REVISED-1

DAIKIN

Marine type Container Refrigeration Unit

Service manual

Model

LKEN5BD15

DAIKIN INDUSTRIES LTD

TR84—8A

This manual describes the features, functions, operation, and maintenance of the container refrigeration unit. In addition, the manuals listed below are also available.

- Parts list
- Compressor disassembly & reassembly manual

Please refer also to these manuals.

DANGER

Do not disconnect plug until power supply is shut off.

CAUTION

Do not start the unit until plugs are connected and generator plant is operated.

NOTE

1. Wind drive spring of recorder whenever chart is renewed.
2. Firmly tighten the cover of the control box not to make water ingress.
3. Confirm that the stop valves in the refrigeration circuits are opened before operation.
4. Confirm whether the cargos are cooled down to the temperature for transportation in advance.
5. After operating the container refrigeration unit for service, wash the unit with fresh water, especially the external section of the unit is to be washed carefully, because much salt sticks on the unit.

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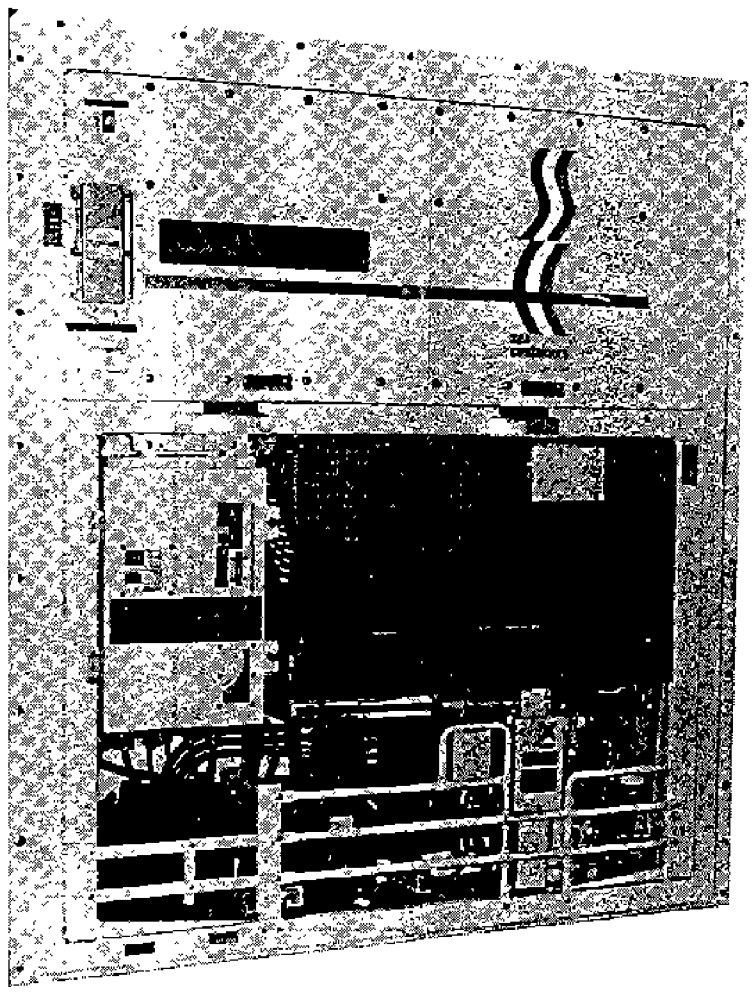
PARTLOW TEMPERATURE CONTROLS
E549A OPERATING MANUAL
(P/N 042 010 01)

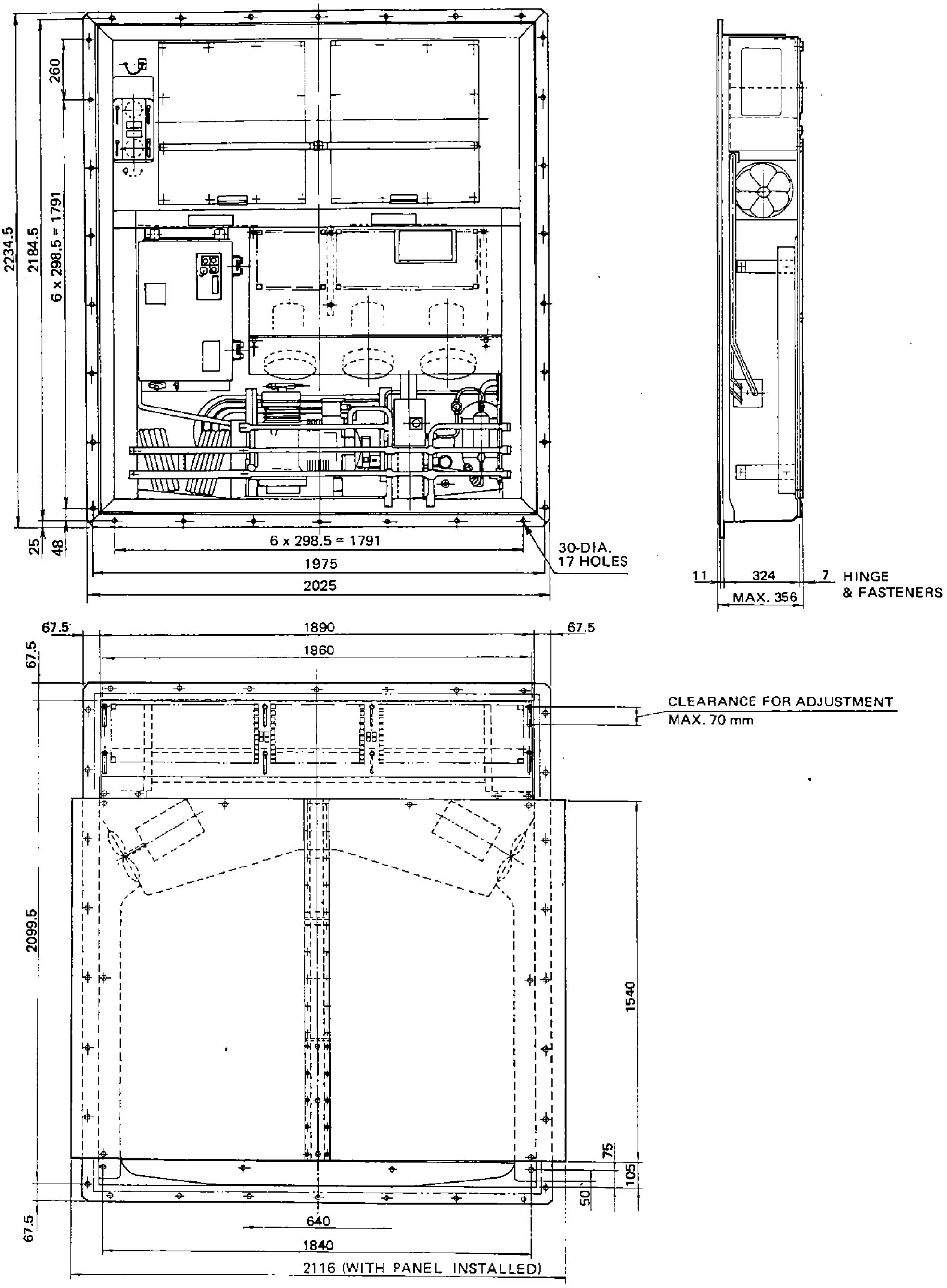
1. Specification

1.1 General specification

Power supply	AC 200V 3 Phase 50/60Hz AC 220V 3 Phase 60 Hz AC 380 ~ 415V 3 Phase 50 Hz AC 440V 3 Phase 60 Hz (Dual voltage rating with voltage selector)
Compressor	Semi hermetic type (3.75 kW)
Evaporator	Cross finned coil type
Air cooled condenser	Cross finned coil type
Water cooled condenser	Hairpin-shaped tube-in-tube type
Accumulator-receiver with heat exchanger	Vertical cylinder type
Fan	Motor direct driven propeller type
Fan motor	Single-phase squirrel-cage induction motor
Defrost	
Heat source	Electric heater
Initiation	Timer or manual switch.
Termination	Sensing evaporator temperature by defrost termination thermostat
Refrigerant control	Thermostatic expansion valve
Capacity control	Suction control + hot gas bypass with modulating control valve
Protection devices	Circuit breaker, Over current relay, Dual pressure switch, Oil pressure protection switch, Fusible safty plug, Firestat, Compressor motor protection thermostat, Fan motor protection thermostat.
Refrigerant	R-12: 4.5 (kg)/9.9 (lbs)
Lubricant	SUNISO 3GS-DI : 2.3 (ℓ)
Weight	Approx. 610 (kg)

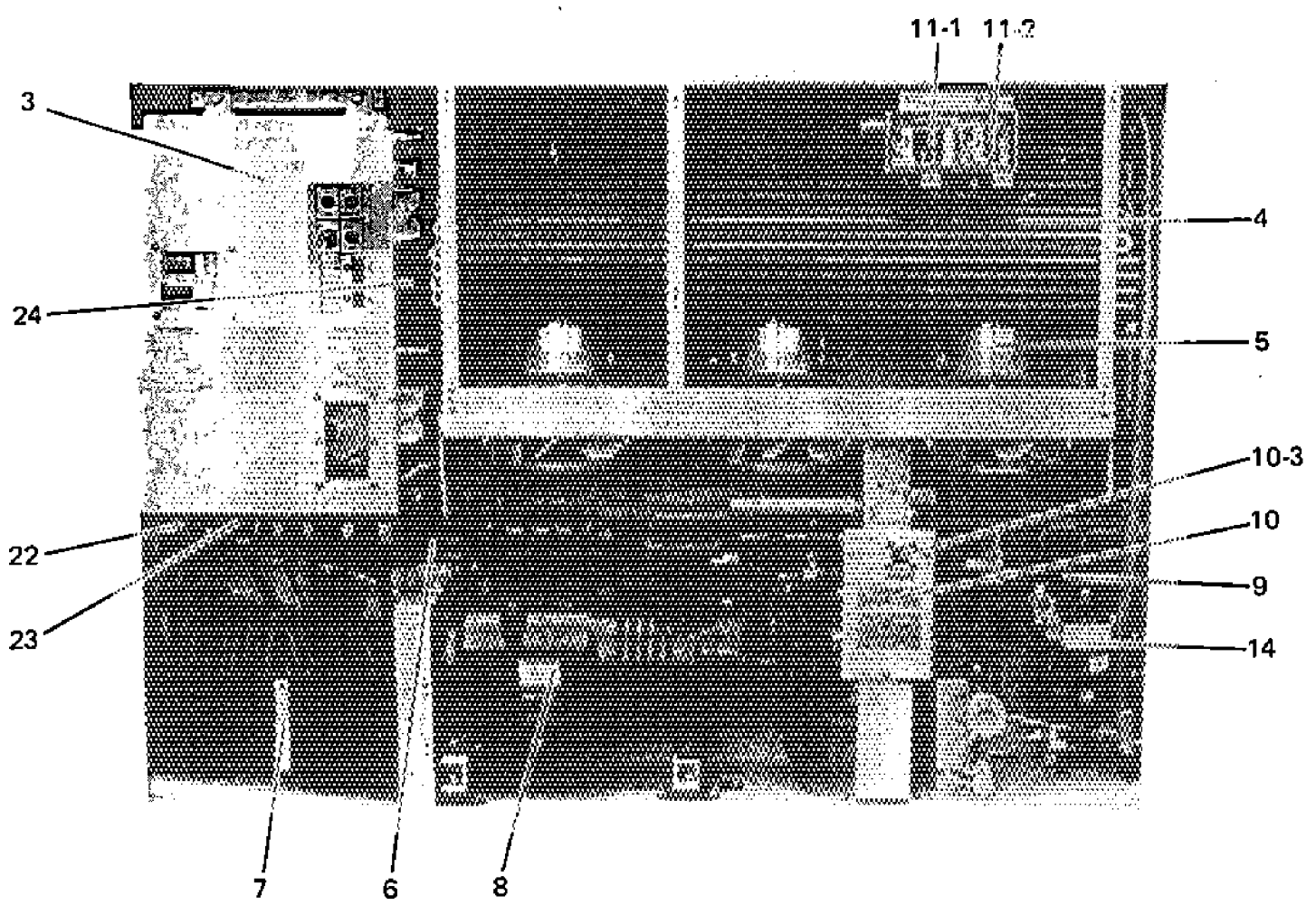


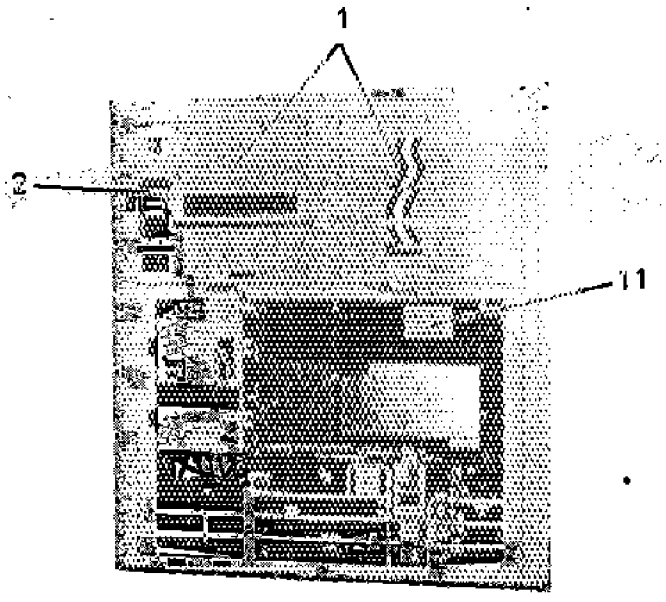
1.2 Outline

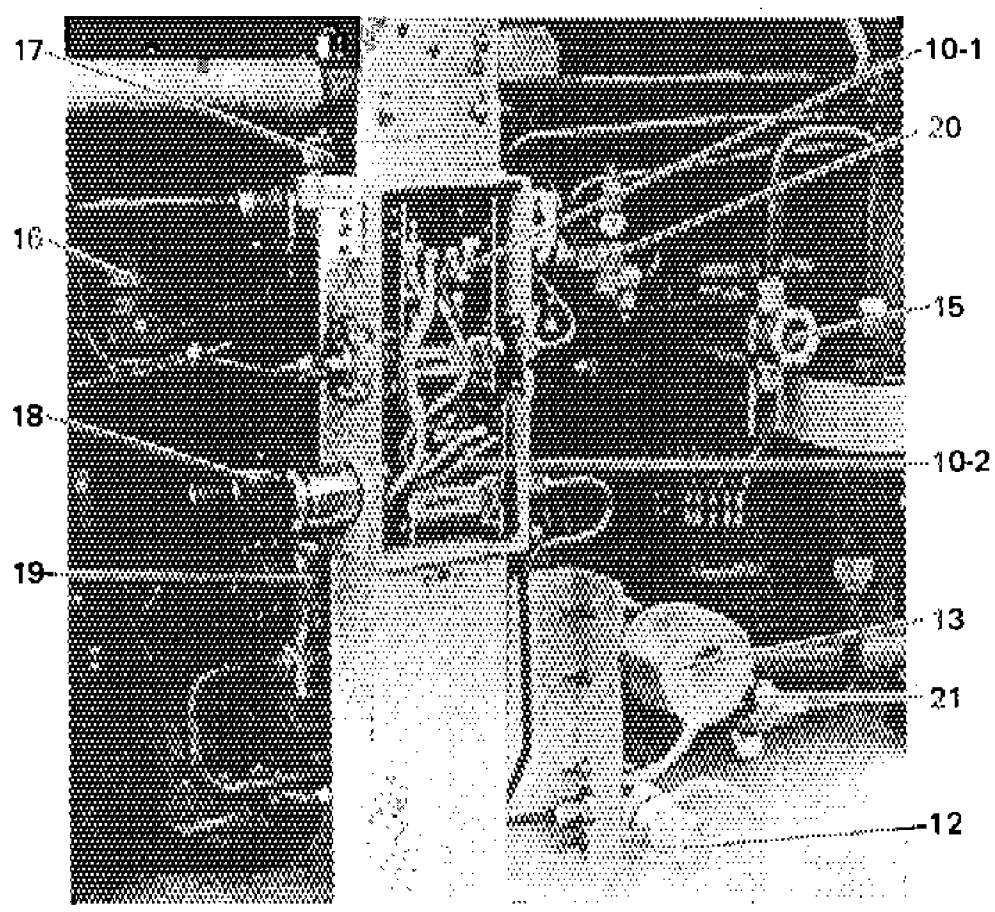


1.3 Construction

(1) Outside

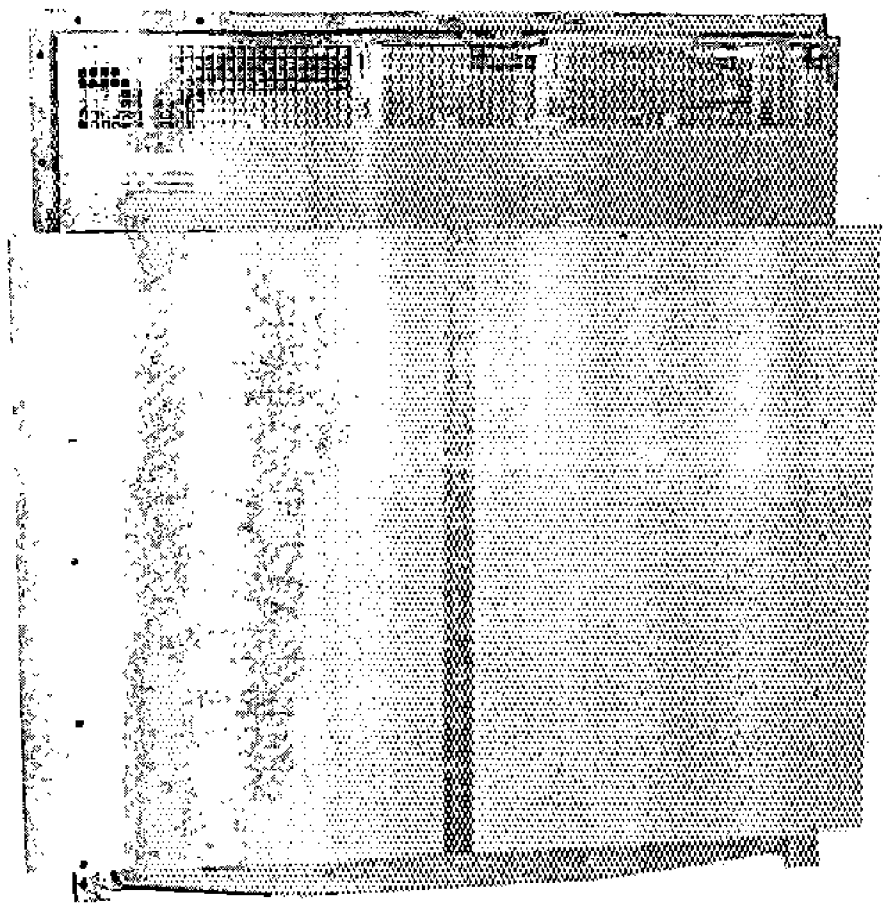




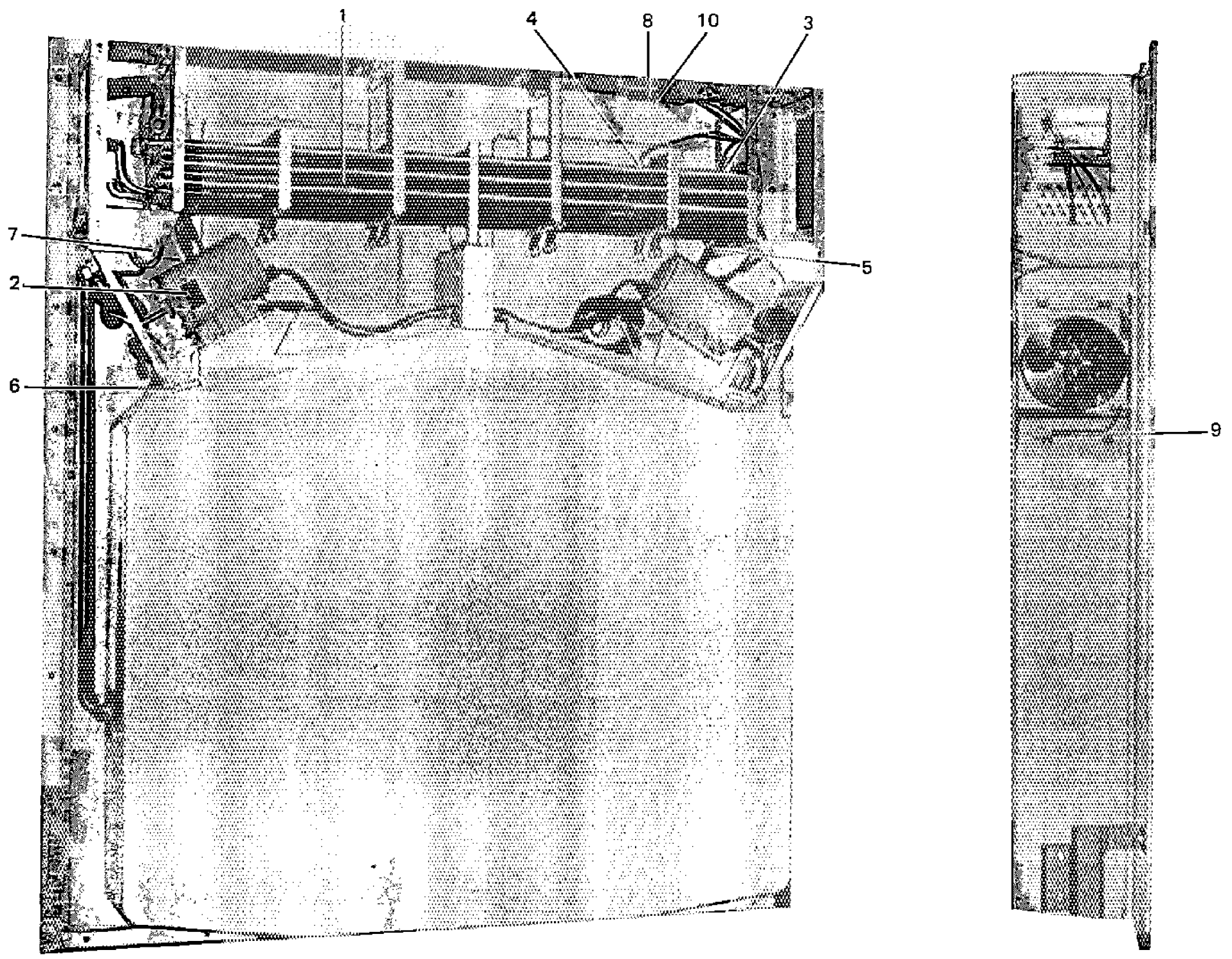


1 Access panel
2 Ventilator
3 Control box
4 Air cooled condenser
5 Condenser fan motor
6 Water cooled condenser
7 Cable stowage
8 Compressor
9 Accumulator-receiver with heat exchanger
10 Pressure switch box (upper)
10 — 1 Oil pressure protection switch ⟨OPS⟩
10 — 2 Water pressure switch ⟨WPS⟩
10 — 3 Reset button for oil pressure protection switch
11 Pressure switch box (lower)
11 — 1 Dual pressure switch ⟨HLPS⟩
11 — 2 Condenser fan high pressure switch ⟨CFHPS⟩
12 Water inlet coupling
13 Water outlet coupling
14 Dryer
15 Liquid/moisture indicator
16 Modulating control valve ⟨MV⟩
17 Solenoid valve ⟨SLS for suction⟩
18 Solenoid valve ⟨LLS for liquid⟩
19 Solenoid valve ⟨HLS for hot gas bypass⟩
20 Stop valve for hot gas line
21 Stop valve for liquid line
22 Power receptacle
23 Power selector
24 Voltage selector switch

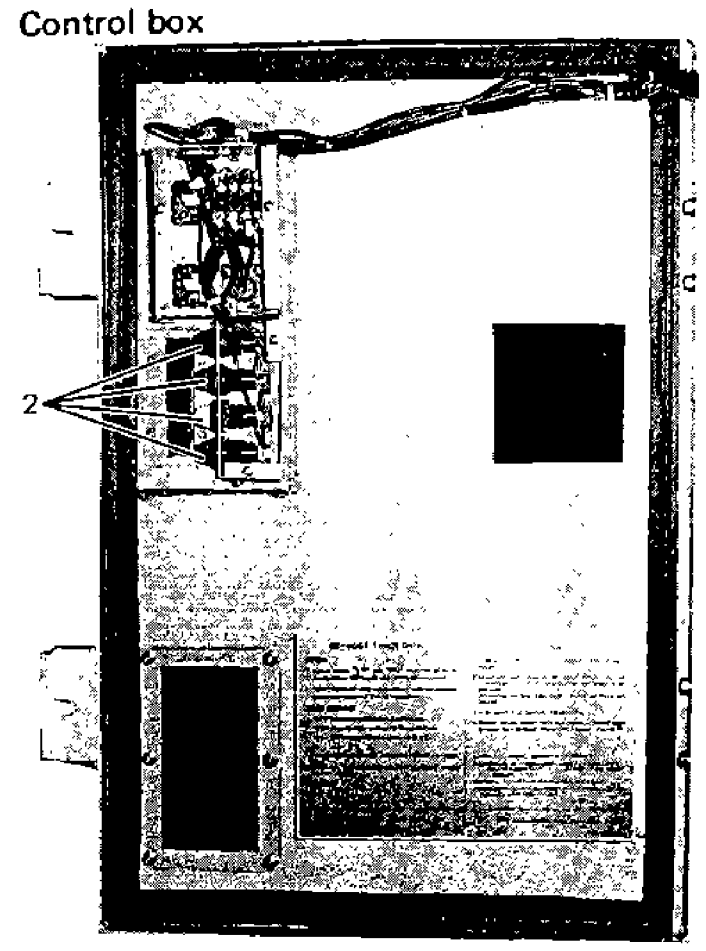
(2) Inside

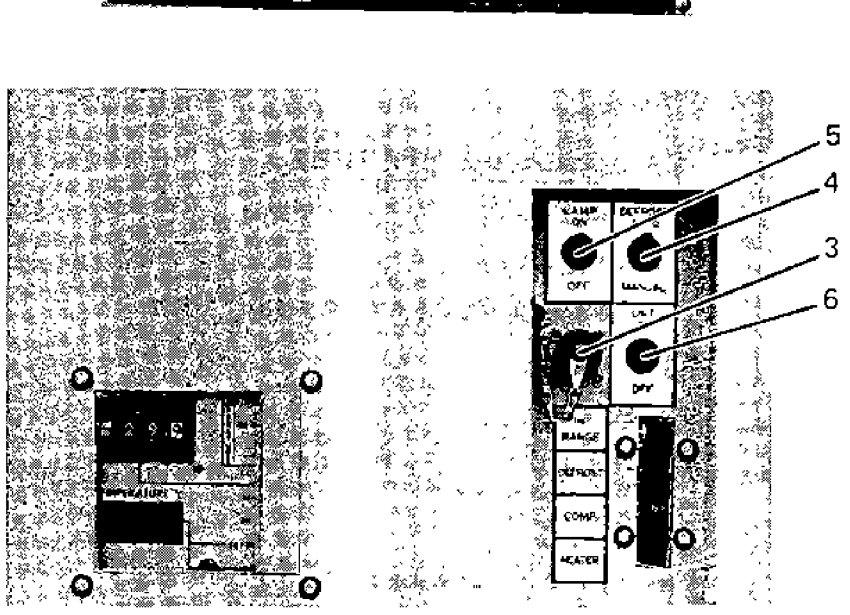


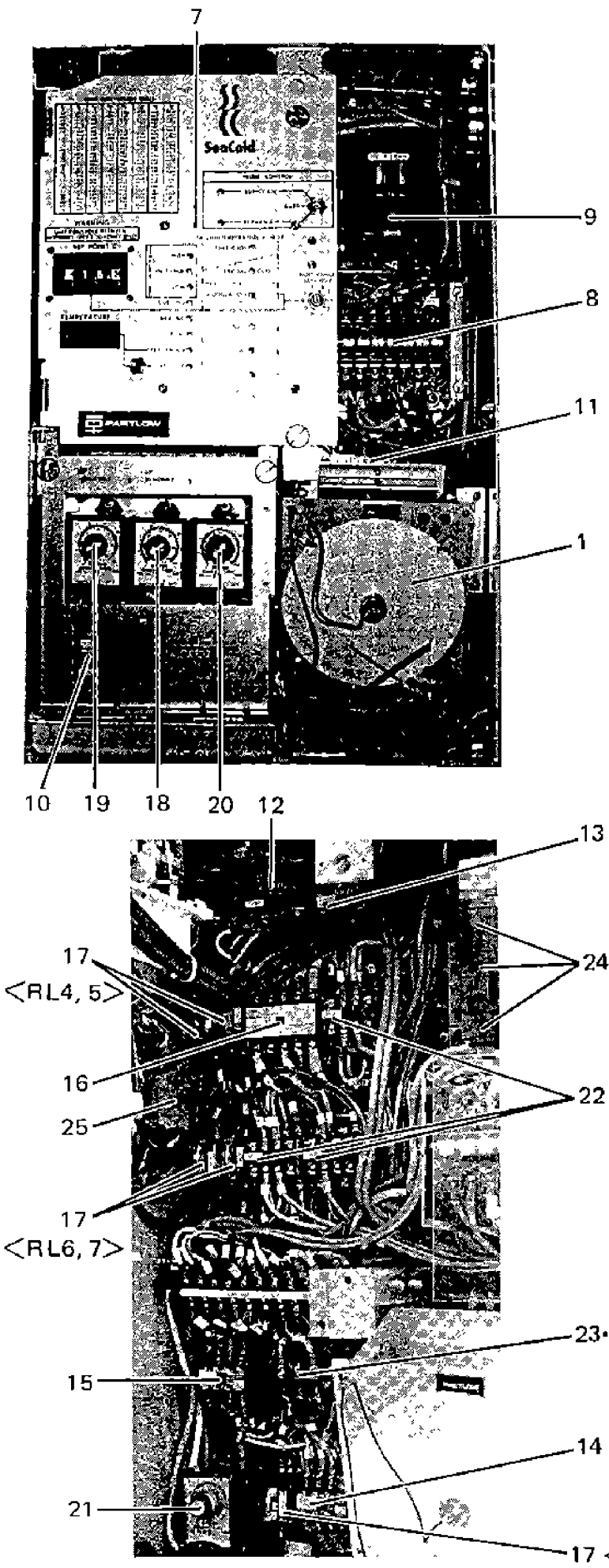
1 Evaporator
2 Evaporator fan motor
3 Defrost termination thermostat
4 Firestat
5 Defrost heater
6 Drain port heater
7 Expansion valve
8 Return air sensor (for controller)
9 Supply air sensor (for controller)
10 Recorder feeler tube



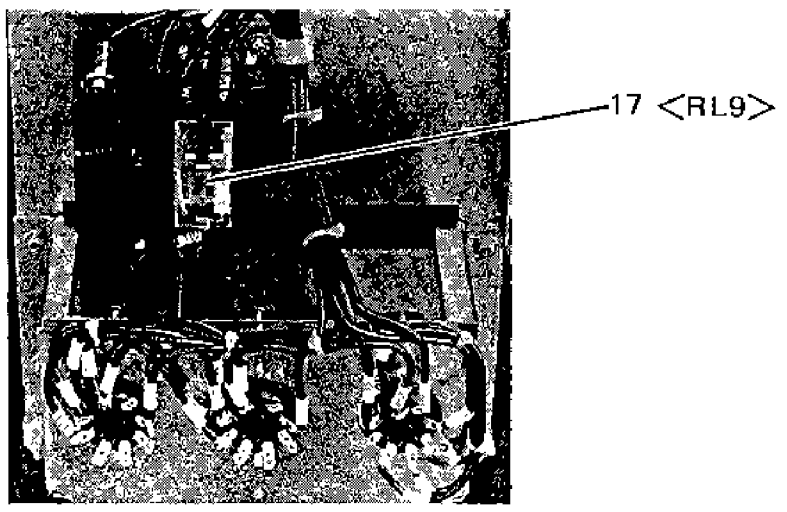
(3) Control box



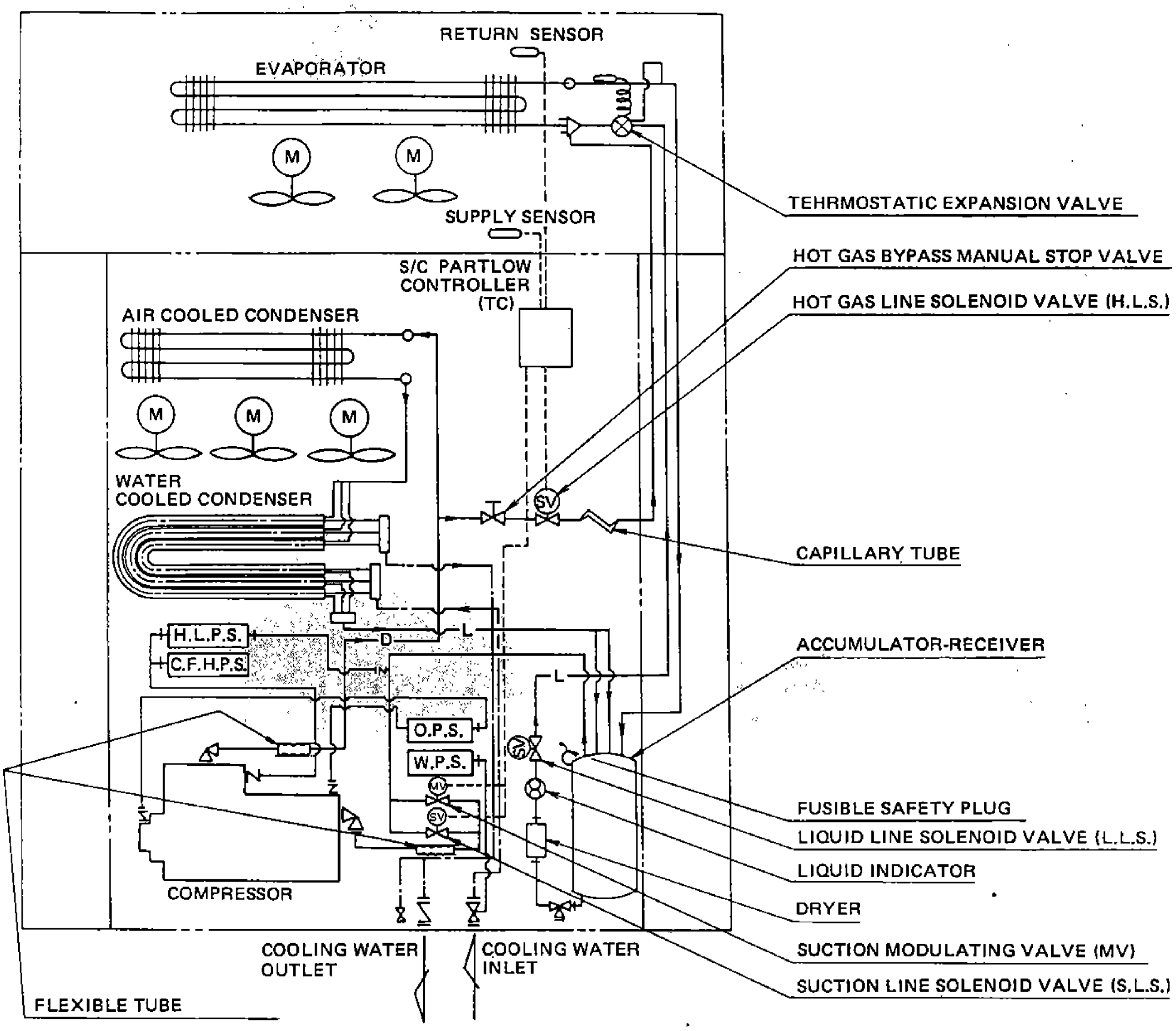




1 Recorder
2 Pilot lamp <AL, WL, GL>
3 Unit ON-OFF switch <ST>
4 Manual defrost switch <MD>
5 Lamp switch <ILS>
6 Cannon receptacle for remote monitoring
7 Partlow controller
8 Voltage selector <VS>
9 Circuit breaker <CB1>
10 Circuit braker <CB2>
11 Transformer <CTR1>
12 Transformer for controller <CTR2>
13 Evap. fan motor relay <EF>
14 Heater relay <HTR1>
15 Heter relay <HTR2>
16 Compressor relay <C>
17 Auxiliary relay <RL4, 5, 6, 7, 8, 9>
18 Defrost timer <DT1> – Short
19 Defrost timer <DT2> – Long
20 In range timer <IRT>
21 Compressor delay timer <CDT>
22 Voltage selector relay <R1, 2, 3>
23 Over current relay <OL>
24 Capacitor <CAP1, 2, 3>
25 Daring ton ass'y for partlow controller



1.4 Piping diagram

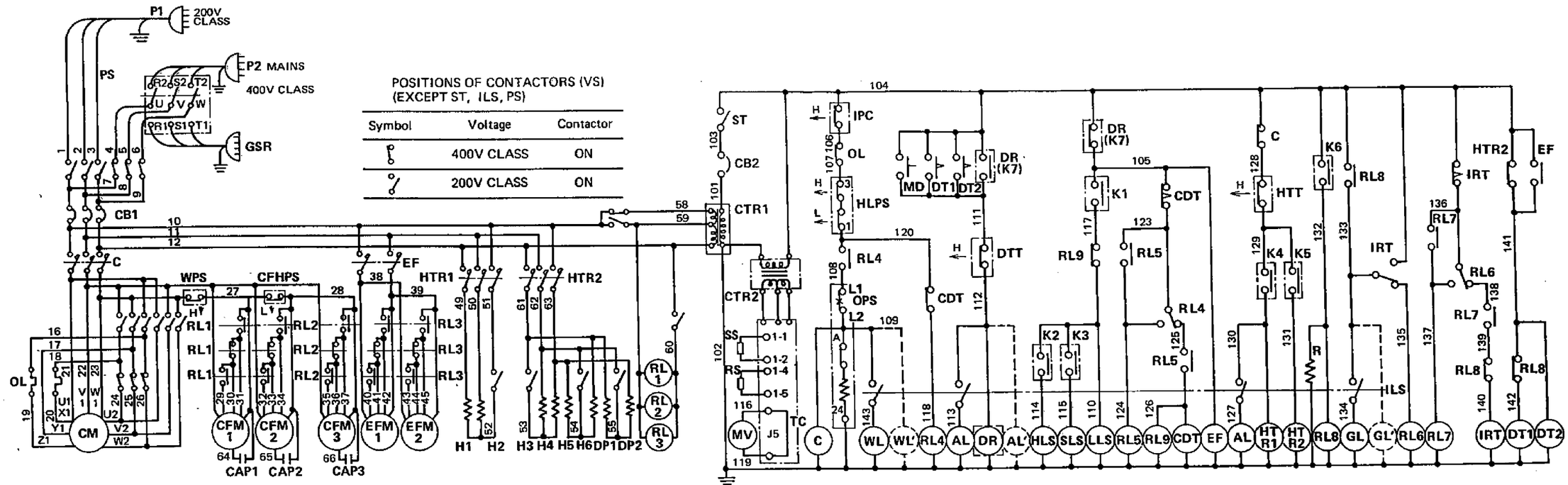


—L— LIQUID PIPE
—S— SUCTION PIPE
—D— DISCHARGE PIPE
—|— FLARE CONN.
—‖— FLANGE CONN.
—-— WATER PIPE
------ ELECTRIC WIRING

HLPS : DUAL PRESS. SWITCH
OPS : OIL PRESS. PROTECTION SWITCH
HPS : HIGH PRESS. CONTROL SWITCH
WPS : WATER PRESS. SWITCH

1.5 Wiring diagram

1.5.1 Sequence wiring



TEMPERATURE CONTROLLER <TC>

OUT PUT RELAY

K1	COOLING
K2	HOT – GAS
K3	BY – PASS
K4	LOW HEAT
K5	HIGH HEAT
K6	IN – RANGE
K7	DEFROST RELAY <DR>

NOTES

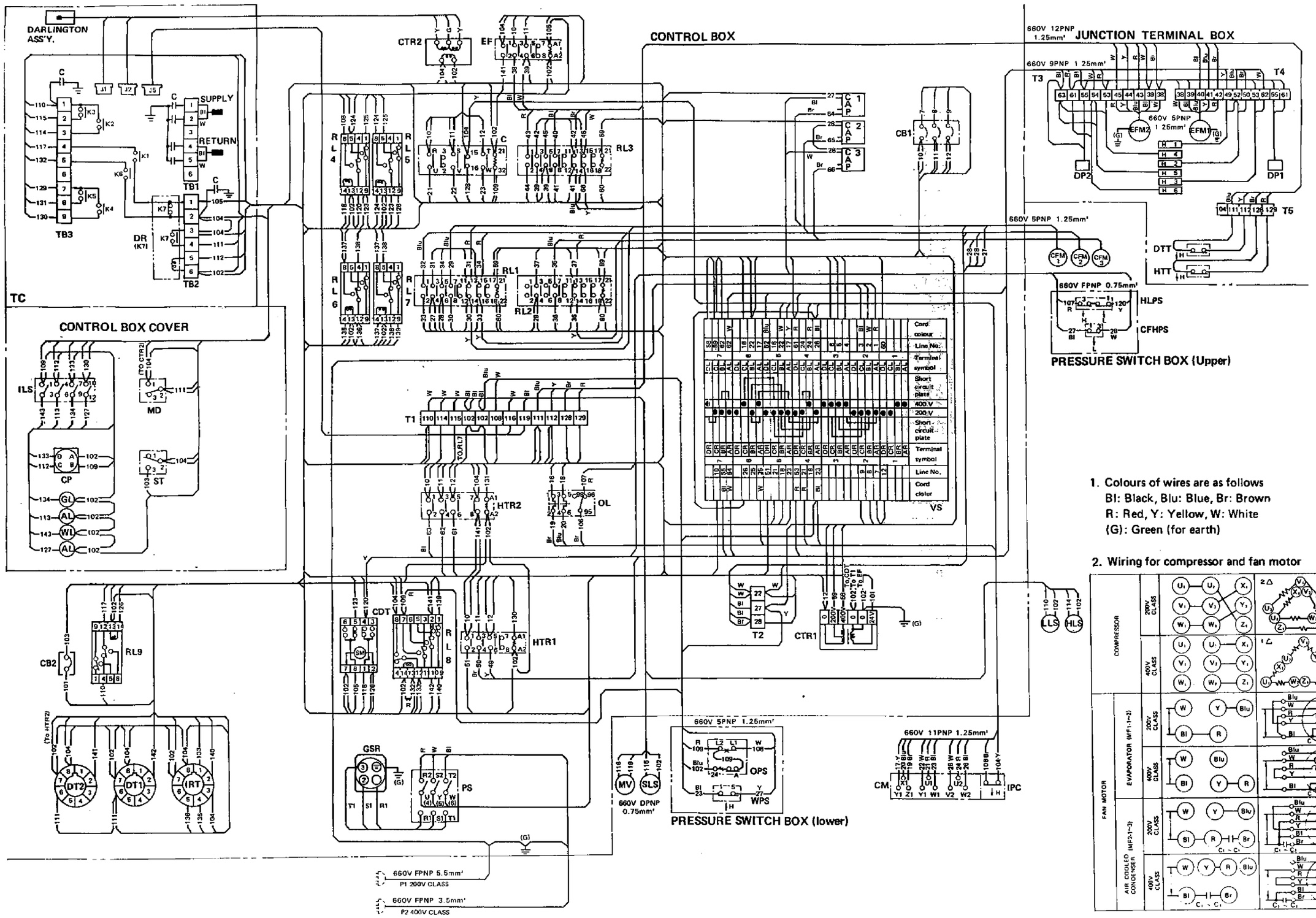
1. Monitoring plug connected as follows.

