

RC9 Instruction Manual For Refrigeration Compressors



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This instruction manual is intended as a guide for the operating staff in charge of the preventive maintenance of the compressor. In addition to data concerning the construction and operation of the machine, the manual contains operating, inspection and maintenance instructions which should necessarily be followed in order to keep the compressor in the proper state under normal working conditions.

However, the working conditions of a compressor largely depend on the type and construction of the plant of which it forms part. Consequently this instruction manual can only be regarded as a guide; it is important that the instructions given by the installation engineer are observed as well. Only then can a prolonged and trouble-free operation of the compressor be guaranteed.

The maintenance instructions are limited to those operations which can be performed by the operating staff and for which no specialist knowledge is needed. Any parts to be replaced can be ordered on the basis of drawings with parts lists.

For more specialized repair and overhaul operations, the installation engineer should be consulted.

Faults and defects of the refrigeration compressor should be remedied as soon as possible by qualified personnel in order to reduce down-time to a minimum and to prevent damage to the compressor. The fault-finding table (Chapter 10) may be used to trace and remedy faults quickly.

It is finally pointed out that in individual cases the construction of the compressor may differ from the normal design, in which event the instruction may no more be applicable at certain specific points. In such cases it is advisable to consult the plant manual or contact the installation engineer. The plant manual referred to above and in other sections of this instruction manual should be supplied by the contractor/installer.

A refrigerating plant is used in cases where a certain room or certain materials are to be brought up to or be maintained at a temperature lower than the ambient temperature. This low temperature is brought about by the evaporator of the refrigerating system. In it a liquid refrigerant evaporates due to its being maintained artificially at low pressure; the heat required for this evaporation is withdrawn from the surrounding atmosphere.

The function of the compressor consists in maintaining this low pressure in the evaporator and this by continuously sucking the vapour thus formed from the evaporator. Therefore the name "suction pump" would have been more appropriate for this machine. It derives its present name from the fact that it compresses the sucked vapour, which thus reaches a high pressure, thereby strongly increasing in temperature. However, this high pressure also involves a higher temperature at which the vapour passes into liquid. This temperature is above the ambient temperature; hence it is possible for the compressed vapour to be condensed on an air or water cooled surface.

This process takes place in the condenser. The liquid thus formed is fed from the condenser to the evaporator again in order to evaporate there anew. In the line between the two apparatuses, a liquid regulator is fitted, which ensures that the right amount of refrigerant flows to the evaporator and maintains the pressure difference between condenser and evaporator.

The correct operation of the compressor highly depends on the rest of the plant. If, for example, the installation contains too many impurities, the compressor may get out of order; also, when the plant itself has been dimensioned, assembled or installed incorrectly, the result may be malfunctioning of or damage to the compressor. In the event of compressor failure, it is therefore mostly necessary also to seek the causes in the other elements of the plant or in a shortage or excess of refrigerant charge.

In general it is essential, therefore, to have on hand an operating manual of the plant. Only then will it be possible to report in time any deviations from the normal operating conditions of the plant and take prompt action before serious breakdowns occur.

The range of RC9 refrigeration compressors includes 3-single-stage and 2 two-stage compressor types. All these types are suitable for the usual refrigerants. The single-stage compressors can also be used as booster.

3.1 GENERAL TECHNICAL DATA

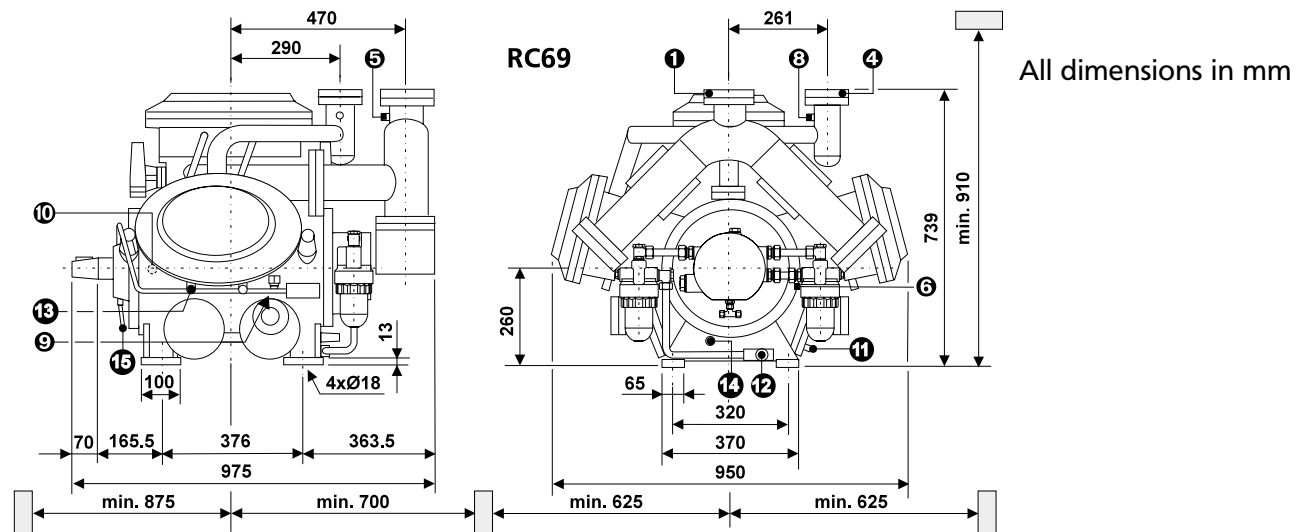
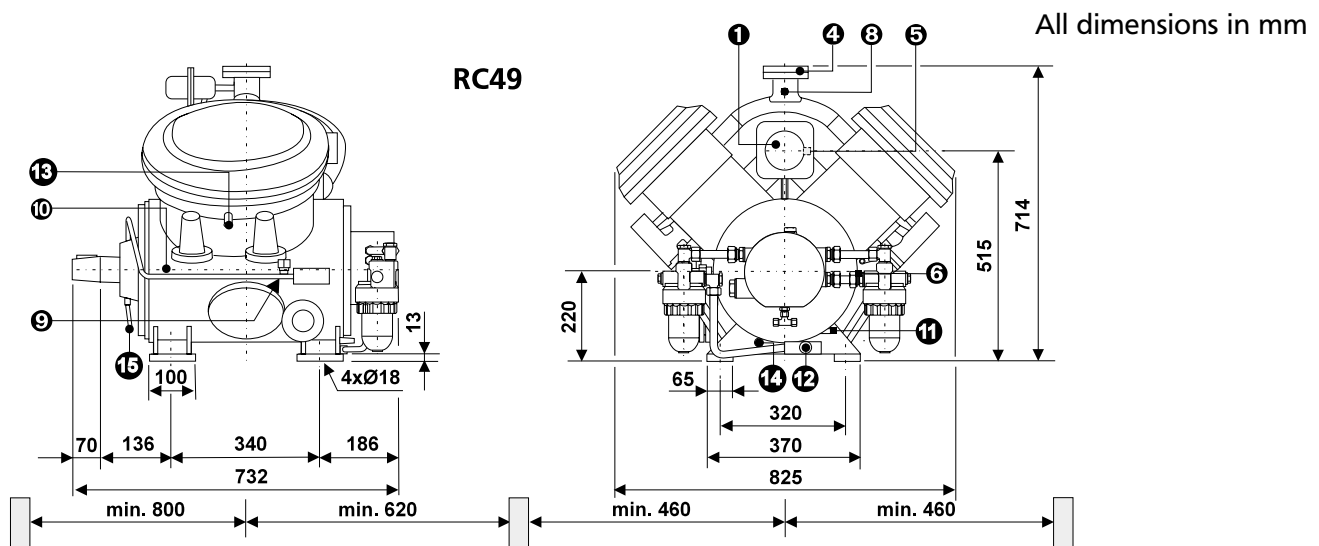
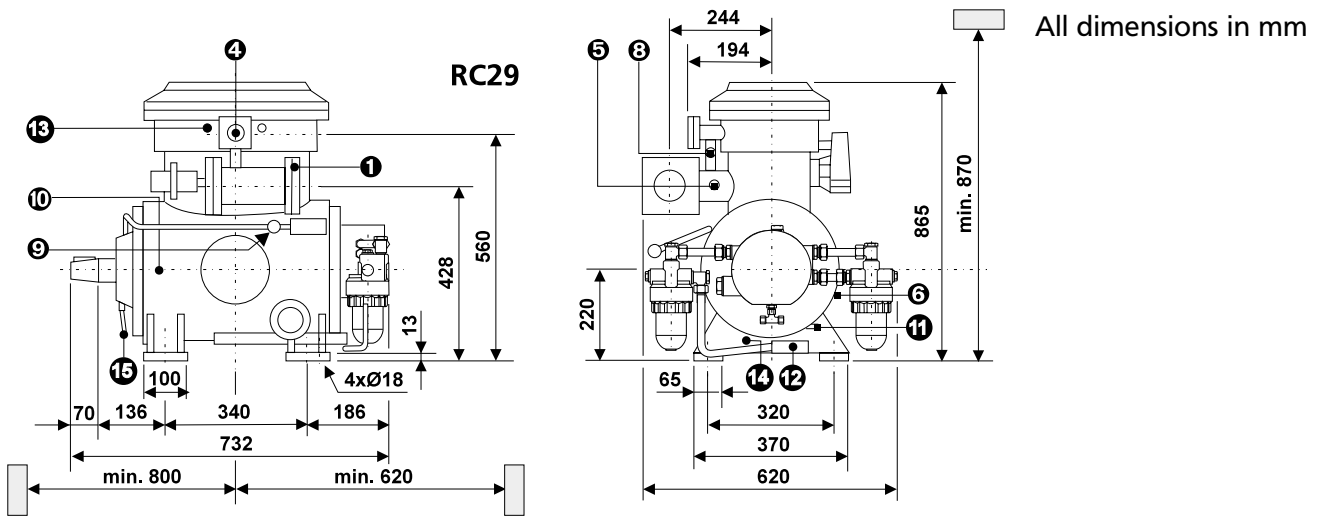
Single-stage compressors			Two-stage compressors			
Compressor type		RC29	RC49	RC69	RC219*	RC429
Number of cylinders	LP	2	4	6	2	4
Weight, without flywheel and accessories	HP	—	—	—	1	2
	kg	270	370	545	370	545
Oil charge** in crankcase	dm ³	3.5	4	8	4	8

*In principle as RC49, less one cylinder, valve assembly, piston and connecting rod.

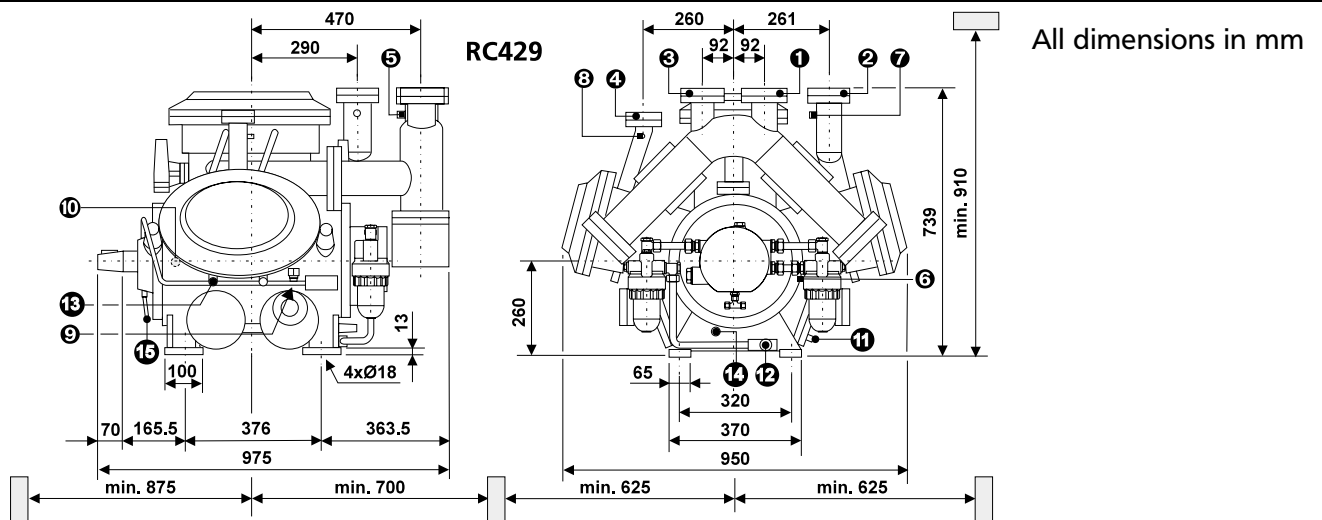
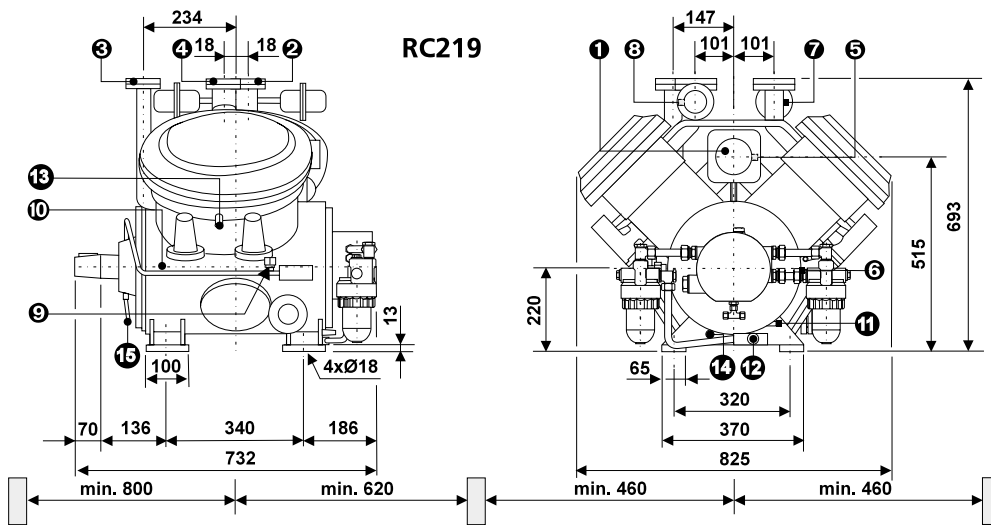
**For further lubrication data, refer to Chapter 3 and 9 and to lubrication oil table 3.1.

Cylinder bore		mm	110
Piston stroke		mm	85
Rotational speed	min. max.	rev/min rev/min	600 1450
Suction pressure (on pressure gauge)	min. max.	bar(e) bar(e)	-0.7 6.0
Max. discharge pressure (on pressure gauge)	max.	bar(e)	21.0
Max. allowable difference between suction and discharge pressure	max.	bar	17.5
Max. discharge temperature	max.	°C	170
Max. oil temperature (measured on suction line to oil suction filter)	max.	°C	70
Direction of rotation			normally counter-clockwise (faced against shaft end)

REMARK: bar(e) means gauge pressure



COMPRESSOR TYPE		MAIN CONNECTIONS hole dia. in counter flange in mm				OTHER CONNECTIONS for all types	
		1	2	3	4		
SINGLE STAGE	RC29	ø55 ¹⁾	ø43	—	—	5 Suction pressure	clamp coupling for 6 x 1 mm steel precision tube
	RC49	ø55 ²⁾	ø62	—	—	6 Crankcase pressure	
	RC69	ø91	ø77	—	—	7 Discharge pressure connection (single-stage) or interstage pressure connection (two-stage)	
TWO-STAGE	RC219	ø55 ¹⁾	ø43	ø43	ø43	8 Discharge pressure connection (two-stage)	
	RC429	ø77	ø62	ø62	ø43	9 Oil pressure	
¹⁾ O.D. of suction line: ø62 mm ²⁾ O.D. of suction line: ø77 mm						10 Return oil separator	1/2" BSP male
						11 Oil temperature	1/2" BSP female with steel precision tube 12 x 1.5 mm
						12 Oil charge and drain valve	
						13 Cooling water supply	
						14 Crankcase heating	
						15 Oil leakage drain of rotary shaft seal	



All compressors are provided with an oil pump. The crankcase oil level must reach about the middle of the sight glass. The amount of oil charge is shown in table 3.1.

The lubrication pressure (i.e. the difference between the oil pressure, measured at the end of the lubricating circuit and the suction pressure) at operating temperature is pre-set at a value of 1.5 bar. The maximum permissible oil temperature is 70 °C, which best can be measured at the suction line to the oil suction filter with a contact thermometer.

The compressor should not be started with an oil temperature below 40 °C.

OIL TYPES

For lubrication of refrigeration compressors, several brands and types of specially developed lubricating oils are on the market. The choice of oil depends not only on its good lubrication properties (viscosity) and chemical stability at the operating conditions of the compressor, but also on kind and operating conditions of the refrigerating plant (solidifying and floc point, solvability). As far as the lubrication properties are concerned, Grasso has tested and approved for use in RC9- compressors the brands and types of oil as listed in the table on page 3.4. Some of the oil types listed in the table may be marketed under other names and/or designations; these oils can also be used, provided their identity can be proved beyond any doubt.

Application of other oils is not permitted without written consent of Grasso.

The choice of the viscosity of the lubricating oils depends on the operating conditions of the compressor. In general, a viscosity of 4 to 4.5 E at 50 °C will satisfy.

However, a higher viscosity should be chosen when a high oil temperature is expected, due to arduous operating conditions, such as:

- a high ambient temperature of the compressor (high engine room temperature)
- a more than normal superheat of the refrigerant suction vapour;
- prolonged part load operation with a large number of cylinders cut out

For less arduous operating conditions a lower viscosity may be used. For strongly varying conditions (e.g. in summer & winter), a viscosity of 4.5 E is recommended. To ensure proper lubrication of the compressor moving parts, the actual oil viscosity under all operating conditions should never be less than 10 to 15 cSt (= 1.85 to 2.35 °E).

IMPORTANT REMARK!

All viscosities mentioned relate to pure oil only and it should be kept in mind that the actual viscosity in the crankcase of an operating compressor, which is decisive for the lubrication, is always lower due to dilution by dissolved refrigerant. The magnitude of the viscosity decrease is not only determined by the type of oil and refrigerant, but also and essentially by the pressure and temperature prevailing in the crankcase.

Table 3.1 Oil to be used for lubrication

BRAND	TYPE	VISCOSITY		
		at 40 °C cSt	at 50 °C mPa.s	°Engler
BP	Energol LPT-F46	54	29	4.4
	* Energol LPT- 68	68	36	5.5
ESSO	* Zerice 46	43	25	3.8
	* Zerice 68	63	34	5.0
	* Zerice S 46	48	27	4.1
FINA	Purfrigol MP 68	54	29	4.4
KUWAIT	Stravinsky C	55	29	4.4
MOBIL OIL	Gargoyle Arctic 300	55	30	4.6
SHELL	* Clavus Oil G 46	46	26	3.9
	* Clavus Oil G 68	68	35	5.4
	* Clavus Oil 46	46	26	3.9
	* Clavus Oil 68	68	35	5.4
TEXACO	Capella WF 68	61	31	4.7
SUN-OIL	Suniso 4 GS ¹⁾	54	29	4.4
	Suniso 5 GS	95	48	7.1

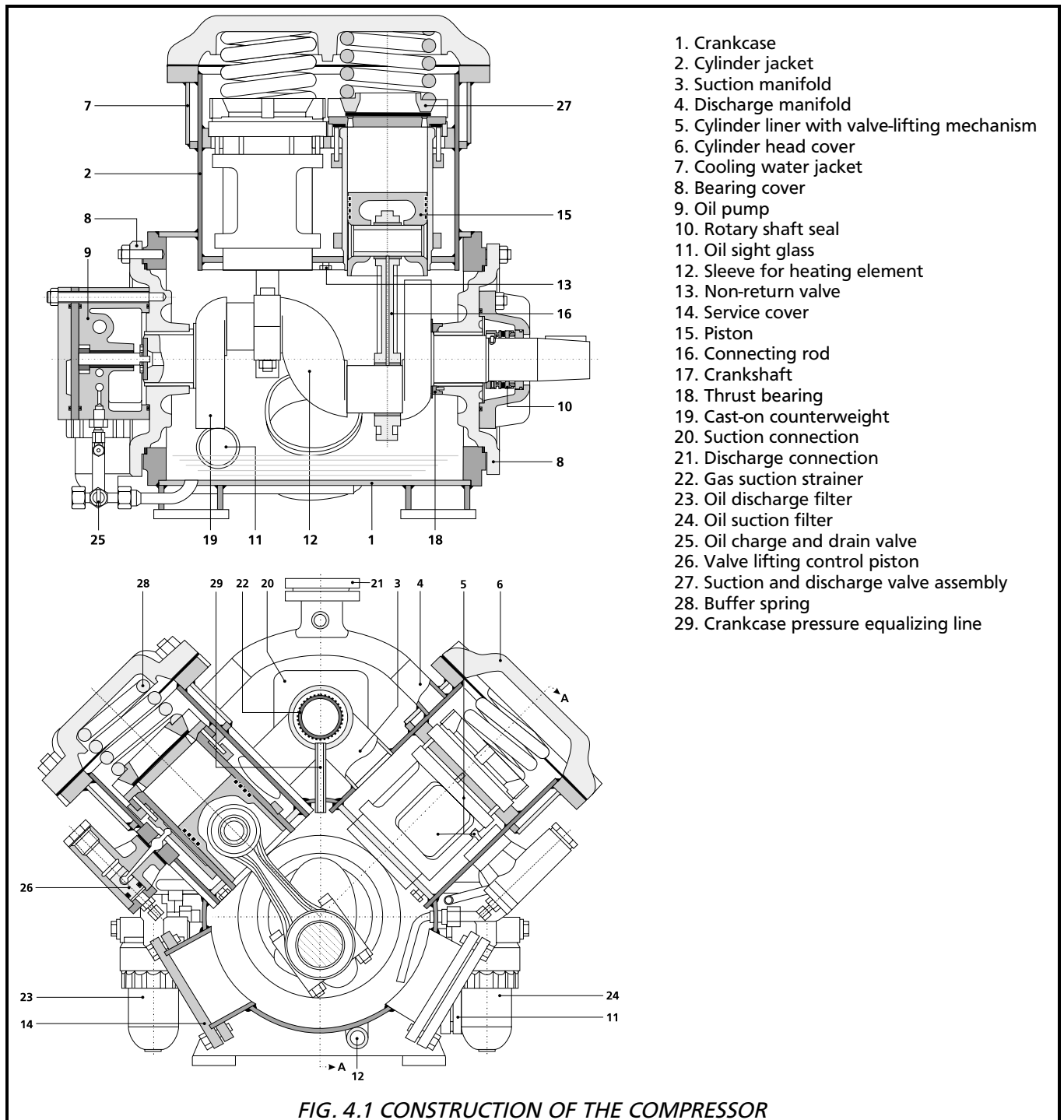
Oil types marked with an asterisk (*) have a viscosity grade number designation according to ISO Standard 3448.

4.1 COMPRESSOR HOUSING (see fig. 4.1)

The compressor housing is of a welded steel construction and comprises both the crankcase and the cylinder jacket(s). In the bottom part of each cylinder jacket, two interchangeable cylinder liners are provided, pressed into two supporting rings welded onto the jacket. The space between

cylinders liner and jacket serves as suction chamber. The discharge chamber is formed by the upper part of the cylinder jacket shut-off by the cylinder head cover.

The crankshaft runs in bearing covers shutting off both sides of the crankcase and on which also the oil pump and the rotary shaft seal housing are fitted. The oil required for compressor lubrication



is at the bottom of the crankcase. To determine the oil level, a sight glass is located on the crankcase. To heat the oil, if necessary, all compressors have a sleeve welded on to the crankcase bottom, into which a heating element (available as an accessory) can be inserted. The oil which is separated in the suction chamber from the refrigerant vapour can flow back to the crankcase via a non-return valve. This valve is fitted between suction chamber and crankcase in the lower supporting ring of the cylinder liners (except in the HP-cylinders in two-stage compressors). The valve, normally open, closes when the crankcase pressure exceeds the suction pressure.

The crankcase interior is accessible via one or two service covers provided on both sides of the crankcase.

4.2 CYLINDERS AND MOVING PARTS (see fig. 4.1)

The cylinders are formed by interchangeable cylinder liners pressed into the supporting rings in the cylinder jackets. The collar on top of the cylinder liners is provided with openings and acts as a seat for the suction valve ring. In the cylinder liners, light metal pistons are located, on which three compression rings and one oil scraper ring are fitted.

The connecting rods have a split-type big end, in which white metal lined steel precision bearing shells are positioned. To provide bearing for the

gudgeon pin, a bronze bush or, in the case of HP-cylinders of two stage compressors, a needle bearing is pressed into the small end.

