

Technical Documentation Engine Operating Instructions

Engine L 48/60

Work No. Edition only for Information

Plant No.

6643-1

MAN B&W Diesel AG • D-86135 Augsburg • Postfach 10 00 80 • Telefon (0821) 3 22-0 • Telex 5 37 96-0 man d



© 1999 MAN B&W Diesel AG

All copyrights reserved for reprinting, photomechanical reproduction (photocopying/microcopying) and translation of this documents or part of it.



6643 B1-01 E

07.99

02/02

Table of contents

					<input type="checkbox"/>	1 Introduction
•	•	•				1.1 Preface
•	•	•		<input type="checkbox"/>		1.2 Product Liability
•	•	•			<input type="checkbox"/>	1.3 How the Operating Instruction Manual is organized, and how to use it
•	•	•			<input type="checkbox"/>	1.4 Addresses/Telephone numbers
					<input type="checkbox"/>	2 Technical details
•	•	•			<input type="checkbox"/>	2.1 Scope of supply/Technical specification
					<input type="checkbox"/>	2.1.1 MAN B&W Diesel AG's Scope of Supply/Technical Specification
•	•	•			<input type="checkbox"/>	2.2 Engine
					<input type="checkbox"/>	2.2.1 Characteristics
					<input type="checkbox"/>	2.2.2 Photos/Drawings
					<input type="checkbox"/>	2.3 Components/Subassemblies
					<input type="checkbox"/>	2.3.1 Standard engine design Crankcase to cylinder head
					<input type="checkbox"/>	2.3.2 Camshaft drive to injection valve
					<input type="checkbox"/>	2.3.3 Supercharger system through engine controls
•	•	•			<input type="checkbox"/>	2.3.4 Special engine designs
•	•	•			<input type="checkbox"/>	2.3.5 Accessories
					<input type="checkbox"/>	2.4 Systems
					<input type="checkbox"/>	2.4.1 Fresh air/Charge air/ Exhaust gas systems
					<input type="checkbox"/>	2.4.2 Compressed air and starting system
					<input type="checkbox"/>	2.4.3 Fuel oil system
					<input type="checkbox"/>	2.4.4 Control of Speed and Output
					<input type="checkbox"/>	2.4.5 Injection timing adjusting device
					<input type="checkbox"/>	2.4.6 Lube oil system
					<input type="checkbox"/>	2.4.7 Cooling water system
					<input type="checkbox"/>	2.5 Technical data
•	•	•			<input type="checkbox"/>	2.5.1 Ratings and consumption data
•	•	•			<input type="checkbox"/>	2.5.2 Temperatures and pressures
					<input type="checkbox"/>	2.5.3 Weights
					<input type="checkbox"/>	2.5.4 Dimensions/Clearances/Tolerances-Part 1
						Categories of information
						Information
						Description
						Instruction
						Data/formulas/symbols
						Intended for ...
						Experts
						Middle management
						Upper management

		<input type="checkbox"/>	<input type="checkbox"/>			2.5.5	Dimensions/Clearances/Tolerances-Part 2
		<input type="checkbox"/>	<input type="checkbox"/>			2.5.6	Dimensions/Clearances/Tolerances-Part 3
					<input type="checkbox"/>	3	Operation/Operating media
					<input type="checkbox"/>	3.1	Prerequisites
		<input type="checkbox"/>			<input type="checkbox"/>	3.1.1	Prerequisites/Warranty
					<input type="checkbox"/>	3.2	Safety regulations
					<input type="checkbox"/>	3.2.1	General remarks
		<input type="checkbox"/>			<input type="checkbox"/>	3.2.2	Destination/suitability of the engine
		<input type="checkbox"/>			<input type="checkbox"/>	3.2.3	Risks/dangers
					<input type="checkbox"/>	3.2.4	Safety instructions
		<input type="checkbox"/>			<input type="checkbox"/>	3.2.5	Safety regulations
					<input type="checkbox"/>	3.3	Operating media
		<input type="checkbox"/>			<input type="checkbox"/>	3.3.1	Quality requirements on gas oil/diesel fuel (MGO)
		<input type="checkbox"/>			<input type="checkbox"/>	3.3.2	Quality requirements for Marine Diesel Fuel (MDO)
		<input type="checkbox"/>			<input type="checkbox"/>	3.3.3	Quality requirements for heavy fuel oil (HFO)
		<input type="checkbox"/>			<input type="checkbox"/>	3.3.4	Viscosity/Temperature diagram for fuel oils
		<input type="checkbox"/>			<input type="checkbox"/>	3.3.5	Quality requirements for lube oil
		<input type="checkbox"/>			<input type="checkbox"/>	3.3.6	Quality requirements for lube oil
		<input type="checkbox"/>			<input type="checkbox"/>	3.3.7	Quality requirements for engine cooling water
					<input type="checkbox"/>	3.3.8	Analyses of operating media
		<input type="checkbox"/>			<input type="checkbox"/>	3.3.11	Quality requirements for intake air (combustion air)
					<input type="checkbox"/>	3.4	Engine operation I - Starting the engine
		<input type="checkbox"/>			<input type="checkbox"/>	3.4.1	Preparations for start/ Engine starting and stopping
		<input type="checkbox"/>			<input type="checkbox"/>	3.4.2	Change-over from Diesel fuel oil to heavy fuel oil and vice versa
		<input type="checkbox"/>			<input type="checkbox"/>	3.4.3	Admissible outputs and speeds
		<input type="checkbox"/>			<input type="checkbox"/>	3.4.4	Engine Running-in
					<input type="checkbox"/>	3.5	Engine operation II - Control the operating media
		<input type="checkbox"/>			<input type="checkbox"/>	3.5.1	Monitoring the engine/ performing routine jobs
		<input type="checkbox"/>			<input type="checkbox"/>	3.5.2	Engine log book/ Engine diagnosis/Engine management
		<input type="checkbox"/>			<input type="checkbox"/>	3.5.3	Load curve during acceleration/manoeuvring
		<input type="checkbox"/>			<input type="checkbox"/>	3.5.4	Part-load operation
					<input type="checkbox"/>	3.5.5	Determine the engine output and design point
		<input type="checkbox"/>			<input type="checkbox"/>	3.5.6	Engine operation at reduced speed
					<input type="checkbox"/>	3.5.7	Equipment for optimising the engine to special operating conditions
					<input type="checkbox"/>	3.5.8	Bypassing of charge air
					<input type="checkbox"/>	3.5.9	Condensed water in charge air pipes and pressure vessels
		<input type="checkbox"/>			<input type="checkbox"/>	3.5.10	Load application
				<input type="checkbox"/>	<input type="checkbox"/>	3.5.11	Exhaust gas blow-off
					<input type="checkbox"/>	3.5.12	Charge air blow-off
					<input type="checkbox"/>	3.6	Engine operation III - Operating faults
					<input type="checkbox"/>	3.6.1	Faults/Deficiencies and their causes (Trouble Shooting)
		<input type="checkbox"/>			<input type="checkbox"/>	3.6.2	Emergency operation with one cylinder failing

