TECHNICAL MANUAL

OPERATION AND SERVICE

AIR CONDITIONER
TRAILER MOUNTED, VAPOR CYCLE
ELECTRIC MOTOR DRIVEN, 120,000 BTU/HR
50 HERTZ, 380 VAC,
MODEL NO. C-5(MOD)/R134A

PART NO.
130K0000-3

KECO INDUSTRIES, INC. FLORENCE, KENTUCKY

CONTRACT NO.
F09603-98-C-0028

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TABLE OF CONTENTS

TABLE OF CONTENTS - CONTINUED

LIST OF TABLES

LIST OF ILLUSTRATIONS

SECTION I

INTRODUCTION AND GENERAL INFORMATION

1-1. INTRODUCTION

1-2. SCOPE. This technical manual contains operation and service instructions for the Model C-5(MOD)/R134A all weather, electric motor driven, trailer mounted air conditioner. The air conditioner is manufactured by Keco Industries, Inc., Florence, Ky 41042. Throughout the remainder of this manual the equipment is referred to either as the "air conditioner" or as the C-5(MOD)/R134A.

1-3. ARRANGEMENT. Section I includes the purpose of the air conditioner, a general description of the C-5(MOD)/R134A with illustrations, and a table of leading particulars. Special tools and test equipment are listed in Section II. In Section III are instructions for preparing the air conditioner for use, storage and shipment. Section IV contains operating procedures, and Section V gives instructions for in-service maintenance and troubleshooting. Use this manual in conjunction with Illustrated Parts Breakdown KM-C-5(MOD)R134A(TM3).

1-4. GENERAL DESCRIPTION

1-5. IDENTIFICATION OF SIDES. In this manual, the front of the C-5(MOD)/R134A is the drawbar end. Left and right sides are determined by standing at the rear and facing the air conditioner. Thus, for example, the side providing access to the control panel is the right, or curb, side.

1-6. USE. The air conditioner is intended for general purpose air conditioning of aircraft avionics during maintenance for pre-flight periods, maintenance shelters, portable hangers and other similar enclosures.

1-7. DESCRIPTION. The C-5(MOD)/R134A is a complete self-contained and portable air conditioning system driven by two motors and a semi-hermetic compressor operating on 380 volt, 3-phase, 50 Hertz, 4-wire alternating current. Once it has been set into operation, the C-5(MOD)/R134A continues to operate automatically.

1-8. As illustrated in fig. 1-1, the air conditioner is completely contained in a unitary enclosure. Power on, off, and airflow are accessible at an external control panel. Refrigeration is produced by a semi-hermetic compressor, condensers, evaporators, and associated controls. An electric fan for condenser cooling and a blower for conditioned air distribution are integrated with the unit. Space is provided for the storage of the unit's power cable.

1-9. The air conditioner operates on the conventional vapor-compression-cycle principle. Cooling is thermostatically controlled. The nominal cooling capacity is 120,000 BTUH (10 tons) air load, 216,000 BTUH (18 tons) evaporator load. The C-5(MOD)/R134A consists of the following major components and related accessory equipment.

a. Refrigeration System.

  (1) Compressor,
  (2) Condenser,
  (3) Receiver,
  (4) Evaporator,
  (5) Piping.

b. Airflow System.

c. Air and Refrigeration Controls.

d. Electrical System.

e. Trailer Structure.

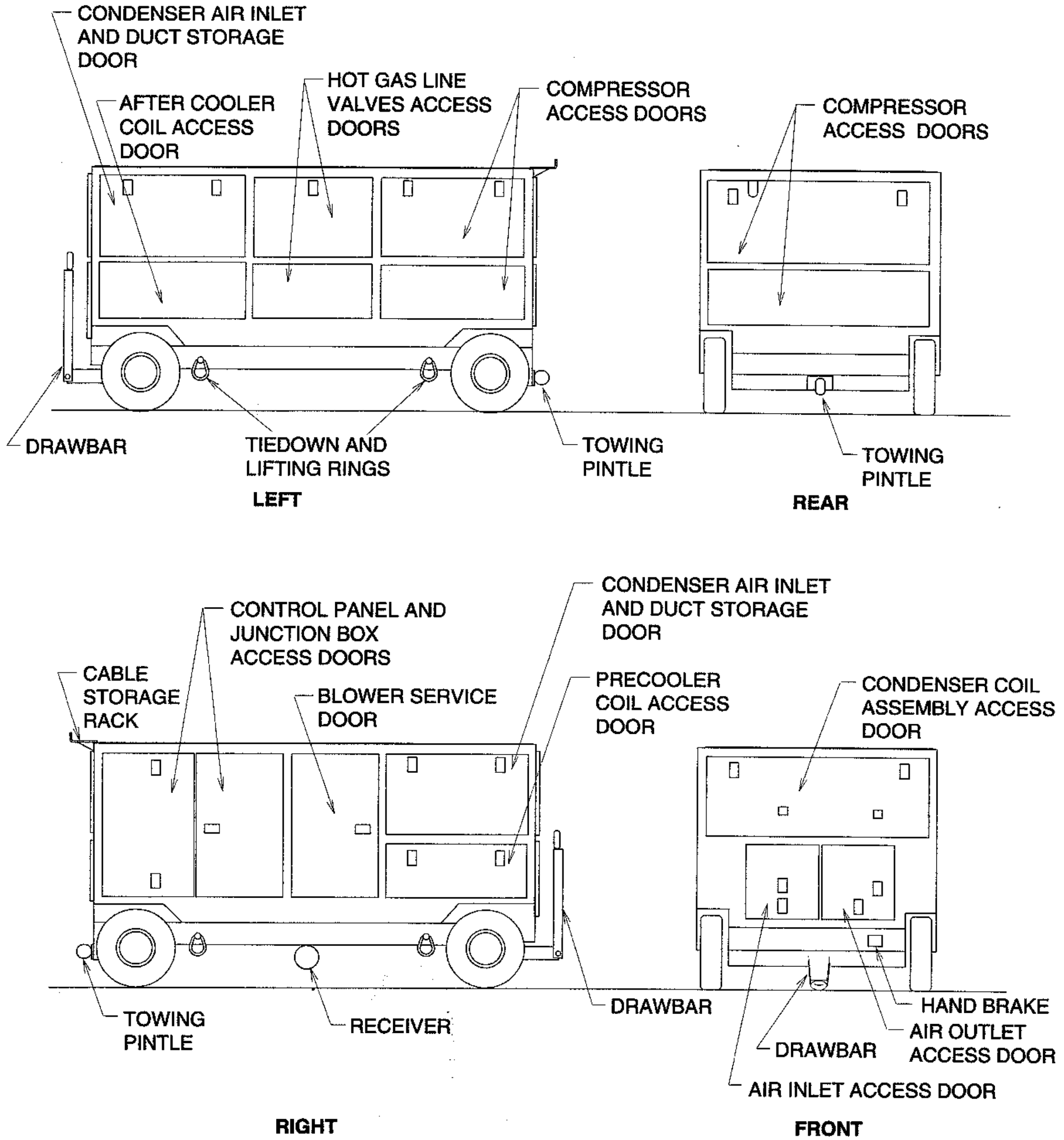


Figure 1-1. Air Conditioner

1-10. REFRIGERANT. The refrigerant system contains a nominal charge of 85 pounds (38.6 kilograms) of R-134A.

1-11. CONDENSER COMPARTMENT. The condenser compartment, located in the top front portion of the air conditioner, contains two condenser coils, the condenser cooling fan, and the fan motor. Condenser airflow enters through screens on the sides of the condenser compartment (fig. 1-2) and is exhausted from the top of the air conditioner.

1-12. EVAPORATOR AND AIR DUCT COMPARTMENT. The evaporator and air duct compartment in the C-5(MOD)/R134A contains two evaporator coils, a mist eliminator, and condensate drains. Thermostatic expansion valves and their associated solenoid and control valves are located along each side of the air duct compartment.

1-13. COMPRESSOR COMPARTMENT. The compressor compartment contains the semi-hermetic compressor and its drive motor, the evaporator blower and its drive motor, an inlet plenum, an outlet plenum, and most of the refrigeration piping valves and other refrigerant components. The refrigerant receiver tank is located under the chassis below the compressor compartment. The inlet plenum contains motor-driven damper vanes for controlling the volume of airflow.

1-14. CONTROLS. The control panel, located toward the rear end on the right side, provides the operator the controls necessary to start and stop the air conditioner and regulate the airflow and conditioned air temperature. Located on the control panels are gages and instruments indicating the status of important system functions. An internal junction box located beneath the control panel contains motor contactors, a transformer, terminal blocks, timers and circuit breakers. The electrical service disconnect circuit breaker is located beneath the control panel.

1-15. EXTERNAL FEATURES. (See fig. 1-1 and 1-2.) Weather tight doors on the air conditioner provide complete access to internal controls, accessories and serviceable parts. As indicated by stencilled instructions, some of the doors must be open during operation to provide unimpeded airflow. All access doors are equipped with flush type latches.

1-16. Four 25-foot (762 cm) sections of flexible duct, 8-inch (20.3 cm) internal diameter (ID), are supplied with the air conditioner.

CAUTION

No more than two air conditioners should be towed in tandem. Failure to comply may result in equipment damage.

1-17. A drawbar (fig. 1-1) is provided for towing. The air conditioner may be towed as fast as 20 mph (32.2 km/hr). A pintle on the rear of the chassis allows an additional air conditioner to be coupled to the first one. A hand operated parking brake keeps the air conditioner from moving during operation.

1-18. Eight rings are provided for tiedown. Four are used with the cable guides to hoist the complete air conditioner. The other four rings on top of the unit are used for hoisting the enclosure only.

1-19. <u>IDENTIFICATION AND LEADING PARTICULARS</u>

1-20. IDENTIFICATION. The air conditioner is identified by a manufacturer's nameplate located on the left side front fill-in panel.

