

SECTION 8, CHAPTER 2

TYPICAL REFRIGERATION SYSTEM

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Introduction

1. The basic principle established in the last chapter was that by adjustment of pressures the refrigerant collects heat from the mass to be cooled and then discards it to atmosphere. Practical application of this principle produces the cold part of a refrigerator.

Refrigeration Cycle

2. If we have a closed vessel (a length of tube is used in a refrigerator) filled with refrigerant in both liquid and gaseous form, pumping away the gas will reduce the pressure and cause the liquid to boil (Fig. 1). Heat then flows from the surroundings into the

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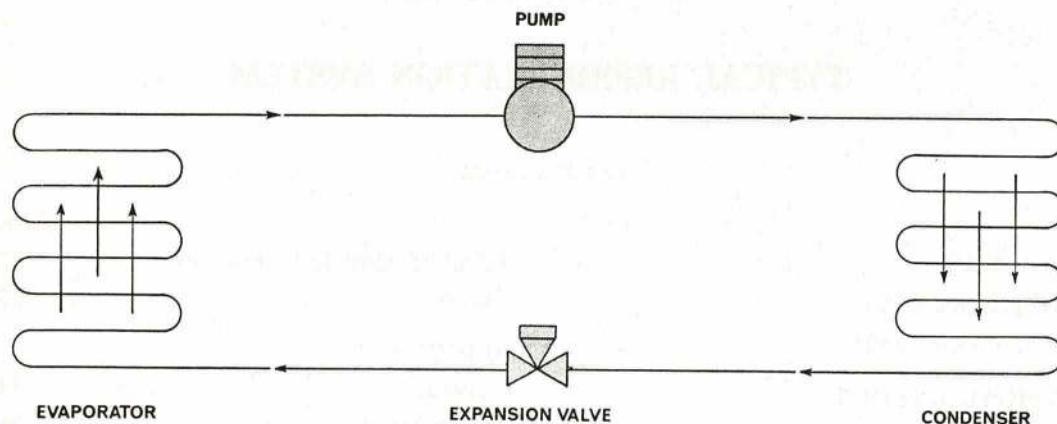


Fig. 1. REFRIGERATION CYCLE

liquid and continuous pumping away of the gas is required to keep the pressure low. The continuous supply of liquid and pumping away of the gas as it is boiled off provides the intake side of the heat pump referred to previously in the last chapter and is termed the **evaporator**.

3. The next stage is another closed vessel which receives the gas pumped from the evaporator. This vessel is cooled by some means such as a fan or a flow of cold water, and when the pressure reaches a point which is too high for the temperature the gas condenses back to liquid form. This is caused by the cooling medium removing heat from the gas, the unit being known as the **condenser**. Thus the heat taken in by the evaporator is transferred to the air or water as applicable and this forms the outlet of the heat pump.

4. As fast as the gas leaves the evaporator it is collected in the condenser and a continuous cycle is obtained by returning the liquid to the evaporator. The pressure in the evaporator is low because this is required to obtain the coldness, whilst the pressure in the condenser is comparatively high because it is cooled by air or water at ordinary room temperature. This pressure difference between the condenser and the evaporator is sufficient to push the liquid back through the **expansion valve** which returns from the condenser to the evaporator just as much liquid as is being evaporated.

Cycle of Operations

5. The actual sequence of operations that occur in a refrigerator can be followed from Fig. 2:

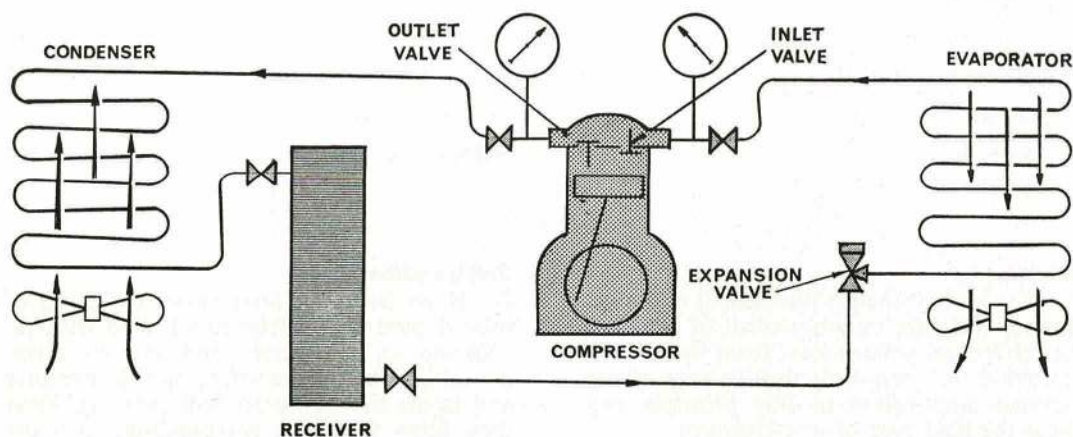


Fig. 2. CYCLE DIAGRAM

- (a) Gaseous refrigerant at a high pressure is pumped by the **compressor** into the **condenser**. Here the gas is cooled and liquefied by means of the condenser fan.
- (b) The condensed liquid drains away from the condenser and passes into the **liquid receiver**.
- (c) From here the liquid passes through a **shut-off valve** and liquid pipeline to the **expansion valve**, where the pressure forces it through the valve.
- (d) As soon as the liquid passes through the valve there is a decrease in pressure, the refrigerant changing from a high pressure to a low pressure liquid.
- (e) It then passes into the **evaporator** where, being colder than the surroundings, it absorbs heat and commences to boil. Thus, the surroundings are cooled by this absorption of heat, and as fast as gas is formed in the evaporator it is pumped back to the condenser by the compressor and the cycle is complete.
6. In a properly designed refrigerator there should not be any liquid left when the refrigerant reaches the end of the evaporator. All the liquid should have been boiled away and the incoming heat will, because there is no more liquid to evaporate, raise the temperature of the gas above the boiling point, and thus the gas becomes superheated.

7. The compressor takes this superheated low pressure gas and, in compressing it, heats it still further and discharges it at a high pressure and still more superheated. This is why the short length of pipe connecting the compressor to the condenser is usually much warmer than the condenser which, of course, must be at the temperature at which condensation takes place.

8. It will probably be realised by now that the cycle of operations explained in the foregoing is actually the heat pump referred to in the last chapter; namely the **vapour compression** method.

TYPICAL LAYOUT

General

9. An electric motor or internal combustion engine is fitted with a centrifugal clutch pulley through which the drive is imparted to the compressor by means of V-belts. The purpose of the fan attached to the clutch pulley is to force air through the condenser unit. The refrigerant charge is contained in the receiver, and piping is used to connect the compressor, condenser and other components fitted in the circuit. It will be noted that included in Fig. 3 are additional components to those shown in Fig. 2, and which were not necessary for consideration of the basic cycle of operations.

