

ADDITIONAL AIRBORNE EQUIPMENT

Reference: AP 4505B, Vol 1 (General and Technical Information).  
AP 4787A, Vols 1 and 6 (Aircraft Vapour Cycle Heat Transfer Equipment).

Introduction

1. This section deals with the water/glycol and vapour cycle systems used to control the operating temperature of the ECM equipment in the rear fuselage section, and the cooling and pressurisation system associated with the radar head of the rear warning system.

ECM Cooling System

2. This system is designed to control the temperature at which the ECM units operate, under all aircraft operating conditions.

This is achieved by circulating a mixture of water ethylene glycol to heat exchangers on each canister containing the ECM equipment and controlling the temperature of the mixture by a Godfrey vapour cycle cooling pack.

All the units in the system are located in the rear section.

Water Glycol Circuit

3. This circuit is charged with a Sodium Benzonate inhibited solution and mixed with water in a volume ratio of 60% glycol to 40% water.

This mixture is circulated through heat exchangers in each canister by two electrically operated pumps in parallel, which receive the mixture from a reservoir.

The fluid is delivered from each pump, to the system, via non-return valves, which prevent by-passing of the mixture back to the reservoir in the event of one of the pumps failing to operate.

4. Delivery of mixture to the canisters is from a main gallery of rigid pipes run between the two rows of canisters. Flexible pipes with quick release Avery bayonet couplings complete the circuit to the canisters and the mixture is returned to the reservoir.

As the maximum heat load from each canister is different, restrictors are fitted in the flexible delivery pipes to ensure that the flow of water/glycol is in proportion to the heat load in the canister. The system can be operated with one or more canisters not fitted in the rear section as the flow through the remaining canisters will be maintained.

Reservoir

5. The reservoir, located in the rear section, starboard side, has a fluid capacity of 7½ pints. A sight glass, mounted on the reservoir for observation of the fluid level, is viewed through a small perspex window in the rear fuselage skinning, starboard side, just forward of the ram air intake for the vapour cycle cooling pack condenser.

6. The reservoir is pressurised with air tapped from the rear bomb door seal system at 10 psi through a combined non-return air inlet and pressure relief valve. This valve operates at 15/18 psi. The pressurisation of the mixture is to prevent evaporation of the liquid and cavitation of the pumps at high altitude.

Controls

7. Cockpit controls consist of ON and OFF push switches and a three position indicator on Panel 81P located at the AEO station.

To operate the indicator a thermostat is positioned in the circuit to read LOW when the coolant temperature is down to  $34^{\circ}\text{F} \pm 1.8^{\circ}\text{F}$ . At this temperature the ECM containers should not be operated so the indicator provides a warning to this effect.

When the water/glycol pumps and the vapour cycle cooling pack pump are switched on by the ON push switch, the indicator remains at the LOW indication until the coolant temperature rises to  $3^{\circ}\text{F}$  above the thermostat setting. This causes the indicator to change to the ON position. With the vapour cycle cooling pack inoperative the indicator changes to OFF.

ECM Canisters

8. The nine canisters mounted in the rear section are all mounted upside down with the coolant bleed plugs at the bottom. For this reason the canisters' heat exchangers must be filled and bled before fitment.

It should be noted that each canister has a coolant jacket of its own and is built into it, and is in no way connected to the main water/glycol system. Therefore, the heat exchange, through the main water/glycol system, is taking heat from the canister coolant which has absorbed heat from the ECM equipment contained within the canister. So the flow of canister coolant is being continually circulated by the convection currents so formed by the heat given up to the coolant and the heat taken away by the heat exchanger.

Canister Remove and Assembly

9. Each canister has its own hoisting system, comprising pulleys and cables, incorporated in the aircraft structure. This system is used in conjunction with a mini-lift hoist.

A typical arrangement consists of two single pulleys in the intercostal above the canister, and a double pulley which is mounted on an axle in a bracket attached to a cross beam at the side of the canister at its base. This bracket also contains a screw pin securing the base mounting of the canister to a rear section cross beam.

10. On removal and assembly of a canister the mini-hoist is hooked into position on a roller and the cable nipple end inserted into a slot in the double pulley. A pip pin is removed from the double pulley and the mini-hoist cable tensioned to take the weight of the canister through the A/c cable. The canister may now be released by removing the screw pins securing the base, then lowered. During lowering, the cable of the mini-hoist winds on to the wheel to which it is attached, whilst the aircraft cable unwinds to lower the canister.

Canister Remove and Assembly (contd)

11. During hoisting of a canister, the action is a reversal of paragraph 10. When the canister is in position and secured by the screw pins, the mini-hoist is unhooked and its cable disconnected. The pip pin is then inserted through the pulley bracket to lock the wheel against rotation. The wheel should be locked to take up as much aircraft cable slack as possible.