A : Earth
B : Compressor (WL)
C : Defrost (AL)
D : In range temp. (GL)

2. Broken line shows external wiring.

P	POWER PLUG	PS	POWER SELECTOR(460V MAINS/GEN-SET)	DR (K7)	DEFROST RELAY
CB	CIRCUIT BREAKER	VS	VOLTAGE SELECTOR (230/460V)	CFHPS	CONDENSER FAN HIGH PRESSURE SWITCH
C	COMPRESSOR CONTACTOR	ST	START SWITCH (UNIT ON-OFF SWITCH)	HLPS	HIGH/LOW (DUAL) PRESSURE SWITCH
EF	EVAPORATOR FAN CONTACTOR	ILS	INDICATOR LAMP SWITCH	OPS	OIL PRESSURE PROTECTION SWITCH
HTR	HEATER CONTACTOR	MD	MANUAL DEFROST SWITCH	WPS	WATER PRESSURE SWITCH
RL	MAGNETIC RELAY	DTT	DEFROST TERMINATION THERMOSTAT	CAP	CAPACITOR
CM	COMPRESSOR MOTOR	HTT	HEAT TERMINATION THERMOSTAT	DT1	DEFROST TIMER (SHORT)
EFM	EVAPORATOR FAN MOTOR	TC	TEMPERATURE CONTROLLER	DT2	DEFROST TIMER (LONG)
CFM	CONDENSER FAN MOTOR	GL, WL, AL	INDICATOR LAMP	IRT	IN RANG TIMER
H	ELECTRIC HEATER	OL	OVER LOAD	CDT	COMPRESSOR DELAY TIMER
DP	DRAIN PORT HEATER	IPC	INTERNAL PROTECTOR COMPRESSOR	HLS	HOT GAS LINE SOLENOID VALVE
MV	MODULATING VALVE	LLS	LIQUID LINE SOLENOID VALVE	SLS	SUCTION LINE SOLENOID VALVE
GSR	GEN-SET RECEPTACLE	CTR	CONTROL TRANSFORMER	R	RESISTOR

1.5.2 Actual wiring

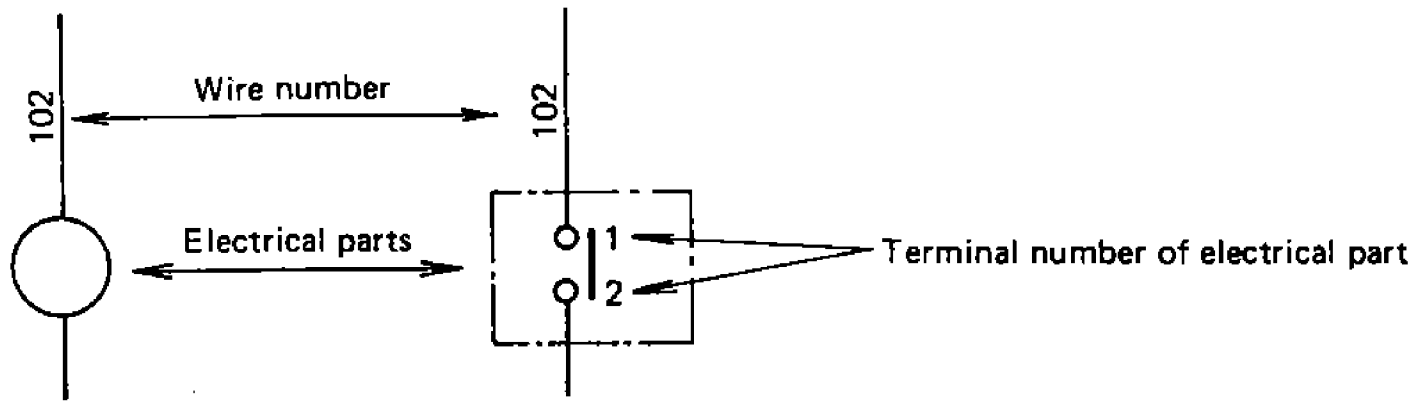


1. Colours of wires are as follows
   Bl: Black, Blu: Blue, Br: Brown
   R: Red, Y: Yellow, W: White
   (G): Green (for earth)

2. Wiring for compressor and fan motor

1.5.3 How to read wiring diagram

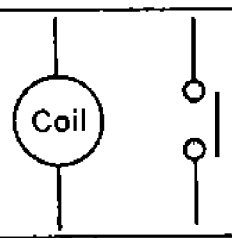
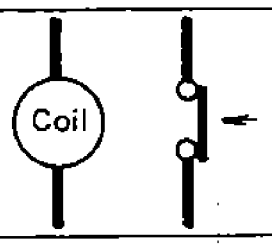
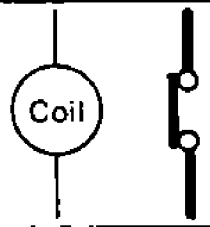
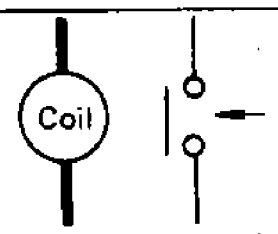
(1) In the wiring diagram, marks and numbers have the meanings given below.



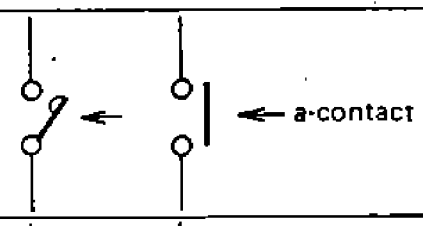
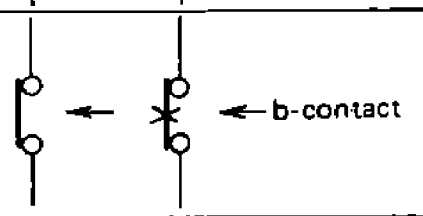
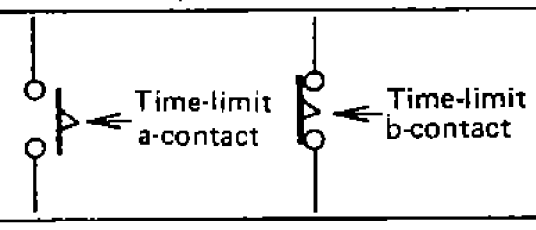
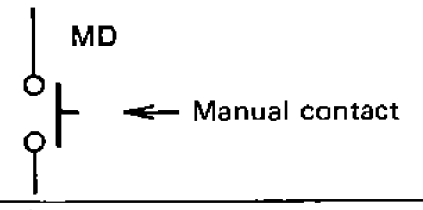
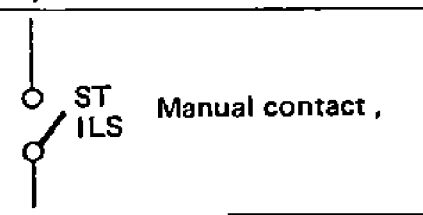
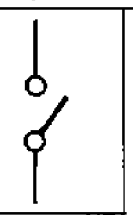
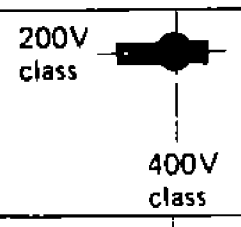
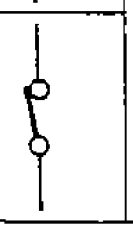
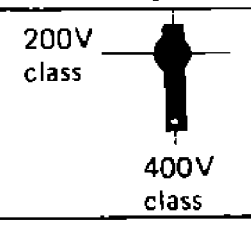
(2) Operation of contacts

a. The wiring diagram indicates the stationary state in which the circuits are not activated.

b. When a coil is energized (supplied with power), the associated contact changes its position.

a-contact (normal contact)		b-contact (reverse contact)	
Contact is OFF when coil is not energized	Contact is ON when coil is energized	Contact is ON when coil is not energized	Contact is OFF when coil is energized
			

c. Kinds of contacts

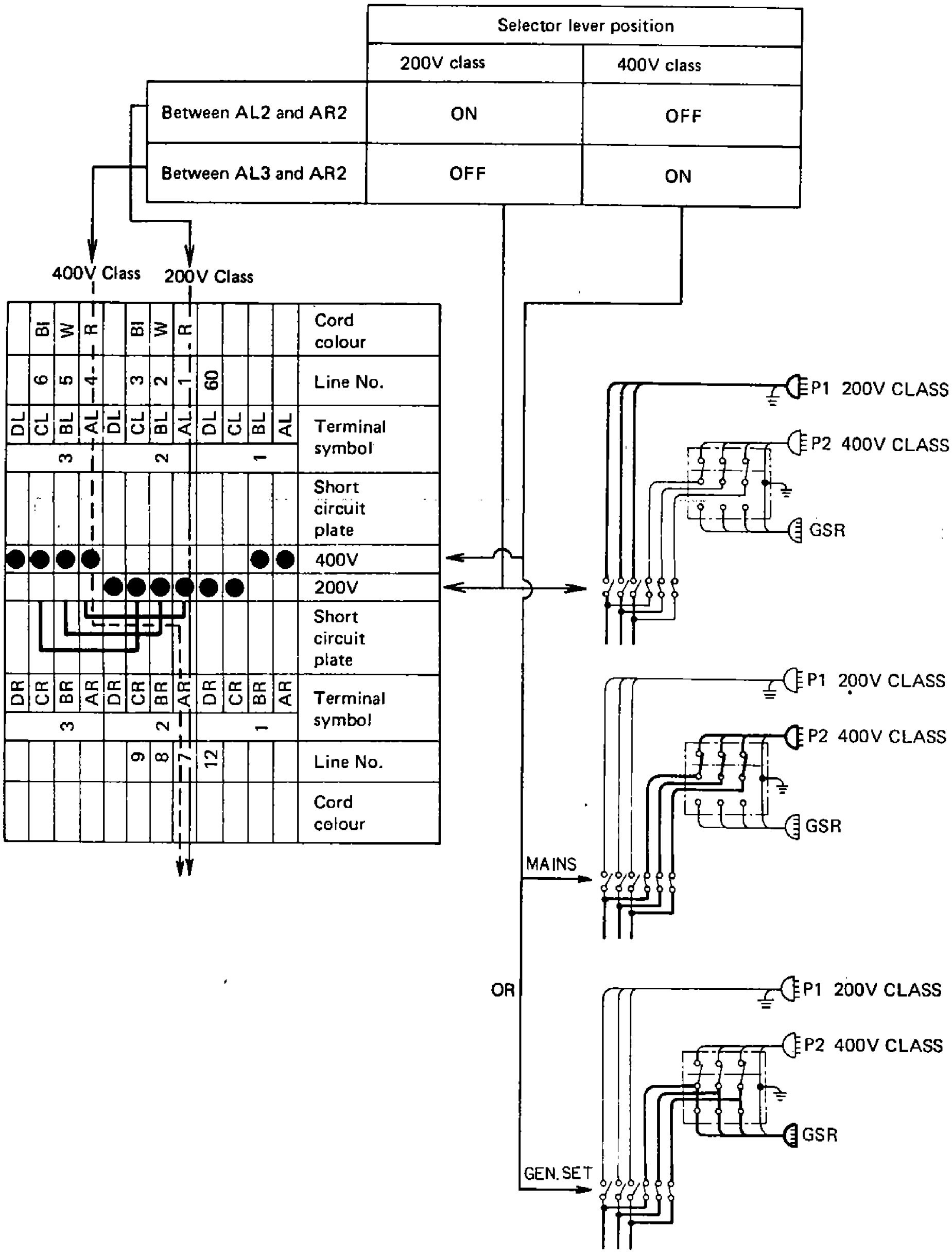
	Operated by electromagnetic force, temperature, or pressure. ("x" denotes the reset button.)
	
	Operates when the timer counting has completed.
	Contact of a snap switch. This turns on as long as the switch is kept pressed and turns off immediately when released.
 Manual contact ,	Contact of a snap switch. This turns on and holds the on state once the switch is turned on.
 Voltage selector contact 〈except ST, ILS〉	This turns on when the selector is set to 200V class 
	This turns on when the selector is set to 400V class 

d. How to read the wiring diagram of the voltage selector switch.

In the chart, "●" denotes that the contact is on.

The following example shows the states between terminals AL2 and AR2, and between AL3 and AR2.

	Selector lever position	
	200V class	400V class
Between AL2 and AR2	ON	OFF
Between AL3 and AR2	OFF	ON



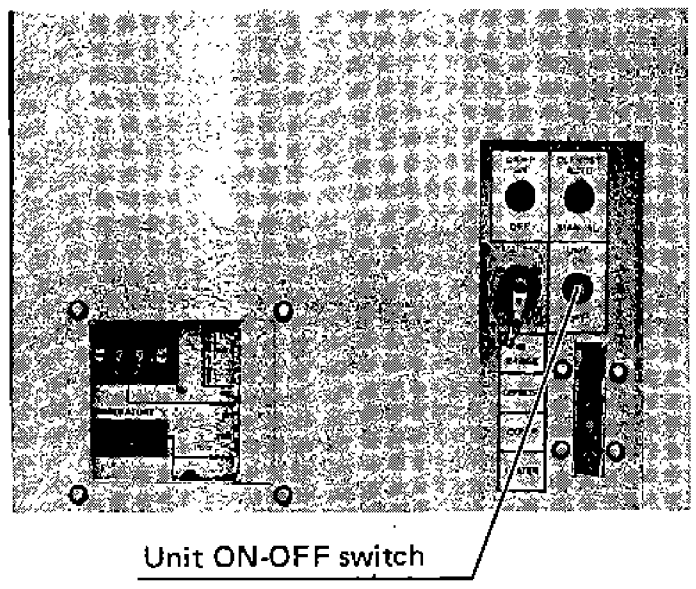
2. Operation

Operate the unit by the procedures given below.

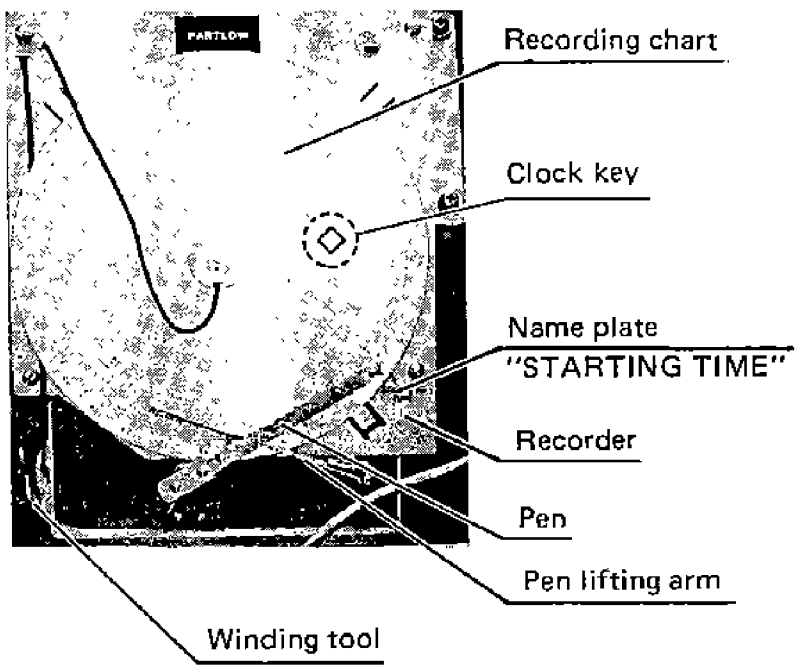
- Preparation
- Operation
- Checking during operation
- Maintenance after operation

2.1 Preparation

(1) Confirm that supply power is off.
Confirm that the power source, the circuit breaker and unit ON-OFF switch <ST> are turned off before checking for safety's sake.

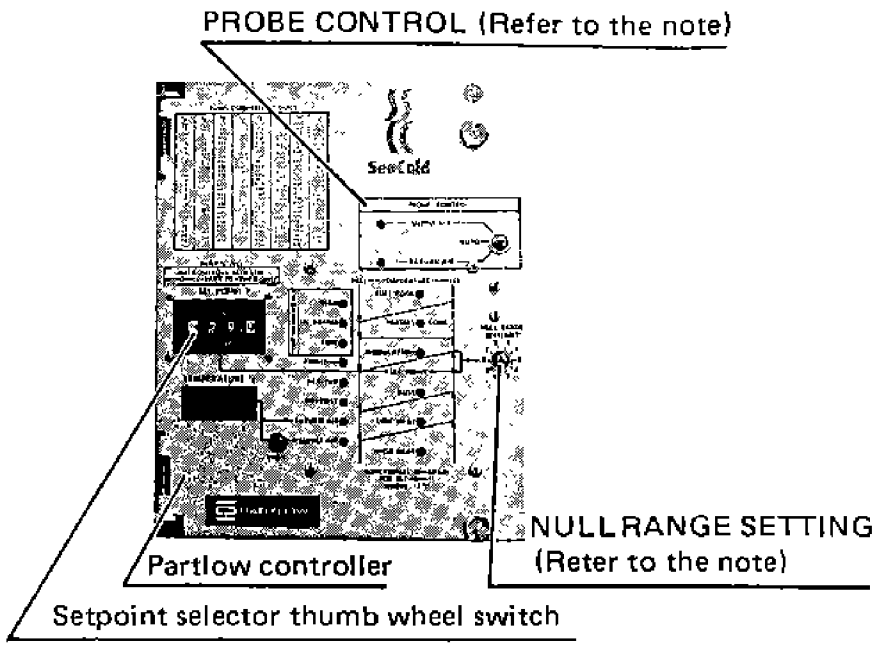


(2) Replacement of recorder chart and winding of clock spring.



- Raise the pen with the pen holder.
- Replace the chart and wind the spring of the 31-day chart drive clock using the provided winding tool. (Do not over wind the spring.)
- Confirm clock movement by the sound of the movements.
- Set up a new chart and bring the date on the chart to the "starting time", arrow and fasten the chart nut firmly.
- Lower the pen on the chart with the pen holder and confirm the recording of the recorder.

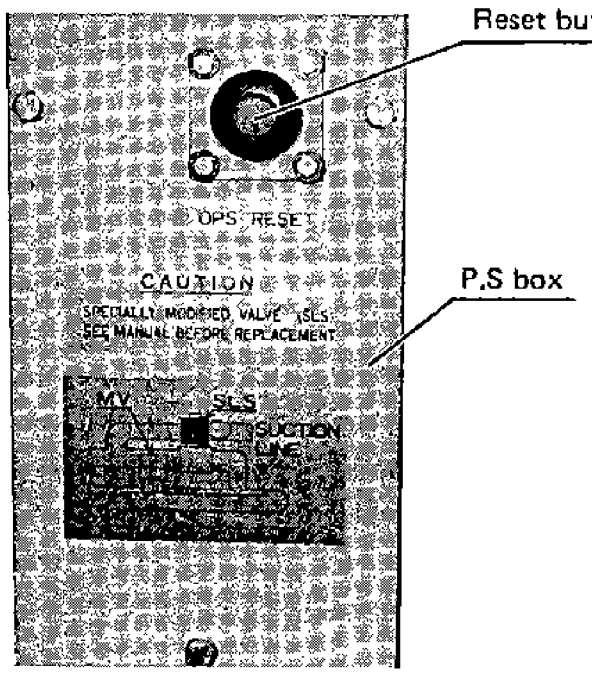
(3) Setting of controller (thumb wheel)



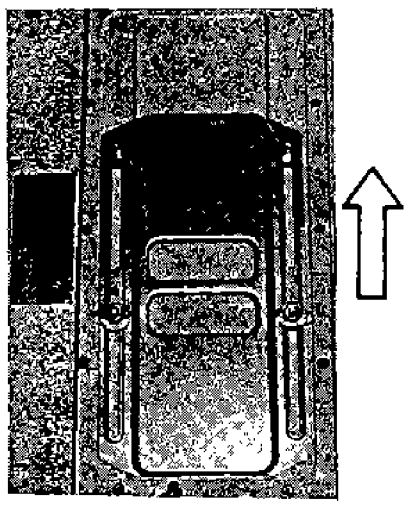
- Open the cover of the control box.
- Rotate the knob of the setpoint selector (thumb wheel switch) on the controller panel and set to the designated temperature.
(Do not confuse ⊞ . . . ned with ⊟ . . . blue.)
Note: Confirm that the controller settings are made as follows.
- PROBE CONTROL . . . "AUTO"
NULL RANGE SETTING . . . "2°C"
(Confirm the position with red point.)

(4) Set the defrost timers <DT1> and <DT2> to the appointed defrost intervals.
Note: Refer to item 4.3.7 on "Defrost timer" and item 3.8 on "Defrost operation".

(5) Reset the oil pressure protection switch.
Reset by pressing the button on the front panel of the PS (Pressure switch) box. The unit does not start unless the switch is reset.



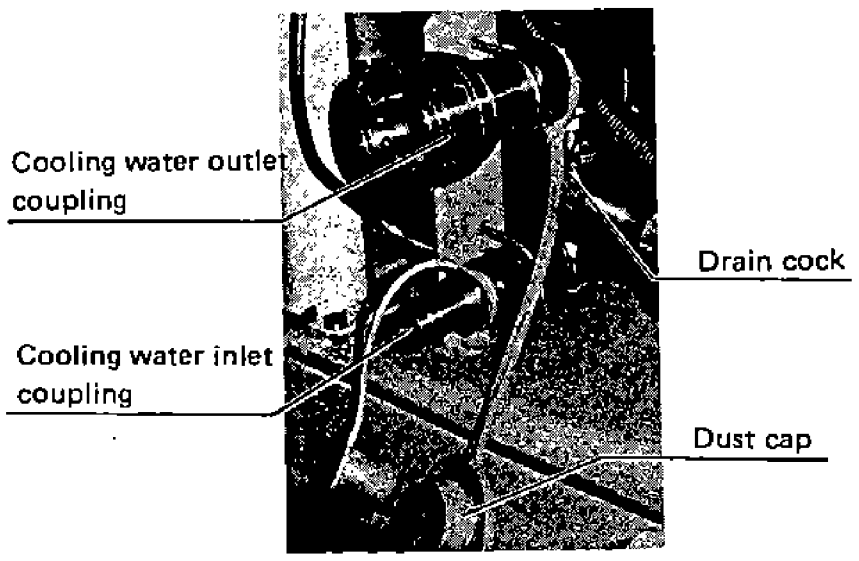
(6) Open or close the ventilator.
Open or close the ventilator according to the cargo.
(Be sure to keep it closed during transportation of frozen cargo.)



Ventilator

(7) Connect the cooling water piping.

- In the case of water-cooled operation, connect the water piping, and supply water through it.



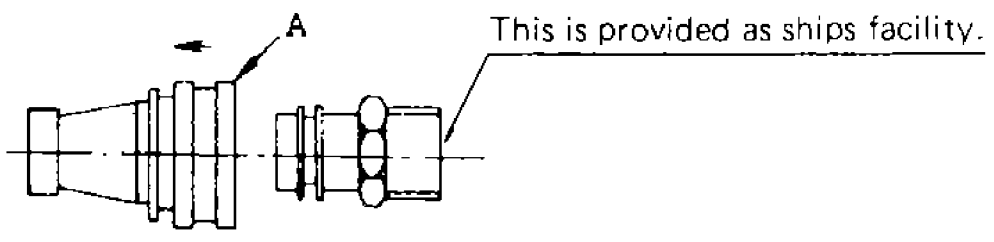
- Connecting method

1. Close the drain cock.
2. Connect the cooling water inlet coupling.
3. Connect the cooling water outlet coupling.
4. Open the drain cock and purge the air.
5. After having completed air purge, close the cock.

- Disconnecting method

1. Disconnect the cooling water outlet coupling.
2. Disconnect the cooling water inlet coupling.
3. Open the cock and drain off.

When the cooling water couplings are connected, insert the coupling on the ship side into the coupling on the unit side until a "click" is heard.
When disconnecting them, pull the coupling on the ship side toward you while pushing the A part of the female coupling in the direction pointed by an arrow mark.



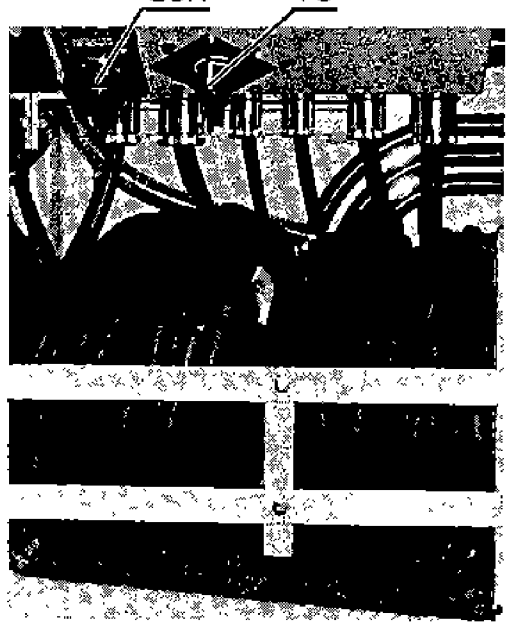
Water connection at outlet side

(8) Check that all refrigerant stop valves are opened.

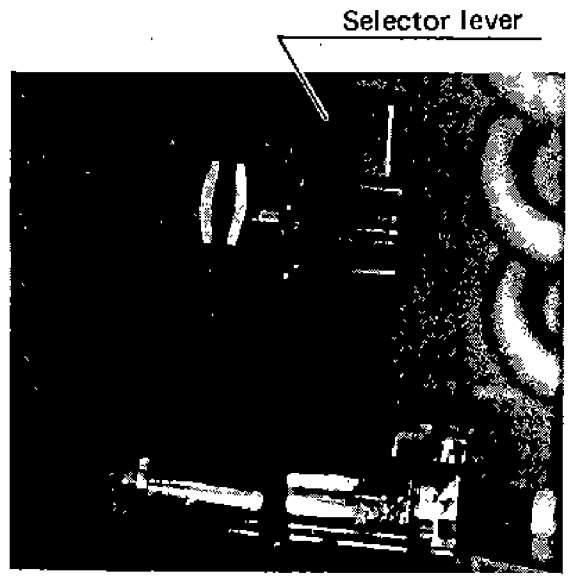
2.2 Operation

(1) Turn off the unit ON-OFF switch <ST> and power selector <PS>.
(2) Insert the plug to the receptacle according to the power source to be used and fasten it securely.

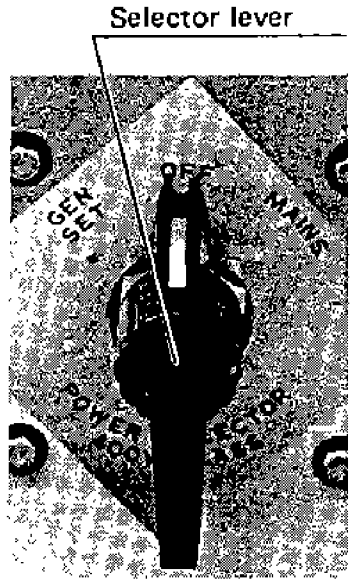
- When using the generator set (400V class), connect the plug of the generator to the receptacle <GSR> of the unit.
- When using the power source (400V class), connect the plug with the 400V class cable (with yellow tube) to suitable receptacle of the facility.
- When using the power source (200V class), connect the plug with the 200V class cable (with white tube) to suitable receptacle of the facility.



(3) Set the voltage selector according to the supply voltage.



Voltage selector <VS>

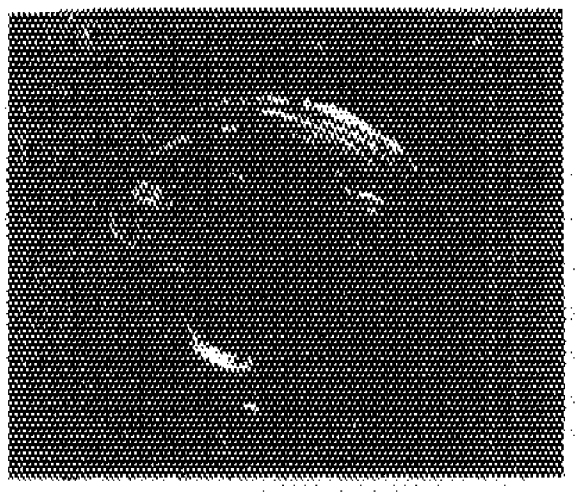
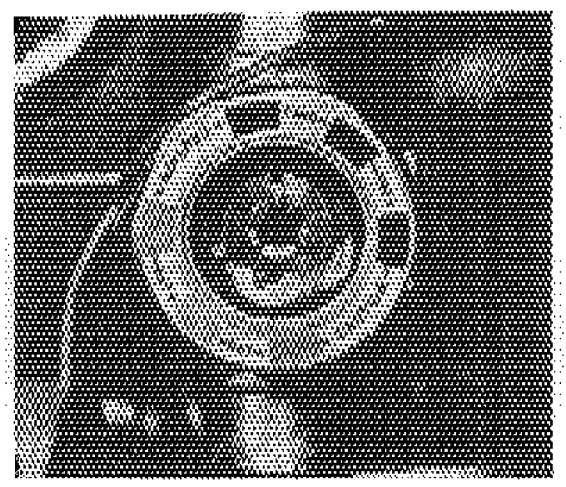


Power selector <PS>

(4) Set the power selector <PS> according to the power source.
(5) Turn on the power switch or start the generator.
(6) Turn on the circuit breakers <CB1> and <CB2> and the unit ON-OFF switch <ST>.
(7) Close the cover of the control box.
If it is loose, water will intrude. Check the tightness the packing and tighten the cover securely.

Note: ● A delay of up to 10 seconds is normal on initial starting of the unit.
● Compressor and condenser fan motors will not start for a minimum time of 6 minutes after compressor is de-energized. To override this time delay (6 minutes), turn off the unit ON-OFF switch <ST> once and turn it on again.
● Light switch <ILS> operates indicator lights.
● Manual defrost switch <MD> will initiate a defrost cycle provided the evaporator temperature is below 1.7°C (35°F).
● If the unit stops 2 ~ 3 minutes after starting, the oil pressure protection switch has been activated in many cases. If this happens, depress the reset button 2 ~ 3 minutes after the unit stops. If it stops again, repeat the same action.

2.3 Checking during operation

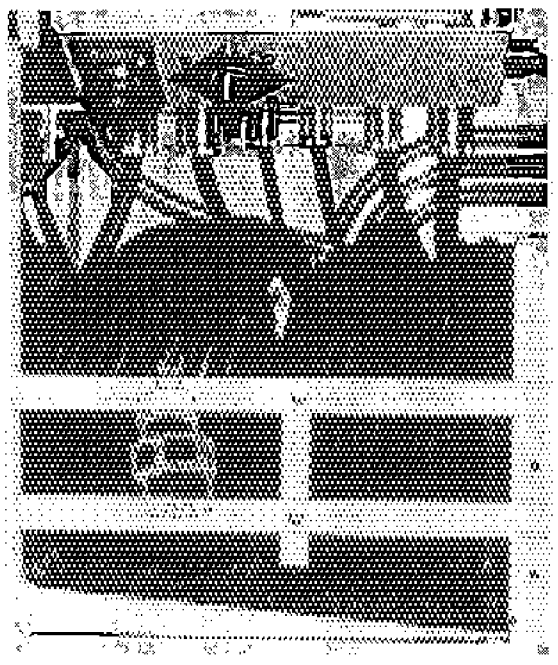
Checking items (precautions)	Method of check
1. Check if unusual noise and vibration is produced from compressor, fan and piping etc.	Visual, sensuous and touching.
2. Check to ensure oil pressure protection switch functions, and the unit does not stop.	
3. Check suction and discharge pressures of the compressor. (For installation of a gauge, refer to "Section 9, page 49".)	Compare observed data with standard ones.
4. Check for proper oil level of compressor. Check to see the oil is clean. (Oil level may fall for a while after starting, but it rises gradually.) 	Visual Oil level should be approx. ¼ to ¾ of its full scale.
5. Check to see if refrigerant is sufficient. (The refrigerant bubbles immediately after starting, but this does not mean that refrigerant is lacking. 	Shortage of refrigerant is indicated by bubbles in the moisture indicator.
6. Check if any moisture is present in refrigerant circuit. (The color of moisture indicator may turn to orange if it has been exposed to gaseous refrigerant for a long time, but this is no indication of trouble.)	Visual The moisture indicator should normally appear deep blue. Orange color is a sign of trouble.
7. Check operating conditions with the pilot lamps and check instrument (Stäfa).	Visual
8. Check if the recorder operates according to the inside temperature.	Visual

2.4 Maintenance after operation

(1) Stopping
To stop the unit, perform defrosting operation with the manual defrost switch and immediately turn off the unit ON-OFF switch <ST> after the compressor has **stopped, (stop the unit with "pump-down" state.)**
After pump down, turn off the circuit breakers.

(2) Set the power selector <PS> to OFF and turns off the power source or stops the generator.

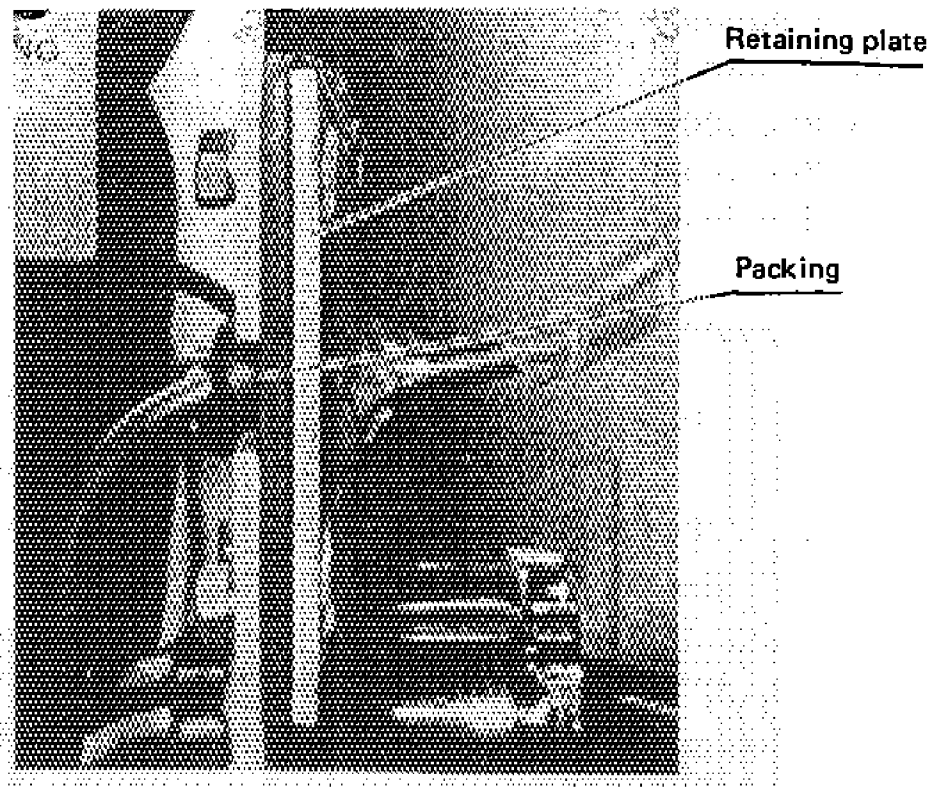
(3) **Stowing the power cable**
Turn the plug's opening downward so that sea and rain water cannot enter the plug when stowing it.



(4) After water-cooled operation
Remove the water piping, open cocks, and drain off.

(5) Close the cover of the control box tightly.

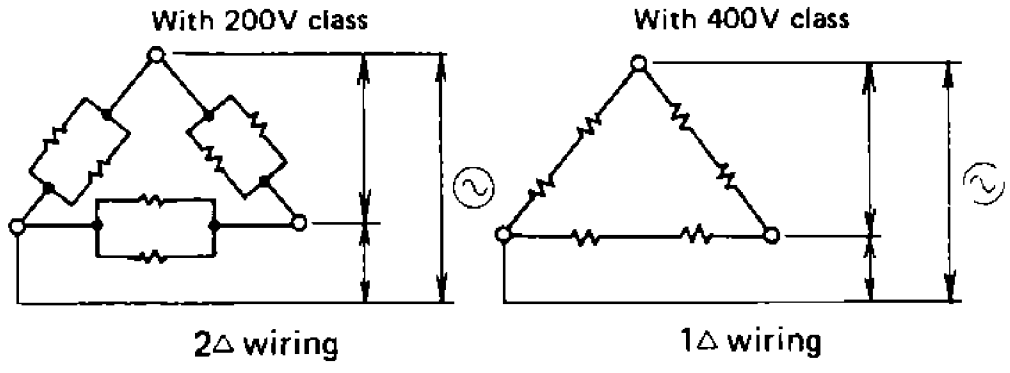
- Note;
  In case of fitting a capillary set plate and a packing be sure not to stand out them from the edge of a control box.



3. Operating modes and circuits

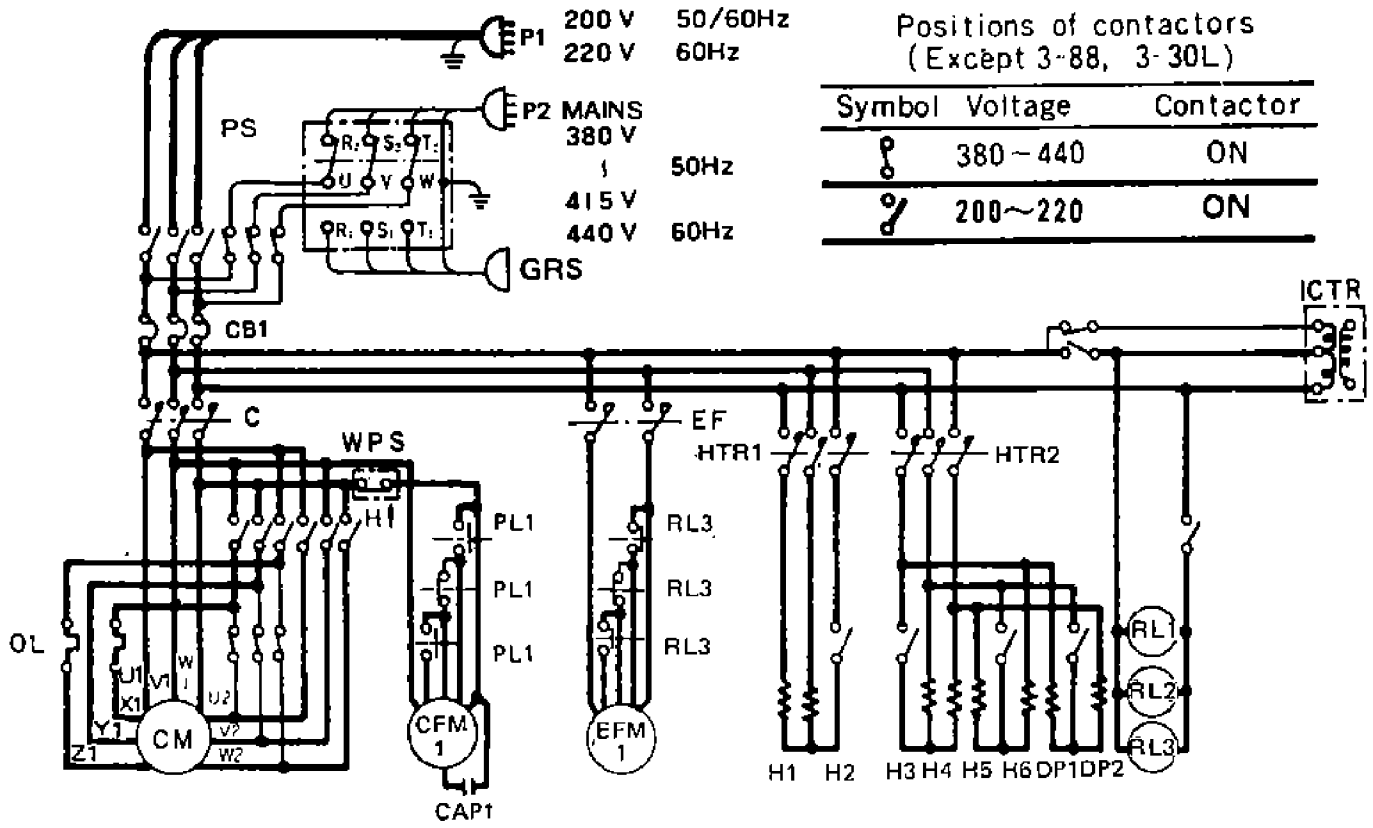
3.1 Voltage selection system (switching over 200V and 400V class)

(1) This unit is adaptable to either of two supply voltages (dual rated voltage). Set the voltage selector (multi-contact cam switch) according to the supply voltage by hand. The voltage selector changes wiring of the motors, electric heaters, and the transformer of the control circuits to supply the relevant voltage.
For example, the internal wiring of the compressor is changed as follows.



