MAKO®

High pressure compressor systems for a variety of commercial & industrial applications.

Mako Compressors Inc.

1634 S.W. 17th St.
P.O. Drawer 1630
Ocala, Florida 32678
904/732-2268
Telex 56-336

TABLE OF CONTENTS

K7 & K51

TABLE OF CONTENTS (CONT'D)

K7 & K51

INTRODUCTION

Mako air systems are designed to process ambient air to high pressure breathing air exceeding CGA standards of at least Grade D. Higher grades are available. A Mako breathing air system is comprised of a multi-stage compressor with intercoolers, aftercoolers, interseparation and after-separation as well as a purification system that removes oil and water vapors, hydrocarbons and in the purification process causes carbon monoxide to be processed and removed from the air stream.

A breathing air system might further consist of storage facilities, either DOT or ASME, rated at 3600 psi, 5000 psi or 6000 psi. The related connections, pressure reduction regulators and filling facilities complete the system.

Mako Compressors Inc. is a prime contractor to the U.S. Government and all government agencies, supplying flyaway gasoline, diesel or electrical powered units.

All of the packages are available as portable units or permanent installations.

FUNCTION OF THE MAKO AIR SYSTEMS

The process of compressing air to high pressures involves two factors that govern the design of compressors:

The first is the increase in temperature due to the heat generated by compression itself.

The second is the related difficulty of lubrication at high pressures.

To overcome the difficulties of high pressure lubrication, the temperature induced by compression must be reduced to a level which permits adequate lubrication.

This is accomplished by performing the compression procedure in several stages and cooling the air between each stage until the required pressure is achieved.

Air enters the system through a particulate filter into the first stage cylinder where the initial compression takes place. Upon leaving the first stage cylinder, the air passes through cooling tubes where the heat is dissipated into the atmosphere, next through a condensate separator where oil and water condensate are removed before entry into the next stage.

This procedure is repeated at each stage until the required pressure is reached in the final stage where the air is again cooled and purified, ready for storage.

Appropriate mechanical devices such as safety valves, control valves, pressure and temperature indicators are incorporated into the system to provide constant monitoring and control throughout the process and insure the safety of personnel.

IMPORTANT SAFETY WARNING

These machines are designed with maximum provisions for the safety and health of operating personnel.

When properly used in accordance with the instructions given in this manual, there will be no risk of injury or hazard to health.

All moving parts must be adequately guarded; i.e. couplings, flywheels, pulleys, belt drives, etc..

All auxiliary equipment must be suitable for the pressures and capacities involved such as pipe work, fittings, connections, safety valves, etc..

In addition, local regulations applicable at the job site must be observed.

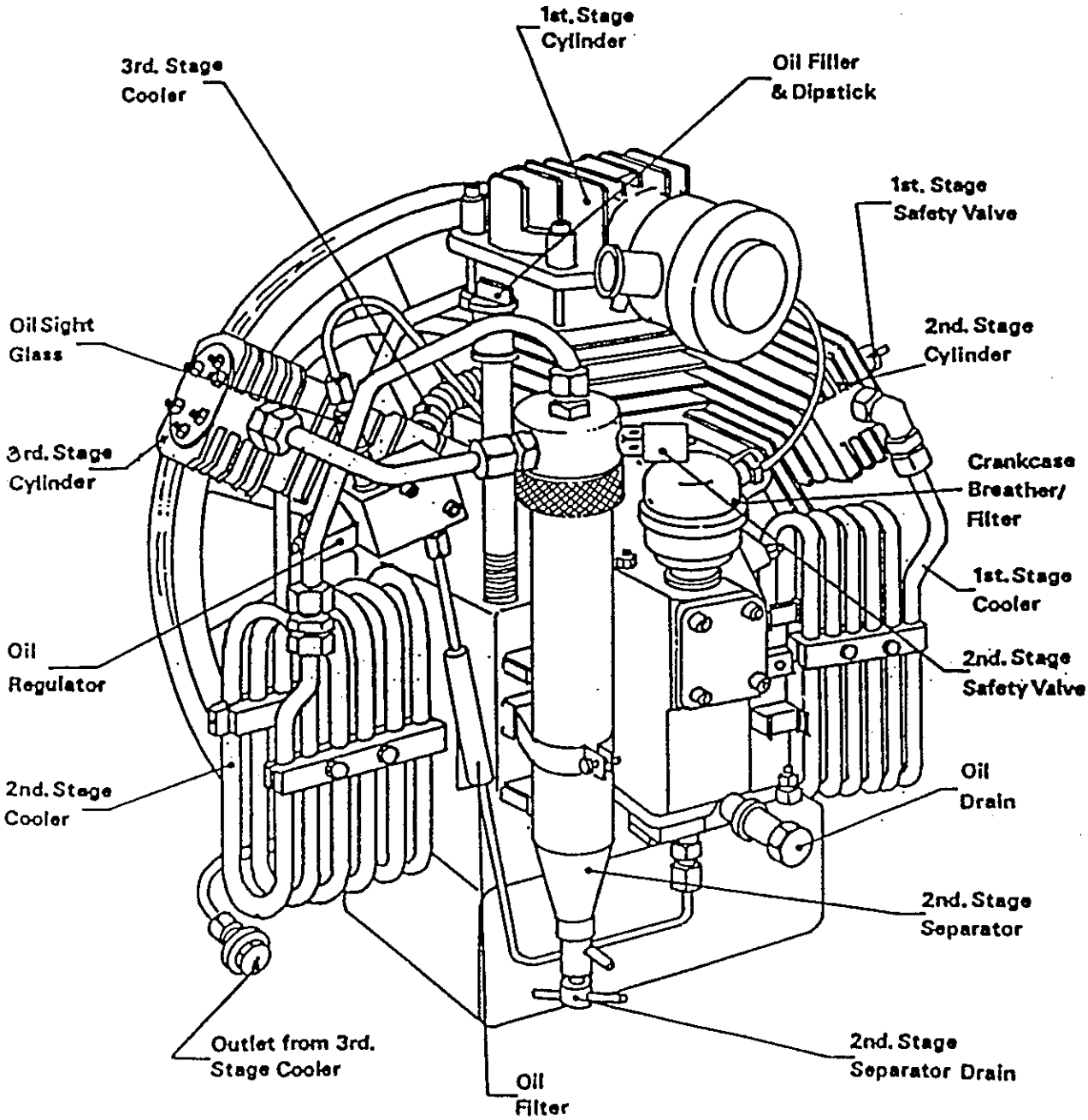
Before performing any maintenance work or dismantling the machine, isolate all electrical supplies and release all pressure from the entire system. Also, isolate the machine from storage vessels and related pipe work.

COMPRESSOR

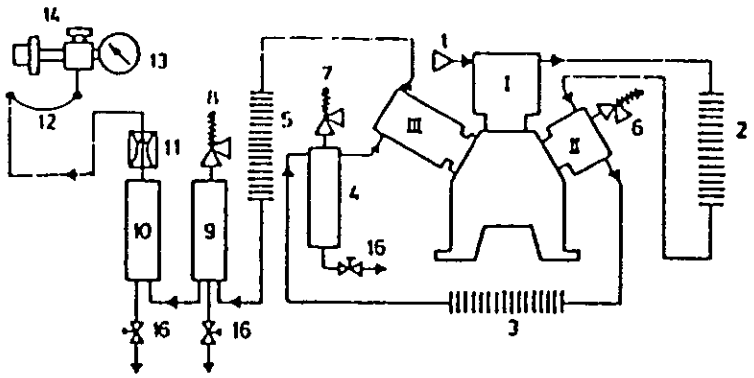
1.1

TYPICAL THREE STAGE COMPRESSOR

K7 & K51



AIR FLOW DIAGRAM



ITEM	DESCRIPTION	ITEM	DESCRIPTION
1.	Intake	9.	Final oil & water separator
2.	Intercooler, 1st stage	10.	Final Purifier
3.	Intercooler, 2nd stage	11.	Pressure maintaining valve
4.	Interseparator, 2nd stage	12.	Filling hose
5.	Aftercooler	13.	Pressure gauge
6.	Safety valve, 1st stage	14.	Filling valve
7.	Safety valve, 2nd stage	16.	Condensate drain valve
8.	Final safety valve		

AIR FLOW DESCRIPTION

Air flow through the compressor is designed so that heat and moisture generated during the compression and cooling process will be removed. Air flows through the micronic intake filter and enters the first stage, is compressed, exits the first stage and passes through the 1st stage intercooler.

The air enters the second stage, is compressed and exits the second stage cylinder where it is cooled in the second stage intercooler, then flows through the second stage condensate separator where oil and water condensate are removed.

The air then enters the final stage, is compressed, exits the final stage and is cooled to nearly ambient temperature in the aftercooler. Oil and water condensate are removed again in the final condensate separator.

The air then flows through the purification system which removes any remaining traces of oil and water, odors and unwanted gases.

The air then flows through the back pressure maintaining valve which insures that the final stage of the compressor and the purification system have a minimum of 1000 to 1500 psi back pressure.

The air then flows through the filling hose, valve and gauge, or into your air storage tanks.

SPECIFICATIONS

COMPRESSOR MODEL	K-51	K-7
Number of cylinders	3	
Number of stages	3	
CYLINDER BORE IN MM		
1st stage	70	8.8
2nd stage	36	
3rd stage	14	
STROKE IN MM	40	
FREE AIR DELIVERY at rated pressure in CFM	5.0	7.0
MAXIMUM CONTINUOUS OPERATING PRESSURE	5000 psi	
HORSEPOWER REQUIREMENTS		
GASOLINE	5.0	7.0
DIESEL	4.9	8.0
ELECTRIC	5.0	7.5
OPERATING SPEED	1300 rpm	
NORMAL WORKING PRESSURE (PSI) AT:	3200 - 5000	3200 - 5000
1st stage	55 - 65	80 - 80
2nd stage	450 - 550	600 - 650
3rd stage	As Set	3200 - 5000
AVERAGE VALVE HEAD TEMPERATURE AT 68°F (AMBIENT)		
1st stage	88 F	
2nd stage	105 F	
3rd stage	130 F	
OIL CAPACITY IN QUARTS	1.7	
MAXIMUM AMBIENT TEMPERATURE	110 F	

Air outlet temperature after exiting from aftercooler will be 15° to 20°F above ambient temperature.

MAXIMUM INCLINATION, ANY DIRECTION 10 degrees

NEVER DISASSEMBLE COMPRESSOR UNTIL ALL PRESSURE HAS BEEN RELEASED FROM SYSTEM.

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT PRIOR NOTICE.

OPERATING CONTROLS AND INDICATORS

ITEM NAME	NORMAL OPERATING POSITION OR INDICATION AND FUNCTION
1st stage pressure gauge (Range 0 to 200 psig)	55 to 65 psig, indicates discharge pressure from 1st stage cylinder
2nd stage pressure gauge (Range 0 - 1500 psig)	450 to 550 psig, indicates discharge pressure from 2nd stage cylinnder
3rd stage pressure gauge (0 to 7500 psig)	Indicates final discharge pressure from 3rd stage cylinder

NOTE: 5000 psi compressors will have higher intermediate readings.

Hour Meter	Indicated lapsed time of operation, for maintenance purposes
Oil Pressure Gauge	750 to 800 psig, indicates oil pressure at final stage cylinder
Power Switch (Auto-Off-Manual)	Turn to Auto or Manual position to start compressor. Turn to OFF position to shut compressor down. (Electric models only)

SAFETY PRECAUTIONS

All electrical connections should be in accordance with recognized electrical codes. Electrical connections should be performed by a licensed electrician.

Before performing maintenance or repair work on the compressor, SHUT THE COMPRESSOR DOWN, disconnect all power and RELIEVE ALL PRESSURE FROM THE SYSTEM.

Do not operate the compressor in excess of its rated speed or pressure and be certain that the direction of rotation is correct.

Check all safety devices regularly for proper operation.

Do not operate the compressor at pressures higher than specified or motor overload may occur and damage to component parts may result.

COMPRESSOR AIR SWITCH

If compressor air switch requires adjustment, use the following procedure:

1. Remove all pressure from the compressor.

2. Loosen lock-nut on pressure switch with a 10mm wrench.

3. Start the compressor and run it until it shuts itself down.

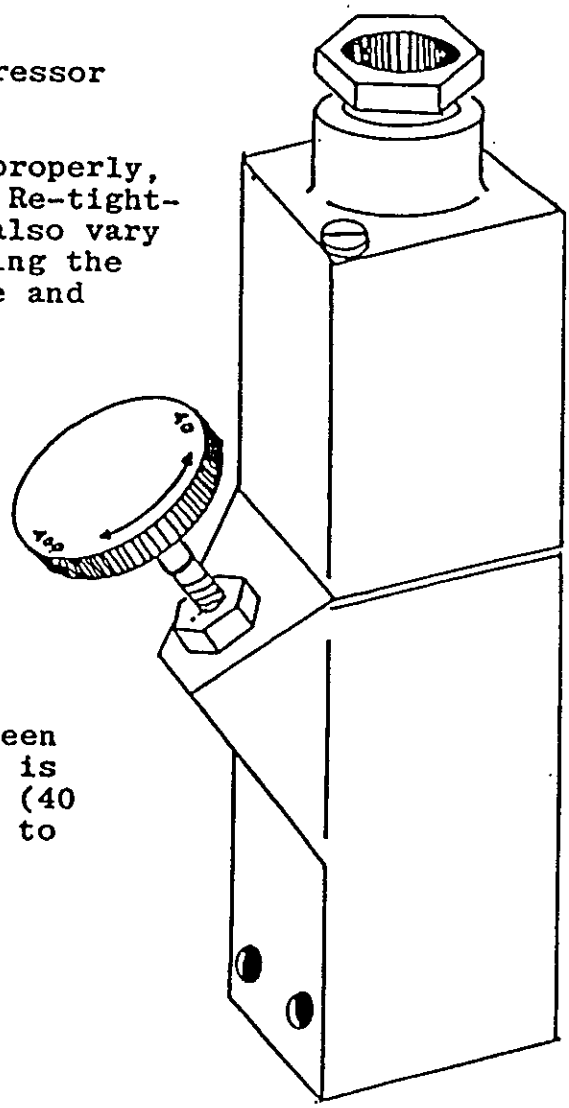
4. Note pressure at which compressor shuts down. If you wish to increase pressure, rotate knob on pressure switch 1/4 turn clockwise to increase pressure or 1/4 turn counter-clockwise to reduce pressure.

   NOTE: Each 1/6 to 1/8 turn of the knob is equal to approximately 75 to 100 psi change.

5. Repeat Step #4 until desired shutdown pressure is reached.

6. Tighten lock-nut and operate compressor normally.

   NOTE: If lock-nut is not secured properly, pressure setting will vary. Re-tightening of the lock nut will also vary the pressure. After tightening the lock nut, check the pressure and adjust accordingly.



WARNING:

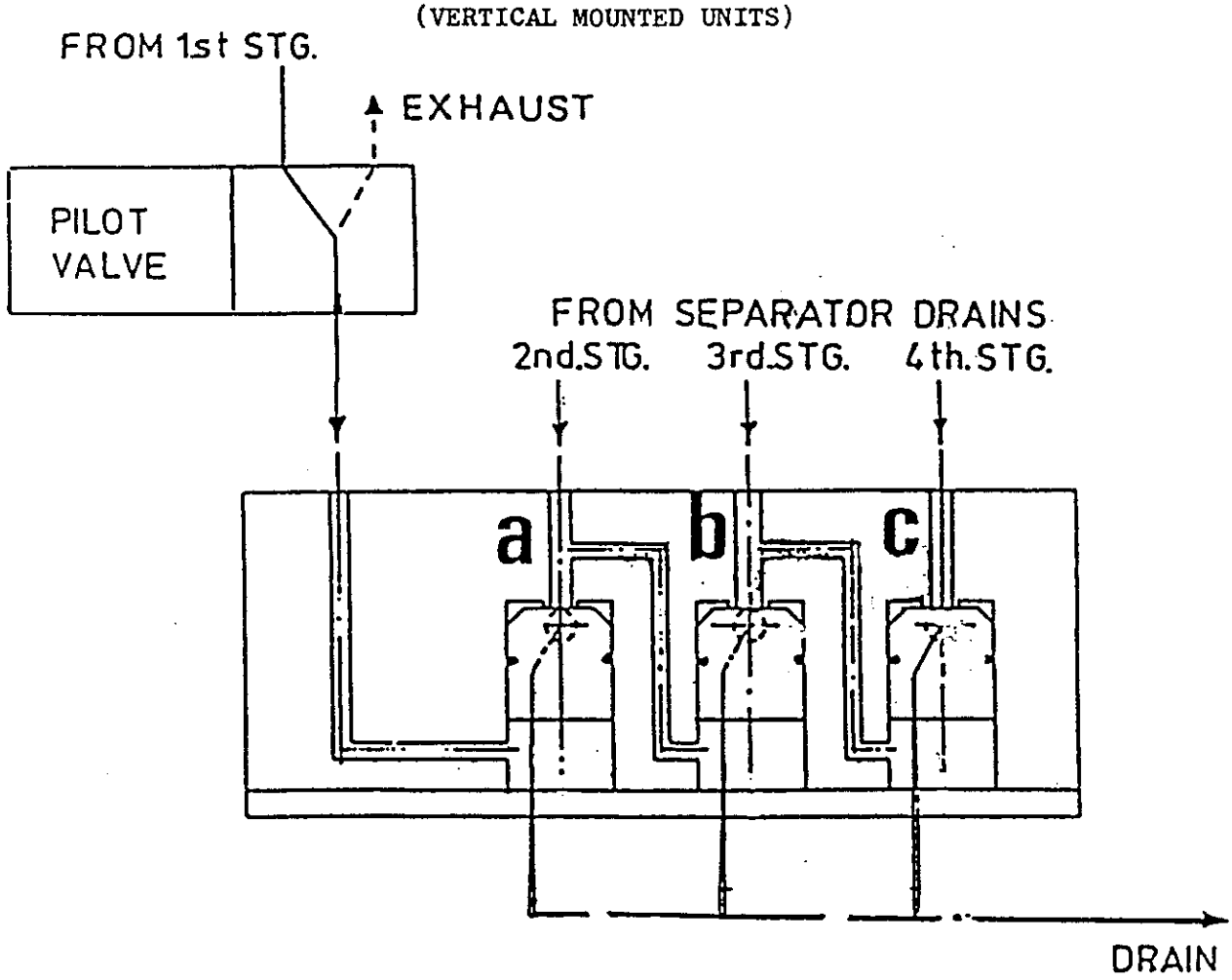
When starting adjustment from scratch, take extreme care not to back out the adjustment knob too far or extreme damage may result.

NOTE:

The only apparent difference between the air switch and the oil switch is the pressure numerals on the knob (40 to 400 on the air switch) and (10 to 100 on the oil switch).

SCHEMATIC ARRANGEMENT OF STOP START CONTROL

(VERTICAL MOUNTED UNITS)



AUTOMATIC DRAIN
VERTICALLY MOUNTED UNITS

MACHINE	A	B	C
K-51 K-7	2 STAGE	BLANK	3 STAGE
K-14 K-15	2 STAGE	3 STAGE	4 STAGE
K-22 K-27	2 STAGE	3 STAGE	4 STAGE

AUTOMATIC DRAIN
FOR VERTICAL MOUNTED UNITS

SYSTEM

The automatic drain functions as an unloader at start up and shut down and as a drain valve while the compressor is running.

In the drain, servo air pressure activates a piston which seals off any escape of air from the compressor second stage. Subsequently second stage pressure activates another piston which seals off the third stage, and for a four stage layout, this operation is further repeated. In this condition all drains are sealed and the compressor runs on load.

Absence of servo air pressure allows dump valve pistons to open and air and condensate to vent.

