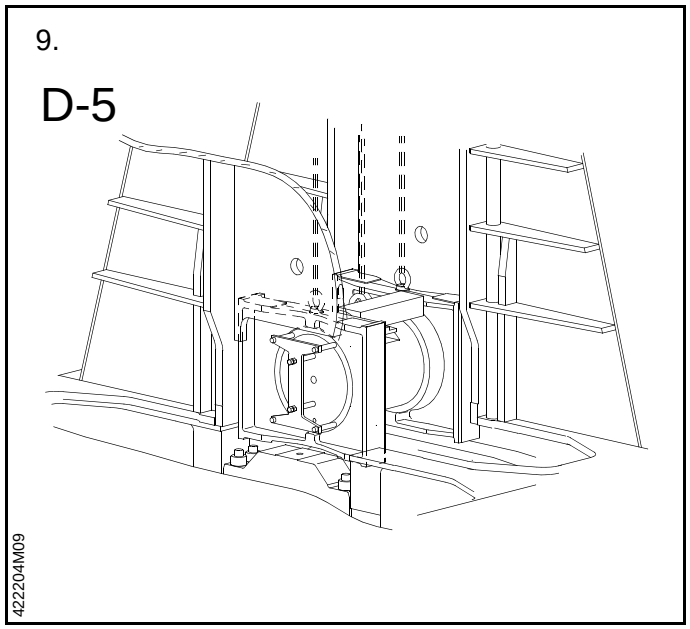
    Using the guide shoe extractor tool, push the crosshead away from the remaining guide shoe, until the crosshead is free of the guide shoe.

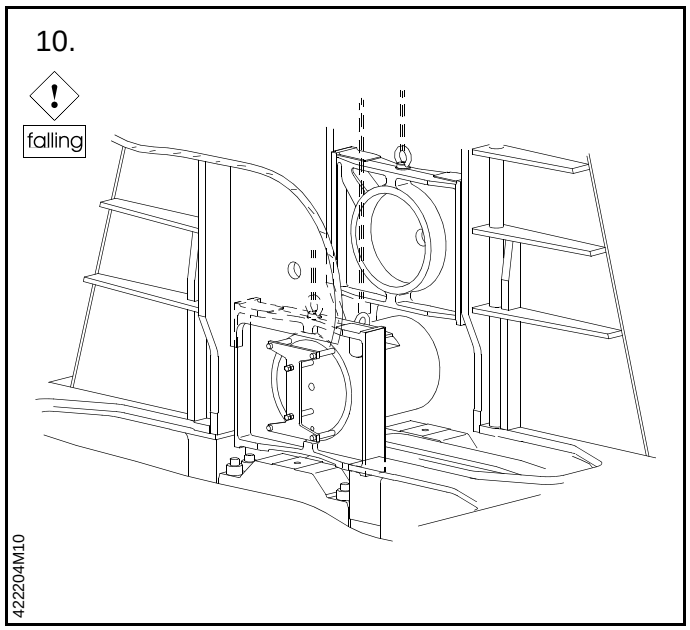
    Follow the movement of the crosshead with the engine room crane.

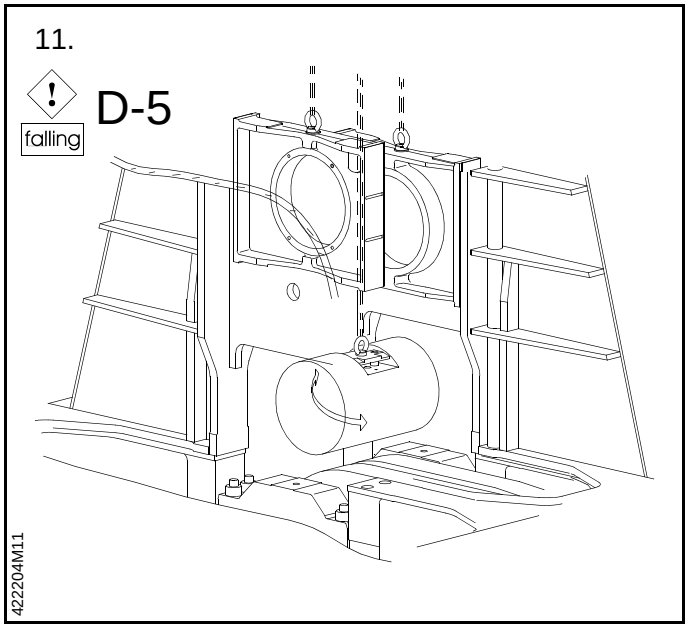
    Dismount the guide shoe extractor tool.

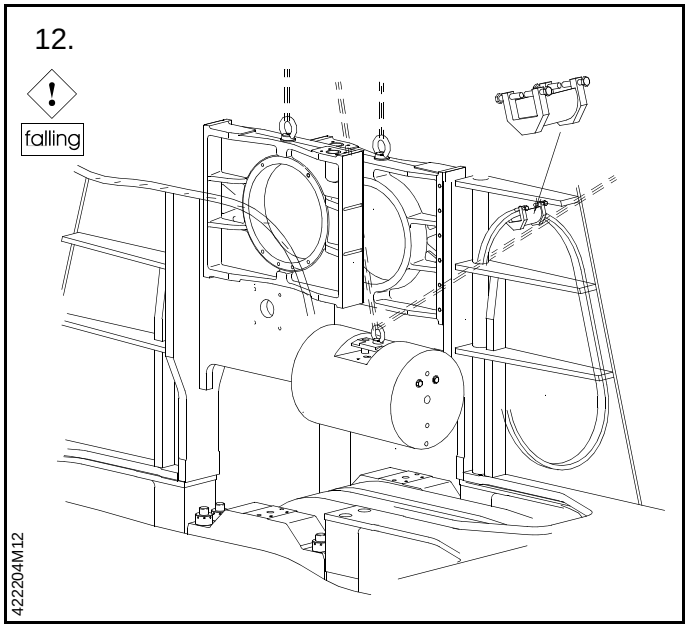
    Lift up the guide shoe.











11. Turn the crosshead 90°.

12. Mount the wire guide tool in the framebox door opening.

    By means of wire rope and tackles, remove the crosshead from the engine.

    Protect the crosshead, for instance with thick or corrugated paper, and land it outside the engine.

    If necessary, remove the guide shoes from the engine.

1. Attach the flat-plaited wire strap to the engine room crane.

   Lift the crosshead into the engine, using wire rope, tackles, and the engine room crane.

2. Turn the crosshead 90°.

3. Lower one guide shoe and mount the guide shoe extractor tool.

   Use the guide shoe extractor tool to pull the crosshead so far through the guide shoe that the other guide shoe can be lowered.

   Follow the movement of the crosshead with the engine room crane.

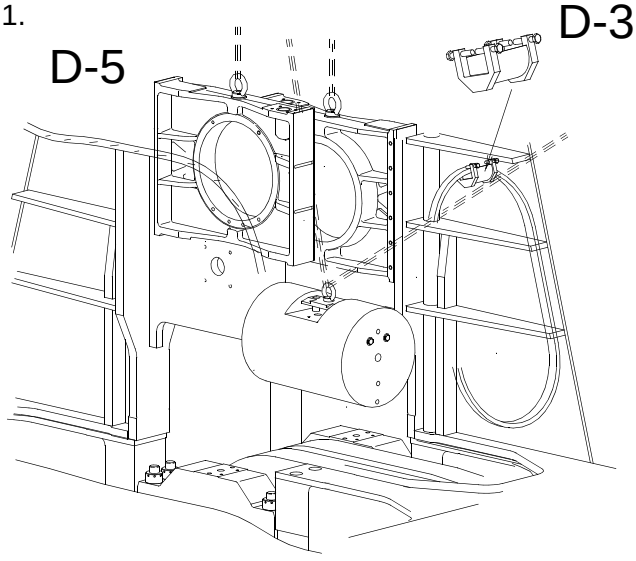
4. Lower the other guide shoe.

   Use the guide shoe extractor tool to push the crosshead so far through the second guide shoe.

   Follow the movement of the crosshead with the engine room crane.

   Dismount the guide shoe extractor tool.

1.



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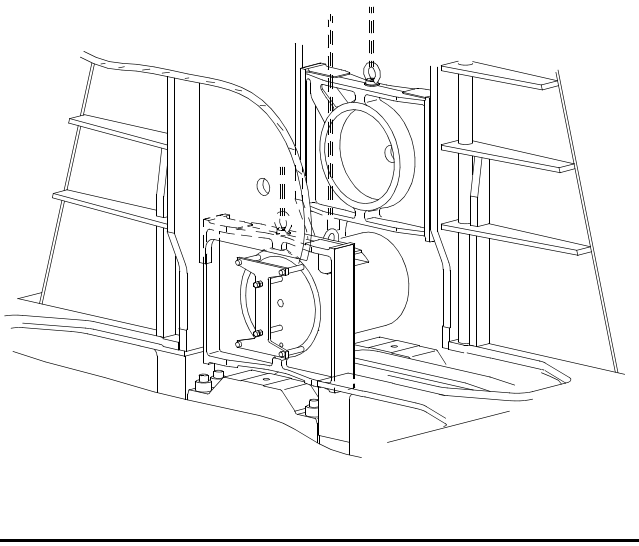

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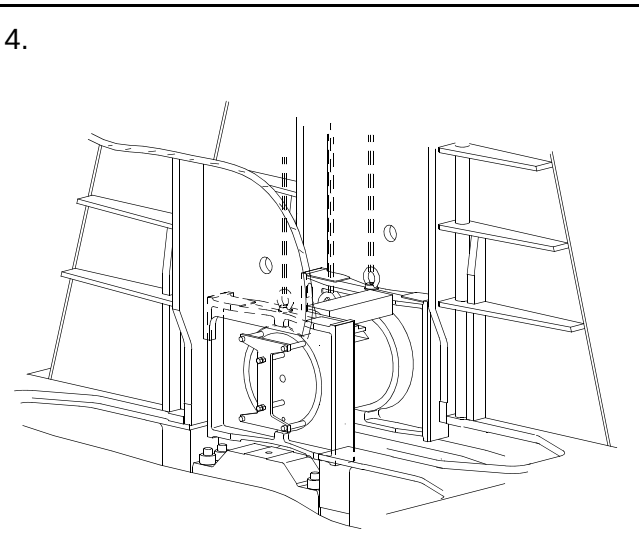
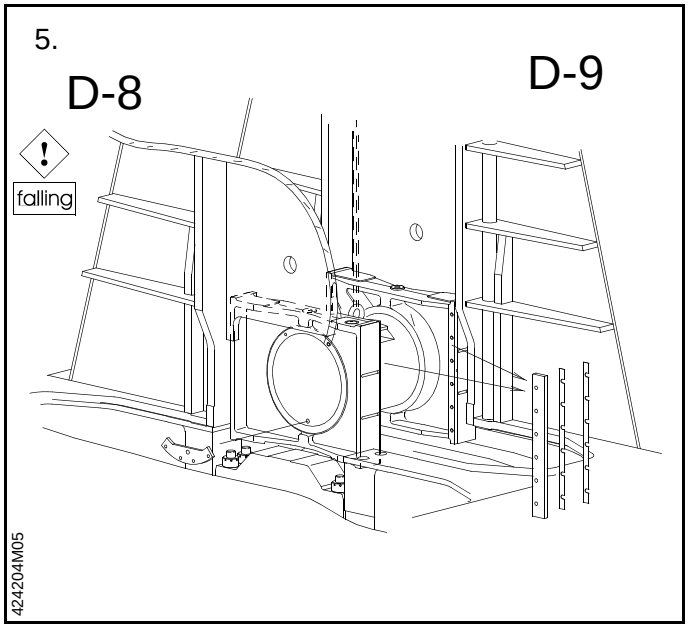
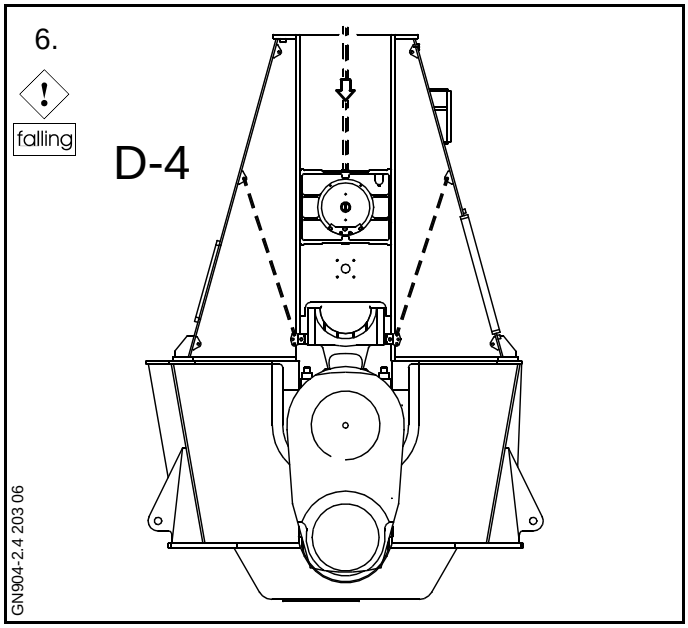
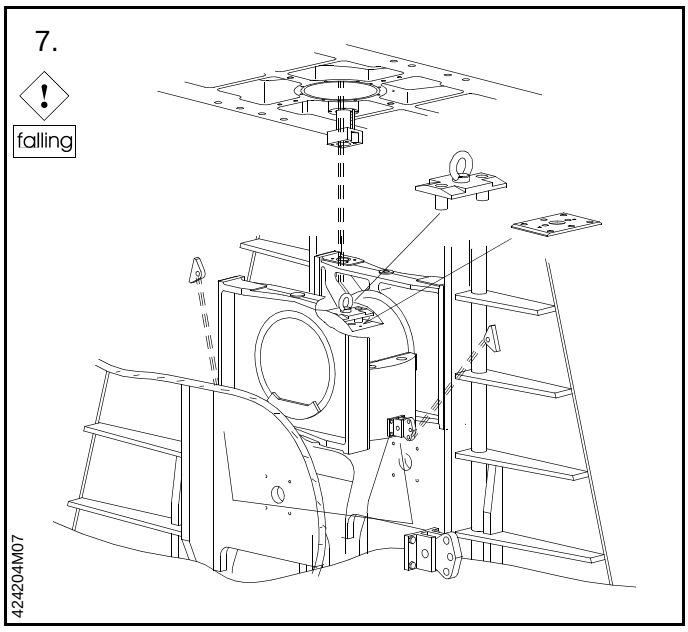








5. Mount the guide plates on the side of the guide shoes.

   Tighten the screws and lock them with locking wire.
   See Procedure 913-7.

   Using the engine room crane, lift the crosshead to a working position and mount the guide strips on the side of the guide shoes.

   Tighten the screws and lock them with locking wire.
   See Procedure 913-7.

6. Using the tackles, lift the connecting rod to a vertical position while turning the crankthrow to **BDC**.

7. When the connecting rod is in a vertical position, lower the crosshead and land it on the connecting rod.

   Remove the lifting attachments from the connecting rod head.

   Remove the lifting tool from the crosshead.

   Mount the shim under piston rod.

8. Lift the crosshead bearing cap into the engine.

9. Mount the spacer rings and the hydraulic jacks for tightening the nuts on the crosshead bearing studs.

   For operation of the hydraulic tools, see Procedure 913.

   Mount the drain oil slotted pipe and the cooling oil outlet pipe on the guide shoe.

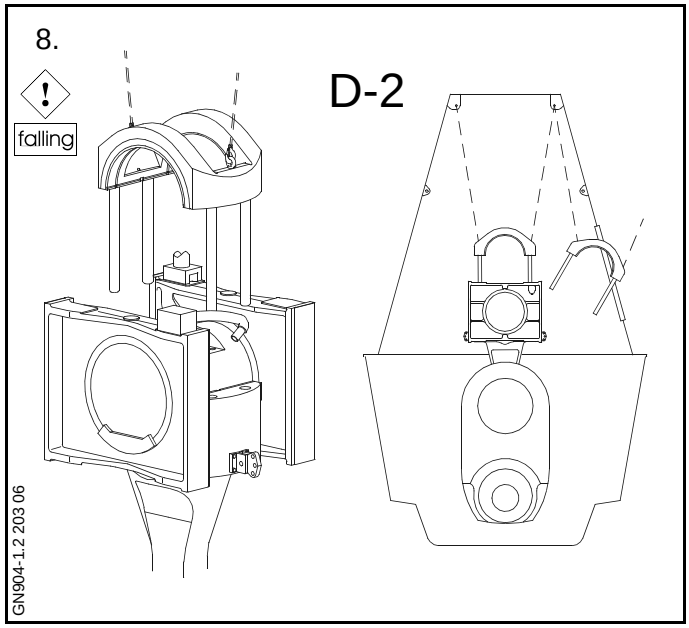
   Turn the crankshaft to **TDC**.

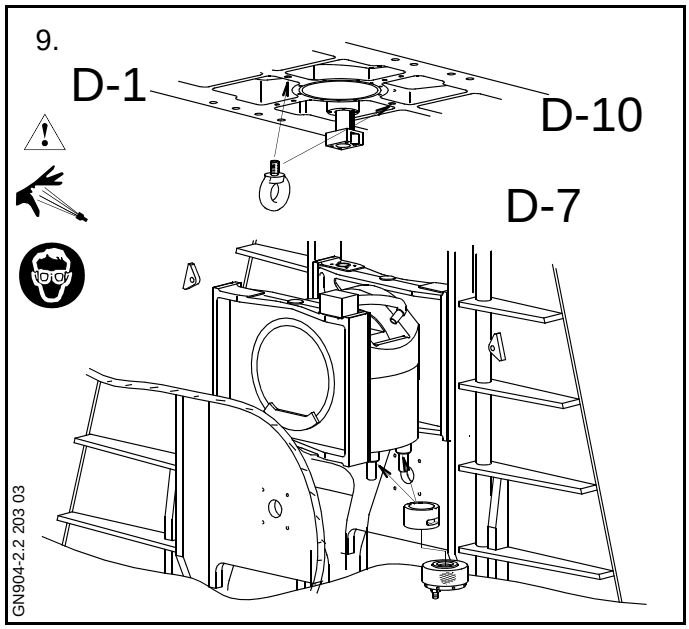
   Land the telescopic pipe on the guide shoe.

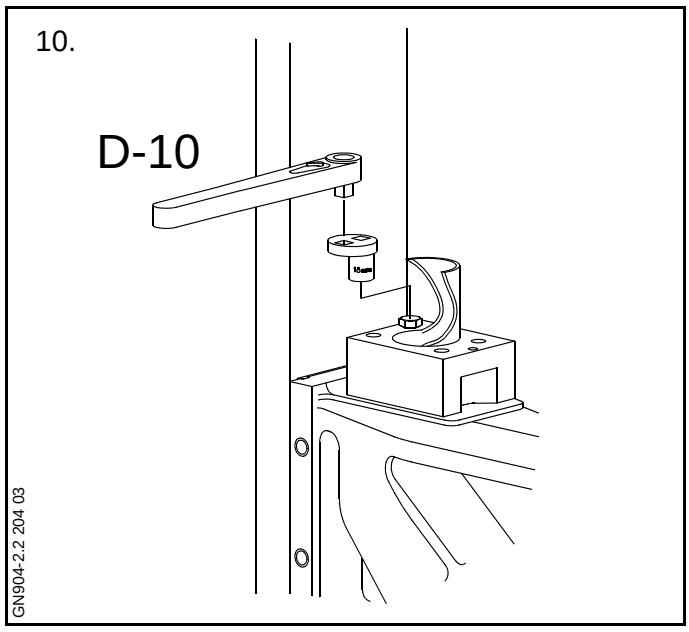
10. For tightening the bolt in the corner behind the telescopic pipe, use the offset tool along with the torque wrench.

11. Mount the lubricating oil pipes on the main bearing caps.

12. Mount the piston.
    See Procedure 902-1.4.







SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Slippy surfaced and risk of falling (while at work in crankcase)
X	Block the starting mechanism	Risk of severe personal injury (while engine being turned)
X	Shut off starting air supply	
X	Engage turning gear	
X	Shut off cooling water	
X	Shut off fuel oil	
X	Shut off lubricating oil	
X	Lock turbocharger rotors	

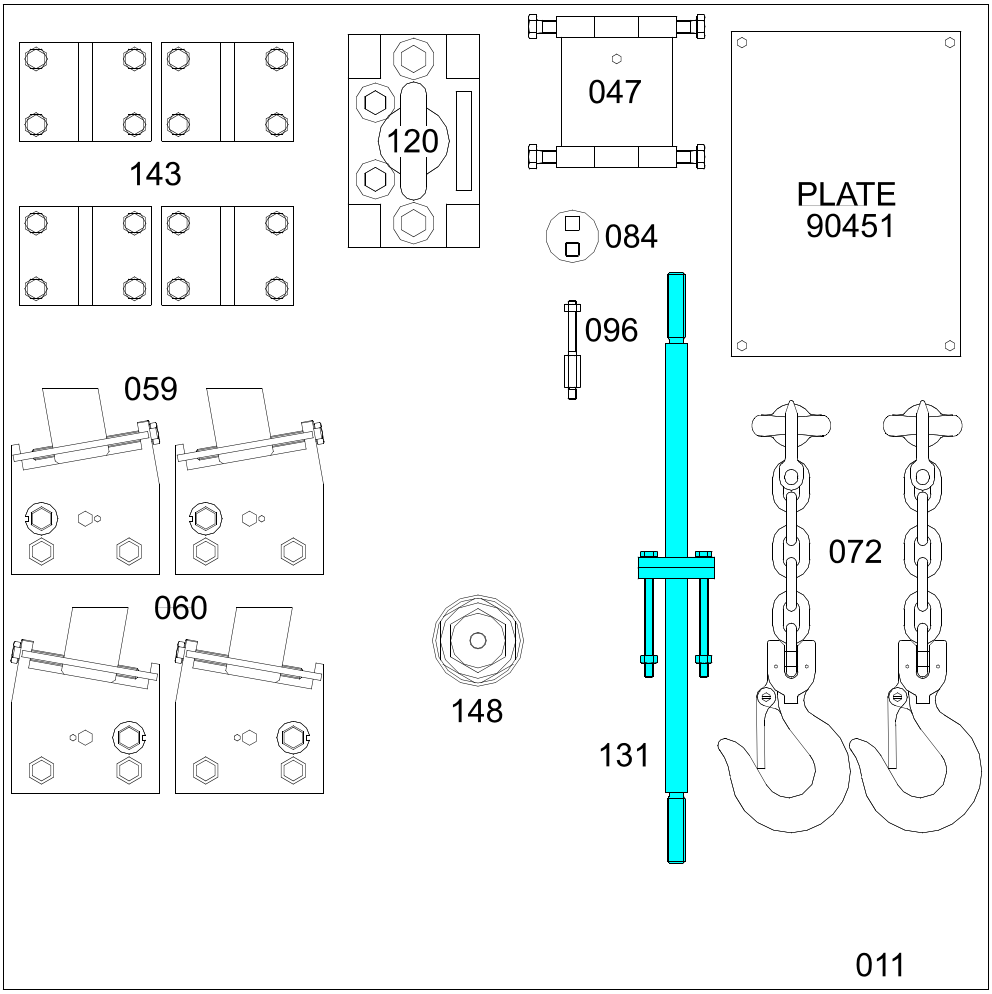
Standard Tools: See Section 913

Data

Meas. points	Acceptance criteria with piston in centre (F-A direction)	Value
PF+PA	N_{max}	0.5 mm
E+G, H+F	N_{max}	0.5 mm
	N_{min}	0.2 mm
	O_{max}	0.8 mm
J, L, K, M	N_{max}	0.9 mm
	N_{min}	0.5 mm
	O_{max}	1.1 mm
ZF/ZA	O_{max}	4.0 mm

N: New and cold engine with staybolts tightened (less than 100 running hours).

O: Engine in service.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In order to achieve uniform measuring conditions on board, the ship's trim must be as close as possible to 0°.

1. Mount a transparent plastic tube along the length of the bedplate.

   Bend each end approx. 250 mm up along the framebox side. *See **T***.

   Fill the tube with water (possibly coloured) until the water level is approx. 100 mm from the end of the tube.

   Trim the ship until the difference between the water level **S** fore and aft is less than 1.5 mm per 1000 mm.

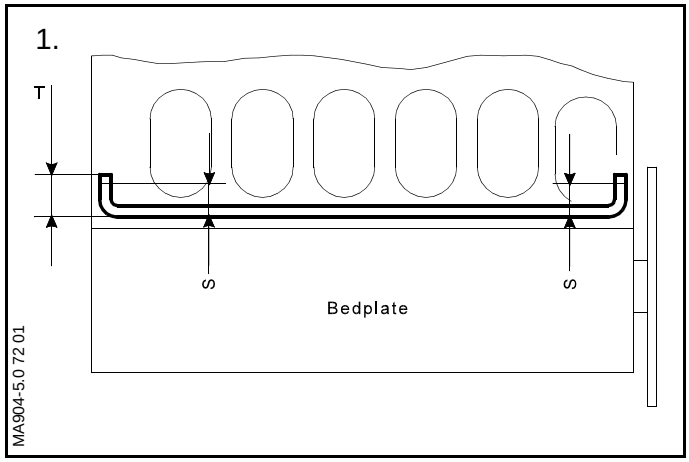
   Measurements are to be taken with a ruler.

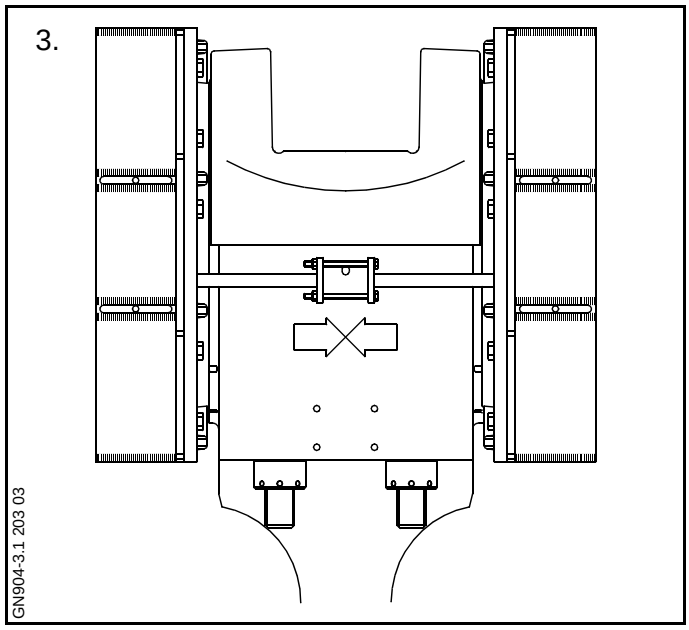
2. Turn the engine in ASTERN direction to 45° after **BDC** (the guide shoe must rest against the crosshead guide).

3. Mount the tool between the guide shoe/ guide strip. For this purpose, use the third threaded hole from bottom of guide shoe (this hole is normally used for fastening the guide strip to the shoe).

   By means of the two screws in the middle of the tool, pull the guide shoes until they rest lightly against the end face of crosshead.

Note!
When the tool is mounted, it is not possible to turn past **TDC** and **BDC**.





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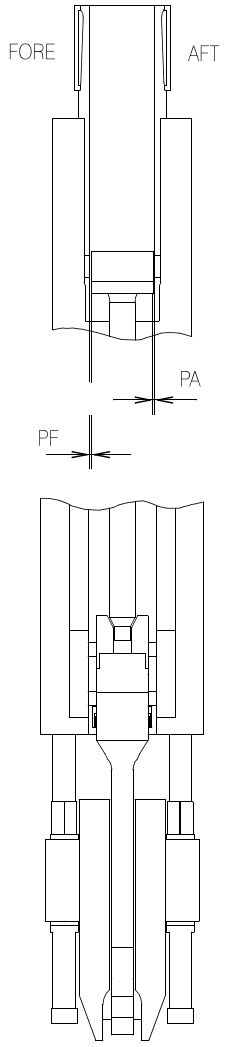

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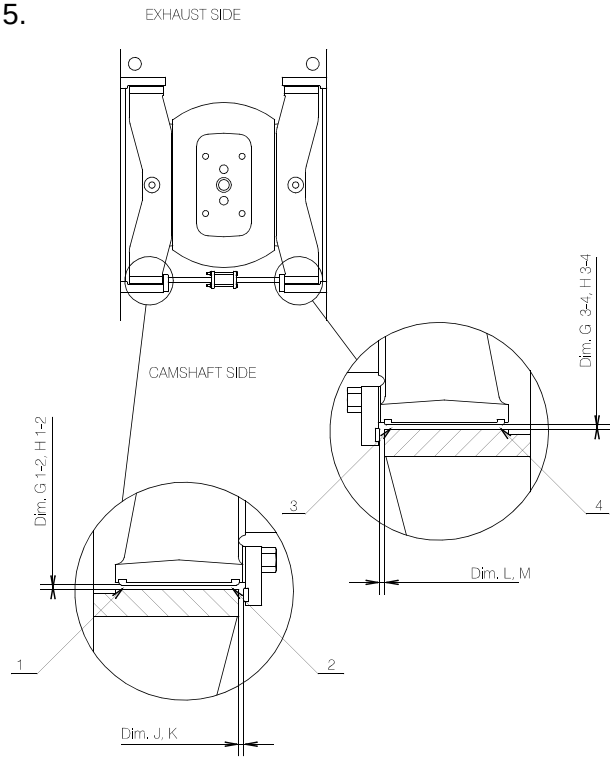


GN904-3.1 203 05

4. Check the centering of the piston in the cylinder liner by measuring the clearance (from the scavenge air space with a long feeler gauge) between the piston skirt and the cylinder liner in the Fore and Aft positions (**PF-PA**).

   Make sure that the piston is clear of the cylinder liner in the fore-and-aft direction.

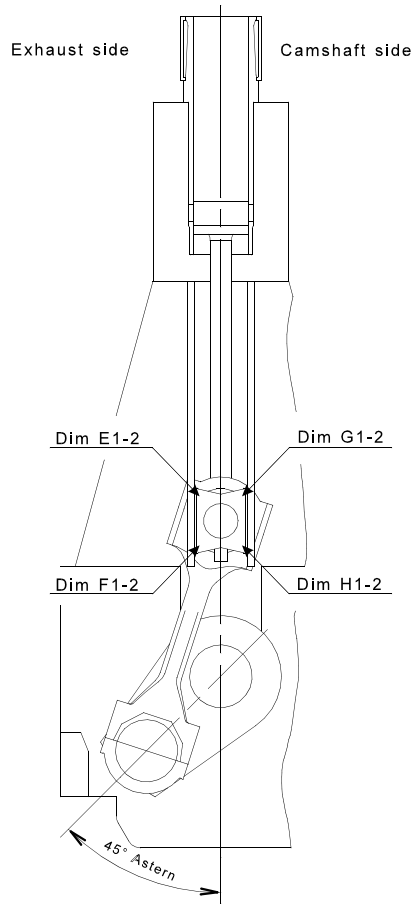
5. Measure the clearance between the guide strips and crosshead guides (**J**, **K**, **L** and **M**).

   Parallelism between the guide strip and guide is to be kept within a tolerance of 0.2 mm per 1000 mm.

6. Check the clearance between guide shoe and crosshead guide (**E**, **F**, **G** and **H**) with a feeler gauge.

7. *It is recommended that the measured results are noted down so that possible later changes can be ascertained.*

6.



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7.

Unit mm	Cyl.	1	2	3
Piston / Liner	PF			
	PA			
Framebox	E1			
	E2			
	E3			
	E4			
	F1			
	F2			
	F3			
	F4			
	G1			
	G2			
	G3			
	G4			
	H1			
	H2			
	H3			
	H4			
	J			
	L			
	K			
	M			
Crankthrow Connecting rod	ZF			
	ZA			

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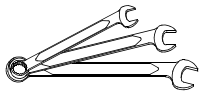
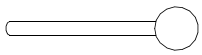
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of high pressure oil
X	Block the starting mechanism	Do not enter area when over head lifting is being carried out
X	Shut off starting air supply	Slippy surfaced and risk of falling (while at work in crankcase)
X	Engage turning gear	Risk of severe personal injury (while engine being turned)
	Shut off cooling water	
	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

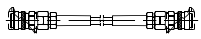
Data

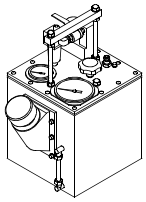
Ref.	Description	Value	Unit
D-1	Clearances in crankpin bearing: *See Vol. 1 "Operation & Data".*		
D-2	Hydraulic pressure - tightening	150	MPa (1500 bar)
	Hydraulic pressure - dismantling	150-165	MPa (1500-1650 bar)
D-3	Crankpin bearing - upper shell	17	kg
D-4	Crankpin bearing - lower shell	14	kg
D-5	Crankpin bearing cap + shell + bearing studs	153	kg

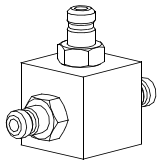
Note!
Permit to Max. 165 MPa (1650 bar) only in a short time.

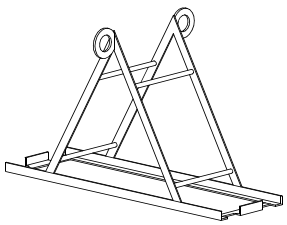
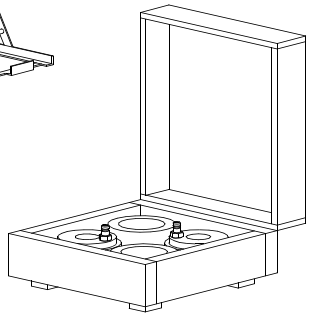
Standard Tools: See Section 913

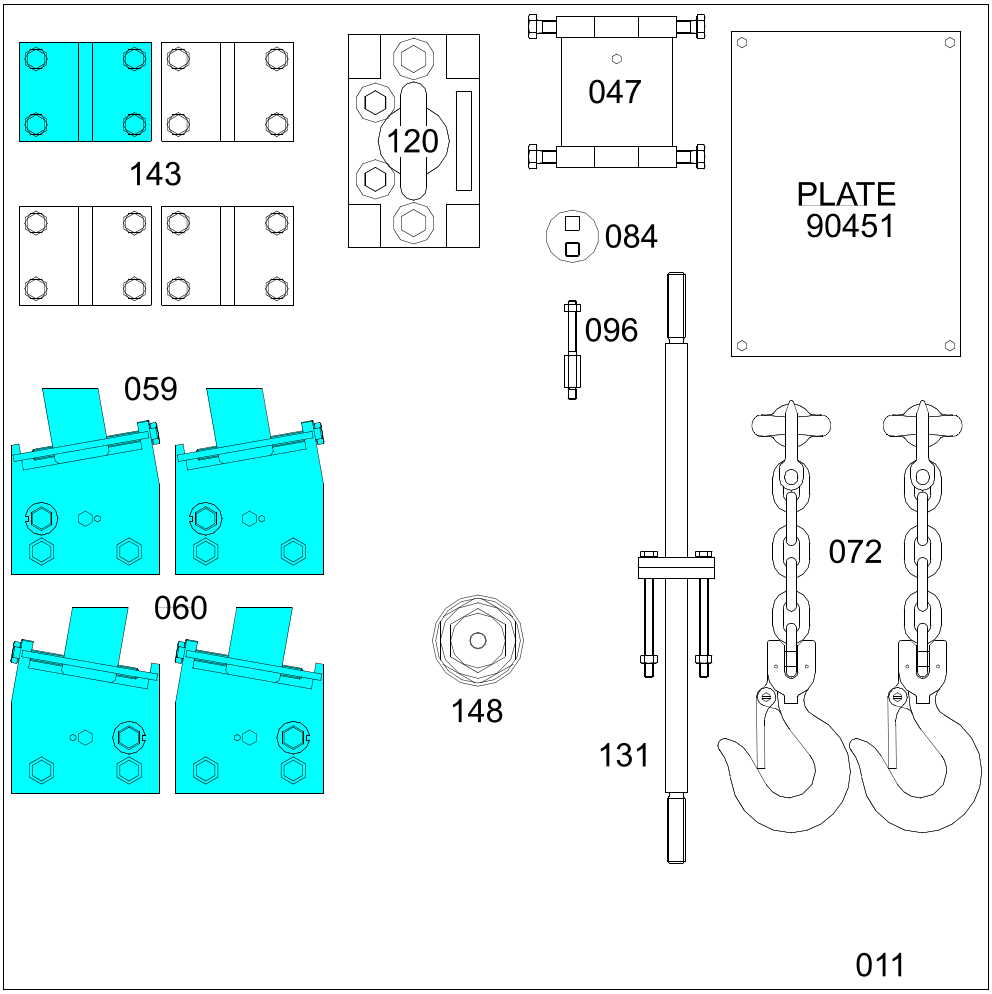





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The bottom clearance between the journal and a new bearing shell is the result of a summation of the production tolerances of the bearing assembly components.

For the bottom clearance of a specific bearing, see the measurement in the Adjustment Sheet.

1. Open the crankcase door at the relevant cylinder.

2. Turn the crank concerned to **BDC**.

3. Measure the clearance in the crankpin bearing by inserting a feeler gauge at the bottom of the bearing shell in both sides. *See Data for bottom clearance.*

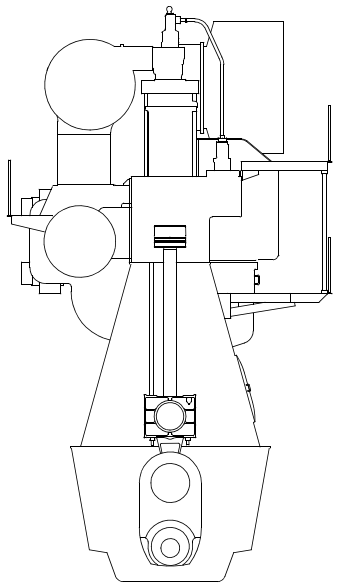
4. When checking the clearances, the discrepancy between the measurements noted in the Adjustment Sheet (or the clearance noted for a new bearing installed later) **must not** exceed 0.1 mm. If so, the crankpin bearing must be disassembled for inspection.
   See Procedure 904-4.2.

5. The wear limit for the crankpin bearing shells is based on an evaluation of the bearing condition at the time of inspection.

   An average wear rate of 0.01 mm per 10,000 hours is regarded as normal.

6. *For further external inspection of the crankpin bearing, see Chapter 708 'Bearings' in the instruction book, Volume I, OPERATION.*

2.



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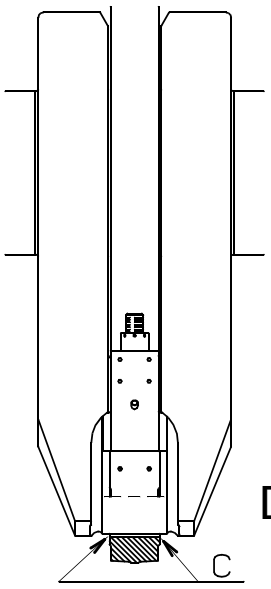

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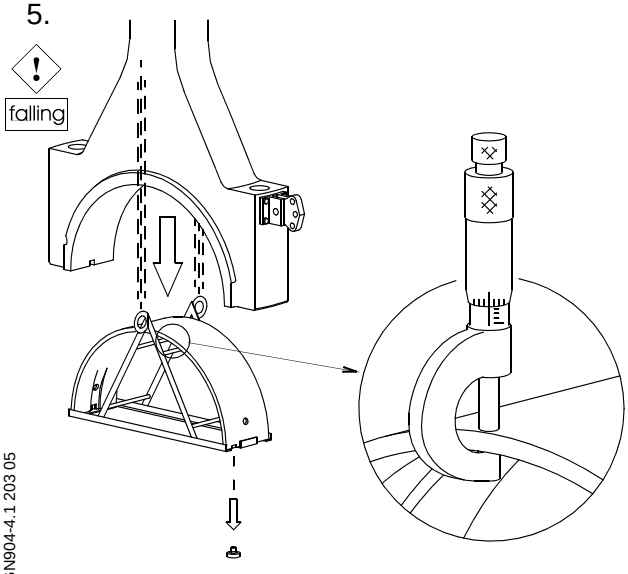

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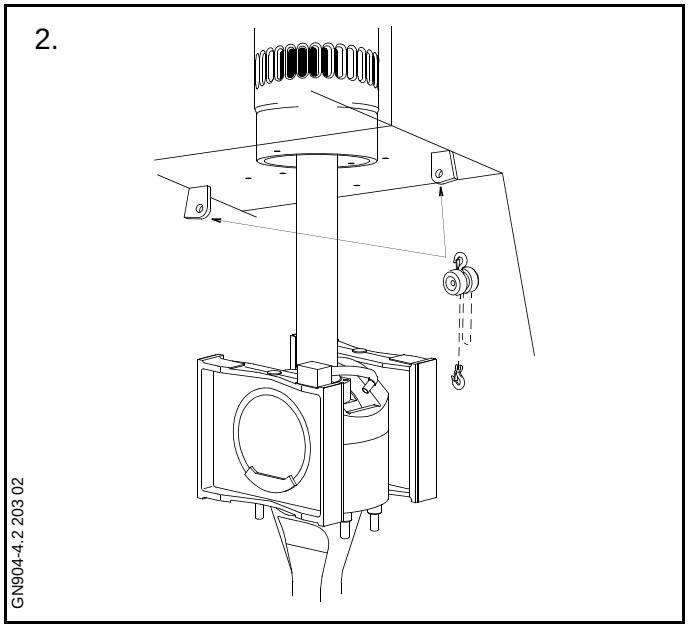
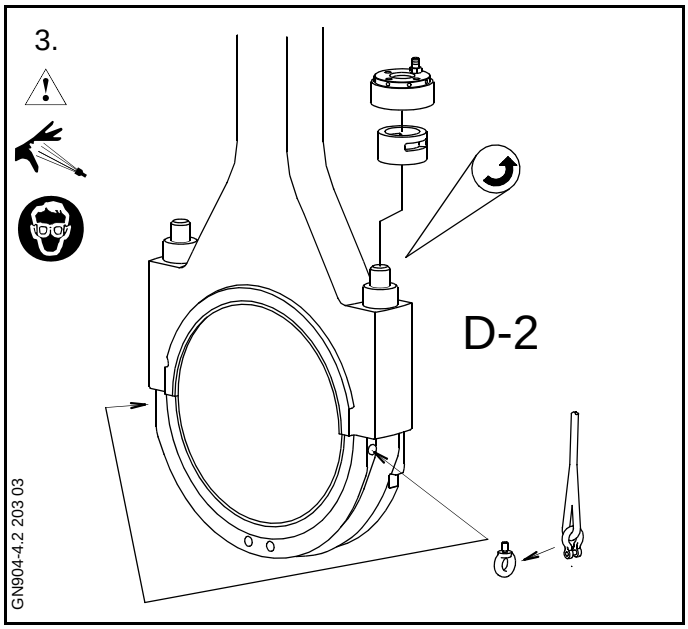
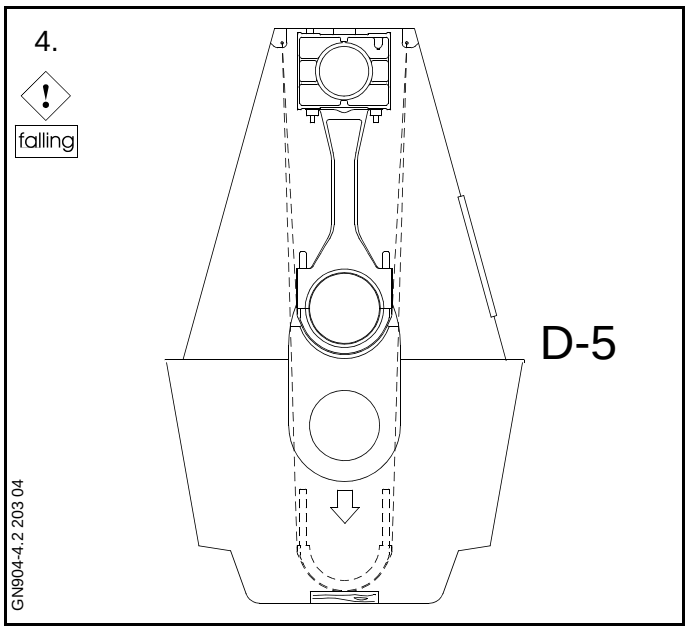






1. Turn the crank to **BDC**.

2. Suspend two tackles from the lifting brackets in the athwartship direction.

3. Turn the crank to **TDC**.

   Mount lifting tool in each side of the crankpin bearing cap and, by means of shackles and wires, hook on the tackles and haul tight.

   By means of the hydraulic jacks, loosen the crankpin bearing stud nuts.

   For operation of the hydraulic jacks, see Section 913.

   Remove the hydraulic jacks and the nuts.

4. **Carefully** lower the bearing cap while ensuring that the studs do not damage the crankpin journal.

   Land the bearing cap on a couple of planks placed in the oil pan.

   Inspect the bearing shell.

5. If the bearing shell needs to be replaced, remove the whole bearing cap from the crankcase.

   Suspend a tackle from the lifting bracket on the inside camshaft side of the frame box above the crankcase door opening.

   Hook the tackle on to the lifting tool on one side of the bearing cap.

   Mount the wire guide in the top of the crankcase door opening.

   Using the tackle from the frame box inside wall, together with a tackle suspended from the platform bracket, lift the bearing cap out of the crankcase.

6. Place the bearing cap on one side on a couple of planks.

   Dismount the bearing shell locking screws and replace the bearing shell by a new one.

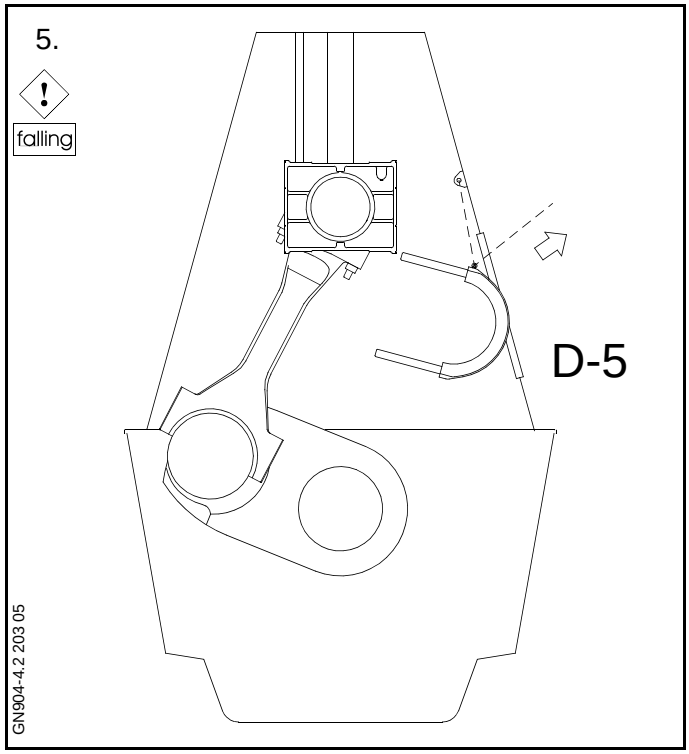
   The bearing shells **must** be replaced in pairs.

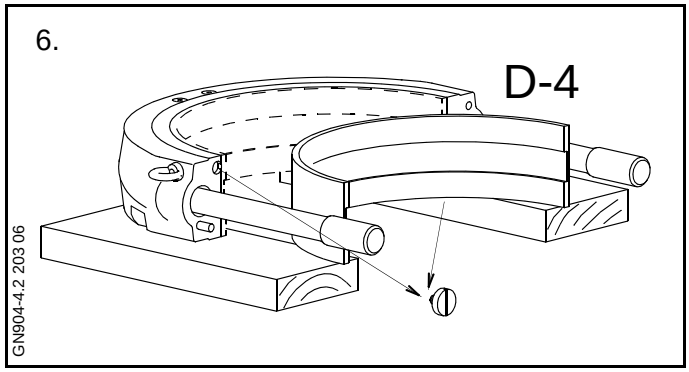
7. Turn to **TDC**.

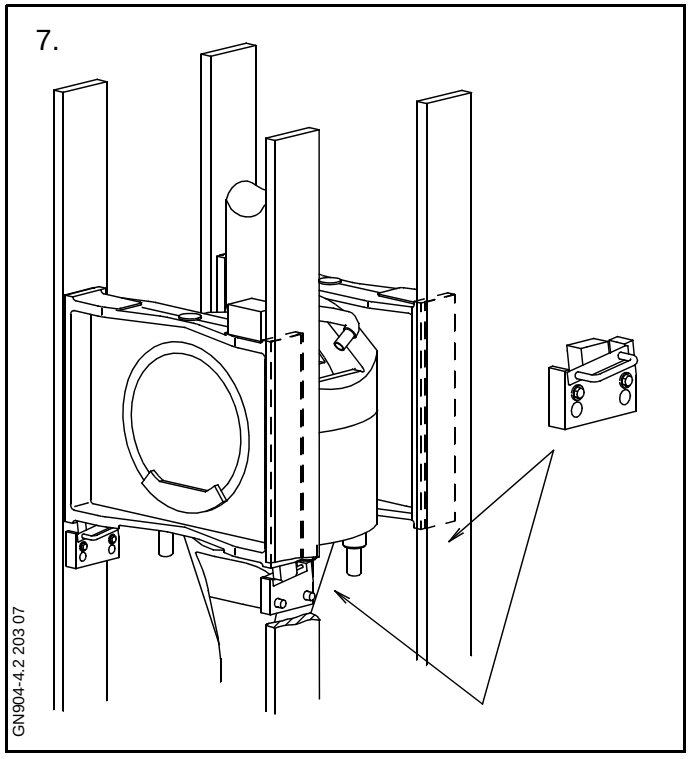
   Mount the four supports for the guide shoes on the crosshead guides.

   Carefully turn down the crank until the guide shoes rest on the supports.

   Adjust the support brackets to the guide shoes so that the weight of the crosshead is distributed evenly on the four supports.







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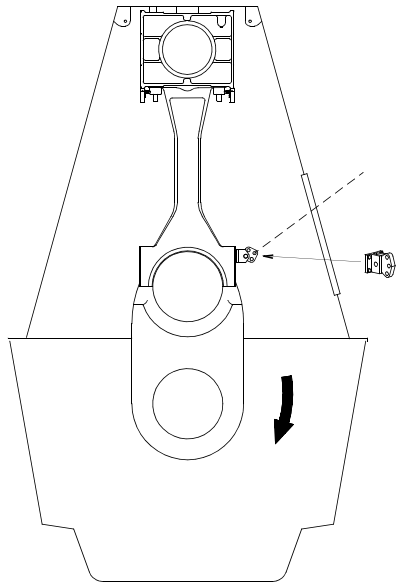

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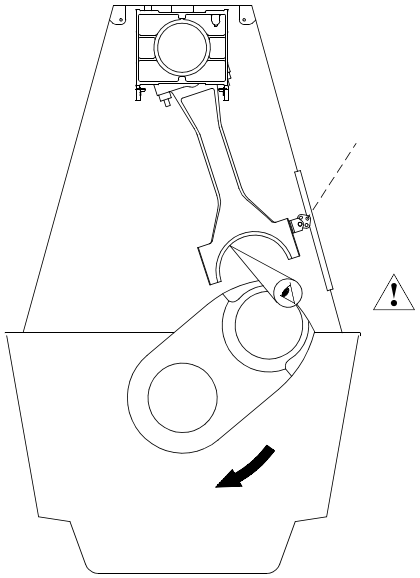

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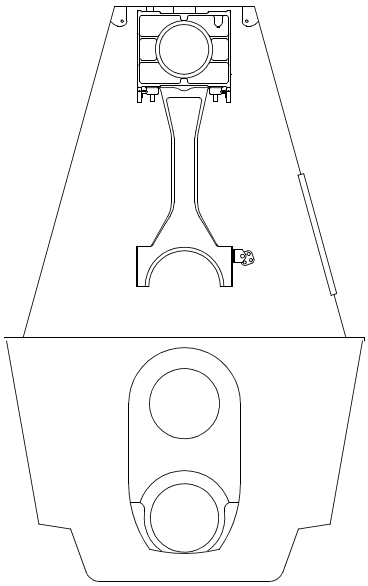

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8. Mount a lifting attachment for securing the connecting rod at the lower end, on one side.

   Hook on the tackle to a beam under the gallery platform and haul tight.

9. **Carefully** turn the crankshaft downwards, while 'following' with the tackle, making sure that the upper part of the bearing comes completely clear of the recess in the crankshaft when the parts begin to 'separate'.

   Continue turning the crankshaft until the bearing surface can be freely inspected.

   Inspect the bearing shell surface and the crankpin journal.

10. If it is necessary to replace the bearing shell, proceed as follows:

    Turn the crankshaft to **BDC**.

    Release the tackle so that the connecting rod is hanging freely.

11. Mount an eye screw in the bottom of each guide shoe.

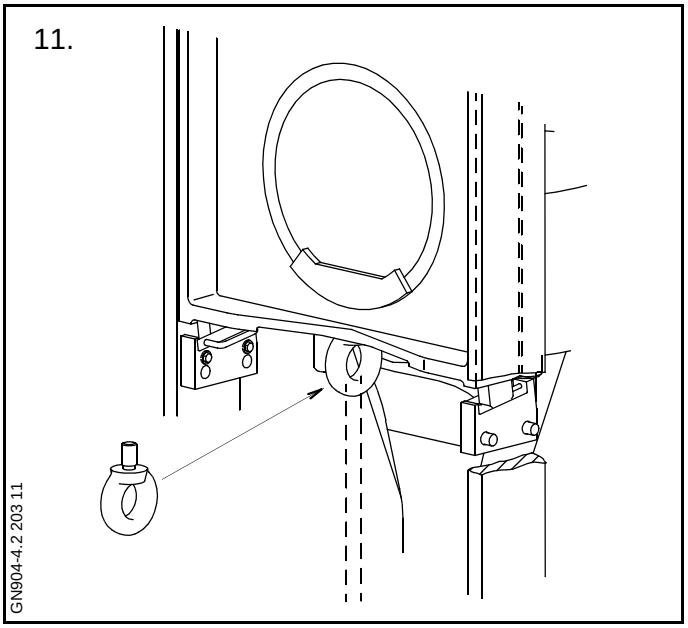
    Suspend two tackles from the eye screws.

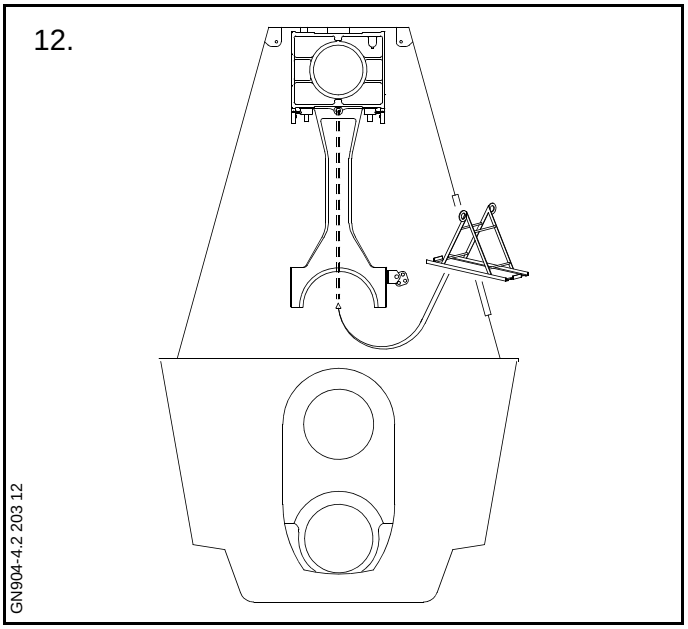
12. Place the lifting tool for the crankpin upper shell on the crank webs and hook the tackles on to the lifting tool.

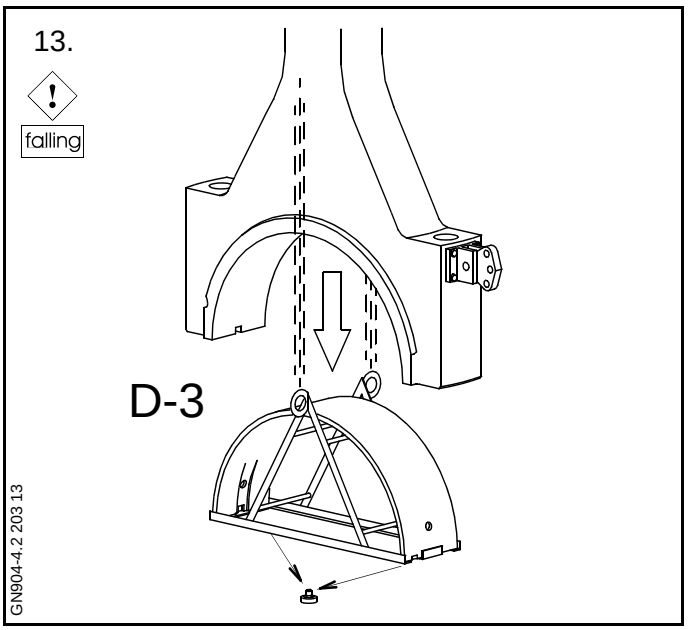
    Mount the tool on the bearing shell in the connecting rod, using the tackles, and haul tight.

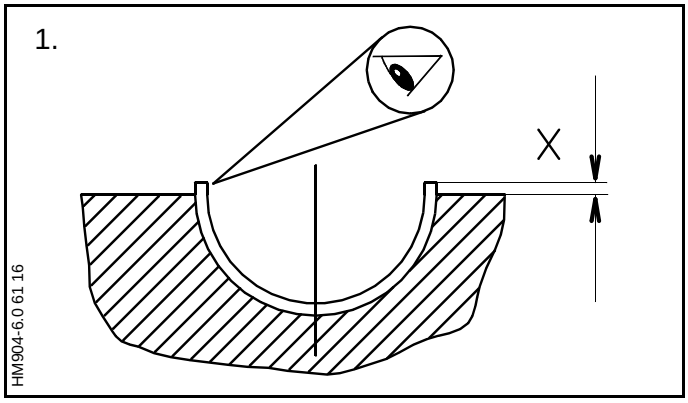
13. Dismount the bearing shell locking screws.

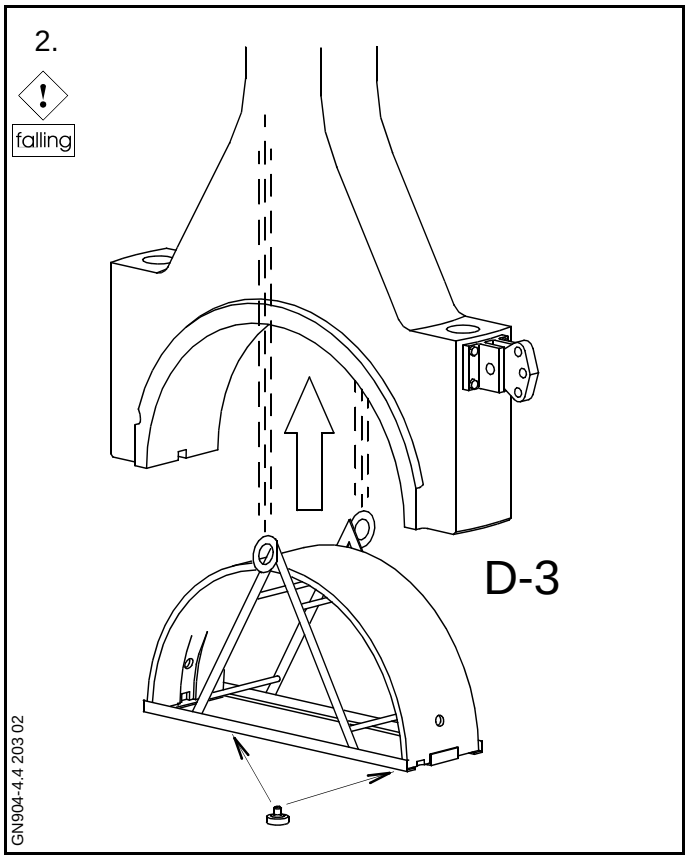
    Lower the lifting tool with the bearing shell, using the tackles.

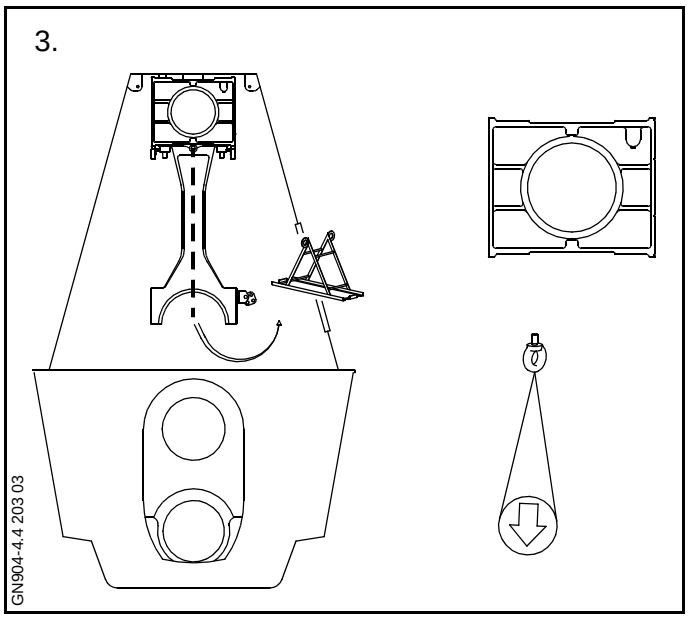












1. If necessary, replace the bearing shells with new ones. The bearing shells **must** be replaced in pairs.

   Bearing shells of three mm undersize are available as spares in case of journal rectification.

   Coat the bearing shell surfaces and the journal with clean oil.

   The excess height **X** is to ensure the correct tightening-down of the bearing shell, and must not be eliminated.

2. Lift the upper bearing shell for the crankpin concerned into the crankcase.

   Carefully lift the bearing shell into position in the connecting rod, and mount the locking screws.

3. Remove the lifting tool, the tackles and the eye screws from the guide shoes.

4. Hook the tackle on to a beam under the gallery platform and on to the lifting attachment on the connecting rod, and haul tight.

   Carefully turn the crankshaft upwards, while following up with the tackle, making sure that the upper part of the bearing enters the recess in the crankshaft when the parts turn together.

   Remove the tackle and the lifting attachment from the connecting rod.

5. Turn the crosshead to **TDC**.

   Remove the guide shoe support brackets from the crosshead guides.

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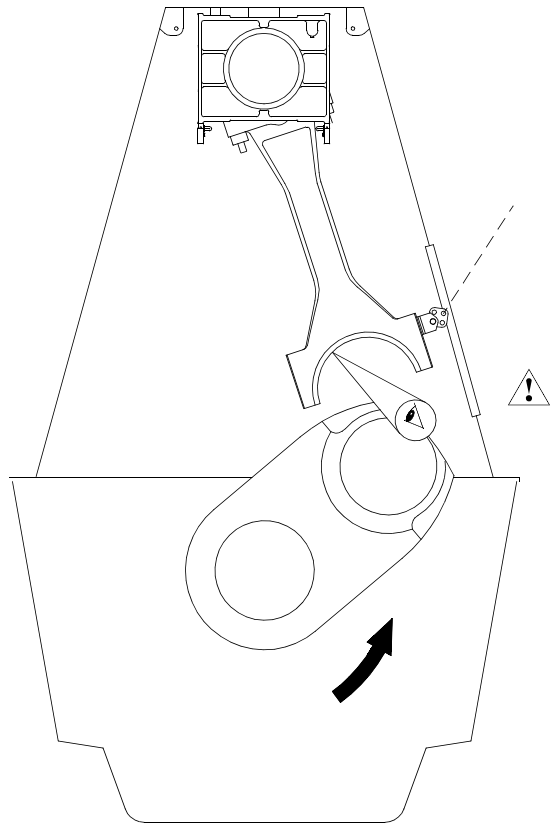

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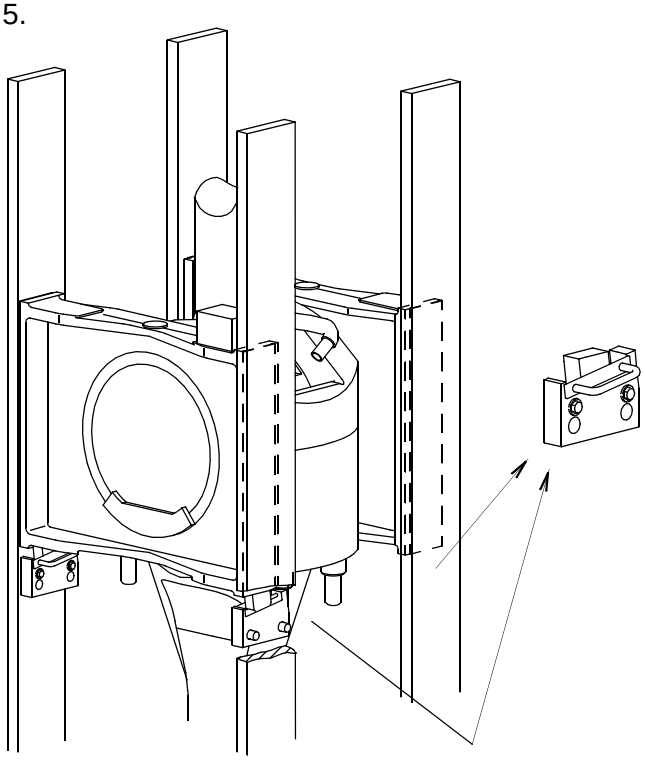

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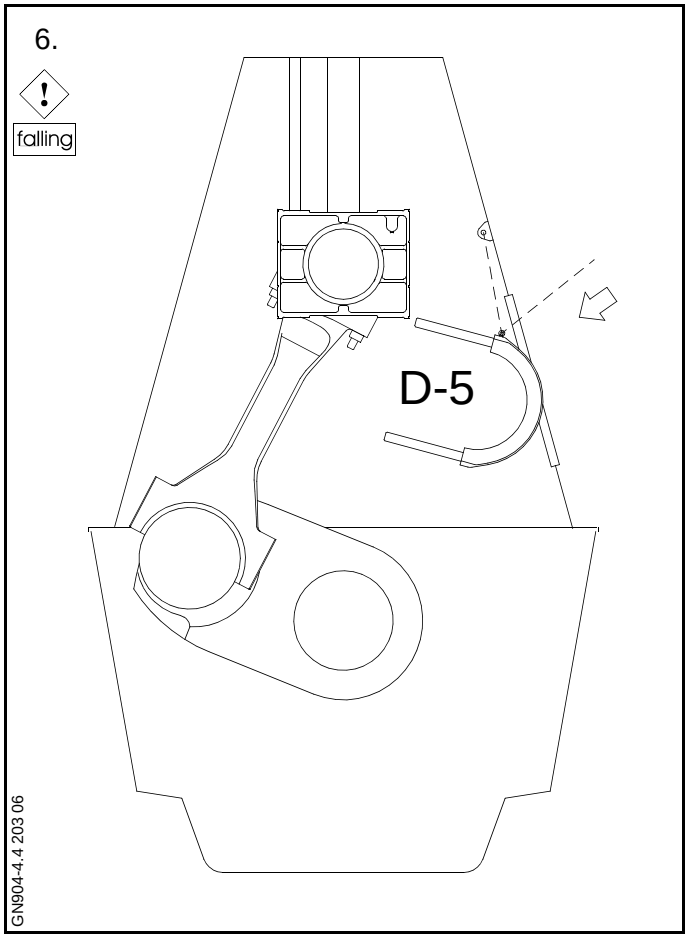
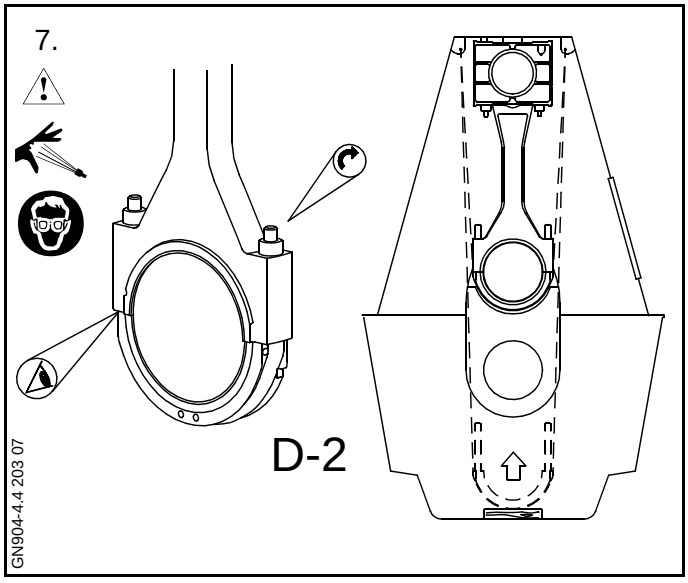




6. Suspend the tackles from the lifting brackets in the top of the frame box.

   Lift the bearing cap assembly into the crankcase and land it on a couple of planks placed in the oil pan.

7. Hook the tackles on to the wire ropes and lift the bearing cap into position against the connecting rod.

Caution!
During mounting, take care that the studs do not damage the crankpin journal, and check that the guide pins mounted in the bearing cap enter the holes in the connecting rod.

Mount the nuts and, by means of spacer rings and hydraulic jacks, tighten the crankpin bearing cap. *See Data*.

For operation of hydraulic jacks, see Section 913.

Remove the tackles from the top of the frame box.

Remove the lifting tools in each side of the crankpin bearing cap.

SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of high pressure oil
X	Block the starting mechanism	Do not enter area when over head lifting is being carried out
X	Shut off starting air supply	Slippy surfaced and risk of falling (while at work in crankcase)
X	Engage turning gear	Risk of severe personal injury (while engine being turned)
	Shut off cooling water	
	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

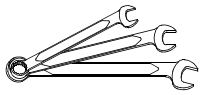
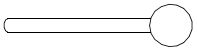
Data

Ref.	Description	Value	Unit
D-1	Hydraulic pressure - tightening	150	MPa (1500 bar)
	Hydraulic pressure - dismantling	150-165	MPa (1500-1650 bar)

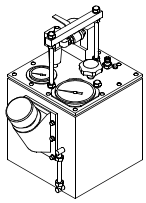
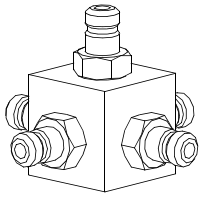
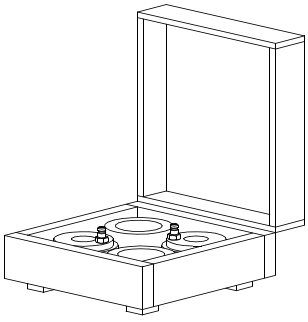
Note!
Permit to Max. 165 MPa (1650 bar) only in a short time.

D-2	Crankpin bearing cap	153	kg
D-3	Connecting rod	1065	kg

Standard Tools: See Section 913



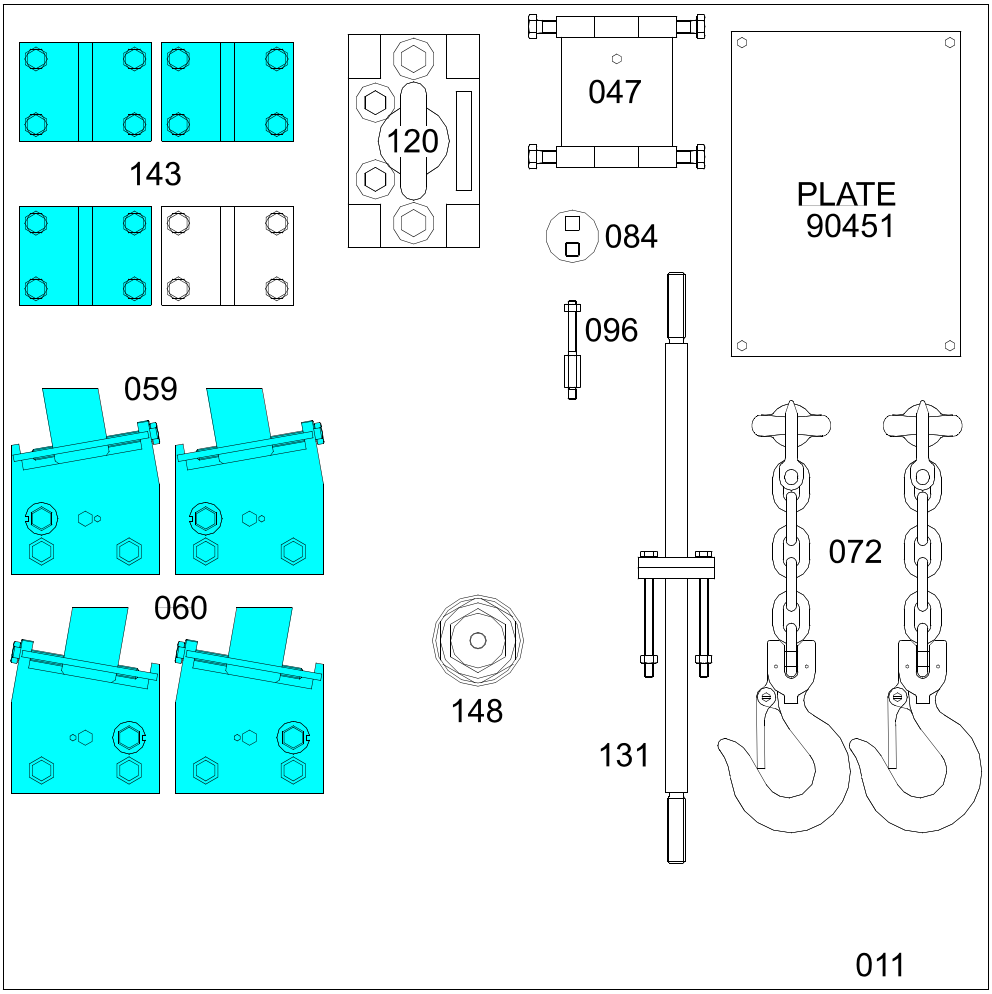

143
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PLATE
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059
060
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011

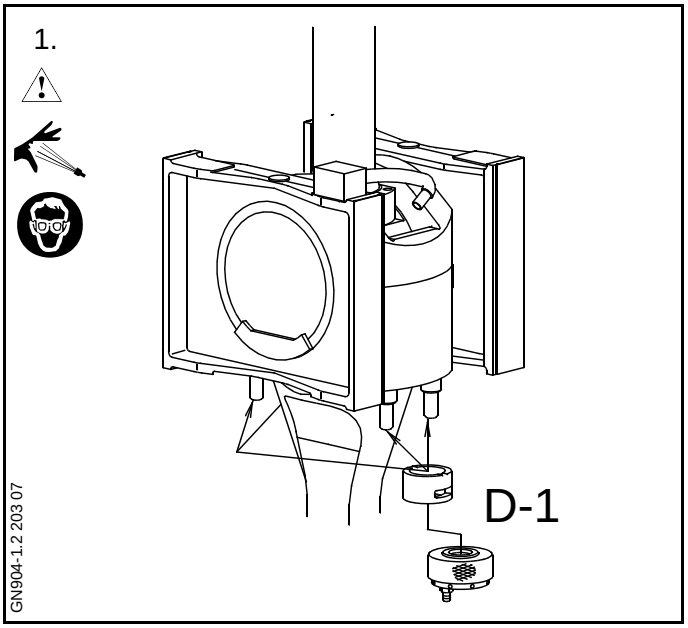
1. Turn the crank to **BDC**.

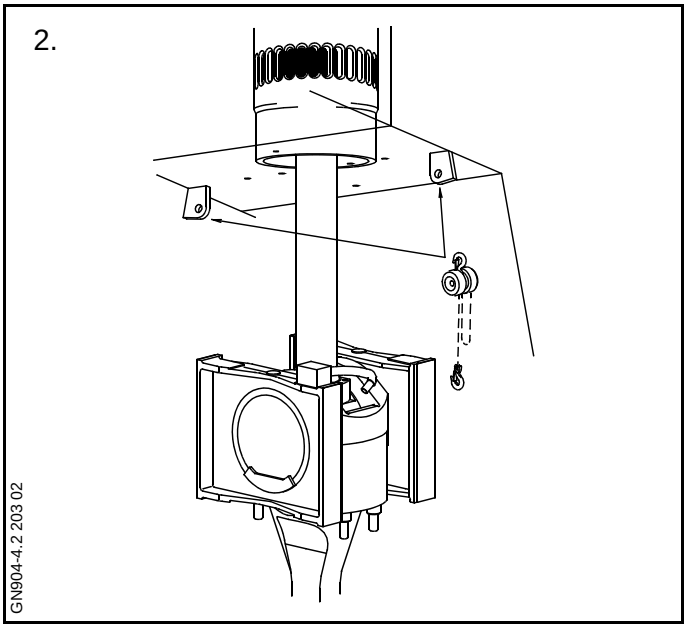
   Dismount the nuts from the crosshead bearing studs.
   See Procedure 904-1.2.

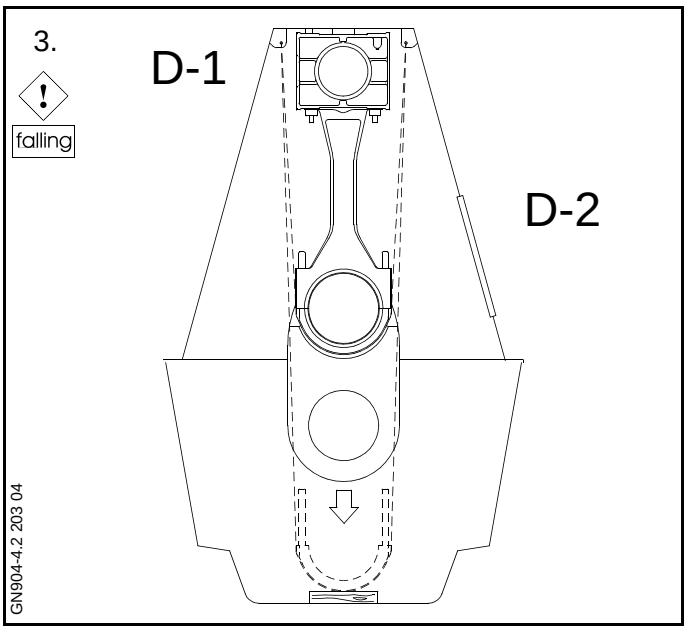
2. Mount two shackles in the top of the crankcase in the lifting brackets, in the athwartship direction, and suspend two tackles.

3. Turn the crank to **TDC**.

   Dismount the crankpin bearing cap, and remove the bearing cap from the engine.
   See Procedure 904-4.2.







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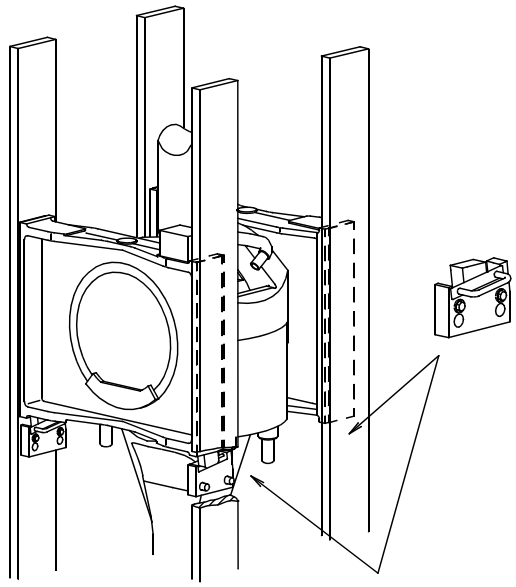
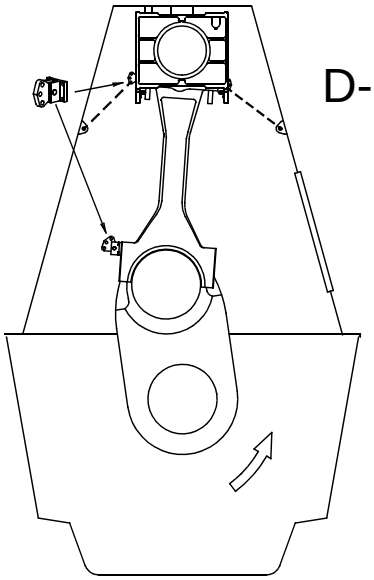


GN904-4.2 203 07

5.



GN904-5.2 203 05

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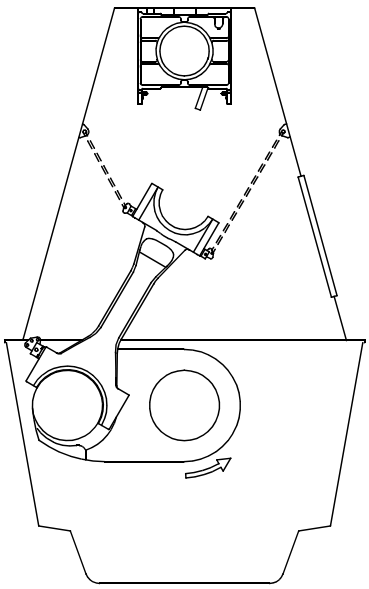


GN904-5.2 203 06

4. Mount the four supports for guide shoes on the crosshead guides.

   Carefully turn the crank down towards the camshaft side, until the guide shoes rest on the supports.

   Adjust the support brackets to the guide shoes so that the weight of the crosshead is evenly distributed on the four supports.

5. Mount the lifting attachments for securing the connecting rod on the head of the connecting rod.

   Fasten tackles to lifting brackets **A** and **B** on the frame box wall, and attach the tackle hooks to the mentioned lifting attachments on the connecting rod head.

   Haul the tackles tight.

   Also mount a lifting attachment on the lower end of the connecting rod, on the exhaust side.

6. Turn the crankthrow carefully towards **BDC** while 'following' with the tackles, thus continuously supporting the connecting rod.

   The crosshead now rests on the four supports.

   Turn the crankthrow to 90° before **BDC**.

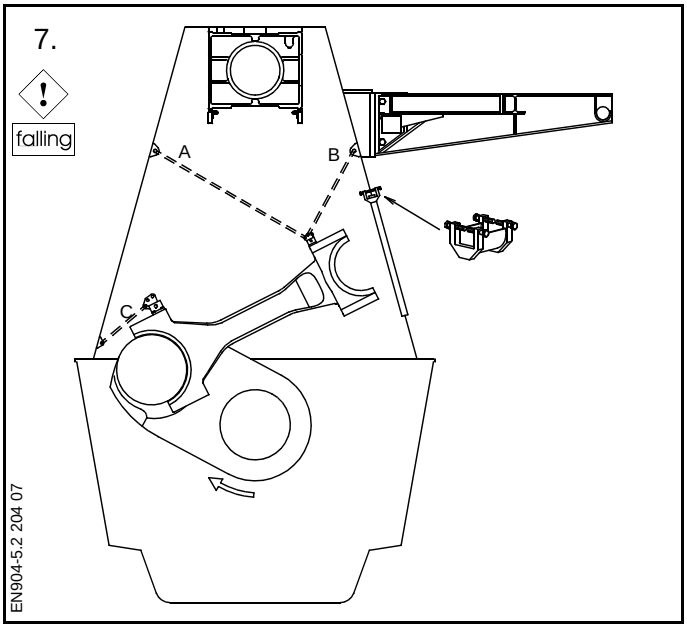
7. Shift tackle **B** from the lifting attachment on one side of the connecting rod to the lifting attachment on the other side.

   Dismount the lifting attachment on the camshaft side of the connecting rod.

   Attach a tackle to lifting bracket **C** on the frame box wall and connect the tackle hook to the lifting attachment on the lower end of the connecting rod.

   Mount the wire guide on the door frame.

   Turn the crankthrow towards **TDC** while 'following' with the tackles, thus continuously supporting and guiding the connecting rod towards the doorway.

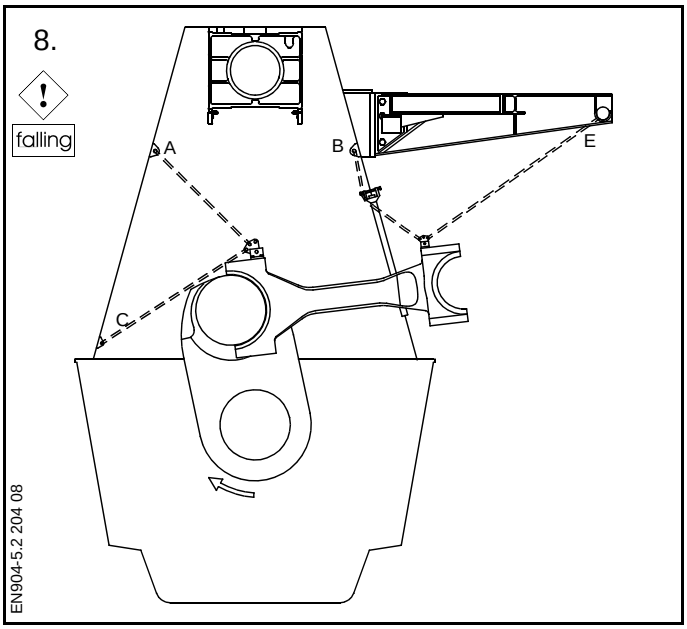


8. Attach a tackle to the gallery-mounted lifting bracket **E**, and hook on to the lifting attachment on the connecting rod.

   Shift tackle **A** from the lifting attachment on the head of the connecting rod to the lifting attachment at the bottom of the connecting rod.

   Turn the crank **carefully** upwards while 'following' with tackles **A**, **B, C** and **E**, guiding the head of the connecting rod out of the doorway.

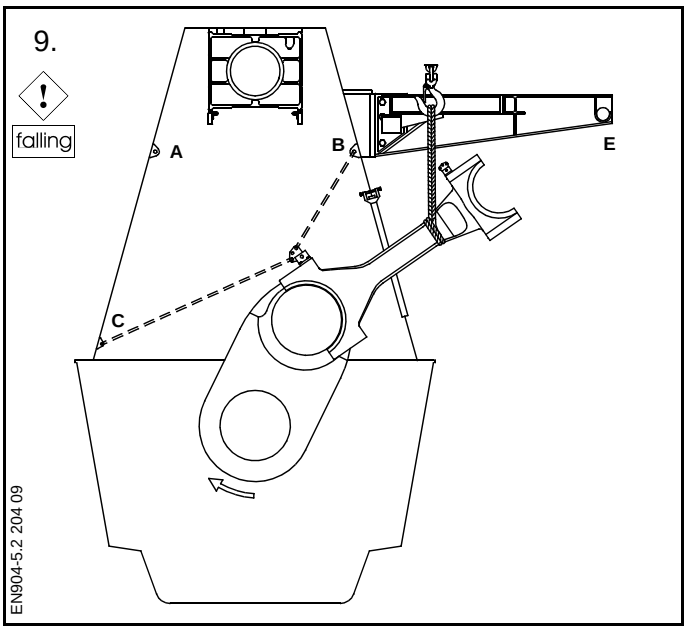
   Shift the tackles from one lifting attachment to the other as necessary.

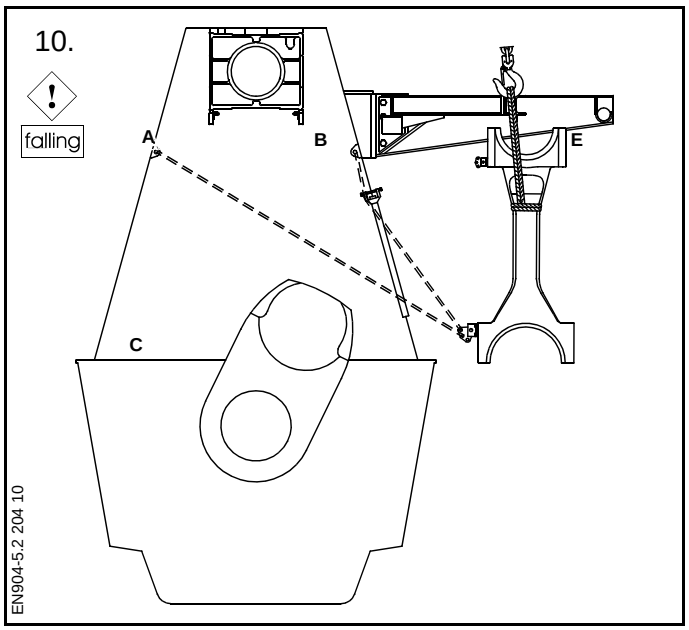


9. Mount a strap around the connecting rod and suspend the connecting rod from the engine room crane. Shift tackle **B** from the lifting attachment on the head of the connecting rod to the lifting attachment at the bottom of the connecting rod.

   Remove tackles **A** and **E**.

   Continue turning upwards till about 30° after **TDC** while 'following' with the tackles and the engine room crane.





10. Shift the tackle from lifting bracket **C** to **A**.

    Lift the connecting rod out of the engine, using the tackles and the engine room crane.

    Remove the tackles, and lift the connecting rod away by means of the engine room crane.

1. Equip the connecting rod with the same lifting attachments as mentioned under dismantling.

   Turn the crank to a position about 25° past **TDC** on the camshaft side.

   Apply clean lubricating oil to the crankpin bearing shell and journal.

2. Carefully lift the connecting rod into the crankcase by alternate use of the engine room crane and the tackles attached to lifting brackets **A** and **B**.

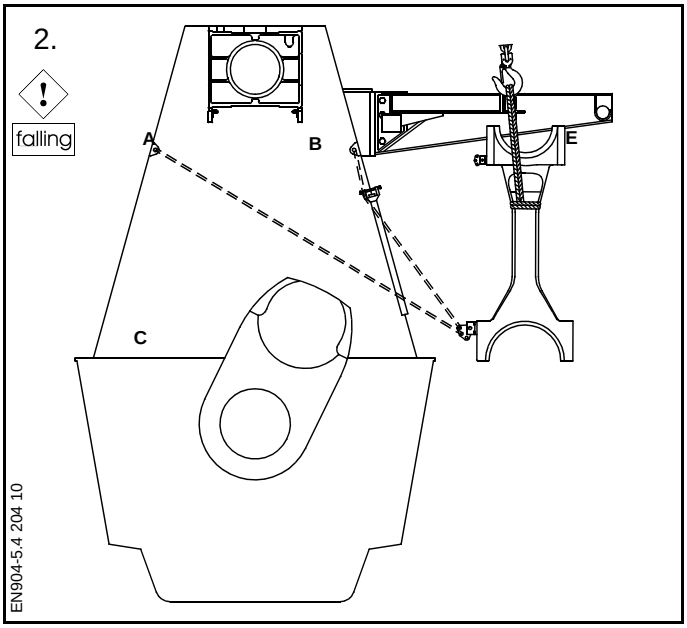
3. When the end of the connecting rod rests on the crankpin journal, attach a tackle to bracket **C** and the lower end of the connecting rod.

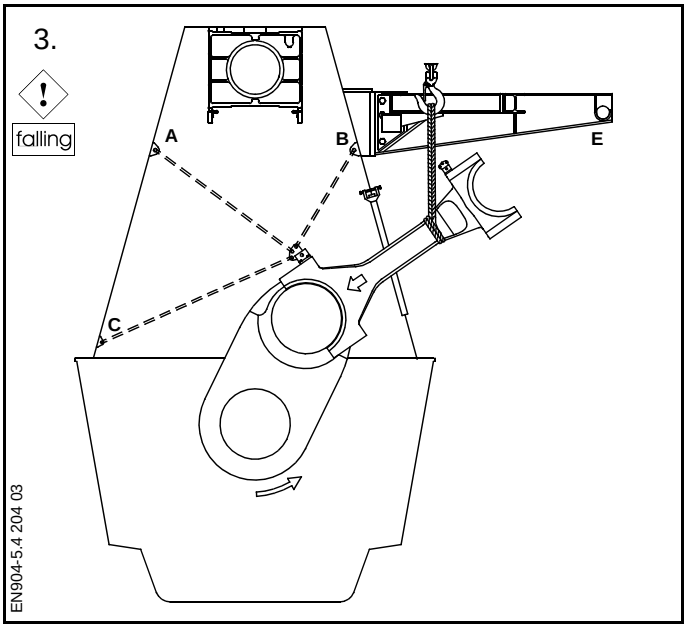
4. Turn the crankthrow towards **BDC**, past **TDC**, while 'following' with the tackles and the engine room crane.

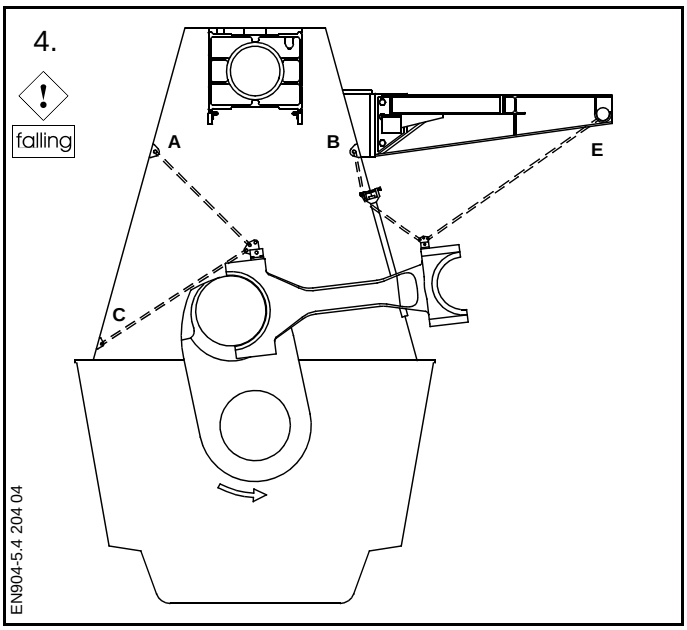
   Shift tackle **B** from the lower end to the upper end of the connecting rod.

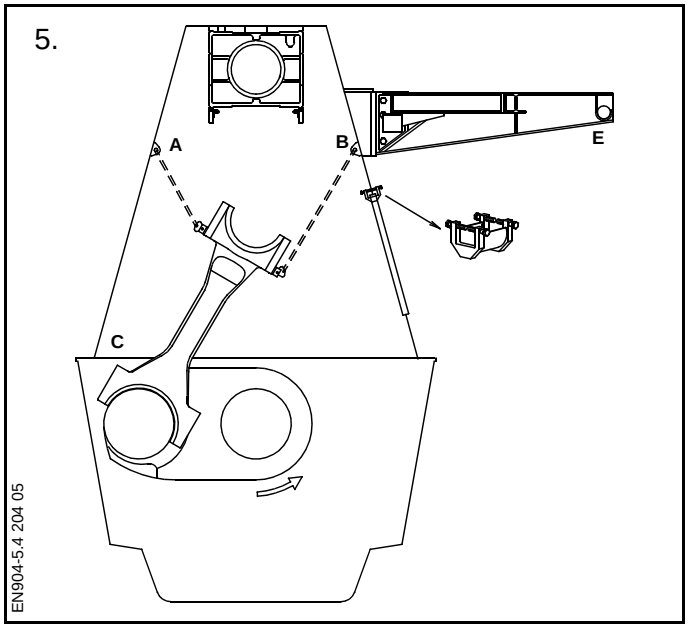
   Attach a tackle to bracket **E** and the upper end of the connecting rod.

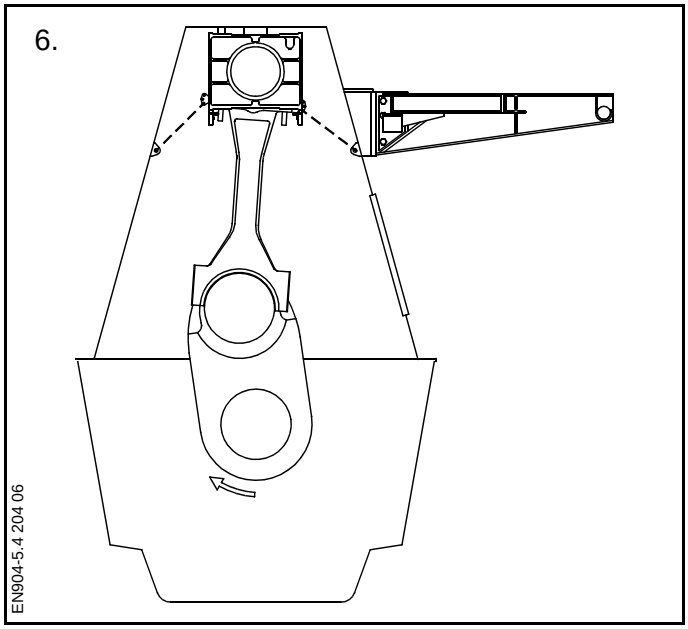
   Haul tight and remove the strap around the connecting rod.

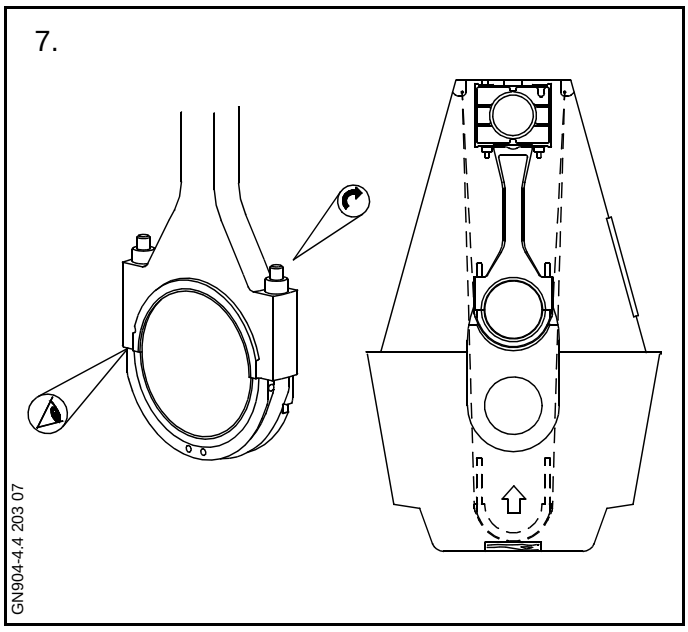












5. Turn the crankthrow to 90° before **BDC**.

   Shift tackle **A** from the lower end to the top of the connecting rod.

   Remove the tackle at **E**.

   Shift tackle **B** from the lifting attachment on one side to the other side of the connecting rod.

   Remove the tackle at **C** and the wire guide on the door frame.

   Remove the lifting attachment at the lower end of the connecting rod.

6. Turn the crankthrow towards **TDC** while 'following' with the tackles.

Caution!
Take care that the studs do not damage the crosshead bearing shell.

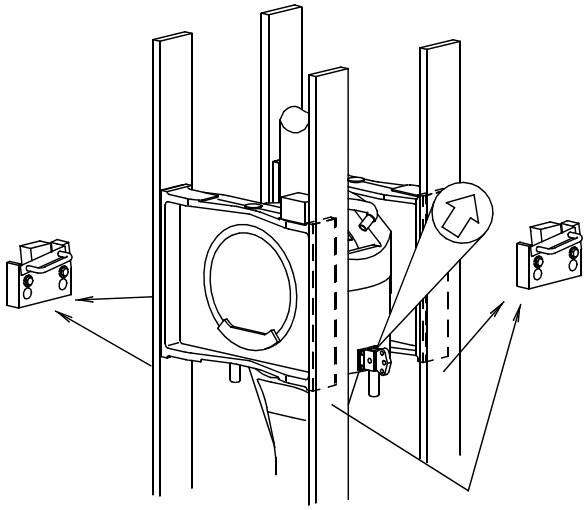
7. When the crank is in **TDC**, mount the crankpin bearing cap.
   See Procedure 904-4.4.

8. Remove the four supports from the crosshead guides and the lifting attachments from the connecting rod.

   Turn the crosshead down far enough to facilitate the tightening of the nuts.

9. Tighten all four crosshead bearing cap nuts simultaneously. *See Data.*

8.



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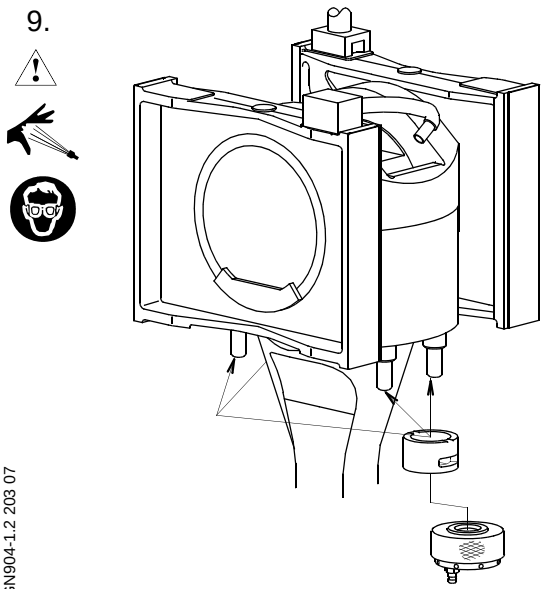

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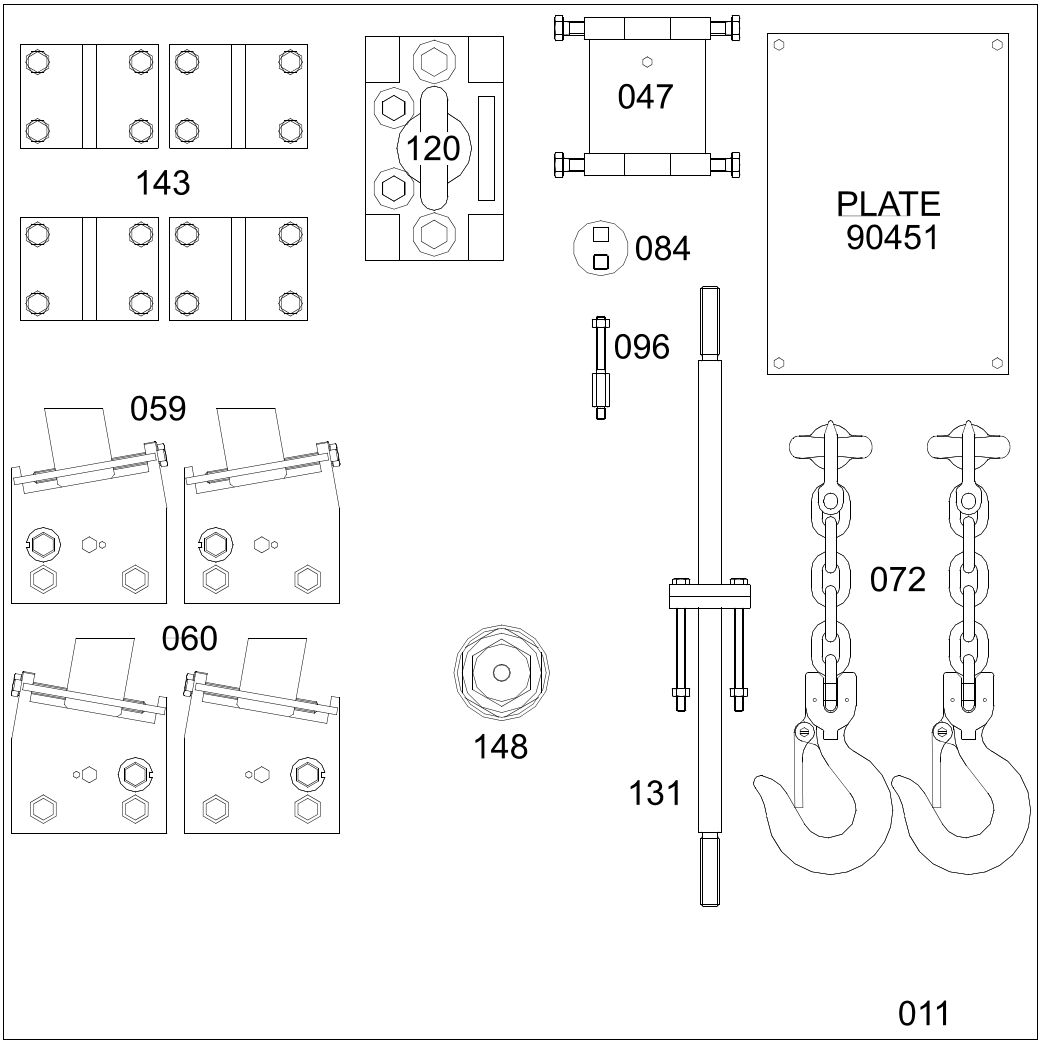
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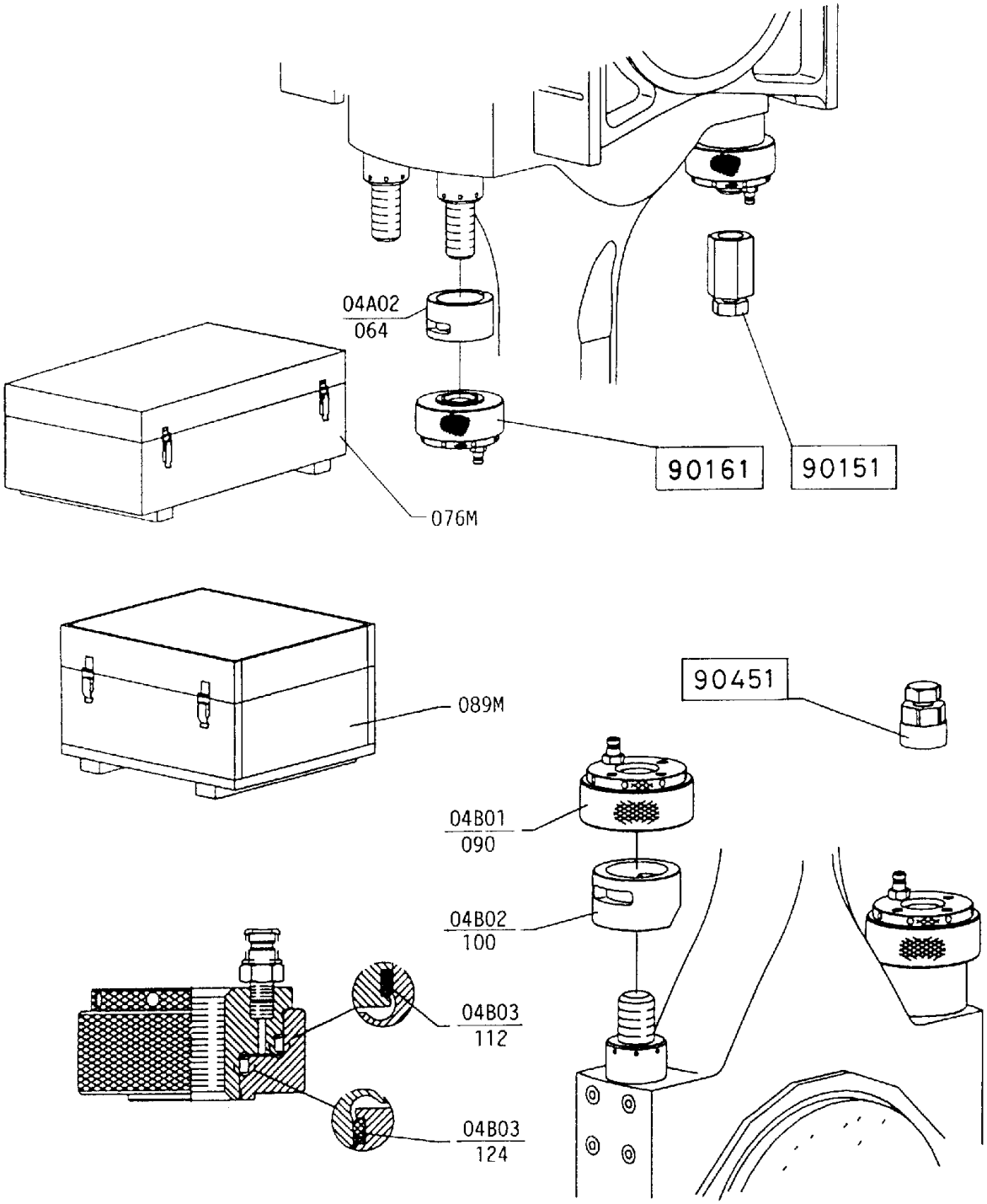
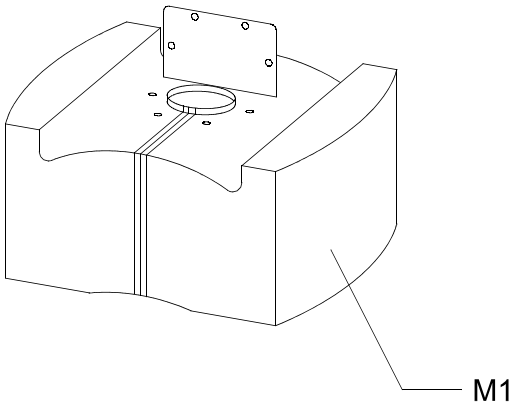
Item No.	Part Description	MES Tools No.	
011	Tool panel *)	(P904)	
047	Wire guide *)	(04A16)	
059	Bracket for support of crosshead	04A12	
060	Bracket for support of crosshead	04A12	
072	Chain for suspending of piston	04A11	
084	Torque wrench offset tool	04A86	
096	Retaining tool for telescope pipe	04A55	
120	Lifting tool for crosshead	04A15	
131	Alignment tool	04A46	
143	Lifting attachment	04B12	
148	Stud setter for connecting rod stud	04B87	
011-148	Tool panel, complete with tools *)	-	
	*) Optional extra		


04A02
064
90161
90151
076M
089M
90451
04B01
090
04B02
100
04B03
112
04B03
124

Item No.	Part Description	MES Tools No.	
076M	Hydraulic tools for crosshead bearing	-	
089M	Hydraulic tools for crankpin bearing	-	
090	Hydraulic jack	04B01	
100	Spacer ring	04B02	
112	O-ring with back-up ring	04B03	
124	O-ring with back-up ring	04B03	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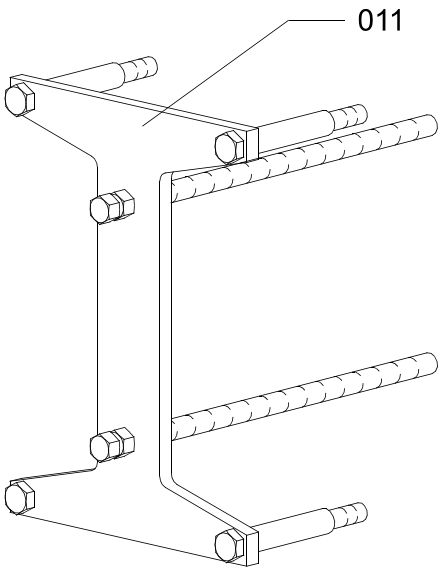
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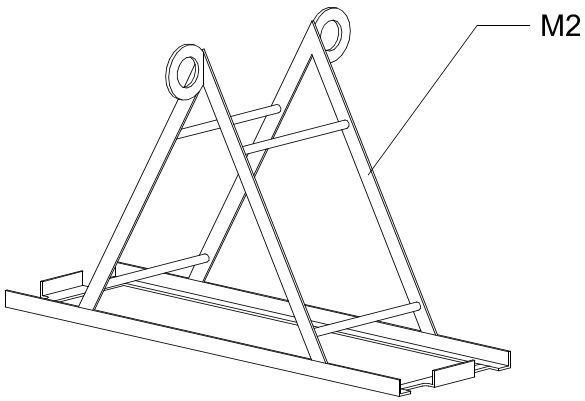

M2

Item No.	Part Description	MES Tools No.	
011	Guide shoe extractor, complete	04A52	
M1	Cover for crosshead	04B15	
M2	Lifting tool for crankpin shell	04A68	

INDEX

CYLINDER COVER

PISTON WITH ROD AND STUFFING BOX

CYLINDER LINER AND
CYLINDER LUBRICATION

CROSSHEAD WITH CONNECTING ROD

CRANKSHAFT, THRUST BEARING
AND TURNING GEAR

MECANICAL CONTROL GEAR

STARTING AIR SYSTEM

EXHAUST VALVE

FUEL OIL SYSTEM

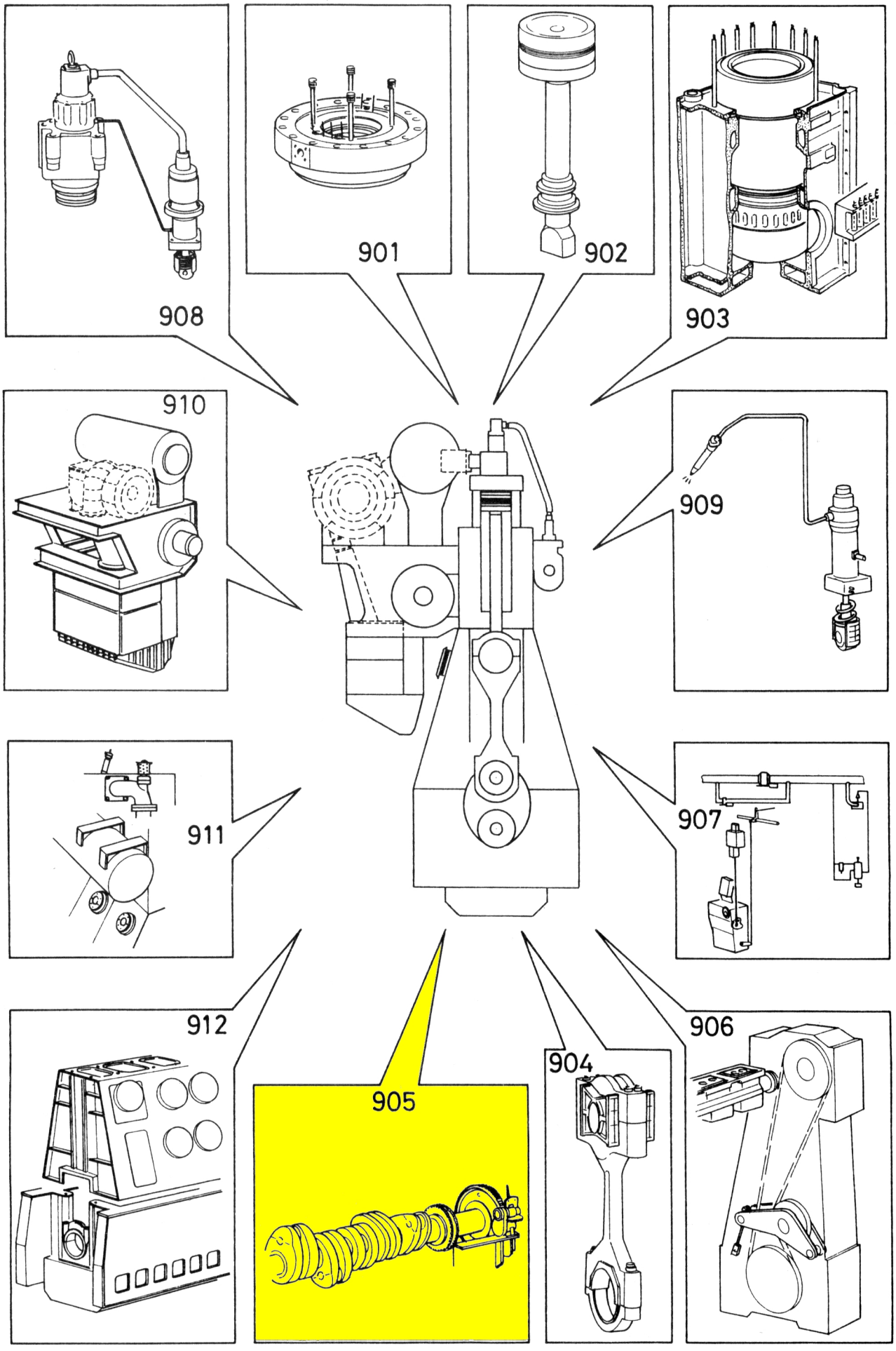
TURBOCHARGER SYSTEM

SAFETY EQUIPMENT

ASSEMBLY OF LARGE PARTS

GENERAL TOOLS

MITSUI
MAN
B&W

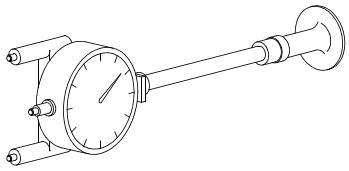


SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Slippy surface and risk of falling (while at work in crankcase)
X	Block the starting mechanism	Risk of severe personal injury (while engine being turned)
X	Shut off starting air supply	
X	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit

Standard Tools: See Section 913



Crankshaft deflection readings should be taken while the ship is afloat (i.e. not while in dry dock.)

As the alignment is influenced by the engine temperature as well as the loading conditions, the deflection measurements should, for comparison, always be made under nearly the same temperature and load conditions.

1. Place a dial gauge axially in the crankthrow opposite the crankpin, as illustrated on the sketch. The correct mounting position is marked with punch marks on the crankthrow. *See also Chapter 708 in Vol. 1.*

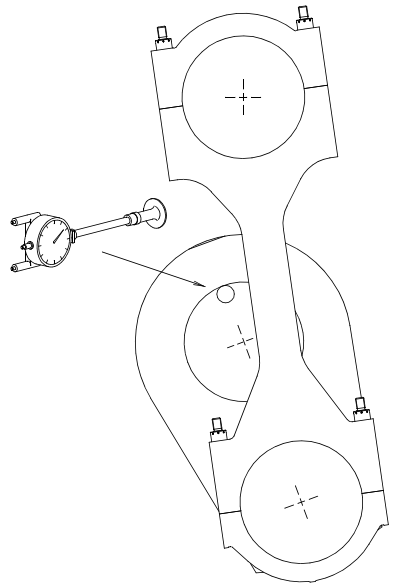
2. "Closing" of the crankthrow (compression of the gauge) is regarded as negative.

3. Set the dial gauge to zero at the **B2** side near **BDC**. Whilst turning anti-clockwise, make the readings for instance when the throw passes the positions:

B2	(near bottom)
E	(exhaust side)
T	(top)
C	(camshaft side)
B1	(near bottom)

1/2 (B2+B1) = B

1.



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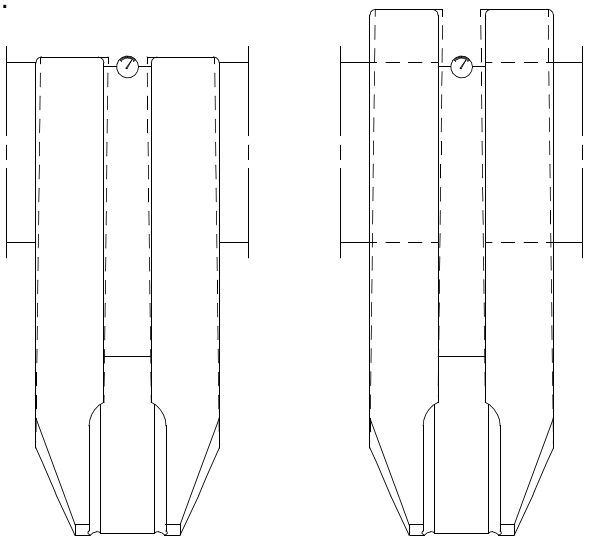
2.



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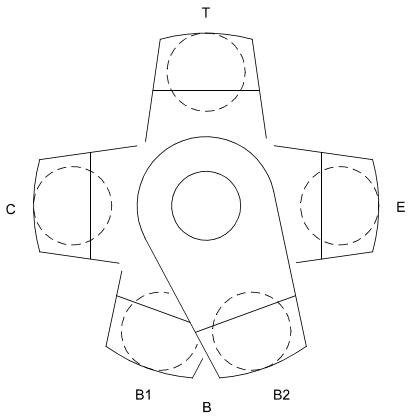
3.

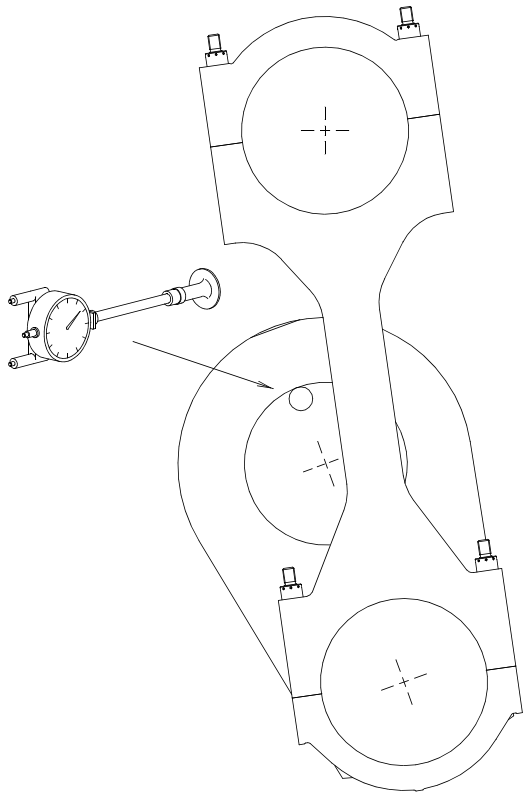


Looking forward

B2
E
T
C
B1
1/2 (B1 + B2) = B

XZ905-1.1 204 03 L0a

4.



XZ905-1.1 204 01 L0a

4. When taking deflection readings for the three aftmost cylinders, the turning gear should, at each stoppage, be turned a little backwards to ease off the tangential pressure on the turning wheel teeth. This pressure may otherwise falsify the readings.

   If the crankshaft deflection (alignment indicator) is approaching the tolerance limits *(see Vol. 1, OPERATION)*, the bearing shells of the two adjacent main bearings must be dismantled and inspected.
   See Procedure 905-2.3 for overhaul of main bearing.

   If the bearing shells are found to be in good order, please contact MITSUI ENGINEERING & SHIPBUILDING CO., LTD. for checking of the bedplate alignment.

   If the excessive crankshaft deflection is found at the aftmost cylinder of the engine, also the alignment of the propeller shart/ drive shaft must be checked by a jack-up test.

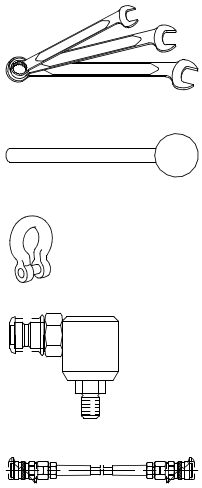
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Slippy surface and risk of falling (while at work in crankcase)
X	Block the starting mechanism	Risk of severe personal injury (while engine being turned)
X	Shut off starting air supply	
X	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

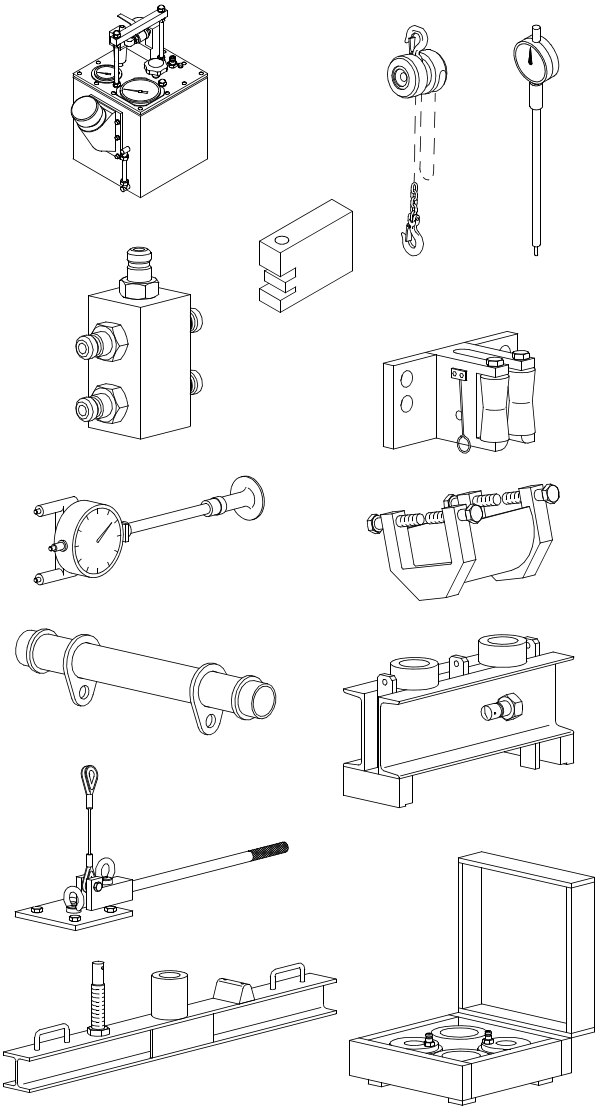
Data

Ref.	Description	Value	Unit
	Top clearance in main bearing *See Vol. 1 "OPERATION"*		
D-1	Main bearing cap	260	kg
D-2	Main bearing shells		
	- upper	17	kg
	- lower	18	kg
D-3	Hydraulic pressure - tightening	150 MPa (1500 bar)	
	Hydraulic pressure - dismantling	150-165 MPa (1500-1650 bar)	

Note!
Permit to Max. 165 MPa (1650 bar) only in a short time.

Standard Tools: See Section 913





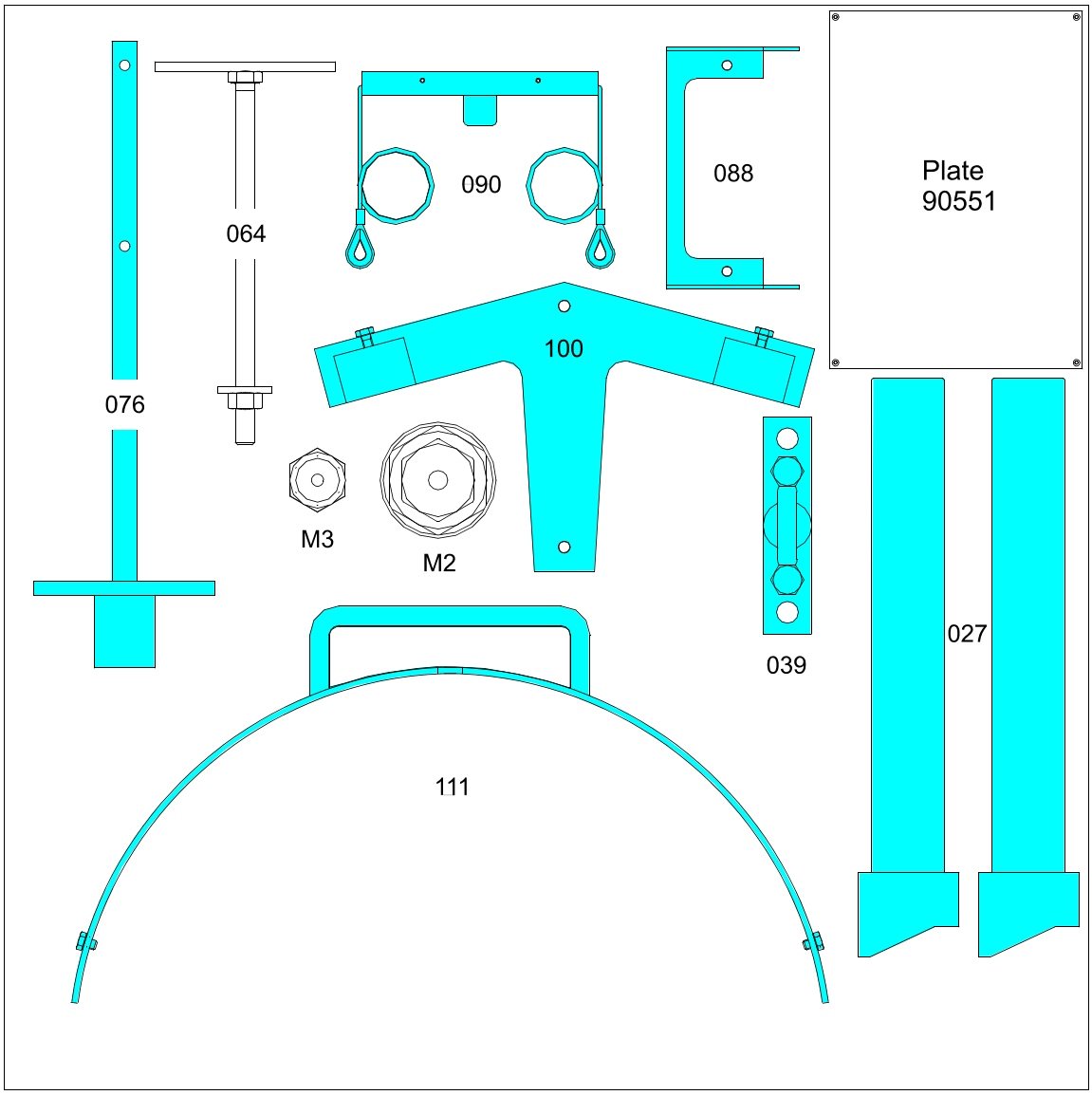

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Plate
90551
100
M3
M2
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111

1. If there is too large a difference in the crankshaft deflection readings (autolog), check the individual bearings.
   See Procedure 905-1.1.

2. Calibrate the main bearing measuring tool:

   Insert the measuring tool in the calibration block.

   Set the dial-gauge to 0 (zero).

   Remove the screws for the lub. oil pipe from the main bearing cap.

3. Insert the measuring tool and check the clearance between the upper shell and the journal.

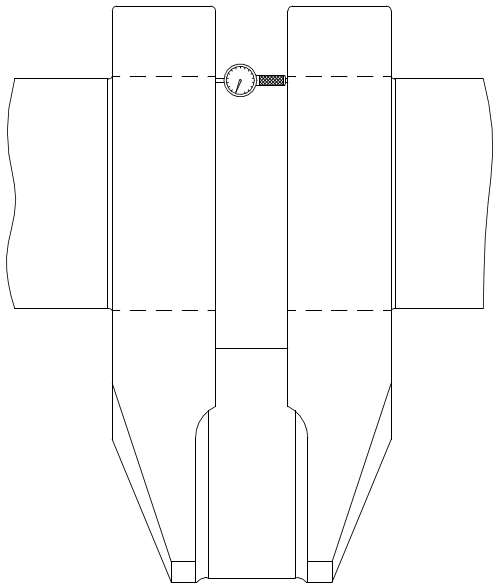
   The difference between the **actual** clearance measurement and the measurement recorded in the Adjustment Sheet (or the clearance noted for a new bearing installed later) **must not** exceed 0.1 mm.

   An appreciable increase in clearance may be an indication of loose staybolts or wear of the lower shell.

4. After measuring, dismount the bearing cap and the upper shell. For further inspection of the bearing, *see Procedure 905-2.2.*

   Inspect the bearing and the journal *(see Vol. 1, OPERATION, Chapter 708, "Bearings").*

1.



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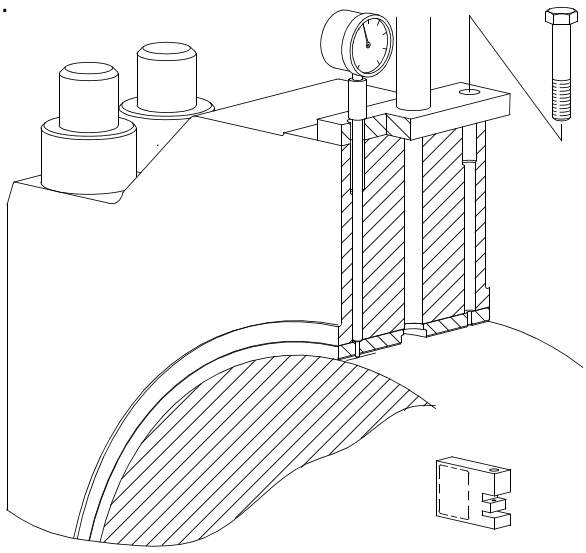

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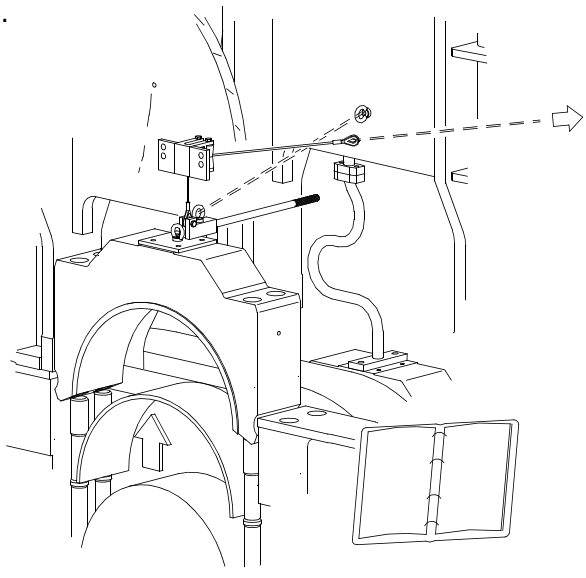

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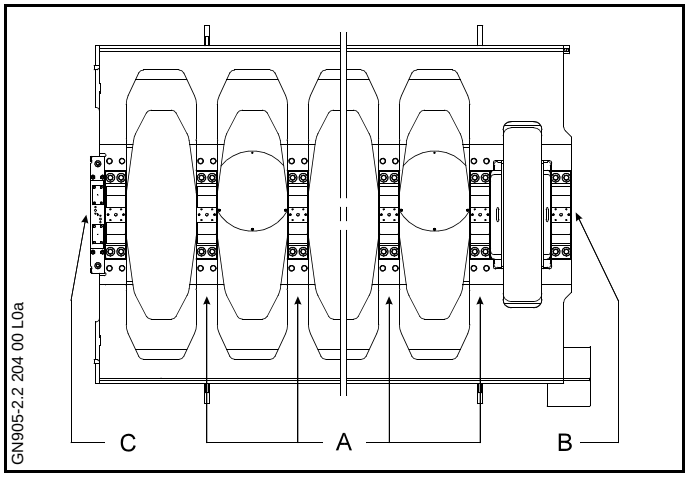


In the following, the main bearings are divided into three categories:

- The main bearings (marked **A**).
- The thrust shaft end journal bearing (marked **B**).
- The axial vibration damper end bearing (marked **C**).

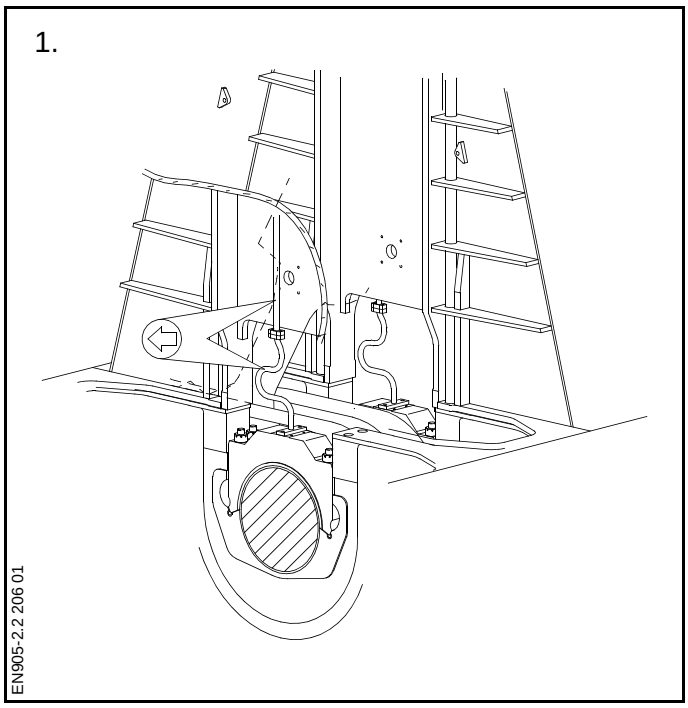
Check and write down the top clearances before carrying out any dismantling.

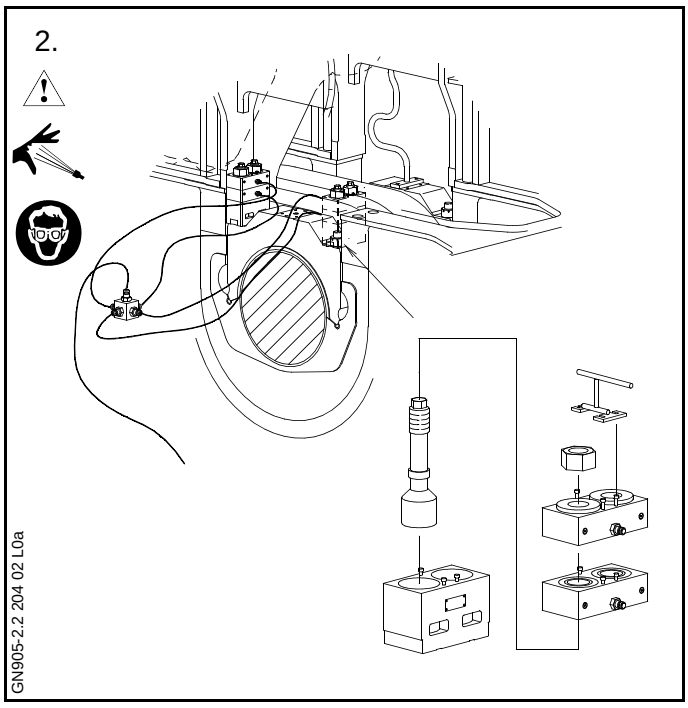
Dismantling of main bearings (A)

1. Disconnect the lubricating oil inlet pipe from the main pipe.

2. Turn the crankthrow so that it points towards the exhaust side of the engine.

   Mount the extension studs, the spacers, the hydraulic jacks and the nuts on the extension studs. Loosen the main bearing stud nuts, using the hydraulic jacks.
   For operation of the hydraulic jacks, see Procedure 913-1.





3. Remove the rectangular nut washers from the bearing cap.

   Attach the lifting tool to the bearing cap.

   Mount the pulley, drive the wire rope through and secure it with the locking pins.

   Rig up a tackle outside the engine, connect it to the wire rope on the lifting tool and haul tight.

   Mount the eye bolt on the web plate opposite to the pulley.

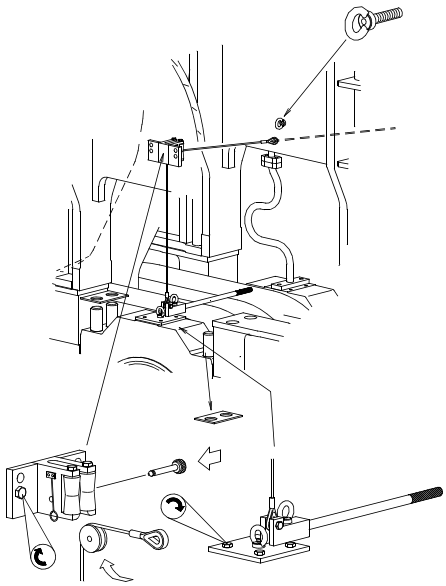
Note!
Before lifting the cap, make sure that there are marking scratches on the cap to indicate its correct position.

4. Lift the cap free of the studs and the crank web.

5. Unscrew the guide handle, hook on a tackle from the bearing cap to the eye bolt on the web plate.

   Move the bearing cap to the middle of the crank section.

3.



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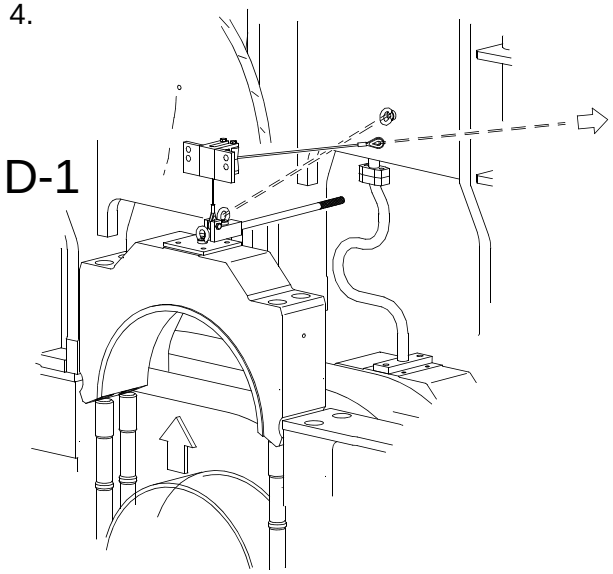

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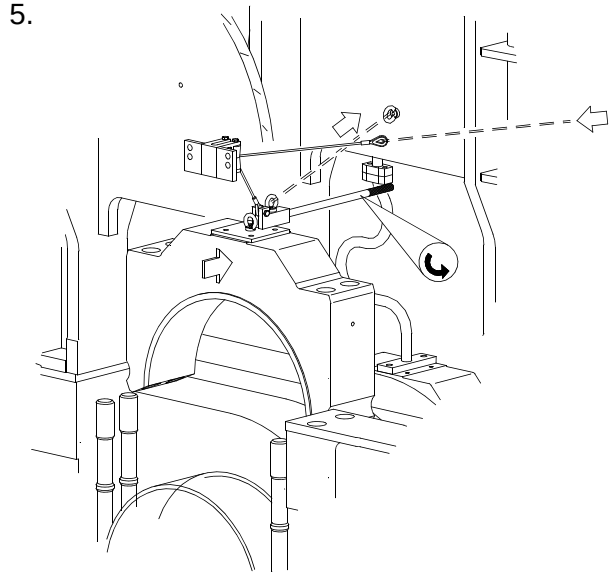

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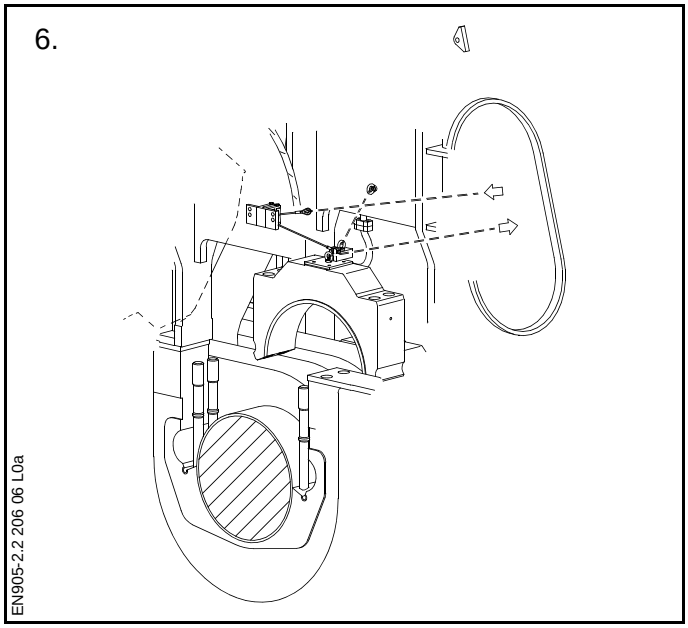
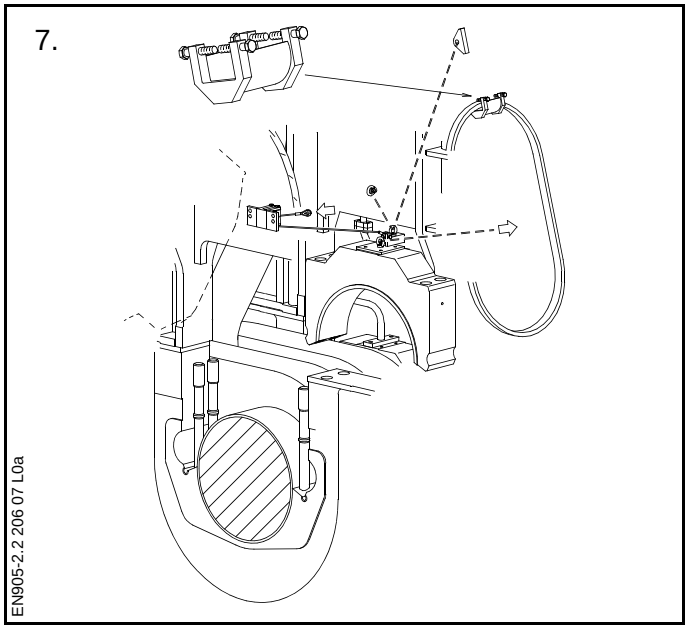
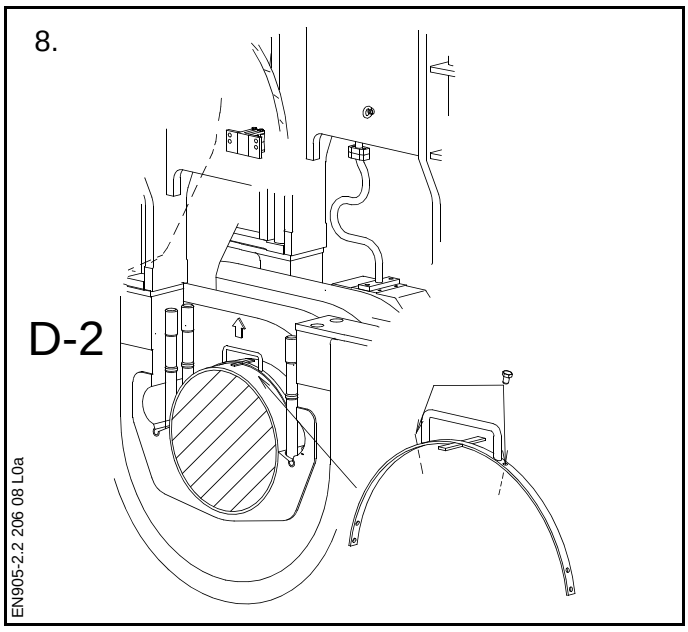






6. Rig up a tackle outside the engine and connect it to the lifting tool on the bearing cap.

   By slackening off the wire rope, and tightening the second tackle, pull the bearing cap towards the crankcase door.

7. Hook on an additional tackle above the crankcase door, and support the weight of the cap, using the other tackles.

   Mount the chain guide in the crankcase doorway.

   Disconnect the wire rope from the pulley, and lift the bearing cap out of the engine.

8. Mount the lifting attachment on the upper shell, and lift the shell out of the engine.

9. If the crankshaft is to be turned while the bearing cap is not in place, use the two stops to prevent the lower shell from being rolled out.

10. Remove the screws from the crosspiece (only screwed in for safe keeping) and screw them into the threaded holes of the hydraulic jacks (for tightening the cylinder cover).

    Replace the snap-on connectors of the hydraulic jacks with angular snap-on connectors.

11. Place the crosspiece in the bedplate with the ends resting on the cross girders, and place the hydraulic jacks beneath the crank webs as shown.

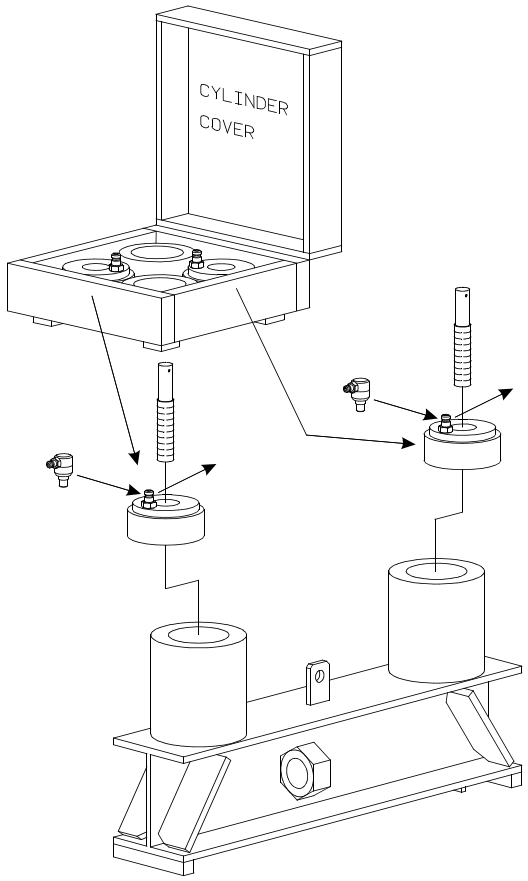
    Tighten the screws against the crank webs.

    Connect the hydraulic jacks to the high-pressure pump and raise the pressure until the crankshaft has been lifted to a height corresponding to the clearance in the adjacent bearing.

    Note down the pressure for later reference.

    If a higher lift is needed, loosen the adjacent main bearing caps.

10.



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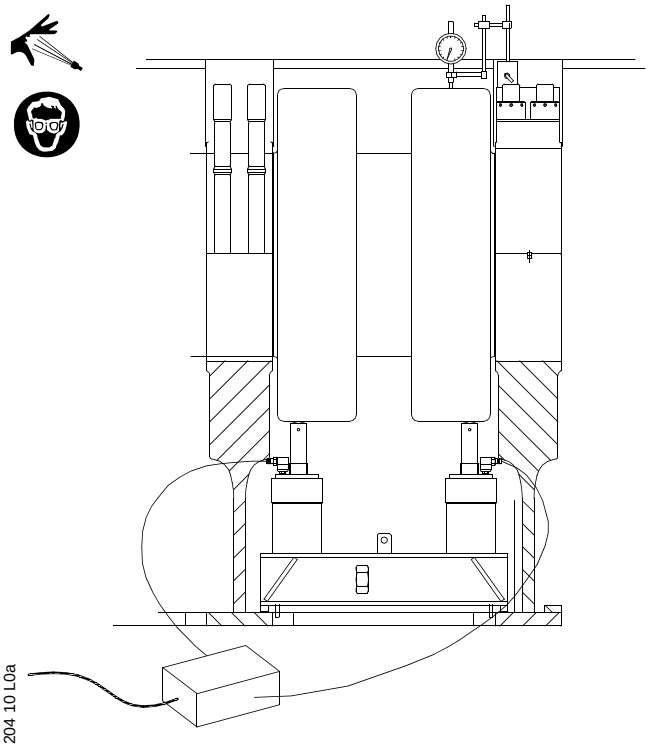

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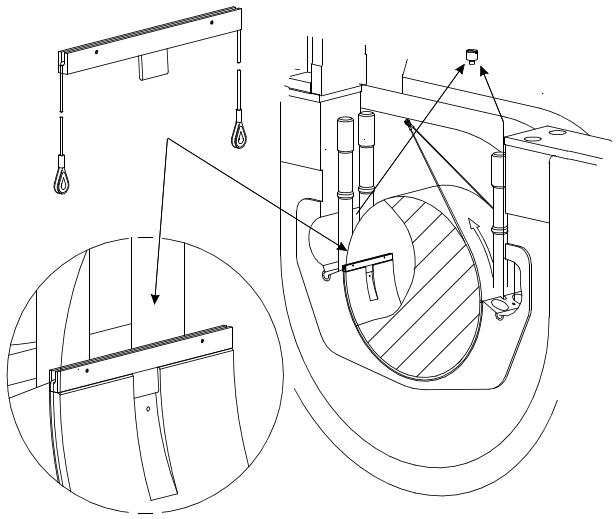


GN905-2.2 204 12

12. Dismount the lock screws from the lower shell.

Place the dismantling tool on the top of the lower bearing shell, making sure that the flap of the dismantling tool enters the oil groove in the bearing shell.

Pull the lower bearing shell round and up until it lies over the main bearing journal.

Take out the lower shell from the crankcase in the same way as the upper shell.

Note!
Never remove the tools for lifting the crankshaft before remounting the lower main bearing shell.

Dismantling of journal bearing in the thrust shaft end (B).

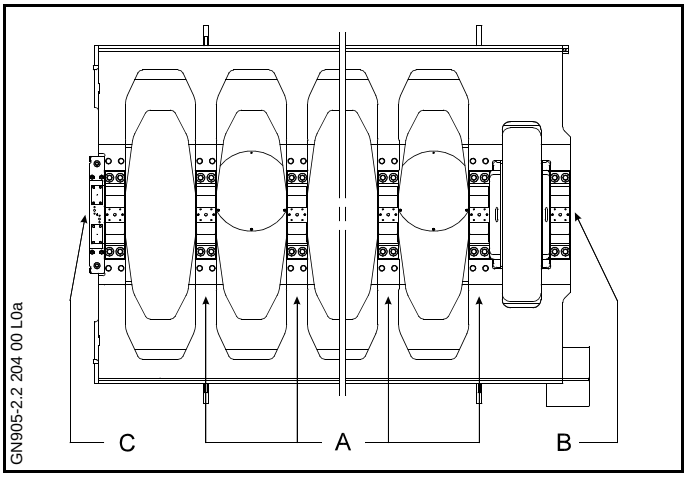
13. Remove the end cover of the scraper ring housing.

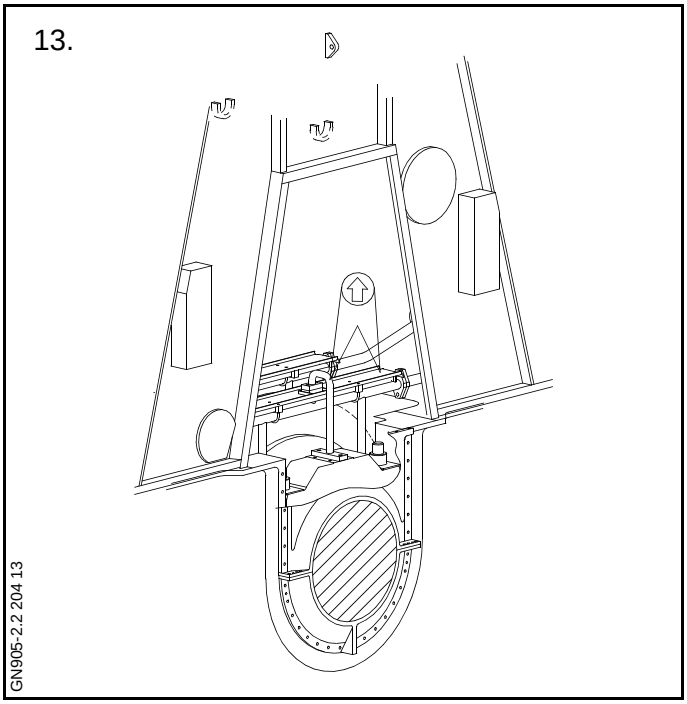
    Disconnect the lubricating oil pipe from the main pipe.

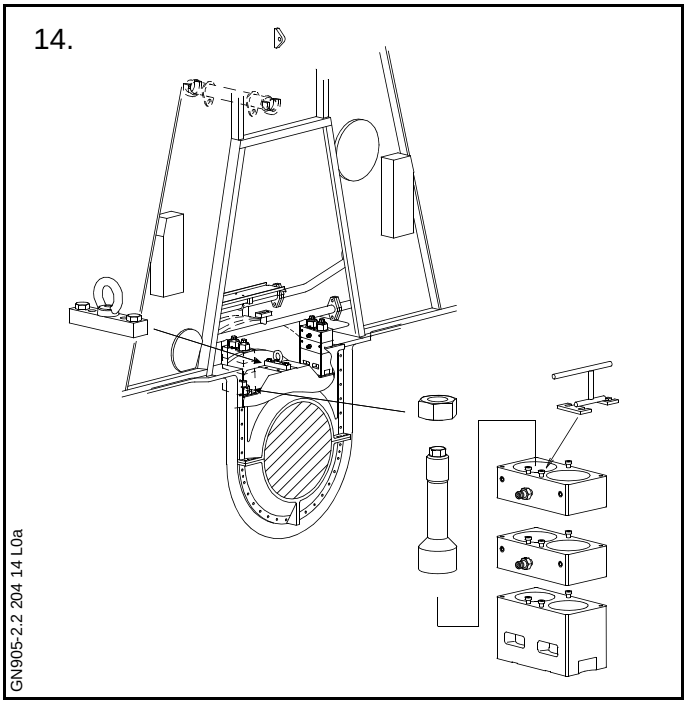
    Turn the crankthrow so that it points towards the exhaust side of the engine.

14. Mount the spacer rings and the hydraulic jacks on the studs, and loosen the main bearing stud nuts.
    For operation of the hydraulic jacks, see Procedure 913-1.

    Mount the crossbar and the lifting attachment on the bearing cap.