Socket Plates and Ballast

12. These plates are similar in shape and dimensions to the canister base mountings and are secured to the aircraft in a similar manner. These plates are fitting in lieu of any canister not mounted in the aircraft before flight. These plates fitted in the three rear canister positions are of mild steel, and bolted to each is a lead ballast disc weighing approximately 245 lbs. The remaining plates are manufactured from JABROC and weight approximately 9 lbs. each.

13. Each plate is fitted with couplings and sockets to which are connected the hoses and leads normally connected to the canister. The couplings are linked together by a bridge pipe which completes the water/glycol circuit and acts in lieu of the flow through a canister heat exchanger. This arrangement enables the water/glycol system to be fully functional at all times and also maintains the flow requirements with any combination of plates or canisters. The bridge pipes must be pre-filled with coolant before fitment to the system.

Vapour Cycle Cooling Pack

14. The Vapour Cycle Cooling Pack is installed to control the temperature of the water/glycol mixture circulating through the heat exchangers of the ECM containers.

The primary function of the pack is to absorb heat from the water/glycol circuit during ECM operating conditions.

The secondary function of the pack is to put heat into the water/glycol circuit when the aircraft is operating in cold ambient conditions where the temperature of the coolant falls below the necessary level. This is approximately 15°C.

15. The Vapour Cycle Cooling Pack consists of the following main components which are all contained on a panel secured to the inside starboard wall at the rear section attached by quick release pins.

- |   |  |
|---|--|
| a. Compressor                                 | b. Vapour/Oil Separator                |
| c. Liquid Receiver                            | d. Filter Dryer                        |
| e. Manual Shut-Off Valve                      | f. Expansion Valve                     |
| g. Evaporator                                 | h. Pressure Maintaining Valve          |
| j. Oil Container                              | k. Hot Gas By-Pass Control Valve       |
| l. High pressure switch                       | m. High temperature switch             |
| n. Time Delay Switch                          | o. Vapour Pressure Sensing Unit (VPSU) |
| p. Vapour Filter Unit                         | q. Compound Gauge                      |
| r. Skin Temperature Gauge<br>(-80°C to +80°C) |  |

/The only

Vapour Cycle Cooling Pack (contd)

The only unit of the Vapour Cycle Cooling Pack system not contained within the pack is the condenser. This is located in a ram air intake/exhaust tunnel on the outside of the rear section, starboard side at the rear. The nose portion of the ram air intake is removeable and embodies an electrically heated anti-icer which is operated in conjunction with the aircraft anti-icing system.

Cooling Operation

16. The VCCP operates on the principle of vapour cycle refrigeration, that is, compression, cooling, expansion and heating. Heated, vapourside refrigerant is drawn from the evaporator into the compressor where it is raised to condensation pressure. In the process of compression it gains further heat.

Oil for lubrication of the compressor rotor bearings is also drawn through the compressor from the oil container. The oil is discharged from the compressor with the refrigerant vapour and both are passed into the vapour/oil separator. The separated oil is piped back to the oil container for re-circulation.

The refrigerant vapour is now passed to the condenser, mounted in the airflow. The cooling action of the ram air extracts the heat so that the refrigerant is now condensed to a liquid form where it is piped back to the liquid receiver, mounted on the VCCP.

The cold liquid refrigerant is then passed through an expansion valve, and on doing so the refrigerant drops in temperature and pressure and changes to a cold wet vapour, which passes to the evaporator to absorb the heat from the water/glycol system which is piped through the evaporator. The heated gas at low pressure now passes from the evaporator to the inlet side of the compressor and the cycle is repeated.

The refrigerant used in the VCCP system is ARCTON 11, or FREON 11, which, in liquid state, is clear and water-white giving a colourless vapour with a faint odour of ether. The circuit, after evacuation of all air, is charged with 12 lbs. of this refrigerant.

The refrigerant vapour pressure is increased by a small charge of nitrogen, introduced into the system to act as a datum pressure.

When the pack is acting as a heater, the nitrogen prevents the pressure in the condenser from falling to a very low value.

An excessively low condenser pressure could so reduce the effect of the hot compressed vapour released when the pressure maintaining valve opens, that the flow from the expansion valve would be induced in sufficient time to counteract the heat load coming on the evaporator. This could result in a high temperature cut out.

Cooling Operation (contd)

The compressor is lubricated with 300 cc. of oil, Aeroshell Turbine 300, which is introduced through a filler plug in the vapour/oil separator.

Control

17. Operating control of the VCCP is carried out by the following components, all of which are contained on the pack.

- a. Expansion Valve.
- b. Pressure Maintaining Valve.
- c. Vapour Pressure Sensing Unit and Hot Gas By-Pass Valve.
- d. High Temperature Switch.
- e. High Pressure Switch.

Expansion Valve

18. The expansion valve, by controlling the rate of flow of the cold wet vapour available to the evaporator, determines the evaporating temperatures. This is effected by a mechanism regulating the flow through the expansion valve orifice, the mechanism being controlled by a temperature sensing device mounted at the outlet of the evaporator.

