

MYCOM

RECIPROCATING COMPRESSOR MANUAL

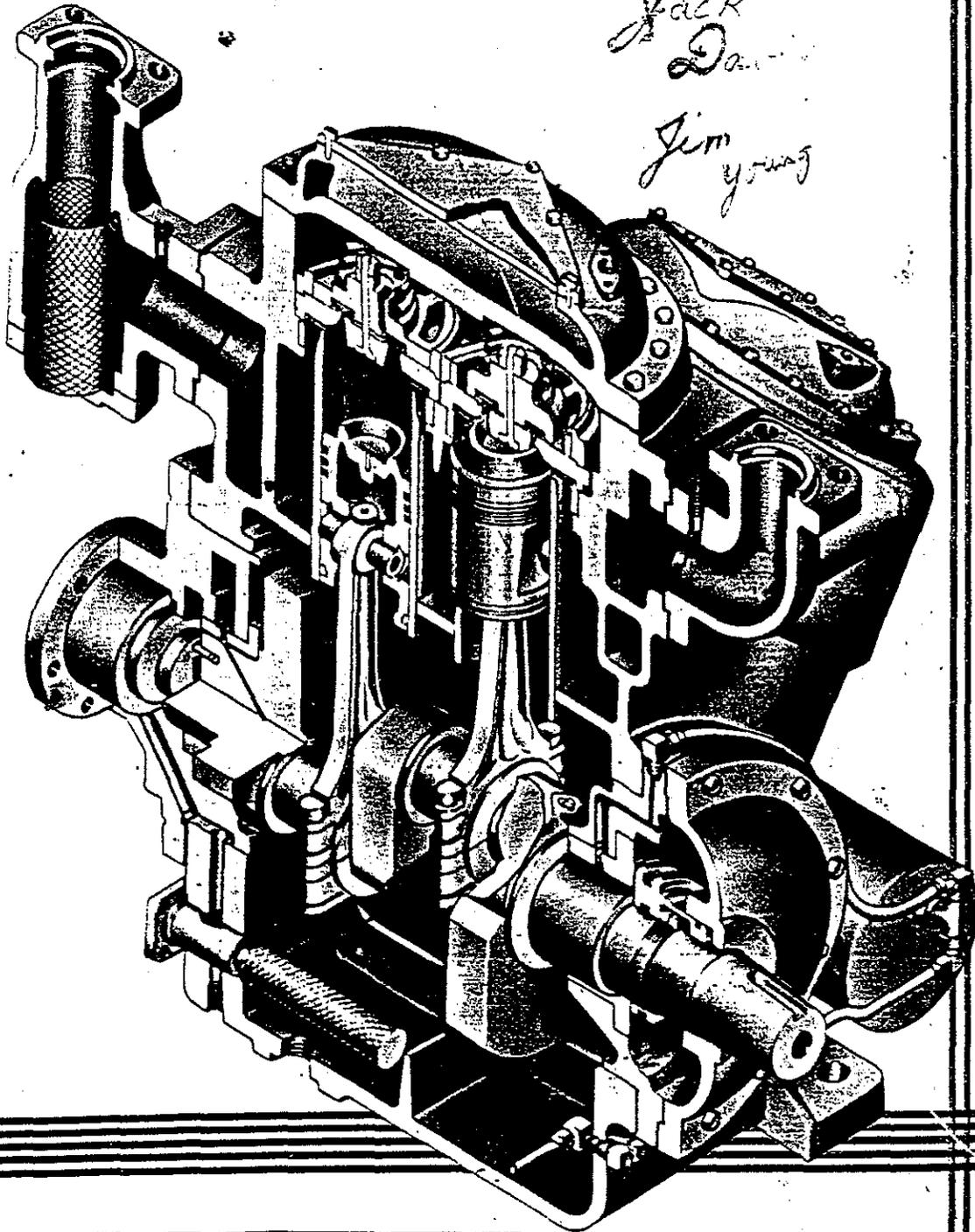
EL-78
A0619

115 Vac

200

Jack
D...

Jim
young

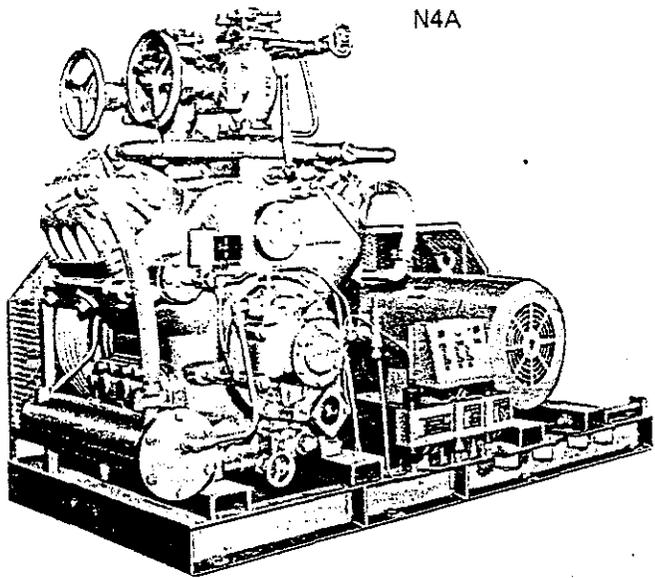


MYCOM
CORPORATION

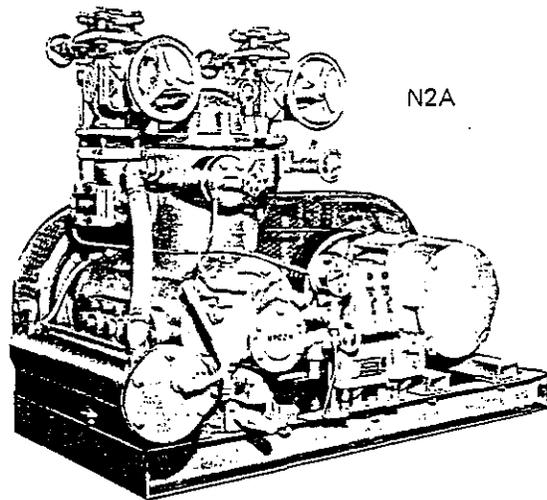
REFRIGERATION AND
AIR CONDITIONING EQUIPMENT

2945 Columbia Street Torrance, California 90503
Telephone: (213) 533-0111 (213) 775-1009

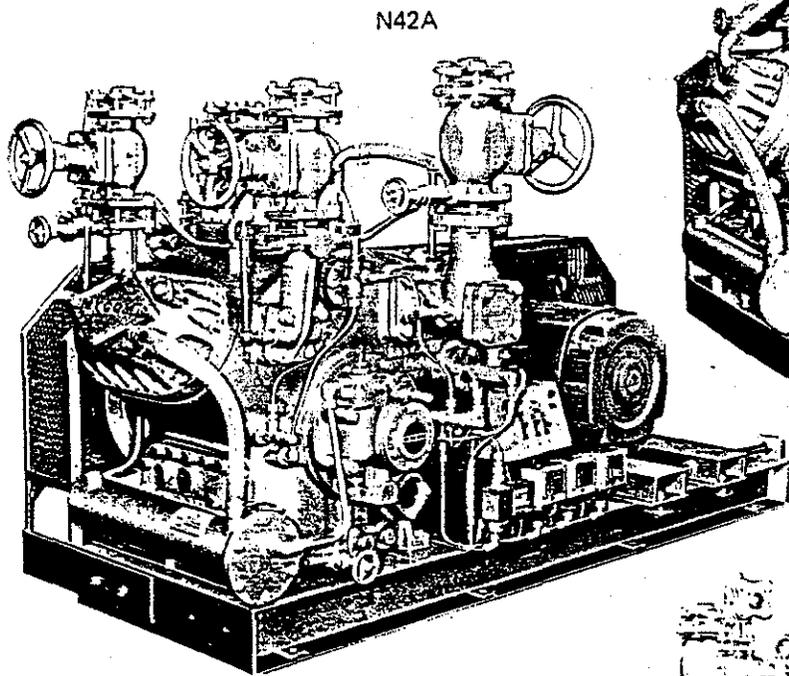
● MYCOM Multi-cylinder Refrigeration Compressors (for land use) (unit)



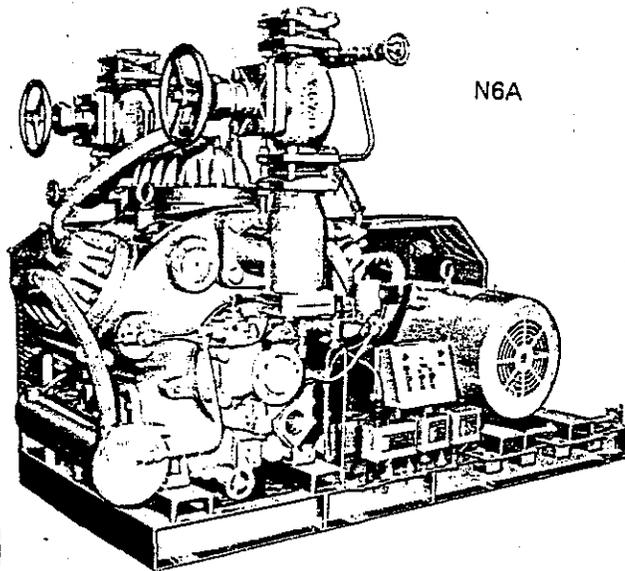
N4A



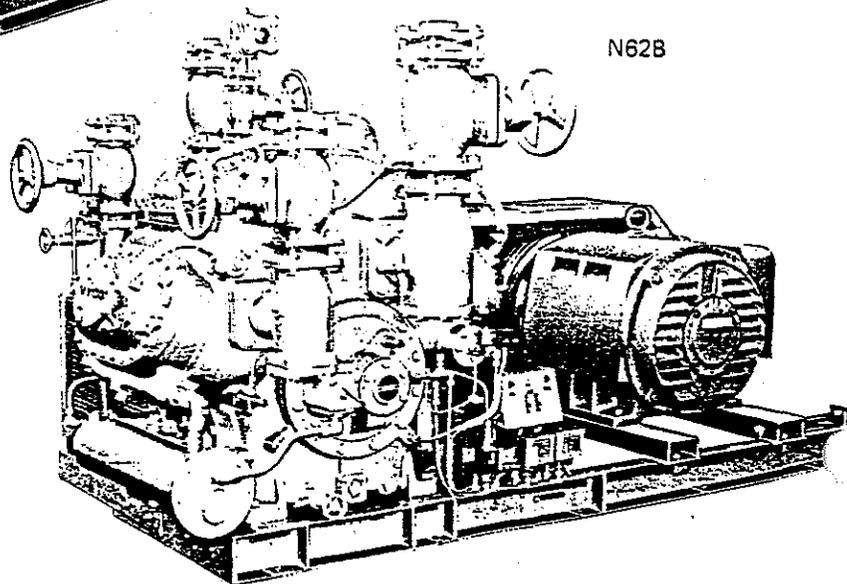
N2A



N42A



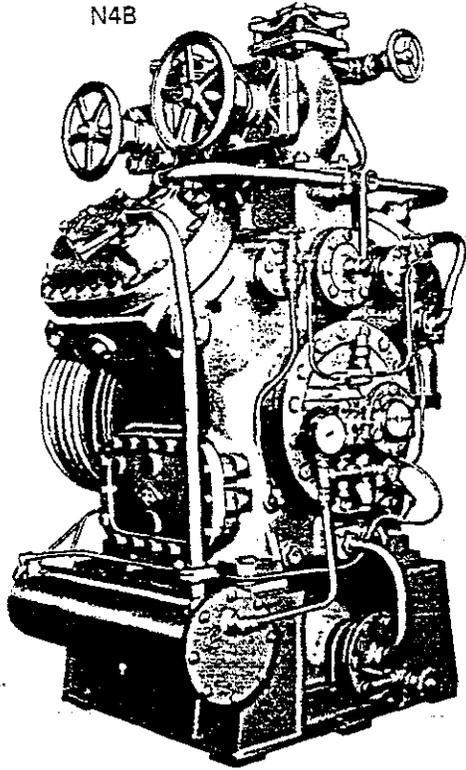
N6A



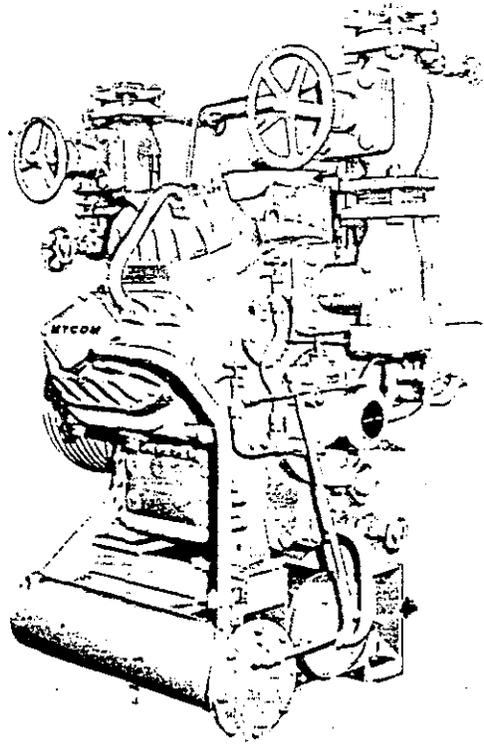
N62B

● MYCOM Multi-cylinder Refrigeration Compressor (for marine use) (Bare)

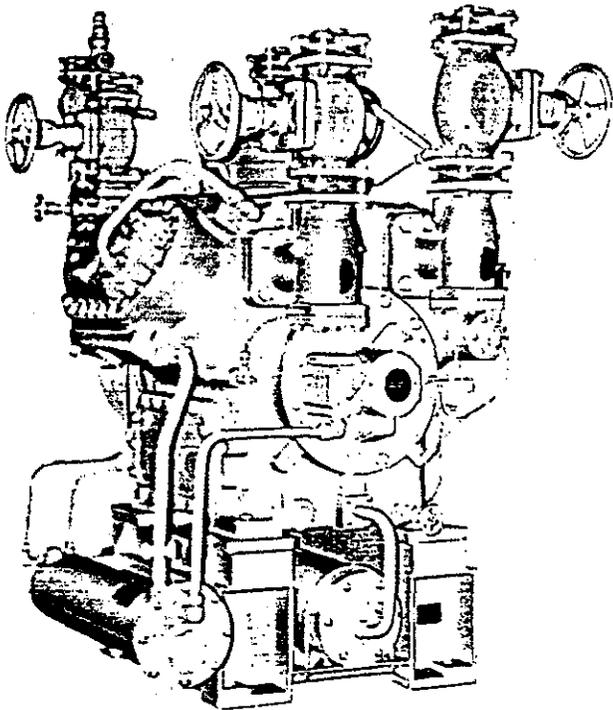
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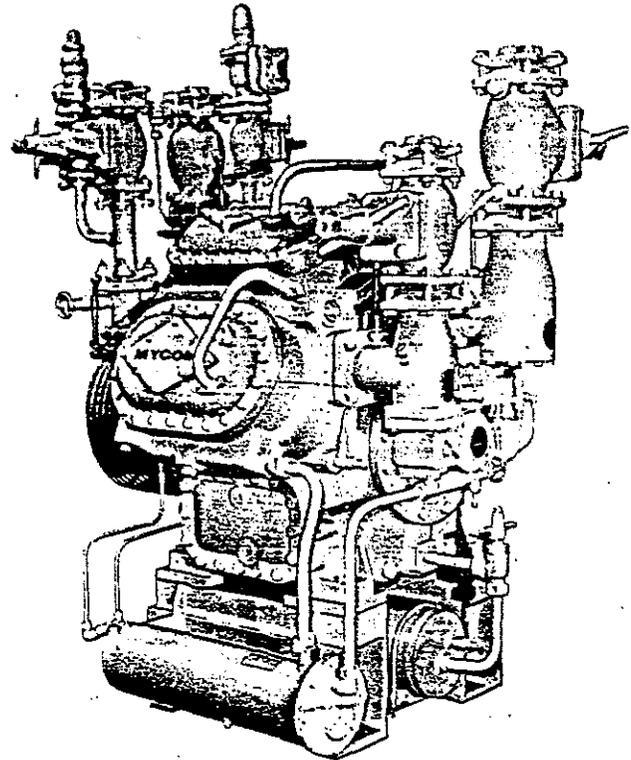
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N42B

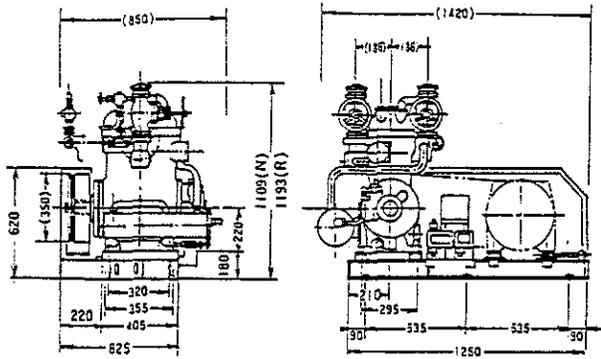


F62B



● Standard Dimensions

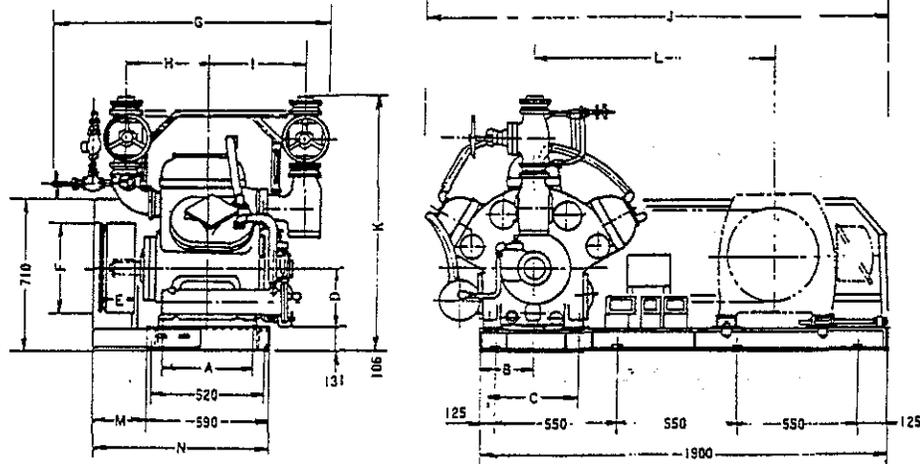
● 2A



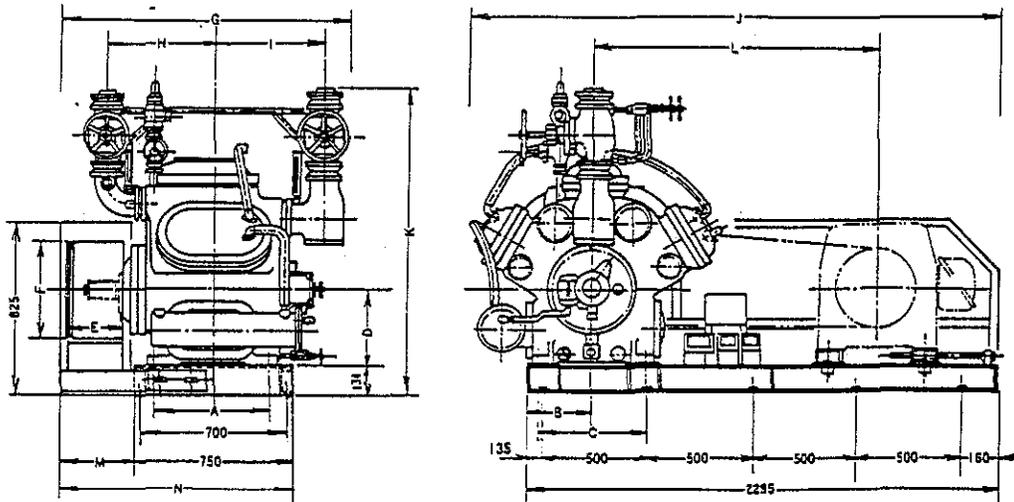
	V belt	Anchor bolt	Net Weight kg	
			Bare	Unit
2 A	B × 4	6	421	600

Net weight: Less motor, pulley and V belts.

● 4A, 6A, 8A

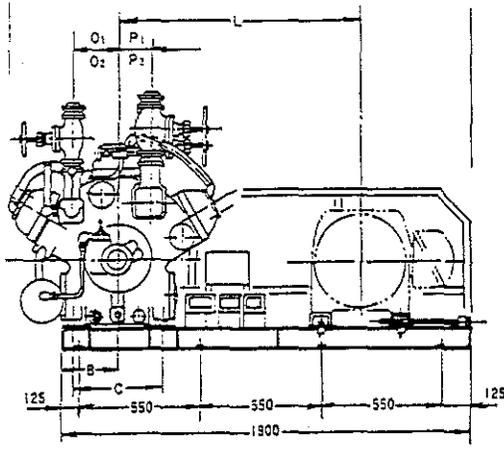
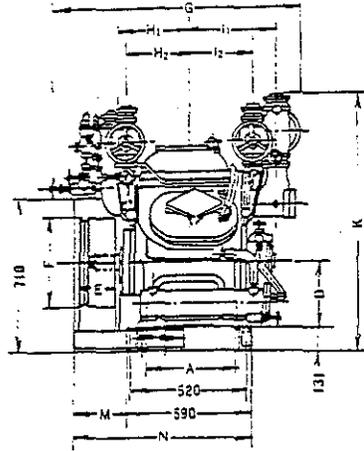


● 4B, 6B, 8B

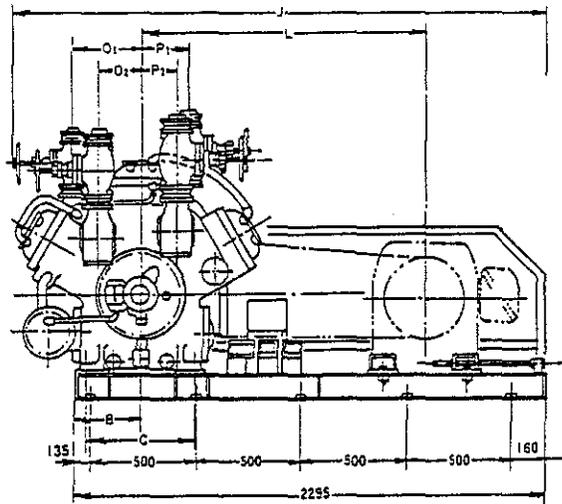
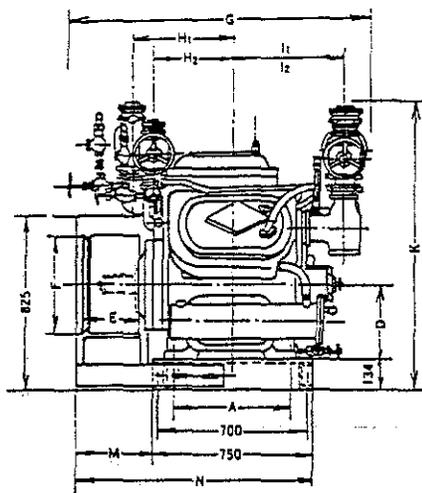


	A	B	C	D	E	F	G	H	I	J	K	L (max)	M	N	V Belt	Anchor bolt	Net Weight kg	
																	Bare	Unit
4 A	406	318	406	260	110	406	(R)1005 (N) 990	164	143	(R)2145 (N)2090	(R)1156 (N)1105	1118	(R)240 (R)225	(R)830 (N)815	C × 4	8	745	950
6 A	406	318	406	260	162	406	(R)1360 (N)1230	377	437	(R)2180 (N)2120	(R)1192 (N)1156	1118	225	815	C × 6	8	835	1105
8 A	416	318	416	290	188	406	(R)1172 (N)1260	(R) 407 (N) 382	(R) 442 (N) 442	(R)2255 (N)2140	(R)1242 (N)1227	1118	265	855	C × 7	8	997	1315
4 B	480	372.5	480	330	214	460	1230	220	180	2460	1353	1509	360	1110	C × 8	10	1400	1850
6 B	544	372.5	510	350	266	460	(R)1430 (N)1390	506	519	2610	(R)1962 (N)1464	1509	360	1110	C × 10	10	1730	2180
8 B	566	372.5	530	350	318	460	R1670 (N)1450	(R) 509 (N) 489	(R) 549 (N) 519	2600	(R)2025 (N)1502	1509	360	1160	C × 12	10	1950	2445

Length unit: mm



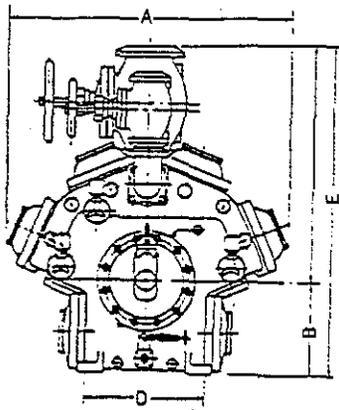
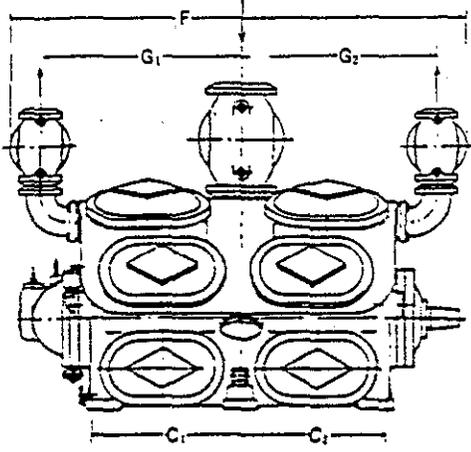
● 42A, 62A



● 42B, 62B

	A	B	C	D	E	F	G	H ₁	H ₂	I ₁	I ₂	J	K	L (max)	M	N	O ₁	O ₂	P ₁	P ₂	V belt	Anchor bolt	Net Weight kg	
																							Bare	Unit
42A	406	318	406	290	110	406	(R)1260 (N)1130	332	287	392	287	2120	1148	1118	225	815	208	208	140	140	C × 4	8	820	1130
62A	416	318	416	320	162	406	(R)1350 (N)1210	337	292	442	292	2140	(R)1570 (N)1232	1118	265	855	263	248	0	0	C × 6	8	1020	1360
42B	544	372.5	510	350	214	460	(R)1395 (N)1420	464	369	524	524	(R)2610 (N)2550	(R)1534 (N)1332	1509	360	1110	311	206	214	165	C × 8	10	1725	2295
62B	566	372.5	530	350	266	460	(R)1525 (N)1450	464	369	519	524	(R)2630 (N)2570	(R)1914 (N)1497	1509	360	1110	351	265	0	128	C × 10	10	1915	2655

Length unit: mm

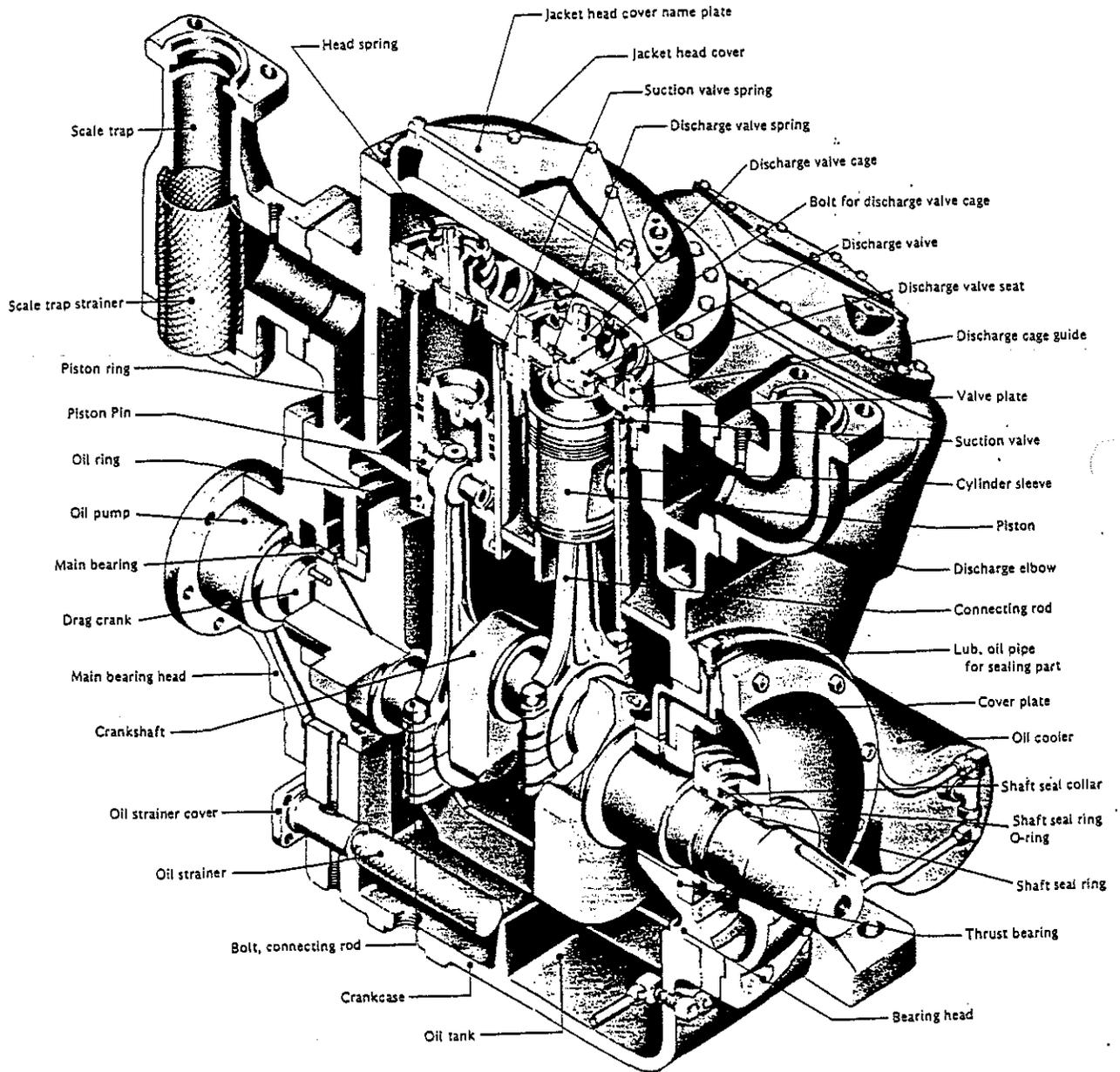


● 12B, 12-4B
(Direct coupling only)

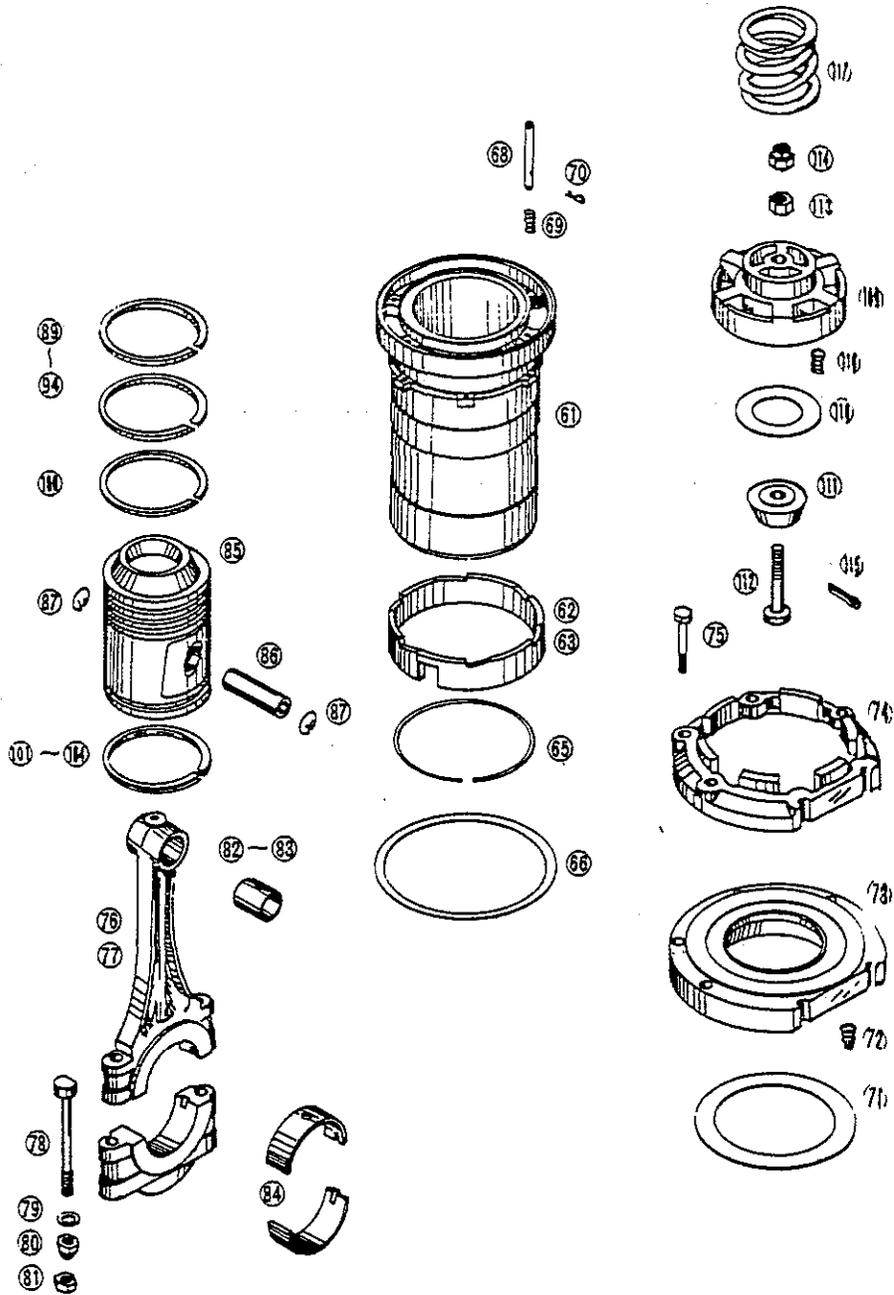
	A	B	C	E	F	G	Anchor bolt	Net Weight kg	
								Bare	Unit
12B	1350	330	1 605 2 505	R1560 N1360	R2334 N1833	1 507 2 507	16	2300	4200
12-4B	R1400 N1350	390	1 620 2 620	R1950 N1415	R2410 N2345	1) 822 2) 776-752	16	3900	4800