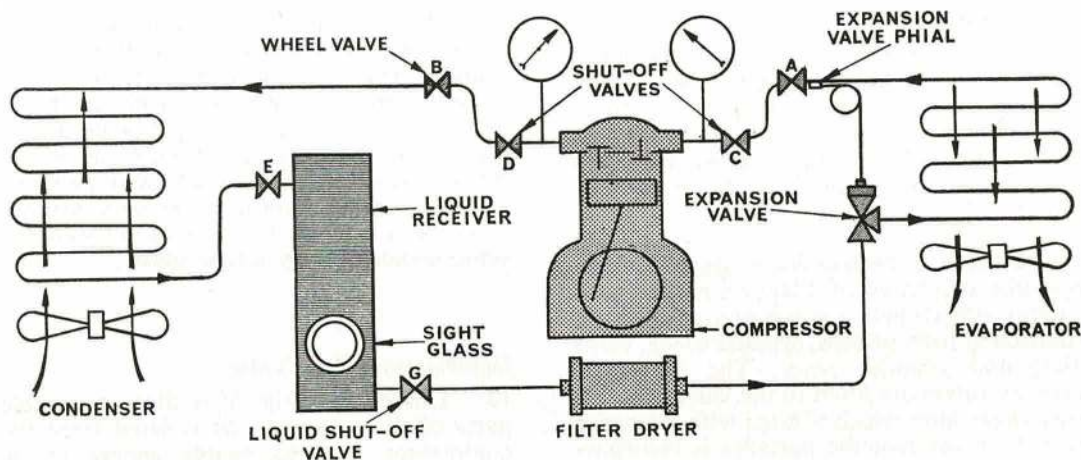


Fig. 3. TYPICAL CIRCUIT

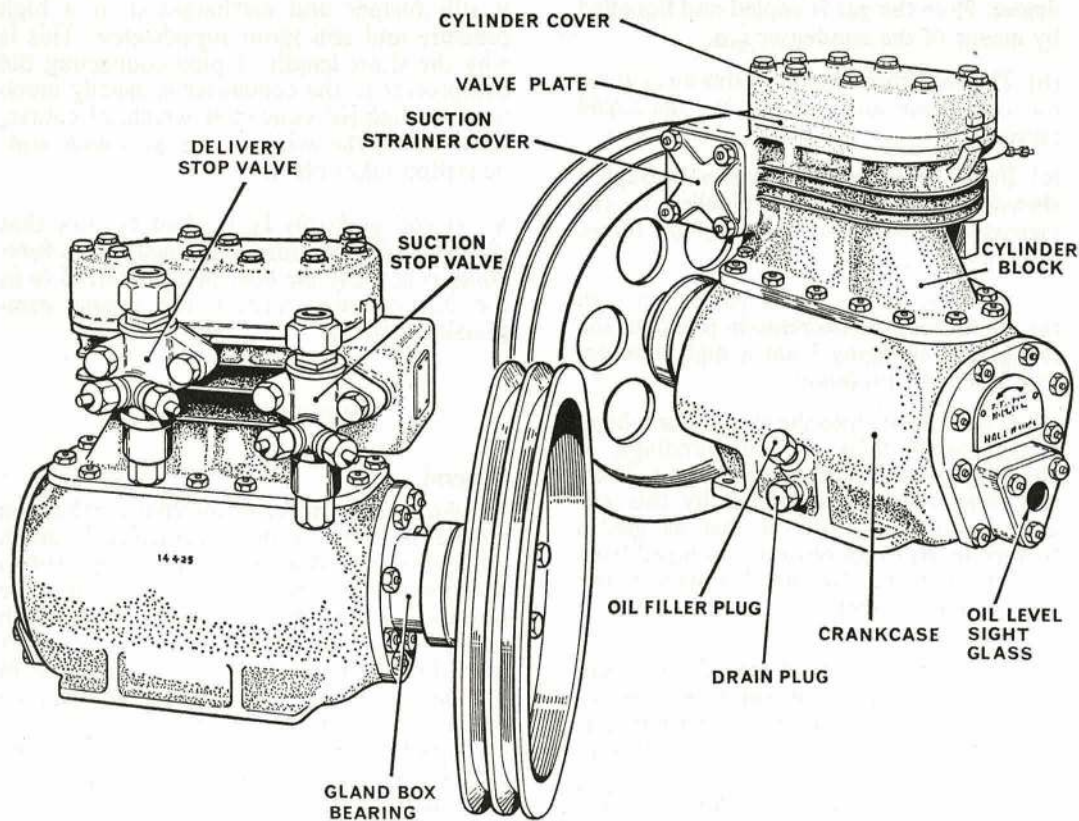


Fig. 4. TYPICAL COMPRESSOR

Compressor

10. The compressor is a mechanical pump that is driven by the power unit. Its purpose is to pump the refrigerant gas from the evaporator and deliver it to the condenser at the required pressure for condensation. There are various types in use and a typical example is shown at Fig. 4.

11. This is a twin-cylinder model which operates at a speed of 1,000 r.p.m. Its main components include a crankcase, crankshaft, connecting rods, pistons, cylinder block, valve plate and cylinder cover. The inlet and delivery valves are fitted to the valve plate. A wire gauze filter which is fitted with a magnet to collect any metallic particles is incorporated in the inlet to the cylinder block. Its purpose is to prevent the ingress of foreign matter to the compressor.

12. The jointing used between the cylinder block and the crankcase and also on the cylinder head and the gland box end plate is made from compressed asbestos fibre; other types of jointing must not be used. The gland box bearing at the driving end of the crankshaft is fitted with a bellows type gland which is spring loaded to prevent leakage from the crankcase. The level of the oil in the sump is indicated by a sight glass.

Double-seated Stop Valve

13. This device (Fig. 5) is fitted to enable parts of the system to be isolated from the compressor, and to enable gauges to be fitted without the introduction of air into the system. These valves are fitted to both suction and discharge sides of the compressor.

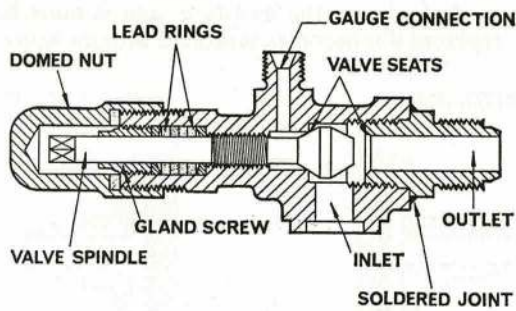


Fig. 5. DOUBLE-SEATED STOP VALVE

14. These valves have three positions, in each of which they carry out a different function as follows:

(a) **Forward Seating.** The valve is turned in a clockwise direction closing the suction or discharge lines and leaving the gauge line connection open to the compressor.