If the amount of refrigerant passing into the evaporator is insufficient to deal with the heat given up by the circulating water/glycol, then the consequent rise in temperature at the evaporator outlet will cause the fluid in the sensing device to expand. This will operate the mechanism to open the expansion valve orifice to pass a greater quantity of refrigerant. The expansion valve will eventually stabilize itself to hold the evaporator outlet temperature at the required constant evaporating temperature.

Conversely, any reduction of the heat load in the evaporator will reduce the flow from the expansion valve, which will again stabilize at the reduced orifice setting.

Pressure Maintaining Valve

19. This valve, positioned in the delivery unit to the condenser, maintains a compressor delivery pressure, that will in low ambient temperatures, when no heat is being given up by the water/glycol, ensures that the pack operates to heat the water/glycol. The maintenance of pressure is also necessary for the rapid recovery of the pack from a heater to a cooler.

The valve is spring loaded to the closed position and operated to open the delivery line when its bellows are compressed by delivery pressure. When the pack is acting as a cooler the delivery pressure is normal and the valve is maintained fully open, allowing the heat vapour to pass to the condenser.

As a result of no heat being given up to the evaporator by the water/glycol circuit, the compressor delivery pressure will fall and, allow the valve to move to closed condition.

/The delivery pressure

Pressure Maintaining Valve (contd)

The delivery pressure will then be maintained at a value equivalent to the valve loading. At this pressure the hot compressed gas will be diverted into the by-pass system to function the pack as a heater, whilst the vapour pressure in the condenser will fall and any flow from the expansion valve will stop.

VPSU and Hot Gas By-Pass Valve

20. As the heat given up by the water/glycol system reduces, the evaporator outlet sensing unit is moving the expansion valve to the minimum so that the rate of heat extraction from the water/glycol is correspondingly reduced. The point is then reached where the water/glycol can no longer supply the heat necessary to maintain the evaporating temperature and, in consequence, the evaporating pressure will also fall. This pressure drop is sensed by the VPSU which, in turn, opens the by-pass valve.

The VPSU is a mechanism which operates to allow the pressure that maintains the by-pass valve on its seat to escape.

When the by-pass valve opens, hot compressed vapour from the compressor by-passes the condenser and goes direct to the evaporator to restore the evaporating temperature and pressure, and the evaporator will be filled with hot vapour which in turn gives up heat to the water/glycol circuit.

A pipe line incorporating a vapour filter unit and orifice is led from the oil separator to join the pipe connecting the VPSU and the by-pass valve. This orifice bleeds hot gas to pressurise the bellows of the by-pass valve and maintain the valve on its seating at all times when the pack is not operating on by-pass.

Time Delay Unit

21. This unit is fitted to ensure that when the compressor is switched off, either from the AEO's position, or by the operation of the high pressure switch, or the high temperature switch, a restart cannot be made until a period of one to two minutes has elapsed. When the compressor stops, a reverse run down is caused by the back pressure set up against the compressor, when the high pressure in the vapour/oil separator equalises with the low pressure in the evaporator.

/Thus if a

Time Delay Unit (Continued)

Thus if a restart were achieved whilst a reverse run-down is happening, severe overloading of the compressor and motor would occur, therefore the time delay unit affords protection to the compressor.

High Temperature Switch

22. The system is safeguarded against excessive temperatures by the automatic high temperature switch incorporating a temperature indicator.

When the temperature in the vapour/oil separator increases beyond the specified maximum, the switch is operated to break the circuit to the compressor and stop it. At the same time the three position indicator at the AEOs position will be de-energised to "OFF", and the action of the time delay unit will be started.

Thus in order to restart the VCCP, three conditions must be satisfied.

- a. The temperature in the pack must drop below the specified minimum to allow the temperature switch to remake.
- b. The time delay period of one to two minutes must have elapsed.
- c. The "ON" push switch at the AEOs position must be pressed.

High Pressure Switch

23. On an increase in pressure beyond the specified maximum in the vapour/oil separator, a spring loaded plunger is depressed in the high pressure switch. The action of this plunger is to operate a micro-switch to cause the same function as the high temperature switch. When the pressure drops below the minimum level the switch will remake and, provided the time delay period has elapsed, a restart can be made by pressing the AEOs "ON" push switch.

VCCP Mounting and Hoists

24. The pack is located in the rear section at three points, that is, by pip pins to brackets on the starboard longeron, at the base of the pack, and the top attachment is a simple lug to which is bolted a short rod, the other end of which is attached by a pip pin to a bracket on the underside of the brake parachute compartment.

A slot and recess, cut into the top lug, provides for attachment of a mini-hoist cable when removing or installing the pack. The mini-hoist is attached to a roller on the underside of a cross-beam. The cable passes upwards, through a hole in the cross beam, through a cable guide and over a pulley assembly. From the rear pulley of this assembly the cable is taken to the top lug of the VCCP.

Rear Warning Installation

25. The tail warning radar unit and scanner, complete with mounting ring and radome, form a quick detachable assembly and is positioned at the extreme rear end of the rear section where the mounting ring mates with the rear face of the former of the rear section. Four spigots of the front face of the mounting ring locate in corresponding holes in the rear section former and the whole assembly is secured to the rear section by four quick release fasteners.

