

# Fuller

Rotary Compressor

**Installation/Operation/Maintenance Manual**

Compliments Of



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# CENTRAL ICE MACHINE COMPANY Refrigeration Supplies

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## WARRANTY

Freezing Equipment Sales, Inc. guarantees that equipment will be free of defects in workmanship and material for one year from date of shipment, providing:

1. Equipment is properly installed, and operated under normal use, in accordance with instructions in this manual.
2. Any claims for such defects are made in writing promptly upon discovery thereof, specifying the nature of such defect. Failure to do so constitutes a waiver of such claim.
3. Part or parts are returned to us within one year of date of shipment from factory, transportation charges prepaid, and which our examination discloses to have been defective.

## LIABILITY

Warranty is limited to repair or replacement of defective parts, at our option. It does not include any labor or other charges made outside our factory for repair or replacement. This guarantee is in lieu of and supersedes any and all other warranties by law or custom, either express or implied. No person, agent or dealer is authorized to give any guarantee on our behalf or assume any other liability on our behalf in connection with our equipment.

## RETURN MATERIAL

Do not return any material without first obtaining authorization and shipping instructions from Freezing Equipment Sales, Inc. Unless these terms are complied with, we can not be responsible for disposition of return material. All transportation charges to and from the factory are to be paid by the buyer.

When a return is to be made, contact your local FES representative and request Return Material Form (RMO) covering particular items under consideration. When requesting form, buyer must furnish model and serial number of compressor, de-

scription of item and reason for request to return material.

## RECEIVING

**Inspection for Shipping Damage:** Before and after uncrating the compressor, look for damage that may have occurred in transit. Check for shortages by matching each item received with those listed on the shipping manifest. If a shortage is found, or damage has occurred, make the necessary notations on the freight bill and contact the carrier immediately. Damage or shortage should also be reported to your local FES representative.

If the equipment is not to be installed immediately, remove the crate and store in a clean dry place. Remove the rotor blades and store them in an airtight container with a moisture absorbing compound such as silica gel. Coat all machined surfaces with a rust preventive to prevent corrosion. This material should be cleaned off with a solvent before putting unit into service. Cover the inlet and discharge. Rotate the shaft every month.

## COMPONENTS

### CYLINDER

The cylinder is made of one piece close-grained cast iron with cooling jacket. Inlet and outlet openings are located on opposite sides of cylinder to avoid reversal of gas flow.

Exclusive undercut bore is a key to higher volumetric efficiency of the Fuller rotary compressor. After boring the cylinder to size, the boring bar is dropped to the point of rotor eccentricity and a second cut is taken at bottom only and at same radius as the rotor. After the bore intersections are blended, this undercut section of the cylinder is parallel to the rotor surface for approximately 30° circumference and, with close running clearance, acts as an effective seal between discharge and suction pressures.

**CYLINDER HEADS** are of one piece construction, made from same material as the cylinder. They are accurately machined and securely bolted and doweled to the cylinder to insure proper alignment.

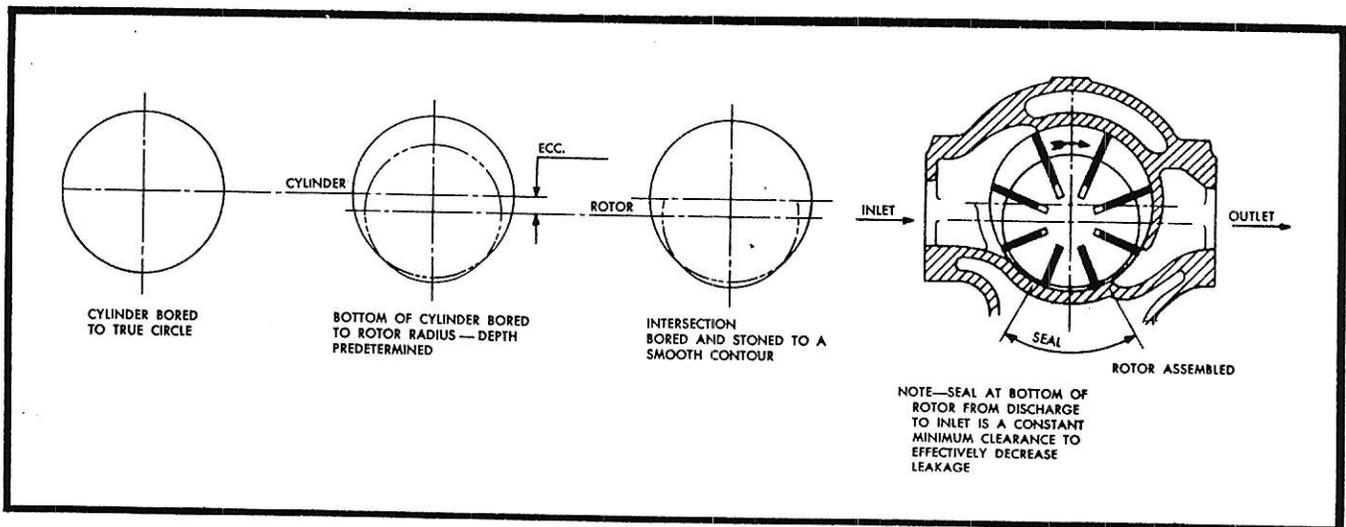


Fig. 1 Exclusive cylinder undercut.

**ROTOR AND SHAFT** are made from a single steel forging with blade slots milled along the entire rotor length. Entire surface of rotor assembly is machined or ground and polished to give a high finish.

**ROTOR BLADES** are fabricated from laminated asbestos impregnated with melamine resin. They are thoroughly heat treated,

accurately cut to size and all surfaces sanded to a smooth finish.

#### SHAFT SEAL

A double mechanical seal Fig. 2 (Ref. a) is used at point where the shaft emerges from the cylinder housing. The seal includes two identical halves forming the

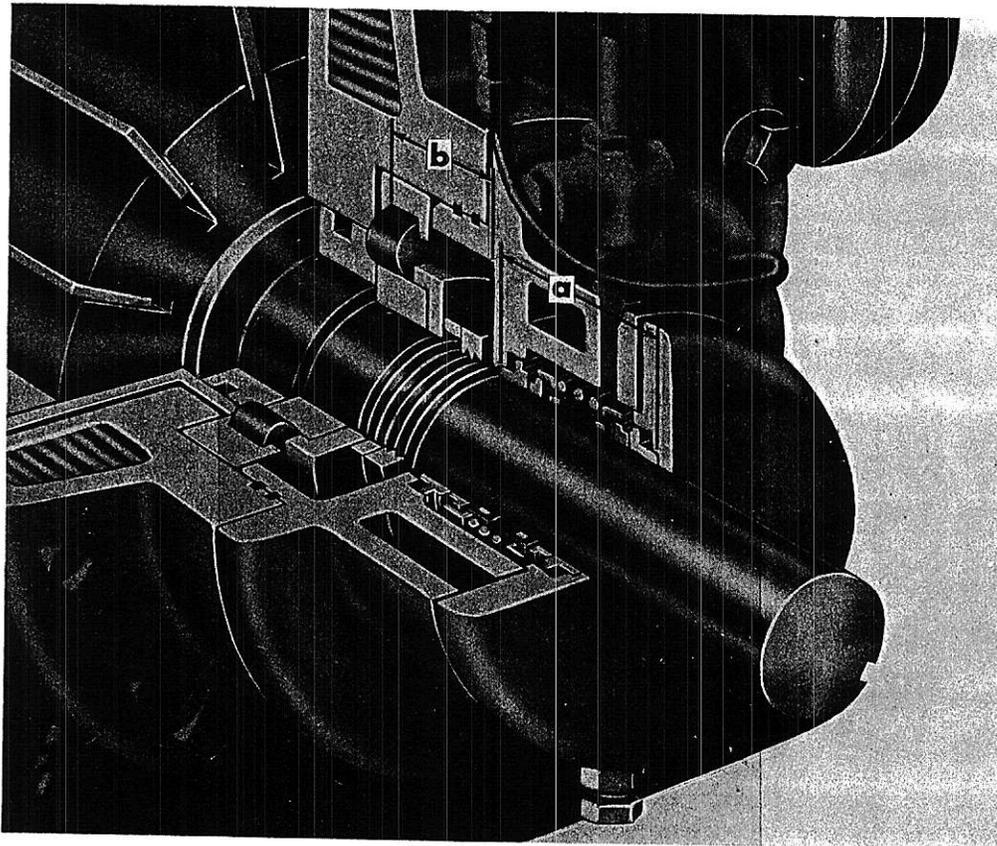


Fig. 2 Sectional view and fixed end bearing.

inner and outer seals each consisting of a rotating carbon ring and a fixed meehanite ring. Seal surfaces run in an oil bath, completely submerged and cooled by circulating jacket oil. Seal chamber area is equalized to compressor discharge to maintain it at atmospheric or positive pressure.

## LUBRICATION

Pressure lubrication is provided by a forced feed lubricator belt driven from the compressor shaft. Lubricator has individual adjustable feed for each lubrication point, and each supply line is fitted with a check valve to prevent gas flow back through the oil lines.

A special pressurized lubrication system is also available for hydrocarbon refrigerants.

## BEARINGS

High grade roller type bearings support the compressor rotor. The fixed bearing inner race, Fig. 2 (Ref. b) assembled on shaft end nearest driver, has a shoulder and separate collar to maintain position of the rotor axially. Bearing on opposite end of compressor does not include a thrust collar and allows shaft to move axially under thermal changes.

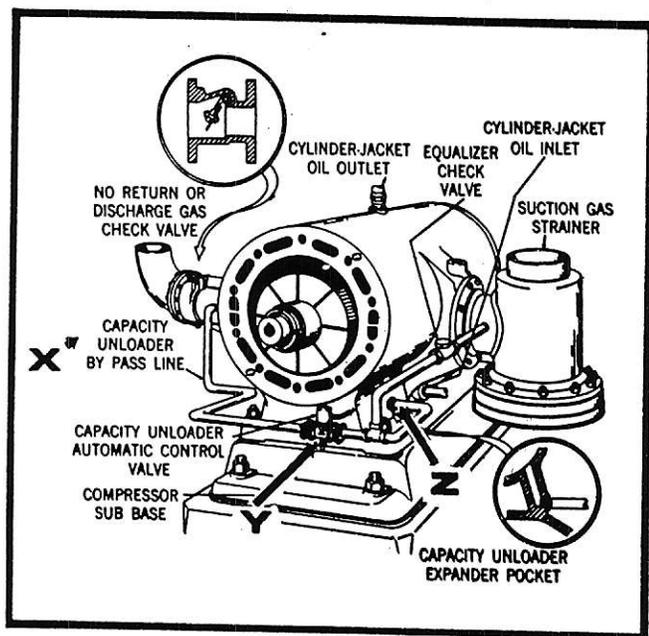


Fig. 3 Exclusive capacity unloader.

Bearings have special selected clearances and standard bearings should not be used.

## DISCHARGE CHECK VALVE

Heavy duty flapper type non-return or check valve is (Fig. 3) mounted and furnished on all compressors to automatically prevent any back flow created by discharge pressure when rotary is not running.

## CAPACITY UNLOADER

All sizes of rotary boosters can be equipped with capacity unloader. (Fig. 3) This is an exclusive FES-Fuller feature built into the rotary cylinder in the form of a gas expansion pocket which extends along the length of the cylinder barrel.

The expansion pocket is cast as an integral part of the cylinder. For this reason, it is necessary to disassemble the compressor and replace cylinder in order to install capacity unloader on an existing rotary. In operation, capacity of rotary is changed by built-in unloader which bleeds off compressed gas from discharge line (X), passes it through solenoid control valve (Y) and discharges it into capacity-unloader-expander pocket (Z). Pressure reduction in the expansion pocket actually cools by-passed gas, reducing rotary horsepower.

Capacity unloader external piping and stop valves are amply sized to prevent pressure reduction from occurring in the by-pass line. Pressure reduction from discharge to suction actually takes place in the expansion pocket which feeds by-pass gas to the rotary at a point directly below the suction gas inlet to the booster. Dissipation of pressure energy is partially converted to work energy in turning the booster rotor effecting reduced horsepower with a corresponding capacity reduction. The change in capacity and horsepower will vary as the compression ratio across the rotary changes.

The energy conversion in the expansion pocket cools the expanding gas and prevents overheating of the rotary under partial load operation. Models 135 and above include

two by-pass gas lines and solenoid stop valves to prevent pressure reduction in the by-pass piping. These larger rotaries must have both solenoid valves operated at the same time.

A vacuum-breaker check valve is also included as a part of the capacity unloader mechanism. This check valve is screwed into the base of the rotary to control gas flow from booster suction to the expansion pocket. During full capacity operation, some refrigerant gas enters the expansion pocket from main suction to break the vacuum in the expansion pocket. During unloader operation, back flow of gas from the expansion pocket to the suction strainer is prevented by the check valve.

### SAFETY CONTROLS

The need for care and maintenance of refrigeration compressors cannot be overstressed. We marvel at the ability of the modern automobile to travel 50,000 miles without a major engine overhaul.

Allowing an average speed of 35 miles per hour, the 50,000 miles represents 1430 hours of operation.

Refrigeration compressors operating 20 hours per day in a food processing plant for a period of six months represents an operating time in excess of 3600 hours--more than twice the operating time of the automobile.

When driving an automobile, we observe the danger signals: Oil pressure, speed, motor knocks, squeaks and high temperature. Your FES-Fuller booster is certainly entitled to the same safety controls, indicating thermometers, pressure gauges and attention as your automobile.

**Low Pressure Safety Control** is necessary when refrigeration load requirements are variable. High pumping efficiency of the rotary will cause suction to pull down to low vacuum under light refrigeration duty. This condition can result in high suction gas superheat and compressor overheating unless pressure safety control is installed. Be sure control is connected between compressor and suction stop valve.

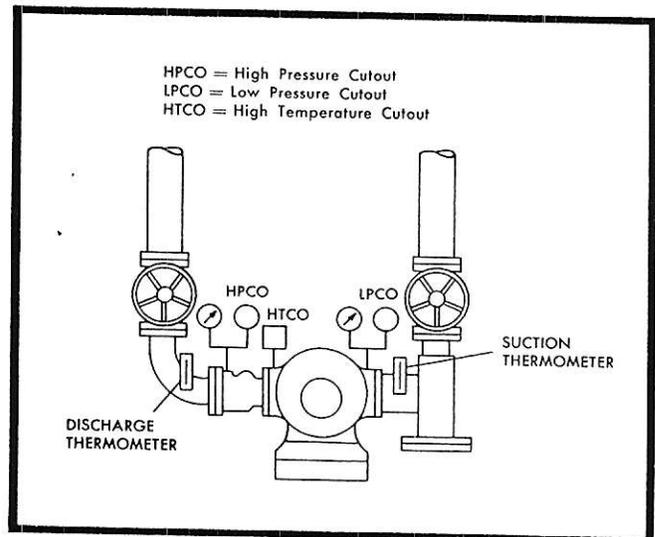


Fig. 4 Rotary safety controls.

**Discharge Pressure Safety Control** is necessary to prevent operation of rotary at pressure differential greater than 45 pounds. Be sure control is connected between compressor and discharge stop valve.

**Discharge High Temperature Cutout** is necessary to shut down booster if discharge temperature reaches 300°F. Plugged tapping on rotary discharge flange is provided for insertion of this control.

**Combination High and Low Discharge Temperature Cutout** can be furnished to shut down booster on high or low discharge temperature. Low temperature function protects compressor when liquid refrigerant is carried into the rotary.

**Indicating Instruments** essential to good maintenance of booster should consist of:

Thermometers to show suction and discharge gas temperatures; also oil temperature on inlet and outlet of oil cooler.

Pressure gauges to show suction and discharge gas pressures; also oil pressure for jacket cooling system.

### CAUTION

CHECK INSTALLATION PAGE 12 FOR PROPER LOCATION AND ADJUSTMENT OF SAFETY CONTROLS.

## SYSTEM DESIGN PRECAUTIONS

The preventative maintenance program for the booster compressor starts with the design of the refrigeration system. A few simple precautions taken at that time will go far to assure successful operation of the rotary booster when installed.