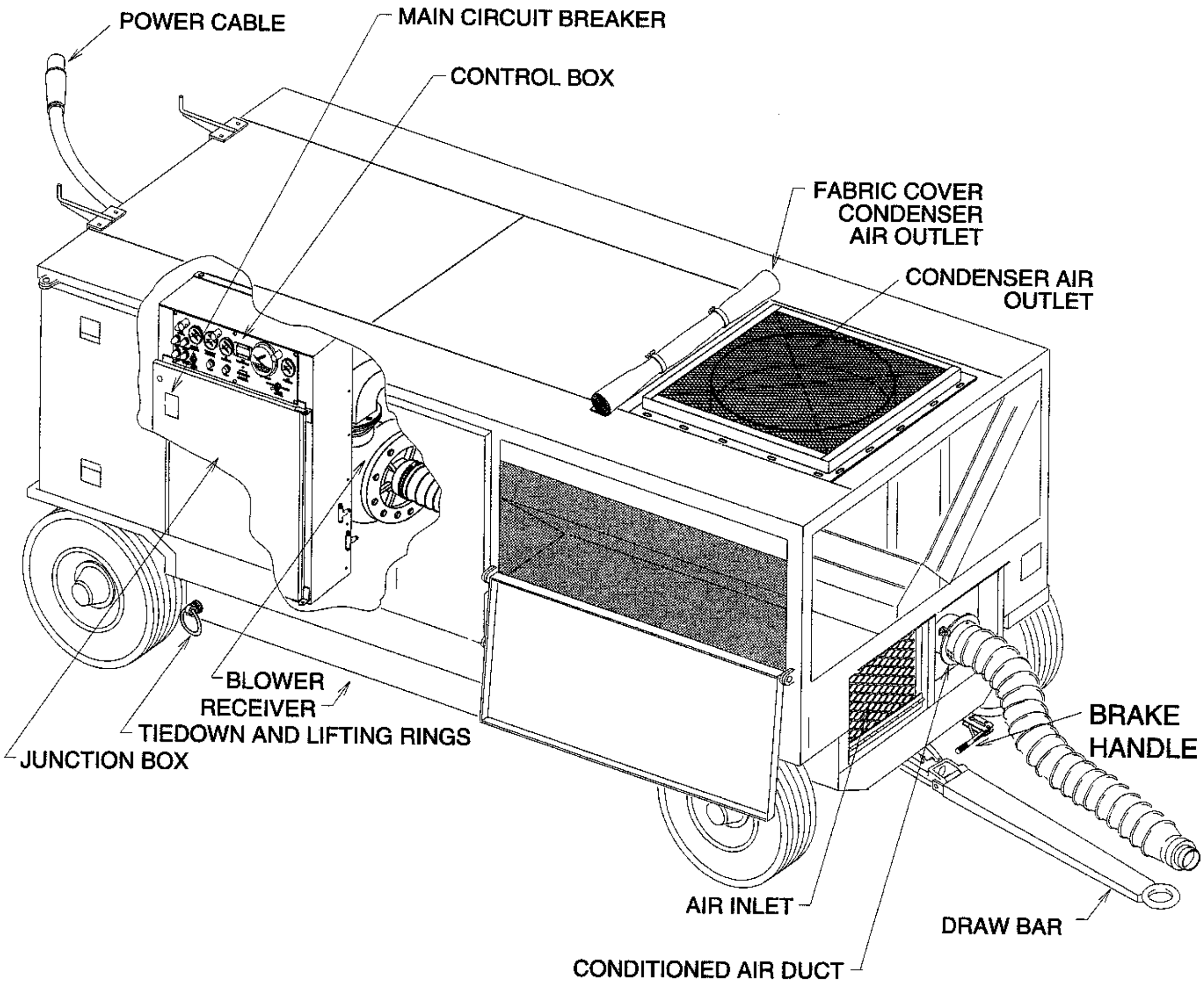


Figure 1-2. Air Conditioner in Operation

1-21. LEADING PARTICULARS.
See table 1-1.

Table 1-1. Leading Particulars

Cooling capacity	120,000 Btu per hour - air load 216,000 Btu per hour - evaporator load
Range of discharge air temperature (manually selected, automatically controlled)	40 to 90 deg F (±3 deg F) (4.4 to 32.3 deg C)
Airflow (manually selected)	20 to 100 lbs/min against a static pressure of 0 to 4 psig
Inlet air temperature range	0 to +125 deg F (-17.8 to 51.7 deg C)
Unit dimensions Length with drawbar in vertical stored position Width, overall Height, overall Cubic volume, overall in stored condition Weight with refrigerant charge Wheel tread Wheel base	 147 inches (373.4 cm) 76 inches (193 cm) 73-1/2 inches (186.7 cm) 475 cubic feet (13.5 cubic meters) 7500 pounds (3402 kilograms) (nominal) 67-3/4 inches (172 cm) 112 inches (284.5 cm)
Ducts (4 furnished), flexible, grounded Length, extended (each duct) Length, stored (each duct) Inside diameter	 25 feet (762 cm) 60 inches (152 cm) 8 inches (20.3 cm)
Maximum towable speed (unimproved or improved surfaces)	20 mph (32.2 km/hr)
Finishing color	Air Force Green iaw FED STD 595 No. 24052
Refrigerant system capacity R134a	85 pounds (38.6 kilograms)

Table 1-1. Leading Particulars - continued

Blower motor rating.	34 horsepower 2500 rpm 380 volt 50 hertz 3 phase 70 amps
Condenser fan motor rating.	4.2 hp 1250 rpm 380 volt 50 hz 3 phase
Compressor (motor) rating.	380 volt 50 hz 3 phase 45 amp

SECTION II

SPECIAL TOOLS AND TEST EQUIPMENT

2-1. SPECIAL TOOLS AND EQUIPMENT.

2-2. Table 2-1 lists the special tools and equipment required for servicing and maintaining the air conditioner. While not a special tool, the baffle shown in fig. 2-1 may be helpful in determining the performance capability of the air conditioner.

2-3. The baffle assembly requires a 3.00 inch (7.62 cm) diameter hole to create an external static pressure of 4 psig.

2-4. The impeller puller is supplied as a special tool and fabricated as shown in fig. 2-2.

Table 2-1. Special Tools and Test Equipment

TOOL/EQUIPMENT NOMENCLATURE	MANUFACTURER AND PART NUMBER	USE AND APPLICATION
Charging Manifold	Imperial No. 467CA or equal	Testing, charging and troubleshooting refrigerant system
Electronic Leak Detector	G. E. Type H-10 or equal	Locating leaks in refrigerant system
Halide Leak Detector	FSN 4940-756-1207 or equal	Locating leaks in refrigerant system
High Vacuum Gage	Kinney KTG vacuum or equal thermocouple gage (0-1000 micron range, 100 micron min. divisions, ±10% accuracy at 50 microns)	Testing refrigerant system for leaks
Impeller Puller	(94833) 120K0976	Pull impeller wheel
Multimeter	NSN 6625-00-149-6301	Electrical testing
Oil Pump, Electric	Fluid servicing check NSN 1730-00-181-4716 Model 2000-B52 Western Fluidics or equal	Add oil to compressor
Vacuum Pump	Kinney KC-3R or equal (.2 micron, 3 cfh)	Evacuating refrigerant system

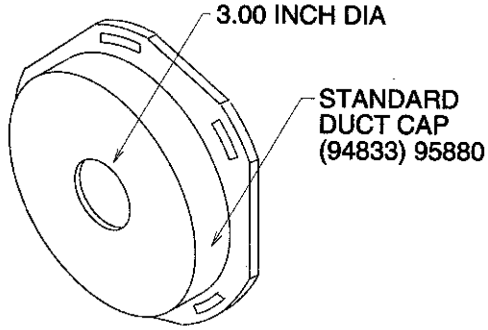


Figure 2-1. Baffle Assembly

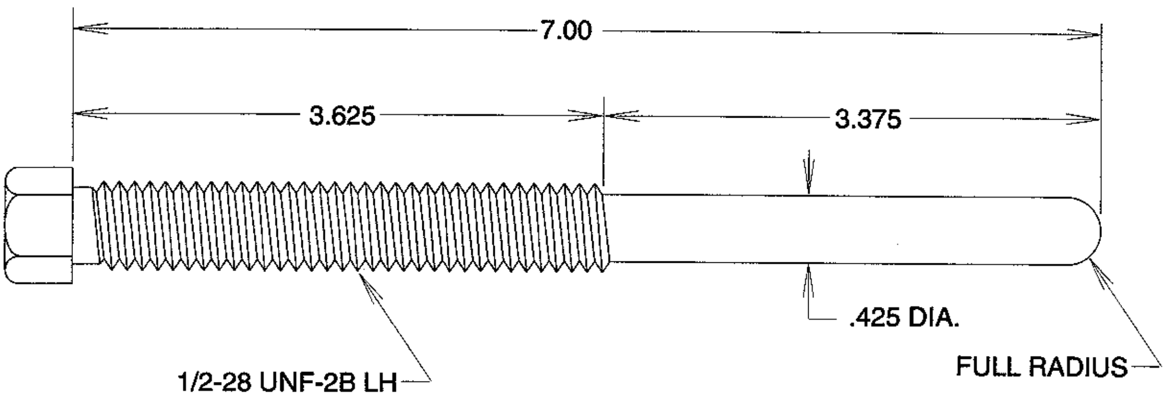


Figure 2-2. Impeller Puller Bolt

SECTION III

PREPARATION FOR USE, STORAGE OR SHIPMENT

3-1. PREPARATION FOR USE

3-2. UNPACKING.

a. If the unit has been shipped by train, remove the wooden frame.

CAUTION

Use cable guide and hoisting/tiedown rings when hoisting. The use of spreader bars is recommended.

b. Remove all paper and tape from panels.

3-3. TOWING, MANEUVERABILITY, AND INSTALLATION PARTICULARS. In selecting a site for the air conditioner and in moving it to the chosen site, note the following particulars.

CAUTION

Never pull more than one vehicle from the rear pintle.

a. The trailer is designed to be towed up to speeds of 20 miles per hour (32.2 km/hr).

b. The trailer is capable of turning in a radius of 17-1/2 feet (5.3 meters) at speeds not exceeding 10 miles per hour (16.1 km/hr).

c. A fully loaded air conditioner has a road clearance of 7-1/2 inches (19 cm).

d. The vehicle is capable of entering, negotiating, and leaving a ramp with a slope of 20 degrees.

e. The unit may be lifted by attaching lifting lines to the four hoisting/tiedown rings located on the sides of the chassis, and routing through cable guides on the chassis roof. Lifting should be performed with a sling hooked through lifting lines.

f. The air conditioner is capable of operating satisfactorily in a tilted position, as long as the tilt does not exceed 8-1/2 degrees.