Activating first stage air pressure is controlled by a solenoid pilot unloader valve mounted on the drain assembly. This solenoid is wired into the compressor starter to unload the compressor during starting and stopping.

MAINTENANCE

Failure of compressor to unload or drain properly or a constant leakage of air from the drain indicates a piston malfunction. This can be rectified by completely dismantling the drain assembly, cleaning and replacing drain piston o-rings.

Make sure gaskets and o-rings are properly seated and all assembly screws correctly tightened.

IMPORTANT NOTE:

It is recommended that an indicator line, either lightly scored or paint marked, be put on the solenoid side and back face before any solenoid removal for maintenance purposes. This will assure that the solenoid will be reassembled correctly and all parts will be aligned in their design positions.

AUTOMATIC DRAIN
FOR HORIZONTALLY MOUNTED UNITS

The automatic drain system consists of an electric timer, a control air receiver, a check valve for the control air, a solenoid valve and automatic drain valve.

Control air from the second stage of the compressor is connected to the normally closed part of the solenoid valve. The solenoid valve, when activated by the electric timer, will open and allow the control air to enter the automatic drain valve, causing it to shift to the open port position which allows the condensate from the second, third and final stages of the compressor to drain.

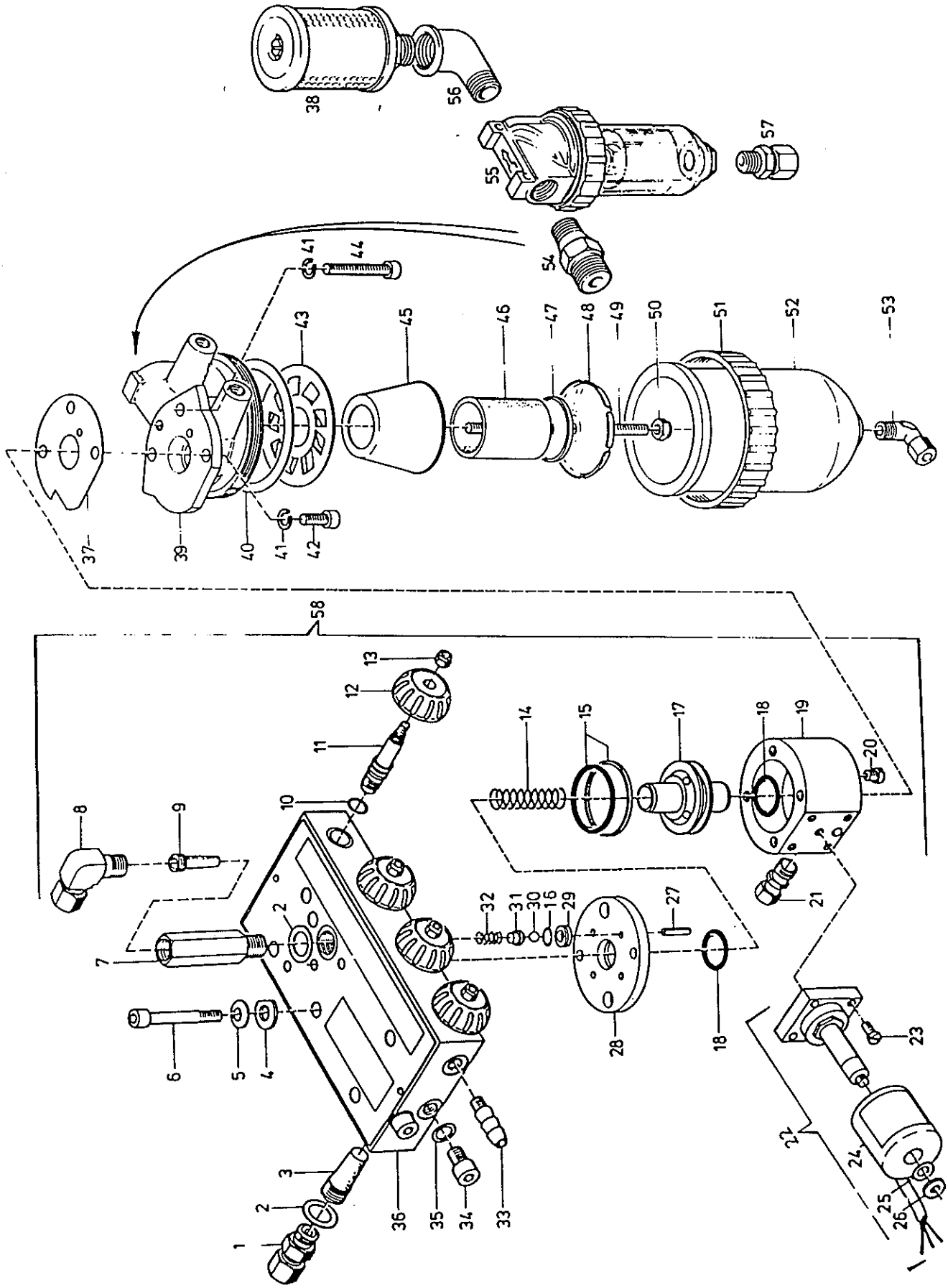
CHECKING THE AUTOMATIC DRAIN SYSTEM

The automatic drain system should be checked at least once a day.

With the compressor under pressure, drain each of the valves individually by turning the knobs slowly to the open position. (Do not open these knobs quickly)

If only small amounts of condensate discharge, the automatic drain system is operating properly. (Refer to trouble shooting guide for further information)

NOTE: The amount of condensate discharge should be equal to a 20 minute operating period and this can only be determined by observing the discharge amount during normal usage.


38
56
55
57
54
41
44
43
45
46
47
48
49
50
51
52
53
37
39
40
41
42
58
13
12
11
10
14
15
17
18
19
20
8
9
2
32
31
30
16
29
27
7
6
5
4
28
18
21
23
22
24
25
26
3
2
1
36
35
34
33

AUTOMATIC DRAIN
HORIZONTALLY MOUNTED UNITS

ITEM	ORDER NO.	DESCRIPTION	ITEM	ORDER NO.	DESCRIPTION
1	L3991384	Connector	30	L3990876	Ball
2	L3990755	Gasket	31	L3990218	Spring Guide
3	L3990423	Filter Insert	32	L3990449	Coil Spring
4	L3991460	Washer	33	L3991468	Hose Liner
5	L3991461	Spring Washer	34	L3991469	Hex Screw
6	L3950111	Internal Hex Screw	35	L3990805	Gasket
7	L3990386	Connector	36	L3991470	Distrib. Manifold
8	L3991377	Elbow	37	L3990486	Gasket
9	L3990900	Filter Insert	38	L3990923	Silencer
10	L3990901	O-ring	39	L3991471	Intermediate Piece
11	L3991462	Spindle	40	L3991472	Gasket
12	L3990794	Handwheel	41	L3990575	Lock Washer
13	L3990847	Hex Nut Self-locking	42	L3991473	Internal Hex Screw
14	L3990299	Coil Spring	43	L3991474	Centrifugal Plate
15	L3990877	Slide Ring & O-ring	44	L3991475	Internal Hex Screw
16	L3990917	O-ring	45	L3991476	Baffler
17	L3991463	Piston	46	L3990842	Filter Insert
18	L3990878	O-ring	47	L3991477	Disc
19	L3991464	Lower Drain Valve	48	L3990842	Baffle Washer
20	L3990902	Nozzle	49	L3991478	Threaded Pin
21	L3991373	Connector	50	L3991479	Hex Nut Self-lockir
22	L3990929	Solenoid Valve Assy.	51	L3991480	Threaded Collar
23	L3991465	Screw	52	L3991481	Cover Assy.
24	L3991466	Coil (for solenoid valve)	53	L3991482	Elbow
25	L3991488	Washer	54	L3991483	Nipple
26	L3991489	Knurled Nut	55	L3991484	Separator
27	L3990441	Pin	56	L3991485	Elbow
28	L3991467	Guide Plate	57	L3991486	Connector
29	L3990456	Ball Seat	58	L3991487	Drain Valve Assy.

LUBRICATION

First, second and third stage cylinders, main bearings and big and small end bearings are all oil mist lubricated.

A cam operated force feed oil pump pressurizes the lubrication system for the final stage and delivers lubricant via an oil pressure regulator to the fourth stage cylinder plunger. Surplus lubricant is returned from the regulator to the crankcase sump. The specified lubricant must be used at all times to ensure safe and efficient operation with minimum wear and maximum protection against moist air corrosion .

OIL SPECIFICATIONS

TYPE OF OIL

For summer operation in excess of 50°F.....SAE 30
For winter operation below 50°F to 5°F.....SAE 20
For winter operation below 5°F.....SAE 5W

The use of the correct oil is important for proper oil flow. By distributing the compressor load over several stages, the oil is not excessively stressed from a mechanical nor a thermic point of view. Oil should be confined to those recommended by our Company.

ONLY THE FOLLOWING OILS ARE CONSIDERED SUITABLE FOR MAKO COMPRESSORS:

MAKO HIGH PRESSURE COMPRESSOR OIL
MAKO SUPER SYNTHETIC COMPRESSOR OIL

As a TEMPORARY substitute, the following oil may be used:

MOBIL Rarus 427
ANDEROL 500 SYNTHETIC OIL

OIL CHANGES

First oil change.....After 25 operating hours
Further oil changes.....After each additional 250 operating hours

NOTE: If operating hours are not reached in six months, oil must be changed to avoid internal corrosion.

OIL CAPACITY: 2.75 pints

POUR OIL IN SLOWLY, SIGHT GLASS LEVEL.

DO NOT MIX DIFFERENT KINDS OF OIL.

OIL PRESSURE SWITCH

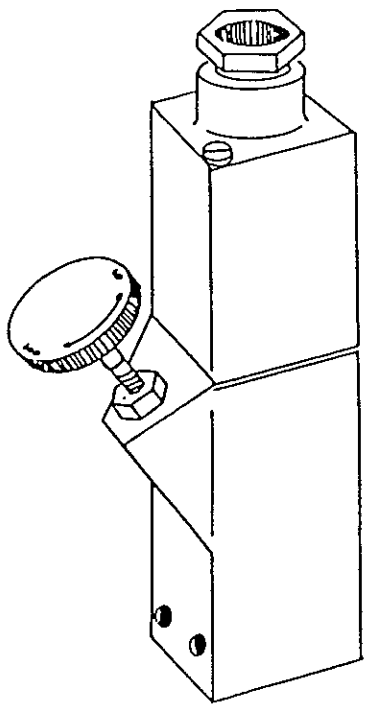
Occasionally, oil pressure switches may require readjustment due to age, vibration or other factors such as the change in viscosity between winter and summer.

Should readjustment be required, use the following procedure:

> Determine if oil pressure is correct by starting the compressor and allowing the oil pressure to stabilize. If oil pressure does not stablize between 750 and 850 psig, the oil pressure regulator must be reset.

OIL SWITCH ADJUSTMENT

1. Loosen the 10mm lock nut on the oil switch knob. The oil switch is identified by the numbers 10-100 on the adjustment knob.
2. Turn the knob counter-clockwise until seven threads show above the lock nut.
3. Start up the compressor and wait until oil pressure is built up to the proper level. Turn the time delay relay to zero.
4. Slowly turn the knob clockwise until the machine shuts off.
5. Turn the knob counter-clockwise ONE turn and lock in place with the 10mm nut.
6. Reset the time delay relay to mid range and tape in place.



THIS COMPLETES THE PROPER SETTING OF THE OIL SWITCH.

OIL PUMP AND REGULATOR

OIL LEVEL CHECK

Check oil level daily prior to operation with the dip stick. Wipe the dip stick with a lint free cloth.

Oil level must be between the minimum and maximum dip stick notches.

Oil level must not exceed maximum, as this will cause excessive lubrication and result in carbonization of valves.

OIL PRESSURE REGULATOR

The oil pressure regulator is mounted on the third stage cylinder and is adjusted to 750 to 800 psig. The regulator may be adjusted by loosening the lock nut in the rear and turning the set screw. Adjustments should be made with the compressor in operation.

A pressure gauge must be connected to the regulator. Turning clockwise will increase the pressure and turning counter-clockwise will decrease the pressure.

VENTING OIL PUMP

Loosen vent screw by one or two turns with unit in operation until oil emerges free of air bubbles. Then tighten vent screw.

INSTALLATION AND PREPARATION FOR OPERATION

READ ALL SPECIFICATIONS AND INSTRUCTIONS.

Remove all crating, blocking and/or other protective material from the compressor.

Inspect for damage components, such as valves, gauges or any other visible sign of damage that may have been caused in shipping.

Check oil level prior to start up of equipment and, if level is not correct, add the required amount of recommended oil. (DO NOT SUBSTITUTE.) Do not mix different kinds of oil. Deterioration of o-rings and seals will result. Cover unused oil to prevent contamination by dirt and dust.

Check all filter housings to be certain that all correct filter elements have been installed prior to operation of compressor.

Rotate flywheel by hand to insure smooth operation.

Check all electrical connections to be sure that no components have been damaged during shipment.

Check all tubing and connections for tightness.

See that all support and mounting brackets are tight.

Attach rubber vibration isolators (shipped with unit) or bolt compressor to floor when located satisfactorily.

NOTE: Since the compressor is an air cooled machine, it is important that it be installed in an area to provide proper ventilation. The compressor should be placed at least 30" away from any wall. Air should be made available from a least two directions. For "In room applications", there should be at least two openings into the room. Each opening should be at least 6 square feet in area. It is preferable that one opening be located close to the ceiling and the other opening close to the floor to facilitate the removal of heated air and the admittance of cooling air. If flowing air is not available, a fan may be used to bring cooling air into the room.

The compressor should never be operated in an ambient temperature in excess of 110°F.

In electrical applications, before wiring the motor to the power supply, the electrical rating of the motor should be checked against the power supply. See name plate on the motor. If the rating is not the same, contact your local power company or electrical contractor for recommendations.

The electrical disconnect should not be located more than fifty (50) feet from the unit.

For compressors with gasoline or diesel engines, open the condensate drain valves to allow the compressor to start without load.

INSTALLATION

GENERAL

Compressor must be installed in a level, well ventilated position clear of fumes, heat or high humidity to insure efficient performance and also to prevent over temperature problems. If sited in a large building, there should be few problems, provided there is a reasonable air gap between the front and back of the compressor and any obstructions..

If positioned in a small or confined building, clean cooling air must be directed or ducted towards the compressor fan insuring that there is also no air flow short circuit.

As all motor power is dissipated in heat to the cooling air, it is essential that expired cooling air has an unobstructed passage and exit.

Another important factor is that all coolers and, in particular the delivery air finned tubing, should be maintained in a clean condition to attain maximum dissipation of compression heat.

In a cold climate the compressor should be installed in a heated location.

Allow sufficient space around the installation to enable safe maintenance working conditions.

Suitable lifting equipment should be readily available.

Protection from severe weather conditions is desirable.

Insure compressor is installed to comply with local Electricity Authority stipulations and that necessary electrical work is carried out by a competent electrical engineer. Check electrical requirements for machine with manufacturer before commencing installation wiring.

BELT DRIVE

Insure that driving and driven pulley grooves are inline and shafts are parallel before and after fixing. Tensioning procedures follow normal practice.

START UP

After the first 25 hours of operation, drain the oil and fill with Mako High Pressure compressor oil.

During the first 100 hours of operation on a new unit or after overhaul, normal mineral type oils may be used.

Following the "break-in" period, Mako Super Synthetic oil may be used.

Certain materials such as rubber, paint, plastic, etc. may not be compatible with synthetic oil. When adding auxiliary equipment, consult the manufacturer for compatibility.

BEFORE STARTING

1. Check complete installation, including pipework and alignment of compressor with driving unit.

2. Remove dry type suction filter element, blow over with low pressure air and re-insert in casing.

3. Insure silencer bore and pipework is clean and blank removed from suction pipe.

4. Insure crankcase is filled to MAXIMUM mark on dipstick with recommended oil. Do not overfill - over lubrication is harmful. It is essential that recommended oil is used for initial 100 hours running-in and also same running period after complete overhaul.

5. Remove valve head and examine cylinder bore. Add small quantity of oil to upper cylinder and ROTATE COMPRESSOR BY HAND to spread oil over cylinder faces.

6. If machine has been idle for six months or more, remove oil pump bearing cover and lubricate the bearing before starting up. INSURE THIRD STAGE PLUNGER IS WELL LUBRICATED WITH RECOMMENDED OIL.

START-UP PROCEDURE

1. Rotate the compressor once or twice by hand to ascertain free movement.

2. Operate starter and immediately check rotation-an attached label or plate indicates correct rotation. A loud knocking noise will be present but this is normal when machine is first started up.

3. Check that oil is flowing in regulator sight glass.

4. Run at reduced pressure; i.e. 500 psi for 15 minutes before bringing slowly onto load.

   NOTE: Purge each section of the system with air before using delivered air to insure no dirt or foreign matter is present.

5. Check and adjust, if necessary, the air pressure switch setting.

6. After 30 minutes operation, check valve heads. Intake pipe to valve heads should be hand warm and outlet pipes hot. This indicates valves are functioning correctly.

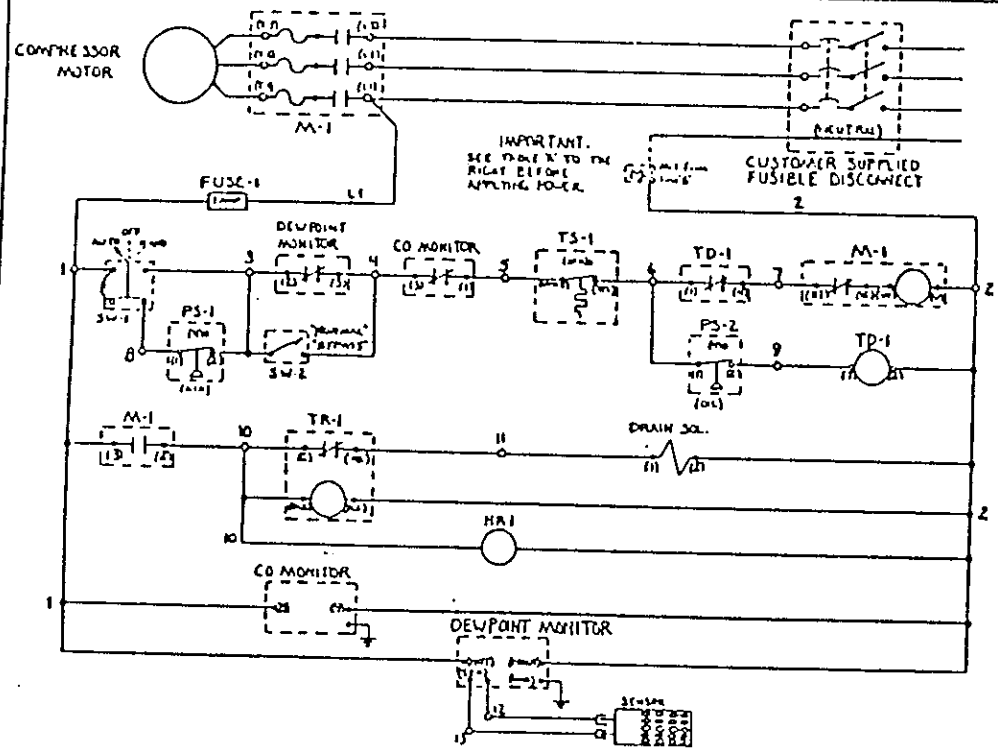


TABLE "A"

IF CUSTOMER'S SUPPLY IS:	CONNECT WIRE #2 (on SAFETY CO.) TO:	CONTROL VOLTAGE BECOMES:
115v 1ø	L2	115v
230v 1ø	NEUTRAL	115v
208-230v 3ø	NEUTRAL	115v
460v 3ø	SEE NOTE #4	115v
575v OR OTHERS 3ø	SEE NOTE #4	115v

TABLE "B"

DELETED OPTION	JUMPER WIRE REQUIRED
DEWPOINT MONITOR	FROM 3 TO 4
CO MONITOR	FROM 4 TO 5
LOW OIL SHUTDOWN	FROM 6 TO 7

THIS MACHINE WAS FACTORY WIRED FOR:

- ☐ 115v
- ☐ 208v
- ☐ 230v ☐ SINGLE PHASE
- ☐ 460v ☐ THREE PHASE
- ☐ 575v
- ☐ OTHER _____

THE FOLLOWING OPTIONS ARE INCLUDED IF CHECKED:

- ☐ DEWPOINT MONITOR
- ☐ CO MONITOR
- ☐ OIL PRESSURE SHUTDOWN
- ☐ HOUR METER
- ☐ AUTOMATIC DRAIN SYSTEM

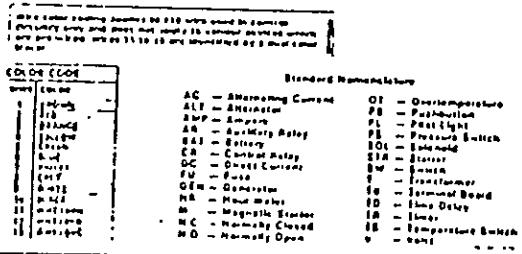
COMPRESSOR MODEL

- ☐ K-5
- ☐ K-7
- ☐ K-11
- ☐ K-15
- ☐ K-22
- ☐ K-27

ASSEMBLY NOTES:

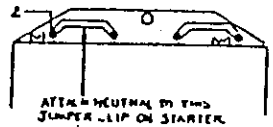
- WHEN DEWPOINT MONITOR IS OMITTED, SW-2 IS ALSO OMITTED SEE TABLE "B".
- WHEN CO MONITOR IS OMITTED, SEE TABLE "B"
- WHEN OIL PRESSURE SHUTDOWN IS OMITTED, PS-2 AND TD-1 ARE REMOVED SEE TABLE "B"
- WHEN THE AUTODRAIN IS OMITTED, TR-1 AND THE DRAIN SOLENOID ARE REMOVED

THERE ARE TWO TYPES OF NORMALY CLOSED TEMPERATURE SWITCH BODIES. ONE IS A METAL CASE WITH THREE WIRES OF WHICH THE WHITE AND YELLOW WIRES ARE USED. THE OTHER IS A RED BODY WITH TWO BLACK WIRES. BOTH SWITCHES OPEN AT 350°F AND SHUTDOWN THE COMPRESSOR. THE FIRST SWITCH IS SHOWN ABOVE IN THE DIAGRAM.