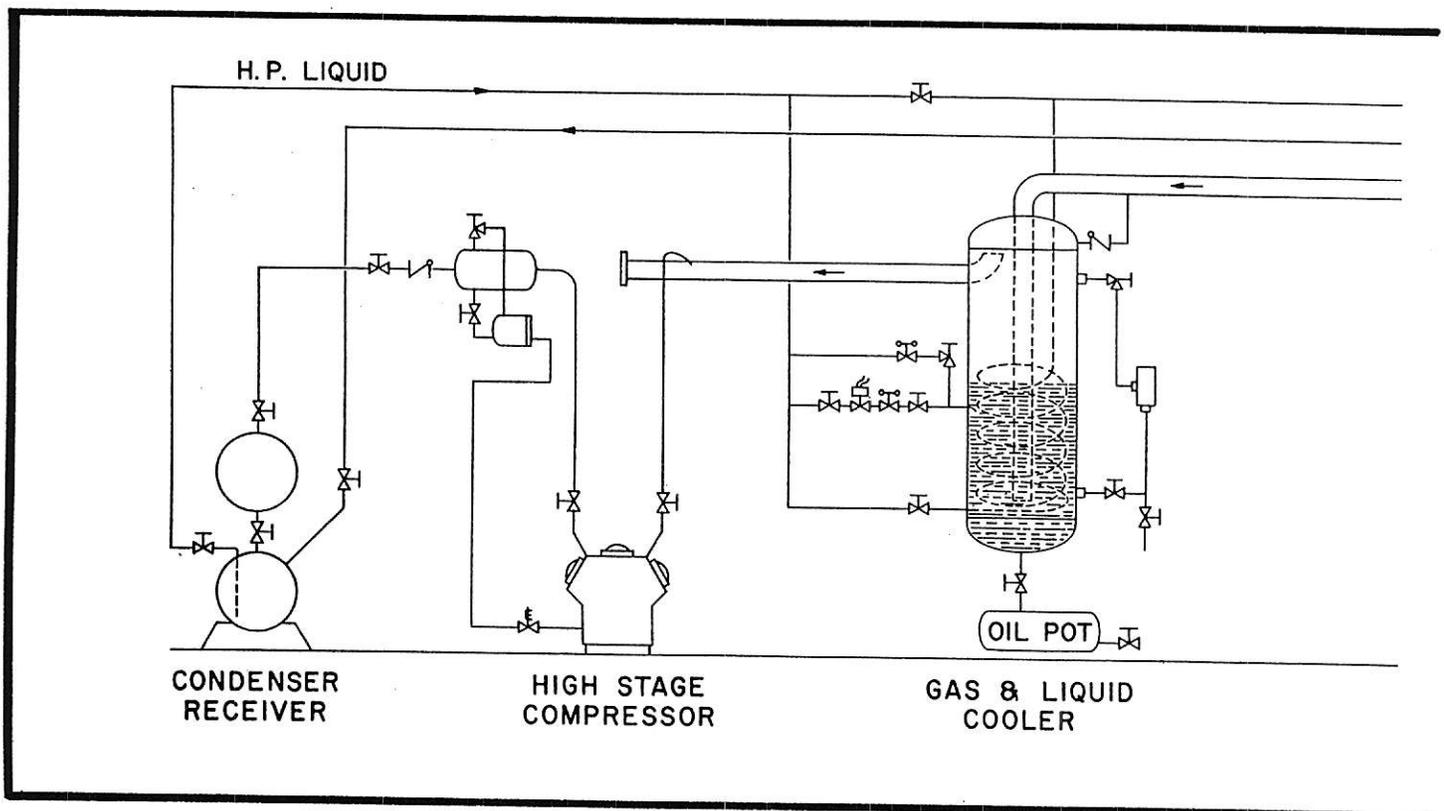
Fig. 5 is a diagram of a typical two stage ammonia system showing suction line trap, booster, inter-cooler and high stage compressor. Refrigerant gas from cooling coils is sucked through suction trap before entering rotary compressor. This trap must be large enough to prevent refrigerant liquid carry-over into the rotary under any operating condition. Carry-over of liquid into any compressor reduces its pumping capacity, destroys lubrication and eventually will result in breakdown.

In small plants, the liquid ammonia accumulation in the suction trap can be boiled off by circulating warm refrigerant liquid through a coil. In larger plants, economy of operation will justify the cost of a liquid ammonia pump or other transfer system

to return this liquid to either the low side cooling coils or the high pressure receiver for re-use.

Suction piping to the booster compressor should come off the side or top of the header, not the bottom. This will eliminate the possibility that liquid ammonia or oil traveling in the suction piping will enter the compressor in a large slug. The piping by-pass around the booster also should be arranged to prevent accumulation of liquid or oil during either single or two-stage operation. There should not be any piping traps in the suction piping.

Discharge gas from the rotary enters the inter-cooler where it passes through a reservoir of ammonia liquid. The intercooler cools the hot discharge gas before it enters the high stage compressor for the second stage of compression. The intercooler also acts as a very efficient oil separator. For this reason, it should be designed and installed to permit easy oil drainage. Since the discharge gas inlet pipe is below the liquid level in the intercooler, any gas leak from high to low pressure side of system during shut-down



may force liquid from intercooler back into the booster. This back flow is prevented by installing a small check valve between the inlet pipe and the shell with the check valve permitting gas flow out of the intercooler. Check valve is closed, when booster is operating and open when booster shuts down. The gas inlet of a horizontal intercooler must also be trapped to prevent gravity flow of liquid out of the intercooler.

Proper selection and application of rotary boosters is just as important as system design. Simplicity of the rotary limits the machine to booster applications where pressure difference across rotary does not exceed 45 psi. Operation beyond this limitation can result in blade breakage and excessive bearing loading.

**CAUTION**

HIGH PUMPING EFFICIENCY OF THE ROTARY REQUIRES CONTROLLED INTERNAL CLEARANCE AND ESTABLISHES A DISCHARGE TEMPERATURE LIMITATION OF 300°F. OPERATING BEYOND

**THIS LIMITATION WILL CAUSE DAMAGE TO INTERNAL PARTS.**

Compression ratio and suction gas superheat are factors which must be controlled to stay within pressure and discharge temperature limitations stated above.

Compression ratio (CR) is the ratio of suction and discharge pressures expressed in their absolute values (gauge pressure plus 14.7 psig). Example: - rotary pumping from zero psig to 25 psig operates at a  $CR = \frac{25 + 14.7}{0 + 14.7} = 2.7$

Lowering the suction pressure to obtain lower room temperatures or raising the discharge pressure on the rotary increases the compression ratio.

Temperature, as well as pressure, of suction gas affects booster compressor performance. Long suction lines carrying low temperature and low pressure gas are frequently found in multi-stage booster applications. The refrigerant gas in passing through these lines from cooling evaporators picks up heat -- especially when lines

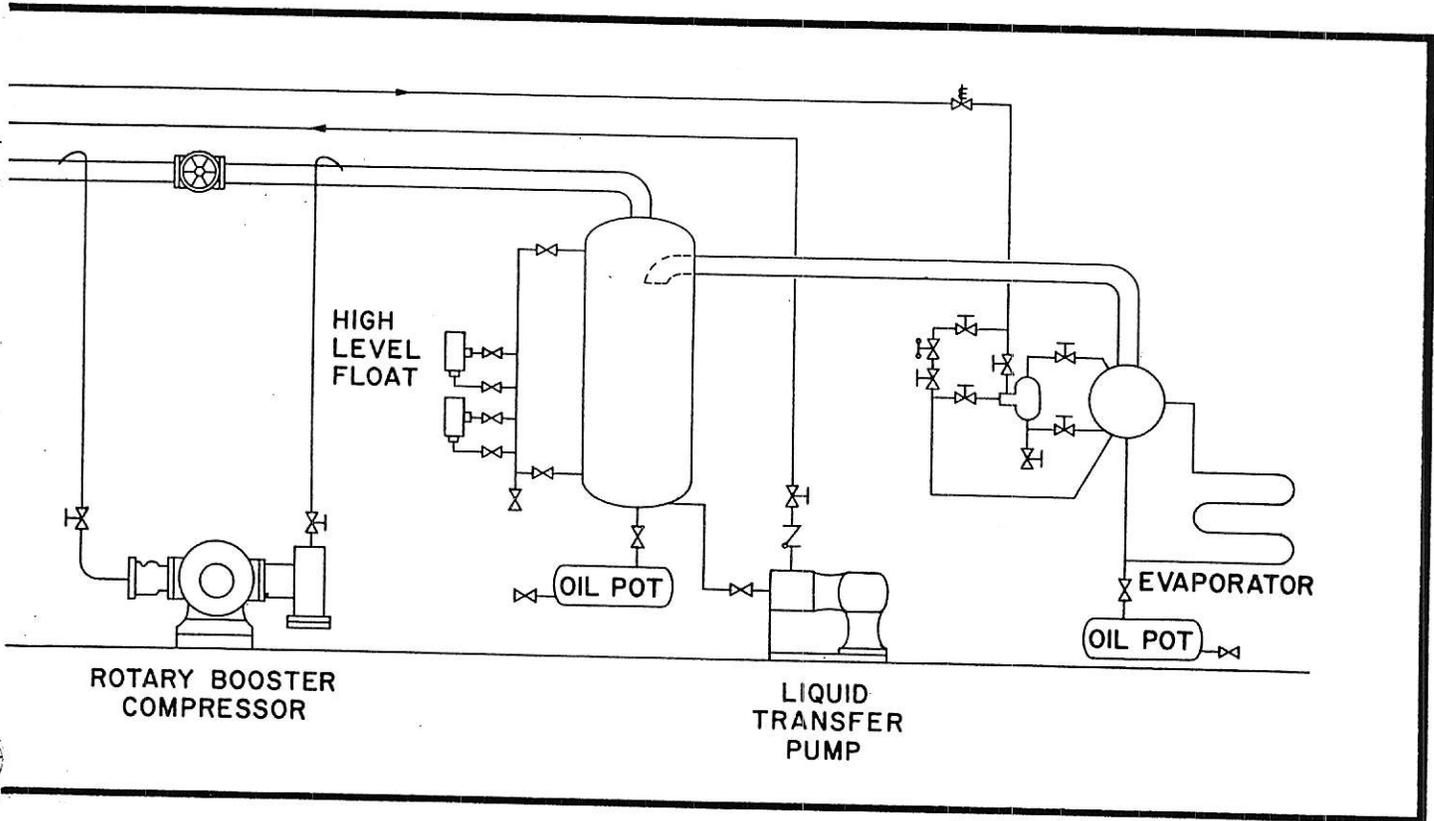


Fig. 5 Two stage schematic diagram.

are poorly insulated or contain no insulation.

Pressure drop through the cooling evaporator and suction lines also causes suction gas to compressor to be less than pressure in the evaporator. Thus, its temperature is higher and pressure lower than the refrigerant temperature in the cooling

evaporator. The increase in suction line gas temperature is referred to as degrees of superheat.

Superheat increases the temperature of the discharge gas and also raises the operating temperature of the compressor itself.

Booster discharge temperature of 300°F. can usually be traced to high compression ratios and high suction gas superheat. Both conditions found in the same plant require excessive compressor maintenance. Lubrication and operation of vital parts are seriously hampered by breakdown of the oil and formation of sludge and carbon deposits.

Buggy type freezing tunnels use a batch type freezing operation where large quantities of warm product are loaded into the tunnel for over-night freezing. After 12 hours of tunnel operation, most of the initial heat in the product has been removed and suction pressure drops to low vacuum.

Production line freezers, such as automatic plate type, conveyors or ice cream novelty machines (Gram, Vitaline, Polarmatic, Amerio etc.) are subject to wide variations in refrigeration requirements due to product changes or production stoppages.

On variable load applications, the suction pressure reduces rapidly and discharge pressure on the booster falls off more slowly. It is not unusual to reach suction pressures of 15 to 20" V with discharge pressures of 15 to 25 psig. Booster operation is then subjected to a combination of high compression ratio and excessive suction gas superheat with booster discharge temperatures rising above 300°F. Therefore, the booster must be shut down by low pressure safety control or discharge temperature cutout before serious damage occurs through overheating.

The affect of high compression ratio and refrigerant suction gas superheat on compressor discharge temperature can be illustrated by reading pressure gauges and thermometers at locations shown in Fig. 4.

Assume ammonia rotary booster pumping from 8.7" vacuum (10.41 psia) to 25 psig (39.7 psia). Saturated ammonia gas at 8.7" vacuum has a corresponding temperature of -40°F. while the thermometer indicates a suction gas temperature entering the compressor of 0°F. This difference in temperature represents 40 degrees F. of suction gas superheat. Under these operation conditions an actual discharge temperature of 220°F. will be read from the thermometer in the discharge gas from the compressor. Compression ratio (C.R.) =  $\frac{39.7}{10.41} = 3.8$

If rotary in Fig. 5 maintains suction pressure and gas temperature while discharge pressure rises from 25 psig to 35 psig, compressor discharge temperature will rise from 220°F. to 250°F.

If rotary in Fig. 5 pumps down to 18.6" V., due to reduced refrigeration requirements, while discharge pressure is maintained at 25 psig, the compressor discharge temperature will rise from 220°F. to 315°F. At these operating conditions the rotary would be pumping from 18.6" V. (5.55 psia) to 25 psig (39.7 psia). Saturated ammonia gas at 18.6" V has a corresponding temperature of minus 60°F. while thermometer indicates a suction gas temperature entering compressor at 0°F.

This difference represents 60 degrees of suction gas superheat. Compression ratio (C.R.) =  $\frac{39.7}{5.55} = 7.15$

Discharge temperature of 315°F. exceeds recommended limitation of 300°F.

Rotary compressors with built-in automatic capacity unloading should be used on variable load applications. Pressure control cycles solenoid valve in capacity unloader piping and maintains a predetermined minimum suction pressure. A second pressure control serves as low limit

to shut down compressor if suction pressure continues to drop.

Curve in Fig. 6 shows maximum recommended discharge pressure to be maintained on rotary booster for a given suction pressure. Operation above discharge pressure limits will cause booster to exceed 300°F. discharge temperature limitation.

Suction and discharge pressure limitations shown in Fig. 6 are based upon 40°F. suction superheat for all suction pressures above 8.7" V. Below this point a constant suction temperature of 0°F. is assumed. When suction superheat exceeds these values, the allowable discharge pressure is lower than limits shown on curve.

## INSTALLATION

### LOCATION

The compressor should be installed in a clean, dry place protected against dust and weather. Sufficient clearance must be available to permit operation of valves, inspection and filling of lubricator, removal of flywheel, and removal of blades and rotor.

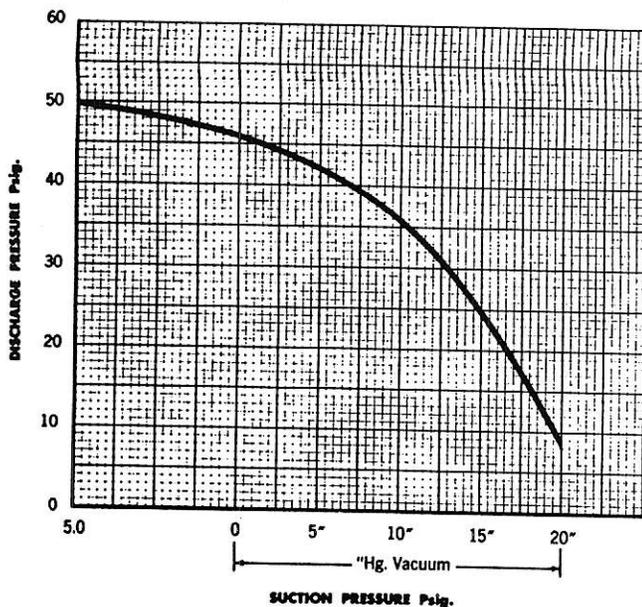


Fig. 6 Suction and discharge pressure limitation chart.

## FOUNDATION

Concrete foundations, extending to firm bearing and with moderate steel rod reinforcing, are recommended. Installation on balconies or steel supports is also satisfactory if sufficient stiffness is designed into the supports to maintain V-belt or coupling alignment.

Simple slab type foundations are normally used to raise the compressor to reasonable height (3 feet to centerline) above floor for ease of inspection and service. Basic design should be for static loadings only. Foundation drawings indicate the necessary dimensions for construction of these foundations and give anchor bolt and sleeve size and locations.

## ERECTION

The unit should be placed on foundation and leveled carefully with wedges located as close to foundation bolts as possible. Check that bolting of cylinder to base is securely tight. Suction and discharge flanges, shaft, and machined leveling pads (on larger cylinders only) may be used as reference surfaces. Similarly, the motor should be mounted providing plenty of flexibility in the motor leads to allow ready movement. If a sleeve bearing motor is used, bring the motor up to speed and mark the running position of the shaft before attempting alignment. This assures that the rotor is in the magnetic center.

## ALIGNMENT

V-belt sheaves are installed as close as possible to compressor and motor bearings to minimize shaft stress. Follow sheave manufacturer's instructions in the rear of this Instruction Manual.

Alignment is checked by stretching a cord across the sheave faces. All four points on the rims must be in contact with the cord. Check sheave alignment each time the motor is moved or the belts are tightened. Assemble one belt on the sheaves to check proper motor base location and to verify that the motor can move to provide sufficient slack and takeup as listed in the table following.

Belt Length	Slack to Apply Belts	Takeup To Tighten
80" to 112"	1"	1-1/2"
112" to 140"	1-1/2"	1-3/4"
140" to 180"	1-1/2"	2-1/4"
180" to 224"	1-3/4"	2-1/2"

Belt length in this table is total circumferential length, not the center distance between sheaves. Following this, compressor and motor bases may be grouted.

Direct-Connected compressors mounted on steel or cast iron combination bases with motors should be leveled and the anchor bolts drawn hand tight prior to grouting the base. Alignment was made in the factory, but must be rechecked after grouting, following instructions in the rear of this Instruction Manual.

