THE TRANE COMPANY
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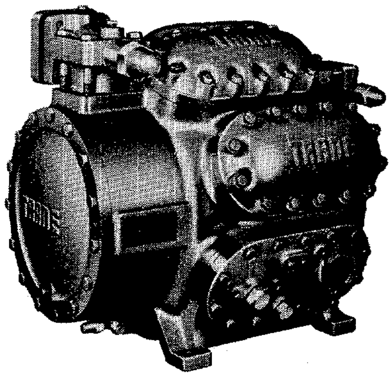
FILE:
TRANE REFRIGERATION PRODUCTS
RECIPROCATING COMPRESSORS
CONDENSER UNITS
OPEN A and B
Operation and Maintenance

LITERATURE FILE NO.
OCOM-M-2
OPER.-MAIN.

SEPTEMBER, 1974
SUPERSEDES 2A2A-1-54



OPEN RECIPROCATING COMPRESSORS

MODELS A and B
4-6-8 CYLINDERS

TESTING AND CHARGING

TESTING BEFORE CHARGING

When the istallation of the system has been completed and before any pipe is covered or any water is turned on the condenser, the entire refrigerant circuit must be thoroughly tested to be sure that it is absolutely tight. There must be no leaks however small. The following prodeecure is recommended:

1. If pressures to be used during this testing exceed the setting of the relief valve, or any of the bellows mechanisms on the pressure controls, remove these various mechanisms before building up the test pressure.

2. Plug the inlet of the thermostatic expansion valve or valves. Usually this can be done by removing the cap screws in the flange body of the valve and inserting a plug into the body of the valve and holding it in place with a solid diaphragm over the inlet at this point. All thermostatic expansion valves on the system should be plugged in this manner. This step is taken to assure that the system on both sides of thermostatic expansion valve is properly tested. The external equalizer line must be disconnected from the expansion valve assembly. Removal of the thermostatic valve power assembly during pressure testing will prevent damage to this part of the valve.

3. HIGH SIDE CONNECTION. Close both the compressor suction and discharge valves tight since the compressor should not be included in the pressure test that follows. Connect a drum of anhydrous carbon dioxide in an upright position to the liquid charging valve. It should be noted that it is absolutely necessary to use a gauge and regulator on the carbon dioxide drum since the pressure may exceed 1,000 pounds per square inch and must be carefully controlled. Also insert a second pressure gauge between the pressure regulator at the drum and the liquid charging valve. Use a flare tee for this gauge. Carbon dioxide should then be admitted slowly until the gauge on the line side of the regulator reads 225 pounds pressure on the highside of the system or a pressure that corresponds to local codes. At this time close the regulator valve at the drum and liquid charging valve tightly. Disconnect the gas drum just ahead of the tee. Cap the tee and open the liquid charging valve so the pressure in the highside of the system can be read on the gauge.

OXYGEN OR ACETYLENE SHOULD NEVER BE USED IN PLACE OF CARBON DIOXIDE FOR HIGH PRESSURE TESTING. A VIOLENT EXPLOSION MAY RESULT.

Installers are frequently tempted to substitute oxygen or acetylene, which may be handy, for anhydrous carbon dioxide. Free oxygen will explode violently when brought in contact with oil in the system. Acetylene may explode spontaneously when put under pressure unless dissolved in a special holding agent such as used in acetylene bottles.

4. LOW SIDE TEST CONNECTION. The external equalizing line, which normally runs from the expansion valve to the suction line, has been disconnected from the expansion valve, as explained in Step 2. The anhydrous carbon dioxide is admitted to the low side of the system through this line. Caution: Be sure that the drum is in an upright position and fitted with a standard gauge and pressure regulator. An additional pressure gauge is installed with flare tee between the regulator and the external equalizer line. A straight-through packless diaphragm valve must also be installed and this is to be placed in the line between the regulator and the pressure gauge. Stop off the external equalizing lines from the other valves with flare plugs. Carbon dioxide should be admitted slowly until the gauge on the line side of the regulator reads 125 pounds pressure. At this point, close the regulator valve at the drum and the packless diaphragm valve. Disconnect the gas drum at the packless valve connection. Cap the open side of the packless valve to prevent leakage through the valve.

NOTE: The test pressures listed above are intended for use in Refrigerant 12 systems only. These pressures are merely suggested pressures. All systems must be tested at pressures which conform to local code regulations.

5. With the test pressures in the system, all sweat or solder connections should be tapped sharply with a rubber or rawhide mallet. They should not be struck hard enough to break a sound connection, but sufficiently hard to start any leaks which might subsequently open due to expansion, contraction or vibration.

6. All pipe joints should then be initially tested for leaks. First, check the gauge pressures. If pressure has dropped, changes in ambient air considered, a major leak is present. Large leaks may be located by the noise of compressed gas escaping from the system. To detect smaller leaks, brush every possible point of leakage with soap solution and watch for bubbles. Follow a definite sequence to be sure that all joints are covered thoroughly. Take plenty of time because of the importance of discovering leaks during this stage of testing.

The soap solution should be of such consistency that it will bubble easily. To insure good bubbling, a few drops of glycerin should be added. If ordinary tap water is too hard, soap will not dissolve well and the resulting scum is not suitable for testing. Wherever possible, use distilled or rain water. Use a small brush. Apply the solution joint by joint. Mark carefully, any spots where leaks occur.

7. As soon as the entire system is bubble tested, break the connections at the charging valve and the external equalizer line, allowing the carbon dioxide in the system escape to the atmosphere. If any leak, whether large or small, has been discovered, it should be repaired at this time. No attempt should be made to repair a leak while the system is under pressure. Neither should bad joints be repaired by remelting and adding more brazing material. The joint should be taken apart, thoroughly cleaned and remade as a new joint.

8. After the system is assumed to be free of leaks, a small quantity of Refrigerant 12 should then be charged into both the high and low side. This should be done by connecting a drum of the Refrigerant first to the charging valve and then the external equalizer line as described previously. Use the equivalent of 5 pounds of Refrigerant 12 for a ten ton system. Charge a larger portion of this amount to the lowside.

Disconnect the Refrigerant 12 drum and reconnect the CO_2 drum, building up the pressures in the system to those mentioned in Step 4 above.

9. The entire system should be checked for leaks. An adequate leak detector should be used. The detector should be run over all sweat fittings, all mechanical couplings and all valves. The leak detection process should be done slowly and carefully to avoid error.

If any leaks are discovered, the gas in the system must be exhausted to the atmosphere; the leaks repaired; the system again charged as described before, and tested.

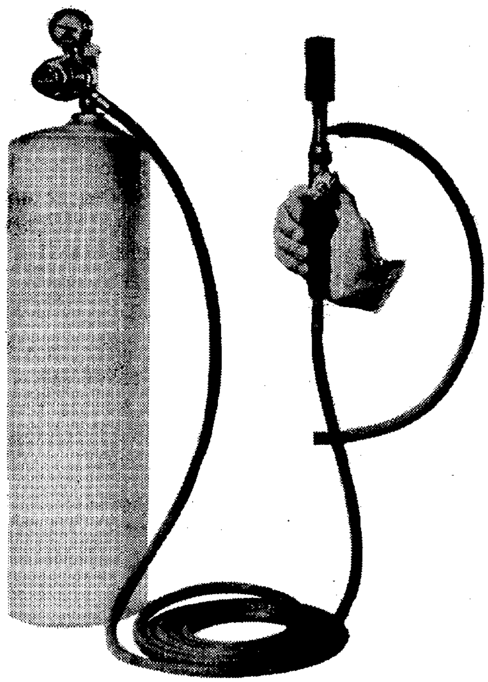


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FIG. 1 Halide Torch for Locating Freon Leaks

10. Once the system is found to be tight and free of leaks by the above methods, it should be allowed to stand for 24 hours with the pressure on. If, after this period of time, there is a change in gauge reading, changes in ambient temperature considered, further testing for leaks must be done. It must be remembered that the pressure will rise or fall about 3 pounds for every 10 F rise or fall of temperature surrounding the system.

Only when this step is completed can the system be considered tight.

11. When testing has been completed, blow off the pressure in the system to the atmosphere. Remove the diaphragm or plug from the expansion valve or valves, and reassemble properly, reconnecting the external equalizer line or lines. Reconnect all controls that were disconnected prior to the testing. The system is now ready for its final evacuation.

12. Never, under any circumstances, should the compressor by used for evacuating the system. It is not designed or intended for this use and if used for this purpose, serious damage will result. Rather, an auxiliary pump vacuum capable of pulling an almost perfect vacuum must be used. The vacuum pump along with a reliable vacuum dehydration indicator should be connected to both the back-seat port of the compressor suction valve and the back-seat port of the compressor discharge valve, as illustrated in Figure 3. This will insure that the system on both sides of the thermostatic expansion is evacuated.

A vacuum indicator may be constructed similar to that shown in Figure 3. This is known as a wet bulb indicator. (Vacuum gauges of the dial type are usually not calibrated accurately enough nor divided into fine enough increments.)

Whenever the wet bulb indicator is used with a system being evacuated, make certain that the wet bulb indicator is connected with the vacuum pump between the wet bulb indicator in the system. Never attach the vacuum pump to one side of the system and the wet bulb indicator to the other side. If this were done, moisture would be drawn from the wet bulb indicator through the system to the vacuum pump.

The wet bulb indicator is a testing device which is used solely to determine the amount of moisture remainig in the system. Whenever the wet bulb indicator is used, wet bulb temperatures within the indicator must be reduced to 35 F or less before the evacuation is completed. Never, under any circumstances, should the wet bulb indicator be opened when the vacuum pump is not in operation. Always provide a shut-off valve between the wet bulb indicator and the vacuum pump, so whenever the

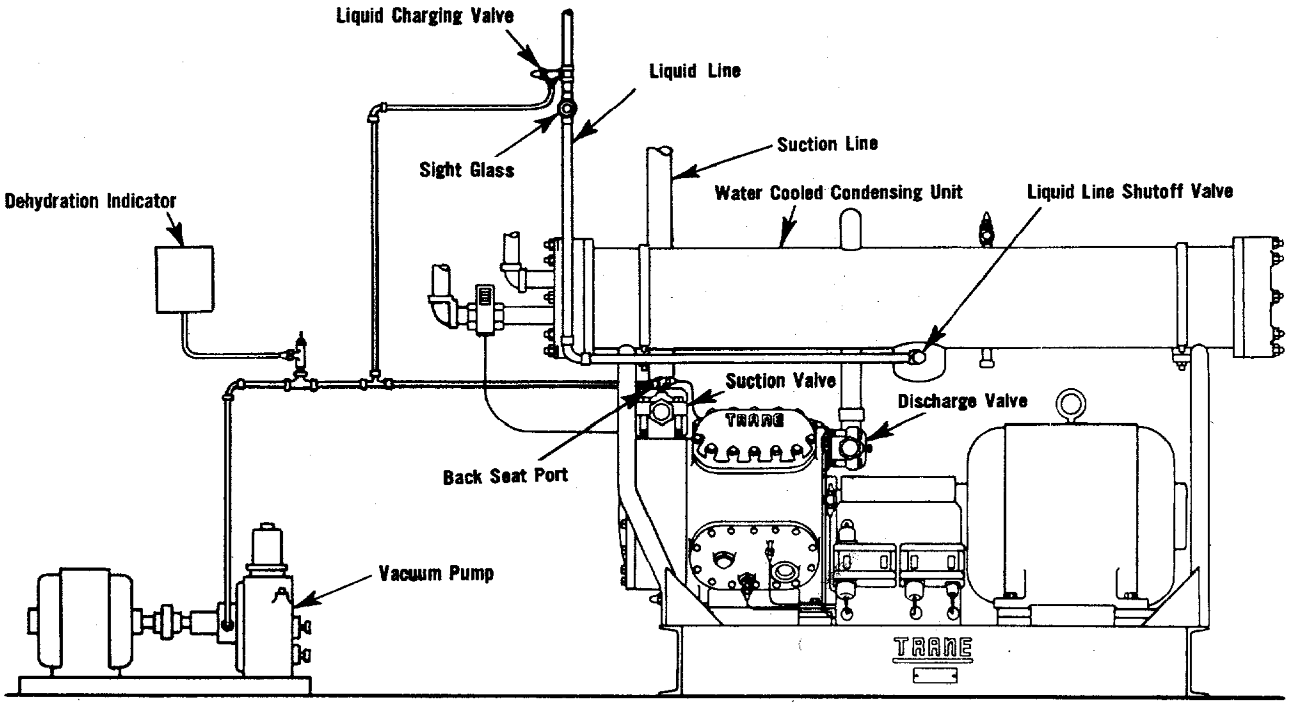

FIG. 2 Recommended Method of Connecting Vacuum Pump for Evacuation Prior to Charging System.

vacuum pump is to be shut down, the wet bulb indicator can be closed off from the system first.