(2) Circuitry

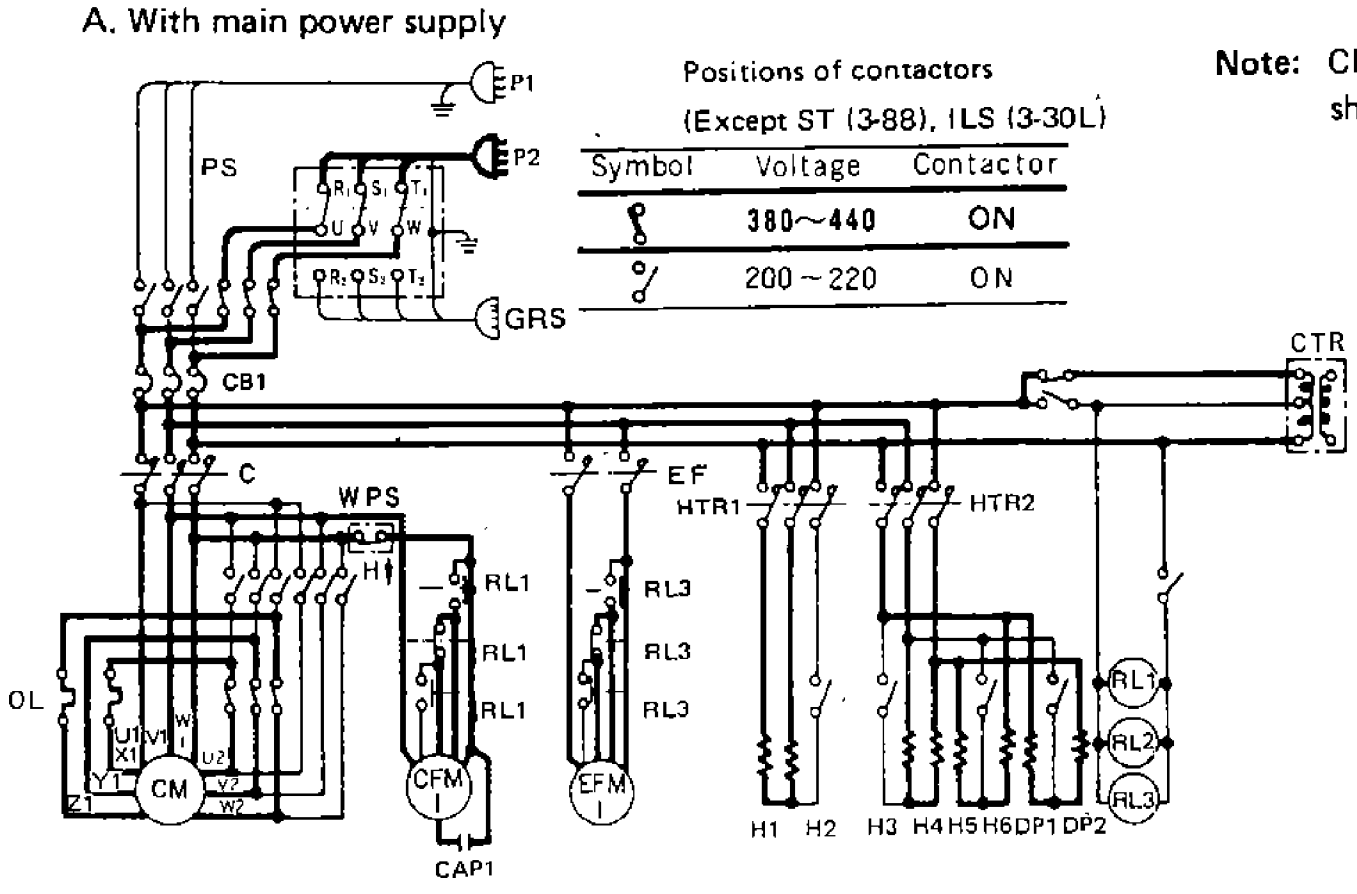
- With 200V class (Set the selector lever to "200V CLASS".)
  The contacts marked " ⚲ " in the sequence chart (except ST, and ILS) are turned on.
  The circuits for 200V class will be set up with the contacts and the voltage selector relay (RL1, 2, 3) are energized.



Note: CFM3, 4 and EFM2 are not shown.

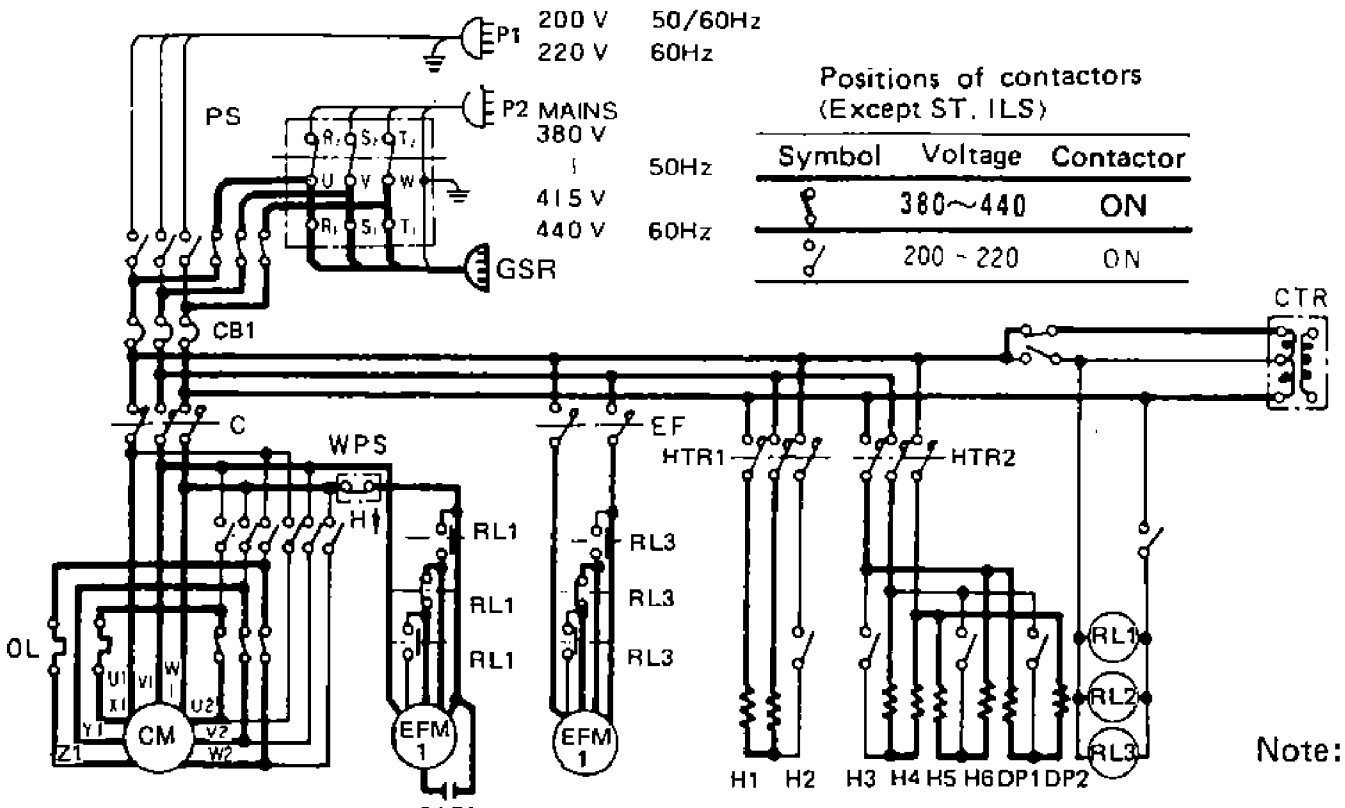
- With 400V class (Set the selector lever to "400V CLASS".)
  The contacts marked " ⚲ " in the sequence diagram are turned on and the circuits for 400V class will be set up (RL1, 2, 3 are off).

  A. With main power supply



Note: CFM3, 4 and EFM2, are not shown.

B. With GEN. SET power supply



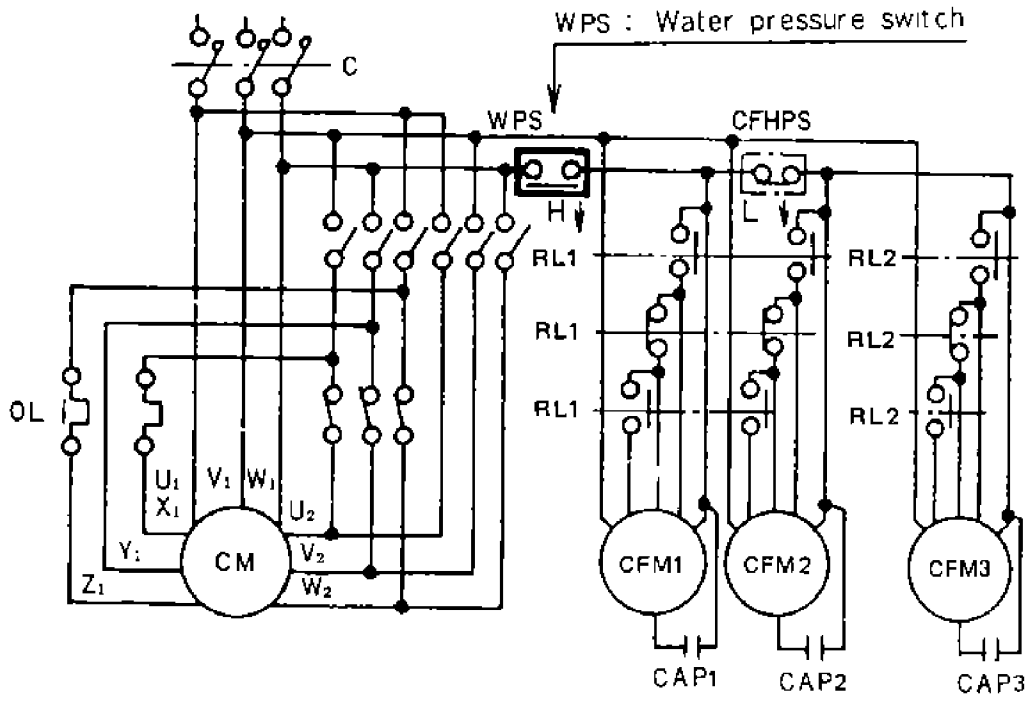
Positions of contactors (Except ST. ILS)

Symbol	Voltage	Contactor
	380~440	ON
	200 ~ 220	ON

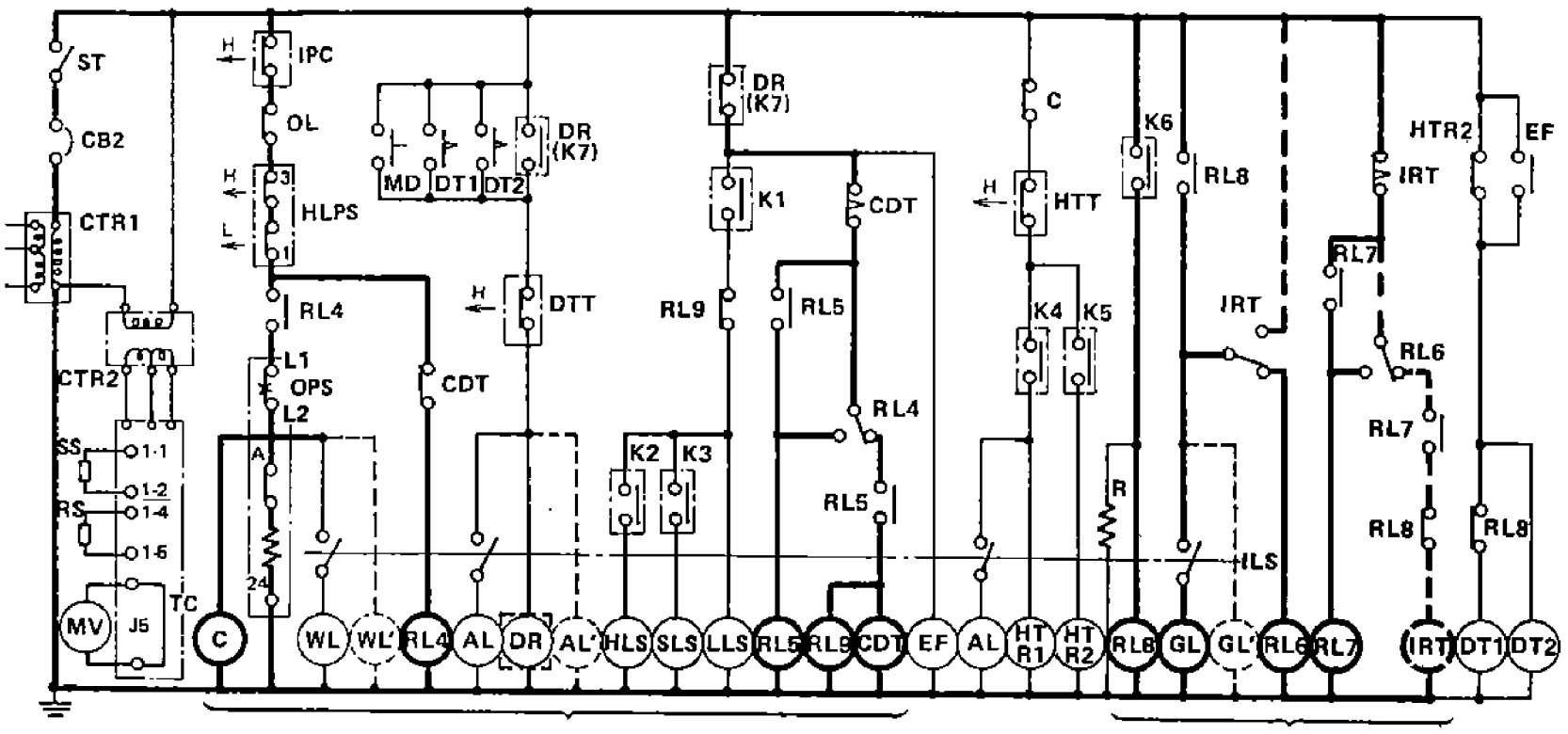
Note: CFM2, 3 and EFM2 are not shown.

3.2 Air cooled and water cooled operation

The unit will operate on either air cooled or water cooled condenser operation.
During transit on land, in depot or on a vessegs deck, the air cooled operation will function, and the operation in ship holds is normally water cooled.
The operation will be changed from air cooled to water cooled automatically by the water pressure switch; i.e. when water pressure at the inlet of the water cooled condenser rises higher than the presetting value, the contact points of the water pressure switch are opened, so the condenser fan motors stop, and the water cooled operation starts.
When the water supply is disconnected. The contacts of the water pressure switch are made and the condenser fan motors rotate.



This diagram indicates air-cooled operation mode. When water pressure is applied to the switch, the switch mechanism moves in the direction of H ↓, so the condenser fan motors <CFM1~ 3> stop, and water-cooled operation starts.



Forced stopping of compressor circuit

In range masking circuit

3.3 Forced stopping of compressor operation (<CDT>, a 6 minute timer)

(1) A compressor delay timer (<CDT>: 6 minutes on 50 Hz. per setting) is provided to protect the compressor from frequent starting and stopping caused by reduction of the low pressure and the turning ON and OFF of the controller thermostat. When the low pressure switch in the dual pressure switch <HLPS> is actuated due to "pump down" or a reduction of the low pressure etc. and the compressor is stopped, the compressor is kept stopped forcibly for 6 minutes even when the restart command by the controller is given or the low pressure switch is reset.

(2) With the low pressure switch opened, the <CDT> starts counting. The forced compressor stopping circuit is actuated during the counting, and the compressor starts again after the 6 minutes has elapsed. Forced compressor stopping is also actuated when any of the safety devices <IPC>, <OL> or <HLPS> other than the low pressure switch is actuated.

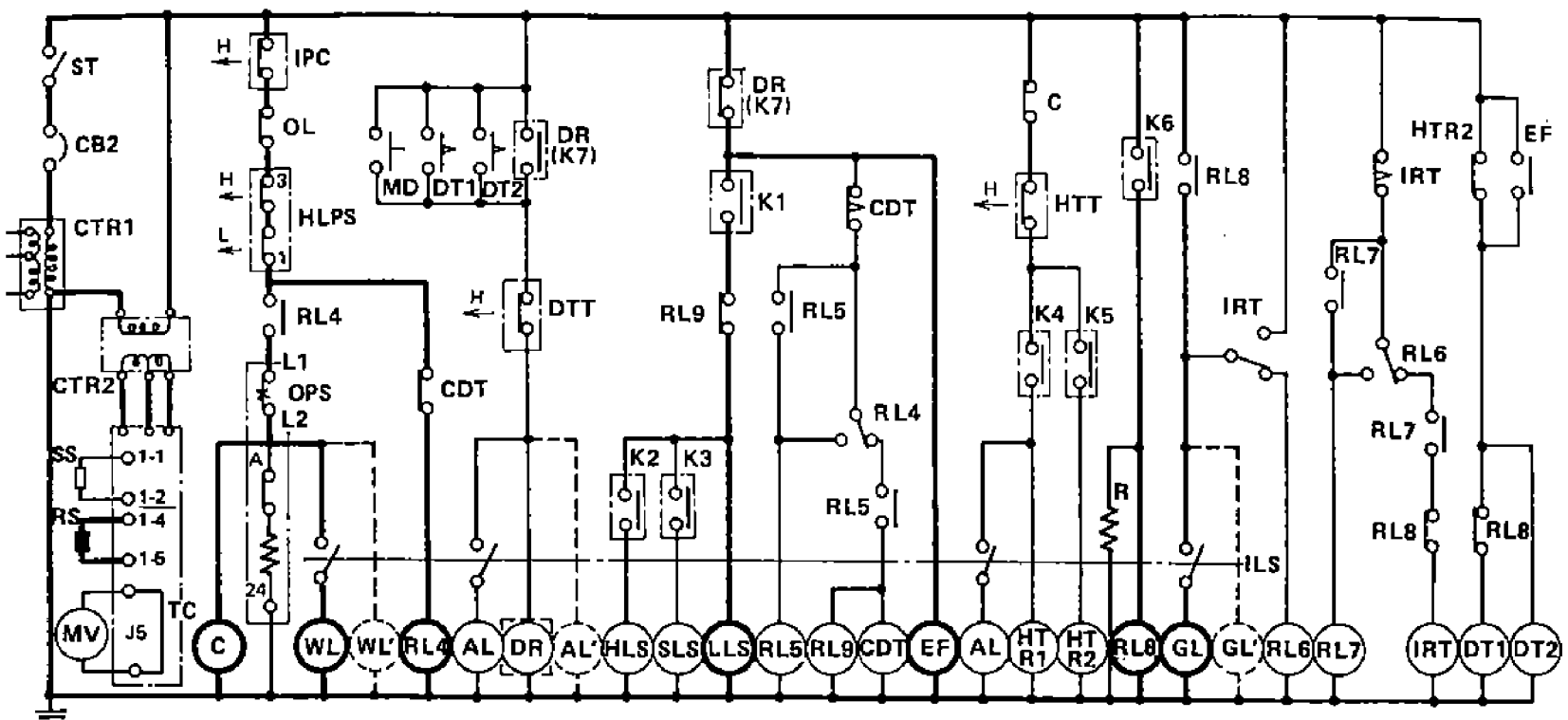
(3) When re-starting the compressor instantly, turn off the unit ON-OFF switch <ST> once, and turn it on again.

3.4 In range masking circuit (forced indication of in range for setting temperature)

(1) When the inside temperature deviates from the proper temperature (when starting or stopping the compressor and during defrosting, etc.), the in range lamp is forced to illuminate by the in range timer for the 90 minutes after the inside temperature has been deviated from in range for the setting temperature.

(2) Upon deviation of the temperature from in range setting, the RL6 relay is de-energized and the <IRT> starts counting. The in range lamp is illuminated on this timer during the counting (90 minutes) (this circuit is shown as thick broken lines ——— on the wiring diagram).

3.5 Frozen operation

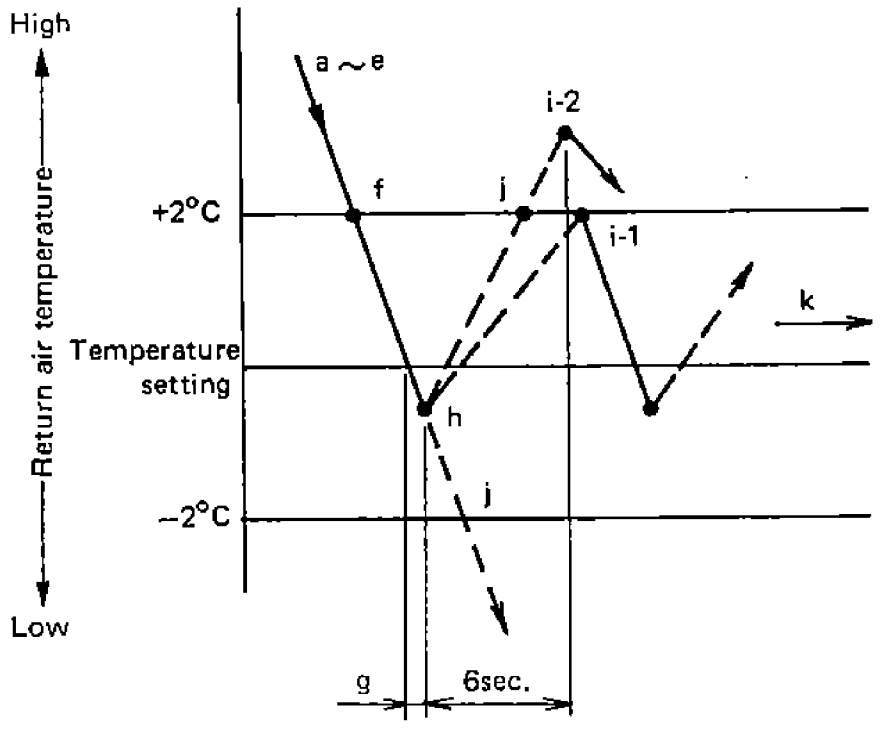


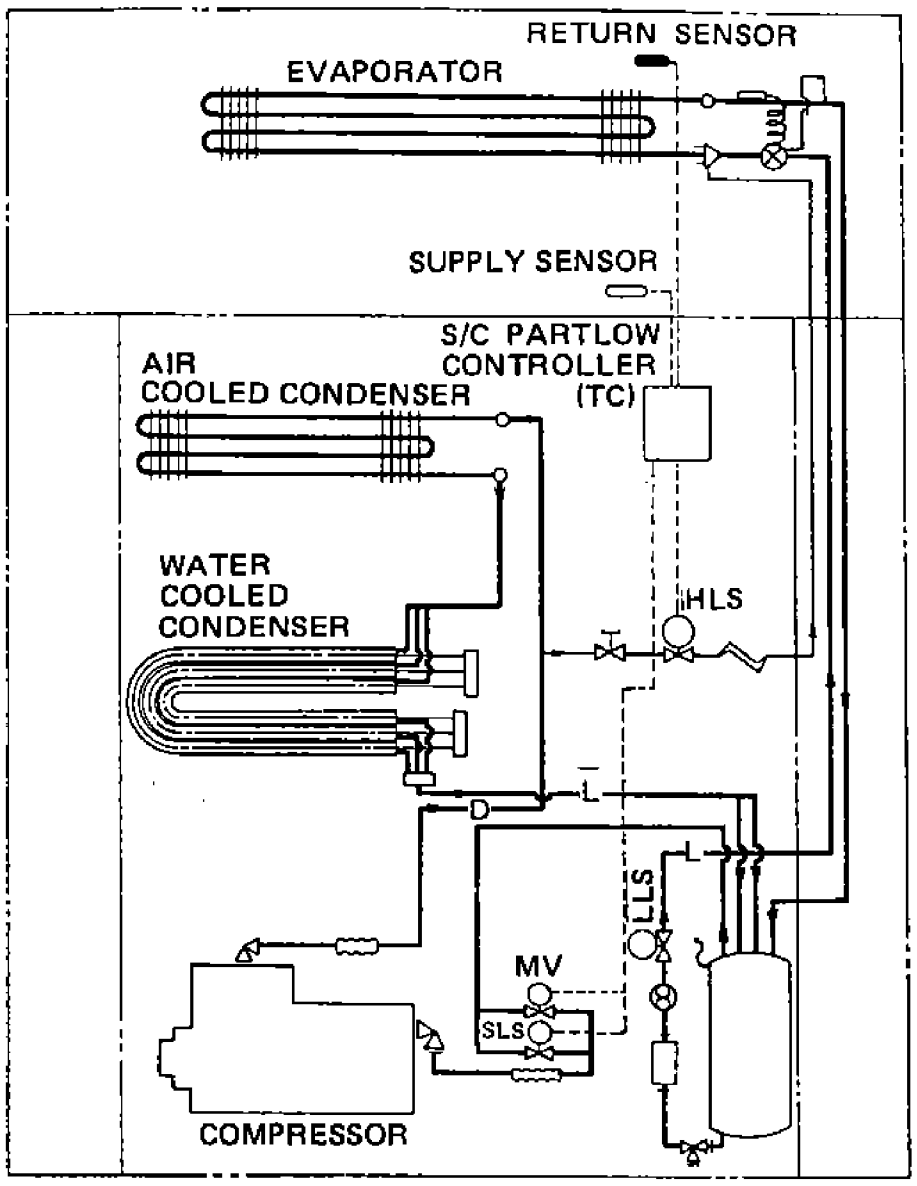
(1) Switching over frozen and chilled modes.
One of the modes will be automatically selected according to the setting of the setpoint selector.

- When the setting is above −7°C: chilled mode
- When the setting is below −7°C: frozen mode

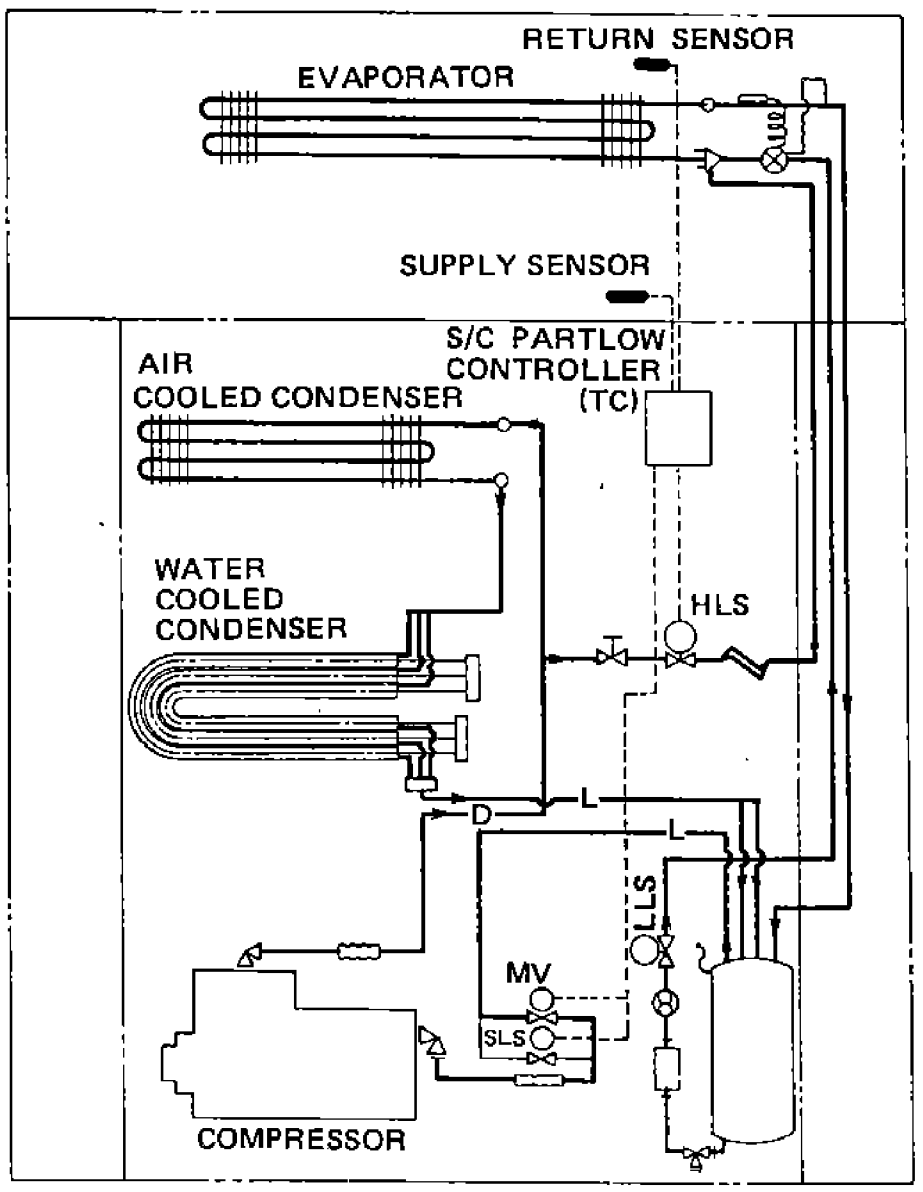
(2) During frozen mode, the compressor will be automatically turned on and off, sensing return air temperature to the evaporator.

a. Turn on <ST> (unit ON-OFF switch).
b. With <EF> (evaporator fan relay) energized, <EMF1> and <EFM2> (evaporator fan motors) start.
c. Liquid line solenoid valve <LLS> is open by K1 relays (for compressor) of <TC> (controller).
d. When <LLS> is open, refrigerant flows and low pressure rises. As it reaches 0.2 kg/cm^2, LP of <HLPS> (dual pressure switch) are turned on.
e. With LP on <RL4>, <C> (compressor relay) gets energized. <MC> (compressor) and <CFM1, 2> and <CMF3> (air-cooled condenser fan motors) will start and <WL> (white lamp) will light up. —— The unit enters in the normal operation and container inside temperature begins to fall. (Hereafter, the NULL RANGE SETTING of the controller is described as 2°C.)
f. When return air temperature to the evaporator falls to 2°C above the preset temperature, (preset temperature plus 2°C), K6 relay (high limit alarm) of <TC> is turned on and <GL> (green lamp) lights up by RL8 (indicating that inside temperature is with in range).
g. When the temperature falls further and drops below the preset temperature, the timer (to delay K1 relay actuation) in the <TC> starts counting, the K1 relay is de-energized after about 50 ~ 75 seconds, the <LLS> is closed, and "pump down" is started.
h. When the low pressure falls down to −40 cmHgV, LP of <HLPS> is turned off; <C> becomes unenergized; <CM>, <CFM1, 2> and <CFM3> etc. stop; and frozen operation stops.
i. When the inside temperature rises and reaches +2°C above the preset temperature, the K1 relay is energized. Then refrigerating starts again, as follows, after the compressor is stopped. (Refer to the item h.).
   i-1. If the K1 relay is energized after 6 minutes from the compressor stops, refrigerating starts again immediately in the order c → d → e, as described previously.
   i-2. If the K1 relay is energized before 6 minutes has elapsed, the refrigerating operation starts again after the <CDT> has completed the counting of 6 minutes. (Refer to item 3.3 for <CDT> operation.)
j. If the inside temperature deviates from in range temperature during the control (±2°C above the preset temperature), the K6 relay is de-energized, but the in range masking timer force the in range lamp to illuminate for 90 minutes. (Refer to item 3.4 for details.)
k. Hereafter, the compressor repeats turning on and off by K1 relay actuation.



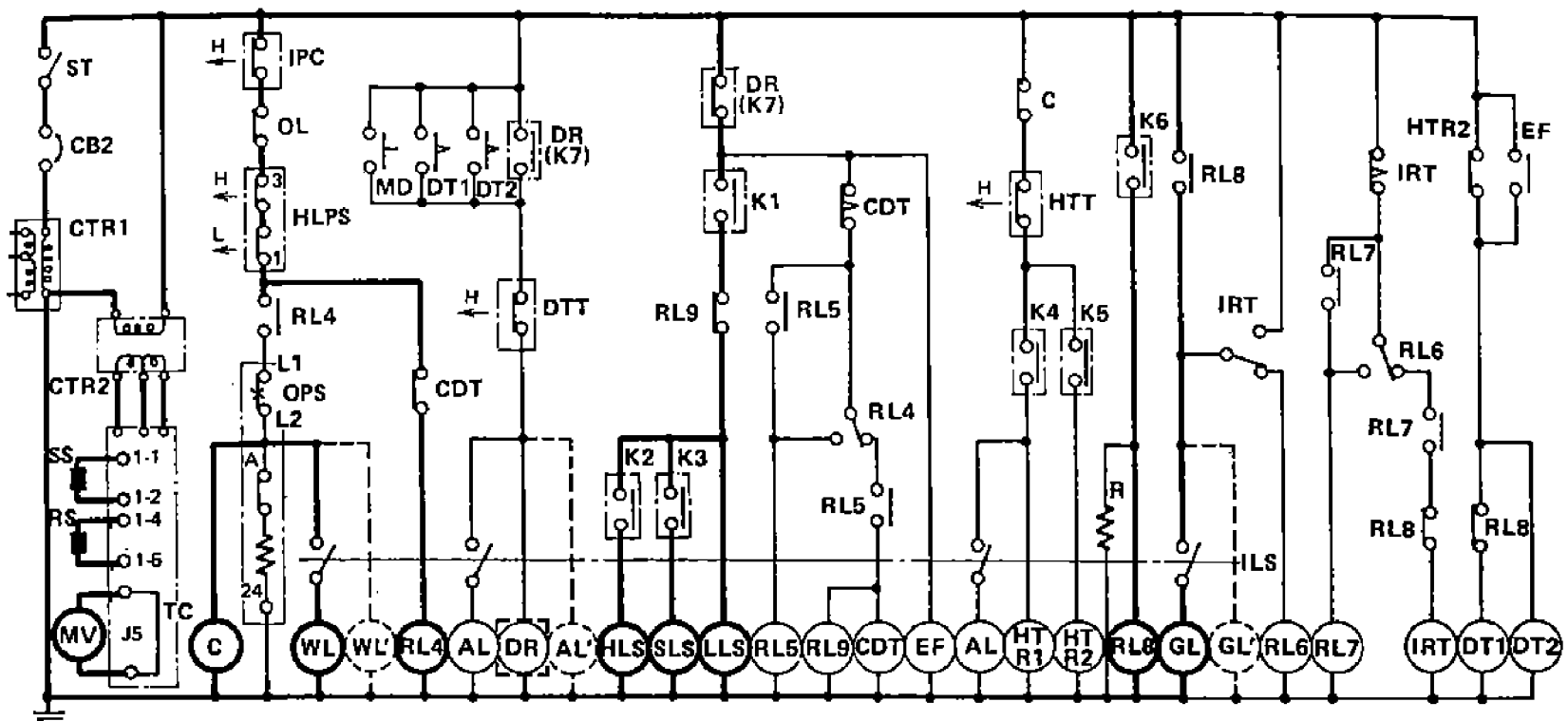


Flow of refrigerant during frozen operation



Flow of refrigerant during chilled operation

3.6 Chilled operation — capacity control



(1) When the preset temperature is above −7°C, chilled operation starts. When the "PROBE CONTROL" switch of the controller is set to AUTO during chilled operation (hereafter described as "AUTO" set), the inside temperature is controlled by the lower temperature of either the supply air or return air of the evaporator.

(2) Refrigeration capacity is reduced by the modulating valve <MV> which controls the amount of suction gas continuously and hot gas bypass.

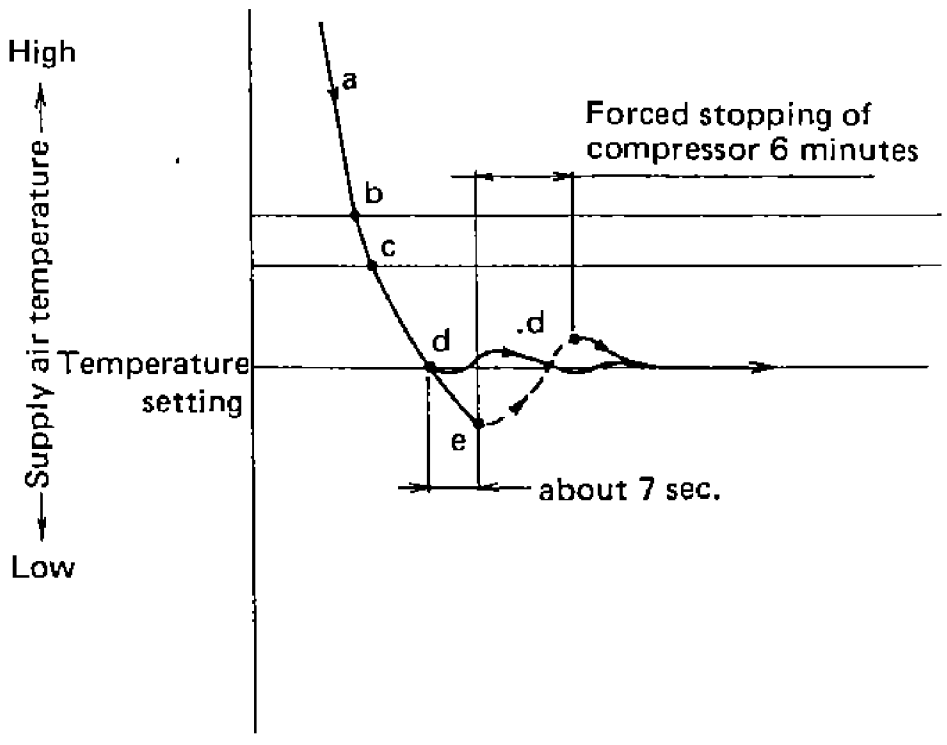
a. The pull down operation is the same as that (steps a ~ e) in the frozen mode.

b. Partial cooling (1): When the control temperature reaches the preset temperature +2.5°C, the K2 relay of the controller is energized to open the hot gas solenoid valve <HLS>, allowing the hot gas to flow.

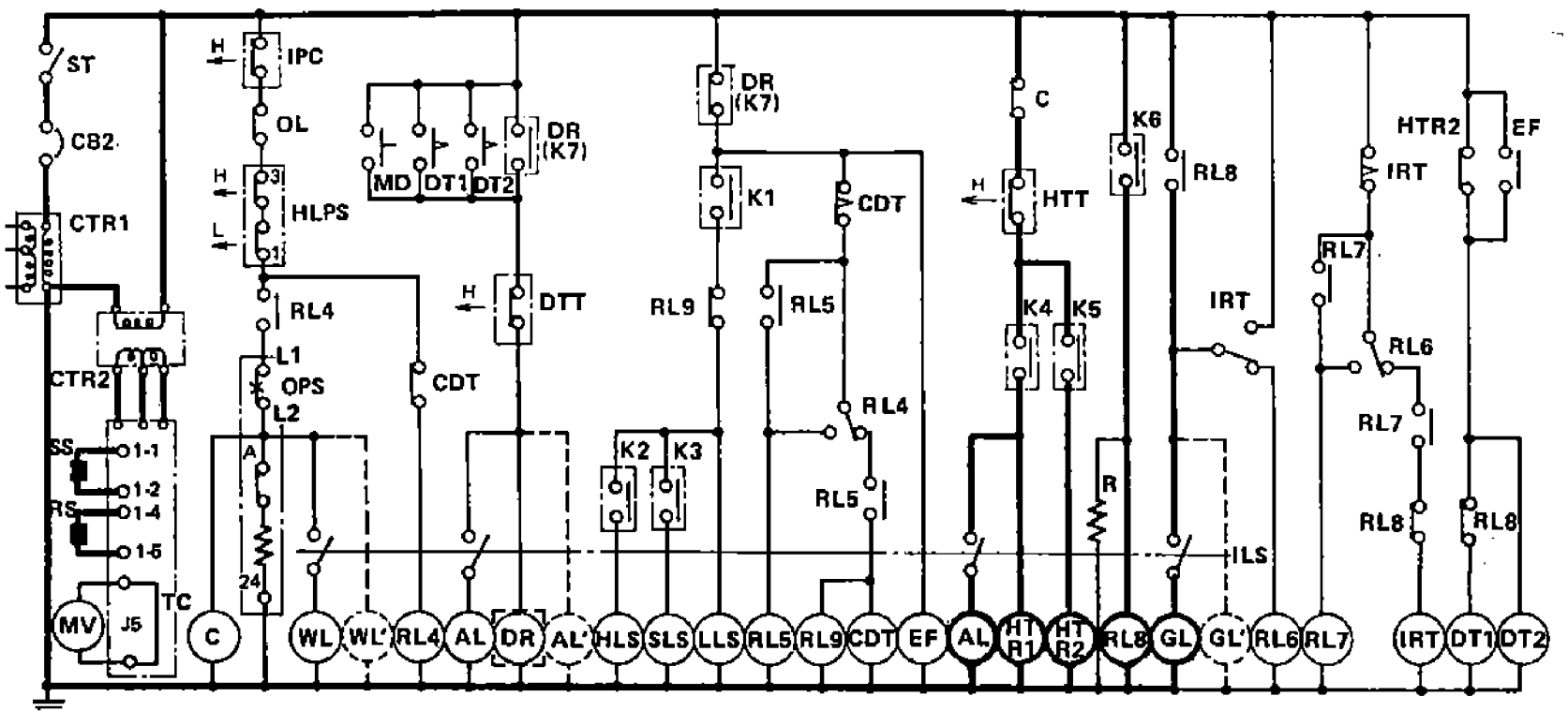
c. Partial cooling (2): When the temperature falls further, to reach the preset temperature +2°C, the K3 relay of the controller is energized to close the suction solenoid valve <SLS>, allowing the suction gas into the compressor through the <MV> only. (<SLS> is closed when it is energized.)

d. Modulation: The output voltage to modulating valve increases as the control temperature nears the preset temperature from b and c above and <MV> starts to close gradually from the fully opened condition, controlling the suction gas until the control temperature is regained for stable operation. The (<MV> is usually in the fully open position and closes when a voltage is applied.)

e. Depending on the operating conditions (such as when the difference between the ambient and preset temperatures is small etc.), the K1 relay of the controller is de-energized after a delay of about 70 seconds (50 ~ 75 seconds) and the compressor stops after "pump down" if the control air temperature drops below the preset temperature before the suction gas control (<MV> actuation) is stabilized.
(If the temperature rises above the preset temperature within 70 seconds, the operation is continued.) The operation starts again after having been stopped for 6 minutes.



3.7 Heating operation



(1) Heating operation will be performed only when the preset temperature is −7°C or higher, as chilled operation. The inside temperature is controlled by the lower temperature of either the supply air or return air.

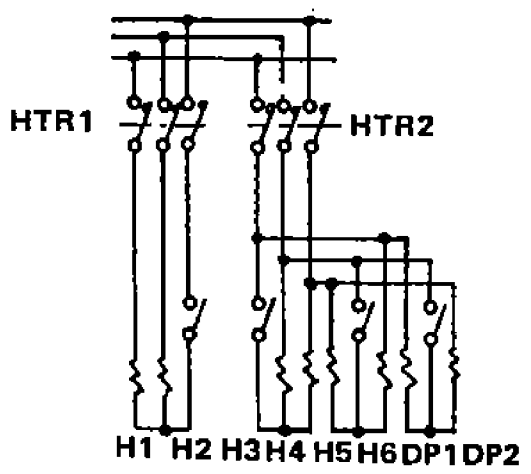
(2) There are two heating modes .

