SECTION 16

E.C.M. COOLING

1. Introduction

The nine ECM containers installed in the rear compartment when operating generate large quantities of heat. To extract this heat, the containers are constructed with a jacket filled with water/glycol. The jacket is equipped with a heat exchanger through which flows a further water/glycol coolant. Each ECM container is interconnected with flexible piping through which the coolant is pumped by two 200V A.C. motor driven pumps. The coolant after extracting heat from the container heat exchangers is then passed through the evaporating chamber of a Godfrey regrigerator where the coolant heat is given up to a refrigerant. The electrical control switches for the cooling system are to be found on panel 81P (A.E.O's station). The control circuit is designated NON ESSENTIAL and is thus shed by operation of the Alternator Failure warning unit or ejection of the R.A.F.

2. Principle of Refrigerator Operation.

Freon gas is first compressed by a 200V A.C. motor driven compressor, and in consequence the gas becomes hot. The compressed and hot gas is then passed through a vapour oil separator and then through condenser, over which cool ram air is flowing. The cooling air thus extracts heat from the compressed gas w ich then begins to condense and form liquid gas droplets as well as cool compressed gas. This mixture is then passed to a receiver which is bascially a reservoir and since there is compessed gas on top of the liquid gas, the liquid gas is forced to flow to an expansion valve where the liquid gas expands, thus becoming cooler and vapourised. The vapourised gas then passes through an evaporating cahmber, extracting heat from the water/glycol pipes and then passes back to the compressor, where the cycle begins again. A brief description of electrical controls and equipment begins in the next paragraph.

3. Control Switches and Indicator

Two double pole push switches labelled COOLING, ON-OFF are fitted to panel 81P. These two push switches control the electrical supplies to two coolant pumps and the refrigerator compressor. Immediately above the two switches is a magnetic indicator which provides the following indications:-

(a) Cooling pack (Refrigerator) operating normally - 'ON'
(b) Cooling pack, just switched on and building up to working temperature - 'LOW'
(c) Cooling pack switched OFF or no power supply - 'OFF'

4. Coolant Pump Motors

Two 200V A.C. star wound induction motors driving associated pumps circulate the coolant around the ECM containers. The 200V A.C. supply to the motors is conveyed via two 3 phase contactors, the operating coils of which are brought under the influence of a coolant high pressure switch fitted into the coolant pipe line. should high pressure develop in the pipe line then the pressure switch operates to switch off the pump motors. When the high pressure has collapsed then pump operation recommences. The pump system is further arranged so that should one pump fail than the remaining pump will circulate coolant at approximately 90% full rate.

5. Low Temperature switch (Thermostat)

A low temperature switch is installed in the coolant pipe line. This switch determines the indications observed on the magnetic indicator on 81P (See paragraph 3). When the coolant temperature is below 0°C the contacts are arranged to give a "LOW" presentation and when the coolant temperature rises to approximately 3°C the contacts are arranged to give an "ON" presentation. The low temperature switch is connected to the indicator via relay 635.

6. Cooling Pack (Refrigerator)

The cooling pack consists of a Godfrey Vapour Cooling Pack - 1 Mk. 1 and operates to extract heat from the container coolant. The pack is installed in the aft end of the ECM fairing and is secured to the airframe by quick release 'pip' pins. The pack condenser (heat exchanger) is fitted externally on the starboard side of the ECM fairing and is faired in by a large ram air scoop. The leading edge of the scoop is equipped with an electric heater brought into operation by the fin de-icing controls on 7P. The Cooling Pack is fitted with the following electrical items:-

a. Motor driver compressor.
b. High pressure switch.
c. High temperature switch.
d. Transistor Time Delay Unit.

7. Compressor Motor

This motor consists of a 200V A.C. delta wound induction motor driving a compressor. The 200V A.C. supply is obtained via a 3 phase contactor and an overload protection unit.