26. The radar head, which extends into the rear section, is braced by an anti-vibration structure of a friction damper and spider assembly. A spigot protruding from the spider centre, locates in a hole in the friction damper, attached to the radar head. To guide the radar head on installation or removal radially disposed rollers, fitted to the unit, bear on Tufnol strips attached

to the ends of four guide rails which are a part of the internal structure of the rear section.

### Pressurisation System

27. The radar head is normally pressurised to 20 psi absolute, by a system completely contained in the rear section. This pressure is retained by inflatable rubber seals on mounting ring and the heat exchanger integral with the radar unit.

28. Twin air cylinders are secured by straps and tension rod turnbuckles to the roof structure in the rear section at the rear.

Each cylinder is pressurised with air to 3000 psi through a charging valve mounted below the rear warning unit. This valve is accessible after removing a louvred panel secured by 3 Dzus fasteners to the port underside of the rear section at the rear. A pressure gauge is also visible to indicate cylinder pressure. A relief valve incorporated in the line between the GCV and cylinders relieves pressures in excess of 3300 psi and is located in the rear section at the rear on the starboard side.

Both cylinders deliver into a common line which is led across to a pressure control panel in the rear section, port side adjacent to the air cylinders.

29. Mounted on this panel is a hand operated line valve, normally open, and is closed for servicing purposes; two pressure reducing valves and two test connections for checking the output of the reducing valves. The pressure air from the cylinders is reduced to 200 psi by the first reducing valve and then reduced to 23 psi absolute by the second valve. At this absolute pressure the air is delivered to the radar head by a flexible hose.

30. Within the radar head is an integral air circuit incorporating a pressure differential valve and a non-return valve. The differential valve passes air to inflate the seals to 23 psi absolute and the unit to 20 psi absolute. The NRV retains the pressure in the seals should the unit pressure fall due to leakage.

A safety valve is fitted to the casing of the radar unit to guard against excessive supply pressure. This is set to operate when the differential pressure between the unit air and external air exceeds 26 psi.

A lamp on the indicator unit, at the AEOs position, lights up when radar head pressurisation is adequate and above 18.5 psi absolute. The equipment is automatically switched "OFF" when the pressure falls below 13.5 psi absolute.

### Cooling System

31. The cooling air supply, admitted by a butterfly valve to the radar head exchanger, is ducted from a flush intake in the port side of the rear fuselage. The valve is electrically actuated to either fully open or close and is mounted inside the rear section with its inlet connected to two inlet ports on the forward face of the heat exchanger, by a branched manifold assembly the common extension of which leads down and connects to a box structure on the inside of the rear fuselage at the lower starboard side. The air is then dispersed through lightening holes in the box to circulate in the rear section.

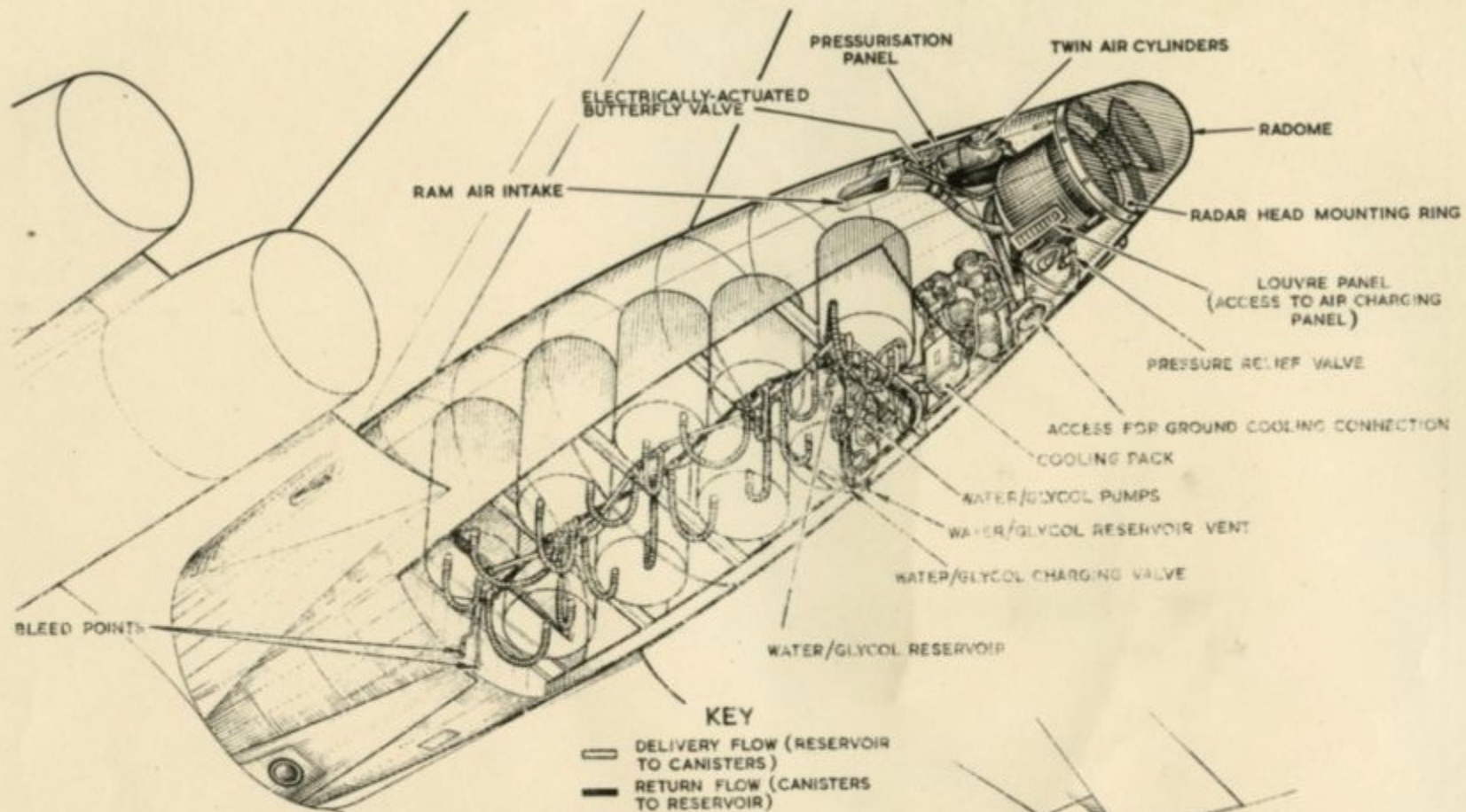
32. The butterfly valve is controlled by a temperature sensing switch fitted to the heat exchanger. This device prevents overcooling of the radar equipment in cold ambient conditions, the ram air being shut off when the temperature in the heat exchanger falls below  $-20^{\circ}\text{C}$ . The valve is opened when the heat generated by the equipment raises the temperature to  $+10^{\circ}\text{C}$ .