3-4. INSTALLATION. To prepare the air conditioner for use, proceed as follows:

WARNING

If operation of the air conditioner is attempted without first opening compressor service valve, serious damage to the compressor and injury to operating personnel could result.

a. Open the compressor service door (see fig. 1-1). Remove the valve caps, and open the suction shutoff valve and discharge shutoff valve (fig. 3-1) by turning the stems fully counterclockwise, then turn back in approximately two turns. Reinstall valve caps and close the service doors.

NOTE

The compressor lubricant oil is Polyol Ester (POE).

b. Open the blower service door (fig. 1-1). Remove the caps and open the two shutoff valves located on the receiver. Turn the valves fully counterclockwise to open. Replace the caps.

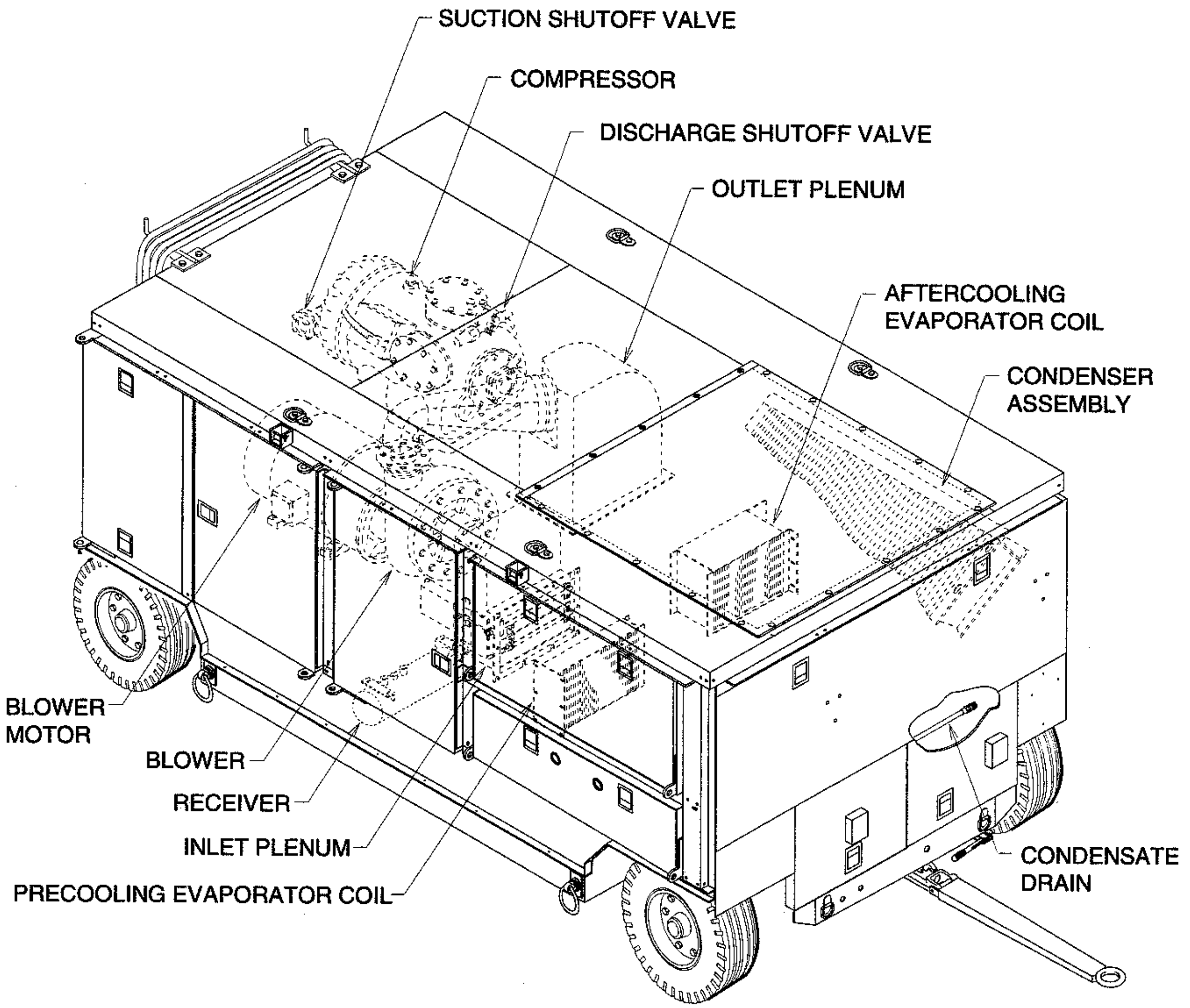


Figure 3-1. Air Conditioner

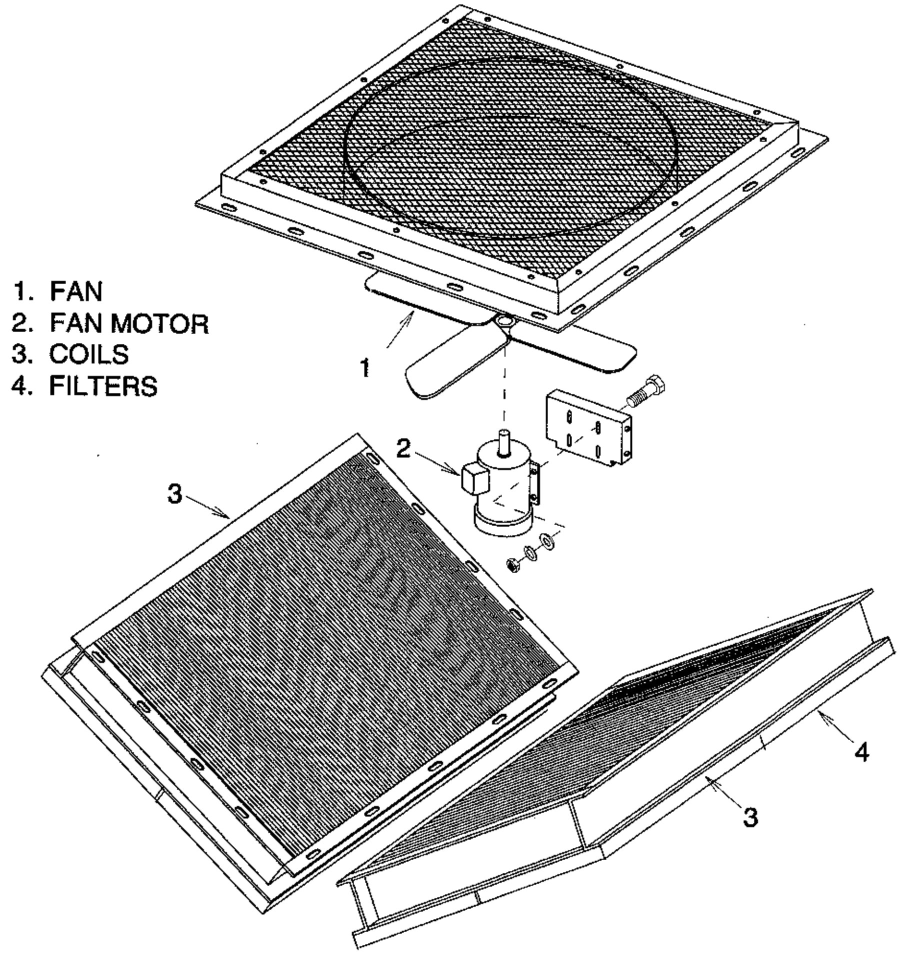


Figure 3-2. Condenser Components

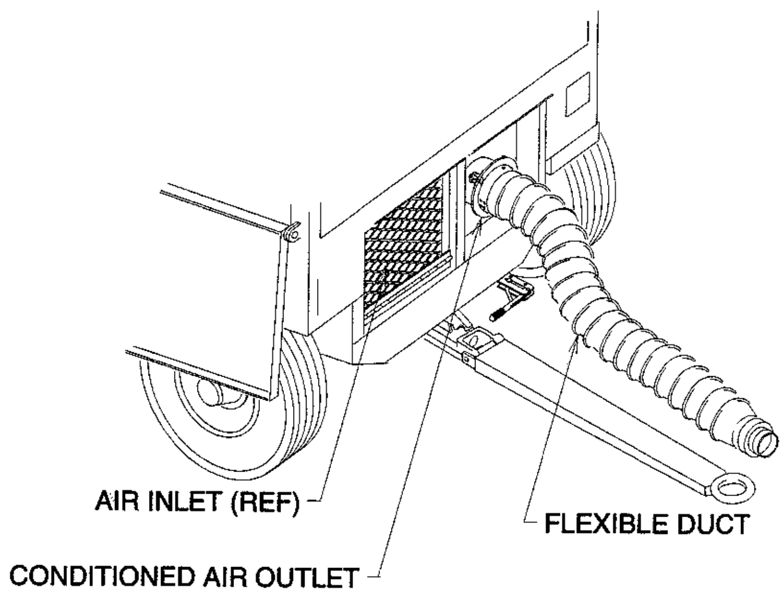


Figure 3-3. Conditioned Air Outlets

NOTE

The oil for the blower gear box is ISO viscosity Grade 32.

c. Check condenser fan (1, fig. 3-2) mounting and bearings.

d. Open the compressor service door (see fig. 1-1). Remove the valve caps and open compressor oil safety switch valves by turning the stems fully counterclockwise. Replace the valve caps.

e. The air conditioner may be checked, as required, to ensure that it can produce pressures from 0 to 4 psig. This may be done by closing off air outlet. Install a baffle manufactured as shown in fig. 2-1.

3-5. EXTERNAL DUCTING.

a. Up to four (connected) 25-foot (762 cm) ducts are used to deliver conditioned air.

b. Open the following doors before operating air conditioner. These doors include the conditioned air inlet/outlet door located at the lower front of the unit, condenser air inlet doors located at the top front on both sides of the unit, and condenser air outlet cover located on top of the unit.

CAUTION

Make all duct connections and installations with the unit shut down.

c. Connect duct(s). The conditioned air outlet panel at the front of the trailer has one outlet for delivering conditioned air. Install the female connector of the ducting at the discharge opening. If desired, secure succeeding ducts to the initial duct by employing the male and female coupling arrangement provided at opposite ends of the ducts.