In this step it is necessary to reduce the system to an almost perfect vacuum to remove absolutely all moisture from the system. The importance of moisture removal cannot be overemphasized. Moisture can result in freezing at the expansion valves or formation of hydrochloric or hydrofloric acid in the presence of Refrigerant 12. Such acid is definitely detrimental to the compressor valves, bearing and seal. Moisture may also cause gumming of the crankcase oil and copper plating of compressor parts.. Before starting the vacuum pump, crack both the compressor suction valve and the compressor discharge valve off the backseat. Be sure that the oil is in the compressor crankcase at the time the system is evacuated, to remove any existing moisture from the oil.

Make sure all stop valves are open. If the solenoid stop valve has a manual lift stem, it should be opened by that stem. If the solenoid has no manual stem, current should be maintained in the valve during evacuation.

13. Operate the pump until a vacuum sufficiently low enough to evaporate moisture is shown on the vacuum indicator. The length of time required will vary with the amount of moisture in the system and the size of the system. Failure to reach a sufficiently low vacuum may be due to:

1. Presence of moisture in the system. This may be removed by continued operation of the vacuum pump.

2. Inefficiency of the vacuum pump. This may be due to leaks within the pump proper, or contaminated oil in the vacuum pump. This may be checked by valving off the system and operating the pump against the vacuum indicator only.

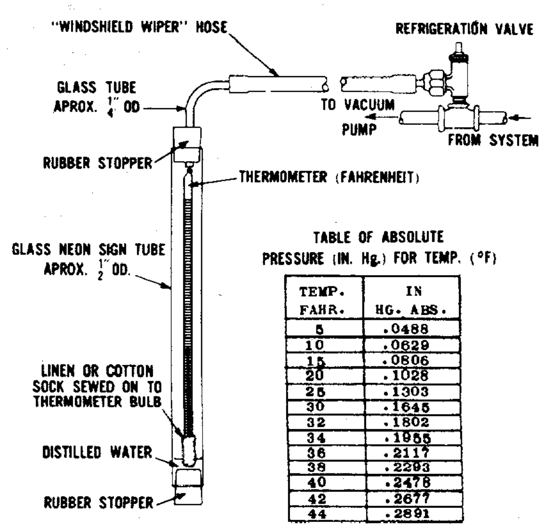

TABLE OF ABSOLUTE PRESSURE (IN. Hg.) FOR TEMP. (°F)

TEMP. FAHR.	IN HG. ABS.
5	.0488
10	.0629
15	.0806
20	.1028
25	.1303
30	.1645
32	.1802
34	.1955
36	.2117
38	.2293
40	.2478
42	.2677
44	.2891

FIG. 3 Vacuum Dehydration Indicator.

3. A leak in the system or in the vacuum pump or its connections. This is unlikely if testing with the halide torch was thoroughly and carefully done.

4. Defective vacuum indicator.

Never attempt to evacuate the system when the air temperature surrounding the system is less than 70 F. After reaching a sufficiently low vacuum, allow the pump to operate for at least four hours.

14. When the system has been evacuated, record the wet bulb reading of the vacuum dehydration indicator. Back-seat the compressor suction valve and close the liquid line charging valve. Close the valve to the vacuum dehydration indicator. Stop the vacuum pump but do not disconnect the pump or the vacuum dehydration indicator. Allow the system to stand a minimum of ten hours. Again crack the suction valve off the back-seat and open the liquid line charging valve. Start the vacuum pump. Allow the vacuum pump to operate for approximately two minutes and then open the valve to the vacuum dehydration indicator. Never open the vacuum dehydration indicator to the system unless the vacuum pump is operating. If there is no noticeable rise in wet bulb temperature or loss of vacuum, the system is evacuated and ready for charging. Back-seat the suction valve, close the liquid line valve, close the valve to the vacuum dehydration indicator, stop the vacuum pump and disconnect the pump and indicator from the system.

15. The same procedure may be followed in preparing the system for a Refrigerant 22 charge. However, since Referant 22 has an even greater affinity for moisture, even greater precautions must be taken in dehydration. Pressures for testing for leaks should be 450 pounds in the highside and 250 pounds in the lowside. Also the equivalent of approximately 2-1/2 pounds of refrigerant for a 10 ton system should be used in testing.

INSPECTION BEFORE CHARGING

Since all parts of the system must function properly during the charging process, it is advisable for the entire system to be given a preliminary check before charging is started. It should be borne in minds, that the evaporator must evaporate all the liquid entering the system, that the compressor must remove the gaseous refrigerant from the evaporator and the condenser must condense the gas discharged by the compressor. Unless each part of the system is operating properly, the charging will be slow and laborious. Therefore, the following check is recommended:

1. Air handling equipment should be checked for—

   a. Proper location of thermostatic expansion valve bulb.
   b. Proper attachment of thermostatic expansion valve bulb to suction line.
   c. Clean and proper filter installation.
   d. Properly position dampers.
   e. Free rotation of fan shaft.
   f. Proper belt alignment and tension.
   g. Adequate lubrication of fan and motor bearings.
   h. Correct fan rotation.

2. Compressors should be checked for—

   a. Adequate motor bearing lubrication.
   b. Proper oil level in compressor. Oil level 7/8 of the way up on the glass.
   c. Open suction and discharge valves and gauges installed in the back-seat ports.
   d. Proper voltages to compressor motor.
   e. Proper heaters in compressor motor starter.
   f. Proper installation and alignment of motor coupling.
   g. Proper sequence of controls and interlocks. The easiest way to do this to to disconnect the compressor motor leads at the motor starter to prevent the motor from running and then operate all the controls including the safety devices.

3. Condenser, Water Cooled, should be checked to assure—

   a. Adequate water fill.

b. Proper operation of float valve.
c. Proper spray pump operation.
d. Free rotation of fan shaft.
e. Proper belt alignment and tension.
f. Adequate lubrication of pump, fan and motor gearings.
g. Correct fan rotation.

4. Controls should be checked for—

a. Electric current to all electric controls.
b. Opening of solenoid stop valve with thermostat set in lowest position.

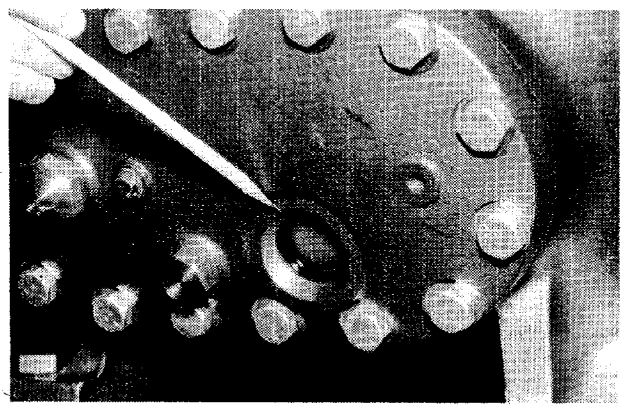

FIG. 4 Oil Level Should Stand 7/8 of the Way Up on the Sight Glass.

HIGHSIDE CHARGING

The initial charge should be given through the highside since it may be accomplished more rapidly than charging through the lowside. Lowside charging is usually reserved for the addition of small amounts of refrigerant after repairs. Highside charging can always be accomplished in the following manner:

1. A drum of refrigerant should be connected to the liquid charging valve as shown in Figure 5. The refrigerant should always be charged through a dehydrator as shown. The dehydrator should be attached as near to the liquid charging valve as possible. Use a dehydrator with a flare inlet and outlet and attach it to the liquid charging valve with a swivel flare nut arrangement if possible. The charging line should be tightly attached to the refrigerant drum and the inlet and outlet of the dehydrator, but the connection at the liquid charging valve should be left relatively loose. The valve on the refrigerant drum should be cracked and enough gas allowed to escape through the loose connection at the liquid charging valve so all the air in the charging line is driven out. This is called purging. When the air has been forced out of the charging line and only gas remains, the connection and the liquid charging valve should be tightened.

2. Both suction and discharge valves should be cracked slightly off the backseat, so that the gauges will function. At this point, it should be noted that if the compressor and condenser are in widely separated locations, the services of two men are required. One should handle that charging at the condenser while the other should be stationed at the compressor. Charging should not be done by one man unless he can plainly see the gauges on the compressor while he is charging the refrigreant.

3. The liquid line shut-off valve on the receiver or condenser should be closed. The condensing mater supply should be turned on. If an evaporative condenser is used, the switch energizing the evaporative condenser fan and spray circuit should be closed.

4. The thermostat should be moved to the lowest setting so that the solenoid stop valve will remain open, or the valve should be opened manually.

5. The liquid charging valve should be opened, and liquid refrigerant admitted slowly at first. The vacuum in the system from the evacuation process will draw a considerable amount of refrigerant into the system. Liquid will enter the system and pass through the evaporator to the compressor.

6. After a short interval the compressor should be started and allowed to run, if it will. If its various protective devices operate to stop the compressor, try starting it again after a few minutes have elapsed. It must always be remembered that the compressor can be damaged more easily than any other part of the system. Therefore, every precaution should be taken to protect it. All of its protective devices should be allowed to perform in their normal way. Above all, the compressor should never be run into a vacuum. That is why it

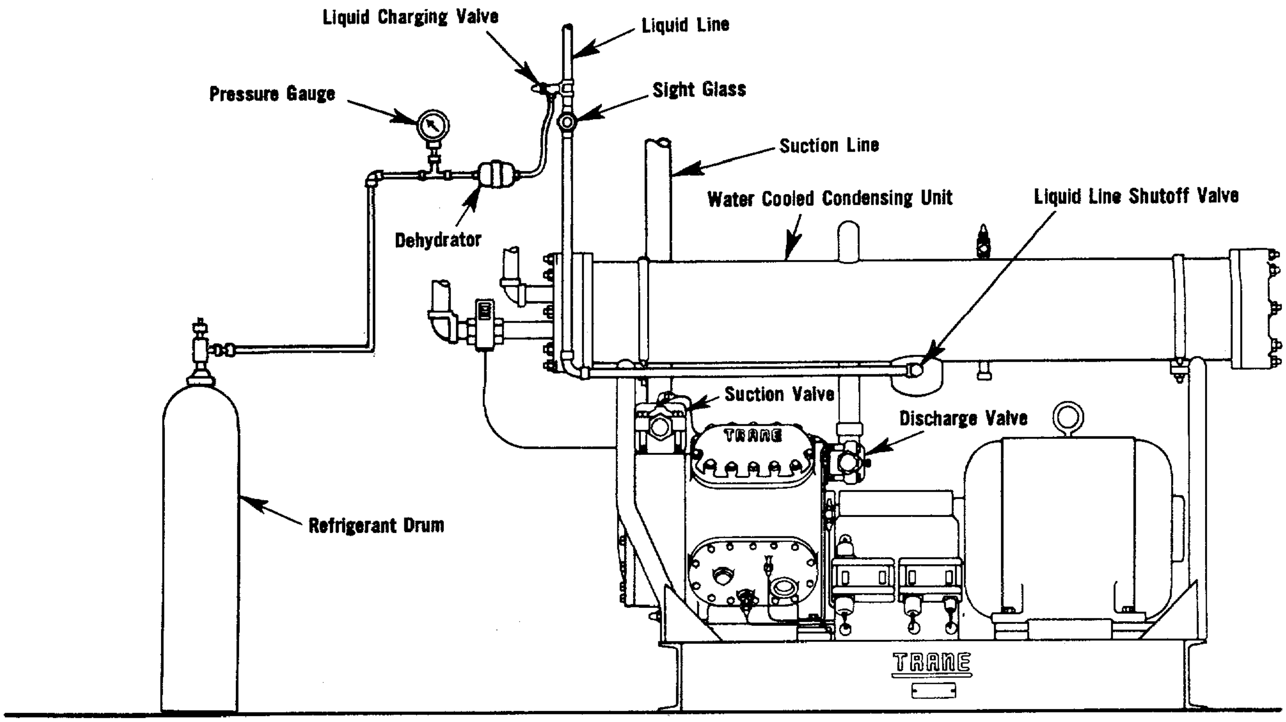

FIG. 5 High Side Charging.

is imperative that the gauges at the compressor should be watched carefully.