ELECTRICIANS NOTES:

1. L3 IS HIGHEST VOLTAGE LEAD ON UNBALANCED THREE PHASE SYSTEMS.
2. CHECK DIRECTION OF ROTATION ON THREE PHASE MACHINES. COOLING AIR SHOULD BE DRAWN THROUGH BELT GUARD AND EXHAUSTED OUT ACROSS THE COMPRESSION CYLINDERS.
3. FOR SINGLE PHASE MACHINES, L3 IS OMITTED AND POWER IS BROUGHT INTO L1 AND L2. THERE IS ONLY ONE HEATER OVERLOAD ELEMENT (~~).
4. ON DELTA SYSTEMS AND SUPPLIES GREATER THAN 230 VOLTS, A TRANSFORMER IS REQUIRED. ON MAKO'S STANDARD 230/460v TRANSFORMER, CONNECT AS FOLLOWS: L1 TO PIN(1), L2 TO PIN (4), WIRE 2 TO PIN(5), INPUT OF FUSE-1 TO PIN(8).
   FOR 460v SUPPLY, JUMPER PIN(2) TO(3).
   FOR 230v SUPPLY, JUMPER PIN(1) TO(3) AND PIN(2) TO(4).
   THE NEUTRAL WIRE IS NOT REQUIRED WHEN A TRANSFORMER IS USED IN THE CONTROL CIRCUIT.
5. LETTERS AND NUMBERS IN PARENTHESIS ARE THE DEVICE TERMINAL LABELS. PLAIN NUMBERS ARE WIRE NUMBERS. AS AN EXAMPLE ⊥o——4 IS WIRE 9 INTO PIN(7).
6. ON INITIAL INSTALATION, IF COMPRESSOR WILL NOT TURN ON, MAKE SURE THE NEUTRAL WIRE (IF REQUIRED) IS SECURELY ATTACHED TO WIRE 2 ON TOP OF THE MAGNETIC STARTER.



AUTHENTICATION			
DRAWN BY PAUL E	DATE 12/15/93	ELECTRIC DIAGRAM K-SERIES, E-V MODELS 5 TO 25 hp, 1 AND 3ø STANDARD MACHINES	CompAir MAKO COMPRESSORS, INC. 1624 S.W. 17 STREET OCALA, FLORIDA 32670
CHECKED BY			
APPROVED BY			
PRODUCT ENGINEER			SIZE C · DRAWING NO 221-063 · REV 0 · SCALE NONE · SHEET 1 OF 1

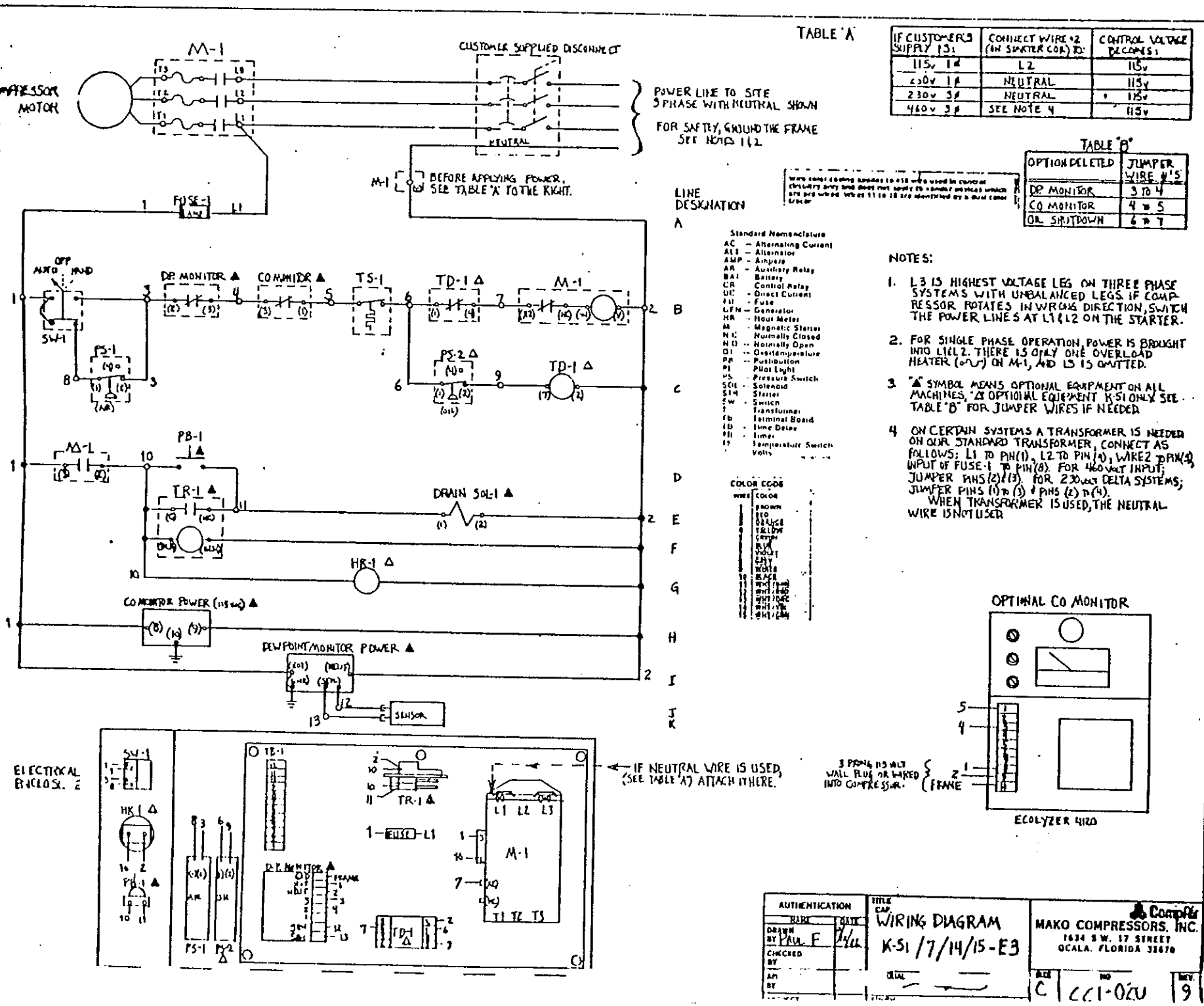


TABLE 'A'
IF CUSTOMER'S SUPPLY IS:
CONNECT WIRE #2 (IN STARTER COIL) TO:
CONTROL VOLTAGE BECOMES:
115v 1ø
L2
115v
230v 1ø
NEUTRAL
115v
230v 3ø
NEUTRAL
115v
460v 3ø
SEE NOTE 4
115v
M-1
COMPRESSOR MOTOR
CUSTOMER SUPPLIED DISCONNECT
POWER LINE TO SITE
3 PHASE WITH NEUTRAL SHOWN
FOR SAFETY, GROUND THE FRAME SEE NOTES 1 & 2
NEUTRAL
M-1
BEFORE APPLYING POWER, SEE TABLE 'A' TO THE RIGHT.
TABLE "B"
OPTION DELETED
JUMPER WIRE #'S
DP MONITOR
3 TO 4
CO MONITOR
4 TO 5
OIL SHUTDOWN
6 TO 7
LINE DESIGNATION
A
B
C
D
E
F
G
H
I
J
K
Standard Nomenclature
AC — Alternating Current
ALT — Alternator
AMP — Ampere
AR — Auxiliary Relay
BAT Battery
CR Control Relay
DC — Direct Current
FU Fuse
GEN — Generator
HR Hour Meter
M Magnetic Starter
NC Normally Closed
NO — Normally Open
OT — Overtemperature
PB — Pushbutton
PL Pilot Light
PS — Pressure Switch
SOL Solenoid
STR Starter
SW Switch
T Transformer
TB Terminal Board
TD Time Delay
TR Timer
TS Temperature Switch
V Volts
COLOR CODE
WIRE COLOR
BROWN
RED
ORANGE
YELLOW
GREEN
BLUE
VIOLET
GREY
WHITE
BLACK
NOTES:
1. L3 IS HIGHEST VOLTAGE LEG ON THREE PHASE SYSTEMS WITH UNBALANCED LEGS. IF COMPRESSOR ROTATES IN WRONG DIRECTION, SWITCH THE POWER LINES AT L1 & L2 ON THE STARTER.
2. FOR SINGLE PHASE OPERATION, POWER IS BROUGHT INTO L1 & L2. THERE IS ONLY ONE OVERLOAD HEATER (ORANGE) ON M-1, AND L3 IS OMITTED.
3. "▲" SYMBOL MEANS OPTIONAL EQUIPMENT ON ALL MACHINES, "Δ" OPTIONAL EQUIPMENT K-S1 ONLY. SEE TABLE "B" FOR JUMPER WIRES IF NEEDED.
4. ON CERTAIN SYSTEMS A TRANSFORMER IS NEEDED ON OUR STANDARD TRANSFORMER, CONNECT AS FOLLOWS; L1 TO PIN(1), L2 TO PIN(4), WIRE 2 TO PIN(3). INPUT OF FUSE-1 TO PIN(6). FOR 460 VOLT INPUT; JUMPER PINS (2) & (3). FOR 230 VOLT DELTA SYSTEMS; JUMPER PINS (1) TO (3) & PINS (2) TO (4). WHEN TRANSFORMER IS USED, THE NEUTRAL WIRE IS NOT USED.
OPTIONAL CO MONITOR
3 PRONG 115 VOLT WALL PLUG OR WIRED INTO COMPRESSOR.
FRAME
ECOLYZER 4120
ELECTRICAL ENCLOSURE
IF NEUTRAL WIRE IS USED, (SEE TABLE 'A') ATTACH IT HERE.
AUTHENTICATION
DRAWN BY PAUL F 7/14
CHECKED BY
APP BY
WIRING DIAGRAM
K-S1 / 7/14/15 - E3
MAKO COMPRESSORS, INC.
1634 S.W. 17 STREET
OCALA, FLORIDA 32670
SIZE C
CC1-020
REV. 9

MAINTENANCE

1. OPERATION AND DAILY MAINTENANCE

Start up procedure (SECTION 3 should be used):

(a) For first run
(b) Following overhaul
(c) After standing idle for a long period

Crankcase oil needs to be changed after major overhaul. Starting procedure should be observed after valve overhaul.

Keep exterior of the compressor clean, especially pipe connections and joints as this will assist in detecting any leaks.

2. STARTING UP

Check crankcase oil level, top up, if necessary, with recommended oil to maximum mark on dipstick.

Hand unload compressor. Operate starter, close unloader(s) and bring on to load. Check machine rotates counter-clockwise when viewed from drive end.

3. RUNNING ON LOAD

Crack all drains at 15 minute intervals to clear condensate.

4. DO NOT RUN THE MACHINE UNLOADED.

5. STOPPING

Open condensate drains, where appropriate.

Stop compressor.

6. STANDING IDLE

Leave condensate drains open.

If machine is to stand idle for more than five weeks (or shorter period if ambient conditions are unfavorable), it is advisable to carry out recommended shutdown procedure.

7. MAINTENANCE SCHEDULE

BEFORE CARRYING OUT ANY MAINTENANCE WORK, INSURE ALL PRESSURE IS RELEASED AND INSTALLATION IS ELECTRICALLY ISOLATED. NEVER ATTEMPT TO STRAIGHTEN BADLY BENT PIPEWORK OR RE-USE DAMAGED UNION FITTINGS.

NOTE: Regular servicing is essential if the design performance of the compressor is to be maintained. Maintenance intervals will depend on operating conditions and the following intervals can be used as a guide when the machine is operated under normal conditions, and may be extended with operating experience. Examination and monitoring during commissioning will give a good indication of the machine's anticipated maintenance requirements.

Observe the following points:

a. If pressure gauges are fitted, check stage pressures are within stand limits-if not fitted, check that safety valves are not operating. The stage pressures give an indication of any valve problems. If a stage pressure increases, investigate the valves in the next stage. For a lower pressure than required, check valve on that stage. Always stop machine if a safety valve opens.

b. Check that oil is visible in sight feed unit.

c. Examine for oil or air leaks which must be rectified immediately.

NEVER TIGHTEN ANY FITTING WHEN IT IS UNDER PRESSURE.

1. Weekly

In addition to operational checks, inspect all nuts, screws and fittings for tightness. Inspect for oil or air leaks.which must be rectified immediately.

2. Periodically

Remove and service suction filter/silencer.

3. Every 600 Hours Running Time (or 16 weeks)

Check that alignment and belt tension is correct.

Remove and service all suction and delivery valves.

4. Every 1200 Hours Running Time (or 32 weeks)

Drain crankcase oil after compressor has been running and oil is still warm. Replace plug and refill crankcase to the maximum mark on dipstick, using recommended oil. Re-check level after oil has had time to settle.

5. Every 3000 Hours Running Time

The compressor should be given a full mechanical check.

Check pressure gauges, if fitted, for correct reading.

Intercooler and aftercooler (if fitted) should be water tested to insure there is no risk of tube failure.

V BELT ADJUSTMENT

1. Remove belt guard.

2. Loosen drive motor securing bolts and slide towards compressor. Examine belts for wear and replace if necessary. If oily or greasy, clean before replacing on pulleys. Always fit new belts in sets of the same type from the same manufacturer.

3. Slide drive unit away from compressor and tension belts to achieve 3/4" (2 cm) deflection when pressed down at a point midway between pulleys. A pencil type belt tension indicator will greatly assist in this procedure.

4. Secure drive unit fixing bolts and replace belt guard.

AFTER FIRST 15 HOURS RUNNING TIME

1. Insure that alignment and belt tensioning is correct.

2. After First 25 Hours Running Time

Change oil in crankcase. When changing oil, drain while warm, *then slowly pour fresh oil into filler neck. Wait 5 minutes, then start compressor and check that oil is flowing in sight glass. With machine still running, loosen vent screw in bottom of oil pump and bleed until bubble free oil emerges. Stop machine and top-up crankcase. Examine valves. See PRINCIPAL FEATURES section for torque settings.

Inspect suction and delivery valves. If they are carbon covered and have heavy lacquer deposits, remove and thoroughly clean. Remove any deposits which may have formed in accessible air passageways.

Fill to recommended level with recommended Mako oils.

3. Every 250 Hours Running Time Thereafter

Drain and change crankcase oil as above.*

Examine valves.

*WHEN DRAINING CRANKCASE, ALWAYS REMOVE LOWER DRAIN PLUG.

DISMANTLING AND REASSEMBLY NOTES

SERVICING VALVE ASSEMBLIES

Keep a spare oiled and maintained set of valves in store for quick compressor servicing.

GENERAL

Valves should have a thin carbon layer and be slightly moist with oil. Valve removal is a simple procedure but the following quidelines should be observed.

FIRST STAGE VALVE

1. Loosen connecting pipe unions, remove valve cover bolts.
2. Disconnect discharge pipe and lift valve cover off.
3. Remove valve head.
4. Disassemble by removing center bolt, insuring valve plates and springs do not fall loose.
5. Clean valve components and examine plates, springs and o-rings for damage. The seating face of each plate/ring should be clean and bright with all round contact, and free from indentations. If severely indented, plate and rings must be replaced.

   ALWAYS REPLACE VALVE PLATES AND RINGS IN SETS.
6. NEVER GRIND VALVE PLATES TO THEIR SEATS.
7. Insure all components are clean, especially valve bodies, as obstructed passages will adversely affect valve operation.
8. For correct assembly, see valve drawing.
9. NEVER REVERSE A VALVE PLATE/RING. Always replace items exactly as removed.
10. Check free movement of valve plates.
11. Tighten center bolt to recommended torque setting.
12. Check o-ring joint under valve.
13. Locate valve spigot into cylinder and replace valve cover.
14. Replace valve cover bolts and tighten down evenly to recommended torque.
15. Replace discharge pipe and tighten connection.

SECOND STAGE VALVE

1. Disconnect inlet and discharge connections, do not disturb elbow fittings in valve head.

2. Remove six socket head bolts.

3. Remove valve head from cylinder by turning slightly to disengage pipe connection and lift valve head clear.

4. Remove two setscrews and separate upper and lower valve head halves, making sure components do not fall loose.

5. Thoroughly clean and examine plates and rings for damage and wear. Examine o-ring and replace if any sign of damage or wear.

6. Place o-ring in groove in upper half of valve head.

7. Assemble valve plates and springs as per

8. Hold two halves together insuring all components are correctly fitted and insert two setscrews. Tighten to recommended torque setting.

9. Locate assembled valve head on cylinder insuring locating peg in cylinder engages in slot in underside of valve head by slightly turning assembly. Insure o-ring is positioned correctly on cylinder and remains there as valve is fitted. Replace six socket head screws and tighten to recommended torque setting.

   THIS PEG AND SLOT FIXTURE INSURES CORRECT VALVE LOCATION.

10. Recouple inlet and discharge connections and tighten.

THIRD STAGE VALVE

1. Disconnect six nuts and remove inlet and discharge pipes.

2. Withdraw valve head from six studs.

3. Remove two setscrews in round bottom housing and disassemble, insuring spring plates and spring do not fall loose.

4. Clean components and examine for damage and wear.

5. Check both o-rings for damage and replace, if necessary.

6. If valve plates/rings need replacing, they must be replaced in sets.

7. Insure all passages in top, middle and bottom parts are clean as obstructions will severely affect performance.

8. To reassemble, place top part upside down on a clean flat surface and put o-ring in groove, drop plates and spring into housing.