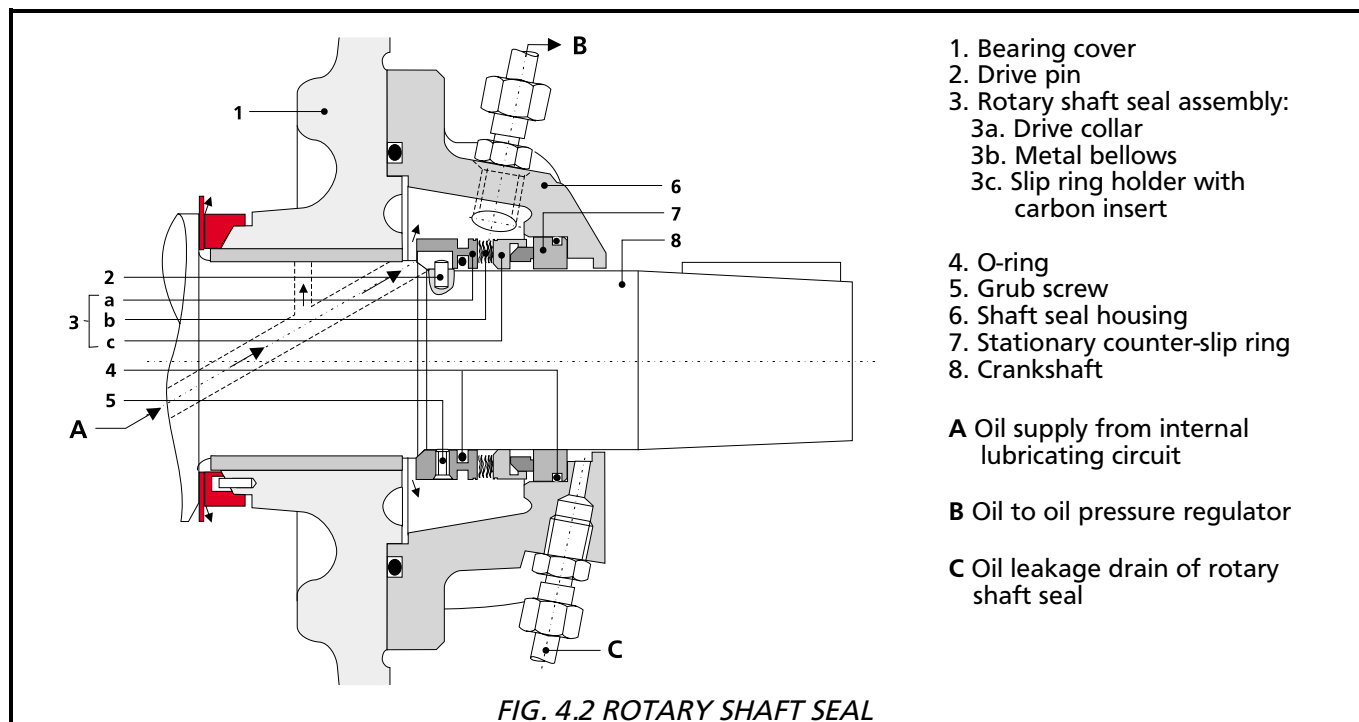
The crankshaft is mounted in slide bearings consisting of interchangeable white metal lined steel bushes pressed into the bearing covers. The crankshaft, furnished with cast-on counterweights, is dynamically balanced. The tapered shaft end with key for taking up flywheel or coupling, is carried gastight through the bearing cover (see par. 4.3, Rotary shaft seal).

4.3 ROTARY SHAFT SEAL

In order to pass the crankshaft (2) gastight outwards, the compressor is provided with a special rotary shaft seal, the construction of which is shown in fig. 4.2.

The sealing between rotating and stationary parts is effected on the sliding surface between a carbon slip ring (7.1) rotating with the crankshaft and a stationary counterslip ring (6) fitted in the shaft seal housing (4). For this purpose the sliding surface of both slip rings is ground to extreme finish and lapped.

The carbon slip ring is carried by the slip ring holder and forms an integral part of the rotary seal assembly (7). This assembly consists of the afore mentioned slip ring holder with carbon insert, a metal bellows (7.2) and a drive collar (7.3). The drive collar in turn is locked on the



1. Bearing cover
2. Drive pin
3. Rotary shaft seal assembly:
 - 3a. Drive collar
 - 3b. Metal bellows
 - 3c. Slip ring holder with carbon insert
4. O-ring
5. Grub screw
6. Shaft seal housing
7. Stationary counter-slip ring
8. Crankshaft

A Oil supply from internal lubricating circuit

B Oil to oil pressure regulator

C Oil leakage drain of rotary shaft seal

crankshaft by means of three grub screws (7.4) and a drive pin (3). The slip ring holder with carbon insert can slide axially over the crankshaft and is pressed on to the counter-slip ring by means of the metal bellows.

O-rings (5 and 7.5) are provided to ensure the sealing between rotary seal assembly and crankshaft and between counter-slip ring and shaft seal housing.

To remove sufficiently the frictional heat developed by the slip rings, the shaft seal is incorporated in the lubricating oil circuit (see further Paragraph 4.10, "Lubrication system").

4.4 SUCTION AND DISCHARGE VALVES (see fig. 4.3)

The suction and discharge valves of the compressor are of the ring type. They contain steel valve rings pressed, under spring tension, on to a seat and shutting off the openings provided in it. The lift of the valve rings is limited by a stroke limiter. The suction valve only has one valve ring retained, together with one sinusoidal spring, between the valve seat type collar of the cylinder liner and a stroke limiter.

The stroke limiter of the suction valve is centred by the collar of the cylinder liner.

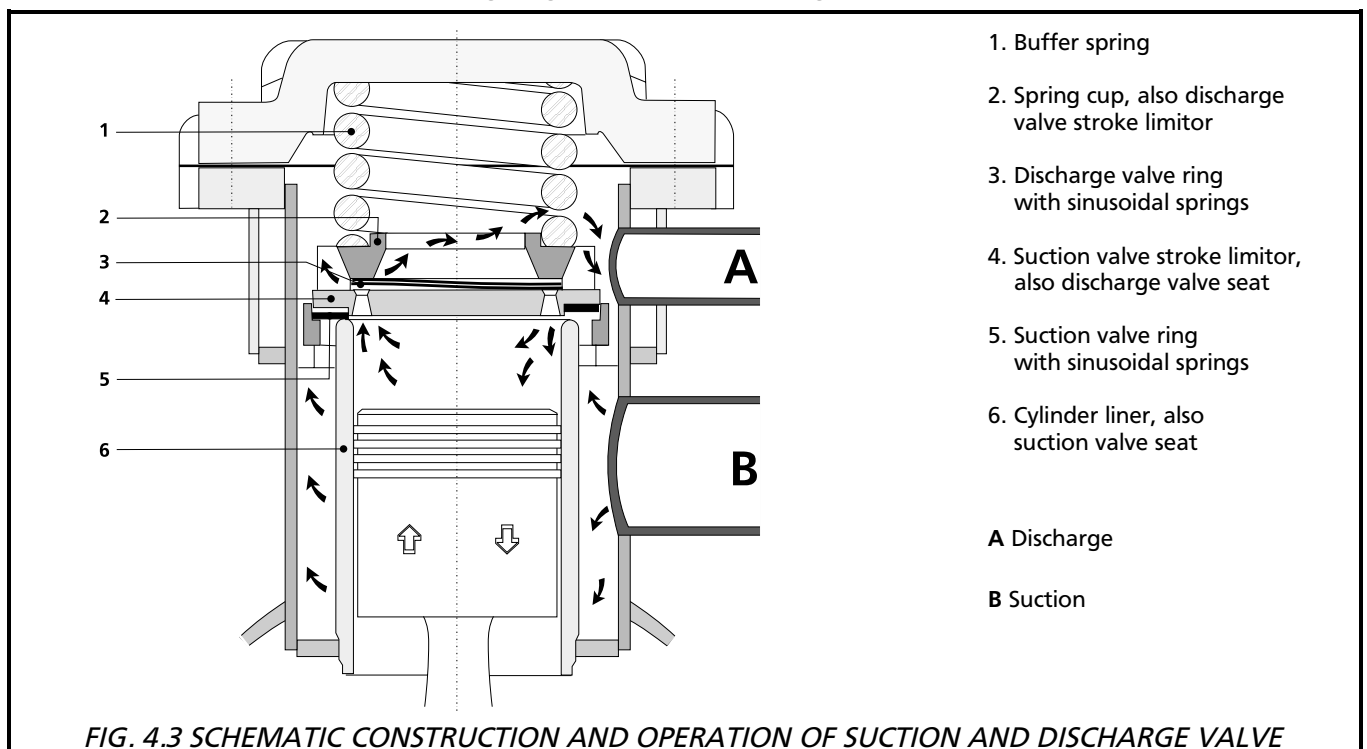
The discharge valve consists of a valve seat and a stroke limiter, fixed together by means of bolts, and between which the one valve ring, together

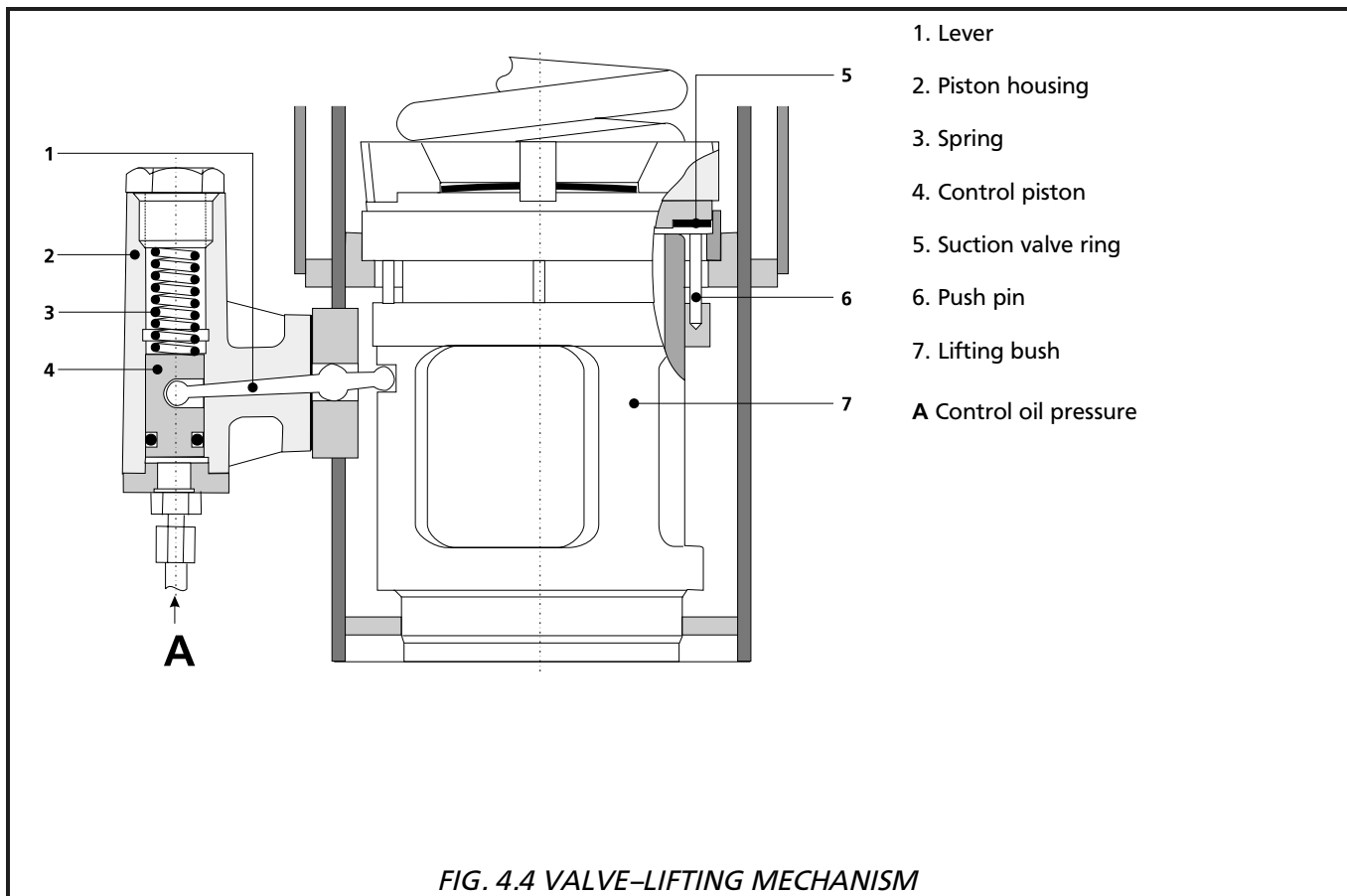
with four sinusoidal springs is placed concentrically. The discharge valve seat and the suction valve stroke limiter are one and the same. The whole assembly is pressed on to the collar of the cylinder liner by a powerful buffer spring. For the function of this buffer spring, see Chapter 6, par. 6.3, Liquid Hammer.

Fig. 4.3 only shows schematically the construction and operation of the suction and discharge valves. For the real construction, reference is made to Chapter 9, Compressor Maintenance.

4.5 VALVE LIFTING MECHANISM (see fig. 4.4)

In order to enable the compressor to start unloaded, all cylinders have to be put out of action mechanically by suction valve ring lifting during compressor standstill. For this purpose a lifting bush is provided in each cylinder, which can move up and down around the cylinder liner. The lifting bush is provided at the top with push pins capable of lifting the suction valve ring from its seat via openings in the collar of the cylinder liner. The lifting bush is connected with an oil pressure controlled spring-loaded piston, located in a housing on the outside of the cylinder jacket, by means of a lever. The piston can be moved upward by control oil pressure from the oil pump. At compressor standstill there is no oil pressure, the piston is forced down by the spring causing the lifting bush with push pins to move upwards





and lift the suction valve ring. Shortly after the compressor has been started, control oil pressure is admitted to the piston and moves it upward, so that the lever tilts, thus pulling the lifting bush with the push pins downwards while the suction valve ring descends onto its seat. After completion of the latter movement, the cylinder is in operation.

4.6 CYLINDER HEAD COOLING

All cylinder heads on the compressor are provided with a cooling water jacket and blanked off water in- and outlet connections.

Only in cases where extremely high cylinder head temperatures occur, will this possibility of cylinder head cooling be used by the installation engineer. In these cases reference is made to the details given in the plant manual.

4.7 PRINCIPAL CONNECTIONS AND SUCTION GAS STRAINER

The suction and discharge chambers of the cylinders open, via one or more lines, into a single suction and discharge connection with flange, with which the compressor is coupled to the

refrigerating plant via stop valves. The (LP)-suction connection is fitted on the suction strainer housing, in which a removable metal strainer element is provided for purifying the intake refrigerant gas. Compressor type RC69 is provided with two strainer elements.

In the case of two-stage compressors, the LP-discharge connection is connected, via an interstage cooler, to the HP-suction connection (see also Chapter 5, par. 5.6, Injection interstage gas cooler). Compressor type RC429 includes already a built-in HP-suction strainer.

All principal connections have nipples for connecting pressure gauges or pressure safety switches.

4.8 PRESSURE EQUALIZING LINE AND OVERFLOW SAFETY VALVES

Between suction strainer housing and crankcase an equalizing line is provided in order to prevent the crankcase pressure* from rising due to piston leakage. Moreover, the crankcase can thus be evacuated for charging lubricating oil or for venting the compressor.

Crankcase pressure = suction pressure for both single- and two-stage compressors
In order to prevent excessive discharge pressures in the compressor, one or more overflow safety valves (number depends on the type of compressor) are provided. These valves act on the difference between suction and discharge pressure and moreover, in the case of two-stage compressors, between suction and intermediate pressure.

The spring-loaded overflow safety valves are adjusted at the works; they blow the gas off to suction when there is an excessive pressure difference.

The overflow safety valves are fitted externally between the suction manifold and the HP and/or LP discharge manifold.

4.9 OIL PUMP, FILTERS AND CONTROL OIL SYSTEM (see fig. 4.5)

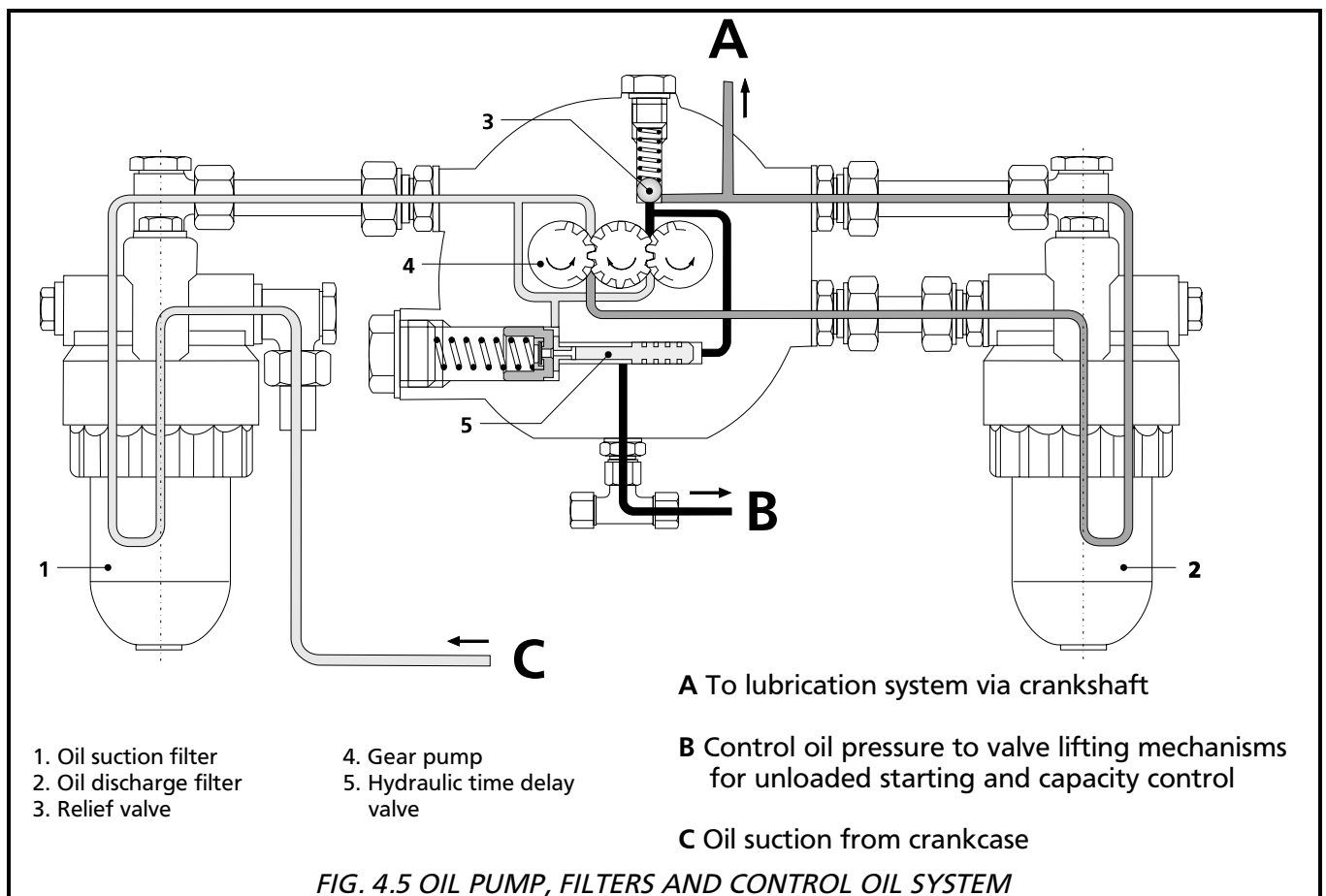
The oil pump is fitted on the bearing cover opposite the compressor driving end and is directly driven by the crankshaft.

The pump housing accomodates a double gear

pump consisting of three gears with the centre gear driven by the crankshaft.

The oil suction and oil discharge filters are fitted to the pump. The oil suction filter contains a metal gauze filter element; the oil discharge filter is provided with a paper filter element retaining the fine (metal) particles suspended in the oil.

The oil is drawn from the crankcase via the oil suction filter. The pressures delivered by the gear pump are a lubricating pressure and a control pressure to operate the valvelifting mechanisms (capacity control). The pressurized lubricating oil is delivered to the discharge filter, led back to the pump housing and into the lubricating system via the crankshaft. The lubricating oil pressure depends on the setting of the lubricating oil pressure regulator built into the lubrication system of the compressor (see also par. 4.10, Lubrication system). The control oil pressure delivered by the pump is regulated by a built-in relief valve connected to the lubrication system. Excess of control oil is thus used for lubrication. The control pressure has been set at 13 - 15 bar above suction pressure.



After starting the compressor, the through-flow of the control oil pressure to the valve lifting mechanisms is interrupted for 30 to 60 seconds by a hydraulic delay valve provided in the pump. This valve consists of a plunger and a spring-loaded piston. During compressor standstill the piston, due to the spring tension, is in its extreme position, as a result of which the plunger shuts off the through-flow of oil. The space behind the piston is filled with oil. As soon as the compressor is operated, plunger and piston will be forced down by the pump pressure, but encounter resistance of the oil behind the piston. This oil should first leak away along the piston before the plunger can clear the through-flow. The delay time depends on the viscosity and consequently on the oil temperature. As soon as the compressor has stopped, it may not be restarted until after 3 minutes in order to prevent the compressor from starting on load. During this period the delay valve is returned by the spring to its original position. A check valve in the piston ensures that the space behind the piston is filled again with oil.

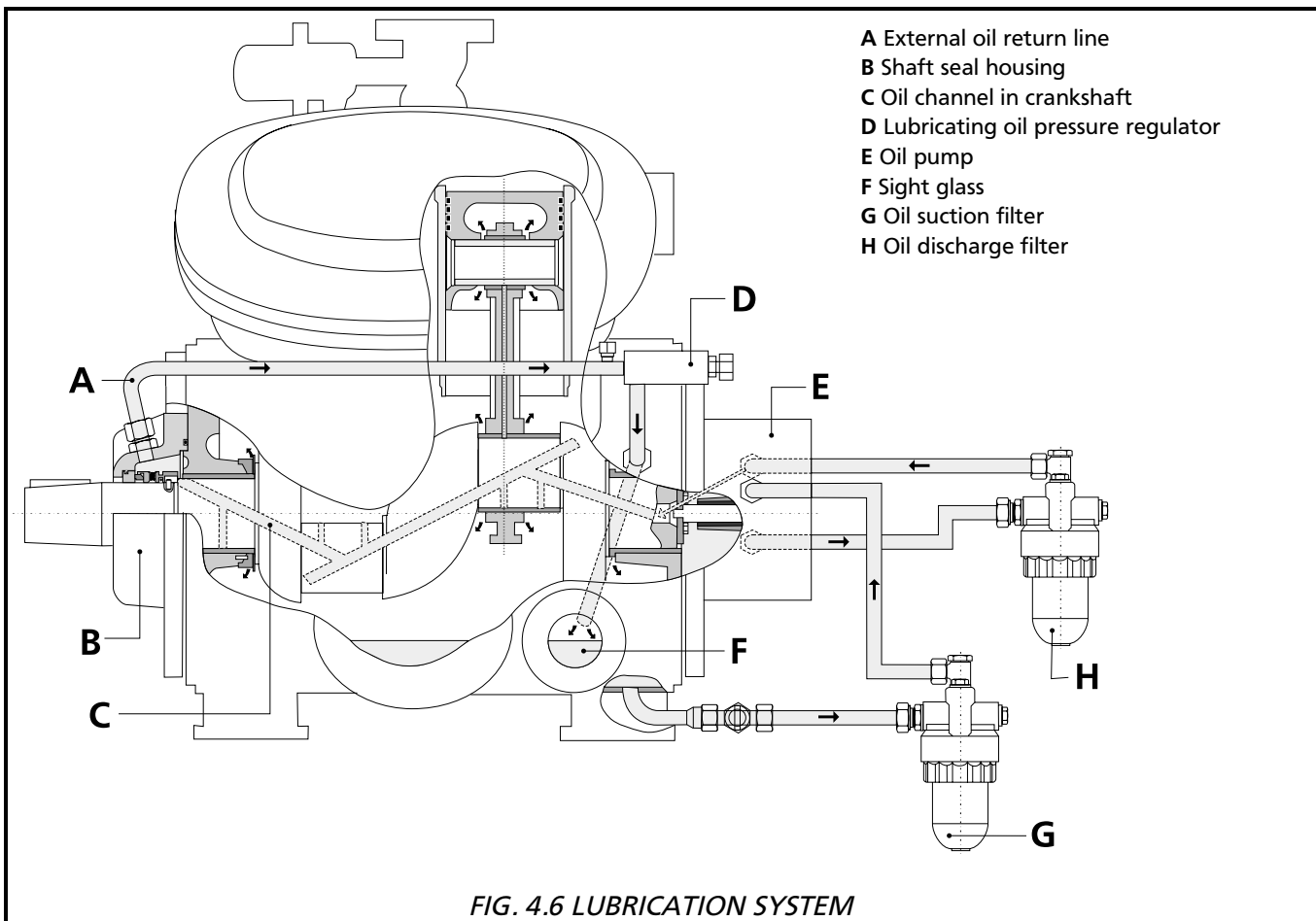
4.10 LUBRICATION SYSTEM

The lubrication of the compressor is effected under pressure; the lubricating oil circuit is shown in fig. 4.6, overleaf

The pump draws the oil from the crankcase via a suction filter and feeds it back under pressure to the oil pump housing via a discharge filter.

From this housing the oil flows into the crankshaft, in which a continuous oil channel is drilled, provided with radially drilled oilways in situ of the bearings. The connecting rods also have an internal oil channel through which the oil is supplied to the small end bearings. Sufficient lubrication of the cylinder walls is ensured by the oil that is forced out of the bearings and splashed around. The oil channel in the crankshaft ends in the shaft seal housing.