Direct-Connected compressors and motors mounted directly on concrete foundations without use of the common base, must be fully aligned prior to grouting, following instructions in the rear of this Manual. Mount and level the compressor as described previously, lightly tighten the anchor bolts, and install the compressor half coupling. Mount the motor on a steel pad, install the motor half coupling and level the motor with the specified gap between shaft ends. If a sleeve bearing motor is used, determine running position of the shaft and use this in all alignment.

Grout compressor and motor bases, or combination base, working the grout thoroughly under the base and filling all anchor bolt sleeves. After grout is set, tighten all anchor bolts firmly. Recheck coupling alignment completely. Check the motor for rotation in direction of the compressor rotation arrow. Make this check before coupling pins or V-belts are installed. Install coupling pins or V-belts. Tension the V-belt drive in accordance with manufacturer's recommendations in the rear of this Instruction Manual. Align the drive by the four-point method with a piece of cord or straight edge. The two sheaves will be aligned when two points (near and far) on the face of each of the sheaves touch the straight edge or the cord when the cord is a straight line.

## REFRIGERANT PIPING

Refrigerant piping connections to the booster are made as shown in Fig. 7. Pipe sizes are shown on MD-1, rear of Instruction Manual. Bolt the suction strainer to compressor inlet flange, being certain that no dirt or debris is in the suction passage, and the discharge connection to check valve outlet flange. Capacity reducer compressors are shipped with suction strainer, vacuum breaker and bypass piping installed. Erect suction and discharge valves, then pipe to mains, making connections into the side or top of mains. Support these risers with hangers - heavy unsupported piping can strain the cylinder. If desired, a drain valve may be fitted to the cover flange of the suction strainer.

The refrigerant relief valve must be connected in the discharge line between the compressor and the shut-off valve.

When pressure testing this piping, apply pressure to the discharge line, then the cylinder should be pressurized through the suction valve, allowing cylinder pressure to build up gradually in order to avoid "popping" the inner face of the shaft seal.

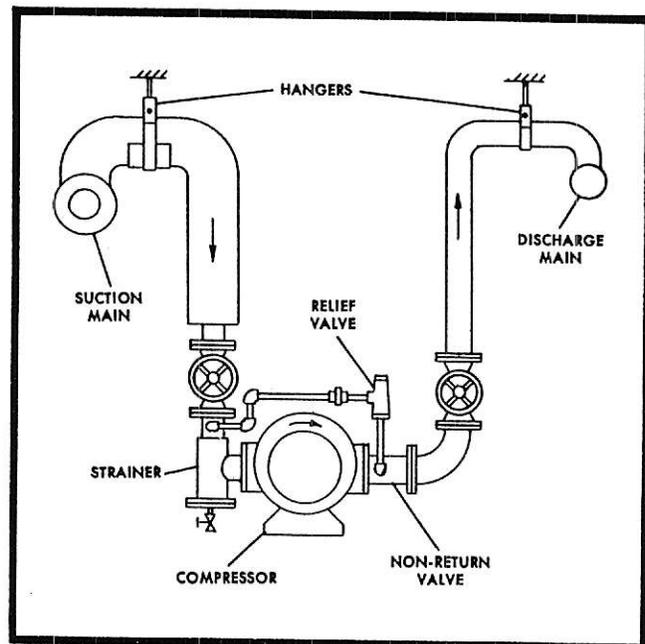


Fig. 7 Refrigerant piping.

Small bleed valves in the seal equalizer piping will not permit a rapid rise of seal chamber pressure, with the result that the inner shaft seal can be blown off its seat and seal oil lost.

The seal circuit is furnished complete with the compressor and requires no assembly or adjustment at erection. Equalizer connections are provided to maintain positive pressure in the seal chamber at all times. See Fig. 12. Valves must not be installed in these lines, except as shown on diagrams for halocarbon compressors.

### JACKET COOLING SYSTEM

The compressor cylinder, heads and seal chamber are jacketed for removal of heat. Oil circulated through these jackets is cooled in an externally mounted water-cooled cooler.

The oil pump and cooler are supplied with the compressor. Cylinder jacket inlet and outlet connections and seal jacket piping are factory mounted. Field piping is connected to the oil pump and to these factory

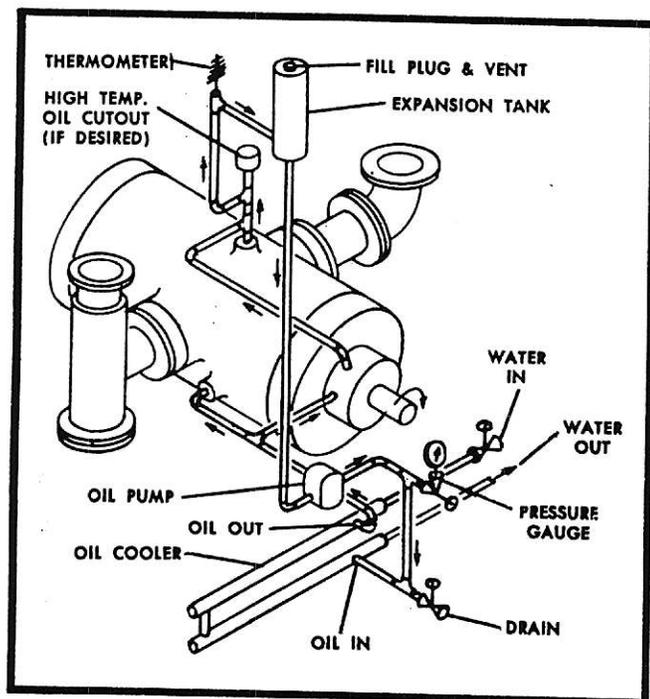


Fig. 8 Jacket oil and water piping.

mounted fittings as shown in Fig. 8. Line sizes are indicated on MD-1 rear of this Manual. Suction side of the oil pump is identified by checking pump rotation, which is in the direction indicated by the compressor arrow. Pump suction is at the tail of this arrow.

Oil flows from the pump through the cooler, thence to the cylinder and seal jackets, which are in parallel. Warm oil from the jackets passes through the expansion tank, thence to the pump suction. The expansion tank should be mounted several feet above the pump suction to avoid cavitation.

The lightest oxidation inhibited transformer or spindle oil should be used in this cooling system. Compressor lubricating oil must not be used. Typical recommended jacket cooling oils are: Esso Univolt N34, Standard of Cal. Chevron Inhibited Insulating Oil, Sun Oil Solnus 55, Texaco Transformer #55.

Approximate Jacket Oil Charge is:

15-16	- 2 Gal.	120	- 15 Gal.
24-25	- 3 Gal.	135-150	- 17 Gal.
30-40-50	- 6 Gal.	175-200	- 25 Gal.
60-70	- 9 Gal.	250-300	- 40 Gal.
80-100	- 11 Gal.	350	- 46 Gal.

The oil cooler is piped with water in the tubes and oil in the annular spaces. Pipe for counterflow of water to oil, with water in and oil out the same end of the cooler. Cooling water should be discharged into an open funnel to permit observation at all times. It is good practice to install a hand or solenoid valve in the water supply line to close when the booster stops. If desired, however, water may continue to circulate through the cooler of a booster stopped by automatic control.

Cooling water quantity must be adequate to insure that oil temperature leaving the compressor does not exceed 115°F. This temperature should be maintained as cold as practicable below 115°F. preferably below 100°F.

## CAUTION

WHERE THE COMPRESSOR ROOM IS SUBJECT TO FREEZING TEMPERATURES, WATER MUST BE DRAINED FROM THE HEAT EXCHANGER AT SHUT-DOWN.

### SAFETY CONTROLS

Safety controls, thermometers and gauges are required for proper operation and control of this booster compressor. Recommended locations for these are shown in Fig. 4. All are mounted as close to the compressor as possible to sense closed valves or dirty strainer. Space does not permit mounting a thermometer at the discharge flange of the compressor, the point at which discharge temperature must be measured. Therefore, 15°F. must be added to indicated temperature for each foot distance between thermometer and flange. Pressure gauge connections may be made at taps indicated for pressure switches, or in mains. Connections to pressure switches must be installed without valves. These switches must be set to stop the compressor within the limits of pressure shown in Fig. 6. Serious overheating and damage to parts will result from failure to follow this practice. High Temperature Cutouts are factory set to open at 300°F. This calibration must be checked and maintained.

The differential between cut-out and cut-in point of these controls is determined by nature of the load and requirements for close regulation of temperature and pressure. In general, the widest possible differential setting is recommended in order to avoid "short-cycling" and accompanying overheating of the motor and its starter. Where the need for close regulation of temperature is combined with rapid fluctuation of load, special design may be necessary.

### WIRING DIAGRAM

Wiring Diagram for recommended hookup of safety and operating controls is shown

in ED-1, rear of Instruction Manual. Contacts of the safety controls are rated 10 amps non-inductive load; thus, can carry the starter coil load. The capacity reducer may be controlled by suction pressure or process temperature. Pressure switches normally used for this purpose have rather low contact rating; therefore, only the unloader solenoid valves should be energized through them.

Under some conditions of batch loading, motor overloads found in initial pulldown may be avoided by reducing compressor capacity during periods of high suction pressure. A low pressure cutout may be wired in parallel with the capacity control switch shown.

In multiple booster installations, temperature or pressure actuated step switches may control starting and unloading of each machine. Safety controls shown are required on all boosters, regardless of other controls employed.

Booster suction pressure must be controlled at startup to avoid overload of booster and high stage compressor motors. Generally this is not a problem in plants which maintain steady conditions and cycle compressors on and off the line to carry load variations. Single boosters or those on a pull-down load may require a "hold back" valve in the suction line, or a pump down cycle may be used. The pump down cycle may, however, result in excessive short cycling, with overheating of motor and starter.

## OPERATION

### PRE-START CHECKLIST

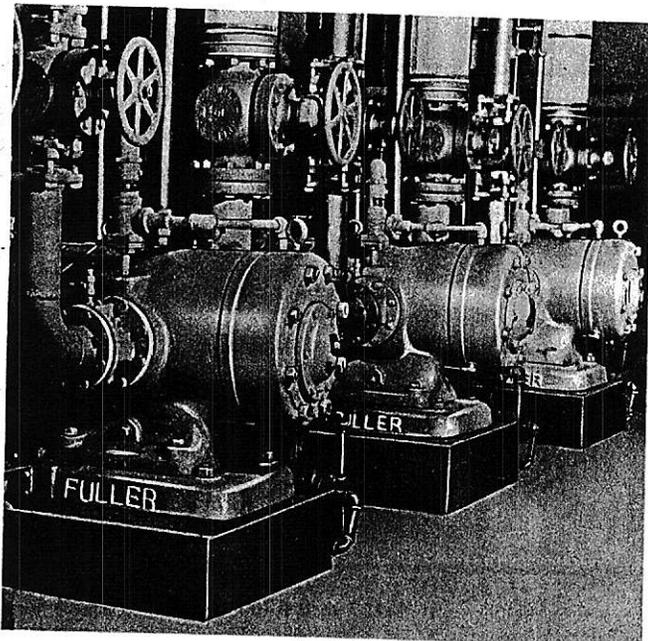
Before starting the compressor initially, after a seasonal shut down, or after repair, check the following:

If stored for a month, or after seasonal shut down, remove the rear head for examination of blades, cylinder wall and bearing. See Inspection and Service.

- The lubricator is full of refrigeration compressor oil. Adjust pumping units for maximum delivery. Disconnect all lube oil tubes at check valves at each point of lubrication and crank the lubri-

cator until all air is purged from tubing. Reconnect the tubing and turn the lubricator 100 revolutions.

- Turn rotor several revolutions by hand to assure complete freedom of all parts.
- Check V-belt tension and alignment of sheaves. If direct-connected, check coupling alignment.
- Jog the motor to check rotation indicated by arrow of the compressor.
- Tighten drive belts on force feed lubricator and jacket oil pump and observe free rotation of oil pump.
- Charge compressor oil into the shaft seal until sight glass is filled to bottom of yellow mark. A fill valve is provided for this purpose.
- Add 1/2 pint of compressor lubricating oil through the pipe tap on top of each bearing.
- Jacket oil expansion tank is 1/3 full of cooling oil.
- Proper setting of all safety controls.
- Turn on cooling water to jacket oil cooler.
- Open discharge stop valve.



- Examine suction line for presence of liquid refrigerant or oil. Temporarily "crack" the suction valve open, then close it. If liquid refrigerant or oil is present, purge suction drop leg before starting compressor.

#### START-UP

When starting a two-stage system, check the high stage compressor according to manufacturer's recommendations. Start it with bypass piping around the booster open. In plants where continuous two-stage operation is planned, this starting bypass may be omitted, and suction gas to the high stage compressor drawn through the booster cylinder. Continue high-stage pull-down until the limit of high stage capacity is reached, generally at suction pressure considerably below normal intermediate, then start the booster. If there is no bypass, be careful to observe that no liquid refrigerant is in the booster cylinder.

Start the booster initially with bypass valve open, suction closed and Low Pressure Cutout blocked closed. With the motor up to speed, close the bypass and gradually open the suction valve, watching for signs of liquid carry-over. When the suction valve is open, remove temporary blocking from Low Pressure Cutout. If suction pressure is above normal and will overload the motor, operate with throttled suction until normal pressure is reached.

#### CAUTION

THE BOOSTER CAN BE OPERATED FOR ONLY VERY SHORT PERIODS WITH CLOSED SUCTION; OTHERWISE, SERIOUS OVERHEATING WILL RESULT.

With the booster operating, check liquid supply to the intercooler (or to discharge line desuperheater in halocarbon system.) Do not fill the intercooler with liquid prior to start up, as gas bubbling through the liquid may raise the level above normal and carry liquid into the high stage compressor.

#### BREAK-IN CHECKLIST

After the booster is started, check the following:

- Operation of all force feed lubricator pumping units. Adjust the drop rate to twice normal flow, see Lubrication.
- Seal oil reservoir. A slight oil loss is normal during "run-in." If loss is excessive, refer to "Shaft Seal," Inspection and Service, page 18.
- Jacket cooling system. Oil pump discharge pressure should be 10 to 20 PSI, depending upon cooler size. Oil temperature out the jacket should be 115°F. maximum, preferably below 100°F. The expansion tank will be 1/2 to 2/3 full when oil is warm. As air is purged from jackets and piping, it may be necessary to add oil to the system.

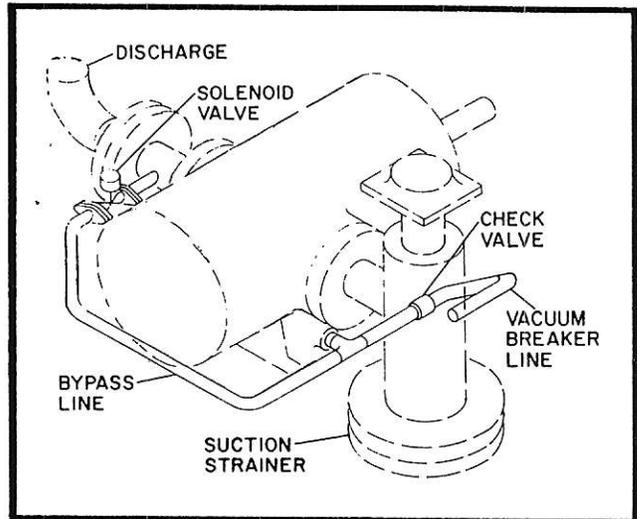


Fig. 9 Capacity reducer piping  
A15 and A16 boosters.

- Operating temperatures of compressor and motor. The discharge side of the cylinder and heads will be the warmest parts of the machine. Several small "hot spots" will be found where solid plugs of metal connect the inner cylinder to the outer wall. Check motor bearing temperature to assure there is no overload due to misalignment or excessive belt tightness.
- Compressor discharge gas temperature must be limited to 300°F. maximum at the cylinder discharge flange. If this temperature is excessive, compare operating conditions with Fig. 6. Also, check the evaporator for light load and the suction line for high superheat. The suction line must be thoroughly insulated.

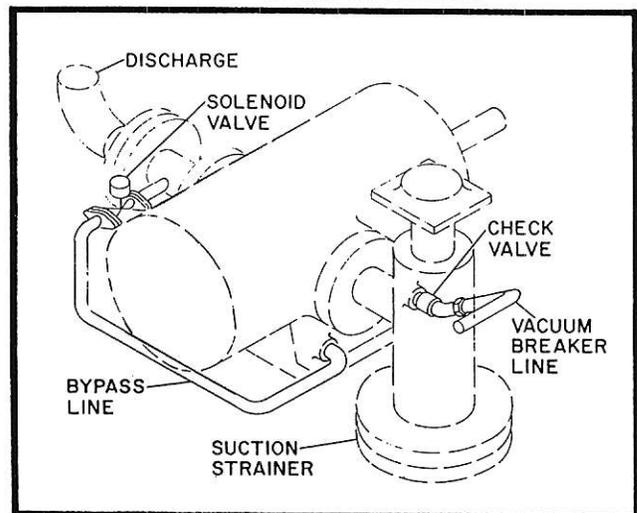


Fig. 10 Capacity reducer piping  
A24 thru A120 boosters.