9. Replace center part insuring peg locates.

10. Place o-ring in bottom part, repeat procedure with plates/ rings.

11. Carefully lift assembled components and place over bottom part, insuring peg locates.

12. When satisfied that all components are correctly assembled, hold together firmly and replace two setscrews and tighten to recommended torque setting.

13. Place assembly over cylinder studs, making sure pegs on cylinder locate in holes on underside of valve head. THIS INSURES CORRECT VALVE LOCATION. Insure o-ring is positioned correctly under valve.

14. Replace six nuts and tighten to recommended torque setting.

MAINTENANCE - GENERAL

1. Clean machine with a fireproof solvent, never gasoline.

2. Do not use suspect gaskets. Remove doubt by replacing.

3. Gudgeon pins are a sliding fit and should not need force to fit or remove.

4. Never assemble piston rings to pistons with a screwdriver. Always use a piston ring retainer.

5. A bearing extractor must be used at all times for bearing removal-never use a hammer.

6. Check that crankshaft alignment is correct and turns freely.

7. O-ring should be smeared with silicone grease before fitting.

8. Particular attention should be paid, when refitting first stage cylinder head. Check o-ring is not damaged, replace the valve cover in the correct position. The cylinder head must be tightened down diagonally to recommended torque, giving opposite bolts half a turn at a time.

9. Turn compressor over by hand to insure that it has complete freedom of movement.

10. Check oil level before starting.

INHIBITION FOR STORAGE

1. Release all pressure from compressor and system.

2. Drain off lubricating oil while still warm.

3. Fill the crankcase to maximum level with PX4 inhibiting oil.

4. Start compressor and run for 10 minutes on light load, with separator drains open. While running, remove inlet filter and inject small quantity of PX4 into intake to insure protection to valves and upper cylinders. Remove third stage plunger and dip in PX4 to insure complete coating of inhibitor.

5. Stop compressor, release all pressure and seal all openings with plugs or masking tape.

6. Drain off inhibitor oil and DO NOT TURN MACHINE OVER AFTER INHIBITING.

7. Attach label stating "DO NOT TURN OVER" and date of inhibition.

8. Cover with waterproof sheet and store in dry position. TURN COMPRESSOR OVER BY HAND FOR SEVERAL REVOLUTIONS BEFORE RECOMMISSIONING.

TROUBLESHOOTING GUIDE

TROUBLE	PROBABLE CAUSE	REMEDY
1. Motor becomes overloaded	Compressor cylinders, connecting rod bushings, crankshaft or piston pins scored	Replace scored parts with new parts
	Valves leak	Lap or replace valves
	(Electric Models) Motor loses a phase or voltage drops	NOTE: If motor becomes overloaded, the overload switch will shut down the compressor. Push the reset button on the starter. If motor becomes overloaded again, check for loss of phase or voltage drop.
2. Compressor oil pressure gauge not indicating an oil pressure of 750 to 800 psig when running.	Foreign material on oil pressure regulator seat.	Remove regulator and clean seat.
	Incorrect regulator valve setting.	Clean and readjust. Set to 750 to 800 psig.
	Oil pressure regulator dirty.	Clean and readjust.
	Air trapped in oil pump.	Vent pump and line.
	Oil pump drive not correct.	Check drive.
	Compressor oil pump parts worn sufficiently to prevent adequate pumping of oil.	Remove, disassemble and clean the oil pump or replace the oil pump (if any parts are worn out).
3. Plastic oil tube exhibits air bubbles.	3rd stage piston worn.	Run compressor with 3rd stage valve head removed. Oil should collect on the piston cylinder edge. If the oil should bubble out rapidly, replace piston and bushing.
	3rd stage outlet valve defective.	Replace.
4. 1st stage pressure gauge not indicating up to pressure when operating.	Faulty intake or discharge valve in 1st stage cylinder.	Remove, inspect, repair or replace faulty parts.

TROUBLE	PROBABLE CAUSE	REMEDY
4. Continued	Air leaking from 1st stage cylinder or intercooler tube lines.	Tighten connections on tube lines or replace fittings not seating properly. Replace any leaking piping.
	Gauge lines clogged with dirt or ice.	Clean lines.
	Air intake or air cleaner dirty.	Disassemble, clean or replace filter cartridge and/or air cleaner element.
	Safety valve leaking.	Repair or replace.
5. 2nd stage pressure gauge not indicating up to pressure when running.	Intake and discharge valves in preceeding cylinder not operating properly.	Remove intake and discharge valves and clean. Replace any broken parts before reassembly.
	Gauge lines clogged with dirt or ice.	Clean lines.
	Air leaking out of 2nd stage intercooling tubes.	Tighten connections on tube lines or replace fittings not seating properly. Replace any leaking fittings.
	Air leaking out of 2nd stage safety valves.	Repair or replace.
6. 1st or 2nd stage pressure gauges indicating a higher than normal pressure.	Intake and discharge valves in next higher stage cylinder not operating properly.	Remove intake and discharge valves and clean. Check valve seats and replace any broken parts before reassembly.
7. 3rd stage pressure gauge indicating a higher than normal pressure.	Pressure switch incorrectly set or malfunctioning.	Readjust or replace.
8. 1st or 2nd stage safety valves pop.	Intake and discharge valves in next stage cylinder not operating properly.	Remove intake and discharge valves and clean. Replace any worn parts.
	Intercoolers or aftercoolers blocked with carbon or ice.	Remove and clean thoroughly.
9. 3rd stage safety valve pops.	Safety valve malfunctioning or dehydrator cartridges clogged.	Replace. Replace cartridges.

TROUBLE	PROBABLE CAUSE	REMEDY
10. Air receiver pressure gauge not indicating up to pressure when running and no air being used at outlet.	Air leaking out of air receiver tube lines.	Tighten connections on tube lines or replace fittings not seating properly. Replace leaking tubes or lines.
	Check valve in receiver line not operating properly.	Replace check valve.
	Final safety valve leaking.	Replace safety valve.
	Faulty pressure gauge.	Replace gauge.
	Pressure switch set too low.	Reset pressure switch.
	Line to pressure switch and gauge blocked.	Remove and clean line.
11. Air receiver pressure gauge indicating a higher than normal pressure.	Pressure switch set too high.	Reset pressure switch.
	Line to pressure switch blocked.	Remove and clean line.
	Pressure switch inoperative.	Replace pressure switch.
12. Compressor running too hot.	Intercooler pressures higher than normal due to intake and discharge valves not operating properly.	Remove intake and discharge valves, clean and replace broken parts.
	Incorrect rotation.	Exchange L1 and L2 at the starter.
	Oil level in crankcase too low.	Add oil, check for leaks.
	Intercooler and aftercooler finned tubes clogged with dirt, oil, grease.	Clean thoroughly.
	Cooling air restricted from entering intercooling shroud.	Clean shroud, check for obstructions.
	Inadequate ventilation through unit.	Open doors or remove obstructions to allow cooling air to circulate.

TROUBLE	PROBABLE CAUSE	REMEDY
13. Condensate accumulating in crankcase or compressor cylinders showing signs of rust.	Compressor not being run for long enough periods.	Run compressor for longer periods even if charging activity has been completed.
14. Compressor piston rings, pistons & cylinders showing abnormal amount of wear.	Compressor lubricating oil not changed at the proper number of operational hours allowing it to become dirty.	Drain and flush crankcase with fresh oil, then drain and replace with correct type and grade of oil.
	Compressor lubricating oil not maintained at the proper level in the crankcase.	Maintain crankcase level above the low level mark at all times.
15. Entire unit very noisy when being operated.	Components not receiving adequate lubrication.	Service all components at the proper intervals to insure smooth operation.
	Loose, worn or damaged components causing excessive vibration.	Tighten all screws, nuts, etc. at frequent intervals. Replace any worn or damaged parts.
16. Priority valve operates at wrong pressure.	Incorrect setting, dirt on valve seat or damaged valve seat.	Repair or replace valve.
	UNITS WITH AUTOMATIC DRAIN SYSTEM	
17. Compressor fails to discharge condensate.	Faulty solenoid valve, faulty timer.	Remove, inspect, repair, clean and/or replace.
	Check valve hung up.	Remove, inspect, clean, repair or replace.
	Post on drain damaged.	Repair or replace.
18. Compressor drains continuously.	Faulty timer. Dirt on valve seat. Part #20 clogged. Faulty solenoid valve.	Repair or replace. Clean. Clean. Repair or replace.
19. Compressor fails to pressurize.	Broken or badly chafed wiring.	Inspect and replace as necessary.
	Faulty pressure switch.	Repair or replace.
	Faulty solenoid valve.	Repair or replace.
	Faulty automatic drain valve.	Repair or replace.

Part numbers shown in the following pages are for both K-7 and K-51.

Part numbers which differ for the K-7 are shown below.

ITEM NO.	DESCRIPTION	QTY	PART NO, K-51	PART NO. K-7
69	CONNECTING ROD, FIRST STAGE	1	C.200534	C.200532
65	PISTON, FIRST STAGE	1	98438/1004	98438/1003
63	PISTON RING, TAPERED, FIRST STAGE	2	98477/1016	98477/1017
64	PISTON RING SCRAPER, FIRST STAGE	1	98477/1038	98477/1039
	PISTON RING, SLOTTED, FIRST STAGE	1	——	98477/1026
60	CYLINDER, FIRST STAGE	1	D.100156	D.100155
144	PAD, COOLER CLIP	1	C.200588	C.200589
147	SCREW SOCKET HEAD	2	95018/0168	95018/0167
	VALVE UNIT, FIRST STAGE	1	98650/1158	98650/1159
59	'O'RING	1	98504/1030	98504/1028
55	COVER, FIRST STAGE	1	D.100206	D.100205
53	SCREW, SOCKET HEAD – 5404 QTY 3 5405 QTY 4		95018/0210	95018/0211
57	TUBE, FIRST STAGE COOLER	1	D.100206	E.60202
	FIRST STAGE DELIVERY UNION			
	STRAIGHT COUPLING – 5404A ELBOW – 5405A			
*	MOUNTING BRACKET	2	——	C.200836
*	TENSION PIN	1	——	95540/0160
*	COOLER PIPE CLIP	6	——	C.200586
*	STEEL PIPE	1	——	C.200878
*	ALUMINIUM PIPE	2	——	C.200879
*	SETSCREW M8 X 1.25 X 25 long	4	——	95000/0256
*	NUT	4	——	95111/0005

6.1

Compressor, Crankcase,
Oil Pump and Separator Assembly
Items 1 thru 39

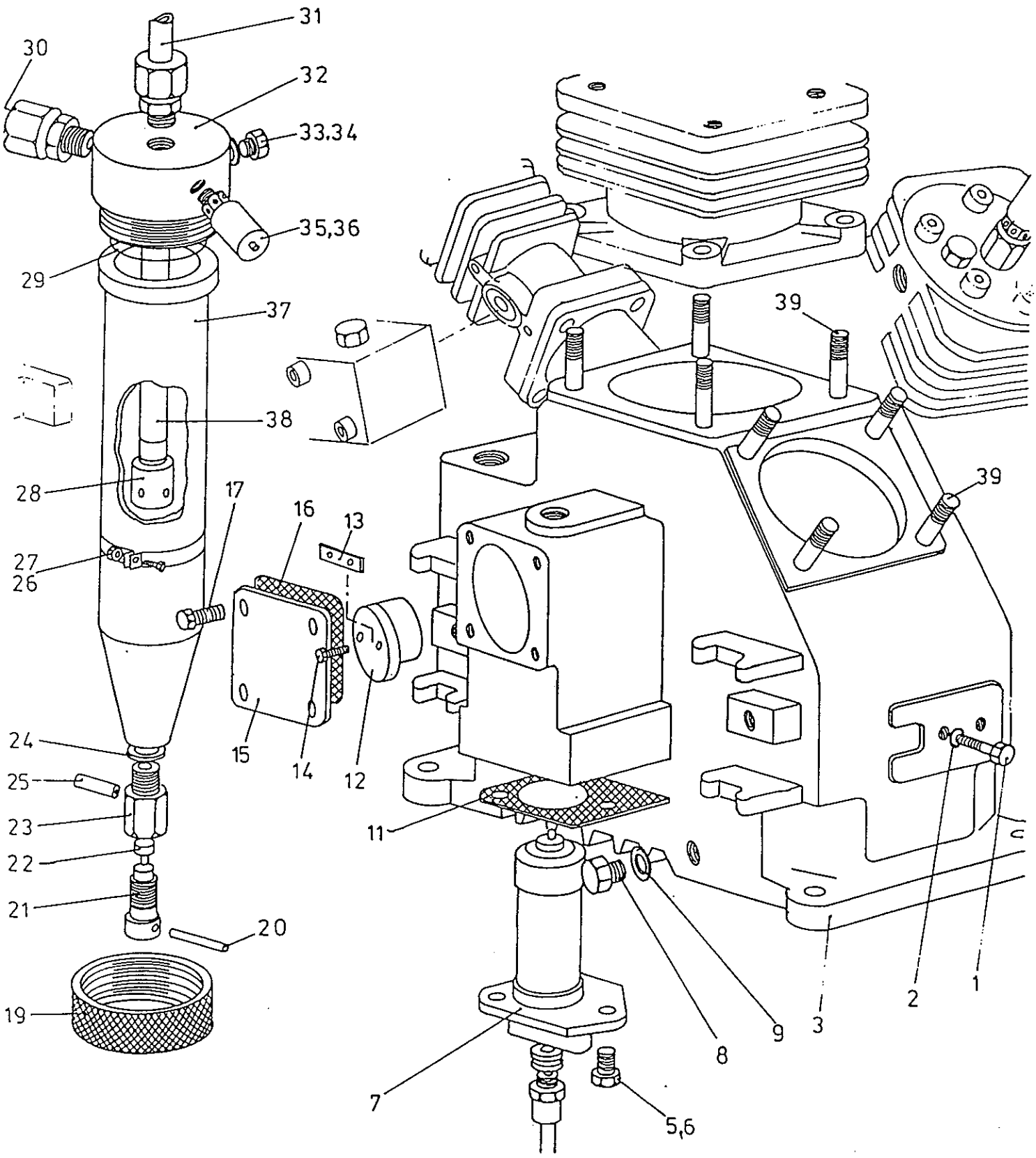


Fig. & Item No.	Part Number	Description	Qty/ Assy.
5-3	VHP 5	Compressor, Air (See Fig. 5-2-1 for NHA)	Ref.
5-3-A	NSP	Crankcase, oil pump & separator assy.	1
- 1	95000-0257	Screw, hex head	4
- 2	95175-0006	Washer, spring	4
- 3	E.60169	Crankcase	1
- 4	C.73514	Pipe, oil drain	1
- 5	95148-0014	Washer	3
- 6	95018-0201	Screw, socket head	3
- 7	98446-1003	Pump, oil	1
- 8	C.22053-2	Plug, oil drain	1
- 9	95649-0007	Washer	1
-10	95405-1003	Socket, pipe, 3/8 in.	1
-11	98502-1017	Gasket, oil pump	1
-12	C.200555-1	Cam, oil pump	1
-13	C.200555-2	Washer, tab	1
-14	95000-0228	Screw, hex head	2
-15	C.200563	Cover, end crankcase	1
-16	98502-1016	Gasket, end cover	1
-17	95018-0199	Screw, socket head	4
-18	95148-0014	Washer	4
-19	C.200650	Nut, collar, separator	1
-20	—	Not Used	
-21	--	Not Used	
-22		Nylon Valve Seat	
-23		Complete Valve Assembly	
-24	—	Not Used	
-25	—	Not Used	
-26	95000-0253	Screw, hex head	1
-27	98150-1006	Clamp, separator	1
-28	C.200653	Deflector, separator	1
-29	95600-0051	O-ring, separator	1
-30	D.100208	Tube, inlet, 3rd stage	1
-31	D.100207	Tube, 2nd stage, cooler to separator	1
-32	C.200651	Cover, separator	1
-33	PS.1814-2	Plug	1
-34	PS.1322-1	Seal	1
-35	98650-1164	Valve, safety, 2nd stage	1
-36	PS.1322-2	Seal	1
-37	98444-1001	Body, separator	1
-38	C.200652	Pipe, down, separator	1
-39	D.100171-8	Stud	8

Figure 5-3B Compressor, 1st Stage and Inlet Filter

Items 40 thru 72

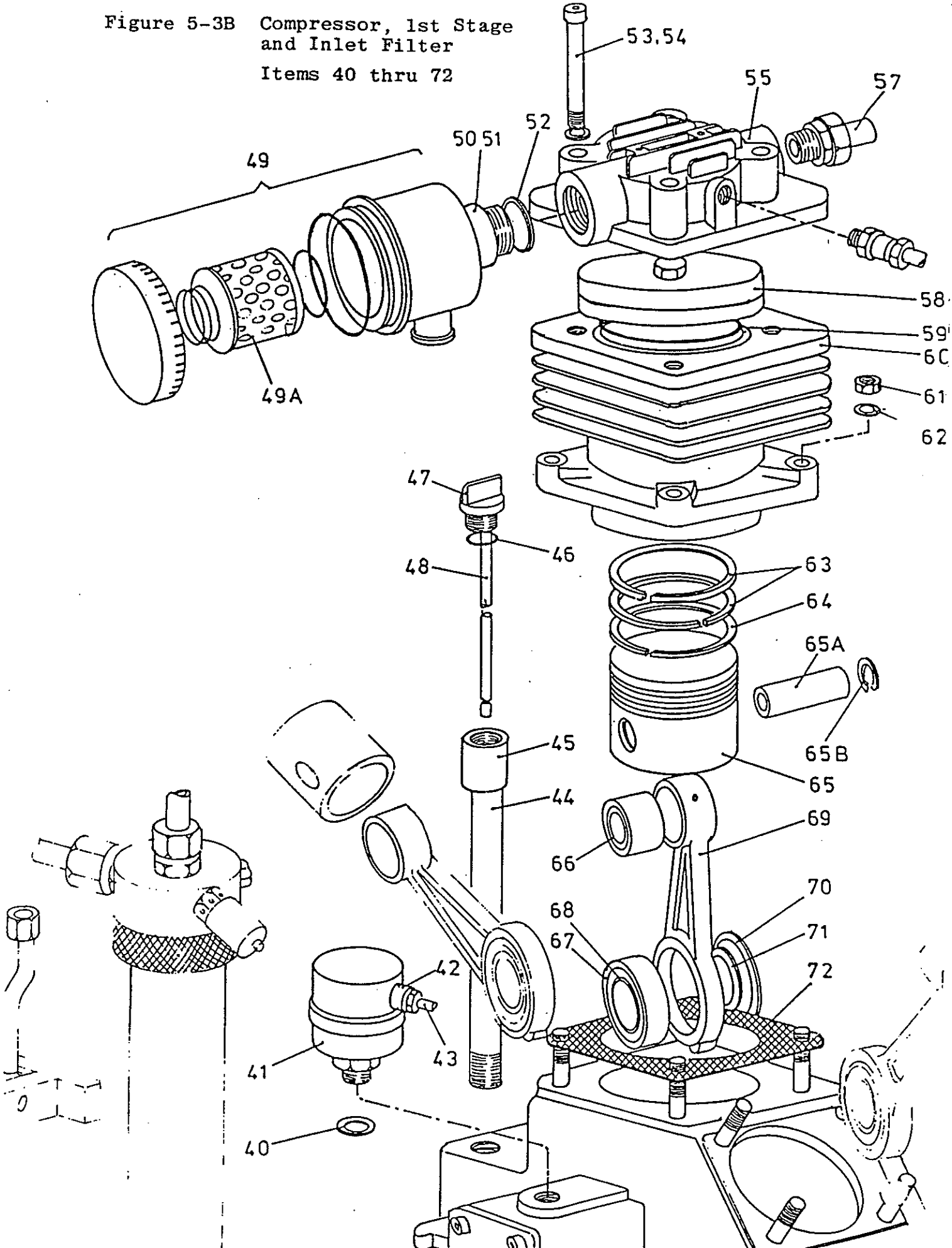


Fig. & Item No.	Part Number	Description	Qty/ Assy.
	41		
5-3-B	NSP	First Stage and Inlet Filter Assy.	1
-40	95640-0009	Washer, breather	1
-41	98262-1035	Breather, crankcase	1
-42	98156-1551	Coupling, plastic	2
-43	98617-5108	Tube, nylon	1
-44	C.73666	Pipe	1
-45	C.200562-3	Socket	1
-46	95600-0040	O-ring, oil filter plug	1
-47	C.200562-1	Plug, oil filter	1
-48	C.200562-2	Dipstick	1
-49	98262-1036	Filter assy.	1
-49A	98262-1037	Element, filter	1
-50	C.200634	Adaptor, inlet filter	1
-51	95600-0045	O-ring, adaptor	1
-52	95640-0017	Washer, fiber	1
-53	95018-0210	Screw, socket head	3
-54	95148-0014	Washer	3
-55	D.100206	Cover, 1st stage	1
-57	100209	Tube, 1st stage cooler	1
-58	98650-1158	Valve, 1st stage, inlet-discharge (See Fig. 5.4)	1
-59	98504/1030	O-ring	1
-60	D.100156	Cylinder, 1st stage	1
-61	95111-0005	Nut	4
-62	95148-0014	Washer	4
-63	98477-1016	Ring, piston, 1st stage, tapered	2
-64	98477-1038	Ring, piston, 1st stage, scraper	1
-65	98438-1004	Piston, 1st stage	1
-65A	NSP	Pin, wrist, 1st stage	1
-65B	NSP	Ring, retainer	2
-66	98076-1022	Bearing, 1st stage wrist pin	1
-67	98076-1021	Bearing, 1st stage crank pin	1
-68	98076-1024	Bearing, crankpin inner ring	1
-69	C.200534	Rod, connecting, 1st stage	1
-70	98660-1060	Spacer, crankpin, outer ring	4
-71	98660-1061	Spacer, crankpin, inner ring	3
-72	98502-1013	Gasket, cylinder, 1st stage	1

