RECIPROCATING REFRIGERATION COMPRESSORS FOR AIR CONDITIONING SYSTEMS

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1. GENERAL

1.01 This section describes the operation and maintenance of reciprocating refrigeration compressors employed in air conditioning installations which use fluorinated hydrocarbons, such as Freon, as the refrigerant.

1.02 This section is reissued to incorporate material from the addendum in its proper location. In this process marginal arrows have been omitted.

1.03 This practice is intended to provide basic information on reciprocating refrigeration compressors so that the maintenance employee will be prepared to operate and maintain the many makes and varieties of machines he is likely to encounter in telephone buildings. It is expected that manufacturers' instruction manuals covering each specific model installed will be available to supplement this practice.

2. DESCRIPTION

2.01 The function of the compressor in the refrigeration cycle is to remove heat-laden refrigerant vapor from the evaporator and to increase the pressure of this vapor to a point at which the condensing process can be readily accomplished.

2.02 Most modern day reciprocating compressors use either dichlorodifluoromethane (R-12) or monochlorodifluoromethane (R-22) which for simplicity sake hereinafter shall be called refrigerant. Other refrigerants, such as ammonia, carbon dioxide, sulphur dioxide, or methyl chloride may be used but have been generally replaced by the aforementioned fluorinated hydrocarbons in the air conditioning field.

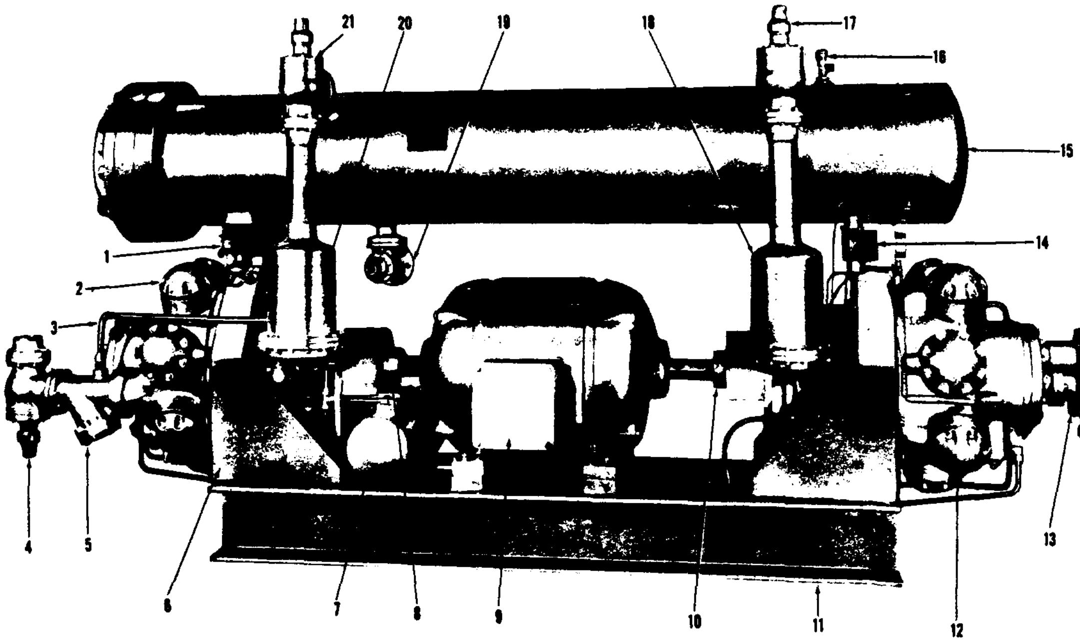
2.03 Reciprocating compressors can be classified according to their cylinder arrangement as vertical, horizontal, radial or "V" type, and as open type or hermetically sealed. Fig. 1 illustrates a radial-type compressor as a part of a condensing unit while Fig. 2 shows a "V" type compressor.

3. COMPONENT PARTS

Figs. 3 and 4 illustrate the major component parts of a "V" type reciprocating compressor. Other types of reciprocating compressors have similar components.

3.01 *Compressor Body:* The compressor body is usually made of cast iron. The body is cast in one or two pieces. The one-piece compressor is cast in one block with a plate under the crankcase while the two-piece type has the crankcase and cylinders cast separately and the parts bolted together.

3.02 *Pistons* in a majority of compressors are made of cast iron. They are classified with regards to the location of the suction valve. The valve-in-head type has the suction valve located in the crown or top of the piston while with the solid head type the suction valve is located in a valve plate. These pistons usually have two or three upper compression rings and one or two oil control rings at the bottom.



1. HIGH AND LOW PRESSURE SWITCH
2. NO. 1 COMPRESSOR
3. PRESSURE RELIEF VALVE TUBE
4. SUCTION SHUT-OFF VALVE
5. SUCTION STRAINER
6. COMPRESSOR SUPPORT
7. OIL TANK
8. MOTOR COUPLING
9. MOTOR
10. MOTOR COUPLING
11. FRAME
12. NO. 2 COMPRESSOR
13. SUCTION SHUT-OFF VALVE
14. DIFFERENTIAL PRESSURE SWITCH (USED IN CONJUNCTION WITH OIL PRESSURE SAFETY SWITCH CONNECTED TO NO. 1 COMPRESSOR ON BACK OF UNIT)
15. CONDENSER
16. PRESSURE RELIEF VALVE
17. DISCHARGE SHUT-OFF VALVE
18. OIL SEPARATOR
19. LIQUID SHUT-OFF VALVE
20. OIL SEPARATOR
21. DISCHARGE SHUT-OFF VALVE