Categories of information

												Information
												Description
												Instruction
												Data/formulas/symbols
												Intended for ...
												Experts
												Middle management
												Upper management

•	•	<input type="checkbox"/>	3.6.3	Emergency operation on failure of one turbocharger
•	•	<input type="checkbox"/>	3.6.4	Failure of the electrical mains supply (Black out)
•	•	<input type="checkbox"/>	3.6.5	Failure of the cylinder lubrication
•	•	<input type="checkbox"/>	3.6.6	Failure of the speed control system
•	•	<input type="checkbox"/>	3.6.7	Behaviour in case operating values are exceeded/ alarms are released
•	•	<input type="checkbox"/>	3.6.8	Procedures on triggering of oil mist alarm
•	•	<input type="checkbox"/>	3.6.8	Procedures in case a splash-oil alarm is triggered
•	•	<input type="checkbox"/>	3.6.9	Procedures on triggering of Slow-Turn-Failure
•	•	<input type="checkbox"/>	3.7	Engine operation IV - Engine shut-down
•	•	<input type="checkbox"/>	3.7.1	Shut down/Preserve the engine
		<input type="checkbox"/>	4	Maintenance/Repair
•	•	<input type="checkbox"/>	4.1	General remarks
•	•	<input type="checkbox"/>	4.2	Maintenance schedule (explanations)
•	•	<input type="checkbox"/>	4.3	Tools/Special tools
•	•	<input type="checkbox"/>	4.4	Spare Parts
•	•	<input type="checkbox"/>	4.5	Replacement of components by the New-for-old Principle
•	•	<input type="checkbox"/>	4.6	Special services/Repair work
•	•	<input type="checkbox"/>	4.7	Maintenance schedule (signs/symbols)
•	•	<input type="checkbox"/>	4.7.1	Maintenance Schedule (Systems)
•	•	<input type="checkbox"/>	4.7.2	Maintenance Schedule (Engine)
		<input type="checkbox"/>	5	Annex
•	•	<input type="checkbox"/>	5.1	Designations/Terms
•	•	<input type="checkbox"/>	5.2	Formulae
•	•	<input type="checkbox"/>	5.3	Units of measure/ Conversion of units of measure
•	•	<input type="checkbox"/>	5.4	Symbols and codes
•	•	<input type="checkbox"/>	5.5	Brochures
Categories of information				
Information				
Description				
Instruction				
Data/formulas/symbols				
Intended for ...				
Experts				
Middle management				
Upper management				

Introduction

- 1 Introduction
- 2 Technical details
- 3 Operation/
Operating media
- 4 Maintenance/Repair
- 5 Annex

Table of contents

•	•	•	□	1	Introduction
•	•	•	□	1.1	Preface
•	•	•	□	1.2	Product Liability
•	•	•	□	1.3	How the Operating Instruction Manual is organized, and how to use it
•	•	•	□	1.4	Addresses/Telephone numbers
Categories of information					
Information					
Description					
Instruction					
Data/formulas/symbols					
Intended for ...					
Experts					
Middle management					
Upper management					

Engines - characteristics,
justified expectations,
prerequisites

Engines produced by MAN B&W Diesel AG have evolved from decades of continuous, successful research and development work. They satisfy high standards and have ample redundancy of withstanding adverse or detrimental influences. However, to meet such expectations, they have to be used to purpose and serviced properly. Only if these prerequisites are fulfilled, unrestricted efficiency and long service life can be expected.

Purpose of the operating and
working instructions

The operating instructions as well as the working instructions (work cards) are thought to assist you in becoming familiar with the engine. They are also thought to provide answers to questions that may turn up later on, and to serve as a guidance in your activities of engine operation and when carrying out maintenance work. Furthermore, we attach equal importance to familiarising you with the methods of operation, causes and consequences, and to conveying the empirical knowledge we have. Not least, in providing the operating and working instructions, we comply with our legal duty of warning the user of the hazards which can be caused by the engine or its components - in spite of a high level of development and much constructive efforts - or which an inappropriate or wrong use of our products involve.

Condition 1

The technical management and also the persons carrying out maintenance and overhaul work have to be familiar with the operating instructions and working instructions (work cards). These have to be available for consultation at all times.

▲▲ Caution! Lack of information and disregard of information may cause severe injury to persons, damage to property and the environment!
Therefore: Please observe the operating and working instructions!

Condition 2

Maintenance and overhaul of modern four-stroke engines requires a previous and thorough training of the personnel. The level of knowledge that is acquired during such training is a prerequisite to using the operating instructions and working instructions (work cards). No warranty claims can be derived from the fact that a corresponding note is missing in these.

▲▲ Caution! Untrained persons can cause severe injury to persons, damage to property and the environment! Never give orders which may exceed the level of knowledge and experience! Access must be denied to unauthorised personnel!

Condition 3

The technical documentation is tailored to the specific plant. There may be considerable differences to other plants. Informations valid in one case may, therefore, lead to problems in others.

▲ Attention! Technical documents are valid for one specific plant! Using information provided for another plant or from outside sources may, therefore, result in disturbances/damages! Only use pertinent information, never use information from outside sources!

To be observed as well ...

Please also observe the notes on product liability given in the following section and the safety regulations in Section 3.

The reliable and economically efficient operation of a propulsion system requires that the operator has a comprehensive knowledge. Similarly, proper performance can only then be restored by maintenance or repair work if such work is done by qualified specialists with the adequate expertise and skill. Rules of good workmanship have to be observed, negligence is to be avoided.

This Technical Documentation complements these faculties by specific information, and draws the attention to existing dangers and to the safety regulations in force. MAN B&W Diesel AG asks you to observe the following:

▲▲ *Caution! Neglect of the Technical Documentation, and especially of the Operating/Working Instructions and Safety Regulations, the use of the system for a purpose other than intended by the supplier, or any other misuse or negligent application may involve considerable damage to property, pecuniary damage and/or personal injury, for which the supplier rejects any liability whatsoever.*

How the Operating Instruction Manual is organized, and how to use it

1.3

Instructions for use

The operating manual contains written and illustrated information. Some of it is generally useful, some of it really must be observed. This information is thought to supplement the knowledge and faculties which the persons have who are entrusted with

- the operation,
- the control and supervision,
- the maintenance and repair

of the engines. The conventional knowledge and practical experience alone will not be adequate.