- Compressor and motor vibration or unusual noises. If vibration is observed, check static balance of the compressor flywheel. One or more stuck blades can also create vibration.
- Relief valve leakage. Relief outlet pipe is at room temperature.
- On capacity unloader compressors, the vacuum breaker line from suction strainer to base of compressor is cold and the bypass solenoid valve(s) are closed during full capacity operation. During 50 per cent capacity operation, the bypass line is hot, the vacuum breaker line is cool. If the vacuum breaker line becomes warm during reduced capacity operation, the check valve is leaking and must be repaired to avoid compressor

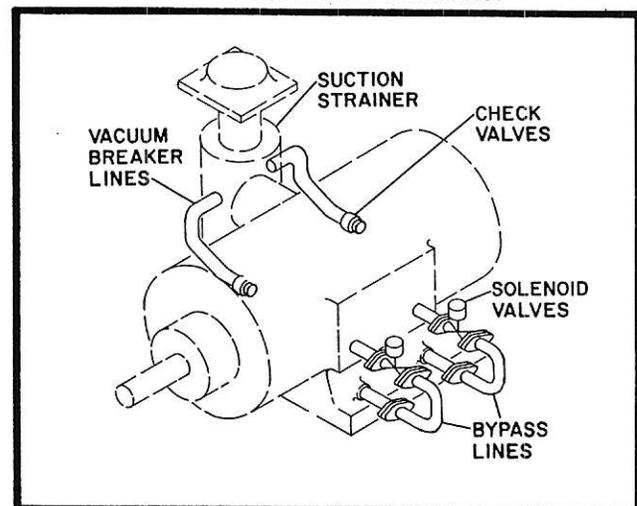


Fig. 11 Capacity reducer piping  
A135 thru A300 boosters.

overheating. Arrangement of this piping on the various size boosters is shown in Figs. 9, 10 and 11.

- Most V-belts used in booster drives will stretch during initial operation and require tightening several times before final running length is reached. Check alignment each time the motor is moved. Veelos belts driving the force feed lubricator and jacket oil pump will stretch, also. Remove links as required to keep these belts tight and driving these vital auxiliaries at full speed.
- In the case of a vertical motor mount, the drive is tightened by jackscrews mounted in saddles on top the cylinder. On smaller compressors, turn jackscrew nuts above and below these saddles. On larger machines, turn the jackscrews themselves. In both arrangements all jackscrew nuts and locknuts must be secure before running the motor.
- Clean suction strainer twice in old system; at least once in new system. This strainer screen is fine enough to catch particles that would wedge between rotor and cylinder, but coarse enough to avoid oil plugging.

#### SYSTEM CHECKS

Booster operating conditions are determined by plant characteristics; thus, start-up and initial operation of the booster will bring to light any problems in the "low side" which require attention. If the booster is installed in an existing plant previously operated at higher suction pressure, check carefully for excessive carryover of liquid and oil from the evaporators. Gas velocities have been increased; liquid and scale will be sucked into the compressor unless adequate precautions are taken.

A trap in the suction line will normally catch all this material. If provided, it permits removal of oil and dirt at this point and either evaporation or transfer of liquid to another part of the system. Verify that liquid can rise to the high level float switch on this trap without carryover to the booster suction. If a trap is not provided, verify that evaporators are op-

erating at full capacity without liquid carryover and that adequate means are provided for oil recovery.

Automatic defrosting of evaporators can produce serious liquid carryover if proper control and equipment are not provided. Also, liquid must not be fed to evaporators when the booster is stopped. This can permit excess accumulation of liquid and result in carryover from the evaporator when the booster starts again.

#### STOPPING PROCEDURE

Stop the compressor with suction valve closed to pump it out. Close the discharge valve when the rotor stops turning and shut off water supply to the oil cooler. This will secure the booster for short periods of time.

If the booster is stopped during periods of wet compression, it may be operated for several minutes with closed suction to warm the blades and drive out any liquid ammonia present.

Boosters in automatic control will stop with service valves open.

Seasonal shut-down requires thorough pump-out of all equipment and storage of charge in the HP Receiver. During the last 15 minutes of booster operation double the lubrication rate to provide a good film of oil on all parts. Turn the rotor slightly once a month to avoid bearing corrosion.

#### LUBRICATION

Oil is fed to cylinder walls and bearings of ammonia compressors by a force feed, belt-driven lubricator. Each connection on the unit is equipped with a check valve to prevent leakage of gas to the lubricator. See Fig. 12. On halocarbon compressors or ammonia compressors with automatic oil return, sight feed lubricators fed by an oil pump (generally on the high stage compressor) are substituted for the force feed lubricator in order to minimize oil accumulation in the system.

Special attention should be given to insure that the correct grade of oil is used at all times. In general, any good refrigeration

oil having a viscosity of 300 SSU at 100°F. is satisfactory; however, severe duty may require a viscosity of 515 SSU. Table 1 lists typical recommendations for lubricating oils and required lubricator drop rates. Lubricator Drop Rate for compressor nominal RPM is stamped on a brass plate attached to each force feed lubricator. Check this nameplate with the table. For Drop Rates at maximum RPM, add one drop per minute; at minimum RPM, subtract 1/2 drop per minute. For compressors fitted with sight feed lubricators multiply Drop Rate by 3.

about 100% in excess of the figures given in Table 1. Following this break-in period, the oil feed rate may be adjusted to the drops per minute per feed shown above.

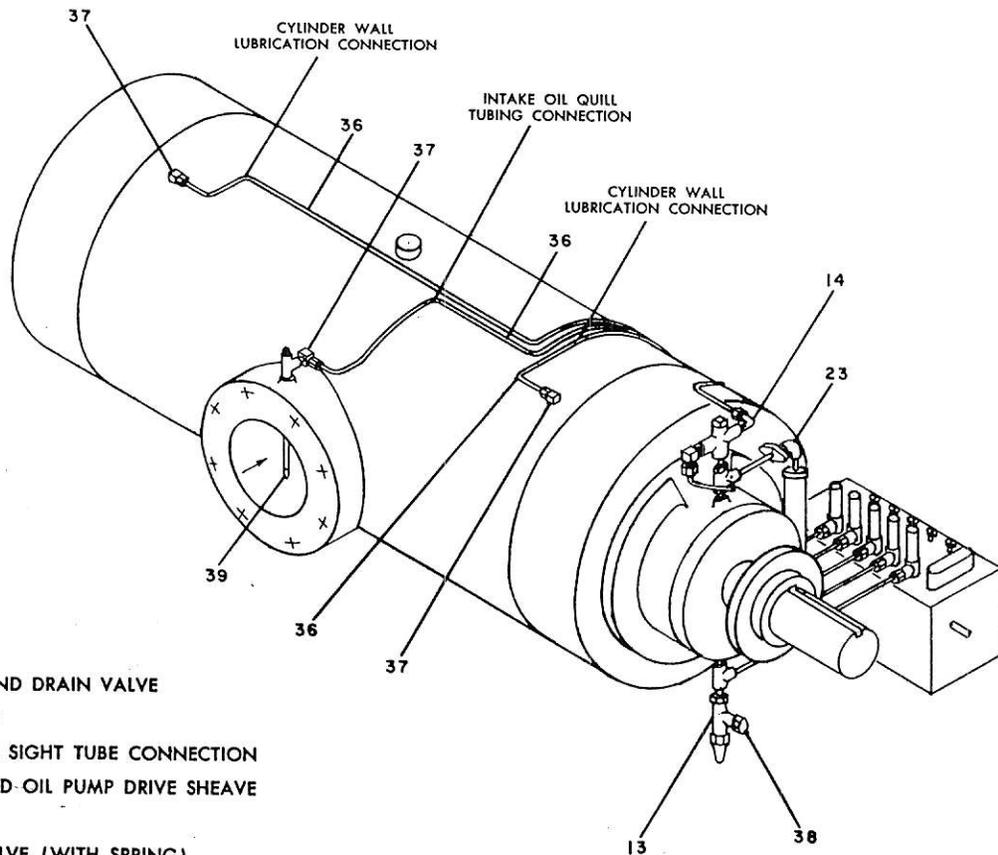
Lubricator Operating Instructions and Parts List are included in the back of this Instruction Manual.

## MAINTENANCE GUIDE

### Daily Operating Check List.

Perform the following checks each 4 hours:

For the first two weeks of operation, set the oil feeds to deliver amounts of oil a-



- 13—SEAL OIL FILL AND DRAIN VALVE
- 14—ORIFICE FITTING
- 23—SEAL RESERVOIR SIGHT TUBE CONNECTION
- 25—LUBRICATOR AND OIL PUMP DRIVE SHEAVE
- 36—OIL TUBING
- 37—BALL CHECK VALVE (WITH SPRING)
- 38—SEAL OIL FILLER CAP
- 39—INTAKE OIL QUILL
- 45—FORCED FEED LUBRICATOR

- Observe that all lubricator pumping units are functioning properly.
- Observe normal oil level in seal.
- Observe normal jacket oil temperature and pressure.
- Observe normal operating temperatures of compressor and motor, checking bearings, seal and discharge gas.
- Detection of vibration or unusual noises.
- Fill lubricator reservoir (daily)

### Monthly Inspection

- Check setting and operation of safety controls.
- Check lubricator drop rate, each pumping unit.
- Check quantity of oil in jacket cooling system.
- Check tightness and alignment of V-belt drive.
- Check tightness of Veelos belts driving lubricator and jacket oil pump.

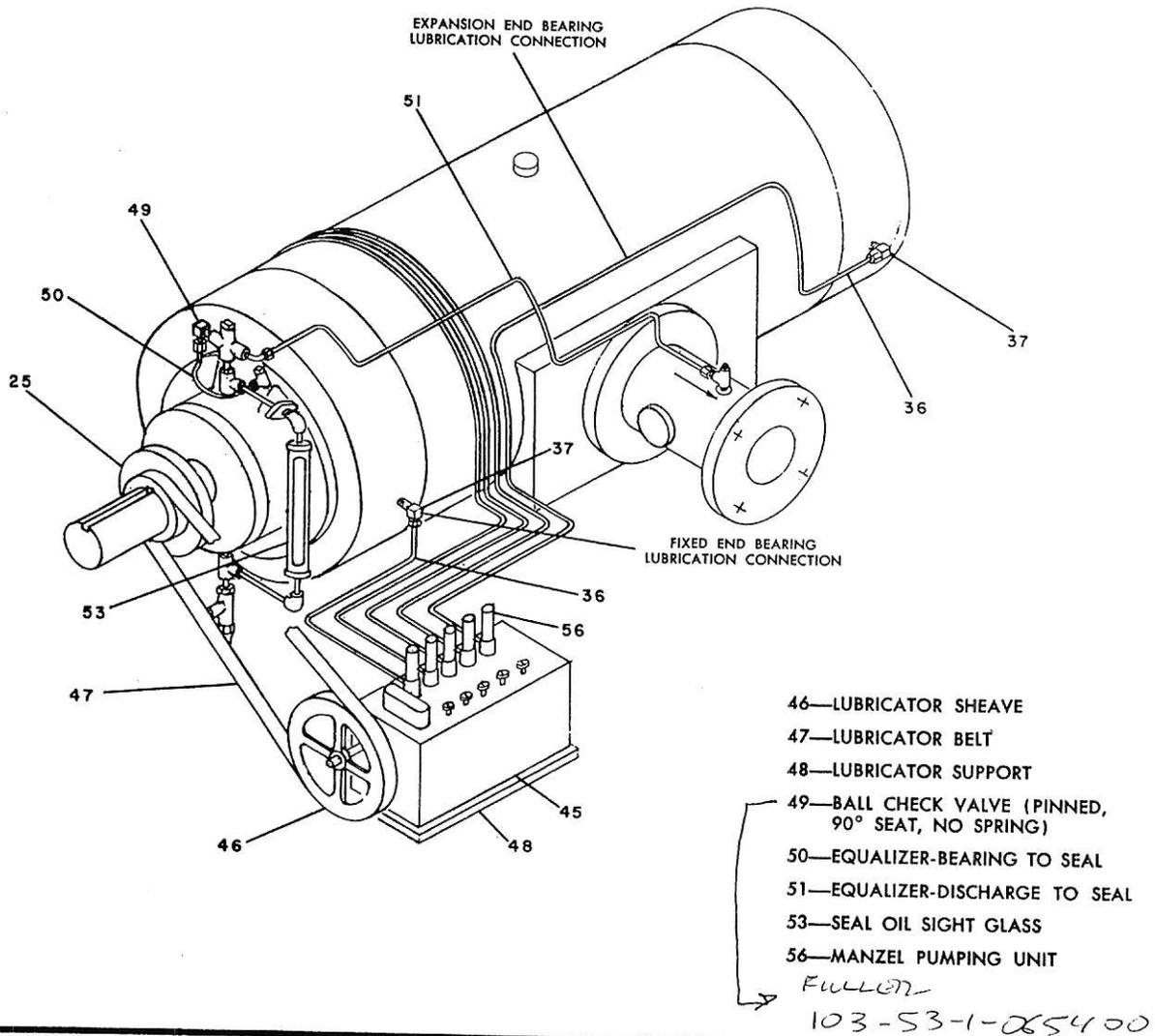


Fig. 12 Standard ammonia compressor lubrication.

**TABLE 1. LUBRICATING OIL REQUIREMENTS**

Characteristic	Ammonia	Halocarbon
SSU @ 100°F.	515 to 300 min.	150
Pour Point, °F.	-30	-35
Floc Test, °F.	-60	-75
Diaelectric Strength	25,000 Volts	25,000 Volts
Preferred Oil	Texaco Capella E	
Typical	Gulf Paramount A	
Recommended	Suniso #4	Suniso #3
Lubricating Oils	Texaco Capella D	Texaco Capella B

**Model 94V Manzel Oil Feed Recommendations**

**Drops Per Minute Per Connection**

Compressor Size	Nom. RPM	Cyl. Head (2 Conn.)	Cyl. Inlet (1 Conn.)	Cyl. Walls	Total Drops
A-15-16	1160	3	3		9
A-24-25	1160	3	3		9
A-30-40-50	1160	4	4		12
A-60-70	870	4	4		12
A-80-100	870	5	5	5(2 Conn.)	25
A-120	690	5	5	5(2 Conn.)	25
A-135-150	690	6	-	6(3 Conn.)	30
A-175-200	575	8	-	8(3 Conn.)	40
A-250-300	575	7	-	7(5 Conn.)	49
A-350	575	10	-	10(5 Conn.)	70
A-508-608	500	11	-	11(7 Conn.)	99

## INSPECTION AND SERVICE

Given reasonable attention and care your FES Fuller rotary booster will provide many hours and years of excellent service. Frequently it will take considerable abuse without breakdown or undue wear. At times warning signs will appear, which, if heeded, will avoid more serious trouble. If damage does occur it is most helpful to know what steps are required for prompt repair, and what may be done to avoid a repetition.

### SHAFT SEAL

A double shaft seal, running in oil, prevents refrigerant leakage and air infiltration. Construction and Parts List are shown in Fig. 13. Ground and polished stationary seats are held in place and

sealed by sirvene gaskets. Carbon faces are held in place and rotated by sirvene friction rings which fit the shaft snugly. Carbon faces are held against stationary seats by spring force and internal pressure applied through the equalizer.

Equalizer connections are illustrated in Fig. 12. Booster discharge pressure is applied through tubing connected to the downstream side of the discharge check valve. If the booster discharge is below atmospheric pressure, this equalizer must be connected to some other point in the system which is slightly above atmospheric pressure. The seal is also equalized to the adjacent fixed end bearing cavity, which generally runs at pressures slightly below compressor discharge. A gravity check valve (part 49) prevents flow from seal to bearing. If bearing pressure temporarily exceeds discharge, gas will flow

through this check valve into the seal. Orifice fitting (part 14) prevents rapid escape of this gas and allows seal pressure to rise.

As received, all connections are made and the seal is filled with oil. If oil has been lost in shipment, charge compressor lubricating oil into the seal up to the bottom of the yellow stripe on the seal oil sight glass. A slight drip may appear, but should stop after "run-in." If oil loss continues, apply a pressure of 75 to 100 PSI to the seal chamber by means of a hand oil pump connected to the oil fill

valve. This should "seat" any parts not in place. Continued leakage will require dismantling.

**Seal Dismantling**— After removing the fly-wheel or coupling half and the dual sheave driving oil pump and lubricator, use emery cloth and a file to dress off rough spots on the shaft which may cut seal parts. Drain oil from the jacket cooling system until the level is below seal jacket inlet. With suction and discharge valves securely closed, drain lub oil from seal chamber. Remove seal cover plate to expose front seal parts for ready inspection and removal.