(b) **Intermediate.** A stop valve which has a gauge or a high pressure cut-out connected to it, should, when in normal use, be opened one turn from its back-seat in

order to allow the gauge or cut-out to function.

(c) **Backward Seating.** In this position the valve has been turned in an anti-clockwise direction as far as it will move, resulting in the suction and discharge lines being open to the compressor but the gauge line is isolated from the compressor.

Condenser

15. As stated previously the hot gas which leaves the compressor is liquefied in the condenser by removal of its latent heat. The type of condenser used will depend upon the size and application of the refrigerator, and may be either water or air cooled; the finned air-cooled type (Fig. 6) is very widely used. The design of the condenser is very important, because if the latent heat is not removed completely then some of the gas will not be liquefied and thus the subsequent cycle is unsatisfactory. On the other hand, if heat is still removed after the extraction of all the latent heat, then unnecessary pre-cooling occurs.

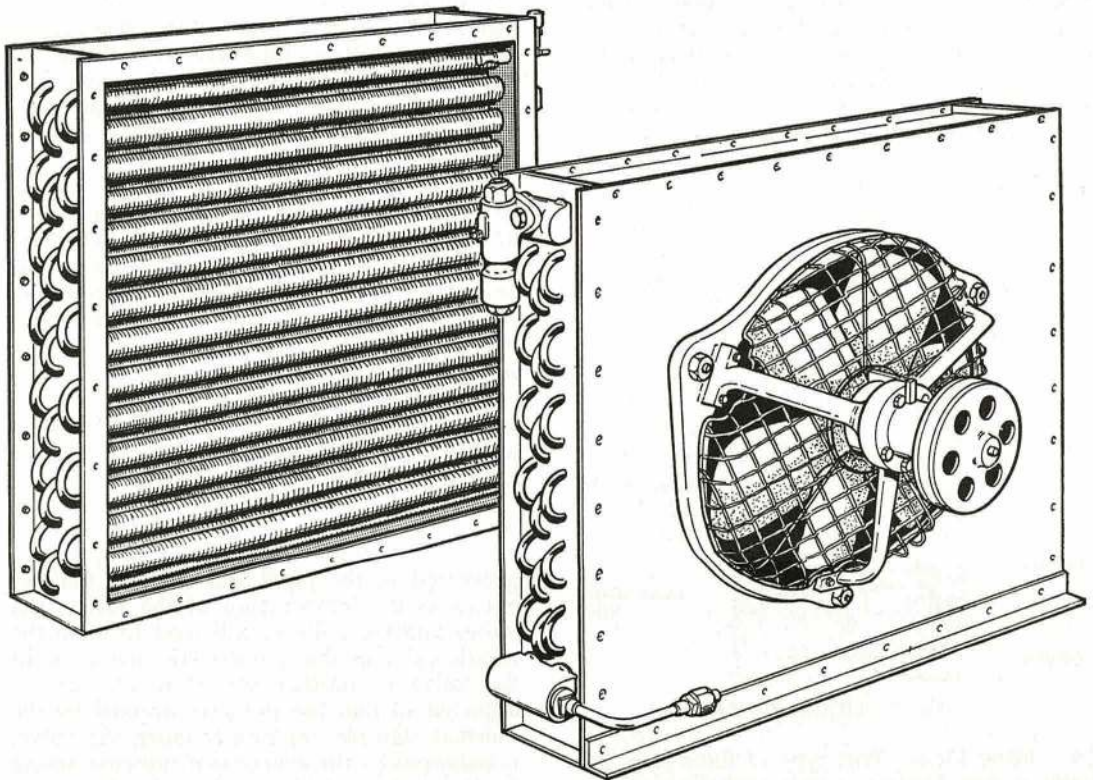


Fig. 6. CONDENSER

Liquid Receiver

16. The liquid receiver acts as a storage vessel for surplus refrigerant resulting from variations in the demand on the plant. Situated at both inlet and outlet sides of the receiver are valves of the simple shut-off type which permit the passage of refrigerant to and from the liquid receiver to be controlled. Its capacity is sufficient to hold the complete gas charge when liquefied. The receiver sight glass is so positioned that under all conditions of operation, liquid refrigerant should be visible; if not, then further charge is required as described later.

Filters

17. It has been previously stated that a filter is fitted to the compressor inlet and it is usually referred to as the inlet or suction filter. There is also another filter installed in the system between the liquid receiver and the expansion valve; this may be a **liquid filter** or a **filter drier**.

18. **Liquid Filter.** The purpose of the liquid filter (Fig. 7) is to collect any foreign matter that may be present in the refrigerant and thus protect the expansion valve. It achieves this purpose by means of wire gauze and a magnet. A stop valve is fitted to the inlet connection at the top of the filter casing.

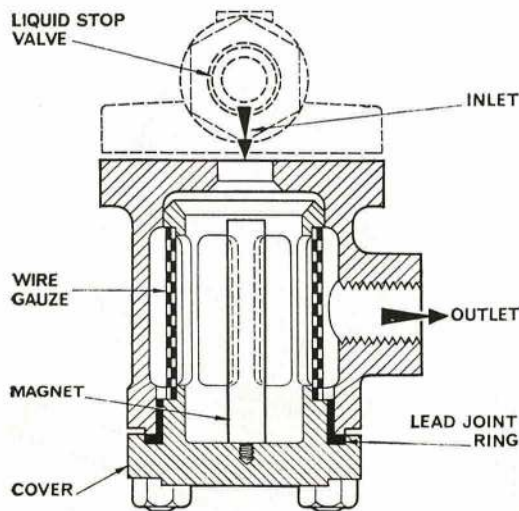


Fig. 7. LIQUID FILTER

19. **Filter Drier.** This type of filter (Fig. 8) collects any foreign matter including water which is undesirable and may be present in the refrigerant. An agent such as **silica gel** is

used to absorb the moisture, and it must be replaced if it becomes saturated with moisture.