7. Charging should be continued until the estimated requirement of the system is approached. When the estimated amount of refrigerant is approached, the liquid charging valve should be closed and the liquid line shut-off valve opened and the flow of refrigerant watched through the refrigerant sight glass. If bubbles appear in the flow, additional refrigerant will be required. When the flow of the liquid through the sight glass is solid, the liquid charging valve and drum valve should be closed. The charging line should not be disconnected.

8. With the system in operation, the liquid line sight glass should be inspected. If bubbles appear in the sight-glass after the system has settled out, there is flash gas present. This indicates a shortage of refrigerant. Just a little more refrigerant may be added. This may cause the liquid refrigerant in a water cooled condenser to rise around more of the condenser tubes. The head pressure gauge should be watched carefully. Too much refrigerant will cause excessive head pressure. If an additional sight glass has been installed between the solenoid stop valve and the expansion valve, the presence of flash gas is indicated by the presence of bubbles.

9. It is frequently necessary to change refrigerant drums during the charging process. When an empty drum is to be removed, the liquid charging valve should be closed tightly. The entire charging line should then be transferred to the new drum. Connections at the drum should be tightened, after which the charging line should be placed loosely on the liquid charging valve connection. The air should then be purged from the charging line as described in paragraph 1, "Highside Charging".

10. It is usually desirable to leave the refrigerant drum and charging line connected until the 72-hour test run has been completed. When the charging line is being removed, the charging valve must be tightly closed. The charging connection should be protected with a seal cap.

PLACING THE SYSTEM IN OPERATION
ADJUSTMENT AND FINAL CHECK

PLACING THE SYSTEM IN OPERATION

Before operating the compressor for the first time, the entire system should again be checked. All refrigeration controls should be put through their complete cycle of operation.

1.DUAL PRESSURE CONTROL
Following the control manufacturer's

instructions, the low pressure switch should be adjusted so it will cut-in (start the compressor) whenever the suction pressure rises above the desired setting. The differential or cut-out points should be adjusted as low as the job will stand to prevent short-cycling.

The high-pressure switch should also be checked. The cut-out point is generally 175 psi.

2. INTERLOCKS
All interlocks should be checked for proper operation. For example, the compressor should be "locked out" if the fans of the air conditioning units are not operating, or the evaporative condenser fails to run properly.

3. THERMOSTATIC EXPANSION VALVE
A check for proper superheat adjustment should be made. A thermometer should be installed on the suction line at the remote bulb of the thermostatic expansion valve as illustrated in Figures 6,7 and 8. The temperature of the refrigerant should be read at a point as near the remote bulb as possible, but on the compressor side of both the remote bulb and the external equalizer line connection. Most accurate temperature reading can be made if a thermometer well has been installed at this point. If no well has been provided, a thermometer may be attached with duct seal or a clip-on type thermometer may be used. In these last two methods, the accuracy of the reading is dependent solely on the bond between the thermometer and the pipe.

The suction pressure should be read at the gauge installed in the back-seat port of the compressor suction valve and converted to temperature. The difference between the thermometer reading on the suction line, and the temperature calculated from the suction pressure, is the superheat. This method does not take into consideration any pressure drop in the low side of the system. If abnormal pressure drop is suspected, steps should be taken to measure it and determine its effect. A method for measuring pressure drop involves installing a tee at the connection between the thermostatic expansion valve external equalizer line and the suction line proper. To this tee, connect a refrigeration compound gauge. This will give the true pressure reading at the evaporator outlet. The gauge can then be used for obtaining the superheat measurements.

Most air conditioning installations should have superheat settings of about 10 F.

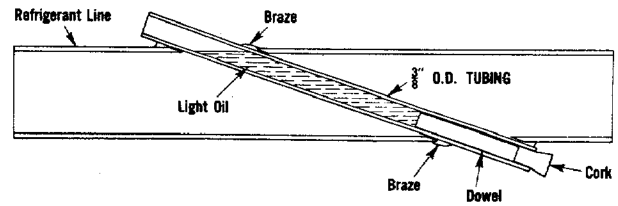

FIG. 6 Suggested Method of Constructing Thermometer Well to Obtain Temperature Readings of Gas in Pipe Lines.

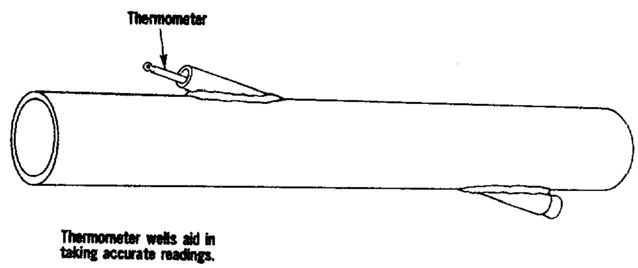

FIG. 7 Thermometer Inserted In Permanent Well.

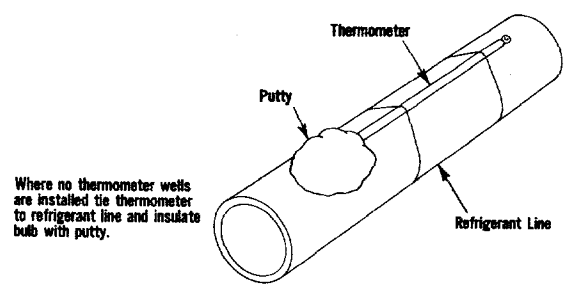

FIG. 8 Method for Taking Temperature Readings Where No Wells Are Available.

4. WATER REGULATING VALVE
A check for operation at desired head pressure should be made. If head pressure is too high, the water regulating valve should be adjusted for increased water flow. If head pressure is too low, the water regulating valve should be adjusted for reduced water flow.

5. THERMOSTAT
Thermostat should be set to maintain room temperature at the desired level.

6. FINALLY
Just before placing the system in operation, the following should be checked:

a. Shut-off valve on water line to shell and tube condenser should be open.
b. Oil in compressor should be at or above center of sight glass.
c. Compressor suction and discharge valves should be open.
d. Turn compressor over several times by hand from the drive coupling to be sure that there is free movement of all parts.
e. All shut-off valves should be in open position except by-pass valves that may be installed for other purposes.
f. Solenoid stop valve should be on a magnetic coil control.
g. All compressor suction, discharge and oil pressure gauges should be connected and open to read operating pressures.
h. Start and stop the compressor several times at ten second intervals and observe compressor pressure gauges. Any operating difficulties should be corrected before proceeding.

When these checks have been completed, the system should be allowed to run normally for at least 3 to 4 days before a final check is made. A service mechanic should remain on the job continuously during these days of initial operation.

During the entire time, the oil level in the compressor must be watched closely. The compressor must not be permitted to run short of oil.

Immediately after the initial running period has begun, amperage and voltage readings on all motors should be taken to determine that motors are operating at the conditions established by the motor nameplate.

During the period, the entire system should be checked several times for refrigerant leaks. All controls should be checked for proper operation, reset if necessary, and calibrated. All operating pressures and temperatures should be observed and recorded. The superheat setting of the thermostatic expansion valve should be checked and adjusted if necessary. The compressor capacity control system should also be adjusted and set. Even though this may be preset at the factory, it should be reset if necessary.

FINAL INSPECTION

Before the system is turned over to the owner, the installer must be certain that everything is in good order and that no more than the normal maintenance attention will be necessary. The best way of avoiding the costly and annoying service trips, that are so often necessary on hastily completed jobs, is to go over the system carefully to be sure that everything is right before finally leaving the job.

WHEN TO MAKE FINAL INSPECTION

The final inspection cannot be made until the system has operated for at least 3 to 4 days. During this run-in period, the oil will have time to collect in any low spots or oil loops. Thus, the amount of oil remaining in the system, outside of the compressor, will be more or less stabilized and any necessary oil can be added with the assurance that the compressor oil level will remain relatively constant. Any scale or foreign material in the refrigerant and water lines will have become loosened and will have found its way to the strainers. The belts on air handling equipment will have taken their initial stretch and will be ready for readjustment. The system will have settled down and any improper adjustments or potential trouble will be apparent. For the final inspection, the following procedure is recommended:

1. The compressor oil level should be checked. If low, oil should not be added immediately but the system should be operated three or four hours and frequently checked to see that the returning oil does not restore the proper level. If the oil has not returned at the end of four hours, oil may be added. If the oil is at the proper level on starting, a frequent

check should be made during the three or four hour run to see that the level remains constant. This can be done while the balance of the checking is done.

2. The flow of refrigerant should be checked at the sight glass. The flow should be solid with no bubbles in evidence. Bubbles, as previously explained, indicate a shortage of refrigerant. If bubbles are present at this time there is probably a leak and the system should be checked completely with an adequate leak detector.

3. The liquid line from receiver to expansion valve should be checked to see that there is no appreciable change in temperature over the length of the line. If a strainer or stop valve is found which has a warm inlet and cold outlet, there is evidence of restricted liquid flow or inadequate subcooling. This will require a check on the proper amount of subcooling. If liquid is properly subcooled, the obstructed part must be removed and cleaned.

4. The superheat setting of the expansion valve should be checked.

5. Head and suction pressure should be checked. If correct, the suction and discharge shut-off valves should be back-seated. Test gauges should be removed (unless permanent) and gauge tappings plugged.

6. System should be stopped and the compressor seal tested with a halide torch to be sure the seal is holding tight.

7. Coupling should be checked for proper alignment and compressor motor should be checked for adequate lubrication. Over lubrication should be avoided.

8. The water strainer ahead of the water regulating valve should be cleaned.

9. Air handling units should be checked. Belts should be adjusted for proper tension and alignment checked. A check for adequate lubrication should be made. Over lubrication should be avoided.

COMPRESSOR CAPACITY MODULATION

In many air conditioning systems multiple air conditioners or multiple evaporators are used. In these systems, the controls function to cut in and out the evaporators in the air conditioners to meet the varying system load conditions. The evaporators are usually fed or controlled by liquid line solenoid valves.

In many systems face and by-pass dampers are installed in the air conditioners. On these systems, air is directed through the evaporator or by-passed around the evaporator, the air movement being controlled by the dampers.

In either case, the suction temperature and suction pressure in the refrigeration system tend to vary in accordance with the load on the evaporators or with the number of evaporators in operation.