Fig. 1 — Radial Condensing Unit

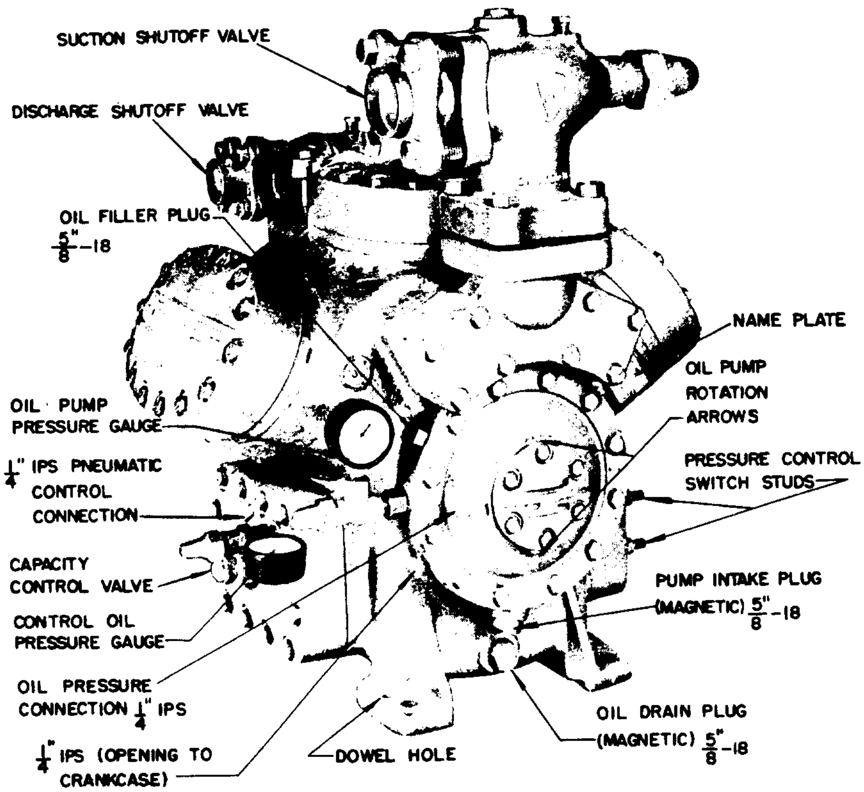


Fig. 2 — "V" Type Compressor

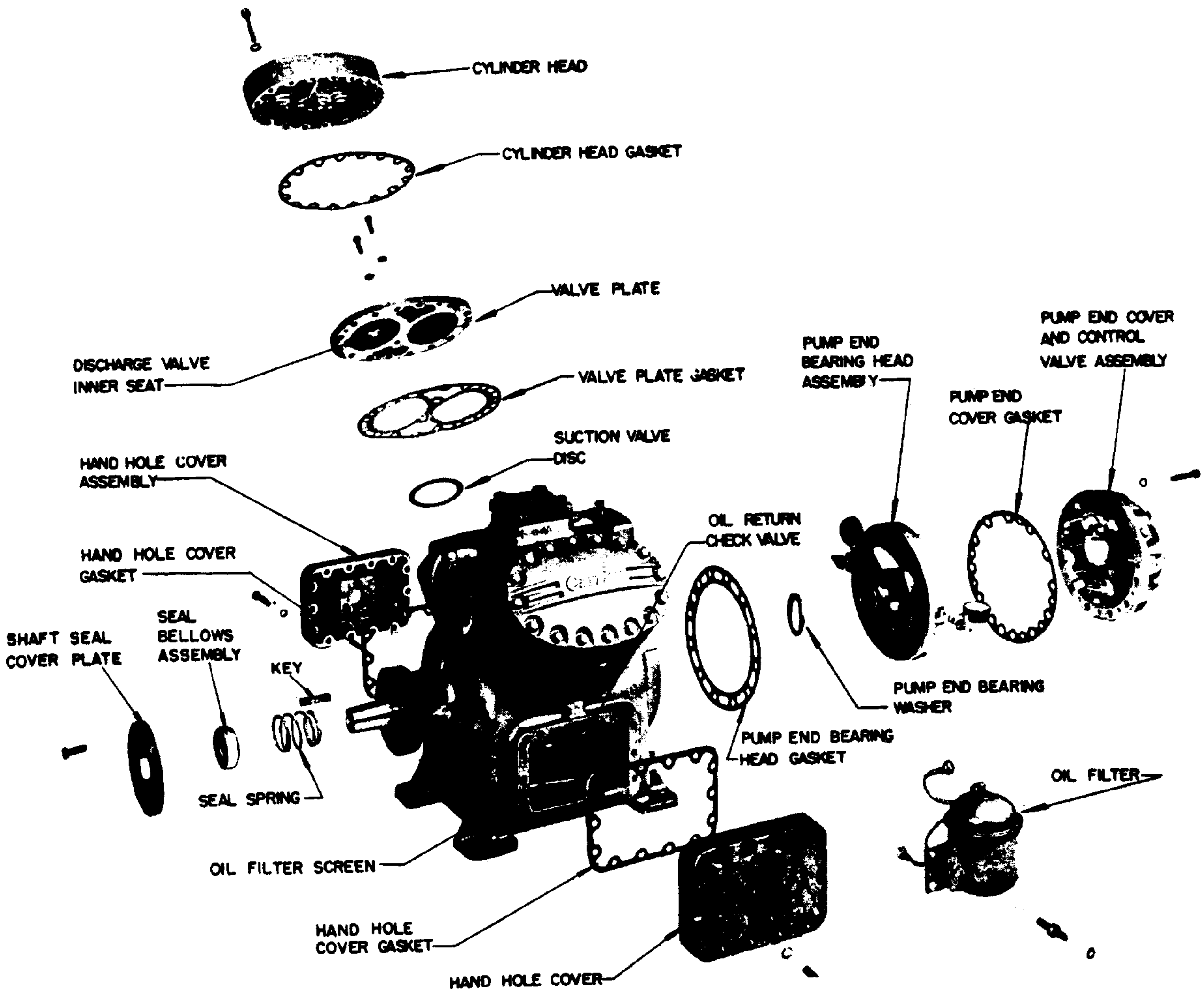


Fig. 3 — Major Components of Compressor Assembly

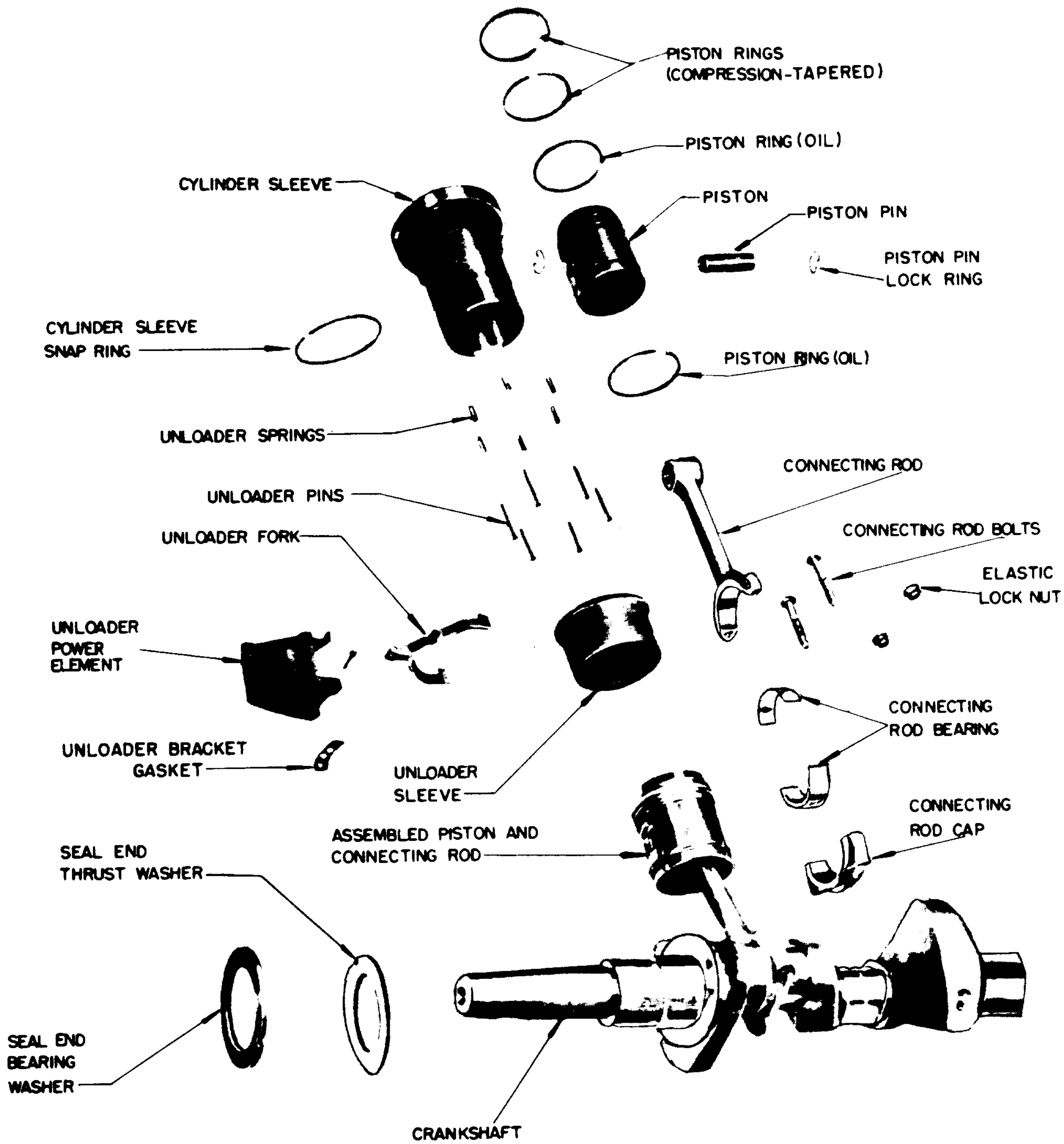


Fig. 4 — Major Component Internal Parts

3.03 *Crankshafts:* Crankshafts are fabricated of alloy steel. They are carefully balanced to eliminate vibration. In a forced lubrication system they are drilled for oil passage. One end is made to take up thrust and the other end to receive the flywheel or motor coupling.

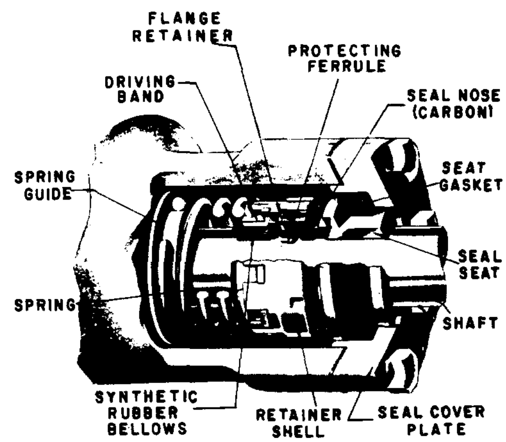
3.04 *Bearings:* The most common material for main bearings is bronze or leaded bronze; however, some larger size compressors use steel-backed centrifugally cast babbitt bearings. The connecting rod bearings are normally made of bronze for the smaller machines and centrifugally cast insert type in the larger units.

3.05 *Cylinder Heads* are made of cast iron and can be classified by the means used to cool them. Cooling of the cylinder heads as well as the cylinders may be by air, water, or refrigerant. Most commercial units are of the air-cooled type.

3.06 *Valves and Valve Plates:* The valves of the compressor can be considered the heart of the system and are subject to severe service. The most common types are the disc or feather valves. These valves are made of special steel and having little weight are able to vibrate in unison with the strokes of the fast moving piston. Some compressors have the suction valve in the piston; however, the trend is to locating both the suction and discharge valves in a valve plate which is bolted between the body and the head thus permitting replacement of both valves with a minimum of difficulty. ***Of primary importance to the servicemen is the proper seating and tightness of the valves.***

3.07 *Cylinder Head Safety Springs:* To prevent serious damage to the compressor some cylinder heads are equipped with a safety spring. Under normal conditions the discharge valve opens and allows gas to pass into the discharge chamber. The lift of the valve is limited by the valve guide. If liquid or oil becomes trapped between the top of the piston and the valve plate a hydraulic pressure is set up and the disc and valve assembly lift allowing the liquid to discharge into the head. The disc and valve assembly are held in place by the safety spring which under normal operation holds the valve in place and reseats the valve after a slug of liquid has passed.

3.08 *Shaft Seals:* (Fig. 5) Seals are provided where the crankshaft goes through the body of the compressor to prevent leakage of gas and oil. Normal packing, such as is common in water valves, is not suitable because of localized wear. A common-type mechanical seal is made of self-lubricating bronze and has a neoprene rubber washer which makes a gas- and oil-tight joint between the ring and shaft shoulder. A spring with a thrust of about 20 pounds, holds the seal firmly against the seal ring. The seal ring turns with the shaft and is secured to it by friction or by a pin which fits into a slot in the shaft. The rotation of the shaft and the oil film maintain the highly polished surfaces that insure a perfect seal. Should a seal leak develop the compressor will lose refrigerant because its crankcase pressure is greater than atmospheric.



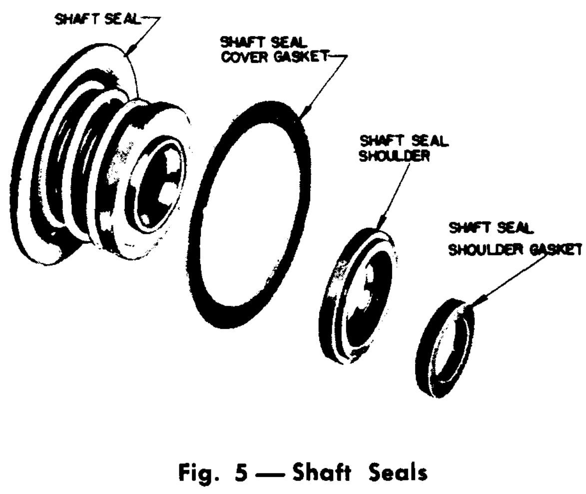


Fig. 5 — Shaft Seals

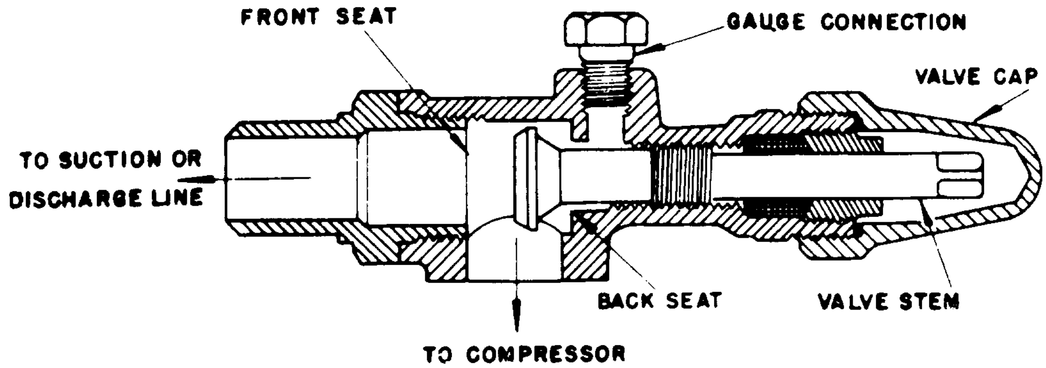


Fig. 6 — Cross Section of Service Valve

3.09 *Service Valves:* Most compressors are equipped with suction and discharge service valves to aid in service operations, Fig. 6. The discharge valve is bolted to the head and the suction valve to either the body or head of the compressor. The valve is known as a back-seating type so that when the stem is turned all the way out, the pressure gauge port and packing are shut off. During normal operation the valve stem is back-seated (see Paragraph 4.02), leaving the line connection open to the compressor. If the valve is closed the gauge port is open to the compressor and the line is shut off. With the stem in midposition the compressor is always open to both the line and the gauge port. Most refrigerant valves are double-seated so that the packing may be changed with a minimum of difficulty. All refrigeration valves should be opened and closed only after the tension has been relieved from the packing by slacking off the packing gland nut one-half turn. The valve stem packing is usually a lead alloy and excessive tightening will damage it and require its replacement. All valve stem caps for packed type valves have gaskets for sealing the valve stem chamber. The gasket must be in place before replacing the cap. On packless valves no leverage other than hand pressure should be used to close the valve; otherwise the diaphragm will be damaged.

3.10 *Unloader Mechanism:* (See Fig. 7) Most recently designed multicylinder compressors come equipped with some form of cylinder unloader mechanism. This device serves a twofold purpose:

(a) Unloaded starting, which permits the motor to start at a reduced load making possible the use of normal starting torque motors.

(b) Capacity control, which automatically regulates compressor capacity to conform to the load. This enables the unit to operate on a varying load with relatively constant suction pressure and coil temperature.