8. High Pressure Switch

The refrigerator gas circuit is of 'closed circuit' pattern and hence should high pressures develop in the refrigerarant pipe lines the circuit must be protected by switching off the compressor motor. This is achieved by operation of the high pressure sensing switch. Once the excess pressure has collapsed the pressure switch contacts revert to normal and the compressor motor may be restarted subject to certain conditions (See paragraph 10).

9. High Temperature Switch

The high temperature switch protects the VCP against overheating and acts to switch off the compressor motor. Once the overheat condition has elapsed the compressor motor may be restarted subject to certain conditions (see paragraph 10).

10. Time Delay Unit

The operating requirements of the refrigerator are such that should the compressor motor be shut down for any of the following reasons it cannot be restarted for a period of 2 minutes.

a. Operation of High Pressure switch.
b. Operation of High Temperature Switch.
c. Operation of Phase Balance Relay.
d. Switching 'OFF' at panel 81P.

This 2 minute delay allows time for the refrigerant pressure to collapse back on to the compressor which drives it in the reverse direction and prevents the 200V A.C. supply to the motor being restored under these reverse operating conditions.

When the refrigerator is operating normally, transistor T1 collector is primed with 28V D.C. from pin D via relay B (NC) and R7, R8.

The capacitors C1/C2 are uncharged since 28V D.C. is applied to their negative plates via pin D.

/Should the

Should the refrigerator stop for any reason then a 28V DC appears at pin C due to the action of relay A de-energising. Simultaneously the 28V DC on C1/C2 'negative' plates is withdrawn and C1/C2 commence to charge - the charging current being taken through T1 collector to emmitor.

The resultant voltage drop across R3 and T2 to conduct and voltage drop across R5 causes T3 to conduct.

NOTE: R3 and R5 potentials are applied to the base electrode of T2 and T3 respectively, T2/T3 collector potentials derived via pin C.

When all three transistors are conducting relay B energises to place a supply to relay C thus holding off the control line to the compressor motor contactor. Relay B also acts to stop the TDU from 'recycling' by breaking its NC contacts.

After a period of approximately 2 minutes, the C1/C2 charging current falls off reducing the potential applied to T1, T1 ceases to conduct cutting off T2 and 5/ and relay C de-energises thus returning control of the compressor motor to the 'ON' push at 81P which must be depressed to restart the VCP.

NOTE: The coolant pumps will continue to run during TDU operation.

11(a) Circuit Operation - Switching 'ON'

Depressing the double pole 'ON' push at 11P results in 28 D.C. being applied to energise R626 which in closing via the HPS operates the coils of R625 and R623 which in closing place a 200V AC supply to run both coolant pumps. Note R626 is held in by its own contacts.

Simultaneously the other pole of the 'ON' push applies a 28V DC supply to energise R710 which in closing operates relay A (Trigger Unit), which in closing operates the compressor motor contactor R627 and the motor commences to run. Note: R627 is held on via the following contacts:- Pin C of the VCP, relay A (NO), relay C (NC), high temperature switch contacts, contacts 1 of the phase balancer and contacts 1 of R627 to maintain relay A energised.

11(b) Circuit Operation - Switching 'OFF'

De pressing the 'OFF' push at 81P results in the 28V DC supply to the coolant pump contactors being interrupted and the motors cease to run. Simultaneously, the 28V DC supply to the coil of relay A is interrupted and R627 de-energises causing the compressor motor to stop. As described in paragraph 10, the TDU sequence is initiated and 2 minutes elapse before restarting can be attempted.

11(c) Refrigerator Failure (Operation of overload protection unit)

Should a 3 phase overload occur then the overload currents are sufficient to strike an SCR circuit which energises relay 710. Relay 710 de-energises relay 627 and stops the compressor motor. Relay 710 will now remain energised until the 28V DC is removed either by operation of the 'OFF' push or removal of the non-essential 28V. The T.D.U. sequence is initiated and prohibits starting for 2 minutes.