If the compressor were to operate at a fixed capacity the suction temperature and pressure would, at times of minimum system load, be so low that the moisture on the surface of the evaporators would freeze. In addition, the suction pressure might even drop below zero pounds gauge pressure. If the low pressure cut-out switch was properly set, at the low suction pressures, the compressor would short-cycle.

In order to balance out such a system, some sort of compressor capacity modulation is required.

Capacity control employs cylinder unloaders. With this arrangement some method is provided that will hold open the suction valves of some of the cylinders.

With the suction valves held open, the piston will draw gas from the suction manifold on the down stroke of the piston but will, on the up stroke of the piston, return the gas, without compressing it, to the suction line.

In single step unloader systems, it is customary to unload one half of the cylinders. In multi-step unloaders, the machines are unloaded in increments, depending upon the number of cylinders in the compressor. With cylinder unloading, the power requirements are decreased almost in direct proportion to the reduction in load.

HOW THE UNLOADER WORKS

To gain a full understanding of the complete operational cycle of the unloader mechanism, consider the mechanism as two distinct components:

1. CAPACITY CONTROL ACTUATOR.
2. CYLINDER UNLOADER MECHANISM--one for each controlled cylinder (top portion figures 9 and 10).

(NOTE: Figures 9 and 10 are schematic drawings and show only the flow of operation.)

CAPACITY CONTROL ACTUATOR

The capacity control actuator reacts to variations in refrigeration load requirements and **transmits** them to the cylinder unloader mechanism, which acts to load and unload the compressor cylinders. To perform this dual function, the capacity control actuator consists of:

1. PRESSURE SENSING DEVICE (Section to the left of the dashed line in the lower portion of Figures 9 and 10).

2. VALVING MECHANISM (Section to the right of the dashed line in the lower portion of Figures 9 and 10).

PRESSURE SENSING DEVICE

This pressure sensing device consists of a chamber (A) which is connected to suction pressure through line (B) and a bellows (C), the inside of which is connected to atmospheric pressure through vent (D). The tendency of the pressure sensing device is to maintain as nearly as possible a predetermined suction pressure. This pressure is the maximum pressure required to satisfy the system and may range from 0 to 50 psi. The specific point is maintained by a balance of forces--suction pressure balanced against a combination of atmospheric pressure and force from spring (E). The amount of tension is adjustable by setscrew (F). When the system requires less than the full refrigeration load, the suction pressure will fall below the predetermined point, causing an unbalance within the device, and the unloading cycle will commence. The drop in suction pressure permits bellows (C) to expand, forcing plunger (G) against lever (H), moving it downward. The downward movement of this lever opens the regulated orifice (I). The opening and closing of this orifice controls the action of the valving mechanism.

VALVING MECHANISM

The function of the valving mechanism is to supply each of the cylinder unloaders with oil under pump pressure when full compressor capacity is required, and to relieve this pressure when cylinders are to operate unloaded. This valving mechanism consists of a hydraulic cylinder containing an annularly grooved floating piston (K).

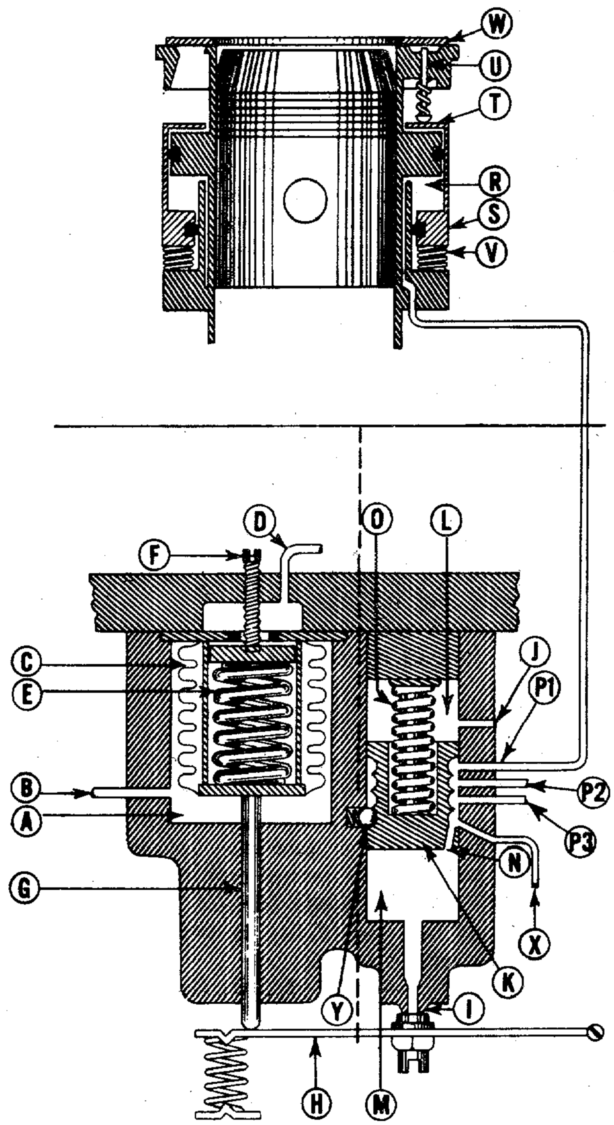

FIG. 9 Schematic Drawing of Cylinder Unloading Mechanism (Loaded)

The annular grooves are constantly connected to the oil pump pressure through line (X).

Above the piston is a chamber (L) which is vented to the crankcase through orifice (J). Below the piston is another chamber (M) connected to the crankcase pressure through regulated orifice (I). Located within the hydraulic cylinder is a spring (O) which tends to move the floating piston toward the lower chamber.

Under full capacity operation, as shown in Figure 9 orifice (I) is shut off. Oil pressure in lower chamber (M) increases because oil under pump pressure is being supplied through line (X). This pressure overcomes the force of spring (O) and floating piston (K) rises in the cylinder. As it rises, the annular grooves in the floating piston coincide in sequence with lines P1, P2 and P3 to the cylinder unloaders providing them with full oil pressure and permitting them to operate at full capacity. To make Figures 9 and 10 as simple as possible, only line P1 is connected to a cylinder unloader mechanism. Lines P2 and P3 are in reality connected to identical mechanisms, and while this discussion is concerned with only one unloader mechanism, it can be extended to cover them all.

When full compressor capacity is not required, regulated orifice (I) is opened through movement of lever (H). Oil bleeds through it, and pressure within the lower chamber approaches crankcase pressure, as shown in Figure 10. Under these circumstances, the force of spring (O) overcomes the pressure in the lower chamber and floating piston (K) is moved downward so that the lines P1, P2 and P3 become connected in sequence to the crankcase pressure through orifice (J). The spring loaded ball (Y) permits the piston to move only in distinct increments, one groove at a time.

In this manner, the valving mechanism supplies or withdraws from each cylinder unloader the oil pressure that operates the unloader mechanism.

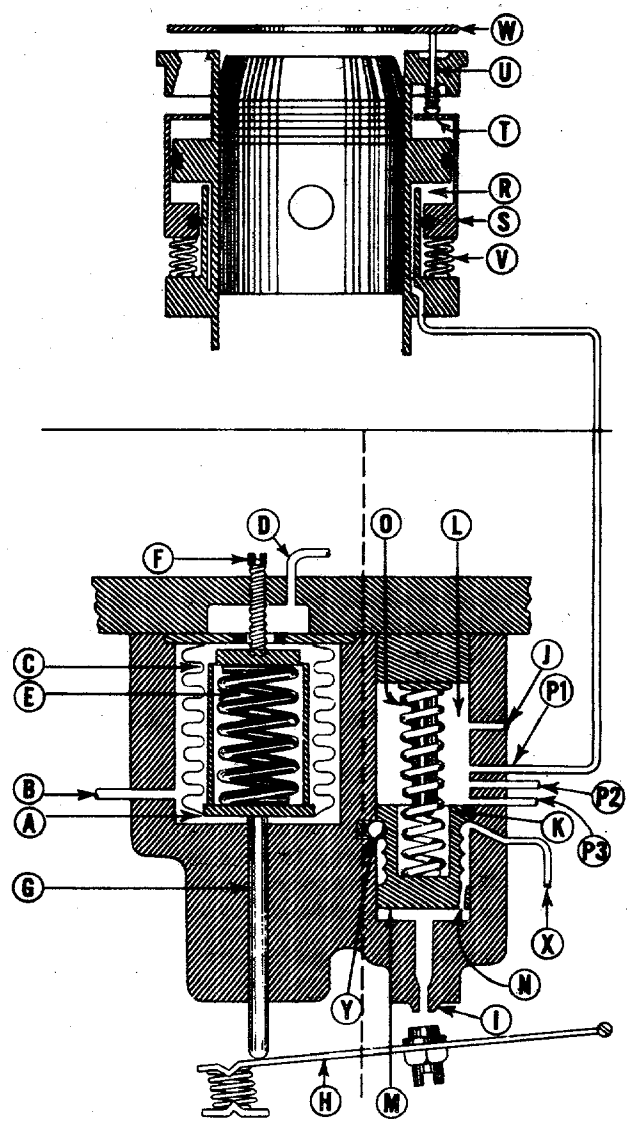

FIG. 10 Schematic Drawing of Cylinder Unloading Mechanism (Unloaded)

THE UNLOADER MECHANISM

When oil from the forced feed lubricating system flows through line P1 from the valving mechanism to the cylinder unloader, it enters annular chamber (R). The inner wall of unloader cylinder is firmly anchored to the cylinder liner. The unloader piston (S), however, is free to move. The up and down movement of this unloader piston raises and lowers takeup ring (T) which raises and lowers suction valve lift pin (U).

Under full capacity operation (Figure 9), oil flows into annular chamber (R) under pressure sufficient to contract the unloader piston spring (V). When oil pressure forces springs to contract, the unloader piston (S) moves down, and takeup ring (T) and the suction valve lift pins (U) move with it. This permits the suction valve (W) to function normally and the cylinder operates to full capacity. When the compressor is to operate at less than full capacity (Figure 10), oil line P1 from the cylinder unloader mechanism is connected to the crankcase pressure through orifice (J) which allows the pressure in the annular chamber (R) to dissipate. The cylinder unloader springs (V) expand, lifting the unloader piston (S). This raises the takeup ring (T), the valve lift pins (U), and holds the suction valve (W) open so that the controlled cylinder is operating in an unloaded condition.

ADJUSTING THE CAPACITY CONTROL

After the system has been placed in operation, the compressor capacity modulation control should be checked and adjusted to meet the requirements of the specific installation.

Figure 11 shows the adjusting screw of the capacity control mechanism located in the control handhole cover assembly. The protecting cover plug has been removed. Turning the adjusting screw clockwise raises the setting of the control range and turning the screw counterclockwise lowers the setting of the control range.

If the compressor is in operation and a constant suction pressure is being maintained by the system, turning the adjusting screw clockwise will cause the compressor to unload, while turning the screw counterclockwise will cause the compressor to load.

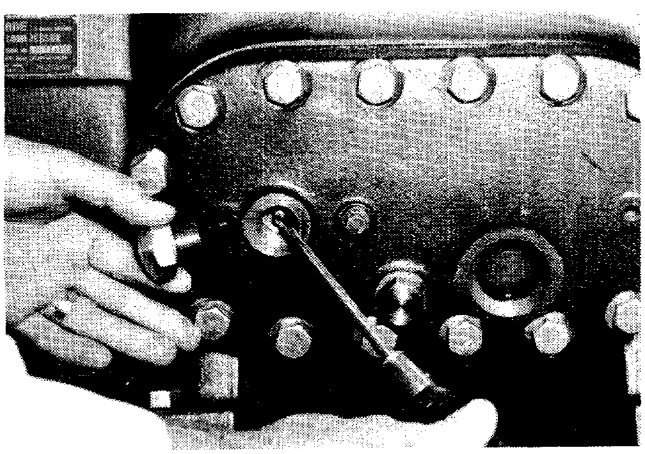

FIG. 11 Capacity Control Adjusting Screw.