Length unit: mm

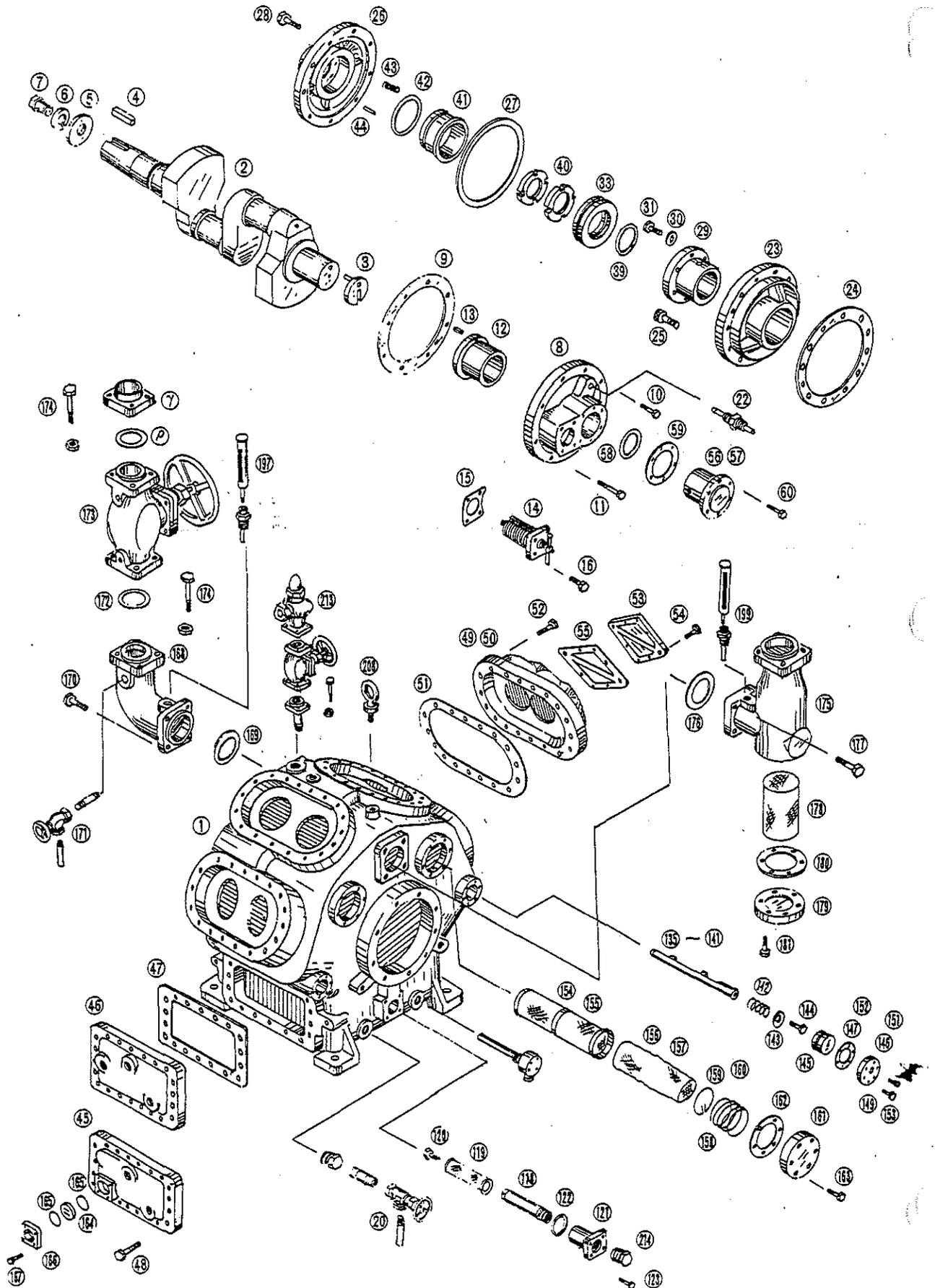
Compressor Assembly, sectional view



Cylinder assembly, exploded view



Compressor assembly, exploded view



MYCOM RECIPROCATING COMPRESSOR PARTS LIST

Index No.	Description	Index No.	Description
1	Crankcase	34 *	Fixing ring
2A	Crankshaft for cast iron piston	35 *	Floating seat
2B	Crankshaft for cast iron piston (white)	36 *	Stop pin
3	Drag crank	37 *	"O" ring
4	Pulley key	38 *	Spring
5	Flat washer, pulley	39	"O" ring, shaft seal collar
6	Lock washer, pulley	40	Locknuts, each 2 p'cs
7	Screw, pulley hub	41	Shaft seal ring
8	Main bearing head	42	"O" ring, shaft seal ring
9	Gasket, main bearing head	43	Helical springs
10	Screw, Hex. head cap (short)	44	Roll pin
11	Screw, Hex. head cap (long)	45	Handhole cover A, with fittings and oil sight glass connections
12	Main bearing	46	Handhole cover B, without oil sight glass
13	Pin, main bearing	47	Gasket, handhole cover
14	Assembly, cuno-filter	48	Bolts, handhole cover
15	Gasket, cuno-filter cover	49	Head cover
16	Bolts, cuno-filter cover	50	Jacket, head cover
17 *	Cuno-filter case for 12B, 12-4B only	51	Gasket, head cover
18 *	Gasket, cuno-filter case for 12B, 12-4B only	52	Bolts, head cover
19 *	Bolts, cuno-filter for 12B, 12-4B only	53	Name plate, head cover
20	Oil charge and drain valve	54	Bolts, name plate
21	Oil relief valve	55	Gasket, name plate
22	Regulating valve, oil pressure	56	Assembly number, oil pump, consists of 56, 57 & 60
23	Bearing head	57	(discontinued number)
24	Gasket, bearing head	58	"O" ring, oil pump
25	Screw, bearing head	59	Gasket, oil pump
26	Cover plate	60	Bolts, each 6 p'cs, oil pump
27	Gasket, cover plate	61	Cylinder sleeve
28	Screws, cover plate	62	Cam ring, leftward sloped
29	Thrust bearing	63	Cam ring, rightward sloped
30	Washer, each 6 p'cs, thrust bearing	64	(discontinued number)
31	Screws, each 6 p'cs, thrust bearing	65	Retaining ring
32 *	Assembly number, shaft mechanical seal (including No. 33, 39, 41 & 42)	66	Gasket, cylinder
33	Shaft seal collar	67 *	"O" ring, cylinder sleeve for compound compressor high side only
34/38 *	Assembly parts, double seal collar for halocarbon refrigerants only	68	Lift pin
		69	Spring, lift pin
		70	Split pin, lift pin
		71	Suction valve

72	Spring, suction valve	145	Unloader piston
73	Valve plate	146	Cover, unloader piston
74	Cage guide, discharge	147	Gasket, unloader piston cover
75	Bolts, discharge cage guide	148 *	Seat, unloader piston cover, before 1971
76 *	Assembly number, connecting rod	149	Screw, unloader piston cover
77	Assembly number, connecting rod, needle bearing	150	Screw, allen headcap, unloader piston
78	Bolts, connecting rod	151/153	(discontinued numbers)
79	Washer, bolt	154	Strainer, suction
80	No. 1 nut,	155	(discontinued number)
81	No. 2 nut,	156	Screen, suction strainer
82	Bushing, connecting rod	157	(discontinued number)
83	Bushing, connecting rod, needle	158	Spring, suction strainer
84	Bearing half	159	Snap ring, suction strainer
85A	Piston, cast iron	160	(discontinued number)
85B	Piston, cast iron (white)	161	Cover, suction end
86	Pin, piston	162	Gasket, suction end cover
87	Lock spring, piston pin	163	Screw, suction end cover
88	Piston ring set	164	Glass, oil sight
89/98	(discontinued number)	165	"O" ring, oil sight glass
99	Oil ring	166	Gland, oil sight glass
100/107	(discontinued number)	167	Screw, oil sight glass gland
108 *	Assembly number, discharge valve set	168	Elbow, discharge
109	Cage, discharge valve	169	Gasket, discharge elbow, in low crankcase side
110	Discharge valve	170	Bolt, discharge elbow
111	Seat, discharge valve	171	Stop valve, air purging
112	Bolt, discharge valve seat	172	Gasket, discharge stop valve inlow
113	Nut, discharge valve,	173	Stop valve, discharge side
114	Nut with groove, discharge valve	174	Bolt, discharge stop valve
115	Split pin, discharge valve, before July 1969	175	Scale trap
116	Spring, discharge valve	176	Gasket, scale trap inlow crankcase side
117	Spring, safety head	177	Bolt, scale trap
118	Screen supporter, oil strainer	178	Screen, scale trap
119	Screen, oil strainer	179	Cover, scale trap
120	Screw, oil strainer	180	Gasket, scale trap cover
121	Cover, oil strainer	181	Screw, scale trap cover
122	Gasket, oil strainer cover	182	Stop valve, suction side
123	Screw, oil strainer cover	183	Bolt, suction stop valve
124 *	Stop valve, oil charge, before July 1969	184	Gasket, suction stop valve
125/134 *	Intermediate bearing, for 12B, 12-4B only	185 *	Assembly number, oil cooler
135/141	Push rod, unloader, Please inform length.	186/196	Oil cooler, (Parts not be supplied separately)
142	Spring, unloader device	197	Assembly number, thermometer, high side
143	Washer, push rod	198 *	Thermometer body, high side
144	Screw, push rod hub	199 *	Assembly number, thermometer, low side

- 200 * Thermometer body, low side
- 201 * Assembly number, thermometer, high stage
low side
- 202 * Thermometer body, high stage low side
- 203 * Assembly number, thermometer, low stage
high side
- 204 * Thermometer body, low stage high side
- 205 * Solenoid valve
- 206 (discontinued number)
- 207 * Valve, unloader
- 208 Hanger bolt
- 209 Assembly number, by-pass valve
- 210 * Oil pressure gauge, 75 mm dia.
- 211 * Oil pressure gauge, 100 mm dia.
- 212 * Nipple, oil gauge
- 213 * Safety valve, external
- 214 Plug, 3/4"

Remarks:

1. Please state the serial number of the compressor for which replacement parts are being ordered.
2. If the serial number is not available, it is necessary to indicate the compressor model number, the type of refrigerant used, and the date of the bill of lading for the compressor.
3. No. 77/83 connecting rod and No. 186/196 oil cooler will be supplied as assembly.
4. The parts number marked * in the index volume are not shown in the exploded drawing. These parts are for special application depending on the type of refrigerant used or other non-standard condition.

SERVICE MANUAL OF MYCOM MULTI-CYLINDER REFRIGERATION COMPRESSORS

TABLE OF CONTENTS

CHAPTER 1. CONSTRUCTION

1.	General Design	17
2.	Mechanism	17
2.1.	Gas compression mechanism	17
2.1.1.	Single stage compression	17
2.1.2.	Compound compression	17
2.2.	Safety head and mechanism of valves	18
2.3.	Unloader mechanism	18
2.4.	Lubrication mechanism	20
2.4.1.	Oil flow for model A	20
2.4.2.	Oil flow for model B	21
2.4.3.	Oil flow for model 12B & 12-4B	21
2.5.	Oil cooler	22
2.6.	Abnormal oil pressure protection	22
2.7.	Shaft seal mechanism	22
2.8.	Automatic control and protection device	23
2.8.1.	General	23
2.8.2.	OP Protection (Oil pressure failure protection switch)	24
2.8.3.	HP Protection (Abnormal high pressure protection device)	25
2.8.4.	LP Protection (Capacity control of compressor)	26
2.8.5.	Control panel	26
2.8.6.	Full automatic control of compressor	26
2.9.	Safety valve	27
2.10.	Oil tank for marine use	28

CHAPTER 2. INSTALLATION AND OPERATION

1.	Installation	29
1.1.	Delivery to the site	29
1.2.	Installation	29
1.2.1.	Installation work	29
1.2.2.	Belt drive	30
1.2.3.	Direct coupling	31
1.3.	Piping	31

1.4.	Cooling water	32
2.	Preparation for operation	33
2.1.	Test of electric connections for automatic control	33
2.2.	Test of switch connections	34
2.3.	Airtight test	34
2.4.	Refrigerant leak test	35
2.5.	Operation under no-load conditions	35
2.6.	Idle running test	36
2.7.	Charging of refrigerant	36
2.8.	Cooling operation	36
2.9.	Stopping operation	37
2.10.	Change of lubricating oil	37
2.11.	Automatic lubricating device	37
2.11.1.	General	37
2.11.2.	Automatic oil return device	37
2.11.3.	Automatic lubricating device	37

CHAPTER 3. DISASSEMBLY AND ASSEMBLY

1.	Disassembly	38
1.1.	Stopping operation	38
1.1.1.	Routine checking	38
1.1.2.	Trouble and repairing	38
1.1.3.	Purging refrigerant	38
1.2.	Preparation for disassembly	39
1.3.	Notes on disassembly	39
1.4.	Removal of water piping	39
1.5.	Removal of head cover	40
1.6.	Removal of head spring	41
1.7.	Discharge valve (assembly)	41
1.8.	Suction valve (assembly)	41
1.9.	Unloader mechanism	42
1.10.	Oil cooler	43
1.11.	Handhole cover	44
1.12.	Disassembly of cylinder sleeve and piston	44
1.12.1.	Cylinder sleeve	45
1.12.2.	Piston and connecting rod	45
1.12.3.	Piston ring	45
1.13.	Shaft seal section	45
1.13.1.	Shaft seal collar	47
1.13.2.	Thrust bearing	48
1.13.3.	Bearing head	48
1.14.	Oil pump	48

1.14.1.	Drag crank	48
1.15.	Crank shaft	48
1.15.1.	Model A & B	48
1.15.2.	Model 12B & 12-4B	48
1.16.	Main bearing head	50
1.17.	Strainer	50
2.	Assembly	51
2.1.	Checking parts	51
2.2.	Assembly of main bearing and main bearing head	51
2.3.	Installation of crankshaft, Model A & B	51
2.4.	Installation of crankshaft, Model 12B & 12-4B	51
2.5.	Bearing head and thrust bearing	52
2.6.	Shaft seal	52
2.7.	Oil pump	53
2.8.	Cylinder section	53
2.8.1.	Piston	53
2.8.2.	Connecting rod	53
2.8.3.	Cylinder sleeve	55
2.9.	Installation in casing	55
2.10.	Unloader mechanism	55
2.11.	Valve plate	56
2.12.	Fitting	56
2.13.	Confirmation of idle running	57
2.14.	Discharge valve (assembly)	57
2.15.	Mounting parts	57
2.16.	Jacket piping	57
2.17.	Final inspection	57

CHAPTER 4. OPERATION OF TWO STAGE COMPRESSION

1.	Preface	58
2.	Operation	58
2.1.	Operation of newly installed equipment	58
2.2.	Preparation for operation	58
2.3.	Refrigerant charge	59
2.3.1.	Initial charge	59
2.3.2.	Chargeing special conditions	60
2.4.	Cooling operation	61
2.5.	Operation of compound compression	61
2.6.	Stopping operation	62
2.6.1.	Temporary stopping	62
2.6.2.	Extended stopping	62
2.6.3.	Routine checking	62

CHAPTER 5. SUPPLEMENTS

1.	Troubles and remedies	63
2.	Compressor troubles	66
3.	Relation between discharge gas temperature and operating pressure	66
4.	Monitoring refrigerating operation	68
5.	List of saturation temperature and gauge pressure	70
6.	Insufficient temperature drop	70
7.	Troubleshooting and overhaul	71
8.	Standards for changing parts	71
8.1.	Compressor oil in the crankcase	71
8.2.	Suction strainer, oil strainer & cuno-filter	71
8.3.	Crankshaft	71
8.4.	Shaft seal parts	71
8.5.	Piston, piston pin & piston ring	71
8.6.	Connecting rod	72
8.7.	Cylinder sleeve	73
8.8.	Discharge valve & suction valve	73
8.9.	Oil pump	73
8.10.	Free length of springs	73
8.11.	Main bearing & thrust bearing	73
8.12.	Gaskets	73
8.13.	Bolts	73
9.	Selection of compressor oil	73
10.	Piston ring	74
11.	Hand tools	75
12.	Pipefittings	76

INDEX OF FIGURES

	MYCOM multi-cylinder refrigeration compressors (for land use)	1
	MYCOM multi-cylinder refrigeration compressors (for marine use)	1
	Standing dimensions	2
	Compressor assembly, sectional view	4
	Cylinder assembly, exploded view	5
	Compressor assembly, exploded view	6
	Parts list	7
Figure	1. Compression mechanism	17
	2. Sectional view of compound type, crankcase	18
	3. Sectional view of valve mechanism	18
	4. Unloader mechanism	19
	5. Unloader mechanism in unloaded condition	19
	6. Unloader mechanism in loaded condition	19
	7. Standard type unloader cover and manual valve	19
	8. Oil pump assembly	20
	9. Oil pump assembly for 12B & 12-4B	20
	10. Compressor rotation direction plate	20
	11. Oil pumping sequence	20
	12. Oil flow chart for Model A	20
	13. Cuno-filter mechanism	21
	14. Oil flow chart for Model B (since July 1969)	21
	15. Oil piping of Model B	21
	16. Oil level standard through oil sight glass	21
	17. Oil flow chart of Models 12B & 12-4B	22
	18. Exploded drawing of oil sight glass	22
	19. Oil cooler Type A	22
	20. Oil cooler Type B	22
	21. Oil relief valve	22
	22. Oil pressure adjusting valve	22
	23. Sectional view of shaft seal, Type A	23
	24. Sectional view of shaft seal, Type B	23
	25. SL-12, control system	24
	26. SH-11, control system	24
	27. Oil pressure failure protection switch (O.P.)	25
	28. Abnormal high pressure protection switch (H.P.)	25
	29. Low pressure control switch (L.P.)	26
	30. Automatic control flow chart of multiple compressor	26
	31. Integrating type controller	27
	32. Remote, automatic control panel	27
	33. Safety valve	27

34.	Oil tank, lower mounting type for marine use	28
35.	Oil tank, side mounting type for marine use	28
36.	Centering for belt drive	29
37.	Centering the coupling	30
38.	Radial coupling (exploded)	30
39.	Radial coupling (sectional)	30
40.	Setting radial coupling	31
41.	Measuring axial center	31
42.	Compressor piping	32
43.	Cooling water piping of compressor	33
44.	Test of working condition of suction valve	36
45.	Model automatic lubrication system	37
46.	Float valve for automatic oil return-type oil separator	37
47.	Float valve for automatic oil supply	38
48.	Method of removing flywheel	39
49.	Crankshaft without flywheel	39
50.	Standard cooling water flow chart (Jacket head cover)	40
51.	Jacket head cover Type B	40
52.	View after head cover is removed	41
53.	How to remove discharge valve assembly	41
54.	Discharge and suction valve assembly	41
55.	Cylinder sleeve and unloader mechanism	42
56.	Sequence of unloader and cylinder sleeve	42
57.	Removal of push rod	43
58.	Cylinder number marks (case side)	43
59.	List of unloader push rod	43
60.	Removing oil cooler	44
61.	Removal of rod cap	44
62.	Removing piston and cylinder	44
63.	Removing piston in improper position	44
64.	Removing from sleeve	44
65.	Assembly number of connecting rod	45
66.	Removing rings	45
67.	Shaft seal section, Type A	46
68.	Shaft seal section, Type B	46
69.	Shaft seal section, Type 12B & 12-4B	46
70.	Shaft seal without cover plate	47
71.	Removing locknuts	47
72.	Removing seal cover	47
73.	Double seal collar	48
74.	Removing seal ring	48
75.	Main bearing section, Type A	49
76.	Main bearing section, Type B	49

77.	Main bearing section, Type 12B & 12-4B	49
78.	How to pull out crankshaft, Type 12B & 12-4B	50
79.	Mediate bearing, Type 12B & 12-4B	50
80.	Removal of suction strainer	51
81.	Oil strainer	51
82.	Main bearing head, Type B	51
83.	How to set locknut	52
84.	Measuring thrust gap	53
85.	Arrangement of rings	53
86.	Mark on ring	53
87.	Assembly numbers for connecting rod	54
88.	Bushing and piston pin of connecting rod	54
89.	Piston, connecting rod and crankshaft (sectional)	54
90.	An example of incorrect assembly	55
91.	How to insert piston into sleeve	55
92.	Assembly makes of sleeve setting	56
93.	Push unloader piston with eye-bolt	56
94.	Test of discharge valve	57
95.	Installing head cover	57
96.	Compound compressor system	58
97.	Piping flow chart of two stage compression	59
98.	Diagram of relation between discharge gas temperature and operating pressure	67
99.	Connecting rod and bearing halve	72
100.	Bearing tolerance	72

SERVICE MANUAL OF MYCOM MULTI-CYLINDER REFRIGERATION COMPRESSOR

CHAPTER 1. CONSTRUCTION

1. General Design

The Mycom multi-cylinder compressor is small and lightweight, and reduces required floor space and weight per unit of refrigerating capacity. It is so designed that capacity control is achieved automatically by an unloader mechanism which is operated by regulating the suction pressure. In starting, the load is automatically reduced by this mechanism, enabling the compressor to start with minimum torque. The load is applied only after the compressor attains its working speed, thus reducing the load on the motor. This means that it can be operated by a motor of smaller capacity than any of its counterparts.

Its speed is 3 to 4 times that of the vertical compressor but its operation is comparatively noiseless thanks to the dynamic balancing system employed. Various refrigerants can be used simply by changing a few parts.

Mycom compressors are divided into two series. One is model A having 3.75" bore and 3" stroke, and the other is model B having 5.125" bore and 3.9375" stroke. These are also divided into two types: single stage and two stage (compound). The construction of the compound compressor is the same as that of the single stage compressor except that the former has two discharge and suction sections.

All parts are fabricated by the limited gauge system and are interchangeable. The replacement of parts can be achieved in a matter of minutes during periodic inspection or when repairs are necessary. All products are shipped only after severe factory performance tests.

Please note, however, that this compressor's superior characteristics cannot be displayed if it is not properly handled. Careful reading of this operating manual will insure correct operation and maintenance of Mycom compressors.

2. Mechanism

2.1. Gas compression mechanism

2.1.1. Single stage compression (Ref. Fig. 1)

The refrigerant vaporized in the evaporator, enters the scale trap (2) through the suction stop valve (1) of the compressor, where scale is removed by a screen installed inside the trap. It then passes through the suction strainer (3) and enters the crankcase suction chamber (4). When the piston (5) starts a suction stroke, the pressure in the cylinder sleeve (6) drops, allowing the gas in the suction chamber to enter the cylinder after pushing up the suction valve (7). When the piston begins its upstroke, the suction valves are closed and the gas is compressed. When the gas pressure becomes higher than the pressure in the discharge section, it pushes up the discharge valves (8) and the

compressed gas is sent into the discharge section. It is then discharged through the discharge elbow (9) and sent to the condenser.

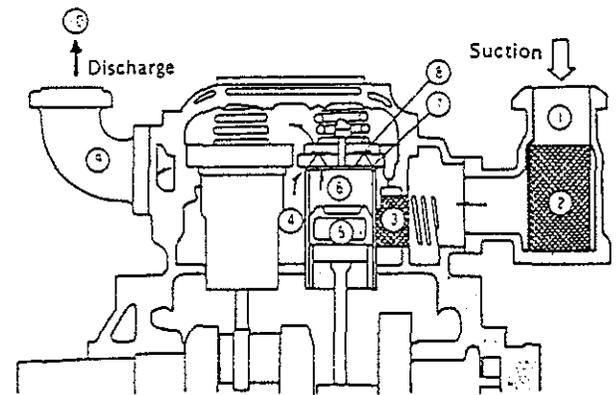


Fig. 1 Compression mechanism

Models A & B are of the same construction

2.1.2. Compound compression

(Two stage compression by a single compressor)

The compound compressor is constructed with two suction chambers and two discharge ports and the interior is divided into two divisions in order to perform the functions of two single stage compressors.

Two cylinders of the compressor function as the high stage while, depending on the size of the compressor, the other four or six cylinder work as the low stage. Viewed from the oil pump side, the low stage cylinders are on the right side of the compressor. (Ref. Fig. 2) The suction chamber and the crankshaft chamber are connected by a pressure equalizing hole of 6mm dia. and another 5mm dia. hole is found between the bottom of the suction gas chamber and the crankshaft chamber which serves as a drain for oil returned from the evaporator and to prevent foaming.

The high stage side is located on the same side as the oil cooler. The high side suction chamber is separated from the low side suction chamber by a wall and airtightness is maintained by the use of an "O" ring in the lower end of the cylinder sleeve. The cylinder is thus sealed off from the crankshaft chamber as this suction chamber reaches a mediate evaporative pressure during operation.

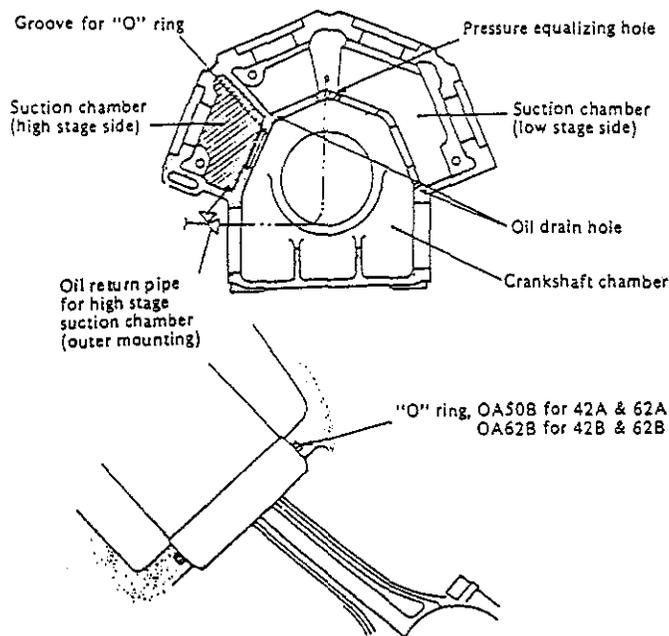


Fig. 2 Sectional view of crankcase, compound type

From the oil drain in the high side suction chamber piping is led to the low stage suction chamber for the purpose of cycling any oil which collects in the high side chamber. This flow is regulated by a manually operated stop valve. Oil from the high side passes to the low side and thence to the crankcase through the oil drain at the bottom of the low side suction chamber. The pressure differential between high and low sides pushes the oil through the pipe. Care should be taken not to open the stop valve more than a quarter turn as this may result in gas of medium pressure flowing into the low side. Please note however that if the valve is completely closed the high side suction chamber will fill with oil and oil hammering will occur.

Special note should be taken that when a compound compressor is being used for single stage operation it is necessary to reduce the pressure in the low stage suction chamber periodically in order to permit accumulated oil in the high side to flow to the low side.

2.2. Safety head and valve mechanism

The safety head spring is compressed between the head cover and the discharge valve assembly. It serves to prevent damage resulting from liquid hammer caused by refrigerant, oil, or foreign matter entering the cylinder by absorbing abnormal pressure.

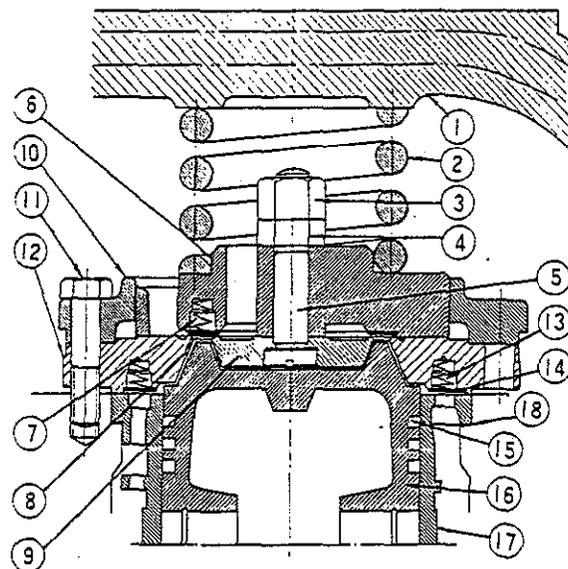


Fig. 3 Sectional view of valve mechanism

1. Head cover
2. Safety head spring
3. No. 2 nut, discharge valve
4. No. 1 nut, discharge valve
5. Bolt, discharge valve fastening
6. Cage, discharge valve
7. Spring, discharge valve
8. Discharge valve
9. Discharge valve seat
10. Cage guide, discharge valve
11. Bolt, discharge valve cage guide fastening.
12. Valve plate
13. Spring, suction valve
14. Suction valve
15. Piston ring
16. Piston
17. Cylinder sleeve
18. Gasket, cylinder sleeve

2.3. Unloader mechanism

Operation of the mechanism is controlled hydraulically by means of either a manual valve or a solenoid valve. Fig. 6 shows the unloader mechanism in a loaded condition, oil pressure being applied to its piston. Figure 5 shows the unloaded condition of the mechanism where no oil pressure is applied and the piston is pushed back by spring force. The push rod then begins to operate, rotating the cam ring right to left.

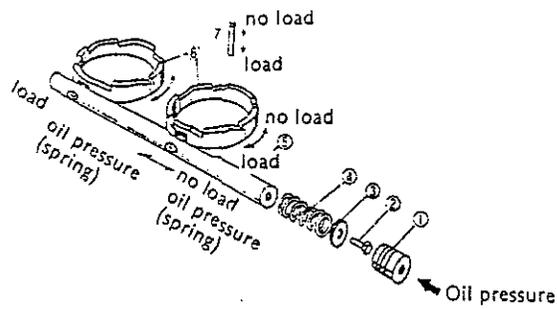


Fig. 4 Unloader mechanism

1. Unloader piston
2. Allen screw, push rod
3. Washer, push rod
4. Spring, unloader device
5. Unloader push rod
6. Cam ring
7. Lift pin

The cam ring has a slant cut and lift pin producing vertical movement along the slant face. The lift pin pushes up the suction valve on the upper surface of the sleeve.

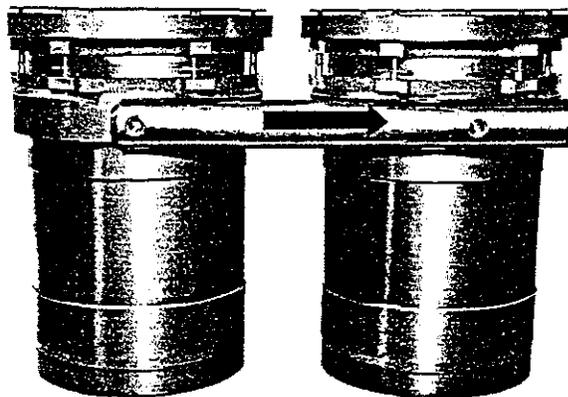


Fig. 5 Unloader mechanism in unloaded condition

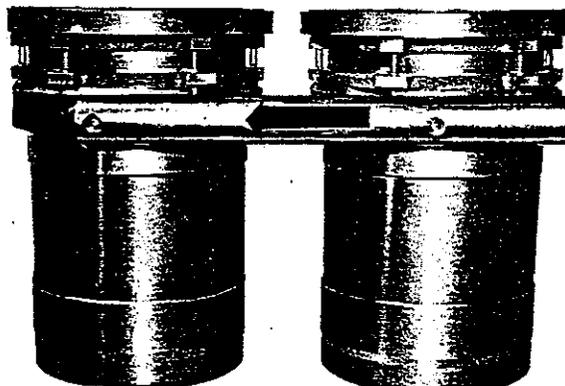


Fig. 6 Unloader mechanism in loaded condition

Consequently, gas escapes to the suction side even if the piston starts compression strokes. This indicates that the unloader mechanism is in an unloaded condition (Ref. Fig. 5).

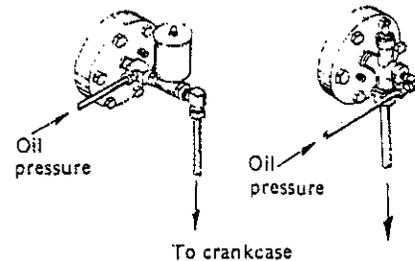
On the contrary, when the lift pin is lowered and the valve is operating on the seat surface, the unloaded mechanism is in a loaded condition (Ref. Fig. 6).

As oil pressure from the oil pump is applied to the unloader mechanism through a throttle nozzle, the unloader mechanism returns to an unloaded condition if the oil pressure is released by closing the manual valve or opening the solenoid valve while it is operating.

Since 1968, the support ring has been omitted so it is not necessary to disassemble the unloader section at the time of disassembly of the cylinder section. This revised type has a mark on the inspection marking surface of the crankcase body.

The unloader piston cover (Ref. Fig. 7) has a manual valve or a solenoid valve mounted externally.

- (1) Unloader solenoid valve (2) Unloader manual valve



- (1) Solenoid valve operation
 load by closing
 no load by opening
- (2) Manual valve operation
 load turn to right
 no load turn to left

Fig. 7 Standard type unloader cover and manual valve

The unloader piping of models 12B and 12-4B is internal and a special piston cover is utilized as shown in Fig. 8. Unloading is achieved by opening the manual valve or solenoid valve while loading is achieved by the closing of these valve.

Capacity control for single stage operation is directly proportionate to the displacement volume, while for a compound or two-stage operation it is reduced by the displacement volume of the low stage side. The ratio of displacement volumes of the high stage and the low stage changes as follows.

- 62A, 62B L:H = 3:1 - 2:1 - 1:1
 42A, 42B L:H = 2:1 - 1:1

2.4. Lubrication mechanism

Lubrication oil is pressure-fed and circulated by means of an oil pump (Fig. 8) employing a trochoid gear. The pump is driven directly off the crankshaft. An arrow on the outer rim of the pump assembly indicates direction of rotation.

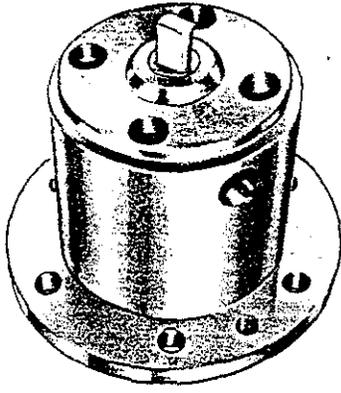


Fig. 8 Oil Pump assembly

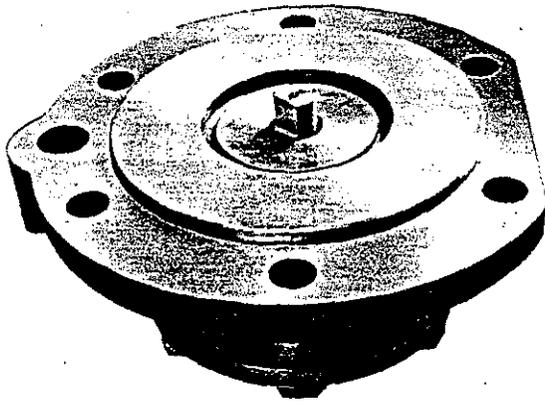


Fig. 9 Oil pump assembly for 12B & 12-4B

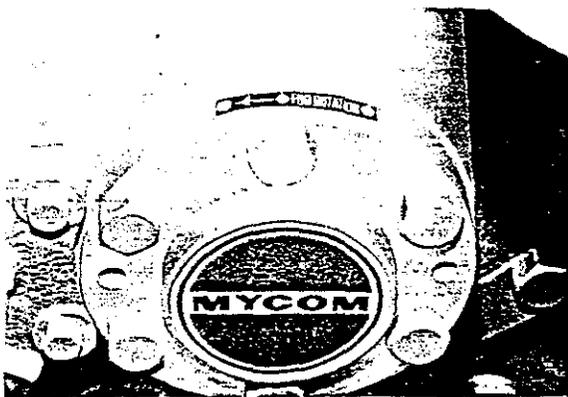


Fig. 10 Compressor rotation direction plate

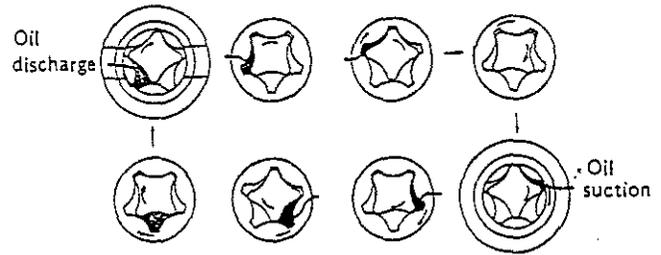


Fig. 11 Oil pumping sequence

2.4.1. Oil Flow for Model A

Lubricating oil from the crankcase is drawn through the oil strainer by the pump and then force-fed to a multiplate type cuno-filter. (Compressors for marine use are equipped with an oil tank which feeds the oil pump except for model 2A which functions in the same manner as the standard compressor.)

Oil from the cuno-filter follows two paths; one for lubricating the compressor, and the other for operating the unloader mechanism. Lubricating oil passes through the oil cooler and thence to the crankshaft seal. From the seal, the oil passes through the thrust bearing and crankshaft where it lubricates the connecting rod bearings and main bearing.