3-6. <u>POWER</u>

3-7. POWER CABLE. Ensure that the air conditioner is located within cable length, 70 ft (21.3 m), range of a suitable source of ac power in accordance with para 3-8. Uncoil the power cable from the unit.

3-8. VOLTAGE AND FREQUENCY. Three phase power is required as follows:

Voltage - 380V ac
Phases - 3 phase
Hertz - 50 hz
Current -
120 amp (operational)
150 amp (circuit protection)

NOTE

The air conditioner is factory wired for phase sequencing as follows:

Line 1 (phase A) - black wire
Line 2 (phase B) - white wire
Line 3 (phase C) - red wire
Ground - green wire

If the facility power is not wired in the same sequence, the motors in the air conditioner might run in reverse and system operation will be deficient. For correct operation, interchange any two phase wires (not ground) at the air conditioner power cable attachment to facility power.

3-9. PREPARATION FOR SHIPMENT

3-10. To prepare the air conditioner for shipment (other than overseas) proceed as follows:

a. Pump down the refrigeration system as detailed in para 5-26.

CAUTION

Steam or vapor pressure cleaning creates hazardous noise levels and severe burn potential. Eye, skin, and ear protection is required.

b. Wash mud and dirt. Remove gravel from suspension, wheels, tires, and other external parts.

c. Clean and remove all debris from compartments and other parts of the air conditioner.

d. Remove rust from metal surfaces with abrasive or other mechanical means. Scrape flaked and peeling parts from all surfaces.

WARNING

In order to avoid excessive system pressures do not apply steam or hot water to the liquid receiver for a time longer than needed for cleaning.

CAUTION

Before vapor or steam cleaning, exercise care to protect, by removal or covering, all control panel, junction box and circuit breaker control components, and the electrical motors.

e. If required, vapor or steam clean the chassis and other exposed surfaces after first removing or protecting all electrical equipment that the steam vapor might damage.

f. Coil power cable onto back of unit.

3-11. PREPARATION FOR STORAGE OR OVERSEAS SHIPMENT

3-12. For periods of extended storage or overseas shipment, proceed as follows. (Refer to table 1-1 for dimensions and weight, and to para 3-3 for towing and maneuverability particulars.)

a. Pump down unit as instructed in para 5-26.

b. Clean the refrigeration components as instructed in paragraphs 5-7 and 5-8.

c. Clean the air filters as instructed in para 5-6.

d. Disconnect and stow the flexible ducts.

SECTION IV

OPERATING INSTRUCTIONS

4-1. THEORY OF OPERATION

4-2. COOLING AIR CIRCUIT. (See fig. 4-1.) Ambient air enters the air conditioner through the intake air filter (9) into the precooling coil (1). The air then passes through the inlet plenum (3) to the blower (8). The inlet plenum contains a motor driven damper for controlling the volume of air flow. The motor driving the damper is controlled from the control panel. Air is discharged from the blower through a transition duct (4) into the outlet plenum (5). Air flows downward through the outlet plenum, turns horizontally and enters the aftercooling coil (2). From the aftercooling coil, the air flows to the air discharge outlet (10).

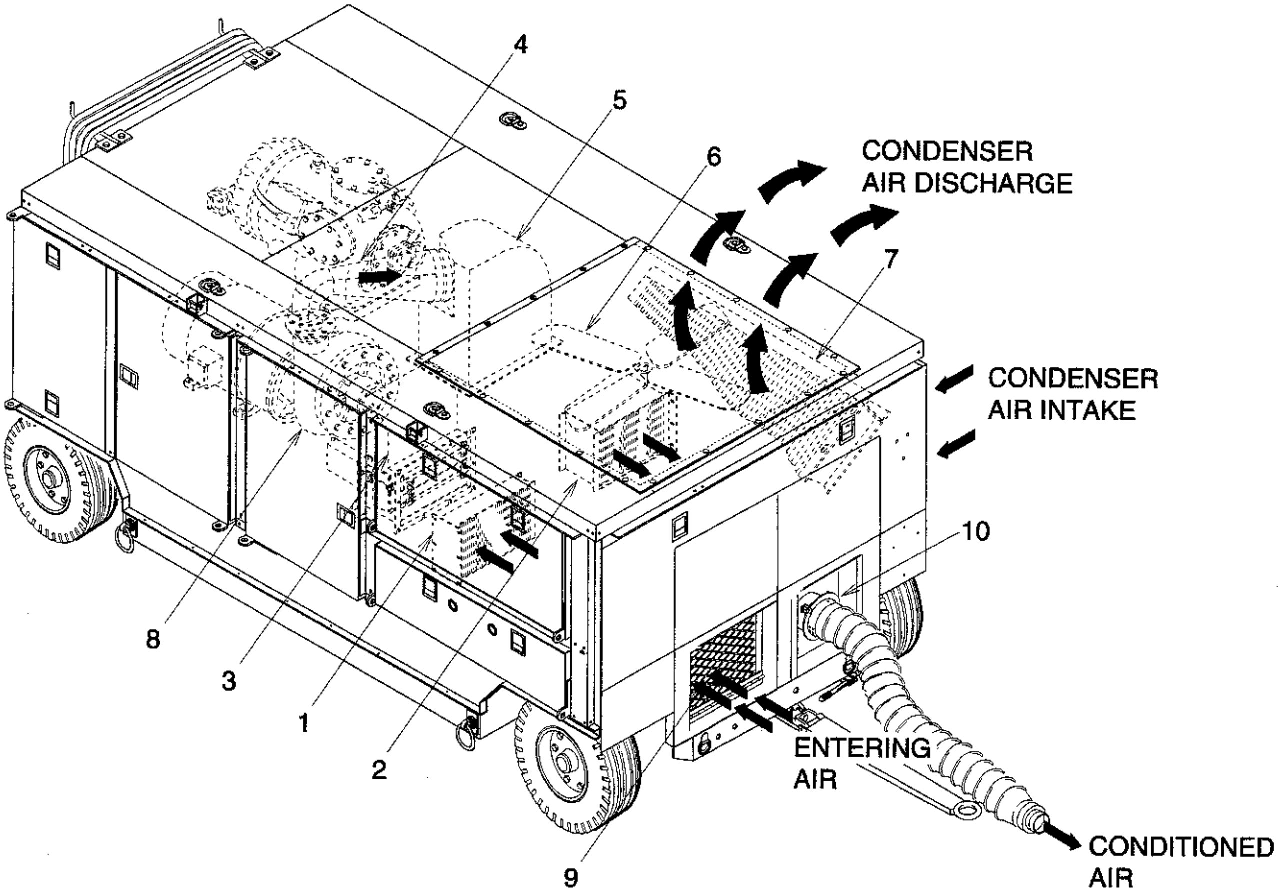
4-3. REFRIGERATION SYSTEM. (Refer to fig. 4-2.) The compressor (B2) converts low pressure gas obtained from the evaporator coils (C3 and C4) into a high pressure gas, then forces it through the condenser coils (C1 and C2). The compressor is equipped with service valves (V1 and V7) for use in refrigeration system maintenance and repair. The compressor also has two service valves (V11 and V12) for the oil safety switch (S5).

4-4. Condenser coils (C1 and C2) cool the high pressure gas until it becomes a liquid under pressure. This cooled, high pressure liquid then passes into the receiving tank (R) which stores it until required by evaporation coils (C3 and C4).

4-5. The high pressure liquid passes into the receiver (R) which acts as a storage tank for the refrigerant until it is needed in the evaporator coil. The receiving tank (R) is sized and designed to hold a complete charge of refrigerant when the refrigerant system is being repaired (refer to para 5-31). Two manual receiver service valves (V8 and V10) are used during the pump down procedure. A 400 psig relief valve (V9) on the receiving tank is used to discharge refrigerant in case of overheating. A sightglass (SG) at the receiver outlet allows a check of the refrigerant charge.

4-6. The high pressure liquid is forced from the refrigerant receiver (R) through the filter drier (D), which filters out foreign material and absorbs moisture from the refrigerant. The normally closed pump down solenoid (L6) forces the refrigerant to back up into the receiver at shut down.

4-7. The liquid refrigerant passes through normally open solenoid valves (L1, L2 and L3) and enters the thermostatic expansion valves (X1, X2, X3, and X4). Each expansion valve meters out the liquid through the attached refrigeration distributor. The refrigerant then enters the evaporator coils (C3 and C4) as a low pressure mixture of liquid and gas.



1 PRECOOLING EVAPORATOR COIL
2 AFTERCOOLING EVAPORATOR COIL
3 INLET PLENUM
4 TRANSITION DUCT
5 OUTLET PLENUM
6 CONDENSER FAN
7 CONDENSER COIL
8 BLOWER
9 INTAKE AIR FILTER
10 AIR DISCHARGE OUTLET