33. A removable round panel, let into the fuselage skin, lower starboard side, gives access to the inside of the box structure and the connection for the delivery hose of a ground cooling trolley, so that during ground operation of the radar head, the cooling air flows in the reverse direction.

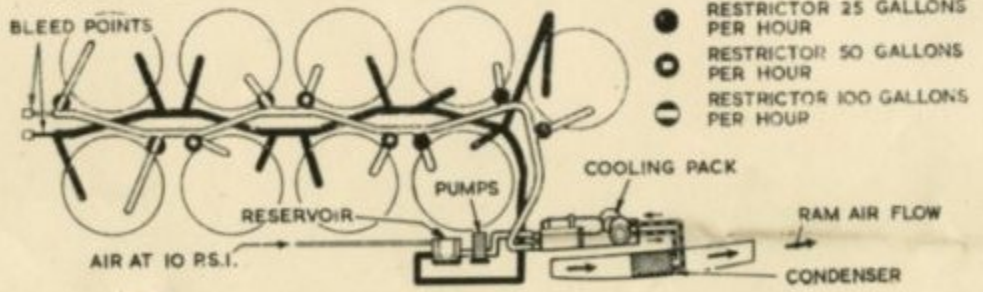
34. To allow the air in the rear section to ventilate to atmosphere during flight, a passage of air is allowed by the louvre panel which has to be removed to gain access to the GCV and pressure gauge of the rear warning pressurisation installation.

Transportation Panel

35. This is provided for attaching to the anti-vibrator spider in order to blank and support the air cooling pipes, if the A/C is flown without the rear warning radar unit. When it becomes necessary to use this panel, the line valve of the radar head pressurisation system must be closed, the flexible supply hose blanked, the electrical leads taped and stowed, and a radome and mounting ring fitted to act as a rear end fairing.



**WATER GLYCOL CIRCUIT DIAGRAM**



**KEY**

- DELIVERY FLOW (RESERVOIR TO CANISTERS)
- RETURN FLOW (CANISTERS TO RESERVOIR)
- REFRIGERANT FLOW
- RESTRICTOR 25 GALLONS PER HOUR
- RESTRICTOR 50 GALLONS PER HOUR
- RESTRICTOR 100 GALLONS PER HOUR

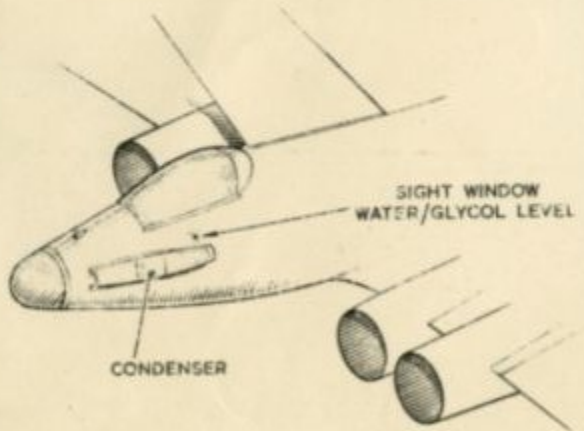


Fig. 1. Cooling system.