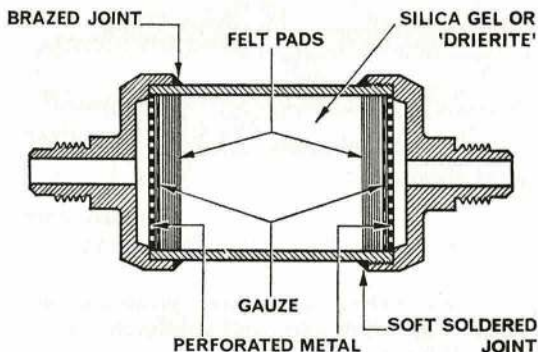


Fig. 8. FILTER DRIER

Expansion Valve

20. The expansion valve (Fig. 9) is also known as the **thermostatic regulator** and is fitted in the system between the liquid filter and the evaporator. Its purpose is to maintain a constant temperature difference between the refrigerant gas leaving the evaporator and the liquid refrigerant boiling in the evaporator. This temperature difference is termed the **superheat** of the gas. The valve therefore permits the whole of the cooling unit to be used at its maximum efficiency under all conditions of thermal load.

21. The valve of the type shown in Fig. 9 is actuated by two bellows elements. The first is subjected to the pressure existing at the entrance to the evaporator and, in conjunction with a spring, it tends to close the valve when the pressure rises. The second element is connected by a capillary tube to a phial which is charged with the same refrigerant as that used in the system. The phial is attached to the suction line at a position on the outlet of the cooling unit coils.

22. If the phial temperature is the same as the suction line temperature, the pressure generated in the phial and thermal bellows varies as the temperature of the return gas varies and the bellows will tend to open the needle valve as the temperature increases. In the valve is another spring which can be adjusted so that the pressure applied by the thermal element, tending to open the valve, is balanced by the evaporator pressure acting on the pressure bellows when the gas in the suction line has reached a predetermined degree of superheat.

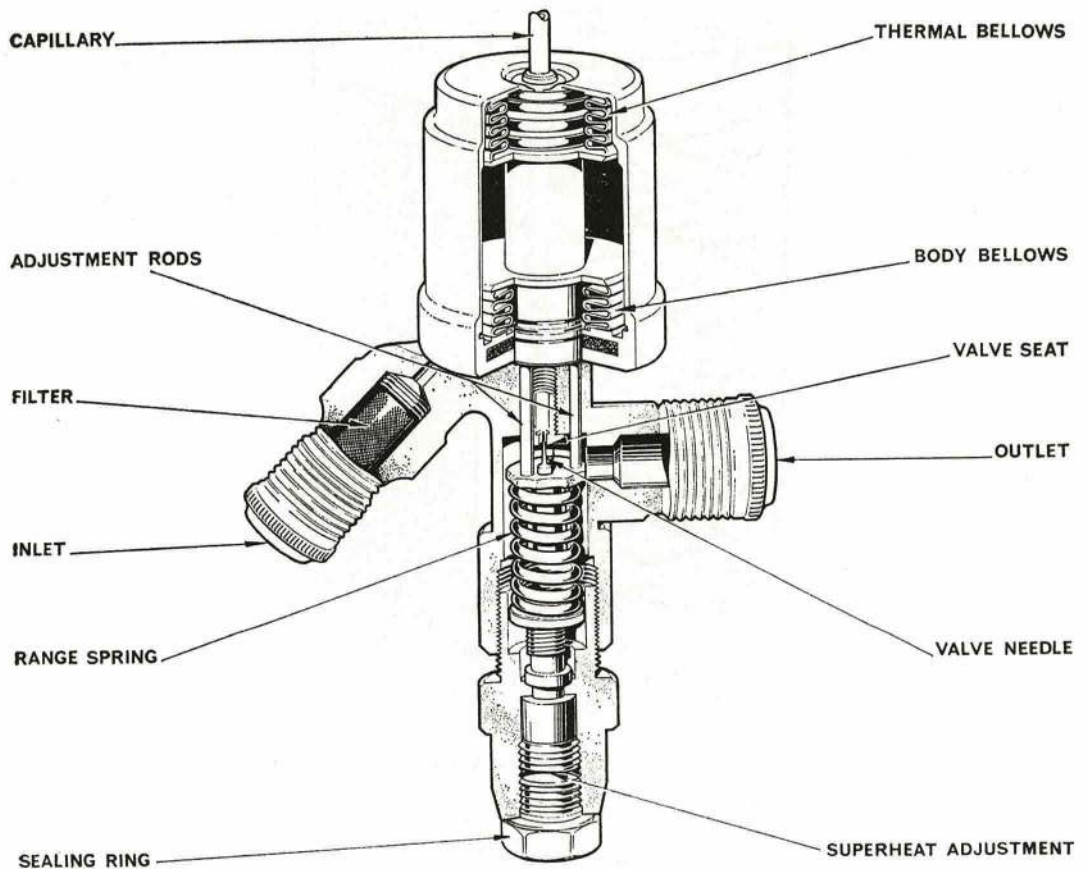


Fig. 9. EXPANSION VALVE

23. Thus, the liquid refrigerant entering the evaporator is allowed to absorb heat until the total amount has changed to gas with a certain degree of superheat. The expansion valve regulates the flow of liquid to the evaporator according to the heat input, and ensures that the flow of refrigerant is such that the whole amount can be evaporated under the prevailing load conditions, thus maintaining the predetermined superheat.

24. Although this component will maintain, automatically, a predetermined temperature difference between the thermal phial and the liquid boiling in the evaporator, this temperature difference corresponds only to the desired degree of superheat while the phial is at the temperature of the gas in the suction line. It is therefore important that there is good thermal contact between the phial and the pipe.

Evaporator

25. This is the part of the system where the refrigerant evaporates to give the cooling effect. Two main classes of evaporator are commonly used:

- (a) **Brine** type coolers—indirect.
- (b) **Fin** type coolers—direct.

26. The former are used mainly in connection with large industrial units which can use the storage effect of brine to advantage. Fin type coolers are used mainly for smaller commercial and domestic refrigeration; these are the type normally found on ground equipment. An evaporator of this type (Fig. 10) is made up of finned tubing mounted in a thermally insulated container. An air delivery fan causes air to flow over the finned surfaces of the tubes where heat is abstracted direct from the air.