Figure 5-3C Compressor, 2nd Stage
and Crankshaft Assembly
Items 73 thru 106

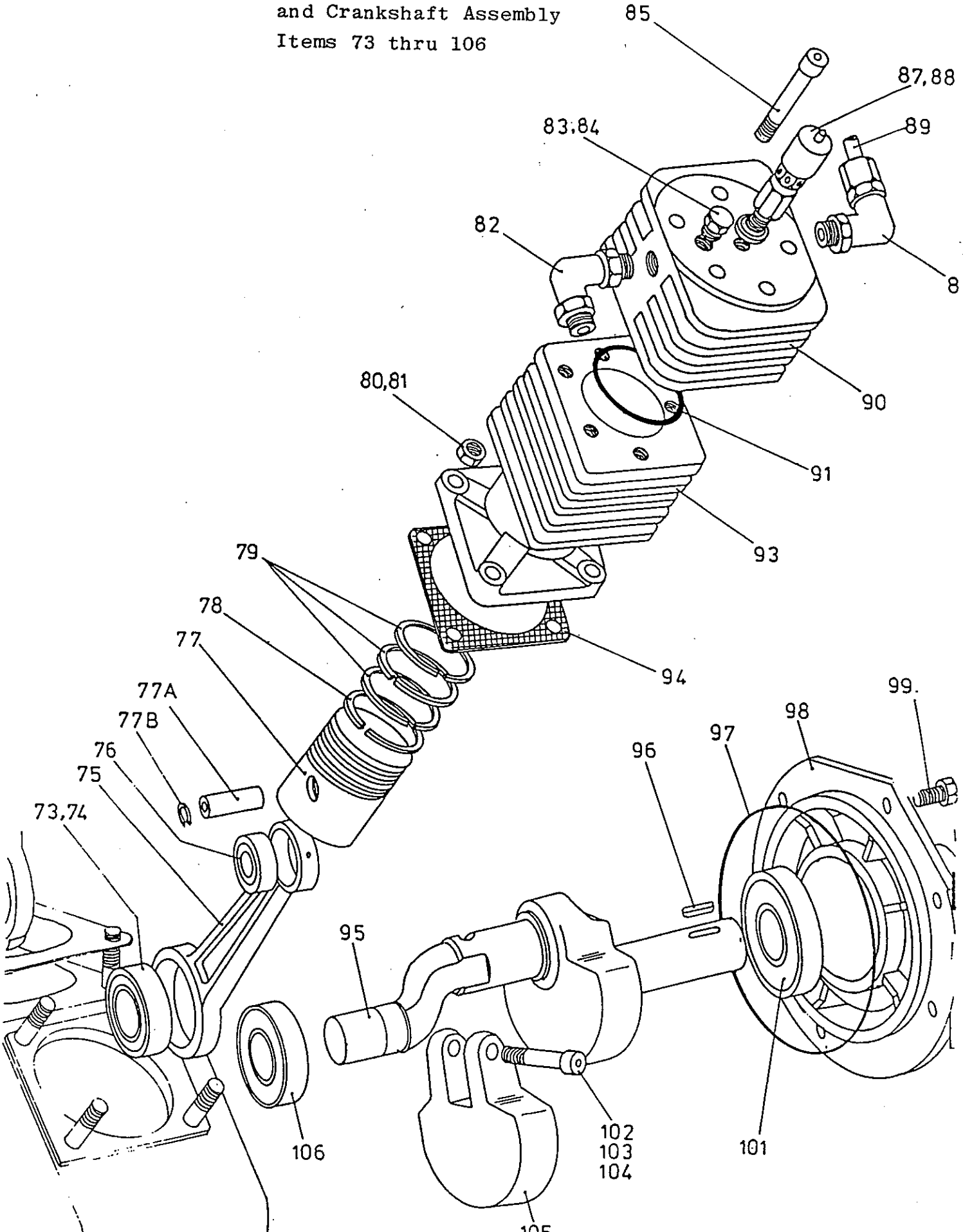


Fig. & Item No.	Part Number	Description	Qty/ Assy.
5-3-C	NSP	Second Stage and Crankshaft Assy.	1
-73	98076-1021	Bearing, crankpin, 2nd stage	1
-74	98076-1024	Bearing, crankpin, inner ring	1
-75	C.200533	Rod, connecting, 2nd stage	1
-76	98076-1023	Bearing, wrist pin, 2nd stage	1
-77	98438-1002	Piston, 2nd stage	1
-77A	NSP	Pin, wrist, 2nd stage	1
-77B	NSP	Ring, retainer	2
-78	98477-1002	Ring, piston, plain, 2nd stage	1
-79	98477-1013	Ring, piston, tapered, 2nd stage	3
-80	95111-0005	Nut	4
-81	95148-0014	Washer	4
-82	PS.2045-7	Elbow	2
-83	PS.1814-2	Plug	1
-84	PS.1322-1	Seal	1
-85	95018-0206	Screw, socket head	6
-86	95148-0014	Washer	6
-87	98650-1163	Valve, safety, 1st stage	1
-88	PS.1322-2	Seal	1
-89	D.100203	Tube, cooler, 2nd stage	1
-90	98650-1160	Valve, 2nd stage, inlet-discharge (See Fig. 5-5)	1
-91	95602-0050	O-ring, cylinder, 2nd stage	1
-92	--	Not Used	
-93	D.100159	Cylinder, 2nd stage	1
-94	98502-1014	Gasket, cylinder, 2nd stage	1
-95	D.100153	Crankshaft	1
-96	95301-0208	Key	1
-97	95600-0098	O-ring, housing	1
-98	D.100154	Housing, bearing, drive end	1
-99	95018-0200	Screw, socket head	6
-100	95148-0014	Washer	6
-101	98076-1019	Bearing, main, drive end	1
-102	95018-0207	Screw, socket head	1
-103	95111-0005	Nut	1
-104	95179-0006	Washer, spring	1
-105	C.200554	Weight, balance	1
-106	98076-1018	Bearing, main, non-drive end	1

Figure 5-3D Compressor, 3rd Stage, Oil Pressure Regulator and 2nd Stage Cooler Coil Items 107 thru 143

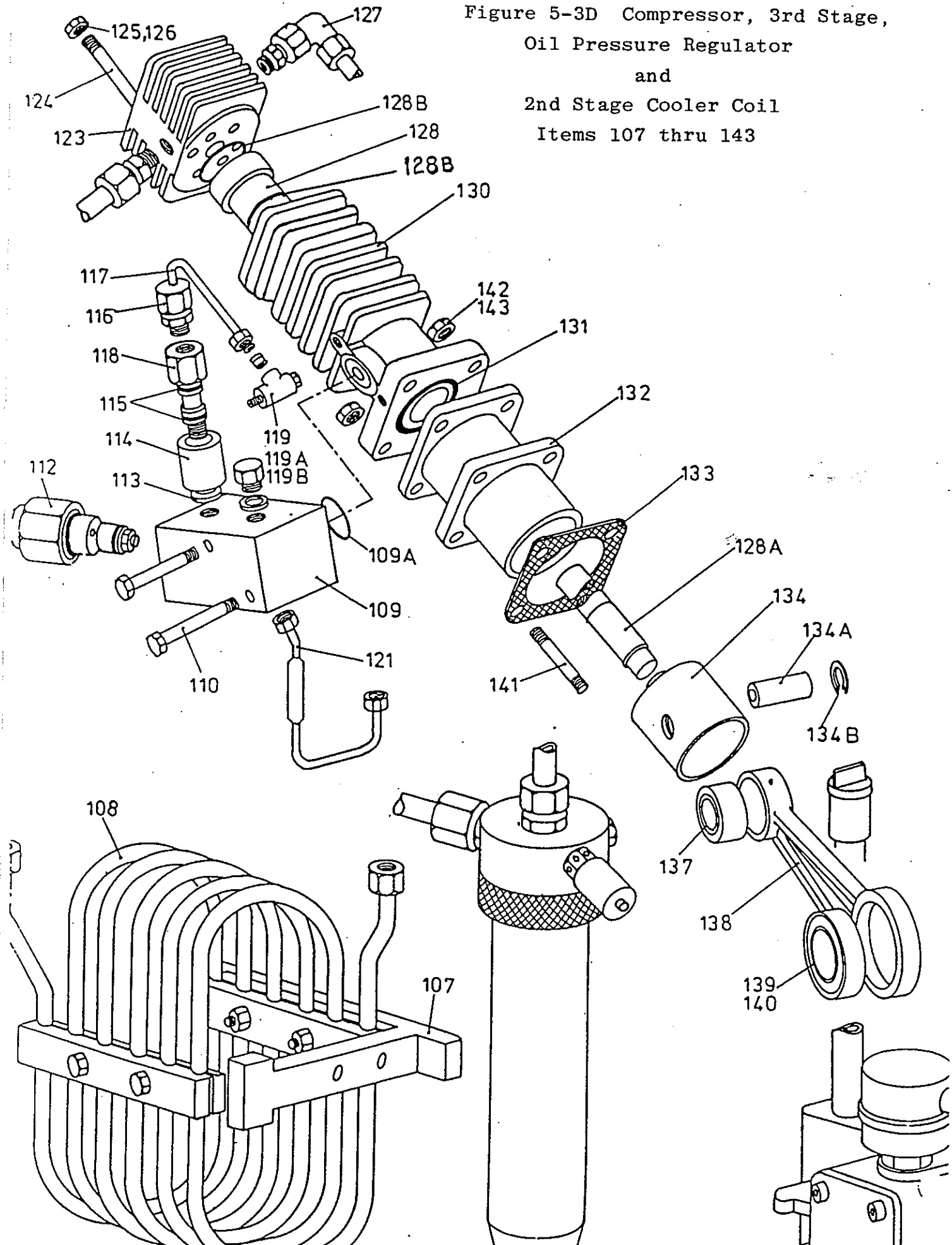


Fig. & Item No.	Part Number	Description	Qty/ Assy.
5-3-D	NSP	Third Stage, Oil Pressure Regulator and Second Stage Cooler Coil	1
-107	D.100183	Bracket, cooler coil	2
-108	E.60188	Coil, cooler, 2nd stage	1
-109	C.200629	Body, oil pressure regulator	1
-109A	95602-0007	O-ring	1
-110	95018-0124	Screw, socket head	2
-111	95602-0007	O-ring, body	1
-112	98650-1162	Valve, oil relief	1
-113	95635-0001	Washer	1
-114	98281-1001	Glass, sight	1
-115	95608-0008	O-ring, sight glass	2
-116	98156-1123	Coupling	2
-117	M31300603450	Pipe, oil feed	1
-118	C.200628	Fitting, lubricator sight glass	1
-119	98156-1665	Banjo assy.	1
-119A	98156-1687	Nut	1
-119B	98156-1709	Sleeve, tube	1
-120	--	Not Used	
-121	98262-1039	Pipe, oil and filter	1
-122	98156-1559	Union	1
-123	98658-1161	Valve, 3rd stage, inlet-discharge (See Fig. 5-6)	1
-124	D.100171-892	Stud	6
-125	95111-0005	Nut	6
-126	95148-0014	Washer	6
-127	98156-1604	Elbow, swivel nut	1
-128	C.200545	Liner, 3rd stage	1
-128A	C.200544	Plunger, 3rd stage	1
-128B	95602-0018	O-ring, liner, 3rd stage	3
-129	C.200546	Ring, cooler, 3rd stage	1
-130	D.100162	Cylinder, 3rd stage	1
-131	98504-1029	O-ring, crosshead, 3rd stage	1
-132	D.100161	Guide, crosshead, 3rd stage	1
-133	98502-1015	Gasket, crosshead, 3rd stage	1
-134	95438-1001	Crosshead, 3rd stage	1
-134A	NSP	Pin, wrist, 3rd stage	1
-134B	NSP	Ring, retainer	2
-135	--	Not Used	
-136	--	Not Used	
-137	96072-0029	Bearing, wrist pin, 3rd stage	1
-138	C.200535	Rod, connecting, 3rd stage	1
-139	98076-1021	Bearing, crankpin, 3rd stage	1
-140	98076-1024	Bearing, crankpin, inner ring	1
-141	D.100171-886	Stud	4
-142	95111-0005	Nut	4
-143	95148-0014	Washer	4

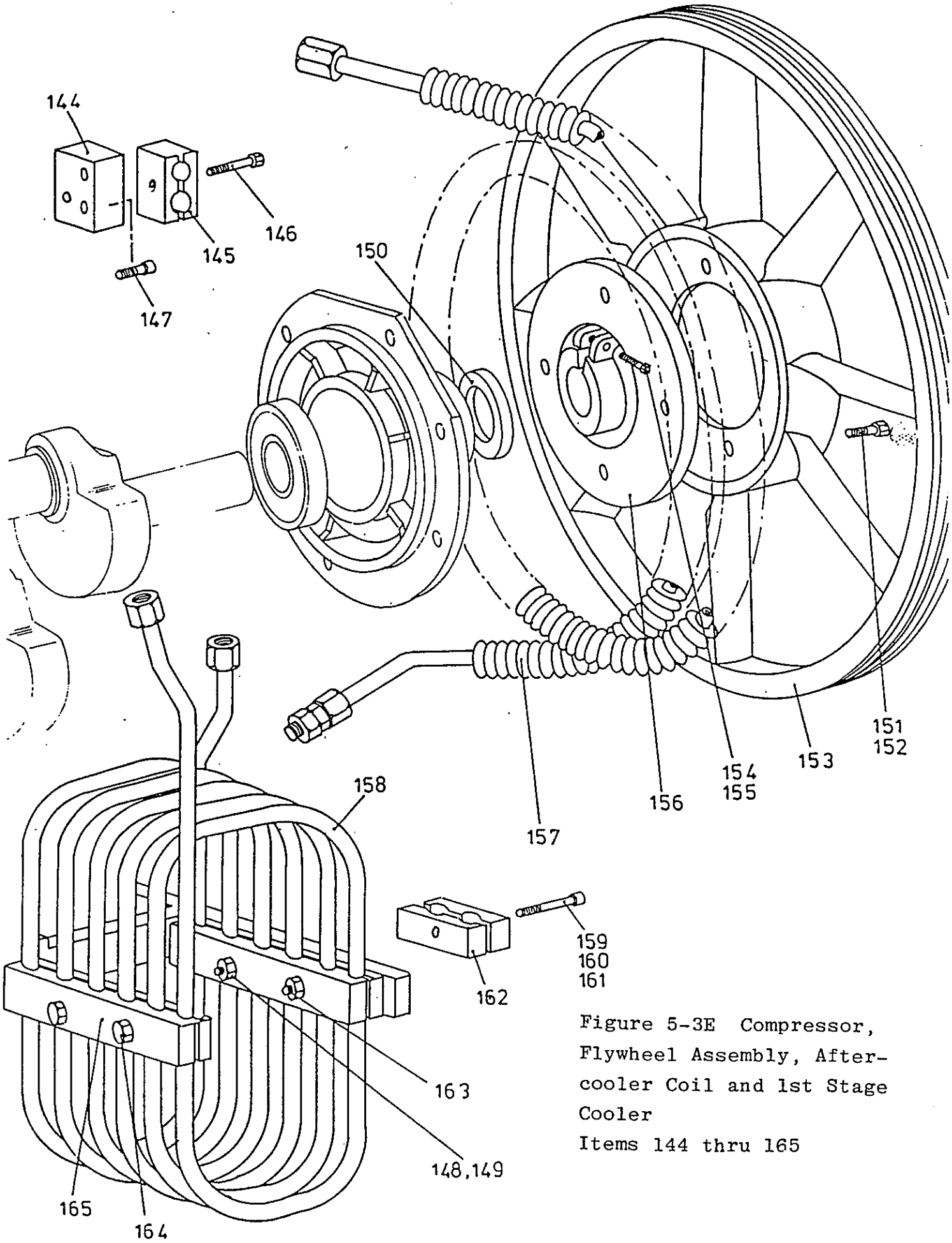


Figure 5-3E Compressor, Flywheel Assembly, After-cooler Coil and 1st Stage Cooler
Items 144 thru 165

Fig. & Item No.	Part Number	Description	Qty/ Assy.
5-3-E	NSP	Flywheel Assy, Aftercooler Coil & First Stage Cooler	1
-144	C.200589	Pad, cooler clip	1
-145	C.200587	Clip, aftercooler	6
-146	95000-0233	Screw, hex head	3
-147	95018-0167	Screw, socket head	2
-148	95111-0004	Nut	8
-149	95148-0013	Washer	16
-150	95605-0057	Seal, crankshaft	1
-151	95018-0200	Screw, socket head	4
-152	95179-0006	Washer, spring	4
-153	E.60179	Flywheel, fan	1
-154	95018-0204	Screw, socket head	1
-155	95179-0006	Washer, spring	1
-156	C.200577	Hub, flywheel	1
-157	E.60193	Coil, aftercooler	1
-158	E.60187	Coil, cooler, lst stage	1
-159	95006-0131	Bolt, hex head	2
-160	95111-0004	Nut	2
-161	95148-0013	Washer	2
-162	C.200586	Clamp, pipe, cooler	6
-163	95000-0234	Screw, hex head	2
-164	95000-0231	Screw, hex head	5
-165	C.200576	Clamp, pipe, cooler	8