The oil pressure regulating valve is mounted at the extreme end of the lubricating path. Thus the oil pressure gauge indicates a pressure slightly lower than that at the main lubricating points along the path. The pressure differential of pump outlet and oil pressure regulating valve is approx. 0.5 kg/cm^2

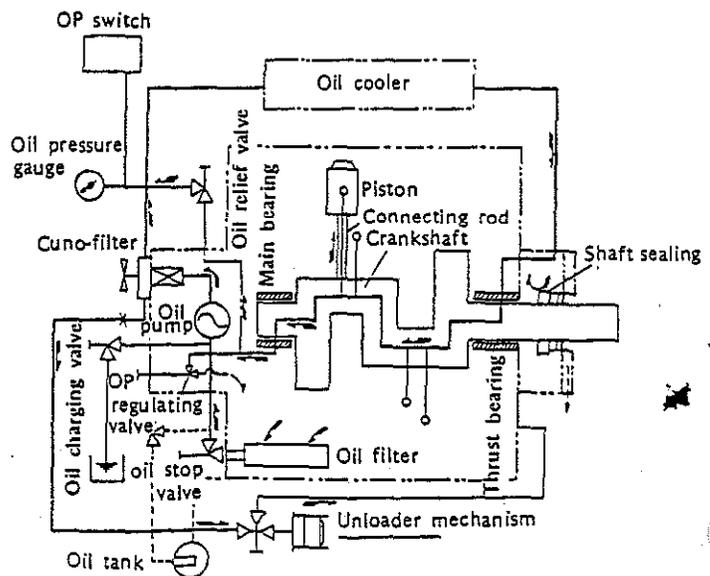


Fig. 12 Oil flow chart for model A

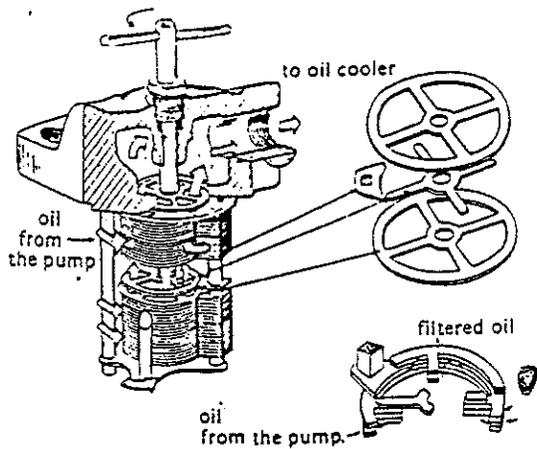


Fig. 13 Cuno-filter mechanism

2.4.2. Oil flow for Model B

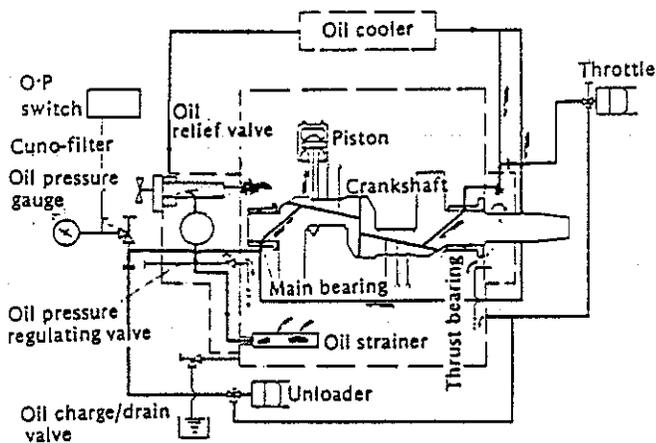


Fig. 14 Oil flow chart for model B (since July 1969)

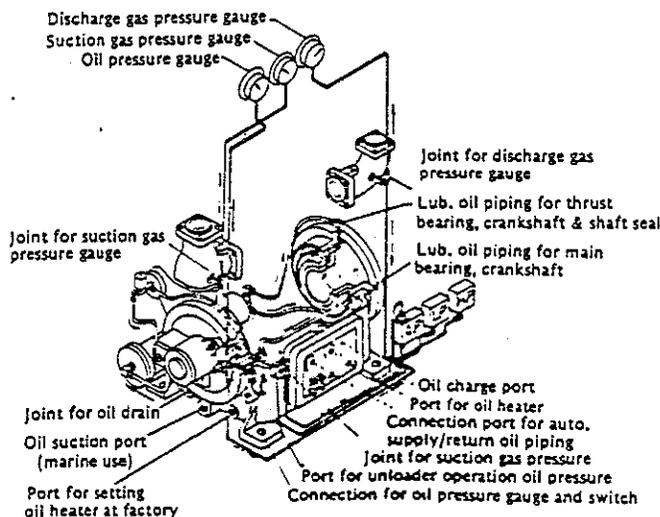


Fig. 15 Oil piping of model B

a) Oil level in the crankcase may be checked by means of the oil sight glass mounted on the handhole cover. The handhole cover may be exchanged when necessary to facilitate easy viewing of the sight glass.

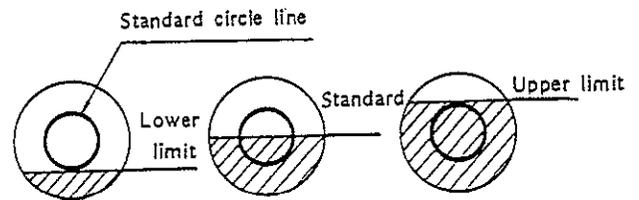


Fig. 16 Oil level standard through sight glass

Initial oil quantity

(ℓ)

Model	2A	4A	6A	42A	8A	62A
Upper limit	6.5	16.0	16.6	16.6	19.8	20.6
Standard	5.0	13.5	11.9	11.9	16.3	16.9
Lower limit	3.5	10.5	7.5	7.5	13.0	13.4
Oil tank volume	—	30.0	30.0	30.0	35.0	35.0

4B	6B	42B	8B	62B
24.9	29.8	30.7	31.2	32.1
19.8	24.0	25.4	25.6	26.2
15.4	19.4	19.7	20.3	20.9
40.0	45.0	46.0	50.0	50.0

b) Oil can easily be charged from the charging mouth, even while the compressor is in operation, if the internal pressure of the crankcase is less than 0 psig (0 kg). When the internal pressure of the crankcase is high, there is a possibility of oil flow-back so care should be taken.

In case of liquid flowback, close the suction stop valve slightly and after checking that the pressure in the crankcase has dropped, charge the oil. Put the oil charging hose deep enough into the oil tank to prevent air being sucked in.

The drum to be used for charging oil must be kept clean. If residue of other oil type remains in the drum, it may be the cause of future trouble.

2.4.3. Oil flow for model 12B and 12-4B

This oil flow system is similar to the model B system, but a mid-bearing on the crankshaft is also lubricated. Therefore the oil flows from the center to the ends of the crankshaft through internal paths and holes inside the crankcase. See figure 18.

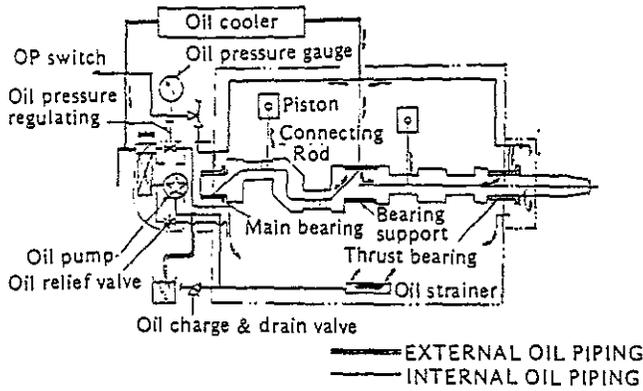


Fig. 17 Oil flow chart of model 12B & 12-4B

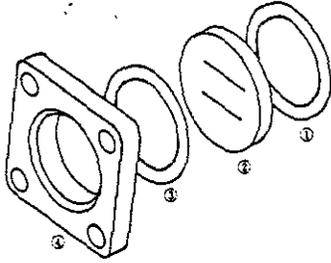


Fig. 18 Exploded drawing of oil sight glass

- (1) "O" ring
- (2) Oil sight glass
- (3) "O" ring
- (4) Gland, oil sight glass

2.5 Oil cooler

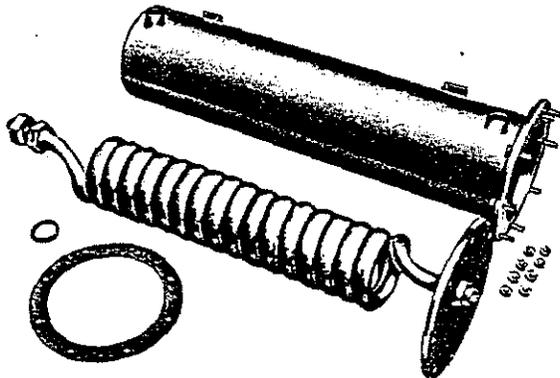


Fig. 19 Oil cooler, Type A

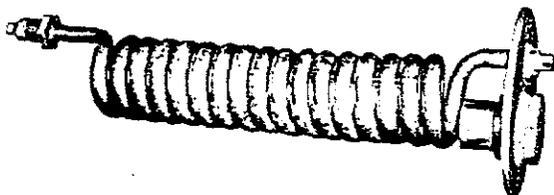


Fig. 20 Oil cooler, Type B

Both type A and type B employ a shell & coil type oil cooler as shown Figure 19 and 20.

The quantity of cooling water required is more than 30 L/min. (The quantity is determined by the water temperature.) Keep the oil temperature under 45°C at the oil cooler outlet. The oil coolers of 12B and 12-4B employ the shell & coil system with 4 passes, and have sufficient cooling capacity even though small in size.

A compressor oil must be used otherwise viscosity of oil will deteriorate at low temperature and will not lubricate sufficiently.

2.6. Abnormal oil pressure protection

All models are equipped with an oil pressure regulating valve for abnormal oil pressure protection on the rear side of the cuno-filter chamber. It exhausts any abnormal high oil pressure resulting from high viscosity at start up.

If the oil pressure cannot be raised after the safety valve has released, dust may have clogged the valve seat. In such case, check valve operation once again or remove the valve and clean.

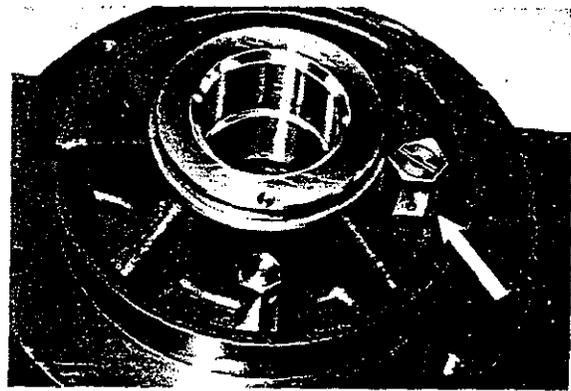


Fig. 21 Oil relief valve

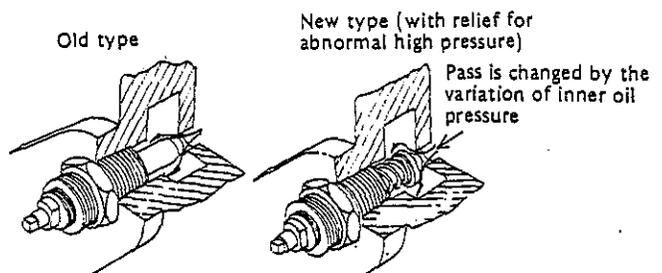


Fig. 22 Oil pressure adjusting valve

2.7. Shaft seal mechanism

The shaft seal mechanism (Figs. 23 & 24) is a simple and efficient sealing device consisting of a shaft seal collar (7), shaft seal ring (5) and "O" rings (6 & 8). The shaft seal collar is fixed to the shaft by a locking ball (9) and thus rotates with the crankshaft. The seal ring is locked to the cover plate by a roll pin (3) and alignment of the friction surfaces of these two parts is assured by the installation of a helical spring (4). The seal is pressure-fed by oil from the pump and is sealed by "O" rings and a lapped friction surface. Leakage of refrigerant and oil is completely eliminated.

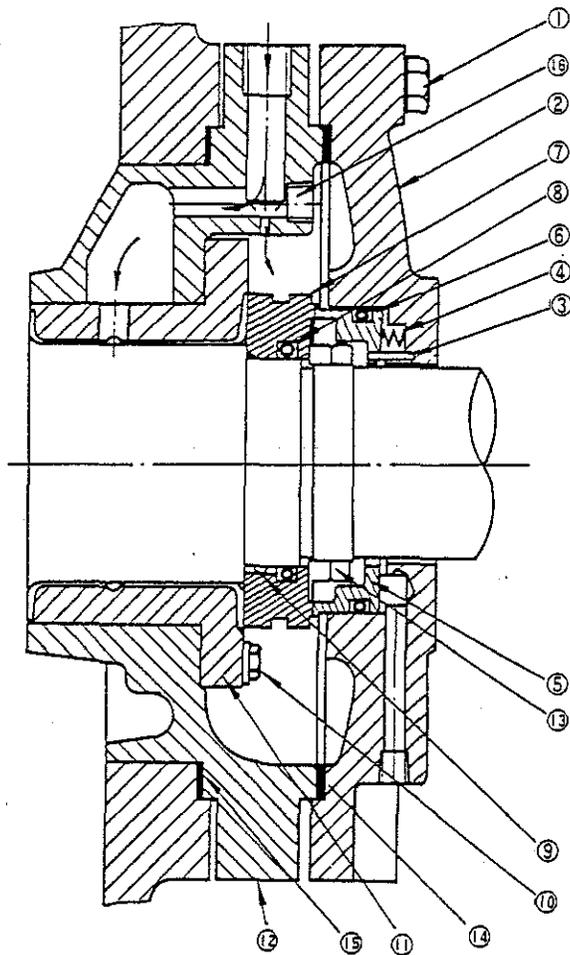


Fig. 23 Sectional view of shaft seal type A

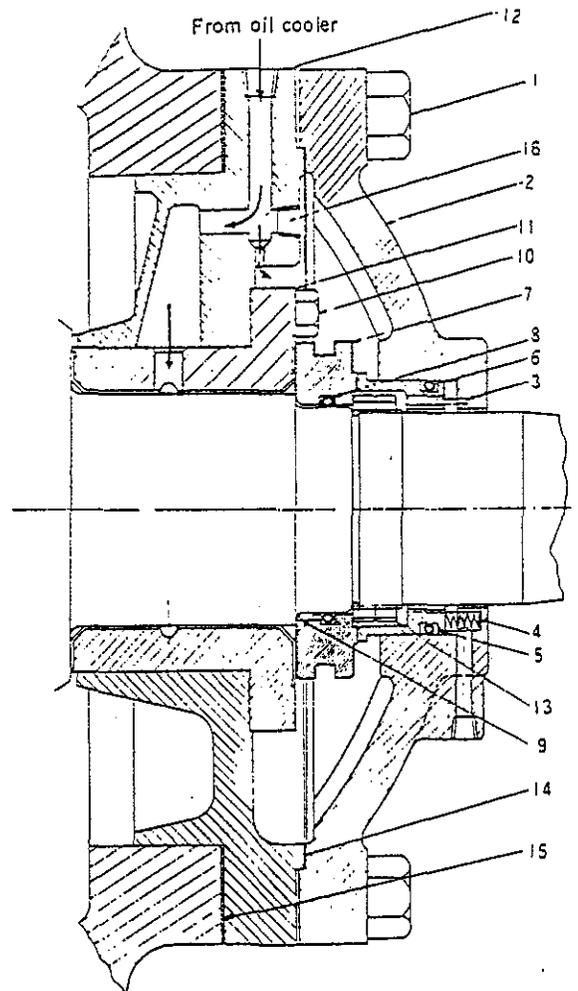


Fig. 24 Sectional view of shaft seal type B

1. Bolt, cover plate
2. Cover plate
3. Roll pin
4. Helical spring
5. Shaft seal ring
6. "O" ring, shaft seal ring
7. Shaft seal collar
8. "O" ring, shaft seal collar
9. Locking ball
10. Screw, thrust bearing
11. Thrust bearing
12. Bearing head
13. Locknut
14. Gasket, cover plate
15. Gasket, bearing head
16. Blind plug

2.8. Automatic control and protection devices

2.8.1. General outline

Automatic control of Mycom compressors is achieved by the control of compressor capacity.

Capacity is controlled by the regulation of pressure on the suction side or by a temperature sensing regulation device, the former being the standard method. Other control systems are available for (1) automatic starting and stopping and regulation of capacity from 0 through 100%, and

(2) for regulation of the capacity by use of the unloader mechanism.

This second control system differs from the standard unloader mechanics in that the compressor is always in an operating condition and does not stop.

The following chart indicates the code designations of Mycom automatic control systems.

First letter	Second letter	Third letter	Fourth letter
Control method	Motor	Control stage	Control voltage
M Manual	H High voltage	1	1 100V
S Semi-automatic	L Low voltage	2	2 200V
F Full-automatic	D DC	3	
	I Internal combustion engine		

S	Disconnect switch	SLh	Manual switch for SV
MS	Magnetic switch	SV	Solenoid valve
MC	Magnetic coil	LH	Pilot light for HP
OR	Overload current relay	LO	Pilot light for OP
M	Motor	LV	Pilot light for SV
SP	Pushbutton	RO	DC resistance for pilot light
ON	Switch on	DS	Disconnect switch
OFF	Switch off	OCB	Oil circuit breaker
HP	High pressure protection switch	A	Ammeter
OP	Oil pressure failure protection switch	NV	No load relay
LP	Low pressure control switch	PB	Pushbutton
SH	Changeover switch	PT	Potential transformer
SL	Changeover switch	CT	Current transformer
⊙	Terminal	SM	Starting interlock

Figure 26 shows a connection diagram of the control system of type SH-11 for semi-automatic operation (operated by a high-voltage motor) with a control voltage of 100 volts, single-stage control.

The potential transformer (PT) for the oil circuit breaker (OCB) is generally designed to supply power only for the pilot light and the no-load relay (NV). Avoid using it for control of the compressor side as it will cause a short circuit of power to the light relay.

2.8.2. OP Protection (Oil Pressure Failure Protection Switch)

When the compressor operates at high speed, its moving parts must be lubricated sufficiently. Lubricating oil is fed to the moving parts under suitable pressure by the oil pump.

Compressor trouble caused by improper lubrication due to a shortage of lubricating oil, or oil pressure failure resulting from mixing of refrigerant in the oil are prevented by this switch.

The oil pressure gauge connected to the discharge side of the oil pump indicates the apparent oil pressure. The actual oil pressure (P) is equal to the apparent pressure (GO) less the pressure in the crankcase (GL). It is desirable that this oil pressure should be maintained at a fixed value for the normal performance of the compressor. Oil pressure failure not only causes improper lubrication of moving parts but also makes the unloader mechanism inoperative, since this is designed to operate by oil pressure.

The switch (OP) is composed of 2 sets of bellows, one of which is connected to the crankcase side, the other being connected to the discharge side of the oil pump. The two bellows work individually and in case the actual pressure does not reach the specified value 17–28 psi (1.2–2 kg), the auxiliary lever contact is held in a closed state, the heater connected to it in series is heated, and after a lapse of 60 to 90 seconds, the bimetallic mechanism operates to open the contact lever. The compressor then stops automatically.

Resetting of this contact lever is done manually. Investigate the causes of the stoppage thoroughly and after correcting them start the compressor again by pushing the reset button. This time delay mechanism is a temperature type,

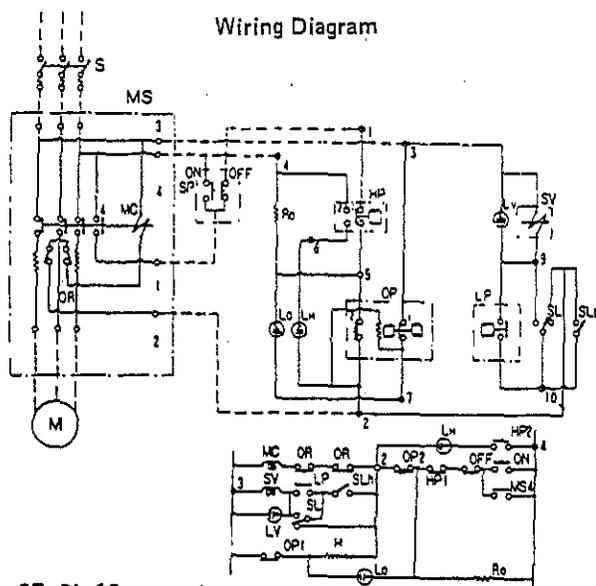


Fig. 25 SL-12 control system
(Semi-automatic, low voltage motor, single stage control 200/220 volt control voltage.)

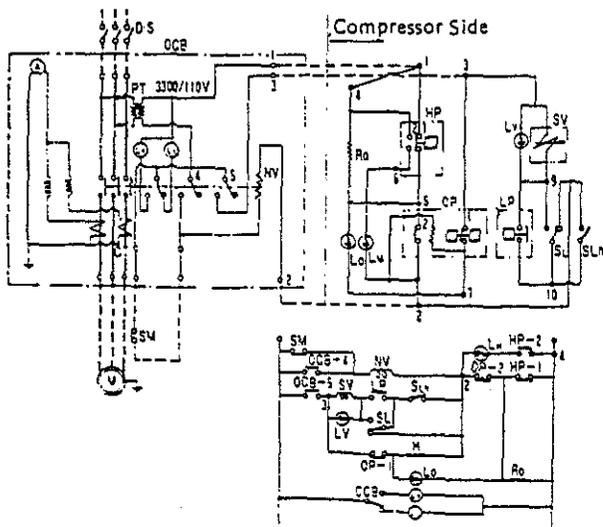


Fig. 26 SH-11 control system
(Semi-automatic, high voltage motor, single stage control 100/110 volt control voltage.)

so it does not return to normal temperature instantly once it is released. If operation is continued, the heater is warmed until the oil pressure rises once again. As a result of this, the point of contact lever opens again and the compressor stops automatically. It will seem as though the switch order. In this case, operate the compressor with the control panel switch on the manual side and return it to the automatic side when the bimetallic mechanism has cooled down, or start operation again as soon as the bimetallic mechanism has cooled down, with the switch on the automatic side.

Adjustment of the time delay is done at the factory prior to shipment. Adjustment at site is not desirable. The pressure limit for the bellows is 214 psig (15 kg) and this should be borne in mind in airtight tests carried out in the field.

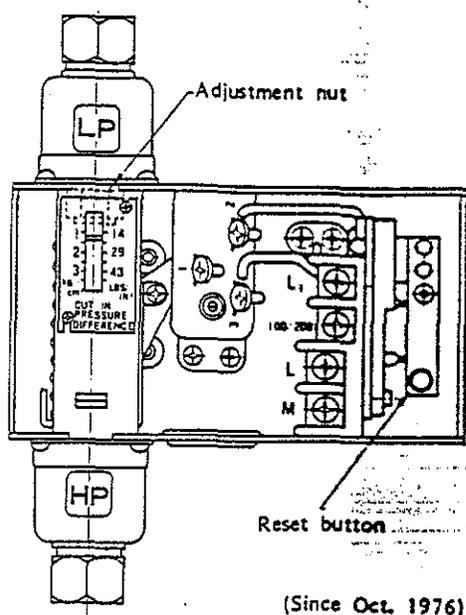


Fig. 27 Oil pressure failure protection switch (OP)

2.8.3. HP protection (Abnormal high pressure protection device).

This device prevents malfunction caused by abnormally high pressure on the discharge side (GH) of the compressor as a result of interruption of cooling water to the condenser (CO), malfunctioning of valves on the discharge side etc. The switch works to open the magnetic switch (SM) and stop the motor (M) just before the safety valve works.

This switch, with a bellows type power element, is designed to open or close the electric circuit by an increase or decrease of pressure applied to the bellows. If the pressure on the discharge side of the compressor becomes abnormally high due to a malfunction of the compressor, the interruption of the cooling water supply to the condenser, or other reasons; it brings the compressor to an immediate stop by cutting the electric circuit, thereby preventing accidents or explosion. The working pressure is increased by turning the larger adjustment nut (A) to the right, and is decreased by turning it to the left.

Adjustment of the difference in working pressure is accomplished with the smaller adjustment nut (B); it is increased by turning it to the right and decreased by turning to the left. As the circuit does not return automatically from its function as a safety device, reset it to starting position with the reset handle. When the compressor stops automatically as a result of HP investigate the cause and after remedying, pull the reset handle and start the compressor again.

The working pressure of the switch should be higher than the normal operating pressure but lower than the working pressure of the safety valve of the compressor. The safety device should be regulated so as to operate before the safety valve is put into operation by abnormally high pressure. To inspect the working pressure of this switch, adjust the scale to the operating pressure by turning the adjustment nut; then calibrate and adjust the working pressure of the switch so as to make the switch work at the specified pressure, or close the suction stop valve after reducing the compressor capacity to a minimum by the unloader mechanism and close the discharge stop valve carefully (referring to the pressure indicated by the pressure gauge on the discharge side) and then inspect the operation.

Special care should be taken as the pressure on the discharge side is being boosted intentionally. Careless handling will cause problems.

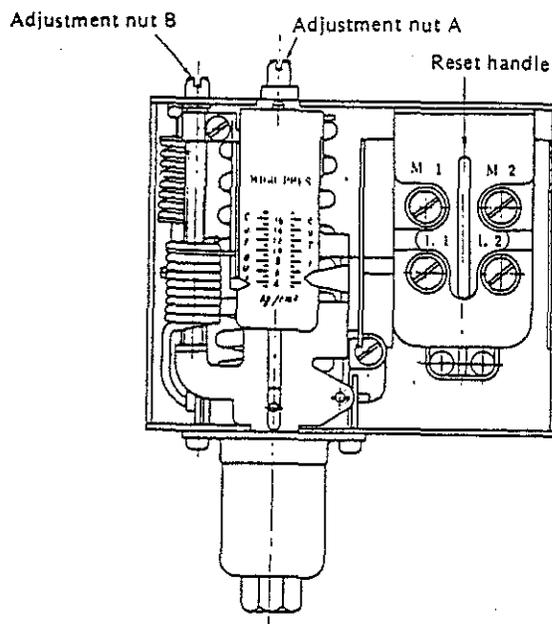


Fig. 28 Abnormal high pressure protection switch (HP)

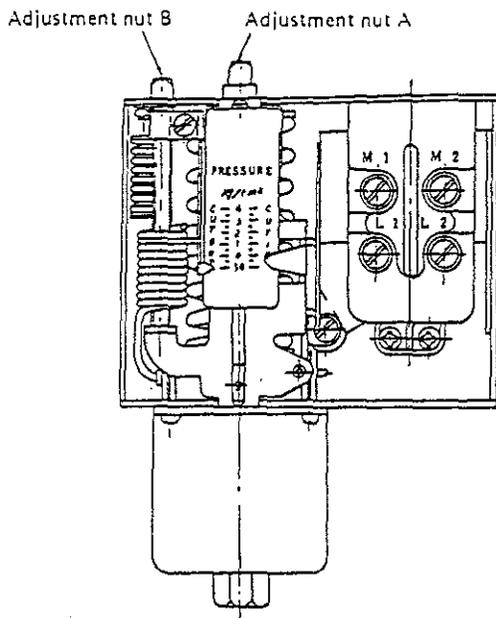


Fig. 29 Low pressure control switch (LP)

2.8.4. LP control (Capacity control of compressor)

The steps of capacity control are decided by the number of cylinders.

Standard steps:

Number of cylinders	Bank	Steps
8	2	3
6	2	2
4	1	1

If the load variation is small and/or more than one compressor is used for one installation, it is not necessary to employ of the control steps as above, because increasing the number control steps only serves to complicate the control devices and make adjustment difficult.

It can be said that the starting and stopping of the compressor are also a form of capacity control. It is possible to operate the compressor with full automation according to the suction side pressure.

Capacity control is achieved by the measurement of the suction side pressure by a low pressure control switch, which automatically controls the open/close cycle of the solenoid valve which is connected to the unloader piston of the capacity control mechanism.

The working pressure can be made higher by turning the adjustment nut A of the low pressure control switch to the right, and lower by turning to the left.

The working pressure difference becomes small by turning the adjustment nut B to the right.

By comparing the suction side pressure of the compressor and gradually closing the suction stop valve, the low pressure control switch works and opens the solenoid valve, and the compressing of this bank stops as a result of dropping oil pressure on the unloader piston. At the same time the indication lamp lights up and the loading current of the motor is reduced.

2.8.5. Control panel

With the standard type, the control panel is placed near the oil pressure high and low switches. The levers for these switches on the control panel must be set to automatic while the compressor is in operation. If you fail to do this, automatic protection of the compressor against oil pressure failure or abnormal increase of the pressure on the discharge side becomes impossible and may lead to trouble.

When the compressor stops automatically with the action of the high pressure protection switch, the pilot light for the switch goes on indicating that the switch is in operation. When the compressor is stopping due to oil pressure failure, the pilot light for the switch goes on. In other words, when the oil pressure and discharge pressure are in normal condition, the lights are off. Pilot lights are turned off by throwing the switches to the manual side, and the compressor can be started. However, to purge refrigerant out of the compressor, to supply oil or to operate the compressor when there is trouble with the protection device, it is sometimes convenient to operate it manually by changing these switch-levers from "Automatic" to "Manual". When the malfunction has been remedied, these switch-levers must be reset to the "Automatic" position.

The control panel, in the case of the fully automatic operation system, is provided with a buzzer. It is used to signal, when the compressor has stopped in the final stage of capacity control. As the compressor starts automatically any time with the recovery of the suction pressure or temperature, do not forget to turn off the disconnecting switch for inspection of the compressor.

2.8.6. Full automatic control of compressor

It is difficult to control fully automatically all compressors in one large refrigeration plant by the system of low pressure control switches as used for single compressor capacity control.

For this purpose, one primary detecting point must be established in order to systematically control the capacities and start/stop operations of multi-compressor systems. This control system is shown in the block diagram of Figure 30.

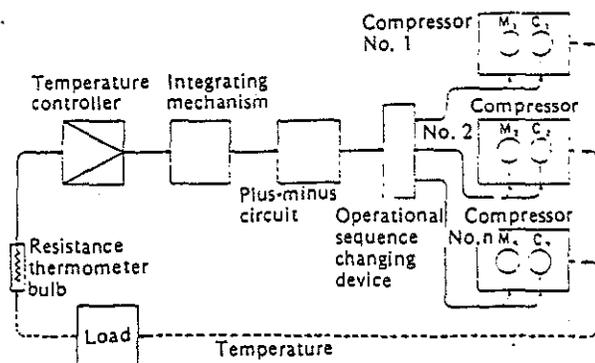


Fig. 30 Automatic control flow chart for multiple compressors

The location of the thermal resistance detector varies depending on the method of freezing. In the case of a brine cooler, the detector is placed to monitor the refrigerant in the cooler, whereas in a liquid pump system it would be positioned so as to monitor the refrigerant in the low pressure receiver.

The detector (resistance thermometer bulb) is inserted in the refrigerant in the appropriate location and its output is proportionally amplified by the amplifier of the automatic temperature controller. Its value is compared with a preset temperature to determine any positive or negative deviation.

This deviation produces a signal which in turn increases or decreases the working capacity of the compressor. This action takes the form of a signal operating an integrating mechanism. The integrator converts the analog quantity to a digital quantity and transmits pulses in response to any deviation. The pulses are calculated in a plus-minus circuit and gradually or successively operate the compressors which have a capacity corresponding to circuit calculations.

The resultant increase or decrease in capacity is sensed by the thermometer bulb in the form of increased or decreased temperature at the detection point and thus a closed loop is formed.

Moreover, a special calculation circuit is employed to prevent frequent repeats of start and stop and a particular value of freezing load.

The operation sequence changing board is extremely useful for daily operation. A simple change-over of jacks alters the running order of compressors in a system and further allows for the exclusion of a compressor from the system for overhauling or other reasons.

This system, called SIC Control, has been developed and standardized by Mycom.

To acquire full automatic control the system must be equipped with various protection devices and interlocks between relative components to ensure safety under abnormal conditions. These protection devices contribute to manpower savings and reduce power consumption significantly.

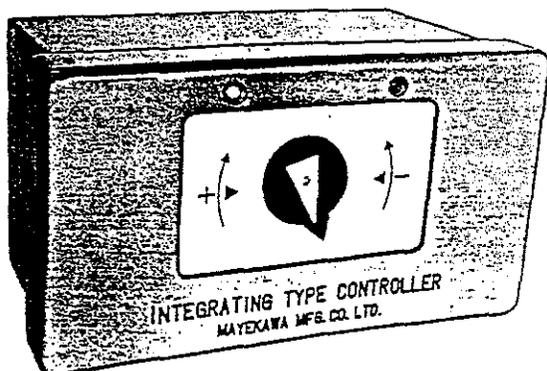


Fig. 31 Integrating type controller

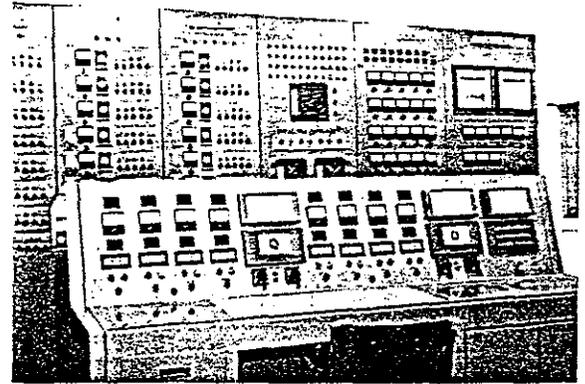


Fig. 32 Remote, automatic control panel

2.9. Safety valve

The valve is set at the following discharge pressures:

	psig	(kg)
Ammonia	250	17.6
R-22	250	17.6
R-12	225	15.8

The valve should be tested at least once a year (minimum pressure test). Test apparatus and standard pressure gauges are necessary for adjustment.

The above are our standard pressure settings for safety valves. If any other pressure setting is required, please contact us at the time of your order.

A spring type safety valve is employed as shown in Figure 33.

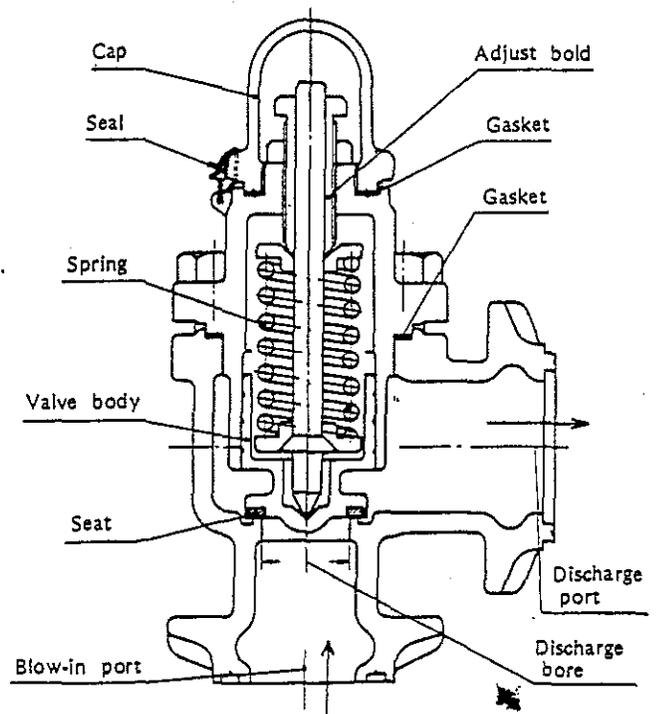


Fig. 33 Safety valve

2.10. Oil tank for marine use

We manufacture special compressors and oil tank units for marine use. These units are designed to eliminate oil pressure drop resulting from rolling and pitching at sea.

Oil tanks for compressors 4A to SB have two shapes as shown in Figures 34 and 35. Fig. 34 shows a tank mounted under the compressor and Fig. 35 shows a side mounted tank. The former type has no pressure equalizing piping, and is connected with a 1 1/2" flange at the center lower part of the crankcase. The other type has two oil flow pipes and one pressure equalizing pipe for purging gas, and is connected to the handhole cover. There is a stop valve in the middle of this pipe. It should not be closed during operation.

The tank cover has a valve for draining oil. The inside of the oil tank must be cleaned after each voyage.

The normal oil level is the same as for land use. Adjust to keep the level in the middle of the sight glass.