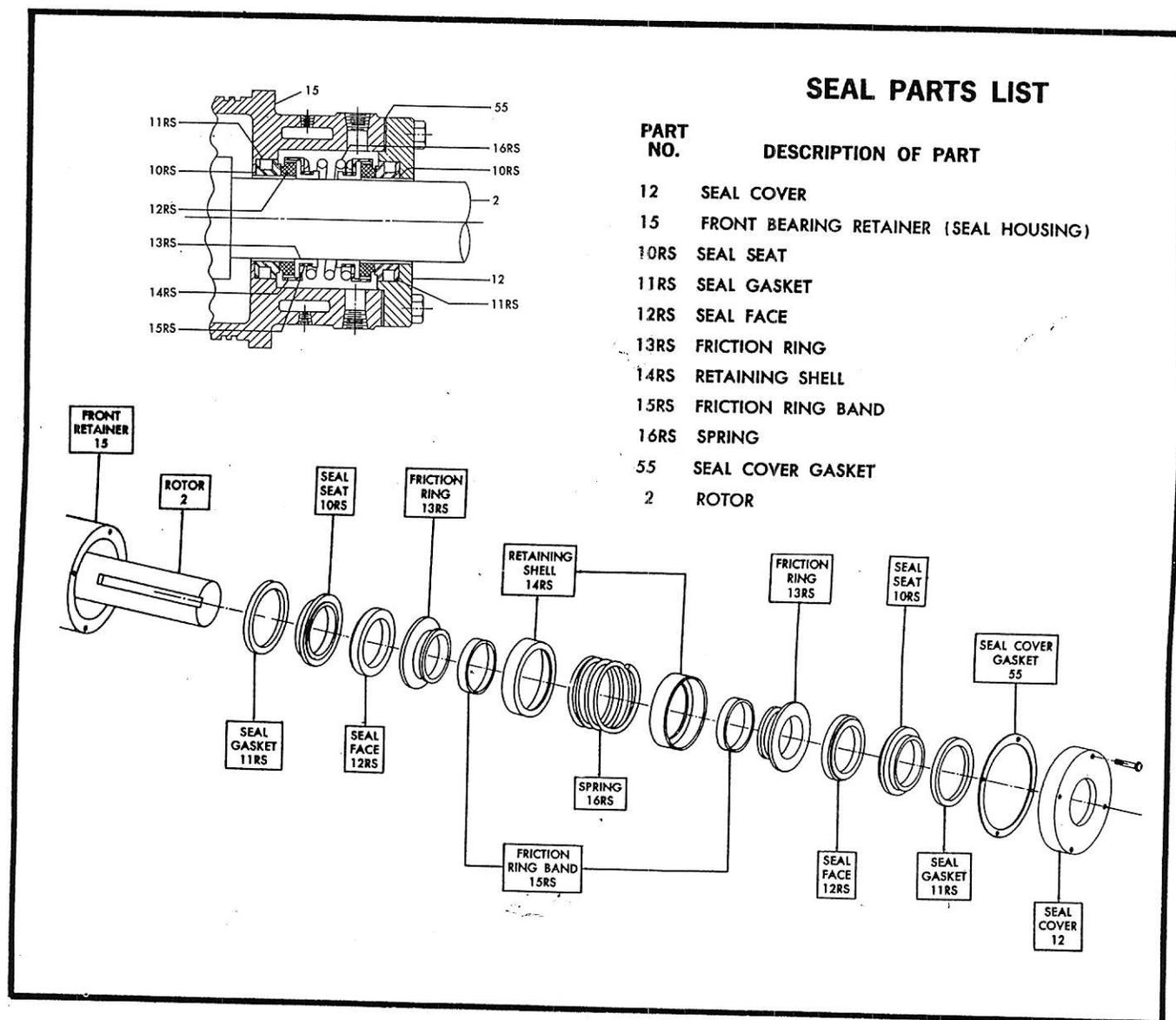


Fig. 13 Seal assembly and parts list.

Disconnect equalizer and jacket tubing from seal housing. Remove flange bolts from seal housing and use two of these bolts to jack housing out of cylinder head. Slide housing forward on shaft until inner seal is readily accessible. Lightly oil the shaft and slide both carbon faces off shaft before removing seal housing.

**Outer Seal Leak** can be serviced by removing the outer seal only. Do not move the seal housing or disturb the inner seal unless seal oil loss exceeds external leakage. Examine seal seat (10RS) for secure fit with gasket (11RS) in counterbore of cover plate. These pieces must be firmly seated in the recess. Check seal seat (10RS) and carbon face (12RS) for uniform wear, scratches, chipping and cracks. Check friction ring (13RS) for snug fit on shaft. Brittleness and cracking of sirvene friction ring and gasket are caused by overheating. This will probably not be observed in new seal parts since some time is required for heat deterioration, if present.

Following inspection, reassemble seal carefully, replacing only those parts showing evidence of defect or wear.

**Inner Face Leak**— Oil lost from the seal without external leakage must flow through equalizer connections or the inner seal face. Since oil will flow through equalizer connection only when the seal is full, continued lowering of oil level means an internal leak, probably due to "popping" the inner seal face away from the seat. Seal parts will be disturbed if cylinder pressure is raised rapidly during testing or operation. To avoid this, always open the discharge valve first, applying discharge main pressure to the seal through equalizer orifice (part 14), then open the suction valve. In the unusual situation where suction main pressure exceeds that in the discharge main, "crack" the suction valve and allow cylinder pressure to rise slowly. This will permit gas to flow through the small equalizer connections and hold seal pressure equal to cylinder pressure. The inner seal can also be "popped" by dirt in the equalizer between bearing cavity and seal. Be sure this line is clean and the gravity check valve (part 49) free of oil and grease which would hold the ball on its

seat. Also clean equalizer to discharge and orifice fitting (part 14).

Dismantle the seal completely and inspect both sets of parts as suggested above. Also inspect exposed parts of the fixed end bearing. Replace only those parts which are defective or worn.

**Old Seal**—Dismantle the seal completely. Thoroughly clean all parts, housing, and all equalizer connections and fittings. Check seal seats (10RS) for secure fit with gaskets (11RS) in housing. Observe wear or scratching of seat face. Examine gaskets for cracking and brittleness caused by overheating. Check carbon faces (12RS) for cracking, chipping, bleeding of babbitt metal from face and wear. Check friction rings (13RS) with ring band (15RS) assembled in place for firm grip on shaft. Examine friction ring for brittleness due to overheating. Replace worn parts. If two or more years old, replace all sirvene and carbon parts unless careful inspection shows good condition.

#### SHAFT SEAL ASSEMBLY

- Using compressor oil, lightly coat seal seats (10RS) and gaskets (11RS). Assemble gasket on seal seat, then push each assembly into the recess in the seal cover flange and the seal housing (fixed end bearing retainer). Each seal seat must be firmly seated in its recess and must be square with the shaft. To assure this, protect the seat face with some soft material such as wood and lightly tap all around the circle to assure proper seating and positioning.
- Assemble the seal housing in cylinder head, being careful not to cut "O" rings in the skirt of this casting. Draw up the flange bolts, but do not attempt to pull the flange into contact with the head: the skirt comes into contact with the fixed end bearing before the flange makes contact with the head.
- Prepare to install the rear seal face (12RS) by removing it from retaining shell (14RS) and coating the rear side with a thin film of grease, then reassemble in retaining shell. The purpose

of this operation is to "stick" the seal face (12RS) and the friction ring (13RS) together during assembly. Examine the rotor shaft keyway for burrs and file off any rough spots which may cut rubber friction rings during assembly. Put a thin coat of oil on the shaft, then slide and turn the friction ring until it moves freely on the shaft, then slide it into position. The lubricating film thus established will permit free movement on the shaft for a short period of time, after which the friction ring will "freeze" to the shaft and then require considerable force to move. Seal face (12RS) must bear snugly against seal seat (10RS). To assure this snug fit and to avoid "popping" seal face (12RS) out of retaining shell (14RS) while sliding on the shaft, apply pressure only to that part of friction ring (13RS) which grips the shaft. Do not push against retaining shell (14RS). Use a steel sleeve or two pieces of wood to do this.

- Put spring (16RS) in place.
- Assemble front seal face (12RS) and friction ring (13RS) on the shaft, locating it to apply a slight compression to the spring. Locate the spring to bear uniformly against retaining shells (14RS) at each end of the spring.
- Use the seal cover plate to push outer friction ring (13RS) and seal face (12RS) into proper position.
- Reassemble all seal equalizer connections and seal jacket connections. Charge compressor lube oil into seal up to the yellow mark on seal sight glass.

Reassemble drive and check alignment as suggested in "Installation" section.

Reconnect jacket oil cooling piping and fill the cooling system, using the light heat transfer oil originally drained out. Jog the compressor a few times with suction valve closed and discharge open to turn over the jacket oil pump to remove all air from system.

Refer to "Operation" section and proceed.

#### YEARLY INSPECTION

A new compressor should be inspected internally during its first year of operation and each year thereafter. Drain oil from the jacket, disconnect lube oil tube from head, remove stud nuts and jack the head off dowels, using two hex head jacking

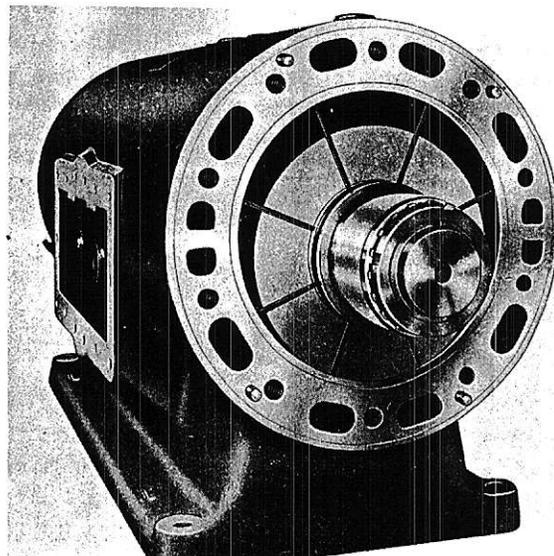


Fig. 14 Typical cylinder with rear head removed. Blades are shown in their normal running position.

screws provided in the head for this purpose. Turn a lifting eye securely into the head and, using a hand hoist, swing the head off the studs and to the floor. If care is exercised while jacking the head off, the gaskets can probably be saved for reuse.

This exposes the compressor for inspection as shown in Fig. 14. The expansion bearing, hub seal ring, blades, rotor slots, cylinder bore and jacket can be examined. Examine oil remaining in the bearing retainer - it should be clean and free of metal chips. The bearing inner race should be tight, with one tab of the lockwasher turned down to secure it.

Check wear of the hub seal ring against the bore of the head. Examine cylinder head and end of rotor for signs of rubbing. If found, this indicates hot operation, which must be avoided in the future. Also, this requires inspection of the fixed end bearing, as the rubbing may have imposed a heavy thrust load upon it. Remove rub marks from the metal, being certain that no metal projects into rotor blade slots to prevent free sliding of blades.

Turn the rotor to permit inspection and removal of all blades. Blades must slide freely in their slots. Push blades hard against the front head to check length. The rear end of the blade should be flush with the end of the rotor. If too long or bowed, blades may be removed, clamped to a

straight piece of steel and held at 300°F. for several hours to dry them. If not back to original size and free to slide in the rotor slots, the blades may be sanded and/or milled.

### CAUTION

THE ENDS OF ALL BLADES MUST BE STRAIGHT AND SQUARE AND ALL BLADES EQUAL IN LENGTH.

Swelling or warping does not destroy the life of the blades, but it does indicate the presence of moisture or liquid ammonia. If blades are 1/32" shorter than the rotor, they should be replaced.

Roughness or chipping of the blades may be filed or sanded. Cracking of the edges indicates liquid pumping. Fraying or brittleness indicates improper lubrication or overheating. Sharp beveling of the edge in contact with the cylinder also indicates lack of lubrication. The rear side of the blade will be found polished and smooth where it is in rubbing contact with the edge of the rotor slot. Excess wear at this point indicates lack of lubrication or operation at excessive pressure. Blades 1/4 inch short in height must be replaced. (New blades are flush with the outside diameter of the rotor.)

Uniform wear of blades may be obtained by reversing them in the slots at each inspection.

*Blade to Slot wall - max.  
10000 - 10 - 040*

While turning the rotor, clean the slots and check circumference for scratches or metal pickup from the bottom of the cylinder. If the rotor has rubbed the cylinder, it must be removed for more thorough examination. Rotor slots must not be worn in width more than 1/32". If new blades are being installed, thoroughly clean rotor slots, using keystone as wide as slot width. Bevel one side to chisel point and work back and forth to remove all debris.

Cylinder walls must be clean and smooth, free of all roughness which will cut blades. Remove all corrosion and carbon and stone out rough projections. When observing the undercut, Fig. 1, for the first time, do not mistake it for an imperfection in the cylinder.

Gauge cylinder head dowel pins for straightness by inserting a drill. Solid pins found in older machines should be replaced by the new hollow type. 7/16" O. D. dowels are gauged by inserting the reverse end of a No. 10 drill, 0.1935" Dia., a depth of 1-1/4 inches. Bent pins must be replaced in order to assure proper bottom clearance between rotor and cylinder. Remove pins by clamping on a channel lock and twisting out. If original dowel holes are out-of-round, redowel the head in accordance with "Redoweling Procedure."

Inspect cooling jackets for debris and clean, if necessary.

Clean water side of jacket oil cooler by removing all plugs at each end and "rodding out" each tube. Chemical cleaning may be required if scale is present. This cleaning may be required more than once a year, depending upon water conditions. The oil side of this cooler may be cleaned by circulating a mixture of hot water and steam.

Dismantle lubricator pumping units and check them for free operation through their full stroke. Clean glasses and ball check valves in a solvent. Use this same solvent to clean the oil reservoir and check valves at each lubrication point.

### TWO-YEAR INSPECTION

Every two years the booster should be dismantled completely for inspection of all moving parts. The rear end of the machine is dismantled and inspected by repeating "Yearly Inspection" procedures. The shaft end is dismantled by removing the flywheel or coupling half, then the dual pulley driving the lubricator and oil pump. Using emery cloth and a file, if necessary, dress off any rough spots on the shaft to prevent damage to seal parts during disassembly.

Oil is drained from the seal housing and then the seal cover plate removed, exposing the front seal parts for ready removal. Seal equalizer and jacket cooling tubing is disconnected. Flange bolts are removed from the seal housing and two of them inserted in the jacking holes provided to force out the seal housing. Sliding the seal housing along the shaft also moves the inner seal parts. Thus they

may be moved forward until readily accessible and then removed before the housing is pulled all the way off the shaft.

The front end bearing is provided with thrust faces to lock the rotor into a fixed position in the front cylinder head. That bearing may be dismantled by removing the locknut and washer. This permits removal of the inner race collar, which then allows the front cylinder head to be removed and the rotor to slide out in either direction.

Use a long drift pin and hammer to loosen bearing locknuts. Look for arrow on locknut to indicate direction of removal. Remove the locknut, lockwasher, spacer and fixed bearing thrust ring. Disconnect oil tubing and jack off the head, following the same procedure used on the rear head. Bearing shims used to establish the fixed end clearance should be removed carefully for reuse.

An interior view of the cylinder is shown in Fig. 16. Suction ports are large, discharge ports are small and well down on the side of the cylinder. In the FES-Fuller machine, an "undercut" will be observed at the bottom of the cylinder. This 3 or 4 inch band is machined to the radius of the rotor to provide the maximum seal between discharge and suction. Seeing it for the first time, some engineers mistake this change in contour for a mechanical defect, rather than a part of the gas sealing system.

Before cleaning, the oil film on the cylinder wall should be observed for thoroughness of lubrication. Any rough spots on

cylinder wall or heads should be stoned smooth to prevent blade damage. Roughness along edges of the rotor slots should be filed off for this same reason. Inspect both bearings for signs of wear on races and rollers. Appearance of "skid" marks or other wear requires bearing replacement.

Inspect shaft seal parts for wear and deterioration. Examine seal seats (10RS) for secure fit with gasket (11RS) in counter-bore and for wear of face. Examine gaskets (11RS) for brittleness caused by overheating. Check carbon faces (12RS) for cracking, chipping, bleeding of babbitt metal from face, and wear of face. Check friction rings (13RS) with ring band (15RS) assembled in place for firm grip on shaft. Examine friction ring for brittleness caused by overheating.

Clean seal equalizer tubing to bearing cavity. Dismantle and clean the ball check valve in this line. This is a gravity type (no spring on top of ball) which must be installed in a position to permit flow from bearing cavity into seal chamber. Its function is to blow down high bearing pressure into the seal cavity to prevent "popping" the inner seal face. Grease or oil in the ball check valve, or dirt in the tubing will keep this from working properly.

Clean equalizer connection and orifice fitting (part No. 14) between seal and compressor discharge pipe. This is connected to the downstream side of the non-return valve to assure that intermediate pressure is applied to the seal chamber at all times.