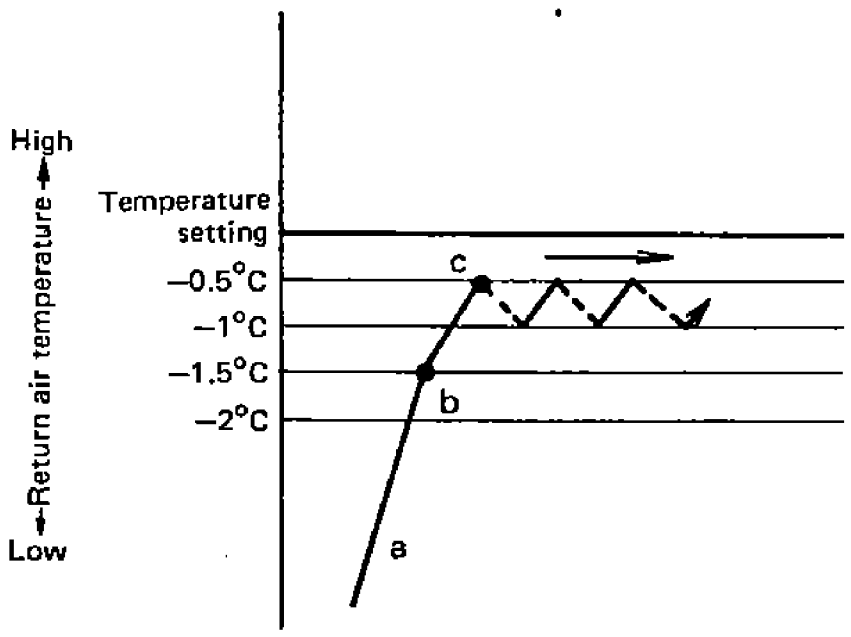
Pull up (High heating)	:	When the control temperature is below −2°C lower than the preset temperature.
Steady state : (Low heating)		When the control temperature is above −1.5°C lower than the preset temperature.

a. High heating: the K4 and K5 relays of the controller are energized, the heater contactors <HTR1 and HTR2> are energized, all the 6 heaters <H1 ~ 6> and drain pan heaters <DP1 and DP2> are charged, and the pull up operation starts.

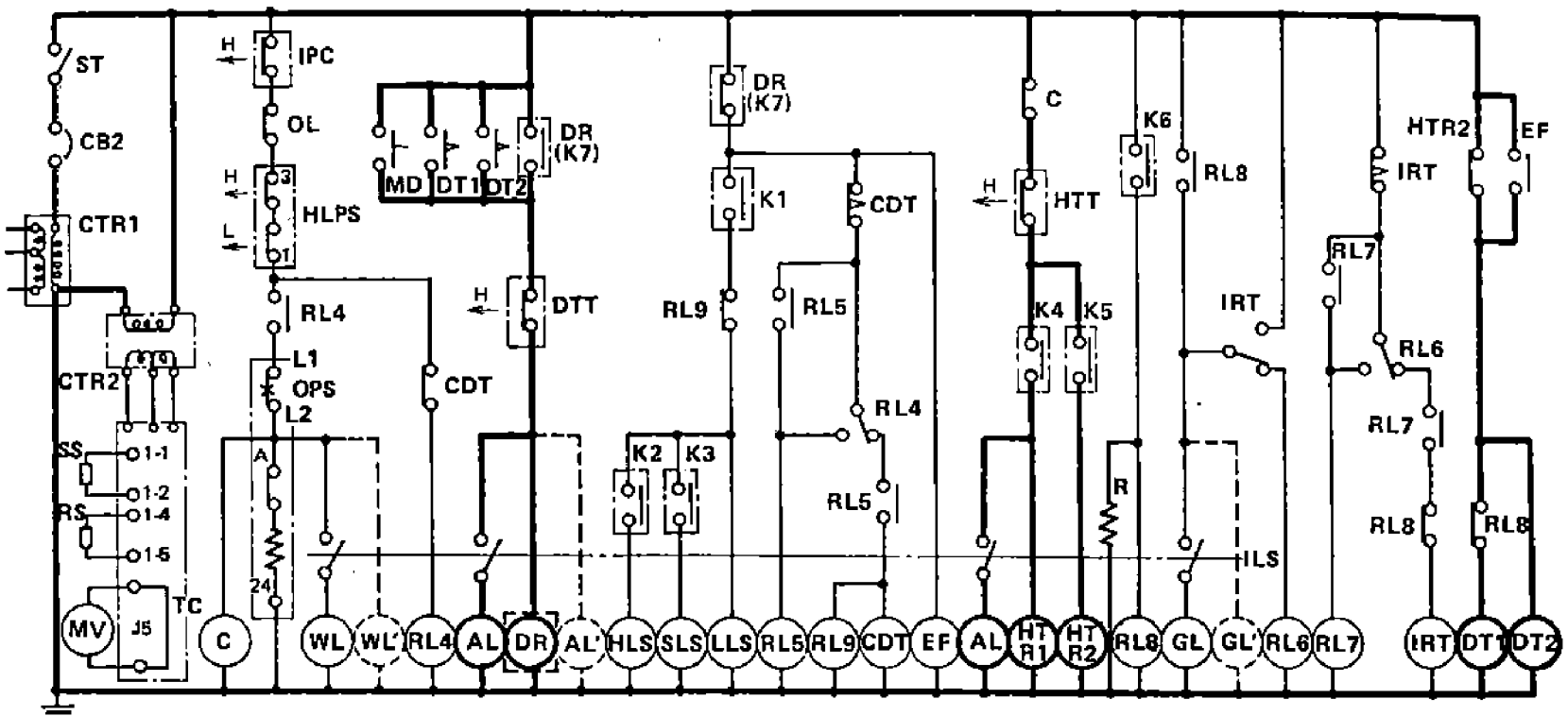
b. Low heating: When the temperature rises to −1.5°C against the preset temperature the K5 relay is de-energized, which actuates the <HTR1> only, and steady state operation starts. At the preset temperature minus −2°C, the K6 relay is energized to illuminate the in range lamp.

c. When the temperature rises above the preset temperature minus −0.5°C, the K4 relay is de-energized also, which stops the heating, generating a NULL condition. Starting and stopping the heating operation is performed by turning on and off the K4 relay.





3.8 Defrost operation



(1) Defrosting operation starts based on the following two conditions.
- Timers <DT1, DT2> are turned on.———Refer to the note.
- The manual defrost switch <MD> is turned on.

If one of those stated above is on, the defrost relay <DR (K7)> is energized and defrosting by electric heater is performed.

(2) When either <DT1>, <DT2> or <MD> is turned on, <DR> is energized, completing the defrost circuit the K1 relay is de-energized to close the <LLS> and <HLS> and the compressor stops after "pump down".

(3) At the same time theK4 and K5 relays are energized energizing <HRT1 and HRT2> the heaters <H1 ~ 6> and <DP1 and DP2> are charged, and defrosting operation starts.

(4) When the evaporator coil temperature rises to 7.2°C after the frost has been removed the defrost termination thermostat <DTT> is turned off to terminate the defrosting operation.

Note: Defrost timers <DT1 and DT2> are factory set to 6 hours (50 Hz.) to operate as follows.

DT1: To count the operating hours at out of in range.

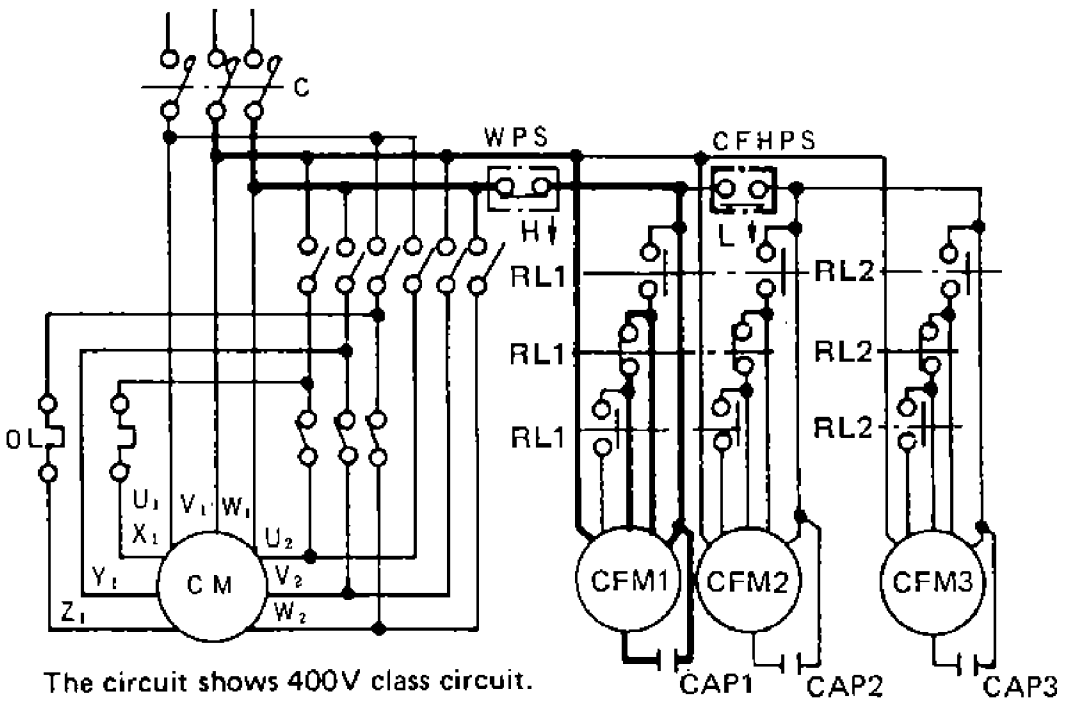
DT2: To count the operating hours within in range.

When there is a lot of humidity or water percent during the initial loading of cargo, following timer settings are recommended for defrosting.

- DT1: 2 ~ 4h ➡ For out of in range such as during the pull-down operation, perform defrosting in short cycle to remove any defrost generated by the initial humidity or water.
- DT2: 6 ~12h ➡ When the temperature is within in range perform defrost in long cycle.

3.9 High pressure control

(1) The condensing pressure (high pressure) falls when the ambient temperature falls during air-cooled operation, and the lower pressure also falls accordingly. If operation is still continued in this condition, the low pressure switch will be turned off (LP of <HLPS> is turned off) and the compressor will stop so that the required refrigeration capacity is not available. To prevent the high pressure from falling, a pressure switch <CFHPS> (which controls the high pressure) stops two condenser fans <CFM2, 3> automatically when the high pressure falls to 7 kg/cm^2 (99.6 psi).



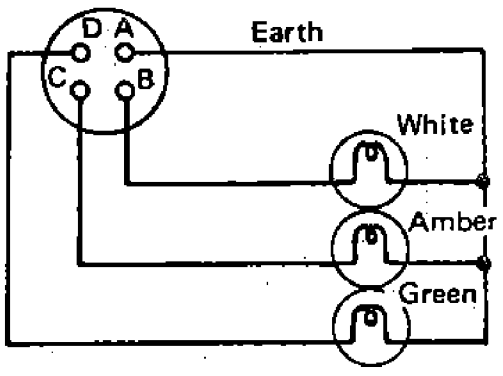
The circuit shows 400V class circuit.

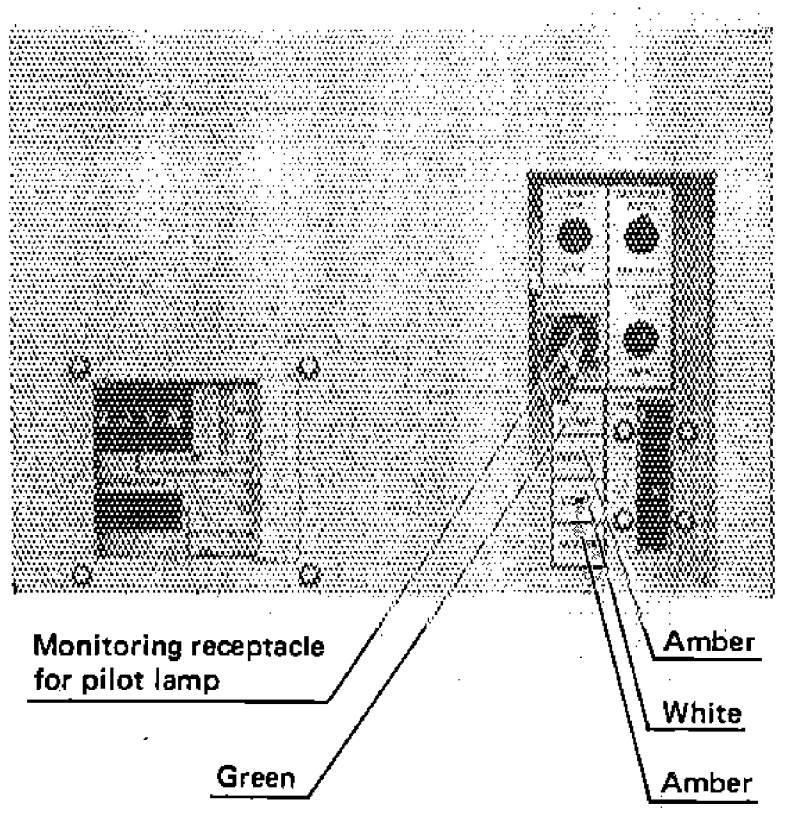
3.10 Pilot lamps and monitoring circuit

(1) Three lamps which indicate operating mode are mounted on the front panel of the control box.

Amber : indicates defrosting mode
White : indicates that the compressor is running
Green : indicates that inside temperature is with in range (within +/−2°C of the preset temperature)

Receptacles for monitoring pilot lamp is also equipped and its connections is shown at below.





(2) How to judge operation state by pilot lamps and function of the components.

Part name		Setpoint selector set above −7°C -Air cooled operation					Defrost	Setpoint selector set below −7°C -Air cooled operation		Water cooled operation
		Cooling			Heating			Cooling		
		Pull down	Partial cool	Modulation (In range)	High heating (Pull up)	Low heating (In range)		Pull down	In range	
Light	Defrost-Amber	×	×	×	×	×	○	×	×	Water cooled condition is the same as air cooled except, ● Water press. switch <WPS> open. ● Condenser fan motor <CFM> de-energized.
	Comp.-White	○	○	○	×	×	×	○	○	
	In range-Green	×	×	○	×	○	○	×	○	
	Heating-Amber	×	×	×	○	○	○	×	×	
Magnetic Switch	Comp. cond. fan motor <C>	○	○	○	×	×	×	○	○	
	Evaporator fan motor <EF>	○	○	○	○	○	×	○	○	
	Heater <HTR1>	×	×	×	○	○	○	×	×	
	Heater <HTR2>	×	×	×	○	×	○	×	×	
Solenoid valve <LLS>		○	○	○	×	×	×	○	○	
Solenoid valve <HLS>		×	○	○	×	×	×	×	×	
Solenoid valve <SLS>		×	×	○	×	×	×	×	×	
Defrost timer	<DT1>	○	○	×	○	×	×	○	×	
	<DT2>	○	○	○	○	○	×	○	○	
Modulating valve <MV>		×	×	○	×	×	×	×	×	
Compressor		○	○	○	×	×	×	○	○	

Note) 1. "○" Mark represent the lighting of lamps or the actuation or energization of devices, "X" Mark represent the estinguishing of lamps or the stopping of devices.
2. The in range lamp is lighted forcibly for 90 minutes, even when the temperature deviates from in range temperature by defrosting.

4. Major components and maintenance

4.1 Components related with refrigeration circuit

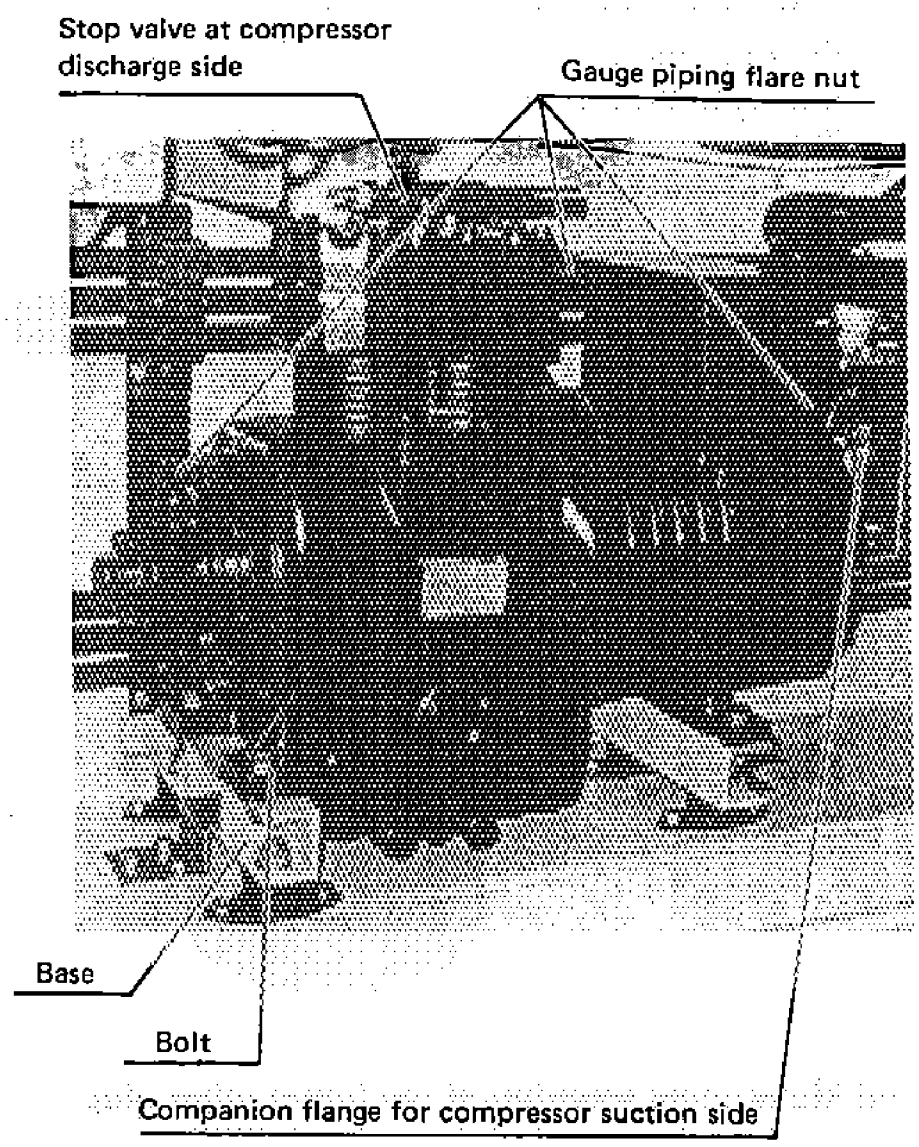
4.1.1 Compressor

The compressor is of a semi-hermetic type with built-in motor so that there are few places where leakage of refrigerant may occur. The reversible lubricating ail pump used produces the required oil pressure regardless of the direction of rotation of the built-in motor.

(a) Replacement

Remove the compressor by the following procedure.

1 Remove the front and base plates and protective bar of the cable stowage.
2 Remove the discharge stop valve, suction stop valve gauge piping flare nut (compressor side) and cable.
3 Remove four bolts (two on each side) fastening the compressor and base.
4 Take out the compressor to the front of the unit.



(b) Installing procedure

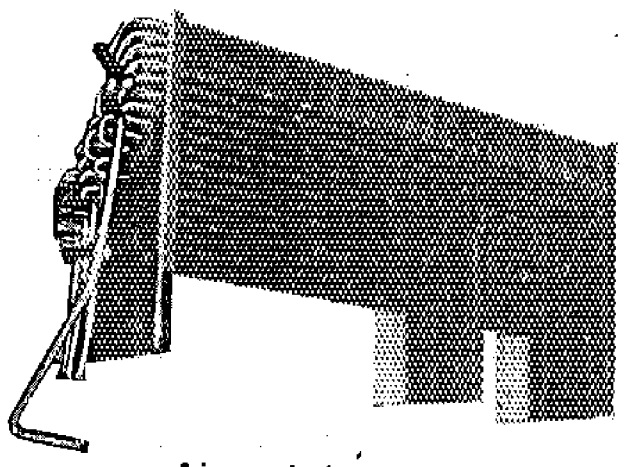
Install the compressor according to reverse procedure given above. When tightening the bolts, refer to the torque values listed.

4.1.2 Air-cooled condenser and evaporator

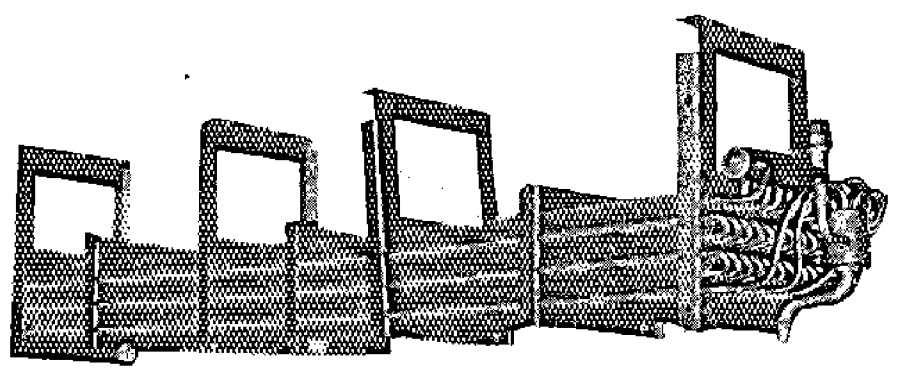
The "cross fin" coil has special corrugated fins. They are compact and very efficient in producing uniform heat exchange efficiency.

(a) Maintenance

Service the air-cooled condenser after removing the air suction grille. Service the evaporator after removing the air return grille or the access panels from outside.



Air cooled condenser



Evaporator

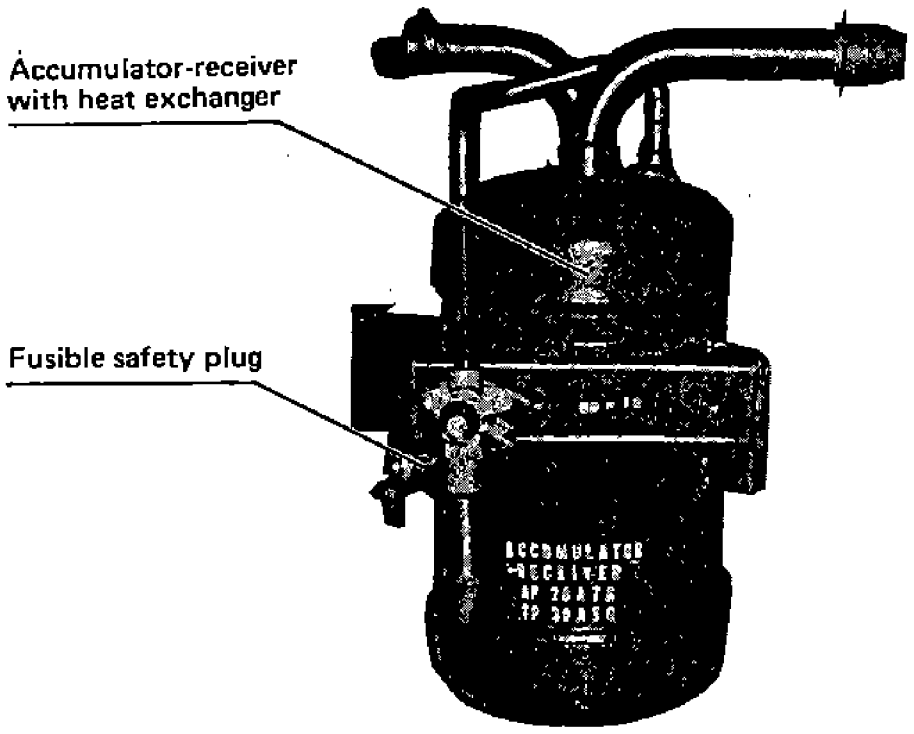
4.1.3 Water-cooled condenser

Of the tube-in-tube type in which cooling water flows in the inner tube while the refrigerant flows between the outside wall and the wall of the inner tube. Since special fins are fitted, the condenser is compact and light.

4.1.4 Accumulator-receiver with heat exchanger

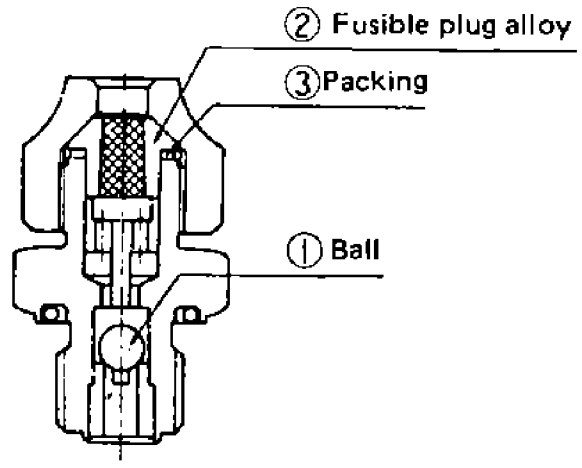
Consists of the accumulator, receiver, and heat exchanger, which are encased in a vertical cylindrical construction; i.e. the heat exchanger passes through the accumulator from its top to the bottom and reaches to the receiver.

This construction reduces heat loss. A fusible safety plug is fitted to the receiver body.



(a) Replacement procedure of the fusible safety plug

When pressure rises abnormally in the system, the fusible safety plug melts itself, so if the fusible safety plug is melted, check possible causes thoroughly. When fusible safety plug functions, the centre of the fusible safey plug alloy ② melts, from which the refrigerant escapes. When the flare nut is removed, ① (ball) will come out under pressure and block the passage of the refrigerant outlet, which prevents the refrigerant from escaping and also the air from entering. Thus, refrigerant loss is extremely minimized.

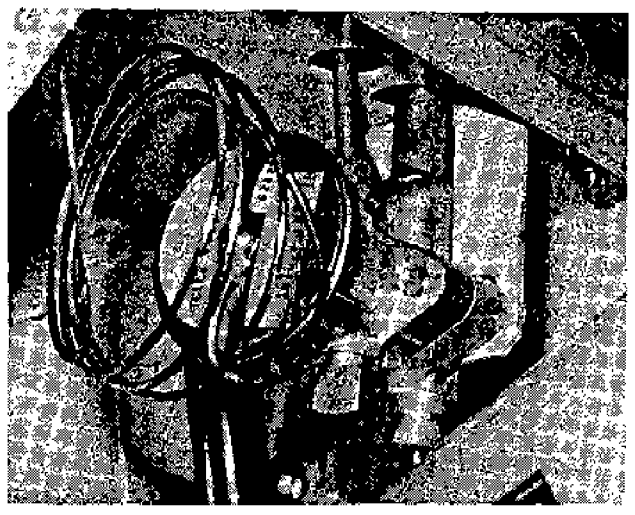


Construction of fusible safety plug

Insert a new ② with ③, and tighten the flare nut.

4.1.5 Expansion valve

The externally equalized expansion valve which is fitted before the evaporator and senses over-heat degree of leaving evaporator refrigerant and controls flow of the refrigerant automatically according to operating conditions. The expansion valve with MOP (MAXIMUM OPERATING PRESSURE) is adopted to protect the compressor motor from overload.



"CAUTION" Whenever adjusting and replacing the expansion valve, the unit should be isolated from the mains supply for safety.

(a) Adjusting the expansion valve

There are two methods to adjust the expansion valve; i.e. one is the adjustment based on the suction operation standard and the other is that based on the frost conditions on the compressor.

(1) Adjustment based on the suction operation pressure

1) Conform that the predesigned volume of the refrigerant has been charged.
2) Attach a pressure gauge to each gauge port and operate the refrigeration unit, maintaining inside temperature at −18°C (−0.4°F). (See connecting of pressure gauge).
3) When inside temperature comes to the preset temperature, compare the suction pressure reading with the standard pressure. (See Standard operation pressure curve)
4) If suction pressure reading differs with the standard pressure, adjust the expansion valve as stated below.
5) After loosening the clamp screw, turn the adjusting screw.
6) Note that pressure will not change after a certain lapse of time.

(2) The adjustment based on frost stated on the compressor.

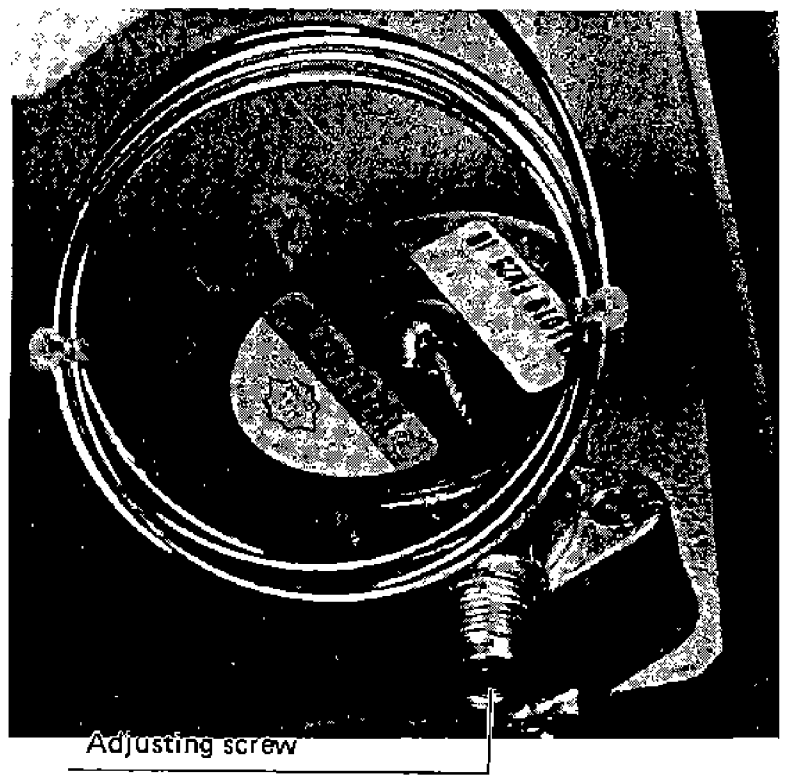
1) Refer to the caution for adjustment of expansion valve as above. At this time, inside temperature should be maintained to −18°C (−0.4°F).
2) Regulate the adjusting screw as stated below based on frost state on the suction pipe and the stop valve of the compressor.
3) Whether or not the adjustment required is judged by frost state of the flange on the suction side of the suction valve.
4) However note that frost state differs with ambient air conditions (temperature and humidity).

Adjusting points for expansion valve

Adjusting screw	Turning direction		Operation state
Adjusting screw of expansion valve	Clockwise		Suction pressure is higher than the standard pressure (Frost forms on the suction pipe rather than the suction flange of the stop valve). Clockwise rotation of the adjusting screw decreases running pressure.
	Counter-clockwise		Suction pressure is lower than the standard pressure (frost forms on the compressor side rather than the suction flange of the stop valve). Counterclockwise rotation of the adjusting screw increases running pressure.

(3) Countermeasures after operation

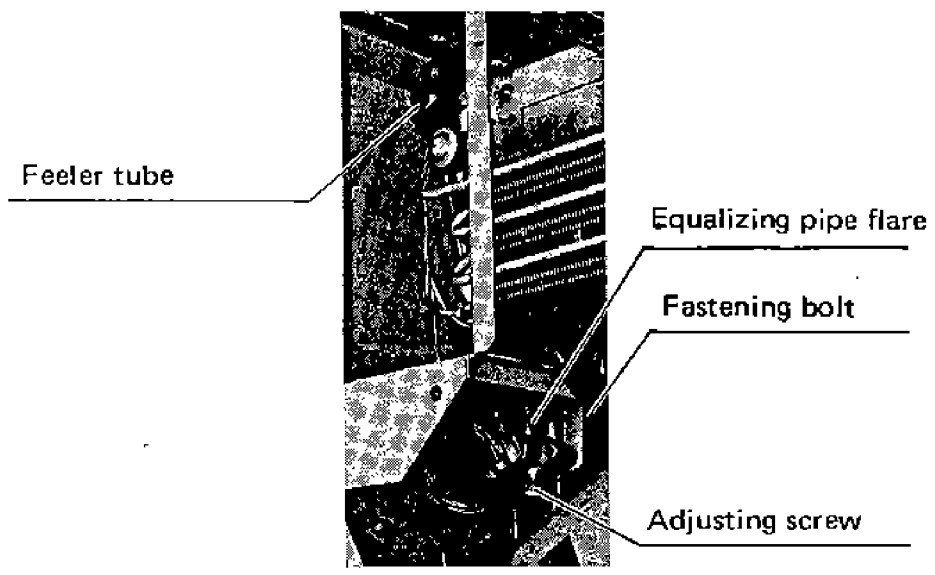
1) Remember the original setting of the expansion valve. If any change is not found with the setting after adjustment of the expansion valve, return the adjusting screw to the original position, as trouble occured caused by other reasons.
2) When the adjusting screw is returned to its original position, firstly turn it passing the original position and then return it to the original position.
3) After adjustment, be sure to tighten up the clamp screw and cap it to prevent the refrigerant from leaking.
4) After completion of the adjustment, operate the unit, keeping inside temperature at −18°C (−0.4°F) and confirm that low pressure is within the range of operating pressure at items 6.



(b) Replacement

For replacement of the expansion valve, remove the access panel located on the front of the unit or by removing the evaporator bulkhead inside the container, and the drain pan back plate located at the left side.

1) Remove the feeler tube, equalizing pipe flare, and fastening bolts. (To replace the cage alone, there is no need to remove the feeler tube.)
2) Remove the power assembly, cage, and packing.
3) Be sure to install a new packing when replacing it.



4.1.6 Liquid/moisture indicator

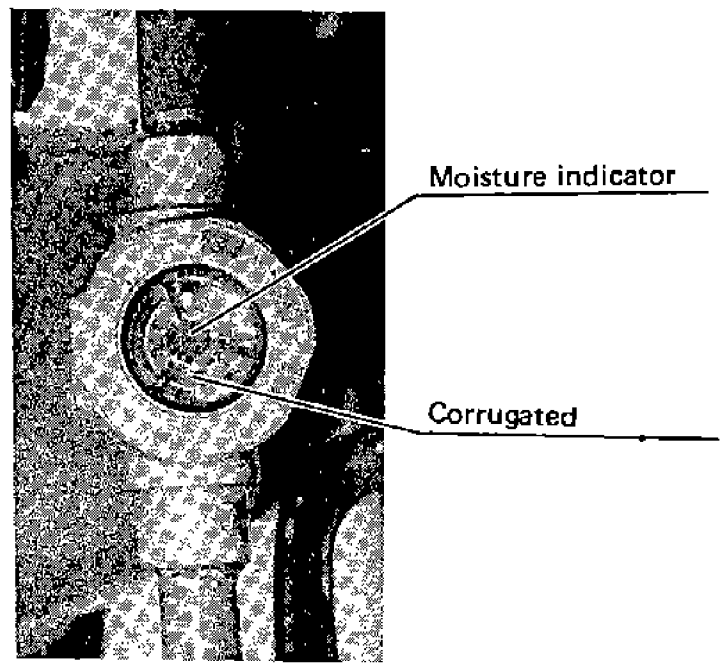
This indicator permits checking of flow of the refrigerant and moisture content in the refrigerant.

(a) Moisture content

The indicator indicates moisture content by the color at the center of the window.

Color	State
Deep blue	Dry
Orange	Wet (moisture contained)

Note: The indicator may appear orange if it has been exposed to gaseous refrigerant for a long time.



(b) Flow of the refrigerant

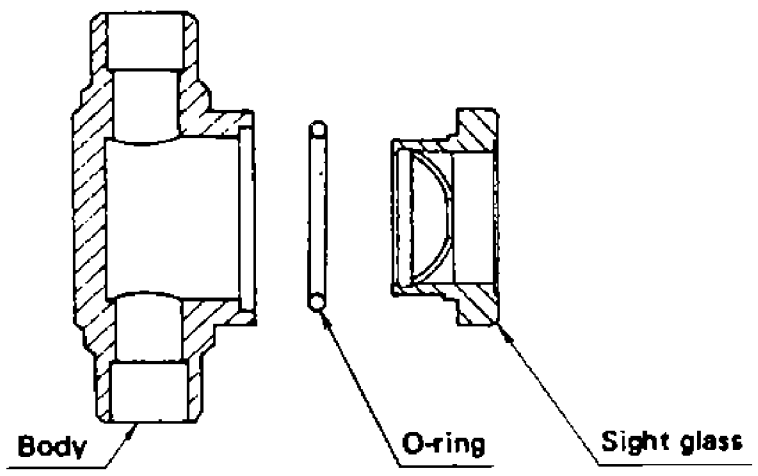
● Check

Operation	Indicator state
At start	Bubbles appear but liquid refrigerant is sealed in 30 minutes to an hour after starting.
During operation	Bubbles may appear more or less. (Particularly appear more during capacity control operation)

If bubbles develop continuously, the refrigerant is possibly running short.

(c) Replacement

1) Put the system in "pump down" state.
2) Turn the sight glass counterclockwise, and remove it together with the O-ring.
3) Apply refrigeration oil to the new O-ring, and fasten the sight glass with torque of 70 ±5 kg-cm. (Do not apply excessive torque, or the O-ring will break.)

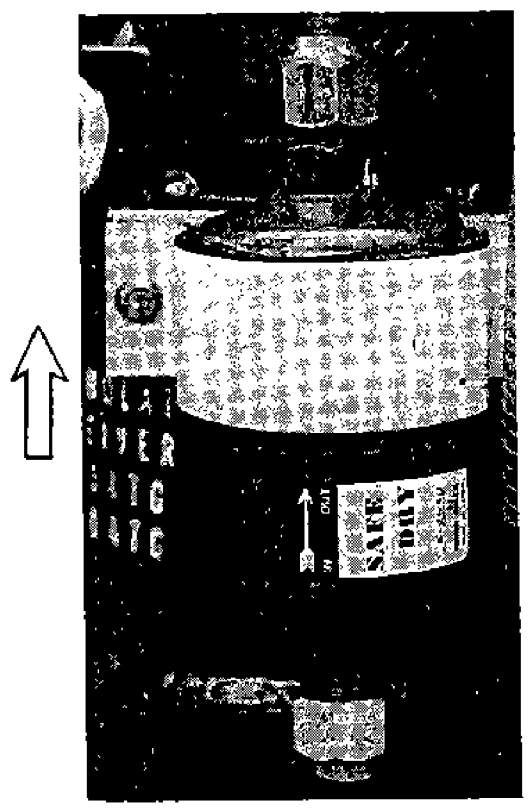


4.1.7 Dryer

This removes moisture and dust from the refrigerant while it is circulated. Replace the dryer if it does not remove moisture or is clogged.
When installing the new dryer, follow the directions given on the nameplate and do not make any mistake about the direction of the dryer.

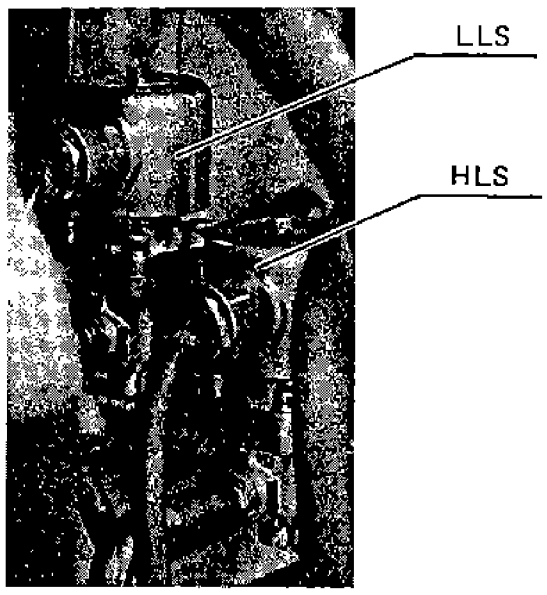
(a) Replacement

1) In "pump down" state (see Service), close the compressor suction stop valve.
2) Then, loosen the flares at the both end of the dryer and replace the dryer quickly.
3) Be careful not to get air into the piping on the solenoid valve side while removing the dryer.
4) After reattachment of the dryer, open the stop valve a little to purge the air in the dryer from the flare on the solenoid valve side and then close it at once.
5) Loosen the flare on the other side, forcedly turn off the low pressure of the dual pressure switch, turn on the master control switch and open the solenoid valve only to purge the air.
6) After completion of the work, open the stop valves to its original state and then inspect the system for gas leakage. Confirm no gas leakage is found.



4.1.8 Solenoid valves <LLS, HLS>

- Solenoid valves are provided in the liquid line and hot gas line. They operate as follows according to operating mode.



(a) During frozen mode

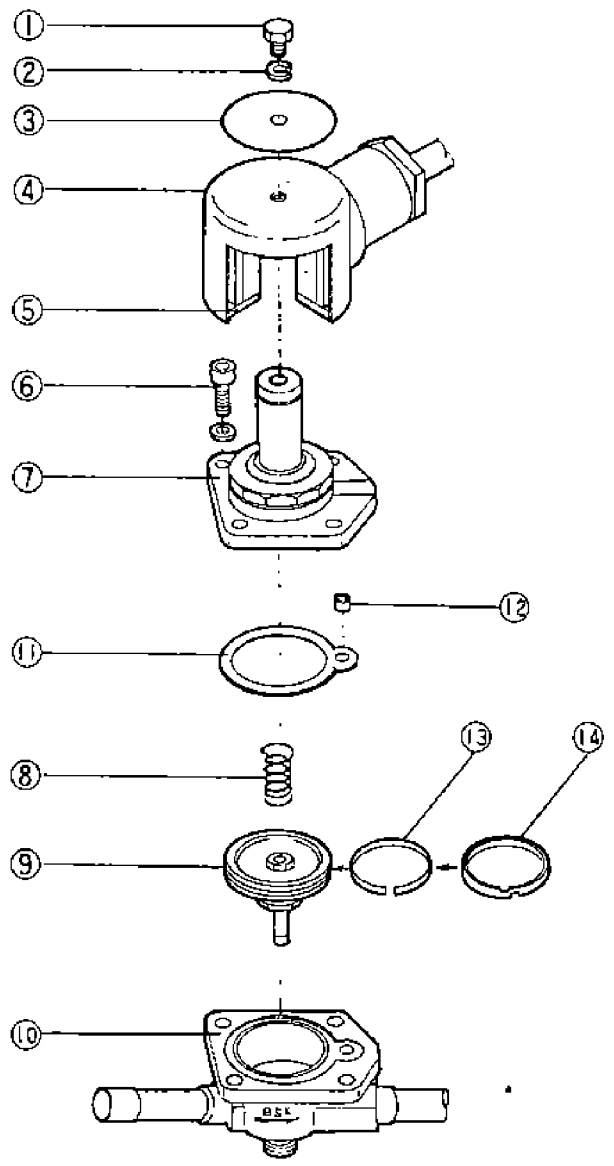
- During operating in the frozen mode, the <LLS> is opened and <HLS> is closed all the time. When stopping the compressor by the controller, <LLS> is closed and stop flow of the refrigerant, performing "pump down".