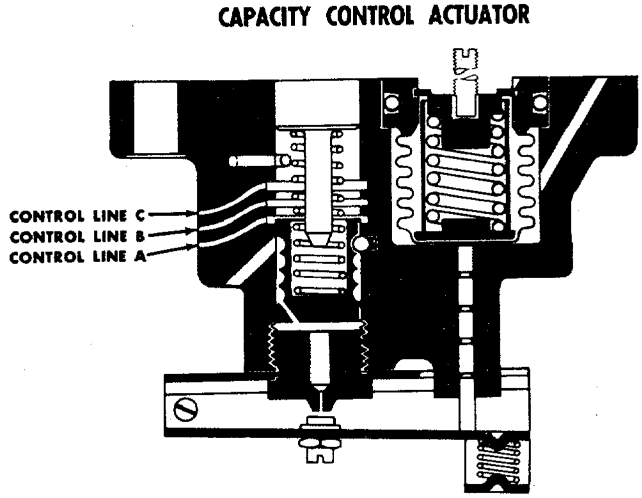

FIG. 12 Capacity Control Actuator

SEQUENCE OF CAPACITY MODULATION

Figure 13 illustrates the sequence of capacity control. The chart shows which cylinders load and unload in response to the action of the valving mechanism.

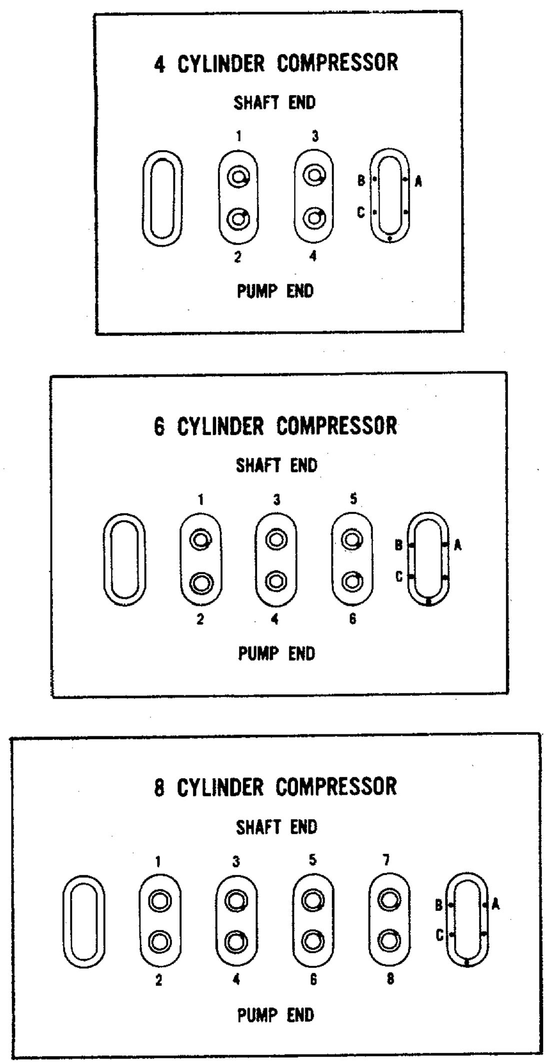

FIG. 13 Cylinder Designation

TABLE 1. Loading and Unloading Sequence

		8 CYLINDER	6 CYLINDER	4 CYLINDER
	INCREASING			
STEP 0		6 Cylinders out 25%	4 Cylinders out 33%	3 Cylinders out 25%
STEP 1	Control Line "A"	Cylinders No. 5 & 6 in - 4 Cylinders out 50%	Cylinders No. 5 in - 3 Cylinders out 50%	Cylinder No. 1 in - 2 Cylinders out 50%
STEP 2	Control Line "B"	Cylinders No. 7 & 8 in - 2 Cylinders out 75%	Cylinders No. 6 in - 2 Cylinders out 66%	Cylinder No. 3 in - 1 Cylinder out 75%
STEP 3	Control Line "C"	Cylinders No. 3 & 4 in - 0 Cylinders out 100%	Cylinders No. 1 & 2 in - 0 Cylinders out 100%	Cylinder No. 4 in - 0 Cylinders out 100%
	DECREASING			
STEP 0		0 Cylinders out 100%	0 Cylinders out 100%	0 Cylinders out 100%
STEP 1	Control Line "C"	Cylinders No. 3 & 4 out - 2 Cylinders out 75%	Cylinder No. 1 & 2 out - 2 Cylinders out 66%	Cylinder No. 4 out - 1 Cylinder out 75%
STEP 2	Control Line "B"	Cylinders No. 7 & 8 out - 4 Cylinders out 50%	Cylinder No. 6 out - 3 Cylinders out 50%	Cylinder No. 3 out - 2 Cylinders out 50%
STEP 3	Control Line "A"	Cylinders No. 5 & 6 out - 6 Cylinders out 25%	Cylinder No. 5 out - 4 Cylinders out 33%	Cylinder No. 1 out - 3 Cylinders out 25%

SETTING THE CAPACITY CONTROL

In most systems it is desirable to maintain a certain minumum suction pressure whether the system is operating at maximum load or at minimum load. In addition, the capacity modulation of the compressor should be set so that the compressor is operating at minimum capacity when the system is at minimum capacity. In some cases, certain compromises must be made to effect a balance during operation.

On some systems it may be just a matter of adjusting the capacity control to begin unloading when a certain suction pressure is reached.

In other systems it will be a matter of setting the capacity control so that the compressor is operating fully unloaded when the system is at minimum load.

The capacity control mechanism has an approximate range of 9 to 10 pounds. With three steps of capacity modulation, this means that there will be approximately 3 to 3½ pounds between steps. The range or differential between steps cannot be changed in the field. However, the point at which the unloading commences can be varied and set at the desired point.

COMPRESSOR CAPACITY

When adjusting the capacity control, it is often necessary to determine how many cylinders are loaded or at what per cent of full capacity the compressor is operating.

The only true indication of the number of cylinders that are loaded at a given time is horsepower required to operate the compressor at that capacity. This can be checked by using a clamp-on volt-ammeter on one leg or phase of the motor leads. With the use of the volt-ammeter, each step of loading or unloading can be checked or determined. Table 2 shows the percentage of horsepower required for the different percentages of capacity.

With the volt-ammeter clamped on, compare the amperage reading on the meter with the full load amperage reading of the compressor motor. With reference to Chart 1, the percentage of compressor capacity can then be determined.

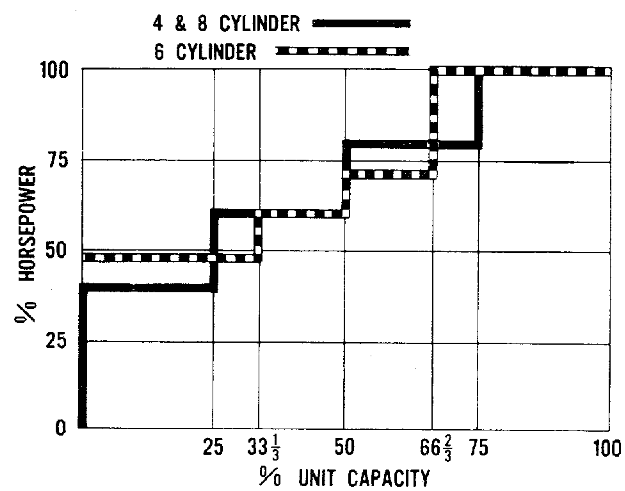

CHART 1.

If the ammeter reading falls between two of the horsepower per cent lines on the table, it may be that the compressor is modulating between steps of capacity.

With a constant load on the compressor and with the volt-ammeter clamped on the motor lead, if the capacity control adjusting screw is turned, the compressor will load and unload and this can be checked by the readings on the meter. As the compressor loads up, step by step, the amperage readings will also go up in definite steps.

FINAL INSTALLATION REQUIREMENTS

After the system has been in full operation for one week, three final installation requirements must be completed as follows:

1. The crankcase of the compressor should be drained. The inspection plate, if the compressor is so equipped, should be removed and the crankcase thoroughly cleaned and swabbed out with carbon tetrachloride or similar cleaner. The compressor should then be recharged with clean, new compressor oil taken from sealed cans.

WARNING: This oil should be the exact lubricant specified by the manufacturer of the compressor for the particular compressor application. No substitutions should ever be made.

2. The bolts in the coupling between the compressor and the motor should be tightened for the last time.

3. All filters in the entire system, both in the compressor and liquid line, should be cleaned.

These last three steps should not be done at the time of final inspection. More regular running time is needed to clear the system of any foreign material. It is imperative that this material be cleaned out, otherwise serious service problems may develop.

NORMAL MAINTENANCE ROUTINE

For proper care of the compressor the following instructions should be followed:

ONCE A WEEK

1. The oil level in the compressor should be checked. If oil appears to be low, the system should be allowed to operate continuously for three or four hours. Oil level should be checked every 30 minutes. If oil continues low, oil should be added. The compressor base should be inspected for oil leakage.

2. If the compressor has force feed lubrication, the oil pressure should be checked. The oil pressure gauge should read about 35 to 50 pounds higher than the suction pressure.

3. The compressor should be stopped and the seal checked for evidence of excessive oil leakage. If excessive leakage is found, the seal should be tested with a halide torch for refrigerant leakage.

4. The condition of the filters in the air handling equipment should be checked. If the filters are dirty, they should be cleaned or replaced.

5. The entire system should be checked for any unusual conditions. A check of the liquid line sight glass should be made when the system is in operation and has been continuously so for at least 30 minutes. Any evidence of improper operation, if found, should be investigated and corrected.

ONCE A MONTH

(Items one through five should be followed.)

6. All motors and fan shafts should be checked for adequate lubrication. Oil lubricated sleeve bearings may require the addition of a small amount of oil. Over lubrication is almost as serious as failure to lubricate. Grease lubricated ball bearings should be lubricated about every six months. Obtain and follow the manufacturer's recommendations.

7. All belts should be checked for proper tension and alignment. If each belt can be depressed about 3/4" to 1" with normal pressure from the thumb, the tension is right.

8. Pulleys and sheaves should be checked for tightness on shafts. If found to be loose, they should not be tightened unless alignment has been checked and corrected.

9. If the system is equipped with gauges, the head pressure should be observed. If the head pressure is higher than normal, the cause should be determined and corrected. Purging of air or other noncondensible gases from the system may be necessary.

10. If an evaporative condenser or cooling tower is used, the condition of the sprays and suction screen should be checked. If algae or scaling are evident, water treatment is necessary. The spray pump should be checked.

ONCE A YEAR

(Those items from 1 through 10 which are applicable should be followed.)

11. Water should be drained from all parts of condensing system and a careful inspection should be made. Fouled condenser tubes should be cleaned. Scale should be removed.

12. If an evaporative condenser or cooling tower is used, the pumps and tanks should be thoroughly flushed and any rust or corrosion scraped away prior to painting. All surfaces should be painted.

13. All motor and fan shaft bearings should be checked for evidence of wear. Shafts should be checked for proper "end play" adjustment.

14. Frayed or worn belts should be replaced.

15. All strainers in the water piping should be cleaned.

16. The condition of the ductwork should be checked.

17. The condition of the drains should be checked. They should be free and should carry away all waste water without danger of stoppage and flooding.