3.11 While there are many kinds of unloader systems they all perform the same basic function, e.g., diverting the discharge gas in each cylinder equipped with an unloader back into the suction manifold. This is accomplished by a mechanical valve lifting assembly which unseats the suction valve when the compressor is not running. When the compressor comes to full speed the unloader is forced to allow the suction valve to seat itself due to a build-up of oil pressure. For capacity control, a valve arrangement controlled by suction gas pressure or branch air pressure from a pneumatic thermostat varies the supply of oil to the various cylinder unloaders. Another type of unloader employs a solenoid to control a three-way valve to load or to unload a cylinder. This solenoid may be activated either by a pressure or temperature control.

3.12 Fig. 7 illustrates one type of unloader mechanism in the "loaded" and "unloaded" positions. The complete assembly consists of a pressure-sensing device, lower portion of each figure to the left of the dash line; a valving mechanism, lower portion to the right of the dash line; and the unloader mechanism, the upper portion.

3.13 The pressure-sensing device maintains a predetermined suction pressure thru a balance of forces consisting of the suction pressure acting in chamber "A" and the action of the spring and atmospheric pressure in bellows "B."

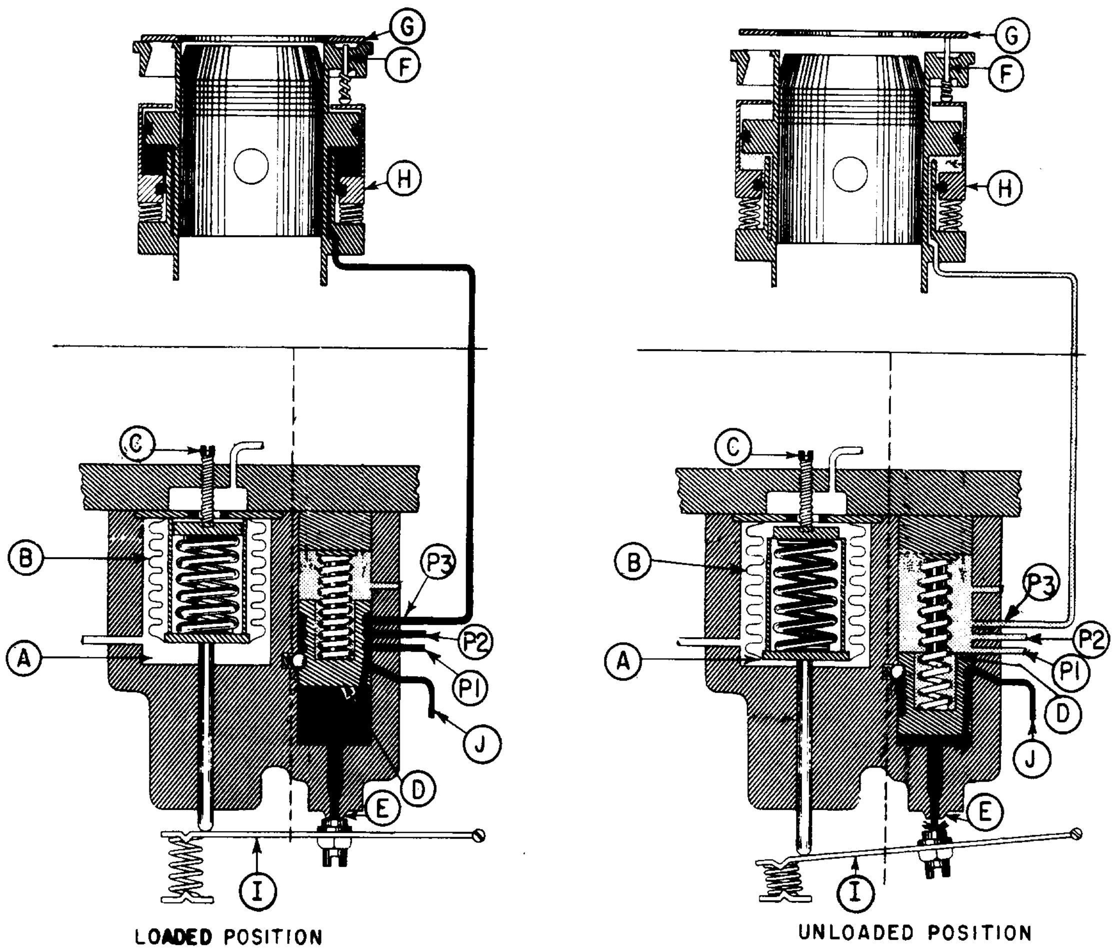


Fig. 7 — Unloader Mechanism

Spring tension can be adjusted at point "C." The function of the sensing device is to regulate the opening of orifice "E" thru changes in suction pressure in chamber "A" as a result of changes in load. Orifice "E" discharges into the crankcase. It will be noted that orifice "E" is closed in the loaded position and open in the unloaded position. During shutdown orifice "E" closes due to the build-up of suction pressure in chamber "A."

3.14 The valving mechanism regulates the supply of oil under pump pressure to operate the various unloaders to suit the requirements of the load. Oil is supplied to the valving mechanism thru line "J" which feeds oil to the chamber below piston "D" and around the annular grooves in the piston. The pressure below the piston is varied from full oil pump pressure to crankcase pressure thru the regulation of orifice "E" by the pressure-sensing device. The chamber above the piston is vented to the crankcase. When the compressor starts the oil pressure builds up under piston "D" forcing the piston upward and allowing oil pump pressure to pass successively to the various unloaders thru "P-1," "P-2," and "P-3."

3.15 The unloader on each piston thru operation of the lifter pins "F" raises or lowers the suction valve "G." In the loaded position oil pump pressure acting on the top of piston "H" causes the lifter pins to retract which allows the suction valve to seat itself. When the system requires less than full refrigeration capacity, the suction pressure will fall permitting the bellows at "B" to expand and move lever "I" downward. As oil pump pressure is allowed to dissipate thru orifice "E," piston "D" moves downward and successively removes oil pump pressure from lines "P-1," "P-2," and "P-3." Loss of oil pump pressure above piston "H" allows it to rise and push on lifter pins "F" which unseat the suction valve "G." With the suction valve unseated the piston can no longer compress the refrigerant gas and the capacity of the compressor is reduced accordingly.

3.16 In normal continuous operation the unloaders load and unload cylinders to adjust the capacity of the compressor to the load on the system. A six-cylinder compressor for example may have unloaders on four cylinders and be capable of adjusting its operation from 1/3 of capacity to full load without stopping. The design of unloader mechanisms and the number of cylinders unloaded on starting varies considerably between manufacturers and compressors. Manufacturers' Operation and Maintenance Manuals should be consulted with regard to the compressor at hand.

3.17 ***Crankcase Oil Heater:*** Some compressors come equipped with an oil heater located in the crankcase. The purpose of the heater is to drive off any Freon which may have become mixed with the oil or has become trapped in the crankcase during shutdown. The heater should be automatically de-energized during the compressor operating cycle to prevent excessive crankcase temperatures and pressures which might cause seal failure and waste of power. On new installations, the proper operation of this item should be checked.

4. TERMS USED IN REFRIGERATION

Certain terms peculiar to the refrigeration industry are defined in the following paragraphs.

4.01 ***Pumping Down:*** Whenever a refrigeration system is to be opened to the atmosphere for service operations or repairs, it is necessary to remove the refrigerant from the part of the system to be opened which process is called pumping down. The refrigerant is confined to the receiver and condenser by closing the liquid line stop valve (commonly known as the king valve) and operating the machine. Thus, all the gas is drawn back through the compressor and confined to the condenser and receiver.

4.02 ***Back-seating a Service Valve:*** Positioning the valve so that the gauge connection may be opened without losing the refrigeration charge.

4.03 ***Charging:*** Term used to denote addition of refrigerant to a system.

4.04 ***Purging:*** Release of air or other noncondensable gases from a system, usually through a purge valve placed on the top of the condenser. Also applied to the sweeping of air out of a newly installed part or connection by releasing refrigerant gas into the part and allowing it to escape from the open end, thus pushing the air ahead of it.

4.05 ***Slugging:*** Refrigerant returning to the compressor as a liquid instead of as a gas causing the valves to be noisy. Also, oil being pumped out of compressor crankcase or returning to it in masses of liquid sufficient to cause the compressor to knock.

4.06 ***Low Side:*** Designates that part of a system lying between the expansion valve and the suction valve in the compressor that is under suction pressure. It includes the evaporating or cooling surface and the suction line. The term is sometimes used also to designate the evaporator coils.

4.07 ***High Side:*** All the remainder of the system, i.e., that under high pressure. Sometimes used also to designate the condensing unit.

4.08 ***Water-regulating Valve:*** A valve used at the water inlet or outlet of the condenser on a water-cooled machine which is operated by the head pressure to admit more or less water to the condenser to maintain a relatively constant head pressure.

5. LUBRICATION

5.01 The lubricating systems for most refrigeration compressors are classified either as "forced feed" or "splash" type. The "forced feed" type is normally associated with the larger or high-speed compressors and the "splash" type with small or slow-speed units.

5.02 ***Forced Feed:*** A small gear-type pump is normally employed to force the oil through a labyrinth of passages and piping drilled through the crankcase, crankshaft, and connecting rods to reach and lubricate the main bearings, pistons, and wrist pins. These pumps are usually located inside the crankcase and driven by the crankshaft. Fig. 8 shows forced feed system of a typical small compressor.

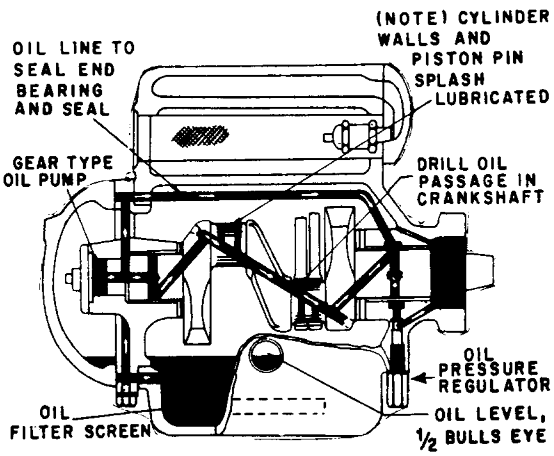


Fig. 8 — Forced Feed Lubrication

5.03 ***Splash Type:*** In this type of system oil scoops located on the lower part of the connecting rods churn through the oil causing the oil to splash throughout the crankcase. It is important to keep in mind that the position of the oil scoops determines the direction of rotation for the compressor.

5.04 ***Crankcase Dilution:*** Adequate lubrication at all times is essential for successful compressor operation. Proper lubrication in Freon installations is made difficult by the tendency of Freon to go into solution with the oil. This has the effect of thinning the oil and of reducing its lubricating properties. Because of this affinity of Freon for the lubricating oil a certain amount of crankcase dilution is always present and the problem is to prevent this dilution from becoming excessive.

5.05 ***Foaming:*** An indication of crankcase dilution is foaming. The greater the dilution the greater the amount of foaming. Foaming develops as the suction pressure in the crankcase is lowered after start-up. A small amount of foaming may be expected, however, excessive foaming will cause the oil to leave the crankcase with a resulting reduction in oil pressure at the bearings.

5.06 During operation, dilution of the crankcase lubricating oil is usually due to a faulty or oversized expansion valve. However, any condition which will allow liquid refrigerant to return to the crankcase, such as inadequate superheat of the return gases will produce crankcase dilution. Whether liquid is being returned to the crankcase can be checked from the operating log by comparing abnormally low suction line and crankcase temperatures with current operating conditions and by noting if excessive foaming is occurring in the crankcase. During operation the heat in the crankcase has a tendency to cause the Freon to vaporize and thus reduces dilution of the lubricating oil so that the return of liquid to the crankcase at this time is not as serious a problem as during shutdown.