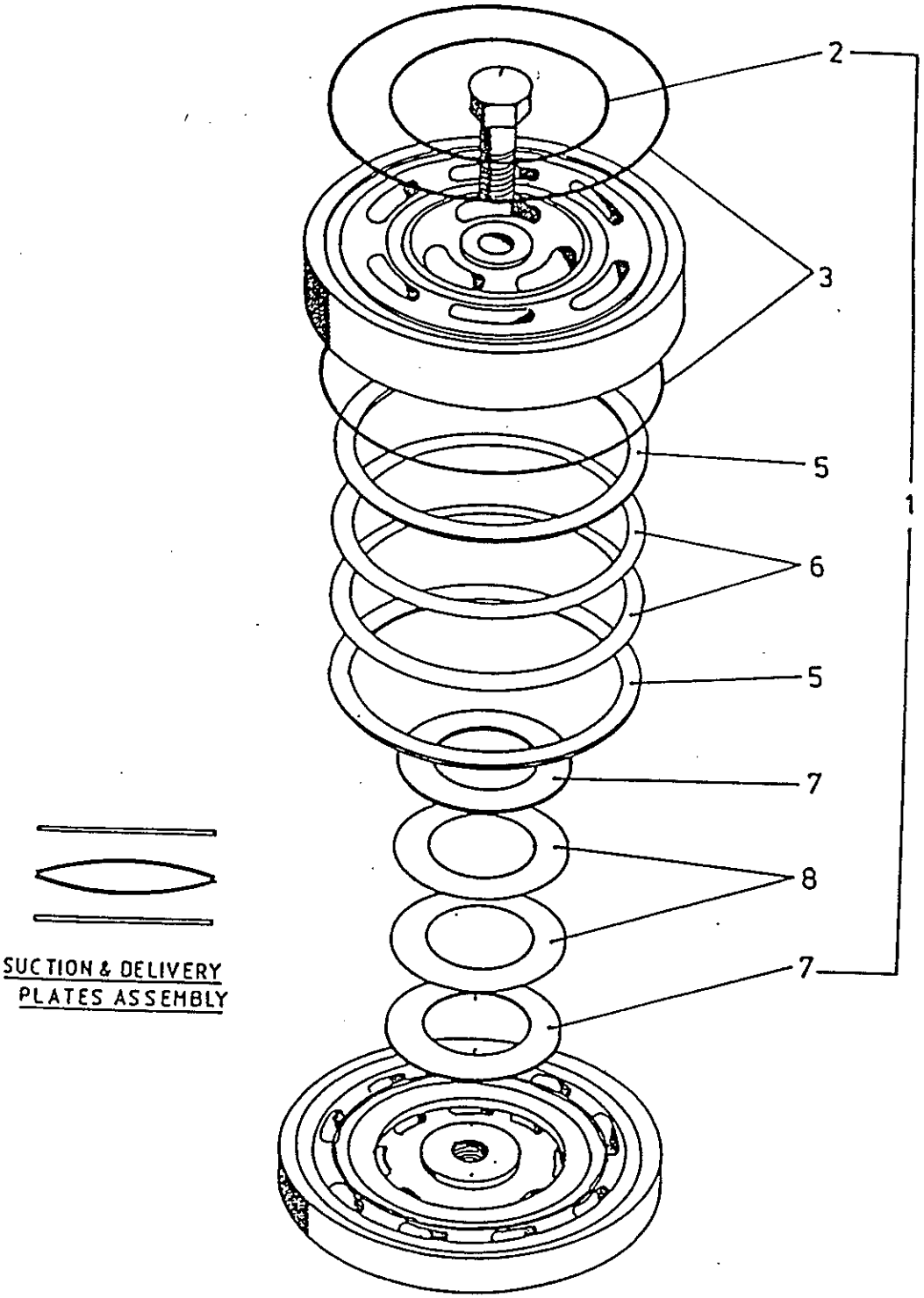
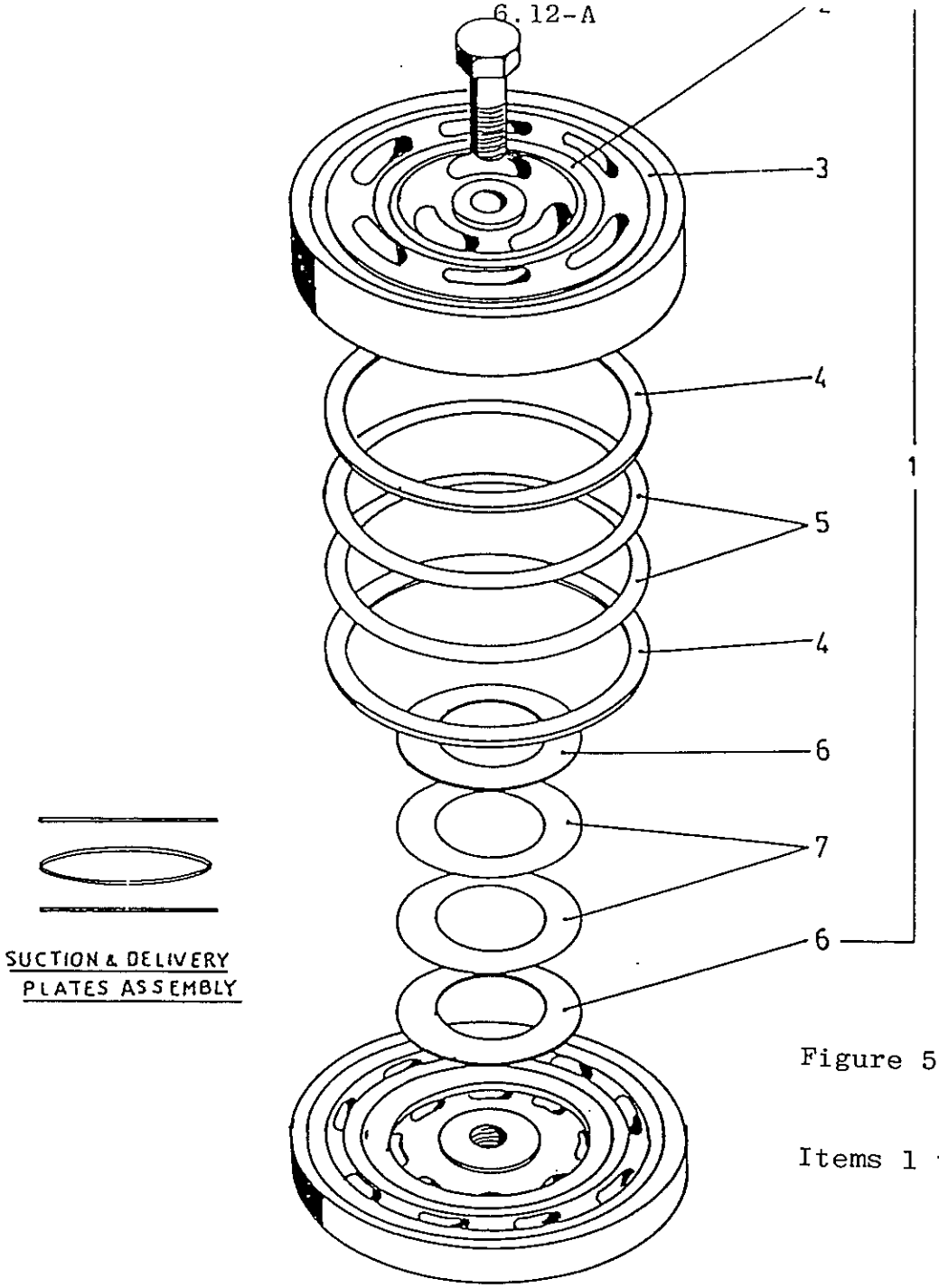


Figure 5-4 Valve, 1st Stage, Inlet-Dischrge K-7
Items 1 thru 8

Fig. & Item No.	Part Number	Description	Qty/ Assy.
5-4	98650-1159	Valve, First stage, inlet-discharge (See Fig. 5-3-58 for NHA)	Ref
- 1	--	Not Used	
- 2	95602-0059	O-ring, Viton	1
- 3	95602-0090	O-ring, Viton	2
- 4	--	Not Used	
- 5	98650-1224	Plate, valve	2
- 6	98650-1223	Ring, valve spring	2
- 7	98650-1226	Plate, valve	2
- 8	98650-1225	Ring, valve spring	2



SUCTION & DELIVERY PLATES ASSEMBLY

Figure 5-4A 1st Stage Valve K-51

Items 1 thru 7

ITEM NO.	DESCRIPTION	QTY	PART NUMBER
1	VALVE COMPLETE	1	98650/1158
2	'O'RING - VITON	1	95602/0050
3	'O'RING - VITON	1	95602/0085
4	SPRING PLATE	2	98650/1203
5	BACKING/VALVE PLATE	2	98650/1204
6	SPRING PLATE	2	98650/1205
7	BACKING/VALVE PLATE	2	98650/1206

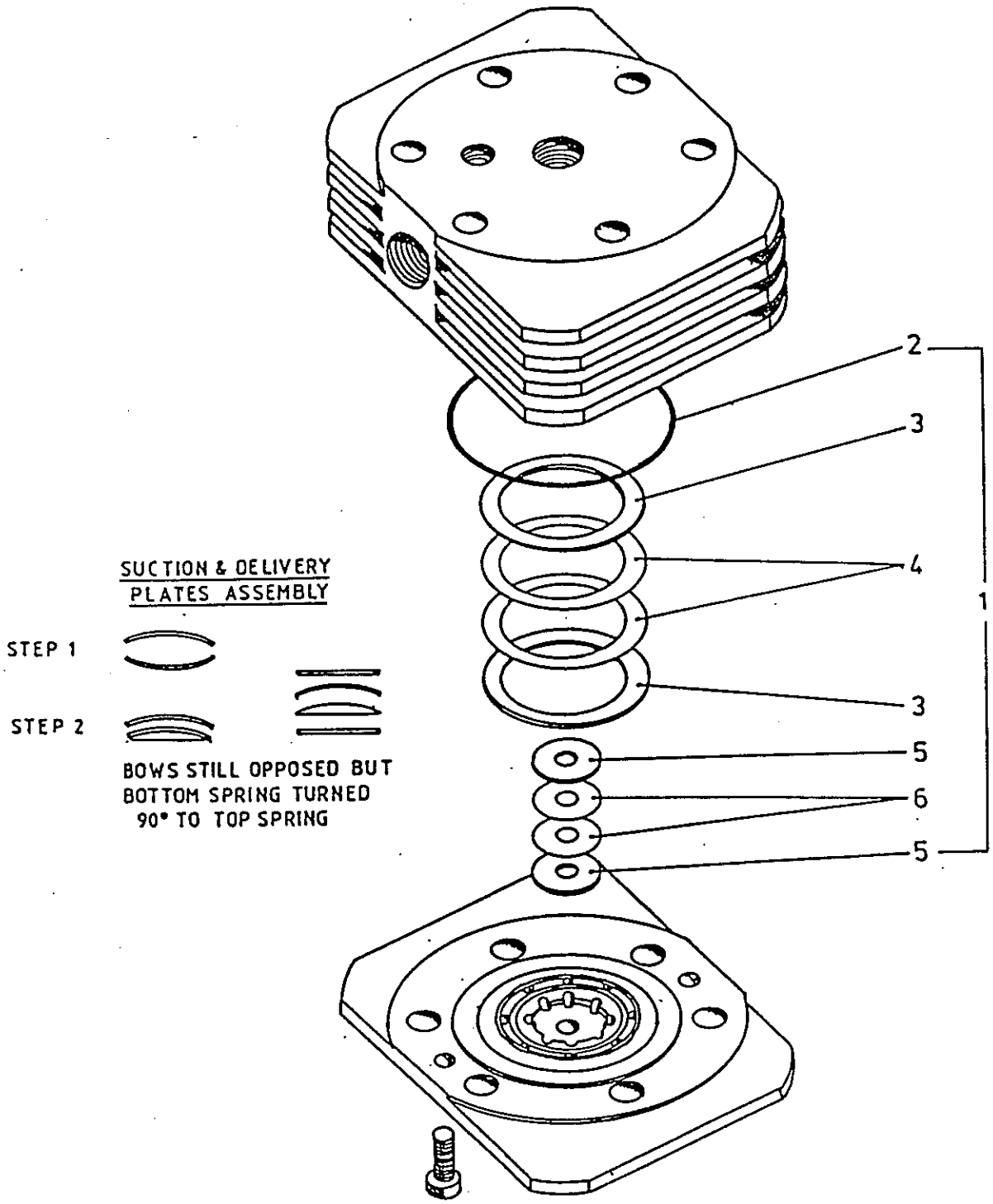


Figure 5-5 Valve, 2nd Stage, Inlet-Discharge
Items 2 thru 6

Fig. & Item No.	Part Number	Description	Qty/ Assy.
5-5	98650-1160	Valve, Second stage, inlet-discharge (See Fig. 5-3-90 for NHA)	Ref
- 1	---	Not Used	
- 2	95602-0054	O-ring	1
- 3	98650-1211	Plate, valve	2
- 4	98650-1212	Ring, valve spring	2
- 5	98650-1213	Plate, valve	2
- 6	98650-1214	Ring, valve spring	2

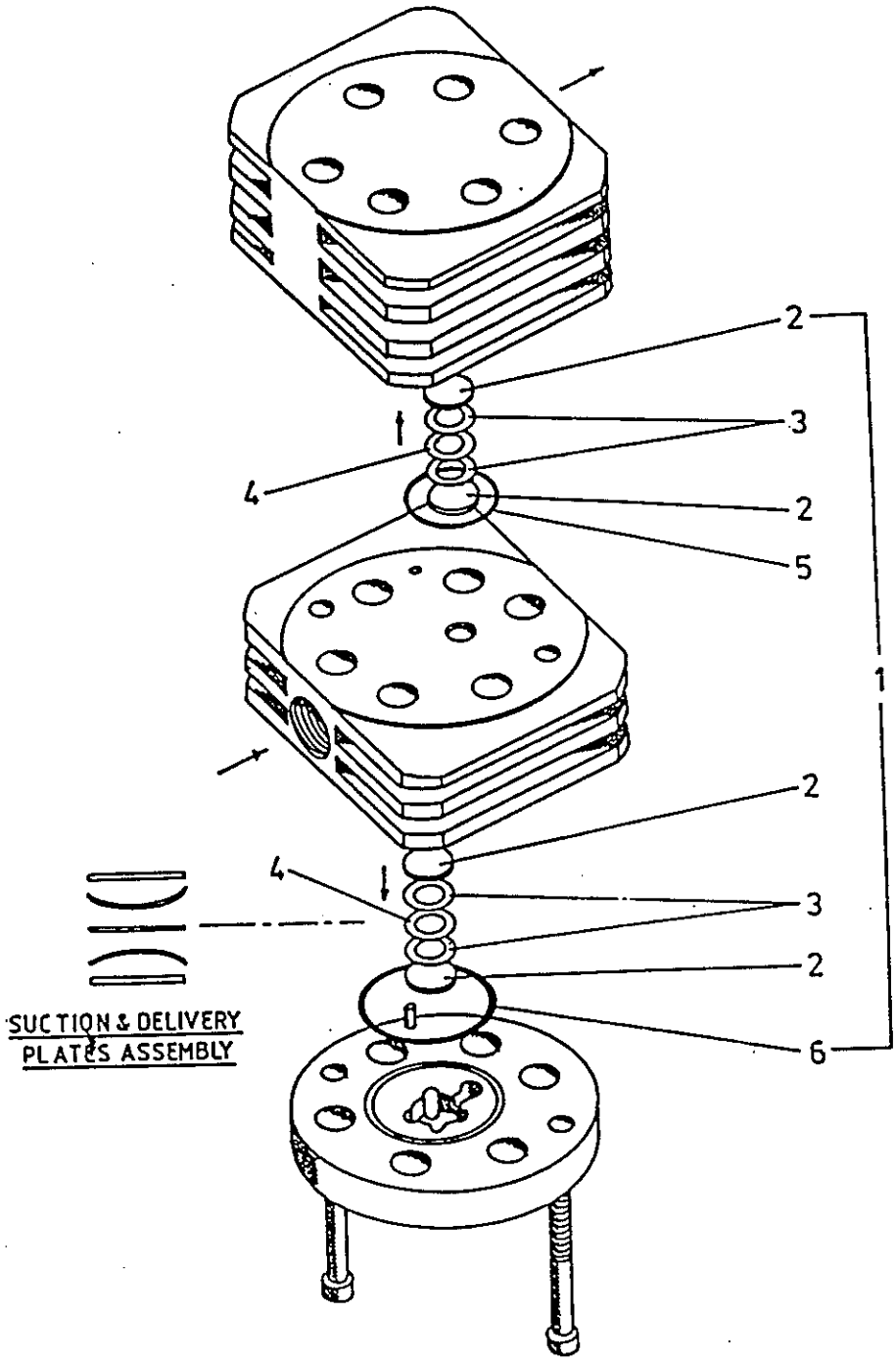
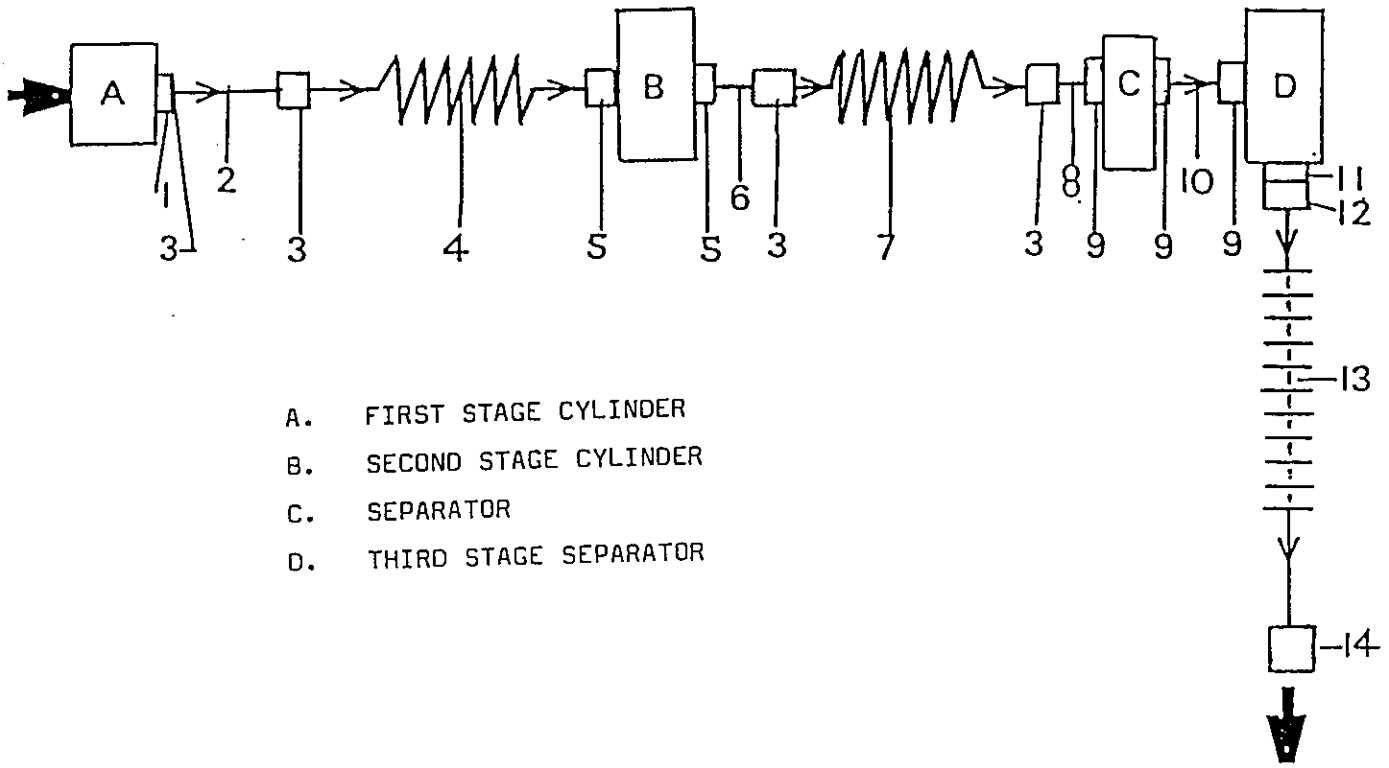