The operating instructions have to be made available to these persons. The people in charge have the task to familiarise themselves with the composition of the operating manual so that they are able to find the necessary information without lengthy searching.

We attempt to render assistance by a clearly organised composition and by a clear diction of the texts.

Structure and special features

The operating instruction manual consists of five sections:

- 1 Introduction
- 2 Technical details
- 3 Operation/Operating media
- 4 Maintenance/Repair
- 5 Annex

It mainly focuses on:

- Understanding the functions/coherences
- Starting and stopping the engine
- Planning engine operation, controlling it according to operating results and economic criteria
- Maintaining the operability of the engine, carrying out preventive or scheduled maintenance work

The manual does not deal with:

- Transport, erection, and dismantling of the engine or major components of it
- Steps and checks when putting the engine into operation for the first time
- Repair work requiring special tools, facilities and experience
- Behaviour in case of/after fire, inrush of water, severe damage and average

What is also of importance

Engine design

The operating manual will be continually updated, and matched to the design of the engine as ordered. There may nevertheless be deviations between the sheets of a primarily describing/illustrating content and the definite design.

Usually a thematic differentiation is made between marine propulsion engines, marine auxiliary engines and engines for stationary plants. Where the factual differences are but slight, the subject is dealt with in a general manner. Such passages are to be read selectively, with the appropriate reservations.

Technical details

For technical details of your engine, please refer to:

- Section 2, "Technical Details"
- Volume A1, to the publication "..... Continuous Development"
- Volume B2, Work Card 000.30
- Volume B5, test run record and commissioning record
- Volume D1, list of measuring, control and regulating instruments
- Volume E1, installation drawing

With the exception of the above-mentioned publication, all documents have been specifically matched to the respective engine.

Maintenance schedule/ work cards

The maintenance schedule is closely related to the work cards of Volume B2. The work cards describe how a job is to be done, and which tools and facilities are required for doing it. The maintenance schedule, on the other hand, gives the periodical intervals and the average requirements in personnel and time.

Addresses/Telephone numbers

1.4

Addresses

Table 1 contains the addresses of Works of the MBD and of the Technical Branch Office in Hamburg. The addresses of MAN B&W service centers, agencies and authorised repair workshops can be looked up in the brochure "Diesel and Turbocharger Service Worldwide" in Volume A1.

Company	Address
Work Augsburg	MAN B&W Diesel AG D-86224 Augsburg Phone +49 (0)821 322 0 Fax +49 (0)821 322 3382
Work Hamburg	MAN B&W Diesel AG Service Center, Werk Hamburg Rossweg 6 D-20457 Hamburg Phone +49 (0)40 7409 0 Fax +49 (0)40 7409 104
Technical Branch Office Hamburg	MAN B&W Diesel AG Vertriebsbüro Hamburg Admiralitätstraße 56 D-20459 Hamburg Phone +49 (0)40 378515 0 Fax +49 (0)40 378515 10
MAN B&W Service Center, agencies and authorised repair workshops	Please look up in the brochure "Diesel and Turbocharger Service Worldwide"

Table 1. Companies and addresses of the MAN B&W Diesel AG

Contact

Table 2 contains the names, telephone and fax numbers of the competent persons who can give advise and render assistance to you if required.

	Your contact		
	Work Augsburg Phone: +49 (0)821 322 Fax: +49 (0)821 322	Work Hamburg Service Center Phone: +49 (0)40 7409 Fax: +49 (0)40 7409	MAN B&W Service Center, agencies, authorised repair workshops
Service Engines	Wascherek MST Phone 3930 Fax 3838	Taucke MST4 Phone 149 Fax 249	Look up in the brochure "Diesel and Turbocharger Service Worldwide" in Volume A1
Service Turcharger	Nickel TS Phone 3994 Fax 3998		
Service Spare parts	Stadler MSC Phone 3580 Fax 3720		

Table 2. Persons to be contacted, telephone and fax numbers

Technical details

- 1 Introduction
- 2 Technical details
- 3 Operation/
Operating media
- 4 Maintenance/Repair
- 5 Annex

Table of contents

•	•	□	2	Technical details
•	•	□	2.1	Scope of supply/Technical specification
•	•	□	2.1.1	MAN B&W Diesel AG's Scope of Supply/Technical Specification
•	•	□	2.2	Engine
•	•	□	2.2.1	Characteristics
•	•	□	2.2.2	Photos/Drawings
•	•	□	2.3	Components/Subassemblies
•	•	□	2.3.1	Standard engine design Crankcase to cylinder head
•	•	□	2.3.2	Camshaft drive to injection valve
•	•	□	2.3.3	Supercharger system through engine controls
•	•	□	2.3.4	Special engine designs
•	•	□	2.3.5	Accessories
•	•	□	2.4	Systems
•	•	□	2.4.1	Fresh air/Charge air/ Exhaust gas systems
•	•	□	2.4.2	Compressed air and starting system
•	•	□	2.4.3	Fuel oil system
•	•	□	2.4.4	Control of Speed and Output
•	•	□	2.4.5	Injection timing adjusting device
•	•	□	2.4.6	Lube oil system
•	•	□	2.4.7	Cooling water system
•	•	□	2.5	Technical data
•	•	□	2.5.1	Ratings and consumption data
•	•	□	2.5.2	Temperatures and pressures
•	•	□	2.5.3	Weights
•	•	□	2.5.4	Dimensions/Clearances/Tolerances-Part 1
•	•	□	2.5.5	Dimensions/Clearances/Tolerances-Part 2
•	•	□	2.5.6	Dimensions/Clearances/Tolerances-Part 3
Categories of information				
Information				
Description				
Instruction				
Data/formulas/symbols				
Intended for ...				
Experts				
Middle management				
Upper management				

2.1	Scope of supply/Technical specification
2.2	Engine
2.3	Components/Subassemblies
2.4	Systems
2.5	Technical data

MAN B&W Diesel AG's Scope of Supply/Technical Specification

2.1.1

Items supplied	The next page is a list of the items we have supplied. We are giving you this list to ensure that you contact the right partner for obtaining information/assistance.
For all items supplied by us ...	For all questions you have on items supplied by us, please contact <ul style="list-style-type: none">● MAN B&W Diesel AG in Augsburg, and for typical service questions, <ul style="list-style-type: none">● MAN B&W service centers,● agencies and● authorised repair workshops all over the world.
For all items not supplied by us ...	For all items not supplied by us, please directly contact the subsuppliers, except the components/systems supplied by MAN B&W Diesel AG are concerned to a major extent or similar, obvious reasons apply.
Technical Specification	The order confirmation, technical specification related to order confirmation and technical specification of the engine contain supplementary information.