18. The condition of the contacts in all starters and controls should be checked.

SEASONAL SHUTDOWN

A refrigeration system should not be allowed to stand for months, unused, with full refrigerant pressure in the lines and equipment. This produces unnecessary strains in the equipment and may allow a loss of the charge through the compressor seal. When cooling is no longer required, the system should be pumped down and the refrigerant stored in the condenser or receiver until the equipment is required the following year. The following shutdown procedure is recommended:

1. The compressor suction shut-off valve should be back-seated. The gauge port plug should be removed and a compound test gauge installed in the suction shut-off valve.

2. Close the liquid valve on the receiver or condenser to retain all the liquid refrigerant in the shell.

3. The solenoid stop valve should be manually opened, or the thermostat should be set to hold the valve open so all the liquid can be withdrawn from the liquid line.

4. If an evaporator pressure regulator is used, the regulator should be set so the pressure in the evaporator can be lowered to 0 psi, or the bypass should be opened around the regulator.

5. The entire system should then be placed in operation. All fans on the air conditioning units should be running in the normal manner. The condensing water supply should be on. If an evaporative condenser is used, it should be operating in the usual way. The compressor will then draw the refrigerant out of the liquid line, cooling coil and suction line and discharge it into the condenser or receiver.

6. The compressor should be operated until the compound gauge on the compressor suction shut-off valve shows 2 psig pressure. To reach this low pressure, it may be necessary to hold the contacts of the low pressure switch in the closed position. Do not block the switch but hold its contacts closed manually. Do not let the compressor operate in a vacuum. After the system has been pumped down to 2 psig, stop the operation of the compressor. Allow the compressor to stand idle for a few minutes. During this time the pressure in the system may build up again due to refrigerant remaining in the oil in the compressor crankcase. After the pressure has built up, repeat the pump down operation, running the pressure down to approximately 2 psig. Repeat the pumping down until the pressure no longer builds up when the compressor is shut down.

7. When the compound gauge shows 2 psig pressure and holds without rise, stop the compressor and immediately close the compressor discharge valve. The compressor suction valve should then be back seated, the compound gauge removed and plug replaced in the back seat port before closing the suction valve. To close these valves, turn the stems clockwise. The system must never be pumped down below 1 or 2 psig gauge pressure. A slight positive pressure should always be left in the system. This

prevents air being drawn in through very minor leaks and the now unmoving seal.

8. After the system is pumped down and all valves are closed, the part of the system containing the charge of refrigerant should be checked for refrigerant leaks.

9. If the system has a water cooled condenser, the condenser water supply valve should be shut off. If the system is subject to freezing temperatures, the condenser water tubes, the water regulating valve and the piping should be drained thoroughly. If draining is at all questionable, the water should be blown off with compressed air and a stong anti-freeze solution added.

10. If an evaporative condenser is used, the system should be drained thoroughly and the make-up water supply shut off. The condenser should be flushed with a hose and inspected for any evidence of corrosion. If rusting is evident, the condenser should be cleaned and painted.

11. The system master switch should be pulled and if possible padlocked in an open position. A warning should be placed on the switch:

THIS SYSTEM MUST NOT BE OPERATED UNTIL PLACED IN READINESS. SERIOUS DAMAGE WILL RESULT IF SWITCH IS CLOSED BEFORE THAT TIME.

SEASONAL STARTING

Before the refrigeration system is started, all related equipment should be inspected. The air handling equipment should be in readiness and filters should be clean. If an evaporative condenser is used, it should be checked to see that all painting and annual maintenance work has been done. The system should be checked for broken water pipes if any have been exposed to freezing temperatures. The supply of lubricant in all bearings should be checked. All shafts should turn freely and be clear of rust. All drains should be open. Having completed this inspection, the system is placed in operation in the following manner:

1. The condenser water supply should be turned on. If an evaporative condenser is used, the tank should be checked to be sure that it is full of water and spray pump is primed.

2. The compressor discharge and suction valves should be back-seated.

3. The compressor should be jogged to be sure the machine is free. Jog the machine by opening and closing motor switch rapidly. The seal should be inspected for evidence of excessive oil leakage.

4. Check the solenoid stop valve to be sure that the valve has not been opened manually and allowed to remain in that position. The valve must close when de-energized.

5. The liquid shut-off valve should be opened and the liquid allowed to enter liquid line from the condenser. The entire system should be checked for refrigerant leaks.

6. The master switch should be closed bringing power up to the compressor motor starter. If the machine does not start immediately, the room thermostat should be reset to a lower temperature so the solenoid stop valve will open. If an evaporative condenser is used, a check should be made to see that the condenser fans and pump are placed in operation when the compressor starts.

7. When the system has run for fifteen or twenty minutes, the oil level in the crankcase should be checked, a check should be made for bubbles in the liquid sight glass, and the oil pressure should be checked. If satisfactory, the room thermostat should be reset to the proper temperature level.

TROUBLE ANALYSIS

COMPLAINT	PROBABLE CAUSE	SYMPTOMS	RECOMMENDED ACTION	Ref. Note
A. Compressor Fails To Start.	1. Power failure.	1. Electric circuit test shows no current on line side of motor starter.	1. Check for blown line fuse or broken lead.	
	2. Disconnect switch open.	2. Electric circuit test shows no current on line side of motor starter.	2. Determine why switch was opened. If everything o.k., close switch.	
	3. Fuse blown.	3. Electric circuit test shows current on line side but not on motor side of fuse.	3. Replace fuse. Check load on motor.	
	4. Low voltage.	4. Electric circuit tester glows but not at full brilliance.	4. Check with volt-meter, then call power company.	
	5. Burned-out motor.	5. Full voltage at motor terminals but motor will not run.	5. Repair or replace.	
	6. Inoperative motor starter.	6. Test for burned-out holding coil or broken contacts.	6. Repair or replace.	
	7. Open control circuit. a. dual pressure control. b. oil failure control. c. motor starter thermal overloads. d. thermostat not set for cooling. e. open circuit from "interlocking" relays.	7. Motor starter holding coil is not energized.	7. Locate open control and determine cause. See individual control instructions.	
	8. Broken or sheared coupling.	8. Motor runs but compressor does not.	8. Repair or replace. Properly realign.	
	9. Frozen compressor due to locked or damaged mechanism.	9. Compressor will not operate.	9. Overhaul compressor.	
	10. Suction pressure below cut-in setting of low pressure cut-out switch.	10. Open contacts on low pressure switch. Suction pressure below cut-in setting.	10. Check for loss of refrigerant. Repair leak and recharge.	
	11. Discharge pressure above cut-in setting of high pressure cut-out switch.	11. Open contacts on high pressure switch. Discharge pressure above cut-in setting.	11. See complaint G.	
	12. Oil-pressure-failure-control switch has cut out.	12. System will restart by resetting oil pressure failure control switch.	12. Check oil level, oil pressure, wiring and control for faulty control.	
B. Compressor "Short Cycles"	1. Intermittent contact in electrical control circuit.	1. Normal operation except too frequent stopping and starting.	1. Repair or replace faulty electrical control.	

COMPLAINT	PROBABLE CAUSE	SYMPTOMS	RECOMMENDED ACTION	Ref. Note
	2. Low pressure controller differential set too close.	2. Normal operation except too frequent stopping and starting.	2. Reset differential in accordance with proper job condtions.	
	3. High pressure controller differential too close.	3. Normal operation except too frequent stopping and starting.	3. Replace faulty control.	
	4. Leaky liquid line solenoid valve.	4. Valve may hiss when closed. Also temperature change in refrigerant line through valve.	4. Repair or replace.	10, 11
	5. Dirty or iced evaporator.	5. Reduced air flow: a. dirty air filters. b. broken fan belt. c. fan belt tension improperly adjusted.	5. Clean or defrost evaporator. Check filters and fan drive.	
	6. Faulty condensing.	6. Excessively high discharge pressure.	6. Check for water failure or evaporative condenser trouble.	
	7. Overcharge of refrigerant or non-condensable gas.	7. High discharge pressure.	7. Remove excess refrigerant or purge non-condensable gas.	13
	8. Lack of refrigerant.	8. Normal operation except too frequent stopping and starting on low pressure control switch.	8. Repair refrigerant leak and recharge.	12
	9. Water regulating valve inoperative or restricted by dirt, or water temperature too high.	9. High discharge pressure.	9. Clean or repair water valve.	
	10. Water piping restricted or supply water pressure too low.	10. High discharge pressure.	10. Determine cause and correct.	
	11. Restricted liquid line strainer.	11. Suction pressure too low and frosting at strainer.	11. Clean strainer.	
	12. Faulty motor.	12. Motor starts and stops rapidly.	12. Repair or replace faulty motor.	
	13. Fouled shell-and-tube condenser.	13. Compressor cuts off and on from high pressure cut-out.	13. Clean condenser tubes.	
	14. Faulty operation of evaporative condenser.	14. Compressor cuts off and on from high pressure cut-out. a. no water. b. spray nozzles clogged. c. water pump not operating. d. coil surface dirty. e. air inlet or outlet obstructed. f. fan not operating.	14. a. fill with water. b. clean spray nozzles. c. repair faulty pump. d. clean coil. e. remove obstruction. f. repair.	

COMPLAINT	PROBABLE CAUSE	SYMPTOMS	RECOMMENDED ACTION	Ref. Note
C. Compressor Runs Continuously	1. Excessive load.	1. High temperature in conditioned area.	1. Check for excessive fresh air or infiltration. Check for inadequate insulation of space.	
	2. Thermostat controlling at too low a temperature.	2. Low temperature in conditioned area.	2. Reset or repair thermostat.	
	3. "Welded" contacts on electrical control in motor starter circuit.	3. Low temperature in conditioned space.	3. Repair or replace faulty control.	
	4. Lack of refrigerant.	4. Bubbles in sight glass.	4. Repair leak and charge.	12
	5. Overcharge of refrigerant.	5. High discharge pressure.	5. Purge or remove excess.	13
	6. Leaky valves in compressor.	6. Compressor noisy or operating at abnormally low discharge pressure or abnormally high suction pressure.	6. Overhaul compressor.	15
	7. Solenoid stop valve stuck open or held open by manual lift stem.	7. Air conditioned space too cold.	7. Repair valve or restore to automatic operation.	
D. Compressor Loses Oil	1. Insufficient oil charge.	1. Oil level too low.	1. Add sufficient amount of proper compressor oil.	
	2. Traps in hot gas and suction lines.	2. Oil level gradually drops.	2. Repitch lines and provide lift loops. (see chapter on refrigerant piping)	
	3. Too low velocity in risers.	3. Oil level gradually drops.	3. Resize vertical lines or provide oil return traps.	
	4. Clogged strainers or valves.	4. Oil level gradually drops.	4. Clean or repair and replace.	1, 9, 11
	5. Loose expansion valve remote bulb.	5. Excessively cold suction.	5. Provide good contact between remote bulb and suction line.	4
	6. Liquid flooding back to compressor.	6. Excessively cold suction. Noisy compressor operation.	6. Readjust superheat setting or check remote bulb contact.	4, 6
	7. Short cycling.	7. Too frequent starting and stopping of compressor.	7. See items under Complaint "B".	
	8. Crankcase fittings leak oil.	8. Oil around compressor base and low crankcase oil level.	8. Repair oil leak and add proper refrigerant oil.	
E. Compressor Is Noisy	1. Loose compressor drive coupling.	1. Coupling bolts loose.	1. Tighten coupling and check alignment.	
	2. Lack of oil.	2. Compressor cuts out on oil failure control.	2. Add oil.	
	3. Dry or scored seal.	3. Squeak or squeal when compressor runs.	3. Check oil level.	