Figure 4-1. Airflow System

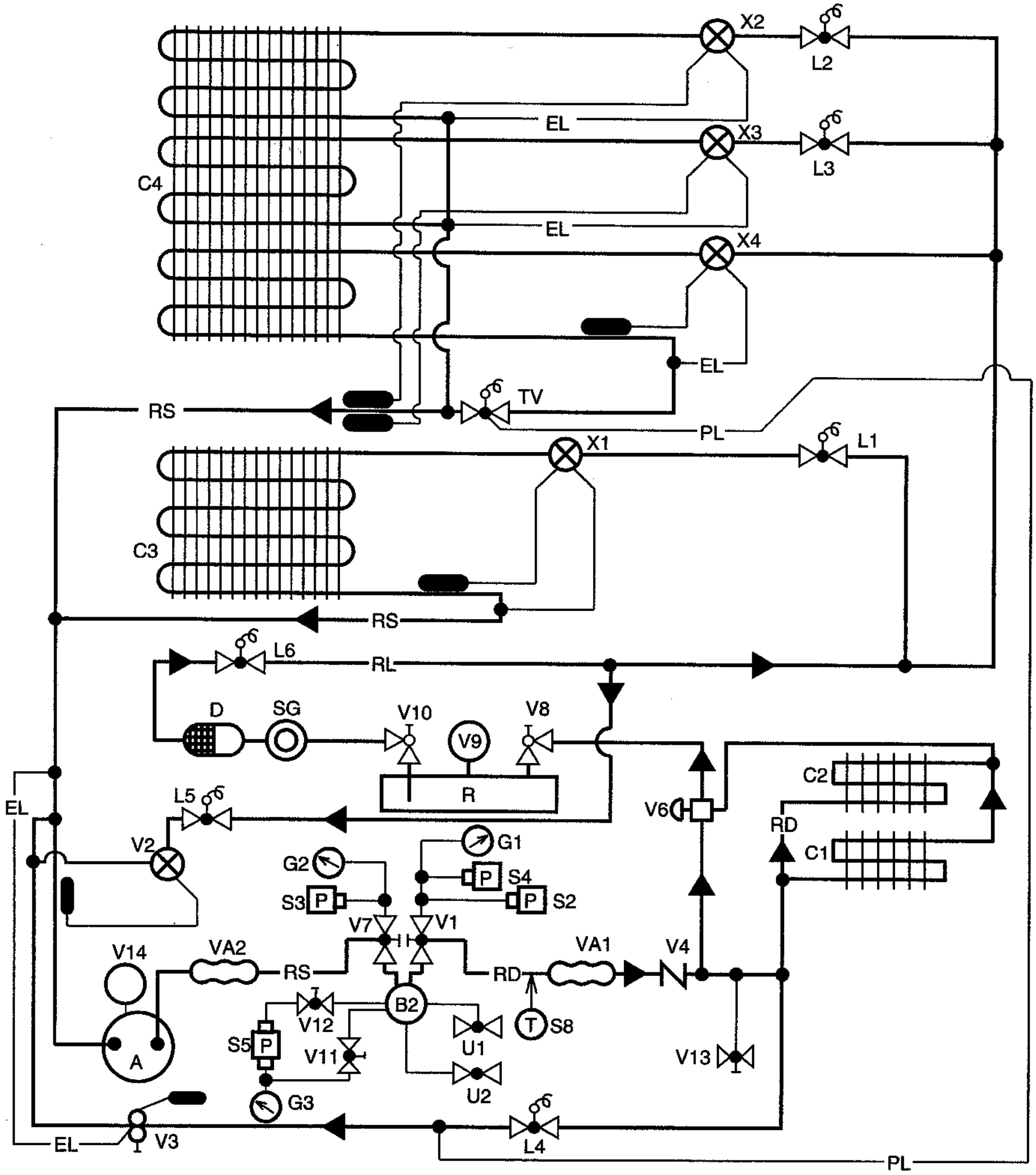


Figure 4-2. Refrigeration System Schematic (Sheet 1 of 2)

LEGEND	
ITEM	DESCRIPTION
A	ACCUMULATOR, SUCTION
B2	COMPRESSOR, REFRIGERATION
C1	COIL, CONDENSER
C2	COIL, CONDENSER
C3	COIL, PRECOLLER
C4	COIL, AFTERCOOLER (3 CIRCUIT)
D	DRIER STRAINER
G1	GAGE, DISCHARGE PRESSURE
G2	GAGE, SUCTION PRESSURE
G3	GAGE, COMPRESSOR OIL
L1	VALVE, SOLENOID, PRECOOLER (N.O.)
L2	VALVE, SOLENOID, AFTERCOOLER (N.O.)
L3	VALVE, SOLENOID, AFTERCOOLER (N.O.)
L4	VALVE, SOLENOID, HOT GAS BYPASS (N.C.)
L5	VALVE, SOLENOID, QUENCH (N.C.)
L6	VALVE, SOLENOID, PUMP DOWN (N.C.)
R	RECEIVER
S2	SWITCH, HIGH PRESSURE CUTOUT (280 PSIG CUTOUT/225 PSIG CUTIN)
S3	SWITCH, LOW PRESSURE CUTOUT (5 PSIG CUTOUT/15 PSIG CUTIN)
S4	SWITCH, CONDENSER FAN (90 PSIG CUTIN/40 PSIG CUTOUT)
S5	SWITCH, LOW COMPRESSOR OIL CUTOUT (15 PSIG WITHIN 90 SEC)
S8	SWITCH, THERMOSTAT (275°F OPEN/200°F CLOSE)
SG	INDICATOR, SIGHT LIQUID
TV	VALVE, SUCTION LINE THROTTLING
U1	VALVE, SOLENOID, COMPRESSOR
U2	VALVE, SOLENOID, COMPRESSOR
V1	VALVE, COMPRESSOR DISCHARGE SERVICE
V2	VALVE, QUENCH
V3	VALVE, REGULATOR, HOT GAS BYPASS (27 PSIG BEGINS OPEN/REG @ 30 PSIG)
V4	VALVE, CHECK
V6	VALVE, HEAD PRESSURE CONTROL (105 PSIG BEGINS OPEN/REG @ 110 PSIG)
V7	VALVE, COMPRESSOR SUCTION SERVICE
V8	VALVE, RECEIVER INLET SERVICE
V9	VALVE, PRESSURE RELIEF (OPENS @ 400 PSIG)
V10	VALVE, RECEIVER OUTLET SERVICE
V11	VALVE, COMPRESSOR OIL CONN. SERVICE
V12	VALVE, COMPRESSOR LOW PRESS. SERVICE
V13	VALVE, ANGLE
V14	VALVE, PRESSURE RELIEF (OPENS AT 350 PSIG)
VA1	VIBRATION ABSORBER
VA2	VIBRATION ABSORBER
X1	VALVE, EXPANSION, PRECOOLER, ADJUSTABLE
X2	VALVE, EXPANSION, AFTERCOOLER, ADJUSTABLE
X3	VALVE, EXPANSION, AFTERCOOLER, ADJUSTABLE
X4	VALVE, EXPANSION, AFTERCOOLER, ADJUSTABLE
EL	EQUALIZER LINE
PL	PILOT LINE
RD	REFRIGERANT DISCHARGE LINE
RL	REFRIGERANT LIQUID LINE
RS	REFRIGERANT SUCTION LINE

Figure 4-2. Refrigeration System Schematic (Sheet 2 of 2)

a. A single solenoid valve L1 feeds liquid refrigerant into the thermostatic expansion valve (X1) supplying the precooling coil (C3). Two solenoid valves, (L2 and L3), operate to feed liquid refrigerant through thermostatic expansion valves (X2 and X3) and into two of the three sections of parallel aftercooling coils (C4). Solenoids L2 and L3 energize with the compressor unloading solenoids (U1 and U2). The hot gas bypass solenoid valve (L4) and quench valve solenoid (L5) are controlled by output from the temperature controller TC located in the control box. A thermostatic expansion valve (X4) supplies the third section of the aftercooling coils (C4).

b. When the compressor (B2) is operating at full load, all cylinders are active and the pump down solenoid (L6) is energized and opened. The three liquid solenoid valves (L1, L2, and L3) are deenergized and open and the throttling valve (TV) is open or modulating to feed the four thermostatic expansion valves (X1 through X4). As the refrigerant load is reduced, compressor capacity is also decreased by the cylinder unloaders. When entering air temperature is below 50°F (10°C) nominal, solenoid valve (L1), which feeds precooling expansion valve (X1), energizes. When solenoid valve (L1) closes, refrigerant is not supplied to the precooling coil (C3).

c. The temperature controller (TC) compares the leaving air temperature, sensed by temperature sensor TS, to the setpoint temperature. The output of TC controls solenoids L2, L3, L4, and L5, unloaders U1 and U2, and temperature control valve TV. The TC checks and updates every second. Once an output is set, it will remain constant until changed by the TC because of a sensed temperature change.

d. The temperature control valve (TV) is fully open when leaving air temperature is 1°F above the setpoint temperature. When leaving air temperature drops to 3°F below the setpoint temperature, the TV is fully closed. The change from full open to full closed will take twelve minutes. This variation regulates the flow of refrigerant to one section of the aftercooling evaporator coils (C4) as supplied by thermostatic expansion valve (X4). The TV is controlled by voltage from the temperature controller TC which is proportional to the sensed temperature change.

e. If fully adjusting the throttling valve (TV) does not satisfy the temperature controller (TC), the temperature controller (TC) determines whether sensed leaving air temperature is 1°F above or 3°F below setpoint temperature. The following actions will occur in sequence, twelve minutes apart:

(1) Solenoids L4 and L5 are always energized (open). Solenoid L4 enables the hot gas bypass valve (V3) to feed gas from the compressor discharge line back into the suction side of the compressor (B2). The constant pressure hot gas bypass valve (V3) maintains a minimum compressor suction pressure of 28 psig regardless of the evaporator load. Solenoid L5 enables the quench valve (V2) to feed liquid into the hot gas bypass line. This prevents compressor damage caused by high suction temperature and allows continuous compressor operation down to zero load.

(2) Solenoid L3 and unloader solenoid U2 are energized and stop the flow of refrigerant through thermostatic expansion valve (X3) to one section of the aftercooling coils (C4) and unload one cylinder.

(3) Solenoid L2 and unloader solenoid U1 are energized stopping the flow of refrigerant through thermostatic expansion valve (X4) to one section of the aftercooling evaporator coils (C4)and unload a second cylinder.

(4) The throttling valve (TV) is normally open (de-energized). It is energized (closes) between compressor cylinder unloadings, opens while cylinders are unloading, and closes again until next unloading cycle.

f. When the leaving air temperature is sensed more than 1°F above the setpoint temperature, the following actions will occur in sequence. See step e. above for more details.

(1) solenoid L2 and unloader U1 deenergize,

(2) solenoid L3 and unloader U1 deenergize.

g. When entering air temperature is below a nominal 50°F (10°C), solenoid L1 energizes.

4-8. The refrigerant passing through the evaporator coils (C3 and C4) absorbs heat from the air circulated through the evaporator by the supply air blower (8, fig. 4-1). Refer to para 4-2 for an explanation of airflow. In the process of absorbing heat, the liquid refrigerant evaporates and becomes a low pressure gas, which is drawn back into the suction side of the compressor (B2, fig. 4-2). Here the cycle starts over.

4-9. ELECTRICAL SYSTEM. Fig. 4-3 and Table 4-1 should be used as reference for the following discussion of the C5 electrical system.