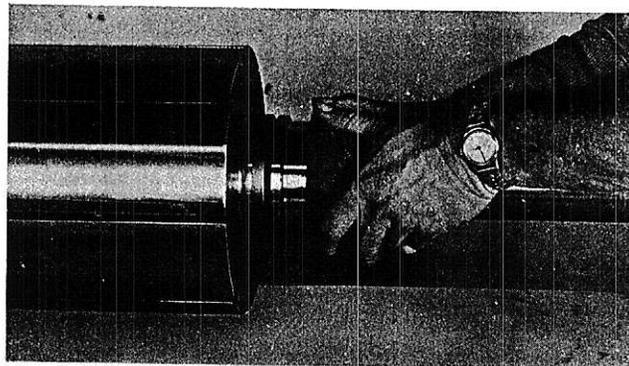


Fig. 15 Installing pre-heated bearing inner race.

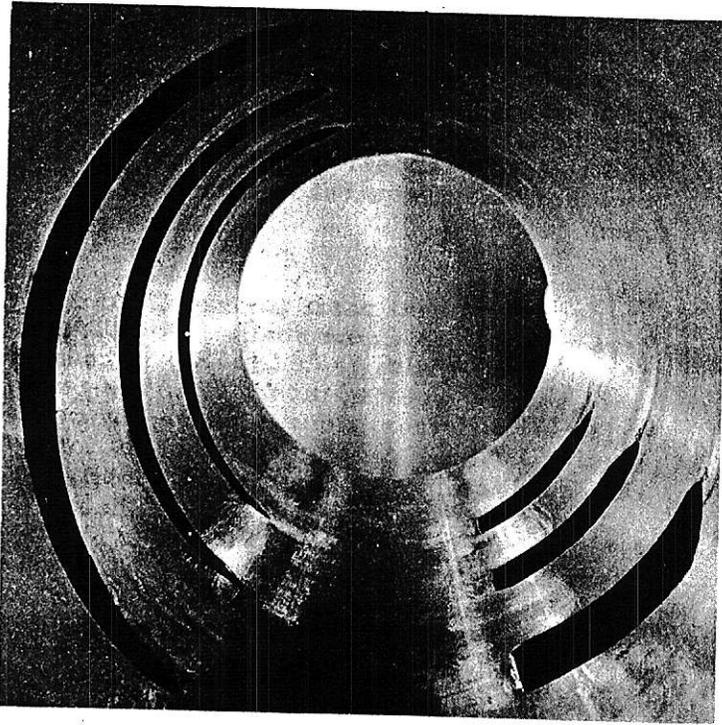
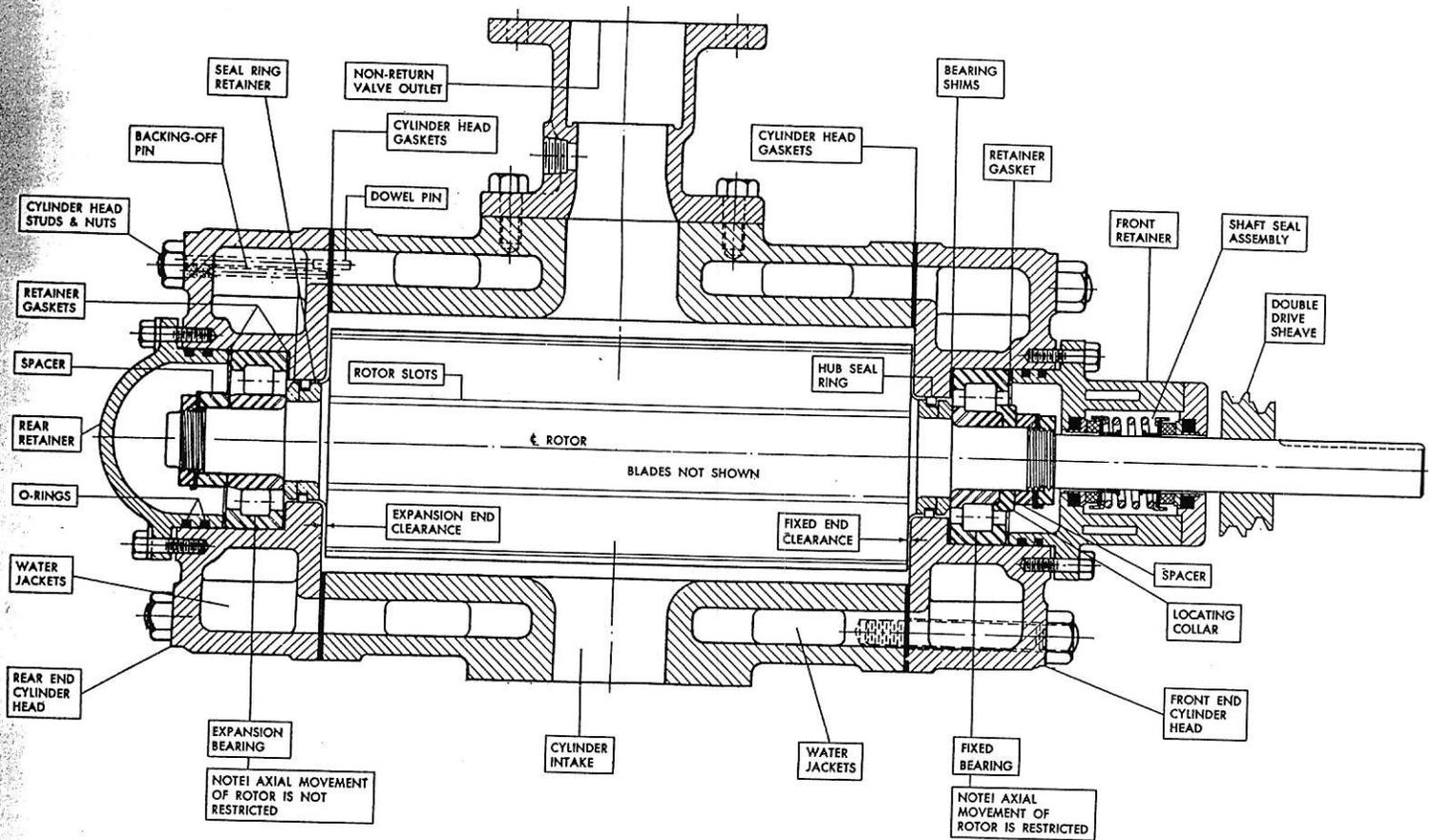
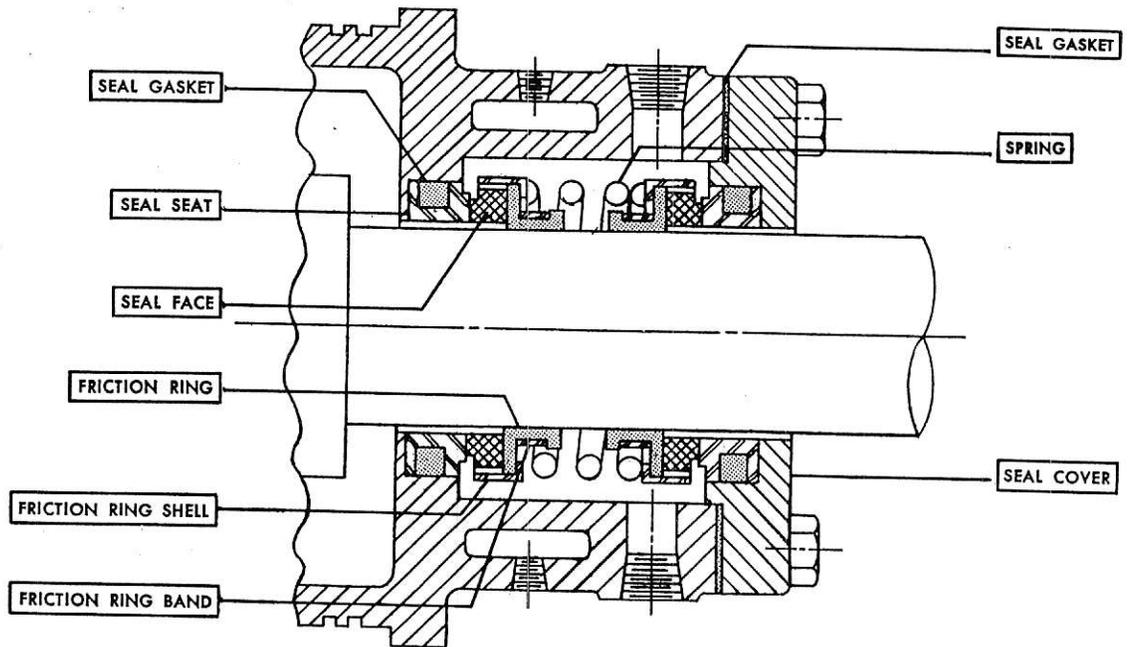
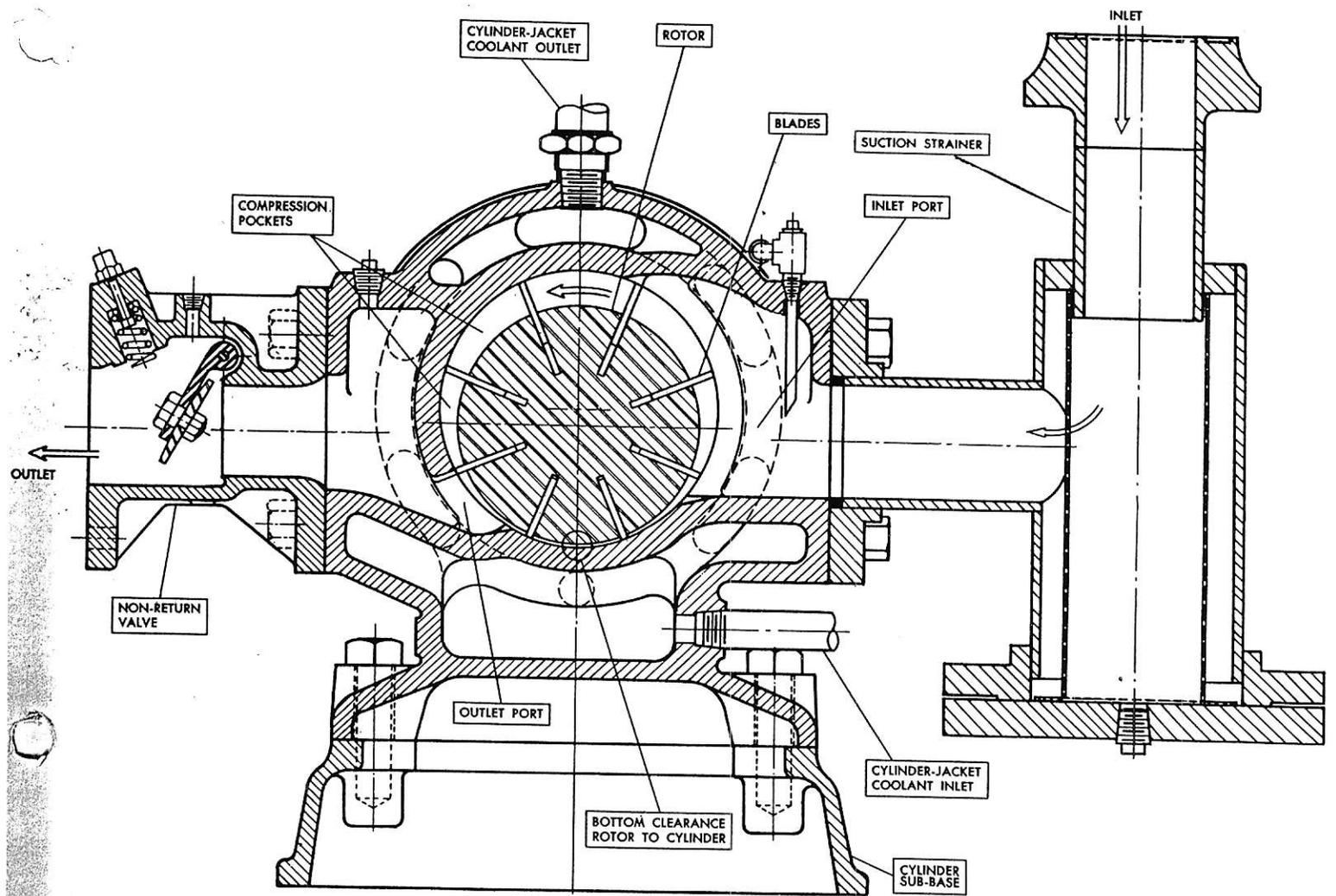


Fig. 16 Interior view of cylinder showing intake and discharge ports. Note smooth intersection of main and undercut bores.





## ASSEMBLY

### BEARINGS AND SEAL RING RETAINERS TO ROTOR

Place rotor on "v" blocks, clean shaft thoroughly and oil lightly. The hub seal retainers and inner race of the bearings are furnished for a shrink fit and must be heated in an oil bath before assembling to shaft. Heat bearing inner races to 275°F. for 15 minutes and ring retainers to 450°F. Do not heat with a torch and do not overheat. See Fig. 15.

Retainers are usually furnished in a two-piece construction from the A-60 size and up. The rings are split for replacement since they can be extended over the assembled bearing race and retainer and slipped into the ring groove.

Bearing inner races are not alike. The fixed bearing inner race, assembled on shaft end nearest driver, has a shoulder and separate collar to hold rotor axially. See Fig. 17. **ALWAYS REPLACE BEARINGS AS COMPLETE ASSEMBLIES - DO NOT INTERCHANGE PARTS.**

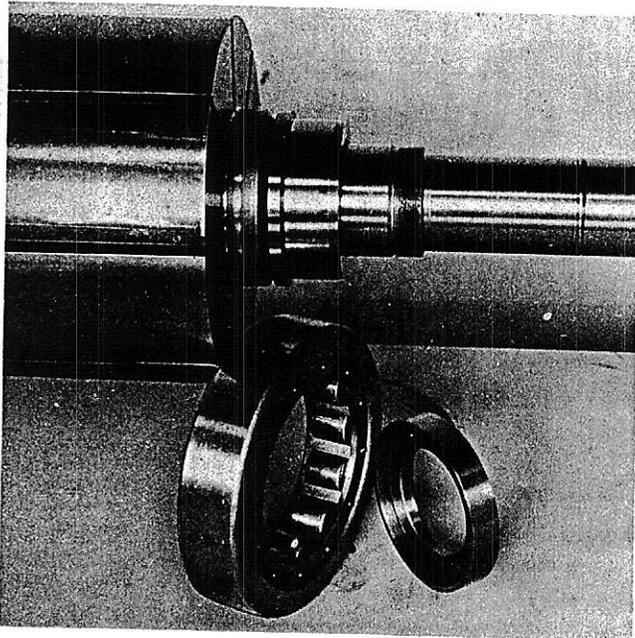


Fig. 17 Fixed end bearing parts with inner race assembled.

### CYLINDER HEAD GASKETS

In replacing gaskets, first measure by micrometer the total thickness of gasket material formerly employed under each cylinder head, then replace with new gaskets

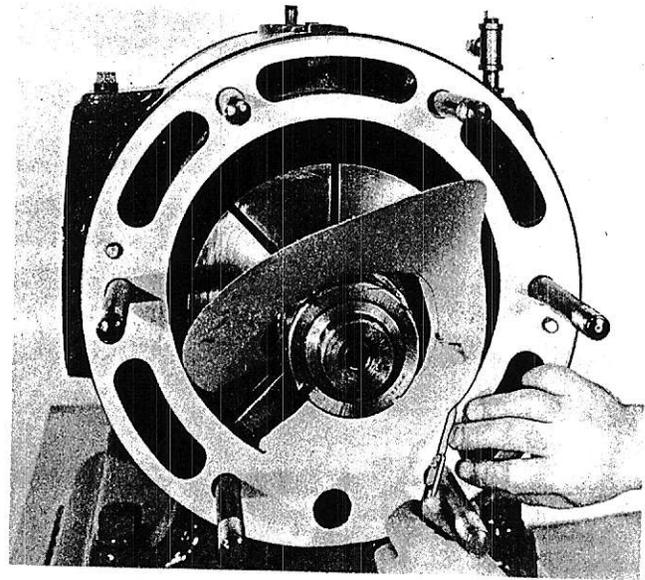


Fig. 18 Trim cylinder head gaskets to suit cylinder bore.

of same total thickness as before, plus two thousandths of an inch for each layer of gasket used. This latter is to allow for compression of new gasket material, which amounts to about .002" for each sheet.

For new parts or if machine work has been done on cylinder, rotor, or heads or if old gaskets cannot be measured, see section on rotor end clearances.

The center of the gasket has purposely not been cut out. This is because it is necessary to match the edge of cylinder wall with the edge of the gasket over the head studs, cutting proper openings for dowels, then with gasket pressed against the end face of the cylinder, run a sharp knife blade around the cylinder bore and cut out the center of gasket to match the edge of cylinder wall all the way around. See Fig. 18. Gasket must NOT extend inside the edge of cylinder bore as that will interfere with the action of the rotor blades. Do not recess it beyond cylinder bore, as this will increase clearance volume.

### ROTOR END CLEARANCES

Front and Rear Heads - (See clearance plate on compressor and illustration on page 24.)

**Fixed End Clearance** at front head is set as follows:

- Place three bearing shims and outer race of front bearing into housing of cylinder

head. Shims are available in thickness of .002", .003", .005" and .010".