Fig. 34 Oil tank, lower mounting type for marine use

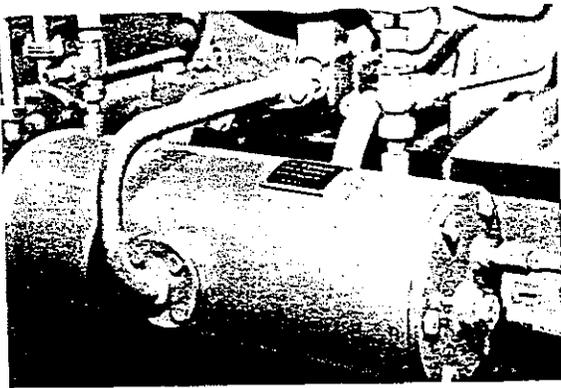


Fig. 35 Oil tank, side mounting type for marine use

CHAPTER 2. INSTALLATION AND OPERATION

1. Installation

1.1. Delivery to the site

- a) Transport your compressor to the installation site while still packed, if at all possible.
- b) If it is to be brought in after unpacking, suspend from the lift rings or hooks on the base. Put padding between the lift cables and the compressor & motor to prevent damage to the equipment.
- c) If it is a bare compressor, hang from the hanging bolt mounted on the top of the compressor.
- d) Avoid attaching ropes to the crankshaft, flywheel or pipes at any time, as damage to the compressor will result.
- e) The hanging bolt of the motor is used only for hanging the motor independently. Never use it for hanging the whole unit.

1.2. Installation

Consideration of the following articles when deciding arrangement & installation position of compressor is extremely important.

- a) Consider carefully the following; Operation handling, supervising, safety, maintenance, disassembly, repairing, piping arrangement, illumination and ventilation.

Ventilation fans should be installed if natural ventilation is not sufficient otherwise temperature problems may occur after completion of the plant.

- b) The foundation of the compressor should be decided by referring to the drawing. Mycom compressors, while being well designed, balanced and compact, still require a foundation strong enough to bear a weight two to three times that of the compressor, including motor. Moreover, it is necessary that concrete or wood piling be utilized to increase the load bearing capacity of the foundation if the installation is on reclaimed land or marsh ground.

Should the compressor be installed on the second, third, etc. stories or on the roof, a vibration-proof base must also be built in order to ensure safe and dependable operation.

1.2.1. Installation work

- a) Position the common base on the foundation and level paying close attention to its longitudinal and lateral orientation. Drive in the foundation bolts (anchor bolts) at the predetermined positions and fix by pouring mortar.

- b) When mortar has hardened, level the base accurately. Tighten the foundation bolts. In tightening, it is convenient to use a wedge. Put the wedge under the base and when a position has been achieved, replace it with a steel plate having the same thickness, then fill the gaps with mortar. If a gap remains between the base and the foundation it may cause vibration.

- c) In the case of a vibration-proof type common base, remove the welding which joins the support base and vibration-proof base after installing the unit in the manner as described above. Draw up the jack-bolts until they are well clear of the support base, that is, until the bolt ends clear the support base even when the rubbers are completely depressed.

- d) In order to minimize vibration passing through to the building, a minimum of 30cm must be allowed between the building foundations and the compressor. In addition, a vibration-proofing material should be utilized between the foundations of the building and the floor concrete.

To eliminate vibration passing through the piping, flexible tubing should be installed in all directions and special attention paid to the supports of the piping.

1.2.2. Belt drive

- a) Each compressor is shipped from our factory with exact centering. When installation has been completed, check that it is still accurate.
- b) In centering, stretch a steel wire on the flywheel side as illustrated in Figure 34 to check deviation of the grooves. Deviation causes premature wear and tear of the belt and shortens the life of the compressor as unnecessary force is applied to the bearings.

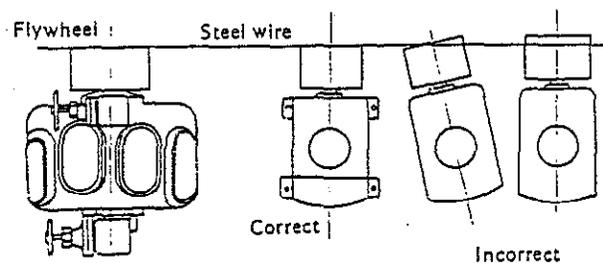


Fig. 36 Centering for belt drive

A slight deviation from center may be allowed for our flexible type coupling. Adjust the center position as accurately as possible to ensure long life of the compressor.

- c) Do not force the V-belts onto the motor pulley. The V-belts must be installed with sufficient slackness. Loosen the slide base of motor and close the gap between the motor pulley and the compressor.

After confirming that the setting of the V-belts in the V grooves is normal, take up the slack by adjusting the motor bolts. The ideal tension of the V-belt is when it is slightly loose, having a play equivalent to its own thickness when depressed at the center. Do not stretch the belts too much; it may shorten the life.

- d) When replacing V-belts, use a full matched set of new belts. Do not use old and new ones together. Mixed usage may cause abnormal vibration and/or shortening of the life of the shorter belt.
- e) After using new belts, confirm tension within 48 hours and continue to check the tension from time to time.
- f) Do not put oil or grease on the V-belt. If found, clean the belt using carbon tetrachloride etc.

1.2.3. Direct coupling

A slight deviation from center may be seen in our coupling which employs the flexible type instead of the rigid type. Adjust the center position as accurately as possible to ensure the long life of the compressor.

A radial type coupling is now adopted where the tyre type was previously employed. The radial type, like the tyre type, is designed to act reliably under severe conducting conditions, i.e. strong torque, twisting, vibration, shock loads etc.

The radial type however can operate well at much higher R.P.M. and with greater torque load than the tyre type, and is employed for this reason.

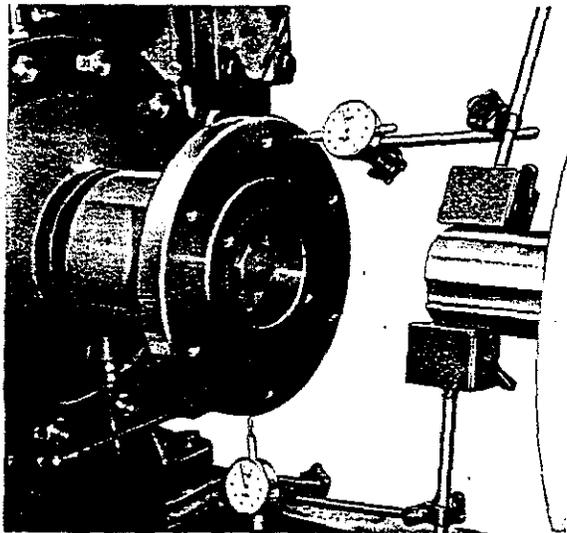


Fig. 37 Centering the coupling

The coupling is composed of three sections; body, spacer and flange. The shaft seal may be checked and exchanged by simply removing the spacer; without moving the compressor or motor.

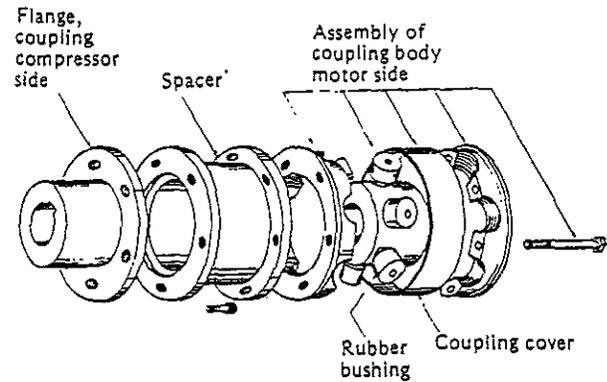


Fig. 38 Radial coupling (Exploded view)

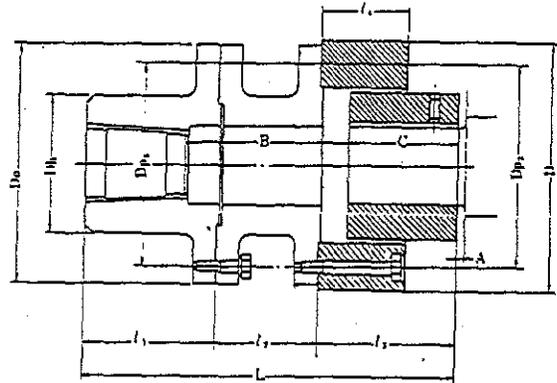


Fig. 39 Radial coupling (Sectional)

Dimensions of Moleflex Radial Coupling:

Type of coupling	Type of compressor	D	Do	Dh	Dp1	Dp2	l ₁	l ₂	l ₃	l ₄	L	A	B	C	Largest dia. of shaft, motor size	Highest allowable
MR 770	2A	197	191	120	158	158	127	100	108	67	335	5	155	89	68	3500
MR 870	Type A	223	215	120	178	178	127	100	125	82	352	5	158	106	76	3200
MR1070	Type B	273	267	160	227	227	175	135	153	106	463	5	215	125	87	2600
MR1270	12B, 12-4B	324	312	180	266	266	175	135	176	118	486	5	218	145	120	2200

Conduction capacity:

Type of coupling	Normal torque kg/m	Allowable angle error	Allowable parallel error	Brake axial power			Compressor
				1000 rpm	1200 rpm	1480 rpm	
MR 770	76	under 200mm dia coupling		44	—	—	2A, 4A
MR 870	152			80	96	117	6A, 8A, 42A, 62A
MR1070	294	under 0.1mm	under 0.1mm	150	180	—	4B, 6B, 8B, 42B, 62B
MR1270	403			210	250	—	12B, 12-4B

Sequence of setting (Ref. Fig. 39 & 40)

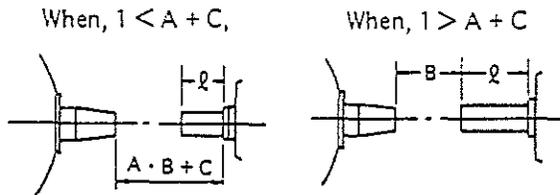


Fig. 40 Setting radial coupling

- 1) Position the compressor and motor on the base as specified, keeping the distance between the ends of the motor shaft and the compressor shaft dimension B apart (If the motor shaft is shorter than A+C, determine the position by calculating the distance between the compressor shaft end and the base of the motor shaft, thus making it A+B+C).
- 2) Mount the coupling flange on the compressor side.
- 3) Mount the magnetic stand of the dial indicator on the shaft of the motor and place the indicator on the outer diameter of the compressor-side coupling.

The parallel error of the compressor/motor shaft centers must be kept under 0.1mm. The dial indicator reading will give the relative error under 0.1mm.

In general, the motor side will be found to be lower, so the height should be adjusted at the motor side.

Relocate the dial indicator on the flange surface and by reading the dial, correct the relative error to under 0.1mm.

Repeat the above, and continue adjusting until the centers of the compressor shaft and the motor shaft are true.

A small error is allowable with the flexible coupling but better results and longer equipment life (less vibration etc.) can be obtained by precise centering of the shafts.

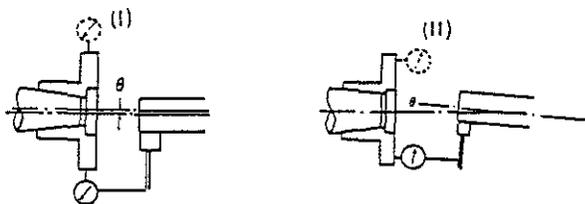


Fig. 41 Measuring axial center

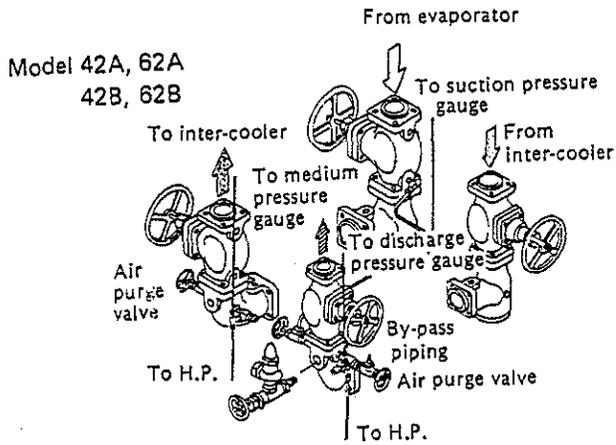
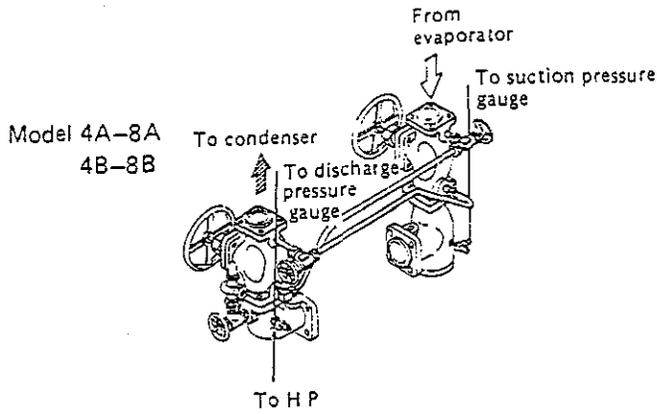
- 4) Bolt down the compressor and motor firmly after adjusting the shaft centers.
- 5) Mount the body of the coupling on the motor shaft. Do not yet tighten up the set bolts.

- 6) Mount the spacer on the flange of the compressor side.
- 7) Attach the body of the coupling to the spacer and secure the set bolts.
- 8) This completes the mounting. Turn by hand to check.

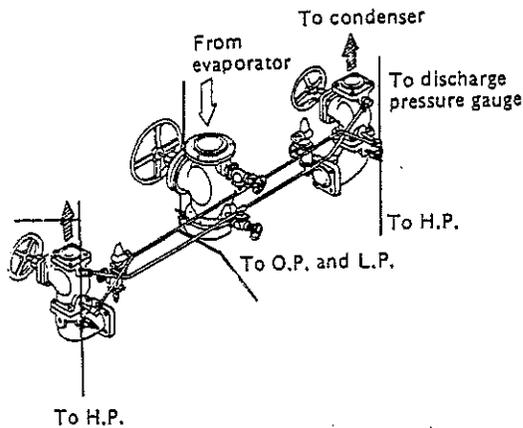
1.3. Piping

- a) Use the utmost care so that dust, etc., does not enter the pipes during assembly.
- b) During assembly at the site, be sure to flush the pipes or clean them with a wire brush before they are installed in order to remove sand, rust, welding slag, etc.
- c) Do not mishandle or step on the bypass pipes of the compressor as damage or impaired operation may result.
- d) Do not use rags to clean the inside of the pipes as waste fibers will remain inside and later clog the strainers of the compressor.
- e) Dry nitrogen gas is sealed inside the compressor for rust-proofing; leave it as it is until piping assembly is completely finished. It can be easily discharged by opening the valves after assembly.
- f) Ensure that water does not enter the pipes. When freon gas is used, in particular, it causes trouble after the compressor is started.
- g) When freon gas is to be used, install suction pipes at an inclined angle for smooth return of oil.
- h) Special care must be taken to remove the blind plates which are generally used on the pipe fittings. Cases have been reported of failure to remove blind plates before operation, the result; serious damage.

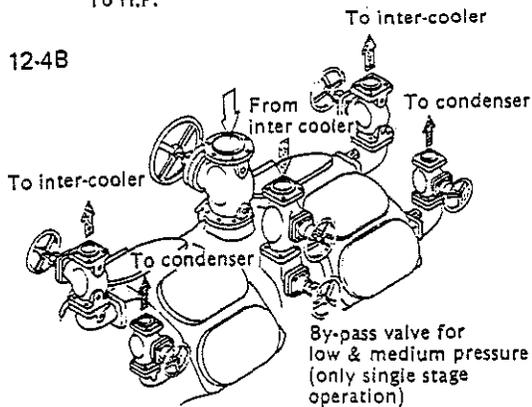
Fig. 42 Compressor piping



Model 12B



Model 12-4B



1.4. Cooling water

To prevent super-heating of the compressor and deterioration of the compressor oil, and also to increase the durability of all moving parts, the crankcase, head-cover and oil cooler are cooled by water.

In the case of Freon R-12, however it is not necessary to cool the head-cover, because the discharge temperature of R-12 does not go very high.

Total quantity of cooling water:

In the case of cooling water temperature being;	(L/min.)								
	2A	4A	6A	8A	4B	6B	8B	12B	12-4B
20°C	18	20	24	28	30	32	38	44	50
30°C	26	30	37	43	40	47	55	66	75

Oil temperature should be kept upto 55°C, but 60°C may be permitted for short periods of time.

Pipe diameter and number of pipes:

Compressor	Inlet	Outlet
2A to 8B	1" (25A) x 1	1" (25A) x 1
12B, 12-4B	3/4" (20A) x 2	1" (25A) x 1

In the case of parallel piping, a water valve must be installed in front of the compressor piping so that the water volume can be adjusted:

In the case of a full automatic compressor, a solenoid valve must be installed between the compressor piping and the water valve to ensure water circulation at the same time as operation start up.

Care should be taken during super heated running in the test operation to ensure a sufficient quantity of cooling water.

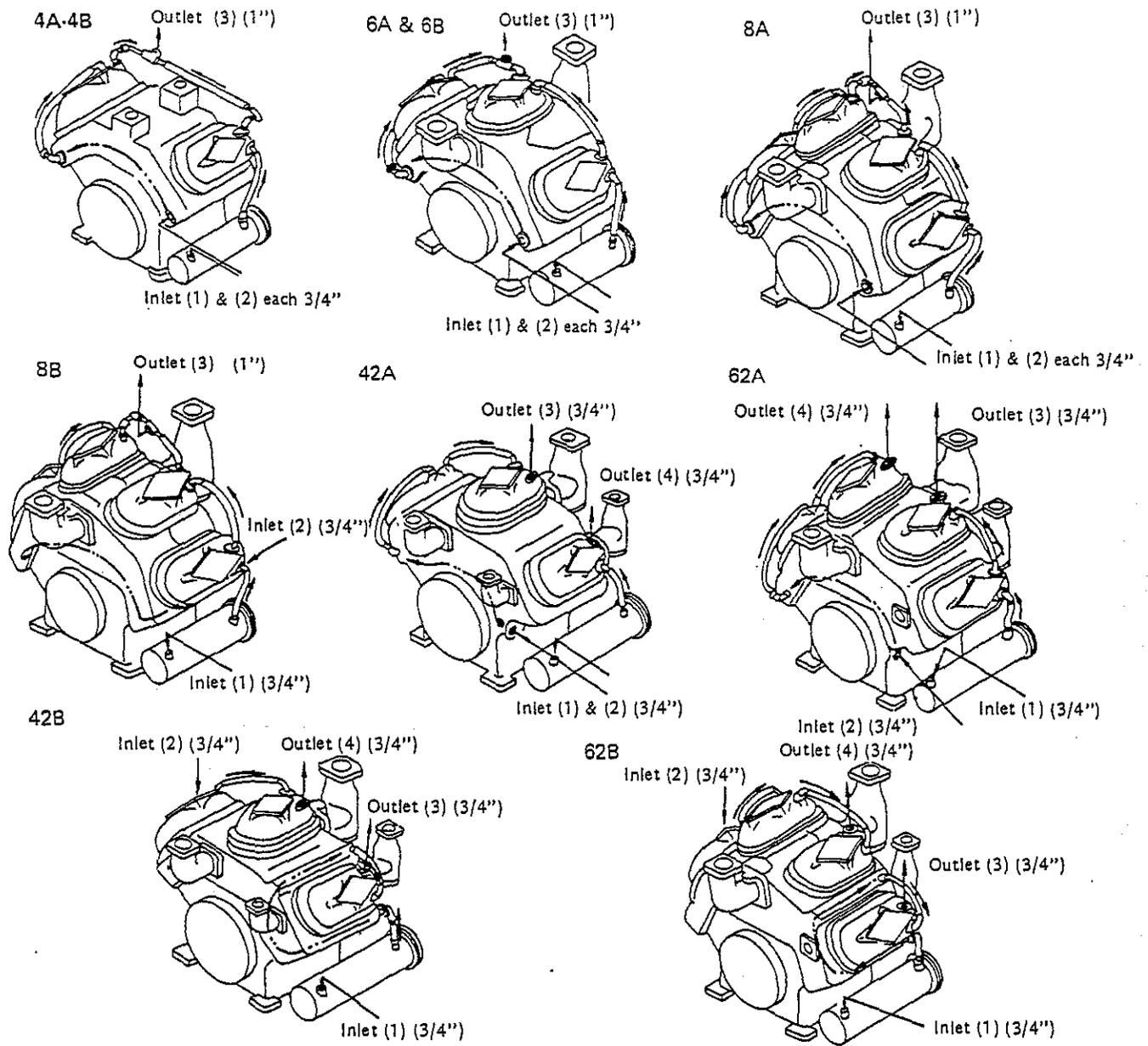


Fig. 43 Cooling water piping of compressor

2. Preparation for operation

2.1. Test of electric connections of automatic control

- a) The compressor is provided with OP, LP, HP and/or DP switches for automatic operation. Their types and numbers vary according to the use of the compressor. For wiring to these switches, the magnetic switch for the main motor and wiring to the switch box, follow our diagram.
- b) Wiring between switches and the control panel is completed and tested at our factory before shipment. When the compressor is installed, wiring between the control panel and magnetic switch or switch box should be done according to the section shown by dotted lines in the wiring diagram.
- c) For fully automatic operation, starting, stopping and capacity control are all done automatically. In semi-automatic operation, only starting is done manually. In this case, make sure that the starting method of the motor is correct. In case of line-start, it is necessary to investigate incoming electric capacity.
- d) Check that the high-voltage switch box is provided with a P.T. (Potential Transformer) of specified capacity and contact.
- e) The internal connections of magnetic switches vary slightly with manufacturers and our wiring diagram is not applicable for all manufacturers. When your magnetic switch is from another manufacturer, wiring must be carried out in accordance with a specially designed wiring diagram.
- f) Check that the oil circuit breaker contains the proper quantity of isolating oil.

- g) For the motor and its high voltage controller in particular, measure and check that insulation resistance is of the specified value.
- h) In testing connections of control systems, insert a fuse at an intermediate position on the wire connection between the magnetic switch and control panel; this prevents the equipment from overheating.
- i) Start the motor in the presence of the engineer in charge of your electrical work.

2.2. Test of switch connections

a) Oil Pressure Failure Protection Switch (OP)

Remove belt or coupling and operate motor only. The motor is normal if it stops automatically in 60 to 90 seconds varying according to atmospheric temperature; as compressor is not in motion, the switch trips when the oil pressure drops to 0 psig (0 kg) and stops the motor. Once the switch is tripped it cannot be reset until the bimetallic element cools. (Ref. Fig. 27)

b) High Pressure Protection Switch (HP)

Operate motor (with the switch for OP switch on the control panel in manual position) and push the reset handle of HP switch to see if the motor stops. This is the same as when the bellows of HP switch trips the control switch due to abnormally high pressure.

When motor stops, cut off the main switch and pull the reset handle of the HP switch toward you to reset. (Ref. Fig. 28)

Avoid making a performance test of the HP switch at higher than the actual working pressure, as it is dangerous.

c) Low Pressure Control Switch and Solenoid Valve

When the automatic-manual changeover switch for capacity control on the control panel is turned to the manual side and the switch is turned from the "Load" to "Unload" side, the pilot light will go on. Also see if the pilot light goes on in a loaded condition. Put the switch on "Load". In this case, judge by the operating sound or vibration of solenoid valve. That is, the light is normal if there is no change when the load-unload change-over switch is moved repeatedly from "Load" to "Unload".

The above-mentioned items complete most of the testing required. When the pressure preset on the LP switch is too high, put the contact lever in operation by pushing up the cam attached to the bellows with a screw-driver and examining the flashing condition of the light. Then with the compressor running; close the suction stop valve during automatic operation, lower the pressure in

the crankcase and test it by changing the current of the motor. (Ref. Fig. 29)

Note: Test of working time of OP switch.

- 1) The OP switch starts operation as soon as the magnetic switch is started and applies voltage to it. Working time of OP switch is measured from the time the change-over switch of control panel is turned from "Manual" to "Automatic". For normal operation, the switch should always be in the "Automatic" position.
- 2) A performance test of HP switch is dangerous but is sometimes required by some inspectors. In such cases (a) the test is conducted after adjusting pressure down to the actual working pressure, and (b) the test is conducted at the specific pressure by stopping cooling water for the condenser and raising the pressure gradually.

2.3. Airtight test

After completing the installation, piping and wiring work, an airtight test of the system is carried out. In this case, the installed pressure gauges are not used and the valves for the gauges are closed. Two pressure gauges, with graduations up to pressures 1.5 to 2 times higher than the test pressure should be provided. The pressure gauges should be provided with stop valves for easy checking of pressure.

- a) Do not use a refrigerating compressor for this test, but use an air compressor or utilize high pressure nitrogen gas.

When ammonia is used as a refrigerant for the system, do not use CO² gas as it will react chemically. When it is freon gas refrigerant do not use air, but use high pressure nitrogen gas or CO² gas. If air is used, its water content enters the pipes easily, causing trouble during operation. To use high pressure nitrogen gas, do not connect the pipe directly from the cylinder but install a reducing valve between it and the compressor.

- b) The refrigerating compressor is not originally designed for compression of air. Therefore the discharge temperature rises sharply with the compression of air and goes above the flash point of lubricating oil, causing such accidents as seizure, explosion, etc.

The flash point of lubricating oil is about 180°C to 200°C. If air of 16°C is compressed to a pressure of 10 kg/cm²G, the temperature rises to more than 260°C, already much in excess of the flash point. The exact flash point is not clear, but even air under atmospheric pressure has a flash point between 300°C to 400°C, so that the temperature easily reaches the flash point when compressed to 20 kg/cm²G by single stage. You must note, it is very dangerous.

Be sure to keep the valves for the pipes to the OP, LP and DP switches closed. If they are left open, damage to

the bellows section and the reset lever of the switch will result.

- c) The temperature of the air compressor may rise unusually quickly so it is therefore necessary to stop operation until cool and start again. Repeat stop/start operation until test pressure is reached.
- d) When the pressure has reached the specified value, inspect for leaks with soapy water or other solution (chemicals for detecting leaks in the airtight test). If no leak is observed leave under pressure for 24 hours and check for any pressure drop. When evaluating the results be sure to take into consideration the changes caused by room temperature.
- e) When an automatic circuit (solenoid valve, thermostatic expansion valve, etc.) is provided on the liquid line, do not forget to keep the manual circuit open or open the solenoid manually or if power is available to the solenoid valve ensure it is in the open position.
- f) When the airtight test is completed, discharge air out of the piping line by opening valves to remove dust and scale.
- g) In the case of a freon gas system, use a vacuum pump and discharge water simultaneously.
- h) Next is the vacuum test. In this test, the compressor is used in the opposite way. Keep vacuum lower than 27.56 in.Hg (700 mm.Hg); close the valve and leave it for 24 hours. If the rise in pressure is smaller than 0.1 in.Hg (5 mm.Hg), the system is regarded as "Passed".

When the temperature is raised to about 135°C to 140°C, the refrigerant R-22 (Freon 22) hydrolyzes, if it contains water of more than 100 ppm, so that hydrofluoric acid and hydrochloric acid are formed. As these acids erode the inside of pipings and the compressor, care should be taken.

2.4. Refrigerant leak test

- a) In case of Ammonia
 - 1) Boost pressure by 70 to 85 psig (5 to 6 kg/cm²) after charging a small amount of ammonia.
 - 2) If burning sulphur is placed near the piping, white smoke can be seen where leakage occurs.
 - 3) If wet phenolphthalein test paper is in the vicinity, the paper turns red.

Leakage of ammonia from the piping can easily be detected by these methods.

- b) In case of Freon

- 1) Charge a small quantity of freon refrigerant. The quantity should be 2.2 pounds for a 10 to 30 ton compressor and 3 to 4.4 pounds for a compressor over 30 tons. If the refrigerant quantity is too small, definite measurements are unobtainable in tests with a Halide gas detector.
- 2) When charging is finished, boost pressure with CO² gas or nitrogen gas and check for leaks with a Halide gas detector. The flame of the detector turns indigo green when there is a leak.
- 3) Leakage from the concentrated parts of pipes can be clearly detected by the use of soapy water or other such solutions.
- 4) Flanges must be inspected with special care. It is necessary for the water drainage valve and the air purge valve be opened and a Halide gas detector inserted.
- 5) When the inspection is completed, make a vacuum again by discharging the gas through the air purge valve which is located under the discharge stop valve.

2.5. Operation under no-load conditions

When the vacuum test is completed, the compressor is operated under a no load condition. In this test, the discharge stop valve is closed. The air purging valve is used as an air discharge port and the suction end cover or scale trap cover is used as a suction port.

- a) When running the compressor within a few months of shipment, it can be operated just after charging refrigerant. If a long time has elapsed, lubricating oil on the moving parts may be exhausted. Therefore, supply sufficient oil to these parts before operation. It is recommended that plenty of oil be circulated throughout the oil system when starting.

If it cannot be handled in the above way, charge more (2 to 5 litres) oil than the standard level; as a temporary oil supply.
- b) Confirm the rotational direction of the compressor and motor and then start. When starting the compressor, check the rise of oil pressure by inching.
- c) When the compressor is running, adjust oil pressure by the oil pressure regulating valve with the reversible ratchet in the hand tool kit. Inspect the temperature rise at each part and check that there is nothing abnormal.
- d) In this test, you must cut the circuit to the LP switch, otherwise, the compressor will not start.
- e) Switch all unloading devices to the unloaded position.

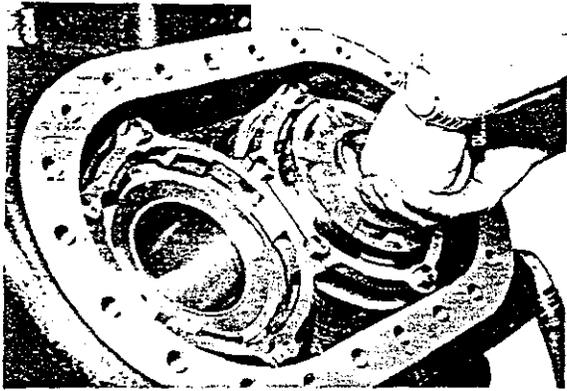


Fig. 44 Test of working condition of suction valve

2.6. Idle running test

- a) It is recommended that compressors whose parts are replaced at the time of periodic inspection or left unused for a long period be inspected by an idle running test prior to operation.
- b) In this test, head cover, safety head spring and discharge valve assemblies are removed from the compressor. (Cylinder sleeves must be firmly fixed.)
- c) Before starting the test, resupply the cylinder section and each bearing with sufficient oil.
- d) During the test, check the following points:

- 1) Check oil rising condition,

Oil quantity is superfluous when oil comes up in large drops. Such a condition, however, exists when the sleeve, piston or compression rings are changed and until they are "worn in". This is no problem, so leave as is.

- 2) Check cylinder walls,

An uniform oil film coats the wall. When the wall is darkened by a stain or metallic substances, it indicates that abnormal abrasion is occurring on the wall. Stop operation immediately and inspect the wall. When the oil film turns light brown, it is due to insufficient lubrication. Raise oil pressure, if it fails to eliminate the cause, then change the arrangement of the compression rings.

- 3) Check unloader operation,

When all the above checks are completed, examine the performance of the suction valve, pressing down the discharge valve assembly as shown in Figure 38. At the same time, confirm that the unloader mechanism is in good working condition by operating it manually. If the valves give off working sounds even while in an unloaded condition, it is due to improper

mounting of the cylinder sleeve, erroneous insertion of push rod, or excess oil pressure. Lift pins are not operating accurately in such cases. It is sometimes due to improper tightening of the valve plate.

- 4) When the above-mentioned steps have been finished, start the no load operation as in 2.5.

2.7. Charging of refrigerant,

(In case of newly installed equipment.)

When nothing abnormal has been found with the compressor, start cooling operations in the following sequence:

- a) Put the compressor in motion and purge the air out of the crankcase through the air purging valve.
- b) As the system reaches the vacuum stage, charge refrigerant directly into the receiver right away. Time required for charging can be shortened by this method.
- c) The quantity of refrigerant to be charged into the receiver is predetermined. When this quantity has been charged into the receiver, then charge into the evaporator using the whole refrigerating cycle through the charging valve provided between the outlet valve of the receiver and the expansion valve.
- d) Before starting the compressor, check that cooling water has been passed to the water jackets of the compressor and condenser. Place the gas cylinder on the ground, inclined at about 30 degrees. Open the valves of the cylinder and the charge valve on the piping line little by little while continuously operating compressor at 28 psig (2 kg/cm^2) of suction pressure.
- e) Select a chamber to be cooled and adjust expansion valves.
- f) The quantity of refrigerant in the cylinder can be judged by tapping, or weighing the cylinder with a platform scale. When frost appears around the valve of the cylinder, it may be considered empty.
- g) When the suction pressure falls below 0 psig (0 kg/cm^2), stop the compressor or raise the pressure by heating the cylinder with hot water. When a water chiller is employed, make sure the water does not freeze.
- h) When the specified quantity of refrigerant has been charged, close the charging valve tightly and open the liquid outlet valve. Then start normal operation.

2.8. Cooling operation

(Refer to Chapter 4, Paragraph 2.4.)

2.9. Stopping operation

(Refer to Chapter 4, Paragraph 2.6.)

2.10. Charging Lubrication oil

When the refrigerating system is newly installed, special care should be taken on the following points for a period of about one month after initial operation. When operation is started, foreign substances in the system return to the compressor so inspect strainer and change the oil, if necessary, in the following manner.

(Ref. Supplements 8.1. for compressor oil)

a) Recommended interval for oil change,

Oil change	1st	2nd	3rd	4th
Days from start of operation	2nd	7th	17th	37th

b) Inspection and cleaning of cloth bag and screen for suction strainer,

Suction strainer	Oil filter
1) 5 hours after initial operation	With every oil change and when draining oil from cuno-filter housing.
2) Once a day from 2nd day to 10th day	
3) Once every 5 days after 11th day	
4) Once every 2 weeks, if the clogging is small	

Take the cloth bag off, after confirming only slight clogging.

The above are only recommended standards. You can adjust the interval according to the conditions of your lubricating oil and strainer.

2.11. Automatic lubrication device

2.11.1. General

Oil must be resupplied to the crankcase keeping a balance with the oil consumption of the compressor, as the compressor sends oil to the discharge side gradually. The oil is sent to the discharge and is separated and extracted in the oil separator, and then, returned to the crankcase automatically or manually. This circulation is repeated.

The oil not separated in the oil separator passes to the evaporator. This quantity should be replenished. But the frequency of replenishment may be reduced if an oil receiver is installed on the line.

We recommend employment of an automatic oil return system, when it is possible to install one oil separator for each compressor. (But it must be avoided if the discharge temperature might become more than 120°C when using ammonia refrigerant, because under such conditions the oil would soon become unusable.)

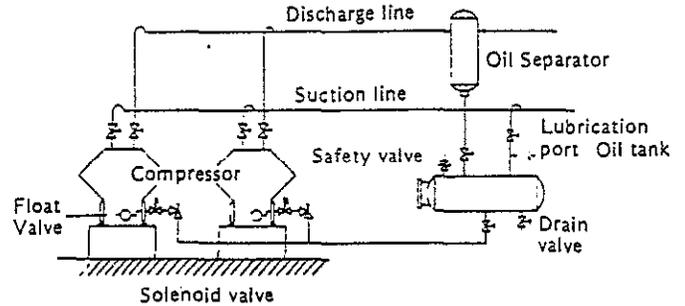


Fig. 45 Model automatic lubrication system

2.11.2. Automatic oil return device

As you see in Fig. 42, the float valve of Mycom's automatic oil return oil separator is rather simple mechanically. Care should be taken when using it in a cold area.

The oil separator must not be installed outdoors and must include a thermostat and solenoid valve so the oil is not returned until the temperature in the oil separator becomes greater than the condensing temperature, otherwise liquid-back occurs in which refrigerant gets into the crankcase and may cause problems such as increased consumption and/or burning.