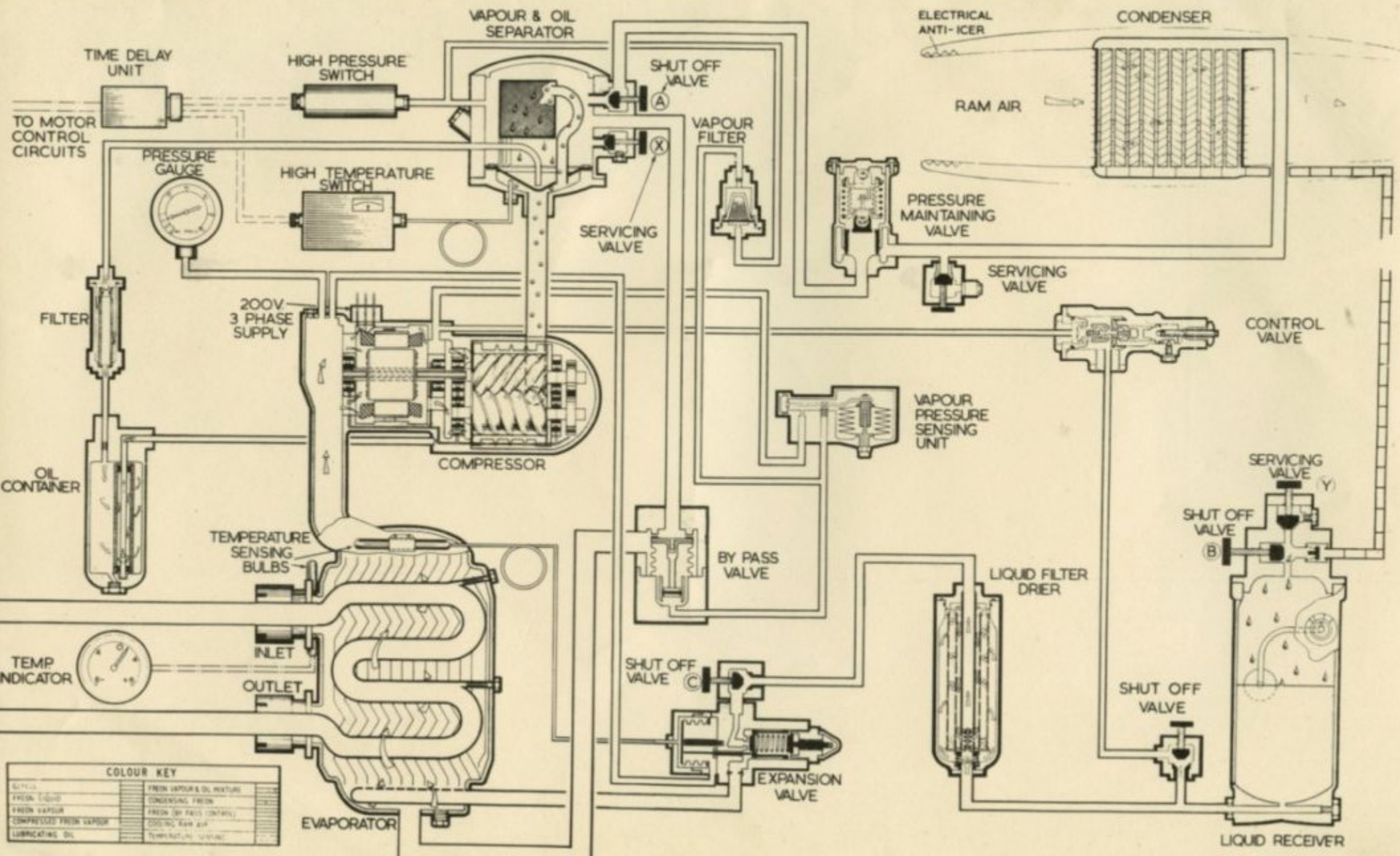
RESTRICTED

# VULCAN B. MK. 2

# E.C.M. COOLING

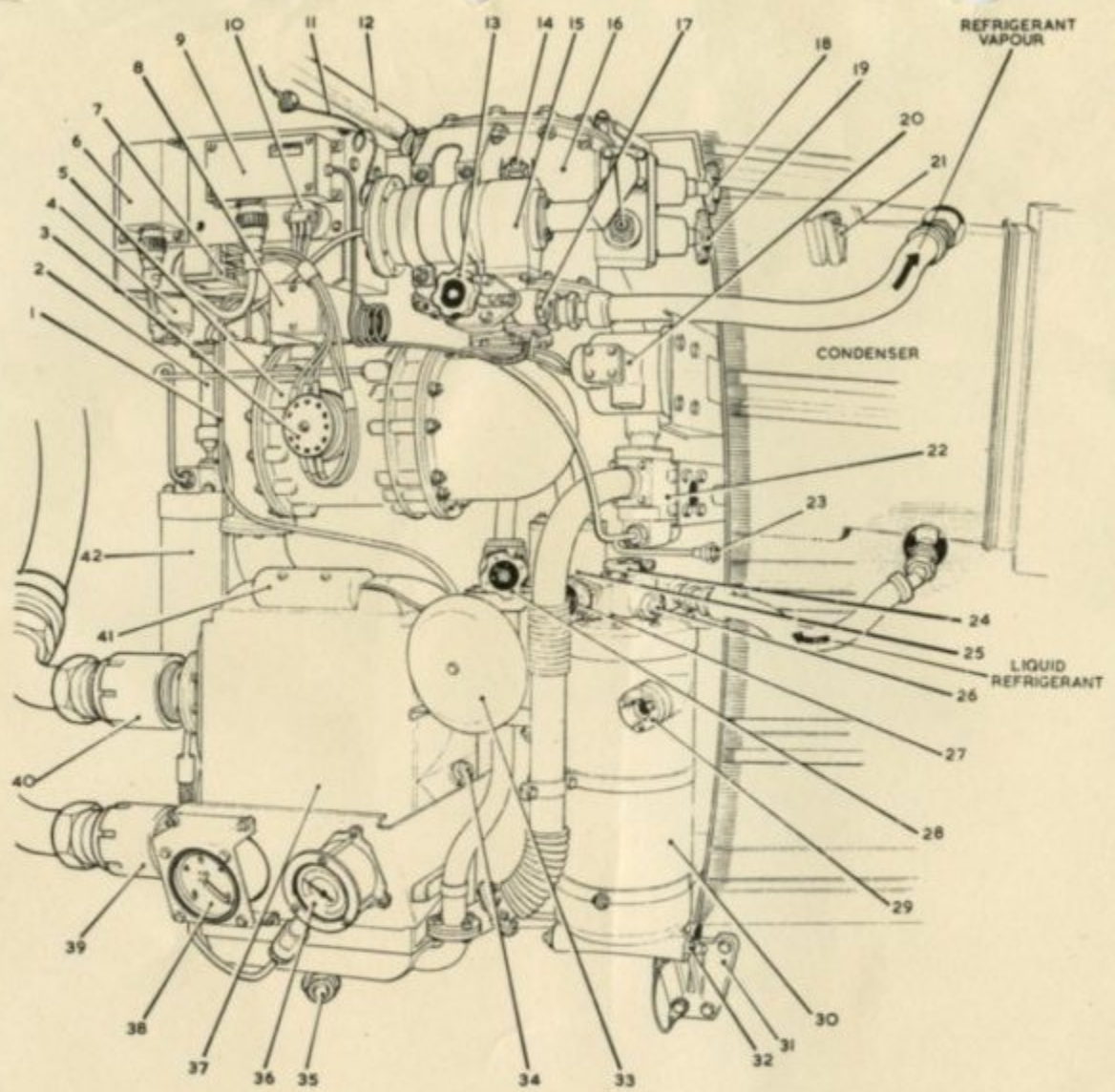
## FREON CIRCUIT

FIG	MOD NO
21	ISSUE NO



**COLOUR KEY**

EVAPORATOR	FREON VAPOUR & OIL MIXTURE
FREON LIQUID	CONDENSING FREON
FREON VAPOUR	FREON (30 P.S.I. CONTG.)
COMPRESSED FREON VAPOUR	CONDENSING RAM AIR
LUBRICATING OIL	TEMPERATURE GAUGE



- KEY
1. PRESSURE BALANCE PIPE
  2. OIL FILTER
  3. TERMINAL BLOCK
  4. FILTER UNIT
  5. MOTOR COMPRESSOR
  6. TIME DELAY UNIT
  7. TERMINAL BLOCK (A.C. SUPPLY CONNECTOR)
  8. RELAY
  9. HIGH TEMPERATURE SWITCH
  10. TRIGGER UNIT
  11. EARTHING WIRE
  12. SUPPORT ROD
  13. CONDENSER SERVICING VALVE
  14. OIL FILLER PLUG
  15. PRESSURE MAINTAINING VALVE
  16. VAPOUR OIL SEPARATOR
  17. SERVICING PLUG
  18. SHUT-OFF VALVE (A)
  19. SERVICING VALVE (X)
  20. VAPOUR PRESSURE SENSING UNIT
  21. CONDENSER SUPPORT BRACKET
  22. BY-PASS VALVE
  23. INSTRUMENTATION POINT
  24. SERVICING VALVE (Y)
  25. FILTER DRIER
  26. SERVICING PLUG
  27. SHUT-OFF VALVE (B)
  28. SHUT-OFF VALVE (C)
  29. LIQUID LEVEL INDICATOR
  30. LIQUID RECEIVER
  31. ATTACHMENT BRACKET
  32. DRAIN PLUG
  33. PROTECTOR FOR EXPANSION VALVE CAPILLARY
  34. WATER/GLYCOL BLEED SCREW
  35. DRAIN PLUG
  36. COMPOUND GAUGE
  37. EVAPORATOR
  38. TEMPERATURE INDICATOR
  39. SELF-SEALING COUPLING (WATER/GLYCOL OUTLET)
  40. SELF-SEALING COUPLING (WATER/GLYCOL INLET)
  41. INSULATOR OVER TEMPERATURE SENSING ELEMENT
  42. OIL CONTAINER