(b) During chilled mode

- During "pull down" the <LLS> is opend and <HLS> is closed. When the inside temperature reaches the preset temperature plus +2.5°C, the controller opens the <HLS> to allow the hot gas to flow. When the operation stops after "pump down", both the <LLS> and <HLS> are closed, as in the case of frozen operation.

(c) Disassembly

- The structure of the solenoid valve is shown at below. (For disassembly, checking, and reassembly, refer to this diagram.)
- When brazing a pipe to the valve, cool the valve body with a wet cloth. (It is not required to disassemble the valve. Remove the coil ass'y from the body.)
- During reassembly, tighten the four bolts x4 with torque of 50—60 kg-cm.



No.	Parts name
①	Set bolt
②	Spring lock washer
③	Name plate
④	Coil ass'y
⑤	Retaining plate
⑥	Set bolt
⑦	Cover ass'y
⑧	Spring
⑨	Piston
⑩	Valve body
⑪	Packing
⑫	Sleeve
⑬	Inner ring
⑭	Piston ring

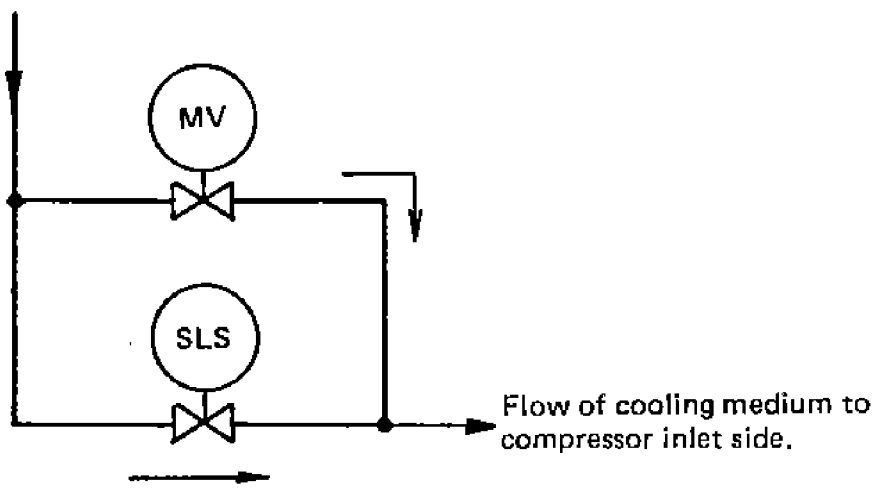
4.1.9 Suction line solenoid valve <SLS>, Modulating valve <MV>

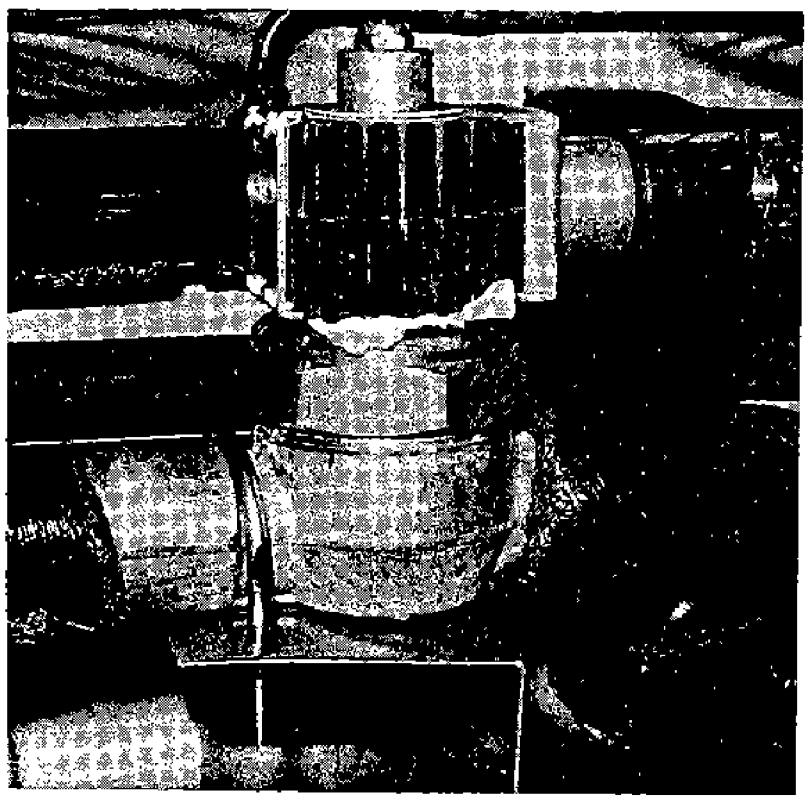
To control the suction gas, a suction gas line solenoid valve <SLS> and modulating control valve <MV> have been installed.

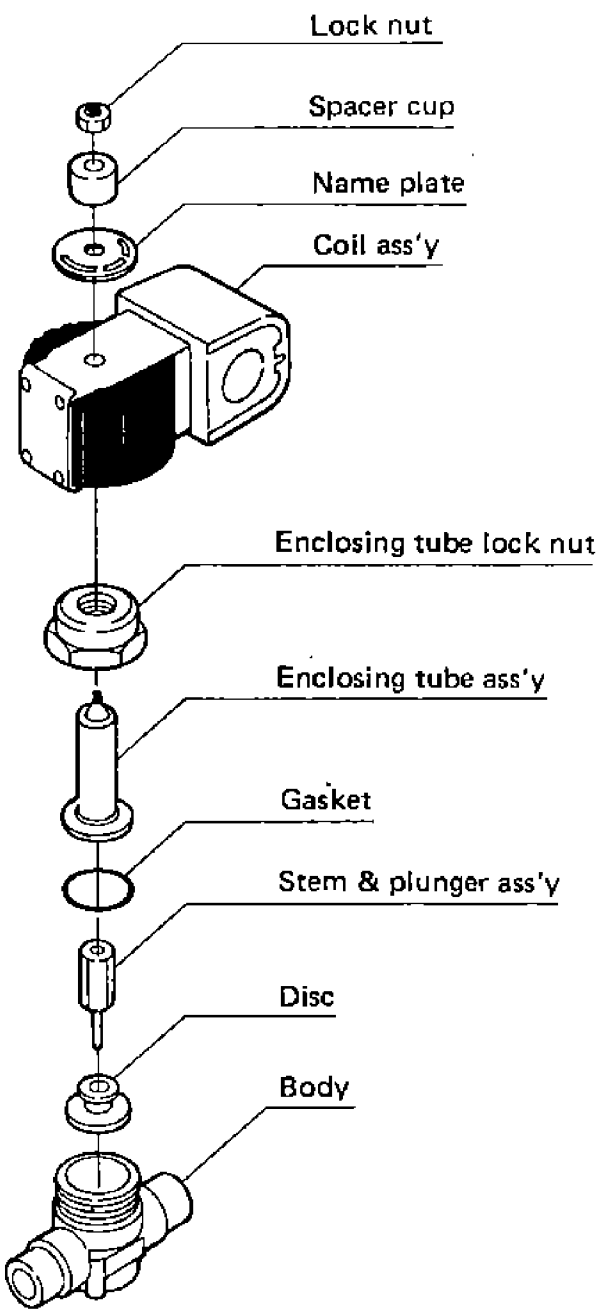
<SLS>, <MV>: { De-energized: open / Energized : close }

(1) <SLS>

During chilled operation: When the control temperature reaches preset temperature plus +2°C, the K3 relay is energized and <SLS> is closed, reducing the amount of suction gas.
(A bleeding port for the forced refrigerant circulating is provided in the lower valve body.)
During frozen operation: Always open.

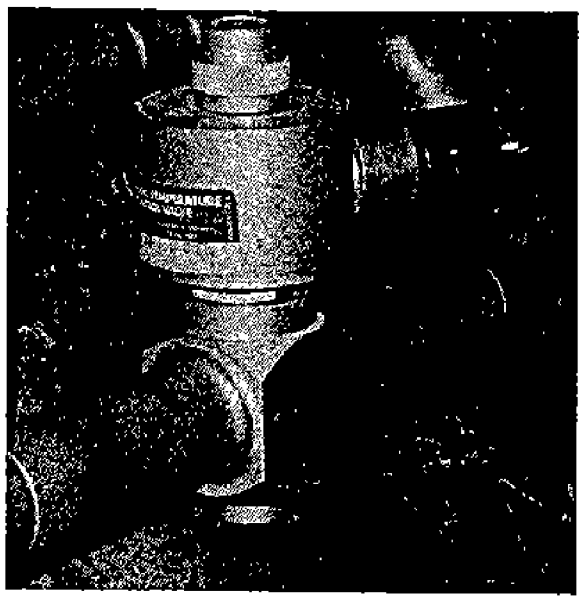






(2) <MV>

During frozen operation: When the control temperature nears the preset temperature after the closing of the <SLS>, the controller outputs the valve operating voltage to actuate the valve in the closing direction and controls the suction gas flow by continuous modulation according to the voltage.



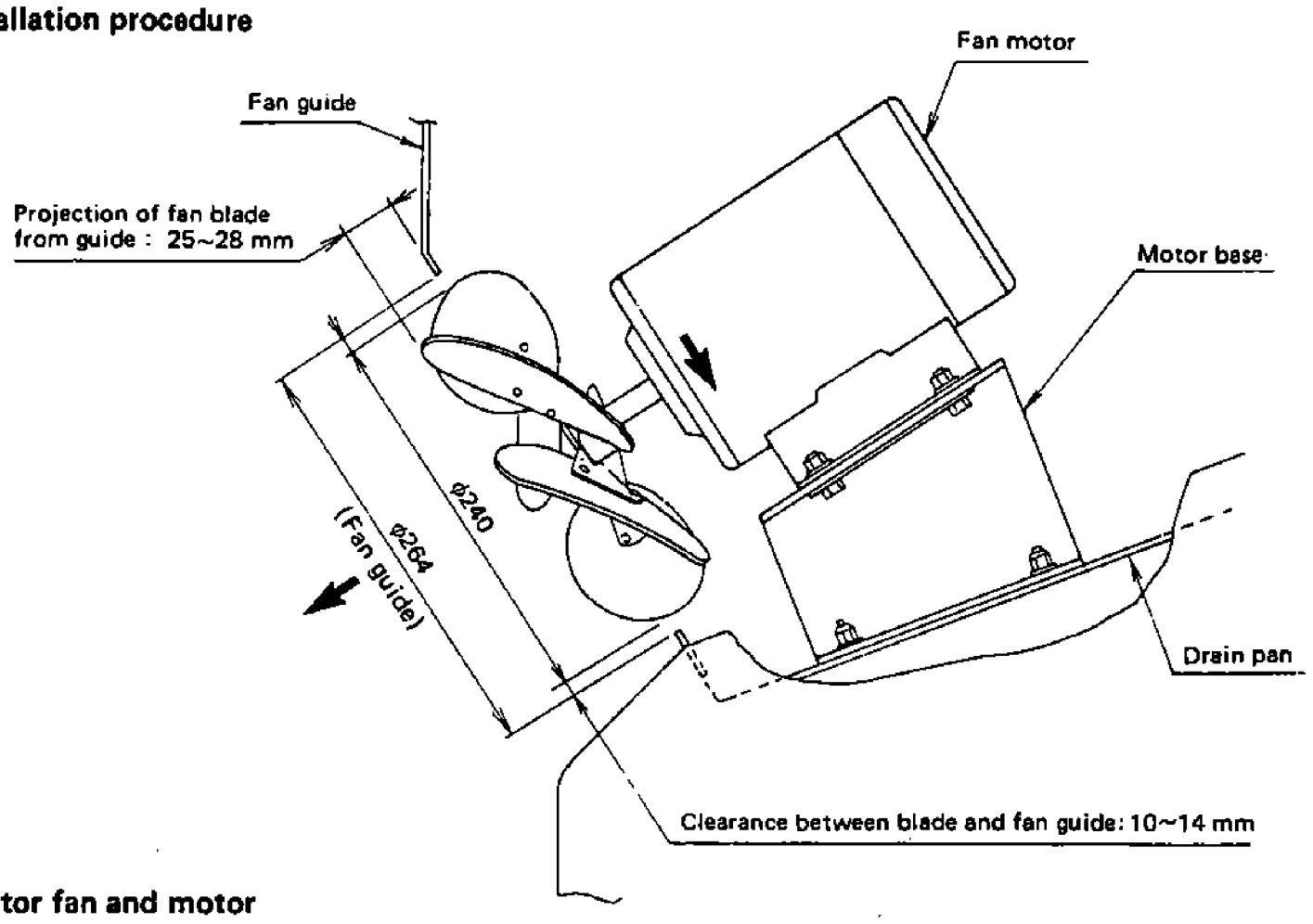
4.2. Components related with the air system

4.2.1 Fans and motors

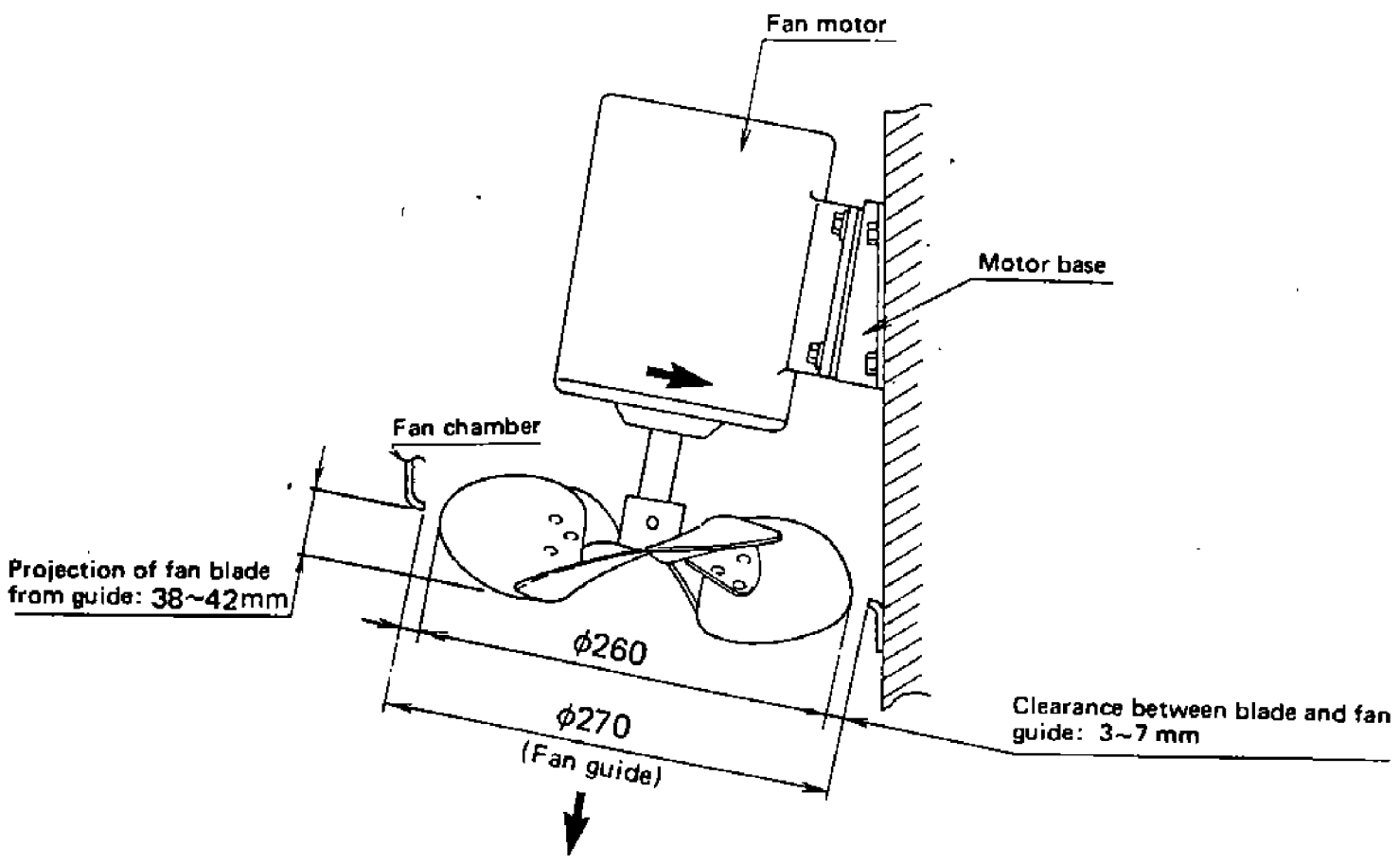
(a) Specifications

		Evaporator	Condenser
Fan	Type	propeller fan	propeller fan
	Number of blades	6 pcs.	6 pcs.
	Blade diameter	ϕ240	ϕ260
Motor	Type	Single-phase, squirrel-cage induction motor	
	Motor output (number of poles)	465W (2P)	60W (4P)
	Capacitor	Built-in	Separate
	Bearing	Ball bearing, 6203 contactless type, rubber shield	

(b) Installation procedure



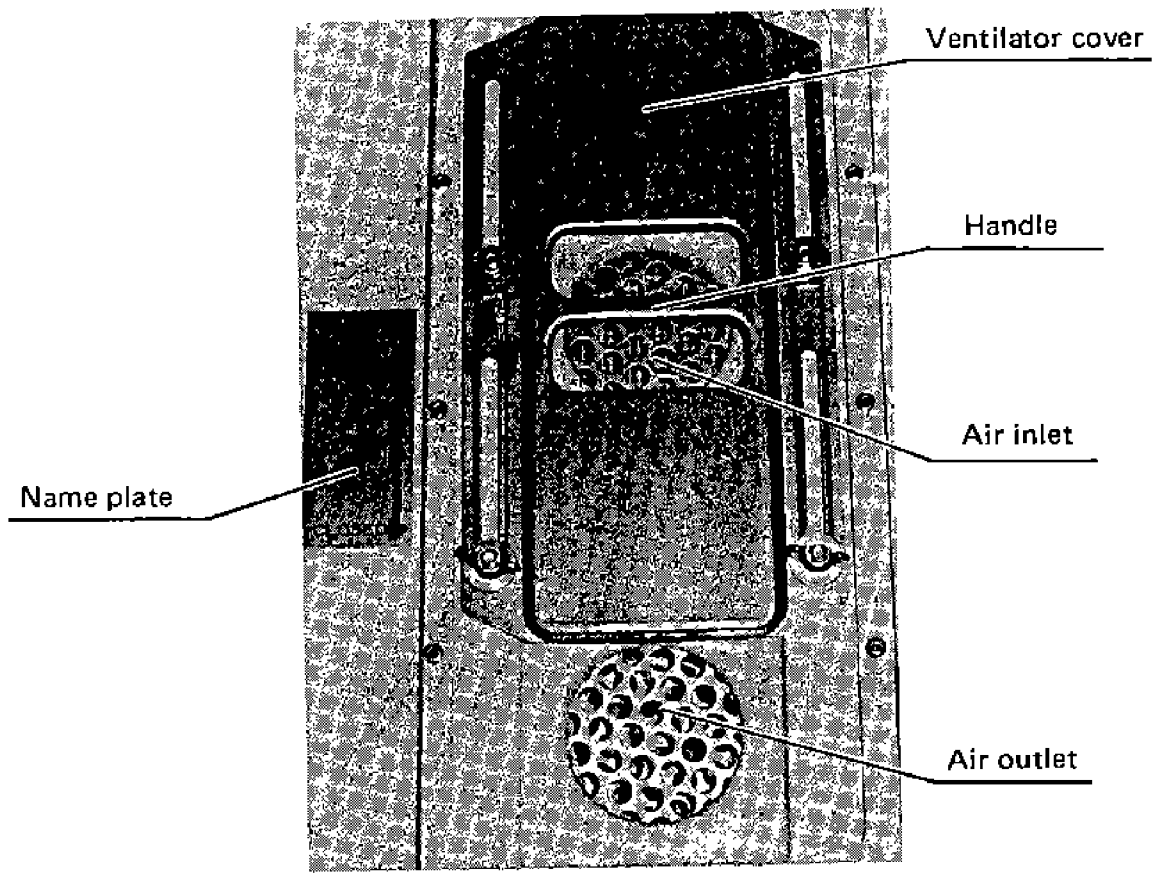
Evaporator fan and motor



Condenser fan and motor

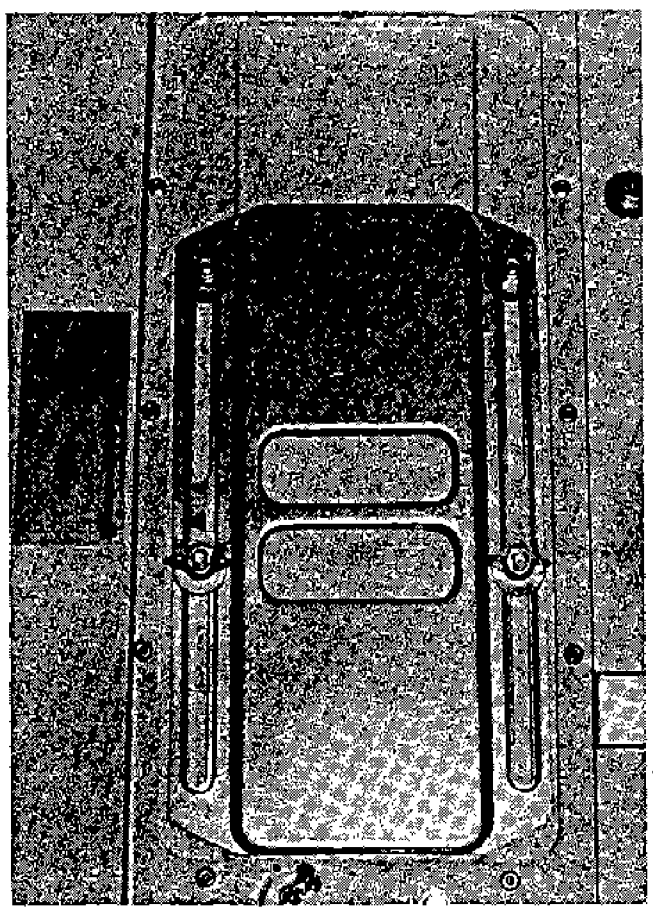
4.2.2 Ventilator

(a) View

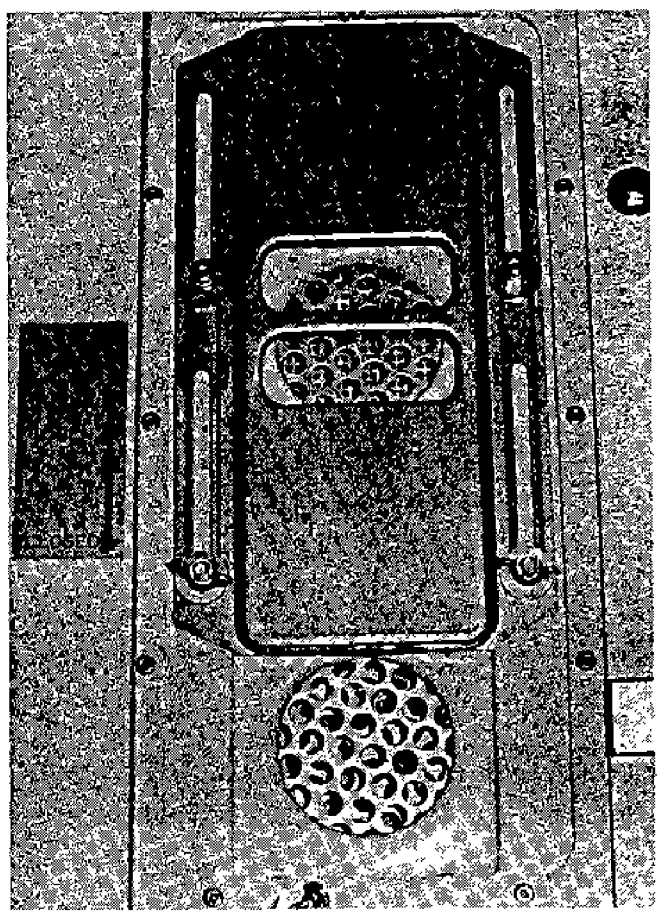


(b) Operation

- If ventilation is not needed:
  Set the handle to CLOSED.



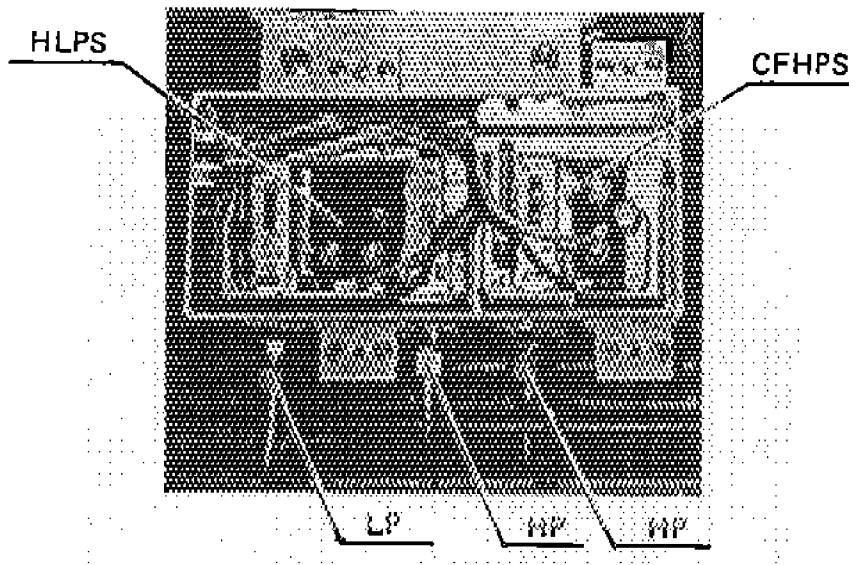
- If ventilation is needed:
  The ventilation opening may be varied over four steps: 1/4, 1/2, 3/4 and 1. Adjust the opening according to ventilation volume.



4.3 Description on electrical and functional parts.

4.3.1 Dual pressure switch <HLPS >

This stops the compressor when the pressure has risen or fallen excessively in the unit. The high pressure may rise above preset of HP if the condenser fan fails or cooling water does not circulate properly, etc. The low pressure may fall below preset of LP if "pump down" has been performed because the refrigeration circuit is blocked or the solenoid valves are closed. In these cases, the switch stops compressor.



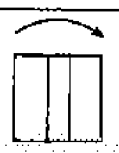
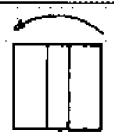
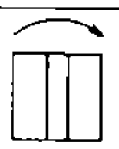
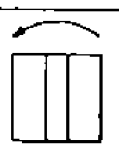
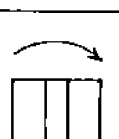
Pressure switch box (Upper)

LP : Low pressure
HP : High pressure

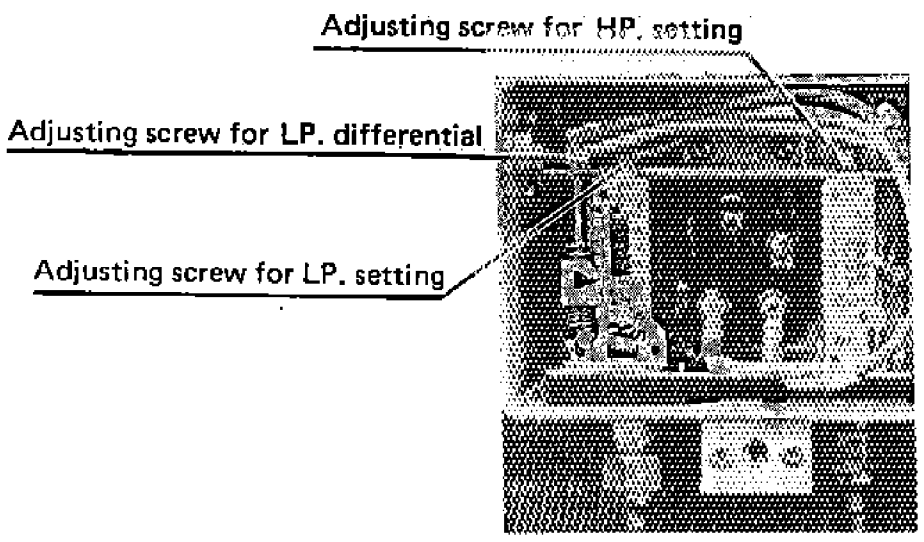
(a) Adjustment method

Adjust the switch by turning the adjusting screw as described below;

Adjusting points of dual pressure switch

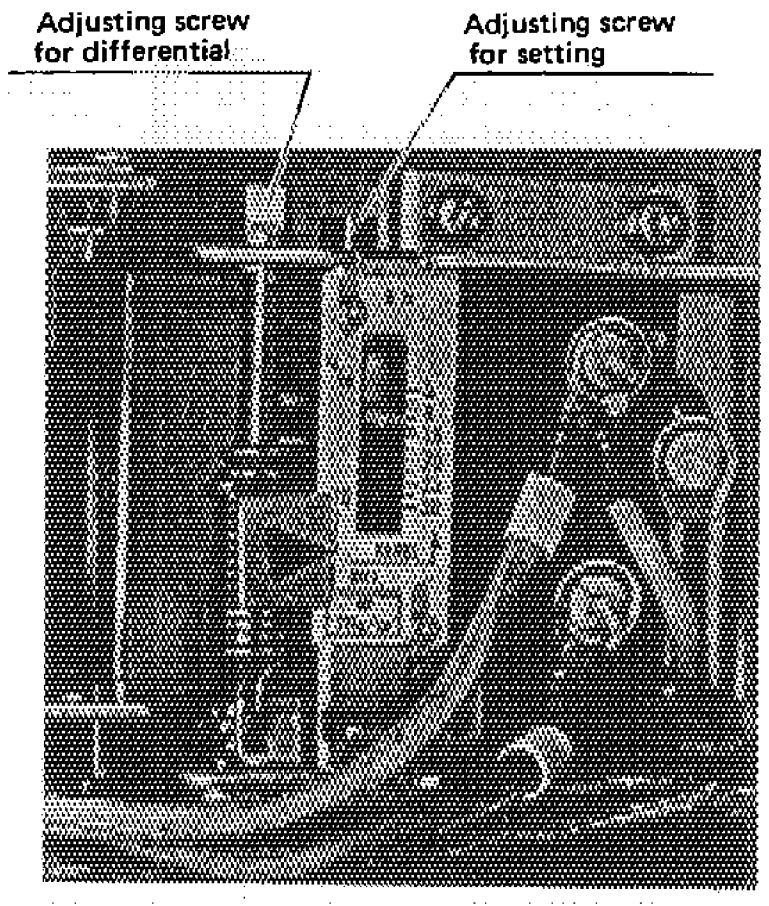
	Adjusting screw	Rotary direction		Function
High pressure side	Setting of adjusting screw	Clockwise		Setting (OFF value) becomes high, and pressure at the stopping of the refrigeration unit becomes high.
		Counter-clockwise		Setting (OFF value) becomes low, and pressure at the stopping of the refrigeration unit becomes low.
Low pressure side	Setting of adjusting screw	Clockwise		Setting (ON value) becomes low, and pressure at the starting of the refrigeration unit becomes low.
		Counter-clockwise		Setting (ON value) becomes high, and pressure at the starting of the refrigeration unit becomes high.
	Setting of adjusting screw for differential	Clockwise		Pressure difference between ON and OFF becomes large and difference between pressure on the starting and on the stopping becomes large.
		Counter-clockwise		Pressure difference between ON and OFF becomes closer and difference between pressure on the starting and on the stopping becomes closer.

Notes: 1) If it is necessary to adjust the adjusting screw for differential, be sure to adjust pressure setting first and then adjust differential.
2) After adjusting the adjusting screw, apply chemical to the bolt head to prevent the bolt from being loosened vibration.



4.3.2 High pressure control pressure switch <CFHPS>

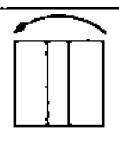
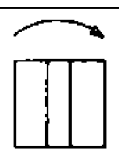
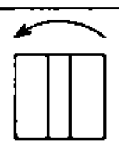
If the ambient temperature is low during air cooled operation, two out of three condenser fans are turned off so that the high pressure should not fall. (As for more details, refer to "high pressure control")



(a) Adjusting method

Adjust the adjusting screw as staged below.

Adjusting points for high pressure control switch

Adjusting screw	Turning direction		Function
Adjusting screw for setting	Clockwise		Setting value (OFF value) becomes low and two fans out of three stop at lower ambient.
	Counter-clockwise		Setting value (OFF value) becomes high and two fans out of three stop higher anibient.
Adjusting screw for differential	Clockwise		Pressure difference between ON and OFF becomes large and stopping period of certain fans is prolonged.
	Counter-clockwise		Pressure difference between ON and OFF becomes small, and stopping period of certain fans is shortened.

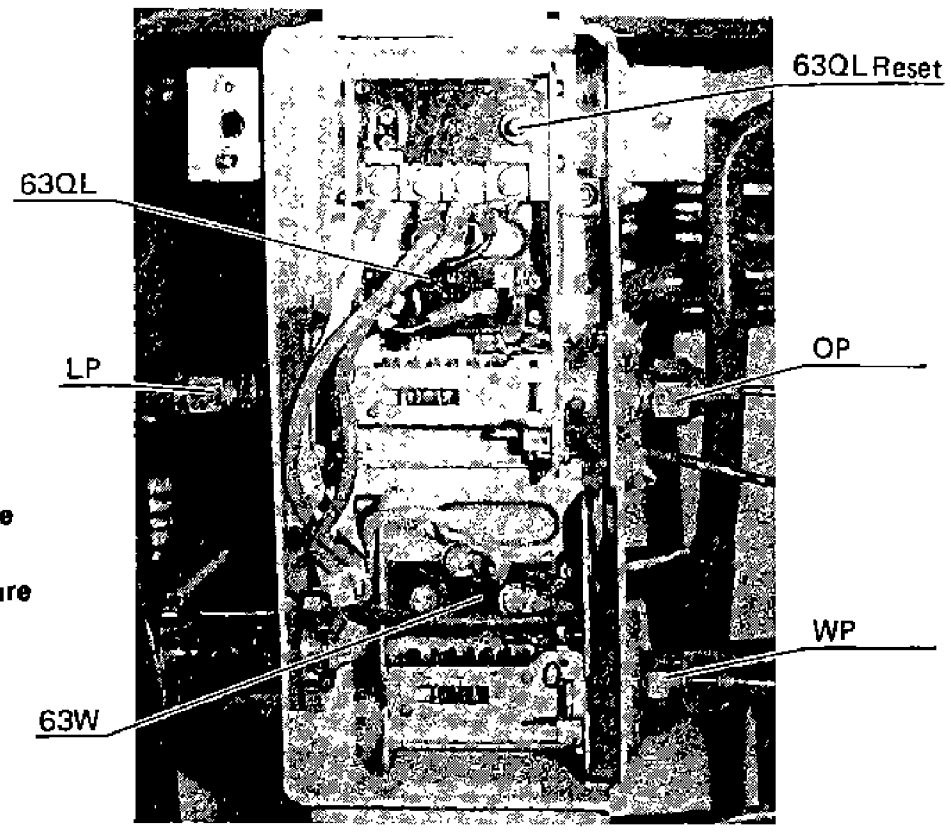
Notes: 1) In case it is necessary to adjust the adjusting screw for differential, be sure to adjust setting first and then differential.

2) After adjustment of the adjusting screws, be sure to apply the following chemical to the bolt heads to prevent them from loosening by vibration.

4.3.3 Oil pressure protection switch <OPS>

Oil pressure (difference between oil pressure and low pressure) falls due to oil pump failure, clogging and oil foaming.

This stops the compressor automatically when oil pressure continuously remains low, because the compressor may be burnt because of oil shortage.



PS box

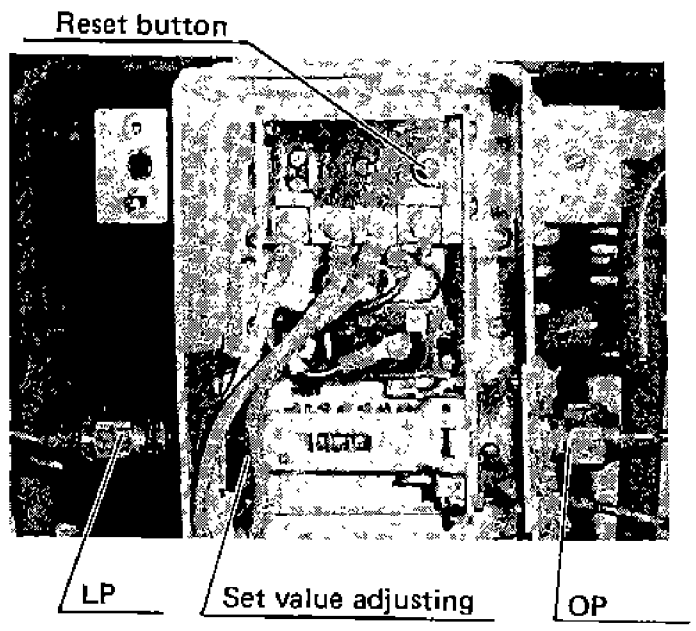
LP: Low pressure
OP: Oil pressure
WP: Water pressure

(a) Operation

The oil pressure (pressure difference) normally rises when the compressor has started. If the pressure does not rise, power will be supplied to the heater of a timer and a bimetal operate after a preset interval, thereby stopping the compressor.

Note: Timing device is affected by ambient temperature and its set period differs with ambient temperature. (Standard temperature 25°C)

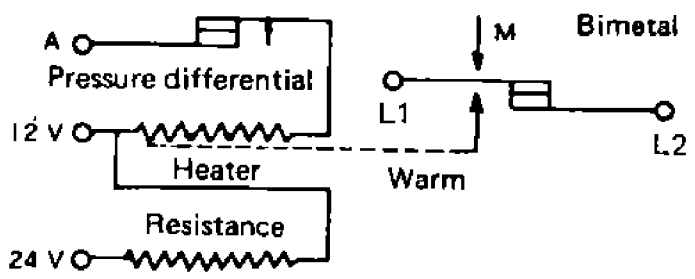
Ambient temperature	Set period
Higher	Shorter
Lower	Longer



Oil pressure protection switch

(b) Resetting

If OPS (63QL) has operated, depress the reset button several minutes after when the compressor stops. (The button will not be reset unless the bimetal is cold.)



Electric wiring in oil pressure protection switch

(c) Adjustment method

Adjust the oil pressure protection switch by turning the adjusting gear as described below.

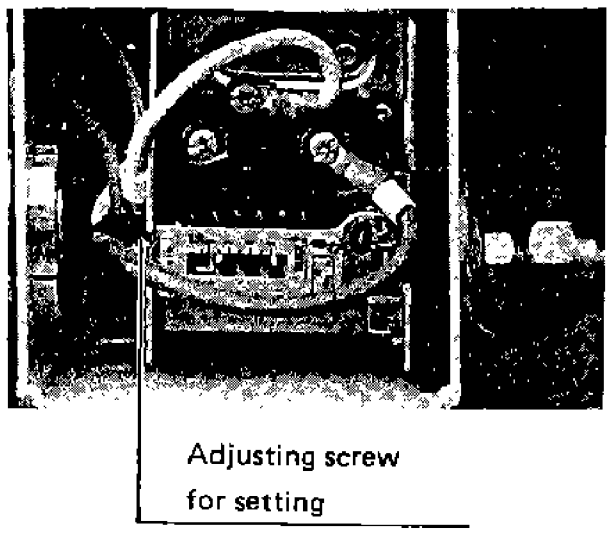
Adjusting points for oil pressure protection switch

Adjusting gear	Turning direction		Function
Adjusting gear for settings	Clockwise		Functional pressure (differential) becomes low and heater circuit is disconnected with low pressure difference.
	Counter-clockwise		Functional pressure (differential) becomes high and heater circuit is disconnected with high pressure difference.

Note: The following turning directions are viewed from the low pressure connection side.

4.3.4 Water pressure switch <WPS>

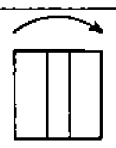
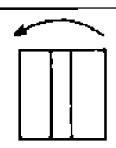
This switches over air and water cooled modes.
If cooling water flows and water pressure rises above a preset water pressure at the inlet, the contact is turned off to stop the condenser fan motor and water cooled operation will start.



(a) Adjusting method

Turn the adjusting screw as stated below.

Adjusting points of water pressure switch

Adjusting screw	Turning direction		Function
Adjusting screw for setting	Clockwise		Setting (OFF value) becomes low, and fans stops quicker
	Counter-clockwise		Setting (OFF value) becomes high, and fan is delayed in stopping.

Note: After the adjustment, be sure to apply loctite to the bolt head to prevent it from being loosened due to operation vibration.

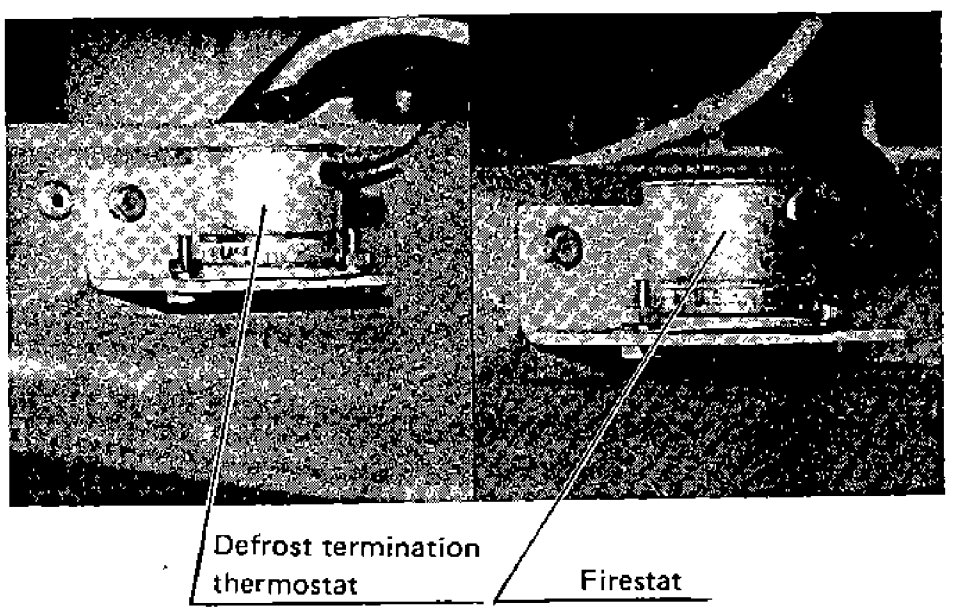
4.3.5 Defrost termination thermostat <DTT>

This senses ambient temperature around the thermostat and will terminate defrosting.