- 2.1 Scope of supply/Technical specification
- 2.2 Engine
- 2.3 Components/Subassemblies
- 2.4 Systems
- 2.5 Technical data

Engine 48/60 - an important member of the middle-speed range - 138 engines sold (as at 09/98)

Overview characteristics

Engines with the designation 48/60 are supercharged 4 stroke engines of in-line or V design with 480 mm cylinder bore and 600 mm piston stroke. They are used as energy generators in ship drive systems. The engines have a series of structural features which are also used in the other members of the middle-speed range. They are therefore based on the broad experience of 760 engines (as at 09/98).

In-line engines 48/60 consist for the most part of static elements such as crankcase, cylinder liners and cylinder heads and of moving elements such as crankshaft with piston, geared drive and camshaft and also fuel pump and valve drive. The turbochargers serve the purposes of fresh air compression and transport of exhaust gases. When viewing onto the coupling, the exhaust gas pipe is at the right (exhaust side AS), and the charge air pipe at the left (exhaust counter side, AGS).

The camshaft is arranged in a trough on the exhaust counter side. It operates the inlet and exhaust valves and drives the fuel injection pumps. The injection timing can be changed using a manual or electric regulating device.

The turbocharger and charge air cooler are generally on the coupling side in the case of propeller operation, and in the case of generator operation arranged on the free end of engine. Using a drive unit at the free end of the engine, cooling water and lubricating oil pumps can be run.

The engine is suitable for fuels up to 700 mm²/s at 50° C up to CIMAC H/K 55. If required, the engine can be set up for operation using MDO.

Engines of series 48/60 have a large stroke-bore ratio and a high compression ratio. These values facilitate optimum combustion chamber configuration and contribute to good partial load behaviour and a high operating ratio.

The engines are equipped with MAN NA-series B&W turbochargers.