4-10. POWER. Three phase, 4 wire alternating current for operation of the C5 is supplied from an external source and is of a voltage and frequency given in para 3-8. Three phase power is supplied through suitable protective circuit breakers to the motors driving the compressor, blower, and condenser fan. Contactors in the motor circuits control power to the motors.

4-11. CONTROL SYSTEM VOLTAGE. Transformer TR (fig. 4-3) reduces the source voltage to 24V ac for operation of the components in the control system. Motor starters, solenoids and relays operate on the control system voltage. Switching is accomplished at control system voltage.

4-12. CONTROL SYSTEM. Transformer TR supplies 24V ac to the control system through a 20 ampere circuit breaker, CB2. Control system actions are as follows:

a. Lamp DS1 illuminates, indicating that unit power is on and that the transformer is supplying 24V ac to the control system circuit.

b. Switch S7 turns on instrument panel lamps DS4 through DS6.

c. Thermostat switch S11 isolates power to the control circuit when the compressor heater is on.

d. Pushbutton switch S1 supplies power through startup relay K8 to blower motor starters K1 and K2 (via 0.1 sec time delay relay TD1). The blower goes into operation.

e. Thirty seconds later, time delay relay TD2 actuates its contacts thus completing the circuit to the compressor motor starters K3 and K4 (via 0.1 sec time delay relay TD3).

f. Also, a circuit is provided to K5, the condenser fan motor starter, through low pressure switch S4. The condenser fan goes into operation automatically when compressor discharge pressure reaches 130±5 psig.

g. With S1 activated, and control relay K6 energized, control power is applied, through 3 sec time delay relay TD4, to the temperature controller TC and subsequently to solenoids L1 through L5, unloaders U1 and U2, temperature control valve TV, temperature potentiometer PT1, temperature sensors TS1 and TS2, and digital display DD.

WARNING

Current monitor relay (K9) is wired to current transformer (CT). Do not remove relay while blower is operating.

h. A direct circuit is provided to air volume control switch S12 and associated circuitry to control damper motor B4. The internal switches of damper motor allow the motor to rotate in a range of 90°. Current monitor relay (K9) overides damper motor (B4) to prevent excessive blower motor amperage. The (K9) relay has a one second delay and must be set so motor does not exceed 60 amps current draw.

4-13. SAFETY CONTROLS. (Refer to fig. 4-2.) Limiting devices are incorporated in the system to safeguard the equipment from damage during operation due to unforeseen conditions.

4-14. The high pressure switch S2 is connected to the compressor by a capillary tube where it senses the refrigerant discharge pressure. If for any reason the pressure rises above 280±10 psig, the high pressure cutout switch deactivates the compressor motor starters K3 and K4 and stops operation. The condenser fan motor continues to operate. When sufficient time has elapsed to allow the pressure to return to normal, the high pressure cutout can be manually reset and the compressor restarted.

4-15. The low pressure switch S3 is connected to the compressor by a capillary tube where it senses the suction pressure. If the pressure falls below 2 (+5, -0) psig, the low pressure cutout switch will deactivate the compressor. At 24±5 psig the switch will close and the compressor will restart automatically.

4-16. The condenser fan is equipped with a fan cycle switch S4 that turns off power to the condenser fan motor when the compressor discharge pressure is 90±5 psig or less. This is necessary to permit low ambient temperature operation. Switch S4 closes at 130±5 psig.

4-17. The high pressure side of the refrigeration system is equipped with a head pressure control valve which begins to open at 105 psig and maintains a minimum condensing pressure of 110 psig. This ensures the desirable pressure differential across the expansion valves.

4-18. The compressor oil safety switch S5 is connected to two fittings on the compressor housing by capillary tubes. One of these tubes senses oil pressure in the compressor lubrication system. The second tube senses suction pressure in the refrigeration system. The oil sump of the compressor is common to suction passage; therefore, it is always under suction pressure. Normal oil pressure is 16 to 22 psig above suction pressure, and when the difference between the oil pressure and refrigerant suction pressure (P OIL - R REFRIG) drops below 5 psig for 120±15 seconds, the oil safety switch interrupts power to the compressor. This protects the compressor from operation without proper lubrication. To restart the compressor, it will be necessary to determine the cause of low oil pressure, correct this condition, and allow the thermal unit in the time delay portion of the safety switch to cool (this takes at least 2 minutes). Then, refer to fig. 4-4 and depress the reset button on the oil safety switch to restart the compressor.

4-19. Switch S9 is located on the precooler door, switch S16 at condenser cover, and switches S6 and S17 are on the condenser inlet doors. These switches prevent the unit from operating, or shut the unit down if operating, when the door and/or cover are not open.

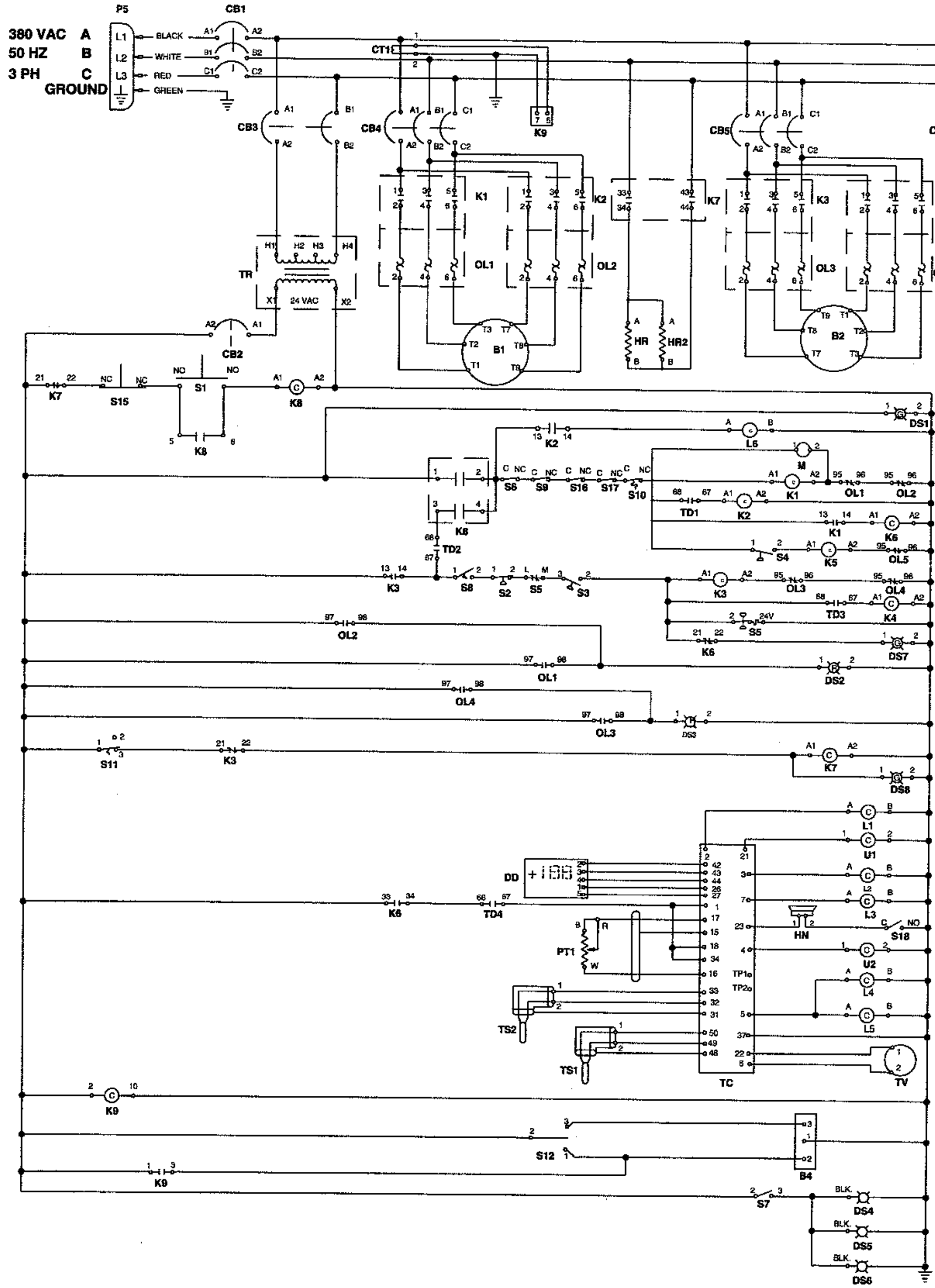
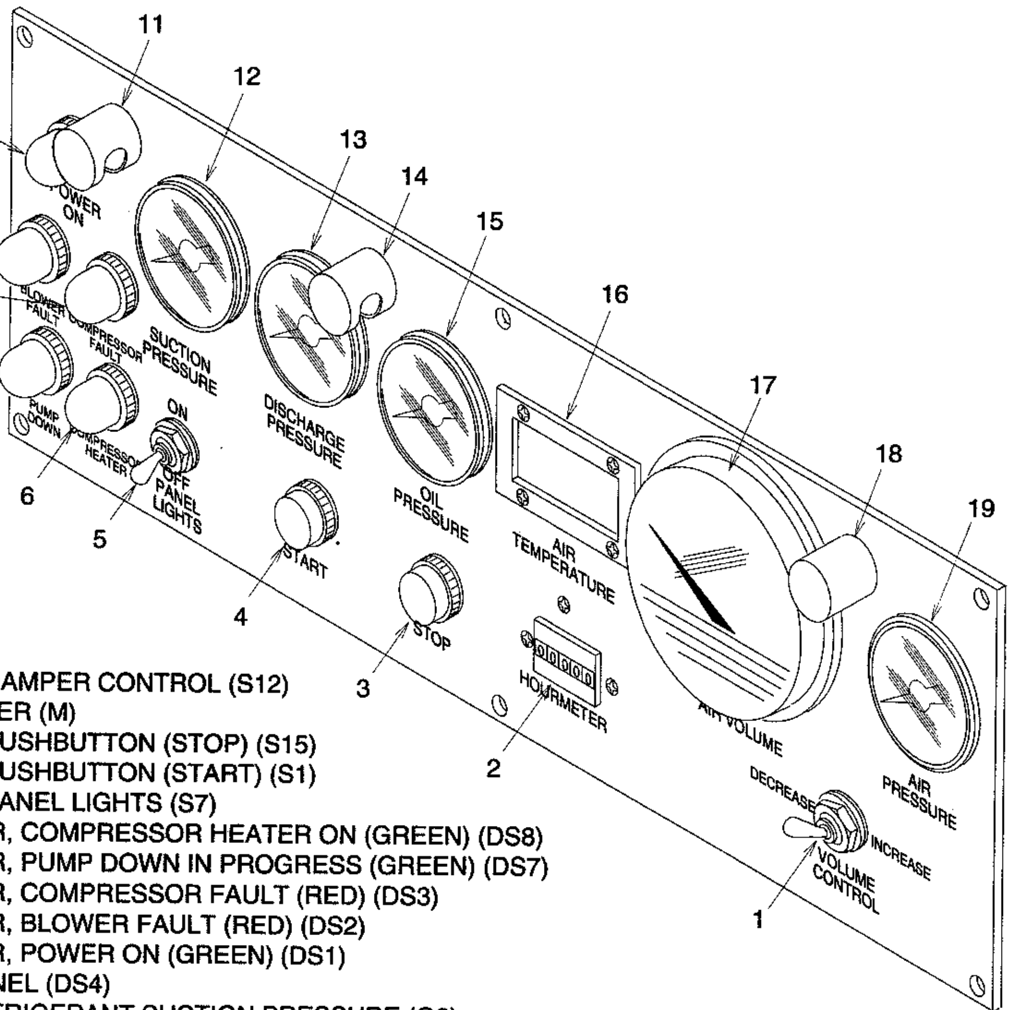