As, besides its lubricating function, the oil also has a cooling function, especially for the rotary shaft seal, the amount of circulating oil is considerably more than that required for lubrication. This excess of oil is led back, via an external line to the pump



end of the crankcase, from where it flows back to the oil sump via an internal line: this oil stream is visible behind the sight glass. In the return line an adjustable lubricating pressure regulator is fitted. This spring-loaded ball valve allows the return oil to pass at a certain pressure only, thus determining the pressure in the lubrication system. The connection for the oil pressure gauge and the lubricating oil pressure safety switch is provided upstream the pressure regulator on the shaft seal housing.

The oil pump supplies, besides the lubricating oil pressure, also a separate control oil pressure for the valve lifting mechanism; for further data refer to chapter 4.9. Oil pump, filters and control oil system.

The accessories of the compressor include those devices and systems with which the efficient operation of the compressor in the installation can be promoted and checked and those which, in the event of failures prevent the compressor from being damaged.

The accessories should be distinguished as follows:

A) Accessories the use of which has been prescribed by the compressor manufacturer, among which:

- Pressure gauges for suction pressure, discharge pressure and oil pressure; in the case of two stage compressors also for the intermediate pressure;
- Pressure safety switches for discharge pressure and lubricating oil pressure;
- For two-stage compressors: Electrically operated capacity control (also to be used as run-in control with which the compressor can proceed as favourably as possible to two-stage compression during the time the installation attains the operating conditions).

B) Accessories the use of which is deemed necessary by the installation engineer, among which:

- Suction pressure safety switch;
- Cylinder head temperature safety device;
- Crankcase heating;
- For single-stage compressors: Manually or electrically operated capacity control.

The choice of the accessories depends on the type of plant, the refrigerant used and the operating conditions; therefore, this choice will be determined by the installation engineer.

In this chapter only those accessories are described that can be supplied by the manufacturer of the compressor. If other accessories have been provided by the installation engineer, their description can be found in the plant manual.

5.1 PRESSURE GAUGES

The pressure gauges necessary for checking the correct operation of compressor and installation are mounted on a panel, each of them being connected to the compressor via a shut-off valve.

For single-stage compressors three pressure gauges have been provided, viz. a suction pressure gauge, a discharge pressure gauge and an oil pressure gauge; moreover, for two-stage compressors, there still is an intermediate pressure gauge.

The gauges indicate the pressure in bars; at a pressure lower than the atmospheric, the pressure gauge indicates a negative value. The scale of suction, discharge and intermediate pressure gauges is adjusted to the refrigerant in the plant, as besides the pressure scale also the saturation temperatures corresponding to the overpressures are given.

5.2 PRESSURE SAFETY SWITCHES

In order to protect compressor and plant, safety switches for discharge pressure, suction pressure and lubricating oil pressure are provided. They are mounted on a panel and connected to the pressure connections of the compressor via the pressure gauge valves. The switch contacts are incorporated in the control current circuit for the drive motor of the compressor.

The discharge pressure safety switch (Danfoss pressure control type RT 5 for halocarbon refrigerants, type RT 5A for NH₃) protects the compressor against excessive discharge pressure. In case the preset pressure is exceeded, the control current circuit is interrupted and the compressor stops.

The suction pressure safety switch (Danfoss pressure control type RT 1 for R12, R22, etc. type RT 1A for NH₃) protects compressor and plant against too low suction pressure. In case the pressure drops below the preset value, the compressor is switched off.

The switching pressure of both switches can be adjusted by turning the main spindle after removing a cap on the top side of the housing. The adjustment can be read on a scale behind the window in the front cover. Between the cut-out pressure and the pressure at which the switch makes circuit again, there is a fixed difference of approx. 0.4 bar in the suction pressure safety switch and of approx. 1 bar in the discharge pressure safety switch.

Both pressure safety switches are provided with a locking device when cut out, so that, on return of the original pressures, the compressor does not become operative automatically again. The switches can be unlocked by pushing a green button on the side; however, this may be done only after the cause of the switching off of the compressor has been investigated and the failure has been remedied. In both switches an auxiliary contact is provided for connection a pilot lamp or a klaxon.

The lubricating oil pressure safety switch protects the compressor against too low lubricating oil pressure. The lubricating oil pressure is the difference between oil pressure and crankcase pressure (=suction pressure) indicated by pressure gauges. The lubricating oil pressure safety switch reacts to this difference, which should be at least 1 bar to ensure proper lubrication.

Two types of lubricating oil pressure safety switches may be used:

a) with locking device and built-in thermal time delay relay (Danfoss differential pressure control type MP 55A for NH3).
With this switch, a differential pressure between 0.3 - 4.5 bar can be adjusted by means of a set disc under the upper pressure bellows inside the switch. The setting value should be at least 1 bar. If the differential pressure decreases, the control current circuit of the motor will be interrupted with a delay of 60 secs. A pilot lamp or klaxon can be connected via an auxiliary contact. When in "break" position, the switch is locked. This lock should be released only after 3 mins. by pressing the reset button on the switch. The permanently set contact differential amounts to 0.2 bar, so that the lubricating oil pressure must be at least 1.2 bar to operate the switch again. In order yet to re-start the compressor and to allow it to build up a sufficient lubricating oil pressure, a thermal time delay relay is provided, which leaves the contacts closed during 60 seconds. In order to check the safety switch for proper operation, a test device is provided inside at the left side of the switch. When this device is depressed and kept in this position, the compressor should stop after 60 seconds.

b) without locking device and without thermal time delay relay (Danfoss differential pressure control type RC 260A).
With this safety switch, the lubricating oil pressure can be adjusted between 0.5 and 4 bar by means of a set disc which is accessible after removing the front cover. The setting value should here, too, be at least 1 bar. An auxiliary contact is provided for connecting a pilot lamp or a klaxon. The permanently set contact differential is 0.3 bar, so that the lubricating oil pressure should be at least 1.3 bar to cause the switch to make circuit again. In order to start the compressor and to allow it to build up lubricating oil pressure, the contact of the safety switch must have been shunted with the aid of a separate time delay relay with locking device

or by a push button switch in the control current circuit for the drive motor.

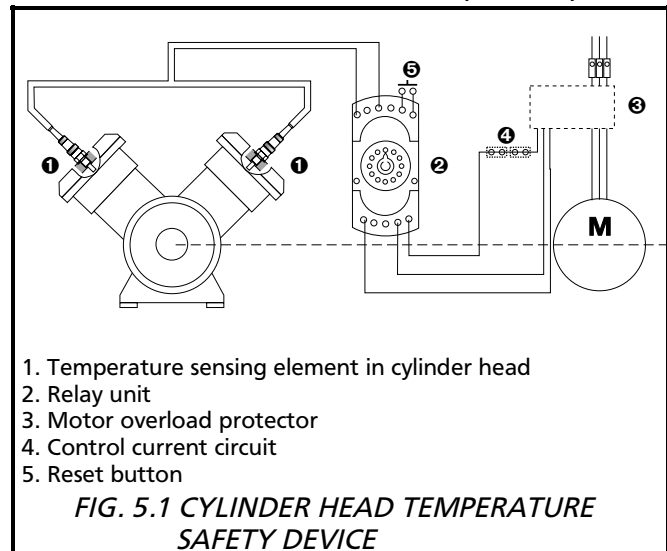
5.3 CRANKCASE HEATING

During standstill of the compressor at low ambient temperatures

- condensation of the refrigerant in the crankcase may occur;
 - the refrigerant may dissolve in the oil to a higher extent;
 - the viscosity of the oil may become so high that too much delay occurs during starting
- These phenomena can be prevented by maintaining the crankcase at a certain temperature. This is effected by a heating element which is screwed into a sleeve provided under the crankcase. The electrical connection should be designed so that the element can only operate during compressor standstill.

5.4 CYLINDER HEAD TEMPERATURE SAFETY DEVICE (see fig. 5.1)

The compressor discharge temperature, measured on the outside of the discharge line upstream the discharge valve, must not exceed 140 °C. It is nevertheless possible that, due to a failure, the temperature in one or more cylinder heads suddenly rises, in which event danger of damage arises. In order to protect the compressor against such danger, it can be equipped with an electronic temperature safety device with sensing elements on all cylinders or on some of them. This safety device interrupts the control current circuit at a local temperature of approx. 170 °C after which the compressor stops. The relay to which the temperature sensing elements are connected, is locked when cut out. A pilot lamp or



klaxon can be connected via auxiliary contacts (see the plant manual).

5.5 CAPACITY CONTROL

In order to adapt the compressor capacity of the cooling load of the moment, a number of cylinders can be put in or out of action either individually or collectively. In this case use is made of the valve lifting mechanism fitted on each cylinder (see chapter 4) and operated by the pump control oil pressure.

The capacity control may be of two-fold design:

- a) with a manually operated oil distributor (single-stage compressors only);
- b) with one up to four three-way solenoid valves which are operated electrically and thus enable automatic control.

Regardless of the control system applied, one or more cylinders are connected direct to the control oil pressure; these cylinders become automatically operative after the unloaded starting of the compressor. The other cylinders can be cut in or out in one or more stages.

Especially in the case of two-stage compressors the use of these switching possibilities can be limited by the operating conditions of the installation (refer to the plant manual). Moreover, the number of switchings per unit of time of one individual cylinder, as well as of the whole compressor, is tied to a maximum (see chapter 8, Supervision during compressor operation).

5.5.1 MANUALLY OPERATED CAPACITY CONTROL (single-stage compressors only) (see fig. 5.2)

In this control system the compressor is fitted with an oil distributor which can be set by hand to several positions. The distributor has six ports: one for the control pressure connection, one for the oil return connection and four for the connection of the valve lifting mechanisms of the cylinders or cylinder groups. Depending on the compressor size, one or more of the last-named ports may be out of use.

The distributor has five positions. In position 1 the control pressure is blocked and the valve lifting mechanisms are connected to the oil return. Only the cylinders directconnected to the control pressure are then in operation. In the positions 2, 3, 4 and 5 the control pressure is admitted step by step to the valve lifting mechanisms of the connected cylinders or cylinder groups, which then become operative.

This control system enables the compressor to be controlled in maximum four steps from minimum up to maximum capacity. After stopping the compressor it is desirable to set the oil distributor again to position 1 (also refer to chapter 7). A survey of the operating cylinders in the various

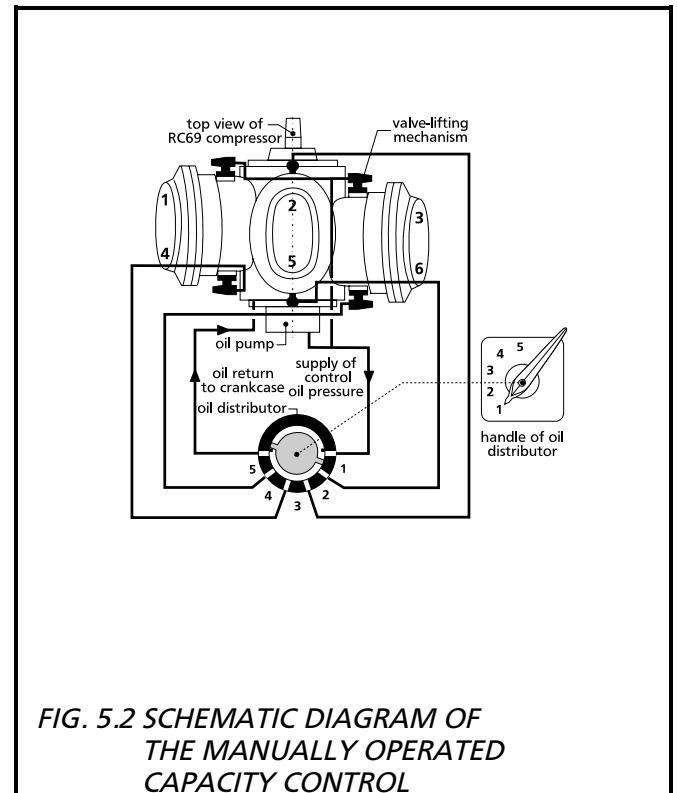


FIG. 5.2 SCHEMATIC DIAGRAM OF THE MANUALLY OPERATED CAPACITY CONTROL

positions of the oil distributor is indicated in table 5.1, overleaf.

5.5.2 ELECTRICALLY OPERATED CAPACITY CONTROL (see fig. 5.3)

For distributing the control pressure to the valve lifting mechanisms of the cylinders or cylinder groups, use is made in this system of one up to four electrically operated three-way solenoid valves; their number depends on the size of the compressor. The solenoid valves fitted on the compressor each have three connections: one for the control pressure (2), one for the oil return (0) and one for the valve lifting mechanism (1). When the valve is not energized, the control pressure connection in each valve is blocked, and the valve lifting mechanism is connected to the oil return, so that the cylinder or cylinder group is out of action. As soon as the valve is energized, the oil return is shut off and the control pressure is admitted to the valve lifting mechanism, causing


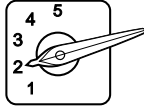
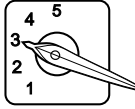
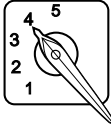
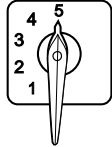
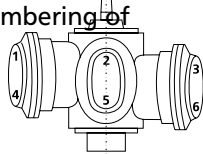






POSITION OF OIL DISTRIBUTOR →					
APPLICATION →	starting and minimum capacity	control up to maximum capacity			
COMPRESSOR TYPE ↓	OPERATING CYLINDERS ↓			Each figure between brackets refers to the swept volume expressed as a percentage of the full load swept volume	
RC29	1 • (50)	1 2 (100)		Typical numbering of cylinders 	
RC49	• 2 3 • (50)	1 2 3 • (75)	1 2 3 4 (100)		
RC69	1 • 3 • • • (33)	1 • 3 • 5 • (50)	1 2 3 • 5 • (67)	1 • 3 4 5 • (83)	1 2 3 4 5 6 (100)

TABLE 5.1 STANDARD STEPS OF THE MANUALLY OPERATED CAPACITY CONTROL (SINGLE-STAGE COMPRESSORS ONLY)

VALVE NO. →						
APPLICATION →	starting and min. capacity	control up to maximum capacity				
COMPRESSOR TYPE ↓	OPERATING CYLINDERS ↓			Each figure between brackets refers to the swept volume expressed as a percentage of the full load swept volume		

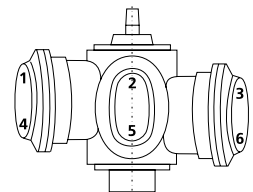


TABLE 5.2 STANDARD STEPS OF THE ELECTRICALLY OPERATED CAPACITY CONTROL (SINGLE-STAGE COMPRESSORS ONLY)

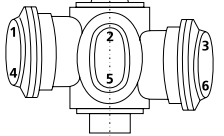
VALVE NO. →	① ② ③ ④	① ② ③ ④	① ② ③ ④	① ② ③ ④	
○ non-energized ● energized					
APPLICATION →	starting	minimum capacity	control up to maximum capacity		
COMPRESSOR TYPE ↓	OPERATING CYLINDERS				Each figure between brackets refers to the swept volume expressed as a percentage of the full load swept volume
RC219 Cylinder no.1 omitted	● ● ③ ●	● 2 ③ 4 (100)			Typical numbering of cylinders 
RC429	① ● ● ● ● ●	① ● ● ● 5 6	① 2 ● ● 5 6	① 2 3 ④ 5 6	

TABLE 5.3 STANDARD STEPS OF THE ELECTRICALLY OPERATED CAPACITY CONTROL OF TWO-STAGE COMPRESSORS

the cylinder or the cylinder group to become operative.

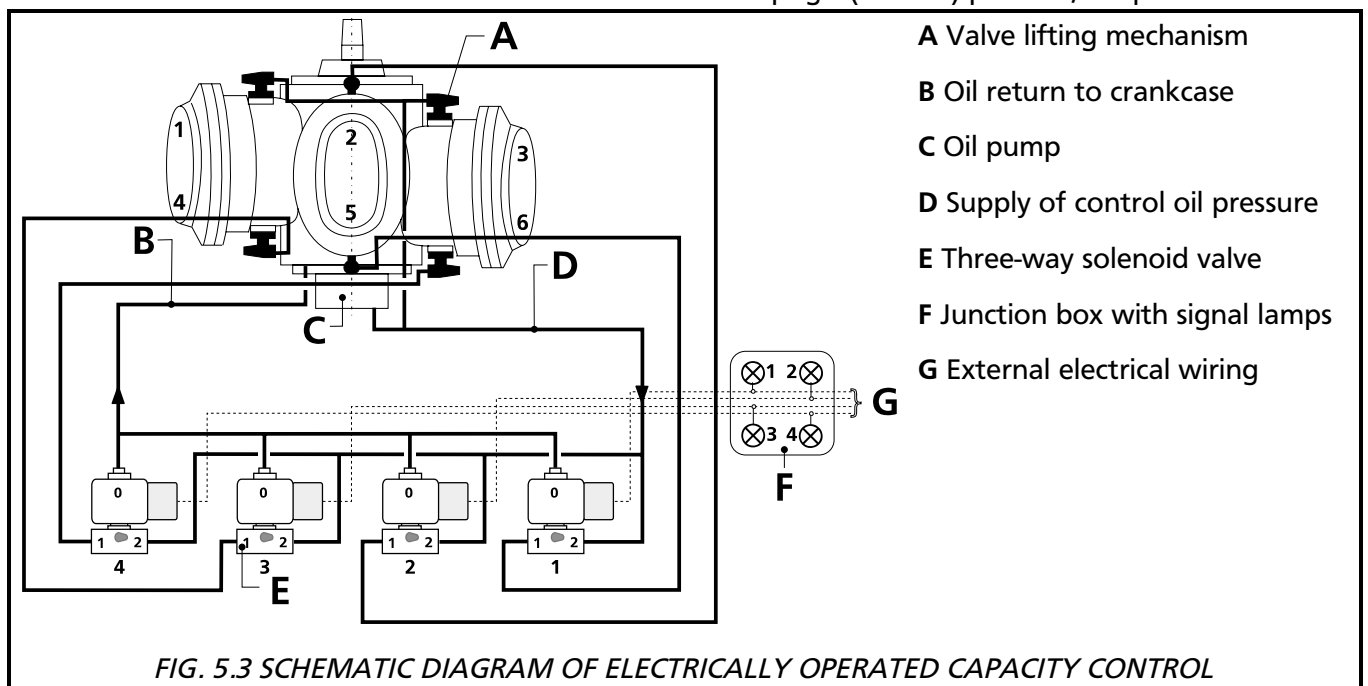
The valves can be energized automatically by e.g. thermostats in the cold stores, a pressure controller on the suction line, etc. (see plant manual).

To each solenoid valve a lamp is connected which lights up as long as the valve is energized. These lamps are all mounted on the front panel of a junction box, in which also the terminals of the

various solenoid valves are located.

As shown in tables 5.2 and 5.3, the combination of burning lamps indicates which valves are energized and consequently which cylinders are in operation. For this purpose, valves and lamps bear equal numbers.

In the event of an electric failure, each valve can be operated individually by hand. For this purpose, a small lever is provided on one side of the valve housing, which, after being pressed and turned in the upright(vertical) position, keeps the valve



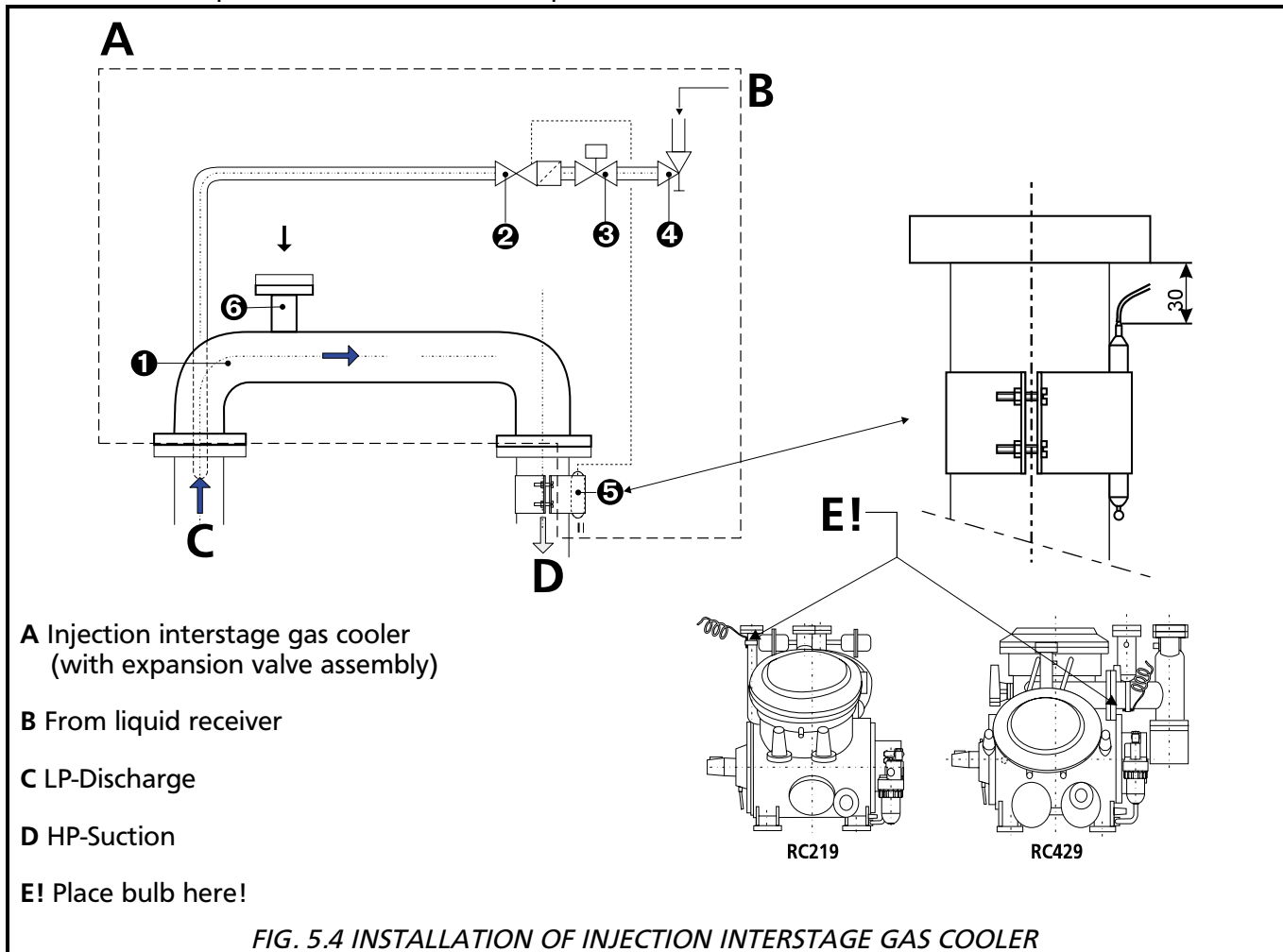
“energized”. However, in this case, the valve can no more be operated electrically in the usual way.

5.6 INJECTION INTERSTAGE GAS COOLER (only in two-stage compressors)

In two-stage compressors, an injection interstage gas cooler may have been provided between the LP-discharge connection and the HP-suction connection. This cooler cools the gas compressed by the LP-cylinders down to 5 to 6 K above the saturation temperature corresponding to the intermediate pressure.

The interstage cooler consists of an amply dimensioned connecting tube, into which, on the LP-discharge side, liquid refrigerant is injected. This injection takes place either direct on the interstage gas cooler or via a separate injection liquid cooler. Due to the evaporation of this liquids, the temperature of the gas to be sucked by the HP-cylinders is reduced. The amount of liquid is controlled by a thermostatic expansion valve, whose temperature bulb must be clamped

externally against the HP-suction line of the compressor (see fig. 5.4, overleaf). At compressor standstill the supply of liquid is cut off by a solenoid valve located upstream the expansion valve. This solenoid valve should be connected electrically so that it opens only when the compressor has come up to speed and LP- as well as HP-cylinders are in operation (see the chapter “Capacity control”).



6.1 UNLOADED STARTING

When the compressor is at standstill, the suction valve rings in all cylinders have been lifted mechanically by the valve lifting mechanism.

As soon as the compressor is started, the oil pump starts to build up pressure in the lubricating oil system. However, the control oil pressure required for controlling the valve lifting mechanisms, remains locked for about one minute due to the action of the time delay valve, incorporated in the oil pump. During the period the compressor attains its operating speed under no-load conditions, whereby the gas drawn into the cylinders is returned again to the suction chambers and the suction manifold via the lifted suction valves. The energy consumption is thus limited to overcoming the starting torque which consists of the pull-out torque, the frictional losses and the flow losses in the suction valves. This prevents a peak load of the electric power system and overloading of motor, drive and equipment.

6.2 LOADED OPERATION OF COMPRESSOR

After the delay time has elapsed, the control oil system is pressurized. For compressors without capacity control this means that all cylinders are operated simultaneously, as their valve lifting mechanism becomes operative and the suction valves come into action. For compressors provided with capacity control, a limited, minimum allowable number of cylinders is operated directly by the control pressure; the other cylinders can, if required, be cut in or out manually via the oil distributor or electrically via the three-way solenoid valves (refer also to Chapter 8, Supervision during compressor operation).

