

SECTION 8, CHAPTER 3

TYPICAL INSTALLATIONS

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Introduction

1. The following installations are typical of the various types in use. More detailed information than that presented is available in the relevant air publication. The compressors used on many of the installations are driven by internal combustion engines which will only be briefly referred to because they have already been covered to some extent in section 5 of this publication. Again, more detailed information is available in the relevant air publication.

RADIO COOLING

Types 2 and 4

2. These units are primarily designed to provide a supply of cooled air to ensure

Fig. 3 in the previous chapter, and the refrigerant used is freon (F12). The compressor is driven by V-belts from an electric motor fitted with a centrifugal clutch pulley. The fan that is bolted to the clutch pulley is used to force air through the condenser assembly. The fan that is mounted at the other end is enclosed in a casing that is bolted to the cooling assembly, and air that has been led to the suction box is taken away from the fan by canvas ducts. Provision is made for the air inlet and discharge openings to be either at the top or at the side of the unit whichever is the more convenient.

4. The compressor, condenser, evaporator and receiver are connected by a system of piping and valves, the refrigerant charge being contained in the receiver. The motor is

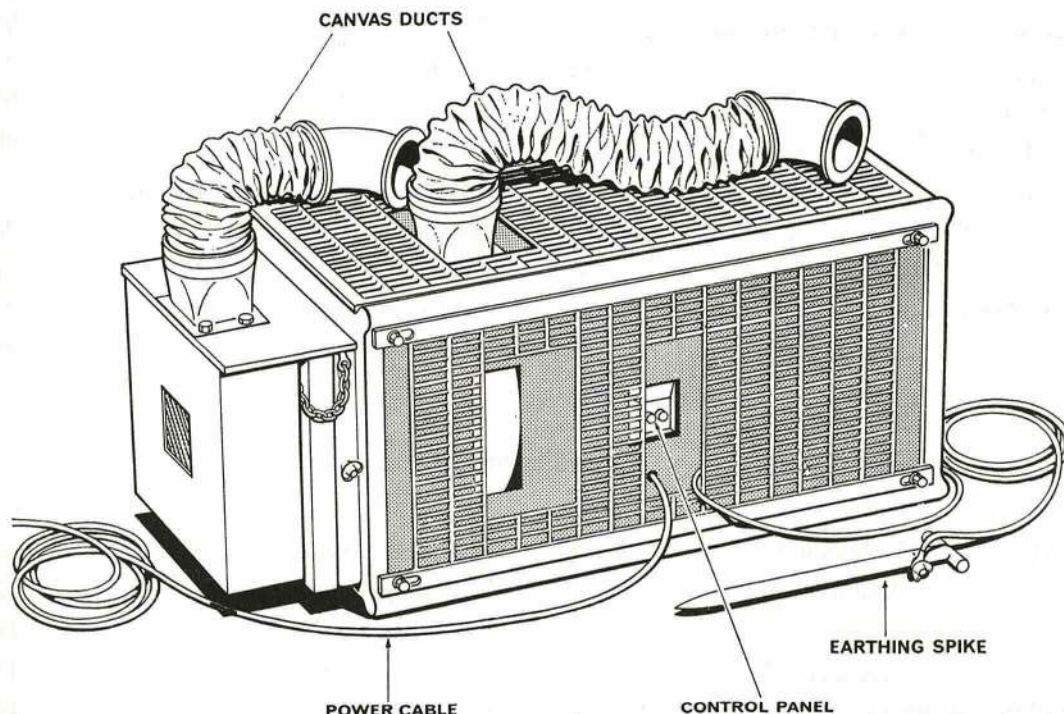


Fig. 1. RADIO COOLING INSTALLATION

satisfactory working conditions for personnel employed in radio and radar cabins and suchlike. Both types are identical in layout (Fig. 1), and are normally fitted on trailers by means of U-bolts around the bottom horizontal tubular members.

3. The circuit for these units is shown at

controlled from the control panel, the power cable being connected to the bottom of the panel by means of a socket and plug. An earth lead and spike are provided and these are housed inside the unit when not in use. The components used in the system are very similar to those described in the previous chapter.

Precautions

5. The operating instructions must be strictly adhered to otherwise damage may result. These instructions are given on plates attached to the equipment and in greater detail in air publication 2897L.

6. Only freon F12 must be used for adding to or recharging the unit circuit.

7. No oil other than the correct grade of oil anti-freeze is to be used for refilling or topping-up the level of oil in the crankcase of the compressor.

8. The oil must not be exposed to the air for any length of time and care should be taken that the drum containing the oil is sealed, both before and after use, and any vessel used for transference of the oil is thoroughly clean and dry.

9. Check that the power supply corresponds to the particulars given on the instruction plate and the starter.

10. The compressor must rotate in a clockwise direction as viewed from the flywheel end, otherwise the locknut securing the eccentric to the compressor shaft will unscrew, giving symptoms similar to a seized compressor.

11. Ensure that the V-belts are kept at the correct tension. If they are too tight the compressor seal bearing or crankshaft will be damaged. Looseness causes slipping, burning and belt slap. To adjust, loosen the compressor holding down bolts and slide the compressor until a single belt can be depressed $\frac{1}{2}$ in. by slight pressure applied with one finger. Take care to maintain correct alignment of the clutch and compressor pulleys when adjusting the belts.

12. When the motor is in regular use it requires one shot of the correct high melting point grease in each grease nipple once every month.

13. The clutch **MUST NOT BE LUBRICATED** in any way.

14. Before the initial start, turn the compressor by hand for a minimum of 30 revolutions by means of the belts or flywheel; **do not use the condenser fan blades for this purpose.** Turning allows the escape of any oil

which may have collected in the compressor head during transit. Evidence of this will be initial difficulty in turning. This precaution should also be taken after long periods of shut-down or movement of the equipment to a new location.

Initial Starting

15. Having completed all the required checks and turned the compressor by hand, proceed as follows:

(a) Remove the caps from the four capped shut-off valves, C, D, E and G (Chap. 2, Fig. 3).

(b) Use a ratchet spanner to turn the four valves fully in an anti-clockwise direction, i.e. until they backseat.

(c) Tighten the gland nuts on the four valves and replace the caps tightly, ensuring that sealing rings (Scotch Rings) are fitted.

(d) Open the wheel valves A and B by turning them fully anti-clockwise.

(e) Switch on the power supply by pressing the "start" button.

(f) Take observations for one hour to check that the equipment is running efficiently.

WARNING . . .

Do not run the equipment under any circumstances with valves A or B closed. Temporary operation as per para. 17(b) and (c) is however permissible.

Starting and Stopping

16. To start and stop the equipment when it is in frequent use, open the wheel valves A and B and connect the supply and switch "ON" and "OFF" by the push buttons as required.

Shutting Down—Short Periods

17. When shutting down for subsequent use or for periods of from one to seven days, proceed as follows:

(a) Press the "stop" button to switch the motor "OFF".

(b) Close the wheel valve A fully in a clockwise direction.

(c) Switch the motor "ON" to turn the compressor for approximately 20 to 30 revolutions (2-3 seconds); switch "OFF" and immediately close the wheel valve B fully in a clockwise direction.

(d) Disconnect the power supply.

Shutting Down—Long Periods

18. When shutting down for periods of over seven days or for storage, proceed as follows:

- (a) Remove the caps from the four valves C, D, E and G.
- (b) Fit service gauges (Chap. 2, Para. 55).
- (c) Close the shut-off valve (G) on the bottom of the receiver fully in a clockwise direction.
- (d) Switch "ON" the motor and allow the compressor to pump refrigerant out of the unit until the suction gauge registers 2 lb per sq. in.
- (e) Switch the motor "OFF".
- (f) Backseat the shut-off valves C and D to isolate the gauges, i.e. turn fully in an anti-clockwise direction. Remove the gauges and replace the plugs tightly.

(g) Close the shut-off valves C, D and E fully in a clockwise direction.

(h) Close the wheel valves fully in a clockwise direction.

(j) Tighten all valve gland nuts and replace the covers tightly, ensuring that sealing rings (Scotch Rings) are fitted.

(k) Disconnect the power supply and display a warning notice. "ALL VALVES CLOSED". Do not operate until valves have been opened.

TROLLEY AIR COOLING Mk. 2A

Introduction

19. This equipment (Fig. 2) is used to provide cool air to facilitate the ground running and testing of aircraft radar installa-