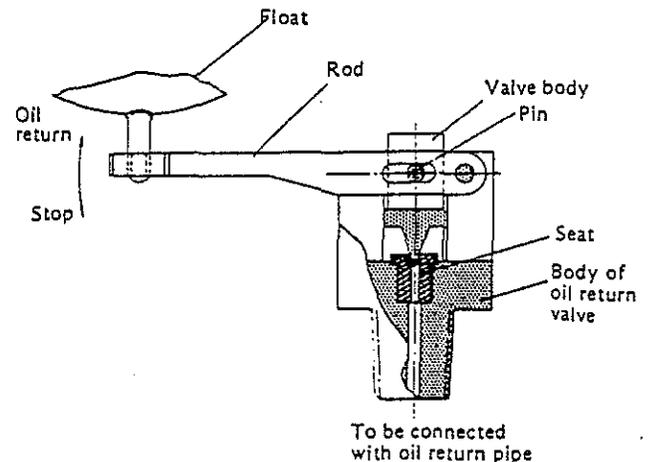


Fig. 46 Float valve for automatic oil return type oil separator

2.11.3. Automatic lubrication device

The mechanics of the float valve of Mycom's automatic lubrication device are as shown in Fig. 47 the valve opens by float action. This system is also used for pressure feed lubrication.

The pressed lubrication system can lubricate from one oil tank to more than two sets of compressors using two flows of suction gas (i.e. high and low stage compressor of compound compression) and cannot equalize the pressure at oil tank.

Equalize the pressure of tank with the highest suction pressure as a minimum.

A float switch is employed as a safety device, it rings an alarm or stops the compressor when oil is charged up to the alarm level.

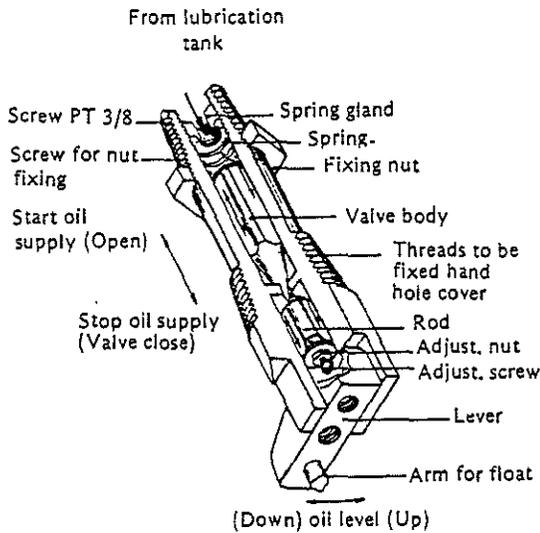


Fig. 47 Float valve for automatic oil supply

Assembly and adjustment: The valve set on the delivered compressor is adjusted at our factory, but note as follows:

This valve is fixed with PT1/2 taper screw on the inside of the hand hole cover. After firmly fixing the longitudinal direction, then fasten by the outside fixing not so it does not turn when setting the external piping.

The normal oil level is at about the middle line of the moving float, so it should be set accordingly.

Slight adjustment can be made by moving the adjustment screw. (Oil level drops by turning the screw to the right, and is raised by turning to the left.)

Larger adjustments can be done by changing the float position.

CHAPTER 3. DISASSEMBLY AND ASSEMBLY

1. Disassembly

1.1. Stopping operation

There are two reasons for disassembly of the compressor, one is routine checking and the other is repair.

1.1.1. Routine checking

In general routine checking is planned to limit the downtime of the compressor, and is for maintenance and safety control. It must guarantee smooth operation at least until the next routine check, so may include replacing or repairing of parts.

First, the compressor must be stopped and the refrigerant of the low pressure side collected into the liquid receiver.

If each unit in a multi-compressor system can be checked alternately, it is equal to temporary stopping, i.e. close the suction stop valve of compressor, and exhaust refrigerant from the crankcase.

After stopping the compressor, close the discharge stop valve to allow refrigerant gas in the discharge assembly to escape to the low pressure side through the by-pass piping.

If the compressor has an automatic control circuit which works by the suction pressure for its' load reducing and stopping, this electric circuit must be changed over to the manual circuit or be shorted.

If ammonia remains, it gives off a strong odour, and must be purged as soon as possible.

In case of Freon, reduce pressure gradually until it becomes 0 kg/cm²G, then stop the compressor. The pressure will reascend for a while, so repeat this handling until the pressure does not gain again.

Care must have taken not to reduce pressure too quickly. If roughly handled, refrigerant in the oil is evaporated, foams and becomes a cause of oil pumping or oil hammer.

1.1.2. Trouble and repairing

When disassembly and repairing is required due to sudden trouble, the compressor must be stopped with the same handling as described above, if the necessary time for stopping has been allowed. But, in many cases, there is no time for gradual stopping, when abnormal conditions are found. Even so, do not forget the correct handling of valves, otherwise it further endangers the equipment.

1.1.3. Purging refrigerant

Eject gas in the discharge section of the stopped compressor. Freon gas may be released into the air, but if it is not a well ventilated room it must be exhausted outdoors using pipes or hose.

Freon gas stays close to the floor, because it is heavier than air, and it suffocates men. A halide torch is used to detect the leakage of freon gas.

Ammonia gas must be discharged into water. Water absorbs ammonia gas up to 600 times its own volume, so even if a small amount is used it is able to absorb a fairly large quantity of gas. In this case, care should be taken to ensure that the water is not sucked into the compressor.

Should liquid flow-back occur it is advisable to bleed both refrigerant and compressor oil into a container.

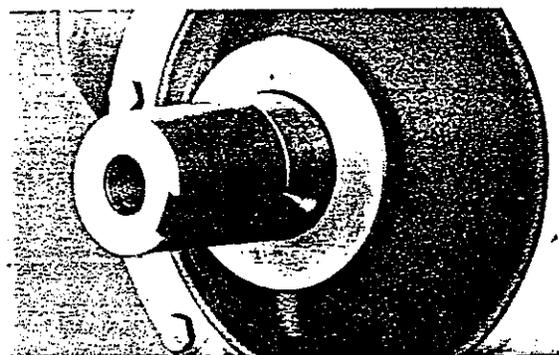


Fig. 49 Crankshaft without flywheel

1.2. Preparation for disassembly

a) The crankcase is in a vacuum state when the compressor is stopped, and should be brought to atmospheric pressure.

Drain the oil from the crankcase through the oil drain valve by removing the oil plug through the hand hole, and also through the piping of the low pressure gauge.

If the compressor is equipped with an automatic oil supply system, do not forget to close all valves of the system. This must also be done for the automatic oil return type oil separator.

b) During disassembly work, cut off all power switches not in use.

c) Drain water out of the jacket heads and block. Drain cocks are provided on the side of the crankcase and the bottom of the oil cooler.

d) Remove belts or coupling and take off the flange and fly wheel as shown in Figure 49.

e) Both flywheel and flange for coupling are tapered on the compressor side, so that they are easily removed by loosening them a little. Handle the components with care.

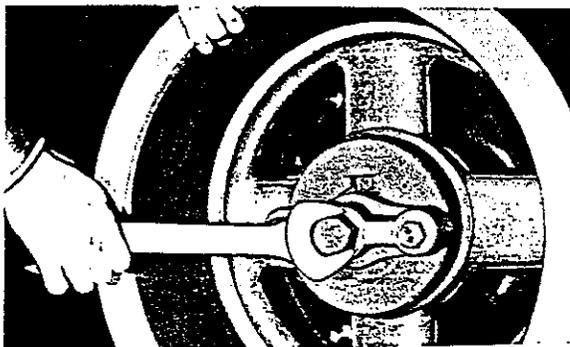


Fig. 48 Method of removing flywheel

1.3. Notes on disassembly

a) Tools must always be kept clean. (Refer to Supplements II)

b) Neatly arrange disassembled parts in order on a table or a surface which is clean, free from moisture and non-abrasive.

c) To wash parts, use pure alcohol, carbon tetrachloride, trichlore-ethylene or light oil. A warmed (45 to 50°C) compressor oil may also be used.

After washing, coat surfaces with lubricating oil. They will get rusty if left without an oil film.

d) Before assembling, clean the parts with compressed air, sponge or a clean cloth, and then coat with clean lubricating oil. Avoid using rags which will shed fiber; it will cause clogging of oil piping.

e) When mounting gaskets, it is advisable that graphite-mixed oil or nondrying packing be applied on one side of the gasket. It makes future disassembling easier.

f) When cylinders are disassembled, their component parts should be arranged neatly, in order of each cylinder. Take special care not to mix connecting rods in particular.

1.4. Removal of water piping

a) The standard cooling water flow chart is as illustrated in Figure 50.

b) Land standard models employ vinyl hose, so loosen the hose bands.

c) Marine standard models employ steel pipe so remove the flange connections.

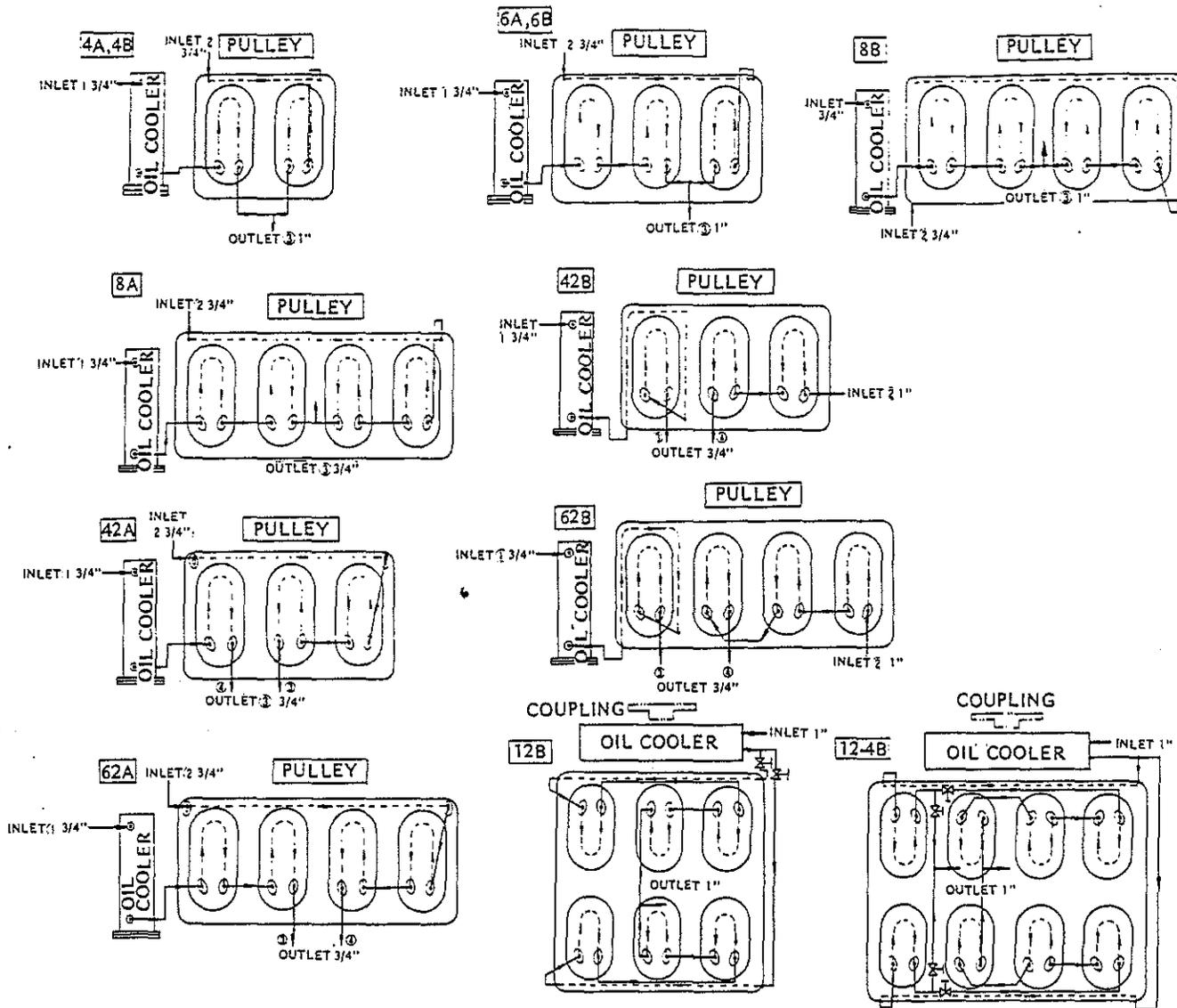


Fig. 50 Standard cooling water flow chart (Jacket head cover)

1.5. Removal of head cover

- a) Two types of head covers exist, those with and without water jacket.
- b) In the case of Model B compressors, first replace any two symmetrically opposite screws with the long ones found in the hand tool kit. Then, remove all screws other than these two long ones from the head cover. Finally loosen these two gradually until the head springs are break the gasket.
- c) If the gasket adheres to the main body or to the head cover, tap the head cover on the side with a mallet after loosening the two screws, or peel the gasket off carefully with a flat chisel or a screwdriver. Be careful not to break the gasket.
- d) Since 1967 Model A head covers have been redesigned.

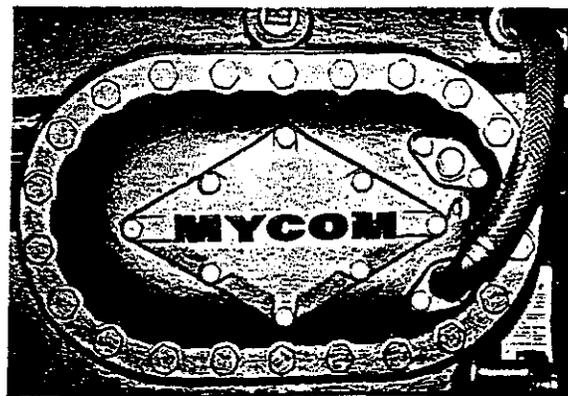


Fig. 51 Jacket head cover, type B

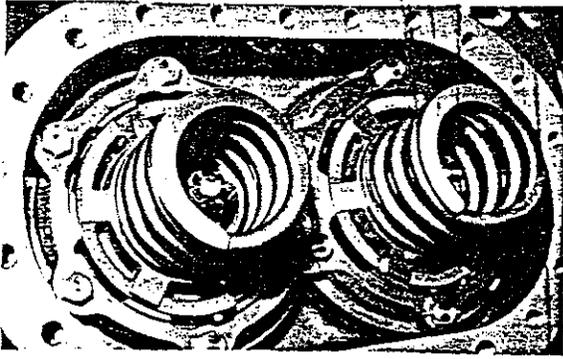


Fig. 52 View after head cover is removed

1.6. Removal of head springs

The safety head springs shown in Figure 48, are pressure-attached between the head cover and discharge valve assembly and their position is determined by the seat of the cage. They can be taken off easily by hand. When carbonized oil, slag and the like adhere to them the discharge valve assembly occasionally comes off with the spring.

Remove the spring only, taking care that no carbonized oil or slag falls into the cylinder.

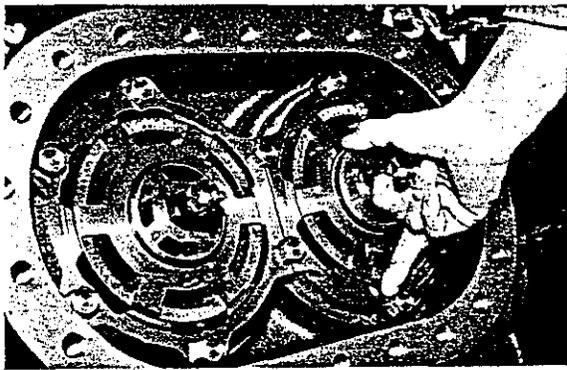


Fig. 53 How to remove discharge valve assembly

1.7. Discharge valve (assembly)

a) As the assembly is kept in position by the cage guide only, the valve assemblies can easily be removed by hand (Fig. 49). However, when carbonized oil and slag adhere to them remove carefully, being careful not to allow any to drop into the cylinder. Also do not drop anything into the cylinder sleeves as this may scratch the linings.

b) Avoid disassembling if the parts appear to be in good condition, i.e. without abrasion of valves or damage to spring or presence of carbonized oil or slag. When disassembling is necessary, do it with care using the tools in the hand tool kit.

c) Sequence of disassembly

1) When a vise is used for disassembling, loosen nuts (AV56) and (AV57) by striking with a hammer and wooden block take care not to damage the seat surface.

2) Pull out bolt (AV55).

3) When the bolt has been pulled out, the discharge valve seat (AV54), discharge valve (AV52) and discharge valve spring (AV53) will come loose. Be careful not to lose the springs as they are very small.

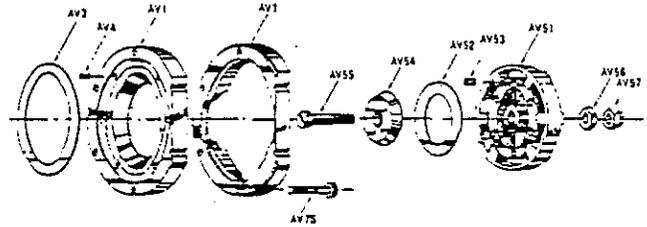


Fig. 54 Discharge and suction valve assemblies. (Model A)

1.8. Suction valve (assembly) (refer Fig. 54).

a) Loosen the screws (AV75) and take them off.

b) The cage guide (AV7) and valve plate (AV1) can be removed together by pulling them out by hand.

c) The springs (AV4) for suction valve (AV3) are generally tightly fixed in the holes of the valve plate (AV1), but handle them with care as some may be loose.

d) The suction valve remains on the seat surface of the cylinder sleeve. Do not separate the valve plate and the cage guide. Place them with the spring side upwards to protect the seat surface from scratches.

1.9. Unloader mechanism

The unloader mechanism must be disassembled prior to the cylinder sleeve. (Refer to Fig. 51)

a) Take off oil piping. It is not necessary to take off the screwed fitting on the unloader piston cover except on 12B model.

b) When electric wiring is connected to the solenoid valve, disconnect this first.

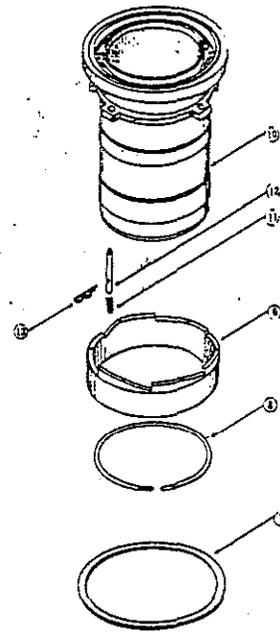
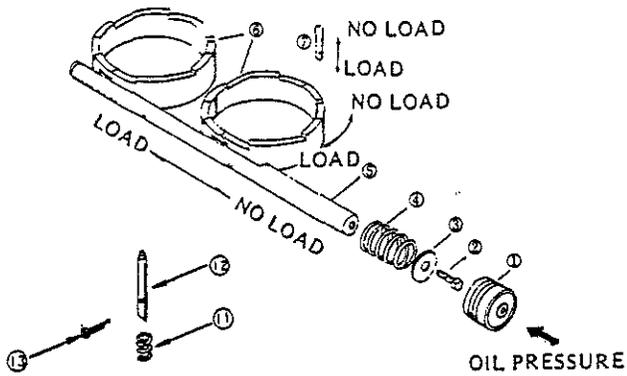
c) Remove the unloader piston cover together with the solenoid valve.

d) Pull out unloader piston (1) using the eyebolt supplied in the hand tool kit, or push in the unloader piston with your thumb and release it quickly so that it is pushed out by the expanding action of the spring (4).

e) Pull out push rod (5) as shown in Fig. 53. Spring (4) and washer (3) are attached to the push rod with a screw (2); do not take them apart.

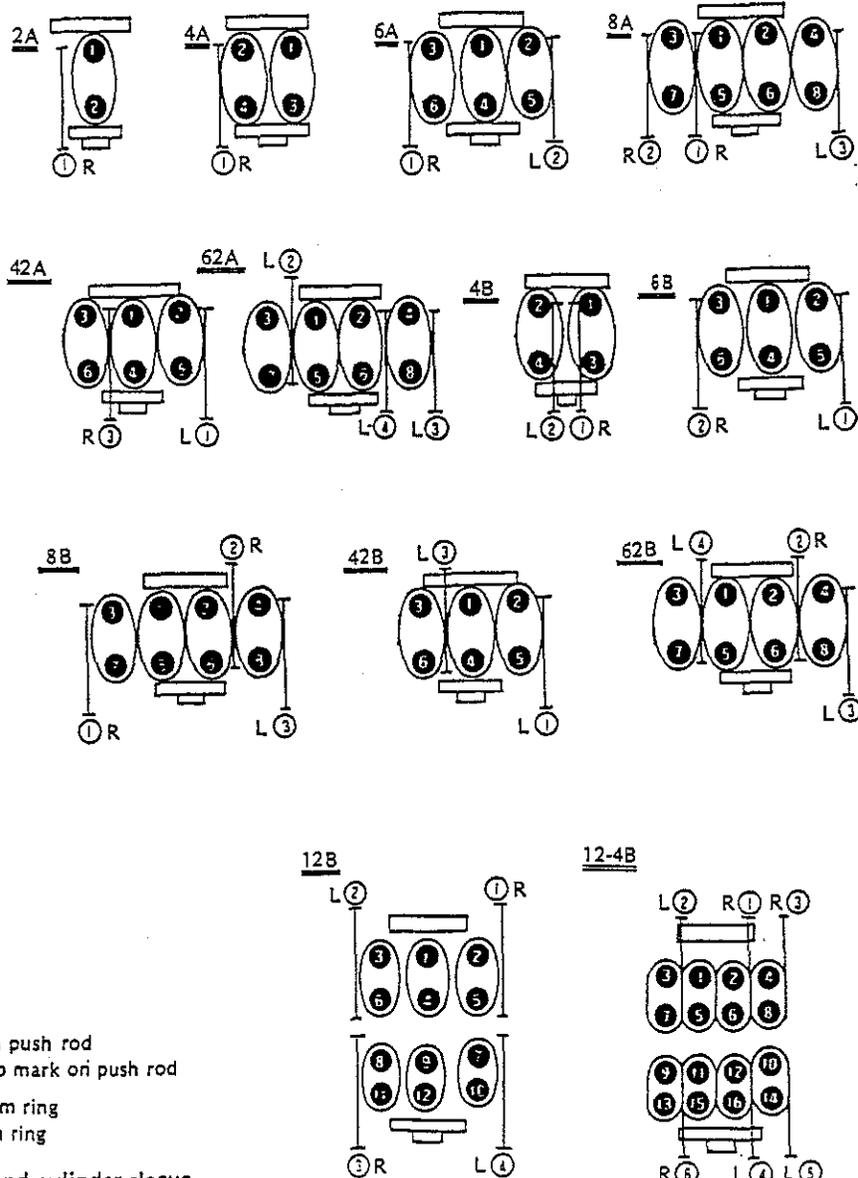
f) The size of the push rod varies depending on the

position. Do not forget to record the original position for these push rods so that you can reinstall them correctly. (Fig. 56)



1. Unloader piston
2. Allen screw, push rod
3. Washer, push rod
4. Spring, unloader device
5. Push rod
6. Cam ring
7. Gasket, cylinder sleeve
8. Retaining ring
10. Cylinder sleeve
11. Spring, lift pin
12. Lift pin
13. Split pin, lift pin

Fig. 55 Cylinder sleeve and unloader mechanism



Remarks: (1) to (6) Stamp mark on push rod
 (1) to (16) in black, Stamp mark on push rod
 R (right), Right sloping cam ring
 L (left), Left sloping cam ring

Fig. 56 Sequence of unloader and cylinder sleeve

1.10. Oil cooler

- a) The cylinder section is disassembled after removing the inspection port cover. Take off the oil cooler before removing the inspection port cover. (No need to take off if marine type.) Oil cooler is attached by 4 screws on the right and left sides. Loosening them slightly, slide the oil cooler upwards and remove from the slot. (Ref. Fig. 59.)
- b) Disassembly of the oil cooler is done in the following order.
- 1) Take off oil piping and bolts.
 - 2) Pull out flange by loosening bolts and nuts.
 - 3) Pull out coil simultaneously with flange. (Ref. Fig. 19 & 20).

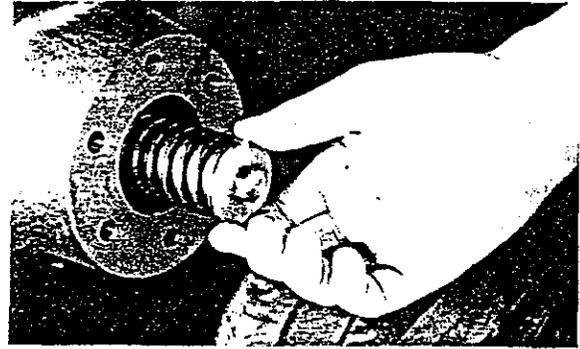


Fig. 57 Removal of push rod



Fig. 58 Cylinder number mark (case side)

No.	Compressor model	2 A	4 A	6 A	8 A	42A	62A	4 B	6 B	8 B	42B	62B	12B	12-4B
1	Art. No.	8AU9	4AU8	6AU8	8AU8	6AU8		8BU8	6BU8	8BU8	6BU8		8BU8	8BU9
	Mark	8A2	4A1	6A1	8A1	6A3		8B1	6B1	8B1	6B1		8B1	8B2
	Full length (mm)	280	275	264	324	308		397	412.5	397	412.5		397	372
2	Art. No.			6AU9	8AU9	6AU9	8AU10	8BU10	6BU9	8BU9		8BU9	16BU25	8BU21
	Mark			6A2	8A2	6A2	8A3	8B3	6B2	8B2		8B2	16B3	8B4
	Full length (mm)			286	280	286	258	366	381.5	372		372	428	341
3	Art. No.				8AU10		8AU10			8BU10	42BU8	8BU10	8BU8	16BU24
	Mark				8A3		8A3			8B3	6B3	8B3	8B1	16B2
	Full length (mm)				258		258			366	356.5	366	397	434
4	Art. No.						8AU9					8BU21	16BU25	8BU10
	Mark						8A4					8B4	16B3	8B3
	Full length (mm)						302					341	428	366
5	Art. No.													16BU25
	Mark													16B3
	Full length (mm)													428
6	Art. No.													8BU8
	Mark													8B1
	Full length (mm)													397

Fig. 59 List of unloader push rods

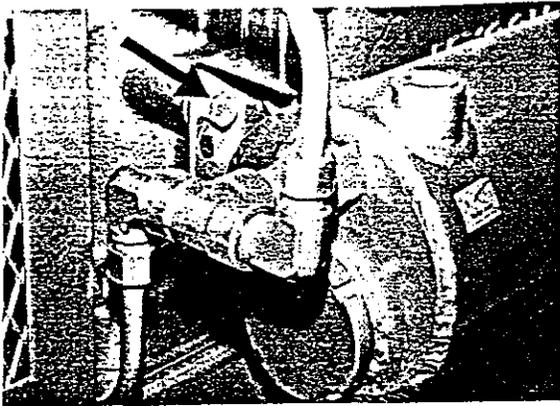


Fig. 60 Removal of oil cooler

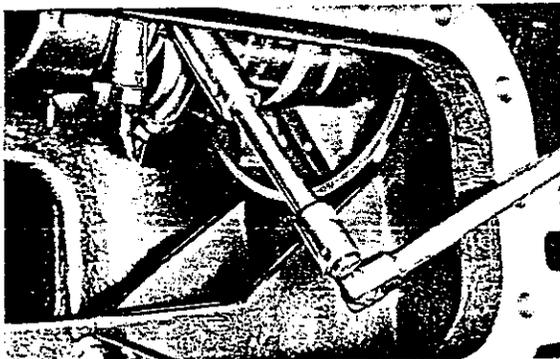


Fig. 61 Removal of rod cap

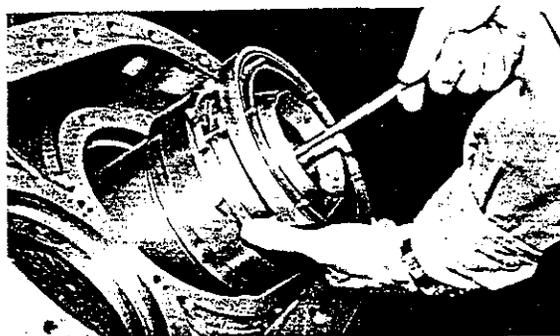


Fig. 62 Removing piston and cylinder

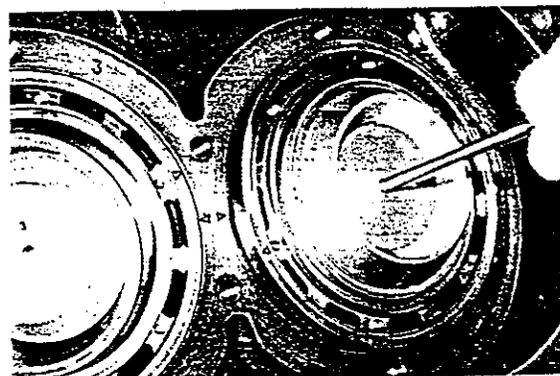


Fig. 63 Removing piston in improper position

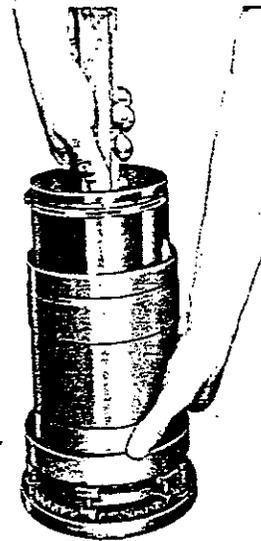


Fig. 64 Removing from sleeve

1.11. Handhole cover

- a) Remove oil feed piping. If the compressor is equipped with an oil tank for the automatic oil supply system, take off pressure equalizing pipe.
- b) Remove all screws except one at top center.
- c) Remove the gasket by partially unscrewing the one remaining screw. Hold the cover securely and remove it carefully. Be careful not to drop the cover. If it is equipped with an oil feed pipe, take care not to damage the float valve installed inside.

1.12. Disassembly of cylinder sleeve and piston

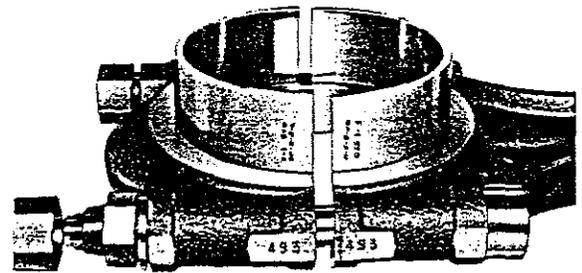
As the size of the connecting rod's big end is larger than the inside diameter of the cylinder sleeve, take the cylinder sleeve, together with piston and connecting rod, from the crankcase.

- a) Remove the bolts and nuts of the connecting rod through the hand hole as shown in Fig. 60. Remove the double locked nuts one by one.

- b) When the nuts have been removed, pull off the cap.
- c) Screw the supplied eyebolt into the hole tapped in the piston top. (Ref. Fig. 61.)
- d) Turn the crankshaft so that the piston comes to the dead bottom position. The connecting rod must be pulled off the bolts. (Index No. 78).
- e) The cylinder sleeve and piston can normally be lifted out together by the eyebolt. If the cylinder sleeve is too tight, loosen it by tapping the bottom end of the sleeve with a wooden block or by hooking a piece of bent iron wire around the guard of the sleeve and pulling. (Ref. Fig. 63.)
- f) Should the cylinder sleeve be too tight and only the piston comes, the compression rings will be withdrawn and released from the cylinder, making disassembly difficult. (Ref. Fig. 62.)
- g) On lifting, be careful not to allow the end of the connecting rod to hit the web plate of the crankcase.
- h) As the connecting rod is part of a set including the cap and the sleeve, all these pieces should be grouped in order.
- i) A connecting rod and a rod metal cover make a pair, so care must be taken not to mix them with the other pieces.

1.12.1. Cylinder sleeve

- a) Place the cylinder sleeve on the table with its upper surface (suction valve side) downward to prevent damage. To prevent damage to the seat surface it is best to take out the lift pin. This can be done by turning the cam ring and then pulling it out, holding the connecting rod. (Ref. Fig. 64.)
- b) Usually, it is unnecessary to disassemble the cylinder sleeve. There are two types of cam rings; one of them has lots facing right and the other has slots facing left. A cam ring, therefore, must be selected according to the position of the cylinder sleeve in crankcase. (Ref. Fig. 56)



Manufacturing assembly number
(There is a cylinder number on
the back side.)

Fig. 65 Assembly numbers of connecting rods



Fig. 66 Removing rings

1.12.2. Piston and connecting rod

Put piston with its top downwards. Remove snap ring for piston pin with pliers, tap piston pin with wooden block and pull it out carefully. Do not take off the bearings from the rod except when a change is necessary.

The connecting rod body and cap have manufacturing assembly numbers (three figures) and one or two figures to indicate piston assembly number (cylinder number) stamped on the surface. Keep each pair together. (Ref. Fig. 65.)

1.12.3. Piston ring

Take off the rings as shown in Fig. 66. Do not take off unless replacement is necessary.

1.13. Shaft seal section

Refer to the following order for disassembly. (Fig. 67 to 69.)

- a) Remove all but two screws from the cover plate, leaving the two symmetrically positioned.
- b) Next, loosen these two screws alternately in the same manner as for the head cover. As inside this cover is an oil reservoir, put a tray under the cover plate during the work.
- c) When the screws are removed, the cover plate disengages from the seat of the bearing head. Draw it out, holding it perpendicular to the crankshaft. Be careful not to drop it on the crankshaft.