6.3 LIQUID HAMMER

Liquid hammer occurs when, together with the refrigerant vapour, liquid is drawn in and forced away. As liquid is not compressible, liquid hammer may cause a sudden impact load on valves and moving parts, which may result in more or less serious damage to the compressor.

The relevant liquid may be either oil or liquid refrigerant. Liquid hammer is reflected in a distinctly audible, sometimes jerking stroke at each revolution. When the phenomenon is symptomatic, the installation engineer should be consulted.

It is sometimes difficult to find out the sort of liquid hammer. Frosting of the cylinder jacket as well as an abnormally low discharge gas temperature may point to the fact that liquid refrigerant is being sucked. Even when no audible liquid hammer occurs (the liquid then retains its misty form), the valves may be damaged due to excessive thermal load. Damage due to an incidental, slight liquid hammer is prevented by means of a buffer spring on the valve assembly (see Chapter 4 fig 4.3).

This chapter deals with the starting and stopping of the compressor in a plant which, after the test run, has been delivered completely ready for operation by the installation engineer. If further contains instructions for resetting the lubricating oil pressure regulator and pressure safety switches, if this should be necessary.

It is recommended to start and stop the compressor according to a fixed procedure in order to prevent errors and possible damage. Especially in the case of plants with manual control, the sequence of the necessary operations has to come up to certain requirements. Therefore, in the instructions given below, reference is made, wherever necessary, to the plant manual. If at some point the plant manual differs from this instruction manual, the installation engineer should be consulted.

7.1 STARTING THE COMPRESSOR

When starting the compressor, distinction should be made between:

- 1) **Starting the compressor for the first time after the plant has been out of operation for a long period of time** (for example, on account of seasonal standstill or maintenance operations). for manually controlled plants as well as for those operating automatically the starting procedure given below should be followed exactly.
- 2) **Restarting the compressor in an already operational plant.**
In the case of manually operated plants only the instructions mentioned under b, e, f, h and j need to be followed, as well as those included in the plant manual. In the case of automatically operating plants, this starting procedure is incorporated in the control system and therefore does not generally require any special care.

The starting procedure is as follows:

- a) Consult the plant manual.
- b) Make sure that the oil level in the crankcase is correct (see Chapter 8) and check whether the shaft seal housing and both oil filter housings are filled with oil (especially after maintenance work).
- c) Check whether the suction stop valve and the stop valve in the return line of the oil separator are closed.

- d) Check whether the discharge stop valve, the pressure gauge valves and (in the case of two-stage compressors) the stop valves in the intermediate pressure line are open.
 - e) **In the case of a compressor provided with a manually operated capacity control:** set the oil distributor to position 1:
In the case of a compressor provided with an electrically operated capacity control: Check whether the manual control lever of all solenoid valves is in its lowest horizontal position.
 - f) (not within 3 minutes after the compressor was stopped) Start the compressor and check whether the oil pressure increases.
 - g) Slowly open the suction stop valve, thereby watching the suction pressure which may not exceed 6 bar (on gauge). Also be careful that no liquid hammer occurs, especially in plants with lower suction lines.
 - h) **In the case of single-stage compressors with capacity control:** After the compressor has started up and one or more cylinders have automatically become operative, cut in the other cylinders as and when required, thereby watching the maximum allowable amperage (it must not be higher than the amperage stated on the motor).
In the case of two-stage compressors with capacity control: 3-4 minutes after the compressor has started and one HP-cylinder becomes operative automatically, cut in the other cylinders stepwise, thereby watching the discharge temperature on both the HP- and LP-side (max. 140 °C), the intermediate pressure (max. saturation intermediate temp. +10 °C) and the max. allowable amperage (not to be higher than the amperage stated on the motor nameplate).
 - j) (if cylinder jacket cooling is applied). Check the cooling water flow.
 - k) Adjust the opening of the pressure gauge stop valves so that the gauge pointers do not vibrate any longer.
 - l) (not during the running-in period of the plant). Open the stop valve in the return line of the oil separator.
- CAUTION! In case of reduced cooling load it is not allowed to cut out so many cylinders of a compressor already operating in two stages that only the HP-cylinder is still operating. At least two LP-cylinders should remain operative.**

7.2 STOPPING THE COMPRESSOR

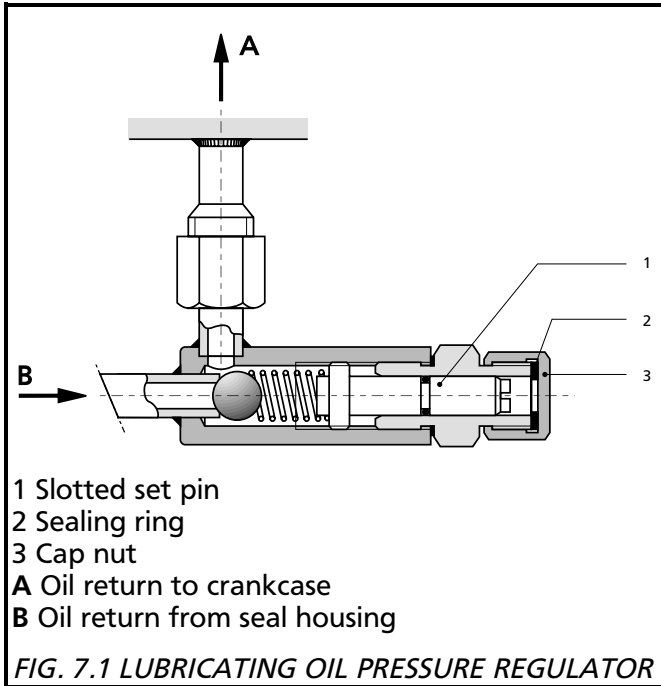
The compressor can be stopped at any moment by switching off the drive motor. However, consult the plant manual for further action required, especially in the case of plants with a

7.3 SETTING OF THE OIL PRESSURE REGULATOR

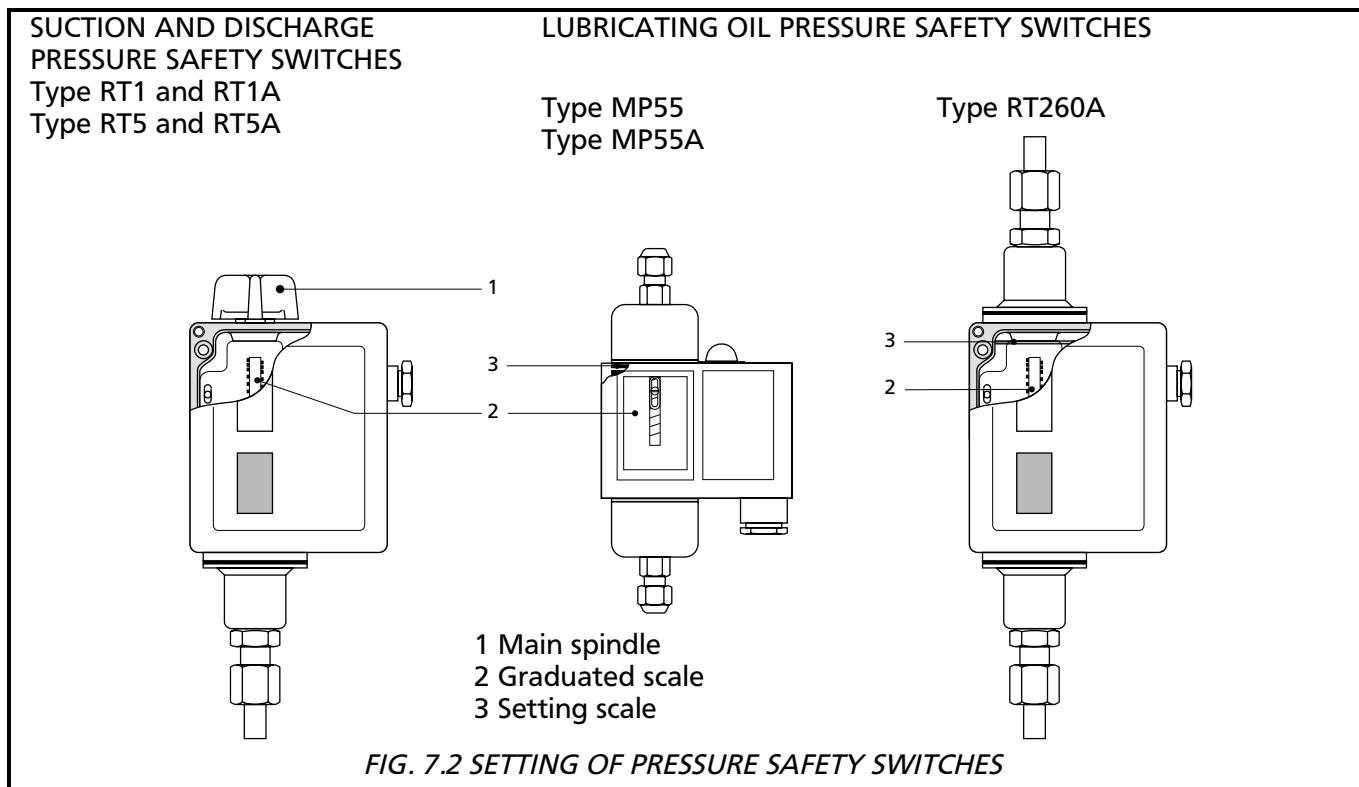
The lubricating oil pressure regulator has been set during the testing of the compressor in the works.

The lubricating oil pressure (i.e. the difference between the oil pressure measured at the end of the lubricating circuit, and the crankcase pressure (suction pressure also depends on the type of oil chosen, the refrigerant used and the operating temperature of the compressor. Therefore it is possible that, after the compressor has been installed in the plant, the lubricating oil pressure regulator needs to be reset. Re-setting takes place as follows:

- a) Start compressor and wait until it has achieved a constant operating temperature.
- b) Determine the difference between the indication of the oil pressure gauge and the suction pressure gauge. This difference should be approx. 1.5 bar.
- c) If the pressure difference is not correct, remove the cap nut with sealing ring from the lubrication oil pressure regulator (see fig. 7.1). Turn the slotted set pin with a screw driver clockwise or counter-clockwise for obtaining a higher or a lower oil



manual control.



pressure respectively, until the required pressure difference has been achieved. After resetting, replace the cap nut with sealing ring on the pressure regulator.

7.4 SETTING OF PRESSURE SAFETY SWITCHES (see fig. 7.2)

The discharge pressure and suction pressure safety switches must be set at the values indicated in the plant manual. The discharge pressure safety switch must be set at a value which is lower than the maximum discharge pressure of the compressor (see chapter 3, Technical data of compressor).

Setting is effected by turning the main spindle with a spanner, after the cap on top of the housing has been removed. The set value can be read from a graduated scale in the front cover.

The lubricating oil pressure safety switch must be set at 1 bar, which is the minimum allowable difference between oil pressure and crankcase pressure (= suction pressure). Setting takes place by turning the setting disc with a screw driver; this setting disc is accessible after the front cover has been removed. The set value can be read from a graduated scale.

8.1 SURVEY OF PERIODICAL INSPECTIONS ("CHECK LIST")
 (Also refer to the explanation overleaf)

CHECK POINTS	FREQUENCY			REMARKS
	daily	weekly	monthly	
Oil level in crankcase	•			The oil level must be between 1 and 3 quarters height of the sight glass. For topping up oil, refer to Chapter 9, Compressor Maintenance.
Colour of the oil			•	The oil should be transparently clear. A disappearing white colour points to dissolved refrigerant.
Lubricating oil pressure	•			The indication of the oil pressure gauge should be 1.5 bar higher than the value shown by the suction pressure gauge.
Oil temperature		•		The maximum allowable temperature is 70 °C, measured on the suction line to the oil suction filter.
Return from oil separator		•		To be checked only when a sight glass is provided in the oil return line.
Oil leakage			•	Remedy visible oil leakage.
Suction pressure		•		Refer to plant manual.
Discharge pressure		•		Refer to plant manual. For the max. allowable discharge pressure refer to Chapter 3, Technical data of compressor.
Suction temperature		•		The suction temperature should indicate at least 5 K superheat.
Discharge temperature		•		The maximum allowable discharge temperature is 170 °C.
Cooling water temperature (if water cooling is applied)		•		Water temperature must be higher than condensing temperature.
Crankcase heating (if provided)			•	During compressor standstill the crankcase bottom side must remain warmer than the surroundings.
Condition of V-belts			•	Check belts for: 1) wear (fraying, cuts etc.) and ensure that they do not touch the groove bottom; 2) Tension. Too low a tension gives rise to excessive flapping or oscillation in operation. For correct tension consult the instructions given by the V-belt supplier.
Adjustment and operation of pressure safety switches			•	Refer to Chapter 7 and to the plant manual.
Switching frequency of the compressor		•		The time interval between stopping and starting should be at least 10 minutes.
Capacity control (if provided)		•		The time lag between the unloading and loading of one cylinder or cylinder group should generally be at least 3 minutes.
Number of operating hours			•	Check the number of operating hours in view of any maintenance operations to be carried out.

Apart from the above check points, the sound produced by the compressor provides a proper standard for its mechanical condition. If abnormal sounds are audible, their cause should be traced and removed immediately in order to prevent serious breakdowns at inconvenient times.

8.2 EXPLANATION TO THE SURVEY OF PERIODICAL INSPECTIONS

In order to prevent sudden failures as much as possible, it is recommended to inspect the compressor periodically at a certain number of points. In many cases a slight deviation from the normal situation need in no way yet interfere with the proper functioning of the compressor, but it may be indicative of a wrong tendency that might in the end lead to a failure. Inspection then enables to take action in time. Thus, a slight but continuous increase of the discharge pressure may be indicative, for example, of a polluting condenser which, if this increase is being noticed, can be cleaned before the excessive discharge pressure causes more serious trouble.

The intensity of the required inspection is to be made dependent on the type of installation and on the risks involved in failures as far as the object to be cooled is concerned.

Particularly in case of fully automatically operating installations, for which little or no personnel is available, the periodical inspection must not be neglected.

The table on the back sums up all the points of the compressor that have to be inspected; it also contains instructions as to how frequently the various inspections have to be carried out.

During the first 50 operating hours the compressor should be checked regularly for all the points mentioned before, at least twice every 24 hours and more frequently in cases where irregularities are found.

However, the list should primarily be used to prevent certain points of inspection for being omitted whereby the frequency stated is to be taken as a standard, also dependent on the experience gained in practice. In the case of deviation the fault-finding table should, if necessary, be consulted (Chapter 10).

Besides the inspection during operation described in chapter 8, the compressor requires regular maintenance. This maintenance is limited to topping up or changing the lubricating oil, regular cleaning of oil filters and gas suction strainer and to the inspection of suction and discharge valves; these operations can be carried out by the operating personnel. Moreover, it is recommended to have the compressor inspected annually by the installation engineer, irrespective of the number of operating hours. A major inspection should at any rate be carried out after every 10,000 operating hours.

9.1 MAINTENANCE SCHEDULE

The maintenance schedule below indicates after how many operating hours maintenance operations have to be carried out. This schedule can be regarded as a directive, based on the experience gained with a large number of compressors.

For most of the maintenance operations the compressor must be put out of action. In order to avoid that this should take place at inconvenient times, the operations should as much as possible be affected during a stand-still period. The schedule has been drawn up in such a way that several operations can be carried out simultaneously, which results in reduced maintenance costs.

9.2 LUBRICATION DATA

The types of oil mentioned in table 3.1 on page 3.3 have the required properties and may therefore be used.

The choice of the type of oil depends on the operating conditions of the compressor and the refrigerant used; this choice should therefore be left up to the installation engineer's decision. It is emphatically pointed out that it is not permitted to mix different types of oil.

If another type of oil is used, first remove all stale oil, consequently also the oil in the filters, oil pump, crankcase, shaft seal, oil separator and oil drains of the installation. Oil change must take place as soon as the oil is dirty. Dirty oil is dark coloured and hardly transparent. In order to find out if it is necessary to change oil, a slight quantity of oil should be drained via the oil drain valve and compared with fresh oil.

9.3 TOPPING UP OIL WITH COMPRESSOR OPERATING

Topping up oil may be carried out with the compressor operating. Use the same oil as present in the compressor (refer to the listed oil on table 3.1). Without affecting the operation of the compressor, the oil may be topped up by means

MAINTENANCE SCHEDULE

Maintenance	Number of operating hours								etc.	
	100 ¹⁾	2500 ²⁾ 5000 7500 ²⁾		10,000	10,100		12,500 ²⁾ 15,000 17,500 ²⁾	20,000		
Cleaning of oil suction filter and renewal of oil discharge filter (ref. to par. 9.6).	×	×	Major inspection to be carried out by installation engineer	×	×	Major inspection to be carried out by installation engineer				
Cleaning of suction gas strainer (ref. to par. 9.7).	×	×			×					
Inspection of suction and discharge valves (ref. to par. 9.8)		×			×					
Draining and change of oil ³⁾ (ref. to par. 9.5).	×	×		×	×					

¹⁾ time dependent on pollution.

²⁾ Only for NH₃-compressors

³⁾ In the case of a possible rapid pollution of the oil, it should be drained and renewed sooner than at the times given above.

For most of the maintenance operations the compressor must be evacuated before in order to remove the refrigerant gas. After completion of the operations the compressor has to be purged. Both compressor evacuation and purging are dealt within this chapter.

of a separate oil pump. This pump enables the oil to be forced into the crankcase via the oil charging valve, against suction pressure. If this oil pump is not available, oil can be charged by reducing the crankcase pressure to below atmospheric pressure. the procedure is as follows:

- a) Connect a hose to the oil charging valve after removing the cap nut with gasket.
- b) Fill the hose with oil and emerge its loose end in a reservoir containing a sufficient amount of oil.
- c) Close the suction stop valve to such an extent that the suction pressure falls below the atmospheric pressure.
- d) Keep the oil charge valve open as long as the oil in the crankcase has attained the required level again. Take care that no air is being drawn into the crankcase.
- e) Slowly open the suction stop valve in order to prevent liquid hammer.
- f) Remove the hose and replace the cap nut with gasket onto the oil charging valve.

9.4 EVACUATION OF COMPRESSOR

- a) Close the suction stop valve and check whether the discharge stop valve is open.
- b) Close the stop valve in the oil return line of the oil separator.
- c) In the case of two-stage compressors with injection interstage gas cooler: shut off the liquid lines of the interstage cooler.
In the case of two-stage compressors with flash interstage cooler: refer to the plant manual.
- d) Shunt the electric contacts of the suction pressure safety switch.
- e) Start the compressor and wait until the suction pressure is below the atmospheric pressure.

MIND: Stop the compressor immediately as soon as the lubricating oil pressure (i.e. the difference between oil pressure and suction pressure) becomes lower than 1 bar.

- f) Stop the compressor and close the discharge stop valve.
- g) Close the stop valve of the discharge pressure gauge and disconnect the line at the lower side of the discharge pressure safety switch.

h) Fix a hose to this connection point and put its open end at some safe place in the free air.

j) Slowly open the pressure gauge stop valve so that the discharge gas still present in the compressor can escape via the hose.

k) Remove the hose.

NOTE:

Connecting the line to the lower side of the discharge pressure safety switch and removing the shunting of the contacts in the suction pressure safety switch should be effected only during compressor purging after the maintenance operations have been completed.

9.5 DRAINING AND CHANGE OF OIL

Small impurities in the refrigerant gas that are not retained by the suction strainer (for example, fly rust, especially in the case of NH₃ installations) eventually find their way in the lubricating oil which thus becomes dirty. Therefore, in the case of a new installation (or after extension or alteration of an existing installation) the oil should be renewed twice during the first 100 operating hours of the compressor (refer to the maintenance schedule on page 9.1).

Draining and change of oil must be carried out with the compressor being at operating temperature. Proceed as follows:

- a) Evacuate the compressor (refer to par. 9.4).
- b) Drain the oil via the oil charging valve. remove the cover and sealing ring of one or more service openings on the compressor side.
- c) Clean the inside of the crankcase with a non-fibrous cloth (don't use cotton waste!); also mind the sight glass. At the same time clean the oil filters (refer to par. 9.6, point b) up to and including g).
- d) Fill the crankcase with fresh oil as far as possible via the service opening(s).
- e) Close the service opening(s) again by placing the cover(s). Especially check the condition of the sealing rings so as to prevent leakage afterwards.
- f) Fill the crankcase further with oil by means of a separate oil pump via the oil charging valve until the oil has reached the required level. If no separate oil pump is available, proceed with point g).

- g) Proceed according to the points h, i and j of the instructions for cleaning oil filters (refer to par. 9.6).

9.6 CLEANING OF OIL FILTERS

In most cases the oil filters have to be cleaned for the first time after 50 operating hours. Besides thorough cleaning of the gauze filter element of the oil suction filter, the (red) paper filter element of the oil discharge filter must be exchanged with the blue marked element. Also after the installation has been extended or modified, the oil suction filter should be cleaned and the (red) oil discharge filter renewed as if the compressor had just been put into operation.

The time at which the next cleaning has to be carried out highly depends on the cleanliness of the installation.

Dirty oil (refer to par. 9.5) may cause clogging of the (grey marked) oil suction filter. A strong pollution of this filter is indicated by a falling oil pressure; in this case it is necessary to clean the filter (ultra-son cleaning system). It is recommended, therefore, regularly to check the oil pressure during the first 50 operating hours. When the filters remain practically clean, cleaning can take place simultaneously with the other maintenance operations.

To clean the (blue and grey marked) filters proceed as follows:

- a) Evacuate the compressor (refer to par. 9.4)
- b) Unscrew the lower filter cup of both filter housings in which event the filter elements are released. Catch the oil in a beaker.
- c) Clean the gauze filter element of the oil suction filter only using a high frequent liquid cleaning system (ultra soon device). After cleaning, thoroughly dry the element; if possible, blow through the filter element with compressed air against the normal oil flow direction. Dip the element into compressor oil and put aside.
- d) Clean both filter cups and dry them with a non-fibrous cloth.
- e) Use the new set of seals! Remove and renew all o-rings including the centre seal of both upper filter housing.
- f) Place the gauze filter element and a new (grey marked) paper filter element in their corresponding filter cups.

MIND! The paper filter element (oil discharge filter) should be placed on the right-hand side of the pump.

- g) Screw the filter cups (do not forget the o-ring around the filter cup) into their corresponding filter upper housings.
- h) Remove the plug on top of the suction filter housing; fill this housing with fresh oil and replace the plug with a new alu ring.
- i) Purge the compressor (refer to par. 9.9).
- j) Check the oil level and top up oil as described in par. 9.3, topping up oil with compressor operating.

9.7 CLEANING OF THE SUCTION GAS STRAINER

- a) Evacuate the compressor (refer to par. 9.4)
- b) Remove the bolts from the suction strainer cover that is most far away from the suction line and remove the cover (if necessary, loosen cover with a rubber or plastic hammer).
- c) Pull the strainer element out of the suction strainer housing without damaging the gauze.
- d) Clean the element by rinsing it in a solvent. Then thoroughly dry the element preferably with compressed air.
- e) Check the gauze for damage.
- f) Slide the strainer element again into the housing and fit the suction strainer cover. Check the sealing ring for proper condition.
- g) Purge the compressor (refer to par. 9.9).

9.8 DISMOUNTING, INSPECTION AND RE-ASSEMBLY OF SUCTION AND DISCHARGE VALVES

The suction and discharge valves of a refrigeration compressor are parts that are heavily loaded both mechanically and thermally. Wear and life time of the valves strongly depend on the working conditions of the compressor.

A high working temperature and rapid temperature variations shorten the life time of the valves, which, for this reason, require regular inspection.

For dismounting, inspection and re-assembly of the valves, proceed as follows (refer to fig. 9.1):

- a) Evacuate the compressor (refer to par. 9.4).

b) Remove the cylinder head cover.

CAUTION!

The nuts on the long studs must be unscrewed last, thus enabling the buffer spring fitted under the cover to extend before the cover is released entirely.

c) Remove buffer spring.

d) Lift the complete discharge valve out of the cylinder liner.

e) Remove the suction valve ring and sinusoidal spring, which are loose on the collar of the cylinder liner.

f) Unscrew and disassemble the discharge valve.

g) Clean all valve parts and check them for break or damage

MIND! If it appears that valve parts are broken, also the cylinder liner and piston of the relevant cylinder must be checked for damage.

The valve rings and valve seats must be undamaged; even the slightest damage may easily cause breakage. Slightly damaged seat edges may be trued up by grinding them on a smooth plate or glass using a fine honing paste. Heavily damaged or chipped-off seat edges can no more be repaired; in such a case a new valve must be fitted.

Valve ring and/or seat should be replaced also when, due to wear, the total score of valve ring and seat is over 0.2 mm.

The sinusoidal springs must also be undamaged and must have sufficient slack height (refer to the table in fig. 9.1).

REMARK!

All valve parts can be obtained separately.

h) Carefully clean all valve parts and slightly oil them with compressor oil; then reassemble the discharge valve.