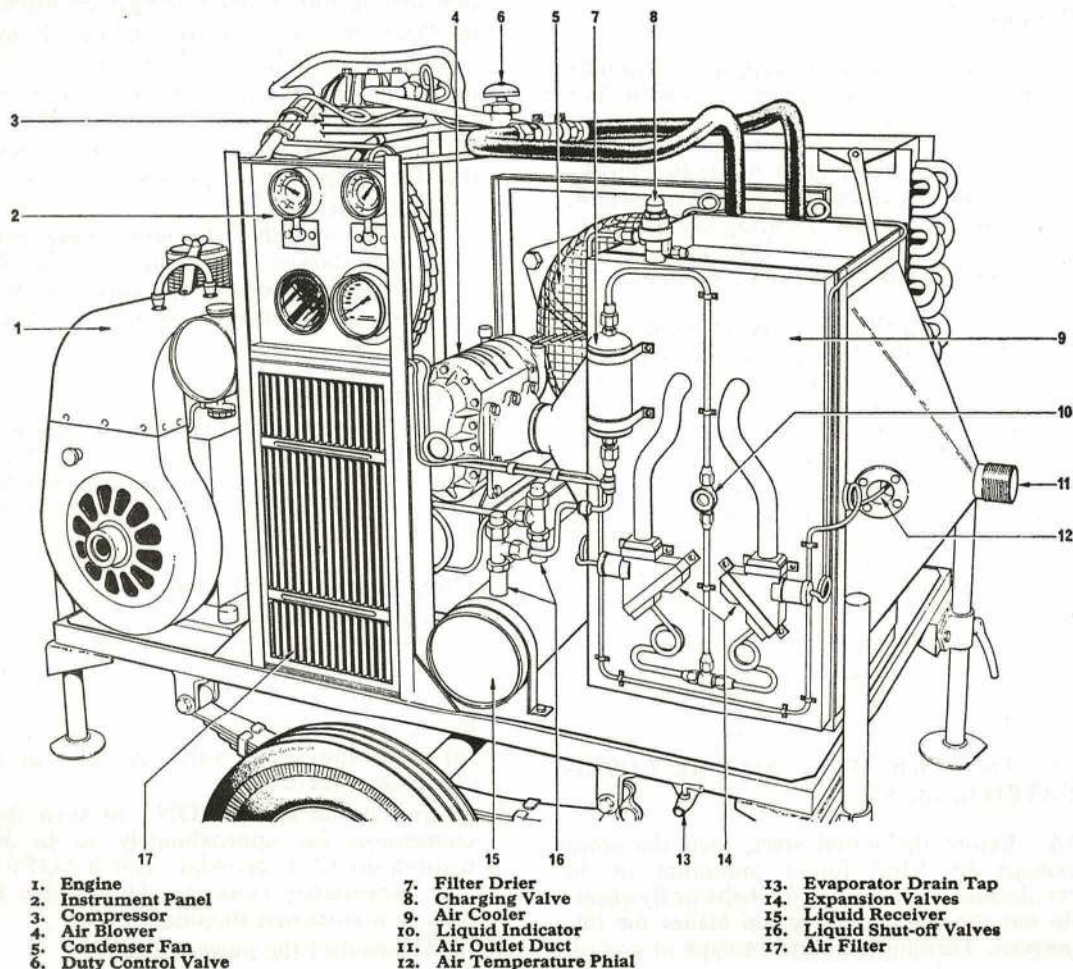


Fig. 2. TROLLEY AIR COOLING MK. 2A

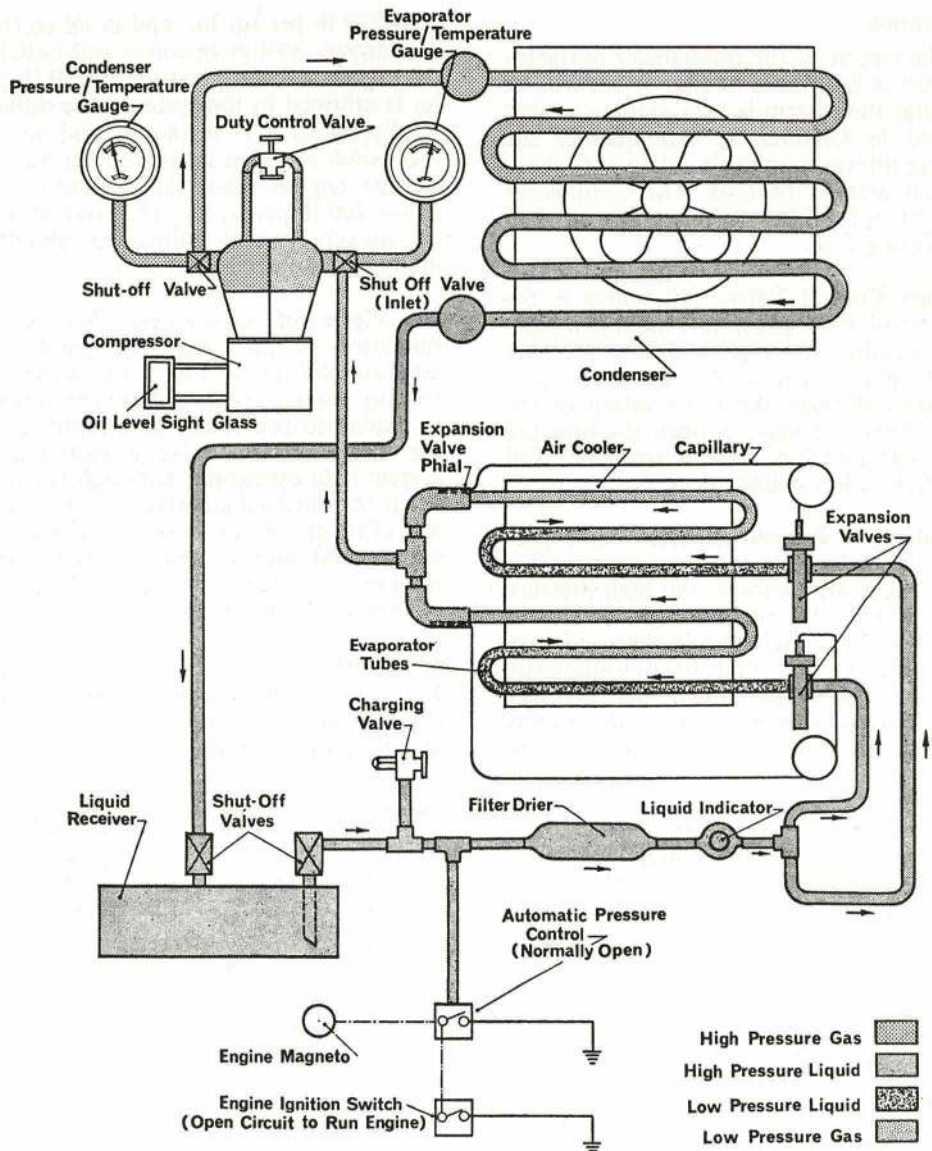


Fig. 3. REFRIGERATION CIRCUIT

tions. Each unit is mounted on a two-wheeled chassis and consists of a Prestcold mechanical refrigeration plant which uses freon 12 as the refrigerant and is driven by a J.A.P. model 55 engine. This operates in conjunction with a Godfrey type K.200 air blower which draws air from the atmosphere and forces it through the air cooler from whence cool air is delivered through a flexible hose to the radar installation.

20. The unit has a maximum cooling capacity of 24,000 B.Th.U./hour and will maintain a minimum output of 10 lb of air per minute at 1 lb per sq. in. gauge. At ambient temperatures of 110–120 deg. F., the air delivery temperature is at least 56 deg. F. below ambient conditions and the air flow is approximately 130 cu. ft. per min. The Mk. 2C trolley has extra fuel capacity to allow 4½ hours continuous running.

(A.L. 27, June 67)

Refrigeration

21. The circuit of the mechanical refrigeration plant is illustrated at Fig. 3. It will be noted that the system is very similar to that described in Chapter 2, consequently the following information deals solely with those items not already covered. The compressor is a Prestcold PS.200 twin-cylinder vertical reciprocating type.

22. **Duty Control Valve.** This valve is the main control of the plant. It is fitted in a pipeline connecting the high and low pressure sides of the compressor. Access to the valve is obtained through the top cowl of the trolley. When the valve is open the pressure on the high and low sides is equalized and thus refrigeration cannot occur.

23. **Automatic Pressure Control.** The purpose of the automatic pressure control (Fig. 4) or, as it is also known, the **high pressure cut-out**, is to switch off the engine when an excessive pressure builds up in the condenser side of the system, and to automatically switch on the engine when the pressure returns to normal and so allow the engine to be restarted. The control has a full range

of 0-250 lb per sq. in., and is set so that the changeover switch operates and switches off the engine when a pressure of 230 lb per sq. in. is attained in the system. The differential is adjusted to 30 lb per sq. in. and this allows the switch to again make contact and switch on the engine when the pressure is at or below 200 lb per sq. in. The control is set by the makers and its adjustment should normally not be interfered with.

24. **Cycle of Operations.** The cycle of operations of the refrigeration plant is shown diagrammatically at Fig. 3 and is the same as for any vapour compression type system, i.e. as explained previously in Chapter 2. When the duty control valve is closed and the system is in operation, although the refrigerant is in continual circulation it does not lose any of its properties. It is in turn evaporated, compressed and condensed, and does not require renewal except to replace losses caused by leakage in the system.

Air Blower

25. The Godfrey type K.200 air blower (Fig. 5) is similar to a supercharger. It is mounted on a platform in the centre of the

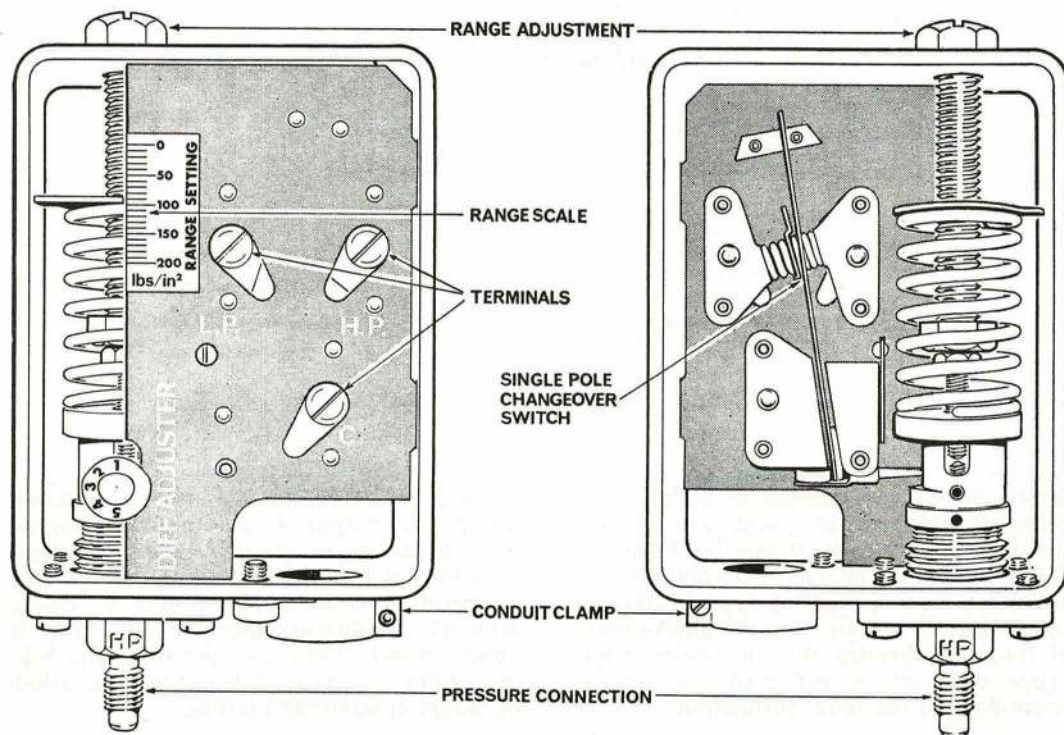


Fig. 4. AUTOMATIC PRESSURE CONTROL

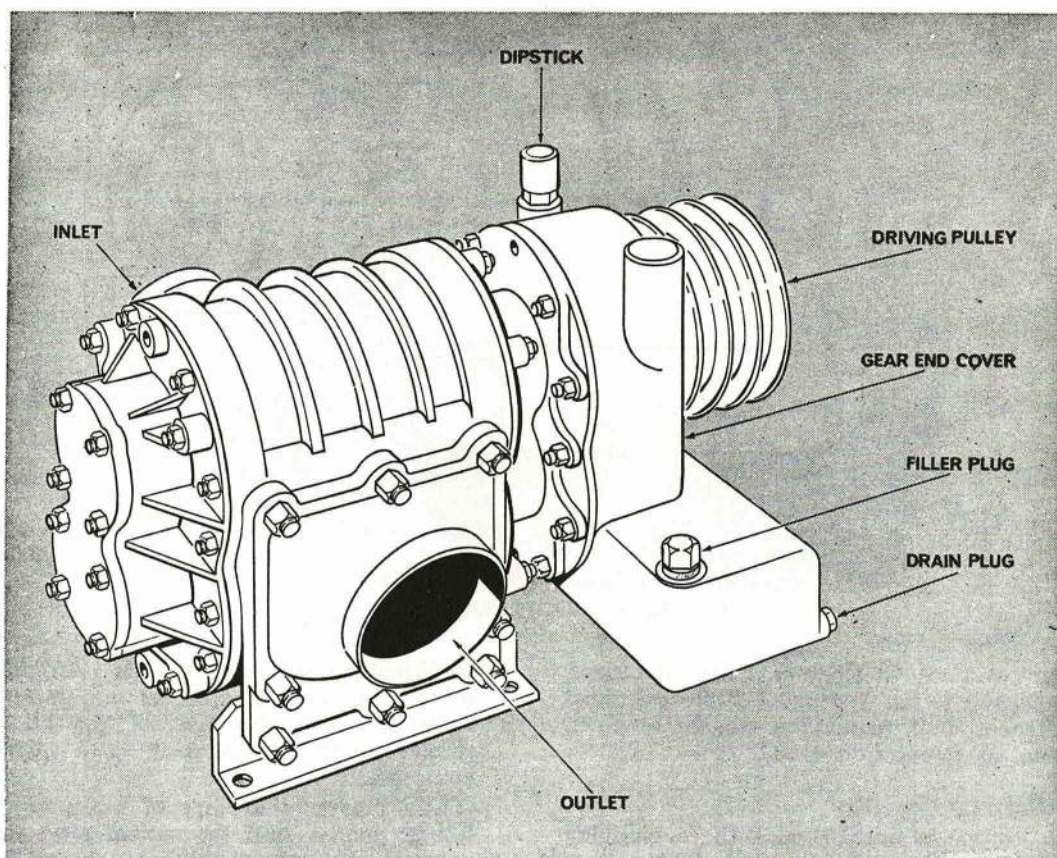


Fig. 5. GODFREY AIR BLOWER

trolley (Fig. 2), its inlet port being connected to the air intake and its outlet port to the air cooler of the refrigeration plant.