COMPLAINT	PROBABLE CAUSE	SYMPTOMS	RECOMMENDED ACTION	Ref. Note
	4. Internal parts of compressor broken.	4. Compressor knocks.	4. Overhaul compressor.	15
	5. Liquid "flood back."	5. Abnormally cold suction line. Compressor knocks.	5. Check and adjust superheat. Valve may be too large or remote bulb loose on suction line. Air entering evaporator too cold for complete evaporation of liquid. Or see B-5.	6, 7
	6. Dirty water regulating valve, too high water pressure or intermittent water pressure.	6. Water valve chatters or hammers.	6. Clean water regulating valve. Install air chamber ahead of valve.	
	7. Expansion valve stuck in open position.	7. Abnormally cold suction line. Compressor knocks.	7. Repair or replace.	4
	8. Compressor or motor loose on base.	8. Compressor or motor jumps on base.	8. Tighten motor or compressor hold-down bolts.	
F. System Short of Capacity	1. Flash gas in liquid line.	1. Expansion valve hisses.	1. Subcool liquid or add refrigerant.	12
	2. Clogged strainer or solenoid stop valve.	2. Temperature change in refrigerant line through strainer or solenoid stop valve.	2. Clean or replace.	1, 10, 11
	3. Ice or dirt on evaporator.	3. Reduced air flow.	3. Clean coil or defrost. See B-5.	
	4. Expansion valve stuck or obstructed.	4. Short cycling or continuous running.	4. Repair or replace expansion valve.	4, 5, 9
	5. Excess pressure drop in evaporator.	5. Superheat too high.	5. Check superheat and reset thermostatic expansion valve.	6
	6. Improper superheat adjustment.	6. Short cycling or continuous running.	6. Adjust expansion valve. Check superheat and reset thermostatic expansion valve.	6
	7. Expansion valve improperly sized.	7. Short cycling or continuous running.	7. Replace with correct valve.	8
G. Discharge Pressure Too High	1. Too little or too warm condenser water.	1. Excessively warm water leaving condenser.	1. Provide adequate cool water, adjust water-regulating valve.	
	2. Fouled tubes in shell-and-tube condenser.	2. Excessively cool water leaving condenser.	2. Clean tubes.	
	3. Improper operation of evaporative condenser.	3. Low air or spray water volume. Scaled surface.	3. Correct air or water flow. Clean coil surface.	
	4. Air or non-condensable gas in system.	4. Exceptionally hot condenser and excessive discharge pressure.	4. Purge.	14
	5. Overcharge of refrigerant.	5. Exceptionally hot condenser and excessive discharge pressure.	5. Remove excess or purge.	13

COMPLAINT	PROBABLE CAUSE	SYMPTOMS	RECOMMENDED ACTION	Ref. Note
	6. Evaporative condenser too small.	6. Condenser appears to be operating satisfactorily yet excessive discharge pressure exists.	6. Recheck condenser rating table for correct size selection.	
H. Discharge Pressure Too Low	1. Too much condenser water.	1. Excessively cold water leaving condenser.	1. Adjust water regulating valve.	
	2. Lack of refrigerant.	2. Bubbles in sight glass.	2. Repair leak and charge.	12
	3. If refrigerant circuit is provided with oil separator, separator may operate improperly. Leaky oil return valve.	3. Continuous flow of oil through oil return line.	3. Repair or replace as necessary.	
	4. Broken or leaky compressor discharge valves.	4. Suction pressure rises faster than 5 lbs. per minute after pressure shut-down.	4. Remove head, examine valves and replace those found to be operating improperly.	15
	5. Leaky relief by-pass valve.	5. Low discharge pressure and high suction pressure.	5. Inspect valve to determine if replacement necessary.	
	6. Evaporative Condenser too large.	6. Condenser appears to to be operating satisfactorily.	6. Recheck condenser rating table for correct size selection.	
J. Suction Pressure Too High	1. Excessive load on evaporator.	1. Compressor runs continuously.	1. See Complaint "C".	
	2. Overfeeding of expansion valve.	2. Abnormally cold suction line. Liquid flooding back to compressor.	2. Regulate superheat setting expansion valve and check to see that remote bulb is properly attached to suction line.	2, 6, 7, & 9
	3. Expansion valve stuck in open position.	3. Abnormally cold suction line. Liquid flooding back to compressor.	3. Repair or replace valve.	4
	4. Expansion valve too large.	4. Abnormally cold suction line. Liquid flooding back to compressor.	4. Check valve rating table, and replace valve if necessary.	
	5. Broken suction valves in compressor.	5. Noisy compressor.	5. Remove head, examine valves and replace those found to be inoperative.	15
	6. Evaporator too large.	6. Compressor runs continuously.	6. Check design conditions for improper selection of equipment.	
K. Suction Pressure Too Low	1. Lack of refrigerant.	1. Bubbles in sight glass.	1. Repair leak and charge.	12
	2. Light load on evaporator.	2. Compressor short cycles.	2. See B-5.	
	3. Clogged liquid line strainer.	3. Temperature change in refrigerant line through strainer or solenoid stop valve.	3. Clean strainer.	1, 10, 11

COMPLAINT	PROBABLE CAUSE	SYMPTOMS	RECOMMENDED ACTION	Ref. Note
	4. Expansion valve power assembly has lost charge.	4. No flow of refrigerant through valve.	4. Replace expansion valve power assembly.	5
	5. Obstructed expansion valve.	5. Loss of capacity.	5. Clean valve or replace if necessary.	9
	6. Contacts on control thermostat stuck on closed position.	6. Conditioned space too cold.	6. Repair thermostat or replace if necessary.	
	7. Compressor capacity control range set too low.	7. Compressor short cycles.	7. Reset compressor capacity control range.	
	8. Expansion valve too small.	8. Lack of capacity.	8. Check valve rating table for correct sizing and replace if necessary.	8
	9. Too much pressure drop through evaporator.	9. Too high superheat.	9. Check for plugged external equalizer.	

TROUBLE ANALYSIS CHART NOTES

1. CLOGGED STRAINER OR FILTER

Occasionally the strainer or filter in the liquid line may become clogged with dirt or other foreign material left in the system during erection. When this happens, the liquid line leaving the strainer will feel cooler than the liquid entering. If it is badly clogged, some sweat or frost may appear at the strainer outlet.

2. THERMOSTATIC EXPANSION VALVE LEAKS

Thermostatic expansion valves very rarely close tight to give positive shut-off to the flow of refrigerant through the valve on the off cycle of the condensing unit. As a result, large quantities of liquid refrigerant may pass through the low side and into the compressor on the off cycle. This causes liquid slugging to the compressor at start-up, which is definitely harmful to the machine.

3. METHOD FOR PREVENTING DIFFICULTIES CAUSED BY THERMOSTATIC EXPANSION VALVE LEAKS

Therefore, rather than relying on the expansion valve to hold back the flow of refrigerant on the off cycle, the installation of a thermostatically controlled solenoid valve in the liquid line ahead of the expansion valve is recommended. It should be wired to operate on a non-recycling pump down circuit. This means that the zone thermostat, when satisfied and not calling for cooling, will de-energize the liquid line solenoid valve coil and the holding coil of the non-recycling relay. This action will cause the compressor to pump out the low side of the refrigerant system and shut it off from the action of the low pressure cut-out switch. The electrical circuit should be so wired that the holding coil of the starter will not be re-energized until the zone thermostat calls for cooling and closes the circuit through the non-recycling relay.

The compressor may also knock, due to liquid flood back. The remote bulb of the thermostatic expansion valve should be checked for improper contact with the suction line.

4. THERMOSTATIC EXPANSION VALVE STUCK IN OPEN POSITION

If the expansion valve is stuck in an open position, there will be an excessive amount of sweating on the suction line and compressor crankcase due to the large amount of liquid being passed into the suction line.

5. THERMOSTATIC EXPANSION VALVE HAS LOST CHARGE

The power element of an expansion valve consists of the remote bulb, capillary tube and the bellows or diaphragm, which actuates the valve cage. If this power element is inoperative or has lost its charge, the valve will either maintain an almost closed position or may close completely. To test for an inoperative power element:

a. Stop compressor.
b. Remove remote bulb from contact with suction line.
c. Place bulb in ice water.
d. Start compressor.
e. Remove bulb from ice water and warm in hand. At the same time check suction line for rapid temperature change which indicates flood through of liquid refrigerant. If refrigerant floods through valve, power assembly operates properly.

WARNING: Do not flood back through suction line for too long a period because excessive liquid flood back can cause severe damage to the compressor.

6. THERMOSTATIC EXPANSION VALVE IMPROPERLY ADJUSTED

If the expansion valve has been improperly adjusted for too low a superheat, too much liquid will be passed to the evaporator. The suction line will be abnormally cold and liquid may slug back to the compressor. If the expansion valve is adjusted for too high a super-heat, too little liquid will be passed to the evaporator and the suction line will be abnormally warm. Superheat must always be adjusted carefully using thermometer and suction gauge.

7. THERMOSTATIC EXPANSION VALVE TOO LARGE

If the thermostatic expansion valve has been improperly selected, and its capacity is too great for the system, the valve will not maintain a consistently level suction pressure. The remote bulb will attempt to control the flow of liquid at its superheat setting but the oversized valve port will pass liquid too rapidly. The presence of liquid near the remote bulb will close the valve and the pressure in the evaporator will drop until the valve opens to pass another slug of liquid. This hunting will cause a suction pressure variation noticeable on the suction pressure gauge. On the usual air conditioning application this variation is usually 10 to 15 psig.

8. THERMOSTATIC EXPANSION VALVE TOO SMALL

If the thermostatic expansion valve is too small, it cannot pass a sufficient amount of liquid to satisfy the evaporator. Under conditions of heavy load, the superheat will be excessive and the system will lose capacity. Under conditions of light load, the system may function properly. Too small expansion valves usually result in abnormally low suction pressure.

9. THERMOSTATIC EXPANSION VALVE IS OBSTRUCTED.

Unless the expansion valve is properly protected by a strainer or filter, foreign matter may obstruct the valve port. If the obstruction is small, the resulting operation will be much the same as though the valve were undersized as described in Note 7. If the obstruction is large and only a small trickle of liquid can pass, the compressor will short cycle. If the obstruction holds the valve open during shut-down, the operation will be as described in Notes 2 and 3. An obstructed expansion valve is usually indicated by a partly warm evaporator and frosting at the evaporator inlet.

10. SOLENOID STOP VALVE LEAKS

If the solenoid stop valve leaks while in a closed position, and the compressor motor is controlled from a low pressure switch, the compressor will usually short cycle, that is, stop and start at frequent intervals. The liquid line leaving the magnetic stop valve will feel cooler than the inlet side, and in some cases, there may be evidence of sweat or frost on the solenoid stop valve outlet.

11. SOLENOID STOP VALVE OBSTRUCTED

If the solenoid stop valve is obstructed, the resulting operation will be much the same as though the thermostatic expansion valve were obstructed or too small. See Notes 7 and 8. An obstructed solenoid stop valve can usually be detected by a temperature change in the refrigerant line through the valve. The liquid line leaving the valve will be colder than the liquid line entering and may even sweat or frost. If the solenoid stop valve is so obstructed that it cannot close, the operation will be as described in Note 9.

12. SHORTAGE OF REFRIGERANT

There should always be sufficient liquid in the receiver to completely submerge the inlet to the liquid line pipe. If there is a shortage of refrigerant, the liquid level will fall below the inlet to the liquid line and a mixture of gas and liquid will pass into the liquid line. Bubbles will appear in the sight glass, and larger the bubbles the more severe the refrigerant shortage. Frequently there will be a hissing or whistle at the expansion valve. The coil and suction line will be relatively warm while the suction pressure will be low due to little or no liquid being supplied to the evaporator if the shortage is severe.

13. OVERCHARGE OF REFRIGERANT

An overcharge of refrigerant will cause high head pressure. Liquid will back up in the condenser and decrease the amount of surface available for condensing and as a result the head pressure will rise. In extreme cases, it may rise to a point where the thermal overload elements in the motor starter or the high pressure cut-out will stop the compressor. This may result in short cycling.