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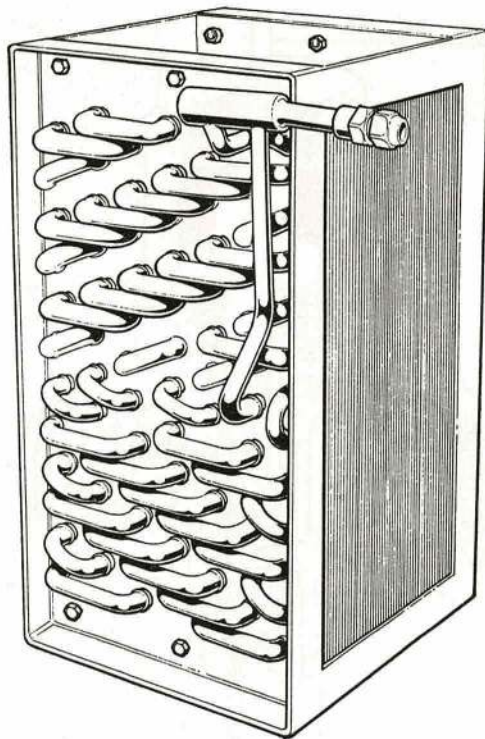


Fig. 10. EVAPORATOR

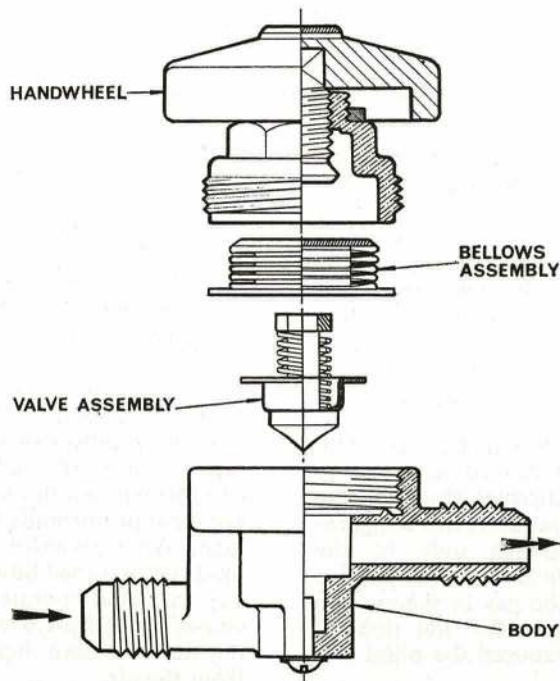


Fig. 11. WHEEL VALVE

Wheel Valves

27. Two of these valves (Fig. 11) are shown "A" and "B" fitted in the circuit illustrated at Fig. 3. They are extra valves that are introduced into the circuit for the purpose of simplifying normal starting-up and shutting-down procedures. They are sometimes referred to as packless shut-off valves.

Gauges

28. The gauges fitted to both the inlet and the outlet sides of the compressor indicate the temperatures at which evaporation and condensation are taking place, provided that the refrigerator is operating correctly. As will be seen later in these notes, these gauges give a good indication as to whether the refrigerator is operating correctly. In actual practice it will be found that the gauges used are frequently of the combined temperature/pressure type. The gauge fitted to the low side of the compressor is calibrated from 0-90 lb per sq. in. and also from 0-30 inches of mercury, whilst the high side registers from 0-250 or 300 lb per sq. in.

Absolute and Gauge Pressures

29. The true pressure of a refrigerant is measured from the absolute zero of pressure and is, in fact, its pressure above perfect vacuum, i.e. total absence of pressure. If the **true** or **absolute pressure** is known then the boiling point is also known exactly. Unfortunately it is not convenient to measure pressures from **absolute zero**, and the standard pressure gauges used in refrigeration work

only measure the difference between the refrigerant pressure and the pressure of the atmosphere.

30. When a pressure gauge registers, for example, 100 lb per sq. in., it means that the pressure being measured is 100 lb per sq. in. above that of the atmosphere, and the reading is known as the **gauge pressure**. It differs from the absolute pressure by an amount equal to the pressure of the atmosphere.

31. Under normal conditions at sea level the pressure of the atmosphere is 14.7 lb per sq. in., and if a gauge registers 100 lb per sq. in. at sea level then the true or absolute pressure is 114.7 lb per sq. in. This relationship must be understood in particular where refrigerators are operated above sea level, in case any references to pressure require correction.

Effect of Altitude on Pressure

32. It follows from the foregoing that height above sea level affects the pressure of the atmosphere and necessitates correction of pressure gauge readings in order to use the temperature/pressure information given in chapter 1 (Figs. 6 and 7). Above sea level atmospheric pressure decreases and gauge readings must be corrected as shown in the table below:

Example

If the pressure gauge reads 30.5 lb per sq. in. at an altitude of 4,000 feet above sea level the corrected refrigerant pressure is 28.5 lb per sq. in. (30.5-2.0).

Height above sea level	Subtract from Gauge Readings if Pressure is recorded	Add to Gauge Readings if Vacuum is recorded
2,000 ft.	- 1.1 lb per sq. in.	+ 2.1 in. vacuum
4,000 ft.	- 2.0 lb per sq. in.	+ 4.1 in. vacuum
6,000 ft.	- 2.9 lb per sq. in.	+ 5.9 in. vacuum
8,000 ft.	- 3.7 lb per sq. in.	+ 7.7 in. vacuum
10,000 ft.	- 4.6 lb per sq. in.	+ 9.3 in. vacuum

Terms

33. The following paragraphs explain certain terms and language that are peculiar to refrigeration engineering.

34. **Pumping Down.** Whenever it is required to open a refrigeration system to atmosphere for service operations or repairs, the refrigerant contained in the affected part of the system must be removed. To do this, the refrigerant is confined to the receiver by closing the liquid line stop-valve and (with a gauge attached to the compressor suction stop valve) operating the machine. Thus all the gas is pumped back to the compressor and liquefied by the condenser, but is prevented from going further by the liquid stop valve.

35. Final evacuation of the "system" should be to a pressure of 1 to 2 pounds so that when it is opened temporarily the slight pressure will permit a small amount of refrigerant to escape and thus prevent the entrance of air. When performing this operation, first pull the gauge pressure down to 0 lb per sq. in. (do not pump a vacuum) and stop the plant. The gauge pressure will build up quite rapidly. Repeat this process until the build-up is slower and if the operation is timed correctly it will rise to slightly above zero and remain so for several minutes.

36. **Charging.** This means the addition of refrigerant to a system from an external source which is usually a cylinder.

37. **Purging.** This means the release of air or non-condensable gases from a system. It is also applied to the practice of pushing air out of a newly installed part or connection by the release of refrigerant into the part and allowing it to escape from the open end.

38. **Slugging.** This denotes noisy compressor valves caused by liquid refrigerant returning to the compressor. Knocking will also occur when oil is being pumped out of the compressor crankcase or is returning in mass to the compressor.

39. **Low Side.** This is the part of the system between the expansion valve and the inlet valve in the compressor. It includes the evaporating or cooling surface, the suction line and the compressor crankcase; it is that part of the system under low pressure.

40. **High Side.** This is all the rest of the system, i.e. that under high pressure.

41. **Frosting Back.** This denotes the appearance of frost on the suction line extending as far back as the compressor.