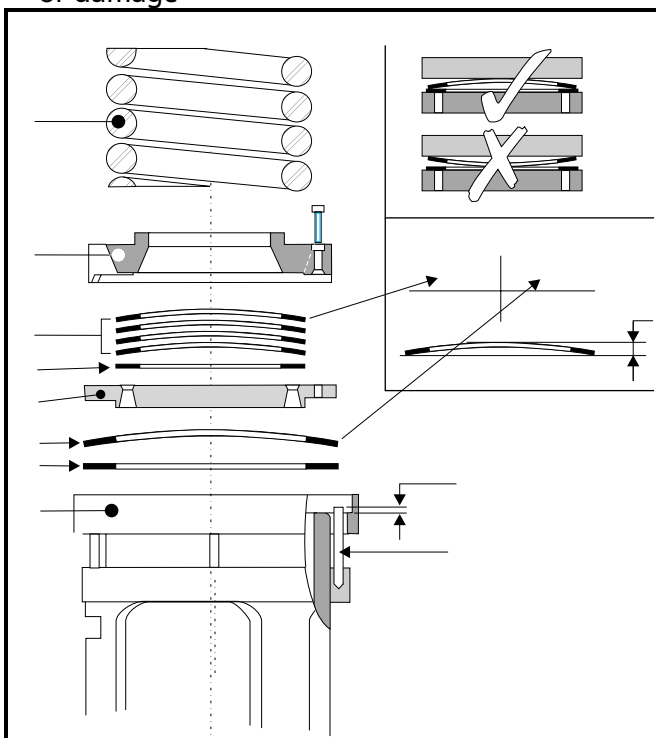
MIND! The sinusoidal springs should be fitted so that the convex side of the springs where the spring profile is flat, bears against the stroke limiter. The other side of which approx only the outer point of the spring profile bears, should therefore rest on the valve ring (see fig. 9.1).

j) After reassembling the discharge valve, check whether the valve ring and springs can be pressed against the stroke limiter, and when released, the valve ring is properly pressed back on to their seat.

k) Check whether the push pins of the valve lifting mechanism project 2.2 mm beyond the suction valve seat.

l) Place the suction valve ring, and the sinusoidal spring on the collar of the cylinder liner, and install the discharge valve and buffer spring into position.

m) Check the gasket of the cylinder head cover and slide the cover over the studs onto the cylinder



1. Buffer spring
2. Stroke limiter (discharge valve)
3. Sinusoidal springs
4. Discharge valve ring
5. Discharge valve seat
6. Sinusoidal springs
7. Suction valve ring
8. Collar of cylinder liner
9. Push pin of valve lifting mechanism

FIG.9.1 SUCTION AND DISCHARGE VALVE ASSEMBLY

head. Make sure that the buffer spring is centred by the cover. Pull the cover with the nuts on the long studs so far down that the other studs sufficiently project beyond the cover.

- n) Screw the nuts onto the other studs and firmly tighten them.
- p) Purge the compressor (refer to par. 9.9).

REMARK!

In order to reduce the downtime involved in this valve inspection, it is recommended to have as many complete valve assemblies in stock as there are cylinders on the compressor. The valves can then be exchanged with the valves to be checked; the original valves can then be inspected at leisure and, if necessary, repaired or replaced.

9.9 COMPRESSOR PURGING

When the compressor has been opened for carrying out maintenance operations, it must be purged before being put into operation again. Purging can be effected by means of the compressor itself, whereby the situation after compressor evacuation is taken as a starting point. The procedure is as follows :

- a) *For compressors equipped with capacity control:*
Cut out as many cylinders as possible.
- b) Start the compressor; the air in it is now blown off via the line disconnected during evacuation at the lower side of the discharge pressure safety switch.
- c) Cut in the other cylinders step-wise as soon as the suction pressure has dropped considerably, and wait until the suction pressure ceases to fall or the oil lubricating pressure safety switch becomes operative.

MIND! Immediately stop the compressor as soon as the oil lubricating pressure (i.e the difference between oil pressure and suction pressure) becomes lower than 1 bar.

- d) Reconnect the line to the discharge pressure safety switch. When the discharge pressure increases, the line must be disconnected again. As soon as the discharge pressure no longer increases, the line can be connected permanently.
- e) Stop the compressor and remove the shunting of the electric contacts of the suction pressure safety switch.

- f) Open the discharge valve and watch the discharge and suction pressure gauges, particularly if maintenance operations have been effected on the valves. Only the discharge pressure gauge may rise; if also the suction pressure gauge rises distinctly, this is indicative of leaking valves due, for instance, to their incorrect assembly. If necessary, remedy this defect.
- g) Start the compressor and slowly open the suction stop valve (mind liquid hammer!).
- h) Open the shut-off valve in the return line of the oil separator.
- j) *For two stage compressors:* open the shut-off valves in the liquid lines of the interstage cooler.
- k) Keep the compressor running for some minutes.
- l) Purge the refrigerating installation (refer to plant manual).

The fault-finding table below may be helpful to quickly trace and remedy failures that interfere with the proper operation of the compressor. It is emphatically pointed out that the cause of a

failure must often be sought in the refrigeration installation itself. Therefore, it is necessary, in addition to this fault-finding table, also to consult the plant manual.

FAULT	CAUSE	REMEDY
A Discharge pressure too high, according to plant manual (discharge pressure safety switch may possibly become operative)	<ol style="list-style-type: none"> 1. Discharge stop valve not wide open enough 2. Discharge pressure gauge defective 3. Condenser capacity too small due to: <ol style="list-style-type: none"> 3a. Pollution 3b. Hardly or no supply of water 3c. Fans do not operate 4. Air in the system 	<ol style="list-style-type: none"> 1. Open fully 2. Repair or replace <ol style="list-style-type: none"> 3a. Clean 3b. Increase water supply 3c. Switch on fans 4. Purge system
B Cylinder temperature too high	<ol style="list-style-type: none"> 1. Discharge pressure too high 2. Too many cylinders cut out 3. Suction pressure too low 4. Excessive superheat of suction gas 5. For two-stage compressors: interstage cooling does not operate properly 6. Room temperature too high 7. Discharge valve defective 8. By-pass safety valve is leaking 	<ol style="list-style-type: none"> 1. See A 2. Cut in more cylinders 3. See D 4. Eliminate cause of excessive superheat 5. Repair* 6. Ventilate engine room better 7. Repair or renew 8. Repair or renew*
C Suction pressure too high	<ol style="list-style-type: none"> 1. Capacity control does not operate 2. Compressor capacity too small 3. Suction pressure gauge defective 4. One or more suction valves defective 5. One or more discharge valves defective 6. By-pass safety valve is leaking 	<ol style="list-style-type: none"> 1. Repair* 2. Consult installation engineer 3. Repair or renew 4. Repair or renew 5. Repair or renew 6. Repair or renew*
D Suction pressure too low (suction pressure safety switch may possibly become operative)	<ol style="list-style-type: none"> 1. Suction stop valve not wide open enough 2. Suction gas strainer polluted 3. Injection control not adjusted correctly 4. Too little refrigerant in installation 5. Suction pressure gauge defective 	<ol style="list-style-type: none"> 1. Open fully 2. Clean 3. Re-adjust control 4. Top-up with refrigerant 5. Repair or renew
E Crankcase frosted or wet just after starting, possibly also during operation	<ol style="list-style-type: none"> 1. Liquid refrigerant in crankcase due to: <ol style="list-style-type: none"> 1a. Room temperature too low 1b. Return from oil separator mainly consists of liquid refrigerant 1c. Installation operates too wet 1d. Liquid separator too small 	<p><i>In the case of big amount of refrigerant: stop compressor and contact installation engineer</i></p> <ol style="list-style-type: none"> 1a. Provide for crankcase heating or, if provided, check it for proper operation 1b. Contact installation engineer 1c. Re-adjust installation and provide for superheat 1d. Contact installation engineer

FAULT	CAUSE	REMEDY
F All cylinders out of action while compressor is operating	1. Control pressure for valve lifting mechanism too low	1. See K
G Too high oil consumption	1. Type of oil not according to lubrication oil table 3.1 (too thin oil) 2. Compressor operates unloaded too frequently 3. No return from oil separator 4. O-rings around control piston of valve lifting mechanism worn or defective 5. Non-return valve at the bottom of suction chamber in cylinder defective 6. Worn out oil scraper rings 7. Loss of oil due to leakage	1. Consult installation engineer 2. Consult installation engineer 3. Check the operation of float valve in oil separator 4. Replace O-rings 5. Replace valve* 6. Replace rings* 7. Repair
H Too high oil pressure during normal operation at working temperature	1. Lubricating oil pressure regulator not adjusted properly or defective 2. Defective oil pressure and/or suction pressure gauge	1. Re-adjust or repair 2. Repair or replace
J Too low oil pressure	1. Too little amount of oil in crankcase 2. Oil suction and/or discharge filter is dirty 3. Lubricating oil pressure regulator not adjusted properly or defective 4. Liquid refrigerant in crankcase 5. Defective oil pressure and/or suction pressure gauge 6. Too large bearing clearance	1. Top up oil 2. Clean or renew 3. Re-adjust or repair 4. See E 5. Repair or replace 6. Renew bearings*
K Too low or no control pressure	1. Hydraulic time delay valve in oil pump is jammed 2. Relief valve in oil pump leaks	1. Dismantle and repair oil pump* 2. Disassemble and repair valve

The operation marked with an * in the column "Remedy" should be carried out by the installation engineer

The standard illustrated parts list on the following pages is meant for identification and accurate specification of current spare parts. Refer to the Monitron CR instruction manual, Chapter 8, Par. 8.7, if equipped with a Monitron CR-Control. In order to facilitate quick retrieval of the required parts, the list and corresponding figures is divided into the following groups of parts:

GROUP OF PARTS	PARTS LIST Page:	CORRESPONDING FIGURE No.:
o Compressor housing with connections and overflow safety valves	2	RC9-1
o Bearing covers	5	RC9-2
o Crankshaft	5	RC9-3
o Piston and connecting rod	6	RC9-4
o Cylinder and valve-lifting mechanism	6	RC9-5
o Suction and discharge valve	9	RC9-6
o Rotary shaft seal	9	RC9-7
o Oil pump	10	RC9-8
o Oil filters	13	RC9-9
o Oil return line	14	RC9-10
o Suction gas strainer	14	RC9-11
o Manual operated capacity control	17	RC9-12
o Electrically operated capacity control	17	RC9-13
o Pressure gauge panel	18	RC9-14
o Safety switch panel	18	RC9-15
o Wall mounting for combi - panel	18	RC9-14/15
o Elastic coupling	21	RC9-16
o Spare parts for clamp couplings	21	RC9-17
o Standard sets of parts, seals and tools	22	————
o Table of oilit sealings for main connections	22	RC9-18

Figures

All parts shown in the figures bear an item number. Assemblies are indicated by a dotted frame with separate item number around the parts included in that particular assembly; the parts themselves bear the same item number, followed by a sequence number (e.g. 2.1, 2.3, 2.3, etc.).

Parts lists

The parts are specified by the headings "Item", "Description" "Ref. no." and "Qty" (= Quantity). If an

asterisk is used instead of the Ref. no., this means that the relevant part cannot be obtained separately.

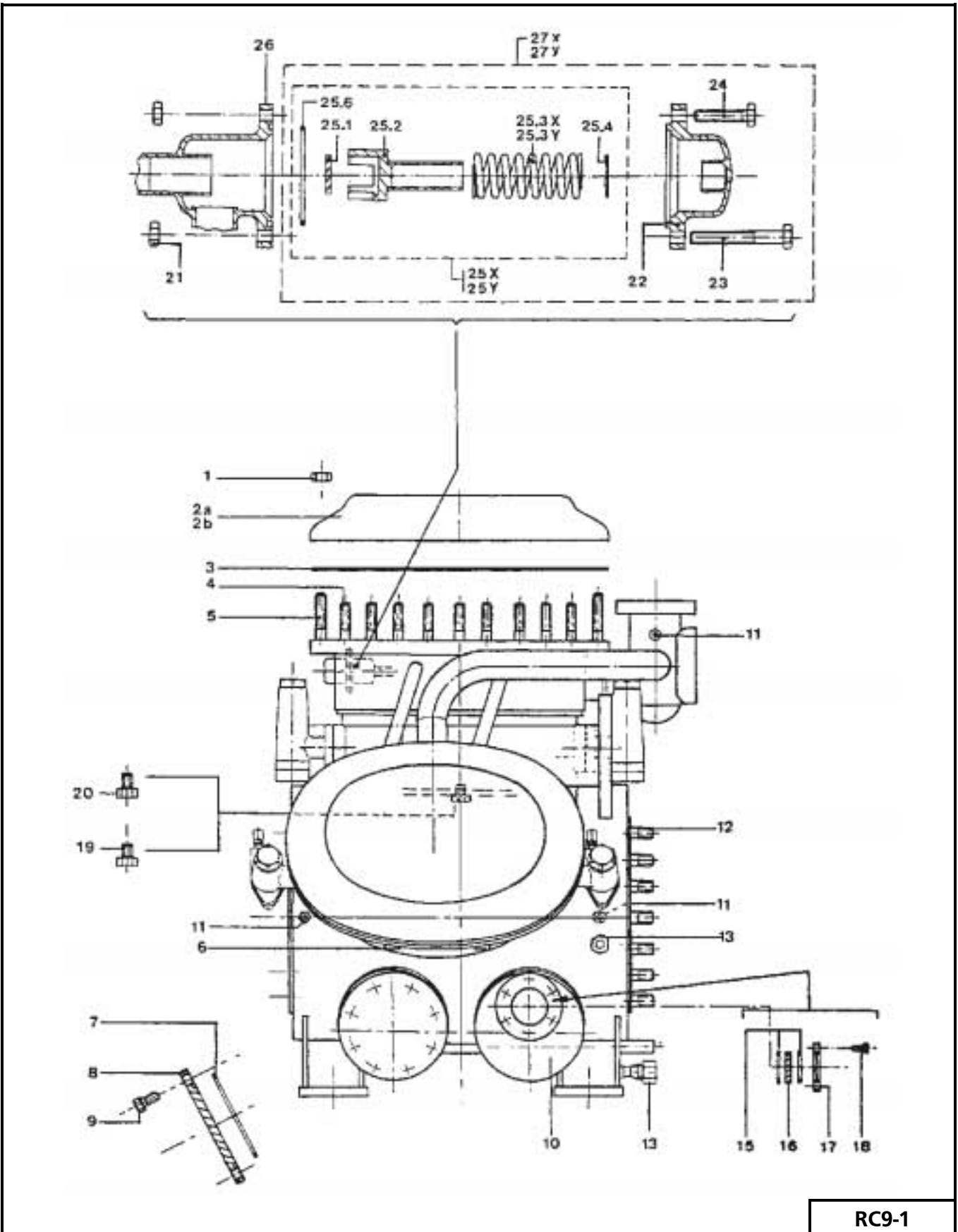
When for some part no quantity has been given, the quantity required depends on the compressor size. When determining the required quantity of parts, it should be considered that the listed quantities relate to the corresponding figure and not to the compressor as a whole. When ordering, for example, bearings for two connecting rods, the quantities stated in the relevant list must be doubled, because these apply to one connecting rod only.

IMPORTANT! How to order!

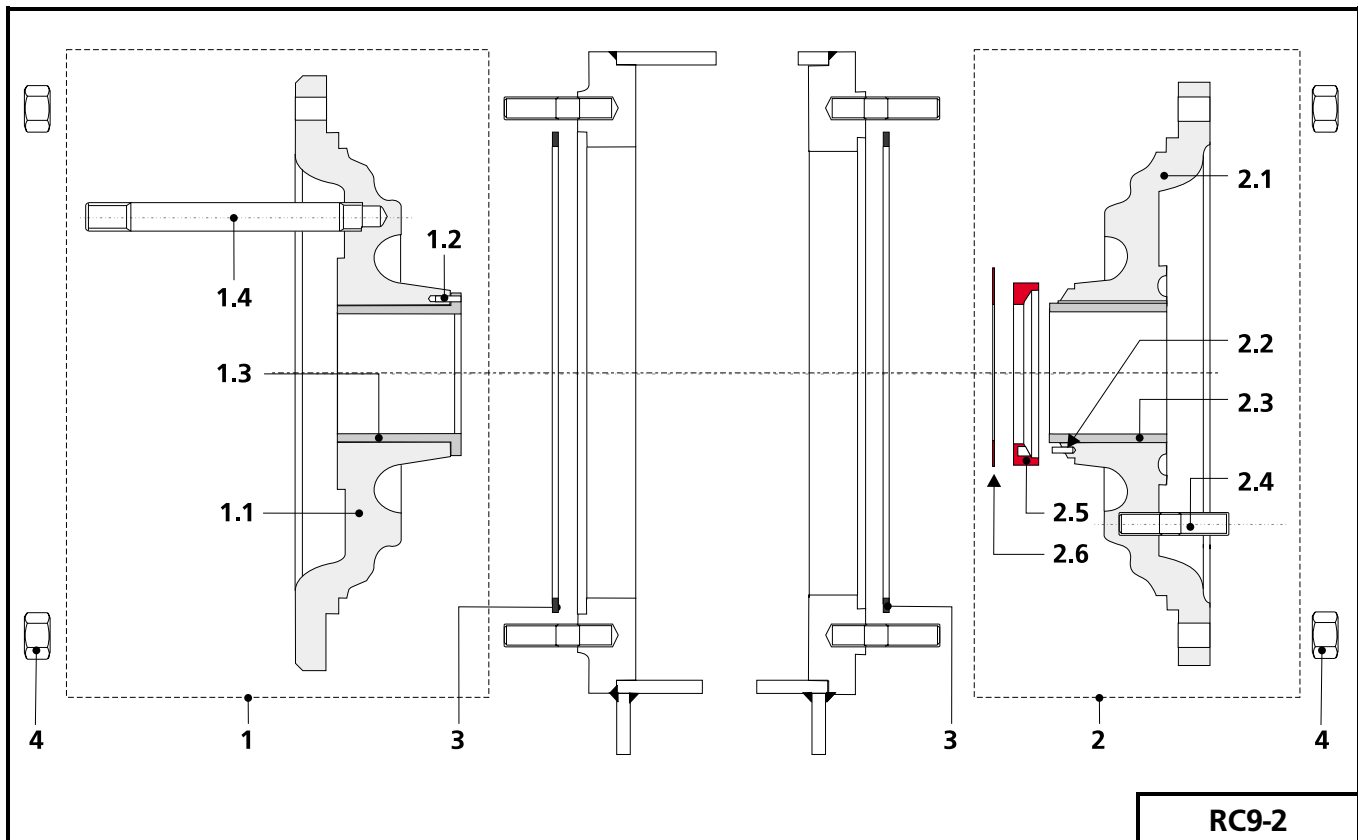
It is emphatically pointed out that a prompt despatch of the correct spare parts can be guaranteed only if the following information is given:

1. Type designation of the compressor
 2. Serial number of the compressor
 3. Quantity, Description and Ref. No. of the required parts.
- |————— shown on the compressor name plate

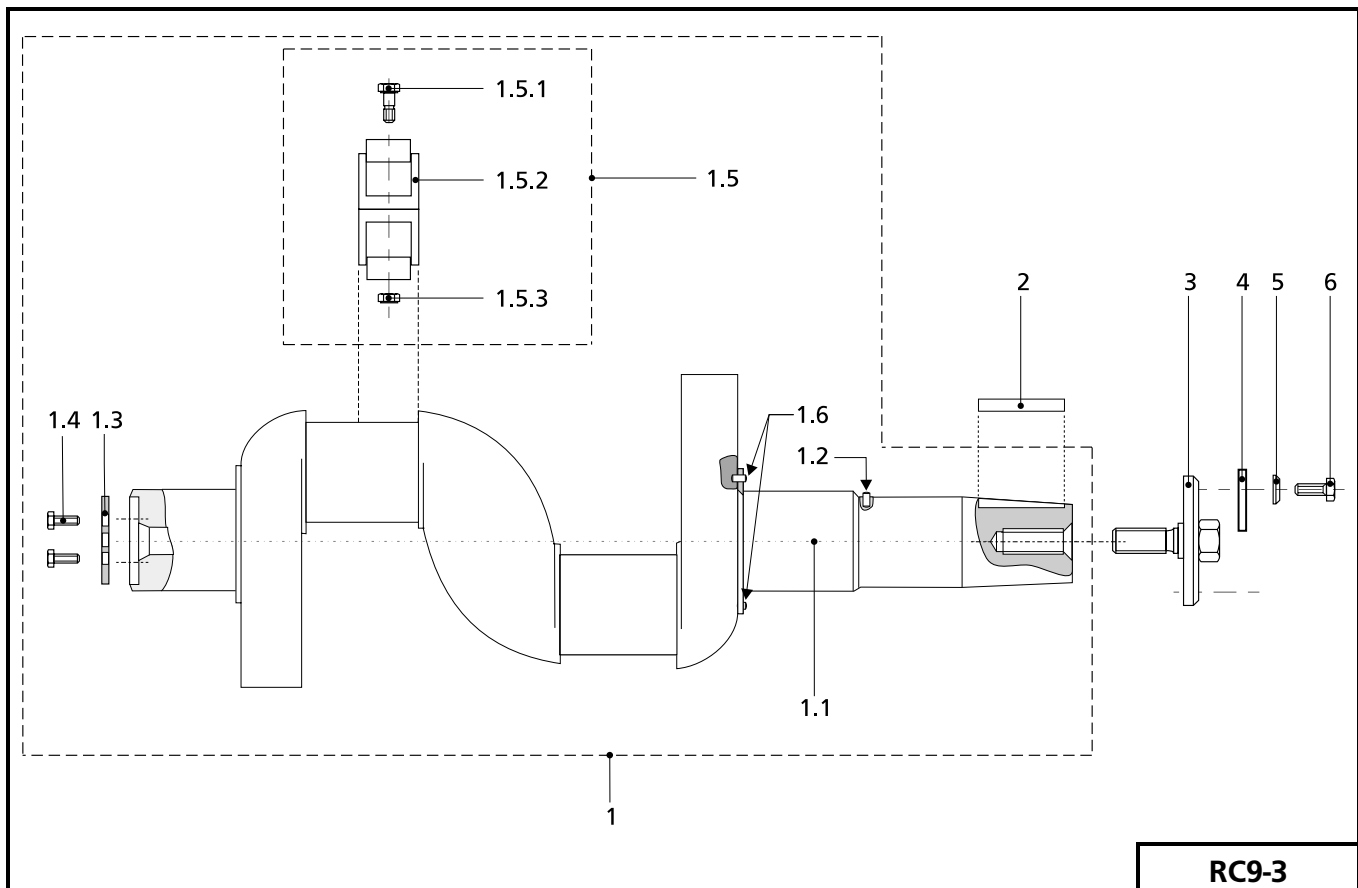
Item	Description	Ref. No.	Qty	Remarks
COMPRESSOR HOUSING WITH CONNECTIONS & OVERFLOW SAFETY VALVES				FIG. RC9-1
1	Hex. nut M20	01.15.110	20	Qty per cylinder cover
2A	Cylinder cover 441x298KA85M	23.15.502	-	without temp. sensor plug holes
2B	Cylinder cover 441x298KA85G13	23.15.510	-	without temp. sensor plug holes
3	Oilit gasket 206x441x1.5	09.07.206	1	
4	Stud M20x55	01.51.155	18	Qty per cylinder head
5	Stud M20x80	01.51.180	2	
6	Cap nut G21	03.31.021	-	
7	Oilit sealing ring 124x136x1.5	09.03.124	-	
8	Service cover 184	05.30.184	2	
9	Hex. head bolt M12x40	01.10.640	8	
10	Service cover 185V65M8	05.16.666	2	Qty per cover
11	Weldable coupling 6x11	03.35.006	-	on 6-cylinder compressors only
12	Stud M16x35	01.51.835	32	
13	Weldable coupling 6x11	03.35.012	1	
15	Oilit sealing ring 50x65x1.5	09.03.050	2	
16	Sight glass 65x15	12.26.065	1	for 6-cyl. compressors: Qty x2
17	Sight glass cover 65	05.16.065	1	
18	Hex. head bolt M8x30	01.10.430	6	
19	Non-return valve 5	06.27.505	-	1 per cyl. head in single stage compr. and on LP-side of two-stage compr.
20	Conical plug T13	03.65.013	-	1 per cyl. head on HP-side of two-stage compressors
21-24	Housing of safety valves 12/21 bar:			
21	Hex. head nut M10	01.15.510	6	
22	Housing top half 18x8	48.13.218	1	
23	Hex. head bolt M10x55	01.10.555	2	
24	Hex. head bolt M10x40	01.10.540	4	
25X	Set of valve parts R-NH3-12 RC9	48.27.512	1	for 12 bar-type valve
25Y	Set of valve parts R-NH3-21 RC9 consisting of:	48.27.522	1	for 21 bar-type valve
25.1	Valve disc 0x23x3	09.42.230	1	
25.2	Valve guide 22x75	48.40.322	1	
25.3X	Spring 4.5x25x9.5x83	11.31.452	1	in item 25X
25.3Y	Spring 5x25x9.5x87	11.31.502	1	in item 25Y
25.4	Adjusting washer M16x28	11.13.829	-	Qty depends on adjustment
25.6	Oilit sealing ring 61x71x1.5	09.03.063	1	
26	Housing top half	48.02.621	1	
27X	Set of valve parts 12 bar LP	48.27.524	1	
27Y	Set of valve parts 21 bar HP	48.27.525	1	