OFF: 7.2°C
ON : 1.7°C

4.3.6 Firestat <HTT>

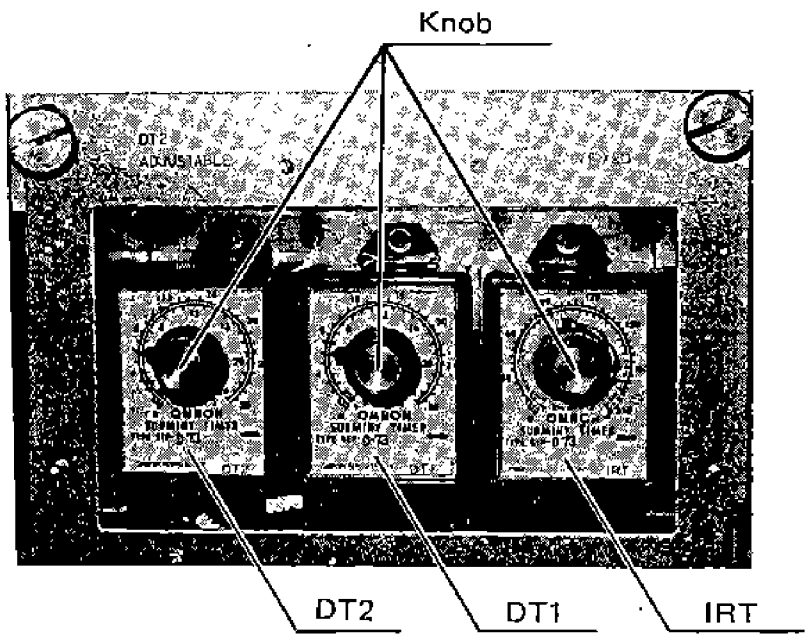
This prevents the electric heaters from overheating.
If the heaters are overheating, the ambient temperature around the thermostat rises and the thermostat cuts off the heaters.
OFF: 71°C
ON : 49°C



4.3.7 Defrost timer <DT1, DT2>

The defrost timer activates defrosting operation automatically at preset intervals. The timer setting is controlled by a knob on its front face. Do not adjust it while operating. Do not set to "0" (hr) it will cause erratic operation.

- Adjustable range : 1~24 hours (60 Hz), 1~28½ hours (50 Hz).
- Once power has been turned off, the timer is reset to the initial state.
- Defrost Intervals
  The factory setting of defrost timers both <DT1> and <DT2> are 6 hours (50 Hz).



The following tablation and note relation to different conditions are suggested.

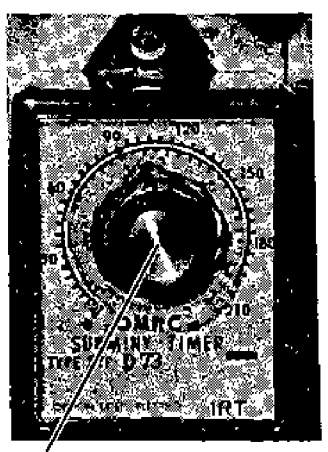
Ref.	Timer setting (HRS)	Condition of cargo
A	12	Seal wrapped cartons and dry cargoes.
B	6	Unwrapped meat or fish.
C	4 OR LESS	Unfrozen wet products or products with high water content.

NOTE) 1. The refrigeration unit should not be used for pulling down the temperature of cargoes or freezing them. The unit has insufficient capacity for such purpose. All cargoes should be loaded into container pre-cooled.
2. Refer to item 3.8 "Notes" on "Defrosting" operation for examples of usage in respect of changes in the settings of <DT1> and <DT2>.

4.3.8 In range timer <IRT>

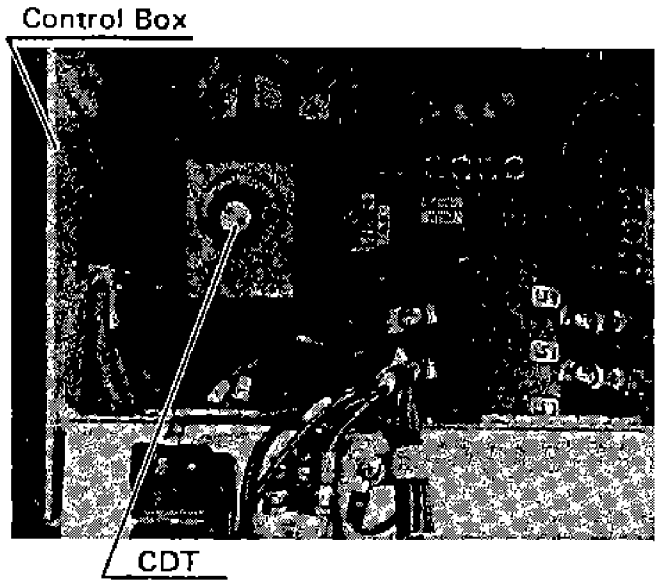
When the control temperature deviates from the in range temperature, the counting starts and the in range lamp is forcibly illuminated for 90 minutes (50 Hz). Do not adjust the preset time because it is fixed.

- Once power has been turned off, the timer is reset to the initial state.



4.3.9 Compressor delay timer <CDT>

- To prevent frequent starting and stopping of the compressor, the <CDT> forcibly keeps the compressor stopped for 6 minutes (50 Hz) from the time it has stopped.
- Do not adjust the preset time because it is fixed.

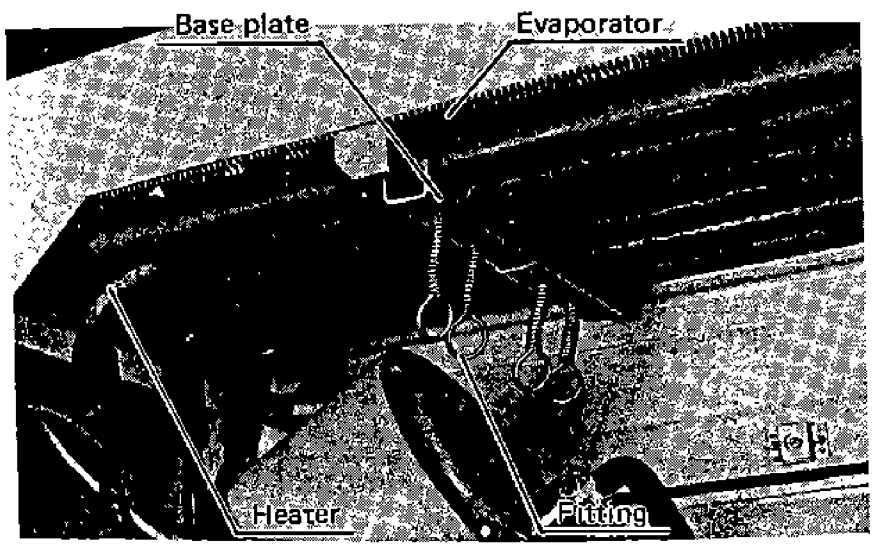


4.3.10 Electric heaters

Two kinds of electric heaters are used.

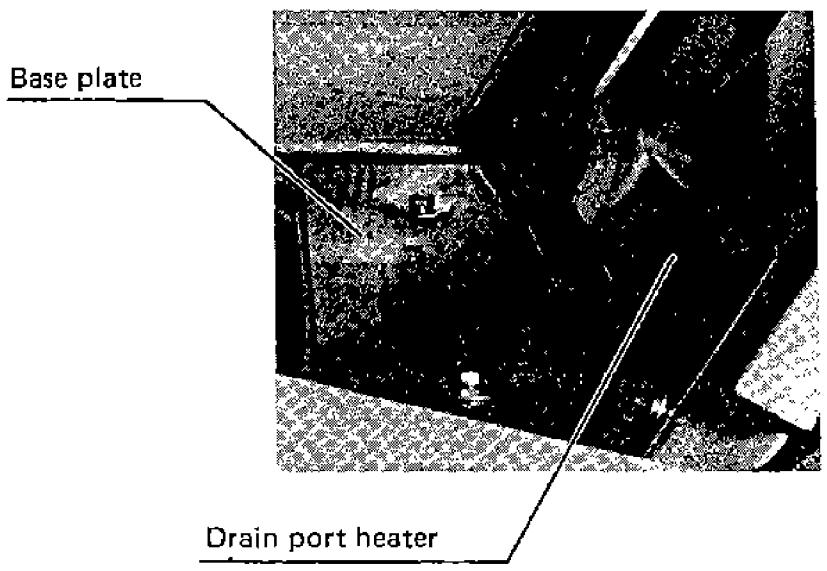
(a) Sheathed heaters (220V AC, 0.65 kW x 6)

These are fitted at the bottom of the evaporator.
H1 through H6 are used for high heating H1 and H2 are used as low heating .
To replace them, lift the fittings up and remove them together with the base plate.



(b) Molded heaters (220V AC, 50W x 2)

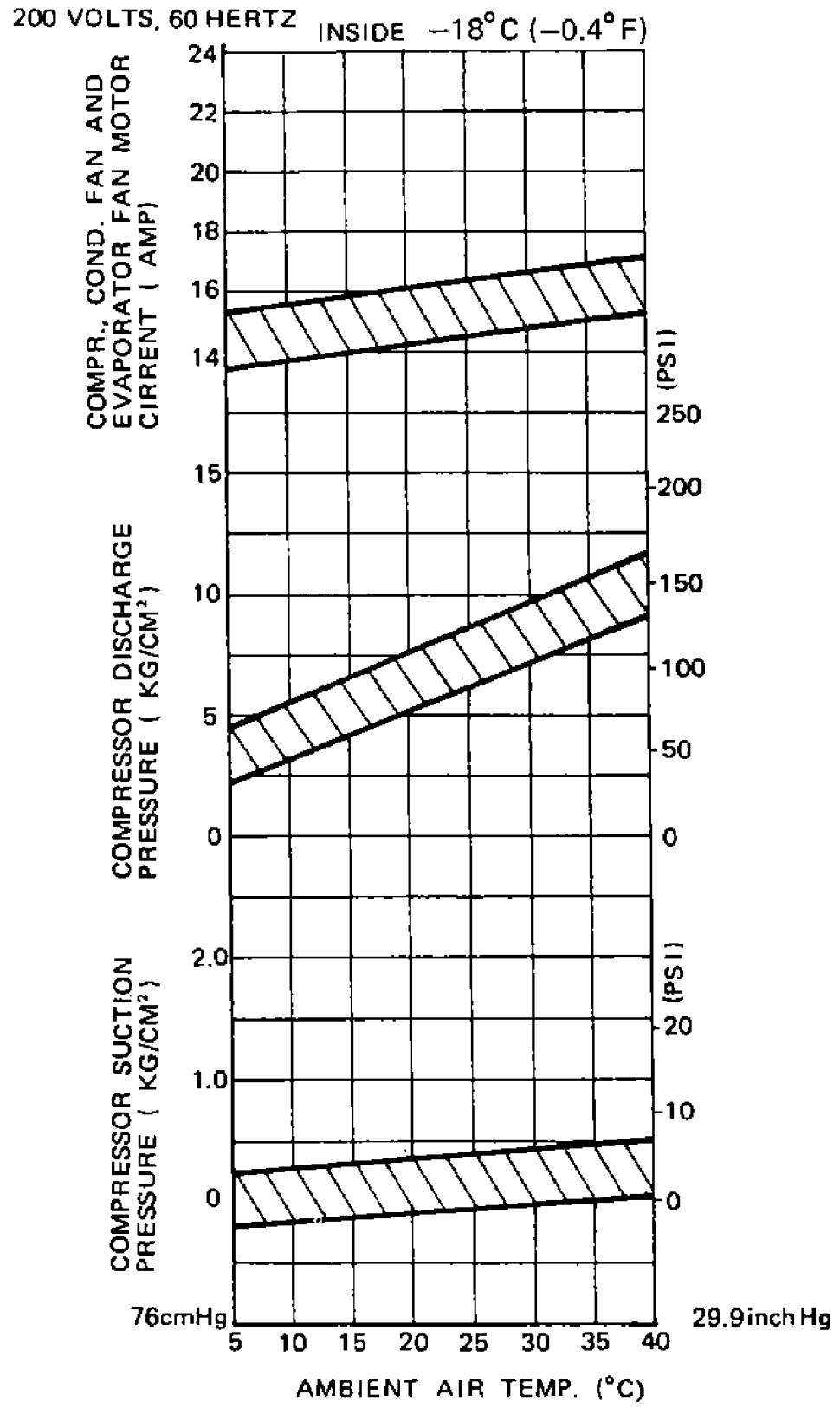
These are fitted at the left and right of the drain pan to prevent the drain port from freezing <DP1, DP2>



5. Set values of functional parts

Part name		Function	Set value
Oil pressure protection switch ONS-C106Q	OPS	Heater circuit OFF ON Timer	1.0kg/cm^2 0.5kg/cm^2 110 seconds (ambient temperature 25°C) More than 5 seconds (ambient temperature 70°C)
Dual pressure switch DNS-D306Q	HLPS	Low pressure OFF ON High pressure OFF ON	40cmHgV 0.2kg/cm^2 20kg/cm^2 16.5kg/cm^2
High pressure control switch SNS-C130Q11	CFHPS	OFF ON	7kg/cm^2 12.5kg/cm^2
Water pressure switch SNS-C106Q6	WPS	OFF ON	1.0kg/cm^2 0.4kg/cm^2
Firestat KLIXON 20420L/L160-4	HTT	OFF ON	71°C (160°F) 49°C (120°F)
Defrost Termination thermostat KLIXON 20420L/L45-1	DTT	OFF ON	7.2°C (45°F) 1.67°C (35°F)
Defrost timer STP-D73	DT1, 2	ON	5h (60Hz) 6h (50Hz)
In range timer STP-D73	IRT	ON	75 min. (60Hz) 90 min. (50Hz)
Compressor delay timer STP-D73	CDT	ON	5min (60Hz) 6min (50Hz)
Overcurrent relay T-20-NP$_2$S$_4$	OL	OFF	5.5A
Circuit breaker (main circuit) MK-53	CB$_1$	OFF	32A
Circuit breaker (control circuit) CP 31	CB$_2$	OFF	7A
Thermal protector for fan motor KLIXON 9700L-01-11 (cond. fan motor) 9700K-01-11 (evap. fan motor)		OFF	120°C (248°F)
Thermal protector for compressor KLIXON 7895 (compressor)	IPC	OFF	105°C (221°F)

6. Operating pressure and running current



< For reference >

	Item		Unit	Value
1	Heater current — during defrosting Measure at primary side of HTR2		A	10.5 (AC 220V)
2	Running current of condenser fan motor		A	0.7 (AC 220V)
3	Running current of evaporator fan motor		A	3.0 (AC 220V)
4	Bolt tightening torque	Compressor	kg·cm/lb·Ft	435/36
		Compressor stop valve flange		225/21
		Fan motor		125/10
		Solenoid valve		55/4.3
		Expansion valve		250/20.5
		Fan		55/4.3

Note : Allowable range of tightening torgue : +10%.

7. Troubles and countermeasures

If the unit does not work properly, inspect it in accordance with "Troubles and countermeasures" to find cause of trouble and repair it.

Troubles and countermeasures

State	Phenomena	Functioning places	Cause	Countermeasures
I. Operation inoperative	A: Condenser evaporator fans and compressor are inoperative.	a. No trouble with unit	Current interruption	Trace cause
			Power source is disconnected.	Connect power source plug to power source.
		b. Circuit breaker function (main circuit)	It functions due to over current.	Trace causes and replace.
		c. Circuit breaker function (control circuit)	It functions due to over current.	Trace causes and replace.
	B: Evaporator fans operate but condenser fans and compressor are inoperative.	a. No trouble with unit	The unit halts (NULL) by function of the controller or in heating operation.	
		b. Oil pressure control	It is not reset yet.	Repair trouble and push down reset button.
		c. Solenoid valve does not function.	Coil is cut out.	Replace it.
		d. Controller malfunctions.	Sensor is damaged or other reasons.	Replace it.
II. Operation stops soon	A: Condenser fans and compressor stop, keeping evaporator fans in operation.	a. Oil pressure protection switch is functioning.	Oil pressure will not rise. Oil is short or oil pump is out of order.	Additional oil charge, or repair oil pump.
		b. No trouble with unit	Controller functions and stops unit.	
	B: Condenser fans and compressor operate on and off repeatedly with evaporator fans in operation.	a. Pressure switch functions. High pressure side	Excessive charge of refrigerant.	Discharge refrigerant.
			Air in system	Air purge
			Insufficient air flow for air cooled operation.	
			Condenser or passage clogged.	Clean or remove obstacles
			Fan blade damaged.	Repair or replace.
			Fan motor does not rotate.	
			Capacitor inoperative.	Replace it.
			Fan motor thermostat has functioned.	Trace causes.
			Insufficient water volume for cooling operation.	
			Condenser is clogged with scale.	
		Lower pressure side	Insufficient refrigerant charge.	Additional charge, seek leaking positions and repair.
			Dryer clogging	Replace
			Moisture chokes	Exchange dryer.
			Gas leakage from feeler tube of expansions valve.	Exchange it.
		b. Over-current relay or compressor protection thermostat has functioned.	Excessive large current due to over-load operation.	Trace causes.

State	Phenomena	Functioning places	Cause	Countermeasures
III. Inside temp. is low than temperature setting	A: Compressor inoperative.	a. Solenoid valve will not close.	Blocked with dust.	Replace it.
		b. Controller does not function.	Sensor is disconnected Defective controller or relay	Replace it.
		c. Sensor is installed wrongly.		Reattach it.
	B: Hotgas bypass does not work	Solenoid valve does not open	Blocked with dust	Repair or replace
			Defective controller or relay	Replace relay or controller
IV. Inside temperature does not drop	A: Inside temperature does not reach to preset temperature (Fans and compressor work)	a. Modulating control valve, suction line solenoid valve does not open.	Blocked with dust valve is defective	Repair or replace
V. Inside temperature is not stable	A: Inside temperature is not stable during chilled (Fans and compressor work properly)	a. Opening of modulating control valve (valve control valtage Y_1) is not stable	Controller is improperly adjusted	Adjust or replace
VI. Heating	A: Heater is inoperative.	a. No trouble with unit	Setting of setpoint selector is under $-7°C$	
		b. Firestat	Insufficient evaporator air volume	
		c. Controller or relay does not function	Defective controller or relay	Replace it.
VII. Defrosting operation	Defrosting and refrigerating operation are repeated in a short period of time.	a. Defrost timer incorrectry set or faulty.	Improper adjustment	Readjustment

8. PTI (Pre Trip Inspection)

To keep the unit in good operating condition, check adjust or repair the unit when necessary. The following is the checking items of PTI (an example of container refrigeration unit checklist).

Container refrigeration unit inspection card

Installed ship name		Date of Inspection	
Container No.		Place of Inspection	
Loaded cargo	Loaded or none	Unit Model No.	
Customer's staff		Unit No.	
Service staff		Compressor No.	

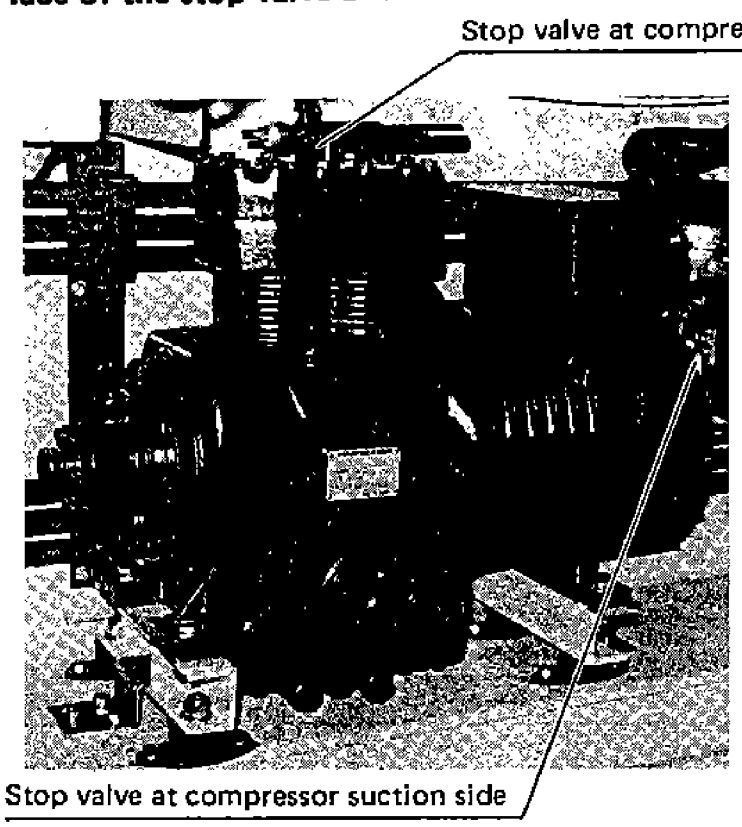
	Check	No.	Check point	Check method	Reference value
Check before operation		1	External appearance of importants parts of container (doors, equipment mount, damaged points)	Visual	
		2	Cleaning interior and exterior of container	Visual	
		3	Checking the smudge of the unit (air-cooled condenser, evaporator)	Visual	
		4	Checking "through" points inside and outside unit	Visual	
		5	The refrigeration circuit for leakage of gas and oil (mainly at joints)	Halide torch, Visual	Flame reaction should be bluish purple
		6	Checking external appearance of power cable and plug	Visual	
		7	Cleaning drain hose	Visual	Shall be free from clogging
		8	Mounted condition of electric heaters	Visual	Make sure that leads are not in contact with heaters
		9	Checking exterior of firestat	Visual	Shall have no damaged part
		10	Tightened condition of cable glands and monitoring receptacle	Retighten with tool	Make sure that they are firmly tightened
		11	Bolts for compressor, fans, and motors, etc. for fastening state	Retighten with tool	Make sure that they are firmly tightened
		12	Clearance between fan and fan guide	Visual	Eraporator fan : 5~9 mm Condenser fan : 3~7 mm
		13	Sealing at control box, and PS box, etc.	Visual	Packing and sealing should be intact
		14	Wire terminals for loosening correction	Visual, driver	
		15	Contact and/or coil of magnetic contactor for burning	Visual	
		16	Unit insulation resistance: Compressor circuit ☐MΩ	DC 500V megger	2MΩ or more
			Unit insulation resistance: Electric heater circuit ☐MΩ		
			Unit insulation resistance: Evaporator fan circuit ☐MΩ		
		17	Checking operation of oil pressure protection switch: CUT OUT ☐ kg/cm² / CUT IN ☐ kg/cm²	Tension gauge Timer	1.0 kg/cm² 110 seconds 0.5 kg/cm² (25°C)
		18	Supply voltage	Check line voltage at primary side of circuit breaker (main circuit)	Within ±10% of related voltage
Check during operation		19	Checking condenser and evaporator fan motors for vibration and noise	Touch and listen	
		20	Checking amount of circulating refrigerant	Check liquid indicator	Make sure that it is sealed
		21	Checking for water in refrigerant	Check liquid indicator	Deep blue
		22	Checking compressor oil level (operating condition)	Check compressor oil level gauge	⊖ (oil level 1/4 — 3/4)
		23	Confirm function of the recorder	Visual, listen	
		24	Checking operation of controller and pilot lamps	Pilot lamp, LED of controller	
		25	Checking manual defrosting operation	Manual defrost switch	
		26	Electric heater operation and current R☐ S☐ T☐	Clamp meter	
		27	Checking operation of defrost termination thermostat (Completing temperature) ☐°C	Mount thermistor to termination thermostat mounting position	OFF 7.2±1.7°C
		28	Unit operating current R☐ S☐ T☐	Clamp meter	−18°C ☐V ☐Hz

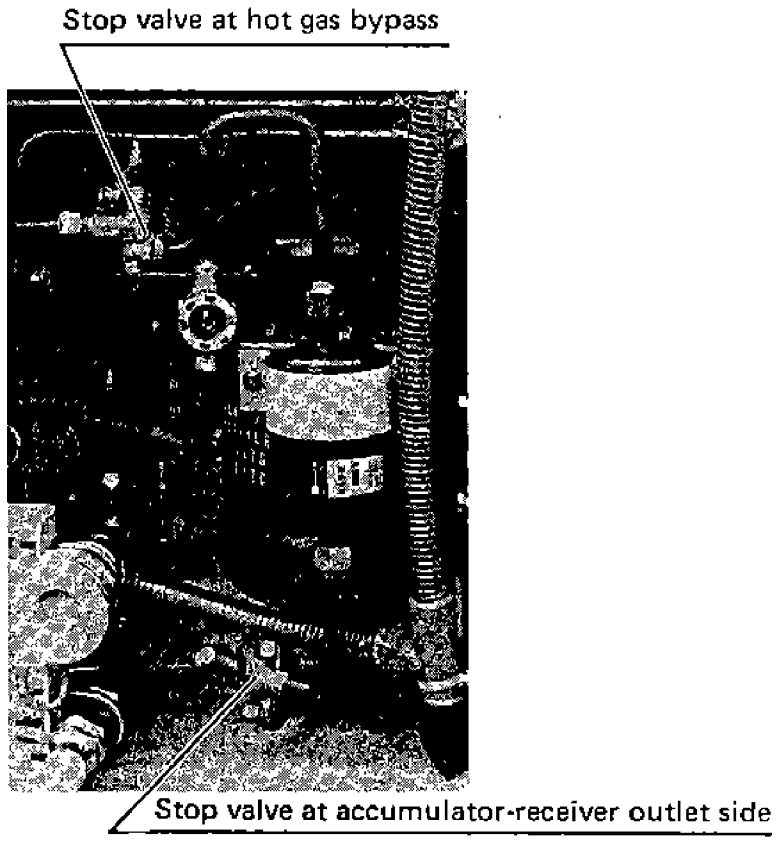
Check		No.	Check point		Check method	Reference value
Check during operation		29	Checking operation of dual pressure switch	H–CUT OUT ☐ kg/cm²	Blind air inlet	20 kg/cm²
				L–CUT OUT ☐ mm HgV	Accomplish pump down by use of the stop valve at the accumulator receiver outlet	400 mmHgV
				L–CUT IN ☐ kg/cm²		0.2 kg/cm²
		30	Checking operation of water pressure switch	Checking switchover from water-cooled to air-cooled operation	Disconnect water coupling	Condenser fan motor shall operate
				Checking switchover from air-cooled to water-cooled operation	Connect water coupling and supply water	Condenser fan motor shall stop
		31	Checking voltage selector	Checking 400V class operation	Place voltage selector lever upward	
				Checking 200V class operation	Place voltage selector lever downward	
		32	Inside temperature °C ☐	0°C	–18°C	Automatic operation at –18°C
			Ambient temperature °C ☐	☐	☐	☐ in one cycle
			LP kg/cm² ☐	☐	☐	☐ COMP OFF ☐ M
			HP kg/cm² ☐	☐	☐	☐ COMP ON ☐ M
			Operating time	Immediately after operation	Operation starting 0°C ☐ Hr ☐ M	Operation starting –18°C ☐ Hr ☐ M	Automatic operation at –18°C ☐ Hr ☐ M
			Operation starting time ☐ ☐			
		33	Checking automatic defrosting	Defrost time ☐ M		
Check after operation		34	Place new chart			
		35	Close caps for control box and PS box, etc.			
		36	Write down details of service on history cards			

9. How to maintenance

9.1 Handling method of the stop valve

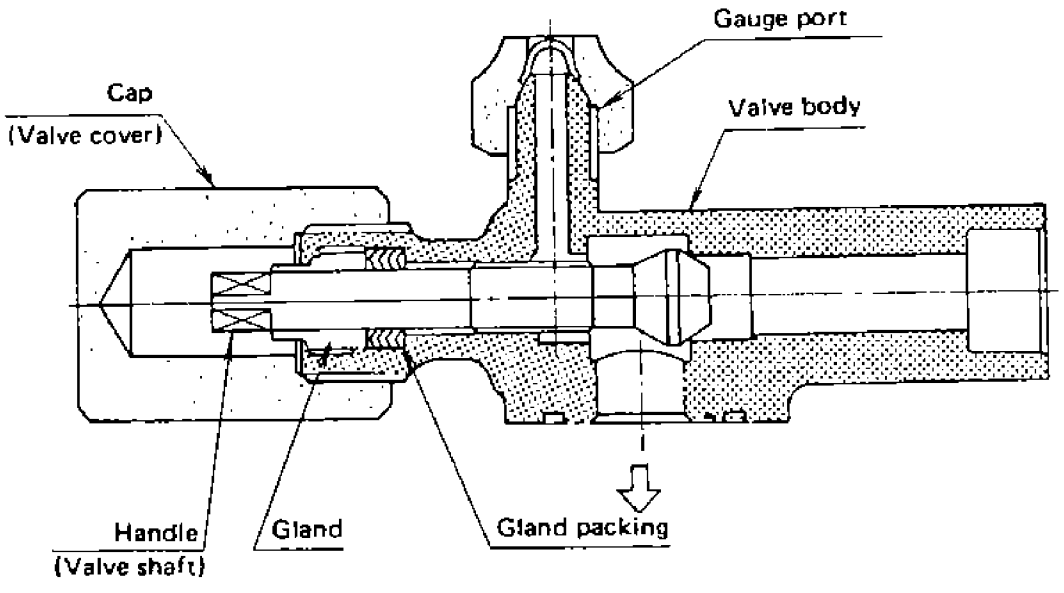
(1) Place of the stop valve and its kind



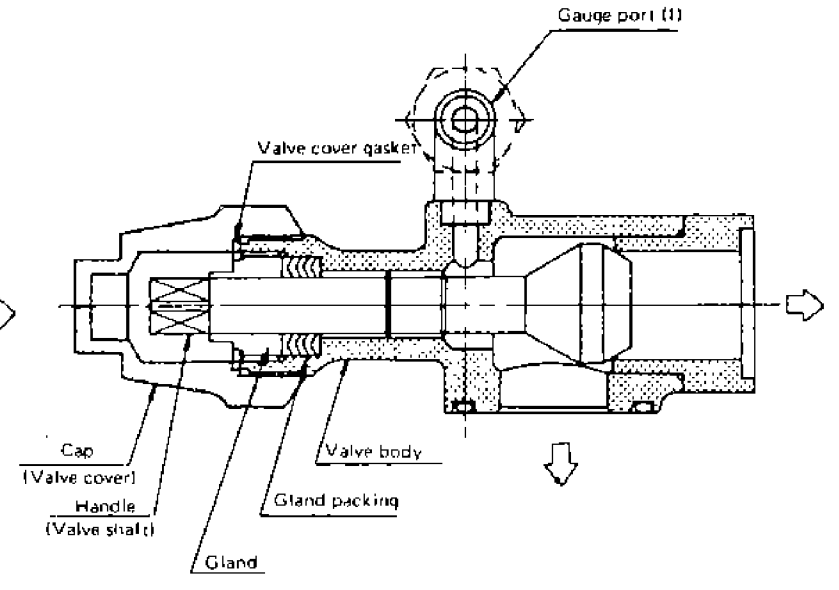


(2) Structure of stop valve

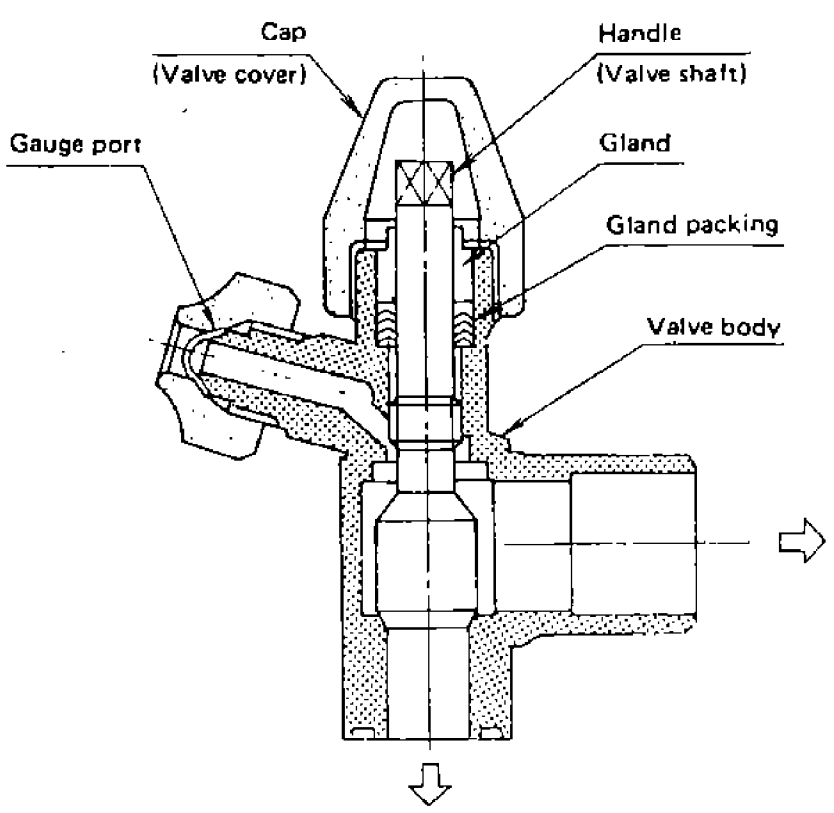
1 Stop valve at compressor discharge side (VSH10VAP-5S)



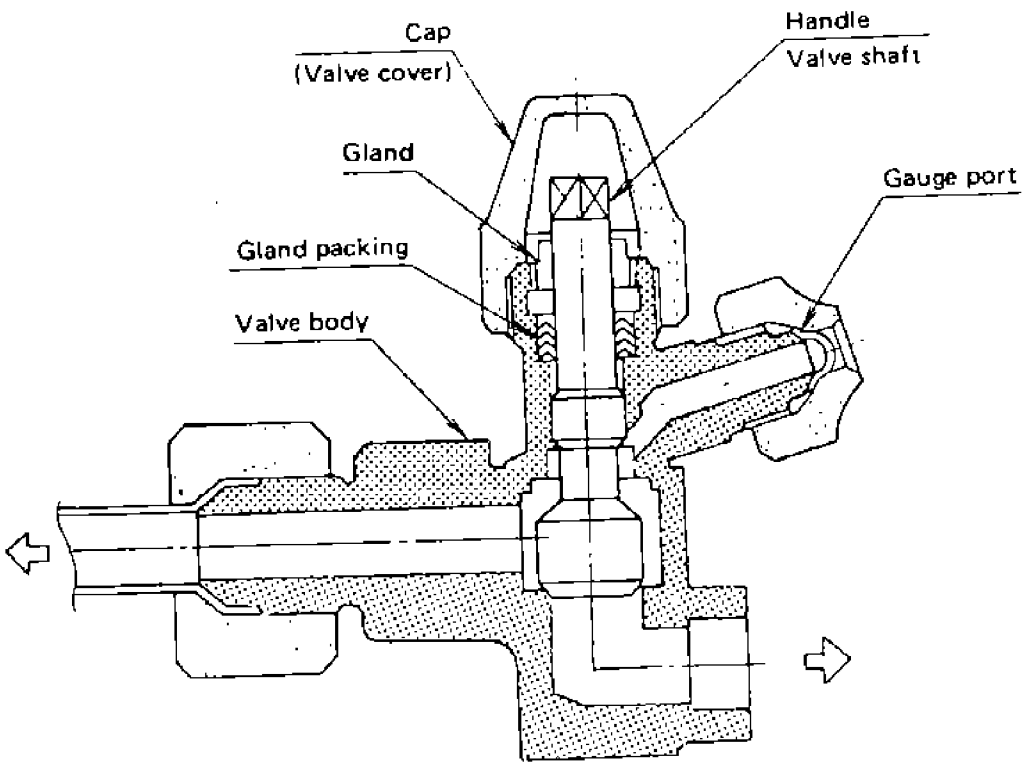
2 Stop valve at compressor suction side (VSH22XBP)



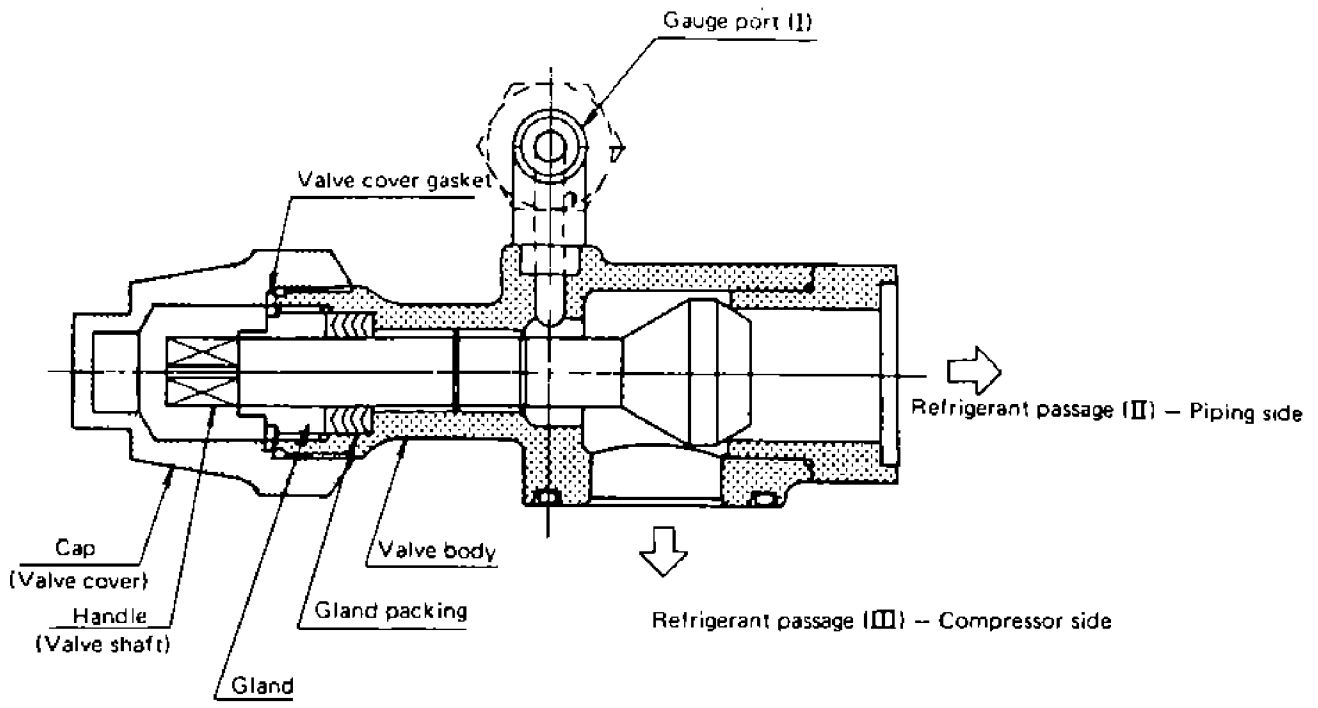
3. Stop valve at accumulator-receiver with heat exchanger outlet side (VSV10CB-4S)



4. Stop valve at hot gas bypass (VSV10CBP-4S-4F)



(3) Handling method

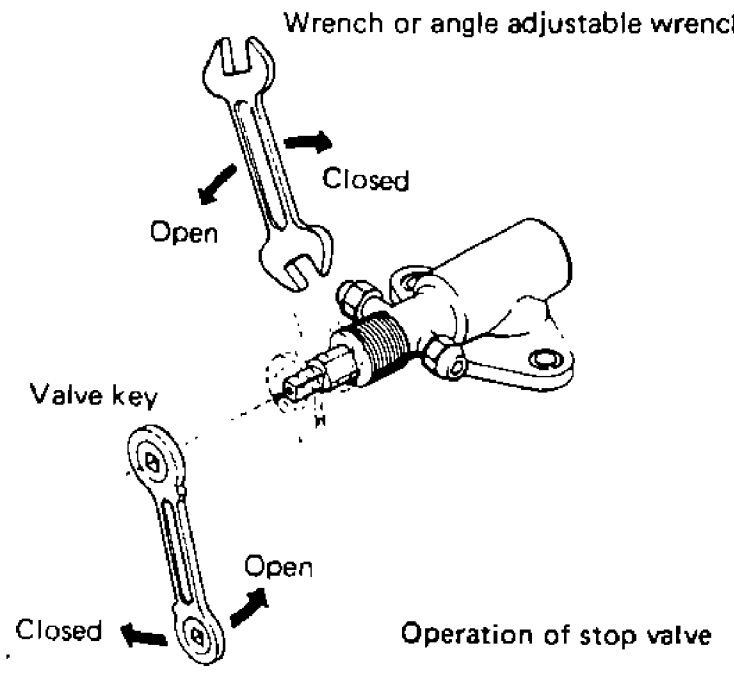


1) Remove the valve cap. At this time, be careful not to lose the gasket.
2) Loosen the gland in a way the refrigerant is not extracted.
3) Fully close the handle . . . . . .The refrigerant passage I is connected to III (Front seat)
4) Fully release the handle . . . . .The refrigerant passage II is connected to III (Back seat)
5) Set the handle at the neutral position . . . . . .The refrigerant passage I is connected to II and III.
6) The refrigerant passage differs with the procedure mentioned in 3, 4, or 5. So select the best passage by necessity.
7) Operate the handle, tighten the gland and place the valve cap as it was after completion of the work. At this time, do not forget to attach the gasket.

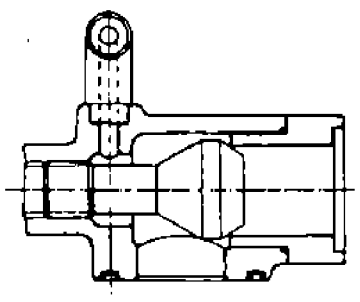
9.2 Attaching or removing points of pressure gauge

(1) Attaching a general pressure gauge

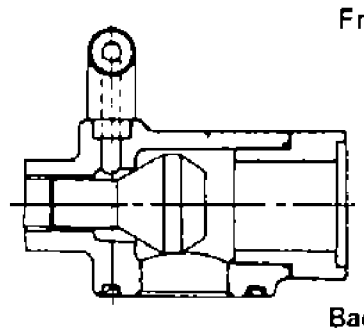
1) After opening the compressor suction valve and the accumulator-receiver valve fully (back seat), connect a pipe to the gauge port.
2) Loosen a little the flare nut on the pressure gauge side and tighten the handle of the stop valve a little (Middle seat) and return it at once. Thus the air is purged.
3) After purging the air, accurately tighten up the flare nut on the pressure gauge side.
4) Close the handle of the stop valve a little, and confirm that the needle of the gauge rises.
5) Be certain that the needle of the pressure gauge does not oscillate during the operation of the unit. If it oscillates, do not close the gauge port fully and open the handle of the stop valve a little.
6) In case the pressure gauge is attached to the low pressure side, if the low pressure is lower than the atmospheric pressure, the air is drawn in the piping during the air purging. So install the pressure gauge after confirming that low pressure is higher than the atmospheric pressure.
7) Operate the unit and confirm that the unit is stopped without pump down.