42. **Saturation.** This denotes the condition of the gaseous refrigerant in the presence of boiling liquid at a given pressure. In tables of refrigerant properties corresponding temperatures and pressures are given at the saturation point.

43. **Superheat.** This means the additional heat beyond that required to produce saturation at any specific pressure. Superheat is usually spoken of in terms of degrees Fahrenheit above saturation temperature.

Example. From Fig. 6, Chapter 1, it is seen that the temperature corresponding to 84 lb gauge pressure is 80°F. If a temperature measurement of refrigerant at 84 lb pressure shows 90°F. the gas would be said to have 10° of superheat.

44. **Crack Open.** This means the opening slightly of a valve or the loosening slightly of a coupling nut.

45. **Briggs Plug.** This is the name of the threaded plug used to seal off the gauge part of a normal shut-off valve.

46. **Dehydrated Piping.** This means the refrigerator piping from which all moisture has been removed.

47. **Refrigerator Load.** This denotes the foodstuffs and such like which occupies cabinet space.

48. **Insulation.** This denotes the packing that is placed around the evaporator to exclude heat.

49. **Restriction.** This indicates a blockage restricting the flow of refrigerant.

50. **Liquid Line.** This means the piping from the liquid receiver to the evaporator.

51. **Discharge Line.** This is the piping from the outlet side of the compressor to the condenser.

52. **Cycling.** This means the movement of the refrigerant around the system from the receiver to the evaporator, compressor, condenser and back to the receiver.

53. **Suction Line.** This is the piping from the evaporator to the compressor; it is often referred to as the inlet line.

SERVICING

General

54. Refrigeration equipment is serviced in accordance with the instructions contained in the basic servicing schedules. The following paragraphs deal with some of the tasks which may require to be performed in the day-to-day operation of refrigeration equipment.

Fitting Service Gauges

55. When it is required to fit service gauges proceed as follows:

- (a) Stop the unit.
- (b) Fit each gauge with a gauge line.
- (c) Fully back seat low and high side shut-off valves.
- (d) Remove the gauge plugs and fit the adaptor unions into the body of the shut-off valves.
- (e) Connect the gauge lines to the unions and tighten the coupling nuts except the ones at the gauges which are left slightly loose.
- (f) Crack open both shut-off valves to let a small amount of refrigerant gas escape at the gauge connection. This will purge any air that may remain in the gauge lines.
- (g) Tighten the unions at the gauges.

Leak Detection

56. There are three methods of testing for refrigerant leaks:

- (a) Soapy water.
- (b) Thin oil.
- (c) Leak detector lamp.

57. Using either of the first two methods, apply a solution of soapy water or thin oil around all joints or suspect leakage points. The presence of bubbles will indicate leakage.

58. **Leak Detector Lamp.** This is the most effective method of detecting a leak and

accurately indicating the exact position; a typical lamp is illustrated at Fig. 12. To operate, pass the open end of the flexible tube over all parts of the system where refrigerant leaks are liable to occur. If the air passing through this tube contains even a minute quantity of refrigerant the burner flame will change colour immediately to a characteristic green, or blue if the amount is large. The following precautions must be observed:

- (a) Ensure that the surrounding atmosphere is free from vapours such as trichloroethylene and carbon tetrachloride which also colour the flame and thus give a false impression.
- (b) Do not fill or pump pressure into the lamp container in an atmosphere polluted with gases or refrigerant which will colour the flame.
- (c) Always keep the fire hazard in mind when using the lamp.

Testing Compressor Valves

59. Poor performance may be traced to the compressor not pumping sufficient gas, the cause being leaking compressor valves. To find if the valves are leaking proceed as follows:

- (a) If the compressor is driven electrically, switch off the unit, fit inlet and outlet service gauges to the compressor and screw in fully the inlet shut-off valve to isolate the evaporator from the compressor.
- (b) Start the motor and after allowing the unit to run for a few minutes, observe on the service inlet gauge the best possible vacuum that can be pulled on the crankcase body. If during such time a hammering noise is heard, switch off the unit for a period. This noise is caused by the presence of vapour in the compressor lubricating oil which is lifted over the valve discs (slugging). The compressor is functioning correctly if it pumps 24–26 inch vacuum or more; the motor can then be switched off. Observe the compound gauge carefully and if the loss of vacuum is pronounced, i.e. the back pressure reading advances to a pressure within approximately five minutes, this is a good indication that the compressor outlet valves are leaking.

Note.—When testing the valves, the pressure observed on the service outlet gauge should be approximately within the range of 60–120 lb per sq. in.