11(d) Refrigerator Failure (Operation of high temperature switch)

If the high temperature switch operates it breaks the supply to R627 and the compressor motor stops. The T.D.U. sequence is initiated and 2 minutes elapses before restarting can be attempted.

11(e) Refrigerator Failure (Operation of High Pressure Switch)

If the high pressure switch operates it causes relay C to energise breaking the supply to the coil of R627, which in de-energising stops the compressor motor. The high pressure switch also applies 28V DC to the 'negative' plate of C4 which has the effect of reducing sparking on relay A contacts.

/11(f) Cooling System Emergency Shut Down

11(f) Cooling System Emergency Shut Down

The system control relay earths are all commoned through contacts of the alternator failure warning unit relay. Thus if two or more primary alternators fail then operation of this relay will shut down the cooling system completely by breaking the common earth. Furthermore ejection of the RAT will shut the system down by its operation of the load shedding contactors.

12. Limitations.

The VCP should never be operated on the ground without a suitable blast air supply connected to the condenser fairing. Failure to comply with this instruction will result in damage to the VCP components. Close co-operation is required between Airframe and Electrical trades when servicing the VCP and the electricain should not disconnect pipe lines without obtaining specialist advice.

13. Safety Precautions

The refrigerant used in the VCP is Freon (Arcton) liquid gas. Like all liquid gases, this gas is extremely dangerous if allowed to come into contact with exposed parts of the body. If allowed to contact the eyes, blindness may be the result. Furthermore wet Freon vapour inhaled will irritate the lungs and cause great pain. Therefore when handling Freon always wear goggles of approved pattern, face protection and gauntlets. Anyone suffering from exposure to Freon is to be treated by the station M.O. immediately.

14. Rear Scanner Cooling System

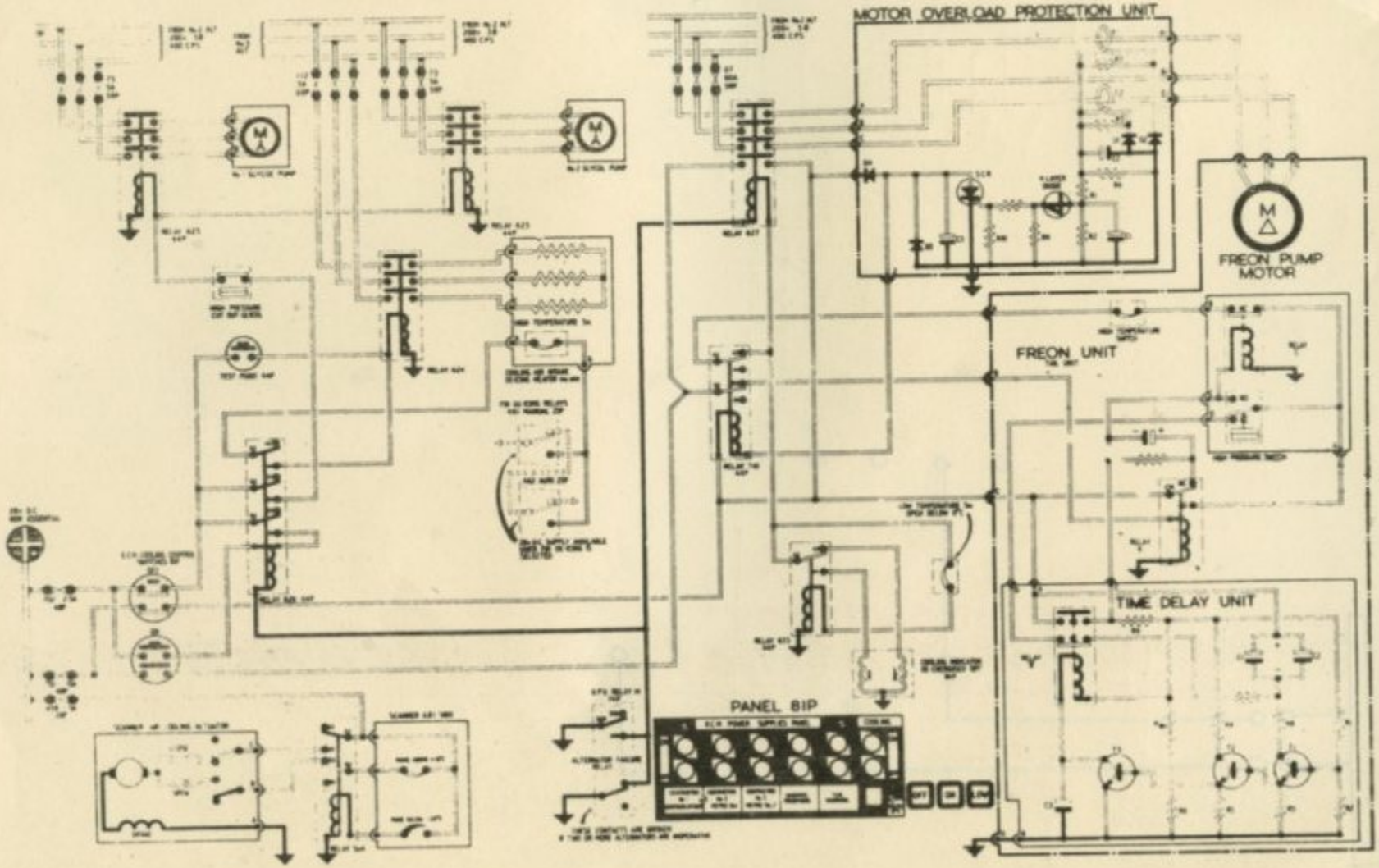
The tail warning scanner is a sealed pressurised item and is equipped with an air heat exchanger. Ram air is admitted through a small NACA intake on the port side of the ECM fairing and directed via an electrically actuated butterfly valve through the heat exchanger.