5.07 An accumulation of Freon in the crankcase during shutdown can lead to a sufficient loss of oil in start-up to cause the unit to stop on a safety lockout through operation of the low-pressure oil safety switch (see Paragraph 5.12) on units so equipped. On units not equipped with such a safety device this condition can develop compressor knock, bearing failure, broken valves, oil logging the evaporator, and seal damage. In addition, machines which utilize crankcase oil pressures to actuate unloader mechanism when operating at reduced oil pressure may cause them to operate in a partially open position which could damage the valve mechanism.

5.08 Common causes of liquid refrigerant finding its way into the crankcase during shutdown include: "Slopover" from a common suction line to a bank of two or more compressors not having automatic suction line stop valves on each compressor; improperly piped suction lines or condensers; or leaking float valves on oil separators. Common solutions consist of crankcase heaters, automatic pumpdown control, suction line automatic stop valves, and correction of improper piping.

5.09 ***Excessive Oil:*** An indication of excessive oil in the system is a crankcase that is cool to the touch after the compressor has been placed in operation. Although different makes of compressors operate at different temperatures, a normal operating temperature range is between 105° F and 140° F. The manufacturer's operating instructions will specify the proper temperature for the particular compressor at hand. On models which circulate water through the cylinder head and oil cooler, a low crankcase temperature might be due to an excessive amount of water being circulated. The manufacturer's operating instructions will specify the proper leaving water jacket temperature.

5.10 ***Loss of Oil:*** Since a certain amount of oil is normally intermixed with the refrigerant as it goes through the compressor it is essential that this oil find its way back to the compressor crankcase in sufficient quantities to maintain a satisfactory balance, e.g., a proper oil level at all times. This oil in circulation with the refrigerant approximates one quart of oil for each 50 pounds of refrigerant in the system.

5.11 Failure of oil to return to the compressor can usually be attributed to improper piping of the suction line or shortage of refrigerant in the system. Since a relatively high velocity of the refrigerant is depended upon to entrain particles of oil in the gas and thus carry these minute oil particles back to the compressor, it can be seen that an installation with oversized piping operates with a reduced refrigerant velocity which might not allow the oil to be returned to the compressor under light load conditions. Similarly, any pockets in the piping that allow the oil to become trapped could result in failure of the oil to be returned. These conditions will manifest themselves in new installations. Borderline cases, however, may function properly for a period of time till, for some reason, a small portion of the refrigerant charge is lost which can result in suction line refrigerant velocities below that necessary to carry the oil back to the compressor. Even in properly piped installations a shortage of refrigerant can result in suction line velocities too low to return oil to the compressor.

In the case of flooded coolers, controls are provided to return the oil. It is, therefore, important that these controls be properly adjusted and observed for operation since they can cause the oil to become trapped in the cooler when inoperative.

5.12 ***Low Oil Pressure Safety Switch:*** There are many other causes for loss of oil, such as leaky seals, broken lines, etc. Since this loss of oil and consequent operation under low oil pressure conditions can result in extensive damage to the compressor, a low oil pressure safety shutdown switch should be installed. The switch should require a manual reset so that the mechanic must find the reason for shutdown and take appropriate action before the machine can be placed in operation again.

> *Note:* Testing the oil safety switch is very important since its proper functioning protects the compressor against low oil pressure. This switch should be tested at least at the seasonal start-up and where feasible, monthly during the operating season. A simple testing procedure is as follows:
>
> (a) After the compressor has been operating sufficiently long for the oil pressure to build up, block the differential pressure switch (safety switch) in the safety shutdown position. The compressor should stop within one minute.

5.13 ***Oil Separators:*** Some systems are equipped with oil separators. The function of this device is to prevent carryover of oil with the refrigerant and is located on the discharge side of the compressor before the condenser. It operates on a float principle so that when the oil reaches a predetermined level the float valve opens and the oil returns to the compressor crankcase.

5.14 ***Oil Selection:*** Each manufacturer will specify the type of oil to be used in his equipment and it is important that his recommendations be followed. Lubricating oil should be charged into the compressor from sealed airtight containers since oil left open to the atmosphere can absorb sufficient amounts of moisture to be detrimental to the system. Fig. 9 illustrates a type of oil charging pump which eliminates the necessity for pumping a vacuum on the crankcase and prevents admission of air into crankcase.

5.15 ***Oil Pressure Regulator:*** A pressure-regulating valve is provided on most compressors, either internally or externally, to release oil from the oil circuit when the pressure goes above the valve setting. These valves come in both adjustable and nonadjustable types. Oil pressure should be checked periodically to protect the equipment.

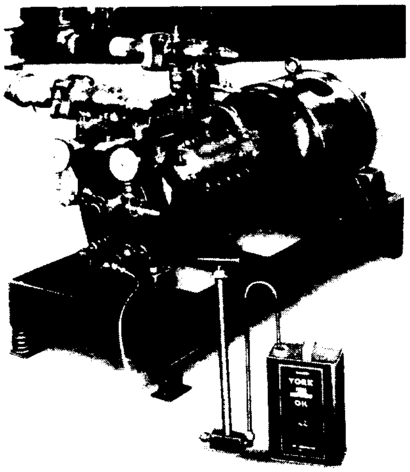


Fig. 9 — Oil Charging Pump

5.16 *Oil Filter:* The oil filter removes foreign particles from the oil. After the first season's operation the filter usually requires removal for cleaning only during the annual routines. Some units are equipped with a disc-type filter with a "T" handle extended through the oil filter cover. For normal operation give this "T" handle one complete turn every 24 hours. Clean cartridge by flushing in a container of clean petroleum spirits, KS-7860.

5.17 *Changing Oil:* Manufacturers vary in their recommendations on the frequency of oil changes but do agree that dirty, gummy, discolored oil should be changed. It is believed that both moisture and high discharge temperatures play a large part in the formation of sludge. When sludges form, discoloration of the oil takes place. However, any condition that results in the discoloration of the oil should be investigated and eliminated. Normally, oil can be expected to last one or more seasons before discoloration. It is advisable to put in new oil when a compressor has been opened for major repairs.

6. DIRT AND MOISTURE

6.01 *Moisture* in refrigeration systems, even in small quantities, can result in extensive damage. When moisture in a system collects at the expansion valve, it freezes and stops the flow of refrigerant. Moisture which collects in the crankcase causes sludging of the oil which results in lack of proper lubrication and extensive corrosion.

6.02 *Dehydration:* The most effective method of dehydrating a system is known as the evacuation method which involves the use of a vacuum pump. Fig. 10 shows a typical hookup.

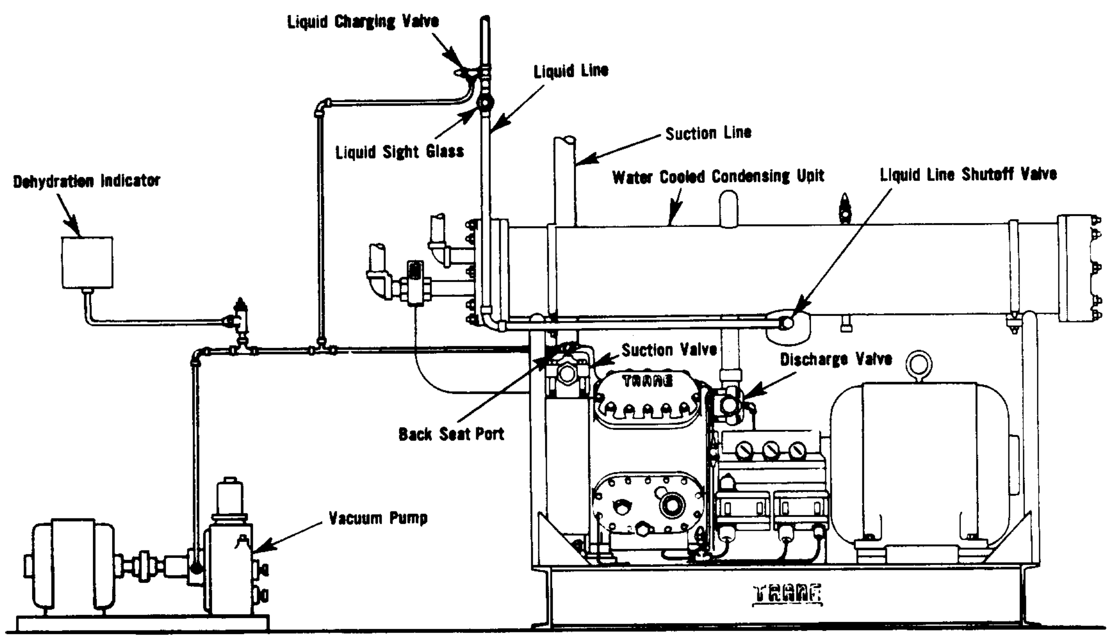


Fig. 10 — Method of Connecting Vacuum Pump for Evacuation Prior to Charging System

To be effective the pump employed should have the ability to draw a minimum vacuum of two-tenths inch of mercury, absolute. For details of evacuating any particular system follow the manufacturer's recommendations.

6.03 Even though a well executed evacuation of a tight system is capable of removing moisture to the point that only one part of moisture per million parts of refrigerant remains, it is well to also install a filter-dryer in the system to safeguard against small quantities of moisture that may find its way into the system during service operations. There are a number of commercial filter-dryers available which employ a desiccant in the form of a moulded porous core that not only absorbs moisture from the system but also removes acid and acts as a filter. A filter-dryer is commonly placed in the liquid line along with a moisture indicating sight glass. When the sight glass shows an indication of moisture the core should be replaced. (On very small systems the entire filter-dryer is replaced.) Consideration should be given to installing a new core after any major compressor overhaul.

6.04 Commercial preparations or alcohol to prevent freezing trouble at expansion valves are not to be used since they normally introduce more problems than they cure. ***THERE IS NO SUBSTITUTE FOR PROPER EVACUATION OF MOISTURE FROM THE SYSTEM.***

6.05 ***Dirt:*** The average installation is provided with strainers but in spite of this, fine particles of rust, pipe scale, solder, copper filings, etc, find their way into the system. Following an original installation or repair job, it is good practice to place a felt sock strainer in the suction strainer to protect the compressor from particles left in the system.

> ***Note:*** Whenever a felt sock is used it should be inspected after a short operating period not longer than one day, and replaced with a clean one. This should be repeated till the sock is found clean when inspected. It is important that this felt strainer be removed once it has served its purpose to avoid an excessive pressure drop. A tag should be placed on any system operating with a felt sock to remind the operator to inspect and remove the strainer when it has done its job.

6.06 It is essential when a repair job necessitates replacement of tubing or parts that the inside surfaces of the parts are clean to the point of being bright. Where brazing or soldering is performed, any oxidation on the inside of the tube should be removed and special care taken to prevent excess flux and solder from accumulating inside the piping. Where iron or steel components are installed they should be free from rust.

7. LEAK TESTING

7.01 ***Cleanliness:*** While cleanliness is a "must" where any type of equipment is concerned, it is of particular importance in compressor operation. There is a large amount of oil vapor entrained in circulating refrigerant. When a leak occurs, the refrigerant escapes into the atmosphere and this point will usually be marked by an oil spot. When equipment is clean, these spots can easily be seen. However, when equipment is covered with oil, dirt or grease, such leaks are difficult to find.