26. The air blower is constructed on the Roots principle (Fig. 6). The figure-eight shaped rotors are borne by ball bearings at one end and roller bearings at the other end, and they are geared together to rotate in opposite directions inside the rotor casing. The gears and the bearings are the only parts requiring lubrication so the gear end cover forms an oil reservoir and is provided with a filler plug, a drain plug and a dipstick. The oil level must **NOT** be allowed to fall below the **MIN.** mark on the dipstick.

27. **Operation.** The blower draws air from the atmosphere through the Vokes filter fitted in the air intake and forces it under pressure through the air cooler, from whence the cool air is delivered through the flexible hose to

the aircraft's radar installation. The temperature of the cooled air before passing through the delivery hose is indicated on the gauge mounted on the instrument panel.

Drain Tap

28. The water formed by condensation in the evaporator is drained through a pipe leading from the base of the air cooler to the left-hand side of the trolley. The drain tap that is fitted to the end of this pipe should be kept closed when the plant is in operation and opened to drain off the water at the completion of each run. In the event of the plant being required to operate for a long period then the tap should be opened periodically to release the water.

Precautions

29. The precautions to be observed when operating and servicing refrigeration equip-

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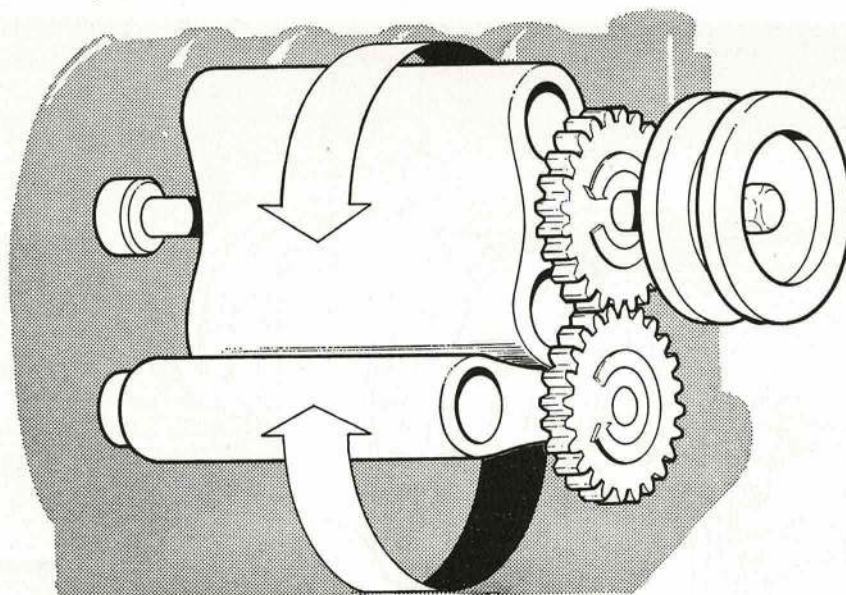


Fig. 6. ROOTS PRINCIPLE

ment as given in Chapter 2 are, of course, applicable to this equipment. If more detailed information is required it can be obtained from air publication 4350A.

Refrigerant Charging

30. It will be noted (Fig. 3) that a charging valve is incorporated in this system. It is positioned on the top of the air cooler and is connected by a pipeline to a T-connection in the liquid line between the receiver and the filter drier. Approximately 18 lb of refrigerant is required for a full charge; the procedure is given in A.P. 4350A.

Pumping Down

31. To pump down, proceed as follows:

- (a) Remove the cover cap from the shut-off valve fitted to the outlet of the liquid receiver and turn the valve spindle fully in a clockwise direction to close the valve.
- (b) Remove the cover plate from the automatic pressure control and use a piece of fuse wire to short the two electrical connections.
- (c) Start the plant and pump down until the pressure registered on the evaporator gauge falls to zero. **Do not pump a vacuum.** Any vacuum would be felt by the evaporator and could cause damage.
- (d) Stop the plant and check for 15 minutes; if the pressure rises, repeat the pumping down operation.

(e) When all the refrigerant is contained in the liquid receiver, close the shut-off valve fitted to the inlet of the liquid receiver or the inlet shut-off valve on the compressor.

(f) To prevent the entry of moisture or foreign matter into the system after the removal of any component from the isolated section, all open pipes and connections must be sealed with blanking plugs immediately the joints are disconnected.

Air Filter

32. Because of the close running clearances of the air blower rotors it is important that the Vokes intake filter is cleaned at the specified periods. A dirty filter places an additional load on the air blower and thus causes overheating. Do not run the plant with the filter removed; the entry of foreign matter into the air system will seriously damage the air blower.

33. To clean the air filter, proceed as follows:

- (a) Remove the air chute and the expanded metal panel covering the air intake.
- (b) Remove the filter from the air intake.
- (c) Tap the filter gently on a wooden block to shake off particles of dust. Do not brush the filter otherwise the fabric will be damaged. A jet of compressed air can be directed onto the inside surface of the filter fabric.

(d) Place the filter in position in the air intake and fit the expanded metal panel and air chute.

TROLLEY AIR COOLING Mk. 5A

Introduction

34. This equipment (Fig. 7) is used to provide conditioned air to the interior and to certain equipment of V-class bomber aircraft. The equipment is mounted on a six-wheeled trolley, the conditioned air being derived from an engine-driven refrigeration plant using freon 12 as the refrigerant and operating in conjunction with a centrifugal fan which supplies the air via the refrigeration evaporator and flexible hoses to the positions in the aircraft.

35. The maximum cooling capacity of the plant is 129,000 B.T.U. per hour, and the maximum air delivery rate is 100 lb per min.

Drive

36. The engine is a Ford type 208E four

cylinder, spark ignition engine which is fitted with a hand lever operated dry plate clutch. Bolted to the clutch housing is a power take-off unit which transmits the drive to the main driving pulley through a trailing link universal coupling.

37. The drive is transmitted to another pulley on the end of the layshaft by eight endless belts which can be tensioned by means of an adjustable jockey roller. Pulleys on the layshaft transmit the drive to the condenser cooling fan (two belts) and the air delivery centrifugal fan (three belts). The inner end of the layshaft is connected by means of a dog coupling to another shaft on which is mounted the compressor drive pulley (six belts). All belts are provided with tensioning pulleys similar to that on the main drive.

Refrigeration Plant

38. Cooling is obtained from a mechanical refrigeration plant which consists of a refrigerant compressor, air cooler (evaporator), air-cooled condenser, liquid receiver, capacity

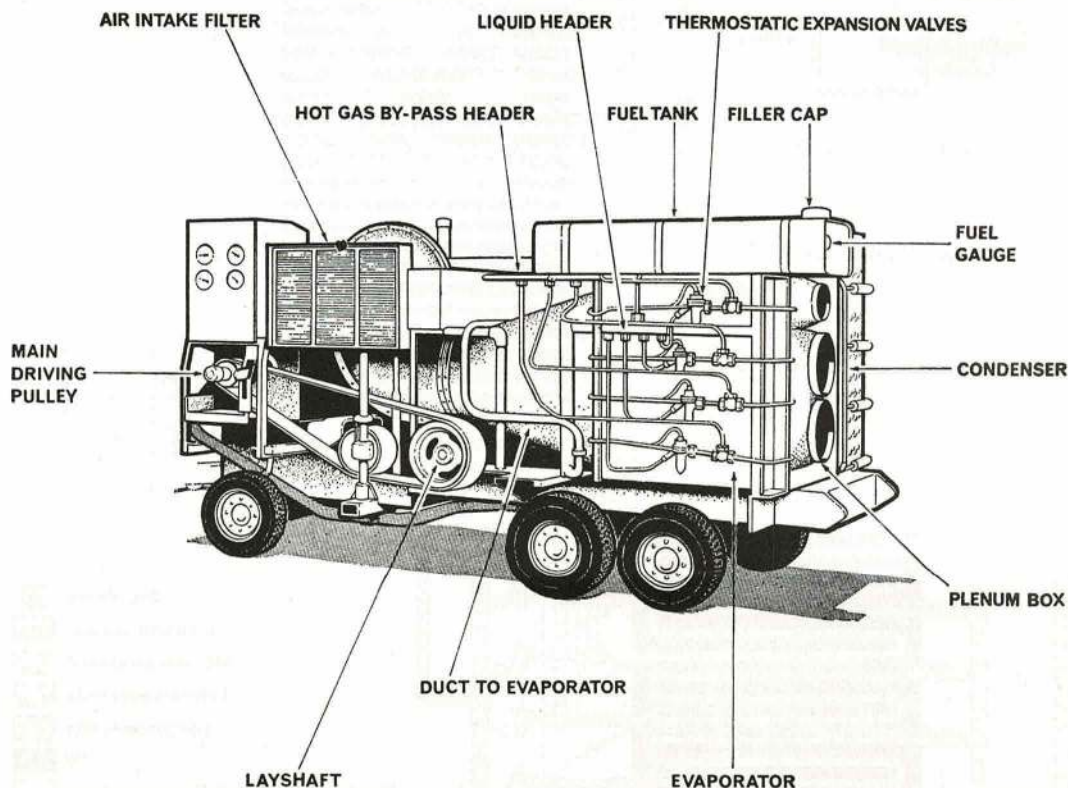


Fig. 7. TROLLEY AIR COOLING MK. 5A

regulator, and the associated valves, pipelines and instruments. The plant is automatic in operation, the cooling output being dependent upon the engine speed which is normally 3,000 r.p.m. The delivery temperature will vary according to ambient conditions.

39. The refrigeration system (Fig. 8) is a closed circuit of pipelines in which the refrigerant (freon 12) circulates. It consists of

the following components:

- (a) Compressor.
- (b) Evaporator (cooler).
- (c) Condenser.
- (d) Liquid receiver.
- (e) Thermostatic expansion valves (four).
- (f) Capacity control valve.
- (g) Drier.
- (h) Solenoid valve.
- (j) Stop valves (five).