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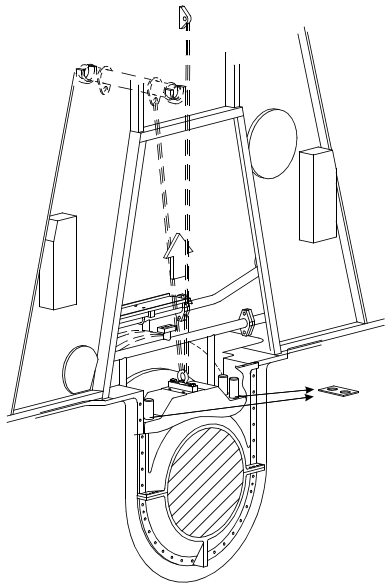


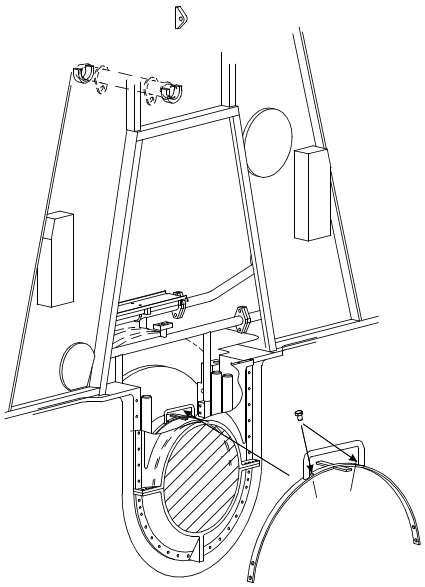
GN905-2.2 204 15 L0a

15. Remove the rectangular nut washers from the bearing cap.

    Mount the lifting attachments with the two wire ropes on the bearing cap and, by alternate use of tackles, lift the cap out of the engine.

16. Mount the lifting attachment on the upper shell, and lift the shell out of the engine.

16.



GN905-2.2 204 16 L0a

17. Plece the crosspiece under the turning wheel as shwon. Mount a dial guge to measure the lift of the crankshaft. Connect the hydraulic jack to the high-pressure pump and raise the pressure until the crankshaft has lifted max. 0.2 mm.

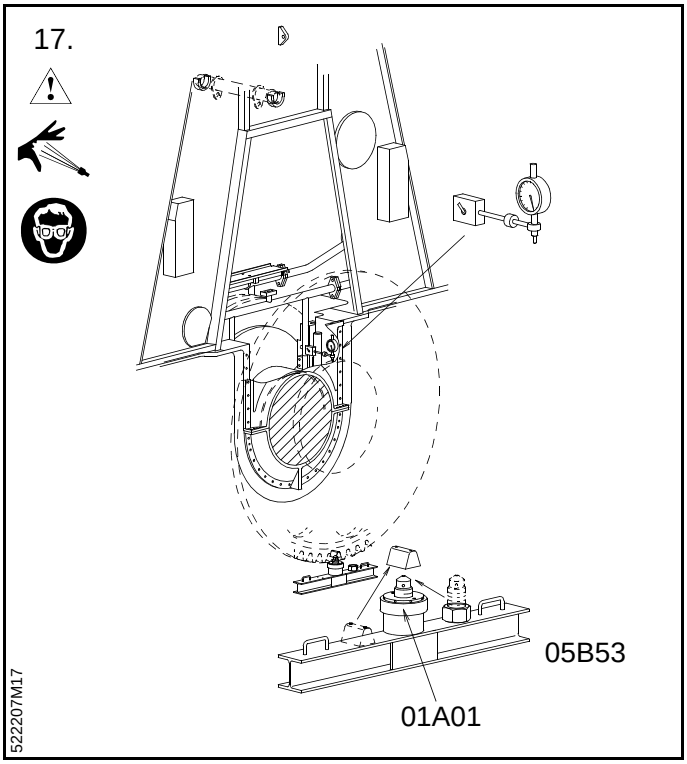
18. Dismount the lock screws from the lower shell.

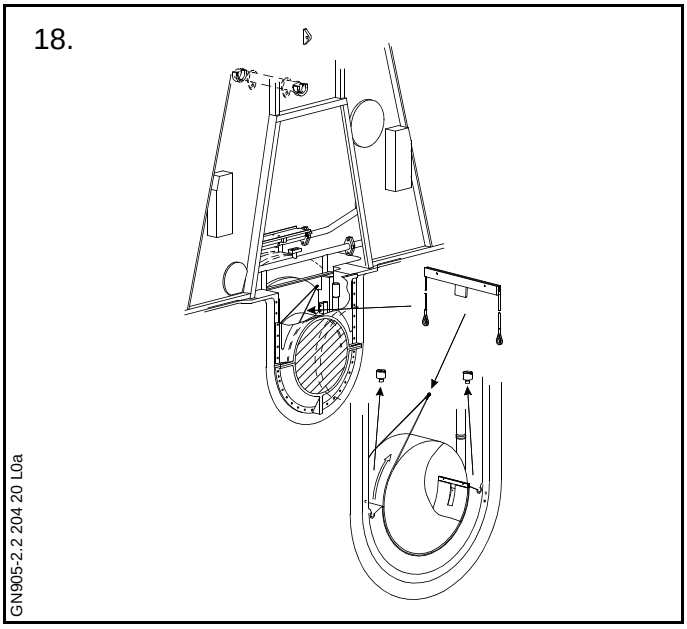
    Place the dismantling tool on the top of the lower bearing shell, making sure that the flap of the dismantling tool enters the oil groove in the bearing shell.

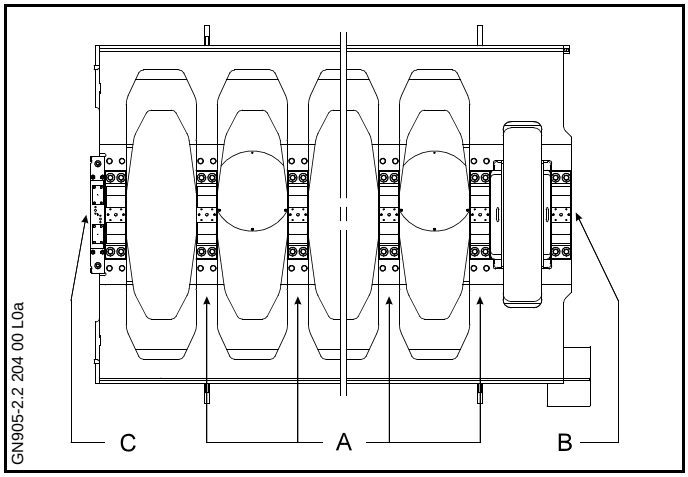
    Pull the lower bearing shell round and up until it lies over the main bearing journal.

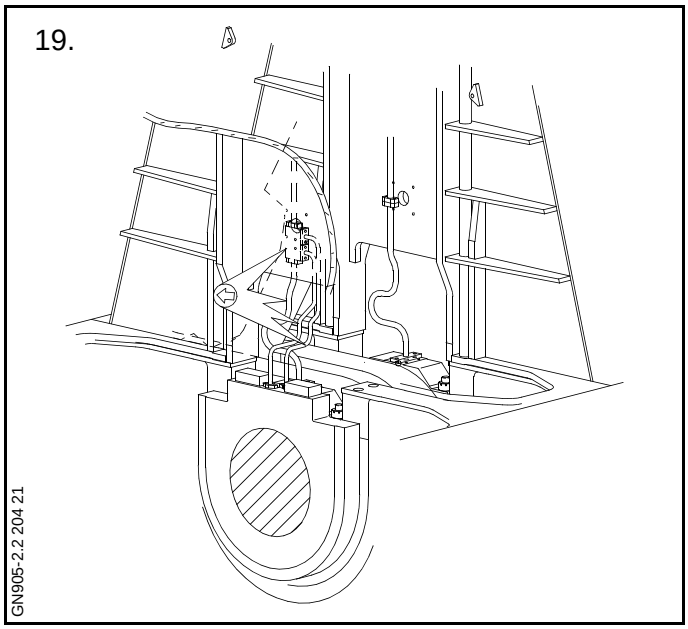
    Take out the lower shell from the crankcase in the same way as the upper shell.

Note!
Never remove the tools for lifting the crankshaft before remounting the lower main bearing shell.









Dismantling of main bearing in the axial vibration damper end (C)

19. Disconnect the lubricating oil pipe and the distributor block from the main pipe.

    Follow the procedure for dismantling of main bearings marked **A**.

    The clearance between the axial vibration damper and the journal can be the decisive factor in judging how much the crankshaft can be lifted.

Note!
Never remove the tools for lifting the crankshaft before remounting the lower main bearing shell.

1. Clean and inspect the bearing shells. *For judging the condition of the bearing, see Vol. 1, Chapter 708, 'Bearings'.*

   If the bearing shells are damaged, contact MITSUI ENGINEERING & SHIPBUILDING CO., LTD. for advice.

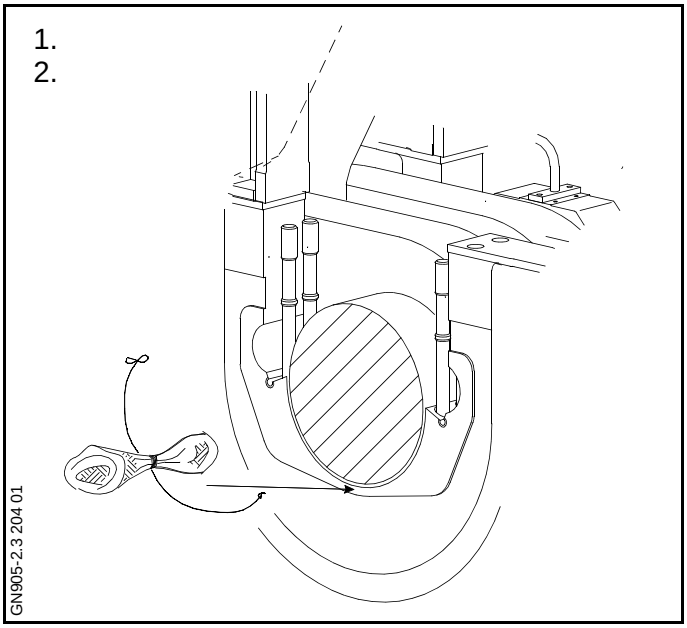
   If replacement of a bearing shell is necessary, both shells must be replaced, as the guide pin holes of the two shells are reamed together.

2. Before remounting:

   - Check the bearing support for damage and burrs. If damage is found, contact MITSUI ENGINEERING & SHIPBUILDING CO., LTD. for advice.

   - Make sure that all parts are clean, use non-fluffy cloth to clean between journal and main bearing support.

   - Lubricate the bearing journal, the main bearing support and the back of the shell.



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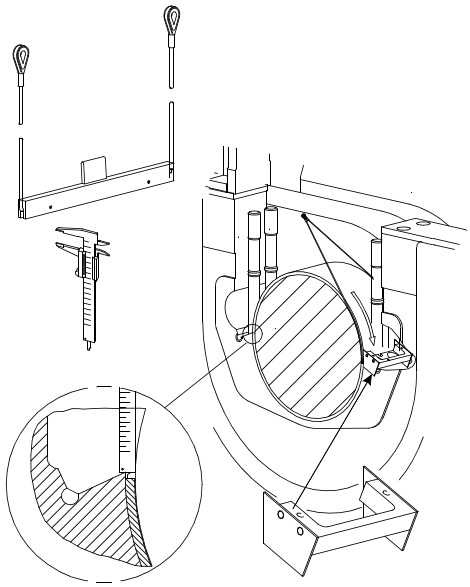

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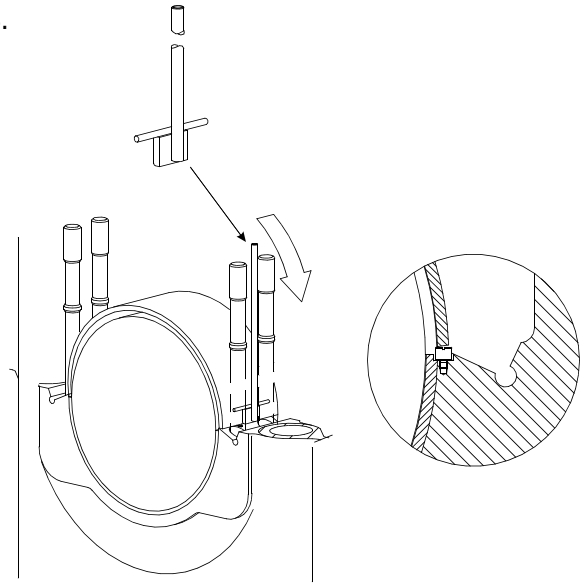

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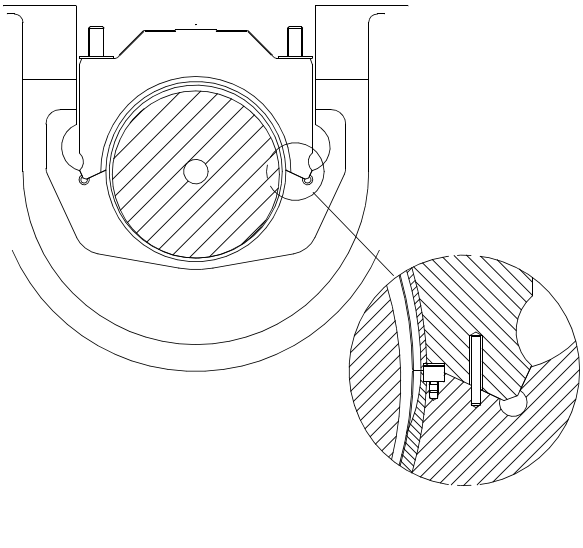


GN905-2.4 204 05

1. Place the guide tool for the lower bearing shell on the main bearing support.

   Lubricate the journal with clean oil.

   Then place the dismantling tool and the lower bearing shell on the journal.

   Push the lower bearing shell downwards while holding the shell back with the dismantling tool.

   Check that the bearing shell is positioned with the same distance on both sides.

2. When the lower bearing shell has been mounted, remove the dismantling tool and the guide tool.

   Mount the lock screws in the bearing support.

3. Lower the crankshaft.

4. When mounting the upper bearing shell, make sure that the edge of the upper shell does not rest on the tip of the bedplate or the lock screws. If so, place the special tool between the studs and press the shell into position.

5. Mount the bearing cap, making sure that the guide pin enters the bearing cap and support correctly.

6. Mount the rectangular nut washers, the nuts, the spacer rings, the hydraulic jacks, and tighten the nuts. *See Data.*

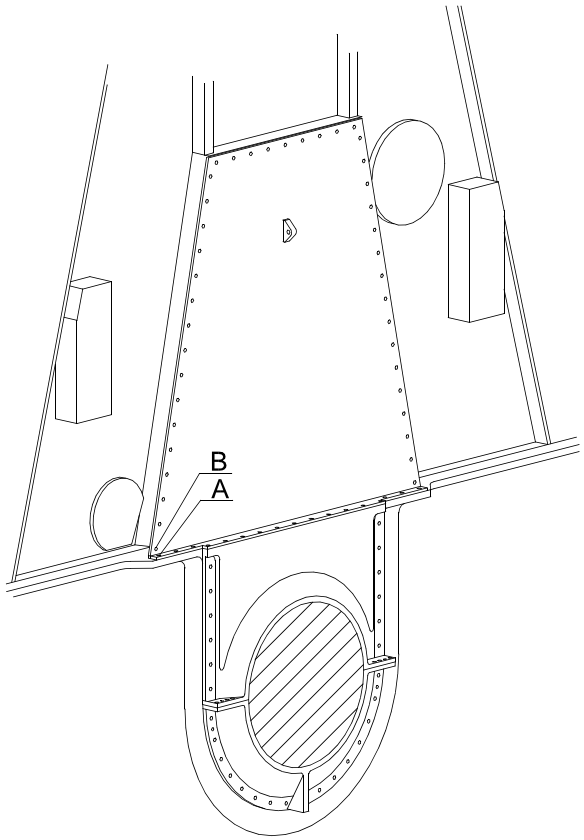
   After tightening the bearing cap, check the clearance once more.

   If a new bearing shell has been mounted, remember to note down the new top clearance in the Adjustment Sheet. *See Vol. 1, OPERATION, Chapter 701.*

Mounting of end cover in thrust shaft end

7. Tighten all screws marked **A** before mounting the screws marked **B**.

7.



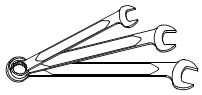
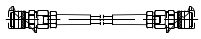
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of high pressure oil
X	Block the starting mechanism	Do not enter area when over head lifting is being carried out
X	Shut off starting air supply	Risk of severe personal injury (while engine being turned)
X	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

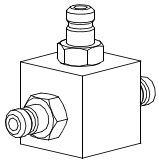
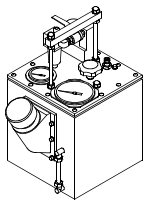
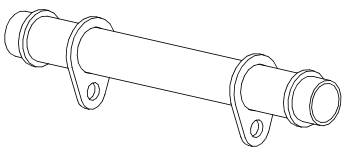
Ref.	Description	Value	Unit
D-1	Stopper	37	kg
D-2	Thrust bearing segment	40	kg
D-3	Hydraulic pressure - tightening	150	MPa (1500 bar)
	Hydraulic pressure - dismantling	150-165	MPa (1500-1650 bar)

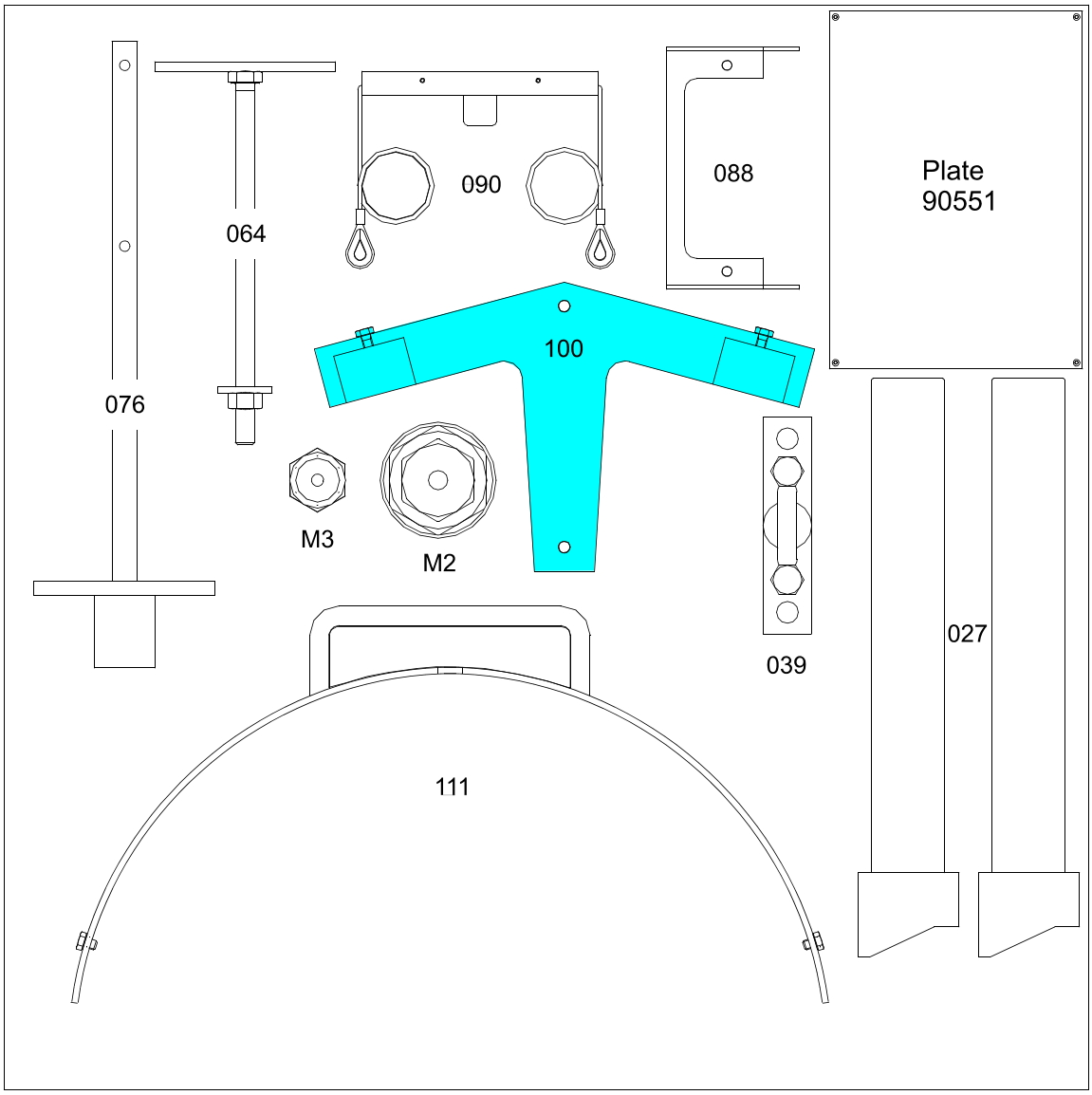
Note!
Permit to Max. 165 MPa (1650 bar) only in a short time.

Standard Tools: See Section 913




064
090
088
Plate
90551
100
076
M3
M2
039
027
111

The clearance in the thrust bearing was measured during testbed trials of the engine and noted down in the 'Adjustment Sheet' which is inserted at the front of Vol. 1, OPERATION.

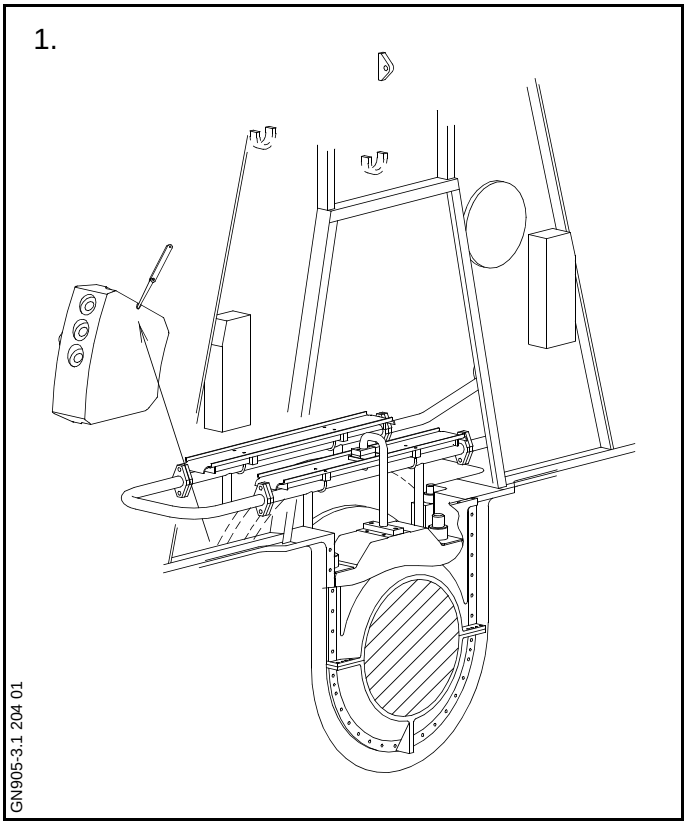
For a new engine the clearance is 0.5-1.0 mm, and for an engine in service it must not exceed 2.0 mm.

For dismantling the segment stopper, see Procedure 905-3.2.

1. There is a wear groove of 1 mm in the uppermost thrust segment. (The segment with thermometers).

   Insert the feeler gauge in this groove on the foremost side of the thrust collar.

   If a feeler gauge of 0.1 mm is **not** able to enter the wear groove, the thrust bearing must be overhauled.



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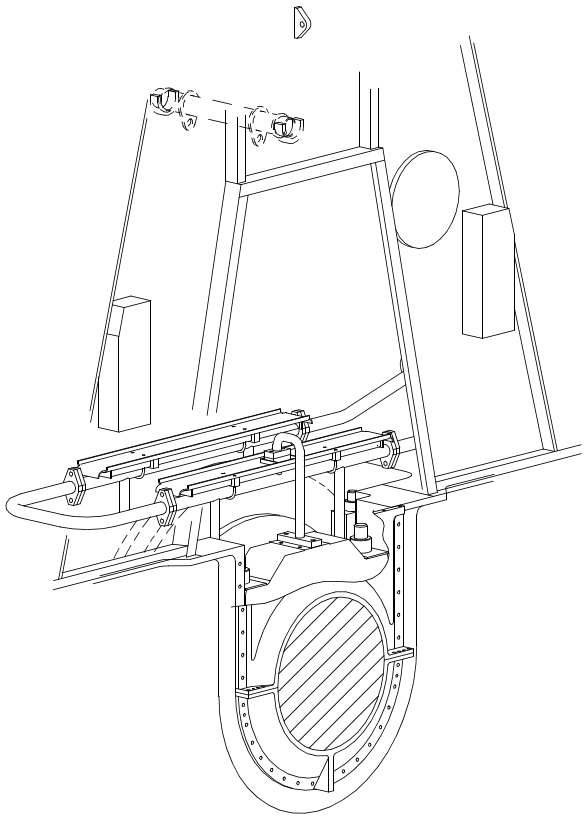

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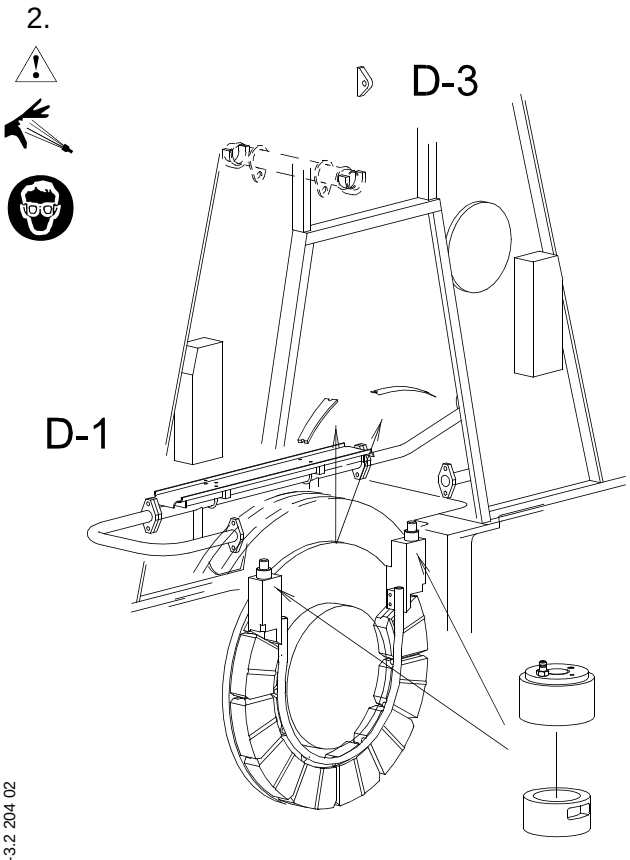


GN905-3.2 204 02

1. Remove the lub. oil pipe from the bearing cap, and the lub. oil pipe for the thrust segments.

   Mount the crossbar.

2. Remove the protective shields from the thrust collar.

   Loosen and remove the nuts from the segment stops. *For operation of the hydraulic jacks, see Procedure 913-1.*

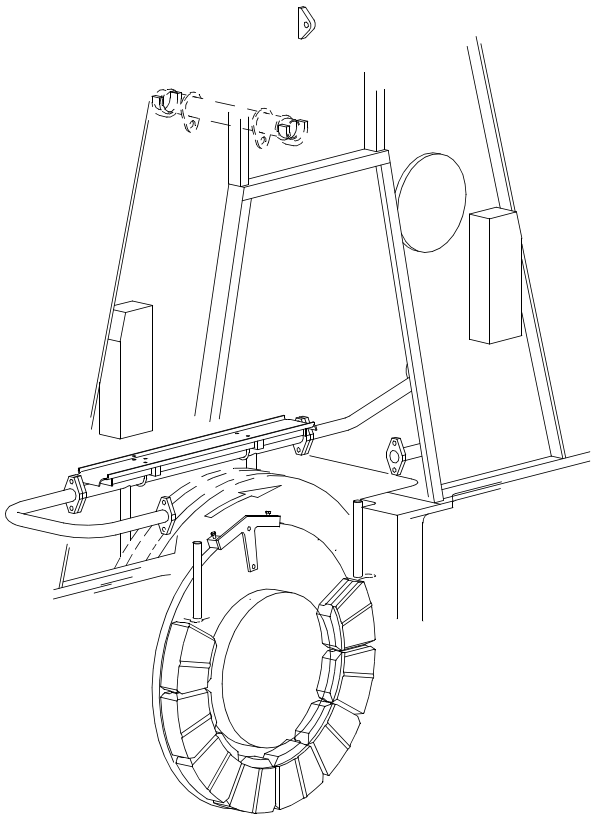
   Remove the stops from the chain drive above the thrust segments (AHEAD or ASTERN) that are to be taken out.

3. Suspend a tackle from the crossbar above the segments which are to be removed.

   For turning-up the thrust segments, mount the segment tool on the chainwheel.

4. Turn up the segments by turning the engine, and remove them from the chain casing.

3.



GN905-3.2 204 03

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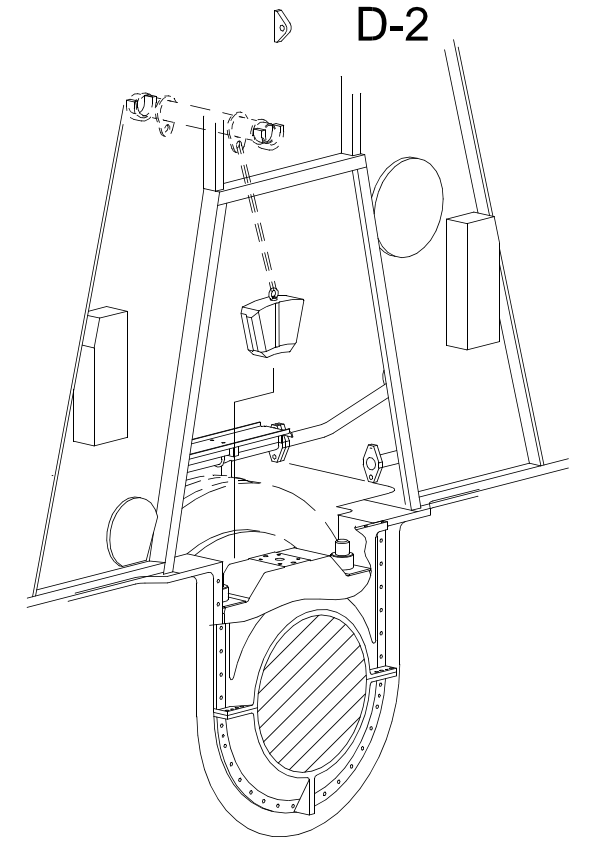

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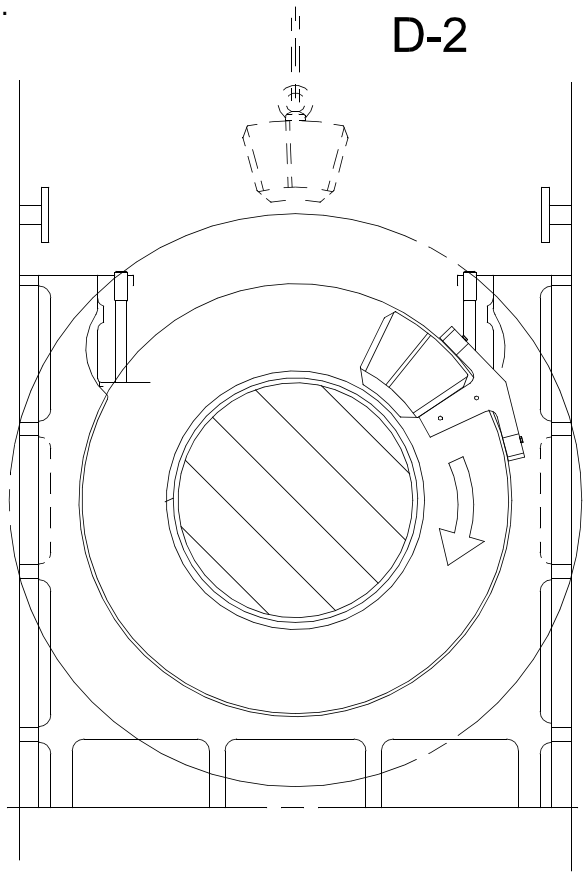

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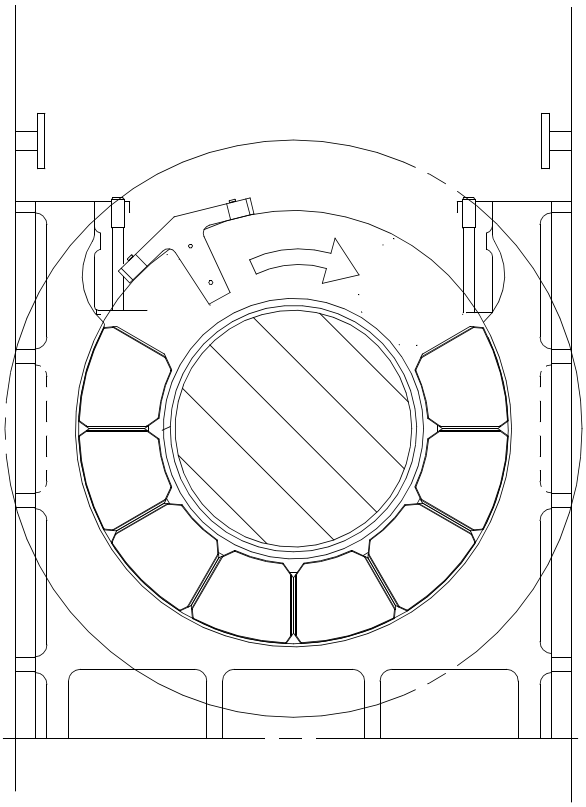


GN905-3.4 204 02

1. Suspend a tackle from the crossbar above the segments which are to be mounted.

   Mount the segment tool on the chainwheel.

   Land the segment on the journal and remove the eye screw from the segment.

   Turn the shaft a little. Land the next segment. Repeat this process until all segments are mounted.

2. After the last segment has been mounted, turn the segment tool up and dismount it.

3. Mount the protective shields the thrust collar.

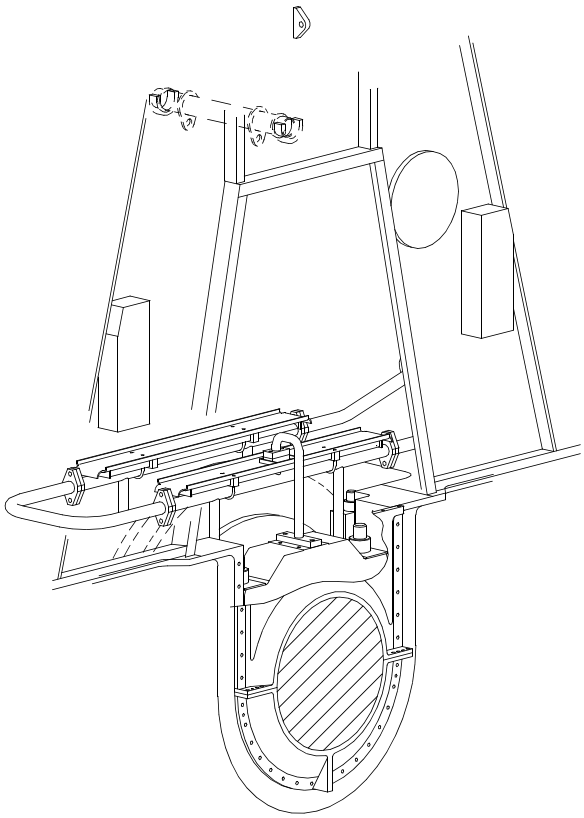
4. Mount the segment stopper.

   Mount the hydraulic jacks and tighten the nuts on the stopper. *See Data.*

5. Mount the lub. oil pipe for the thrust segments, and the lub. oil pipe on the bearing.

6. When mounting the end cover, ensure that all screws marked **A** are tightened before tightening the screws marked **B**.

5.



GN905-3.2 204 01

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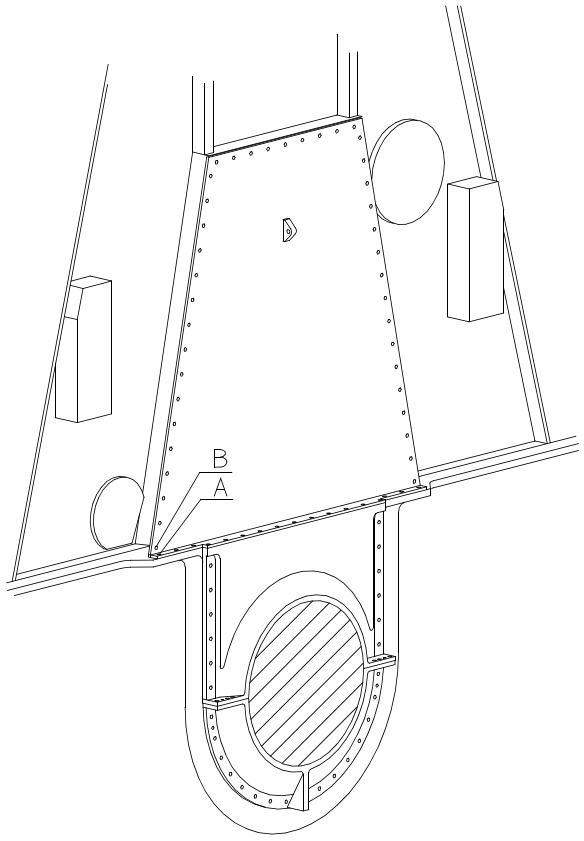


GN905-3.4 204 06

SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of high pressure oil
X	Block the starting mechanism	Do not enter area when over head lifting is being carried out
X	Shut off starting air supply	
X	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit
D-1	Damper housing, upper part	145	kg
D-2	Hydraulic pressure - tightening	150	MPa (1500 bar)
	Hydraulic pressure - dismantling	150-165	MPa (1500-1650 bar)

Note!
Permit to Max. 165 MPa (1650 bar) only in a short time.

D-3	Outer studs - screwing-in torque	300	Nm
D-4	Nuts on inner studs - tightening torque	500	Nm
D-5	Horizontal screws - tightening torque	450	Nm
D-6	Clearance at joints	5	mm

Calibration of springs:

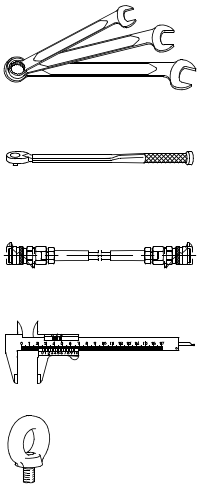
Spring for the middle oil seal:

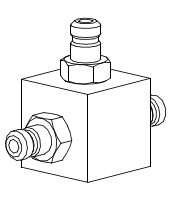
L_0	.....0 N..... Check length	1870 mm
L_1	35±4 N..... Check length	2255 mm
L_2	66±7 N..... Check length	2595 mm

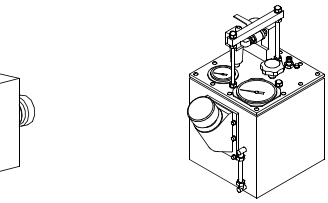
Spring for the side oil seals:

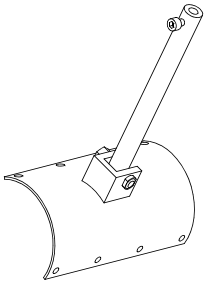
L_0	.....0 N..... Check length	1570 mm
L_1	25±3 N..... Check length	1810 mm
L_2	44±5 N..... Check length	1984 mm

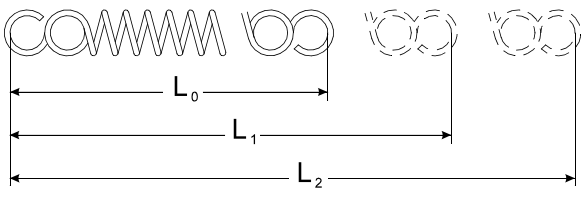
Standard Tools: See Section 913











For checking the effectiveness of the axial vibration damper, it is necessary to measure the longitudinal movements of the fore end of the crankshaft during running.

The measurement (or reading) should be taken at the same r/min as during the sea trials. (Preferably 90% and 100% of MCR).

As different equipment may be mounted on the specific engines, the checking procedure describes three systems:

A: Electronic, (with Axial Vibration Monitor)

B: Mechanical, (without angle encoder fore)

C: Mechanical, (with angle encoder fore)

A: Electronic, (with Axial Vibration Monitor)

A proximeter probe is built on to the lower part of the damper housing. The probe is connected to a control unit which displays peak-to-peak movements and sends signals to the engine control systems.

1. The peak-to-peak value displayed in mm on the control unit should be periodically recorded and compared to the original ones obtained during the sea trial and the value given below.

   If the peak-to-peak value is less than the value shown below, overhaul of the damper is not necessary.

   Limits for permissible peak-to-peak values:

S50MC-C					
Cyl.	4	5	6	7	8
mm	1.27	1.57	1.88	2.18	2.56

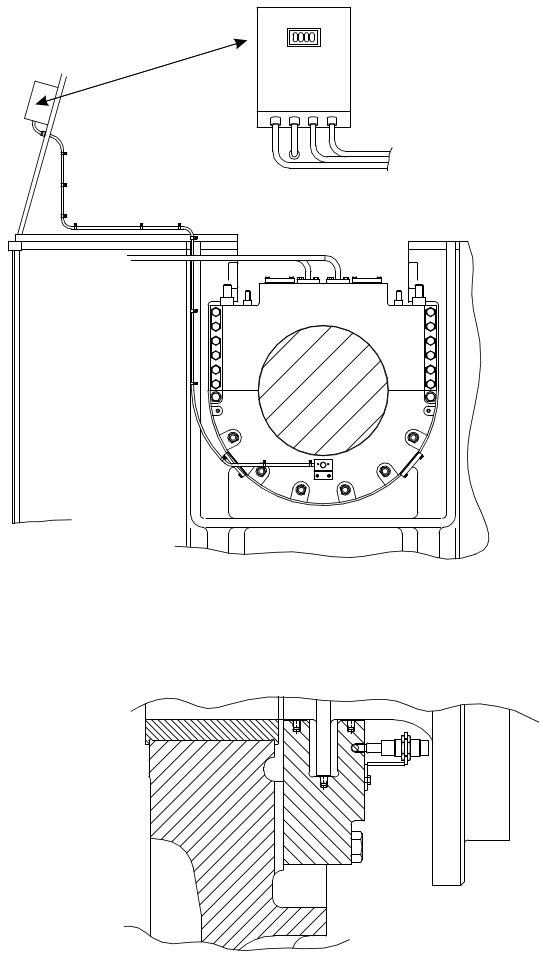
2. The alarm values which are set in the control system, are shown below.
   The engine should not be operated continuously over the value shown below.

   Limits for permissible peak-to-peak values:

S50MC-C					
Cyl.	4	5	6	7	8
mm	1.69	2.09	2.50	2.90	3.41

   If the peak-to-peak value exceeds the *Normal Service Value*, it is necessary to overhaul the axial vibration damper, *see Procedure 905-5.2.*

1.



GN905-5.1 204 06

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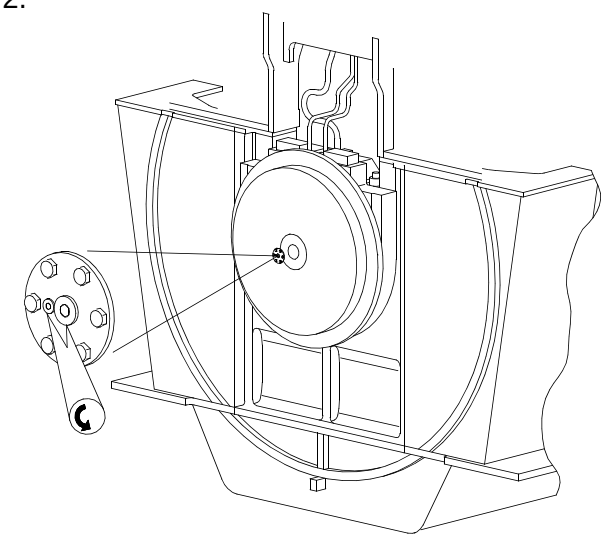

GN905-5.1 204 02

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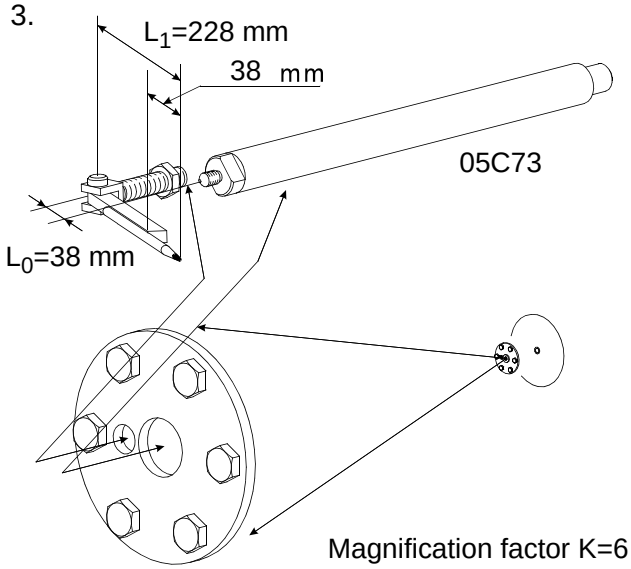


GN905-5.1 204 03 L0a

B: Mechanical, (without angle encoder fore)

1. When checking the effectiveness of the axial vibration damper in service (which is recommended every 8000 hours and just after overhauling of axial vibration damper), a special measuring tool has to be mounted in the shield on the forward end of the engine, in order to measure the axial movement of the crankshaft fore end.

   The actual measurement obtained should be compared with the original values obtained during the sea trial, and with limits given on the next page.

2. The followin procedure should be followed:

   Stop the engine.

   Unscrew the two plugs from the cover at the front end of the engine.

3. Screw the shaft piece into the fore end of the crankshaft, through the large hole in the cover.

   Screw the measuring arm into the small hole so that the arm is perpendicular to the shaft piece. Tighten the lock nut.

4. Attach a pencil to the arm.

Note!
The distance to the end of the pencil should only exceed the arm length by **38 mm**, so that the magnification factor $K=L_1/L_0$ becomes 6.

5. The measurement should be taken at the same r/min as used during the sea trials (preferably 90% and 100% of MCR).

   Start the engine and hold the arm against the shaft piece. Hold a paper block with a solid backing plate by hand and moved lightly downwards on the pencil.

   To ensure a certain inertia, the backing plate should have a mass of approx. 1-2 kg.

   The axial movement recorded on the paper block must be measured with a slide gauge as shown in the sketch.

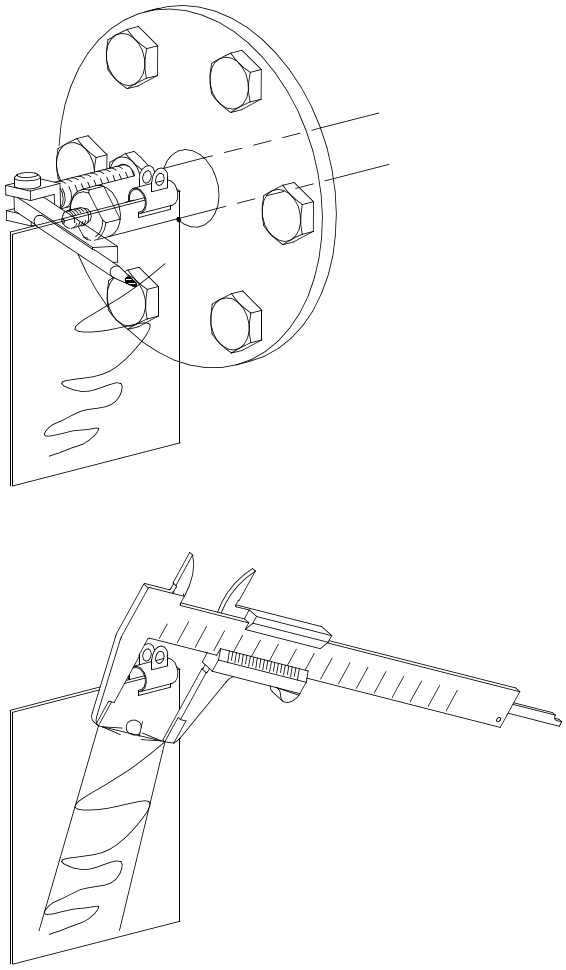
   If the peak-to-peak distance **a** in mm does not exceed the values given below, it is not necessary to overhaul the damper.

   Limits for peak-to-peak distance **a** (mm):

   Magnification factor K=6

S50MC-C					
Cyl.	4	5	6	7	8
mm	7.62	9.42	11.3	13.1	15.4

5.



GN905-5.1 204 05

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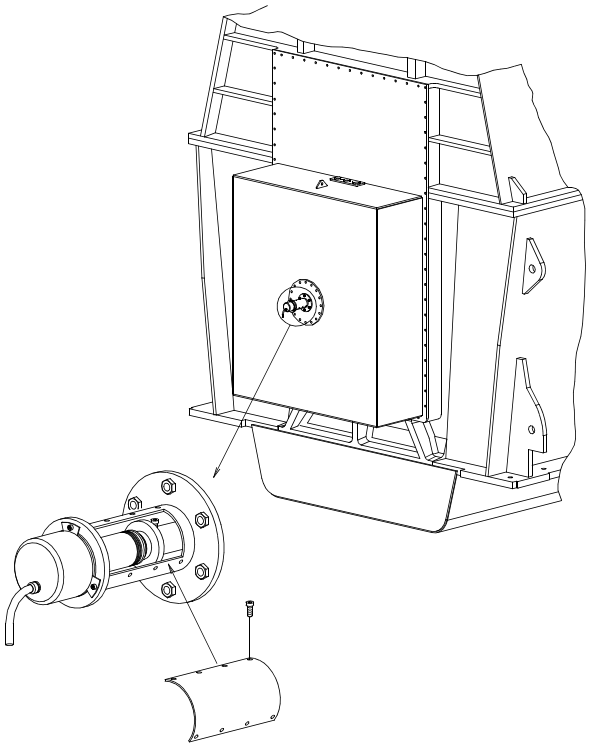

MN905-5.1 214 04 L0a

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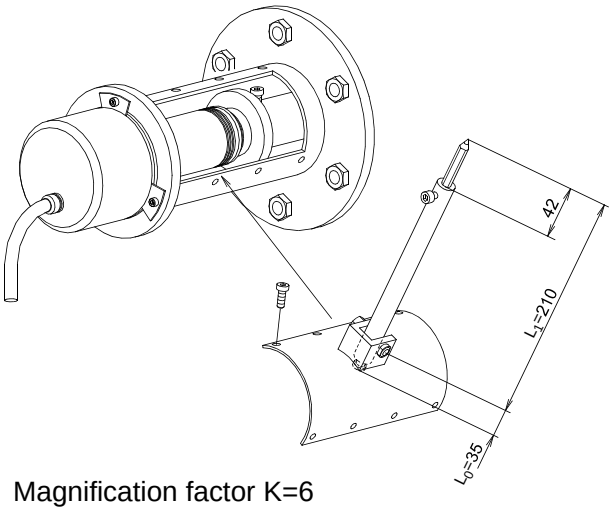


MN905-5.1 214 05 L0a

Magnification factor K=6

C: Mechanical, (with angle encoder fore)

1. When checking the effectiveness of the axial vibration damper in service (which is recommended every 8000 hours), a special measuring tool has to be mounted in the shield on the forward end of the engine, in order to measure the axial movement of the crankshaft fore end.

   The actual measurement obtained should be compared with the original values obtained during the sea trial, and with the limits given on the next page.

2. The following procedure should be followed:

   Stop the engine.

   Dismount the cover on top of the angle encoder housing at the front of the engine. Apply Molykote™ on the side of the shaft cam.

3. Mount the axial vibration measuring tool with the screws from the cover.

   Attach a pencil to the arm.

Note!
The distance to the tip of the pencil shoud only exceed the arm length by **42 mm**, so that the magnification factor $K=L_1/L_0$ becomes.

4. The measurement should be taken at the same r/min as used during the sea trials (preferably 90% and 100% of MCR).

   Start the engine and pull the measuring arm against the shaft cam with one hand. With the other hand, move a sheet/block of paper, clipped on to a solid backing plate, lightly downwards against the tip of the pencil.

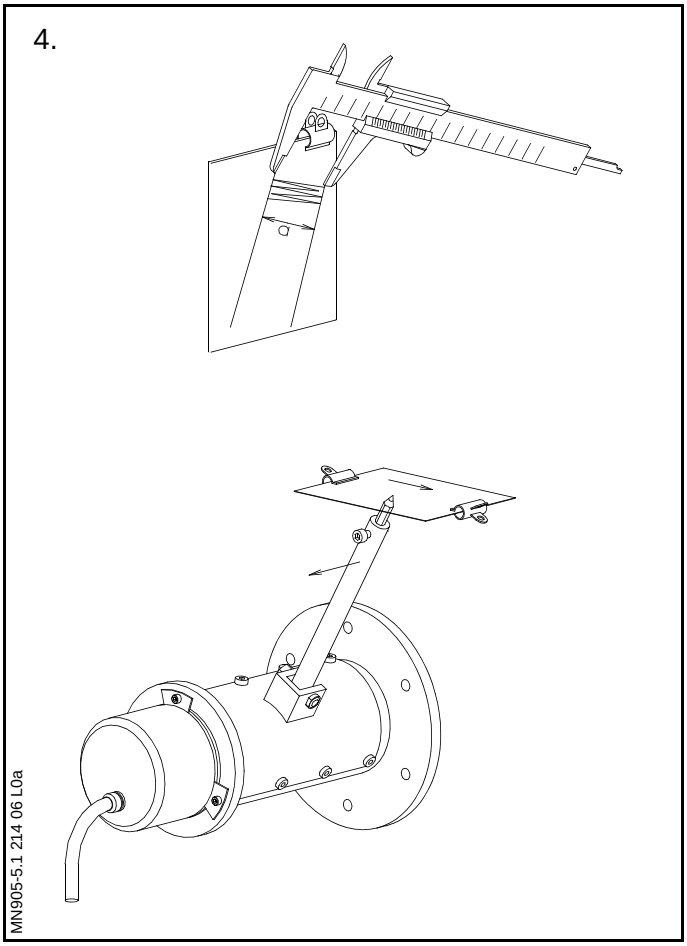
   To ensure a certain inertia, the backing plate should have a mass of approx. 1-2 kg.

   The axial movement recorded on the paper block must be measured with a calliper as shown in the sketch.

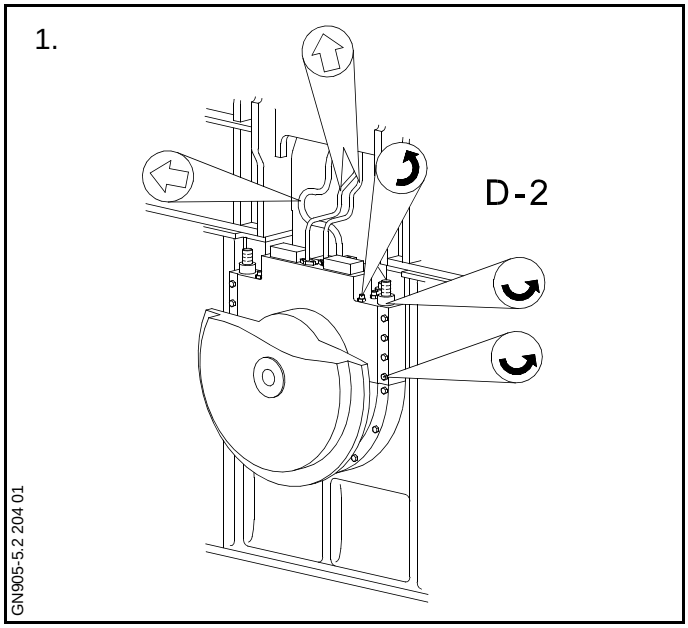
   If the peak-to-peak distance **a** in mm does not exceed the values given below, it is not necessary to overhaul the damper.

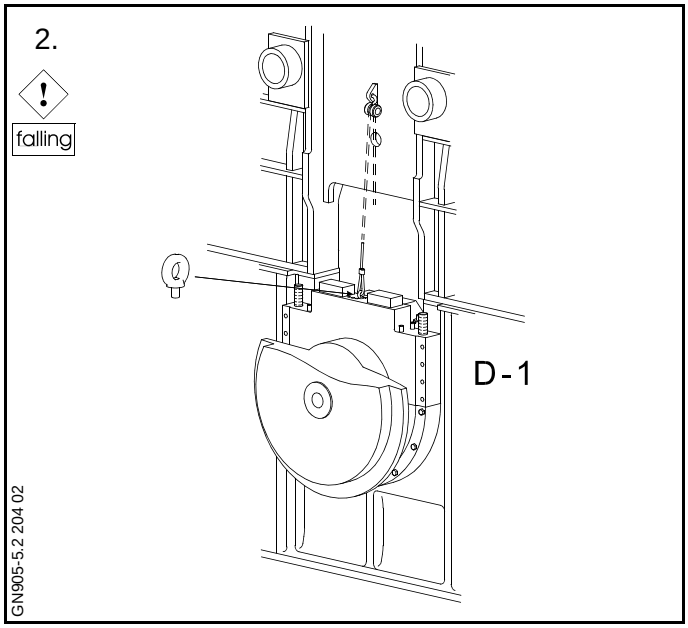
   Limits for peak-to-peak distance **a** (mm):

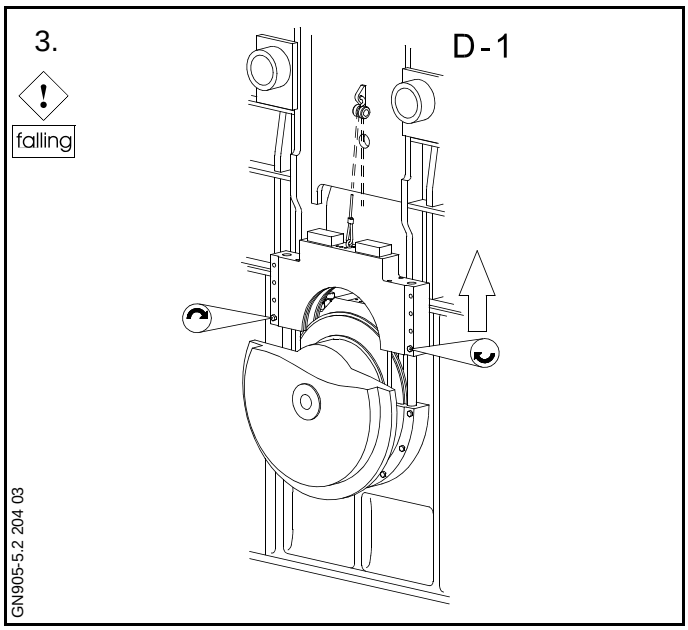
   Magnification factor K=6



S50MC-C					
Cyl.	4	5	6	7	8
mm	7.62	9.42	11.3	13.1	15.4







1. Dismantling of the axial vibration damper is carried out from cyl. No. 1 or from the front end of the engine.

   Disconnect and remove the oil pipes from the foremost bearing cap and the axial vibration damper housing.

   Loosen and remove the screws and nuts from the damper housing upper part.

2. Only the upper part of the housing needs to be removed, while the lower half remains mounted on the bedplate.

   Mount a lifting eye bolt on the upper part.

3. By means of tackle and wire rope, separate and raise the upper part of the damper housing to a position in which it is possible to change the oil seals and springs.

   Keep the upper part in position by inserting two screws in the damper housing.

1. Dismantle and remove the springs from the seal rings.

   Remove and discard the seal rings.

2. When mounting new seal rings, the following procedure should be done in order to assemble the damper without damaging the seal rings.

   (1) Mark the center of the back side of each of the longer half ring with paint.

   Insert the longer half ring and the springs into the lower part of the housing.

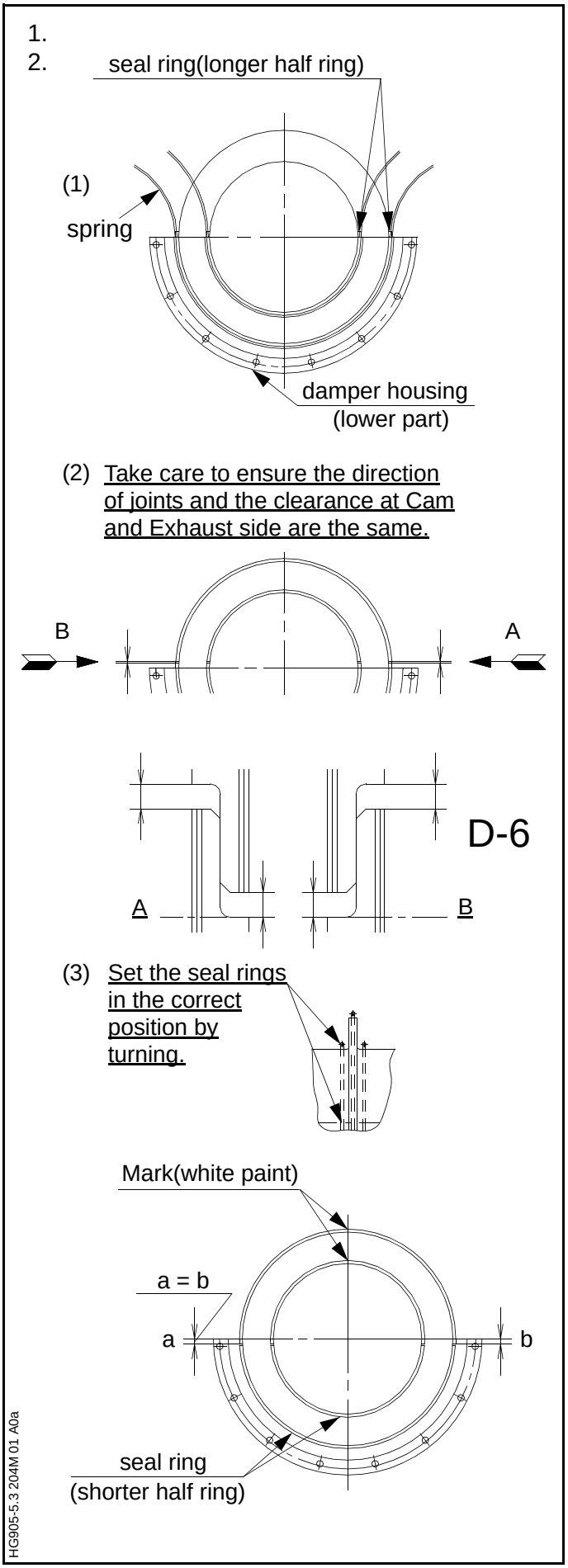
NB!
Each seal ring consists of 2 parts. The longer part will be called the longer half ring. The other will be called the shorter half ring.

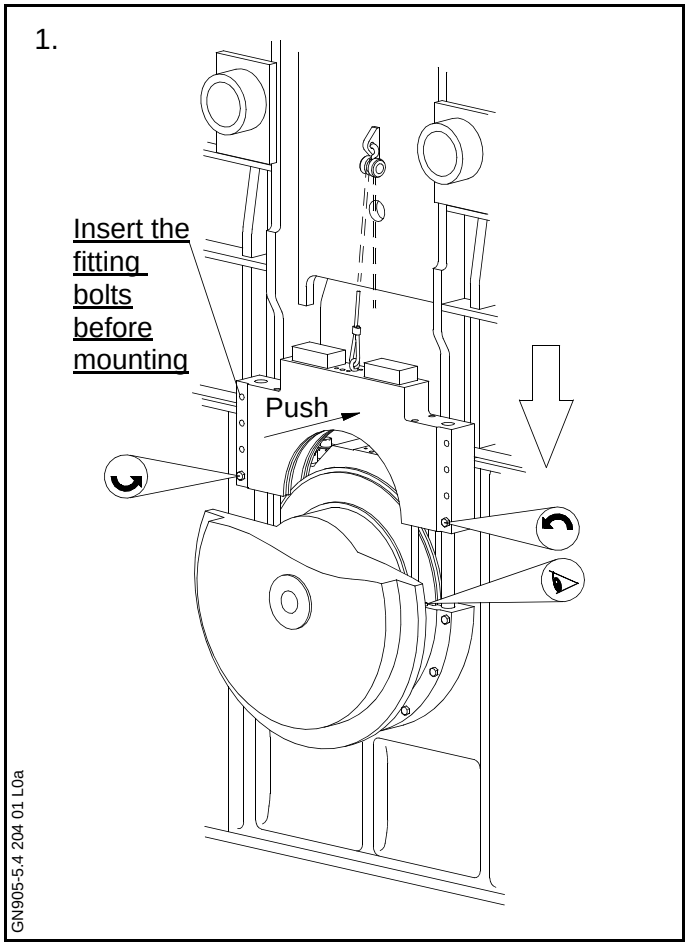
   (2) Connect the shorter half ring to the longer half ring with the springs. Take care to ensure the direction of joints and the clearances at Cam and Exhaust side are the same.
   The springs can be hooked in place. Be certain that they are aligned in the center of the groove of the seal ring.

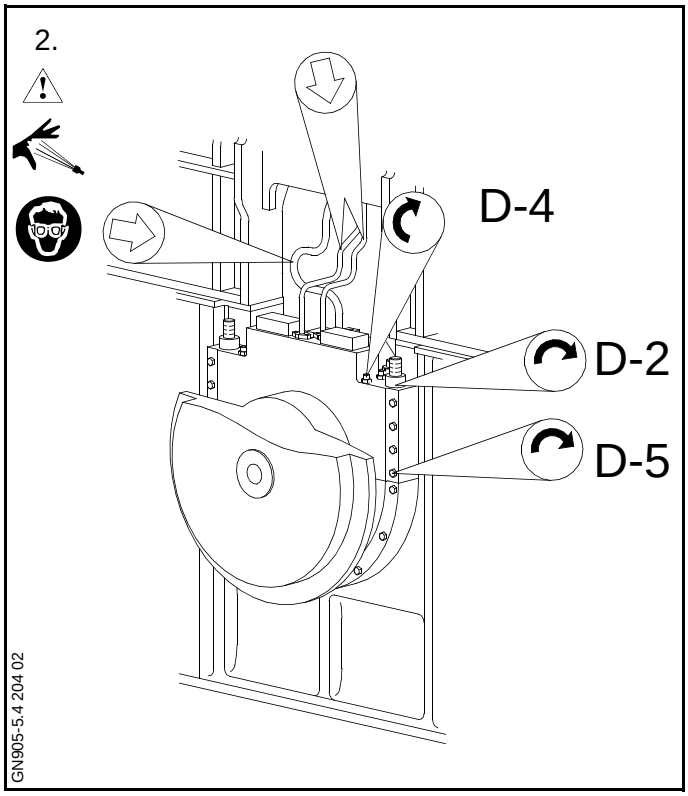
   (3) Before the upper parts of the damper housing are mounted, it is necessary to set the seal rings in the correct position. This is done by turning the seal rings 180 degrees.

NB!
The engine turning system must be used to rotate the seal rings. They may not be rotated by hand.

Stop turning the seal rings when the white mark on the longer half ring is located at the top. At this point, the shorter half ring is in the lower part of the damper housing and the joints are located in the positions indicated in figure (1).







1. Unscrew/release the upper part of the damper housing.

   It is recommended that the fitting bolts be inserted before mouting the damper on the bed plate. In some instances, the fitting bolts cannot be inserted after mounting the damper on the bed plate due to limited space.

   The upper part of the damper should be lowered slowly, while pushing it against the contact surface of the bed plate. The upper part of the damper housing must not contact the seal rings. If there is a rake in the ship, the inclination must be considered when mounting the upper part of the damper housing.

NB!
If it is difficult to align the upper and lower parts of the damper, it is possible that the seal ring is between the lower and upper part of the damper. In this case, tap gently with a hammer in the direction of Cam-Exhaust. Then allow the weight of the upper part of the housing to align the upper and lower parts of the damper housing. Do not use force on the upper part of the housing to force the housing into position. If it is still difficult to align, then dismount the upper part of the damper once and confirm that the seal rings are correctly set, and remount it.

   Be aware of the two guide pins from the lower part of the damper housing, which ensure positioning the upper part.

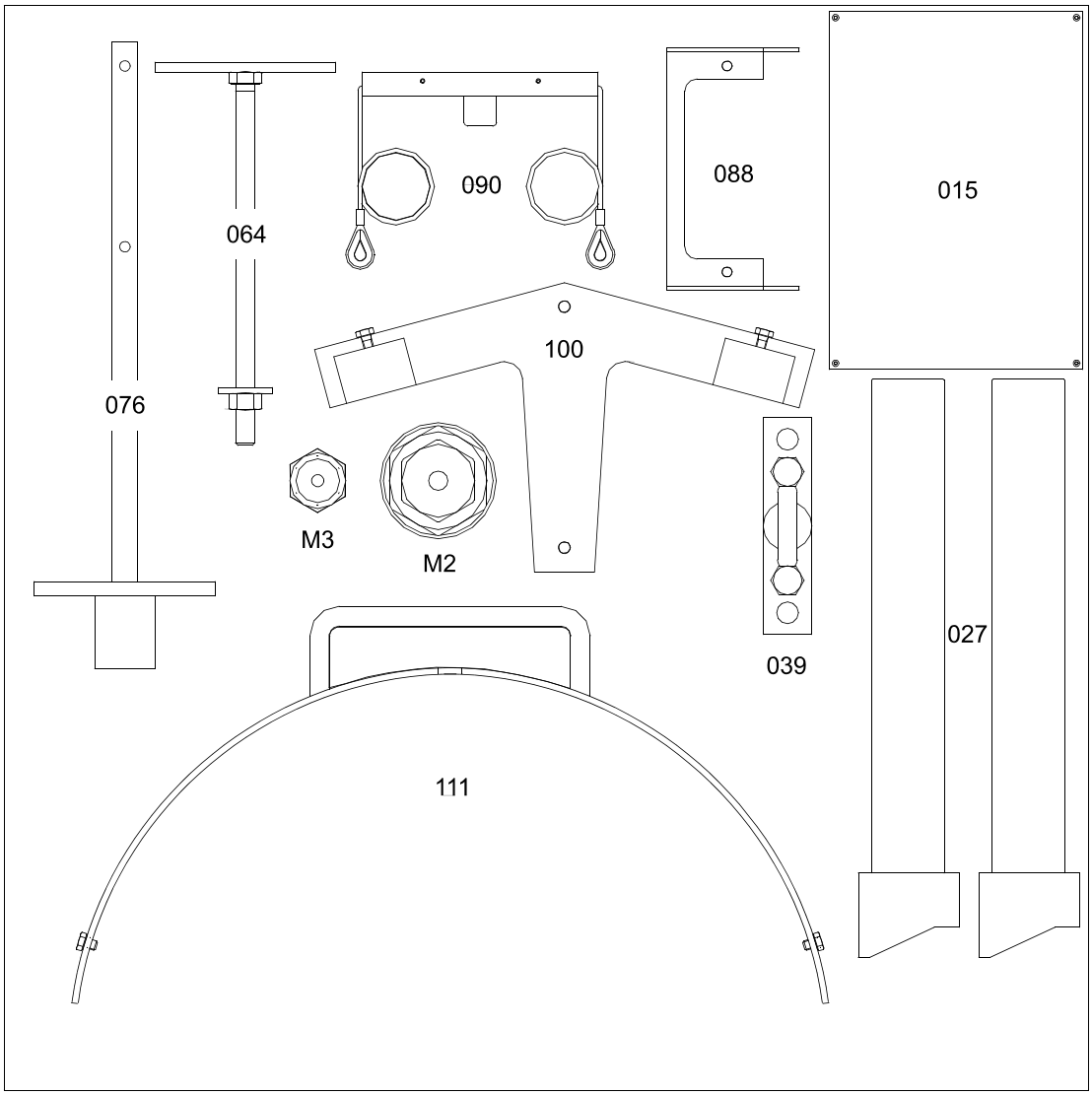
   If the studs have been removed, then moust them again at this stage.
   See Data.

2. Mount the horizontal screws.

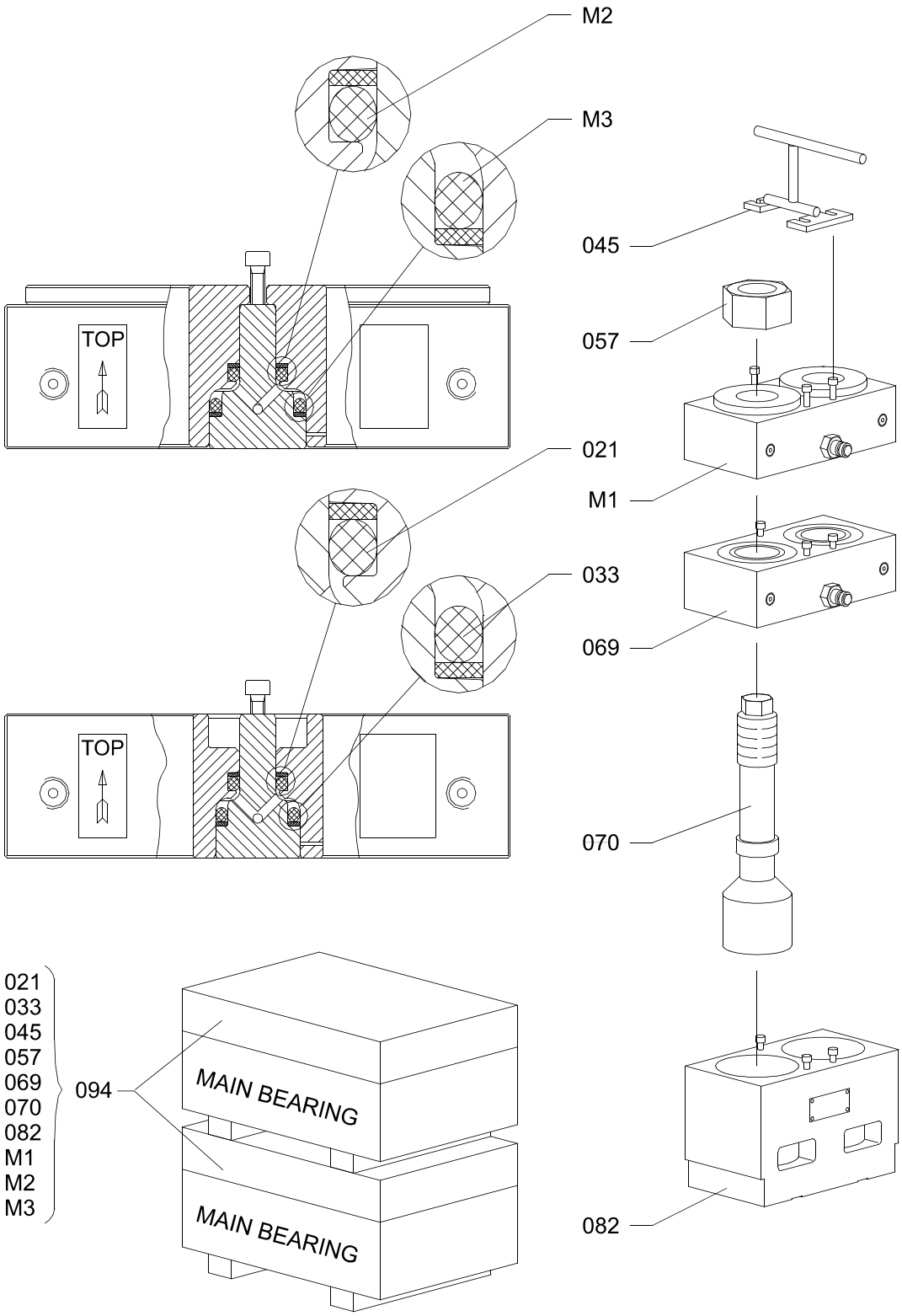
   Tighten the screws. *See Data.*

   Mount and tighten the nuts on the vertical studs. *See Data.*

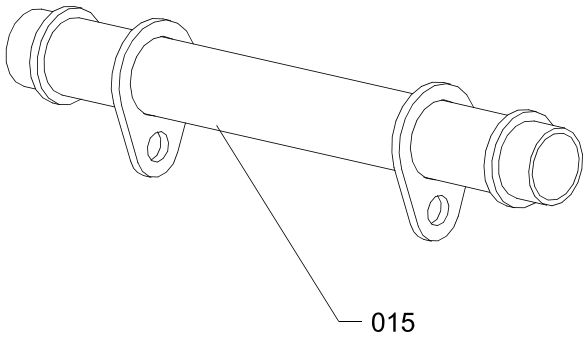
Caution!
It must be comtirmed the effectiveness of the axial vibration damper by the measurement (*see 905-5.1*), at the running condition just after overhauling.

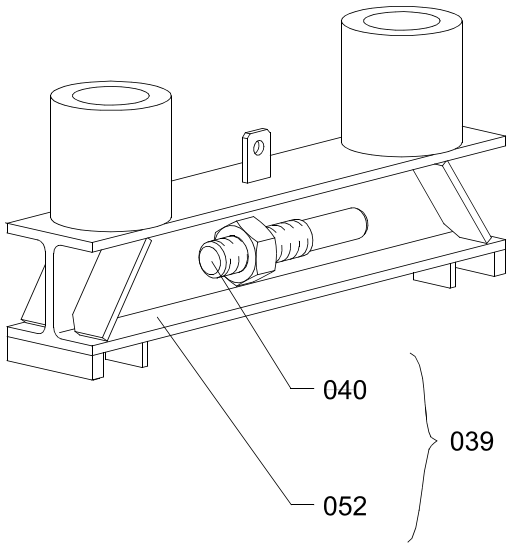

076
064
090
088
015
100
M3
M2
039
027
111

Item No.	Part Description	MES Tools No.	
015	Tool panel *)	(P905)	
027	Retaining tool for bearing shell	05A50	
039	Lifting tool for journal bearing cap	05B11	
064	Lifting tool	11B71	
076	Mounting tool for thin bearing shell	05A58	
088	Mounting tool for thin bearing shell	05A59	
090	Dismantling tool for main bearing shell	05A52	
100	Tool for segments	05B59	
111	Lifting tool for main bearing shell	05A12	
M2	Stud setter for main bearing stud	05A87	
M3	Stud setter for axial vibration damper	05C87	
015-M3	Tool panel, complete with tools *)	-	
	*) Optional extra		

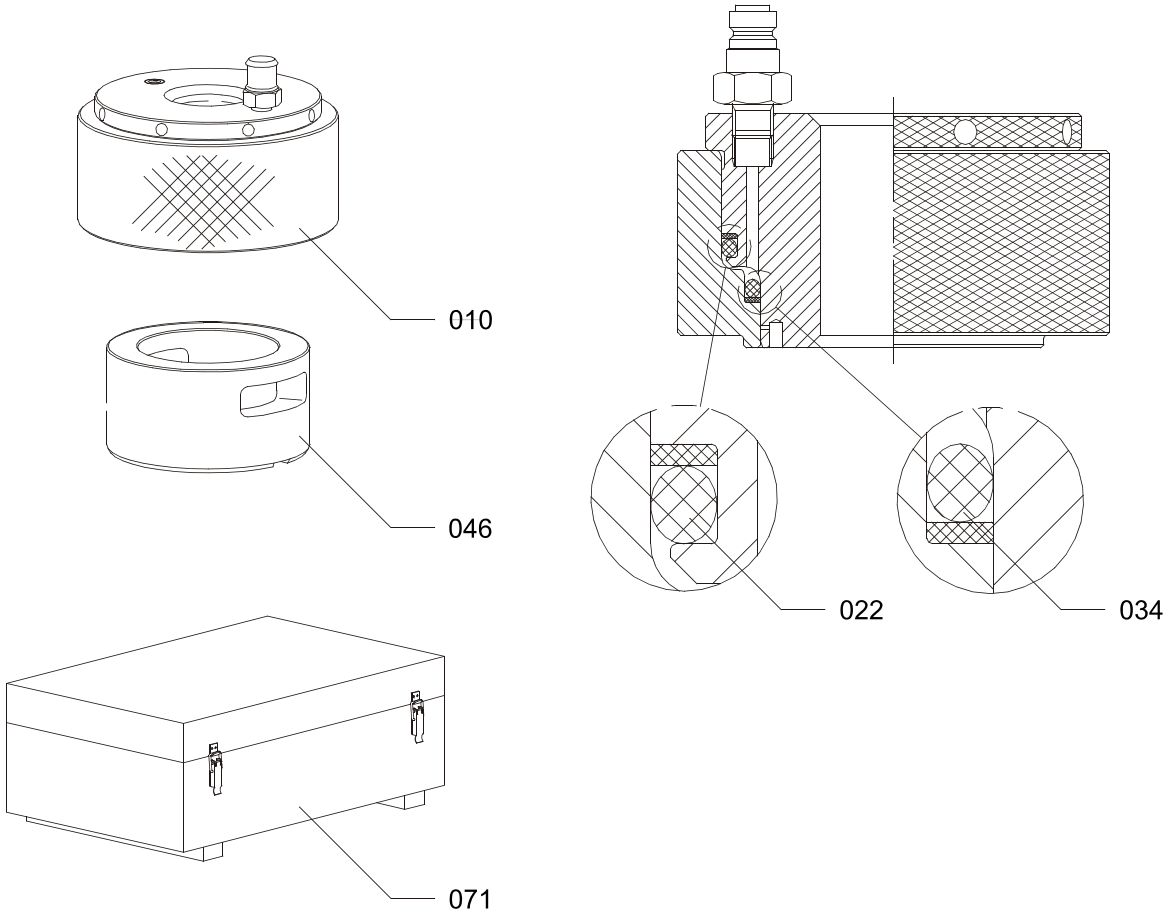

M2
M3
045
057
021
M1
033
069
070
082
TOP
TOP
021
033
045
057
069
070
082
M1
M2
M3
094
MAIN BEARING
MAIN BEARING

Item No.	Part Description	MES Tools No.	
021	O-ring with back-up ring	05A03	
033	O-ring with back-up ring	05A03	
045	Lifting tool	05A19	
057	Nut	05A09	
069	Hydraulic jack	05A01	
070	Extension stud	05A04	
082	Supporting block	05A02	
094	Hydraulic tools for main bearing and journal bearing, complete	-	
M1	Hydraulic jack	05A06	
M2	O-ring with back-up ring	05A08	
M3	O-ring with back-up ring	05A08	

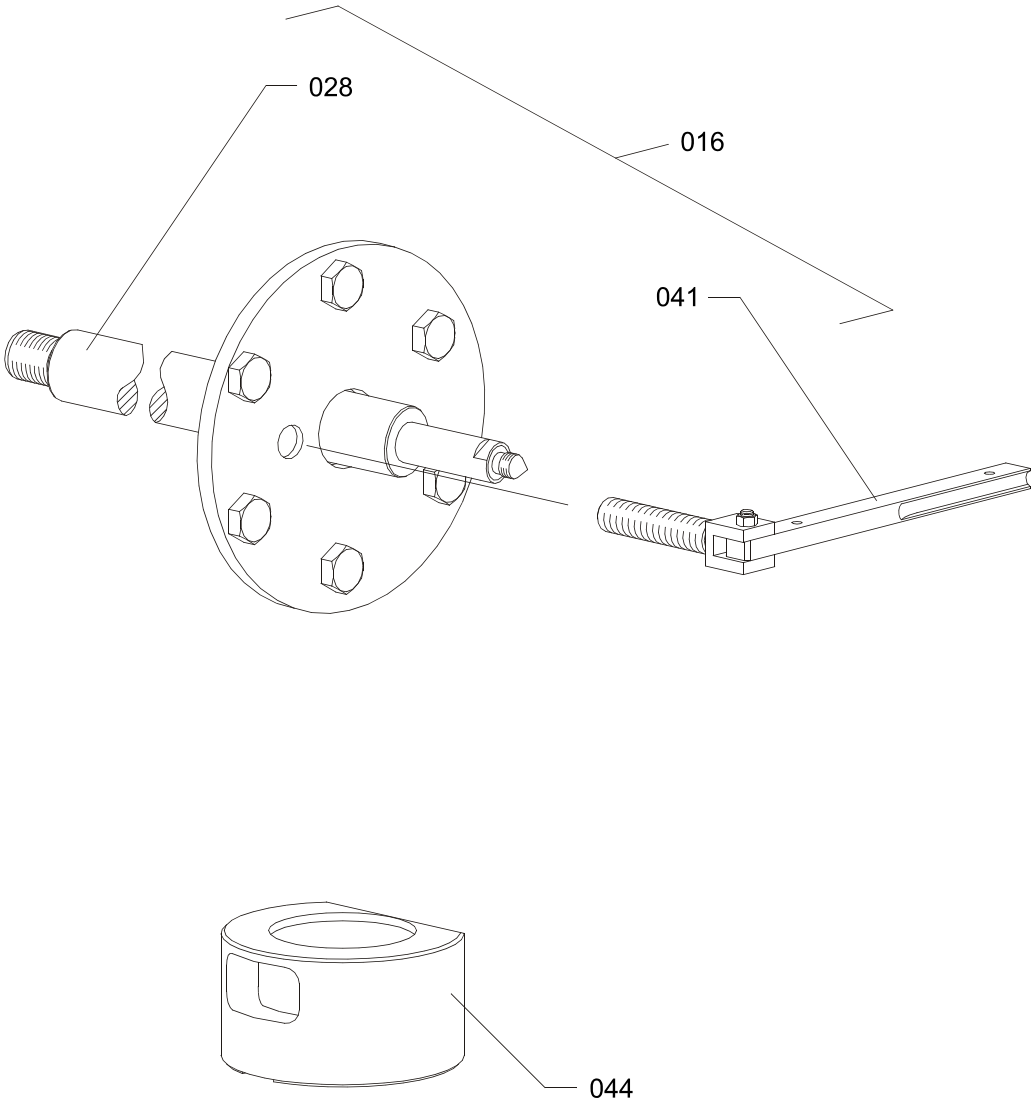

015


040
039
052

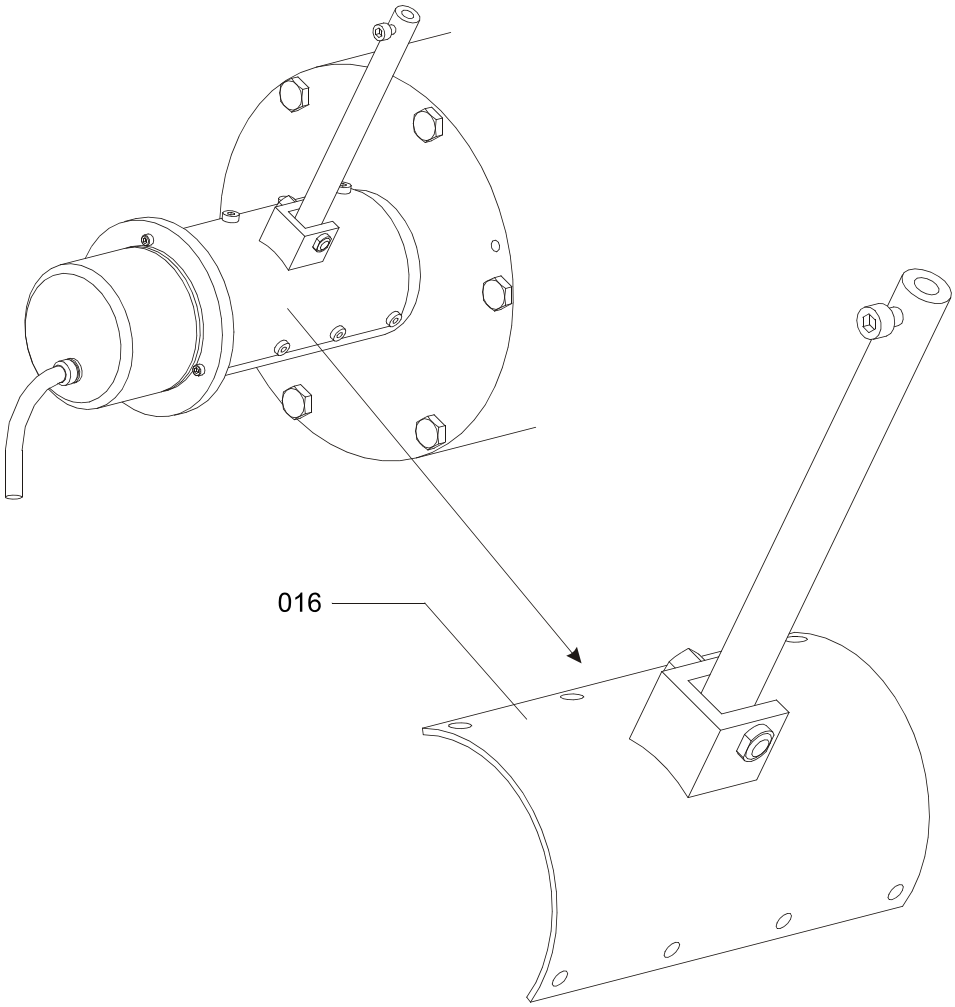
Item No.	Part Description	MES Tools No.	
015	Crossbar	05B12	
039	Lifting tool for crank shaft	05A51	
040	Screw	05A51	
052	Crosspiece	05A51	


010
046
071
022
034

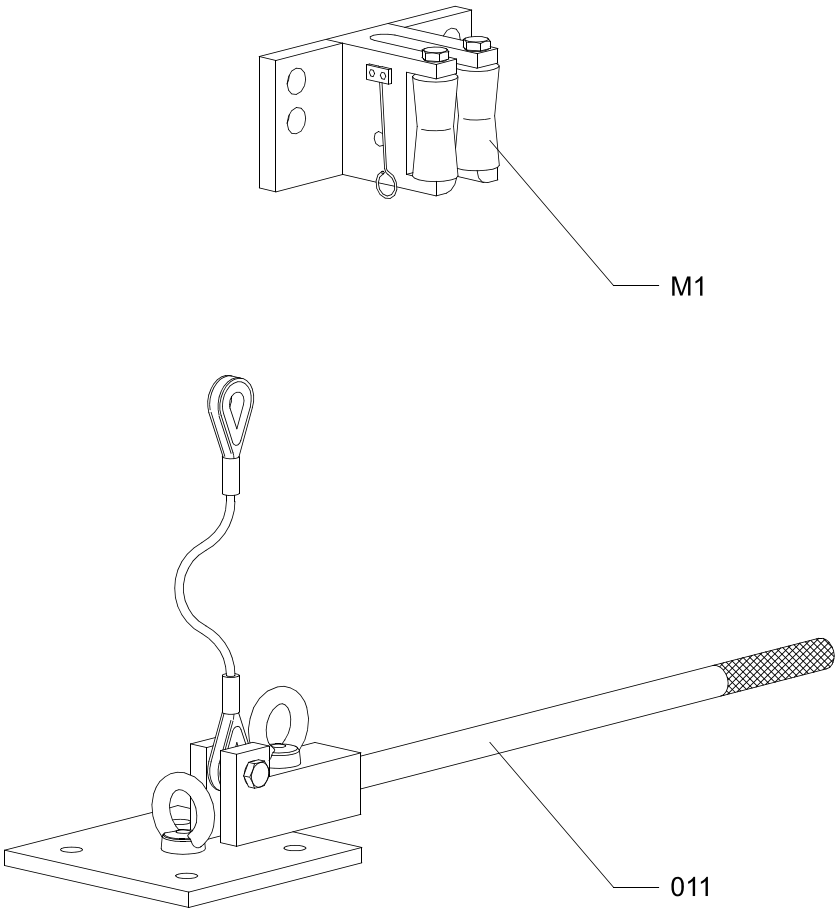
Item No.	Part Description	MES Tools No.	
010	Hydraulic jack	05F01	
022	O-ring with back-up ring	05F03	
034	O-ring with back-up ring	05F03	
046	Spacer ring	05F02	
071	Hydraulic tools for torsional vibration damper, complete	-	


028
016
041
044

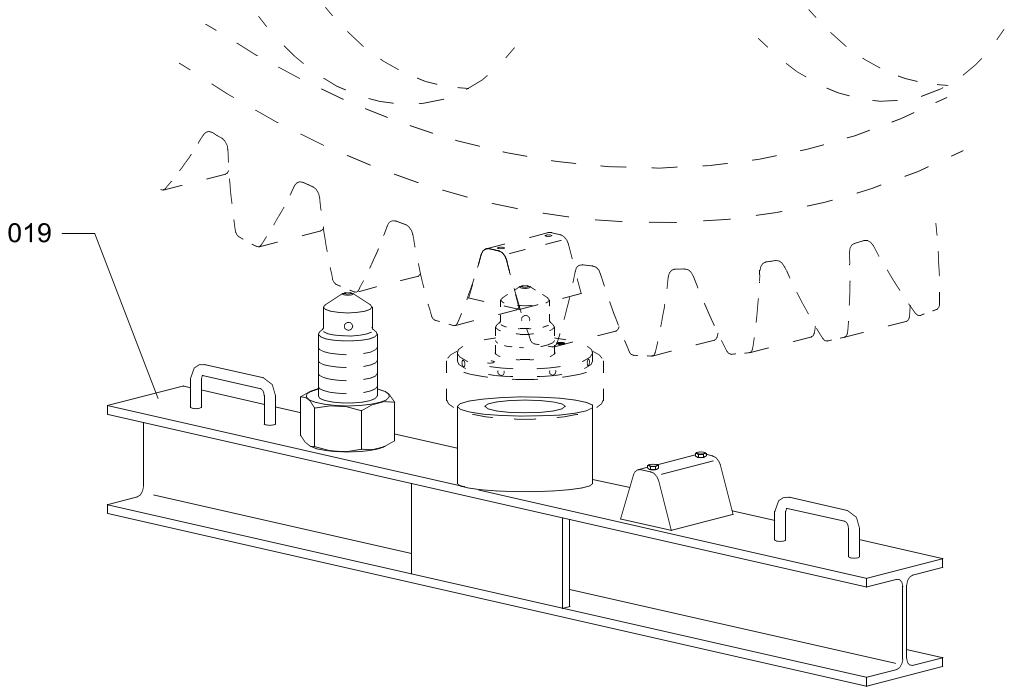
Item No.	Part Description	MES Tools No.	
016	Measuring tool for axial movement, complete	05C73	
028	Shaft piece	05C73	
041	Measuring arm	05C73	
044	Spacer ring	05C02	


016

Item No.	Part Description	MES Tools No.	
016	Measuring tool for axial movement	05C73	


M1
011

Item No.	Part Description	MES Tools No.	
011	Lifting tool for main bearing cap	05A15	
M1	Pulley for wire for main bearing	05A13	


019

Item No.	Part Description	MES Tools No.	
019	Lifting tool for thrust shaft	05B53	

INDEX

CYLINDER COVER

PISTON WITH ROD AND STUFFING BOX

CYLINDER LINER AND
CYLINDER LUBRICATION

CROSSHEAD WITH CONNECTING ROD

CRANKSHAFT, THRUST BEARING
AND TURNING GEAR

MECANICAL CONTROL GEAR

STARTING AIR SYSTEM

EXHAUST VALVE

FUEL OIL SYSTEM

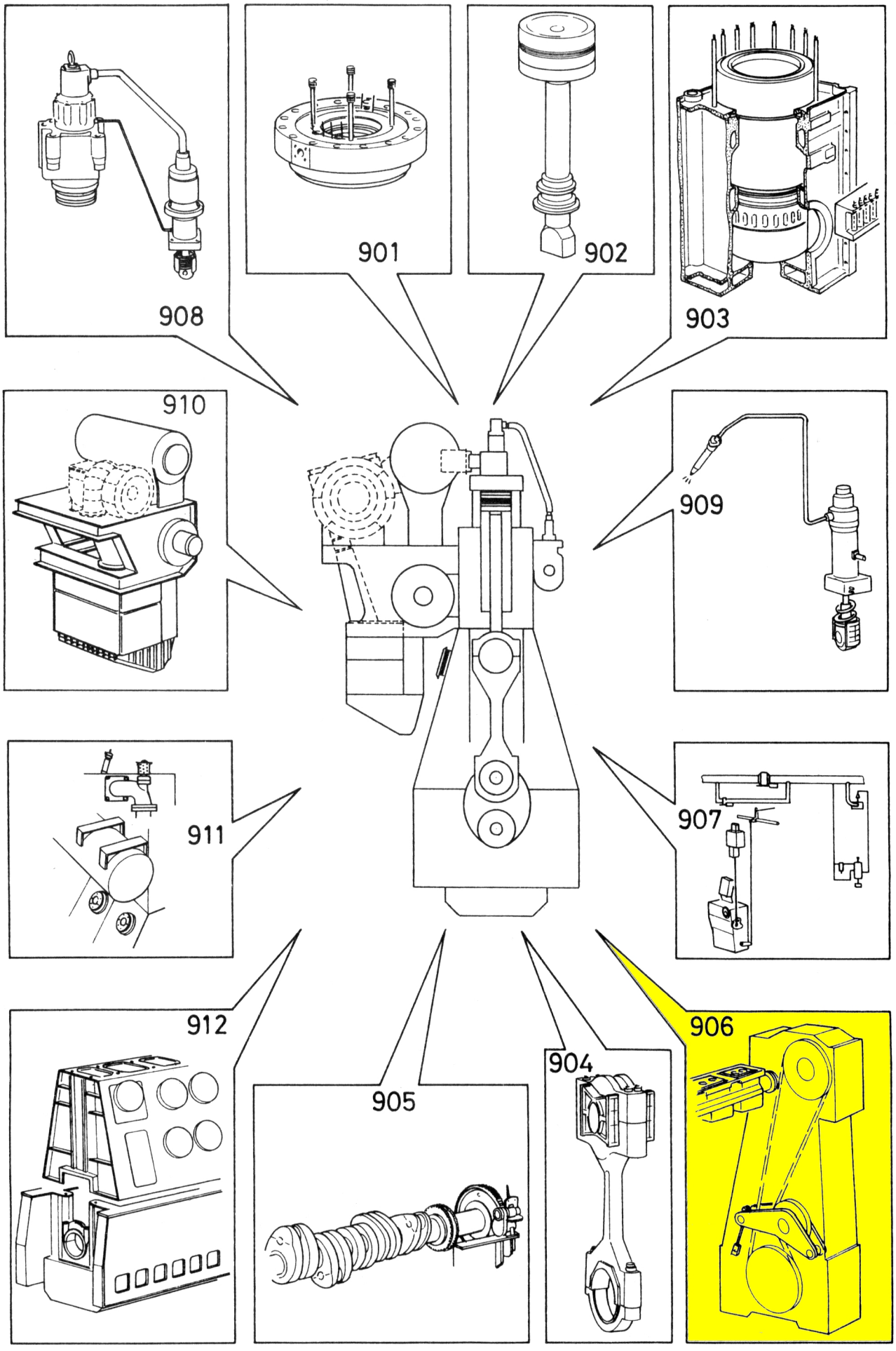
TURBOCHARGER SYSTEM

SAFETY EQUIPMENT

ASSEMBLY OF LARGE PARTS

GENERAL TOOLS

MITSUI
MAN
B&W

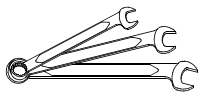


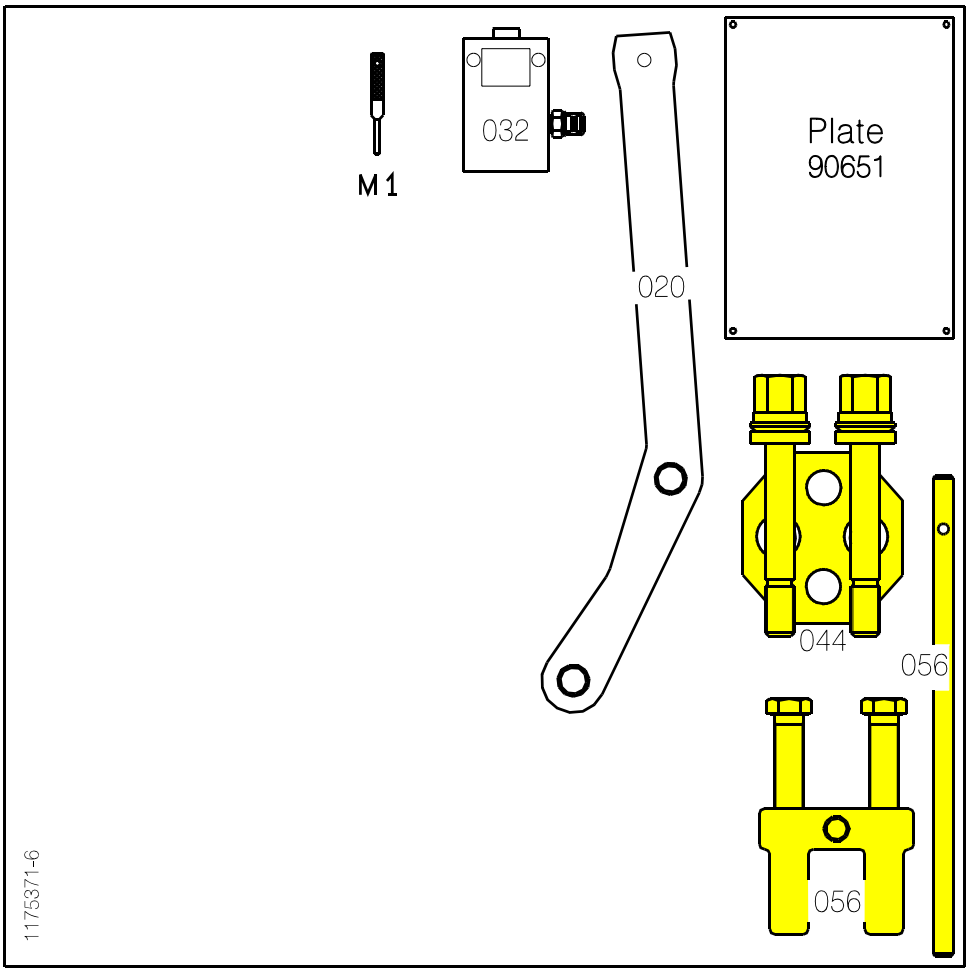
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Slippy surfaced and risk of falling (while at wok in crankcase)
X	Block the starting mechanism	Risk of severe personal injury (while engine being turned)
X	Shut off starting air supply	
X	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit
D-1	Max. wear of teeth on chain wheel	3.0	mm
D-2	Original length (chain pitch x 10 links)	835.0	mm
D-3	10 links measurements + 1% of a tensioned chain = scrapping of chain	843.4	mm

Standard Tools: See Section 913

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Carry out the inspection as follows:

1. Make a general inspection for loose bolts and screws.

2. Inspect lube oil pipes for damage, and check jet nozzles for possible stoppages or deformations.

3. Examine the rubber track of the guideways for cracks or other damage.

   Replace the guideway if bits have started to be “plucked out” of the rubber track.

4. Check the teeth of the chain wheels. If abnormal wear is found, take a measurement *(see Data)*.

   Measurements are best taken by placing a short straight-edge over points **A** and **B** and then measuring the distance D-1.

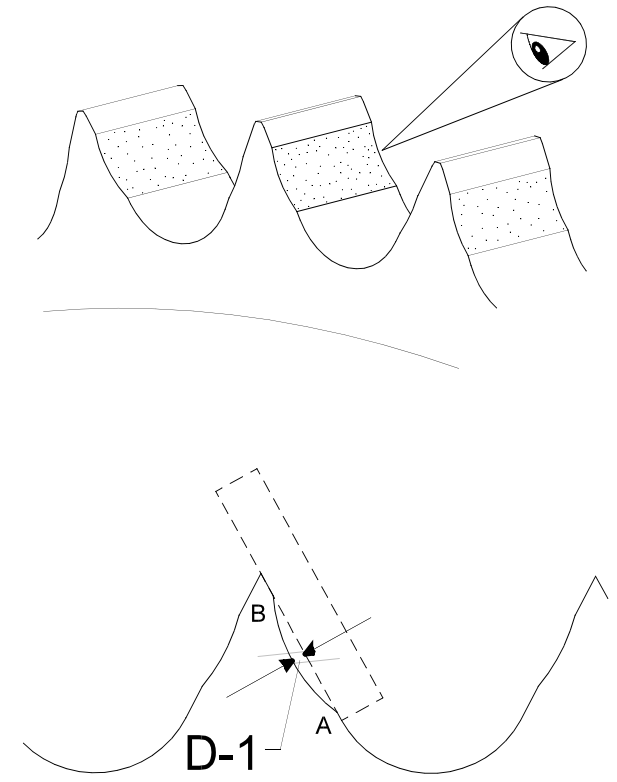
5. If abnormal wear is observed at the bottom of the teeth, make a drawing in scale 1:1 of the teeth and wear profile.

   Measure the geometry of the bottom and note down all available measurements including D-A and D-B on the drawing. D-B is best found by placing a short straight-edge between the tip of the two teeth.

   For assessing the measurement results, contact MES.

   In most cases, scratches caused by the side plates of the chain will be found on the sides of the teeth. Such scratches can generally be considered normal.

4.



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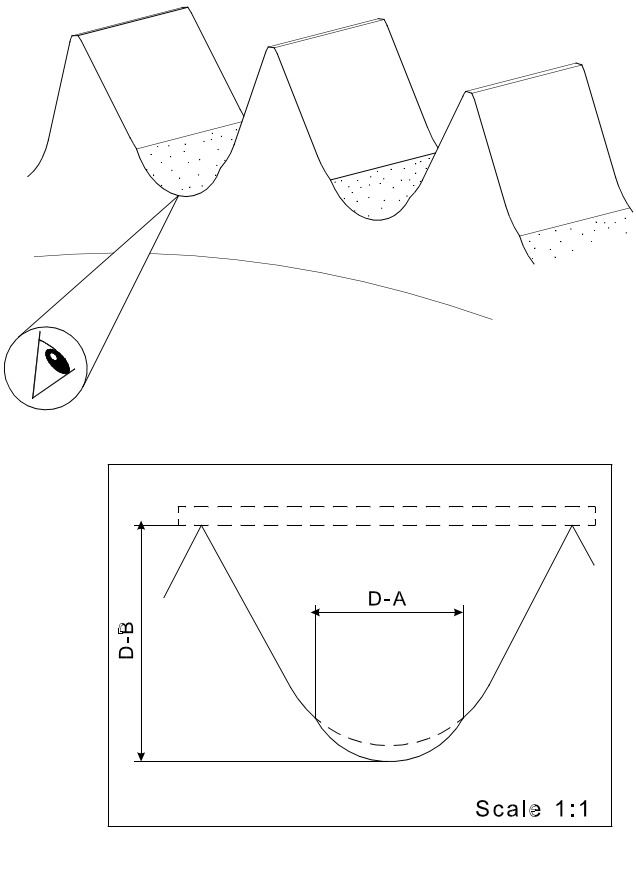
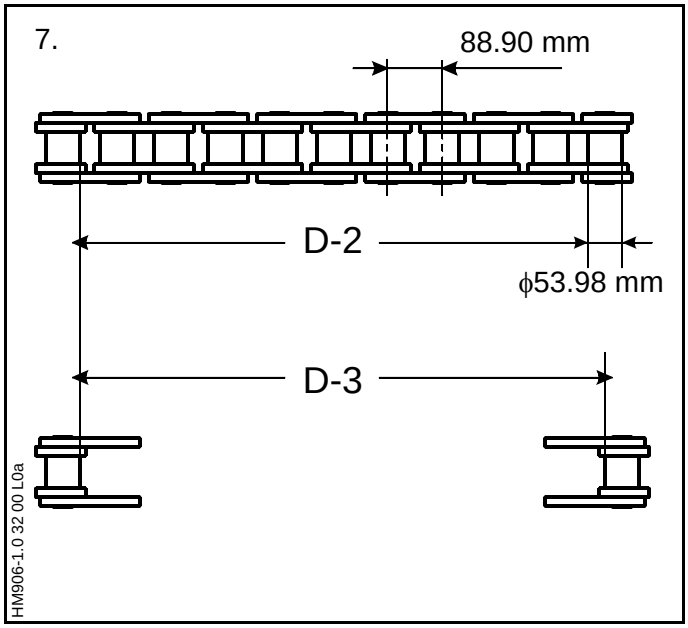




6. Check the chains for cracks on possibly defective rollers and side plates.

   Check that the chain rollers can run freely and that the chain links can freely move on the pin and bushing (that they are not “seized” between the pin and the bushing).

   It is normal, however, that the rollers get light, circumferential scratches during the running-in period. These fine scratches are of no importance and need not be considered.

   It is recommended to turn the chains a complete rotation and check each single link.

7. Check chain wear by measuring the length of 10 chain links and comparing the result with the value given in Data.

   If necessary, adjust the chain tightener.
   See Procedure 906-2.3.

It may become necessary to disassemble the chain if, for instance, cracked rollers or seizures between pin and bushing have been discovered during the inspection.
See Procedure 906-1.1.

Note!
Every time a chain link is disassembled, a new link must **always** be fitted as the link pin press-fit is destroyed when breaking the chain. When a new link is fitted in one chain, the corresponding link in the other chain must also be renewed.

1. Remove the tension on the chain by loosening the chain tightener.
(See Procedure 906-2.3).

   Turn the engine until the slack part of the chain, with the chain link that is to be disassembled, is in a favourable position for the work.

2. Mount a wire round the link rollers a short distance from the disassembly point, and tighten the wire lightly with a tackle.

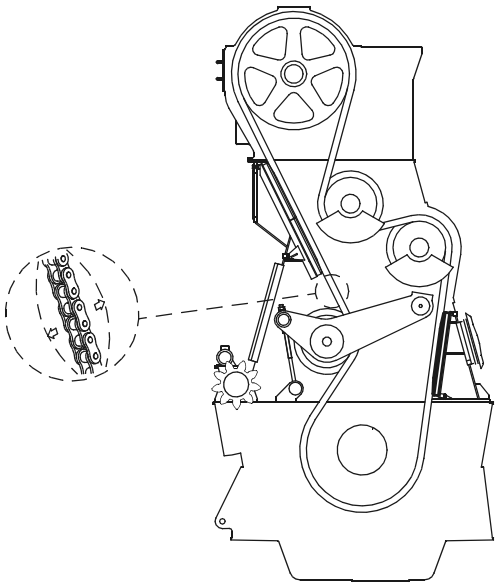
   Protect the link rollers over which the wire is wrapped.

Note!
If the chain is to be completely removed, contact MES for further information.

The riveting of the pins that are to be pressed out is to be or ground away.

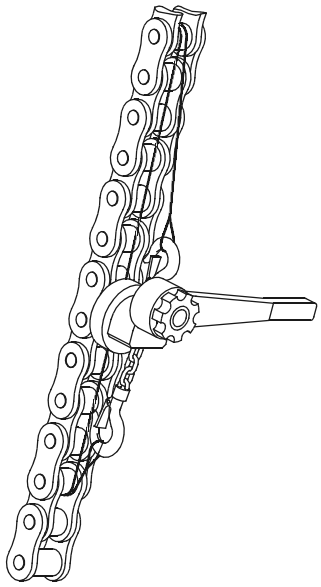
3. Place the chain bursting tool over the outer chain link, and dismantle the link by alternately tightening the screws on the tool.

1.



GN906-1.2 203 01

2.



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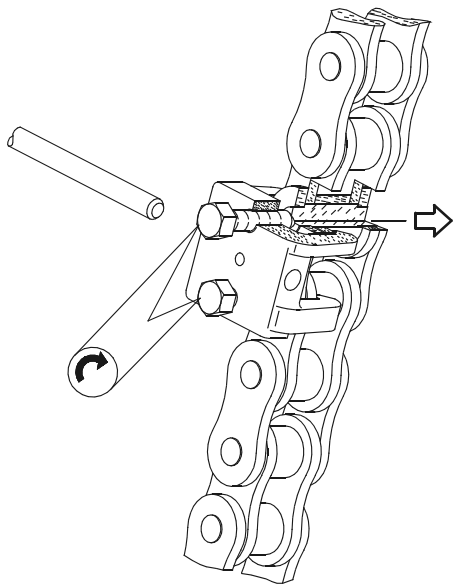

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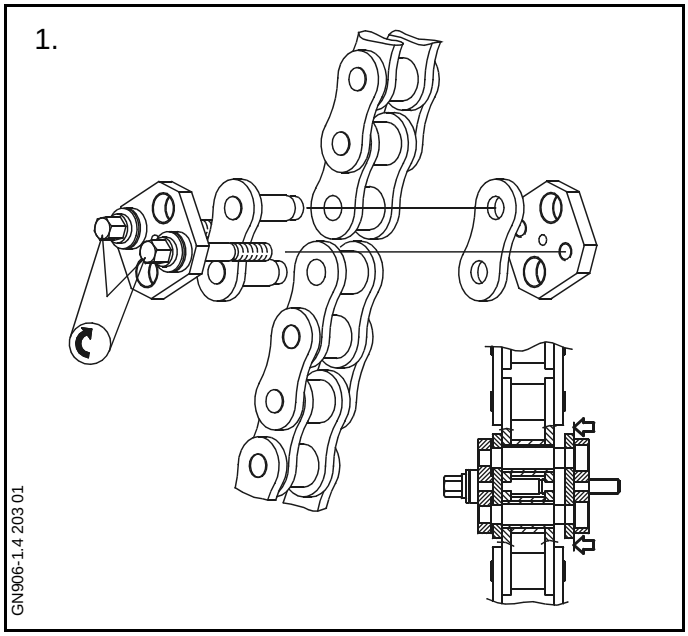


Before assembling the inner and outer links, clean the pins and bushings.

1. Combine the inner chain link with the outer chain link and mount the compression tool.

   Force the loose side plate of the outer link into place by alternately tightening the screws on the compression tool.

2. When the link has been assembled, remove the compression tool and lock the pin ends by riveting.

   Repeat this procedure until the chain has been assembled.

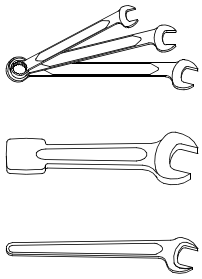
   Remove the tackle and wire and adjust the chain tension.
   (See Data and Procedure 906-2.3).

SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Slippy surfaced and risk of falling (while at wok in crankcase)
X	Block the starting mechanism	
X	Shut off starting air supply	Risk of severe personal injury (while engine being turned)
X	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit
D-1	Clearance	0.1	mm
D-2	Tightening angle (= 12 hexagons)	720	°
D-3	Reduced tightening angle (= 10 hexagons)	600	°
D-4	Max. distance	265	mm

Standard Tools: See Section 913



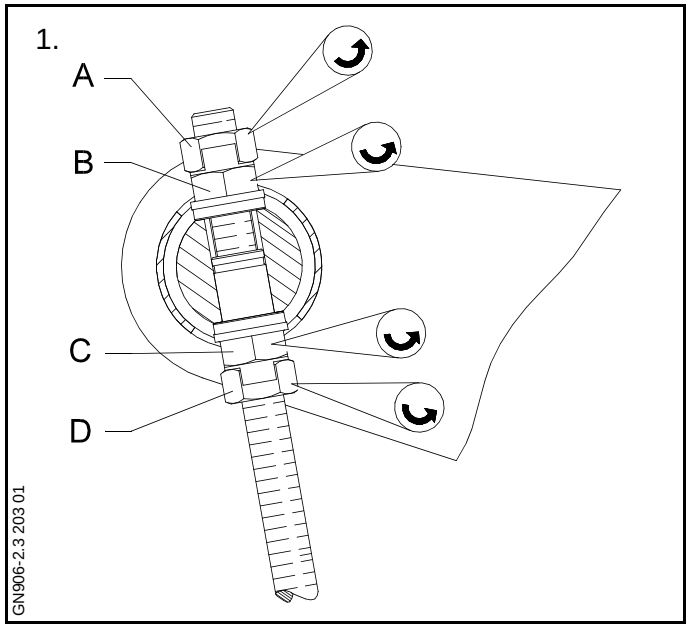
1. To retighten the chains, loosen nuts **A**, **B**, **C** and **D** to free the chain tightener bolt.

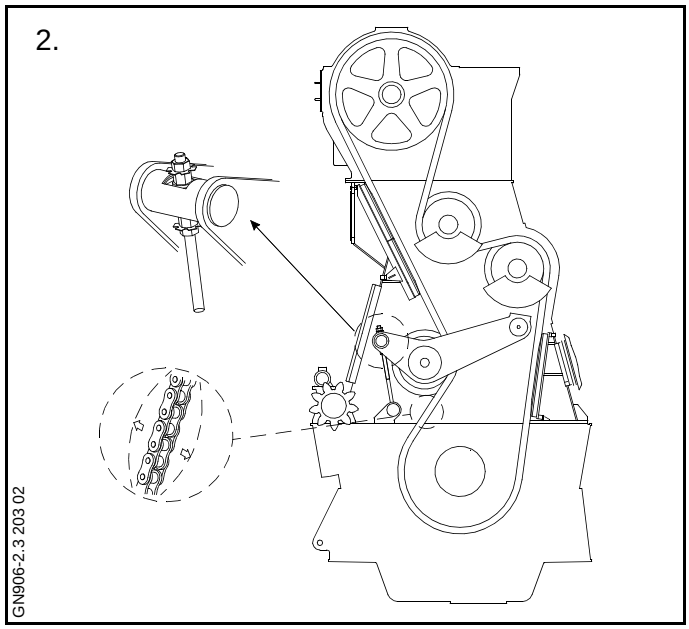
2. Turn the engine so that the slack part of the chains is on the same side as the tightener wheel.

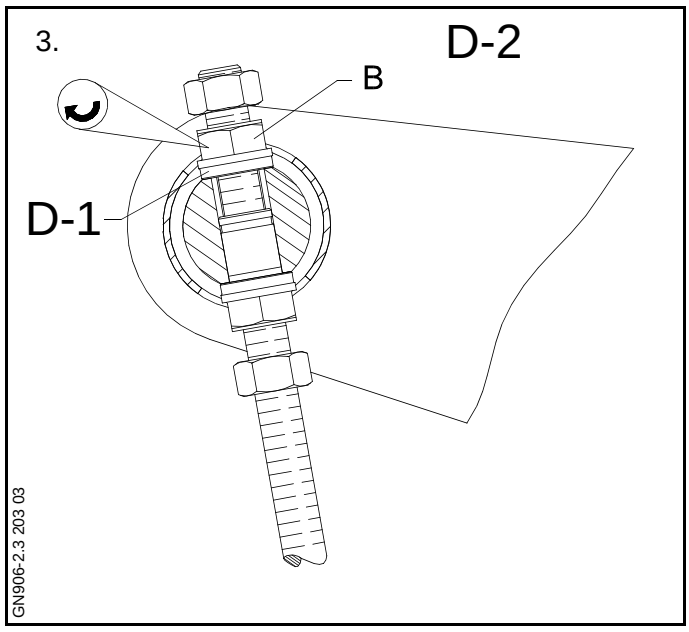
   If balanceweights are mounted, continue the turning until they are hanging vertically downwards.

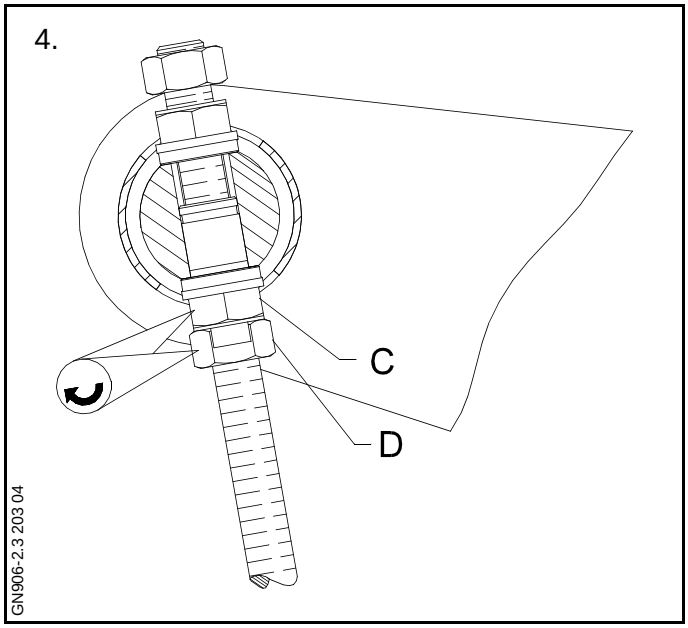
3. With the balanceweights in this position, tighten nut **B** on the chain tightener bolt until there is a clearance between the shaft and the nut as stated in **D-1**.

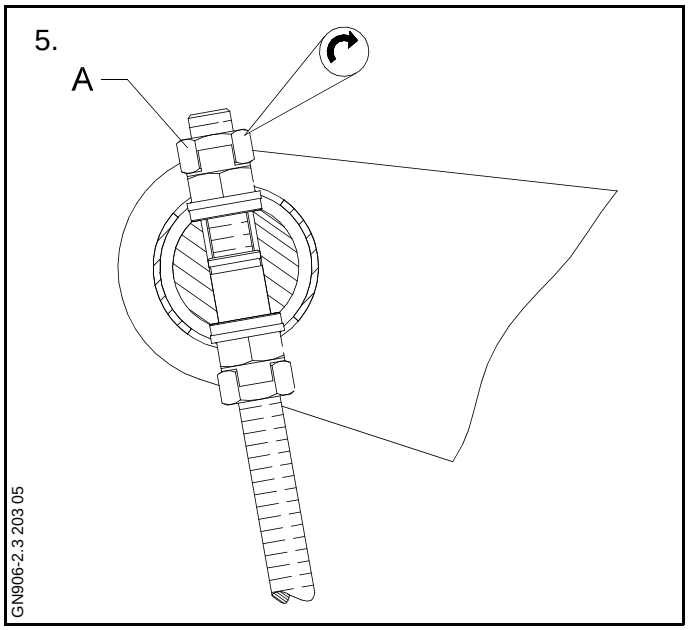
   Then tighten nut **B** as stated in **D-2** *(see Data).*

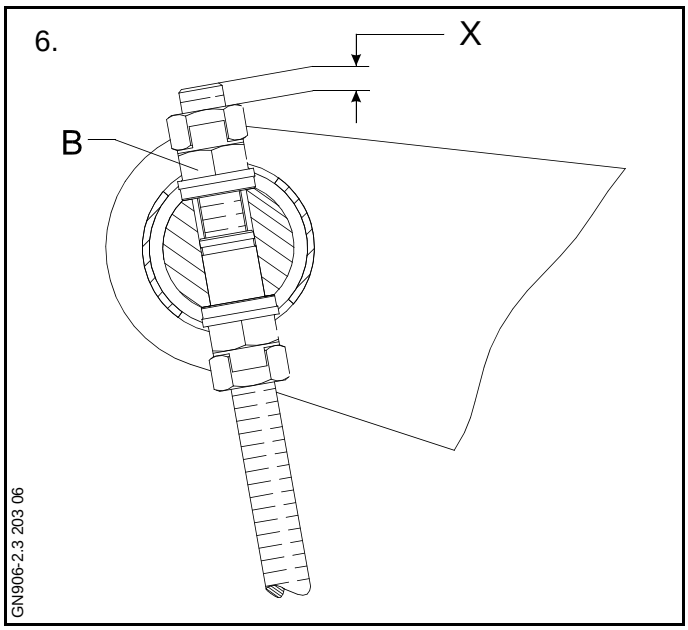












4. Tighten nut **C** hard against the contact face of the shaft.

   Tighten nut **D**.

   Lock nuts **C** and **D** with the tab washer.

5. Tighten nut **A**.

   Lock nuts **A** and **B** with the tab washer.

6. Measure distance **X**.

7. If the chain is worn (**X** >165 mm), repeat the procedure from step 1, but tighten nut **B** only to the reduced tightening angle, *see Data.*

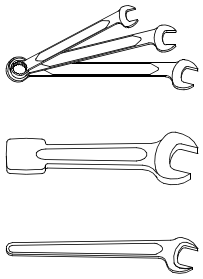
   If distance **X** exceeds the max. distance *(see Data)*, find and eliminate the cause of the abnormal chain elongation, e.g. a defective chain, damaged chain wheels or bearings, etc. Repeat the procedure from step 1.

SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Slippy surfaced and risk of falling (while at wok in crankcase)
X	Block the starting mechanism	Risk of severe personal injury (while engine being turned)
X	Shut off starting air supply	
X	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit
D-1	Clearance	0.1	mm
D-2	Tightening angle (= 7hexagons)	420	°

Standard Tools: See Section 913



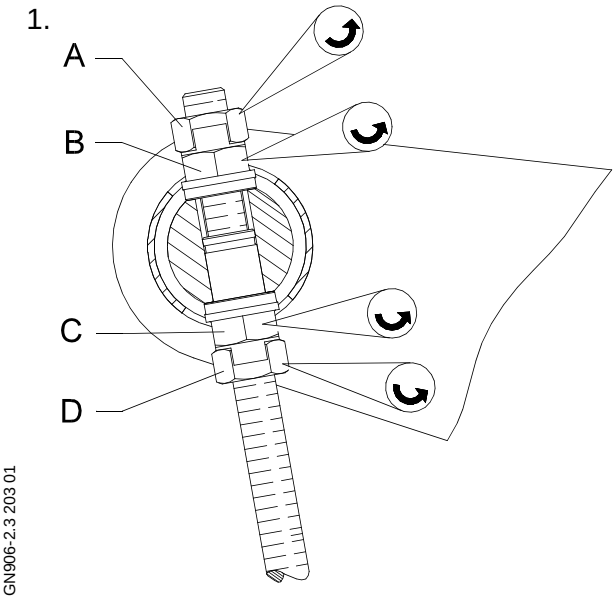
1. To retighten the chains, loosen nuts **A**, **B**, **C** and **D** to free the chain tightener bolt.

2. Turn the engine so that the slack part of the chains is on the same side as the tightener wheel.

3. Tighten nut **B** on the chain tightener bolt until there is a clearance between the shaft and the nut as stated in **D-1**.

   Then tighten nut **B** as stated in **D-2** *(see Data).*
   For chain wear, see Procedure 906-1.1.

1.



GN906-2.3 203 01

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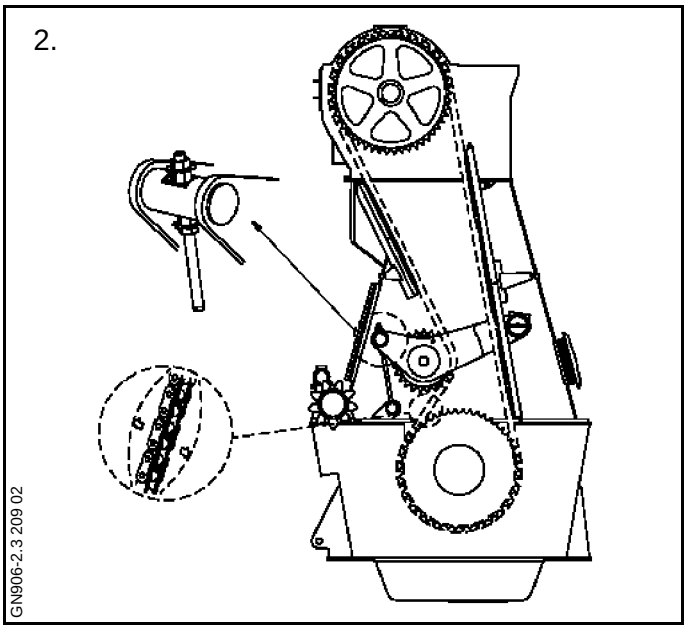

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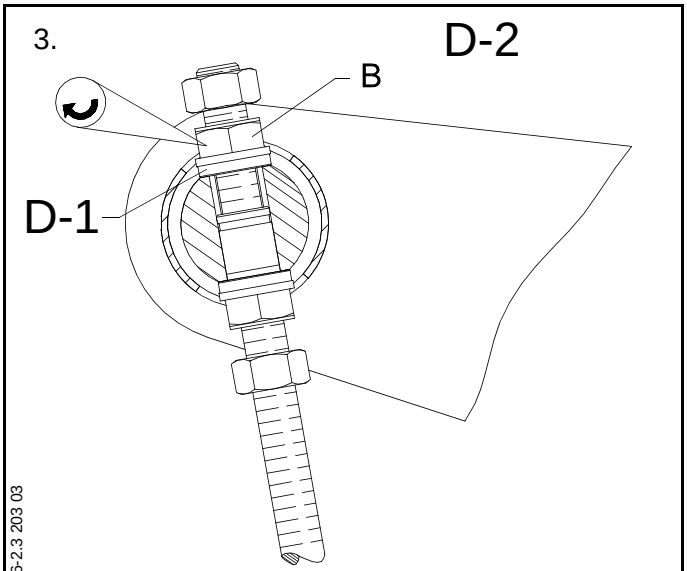
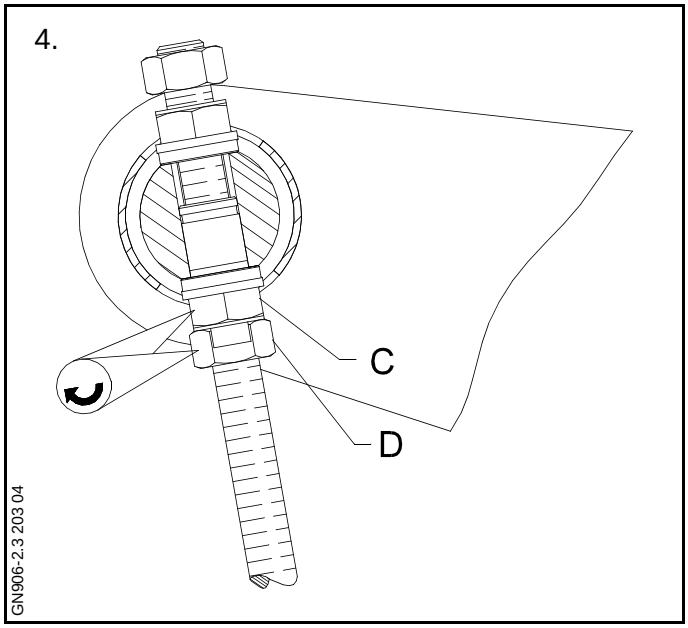
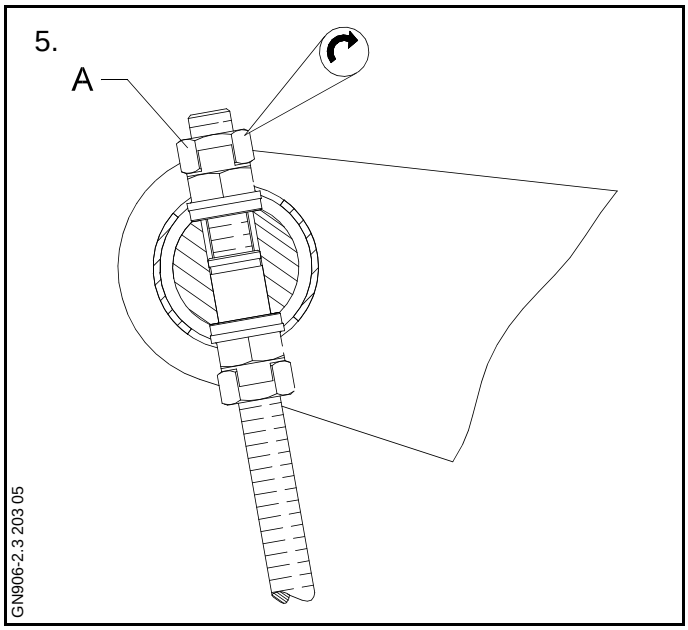
3.



GN906-2.3 203 03





4. Tighten nut **C** hard against the contact face of the shaft.

   Tighten nut **D**.

   Lock nuts **C** and **D** with the tab washer.

5. Tighten nut **A**.

   Lock nuts **A** and **B** with the tab washer.

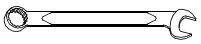
   The number of times that retightening can be carried out depends on when the limit for scrapping the chain has been reached. *See Data page 106-1.*

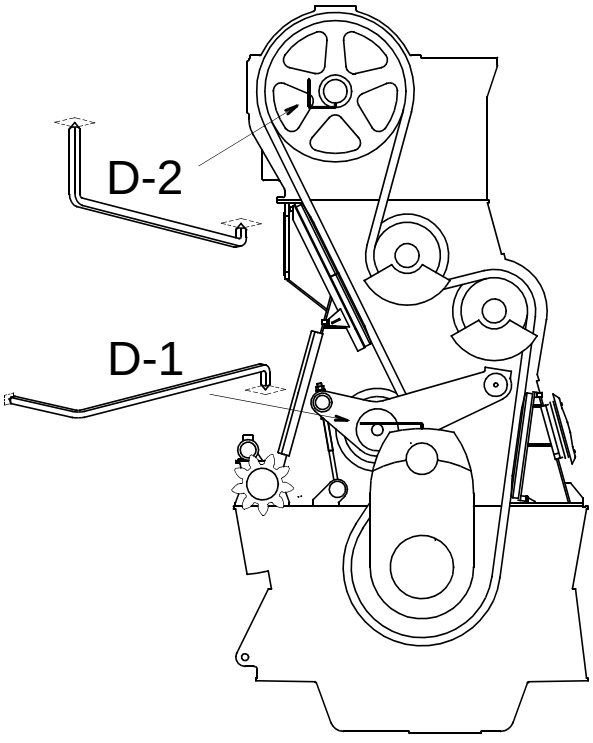
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of severe personal injury (while engine being turned)
X	Block the starting mechanism	
X	Shut off starting air supply	
X	Engage turning gear	
	Shut off cooling water	
X	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit
D-1	Pin gauge for top dead centre of crankthrow No. 1 Check measurement	608	mm
D-2	Pin gauge for camshaft Check measurement	200	mm
D-3	Max. permissible change in lead angle	2	°

Standard Tools: See Section 913





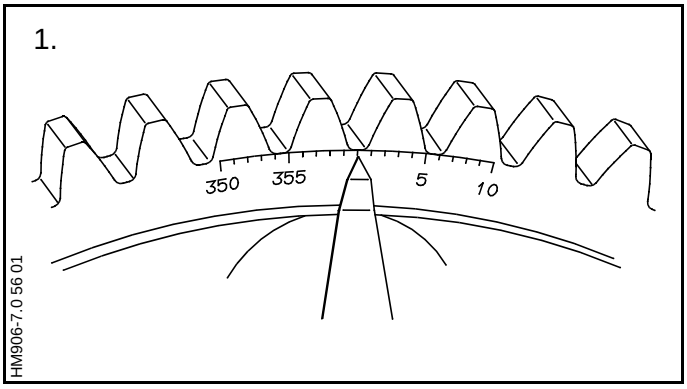
When referring to this page, please quote Data Sheet 106-3 Edition 02M
MITSUI ENGINEERING & SHIPBUILDING CO., LTD.
4E-91308

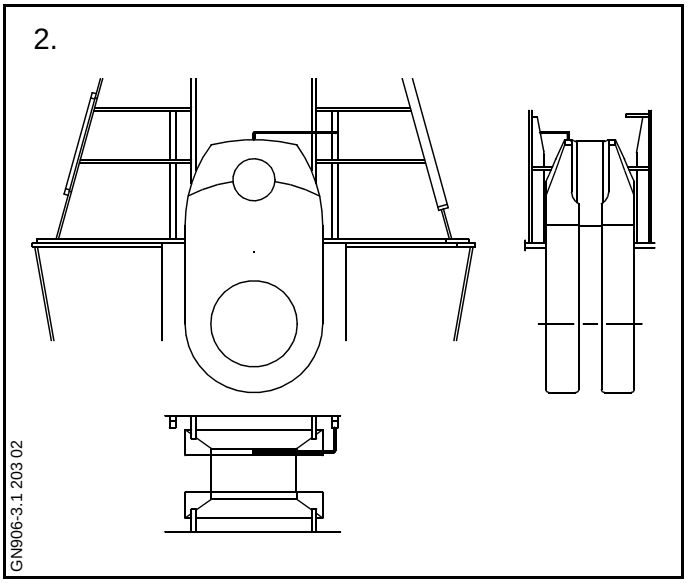
1. Turn the crankthrow for cylinder 1 to TDC.

   Turn in the AHEAD direction to ensure that the tension of the chain on the chain drive is correct. If necessary, adjust the chain tension.
   See Procedure 906-2.3.

   Check the TDC of cylinder 1 against the mark on the turning wheel.

2. Check the TDC position with the pin gauge on the crankthrow, **D-1**.





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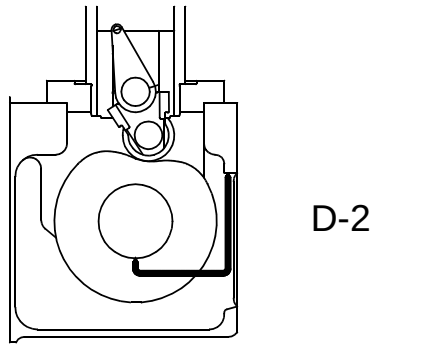
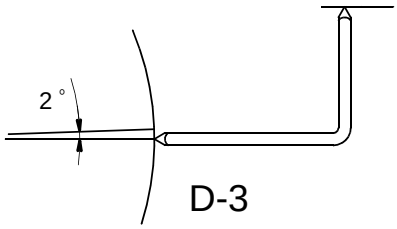


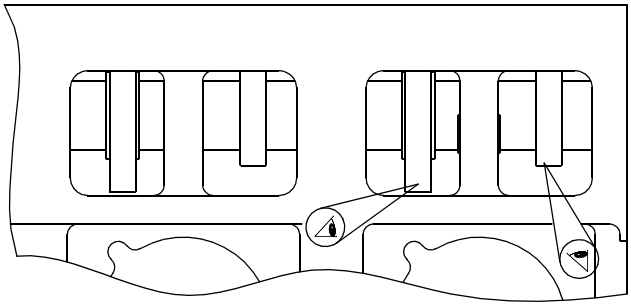
D-2



D-3

GN906-3.1 203 03 L0a

5.



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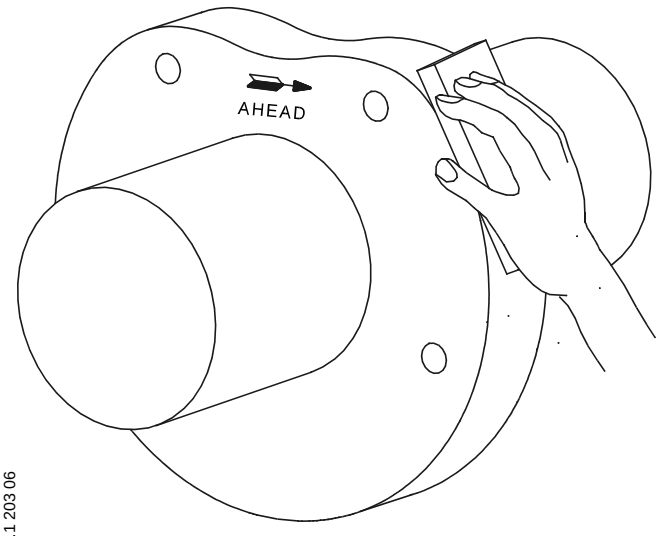
6.



GN906-3.1 203 06

3. Position the camshaft pin gauge in the centre punch mark, and measure the deviation, if any, in lead angle.

   *For max. permissible change, see **D-3.***

4. Check and adjust the cylinder lubricator.
   See Procedure 903-2.1.

   Check the setting of the starting air distributor.
   See Procedure 907-1.1.

5. When checking the camshaft position, also check the running surface of the cams.

   As the inspection must include the entire surface of the cam, the cam should be turned the whole way round during the inspection.

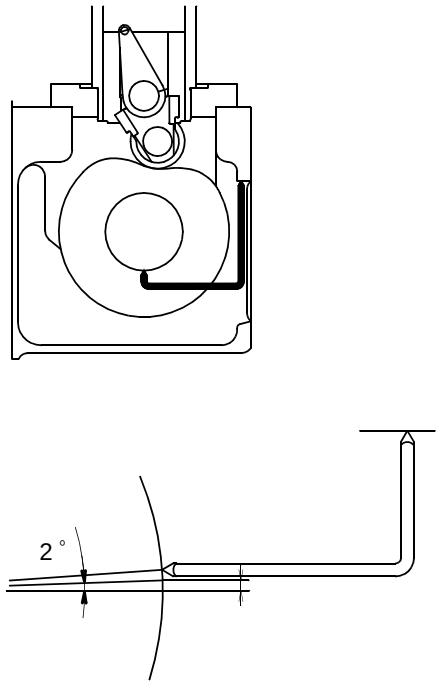
   The running surface of the cam must be completely smooth and bright.

6. If light scratches are ascertained, remove them by carefully polishing the cam in the direction of rotation with a fine carborundum stone. Such light scratches can appear if the roller guide and the cam are not correctly aligned.

   In the event of heavier scratches or direct flaking of the material on the running path, MES Diesel should be contacted for further instructions.

1. If the chains prove to be so heavily worn that the deviation between the measuring points and the pin gauge has reached the maximum value stated in Procedure 906-3.1, MES should be contacted for further instructions.

1.

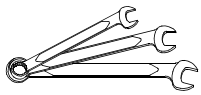


SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of high pressure oil
X	Block the starting mechanism	Do not enter area when over head lifting is being carried out
X	Shut off starting air supply	
X	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

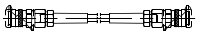
Data

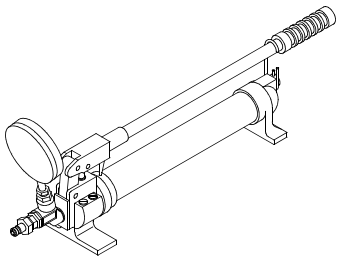
Ref.	Description	Value	Unit
D-1	Weight of bearing cap	12.8	kg
D-2	Tightening torque – screws for bearing cap	125	Nm
D-3	Clearance between cap/ bearing housing	3+/-0.3	mm
D-4	Max. wear on bearing shell	0.10	mm

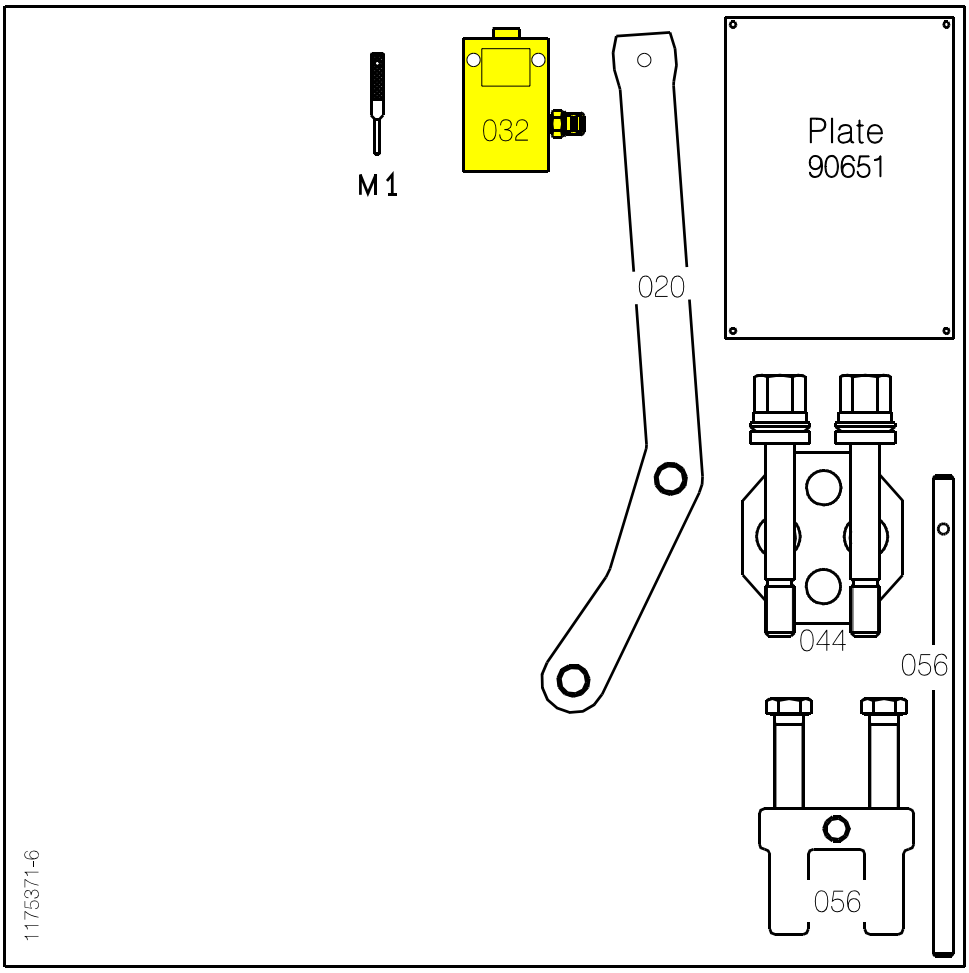
Standard Tools: See Section 913



100-750 Nm



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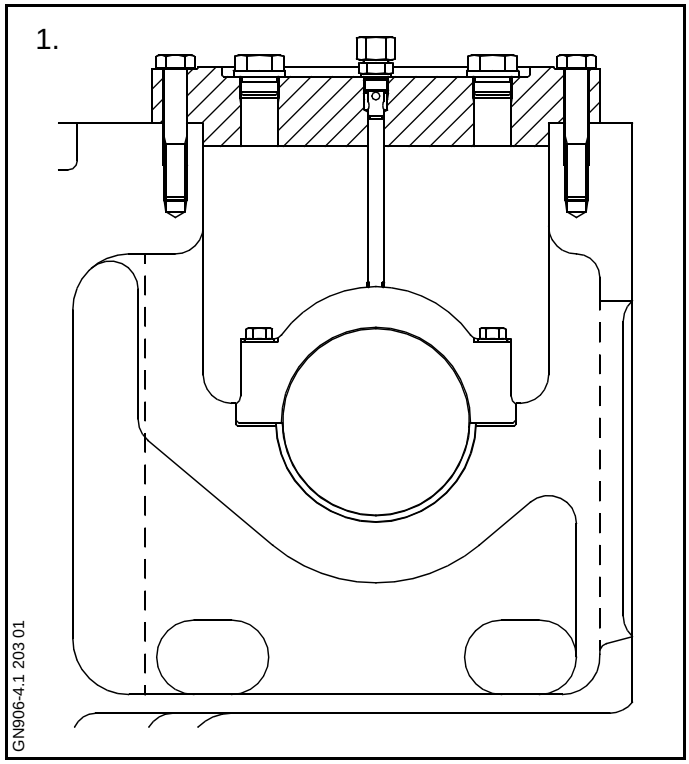
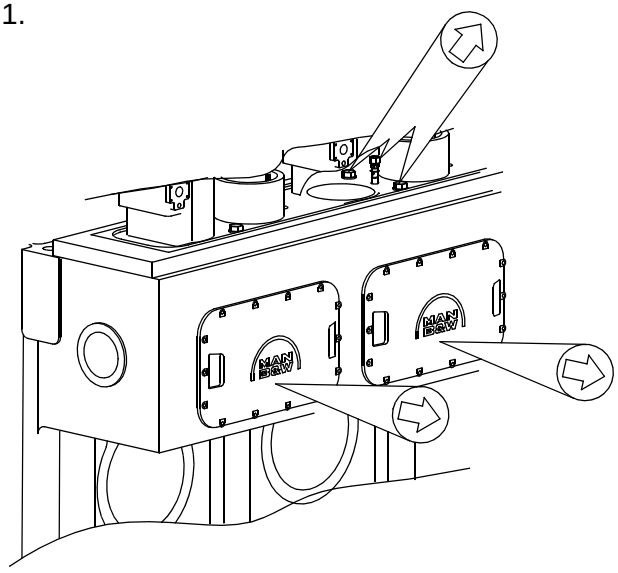
1. Dismount the inspection covers from the front of the camshaft housing.

   Check for wiped-out metal at the bearing ends, and for fragments of metal in the camshaft housing. In the event of any signs of anomalies, the bearing shell must be dismantled for closer investigation and, if necessary, the bearing shell must be replaced.

   If no anomalies are found during the visual inspection, dismantling need only be carried out in connection with Class surveys.

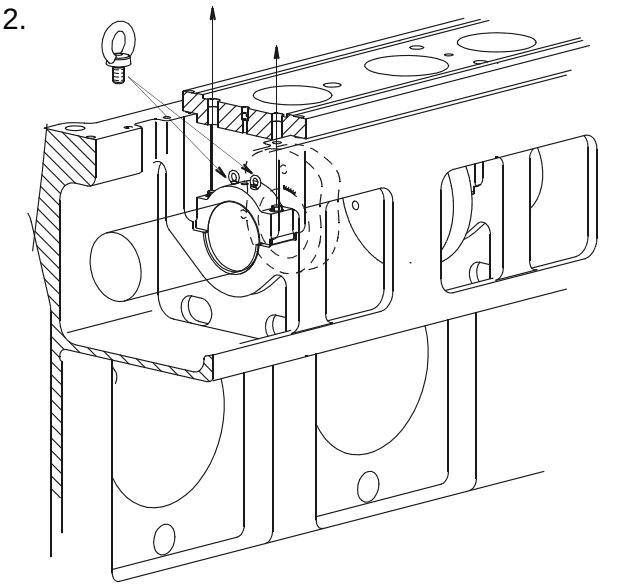


1.



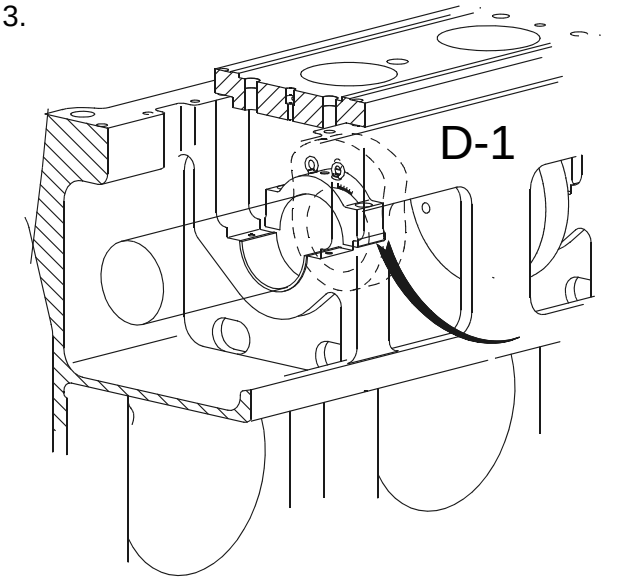
GN906-4.2 203 01

2.



GN906-4.2 203 02

3.



GN906-4.2 203 03

Warning!

Before dismantling any camshaft bearings, the main chain **must** be relieved of tension by loosening the chain tightener to avoid damaging engine parts.

See Procedure 906-2.3.

1. Remove the inspection cover from the camshaft housing.

   Dismount the lubricating oil connecting pipe and the plug screws from the baseplate over the bearing in question.

   Lift the roller guide of the exhaust valve hydraulic pump.
   See Procedure 908-7.

2. Loosen the bearing cap screws through the holes in the baseplate.

   Remove the screws from the bearing cap.

   Mount two 10 mm eye bolts in the pertaining threads on top of the bearing cap.

3. Slide the bearing cap carefully towards the exhaust cam disc.

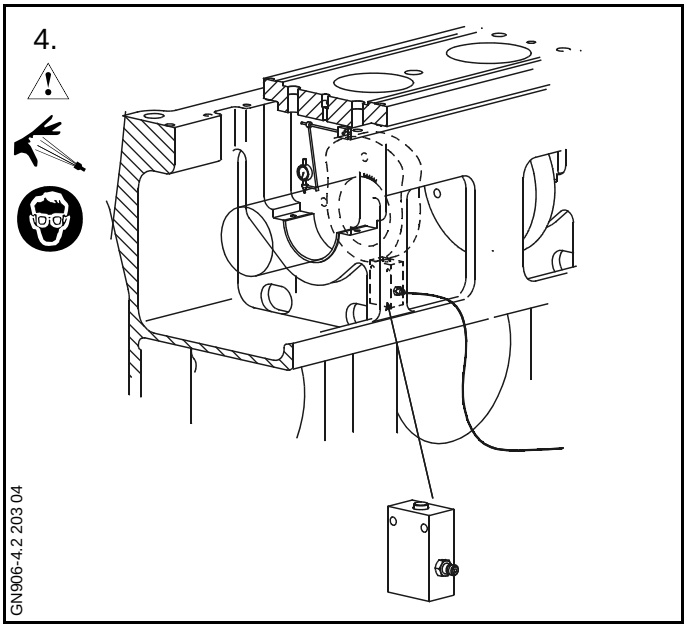
   Turn the bearing cap and pull it out through the inspection opening.

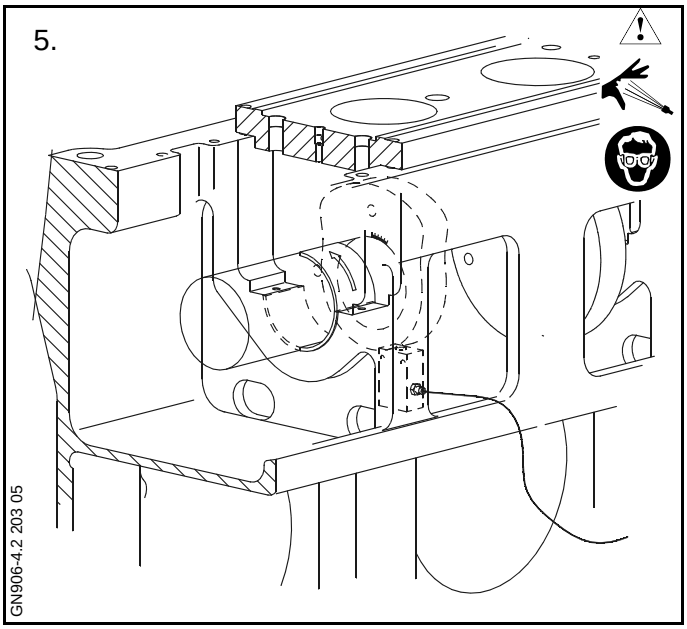
4. Place the hydraulic jack in the camshaft housing underneath the circular part of the exhaust cam.

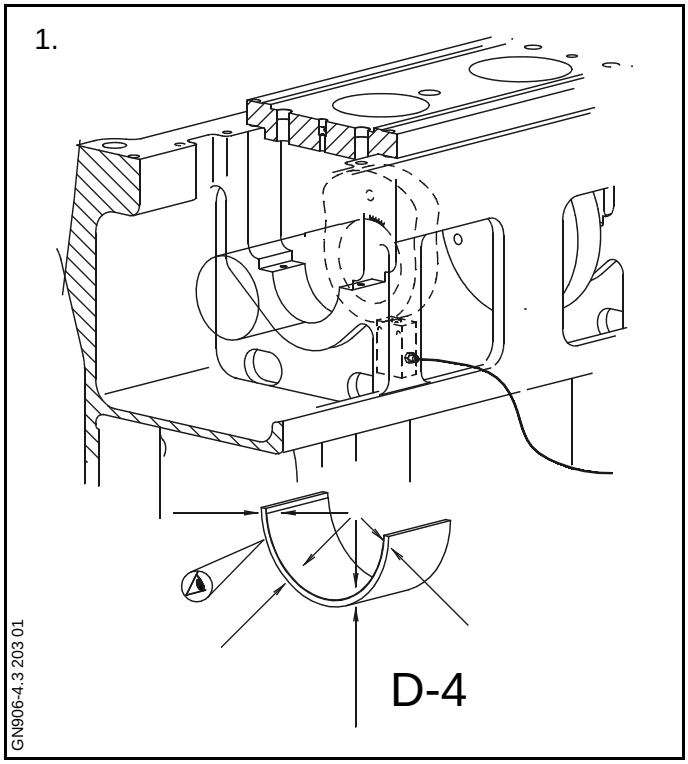
   Place a dial gauge on the camshaft, and lift the camshaft 0.30 mm.