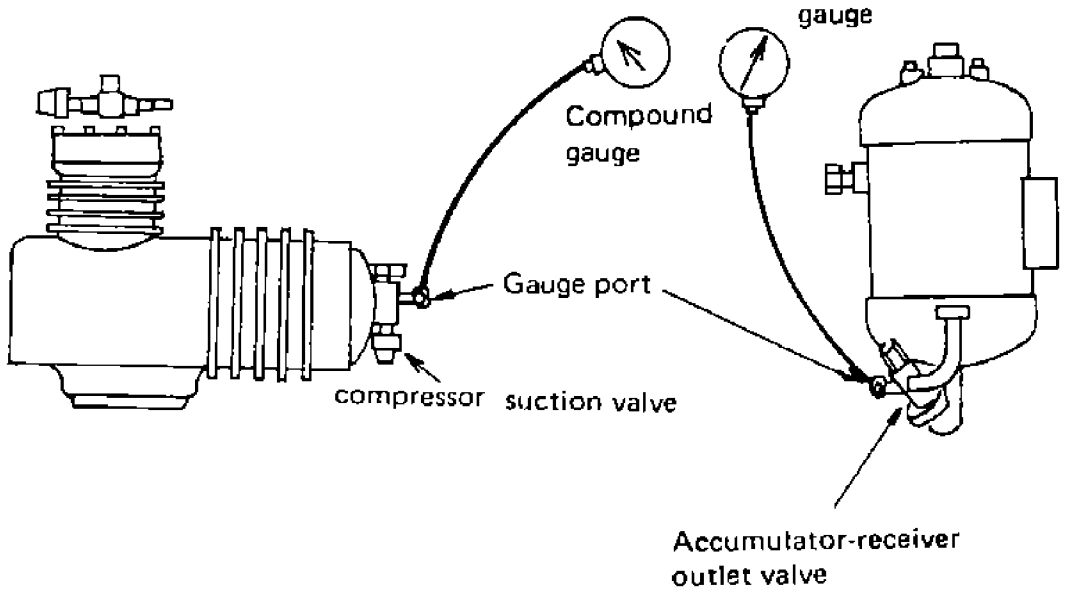
Operation of stop valve



Front seat

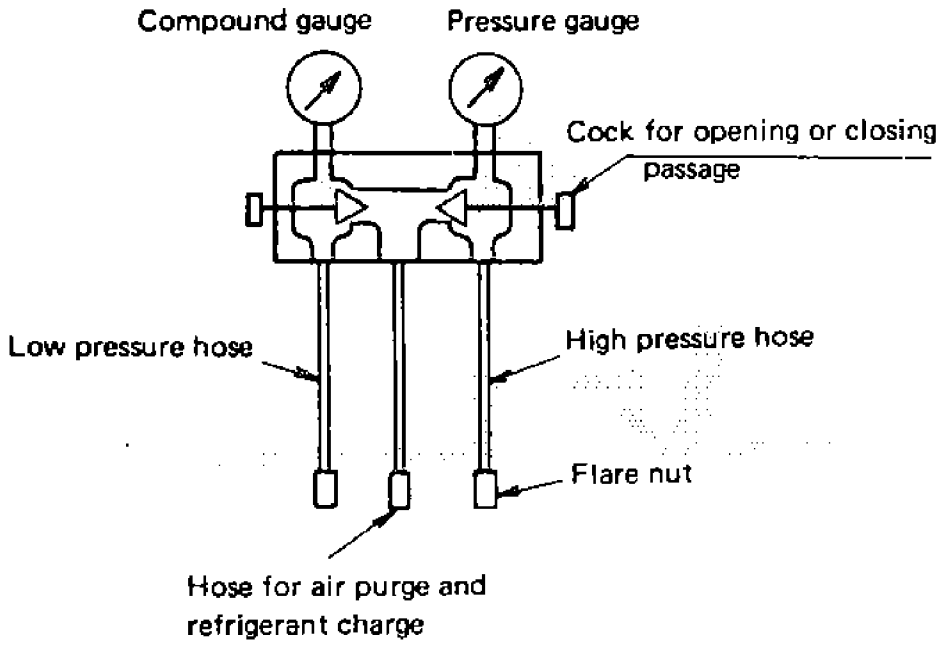


Back seat

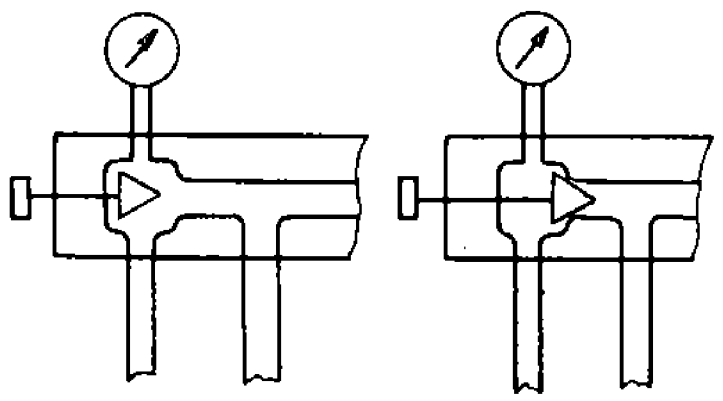


(2) Attaching the gauge manifold

1) With regard to mounting points, note the same caution as that for general pressure gauges.
2) Open the cocks which are attached to the both sides of the gauge manifold when mounting. Loosen the blind cover of the centre hose, and close the gauge port for the compressor suction valve and the accumulator-receiver outlet valve. (Back seat)
3) Attach the flare nut of the hose of the manifold on the high pressure side tightly and the on the low pressure side loosely.
4) Loosen the accumulator-receiver outlet valve and vent the air from the hose on the low pressure side and the centre hose and then once again keep the stop valve in the back seat state. After that tighten up the flare nut on the low pressure side.
5) After closing the cocks of the gauge manifold, keep the cock of the compressor suction valve and accumulator-receiver outlet valve at the neutral seat and measure pressure.



Structure of gauge manifold



Opening state Closing state

Opening and closing states of gauge manifold

(3) Removing the pressure gauge and the gauge manifold, as stated below.
When the high pressure hose is removed, note that the liquid refrigerant in the hose may jet out, which is very dangerous.

1) Hold the handle of the stop valve in the back seat state, and close the gauge port.
2) Open the cock (in care of gauge manifolds) or the flare nuts (in case of general pressure gauges) a little to extract the refrigerant from the hose. At this time, do not open it suddenly so as not to joint out liquid refrigerant.
3) After extracting the refrigerant from the hose, remove the pipe connection for the gauge piping.
4) Place the blind cover on the gauge port of the stop valve, accurately tighten up the flare nut and confirm no refrigerant leaks.

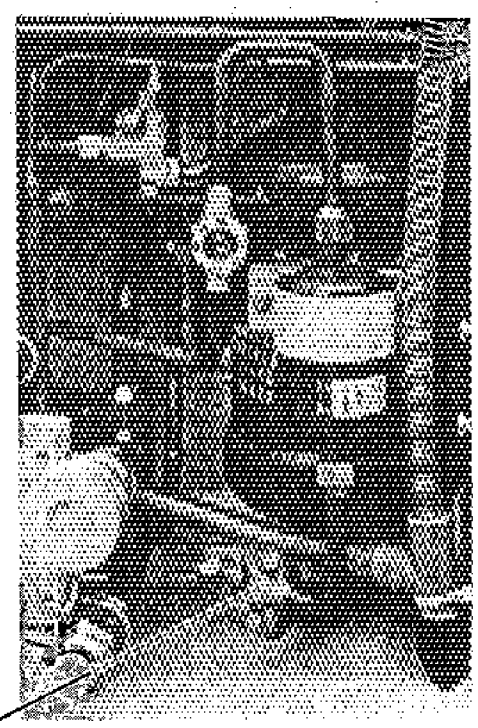
Note: Since the blind cover is very small, be careful not to loose it.

9.3 Pump down

Pump down means that the refrigerant in the refrigeration circuit is liquidized and collected in the Accumulator-receiver with heat exchanger. This work is required to repair the refrigeration circuit for minimizing leaking volume of the refrigerant and risks due to pressure rising.

< Working procedure >

1) Install pressure gauges to the high pressure side.
2) Operate the refrigeration unit (either on water cooled or air cooled operation)
3) Close the accumulator-receiver outlet valve.
4) Stop the operation when reading of the low pressure gauge becomes o.1 kg/cm^2 and close the compressor discharge valve.
5) After a short while, read the low pressure gauge. If pressure rises, open the compressor discharge valve and repeat the same procedure.
6) Repeat the same procedure two or three times, and the refrigerant is collected in the accumulator-receiver with heat exchanger. If no pressure gauge is attached, the unit is stopped by the low pressure setting of the dual pressure switch.



Stop valve at accumulator-receiver outlet side

9.4 Charging and purging the refrigerant

(1) Purging non-condensable gas

If non-condensable gas such as air exsits in the refrigeration circuit, it is collected by the accumulator-receiver with heat exchanger, which raise pressure in the accumulator-receiver with heat exchanger abnormally high and reduces heat transferring ratio of the condenser surface. It is, therefore, very important to extract non-condensable gas.
If discharge pressure is abnormally high (even though cooling water volume is increased, in case of water cooled operation) and will not return to the normal pressure, inspect if non-condensable gas such as air exsists in the following method.

- Stop the compressor, close the accumulator-receiver oultet valve and wait until leaving and entering cooling air (or water) of the air (water) cooled condenser become equal. If there is any difference between saturated pressure corresponding to cooling air (water) and condensing pressure, non-condensable gas exists.

In this case, purge non-condensable gas as stated below.

1) Accomplish pump down
2) Condense the refrigerant as much as possible, and then discharge it from the gauge port of the compressor discharge valve.
3) Discharge the condensed refrigerant repeatedly reading the pressure gauge until condensing pressure becomes saturated pressure.

(2) Refrigerant purge

There are two methods of refrigerant purge; i.e. one is for collecting the refrigerant extracted in a cylinder and the other is for discharging it to the atomosphere.

(a) Collecting the refrigerant in a cylinder

1) Prepare an empty cylinder which has been dried by forming vacuum inside and weigh it.
2) The cylinder is connected to the gauge port of the Accumu-receiver with heat exchanger by piping with the cylinder cock closed, and then loosen the flare nut on the cylinder side a little to vent the air from the piping.
3) Operate the refrigeration unit to pump down the refrigerant.
4) After completion of pump down, open the gauge port of the accumulator-receiver with heat exchanger and then open the cock of the cylinder to collect the liquid refrigerant into the cylinder.
5) After collecting the refrigerant, close the gauge port and the cock and then remove the piping.
6) Be certain that the refrigerant has been collected in the cylinder by weighing it.
7) As for the refrigerant remaining in the refrigeration circuit, extract it to the atmosphere.

(b) Extracting the refrigerant to the atomosphere

1) Open the gauge port on the suction side of the compressor to extract the gaseous refrigerant to the atmosphere.
2) Do not open the compressor discharge valve or the gauge port of the accumulator-receiver with heat exchanger, otherwise the refrigerant oil and the liquid refrigerant are discharged, which may result in shortage of oil or getting chillblains.
3) Do not extract the refrigerant in a closed room and also confirm there is no fire around it. Although the refrigerant is non-toxic, there may be fear of suffocation. In addition, if the refrigerant contacts with fire, it yields phosgene gas (toxic gas).

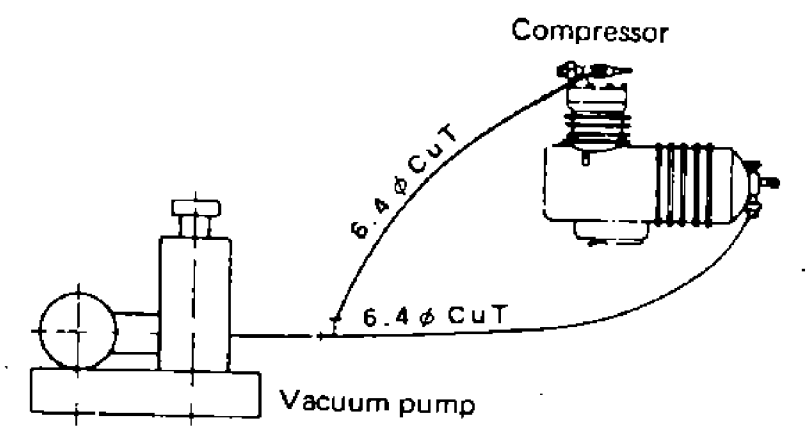
(3) Vacuum drying and charging refrigerant and refrigeration oil

If all the refrigerant has leaked out and the air is intermixed in the refrigeration circuit, repair a cause of trouble and do vacuum drying. Then charge the predesigned volume of refrigerant. In case the refrigerant oil is replaced, do the same.
(Required tools)

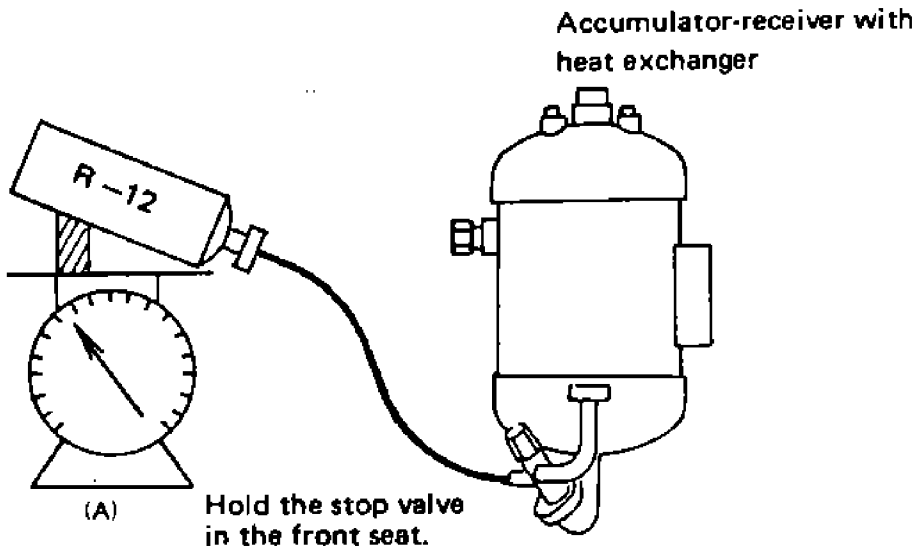
1. Refrigerant cylinder (20 kg) for R-12 (CCl_2F_2) with mouth piece
2. Refrigeration oil (20ℓ can) SUNISO 3GS-DI)
3. ϕ6.4 CuT (with two flare nuts)
4. Pressure gauge (20 kg/cm^2), compound gauge (10 kg/cm^2 x 75 cmHg) } or gauge manifold
5. Weighing scale (Up to 50 kg)
6. Tools
7. Vaccum pump

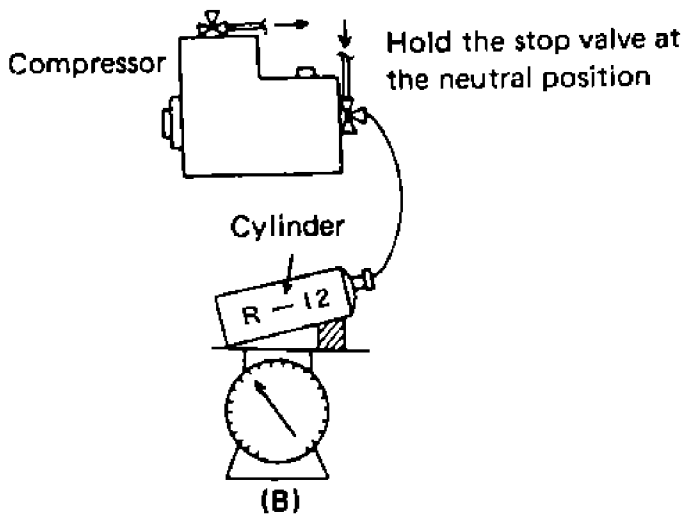
(a) In case the refrigerant is replenished without exchanging the refrigeration oil.

1) Connect the vacuum pump to the gauge ports of the compressor suction and discharge valves, form vacuum down to 76 cmHg, hold the stop valve in the back seat state and then remove the vaccum pump, leaving the vacuum state in the refrigeration circuit. However, when air enters in the refrigeration circuit, form the vaccum in the circuit down to 76 cmHg and leave it for more than 2 hours (vaccum drying).



2) To evacuate the refrigeration circuit between the solenoid valve and expansion valve, reduce pressure of the circuit below the preset level of the low pressure switch lower the presetting level of the set point selector, operate the refrigeration unit, and open the solenoid valve for evacuation. At this time (vacuum drying), the compressor remains idle since the low pressure switch is off, and the solenoid valve alone open.

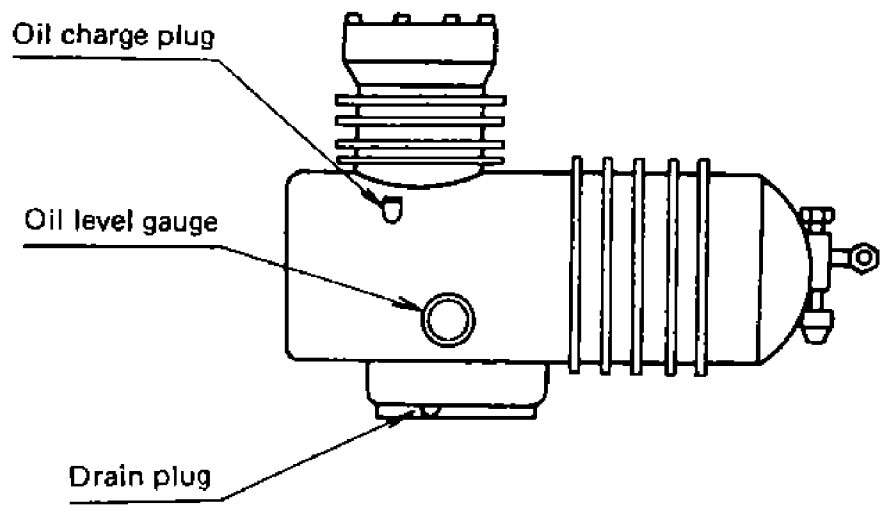




3) Place a refrigerant cylinder on the weighting scale, and record its weight.
4) In case the refrigerant is charged in the liquid state, do it as shown in the above figure (A). Prevent the liquid refrigerant collected in the accumulator-receiver with heat exchanger from flowing to the low pressure side. If the refrigerant is hardly charged, operate the compressor to charge it.
5) In case the refrigerant is charged in the gaseous state, do it as shown in the above figure (B). If the refrigerant is hardly charged, operate the compressor to charge it.
6) Charge the predesigned volume of the refrigerant in the above stated methods either in 4 or 5.
7) After completion of refrigerant charge, hold the stop valve in the back seat state and confirm that if the predesigned volume of the refrigerant has been charged by operating the refrigeration unit.

(b) Charging the refrigerant as well after replenishment of refrigerant oil

1) Extract the refrigerant oil. → Firstly discard all the gas so that pressure in the refrigerant circuit becomes 0. Then loosen the drain plug at the bottom of the compressor to extract all the oil. At this time, firstly open the oil charge plug and then the drain plug to prevent the oil from jetting out.



2) Tighten up the drain plug.
3) Charge the predesigned volume of the oil from the charge plug of the compressor.
4) Accomplish vacuum drying and refrigerant charge stated in (1).
5) Be sure to stop the compressor while this work is accomplished.
6) When the refrigeration oil is discarded, be sure to remove the oil level gauge for cleaning.
7) Recommendable refrigeration oil is SUNISO 3GS-DI. SUNISO 3GS – DI is superior to SUNISO 3GS in heat resistance.
   Maker of SUNISO 3GS – DI is SUN OIL CO., LTD. (U.S.A.)
8) Do not mix two refrigeration oils.
9) Do not use oil which is left opened to the atomosphere for a long time, as it may contain water. In case oil still remains in the oil can after charging, be sure to cap it.

(c) In case only the refrigeration oil is exchanged.

1) Operate the refrigeration unit to pump down the refrigerant by use of the accumulator-receiver outlet valve and stop it when low pressure becomes 0.1kg/cm_2.
2) Tighten up the discharge valve of the compressor.
3) Open the gauge port on the suction side to extract the refrigerant on the low pressure side.
4) Charge the oil from the oil charge plug. At this time, form the vaccum gradually to hasten oil charge.
5) Restore the stop valve to its original state.

PARTLOW TEMPERATURE CONTROLS

E549A OPERATING MANUAL

P/N 042 010 01

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OPERATING MANUAL

MODEL E549A MODULATING TEMPERATURE CONTROL SYSTEM FOR SEA CONTAINERS. ADAPTED TO DAIKIN INDUSTRIES LTD SYSTEM

Partlow's solid state Model E549A controller electronically actuates a modulating valve in this system to proportionally correct for minute variations in cargo container temperature. Three-mode PID adjustable control of cooling eliminates the sawtooth characteristic of on-off temperature control.

Six electro-mechanical relay outputs provide pilot control for bypass and hot gas solenoid actuation, compressor on-off switching, the high/low heat switching functions and the 24 VAC in range system indicator lights. A seventh relay energized by a separate device external to the E549A controls defrost.

All operational functions are schematically displayed on the control panel cover and monitored by LED indicators (Fig. 1).

The unit controls temperature between –29.9°C and +29.9°C with thumbwheel selection of setpoint. Input RTD sensors reflect return air and supply air temperature, with automatic control provided by the lower-temperature sensor. Return air temperature is digitally displayed, with pushbutton provision for momentary display of supply air temperature on the same panel.

1 Control Specifications

1.1 Specifications

(1) Input Spans . . . . . Resistance temperature detectors; input signal from a 2-wire RTD with nominal resistance of 1000 ohms at 0°C, platinum element with temperature coefficient of .000385 ohm / ohm/°C.

Input impedance: 1.5 megohms typical, 300K ohms minimum.

(2) Setpoint . . . . . Thumbwheel: Accuracy ±1.0% of span (typical). Resolution 0.1°C.

(3) Display . . . . . LED Digital: Accuracy ±1.0% of span to nearest 0.1 digit from 0 to 55°C ambient ±2% –40 to 0 and 55 to 70°C ambient 0.3" character size.

1.2 ON-OFF Switching Points

	°C	Controller Output Modes
(1) Falling Temperature		
Compressor Output Closed	———	Full Cool
Hot Gas Valve Output Closes	+2.5°	Partial Cool
Bypass Output Closes	+2.0°	Partial Cool
Modulation On	Varies	Partial Cool
Compressor Output Opens	S.P.	Null
Heat I Output Closes	–1.0°	Low Heat
Heat II Output Closes	–2.0°	High Heat
(2) Rising temperature		
Heat II Closed	———	High Heat
Heat II Opens	–1.5°	Low Heat
Heat I Output Opens	–0.5°	Null
Compressor Output Closes	S.P. & Null	Partial Cool
Bypass Output Opens	+2.5°	Partial Cool
Hot Gas Output Opens	+3.0°	Partial Cool
Modulation Off	Varies	Full Cool
Compressor Output Remains Closed	———	Full Cool

1.3 Electro-Mechanical . . . . . 24VDC coil, 10 amps 125/250 VAC contact.

(1) Modulating Output . . . . . 0 to approx. 1.3 amps, 13.1 VDC variable with mod. valve coil temperature.

(2) Control Adjustments . . . . . **Gain (Proportional Band):** Adjustable from 2 to 50 (proportional band 50 to 2%).

Integral (Auto Reset): Adjustable from off to 1 repeat per minute. Reset windup inhibition prevents automatic reset from contributing to overshoot on initial startup, cooling only.

Derivative (Rate): Adjustable from .01 to 3 minutes.

1.4 Control panel (Fig. 1)

(1) Thumbwheel Setting — Select desired setpoint from –29.9°C to +29.9°C. Mechanical stops installed to prevent exceeding these limits.

(2) Temperature Digital Display — Normally displays return air temperature; (supply air temperature momentarily displayed by depressing pushbutton). Display flashes if temperature exceeds approximately ±31.0°C. All digits flash together.

(3) Probe Control Switch (3-position) — Positioned **left**, unit operates from the **return air** probe. Positioned **right**, unit operates from the **supply air** probe. **Centered**, on **Auto**, unit operates on lower temperature of supply or return air. Tie wire sealing provision is standard.

(4) Null Range Setting (10 position) — Expands upper limit of temperature null range (compressor on) from set-point to 9°C above setpoint in 1°C increments. Stop provided between 9°C and 0°C. Tie wire sealing provision is standard.

(5) Display indicators (16 LEDs)

- **Controlling on supply air** (RED) — supply air RTD voltage used for control.
- **Controlling on return air** (RED) — return air RTD voltage used for control.
- **Full cool** (YELLOW) — cooling, compressor on without attenuation of bypass, hot gas or modulating valves.
- **Partial cool** (YELLOW) — cooling, compressor attenuated by hot gas valve.
- **Modulation** (RED) — cooling, compressor attenuated by modulation valve.
- **Null** (YELLOW) — neither cooling nor heating is active.
- **Heat I** (RED) — Heater I is on.
- **Heat II** (RED) — Heaters I and II are on.
- **Temperature range high** (RED) — controlling temperature is higher than setpoint **plus 2°C or null range setting, whichever is greater.**
- **Temperature in range** (GREEN) — controlling temperature is no higher than 2°C above setpoint, or null range setting, whichever is greater or no lower than setpoint minus 2°C.
- **Temperature range low** (RED) — controlling temperature lower than setpoint minus 2.0°C.
- **Cooling** (YELLOW) — compressor is activated.
- **Heat on** (RED) — Heater I is activated.
- **Defrost** (YELLOW) — compressor off; Heat I and Heat II are activated.
- **Return air** (RED) — return air temperature is displayed on the digital LED readout.
- **Supply air** (RED) — supply air temperature is displayed on the digital LED readout when pushbutton is actuated. Note correct display is not instantaneous, allow indication to stabilize.

1.5 Relay Functions (Figs. 3, 5 and 6) Referenced LED's are on relay plate.

(1) Compressor Relay (K1) Normally Open
Circuit closes across TB3-4 and TB2-1 and relay pack LED actuates when compressor relay coil is energized. When cooling need is satisfied and K1 contacts are signalled to open, there is incorporated an integral 70 sec. (50 to 75 sec.) time delay. Only upon completion of the time delay will compressor turn off. Note that 75 sec. must be allowed before a new time delay period can be initiated.

(2) Hot Gas Relay (K2) Normally Open
Circuit closes across TB3-1 and 3 and LED actuates when hot gas relay coil is energized.

(3) Bypass Relay (K3) Normally Open
Circuit closes across TB3-1 and 2 and LED actuates when bypass relay coil is energized.

(4) Heat I Relay (K4) Normally Open
Circuit closes across TB3-7 and 9 and LED actuates when Heater I relay coil is energized.

(5) Heat II Relay (K5) Normally Open
Circuit closes across TB3-7 and 8 and LED actuates when Heater II relay coil is energized.

(6) In Range Relay (K6) Normally Open
Circuit closes across TB3-5 and TB2-2 and LED is actuated when temperature is within setpoint plus null setting range, or setpoint plus 2°, whichever is greater.

(7) Defrost Relay (K7)
Provided by an input external to the temperature controller; one set of contacts provides a signal (open or ground) to the controller logic.

1.6 Printed Circuit Board Functions (See Fig. 2 for location in controller)

(1) RTD PCB (046, 019, 06)
Replacement requires precalibration by factory. See replacement parts list or use of (046, 019, 06) calibration procedure which follows.

- Detection of resistance change of supply air RTD and return air RTD.
- Generation of minus 5 volt reference.
- Development of setpoint voltage.
- Development of ± error voltage.

(2) PID PCB (046, 021, 06)
Replacement requires precalibration by factory. See replacement parts list or use of (046, 021, 06) calibration procedure which follows.

- Development of controlled error (±CE). Error output is normal unless setpoint is –7°C or less. When either freeze mode or probe error occur, controlled error goes to minus 15V.
- Development of bypass signal.
- Development of hot gas signal.
- Development of 200 Hz with variable duty cycle.

(3) Analog PCB (046, 027, 05)
- Provision for expansion of null range above setpoint for temperature rise.
- Selection of lower-temperature probe — supply air or return air — for temperature control.
- Indication of which probe is in control.
- Selection of return air control when in freeze mode.
- Detection of sign change for ±°C digital display.
- Detection of an open or shorted probe and provision for selection of alternate probe through probe control switch.

(4) Logic PCB (046, 026, 05)

- Detection of null.
- Detection of Heat output #1
- Detection of Heat output #2
- Indication of in range, over range above setpoint plus null setting, and under range below setpoint minus 2°.
- Generation of null mode upon detection of a bad probe.
- Generation of defrost mode when defrost relay is activated.

(5) Display Driver and Power Supply PCB (046, 025, 06)

Replacement requires precalibration by factory. See replacement parts list or use of (046, 025, 06) calibration procedure which follows.

- Conversion of analog probe temperature to digital drive for 3 digits of the 4-digit display (± driven by analog PCB assembly 046, 027, 05).
- Detection of out-of range or bad probe signal.
- Provision of power for all controller relays, the modulating valve and electronics.

(6) LED Indicator PCB (046, 023, 05)

- Contains the following LED indicators:

– L1	(RED)	Control Supply Air
– L2	(RED)	Control Return Air
– L3	(YELLOW)	Fill Cool
– L4	(YELLOW)	Partial Cool
– L5	(RED)	Modulation
– L6	(YELLOW)	Null
– L7	(RED)	Low Heat – Heater I on
– L8	(RED)	High Heat – Heater II on
– L9	(RED)	Display Supply Air
– L10	(RED)	Display Return Air
– L11	(YELLOW)	Defrost
– L12	(RED)	Heat on
– L13	(Yellow)	Cooling – Compressor
– L14	(RED)	Out of Range – Below
– L15	(GREEN)	In range
– L16	(RED)	Out of Range – Above

(7) 4-Decade Display (046, 022, 05)

- Normal display of return air temperature.
- Momentary display of supply air temperature when pushbutton is depressed. **NOTE:** Display is not instantaneous. To provide display stability, some time delay is used in circuitry. It is therefore necessary to keep pushbutton depressed long enough for display to reach actual temperature as seen by essentially steady reading.
- Generation of flashing display when required.

2. Functional Description

2.1 Chill Mode Temperature Drop — Always Controls On Lower Temperature Probe In Auto Select Position. Stated Temperatures Are Nominal.

(1) Full Cool

Lower temperature probe is above setpoint and above upper limit of modulated proportional band.

- Normally-open compressor relay contacts are **closed**, calling for compressor on.
- Modulated control valve current is at **minimum** output, maintaining control valve to full open position.
- Normally-open bypass contacts are **open**, calling for bypass valve **open**.
- Normally-open hot gas relay contacts are **open**, calling for hot gas valve **closed**.

(2) Modulated Control Range:

Lower sensed temperature drops to within upper limit of the modulated control range (proportional range).

- The normally open hot gas valve closes and with continued approach to setpoint, modulated control valve current **increases** with decrease in sensed temperature at lower temperature probe, thus modulating cooling capacity.
- Automatic reset begins to shift the proportional band in the direction of setpoint.
- Rate control adds correction, which minimizes overshoot on initial pull-down and load/setpoint changes.
- Normally open suction bypass relay contact closes.

(3) Null

Lower (supply or return air) temperature drops to setpoint after approx. seventy second time delay.

- Normally-open compressor relay contacts **open**, calling for compressor **off**.

(4) Heat I

If lower sensed temperature drops to Null $-1^{\circ}C$.

- Normally-open Heat I relay contact **closes**, calling for half of available heat **on**.

(5) Heat II

If lower sensed temperature drops to Null $-2^{\circ}C$.

- Normally-open Heat II relay contact **closes**, calling for remaining half of available heat **on**.

2.2 Chill Mode Temperature Rise

(1) Heat II

Lower sensed temperature is below Null $-2^{\circ}C$.

- Normally-open Heat I and Heat II relay contacts are **closed**, calling for **full heat**.

(2) Heat I

Lower sensed temperature rises to Null $-1.5^{\circ}C$.

- Normally-open Heat II relay contact **opens**, calling for **half** of available heat **off**.

(3) Null

Lower sensed temperature rises to setpoint $-5^{\circ}C$.

- Normally-open Heat I relay contact **opens**, calling for remaining half of available heat **off**.

(4) Null Termination

Lower sensed temperature rises to setpoint plus null range switch setting.

- Normally-open compressor relay contact **closes**, calling for compressor on. External (from E549A) 6 minute time delay may inhibit actual compressor start.
  Control re-enters the modulated, or full cool, range depending on the null range switch setting. The modulating valve is continuously positioned even during compressor-off periods.

2.3 Modulation Characteristics

Modulated band is biased so that the minimum modulated valve position occurs at setpoint, if the auto reset and rate corrections are zero. Under dynamic conditions, however, auto reset and rate corrections may not be zero, with the possibility that the modulated control valve position could be greater than minimum when setpoint is reached.

2.4 Frozen Mode

For setpoint settings of $-7^{\circ}C$, or less, control valve modulation, bypass, hot gas and heat switches are inhibited. Control valve is maintained at **full open** position; compressor functions as in the chill mode (no heat).
Controller outputs function in response to sensed temperature at only the **return air** probe for setpoints of $-7^{\circ}C$, or below.

2.5 Defrost Mode

The defrost mode is remotely activated. When the defrost cycle is energized, a pair of normally-open defrost relay contacts **close**. When the defrost cycle is sensed, the normally-open compressor relay contact **opens**, calling for compressor **off**, and the normally-open Heat I and Heat II relay contacts **close**, calling for **full** heat.

2.6 Setpoint

Setpoint settings are restricted to within the range of $-29.9^{\circ}C$ to $+29.9^{\circ}C$ by mechanical setpoint end stops.

2.7 Digital Temperature Display

The digital temperature display continuously shows temperature at the **return air** probe to reflect temperature being recorded by the Model TRUW incorporated in this system. Supply air temperature is momentarily displayed on the same panel when the supply air pushbutton is depressed and enough time permitted for the new reading to settle out.

2.8 Probe Select Switch

The probe select switch permits choice of controller response to supply air probe, return air probe or lower-temperature probe (auto), except for frozen mode operation at setpoints below $-7^{\circ}C$.

2.9 In Range Relay

The in range relay is energized by the controller whenever the temperature at the controlling probe is between setpoint minus 2° and setpoint plus 2° or null range switch setting, whichever is greater.

2.10 Probe Failure

The controller assumes a probe failure when the sensed temperature at either probe is $-46^{\circ}C$, or less, or higher than $74^{\circ}C$. Shorted or open probe circuit hence will be detected as equivalent resistance values will be outside this range. (Temperatures are approximate.)

2.11 Access

Loosen two captive screws at top and bottom of **right** side of hinged front panel, Fig. 1, and swing panel open. This provides access to rear wall-mounted transformer, printed circuit board assemblies and probe simulator switches. Five PCB assemblies are removable after removing bottom plate. Boards are keyed to prevent insertion into incorrect positions.

2.12 Wiring

Make electrical connections according to terminal board and input power wiring diagrams in Fig. 3.

3. Pre-Calibration Check

Two spring-loaded switches, labeled **Return** and **Supply**, are shown in Fig. 4. Each switch has three positions: 1) Center position for actual probe temperature sensed; 2) Forward position simulating 0°C (32°F), and; 3) Back position simulating –17.8°C (0°F).

3.1 To Check Accuracy of the LED Process Display:

(1) Turn panel-mounted probe control switch to **return** air.

(2) Hold return air probe simulator switch at 0°C

(3) LED process display should indicate 0°C ±6°C.

(4) Hold return air probe simulator switch at –17.8°C.

(5) LED process display should indicate –17.8°C ±.6°C.

(6) Turn probe control switch to **supply** air.

(7) Hold supply air probe simulator switch at 0°C.

(8) Depress supply air pushbutton; LED process display should indicate 0°C ±.6°C.

(9) Hold supply air probe simulator switch at –17.8°C.

(10) Depress supply air pushbutton; LED process display should indicate –17.8°C ±.6°C.

3.2 To Check Accuracy of the Thumbwheel Setpoint:

(1) Turn probe control switch on front panel to **supply air.**

(2) Set thumbwheel setpoint to –5°C.

(3) Set null switch to 0°C.

(4) Hold supply air probe simulator at 0°C, which should actuate YELLOW **full cool** and **cooling** LED on RED temperature **high** and controlling on **supply air** LED on.

(5) Continuing to hold supply air probe simulator switch at 0°C, increase setpoint until YELLOW **partial cool** LED comes on at –2.5°C ±.6°C. Further increase setpoint until RED **modulation** LED comes on and YELLOW **full cool** goes off. This should be at –1°C±.6°C.

(6) With supply air probe simulator still at 0°C, increase setpoint until YELLOW **null** LED comes on and YELLOW **cooling** and RED **modulation** go off. This should occur at 0°C ±6°C.

(7) Increase setpoint until the RED **low heat** and **heating** LEDs come on at +1°C ±6°C.

(8) Further increasing setpoint until RED **high heat** LED comes on at +2°C ±6°C.

4. Calibration Procedure

Calibration adjustments are located on the **RTD (046, 019, 06)** and **Display Driver & Power Supply (046, 025, 06)** circuit boards, as shown in Fig. 2. Refer to Fig. 2 for all trimpot and test point locations in the following procedures:

Equipment Needed: 2 RTD Simulators (part number Y550A)
1 Digital Multimeter

- **Display Driver & Power Supply (046, 025, 06)**

Meter to:
TP3 adjust R27 for +15 VDC
TP2 adjust R21 for +5.000 VDC
TP4 adjust R28 for –15 VDC

4.1 RTD (046, 019, 06) Board

(1) Turn pots R3 and R4 fully counterclockwise.

(2) Connect milliammeter to TB-1 terminals 5 (black lead) and 4 (red lead) for **return air**, and TB-1 terminals 2 (black lead) and 1 (red lead) for **supply air**. See Fig. 5.

(3) Adjust R6 (return air) and/or R1 (supply air) until the milliammeter reads –2.00 milliamps.

(4) Connect RTD simulator(s) to TB-1 terminals 5 and 4 (return air) and 2 and 1 (supply air).

(5) Adjust the simulator (s) to 882.10 ohms (–29.9°C.), thumbwheel setpoint to –29.9°C.

(6) With voltmeter red lead on TP5 (return air), black lead on TPC (TP5) of the power supply/display driver board, adjust R5 until voltmeter reads 0.000 VDC.

(7) With voltmeter red lead on TP3, adjust R2 to read 0.000 VDC.

(8) Adjust simulator (s) to 1116.30 ohms (+29.9°C.), thumbwheel setpoint to +29.9°C.

(9) With red lead on TP5, adjust R4 to read +10.000 VDC.

(10) With red lead on TP3, adjust R3 to read +10.000 VDC.

(11) Repeat Steps 5 through 10 until all readings are correct.

(12) Adjust simulator (s) to 1000.00 ohms (0°C.).

(13) Set thumbwheel setpoint to 00.0°C.

(14) With red lead on TP7, adjust R7 to read –5.000 VDC.

(15) With red lead on TB8, adjust R8 to read 0.000 VDC.

4.2 Display Driver & Power Supply (046, 025, 06)

NOTE: The RTD board must be calibrated **before** this board.

(1) Turn R3 fully counterclockwise.

(2) Adjust the simulator to 1000.00ohms(0°C.).

(3) Connect red lead on voltmeter to TP1 and black lead on TPC (TP5).
Record reading after allowing one minute to stabilize. NOTE: This reading will be approximately zero; differences can be either positive or negative. Observe polarity in Step 5, below.

(4) Adjust the simulator to 1116.30 ohms (+29.9°C), thumbwheel setpoint to +29.9°C.

(5) With red lead on TP1, adjust R3 to read –0.3, plus reading obtained in Step 3.

(6) Repeat Steps 2 through 5 until no adjustment is necessary.

(7) Adjust R6 until LED display reading equals +29.9°C.

(8) Adjust thumbwheel setpoint to 0°C.

(9) Switch Y-550A's to variable mode and set temperature dial (Y550A's) to approximately +1°C.

(10) Slowly decrease return air on Y550A until minimum DC volts reading is obtained at TP1.

(11) Adjust R7 until LED display reading equals +00.1°C.

(12) Repeat steps 7 through 11 no further adjustments are necessary.

4.3 Output Adjustments PID (046, 021, 06) Board

The following adjustments should be made for optimizing system functioning. They are not intended for routine use in pre-tripping or calibration:

• Proportional Band (Gain)	R1	To increase	Turn Clockwise
• Auto Reset (Integral)	R7	To increase	Turn Clockwise
• Rate (Derivative)	R5	To increase	Turn Clockwise
• Hot Gas Solenoid	R4	To raise	Turn Clockwise
• Bypass Solenoid	R3	To raise	Turn Counterclockwise

5. Trouble-Shooting

- To remove one or more circuit board assemblies, first remove bottom retainer plate. Boards can then be withdrawn on a downward pull from connector plate. Make sure retainer plate is replaced when circuit board changes have been made.
- Relay replacement: Release wire retainer yoke, unplug relay from socket. Be sure retainer wire is snapped in position on replacement relay.

5.1 Power Supply

Check voltage to primary of control transformer. Voltage should be between 17 and 28 VAC.

- Check voltage from center tap on secondary (output) side of control transformer to each of the remaining two secondary output terminals of the transformer. Voltage should be 24 VAC nominal for each measurement.
- Check plug connector from transformer secondary to printed circuit board in position P5 to insure that it is properly connected (Fig. 4), (center, unoccupied connector).
- If above checks fail to resolve the problem, disconnect plug connectors from power supply board in position P5 and replace circuit board; re-install plug connectors. Be sure to review calibration procedure on the new board for proper adjustment of temperature display driver trimpots R3, R6 and R7 (page 15).
- If all field efforts fail to identify the problem, replace controller and return malfunctioning instrument to The Partlow Corporation, New Hartford, New York, 13413 USA.