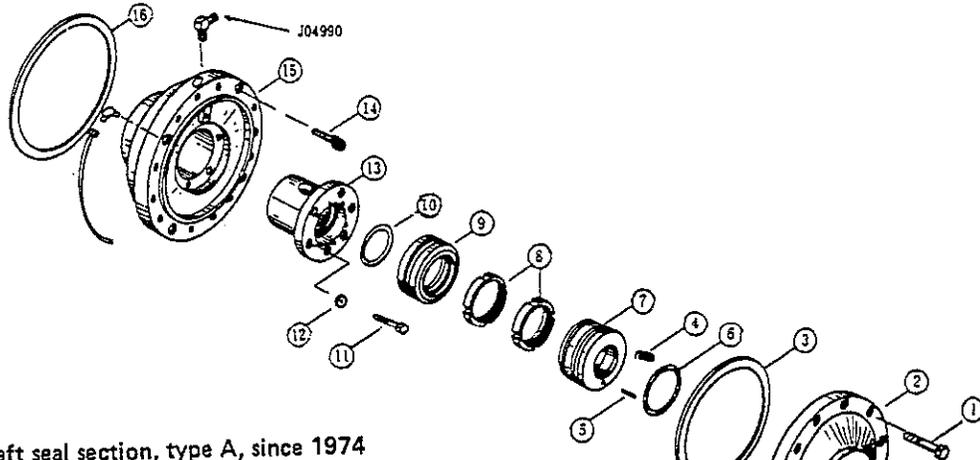


Fig. 67 Shaft seal section, type A, since 1974

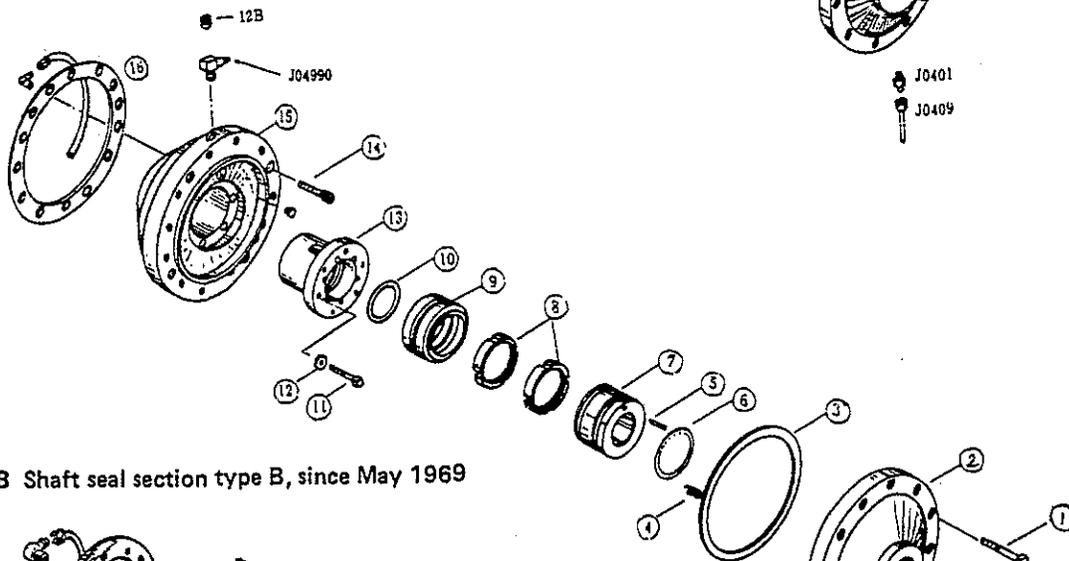


Fig. 68 Shaft seal section type B, since May 1969

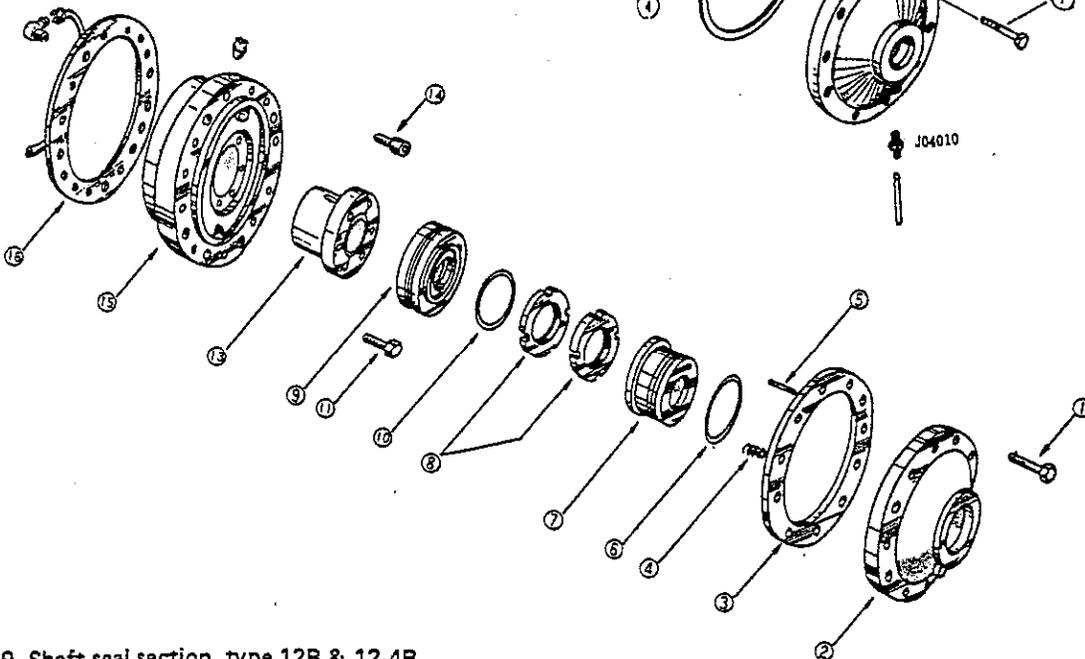


Fig. 69 Shaft seal section, type 12B & 12-4B

No.	Name of part	Type A		Type B		12B & 12-4B	
		Art. No.	Q'ty	Art. No.	Q'ty	Art. No.	Q'ty
1	Screw, cover plate	AM8S	8	BM8S	12	BM8S	12
2	Cover plate	AM8	1	BM8	1	BM8	1
3	Gasket, cover plate	AM10	1	BM10	1	BM10	1
4	Helical spring	AM7	(N) 8 (R) 12	BM7	10	BM7	10
5	Roll pin	PP4-11	1	PP5-10	1	PP5-10	1
6	"O" ring, shaft seal ring	OA46B	1	OA51B	1	OA51B	1
7	Shaft seal ring	AM5	1	BM5	1	BM5	1
8	Locknut	AM4	2	BM4	2	BM4	2
9	Shaft seal collar	AM2	1	BM2	1	BM2	1
10	"O" ring, shaft seal collar	OA39B	1	OA47B	1	OA47B	1
11	Screw, thrust bearing	A11S	6	B11S	6	B11S	6
12	Washer, thrust bearing	A44	6	B44	6	B44	6
13	Thrust bearing	A11C	1	B11D	1	B11D	1
14	Screw, bearing head	A8S	4	B6S	4	B6S	4
15	Bearing head	A8C	1	B8B	1	12B8	1
16	Gasket, bearing head	A9	1	B9	1	12B9	1

Shaft seal component (Ref. Fig. 67 to 69)

1.13.1. Shaft seal collar

- a) When the shaft seal mechanism is as shown in Fig. 70, remove the locknuts (8) using extreme care to avoid scratching the moving surface of the shaft seal collar (9). (Ref. Fig. 71)
- b) When the locknuts have been removed, pull out the shaft seal collar (9) through the groove on the outer circumference as shown in Fig. 72. Never risk gouging it by putting a screwdriver between the seal collar and the thrust bearing (13) even when it will not part easily.

The components of the double seal collar for Freon are shown in Fig. 73.

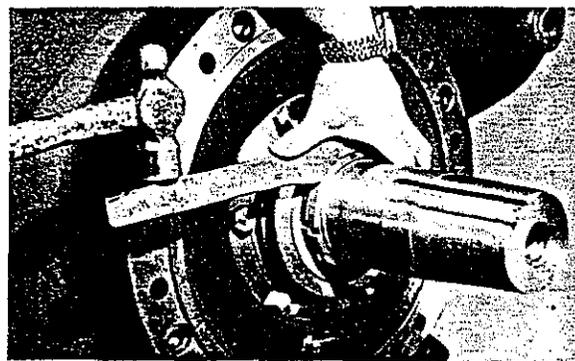


Fig. 71 Removing locknuts

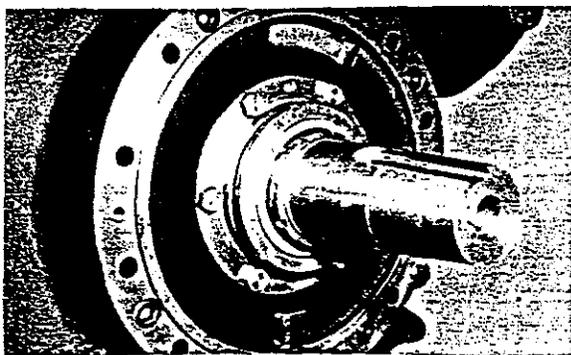


Fig. 70 Shaft seal without cover plate

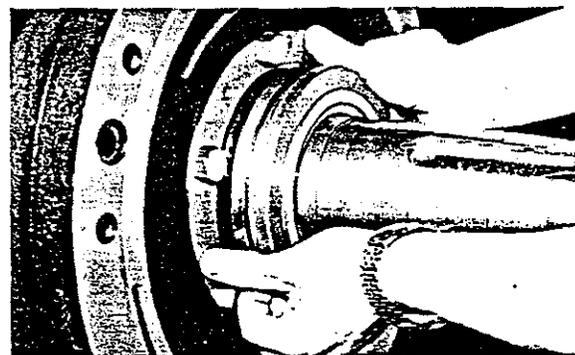


Fig. 72 Removing seal collar

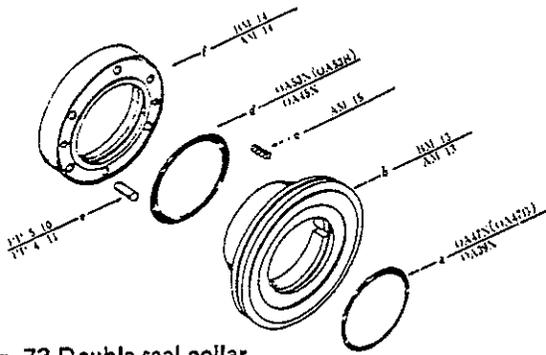


Fig. 73 Double seal collar

The part number in () is for 12B & 12-4B when ammonia.

	Name of part	Type A		Type B	
		Part	Q'ty	Part	Q'ty
a.	"O" ring shaft seal collar	OA39N	1	OA47N	1
b.	Retainer ring, double seal collar	AM13	1	BM13	1
c.	Spring, double seal collar	AM15	6	AM15	8
d.	"O" ring, double seal	OA45N	1	OA53N	1
e.	Pin, double seal collar stopper	PP411	1	PP510	1
f.	Floating seat, double seal collar	AM14	1	BM14	1



Fig. 74 Removing seal ring

1.13.2. Thrust bearing

When the screws have been removed, draw out the thrust bearing with the pulling screws by lifting up the crankshaft slightly.

1.13.3. Bearing head

Remove the screws (14) and then draw the bearing head out with the pulling screws in the hand tool kit. Just before it comes away through the opening of the crankcase, it should be held by two people, as it is very heavy (about 20 kgs). It should be pulled out carefully keeping it perpendicular to the crankshaft.

1.14. Oil pump

- Before removing, take note of the arrow mark (Fig. 10) indicating the direction of rotation.
- To remove oil pump, press out the pump by inserting eye-bolts in the two blind bolt holes and press out evenly.

- Leave the oil pump as an assembly unless it is absolutely necessary to disassemble. As an "O" ring remains on the main bearing, it must also be removed.

1.14.1. Drag crank

When the oil pump is pulled out, the crankshaft end is seen where the drag crank is attached. It can easily be taken off from the crankshaft by hand.

1.15. Crankshaft

1.15.1. Model A & B

Wrap the bearing surfaces in cloth to protect them from damage. The crankshaft is held at one end by the main bearing. Therefore it is best to keep the other end in position with a wood block inserted from the hand-hole side.

If the crankshaft is twisted before it is pulled out completely, it will scar the bearing surface of the main bearing. Therefore, pull it out straight, slowly and carefully.

1.15.2 Model 12B & 12-4B

To remove the crankshaft of types 12B & 12-4B, disassemble the main bearing head first. Then the shaft is held only by the mediate bearing as shown Figure 78.

- Before disassembling the main bearing, drain the oil inside the cuno-filter case by pulling out the drain plug. About 3 litres can be collected. Refer to Figure 77.
- Remove the oil pump assembly (56) by loosening the screws DG1-6-1. Do not loosen screws DG1-7-1. These screws are loosened only when reversing the direction of revolution. For this purpose loosen screws (60) and turn the oil pump assembly (56) 180°.
- Remove the drag crank (3).
- Using a box wrench, loose the locknut of the taper pin (133) which holds the mediate bearing to the main body. Refer to Figure 79.
- When the locknut has been slackened off about 5mm, tap the taper pin (131) and pull out.
- Although not included in our standard tool kit, a special shaft disassembly tool is available by order and will make this job much easier. (Refer Fig. 78)
- Push out the shaft with a wood block from the hand-hole cover side until the shaft comes out at the position shown as Figure 78. Then hang the shaft at mediate bearing and pull out completely.
- Release the mediate bearing by propping up the main bearing and thrust bearing sections with wood blocks. Draw out the taper pin, and the mediate bearing separates into two pieces.

Fig. 75 Main bearing section, type A

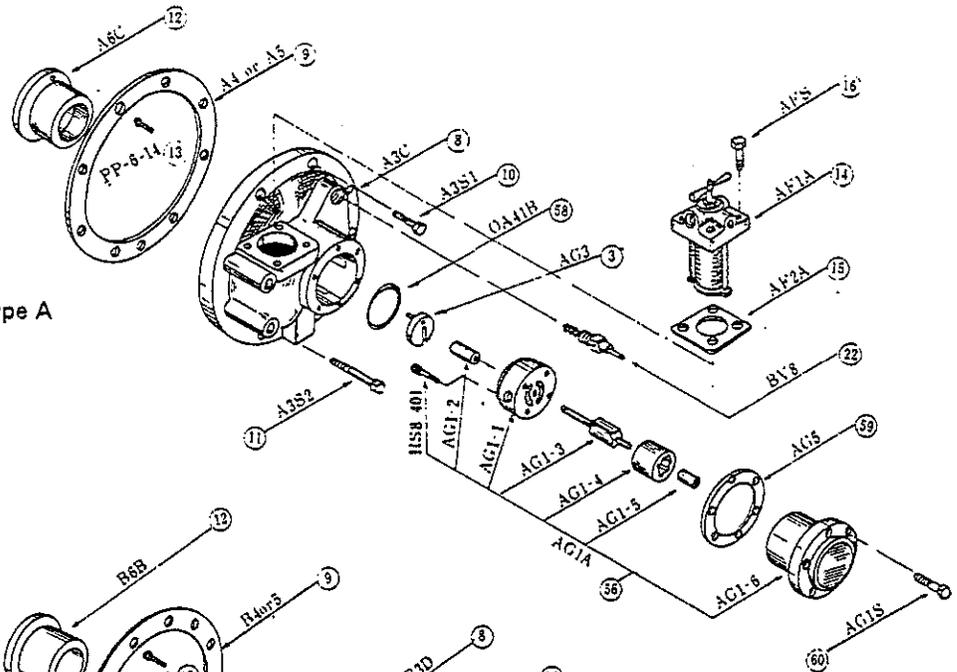


Fig. 76 Main bearing section, type B

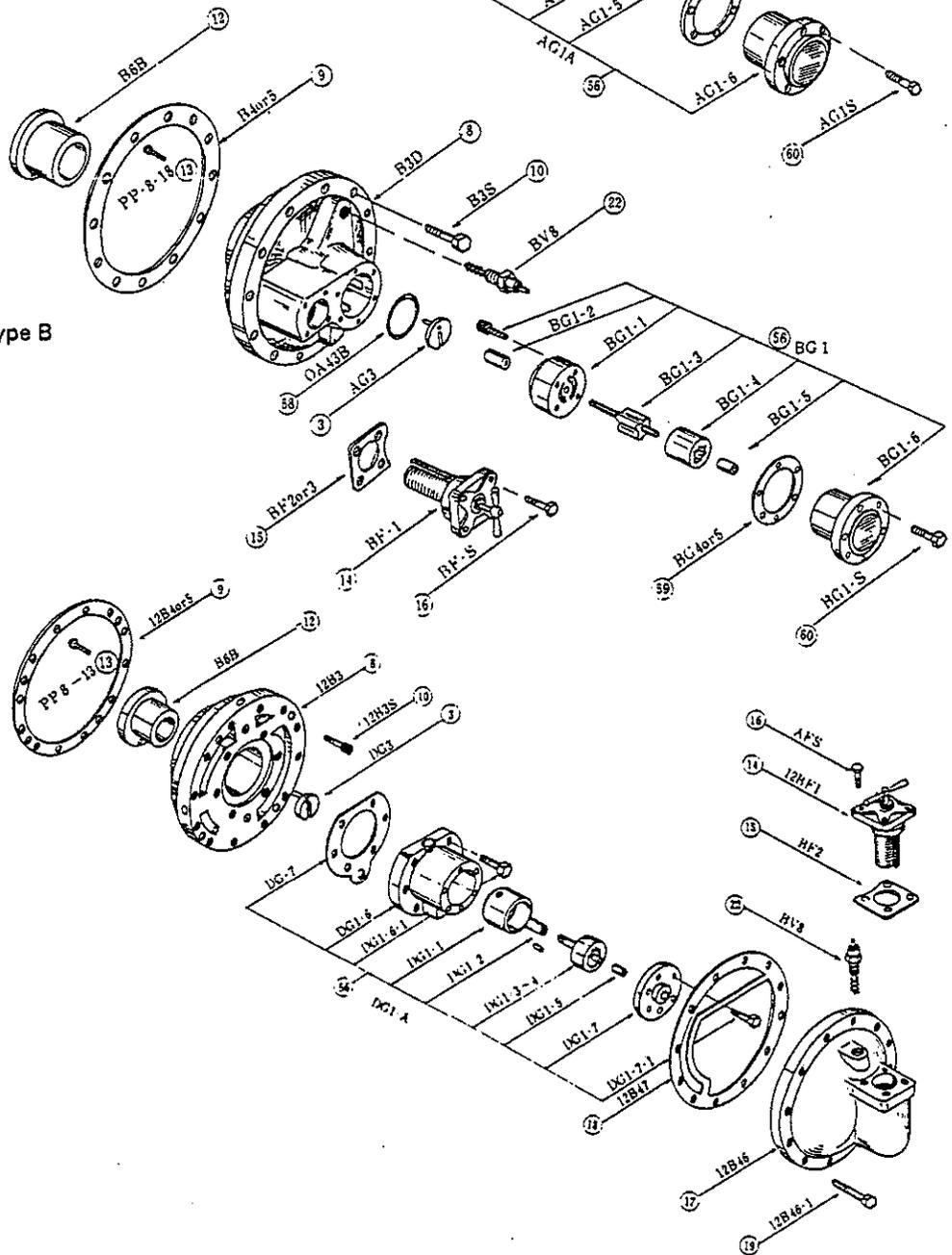


Fig. 77 Main bearing section, type 12B & 124B

Parts list of main bearing

Index No.	Name of part
3	Drag crank
8	Main bearing head
9	Gasket, main bearing head
10	Screw, main bearing head
12	Main bearing
13	Vis, main bearing
14	Cuno-filter assembly
15	Gasket, cuno-filter cover
16	Screw, cuno-filter cover
17	Case, cuno-filter
18	Gasket, cuno-filter case
19	Screw, cuno-filter case
21	Oil relief valve
22	Oil pressure regulating valve/oil relief valve
56	Oil pump assembly
60	Screw, oil pump

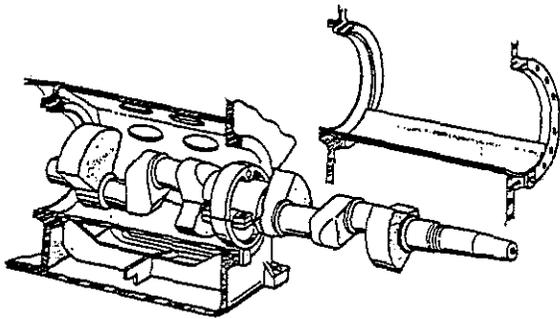


Fig. 78 How to pull out crankshaft, Model 12B & 12-4B

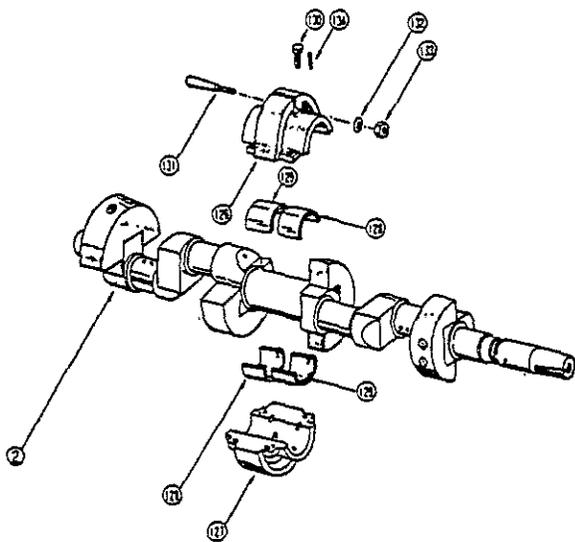


Fig. 79 Mediate bearing, for model 12B & 12-4B

Parts list of crankshaft section:

Index No.	Name of part	Art. No.	Q'ty
2	Crankshaft	12B2	1
	Oil drain plug	JOAP 10	1
126	Mediate bearing (upper)	B542	1
127	- do - (lower)	B541	1
128	- do - metal A	B543	2
129	- do - metal B	B544	2
130	- do - screw	B545	4
131	Taper pin	B546	1
132	Washer, taper pin	B548	1
133	Locknut, - do -	B549	1
134	Taper pin (threaded)	B547	2

1.16. Main bearing head

- Remove the pipes for oil pressure service and then remove the main bearing head with care in the same way as the bearing head. The cuno-filter cannot be turned if the filter disks are bent.
- Loosen the screws (10). During disassembly of model A, the screws cannot be taken off without disassembling the cuno-filter first, but on model B it is possible.
- Take off the gasket attached to the main bearing. Care must be taken not to damage the gasket.

1.17. Strainer

The following are utilized.

Model	2A	4A	6A	8A	42A	62A	4B	6B	8B	42B	62B	12B	12-4B
Scale trap						*				*	*		
Suction strainer	*	*	*	*	*		*	*	*			*	*

a) Scale trap,

Remove the end cover of the scale trap. The screen is then easily removed as it is simply held down by the cover. Sometimes a small quantity of oil remains in the trap. Therefore, when removing the cover, put a tray underneath.

b) Suction strainer,

The suction strainer is held down by a spring. Take off the screws for the cover, remove the spring, and then the suction strainer. The screen in the strainer is locked with a snap ring as shown in Fig. 80 and is easily removed.

The suction strainers of models 12B & 12-4B have no snap rings.

c) Oil strainer,

The oil strainer can be removed easily by opening the oil strainer cover and/or handhole cover.

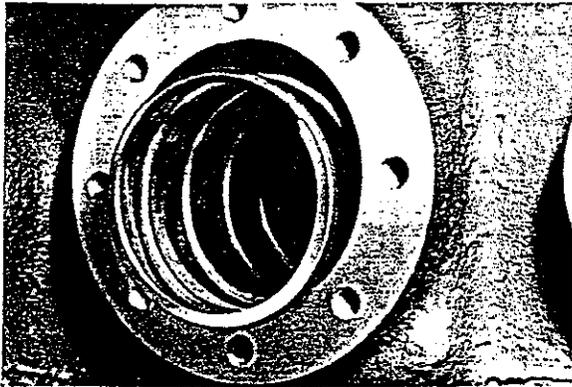


Fig. 80 Removal of suction strainer

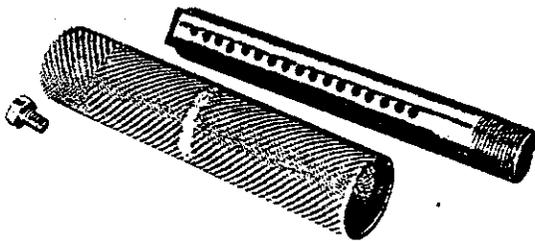


Fig. 81 Oil strainer

2. Assembly

2.1. Checking parts

When changing parts (in accordance with the established standards given in Supplement 8) after inspection or repair is finished, the parts are assembled in the reverse order of disassembly.

- Clean the parts and the crankcase thoroughly using light oil or gasoline, etc. and coat surfaces with lubricating oil.
- Before assembling, apply a sufficient quantity of oil particularly to moving parts.
- To clean, do not use woolen fabrics as fibre will remain.
- After inspection, gaskets should be coated with lubricating oil or a graphite/oil mix.
- Tighten the screws symmetrically.
- Take care in assembling models 12B & 12-4B.

The assembly order for their shaft section is different from other models.

2.2. Assembly of main bearing and main bearing head

- On assembling, note carefully the position of the gasket hole; oil will not be sucked up if there is any deviation in the position of the oil suction port. Special care must be taken for models 12B & 12-4B.
- Position the main bearing on the main bearing head before it is fixed the crankcase, checking the position of the pin for the main bearing and also confirming the position of the oil hole.
- Install the cuno-filter after the main bearing head has been installed.
- In the case of models 12B & 12-4B, the shaft must be assembled before attaching the main bearing and head.

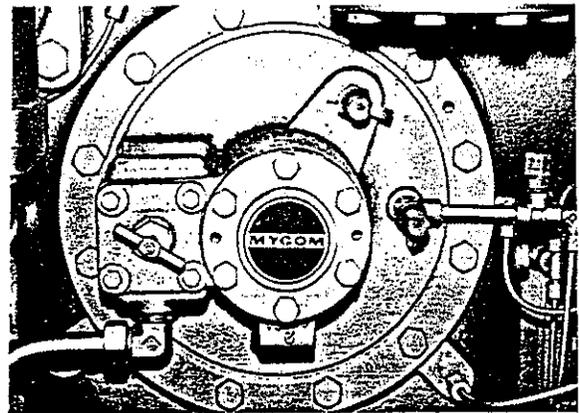


Fig. 82 Main bearing head, type B

2.3. Installation of crankshaft, model A & B

Set the crankshaft into the crankcase taking care to protect the bearing surfaces from damage.

When a block is used to insert the crankshaft into the crankcase, be careful not to leave any residue inside the crankcase, and inspect after assembly is finished.

Put the crankshaft completely into the main bearing in one move.

2.4 Installation of crankshaft, model 12B & 12-4B

- Fix the mediate bearing to the crankshaft first. Each half of the bearing holds two babbit halves. Confirm that the locking notches match and that the oil groove and oil hole are correctly orientated. If set in reverse, oil will escape and serious damage will result.

Set the notched edge of the bearing babbit in first and then push in the opposite side. When renewing the metal especially, take care that the bearing metal is not damaged against the housing. If necessary file smooth.

- b) When installing the metal, the ends protrude slightly but this is unimportant as the metals shape themselves to the housing when installation is completed.
- c) Confirm that the marks at both ends of metal match. Measure the inner diameter with a cylinder gauge before setting the shaft. The out-of-roundness must be within 0.02 mm.
- d) Before tightening, apply compressor oil to the bearing surfaces. Fasten the bolts alternately and drive in the lock pin until tight.
- e) After completing the fastening, turn the mediate bearing by hand. It should turn smoothly and freely. The taper pin must be positioned on the top before installing the shaft in the housing. This positioning cannot be accomplished after installation, so adjust carefully at this point.
- f) Check for scars or marks on the outer surround and correct if found.
- g) Slide onto the crankcase. The taper pin must be positioned on the top.
- h) Temporarily fasten the taper pin and locknut.
- i) After installing the main bearing head, bearing head and shaft seal assembly, adjust the mediate bearing placed with evenly gaps at each ends, and then fasten tightly the locknut of taper pin.

2.5. Bearing head and thrust bearing

- a) There are two kinds of port in the bearing head dependant on the oil feeding method. In model A compressors, the bearing head has an upward oil feeding port (refer to Fig. 12). In model B compressors, it is downward (refer to Fig. 14), since July 1969, and in model 12B & 12-4B compressors, it is an upward oil feeding port (refer to Fig. 17). Older type compressors, both A & B, have the downward feeding port. Alternately tighten the screws securely.

Model A (since July 1974), B (since July 1969), 12B and 12-4B compressors have pipes for seal oil return. Take care not to bend these pipes. The direction of oil escape must be towards the oil in the crankcase.

- b) Check that it is correctly positioned in relation to the bearing head and match these two ports perfectly.
If the thrust bearing is an aluminum backed metal, do not forget to use a washer when fastening.
- c) After tightening the thrust bearing, turn the crankshaft by hand to check for abnormality.
- d) The four screws must be fastened tightly. If this cannot be accomplished, disassemble the cover plate and set them up again.

2.6. Shaft seal

- a) Turn the notch of the seal collar upward, fit the locking ball of the crankshaft in the notch, and insert the seal collar by hand, taking care not to damage the "O" ring.
If it does not enter easily, push it forward by tightening the locknut carefully; check whether the locking ball is seated in the noth. (Ref. Fig. 83)

- b) Tighten the locknuts, alternately, tapping the spanner handle with a hammer.

Take care not to damage the friction surface of the seal collar.

- c) After pulling out the crankshaft by rotating it by hand, measure the clearance between the seal collar and the thrust bearing with a thickness gauge at the top and bottom and also right and left positions. (Ref. Fig. 84 & Supplement 8.3.)
- d) Fit the seal ring on the cover plate. Push the roll pin in the hole and examine its operation by applying equal force on the seal ring by hand. Care should be taken in selecting the "O" ring, according to the refrigerant, i.e. Ammonia, Freon R-12 and R-22.
- e) Occasionally in case of Freon for model A, two pieces of helical springs are added.
- f) Apply a sufficient quantity of oil to the friction surface of the seal collar and seal ring.
- g) Inspect the gasket. If it is a new gasket, apply oil and fit to the cover plate.
- h) Fit the cover plate over the crankshaft. Tighten the bolts uniformly and ensure that the oil drain pipe points downward.



Fig. 83 How to set locknuts

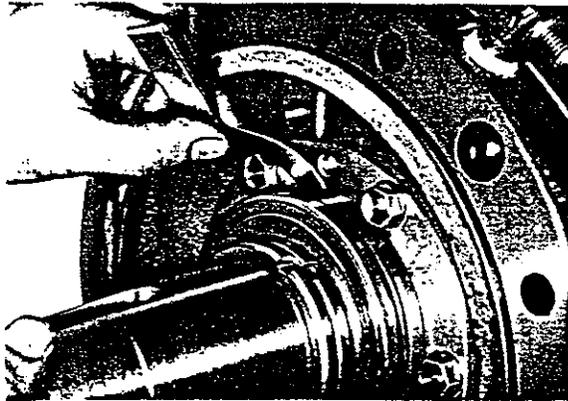


Fig. 84 Measuring thrust gap

2.7. Oil pump

- a) Insert the drag crank so that the pin hole on the crankshaft comes to the top. The groove comes in the center.
- b) Attach the "O" ring to the oil pump.
- c) Insert the oil pump with its notch in the same direction as the groove of the drag crank. Do not tighten forcibly if the shaft of the oil pump does not enter into the groove.
- d) Tighten the screws uniformly after checking the direction of rotation.

2.8. Cylinder section

2.8.1. Piston

- a) Mount the compression and oil rings on the pistons. Do not align the ring gaps. (Refer to Fig. 85.)
- b) In mounting compression rings, the stamped surfaces should be facing upwards. (Ref. Fig. 86.)



Fig. 85 Arrangement of rings

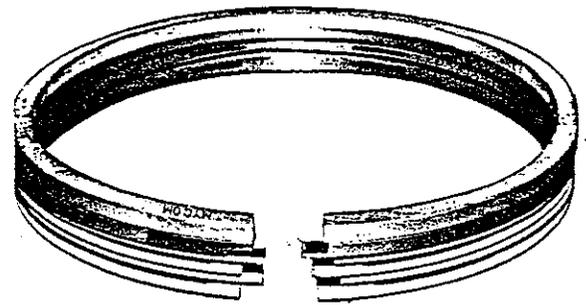


Fig. 86 Mark on ring

- c) The standard arrangement of the rings is shown as follows. These can be changed depending on various conditions.

Combination of Piston Rings (Same usage for A and B type):

Ring	III type piston (Since Sept. 1973)		II type piston (before Sept. 1973)	
	NH3	R12, 22	NH3	R12, 22
1st	GA-P	FC-P	GA-P	FC-P
2nd	FC-UC	FC-UC	FC-P	FC-P
3rd	FC-PC-BC _{3p}	FC-PC-BC _{3p}	FC-UC	FC-UC
4th	FC-PC-BC ₃	FC-PC-BC ₃	FC-PC-BC ₃	FC-PC-BC ₃

Since September 1973, we have manufactured new rings only, which are best suited to use on the type-III. When you need to renew the rings of type II pistons, you use the combination shown on the right side of the above table. At that time, please make oil holes in the II type piston as follows:

Type A, in the 3rd groove, 12 holes each 2.5mm dia.
Type B, in the 3rd groove, 12 holes each 3mm dia. and below the 3rd groove, 6 holes 3mm dia.

Fig. 89 List of piston ring components,
For model A & B compressors

- d) Special care must be taken when handling piston rings as they warp easily. Warping may cause oil loss.
- e) It must be confirmed that the rings move freely in the grooves of the piston. If not, the ring is probably warped. The gap between the ring and groove width is about 0.05 to 0.09mm as standard.

2.8.2. Connecting rods

Connect the piston and the connecting rod with the piston pin. It is ideal if the piston pin is tight in the pin hole of the piston but slightly loose in the bushing hole of the connecting rod. The tolerance between the bushing and the piston pin is 0.03 to 0.06mm. For this reason, it is sometimes driven into the pin hole utilizing a block pad.

When replacing the bearings, do not mix the upper and lower halves. Fit the halves into the rod and cap. Do not

forget to put the half having the oil hole in the center in the rod side, not in the cap. When the connecting rods are being assembled on the crankshaft, the numbers punched on the rod and cap must be matched. (Ref. Fig. 87)

The replacement of old type connecting rods by the new type is acceptable.

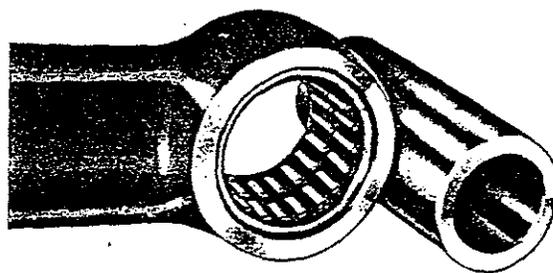


Fig. 88 Bushing and piston pin of connecting rod. (Needle bearing type)

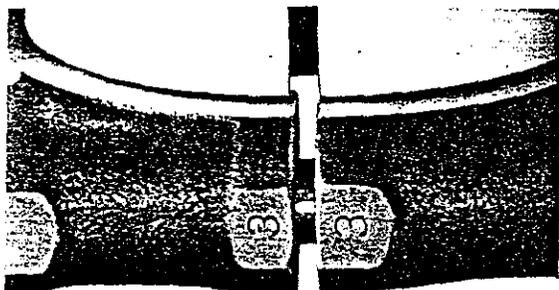


Fig. 87 Assembly numbers for connecting rod

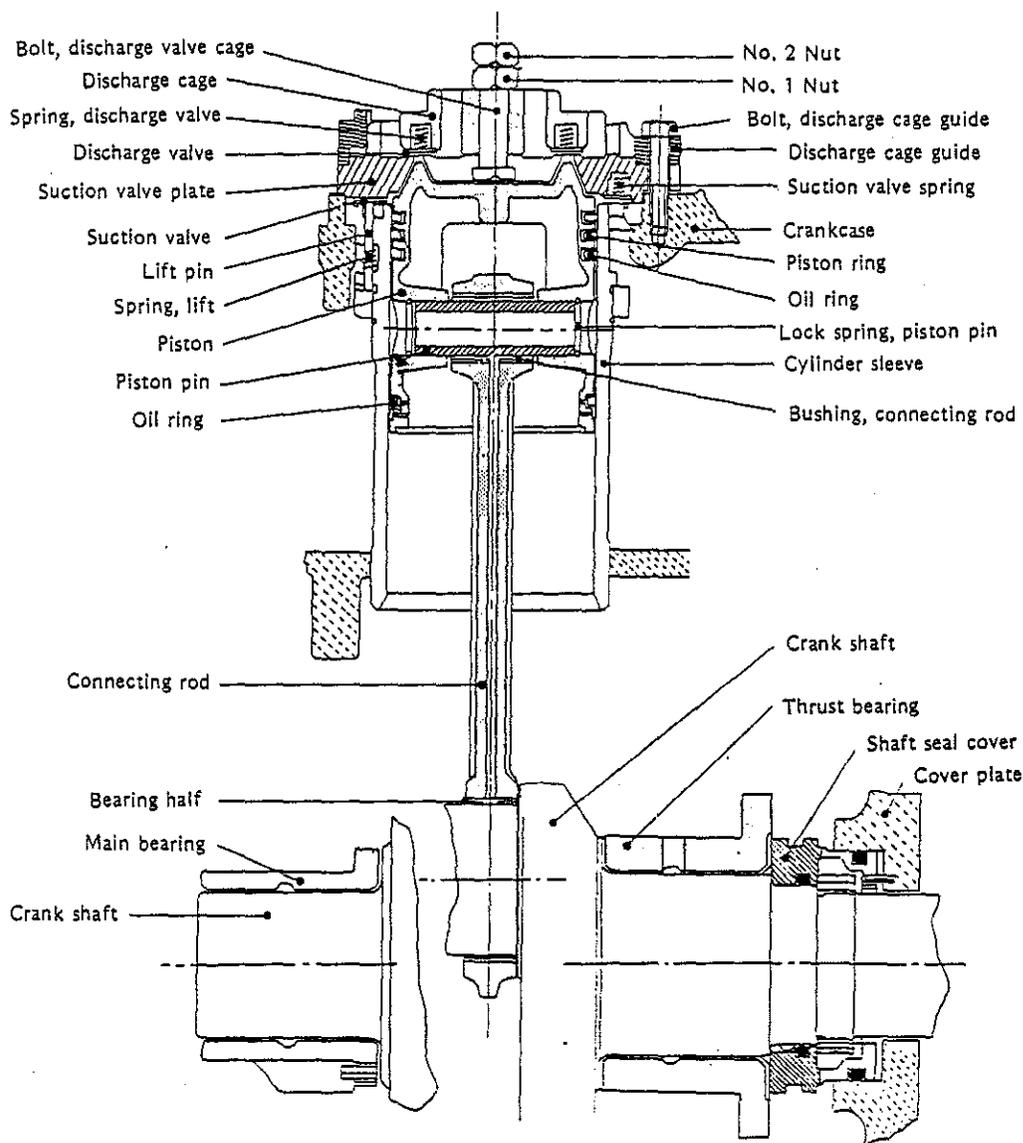


Fig. 89 Piston, connecting rod and crankshaft. (Sectional)

2.8.3. Cylinder sleeve

- a) Check the direction of the notch on the cam ring referring to the cylinder numbers marked on the crankcase and the direction of push rods.