5. Press lightly on the upper edge of the shell to turn the shell up over the camshaft.

   Remove the shell from the camshaft housing.







1. For assessment of the bearing condition, *see Volume I operation, Chapter 708 'Bearings'.*

   Inspect the entire surface of the bearing journal for seizures.

   If seizures are found on the bearing journal surface (on account of bearing breakdown), polish the surface with a fine carborundum stone to re-establish a bright and smooth surface.

   By closely examining the sliding surface of the bearing shells visually, an impression can be formed of whether the lubrication of the bearing surface has been insufficient or entirely missing. Normally, camshaft bearing damage only occurs due to faulty lubrication.

   Measure the thickness of the bearing shell with a micrometer to check the amount of wear.

1. Clean the bearing journal, the bearing support and the bearing shell.

2. Coat the bearing shell with oil, mount the shell on the camshaft, and turn it into place.

3. Place the bearing cap on the camshaft next to the exhaust cam.

Note!
Be careful not to scratch the exhaust cam roller surface.

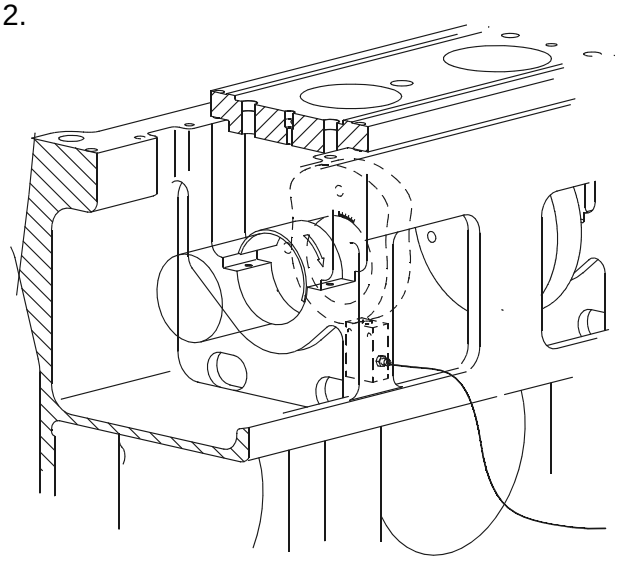
Turn the bearing cap to an upright position and slide it carefully onto the bearing shell.

Remove the eye bolts and mount the outermost bearing cap screw.

4. Tighten the outermost screw lightly until the clearance given in D-3 is reached. Then mount and tighten the innermost screw with a torque spanner. See Data D-2. This procedure ensures that the outermost screw will obtain the correct torque.

Check the torque on the outermost screw with a torque spanner.

2.



GN906-4.4 203 02

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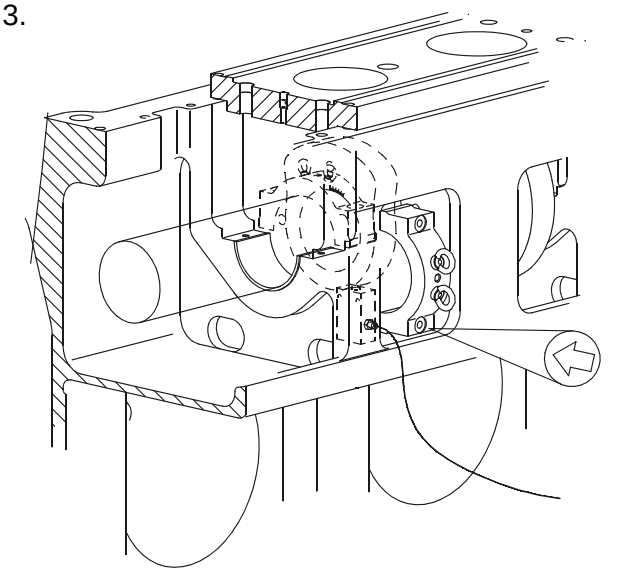

GN906-4.4 203 03

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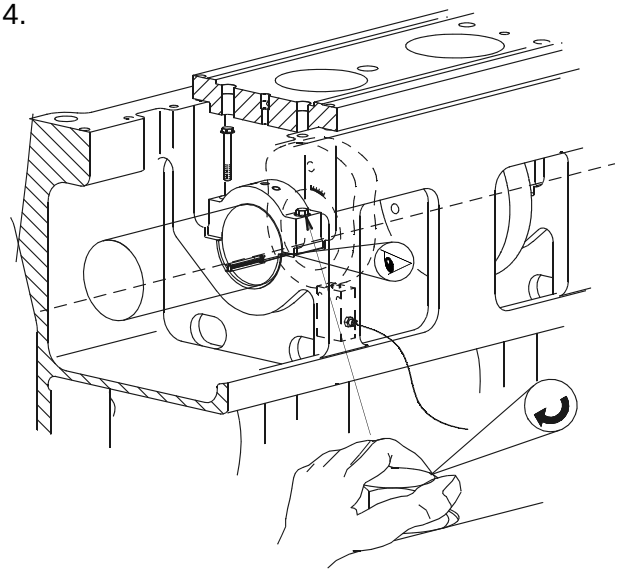

GN906-4.4 203 04

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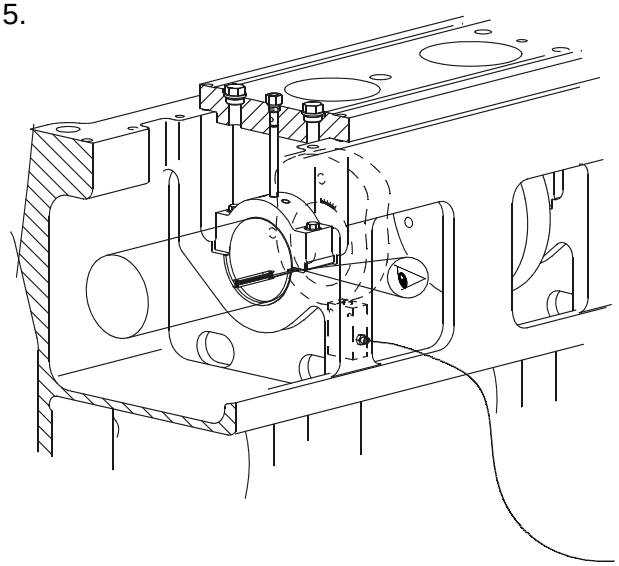

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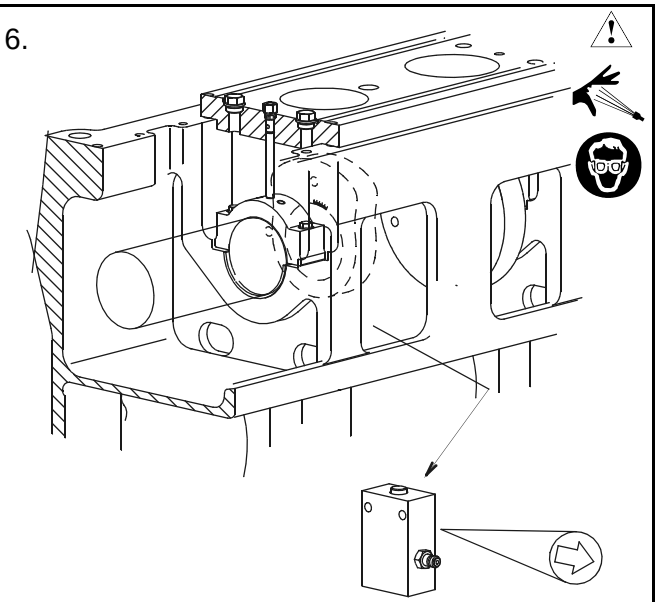

GN906-4.4 203 06

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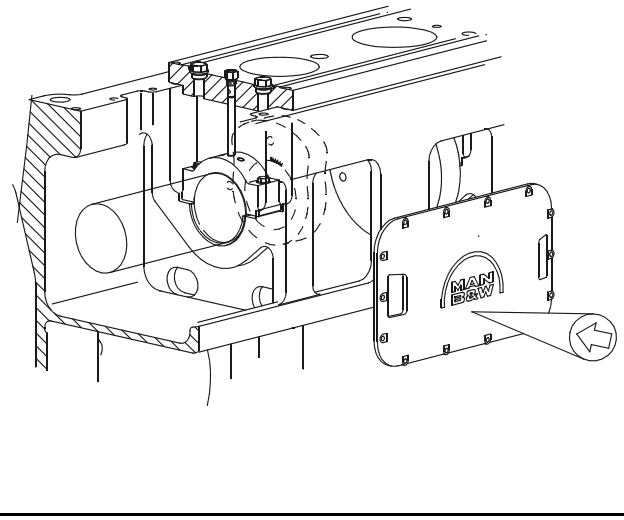


GN906-4.4 203 07

5. Check the clearance D-3. Then mount the lubricating oil pipe and the plug screw in the baseplate.

6. Lower the camshaft into position. Remove the hydraulic jack from the camshaft housing.

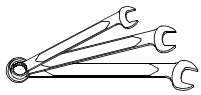
7. Clean the camshaft housing and mount the inspection covers.

SAFETY PRECAUTIONS

X	Stopped engine
X	Block the starting mechanism
X	Shut off starting air supply
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Shut off lubricating oil
	Lock turbocharger rotors

Data

Standard Tools: See Section 913



If dismantling has been necessary, the flyweights must be assembled in the correct position in relation to the engine crankshaft. Incorrectly mounted flyweights can cause (heavy) vibrations of the engine.

Note!
The following applies to a **clockwise-rotating** engine

Aftmost 2nd Order Moment Compensator

Turn the crankthrow of cylinder No. 1 in the AHEAD direction to the position shown in the figures for 4, 5, 6-cylinder engines, respectively.
Check that the flyweights point vertically downwards (max. deviation one-half chainwheel tooth pitch).

Turn the camshaft relative to the crankshaft in accordance with the 'valve opening diagram', and then mount the chain.
Tighten the chain in accordance with the instruction.
See Procedure 906-2.3.

Turn the crankthrow of cylinder No. 1 in the AHEAD direction to TDC and carry out fine adjustment of the camshaft.

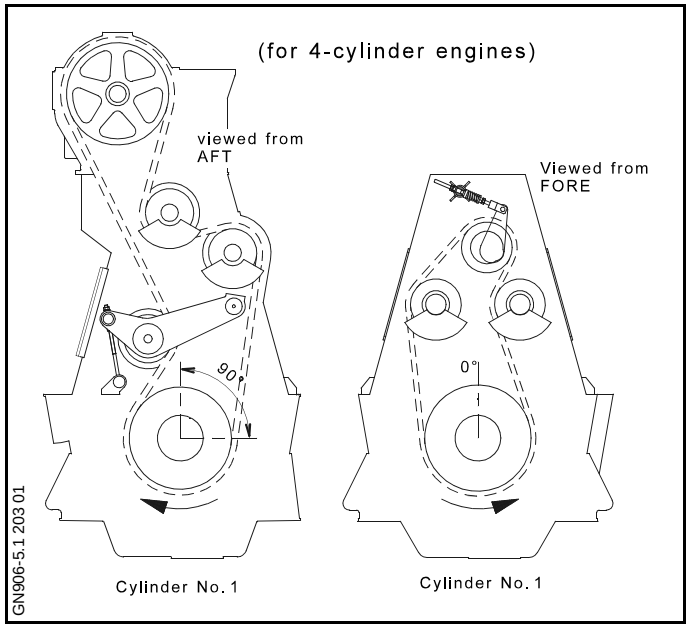
Foremost 2nd Order Moment Compensator

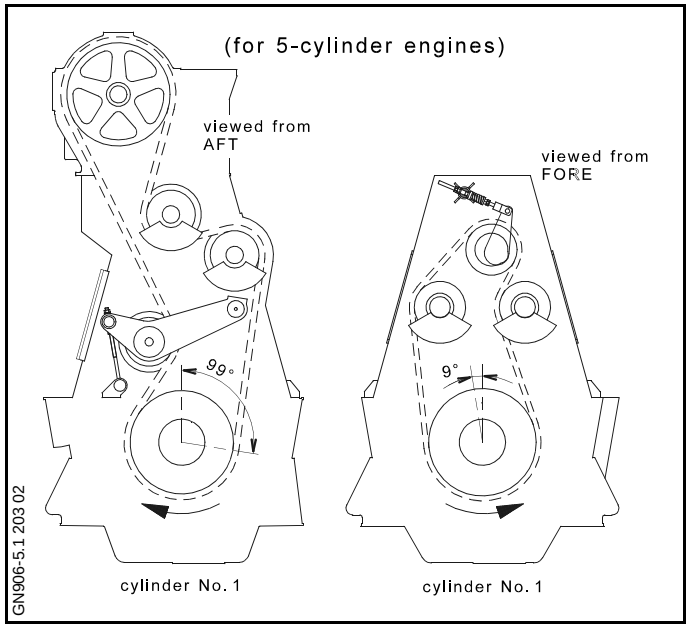
Turn the crankthrow of cylinder No. 1 in the AHEAD direction to the position shown in the figures for 4, 5, 6-cylinder engines, respectively.

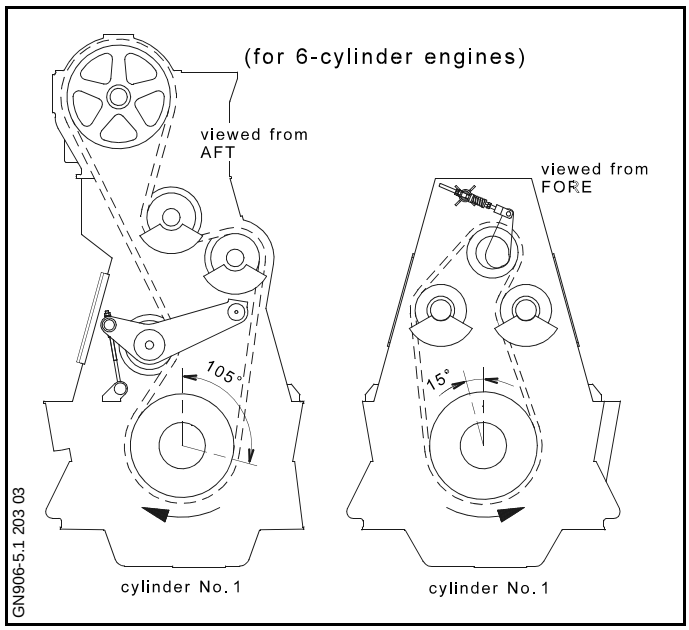
Check that the flyweights point vertically downwards (max. deviation one-half chainwheel tooth pitch) and then mount the chain.

Tighten the chain in accordance with the instruction.
See Procedure 906-5.3.

Note!
For an **anticlockwise-rotating** engine, the degrees mentioned in the respective figures must be **before** TDC, not **after** TDC.







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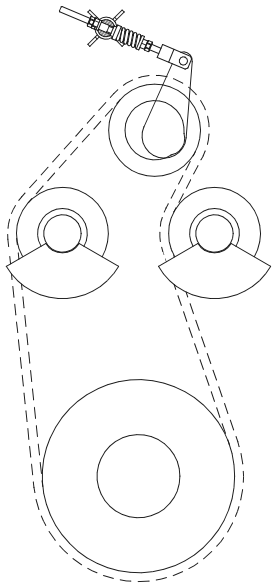

GN906-5.3 203 01

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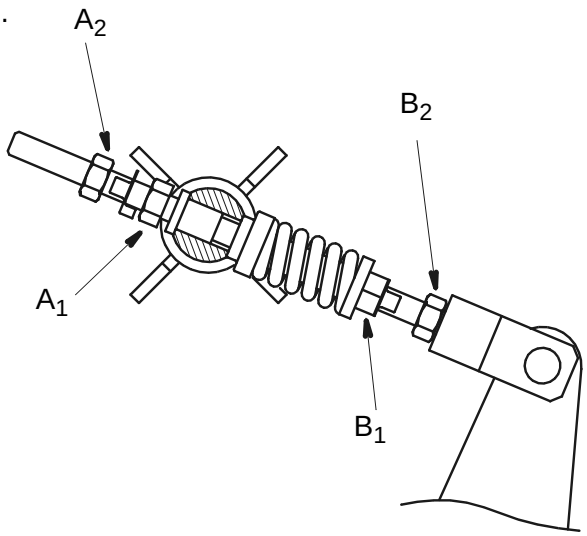

GN906-5.3 203 02 L0a

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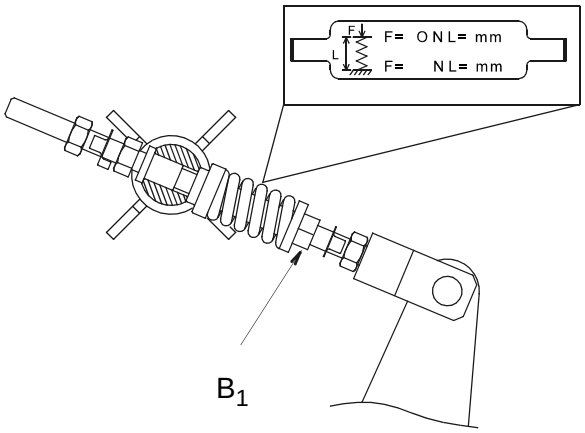


GN906-5.3 203 03

1. When tightening the chain, bring the two flyweights to a vertical downward position.

2. Release the lock washers and loosen nuts **A1**, **A2**, **B1** and **B2**.

3. Tighten nut **B1** until the length of the spring matches the number of mm indicated on the dataplate mounted on the spring, (F=11800 N L=xxx mm).

4. Tighten nut **A1** lightly.

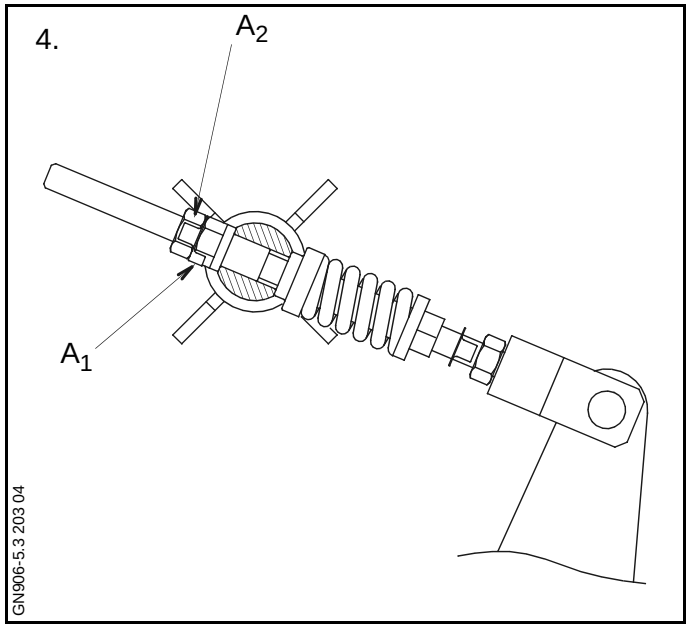
   Make sure that this does not compress the spring further.

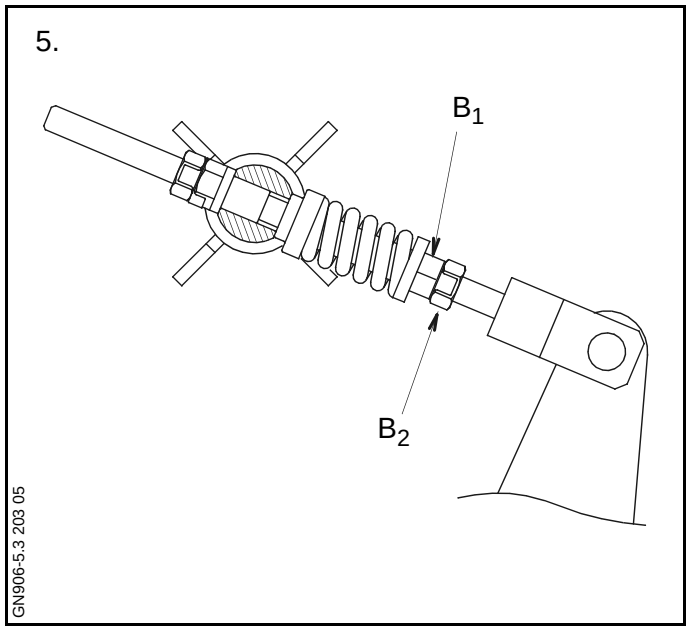
   Tighten nut **A2** while holding nut **A1** with a spanner.

   Lock both nuts with the lock washer.

5. Tighten nut **B1** until the thrust flange of the spring lies hard against the distance tube.

   Tighten nut **B2**, and lock both nuts with the lock washer.





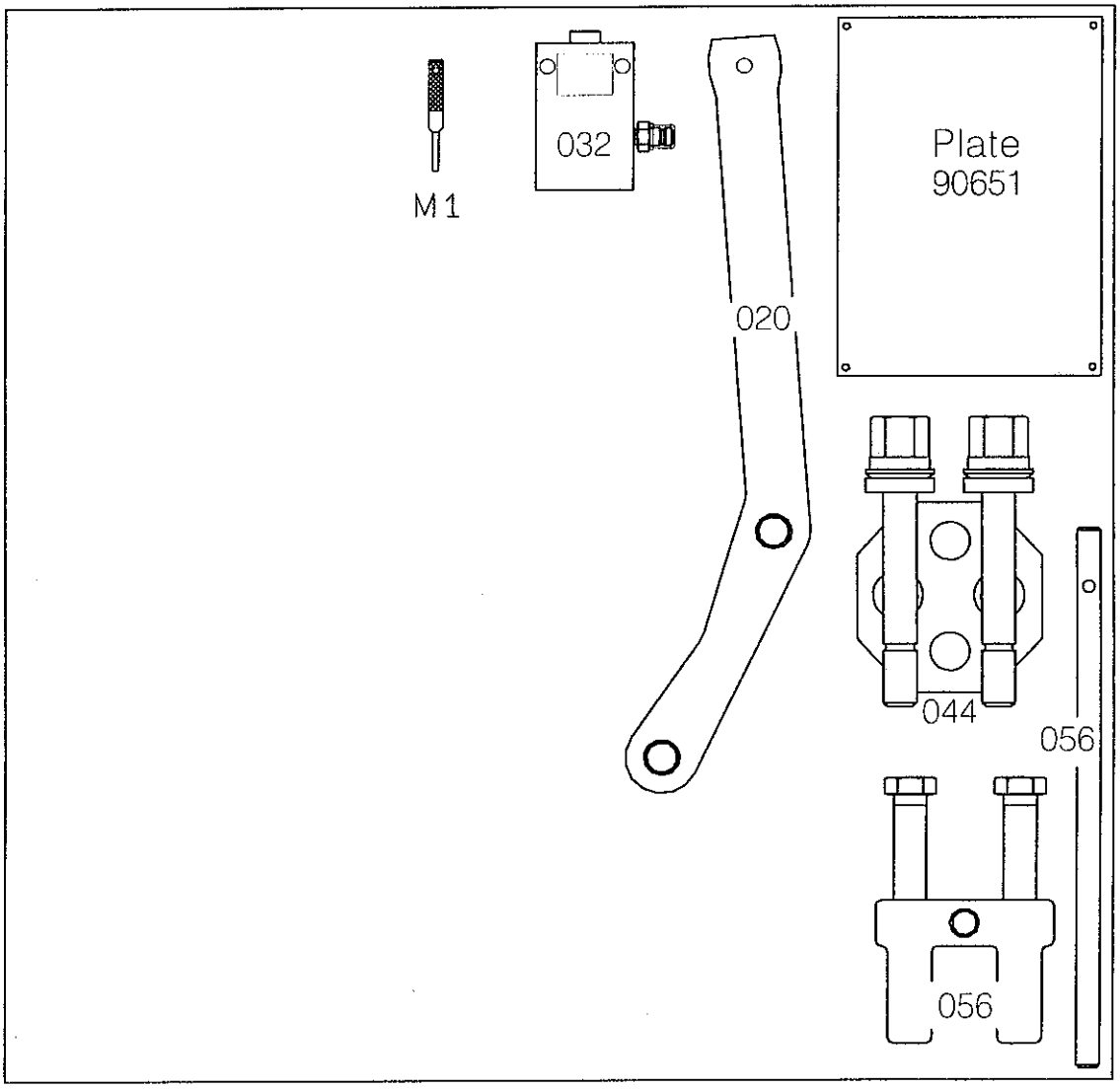

M1
032
020
Plate
90651
044
056
056

Plate 90651-128M Chain Drive and Camshaft Panel

Item No.	Part Description	MES Tools No.	
019	Tool panel *)	(P906)	
020	Pin spanner	06A85	
032	Hydraulic jack for lift for camshaft	06A06	
044	Chain assembling tool	06B52	
056	Chain disassembling tool	06B51	
M1	Test pin for starting air distributor	07C71	
019-M1	*) Tool panel, complete with tools	-	
	*) Optional extras		

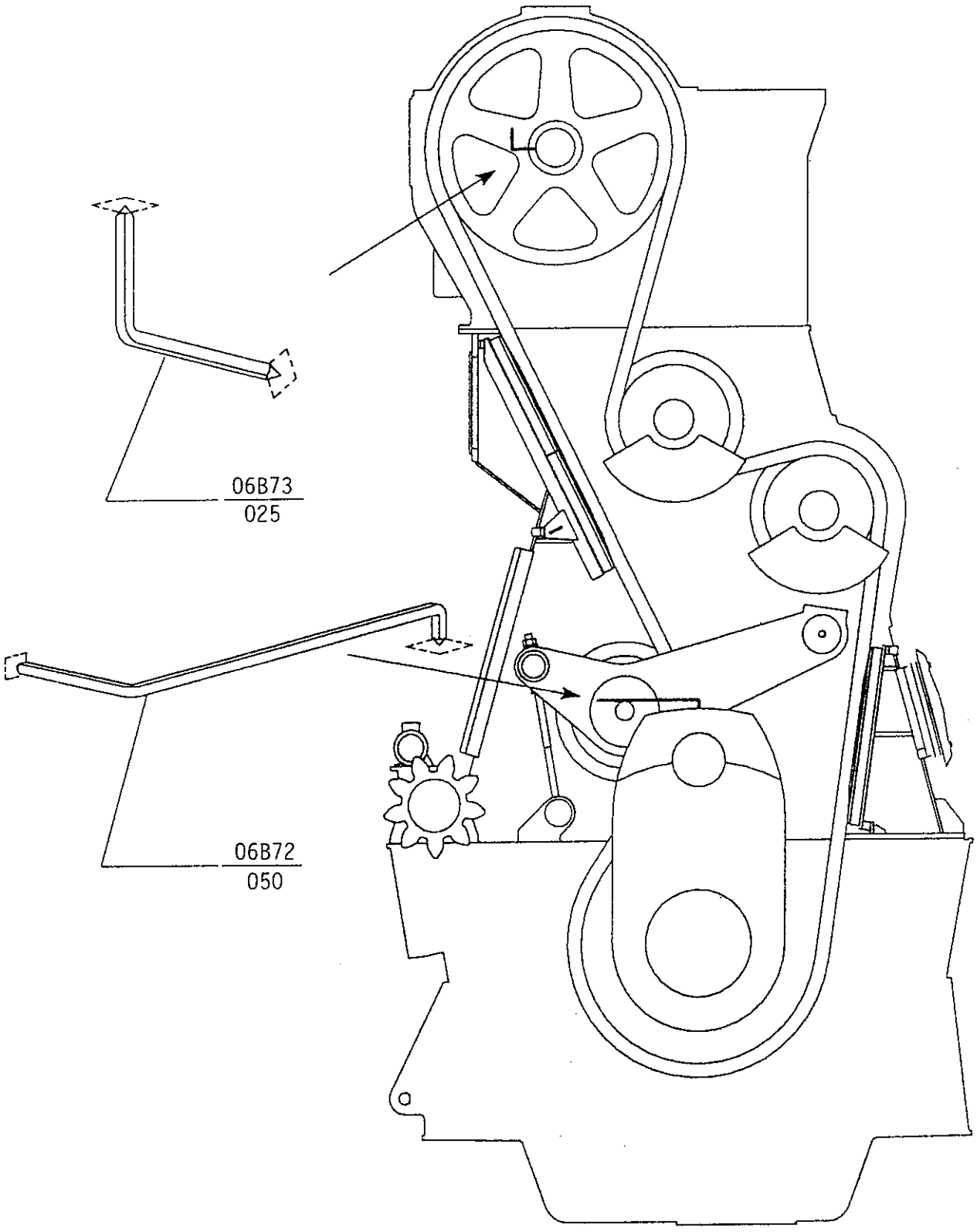
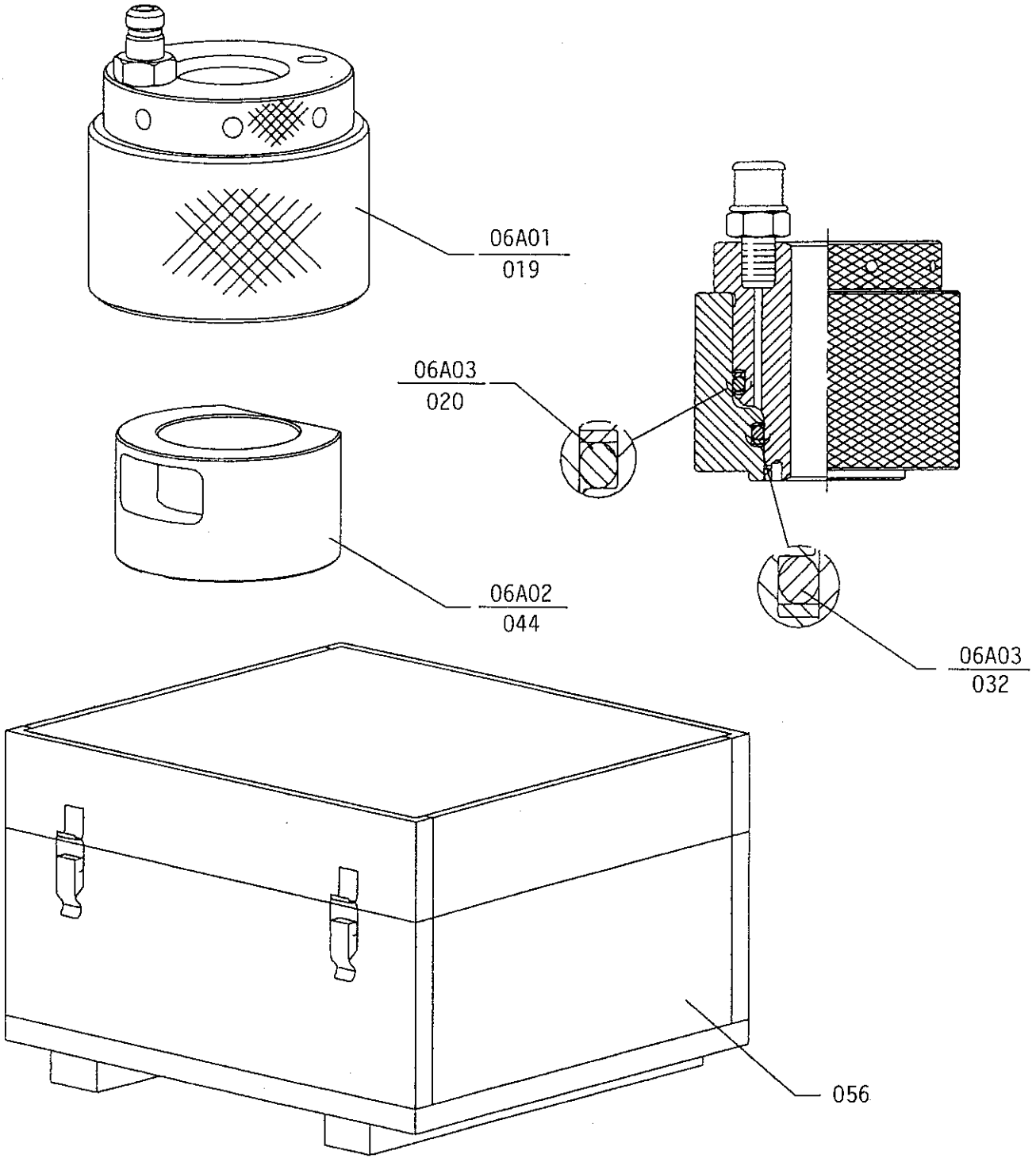

06B73
025
06B72
050

Plate 90661-47M Camshaft - Tools

Item No.	Part Description	MES Tools No.	
025	Pin gauge for camshaft	06B73	
050	Pin gauge for crankshaft	06B72	



4E-91308

Plate 90662-40M Camshaft - Tools

Item No.	Part Description	MES Tools No.	
019	Hydraulic jack	06A01	
020	O-ring with back-up ring	06A03	
032	O-ring with back-up ring	06A03	
044	Spacer ring	06A02	
056	Hydraulic tool for camshaft bearing, complete	-	

INDEX

CYLINDER COVER

PISTON WITH ROD AND STUFFING BOX

CYLINDER LINER AND
CYLINDER LUBRICATION

CROSSHEAD WITH CONNECTING ROD

CRANKSHAFT, THRUST BEARING
AND TURNING GEAR

MECANICAL CONTROL GEAR

STARTING AIR SYSTEM

EXHAUST VALVE

FUEL OIL SYSTEM

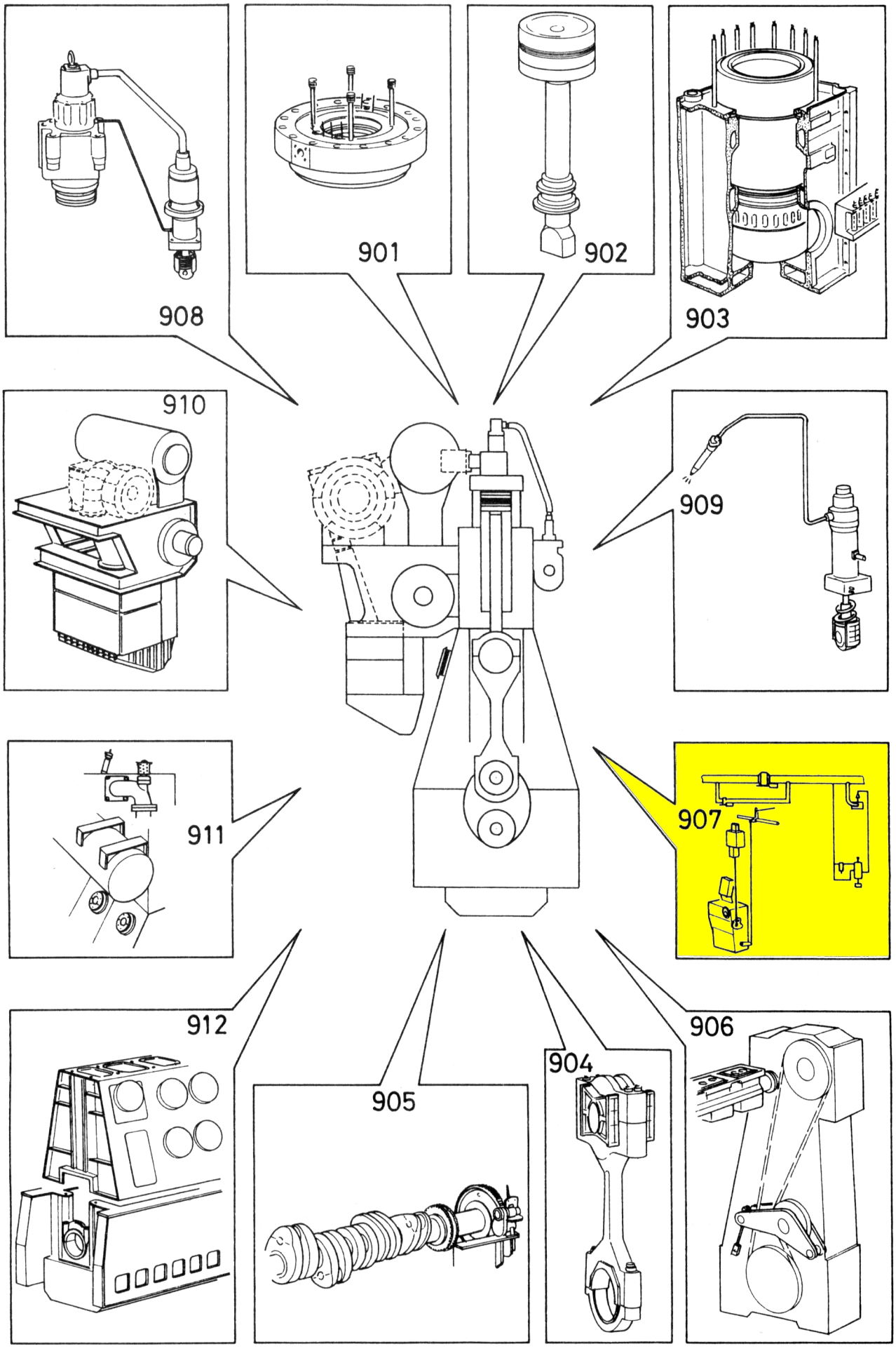
TURBOCHARGER SYSTEM

SAFETY EQUIPMENT

ASSEMBLY OF LARGE PARTS

GENERAL TOOLS

MITSUI
MAN
B&W

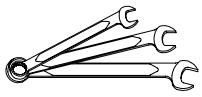


SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of high pressure oil
X	Block the starting mechanism	Risk of severe personal injury (while engine being turned)
X	Shut off starting air supply	
X	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

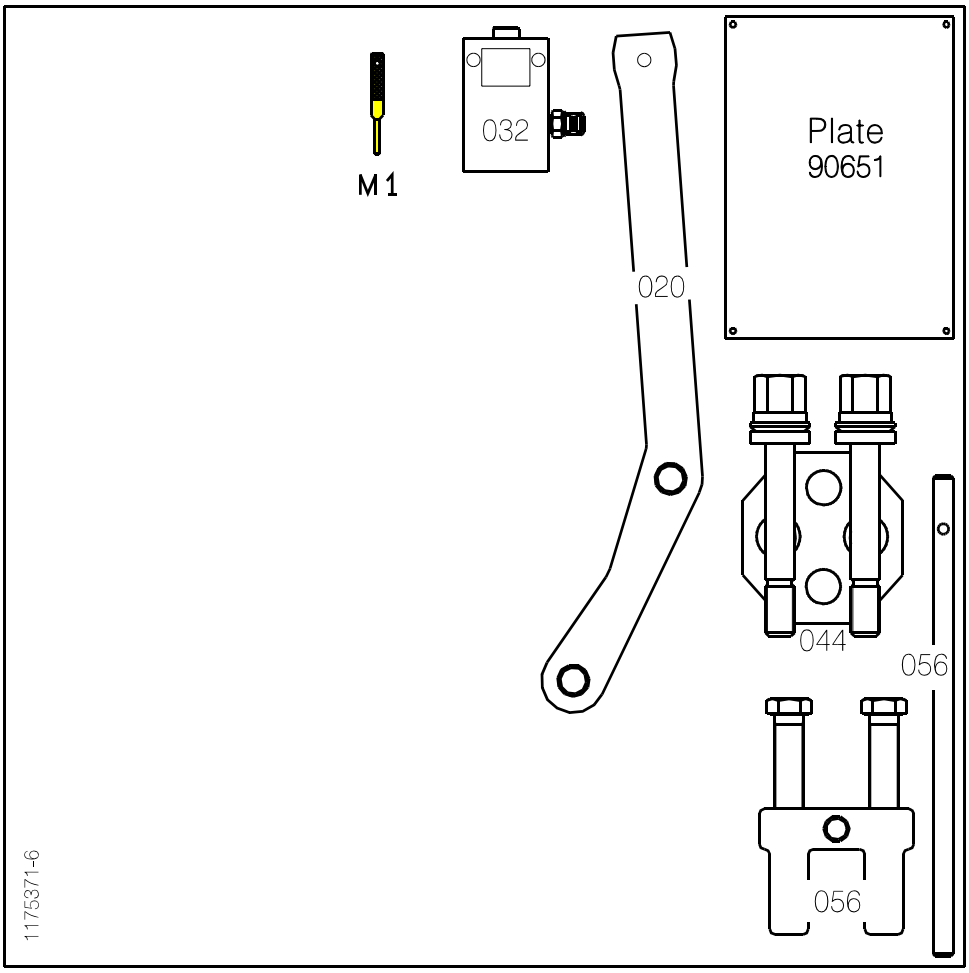
Data

Ref.	Description	Value	Unit
D-1	Clearance between gear wheel and bushing:		
	Min.	0.9	mm
	Max.	1.6	mm
D-2	Tightening torque – gear wheel on camshaft	90	Nm

Standard Tools: See Section 913



40-280 Nm


M1
032
020
Plate
90651
044
056
056
11753371-6

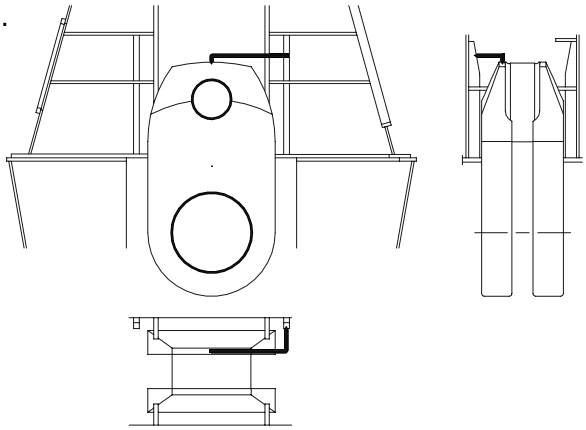
1. Turn the engine in AHEAD direction to bring the piston of cylinder No. 1 to TDC.

   Check with the pin gauge.

2. Remove the plug screw and gasket from the side of the distributor housing, and insert check pin **K** in slot **S**.

3. If the check pin cannot enter the slot, i.e. if the slot is not aligned with the hole in the distributor housing, the air distributor must be adjusted.
   See Procedure 907-1.3.

1.



GN906-3.1 203 02

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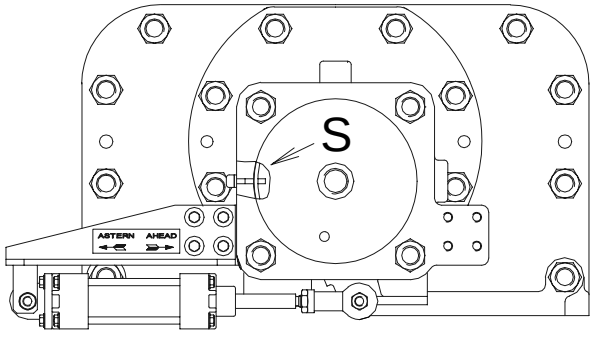

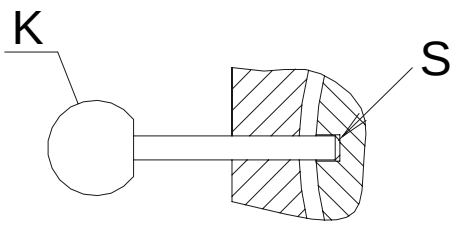

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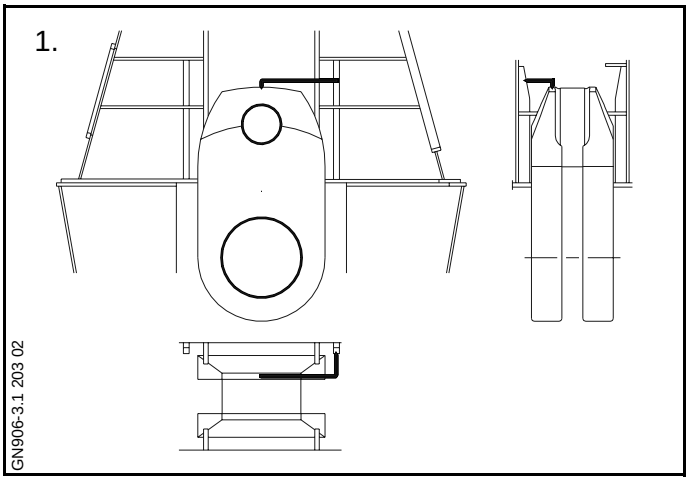
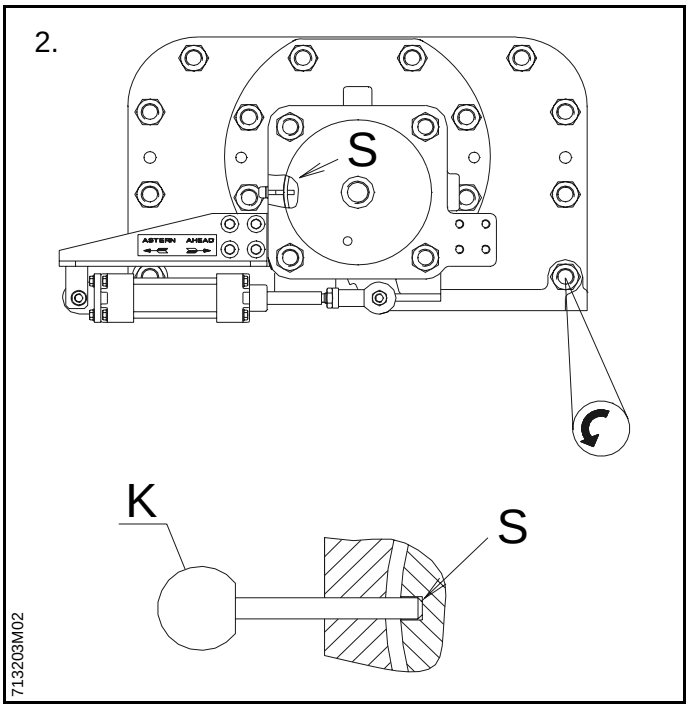
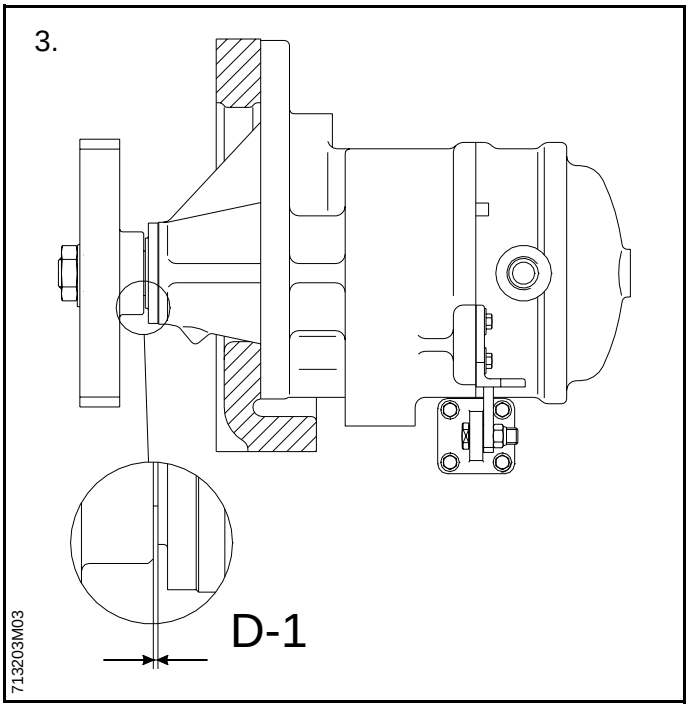






1. Turn the engine in AHEAD direction to bring the piston of cylinder 1 to TDC. Check with the pin gauge.

2. Dismount the end cover of the camshaft housing, along with the starting air distributor, from the engine.

   Remove the plug screw and gasket from the side of the distributor housing, and insert check pin **K** in slot **S**.

   Turn the shaft together with the distributor disc until check pin **K** enters slot **S** in the disc and keep it there.

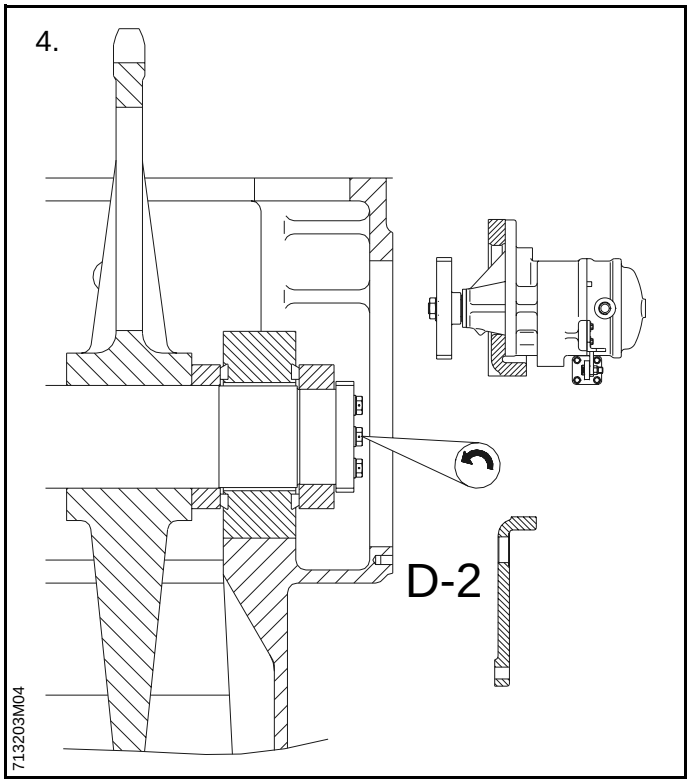
3. Check and, if necessary, adjust clearance D-1 between the gear wheel and the bushing.

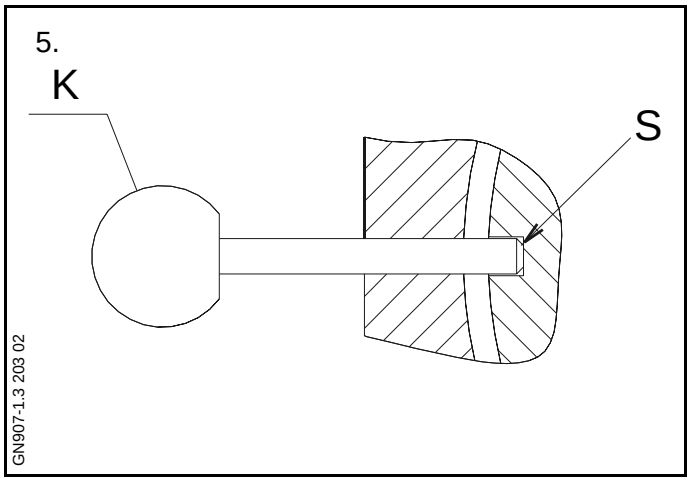
4. Remove the lower half of the cover for the gearwheel drive. Mount the upper half of the cover for the gearwheel drive with the complete starting air distributor by loosening the gear wheel on the camshaft and engage the two gear wheels by turning the wheel on the camshaft.

   Tighten and lock the gear wheel screws on the camshaft, *see Data, D-2*.

   Mount the lower half of the cover for the gearwheel drive.

5. Remove check pin **K** from the distributor housing and mount the gasket and plug screw.



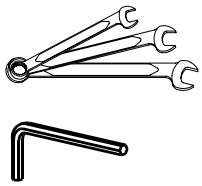


SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	May cause spring under tension
X	Block the starting mechanism	
X	Shut off starting air supply	
	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit
D-1	Weight of starting air valve	20	kg
D-2	Tightening-up torque	180	Nm
D-3	Valve tightening	175+/–20	Nm

Standard Tools: See Section 913



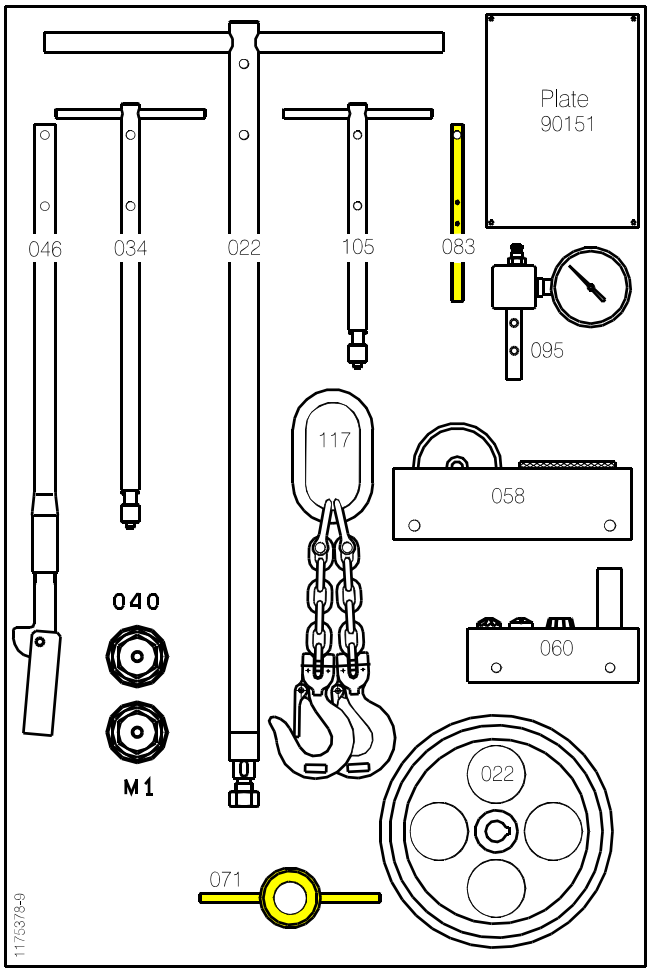


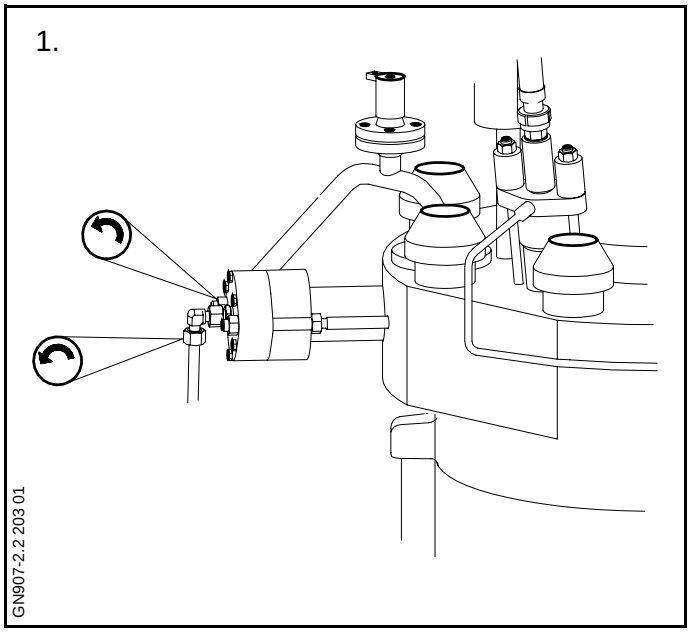
Plate
90151
046
034
022
105
083
095
117
058
040
060
M1
022
071
1175378-9

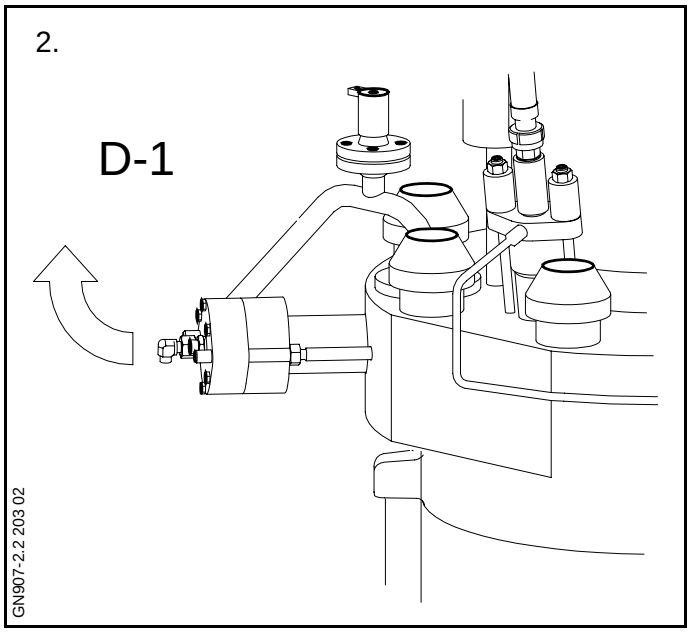
1. Shut off the starting air and control air inlet.

   Dismount the control air pipes.

   Unscrew the fixing nuts of the starting valve flange.

2. Pull the starting air valve out of the cylinder cover and remove it from the engine.





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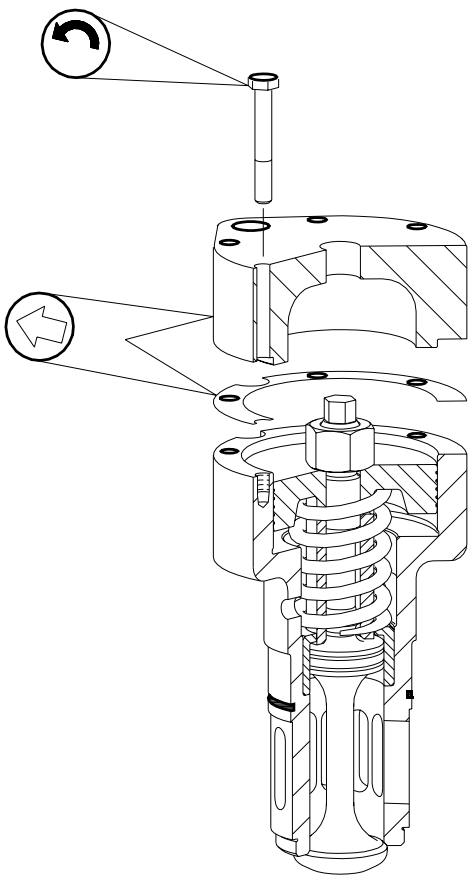
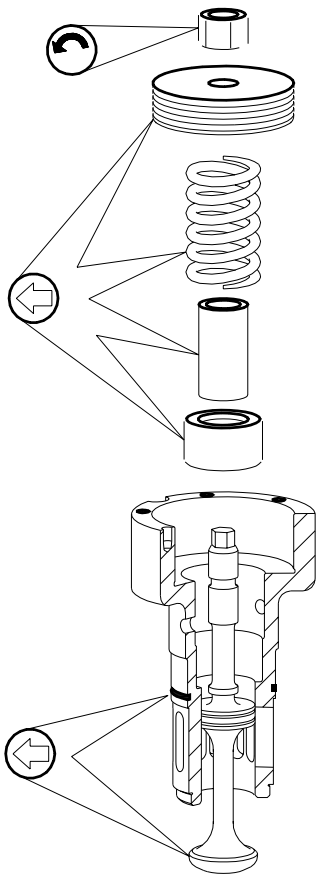


GN907-2.3 203 01

2.



GN907-2.3 203 02

1. Remove the top cover fixing screws and remove the cover.

   Remove and discard the gasket.

2. Screw off the valve spindle nut and remove the valve spindle from the valve housing.

   Take out the piston, distance pipe, valve spring, and the liner.

   Remove and discard the O-ring.

3. Grind the valve housing seating with the grinding ring after applying grinding paste. Carborundum No. 200.

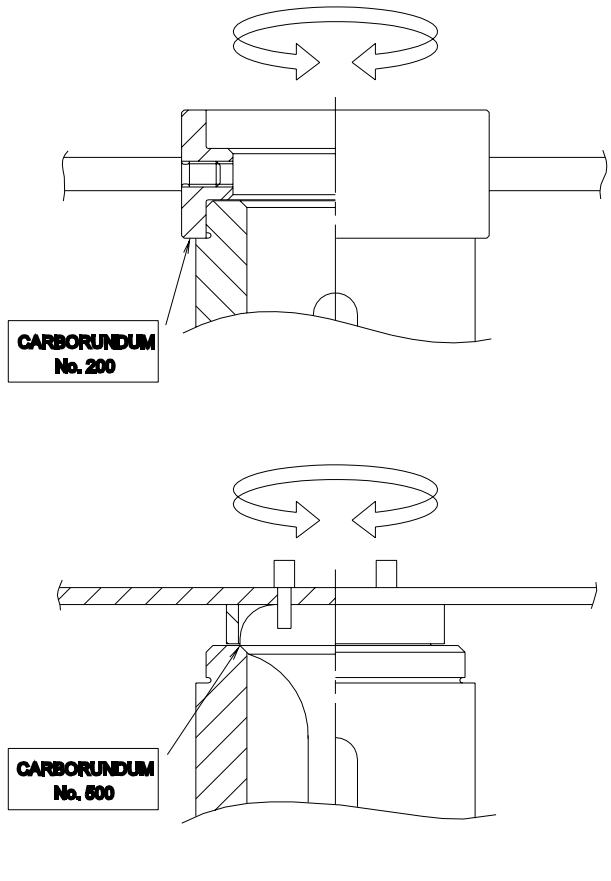
   Grind the seatings of the spindle and housing to match, using the face wrench to rotate the valve spindle.
   Carborundum No. 500.

4. Thoroughly clean all parts before reassembling the valve.

   Lubricate all internal parts (sliding surfaces) with, for instance, Molybdenum Disulphide, MoS_2.

5. First mount the liner in the valve housing, then the valve spindle, the distance pipe, the spring and the piston.

3.



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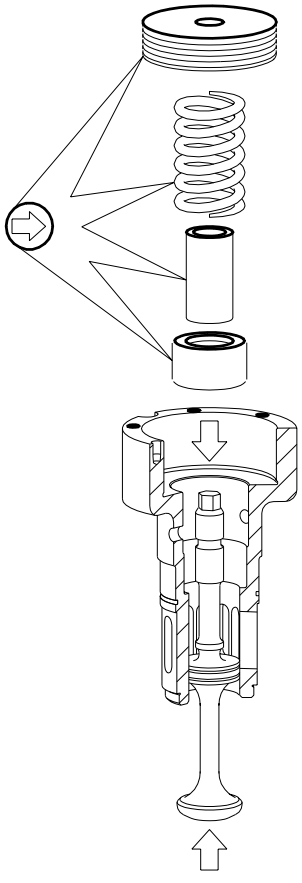

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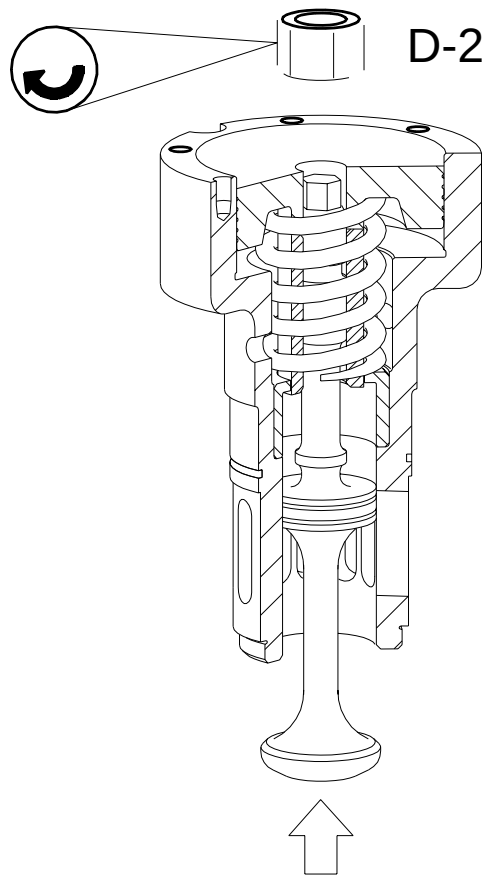

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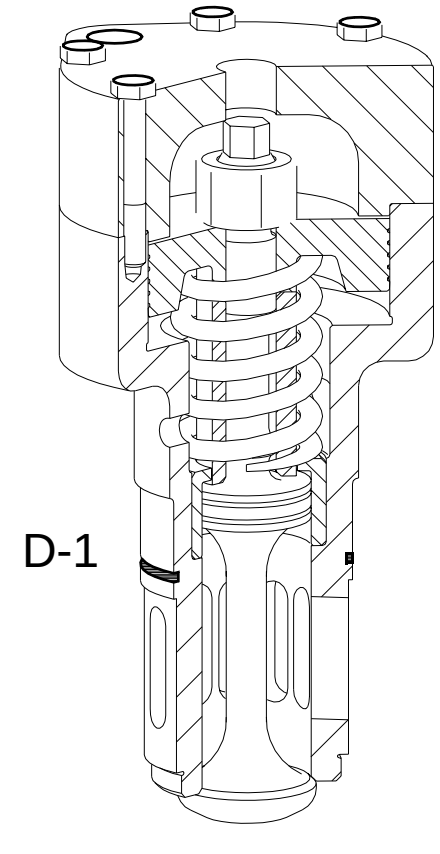

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6. Mount the nut on the valve spindle and tighten the nut, see D-2.

7. Place a new gasket on the valve housing.

   Mount and tighten the top cover.

   Replace the O-ring on the valve housing.

8. If the starting air valve is not to be mounted in the engine immediately after the overhaul, all openings of the valve should be covered with plastic to prevent dirt from entering the valve during storage.

1. Carefully clean the starting valve bore in the cylinder cover and, if necessary, recondition the seat for the starting valve in the bore.
   See Procedure 901-1.3.

   If not already done, replace the O-ring on the overhauled valve and lubricate with Neverseize or Molybdenum Disulphide, MoS_2.
   For overhaul, see Procedure 907-2.3.

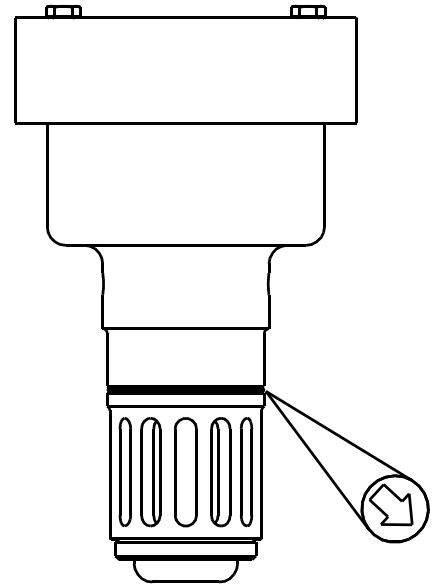
2. Mount the valve in the cylinder cover.

3. Mount the nuts and tighten-up alternately, in at least three steps, to an angle of 40°.

   Loosen the nuts again and repeat the procedure to reach the full tightening angle or torque, D-3.

   Mount the control air pipes and turn on starting air and control air.

1.



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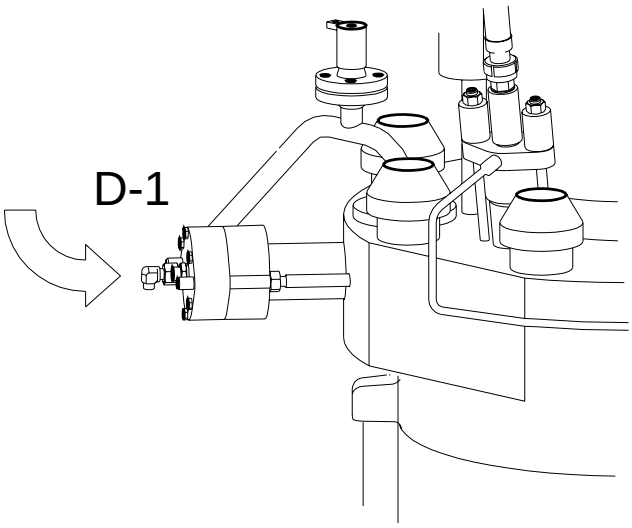

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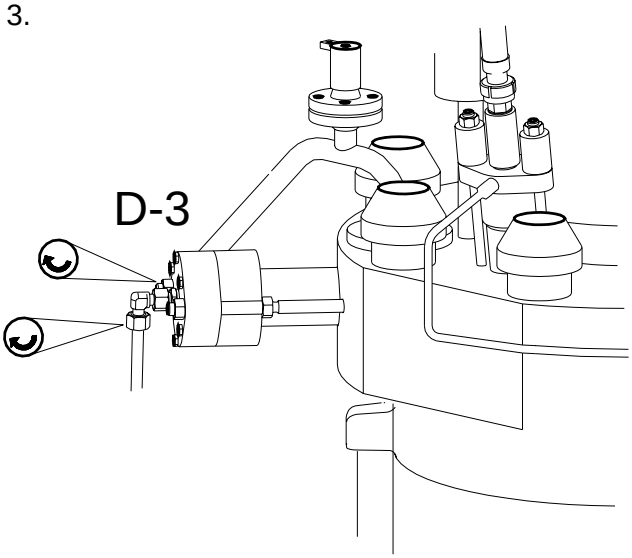

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MECANICAL CONTROL GEAR

STARTING AIR SYSTEM

EXHAUST VALVE

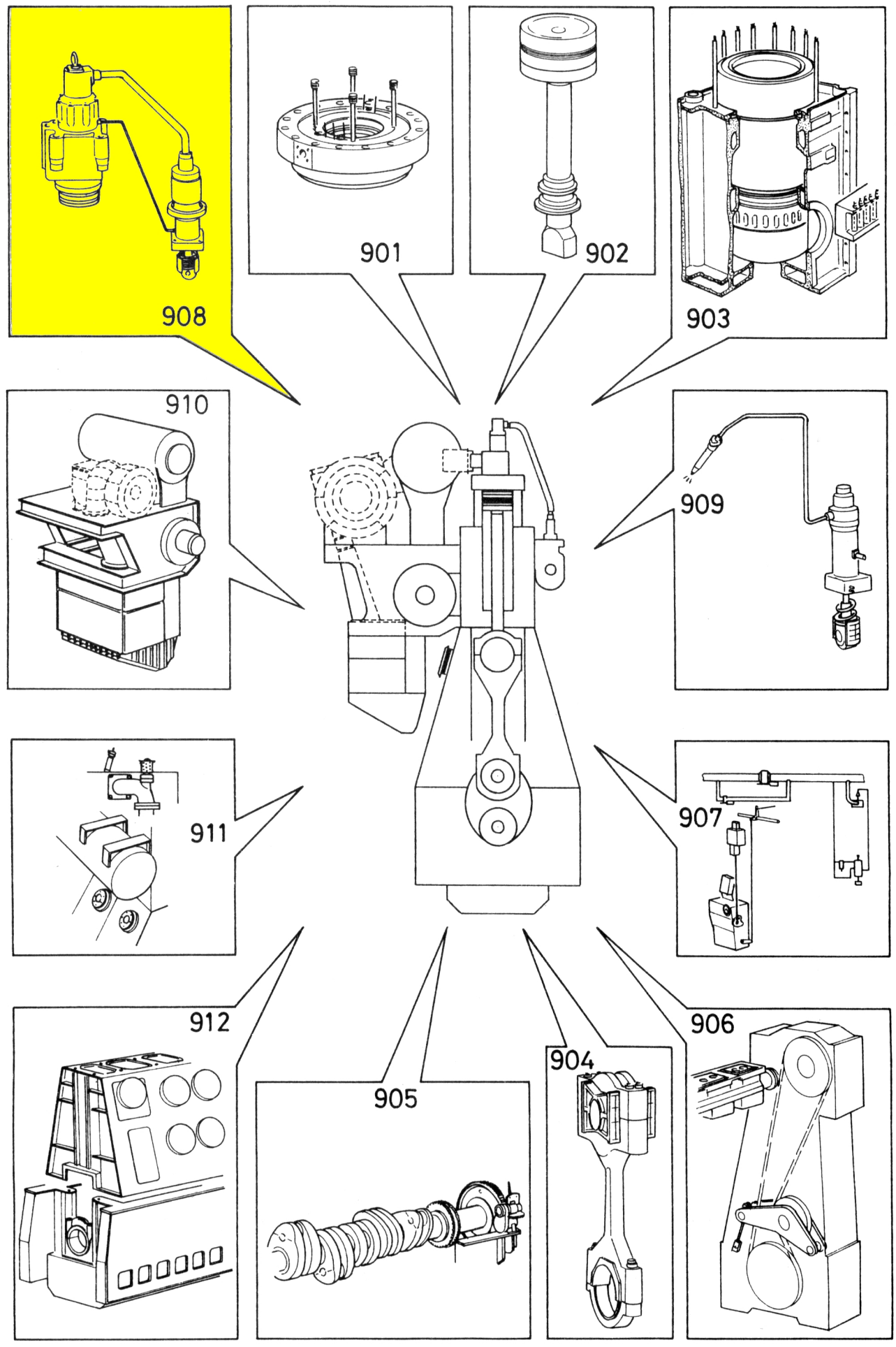
FUEL OIL SYSTEM

TURBOCHARGER SYSTEM

SAFETY EQUIPMENT

ASSEMBLY OF LARGE PARTS

GENERAL TOOLS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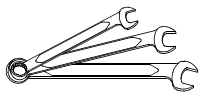
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Do not enter area when over head lifting is being carried out
X	Block the starting mechanism	
X	Shut off starting air supply	
	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit
D-1	Weight of high-pressure pipe	34	kg
D-2	High-pressure pipe - tightening torque	36	Nm

Standard Tools: See Section 913



20 - 90 Nm

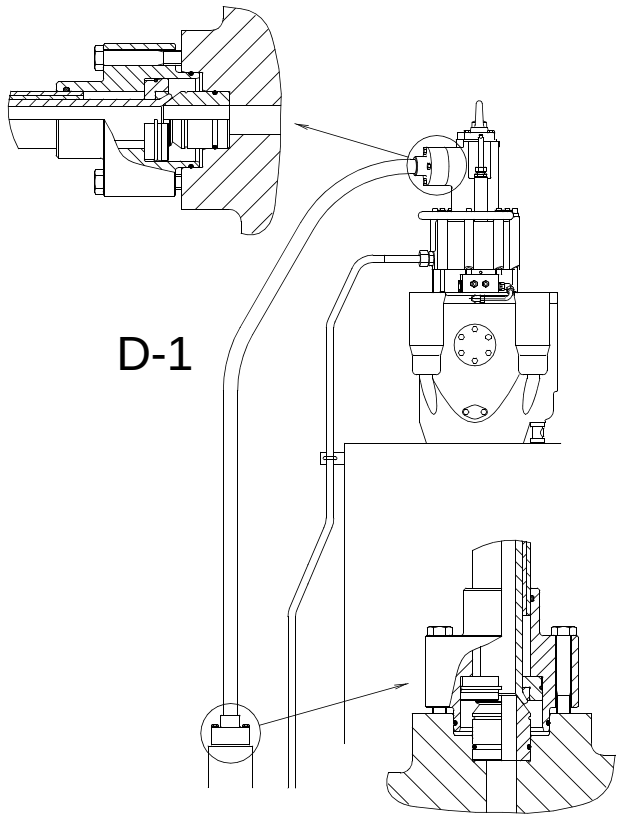
1. When replacing the hydraulic high-pressure pipe, exhaust valve or hydraulic actuator, check the high-pressure pipe sealing surfaces.

2. Before dismounting the high-pressure pipe, stop the camshaft oil pump.

   Loosen the screws for the high-pressure pipe and lift the pipe slightly away from the actuator to let the oil in the pipe drain through the drain holes in the actuator.

3. Remove the screws in both ends of the high-pressure pipe. Lift the high-pressure pipe away from the engine.

1.



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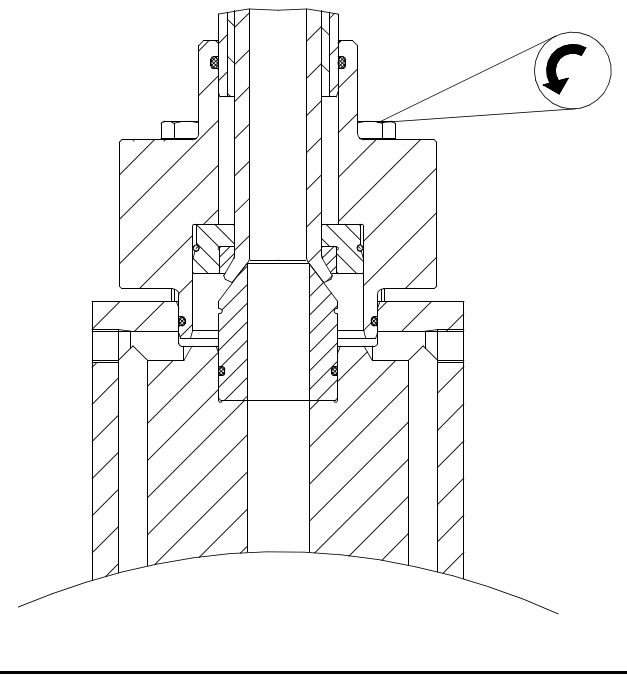

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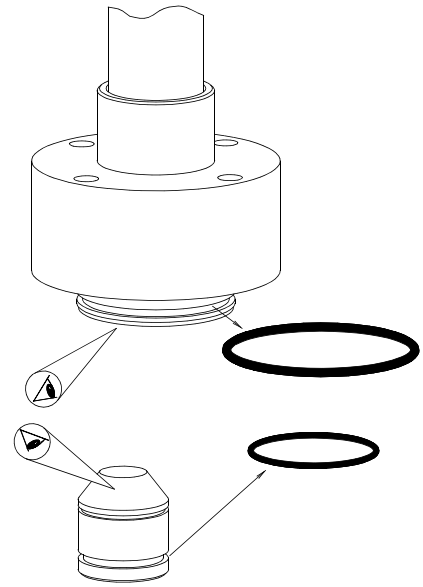

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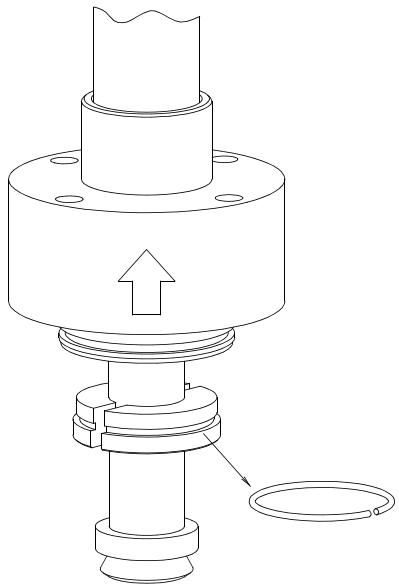

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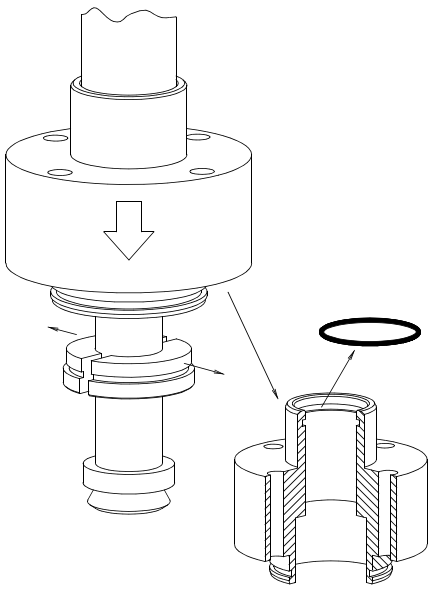

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The two ends of the pipe are identical and should both be overhauled as follows:

1. Remove the thrust piece from the actuator/ exhaust valve.

   Remove and discard the O-rings from the thrust piece and the thrust flange.

   Clean and inspect the conical seats of the high-pressure pipe and the thrust piece.

Note!
It is no need to recondition both seats on the structure. However, great care must be taken not to damage the seats of the thrust piece/ high-pressure pipe when overhauling.

2. To change the internal O-ring, proceed as follows:

   Lift the thrust flange upwards.

   Remove the spring ring from the two-part sleeve.

3. Remove the thrust flange from the pipe end.

   Remove and discard the internal O-rings.

   Mount new internal O-rings lubricated with a little camshaft lubricating oil.

4. Assemble the high-pressure pipe in the reverse order to disassembling.

1. Mount new O-rings, lubricated with a little camshaft lubricating oil, on the thrust pieces and thrust flanges.

   Mount the thrust pieces on the actuator/exhaust valve.

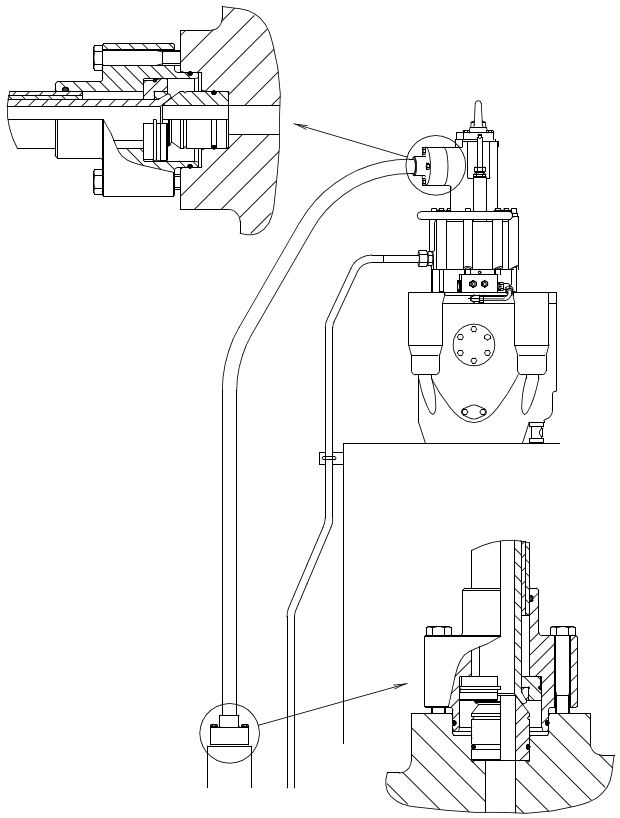
   Mount the high-pressure pipe on the engine.

Note!
When mounting the high-pressure pipe, take care not to damage the conical seats of the pipe/thrust pieces.

2. After fitting the pipe to the exhaust valve and actuator, tighten up the screws of the pressure flanges diagonally, *see Data.*

3. Check the system for tightness.
   See Procedure 908-3.1.

1.



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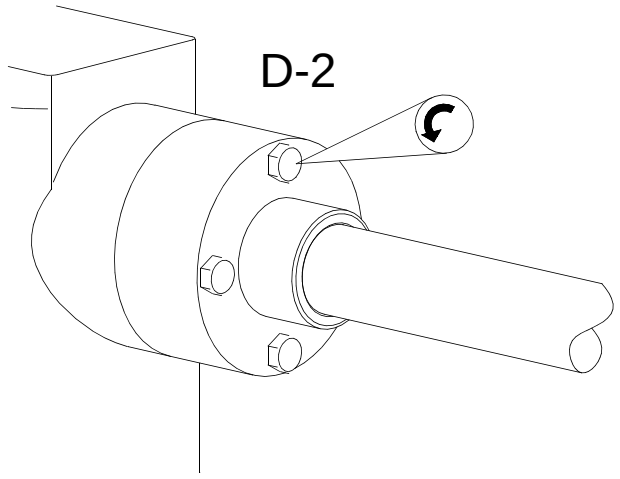

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SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of high pressure oill
X	Block the starting mechanism	Do not enter area when over head lifting is being carried out
X	Shut off starting air supply	
X	Engage turning gear	
X	Shut off cooling water	
	Shut off fuel oil	
X	Shut off lubricating oil	
X	Lock turbocharger rotors	

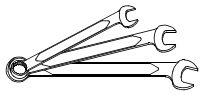
Data

Ref.	Description	Value	Unit
D-1	Exhaust valve, complete	444	kg
D-2	Exhaust valve housing	237	kg
D-3	Oil cylinder	80	kg
D-4	Air cylinder	75	kg
D-5	Spindle	43	kg
D-6	Bottom piece	52	kg
D-7	Oil cylinder, inside diameter max.	71.2	mm
D-8	Piston rings, min. thickness	2.6	mm
D-9	Min. distance to piston	47.0	mm
D-10	Max. distance to piston	51.2	mm
D-11	Min. diameter of spindle stem	59.8	mm
D-12	Tightening torque, oil cylinder	70 (7.1	Nm kgf•m)
D-13	Tightening torque, screws for lifting bolt	50 (5.1	Nm kgf•m)
D-14	Tightening torque, safety valve	50 (5.1	Nm kgf•m)
D-15	Opening pressure, safety valve	2.1 (21	MPa bar)
D-16	Vertical grinding angle of spindle	30.5	°
D-17	Vertical grinding angle of housing seat	30	°
D-18	Max. grinding of seat	2.3	mm
D-19	Gap of bottom piece	1.0	mm
D-20	Max. burn-off of piece	8.0	mm
D-21	Max. grinding of spindle	2.0	mm
D-22	Hydraulic pressure - tightening	150 (1500	MPa bar)
	Hydraulic pressure - dismantling	150-165 (1500-1650	MPa bar)

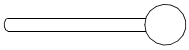
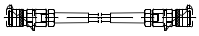
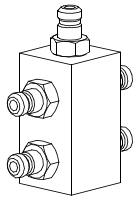
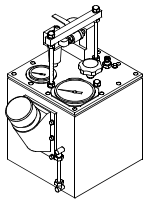
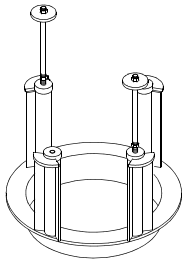
Note!
Permit to Max. 165 MPa (1650 bar) only in a short time.

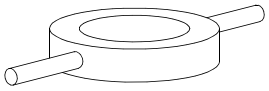
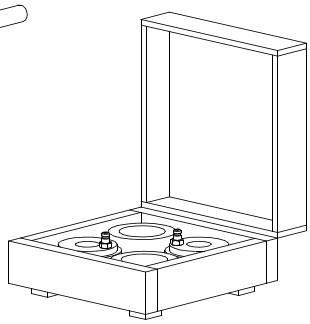
D-23	Max. diameter, top	60.6	mm
D-24	Max. diameter, bottom	62.0	mm

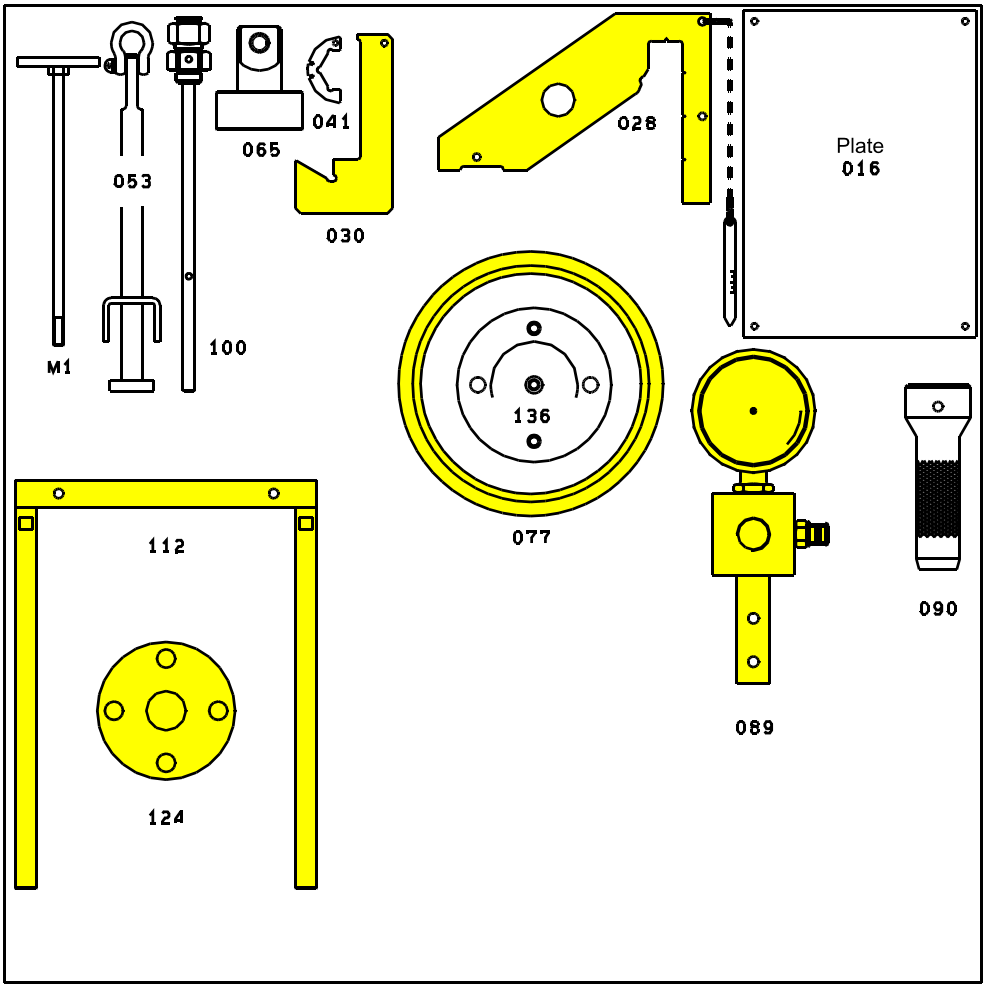
Standard Tools: See Section 913



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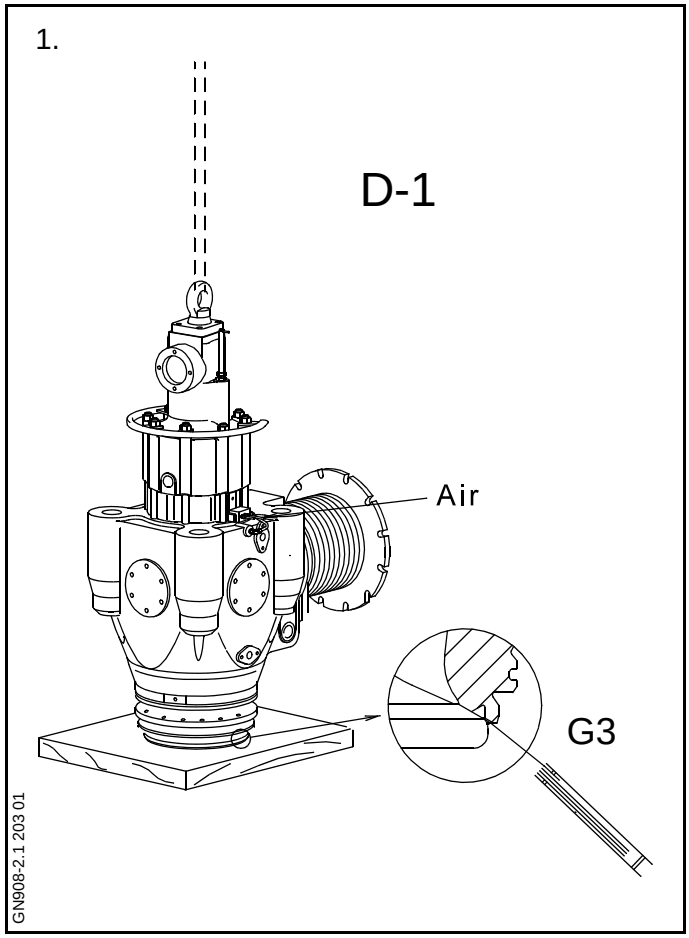
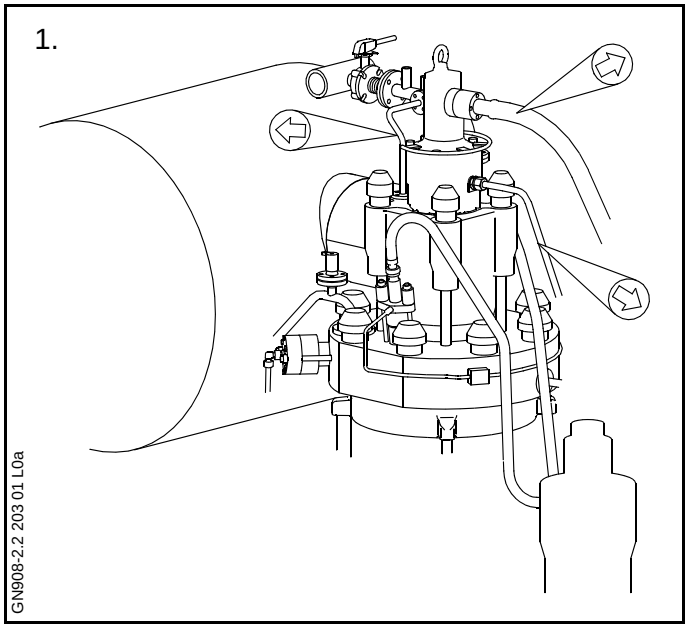
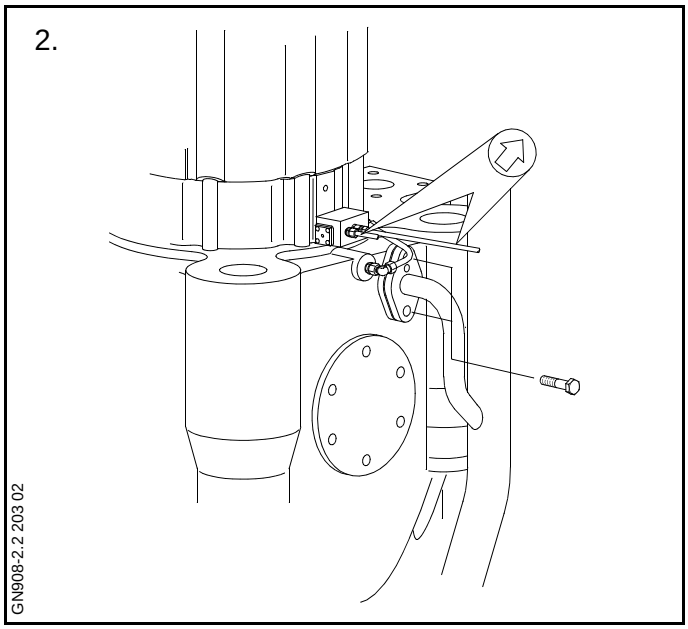
090

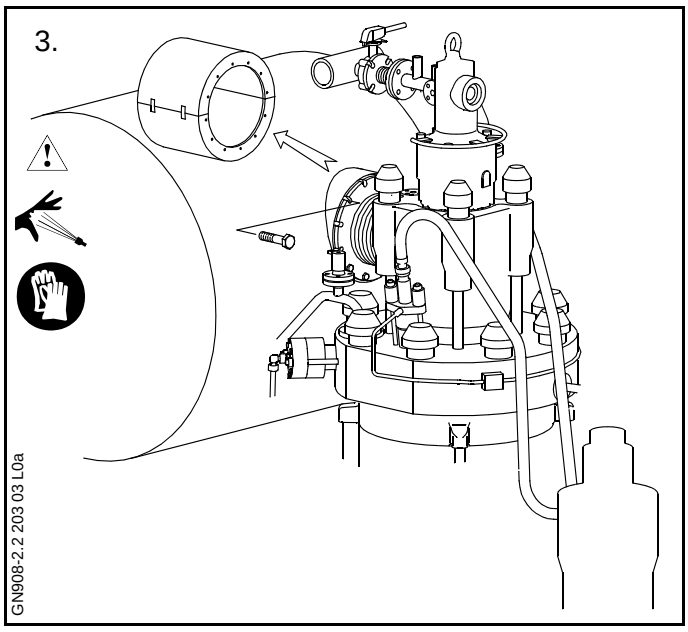
1. Before mounting an overhauled exhaust valve in the engine, it is recommended to check the valve as follows:

   - Lift up the valve with the engine room crane (which makes the valve open).
   - Connect compressed air to the pneumatic piston. The valve should now close.
   - Check that a 1.0 mm feeler gauge can be inserted about 15 mm into gap **G_3**, to ensure that there is a clearance between the outer parts of the seating faces of valve housing and the spindle.
     See Procedure 908-2.3.
   - After shutting-off the compressed air supply and releasing the vent plug screw located just above the ball cock on the air cylinder, the exhaust valve should open.
   - After doing this a couple of times, leave the valve closed and shut-off the compressed air. The valve should remain closed for at least 10 to 15 minutes.









1. Close the cooling water inlet and outlet, and drain the exhaust valve.

   Dismount the high-pressure pipe for the hydraulic valve actuation.
   See Procedure 908-1.2.

   Disconnect the cooling water outlet pipe from the exhaust valve.

   Dismount the return oil pipe and the sealing air pipe from the exhaust valve.

2. Dismount the air pipes for the pneumatic exhaust valve.

   Remove the screws of the cooling water inlet flange at the side of the exhaust valve.

3. Remove the plate jacket with insulation from the intermediate pipe and remove the screws which attach the intermediate pipe to the inlet pipe of the exhaust receiver.

Note!
The four lowermost screws need only be loosened, not removed.

4. Remove the protective caps from the exhaust valve studs, and mount the four hydraulic jacks.

   Connect the high-pressure pump to the jacks by means of the distributor block and four high-pressure hoses.

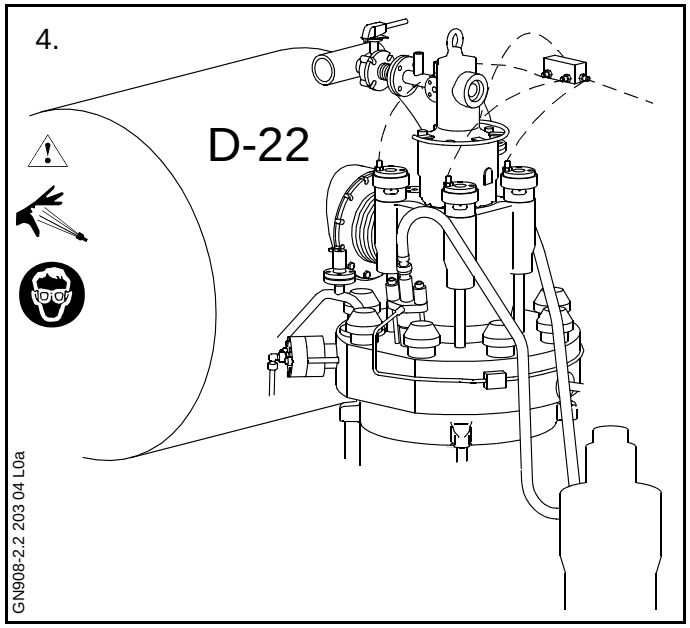
   Bleed the hydraulic system and raise the pressure as stated in Data. Then loosen and remove the nuts.
   See Procedure 913-1.

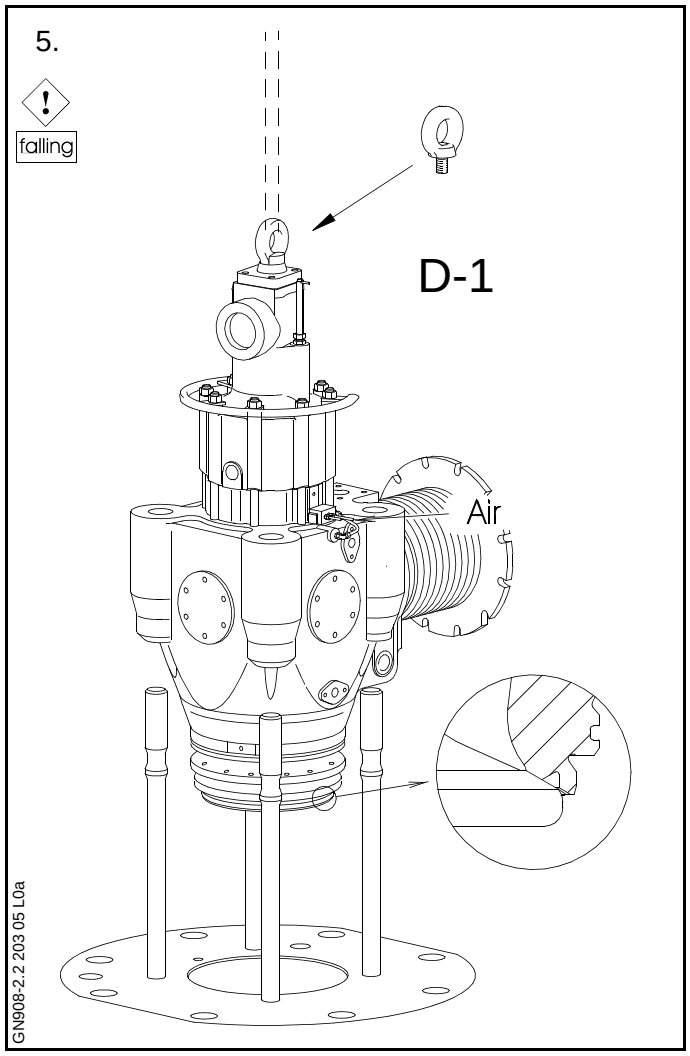
5. Mount the eye screw in the lifting tool on top of the exhaust valve.

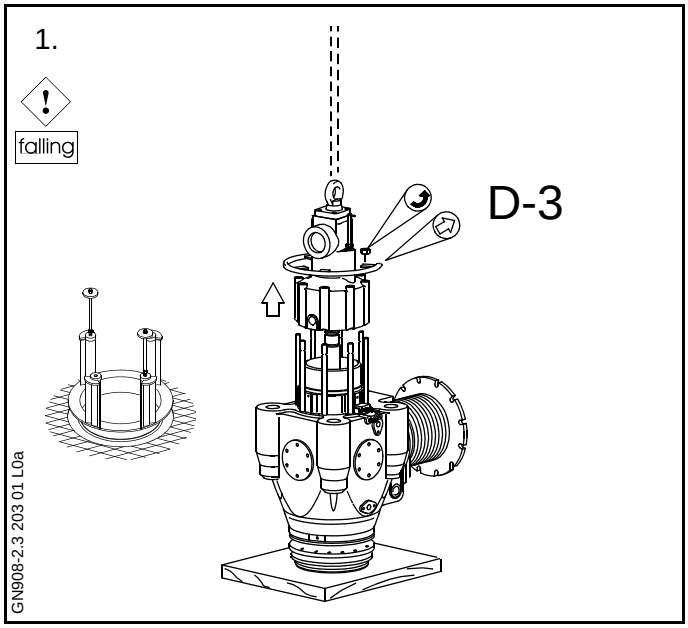
   Attach the crane to the lifting tool fitted on top of the valve and lift away the exhaust valve.

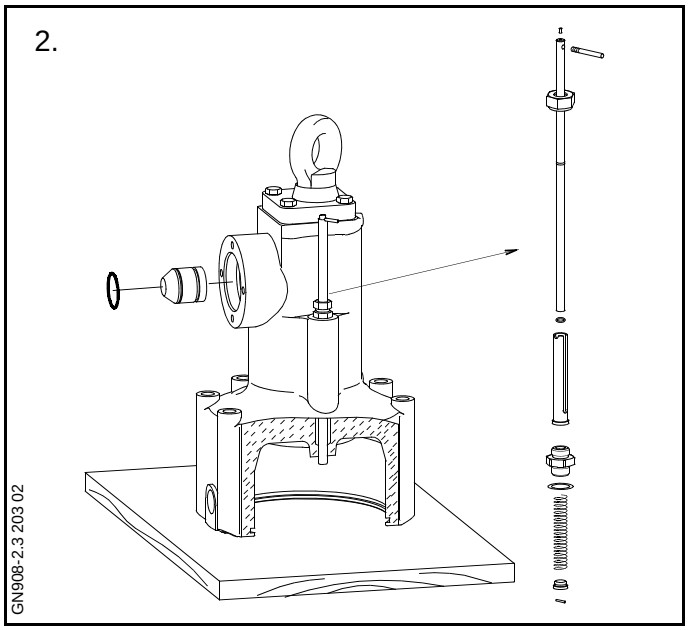
   Carefully clean the exhaust valve bore in the cylinder cover and recondition the seating and sealing surfaces of the bore, if required.
   See Procedure 901-1.3.

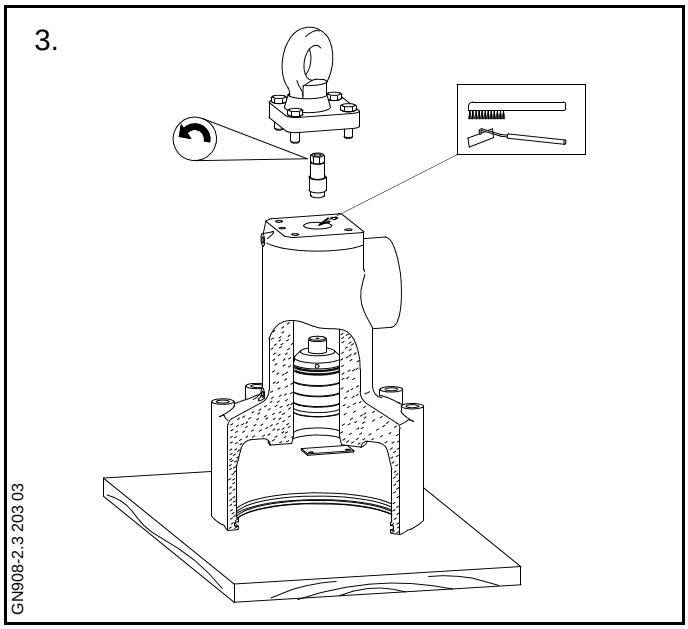
   For overhaul of the exhaust valve, see Procedure 908-2.3.











1. Place the exhaust valve on a wooden support or the stand on the platform.

   Remove the eight nuts and the safety strap from the oil cylinder.

2. Lift away and place the oil cylinder on a wooden support.

   Dismount and inspect the O-rings and the thrust piece of the hydraulic high-pressure pipe for marks.

   Replace the O-rings and thrust piece, if necessary.

   Check the functioning of the exhaust valve rotation indicator.

3. Loosen the screws and remove the lifting eye screw from the oil cylinder to gain access to the orifice plug.

   Unscrew and clean the orifice plug.

   Check and clean the bore for the orifice plug in the top of the oil cylinder.

4. Place the oil cylinder in a horizontal position.

   Remove and discard the sealing ring.

   Remove the flange and take out the piston.

   Inspect the bore of the oil cylinder for scoring and check its measurements.

   If the diameter of the bore exceeds the value stated in Data, send the oil cylinder to MITSUI ENGINEERING & SHIPBUILDING CO., LTD.

5. Release the vent plug screw located just above the ball cock on the air cylinder to let the air escape from below the piston.

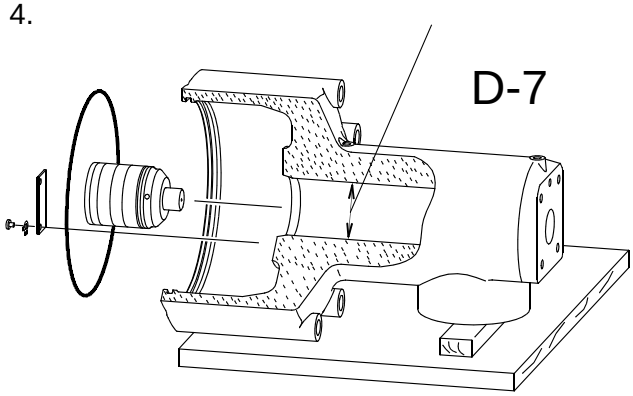
   Remove the four screws from the flange on top of the air piston and dismount the flange.

   Loosen the air piston from the conical locking ring by means of a tin hammer, and remove the conical locking ring.

6. Pass lifting straps through the four bores of the valve housing and lift the valve housing clear of the valve spindle.

   Take care – when the internal O-ring in the air piston and the internal rings for the sealing arrangement at the bottom of the air cylinder pass the groove for the conical ring at the top of the spindle.

4.



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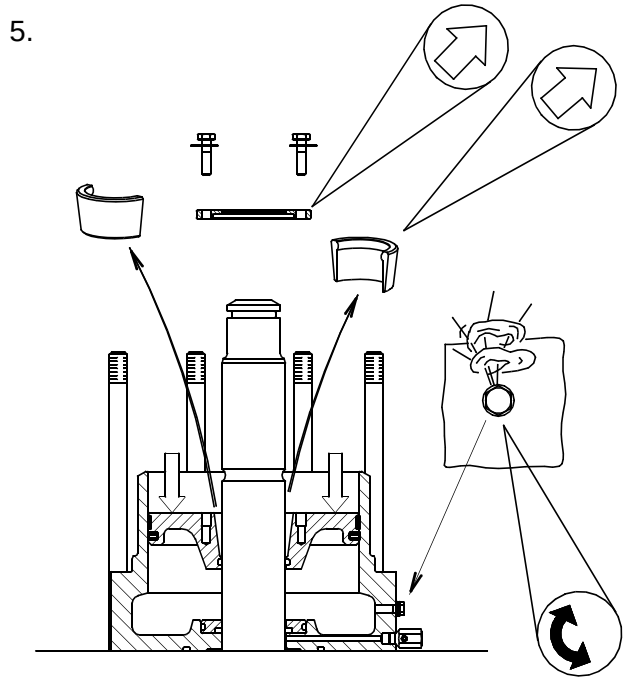

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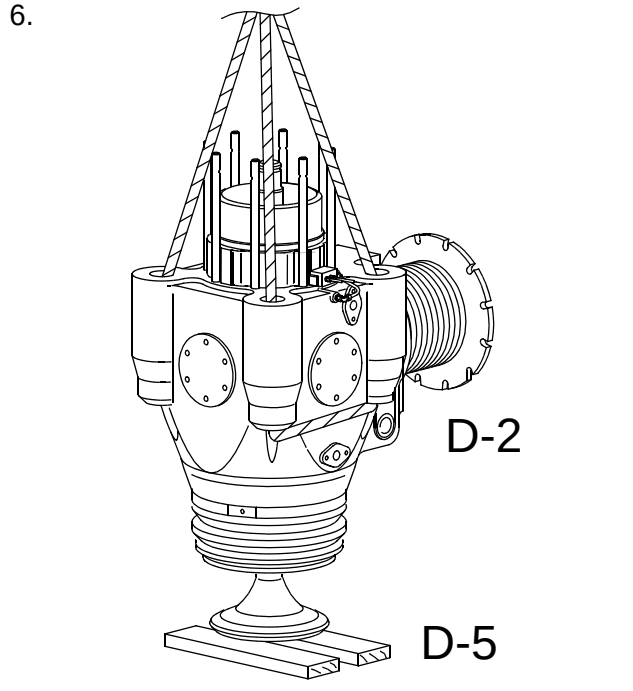

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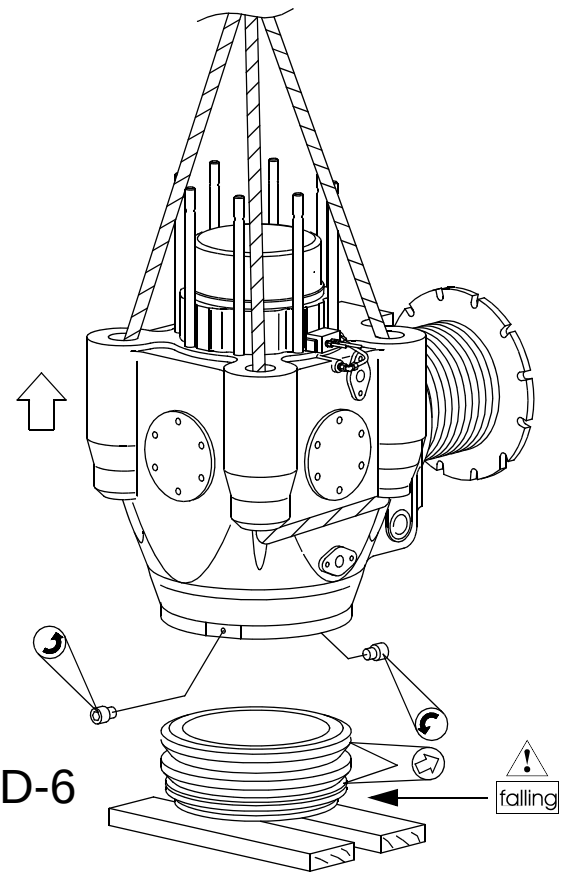

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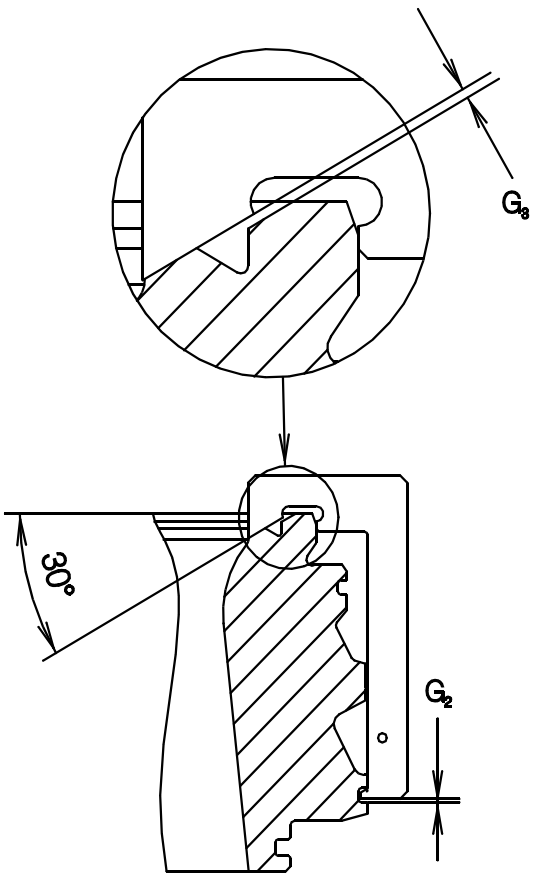


7. Poise the valve housing above a couple of planks, leaving a distance of approx. 10 mm between the bottom piece and the planks.

   Remove the lock screws which retain the bottom piece and allow the bottom piece to fall the 10 mm on to the planks. If the bottom piece has become stuck, use a tin hammer to release it.

   Remove the O-rings from the bottom piece and clean all the cooling bores.

Bottom piece:

8. Inspect the seating of the bottom piece **carefully** for damage and check with the template.

Note!
Before using the template, thoroughly clean the contact faces on the valve housing seat with a steel brush. All measurements should be taken at four diametrically opposite points on the circumference of the bottom piece seating

   Take measurements $\mathbf{G_2}$ and $\mathbf{G_3}$, using a feeler gauge. Compare the results with the figures stated in Data D-18 and D-19.

9. If burn marks are visible on the bottom piece seating OR $\mathbf{G_3}$ does **not** equal D-19, THEN the valve housing seat must be ground.

   If the template rests on the lower surface in the groove, i.e. $\mathbf{G_2}$ = 0, THEN the bottom piece seating must **not** be ground, regardless of burn marks or $\mathbf{G_3}$.

   Contact MITSUI ENGINEERING & SHIPBUILDING CO., LTD. Diesel for advice on reconditioning.

10. If it is necessary to grind the seating, proceed as follows:

    Before placing the bottom piece on the grinding machine, away the grinding head from the grinding table.

    Mount two eye screws in the bottom piece and place the bottom piece on the circular table of the grinding machine. Make sure, by means of a dial indicator, that the bottom piece is correctly centered.

Note!
The pointer of the angle adjusting device setting of the grinding head is to correspond with the mark S.

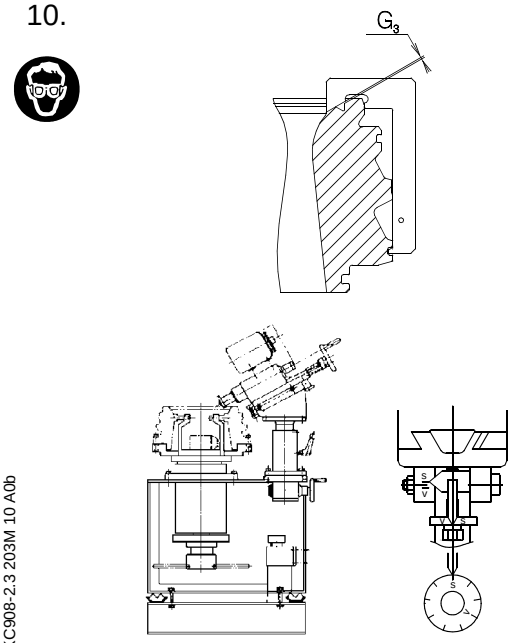
Regarding the use of the grinding machine, see separate instructions.

After grinding, re-check the seating of the bottom piece with the template.

Use a feeler gauge and the template to measure how much has been ground away from the seating.

Grind the recess so that gap **G_3** equals D-19 as stated on the Data sheet.

10.



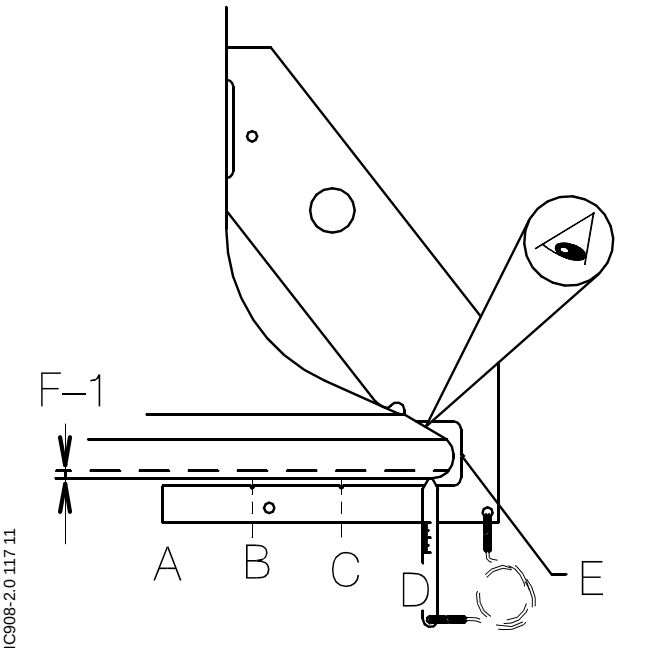
Valve spindle

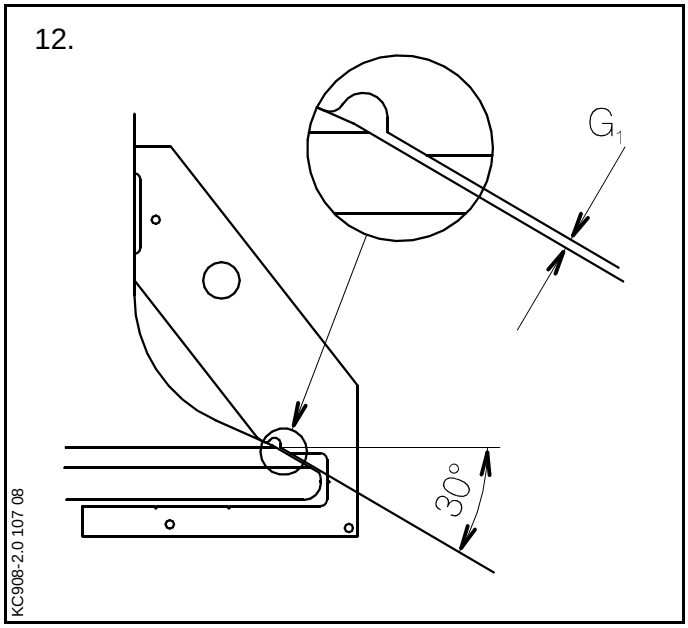
11. Inspect the seating of the valve spindle for burn marks.

    Check the burn-off F1 of the valve spindle by measuring at each of the points **A, B, C, D** and **E**, indicated by means of notches in the template.

Note!
Before using the template, clean the contact faces on the valve spindle thoroughly with a steel brush**.** All measurement should be taken at four diametrically opposite points on the circumference of the valve spindle.

11.





12. Measure gap $\mathbf{G_1}$ between the template and the seating of the spindle.

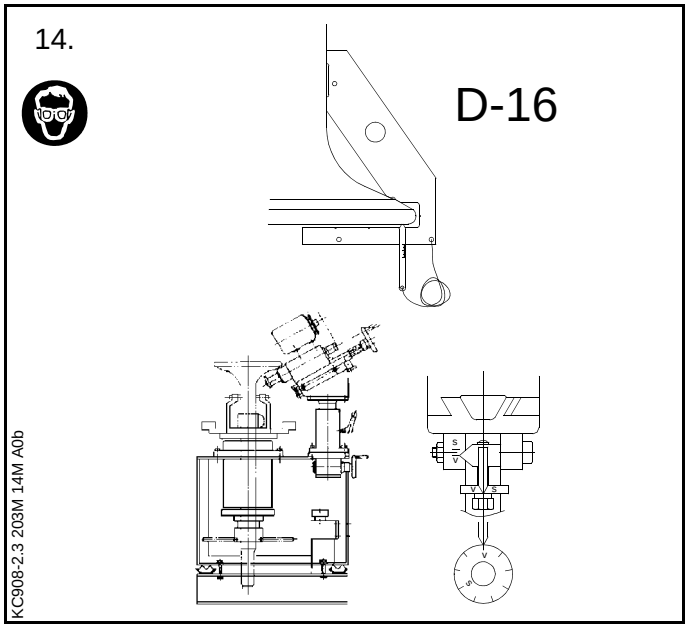
13. If burn marks are visible on the seating of the spindle, the valve must be ground.

    If gap $\mathbf{G_1}$ exceeds the max. value D-21, see Data, OR the burn-off $\mathbf{F_1}$ exceeds the max. burn-off D-20, the spindle must not be ground.

    Contact MITSUI ENGINEERING & SHIPBUILDING CO., LTD. for advice on reconditioning.

14. To grind the seating of the spindle, place the spindle in the grinding machine.

    Check the alignment with a dial gauge.

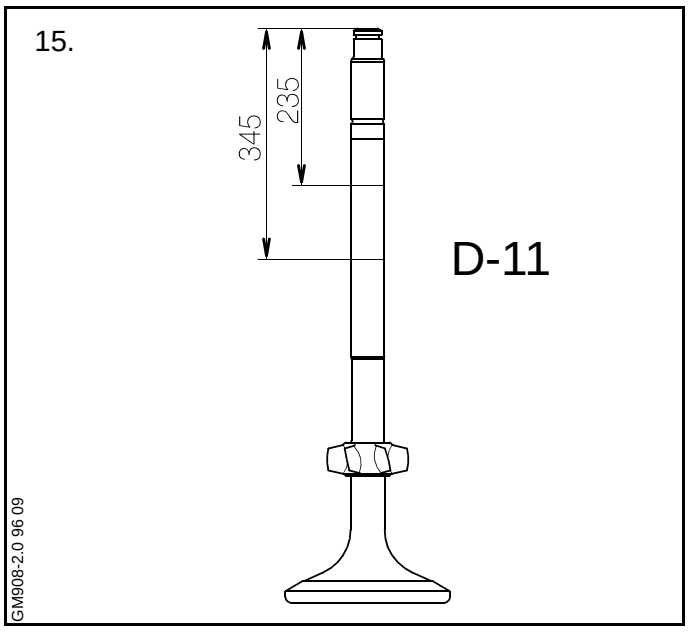


Note!
The pointer of the angle adjusting device setting of the grinding head is to correspond with the mark V.

Regarding the use of the grinding machine, see separate instructions.

During grinding, measure the gap $\mathbf{G_1}$ frequently. The max. grinding of the spindle, *see Data,* must **not** be exceeded.

If the max. grinding is reached and burn marks are still visible on the seating of the spindle, contact MITSUI ENGINEERING & SHIPBUILDING CO., LTD. for advice on reconditioning.



15. Check the spindle stem for wear in the area between 235 mm and 345 mm measured from the top of the spindle.

    If the stem diameter is less than stated in Data, or the hard facing layer is worn away, contact MITSUI ENGINEERING & SHIPBUILDING CO., LTD. for advice.

16. Dismount the air piston from the air cylinder, and check the teflon guide ring and teflon sealing ring for wear.

    Mount two eye screws in the air cylinder and dismount the air cylinder.

17. Clean the air cylinder and check the running surface for wear or possible scores.

    Remove the four screws in the bottom of the air cylinder.

    Dismount and check the flanges and the sealing rings of the sealing air arrangement.

    Fit new O-rings and sealing rings when mounting the flanges in the bottom of the air cylinder.

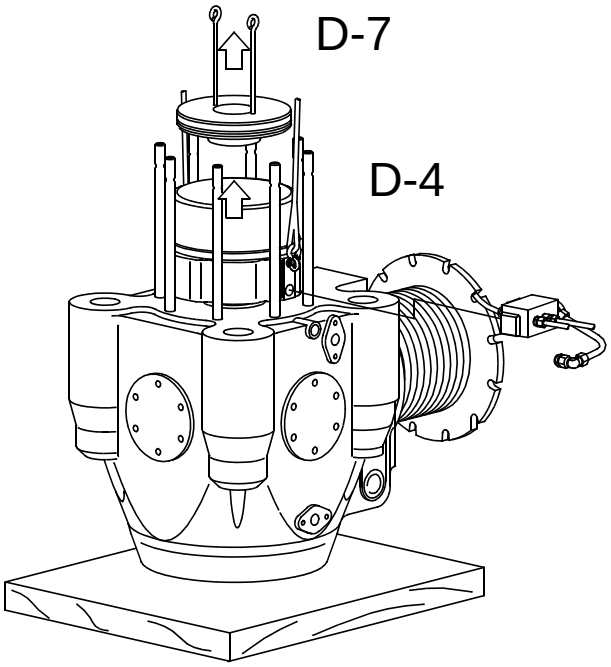
    Make sure to mount the sealing rings correctly, see the sketch.

    Tighten the four screws.

18. Replace the sealing ring in the groove at the very bottom of the air cylinder.

    Remove the protective cap from the safety valve, dismount the valve from the air cylinder, and replace the gasket and sealing ring.

16.



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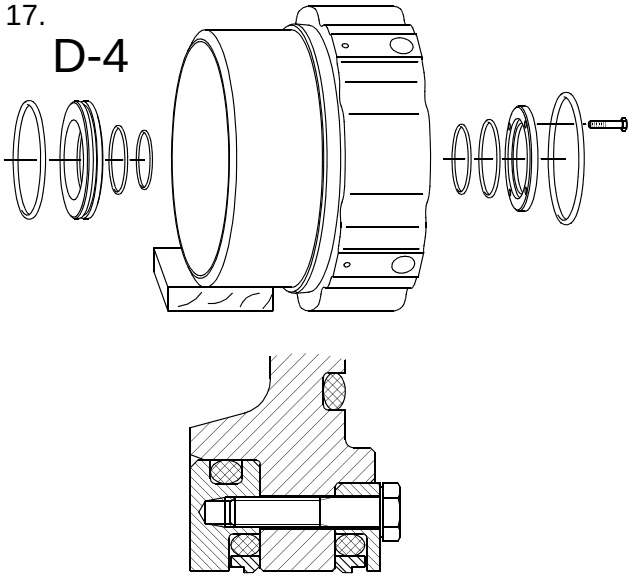

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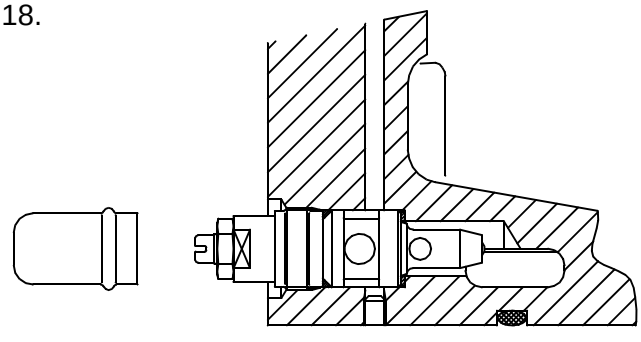

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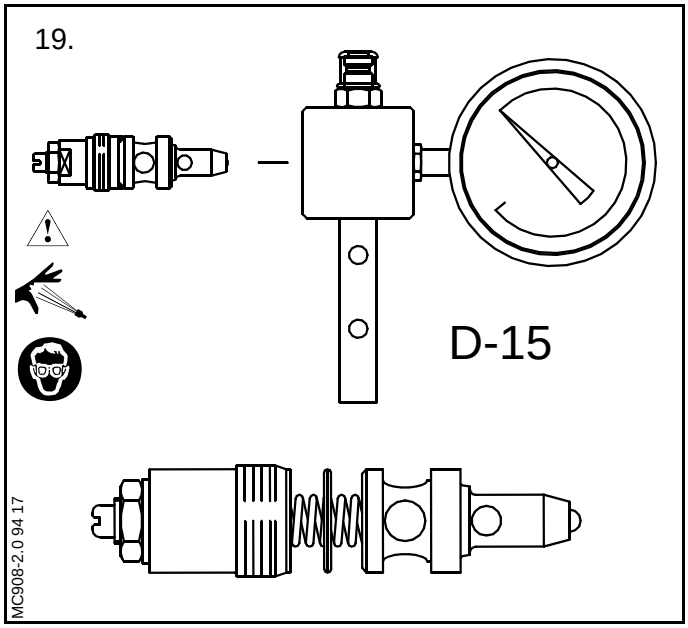
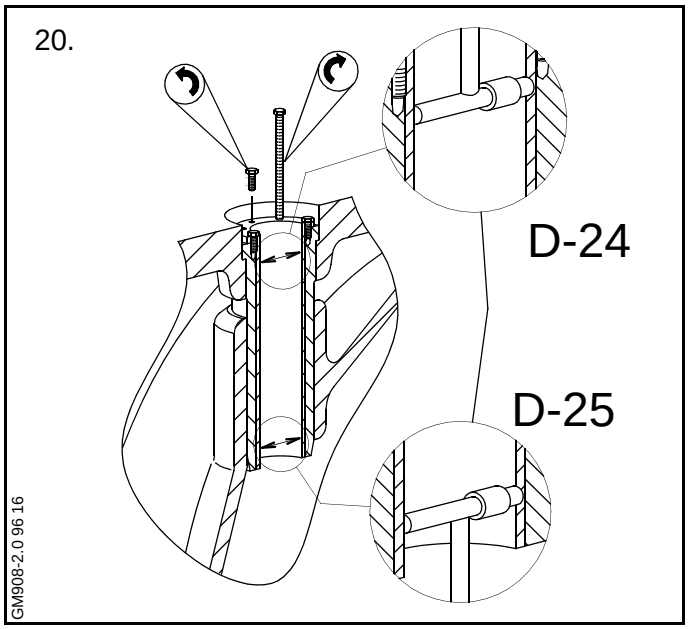
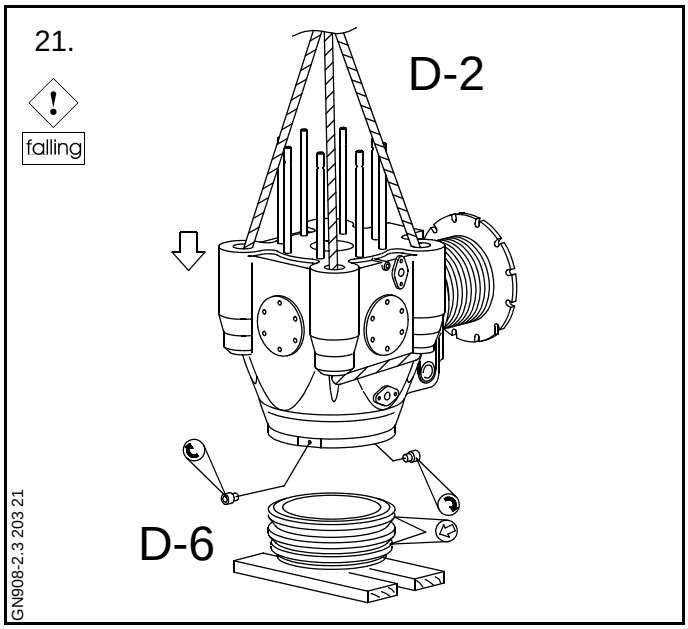






19. Place the valve in the pressure testing device.

    Connect the testing device with the high-pressure pump by means of a hose.

    Check the opening pressure, *see Data*.

    If the opening pressure is not correct, loosen the lock nut and, using a screwdriver, adjust the safety valve until the correct pressure is indicated.

    Tighten the lock nut and test the opening pressure once more.

    When mounting the safety valve in the air cylinder, use only the machined faces on the valve housing and tighten, see Data.

    Finally, mount the protective cap.

20. Inspect the bushing in the spindle guide for wear. *See Data*.

    If it proves necessary to replace the bushing, pull it clear by means of four dismantling screws.

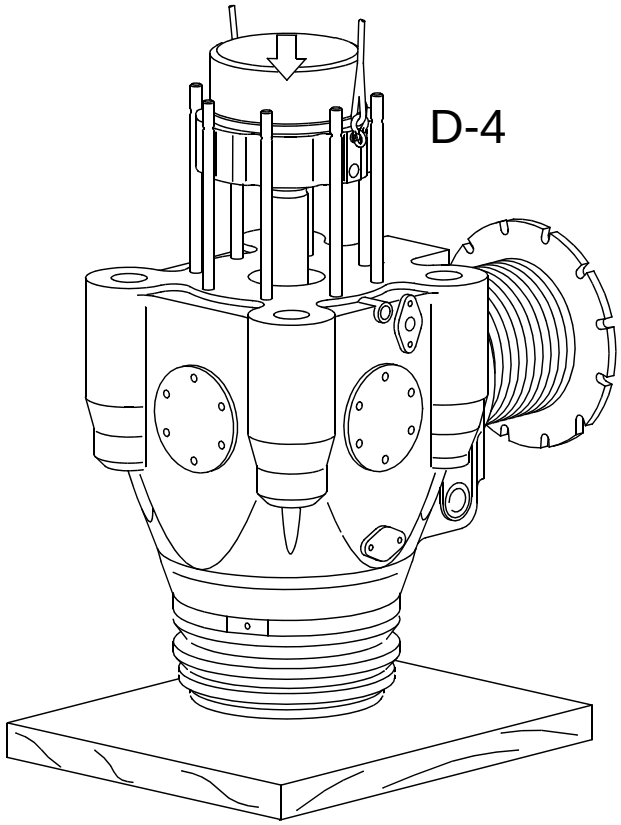
21. Mount the bottom piece (with new O-rings) on the valve housing and secure with the screws.

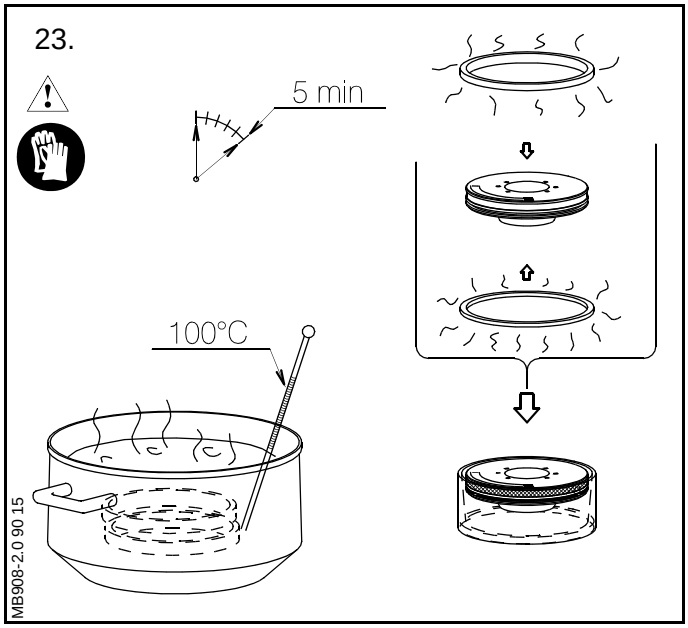
    Mount the valve spindle in the valve housing.

22. After overhauling and remounting the valve spindle and bottom piece in/on the valve housing, guide the air cylinder with the sealing air arrangement down over the valve spindle.

Caution!
To avoid damage, take great care when the internal rings (well-coated with ordinary lube oil) pass the groove for the conical locking ring.

22.





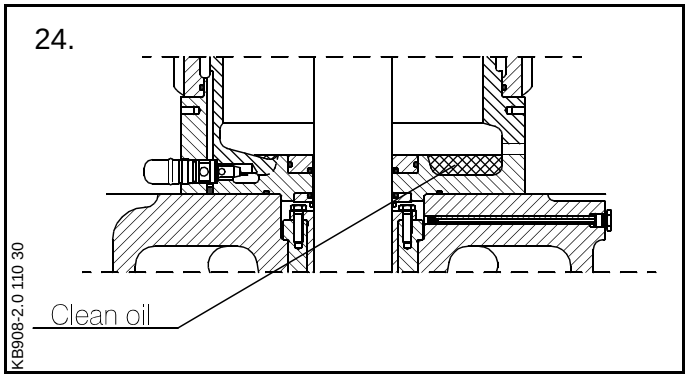
23. If it is necessary to replace the rings, cut them and remove them.

Be careful not to damage the edges of the ring grooves in the piston.

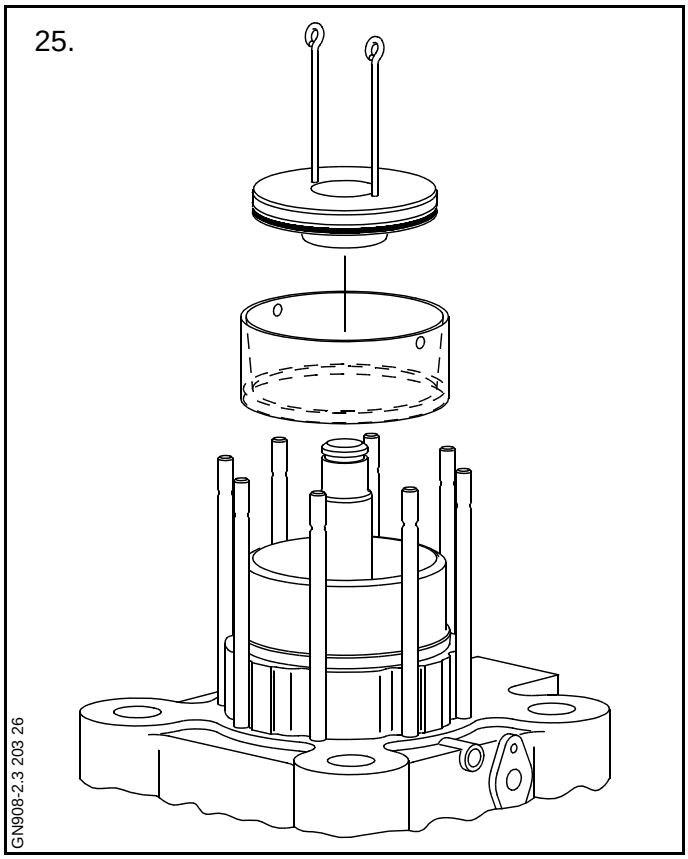
Mount the new O-ring in the groove of the air piston.

Caution!
Before mounting, heat the new teflon rings in 100°C hot water for at least five minutes. When mounting the teflon rings, **be careful** not to damage the running surfaces.

After mounting, compress the teflon rings by means of the conical ring. This is done by pressing the air piston through the conical ring.



24. Fill the sealing air chamber and the lower part of the air cylinder with clean lubricating oil.



25. Fit the conical guide ring for the air piston on the air cylinder.

Lower the air piston over the valve spindle down into the air cylinder.

Caution!
To avoid damage, take great care when the internal sealing ring in the air piston passes the groove for the conical locking ring.

Remove the conical guide ring from the air cylinder.

26. Mount the conical locking ring and lift the air piston up around the locking ring.

    Remove the eye screws.

    Mount the flange on top of the air piston and, by means of the four screws, tighten the air piston and the flange together.

27. Remove the piston rings from the oil piston and check them for wear.

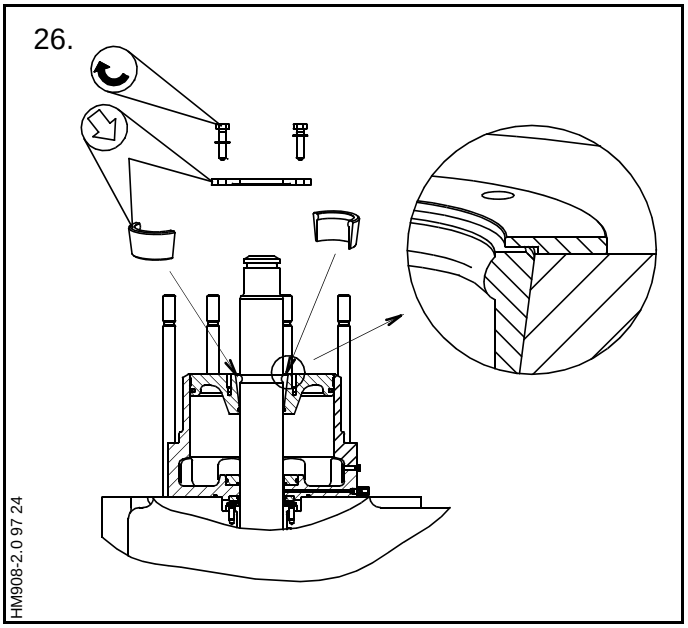
    If the thickness of the rings has worn down to the minimum, see Data, discard the rings and mount new ones.

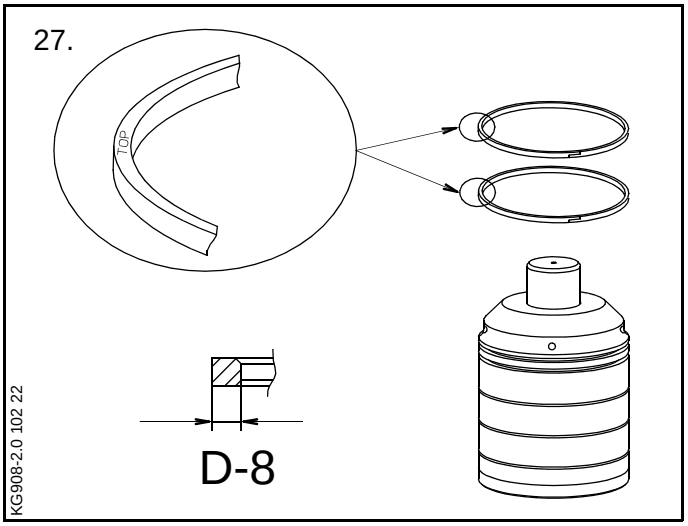
    Check that the **TOP** mark on the piston rings faces upwards, when mounting.

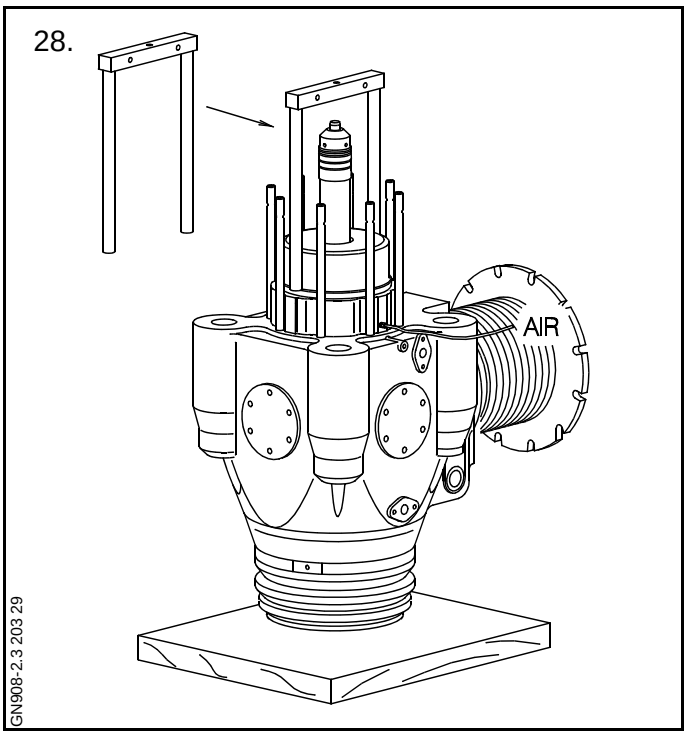
28. Mount the piston on top of the spindle and check the functioning of the damper piston.

    Connect compressed air supply to the space below the air piston, so as to keep the valve closed, and to keep the air cylinder in close contact with the valve housing.

    Place the measuring tool on the air cylinder across the piston.







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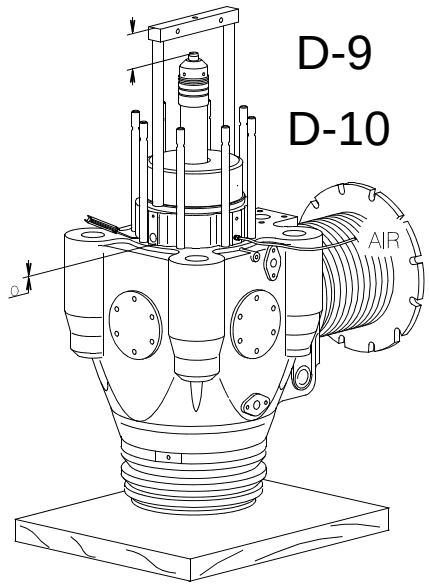

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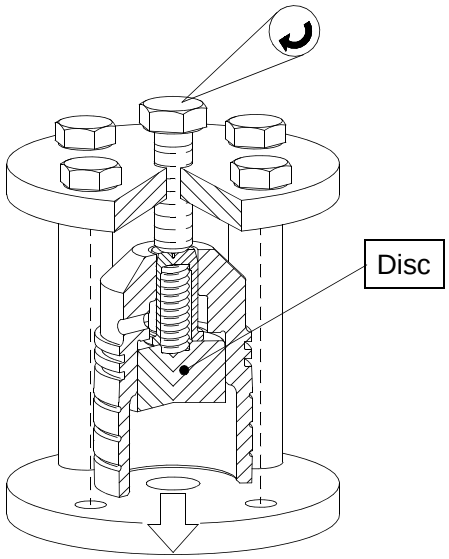

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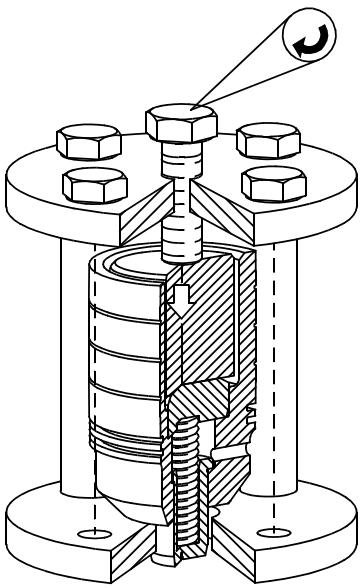


29. Check the mesh of the damper piston by checking the distance from the upper edge of the crossbar to the top of the damper piston. *See Data*.

    If the measurement is outside the value stated in Data, adjustment must take place by changing the disc in the damper piston as follows:

30. Place the piston in the special tool.

    Press out the disc with the centre screw.

    If necessary, change also the spring and the piston.

31. Assemble the damper piston with the new disc in the special tool.

    Place the piston upside down in the tool and press the disc into place in the piston.

    Check the mesh once more, repeating points 28 and 29.

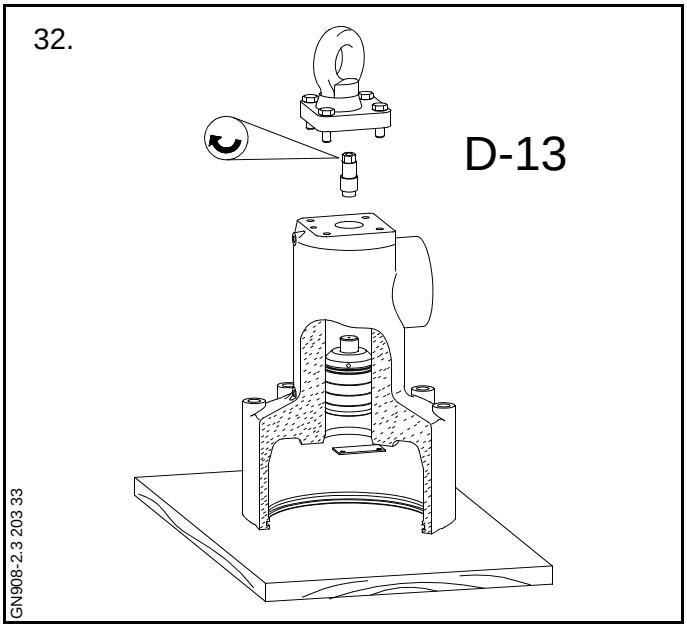
32. After carefully cleaning and visually checking all the parts, assemble the parts and mount the piston, orifice plug and lifting eye in the oil cylinder. *See Data*.

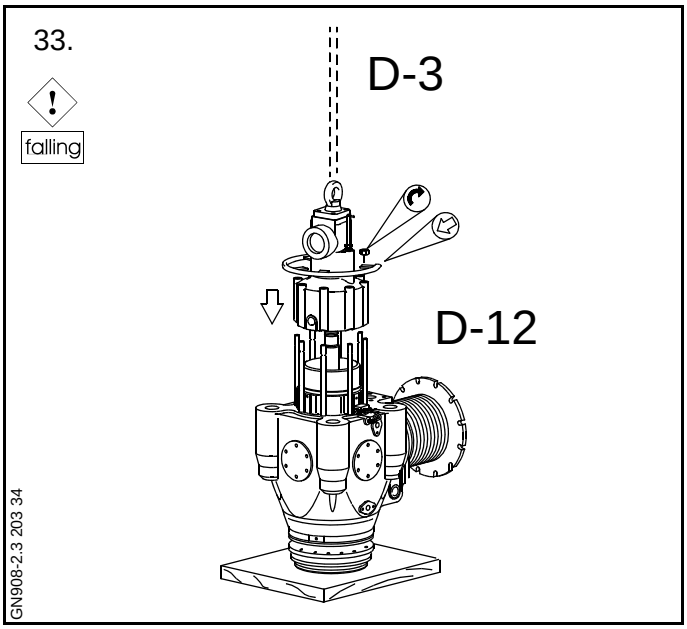
33. Mount a new sealing ring in the inner groove of the oil cylinder.

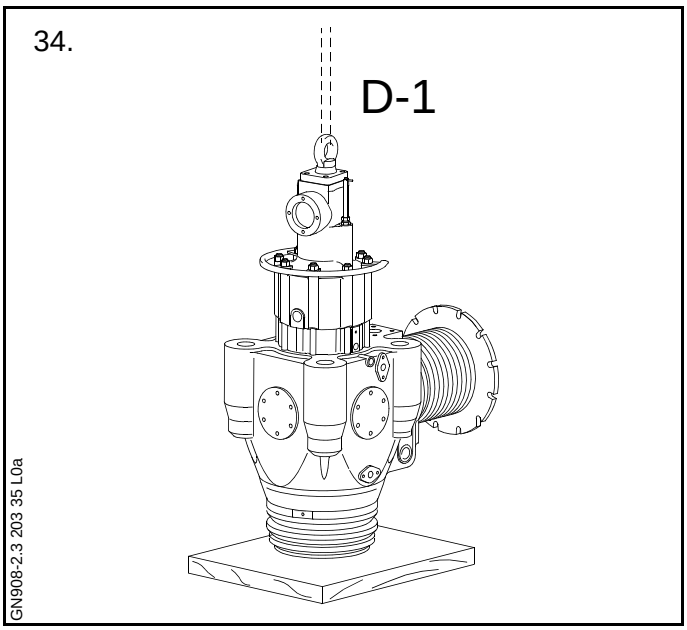
    Mount the overhauled oil cylinder on top of the air cylinder.

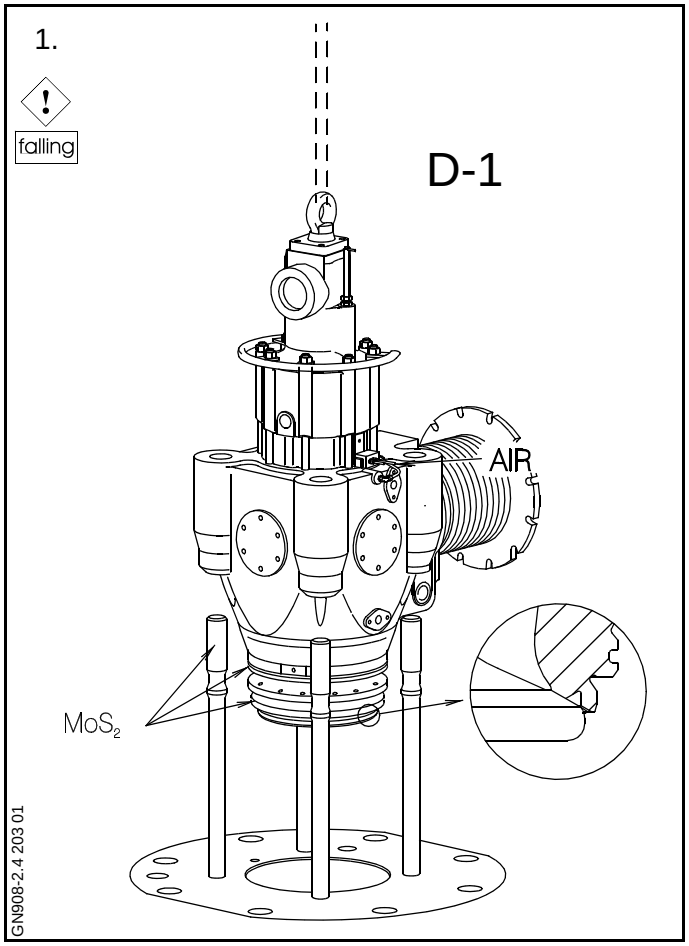
    Mount the safety strap and tighten the nuts. *See Data.*

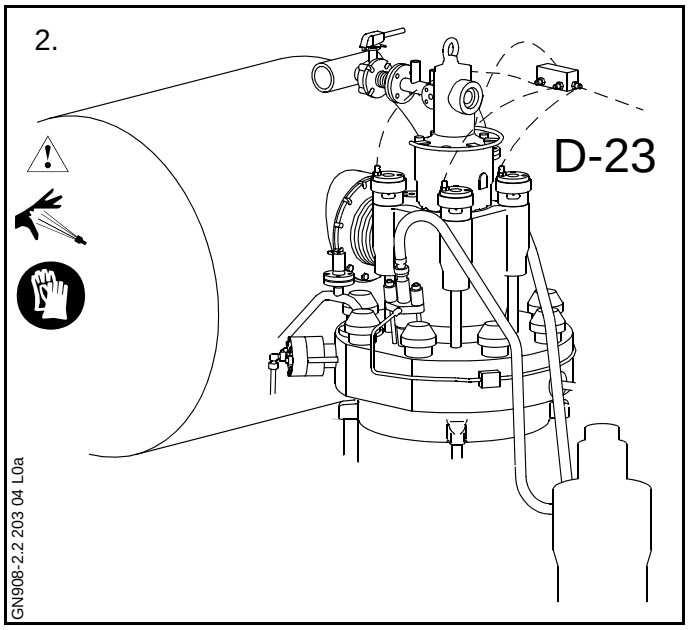
34. Blow through the orifice pipe in the exhaust valve housing with compressed air to remove any obstructions.











1. After fitting new O-rings on the seat and the water connection, lift the overhauled exhaust valve.

   Lubricate the O-rings and the threads of the studs with molybdenum disulphide (MoS_2).

   Position the valve in the cylinder cover bore, guiding it in accordance with the exhaust flanges and the water connection.

Note!
Before mounting the valve on the engine, connect compressed air to the pneumatic piston to keep the exhaust valve closed during the mounting.

2. Mount the nuts and the hydraulic jacks. Raise the pressure to the value indicated in Data and tighten up the nuts.

   Relieve the system of pressure, remove the hydraulic jacks and the high-pressure hose, and fit the protective caps.

3. Connect the intermediate pipe to the flange at the exhaust receiver.

   Attach the insulation jacket.