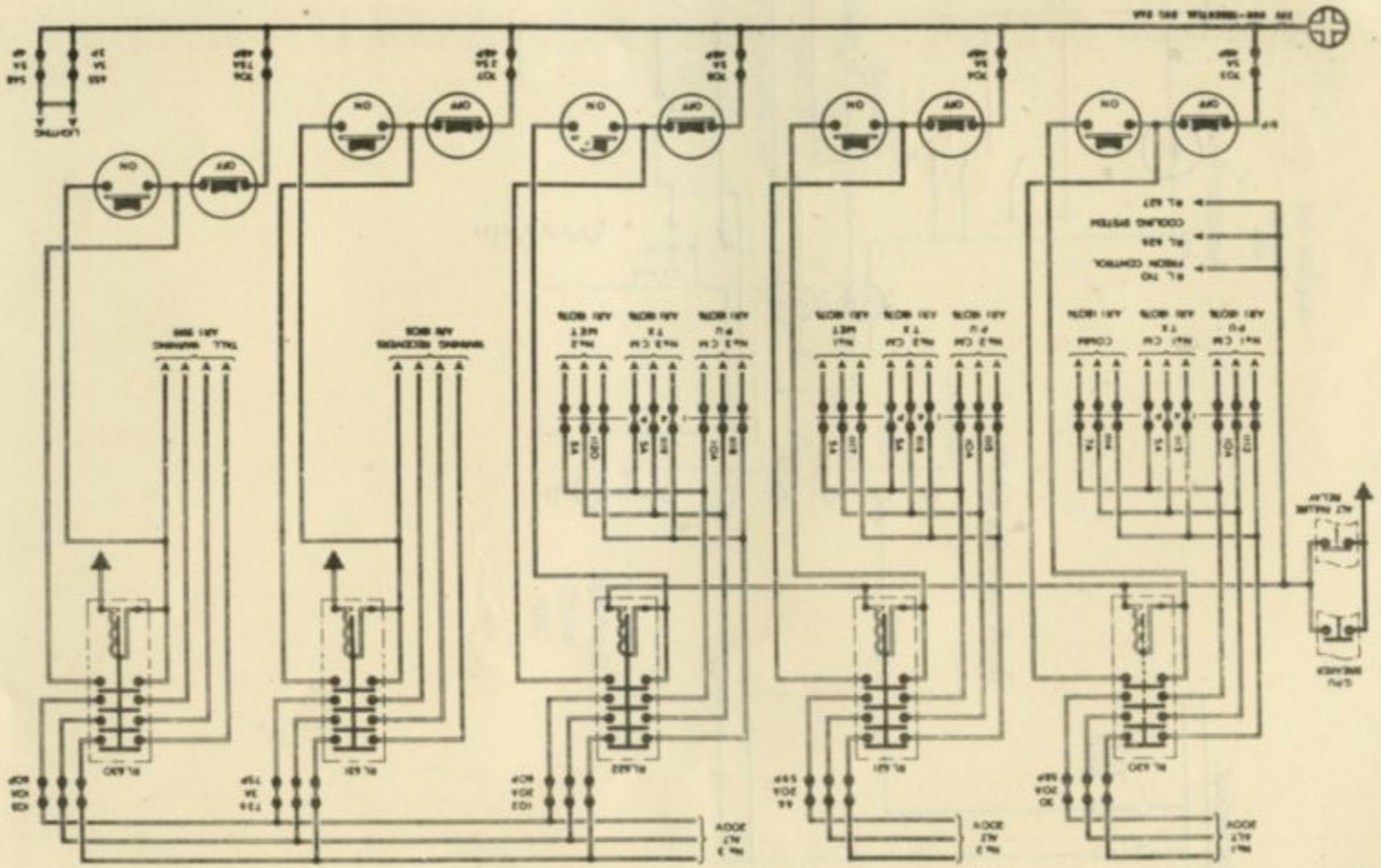
15. Major Component Table

Component	No.	Location
Water/Glycol Pump Motor Rotol Type RM.1/5	2	Just forward of VCP
Compressor Motor Godfrey Type ACM8/200 mk.1	1	VCP (Stbd. aft of ECM compartment)
High temperature switch Part No. 166588/1	1	VCP above compressor motor
Time Delay Unit Clifford Edwards Type TP 4680 Part No. 166901	1	VCP (Behind high temperature switch)
High Pressure switch Clifford Edwards Type.	1	VCP (Inside box panel behind high temp switch.