7.02 ***Halide Leak Detector:*** A very valuable tool in the maintenanceman's tool kit is the halide torch, see Fig. 11. It is an open flame tool which utilizes color changes in the flame to detect the presence of Freon gas, and extreme care must be exercised in its use. Do not enter a room in which the leak is suspected with a lighted torch until the room has been thoroughly aired since any area improperly aired before making tests will decrease the accuracy of the test as the flame will indicate gas present anywhere in the room.

7.03 The halide torch has a small copper plate in the combustion chamber and a flexible suction tube connected to the air intake. In ferreting out the leak, the end of the tube is held near the suspected leakage area. Ordinarily, the torch burns with a blue-tinged almost colorless flame. In the presence of Freon gas this flame turns a brilliant green. The fuel must be chemically pure and the container should not be opened in a room that might contain a trace of Freon vapor. It is well to remember that air containing traces of carbon tetrachloride or chlorine will also produce a green flame.

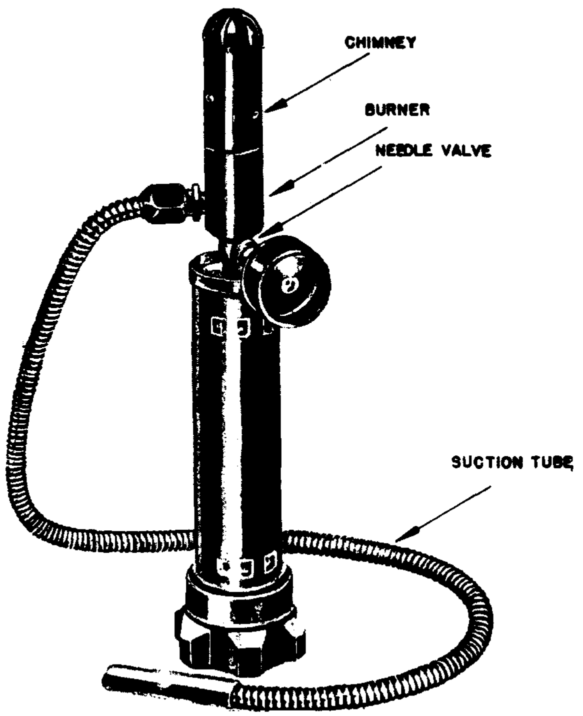


Fig. 11 — Halide Torch

7.04 ***Testing*** with oil or soap suds at joints is used where the use of a torch is not permitted since this method will only locate larger leaks and is unsatisfactory for determining the tightness of a system.

7.05 ***Precautions:*** When it is desired to put a vacuum on the system prior to charging, use a vacuum pump designed for that type of service and ***not*** the compressor. The compressor is not designed to handle air and will not pull down to as low a vacuum as a pump designed for that service.

7.06 When it is necessary to build up pressure in a system to test for leaks, use a refrigerant or an inert gas, such as nitrogen. Do not use the compressor to pump up the system; it is not designed to be used as an air compressor for when used with air it is apt to overheat and become damaged.

8. OPERATION

8.01 ***Operator Coverage:*** Most refrigeration installations come equipped with controls and safety devices to enable the equipment to operate on a fully automatic basis. This may lead to the belief that since the equipment operates automatically and is equipped with safety devices to shut the plant down in the event of a failure, the only time a mechanic is needed to check the plant is at the seasonal start-up and after a failure has occurred. This is not true. The time to stop serious mechanical breakdowns is in their early stages, which, in many cases, is long before the safety devices shut the plant down. Automatic operation does not preclude the need for qualified mechanics to make periodic inspections and to record pertinent operating data.

8.02 ***Manufacturers' Instructions:*** When a new system is taken over for operation and maintenance a set of the Manufacturers' operating instructions should accompany it. It is important that the people responsible for the equipments' operation become familiar with the contents of these instructions and that they be kept in a place readily available to anyone who may have occasion to work on the equipment.

8.03 ***Log Sheets:*** The expression "a stitch in time saves nine" certainly applies in maintenance work. A small defect corrected when it first appears can save considerable sums of money and shutdown time later on. One of the best aids for detecting trouble in refrigeration systems is through the intelligent use of operating log sheets. In addition to helping to spot trouble before it becomes serious, log sheets can materially cut down operating costs by showing up such things as water valves being out of adjustment with the resultant excessive use of water.

8.04 The value of the log sheet lies in not only pinpointing trouble as it starts to happen, but also as an aid in diagnosing chronic malfunctioning of the equipment. Since each machine establishes a normal operating pattern of pressures and temperatures for given conditions, deviations from these patterns can be warnings of developing trouble and the form that these deviations take assist in pinpointing the trouble. A typical example of an operating log is illus-

RECIPROCATING REFRIGERATOR LOG

BUILDING LOCATION ____________________ UNIT ____________________

		EVAPORATOR							CONDENSER			COMPRESSOR					MOTOR				AIR TEMP.				
		CHILL WATER TEMP. °F			EXPANSION VALVE				WATER TEMP. °F																
DATE 1	TIME 2	IN 3	OUT 4	CHILL WATER PRESSURE 5	#1 SUPER HEAT °F 6	#2 SUPER HEAT °F 7	#3 SUPER HEAT °F 8	#4 SUPER HEAT °F 9	IN 10	OUT 11	LIQUID FREON LEVEL 12	CONTROLLER OPER. POSITION 13	DISCHARGE PRESSURE 14	SUCTION PRESSURE 15	OIL LEVEL 16	OIL PRESSURE 17	BELT CONDITION 18	BEARINGS TEMPERATURE °F. 19	BEARING OIL LEVEL 20	AMPERE LOAD 21	OUTSIDE D. B. 22	OUTSIDE W. B. 23	ROOM D. B. 24	OPERATORS INITIALS 25	REMARKS

COMPRESSOR R.P.M. ____________

MOTOR R.P.M. ____________

REMARKS:

Fig. 12 — Typical Log Sheet

trated in Fig. 12. (Not carried in general stationery stock.) It is desirable to record operating data daily; however, where this is not feasible the minimum check should be weekly.

8.05 *Daily Operation Checks:* In conjunction with keeping a daily log on the operation of the compressor (see Paragraph 8.04), the mechanic should be alert for such things as unusual noises, odors, oil or water spots, and abnormal temperatures and pressures. Some of the more important items to be checked are:

(a) ***Oil Pressure and Level:*** The pressure in the lubrication oil circuit is a function of the crankcase pressure. For example, on certain Carrier models the correct oil pressure is 45-55 pounds more than crankcase pressure. Consult manufacturer's operation manual for correct oil pressure for the equipment on hand. Check through sight glass for proper level and foaming.

(b) ***Discharge Temperature and Pressure:*** Operation of the compressor at excessive discharge temperatures can cause the lubricating oil to carbonize, which leads to lubrication failure, valve breakage, and serious compressor damage. ***Excessive temperatures would be in the range of 250° F to 275° F.*** Typical conditions under which excessive discharge temperatures might be encountered are during partial loading of the compressor. When partially loaded the suction pressure may be pulled down lower than the level for which the unit is designed. Maintaining a discharge pressure near design level at this time results in a higher compression ratio with a corresponding increase in discharge temperature. Similarly, at low load operation, suction gas superheating is greater and also contributes to the possibility of excessive discharge temperatures. Another cause of high discharge temperatures can be leakage at an internal relief valve resulting in heating due to gas recirculation. On compressors equipped with internal relief valves, the tightness of the valves should be checked whenever overheating is noticed.

(c) ***Crankcase Temperature:*** A maximum crankcase temperature measured at the seal housing would be 212° F; however, more normal temperatures would be in the range of 105° F to 140° F (see Paragraph 5.09).

(d) ***Head and Suction Pressures:*** These two pressures show whether compressor suction and discharge valves are operating correctly. If suction pressure is abnormally high and discharge pressure abnormally low, it is possible that either suction or discharge valves are leaking. This condition would usually be accompanied by lack of refrigeration and a long running time.

(e) ***Seal*** for oil leak.

(f) ***Motor*** and motor bearings for excessive temperatures.

(g) ***Belts*** or coupling for tightness or unusual noises.

8.06 *Weekly Operational Checks:* In addition to the daily checks made of the above items, weekly checks should be made of the following:

(a) ***Unloader*** control operation should be checked by manually reducing the load and listening for the characteristic sound of the unloaders cutting in. A more reliable means is with a "tong tester." By reading the motor current draw one can see a definite jump or drop of current as the unloaders cut out or in as the load is manually increased or dropped.

(b) ***Electrical*** controls should be checked for worn contacts, loose connections, broken insulation as well as overheated electrical circuits and arcing.

(c) ***Controls*** should be checked to see that the equipment is maintaining the conditions of humidity and temperature for which it was designed.

9. ANNUAL INSPECTION AND MAINTENANCE

9.01 *Maintenance Check Lists:* Because of the many items which make up a complete air conditioning system certain procedures must be followed to insure that proper maintenance is given to each one of them. BSP, Section H51.350, Building Mechanical Equipment Scheduling Routine Maintenance, outlines such procedures.

> *Note:* ***Equally important to setting up of a routine maintenance schedule is the follow-through to see that the operations are performed as scheduled.***

9.02 ***Seasonal Shutdown and Annual Inspection:*** An annual inspection should be performed on all equipment. If the unit has been operating satisfactorily, only a spot check is necessary. When operating checks indicate malfunctioning, a more detailed inspection should be undertaken. On equipment which is shut down for the winter this work can best be scheduled to be performed during the shutdown period. On equipment which is required to be on the line continuously, a time should be chosen when the effect of the disruption of service will be held to a minimum.

(a) Before shutting down for a season a complete check should be made of compressor operation so that all needed repairs can be taken care of during the winter routine.

(b) Check the system thoroughly for leaks with a halide torch.

(c) Pump down the compressor by closing the liquid line stop valve on receiver. It will be necessary to hold the pressurestat switch closed to allow the motor to continue operation. Run the compressor until the suction pressure holds steady in the vicinity of two pounds gauge. In the event the compressor makes a pounding noise during this operation, stop the unit for a few minutes and restart. When the unit holds a steady suction pressure of about two pounds, stop the unit, pull the compressor disconnect switch, and close the discharge valves. Failure to reach a pressure of about two pounds is an indication of leaky discharge valves. ***Tag all valves that have been closed and put tag on disconnect switch warning of closed valves.***

(d) On belt-driven compressors, slack off or remove belts.

(e) If compressor is to be opened for repair or internal inspection, drain oil through a fine strainer and check for evidence of sludge or foreign material. On units equipped with a magnetic oil plug, check for evidence of metal filings which if found would indicate abnormal wearing of compressor parts and would warrant further investigation.

(f) Remove crankcase inspection plate and clean plate with a lint free cloth. Check for loose connecting rods and main bearings. If it is a splash-lubricated compressor pour oil into the oil holes leading to the bearings to make sure there is no stoppage.

(g) Remove at least one cylinder head and valve plate to expose piston. Check piston for wear using feeler gauges, and establish present clearance against manufacturers' recommended clearance. Examine valves for roughness of valve seat, pitting, wear, or copper plating. See that valves ride freely in guide post. Check valve lift clearance.

(h) Clean suction oil filters.

(i) Reassemble all parts using ***new*** gaskets of a type and thickness recommended by the manufacturer.

(j) Refill with oil and close up system.

(k) Record all findings in card file on Form E-3925 (see BSP, H51.350). In succeeding annual inspections a different section of the compressor should be spot-checked. If the spot-check inspection indicates excessive wear or breakage, the compressor should be checked more thoroughly.