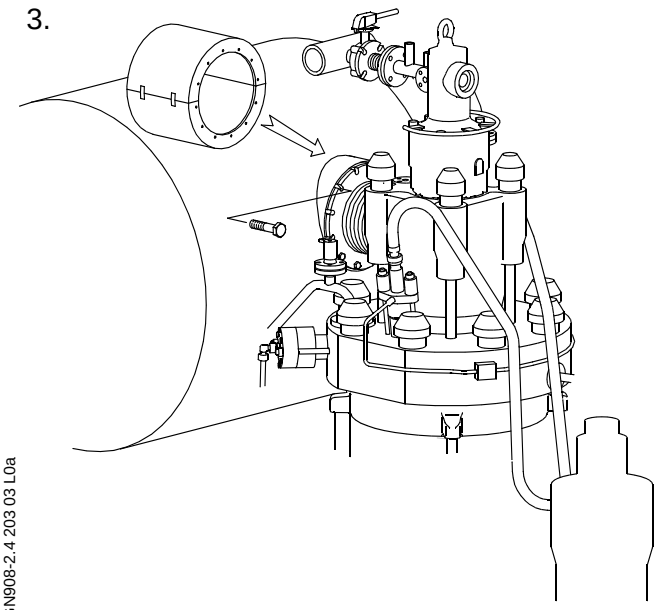
4. Mount the cooling water inlet and outlet pipes on the exhaust valve.

   Mount the high-pressure pipe, the return oil pipe, the sealing air pipe and the air pipe for the pneumatic exhaust valve.

   Open the lub. oil supply and the cooling water supply to the exhaust valve.

Caution!
The air supply to the exhaust valve must always be connected **before** starting the camshaft oil pumps. This is **very** important, because otherwise the valve will open more than normal**.**

3.



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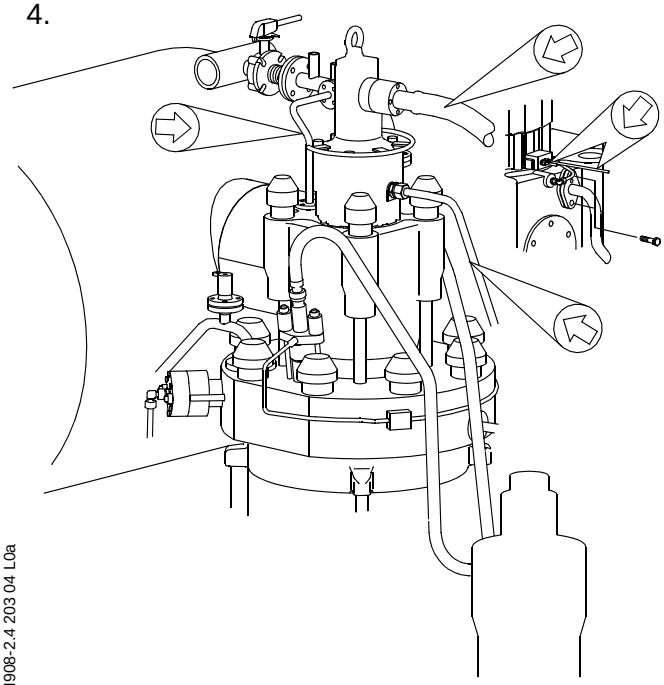

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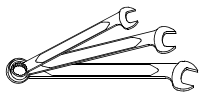
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Do not enter area when over head lifting is being carried out
X	Block the starting mechanism	Risk of severe presonal injury (while engine being turned)
X	Shut off starting air supply	
X	Engage turning gear	
	Shut off cooling water	
X	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

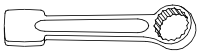
Ref.	Description	Value	Unit
D-1	Weight of high-pressure pipe	34	kg
D-2	Weight of hydraulic actuator	72	kg
D-3	Oil cylinder, inside diameter	71.2	mm
D-4	Piston rings, min. thicknessmax.	2.6	mm
D-5	Hydraulic actuator - tightening angle	25	°
D-6	Locking plate - tightening torque	10	Nm

Standard Tools: See Section 913



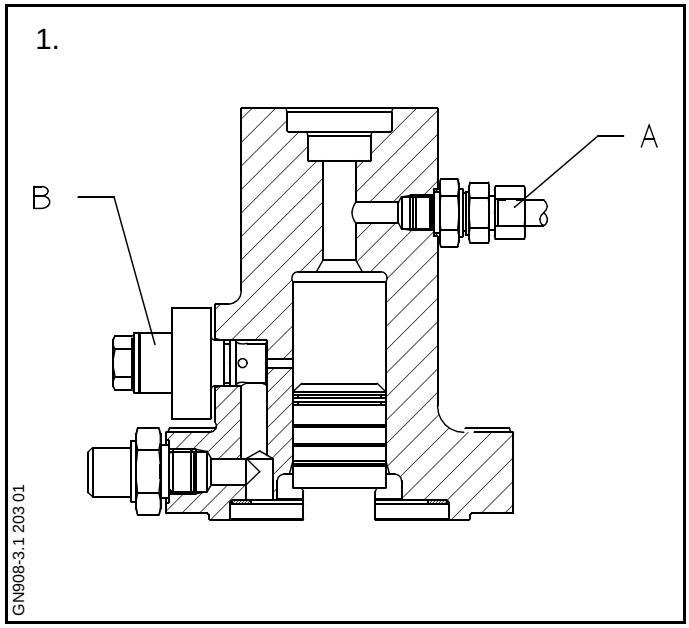
20 - 90 Nm, 100 - 750 Nm

2 x M12



1. The non-return valve **A** is built into the oil inlet pipe to the actuator.

   To check the valve, disconnect and clean it and connect a supply of working air (0.7 MPa (7 bar)) to the outlet side of the valve (the side facing the actuator). If an air flow is felt at the inlet side of the valve, it must be overhauled.

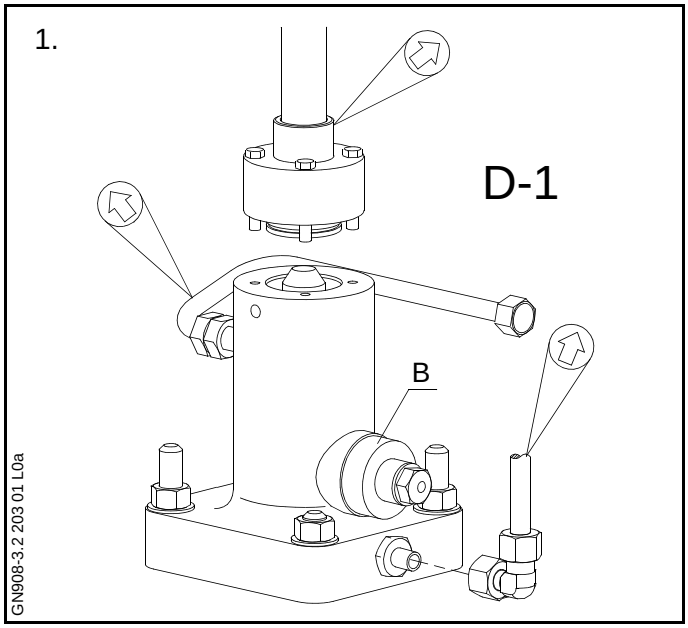


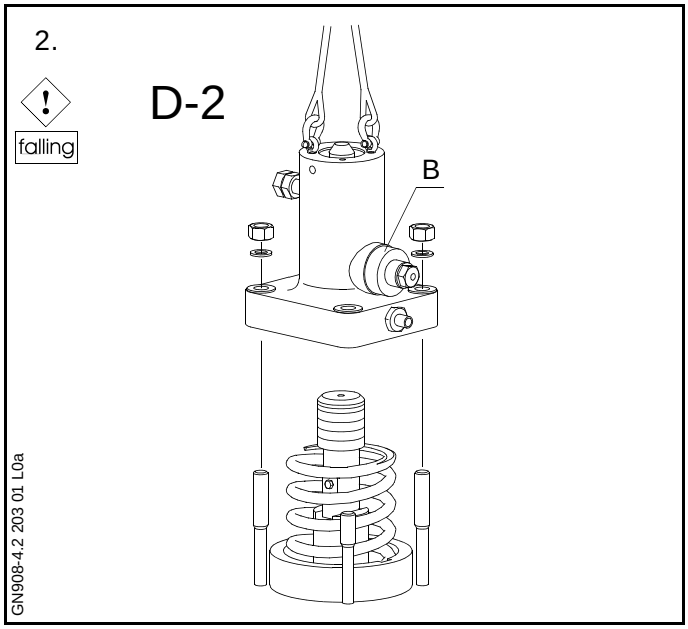
Caution:For reversible 4-5 cyl. engines only.

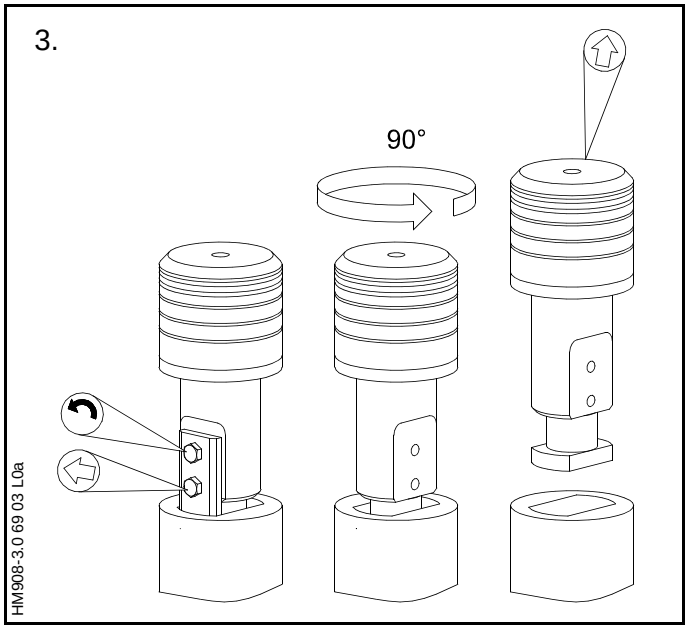
During the starting sequence in ASTERN direction, the exhaust valve will start to open while the cylinder is still being supplied with starting air.

The puncture valve **B** will delay opening of the exhaust valve until the starting air sequence has finished.

Note!
The puncture valve is not standard on all engins, but for reversible 4-5 cyl. engines.







1. Stop the engine and shut off the oil supply.

   Turn the camshaft so that the roller rests on the circular part of the cam.

   Remove the inspection cover of the camshaft housing to inspect the position of the exhaust cam.

   Dismount the inlet pipe and the drain pipe from the exhaust valve.

   Dismount the screws of the high-pressure pipe flange, and lift away the high-pressure pipe. *See Data **D-1**.*
   See Procedure 908-1.

2. Fit eye screws in the lifting holes of the actuator housing and hook on a tackle.

   Unscrew the nuts on the two short studs, then loosen the nuts on the long studs successively until the tension of the roller guide spring is relieved.

   Dismount the nuts and lift the housing carefully up, leaving the piston on the top of the roller guide.

   Remove the spring.

3. Remove the locking plate for the piston. Turn the piston **90°** to free it from the bayonet joint.

   Remove the piston from the roller guide.

B:Punctur valve
Use only for reversible 4-5 cyl. engines.

1. Clean the piston in kerosene and blow dry with compressed air.

   Take off the piston rings and check them for wear. If the ring thickness has worn down to the minimum *(see Data **D-4**)*, discard the rings and mount new ones.

   Check that the **TOP** mark on the piston rings faces upwards when mounting.

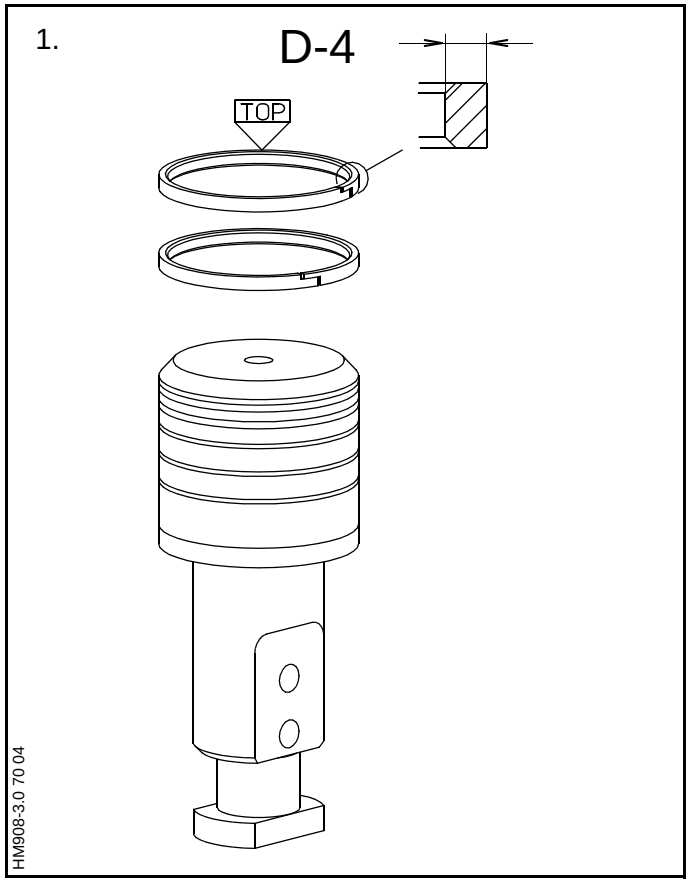
   Inspect the sliding surfaces of the piston for scratching or seizure marks.

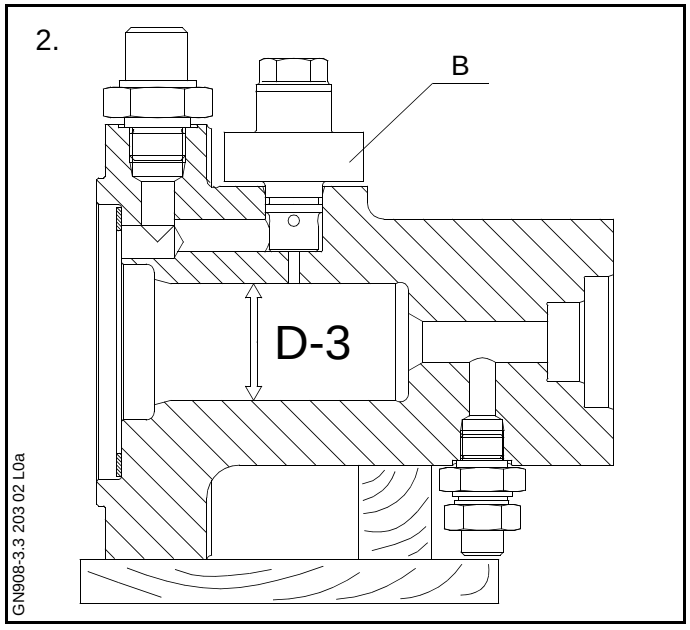
2. Clean the oil cylinder and inspect the bores for deposits.

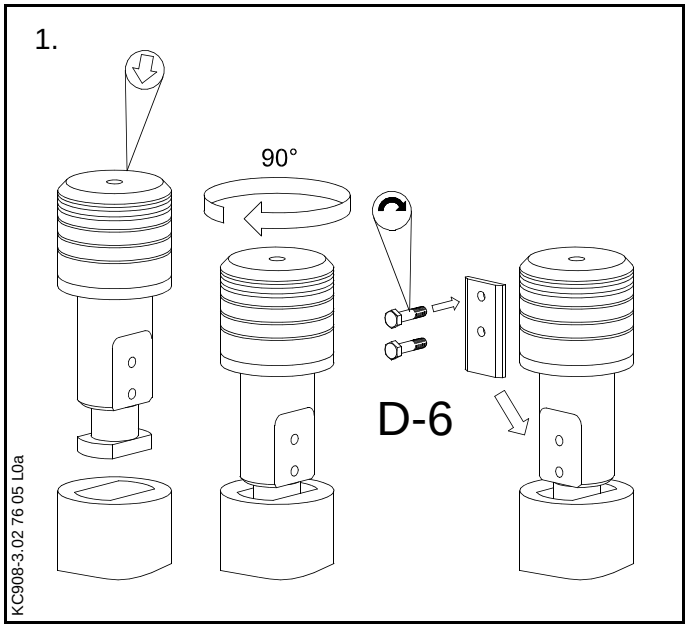
   Check the bore of the oil cylinder for possible scores and measure it for wear.

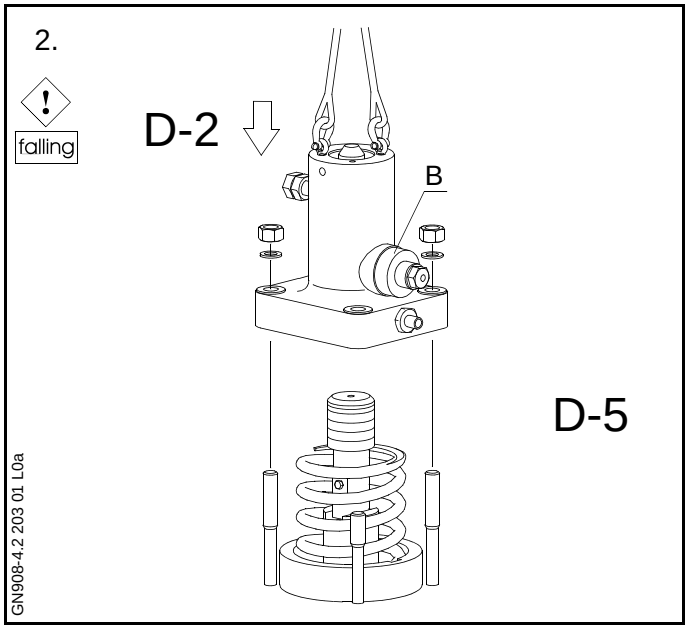
   If the bore is seized or has worn down to the measurement stated in *Data **D-3***, send the oil cylinder to MITSUI ENGINNERING & SHIPBUILDING CO., LTD. for reconditioning.

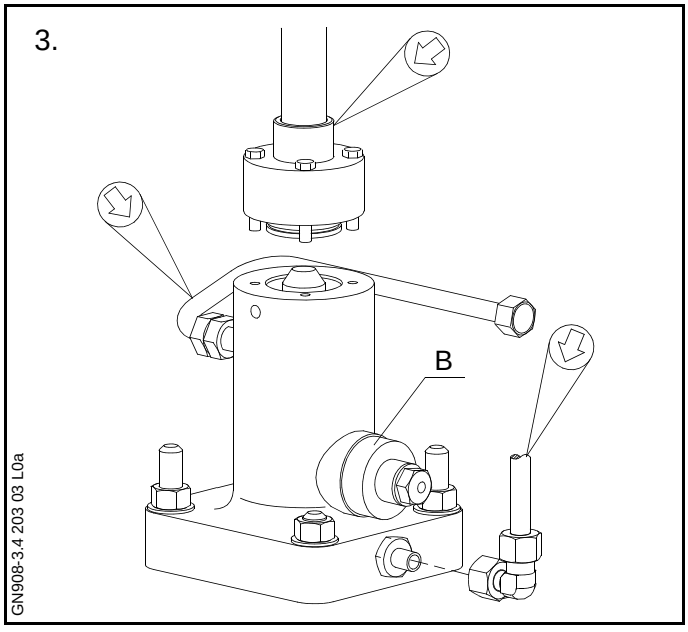
B:Punctur valve
Use only for reversible 4-5 cyl. engines.











1. Mount the actuator piston in the roller guide and turn **90°** to lock it in the bayonet joint.

   Mount the locking plate and tighten as stated in Data **D-6**. Lubricate the piston with plenty of camshaft lubricating oil.

2. Mount the spring on the roller guide. Carefully lower the actuator housing on to the piston, taking care not to damage the piston rings.

   Mount the washers and the nuts on the two long studs and tighten alternately until the actuator housing rests firmly against the roller guide housing.

   Mount the washers and nuts on the two short studs. Tighten all four nuts as stated in Data **D-5**.

3. Mount the oil inlet pipe and the drain pipe from the exhaust valve.

   Mount the hydraulic high pressure pipe. *See Procedure 908-1.*

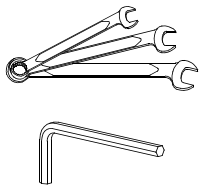
B:Punctur valve
Use only for reversible 4-5 cyl. engines.

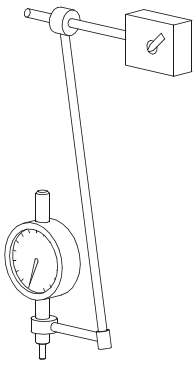
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Do not enter area when over head lifting is being carried out
X	Block the starting mechanism	Risk of severe personal injury (while engine being turned)
X	Shut off starting air supply	
X	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

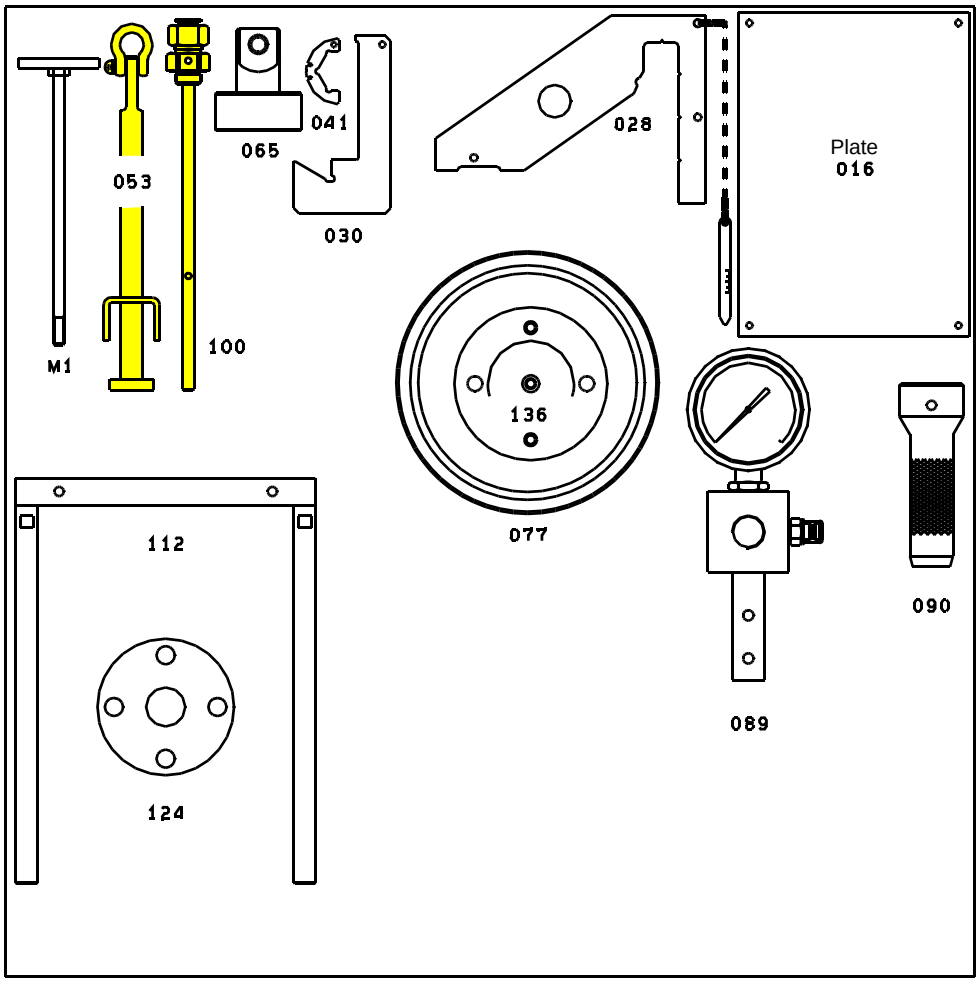
Data

Ref.	Description	Value	Unit
D-1	Weight of roller guide, complete	37	kg
D-2	Max. clearance roller/bushing/shaft pin	0.5	mm

Standard Tools: See Section 913



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1. The exhaust valve roller guide can be partially checked while mounted on the engine, using the following procedure:

   Lift the roller guide.
   See Procedure 908-5.

2. Remove the camshaft inspection cover.

   Turn the engine to provide the maximum space between the roller guide and the cam disc.

   Check the movability of the roller by turning this by hand to ascertain if the roller moves freely and without unnecessary resistance or “hard” points.

   Also inspect the surface of the roller for possible damage marks, seizures or scratches. Make sure that no traces of bearing metal exist in the roller guide housing.

   Check the clearance in the slide bearing by lifting the roller relative to the roller guide and measuring the difference in distance between the cam disc and the roller in the upper and lower positions of the roller.

3. A more suitable and reliable method is to check the roller guide and the bearing clearance when the roller guide is dismounted.

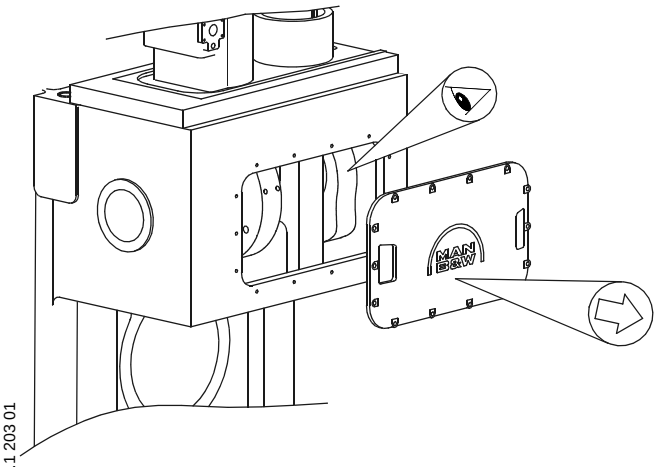
   For dismantling of the roller guide see Procedure 908-4.2.

4. Inspect the surfaces of the roller guide and the roller for damage marks, seizures or scratches.

5. To measure the clearance in the roller guide slide bearing, place the roller guide vertically upside down on a couple of planks with the roller hanging freely.

6. Place a dial gauge against the roller. Then lift the roller as much as the clearance permits, which makes it possible to read the clearance **D-2** directly on the dial.

2.



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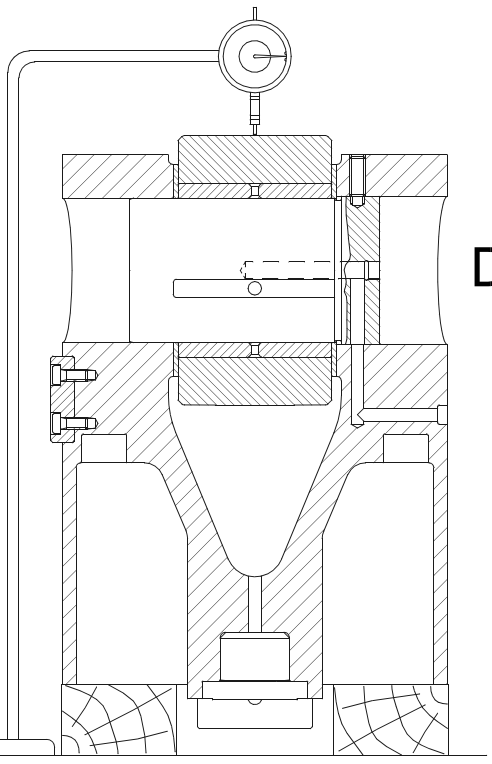
5.



GN908-4.3 203 02

7. It is recommended that the roller guide shold **ONLY** be dismantled if:

   - irregularities when turning the roller,
   - damage to the roller,
   - larger clearance than stated on the Data sheet,
   - seizure marks on the slide surfaces,

   have been observed during the checking of the roller guide.

Note!
For disassembling of the roller guide, contact MITSUI ENGINEERING & SHIP-BUILDING CO., LTD.

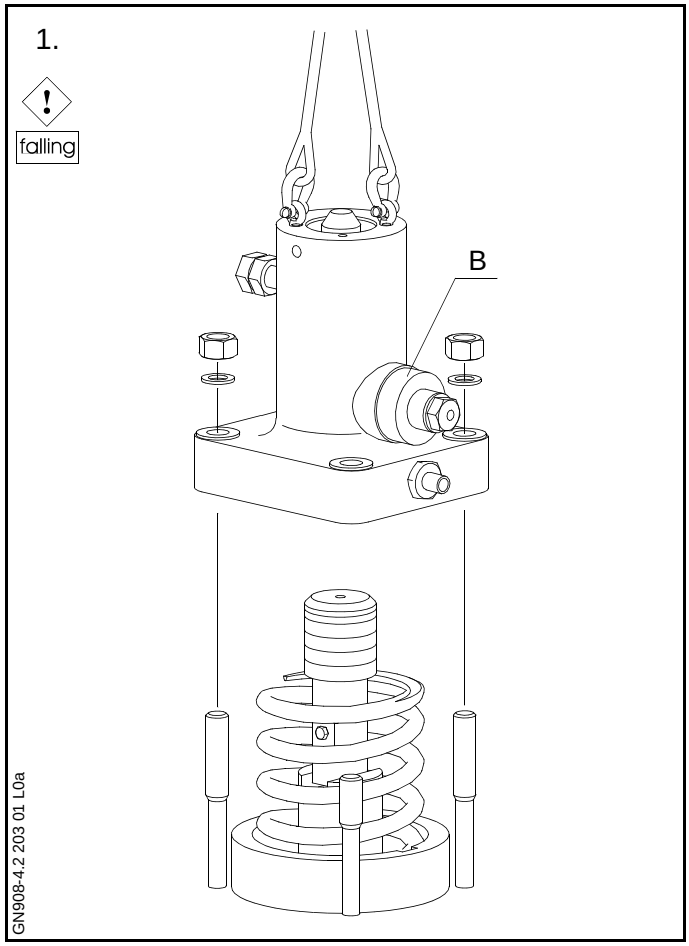
1. Dismantle the hydraulic actuator above the exhaust valve roller guide.
   See Procedure 908-3.2.

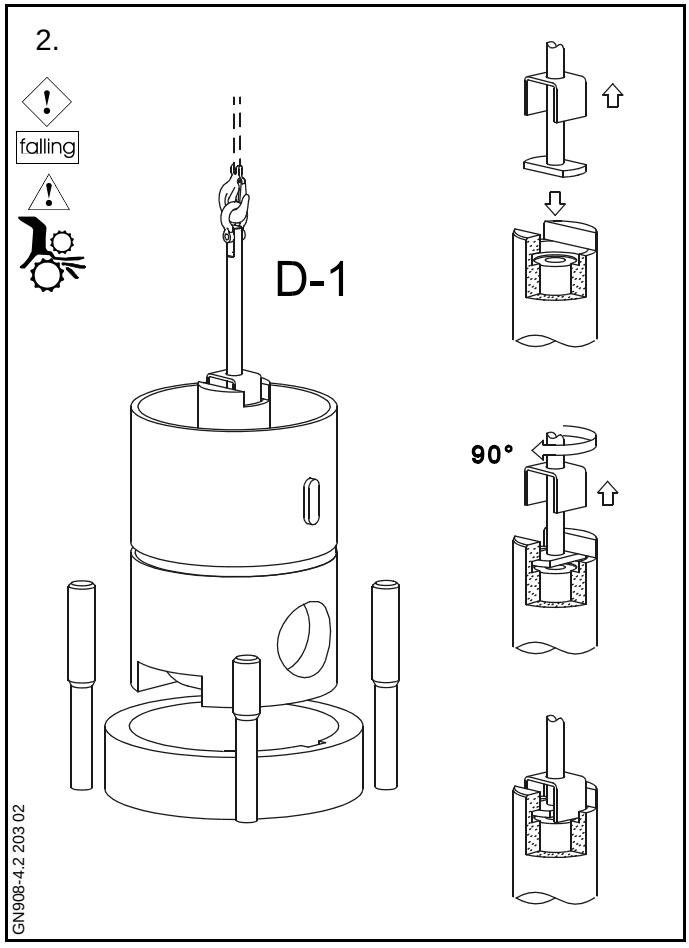
2. Mount the roller guide lifting tool as follows:

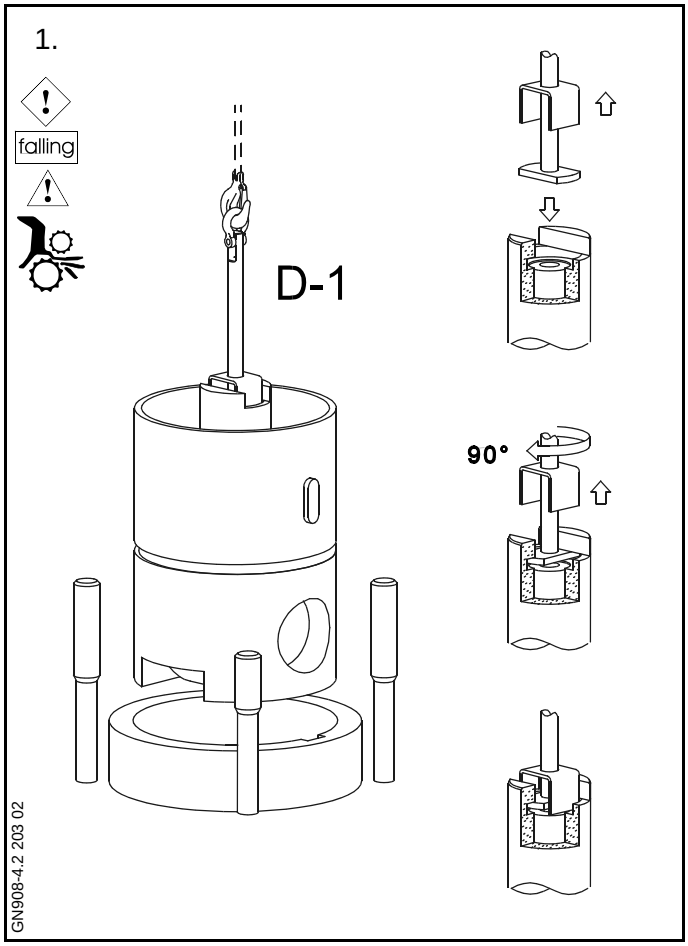
   - Lift the lock ring of the tool up on the shaft of the tool.
   - Place the tool in such a manner that its foot rests on the thrust piece in the bayonet joint of the roller guide.
   - Turn the tool **90°** so as to allow the foot to engage properly in the bayonet joint.
   - Lower the lock ring, thereby securing the foot in the locked position.

   Lift the roller guide out of the roller guide housing, using the crane. Take care not to damage the sliding surfaces of the roller guide when lifting.

B:Punctur valve
Use only for reversible 4-5 cyl. engines.







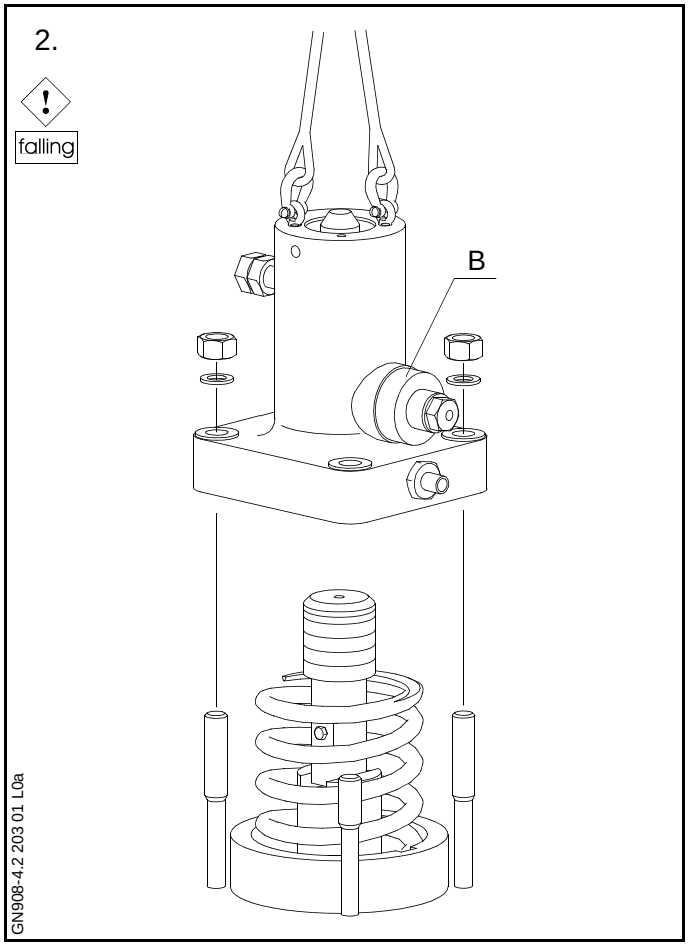
1. Mount the lifting tool for the roller guide as follows:

   - Lift the lock ring of the tool up on the shaft of the tool.
   - Place the tool in such a manner that its foot rests on the thrust piece in the bayonet joint of the roller guide.
   - Turn the tool **90°** so as to allow the foot to engage properly in the bayonet joint.
   - Lower the lock ring, thereby securing the foot in the locked position.

   Clean and lubricate the sliding surfaces of the roller and the roller guide and lower it carefully into the roller guide bushing.

   Remove the lifting tool.

2. Mount the actuator.
   See Procedure 908-3.4.



B:Punctur valve
Use only for reversible 4-5 cyl. engines.

SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of severe personal injury (while engine being turned)
X	Block the starting mechanism	
X	Shut off starting air supply	
X	Engage turning gear	
	Shut off cooling water	
X	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit

Standard Tools: See Section 913

For checking the position of the exhaust cam, turn the engine in AHEAD direction until the roller guide (measured on the activator plunger) has been lifted 10 mm.

If the cam has been correctly adjusted, the crankthrow for the cylinder concerned will then be in a position of **A°** past its TDC.

To check the lead angle, continue turning in AHEAD direction until the roller guide has been lifted 10 mm, corresponding to a turn of **B°** of the crankshaft.

The lead angle is then

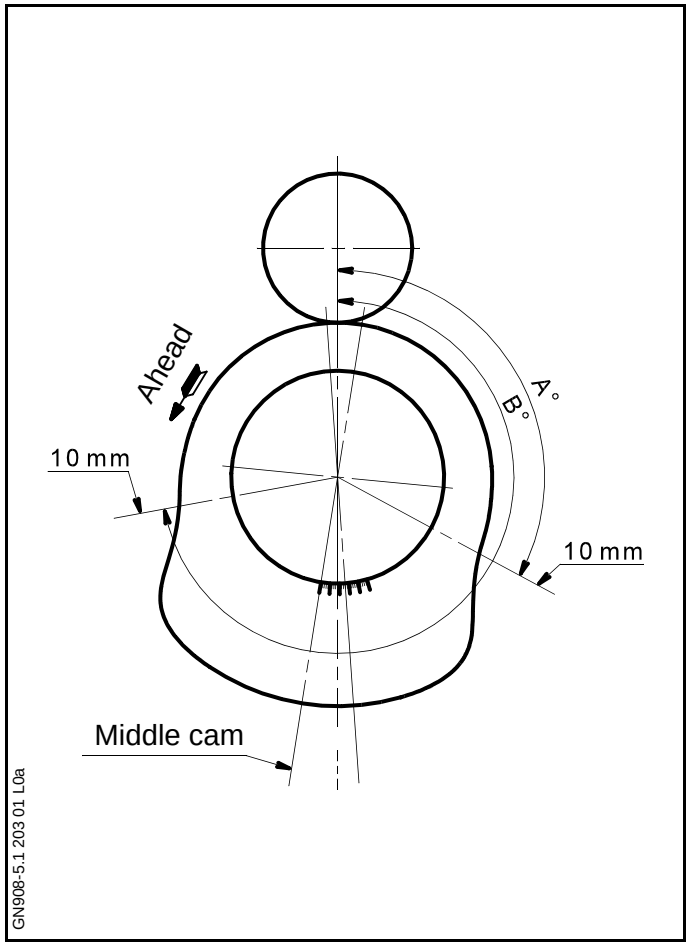
$$180° - \frac{A° + B°}{2}$$

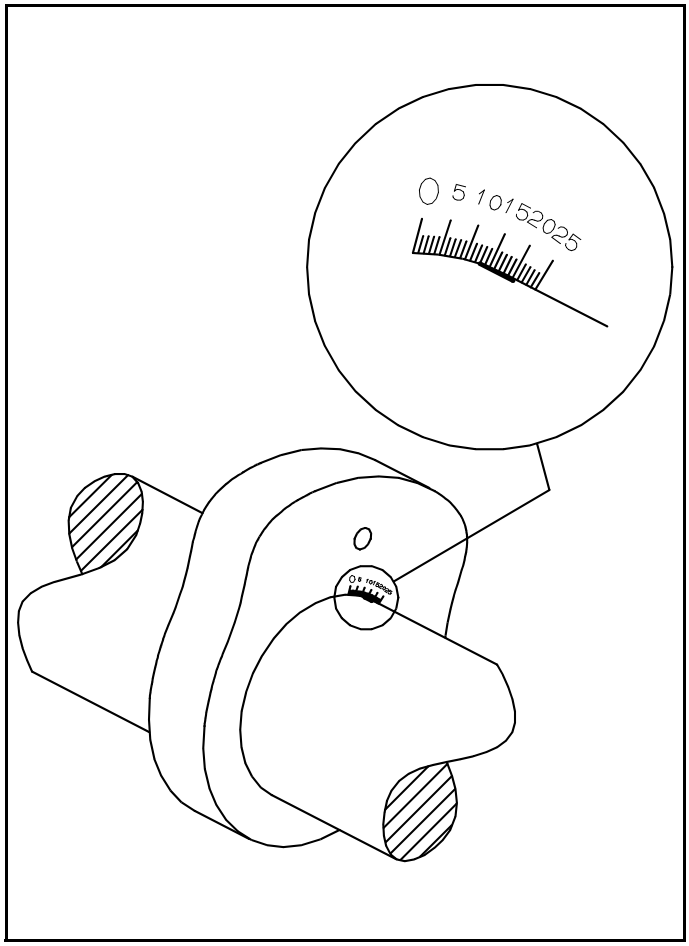
The correct position of the cam must be within +/-0.5°.

The illustration shows the position of the exhaust cam for a 6-cyl. standard engine, when the piston of the cylinder concerned is in **TDC**. *See the adjustment sheet in Vol. 1, operation, Chapter 701, for the "lead angle" of the plant in question.*

The cam lead can be checked visually by reading directly the scale position of the exhaust cam over the marking scratch on the camshaft and comparing this angle with the angle stated in the adjustment sheet.

At the same time, it is recommended to check the position of the camshaft with the pin gauge. *See Procedure 906-3.1.*





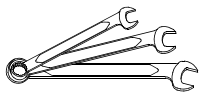
SAFETY PRECAUTIONS

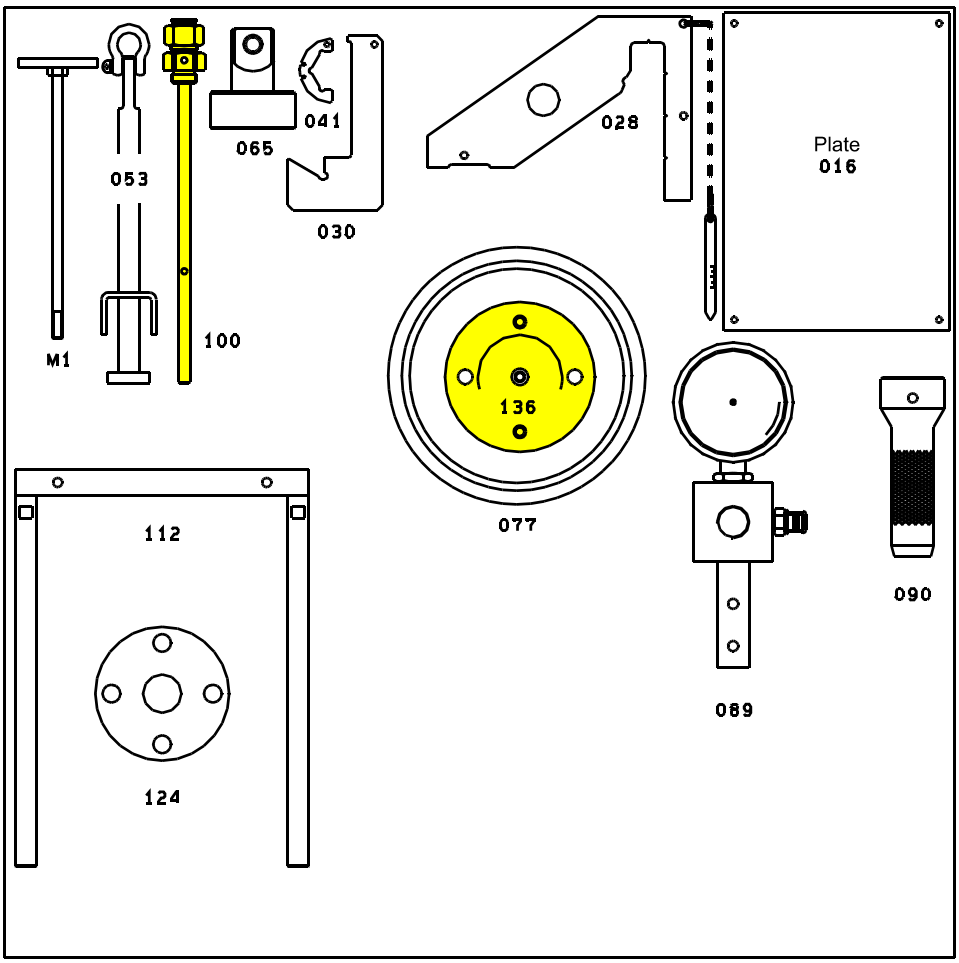
X	Stopped engine
X	Block the starting mechanism
X	Shut off starting air supply
X	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Shut off lubricating oil
	Lock turbocharger rotors

Data

Ref.	Description	Value	Unit
D-1	Weight of high-pressure pipe	34	kg

Standard Tools: See Section 913

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Engine trouble might require that a cylinder be taken out of action. The engine can continue operation with the fuel and exhaust systems of a single cylinder disconnected.
See Vol. 1, Section 704.

This can take place with the exhaust valve locked in either the open or the closed position. Either way, carry out the following procedure:

1. Lift the relevant fuel pump roller guide.
   See Procedure 909-16.

2. Dismantle the hydraulic high-pressure pipe.
   See Procedure 908-1.3.

3. Dismantle the connecting sleeve and the oil inlet pipe. Discard the sealing rings. Blank off the connection from the main oil pipe with a plug screw.

4. Remove the inspection cover of the camshaft housing. Turn the engine until the exhaust roller guide is at **TDC**.

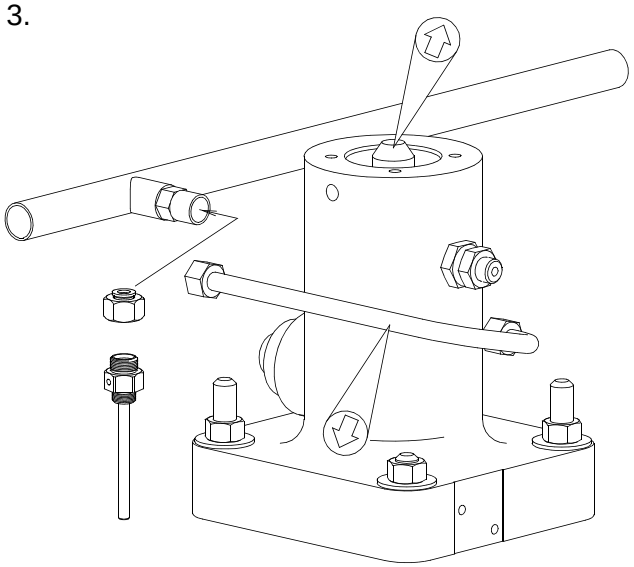
5. Position the lifting tool on the actuator and screw the spindle into the top of the actuator piston.

   Tighten the lowermost nut on the tool to pull up the roller guide as far as possible.

   Tighten the upper nut of the tool against the lower nut to secure the roller guide in this position.

6. If the cylinder is to operate with the exhaust valve closed, the air supply must remain connected to the air cylinder of the exhaust valve. No further action is required.

3.



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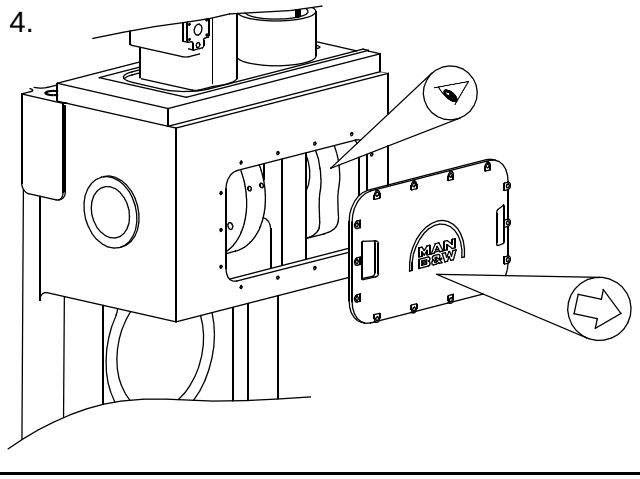

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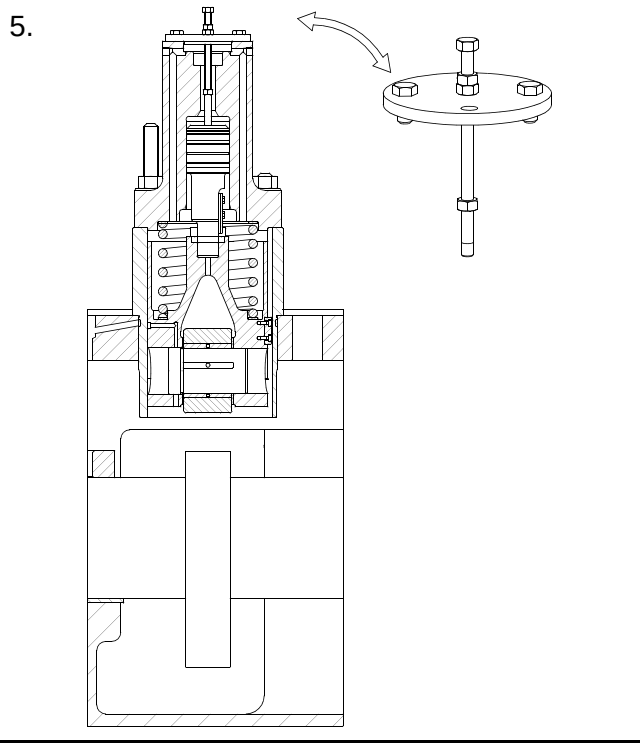
5.



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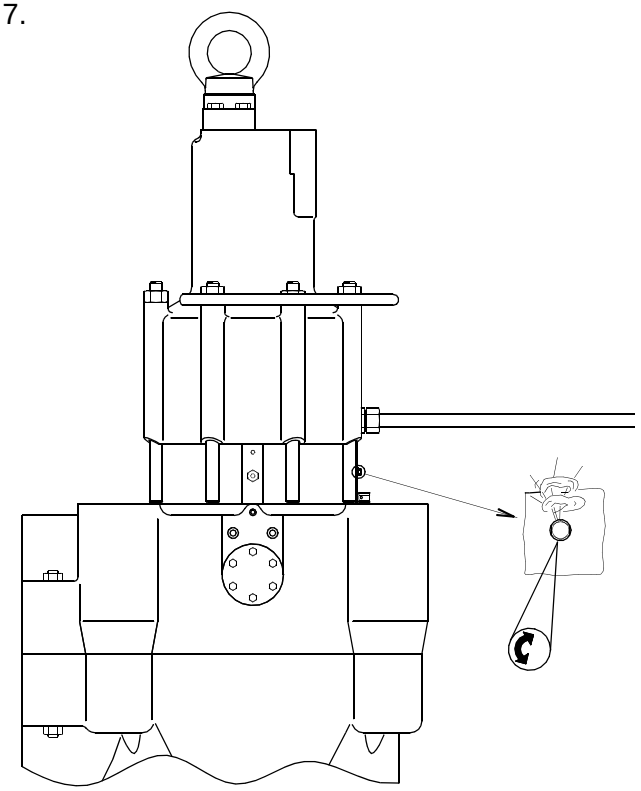

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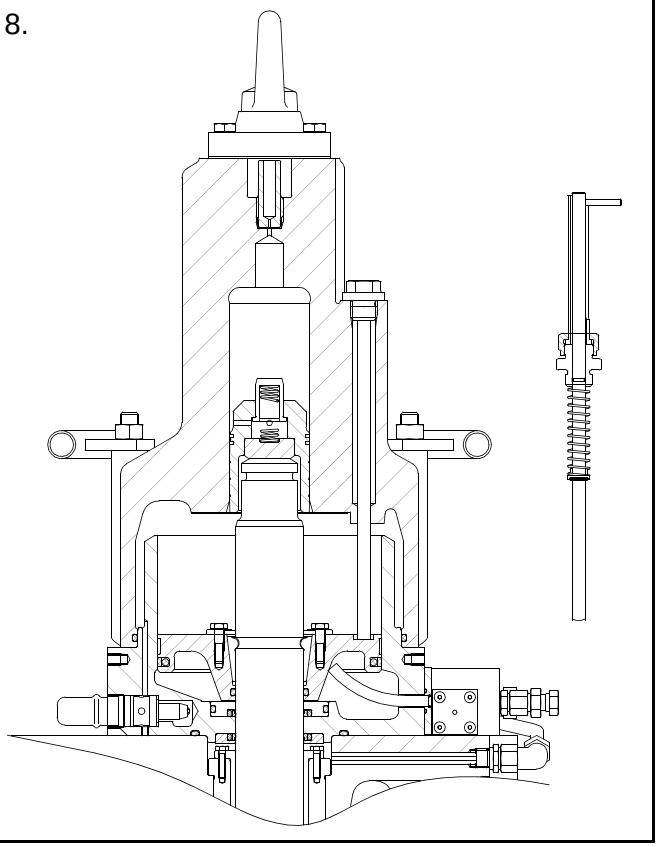


GN908-7 203 08

If the cylinder is to operate with the exhaust valve open, continue the procedure as follows:

7. Turn off the air to the exhaust valve.

   Remove the venting plug screw, fitted just above the ball cock on the air cylinder, to let the air inside the air cylinder escape.

8. Dismantle the rotation indicator on the air cylinder and mount the tool for opening of the exhaust valve.

   The tool will keep the piston of the air cylinder in the bottom position and thus keep the exhaust valve open.

After overhaul of the cylinder unit, re-engage the exhaust valve gear as follows:

9. Loosen the nuts of the lifting tool to lower the roller guide on to the exhaust cam. Remove the tool.

10. If the engine has been running with the exhaust valve open, remove the tool mounted in the air cylinder and mount the rotation indicator.

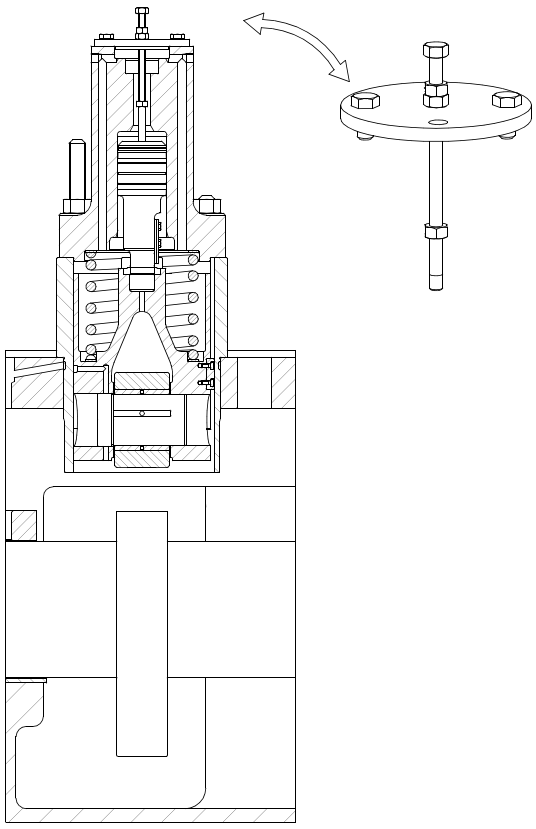
    Re-connect the air supply to the air cylinder.

11. Mount the oil inlet pipe and the connecting sleeve on the actuator housing, after fitting new sealing rings on the connecting sleeve.

12. Mount the hydraulic high-pressure pipe. *See Procedure 908-1.2.*

13. Engage the fuel pump roller guide. *See Procedure 909-16.*

9.



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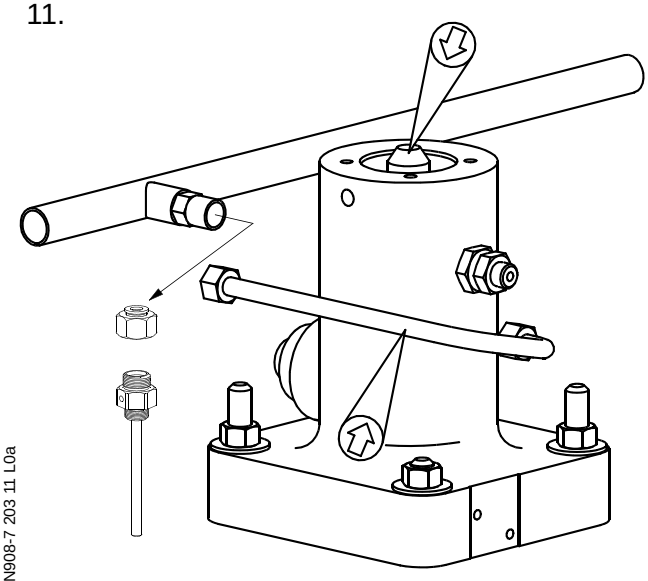
11.



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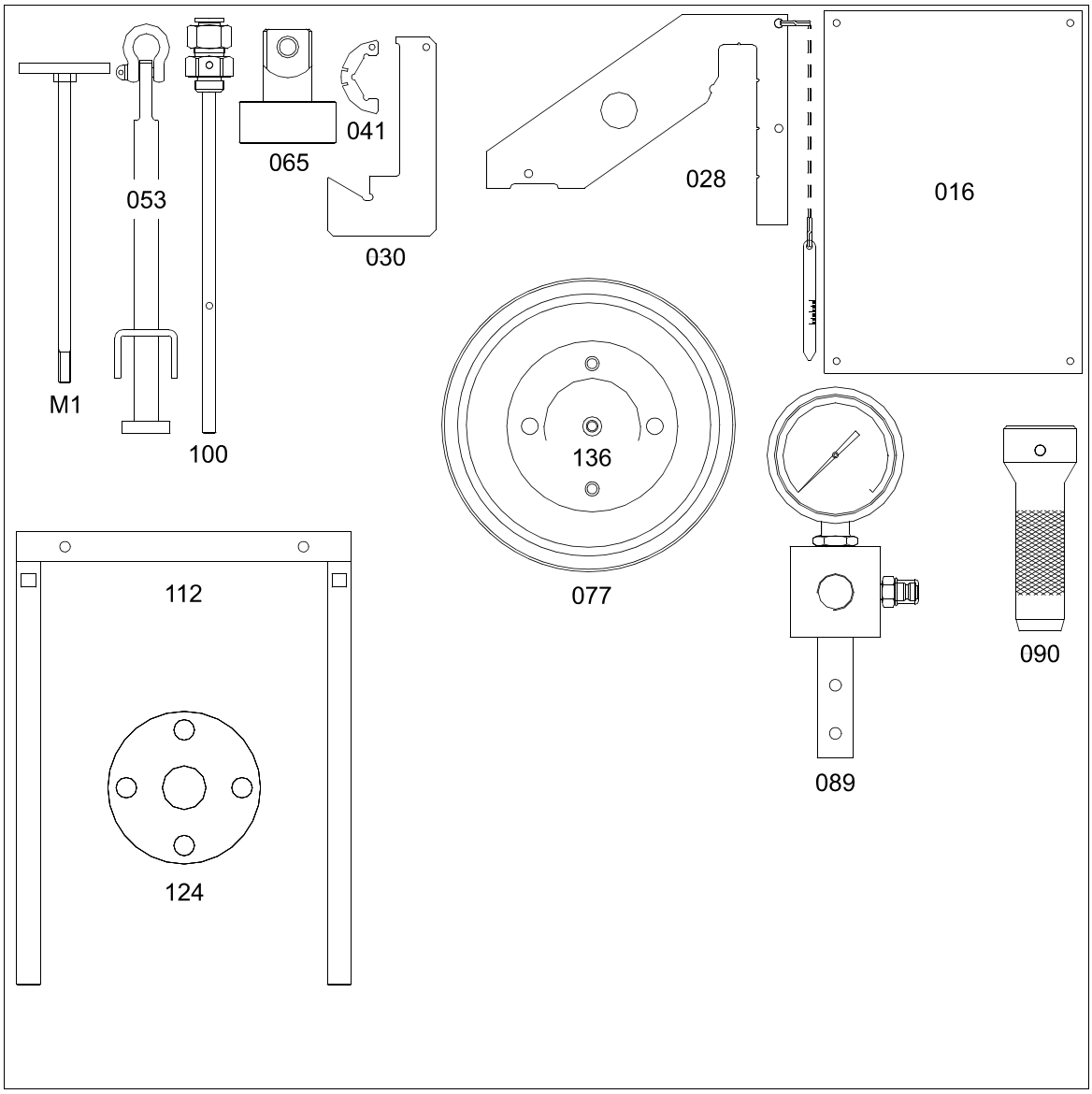
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Plate 90851-126M Exhaust Valve Panel

Item No.	Part Description	MES Tools No.	
016	Tool panel *)	(P908)	
028	Gauge for valve spindle	08A75	
030	Gauge for valve seat	08A76	
041	Tightening gauge	08B71	
053	Lifting tool for roller guide	08B11	
065	Lifting tool for spindle	08A12	
077	Cone ring	08A51	
089	Pressure testing device	08A71	
090	Stepped drift	08B55	
100	Tool for opening of exhaust valve	08A60	
112	Measuring tool	08A73	
124	Tool for hydraulic piston	08A46	
136	Lifting tool for exhaust valve gear	08B12	
M1	Measuring tool for advance angle	08B73	
016-M1	*) Tool panel, complete with tools	-	

*) Optional extra

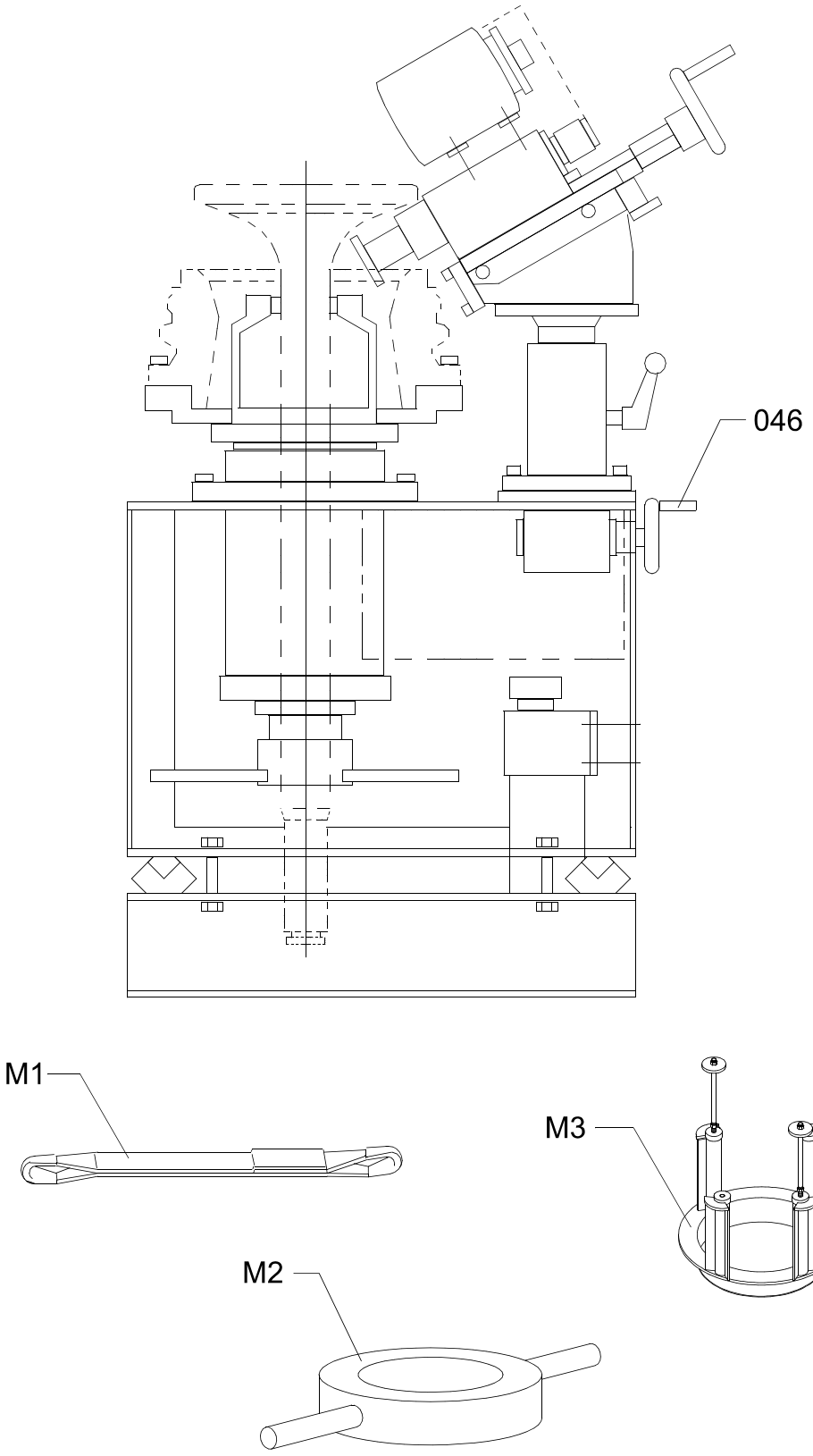
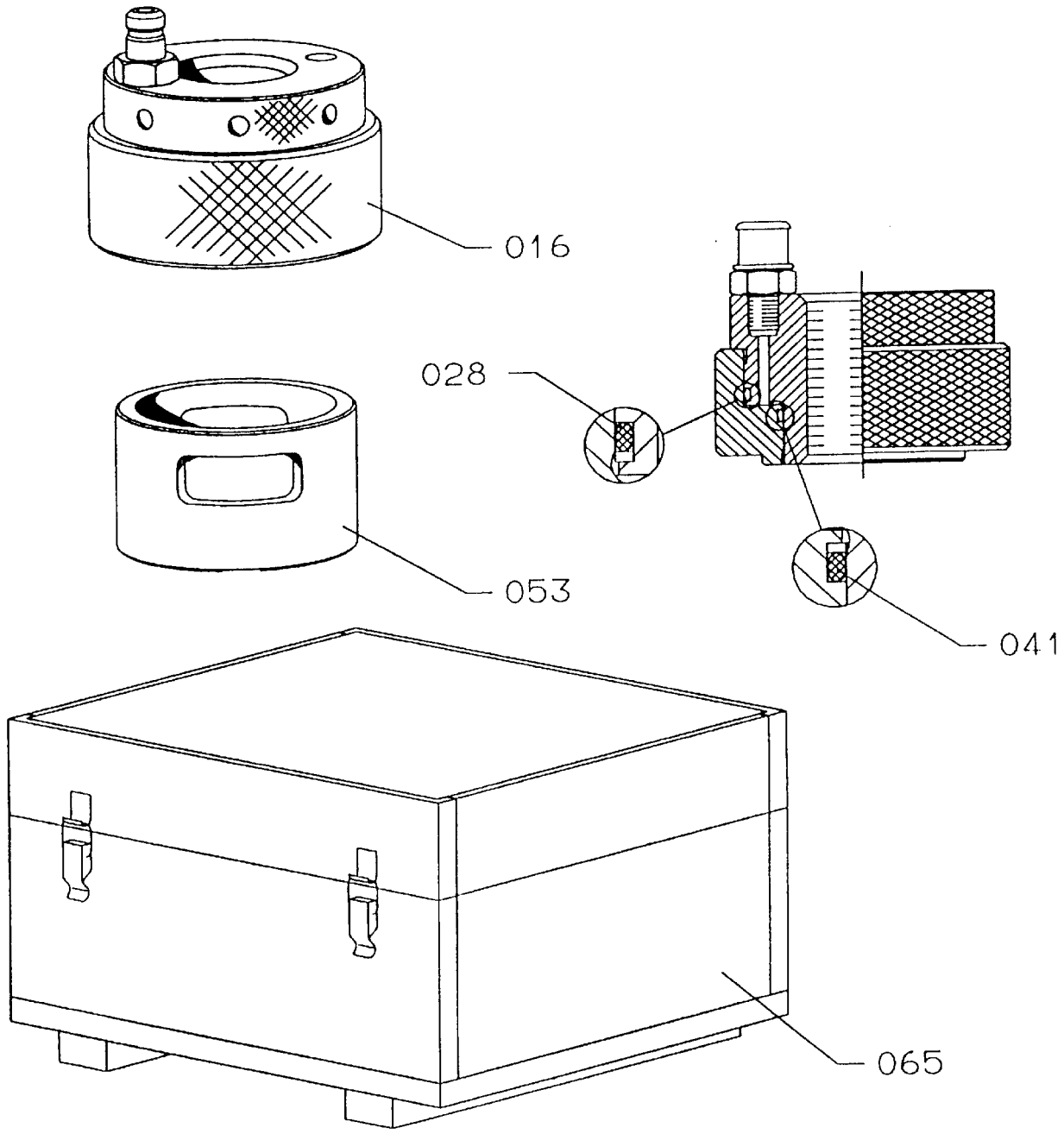

046
M1
M3
M2

Plate 90861-34Ma Exhaust Valve - Tools

Item No.	Part Description	MES Tools No.	
046	Grinding machine, complete	08A25	
	When ordering spare parts, please refer to the YAMASHINA SEIKI CO., LTD..		
M1	Sling for exhaust valve	08A18	
M2	Grinding ring	08A21	
M3	Stand for exhasut valve	08A55	


016
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065

Plate 90862-85M Exhaust Valve - Tools

Item No.	Part Description	MES Tools No.	
016	Hydraulic jack	08A01	
028	O-ring with back-up ring	08A03	
041	O-ring with back-up ring	08A03	
053	Spacer ring	08A02	
065	Hydraulic tools for exhaust valve studs, complete	-	

INDEX

CYLINDER COVER

PISTON WITH ROD AND STUFFING BOX

CYLINDER LINER AND
CYLINDER LUBRICATION

CROSSHEAD WITH CONNECTING ROD

CRANKSHAFT, THRUST BEARING
AND TURNING GEAR

MECANICAL CONTROL GEAR

STARTING AIR SYSTEM

EXHAUST VALVE

FUEL OIL SYSTEM

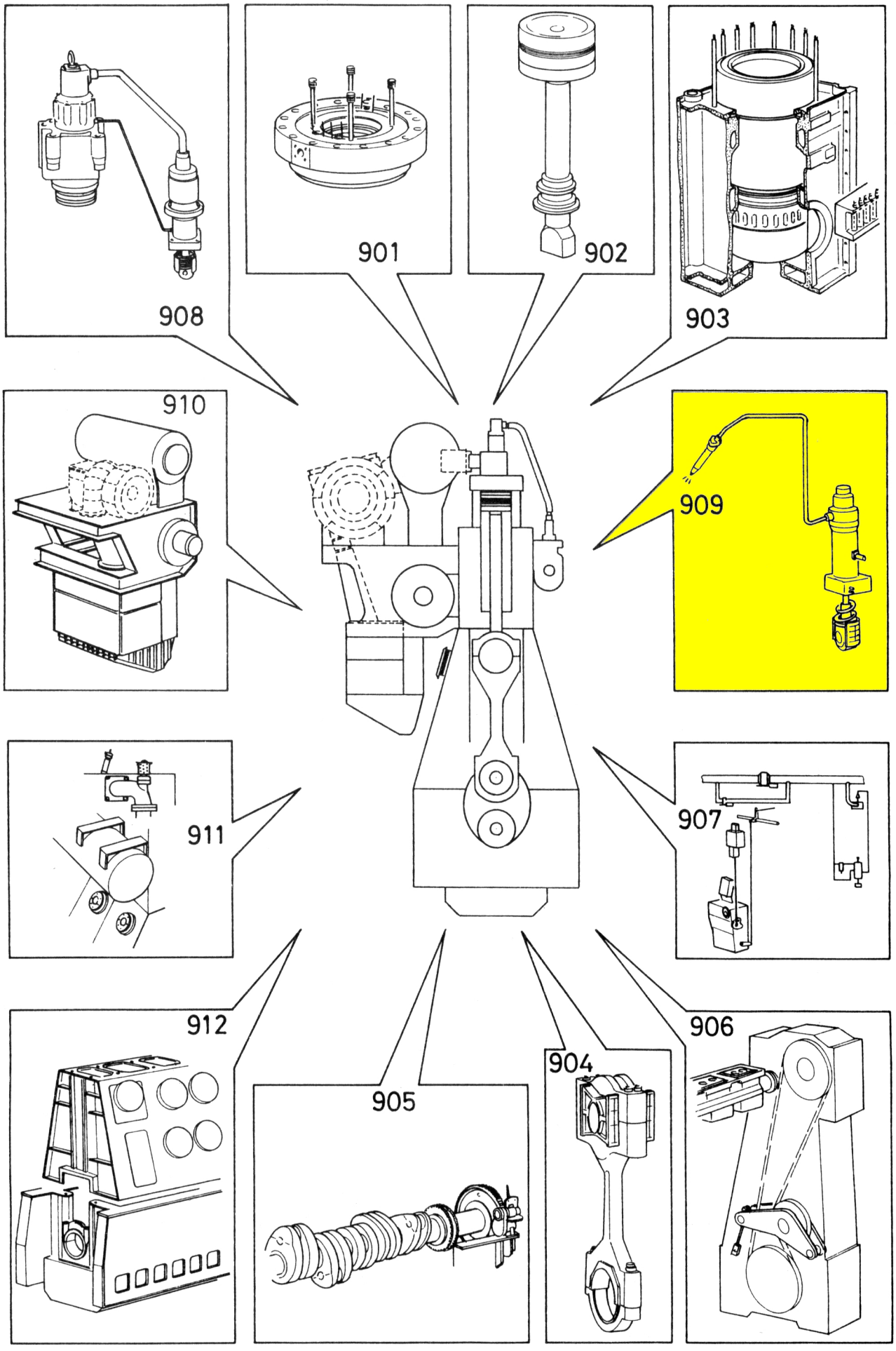
TURBOCHARGER SYSTEM

SAFETY EQUIPMENT

ASSEMBLY OF LARGE PARTS

GENERAL TOOLS

MITSUI
MAN
B&W

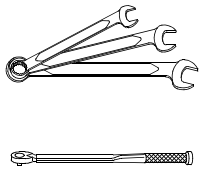


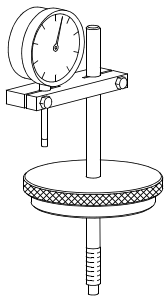
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of hot surfaces
X	Block the starting mechanism	Risk of severe personal injury (while engine being truned)
X	Shut off starting air supply	Naked flames prohibited
X	Engage turning gear	
	Shut off cooling water	
X	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

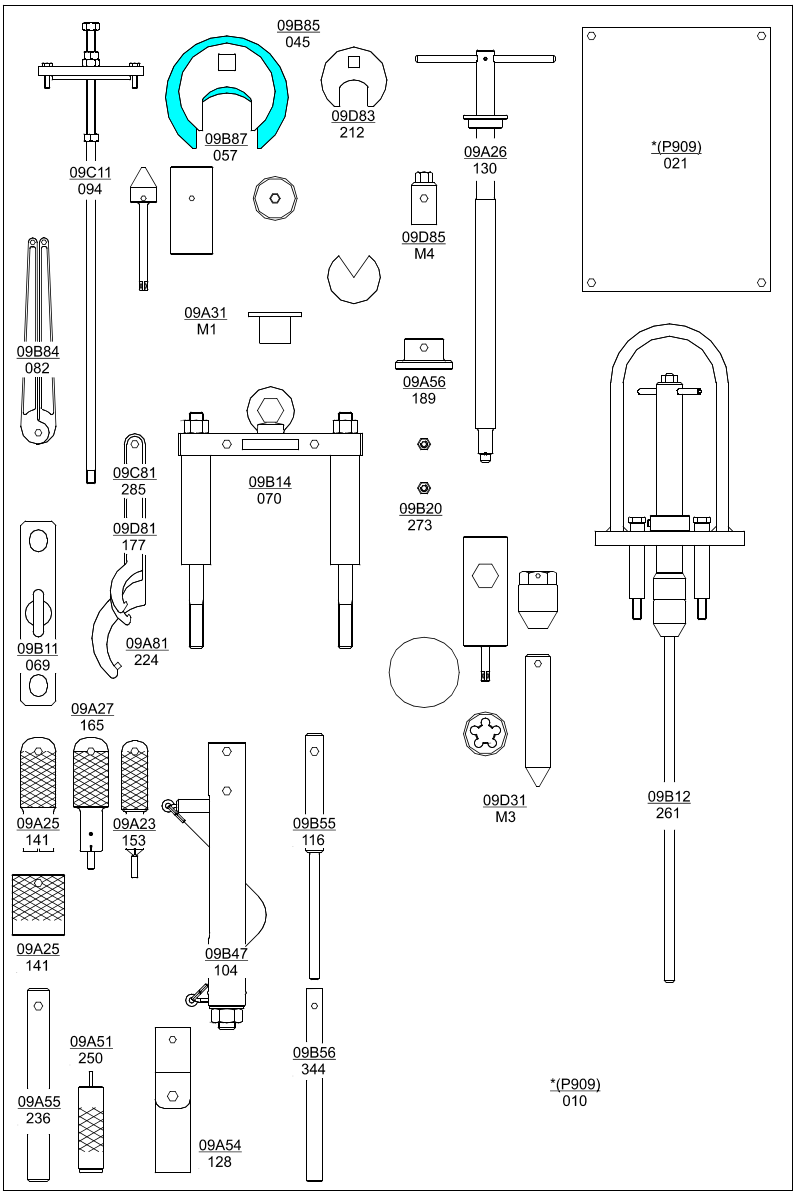
Data

Ref.	Description	Value	Unit
D-1	Puncture valve - tightening torque	890	Nm
D-2	Lead change at 1 index mark on $\mathbf{p_{max}}$-rack	1	mm
D-3	$\mathbf{p_{max}}$ change at 1 mm change of lead	0.3-0.4	MPa (3-4 bar)
D-4	Index range of $\mathbf{p_{max}}$-rack	0-8	

Standard Tools: See Section 913



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09D85
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M1
09B84
082
09A56
189
09C81
285
09B14
070
09B20
273
09D81
177
09B11
069
09A81
224
09A27
165
09D31
M3
09B12
261
09A25
141
09A23
153
09B55
116
09A25
141
09B47
104
09A51
250
09B56
344
09A55
236
09A54
128
*(P909)
010

1. The lead **a** of the fuel pump (= the effective lead) is defined as the number of mm which the top edge of the fuel pump plunger is lifted above the upper edge of the cut-off holes when the main piston of the cylinder concerned is in **TDC**.

2. Turn the engine until the main piston of the cylinder concerned is in **TDC**.

   Shut off the fuel oil inlet. Open the drain valve (at the bottom of the pump housin), enabling the oil to escape from the housing. Unscrew the drain oil pipe from the fuel pump.

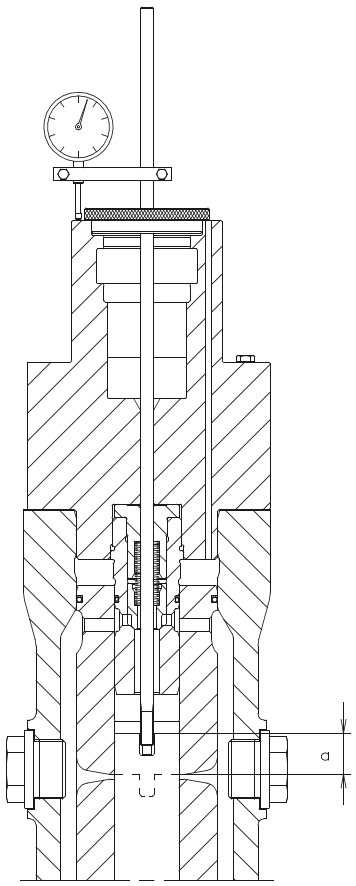
Note!
Before dismantling any part of the fuel pump, make sure thet the pump has been relieved of pressure and that all oil has been drained off.

   Disconnect the air pipe for the puncture valve.

   Dismount the protective cap and the puncture valve from the top cover.

   Dismount the erosion plugs from the fuel pump housing.

1.



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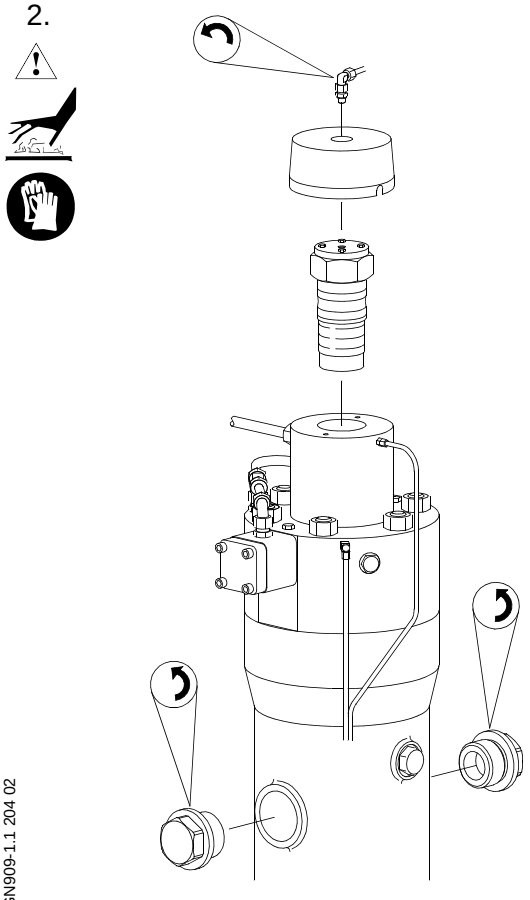

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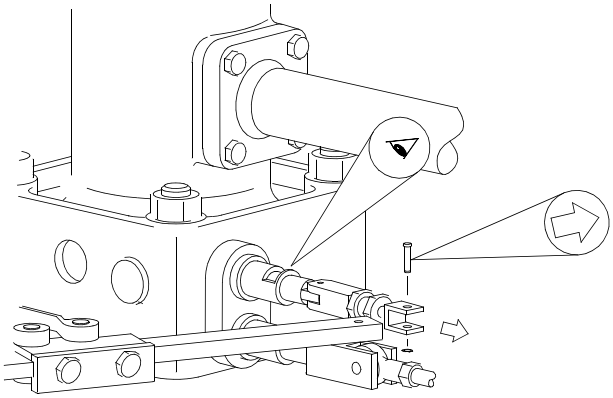

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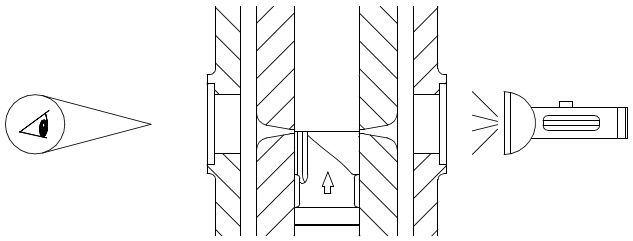

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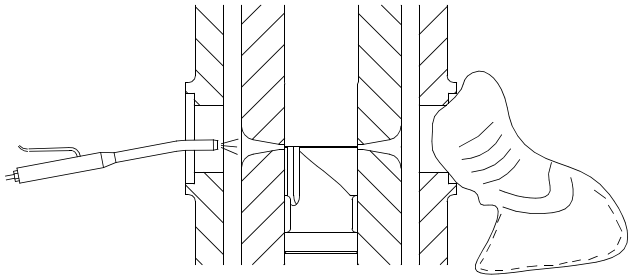

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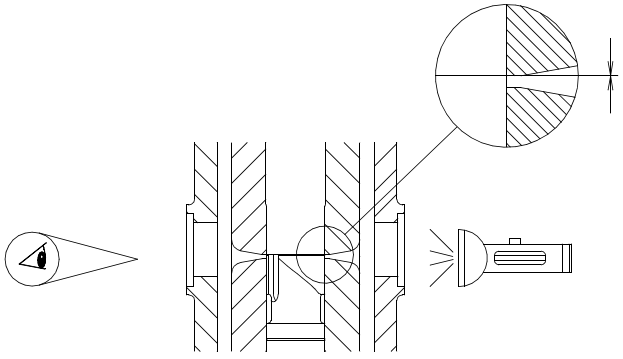


GN909-1.1 204 06

3. Remove the pin in the forked lever which connects the actuator and the **VIT**-index arm. Pull out the **VIT**-index arm to index 0 (zero).

4. Shine a torch through one of the fuel pump barrel cut-off holes and look through the other cut-off hole.

   Turn the engine in AHEAD direction until the top of plunger is in the middle of the cut-off hole.

5. Use compressed air to blow away any oil from the top of the plunger and the cut-off holes.

   If necessary, pour diesel oil through the hole in the top of cover to remove any fuel oil deposits from te top of the plunger or the cut-off holes.

6. Use compressed air to blow away any oil from the top of the plunger and the cut-off holes.

   If necessary, pour diesel oil through the hole in the top of cover to remove any fuel oil deposits from te top of the plunger or the cut-off holes.

7. Mount the measuring tool on top of the fuel pump top cover.

   Push the measuring pin fully down into the threaded hole in the top of the pump plunger.

   Adjust the bracket which holes the dial gauge until the pin of the dial gauge is pressed completely in. Adjust the dial gauge scale to 0 (zero).

8. Turn the engine in AHEAD direction until the main piston of the cylinder concerned is in **TDC**.

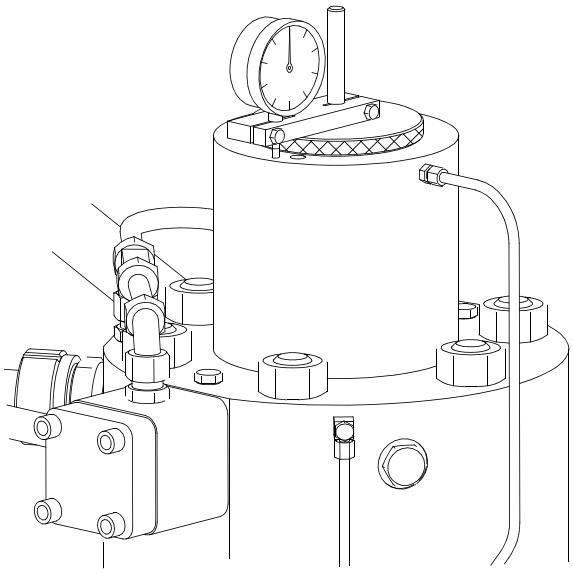
   Determine that the main piston is exactly at **TDC** by checking the position of the crankthrow and the marks on the turning wheel.

   Read the measuring result, which is the lead **a** of the fuel pump, on the dial gauge. Note down the result.

9. Remove the measuring tool from the fuel pump.

   Replace the O-rings on the puncture valve and re-mount the puncture valve in the top cover. *See Data.*

7.



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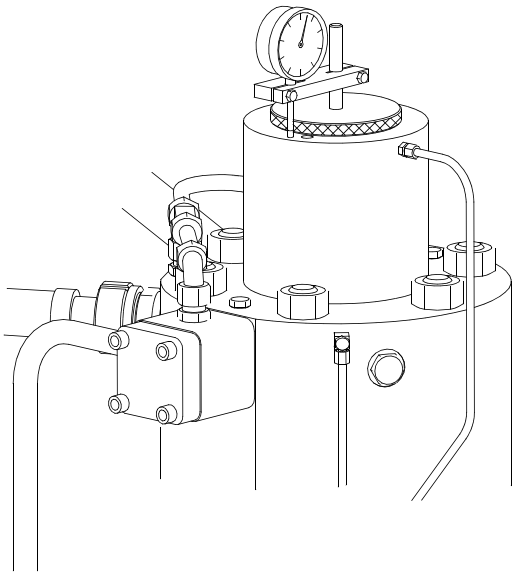

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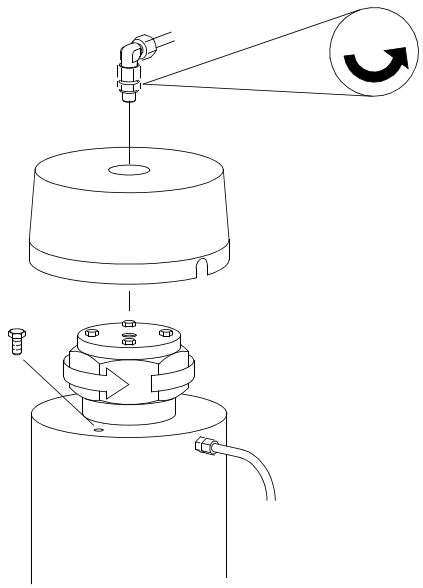

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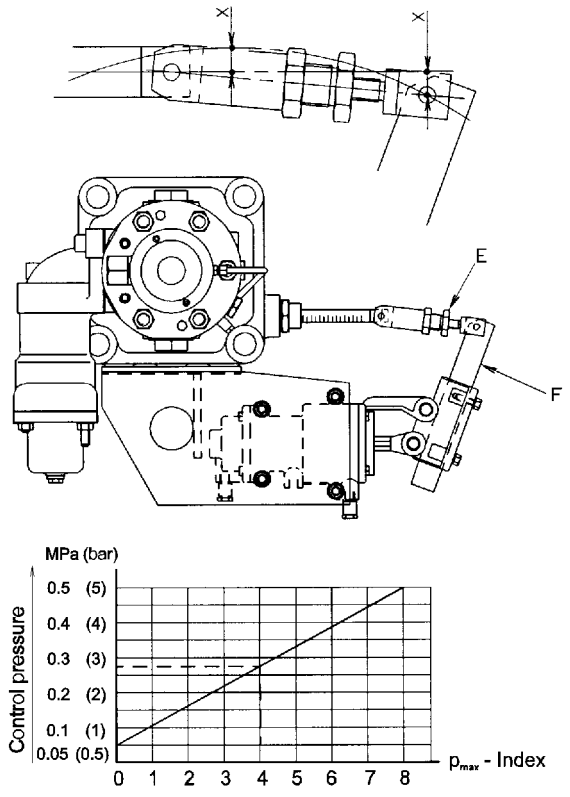

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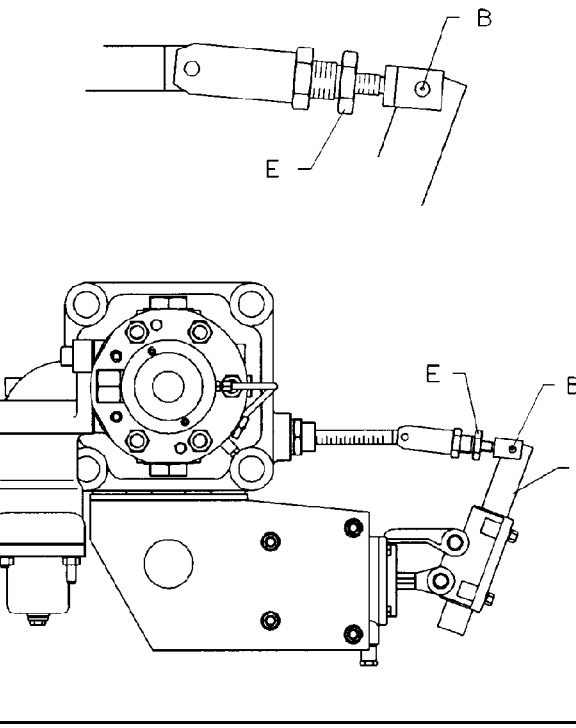


1. Adjustment of the maximum combustion pressure of a single cylinder can be effected by moving (relatively) the cut-off holes of the pump barrel in relation to the top of the pump plunger.

   If the maximum combustion pressure is to be increased, corresponding to an increase of the lead **a**, increase the index on the $\mathbf{p_{max}}$-rack (**VIT**-index arm), relative to the increase required (advancing the injection moment).

   If the maximum combustion pressure is to be decreased, corresponding to a reduction of the lead a, decrease the index on the $\mathbf{p_{max}}$-rack (**VIT**-index arm), relative to the decrease required (retarding the injection moment).

2. Before adjusting the pump lead, it is recommended to disconnect th epump barrel from the threaded guide.

3. Adjust the servo air cylinder by displacing lever **F** so that the camber height **X** is evenly distributed.

   Adjust the $\mathbf{p_{max}}$-rack (**VIT**-index arm) by displacing the connecting link **E** in accordance with the diagram.

   In order to distribute any possible deviation, the control air pressure of 0.275 MPa (2.75 bar) should correspond to index 4.0 on the $\mathbf{p_{max}}$-rack.

4. After this adjustment, assemble the fuel pump. *See Procedure 909-6.4.*

   After some readings in service, it may be necessary to make a final adjustment of the $\mathbf{p_{max}}$ pressure of the corresponding cylinder.

5. Adjustment of the $\mathbf{p_{max}}$ can be carried out on the individual fuel injection pumps by first removing pin **B** and then adjusting link **E**. The link can be adjusted by approx. 3 index marks.

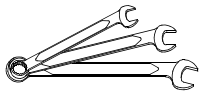
6. If no further adjustment is possible according to the above procedures, the cam disc has to be adjusted.
   See Procedure 909-3.3.

SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of high pressure oil
X	Block the starting mechanism	Risk of severe personal injury (while engine being truned)
X	Shut off starting air supply	
	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit

Standard Tools: See Section 913



The engine may be equipped with either a mechanical or an electronic **VIT** (Variable Injection Timing) system.

If the fuel quality has changed or if the fuel pumps are worn, the $\mathbf{p_{max}}$ will change. Adjusting the $\mathbf{p_{max}}$ of all the cylinders is done by adjusting the **VIT** system in the following way:

Mechanical VIT system

1. The pilot valves have been pre-adjusted to 0.05-0.5 MPa (0.5-5.5 bar) control air pressure , corresponding to 0.5-8.0 mm pressing-in of pin **C**.

   To check a pilot valve already mounted on the engine, remove the inlet and outlet pipe connections at **A** and **P**, and connect a pressure gauge at **A** and a pipe with working air (pressure 0.7 MPa(7 bar)) at **P**, on the pilot valve.

   Check that the pressure on the pressure gauge and the pressing-in of pin **C** is in accordance with the curve.

   Any necessary adjustment is done by turning adjusting screw **B**.

2. Fine adjustment of the $\mathbf{p_{max}}$ pressure in the breakpoint (for all the cylinders) is to be carried out by axial displacement of the bracket with the pilot valve.

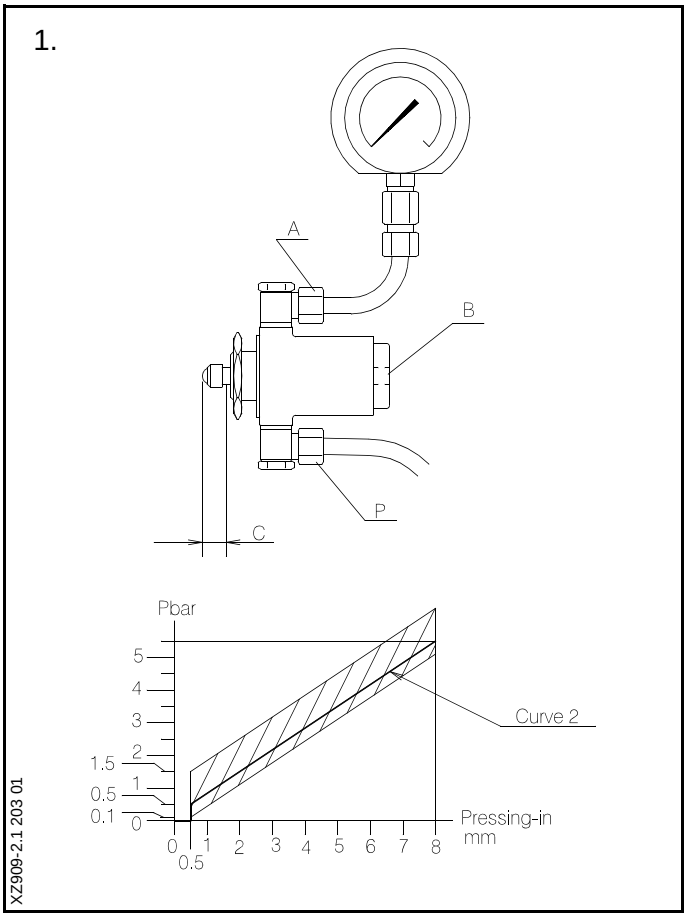
   Release the screw and nut which secure the bracket with the pilot valve to the larger bracket through the slotted holes.

   Increase the $\mathbf{p_{max}}$ pressure by moving the pilot valve toward the lever.

   Decrease the $\mathbf{p_{max}}$ pressure by moving the pilot valve away from the lever.

   See also Vol. 1, Chapter 703.

1.



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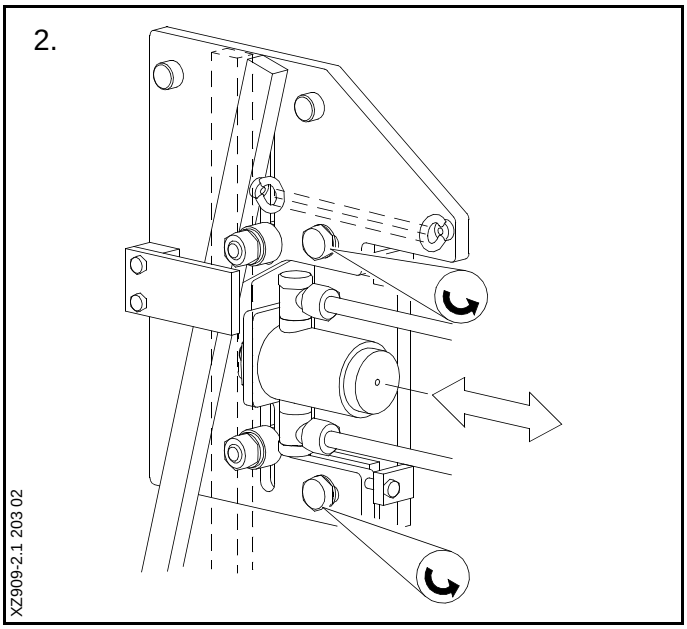

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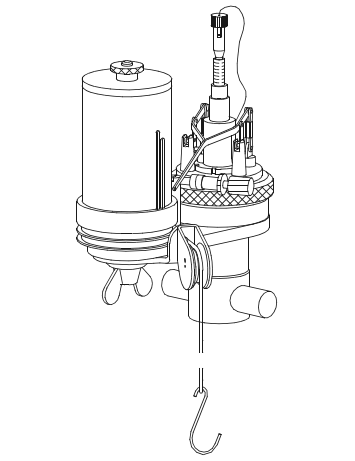
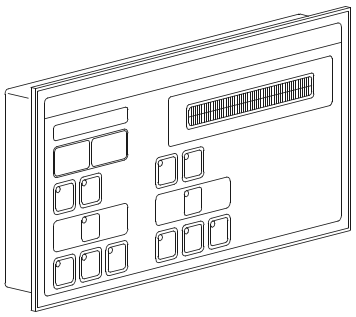




GN909-1.4 203 03

Electronic VIT system

3. The adjustment should be based on a set of indicator diagrams taken when the engine is running just above the breakpoint.

4. On the panel in the engine room control room, change the $\mathbf{p_{offset}}$ value in accordance with the required increase or decrease in the $\mathbf{p_{max}}$ pressure. One graduation mark on the $\mathbf{p_{offset}}$ scale corresponds to a change in $\mathbf{p_{max}}$ of 0.1 MPa (1 bar).

5. Check the adjustment by taking a **new** set of indicator diagrams while the engine is running just above the breakpoint.

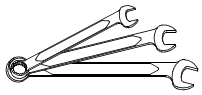
SAFETY PRECAUTIONS

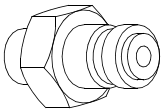
X	Stopped engine
X	Block the starting mechanism
X	Shut off starting air supply
X	Engage turning gear
	Shut off cooling water
X	Shut off fuel oil
X	Shut off lubricating oil
	Lock turbocharger rotors

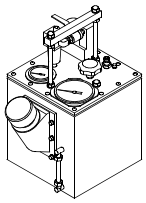
Data

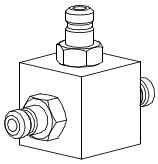
Ref.	Description	Value	Unit

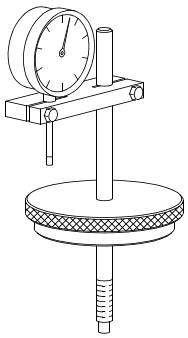
Standard Tools: See Section 913

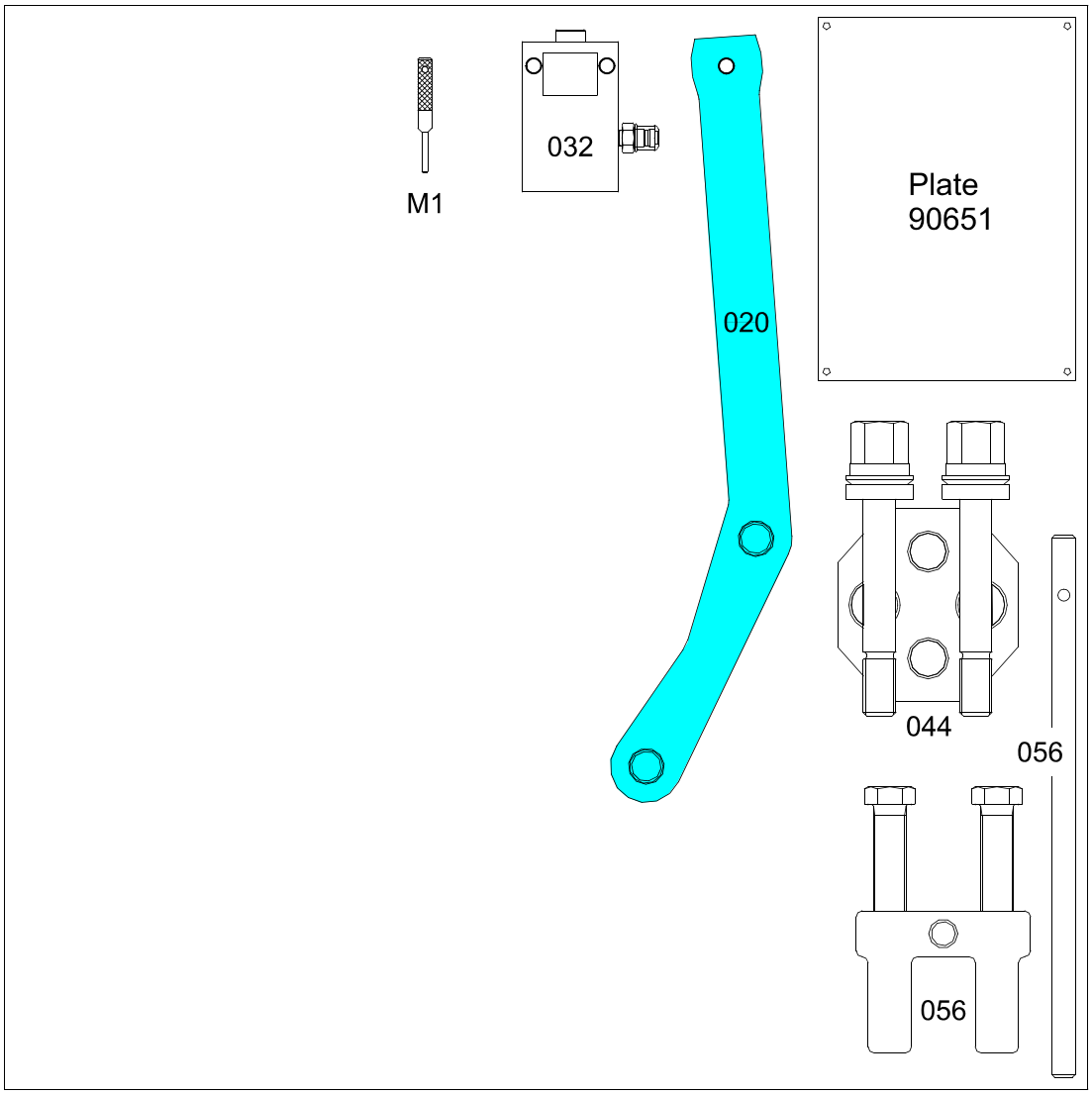








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056

1. Make sure that the reversing mechanism is in AHEAD position.

   Remove the inspection cover from the camshaft housing.

Note!
Before dismantling any part of the fuel pump, make sure that the pump has been relieved of pressure and that all oil has been drained off.

2. Dismount the pipe connections and the puncture valve from the fuel pump top cover, and mount the dial gauge.
   See Procedure 909-1.1.

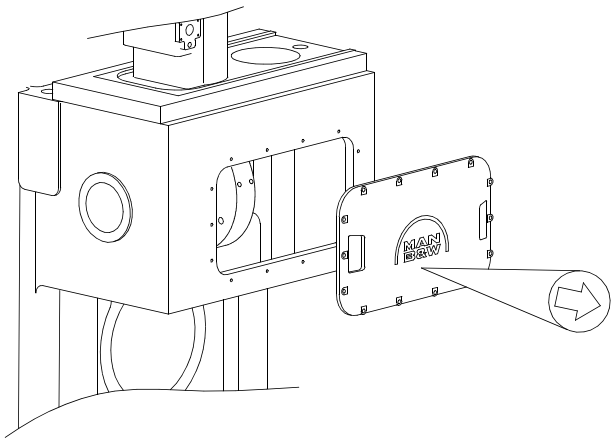
   Adjust the **VIT** index to 0 (zero).

   Turn the engine until the piston concerned is in **TDC**.

   Measure the fuel pump lead using the measuring tool.
   See Procedure 909-1.1.

3. Compare the fuel pump lead with the value in the Adjustment Sheet, and adjust the fuel pump cam as necessary.

1.



GN909-3.3 203 08 L0a

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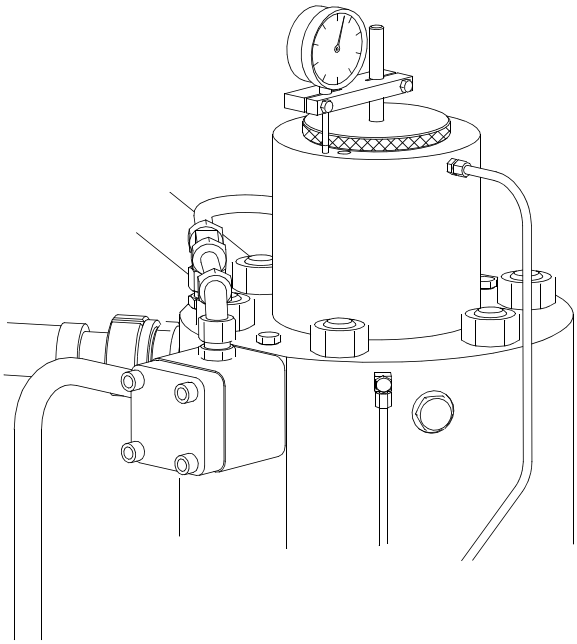

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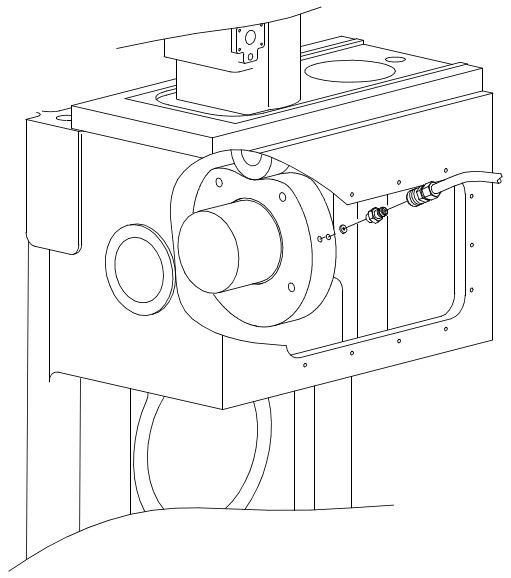

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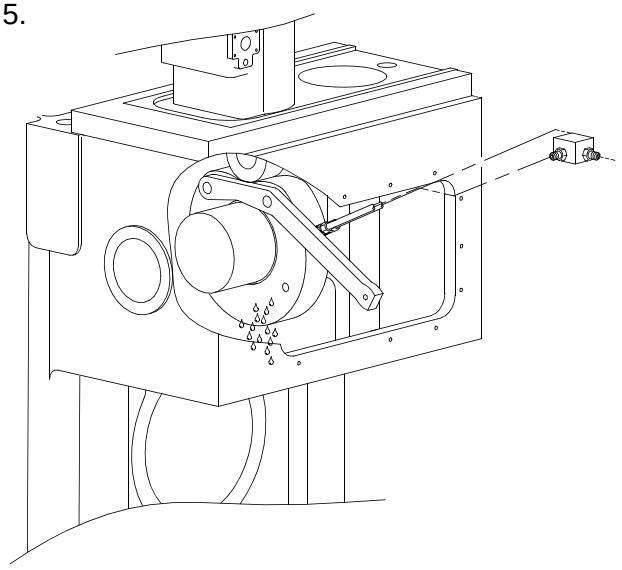

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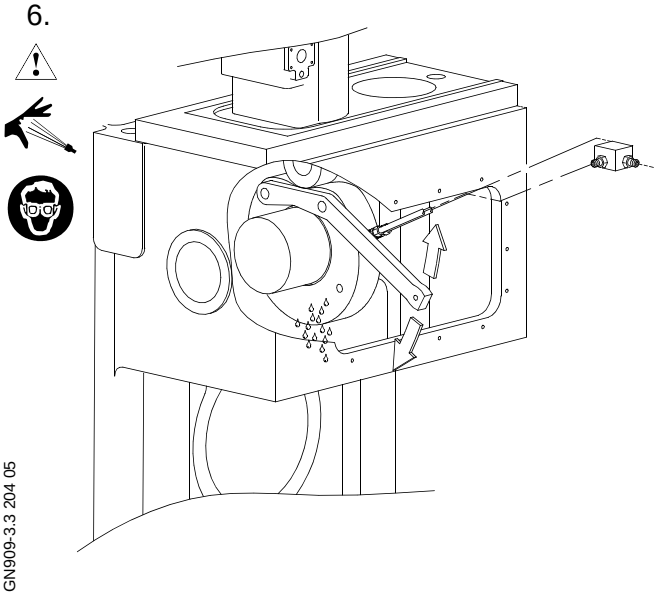


GN909-3.3 204 05

4. Turn the camshaft until there is access to the oil ducts in the fuel cam through the inspection opening.

   Insert three copper gaskets in each oil duct.

   Mount snap-on couplings in the oil ducts, but do not tighten them.

   Fit hoses between the snap-on couplings and the distributor block and between the distributor block and the hydraulic high-pressure pump.

5. Mount the special spanner on the fuel cam disc, ensuring that the two pins enter the holes in the cam.

6. Apply light pressure to the hydraulic system and, after venting the system, tighten the snap-on couplings.

   Raise the hydraulic pressure until oil seeps out along the camshaft under the cam disc.

   Turn the cam disc, using the fitted spanner, until the desired change of lead is read directly on the measuring tool. *(The necessary turning of the cam disc is calculated as described in Procedure 909-1.)*

   To increase lead and $\mathbf{p_{max}}$:
   - turn the cam disc AHEAD.

   To reduce lead and $\mathbf{p_{max}}$:
   - turn the cam disc ASTERN.

7. After completing the desired turning of the cam disc, relieve the hydraulic system of pressure and dismount the spanner and the hydraulic equipment.

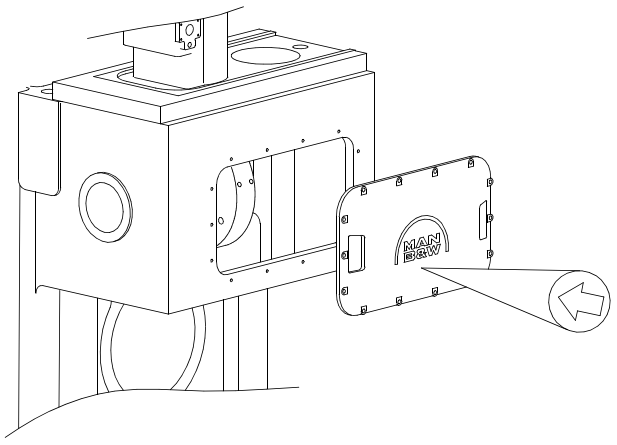
   After carrying out adjustment, measure the fuel pump lead again (still with **VIT** index on 0 zero).
   See Procedure 909-1.1, and re-adjust the cam if required.

   Note down and file the new results for purposes of comparison with future measurements and adjustment.

8. Mount the inspection cover on the camshaft housing.

9. Mount a new or overhauled puncture valve in the fuel pump top cover, *see Procedure 909-8.4.*

8.



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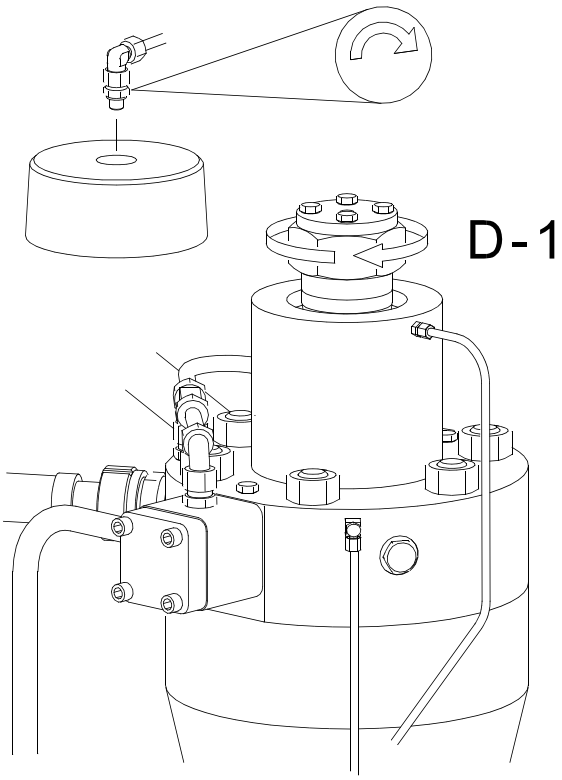

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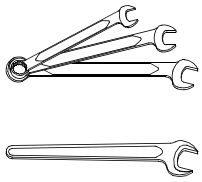
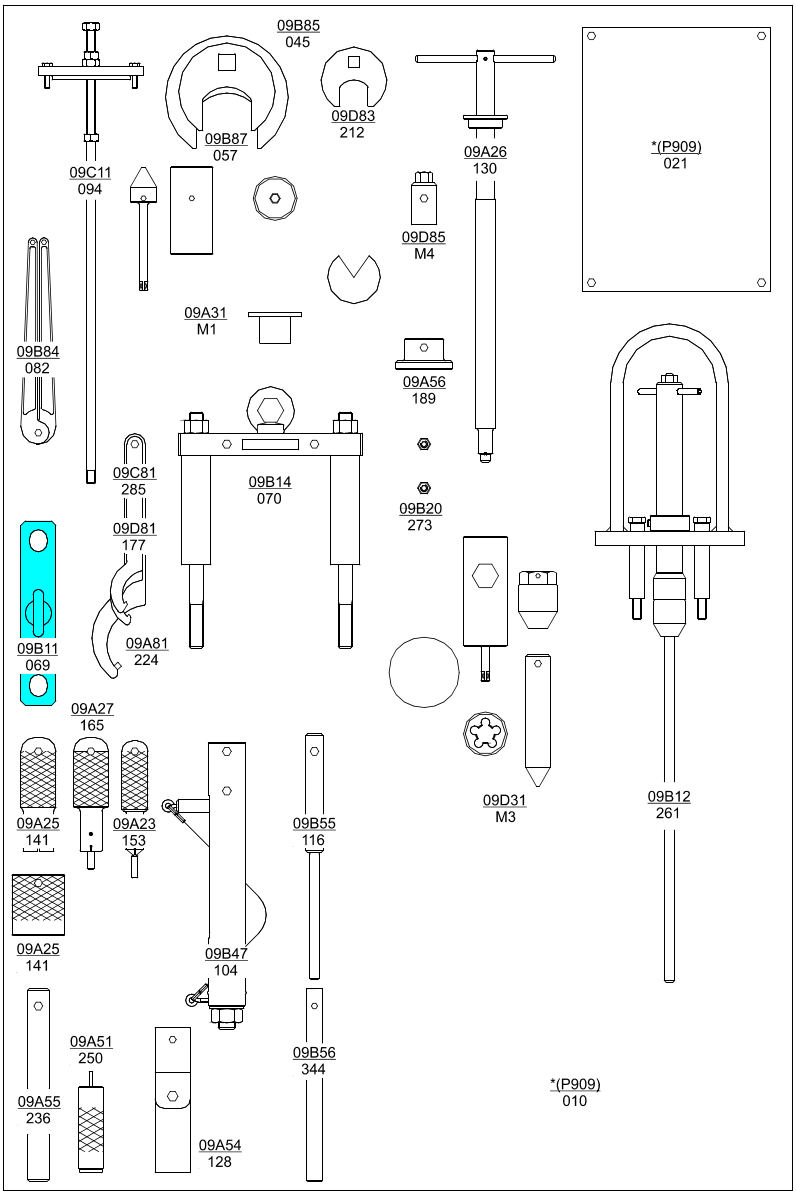
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of hot surfaces
X	Block the starting mechanism	Do not enter area when over head lifting is being carried out
X	Shut off starting air supply	Risk of severe personal injury (while engine being turned)
X	Engage turning gear	
	Shut off cooling water	
X	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit
D-1	Shock absorber, complete	21	kg
D-2	Pump housing nuts - tightening angle	62	°
D-3	Weight of pump housing	116	kg

Standard Tools: See Section 913

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09D31
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Note!
Before dismantling any part of the fuel pump, make sure that the pump has been relieved of pressure and that all oil has been drained off.

1. Dismantle the fuel pump top cover.
   See Procedure 909-5.2.

2. Dismantle the barrel/plunger assembly.
   See Procedure 909-6.2.

3. Remove the screws holding the fuel oil inlet pipe between the fuel pump and the fuel inlet valve.

   Remove the fuel oil inlet pipe.

   Discard the gaskets.

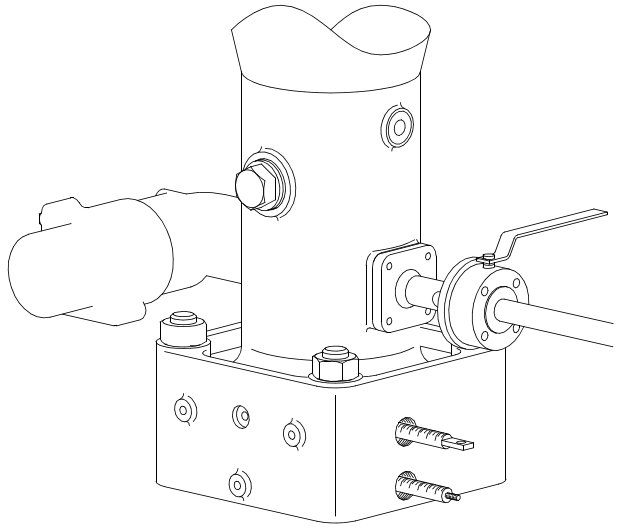
4. Unscrew the nuts at the base of the fuel pump.

   Fit the lifting tool using the top cover studs/ nuts, and lift the pump housing away.

   Take care not to damage the threads of the studs.

   Land the fuel pump on wooden planks.

3.



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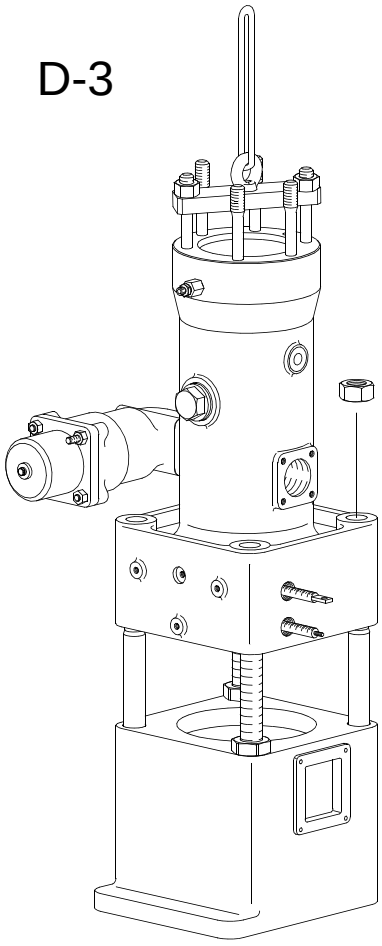

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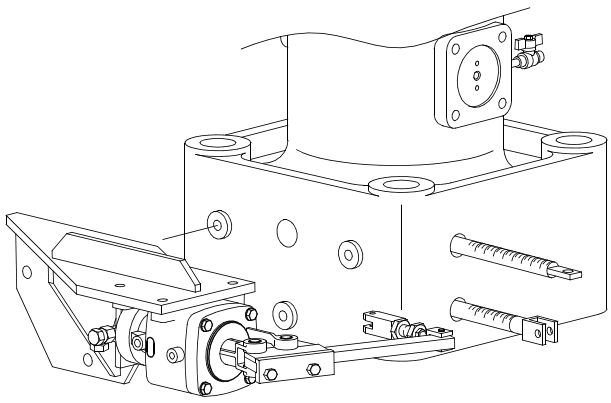

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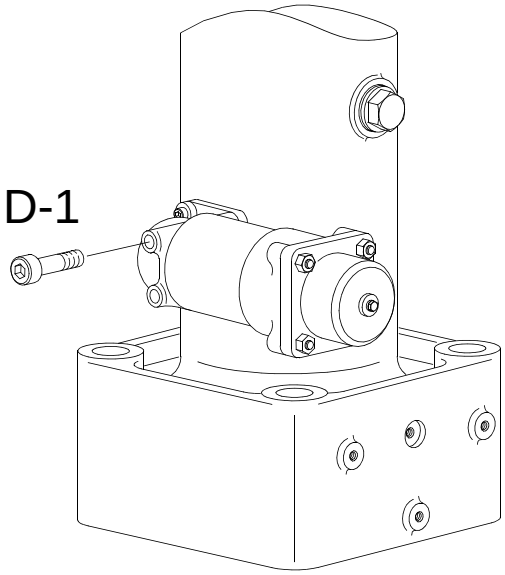

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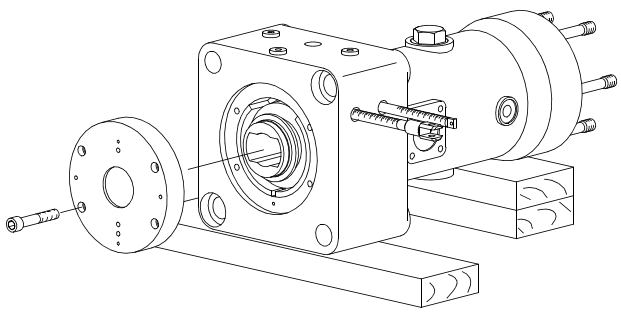

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1. If the fuel index arm or the **VIT** index arm of the fuel pump is moving too tightly, the regulating and timing systems of the fuel pump must be overhauled.

2. In order to carry out this overhaul, the top cover and plunger/barrel assembly of the fuel pump must have been removed, and the fuel pump must have been dismantled from the pump base and landed on wooden planks.
   See Procedure 909-4.2.
   See Procedure 909-5.2.
   See Procedure 909-6.2.

3. Dismantle the actuator and actuator bracket.

4. If not already done, dismantle the fuel pump shock absorber.

   If necessary, overhaul the fuel pump shock absorber.
   See Procedure 909-9.3.

5. Tilt the fuel pump housing into a horizontal position on the wooden planks.

   Dismantle the screws and the bottom plate from the fuel pump housing.

   If the bottom plate is stuck, loosen it by screwing two M10x70 mm screws into the holes of the bottom plate.

6. Dismantle the:

   - Fuel index arm
   - Regulating guide
   - Sleeve

7. Dismantle the:

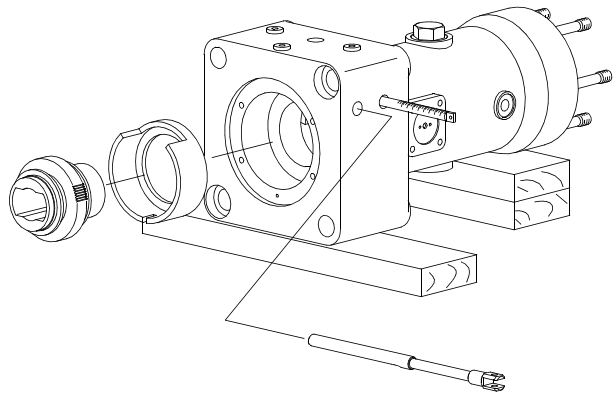
   - Guide screw
   - **VIT** index arm
   - Timing guide

8. Remove the caps from the back of the fuel pump housing.

   Remove the orifice plug from the front side of the fuel pump housing.

   Discard all seal rings and gaskets.

6.



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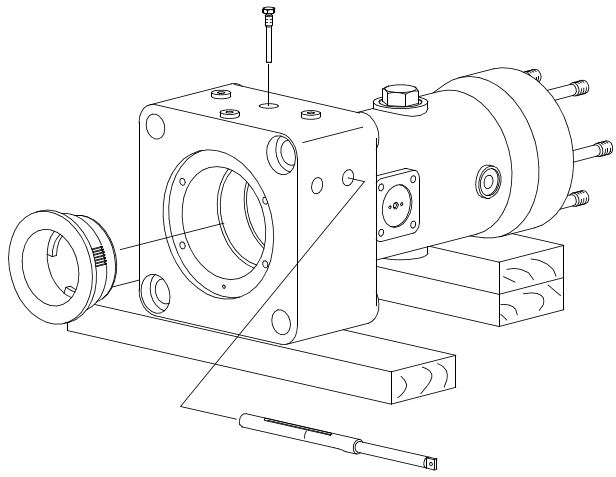

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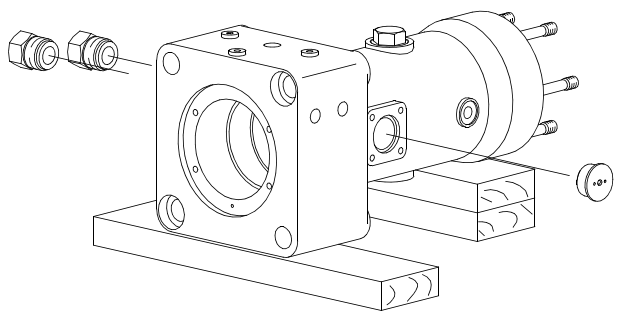

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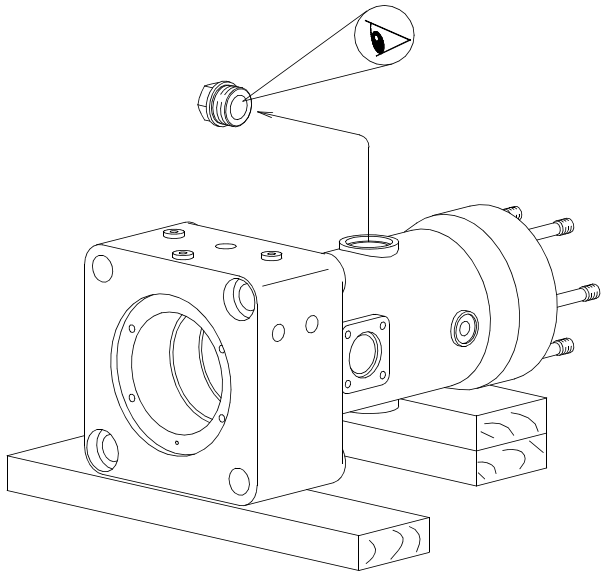

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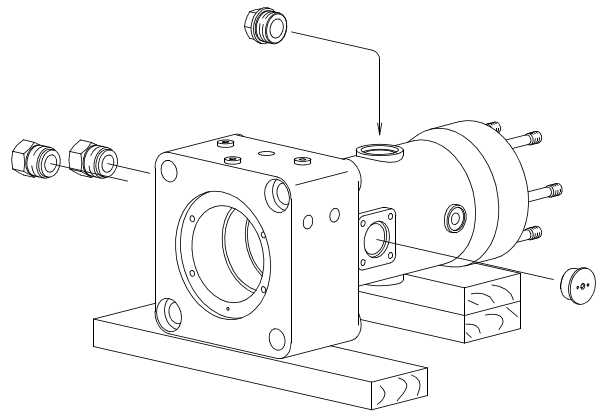

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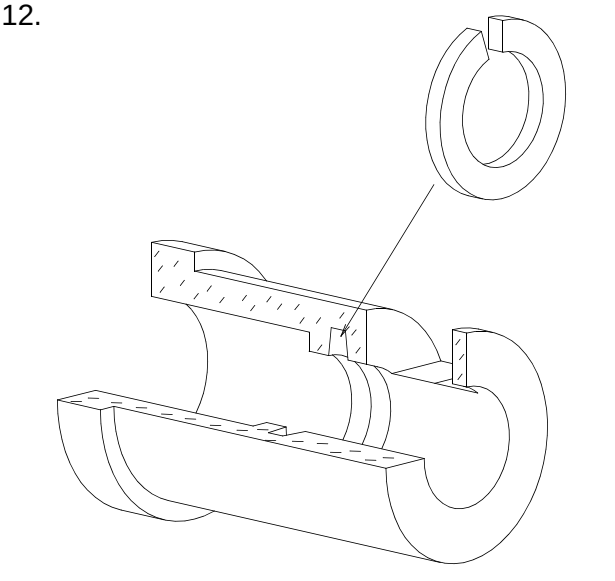


HC909-3.4 121 11

9. Dismantle and inspect the plug screws in both sides of the fuel pump housing.

   If eroded, replace the plug screws.

10. Clean all the dismantled parts of the fuel pump thoroughly in diesel oil or kerosene. Dry all parts carefully.

    Clean all inside surfaces of the fuel pump housing.

    Check that all the bores of the fuel pump housing are clean.

11. Mount new seal rings and gaskets.

    Mount the caps and the orifice plug.

    Mount new seal rings on the plug screws and mount the plug screws.

Note!
Lubricate the threads of all the parts with Molybdenum Disulphide (MoS_2) before mounting.

12. Mount new seal rings in the sleeves that are provided with a pointer scratch.

Note!
Soak the seal rings in lubricating oil before mounting.

Mounting

13. Lubricate the following with molybdenum disulphide (MoS_2):

    - all internal surfaces of the fuel pump housing
    - the sliding surfaces of all parts of the regulating and timing systems.
    - the teeth of the:

      regulating guide

      timing guide

      VIT index arm

      fuel index arm.

14. Mount the **VIT** index arm and the guide screw.

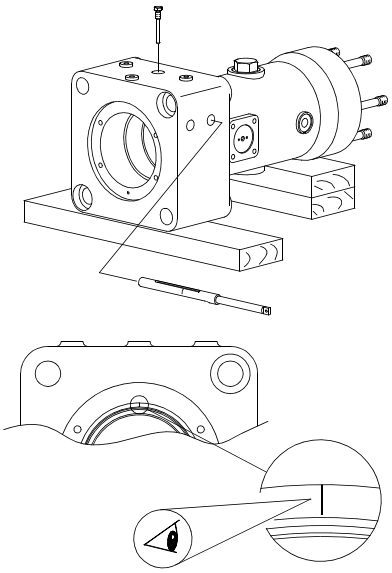
    Adjust the position of the **VIT** index arm so that the scratch mark is aligned with the centre of the fuel pump housing.

15. Mount the timing guide in the fuel pump housing.

    The timing guide must be mounted in such a way that the scratch marks on the timing guide, on the **VIT** index arm and on the fuel pump housing are aligned.

16. Mount the sleeve in the fuel pump housing, ensuring that the notch in the side of the sleeve is aligned with the pin hole in the fuel pump housing.

14.



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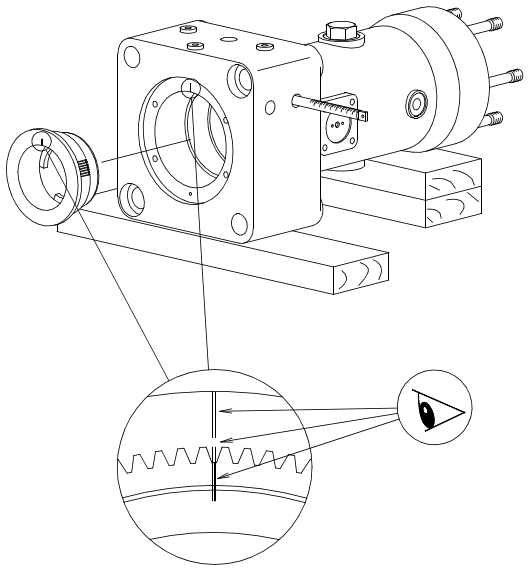

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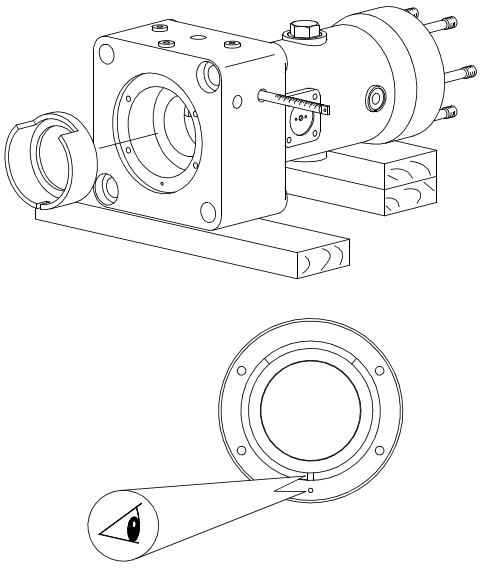

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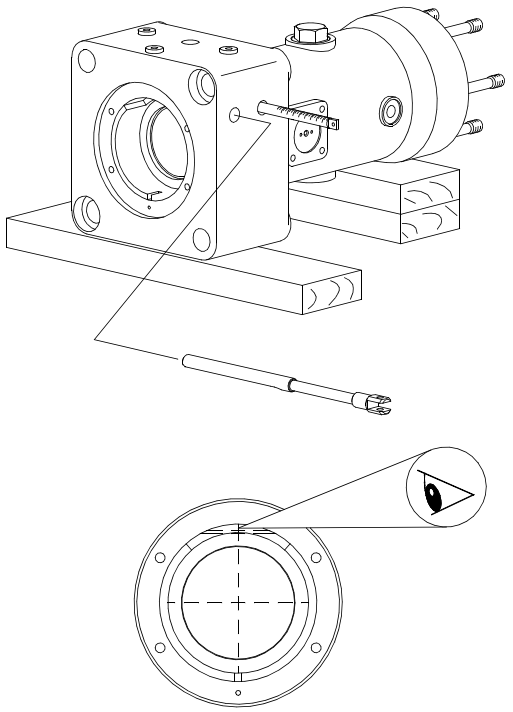

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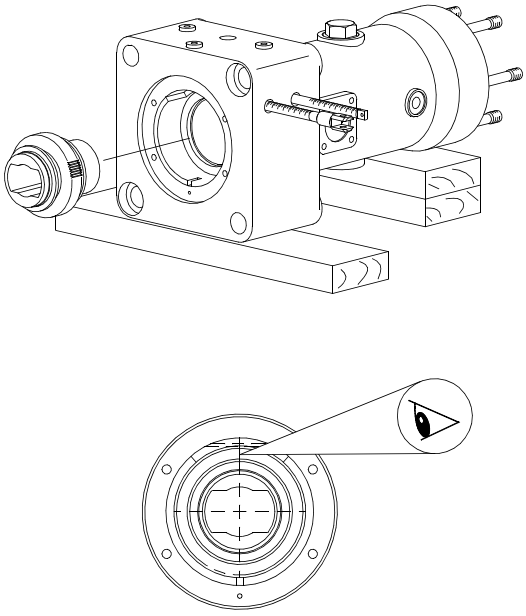

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17. Mount the fuel index arm.

    Adjust the position of the fuel index arm so that the scratch mark on the fuel index arm is aligned with the centre of the fuel pump housing.

18. Mount the regulating guide in the fuel pump housing.

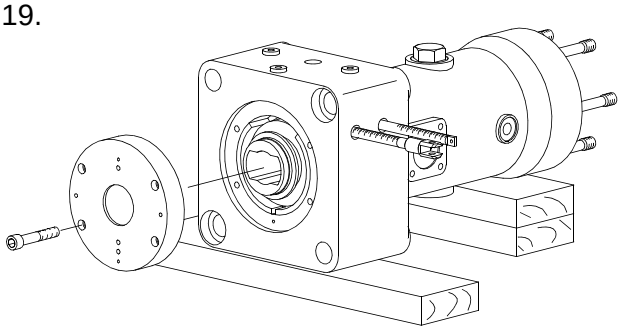
    The regulating guide must be mounted so that the scratch mark on the regulating guide is aligned with the scratch mark on the fuel index arm.

19. Mount the bottom plate on the fuel pump housing.

20. Return the fuel pump to a vertical position. Mount the shock absorber on the fuel pump.

21. Mount the actuator and actuator bracket on the side of the fuel pump.

19.



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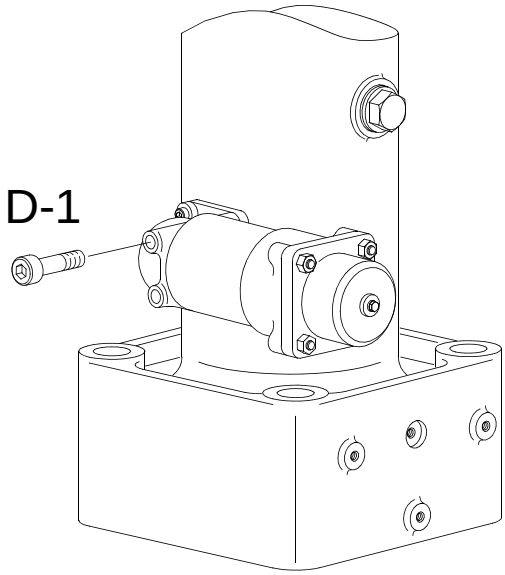

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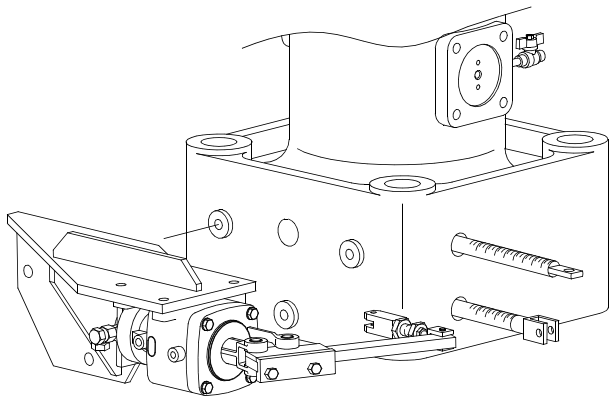

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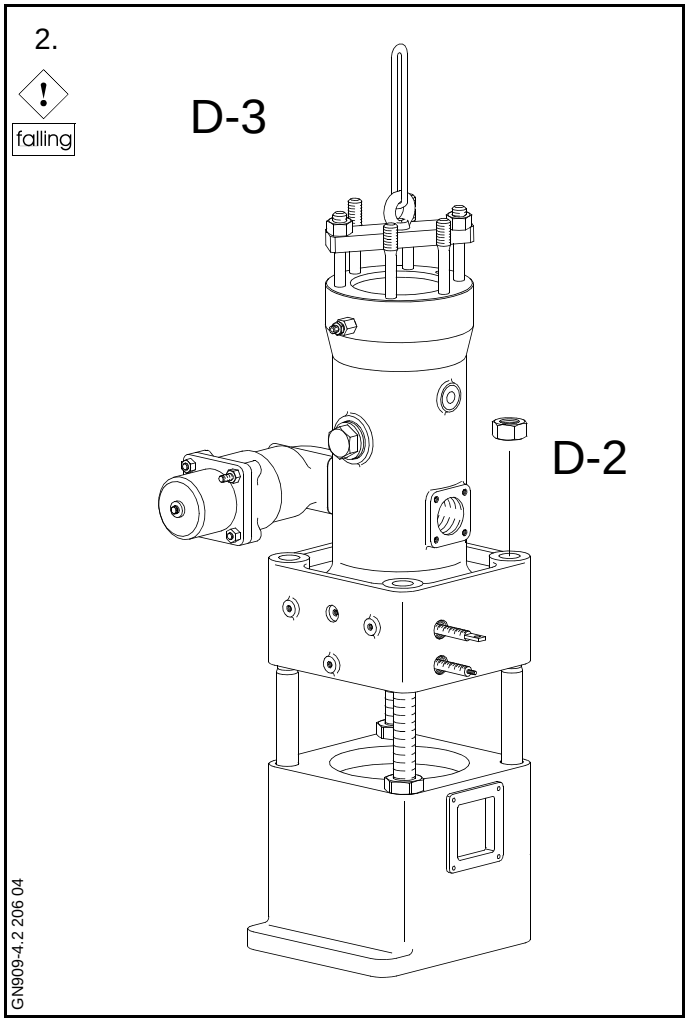
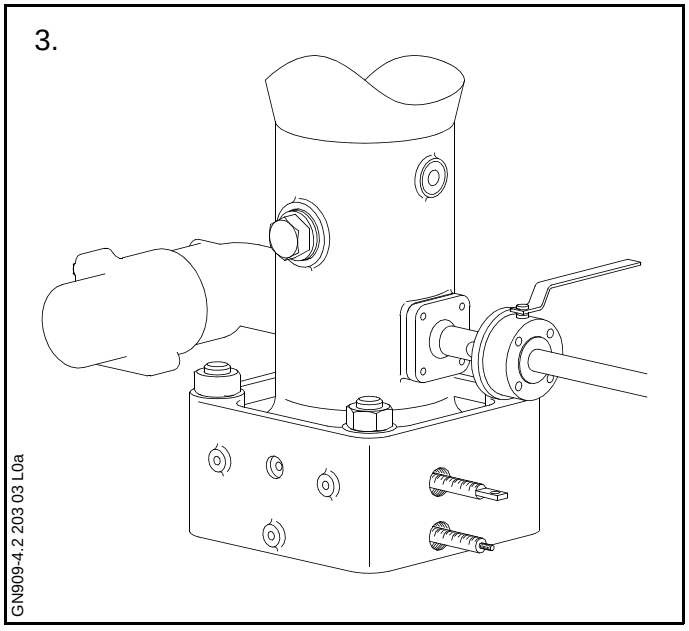




1. Before mounting the fuel pump housing, make sure that all sliding faces and threads are cleaned and lubricated with MOLYKOTE antifriction spray D321R or molybdenum disulphide (MoS_2).
   See Procedure 913-11.

2. Lower the fuel pump housing on to the pump base, taking care not to damage the threads of the studs.

   Remove the lifting tool.

   Fit and tighten the nuts at the base of the pump housing.

3. Mount the fuel oil inlet pipe between the pump housing and the inlet valve.

4. Mount the barrel assembly in the fuel pump housing.
   See Procedure 909-6.4.

5. Mount the top cover on the fuel pump housing.
   See Procedure 909-5.4.

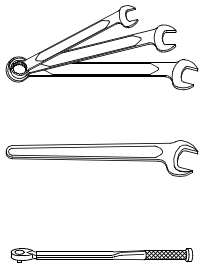
6. Mount the puncture valve, the drain oil pipes, and the compressed air pipes.

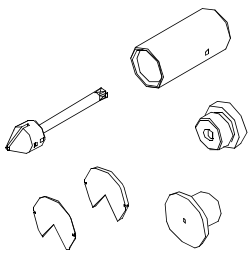
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of hot surfaces
X	Block the starting mechanism	
X	Shut off starting air supply	
X	Engage turning gear	
	Shut off cooling water	
X	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

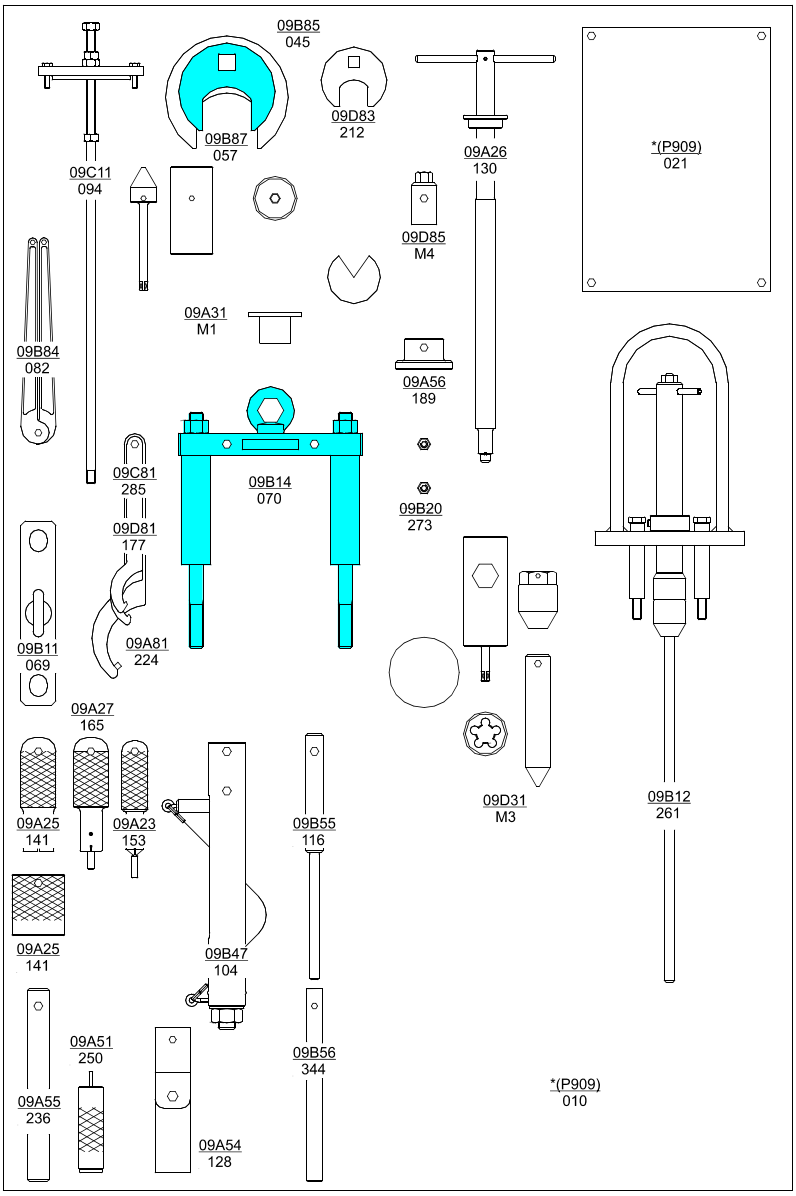
Data

Ref.	Description	Value	Unit
D-1	Weight of top cover	37	kg
D-2	Max. milling/grinding diameter of seat	18	mm
D-3	Top cover nuts - tightening torque	210	Nm

Standard Tools: See Section 913



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1. Shut off the fuel oil inlet.

   Open the drain cock (at the bottom of the pump housing), and drain off any oil left in the high-pressure pipe and the fuel pump.

Note!
Before dismantling any part of the fuel pump, make sure that the pump has been relieved of pressure and that all oil has been drained off.

   Dismount all drain pipes and the pipe connections to the puncture valve.

   Dismount the high-pressure pipes between the top cover and the fuel valves.
   See Procedure 909-14.2.

Note!
If the puncture valve is to be overhauled, remove the puncture valve from the top cover at this stage. *See Procedure 909-8.2.* Subsequently, the fuel pump lead can be measured. *See Procedure 909-1.1.*

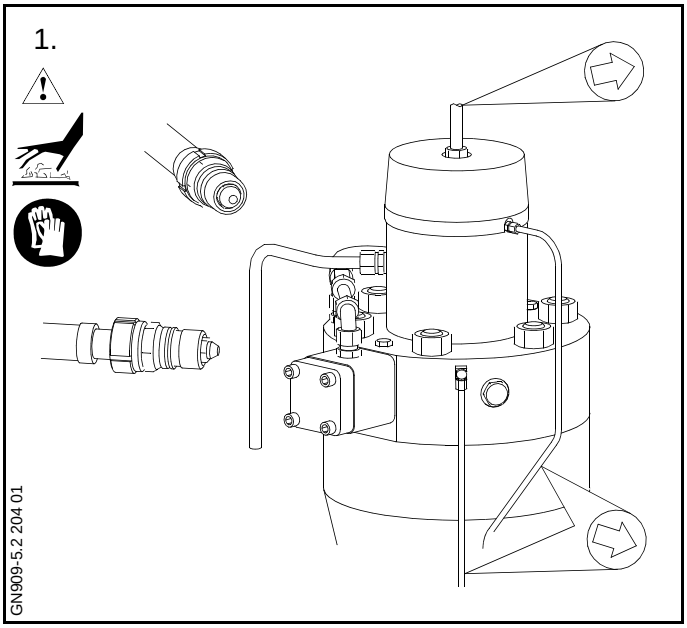
2. Remove the top cover fixing nuts and mount the dismantling screws for top cover in the two threaded holes.

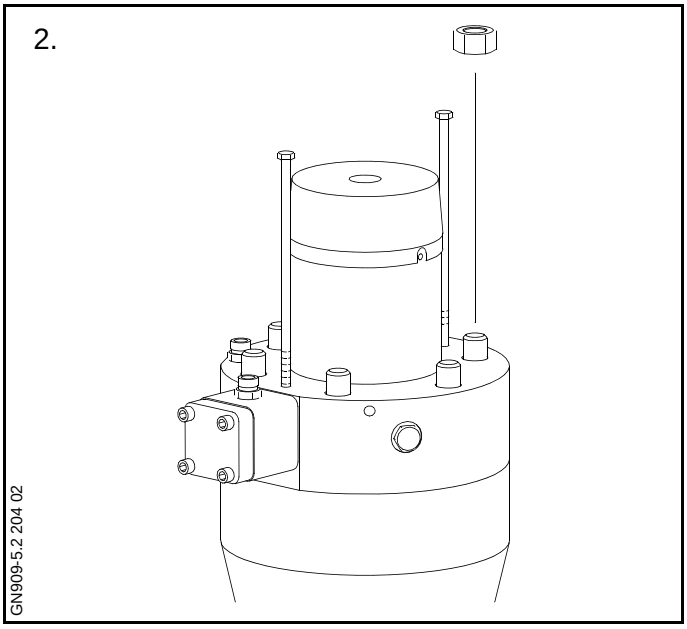
   Pull the top cover with suction valve and puncture valve (if still mounted) free by tightening the dismantling screws.

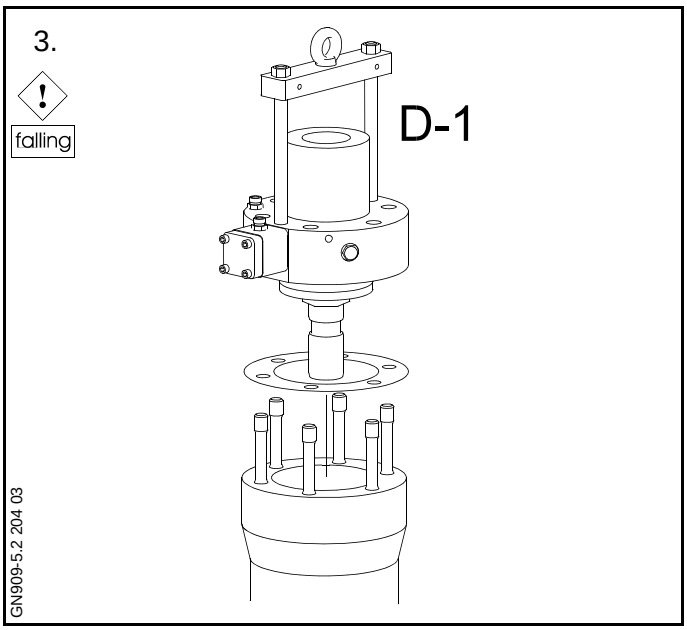
   When the top cover is loose, remove the dismantling screws and mount the lifting tool in the threaded holes instead.

3. Lift the top cover carefully off.
   For overhaul of top cover, puncture valve and suction valve, see Procedures 909-5.3, 909-7.3, 909-8.3.

   Discard the gasket.







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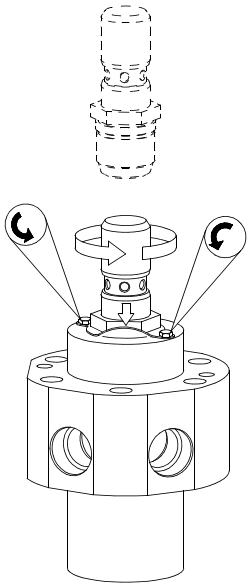

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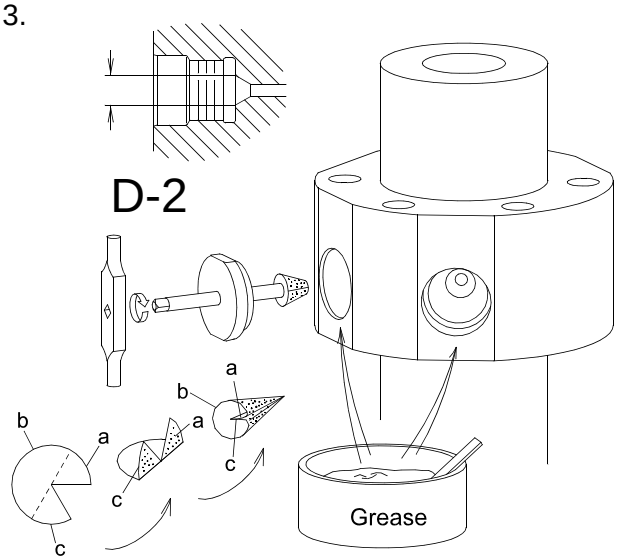

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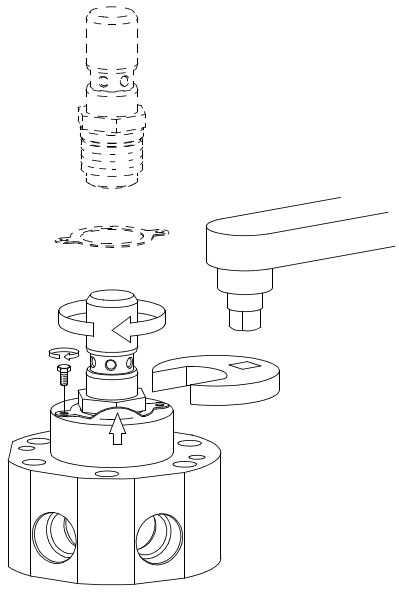

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1. If not already done, dismount the protective cap and the puncture valve from the top cover.
   See Procedure 909-8.2.

2. Dismantle the suction valve and the lock washer from the top cover.
   See Procedure 909-7.2.

3. Fill the oil ducts of the top cover with vaseline or heavy grease.

   Screw the guide, with the grinder, into the high-pressure pipe thread.

   Grinding the seat until a smooth surface is achieved.