Since 1968, the support ring has been omitted from the cylinder sleeve. It simplifies the disassembly of these parts, because it is not necessary to disassemble the unloader section when pulling off the cylinder sleeve.

- b) The lower end of the cylinder sleeve is beveled, so that the piston and rings can be inserted easily. If the top ring enters the piston can be pushed in easily. Push it in taking care not to damage the other rings.

Care should be taken not to damage the seat surface of sleeve or the corners of the piston. Such damage will scar the inside the cylinder sleeve in operation.



Fig. 90 An example of incorrect assembly
The slanted notches are facing in opposite directions.



Fig. 91 How to insert piston into sleeve

2.9. Installation in casing

- a) Screw the eyebolt into the piston head.
- b) Attach the cylinder sleeve gasket to the back of the sleeve guard with oil.
- c) Inspect the assembled connecting rod and cap.
- d) Check the cylinder number.
- e) Turn the crankshaft to bring the appropriate crank pin to dead bottom.
- f) Bring the piston to the dead top point of the cylinder sleeve.
- g) Do not insert the crank fastening bolt pin, as it may damage the shaft. The numbering marks of the connecting rod and cylinder sleeve must be turned to face the direction of the handhole side.
- h) Assemble in the reverse order of disassembly. The unloader push rod must be kept in the condition shown by Fig. 54. When the guard of the cylinder sleeve enters into the seat of crankcase, push down the piston and install the connecting rod on the crankshaft, supporting its large end by hand. Take care not to damage the crankshaft with the bolts.
- i) Mount the cap. Be sure the match the pairs of numbers stamped on the surfaces.
- j) Tighten the bolts with a torque wrench according to the torque loads indicated below. The proper torque must be obtained otherwise the cap of the rod will become out-of-round.

Bearing Half Tightening Torque

ft/lb (kg/m)

Nuts	Model A	Model B
1st nut	45 (600)	90 (1200) in case of single nut
2nd nut	35 (450)	60 (800)

- k) Install the cylinders one by one rotating the crankshaft slowly. The cylinder sleeves will jump up if the crankshaft is rotated abruptly as it is not yet tightened down.
- l) Check the lateral play of the connecting rods.

2.10. Unloader mechanism

- a) Check the mounting position of the push rod. It enters smoothly when pushed in slowly if the cam ring notch is accurately located.

- b) When the push rod has been inserted, correctly locate the position of the cylinder sleeve, setting it to the countermark (refer to Figure 92).
- c) Insert the unloader piston. Examine the movement of the lift pin by pushing the unloader piston with your thumb.
- d) If the lift pin does not come up above the seat surface of the cylinder sleeve when the countermarks meet and the unloader piston is pushed, nor goes back when it is released, examine whether the length of the push rod is correct or whether the correct cam ring is being used.
- e) When all inspections are finished, mount the unloader piston cover.

In the case of newly replaced sleeves, take special care when stamping marks. If the setting is incorrect, unloading will become irregular and damage to the valve may result.

To stamp the marks on a new sleeve, push in the unloader piston using a hanger eye-bolt to bring the lift pins of new sleeve to a position level with the seat. So positioned, the lift pin moves in and out at the middle part of the piston strike. Now set the other lift pins. Position the same as above by turning the sleeve and then stamping the marks.

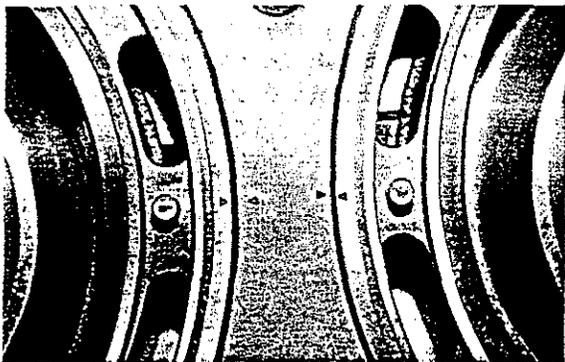


Fig. 92 Assembly marks of sleeve setting

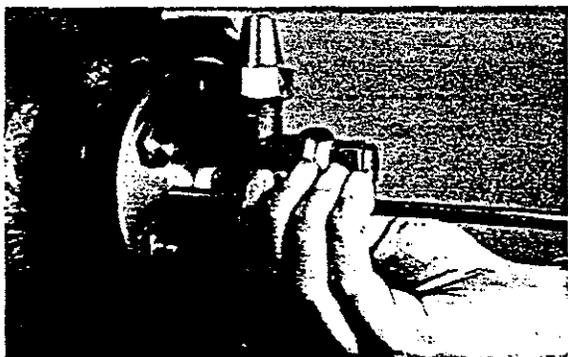


Fig. 93 Push unloader piston with eye-bolt

2.11. Valve plate

- a) Mount the suction valve springs. As the springs are slightly tapered, push them in large end down twisting against the coils.
- b) For the cylinder with the unloader mechanism, remove the cap bolt on the unloader cover, screw in an eyebolt, and put the bank in the loaded position. Lower the lift pins by pushing the unloader piston with the eyebolt screwed in as shown in Figure 94. Neglecting this step will cause damage to the suction valve or problems such as gas leakage after assembly.
- c) Join the suction valve assembly and the valve plate. Check that the valve is set properly.
- d) To identify the valve plate, two classifications, according to the model of the compressor, are used:

Classification 1: 2A 4A 6A 8A 42A 62A 4B(old) 6B 8B

Classification 2: 4B(new) 6B 8B 12B 42B 62B 12-4B

1) Classification 1,

The valve plate in effect caps the cylinder sleeve which extends above the surface of the crankcase 0.004 in (0.1 mm). If the sleeve does not extend this far above the surface, add another cylinder gasket to meet the required tolerance.

2) Classification 2,

The valve plate in effect is seated inside the cylinder. In this case the sleeve top is 0.0354 in (0.9mm) below the top of the cylinder wall.

- e) Put on the guide and tighten the bolts. Ensure that bolts are tightened evenly.
- f) When the valve plate has been attached, pull out the eyebolt from the unloader cover. Do not forget to screw in the cap screw (alien head) immediately after removal of the eyebolt.

2.12. Fitting

- a) Fit the screen for the scale trap, the suction strainer, and oil strainer.
- b) Before attaching the hand hole cover, feed a sufficient quantity compressor oil into the crankcase.
- c) Attach the inspection port cover, the oil cooler and then connect the oil piping. Clean the oil pipes by blowing air or passing light oil through them.

2.13. Confirmation of idle running

Refer to item 2.6 "Idle running test" of "Preparations for operation."

2.14. Discharge valve (assembly)

- a) Put the discharge valve on the springs and tighten the bolt, pressing down valve seat by hand.
- b) Tighten nuts No. 1 and No. 2 (grooved nut). Torque to values given below.

lb/ft (kg/m)

Nuts	Model A	Model B
No. 1	80 (11.0)	90 (12.0)
No. 2	60 (8.0)	60 (8.0)

When the assembly of these parts is finished, check operation as shown in Figure 97.

- c) Remove any carbonized oil or slag with a wire brush taking care not to damage the seat surface.



Fig. 94 Testing of discharge valve

2.15. Mounting parts

When idle running operation is finished, mount the discharge valves, the safety head springs and the head covers. Mounting the head cover is easily done by screwing a headless bolt into the top center to support the head cover.

Torque valves of the head cover bolts are as follows:

Model A	800 kg/cm
Model B	1200 kg/cm

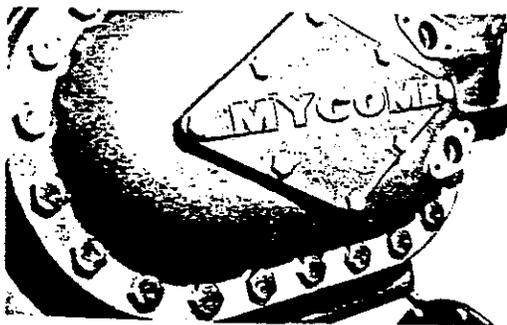


Fig. 95 Installing head cover

2.16. Jacket piping

Install after cleaning the inside of the water jacket completely.

2.17. Final inspection

Carry out final inspection before starting refrigerating operation. Check whether eyebolt has been removed from the unloader piston cover, whether self-flaring nut for oil pipings are securely tightened, etc.

CHAPTER 4. OPERATION OF TWO STAGE COMPRESSION

1. Preface

The attached flow chart (Fig. 97) of a two-stage compression system shows the most common piping flow using a liquid pump.

Operators should know the piping system, in particular the position and function of each valve, and special features of their refrigeration system. This flow chart shows two compressors for two stages, high and low, but when your system is compound, (type 42A, 62A, 42B, 62B & 12-4B) you must note the following substitutions:

Two stage	Compound
#30, Suction stop valve (L)	#12, Discharge stop valve (L)
#11, Suction stop valve (H)	#1, Discharge stop valve (H)
#31, Discharge valve (L)	Corresponding discharge valve (H)
#32, Suction valve (H)	Corresponding suction valve (L)

(L) Low stage side, (H) High stage side

and handle the compound compressor by starting revolution as a high stage side compressor and a low stage side compressor at the same time.

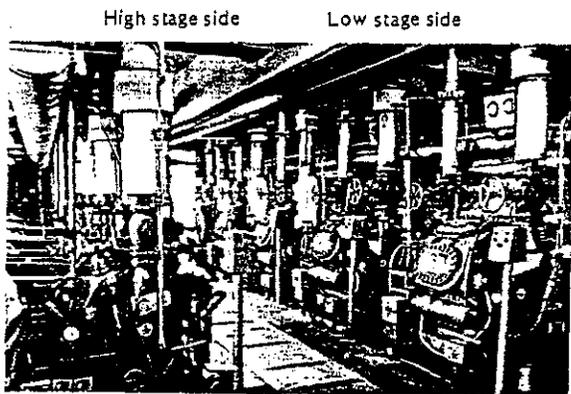


Fig. 96 Compound compressor system

2. Operation

2.1. Operation of newly installed equipment

Refer to flow chart. (Fig. 97).

Each refrigerating system has a different construction, working principle, etc., therefore, operating engineers (in the case of new plants in particular) should ask the engineer in charge of the installation of their refrigerating system for explanations and carry out test runs with the help of the contractors who did the job. You should not take delivery of the system until you are fully convinced of its performance.

2.2. Preparation for operation

(from initial air purge to refrigerant charge)

Check the installation condition of the complete refrigerating system, piping and wiring arrangements, etc. with the sectional flow charts.

Confirm that you have certificates verifying the air tightness of pipes, valves and other necessary parts and apparatus. Confirm that there are certificates for hydraulic and pneumatic tests for the relevant apparatus.

- a) Refer to Chapter 2, and review all necessary points.
- b) If there is no vacuum inside the apparatus, you must first bring it to this state by purging air.
 - 1) Close all drain, purge and other valves around the sides of the compressor, and open connecting valves for circulation in the apparatus.
 - 2) Make a vacuum of 650–700mmHg by connecting the purge valve to a vacuum compressor.
 - 3) Supply cooling water before operating the compressor.

When the compressor is high stage side only.

Close #1 and fully open lower purge valve.

When the compressor is compound or tandem type also close # 12 and open lower purge valve

Carefully watch oil pressure of the compressor and for overheating at the discharge parts.

Alternate air purging method.

Close valve #2, remove the bonnet of valve #1, and let the air escape between #1 and #2, using the by-pass valve.

Choose the most convenient of the above methods.

- 4) As the compressor and the piping path are in a vacuum, the refrigeration oil within the compressor may boil. Watch out for oil hammer while operating. Operate the compressor continuously until the vacuum is approximately 600–700 mmHg and then cease operation. When stopping, shut off the compressor purge valve. If any air remains in the apparatus when starting actual operation, pressure will rise, wasting electricity and making it necessary to repeat air purging. Therefore purge procedures should be done correctly the first time.

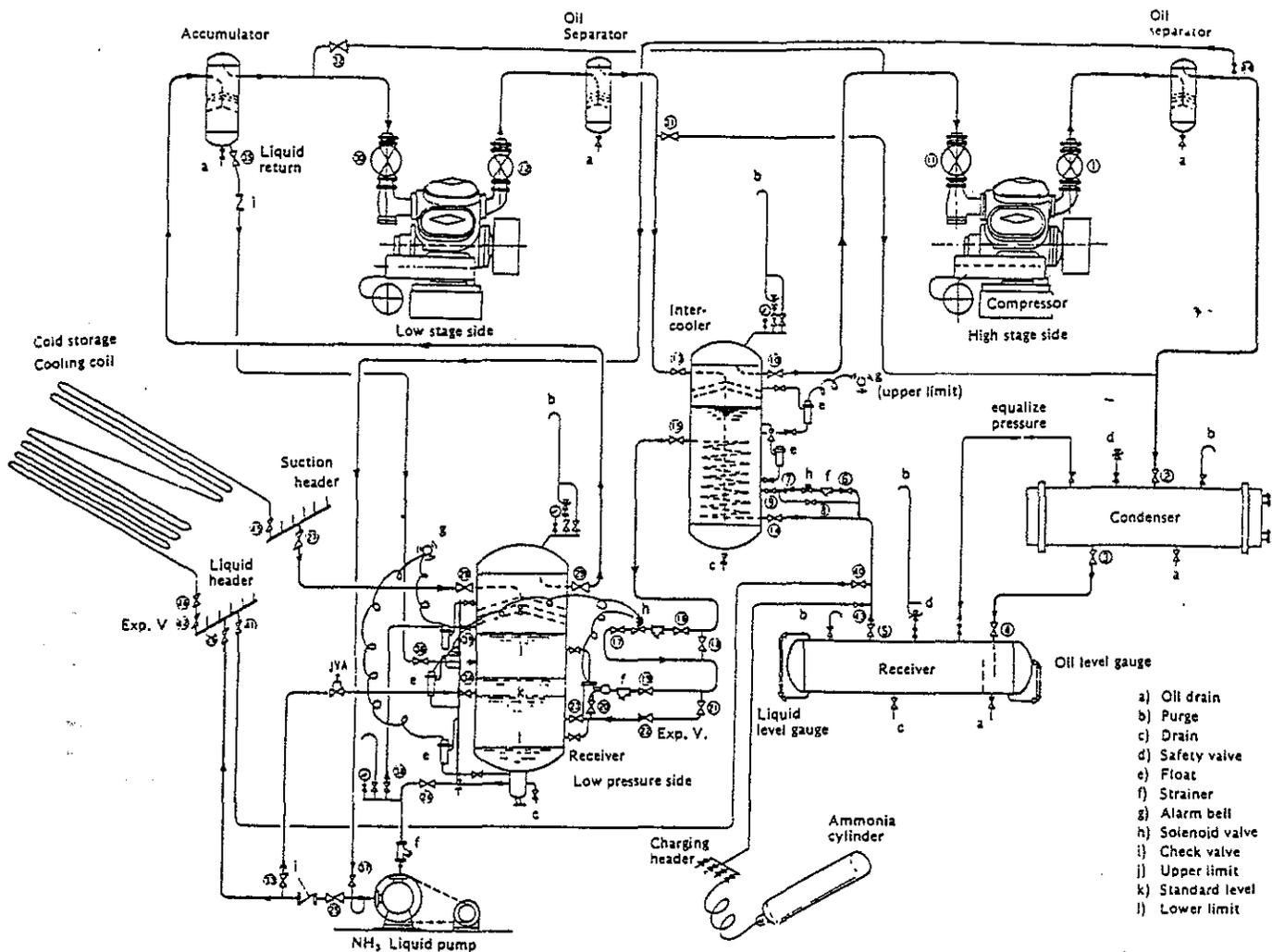


fig. 97 Piping flow chart of two stage compression

2.3. Refrigerant charge

2.3.1. Initial charge

- After creating the necessary vacuum within the compressor, prepare for charging by suspending the ammonia cylinder at an angle of about 30°, connection downwards, and connecting to the charge header.
- As a general rule, use the high stage side compressor and operate as a single stage.
- Check the open/close status of all valves.

Close: Drain valve and purge valve.

Open: Main safety valve, pressure equalizing valve liquid level gauge stop valve and main pressure gauge valve.

List No. 1

Type of equipment	Open valve	Closed valve
1. Compressor (high stage)	—	#1, 11
2. Oil separator	—	#31, 44
3. Condenser	#2, 3	—
4. Receiver (high pressure)	#4, 5	#40
5. Inter-cooler	*#43, *7, *9	#6, 8, 14
6. Receiver (low pressure)	*#22, #16, 17, 19, 20, 23, 28, 29, 34, 36, 39	#18, 21, 24
7. Ammonia pump	#25, 33, 38	#37
8. Suction & liquid header	*#41, 42, 46, #27, 45	#26
9. Accumulator	#32, 35	—
10. Compressor (low stage)	—	#12, 30

* should be adjusted

Exception for compound two-stage and tandem type compressor.

Close #13, open #31 and operate for single stage compressing of low stage.

In this case, the motor capacity is small, so be careful to maintain suitable unloading and check for superheating of discharging temperature.

- d) Supply cooling water to condenser and compressor, after confirming open/close status of valves.
- e) Open #5 & 43, and also slowly open the valve of the ammonia cylinder for directly filling liquid to the high pressure side receiver. As soon as it becomes hard to charge, close #5 and open #40 to enclose the liquid in the low pressure side.
- f) Open #1, start the compressor, and open #11. Control the expansion valve of the liquid header and make the suction pressure 1–2 kg/cm².
- g) Continue to supply ammonia until the filling limit is reached. Bring down the pressure to under 0 kg/cm² of gas in the low pressure side and close #11, stop operation of compressor and close #1. Continue to supply cooling water for 20 to 30 minutes after stopping operation.

Exception for two-stage compressor,

Close #30 & 11 and after stopping the compressor, close #1 & 12.

- h) Liquid increases in the receiver during operation. Generally it will come up to the standard level but if it increases a lot and the low side pressure becomes high, it is necessary to control it.

2.3.2. Charging Special conditions

When the absence of piping makes single stage operation impossible with a compound compressor. (i.e. without piping for #31 & 32.)

- a) Refer to the above table, but of course with #31 & 32 omitted.
- b) Open #43 & 5, and also slowly open the valve of the ammonia cylinder, for directly filling the liquid to the high pressure side receiver. As soon as it becomes hard to charge, close #5. Up to this point it is the same as the above.
- c) Open #6 and supply liquid to the inter-cooler. Open #9 from one to one-and-a-half turns and at the same time open #12 & 1, then start the compressor. Make no-load at all the cylinders of the low stage. Open #11 slowly. Confirm the action of float switches and solenoid valves beforehand.

- d) When the liquid reaches the standard level in the intercooler, open #40 and lead the liquid to the low pressure side by turning the expansion valve of the liquid header one to one-and-a-half turns. Open valve #30 and load one of the unloaders. Operate and watch the loading of motor. Be careful about overloading, control high stage and low stage at the capacity ratio 1:1 at the beginning, and then adjust low pressure to 1–1.5 kg/cm²

- e) Operate continuously until it reaches the standard quantity. The quantity will be increased in proportion to the load of the motor.

Exception: When there are no piping lines #40 & 41, operate the ammonia pump intermittently and send the liquid to the evaporator. It is not possible to do continuous operation because not enough liquid is supplied initially. It is much quicker to fill up by the manual circuit, than by using the liquid pump for the initial charge.

2.4. Cooling operation

Use single stage operation until the temperature comes down to a suitable point under –15°C for two stage compression.

- a) Generally use the high stage side compressor, but when used at the same time as a low stage compressor, confirm the capacity of the motor and adjust the unloader to obtain suitable load.
- b) Confirm the open/close status of all valves. (Ref. List No. 2)
- c) Check that all conditions are ready for operation, then supply cooling water to the compressor and condenser.
- d) Open discharge valve #1 of the high stage side compressor and start. Open valve #11 slowly to the full open position.
- e) Open the outlet valve of the high pressure side receiver and open valve #40. Open expansion valve #42 about 1/4 turn. Adjust the low pressure gauge to 1–2 kg/cm² for continuous operation.
- f) Open valve #16, and supply liquid to the low pressure side receiver when the temperature goes down to between 0° to 5°C.
- g) When liquid has filled the low pressure side receiver, switch to operation of ammonia pump. Open valve #24 and confirm that the liquid is entering the pump. Close valve #40 and open valve #26, then let the pump start. Operate the pump intermittently at the beginning, as the liquid in the low pressure side receiver will soon run out.

- h) Initially, it is much quicker to use manual circulation #21, 22, together for the supply of liquid to the low pressure side receiver. Close valve #22 after completing.
- i) Let the liquid pump run continuously when the evaporator contains sufficient liquid. Adjust the flow rate control valve #42 Exp. to give an equal supply to all the coils of the evaporator. For this adjustment close valve #42 and all relative valves slightly until the discharge pressure becomes 2 kg/cm². (Lift of fluid is about 30 meters.) One adjustment is enough, so do it very carefully.
- j) Switch to two stage compressing when the refrigerating temperature reaches -10°C to -15°C.
- k) It is acceptable to do this switching while the compressor is operating, but for the beginner it is safer to stop the compressor after closing valve #5, and bringing the low pressure down to about 0 kg/cm².
- c) Open valve #12, start operation, and slowly open valve #30. Watch the loading conditions of the motor. Sometimes it is necessary to unload. (Sometimes the low pressure rises due to the evaporation of liquid remaining from single stage compressing.)
- d) When starting, watch the level of liquid in the low pressure side receiver and operate the ammonia pump intermittently after the low pressure goes down to about 0 kg/cm².
- e) Watching the load on the motor, operate the low stage compressor, and switch to full load operation. (The time when it is possible to switch changes according to the capacity of the motor.)
- f) The pressure in the inter-cooler will be balanced after the gauge has fluctuated due to loading of the low stage, the supply of liquid to the inter-cooler and the high pressure, etc. Generally this fluctuation will be between 1 to 3 kg/cm², but it is nothing to worry about. If it goes over 4 kg/cm², then stop the low stage side or adjust unloading.

List No. 2

Type of equipment	Open valve	Closed valve
1. Compressor (high stage)	—	#1, 11
2. Oil separator	#32,	#31, 44
3. Condenser	#2, 3	—
4. Receiver (high pressure)	#4	#5, 40, 43
5. Inter-cooler	* #7, *9 #10, 13, 14, 15	#6, 8, 43, 40
6. Receiver (low pressure)	#17, 19, 20, 23, 28, 29, 34, 36, 39	#16, 18, 21, 22
7. Ammonia pump	#33, 38	#24, 37
8. Liquid header	#27, 41, 45 * #42, *46	#26
9. Accumulator	#32, 35	#12, 20
10. Compressor (low stage)	** #31	** #13

* should be adjusted

** in case of a compound compressor and/or low stage side compressor.

2.5. Operation of compound compressor

Do not forget that it is a general rule that the compressor be first started from the high stage side. Generally the system has an electrical interlock but an accident may result from opposite operation.

Close valve #32 for switching to two-stage from single stage. (In the case of the low stage side, also used for single stage, close valve #31 and open valve #13.)

- b) Open discharge valve #1 at the high stage side and start operation, then slowly open valve #11. Supply the liquid to the inter-cooler by opening valves #5 & 6. Start operation of the low stage side compressor when the pressure reaches approx. 0 kg/cm².

- g) Adjust valve #9 to eliminate tripping of the solenoid valve at short intervals.

- h) During refrigerating operation, the operator must keep to the rules of supervision and take accurate records of operating conditions at least every one or two hours.

2.6. Stopping operation,

2.6.1. Temporary stopping

- a) Close valve #5, and withdraw enough of the gas at the low pressure side to make the pressure as low as possible (under 0 kg/cm²) and close valve #30. Stop the low stage side compressor, and close valve #12.

- b) Bring the pressure down to 0 kg/cm² at the inter-cooler and close valve #11. Stop the high stage side compressor, and close valve #1.

- c) Supply cooling water for 20 to 30 minutes after the compressor has stopped.

2.6.2. Extended stopping

- a) Withdraw as-much refrigerant as possible from the low pressure side to the receiver of the high pressure side. For this purpose it is necessary to stop and start the compressor several times, until the liquid pipe of the high pressure side, after valve #5 frosts.

- b) Close the stop valves between each set of apparatus.

* The above describes the general method of operating and handling this equipment. Each operator should independently study and develop a method which is best suited to his particular equipment.

* Routine checking:

It is necessary to conduct routine checking of all equipment to facilitate operation of the equipment and bring about efficient refrigeration.

The operator's logbook is not merely for the sake of records, but should enable you to take all necessary measures for the prevention of accidents.

2.6.3. Routine Checking

1. Check the oil in the crankcase of the compressor, not only for quantity; but more importantly, for oil stain.

2. Checking the tension of V belts.

Fastening bolts of coupling.

Flexible rubber parts, for cracks, wear or any damage.

3. Water circulation.

Staining of the cooling tower and the evaporative condenser.

Condition of spray nozzle.

Scale in the pipes.

Sediment clogging the oil cooler.

4. High compression ratio.

Check the discharge valve assembly and remove carbon at least once every two or three months.

5. Extract the oil from each set of apparatus.

Purge air from the condenser.

6. Check the operation of all safety devices.

HP, OPM discharge pressure of safety valves, etc.

CHAPTER 5. SUPPLEMENTS:

1. Troubles and remedies

Sign	Symptoms	Cause	Trouble	Remedy
(1) Electric motor does not operate	1) Motor buzzes and does not start. Pulley won't rotate by hand even after removing belts.	A. Motor trouble. B. Belt is too tight. C. Load is excessively large. (Pressure on high side and pressure in crankcase are too high.) D. Voltage is low. E. Cylinder sleeve, piston, ring, or metal section (shaft seal mechanism) is seized up or becoming seized. F. Single-phase connection to automatic control system or electric equipment is not correct.	Fuses are blown. Motor short. Motor short. Motor short. Sleeve, piston or shaft seal mechanism is seized. Automatic devices are damaged.	(a) Inspect, repair or replace. (b) Adjust. (c) Open by-pass valve (crankcase low pressure) to purge pressure in the crankcase. Close suction stop valve, open discharge stop valve and start compressor again simultaneously. (e) Disassemble and inspect, adjust or change defective parts. (f) Inspect and adjust.
	2. No reaction, when magnetic switch button is pushed.	A. Fuses are blown. B. Magnetic switch contact is not good or overload relay is still in operating mode. C. Wire is cut. D. OP or HP switch is still in operating mode. Either or both of them are not reset.	Machine becomes inoperative. - " - - " - - " -	(a) Inspect and replace. (b) Inspect, repair or replace. - " - (c) Reset, (Return to initial (d) position)
	3. Power is supplied when hand is on magnetic switch button but interrupted when hand is off.	A. Connections to automatic control devices are not correct. B. Auxiliary contact is defective.	Machine becomes inoperative. - " -	(a) Inspect and adjust. (b) Inspect, adjust or replace.
	4. Motor stops shortly after starting.	A. OP switch trips. (a) Oil is exhausted. (b) Oil pressure is low. B. Discharge pressure is too high, and HP switch trips. (a) Condenser is filled with non-condensable gas. (b) Suction pressure is too high. C. Liquid flows back into crankcase and checks pressure rise. Consequently, OP switch works. D. Connections to automatic control devices and magnetic switch are not correct. E. Overload relay is working or OP switch activates.	Compressor becomes inoperative or is seized. Motor short or machine becomes inoperative. Machine becomes inoperative. Control system is damaged or shorted. Start is impossible.	(a) Replenish oil. (b) Adjust oil pressure. (a) Purge non-condensable gas. (b) Take steps to increase load. (c) Change oil in crankcase or remove refrigerant from crankcase by operating compressor and then feeding warm oil. (d) Inspect and adjust. (e) Wait till bimetal switch cools (about 5 minutes). In this case, change OP switch to "Manual" and start operation. After approx. 10 minutes return to "Automatic" operation after investigating the cause.

Sign	Symptoms	Cause	Trouble	Remedy
(II) Abnormally high pressure	<ol style="list-style-type: none"> 1. Condenser is warmer than usual. Head cover is overheated. 2. Cooling water in evaporative condenser is warm. 3. Condenser is warm at the top but cooler at the bottom. Crankcase is frosted. 4. Needle of high pressure gauge fluctuates. Condenser is slightly warmer than usual. 	<p>Cooling water quantity is not sufficient or water temperature is too high. Cooling water is not distributed uniformly. Cooling pipes are stained. Fan trouble or spray nozzle and strainer are clogged.</p> <p>Refrigerant or oil remains in condenser, reducing cooling surface area. (a) Clogging between condenser and receiver. (b) Overcharging of refrigerant (Receiver is full and liquid remains in condenser.)</p> <p>Air in condenser or high pressure gauge malfunctioning. Gas passage is blocked as oil separator is filled with oil.</p>	<p>HP switch trips or safety valve opens. Power consumption increases remarkably.</p> <p>Cooling capacity decrease.</p> <p>- " -</p> <p>- " -</p>	<p>Increase cooling water flow or lower water temperature. Make water distribution uniform or clean cooling pipes.</p> <p>Inspect, repair and clean.</p> <p>(a) Inspect, adjust and remove obstacles. (b) Discharge refrigerant.</p> <p>Purge air. Drain oil.</p>
(III) Discharge pressure is too low	<ol style="list-style-type: none"> 1. Condenser and receiver are cold. 2. Liquid pipe is frosted. Suction pressure becomes vacuum. 3. Crankcase is frosted. Head covers are also cold. 4. Suction pressure is low and expansion valve hisses. 5. Suction pressure is high. 	<p>Cooling water quantity is too large or cooling water temperature is low. Liquid pipe or suction pipe is clogged.</p> <p>Wet compression due to excessive opening of expansion valve (suction temperature is low due to liquid flowback). Shortage of refrigerant.</p> <p>Gas leakage from suction valve, discharge valve, piston rings or by-pass valve seat.</p>	<p>Capacity decreases.</p> <p>Danger compressor discharge section being damaged by liquid hammer.</p> <p>Cold storage chamber is not cooled sufficiently.</p> <p>Capacity decreases. Sleeve is seized.</p>	<p>Adjust water flow regulating valve. Adjust valves, inspect and clean.</p> <p>Close expansion valves, with compressor in operation.</p> <p>Charge refrigerant.</p> <p>Inspect valves and piston rings, repair. Adjust or repair.</p>
(IV) Suction pressure is too high	<ol style="list-style-type: none"> 1. Crankcase is frosted. 2. Ammeter needle rises. 3. Pressure on high side is low. No frost. 	<p>Expansion valve opening is excessive. Increase in load. Decrease in compressor capacity (gas leakage from suction valve, discharge valve, sleeve or safety valve).</p>	<p>Liquid hammer occurs.</p> <p>Motor short. Cold storage chamber is not cooled.</p>	<p>Adjust operation (Close expansion valves) Adjust operation. Disassemble and inspect. Change defective part.</p>
(V) Suction pressure is too low	<ol style="list-style-type: none"> 1. Temperature of cold storage chamber or brine temperature is high compared to temperature on low side. 2. Liquid flows back when expansion valves are opened. 3. Suction pressure is low compared to the temperature of cold storage chamber or brine temperature from the start of operation. 	<p>Refrigerant quantity is too small or expansion valve is closed too much.</p> <p>Oil remains in cooling coils. Too much frost or ice on cooling coils. Diameters of cooling coils and suction pipes are too small for their length or there is too much resistance. Strainers on compressor and suction line are clogged with rust or residue.</p>	<p>Cold storage chamber is not cooled sufficiently.</p> <p>- " -</p> <p>- " -</p>	<p>Replenish refrigerant or adjust operation.</p> <p>Drain oil. Defrost.</p> <p>Wrong piping arrangement or wrong design. Investigate and improve.</p> <p>Clean</p>

Sign	Symptoms	Cause	Trouble	Remedy
(VI) Abnormal sound is heard during operation	<ol style="list-style-type: none"> 1. Metallic sound is heard continuously. 2. Shaft seal mechanism is overheated. 3. Crankcase is frosted. 4. Heavy discharge sound around head covers. 	<ol style="list-style-type: none"> A. Foreign matters entered between cylinder head and piston. B. Discharge valve, suction valve or piston ring is damaged. C. Abrasion, seizure or breakage of metals, etc. D. Abnormal high pressure. E. Oil pump is damaged. F. Liquid hammer. G. Oil hammer 	<p>Danger of discharge section, piston or shaft breakage.</p> <p>Extremely dangerous.</p> <p>Danger of seizure.</p> <p>Discharge section or piston is broken.</p>	<ol style="list-style-type: none"> a) Disassemble, repair or replace. b) Disassemble and replace. c) Disassemble and replace. (Be careful as this trouble is sometimes caused by clogging of oil pipe.) d) Stop operation immediately, investigate causes and repair. e) Stop operation immediately, investigate the causes and repair. f) Tighten expansion valves during operation. g) Prevent abnormal oil consumption. (If liquid flowback occurs simultaneously, take the above-mentioned steps at the same time.)
(VII) Crankcase is overheated	<ol style="list-style-type: none"> 1. Head cover is overheated. <ul style="list-style-type: none"> (i) Discharge pressure is high. (ii) Suction pressure is high. 2. Oil temperature rises. 3. Cooling water for compressor does not flow smoothly. 4. Shaft seal mechanism is unusually hot. 	<p>Increase in compression ratio due to rise of condensing temperature or increase of refrigerating load.</p> <p>Accumulated carbonized oil or slag or clogging of gas passage due to combustion of lubricating oil. Discharge valve plate is broken, or gas is leaking.</p> <p>Oil cooler is defective or lubricating oil is insufficient. Pump is overheated due to stained oil or clogged oil strainer.</p> <p>Cooling water quantity is insufficient or water passage clogged.</p> <p>Mechanism is seizing.</p>	<p>Oil waste. Increase in adhesion of carbonized oil or slag.</p> <p>Abrasion or breakage of metal section, and seizure of sleeve. Cooling capacity decreases.</p> <p>Carbonized oil or slag adhesion or pump seizure.</p> <p>Abrasion or seizure in metal section or adhesion of carbonized oil or slag in discharge section. Seal seizure or breakage.</p>	<p>Increase cooling water quantity for condenser or lower water temperature.</p> <p>Disassemble, inspect and clean or replace.</p> <p>Disassemble, inspect and replace. Lower pressure on high side. Clean oil cooler. Increase cooling water quantity. Change oil. Clean oil filter.</p> <p>As lubricating oil has deteriorated, replace. Increase cooling water quantity.</p> <p>Repair or replace.</p>
(VIII) Oil consumption is extraordinary	<ol style="list-style-type: none"> 1. Crankcase becomes frosted easily. 2. Nothing abnormal is found elsewhere. 3. Head cover is overheated. 4. Ammeter needle rises (consumption increases power) even when refrigerating load is normal. 5. Oil pressure is too high. 6. Oil pressure is low. 7. Crankcase is overheated. 	<p>Liquid flowback which causes boiling of oil. Equalizing hole of crankcase is clogged (too large in case of vacuum operation) or suction strainer is choked up.</p> <p>Oil is wasted by burning due to abnormally high pressure. Cylinder sleeve is broken or being seized or ring is worn or scuffed.</p> <p>Oil pressure is too high while oil viscosity is normal. Oil viscosity decreases (bubbles or oil temperature rises). Overheated operation due to abnormally high pressure on high side.</p>	<p>Compressor becomes inoperative. Oil hammer occurs.</p> <p>Accumulation of carbonized oil or slag. Sleeve or piston is seized.</p> <p>Oil hammer occurs.</p> <p>Moving parts seize.</p> <p>Oil viscosity decreases. Adhesion of carbonized oil or slag.</p>	<p>Adjust operation. Refer to Article VI on liquid hammer. Inspect and clean strainer.</p> <p>Lower pressure on high side. (Refer to Article II). Inspect, adjust or replace.</p> <p>Adjust.</p> <p>Replenish or replace oil.</p> <p>Replace with proper viscosity oil. Lower pressure on high side.</p>

2. Compressor troubles

Trouble	Cause
Compressor stoppage due to electrical failure	Motor trouble. Disconnection, seizure, imperfect insulation, lack of oil. Component part of control system or control panel safety device is out of order or not adjusted correctly.
Trouble due to mechanical or other defect of compressor.	Seizure, abrasion or breakage, imperfect assembly, employment of defective materials. Leakage from valves, leakage from safety valve. Compressor becomes inoperative due to deterioration of lubricating oil, seizure or carbonization of oil due to mixing with other kind of oil.
Trouble due to defective driving method.	* Breakage, slipping or slackening of V belt, flywheel imbalance, incorrect angle, or pitch of groove. Inaccurate alignment.
Overheating	Pressure on high side is too high. Shortage of cooling water, stained oil or water, or clogging of cooling water jacket. Insufficient line passage due to carbonized oil or slag accumulation, rough operation of valve. Seizure of moving parts or shortage of lubricating oil.
Excessive noise	Large compression ratio, abrasion or slackening of moving parts, shortage of oil pressure or oil supply quantity, head spring hits disc due or hammer caused by liquid flowback.
Abnormal compressor vibration.	Slackening of base retainer bolts, incomplete foundation work, imperfect tightening of base and foundation, improper position of pipe stays, motor imbalance pulley, incorrect adjustment of balance section, inaccurate alignment of V belt or sympathetic resonance with factory building.
Abnormal oil consumption	When oil is mixed with liquid in the case of liquid flowback, when a vacuum occurs in the crankcase by closing the suction stop valve suddenly when gas flow is not uniform, when crankcase is overheated, abnormal abrasion of piston rings, scuffing of piston and sleeve or excessively high oil pressure.
Lubricating oil is stained.	Water has entered crankcase, metallic particles in oil or oil of other kind or oxide is mixed in. When sea water is used as cooling water, corrosion may occur, allowing sea water to leak out.
Oil leakage from shaft seal mechanism.	Imperfect fitting, imperfect sealing as a result of deterioration of "O" rings.
Pressure gauge indication is incorrect.	Inadequate gas or oil pressure.
Cooling water jacket is broken by frost.	In severely cold areas, especially in the winter season, jacket is sometimes cracked by freezing of water not been drained out through drain cock.