14. AIR IN SYSTEM, PURGING

If air or other non-condensible gases are present in the system, they will tend to move toward and collect at the condenser. The head pressure will rise to a point above the pressure corresponding to the temperature at which the vapor is condensing. In extreme cases, the pressure may rise to a point where either the high pressure cut-out or the thermal overload elements in the starter may stop the compressor.

To determine whether or not there is air in the system, the compressor must be allowed to stand idle long enough for the entire system to cool down to the temperature of the surrounding air. The water to the condenser should be shut off. It is usually desirable to drain all of the water from the condenser tubes. After the entire system has attained the same temperature as the surrounding room air, the reading of the head pressure gauge should not be more than 10 psi above the saturation pressure corresponding to the surrounding air temperature.

15. BROKEN VALVES IN COMPRESSOR

Broken suction valves or broken or leaky discharge valves in a compressor are generally indicated by the suction pressure rising rapidly as soon as the machine is stopped. If the suction pressure rises faster than 5 psi per minute, it is an indication that the compressor discharge valves are not holding. Before the compressor is opened, however, it should be determined that the pressure rise is not due to other causes such as leaky expansion or solenoid stop valve or leaky relief bypass.

COMMON SERVICE OPERATIONS

REFRIGERANT PUMP DOWN

1. The compressor suction and discharge shut-off valves should be back-seated. Suction valve back-seat port plug should be removed and a compound test gauge installed. Suction shut-off valve should be cracked off the back-seat so the test gauge will function.

2. The liquid shut-off valve on the receiver or condenser should be closed to retain all of the liquid in the shell. The solenoid stop valve should be manually opened or the thermostat reset to hold the stop valve open so all of the liquid can be withdrawn from the line.

3. Compressor should be started and allowed to run. It may be necessary to remove the cover from the dual pressure control and hold the low pressure contacts closed as the suction pressure must be pumped well below the normal cutout setting, or to 1 to 2 psi pressure.

4. If an evaporator pressure regulator valve is used, the regulator should be set so the pressure in the evaporator can be lowered to 0 psi gauge, or if the valve has a bypass, open the bypass around the regulator.

5. Suction pressure gauge should be watched. When the suction pressure has been reduced to 2 psi gauge, the compressor must be stopped and the discharge shut-off valve quickly closed. If the receiver has separate shut-off valve on its inlet, this, also should be closed. This will trap practically all of the refrigerant in the receiver. The slight pressure remaining in the lines should be left there until the system is opened, to prevent air and moisture from being drawn in.

6. The system should never be pumped to a vacuum, then opened to the atmosphere. A vacuum in the lines, when opened would fill the system with air carrying a very undesirable amount of moisture.

WARNING: If the refrigerant lines to be opened to the atmosphere are colder than the ambient air temperature, a considerable amount of sweating will take place on the inside, as well as the outside, surface of the exposed or open piping. Always allow refrigerant piping to warm up to the ambient air temperature before opening the system to the atmosphere.

REPLACING PARTS

1. When the system has been pumped down, it may be opened and the defective part removed for repair or replacement. As soon as the defective part has been removed, the open lines should be

plugged and left plugged until the new part is to be installed.

2. When the new or repaired part is being installed the joint should first be made on the liquid side of the system. This joint having been made, the liquid valve should be cracked for an instant and the gas from the system allowed to purge the air in the new part. When the air is purged, the remaining joint can be made.

3. The liquid valve should be opened just long enough to put pressure on the new part, then closed. The new part and all nearby joints should be tested with a halide torch.

4. It should be noted that this method is applicable only after small repairs. Should any major work, such as opening the evaporator or compressor, be necessary, it is far better to evacuate the system similar to the method outlined for testing and charging of a new system.

STARTING UP AFTER REPAIRS

1. When the system has been properly repaired, all joints have been tested and found tight, and when properly purged or evacuated the system is ready to start.

2. The compressor discharge and suction shut-off valves should be opened and in that order. The receiver shut-off valves should also be slowly opened and the liquid allowed to enter the system. If the solenoid stop valve was manually opened, it should now be reset for automatic operation. The pressure in the system should now cause the low pressure switch to function and start the compressor.

3. The suction shut-off valve should be back-seated, the test gauge removed and the back-seat port plugged. Oil level in the crankcase and the sight glass in the liquid line should be checked to see that the system has plenty of oil and refrigerant.

ADDING REFRIGERANT

1. The compressor suction shut-off valve should be back-seated and the back-seat port plug removed.

2. The charging line from the refrigerant drum to the back-seat port should be connected as shown in Figure 14. Air should be purged from the charging line before tightening the connection. Refrigerant should be charged into the system through a suitable dehydrator.

3. The refrigerant drum should be held in a vertical position with the charging line at the top so only gas can enter system.

4. The compressor should be started and the system allowed to operate in a normal manner. With the compressor running, the suction shut-off valve should be cracked off the back-seat and the refrigerant drum valve opened. Gas should be allowed to enter the system.

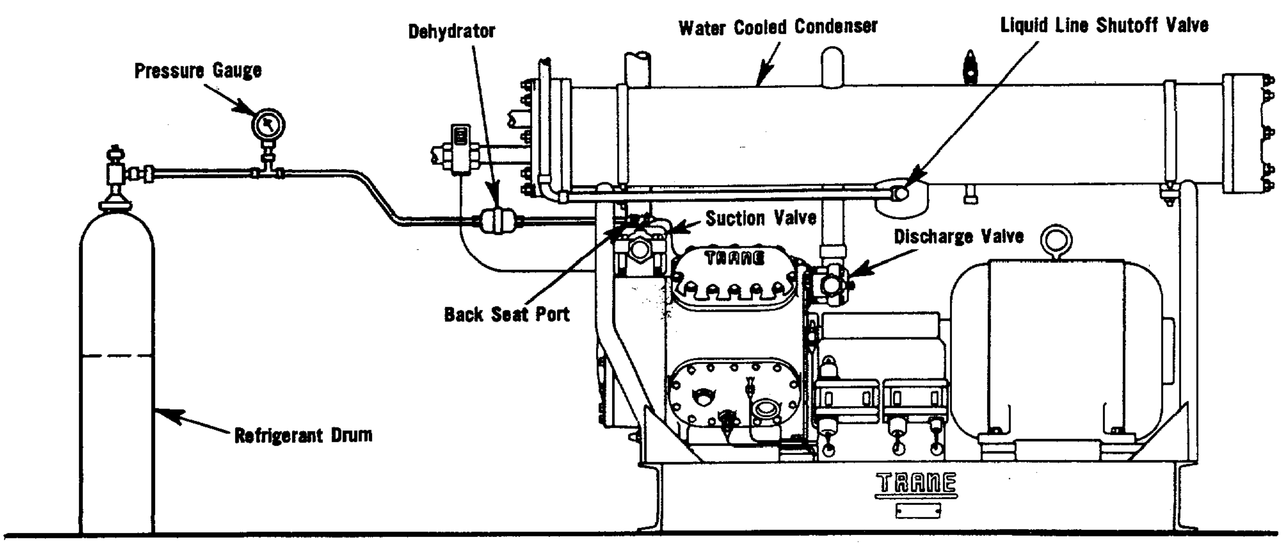

FIG. 14 Low Side Charging

5. The liquid sight glass should be watched. When the charge is adequate, no bubbles will be seen. The drum valve should be shut-off, the compressor suction shut-off valve back-seated, the charging line removed, and the gauge or gauge port replaced.

6. The oil level in the compressor crankcase should be checked.

REMOVING REFRIGERANT

1. An empty or partly empty refrigerant drum should be connected to the charging connection on the liquid line. The charging line should be purged to remove air and moisture.

2. The refrigerant drum should be packed in cracked ice and salt until the temperature of the drum is sharply reduced and the pressure within the drum is well below the pressure in the high side of the system.

3. The compressor should be started. The drum valve should be opened. The charging valve should be opened slowly, allowing refrigerant to flow into the drum. The head pressure gauge should be watched. The charging valve should be closed as soon as the head pressure becomes normal. The refrigerant drum valve is then closed.

4. The liquid sight glass should be checked. If bubbles are apparent, too much liquid has been removed from system. If some refrigerant must be returned to the system, the ice should be removed from around the drum and the drum should be heated, using burlap soaked in hot water. When pressure is restored to the refrigerant drum, the drum should be inverted so the charging line is at bottom and only liquid will be charged. The system should be charged until bubbles in the sight glass disappear.

5. The drum valve and the charging valve should be closed. The charging line should be removed and the protective cap replaced on the charging connection.

6. The oil level in the compressor crankcase should be checked.

ADDING OIL TO THE COMPRESSOR

Most systems will require the addition of some oil before the level in the crankcase can be properly maintained. This is due to an amount of oil remaining in the evaporator, condenser and pipe lines at all times. For the purpose of estimating, it may be assumed that the system will require the addition of approximately 1 pint of oil for every 10 pounds of refrigerant charged into the system.

Oil may be added by charging it into the crankcase with a suitable oil pump while the compressor is in operation. The pump should be loosely attached to the oil charging valve connection. With the charging valve closed, the pump should be operated sufficiently to purge air from the oil line to the valve, or until oil appears at the connection. Then the connection should be tightened and the oil charging valve should be opened. Sufficient oil should be pumped into the crankcase to bring the oil to the proper level as indicated at the sight glass. Oil should be charged into the system through a suitable dehydrator. While the compressor continues to operate, the oil charging valve should be closed tightly and the oil pump disconnected.

REMOVING OIL FROM CRANKCASE

Excess oil can be removed from the compressor crankcase at the oil charging valve, which is located beneath the oil level of the compressor. To remove oil, first, pump down the compressor. Then, after connecting a flexible tube to the oil charging valve connection, open the valve slowly and allow the oil to run into a suitable container. Special care should be taken in removing the oil because of oil foaming. The foaming, not only may cause the oil to overflow from the container into which it is being drained, but it also makes it difficult to determine the amount of oil being removed.

When sufficient oil has been drained, the oil charging valve should be closed tightly and the compressor started. The compressor should be allowed to run for some time, after which the oil level should be rechecked.

PURGING NON-CONDENSABLE GASES

To determine whether or not purging is necessary, the system must be shut down until all parts of the system reach the same temperature. On systems having water cooled condensers, it is advisable to drain all of the water from the condenser to expedite the temperature leveling.

When all parts of the system have reached the same temperature level, the condenser pressure is read. If the pressure in the condenser is more than 10 psi, above the saturation pressure temperature equilibrium for Refrigerant 12 and Refrigerant 22, the system should be purged as non-condensable gases are present. For example, if the temperature of the refrigerating equipment has levelled off at 90 F and the gauge on the compressor shows a condenser pressure of 117 psi, the system requires purging because the pressure, corresponding to 90 F is only 99.6 psi or more than 17 psi less than the pressure actually registered.

To purge a system having a water-cooled condenser, the system should be pumped down in the manner described under "REFRIGERANT PUMP DOWN." After stopping the compressor, close the compressor discharge shutoff valve tightly. Allow the condenser water to run for approximately five minutes before opening the purge valve in order to condense as much of the vapor as possible. At the end of this time the purge valve is cracked for an instant, then closed. After three or four minutes, the purge valve is opened for an instant, then closed. This is usually repeated several times at three or four minute intervals during which time the condenser water is allowed to run continuously. The water regulating valve is blocked open if necessary. After purging, the system may be placed back in regular operation.

If no regular purge valve is included on the water-cooled condenser, the system is purged through the discharge shut-off valve using front-seat port. Loosen carefully but do not remove completely.

To purge a system having an evaporative condenser, the procedure is the same except that the condenser shut-off valve, at the hot gas inlet to the condenser, is closed immediately upon stopping the compressor. The spray water and the condenser fan are allowed to run for the same reason water was allowed to circulate through the water-cooled condenser.