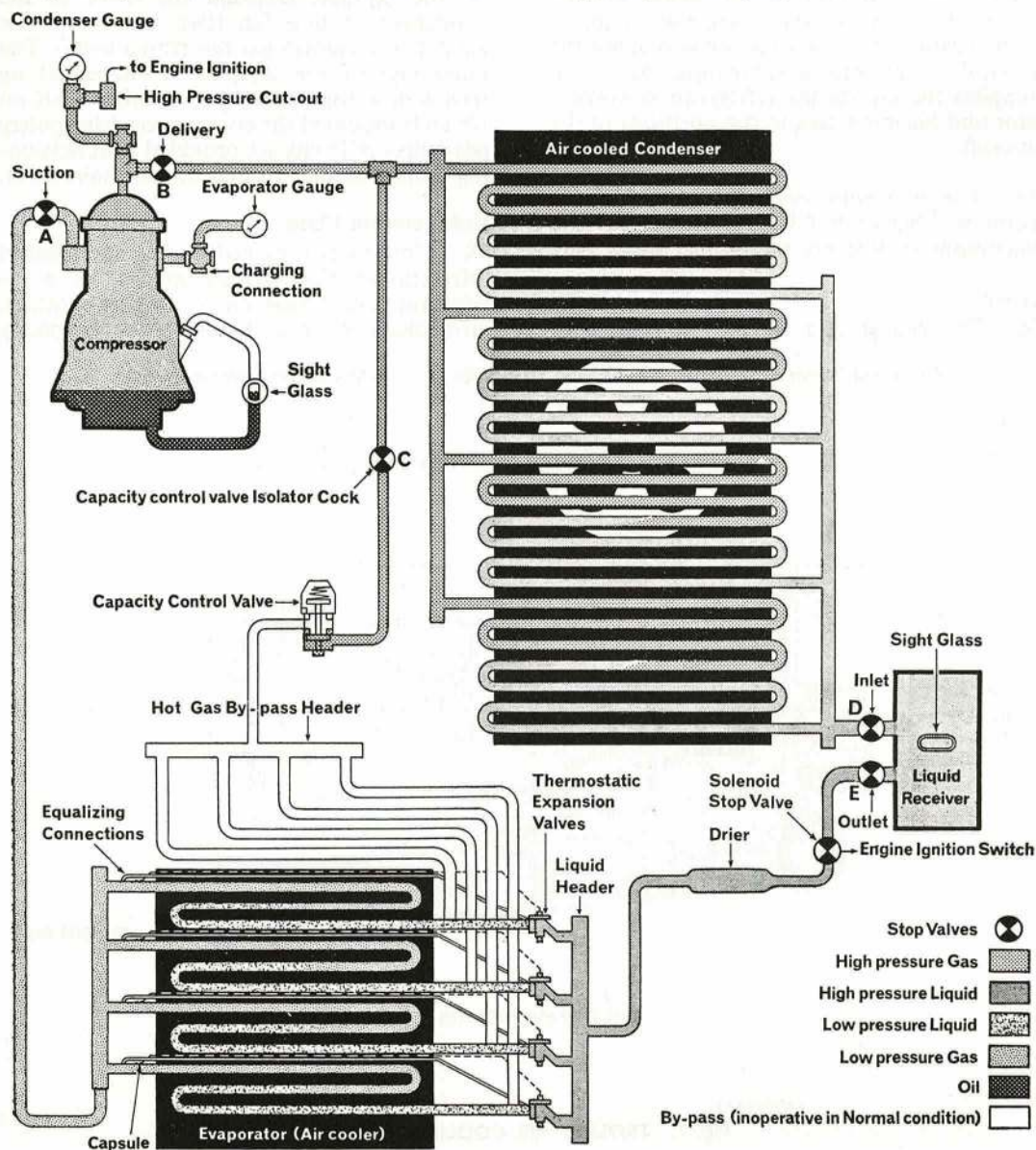


Fig. 8. REFRIGERATION SYSTEM

40. The compressor is a Lightfoot type VT7 twin cylinder model, and the circuit is quite normal, i.e. divided into high and low pressure sides. The compressor is located at one junction of the two pressures and the thermostatic expansion valves at the other.

41. The thermostatic expansion valves act as pressure reducing valves at the junction and they regulate the amount of liquid refrigerant allowed to pass into the evaporator by automatically adjusting the flow of liquid to suit the cooling demand as affected by the ambient conditions. A greater quantity of heat must be removed from air of high humidity (high moisture content) than from the same amount of air of low humidity for a given drop in temperature. Hence the evaporator has to do more work under damp conditions than under dry conditions, thus requiring a greater or less quantity of liquid to evaporate accordingly.

42. **Capacity Control Valve.** The capacity control valve (Fig. 9) is another regulating device that is used in the refrigeration system. Its purpose is to limit the temperature to which the air delivery can be reduced, thus preventing freezing and the formation of obstructive ice in the evaporator. This minimum temperature as shown on the outlet thermometer is 40 deg. F. The valve is

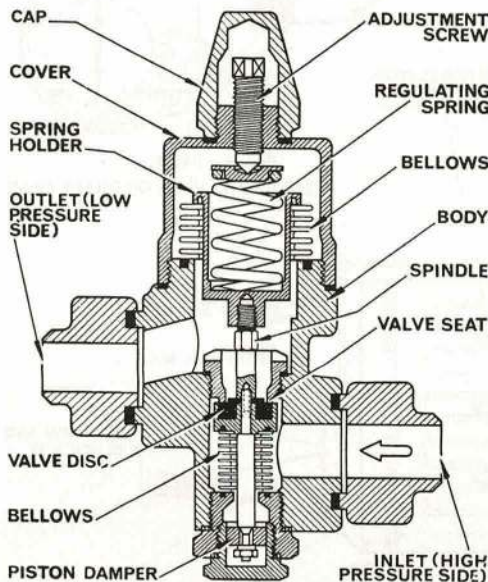


Fig. 9. CAPACITY CONTROL VALVE

situated in a pipeline which, under certain conditions, short circuits the condenser and by-passes a proportion of the refrigerant directly from the high to the low pressure side of the circuit.

43. When the air passing into the evaporator is already at a low humidity and temperature, the thermostatic expansion valves reduce the supply of liquid through the evaporator and the closing of the valves causes a decrease of pressure on the low pressure side of the circuit. The capacity control valve is set to prevent this pressure falling below 22 lb per sq. in. gauge. A pressure of 22 lb per sq. in. gauge means that the thermostatic expansion valves would be almost closed, i.e. passing little or no liquid since there would be little or no superheat to affect the phials. Under these conditions the compressor is trying to pump a vacuum and so could sustain damage.

44. When the pressure falls to approx. 30 lb per sq. in. gauge the valve begins to open and allows refrigerant vapour to pass from the high to the low side of the circuit, via the hot vapour by-pass header and the four evaporator pipes. The hot refrigerant vapour causes a rise in temperature in the evaporator, which prevents freezing and ultimately warms the phials which cause the thermostatic valves to reopen. When normal operating conditions are regained the capacity control valve closes.

45. A stop valve (C) is situated in the by-pass pipe across the circuit. This valve can be closed to render the capacity control valve inoperative, thus completely separating the high and low sides of the system.

46. **Solenoid Valve.** The purpose of this valve is to separate the delivery and low pressure sides of the circuit automatically when the refrigeration plant stops. Immediately after a stoppage the delivery side still contains hot vapour which could pass to the low pressure side and condense when the plant cooled. On restarting, this liquid condensate could be pumped into the compressor and probably cause damage. The solenoid prevents this happening, and the piping is so arranged that any condensate drains harmlessly back into the receiver. Similarly any condensate collecting in the capacity control valve is—should the valve open after restarting—passed through into the evaporator to ensure that it vaporizes before reaching the

inlet side of the compressor. The solenoid valve is energized through the engine ignition switch so that it opens when starting and closes when the engine is switched "OFF", either by hand or by the high pressure cut-out.

Air Equipment

47. The air cooling and delivery equipment is illustrated at Fig. 10.

48. **Intake, Filter.** A Vokes Milli-Vee dry type frame filter is situated in the intake behind the canopy grille.

49. **Delivery Fan.** The six bladed centrifugal type fan (Fig. 11) is carried on a ball and roller bearing assembly. The drive is taken by a three grooved pulley and belts from the layshaft. Lubrication is by means of grease caps.

50. **Air Cooler.** Air from the fan passes to the air cooler where it passes over four banks of finned copper evaporator pipes. At the outlet a water eliminator is fitted (Fig. 10). This comprises a chamber having a number of deflector blades upon which moisture can

collect as it condenses out of the delivery air because of the drop in temperature. Such water drains into a **Spirex drain trap** which operates on the ball valve principle. Mounted on the end of the air cooler is the **plenum box** from which the total delivery is distributed as required by the two 5 in. and one 3 in. bore outlet ducts.

51. **Adapters.** Two conical adapters (Fig. 12) are provided for fitting between the plenum box and the large hoses. Their design ensures a steady flow and reduction of back pressure; thus they must always be in place when the equipment is operated. The curved adapter is made to fit the 5 in. end of either of the conical adapters, as required, and its purpose is to direct the hose at a convenient angle to prevent kinking. Securing is done by toggle clamps.

52. **Hoses.** The two 5 in. bore hoses (Fig. 12) are made of canvas on a wire foundation, and they have a protective canvas laced-on covering. They are handled by means of loops of webbing at the connector ends, and the outer cover can be drawn over the end fittings