NOTE:  
LAGGING WHICH NORMALLY ENCLOSES ITEMS 15, 16, 20 AND 22  
HAS BEEN OMITTED IN ORDER TO SHOW COMPONENT DETAIL

Fig. 3. Cooling pack installation.  
**RESTRICTED**

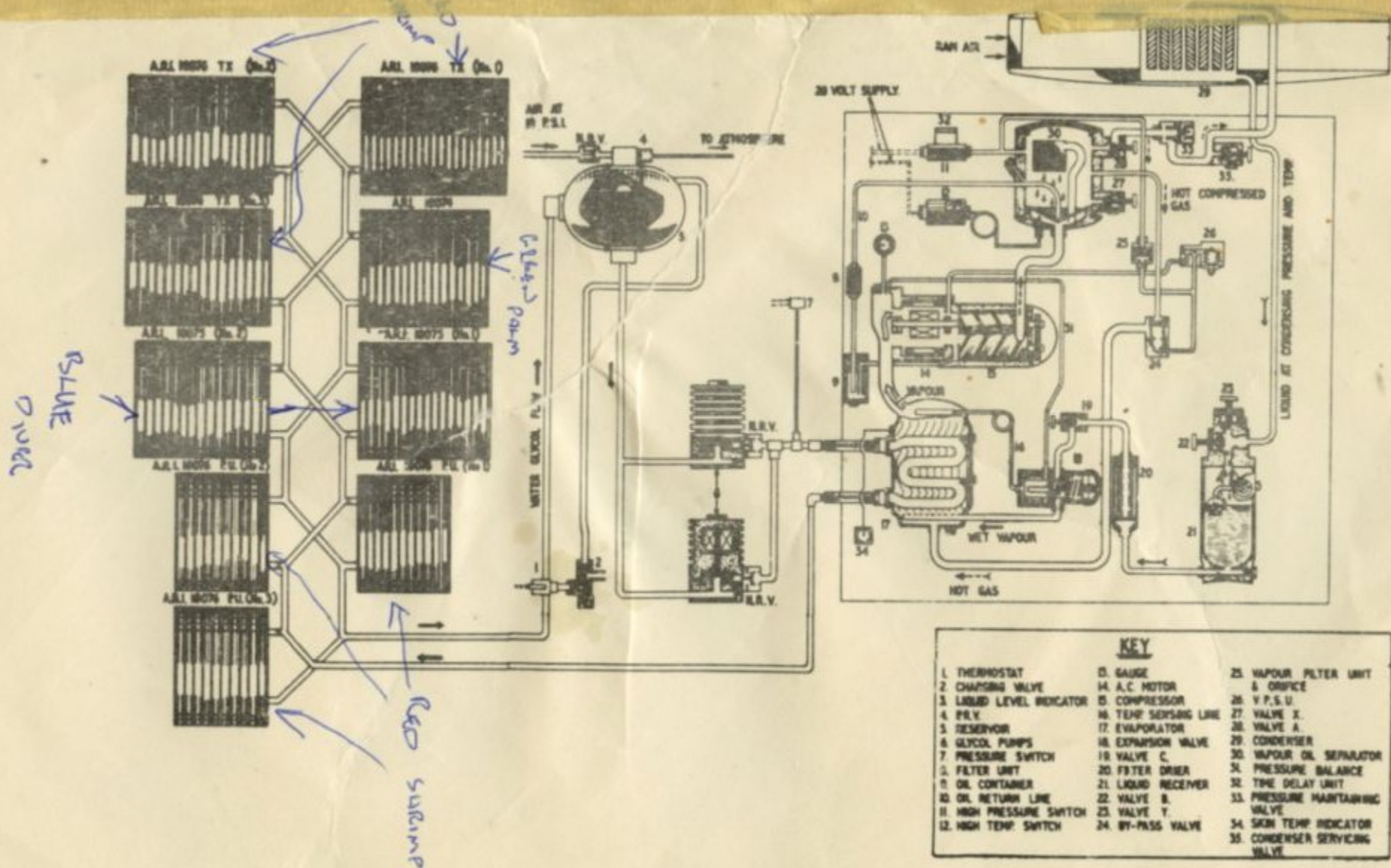


Fig. 2. Cooling system diagram

RESTRICTED

This file was downloaded  
from the RTFM Library.

Link: [www.scottbouch.com/rtfm](http://www.scottbouch.com/rtfm)

Please see site for usage terms,  
and more aircraft documents.