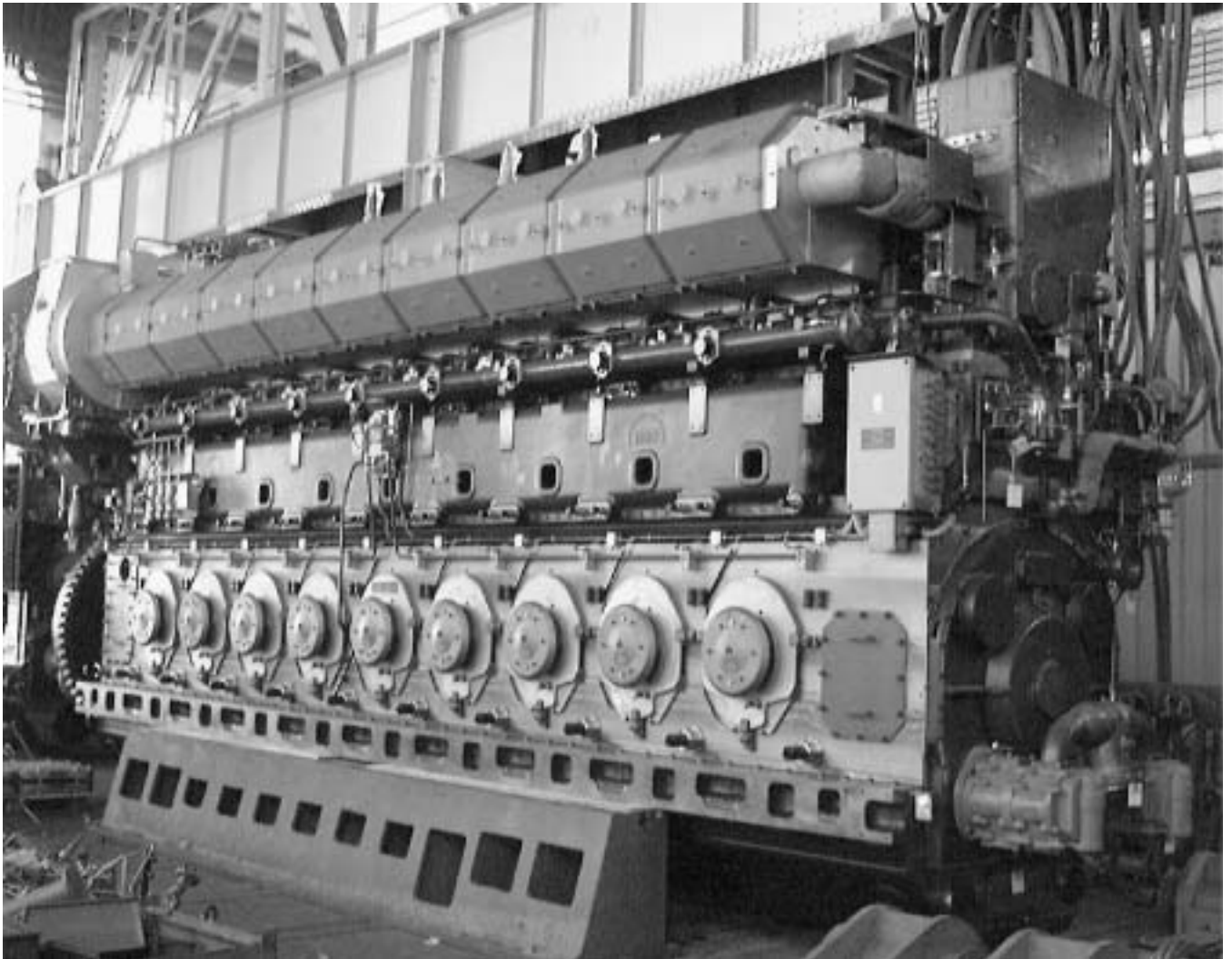


Figure 1. 9 cylinder four-stroke engine L 48/60, viewed from the exhaust side

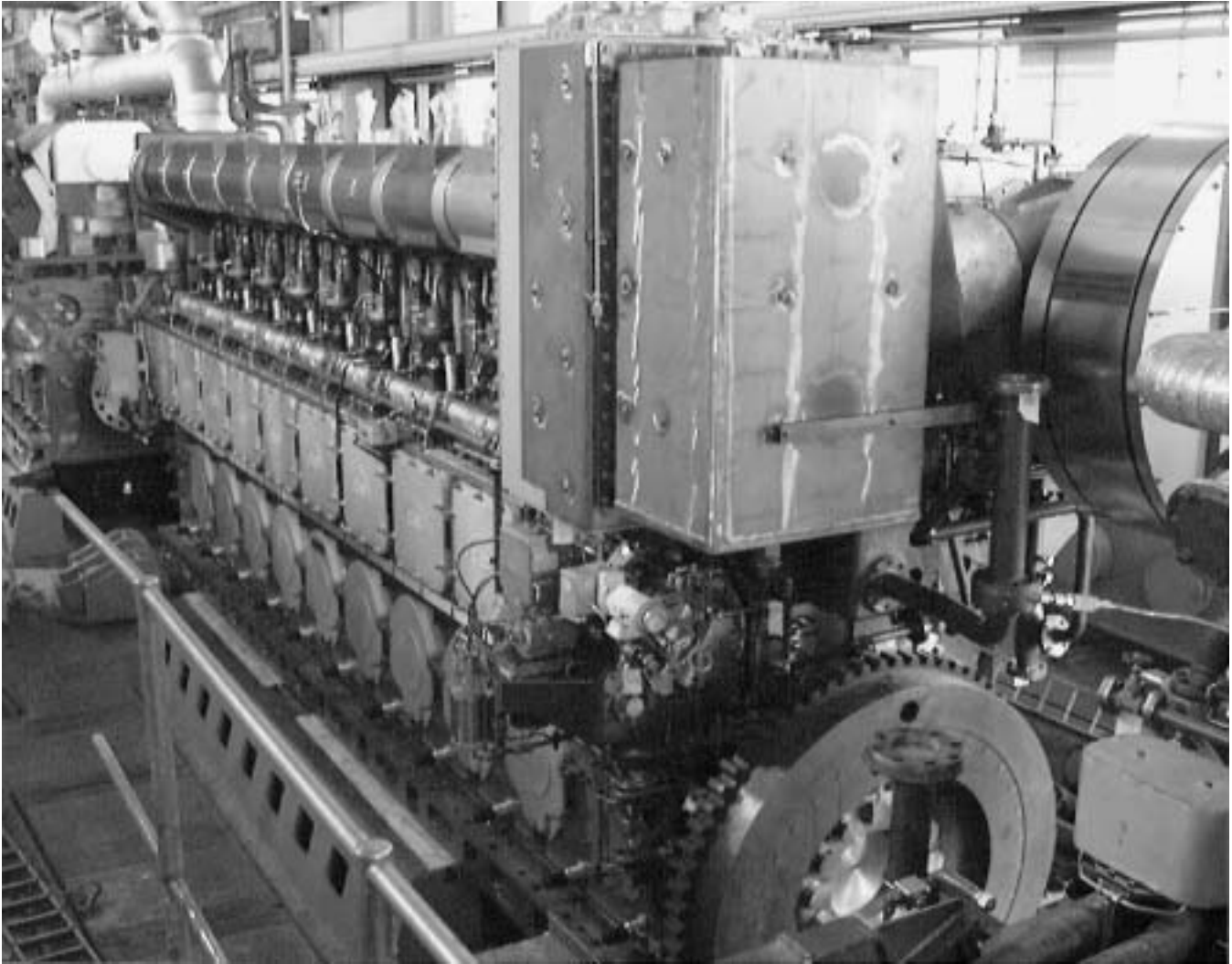


Figure 2. 9L 48/60, viewed from the coupling side

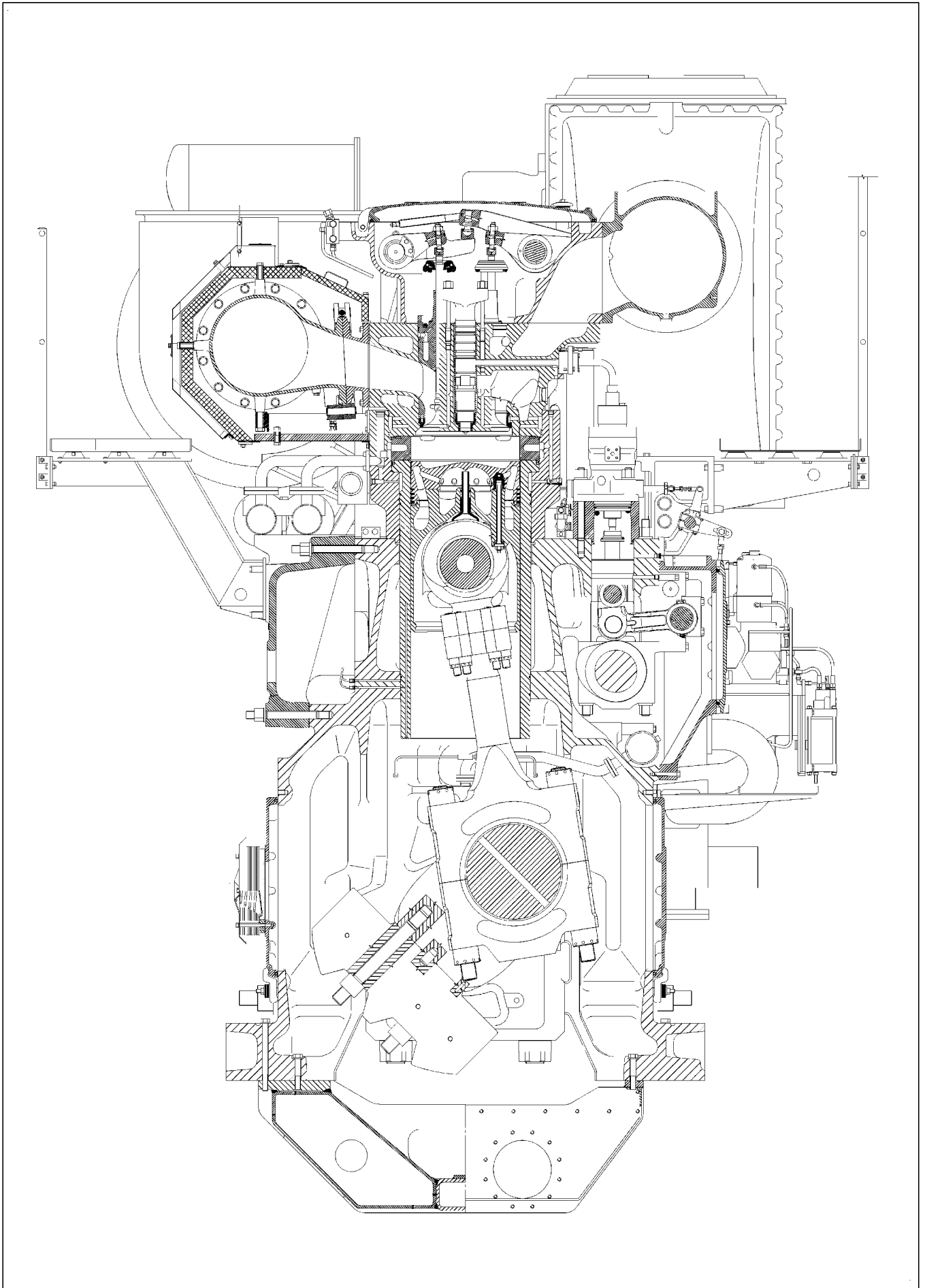


Figure 3. Engine cross section (with V oil sump or oil sump without fittings), viewed from the engine's free end