9.03 ***Seasonal Start-Up:*** Before setting the compressor in operation for the season the following steps should be taken:

(a) Open all valves that were closed on shutdown.

(b) Check system for leaks.

(c) Check belts or coupling for proper tension or alignment.

(d) Check oil level.

(e) Check refrigerant level.

(f) Install new dryer.

(g) Check electrical circuits and fuses.

(h) Start compressor.

(i) TEST ALL LIMIT AND SAFETY SWITCHES.

9.04 ***Compressor Overhaul:*** A major overhaul of the compressor should be considered when there is a definite lowering in compressor output as compared to when it was new. While this efficiency can not be directly measured, there are several indications of this drop in output, including:

(a) The inability of the compressor to deliver high head pressures.

(b) The lowering of cylinder head temperature.

(c) Oil frothing.

(d) Lower power requirements for the electric motor under full load.

A compressor operating at 1750 rpm for 10,000 hours has made as many revolutions as an automobile engine that has traveled a distance of 300,000 miles. Few would run an automobile 300,000 miles before contemplating engine overhaul; however, with proper operating procedure compressors may be expected to operate 10,000 hours or longer before overhaul becomes necessary.

If a compressor is required to operate continuously it can accumulate about 8,700 hours in a single year. However, an average air conditioning application would run about 4 years to accumulate 8,700 hours of operation.

Where it is decided to do a major overhaul the manufacturer's manual should be closely followed. A few important points to remember when overhauling a compressor are:

(a) Connecting rod caps as well as most other parts do not wear evenly and thus are not interchangeable when they are put back in the compressor. Parts that are to be re-used should be matched with their original companion part.

(b) The ideal solvent used for cleaning compressor parts is one that will leave a light film of oil and do a satisfactory cleaning job. ***Carbon tetrachloride should not be used.*** Kerosene does not evaporate and therefore leaves too much oil on the part. Kerosene may also have sulfur, gums, or other impurities which when added to the refrigerant oil may spoil or dilute it. Petroleum spirits, such as KS-7860 is recommended for cleaning polished steel parts, crankcase, etc. Care should be exercised to keep the solvents clean for dirty solvents may leave more grit and solids on a part than it had before cleaning.

(c) Pay particular attention to replacing all cotter pins, locking wires, and lock nuts. Always use ***new*** pins and locking wires.

(d) The elastic lock nuts on connecting rods can only be used once. ***Do not re-use.***

9.05 ***Checking Refrigerant Charge:*** Liquid receivers and condensers are usually fitted with liquid level test cocks to test for sufficient refrigerant charge. Run the unit under normal load and open the liquid level test cock. If only vapor issues from the outlet, the system is insufficiently charged. Protective goggles should be worn during this operation.

9.06 Where a system has a sight glass in the liquid line, a clear liquid without bubbles, indicates sufficient refrigerant. A cloudy appearance with liquid showing clear at intervals indicates a slight shortage. Many bubbles or no visible liquid indicates extreme shortage.

9.07 ***Adding Refrigerant:*** In general, there are two methods of adding refrigerant to a system: (1) Through the suction line, Fig. 13, or (2) into the liquid line, Fig. 14. Refrigerant that has been transferred from the original factory drum to a service cylinder may contain dirt, scale, and moisture, therefore, it is best to vaporize the refrigerant before admitting it into the system. If a large amount of refrigerant is to be charged and the refrigerant is contained in its original cylinder the refrigerant may be added through the liquid line charging valve.

(a) Charging refrigerant through the suction service valve:

(1) Back-seat the suction valve and connect the refrigerant cylinder to the gauge port. A gauge should be installed as shown in Fig. 13.

(2) Purge the charging line, screw in the stem of the suction valve a couple of turns and start the compressor. Avoid any sudden rise in suction pressure (not over two pounds) by controlling the flow of refrigerant with the cylinder valve.

(3) Check the refrigerant charge frequently and when a sufficient amount is in the system close the cylinder valve, back-seat the suction valve and disconnect the cylinder.

Note: As refrigerant is added to the system the pressure in the cylinder will finally drop to the level of the suction pressure. All refrigerant can be drawn from the cylinder by front-seating the suction valve and pulling a vacuum on the cylinder. ***When using this method always charge with the cylinder in an upright position*** to avoid damaging the compressor by drawing liquid through the suction valve.

(b) Charging refrigerant through the liquid line:

(1) Liquid refrigerant may be charged into the system through a valve in the liquid line between the receiver and the expansion valve as shown in Fig. 14.

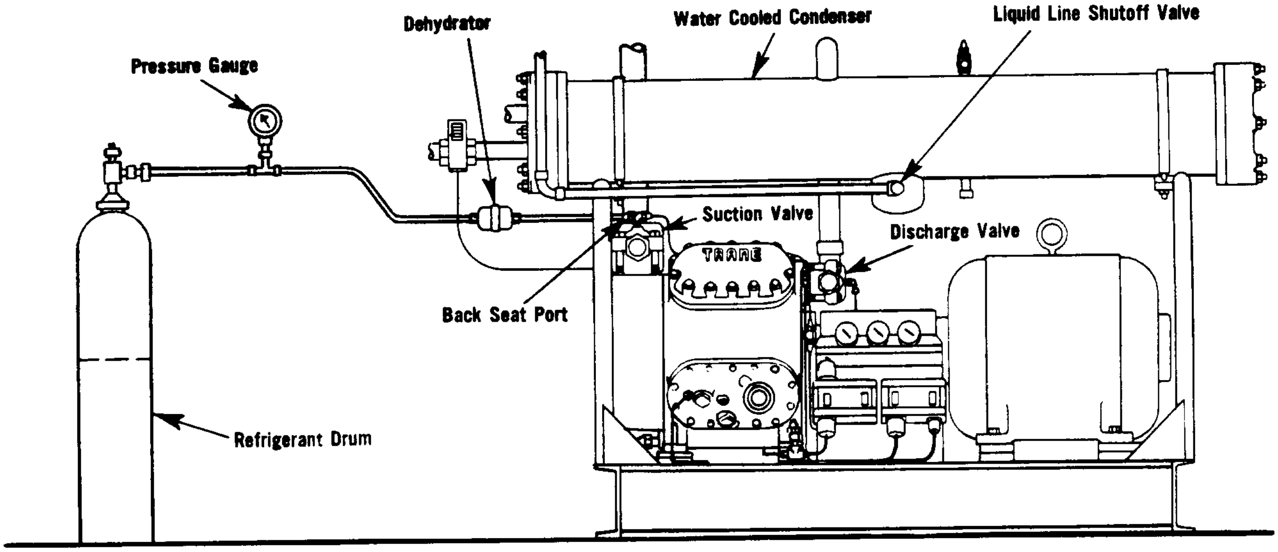


Fig. 13 — Low Side Charging

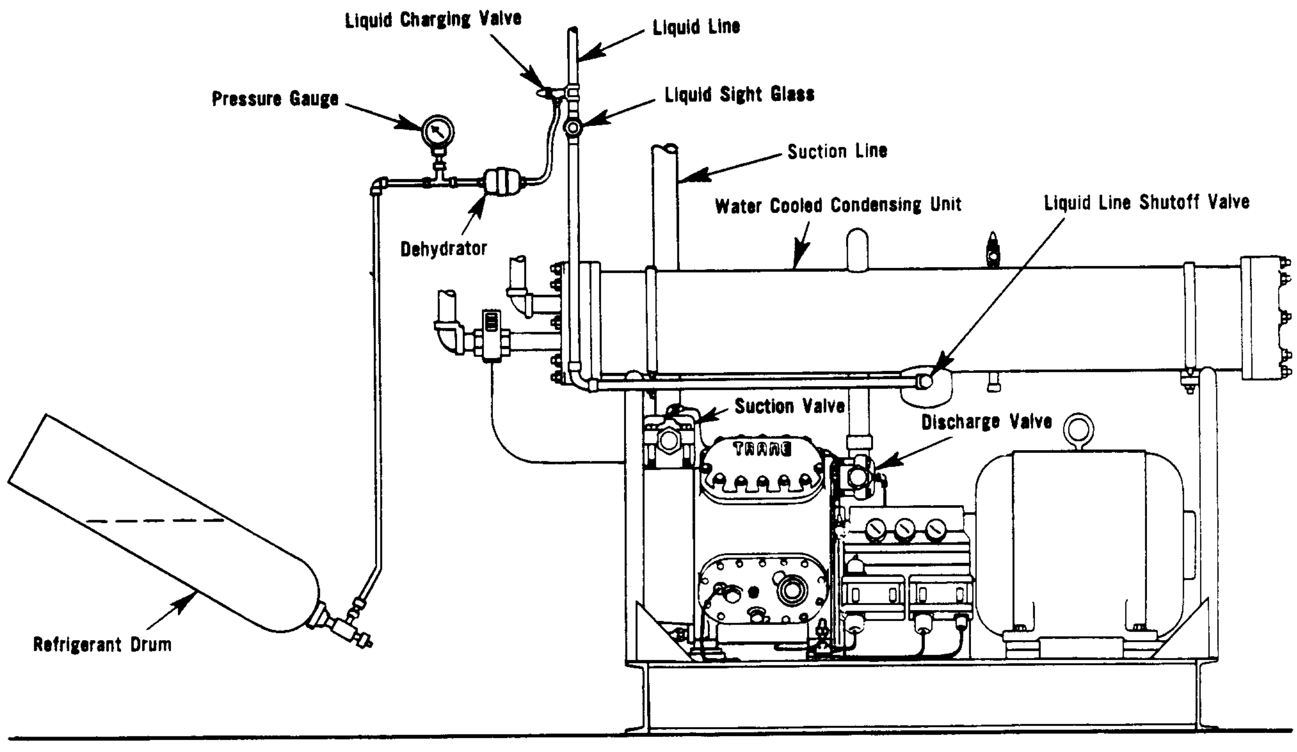


Fig. 14 — High Side Charging

(2) The charging valve should be located ahead of the dryer and liquid line strainer. If there is no dryer in system install a temporary dryer and strainer between the refrigerant drum and liquid line.

(3) The refrigerant cylinder should be inverted so that the liquid covers the discharge valve in the top of the cylinder.

(4) After all the liquid refrigerant has been drawn from the cylinder the remaining refrigerant can be extracted by connecting to the suction port and drawing a vacuum on the cylinder as in (a) above.

10. RECORDS

10.01 ***Maintenance Records:*** Seal replacement, oil changes and parts replacement, should all be a matter of record. A part that lasts its normal lifetime and then fails may mean nothing in the over-all maintenance setup, but repeated failures are an indication that something is wrong; poor installation, inadequate lubrication, or perhaps the part is the wrong type for that particular machine. If no record is kept of replacements, the operator may not be aware that these conditions exist. Similarly, records should be kept of initial suction and discharge pressures, and condensing temperatures. These are alarms in the compressor system and noting any abnormal changes in the readings may aid in preventing breakdown, or loss of compressor efficiency. Refer to BSP, H51.350, for recording methods and use of Form E-3927.

11. SAFETY PRECAUTIONS

11.01 Reciprocating compressors are as safe as modern design can make them. Nevertheless, a certain amount of care must be observed while working on and about them and certain precautionary measures observed when handling refrigerants. The following safety rules must be observed by all personnel engaged in reciprocating compressor maintenance and operation.