RC9-1



RC9-2



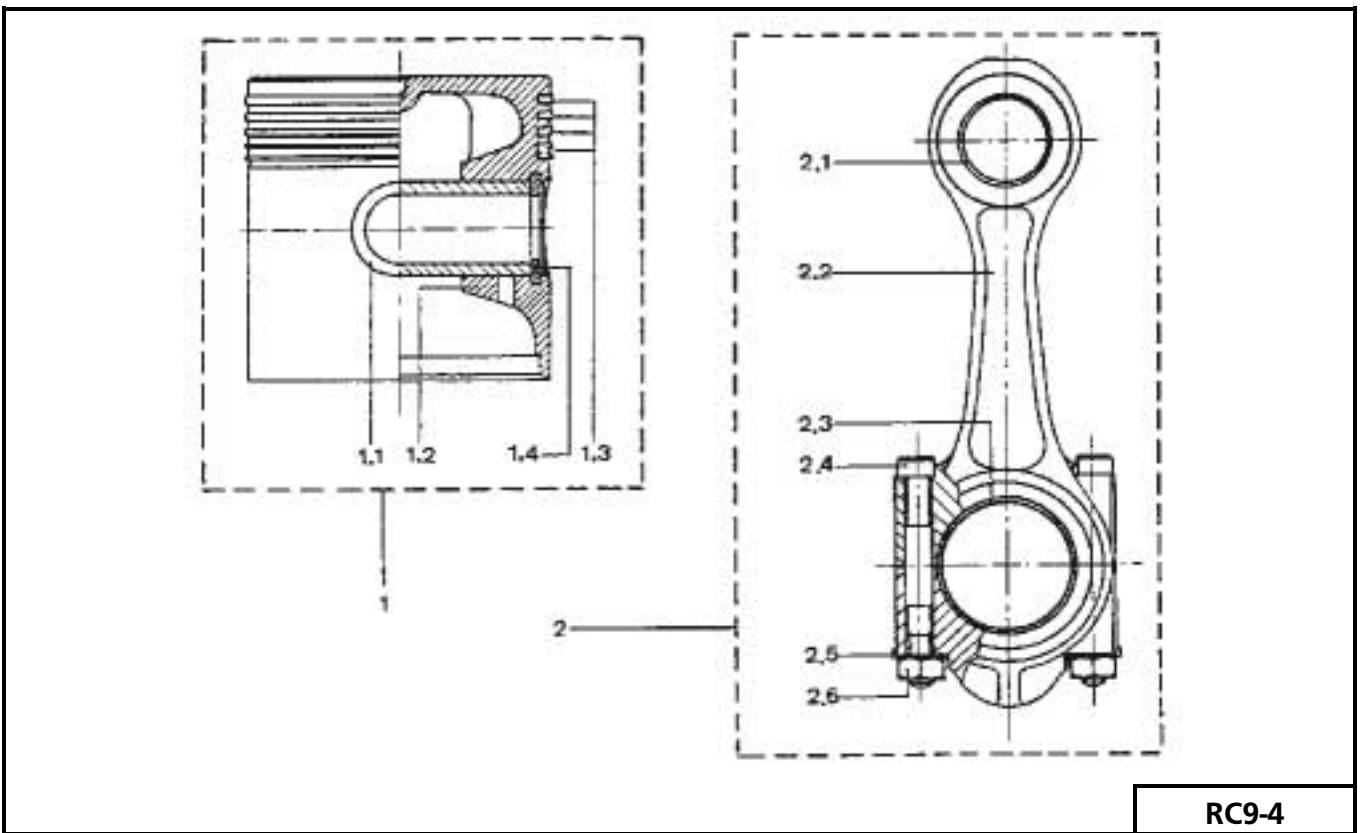
RC9-3

Item	Description	Ref. No.	Qty	Remarks
BEARING COVERS				FIG. RC9-2
1	Bearing cover assy KA85MSB	*	1	Oil pump side
1.1	Bearing cover KA85M	21.14.921	1	
1.2	Cylindrical pin 4x12	11.06.412	1	
1.3	Bearing sleeve 65x72x65	11.46.766	1	
1.4	Stud M12x138	01.51.617	6	
2	Bearing cover assy KA85M SUB A	*	1	Drive side
2.1	Bearing cover B KA85	21.14.931	1	
2.2	Cylindrical pin 4x8	11.06.408	1	
2.3	Bearing sleeve 65x72x62	11.46.767	1	
2.4	Stud M12x35	01.51.635	6	
2.5	Thrust ring 72x102x15	11.68.172	1	
2.6	Thrust disc 71x109x1	11.68.171	1	
3	Qilit sealing ring 242x258x1	09.02.242	2	1 mm thick
	Oilit sealing ring 242x258x1.5	09.03.242	2	1.5 mm thick
4	Hex. nut M16	01.15.810	32	

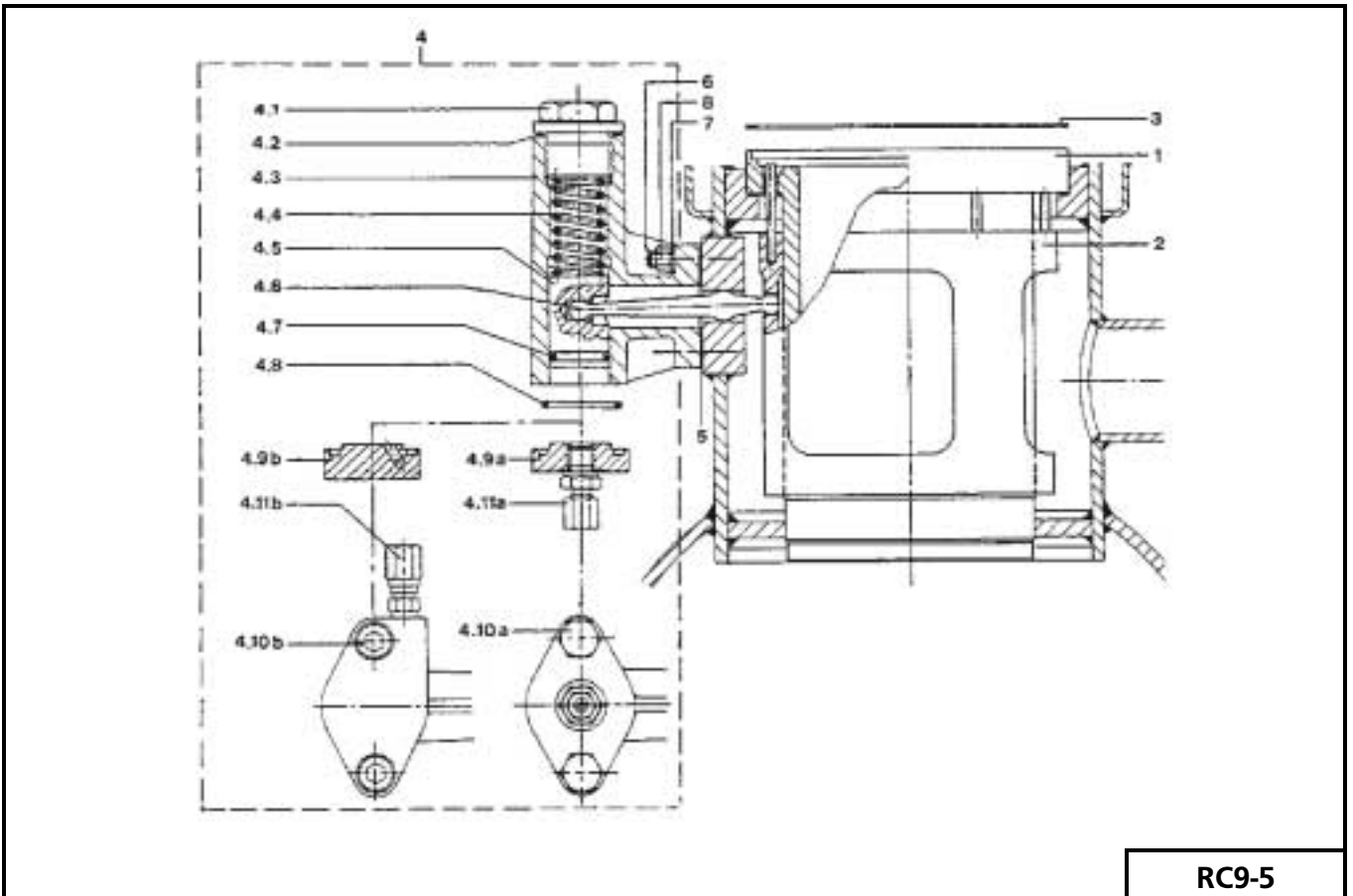
CRANKSHAFT				FIG. RC9-3
1A	Crankshaft E-KA20	22.15.202	1	2-cyl. compressor
	(with approval) K-KA20	22.15.212	1	
1B	Crankshaft E-KA40	22.15.402	1	3 and 4-cyl. compressor
	(with approval) K-KA40	22.15.412	1	
1C	Crankshaft E-KA60	22.15.602	1	6-cyl. compressor
	(with approval) K-KA60	22.15.612	1	
1.1	Crankshaft E/K-RC9	*	1	
1.2	Cylindrical pin 4x8	11.06.408	1	
1.3	Carrier disc 57x9	11.25.009	1	
1.4	Locking bolt M6x16	01.65.316	4	
1.5	Spacer assy 65x130x36A	11.12.966	1	
1.5.1	Fitted bolt M10	01.24.501	2	for 3-cyl. compressor only!
1.5.2	Spacer 65x130x36	*	1	
1.5.3	Lock nut M10	01.45.500	2	
1.6	Cylindrical pin 6x12	11.06.612	2	
2	Key 16x10x56	11.02.656	1	
3	Hub locking disc M16x82	19.15.882	1	
4	Locking plate M16xM8	11.14.848	1	to be supplied with flywheel or flexible coupling
5	Washer M8	11.13.401	4	
6	Hex. head bolt M8x30	01.10.430	4	

Item	Description	Ref. No.	Qty	Remarks
PISTON AND CONNECTING ROD				FIG. RC9-4
1	Piston assy S110x40x110FA85	24.06.000	1	
1.1	Gudgeon pin 28x40x90RC9	24.20.300	1	
1.2	Piston	*	1	
1.3	Set of piston rings 110KA85	09.74.114	1	
1.4	Snap ring 40	11.04.040	2	
2a	Con rod assy S65x210KA85	24.06.500	1	in single-stage compr. and in LP- cyl. of two-stage compressors
2.1a	Bearing bush 40x46x38	11.46.440	1	
2.2a	Connecting rod E70x210KA85	*	1	
2b	Con rod assy 65x210RC9 HD	24.21.550	1	in HP-cyl. of two-stage compr. only
2.1b	Needle bearing RNA 69/32	11.63.452	1	
2.2b	Connecting rod 70x210RC9 HD	*	1	
2.3	Bearing shell 65x30	11.44.365	1	
2.4	Con rod bolt MF12	01.11.601	2	
2.5	Locking plate M12	11.19.600	2	
2.6	Hex. nut MF12	01.47.605	2	
CYLINDER AND VALVE LIFTING MECHANISM				FIG. RC9-5
1	Cylinder liner 110FA85	23.06.000	1	
2	Lifting bush FA85	27.06.600	1	
3a	Oilit sealing ring 150x160x1	09.02.150	1	1 mm thick
3b	Oilit sealing ring 150x161.5x1.25	09.01.150	1	1.25 mm thick
3c	Oilit sealing ring 150x160x1.5	09.03.150	1	1.5 mm thick
4	Valve-lifting mechanism	*	1	
4.1	Plug G33	01.36.336	1	
4.2	O-ring 3x33	09.52.300	1	
4.3	Piston housing FA55M	27.10.501	1	with O-ring groove only ¹⁾
4.4	Spring 3.2x22x9x80	11.31.322	1	
4.5	Control piston	27.10.520	1	
4.6	Lever FA55	27.10.550	1	
4.7	O-ring 3.53x23.4	09.52.360	1	
4.8	O-ring 3.5x36	09.52.348	1	
4.9a	Cover 060G13	05.38.013	1	
4.10a	Hex. head bolt M10x25	01.10.525	2	for 2- and 4-cyl. compressors
4.11a	Nipple coupling 6G13	03.38.136	1	
4.9b	Cover KA60x85A	27.14.605	1	
4.10b	Socket head screw M10x20	01.04.520	2	for 6-cyl. compressors only
4.11b	Nipple coupling 6G10	03.38.106	1	
5	Oilit gasket 20x58x1.5	09.07.020	1	for housing (4.3) with gasket recess
	O-ring	09.52.367	1	for housing (4.3) with O-ring groove ¹⁾
6	Stud M8x22	01.51.422	4	
7	Washer M8	11.13.401	4	
8	Hex. nut M8	01.15.410	1	

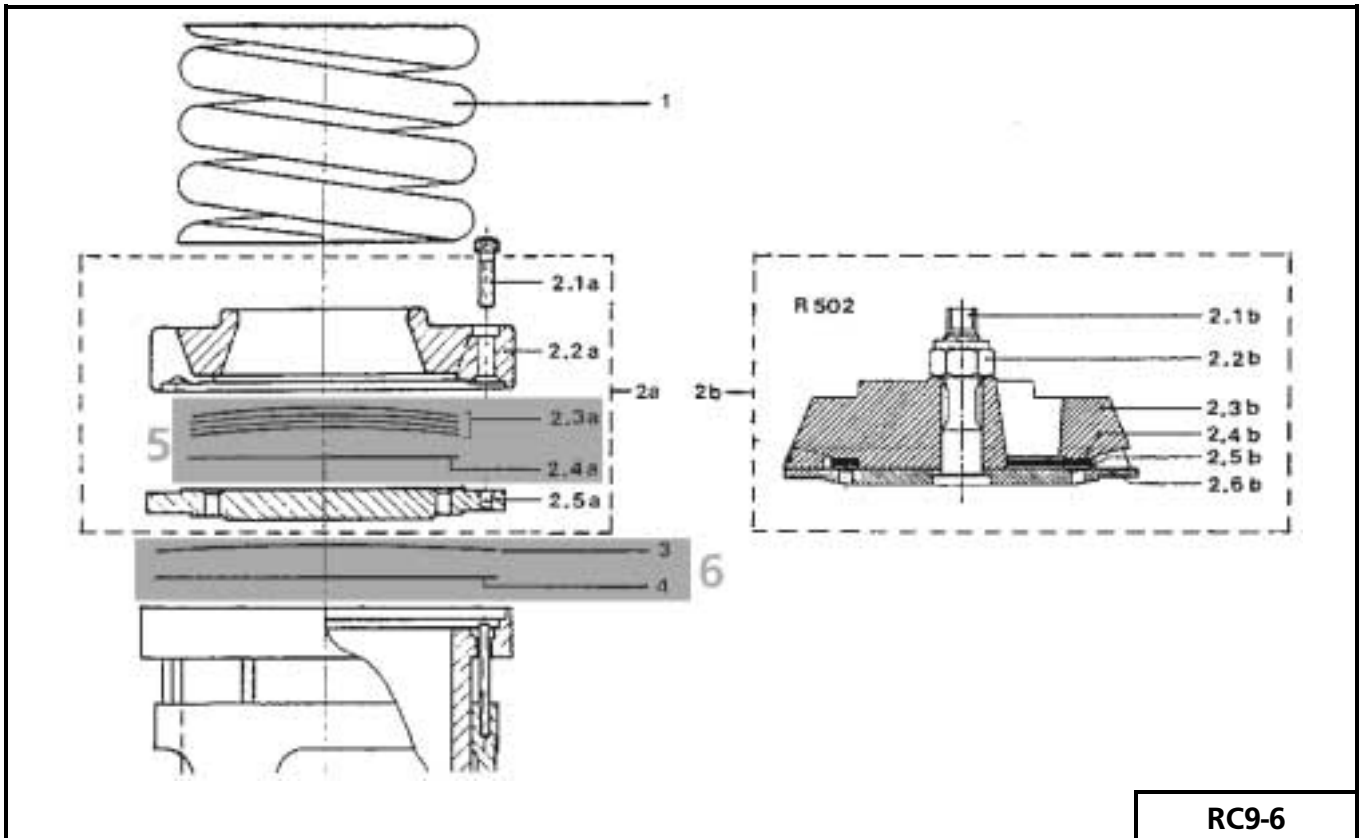
¹⁾ This piston housing (Ref. Nr. 27.10.501) always includes an O-ring with Ref. Nr. 09.52.367.