5.2 Control Sequencing and Output

Since the E549A front panel provides extensive visual indication of the controller's operational status, an evaluation of the front panel System Mimic display should be the first step in analyzing controller problems.

In addition to the system Mimic display, LEDs on the relay tray identify which relays are energized so that the repair technician can readily determine if the problem is with the controller, the output device or wiring external to the instrument.

A review of the controller sequence for temperature fall and rise cycles in both chilled and frozen (below –7°C set-point) modes should be made. Controller output status during each phase in the sequence is shown in Fig. 6.

5.3 Probe Fallure

A probe failure is assumed when sensed temperature at either probe is –46°C, or less, or above 74°C. A probe failure shuts off the compressor and puts the controller output in the null mode. Identification of the failed probe is made reference to the following guide.

Digital Ind.	Return LED	Supply LED	Controller Output	Probe Condition
OK★	Off	On	Null	Supply Air Short
OK★	On	Off	Null	Supply Air Open
Flashes	On	Off	Null	Return Air Short
Flashes	Off	On	Null	Return Air Open

★ Depress temperature display pushbutton, Digital Temperature Display flashes.

If in "Auto," controller will enter Null condition should either probe fail. Using above table, operator may select remaining good probe manually and resume control.

6. E549A Trouble-Shooting Guide

Symptoms	Possible Causes	Corrective Action
No front panel LES's lit.	No power to the controller	Check for 24 VAC to controller transformer primary (See Fig. 7).
No temperature display indication	Possible open transformer	Check controller transformer secondary for 48 VAC across the two outer most secondary terminals (yellow cable wire).
		If no output replace transformer.
	Bad cable connection from transformer to controller	Check to see that cable is properly attached to transformer per Fig. 7 and that other end of cable is securely plugger into J2 power supply/ display driver circuit board. Ref. Figs. 2, 7.
		Inspect transformer cable for damage or faulty termination crimp. Replace cable if necessary.
	D.C. Power Supply failure	Check for +15 and –15 VDC at test points TP3 and TP4 respectively of Power Supply/Display Driver Circuit board with common lead of D.C. voltmeter connected to test point TPC (TP5) (See Fig. 7).
		If no +15 VDC is measured at TP3 check cable connection from +15V voltage regulator to plug connector J4 (green) of Power Supply/Display Driver Circuit Board (See Fig. 7).
		Replace +15V. regulator.
		Replace Power Supply/Display Driver Circuit Board.
No Modulation Output	Failed Darlington valve driver	Check cable connection from valve driver assembly to plug connector J1 of Power Supply/Display Driver Assembly.
		Replace valve driver.
No Modulation Output, Cont'd.	PID Circuit Board Malfunction	Replace PID Circuit Board
	RTD Circuit Board Malfunction	Replace RTD Circuit Board
No Relay Switched Output	Bad cable connection from power supply to relay circuit board	Check relay circuit board cable connection to J3 (red) connector plug of Power Supply Driver Circuit Board.
		Check for –24VDC across the terminals of connector J3 (red).
	Incorrect of faulty external wiring to controller terminal blocks	Verify external wiring connections per Fig. 3 are correctly wired and securely fastened to the terminal block.
		Inspect external wiring for damage or faulty crimp at wire terminations.
	Faulty Relay	Inspect relay circuit board to insure all relay are securely installed in their sockets.
		Check relay indicator LED associated with faulty output. If LED is ON, relay is ON.
		If relay LED is ON, relay maybe faulty. Replace relay.
	Logic Circuit Board Malfunction	Replace logic circuit board.

Symptoms	Possible causes	Corrective action
Relay Output on all the time.	Contacts shorted or welded together	Replace relay.
	Output snubber capacitor shorted	Replace relay circuit board.
	Relay Control Circuit Fault	If relay indicating LED is **ON** continuously, replace **PID** circuit board. If output fault is associated with the **partial cool** (hot gas) or **bypass** output functions, replace logic circuit board if output fault is other than **partial cool** or **bypass.**
Relay Output on all the time, cont'd.	Shorted internal control wiring between circuit board card cage module and relay board.	Inspect wiring circuits, connectors and circuit board paths for shorts.
Incorrect temperature indication	Faulty sensor probe	Check for proper indication with simulator switch held in 0°C or −17.8°C position. Replace probe.
	Fault in sensor internal control wiring	Inspect internal wiring circuit.
	Bad probe simulator switch	Replace probe simulator switch.
	Control out of calibration	Re-calibrate.
	Faulty power Supply/Display Driver Circuit Board.	Replace Power Supply/Display Driver Circuit Board.
	Faulty RTD Circuit Board	Replace RTD Circuit Board.

7. Start-Up Procedure

Upon application of power, it is normal for the relays and the front panel LED's to momentarily actuate.

7.1 Setpoint Selection

Setpoint is selected between −29.9°C and +29.9°C on a thumbwheel setting station located center left on the control panel. Thumbwheel movement may cause relay and front panel LED actuation.
Above the setting station is a °F/°C temperature conversion table.

First, set plus or minus on the far left thumbwheel. Then, set in desired setpoint temperature on the two middle thumbwheels. The fourth thumbwheel provides refinement of setpoint temperature of 0.1°C.

The four-segment LED panel beneath the thumbwheel setting assembly displays the plus or minus sign and temperature to the nearest 0.1°C as reflected by either RTD sensor in the temperature-controlled carge area.
(Note: Transient operation of LED's & relays is normal when thumbwheel is moved.)

7.2 Probe Control Selection

Select the temperature probe desired for input to the controller. The Probe Control Switch to the right of the conversion table on the front panel provides selection of Return Air probe, Supply Air probe, or Auto, which produces automatic lower-temperature input.

Note: Return Air temperature is always displayed on the LED readout, no matter which prove is providing input to the controller.
This insures that the displayed temperature will agree with the temperature recorded on the separate 6-inch recorder with its single sensor in the Return Air.

Momentary display of Supply Air temperature is shown on the same panel when the pushbutton is depressed.
Note: Supply Air temperature display is not instantaneous; wait for temperature reading to settle out.

7.3 Null Range Setting

The null range setting assembly enables operator selection of temperature difference between compressor Off (fixed at setpoint) and compressor On.
This permits maximum compressor time Off for particular types of loads in the container.

8. Reference Figure

8.1 Front Panel

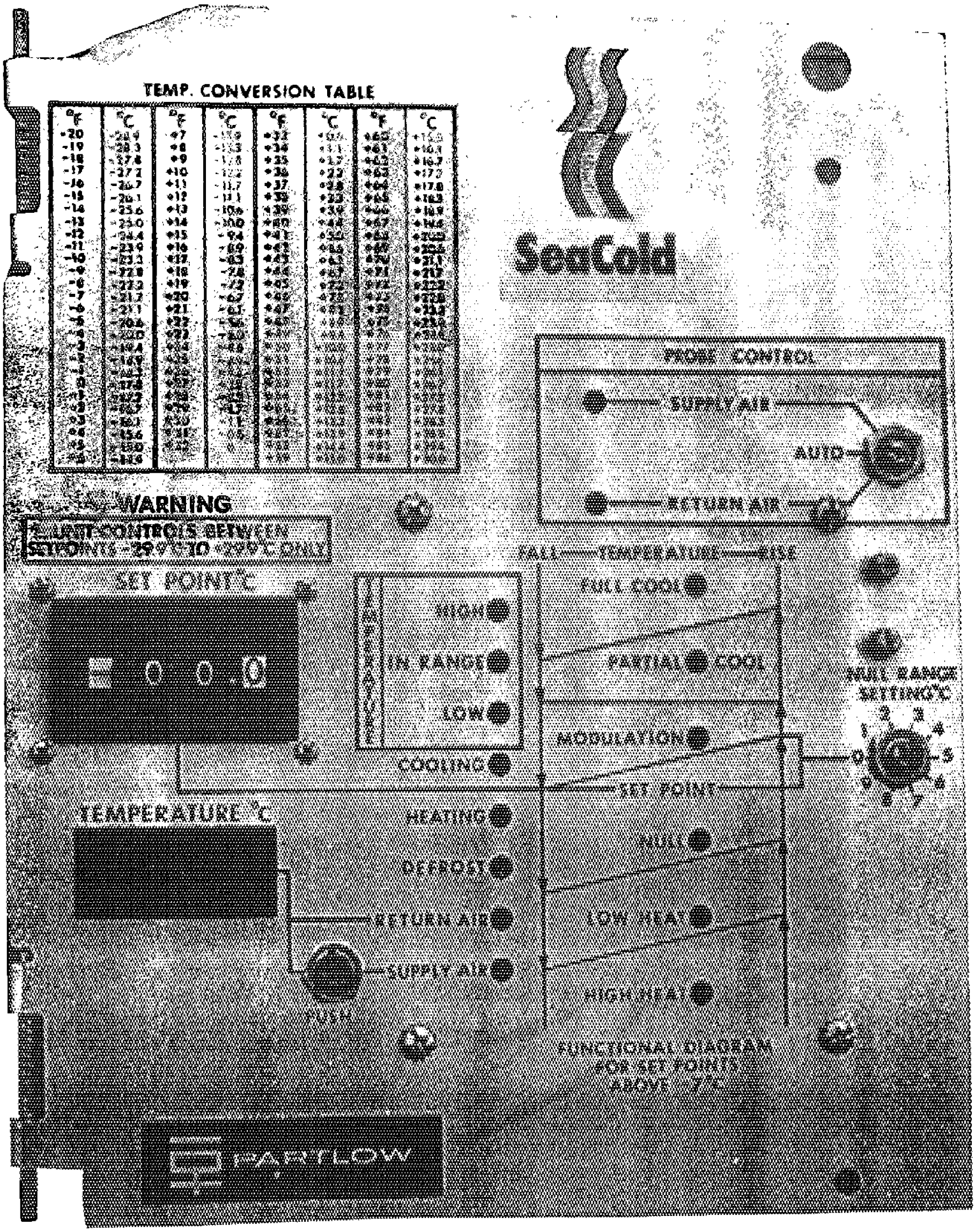


FIG. 1

8.2 Circuit Board/Test Point/Adjustment Locations

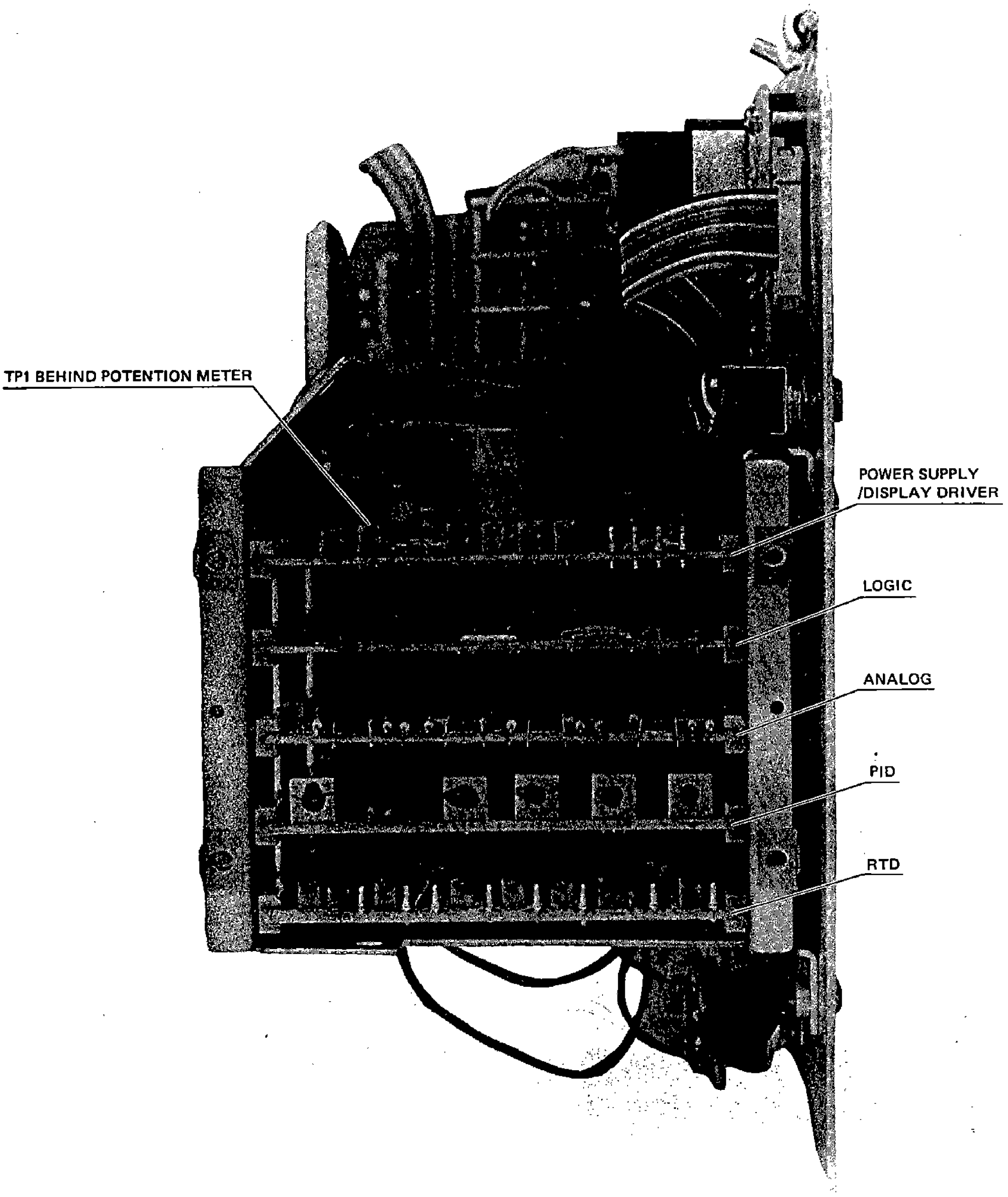


FIG. 2

8.3 Relay Board External Wiring Terminations

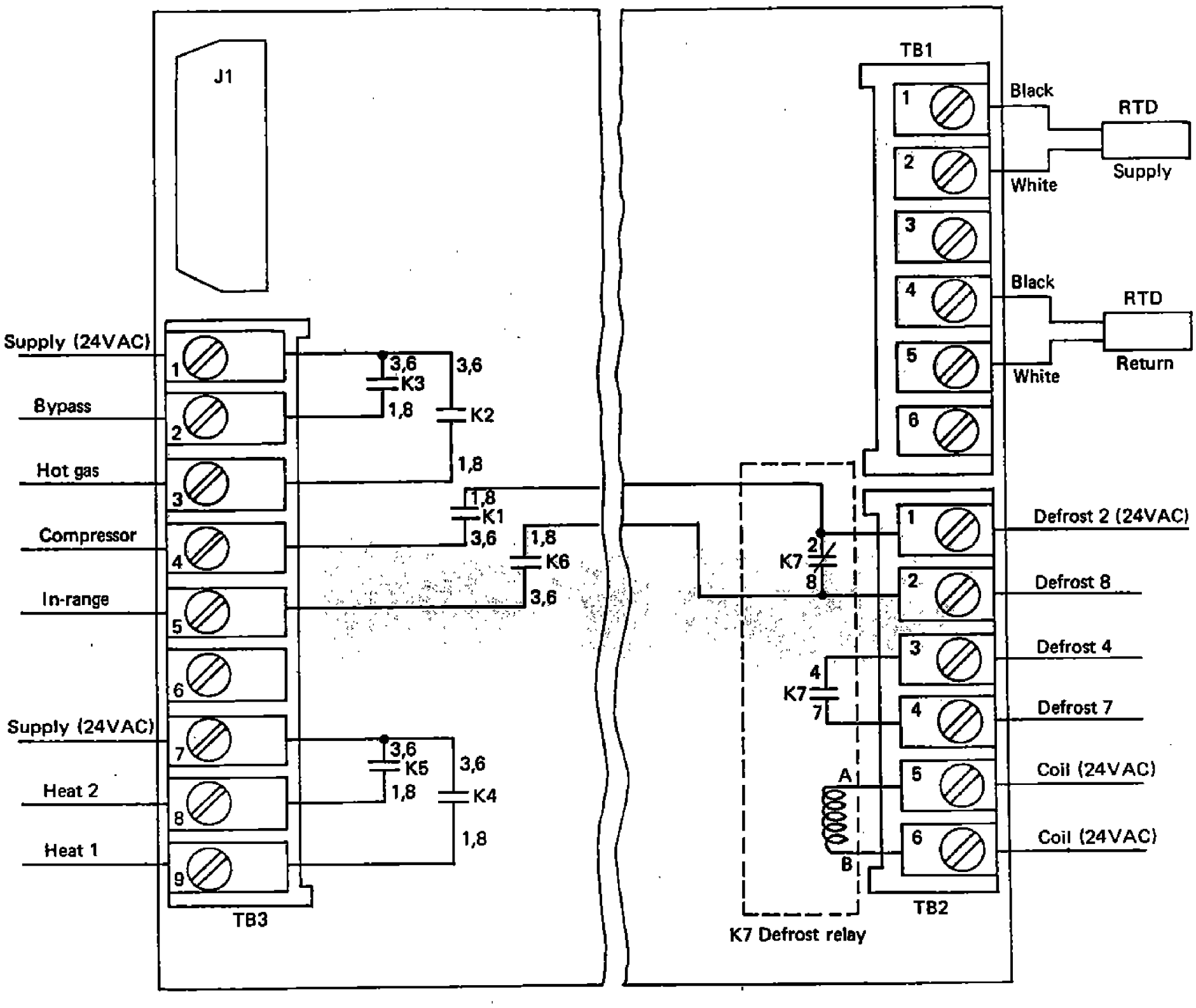


FIG. 3

8.4 Probe Simulator Switch/Serial No. Tag

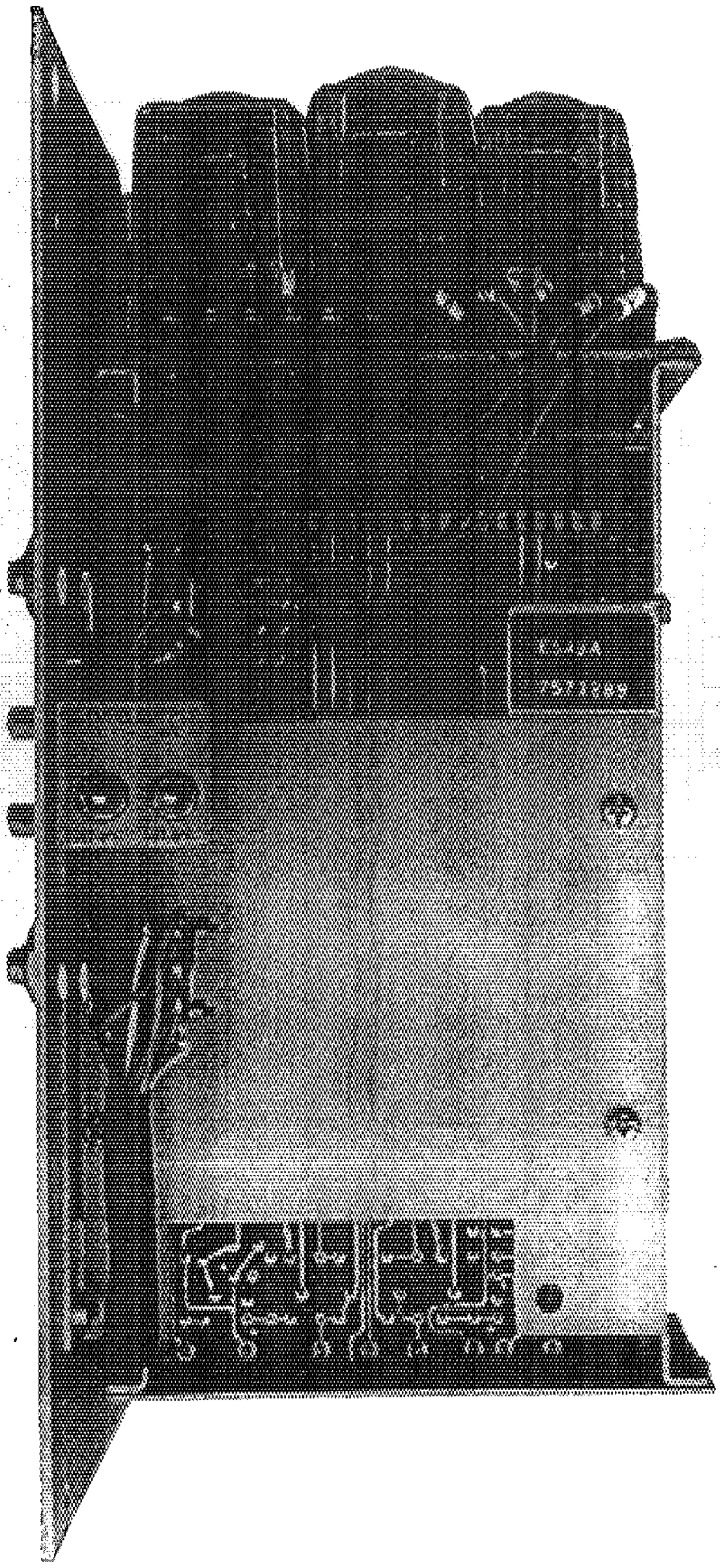


FIG. 4

8.5 Relay Output Circuit Board — Top View

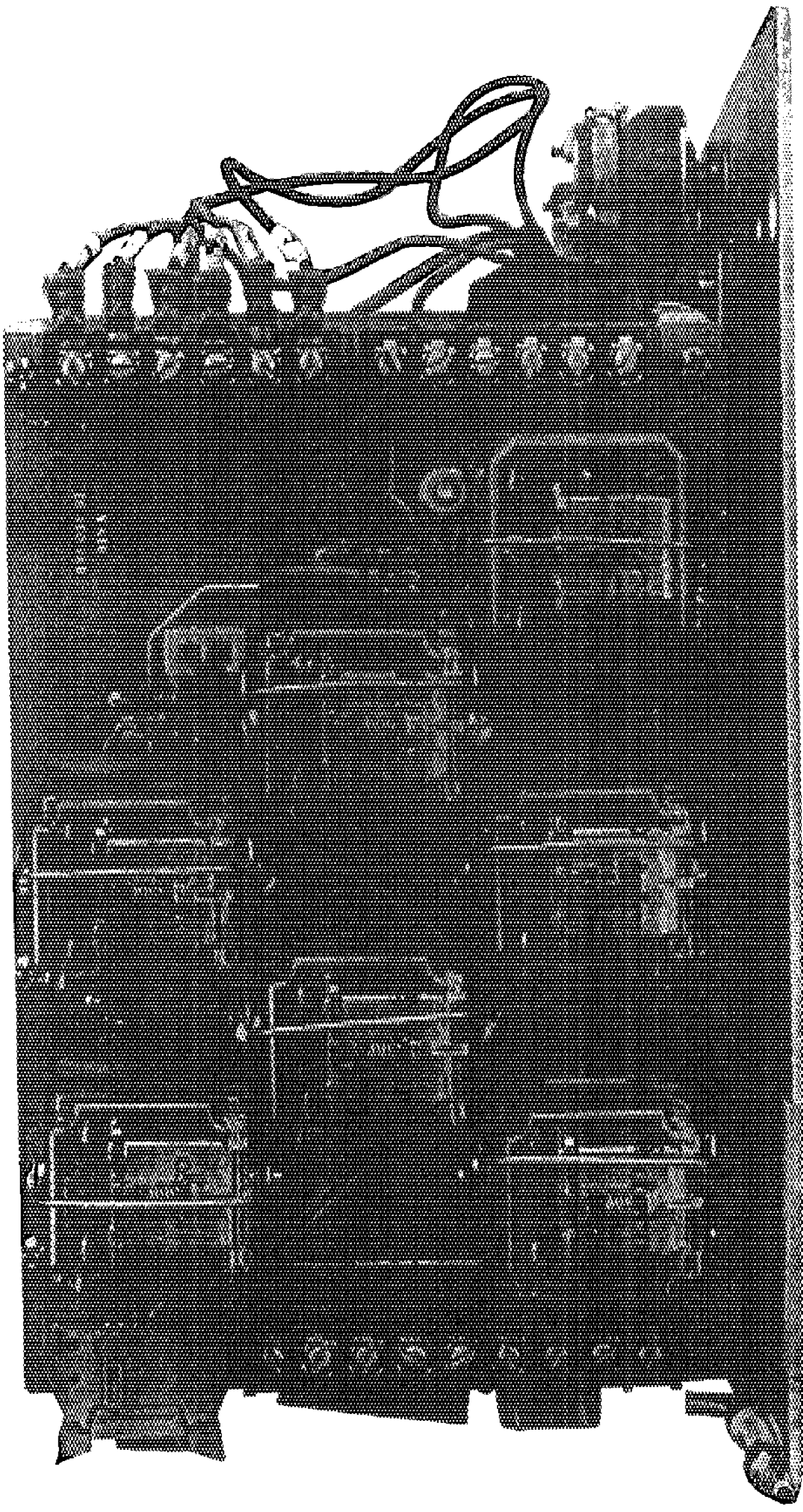


FIG. 5

8.6 Relay Status Table

Output Relay of Modulating Circuit / UNIT STATUS	Compressor K1	Hot Gas K2	Bypass K3	Heat I K4	Heat II K5	In range K6	Valve Current Iv	Defrost K7
Full Cool	on	off	off	off	off	off	min	off
Partial Cool	on	on	off	off	off	–		off
Modulation	on	on	on	off	off	–		off
Null	off	–	–	–	–			off
Low Heat	off	–	–	on	off	off	max	off
High Heat	off	–	–	on	on	off	max	off
In range	–	–	–	–	–	on	–	–
Cooling	on	–	–	–	–	–	–	off
Heating	off	–	–	on	–	–	–	off
Defrost	off	–	–	on	on	–	–	on
Out of Range (above or below)	–	–	–	–	–	off	–	–
Bad Probe	off	–	–	off	off	–	–	–

FIG. 6

Key

– = on or off (not significant)
M = modulating
max = approx. 1.3 amp
min = approx. 0 amp

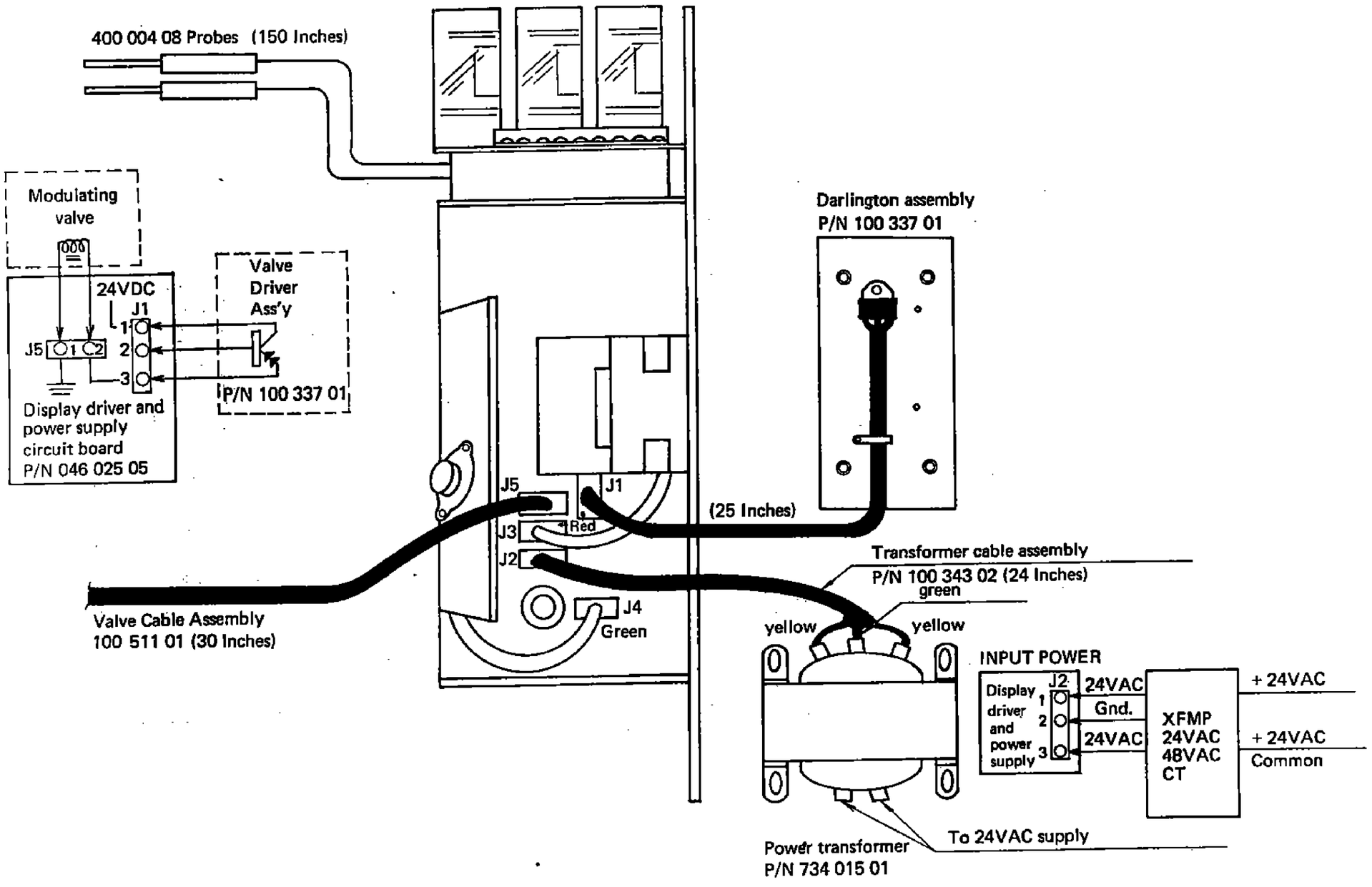


FIG. 7

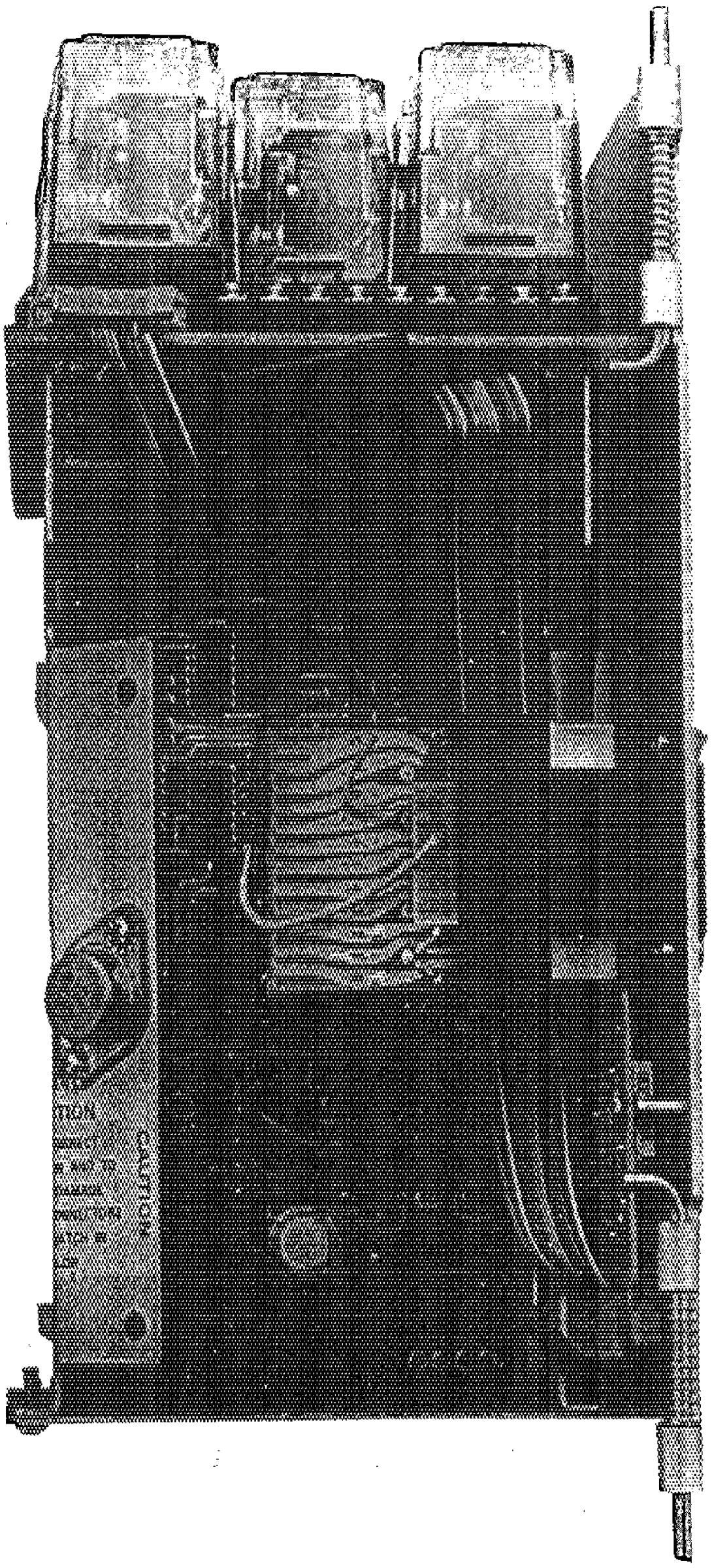


FIG. 8

9. Other Attachments

9.1 Installation and Wiring Instructions

After unpacking the Model E549A and its peripheral equipment, check for obvious shipping damage. Make sure that the plug-in relays on top of the instrument are fully seated in their sockets and their hold-down springs are in place. Also note whether the J3 red connector and the J4 green connector are fully seated on the display driver and power supply circuit board.

Hang the E549A by the hinge pins in the control box. Then install the Darlington Heatsink and Cable Assembly (100 337 01) at site selected for adequate heat dissipation. Mounting surface should be smooth and clean to ensure low thermal resistance. **Do not remove the gray backing material from the mounting plate.** Also, be sure that the four nylon shoulder washers are installed in the mounting holes. These insulation materials are necessary to ensure electrical isolation of the valve drive plate from the control box.

When the mounting plate is installed, plug the assembly cable into J1 red connector, as shown in the Figure 7 schematic.

The E549A Transformer, (734 015 01), with its 3-wire cable assembly, is mounted at designated location. Connect the cable to the 3-terminal side of the transformer, with the green wire on the center terminal and the two yellow wires on the flanking lugs. Plug the other end of the transformer cable assembly into the J2 white connector (Figure 7).

The opposite side of the transformer has two lugs, to which is connected the power supply (24 VAC, 4-ampere, 60Hz).

The E549A is locked into the control box by two spring-loaded hinge pins on the left side of the cover and two captive mounting screws on the right side.

The customer-supplied 2-wire cable from the modulating valve is plugged into the J5 white connector, as shown in Figure 7.

9.2 Replacement Parts List

MODEL E549A	Parts No.
Relay/Power Supply Cable Assembly	100 344 01
Mother Board Assembly, Wired	400 101 01
Bottom Plate Assembly	100 320 01
RTD P.C. Board Assembly	046 019 06
P.I.D. Board Assembly	046 021 06
Logic P.C. Board Assembly	046 026 05
Analog P.C. Board Assembly	046 027 05
Display Driver & Power Supply Board Assembly	046 025 06
Probe Switches & Bracket Assembly	100 339 01
Locking Screw (2)	100 367 01
Relay P.C. Board Assembly	046 024 05
Relay (except defrost)	718 006 01
Thumbwheel Switch Assembly	500 052 00
Regulator Socket & Cable Assembly	100 338 01
+15 Volt Regulator	709 041 01
+15 Volt Regulator Insulator	708 006 01
Spring (2)	642 004 01
Retaining Ring (2)	616 001 04
Hinge Pin, Front Panel	100 336 01

4-Decade Display P.C. Board Assembly	046 022 05
Front Panel Lens	PPA-107
Darlington Heatsink and Cable Assembly	100 337 01
Transformer Cable Assembly	100 343 02
Modulating Valve Cable Assembly (unfinished)	100 511 01
Probe Assembly, Supply Air or Return Air	400 004 08
LED Indicator P.C. Board Assembly	046 023 05
Probe Control Switch & Cable Assembly	100 341 01
Null Range Switch & Cable Assembly	100 342 01
Supply Air Pushbutton Switch & Cable Assembly	100 340 01
E549A Transformer	734 015 01
Mother Board Cable	500 065 01
Customer Loge	626 011 01
Defrost Relay	718 024 01
Operating Manual — Partlow Model E549A	042 010 01

9.3 Pre-Trip Maintenance Check

(1) Set probe control switch to **SUPPLY.**
Probe control supply LED **ON.** Return LED **OFF.**

(2) Set thumbwheel setpoint to −10°C.

(3) Set null range setting switch to desired position, 0 ~ 9°C.

(4) Hold **SUPPLY AIR** simulator switch, located behind the front panel, to the 0°C position.

(5) Depress the red pushbutton switch and observe the digital display; should indicate 0°C ±6°C. Also the red supply air LED should be **ON,** red return air LED **OFF.**

(6) Release the pushbutton switch. The red return air LED should now be **ON** and red supply air LED **OFF.** The digital display should be indicating ambient temperature inside the box.

(7) With the **SUPPLY AIR** simulator switch held at 0°C, the following front panel LED's, relays and relay LED's should be **ON.**

Probe Control Supply Air*
Full Cool
Temperature High
Cooling
Return Air*

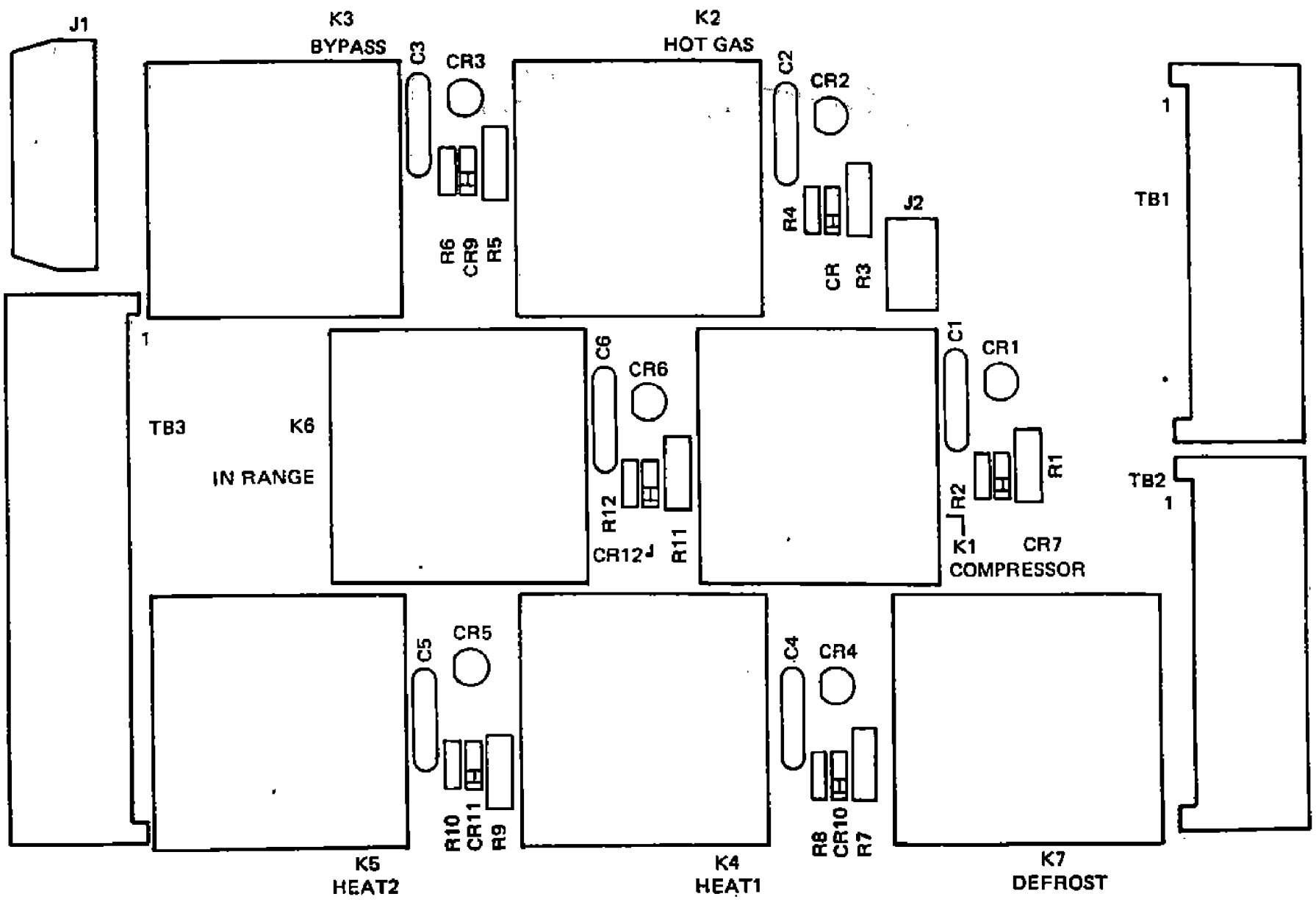
(8) Increase the thumbwheel setpoint from −10.0° through 0°C.
Observe the following relay and/or LED sequence:
Note: Whatever setting was selected for null range, at that degree setting away from 0°C, green in range LED, K6 & CR6 should come **ON.** Min. 2°C.
Example: 5°C null range setting
When thumbwheel setpoint indicates −05.0°C ±.6°C.
Relay & LED should actuate.

* Note: These LED's will always be on throughout the check.

Light Actuation Tolerances	K1 CR1	K2 CR2	K3 CR3	K4 CR4	K5 CR5	K6 CR6	E549 Front Panel LED's ON*
Varies w/null Range Setting	On	Out	Out	Out	Out	On	Full Cool, Cooling, In Range
−3.1°C to −1.9°C	On	On	Out	Out	Out	On	Partial Cool, Full Cool, Cooling, In Range
−2.6°C to −1.4°C	On	On	On	Out	Out	On	Same
−1.6°C to −0.4°C	On	On	On	Out	Out	On	Modulation, Partinl Cool, Cooling, In Range
0°C to 0.6°C	Out	On	On	Out	Out	On	Null** In range
+0.4°C to 1.6°C	Out	On	On	On	Out	On	Low Heat, Heating, In Range
+1.4°C to +2.6°C	Out	On	On	On	On	Out	High Heat, Temperature Low, Low Heat, Heating

* Probe Control Supply Air and Display Return Air Always On.
** After about 70 second delay

K7 (Defrost) will actuate front panel defrost LED when external defrost signal is applied.



(046, 024, 05) Relay P.C.Board Assembly
Note: All LED's are red.