11.02 All machines should meet the safety requirements of the local codes and in the absence of any local codes the installation should conform to American Society of Heating, Refrigerating and Air Conditioning Engineers, Standard 15-58. Copies may be obtained from the society at 345 East 47th Street, New York 17, New York.

11.03 Before performing service work on the compressor first disconnect the electric power supply switches and tag them to prevent accidental closing.

11.04 Fluorinated hydrocarbon refrigerants (R-12 or R-22) are accounted safe refrigerants. They are considered nontoxic and nonflammable. They should, however, be handled with care. Some precautions would be:

(a) Handle refrigerant containers with care.

(b) Never discharge refrigerant into a confined space where there is an open flame.

(c) Do not fill a refrigerant container to more than 80% of its volume.

(d) Do not allow the direct rays of the sun to strike a charged or partially charged container over an extended period of time.

(e) Never apply heat to a refrigerant container with a blow torch, Prestolite torch, or with any other direct heating devices. When it is necessary to warm a refrigerant container, use a shallow vessel containing lukewarm water or apply heated cloths.

(f) Always replace the container cap after using.

(g) Goggles should be worn when opening any refrigerant line connection. The connection should first be loosened slightly to make certain no liquid refrigerant is present.

(h) If refrigerant contacts the eyes seek immediate medical attention. If this is not available irrigate with sterile mineral oil. Should the irritation continue, wash with Boric Acid solution or a sterile salt solution of not more than 2% salt.

(i) Should refrigerant contact the skin treat the same as frostbite, e.g., gently cover the frozen part with the hand or other body surface until the part is thawed and circulation is restored. If this can not be done cover the part with extra clothing until thawed. ***Do not*** expose to hot stove, fire, or any other source of extreme heat and ***do not*** rub with snow or anything else as rubbing may injure the tissue.

(j) If a person is overcome with refrigerant administer artificial respiration. The "Freons," while classed as nontoxic, can, upon continuous breathing, create an unhealthy anemic condition of the blood.

(k) The vapors of fluorinated hydrocarbon refrigerants going through a flame break down into phosgene, so do not breathe the fumes during leak tests with a torch. Do not work near a soldering or blow torch or appliance flame when free refrigerant vapor exists, unless the space is well ventilated.

11.05 The first aid recommendations in Paragraph 11.04 are intended only when a doctor is not available or is delayed. In all cases, professional medical aid should be obtained as soon as possible.

12. TROUBLE CHART FOR RECIPROCATING REFRIGERATION COMPRESSORS

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	REMEDY
Compressor Fails to Start	1. No current on line side of motor starter.	a. Power failure.	a. Check for blown line fuse, open circuit breaker, or broken lead.
		b. Disconnect switch open.	b. Determine why switch was opened. If everything is O.K. (be positive no one is working on circuit), close switch.
	2. Current on line side but not on motor side of fuse.	a. Fuse blown.	a. Replace blown fuse. Check load on motor.
	3. Low voltage on line side of motor.	a. Failure at power station or in power equipment serving building.	a. Notify power company.
	4. Motor hums but does turn over.	a. Low voltage or loss of a phase.	a. Check dash pots or blown fuse on one phase, routine and restore.
	5. Full current at motor terminals (line side) but motor does not run.	a. Burned out or open in motor.	a. Repair or replace motor.
	6. Motor starter holding coil not energized.	a. Open control circuit in: 1) Dual pressure controls. 2) Oil failure controls.	a. Locate open control and determine cause and restore.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	REMEDY
Compressor Fails to Start (Cont'd)		3) Motor starter thermal overloads out.	
		4) Thermostat not set for cooling or defective.	
		5) Open circuit due to open interlocking relay.	
		6) Freeze controls in chiller.	
	7. Open contacts on low-pressure switch with suction pressure below cut-in pressure.	a. Suction pressure below cut-in setting of low-pressure cut-out switch.	a. Check for loss of refrigerant. Repair leak, if any, and recharge system.
		b. Faulty low-pressure switch.	b. Replace or repair switch.
	8. System will restart on resetting of oil pressure failure control switch but cuts out after short period.	a. Loss of oil.	a. Check for leak and add oil to proper oil level. Check for build-up after starting.
		b. Excessive refrigerant in oil.	b. Add ***mild*** heat (105°F) to boil off refrigerant — check oil level.
		c. Temperature of crankcase too cold during off periods allowing refrigerant to collect in crankcase oil.	c. Consider installing heater in crankcase if trouble is chronic or check operation and temperature setting and output of existing heater where installed.
		d. Improper suction line piping.	d. Correct for faulty piping.
		e. Stuck float in oil separator.	e. Free up float.
		f. Inoperative mechanism in flooded-type coolers.	f. Free up mechanism.
	9. V-belts slipping or motor pulley slipping.	a. Improperly set setkey on pulley. Motor mounts loose.	a. Tighten or replace belts. Tighten set screws on pulley or motor mounts.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	REMEDY
Compressor Fails to Start (Cont'd)	10. Current on line side of starting switch but switch not made.	a. Defective holding coil in switch.	a. Replace coil.
	11. Seized compressor.	a. Broken piston or other broken parts which cause piston to seize.	a. Repair compressor and determine reason for failure.
		b. Improper lubrication and failure of safety controls to operate.	b. Repair compressor and determine cause of failure.
	12. Insufficient pressure control.	a. No charge of gas in system operated by low-pressure control.	a. Check for leaks — add refrigerant.
Inadequate Cooling	1. Low discharge pressure + high suction pressure + high superheat at evaporator and:		
	a. Discharge and liquid lines cooler than normal.	a.1) Compressor belts slipping.	a.1) Tighten belts.
		2) Leaky compressor valves.	2) Replace valves.
		3) Leaky piston rings.	3) Replace rings.
	b. Rising temperature in conditioned space.	b.1) Improper solenoid operation.	b.1) Correct operation.
		2) Worn or damaged unloader power element.	2) Replace unloader element.
	c. Compressor not running up to speed.	c. Low line voltage.	c. Stop compressor till proper voltage can be supplied.
	2. High discharge pressure + high suction pressure + high superheat at evaporator and:		
	a. Receiver pressure low.	a. Partially closed discharge stop valve.	a. Open valve.
	b. Motor and compressor discharge hot — liquid line warmer than normal — little, if any, water discharged from condenser and very warm.	b. Restricted water flow.	b. Increase water flow.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	REMEDY
Inadequate Cooling (Cont'd)	c. Motor and compressor discharge hot — liquid line warmer than normal — discharge water from condenser very warm and quantity excessive.	c. Temperature of incoming water too high.	c. Provide cooler source of water — increase size of condenser.
	d. Motor and compressor discharge hot — liquid line warmer than normal — discharge water cool and quantity excessive.	d. Dirty condenser.	d. Clean condenser.
	e. Motor and compressor discharge hot — liquid line warmer than normal — water temperature and quantity normal.	e. Foreign gases in system.	e. Purge system of foreign gases.
	f. Motor and compressor discharge hot — liquid line warmer than normal and compressor has tendency to flood at start.	f. Too much refrigerant in system.	f. Removes excess refrigerant.
	3. Low suction pressure — high superheat at evaporator — low or normal discharge pressure and:		
	a. Liquid line cooler than normal.	a. Obstruction in liquid line — strainer stopped.	a. Remove obstruction.
	b. Suction pressure remains low when compressor is stopped.	b. Expansion valve stuck closed.	b. Repair or replace expansion valve.
	c. Lower portion of evaporator appears inactive.	c. Oil trapped in evaporator.	c. Remove oil from evaporator.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	REMEDY
Inadequate Cooling (Cont'd)	d. Rising temperature in conditioned space.	d. Shortage of refrigerant.	d. Bring refrigerant charge up to normal. Check for leak.
	e. Hissing at expansion valve — liquid line cooler than normal.	e. Liquid stop valve partially closed or too small — liquid line strainer plugged.	e. Open or replace. Clean strainer.
	f. Suction pressure in evaporator is much higher than at compressor.	f. Suction line partially stopped.	f. Remove obstruction.
	4. Low discharge pressure — high suction pressure — low superheat at evaporator and crankcase sweating or frosting.	**a. Feeding liquid too fast.**	**a. Adjust expansion valve.**
Compressor Noisy	1. Ticking or rattling of compressor.	a. Loose foundation bolts or hold down bolts.	a. Tighten bolts.
	2. Increased and steady valve clatter when a cylinder is unloaded.	a. Insufficient oil pressure.	a. Clean control oil strainer, adjust oil pressure or replace oil pump as indicated.
		b. Insufficient valve lifter pin lift when cylinder is unloaded.	b. Replace defective valve lifter mechanism parts.
	3. Sharp, medium pitched metallic hammer at cylinder head when a cylinder is unloaded.	a. Insufficient clearance between piston and valve plate.	a. Replace over tolerance parts.
	4. Rattle or howl originating at stop valve.	a. Vibration of disc in discharge stop valve.	a. Back-seat valve.
	5. Hammering sound at coupling coincident with unloader operation.	a. Loose coupling parts or keying.	a. Tighten coupling parts and set screws. Replace poorly fitted motor shaft key.
	6. Control pressure dip when cylinder unloads is not abrupt. Valve hammer or clatter when loading or unloading takes place.	a. Sluggish hydraulic relay.	a. Replace hydraulic relay.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	REMEDY
Compressor Noisy (Cont'd)	7. Valve hammer or clatter when unloading or loading takes place.	a. Defective valve lifter mechanism.	a.1) Replace stuck lifter pins. 2) Check unloader fork for alignment. 3) Check power element for sticky piston. 4) Leakage of oil at tube connection to power element.
	8. Hydraulic engine knock.	a. Too much oil in circulation.	a. Check oil level and check for oil at refrigerant test cock.
	9. Low crankcase oil level.	a. Insufficient oil in system.	a. Add oil and check for leak.
		b. Oil not returning to crankcase from system due to: 1) Improper piping of suction lines. 2) Insufficient refrigerant in system. 3) Float in oil separator stuck. 4) Oil return mechanism in flooded-type cooler inoperative. 5) Continuous operation of compressor under light load conditions.	b. Determine reason for oil not being returned and correct.
	10. Hissing.	a. Insufficient refrigerant flow through hand expansion valve.	a.1) Check refrigerant level and add if needed. 2) Adjust valve setting.
	11. Bearing noise.	a. Worn bearings.	a. Check for wear and replace where required.
	12. Vibration transmitted to building structure.	a. Foundation improperly isolated.	a. Check foundation to see if any part of foundation extends down to floor.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	REMEDY
Compressor Noisy (Cont'd)		b. Electrical connections rigidly made to compressor and building structure.	b. Install flexible connection in all conduit fastened to building structure and equipment.
		c. Improper support or isolation of piping.	c. Provide vibration loops in piping and isolation-type hangers to support piping from building structure.
	13. Seal squeak.	a. Low oil level.	a. Check for reason for low oil and add oil to proper level.
		b. Defective seal.	b. Replace seal.
	14. Slugging.	a. Flooding back of refrigerant.	a.1) Check thermal bulb location and fastenings. 2) Reset expansion valve. 3) Loop suction line so refrigerant will not flood back on off cycle.
	15. Vibration.	a. Insufficient mass or size of foundation.	a. Increase size of foundation.
		b. Belts too tight.	b. Loosen belts.
	16. High-pitched hiss in discharge line.	a. Restriction in discharge line.	a. Remove restriction.
		b. Discharge valve not wide open.	b. Open discharge valve wide.
		c. No muffler in line.	c. Install muffler in discharge line.
	17. Valves pounding and high head pressure.	a. Foreign gases in system.	a. Purge system.
		b. Broken parts in compressor.	b. Remove head. Examine valves of pistons.
	18. Belt squeal or slap.	a. Dirty, worn or loose belts.	a. Clean. Do not use belt dressing on V-belts. Check pulley alignment. Tighten. Replace worn belts. (Section 770-220-308)