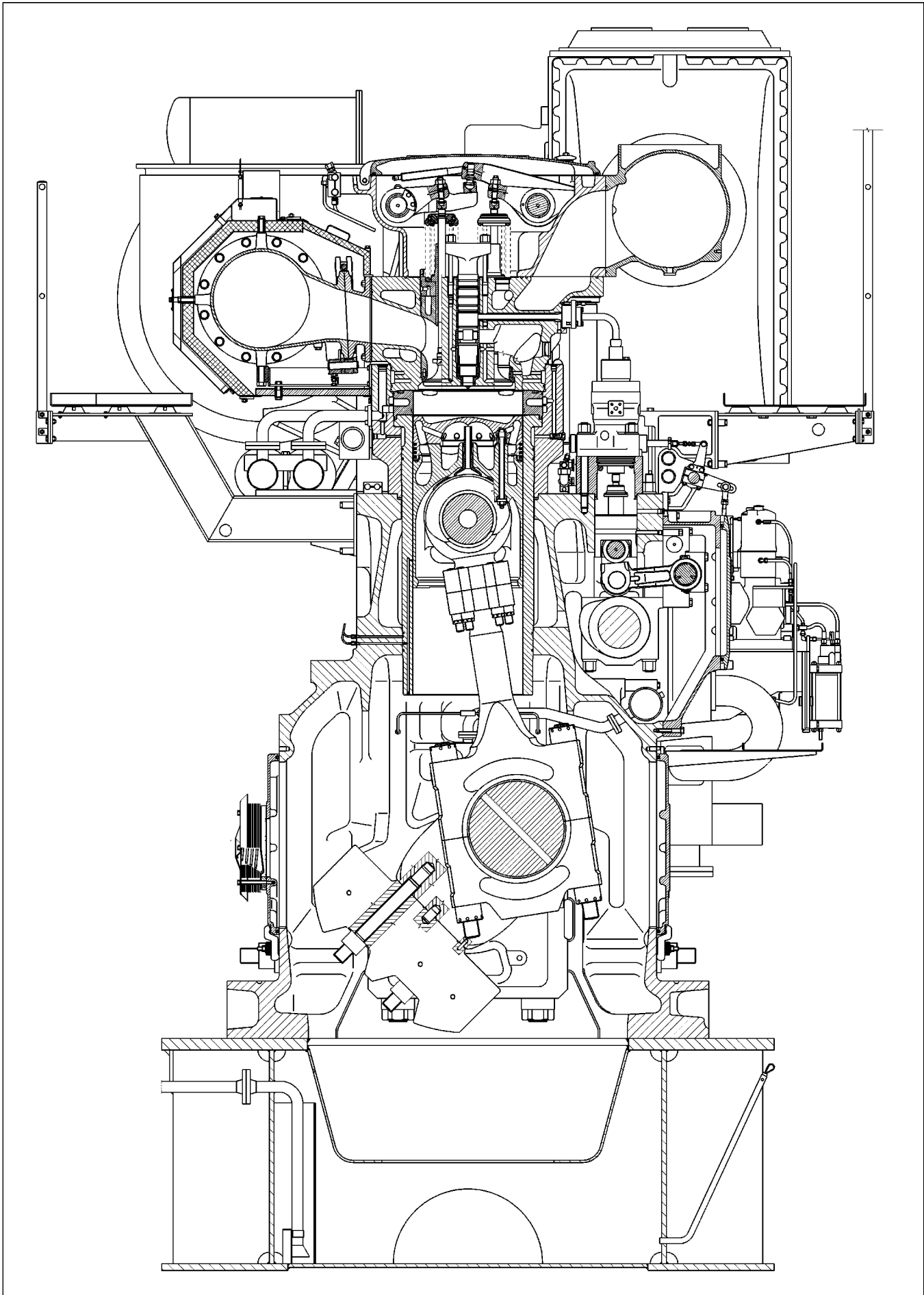


Figure 4. Engine cross section (with foundation frame), viewed from the engine's free end