Figure 4-3. Wiring Schematic (Sheet 1 of 2)

COMPONENT REFERENCE LIST	
SYMBOL	DESCRIPTION
B1	BLOWER MOTOR ASSY. MODIFICATION
B2	MOTOR, COMPRESSOR
B3	MOTOR, CONDENSER FAN
B4	MOTOR, DAMPER
CB1	CIRCUIT BREAKER, MAIN
CB2	CIRCUIT BREAKER, CONTROL
CB3	CIRCUIT BREAKER, 2 POLE
CB4,5	CIRCUIT BREAKER, 3 POLE
CB6	CIRCUIT BREAKER, 3 POLE
CT1	CURRENT TRANSFORMER
DD	DISPLAY, DIGITAL
DS1	INDICATOR, POWER ON (GREEN)
DS2	INDICATOR, BLOWER FAULT (RED)
DS3	INDICATOR, COMPRESSOR FAULT (RED)
DS4,5,6	LIGHT, PANEL
DS7	INDICATOR, PUMP DOWN IN PROGRESS (GREEN)
DS8	INDICATOR, COMPRESSOR HEATER ON (GREEN)
HN	HORN, HIGH\LOW AIR TEMP. WARNING
HR	HEATER, COMPRESSOR
HR2	HEATER, FLEXIBLE (COMPRESSOR)
K1,2	STARTER, BLOWER MOTOR
K3,4	STARTER, COMPRESSOR MOTOR
K5	STARTER, CONDENSER FAN MOTOR
K6	RELAY, CONTROL
K7	RELAY, COMPRESSOR HEATER
K8	RELAY, STARTUP
K9	CURRENT MONITOR
L1	SOLENOID VALVE, PRECOOLER
L2,3	SOLENOID VALVE, AFTERCOOLER
L4	SOLENOID VALVE, HOT GAS BYPASS
L5	SOLENOID VALVE, LIQUID QUENCH
L6	SOLENOID VALVE, PUMP DOWN
M	HOURMETER
OL1,2,3,4	RELAY, THERMAL OVERLOAD (K1,2,3,4)
OL5	RELAY, THERMAL OVERLOAD (K5)
PT1	POTENTIOMETER, PANEL MOUNT
S1	SWITCH, PUSHBUTTON (START)
S2	SWITCH, HIGH PRESSURE
S3	SWITCH, LOW PRESSURE
S4	SWITCH, LOW PRESSURE
S5	SWITCH, DIFF. OIL PRESS.
S6,9,16,17,18	SWITCH, PUSH
S7	SWITCH, PANEL LIGHTS
S8	SWITCH, THERMOSTAT (DISCH. LINE)
S10	SWITCH, THERMOSTAT (BLOWER BLOCKAGE)
S11	SWITCH, THERMOSTAT (COMPRESSOR)
S12	SWITCH, DAMPER CONTROL
S15	SWITCH, PUSHBUTTON (STOP)
TC	CONTROLLER, SUCT. THROT. VALVE
TD1	TIME DELAY, BLOWER MOTOR (K1)
TD2	TIME DELAY, BLOWER MOTOR (K2)
TD3	TIME DELAY, COMP. MOTOR (K3)
TD4	TIME DELAY, COMP. MOTOR (K4)
TR	TRANSFORMER, POWER
TS1	TEMPERATURE SENSOR (DISCHARGE)
TS2	TEMPERATURE SENSOR (AMBIENT)
TV	VALVE, SUCTION THROTTLING
U1,2	SOLENOID VALVE, UNLOADER

Figure 4-3. Wiring Schematic (Sheet 2 of 2)



1 SWITCH, DAMPER CONTROL (S12)
2 HOURMETER (M)
3 SWITCH, PUSHBUTTON (STOP) (S15)
4 SWITCH, PUSHBUTTON (START) (S1)
5 SWITCH, PANEL LIGHTS (S7)
6 INDICATOR, COMPRESSOR HEATER ON (GREEN) (DS8)
7 INDICATOR, PUMP DOWN IN PROGRESS (GREEN) (DS7)
8 INDICATOR, COMPRESSOR FAULT (RED) (DS3)
9 INDICATOR, BLOWER FAULT (RED) (DS2)
10 INDICATOR, POWER ON (GREEN) (DS1)
11 LIGHT, PANEL (DS4)
12 GAGE, REFRIGERANT SUCTION PRESSURE (G2)
13 GAGE, REFRIGERANT DISCHARGE PRESSURE (G1)
14 LIGHT, PANEL (DS5)
15 GAGE, OIL PRESSURE (G3)
16 DISPLAY, DIGITAL (DD)
17 GAGE, AIR VOLUME
18 LIGHT, PANEL (DS6)
19 GAGE, AIR DISCHARGE PRESSURE

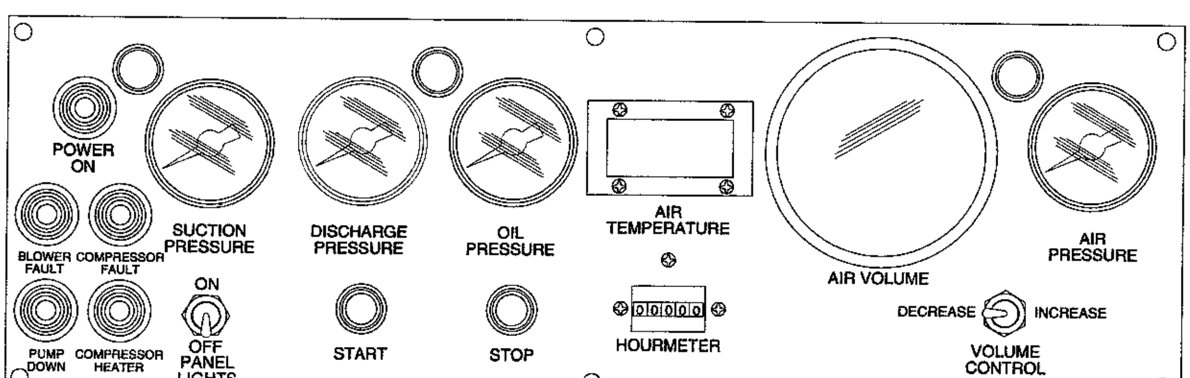


Figure 4-4. Controls and Instruments (Sheet 1 of 2)

20 SWITCH, HIGH PRESSURE (S2)
21 SWITCH, LOW PRESSURE (S3)
22 SWITCH, DIFF. OIL PRESS. (S5)
23 STARTER, COMPRESSOR MOTOR (K4)
24 STARTER, COMPRESSOR MOTOR (K3)
25 CURRENT MONITOR (K9)
26 STARTER, BLOWER MOTOR (K2)
27 TRANSFORMER, POWER (TR)
28 CONTROLLER, SUCT. THROT. VALVE (TC)
29 STARTER, BLOWER MOTOR (K1)
30 SWITCH, PUSH (S18)
31 HORN, HIGH\LOW AIR TEMP. WARNING (HN)
32 CIRCUIT BREAKER, MAIN (CB1)
33 CURRENT TRANSFORMER (CT1)
34 CIRCUIT BREAKER, 3 POLE (CB4)
35 CIRCUIT BREAKER, 2 POLE (CB3)
36 CIRCUIT BREAKER, CONTROL (CB2)
37 CIRCUIT BREAKER, 3 POLE (CB5)
38 RELAY, COMPRESSOR HEATER (K7)
39 POTENTIOMETER, PANEL MOUNT (PT1)
40 CIRCUIT BREAKER, 3 POLE (CB6)
41 RELAY, STARTUP (K8)
42 STARTER, CONDENSER FAN MOTOR (K5)
43 RELAY, CONTROL (K6)
44 SWITCH, LOW PRESSURE (S4)
45 RELAY, TIME DELAY (TD1)
46 RELAY, TIME DELAY (TD2)
47 RELAY, TIME DELAY (TD3)
48 RELAY, TIME DELAY (TD4)