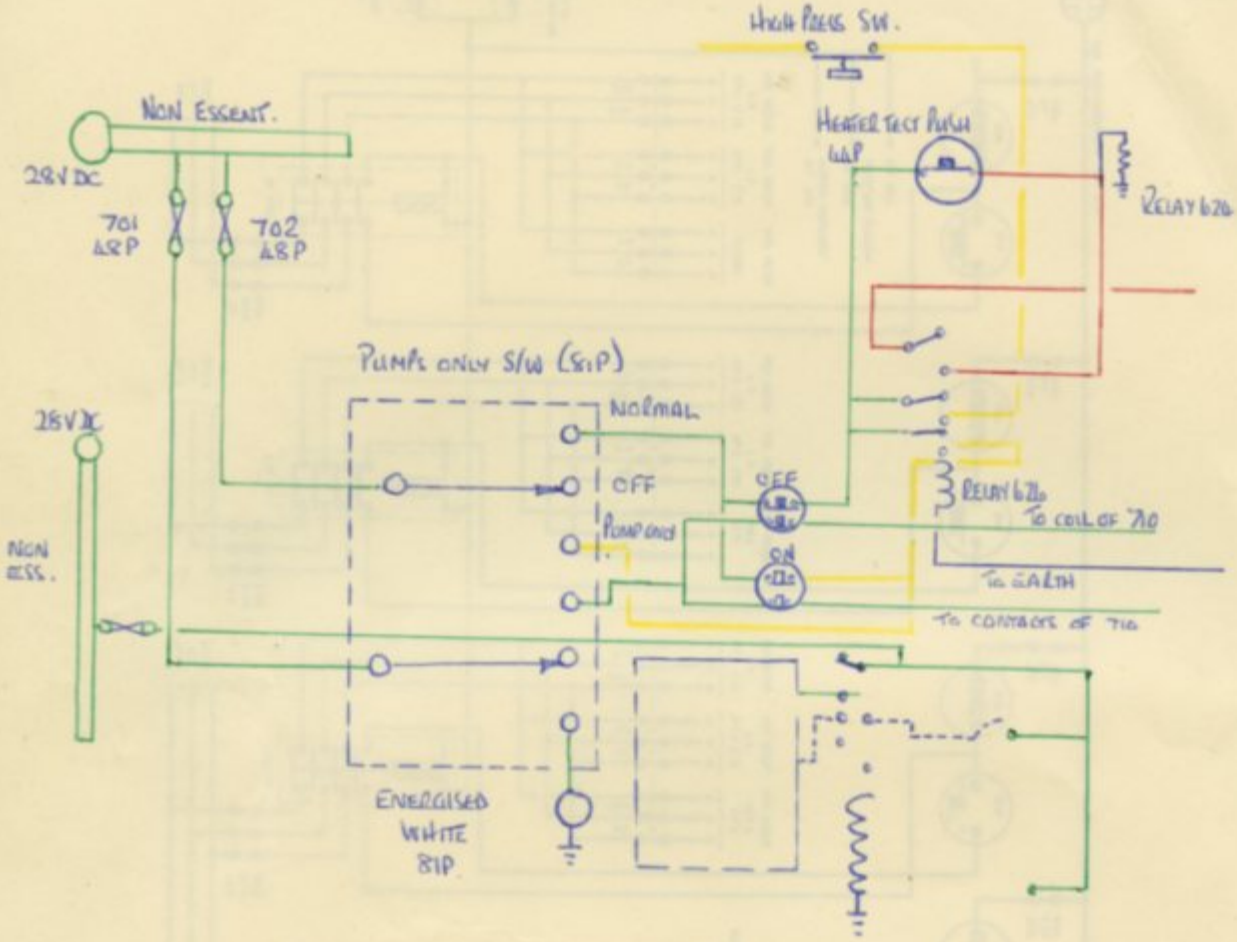
/Trigger Unit Relay

Trigger Unit Relay A Type TP.4550	1	VCP (Under high temp. switch)
Temp. gauge - 80° - 0 -+ 80°C	1	VCP
Phase Balance Relay Rotax type F4909/1	1	44P (Just fwd. from VCP)
Compressor Contactor Relay 627 D.6704/2	1	44P
Relay 710 Plessey type 7CZ 103739/2	1	VCP
Relay 626 7CZ/105411/2	1	44P
Relay 635 Plessey type 7CZ 103739/2	1	44P
W/G pump contactors relays 625 623 Type D6311	2	44P
W/G pump high pressure switch type F.O.M.	1	Adjacent to W/G pump motors
Cooling system 'ON' push switch 'OFF' push switch	1 1	81P
Indicator 7CZ/ 107626/32	1	81P


MOTOR OVERLOAD PROTECTION UNIT
FREON PUMP MOTOR
FREON UNIT
TIME DELAY UNIT
PANEL 81P



COM MOD 032


HIGH PRESS SW.
NON ESSENT.
28V DC
701 ASP
702 ASP
HEATER TEST PUSH 4AP
RELAY 620
PUMPS ONLY S/W (5 P)
NORMAL
OFF
PUMPS ONLY
28V DC
NON ESS.
OFF
ON
RELAY 620
TO COIL OF 710
TO EARTH
TO CONTACTS OF 710
ENERGISED WHITE 8P