   After completing the grinding, use compressed air to blow the vaseline/ grease out from the oil ducts.

   Clean the top cover with diesel oil/gas oil, and blow dry with compressed air.

Note!
Make sure that all bores and threads inside the top cover are absolutely clean.

   If necessary, recondition the seats of the fuel oil high-pressure pipes.
   See Procedure 909-14.

4. Mount a new lock washer and a new or overhauled suction valve in the top cover.
   See Procedure 909-7.4.

1. Make sure that the inside of the fuel pump housing and the top of the fuel pump barrel is completely clean.

2. Mount a new gasket on top of the pump housing.

   Lubricate all sliding faces, studs and seal rings with "MOLYKOTE antifriction SPRAY D32IR" or molybdenum disulphide (MoS_2). *See Procedure 913-11.*

   Mount the overhauled top cover (with overhauled suction valve and reconditioned seatings for the high-pressure pipes) on the pump housing.

   Check that the guide pin in the top cover enters the hole in the pump housing.

Warning!
As a safety precaution, and **before** mounting the top cover nuts, turn the engine one revolution. When doing this, the top cover **must not** move upwards!

3. Mount the top cover fixing nuts, and tighten them diagonally to the torque indicated in Data.

   Measure the lead of the fuel pump and adjust, if necessary. *See Procedure 909-1.1.*

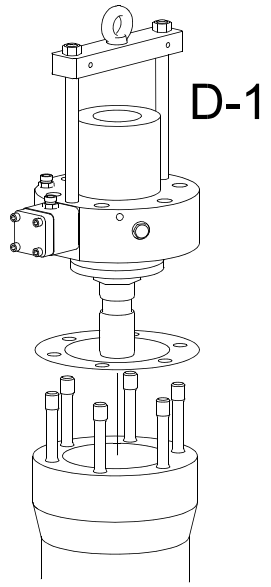
   At the same time, it may prove necessary to adjust the lead of the cam disc.
   See Procedure 909-3.3.

4. Finally, mount a new or overhauled puncture valve on the top cover. *See Procedure 909-8.4.*

   Mount the protective cap over the puncture valve and the two screws in the top cover. Mount the high-pressure pipes and the drain valve in the bottom pf the pump housing.

   Mount the drain pipes on the top cover and the connecting pipe to the puncture valve. Open the fuel oil inlet.

1.



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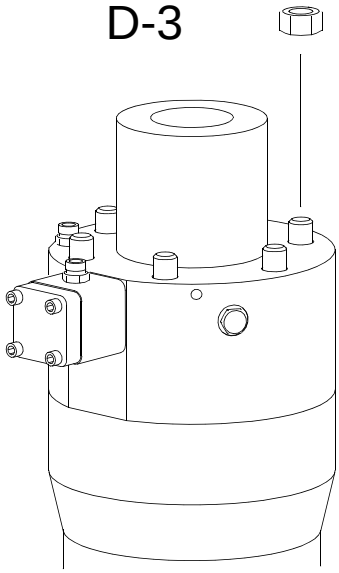

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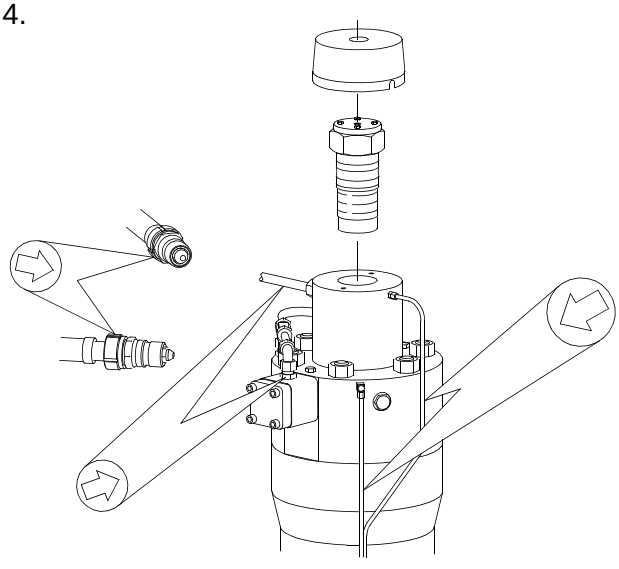

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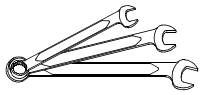
SAFETY PRECAUTIONS

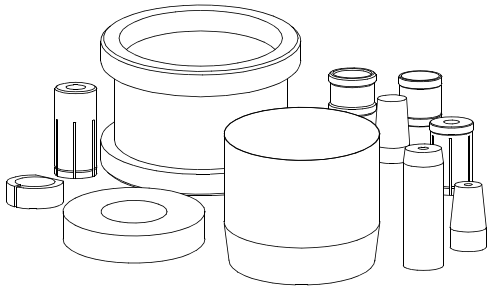
X	Stopped engine
X	Block the starting mechanism
X	Shut off starting air supply
X	Engage turning gear
	Shut off cooling water
X	Shut off fuel oil
	Shut off lubricating oil
	Lock turbocharger rotors

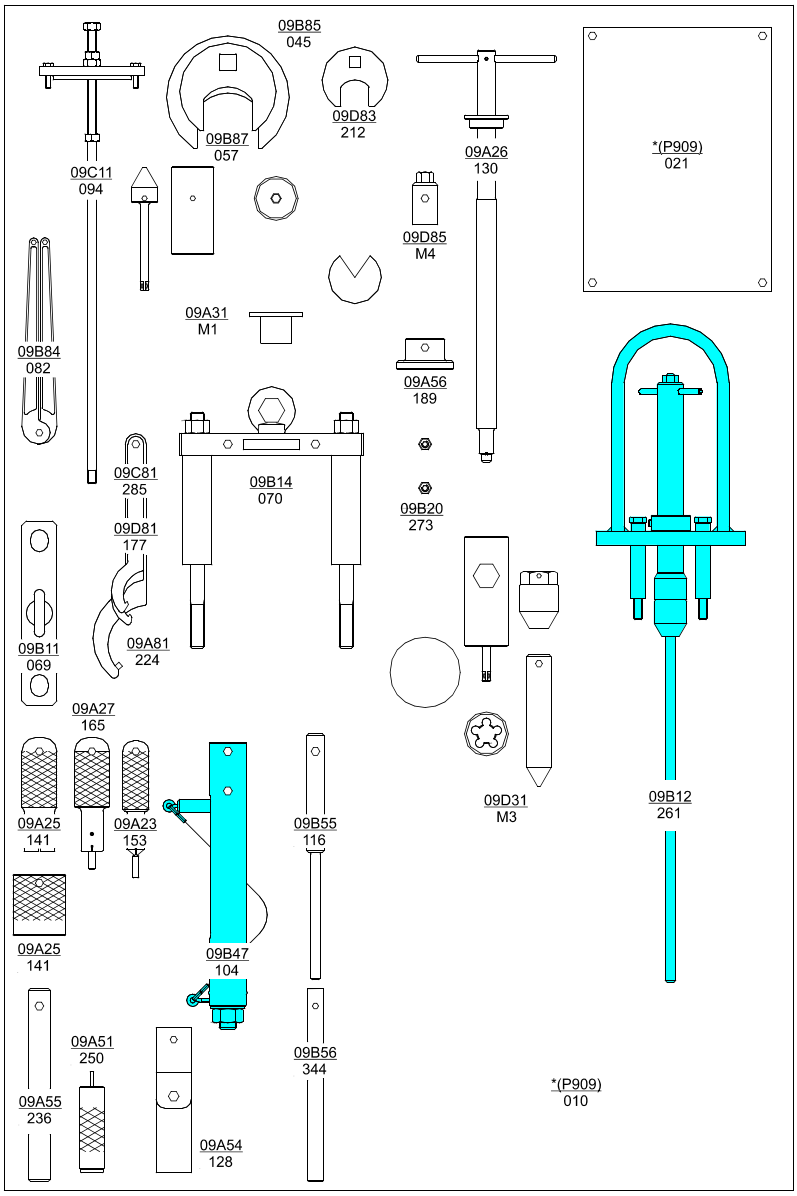
Data

Ref.	Description	Value	Unit
D-1	Weight of barrel assembly	31	kg
D-2	Weight of plunger	7	kg

Standard Tools: See Section 913



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1. Position the lifting tool for the barrel/plunger assembly (without measuring pin) in such a manner that the two distance tubes of the tool rest on the pump barrel.

   Make sure that the two guide pins in the bottom of the lifting tool enter the holes in the top of the plunger.

   Secure the lifting tool by screwing the two screws into the pump barrel.

   Loosen the stop ring on the spindle of the tool and press the spindle down against the pump plunger.

   Turn the spindle in this position until the two guide pins engage with the two holes in the plunger top.

   Tighten the center screw of the spindle against the plunger.

2. Remove the pump barrel guide screw from the pump housing.

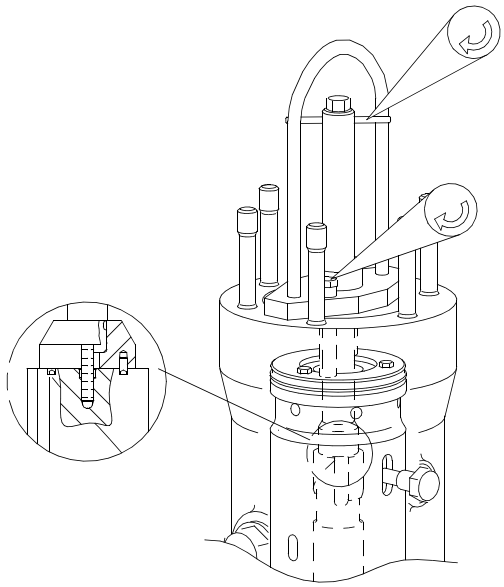
3. Disconnect the links for the timing drive and the regulating drive. Dismount the union and pointer for the timing drive and the regulating drive.

   Note the position of the scratch mark on the lever arm.

   Remove the locking plate and the lever arm.

   Mount the extractor tool and connect the timing toothed rack to the pulling rod by means of the pin.

1.



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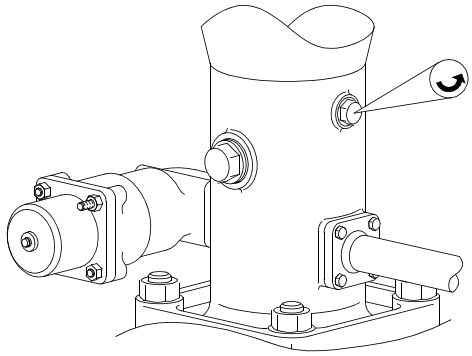

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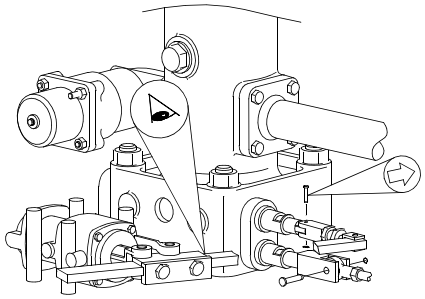

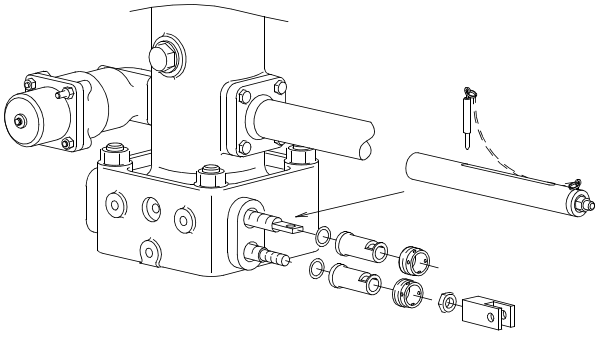

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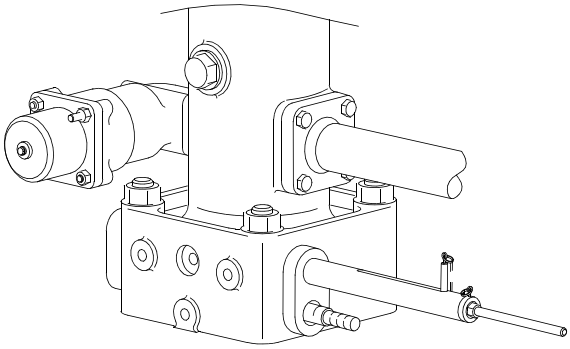

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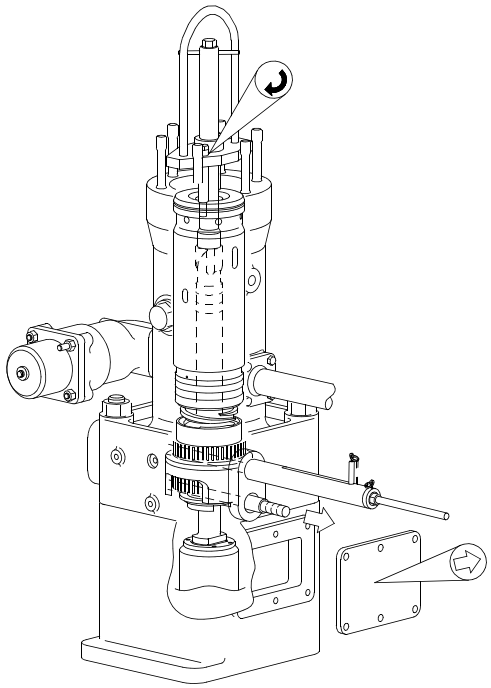

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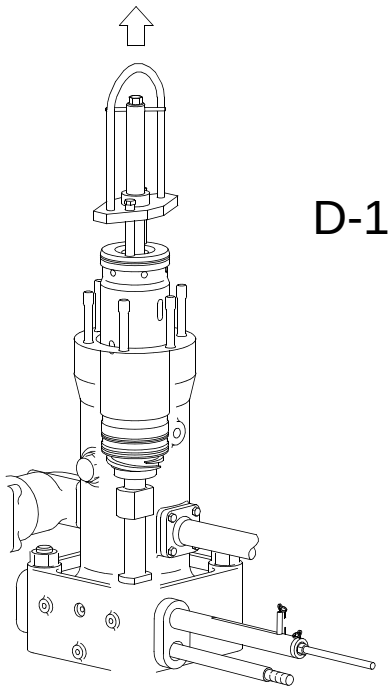
6.

falling



D-1

GN909-6.2 204 06

4. Turn the nut at the end of the pulling rod, whereby the timing rack will move outwards.

   Continue turning the nut until the pin reaches the outer position of the slot in the tool, whereby the thread of the fuel pump barrel goes clear of the timing guide.

   Keep the toothed rack in this position during the overhaul or replacement of the pump barrel.

   There is now a distance between the lifting tool and the pump housing.

5. Pull the regulating toothed rack outwards until the plunger foot has been turned clear of the bayonet joint in the roller guide.

   This can be ascertained by watching the handles on the spindle of the lifting tool. These will be parallel with the fore-and-aft direction of the engine when the plunger has been turned into position.

   Remove the cover of the pump base to make sure that the plunger is able to go clear of the bayonet joint.

   Lift the spindle so that the plunger foot goes clear of the bayonet joint.

   Move the stop ring of the spindle into contact with the upper flange of the tool, and lock the stop ring in this position by means of the stop screw.

6. Carefully lift the barrel/plunger assembly out of the pump housing.

   Dismount the tool.

   Press the plunger upwards to the bottom of the barrel.

   Send the barrel/plunger assembly to the MITSUI ENGINEERING & SHIPBUILDING CO., LTD. for repair, or overhaul it on board as described in Procedure 909-6.3.

1. Set up the pump barrel/plunger in a bench vice provided with “soft” jaws.

   Remove and discard the seal rings from the barrel.

2. Pull the plunger carefully out of the barrel.

   Carefully clean the plunger (for example in clean kerosene) and blow it dry with compressed air.

   Check the plunger for wear or seizure marks. Also inspect the top of the plunger for cavitation marks.

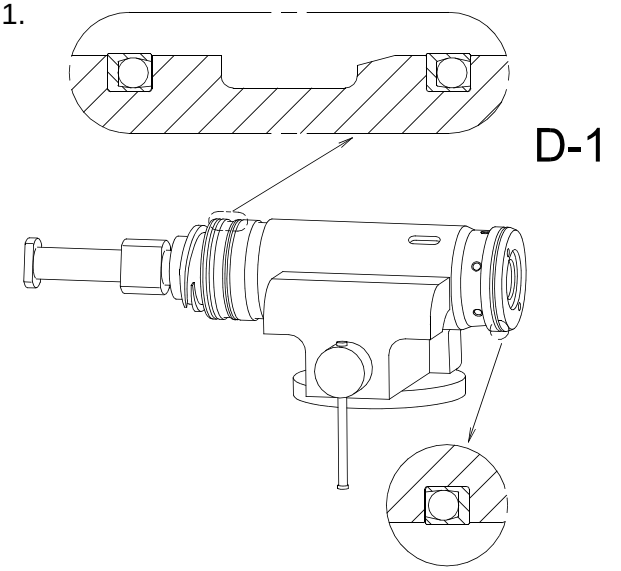
3. Clean the bores in the upper end of the plunger and blow dry with compressed air.

   Clean the barrel and blow it dry with compressed air.

   Check the barrel for wear or seizure marks.

   If either plunger or barrel shows signs of wear or seizure marks, both parts must be replaced, as they are ground to match and cannot be replaced individually.

1.



GN909-6.3 204 01

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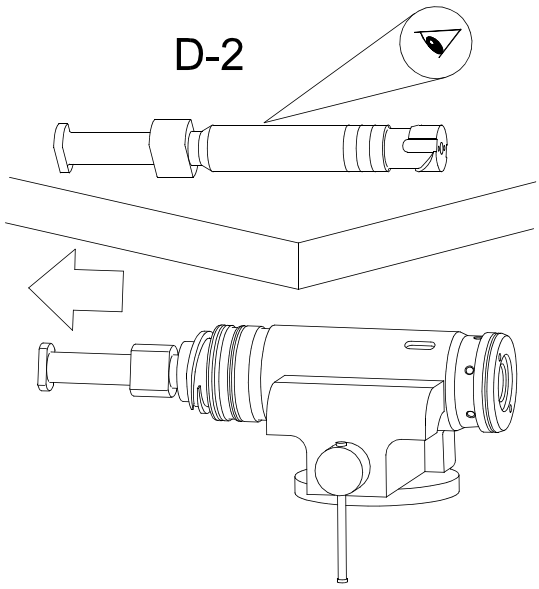

GN909-6.3 204 02

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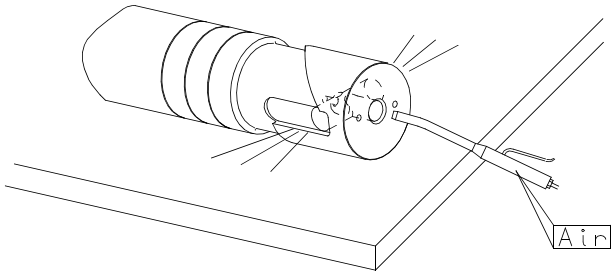

MA909-3.2 122 03

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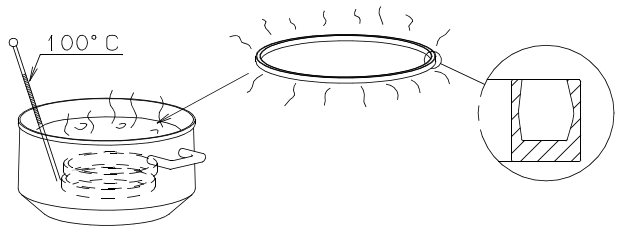

MB909-3.2 95 03

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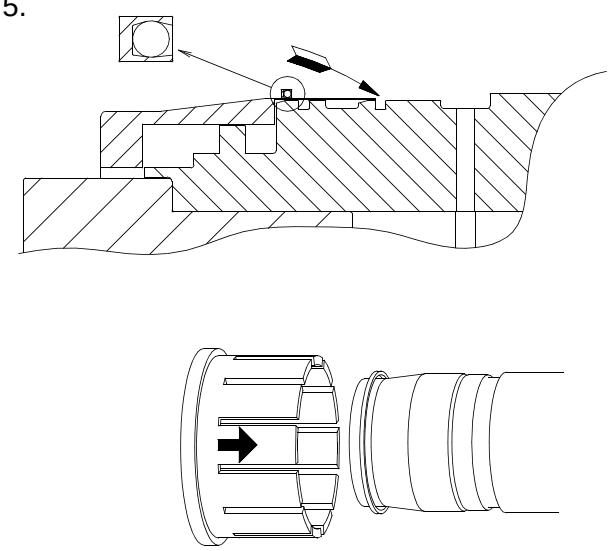

GN909-6.3 204 04

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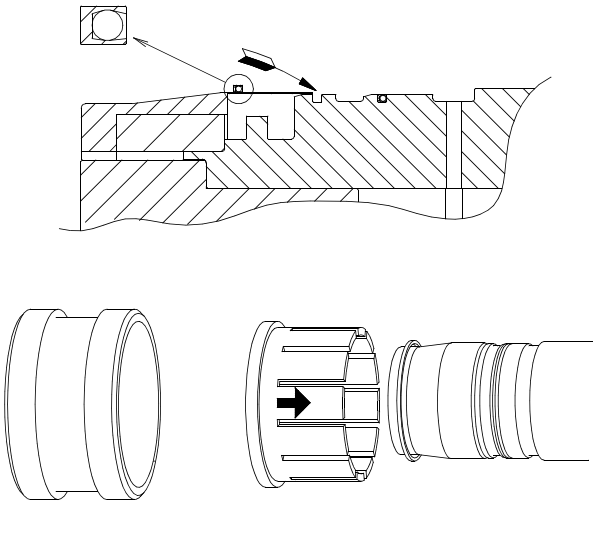


GN909-6.3 204 05

4. Before mounting new seal rings on the barrel, **heat them in 100°C hot water** for at least five minutes.

5. When mounting the new seal rings on the lower end of the pump barrel, the inner seal ring must be mounted first.

   Mount the guide stick in the barrel and position the big cone on the barrel.

   Place the spring-loaded seal ring on the cone with the spring facing upwards, *see the sketch.*

   Use the pusher tool to push the seal ring into the groove.

6. When mounting the seal ring in the outer groove, place the spacer tool inside the cone to obtain the correct distance to the groove, and repeat the above procedure.

   After mounting the seal rings, compress them by pressing the “sizer” tool over the seal rings.

7. Mount the guide stick and cone on the top end of the barrel and mount the uppermost seal ring in the same way as above.

   Make sure that the spring faces downwards, *see the sketch.*

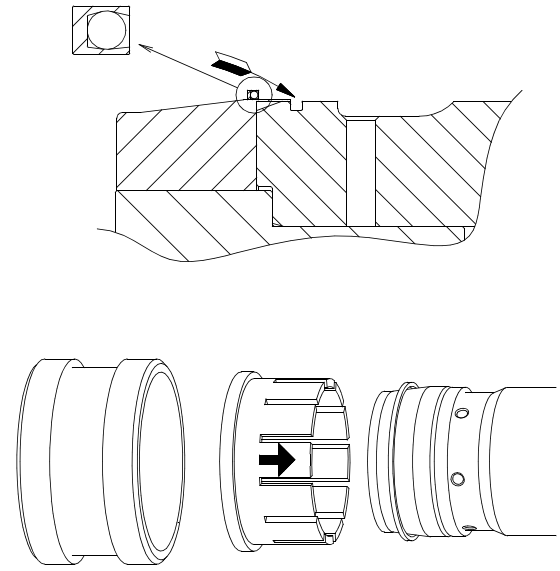
8. Lubricate the plunger with molybdenum disulphide (MoS_2).

   Carefully slide the plunger into the barrel and press it to the bottom.

Note!
Do not use force as this will damage the sliding surfaces of the plunger or barrel.

If the barrel assembly is not to be mounted immediately, all openings must be covered with plastic to prevent dirt from entering the barrel assembly during storage.

7.



GN909-6.3 204 06

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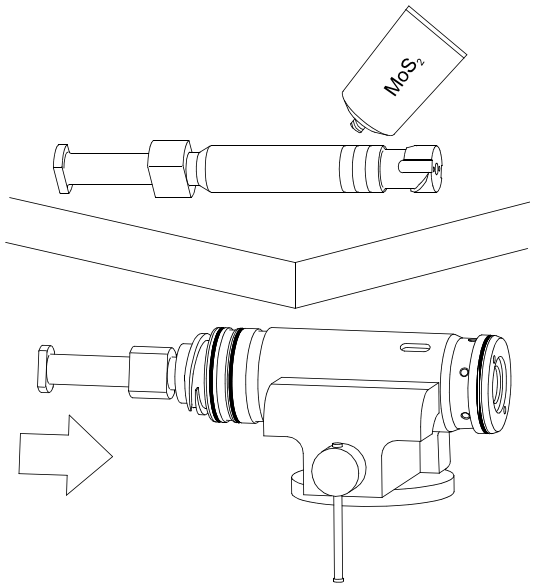

GN909-6.3 204 07

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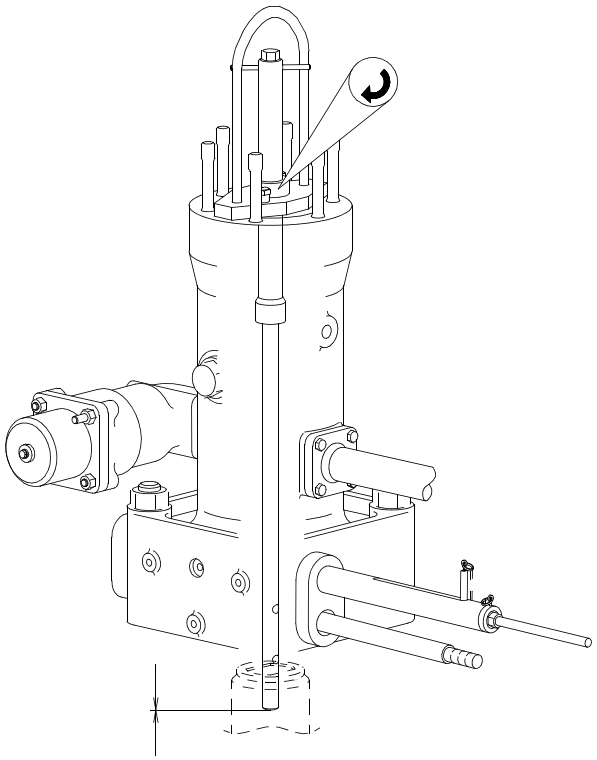
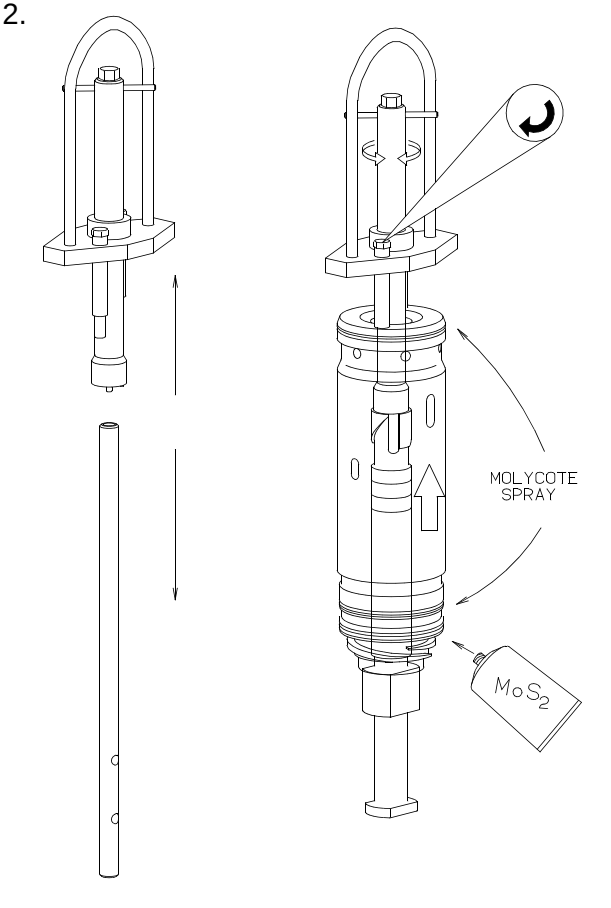


HN909-6.4 207 01

2.



HN909-6.4 207 02

1. Place the supplied measuring pin - which is of the same length as the plunger - on the spindle of the lifting tool, and fasten it by tightening the center screw of the spindle. Loosen the stop ring on the spindle.

   Place the tool on the pump housing, and press the spindle down until the pointed end of the measuring pin is in contact with the thrust piece of the roller guide.

   Then press the stop ring down until it reaches the flange of the tool and lock it there by tightening the screw of the stop ring against the spindle.

   The stop ring is to remain tightened in this position until the plunger has been correctly mounted.

   The engine **must not** be turned until the mounting of the barrel/plunger assembly has been completed.

2. Dismount the tool from the pump housing and remove the measuring pin from the spindle. Then mount the tool on the barrel/ plunger assembly which is ready for mounting.

   Secure the tool to the barrel by tightening the two screws, and attach the plunger to the spindle of the tool by tightening the center screw of the spindle. The tool is thus fixed on the barrel in such a way that its correct positioning is ensured during mounting.

   Before mounting the barrel/plunger in the pump housing, lubricate the thread for the timing guide and all seal rings with molybdenum disulphide.

   Using the spindle of the tool, pull the plunger as high up in the barrel as possible, at the same time turning the spindle so as to position the plunger foot correctly in relation to the cutout of the regulating guide.

3. Pull the regulating toothed rack as far out as possible and check that the extractor tool is mounted correctly on the timing toothed rack when this is in its outer position.

4. Check that the slot in the barrel coincides with the hole for the guide screw.

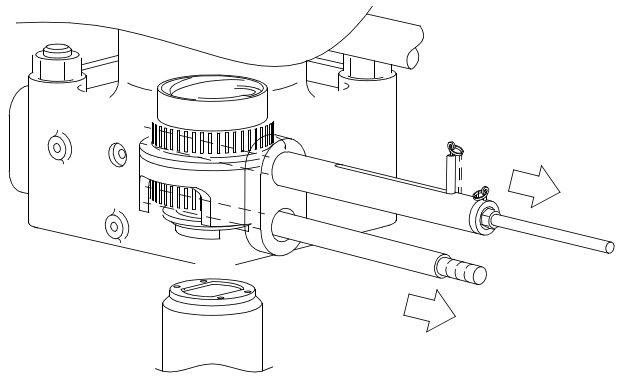
   Lower the barrel assembly carefully into the pump housing.

   If necessary, turn the regulating guide a little (using the toothed rack) to make the foot and the regulating block of the plunger fit properly in the cutout of the regulating guide.

   Lowering the barrel assembly so far down into the pump housing that the seal rings of the barrel are about to enter the bore in the pump housing.

   Then continue pressing down the barrel/ plunger assembly until the barrel assembly rests on top of the timing guide. There will be a gap between the tool and the pump housing.

3.



GN909-6.4 204 03

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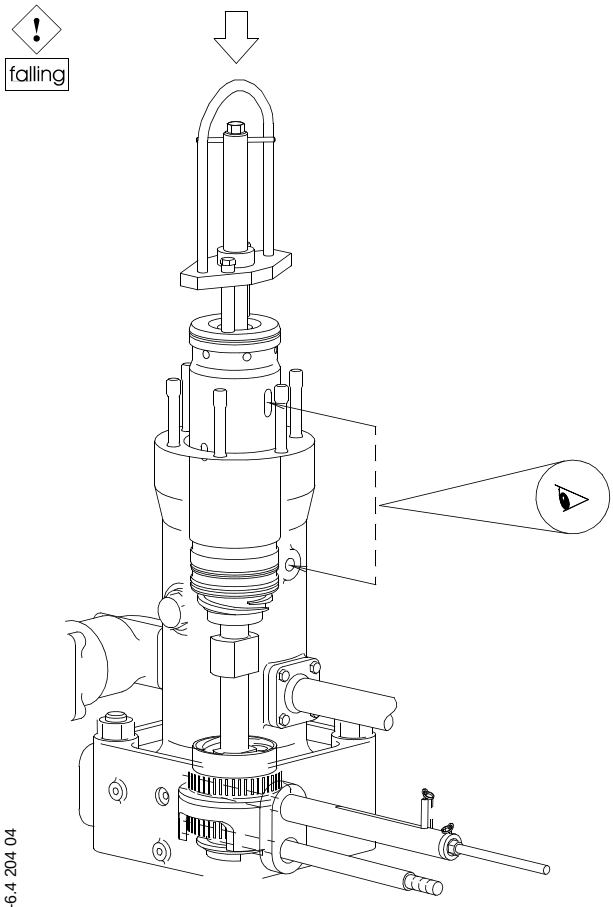

GN909-6.4 204 04

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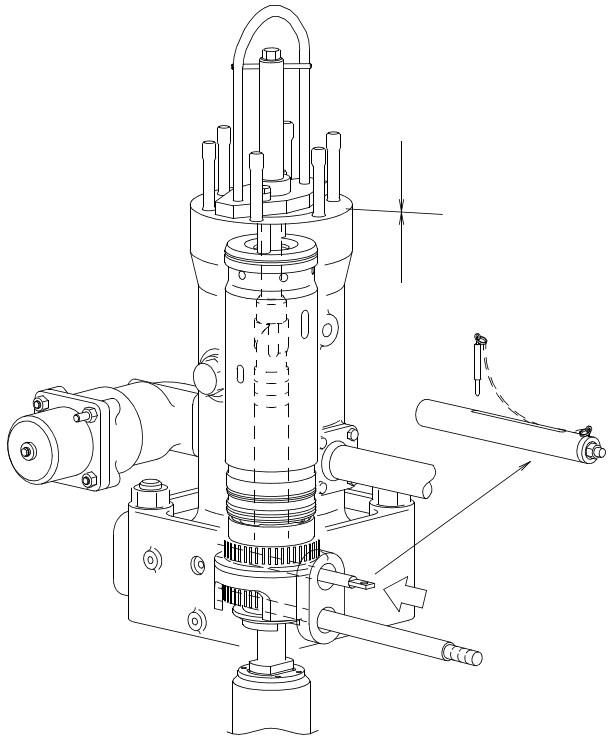

GN909-6.4 204 05

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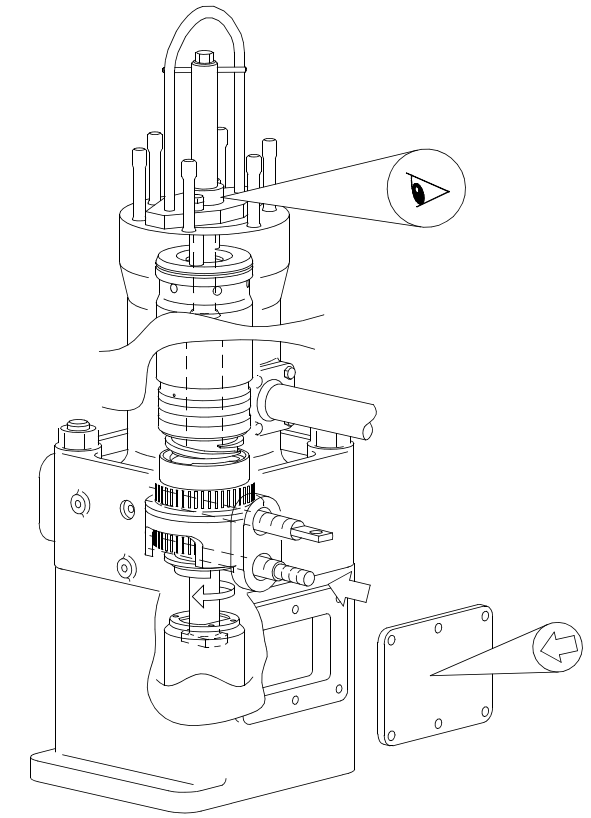


GN909-6.4 204 06

5. Loosen the nut on the extractor, disconnect the pulling rod from the timing toothed rack, and remove the extractor.

   Engaging the thread of the fuel pump barrel with the timing guide is accomplished by pressing-in the toothed rack. (A pressure of about 30 kg may be required.)

   Check that the toothed rack is correctly engaged by pressing-in the rack. When doing this, the pump barrel shall move downwards.

   The top flange of the tool is now resting on the top of the pump housing.

6. After 'landing' the barrel assembly, press the plunger down **into contact** with the thrust piece of the roller guide.

   Check that the stop disc of the spindle is in full contact with the flange of the tool, as when measuring.

   If necessary, turn the regulating guide a little (using the toothed rack) to make the plunger foot fit properly in the cutout of the roller guide. Inspect the position of the plunger foot through the inspection hole.

   When the plunger is in place, press the regulating rod in, thereby turning the plunger by means of the regulating guide and causing the plunger foot to "interlock" with the bayonet joint of the roller guide.

   Check that the plunger is correctly engaged by pulling at the spindle of the lifting tool. When doing this, it **must not** be possible to lift the spindle.

   Mount the inspection hole cover.

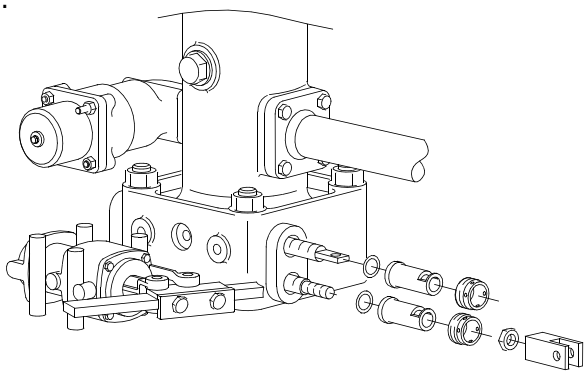
7. Mount the pointer and union for the timing rack.

   Mount the links for the timing drive and the regulating drive in place in accordance with the marks.

8. Mount the guide screw for the pump barrel in the pump housing.

   Remove the center screw from the plunger, and remove the tool.

7.



GN909-6.4 204 07

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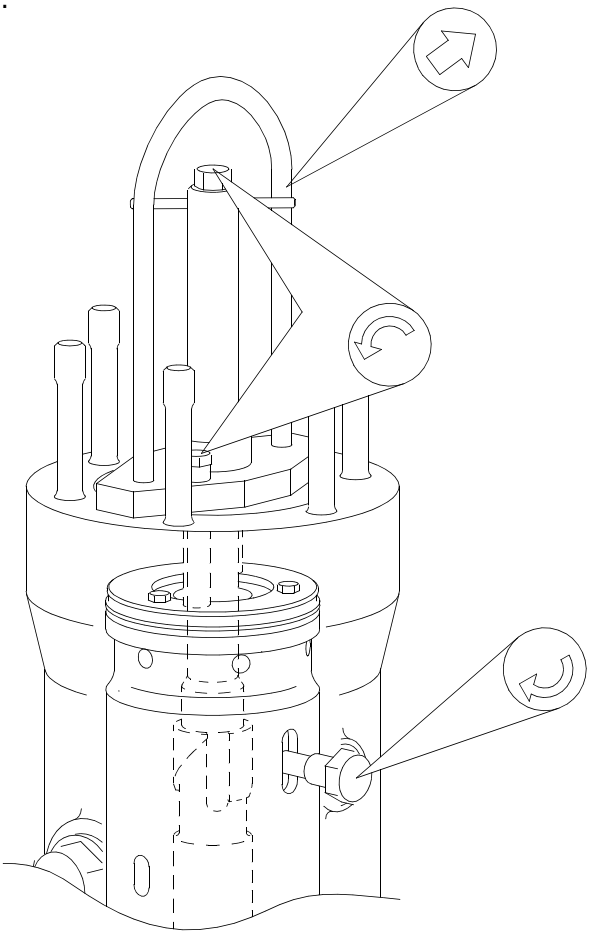


GN909-6.4 204 08

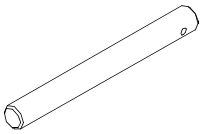
SAFETY PRECAUTIONS

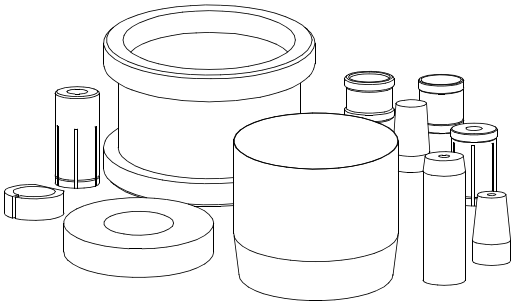
- [ ] Stopped engine
- [ ] Block the starting mechanism
- [ ] Shut off starting air supply
- [ ] Engage turning gear
- [ ] Shut off cooling water
- [ ] Shut off fuel oil
- [ ] Shut off lubricating oil
- [ ] Lock turbocharger rotors

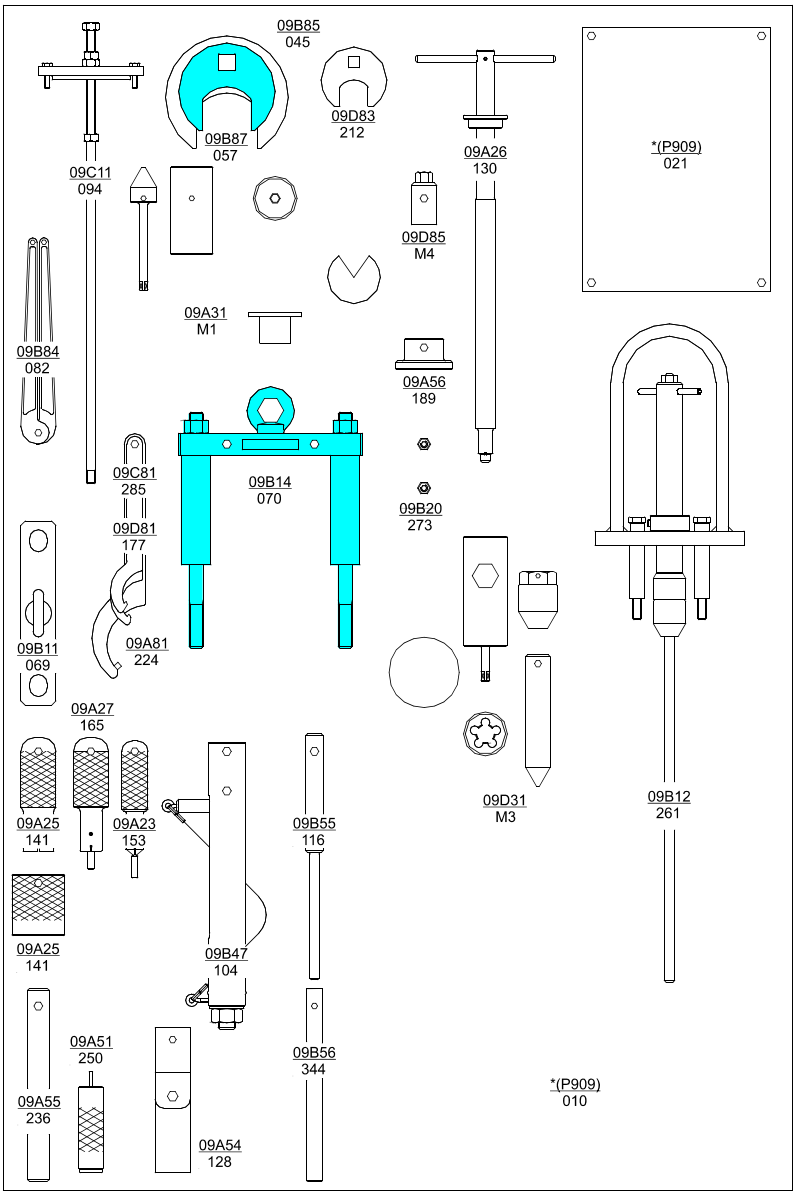
Data

Ref.	Description	Value	Unit
D-1	Suction valve - tightening torque	900	kg
D-2	Weight of top cover + suction valve	37	kg

Standard Tools: See Section 913



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09B87
057
09D83
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09A26
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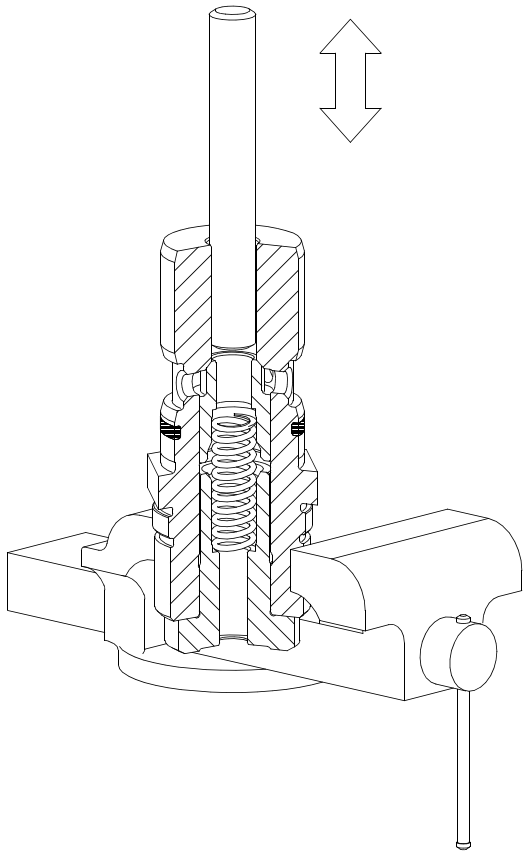
*(P909)
021
09C11
094
09D85
M4
09A31
M1
09B84
082
09A56
189
09C81
285
09B14
070
09B20
273
09D81
177
09B11
069
09A81
224
09A27
165
09A25
141
09A23
153
09B55
116
09D31
M3
09B12
261
09A25
141
09B47
104
09A51
250
09B56
344
09A55
236
09A54
128
*(P909)
010

1. Using a brass mandrel, check that the valve slide can slide freely up and down inside the suction valve.

2. Check the seats for tightness by filling the discharge hole with diesel oil or gas oil, and wait five minutes. No oil may seep through the seats of the slide/housing.

3. If the suction valve is not to be mounted on the engine immediately after the checking, cover all openings of the valve with plastic to prevent dirt from entering the valve during storage.

1.



HN909-7.1 207 01

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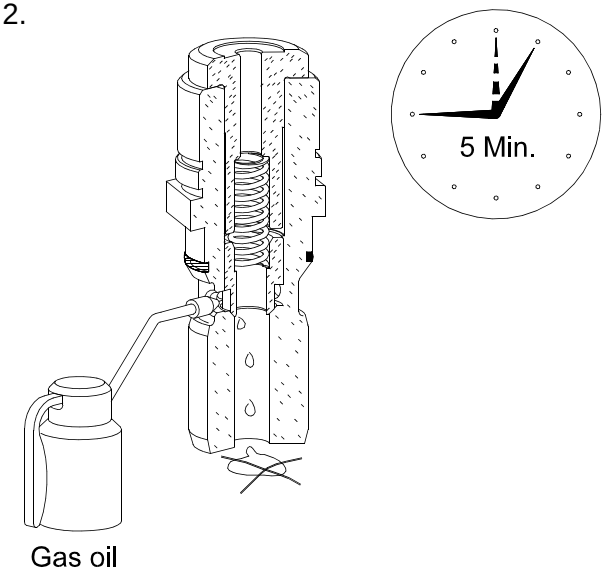
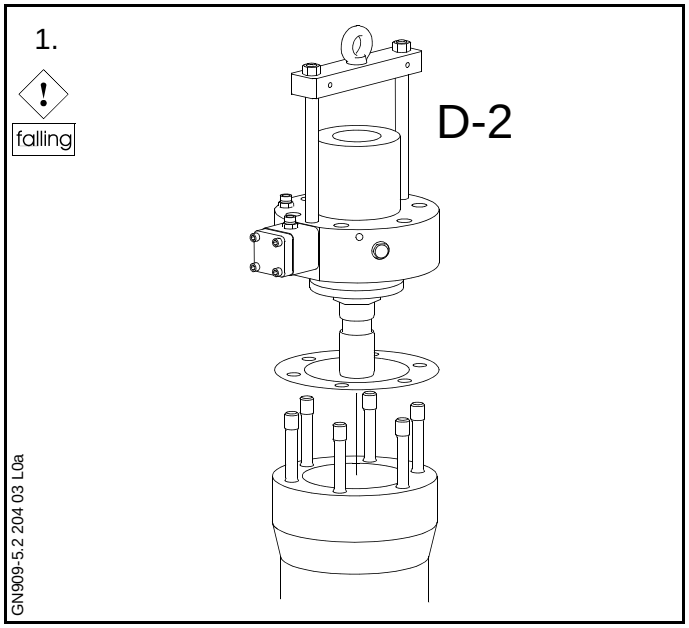
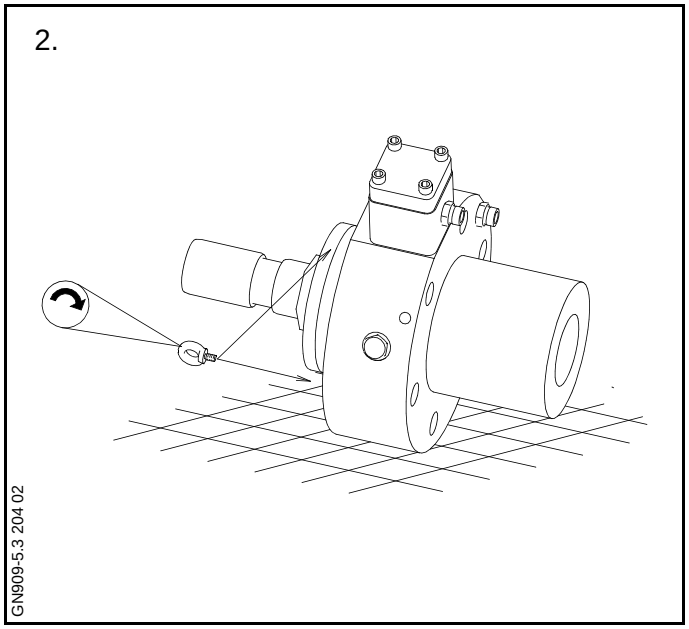
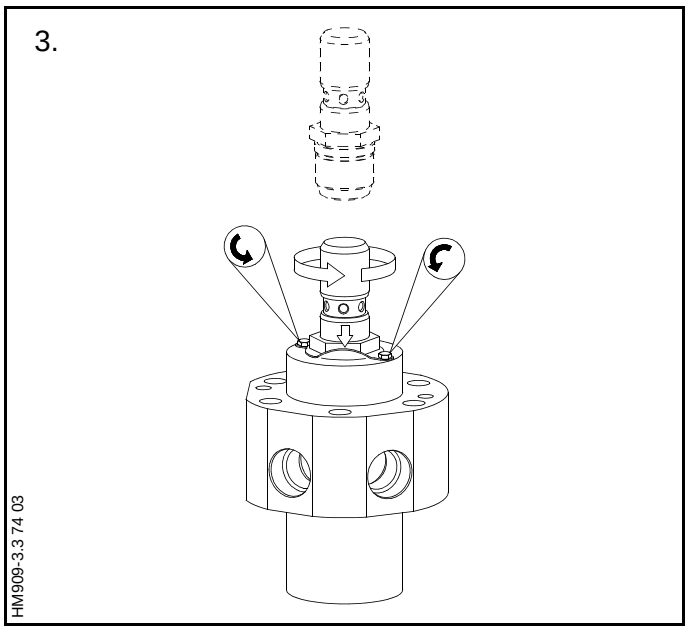


GN909-7.3 204 04







1. Dismantle the fuel pump top cover and suction valve assembly from the fuel pump housing. *See Procedure 909-5.2.*

Note!
Before dismantling the top cover, it is recommended to dismantle the fuel pump puncture valve, *see Procedure 909-8.2.*

2. Mount two eye bolts in the bottom of the top cover and turn it upside down.

3. Fix the top cover in an upside down postion, for example in a bench vice.

   Release the suction valve lock washer.

   Dismount the suction valve from the top cover.

   Remove and discard the lock washer.

1. Set up the suction valve in a bench vice with “soft” jaws and, using a brass mandrel and a hammer, release the spring guide from the valve thrust piece.

   Disassemble the other parts of the suction valve and clean the parts thoroughly in clean diesel oil.

   Remove and discard the seal ring from the valve thrust piece.

2. Inspect the seat of the valve slide and the seat in the thrust piece for damage. If the seats are damaged, both the suction valve and the valve slide must be discarded.

   Lapping of the seats must not be attempted.

3. Mount the O-ring in the groove of the seal ring and position the cone on the thrust piece.

   Place the seal ring on the cone and, using the pusher tool, push the seal ring on to the groove.

Note!
Make sure that the seal ring is mounted correctly. *See the sketch.*

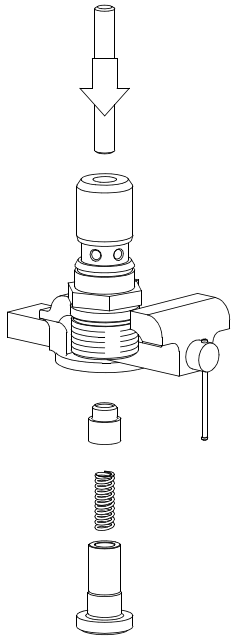
   After mounting the seal ring, compress it by pressing the “sizer” tool over the seal ring.

4. Clean and overhaul all internal parts, and lubricate them with molybdenum disulphide (MoS_2).

5. Re-assemble the suction valve.

6. Check the suction valve after the overhaul. *See Procedure 909-7.1.*

1.



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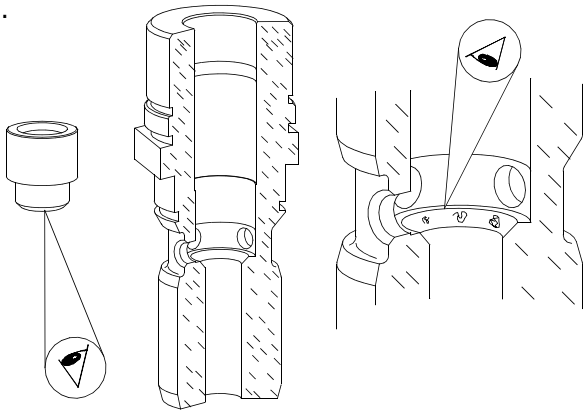

KB909-3.3 105 06

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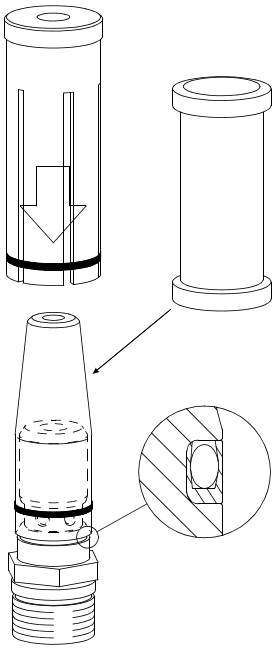

XZ909-7.3 204 03

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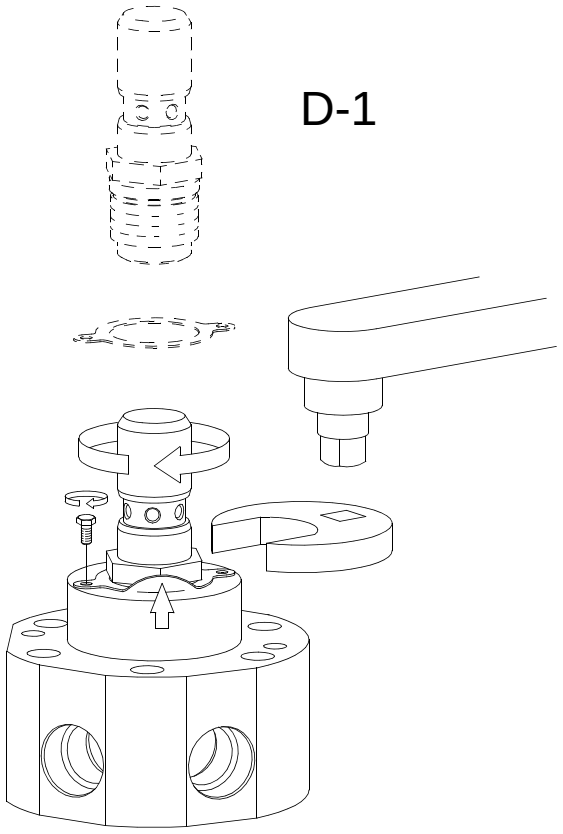

HM909-3.3 74 13

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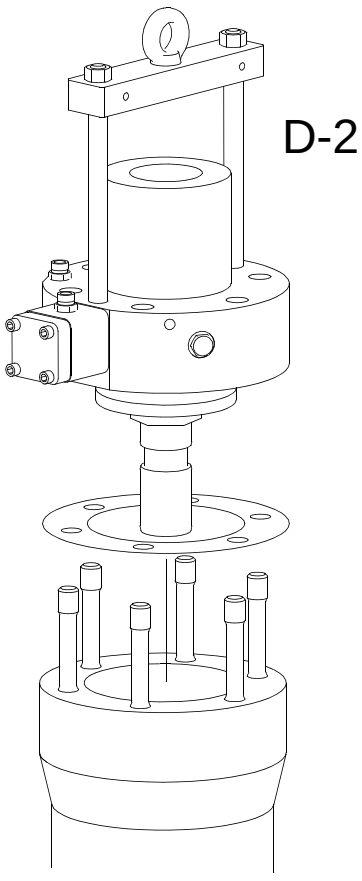


GN909-5.2 204 03 L0a

1. Fix the fuel pump top cover in an upside down position, for example in a bench vice.

   Lubricate the thread of the suction valve with copper grease.

   Make sure that the bore for the suction valve in the top cover is absolutely clean.

   Fit a new lock washer and mount a new or overhauled suction valve in the top cover.

   Fit the two screws which secure the lock washer.

   Tighten the suction valve with a torque spanner. *See Data.*

   Lock the suction valve in position by bending up an edge of the lock washer over one of the flats of the valve.

2. Mount the top cover in the fuel pump housing. *See Procedure 909-5.2.*

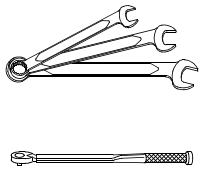
SAFETY PRECAUTIONS

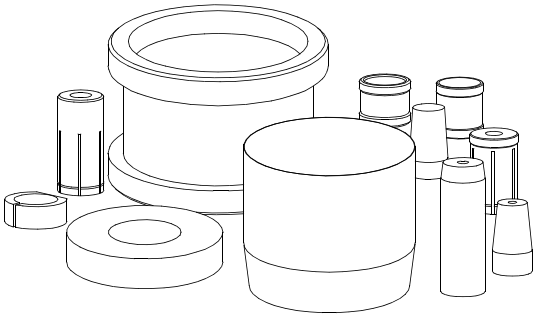
☐	Stopped engine
☐	Block the starting mechanism
☐	Shut off starting air supply
☐	Engage turning gear
☐	Shut off cooling water
☐	Shut off fuel oil
☐	Shut off lubricating oil
☐	Lock turbocharger rotors

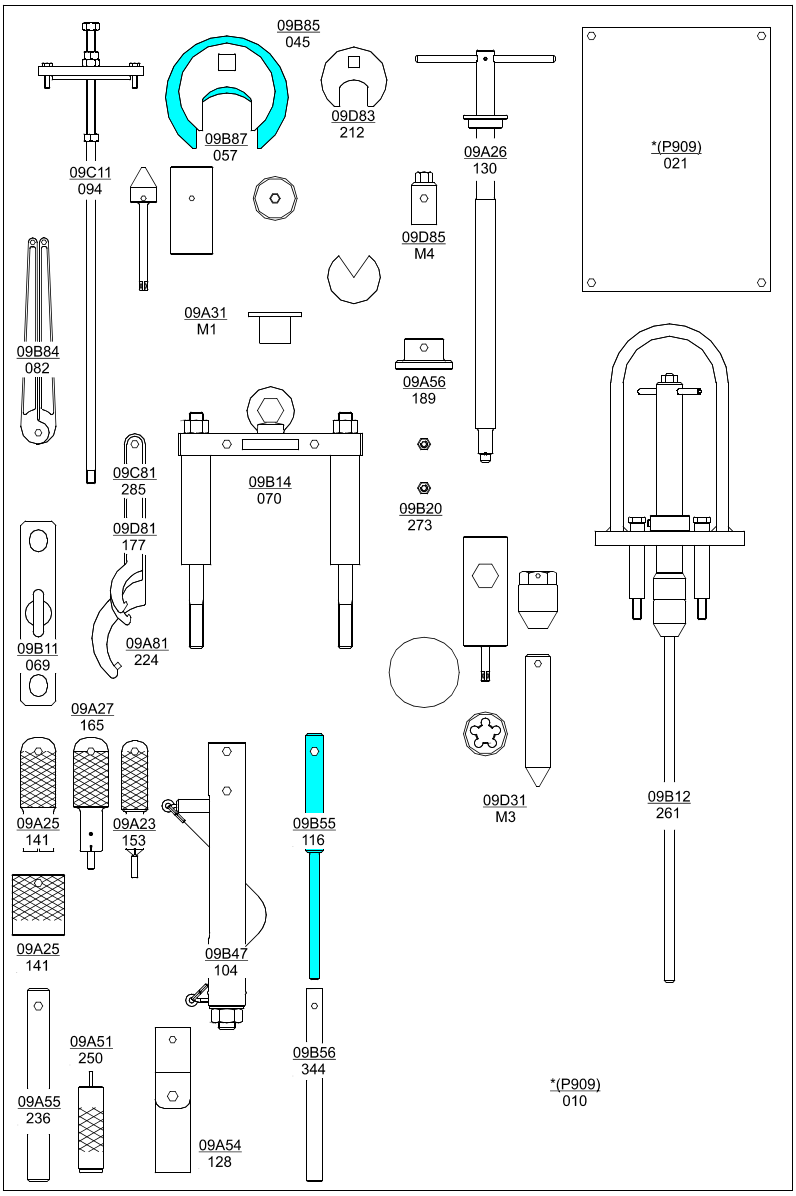
Data

Ref.	Description	Value	Unit
D-1	Puncture valve - weight	5	kg
D-2	Puncture valve - tightening torque	890	Nm

Standard Tools: See Section 913



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*(P909)
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09C81
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09D81
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010

1. Shut off the fuel oil inlet.

   Open the drain cock at the bottom of the pump housing and drain off any oil left in the fuel oil high-pressure pipe and fuel pump.

Note!
Before dismantling any part of the fuel pump, make sure that the pump has been relieved of pressure and that all oil has been drained off.

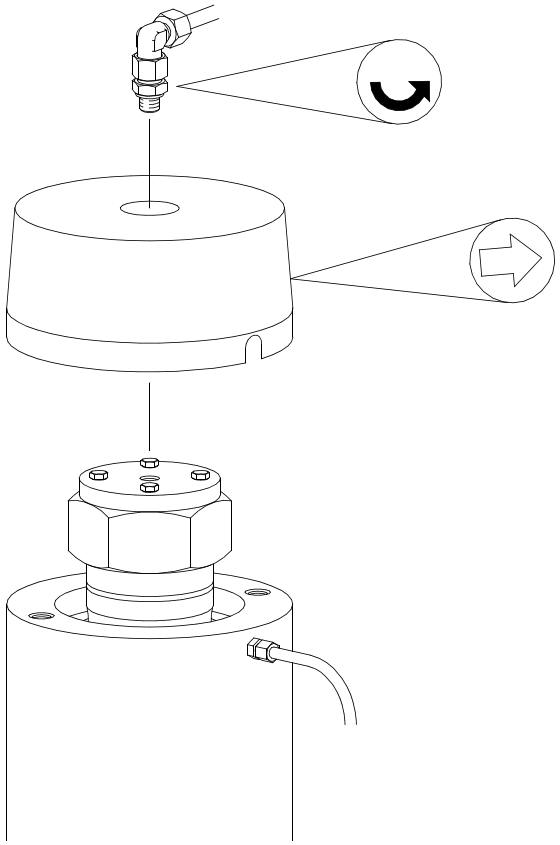
2. Dismantle the control air pipe and the protective cap above the puncture valve.

3. Unscrew and remove the puncture valve from the fuel pump top cover.

4. After dismantling it is recommended always to overhaul the puncture valve.

   If the overhaul cannot take place immediately after the dismantling, it is recommended to place the puncture valve immersed in diesel oil until the overhaul.

2.



HN909-8.2 207 02

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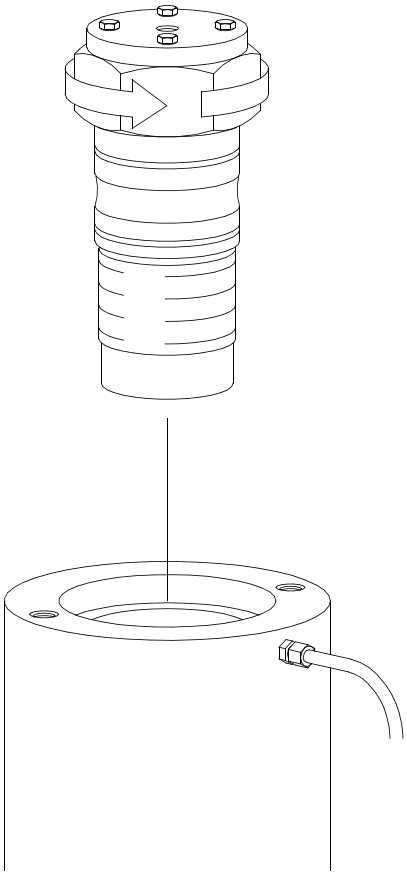

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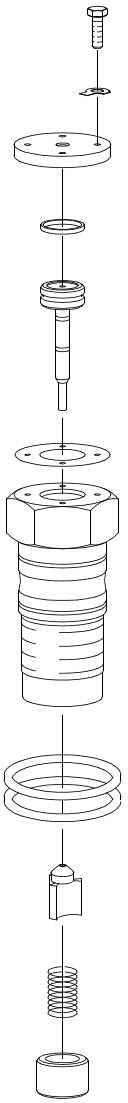

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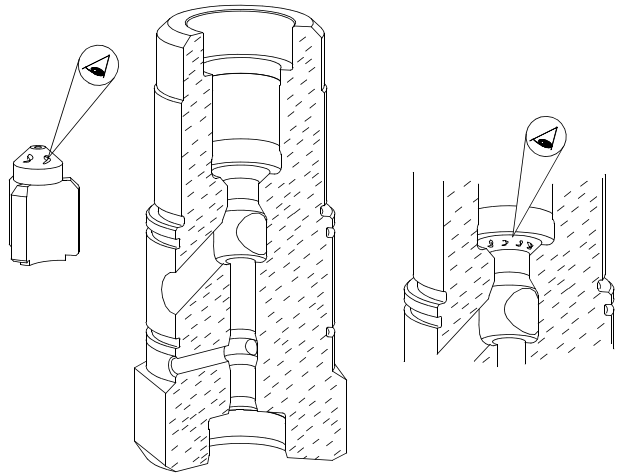


GN909-8.3 204 02

1. Remove and discard the O-rings from the puncture valve.

   Set up the puncture valve in a bench vice with “soft” jaws.

   Loosen and remove the four screws and dismount the plug. Use a screw to remove the air piston from the housing.

   Remove and discard the seal rings from the air piston.

   Disassemble the other parts of the puncture valve, using a brass mandrel and a hammer. Take care not to damage the valve seat.

   Thoroughly clean all the parts in clean diesel oil.

2. Inspect the conical seats of the valve housing and the valve slide for wear marks or scratches.

   If the seats are damaged, the valve housing and the valve slide must be discarded.

   Lapping of the valve seats must not be attempted.

3. When mounting the new seal rings on the spindle of the air piston, the inner seal ring must be mounted first.

   Mount the O-ring in the ring groove and position the large cone on the spindle.

   Place the seal ring on the cone and, using the pusher tool, push the seal ring on to the O-ring in the groove.

   After mounting the seal ring, compress it by pressing the “sizer” tool, over the seal ring.

   Mount the outer seal ring in the groove using the short cone, and repeating the above procedure.

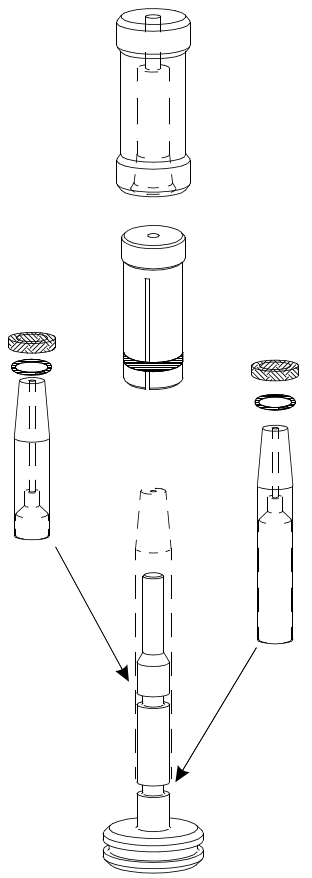
4. The new seal ring is mounted on the head of the air piston in accordance with the same procedure as above.

   Before assembling the puncture valve, lubricate all parts with “MOLYKOTE anti-friction SPRAY D321R” or molybdenum disulphide (MoS_2).

   Mount new O-rings on the housing.

5. If the puncture valve is not to be mounted on the engine immediately after the overhaul, cover all openings of the valve with plastic to prevent dirt from entering the valve during storage.

3.



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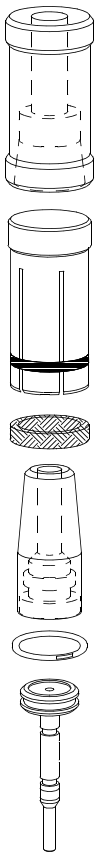

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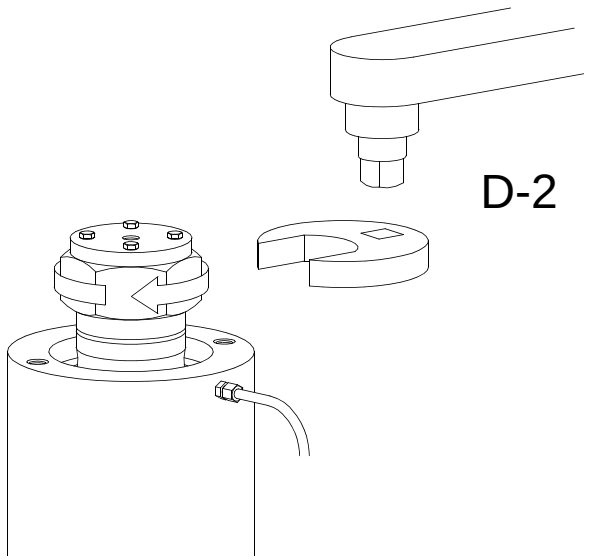

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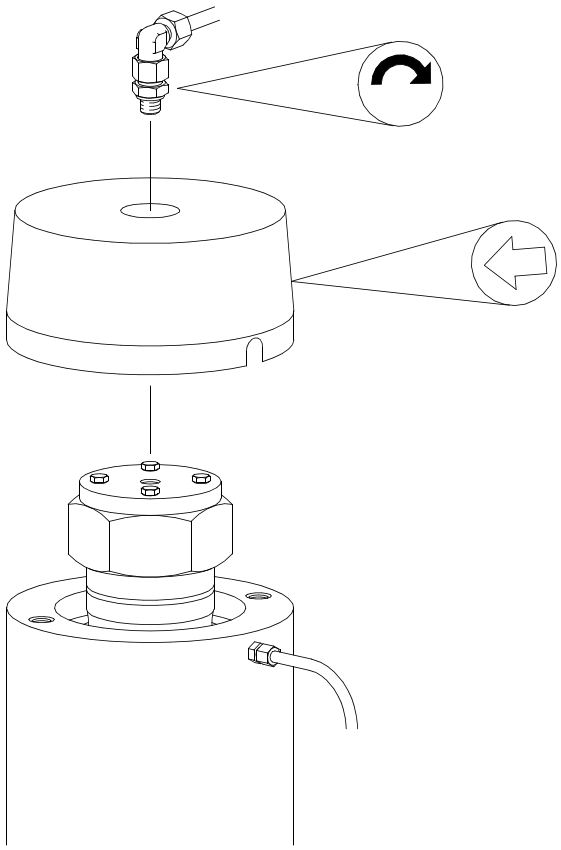


HN909-8.4 207 03

1. Make sure that the bore for the puncture valve in the fuel pump top cover is absolutely clean.

   Mount new O-rings on the puncture valve.

   Lubricate the thread of the puncture valve with copper grease.

2. Screw the puncture valve into the bore in the top cover.

   Using a crowfoot wrench and a torque spanner, tighten the puncture valve to the torque stated in Data.

3. Mount the protective cap and the control air pipe on top of the puncture valve.

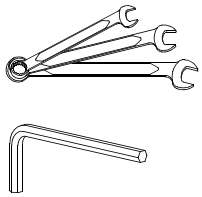
4. If open, close the drain cock on the fuel pump.

SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	May cause spring under tension
X	Block the starting mechanism	
X	Shut off starting air supply	
X	Engage turning gear	
	Shut off cooling water	
X	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

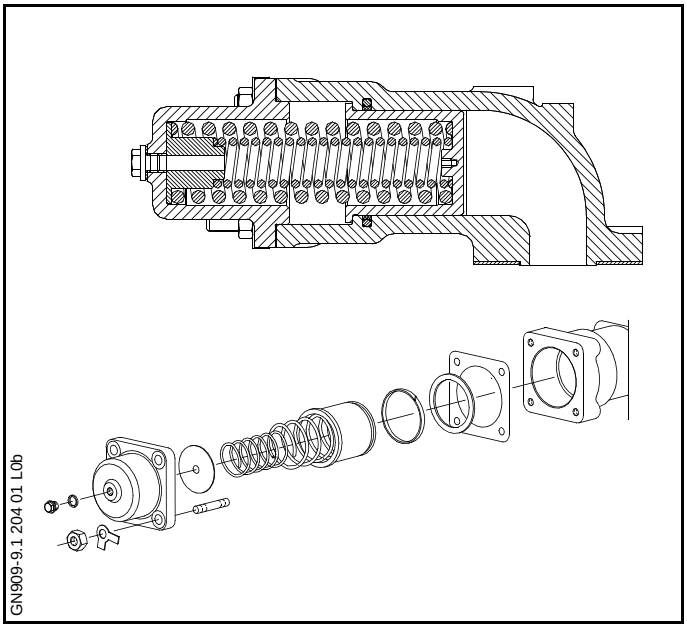
Data

Ref.	Description	Value	Unit
D-1	Fuel pump shock absorber complete	21	kg

Standard Tools: See Section 913



To ensure satisfactory operation, the functioning of the fuel pump shock absorber should be checked at regular intervals. Normally, inspection is necessary only at the intervals stated in the maintenance programme. The checks should be carried out while the engine is operating.



1. Remove the plug from the end cover of the shock absorber. Check that air is “pulsating” through the threaded hole.

   Short bursts of air should be felt against the hand, corresponding to the strokes of the fuel pump.

   The air pulses occur when the shock absorber piston is working and the air below the piston is being compressed and forced out through the threaded hole.

2. To check the “tightness” of the piston, measure the amount of leakage oil flowing from the drain pipe of the shock absorber housing. Note down the amounts measured and compare with earlier measurements.

   Increasing amounts indicate a deteriorating piston sealing. Excessive amounts indicate that the shock absorber requires overhauling.
   See Procedure 909-9.3.

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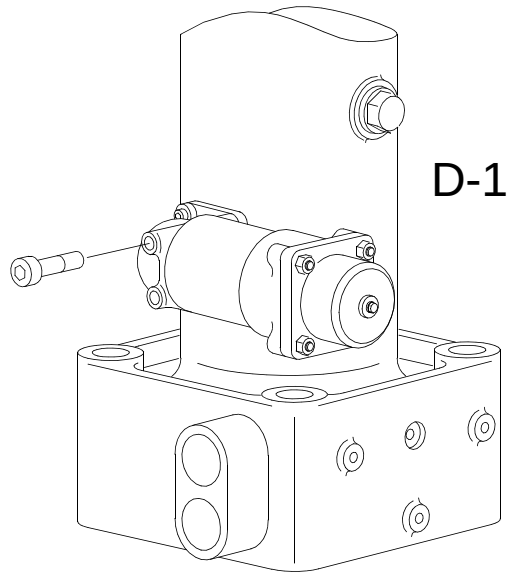

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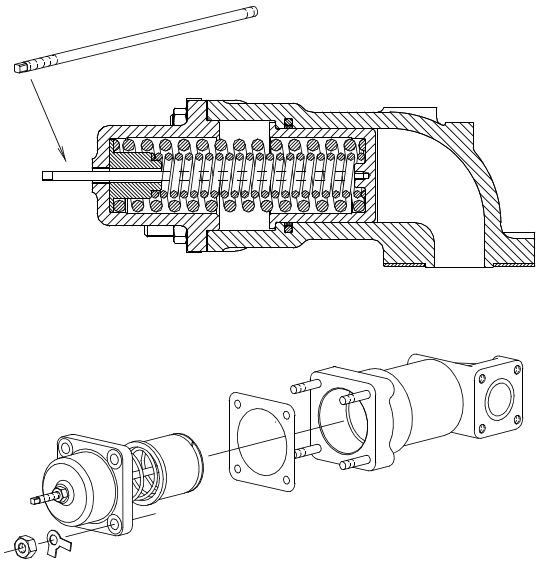

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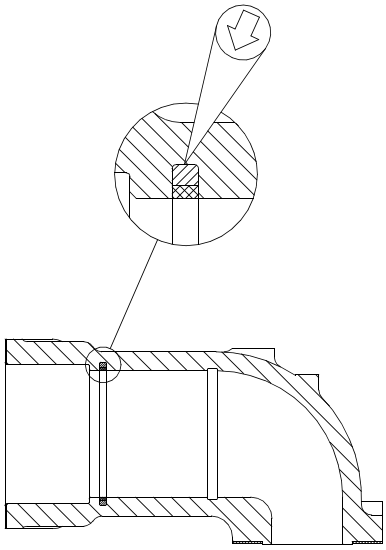


GN909-9.3 204 04 L0a

Note!

Before dismantling any part of the fuel oil system, make sure that the system has been relieved of pressure and that all oil has been drained off.

1. Remove the shock absorber drain pipe. Place a wire strap around the shock absorber and hook on the engine room crane. Loosen the screws holding the shock absorber and remove it from the fuel pump housing.

2. Remove the plug from the end cover of the shock absorber. Fit a threaded rod between the piston and the end cover to counteract the force of the springs. Loosen the screws of the end cover and remove the end cover and piston. Discard the gasket.

3. Loosen the nut on the threaded rod to relieve the springs and remove the threaded rod. Remove and discard the seal ring in the shock absorber housing and the wear ring on the piston.

4. Clean all parts and polish the sliding surfaces of the piston and the shock absorber housing. Mount a new seal ring in the shock absorber housing and a new wear ring on the piston.

5. Mount the springs and the spring guide between the end cover and the piston, using the threaded rod.

   Lubricate all sliding surfaces and assemble the shock absorber. Take care not to damage the seal ring or wear ring when mounting the piston. Check that the piston slides easily in the shock absorber housing.

6. Mount the end cover. For tightening the nuts, *see Data*. Look with the locking device. Remove the threaded rod and insert the plug.

7. Fit a new gasket on the fuel pump housing and mount the shock absorber. Mount the shock absorber drain pipe.

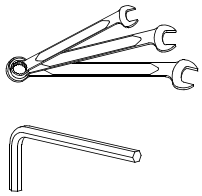
   If an excessive amount of drain oil is still observed after the overhaul, the shock absorber must be replaced and the damaged one sent to MITSUI ENGINEERING & SHIPBUILDING CO., LTD. for reconditioning.

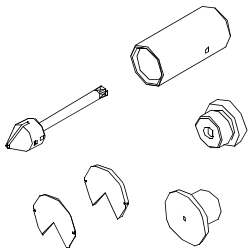
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of high pressure oil
X	Block the starting mechanism	Risk of hot surfaces
X	Shut off starting air supply	Naked flames prohibited
	Engage turning gear	
	Shut off cooling water	
X	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

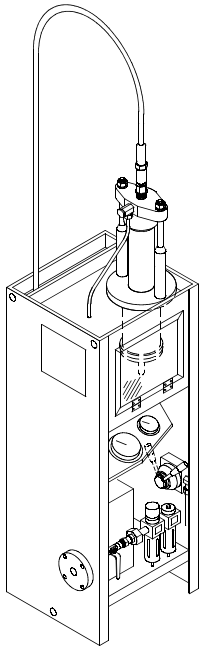
Data

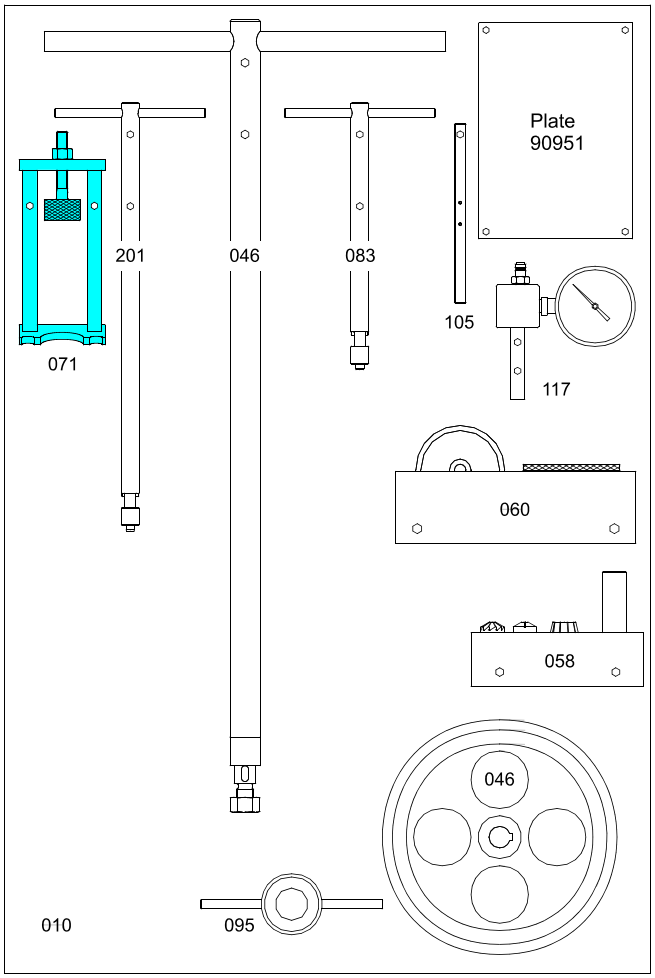
Ref.	Description	Value	Unit
D-1	Max. diameter	18	mm
D-2	Weight of fuel valve	8	kg
D-3	Opening pressure	35 (350	MPa bar)
D-4	Fuel valve - tightening torque	25	Nm

Standard Tools: See Section 913





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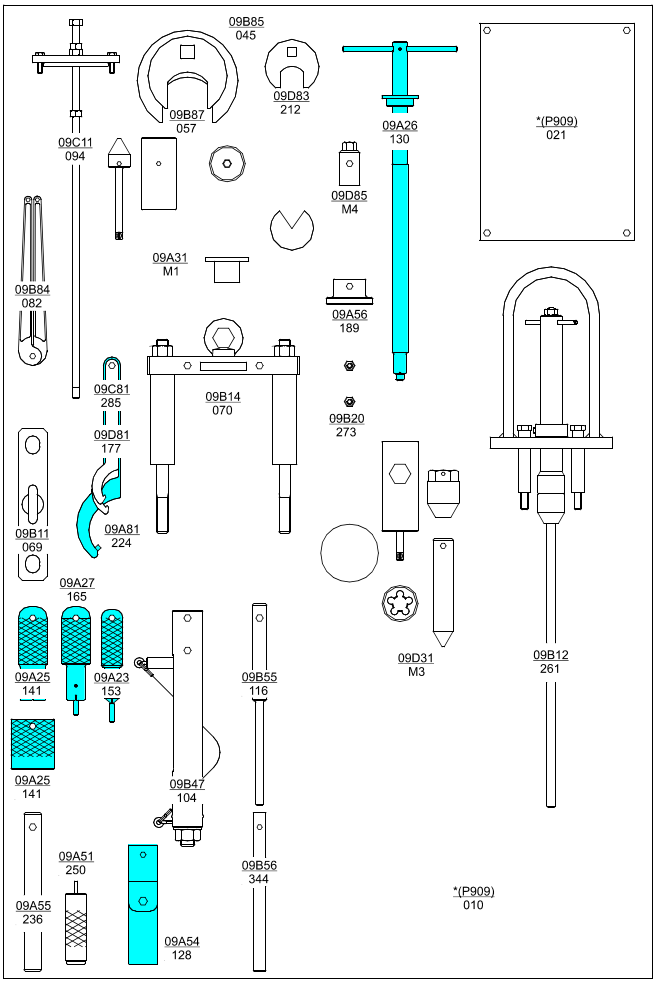
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The fuel valves must be given the utmost attention and care, as the greater part of irregularities that may occur during the running of the engine can be attributed to defects in these valves.

If the engine gives normal performance in accordance with diagrams and exhaust temperatures, it is only necessary to inspect the fuel valves after the service period stated in the Checking and Maintenance Programme.
See Chapter 900-1.

In order to obtain reliable results during testing of the fuel valves, all fuel valves that are dismantled from the engine must be disassembled, cleaned, inspected and re-assembled before testing.
See Procedure 909-11.3.

All fuel valves must be function tested before being mounted in the cylinder cover.

For the fuel valves after operating with C heavy oil, function tested must be carried out after dismounting and cleaning.

1. **Equipment demands**

1.1 Test pump unit:
Regarding operation of the test pump unit, see the supplier's insutructions.

1.2 Prescribed oil:
Hydraulic oil (rust-preventing) with a viscosity of between 7 and 10 Cst at 50°C.

Note!
Use clean oil only.

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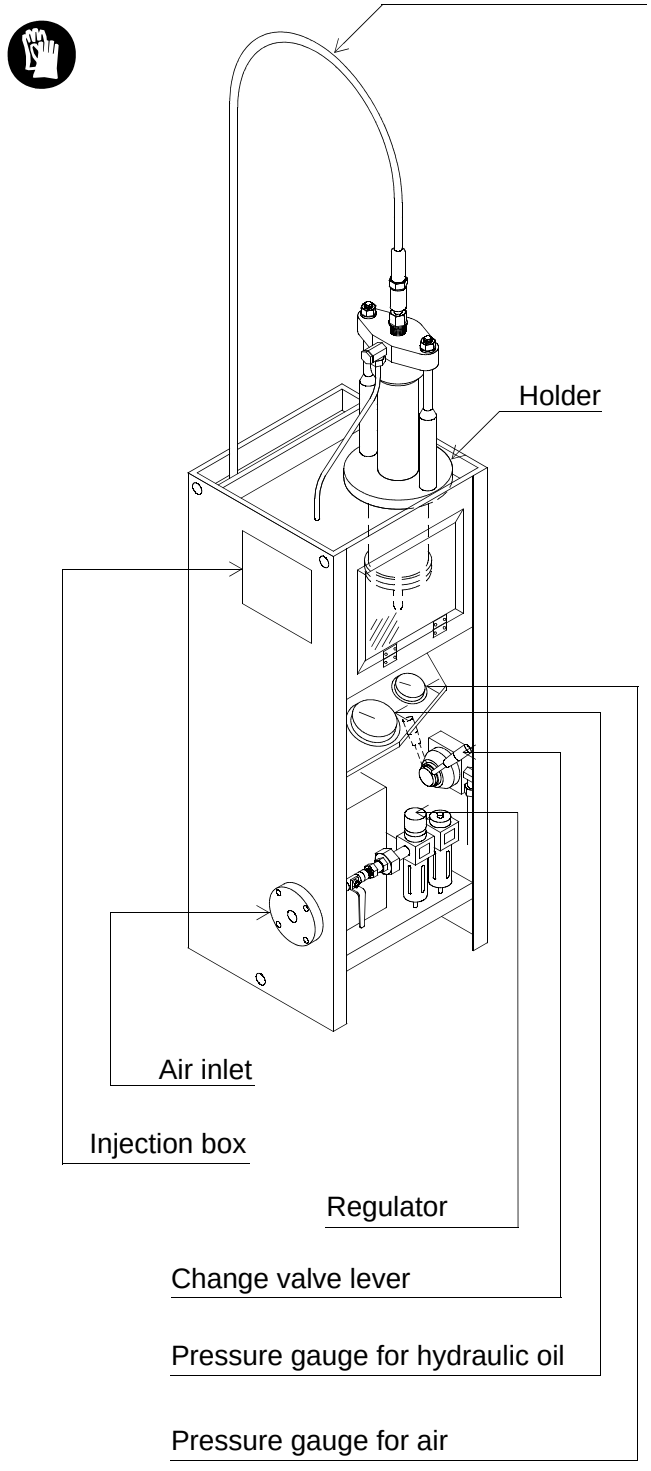

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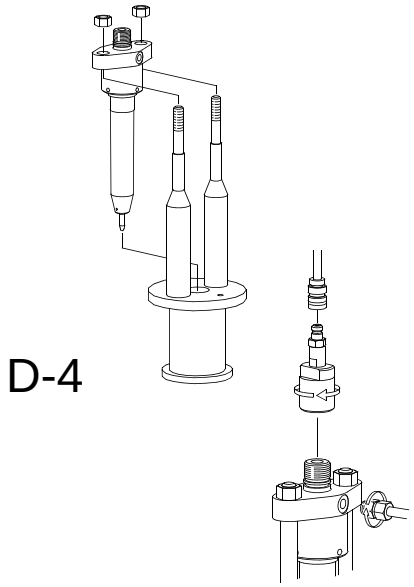

D-4

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2. **Setting-up the fuel valve**

Place the fuel valve in the holder and secure it with the nuts. Mount the high-pressure hose between the pressure testing pump and the fuel valve.

3. **Pressure testing procedure**

The subsequent items, which must be followed in the sequence stated. Items 4, 6, 7 and 8 are each divided into the following five groups:

A. Objective

B. Procedure

C. Acceptance criteria

D. Cause of fault

E. Other description

4. **Flushing**

A. Objective:

Remove air in the system.

B. Procedure:

Set the air pressure to about 0.1 MPa (1 bar) by the requlator.

Operate the lever of change valve by pushing/pulling repeatedly until non air mixed oil flow out from drain hole of top cover.

C. Acceptance criteria:

No oil leakage from the nozzle holes.

D. Cause of fault:

If the oil leakage occurred from nozzle holes in the above point **C**, incorrect fitting of fuel valve on test device is considered.

E. Other description:

If the oil is not flow out from drain hole on top cover, the vent hole of thrust piece is closed by defective slide valve in the non-return valve.

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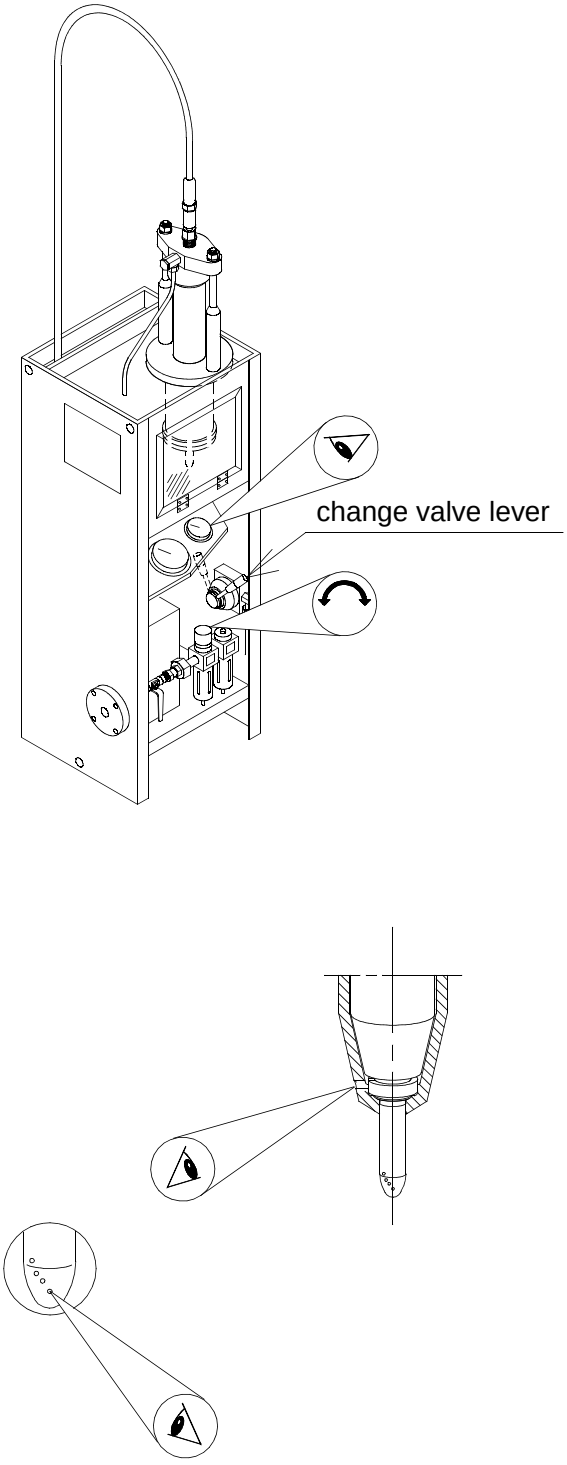

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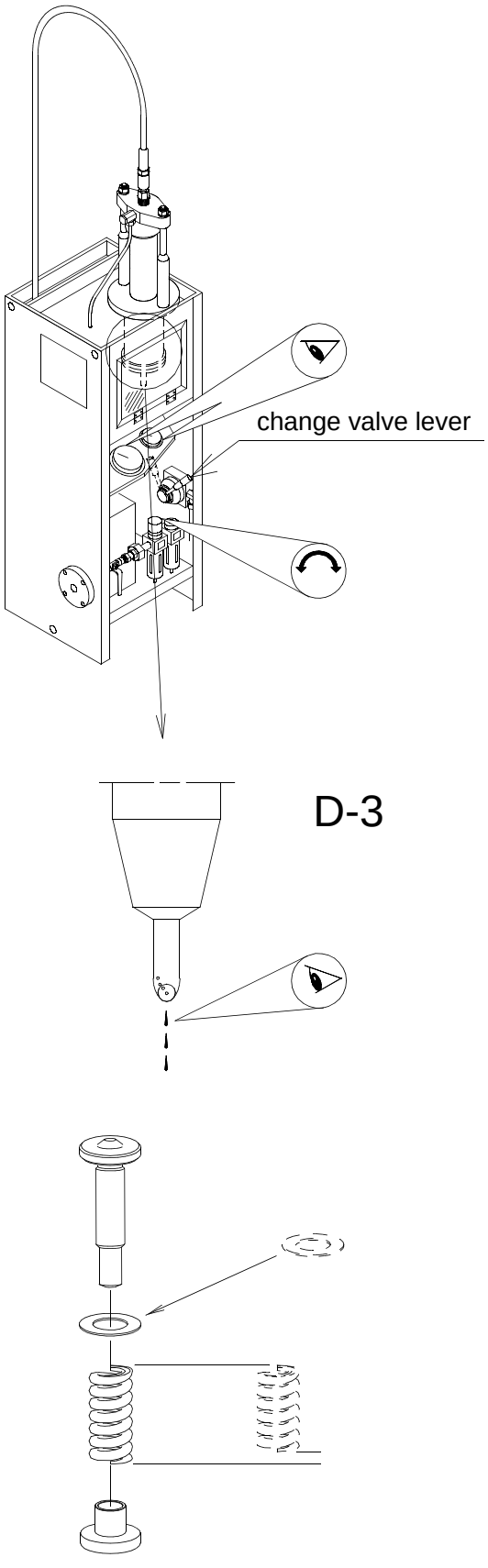

5. **Atomization test**

Testing of the atomization of the fuel valve is not considered necessary, as the capacity of the fuel pump on the engine is substantially larger than the capacity of the pressure testing pump.

This always ensures proper atomization of the fuel during operation of the engine, provided that the results of tests 4, 6, 7 and 8 are satisfactory.

6. **Opening pressure**

A. Objective:

To check the opening pressure.

B. Procedure:

Set the air pressure to about 0.6 MPa (6 bar) by regulator.

Increase the oil pressure by pulling the lever slowly until the oil can be observed through the nozzle hole.

C. Acceptance criteria:

Check the opening pressure on the pressure gauge.

D. Cause of fault:

If the opening pressure is higher than specified in **D-3**, the cause may be that a wrong type of spring is used - replace the spring on the thrust spindle, if necessary, replace the complete thrust spindle.

If the opening pressure is lower than specified in **D-3**, the cause may be that the spring has sagged - replace the spring, or add a special thin disc.

Note!
Special thin discs are available as spares.

If a spring or a disc has been changed, the pressure testing procedure of the fuel valve must be repeated from step 4.

7. **Sealing test and sliding function**

A. Objective:

To check the needle valve seat for tightness and the slide for correct closing.

B. Procedure:

B-1. Set the air pressure to about 0.1 MPa (1 bar) by the regulator.

B-2. While the lever of change valve is operating, adjust the regulator until the oil pressure is built up to about 8-10 MPa (80-100 bar) below the opening pressure.
During the built up pressure is maintained about 10 seconds, observe the nozzle holes.

B-3. Push the lever at the oil pressure is built up condition, observe the pressure gauge of hydraulic oil and leakage of hydraulic oil from the drain hole of the valve head.

C. Accepatance Criteria:

C-1. Sealing test
Oil must not be leaked from the nozzle holes.

It shows the normal condition that the leak oil flows out from the drain hole of the valve head.

C-2. Sliding test
The pressure drops relativery slowly to about 1.5 MPa (15 bar), after which it drops guickly to 0 MPa (0 bar) because the slide valve in the non-return valve is pressed against the conical seat and the vent hole for circulation of oil is made open (It can be judged two from increasing of the leak oil from the drain hole when the fuel valve is full of oil).

7.
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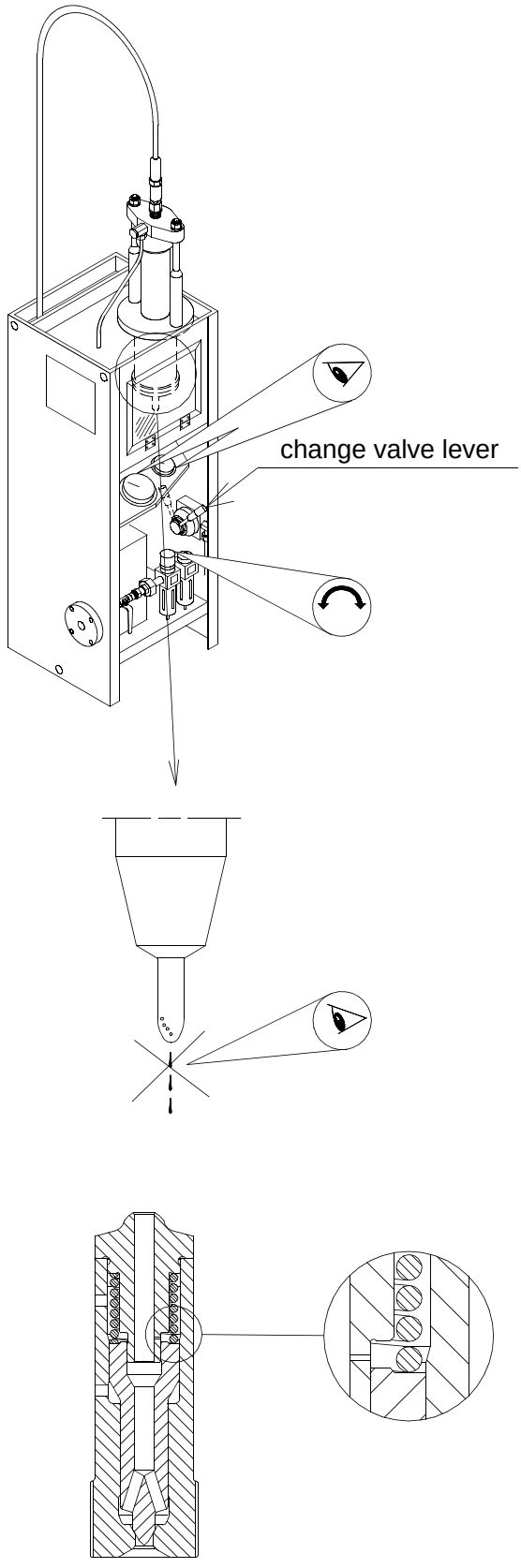

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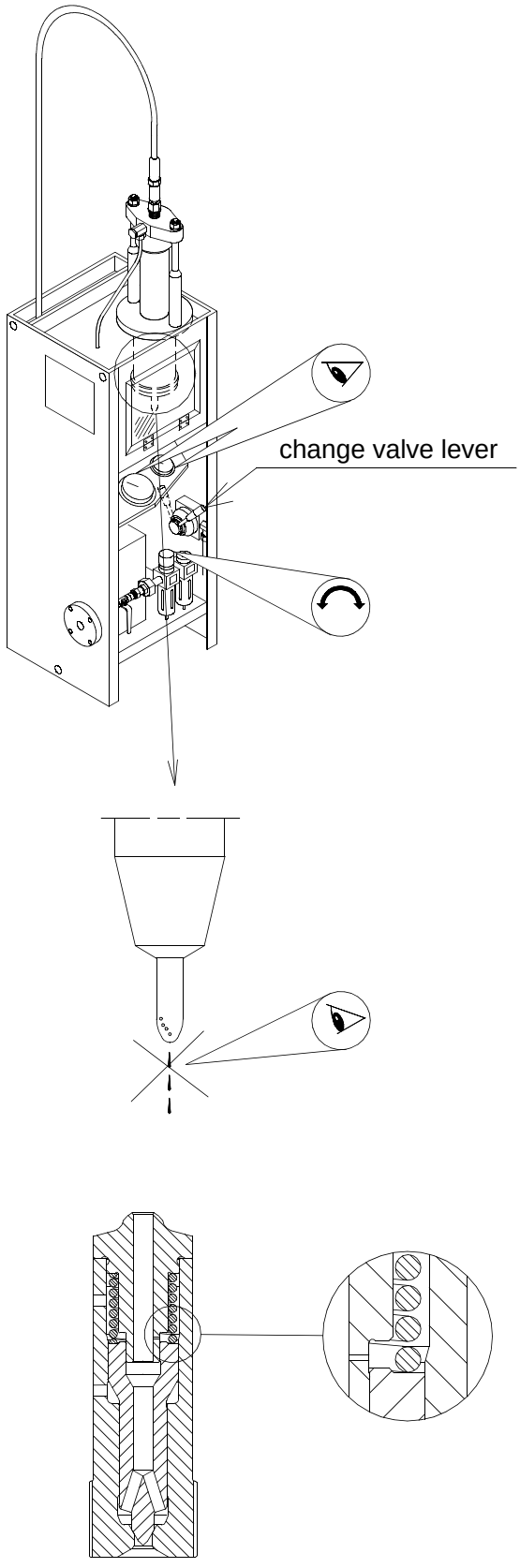

D. Cause of fault:

D-1. Sealing test

If oil flows out of the nozzle holes, the cause is either:

- Defective spindle guide at needle seat, or a sticking spindle. Examine and/or replace the spindle guide.
  See Procedure 909-12.3.

- Too quick pressure drop:

  - the clearances of the movable parts, both of the spindle guide and of the non-return valve, are too large, or

  - the seats between the thrust piece/ spindle in the spindle guide or thrust piece/valve slide in the non-return valve are damaged.

Examine and/or replace both the spindle guide and non-return valve.
See Procedure 909-12.3.
See Procedure 909-13.3.

D-2. Sliding function

The pressure drops relatively slowly to about 1.5 MPa (15 bar), after which it drops quickly to 0 (the slide is pressed against the conical seat and opens for circulation oil).

Note!
There will always be an oil flow from the leak oil outlet when the fuel valve is full of oil.

If a quick pressure drop from 1.5 to 0 MPa (15 to 0 bar) cannot be registered:

- The valve slide is sticking; or

- the vent hole in the thrust piece is blocked.

If so, disassemble and examine the spindle guide, replace if necessary.
See Procedure 909-12.3.

8. **Pressure test, O-ring sealings**

A. Objective:

To ensure that the leak oil (circulation oil) remains in the closed system.

B. Procedure:

Build up a working pressure of about max. 1.0 MPa (10 bar) setting of regulator, and operate the lever of change valve until oil flows out of the leak oil outlet.

C. Acceoatance criteria:

Close the leak oil outlet with a gasket and plug screw.

The lever of change valve is kept operating. Increase the hydraulic oil pressure to about 10 MPa (100 bar) by adjusting of the rgulator.

Stopped to operate the lever of change valve, and observe the pressure gauge of hydraulic oil and the oil leakage from the O-ring part.

The built-up pressure of about 10 MPa (100 bar) should be maintained.

The leak oil from the O-ring part should not be reconized.

D. Acceoatance criteria:

If oil leaks out at the union nut, the O-ring in the uppermost groove of the fuel valve housing is defective, and must be replaced.

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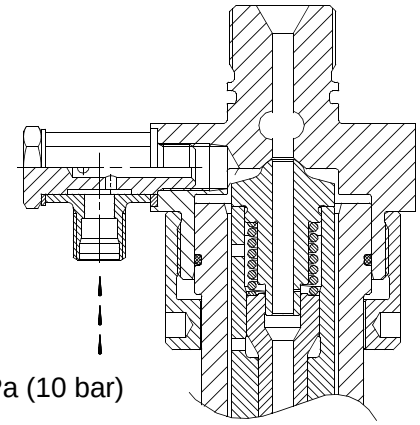

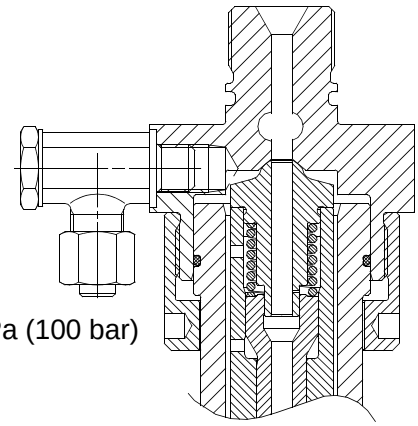

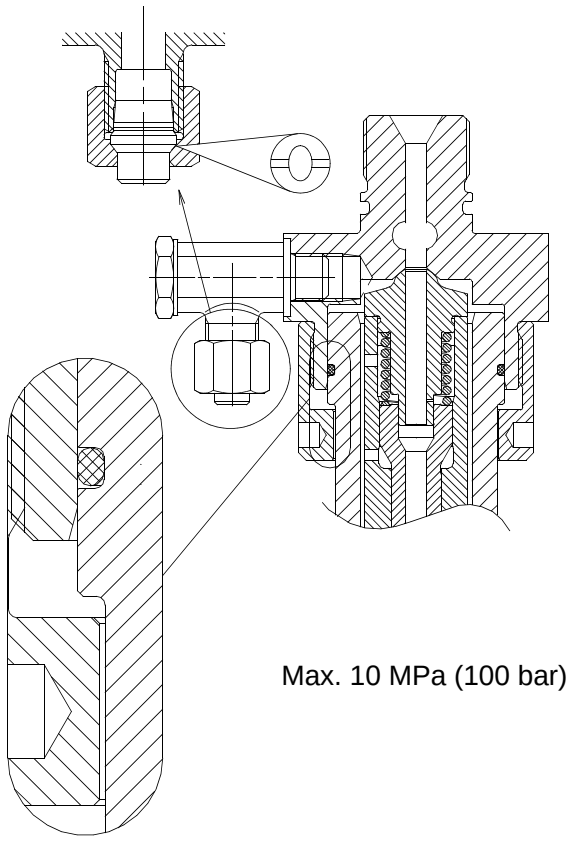

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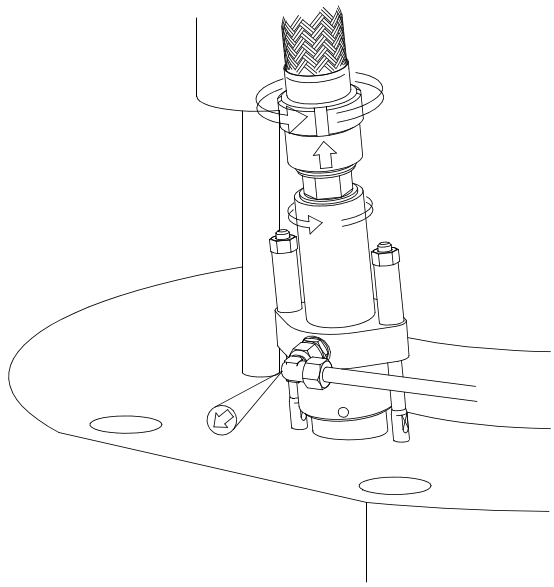

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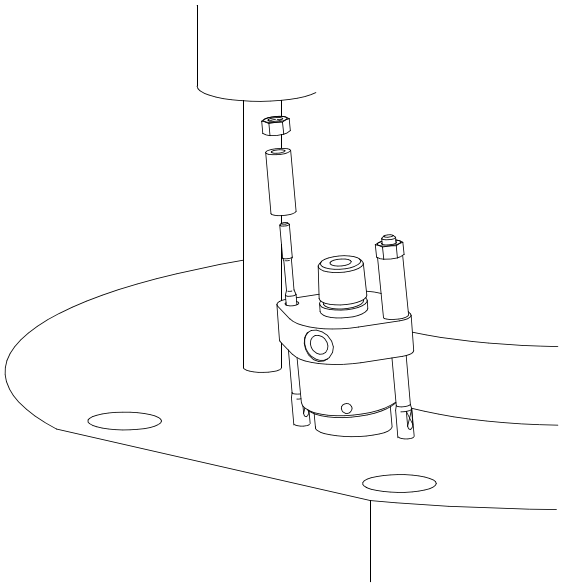

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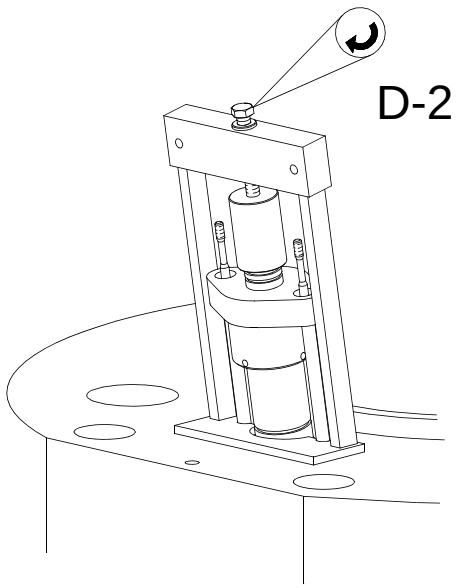


HN909-11.2 206 03

1. Close the fuel oil inlet and outlet valves, and drain the high-pressure pipe and the fuel valve.

   Remove the high-pressure pipe. *See Procedure 909-14.2.*

   Disconnect the return oil pipe from the fuel valve.

2. Unscrew and remove the nuts and the tubular spacers.

3. Take out the valve. If the valve is sticking, use the fuel valve dismantling tool to pull the fuel valve clear of the top cover.

   If the valve is not to be overhauled immediately, the valve should be placed immersed in diesel oil until overhauling.

When fuel valves are overhauled, all parts should be handled carefully and be kept clean.

Use only clean, non-fluffy rags for wiping purposes, and compressed air for further removal of liquid or solid impurities. Whenever fuel valves are overhauled, all seal rings should be discarded and replaced by new, faultless seal rings before reassembly.

1. Remove and discard the O-rings.

   Disassemble the fuel valve by screwing off the union nut with a hook spanner while retaining the valve in, for instance, a bench vice provided with “soft” jaws.

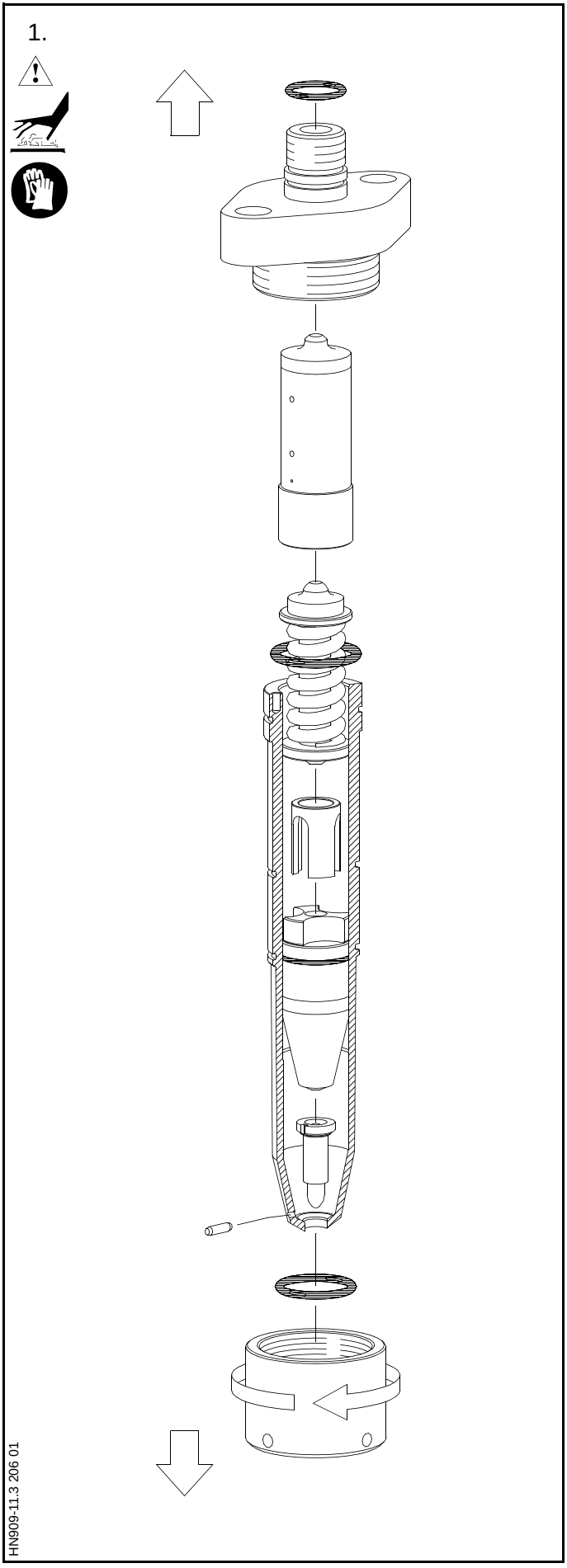
   Pull the valve head clear of the valve housing.

   Remove the:

   - Non return valve
   - Thrust spindle
   - Thrust foot
   - Spindle guide
   - Fuel nozzle

   from the valve housing.

   Remove and discard all the O-rings.



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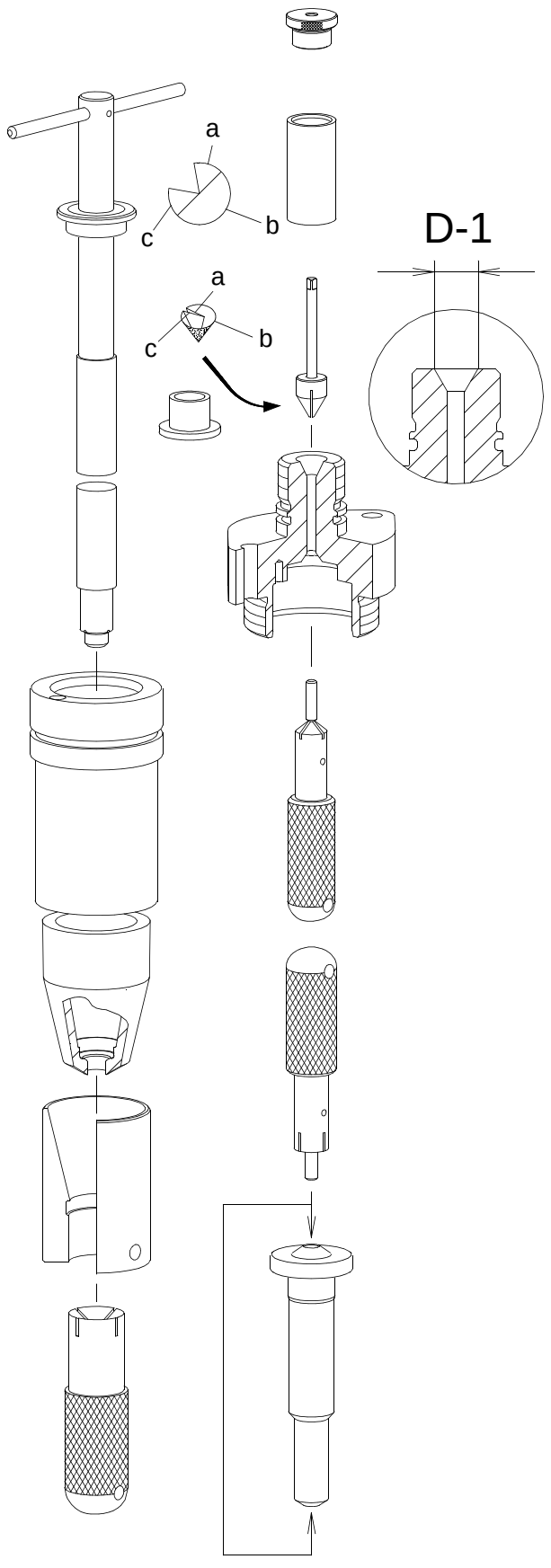


2. **Carefully** clean and examine all surfaces of the:

   - Fuel valve housing
   - Fuel valve head
   - Thrust spindle

   If necessary, grind the seating surfaces by means of the grinding mandrels supplied and a fine-grain abrasive (such as Carborundum No. 500).

   This grinding must only be carried out manually.

   After the grinding, wash the parts in gas oil and blow clean by means of compressed air to remove any remains of the grinding compound.

   Grind the sealing surfaces for the high-pressure pipe in the valve head by means of the grinding tool.

   If consisit of guide, bush mandrel, emery cloth and stamp. The grinding mandrel is turned in the chuck of a portable drilling machine etc.

Note!
Take care not to exceed the maximum diameter of the seat, *see Data.*

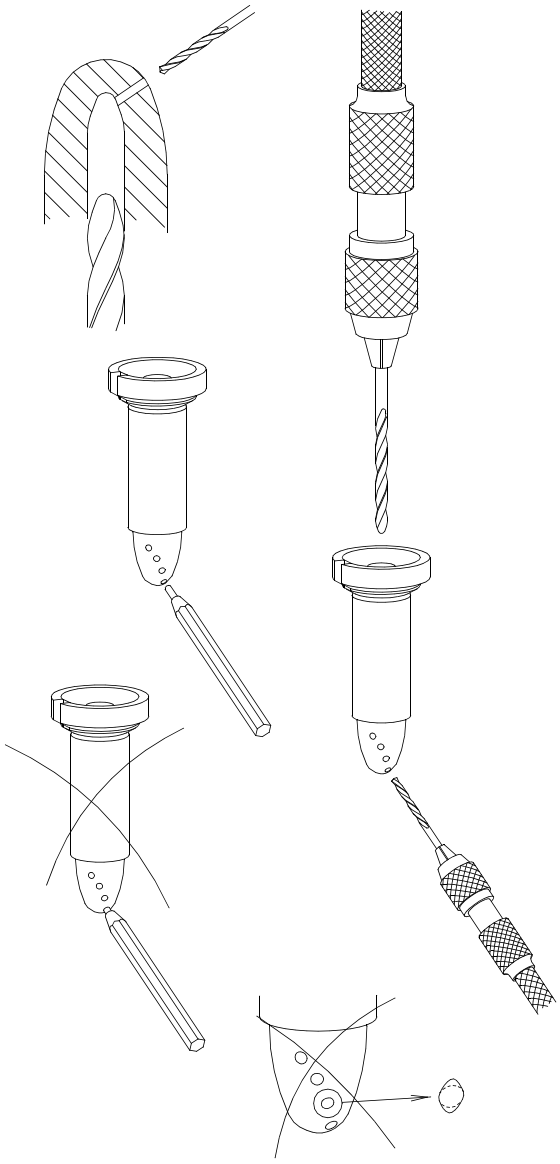
3. Clean any carbon deposits from the central bore of the fuel nozzle and the spray holes, using gas oil and the special drills supplied.

   Then test the spray holes with the test pin. If the test pin is able to enter just one of the holes, the fuel nozzle must be discarded.

   The also applies to nozzle with oval holes (can be ascertained with a magnifying glass).

4. The complete spindle guide, including the fuel nozzle, should be sent to an authorised the MITSUI ENGINEERING & SHIP-BUILDINNG CO., LTD. for repair shop for overhaul. If this is not possible, the spindle guide may be overhauled on board.
   See Procedure 909-12.3.

3.



GN909-12.3 204 07

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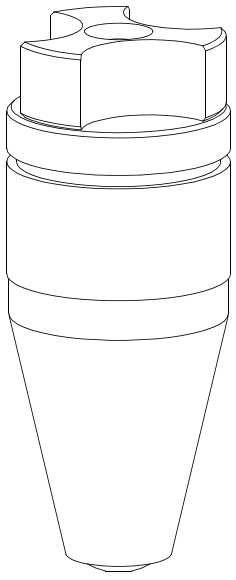

HN909-11.3 206 04

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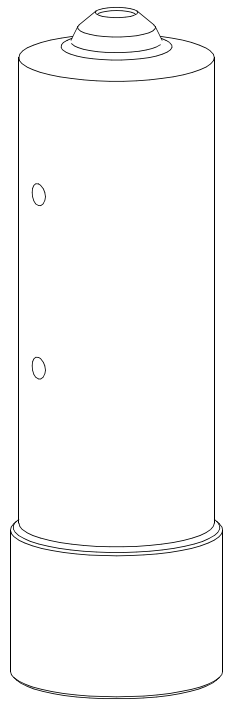

GN909-11.3 204 04

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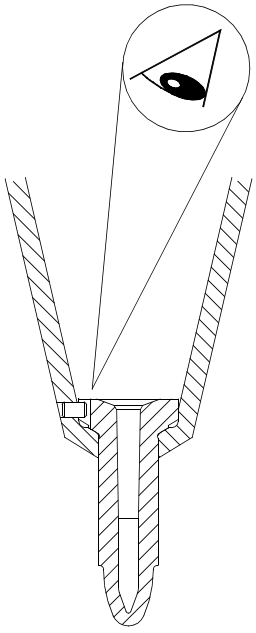


MC909-6.1 69 06

5. The non-return valve should be sent to an authorised the MITSUI ENGINEERING & SHIPBUILDINNG CO., LTD. repair shop for overhaul. If this is not possible, the non-return valve may be overhauled on board. *See Procedure 909-13.3.*

6. Mount the fuel nozzle, in the fuel valve housing.

Note!
Make sure that the fuel nozzle engages correctly with the guide pin in the fuel valve housing. This can be ascertained by attempting to turn the nozzle after mounting. It must **not** be possible to turn the nozzle.

7. Mount:

   - the fuel nozzle
   - the spindle guide
   - the thrust foot
   - the parts of the thrust spindle
   - the non-return valve

   in the fuel valve housing.

   Mount a new O-ring in the uppermost groove of the fuel valve housing.

8. Place the union nut on the valve housing and set up the housing in a bench vice.

   Fit the valve head with new O-rings.

   Make sure that the guide pin between valve housing and valve head is intact, and press the valve head down into the valve housing.

   Lubricate the thread of the valve head with molybdenum disulphide (MoS_2).
   For the correct use of this lubricant, see Procedure 913-11.

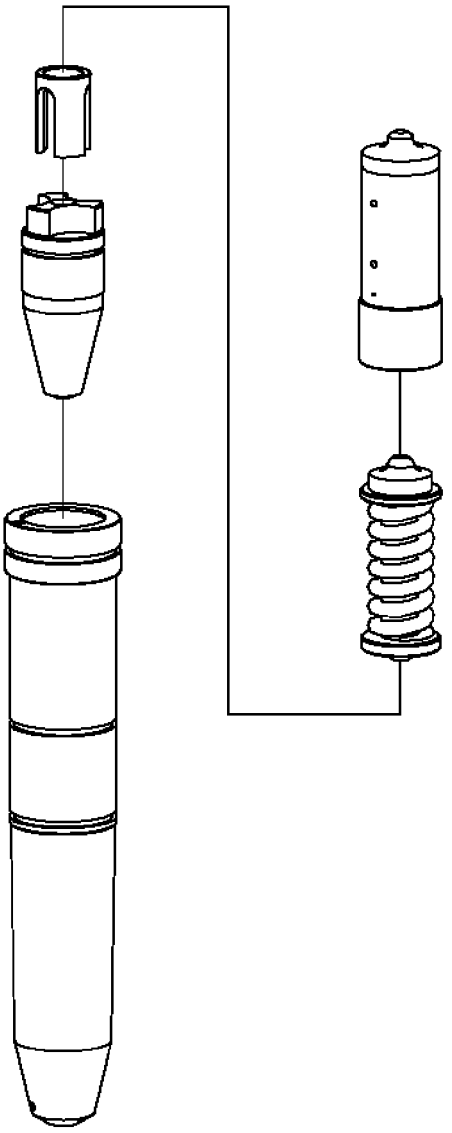
   See that the guide pin between valve housing and valve head engages correctly so as to prevent relative turning of the parts.

   Assemble the valve by means of the union nut. However, proper tightening together will not be obtained until the valve is correctly mounted in the cylinder cover or pressure testing rig.

   After overhaul, the fuel valve must be tested in the test rig.
   See Procedure 909-11.1.

9. If the fuel valve is not to be mounted in the engine immediately after the overhaul, cover all openings of the valve with plastic to prevent dirt from entering the valve during storage.

7.



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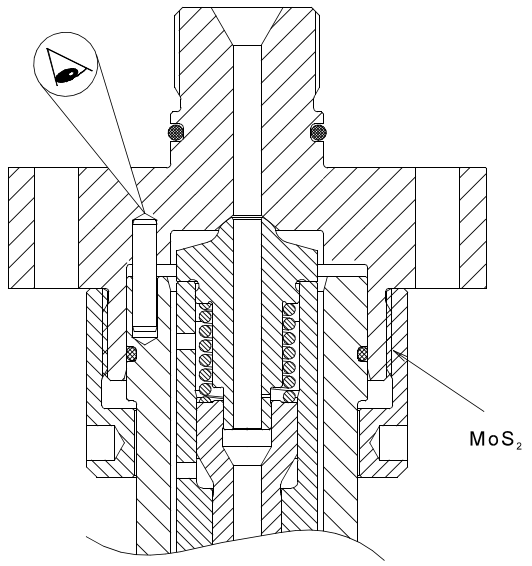

GN909-11.3 204 07

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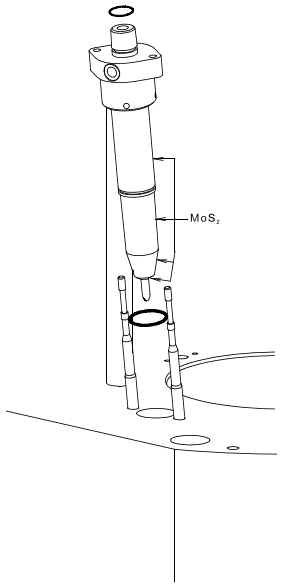

GN909-11.4 204 01

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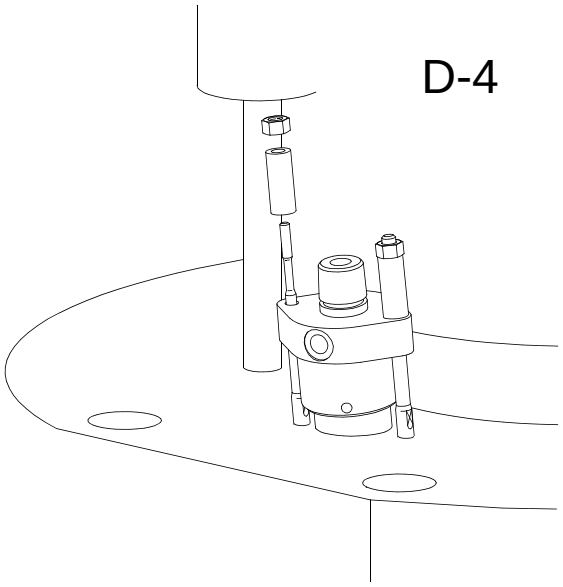

GN909-11.2 204 02

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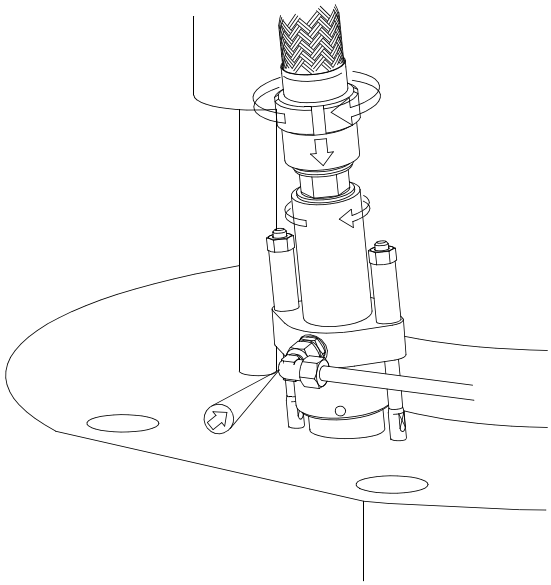


GN909-11.4 204 02

1.

Note!
All fuel valves must be function-tested before being mounted in the cylinder cover, *see Procedure 909-11.1.*

Before mounting the fuel valve, thoroughly clean the valve bore in the cylinder cover and check the seating in the bore for marks which, if any, must be eliminated.
(For reconditioning of valve bore in cylinder cover, see Procedure 901-1.)

If not already done, mount a new O-ring on the fuel valve. Mount a new O-ring in the groove on the valve housing.

Lubricate the valve with molybdenum Disulphide (MoS_2).

2. Mount the valve in position in the cylinder cover.

Mount the tubular spacers and the nuts. Tighten the nuts as stated in Data.

3. Lubricate the thread on the union nipple of the fuel oil pipe with a heat resistant anti seize grease before mounting.

Mount and tighten the fuel oil pipe.
See Procedure 909-14.4.

Reconnect the return oil pipe to the fuel valve.

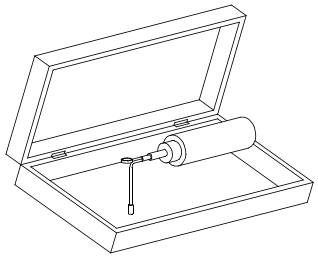
Turn on the fuel oil supply.

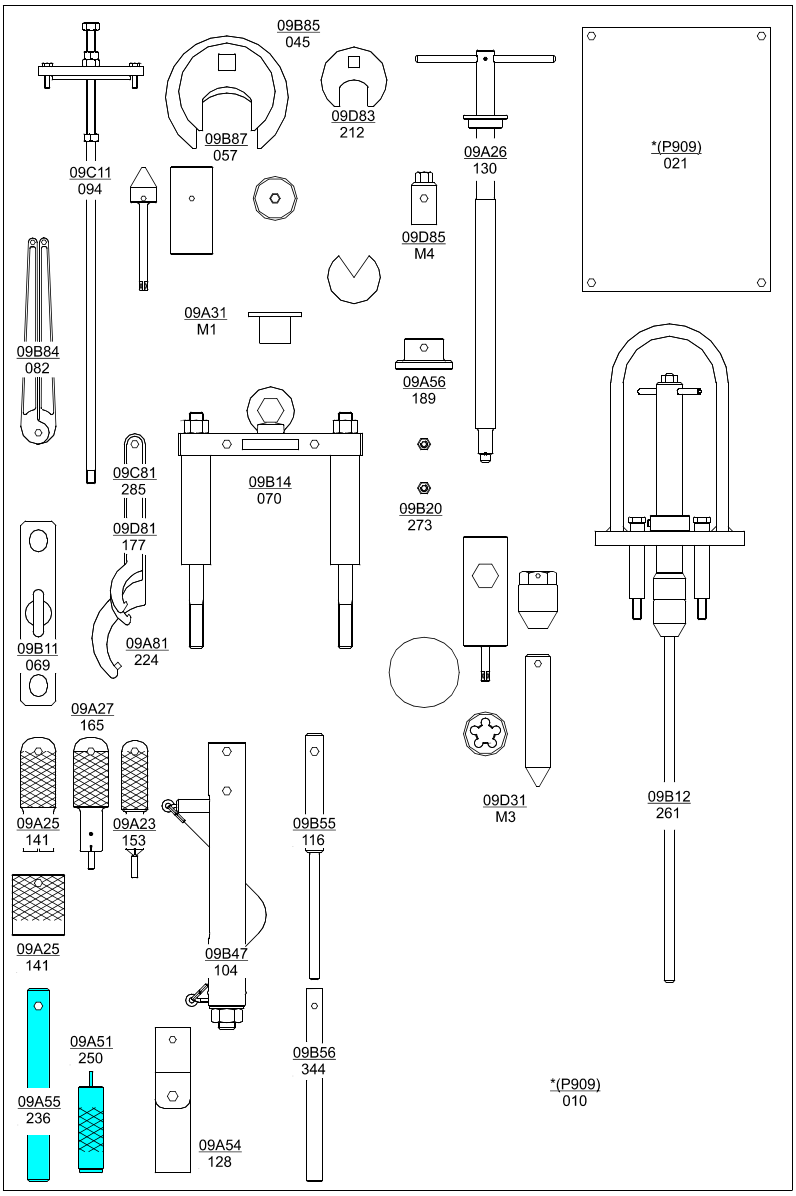
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
☐	Stopped engine	Naked flames prohibited
☐	Block the starting mechanism	
☐	Shut off starting air supply	
☐	Engage turning gear	
☐	Shut off cooling water	
☐	Shut off fuel oil	
☐	Shut off lubricating oil	
☐	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit

Standard Tools: See Section 913

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09B14
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09D31
M3
09B12
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09A25
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09A51
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09A55
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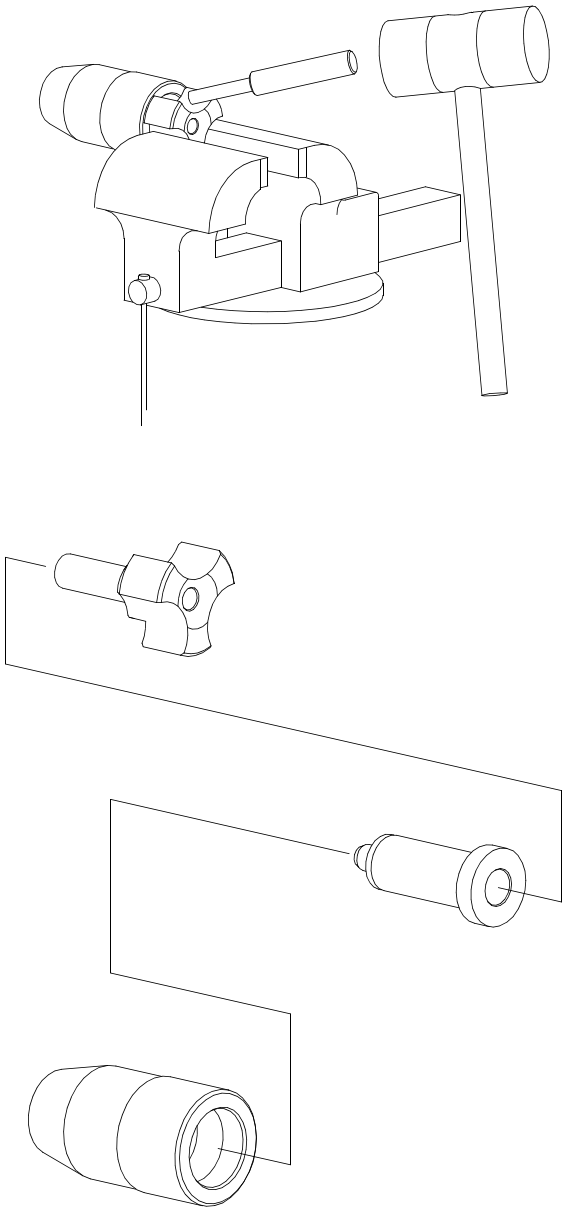
Note!
Extreme care and accuracy should be exercised when carrying out this operation.

1. Clean the outside of the spindle guide in pure gas oil or kerosene. The individual parts of the spindle guide are not interchangeable, threfore only one guide is to be disassembled at a time.

Note!
The spindle guide, thrust piece and spindle are matched parts and may not be replaced individually.

2. Place the spindle guide in a bench vice provided with “soft” jaws, and use the brass mandrel as shown to disassemble the spindle guide.

2.



GN909-12.3 204 02 L0a

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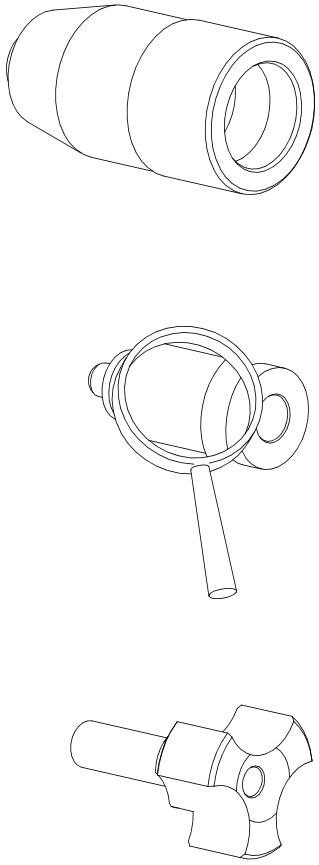

GN909-12.3 204 03 L0a

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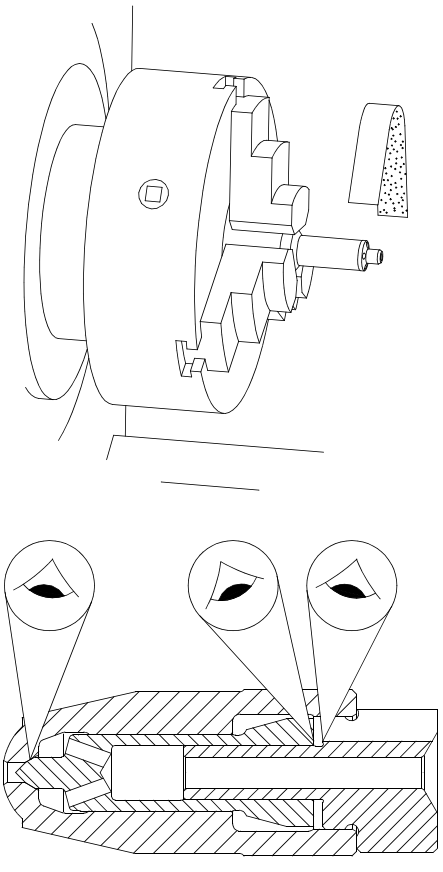


GN909-12.3 204 04 L0a

3. Clean all the parts of the spindle guide in gas oil and blow clean.

   Clean all parts again in kerosene or 'Electrocleaner' and blow dry with compressed air.

   Place all the parts on a clean, lint-free cloth and exmine them through a 8-10 times magnification magnifying glass.

   During the examination, pay special attention to the seating surfaces and sliding surfaces of the parts.

4. Remove deposits or very fine scratches by placing the spindle, thrust piece or spindle guide respectively in a lathe, as shown, and polishing with a very fine conventional polishing linen 'grade 360'.

   Use also a little oil for the polishing (a coarser polishing linen must **absolutely not** be used).

   After polishing clean the parts again and recheck the seat on thrust piece/spindle, the seat on slide valve/spindle, and the seat on spindle/guide. Use an 8-10 times enlargement magnifying glass.

Note!
Grinding the seat on slide valve and spindle guide should not be done on board due to possible to change the relative seat angle between both.

If the seats are not in order, i.e. if there are pressing-in marks or similar on the seats, the complete spindle guide must be discarded.

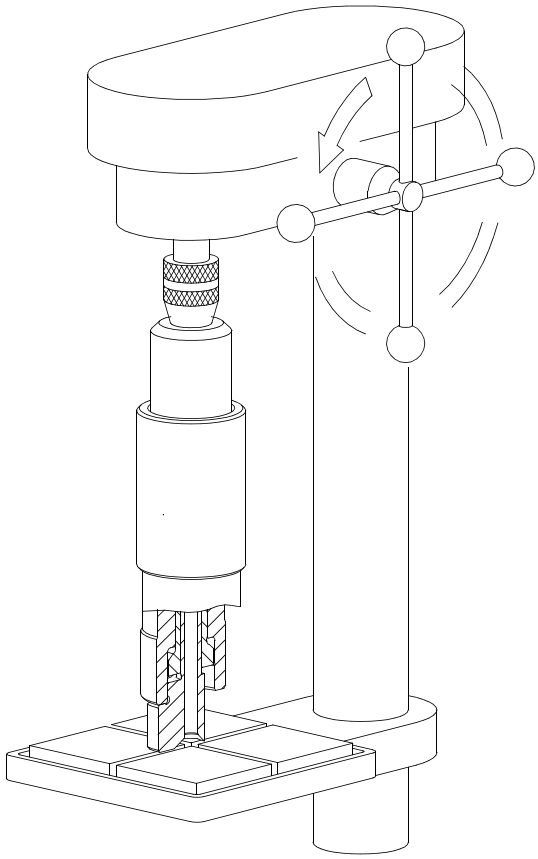
5. Lubricate the sliding surfaces of the spindle, spindle guide and thrust piece with Molybdenum Disulphide (MoS_2).
   See Procedure 913-11.

   Place the parts on the plane of a drilling machine or hydraulic press and position the mounting tool over the parts. Make sure that all the parts are perfectly aligned.

   Press the spindle guide on to the thrust piece.

6. If the spindle guide is not to be mounted in a fuel valve immediately after the overhaul, cover all openings of the spindle guide with plastic to prevent dirt from entering the spindle guide during storage

5.



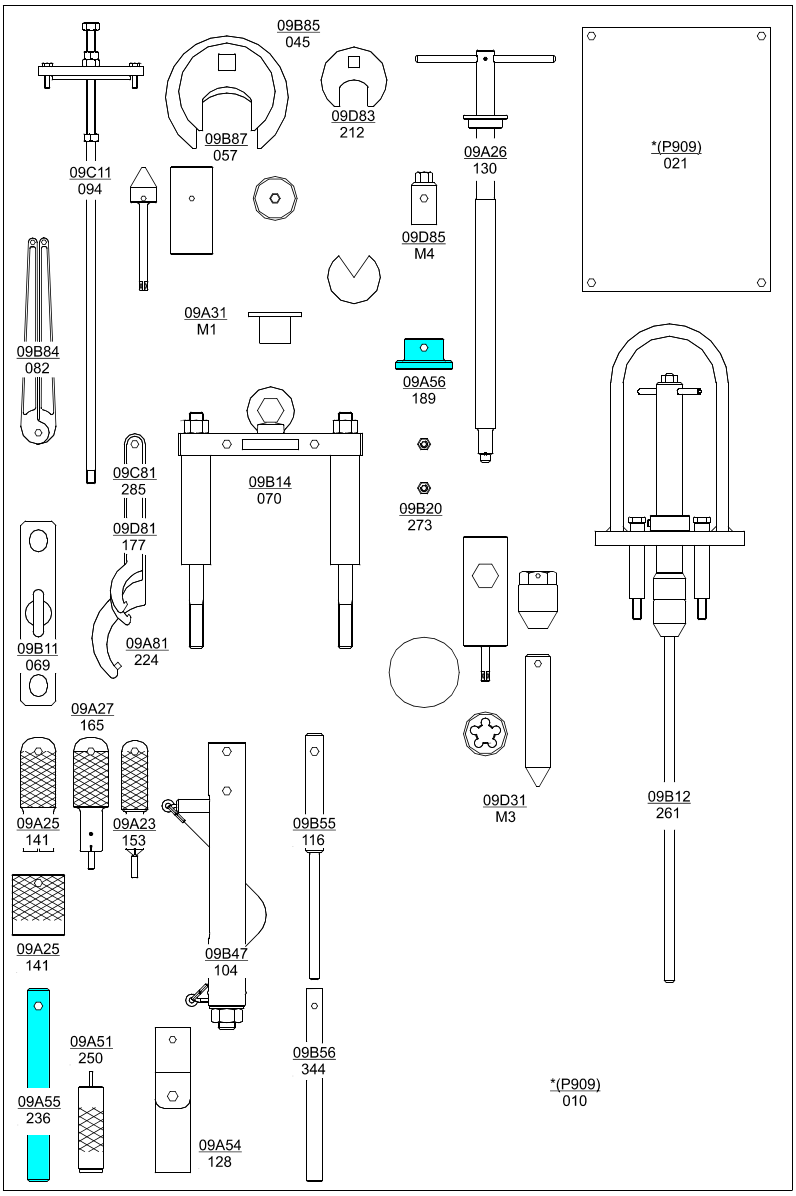
GN909-12.3 204 15

SAFETY PRECAUTIONS		CAUTION FOR SAFETY
	Stopped engine	Naked flames prohibited
	Block the starting mechanism	
	Shut off starting air supply	
	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit

Standard Tools: See Section 913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09C81
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09D31
M3
09B12
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09A25
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09A23
153
09B55
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09A25
141
09B47
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09A51
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09A55
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09A54
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010

Note!
Extreme care and accuracy should be exercised when carrying out this operation.

1. Clean the outside of the non-return valve with pure gas oil. The individual parts are not interchangeable, therefore only one guide is to be disassembled at a time.

Note!
Except for the slide valve spring, defective parts cannot be replaced by new ones.

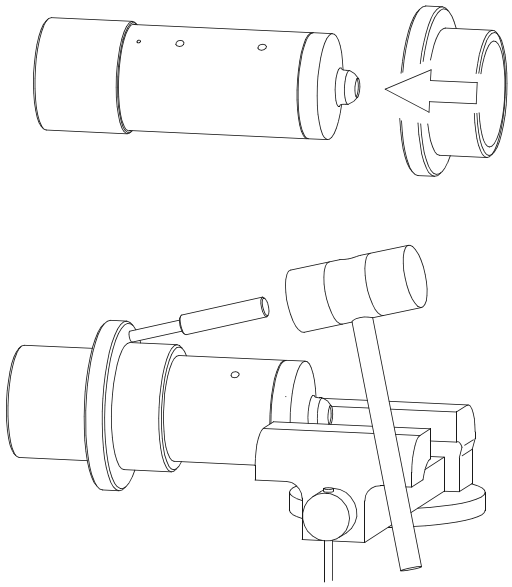
Place the non-return valve as shown in **Fig. 1** in a bench vice provided with “soft” jaws, and disassemble the non-return valve, using the disassembling tool and a hammer as shown.

2. Clean all the parts for the spindle guide in gas oil and then blow clean.

   Finally, clean in either gas oil or kerosene or ‘Electrocleaner', and blow the parts dry with compressed air as shown in **Fig. 2**.

3. Now place the parts on clean, lint-free rags and examine with an 8-10 times enlargement magnifying glass as shown in **Fig. 3**.

1.



GN909-13.3 203 01

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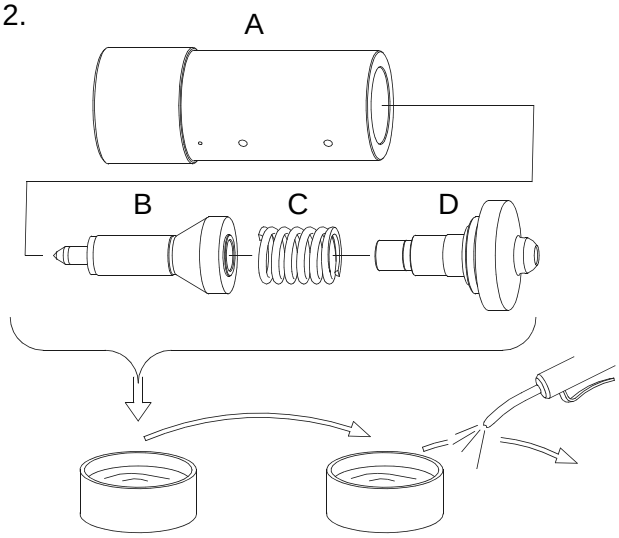

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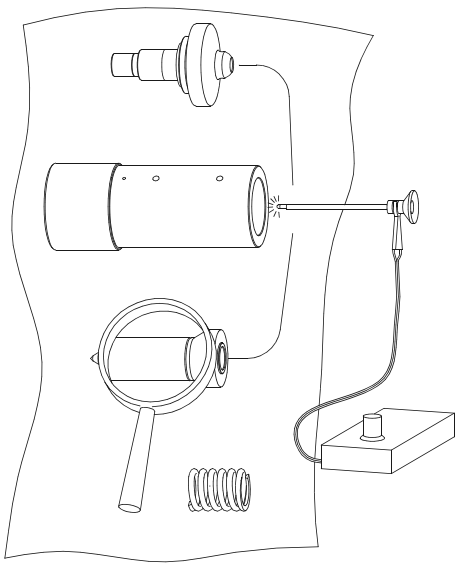

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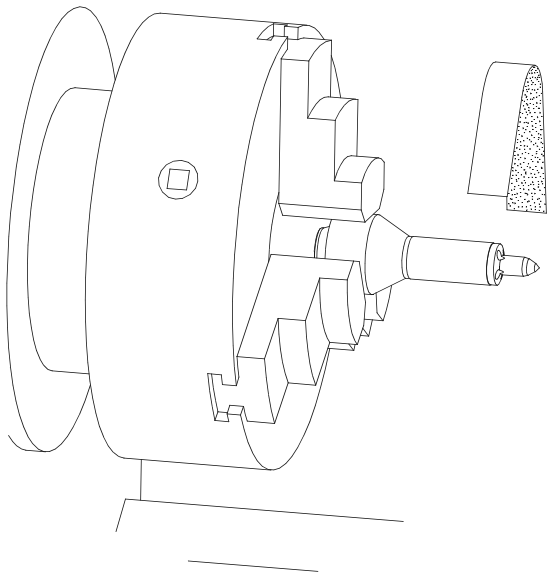
4.



GN909-13.3 203 04

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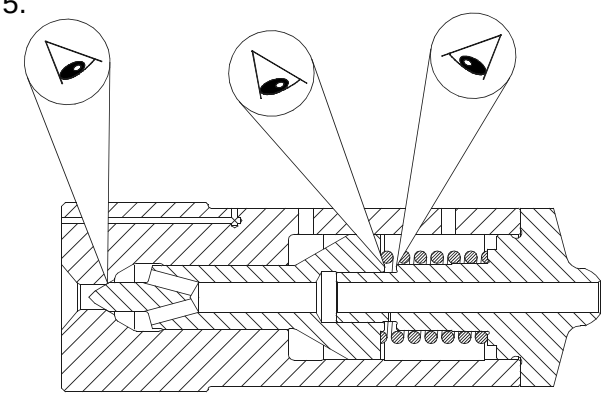

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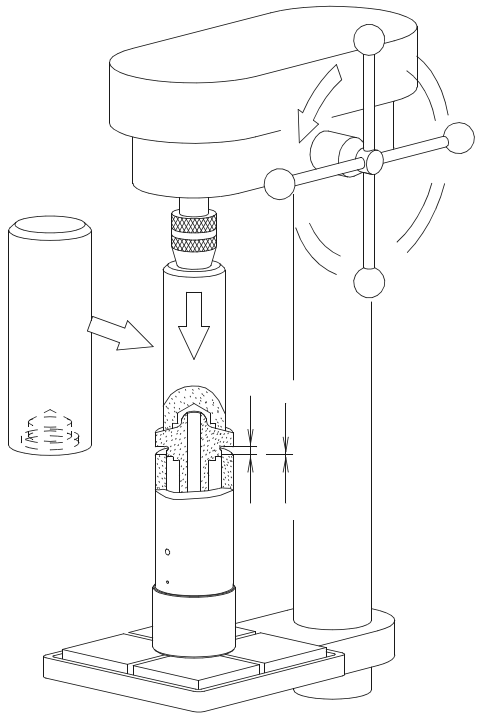


GN909-13.3 203 06

4. Examine the slide faces of movable parts for coating. Vent slide **B**/housing **A** will be too tight if there is a coating. (The letters **A-D** refer to the letters/parts in **Fig. 2**).

   Fix vent slide **B** and, subsequently, housing **A** in a lathe as shown in **Fig. 4** and remove the coating by means of very fine conventional polishing linen “grade 360”.

   Also a little oil should be used (a coarser polishing linen must **absolutely not** be used).

5. Check spring **C** for the thrust piece for outside wear marks. If defective, it should be exchanged.

   Check the seat on thrust piece **D**/vent slide, and the seat on vent slide/housing. Use an inspection lamp and an 8-10 times enlargement magnifying glass.

Note!
Grinding the seat on slide valve and housing guide should not be done on board due to possible to change the relative seat angle between both.

   If the seats are not in order, i.e. if there are pressing-in marks or similar on the seats, the complete spindle guide must be discarded.

6. Mount the non-return valve as follows:

   - Lubricate all movable parts with molybdenum disulphide (MoS_2).
   - Place the loosely-assembled non-return valve on the plane of a drilling machine, with the tool positioned as shown in **Fig. 6**.
   - Make sure that the thrust piece and the other parts are perfectly aligned and that the thrust piece is guided in the vent slide.
   - Press the handle until the housing and thrust piece meet.

7. If the non-return valve is not to be mounted in a fuel valve immediately after the overhaul, cover all openings of the non-return valve with plastic to prevent dirt from entering the valve during storage.

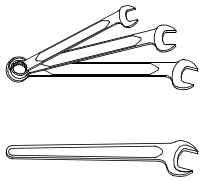
SAFETY PRECAUTIONS

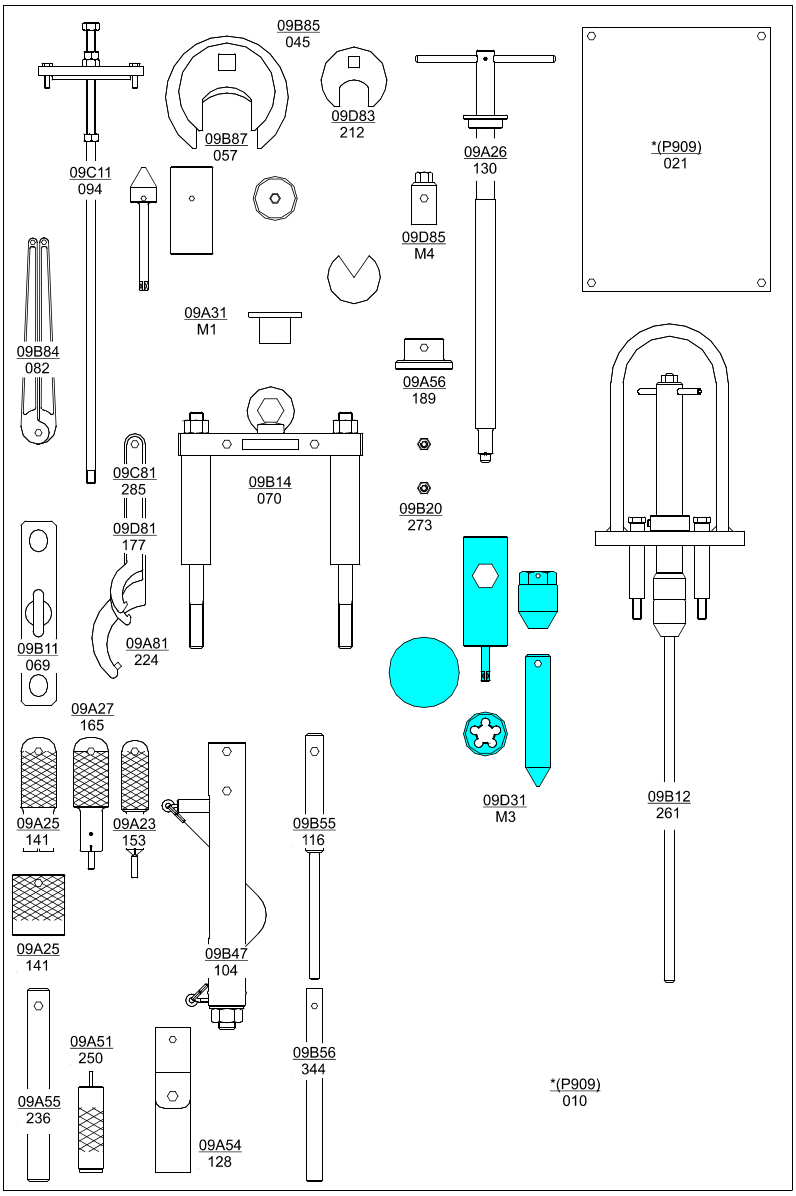
X	Stopped engine
X	Block the starting mechanism
X	Shut off starting air supply
	Engage turning gear
	Shut off cooling water
X	Shut off fuel oil
	Shut off lubricating oil
	Lock turbocharger rotors

Data

Ref.	Description	Value	Unit
D-1	Distance from pipe end to thrust bushing lower edge (fuel pump end and fuel valve end)	11	mm
D-2	Weight of fuel oil pipe	7	kg

Standard Tools: See Section 913

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09C81
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09B14
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1. Whenever the fuel oil high-pressure system is dismantled, it is necessary, before re-mounting the high-pressure pipes, to carefully inspect the tapered contact surfaces of the pipe ends, together with their seats in fuel valves and fuel pump top cover.