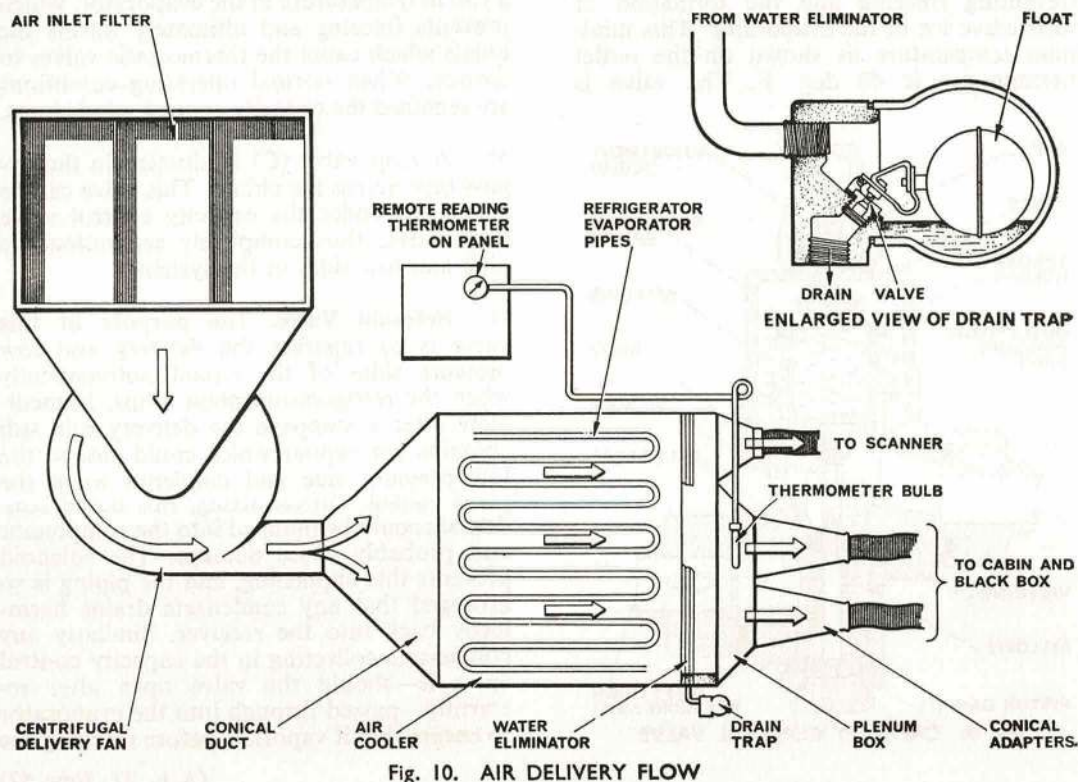


Fig. 10. AIR DELIVERY FLOW

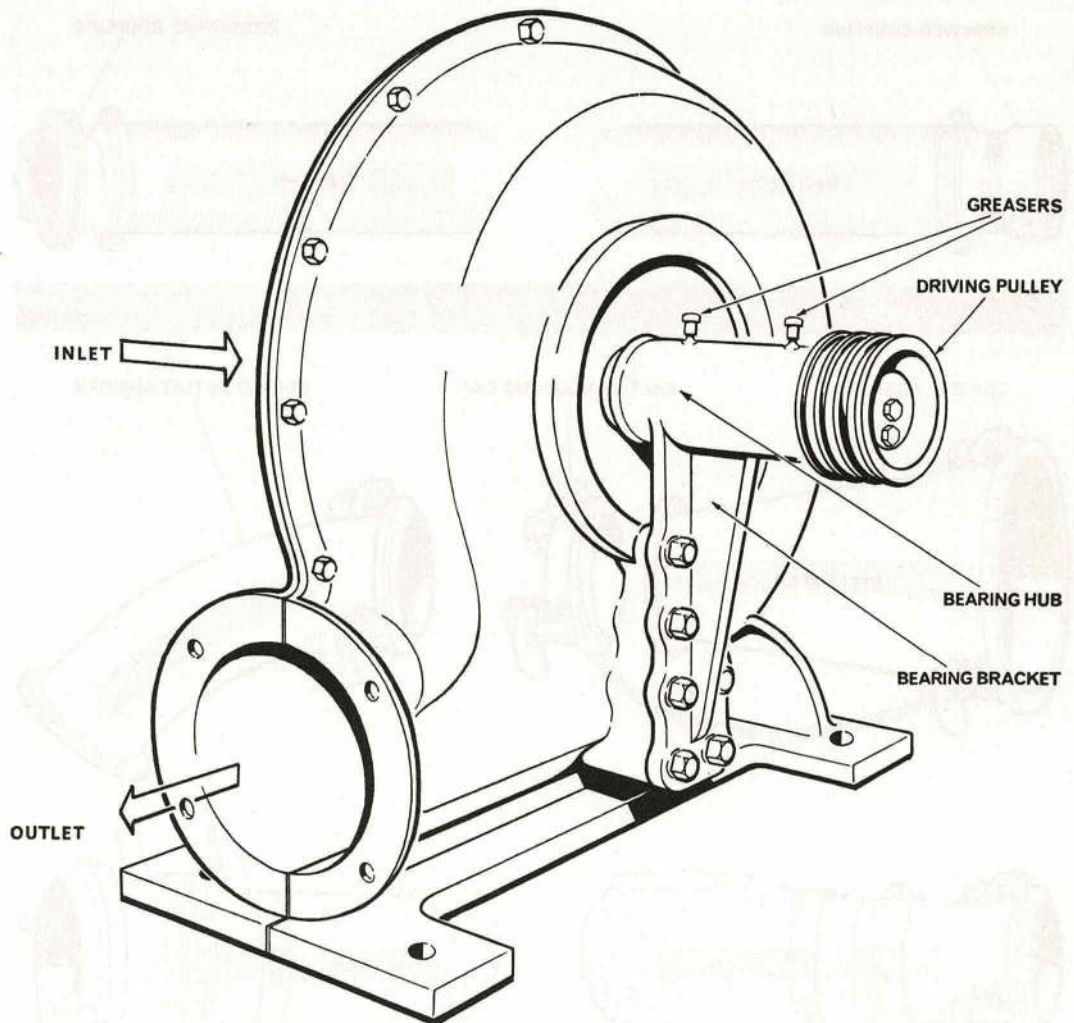


Fig. 11. DELIVERY FAN

when the coupling is complete. They are identified by labels on the aircraft coupling end and **MUST NOT** be interchanged because the cabin hose inlet incorporates a plate that is not fitted in the other hose. The 3 in. scanner cooling hose is as shown (Fig. 12).

Operating Instructions

53. Before starting the engine:

- (a) Ensure that the battery is in a charged condition.
- (b) Check gasoline, oil and coolant for the engine.
- (c) Check the oil level in the compressor.

Correct level is at mid-position in the sight glass when the plant is not in operation.

(d) Check the engagement of the sliding shaft coupling in the compressor drive layshaft.

(e) Check the refrigerant level in the liquid receiver sight glass.

(f) Ensure that all valves in the refrigeration circuit are open (backseated).

(g) Check that the earthing chain is in contact with the ground.

54. To operate proceed as follows:

- (a) Remove the blanking caps on the three delivery outlets.

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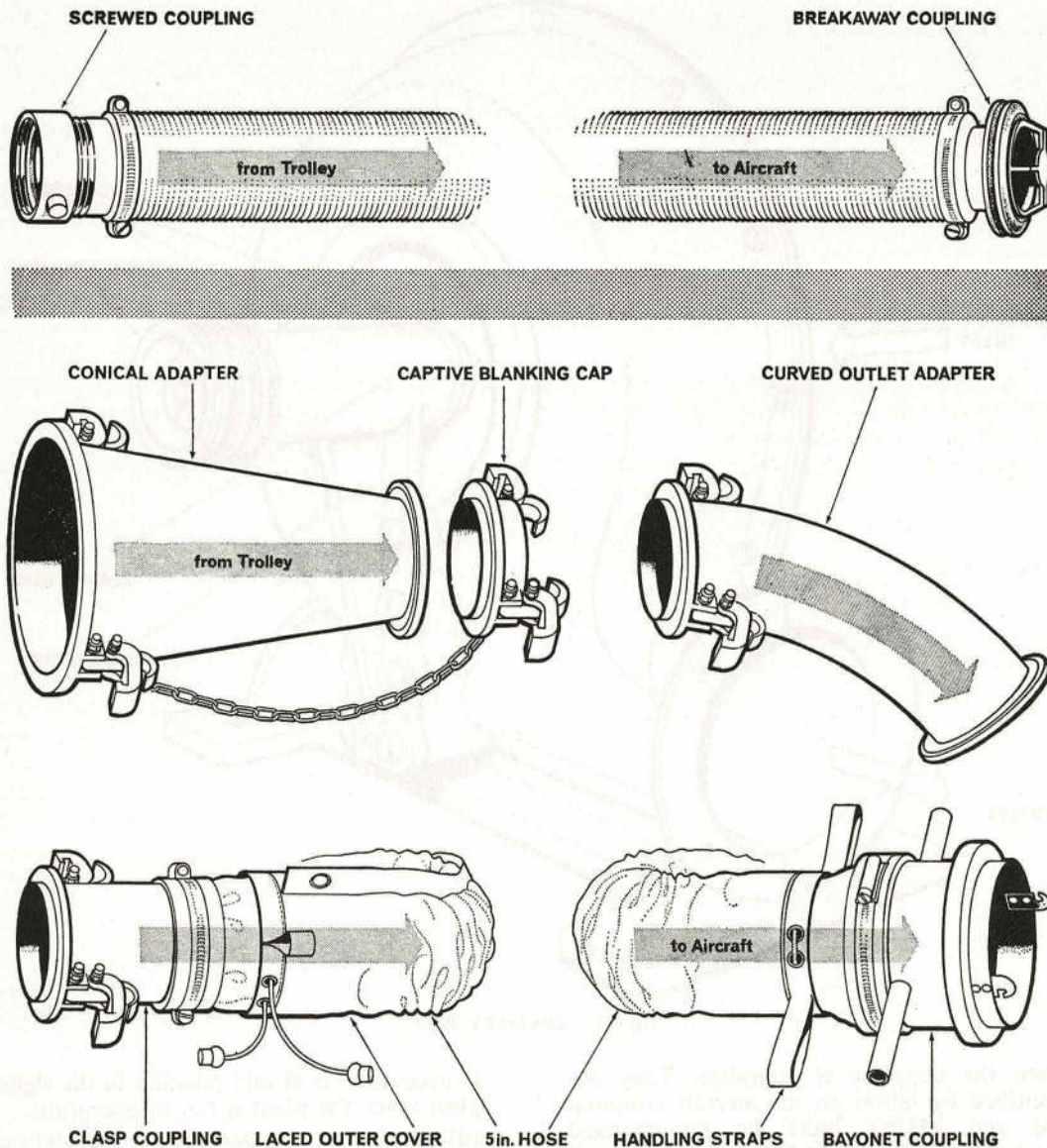


Fig. 12. HOSES AND ADAPTERS

- (b) Fit the conical adapters and the curved one if required.
- (c) Remove the delivery hoses from stowage and couple to the outlets and the aircraft.
- (d) Switch "ON" the battery isolating switch and the master switch.
- (e) Ensure the clutch lever is disengaged, i.e. it is up in the position marked "OUT".

- (f) Turn on the fuel supply cock and pull out the choke.
- (g) Operate the ignition switch to "ON"; the ignition warning light should glow.
- (h) Operate the starter, start the engine and allow it to warm up, pushing in the choke when not required.
- (j) Ease the clutch into engagement gently whilst controlling the engine speed to balance the load.

(k) Adjust the throttle until the tachometer registers 3,000 r.p.m.

Note.—The engine must not be run with the clutch disengaged for more than two minutes.

55. Under certain atmospheric conditions there may be a steady flow of water from the drain trap and therefore, if possible, the trolley should be positioned where this can flow away or be collected in a receptacle for disposal.

56. **Layshaft Disengaged.** If it is required to run the air delivery fan only, i.e. cooling is not necessary, proceed as follows:

- (a) Remove the locking wire and unscrew the locking bolt until it is free of the engagement hole in the guide block.
- (b) Push the driving dog out of engagement until the locking bolt lines up with the second engagement hole.
- (c) Tighten the locking bolt ensuring that it enters the second hole.
- (d) Wire lock the bolt to the driving dog.
- (e) Close the liquid receiver outlet valve.

Note.—This is essential because the solenoid valve opens automatically on starting the engine.

57. **Stopping.** To stop the engine and plant:

- (a) Close the throttle to reduce engine speed to about 1,500 r.p.m.
- (b) Disengage the clutch and at the same time close the throttle to prevent racing of the engine.
- (c) Switch "OFF" the ignition switch.
- (d) Turn "OFF" the fuel cock. Switch "OFF" the master switch.
- (e) If the unit is not to be used for some time switch "OFF" the battery isolating switch.

Note.—In an emergency it is permissible to switch "OFF" the plant with the clutch still engaged.

58. **Shut Down.** If the plant is to be out of use for a long period it should be pumped down in the normal manner in accordance with the instructions in the relevant A.P., care being taken that pumping ceases when the low pressure gauge registers zero. **Do not pump a vacuum.**

59. **Replenishing Refrigerant.** When refrigerant is required in the system, stand the cylinder on the ground alongside the trolley and then proceed as follows:

- (a) Close the capacity control valve isolator (C).
- (b) Remove the cap from the "T" valve on the charging connection and close the valve.
- (c) Remove the cap on the charging connection and connect the charging pipe union to the charging connection loosely so that vapour will escape from the union.
- (d) Purge the charging pipe by opening the cylinder valve slightly and whilst the vapour is escaping through the loose connection tighten the union nut. Close the cylinder valve.
- (e) Start the engine, run the plant and open the "T" valve on the charging connection.
- (f) With the compressor running steadily, open the valve on the refrigerant cylinder slowly and allow refrigerant to pass into the system. The cylinder must always be at a lower level than the charging connection so that only vapour is admitted; the presence of liquid could damage the compressor.
- (g) When replenishment is complete, close the valves on the cylinder and the charging connection.
- (h) Disconnect the charging pipe and remove the cylinder. Replace the charging connection blanking cap and tighten it.
- (j) Open the "T" valve again and replace its cap.
- (k) Open the capacity control valve isolator valve.

60. **Replenishing Compressor Oil.** Proceed as follows:

- (a) Close the low pressure valve (A) and the capacity control valve isolator (C).
- (b) Start and run the unit until the low pressure gauge registers approx. 1 lb per sq. in. **Do not pump a vacuum.**
- (c) Stop the unit and disconnect the oil pipe (sight glass) at its entry to the compressor crankcase. Allow any vapour to escape.
- (d) Use a funnel in the inlet and replenish oil until the correct level is observed in the sight glass. All equipment used must be clean and dry.

(e) Remove the funnel and connect the oil pipe but do not tighten the union.

(f) Turn on valve (A) and allow refrigerant vapour to purge the air from the crankcase for approx. one minute; tighten the union. Check the refrigerant level in the liquid receiver sight glass.

(g) Start and run the plant. Check the oil inlet union for leakage, and replenish the refrigerant charge if necessary.

AIR SUPPLY TROLLEY Mk. 2

Introduction

61. This equipment (Fig. 13) is used to supply relatively dry air to the ventilated suits of aircrew waiting in aircraft on the ground during warm weather. Up to three suits can be serviced at the same time, air being supplied to each suit at the rate of 8 cubic feet per minute at a pressure of $7\frac{1}{2}$ lb per sq. in.

62. Air passes into a Wade air blower where it is compressed to $7\frac{1}{2}$ lb per sq. in. It then passes through a Prestcold mechanical

refrigeration plant, an evaporator, a water separator, a distributor box and hoses to the suit or suits; a safety valve is included in the circuit.

Drive

63. Power for the operation of the refrigeration plant and the air blower is supplied by a Coventry Victor type AN4, Mk. 2B spark ignition engine. The engine is coupled by means of a Twiflex automatic flexible clutch coupling to a layshaft which is mounted in ball and roller bearings in an oil-bath type chain case. Three drives from the chain case operate:

- (a) A shaft which carries the fan that provides the cooling air for the cooling block.
- (b) The refrigerant compressor.
- (c) The air blower.