Figure 5-6 Valve, 3rd Stage, Inlet-Discharge
Items 2 thru 6

Fig. & Item No.	Part Number	Description	Qty/ Assy.
5-6	98650-1161	Valve, Third stage, inlet-discharge (See Fig. 5-3-123 for NHA)	Ref.
- 1	—	Not Used	
- 2	98650-1196	Plate, valve	4
- 3	98650-1197	Ring, valve spring	4
- 4	98650-1198	Plate, valve center	2
- 5	95602-0016	O-ring, Viton	1
- 6	95602-0018	O-ring, Viton	1

PIPEWORK AND FITTINGS

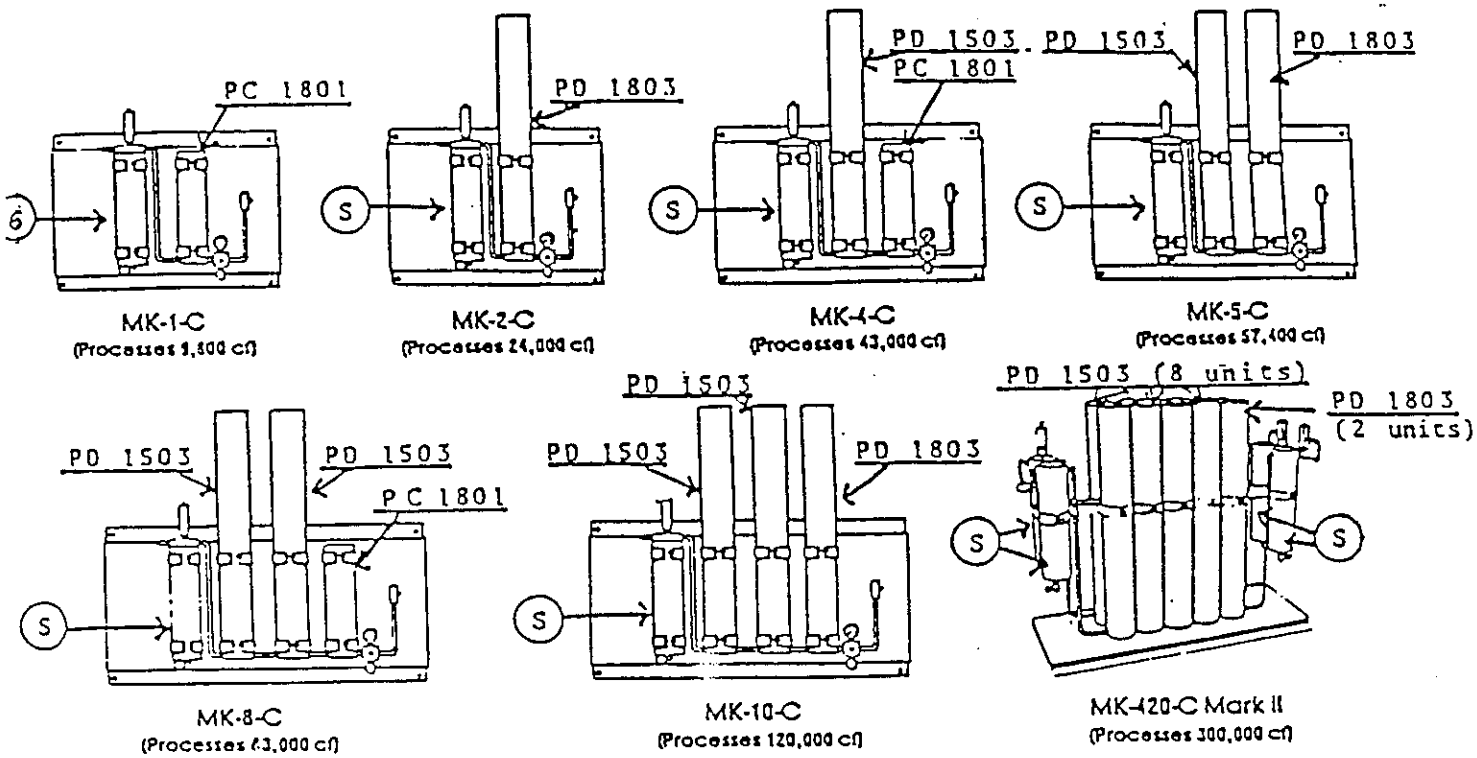


A. FIRST STAGE CYLINDER
B. SECOND STAGE CYLINDER
C. SEPARATOR
D. THIRD STAGE SEPARATOR

ITEM NO.	DESCRIPTION	PART NO. K-51	PART NO. K-7	QTY K-51	QTY K-7
1	STUD COUPLING	PS.1964/11	-	1	-
2	ALUMINIUM TUBE, Ø ½" X 14G	D.100209	E.60202	1	1
3	STRAIGHT COUPLING	98156/2552	98156/2552	3	3
4	ALUMINIUM TUBE, Ø ½" X 14G	E.60187	E.60187	1	1
5	STUD ELBOW	98156/2533	98156/2533	2	3
6	ALUMINIUM TUBE, Ø ½" X 14G	D.100203	D.100203	1	1
7	ALUMINIUM TUBE, Ø ½" X 14G	E.60188	E.60188	1	1
8	ALUMINIUM TUBE, Ø ½" X 14G	D.100207	D.100207	1	1
9	STUD COUPLING	98156/2515	98156/2515	3	3
10	ALUMINIUM TUBE, Ø ½" X 14G	D.100208	D.100208	1	1
11	MALE CONNECTOR BODY	98156/1574	98156/1574	1	1
12	SWIVEL NUT ELBOW	98156/1604	98156/1604	1	1
13	THIRD STAGE COIL	E.60193	E.60193	1	1
14	UNION	98156/1559	98156/1559	1	1

THE MAKO PURIFICATION SYSTEM

THE MAKO PURIFICATION SYSTEM



NOTE: The MK-200-C (not shown) processes 9800 cuf.

Shown above are the standard models of the Mako purification system.

Air (or other gas), upon leaving the compressor, enters the "Final Separator" which eliminates most oil and water vapor. The separator is designated by the letter "S" in drawings.

The air or gas then passes through one or more "Dryer Chambers" with removable cartridges; the part numbers PC 0000 and PD 0000 show the cartridge to be used in each chamber for the removal of the balance of oil and water vapor.

Cartridges must be inspected periodically at intervals as determined by usage and ambient conditions of temperature and moisture. Replace cartridge immediately when inspection indicates it has lost it's efficiency through age or saturation.

Detailed information on the final separator and dryer chamber with instructions for changing cartridges are shown in the following pages.

After leaving the purification system, the air or gas enters the "Storage System" and/or the "Fill Station".

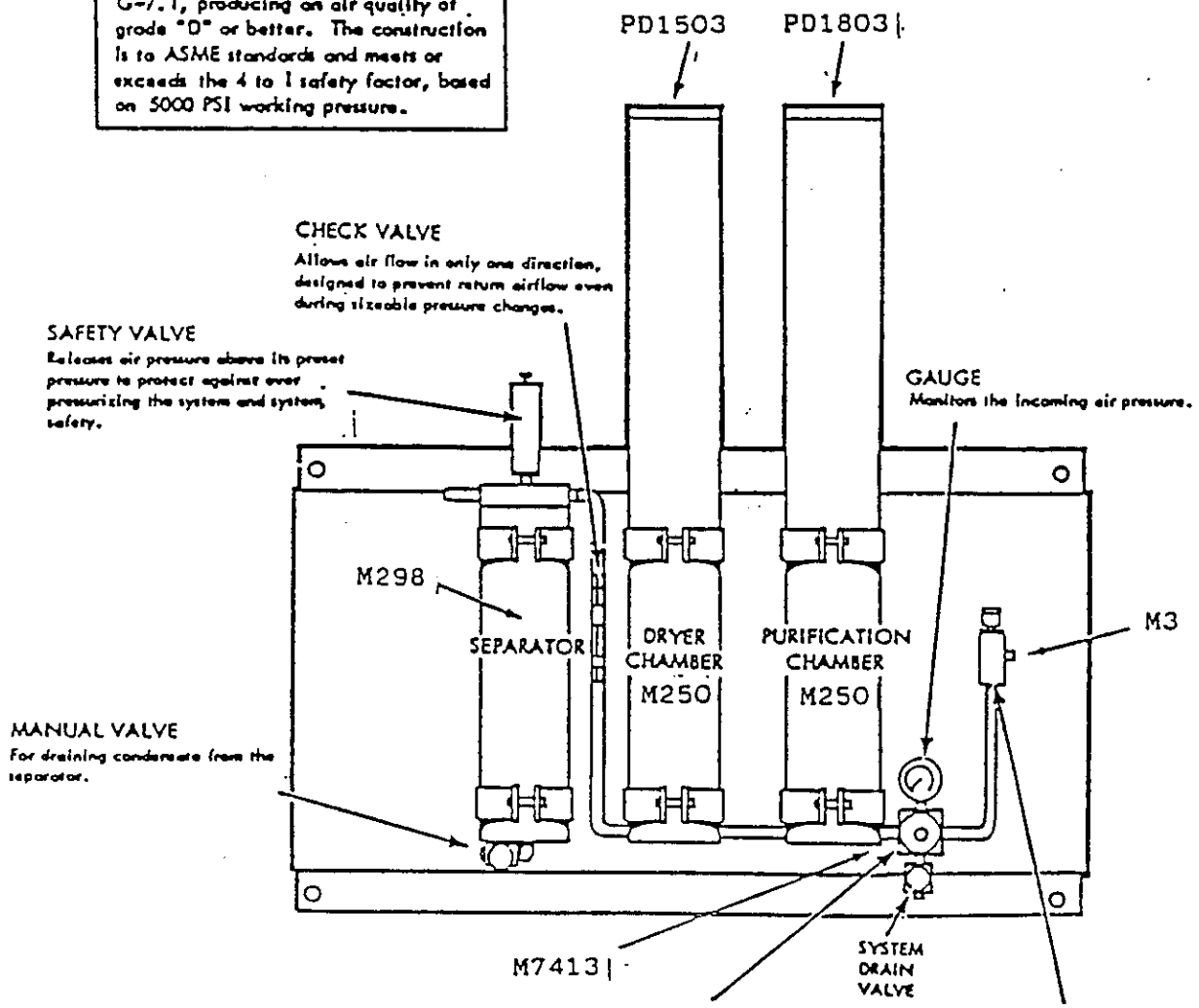
The systems illustrated are designed for the processing of breathing air requiring the highest degree of purification.

In processing other gases where purification is not so critical, the system may be simplified by minimizing the number of dryer chambers

From the diagram you see a complete MK-5-C and its added components.

Other optional accessories are available to provide maximum flexibility in any system you may choose. Visual moisture/CO indicator can be mounted on top of final purifier.

Mako purification systems meet the standards of the Compressed Gas Association (CGA) specification G-7.1, producing an air quality of grade "D" or better. The construction is to ASME standards and meets or exceeds the 4 to 1 safety factor, based on 5000 PSI working pressure.



NOTE: The above drawing shows a wall mounted system. The location of the Moisture/CO indicator on vertical mounted units and details of it's operation are shown in succeeding pages.

FINAL SEPARATOR

REF. C-21-138

OPERATING INSTRUCTIONS:
For Type M298 Condensate Separator
Design Pressure: 5000 PSI

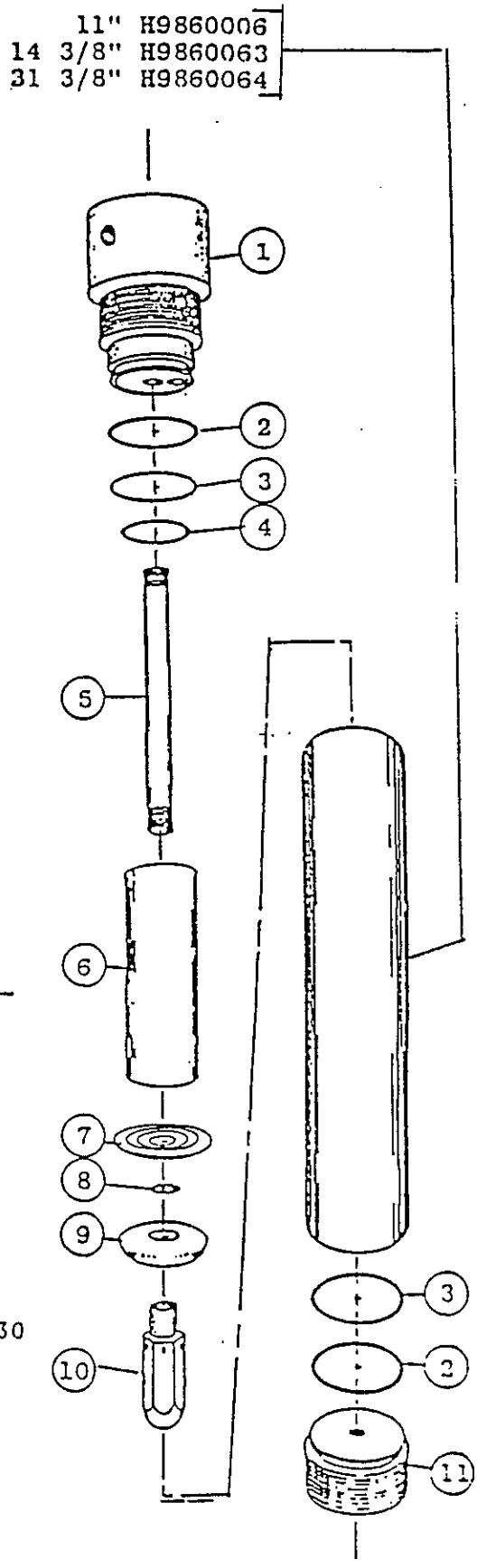
This device will mechanically separate liquid condensate from the air stream. It is most effective when operated at a pressure of more than 1500 PSI and must be drained at least once each hour of compressor operation. After processing 100,000 cubic feet of air, the M298 should be dismantled, cleaned and inspected to determine a regular cleaning schedule.

Recommended Cleaning Method:

1. Be certain all pressure has been drained and that the air source has been electrically locked out.
2. Remove top plug.
3. Clean the sintered metal element and the cylinder body with soapy water, rinse with fresh water and blow dry.
4. Replace "O" ring, backup rings and gasket; lubricate with silicone grease. Use "Neverseez" or equivalent lubricant for threaded parts.
5. Reassemble, bubble test for leaks by pressurizing to 100 PSI, 500 PSI, 1000 PSI and to normal operating pressure.

ITEM	ORDER NUMBER	DESCRIPTION
1	L3940120	Top Plug
2	L3950004 (M305)	Backup Ring
*3	L3950005 (M301)	O-ring
4	L3940121	Rubber Washer
5	L3940047	Sintered Element
6	L3940122	Tube
7	L3940124	Deflection Plate
8	L3940125	O-ring
9	L3940126	Deflection Ring
10	L3940127	Nozzle
11	H9860014	Bottom Plug

*For Natural Gas Units, use Part No. L3940130



THE MAKO DRYER CHAMBER

The dryer chamber contains a chemical cartridge which removes moisture by absorption. This chamber must be properly maintained to obtain maximum efficiency.

In each of the models shown, at the discharge end of the system, the final chamber is equipped with a sight glass, the "Moisture/CO Indicator".

Remove the two allen head cap screws on top of the chamber to lift off the cover and expose the "Sight Glass". The glass may be cleaned with a non-detergent soap. The cover must always be replaced to protect the glass.

The indicator consists of two concentric circles chemically treated so that, under safe conditions, the inner circle, the CO (carbon monoxide) indicator, will appear yellow in color while the outer circle, the moisture indicator, will appear blue.

If there is an excess of CO, over .02 percent, the inner circle will change from yellow to dark grey.

If there is an excess of moisture, greater than 40 percent relative humidity, the outer circle will change from blue to pink.

One to four minutes of operation with contaminated air will activate the CO/Moisture indicator.

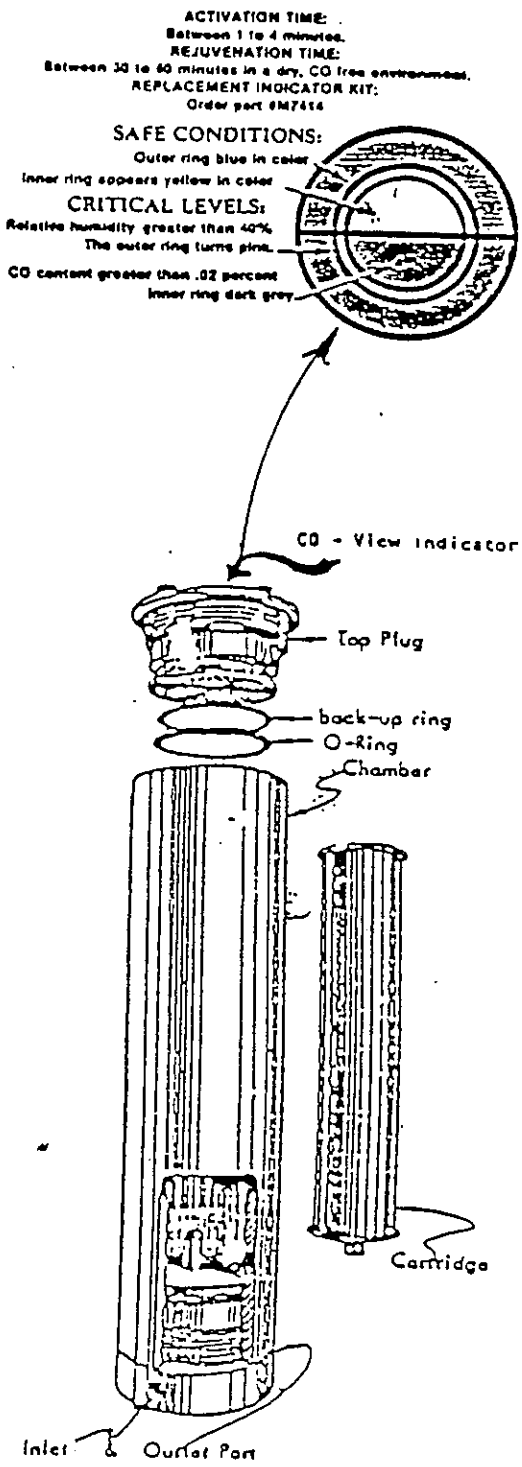
Thirty (30) to sixty (60) minutes of operation in a dry, CO free environment will restore the indicator to its original color.

The condition of the air in the system may also be tested by checking the outlet air with a CO or dewpoint monitor.

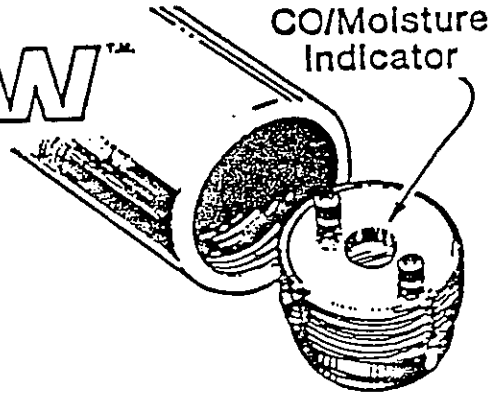
If conditions show up doubtful under either test, change the cartridge immediately.

Periodic inspection of air quality should be made at intervals as determined by usage.