   Furthermore, the position of the thrust bushing on the pipe end must be checked. If the distance is incorrect, compared with the measurement stated in Data, it should be adjusted by screwing the thrust bushing up or down the pressure pipe.

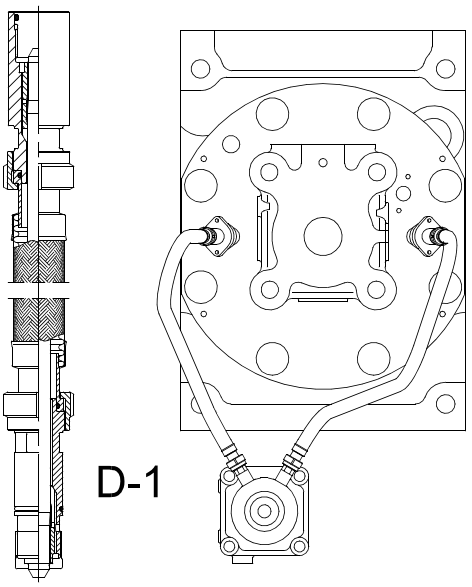
2. If the pipe end requires reconditioning, dismantle the high-pressure pipe as follows:

   - Lift up the union nut with flexible protective hose, together with the coupling nut, on the high-pressure pipe and screw off the thrust bushing.

   - Take off the coupling nut and, when the thrust bushings at both ends of the pipe have been dismounted, pull the flexible protective hose with union nuts off the high-pressure pipe.

3. Shape-up the threads on the pipe ends by means of the nut die.

1.



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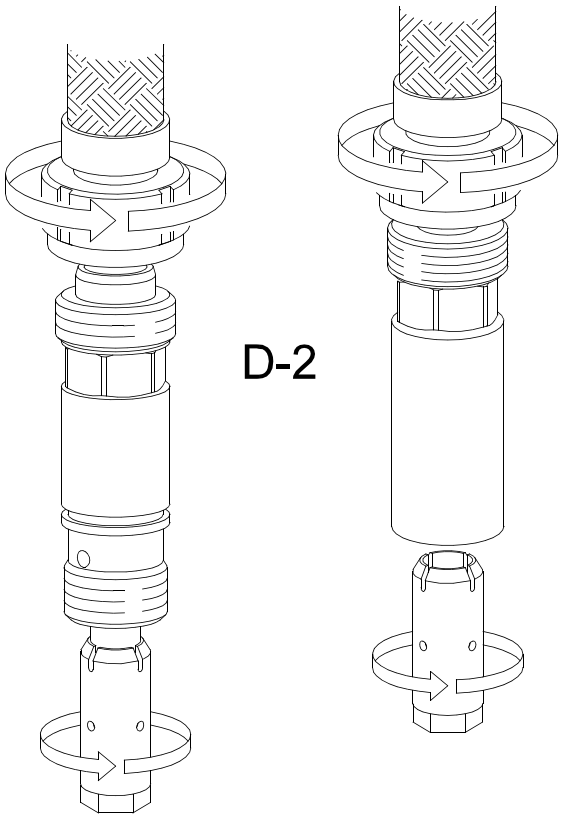
2.



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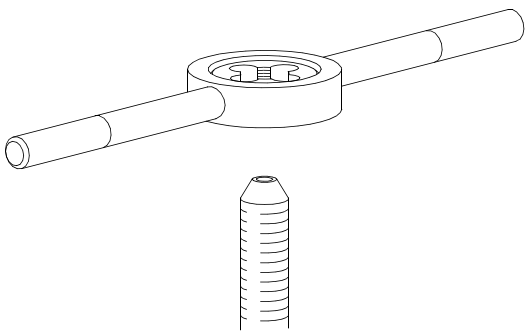
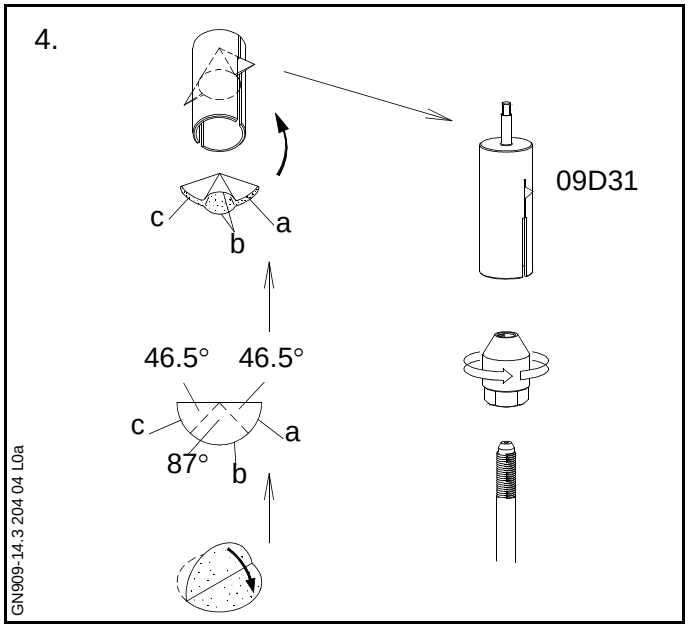
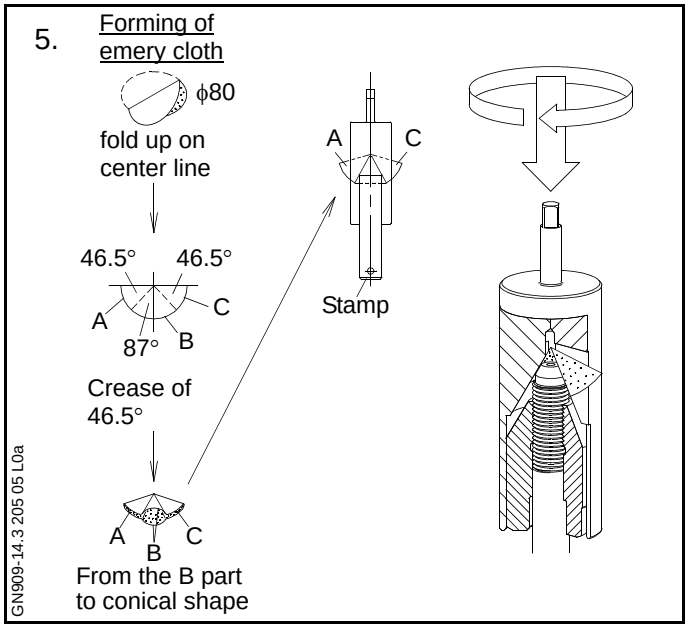
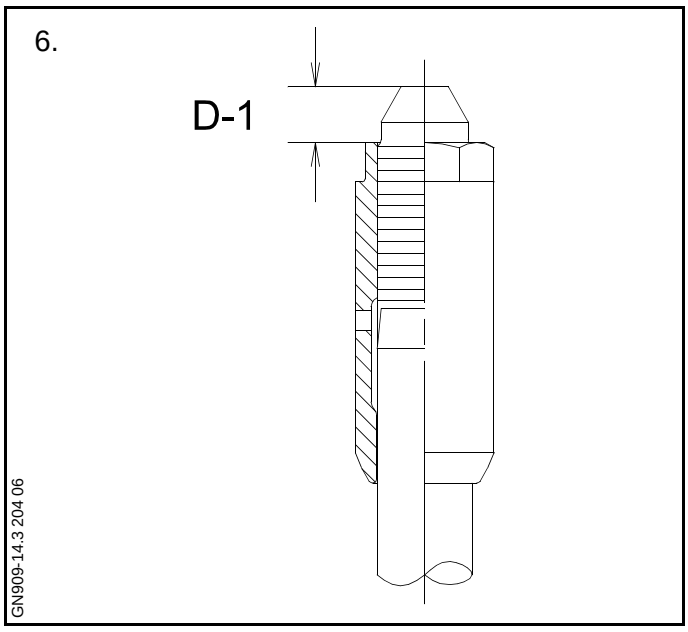
3.



GN909-14.3 204 03







4. Tools for reconditioning of high-pressure pipes consist for each pipe dimension of:

   Case, emery, guide sleeve and dice.

5. Reconditioning of the pipe ends is carried out by the following procedures.

   Mount the guide to the pipe end and cover the grinding case which has been fitted a emery cloth on the pipe end.

   The grinding is carried out so that hte emery cloth is pressed to the pipe end with suitable force while turning the case fitted the emery cloth.
   The case is turned by means of a drilling machine, etc.

Forming of emery cloth:

   Forming of the emery cloth is carried out by the procedure shown on the illustration.
   The conical part **B** is formed by means of the stamp supplied as the tool.

6. When assembling the high-pressure pipe, screw the thrust bushings so high up on the thread of the pressure pipe that the distance between the pipe end and the bottom edge of the thrust bushing is as stated in Data.

   Replace the O-rings.

   Before mounting a high-pressure pipe, check the centre distances between pipe ends and seats, and lubricate the threads of the union nuts with molybdenum disulphide (MoS_2).

   It is of great importance for the mounting, and a condition for obtaining tight joints, that the pipes fit the seats accurately.

   For reconditioning of seat in fuel valve, see Procedure 909-11.3.

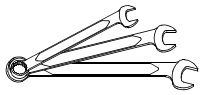
   For reconditioning of seat in fuel pump top cover, see Procedure 909-5.3.

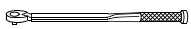
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of hot surfaces
X	Block the starting mechanism	Do not enter area when over head lifting is being carried out
X	Shut off starting air supply	Risk of severe personal injury (while engine being turned)
X	Engage turning gear	May cause spring under tension
	Shut off cooling water	
X	Shut off fuel oil	
X	Shut off lubricating oil	
	Lock turbocharger rotors	

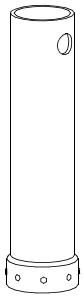
Data

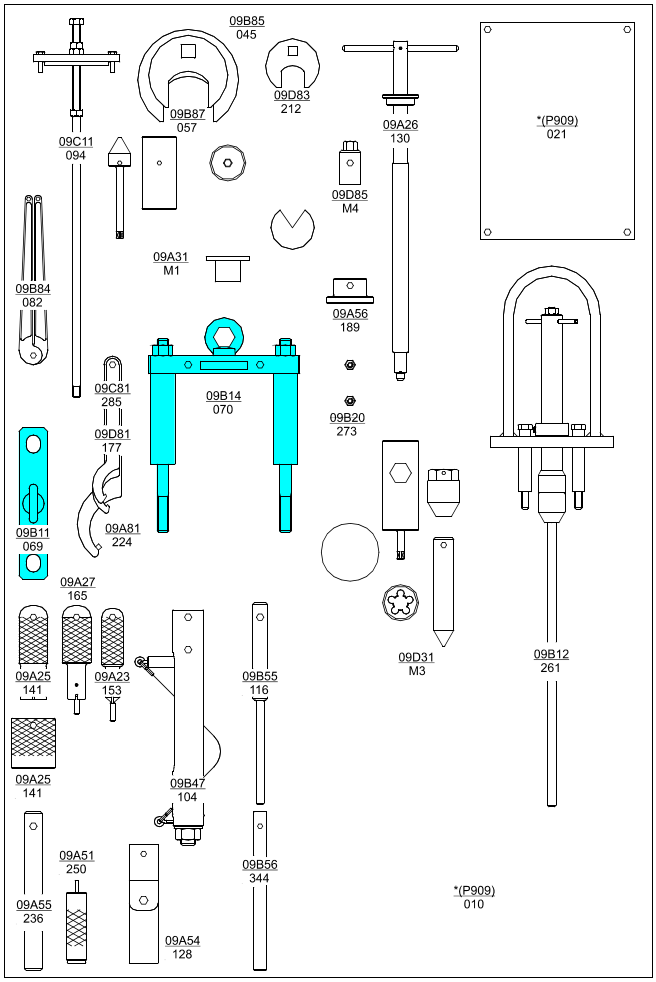
Ref.	Description	Value	Unit
D-1	Weight of pump housing	132	kg
D-2	Weight of barrel assembly	31	kg
D-3	Pump base	66	kg
D-4	Fuel pump roller guide	58	kg
D-5	Roller/bushing/shaft pin - max. clearance	0.5	mm
D-6	Weight of top cover complete	42	mm
D-7	Fuel pump housing nut - tightening angle	62	°
D-8	Nut, reversing shaft - tightening torque	80	Nm

Standard Tools: See Section 913





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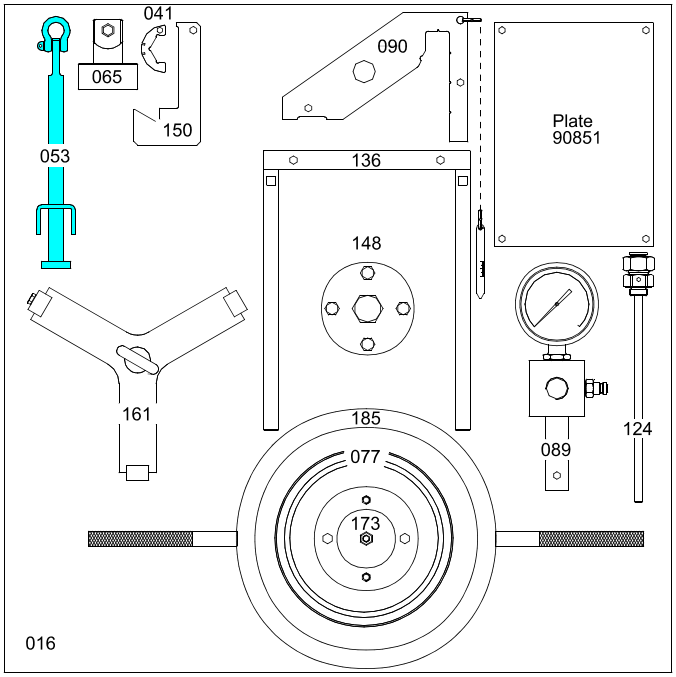
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Roller guide mounted in engine

1. The fuel pump roller guide can be partially checked while mounted in the engine, using the following procedure:

2. Lift the fuel pump roller guide.
   See Procedure 909-16.

3. Remove the cover on the camshaft housing to inspect the fuel pump roller guide.

   Turn the engine to provide the maximum space between the roller guide and the cam disc.

   Turn the roller by hand to check that it can move freely and without unnecessary resistance or “hard” points.

   Also inspect the surface of the roller for possible damage marks, seizures or scratches. Make sure that there are no traces of bearing metal left in the roller guide housing.

   Check the clearance in the slide bearing by lifting the roller relative to the roller guide and measuring the difference in distance between the cam disc and the roller in the upper and lower positions of the roller.

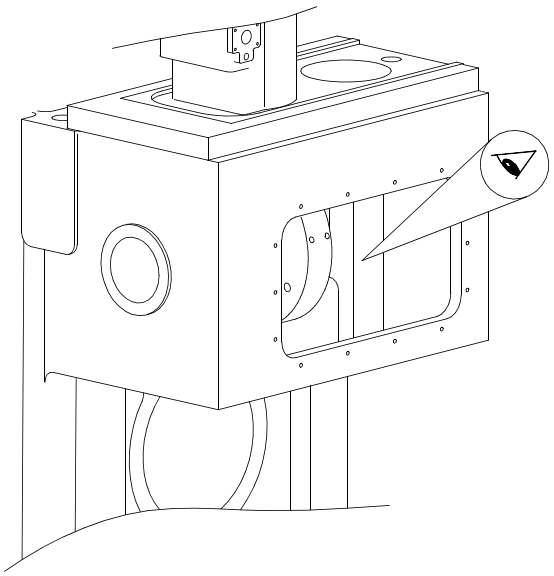
4. Lower the roller guide onto the fuel cam again.
   See Procedure 909-16.

5. Using the telegraph, move the roller guide to the AHEAD position.

   Check that the reversing link is fully tilted over in AHEAD position.

   Carry out the same check in the ASTERN position.

3.



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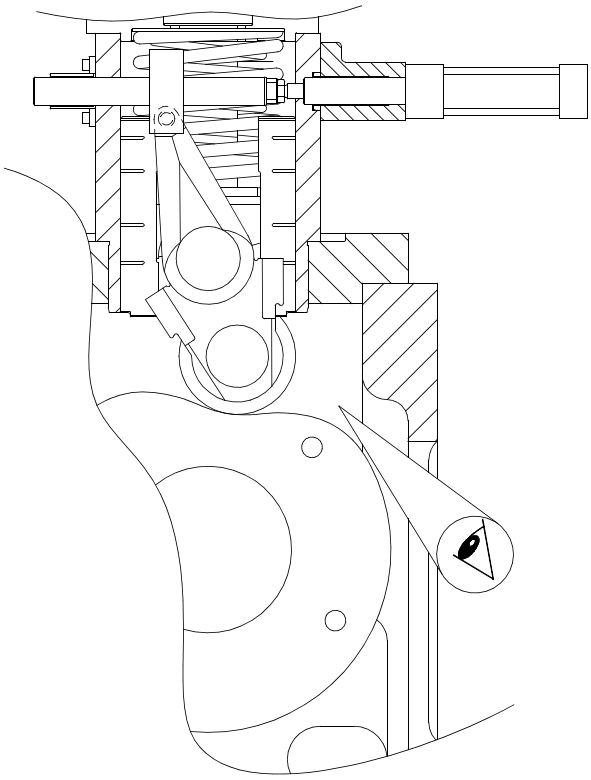

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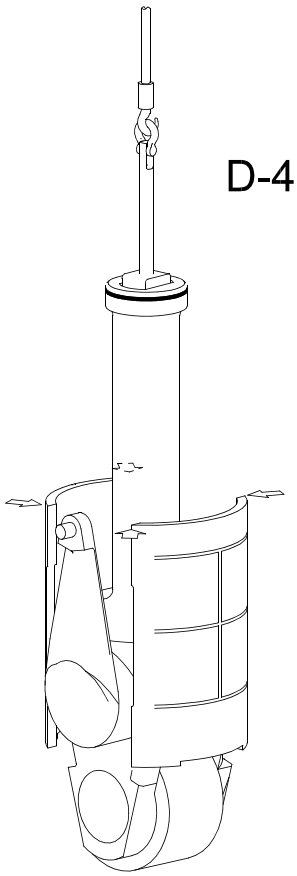

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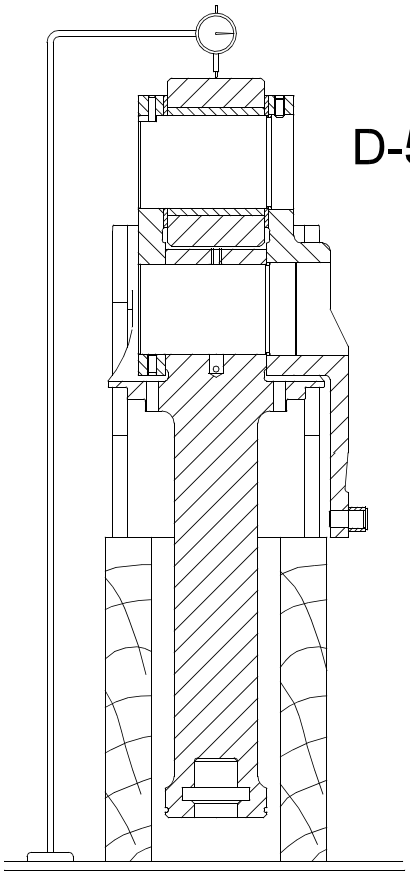

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Roller guide removed from engine

A more suitable and reliable method is to check the roller guide and the bearing clearance after the roller guide has been dismounted:

6. Dismount the roller guide from the engine. *See Procedure 909-15.2.*

7. Check the surface of the roller and the sliding surfaces of the roller guide, and measure any ovalness.

8. Turn the roller guide upside down and land it in a vertical position on a couple of planks, with the roller hanging freely.

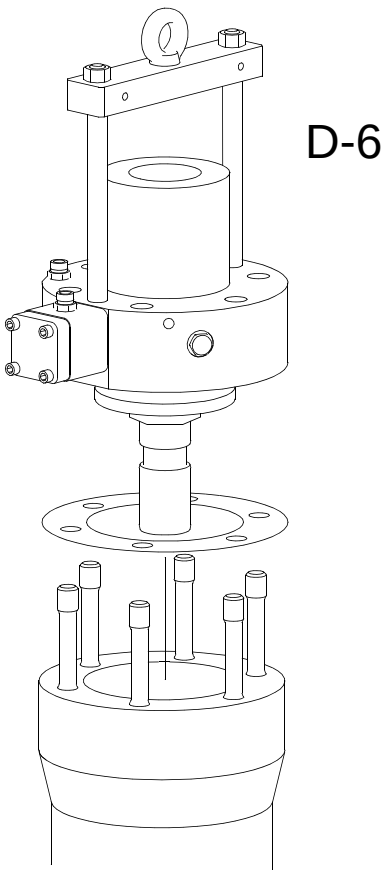
   Measure the clearance in the slide bearing by placing a dial gauge against the roller and lifting the roller as much as the clearance permits.

Note!
Before dismantling any part of the fuel pump, make sure that the pump has been relieved of pressure and that all oil has been drained off.

1. Dismantle the top cover of the fuel pump. *See Procedure 909-5.3.*

2. Dismantle the fuel pump barrel assembly. *See Procedure 909-6.3.*

1.



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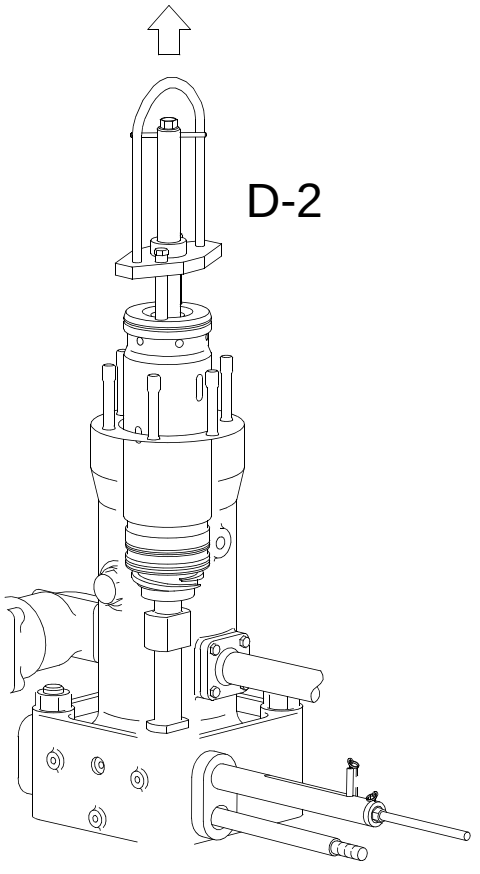

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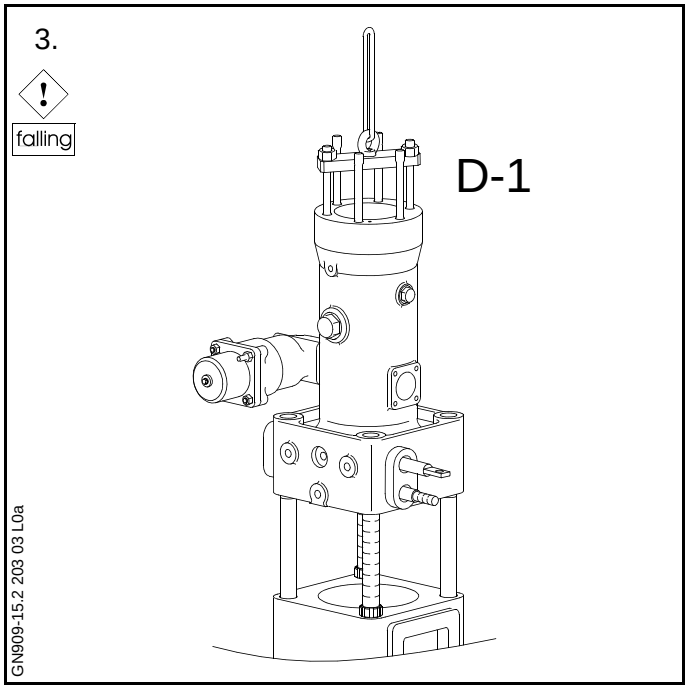


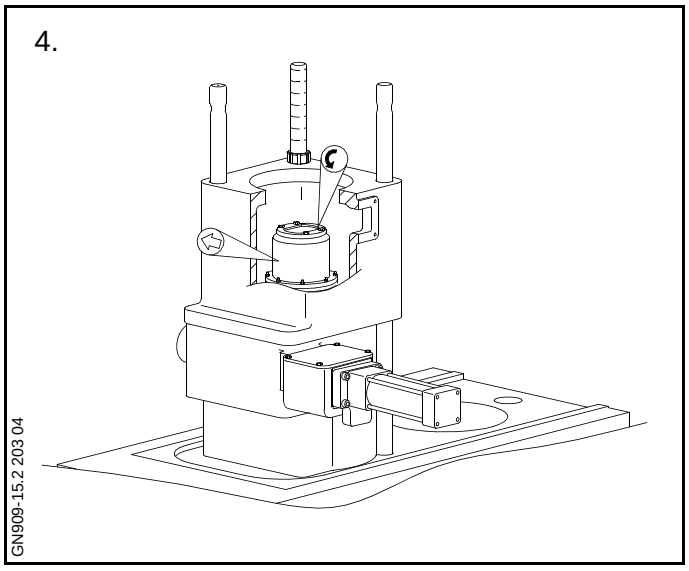
3. Loosen and remove the screws from the sealing cap on top of the roller guide.

Note!
When lifting the fuel pump housing, take care not to damage the threads on the studs.

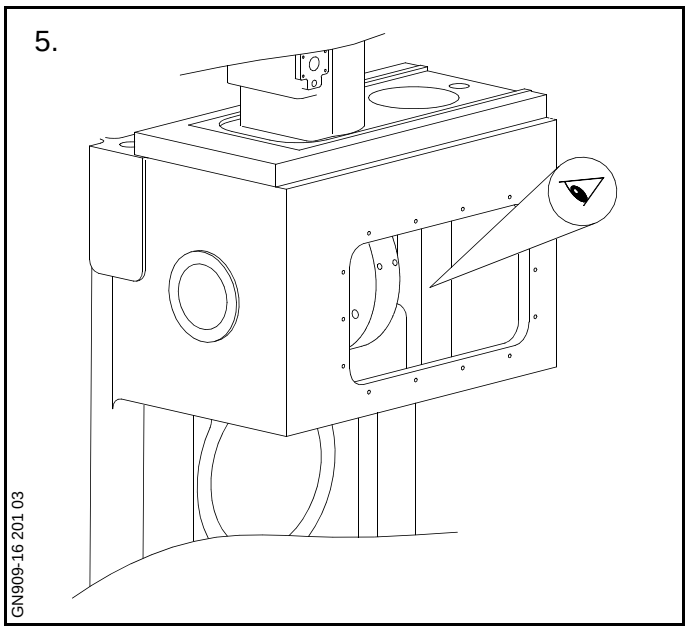
4. Loosen and remove the screws from the sealing cap on top of the roller guide.

   Remove the sealing cap from the roller guide/sealing arrangement housing.

   Remove and discard the O-ring from the groove in the top of the roller guide.



5. Remove the cover on the camshaft housing to inspect the position of the roller guide. Turn the engine until the roller guide is at **BDC**.



6. Using the special tube-shaped socket wrench, loosen the nuts on the two threaded studs successively until the roller guide springs are relieved.

   Remove the nuts, mount two eye screws in the pump base and lift it away.

   When lifting, take care that the bushing of the pump base slides against the neck of the roller guide without scratching.

   Remove the springs from the roller guide.

7. Mount the roller guide lifting tool as follows:

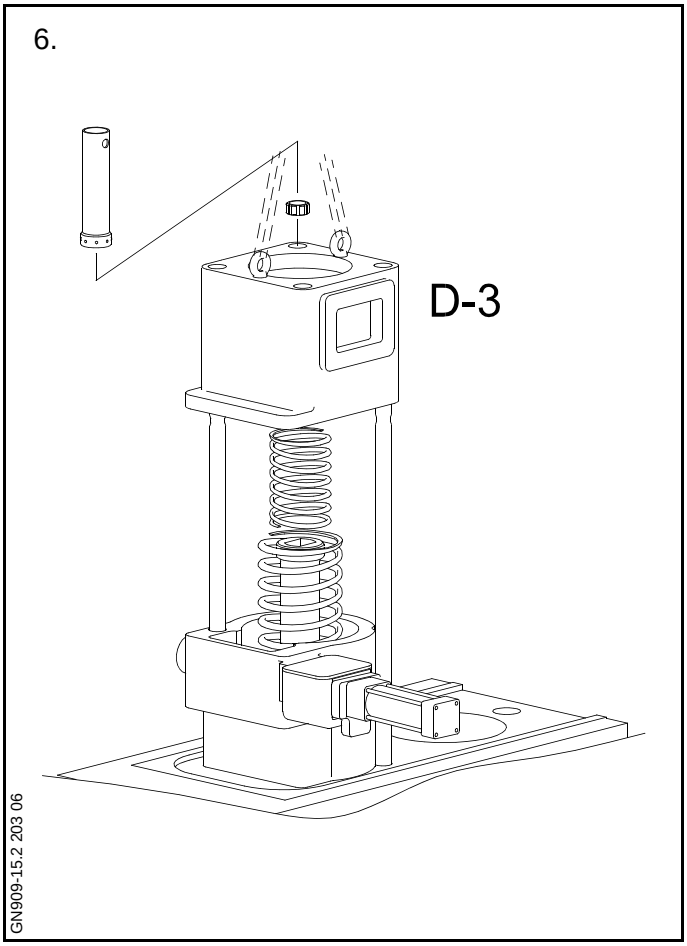
   - Lift the lock plate of the tool up on the shaft of the tool.
   - Position the tool so that its foot rests on the thrust piece in the bayonet joint of the roller guide.
   - Turn the tool 90° so as to allow the foot to engage properly in the bayonet joint.
   - Lower the lock plate, thereby securing the foot in the locked position.

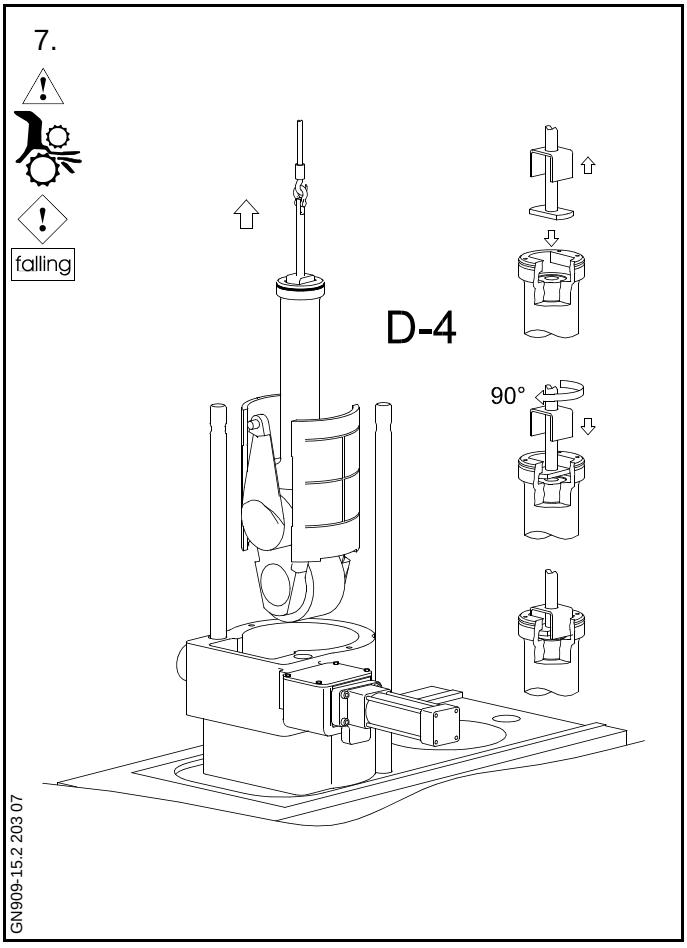
   Lift the roller guide out of the roller guide housing, using the crane.

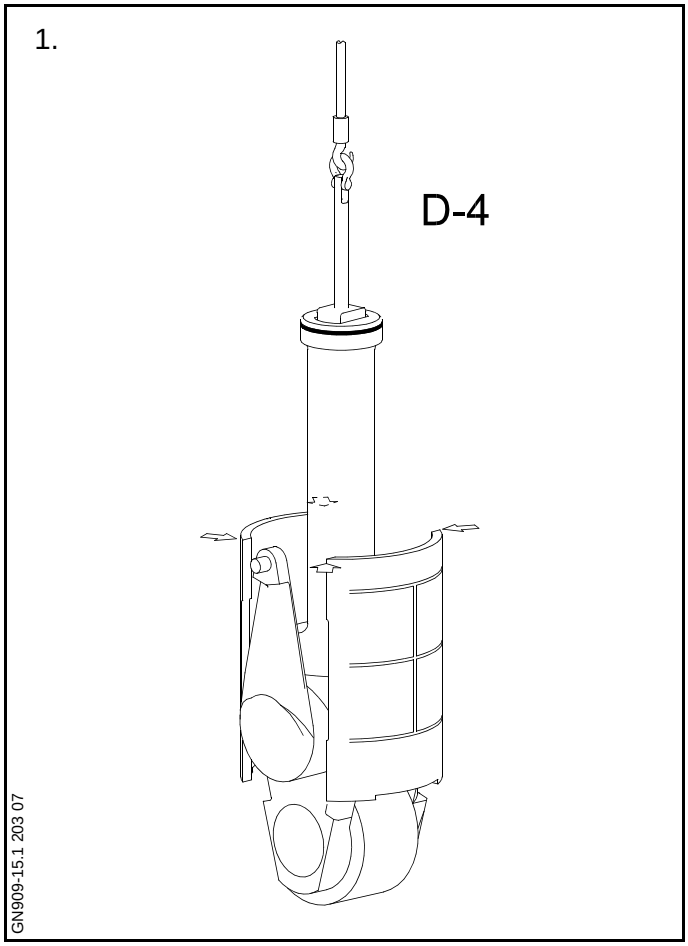
   When lifting, take care that the slide surfaces of the roller guide do not scrape against the roller guide bushing.

   Land the roller guide on wooden planks.

8. Check the roller guide.
   See Procedure 909-15.1.







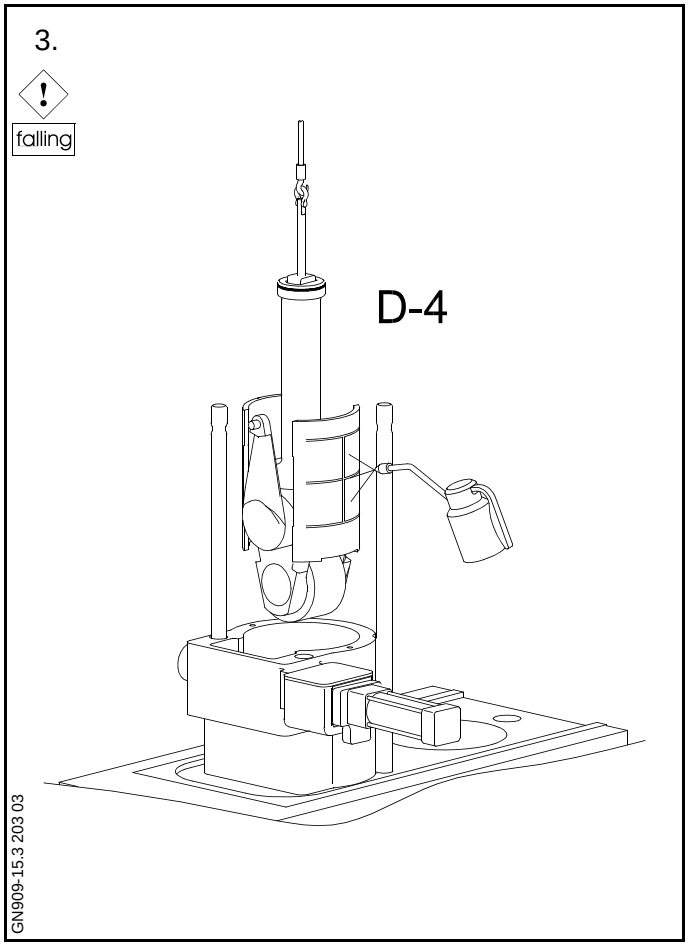
1. Inspect and check the fuel pump roller guide.
   See Procedure 909-15.1.

2. It is recommended that the roller guide should **ONLY** be disassembled if

   - irregularities when turning the roller,
   - damage to the roller,
   - larger clearance than stated on the Data sheet,
   - seizure marks on the slide surfaces,

   have been observed during the checking of the roller guide.

Note!
For disassembling of the roller guide, contact the MITSUI ENGINEERING & SHIPBUILDING CO., LTD..



3. If no irregularities are found, just clean and lubricate the roller guide before mounting it in the roller guide bushing.

1. Lubricate the roller guide with plenty of camshaft lubricating oil, and mount it in the roller guide bushing, using the lifting tool.

   During mounting, take care not to scratch the sliding surfaces of the roller guide.

2. After mounting the roller guide with the reversing link, check the clearance between the roller guide and the guide plate mounted in the roller guide bushing.

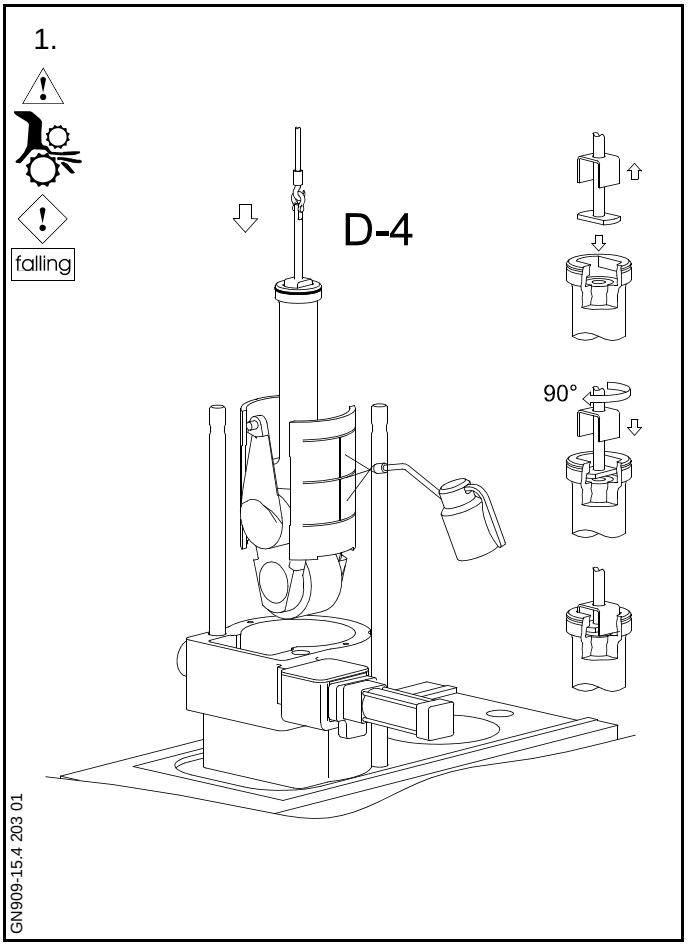
   Turn the camshaft so that the roller guide is lifted approx. 20 mm.

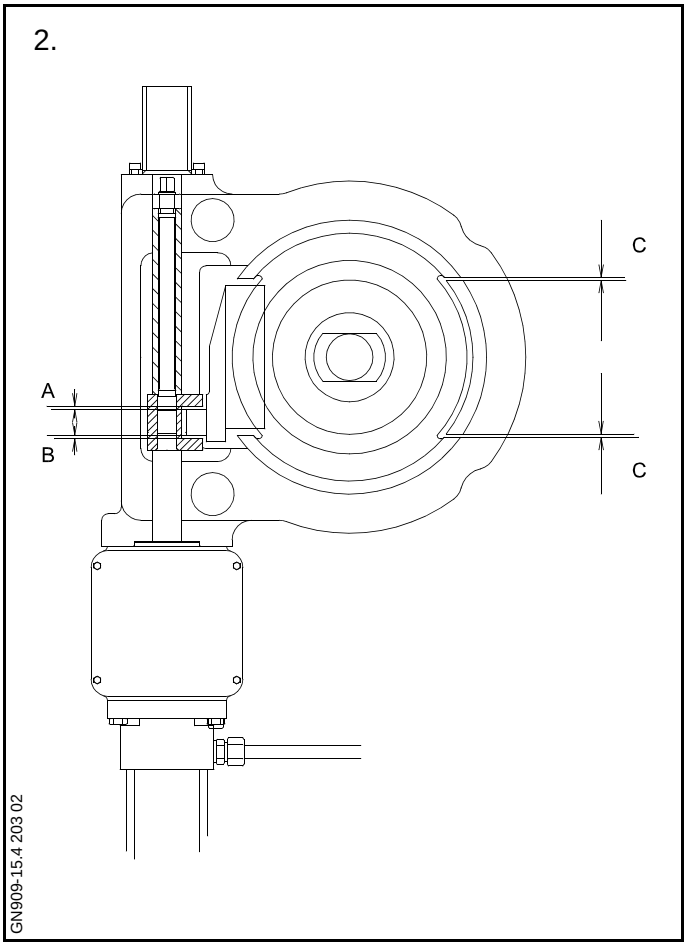
   The clearance **C** between the roller guide and the guide plate must be the same at both ends ± 0.1 mm.

   The clearances **A** and **B** between the guideway and the pin of the reversing link (arm) must be checked in the AHEAD and ASTERN positions.

   Connect working air to the air cylinder, and check that the reversing mechanism is working smoothly.

   The clearances **A** and **B** must be approx. the same in both postions. Neither **A** or **B** must be less than 0.2 mm.





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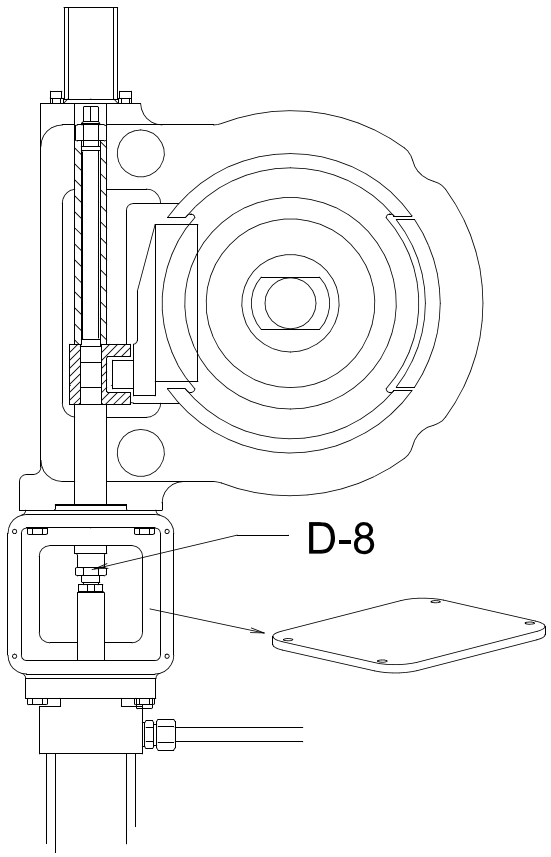

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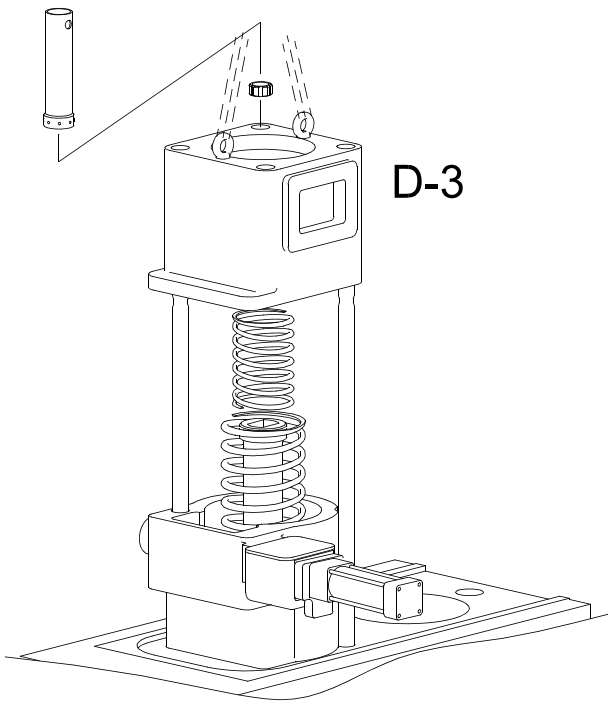

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3. If adjustment is necessary, it must take place in the ASTERN position.

   Remove the cover over the shaft connection.

   Loosen nut **D** and carry out the adjustment.

   After adjustment, shift to AHEAD position and check the clearances **A** and **B** once more.

   Finally, shift again to ASTERN.

   Tighten nut **D** (*see Data*), and lock the nut with Loctite type: Screw Lock No. 59.

   Mount the cover over the shaft connection.

4. Turn the engine until the roller guide is at **BDC**.

5. Mount the springs and the spring seat discs over the roller guide.

   Mount the pump base over the roller guide and the springs.

   Mount the two special nuts on the threaded studs.

   Using the special tube-shaped socket wrench, tighten the nuts until the pump base is fastened tightly to the roller guide bushing.

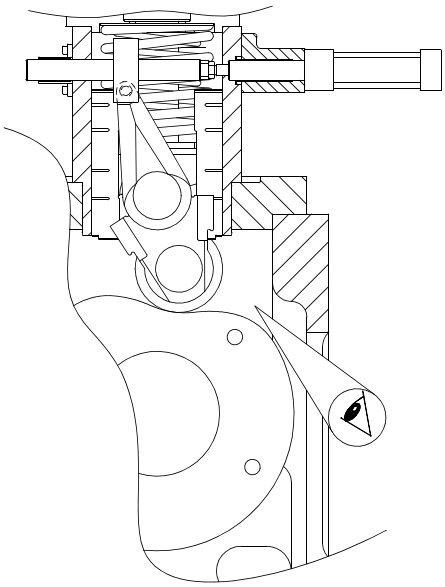
6. Check the movement of the reversing link. *See Procedure 909-15.1.*

7. Replace the scraper rings in the sealing cap as follows:

   Loosen and remove the screws and nuts from the bottom of the cap, remove the retaining flange and ring holder with scraper ring.

8. Replace the axial scraper ring in the bottom of the cap. Check that the O-ring and scraper ring are mounted correctly. *See the sketch*.

6.



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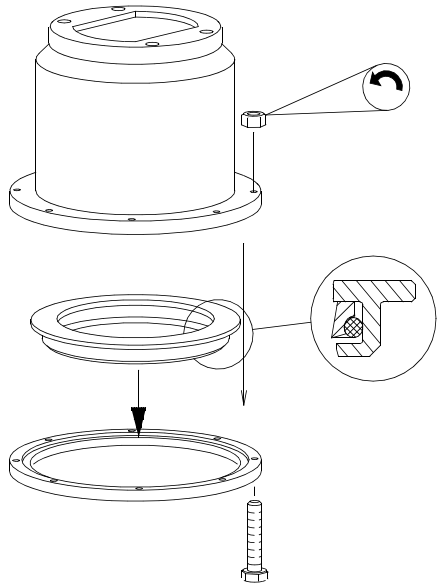

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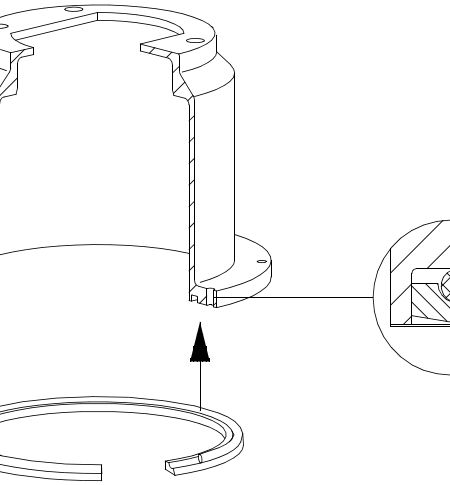

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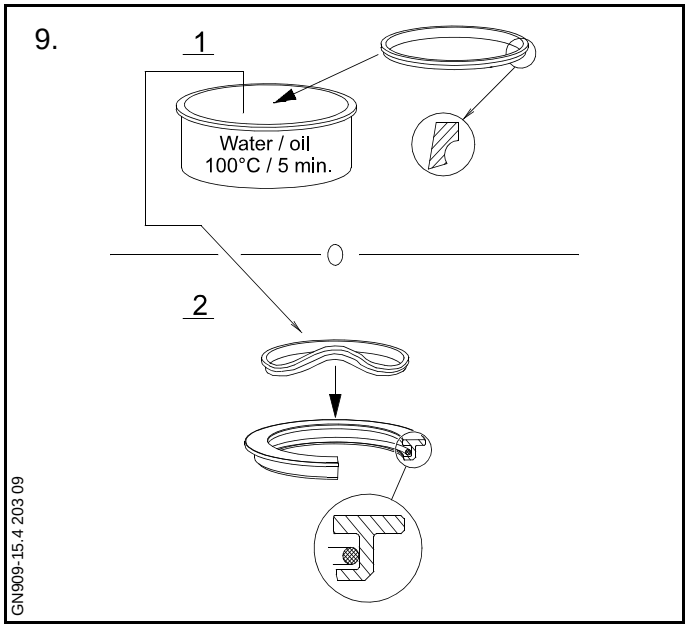
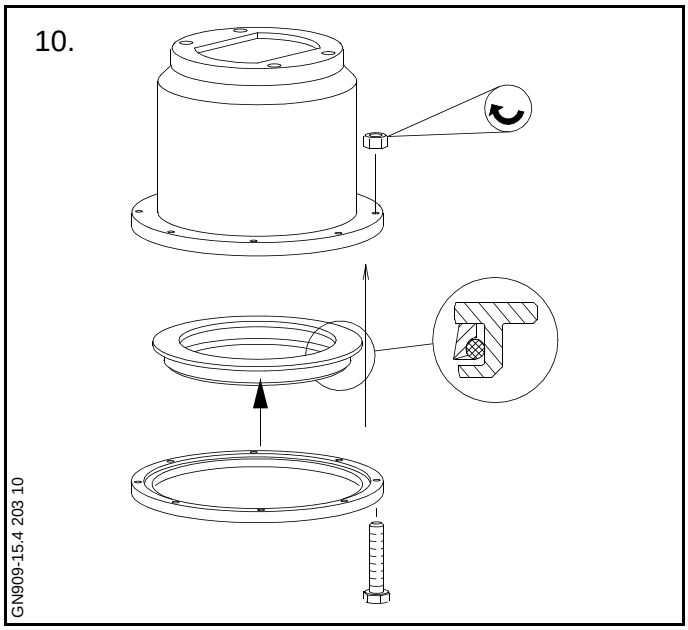
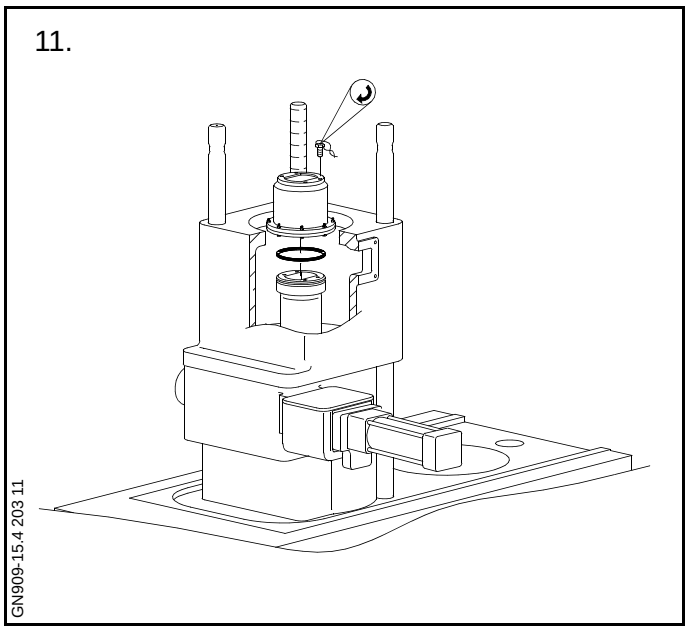






9. Remove the scraper ring and O-ring from the ring holder.

   Place the new O-ring in the ring holder.

   Before mounting, the new scraper ring must be heated in 100°C hot water or oil for at least five minutes.

Note!
When mounting the scraper ring in the groove, fold the ring without making any sharp edges, and be careful not to cut the scraper ring on the edge of the ring groove when pressing it in.

10. Check that the O-ring and scraper ring are mounted correctly. *See the sketch.*

    Assemble the sealing cap, the ring holder and retaining flange.

    Tighten the nuts on the screws.

    After tightening, check that the holder can be moved.

11. Mount a new O-ring in the groove on top of the roller guide.

    Mount the sealing cap on top of the roller guide, over the sealing bush inside the pump base.

    Tighten the screws and lock with locking wire.

12. Mount the fuel pump housing.
    See Procedure 909-4.4.

    Mount the top barrel assembly.
    See Procedure 909-6.4.

    Mount the top cover.
    See Procedure 909-5.4.

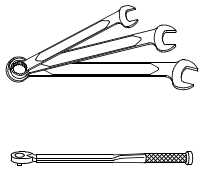
SAFETY PRECAUTIONS

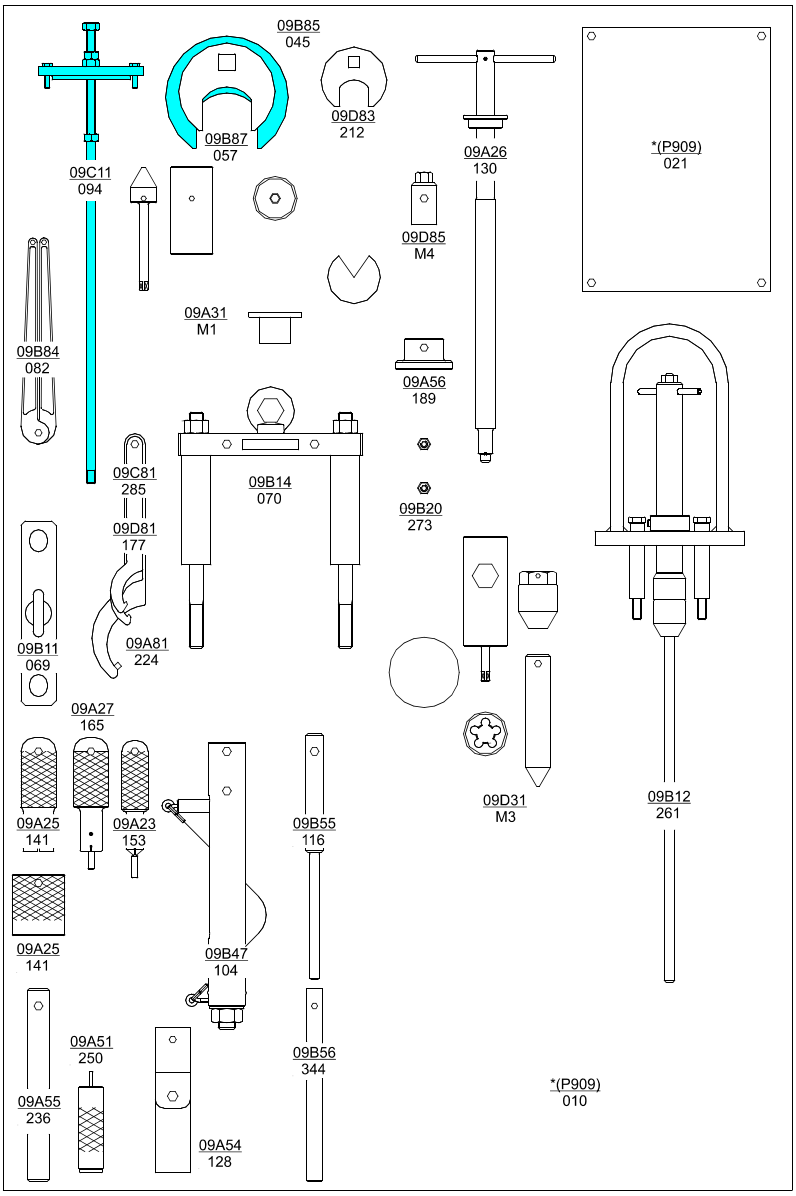
X	Stopped engine
X	Block the starting mechanism
X	Shut off starting air supply
X	Engage turning gear
	Shut off cooling water
X	Shut off fuel oil
	Shut off lubricating oil
	Lock turbocharger rotors

Data

Ref.	Description	Value	Unit
D-1	Puncture valve - tightening torque	890	Nm

Standard Tools: See Section 913

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Disengagement of fuel pump

Warning!
Disengagement or re-engagement of the fuel pump roller guide or the exhaust valve roller guide must **only** take place at engine standstill.

1. Engine trouble might require a cylinder to be taken out of action. The engine can continue operation with the fuel and exhaust systems of a single cylinder disconnected. *See Vol. 1, Section 704*.

   To disconnect the fuel pump of a single cylinder, proceed as follows:

2. Remove the puncture valve from the fuel pump.

Note!
Before dismantling any part of the fuel pump, make sure that the pump has been relieved of pressure and that all oil has been drained off.

3. Remove the cover on the camshaft housing. Turn the engine until the fuel pump roller is at **TDC**.

4. Mount the lifting tool on the fuel pump top cover and secure it in position with the two screws.

   Turn the uppermost nut to screw the spindle of the lifting tool into the fuel pump plunger.

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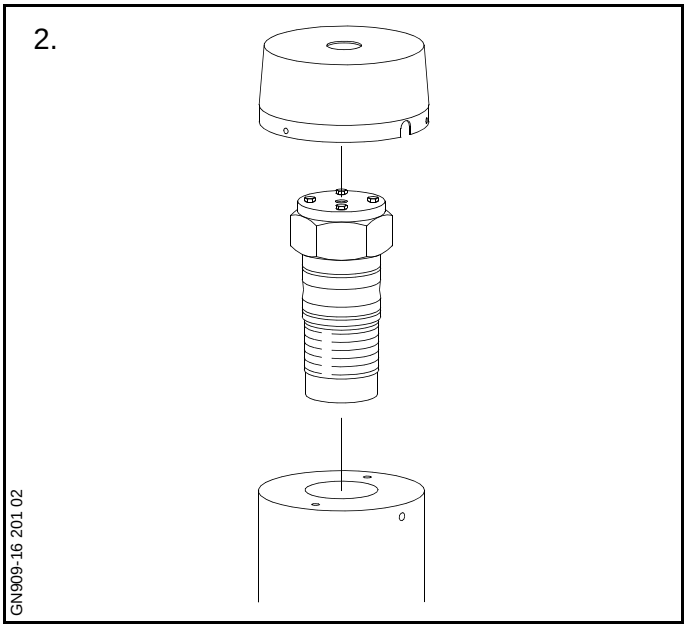

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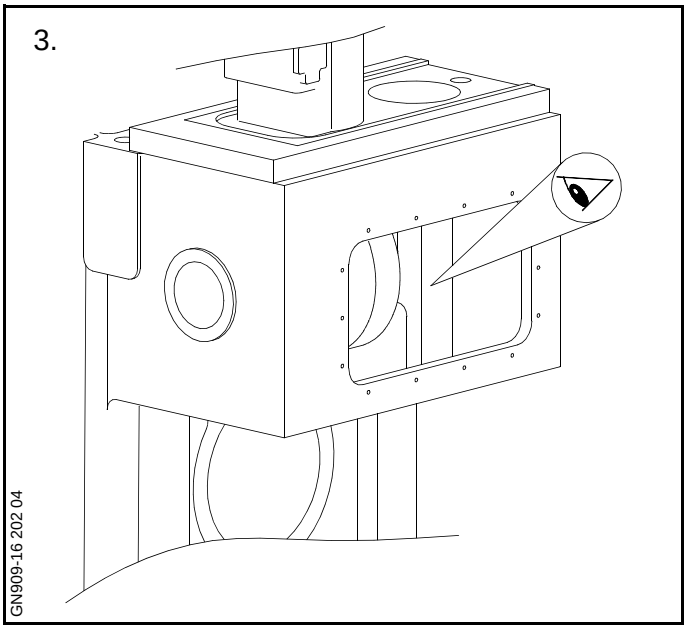

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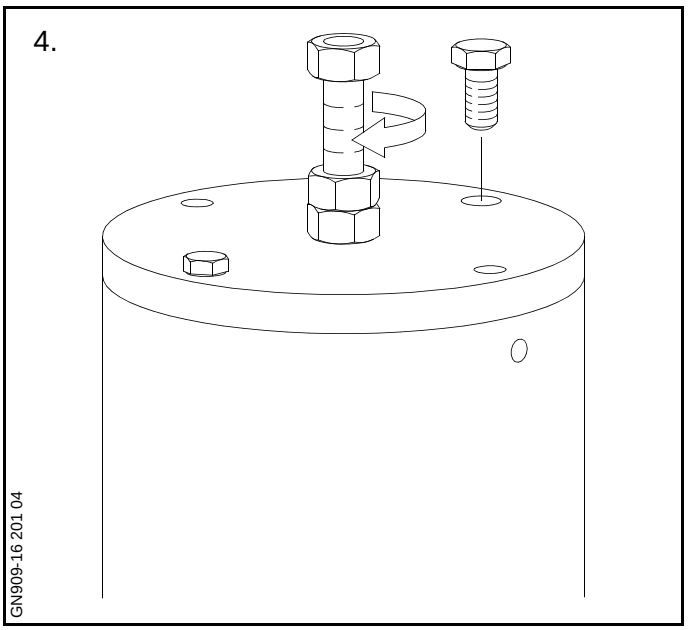

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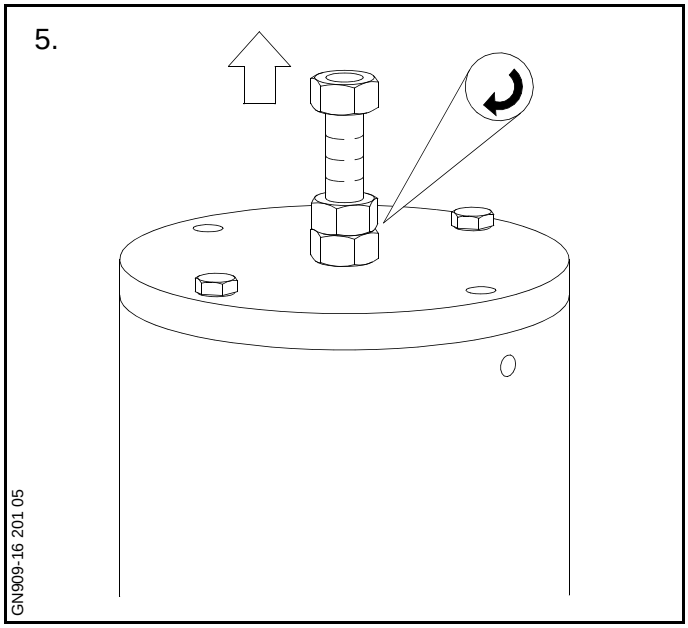
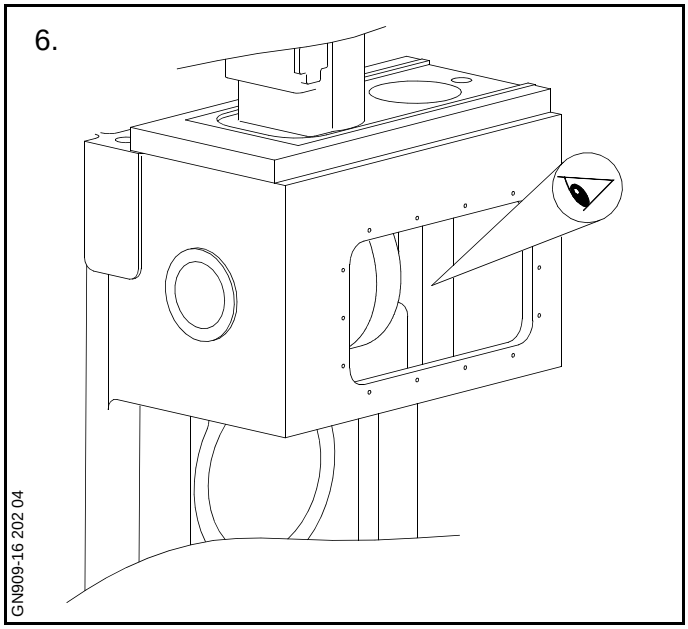
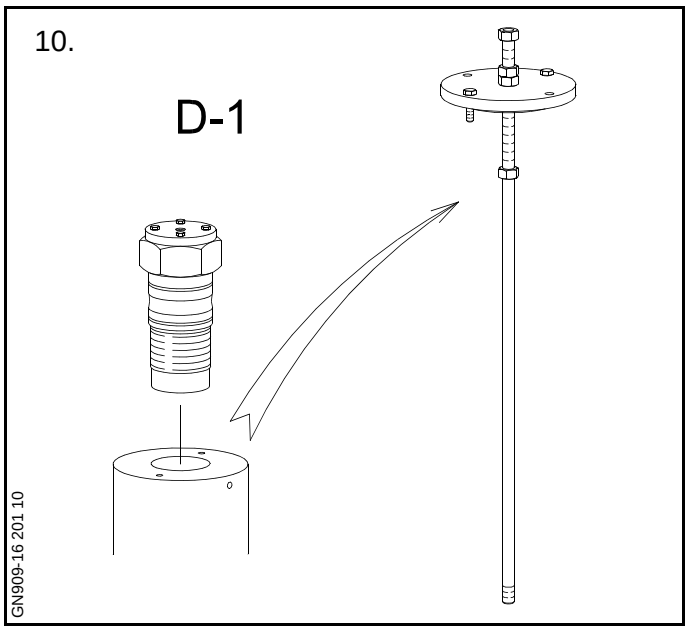






5. Tighten the lowermost nut on the tool to pull the roller guide upwards as far as possible.

   Tighten the middle nut of the tool against the lowermost nut to secure the roller guide in this position.

6. Turn the engine one full revolution and inspect through the opening in the camshaft housing to make sure that the roller guide is clear of the fuel cam.

7. If necessary, disengage th eexhaust valve actuator.
   See Procedure 908-7.

   The engine can now operate on the remaining cylinders. *See Vol. 1, Section 704*.

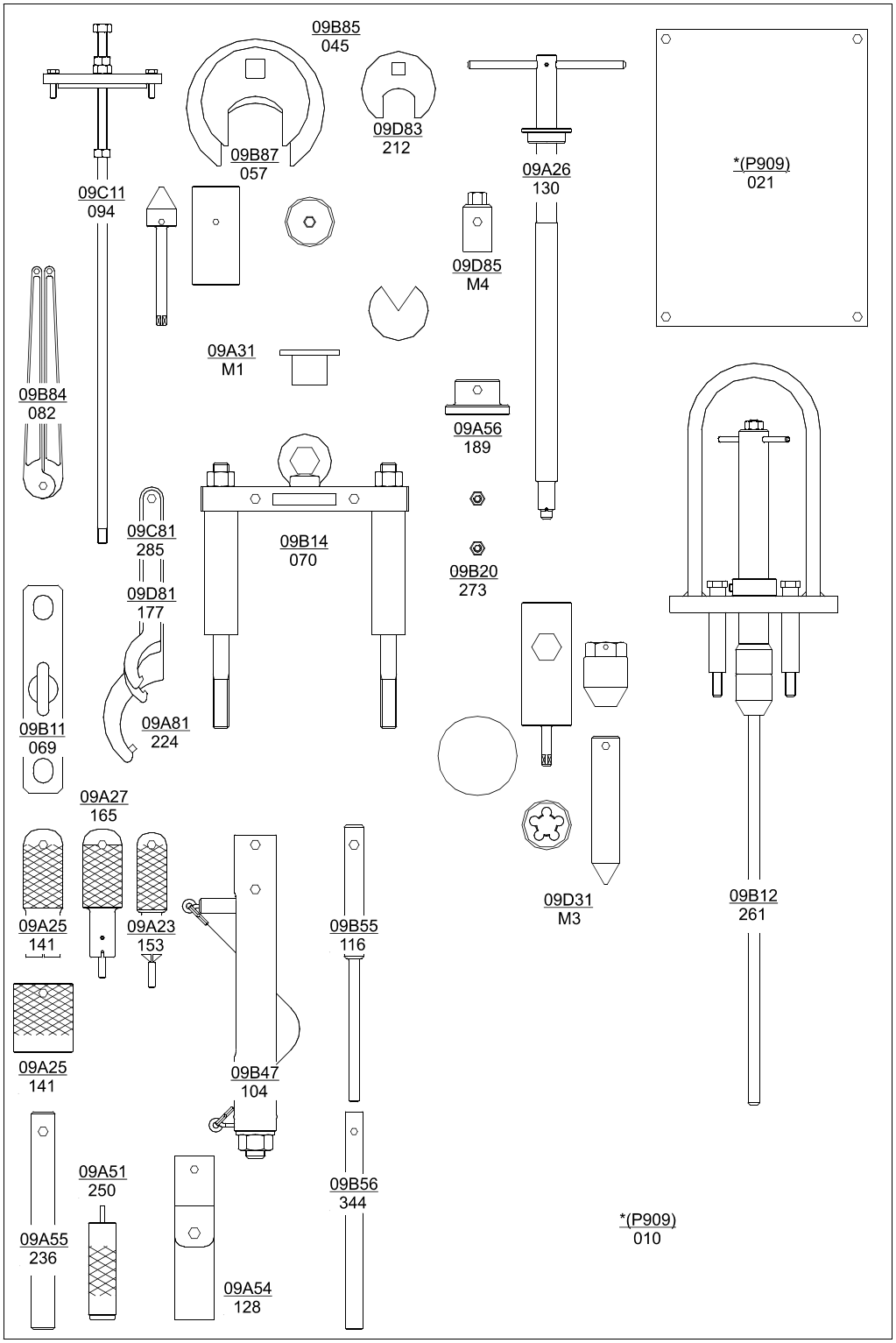
Re-engagement of fuel pump

Warning!
Re-engagement of the fuel pump must **only** take place at engine standstill.

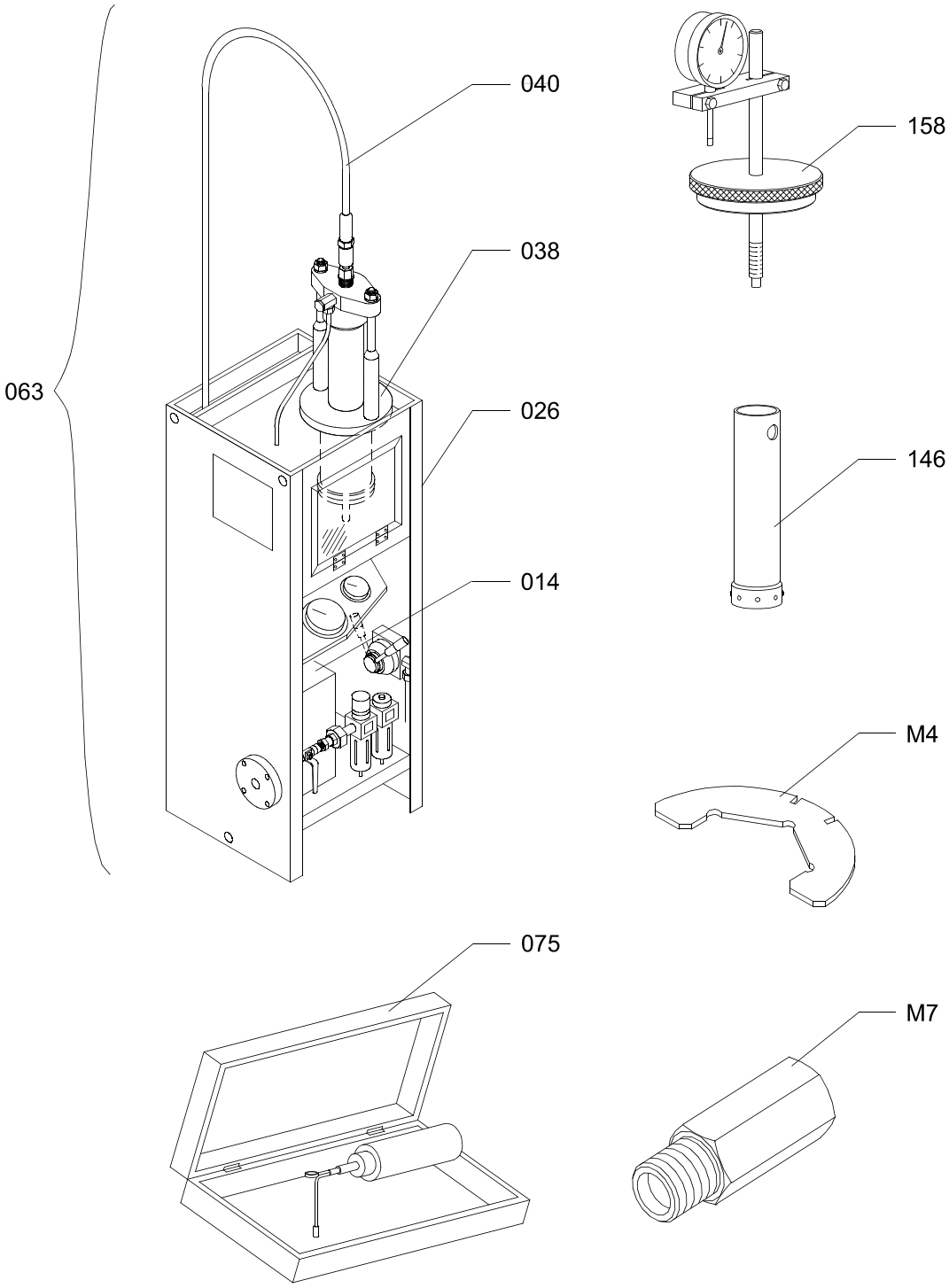
8. Remove the cover on the camshaft housing. Turn the engine until the circular section of the fuel cam is positioned upwards.

9. Lower the roller guide on to the fuel cam in the reverse order to lifting.

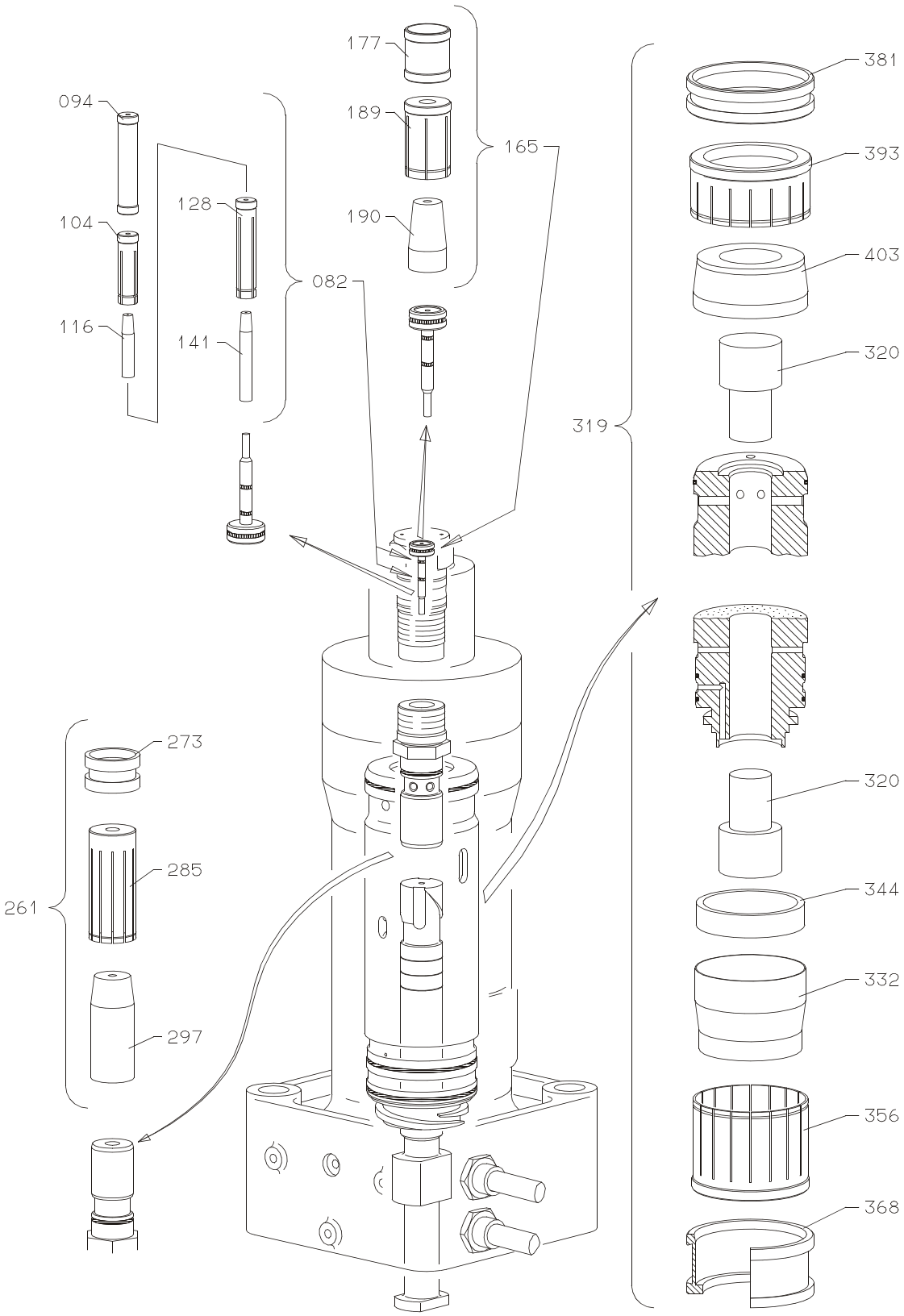
10. Remove the lifting tool and re-mount the puncture valve.


09B85
045
09B87
057
09D83
212
09A26
130
*(P909)
021
09C11
094
09D85
M4
09A31
M1
09B84
082
09A56
189
09C81
285
09B14
070
09B20
273
09D81
177
09A81
224
09B11
069
09A27
165
09A25
141
09A23
153
09B55
116
09D31
M3
09B12
261
09A25
141
09B47
104
09A51
250
09B56
344
09A55
236
09A54
128
*(P909)
010

Item No.	Part Description	MES Tools No.	
010	Tool panel *)	(P909)	
021	Name plate *)	(P909)	
045	Crowfoot spanner	09B85	
057	Crowfoot spanner	09B87	
069	Lifting tool	09B11	
070	Lifting tool	09B14	
082	Pin spanner	09B84	
094	Lifting tool for fuel pump roller guide	09C11	
104	Tool for p max. rack	09B47	
116	Stepped drift	09B55	
128	Cleaning set	09A54	
130	Grinding mandrel	09A26	
141	Grinding mandrel	09A25	
153	Grinding mandrel	09A23	
165	Grinding mandrel	09A27	
177	Hook spanner	09D81	
189	Flange	09A56	
212	Crowfoot spanner	09D83	
224	Hook spanner	09A81	
236	Drift	09A55	
250	Assembling tool for spindle guide	09A51	
261	Lifting tool	09B12	
273	Screw	09B20	
285	Hook spanner	09C81	
344	Drift	09B56	
M1	Grinding tool for seat for fuel oil pipe	09A31	
M3	Grinding tool for fuel oil pipe	09D31	
M4	Socket for thrust piece	09D85	
010-M4	Tool panel, complete with tools *)	-	
	*) Optional extras		


063
040
038
026
014
075
158
146
M4
M7

Item No.	Part Description	MES Tools No.	
014	Test rig, complete	09A71	
026	Table	09A71	
038	Rig fuel oil valve	09A71	
040	High-pressure hose	09A71	
063	Test rig, complete	09A71	
075	Probe light with magnifier, complete *)	(09A75)	
146	Socket wrench	09C86	
158	Measuring tool for fuel pump lead, complete	09B75	
M4	Tightening gauge for fuel pump housing	09C71	
M7	Plug for puncture valve control air	09C60	
	*) Optional extra		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094
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082
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141
381
393
403
320
319
273
320
285
261
344
332
297
356
368

Item No.	Part Description	MES Tools No.	
082	Tools for mounting of kanut seal ring on puncture valve spindle	09B51	
094	Sizer		
104	Pusher		
116	Cone		
128	Pusher		
141	Cone		
165	Tools for mounting of kanut seal ring on puncture valve spindle		
177	Sizer		
189	Pusher		
190	Cone		
261	Tools for mounting of seals on suction valve		
273	Sizer		
285	Pusher		
297	Cone		
319	Tools for mounting of seals on pump barrel		
320	Guide stick		
332	Cone		
344	Spacer		
356	Pusher		
368	Sizer		
381	Sizer		
393	Pusher		
403	Cone		

INDEX

CYLINDER COVER

PISTON WITH ROD AND STUFFING BOX

CYLINDER LINER AND
CYLINDER LUBRICATION

CROSSHEAD WITH CONNECTING ROD

CRANKSHAFT, THRUST BEARING
AND TURNING GEAR

MECANICAL CONTROL GEAR

STARTING AIR SYSTEM

EXHAUST VALVE

FUEL OIL SYSTEM

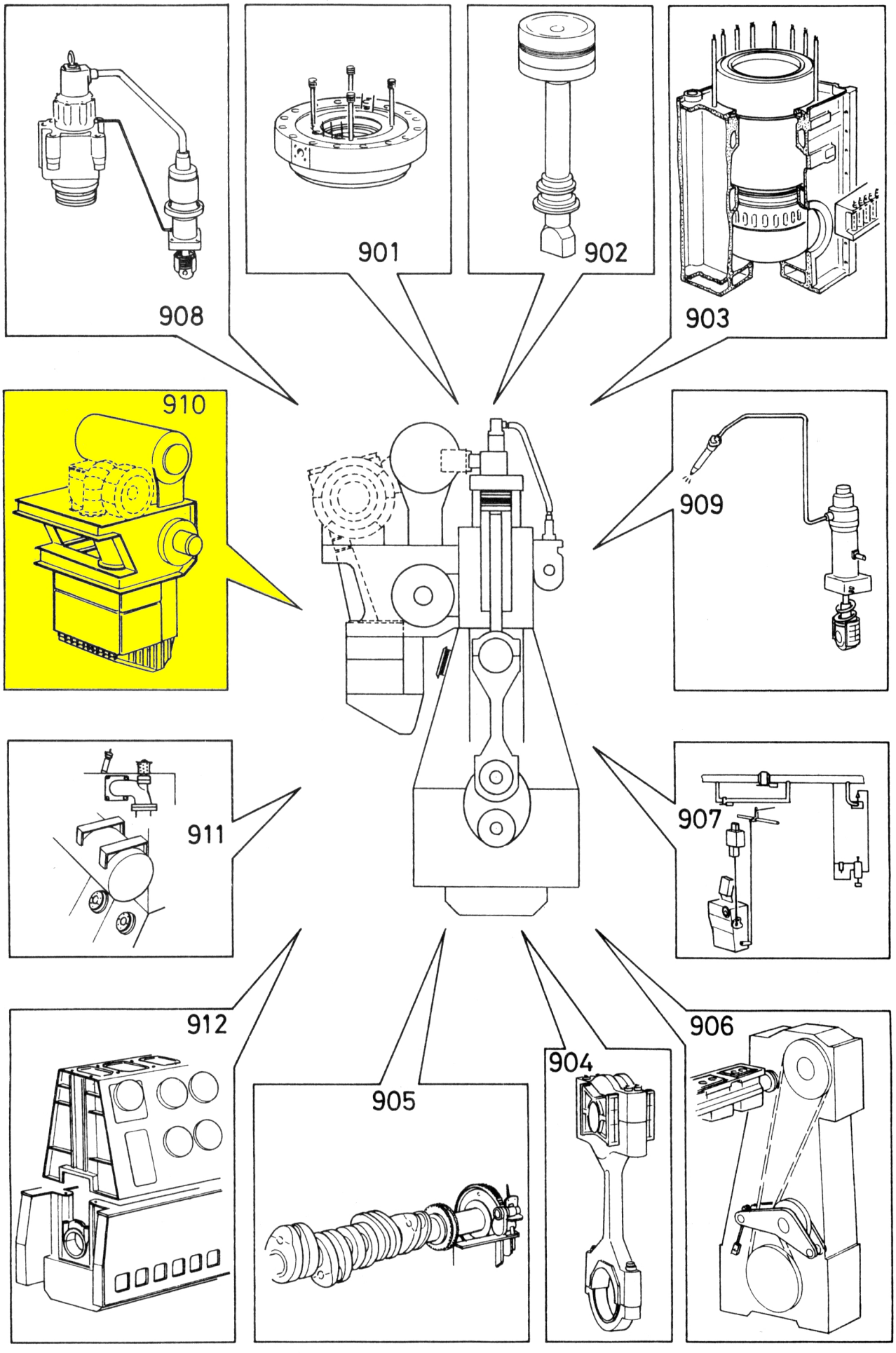
TURBOCHARGER SYSTEM

SAFETY EQUIPMENT

ASSEMBLY OF LARGE PARTS

GENERAL TOOLS

MITSUI
MAN
B&W



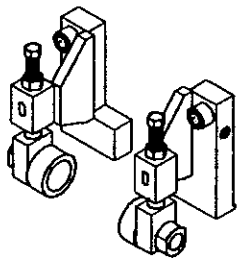
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Entrance into the scavenge air box prohibited before cleaning
X	Block the starting mechanism	Do not enter area when over head lifting is being carried out
X	Shut off starting air supply	
X	Engage turning gear	
X	Shut off cooling water	
	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

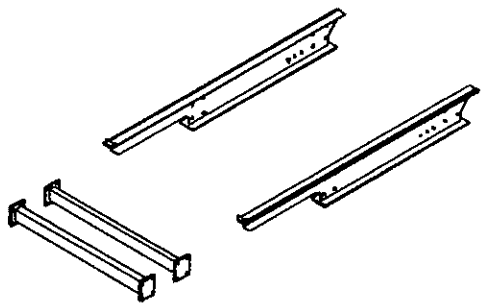
Data

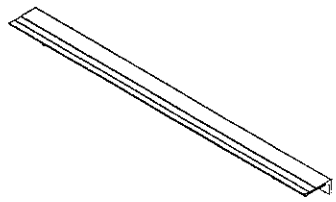
Ref.	Description	Value Unit
D-1	Air cooler element	1200 kg

Standard Tools: See Section 913

2 x 2000 kg







1. For the day-to-day checking of the scavenge air cooler, measure the drop in pressure and temperature of the scavenge air across the cooler during operation of the engine.

   Compare these measurements with the testbed data. *For further evaluation of the measurements, see instruction book Volume 1, Chapter 706.*

2. An increase in the air pressure drop across the scavenge air cooler indicates fouling of the air side of the cooler.

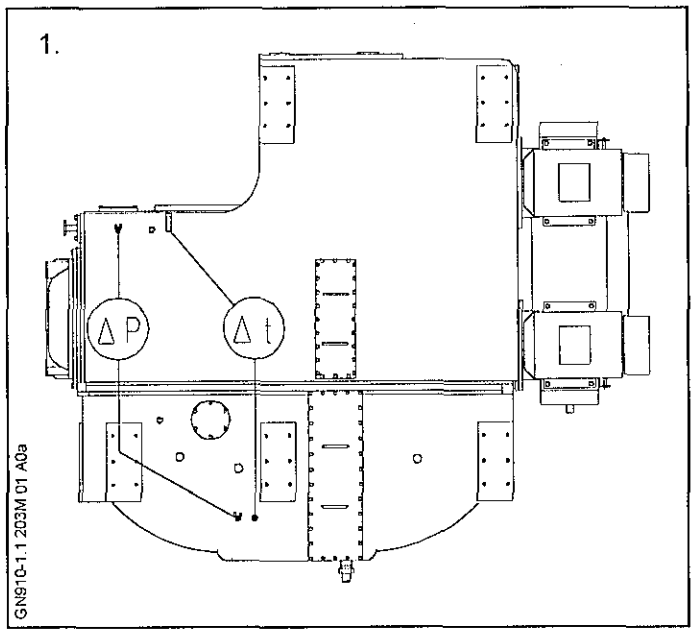
   A decrease in the air temperature drop across the scavenge air cooler indicates fouling of the water side of the cooler.

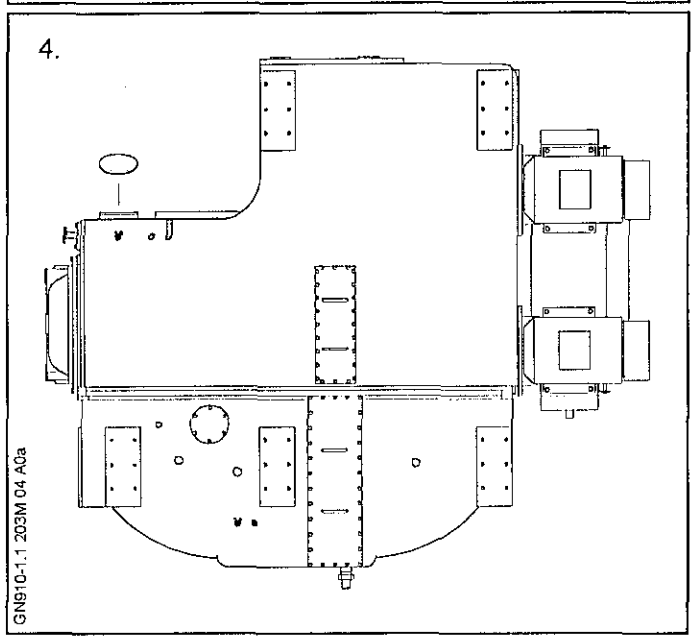
3. If the measurements indicate fouling of the air cooler, it is recommended to inspect the air cooler elements as follows:

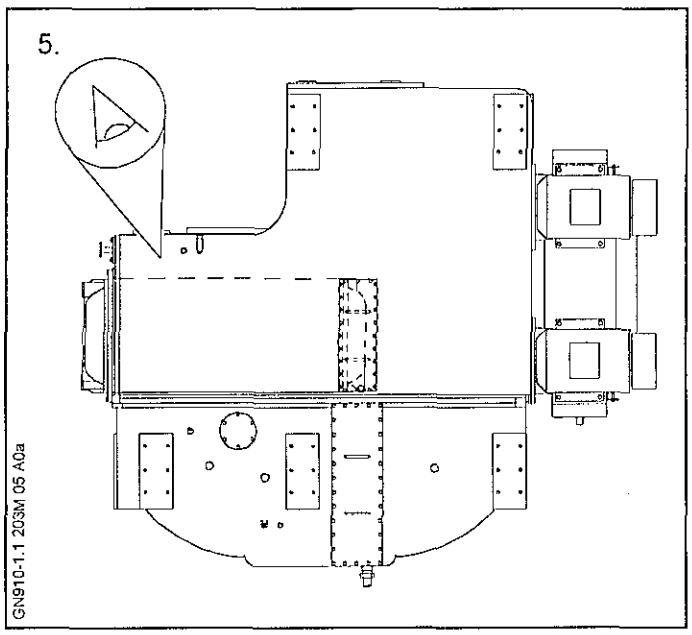
4. *Remove the top cover of the air cooler.*

5. Visually inspect the air cooler elements through the opening.

   If the elements are fouled, clean the elements.
   See Procedure 910-1.2.
   See Procedure 910-1.3.







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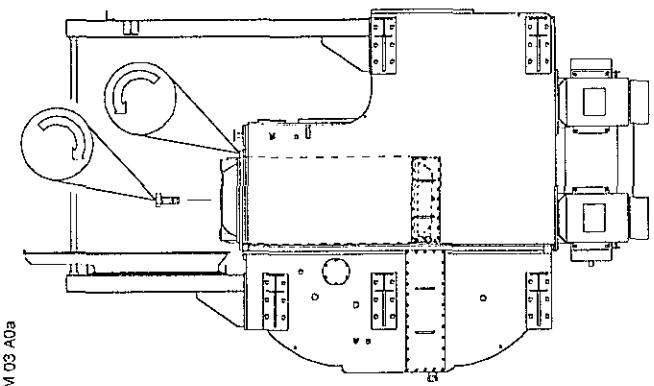
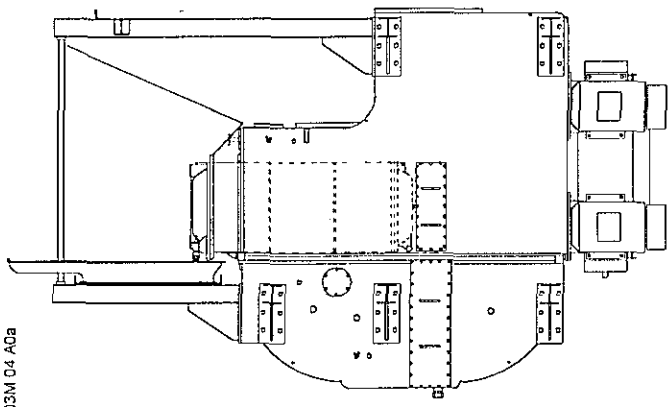


GN910-1.2 203M 03 A0a

4.



GN910-1.2 203M 04 A0a

1. Close the cooling water inlet and outlet valves of the air cooler.

   Drain off the cooling water by opening the drain cooks.

2. Remove the screws connecting the cooler inlet and outlet pipes to the air cooler element.

3. Remove the screws which fasten the cooler element to the cooler housing.

   Set the dismantling screws to the outermost tube plate.
   Pull the cooler element from the cooler housing using the dismantling screws.
   (The pair of wheels fixed at the innermost *end of the cooler element is being placed* on the rails arranged on the cooler housing.)

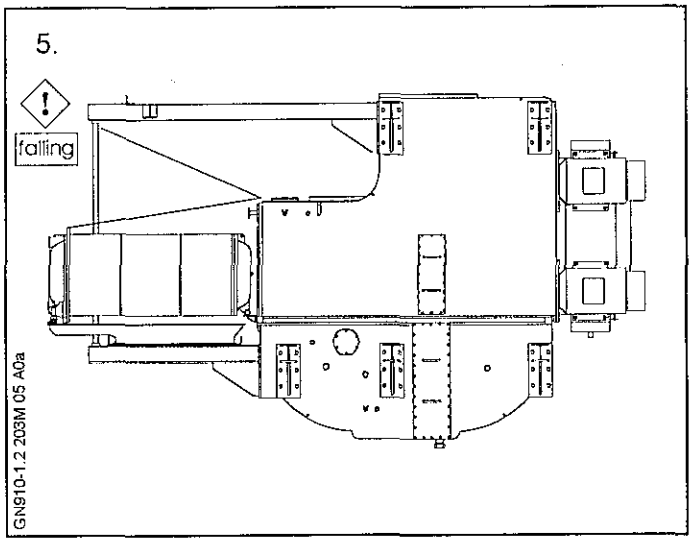
4. Mount the pair of rails on the gallery, and tighten it to the gallery bracket by means of the bolts and nuts.

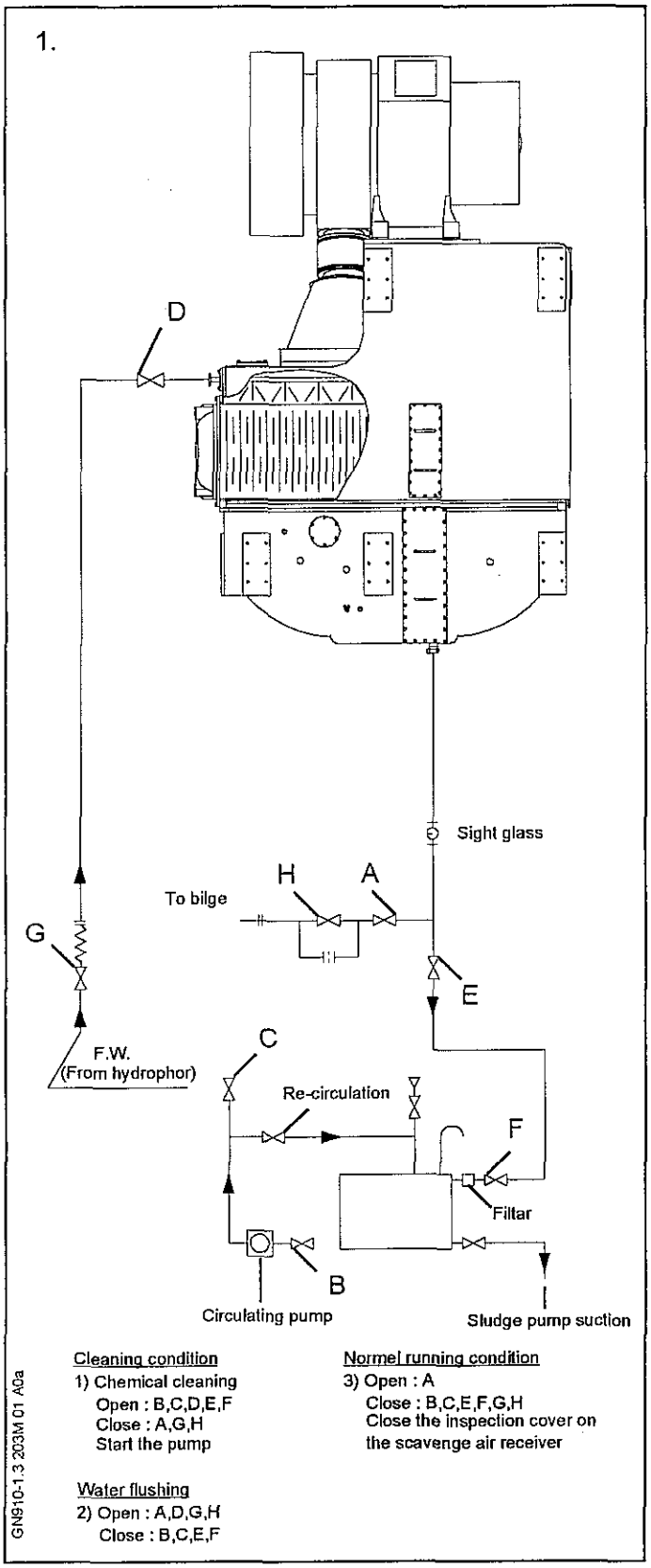
   Mount the pair of wheels on the outermost tube plate, and tighten the thrust screws to make the wheels support the cooler element.

Note!
During the pulling out work of the cooler element, it is necessary to use a rope A in order to prevent the excessive movement of the cooler element by the inertia force.

5. Pull the cooler element halfway out of the cooler housing, checking during this procedure that the outermost pair of wheels is being guided between the two guide rails.

   When the cooler element has been pulled *halfway out, mount the support on which* the innermost pair of wheels can run.





1. The air side of the cooler is cleanded by injecting a chemical fluid through the spray pipe arrangement fitted to the air chamber above the cooler element.

2. It is recommended to use one of the following cleaning fluids, or a similar product.

   1) Product: ACC 9, produced by Drew Chemical Corp., New York, USA

   2) Product: 80 B, produced by Vecom Int., Massluis, Holland.

   3) Product: NEOS-one-1, produced by NEOS CO., Ltd., Tokyo,Japan

3. Cleaning should be carried out in the following sequence:

   1) Do not start cleaning until the engine has been at a standstill for about 30 minutes. Do not disconnect the compressed air supply to the exhaust valve.

   2) Follow the detailed cleaning instructions displayed at the cleaning pipe on the engine.
   To ensure satisfactory spraying of the cleaning fluid, the circulating pump pressure must be at least 0.07 MPa(0.7 bar).

   3) Continue the cleaning process for at least 30 minutes. The time required depends on the frequency with which cleaning is carried out and the chemical product used.

   4) After cleaning, flush the cooler with clean water until the water appearing in the sight glasses is clean and pure.

   5) Inspection is carried out either by removing the cover on top of the cooler or by dismantling the charging air pipe.

4. Clean the water side of the cooler can be done with the end cover of the cooler removed.

   Close the cooling water inlet and outlet valves.
   Drain off the cooling water by opening the drain cook.

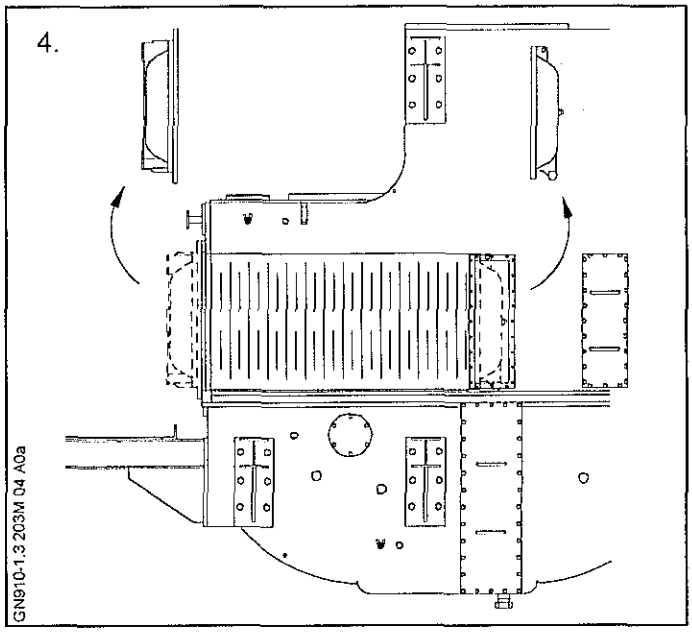
   Access to the covers on the waterflow reversing chamber is throgh covers on the cooler housing.

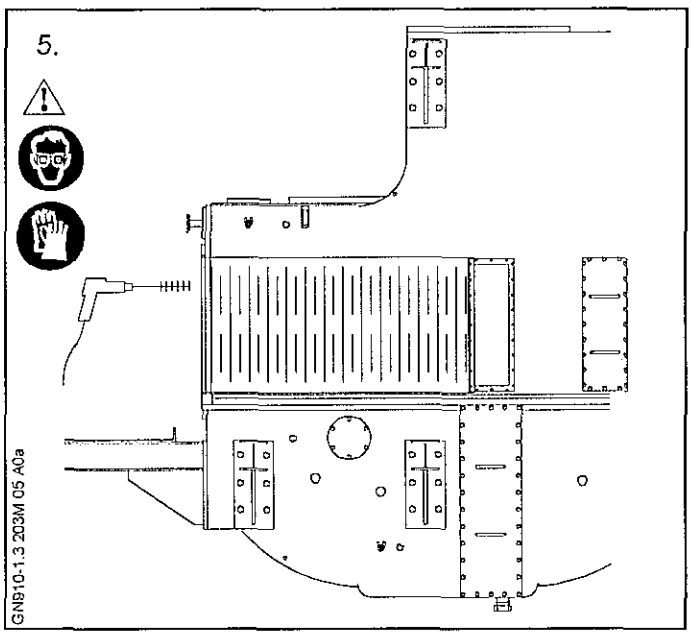
   The end cover of the cooler is to be dismantled.

5. Clean the inside of the tubes by means of the supplied cleaning brush, mounted on a drilling machine.

   In the event of a leaking tube, plug both ends of the tube using a brass or copper plug.

   In the event of leakage between a tube and the tube plate, roll the tube using the tube expander.





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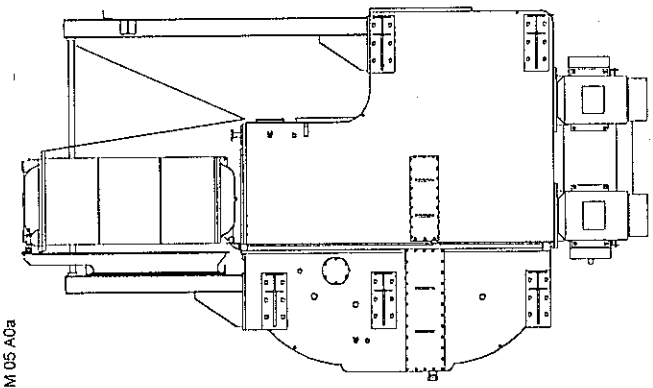

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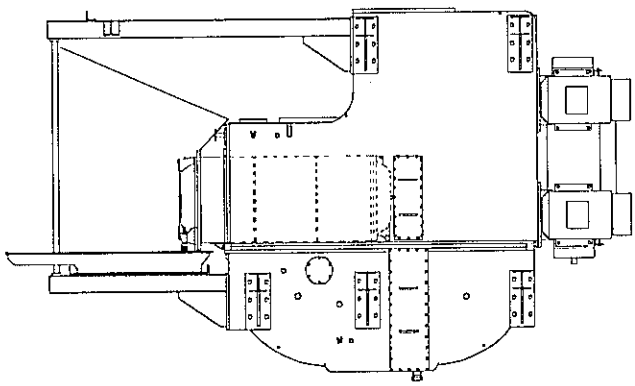
1. When the cooler element has been pushed halfway in the cooler housing, dismantling the support.

2. The cooler element has been pushed in the cooler housing.

   Dismantling the pair of wheels on the outermost tube plate.

   Dismantling the pair of rails on gallery.

2.



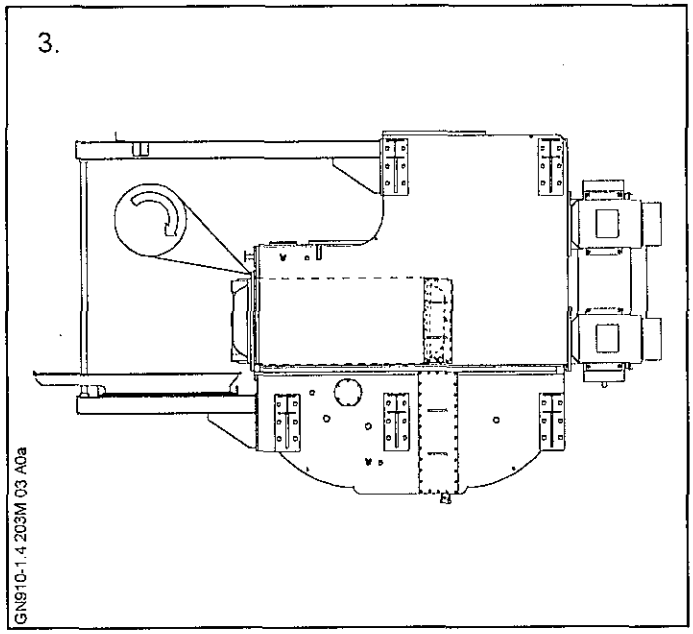
GN910-1.2 203M 04 A0a

3. Mount the screw for securing the cooler element to the air cooler housing.

4. Mount the cooler inlet and outlet pipes on the air cooler element, and connect all the drain pipes.

5. Fully open the cooling water inlet and outlet valves of the air cooler.

   Close the drain cock.

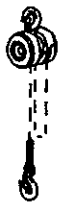


SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Entrance into the scavenge air box prohibited before cleaning
X	Block the starting mechanism	Do not enter area when over head lifting is being carried out
X	Shut off starting air supply	
X	Engage turning gear	
X	Shut off cooling water	
	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

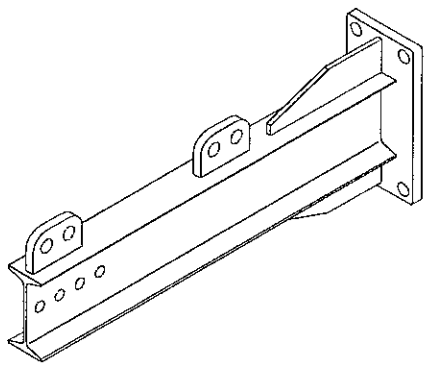
Data

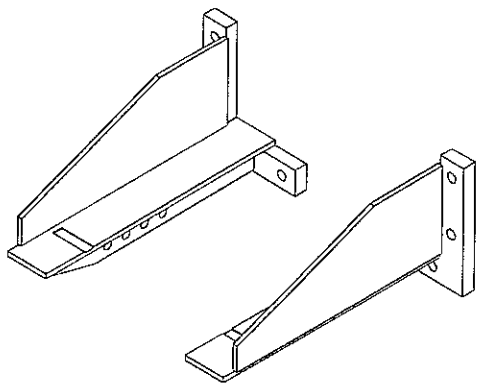
Ref.	Description	Value Unit
D-1	Air cooler element	1410 kg

Standard Tools: See Section 913



2 x 1500 kg





1. For the day-to-day checking of the scavenge air cooler, measure the drop in pressure and temperature of the scavenge air across the cooler during operation of the engine.

   Compare these measurements with the testbed data. *For further evaluation of the measurements, see instruction book Volume I, Chapter 706.*

2. An increase in the air pressure drop across the scavenge air cooler indicates fouling of the air side of the cooler.

   A decrease in the air temperature drop across the scavenge air cooler indicates fouling of the water side of the cooler.

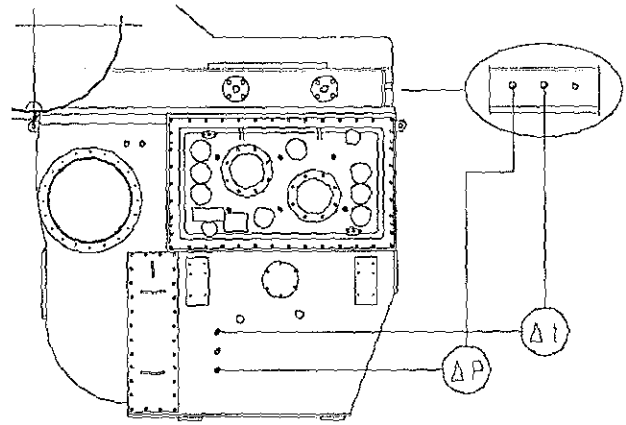
3. If the measurements indicate fouling of the air cooler, it is recommended to inspect the air cooler elements as follows:

4. Remove the top cover of the air cooler.

5. Visually inspect the air cooler elements through the opening.

   If the elements are fouled, dismantle and clean the elements.
   See Procedure 910-1.2.
   See Procedure 910-1.3.

1.



GN910-1.1 203M 01 A0a R

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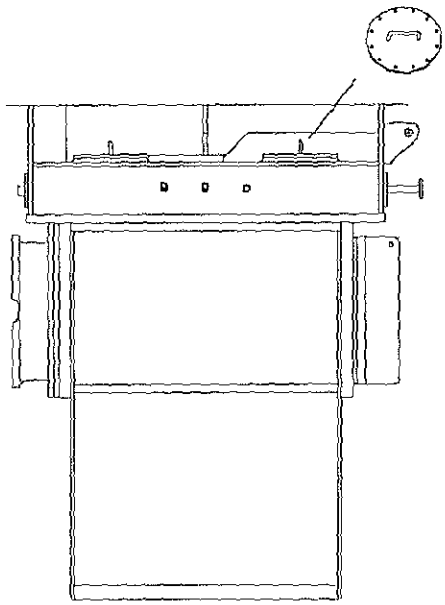

GN910-1.1 203M 04 A0a R

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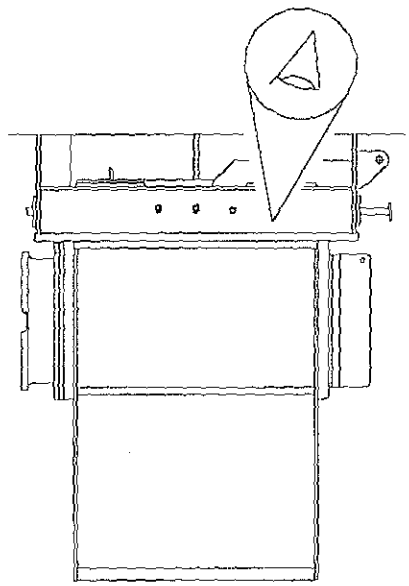
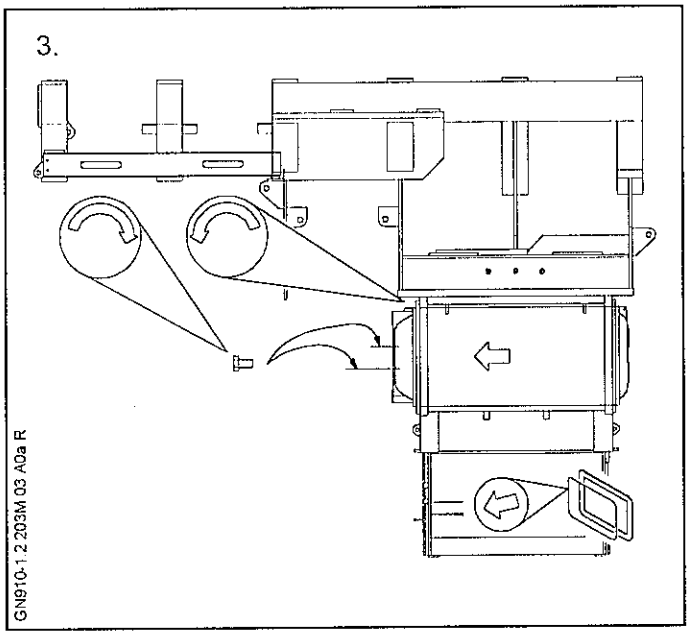
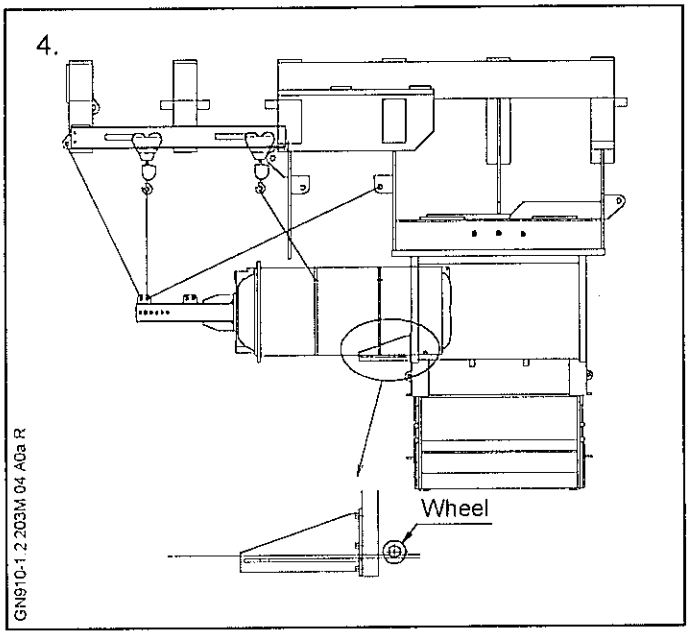


GN910-1.1 203M 05 A0a R





1. Close the cooling water inlet and outlet valves of the air cooler.

   Drain off the cooling water by opening the drain cocks.

2. Remove the screws connecting the cooler inlet and outlet pipes to the air cooler element.

   Disconnect the drain pipes from the air cooler.

3. Remove the sealing flange and sealing ring from cooler housing.

   Remove the nuts which fasten the cooler element to the cooler housing.

   Press the cooler element free, using dismantling screws.

4. Mount the lifting attachment to the air cooler.

   Mount atrolley and hook the tackles.

Note!
During the pulling out work of the cooler element, it is necessary to use another rope in order to provent the excessive movement of the cooler element by the inertia force.

Lift and pull the cooler element halfway out of the cooler housing by the tackles.

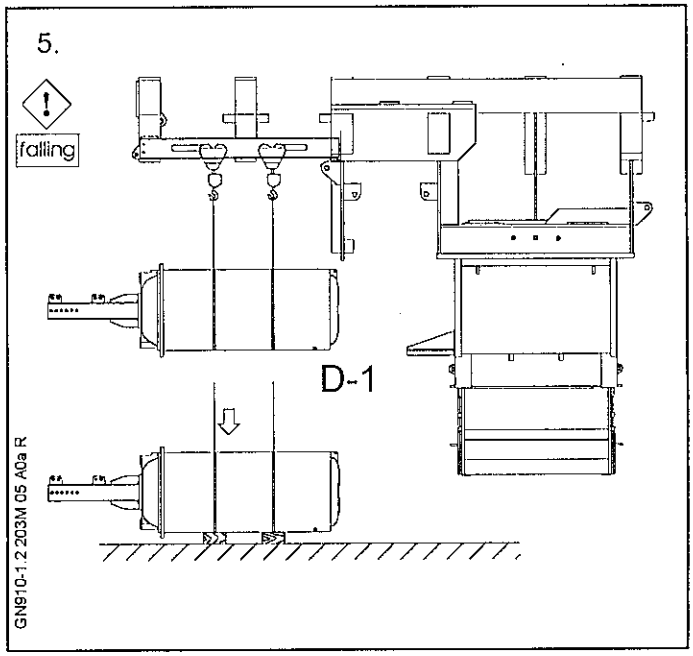
Mount the two rails on which the inner most pair of wheels can ran.

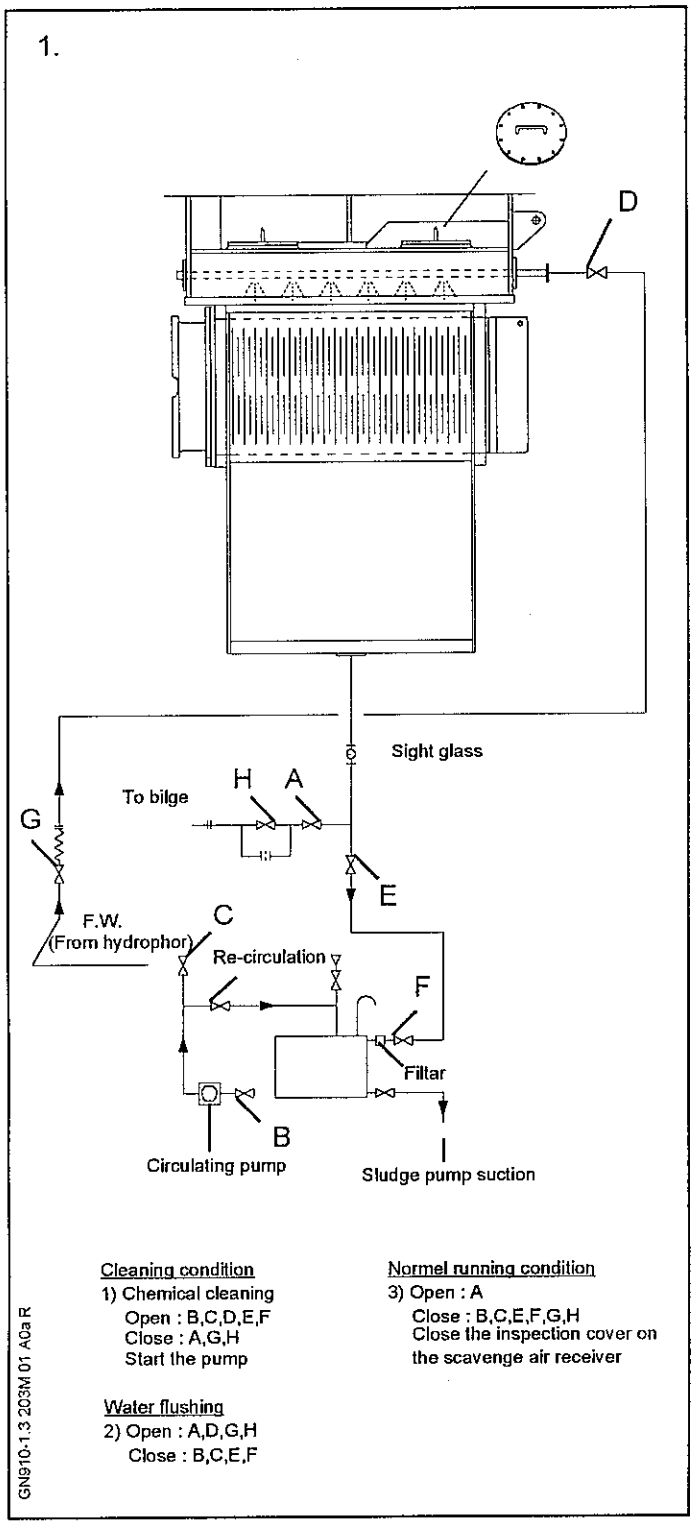
Mount a wire rope to the cooler element body. Remove the tackle from the lifting attachment and hook it to the wire rope.

5. Pull the cooler element out of the cooler housing completely.

   Mount a wire rope to the cooler element body, and hook to the tackle.

   Lowering the cooler element to the floor.





1. The air side of the cooler is cleaned by injecting a chemical fluid through the spray pipe arrangement fitted to the air chamber above the cooler element.

2. It is recommended to use one of the following cleaning fluids, or a similar product.

   1) Product: ACC 9, produced by
   Drew Chemical Corp., New York, USA

   2) Product: 80 B, produced by
   Vecom Int., Maassluis, Holland.

   3) Product: NEOS-one-1, produced
   by NEOS CO., Ltd., Tokyo,Japan

3. Cleaning should be carried out in the following sequence:

   1) Do not start cleaning until the engine has been at a standstill for about 30 minutes. Do not disconnect the compressed air supply to the exhaust valve.

   2) Follow the detailed cleaning instructions displayed at the cleaning pipe on the engine.
   To ensure satisfactory spraying of the cleaning fluid, the circulating pump pressure must be at least 0.07 MPa(0.7 bar).

   3) Continue the cleaning process for at least 30 minutes. The time required depends on the frequency with which cleaning is carried out and the chemical product used.

   4) After cleaning, flush the cooler with clean water until the water appearing in the sight glasses is clean and pure.

   5) Inspection is carried out either by removing the cover on top of the cooler or by dismantling the charging air pipe.

4. Cleaning the outside of the cooler can be done with the water chamber removed.

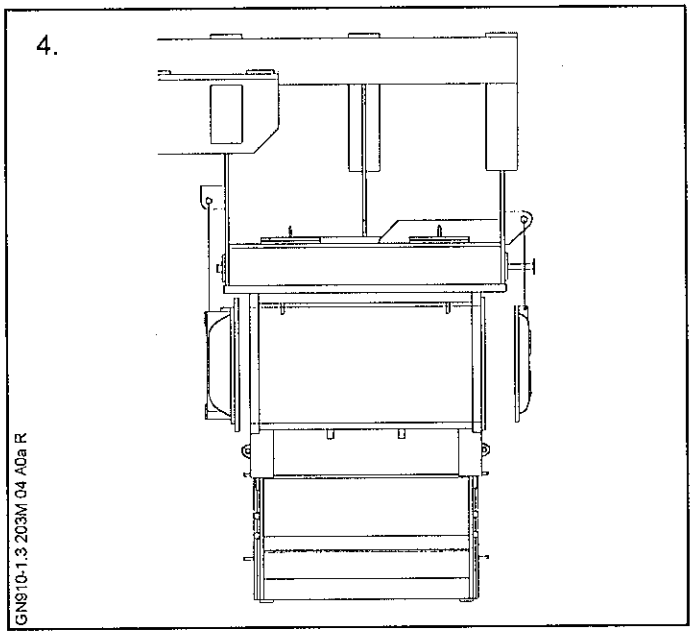
   Close the cooling water inlet and outlet valves.
   Drain off the cooling water by opening the drain cock.

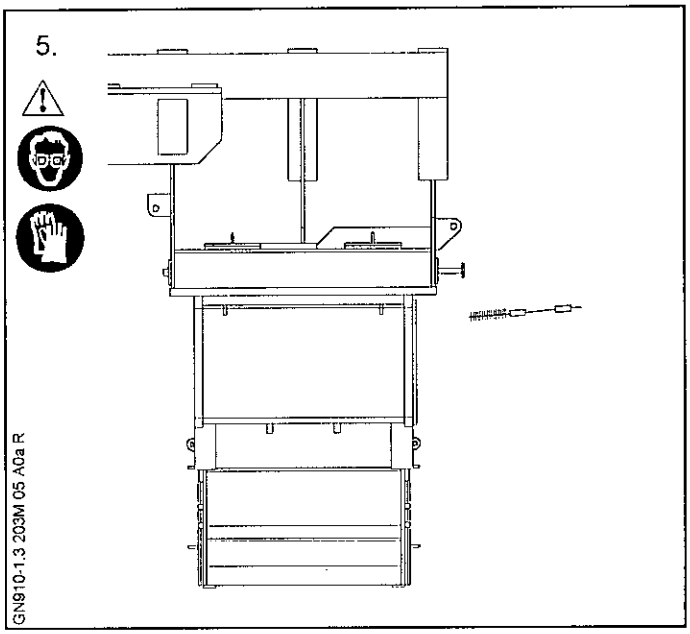
   Loosen and remove the screw in the water chamber and dismount the water chamber.

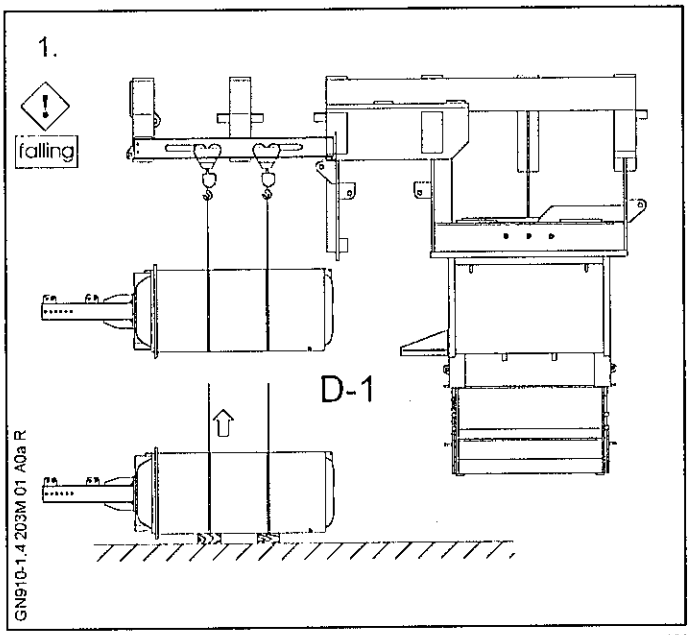
5. Clean the inside of the tubes by means of the supplied cleaning brush, mounted on a drilling machine.

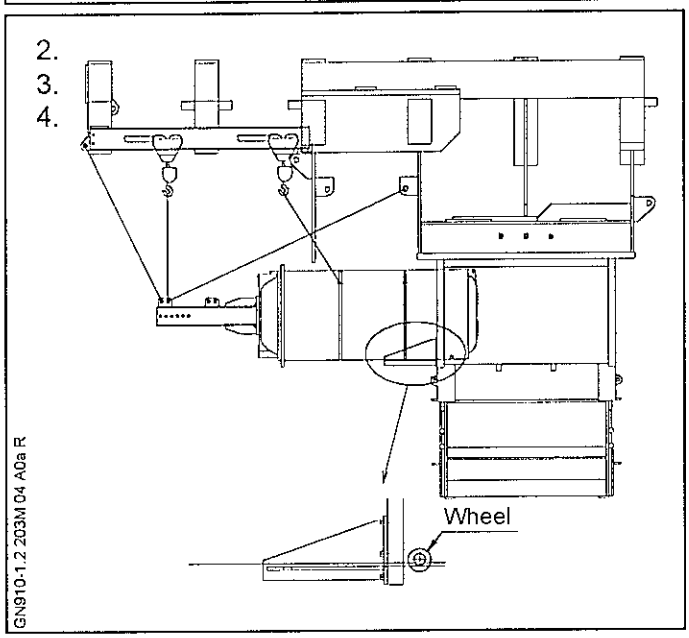
   In the event of a leaking tube, plug both ends of the tube using a brass or copper plug.

   In the event of leakage between a tube and the tube plate, roll the tube using the tube expander.









1. Mount a wire rope to the cooler element body, and hook to the tackle.
   Lifting the cooler element from the floor.
2. Put the cooler element on the two rails.
3. Push the cooler element halfway in the cooler housing by the tackles.
4. Remove the two rails from the cooler housing.

   Push the cooler element in the cooler housing.

   Remove the lifting attachment to the air cooler.

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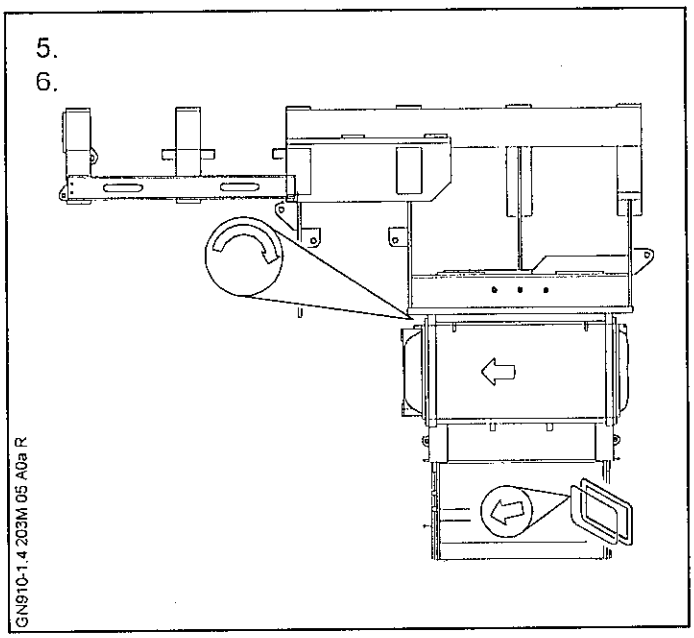
5. Mount the searing flange and sealing ring to cooler housing.

6. Tightening nut for fasten the cooler element to the cooler housing.

7. Mount the cooler inlet and outlet pipes on the air cooler element, and connect all the drain pipes.

8. Fully open the cooling water inlet and outlet valves of the air cooler.

   Close the drain cock.

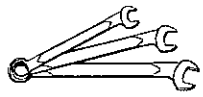


SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Entrance into the scavenge air box prohibited before ventilating
X	Block the starting mechanism	
X	Shut off starting air supply	
	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit

Standard Tools: See Section 913



22

This procedure includes both the main non-return valve and the non-return valve for the auxiliary blowers.

Both sets of non-return valves are accessed via the scavenge air receiver.

Note!
Access to the scavenge air receiver must **not** be attempted until the air in the receiver is clean.

Main Non-Return Valve

1. Inside the scavenge air cooler housing, lift up the valve flap of the valve that is to be overhauled.

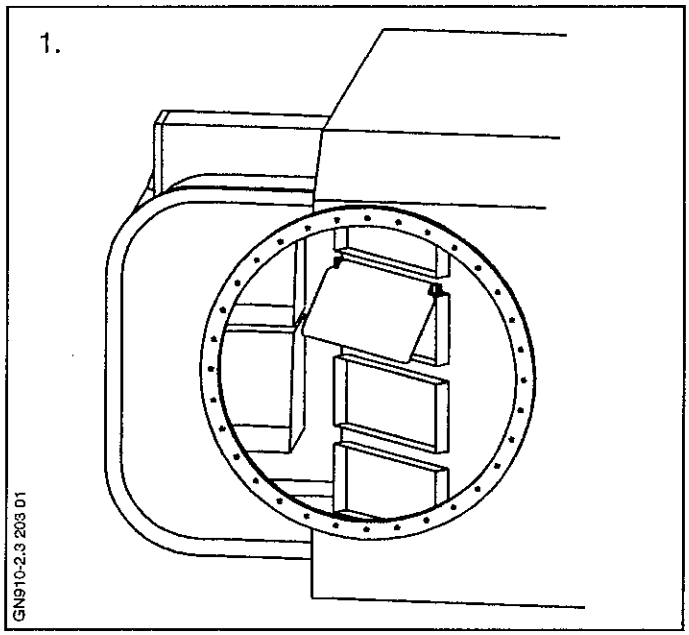
2. Remove the screws behind the valve flap. Remove the valve from the engine.

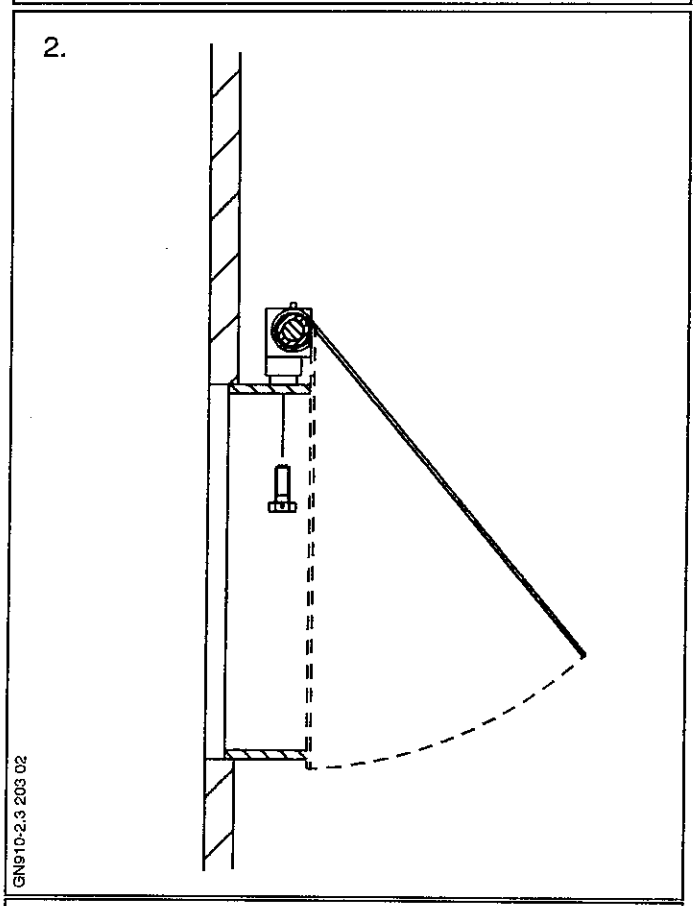
3. Remove the spring pin from the valve shaft and knock the valve shaft out of the valve flap.

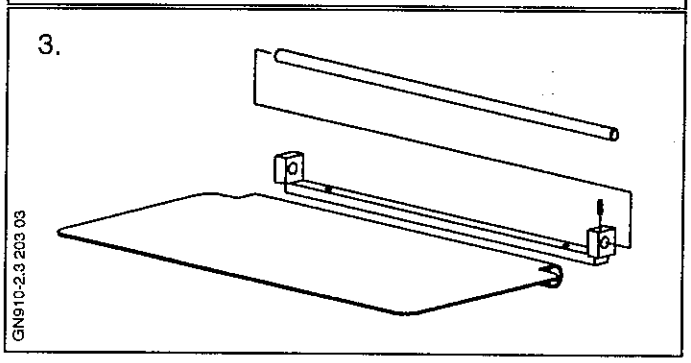
   Clean the valve shaft and the slide bearings inside the valve flaps. Lubricate the valve shaft and the slide bearings with molybdenum disulphide (MoS_2).

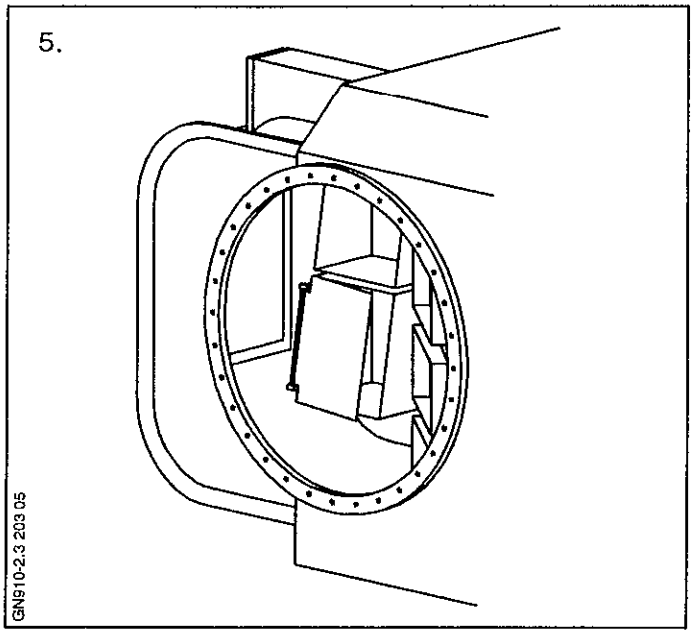
   After the overhaul, it must be possible to move the valve flap by the light touch of a finger.

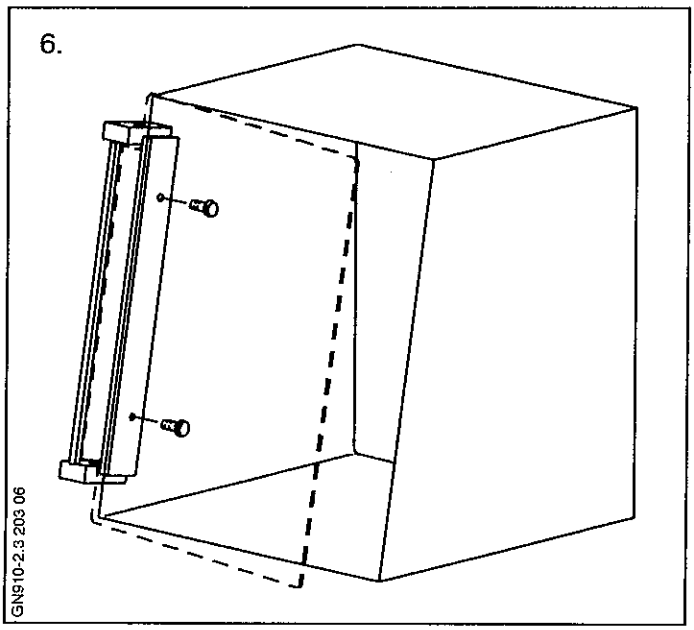
4. Assemble the valve and re-mount it in the scavenge air cooler housing.

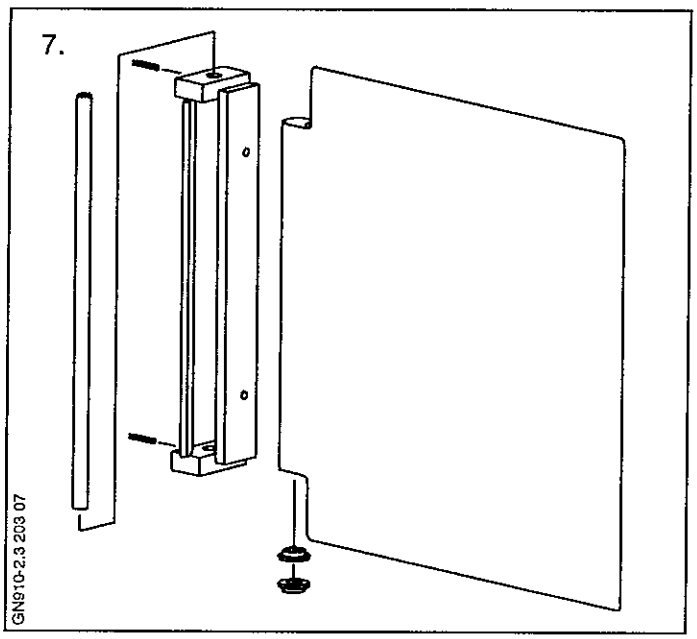












Non-Return Valve for Auxiliary Blowers

5. Inside the scavenge air cooler housing, lift up the valve flap of the valve to be overhauled.

6. Remove the screws behind the valve flap. Remove the valve from the engine.

7. Remove the spring pins from the valve shaft and knock the valve shaft out of the valve flap.

   Clean the valve shaft, the slide rings and the slide bearings inside the valve flaps. Lubricate the valve shaft, the slide rings and the slide bearings with molybdenum disulphide (MoS_2).

   After the overhaul it must be possible to move the valve flap by the light touch of a finger.

8. Assemble the valve and re-mount it in the scavenge air cooler housing.

Non-Return Valve (T/C:REAR)

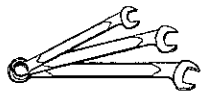
Data

SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Entrance into the scavenge air box prohibited before ventilating
X	Block the starting mechanism	
X	Shut off starting air supply	
	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit

Standard Tools: See Section 913



Access to the non-return valves in the scavenge air receiver takes place - after the engine has been stopped - through the inspection openings of the receiver.

OBS!
Access to the scavenge air receiver space must not take place until the air in the receiver is clean.

Main Non-Return Valve

1. Remove the two outermost and middle bolts (which fasten the valve assembly to the housing). Lift the complete valve assembly out of the air receiver.

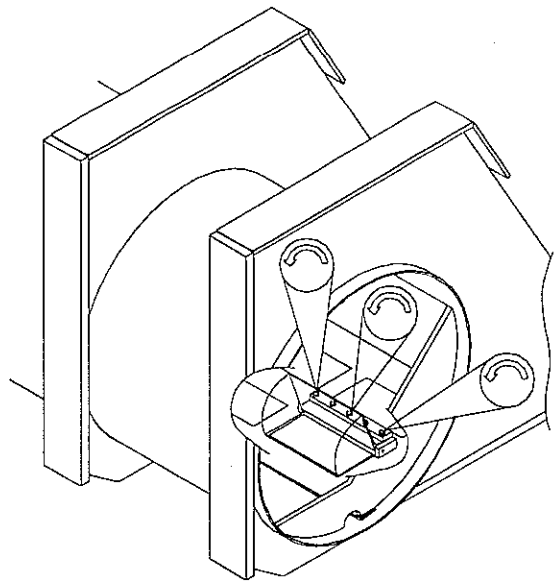
2. Knock out the spring pin which secures the axle and the valve flap to the support and press out the axle. Now the valve flap is free and can be replaced.

3. For further dismantling, remove the two screws which hold the supports and the clamp together as an assembly.

4. When mounting, secure the axle and the valve flap to the support by means of the spring pin.

   Finally, mount the complete non-return valve in the inlet casing.

1.



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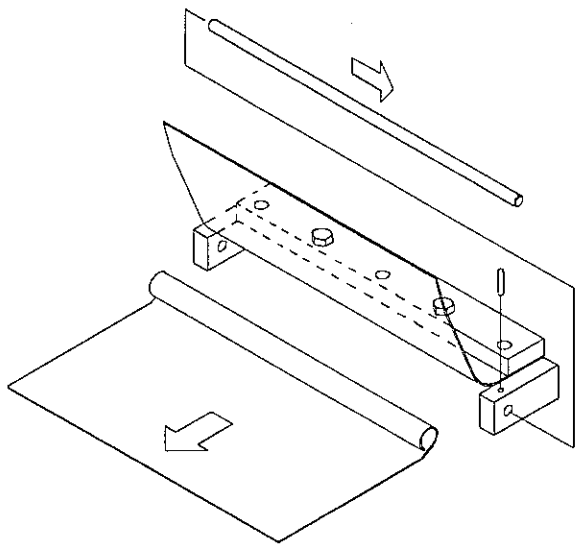

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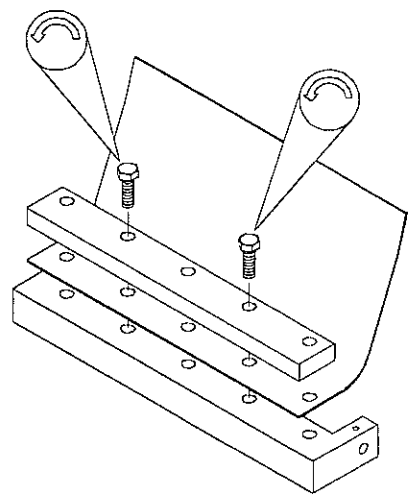

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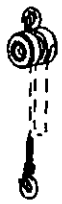
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of electric shock
X	Block the starting mechanism	
X	Shut off starting air supply	
	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value Unit
D-1	Weight of blower unit, complete *)	up til 1075 kg

*) Depending on electric motor type and number of cylinders of engine (size and capacity of auxiliary blower)

Standard Tools: See Section 913



2000 kg

30

1. Depending on the type of overhaul, disconnect the cable connections to one or both blower motors.

   The overhaul can be carried out either by dismantling the complete blower unit or just dismantling the individual blower wheel which is to be replaced/overhauled.

2. **Complete Blower Unit**

   Hook a shackle and a tackle to the lifting bracket in the top of the blower unit. It may be necessary to remove one or more of the gallery plates.

   Remove all screws in the outlet flange of the blower unit.

   Remove all screws in the lower inlet flange of the blower unit.

   Remove all screws in the upper inlet flange of the blower unit.

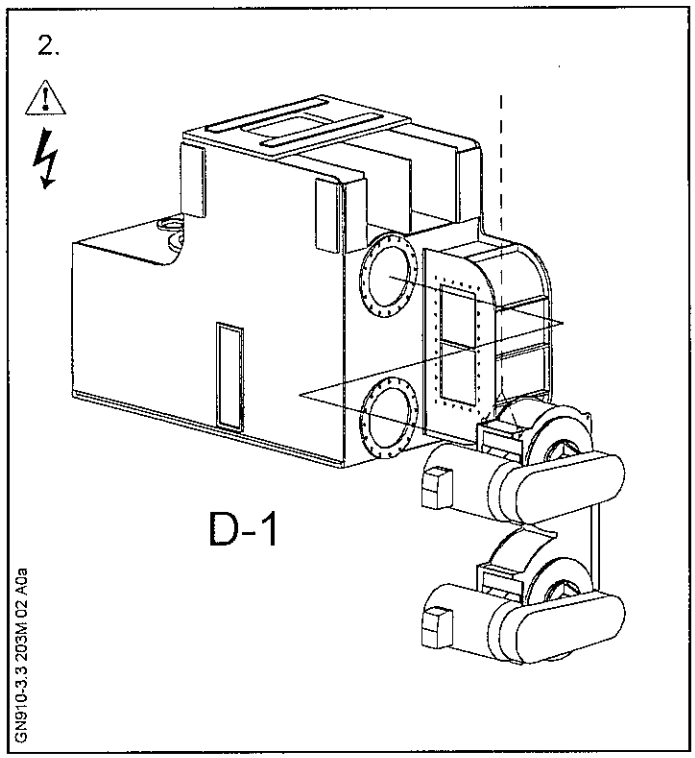
   Lift away the blower unit and land it on wooden planks for further dismantling/ overhaul.

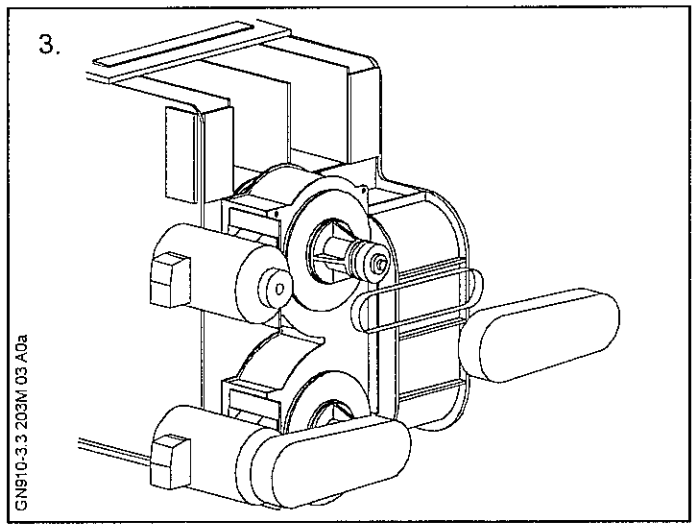
3. **Blower Wheel**

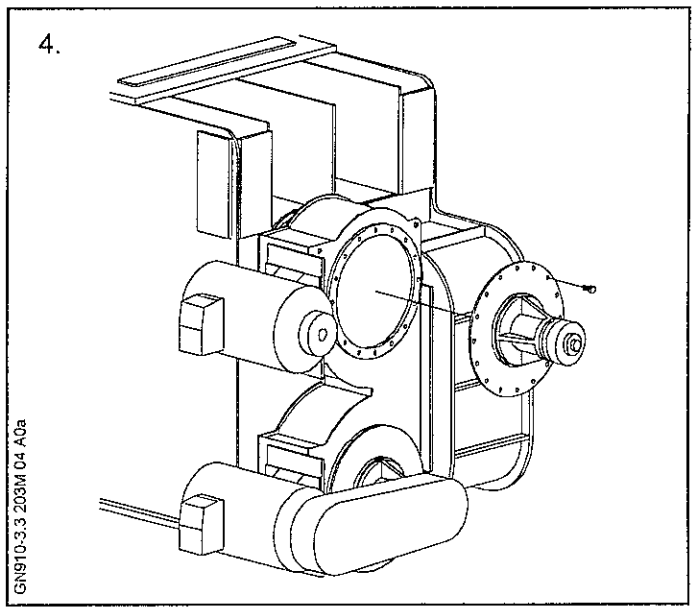
   Remove the safety guard and the driving belt.

4. Remove the screws in the blower flange and lift away the blower flange complete with blower wheel and bearing housing.

   For overhaul of blower wheel and bearings, see blower manufacturer's instructions.







5. **Electric Motor**

The electric motors can be dismantled without removing the blower housing.

Remove the safety guard and the driving belt.

Hook a shackle and a tackle to the motor. It may be necessary to remove one or more of the gallery plates.

Remove all screws in the flange of the motor.

Lift away the motor and land it on wooden planks for further dismantling/overhaul.

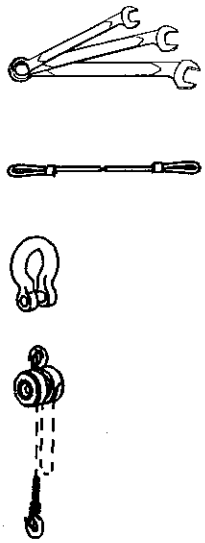
SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of electric shock
X	Block the starting mechanism	
X	Shut off starting air supply	
	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value Unit
D-1	Weight of blower unit, complete *)	up till 840 kg

*) Depending on electric motor type and number of cylinders of engine (size and capacity of auxiliary blower)

Standard Tools: See Section 913



1000 kg

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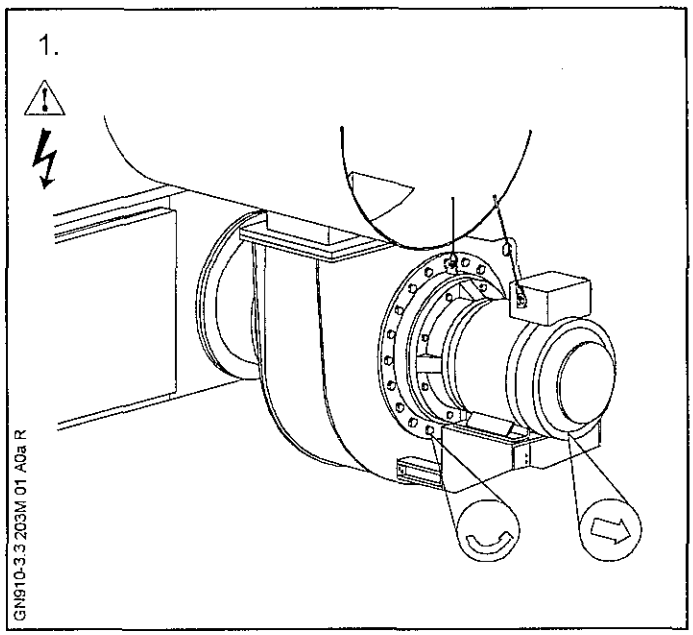
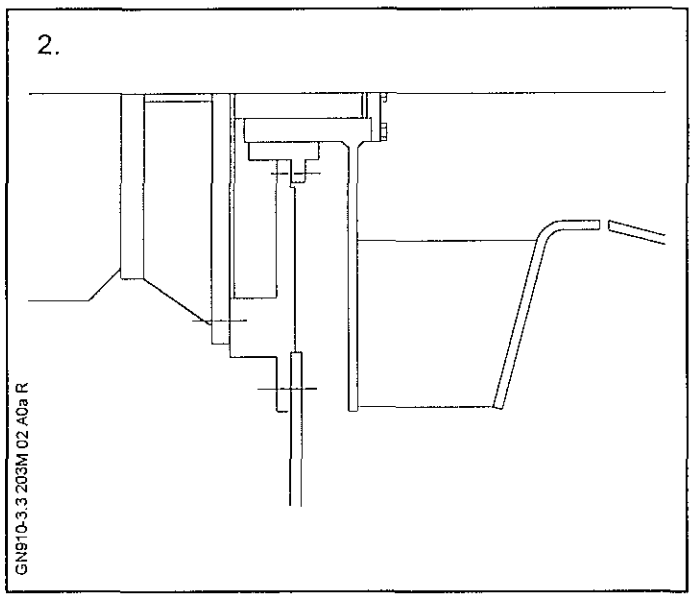
MITSUI ENGINEERING & SHIPBUILDING CO., LTD.
4E-91312

1. Disconnect the cable connections to the blower motors.

   Wire ropes with shackle as well as two tackles suspended from mountings on the gallery bracket are to be hooked on to the blower flange, before removing the screw in the flange.