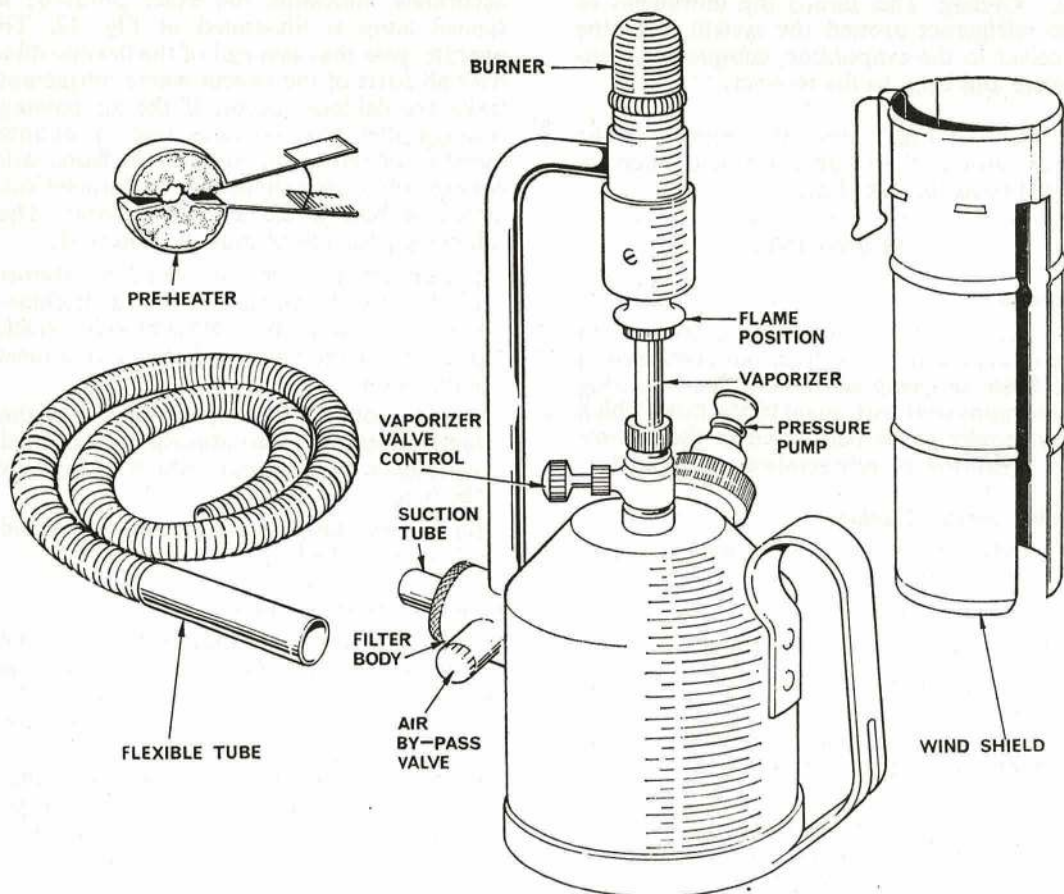


Fig. 12. LEAK DETECTOR LAMP

Isolating the Compressor

60. When it is required to isolate the compressor for purposes of removal or repairs, proceed as follows:

- (a) Stop the unit.
- (b) Fit service gauges (para. 55).
- (c) Close the inlet shut-off valve to isolate the compressor from the cooling coils.
- (d) Start the unit and allow the pressure in the crankcase to fall to 0-2 lb per sq. in.
- (e) Stop the unit and close the outlet shut-off valve.
- (f) Release the refrigerant gas from the compressor head by loosening the coupling nut on the outlet gauge.

Compressor Shaft Seal

61. Leakage of refrigerant from the system

or entry of air into the system at the flywheel end of the compressor shaft is prevented by means of a bellows-type seal assembly (Fig. 13). The actual sealing is effected by the film of oil between the two faces of the rotating and stationary components, and therefore the correct oil level in the compressor must be maintained.

62. It is also essential to prevent the ingress of dirt or other foreign matter between the two seal faces. Before removing the seal assembly the compressor must be isolated (para. 60). If the seal faces are dirty or slightly scratched it is permissible to lap them with metal polish on a piece of plate glass. Ensure thorough cleanliness when assembling.

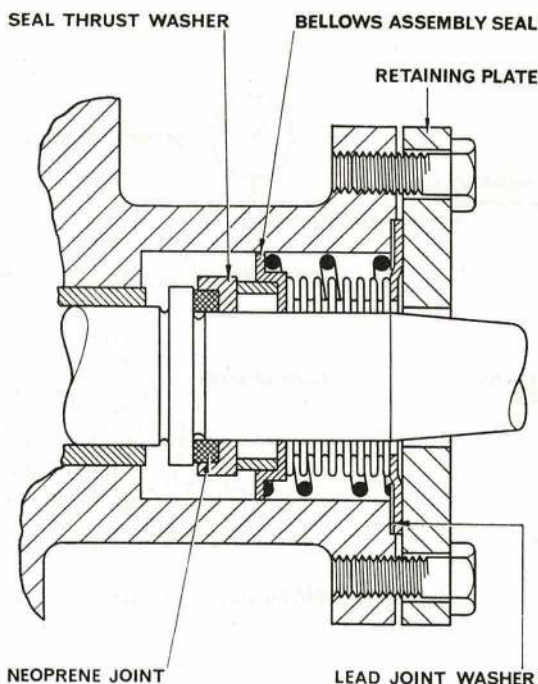


Fig. 13. SEAL ASSEMBLY

Checking the Oil Level

63. The first operation is to remove any gas pressure from the compressor crankcase and refrigeration oil (so that the crankcase pressure balances at 2 lb per sq. in.) as described in para. 60. **THIS PROCEDURE IS MOST IMPORTANT.**

64. Two plugs are located on the crankcase, the upper one being in line with the maximum oil level and the lower one the minimum oil level. Unscrew and partly remove the top plug first. If oil runs out no addition is required and the plug must be replaced tightly. If oil does not run out, unscrew the lower plug and if oil escapes from here then the oil level is within satisfactory limits. If oil does not escape from the lower hole, half a pint of refrigeration oil must be added as described in para. 65. Care should be taken to lose as little oil as possible when removing the plugs and they must be tightened immediately the level has been checked.

Adding Refrigeration Oil

65. When additional refrigeration oil is required proceed as follows:

- (a) Stop the unit, fit service gauges to the compressor and screw in fully the inlet shut-off valve to isolate the evaporator from the compressor.
- (b) Close the inlet gauge shut-off valve.
- (c) Pour half a pint of refrigeration oil into a clean container which must be completely free from moisture.
- (d) Disconnect the $\frac{1}{4}$ in. pipe-line at the compound inlet gauge. Bend the pipe over and submerge the open end in the oil close to the bottom of the container.
- (e) Start the unit and run for two to three minutes. Open the shut-off valve on the gauge-line; the oil will now pass into the compressor and care must be taken to keep the pipe submerged in the oil, otherwise air will pass into the system.
- (f) When most of the oil has passed into the compressor and before the end of the pipe is uncovered, close the shut-off valve and stop the unit.
- (g) Remove the pipe from the oil, bend the tubing back into position and re-connect the compound gauge.

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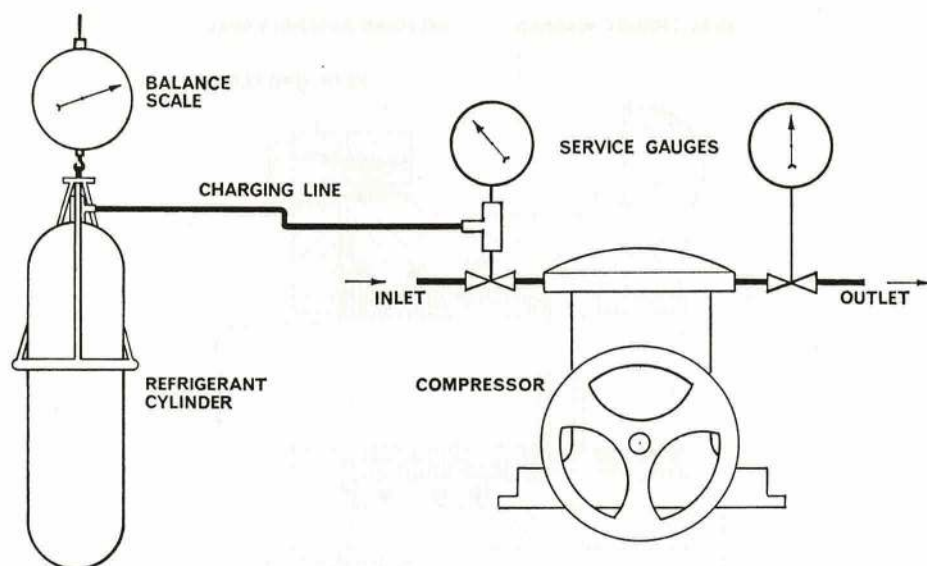


Fig. 14. REFRIGERANT CHARGING

Charging the System

66. If the refrigerant system has lost all or part of its refrigerant charge, any leakage must first be located by one of the methods described (paras. 56–58). After all leaks have been rectified additional refrigerant must be added as follows:

(a) Stop the unit and fit a high pressure gauge to the high side of the compressor.