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	REMEDY
Compressor Noisy (Cont'd)	19. Water valve chatters.	a. Excessive water pressure.	a. Install water pressure reducing valve.
		b. Water valve too large in capacity and stem may be hitting seat because valve is throttled too low.	b. Install smaller valve.
	20. Pulsating from discharge pressure fluctuation.	a. Pulsating effect of compressor piston is transmitted to valve operating mechanism.	a. Connect refrigerant line to bellows of valve to source of constant pressure such as liquid valve or line.
	21. Miscellaneous noises.	a. Worn parts with excess tolerance such as pistons, piston pins, etc.	a. Replace.
		b. Loose flywheel or pulley.	b. Tighten.
		c. Broken suction or discharge valves.	c. Replace.
Compressor "Short Cycles"	1. Normal operation except too frequent stopping and starting.	a. Intermittent contact in electrical control circuit.	a. Repair or replace faulty electrical control.
		b. Differential on high- or low-pressure controllers set too close.	b. Reset differentials in accordance with proper job conditions.
	2. Low-pressure cut-out.	a. Insufficient air, coils on evaporator clogged with frost.	a. Defrost and check for cause such as dirty filters, slipping fan belts, etc.
		b. Liquid suction or expansion valve screens plugged.	b. Pump down and clean screens.
		c. Compressor too large for load.	c. Slow down compressor by decreasing motor pulley size.
		d. Discharge valve leaks slightly.	d. Repair or replace valve.
		e. Thermal bulb on expansion valve has lost charge.	e. Detach thermal bulb from suction line and hold in the palm of one hand, with the other hand gripping the section line. If flooding through is

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	REMEDY
Compressor "Short Cycles" (Cont'd)			observed, bulb has not lost its charge. If no flooding through is noticed, replace expansion valve.
		f. Room thermostat in path of cold air.	f. Place thermostat so that it is in path of return air.
		g. Low refrigerant charge.	g. Check for leaks — charge refrigerant.
		h. Moisture frozen in orifice of expansion valve or orifice plugged with dirt.	h. Remove moisture or dirt (install system dryer).
	3. High-pressure cut-out.	a. Insufficient water flowing through condenser.	a. Adjust water-regulating valve, or check for cause such as clogged strainer.
		b. Clogged or fouled condenser.	b. Clean condenser.
		c. Condenser capacity reduced due to overcharge of refrigerant.	c. Remove excess refrigerant.
		d. Air in system.	d. Purge condenser.
Compressor Runs Continuously	1. Refrigerated space too warm with a:		
	a. Low suction pressure + low discharge pressure.	a.1) Low refrigerant charge.	a.1) Test for leaks and charge refrigerant.
		2) Expansion valve power element dead or weak.	2) Replace expansion valve or renew power element.
	b. Low suction pressure + normal or low discharge pressure.	b.1) Thermal expansion valve not adjusted or feeding properly.	b.1) Adjust, repair, or replace thermal expansion valve.
		2) Dirty strainers in liquid line.	2) Clean strainers.
		3) Moisture frozen in orifice or orifice plugged with dirt.	3) Remove moisture or dirt (install dryer in system).
	c. Low suction pressure + normal discharge pressure.	c.1) Air flow through evaporator restricted or stopped.	c.1) Remove restriction. Check fan and direction of rotation on forced air evaporators.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	REMEDY
Compressor Runs Continuously (Cont'd)		2) Dirt or scum on evaporator surface.	2) Clean oil from surface.
	d. High suction pressure + normal discharge pressure.	d.1) Defective suction or discharge valves, or badly worn compressor.	d.1) Repair or replace compressor.
		2) Thermal valves flooding.	2) Adjust superheat (5° to 10° F).
		3) Load exceeds capacity of condensing unit.	3) Reduce load, or install larger condensing unit. Check for wild steam coils.
	e. High suction pressure + high discharge pressure.	e. Dirty condenser, or restricted flow of condensing medium (water or air) or wrong rotation of air-cooled condensing unit.	e.1) Clean condenser or remove restriction. 2) Check air flow on air-cooled condensers.
	f. High suction pressure (in system) + normal or low discharge pressure.	f. Compressor suction strainer clogged.	f. Clean suction strainer.
	2. Refrigerated space too cold with a:		
	a. Low suction pressure + normal discharge pressure.	a.1) Thermostat set too low.	a.1) Readjust thermostat.
		2) Thermostat improperly located.	2) Relocate thermostat.
		3) Defective thermostat.	3) Replace thermostat.
		4) System set on manual operation.	4) Change setting to automatic operation.
		5) Welded contacts on electrical control in motor starter circuit.	5) Repair or replace faulty control.
Cylinders Will Not Load and/or Unload	1. Compressor will not load.	a. Low oil pressure.	a. Adjust oil pressure.
		b. Capacity control valve solenoid coil inoperative.	b. Replace.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	REMEDY
Cylinders Will Not Load and/or Unload (Cont'd)		c. Power element stuck open.	c. Repair.
		d. Broken pressure line to power element.	d. Repair.
		e. Plugged pressure line to power element.	e. Clean out.
		f. Temperature controller inoperative.	f. Replace.
	2. Control oil pressure can not be raised by control valve adjustment.	a. Stopped control oil strainer.	a. Clean or replace strainer.
	3. Refrigerant leak detected when thread protector above adjusting stem is removed.	a. Refrigerant leakage to atmospheric side of control valve bellows.	a. Temporary correction of slight leakage is to leave thread protector out. Replace cover assembly.
	4. Foaming in crankcase.	a. Crankcase dilution.	a. Examine expansion valve for flooding. See section on lubrication.
	5. Any one cylinder will not load due to:		
	a. Control oil pressure can not be raised to pump pressure.	a. Control valve does not close.	a. Replace control valve.
	b. Pump and control oil pressure low.	b. Low pump pressure.	b.1) Clean control oil strainer. 2) Adjust oil pressure. 3) Replace pump if necessary.
	c. Low control oil pressure with drop in pump pressure at one step of unloading.	c. Broken oil line to power element.	c. Repair broken oil line.
	6. Compressor will not unload.	a. Capacity control valve inoperative.	a. Repair.
		b. Power element stuck shut.	b. Repair.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	REMEDY
Cylinders Will Not Load and/or Unload (Cont'd)		c. Plugged pressure line to power element.	c. Clean out line.
		d. Temperature controller inoperative.	d. Repair or replace.
		e. Load selector handle in wrong position.	e. Change.
		f. Rotary disc valve in wrong position.	f. Change.
	7. Control oil pressure can be adjusted from pump pressure to 6 psi above crankcase pressure without unloading compressor.	a. Stuck hydraulic relay.	a. Replace control cover assembly.
Low Suction Pressure	1. Bubbles in sight glass.	a. Lack of refrigerant.	a. Check for leak and add refrigerant.
	2. No flow of refrigerant through expansion valve.	a. Expansion valve power assembly has lost charge.	a. Replace expansion valve power assembly.
	3. Temperature change in refrigerant line through strainer.	a. Clogged liquid line strainer.	a. Clean strainer.
	4. Loss of capacity.	a. Obstructed expansion valve.	a. Clean valve or replace if necessary.
		b. Liquid line solenoid valve closed.	b. Examine solenoid coil and adjust or replace.
		c. Cooler tubes dirty.	c. Clean.
	5. Lack of capacity.	a. Check expansion valve adjustment	a. Adjust valve.
		b. Expansion valve too small.	b. Check valve rating table for correct sizing and replace if necessary.
	6. Too high superheat.	a. Too much pressure drop through evaporator.	a. Check for plugged external equalizer line.
	7. Coils frosting up.	a. Restricted air flow due to dirty filters or closed damper.	a. Check filters and dampers.
High Suction Pressure	1. Abnormally cold suction line. Liquid flooding back to compressor.	a. Overfeeding of expansion valve.	a. Regulate superheat setting of expansion valve and check to see that remote bulb is properly attached to suction line.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	REMEDY
High Suction Pressure (Cont'd)		b. Expansion valve too large.	b. check valve rating table and replace valve if necessary.
Low Discharge Pressure	1. Excessively cold water leaving condenser.	a. Too much condenser water.	a. Adjust or repair water-regulating valve.
	2. Bubbles in sight glass.	a. Lack of refrigerant.	a. Check system for leak and add refrigerant.
	3. Continuous flow of oil through oil return line. (Oil return line will be warmer than normal.)	a. Oil return valve or trap open. (This does not apply to some types of flooded chillers)	a. Correct condition.
	4. Suction pressure rises faster than 5 lbs. per min. after pressure shutdown.	a. Broken or leaking compressor discharge valve.	a. Install new valves.
	5. High suction pressure.	a. Leaky relief bypass valve.	a. Inspect and replace if found defective.
High Discharge Pressure	1. Excessively warm water leaving condenser.	a. Too little or too warm condenser water.	a. Provide adequate quantities of sufficiently cool water.
	2. Excessively cool water leaving condenser.	a. Dirty tubes in shell and tube condenser.	a. Clean tubes.
	3. Low air or spray water volume. Sealed surface of evaporative coils.	a. Improper operation of evaporative condenser.	a. Correct air or water flow. Clean coil surface.
	4. Exceptionally hot condenser.	a. Air or non-condensable gas in system.	a. Purge.
		b. Overcharge of refrigerant.	b. Remove excess.
Low Oil Pressure	1. Low oil pressure.	a. Compressor rotation reversed.	a. Check rotation and correct.
		b. Oil gauge inaccurate.	b. Check gauge and replace.
		c. Pressure relief valve stuck open.	c. Check pump and adjust.

SYMPTOM	TROUBLE FOUND	POSSIBLE CAUSE	REMEDY
Low Oil Pressure (Cont'd)		d. Oil pump badly worn.	d. Replace oil pump.
		e. Compressor bearings badly worn.	e. Replace bearings.
		f. Clogged oil suction strainer.	f. Clean strainer.
		g. Clogged oil line.	g. Remove obstruction.
		h. Defective adjusting mechanism.	h. Repair or replace.
		i. Excessive oil foaming — oil pump not delivering solid stream of oil.	i. Expansion valve open too wide or defective.
Oil Leaves Crankcase	1. Low oil level in crankcase.	a. Too much refrigerant flooding back.	a. Adjust expansion valves and check thermal bulbs for proper mounting. Check refrigerant piping.
		b. Expansion valves leaking.	b. Valves may be wire drawn on needle and seat from passage of vaporous refrigerant through valve.
		c. Leaking piston rings or worn cylinder.	c. Replace rings or rebore cylinder and install preseize rings.
		d. Improperly installed suction line.	d. Line should contain inverted "U" with top of "U" at least level with top of coil.
		e. Oil return regulating valve not set properly on cooler.	e. Adjust valve.
Oil Does Not Return to Crankcase	1. Low oil level in crankcase.	a. Oil check valve stuck shut.	a. Remove external check valve. Gate should swing freely. If not, burrs on hinge pinhole may be causing trouble.
		b. Expansion valve not flooding coil.	b. Adjust to flood coil.
		c. Flooded system — no oil bleeder line.	c. Install and adjust oil bleeder line.