2. The end cover complete with blower can now be pulled free of the suction pipe by means of the two tackles.



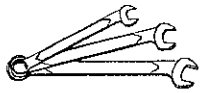


SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Entrance into the scavenge air box prohibited before cleaning
X	Block the starting mechanism	Do not enter area when over head lifting is being carried out
X	Shut off starting air supply	
	Engage turning gear	
X	Shut off cooling water	
	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value Unit
D-1	Water mist catcher	201 kg

Standard Tools: See Section 913



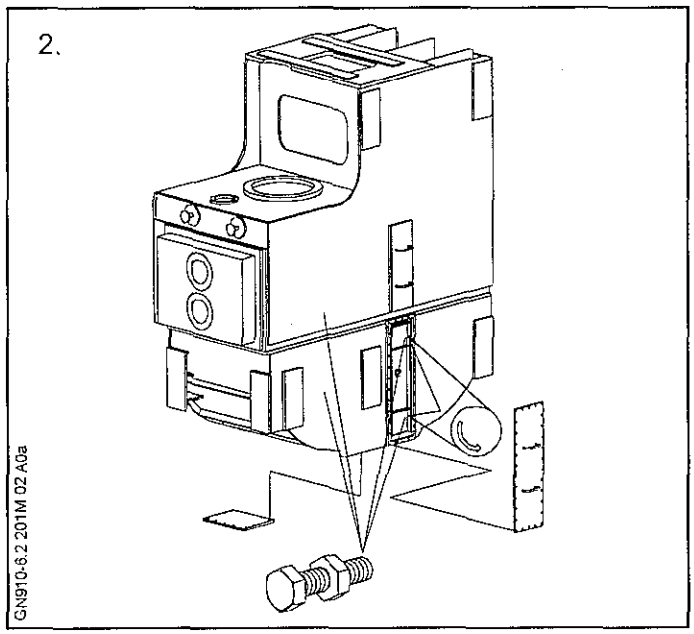
When referring to this page, please quote Data Sheet 110-6 Edition 01M
MITSUI ENGINEERING & SHIPBUILDING CO., LTD.
4E-91312

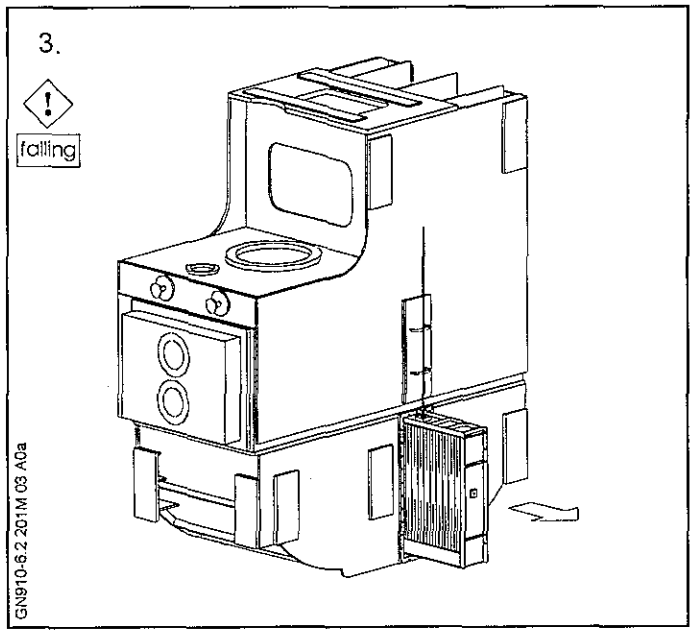
1. *Normally it is not necessary to remove the* water mist catcher elements from the scavenge air cooler housing. If, however, the water mist catcher elements have *fouled or are damaged, they must be* dismantled for cleaning or repair.

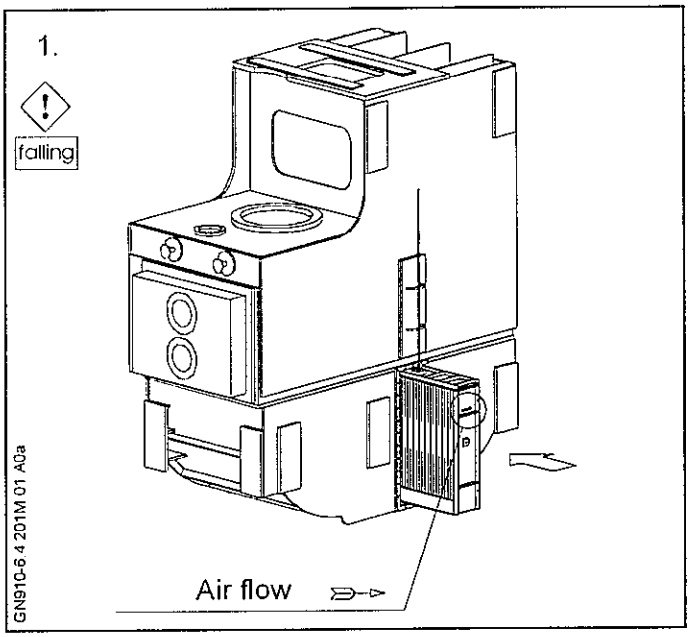
2. Remove the screw from the cover of the end of the air cooler frame.
   Dismount the cover.
   Dismount the small bottom end cover.

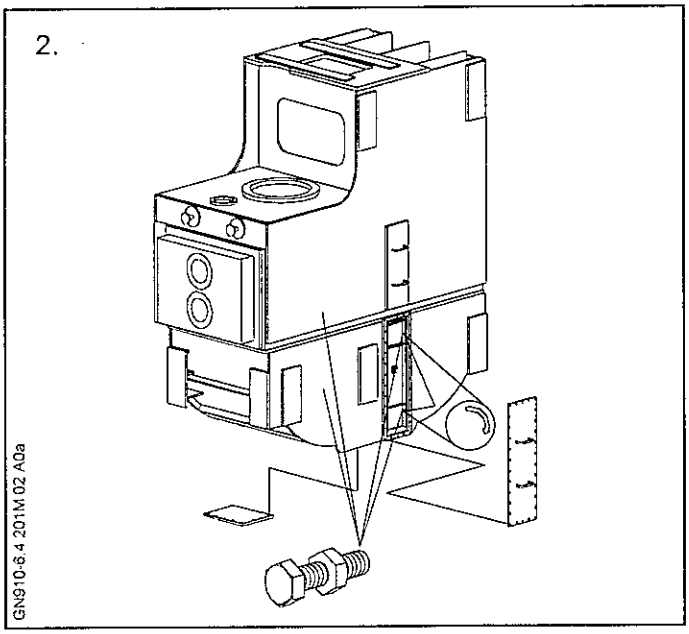
   Loosen the screws which fasten the water mist element to the cooler frame, through the small end cover.

3. Pull out the water mist element.









1. Push the water mist catcher elements into the scavenge air cooler housing.

Note!
Make sure to mount the elements in the same position as before dismantling. Check with the marking on the element.

2. After mounting, tighten the element to the air cooler frame.

   Finally, mount the end cover and small bottom end cover on the cooler frame.

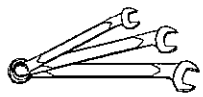
SAFETY PRECAUTIONS

X	Stopped engine
X	Block the starting mechanism
X	Shut off starting air supply
	Engage turning gear
X	Shut off cooling water
	Shut off fuel oil
	Shut off lubricating oil
	Lock turbocharger rotors

Data

Ref.	Description	Value Unit
D-1	Water mist catcher	235 kg

Standard Tools: See Section 913



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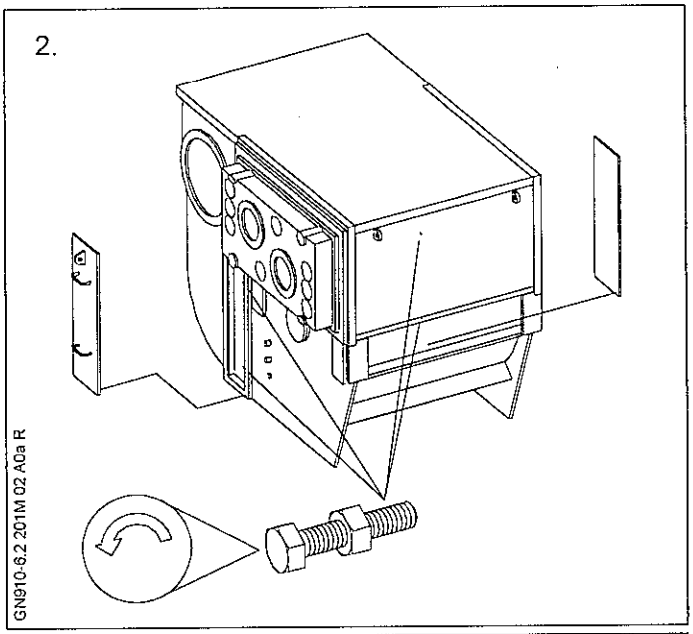
MITSUI ENGINEERING & SHIPBUILDING CO., LTD.
4E-91312

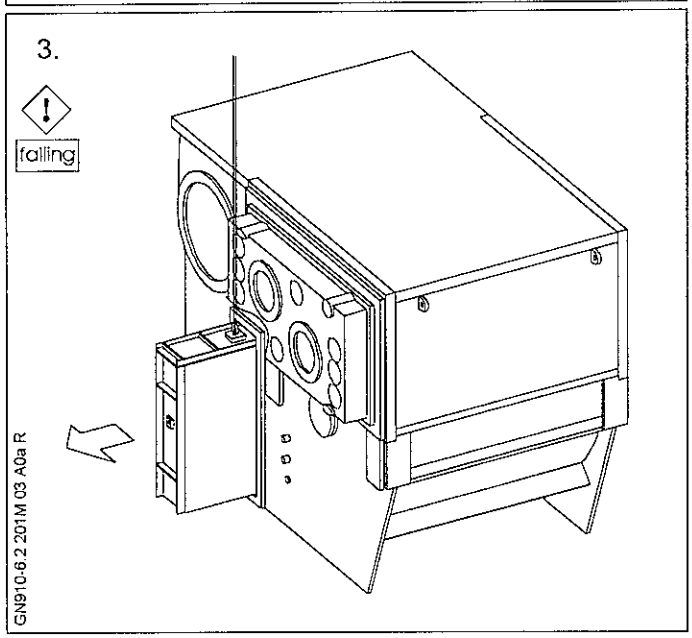
1. Normally it is not necessary to remove the water mist catcher elements from the scavenge air cooler housing. If, however, the water mist catcher elements have fouled or are damaged, they must be dismantled for cleaning or repair.

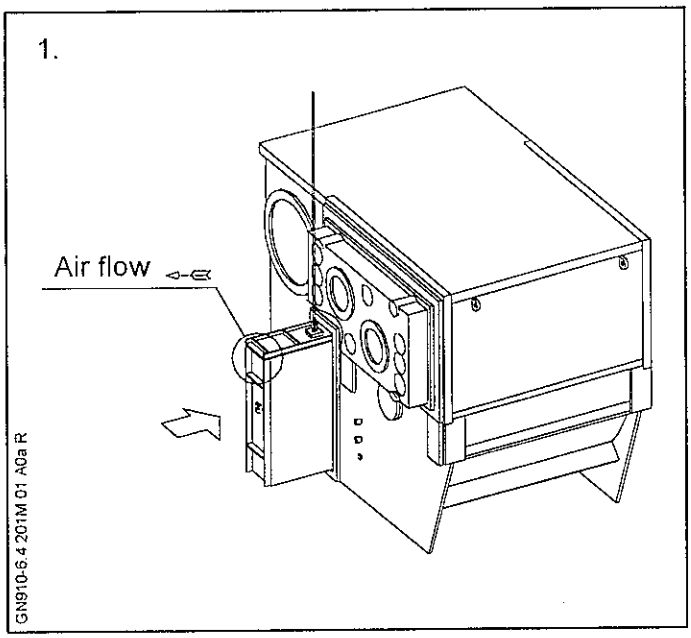
2. Remove the screws from the two covers, one on each end of the air cooler frame.

   Loosen the screws which fasten the water mist element to the cooler frame, through the small end cover.

3. Pull out the water mist element.





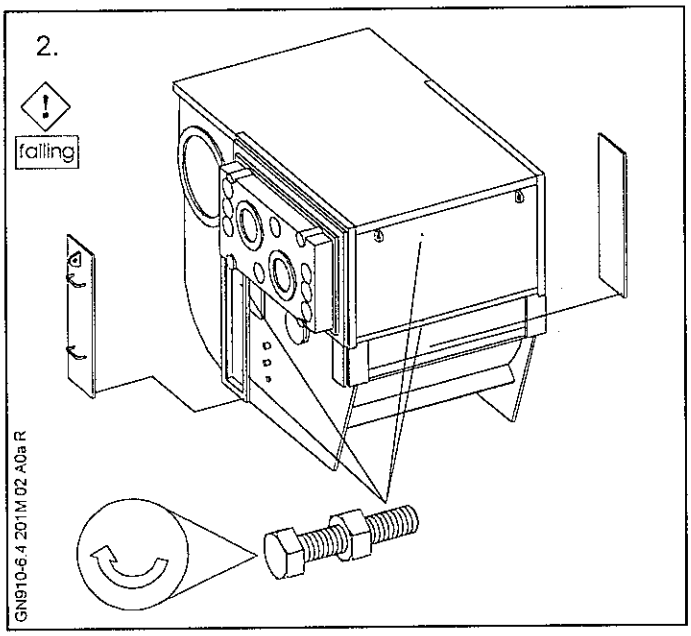


1. Push the water mist catcher elements into the scavenge air cooler housing.

Note!
Make sure to mount the elements in the same position as before dismantling. Check with the marking on the element.

2. After mounting, tighten the element to the air cooler frame.

   Finally, mount the two covers on the cooler frame.

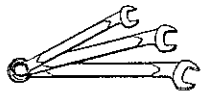


SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Entrance into the scavenge air box prohibited before ventilating
X	Block the starting mechanism	
X	Shut off starting air supply	
	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

Data

Ref.	Description	Value	Unit

Standard Tools: See Section 913



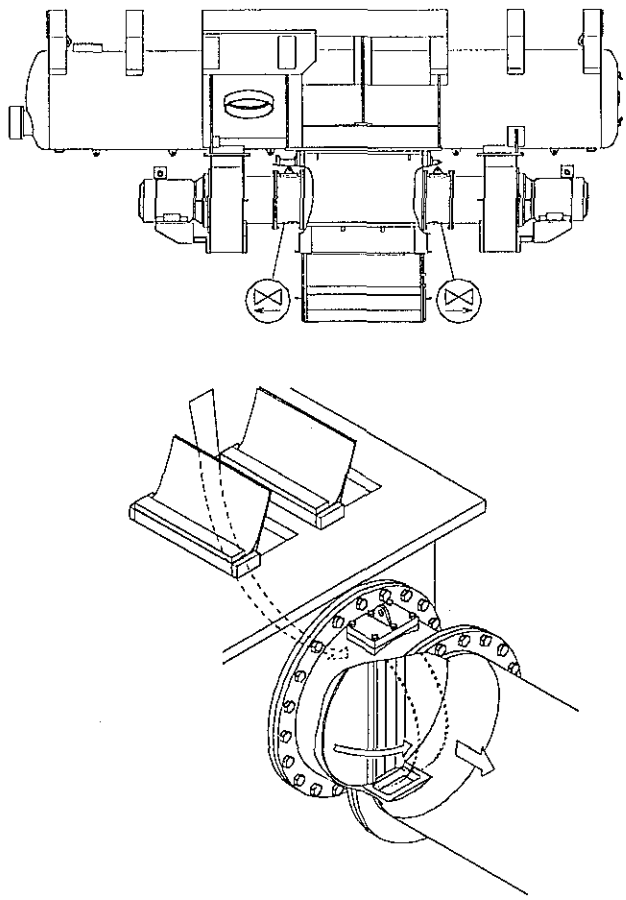
1. It is important that the automatic non-return valves (butterfly valves) always function easily and unimpeded.

   The movability of the valve flaps should therefore be checked at suitable intervals. The valve shall open for the air flow from the valve housing to the auxiliary blower.

   Access to the butterfly valves is made through the manhole covers of the receiver after the engine has stopped running and it has been ascertained that the air in the receiver is pure.

   Open the valve plate of the non-return valve which has been fitted on the upper face of the valve housing in the receiver by means of a hand.
   By inserting a hand from this opening, inspect the movability of the two valve flaps for the butterfly valves.
   The flaps shall move so easily that the finger up.

1.



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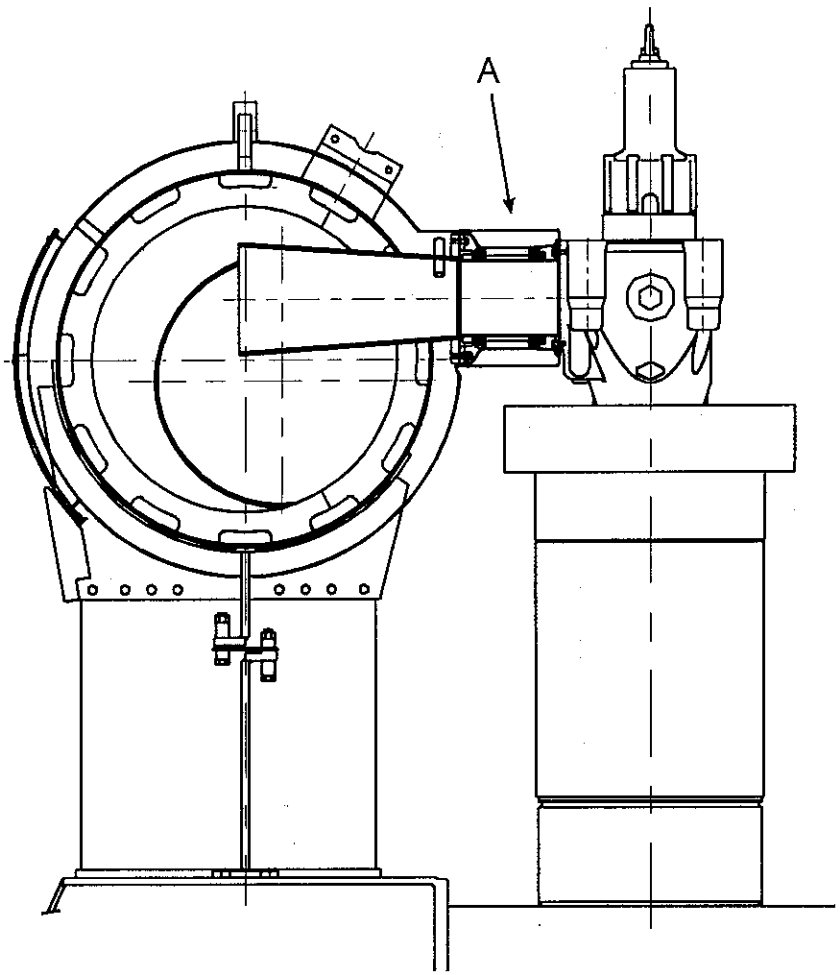
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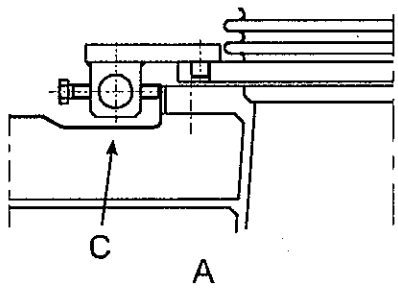
C
A

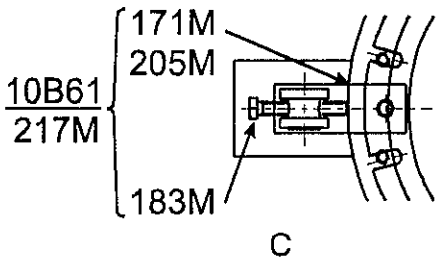
171M
205M
10B61
217M
183M
C

Plate 91061-34Ma Turbocharger System - Tools

Item No.	Part Description	MES Tools No.	
171M	Compensator extender	(10B61)	
183M	Screw	(10B61)	
205M	Nut	(10B61)	
217M	Compensator extender, complete	10B61	

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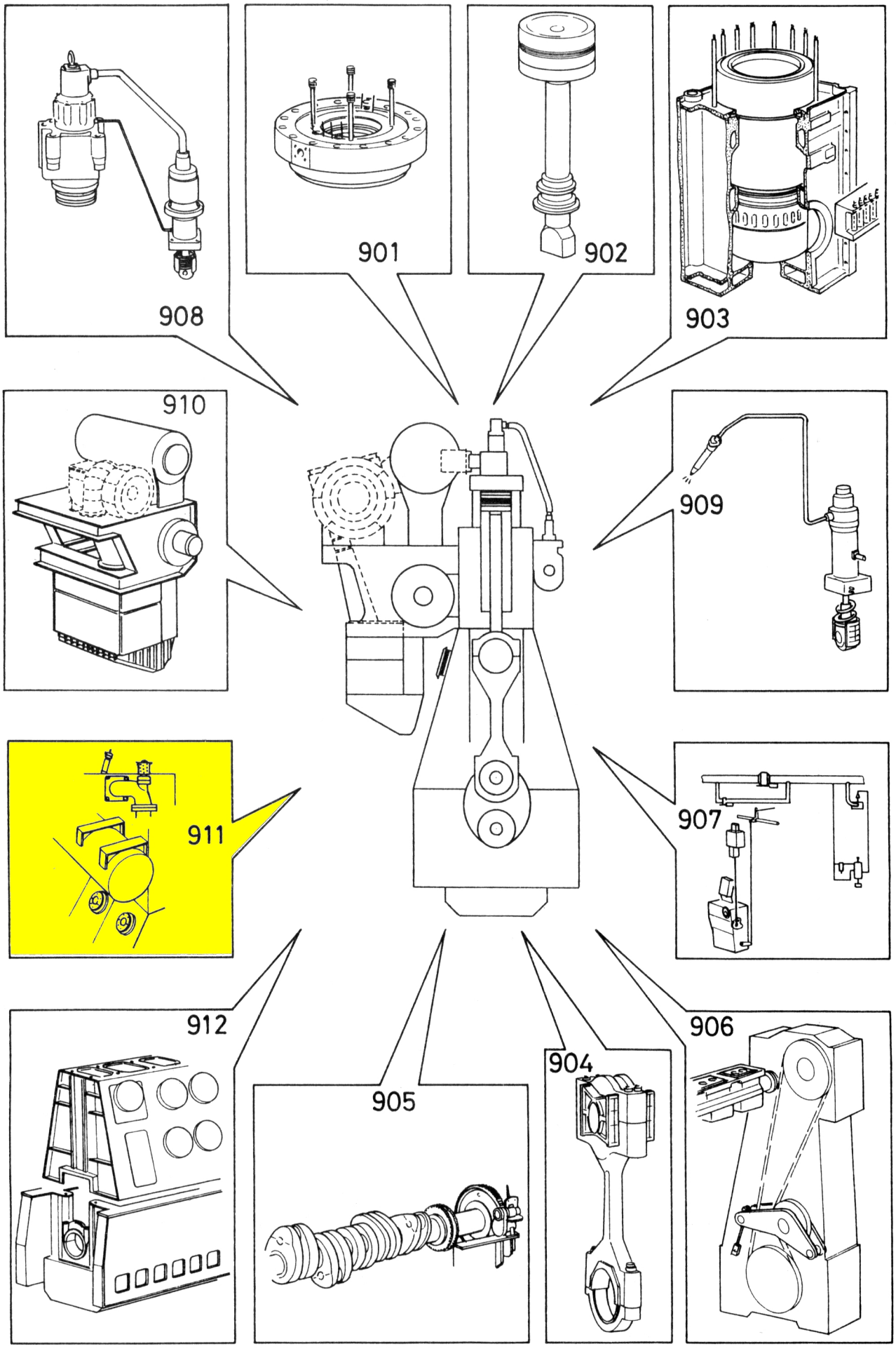
SAFETY EQUIPMENT

ASSEMBLY OF LARGE PARTS

GENERAL TOOLS

MITSUI
MAN
B&W

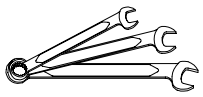


SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of high pressure oil
X	Block the starting mechanism	
X	Shut off starting air supply	
	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

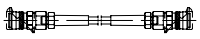
Data

Ref.	Description	Value	Unit
D-1	Tightening torque–valve housing	45	Nm
D-2	Opening pressure	20 (200 bar) +/-0.5 MPa (+/-5 bar)	MPa

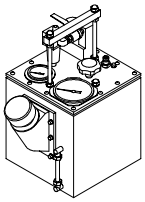
Standard Tools: See Section 913



40-280 Nm



3 m



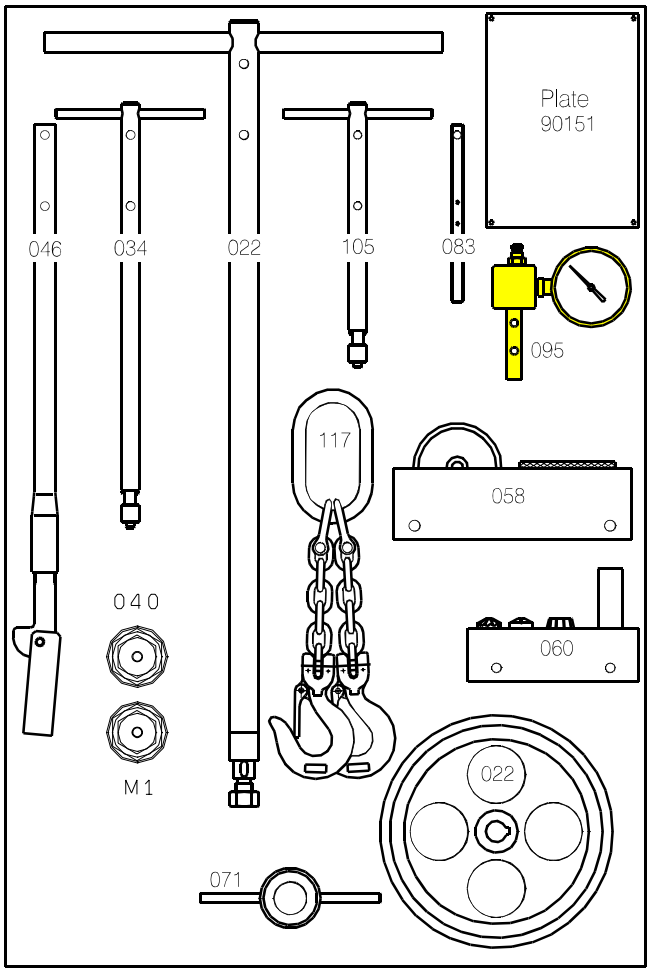
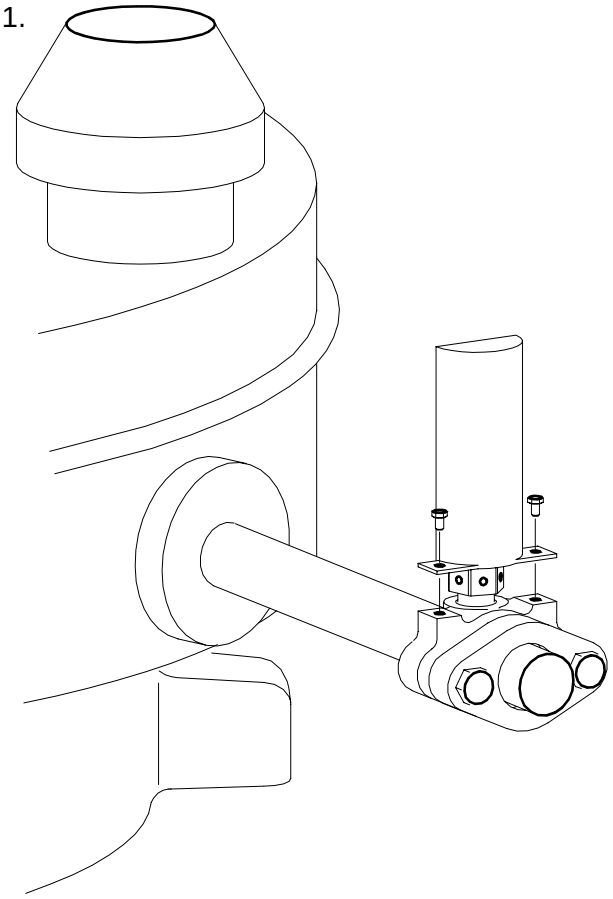


Plate
90151
046
034
022
105
083
095
117
058
040
060
M1
022
071

1. Remove the guard surrounding the safety valve.

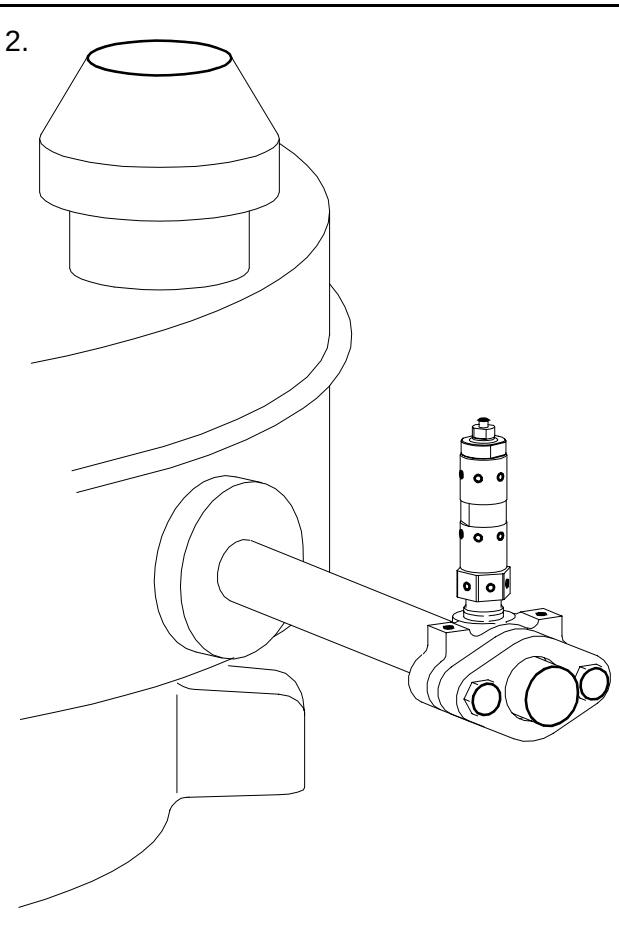
2. Unscrew the safety valve from the extension pipe.

1.



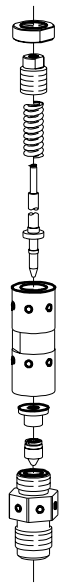
GN911-1.2 203 01

2.



GN911-1.2 203 02

1.



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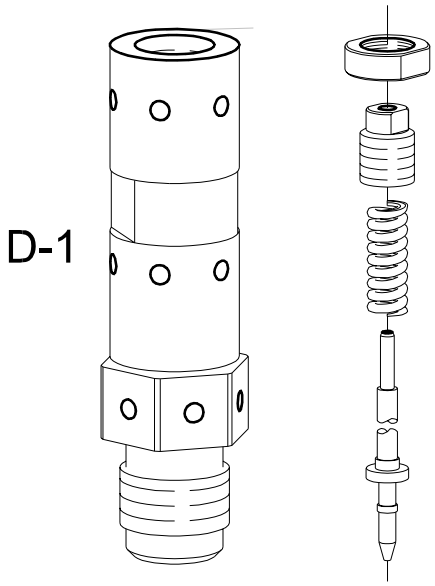
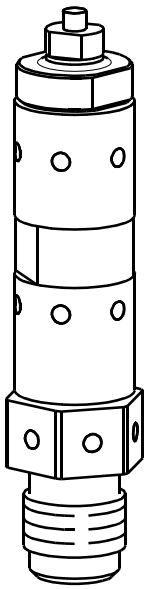


HM911-1.0 27 02

3.



HM911-1.0 27 03

1. If necessary, dismantle the safety valve and clean all the parts in either gas oil, kerosene, or 'electro-cleaner'.

2. Assemble the safety valve in two steps:

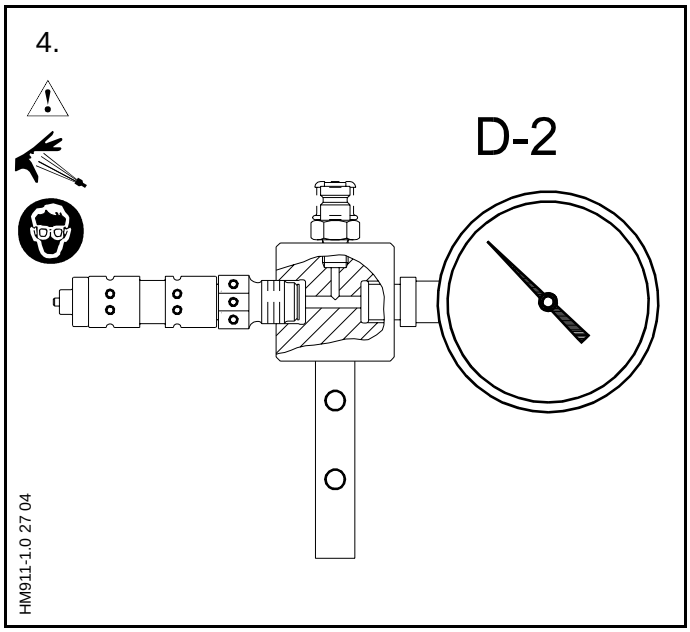
   - Insert the valve flap and the stop ring in the valve guide and screw on the valve housing.
   - Tighten the housing to D-1, loosen and tighten again to D-1.

3. Then mount:

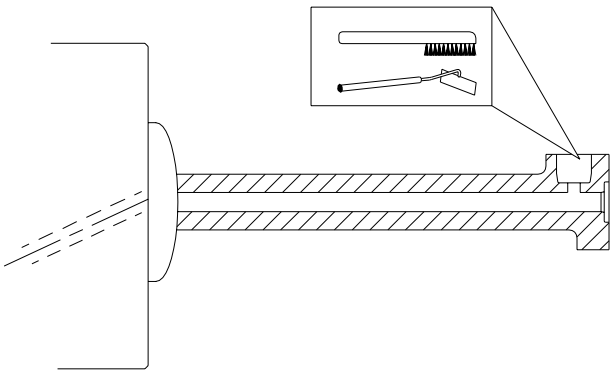
   - the valve spindle
   - the spring
   - the adjusting screw
   - the lock nut

4. To set the safety valve opening pressure:

   - Set up the safety valve in the testing device.
   - Connect the testing device to the hydraulic pump.
   - Loosen the lock nut on the safety valve.
   - Turn the adjusting screw until the valve just closes.
   - Bleed the valve and hose until oil, without air bubbles, flows out from the openings of the safety valve.
   - Tighten the adjusting screw of the safety valve until the correct pressure is indicated (see D-2).
   - Tighten the lock nut.
   - Test the opening pressure.
   - Remove the valve from the testing device.



1.



GN911-1.4 203 01

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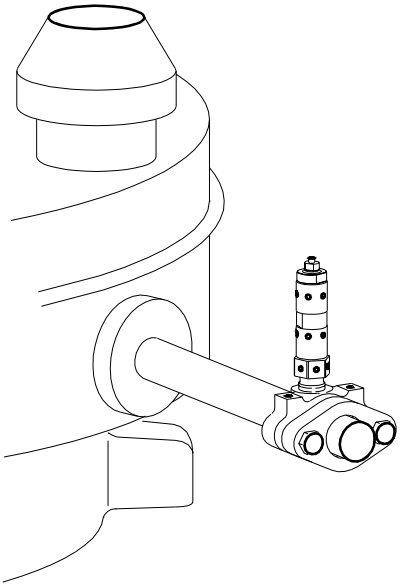
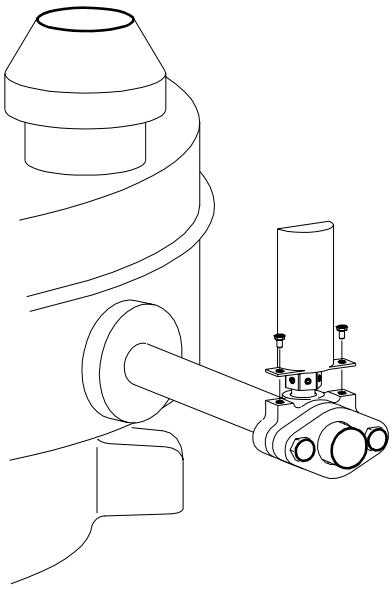


GN911-1.2 203 02

3.



GN911-1.2 203 01

1. Pierce the bore in the extension pipe, and blow it clean.

   Clean the sealing ring grooves.

2. Mount a new or overhauled safety valve and a new sealing ring on the extension pipe.

   When mounting the safety valve on the extension pipe, apply tools only on the hexagon on the safety valve.

3. Mount the guard surrounding the safety valve.

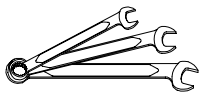
SAFETY PRECAUTIONS

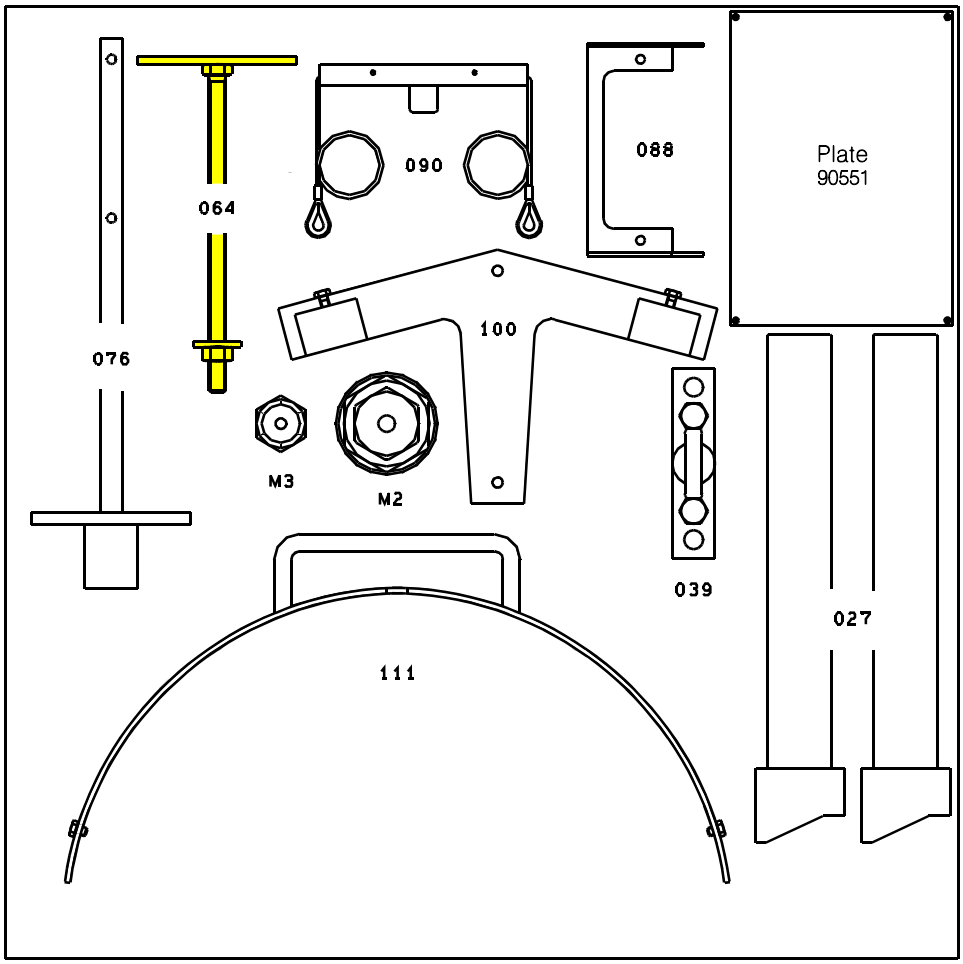
X	Stopped engine
	Block the starting mechanism
	Shut off starting air supply
	Engage turning gear
	Shut off cooling water
	Shut off fuel oil
X	Shut off lubricating oil
	Lock turbocharger rotors

Data

Ref.	Description	Value	Unit

Standard Tools: See Section 913




076
064
090
088
Plate
90551
100
M3
M2
039
027
111

1. Test the functioning of the relief valves on the crankcase wall by means of the tool supplied.

2. Screw the tool into the valve plate nut.

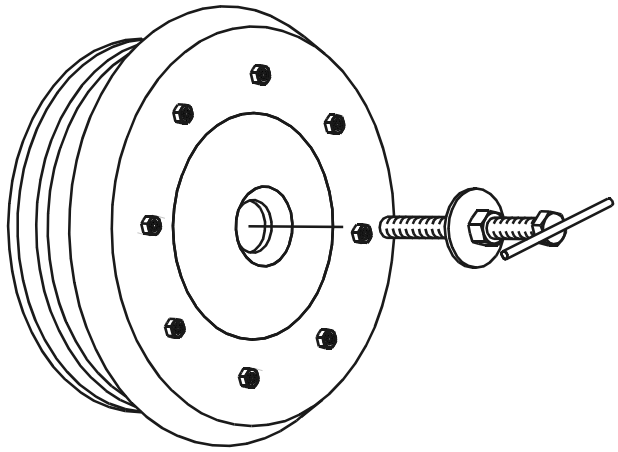
3. Turn the nut of the tool 20-25 revolutions to open the valve.

4. Turn back the nut and remove the tool.

5. During running of the engine check if there are any leaks.

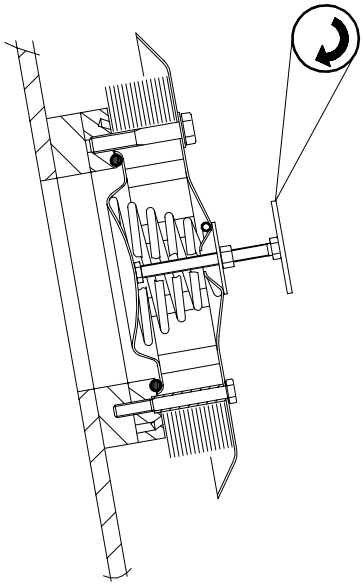
   If a leak occurs, dismantle the relief valve and fit a new O-ring.

1.



HM911-2.0 27 01

2.



GN911-2.0 27 02

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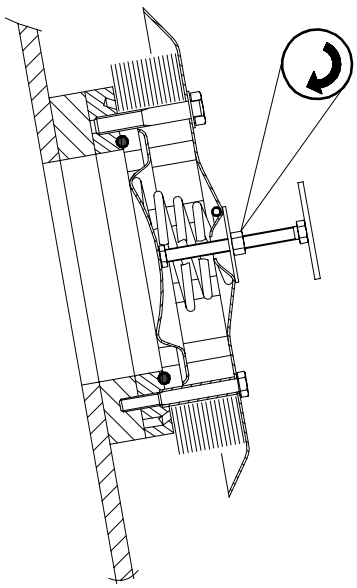

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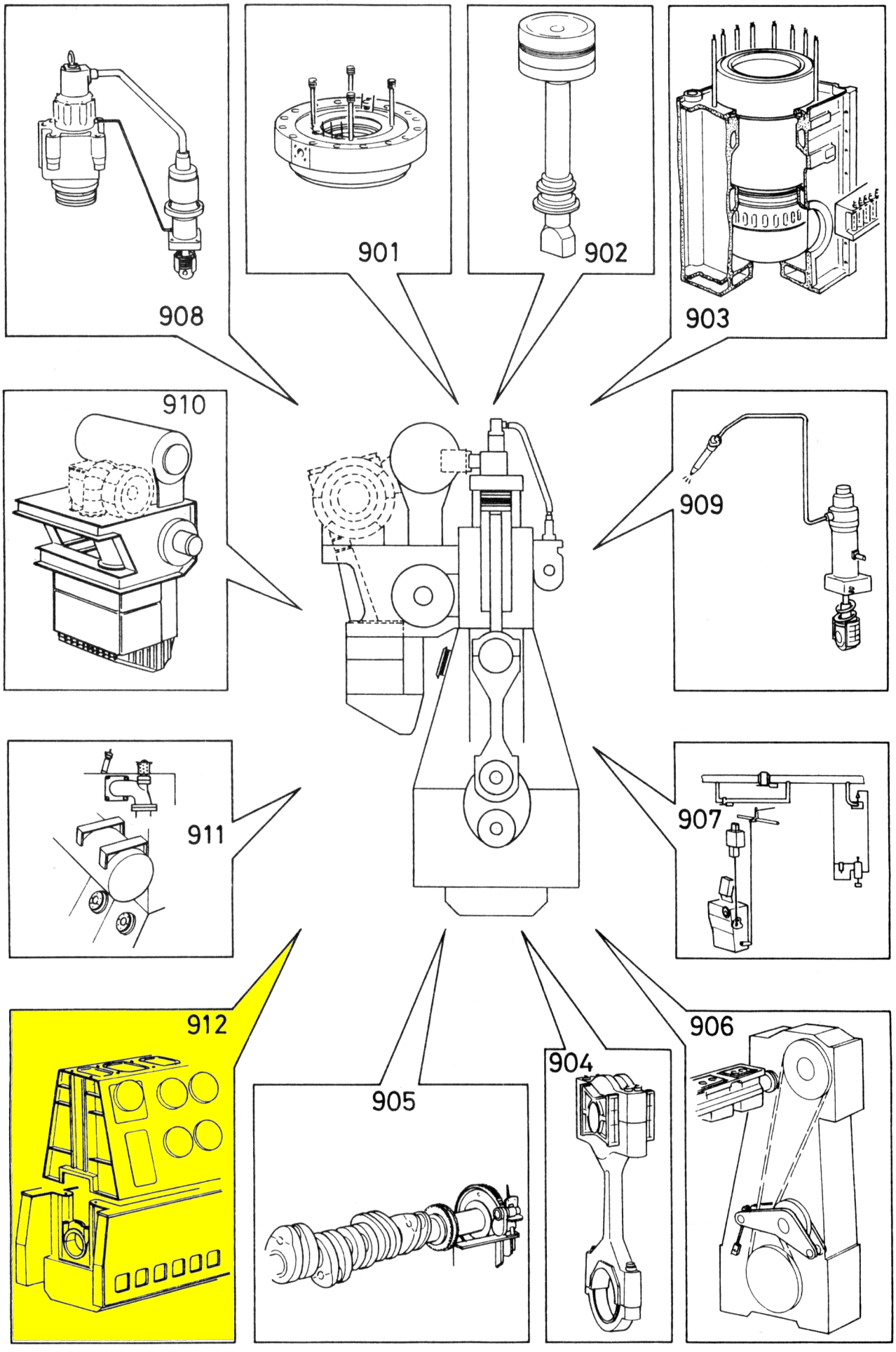
MITSUI
MAN
B&W



SAFETY PRECAUTIONS		CAUTION FOR SAFETY
☐	Stopped engine	Risk of high pressure oil
☐	Block the starting mechanism	Protectors to be worn
☐	Shut off starting air supply	
☐	Engage turning gear	
☐	Shut off cooling water	
☐	Shut off fuel oil	
☐	Shut off lubricating oil	
☐	Lock turbocharger rotors	

Data

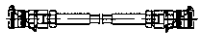
Ref.	Description	Value Unit
D-1	Tightening pressure for holding down bolts	150 MPa (1500 bar)
D-2	Tightening pressure for end chock bolts	150 MPa (1500 bar)
D-3	Increased tightening pressure (only for initial tightening of end chock bolts)	165 MPa (1650 bar)
D-4	Hydraulic pressure for cylinder cover:	
	- tightening	150 MPa (1500 bar)
	- dismantling	150-165 MPa (1500- bar) 1650

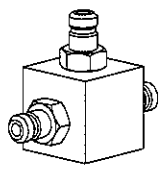
Note!
Permit to Max. 165 MPa (1650 bar) only in a short time.

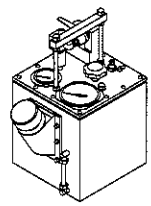
D-5	Check holding down bolts and end chock bolts for correct tightening after the following service hours:	
	1st check	500 hours
	2nd check	1000 hours
	3rd check	2000 hours
	4th check	4000 hours
	5th check	8000 hours
	Subsequently at intervals of	8000 hours

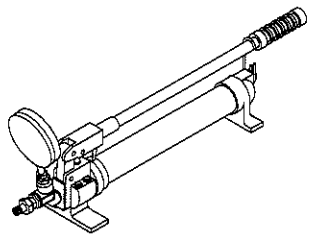
Engine on **Cast Iron** supporting chocks

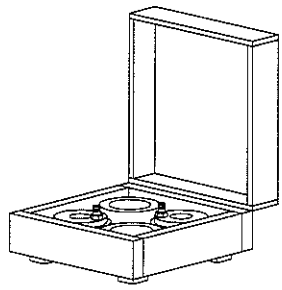
Standard Tools: See Section 913











Note!
The hydraulic jack used for tightening the holding down bolts is marked with: For: Holding down bolts The larger jack used for tightening the end chock bolts is marked with: For: End chock bolts

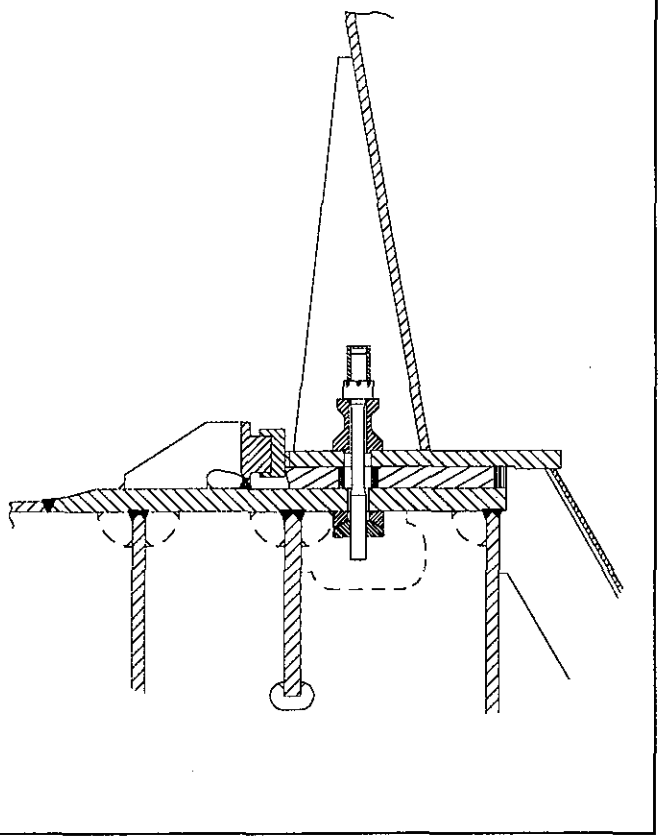
Hydraulic tightening of holding down bolts and end chock bolts is carried out as detailed in section 913-1. The normal tightening pressure is indicated on the data sheet and is also stamped on the tightening tool.

For the initial tightening of the end chock bolts, raise the pump pressure to the value indicated on the data sheet. Then tighten the nut firmly and relieve the hydraulic tool completely of pressure. After about two minutes, raise the pressure again until the nut can be loosened. Now adjust the pressure to the normal tightening pressure indicated, tighten the nut firmly, and relieve the system of pressure.

For the initial tightening of end chock bolts, the following alternative procedure can be followed:

Tighten the bolts to the increased pressures stated on the data sheet and leave the bolts so tightened till after the sea trials, following which they are to be retightened to the normal value indicated on the data sheet and on the hydraulic tightening tool.

1.



Checking the Bolt Tightening

1. The holding down bolts and end chock bolts must be checked for correct tightness at the intervals indicated on the data sheet.

   Before checking the bolt tightening, check the fitting of the supporting chocks as far as conditions of access permit.

   To check the bolt tightening, raise the pressure on the hydraulic tool slowly while constantly attempting to loosen the nut with the tommy bar. The oil pressure indicated on the pressure gauge when the nut comes loose ('loosening pressure') is noted down in the checking table, see drawing Nos. 782225-0 and 782226-2, following which the bolts are tightened to the normal tightening pressure.

   The condition of the bolted joints, and thus the general condition of the foundation, can be effectively checked by comparing the tables from successive bolt checks.

   If the 'loosening pressure' is below 80 per cent of the tightening pressure, the correct fitting of the relative chocks shall always be checked with loose bolts. If the chocks are in position and correctly fitted, the bolts should be taken out for inspection of threads and contact faces.

Cast Iron Supporting Chocks

2. The supporting chocks shall be so adapted that a 5/100 mm feeler gauge cannot enter at more than 5 per cent of the entire circumference. Whether the chocks are in position can, when the respective bolts have been loosened, be checked by gently tapping on the chocks with a hook iron.

   When a loose chock has been moved into position, the fitting of the adjacent chocks shall be checked with a feeler gauge.

   If several chocks positioned next to each other have worked loose, crankshaft deflection readings must be taken after the chocks have been refitted.

Side Chocks and Side Chock Liners

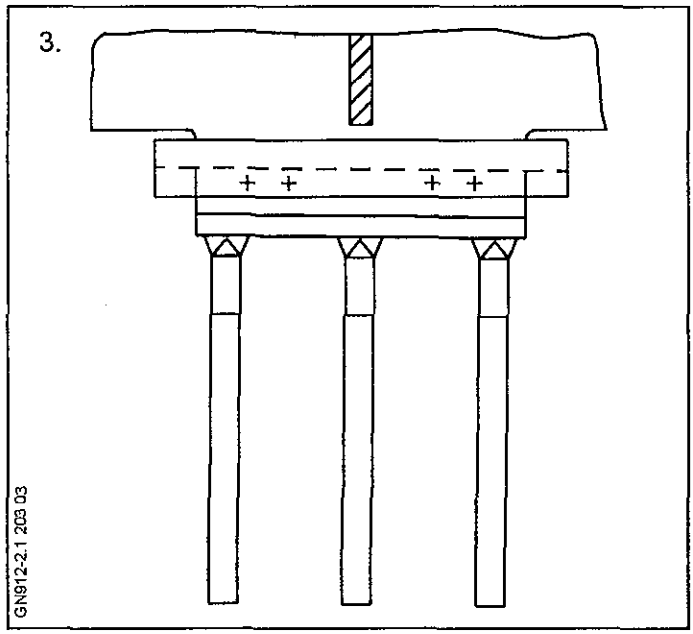
3. After fitting the liners to an 80 per cent contact area on both sides of the liners, knock the liners a further 3 to 4 mm inwards.

   The liners located in way of each main bearing on either side of the engine must be fitted and knocked into position simultaneously.

   The first time the ship is sailing in a fully-loaded condition after the engine has been operating for 1,000 hours, all side chocks should be checked to see whether the liners can be knocked further inward.

   The fit of the side chock liners should be checked with a feeler gauge each time the loosening pressure of the holding down bolts is checked, and thus at the same time intervals.

   The feeler gauge is applied at the 7 points indicated on drawing No. 782226-2, and the measurements found are entered in the relevant table. These results are used to determine whether refitting or, possibly, replacement of the liners is necessary.



If the measurements at 3 points or more have increased 5/100 mm or more from the initial results, we recommend that the following procedure is followed:

1. Loosen the hexagon screws.

2. Try to knock the liner further inward.

3. Measure again at the 7 points indicated on drawing No. 782226-2.

If this procedure does not improve the situation, the liner must be removed, and it must be checked that the actual contact area is more than 80 per cent of the possible contact surface areas on both sides of the liner.

The liners are secured in their correct position by means of hexagon socket set screws with cup point.

MITSUI MAN B&W

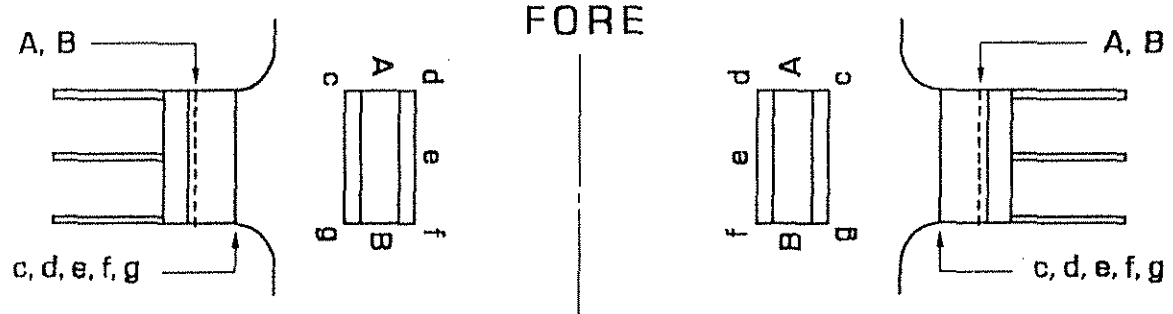
Checking Hydraulically Tightened Holding Down Bolts Drwg. 782225-0
MC Engines

Engine frame No.	Bolt No.	Port side pressure	Port side % dev.	Port side remarks	Cylinder No.	Starboard side pressure	Starboard side % dev.	Starboard side remarks	Bolt No.	Engine frame No.
1	1								1	1
	2								2	
	3								3	
	4				1				4	
2	1								1	2
	2								2	
	3								3	
	4				2				4	
3	1								1	3
	2								2	
	3								3	
	4				3				4	
4	1								1	4
	2								2	
	3								3	
	4								4	
5	1								1	5
	2								2	
	3								3	
	4								4	
6	1								1	6
	2								2	
	3								3	
	4								4	
7	1								1	7
	2								2	
	3								3	
	4								4	
8	1								1	8
	2								2	
	3								3	
	4								4	
9	1								1	9
	2								2	
	3								3	
	4								4	
10	1								1	10
	2								2	
	3								3	
	4								4	
11	1								1	11
	2								2	
	3								3	
	4								4	
12	1								1	12
	2								2	
	3								3	
	4								4	
13	1								1	13
	2								2	
	3								3	
	4								4	
14	1								1	14
	2								2	
	3								3	
	4								4	
	1								1	

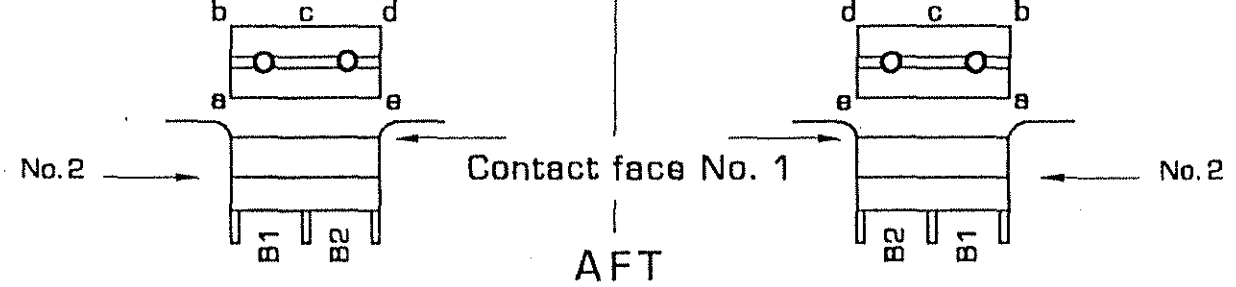
Drwg. 782226-2 **Checking Side Chocks and End Chocks with Bolts MC Engines**

Port side									Starboard side								
Chock No.	Point							Cylinder No.	Point							Chock No.
	A	B	c	d	e	f	g		A	B	c	d	e	f	g	
1								1								1
2								2								2
3								3								3
4																4
5																5
6																6
7																7
8																8
9																9
10																10
11																11
12																12
13																13
14																14

FORE



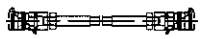
Port side									Starboard side								
Ch No.	Bolt No.	Pressure MPa (bar)	Deviation %	Point					Point					Deviation %	Pressure MPa (bar)	Bolt No.	Ch No.
				a	b	c	d	e	a	b	c	d	e				
E	1															1	E
	2															2	



4E-91314

SAFETY PRECAUTIONS		CAUTION FOR SAFETY
☐	Stopped engine	Risk of high pressure oil
☐	Block the starting mechanism	Protectors to be worn
☐	Shut off starting air supply	
☐	Engage turning gear	
☐	Shut off cooling water	
☐	Shut off fuel oil	
☐	Shut off lubricating oil	
☐	Lock turbocharger rotors	

Standard Tools: See Section 913



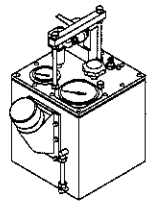
Data

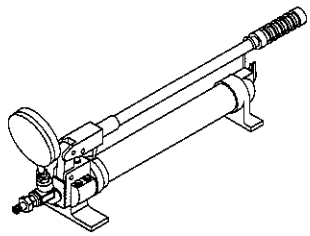
Ref.	Description	Value	Unit
D-1	Tightening pressure for holding down bolts	150	MPa (1500 bar)
D-2	Tightening pressure for end chock bolts	150	MPa (1500 bar)
D-3	Increased tightening pressure (only for initial tightening of end chock bolts)	165	MPa (1650 bar)
D-4	Hydraulic pressure for cylinder cover:		
	- tightening	150	MPa (1500 bar)
	- dismantling	150-165	MPa (1500- bar) 1650

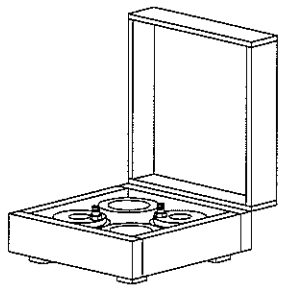
Note!
Permit to Max. 165 MPa (1650 bar) only in a short time.

D-5	Check holding down bolts and end chock bolts for tightness after the following service hours:	
	1st check	500 hours
	2nd check	1000 hours
	3rd check	2000 hours
	4th check	4000 hours
	5th check	8000 hours
	Subsequently at intervals of	8000 hours

Engine on **Epoxy** supporting chocks







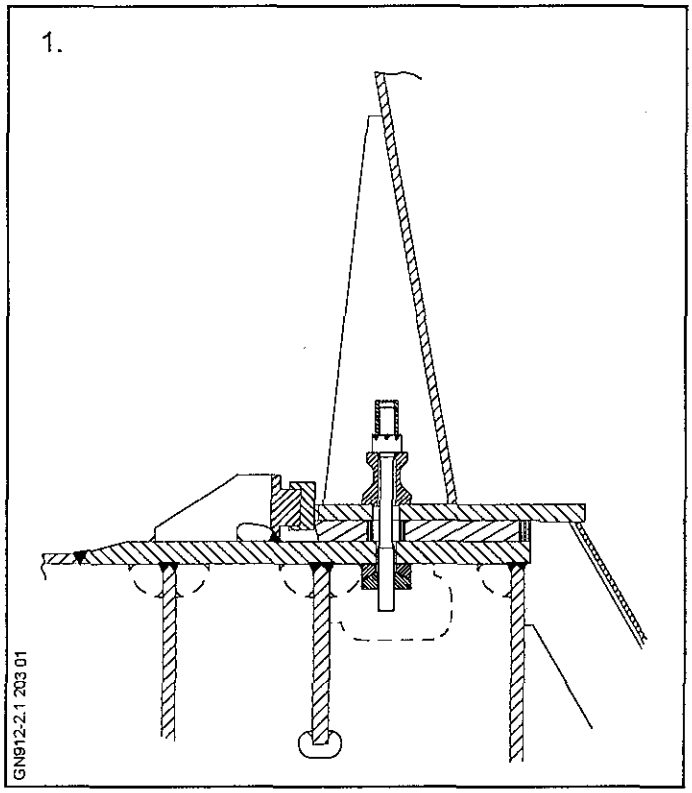
Note!
The hydraulic jack used for tightening the holding down bolts is marked with: For: Holding down bolts The larger jack used for tightening the end chock bolts is marked with: For: End chock bolts

Hydraulic tightening of holding down bolts and end chock bolts is carried out as detailed in section 913-1. The normal tightening pressure is indicated on the data sheet and is also stamped on the tightening tool.

For the initial tightening of the end chock bolts, raise the pump pressure to the value indicated on the data sheet. Then tighten the nut firmly and relieve the hydraulic tool completely of pressure. After about two minutes, raise the pressure again until the nut can be loosened. Now adjust the pressure to the normal tightening pressure indicated, tighten the nut firmly, and relieve the system of pressure.

For the initial tightening of end chock bolts, the following alternative procedure can be followed:

Tighten the bolts to the increased pressures stated on the data sheet and leave the bolts so tightened till after the sea trials, following which they are to be retightened to the normal value indicated on the data sheet and on the hydraulic tightening tool.



Checking the Bolt Tightening

1. The holding down bolts and end chock bolts must be checked for correct tightness at the intervals indicated on the data sheet.

   For this purpose, raise the pressure on the hydraulic tool slowly while constantly attempting to loosen the nut with the tommy bar. The oil pressure indicated on the pressure gauge when the nut comes loose ('loosening pressure') is to be noted down in the checking table, see drawing Nos. 782225-0 and 782226-2, following which the bolts are tightened to the normal tightening pressure.

   The condition of the bolted joints, and thus the general condition of the foundation, can be effectively checked by comparing the tables from successive bolt checks.

   If the 'loosening pressure' is below 80 per cent of the tightening pressure, the relative chocks shall always be checked for possible defects. If the chocks are in position and in order, the bolts should be taken out for inspection of threads and contact faces.

Checking of Epoxy Supporting Chocks

2. If a number of measuring pins have been welded to the tanktop, the heights of the epoxy supporting chocks are to be checked immediately after finishing the checking of the loosening pressures of the holding down bolts and the retightening of these.

   The distance between the measuring pins and the bedplate is to be measured with a blade gauge and noted down. Any possible settling of the chocks during the intervals between measurements can thereby be followed.

Side Chocks and Side Chock Liners

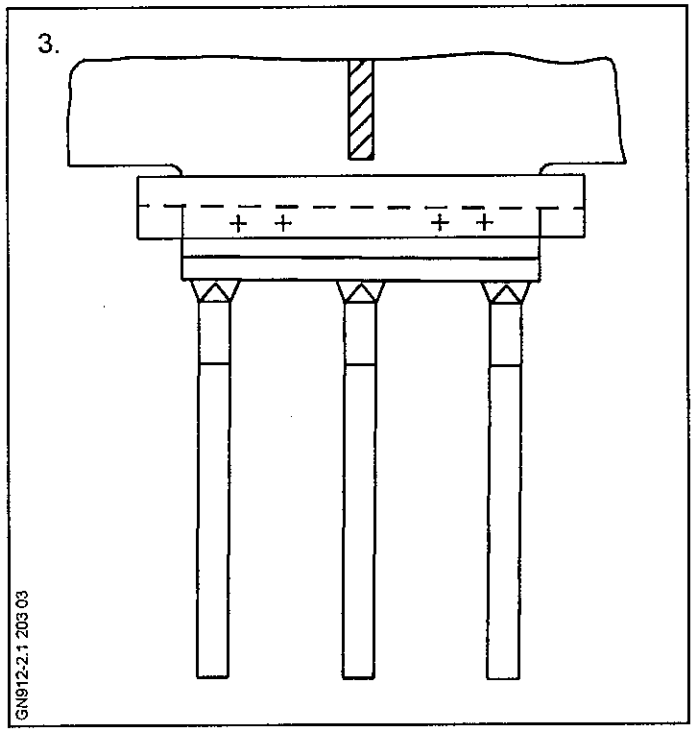
3. After fitting the liners to an 80 per cent contact area on both sides of the liners, knock the liners a further 3 to 4 mm inwards.

   The liners located in way of each main bearing on either side of the engine must be fitted and knocked into position simultaneously.

   The first time the ship is sailing in a fully-loaded condition after the engine has been operating for 1,000 hours, all side chocks should be checked to see whether the liners can be knocked further inward.

   The fit of the side chock liners should be checked with a feeler gauge each time the loosening pressure of the holding down bolts is checked, and thus at the same time intervals.

   The feeler gauge is applied at the 7 points indicated on drawing No. 782226-2, and the measurements found are to be entered in the relevant table. These results are used to determine whether refitting or, possibly, replacement of the liners is necessary.



If the measurements at 3 points or more have increased 5/100 mm or more from the initial results, we recommend that the following procedure is followed:

1. Loosen the hexagon screws.

2. Try to knock the liner further inward.

3. Measure again at the 7 points indicated on drawing No. 782226-2.

If this procedure does not improve the situation, the liner must be removed, and it must be checked that the actual contact area is more than 80 per cent of the possible contact surface areas on both sides of the liner.

The liners are secured in their correct position by means of hexagon socket set screws with cup point.

MITSUI MAN B&W

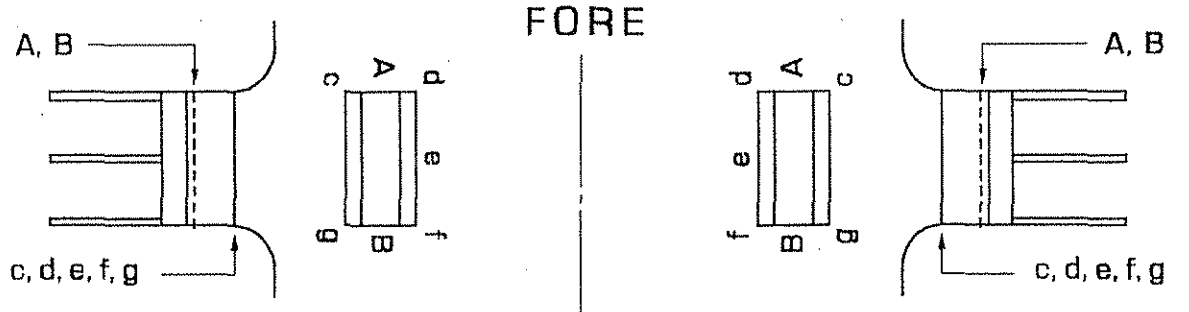
Checking Hydraulically Tightened Holding Down Bolts Drwg. 782225-0
MC Engines

Engine frame No.	Bolt No.	Port side pressure	Port side % dev.	Port side remarks	Cylinder No.	Starboard side pressure	Starboard side % dev.	Starboard side remarks	Bolt No.	Engine frame No.
1	1								1	1
	2								2	
	3								3	
	4				1				4	
2	1								1	2
	2								2	
	3								3	
	4				2				4	
3	1								1	3
	2								2	
	3								3	
	4				3				4	
4	1								1	4
	2								2	
	3								3	
	4								4	
5	1								1	5
	2								2	
	3								3	
	4								4	
6	1								1	6
	2								2	
	3								3	
	4								4	
7	1								1	7
	2								2	
	3								3	
	4								4	
8	1								1	8
	2								2	
	3								3	
	4								4	
9	1								1	9
	2								2	
	3								3	
	4								4	
10	1								1	10
	2								2	
	3								3	
	4								4	
11	1								1	11
	2								2	
	3								3	
	4								4	
12	1								1	12
	2								2	
	3								3	
	4								4	
13	1								1	13
	2								2	
	3								3	
	4								4	
14	1								1	14
	2								2	
	3								3	
	4								4	
	1								1	

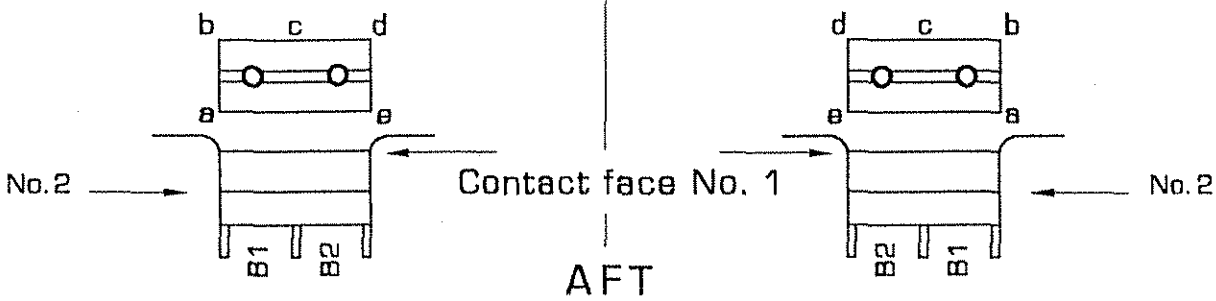
Drwg. 782226-2 Checking Side Chocks and End Chocks with Bolts
MC Engines

Port side									Starboard side								
Chock No.	Point							Cylinder No.	Point							Chock No.
	A	B	c	d	e	f	g		A	B	c	d	e	f	g	
1								1								1
2								2								2
3								3								3
4																4
5																5
6																6
7																7
8																8
9																9
10																10
11																11
12																12
13																13
14																14

FORE



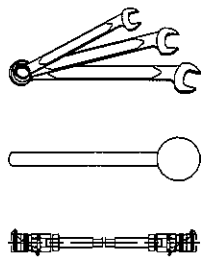
Port side										Starboard side									
Ch No.	Bolt No.	Pressure MPa (bar)	Deviation %	Point						Point					Deviation %	Pressure MPa (bar)	Bolt No.	Ch No.	
				a	b	c	d	e		a	b	c	d	e					
E	1																1	E	
	2																2		



4E-91314

SAFETY PRECAUTIONS		CAUTION FOR SAFETY
X	Stopped engine	Risk of high pressure oil
X	Block the starting mechanism	Protectors to be worn
X	Shut off starting air supply	
	Engage turning gear	
	Shut off cooling water	
	Shut off fuel oil	
	Shut off lubricating oil	
	Lock turbocharger rotors	

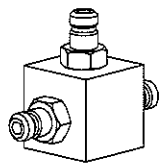
Standard Tools: See Section 913

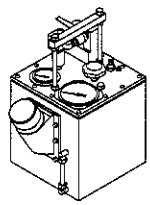


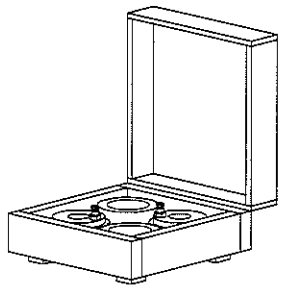
Data

Ref.	Description	Value Unit
D-1	Hydraulic pressure	
	- tightening	150 MPa (1500 bar)
	- dismantling	150-165 MPa (1500-1650 bar)
D-2	Hydraulic pressure for cylinder cover:	
	- tightening	150 MPa (1500 bar)
	- dismantling	150-165 MPa (1500-1650 bar)

Note!
Permit to Max. 165 MPa (1650 bar) only in a short time.







Stay Bolts

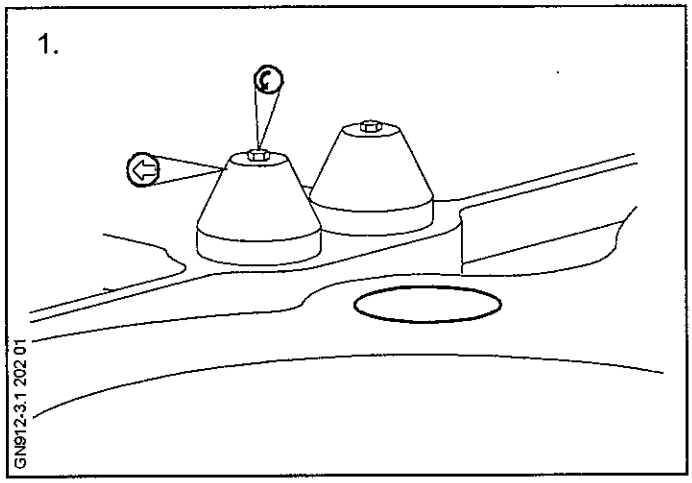
Checking

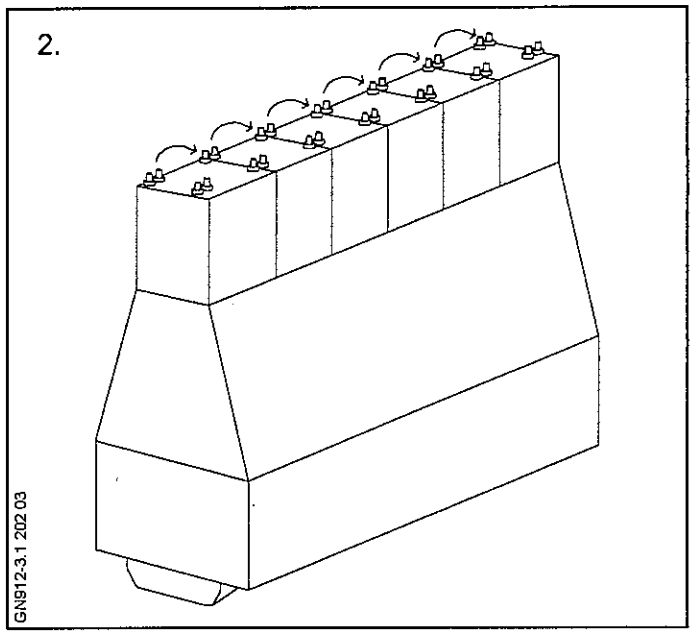
1. Before retightening the stay bolts, remove the protective caps.

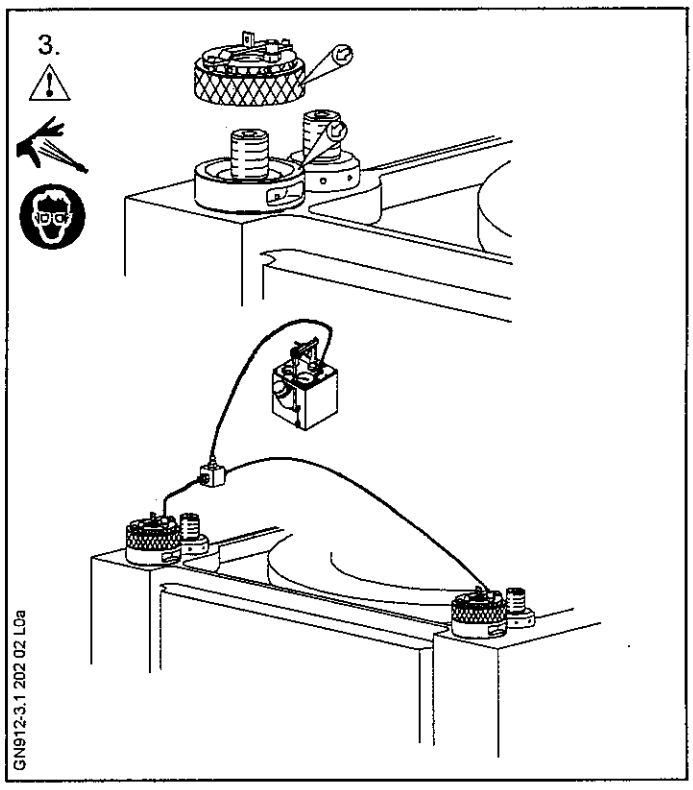
2. Retighten the stay bolts in pairs, working from fore to aft of the engine.

3. Clean the contact faces and mount the hydraulic tools on a pair of stay bolts positioned opposite each other.

   Connect the high-pressure pump by means of the high-pressure hoses, so that the two stay bolts are tightened in one operation.







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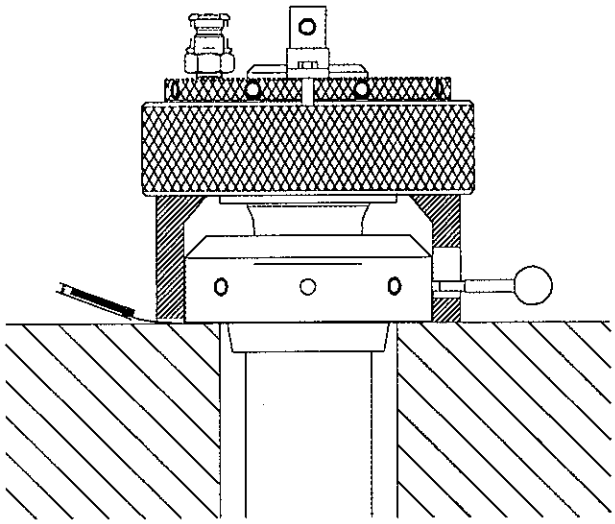

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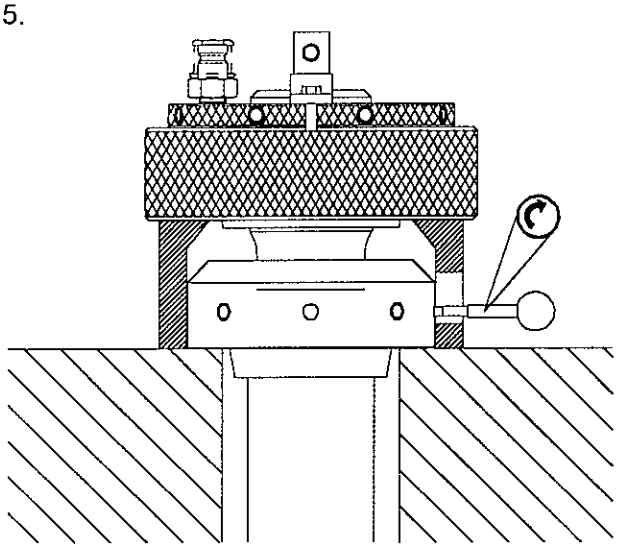
4. Maintain the hydraulic pressure at the value indicated in D-1, and retighten the stay bolt nuts with a tommy bar. Before relieving the system of pressure, check with a feeler gauge that the nuts bear against the contact face.

5. When all stay bolts have been retightened, reconnect the hydraulic tools to the pair of stay bolts first tightened. Tighten to 10% below D-1 and check if the nut is loose.

   If the nut is **not** loose:
   Tighten the stay bolts to D-1.

   If the nut is loose:
   Tighten **all** stay bolts once again to D-1.

5.



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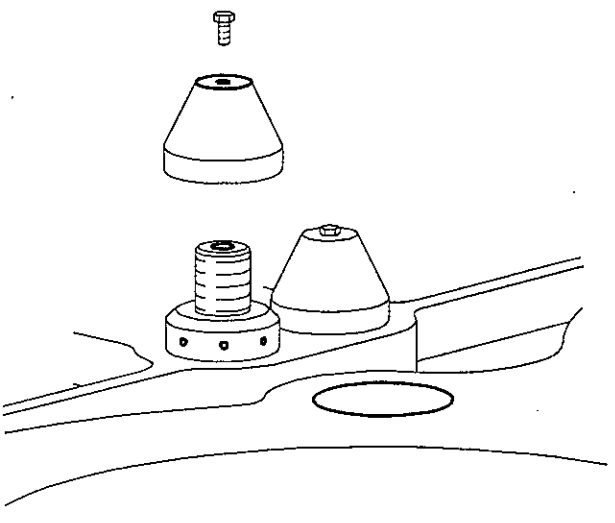
6. After completing the retightening procedure, mount the protective caps.

6.



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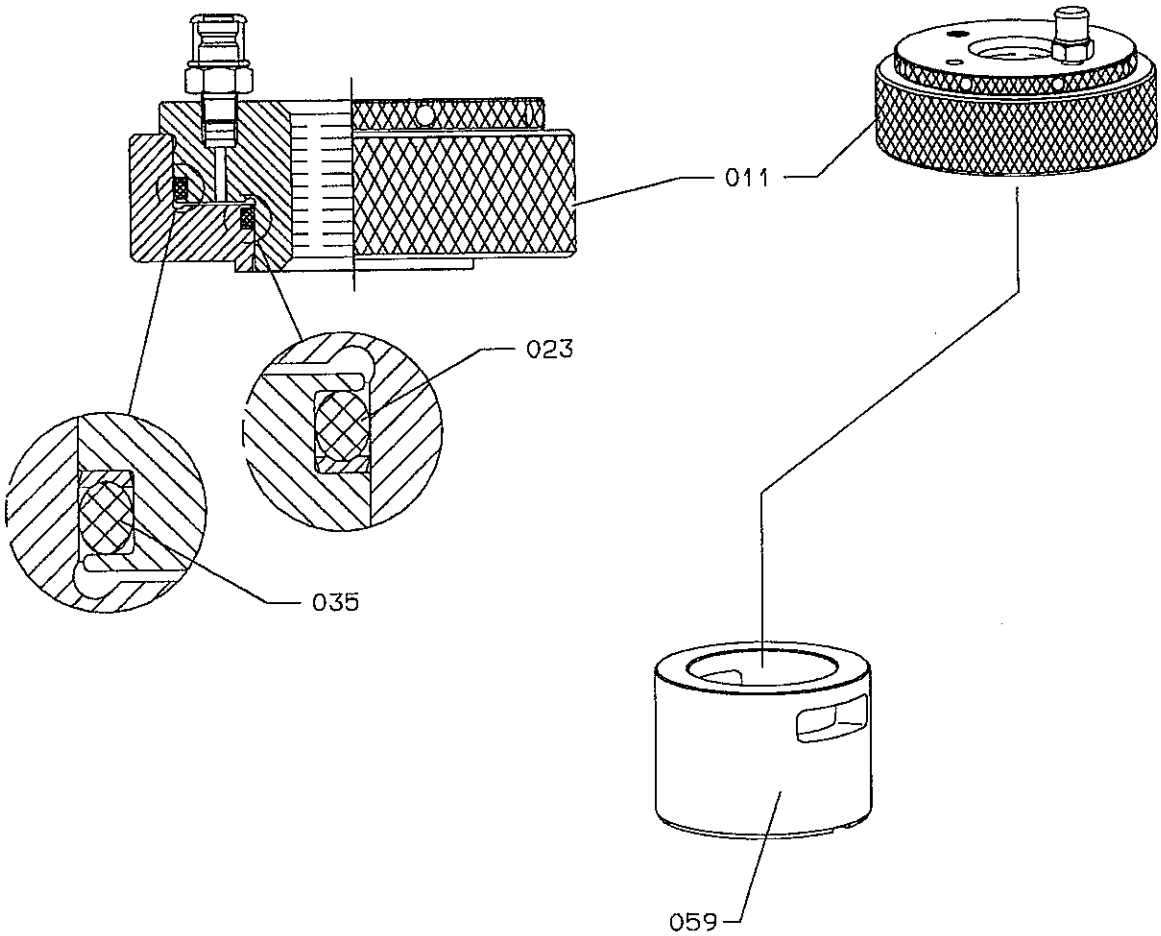
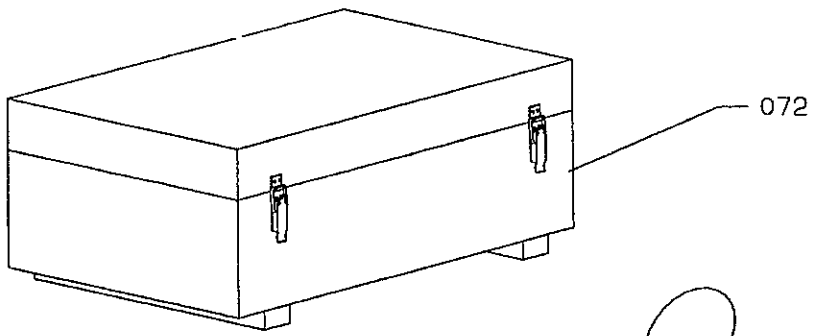

011
023
035
059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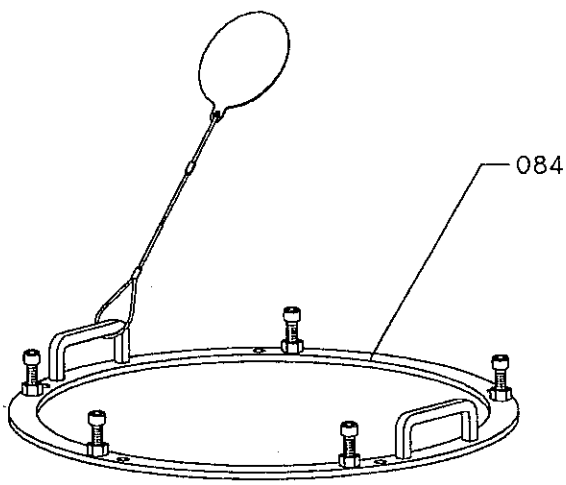
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Plate 91261-51M Large Parts - Tools

Item No.	Part Description	MES Tools No.	
011	Hydraulic jack	12A01	
023	O-ring with back-up ring	12A03	
035	O-ring with back-up ring	12A03	
059	Spacer ring for stay bolts	12A02	
072	Hydraulic tools for stay bolts, journal bearing and end chock bolts, complete	-	
084	Cover for oil drain *)	(12B51)	
	*) Optional extra		

Hydraulic Tools for Holding-Down Bolts and End Chock Bolts

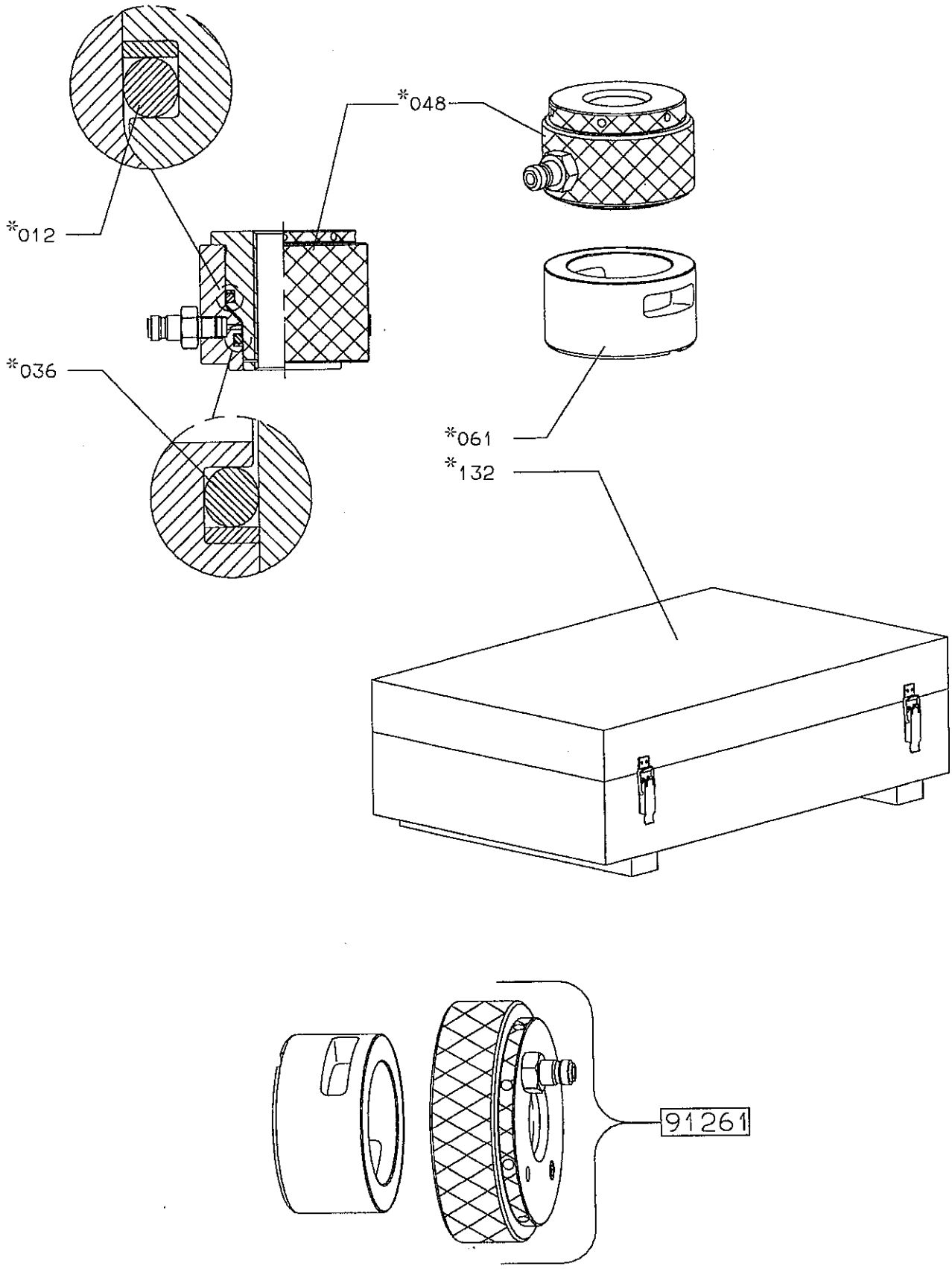

Plate 91263-43M Hydraulic Tools for Holding - Down Bolts and End Chock Bolts

Item No.	Part Description	MES Tools No.	
012	O-ring with back-up ring *)	(24A03)	
036	O-ring with back-up ring *)	(24A03)	
048	Hydraulic jack for holding - down bolts M36 × 4 *)	(24A01)	
061	Spacer ring *)	(24A02)	
132	Hydraulic tools for holding - down bolts, complete *)	-	
	*) Optional extras		

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PISTON WITH ROD AND STUFFING BOX

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CYLINDER LUBRICATION

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AND TURNING GEAR

MECANICAL CONTROL GEAR

STARTING AIR SYSTEM

EXHAUST VALVE

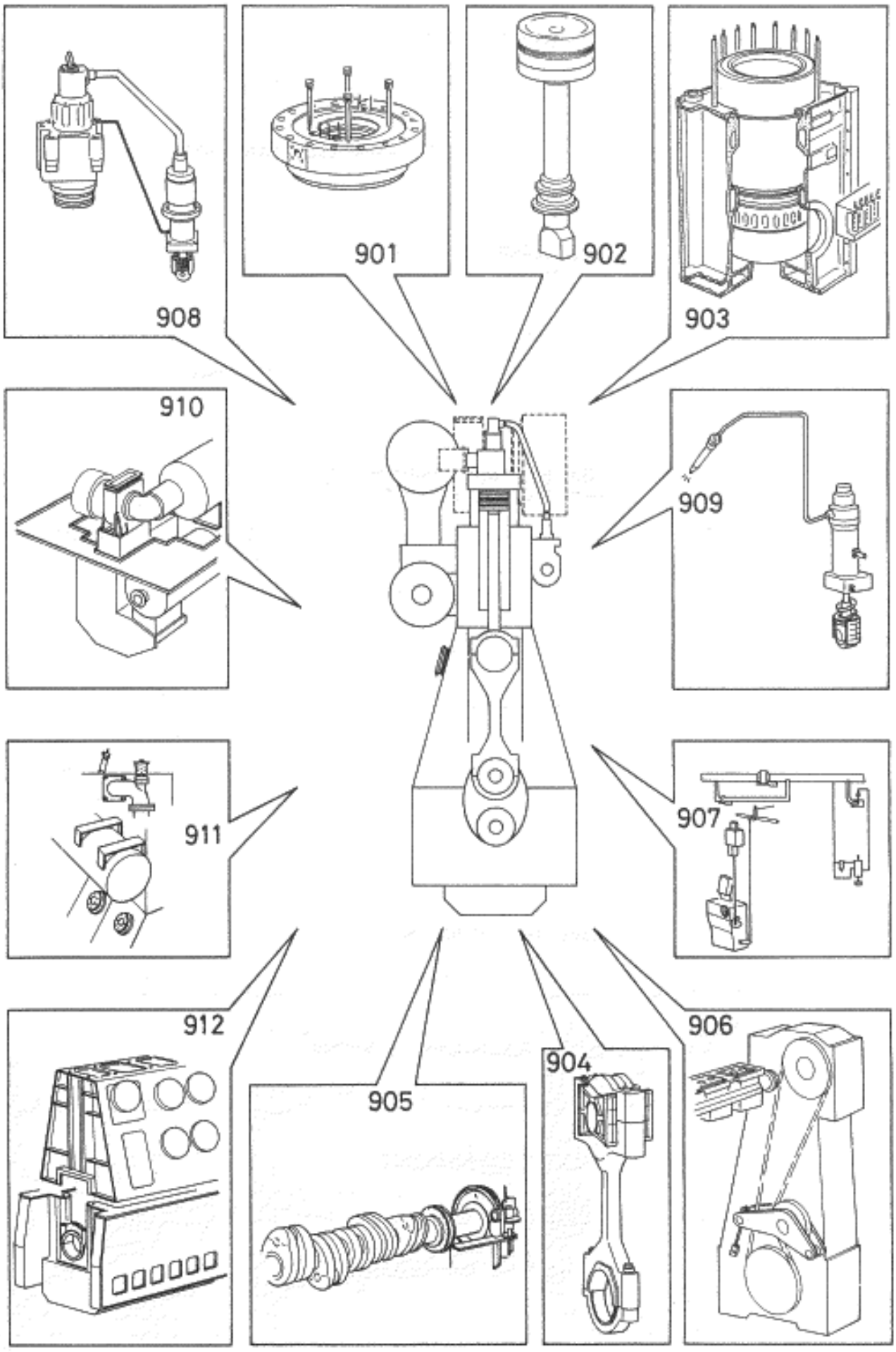
FUEL OIL SYSTEM

TURBOCHARGER SYSTEM

SAFETY EQUIPMENT

ASSEMBLY OF LARGE PARTS

GENERAL TOOLS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Testing Tools for Fuel Valve

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913 GENERAL TOOLS

913.01 GENERAL TOOLS

A. Snap-on coupling

B. Tool attachment thread

C. Bleed screw

D. Piston

E. Cylinder

F. Sealing rings

G. Spacer ring

H. Tommy bar

I. Nut

J. Stud or bolt

K. Extension stud

L. Lifting tool

S. Clearance

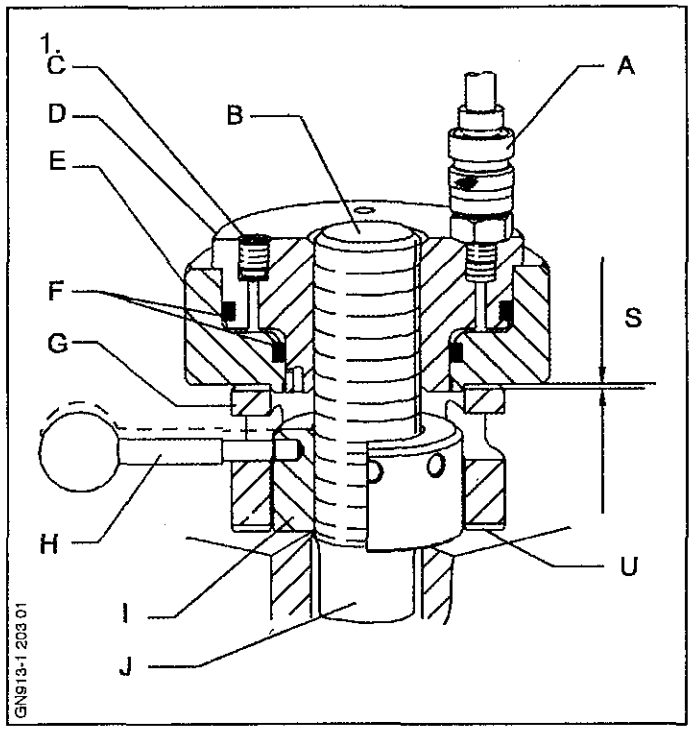
U. Milled recess for feeler gauge

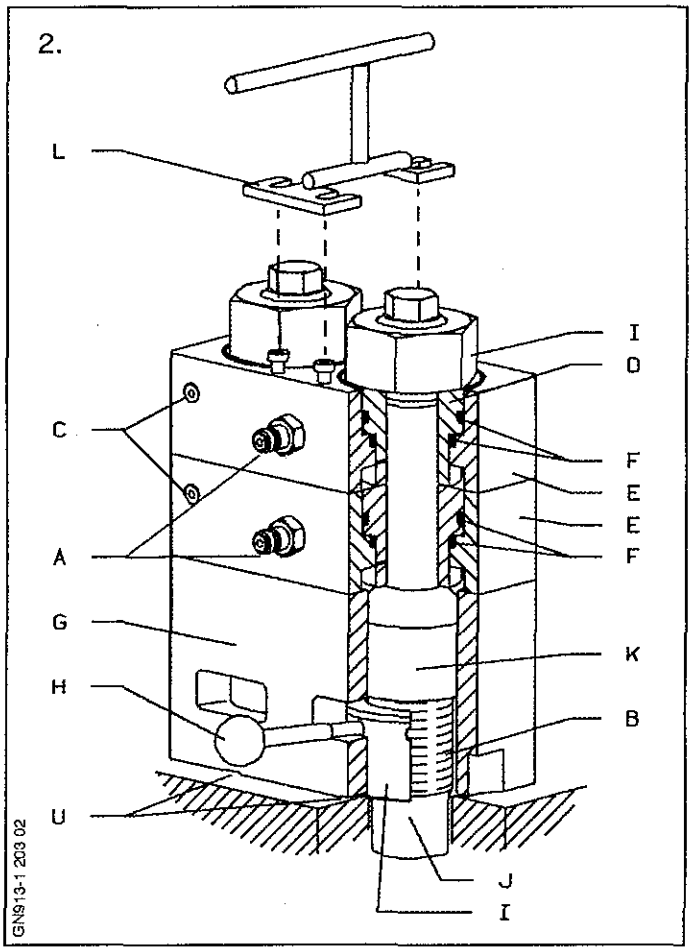
Studs or bolts provided with threads for attaching hydraulic tools and with circular nuts must only be loosened and tightened up by means of the hydraulic tools supplied.

The jack(s) is/are connected, via a distributor block, to a high-pressure pump, which is set to deliver hydraulic oil at the pressure indicated on the jack and on the data sheet in the relevant section of this instruction book. The stud or bolt concerned is thereby lengthened relative to the oil pressure applied and the piston area, and the nut can be loosened or tightened, as required, with the aid of a tommy bar.

The jacks must never be overloaded or exposed to blows or impacts. They are marked with a "Max. lift", which must not be exceeded.

1. The hydraulic tools, except those for the main bearings, consist of a jack with an internal thread to suit the tool attachment thread on the stud or bolt, and a spacer ring which is to be placed under the jack and around the nut that is to be loosened or tightened.





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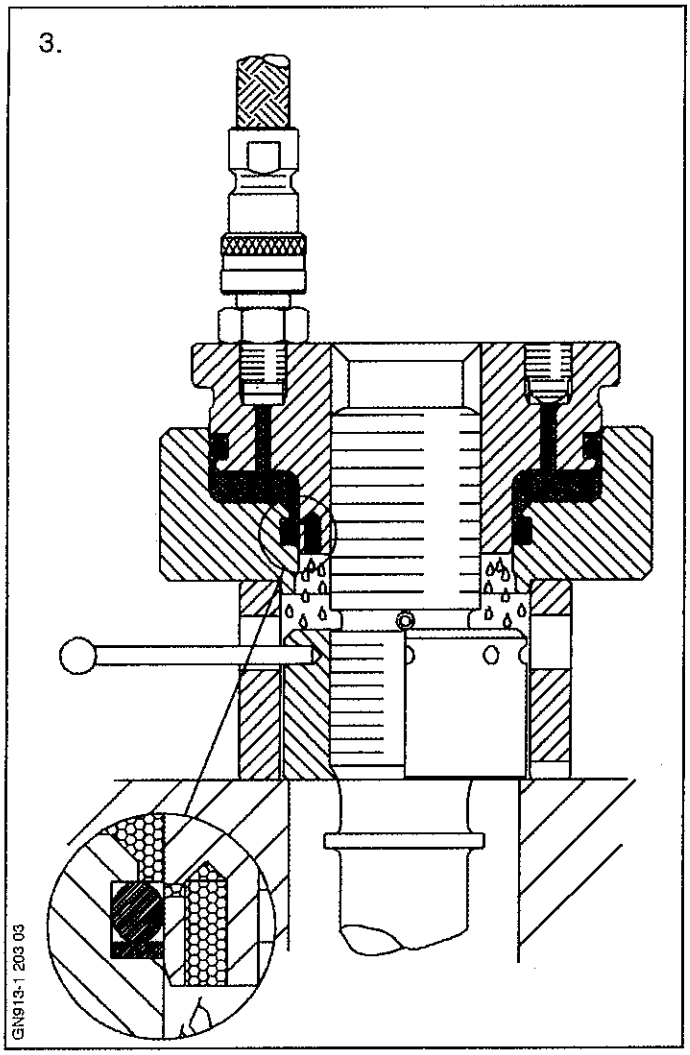


2. For the main bearings, the hydraulic tool consists of a double jack with two extension studs. This jack is designed for the simultaneous dismantling of both nuts on one side of the main bearing.

3. The hydraulic jacks are so designed that, in the event that the "Max. lift" limit is exceeded, the pressure is relieved at the bottom of the pressure chamber and the oil will be pressed out into the space between the stud and the spacer ring.

   When the pressure is relieved in this way, the lowermost sealing ring will in most cases be damaged. Therefore inspect and, if necessary, replace this sealing ring.

   The oil used must be pure hydraulic oil or turbine oil (with a viscosity of about SAE 20). Oils such as, for instance, lubricating oil (system oil) or cylinder lubricating oil must **not** be used, as these oils are normally alkaline and can thus damage the back-up rings.

   The following instructions must be closely followed to prevent accidents or damage, and after use the jacks should be cleaned and kept in the wooden boxes supplied.

Warning!
Eye protectors and gloves **must be** used when using hydraulic tools.

Single Hydraulic Jack

4. Carefully clean the tool attachment thread, the nut and the surrounding parts.

   Grease the tool attachment thread with molybdenum disulphide grease or with graphite and oil or similar.

   Place the spacer ring around the nut in such a position that the tommy bar can be applied through the slot when the nut is to be loosened.

5. Screw the jack on to the tool attachment thread of the bolt/stud, until the cylinder of the jack bears firmly against the spacer ring.

   Connect the hydraulic jack, the distributor block and the high pressure pump by means of high pressure hoses.

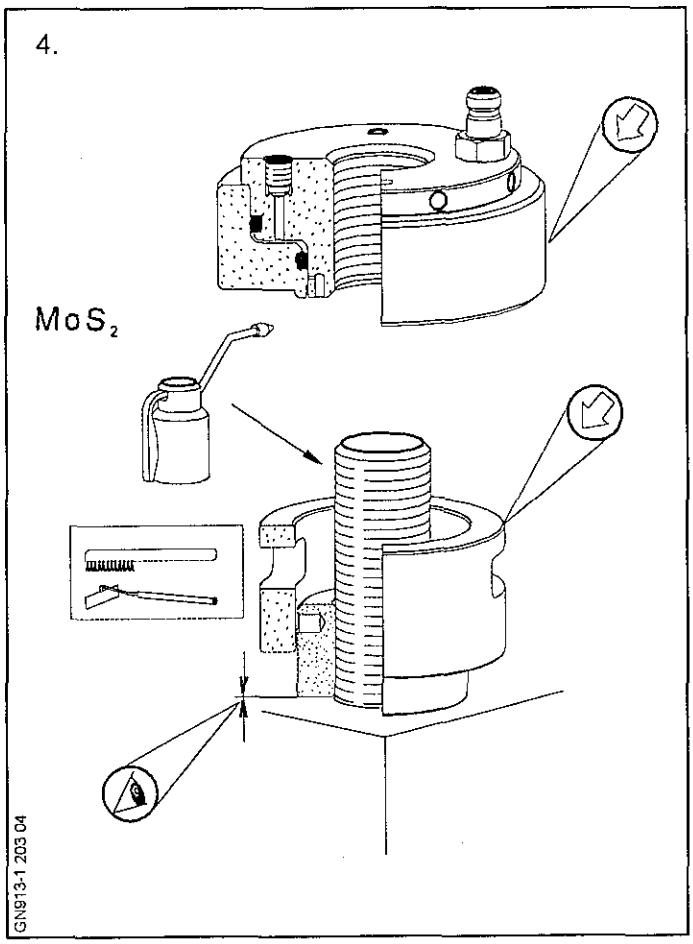
   Unscrew the jack to create a clearance between the jack and spacer ring. *See sketch.*

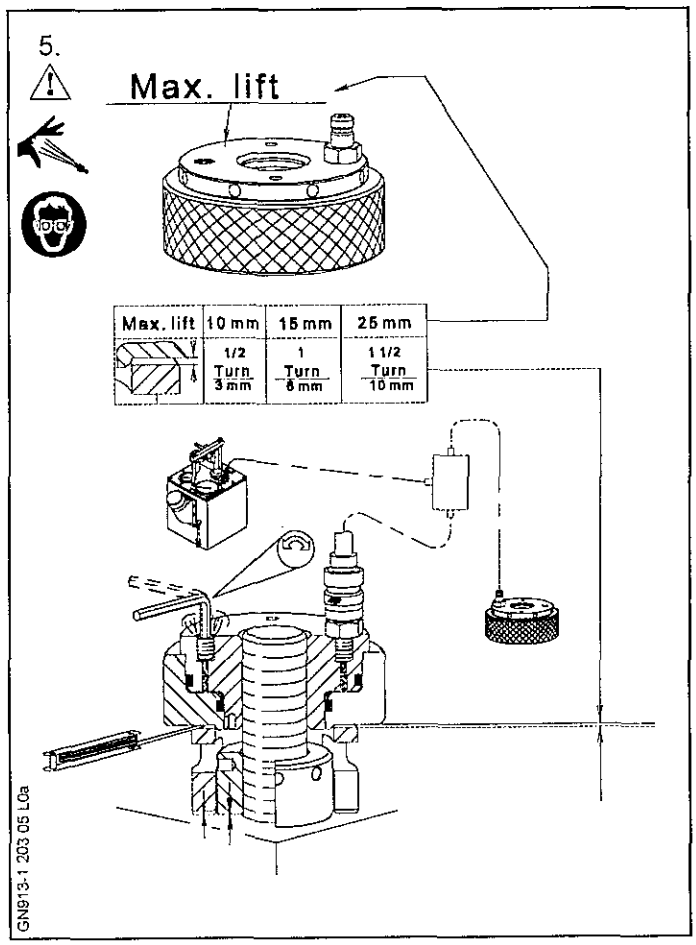
   Loosen the bleed screw in the jack and fill up the system with oil until oil without bubbles, flows out of the bleed hole. Then tighten the bleed screw again.

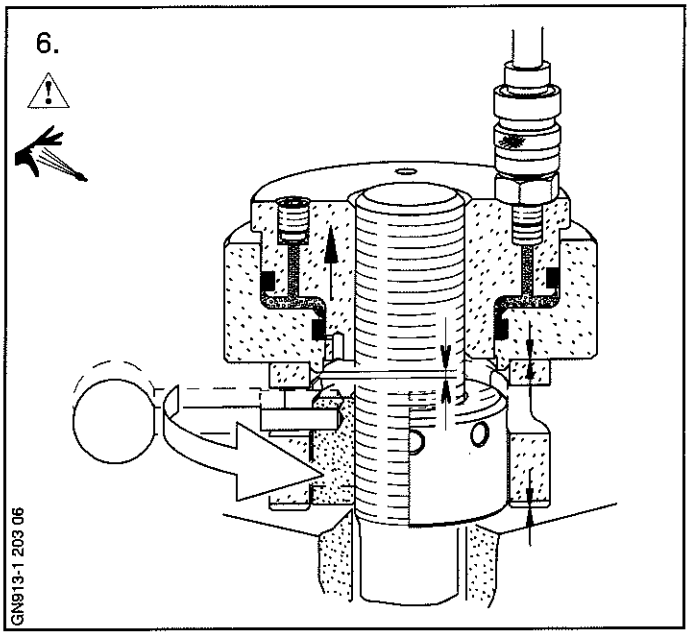
   When loosening nuts on very long bolts (e.g. staybolts) it is recommended to unscrew the jack *an additional half turn.*

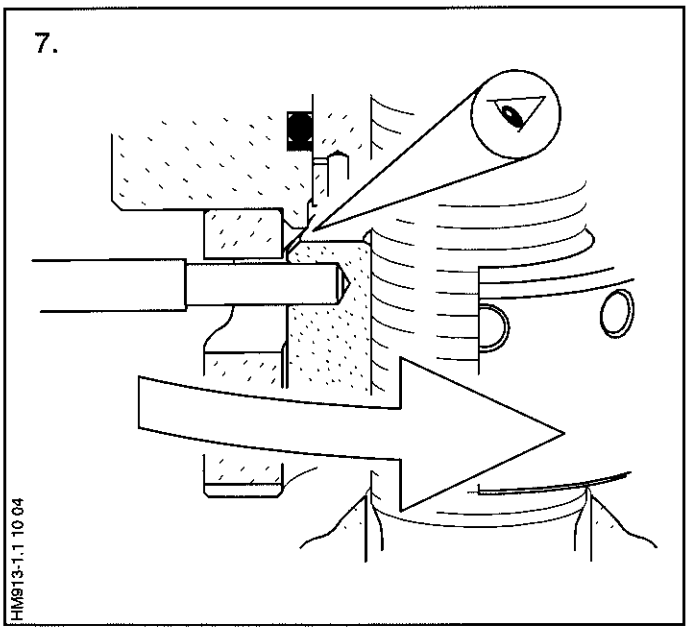
   The clearance between the jack and spacer ring ensures dismantling of the jack after loosening the nut.

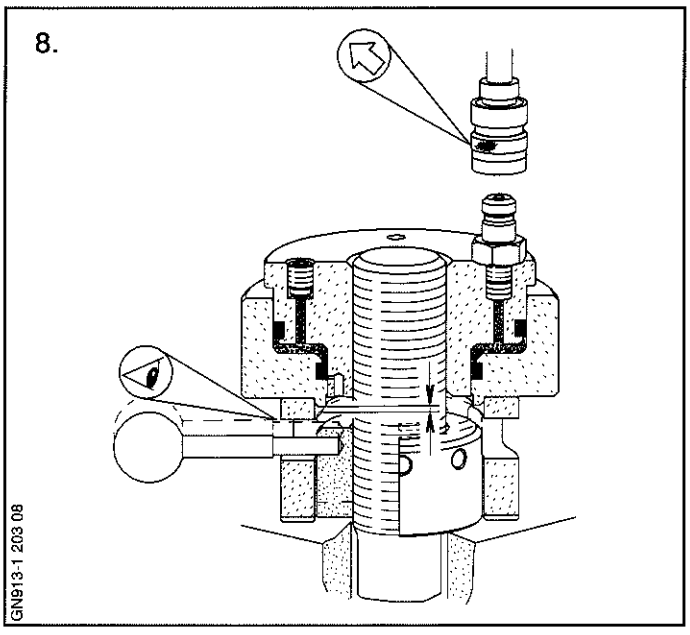
   After adjustment, check that the parts are guided correctly together and that there is no clearance between the piston and cylinder of the jack.











6. Increase the oil pressure to the prescribed value. If the nut does not come loose, the pressure may be increased by approx. 15 MPa(150 bar).

Note!
Permit to Max. 165 MPa (1650 bar) only in a short time.

7. Unscrew the nut with the tommy bar, making sure that the nut is not screwed up against the jack.

8. Relieve the system of pressure, disconnect the high-pressure pump, and remove the hydraulic tools.

Note!
Make sure **not** to exceed the "max lift" stamped on the jack.

Double Hydraulic Jack

9. Carefully clean the tool attachment threads, the main bearing studs, the nuts and the surrounding parts.

   Grease the tool attachment threads with molybdenum disulphide grease or graphite and oil or similar.

   Mount the extension studs on the main bearing studs.

   Using the lifting tool, place the spacer ring over the extension studs in such a position that the tommy bar can be applied through the slots for the purpose of loosening the nuts.

10. Press the pistons and the cylinder of both the hydraulic jacks firmly together.

    Mount the two jacks (one by one using the lifting tool) over the extension studs and land them on the spacer ring.

    Make sure that both the cylinders of the jacks and the spacer ring are guided correctly together.

    Screw the upper nuts on to the threads of the extension studs until the cylinders of the jacks bear firmly against each other and against the spacer ring.

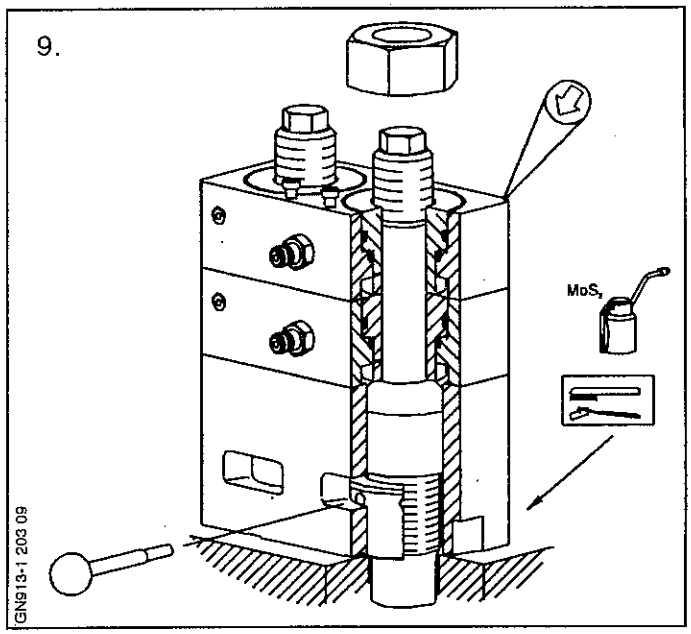
11. The clearance between the pistons and the cylinder of the top jack is adjusted by unscrewing the upper nuts 1 turn ≈ 3 mm.

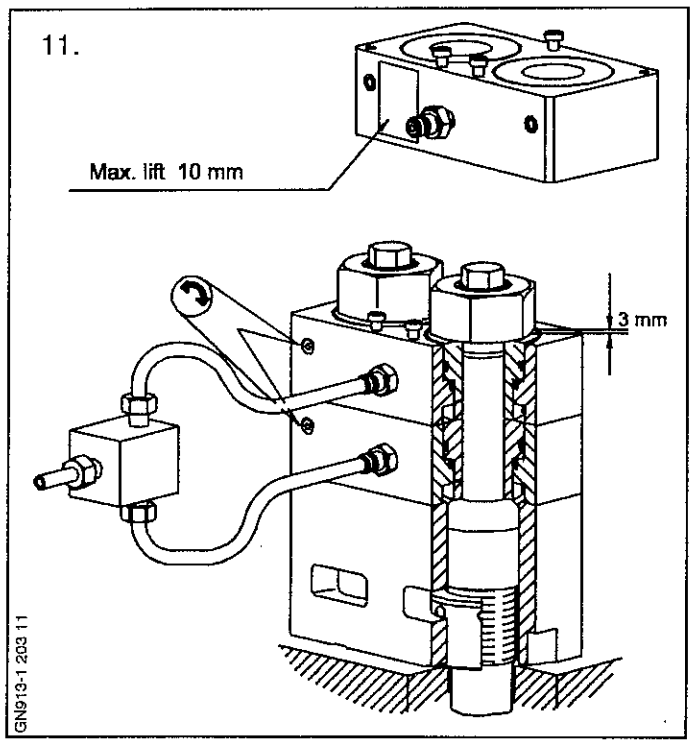
    The clearance between the jack and spacer ring ensures dismounting of the jack after loosening the nut.

    Connect the hydraulic jacks, the distributor block and the high pressure pump by means of high pressure hoses.

    Loosen the bleed screws in both jacks, and fill up the system with oil until oil, without bubbles, flows out of the bleed holes.

    Re-tighten the bleed screws.





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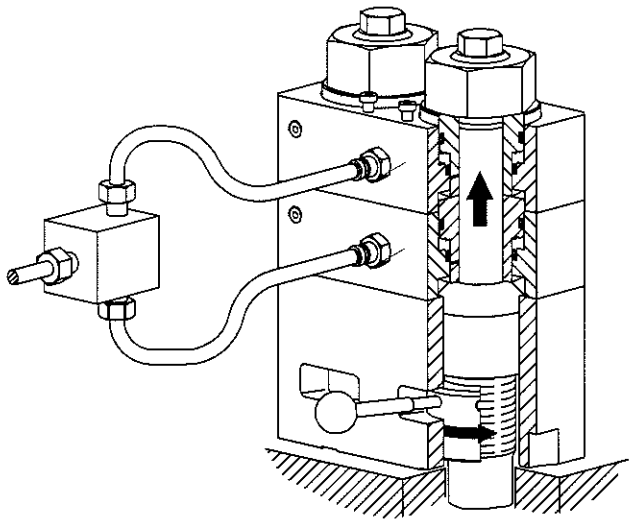


GN913-1 203 12

12. Increase the oil pressure to the prescribed value. If the nut does not come loose, the pressure may be increased by approx. 15 MPa(150 bar).

Note!
Permit to Max. 165 MPa (1650 bar) only in a short time.

13. Unscrew the lower nuts 1½ turns with the tommy bar, making sure that the nuts are not screwed up against the extension stud.

14. Relieve the system of pressure, disconnect the high-pressure pump, and remove the hydraulic tools.

Note!
Make sure **not** to exceed the "max lift" stamped on the jack.

Single Hydraulic Jack

15. Thoroughly clean the nut, the thread, the contact faces, and the surrounding parts.

    Clean and lubricate the tool attachment thread and the thread in the nut with molybdenum disulphide grease or with graphite and oil or similar.

    Fit the round nut on the thread and tighten it with the tommy bar.

    Check with a feeler gauge that the contact face of the nut bears on the entire circumference.

    Place the spacer ring around the nut in *such a position that the tommy bar can be* applied through the slot for the purpose of tightening the nut.

16. Press the piston and the cylinder of the jack firmly together.

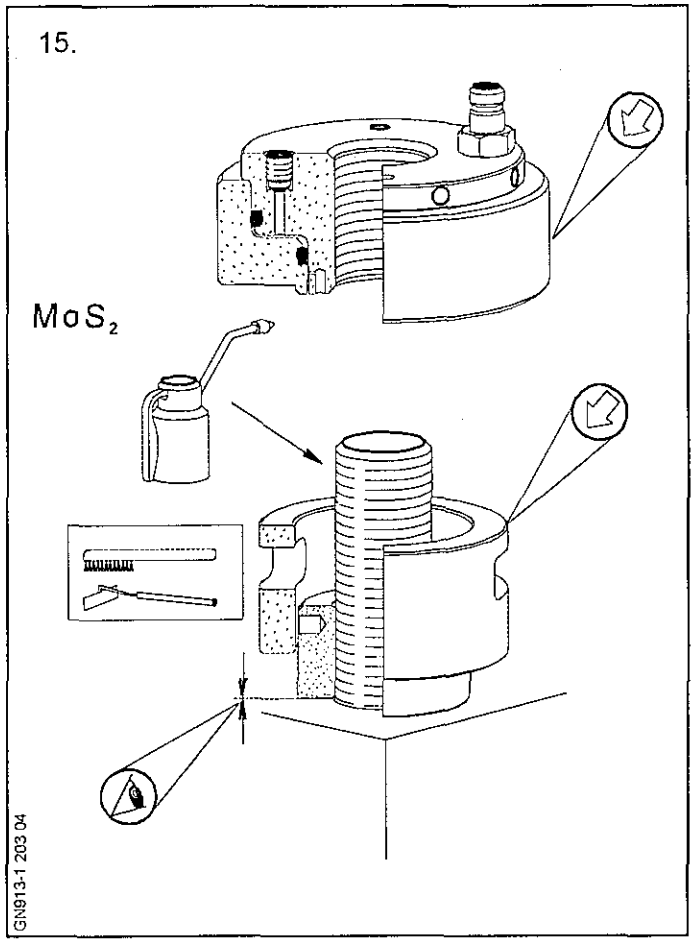
    Screw the hydraulic jack on to the tool attachment thread.

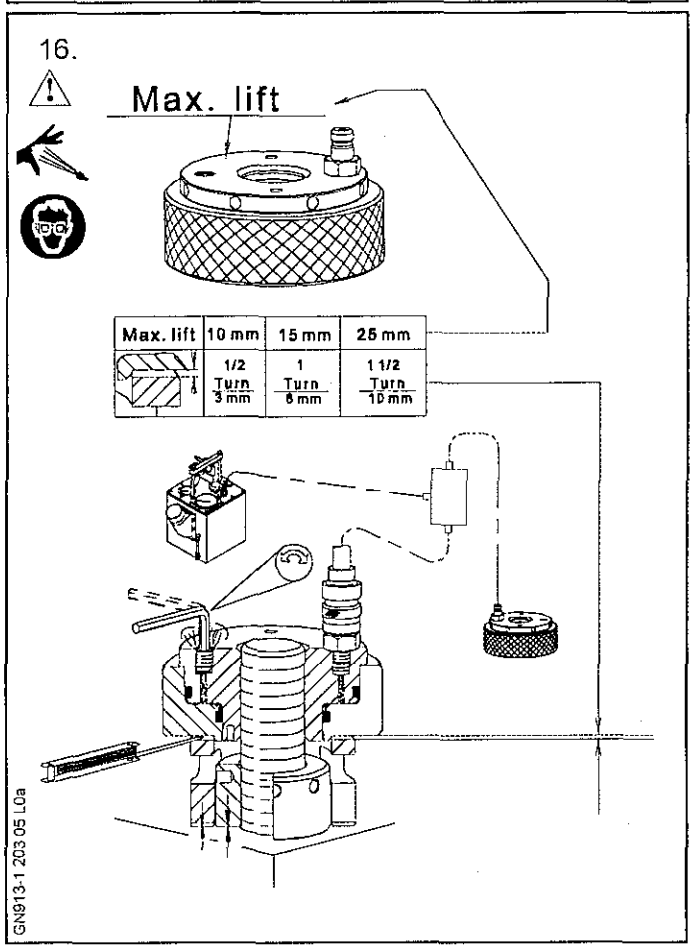
    Make sure that the cylinder of the jack bears firmly against the spacer ring and that the parts are guided correctly together

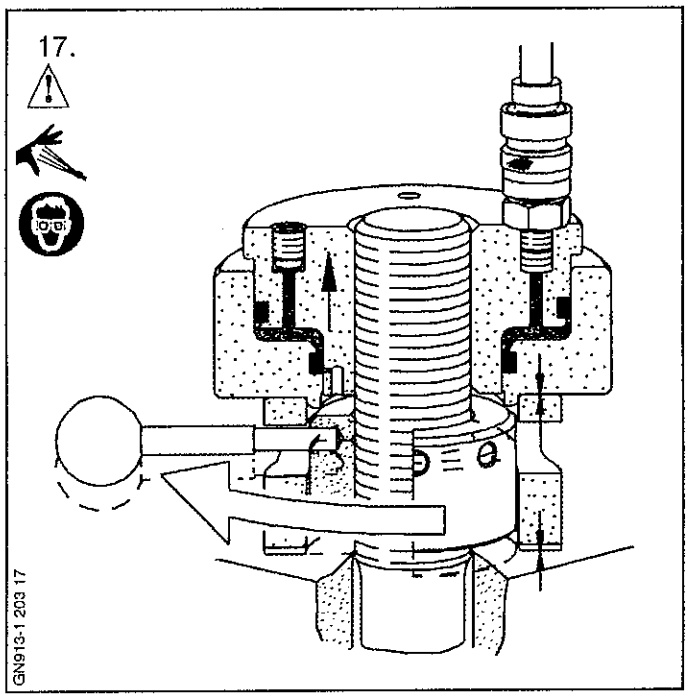
    Connect the hydraulic jack, the distributor block and the high-pressure pump by *means of high-pressure hoses.*

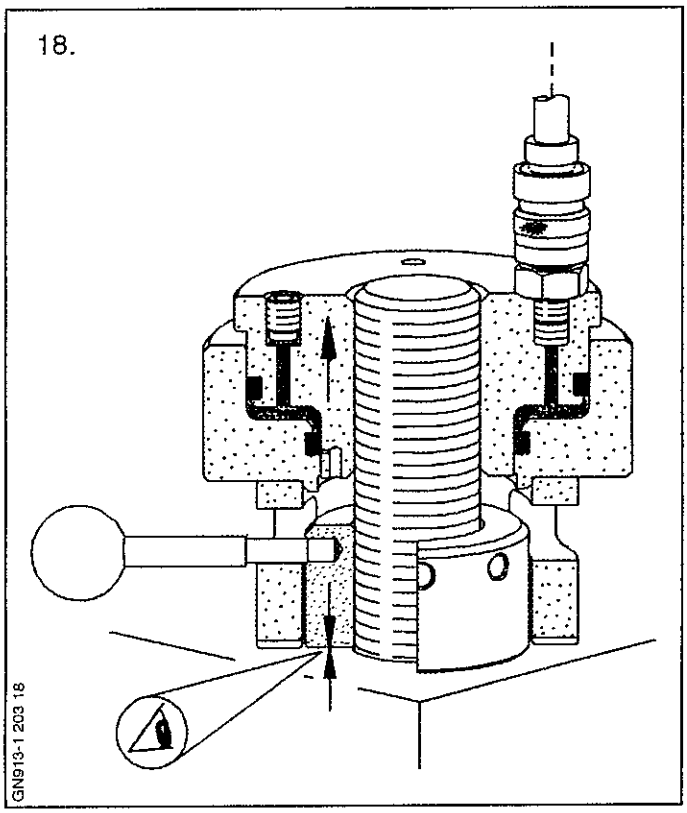
    Loosen the bleed screw in the jack and fill up the system with oil, until oil without bubbles flows out of the bleed hole.

    Re-tighten the bleed screw.









17. Increase the oil pressure to the prescribed value, and tighten the nut by means of the tommy bar applied through the slot of the spacer ring.

18. While maintaining the pressure, check with a feeler gauge introduced through the recess at the bottom of the spacer ring that the nut bears against the contact face.

19. Relieve the system of pressure, disconnect the pump, and remove the hydraulic jack.

20. When new studs, bolts or nuts are tightened for the first time, do not remove the jacks, but loosen the nut as described under 'Loosening', points 6-7-8, and then tighten the nut again according to the procedure under 'Tightening', points 17-18-19.

Double Hydraulic Jack

21. Thoroughly clean the nuts, the threads on the main bearing studs, the contact faces, and the surrounding parts.

    Clean and lubricate the tool attachment thread and the threads in the nuts with molybdenum disulphide grease or with graphite and oil.

    Fit the round nuts on the threads and tighten them with the tommy bar.

    Check with a feeler gauge that the contact faces of the nuts bear on the entire circumference.

    Mount the extension studs on the main bearing studs.

    Using the lifting tool, place the spacer ring over the extension studs in such a position that the tommy bar can be applied through the slots for the purpose of tightening the nuts.

22. Press the piston and the cylinder of both the hydraulic jacks firmly together.

    Mount the two jacks (one by one using the lifting tool) over the extension studs and land them on the spacer ring.

    Make sure that both the cylinders of the jacks and the spacer ring are guided correctly together.

    Screw the upper nuts on to the threads of the extension studs until the cylinders of the jacks bear firmly against each other and against the spacer ring.

23. Connect the hydraulic jacks, the distributor block and the high pressure pump by means of high pressure hoses.

    Loosen the bleed screws in both jacks, and fill up the system with oil until oil, without bubbles, flows out of the bleed holes.

    Re-tighten the bleed screws.

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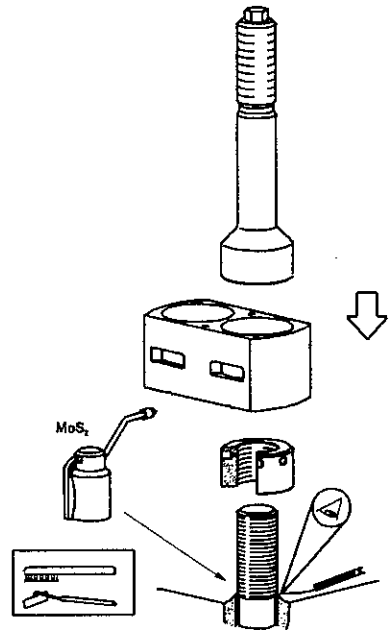

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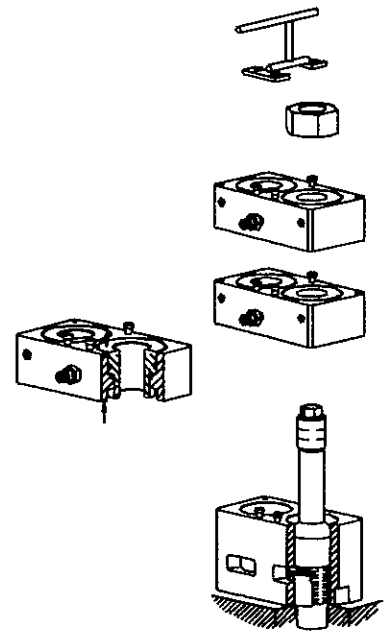

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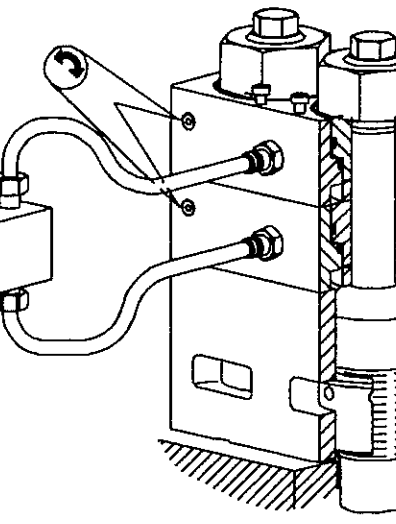

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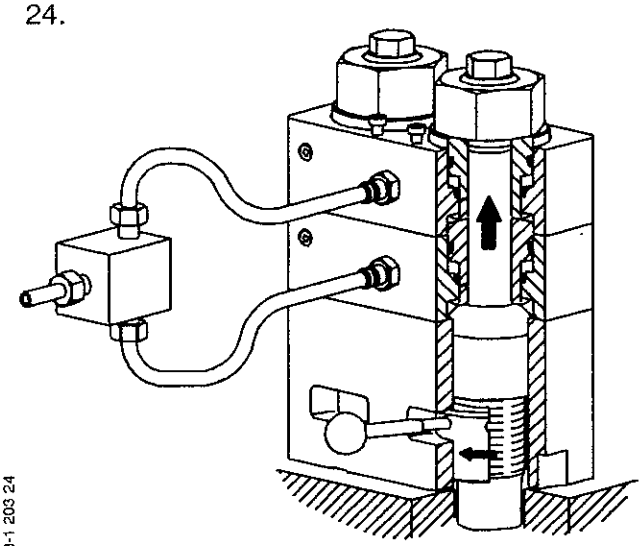

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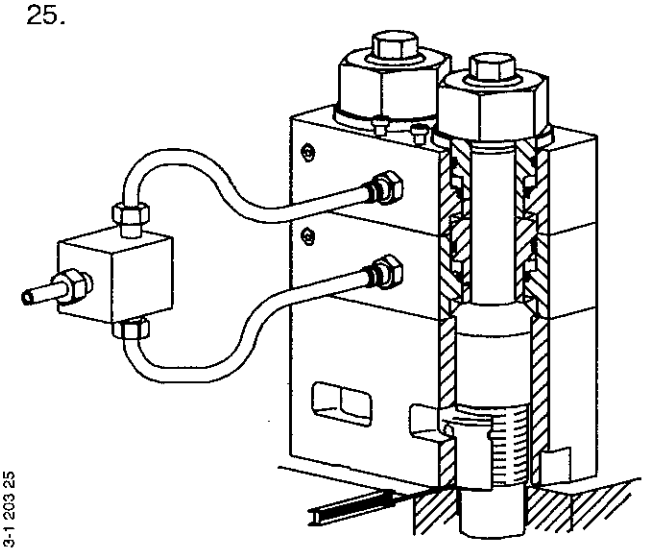

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24. Increase the oil pressure to the prescribed value, and tighten the nuts by means of the tommy bar applied through the slots of the spacer ring.

25. While maintaining the pressure, check with a feeler gauge introduced through the recesses at the bottom of the spacer ring that the nuts bear against the contact face.

26. Relieve the system of pressure, disconnect the pump, and remove the hydraulic tools.

27. When new studs, bolts or nuts are tightened for the first time, do not remove the jacks, but loosen the nuts as described under 'Loosening', points 12-13-14, and then tighten the nuts again according to the procedure under 'Tightening', points 24-25-26.

28. The hydraulic jacks require no maintenance except replacement of defective sealing rings, each of which consists of an O-ring and a back-up ring fitted in ring grooves in the piston and cylinder.

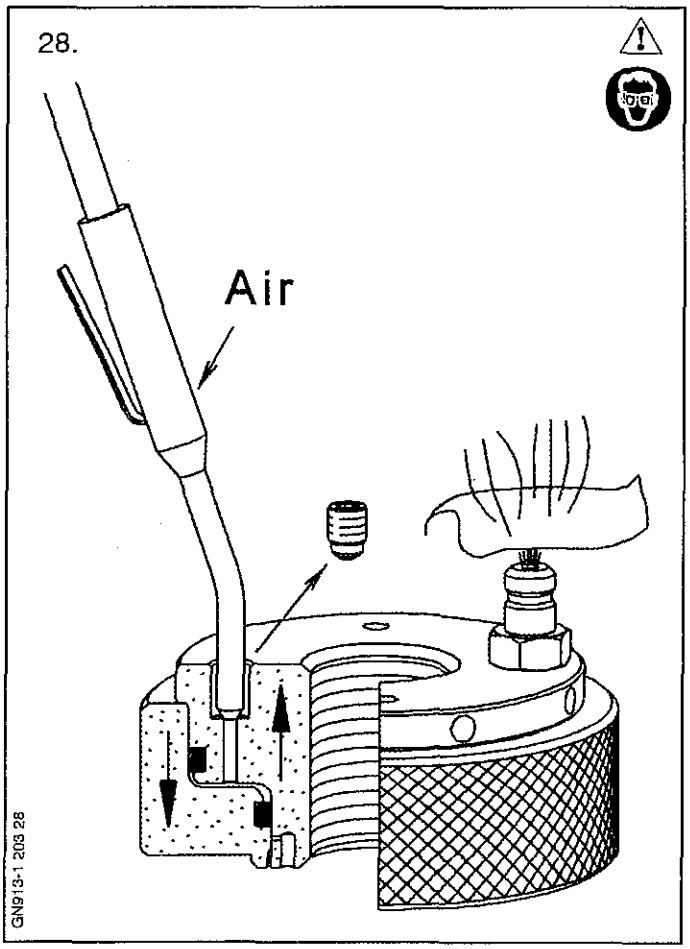
    The piston and cylinder are easily separated by taking out the bleed screw and pressing the parts apart with the help of compressed air.

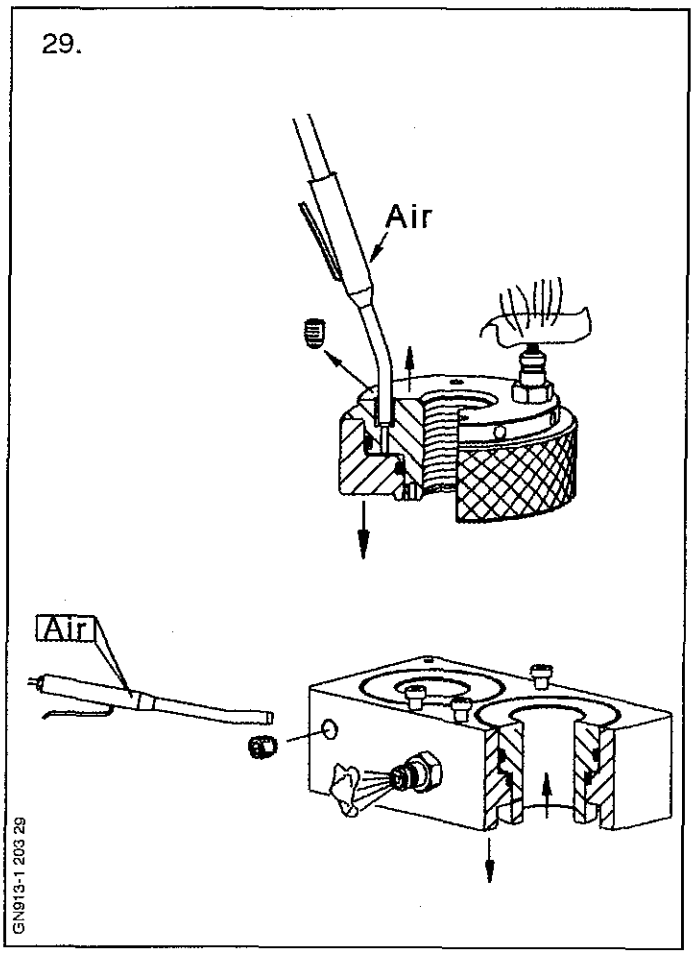
Warning!
Always use eye protection when working with compressed air.

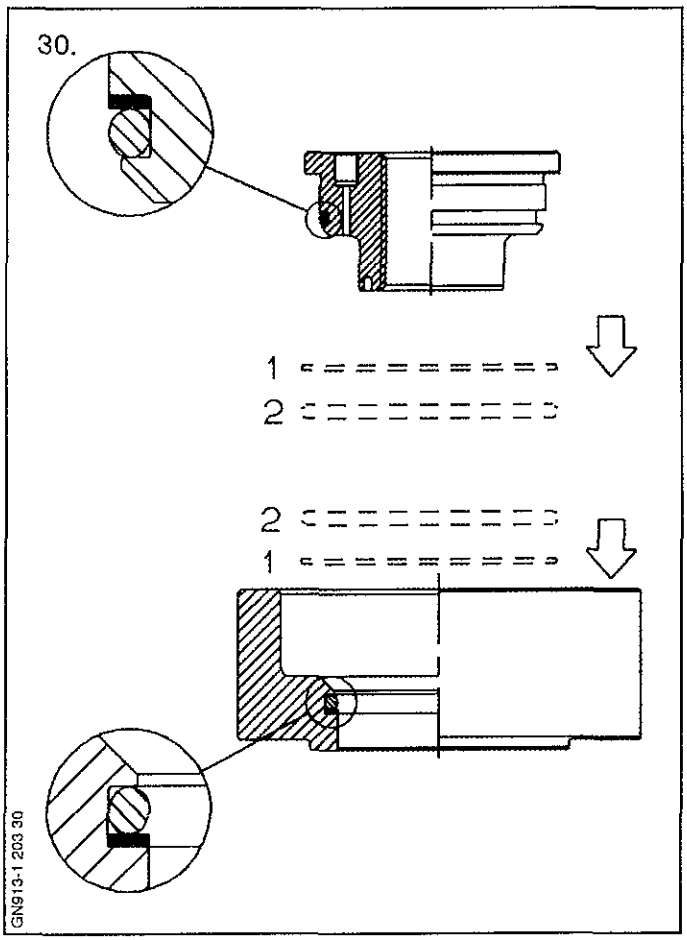
    Make sure that there are no marks or scratches on the sliding surfaces of the parts. The presence of metal particles will damage the sealing rings.

    Keep the sliding surfaces and threads coated with acid-free grease or molybdenum disulphide grease.

29. The pistons and cylinders of the double jacks are separated in the same easy way as described for the single jack.







30. When changing the sealing rings, first mount the back-up ring and then the O-ring.

Warning!
Note that the back-up ring (1) **must** be away from the pressure chamber and the O-ring (2) close to the pressure chamber.

See the sketch for the correct mounting of both the upper and the lower sealing rings. The same principle applies to all the jacks.

31. After fitting the sealing rings, coat the piston and cylinder with molybdenum disulphide grease and press the piston and cylinder together. See that the rings do not get stuck between the piston and cylinder.

Before screwing the nuts on, the threads and the contact faces should be greased with a mixture of graphite and oil or molybdenum disulphide with a friction coefficient $\mu = 0.1\text{-}0.12$ (e.g. MOLYKOTE paste type G).

The nuts should fit easily on the thread, and it should be checked that they bear on the entire contact face.

In the case of new nuts and studs, the nuts are to be tightened and loosened two or three times so that the thread may assume its definite shape; thus obviating the risk of loose nuts.

Nuts secured with a split pin are to be tightened to the stated torque and then to the next split-pin hole.

The torque spanner must not be used for torques higher than those stamped on it, and it must not be damaged by hammering on it or the like.

Preparations

Before screwing on the nuts, grease the threads and the contact faces with a mixture of graphite and oil or molybdenum disulphide with a friction coefficient.

μ = 0.1–0.12 (e.g. MOLYKOTE paste type G)

The nuts should fit easily on the thread, and it should be checked that they bear on the entire contact face.

Pre-tightening with a torque spanner

Before tightening the nuts according to a tightening gauge or tightening angle, they must be pre-tightened with a torque spanner.
See Procedure 913-5.

Apply a pre-tightening torque of:
– thread ≤ M20: 50 Nm,
– thread > M20: 100 Nm

This is in order to ensure a uniform basis for the subsequent tightening with gauge or tightening angle.

Tightening with a tightening gauge

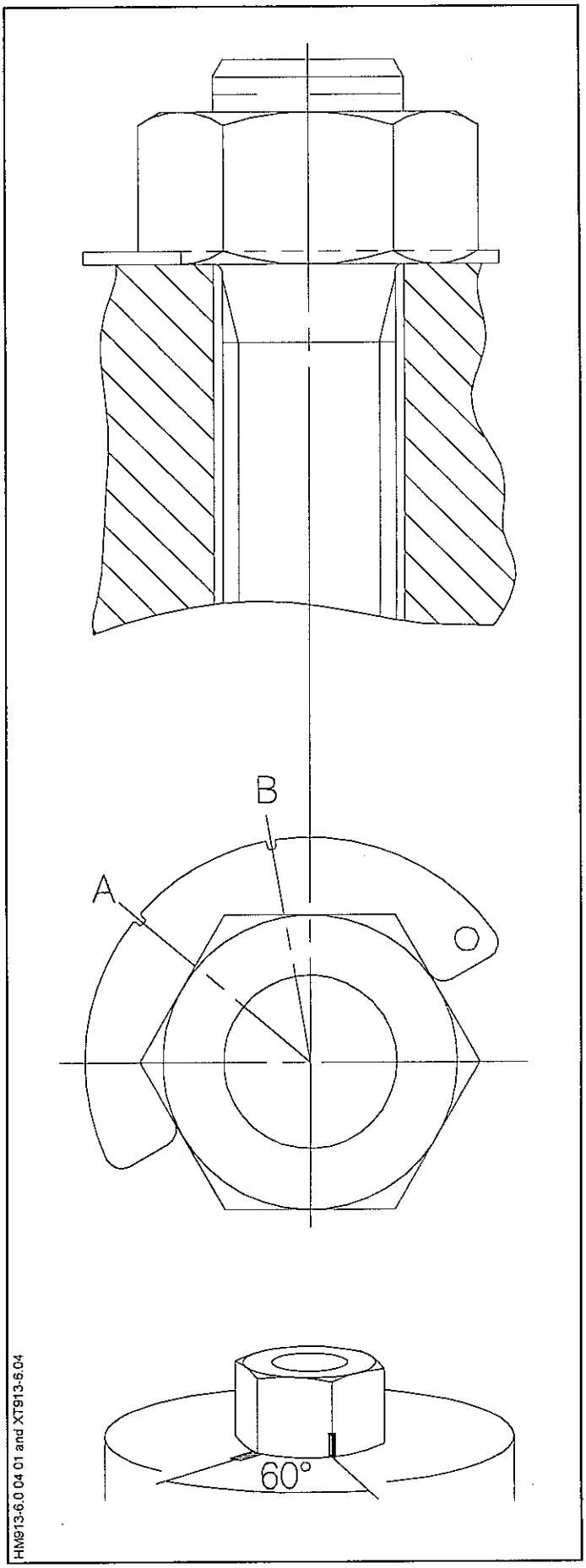
After pre-tightening, place the tightening gauge round the nut, and mark off with chalk on the nut at slot **A** on the tightening gauge, and make another chalk mark on the contact face at slot **B**. Then tighten the nut until the two chalk marks coincide.

Tightening without a tightening gauge

For tightening angles of e.g. 30°–45° and 60°, we usually do not deliver a tightening gauge.

Therefore, after pre-tightening, mark the angle on a corner of the nut and on the contact face, respectively. Then tighten the nut until the two marks coincide.

When tightening new studs or bolts for the first time, loosen again and repeat the procedure – including pre-tightening with a torque spanner, to allow the parts to settle.
See Procedure 913-5.



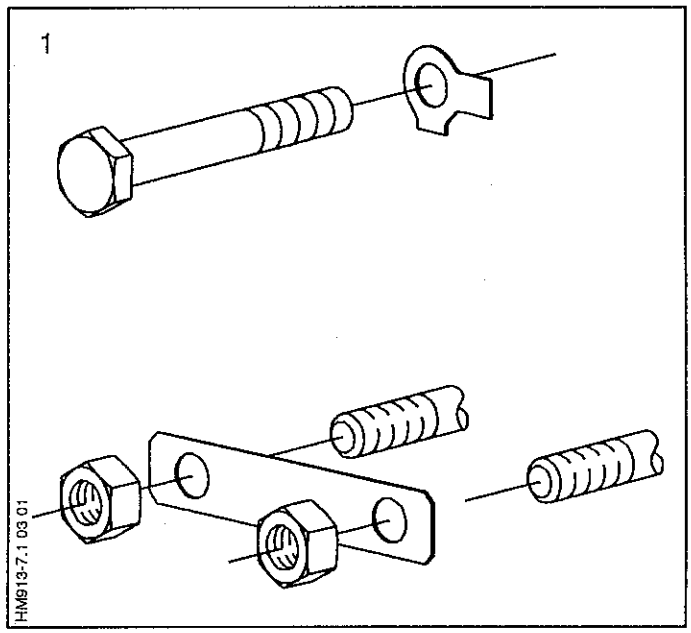
All screwed and bolted connections inside the engine, as well as all movable joints, are secured against untimely loosening by means of different types of locking devices.

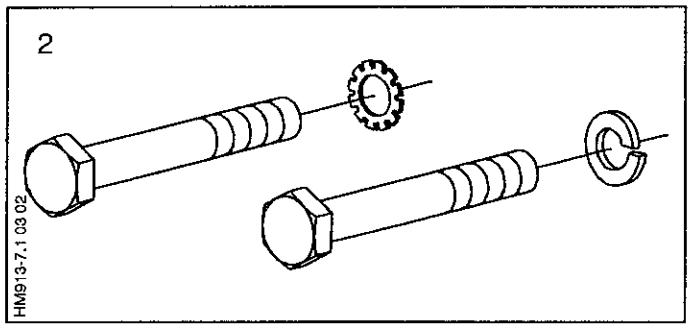
When reassembling the engine after overhauls, it is vital that all such screws and nuts are again locked correctly.

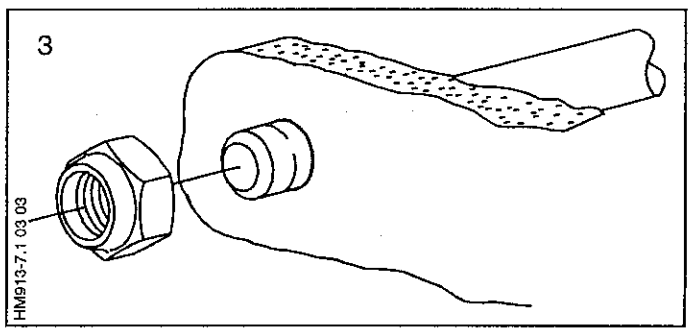
1. **Lock washers**, tab washers, locking plates, etc., must always be replaced. The tab-like projections, etc., on the washers are to be bent back over one of the flats of the screw or nut concerned.

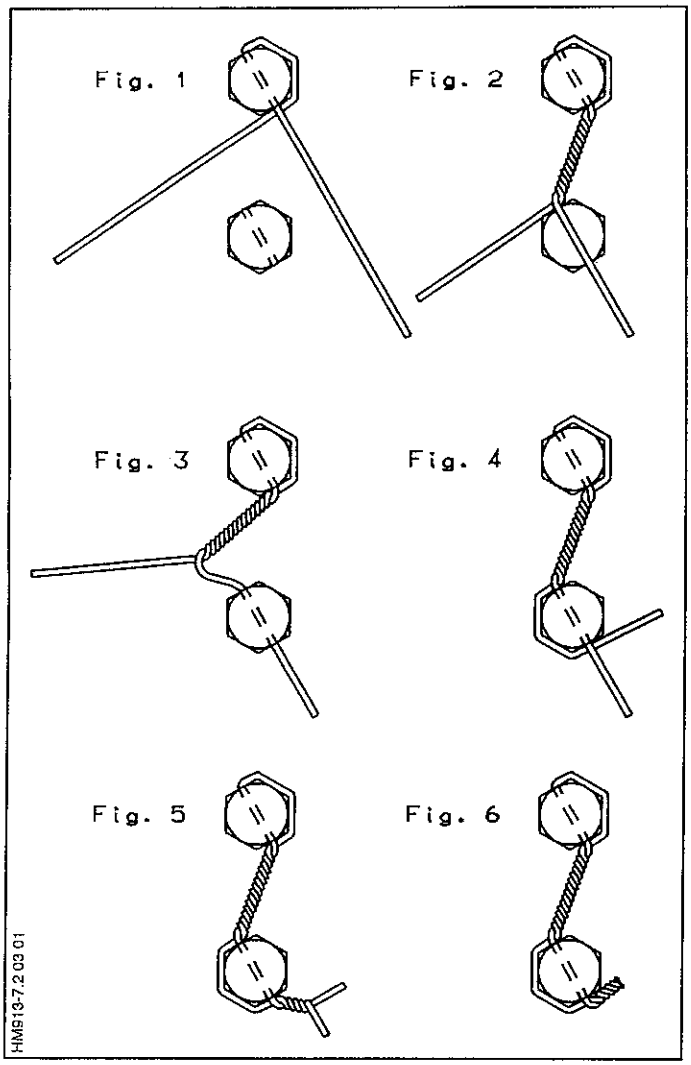
2. Used **spring washers** must be replaced.

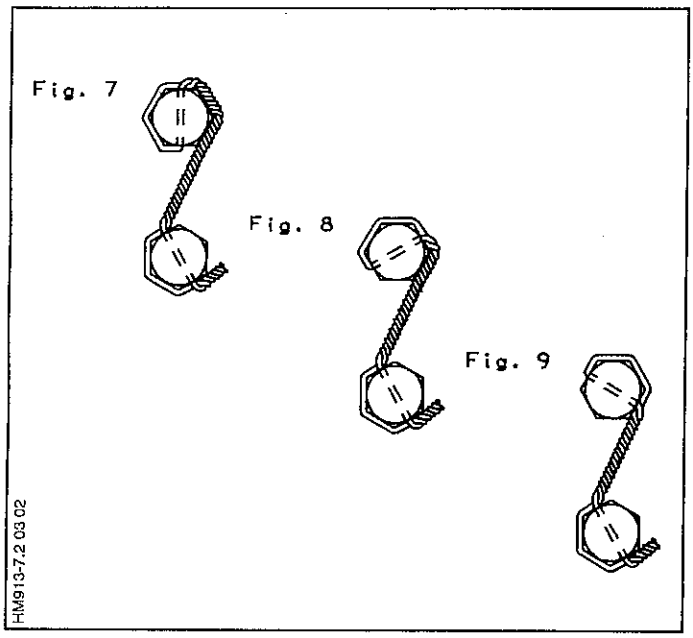
3. **Self-locking nuts** may only be used five times. Therefore, give the nut a centre punch mark each time it is loosened.











Locking wire should be fitted after the screws or nuts have been tightened to the correct torque. Do not overtighten or loosen the units to get a correct alignment of the wire holes. Always fit new wire after tightening-up the units.

Any tendency of the screws or nuts to loosen will be counteracted by a tightening of the locking wire. Do not secure more than four units in a series, unless otherwise specified.

Fig. 1: Insert wire, grasp the upper end of the wire and bend it around the head of the screw, then under the other end of the wire, be sure that the wire is tight around the head.

Fig. 2: Twist the wire **clockwise** until it is just short of the hole in the second screw. Keeping the wire under tension, twist it until tight. When the wire is tight, the wire shall have approximately 7-10 twists per 25 mm. One twist is a twist of the wires through an arc of 180°, equal to half of a complete turn.

Fig. 3: Insert the uppermost wire in the second screw, and pull it tight.

Fig. 4: Bend the lower wire around the screw, and under the end protruding from the screw.

Fig. 5: Keeping the wire under tension, twist it min. 3 twists, **counterclockwise** until tight.

Fig. 6: During the final twisting motion, bend the wire along the screw head. Cut off excess wire.

Fig. 7-9: Show the preferred ways of mounting the locking wire on screws with wire holes oriented in different angles.