(b) Attach a charging line to the gauge union on the low side valve.

(c) Install another line on the refrigerant service cylinder and connect it to the charging line by means of a "tee" piece to which a low pressure gauge has been fitted. The cylinder must be in an upright position (Fig. 14) so that gas only will be added. Liquid refrigerant must not be allowed to enter the compressor otherwise damage may be caused to the compressor valves.

(d) Purge the charging line by opening the valve on the refrigerant cylinder and releasing the coupling nut at the gauge union momentarily.

(e) Fully forward seat the low side valve to isolate the evaporator.

(f) Start the unit and open the refrigerant cylinder slightly, using the cylinder valve to adjust the flow of refrigerant to the compressor. An average pressure difference of 5–10 lb per sq. in. should be maintained.

(g) If all the refrigerant has been lost, continue charging until the balance scale shows that the correct weight of refrigerant has been added.

(h) If only partial loss has occurred, add 6 oz. of refrigerant at a time, close the cylinder valve, back seat the low side valve and test. Repeat until the gauges show that the system is working correctly.

(j) When sufficient refrigerant has been added disconnect the cylinder and gauges.

Note.—Unless specific instructions are issued for charging a particular type of cooling unit or refrigerator the foregoing procedure must be used with the exception of (h). The amount of refrigerant added at one time whilst topping-up must be adjusted by taking into account the capacity of the unit concerned.

Overcharge of Refrigerant

67. If too much refrigerant has been added to the system filling the liquid receiver and the condenser, it may be found that the lower parts of the condenser are flooded with refrigerant which greatly reduces the effective condensing area. When the unit is in operation this overcharge is indicated by the following:

- (a) The lower sections of the condenser and the complete receiver remain comparatively cool.
- (b) The upper parts of the condenser become abnormally warm.
- (c) The condensing pressure is abnormally high.

68. When the unit is not in operation and has cooled down completely to the temperature of the surrounding air, the pressure in the condenser system should fall to that corresponding to the air temperature which may be read from the pressure/temperature table and graph, Chapter 1 Figs. 6 and 7. Ensure that the unit is not exposed to the sun or otherwise made warmer than the surrounding air before making this check. If the gauge reading is higher than the normal gas pressure for the prevailing temperature, the presence of air in the system is indicated.

Undercharge of Refrigerant

69. Refrigerant should always be indicated in the sight glass over the normal working range of the unit. An undercharge of refrigerant causes the following conditions:

- (a) Poor refrigeration.
- (b) Low condensing pressure.
- (c) Partial frosting of the evaporator coil.
- (d) Low intake pressure in the evaporator.

Air in the System

70. This may be caused either by carelessness when replacing parts or by a leak on the low side if the system has been working at a pressure below that of the atmosphere.

71. Air will not condense under the normal temperature and pressure conditions existing in a refrigeration system and therefore it becomes an inert substance which remains in the compressor head, condenser and liquid receiver. This results in:

- (a) Increased head pressures.
- (b) Reduced condenser efficiency.
- (c) Poor refrigeration.

72. With sufficient air in the system the head pressures will become so high that the compressor will be overloaded; this could result in tripping of the thermal relay in the motor starter. The symptoms are somewhat similar to an overcharge of refrigerant, and the actual cause can be found by stopping the unit and allowing it to cool to the temperature of the surrounding air. If there is air in the system the head pressure will not return to a normal reading. Reference should be made to the pressure/temperature table and graph, Chapter 1, Figs. 6 and 7.

73. **Purging the Air.** When it is necessary to purge air from the system proceed as follows:

- (a) Connect service gauges.
- (b) Leave the unit switched off for half an hour.
- (c) Purge a small quantity of gas from the compressor head and condenser by releasing one of the couplings at the service high-pressure gauge.
- (d) When the pressure is considered to be normal secure the coupling nut at the service gauge.
- (e) If all the air has not been removed the procedure must be repeated. Care must be taken to carry out these operations slowly, because fast purging tends to remove oil from the system and will also cause the liquid refrigerant to boil and mix with the air at the top of the condenser.

Gas Cylinders

74. The standard colour scheme for the identification of gas cylinders containing freon 12 is **GREY** paint for the **bottom half** of the cylinder and **PURPLE** paint for the **top half** of the cylinder. Cylinders are supplied in one size which contains 51 lb of refrigerant. The content of a cylinder is assessed by its weight, but as an indication if it is not possible to weigh the cylinder when a plant is being charged, it will be seen that frost appears on the outside of the cylinder as the refrigerant is withdrawn. This frost gradually thaws, starting from the top, as the cylinder empties, and disappearance of the frost is an indication that the cylinder is empty.

FAULTS—CAUSES

Symptoms	Cause
Motor overload relay trips.	Condenser blocked. Belts too tight. Motor bearings seized through lack of adequate lubrication. Low voltage to the motor.
Compressor difficult to start.	Air or other non-condensable gases in the system. Too much refrigerant in system. Too much oil in circulation. Belts too tight. Motor bearings need grease.
Compressor will not start.	Belts too tight. Low voltage to motor. Belts slipping and failing to turn compressor under load. Overload relay tripped, press re-set button on motor.
Crankcase sweats.	Faulty expansion valve. Too much oil in circulation. Too much refrigerant in circulation.
Insufficient capacity.	Too little refrigerant in system. Surface of evaporator coil dirty. Dirty filter. Air in system. Too much oil in circulation. Liquid strainer dirty. Expansion valve faulty. Condenser blocked. Belts slipping. Condenser coils dirty. Suction valve leaking.
Belts fraying at edges.	Belts too tight. Belts too loose. Belt pulleys out of alignment.
Coil frosts or frosting back.	Surface of evaporator coil dirty. Blocked or dirty filter. Faulty expansion valve.
Compressor knocks.	Too much oil in circulation. Liquid refrigerant in compressor. Air in the system. Faulty expansion valve. Drive belts slipping. Suction valve leaking.
Low suction pressure.	Lack of refrigerant. Blocked or choked suction line. Liquid or shut-off valve partially closed or blocked. Faulty expansion valve.
High suction pressure.	Faulty or wrongly adjusted expansion valve. Leaking cylinder head valves.



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