ALWAYS REPLACE THE COVER, not only to protect the sight glass, but also to guard against contamination by adverse ambient conditions: humidity, exhaust fumes, etc.



COview™



Features:

Integral monitoring of moisture and Carbon Monoxide.

Interchangeable with existing Mako purification system chambers.

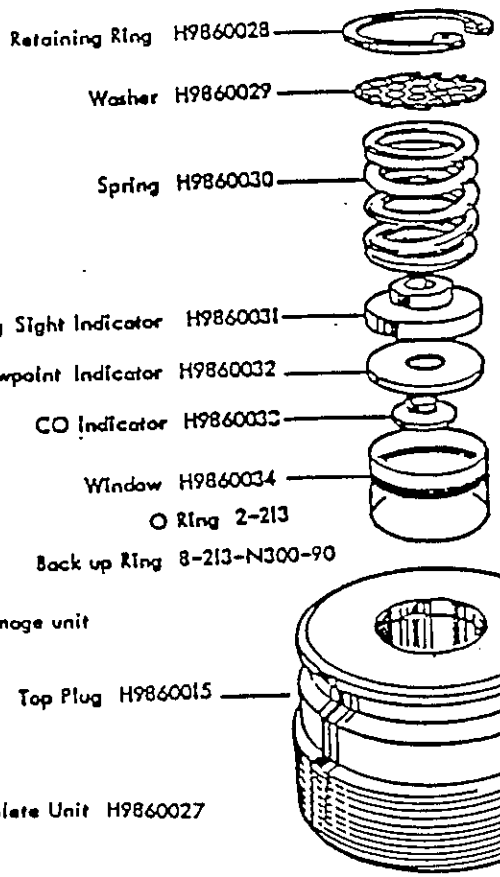
Rates at 5000 psi working pressure (20,000 psi test).

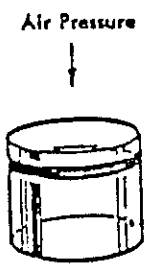
Dual air stream monitor for Carbon Monoxide (.02% threshold) and relative humidity above 40%.

Activates within 1 to 4 minutes.

Rejuvenates between 30 to 60 minutes in a pure air environment.

Replacement Indicator kit available (M7414).





NOTE.
Failure to install window properly will damage unit and could cause serious injury!

CARTRIDGE LIFE

Cartridge life may be determined by the following formula:

Maximum capacity divided by hourly output equals cartridge life.

EXAMPLE:

A K-14 compressor using a MK-1C purification system will have a maximum capacity of 9,800 cubic feet (from drawing on page)

Hourly output is 9.2 cfm (from chart, page)

9.2 x 60 = 552 cubic feet per hour.

$\frac{9800}{552}$ = 17.7 hours cartridge life

In any case, the cartridge must be changed after six (6) months regardless of usage. Cartridges have a shelf life of 6 months from the date of manufacture.

When conditions indicate the need for a cartridge change, all cartridges in the system must be replaced.

DO NOT remove cartridge from the sealed package until ready for use. Avoid contamination by handling and exposure.

INSTRUCTIONS FOR CHANGING THE CARTRIDGE

Depressurize the system and remove the top plug. Place a wrench between the two allen head cap screws on top of the dryer chamber and turn (counter clockwise).

Remove the old cartridge and inspect the inside of the pressure vessel. Clean the inside with a (clean) lint free cloth.

If oily substances are found, disassemble the entire chamber and wash all parts in hot soapy water, rinse with clean water and blow dry.

DO NOT OVER TIGHTEN

Before reassembly, the o-rings should be lubricated with silicone grease. Apply a small amount of "Never-Seeze" to the threads, then reassemble the unit.

A new cartridge should be installed with the utmost care.

After the seals are removed from the cartridge ends, lower the cartridge into the chamber.

The cartridge slides over the mating tube in the bottom plug.

Each cartridge has a new o-ring installed in the adaptor fitting.

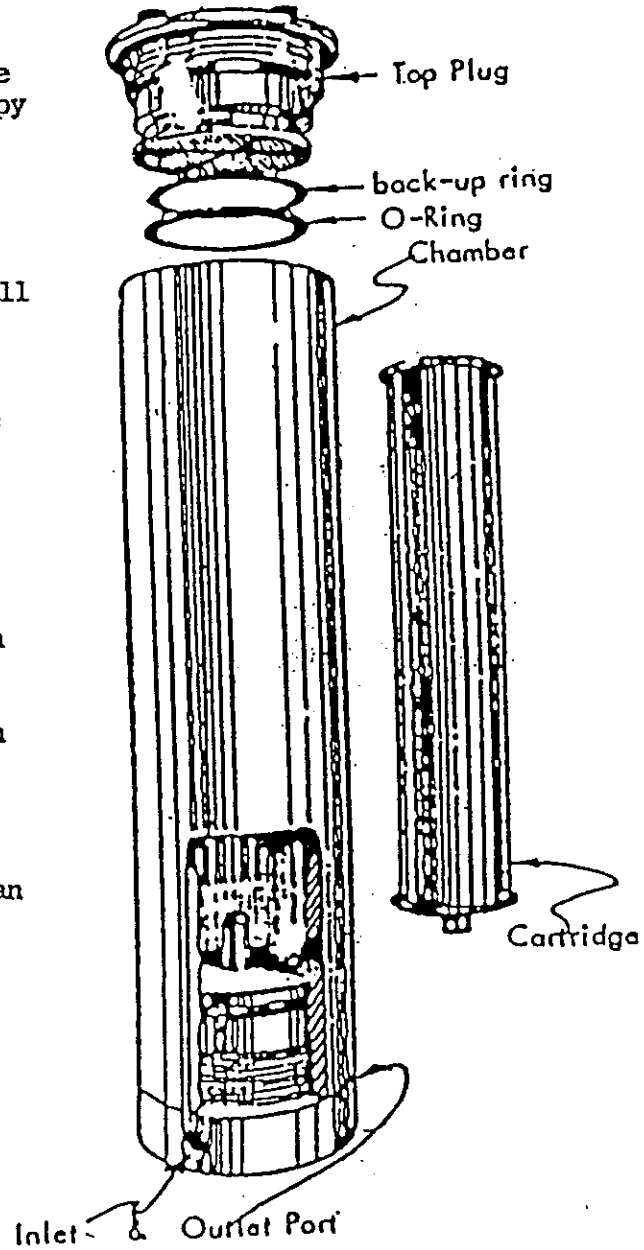
Replace the top plug, making sure that the threads engage properly. If binding is encountered, check cartridge position and clean the threads.

Pressurize SLOWLY and make leak test at 500psi, and at final pressure.

WARNING: DO NOT TIGHTEN ANY FITTINGS UNDER PRESSURE.

SEALS: Back up ring PN M305
O-ring PN M301

PORT SIZE: Inlet & Outlet 9/16-18 UNF 2B
Straight thread O-ring seal



PURUS-STANDARD 3200 PSI.
ALL OTHER MODELS - 5000 PSI.

CFM**	AIR COOLED MODEL	COMPRESSOR SYSTEMS: VERTICAL	HORIZONTAL	MAGNETIC STARTER	PRESSURE S/S	GAUGE PANEL	BELT GUARD	HIGH TEMP. SWITCH	LOW OIL PRESSURE SWITCH	FILL HOSE	HOUR METER	ELECTRIC START	AUTO DRAIN	CABINET	PURIFICATION SYSTEMS: MK-200-C	MK-1-C	MK-2-C	MK-4-C	MK-5-C	MK-10-C	MK-420-C
2.5	MAKO MINI G.		•				•★	A		•					C						
2.5	MAKO MINI E1		•				•★	A†		•					C						
3.2	PURUS G		•				•	A		•					C						
2.5	PURUS E1-2HP		•				•	A†		•					C						
3.2	PURUS E1-3HP		•	A	A►		•★	A►		A	A				•		A	B	B	B	
3.2	PURUS E3-3HP		•	A	A►		•★	A►		A	A				•		A	B	B	B	
5.0	KA-51-E1	•	A	•	•	A	•	•	A	•	A		A	A	•		A	A	A	B	
5.0	KA-51-E3	•	A	•	•	A	•	•	A	•	A		A	A	•		A	A	A	B	
5.0	KA-51-G		•			A	•	A	A*	•	A				•		B	B	B	B	
5.0	KA-51-D		•			A	•			•	A				•		B	B	B	B	
7.0	KA-7-E1	•	A	•	•	•	•	•	•	•	•		A	A		•	A	A	A	B	
7.0	KA-7-E3	•	A	•	•	•	•	•	•	•	•		A*	A		•	A	A	A	B	
7.0	KA-7-G		•		A	•	•	A	A*	•	A	A	A*			•	B	B	B	B	
7.0	KA-7-D		•		A*	•	•	A*		•	A	A	A			•	B	B	B	B	
9.2	KA-14-E1	•	A	•	•	•	•	•	•	A	•		A	A		•	A	A	A	B	
9.2	KA-14-E3	•	A	•	•	•	•	•	•	A	•		A*	A		•	A	A	A	B	
9.2	KA-14-G		•		A	•	•	A	A*	A	A		A*			•	A	A	B	B	
9.2	KA-14-D		•		A*	•	•	A*†	A*†	A	A	A	A			•	A	A	B	B	
16.0	KA-15-E3	•	A	•	•	•	•	•	•	A	•		A	A			•	A	A	B	B
16.0	KA-15-G		•		A	•	•	•	•	A	•	•	A	A			•	A	B	B	B
16.0	KA-15-D		•		A†	•	•	•†	•†	A	•	•	•				•	A	B	B	B
22.0	KA-22-E3	•	A	•	•	•	•	•	•	A	•		•	A				•	A	A	B
22.0	KA-22-G		•		•	•	•	•	•	A	•	•	•					•	A	A	B
22.0	KA-22-D		•		A†	•	•	•†	•†	A	•	•	•					•	A	A	B
26.5	KA-27-E3	•	A	•	•	•	•	•	•	A	•		•	A					•	A	B
26.5	KA-27-G		•		•	•	•	•	•	A	•	•	•						•	A	B
26.5	KA-27-D		•		A	•	•	•†	•†	A	•	•	•						•	A	B
	Cabinet Enclosed																					
9.2	4500 3 PH	•		•	•	•	•	•	•	A	•		•	•					•	A	
9.2	4500 1 PH	•		•	•	•	•	•	•	A	•		•	•					•	A	
16.0	5000 E3	•		•	•	•	•	•	•	A	•		•	•					•	A	
	Water Cooled																					
29.5	MHP-40-E3	•	A	•	•	•	•	•	•	A	•		•							•	A
29.5	MHP-40-D		•		A	•	•	†	†	A	•	•	•							•	A
77.5	MHP-95-E3		•	•	•	•	•	•	•	A	•		•								•
77.5	MHP-95-D		•		A	•	•	†	†	A	•	•	•								•

A = Available
A* = Available Only With Elec. Start 12V DC.
B = Available Wall Mt. Only
• = Std. Equipment
** = Free Air At 2800 PSI
† = Warning Lights, No Shutdown
► = Only With Magnetic Starter
★ = Direct Drive
C = Mini Purification Std.
G = Gasoline Engine
D = Diesel Engine
E1 = Single Phase Electric Motor
E3 = Three-Phase Electric Motor

MAKO PURIFICATION STANDARDS

The figures in this table are for air after compression. Therefore, it is necessary to provide a means of removing unwanted components from the compressed air.

MAKO's Air System will process air to the following standards:

COMPONENT	WITH CO-REMOVAL	WITHOUT CO-REMOVAL
OXYGEN: (O2) By volume	Negligible Effect	No Effect
CARBON DIOXIDE: (CO_2) By volume	Less than 200 ppm	Less than 200 ppm
CARBON MONOXIDE (CO)	undetectable	Content depends on air being processed.
OIL VAPORS	Less than 5 Mg/M3	Less than 5 Mg/M3
ODORS	NONE	NONE
PARTICULATES & SOLIDS	NONE	NONE
DEW POINT	-105F	-105F
NOXIOUS GASES: (Nitrogen Oxides, Sulfur compounds, etc.)	Less than 1 ppm/w	Less than 1 ppm/w

AIR TECHNICAL DATA

AIR TECHNICAL DATA

The air we breathe is a combination of gases and is sometimes contaminated by foreign substances. Air purification (necessary when compressing air for breathing purposes) is even more important. In its cleanest form air contains 11 different gases; two, Nitrogen and Oxygen are critical to the human respiratory system. A typical sample of uncontaminated air will contain 78% Nitrogen and 21% Oxygen. The remaining nine gases represent approximately 1%.

The average person consumes, during a 24 hour period, approximately 26 cubic feet of oxygen. The weight of this oxygen is approximately equal to the weight of food consumed during the same period or about 2½ lbs. In removing oxygen from inhaled air, over 500 cubic feet of air must be breathed to obtain the 26 cubic feet of oxygen.

When oxygen drops to about 16% (by volume) the individual is said to experience anoxia. Symptoms are blurred vision, mental confusion and impaired muscular coordination. These symptoms intensify as the oxygen content is further reduced and about 11% unconsciousness results. Prolonged exposure below 11% will cause death.

The oxygen content of compressed air for human respiration should be held within narrow limits. A value of 21% provides adequate oxygen for physiological needs and is the customary standard for breathing systems, although other applications aim for standards between 19 and 25%. Oxygen content above 25% sharply increases fire and health hazards for the user.

COMPOSITION OF AIR

COMPONENT	% BY VOLUME
Nitrogen	78.0840000
Oxygen	20.9476000
Argon	0.9340000
Carbon Dioxide	0.0314000
Neon	0.0018180
Helium	0.0005240
Methane	0.0002000
Kryton	0.0001140
Hydrogen	0.0000500
Nitrous Oxide	0.0000500
Xenon	0.0000087

CONTAMINANTS

Contaminants can be grouped into two categories:

1. Those that ultimately cause a disease of lung tissue or damage to any part of the lungs.

2. Those which have no direct effect upon the lungs but pass into the bloodstream either impairing the oxygen carrying capacity of the red blood cells or being carried to other parts of the body with direct toxic effect upon other tissues.

DEFINITIONS

AEROSOLS are microscopic particles or liquid droplets dispensed in air. They are so small that they remain in the air for extended periods. Larger particles will usually be filtered out before entering the lungs. Smaller particles enter the respiratory tract and will be deposited in the lungs, sometimes in large quantities. The aerosols not expelled during the breathing process will form deposits with harmful effects on the body such as lung disease.

The aerosols which contain oil are especially dangerous. Refined petroleum oils behave in the lungs as a neutral foreign body. If the inhaled concentration of these oils is sufficiently high or prolonged, lung damage and lipoid pneumonia may result.

CARBON MONOXIDE is the deadliest of the toxic gases even in small amounts. This gas is colorless and odorless and therefore undetectable without instrumentation. When inhaled, it quickly passes into the bloodstream, combining with the momoglobin in the red blood cells resulting in oxygen starvation. Depending upon the concentration and duration of the exposure, the effect of carbon monoxide will vary from headaches to unconsciousness and ultimately death.

CARBON DIOXIDE is also a toxic gas, but it can be tolerated in much higher concentrations without ill effects. The concentration of this gas in air is normally 300 PPM. The maximum allowable concentration is 300 to 1000 PPM by volume per U.S. standards. Increasing carbon dioxide stimulates the respiratory system leading to an increased rate and depth of breathing, causing the intake of other contaminants.

MOISTURE CONTENT: A high moisture content in compressed air interferes with control mechanisms, causes corrosion and can cause orifices to freeze. Other natural air components have no apparent physiological effects upon the user or systems.

TOXIC EFFECTS OF CARBON MONOXIDE ON THE HUMAN BODY

Effect of Carbon Monoxide on the Human Body
(Toxic symptoms developed by a stationary person exposed to Carbon Monoxide.)

Concentration of CO in air	Inhalation time and toxic symptoms developed:
0.02% (200 ppm)	Slight headaches within 1-3 hours.
0.04% (400 ppm)	Frontal headache within 1-2 hours becoming widespread in 2.5 to 3.5 hours.
0.08% (800 ppm)	Dizziness, nausea and convulsions within 45 minutes. Insensible within 2 hours.
0.16% (1,600 ppm)	Headache, dizziness and nausea within 20 minutes. Death within 2 hours.
0.32% (3,200 ppm)	Headache, dizziness and nausea within 5-10 minutes. Death within 30 minutes.
0.64% (6,400 ppm)	Headache, dizziness in 1-2 minutes. Death in 10-15 minutes.
1.28% (12,800 ppm)	Death in 1-3 minutes.

TOXIC EFFECT OF VARIOUS CONTAMINANTS

Effect	Fatal concentration if inhaled for 5-10 minutes.		Acute poisoning if inhaled for 30-60 minutes.		Temporary discomfort if inhaled for 30-60 minutes.	
Toxic Gas	mg/	ppm or cc/m^3	mg/	ppm or cc/m^3	mg/	ppm or cc/m^3
Chlorine	0.7	500	0.07	50	0.007	5.0
Hydrogen Chloride	4.5	3,000	1.5	1,000	0.15	100
Hydrogen Sulfide	1.2	800	0.6	400	0.3	200
Sulfurour Acid	8.0	3,000	1.2	400	0.3	100
Ammonia	3.0	5,000	1.5	2,500	0.15	250
Hydrogen Phosphide	1.4	1,000	0.6	400	0.15	100
Hydrogen Arsenide	1.0	300	0.2	60	0.06	20
Carbon Monoxide	6.0	5,000	2.4	2,000	1.2	1,000
Carbon Dioxide	165	90,000	90	30,000	55	30,000
Phosgene	0.2	50	0.1	25	0.004	1.0
Benzene	65	20,000	25	7,500	10	3,000
Chloroform	125	25,000	75	15,000	25	5,000
Carbon Tetrachloride	350	50,000	175	25,000	70	10,000
Carbon Disulfide	6.0	2,000	3.0	1,000	1.5	500
Hydrogen Cyanide	0.2	200	0.1	100	0.05	50
Benzine	120	30,000	80	20,000	60	15,000
Acetylene	550	500,000	275	250,000	110	100,000
Ethylene	110.0	950,000	920	800,000	575	500,000

To protect human life limits have been established for breathing air quality. Air suitable for human respiration must meet minimum standards as established by various governing bodies, including the U.S. Navy, Compressed Gas Association, The Federal Government and the State of California.

The standards cited below are usually referred to as "Grade D", in reference to The Compressed Gas Association Table #1. These standards apply to compressed air for use in filling open circuit breathing systems.

All standards reviewed define minimum acceptable standards. An increase in any component is reason to reject that air as unsuitable for breathing purposes.

WORLD AIR STANDARDS

COMPONENT	U.S. FEDERAL II-C	U.S. NAVY	OSHA	U.S.C.G.A.	CALIFORNIA	GERMANY 200	SWEDEN	ENGLAND	MAKO AIR SYSTEMS WITH CO REMOVAL
Oxygen O_2	20-22%	20-22%	19-20%	19-23%	19-21%	20	STD's	BS 400+ Bart .2	note 1
Carbon Dioxide CO_2	0.10%Max. 1000 ppm	0.05%Max 500 ppm	300 ppm	0.10%Max 1000 ppm	300 ppm	4000ppm		500 ppm	Less than 200 ppm
Carbon Monoxide CO	10ppm	20ppm	10 ppm	20 ppm	10 ppm	80ppm	30ppm	10 ppm	un-detectable
Water H_2O	SAT.	SAT.	70 ppm	1 Mg/M3	70 ppm	50 Mg/M3	50 Mg/M3	.5°C	-105F
Dewpoint									-105F
Oil Vapor Hydrocarbons	.005Mg/L	5Mg/M3		1Mg/M3			5Mg/M3	1Mg/M3	Less than 5Mg/M3
Odors		NONE							NONE

note 1 - Oxygen is not affected by MAKO systems. Content depends on air being processed.