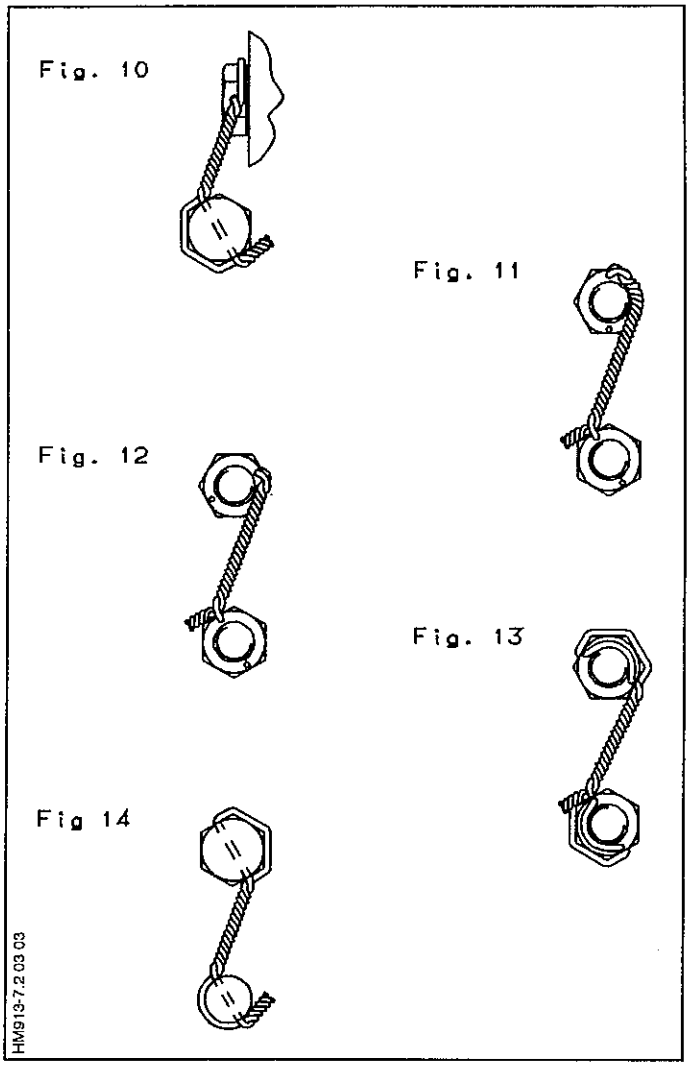
Fig. 10: Shows how to route the locking wire on screws in different planes.

Fig. 11: Wire that passes over the top of a nut is an acceptable alternative only if it routes around the protruding screw thread.

Fig. 12: Wire that passes over the top of a nut is also an acceptable alternative if the hole is located as shown in the figure.

Fig. 13: Where drilling of locking wire holes has caused a thin wall section, route the wire as shown in the figure, to prevent damage to the nut.

Fig. 14: Locking wire can be mounted to any other part of the assembly if nothing else is possible.

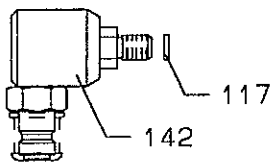


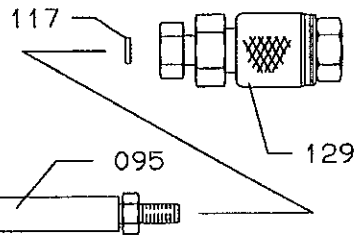
Molybdenum Disulphide (MoS_2)

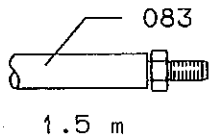
The following procedure is to be followed prior to the mounting of metal surfaced parts which are to function as seals.

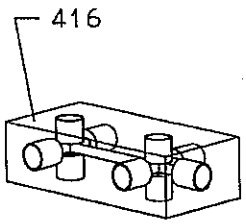
- Clean the surface with a cleaning fluid and ensure that the entire surface is completely free of grease.
- Allow 5 minutes for the cleaning fluid to evaporate.
- With a clean leathercloth, and using circular movements, rub a mixture of fine-grained particles of Molybdenum Disulphide (MoS_2) and mineral oil (e.g. Molycote G-n Plus, or the like) hard onto the metal surface.
- Remove any excessive paste and ensure that the metal surface is only coated with a thin, uniform, layer of the above mixture.
- Protect the wet paste and cloth from dust or other foreign particles.

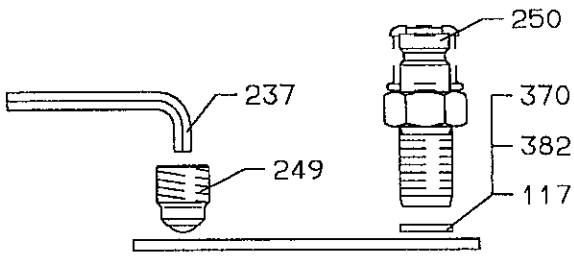
Part No.					1.5 m	3 m			
010	1.5 m		2	2	1				
022	3 m		2	2		1			
046		3		3			1		
058		5		5				1	
404		9		9					1

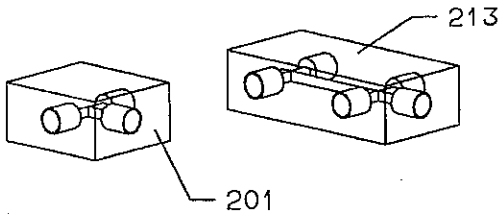


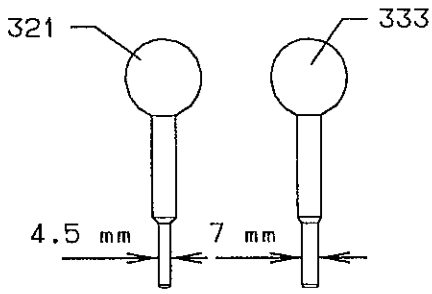


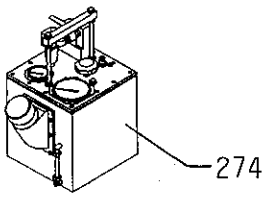












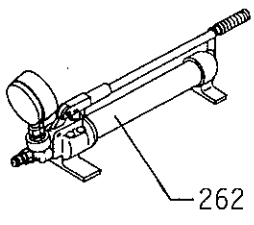
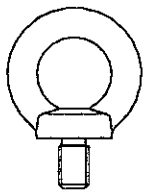


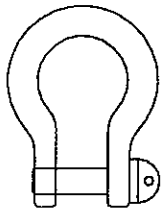
Plate 91351-20M Accessories for Hydraulic Tools

Item No.	Part Description	MES Tools No.	
010	Flexible high-pressure hose (1,5 m), complete	13A10	
022	Flexible high-pressure hose(3 m), complete	13A09	
046	3-way distributing piece, complete	13A04	
058	5-way distributing piece, complete	13A05	
083	Flexible high-pressure hose, 1,5 m	(13A10)	
095	Flexible high-pressure hose, 3 m	(13A09)	
117	Gasket	—	
129	Snap-on coupling, female with protective plug	—	
142	Screwed connection 90°	—	
201	3-way distributing piece	(13A04)	
213	5-way distributing piece	(13A05)	
237	Wrench	13A95	
249	Bleeder screw	—	
250	Snap-on coupling, male with protective cap	—	
262	Manual high-pressure pump	13A02	
274	Pneumatic/hydraulic high-pressure pump	13A01	
321	Tommy bar, 4.5 mm	13A95	
333	Tommy bar, 7 mm	13A95	
370	Gasket 6 mm mild steel	—	
382	Gasket 9 mm mild steel	—	
404	9-way distributing piece, complete	13A06	
416	9-way distributing piece	(13A06)	



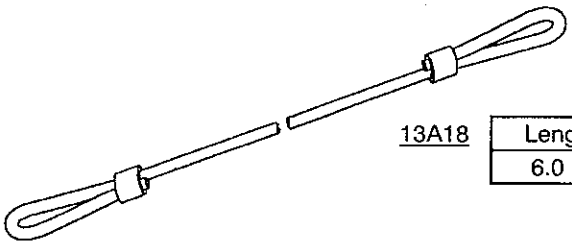
13A20

Thread	Max. load	B&W Standard No.
M10	2.3 kN ~ 230 kg	EN69G10
M12	3.4 kN ~ 340 kg	EN69G12
M16	7.0 kN ~ 700 kg	EN69R16
M20	12.0 kN ~ 1200 kg	EN69R20
M24	18.0 kN ~ 1800 kg	EN69R24
M30	36.0 kN ~ 3600 kg	EN69R30



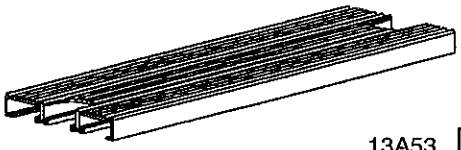
13A19

Thread	Max. load	B&W Standard No.
M12	9.0 kN ~ 900 kg	(EN518G12)
M16	15.0 kN ~ 1500 kg	(EN518G16)
M20	24.0 kN ~ 2400 kg	(EN518G20)
M24	37.0 kN ~ 3700 kg	(EN518G24)
M30	60.0 kN ~ 6000 kg	(EN518G30)



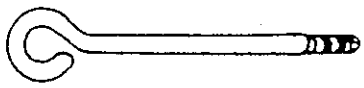
13A18

Length	Max. load	Item No.
6.0 m	58.0 kN ~ 5800 kg	—



13A53

Length	Item No.
750 x 250 mm	—



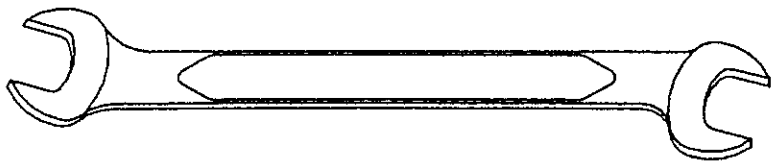
13A21

Thread	Max. load
M8	

Combination spanner

13A81

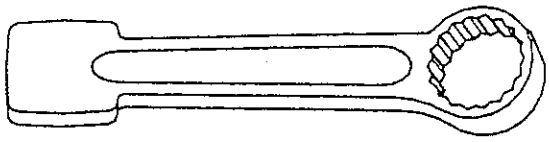
Size	MAN B&W Standard No.	Size	MAN B&W Standard No.
10	EN554K10	19	EN554K19
11	EN554K11	21	EN554K21
12	EN554K12	22	EN554K22
13	EN554K13	24	EN554K24
14	EN554K14	27	EN554K27
16	EN554K16	30	EN554K30
17	EN554K17	32	EN554K32
18	EN554K18	36	EN554K36



Double open-ended spanner

13A82

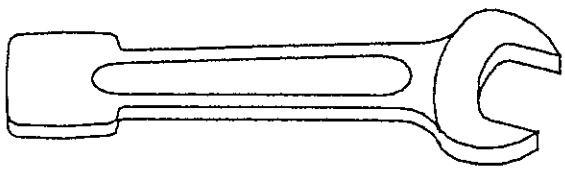
Size	MAN B&W Standard No.	Size	MAN B&W Standard No.
6 - 7	EN552F67	24 - 27	EN552F2427
8 - 10	EN552F810	30 - 32	EN552F3032
12 - 14	EN552F1214	36 - 41	EN552F3641
13 - 17	EN552F1317	46 - 50	EN552F4650
16 - 18	EN552F1618	55 - 60	EN552F5560
19 - 22	EN552F1922		



Ring impact spanner

13A84

Size	MAN B&W Standard No.	Size	MAN B&W Standard No.
30	EN554L30	55	EN554L55
32	EN554L32	60	EN554L60
36	EN554L36	65	EN554L65
41	EN554L41	70	EN554L70
46	EN554L46	75	EN554L75
50	EN554L50	80	EN554L80



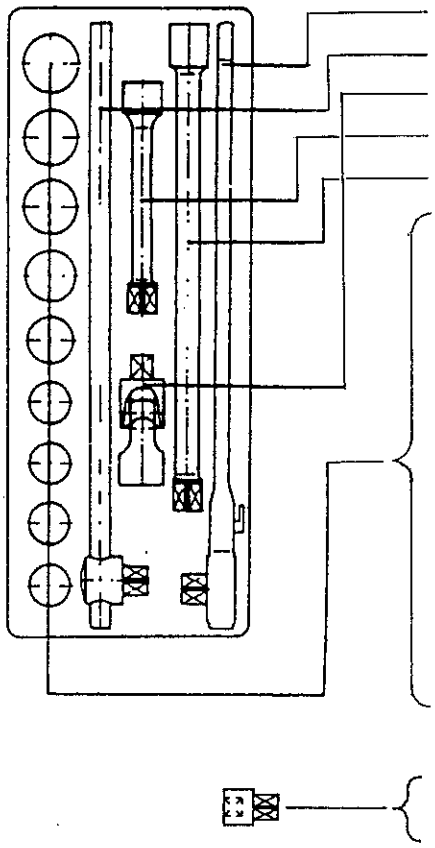
Open-ended impact spanner

13A85

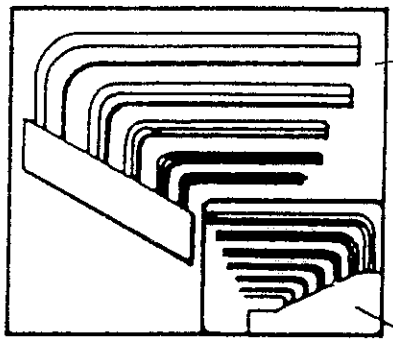
Size	MAN B&W Standard No.	Size	MAN B&W Standard No.
30	EN553E30	55	EN553E55
32	EN553E32	60	EN553E60
36	EN553E36	65	EN553E65
41	EN553E41	70	EN553E70
46	EN553E46	75	EN553E75
50	EN553E50	80	EN553E80

Spanners

Plate 91363-28M

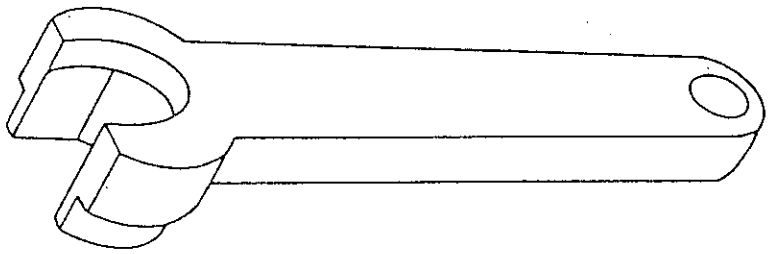


	13A86	13A87
	B&W Standard No.	B&W Standard No.
Designation	Small set	Large set
Complete	EN563H 1	EN563H 2
Ratchet	EN506B 12.5	EN506B 20.0
Slide T-handle	EN506A 12.5	EN506A 20.0
Universal joint	EN506P 12.5	EN506P 20.0
Extension	EN506F 12.5125	EN506F 20.0200
Extension	EN506F 12.5250	EN506F 20.0400
Socket	EN506L 10	EN506L 24
Socket	EN506L 13	EN506L 27
Socket	EN506L 16	EN506L 30
Socket	EN506L 17	EN506L 32
Socket	EN506L 18	EN506L 36
Socket	EN506L 19	EN506L 41
Socket	EN506L 22	EN506L 46
Socket for internal hexagon	EN506G 5	EN506G 14
Socket for internal hexagon	EN506G 6	EN506G 17
Socket for internal hexagon	EN506G 7	EN506G 19
Socket for internal hexagon	EN506G 8	
Socket for internal hexagon	EN506G 10	
Socket for internal hexagon	EN506G 12	
Box	EN563G 1	EN563G 2
Reducing adapter		凹12.7 凸19
Reducing adapter		凹25.4 凸19

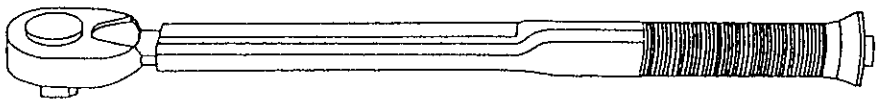


13A88	Socket wrench set for internal hexagon	B&W Standard No.
	Size Complete	EN549G 1
	7 mm	EN549A 7
	12 mm	EN549A 12
	14 mm	EN549A 14
	17 mm	EN549A 17
	19 mm	EN549A 19

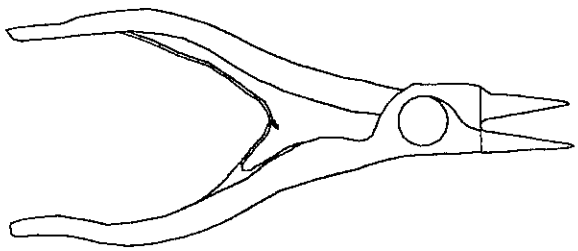
13A88	Socket wrench set for internal hexagon	B&W Standard No.
	Size Complete	EN549E 1
	1.5 mm	EN549A 1.5
	2 mm	EN549A 2
	2.5 mm	EN549A 2.5
	3 mm	EN549A 3
	4 mm	EN549A 4
	5 mm	EN549A 5
	6 mm	EN549A 6
	8 mm	EN549A 8
	10 mm	EN549A 10



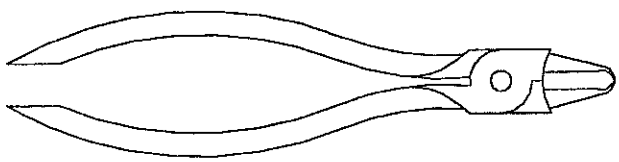
011



035
047
059
060



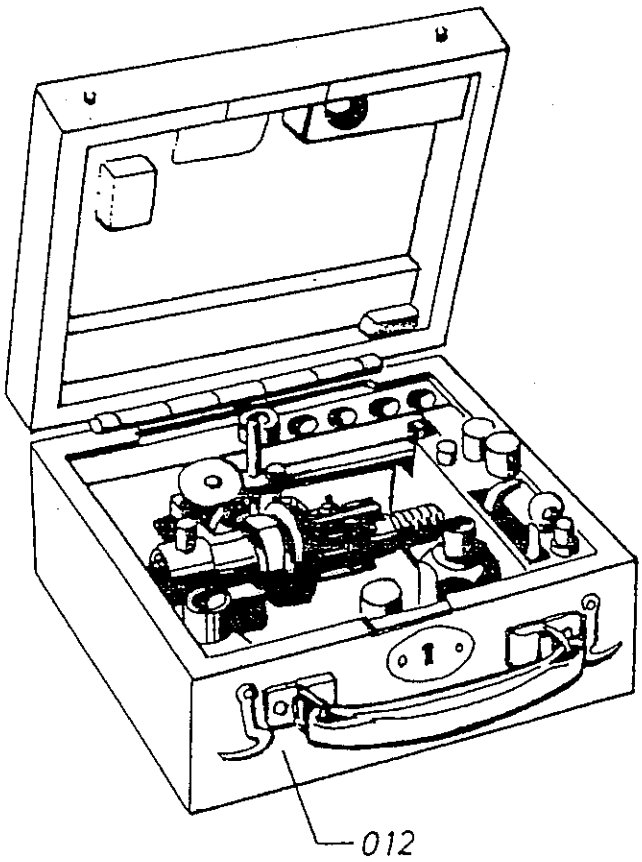
072
084
096
106
118
M1



131
143
155
M2

Plate 91364-48M Spanners, etc.

Item No.	Part Description	MES Tools No.	
011	Open spanner	13A90	
035	Torque spanner 20-90 Nm	13A91	
047	Torque spanner 40-280 Nm	13A91	
059	Torque spanner 100-750 Nm	13A91	
060	Torque spanner 500-2100 Nm	13A91	
072	Pliers for circlip 4-9	13A92	
084	Pliers for criclip 10-18	13A92	
096	Pliers for circlip 19-30	13A92	
106	Pliers for circlip 32-58	13A92	
118	Pliers for circlip 60-80	13A92	
M1	Pliers for circlip 82-165	13A92	
131	Pliers for circlip 19-30	13A92	
143	Pliers for circlip 32-58	13A92	
155	Pliers for circlip 60-80	13A92	
M2	Pliers for circlip 82-175	13A92	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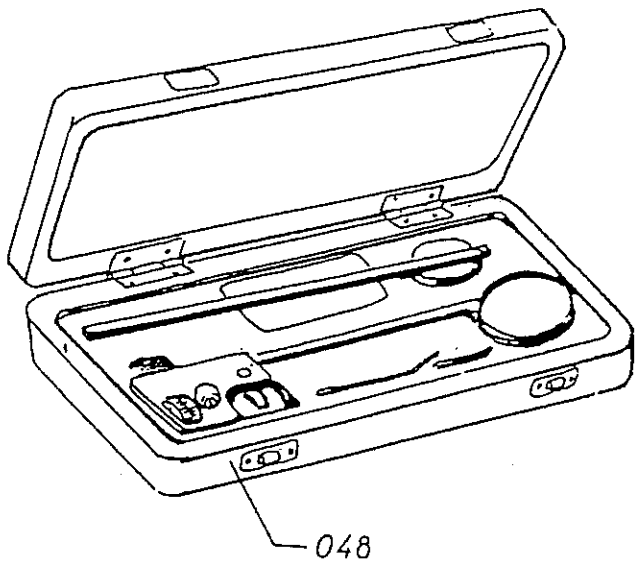
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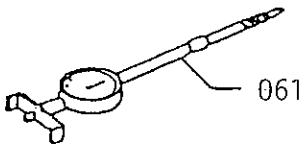
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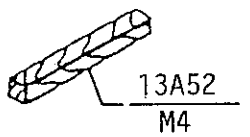
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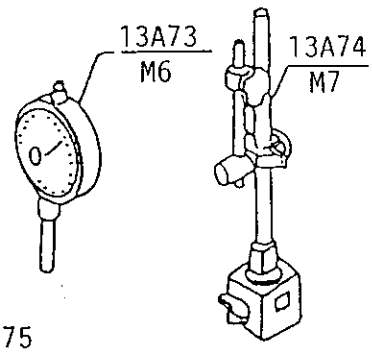
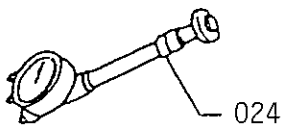

13A73
M6
13A74
M7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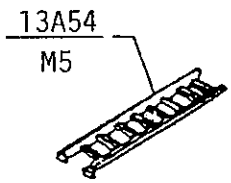
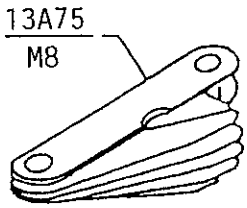
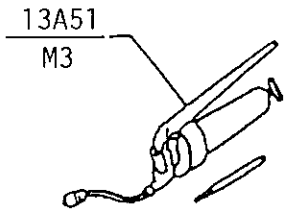
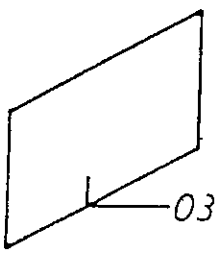

13A54
M5


13A75
M8


13A51
M3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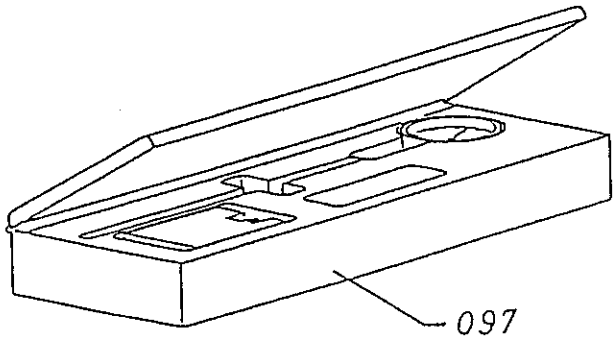
097

Plate 91366-54M Instruments

Item No.	Part Description	MES Tools No.	
012	Indicator, complete	13A76	
024	Crankshaft measuring tool (Autolog), complete	13A80	
036	Indicator, paper	13A77	
048	Planimeter, complete *)	(13A78)	
061	Cylinder gauge, complete	13A79	
097	Measuring tool for main bearing clearance	13A71	
M3	Greese gun	13A51	
M4	Sleeper	13A52	
M6	Dial gauge	13A73	
M7	Holder with magnet base	13A74	
M8	Feeler gauge	13A75	
	*) Optional extra		

913 GENERAL TOOLS

913.02 GRINDING MACHINE FOR EXHAUST VALVE

yasec

EXHAUST VALVE SPINDLE & SEAT GRINDING MACHINE

TYPE-L/S50MC

SERVICE MANUAL

SERVICE MANUAL No.
MR 7319①

YAMASHINA SEIKI CO.,LTD.

C O N T E N T S

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PARTS LIST 18

⚠ Precautions for Safety Operations

- This manual refers to operations and operation precautions of our Grinding Machine . Before you use this device, be sure to carefully read through this manual for the complete understanding of the device. The operation should be carried out by experienced operators.

- Please keep this manual at an easily accessible place so that the operator can use it whenever he or she is going to operate the device.

- This manual basically classifies and indicates the degree of harm or damage, which may occur against any improper operation of the device, in the three category of "DANGER", "WARNING" and "CAUTION". The definition of these terms and the attention symbols are as follows.

⚠	DANGER	Should an improper handling is attempted, such critical risks which could result in a fatal injuries are impending.
⚠	WARNING	Should an improper handling is attempted, such dangerous possibilities which could result in a serious injuries are expected.
⚠	CAUTION	Should an improper handling is attempted, such possibilities that could result in physical damage or injuries, or only material damages are expected.

* Note that even in case of the CAUTION items, there might result in significant injuries depending on the situation. Be sure to understand and observe these descriptions since either of these symbols states important cautions.

⚠ DANGER

- ○ Never touch the terminals in the control box with the electric power being supplied. Be sure to provide grounding to avoid electrical shocks.
- ○ Since the grinding chips may spread in sparks, be sure to move such materials that may easily take fire or may easily be damaged to the area where no danger is anticipated.
- ○ Be sure to always use the grindstone cover during the operation.
- ○ When the grinder is improperly operated, the grindstone may be broken, thus causing fatal or serious injuries.

TE-14752

⚠ WARNING

- ○ The grindstone should not be used whenever it is accidentally dropped, hit with something hard, or when it is found to be unusual during the inspection.
- ○ Do not touch the rotating grindstone with your fingers or a part of your body.
- ○ Do not take your steps, during the operation, into the area in the rotational direction of the grindstone.
- ○ The rotational direction of the grindstone should be the same as the arrow indicates. When it is reversely rotated, the grindstone may come off, thus resulting in an accident.
- ○ Be sure to put such protective devices as goggles and a dust must during the operation.
- ○ For the grindstone, please use the genuine parts which are specified by YAMASHINA. Never use unauthorized parts since they may be a cause of unexpected accidents.
- ○ Before starting the daily work, a trial operation should be performed for one minutes or over, and in case the grindstone is replaced, it should be for three minutes or over. During this period of time, the operator should stand by at a safe place since the grindstone may be broken during this performance.

⚠ CAUTION

- ○ Those who has no sufficient experience in the operation of the grinder should not try to replace the grindstone or make the trial operations.
- ○ For the handling of grindstone, be sure to observe the three principles, "No Rolling, No Dropping and No Hitting."
- ○ Grindstones should be stored on tool shelf, etc. in a dry area.
- ○ The cutting amount and feeding speeds should conform to the specified number. Otherwise, an abnormal wear of the grindstone or abnormal grinding of works.
- ○ When you notice, during the operation, the operation of the machine is not smooth or something is wrong with the machine, immediately stop the operation and inspect it, or repair it, as required.
- ○ In case the grindstone is mounted on the flange, nuts should not be over-tightened.
- ○ Do not enter in to the area where sparks are available.
- ○ For moving the machine, hoist it by using eyebolts.
- ○ The legs of the machine should be welded to the deck.
- ○ Always pay attention to maintain the machine in good condition and keep it clean.

I. INTRODUCTION

1. summary

Thank you very much for your purchase on "YASEC Grinding Machine" this time. This operation manual is issued to set forth the recommendations and procedures to be read any understood before use for maintaining and servicing this model including operational instructions and the capacity of the model, such that this model can be effectively and safely operated.

Conventionally, it took a long time for grinding exhaust valves and sealing parts for marine diesel engines. There are also problems in such grinding operation. In order to overcome such drawbacks, we, a maker of special machine tool and cylinder lubricators, developed an up-to-date new model "YASEC" on the basis of our technology and experience forstered by our technical research and industrial rationalization over many years. We are confident that the performance of this model will meet your expectations.

The grinding wheel slide is equipped with a fine angle adjusting device.

2. Specification

Grinding wheel spindle speed	:	4800 rpm (4800 min^{-1})
Work spindle speed	:	9.5 rpm (8 min^{-1})
Wheel size (Dia×Width ×Bore)	:	φ90x10xφ16
Slide angle adjusting range	:	29.9° ～30.6°
Wheel motor	:	AC 3φ 440v 60Hz 400W
Work motor	:	AC 3φ 440v 60Hz 100W

3 notes upon use

It is highly recommended for operating a grinding machine safely with the grinding wheel to follow the procedures described below, since any improper use may cause extremely dengerous accident.

○ When a new grinding wheel is replaced, run it idly for more than 3 minutes in order to make sure there is no unusual noises or vibrations on the machine.
During this operation, wait at a place of safety and watch it carefully, in order to avoid any possible accident which may be encountered, such as cracking of the wheel.

○ Run it idly for more than one (1) minute and make sure there is no abnormality before you start the operation.

○ Keep the cutting depth and feed speed below the specified values, respectively, otherwise resulting in the abnormal abrasion or crack of the grinding wheel, or the abnormal cutting on a work.

○ Fix the wheel cover whenever in use.

○ Keep your hands or body away from the wheel running.

○ Wear a protective glasses when you work on the machine to protect your eyes.

○ Keep anything which is inflammable or easy to be damaged, away from the place near the machine, since the sparks of ground metal powder are scattered around.

○ Use maker specified parts of consumption such as a grinding wheel , other wise unexpected accident may occurs.

○ Stop the machine immediately when you realize during operation that it does not work normally, and then check it and repair it if necessary.

○ Keep the machine clean regularly.

Ⅱ. Grinding procedures

1. Vertical slide unit

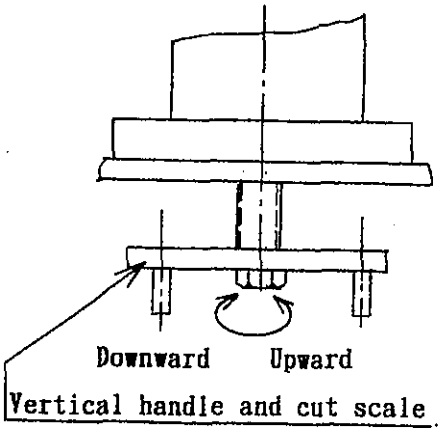


Fig. 1

○ Turn the vertical slide handle clockwise, the vertical slide unit moves downward.
(As shown in Fig. 1)

○ One graduation of the micro collar corresponds to the cutting depth 0.005mm.

○ After having set the depth of cut for the grinding wheel tighen the clamping lever (14) at the side of slide pipe housing (9) to prevent shifing during grinding.

2. Mounting valve spindle

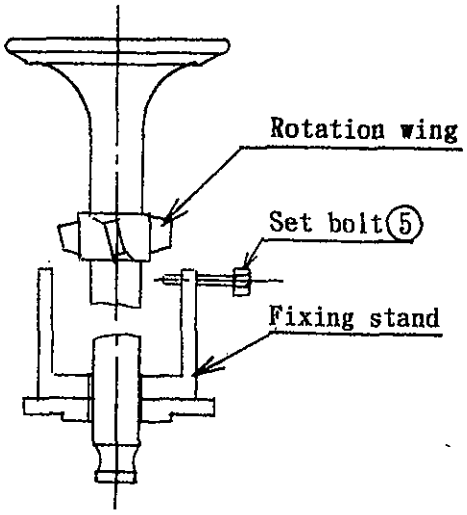


Fig. 2

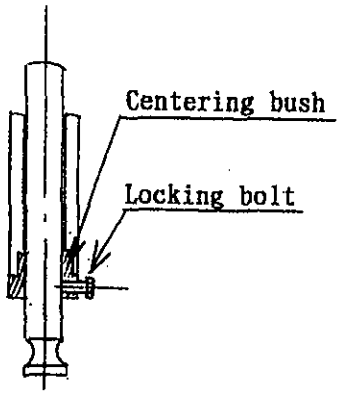


Fig. 3

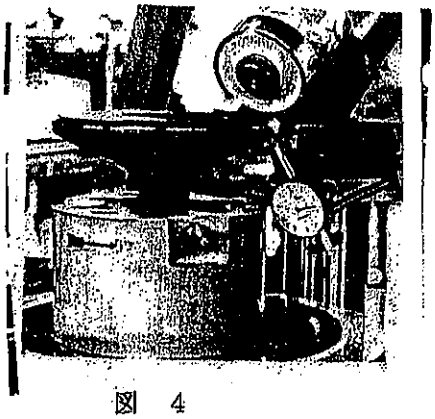


図 4

Fig. 4

○ Loosen three set bolts (5) that each bolt does not touch the rotation wing, until the each tip is aligned with the internal diameter.

○ Make sure that no bolt of the locking bolt at the bottom project in the hole in its center.

○ Insert the valve spindle from above until it hits the rotation wing.

○ Lightly tighten the locking bolt at the side of centering bush.

4E-94932

○ Lightly tighten the three set bolts.

○ Set a dial gauge to the seat surface of valve spindle. (As shown in Fig. 4)

○ Set to the spindle start cam switch on the control box. The valve spindle will rotate counter clockwise when viewed from above.

Centering should be carried out with a dial gauge in accordance with the following procedures.

a) Slightly tighten three centering bolts in the valve spindle mounting, so that the each height of the three bolts sticking out, L1, L2, and L3 are visualy adjusted to be equal each orther. (As shown in Fig. 5)

b) Set a dial gauge at right angles to the valve spindle seat surface. (As shown in Fig. 6)

c) Read the Max. and Min. with the dial gauge, and mark it at each point.
(As shown in Fig. 7)

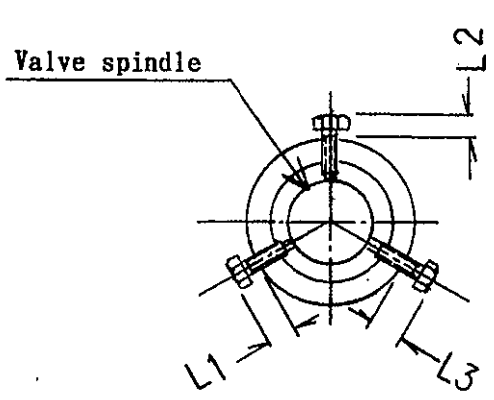


Fig. 5

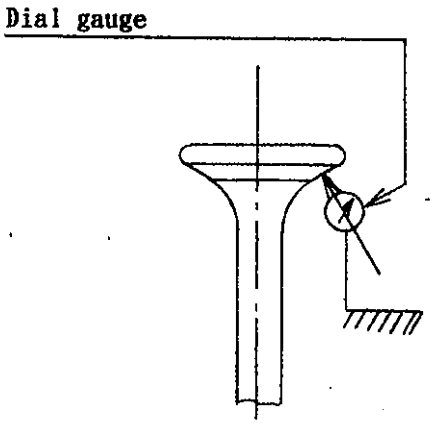


Fig. 6

d) Calcuates the following equation.
(Max. valve −Min. valve)/2 =A/2

e) Rotate the work spindle for positioning, so that the contact of the dial gauge comes to the position P2 in Fig. 7. (as shown in Fig. 8)

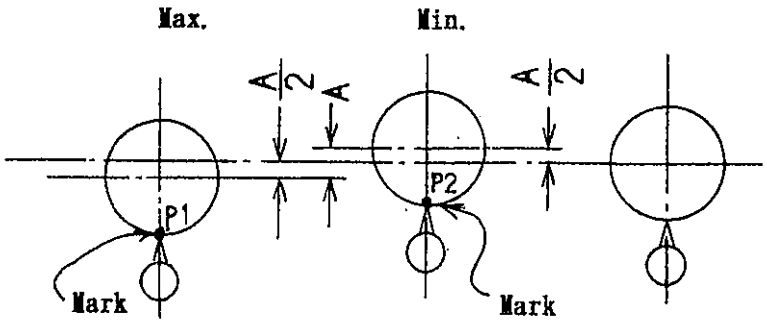


Fig. 7

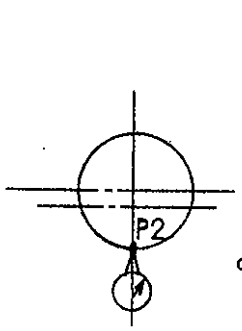


Fig. 8

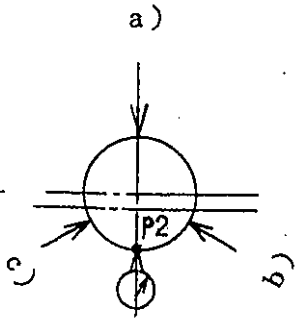


Fig. 9

f) Slightly loosen the centering bolts b), c), located in the direction of the contact, and tighten the bolt a) to move a thing in the derection of the contact by A/2. (As shown in Fig. 7)
Make sure that both bolts b), c) are tightened in this state.
In this manner, move the thing in the direction of the Min. value by the value of the equation: (Max. value − Min. value) /2, and then by repeating this procedures 4 ~5 times, so that the de-flection indicated on the dial gauge may be less than 0.04mm.

3. Fine angle adjusting device and adjusting method

For the seat surface of a valve spindle and seat is able to be ideal form, the fine angle adjusting device is provied for "YASEC" grinding machine.
Reference angle 30 degrees (Same as the valve angle) is a position where the lower end of the preserve plate (78) meet with the marked line. (As shown in Fig. 10 and Fig. 26)
The mark S on the micro collar is to correspond with the pointer B (70) in this state. (As shown in Fig. 27)
Set the mark V on the micro collar (65) to correspond with the pointer B (70) for "Valve spindle grinding" operation.
Set the mark S on the micro collar (65) to correspond with the pointer B (70) for "Valve seat grinding" operation.
The positions S and V of the position plate (68) represent only approximate positions, so when the operation is shifted from the valve spindle to the valve seat and vice versa, the each setting should be carried out by the S and V on the micro collar (65) and the pointer B (70).

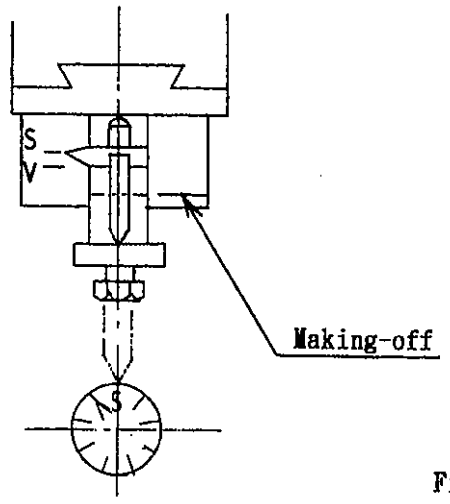


Fig. 10

Sometimes try to make sure that the lower end of the preserve plate (78) at the position of the mark S on the micro collar (65) is to correspond with the marking off. Positioning with the micro collar should be carried out in the direction of pushing up the angle adjusting bolt (64).

4. Mounting valve seat

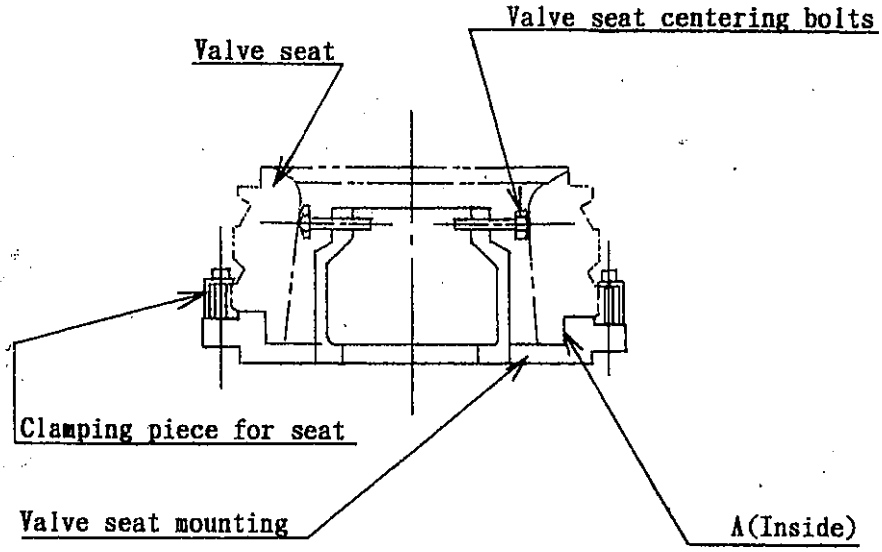


Fig. 11

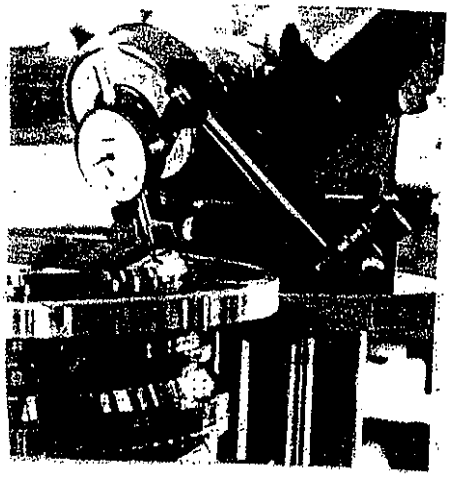


Fig. 12

- ○ Removed the valve seat from the valve cage and clean it. The portion A to be in contact with the valve seat mounting should be especially carefully cleaned.
- ○ mount the valve seat on its mounting.
- ○ Set a dial gauge to the seat surface.
- ○ Strain the valve seat slightly with the hexagon portions of three centering bolts in the valve spindle mounting.
- ○ Switch on the valve seat for starting on the control box. The valve seat will rotate clock wise when viewed from above. Make centering by the centering bolt so that the deflection indicated on the dial gauge may be less than 0.04mm.
- ○ Switch off for stop.
- ○ The centering operation is in the same way as with the valve spindle.
- ○ Fixing the valve seat with clamping piece and M10 hexagon socket head cap screws.
- ○ Rotate it once more to confirm that the deflection is small enough.

5. Grinding valve spindle

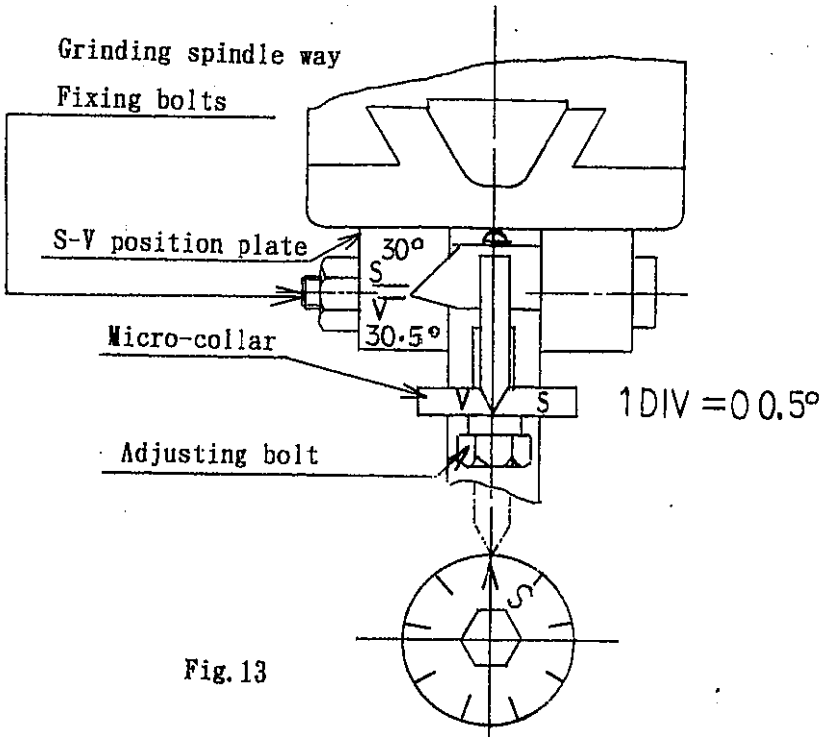


Fig. 13

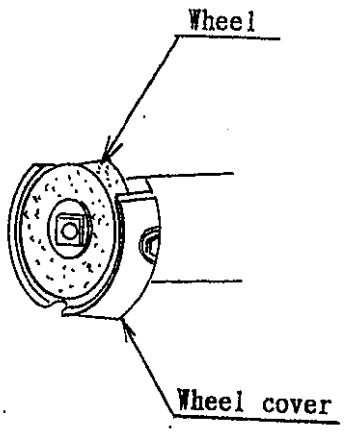


Fig. 14

○ Slightly loosen the nut of the wheel spindle way 19 clamping bolt 21 . (Only one part on the upper side.)

○ Rotate the micro collar of adjusting bolt for fine angle from the valve seat position to the right direction by 6 divisions to corresponded with V on the micro collar. While the mark of 30.5° on the S-V position plate 68 is in agreement with the pointer A 69. (As shown in Fig. 13)

○ Tighten the nut of the wheel spindle way fixing bolt.

○ Attach the opening of the wheel cover upward. (As shown in Fig. 14)

○ Switch on the wheel spindle starting.

○ Switch on the work spindle starting.

○ Down the vertical slide, so that the wheel is below the extended line of the work spindle seat surface.

○ Feed the vertical slide until the wheel comes in contact with its seat surface slightly. Then feed the wheel slide at specified speed onto the surface at the full length to make sure that the wheel has an even contact with the seat surface. Check for the angle again when there is any gap between the wheel surface and the seat surface, or the contact pressure is relatively high. When the angle seat is correct, adjust the vertical slide to grind the higher position compared with the orthers.

○ Feed the wheel slide forward by the depth of cut to less than 0.01mm (2 graduation) stroke to perform a rough grinding by repeating it several times or approx. several times in accordance with the state of the seat surface.

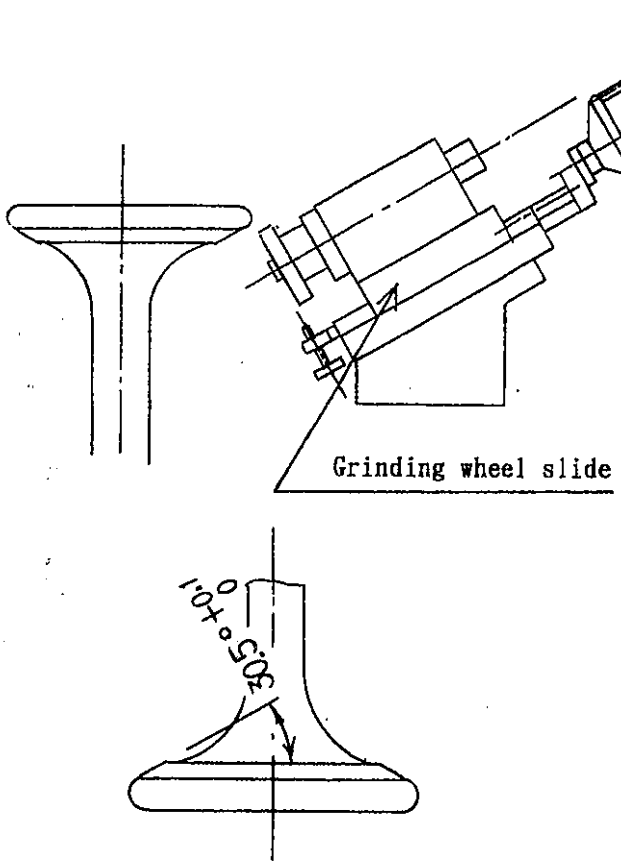


Fig. 15

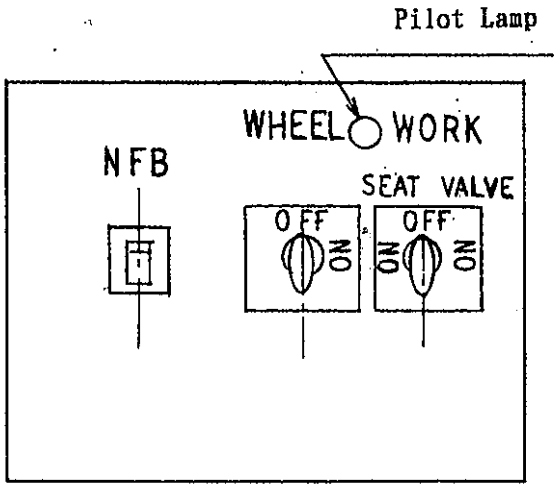


Fig. 16

○ The feed speed of the wheel slide for the finish grinding is approx. 1/6 revolution with the wheel feed handle (0.33mm/rev) as per the revoiution of work spindle.

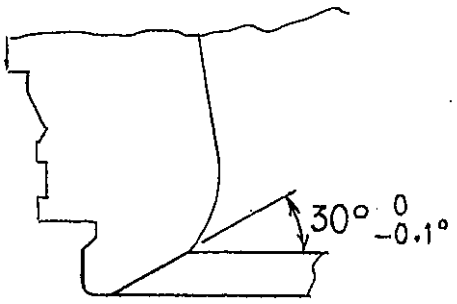
6. Grinding valve seat

○ Re-mount the wheel covers turned downward.

○ Slightly loosen the nut of the wheel spindle way (19) clamping bolt (21).
(Only one part on the upper side.)

○ Once lower the S-V position plate (68) of angle adjusting bolt and fit it to correspond with the S of the micro collar in the direction of pushing up. (While the mark of 30° on the S-V position plate (68) is to correspond with the pointer A (69).)
after that, push down the wheel spindle way, so that the end of angle adjusting bolt contacts without any gap, and tighten the nut of the wheel spindle way fixing bolt.
(As shown in Fig. 18, 19)

○ Grinding in the same way as with the valve spindle.



Valve seat angle

Fig. 17

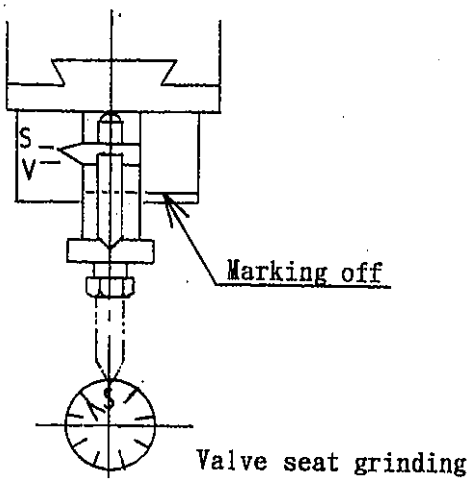


Fig. 18

7. Angle adjusting for seat surface (Un-usual operation)

When valve spindle or valve seat surface to be grind is required to set at angles orther than 30.5 ° or 30 ° the fine adjusting can be readily carried out with the following procedures.

○ Slightly loosen the nut of the wheel spindle way, clamping bolt. (Only one part on the upper side.)

○ Rotate the micro collar of angle adjusting bolts from the mark S or V position by required graduation. The one graduation of micro collar denotes 0.05. This operation should be carried out in pushing up.

○ Make sure that there is no gap at the end of the angle adjusting bolt.

○ Tighten the nut of the wheel spindle way fixing bolt. (Only one part on the upper side.)

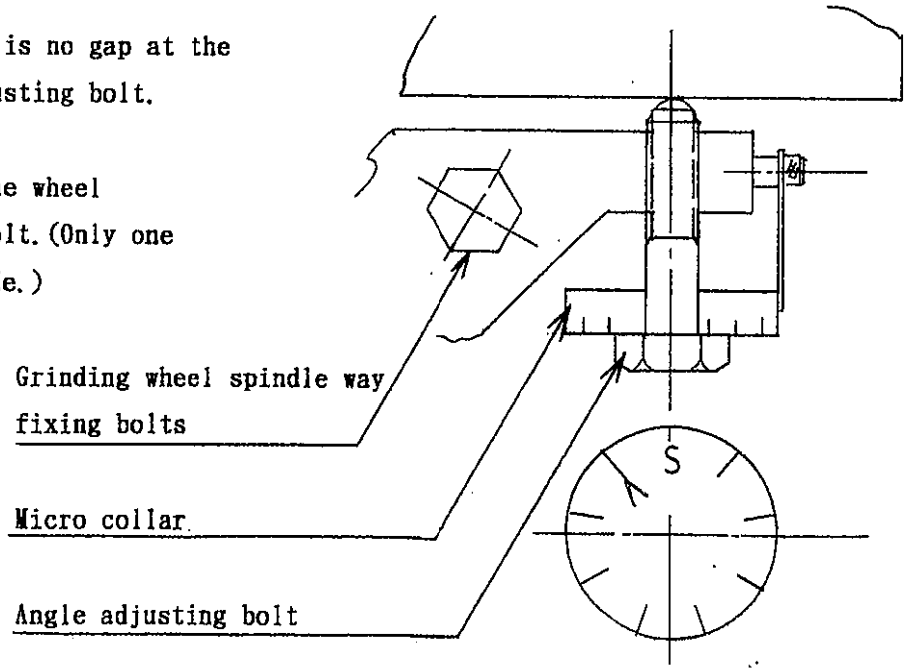


Fig. 19

8. General remarks for grinding operation

○ Max cutting feed capacity is 0.01mm. (An ordinary grinding wheel)
Grinding with an excessive cutting feed may cause the following trouble, therefor an effective grinding operation can not be secured.

1) The wheel surface is loading and the grinding operation can not be properly carried out.

2) The increase in the diameter of the wheel with the increase in the temperature of the wheel results in the increase in cutting feed, and such vicious circle finally causes the crack on the wheel.

3) Cracks on the circumference of the wheel.

○ The feed speed for rough grinding should be at apporox. 1/3 revolution with the wheel feed handle (Feed screw pitch is 2mm, so the feed is 0.67mm for one revolution of a work) for one revolution of a work.
The feed operation should be carried out sequentially.

○ Cutting feed for finish grinding is at 0.005mm (1 graduation).

○ The feed for the finish grinding is at approx. 1/6 revolution of a work.

○ Stop the grinding operation at once when the wheel surface is loading (Metallic noises occur in the grinding noises). Then take the wheel off from the grinding surface by the use of the vertical handle, and carry out dressing tooling with a diamond dresser. (As shown in Ⅲ－1 for procedures)

○ Check the wheel, when the amout of cutting feed or the wheel surface is loading by the temperature of the wheel surface increases drastically (not less than room temperature +20°)

○ Set to appropriate vaules of the amount and rate for cutting feed again when the wheel is loading only by two or three times operation (As shown in item 1, 2 for the appropriate vales.)

Set this adjustment from the begining after there is a period of idle time (for 10 minutes at room temperature not less than of 25 ℃ for 5 minutes at temperature less than of 20℃) since the diameter of the wheel decreases.

Ⅲ. Dressing and tooling for the grinding wheel

1. Dressing

This operation is carried out when the surface of the wheel is loading.

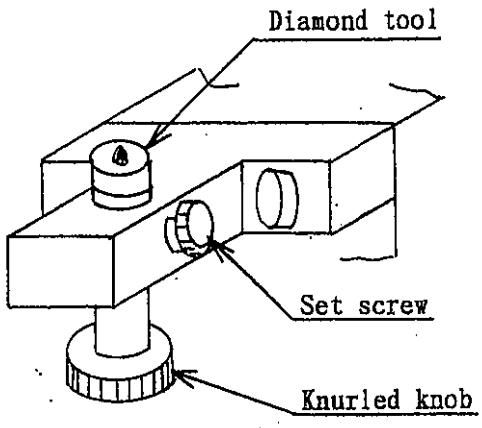


Fig. 20

2. Tooling

This operation is carried out when the surface of the grinding wheel is deformed by abrasion.

The filling of the valve spindle and valve seat described in this manual is the material which is grindable with a grinding wheel made of an aluminium oxide system, Dressing" and "Tooling " jobs can be performed simultaneously with a diamond tool.

○ Tooling operation should be carried out when the grinding wheel is replaced or retightened.

○ Move forward the wheel slide to bring the wheel to beside the diamond tool.

○ Adjust the knurled knob so that the diamond tool tip cuts the surface of the wheel about 0.01～0.03mm.

○ In state that the wheel turning stops, rotate the wheel for tooling operation, by which a cutting depth of approx. 0.01mm is obtained.

○ Tighten the set screw to fix the diamond tool, move forward and reverse wheel slide for tooling operation.

○ The diamond tool is threaded in M12 and pitched in 1.75, i.e., one revolution makes a cutting depth of 1.75mm. Generally the preferable cutting feed is approx. 0.05 ～ 0.09mm revolution.

○ When the wheel is replaced with a new one, first try to rotate it for about three (3) minutes, and retightened for about two (2) minutes to check to see if it is free from crack or any other defects, and then start dressing.

Read the items described in 1-3 carefully.

○ The nuts of the wheel set bolt is left-hand thread.

○ Feed rate for tooling and dressing can be feed at approx. 10 ~15 seconds per stroke. When the speed is too slow, the surface of wheel is easily flattened.

Ⅳ. Various adjustment and maintenance

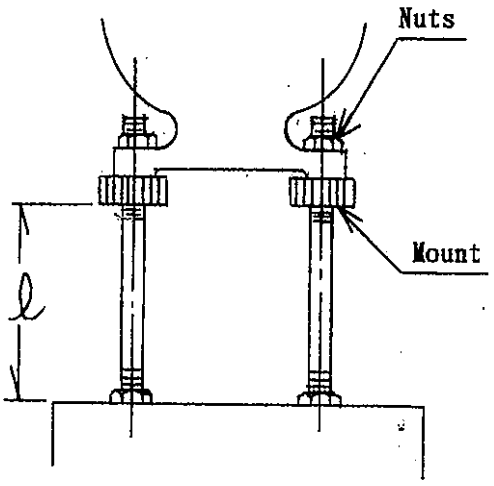
1. Adjusting belts

○ When the V- belt is found to slip, restoring them.

○ Loosen four nuts.

○ Since the mounts are threaded, adjust four "ℓ" dimensions according to the belt length.

○ Tighten four nuts.



Flg. 21

2. Vibration isolating mounts

In order to prevent and absorb the vibration of the grinding machine, vibration isolating mounts is supplied as an accessory.
When operating the grinding machine, loosen the fixing nut ⓓ so that the weight of the grinding machine is charged on the rubber.
In case of removal or non-operation for long time of the grinding machine.
Tighten the bolt and nut so that the weight is not applied to the rubber.

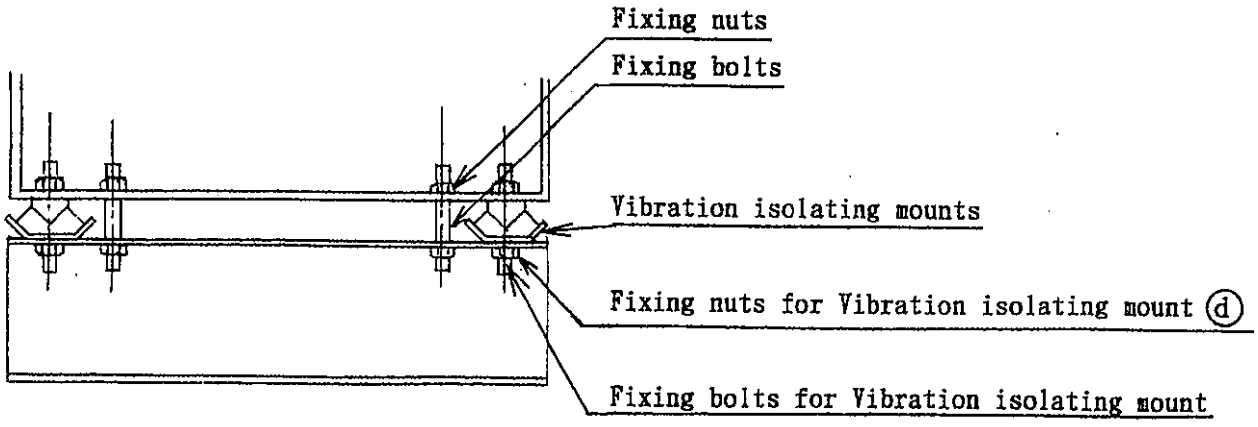


Fig. 22

3. Maintenance and inspection

The grinding machine will operate semipermanentaly expect replacement of the wheel and belts, and in order to operate a machine in good condition, however, special attention should be paid to the following.

○ Make sure that the wheel spindle rotates clockwise when view from the wheel side.

○ Special care should be taken for rustproofing the sliding parts and the top surface of the valve seat mounting.
Apply a rust priventing oil to the non painted position when the machine is kept idle for a long time.

○ Supply a lubrication oil into 2 oil cups provided at the both side of the wheel spindle slide portion and one oil cup at the vertical slide before a grinding operation stars. (As shown in Fig. 23)

○ Tappered roller bearings 4th-grade are used for the wheel spindle.
When the necessity of disassembly arised, return the machine to our factory.

○ Adjust the jib (67) with the adjust bolts (76) provided at the side of the slide, when the wheel spindle slide is excessively light or heavy. (As shown in Fig. 27)

○ Clean the wheel spindle slide way carefully after used.

○ It is highly recommended to carry out periodical maintenance services including the check and adjustment for the grinding wheel spindle angle at the first 5 year and then every 3 year, made by us for pay, such that the machine can be used comfortably and safely.

☆ Advise us the type and manufacture number of the model marked on the plate, and the serial number and name of each part listed on the part table at the end of this manual when you place your order of parts on us for replacement. It should be noted that it will be unwarrantable if any parts other than the maker specified part are used.

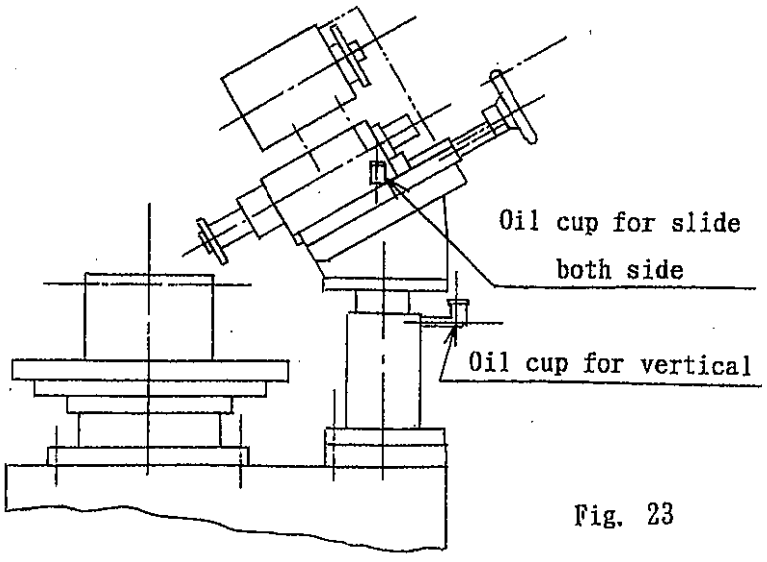
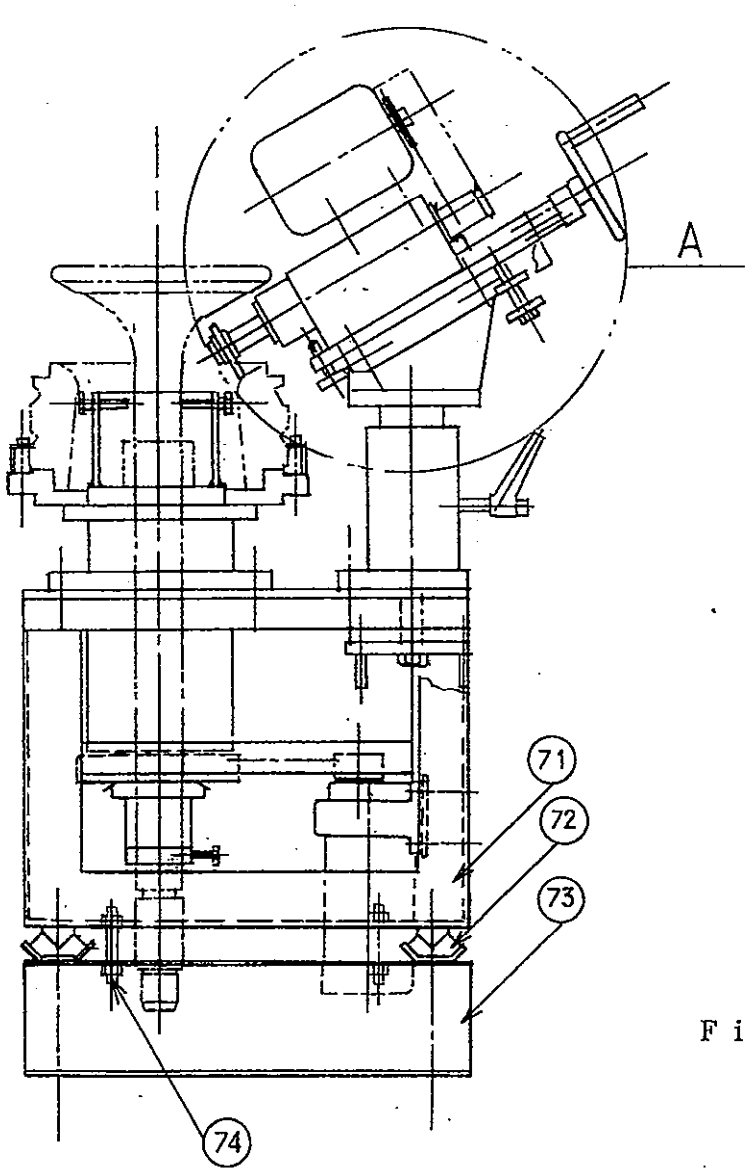


Fig. 23



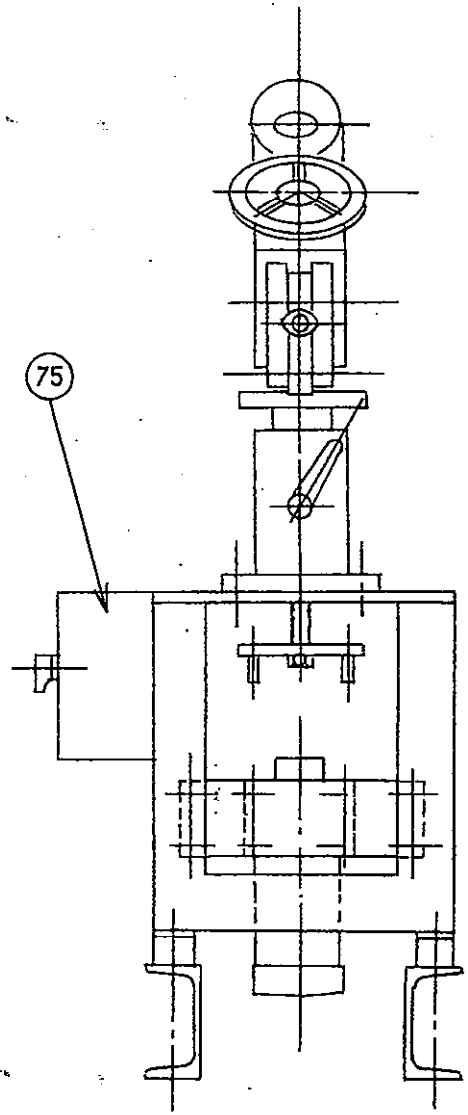


Fig. 24

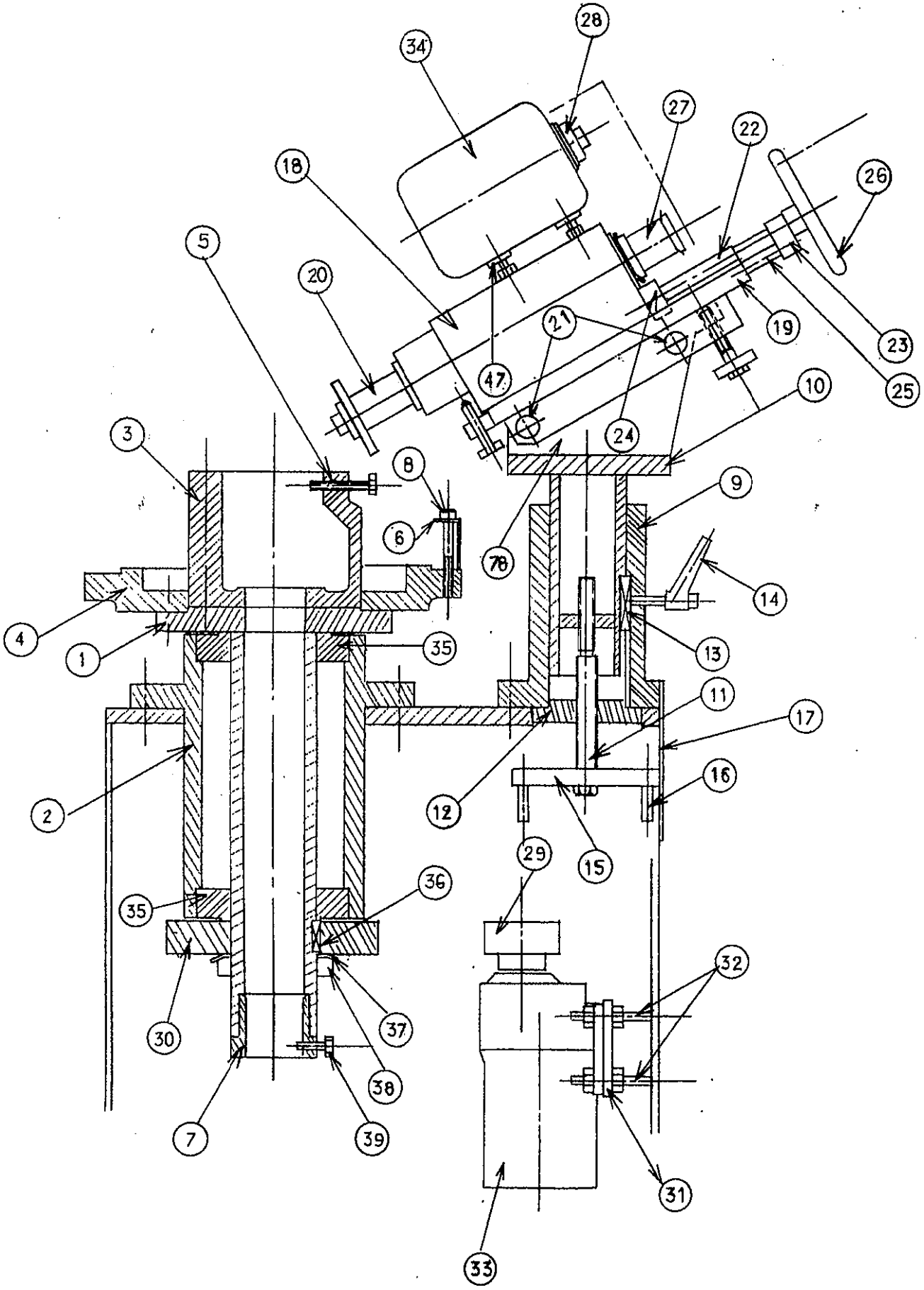


Fig. 25

Detail "A"

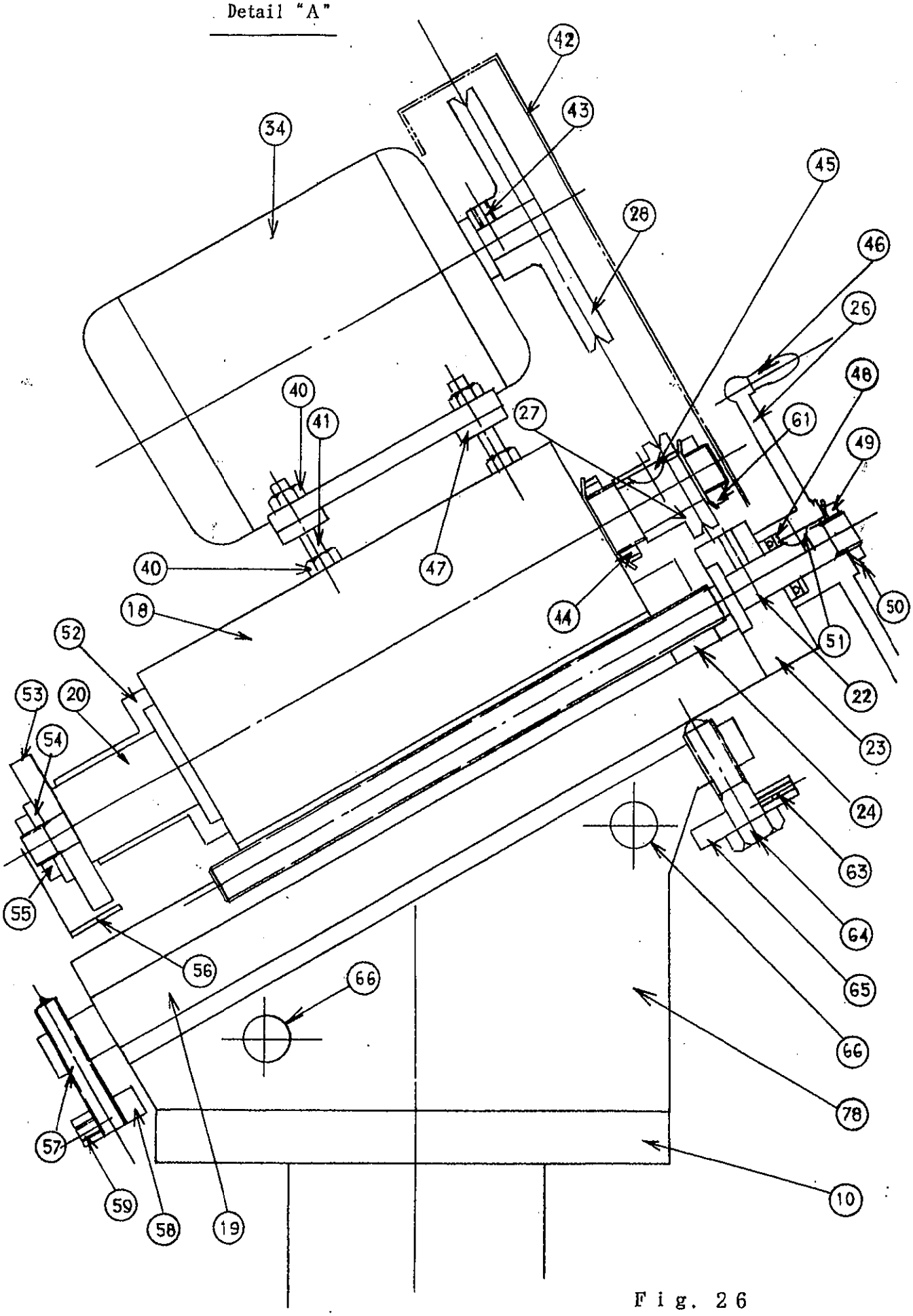


Fig. 26

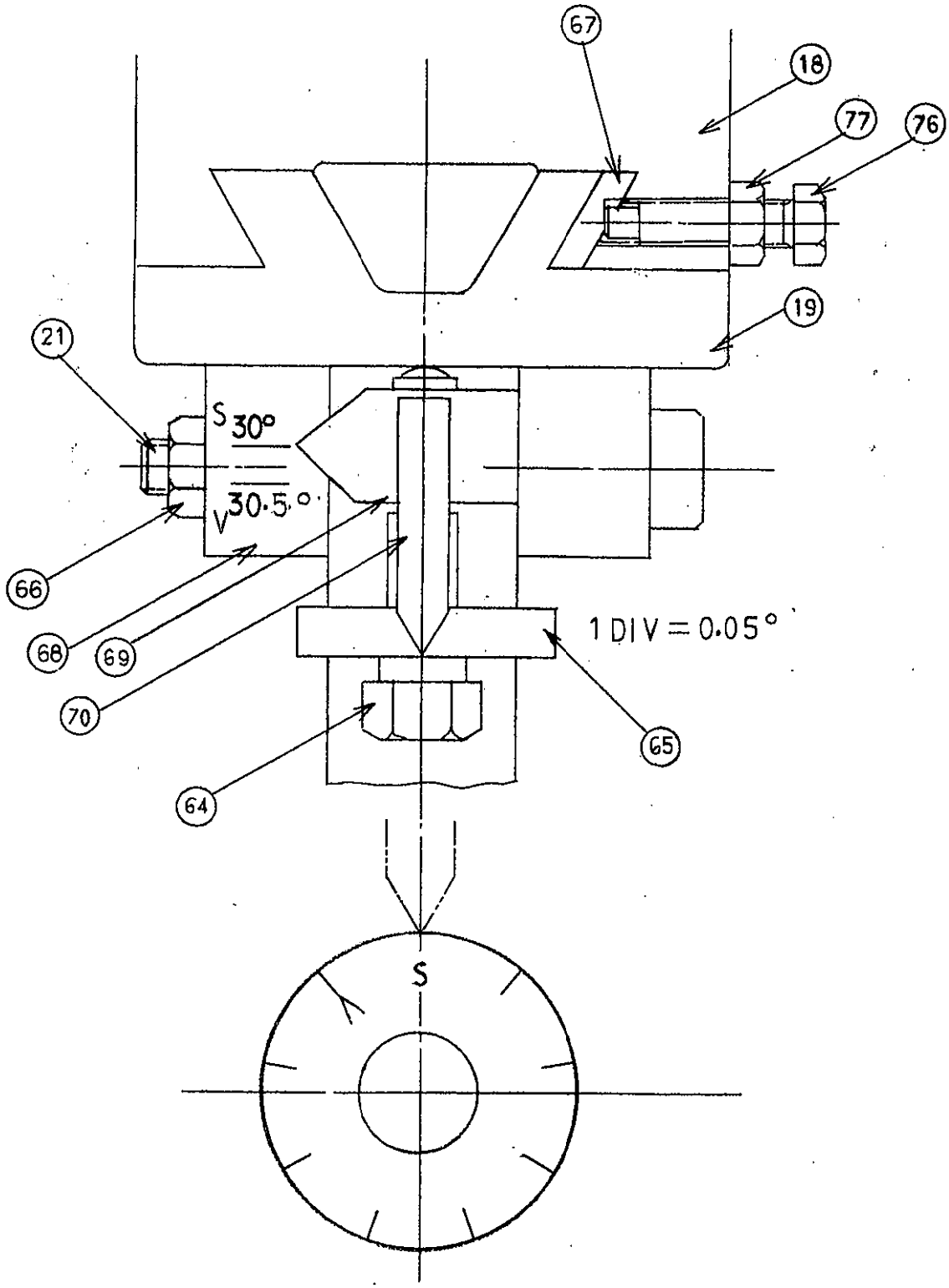


Fig. 27

L/S50MC EXHAUST VALVE SPINDLE & SEAT GRINDING MACHINE PARTS LIST

No.	NAME	MATERIAL	No.	NAME	MATERIAL
1	Work spindle	SS400	41	Stud bolt	SS400
2	Work spindle housing	FC200	42	Pulley cover	SPC
3	Valve spindle mounting	FC200	43	Hexagon socket head bolt	SCM
4	Valve seat mounting	FC200	44	Bearing nut	S45C
5	Valve spindle & seat set bolts	ss400	45	Key	S50C
6	Valve seat clamping piece	SPC	46	Handle knob	SS400
7	Centering bush	FC200	47	Washer	SS400
8	Valve seat clamping bolts	SCM	48	Thrust bearing	SUJ
9	Slide pipe housing	FC200	49	Handle clamping nut	-
10	Slide pipe	SS400	50	Washer	SPW
11	Differential screw	SS400	51	Key	S50C
12	Nuts for vertical	SS400	52	Wheel cover adapter	FC200
13	Slide key	S50C	53	Wheel	-
14	Clamping lever	SS400	54	Washer	SPW
15	Handle and cut scale	SS400	55	wheel clamping nut	SS400
16	Cut scale knob	SS400	56	Wheel cover	SS400
17	Reference plate	SPC	57	Diamond tool	-
18	GRINDING WHEEL HOUSING	FC200	58	Knob	SS400
19	GRINDING WHEEL spindle way	FC200	59	Hexagon socket head bolt	SCM
20	Spindle (GRINDING WHEEL)	S45c	60	-	
21	Fixing bolt	SS400	61	Pulley clamping nut	S45C
22	Slide feed screw	S45c	62	-	
23	Feed screw bracket	FC200	63	Hexagon socket head bolt	SCM
24	Feed screw nut	S45c	64	Angle adjusting bolt	SS400
25	Feed screw bracket collar	STPG	65	Micro collar	SS400
26	Wheel handle	FC	66	Clamping bolt	SS400
27	Spindle pulley	S45C	67	Jib	FC200
28	Motor pulley	S45C	68	S-V position plate	ALP
29	Geared motor pulley	FC200	69	Pointer	ALP
30	Work pulley	FC200	70	Pointer	ALP
31	Geared motor mount	SS400	71	Base	SS400
32	Geared motor stud	SS400	72	Vibration isolating mounts	Rubber
33	Geared motor		73	Leg	SS400
34	Motor		74	Fixing bolts	SS400
35	Bearing	SUJ	75	Control box	-
36	Key	S50C	76	Jib adjusting bolts	SS400
37	Washer	SWP	77	Fixing nut	SS400
38	Bearing nut	S45C	78	Preserve plate	SS400
39	Rocking bolt	PBB			
40	Hexagon nut	S20C			

M. E. S

L/S 5 0 M C

Grinding machine

Hardfacing

Spindle • • ALLOY 50

Seat • • SCM440(N)

First edition MAY. 1999

Servise manual No.

MR 7 3 1 9 1

913 GENERAL TOOLS

913.03 TEST DEVICE FOR FUEL INJECTION VALVE

INSTRUCTIONS FOR TEST PUMP UNIT FOR MAIN DIESEL ENGINE FUEL VALVE

MODEL NIT678

NAGAO MACHINERY WORKS CO.,LTD.

4X-08911

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2. MAIN SPECIFICATIONS ---------- P1

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9. GENERAL NOTICE MATTERS ---------- P8, 9

10. PARTS DRAWING ---------- P10

1. FOREWARD

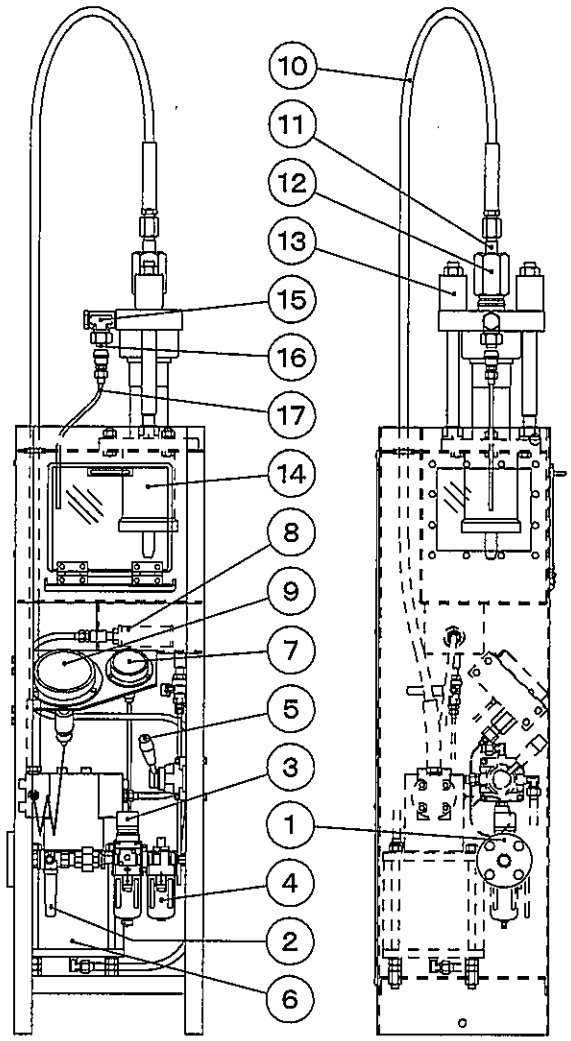
This unit is the special testing apparatus for the purpose of the various pressure tests of diesel engine fuel valves (conical type/slide type). Before using this unit, it is essential for the engine room personnel to be acquainted with the contents of this manual and to follow the instructions strictly because fuel oil pressure during the test will be very high.

2. MAIN SPECIFICATIONS

Booster's area ratio ----------	1:100
Max. air pressure ----------	0.9 MPa
Injection oil amount ----------	20 cc/stroke
Air consumption amount ----------	0.03 Nm^3/stroke (air press. 0.6 MPa)
Tank capacity ----------	1.1 L (prescribed oil)
Total weight ----------	73 kg
Air source pressure ----------	0.6～0.9 MPa

3. PART NAMES

fig. 1



No,	PART NAMES
1	Air supply connection
2	Stop valve
3	Regulator
4	Lubricator
5	Change valve
6	Booster pump
7	Air pressure gauge
8	Oil filter
9	Fuel oil pressure gauge
10	High pressure hose
11	Inlet connection
12	Cap nut
13	Spring housing
14	Holder
15	Stud elbow
16	Drain plug
17	Drain tube

4. DIAGRAM FOR TEST PUMP UNIT (see fig.3)

This pump unit is used for the purpose of the various tests of the fuel valves furnishing high pressure fuel oil compressed by the booster pump, as shown in fig.3.

(1). The air ratio of the booster is 1:100.

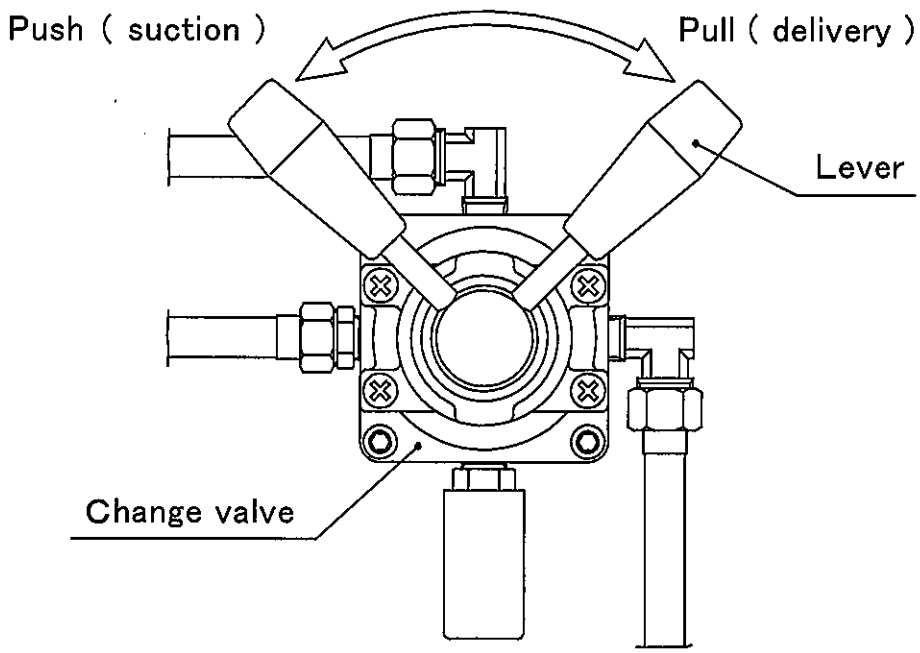
For example : When the air pressure is set at 0.1 MPa, the delivery pressure of fuel oil is 10 MPa.

(2). The compressed air is controlled by regulator, and passes through the change valve to the air cylinder in the booster pump. The air pressure controlled by the regulator is indicated on the air pressure gauge.

(3). The delivery pressure of the fuel oil increases or decreases is in proportion to the pressure of compressed air. When the lever of the change valve is pushed, the fuel oil is sucked into the booster pump. When pulled, the fuel oil is delivered from the booster pump.

Note : It is necessary for the lever to be held in the desired position until the stroke end of booster pump is detected.

fig. 2



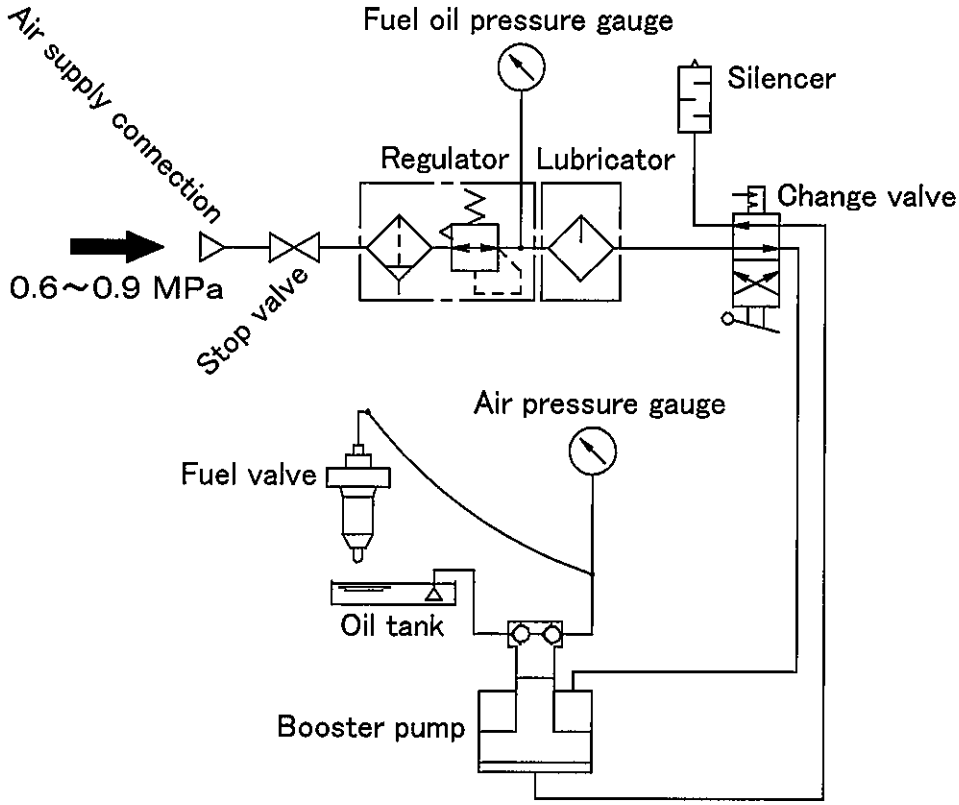
(4). The fuel oil is supplied to the fuel valve after passing through the oil filter in oil tank fitted in the injection box and increased the pressure by booster pump.

The fuel oil pressure is indicated on the fuel oil pressure gauge.

When the booster pump reaches the stroke end, the delivery of fuel oil stops.

The capacity of this pump unit is 20 cc/stroke. If the desired pressure is not reached and the pressure on the fuel oil pressure gauge drops, it will need to operate the lever of the change valve repeatly as stipulated in (3).

fig. 3



5. PREPARATION OF TEST

(1). Ascertain that the fuel oil (prescribed oil) is filled properly in the oil tank.

Note : The fuel valve is very sensitive to dirt etc.. When supplying the fuel oil, it is necessary to use clean oil. If it is dirty, the fuel oil must be replaced with new one and/or clean fuel oil.

Prescribed oil : Hydraulic oil (rust-preventing) with a viscosity between 7 and 10 cSt at 50℃.

(2). Check the amount of the oil at the lubricator.
(Turbine oil No.1, correspond to ISO, VG32, capacity 130cc.)

(3). Open the stop valve to ascertain at 0 MPa on the air pressure gauge. If any air pressure exists on the air gauge, turn the knob of the regulator to counterclockwise till the air pressure gauge indicates at 0 MPa.

(4). Air venting from fuel oil system.
When the fuel oil has been supplied or replaced before using this unit, the air venting should be carried out according to the following instructions.

4-1). To prevent injury due to spurting the high pressure fuel oil, the end of the high pressure hose should be inserted, fixed to the inside of the holder and hold the hose by hand to ascertain which is attached to the holder.

4-2). The handle of regulator is turned to clockwise, and the air pressure set to approx. 0.1 MPa, then feed the fuel oil to the system by operating the lever of the change valve. This operation must be repeated until no foamy fuel oil flows out.
Note : It is necessary to operate the lever of change valve until you detect that the stroke end of the booster pump is detected.

6. FITTING OF FUEL VALVE

(1). When fitting the fuel valve onto the holder, for the purpose of safety, the air pressure should be released completely by regulator and the stop valve must be fully closed to set the air pressure to 0 MPa.

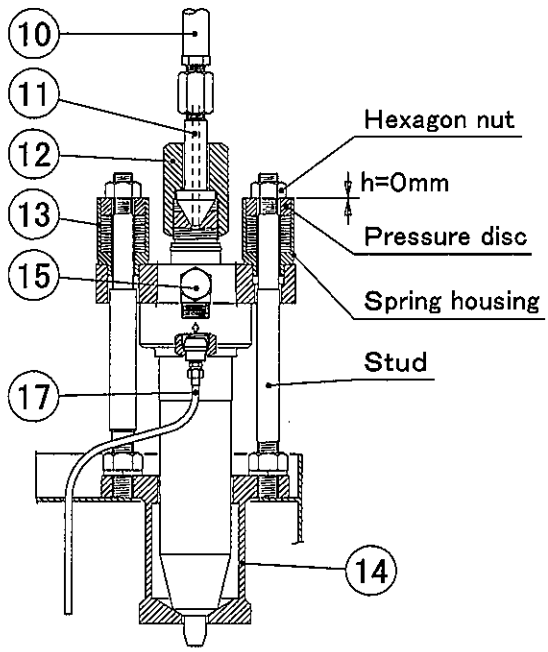
(2). Clean the inside of the holder, then set the fuel valve correctly according to the plate which indicates the injecting direction.

(3). Instruction for fixing each type of fuel valve on holder.

3-1). K98MC～L/S50MC

Set the spring housings onto the studs of the holder for connecting the high pressure hose and the fuel valve. Tighten the hexagon nuts on each side of the stud of the holder relatively till the top face of the pressure disc is on the level with the top face of the spring housings.

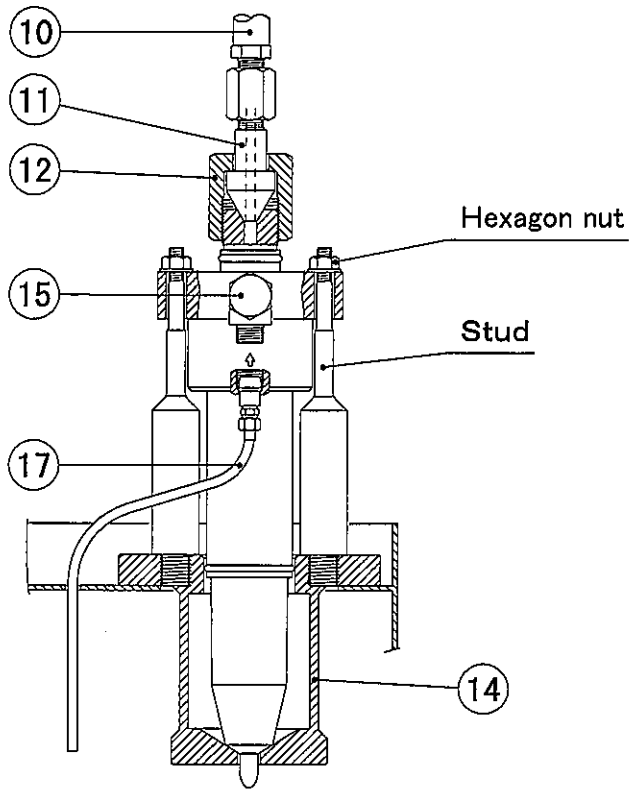
fig.4



3-2). S46/50MC-C/S50ME-C

Screw the hexagon nuts with plane washers onto studs of the holder, Tighten the hexagon nuts on each side of the studs relatively with the torque of 25 Nm.

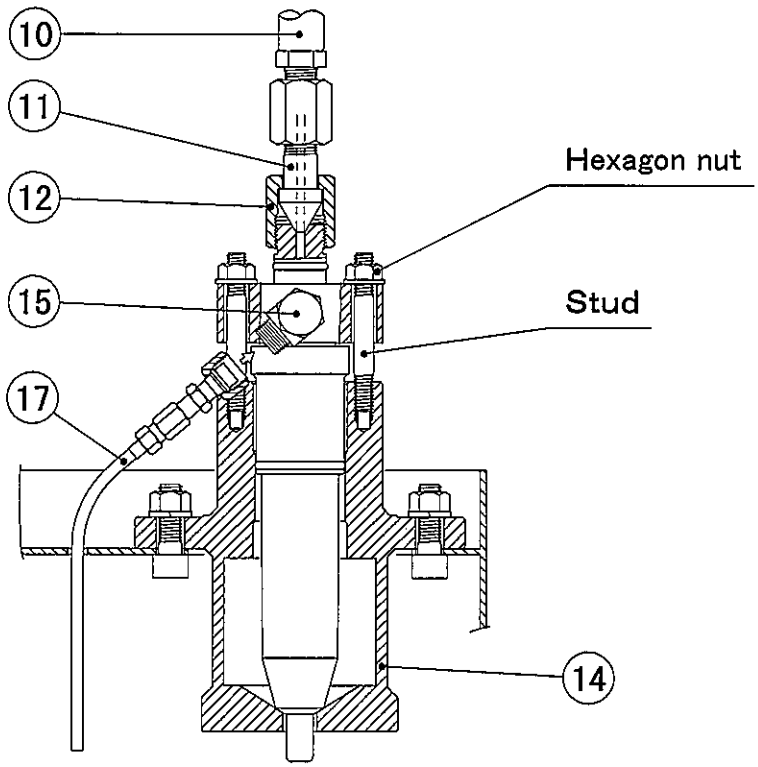
fig.5



3-3). L/S35/42MC

Screw the hexagon nuts with plane washers onto studs of the holder, Tighten the hexagon nuts on each side of the studs relatively with the torque of 20 Nm.

fig.6



(4). Thoroughly clean the oil inlet connection, seating surface of the fuel valve, and check for any defects or dust. Connect this pump unit to the fuel oil system by tightening the cap nut on the fuel valve head.

(5). Connect the stud elbow of the drain tube to the drain hole of the fuel valve, then insert the other side of the drain tube into the hole which is set on the oil tray.

7. TESTING ITEMS & OPERATION PROCEDURE.

7-1). Air venting of fuel valve.

Turn the handle of the regulator to clockwise, and set the air pressure to approx. 0.1 MPa. Then feed the fuel oil to the system by operating the lever of the change valve. This operation must be repeated until no foamy fuel oil flows out.

Note : It is necessary to operate the lever of change valve until the stroke end of the booster pump is detected.

7-2). Sealing test and sliding function.

To confirm the tightness of the valve spindle against the seating in the spindle guide, check the oil leakage from the nozzle of the fuel valve. Furthermore, check the movement of the slide valve.

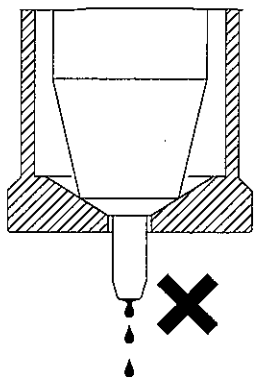
If required, the slide valve unit should be replaced with new/repaired one.

Note : The measure should be done according to the instruction book with individual engine.

(1). To check the oil leakage at each connecting joint of fuel oil system by setting the air pressure to approx. 0.1 MPa. No leakage shall be checked with operating the lever of the change valve.

(2). The air pressure is to be set to approx.8～10 MPa below the opening pressure with operating the lever of change valve. No leakage from nozzle shall be checked at this condition.

fig.7



(3). The pressure drops relatively slowly to about 1.5 MPa, after which it drops quickly to 0 MPa because the slide valve in the non-return valve is pressed against the conical seat and the vent hole for circulation of oil is made open.
(It can be judged from increasing to the leak oil from the drain hole when the fuel valve is full of oil)

7-3). Opening pressure.

(1). Set the air pressure to 0.6 MPa.

The opening pressure test is continue to be done after finishing the checking of 7-2).

Increase the fuel oil pressure by pulling the lever of change valve slowly until the valve opens and oil is forced out from the fuel nozzle, then read the pressure on the pressure gauge as opening pressure.

Note : Refer to the instruction book with individual engines.
If the opening pressure has not been obtained with the regular pressure, the spring on the thrust spindle must be replaced with new one.

Note : If the desired pressure is not able to reach and the pressure of fuel oil pressure gauge drops, the repeat operation of the lever of the change valve is necessary.

7-4). Tightness test of "O" ring.

Check the oil tightness of "O" ring between the valve head and housing by filling the fuel oil in the fuel valve and raising the oil pressure.

Note : If the oil tightness is not in order, the "O" ring is to be replaced.

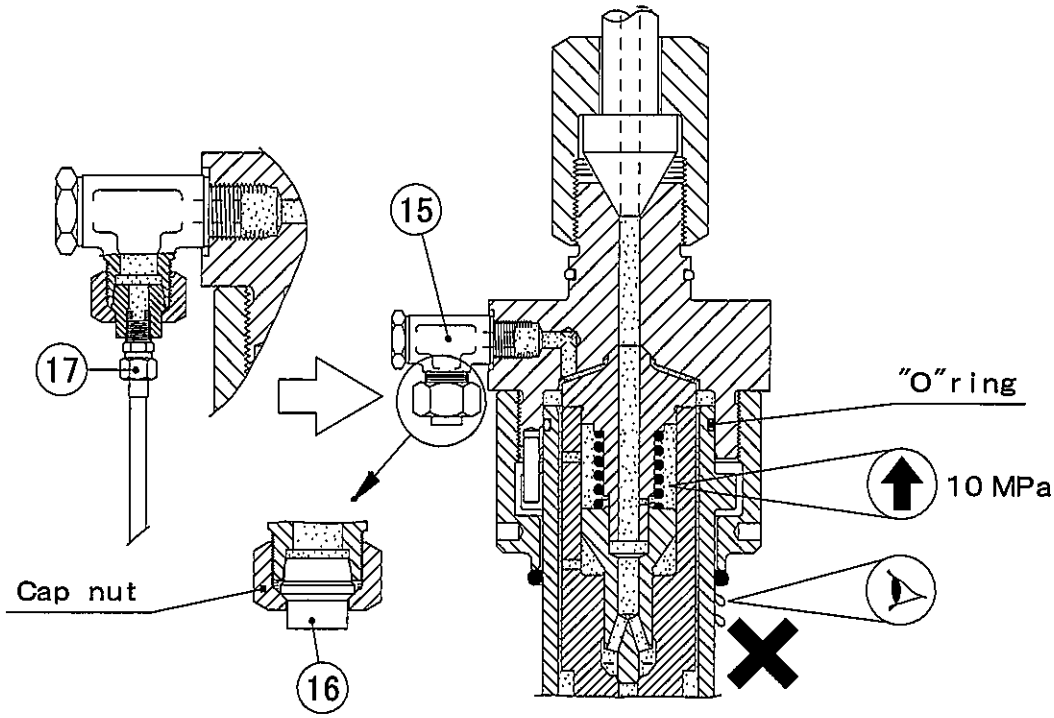
(1). The test is advanced to the following step if the fuel oil flows out from the drain tube.
If the fuel oil does not flow out from the drain tube, the pressure is slowly raised again by control the regulator and make sure that the oil pressure does not exceed by "1 MPa" to prevent the activation of the slide valve. Feed the fuel oil to fuel valve by operating the lever of the change valve.

(2). After confirming that the fuel valve is filled with fuel oil, close the drain passage by the drain plug after removing the drain tube.

(3). Deliver the fuel oil increased the pressure up to approx.10 MPa to the fuel valve by operating the lever of the change valve.
Check no oil leakage or drop of oil pressure on the fuel oil pressure gauge.

(4). After finishing the pressure test, set the air pressure to "0 MPa", and release the fuel oil pressure by loosening the cap nut on the drain plug slightly. Further, the drain plug must be used only for this test. For the other tests, the drain tube must be used.

fig.8



8. REMOVAL OF FUEL VALVE

Remove the fuel valve safety, close the stop valve, set the air pressure to "0 MPa", and confirm that no fuel oil pressure remains in the oil system.

9. GENERAL NOTICE MATTERS

(1) This pump unit is designed for 7-2), 7-3) and 7-4) tests and the atomization test is not executed.

Please note the following.

1-1). For conical type fuel valves

The atomization of the fuel oil is depended on the nozzle diameter, the nozzle length, the opening pressure of the fuel valve, the fuel oil velocity of the fuel pump etc.. The state of the atomization using of the test pump unit is not same as the atomization of the actual engine. On the other hand, the condition of each part of fuel valve can be judged by executing the mentioned tests, thus the injection test is considered to be no necessary.

1-2). For slide type fuel valves

Do not attempt to carry out an atomization test on slide type fuel valves, as this may damage the cut-off slide and nozzle. An atomization test may damage the valve by making the needle oscillate, with a small lift at a very high frequency, The sudden drop of high pressure across the cut-off edge and the high contact pressure between slide and fuel nozzle, in combination with the poor lubricity of

the test oil, increases risk of seizures between cut-off slide and nozzle. All of these conditions involves the risk of seizures between the cut-off slide and the nozzle.

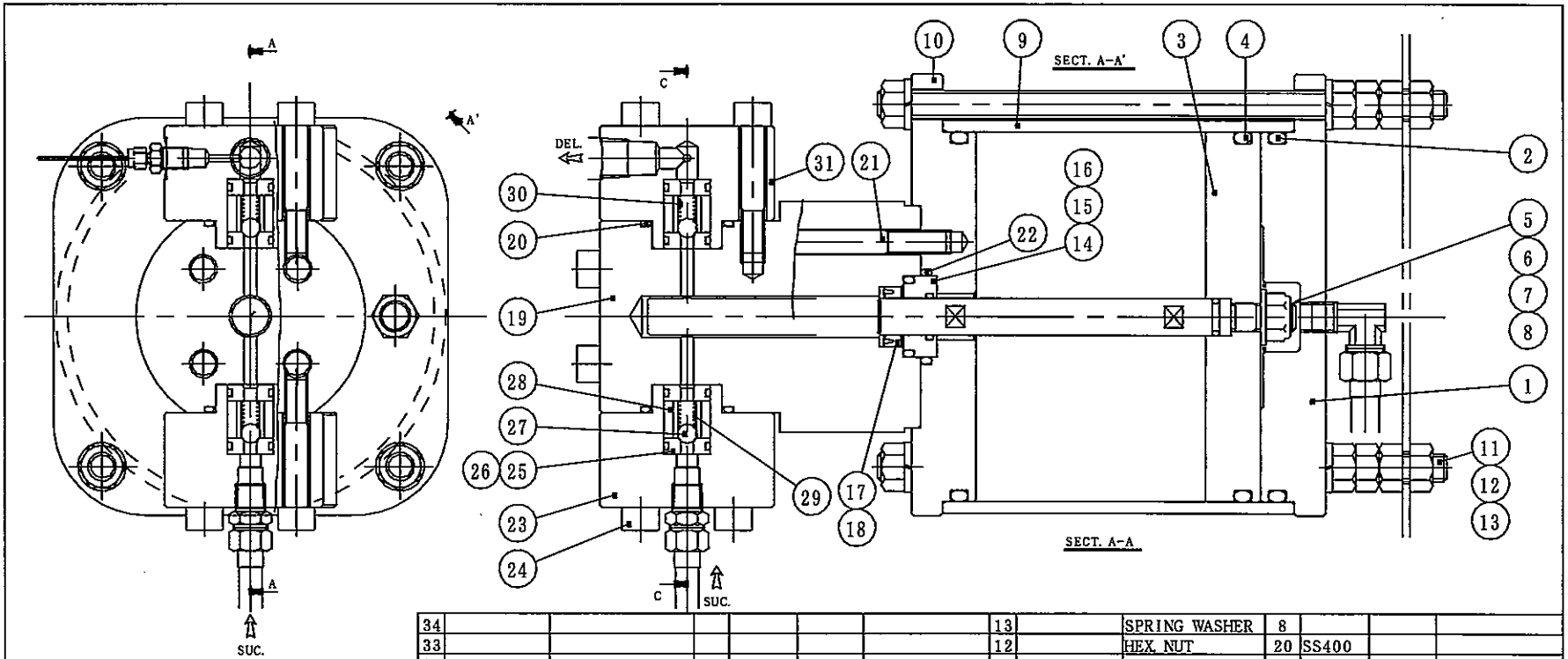
(2). As the fuel oil is forced out with injection, careful attention should be paid to the ventilation and the possibility of fire.

(3). It is necessary to tighten surely at each joint of the test pump unit because the oil system is filled with high pressure oil.

(4). Replace the high pressure hose with new one, if signs of deterioration on the hose appears with long use.

(5). Do not expose the hand nearly the fuel nozzle when testing because the oil jet may pass through the hand. When accessing the pump unit, it is necessary that the air pressure must be released completely.

(6). The clean oil must be used for supplement and the dirty oil should be replaced with new one.



記号	図番	名称	個数	材料	重量	備考
34						
33						
32						
31	NIT2089	BOX CAP (DEL.)	1	S45C		
30		DEL. SPRING	1	SWP		
29		SUC. SPRING	1	SWP		
28	NIT2088	BALL GUIDE	2	C3604B2		
27		BALL	2	SUJ2		
26		O-RING	4	NBR		
25	NIT2087	VALVE SEAT	4	HBSB2		
24		HEX SOCKET HEAD BOLT	8	SCM435		
23	NIT2086	BOX CAP (SUC.)	1	S45C		
22		O-RING	1	NBR		
21		HEX SOCKET HEAD BOLT	4	SCM435		
20		O-RING	2	NBR		
19	NIT2085	CYLINDER BOX	1	S45C		
18		BACK-UP-RING	1	TEFRON		
17		U-SEAL RING	1	POLI-URETAN		
16		O-RING	1	NBR		
15		O-RING	1	NBR		
14	NIT2084	BUSH	1	BC6		
13		SPRING WASHER	8			
12		HEX. NUT	20	SS400		
11		TIE BOLT	4	SS400		
10	NIT2083	ROD COVER	1	SS400		
09	NIT2082	AIR CYLINDER	1	STKM13C		
08		PLAIN WASHER	1	SS400		
07		HEX. NUT (U-NUT)	1	SS400		
06		O-RING	1	NBR		
05	NIT2081	PLUNGER	1	SUJ2		
04		O-RING	1	NBR		
03	NIT2080	PISTON	1	S45C		
02		O-RING	2	NBR		
01	NIT2079	HEAD COVER	1	SS400		

表面あらさ / 寸法許容差 / 普通寸法許容差 / 1組分重量 / 投図番 / 形式 NIT678

熱処理 / 焼入 焼もどし 浸炭 指定 深さ / かたさ 付

表面処理

区分	中級	粗級
6以下	±0.1	±0.2
6を超え 30以下	±0.2	±0.5
30を超え 120以下	±0.3	±0.8
120を超え 400以下	±0.5	±1.2
400を超え 1000以下	±0.8	±2.0
1000を超え 2000以下	±1.2	±3.0

削り加工部

投図名称

尺度

名称 BOOSTER PUMP

NAGAO MACHINERY WORKS CO,LTD
㈱ 長尾鉄工株式会社

製図 2003-8-14 合田

図番 NIT2181

3角法

913 GENERAL TOOLS

913.04 HYDRAULIC PUMP

AIR DRIVEN HYDRAULIC OIL PUMP

NPU2000A

INSTRUCTION MANUAL

NAGAO MACHINERY WORKS CO., LTD.

Tamahara3-6-2, Tamano, Okayama, Japan.
TEL (0863) 31-5101
FAX (0863) 31-0584

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2. Particulars ---------- 1

3. Components ---------- 2

4. Line Diagram ---------- 3

5. Preparations ---------- 4

6. Operation ---------- 5

7. Caution ---------- 5

1. Introduction

This device is designed to deliver the high pressure oil to many of the hydraulic tools for the diesel engine using compressed air.

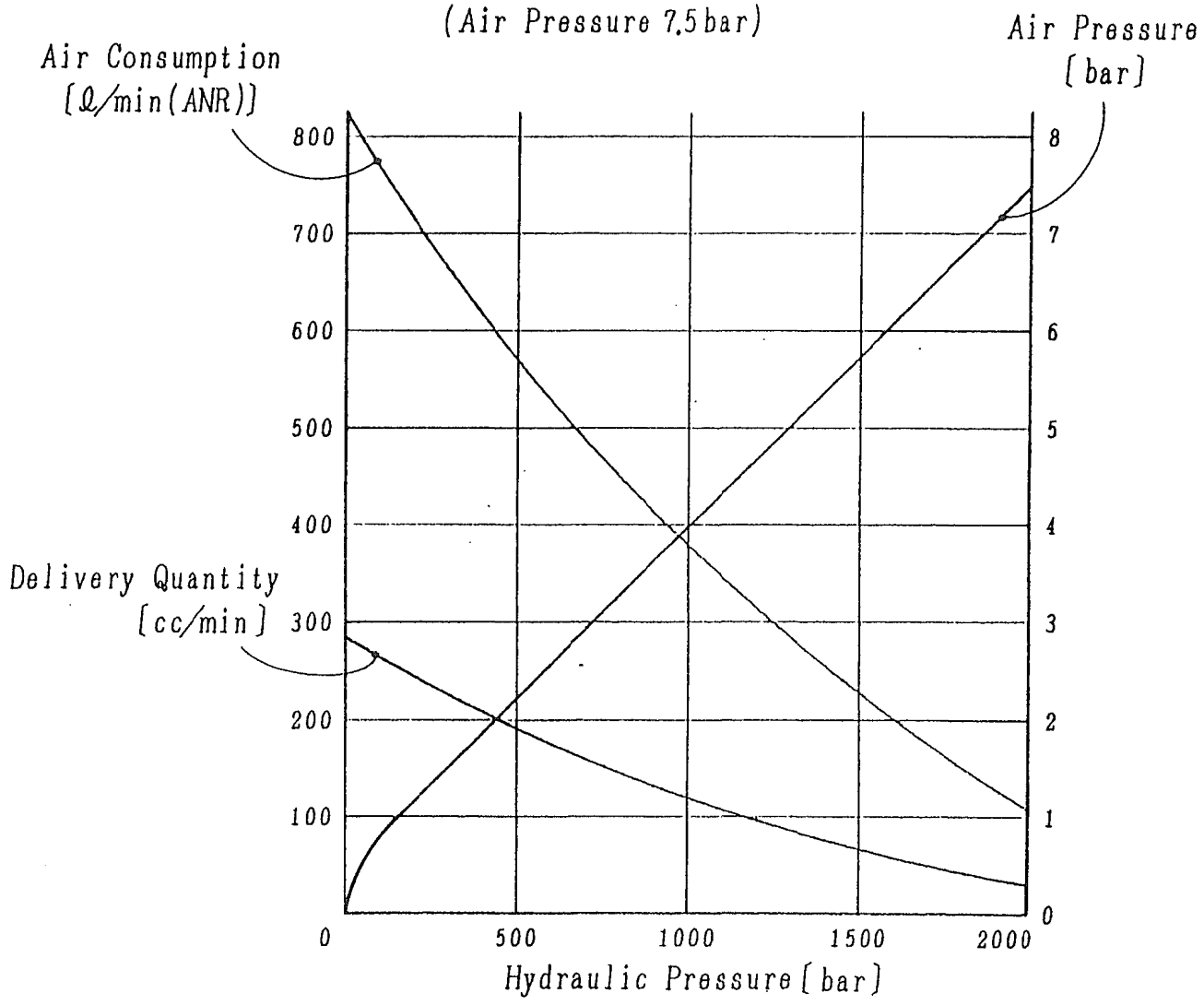
Please be aware of the working principle and the operation procedure before use by reading this instruction manual.

2. Particulars

Maximum Pressure	2000 bar
Air Pressure	6.5 ~ 9 bar
Delivery Quantity	1.7 cc/stroke
Oil Tank Capacity	5 ℓ
Total Wight (incl. oil)	23 kg

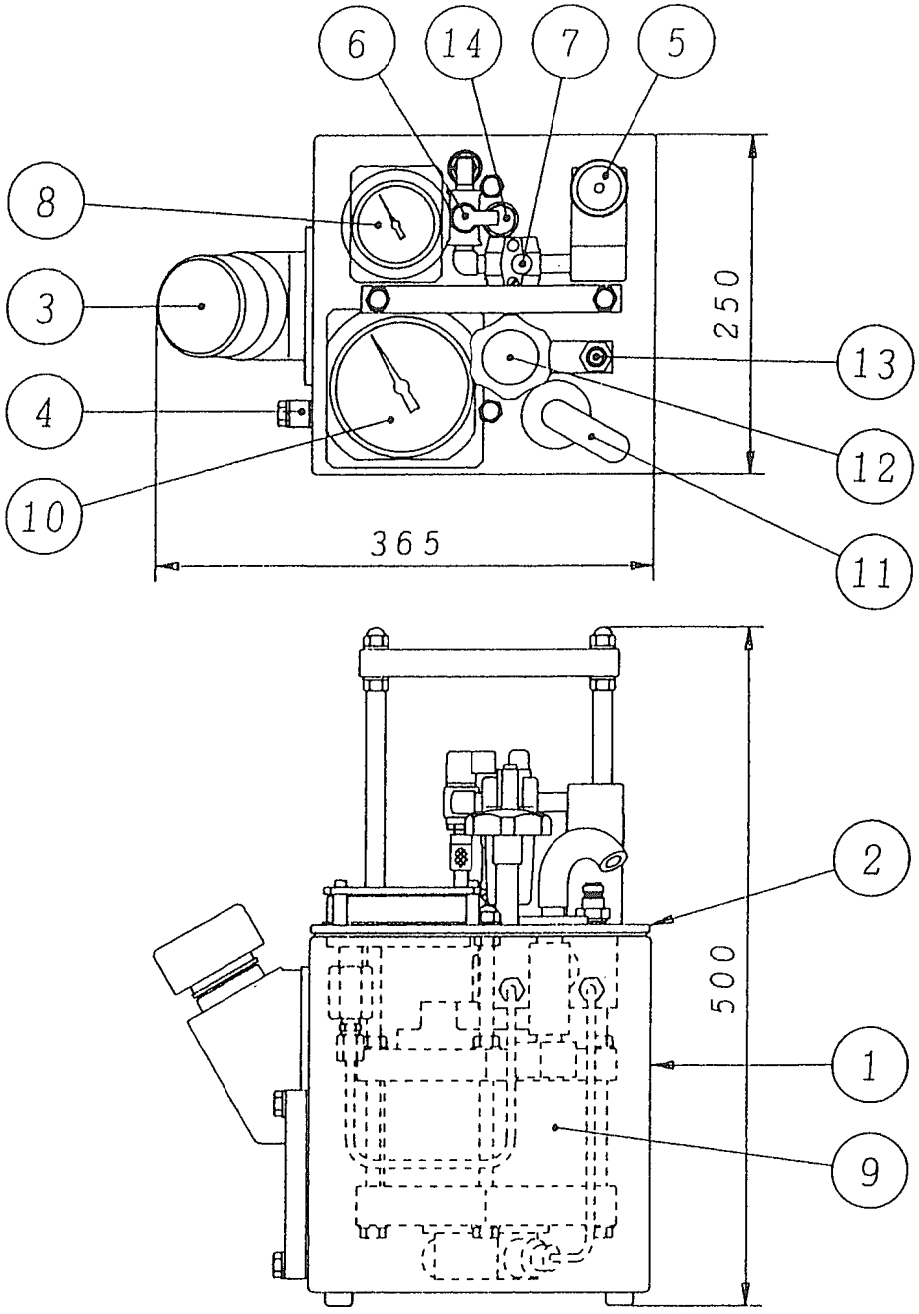
Performance Curve

(Air Pressure 7.5 bar)



4E-75363

3. Components



No.	Name	No.	Name
1	Oil Tank	8	Air Pressure Gauge
2	Panel	9	Booster Pump
3	Tank Cap	10	Hydraulic Pressure Gauge
4	Level Gauge	11	Ehxaust Port
5	Air Supply Port	12	Release Valve
6	Stop Valve	13	Hydraulic Port
7	Oiler	14	Air Relief Valve

4E-75363

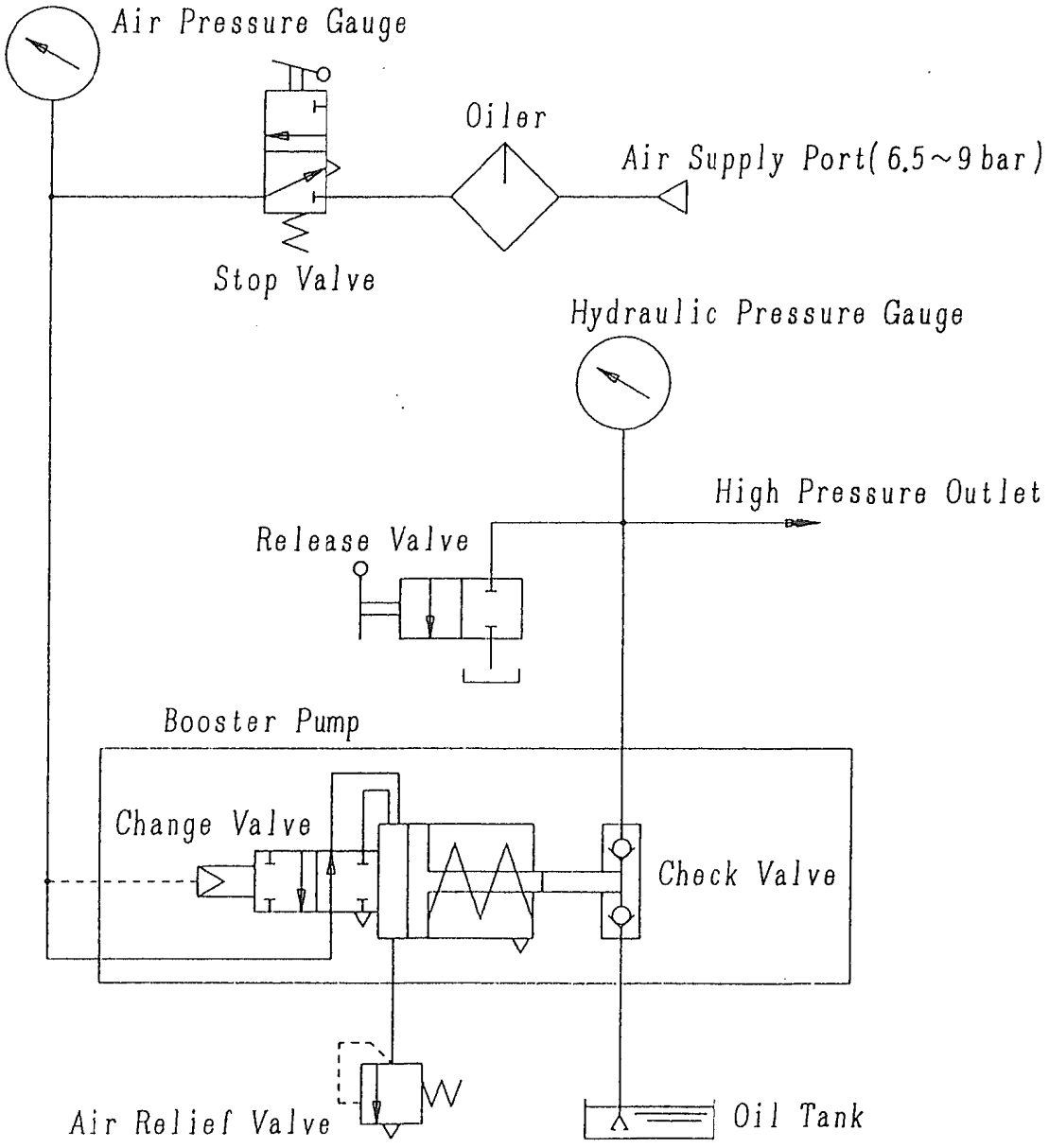
4. Line Diagram

As shown in the diagram, this pump unit supplies the high pressure oil made by the booster pump to the hydraulic tool.

1) Pressurized air comes in from the air supply port. Then, it goes through the oiler and stop valve to the booster pump, where it presses down the piston and after that it is exhausted.

2) The oil sucked into the high pressure cylinder is pressurized by the piston and pushed out through the check valve.

3) The oil, after finished its work at the hydraulic tool, goes back to the oil tank when the release valve is opened.

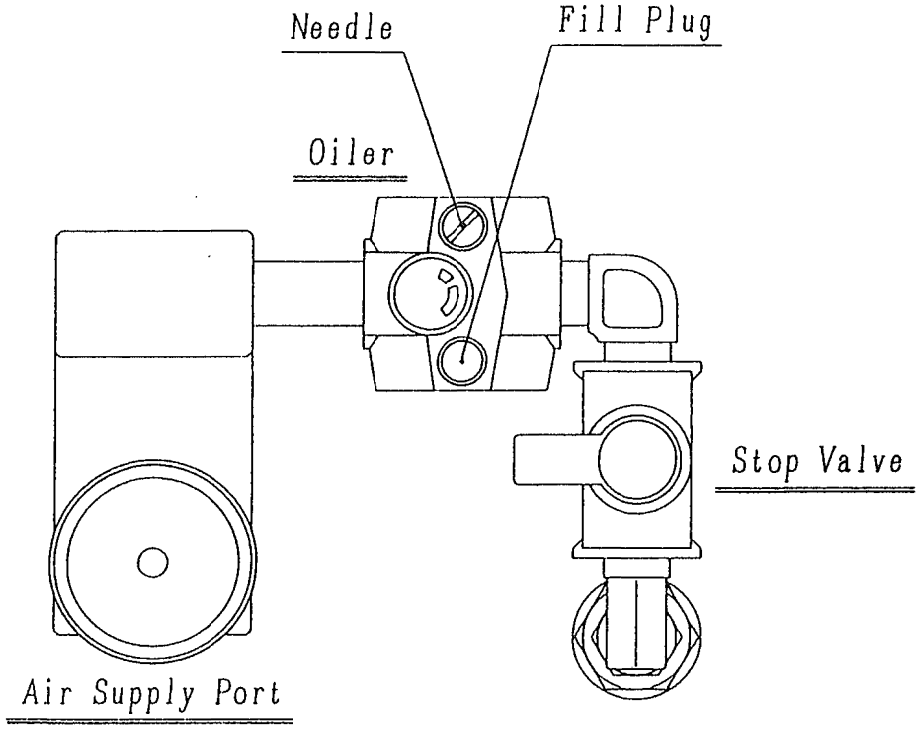


4E-75363

5. Preparations

1) Check the oil amount in the oil tank by the level gauge. If necessary, supply the oil from the tank cap to the upper level line of the level gauge. Type of oil: Turbine oil ISO VG32-46, amount 5 liter.

2) Check the oil level in the oiler. Befor oiling, never fail to separate the air supply hose from the air supply port, after that supply the oil from the fill plug on the top of the oiler.
Type of oil: Turbine oil ISO VG32, amount 25 cc.
Adjust the turn of the needle so that a drop of oil comes out in about 10 strokes of the pump. (turning adjusting screw clockwise, the amount decreases)



3) Before attaching the high pressure hose to the hydraulic tool, deaeration should be made in the following manner;
a. Check that the release valve is fully closed.
b. Open the stop valve. Watch the tip of the hose and close the stop valve. When the oil starts to come out without air. ref. Note on page 6.
c. Connect the hose to the hydraulic tool.

6. Operation

1) After the deaeration of the high pressure hose, connect the quick coupling of the hose (female) to that of the hydraulic tool (male).

2) Check that the release valve is fully closed.

3) Deaerate the hydraulic tool.

4) Check to see that the pressure of air supply is satisfied by the pressre gauge, with reference to the performance curve (hydraulic press./air press.) as page 1.

5) Open the stop valve watching the hydraulic pressure gauge. The pressurized oil starts to come into the hydraulic tool.

6) As soon as the hydraulic pressure gauge reading reaches the wanted figure, close the stop valve quickly. The pump stops working and the delively of the oil is stopped. If the hydraulic pressure reaches 1700bar the air relief valve starts to work and the oil delivery is stopped.

7) When finishing the use of the pressurized oil, open the release valve keeping the stop valve closed.
The oil goes back to the tank through the release valve.

7. Caution

1) The principle of this pump is very simple but the connection of the hose should be made carefully because the highly pressurized oil is delivered.

2) Supply oil must be always fresh and cloan. Change the oil every 50 hr of use or on the occasion of polluted degree.

3) Since there is no pressure adjusting mechanism except an air relief valve, be careful not to give too much pressure to the hydraulic tool. When the stop valve is open, keep eyes on the pressure gauge.

4) Before disconnecting the hose, confirm that the hydraulic pressure is 0.

913 GENERAL TOOLS

913.05 INSTRUCTION FOR USE OF ENGINE INDICATOR

図 面 来 歴 PLAN HISTORY	K/L/S-MC S-MC-C

配布先		
ﾃﾞ製生—ﾃﾞ		
ﾃﾞ製生—素		
外注先		
ﾃﾞ製—溶		
ﾃﾞ製—機		
ﾃﾞ製—試		
ﾃﾞ製—組技		
ﾃﾞ製—組ﾃﾞ		
玉F分室	(1)	
提出		
控		
合計	ゼロックス	(1)
	白焼	

SERVICE INSTRUCTIONS FOR ENGINE INDICATOR (TYPE 50Z1)

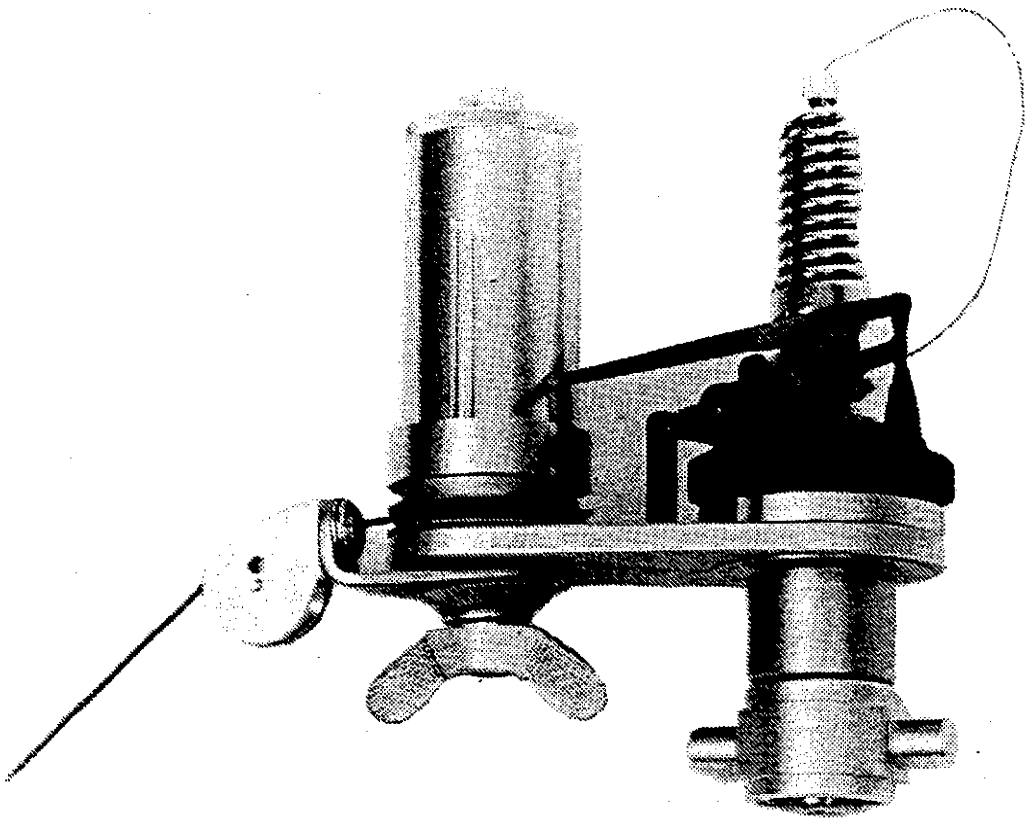
類似参考図	代替図	計画図	製作参考図

日付 DATE	課員 STAFF	担当 CHG. ENGR.	課補 ASST. CHIEF	課長 SECT. CHIEF		R
						9
						8
						7
						6
						5
						4
						3
						2
99.01.22	—	田渕	看図	—	最新図に差し替える。	1
	—	中田	—	—		0

ディーゼル工場第1設計部 DIESEL ENGINE FACTORY DESIGN DEPARTMENT	図面種類	区分番号	図面番号 DRG. NO. 4D-97972

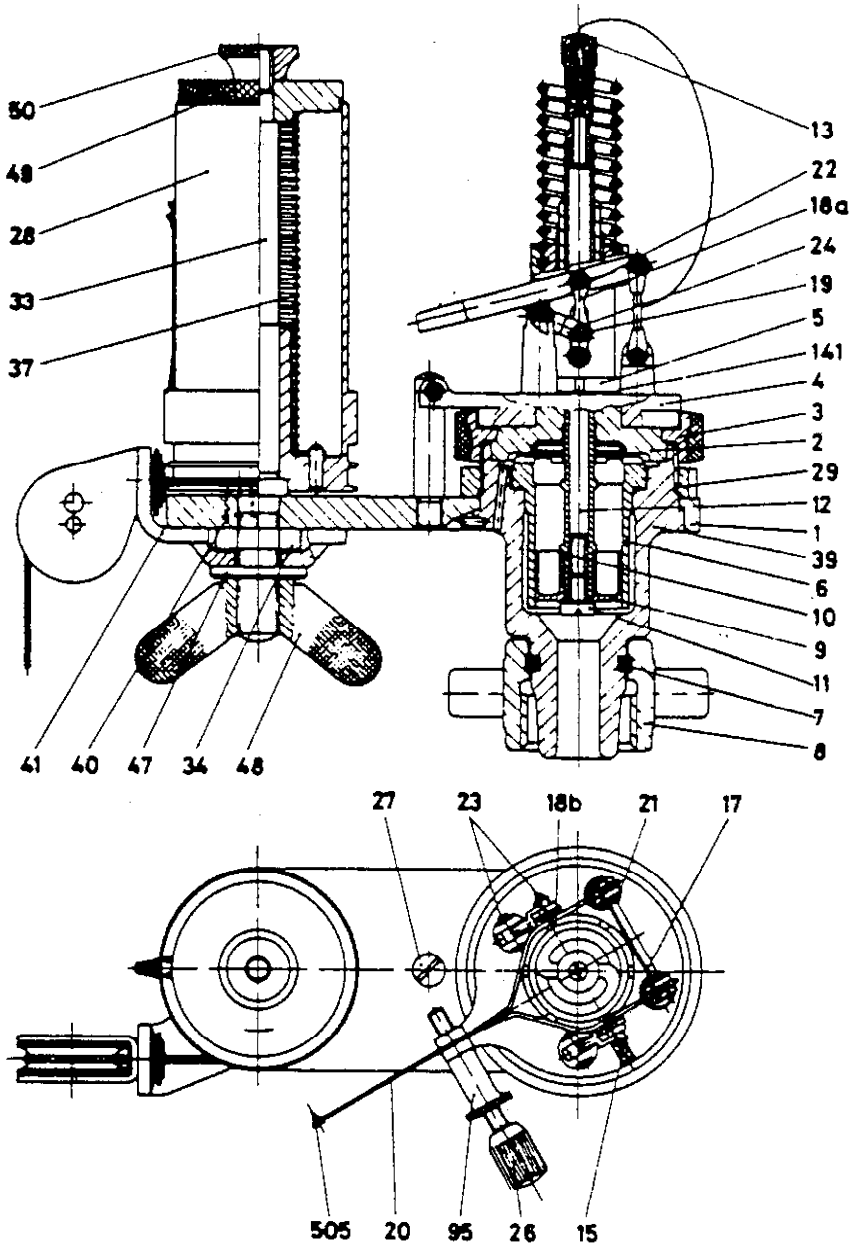
LEUTERT™

INSTRUMENTS • CONTROL • AUTOMATION SINCE 1941



Service Instructions
Engine Indicator
Type 50 Z 1

F. LEUTERT GmbH & Co.
Schillerstrasse 14
D-21365 Adendorf · Germany
Telephone: +49-4131-959 0 · Telefax: 959111
E-Mail: leutert@t-online.de



⚠ ATTENTION ⚠

Before using indicator, open indicator valve or cock, blow out any dust, and close it again.

CAUTION: hot gas and particles may be ejected

WEAR GLOVES AND SAFETY GLASSES !

Piston size		max. pressure
	∅ mm	p in bar
1/1	20,27	30
1/5	9,06	150
1/10	6,41	300
1/20	4,53	600

When ordering spare parts, please specify the serial number of your Indicator and advise the part-no. in question.

Pos.	Description	Part- No.
1.	Drum carrier	4651.0.11.03005
2.	Spring support compl.	4651.0.11.10090
	Stop washer	4651.0.11.10003
	Retaining ring	4651.0.11.10004
	Screw M2,5x6	Stschaft M25.06
3.	Ring nut	4651.0.11.10100
4.	Turning ring	4651.0.11.11001
5.	Slotted nut, small	4651.0.11.10001
6.	Cylinder 1/1, 1/5, 1/10	
7.	Wedge	4651.0.11.03102
8.	Coupling nut	4651.0.11.03103
9.	Piston 1/1, 1/5, 1/10	
10.	Cylindrial pin 1m6x6	Zstift D01.0064
11.	Piston screw	4651.0.11.10005
12.	Piston rod 1/1, 1/2, 1/5	4651.0.11.10200
13.	Spring cap	4651.0.11.10300
15.	Coupling pin	4651.0.11.10008
17.	Swing lever	4651.0.11.11007
18.a	Coupling link left	4651.0.11.11200
18.b	Coupling link right	4651.0.11.11300
19.	Counter link	4651.0.11.11005
20.	Recording lever	4651.0.11.11100
21.	Link bolt short	4651.0.11.11004
23.	Link bolt long	4651.0.11.11003
22./24.	Retaining ring	Seeg-SRS 1.032
26.	Knurled handle	4651.0.11.11400
27.	Stop column	4651.0.11.03004
28.	Drum cylinder compl. ⌀40	4651.0.11.01100
	Drum cylinder compl. ⌀50	4661.0.11.01100
	Drum compl. ⌀40	4651.0.11.01000
	Drum compl. ⌀50	4661.0.11.01000
29.	Slotted nut, large	4651.0.11.03002
33.	Drum axle	4651.0.11.01002
34.	Nut M10	Mutter M10.056
37.	Drum spring	4651.0.11.01003
39.	Under-part. compl.	4651.0.11.03100
	Under-part w. drum-carrier	4651.0.11.03000
40.	Stop screw	4651.0.11.03003
41.	Guide roll compl. ⌀40	4651.0.11.02000
	Guide roll compl. ⌀50	4661.0.11.02000
47.	Washer ⌀10,5	Uschei D10.0070
48.	Wing nut, M10	Mutter M10.0053
49.	Drum cover ⌀40	4651.0.11.01200
	Drum cover ⌀50	4661.0.11.01200
50.	Drum knob	4651.0.11.01001
95.	Knurled nut	4651.0.11.11009
141.	Elasic washer	4651.0.11.10002
505.	Recording pencil	4651.0.11.11011
	Upper-part 1/1, 1/2, 1/5 compl. without piston and cylinder	4651.0.11.10000
	Recording mechanism compl.	4651.0.11.11000

Tools and Accessory

Screwdriver; large	9000.0.00.39319
Screwdriver, small	9000.0.00.39318
Flat pliers	9000.0.00.39406
Indicator cord with hemp, 10m	9000.0.00.39714
Block indicator paper 145x65	9000.0.00.39722
Block indicator paper 180x65	9000.0.00.39723
Cylinder spanner 1/1+1/2	4651.0.98.02100
Cylinder spanner 1/1+1/5	4651.0.98.02200
Bottle cylinder oil 10 cm³	4651.0.98.00100
Cord-tightening hook	4651.0.98.00001
Hollow spanner	4651.0.98.00002
Cylinder spanner	4651.0.98.01000
Wooden box	4651.1.98.03100

Indicator spring and wooden scale as per table

Table of Indicator Springs Type 50Z1

Piston Size	⌀ mm	Part.- No. 4651.0.71.	03000	04000	05000	06000	07000	08000	09000	10000	11000	12000	13000	14000	15000	16000	17000	18000
		Spring - No.	50 / 2 bar	50 / 2,5 bar	50 / 3 bar	50 / 4 bar	50 / 5 bar	50 / 6 bar	50 / 7 bar	50 / 8 bar	50 / 10 bar	50 / 11 bar	50 / 12 bar	50 / 14 bar	50 / 16 bar	50 / 20 bar	50 / 25 bar	50 / 30 bar
1/ 1	20.27	Scale mm / bar	25	20	16	12	10	8	7	6	5	4.5	4	3.5	3	2.5	2	1.5
		max. pressure bar	2	2.5	3	4	5	6	7	8	10	11	12	14	16	20	25	30
1/ 5	9.06	Scale mm / bar								1.2	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3
		max. pressure bar								40	50	55	60	70	80	100	125	150
1/10	6.41	Scale mm / bar								0.6	0.5	0.45	0.4	0.35	0.3	0.25	0.2	0.15
		max. pressure bar								80	100	110	120	140	160	200	250	300
1/20	4.53	Scale mm / bar								0.3	0.25	0.225	0.2	0.175	0.15	0.125	0.1	0.075
		max. pressure bar								160	200	220	240	280	320	400	500	600

Characteristics:

Manufacturers:	F.Leutert GmbH	Height max.:	appr. 170 mm
Design:	Type 50Z1	Width max.:	appr. 75 mm
Diagram height:	max. 50 mm		
Diagram length:	max. 80 mm (110)	Weight:	appr. 1,2 kg
Drum Diameter:	40 mm (50)	Weight incl. wooden box +	
Pressure records:	up to 600 bar	accessories:	appr. 5 kg

Natural vibration frequency per minute: 3000...12000
(depending on piston and spring)

Maximum speed: 400 rpm
300 rpm when using a drum of 50mm dia.

The applicability of the indicator not only depends on the speed of the engine, but also on the pressure change rates.

Applicability:

The standard design of the Leutert indicator Type 50Z1 is a handy instrument for many applications and is used for taking single diagrams from steam engines and any internal combustion engines, compressors, blowers, pumps and other reciprocating engines. The applicability of the indicator is limited by the natural vibration frequency of its moving parts. The natural vibration frequency is given by the design of the instrument and the piston and spring actually used.

Technical notes:

The sectional drawing of the indicator Type 50Z1 shows that the under-part **(39)** is mounted in the drum carrier **(1)** by means of a slotted nut **(29)**. Depending on the expected maximum pressure, 2 types of under-parts are available: One under-part for any of the interchangeable cylinders for piston 1/1, 1/5 and and one for the piston 1/10 and 1/20.

Recording mechanism:

The recording mechanism must be handled with extreme care; slightest damage may lead to substantial recording errors. The links must never be diassembled and should always be sufficiently lubricated with cylinder oil. The recording pencil (**505**) is interchangeable. When inserting the upper-part, tighten ring nut (**3**) just very slightly and use the knurled handle (**26**) to move the recording levers until the pencil touches the drum. Firmly tighten the ring nut in this position. The stop pin engaging with turning ring (**4**) is now at the front end of its slot and provides sufficient clearance for engaging and disengaging the recording levers. If the recording pencil is pressed on the drum too hard, faulty diagrams will result. If the ring nut (**3**) is slackened, the recording levers can be turned around and arrested in any desired position.

Piston :

Piston (**9**) is made of one piece with very thin walls to obtain a mass reduction. The piston may be removed by loosening srew (**11**). If a piston or piston rod is ordered, we generally recommend to send us the indicator.

For exchanging piston (**9**) and cylinder (**6**) the upper-part is removed after loosening the ring nut (**3**). The accessory steel key should now be used to unscrew and exchange the cylinder. The piston of the size 1/20 is made of one piece integral with the piston rod. Therefore, when exchanging this piston, the rods must also be removed. For this purpose unscrew the spring cap (**13**) and remove the coupling pin (**15**) by gripping its flat head with the small accessory pliers and slightly moving the pin. Now, pull the piston rod downward. When inserting the new piston rod, make sure that the coupling pin is inserted into the link (**18a**) with the larger bore and into that side of the piston rod which is marked by a punched spot.

Indicator spring

The indicator spring is a double-coiled, easily interchangeable tension spring. All springs are precisely calibrated and marked with the spring scale and the maximum pressure related to a piston size 1/1. Use small pistons of the size 1/5, 1/10, 1/20 for pressures exceeding 30 bar, then, 5-fold, 10-fold, 20-fold pressures may be indicated with the same springs. Selection as per spring table. When selecting springs note that the highest frequency of natural vibration can be obtained if using the largest piston size possible with appropriately strong springs. When ordering springs, kindly state the serial number of your indicator. **Springs of the previous indicator Type 50 have metric thread, those for Type 50Z and Type 50Z1 are threaded to the inch.**

Mounting the spring:

Remove spring cap **(13)** at the upper end of the piston rod, place the spring over the piston rod so that the small ball on the spring engages with the corresponding slot of the piston rod, and firmly tighten the spring, finally replace spring cap **(13)**.

Raising the atmospheric line for low-pressure springs:

If necessary, the atmospheric line of the diagram can be raised by placing one or more washers (must be ordered separately) on the spring support before mounting the spring.

Paper drum:

The standard drums of the Leutert indicators are designed to combine high strength with low mass. The drum is returned by the incorporated spring **(37)**. Any spring bias can be adjusted during operation by turning drum cover **(49)**. The drum can be disassembled without using a tool simply by pulling off the cover.

Drums available for the indicator Type 50Z1:

- standard drum of 40 mm dia.
- special drum of 50 mm dia.

Paper drum drive:

On engines with an accessible crosshead guide, the paper drum is usually driven from the crosshead guide or from the connecting rods of engine. Then, the piston stroke must be reduced to diagram length by means of **stroke reducers**.

Indicator cord:

The cord should be so arranged that the connection is preferrably short without unnecessary deviations. Lateral movements of the cord must be avoided as they would lead to errors in the drum motion.
The length of the cord should be so dimensioned that the drum will definitely not touch the drum stop **(40)** below the drum bottom in its dead centre positions. **Cord guide rolls** are recommended for guiding the cord.

Cord tightening hook:

It is recommended to use a cord tightening hook. The cord will automatically jam in the slot if it is pulled.

Mounting the indicator:

The indicator should be mounted preferably near to the engine cylinder to be tested. An indicating valve must be provided.
If the indicator connections are arranged at the side of the engine cylinder, the indicator will be in a horizontal position. But neither this, nor suspended arrangement will affect the proper performance of the indicator.

Preparatory Work for indicating:

Prior to operation, lubricate the operative surfaces of the cylinder, piston, piston rod and piston rod guide with top - quality, non-viscous cylinder oil. Make sure that the seat of spring support **(2)** and the pertaining seat of under-part **(39)** are absolutely clean before inserting the upper-part.

Always blow through the connection line before mounting the indicator to prevent wrong indication of the engine pressure by any condensed water, oil or soot deposits in the connection line. For later evaluation purposes it is very important to note the necessary data on the diagram, such as piston size of the indicator, spring number, engine number etc. **Check the maximum pressure of the indicator spring!**

Cleaning and Lubrication:

Strictly adhere to the following procedure: After every operation the Indicator must be thoroughly cleaned, oiled and replaced in its box. The instrument should be cleaned with a lint - free rag, the cylinder only with the cylinder cleaner stored in the box. The sliding surfaces of the cylinder and piston rod guide should be lubricated with top - quality, non - viscous cylinder oil(oil bottle stored in the box). If testing internal combustion engines, piston and rod should be lubricated periodically after 10 to 15 diagrams. With the same oil the links of the recording mechanism and the drum running surface should be lubricated occasionally after removing the drum cover.
Carbon deposits on the piston or cylinder should never be scratched off, but always be removed by washing them with benzine or petroleum.

Other LEUTERT Indicators:

- Indicators for high - speed engines
- Special designs
- electronic Indicators
- Valves
- Diagram paper

Our Engineering Service will gladly give you recommendations.

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913.06 TIGHTENING METHOD OF TOP BRACING

TIGHTENING OF TOP BRACING

Bolts for top bracing are to be tightened hydraulically. As regards tightening force, see the table on the right.
If one or more links are omitted, the tightening force of the remaining links are to be increased accordingly. If for example 4 links are specified and 1 is omitted, the 3 remaining links are to be tightened by 33.3% extra. The tightening should be checked as follows:

Check if relative movements occur between top bracing and fastening plate by following method. (or similar). Carry out checking of the top bracing at the fore end, the center, and the aft end of the engine.

1) add the scratch mark on the fork plate and observe the mark, or
2) finger-touch at the same time the casing bracket plate and one of the fork plate.

If ascertaining relative movements are observed, increase the tightening by 40%(at all top bracing s).At the same time, observe hydraulic pressure at which the nuts at all top bracings can be loose ned.If the relative movement (after having increased the tightening pressure) has still not disappea red,
increase the tightening force with an additional of 40%, and again observe the loosening pressure at each bolt.

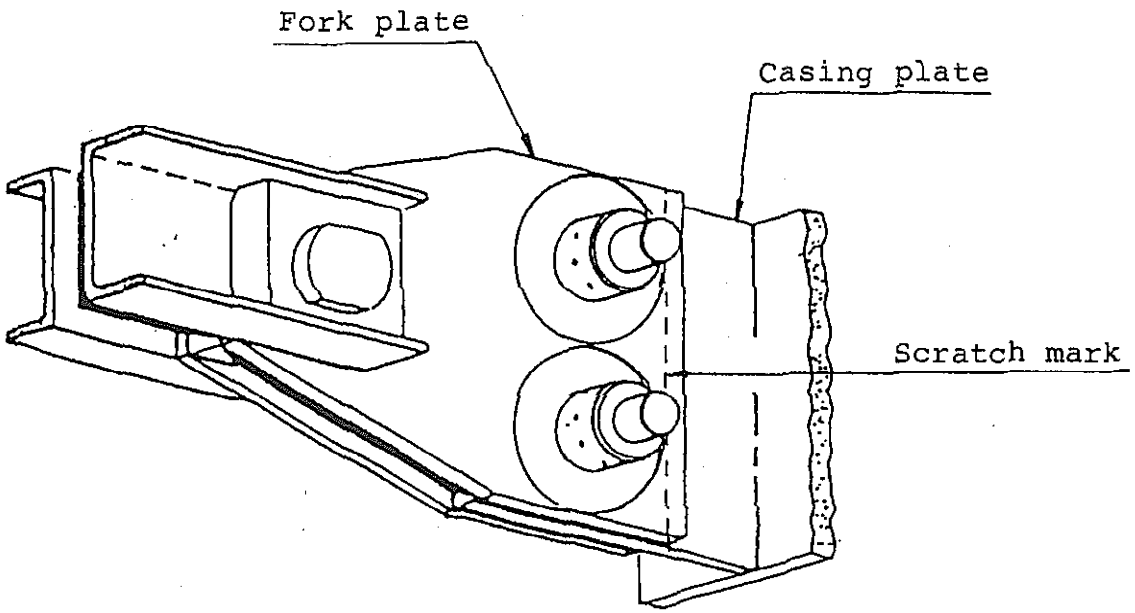
After some time in service the top bracing might become ineffective due to wear of the friction material or by some reasons.
The tightening should therefore be checked (as described above) if :

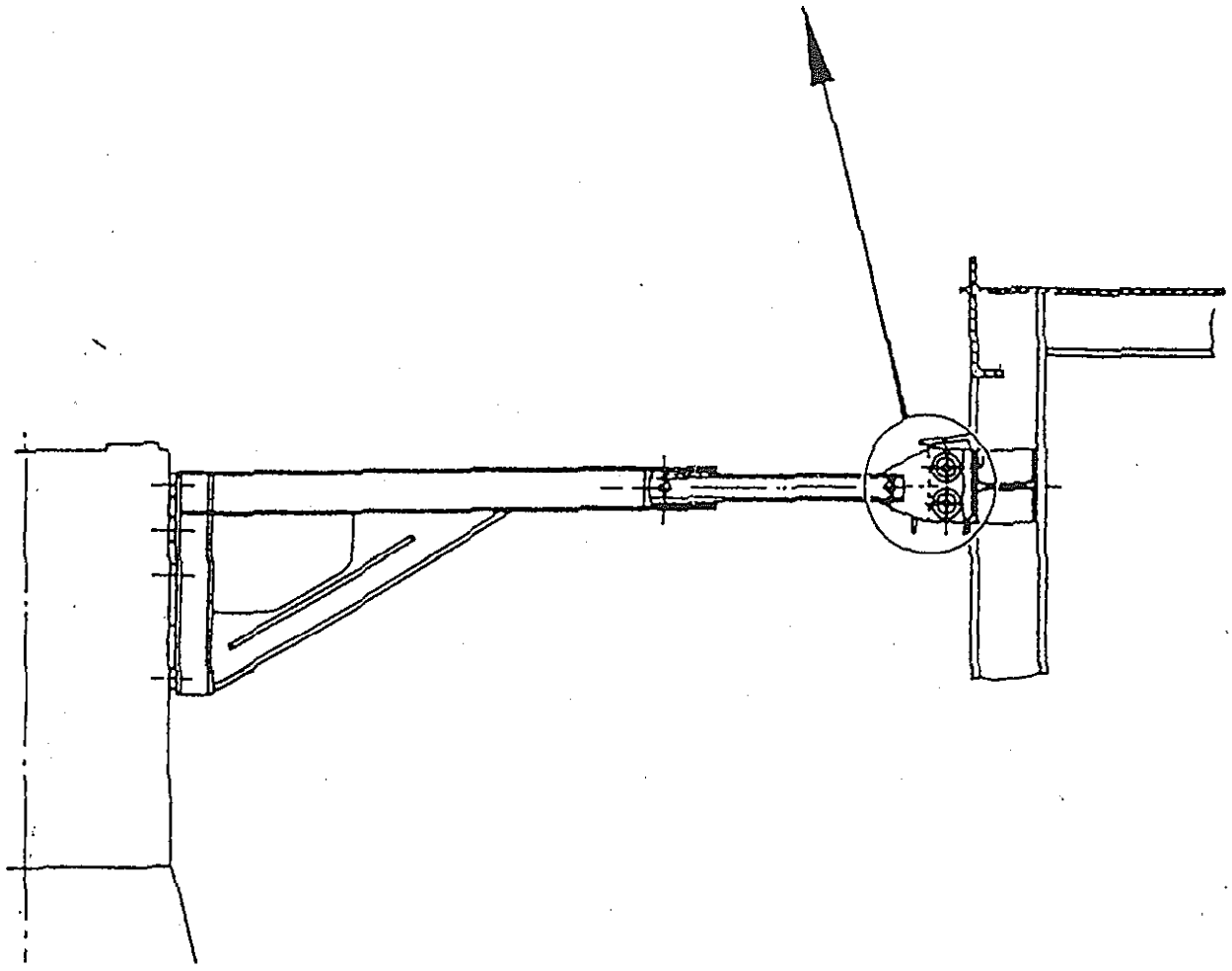
1) Unexpected change of level of hull vibrations are observed, or
2) The turbocharger(s) start to vibrate intensely.

If the above mentioned is not observed, the checking should be carried out once or twice a year.

Engine type	Tightening force	Piston area of hydraulic jack	Oil pressure		
	Standard		Standard	+40%	+2x40%
	kN	cm^2	MPa (kg/cm^2)		
S90MC-T	250	-	-	-	-
K90MC	230	121	21.0 (214)	29.0 (296)	38.0 (387)
K90MC-C	265	142.9	20.0 (204)	28.0 (286)	36.0 (367)
L90MC	175	-	-	-	-
S80MC	130	89.5	16.0 (163)	22.0 (224)	29.0 (296)
K80MC-C	160	-	-	-	-
L80MC	145	89.5	18.0 (184)	25.0 (255)	32.0 (326)
S70MC	101	70.7	16.0 (163)	22.0 (224)	29.0 (296)
L70MC	116	70.7	18.0 (184)	25.0 (255)	32.0 (326)
S60MC-C	-	-	-	-	-
S60MC	79	47.1	18.0 (184)	25.0 (255)	32.0 (326)
L60MC	87	47.1	20.0 (204)	28.0 (286)	36.0 (367)
S50MC-C	66	24.5	29.0 (296)	41.0 (418)	52.0 (530)
S50MC	59	37.1	17.0 (173)	24.0 (245)	31.0 (316)
L50MC	66	37.1	19.0 (194)	27.0 (275)	34.0 (347)
S46MC-C	-	-	-	-	-
S/L42MC	40	61.8	7.0 (71)	10.0 (102)	13.0 (133)
S/L35MC	20	70.7	3.0 (31)	4.2 (43)	5.4 (55)

Note : Jack efficiency = 0.92





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80.07.10	KLH	KLH	06-16/7	—	REPL OF	PART NO

			B & W ENGINEERING
WEO NO 3 84 608	S 3	Measuring proposal for vibrations of topbracing in relation to hull	78 25 61 5