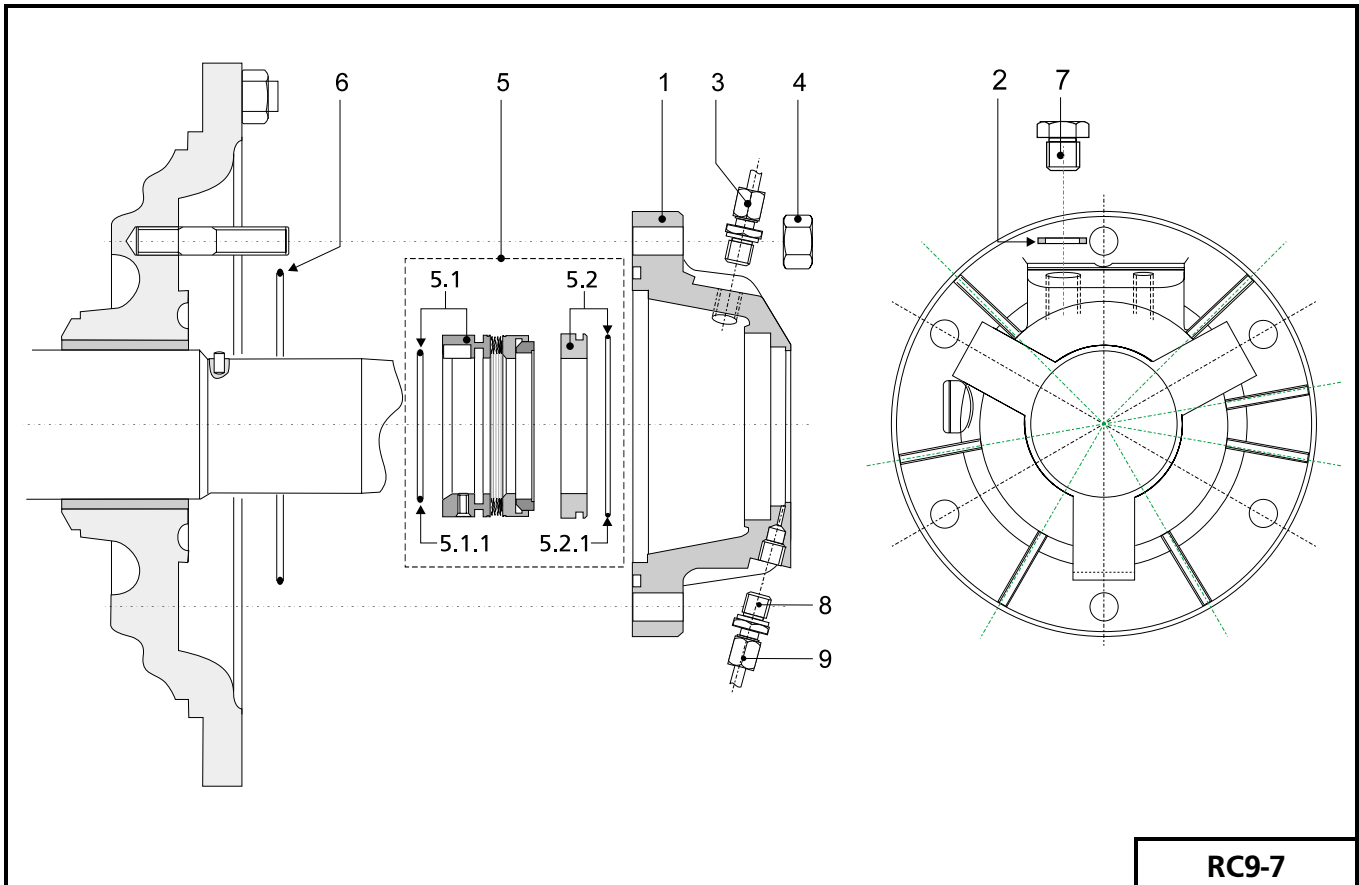
RC9-4



RC9-5



RC9-6

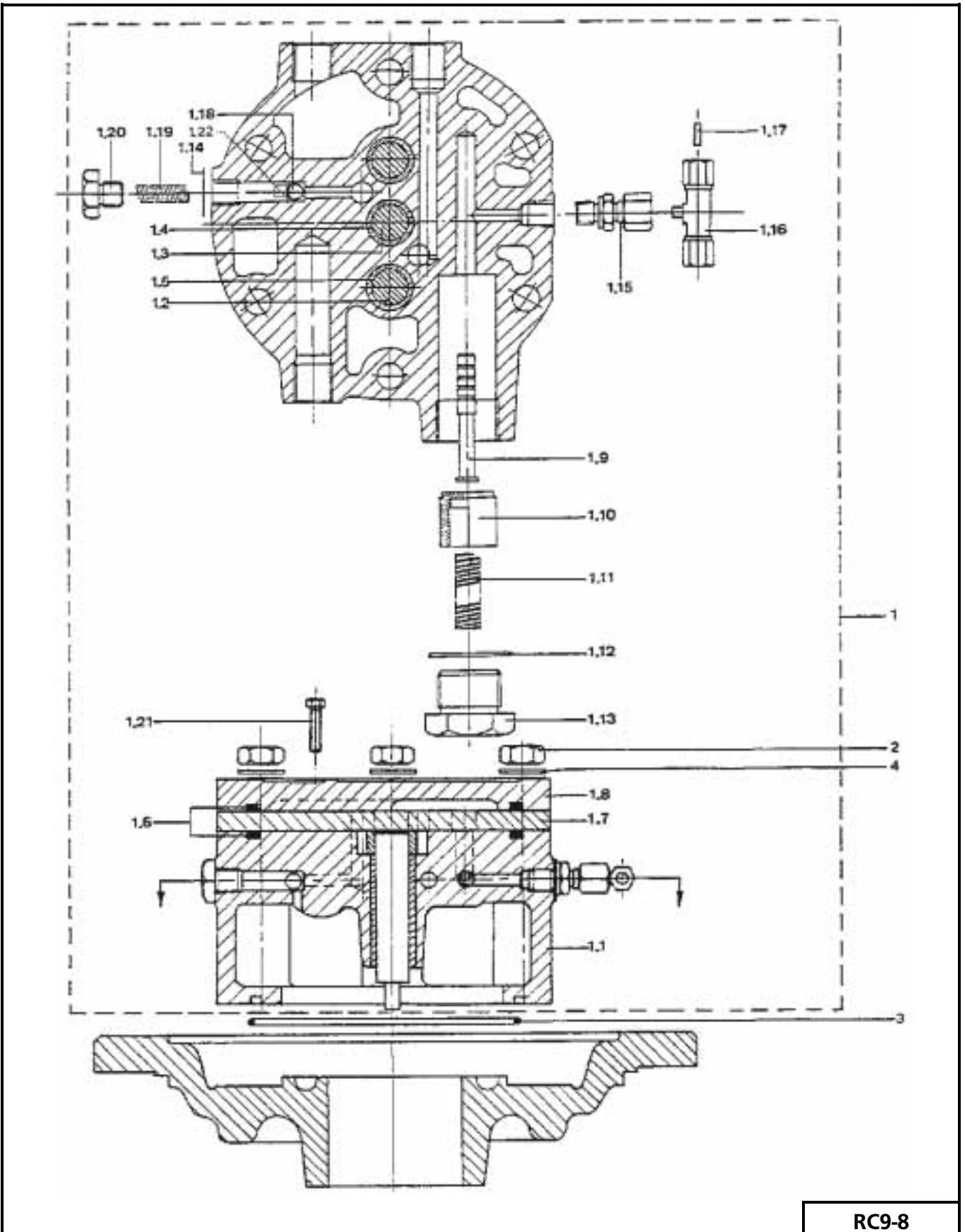


RC9-7

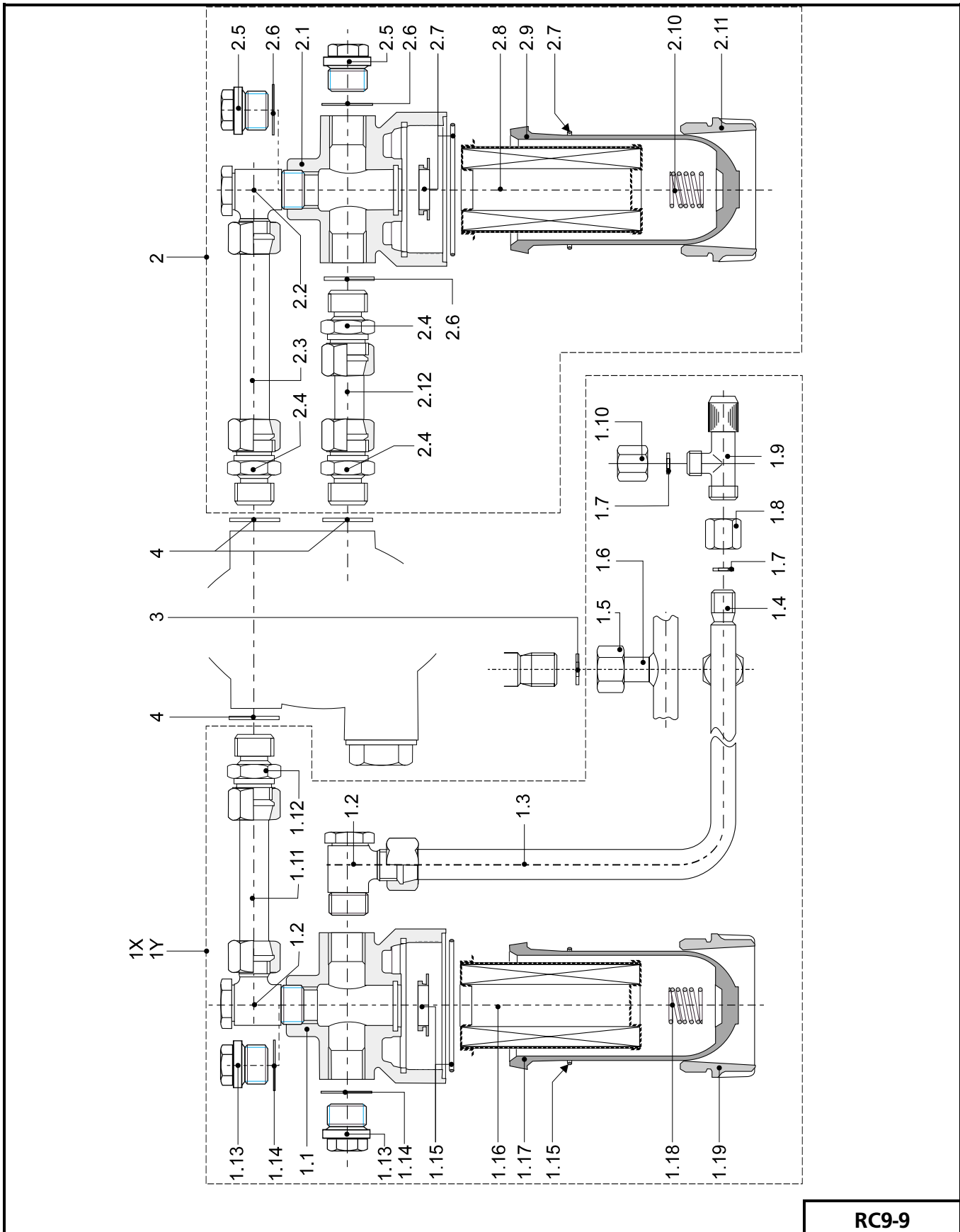
Item	Description	Ref. No.	Qty	Remarks
SUCTION AND DISCHARGE VALVE				FIG. RC9-6
1	Spring 18x111x3x118	11.31.183	1	
2a	Discharge valve assy RC9A	27.21.101	1	for all refrigerants, except R502
2.1a	Socket head screw M6x25	01.04.325	2	
2.2a	Stroke limiter RC9	27.20.350	1	
2.3a	Sinusoidal spring 90x115	*	4	
2.4a	Discharge valve ring 90x115x1	*	1	
2.5a	Valve seat RC9B	27.20.102	1	
2b	Discharge valve assy RC9-R502	27.21.111	1	for refrigerant R502 only
2.1b	Fitted bolt M16x74	01.24.874	1	
2.2b	Self-locking nut M16	01.45.800	1	
2.3b	Stroke limiter RC9-R502	27.20.360	1	
2.4b	Sinusoidal spring 90x115	*	3	R502:use only 3 of 4 springs of set 11.34.850!
2.5b	Discharge valve ring 90x115x1	*	1	
2.6b	Valve seat RC9-R502	27.20.111	1	
3	Sinusoidal spring 121x150	*	1	
4	Suction valve ring 121x150x1	*	1	
5	Set of discharge valves and springs	11.34.850	1	one set per cylinder
6	Set of suction valve and springs	11.34.852	1	one set per cylinder
ROTARY SHAFT SEAL				FIG. RC9-7
1	Shaft seal housing RC9	26.06.211	1	
2	Alu sealing ring 17x21x1	09.12.016	1	
3	Nipple 12G17	03.38.171	1	
4	Hex. nut M12	01.15.610	6	
5	Shaft seal assy 060-B, incl. O-ring pos. 6	09.62.910	1	1)
	Shaft seal assy 060-B	09.62.067	1	for Grasso Chiller application only 1)
5.1	Slip ring assy	*	1	
5.1.1	O-ring 3.53x59.72	09.52.359	1	
5.2	Counter slip ring assy	*	1	
5.2.1	O-ring 3.53x69.44	09.52.318	1	
6	O-ring 5.33x133.4	09.52.540	1	
7	Plug G21	01.36.216	1	
8	Nipple coupling 12G21	03.38.212	1	
9	Bent steel precision tube ø12x1.5 mm	04.02.212	1	

1) A mounting instructions leaflet is always supplied with each complete shaft seal.

Item	Description	Ref. No.	Qty	Remarks
OIL PUMP				FIG. RC9-8
1	Gear pump RC9	18.10.150	1	
1.1	Pump housing KA85M	26.14.501	1	
1.2	Gear wheel 2x17G18	19.37.467	2	— obtainable as set only
1.3	Gear wheel 2x17D18	19.37.417	1	
1.4	Bearing bush 18x24x61	11.46.718	1	
1.5	Bearing bush 18x24x44	11.46.418	2	
1.6	O-ring 5.33x133.4	09.52.540	2	
1.7	Spacer plate KA85	26.14.700	1	
1.8	Pump cover KA85	26.14.600	1	
1.9	Plunger 10K110M	26.16.801	1	
1.10	Plunger piston 30K110	26.17.830	1	
1.11	Spring 1.1x15x15x97	11.31.117	1	
1.12	Alu sealing ring 34x44x1	09.12.034	1	
or	O-ring 3x33	09.52.300	1	
1.13	Plug G33	01.36.336	1	
1.14	Alu sealing ring 13.5x20x1	09.12.014	1	
1.15	Nipple coupling 6G13	03.38.136	1	
1.16	Tee-coupling E6x6x6	03.40.306	1	
1.17	Cylindrical pin 6x12	11.06.612	1	
1.18	Steel ball W10	11.19.006	1	
1.19	Spring 1.25x9.5x9.5x36	11.31.137	1	
1.20	Plug	01.36.140	1	
1.21	Hex. head bolt M6x35	01.10.335	2	
1.22	Spring seat	11.06.811	1	
2	Hex. nut M12	01.15.610	6	
3	O-ring 5.33x133.4	09.52.540	1	
4	Washer M12	11.13.601	6	



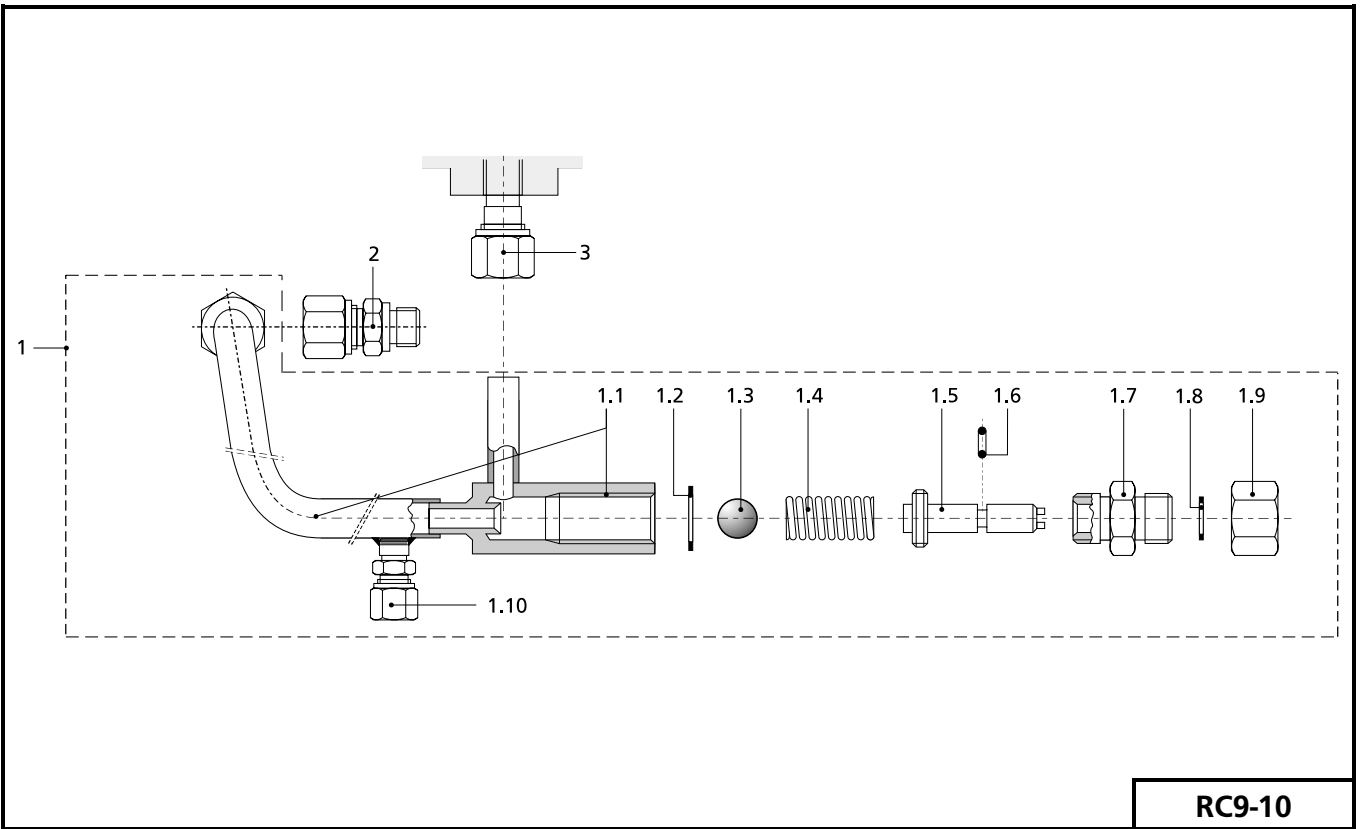
RC9-8



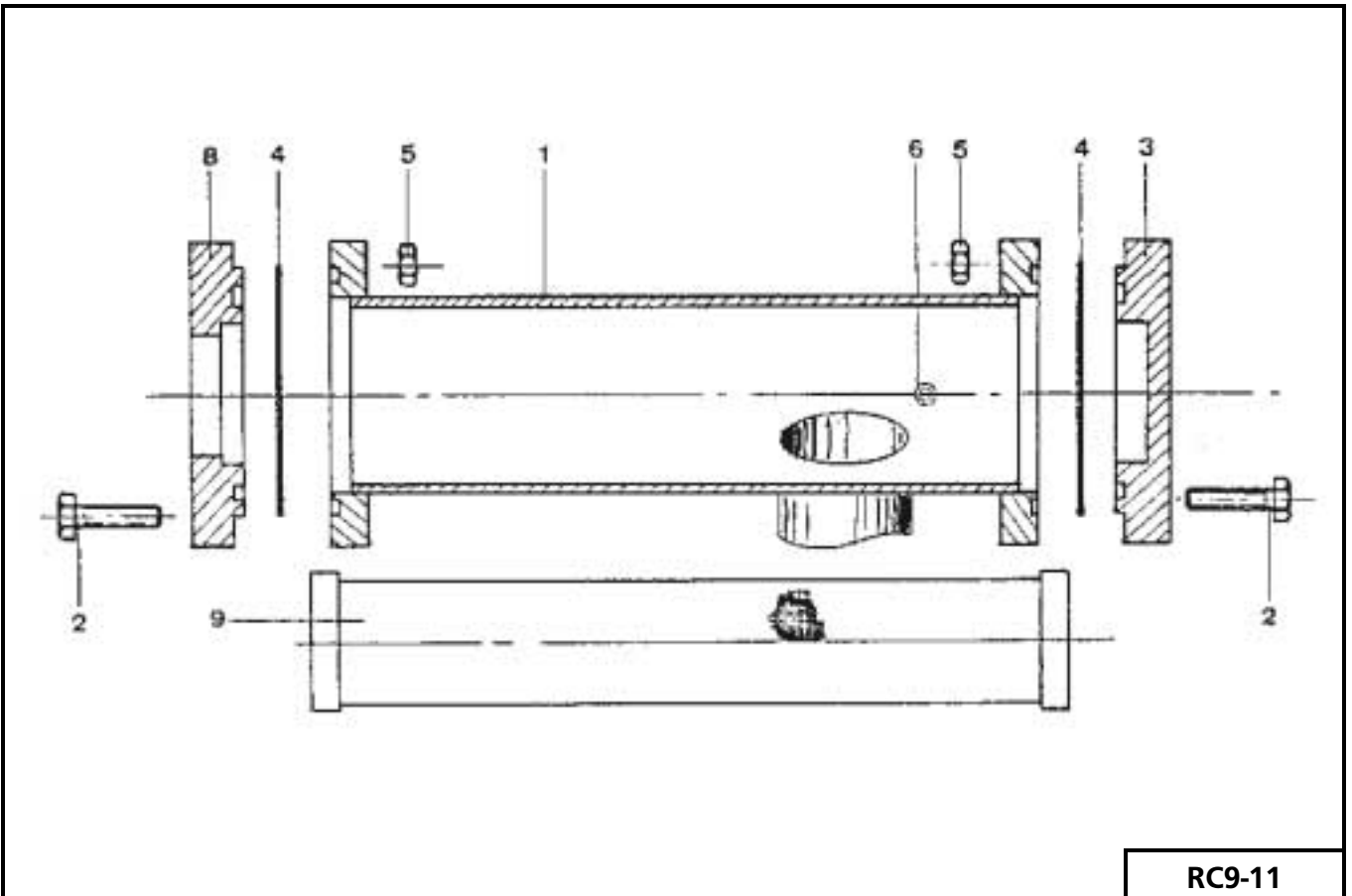
RC9-9

Item	Description	Ref. No.	Qty	Remarks
OIL FILTERS				FIG. RC9-9
1X	Oil suction filter assy RC9	07.15.909	1	on compr. types RC29, RC49 & RC219
1Y	Oil suction filter assy RC9	07.15.969	1	on compr. types RC69 & RC429
1.1	Filter upper housing	*	1	
1.2	Swivel coupling 16G21	03.39.216	1	
1.3	Steel precision pipe 16 x2	*	—	
1.4	Weldable nipple G21L	*	1	form one welded piece
1.5	Union nut G21R	*	1	
1.6	Pipe end G21	*	—	
1.7	Alu sealing ring 10x18x1	09.12.010	2	
1.8	Union socket G21RxG21L	03.29.921	1	
1.9	Stop valve TAH8	06.07.013	1	
1.10	Cap nut K21R	01.17.021	1	
1.11	Steel precision pipe 16 x2	*	—	
1.12	Nipple coupling 16G21	03.38.212	1	
1.13	Plug G21	01.36.216	2	
1.14	Alu sealing ring 21x27x2	09.14.023	2	
1.15	Set of sealing rings	09.90.030	1	
1.16	Gauze filter element (blue marked on top)	07.16.695	1	
1.17	Filter cup 25	*	1	
1.18	Spring	*	1	
1.19	Ring nut	*	1	
2	Oil discharge filter assy RC9	07.15.809	1	
2.1	Filter upper housing	*	1	
2.2	Swivel coupling 16G21	03.39.216	1	
2.3	Steel precision pipe 16x2	*	—	
2.4	Nipple coupling 16G21	03.38.212	3	
2.5	Plug G21	01.36.216	2	
2.6	Alu sealing ring 21x27x2	09.14.023	3	
2.7	Set of sealing rings	09.90.030	1	
2.8	Discharge Paper filter element set	20.38.124	1	Sealings included
2.9	Filter cup 25	*	1	
2.10	Spring	*	1	
2.11	Ring nut	*	1	
2.12	Steel precision pipe 16x2	*	—	
3	Alu sealing ring 10x18x1	09.12.010	1	
4	Alu sealing ring 21x27x2	09.14.023	3	

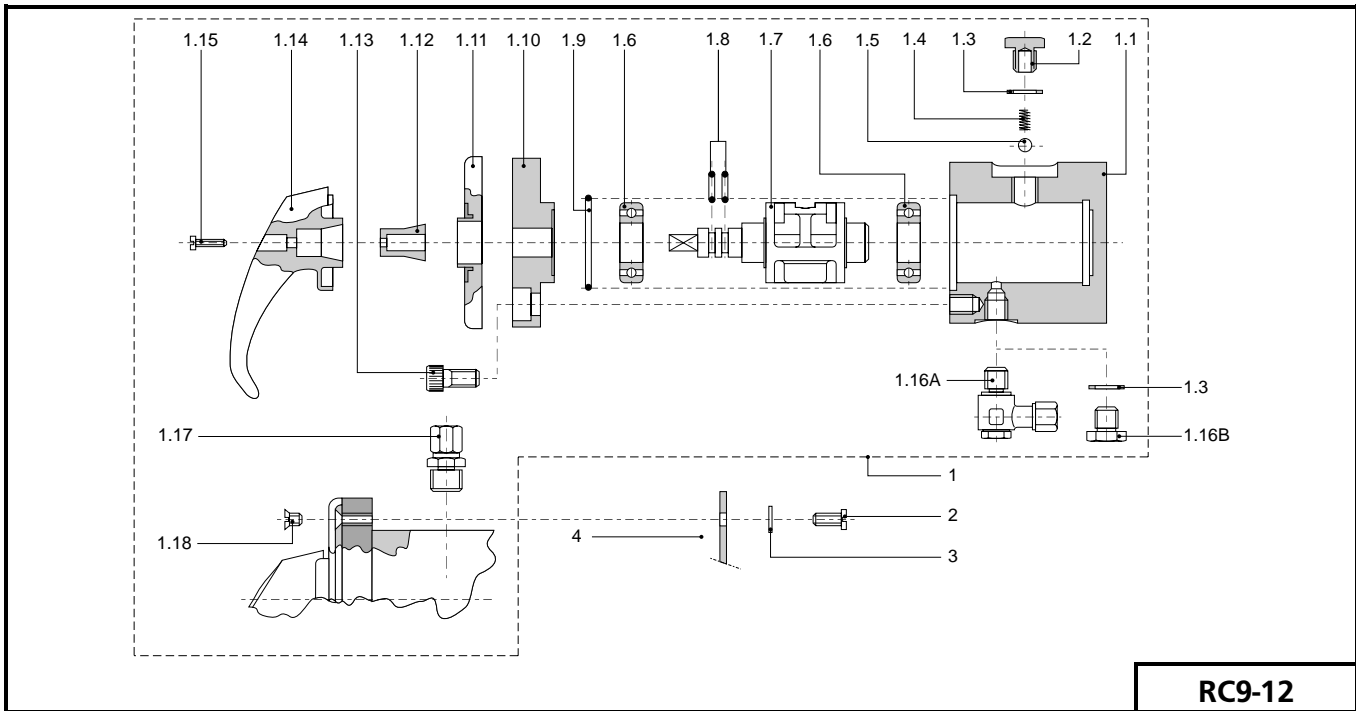
Item	Description	Ref. No.	Qty	Remarks
OIL RETURN LINES				FIG. RC9-10
1a	Oil return line G21x360	44.05.924	1	2-cyl. compressor
1b	Oil return line G21x400	44.05.945	1	3- and 4-cyl. compressor
1c	Oil return line G21x440	44.05.964	1	6-cyl. compressor
1.1	Valve housing H9K	*	–	
1.2	Alu sealing ring 21.5x27x1	09.12.022	1	
1.3	Steel ball W16	11.19.010	1	
1.4	Spring 1.25x14x9x3.55	11.31.134	1	
1.5	Thrust bolt G21x60S	01.35.218	1	
1.6	O-ring 1.78x8.73	09.52.184	1	
1.7	Nipple G21CxG21	03.04.921	1	
1.8	Alu sealing ring 10x18x1	09.12.010	1	
1.9	Cap nut GK21R	01.17.021	1	
1.10	Weldable coupling 6x11	03.35.006	1	
2	Coupling 12G21	03.38.212	1	
3	Weldable coupling 6x11	03.46.028	1	
SUCTION GAS STRAINER				FIG. RC9-11
1	Suction strainer housing	*	1	
2a	Hex. haed bolt M16x60	01.10.860	8	
3a	Blind flange 89B	05.14.089	1	RC29, RC49 and RC219
4a	Oilit ring 98x112x1.5	09.03.098	2	
5a	Hex. nut M16	01.15.810	8	
2b	Hex. head bolt M20x70	01.10.170	8	
3b	Blind flange 108B	05.14.108	2	RC69 and RC429
4b	Oilit ring 117x131x1.5	09.03.117	2	
5b	Hex. nut M20	01.15.110	8	
6	Weldable coupling 6x11	03.35.006	–	
8	Flange 89-60	05.02.261	1	RC29, RC49 and RC219
9a	Strainer element 360x110	07.16.360	1	RC29
9b	Strainer element 600x110	07.16.600	1	RC49 and RC219
			2	RC69 and RC429