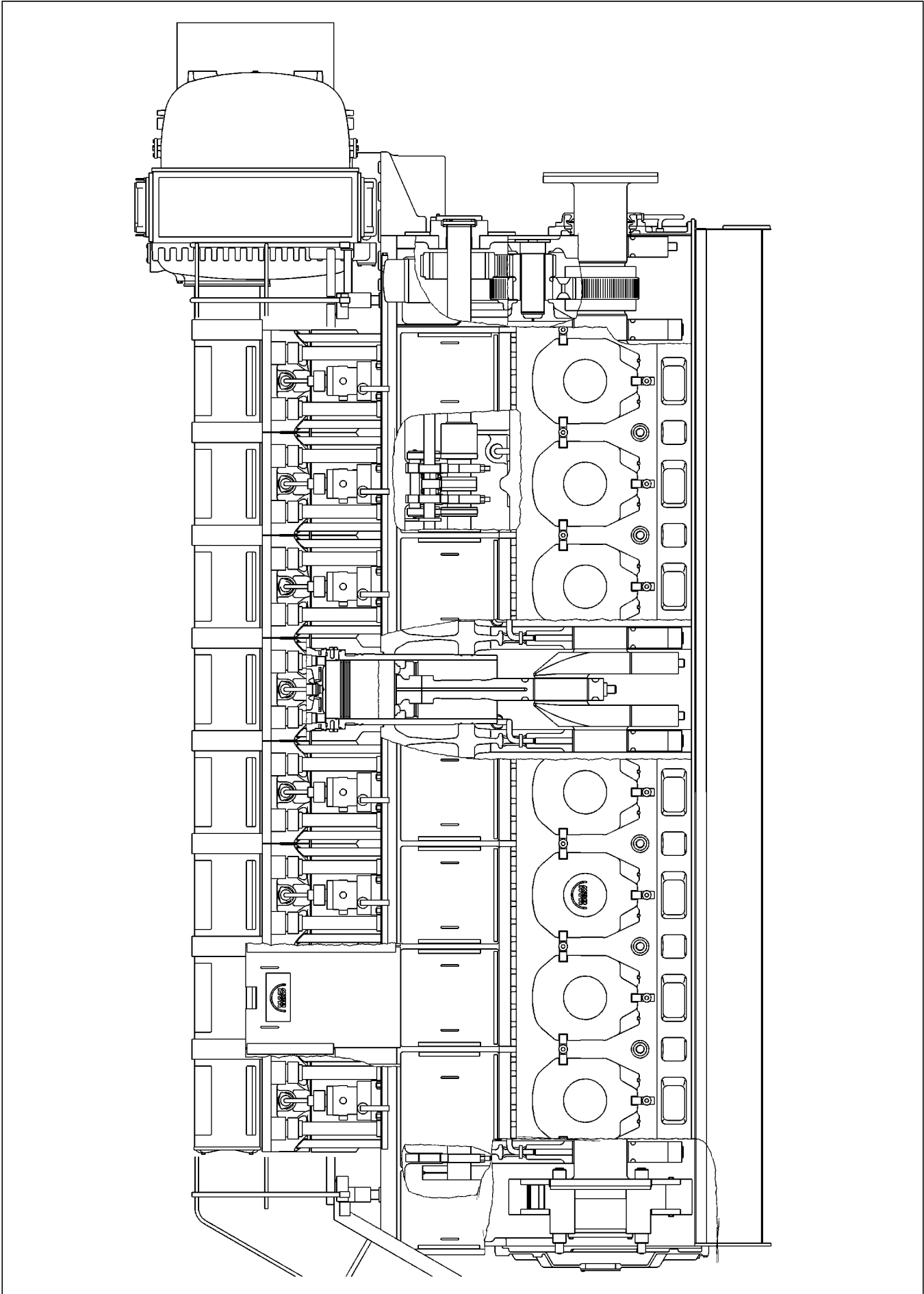


Figure 5. Longitudinal section (with oil sump), viewed from the control side - illustration turned by 90°

- 2.1 Scope of supply/Technical specification
- 2.2 Engine
- 2.3 Components/Subassemblies
- 2.4 Systems
- 2.5 Technical data

Standard engine design

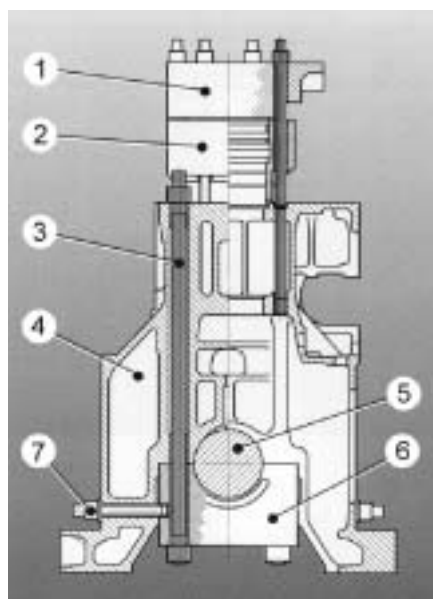
Crankcase to cylinder head

2.3.1

Crankcase

Crankcase/main bearing/tie rod

The engine crankcase (4) is made of cast iron (see Fig. ①). It is made in one piece and designed to be very rigid. Tie rods (3) reach from the lower edge of the suspended crankshaft bearing to the upper edge of the crankcase and from the upper edge of the cylinder head (1) to the diaphragm. The bearing caps (6) of the main bearing are in addition laterally tensioned using the casing. The camshaft drive gears and the vibration damper casing are integrated in the crankcase.



- 1 Cylinder head
- 2 Backing ring
- 3 Tie rods
- 4 Crankcase
- 5 Crankshaft
- 6 Crankshaft bearing cover
- 7 Cross tierods

Figure 1. Main components

Cooling water/lubrication oil

The crankcase does not have any water passages. The lubrication oil is fed to the engine through a distribution pipe located on the exhaust side over the crankcase covers. This pipe supplies the crankshaft bearing, big end bearing, camshaft drive, camshaft, eccentric shaft, injection pumps, the block distributor of the cylinder lubrication system and the turbocharger.

Access

Through large covers on the side walls (see Fig. ②) the engine parts are easily accessible. In the case of marine engines, the exhaust side crankcase covers are generally equipped with safety valves; this is only partly the case with stationary engines.

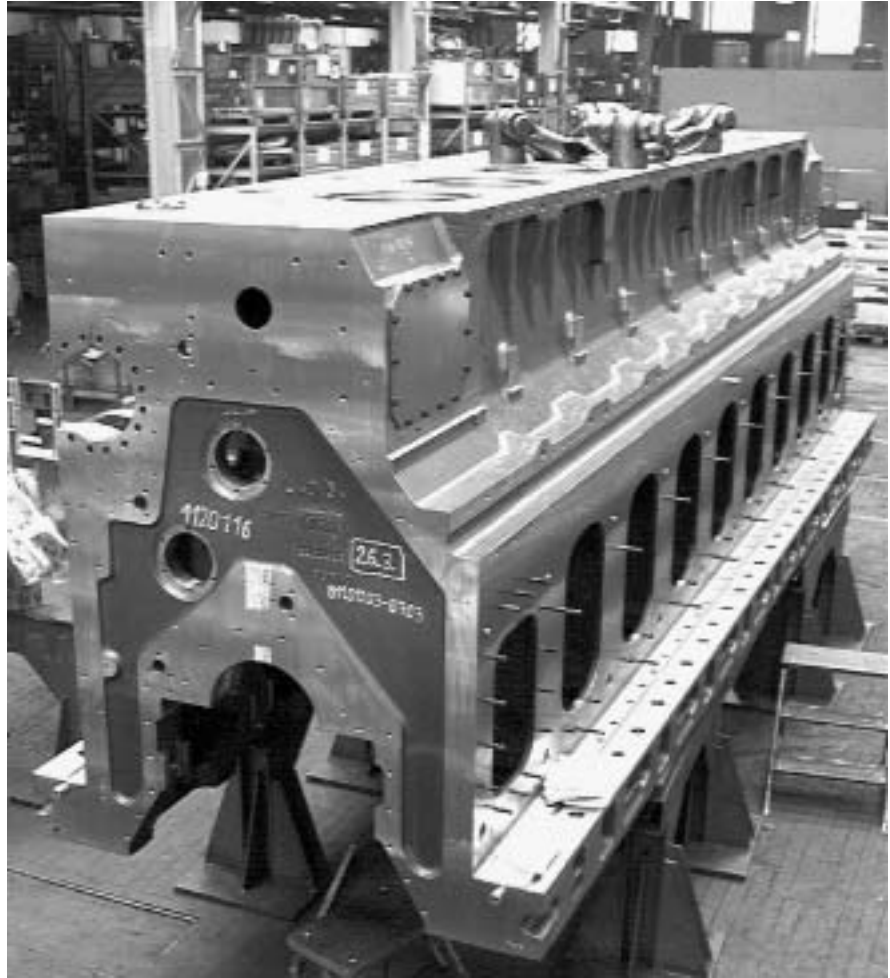


Figure 2. Crankcase, viewed from the coupling end

Oil sump

The oil sump is welded from sheet steel. It catches oil which drips from the engine and feeds it into the lower-lying lubrication oil tank. In engines with a rigid or semi-elastic bearing arrangement, an oil sump without fitting (a) is used. In engines with an elastic bearing arrangement, a reinforced oil sump (b) is used (see Figure 3).