- Place cylinder head over front end of rotor assembly. Care should be taken to hold bearing outer race and head central to rotor to prevent damaging bearing inner race and hub seal retainer surfaces.
- Assemble the fixed bearing locating collar, fixed spacer and locknut. Do not assemble lockwasher at this time. Tighten locknut firmly.
- Assemble front retainer and fasten tightly to cylinder head. Do not attempt to draw retainer flange tight against head: the skirt comes into contact with the bearing outer race before the flange contacts the head.
- Check for maximum clearance by using three feelers, of equal thickness, inserted between face of cylinder head and end of rotor at three equally spaced points. See Fig. 19. Be sure cylinder head is pulled away from rotor face so that the clearance obtained is maximum. Actual clearance may vary plus .002", minus .000".
- If clearance obtained is more than required amount, the bearing retainer and head must be removed and extra shims added. If less, necessary shims must be removed.

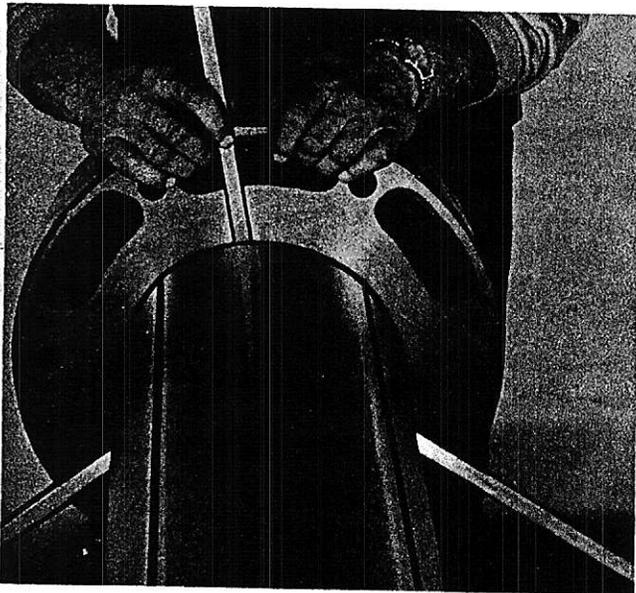


Fig. 19 Checking fixed-end clearance between rotor and front head.

- Check minimum clearance by pushing cylinder head against rotor and inserting feelers at three equally spaced points. Check minimum clearance to be certain that it equals or exceeds values listed in table 2.
- If doweling is required, establish bottom clearance as indicated in next section.

If doweling is not required, complete fixed end assembly as follows:

- Remove bearing retainer, locknut, bearing locating collar and cylinder head with bearing outer race assembled. Place two asbestos gaskets next to cylinder face, trim to suit and reassemble head. Be sure hub seal ring is in place. If teflon rings are used, bend them "oversquare" to assure snug fit in retainer groove while mounting cylinder head. Assemble lockwasher to rotor at this time and bend locking ear into nut groove after tightening locknut firmly.
- Tighten nuts on studs evenly and firmly. Be sure backing-off screws and pins are in place in head. Do not install front bearing retainer.

**Expansion End Clearance** at rear head is fixed as follows:

- Push rotor back against the face of the front head. Place straight edge across face of cylinder at rear end and with feelers, measure clearance back to face

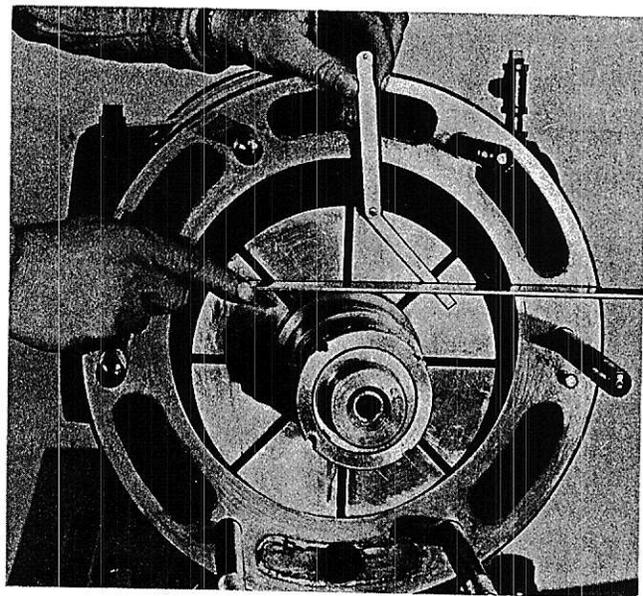


Fig. 20 Checking clearance between rotor and cylinder face at rear end.

of rotor as shown on Fig. 20. Subtract this clearance from the sum of the fixed-end clearance, expansion-end clearance and .002" for each gasket estimated to be used. This gives the total gasket thickness required at expansion end between rear head and cylinder.

**NOTE:** Where rotor extends beyond end of cylinder, add this clearance dimension to the sum of the fixed end clearance, expansion end clearance and .002" for each gasket to give the total gasket thickness.

- Install the quantity of gaskets as estimated above and trim to suit.
- Check for proper gasketing with a lead wire having a diameter slightly greater than the sum of the fixed end clearance, expansion end clearance, and .002" for each gasket. Hang this from the top of the rotor as shown in Fig. 21 with the wire following the periphery or outside diameter of the rotor. In compressors fitted with tapered cylinders, minimum clearance is found on the discharge side of the horizontal center line. In square cylinders, the cold clearance is uniform around the periphery of the rotor.

**NOTE:** Booster sizes 135 and larger are fitted with tapered cylinders beginning with serial number #69-20964-103.

- With bearing outer race assembled, install rear head on studs and tighten firmly and evenly. Then, remove head,

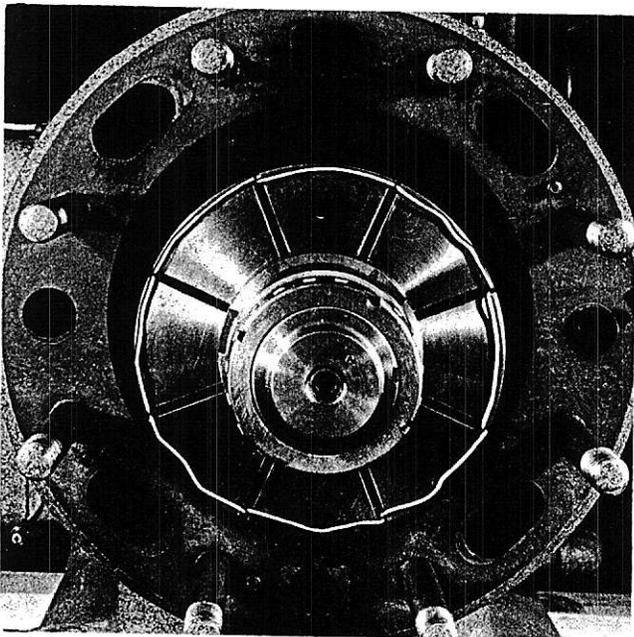


Fig. 21 Checking expansion end clearance with lead wire at rear head.

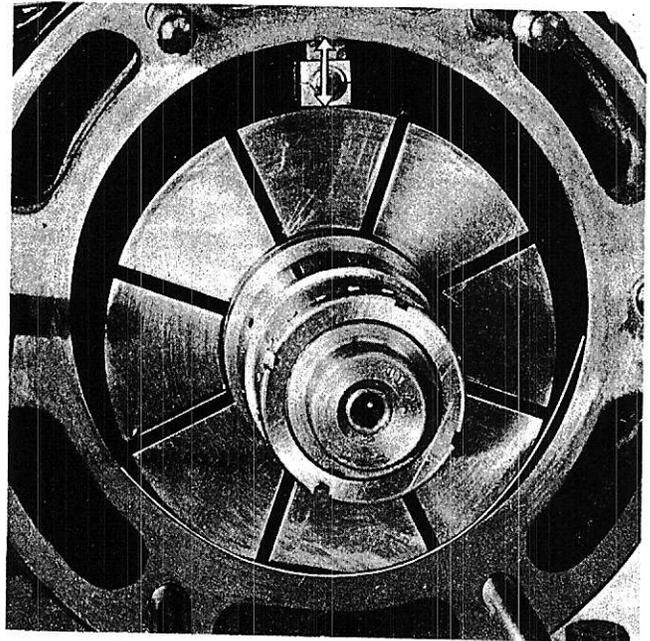


Fig. 22 Wedge rotor against shim stock laid across bottom of cylinder bore at each end to establish bottom clearance.

using backing-off screws and pins to pull clear of dowel pins. Remove lead wire and measure. If lead measurement exceeds sum of fixed end clearance, expansion end clearance and .001" for each gasket for future compression; remove sufficient head gaskets to correct. If less, add sufficient gaskets. For tolerance on this total clearance (See Table 2).

- Indicator method of establishing rotor end clearances.
- Place rotor in cylinder barrel. Install one 1/32" and one 1/64" thick gasket on each end of the cylinder following the procedure outlined and illustrated on page 26.
- Assemble fixed end cylinder head on rotor with outer race of bearing installed. Place race with bearing manufacturer's name at the top and facing outside. Install .010" bearing shims behind outer race. Do not install bearing locknut or bearing retainer at this time.
- Assemble expansion end cylinder head on rotor with bearing, lockwasher and locknut installed.
- Tighten heads firmly using all the stud nuts on each head.
- Mount dial indicator on expansion end cylinder head of compressor and set to indicate end of rotor shaft.

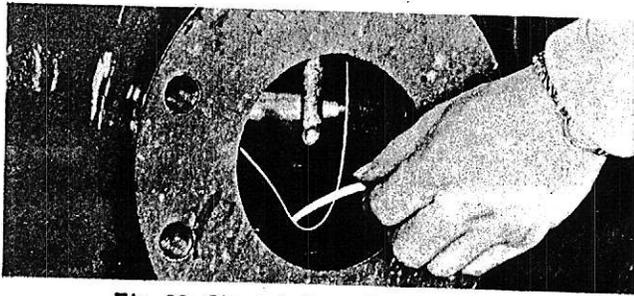


Fig. 23 Check bottom clearance using long feeler gage thru inlet or outlet ports.

- Force rotor forward against the fixed end head using a bar or jack. With rotor in contact with fixed end head set dial indicator to zero setting, making sure the contact point is against the shaft.
- Using bar or jack, force rotor against the expansion end head. With rotor against head, read and record dial indicator reading as "A". This reading is the total float of the rotor between the heads. Repeat procedure several times to verify reading. It should equal the sum of the maximum fixed and minimum expansion end clearances given on the compressor clearance plate and in Table 2, plus .001" for each cylinder head gasket used. If reading differs from this sum, readjust head gasket thicknesses to correct.
- Install fixed end bearing thrust collar, bearing spacer, lockwasher and locknut. Tighten locknut but do not bend lockwasher tab at this time.
- Force the rotor against the fixed end head, and again set the dial indicator to zero.
- Mount fixed-end bearing retainer, with "O"

rings removed, and bolt up tightly. Do not attempt to draw retainer flange tight against head because the skirt comes into contact with the bearing outer race before the flange contacts the head. This step moves the rotor away from the fixed end head in the amount of the minimum fixed end clearance. Read dial indicator and record reading as "B". Repeat procedure several times for accuracy.

(NOTE: See Table 2 for tolerances and minimum fixed end clearances for the various size compressors.)

- Adjust bearing shims to get the correct minimum fixed end clearance. Add shims to decrease—remove shims to increase clearance. After obtaining proper clearance, bend lockwasher tab to secure locknut and install bearing retainer.
- Force rotor toward fixed end and set dial indicator to zero.
- The rotor should now be forced toward the expansion end head again using a bar or jack. This movement represents the axial clearance in the bearing. Read and record as "C".
- The following values have now been established:  
 "A" — Total rotor float.  
 "B" — Minimum fixed end clearance.  
 "C" — Axial play of bearing.  
 "B" + "C" — Maximum fixed end clearance.  
 "A" — "B" + "C" + .001" for each cylinder head gasket = Minimum expansion end clearance.  
 Verify that these final dimensions agree with Table 2 within the tolerances listed.

TABLE 2

Size	FIXED END CLEARANCE - F. E.				EXPANSION END - E. E.	
	Minimum	Tolerance	Maximum	Tolerance	Minimum	Tolerance
A608 508	.015	+ .003 -0	.030	- .003 +0	.147	+ .007 - .003
A350	.012	+ .003 -0	.028	- .003 +0	.103	+ .005 - .003
A300 250	.010	+ .003 -0	.027	- .003 +0	.091	+ .005 - .003
A200 175	.010	+ .003 -0	.023	- .003 +0	.061	+ .005 - .003
A150 135	.010	+ .003 -0	.022	- .003 +0	.061	+ .005 - .003
A120 110	.004	+ .002 -0	.012	- .002 +0	.047	+ .003 - .003
A100 80	.004	+ .002 -0	.012	- .002 +0	.044	+ .003 - .003
A70 60	.004	+ .002 -0	.012	- .002 +0	.034	+ .003 - .003
A50 40 30	.003	+ .001 -0	.010	- .001 +0	.030	+ .003 - .003
A25 24	.002	+ .001 -0	.009	- .001 +0	.024	+ .003 - .003
A15	.002	+ .001 -0	.009	- .001 +0	.016	+ .002 - .002

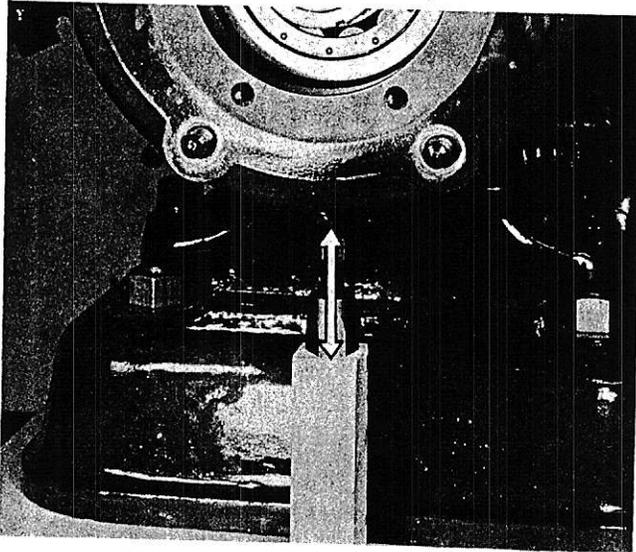


Fig. 24 Lift or jack cylinder head to remove clearance between bottom two bearing rollers and inner race.

- If doweling is required, establish bottom clearance as indicated in next section.

If doweling is not required, complete final assembly as follows:

- Install blades from rear end and be sure they are lightly oiled and fit freely in slots.
- Install hub seal rings.
- Reassemble rear head and tighten nuts on studs evenly and firmly. Be sure backing-off screws and pins are in place in head.
- Push rotor toward rear end and assemble rear bearing retainer with retainer "O" rings. Be sure to tighten retainers evenly and firmly to heads.
- Assemble seal and install drive as instructed in the section, "Shaft Seal".
- Refer to operation section and proceed with start-up accordingly.

#### DOWELING AND BOTTOM CLEARANCE

(See page 25 and clearance plate on compressor.)

- Bolt cylinder feet to firm support. Insert rotor (with bearing inner races assembled) into cylinder and place on shim stock or feeler located approximately

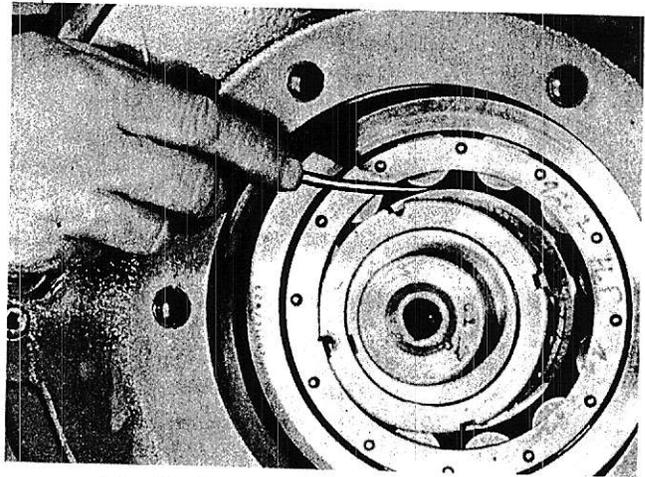


Fig. 25 Equalize clearance between corresponding rollers on either side of inner race by positioning cylinder heads on studs.

1-1/2" from each end. Rotor is assumed to have been indicated and runs true within .001", body to bearing journals, and .003" for shaft at coupling.

Select shims or feelers that are .001" to .002" thicker than bottom clearance specified on name plate and equivalent in length to about half of rotor diameter.

Place fixed end of rotor flush with cylinder face. Insert rotor "jacks" (between top of rotor and cylinder bore) directly above feelers and wedge tightly to cylinder bore. (See Fig. 22).

**NOTE:** If an assembled nut and bolt is used as a rotor "jack", be sure to protect rotor and cylinder surfaces with brass or aluminum sheet stock. Brass or hardwood wedges can also be used.