3. Relation between discharge gas temperature and operating pressure.

Notes:

- Discharge gas temperature T_d is a value on the Mollier diagram, as it is an insulated compression, (degree of superheat is 0°C), but it is not the actual temperature, because the jacket is cooled by water, and also the actual temperature becomes higher if there is condensible gas such as air present.
- If suction gas is heated, the actual temperature will be higher with that degree of superheat than the value on the diagram.

3. The approximate operating range limits are as follows.

Compression ratio: 9
 Discharge gas temperature: 140°C (actual value) is acceptable
 (but if operation time is short, 180°C .)
 Use 130°C on the diagram, when the degree of superheat is 10°C .

Evaporative temperature:

$$T_e = -47.3 + 0.632 T_c - 2.5 \left(\frac{P_d}{P_s} - 9 \right)$$

($\frac{P_d}{P_s}$ unchanged)

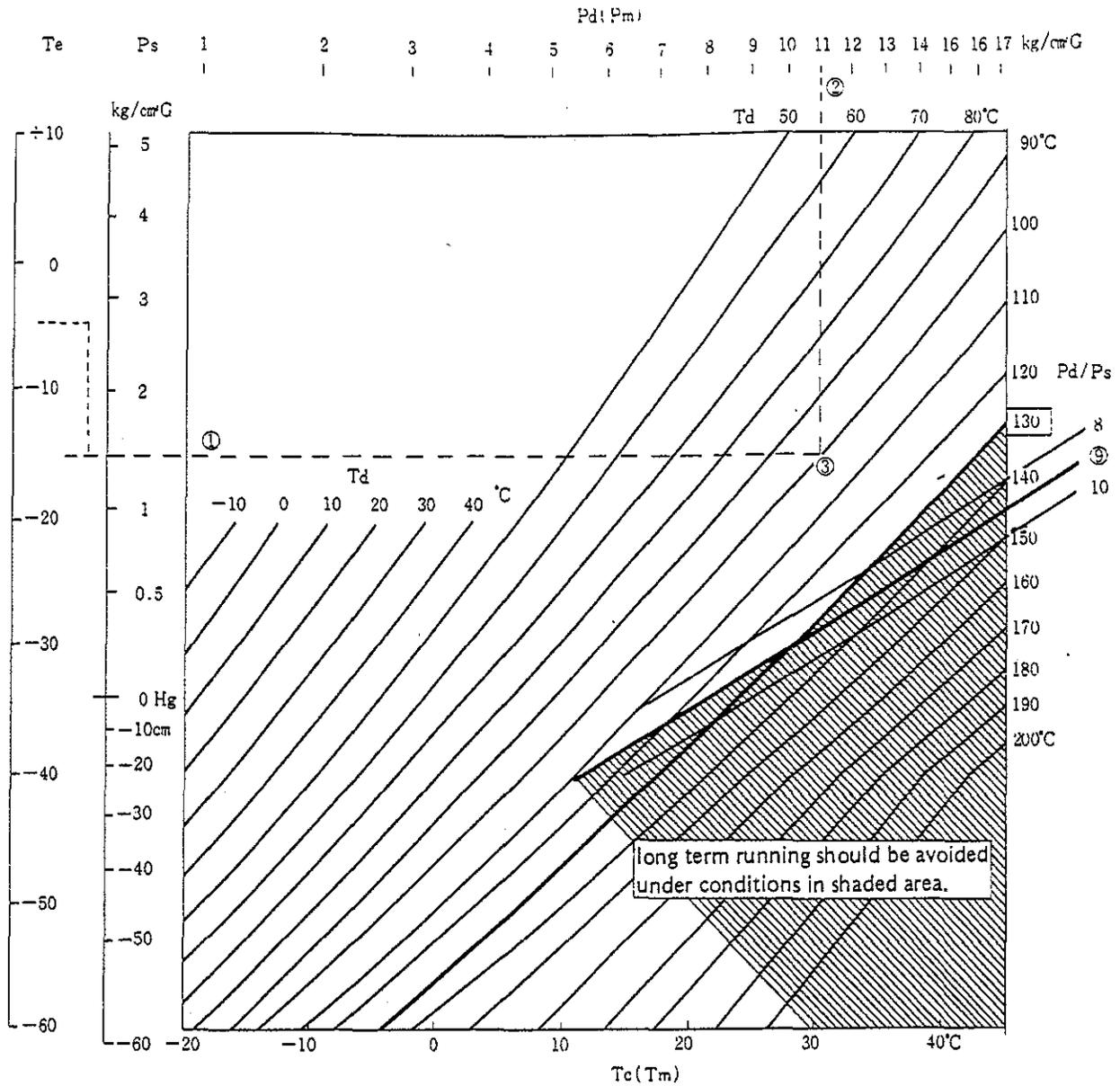


Fig. 98 Diagram of relation between discharge gas temperature and operating pressure

Obtaining the discharge temperature T_d from the above figure.

- Ps Suction pressure 1.4 kg/cm² (T_s -15°C)
- Ts Suction gas temperature
-5°C (degree of superheat .. 10°C)
- Pd Discharge pressure
11 kg/cm² (T_c about 30°C)

Then, for discharge gas temperature:

You may get about 100°C at the intersection point (3) where (1) and (2) cross.

Add superheat 10°C, because suction gas is saturated condition.

$T_d = 100^\circ\text{C} + 10^\circ\text{C} = 110^\circ\text{C}$ This value must be near the actual discharge gas temperature. Do not use any value in the shaded area for the good of the compressor however.

Checking must be done at once when abnormal discharge temperature conditions are found, even if there is no change in the conditions of operation, otherwise extensive damage, broken valves etc. may result.

4. Monitoring Refrigerating Operation

	Normal Conditions	Abnormal Conditions	Cause	Remedy
Pressure on high side (psig)	Ammonia & R-22 114-190 psi (8-13.5 kg) R-12 85-130 psi (6-9 kg)	Higher than 190 or 130 psi respectively	<ol style="list-style-type: none"> 1) Cooling water is inadequate or water temperature is high 2) Cooling surface of condenser is stained 3) Refrigerant overcharging receiver is full and refrigerant stays in condenser 4) Air in the system gauge needle fluctuates 5) Condenser capacity is insufficient 	<p>Increase cooling water quantity</p> <p>Clean</p> <p>Adjust quantity of refrigerant</p> <p>Purge air</p> <p>Install additional unit</p>
		Lower than 114 or 85 psi respectively	<ol style="list-style-type: none"> 1) Shortage of refrigerant or leakage 2) Cooling water temperature is low 	<p>Adjust</p> <p>No remedy needed.</p>
Pressure on low side (psig)	Ammonia Freezing chamber 0.9 in. Hg - 7 psi (250 mm.Hg - 0.5 kg) Cold storage 0-10 psi (0-0.7 kg) Ice making 14-23 psi (1-1.6 kg) R-12 21-42 psi (1.5-3.0 kg)	Not within the ranges given at left	<p>When pressure on low side is too low</p> <ol style="list-style-type: none"> 1) Expansion valve is closed too much or is clogged 2) Oil remains in evaporator 3) Evaporator is frosted 4) Temperature is below specified value <p>When pressure on low side is high (storage chamber is not cooled)</p> <ol style="list-style-type: none"> 1) Refrigerating load increased 2) Refrigerating capacity decrease 3) Refrigerant leakage 	<p>Improve refrigerant flow</p> <p>Drain</p> <p>Defrost</p> <p>Control capacity</p> <p>Install additional unit</p> <p>Inspect and adjust</p> <p>Inspect and adjust</p>
	Oil pressure (psig)	Pressure on low side + 17-28 psi (1.2-2 kg) Oil can be seen through oil sight glass	Higher than the value given at left	<ol style="list-style-type: none"> 1) Oil pressure is not correctly adjusted 2) Oil viscosity increased as a result of liquid flowback (initial state of flowback).
		Lower than the value given at left:	<ol style="list-style-type: none"> 1) Viscosity of oil decreased due to rise in oil pressure 2) Cuno-filter is clogged 3) Oil quality deteriorated 4) Oil pump trouble 	<p>Adjust oil pressure</p> <p>Clean the filter</p> <p>Change oil</p> <p>Inspect and repair</p>
Temperature (discharge)	Ammonia & R-22 176-284°F (80-140°C) R-12 104-194°F (40-90°C)	Higher than the value given at left	<ol style="list-style-type: none"> 1) Abnormally high pressure 2) Increase compression ratio 3) Shortage of cooling water 4) Gas leakage (from piston rings, sleeve or valve) 5) Clogging due to carbonized oil and slag in discharge section. 6) Suction strainer clogged 7) Scuffing of sleeve 8) Overheated operation 	<p>Refer to pressure on high side</p> <p>Refer to pressure on high side</p> <p>Increase water quantity or clean</p> <p>Inspect and repair</p> <p>Clean</p> <p>Clean</p> <p>Replace.</p> <p>Adjust expansion valve</p>
		Lower than the value given at left	<ol style="list-style-type: none"> 1) Liquid flowback 2) Unloader mechanism is in un-loaded condition 3) Pressure on high side is abnormally low 	<p>Close expansion valve</p> <p>Investigate the cause and adjust</p> <p>Inspect</p>

	Normal Conditions	Abnormal Conditions	Cause	Remedy
Temperature (shaft seal section)	86-131°F (30-55°C) Inspection point a) Oil pump b) Compressor shaft seal on flywheel side	Higher than the values given at left.	<ol style="list-style-type: none"> 1) Abnormally high pressure 2) Overheated operation 3) Shortage of cooling water for compressor jacket 4) Clogging of cooling water jacket 5) Rise in oil temperature 6) Increase in compression ratio 7) Trouble with oil pump 8) Scuffing 9) Clogging of oil piping 	<p>Lower pressure on high side Adjust expansion valve Increase water quantity</p> <p>Clean</p> <p>Lower temperature Clean oil cooler Lower pressure on high side Inspect and repair Inspect and repair Inspect, repair or clean</p>
		Lower than the value given at left	<ol style="list-style-type: none"> 1) Liquid flowback 	<p>Adjust expansion valve Raise oil temperature</p>
Electric current	Within specified rate (refer to motor specifications, capacity and horsepower of compressor)	Higher than specified rate	<ol style="list-style-type: none"> 1) Increase in load 2) Pressure on high side is high and pressure on low side is also high 3) Voltage drop 4) Scuffing in compressor 5) Trouble with motor, particularly, motor overheating 	<p>Set unloader mechanism in motion, install additional unit or close suction stop valve</p> <p>Adjust Inspect and repair Inspect and repair</p>
		Ammeter needle fluctuates	<ol style="list-style-type: none"> 1) Slip ring is damaged by burning (wound rotor type motor) or contact is not good 	<p>Inspect and repair</p>
Voltage	As specified	Lower than specified value	<ol style="list-style-type: none"> 1) Incoming power capacity shortage 2) Generator capacity shortage 3) Main power shortage 	<p>Install additional unit</p> <p>Install additional unit Contact electric company for adjustment</p>

5. List of saturation temperature and gauge pressure

Temperature	Evaporative temperature and pressure									Condensing temp. and pressure				°C
	-40	-35	-30	-25	-20	-15	-10	-5	0	25	30	35	40	
Ammonia (NH ₃)	22.16 (cm ² Hg)	6.08 (cm ² Hg)	0.19	0.51	0.91	1.38	1.93	2.59	3.35	9.19	10.86	12.73	14.82	kg/cm ²
Freon (R12)	27.89 (cm ² Hg)	15.50 (cm ² Hg)	0.72 (cm ² Hg)	0.23	0.51	0.83	1.20	1.63	2.11	5.61	6.56	7.61	8.76	kg/cm ²
Freon (R22)	0.04	0.31	0.63	1.02	1.46	1.98	2.58	3.29	4.04	9.61	11.12	12.78	14.60	kg/cm ²

6. Insufficient temperature drop

Symptoms	Cause	Remedy
Pressure on low side does not fall	<ol style="list-style-type: none"> 1) Shortage of capacity <ol style="list-style-type: none"> a) Refrigerating compressor b) Evaporator c) Condenser 2) Increase in load 3) Insufficient insulation or deterioration of insulating material 4) Abnormally high pressure 5) Leakage of refrigerant 	Inspect. If nothing is abnormal, install additional unit. Install additional unit Install additional unit Install additional unit If temporary, continue operation If continuous, install additional unit Inspect and repair Reduce pressure on high side by increasing cooling water, cleaning condenser, purging air or installing additional unit Inspect and repair
Pressure on low side is low Suction line is not frosted Liquid flowback is apt to occur	<ol style="list-style-type: none"> 1) Heated operation (expansion valve closed too much) 2) Shortage of cooling surface 3) Too much frost on evaporator 4) Oil stays in evaporator 5) Suction line is too small 	Adjust (open) expansion valve Install additional unit Defrost Drain oil Repair piping
Pressure on high side is high Lower part of condenser is cold Receiver is full of liquid	<ol style="list-style-type: none"> 1) Shortage of cooling water or rise in water temperature 2) Shortage of condenser capacity 3) Staining of condenser tubing 4) Overcharging of refrigerant 5) Clogging of discharge line 	Increase water quantity Install additional unit Clean Withdraw refrigerant Repair piping
Excessive oil consumption (temperature on discharge side rises)	<ol style="list-style-type: none"> 1) Abrasion of compression rings 2) Scuffing 3) Leakage of refrigerant 	Replace Inspect and repair Inspect and repair

7. Troubleshooting and overhaul

There are two times when compressor problems are most likely to happen. The first is at the start of operation, including test running, and the next is when abrasion occurs.

Care should be taken on these points when starting test running. After a certain period of test running, the compressor runs in a stable condition. Periodical checking must be made avoid by abrasion problems.

- a) A compressor is overhauled once every 6,000 hours of operation as a rule. Even if the compressor is used for only a short time, it is advisable to overhaul once a year.
- b) A refrigerating system which is operated for more than 8,000 continuous hours should have a periodic inspection once a year. In addition to this, the valves and bearing and crank metal sections should also be inspected at least once a year.
- c) If the discharge temperature is too high, carbonized oil or slag adheres easily to the discharge section. Overhaul the discharge valve section and change oil when necessary.
- d) If the cooling water contains a large amount of suspended minerals examine the inside of the cooling section of the crankcase, oil cooler, etc., and clean if necessary.
- e) Prior to operating a compressor which has been left unused for a long period, do the following:
 - (3) Carrying out a working test of protection devi
 - (3) Carry out a working test of protection devices, automatic control devices and/or supply device.
 - (4) Clean all strainers.

8. Standards for changing of parts

To operate MYCOM compressors in their best condition, inspect according to the following standards and make repairs whenever necessary.

8.1. Compressor oil in the crankcase

Check the oil in the oil drum (bottom part of crankcase) in the crankcase through the hand hole cover. If a scale, metal powder etc. are found, determine the source of correct. The cause may be scale from suction side piping, abrasion of cylinder or piston rings, etc.

If yellow metal powder is found in the oil, it is from abrasion of piston ring.

8.2. Suction strainer, oil strainer and cuno-filter

Clean with trichlorethylene, carbon tetroxide or light oil. Inspect to make sure solder is not off or screen is not broken. A broken screen allows foreign matter to enter and

causes scuffing of the compressor. Stainless steel must be welded with flux treatment.

Inspect to see if filter discs and blades move smoothly. Sometimes, blades are bent. If residue is deposited inside, remove with a safety razor blade and clean the inside by passing light oil or blowing compressed air from inside (in the direction of oil pipe fittings). If this is done from outside, foreign matter will remain inside and enter oil pipe during operation, causing abrasion and scuffing of the compressor.

8.3. Crankshaft

The abrasion of wearing parts of the bearing must be checked and measured by a micro-meter. In practice, it is sufficient to measure gaps between the metals, and the abrasion can easily be found by feeling the bearing surface. If scars are found, they must be polished with fine emery paper or wet stone.

The oil hole passing through the shaft must be well cleaned. Clean and pass oil into the blind hole several times. Do not forget to fasten the blind plug after.

Replace the crankshaft only if abrasion exceeds the values listed below:

* Padding is absolutely not allowed.

	ϕ (mm)	
	Model A	Model B
Connecting rod bearing	69.85	89.82
Thrust bearing	82.40	111.85
Main bearing	66.90	91.85

8.4. Shaft seal parts

If the moving surface of the seal collar or the seal ring does not make good contact, correct the surface by lapping or grinding with a fine compound. After correcting, remove the compound. The moving surface of the seal collar should not be stepped. Replace any "O" rings which have hardened, expanded or cracked.

8.5. Piston, piston pin and piston ring.

The piston is rarely subject of abrasion. When its outer diameter becomes smaller than the value shown below, replace the piston with a new one.

	ϕ (mm)	
Piston	Model A	Model B
Outer diameter	94.8	129.78

If any vertical scratches are found on the surface, remove. If the width of the ring groove has become markedly wide larger than 0.10mm, replace as this will cause abnormal oil consumption. The piston pin should fit tightly in the pin hole of the piston. However, if the clearance between the pin and the hole becomes larger than 0.20mm (model A) or 0.25 (model B) replace the pin. Clearance for new pin is 0.10mm.

Replace the piston pin when the outer diameter of the pin becomes smaller than the values below:

	ϕ (mm)	
Piston pin	Model A	Model B
Outer diameter	25.05	39.90

The life of compression rings varies according to the operating conditions under which they are used. Judge whether they are to be replaced at the time of inspection. If the contact between the compression ring and the cylinder wall is not good or abrasion is unusual, replace the defective compression ring with a new one.

If abrasion is uniform and the amount of abrasion is not clear, either replace with a new one or determine the clearance by putting the ring in a comparatively new cylinder sleeve; if it is larger than the value shown below, replace the ring with a new one.

	(mm)	
Rings	Model A	Model B
Gap clearance top ring	2.0	2.5

If there is burring of the edges of the ring, remove by chamfering with a grinder.

8.6. Connecting rod

Replace the connecting rod if the clearance between the bushing and piston pin (new one) exceeds 0.20mm. To replace the bushing only a jig is required. If this replacement is unavoidable, give a honing finish after pressure-insertion. When inserting, see that the piston pin hole is perpendicular to the rod. The bearing halves should be replaced if the clearance between bearings and crankshaft exceeds the value shown below.

	(mm)	
Connecting rod	Model A	Model B
Clearance	0.25	0.30

The bearing is designed so that the radius is larger than that of the connecting rod and the bearing halves make a perfect circle when tightened; (i.e. the diameter of the bearings is larger than that of the connecting rod). If the two circles have the same diameter, replace it with a new one even if it is not worn. To assemble, install each bearing half with notches in the same direction.

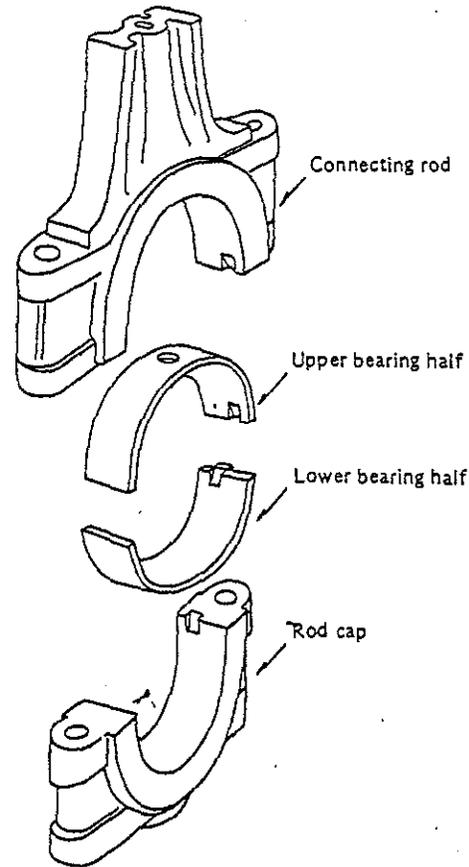


Fig. 99 Connecting rod and bearing halves

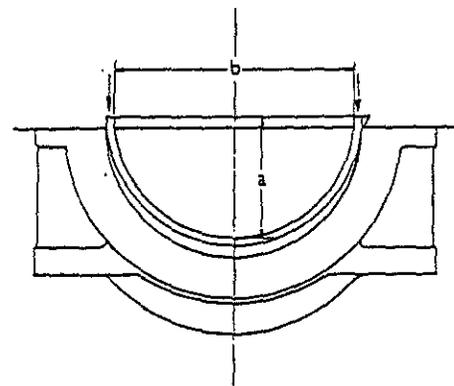


Fig. 100 Bearing tolerance

- 1) To replace the bearing halves with new ones, when you find that the width of the groove of the bearing notch section is larger than that of the connecting rod groove section by a maximum of 0.1mm, reduce the excessive part with a fine file and join them together.
- 2) In case of replacement, make sure the edge of the bearing is not protruding beyond that of the connecting rod. Standard dimension of the bearing is $2a < b$. When it is $2a = b$, do not use it, as it is a bearing of inferior quality. Therefore, to install the bearing, they are not tightly fixed unless you push them in with your thumbs.

8.7. Cylinder sleeve

The standard height of the seat surface of the cylinder sleeve is 0.5mm. The guard thickness is reduced when the seat surface of the cylinder sleeve guard is lapped, so adjust the reduced thickness with the gasket for the cylinder sleeve. The thickness of one gasket is 0.2mm.

If the inner surface of the sleeve is not a mirror surface but has vertical scratches, cloudiness or marks of seizure from scale, make the surface smooth with a piece of fine GC grinder or emery paper which is finer than No. 1200. The degree of abrasion can be seen by comparing with the upper part ... about 3mm from the top ... where the top compression ring does not reach. The clearance between the piston and the cylinder sleeve determines whether the later should be replaced.

If the maximum clearance between the bottom of the piston and the cylinder sleeve exceeds the value shown below, replace only the sleeve with a new one. If the clearance is still larger than the value mentioned below, even after the sleeve has been renewed, then change the piston also.

Cylinder sleeve	Model A	Model B
Maximum clearance with piston	0.30	0.35
Maximum inside diameter	95.15	130.15
Standard inside diameter	95.0	130.0

8.8. Discharge valve and suction valve (assembly)

Remove carbon deposits with a wire brush. The life of the plate valve is about 6,000 hours. When this period has elapsed it is recommended that you renew the plate.

The maximum allowable abrasion is 0.2mm from the standard thickness, which is 1mm for type A and 1.3mm for type B.

Even if the seat surface is not worn, replace it with a new one if the surface of the valve does not make uniform contact with the springs. Also check the springs.

Valves seats for discharge and suction valves;

A seat surface which is not worn uniformly is to be adjusted by lapping. If the valve seat has dents or marks due to refrigerant leakage, renew the seat, depending on the severity of the dent or mark.

The maximum allowable abrasion of the valve seat is 0.25mm.

The cylinder gasket must be prepared beforehand, as top clearance is changed after correction of the seat.

8.9. Oil pump

If the oil pressure does not rise even after adjusting the oil pressure regulating valve during operation and if the cause is not abrasion of the bearings, take the following steps.

Move the oil pump shaft back and forth holding the shaft with your fingers. If there is a crack in the bushing or on

the side, the part is worn away. In this case, replace the whole assembly. However, never disassemble the assembly when nothing is wrong with it.

If the oil pressure does not rise when the oil pump is in normal condition, inspect the safety valve and/or the oil strainers for abnormality.

8.10. Free length of springs

The springs for discharge and suction valves are changed after periodic inspection carried out after every 6,000 hours of operation. Renew other springs when they become shorter than the standard free length. The maximum allowable shortening is 10% from the standard length

Standard free length of springs: (mm)

Springs	Model A	Model B
Helical	19.0	16.0
Suction valve	13.0	13.0
Discharge valve	12.7	12.7
Head	82.0	92.0
Lift pin	10.0	12.5
Unloader device	72.0	75.0

8.11. Main bearing and thrust bearing

If the gaps between main bearing, thrust bearing and shaft become larger than the values shown below, renew.

The motor side of the thrust bearing is easily abraded so do not over tension the belts.

(mm)

	Model A	Model B	
			Mediate bearing
Maximum clearance between the bearing and the shaft	0.25	0.30	0.45
Inner diameter:			
Main bearing	67.15	92.18	
Thrust bearing	82.65	112.18	
Thrust gap	maximum 0.3		

8.12. Gasket

Replace if broken or elasticity is gone. Check the matching of holes for bolts and oil at assembly!

8.13. Bolts

Inspect to see whether the bolts for connecting rod and discharge valve seat are broken. Renew them if the threads are dull. Also inspect the threads of the head cover screws and replace if are dull. Special care should be taken after trouble such as oil hammer, liquid hammer and or burning have occurred.

9. Selection of compressor oil

The quality of the lubricating oil significantly affects the

life of a compressor. Therefore, use oil of the best quality. If a large amount of carbonized oil or slag adheres to the discharge valve cage, or if moving parts show premature abrasion when the compression ratio and the discharge pressure are not high and the oil consumption is normal, check the following:

- a) Whether oil contains impurities or any foreign matter, or whether oil is of poor quality.
- b) Whether oil is stained or aged, even when it is an oil of fine quality.

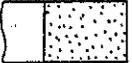
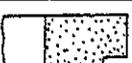
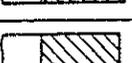
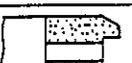
Judging the quality of lubricating oil is very difficult. Generally, it can be judged only after actual use. Therefore, the best way is to buy a well known brand from a reliable dealer. Avoid selecting oil by price only.

The important factors for the oil are viscosity against the temperature rise, low pour point and high flash point. After purchasing, oil should be stored with the utmost care to avoid contamination by impurities such as water or dust. This could cause abrasion or corrosion of the compressor.

Class No.	Color (union)	Reaction	Flash Point	Viscosity 86°F (30°C)	Redwood per sec. 122°F (50°C)	Corrosion	Pour Point	Rate of Emulsification by Evaporation (per sec)
150	Max 3	Neutral	311°F up (155°C)	152 ± 20	Min 60	Max 1	Lower than -27.5°C	Max 200
300	Max 4	Neutral	329°F up (165°C)	301 ± 20	Min 91	Max 1	Lower than -22.5°C	Max 200

Class No. 300 oil is usually used; Capella D, Daphne CR42 (or CR45), or Suniso 4G are most suitable for MYCOM compressors.

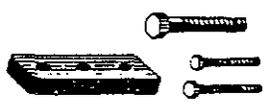
10. Piston ring

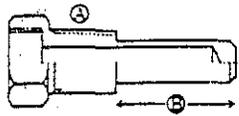
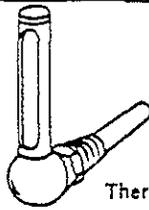
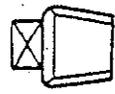
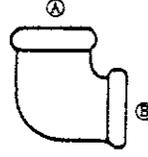
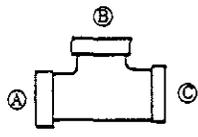
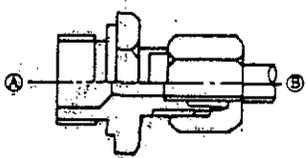
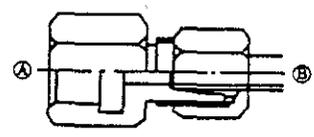
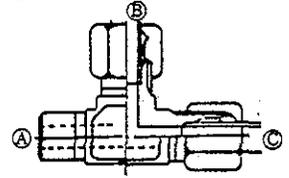
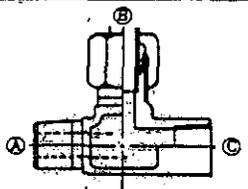
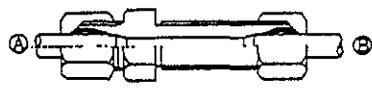
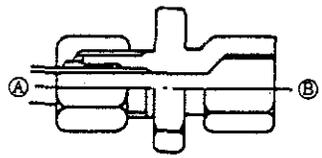
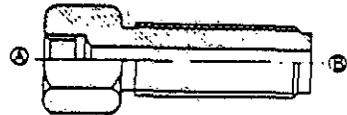
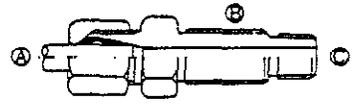
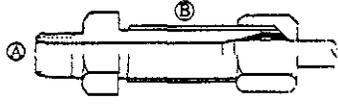
	Sectional view	Kind	Specification	Parts No.	
				Type A	Type B
P I S T O N R I N G		FC-P	For Freon use, Top.	SAP411	SBP411
		GA-P	For NH ₃ use, Top.	SAP431	SBP431
		FC-UC	For NH ₃ & Freon, 2nd.	SAP413	SBP413
		FC-T		AP412	BP412
		GA-T ₂		AP432	BP432
		GA-UC		AP433	BP433
O I L R I N G		FC-PC-BC _p	For NH ₃ & Freon, 3rd.	SAP527	SBP527
		FC-PC-BC _s	For NH ₃ & Freon, 4th.	SAP528	SBP528
		FC-C ₁		AP514	BP514
		FC-PC-BC ₁		AP525	BP525
		GA-C ₁		AP534	BP534

* Standard

○ Semi standard

11. Hand Tools

Name		Q'ty	Series A	Series B
Box Spanner		1 1 1 1 1	Width across flats of socket " 14 mm " 17 mm " 21 mm	Width across flats of socket " 17 mm " 19 mm " 21 mm " 26 mm " 21 mm long socket " 26 mm
Box Spanner Handle		1	300 g	300 g
Hexagon Bar Spanner		1 1	Width across flats 5 mm " 10 mm	Width across flats 5 mm " 14 mm
Double Headed Wrench		1 1 1	14 ~ 17 mm 17 ~ 19 mm 21 ~ 23 mm	14 ~ 17 mm 17 ~ 19 mm 21 ~ 23 mm
Pulley Puller		1	With 1 bolt 5 3/4" x 100 mm With 2 bolts 1 1/2" x 45 mm	With 1 bolt 3/4" x 100 mm With 2 bolts 1/2" x 45 mm
Locking Nut Spanner		1	Small	Large
Hanger Eye Bolt		1	1/4"	5/16"
Monkey Wrench		1	10"	10"
Extension Bar		1	6"	10"
Ratchet handle		1	1/4"	1/4"
Sponge		1	20 x 160 x 160 (mm)	20 x 160 x 160 (mm)
Oil Charging Hose		1	15φ x 20φ x 750 (mm)	15φ x 20φ x 750 (mm)
Discharge Valve Disassembly Tool		1	With 2 bolts	With 2 bolts
Stud Bolt, Polished		2	1/2" x 69 mm	5/8" x 60 mm

					
Temperature measuring plug		Thermometer (I type)		Thermometer (L type)	
Art. No.	Ⓐ × Ⓑ	Art. No.		Art. No.	
JO 470A JO 480A	$\frac{1}{2}$ P.T × long $\frac{1}{2}$ P.T × short (for 42A)	THS TLS	For high pressure use (0 ~ 200°C) For low pressure use (-50 ~ 50°C)	THL TLL	For high pressure use (0 ~ 200°C) For low pressure use (-50 ~ 50°C)
					
Square plug (for low pressure)		Elbow		Tee	
Art. No.		Art. No.	Ⓐ × Ⓑ	Art. No.	Ⓐ × Ⓑ × Ⓒ
JOAP 8 JOAP10 JOAP15 JOAP20 JOAP25 JOAP32 JOAP40	$\frac{1}{4}$ P.T $\frac{3}{8}$ P.T $\frac{1}{2}$ P.T $\frac{3}{4}$ P.T 1 P.T 1 $\frac{1}{2}$ P.T 1 $\frac{3}{4}$ P.T	JOL 8H JOL10H JOL15H JOL20H	$\frac{1}{4}$ P.T × $\frac{1}{4}$ P.T $\frac{3}{8}$ P.T × $\frac{3}{8}$ P.T $\frac{1}{2}$ P.T × $\frac{1}{2}$ P.T $\frac{3}{4}$ P.T × $\frac{3}{4}$ P.T (For high pressure use)	JOT 8H JOT10H JOT15H JOT20H	$\frac{1}{4}$ P.T $\frac{3}{8}$ P.T $\frac{1}{2}$ P.T $\frac{3}{4}$ P.T (For high pressure use)
					
Seat for unloader manipulate valve		Half union		Special tee (reduction)	
Art. No.	Ⓐ × Ⓑ	Art. No.	Ⓐ × Ⓑ	Art. No.	Ⓐ × Ⓑ × Ⓒ
JO 4270 JO 4260	W19 thread 16 × 6 φ W19 thread 16 × 8 φ	JO 4240 JO 5450	$\frac{3}{8}$ P.F × 6 φ $\frac{3}{8}$ P.T × 8 φ	JO 5510	$\frac{3}{8}$ P.T × 12 φ × 6 φ
					
Special tee		Electric control fitting		Electric control fitting	
Art. No.	Ⓐ × Ⓑ × Ⓒ	Art. No.	Ⓐ × Ⓑ	Art. No.	Ⓐ × Ⓑ
JO 5520	$\frac{3}{8}$ P.T × 12 φ × $\frac{1}{4}$ P.T	JO 5680	8 φ × W16 ¹⁸ thread/in	JO 3030	6 φ × W11 ²⁰ thread/in
					
Electric control fitting		Electric control fitting		Electric control fitting	
Art. No.	Ⓐ × Ⓑ	Art. No.	Ⓐ × Ⓑ × Ⓒ	Art. No.	Ⓐ × Ⓑ
JO 3020	W11 ²⁰ thread/in × W16 ¹⁸ thread/in	JO 3010-1	8 φ × W16 ¹⁸ thread/in × $\frac{1}{4}$ P.T	JO 5690	$\frac{1}{4}$ P.T × W16 ¹⁸ thread in

We reserve the right to change design specifications according to technical developments and improvements without notice.