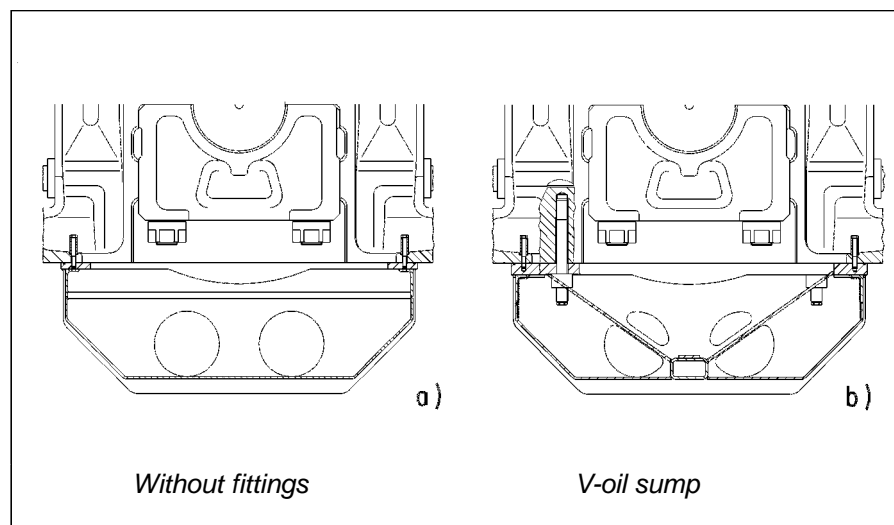
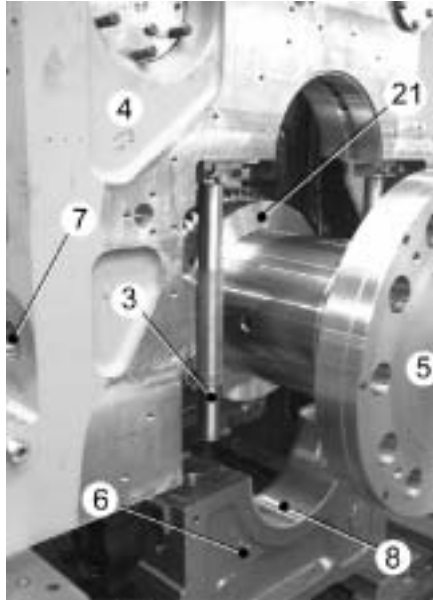


Figure 3. Oil sump

Crankshaft bearing

Bearing cap/tie rods

The main bearing covers (6) are arranged in a suspended position (see Fig. 4). They are held by the continuous tie rods (3). The lateral tension is maintained by the cross tierods (7). They stabilize the form of the bearing body and prevent lateral yielding of the crankcase under the effective ignition pressures.



- 3 Tie rods
- 4 Crankcase
- 5 Crankshaft
- 6 Main bearing cap
- 7 Borehole for cross tie-rods
- 8 Bearing shell
- 21 Camshaft-drive gears

Figure 4. Crankshaft with main bearing

Locating bearing

The locating bearing, which establishes the axial position of the crankshaft, is situated on the coupling end. It consists of the two-part camshaft drive gear on the crankshaft and butting rings, which rest on the first thrust bearings.

Crankshaft

Crankshaft/counterweights/ drive wheel

The crankshaft is forged from a special steel. It is arranged in a suspended position and has two counterweights for each cylinder that are held in place by anti-fatigue bolts that more or less counteract the oscillating mass (see Figure 5). The drive wheel for the geared drive consists of two segments. They are held together by four tangentially arranged screws.

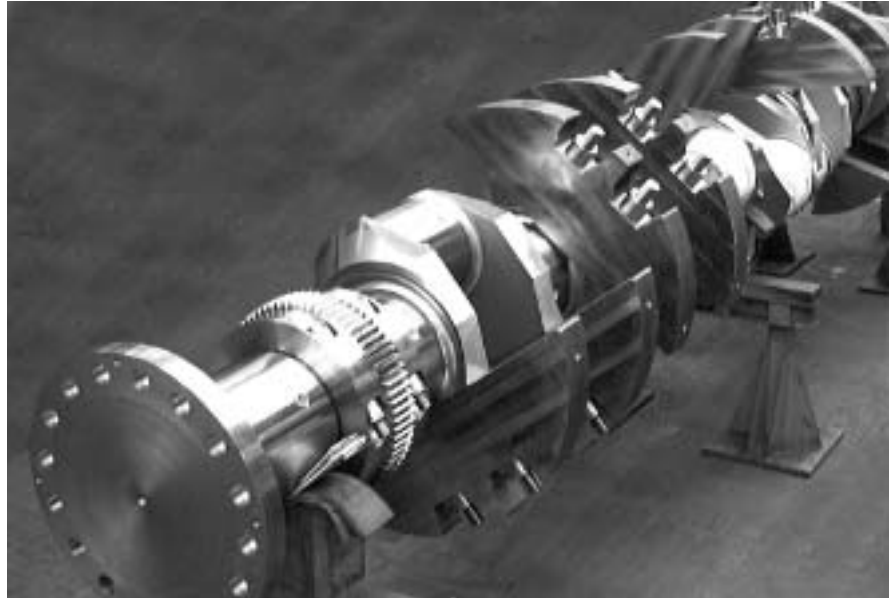


Figure 5. Crankshaft with camshaft drive gear and attached counterweights

Flywheel

The flywheel is located on the flange of the crankshaft on the side of the coupling. With the help of a turning gear, the gear rim of the flywheel can be used to turn the engine during maintenance work.

Torsional vibration damper

Rotary oscillations, produced by the crankshaft when excited, are reduced using a vibration damper (see Fig. 6), which is located on the free side of the engine. The vibrations are transmitted from the internal part to sleeve spring assemblies where they are damped through friction and cushioning. The internal part is designed so that cooling water and lubrication oil pumps can be driven using a screwed on gear rim (not visible in figure).



Figure 6. Torsional vibration damper, with some spring assemblies in place