Refrigeration Plant

64. The refrigeration plant consists of a fan-cooled cooler block, a compressor, a liquid

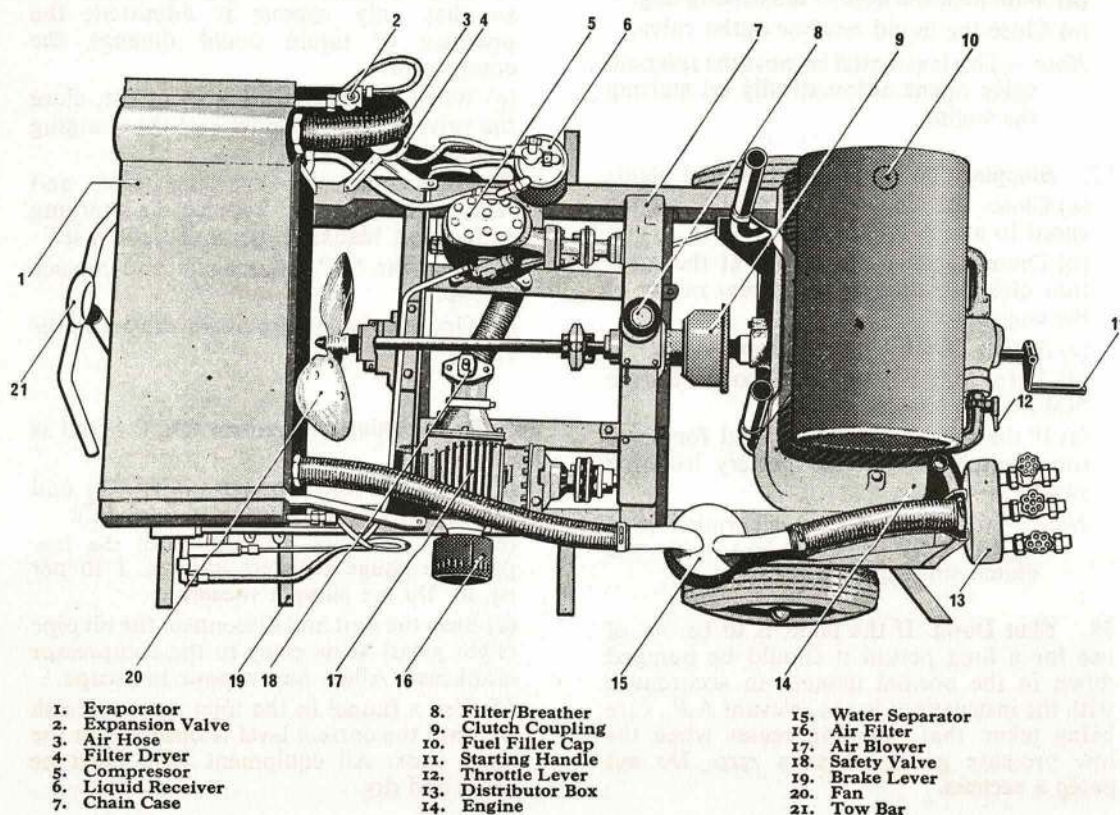


Fig. 13. AIR SUPPLY TROLLEY MK. 2

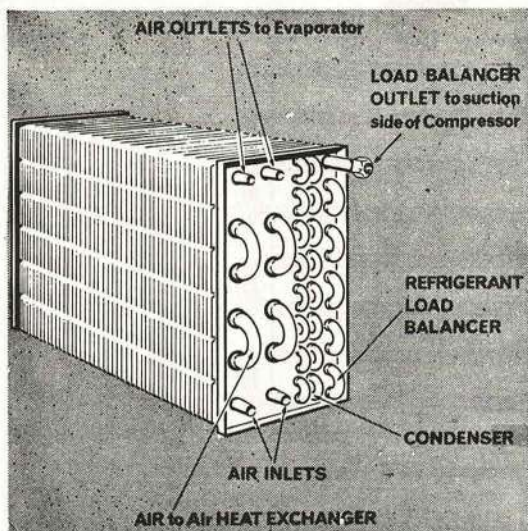


Fig. 14. COOLER BLOCK

receiver, a silica gel filter drier, a constant pressure expansion valve, an evaporator and the associated pipelines.

65. **Cooler Block.** The cooler block (Fig. 14) is of the air-cooled type. The block embodies three runs of tubes; one run forms a condenser, the second a refrigerant load balancer and the third an air-to-air heat exchanger (this run is not actually a part of the refrigeration plant).

Refrigeration Cycle

66. The cycle of operations of the refrigeration plant is illustrated at Fig. 15. The liquid refrigerant at high pressure passes from the liquid receiver to the filter drier, from whence it passes to the expansion valve, where the pressure is decreased, and thence into the evaporator.

67. In the evaporator the refrigerant extracts heat from the air and is vaporized. The low pressure vapour then passes through the refrigerant load balancer, where any remaining liquid evaporates, and then passes to the compressor where its pressure is increased to approximately 250 lb per sq. in. The vapour now at high pressure, passes from the compressor to the condenser where it condenses and returns to the liquid receiver, thus completing the cycle.

Air Circuit

68. The path followed by the air is illustrated at Fig. 16. Air from the atmosphere passes through the air cleaner to the air blower where it is compressed. It then passes through the body of the safety valve and then via flexible tubing to the heat exchanger (pre-cooler) in the cooler block.

69. The air then passes to the evaporator and thence via the water separator to the distributor box. The supply hoses are connected to three bib-cocks mounted on the distributor box, and these cocks can be adjusted to suit individual requirements. Under no circumstances should the cocks be closed fully when the plant is in operation.

DOMESTIC REFRIGERATORS

General

70. The domestic application of refrigeration is in the form of a cabinet in which perishable food-stuff can be kept in a wholesome condition for periods sufficient to meet normal requirements. To achieve this, the refrigerator must be able to maintain a temperature within the range 35°F. (2°C.) to 50°F. (10°C.) at all times.

Principle

71. The principle of operation is illustrated at Fig. 17. When the air around the evaporator is cooled its density and weight are increased, causing it to move downwards. As this air passes over the contents of the cabinet it receives heat from them and thus becomes less dense and not so heavy, so that the air now rises to the top of the cabinet. This causes circulation of the air as shown in Fig. 17. The air in the cabinet is at its lowest temperature immediately below the evaporator and is warmest in the top left-hand corner. Advantage should be taken of this fact when positioning the different contents. The cabinet temperature is regulated normally, except for kerosine operated equipment, by means of a thermostat.

Absorption Type

72. The continuous absorption type of cooling unit is illustrated diagrammatically at Fig. 18. There are no moving parts and operation is by the application of a limited amount of heat. The unit comprises four main parts connected by tubes and charged

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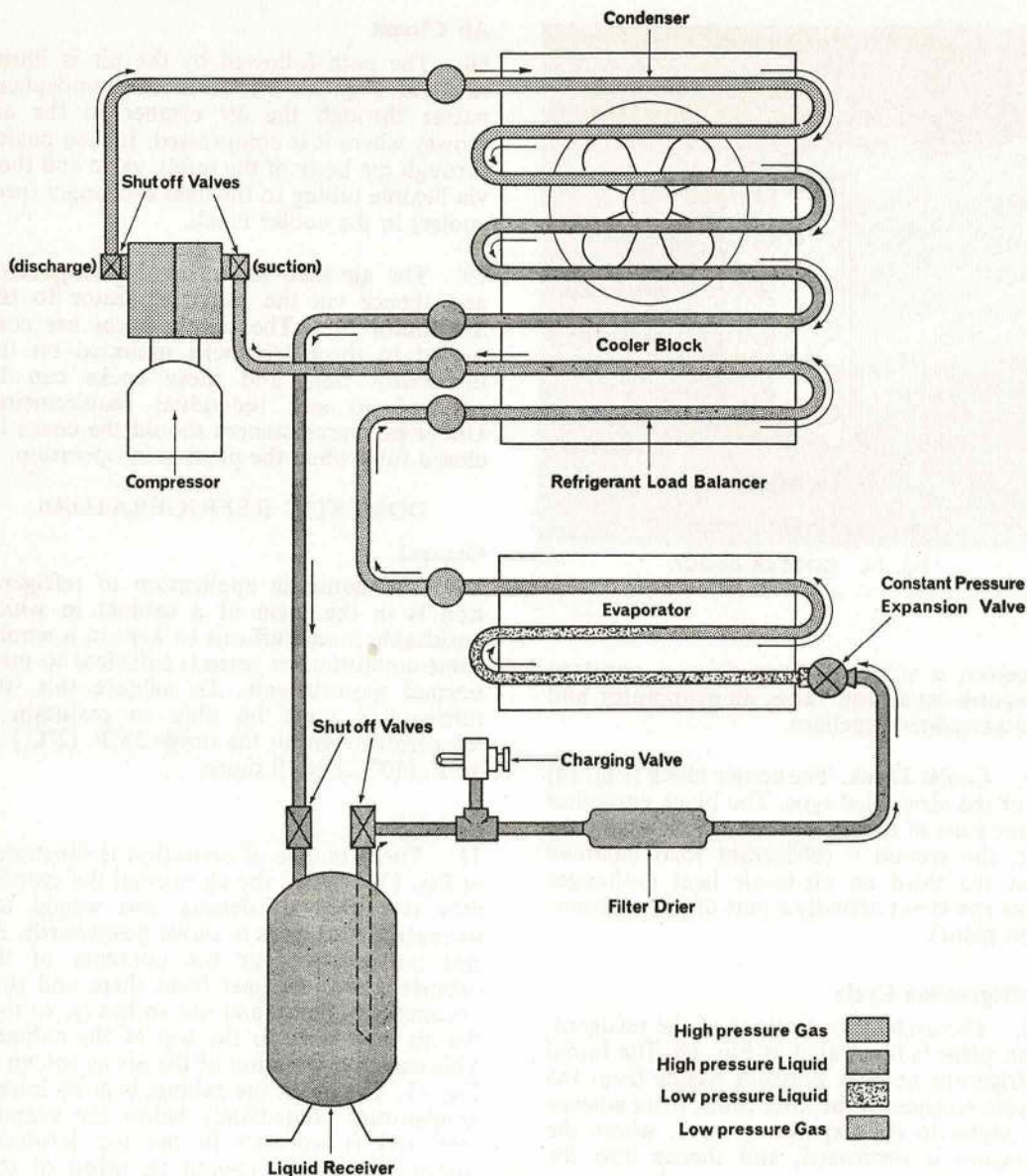


Fig. 15. REFRIGERATION CYCLE

with a quantity of ammonia, water and hydrogen at a pressure that is sufficient to condense ammonia at ordinary room temperatures; the unit is then sealed. The main parts are:

- The boiler system.
- The condenser.
- The evaporator.
- The absorber.

73. The boiler system contains some of the ammonia in a relatively strong solution in

water and, when heat is applied, vapour bubbles are formed which rise and take with them a weak solution of ammonia. This weak solution passes into the reservoir whilst the vapour proceeds along the pipe where, after bubbling through the strong ammonia solution (gaining more ammonia) it rises via the vapour pipe into the water separator. At this point any water vapour is condensed and drains back into the boiler system, leaving the dry ammonia vapour to pass along to the condenser.