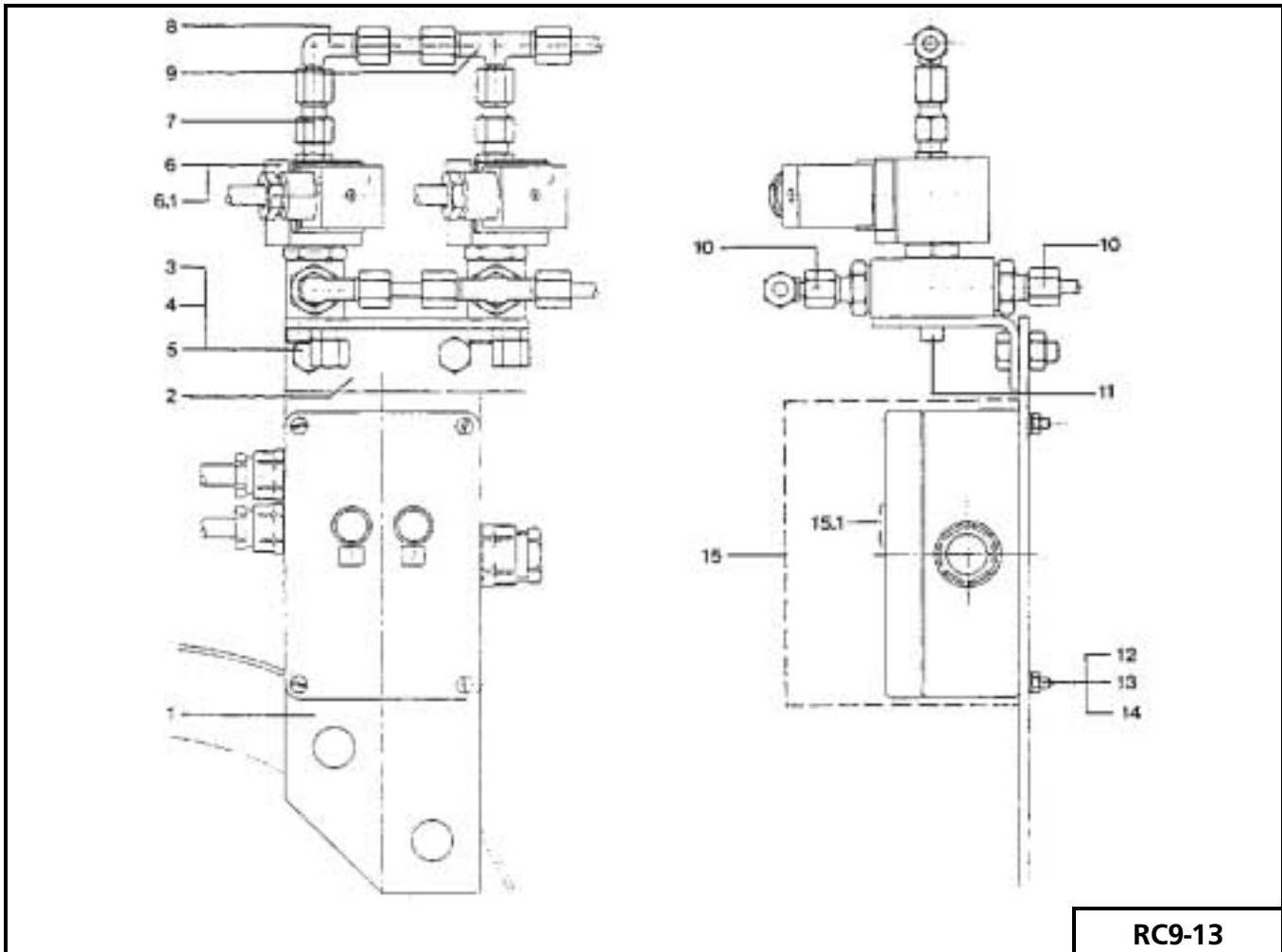
RC9-10



RC9-11



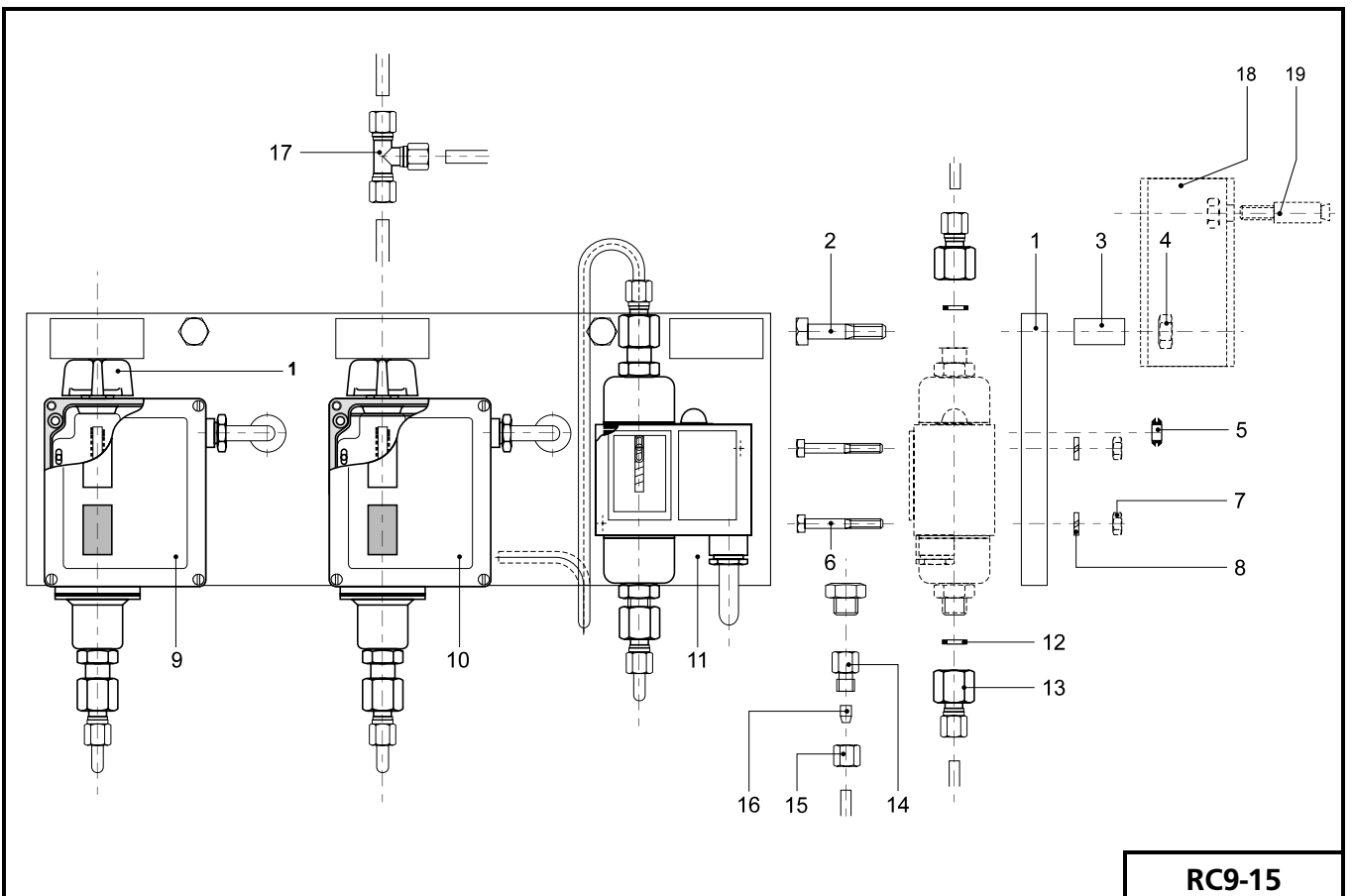
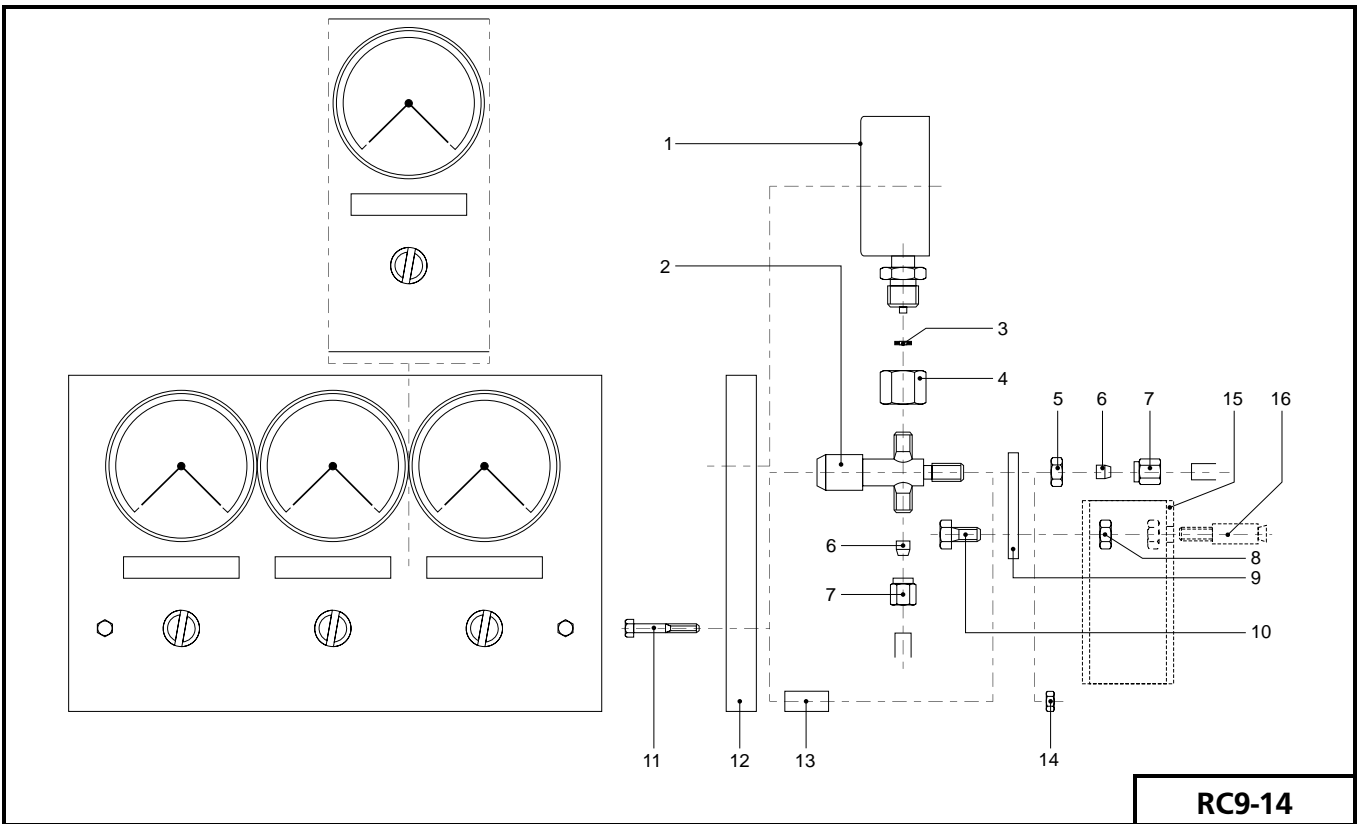
RC9-12

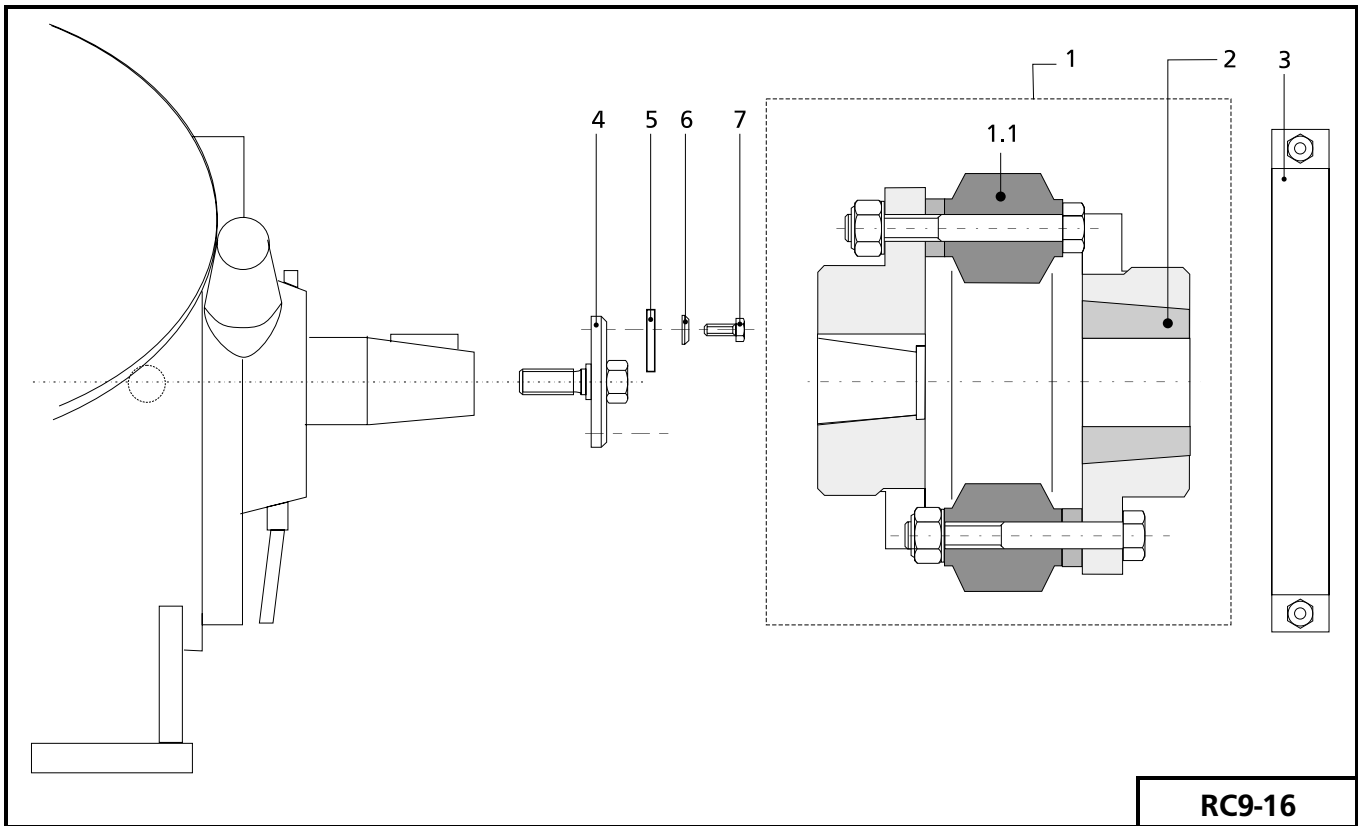


RC9-13

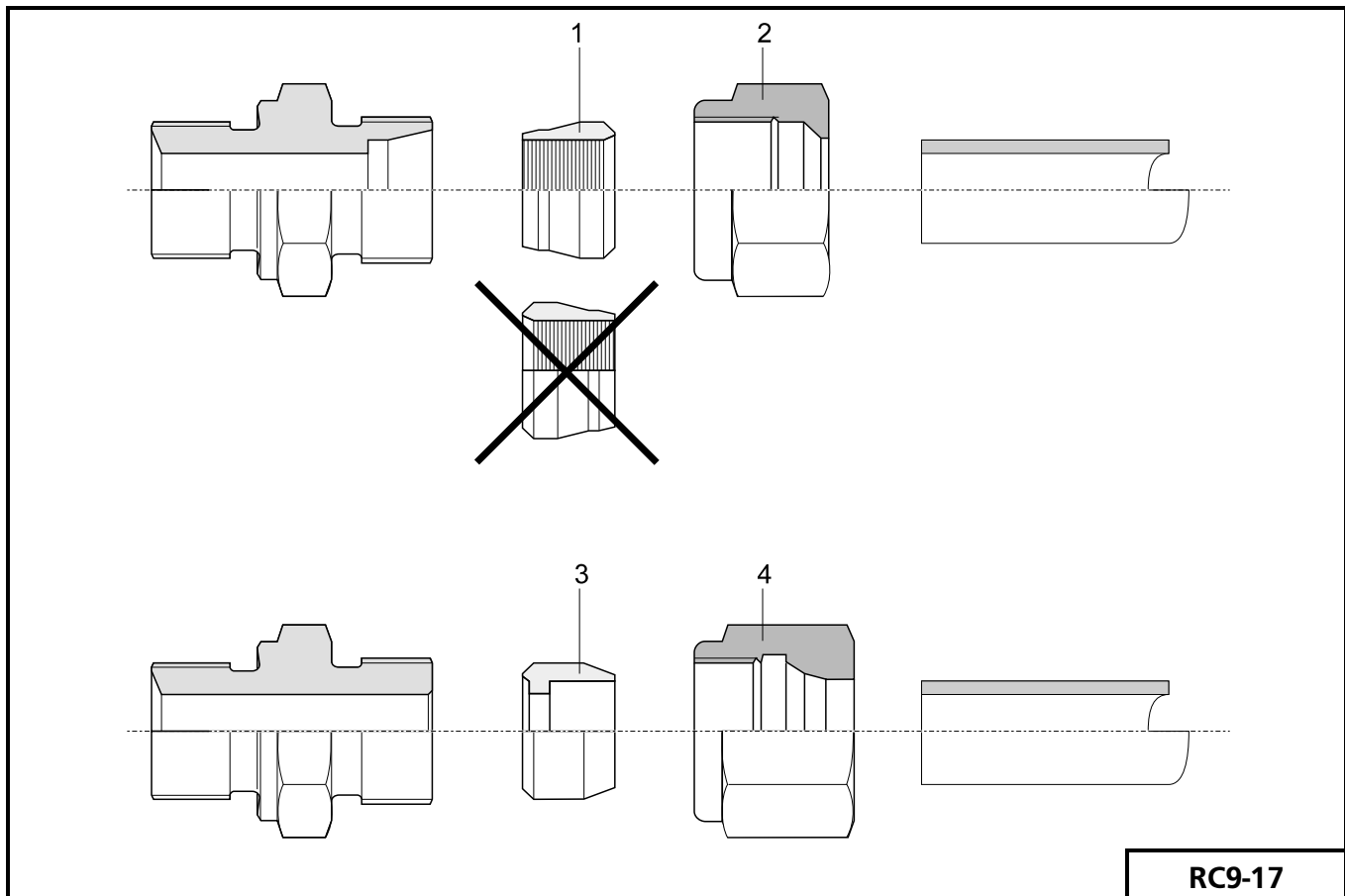
Item	Description	Ref. No.	Qty	Remarks
MANUALLY OPERATED CAPACITY CONTROL				FIG. RC9-12
1	Manually capacity control 6x6G13	12.73.114	1	
1.1	Oil distributor housing	*	1	
1.2	Plug G13	01.36.136	1	
1.3	Alu sealing ring 13.5x20x1	09.12.014	–	
1.4	Spring 0.75x5.2x7.5x18	11.31.083	1	
1.5	Steel ball W6	11.19.004	1	
1.6	Ball bearing 6004	*	2	
1.7	Distributor spindle 42x106	*	1	
1.8	O-ring 2.5x10	09.52.252	2	
1.9	O-ring 3.5x44	09.52.350	1	
1.10	Cover 90x15	*	1	
1.11	Indication plate 088	11.76.088	1	
1.12	Bush 8x8	48.46.108	1	
1.13	Socket head screw M10x20	01.04.520	3	
1.14	Hand grip 040	02.49.040	1	
1.15	Cylinder head screw M4x20	01.68.220	1	
1.16A	Swivel coupling 6G13	03.39.136	–	— total quantity: 5
1.16B	Plug G13	01.36.136	–	
1.17	Nipple coupling 6G13	03.38.136	1	
1.18	Countersunk head screw M5x10	01.69.910	4	
2	Hex. head bolt M8x16	01.10.416	4	
3	Lock washer M8	11.13.401	4	
4	Support I180x240	02.34.824	1	except 6-cylinder compressors
ELECTRICALLY OPERATED CAPACITY CONTROL				FIG. RC9-13
1	Support I80x240	02.34.824	1	
2	Support L30x110A	02.38.313	1	
3	Hex. head bolt M8x16	01.10.416	2	
4	Serrated lock washer M8	11.13.403	2	
5	Hex. nut M8	01.15.410	2	
6	Three-way solenoid valve 220HB	06.80.410	–	
6.1	Valve coil 110-120/50-60	13.16.311	–	
	220-240/50-60	13.16.322	–	
7	Socket coupling 6G10	03.37.106	1	— quantities per valve
8	Angle coupling EV6x6	03.52.006	(2)	
9	Tee-coupling EV6x6x6	03.54.006	(2)	
10	Nipple coupling 6G10	03.38.106	2	
11	Socket head screw M5x8	01.04.208	2	
12	Hex. nut M4	01.15.211	2	
13	Washer M4	11.13.201	2	
14	Cylinder head screw M4x16	01.68.216	2	
15	Junction box (synthetic)	*	1	
15.1	Lamp, bayonet fixing:			
	24V	13.08.624	–	
	48V	13.08.648	–	
	110V	13.08.610	–	
	220V	13.08.620	–	
16	Connector	13.16.610	1	Without LED
		13.16.611	1	With 220V-AC/DC LED
		13.16.615	1	With 48V-AC/DC LED

Item	Description	Ref. No.	Qty	Remarks	
PRESSURE GAUGE PANEL				FIG. RC9-14	
1	Pressure gauge Discharge pressure (except booster)	NH3-P-100 R-P/100	12.10.113 12.12.113	1 1	NH3, single stage and two stage R22, single stage and two stage
	Suction pressure, intermediate pressure and discharge pressure-Booster)	NH3-Z-100 R-Z-100	12.10.114 12.12.116	1 2 1 2	single-stage NH3 two-stage NH3 and booster NH3 single-stage R22 two-stage R22 booster R22
	Oil pressure	NH3-O-100 R-O-100	12.15.114	1 1	NH3/halocarbons
2	Stop valve TAH4C		06.07.007	1	quantities per gauge
3	Alu sealing ring 6.5x11x1		09.12.007	1	
4	Union socket G21RxG21L		03.29.921	1	
5	Hex. nut MF12		01.47.605	1	
6	Clamping sleeve S6		03.34.106	2	
7	Union nut MF12x1.5		03.51.006	2	
8	Hex. nut M10		01.15.510	2	
9	Mounting strip		*	1	
10	Hex. head bolt M10x20		01.10.520	2	
11	Hex. head bolt M6x45		01.10.345	2	
12	Front panel		*	1	
13	Spacer sleeve 13.7x2.2x31		*	2	
14	Hex. nut M6		01.15.310	2	
STANDARD SAFETY SWITCH PANEL				FIG. RC9-15	
1	Panel 5x100		*	1	for NH3 for halocarbons
2	Hex. head bolt M10x50		01.10.550	2	
3	Spacer sleeve 17.1x2.3x34		*	2	
4	Hex. nut M10		01.15.510	2	
5	Grommet 2-13		09.24.212	2	
6	Cylinder head screw M4x50		01.68.250	6	
7	Hex. nut M4		01.15.211	6	
8	Lock washer M4		11.13.203	6	
9	Discharge pressure safety switch type RT5 (R12, R22, etc.)		12.61.151	1	
	type RT5A (NH3)		12.60.151	1	
10	Suction pressure safety switch type RT1 (R12, R22, etc.)		12.61.121	1	
	type RT1A (NH3)		12.60.121	1	
11	Oil pressure safety switch type MP55 (R12, R22, etc.)		12.61.232	1	
	type MP55A (NH3)		12.60.232	1	
	type RT260A (NH3, R12, R22, etc.)		12.60.240	1	
12	Alu sealing ring 8x14.5x1		09.12.008	4	
13	Socket coupling 6G17		03.37.176	4	
14	Socket coupling 6F6		03.37.906	4	
15	Union nut		*	4	
16	Clamping sleeve S6		03.34.106	4	
17	Tee-coupling S6x6x6		03.40.006	1	
WALL MOUNTING FOR COMBI-PANEL				FIG. RC9-14/15	
15/20	Support 100x30		02.32.341	2	
16/21	Wedge bolt M10x80		01.28.380	4	





RC9-16



RC9-17

Item	Description	Ref. No.	Qty	Remarks
ELASTIC COUPLING				FIG. RC9-16
1a	Coupling type 42 (complete)	*	1	to facilitate mounting, a steel strip is clamped around the coupling element, which must be removed before putting the compressor into operation
1.1a	Coupling element 42	19.18.842	1	
1b	Coupling type 61 (complete)	*	1	
1.1b	Coupling element 61	19.18.861	1	
1c	Coupling type 91 (complete)	*	1	
1.1c	Coupling element 91	19.18.891	1	
1d	Coupling type 182 (complete)	*	1	
1.1d	Coupling element 182	19.18.818	1	
2	Clamping sleeve	*	1	
3	Tire clamp (coupling tool)	15.08.232	1	
	Tire clamp (coupling tool)	15.08.244	1	for coupling element 61 ¹⁾
	Tire clamp (coupling tool)	15.08.280	1	for coupling element 91 ¹⁾
	Tire clamp (coupling tool)	15.08.376	1	for coupling element 182 ¹⁾
4	Hub locking disc M16x82	19.15.882	1	to be supplied with flywheel or flexible coupling
5	Locking plate M16xM8	11.14.848	1	
6	Washer M8	11.13.401	1	
7	Hex. head bolt M8x30	01.10.430	4	

PARTS FOR CLAMP COUPLINGS				FIG. RC9-17
1a	Clamping sleeve P6	03.34.506	--	to be used on clamp couplings with reference number: 03.37.106 03.37.176 03.38.131 03.38.136 03.39.136 03.40.006 03.35.006 03.35.016 03.38.212 03.52.006 03.54.076
2a	Union nut M12x1.5 (DIN 2353)	*	--	
	Union nut M14x1.5 (DIN 2353)	*	--	
1b	Clamping sleeve P16	03.34.516	-	
2b	Union nut MF24x1.5 (DIN 2353)	*	-	
3	Clamping sleeve S6	03.34.106	-	
4	Union nut MF12x1.5 (special)	03.51.006	-	

¹⁾ When ordering this tire clamp always indicate the type number of the elastic coupling.

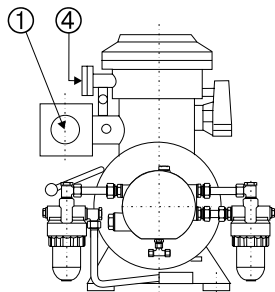
STANDARD SETS OF PARTS, SEALS AND TOOLS

NO FIGURE

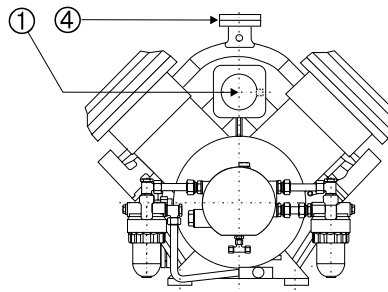
Item	Description	Ref. No.	Qty for compressor types		
			RC29	RC219/49	RC429/69
1	Set of special tools	20.20.010	1	1	1
2	Basic set of spare parts Additional set of spare parts	20.20.021 20.20.031	1 -	1 1	1 2
3	Basic set of gaskets and seals Additional set of gaskets and seals	09.90.007 09.90.008	1 1	1 2	1 3

OILIT SEALING RINGS FOR SUCTION-, INTERMEDIATE- AND DISCHARGE CONNECTIONS (FIG. RC9-18)

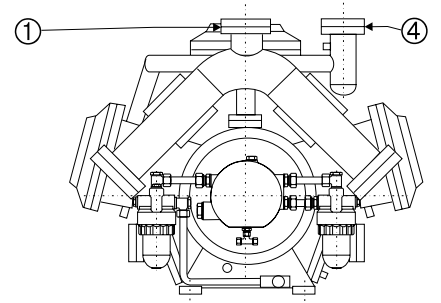
COMPRESSOR		(LP) SUCTION		INTERMEDIATE				(HP) DISCHARGE	
				LP DISCHARGE		HP SUCTION			
MODEL		SIZE	PART NO.	SIZE	PART NO.	SIZE	PART NO.	SIZE	PART NO.
RC29	SINGLE-STAGE	98X112X1.5	09.03.098					48X58X1.5	09.03.048
RC49		98X112X1.5	09.03.098					67X81X1.5	09.03.067
RC69		98X112X1.5	09.03.098					84X98X1.5	09.03.084
RC219	TWO-STAGE	98X112X1.5	09.03.098	48X58X1.5	09.03.048	48X58X1.5	09.03.048	48X58X1.5	09.03.048
RC429		84X 98X1.5	09.03.084	48X58X1.5	09.03.048	84X98X1.5	09.03.084	84X98X1.5	09.03.084
		FLANGE NO. 1		FLANGE NO. 2		FLANGE NO. 3		FLANGE NO. 4	



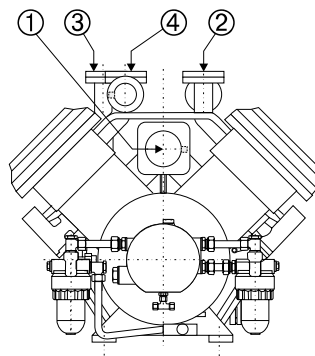
RC29



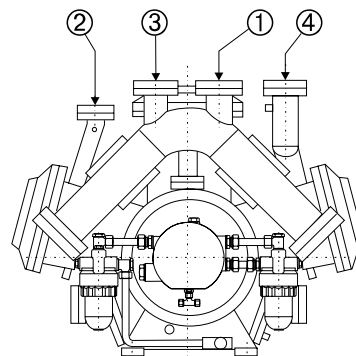
RC49



RC69



RC219



RC429

RC9-18



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