- Verify bottom clearance at center and both ends of cylinder with long feeler gauges inserted thru inlet and/or discharge ports. Be sure feelers are inserted far enough to carry down over cylinder undercut and underneath rotor body. (See Fig. 23.)

Tolerances on bottom clearances are plus .001"--minus .000" for rotors to 10" in diameter and plus or minus .001" for larger rotors.

- Install cylinder head gaskets as determined by section on rotor end clearances. Use a minimum of two gaskets at fixed

end. Do not trim center to suit bore at this point.

- Assemble the heads to cylinder (with bearing outer races in place) and centralize on studs.

### CAUTION

EXERCISE CARE AS HEAD PASSES OVER HUB SEAL RING TO AVOID BREAKAGE. TEMPORARILY INSTALL PLAIN FLAT WASHERS ON BOTTOM TWO STUDS AND TIGHTEN THESE NUTS. THE BEARING ROLLERS SHOULD NOW TURN FREELY IN THE OUTER RACE. POSITION BEARING SO THAT THE BOTTOM TWO ROLLERS STRADDLE THE VERTICAL CENTER-LINE.

- Jack, or lift with hoist, each head vertically till all clearance is removed between bottom two rollers and bearing races. See Fig. 24. Centralize remaining rollers by shifting head radially from side to side, so that clearance between corresponding rollers on either side of vertical centerline are equal. Check roller clearance with "feelers" as shown in Fig. 25. Tighten all cylinder head stud nuts firmly.
  - Cover exposed bearings with cloths and drill (2) 1/4" diameter holes (180° apart) 5/8" to 3/4" deep into cylinder using "lead" holes in cylinder head. Redrill these holes to 1/64" less than dowel pin diameter and hand ream to size. Blow out cuttings and remove covers.
- Dowels 5/16" x 1" long are used below the A-30 size and 7/16" x 1-1/4" long above.
- Drive a dowel pin into each hole with a solid "drift" until pin bottoms in cylinder. Pins are inserted beveled-end first.
  - Remove cylinder heads, rotor jacks and feeler strip so that rotor is free in cylinder. Break edges of newly drilled dowel holes on cylinder side of heads with a counter-sink. Dowels must be

tight in cylinder and protrude approximately 3/8" to 1/2" beyond cylinder ends.

- \* Reassemble heads to cylinder and bearing retainers to heads and make a final check of bottom clearance as described previously. Be sure cylinder head backing-off pins are in place before assembly.

Complete final assembly as described previously.

Special tools, as follows, can be procured from Freezing Equipment Sales for the 7/16" dowels:

- 1/4" high speed drill, 8" flute, 12" overall.
- 27/64" high speed, straight shank extension drill, 8" flute, 12" overall.
- 7/16" spiral flute reamer with extended shank, 12" overall.

Other tools required for redoweling and obtaining clearances during assembly are:

- 2 - 1/4" T handle hex wrench - for cylinder head jack screws.
- 1 - 1" x 1" x 6" CP-120 Carborundum stick-to smooth rough spots on heads and cylinder walls.
- 1 - Starrett #245 engineers taper, wire and thickness gauge.
- 3 sets - #10 Feeler stock, each set consisting of one .0015", .002", .003", .004", .005", .006", .007", .008", .009", .010", .011", .012", .013", .014", .015" - to measure end and bottom clearances.

## TROUBLE SHOOTING

Operating difficulties and failures are discussed in this Section, symptoms indicated, and probable causes listed. Refer to the appropriate Manual Section for instructions on inspection and repair. Compressor damage must be repaired; it is equally important to correct operating conditions which caused this damage. Let's avoid a repetition!

**Bearing Failure, Fixed End** is indicated by noise, hot cylinder head, leaking shaft seal, or visible longitudinal shaft "float." In severe failure, the rotor may jam.

Lubrication failure or use of light oil should be checked first. Inspect lubricator pumping unit and oil tubing. If bearing cavity contained less than 1/2 pint or 1 pint of oil (depending upon size), lubrication failure is indicated. Heavy thrust loads created by rotor rubbing the rear head, stuck blades, or liquid "slugging" will damage this bearing. High operating temperatures or bent rotor shaft can also cause bearing failure.

Inspect all internal parts. Check shaft runout as instructed in "Rotor Jammed" paragraph, this Section.

**Belts Slipping** indicate overload, can also cause motor overload. Check drive alignment for uniform distribution of load over all belts and tighten the drive according to instructions in the rear of this Manual. If slipping continues, check lack of lubrication, tight blades, or a bad bearing.

Overheating of cylinder and heads will normally be found. Check and adjust the lubricator. Stop the compressor with suction valve closed. If it spins freely, internal parts are all right. If the rotor is tight, secure the compressor, remove rear head and inspect compressor as directed in "Yearly Inspection."

**Blades Broken** frequently jam the rotor, or produce noisy operation, vibration, hot operation and/or loss of capacity. Dismantle compressor as instructed in "Two-Year Inspection." If rear head is difficult to remove, dismantle front head first, which may permit sufficient rotor movement to free rear head.

Clean cylinder, discharge piping, check valve and expander pocket thoroughly to remove all debris. Examine cylinder for signs of damage if rotor has wedged blade against cylinder wall. If necessary, apply a pressure test to cylinder by assembling heads with gaskets on cylinder (rotor not installed), bring cylinder temperature up to 150°F. by circulating hot water through jackets, then with water remaining in jackets, apply 75 PSIG test pressure by means of air or compressed gas and observe in-

terior of cylinder for leaks. A cold pressure test is not always conclusive.

**CHECK ROTOR AND SHAFT FOR BENDING. INSPECT DOWEL PINS.** See "Rotor Jammed" paragraph for details.

Old blades worn in height and width will jam in slots and break. Warped or swollen blades, or those jammed by dirt in the rotor slots will break if not free to retract fully within the rotor after passing the discharge port. Liquid refrigerant or oil in the cylinder at startup, or heavy "slugging" while running will break blades.

**Blades Stuck or Binding** are indicated by overheating, belt slipping, motor overload, or failure of shaft to turn freely. Dismantle compressor as directed in "Yearly Inspection" Section and repair or replace blades.

Excessive return of sludge from evaporator jams rotor slots. Liquid ammonia in cylinder during shutdown will warp and expand blades. Long blades will rub against heads and be restricted from sliding freely in rotor slots.

**Hot Operation** results from wrong operating conditions, improper adjustment, or mechanical defect of some part. Check the following:

- Suction and discharge pressures must not exceed those given in Fig. 6. Change conditions to conform if necessary.
- Low suction pressure due to light load, "starved" evaporator, oil logged evaporator, clogged suction strainer, or excessive throttling by hand valve or suction pressure regulator. Set Low Pressure Cutout to stop compressor at higher pressure. On batch freezing applications do not permit "short cycling" at end of freezing cycle.
- Suction temperature should be less than 50°F. above saturation temperature corresponding to suction pressure. Normal suction superheat is 10 to 30°F. Lack of or leaking suction line covering, "starved" evaporator, or faulty design must be corrected to lower suction gas superheat.
- Jacket oil pump belt tight and pump running at full speed. Usual oil temperature range is approximately 10°F. Higher range indicates low oil circulation.

- Loss of jacket cooling oil.
- High cooling water temperature, or not enough cooling water--5 GPM for each oil cooler circuit is the normal requirement.
- Dirty water or jacket oil circuit. Remove plugs and mechanically clean the inside of the tubes. Clean oil cooler and jackets by steam, or by circulating solvent.
- Leaking relief valve, or booster by-pass.
- Lack of lubrication - check lubricator drop rate, be sure oil is not accumulating in bottom of lubricator sight glass.
- Worn or stuck blades - blades worn 1/4" or more in height or 1/32" short of rotor length must be replaced. Verify that blades are free to slide in rotor slots and are not rubbing against cylinder heads. When pushed against the front head, blades should not project beyond the rear end of rotor. If blades must be sanded or shortened, see instructions on blades under "Yearly Inspection."
- Vacuum breaker check valve in capacity reduction compressor stuck open while operating at 50 per cent capacity. Vacuum breaker line between suction strainer and base of compressor is cool during 50 per cent capacity operation. If this line is hot, the check valve in base of compressor is stuck open and must be freed.
- Damaged bearing will generally overheat cylinder head.
- Leaking hub seal ring will overheat cylinder head.

**Liquid Slopover** can cause serious compressor damage at start up and during operation. Even small amounts of liquid in the cylinder at start up will break blades. Small amounts entering the compressor during operation can be handled in most cases, but a large "slug" of liquid refrigerant or oil will cause serious damage to blades, overload the bearings and bend the rotor. Every effort should be made to prevent liquid from entering the compressor by providing adequate traps, draining headers, and connecting compressor suction lines to the top of the header.

**Loss of Capacity—** Check the following:

- "Starved" evaporator
- Seal "blown" in H.P. Receiver, or hot gas accidentally entering evaporator through defrosting valve.
- Clogged suction strainer
- Slipping V-belts, resulting in low compressor speed.
- Liquid "slop-over."
- Blades worn more than 1/4" in height, or 1/32" shorter than rotor.
- Excessive rotor clearance between cylinder heads and/or bottom of cylinder.
- Leaking relief valve, booster by-pass valve open or leaking. Either of these will also cause compressor overheating.
- By-pass valve open on capacity unloader compressor.

**Motor Overload—** Check starter overload elements for proper size and setting. High ambient temperatures will cause overload elements to trip below normal rating. Loose wires may cause local overheating and excessive current draw. High motor temperature may be normal-check design temperature rise stamped on motor name plate. Check motor bearings for overheating due to excess belt pull or misalignment. Check motor amps in all 3 phases.

Compressors will exceed design horsepower requirements if suction and/or discharge pressures are above normal. For temporary correction, throttle booster suction. Throttled operation for long periods will overheat the booster; therefore, watch booster discharge temperature. Excess liquid "slugging" can also overload the motor. Throttle the suction for temporary relief; then locate the source and correct it.

Lack of lubrication, tight blades, or a bad bearing may cause excess power consumption by the compressor. See "Belts Slipping," this Section.

**Rotor Jammed—** If the rotor will not turn, dismantle the compressor as instructed in

"Two-Year Inspection" and inspect for stuck or broken blades, rotor rubbing rear or front head, rotor rubbing bottom of cylinder, damaged front or rear bearings. Complete repair instructions are given in the section referred to. If compressor is hot, drain jackets and allow to cool before opening. If rear head is difficult to remove, removal of front head may be easier and may permit sufficient rotor movement to free rear head.

If blades are broken or stuck, proceed with inspection and repair as directed in preceding paragraphs on Blades, this Section.

Rub marks on cylinder heads may be stoned smooth. Refacing is required if indentation exceeds .005". When refacing a head, be certain the finished face is square with the bearing cavity; if not, the bearing will be cocked and wear rapidly. Also, when machining the head, cut the fillet radius to original shape to restore the original clearance between rotor shaft and head.

Any scuff marks in the bottom of the cylinder can be stoned smooth. Reboring is unnecessary unless the patch of disturbed metal exceeds 10 per cent of cylinder length and .010" depth. Do not mistake the "undercut" for cylinder scoring.

Metal picked up by the rotor, on ends or circumference, must be removed by grinding. This metal is too hard to be cut by tools normally available. Center the rotor in a lathe and mount a grinder on the tool post. Following this operation, carefully clean and deburr rotor slots to assure free blade movement.

**CHECK ROTOR AND SHAFT FOR BENDING AFTER ANY ROTOR JAM.** With bearing outer races in place, mount outer races in "V" blocks and indicate drive shaft at outer end, center, and in front of bearing locknut; indicate rotor body at each end and at middle; indicate end of stub shaft carrying rear bearing. If a bearing is damaged, remove inner race and support shaft in "V" block located in way of bearing inner race. Maximum tolerance on runout at any point is .003", ignoring spots of metal pickup. If less than .020", shaft runout can be corrected by straightening. Runout of the rotor body is generally corrected by machining or grinding. After

straightening, inspect shaft for cracks by X-ray or Magna-fluxing. Twisted shafts can be corrected only by remachining the keyway, in which case the flywheel hub must be reslotted to match.

**AFTER ANY ROTOR JAM INSPECT DOWEL PINS FOR BENDING AND TIGHT FIT IN HOLES.** See "Yearly Inspection" for procedures. Re-dowel the heads if dowel holes are not true.

Following are typical causes of the difficulty indicated:

- Rotor rubbing rear head - Discharge gas temperature above 300°F. will cause the rotor to expand, use up all the expansion end clearance and strike the rear head. Also, this rubbing will frequently overload thrust faces of the fixed end bearing and cause it to fail.
- Rotor rubbing front head - Improper setting of fixed end clearance or failure of the fixed end bearing will permit this rubbing.
- Rotor rubbing cylinder - High discharge gas temperature may expand the rotor to use up all clearance between bottom of rotor and cylinder wall. Accumulation of liquid refrigerant in a warm cylinder during temporary shutdown will warp the rotor. On startup, if temperatures have not equalized and straightened the rotor, the convex section will strike the cylinder wall.

**Seal Leakage**— See Shaft Seal Section.

**Short Cycling** is caused by plant operating conditions. It should be corrected in order to avoid damage to motor and starter. Determine the control responsible for short cycling and either readjust it or modify operating conditions slightly to avoid the problem. If readjustment of controls will not solve the problem, it may be necessary to install a timer to increase the interval between starts.

**Vibration and Noise** of the compressor may be caused by stuck blades or a worn bearing. See "Yearly Inspection" for instructions on blade inspection. A worn bearing will generally be indicated by noise and/or a hot cylinder head. Remove V-belts or coupling pins and run motor at no load to check possible motor unbalance. Check balance of compressor flywheel.

## RECOMMENDED SPARE PARTS

(For Compressors installed in Continental United States and Canada)

<u>Quan.</u>	<u>Item</u>	<u>Part No.</u>
1 Set	Blades (8/Set)	3
1 Set	Cylinder Head Gaskets (4/Set)	21
1 Set	Hub Seal Rings (2/Set)	17
1	Shaft Seal Assembly W/Gasket	10RS thru 16RS and 55
1 Set	"O" Rings (4/Set)	24

### Add to Above

(For Continental United States and Canadian Remote Areas lacking direct shipment means and for ALL Export Shipments)

<u>Quan.</u>	<u>Item</u>	<u>Part No.</u>
1	Fixed End Bearing W/Locknut and Washer	6 and 8
1	Expansion End Bearing W/Locknut and Washer	7 and 9
1 Set	Bearing Shims (3/Set)	22
1	Jacket Coolant Pump	
1	Jacket Coolant Pump Belt	
1	Lubricator Pumping Unit (For every 3 Units on Compressor) (3 unit reqs. 1) (5 unit reqs. 2) (7 unit reqs. 3)	
1	Lubricator Belt	47

Always Order Spare and Replacement Parts by Description and Part Number as shown on Spare Parts Lists in this Manual.

Always Include Machine Size and Serial Number as stamped on nameplate.

Order From  
 FREEZING EQUIPMENT SALES, INC.  
 1405 NORTH DUKE STREET  
 YORK, PENNSYLVANIA. 17404  
 Phone 717-8545524

Spare blades are supplied in a sealed can to provide protection during storage. Do not open can until ready to install blades.

Replacement bearings should be procured from Freezing Equipment Sales, as they are assembled with special internal clearances to suit the design of this compressor. No parts of bearing assembly are interchangeable.

### PARTS LIST

PART NO.	DESCRIPTION OF PART
1	CYLINDER
2	ROTOR
3	BLADES
4	FRONT HEAD
5	REAR HEAD
6	FRONT BEARING FIXED END
7	REAR BEARING EXPANSION END
8	FRONT LOCKNUT & WASHER
9	REAR LOCKNUT & WASHER NOTE—NUTS ARE RIGHT AND LEFT HAND THREAD TO TIGHTEN AGAINST ROTATION
10	FRONT SPACER
11	REAR SPACER
15	FRONT RETAINER
16	REAR RETAINER
17	HUB SEAL RING
18	SEAL RING RETAINER, 2-PCE, A60 AND ABOVE
19	STUDS & NUTS
20	DOWEL PINS FRONT & REAR

### PARTS LIST

PART NO.	DESCRIPTION OF PART
21	HEAD GASKETS FRONT & REAR
22	FRONT BEARING SHIMS
24	O RINGS
26	NON-RETURN VALVE BODY
27	HINGE DISC ASSY. INCL. BOLT & NUT
28	HINGE PIN & WASHERS
29	SPRING
30	LOCK SCREW
31	WASHER
32	CAP NUT
33	LEAD WIRE GASKET
34	INLET FLANGE GASKET
35	OUTLET FLANGE GASKET
57	SUCTION STRAINER BODY
58	SUCTION STRAINER SCREEN
59	STRAINER COVER GASKET
60	STRAINER COVER
61	STRAINER DRAIN PLUG

*BIC @ 125  
Jacket oil Temp  
Cutout  
Auto Reset*

*BIC @ 300  
High Temp Cutout  
A30 to 155  
Manual Reset*

*BZC  
Combo Hi-Low*