TYPICAL INSTALLATIONS

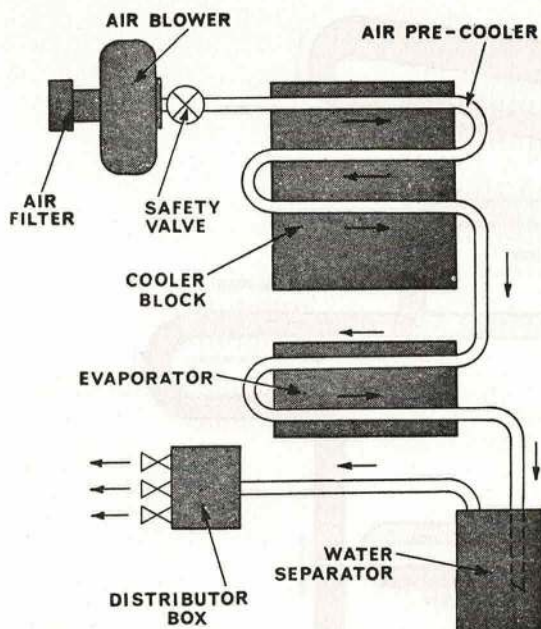


Fig. 16. AIR CIRCUIT

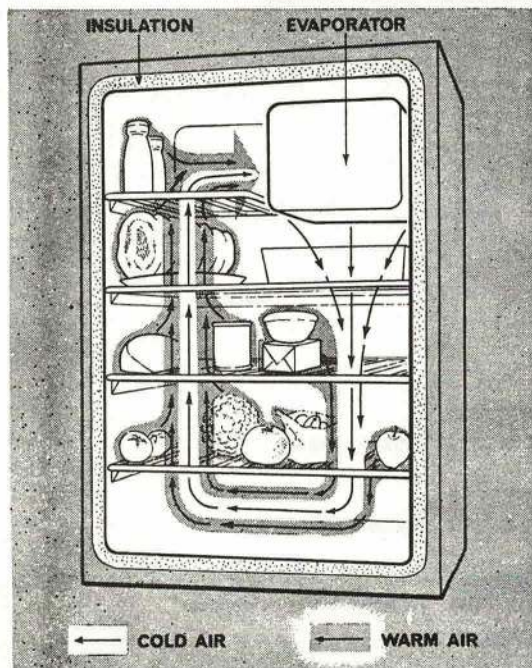


Fig. 17. AIR FLOW

74. The dry ammonia vapour loses heat to the air which circulates over the fins of the condenser, thus causing the vapour to change

to a liquid state and flow into the evaporator. The evaporator is also supplied with hydrogen which lowers the pressure sufficiently to allow the liquid ammonia to evaporate and this action extracts heat from the evaporator and storage space, thereby reducing the temperature inside the refrigerator.

75. The mixture of hydrogen and ammonia vapour now passes from the evaporator to the absorber vessel. Also entering the upper part of the absorber is a continuous trickle of the weak ammonia solution that is fed from the reservoir by gravity. As it passes through the absorber this solution contacts the hydrogen and ammonia vapour and readily absorbs the ammonia, leaving the hydrogen free to rise through the absorber coil and return to the evaporator. The hydrogen thus circulates continuously between the absorber and the evaporator. The strong ammonia solution produced in the absorber flows down to the absorber vessel and thence to the boiler system, thus completing the cycle of operation.

Notes—

1. Because the liquid circulation is gravitational it is essential that the unit is positioned upright.
2. The heat generated in the absorber must be dissipated into the surrounding air. Heat must also be dissipated from the condenser so that the ammonia vapour is cooled sufficiently for it to liquefy. Circulation of air is required therefore over both the absorber and the condenser.
3. Because the unit operates by means of the heat applied to the boiler system, it is essential that this heat is properly applied and kept within the required limits.

76. **Heating Equipment.** The general arrangement of the heating equipment is illustrated at Fig. 19. Other appliances may use bottled gas or electricity. The wick-type burner is fed by the tank which has a fuel capacity sufficient to operate for approximately one week. A mirror mounted on an extendible arm enables the flame to be seen from the front of the cabinet. Withdrawal and replacement of the tank and burner are simple operations, automatic location of the metal insert on the lamp glass under the boiler tube being provided.

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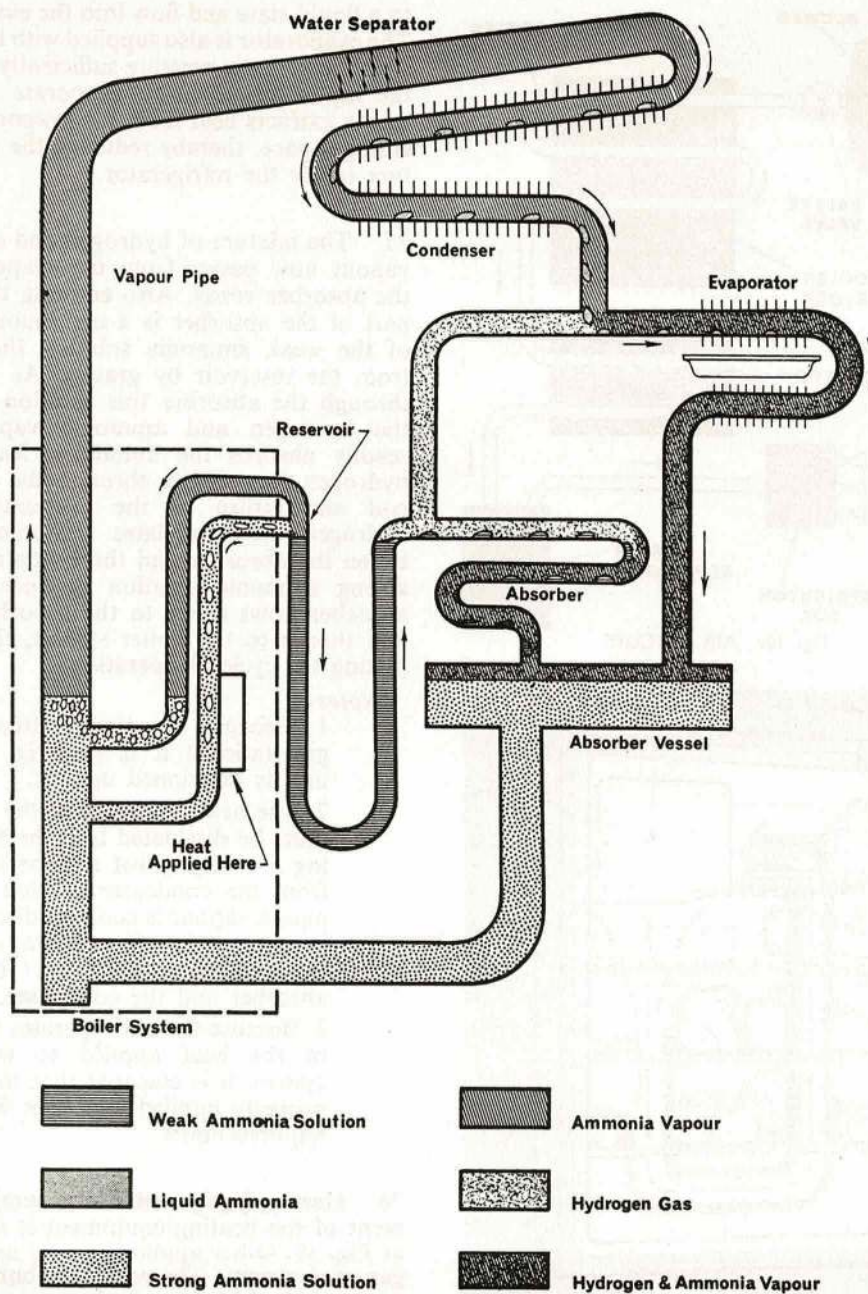


Fig. 18. ABSORPTION TYPE

77. A good fit between the insert and the boiler tube is essential, otherwise the entrance of cool air into the flame will cause smoking. Movement of the fuel tank in the channel-iron runners should be quite free and, when correctly positioned, the weight of the tank will keep

the metal insert pressed firmly against the bottom of the boiler tube. Adjustment to the positioning of the runners is provided to overcome any trouble in this respect by adding or subtracting from the packing washers used on the screws securing the tank holder.

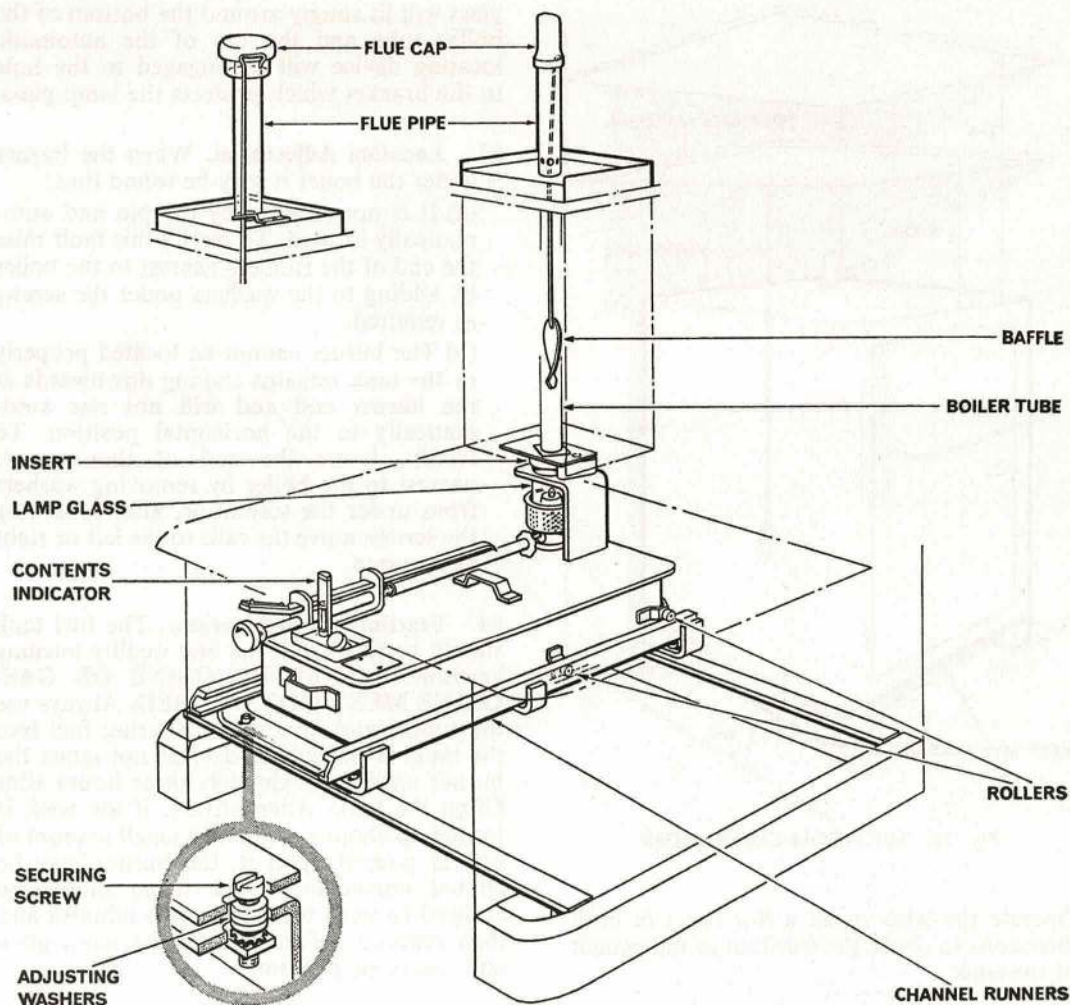


Fig. 19. HEATING EQUIPMENT

78. Refrigerator Location. The refrigerator must be installed upright and on a firm base, and a circulation of air over the fins of the cooling unit is essential. The minimum space to be allowed around the outside of the cabinet should be as shown at Fig. 20. If the space above the cabinet is less than 2 ft. 6 ins. the surface immediately above the refrigerator should be protected with fireproof material at a minimum distance of 1 ft. 4 ins. A minimum of 4 ins. clearance is required at the hinge side to enable the door to be opened sufficiently to allow removal of the shelves. A space of at least 1 inch is required at the back when the ambient temperature is over 95°F. (35°C.). The space at the bottom must

be left free at all times and the ventilation opening at the rear must **NOT** be covered in any manner.

79. Flue and Baffle. Ensure that all packing material around the flue top is removed and, where required, the pipe, cap and baffle must be fitted as shown on the label attached to the baffle support. **It is important that the baffle is correctly located as per the instructions for the particular model.**

80. Burner Location. Before filling the fuel tank, ensure that the burner and tank support are undamaged and that the burner, complete with lamp glass and insert, is correctly fitted.

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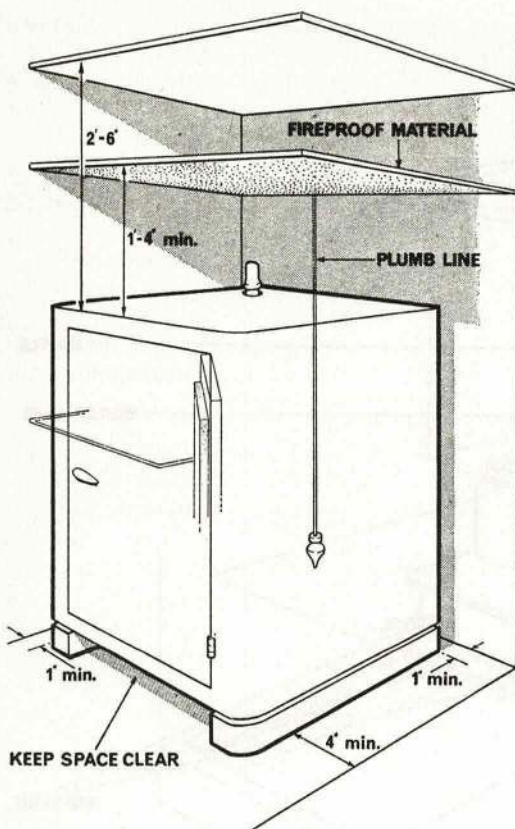


Fig. 20. LOCATION CLEARANCES

Operate the wick raiser a few turns in both directions to check the freedom of movement of the wick.

81. Lamp Glass and Insert. Ensure that it is known which type is fitted. On some models the lower disc of the insert is provided with a split sealing ring which is intended to tighten against the inner surface of the lamp glass. In such cases, in order to obtain a good fit, the sealing ring should be opened out before placing the insert in the lamp glass. This instruction does not apply to the sealing ring used with the alternative moulded type of lamp glass.

82. Place the tank, still empty, so that its first pair of rollers locate in the runners of the tank holder, and push the tank carefully as far as it will go towards the back of the cabinet, ensuring that the second pair of rollers also engage in the runners. When positioned under the boiler correctly the tank will be horizontal, the insert on the lamp

glass will fit snugly around the bottom of the boiler tube and the pin of the automatic locating device will be engaged in the hole in the bracket which protects the lamp glass.

83. Location Adjustment. When the burner is under the boiler it may be found that:

(a) It is not stopped by the pin and automatically located. To rectify this fault raise the end of the runners nearest to the boiler by adding to the washers under the screws as required.

(b) The burner cannot be located properly or the tank remains sloping downwards at the burner end and will not rise automatically to the horizontal position. To rectify, lower the end of the runners nearest to the boiler by removing washers from under the screws or, after loosening the screws move the rails to the left or right as required.

84. Starting the Refrigerator. The fuel tank should be filled with the best quality burning kerosine. **POWER KEROSENE OR GASOLINE MUST NOT BE USED.** Always use the funnel and filter when pouring fuel into the tank. If the wick is dry, do not ignite the burner until approximately three hours after filling the tank. Alternatively, if the wick is turned up about $\frac{1}{8}$ inch and a small amount of fuel is poured upon it, the burner may be ignited immediately. The flame should be allowed to burn for one or two minutes and then reduced before putting the lamp glass and insert in position.

85. Place the tank under the cabinet and shake it gently to ensure that the insert surrounds the bottom of the boiler tube properly and does not rest against the edge. If all is correct, the lamp glass and insert will be correctly positioned with the guide pin on the bottom of the boiler casing fitting into the hole in the lamp glass protecting bracket. When correctly fitted there should be no visible air gaps between the metal insert and the bottom of the boiler tube. If a gap exists, again shake the tank gently and if the gap still persists, further adjustment of the runners and tank holder is required.

86. Adjust the flame to the "half" setting and, because the flame tends to increase as the burner warms up, it should be inspected occasionally during the first hour of operation and if necessary adjusted.

87. **Fault Diagnosis.** The system of the absorption type refrigerator is completely sealed, therefore, the faults that can occur are caused almost entirely by failure or malfunction of the heater unit. In the event of the system being found to be leaking the unit must be returned to the manufacturer for repair and recharging.

88. Units fitted with gas or electrically operated heaters are comparatively trouble free, but oil burning types need constant attention and servicing to ensure efficient operation. The positioning of this type of refrigerator is critical and can be the cause of faulty operation. The following paragraphs detail some of the most common causes of failure.

89. **Too High Evaporator Temperature.** This can be caused by:

- (a) **Bad Positioning.** The refrigerator should be placed as per the instructions (Fig. 20).
- (b) **Poor Circulation.** The top of the cabinet must be kept clear at all times to ensure the efficient circulation of air around the rear of the cabinet through the louvres at the top.

90. **Cooling Cabinet Temperature Too High.** This may be caused by:

- (a) Faulty door seal allowing air to enter the cabinet.
- (b) Entry of air past the seal around the port where the evaporator enters the cooling cabinet.
- (c) Service load too great, i.e. frequent door opening, placing hot foodstuffs in cabinet or too great a quantity.
- (d) Poor circulation of air around the inside of the cabinet caused by poor stowage of the contents.

91. **Heater Unit Faulty—Electric Element Systems.** This could be the cause of:

- (a) **No Refrigeration.** Caused by:
 - (i) Burnt out heater element.
 - (ii) Short in electrical circuit.
 - (iii) Failure of mains supply.
 - (iv) Current switched off.
- (b) **Evaporator Coil Frosted Up.** Caused by:
 - (i) Failure of temperature control switch.
 - (ii) Excessive current.
 - (iii) Both (i) and (ii) occurring together.

92. **Heater Unit Faulty—Gas Operated Systems.** This could be the cause of:

- (a) **No Refrigeration.** Caused by failure of the gas jets or the supply.
- (b) **Poor Refrigeration.** Caused by:
 - (i) Blocked or faulty jets.
 - (ii) Faulty positioning of the jets under the bubble pump.
 - (iii) Draughts affecting the gas jet.
- (c) **Coil Frosted Up.** Caused by too high a flame which would allow too much ammonia to enter the system. This would increase the operating pressures and result in excessive refrigeration.

93. **Heater Unit Faulty—Oil Burning Systems.** This could be the cause of:

- (a) **High Evaporator Temperature.** Caused by:
 - (i) Flame too low.
 - (ii) Refrigerator not level.
 - (iii) Incorrectly positioned burner unit.
 - (iv) Flue pipe missing or badly located.
 - (v) Poor or contaminated fuel.
- (b) **Intermittent Refrigeration.** Caused by:
 - (i) Refrigerator not level.
 - (ii) Draughts or flaring burner.
- (c) **Too much Refrigeration.** Caused by the flame being too high for the prevailing temperatures.

94. **Leak Detection.** With this type of system leaks are fairly easy to detect by smell because ammonia when allowed to mix with air has a pungent odour. If a leak is suspected it can be located by passing a lighted sulphur taper over the parts of the system. The presence of a leak will be indicated by a whitish deposit.

Compressor Type

95. Present day compressor type (Fig. 21) cooling systems are of the "sealed" pattern. The motor and compressor are contained in an airtight housing to which the condenser and evaporator are connected by means of copper tubing. An expansion valve is not required because its function is taken over by the use of a very small bore pipe (liquid line capillary). Most sealed systems use a filter-drier to trap any moisture or foreign matter that may be present.

96. The system is charged with a specified amount of freon 12 and sufficient oil to last

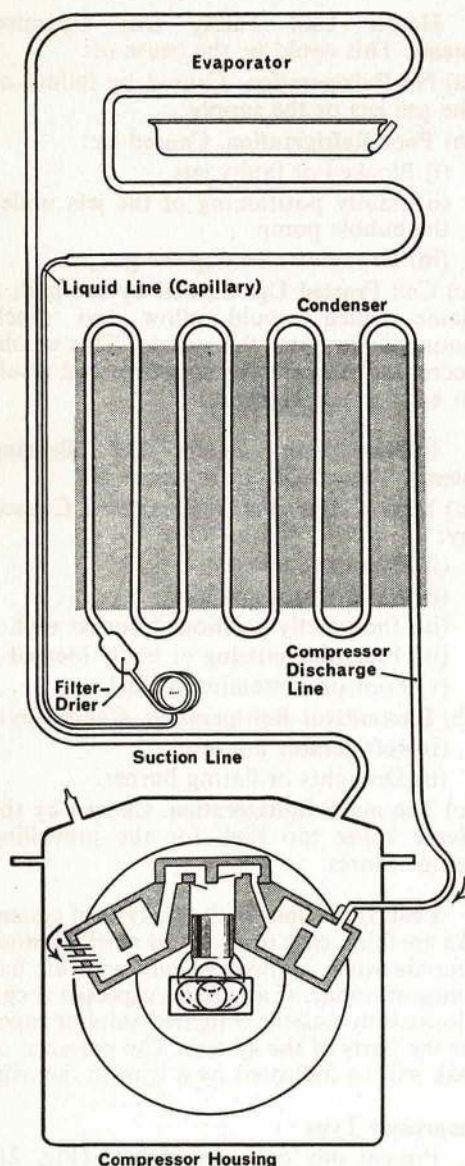


Fig. 21. COMPRESSOR TYPE

the "life" of the system. Topping-up with refrigerant and oil after repair can be done only if special equipment is available for this purpose. The compressor is driven by a single phase fractional horsepower A.C. motor. The motor, being of the split phase type, has an auxiliary winding on the stator which is out of phase with the main windings and so provides the impetus necessary for starting. This involves the use of a relay to assist the motor during the initial period of starting.

97. A thermal cut-out is provided to interrupt the current to the motor in the event of the load becoming excessive and the temperature of the motor/compressor housing rising above 140°F. It is in series with the motor and contains a coil of heater wire which, when excess current passes, heats up a bi-metal disc and opens the contacts. It automatically resets itself on cooling. The device is designed with sufficient time lag to prevent the switch tripping during normal starting when the high current surge is momentary.

98. **Cycle of Operations.** When the motor is started, refrigerant vapour passes along the low pressure line (large diameter tubing) and into the compressor housing. It enters the compressor via the inlet valve, is compressed and leaves via the outlet valve, passing along the discharge line and into the condenser. The heat that the refrigerant vapour absorbed in the evaporator together with that generated in the compressor is radiated to the atmosphere by the cooling fins. This cooling of the condenser liquefies the refrigerant vapour and the liquid refrigerant passes into the filter-drier where any traces of water vapour are removed.

99. The liquid refrigerant leaves the filter-drier and passes through the very small bore tube (capillary) into the evaporator. This tube controls the rate of flow of the refrigerant and thus ensures proper expansion of the refrigerant in the evaporator. The capillary tube is either soldered to the outside of the low pressure line from the evaporator or, passes inside the line for a certain length so as to form a kind of temperature exchanger. Thus the liquid refrigerant entering the evaporator is cooled by the cold vapour passing to the compressor. This arrangement not only adds to the efficiency of the cooling system, it also helps to keep the temperature of the low pressure line higher than the dew point and thus prevent undue sweating of the line.

100. In a compressor system there is a high pressure side which includes the capillary and the condenser, and a low pressure side which includes the low pressure line and the evaporator. All systems do not employ the same pressures, but 125 lb per sq. in. for the high side and 15 lb per sq. in. for the low side can be taken as fairly average figures. When the motor is switched "OFF" (manually or by the thermostat) the compressor ceases to operate and the "high side" pressure falls gradually until equilibrium is reached, usually in approximately four to five minutes.

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