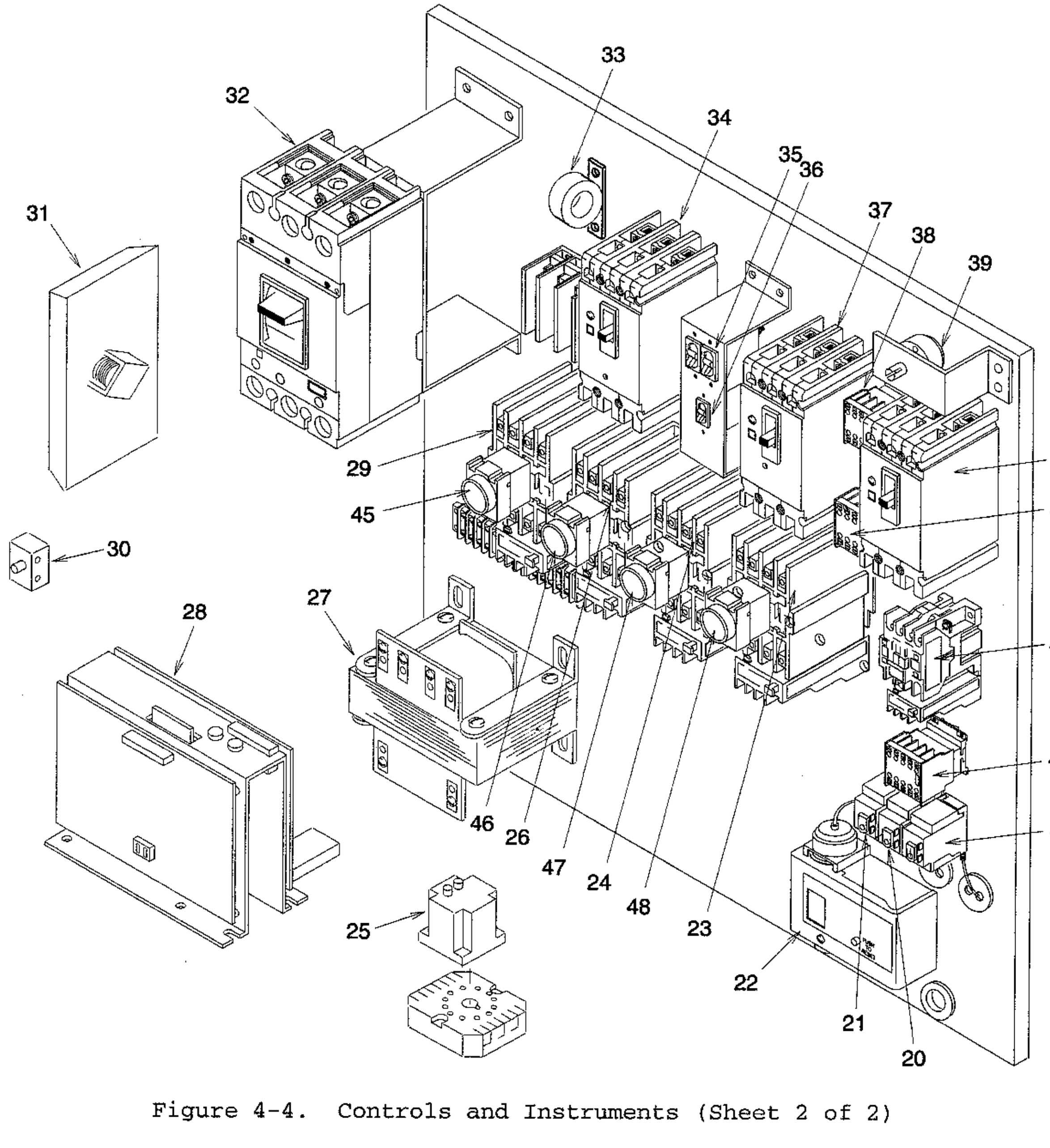


Figure 4-4. Controls and Instruments (Sheet 2 of 2)

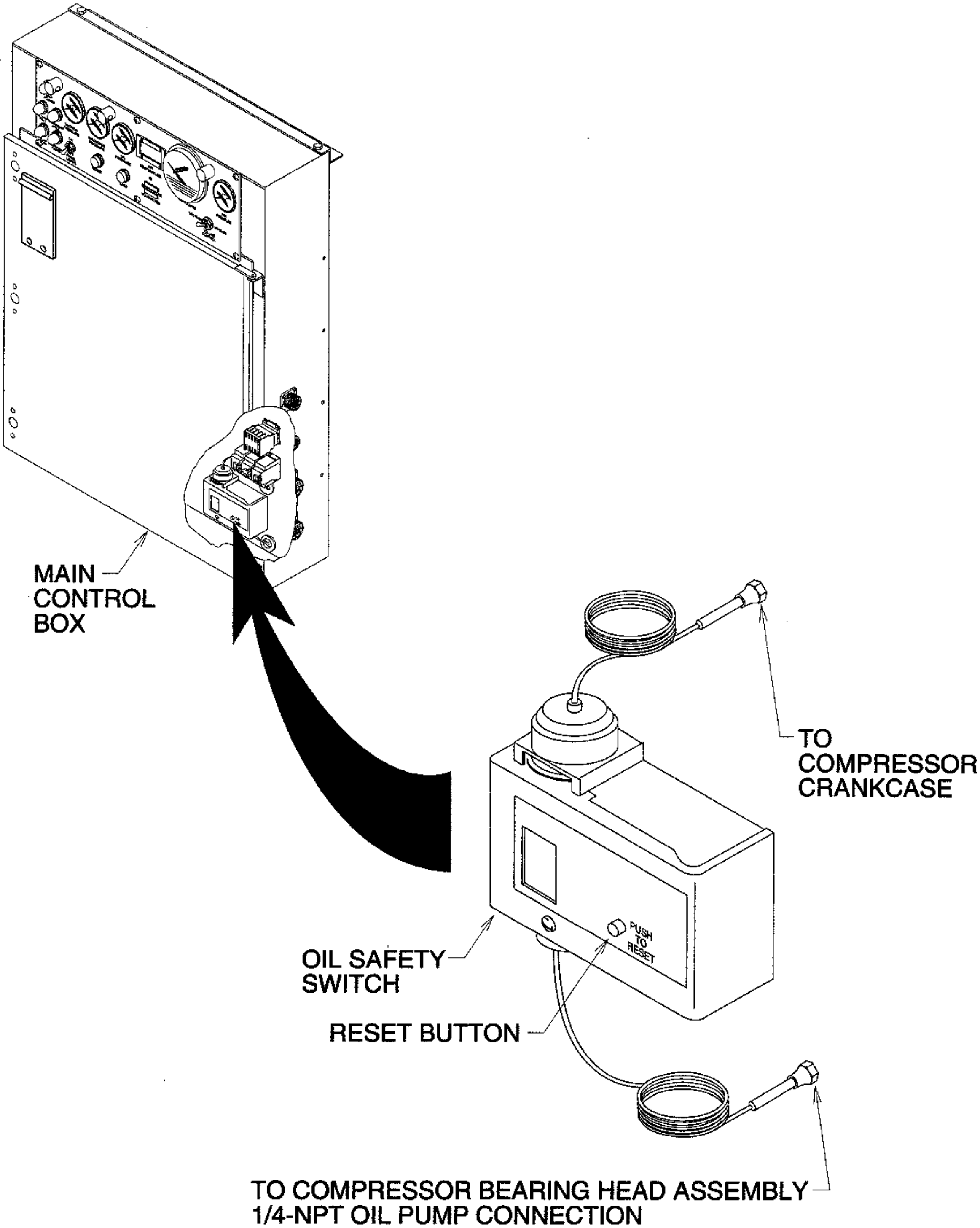


Figure 4-5. Oil Safety Switch and Reset Button

4-20. The blower blockage thermostat S10 senses inlet air temperature to the blower and shuts down the unit if the temperature reaches 150±5°F. This thermostat closes when the temperature drops to 130±5°F and restarts the unit.

4-21. The discharge line thermostat S8 is located in the refrigerant discharge line at the compressor and senses refrigerant gas temperature. This thermostat opens if the gas temperature reaches 275±8°F and shuts down the compressor. The thermostat contacts close and restart the unit when the gas temperature drops to 200±6°F.

4-22. Circuit breakers CB1 through CB6 protect the various power and control circuits in the unit. The three motors (B1, B2, and B3) are also protected by thermal overloads OL1 through OL5.

4-23. OPERATING PROCEDURES

4-24. DOORS. Open all doors which must be open to operate air conditioner. (See para 2-5.b.). Open condenser air discharge cover on top of unit.

CAUTION

Never attempt to connect ducts with blower operating.

4-25. DRAIN CAP. Remove cap from condensate drain (fig. 3-1). Install hose and route drain hose to a suitable location.

4-26. DUCTING. Check that all required ducting is connected at front of unit. (Refer to para 3-5.) Do not connect duct to aircraft.

4-27. CONTROLS. Refer to fig. 4-4 for location of controls and indicators, and to table 4-2 for an explanation of each.

4-28. STARTING. To start the air conditioner, proceed as follows:

NOTE

Before starting the unit refer to table 4-1 for nominal operating indication of gages. Unit will not operate if crankcase heater light is on indicating a cold compressor. At start-up, digital display (DD) will show 888 for a brief time. This is a normal self test and does not indicate an error. If a fault would occur, the error messages would be as follows: 444 - broken set point potentiometer (PT1), 555 - broken ambient temperature sensor (TS2), 666 - broken discharge temperature sensor (TS1), and 999 - unit not cooling. The display can be changed by by positioning the two DIP switches (1 and 2) on digital display (DD) circuit board as follows: 1 OFF and 2 OFF - ambient temperature, 1 ON and 2 OFF - set point temperature, and 1 ON or OFF and 2 ON - discharge temperature.

a. Open control panel and turn main circuit breakers CB1 through CB6 (1, fig. 4-4) to ON.

b. If necessary, turn PANEL LIGHTS switch (2) to ON.

c. Push START switch to start unit. Run for 15 seconds to purge ducts then stop unit. Connect duct to aircraft and restart unit.

d. Adjust supply air VOLUME CONTROL as indicated until desired airflow (pounds per minute) is indicated on air discharge volume gage.

NOTE

If the unit has not been used for some time, refrigerant may have migrated to the compressor crankcase. This may cause the compressor to exhibit low net oil pressure which will trip the oil safety switch. This is not an uncommon occurrence and will not adversely affect the compressor. Reset the oil safety switch and restart. If after repeating this operation two more times, the unit still trips, check for causes of low oil (leak, migration, etc.) and correct.

e. Final temperature adjustment is made by rotating TEMPERATURE CONTROL (39, fig. 4-4) to desired position. Allow fifteen minutes for stability and adjust as necessary.

4-29. Periodically check air delivery and temperature, and adjust as necessary. Check oil level at compressor sight glass and refrigerant condition at liquid line sight glass. Correct as indicated.

4-30. STOPPING.

a. Push STOP switch. Blower stops but air conditioner operates until pump down indicator lamp goes off.

b. If air conditioner is not to be used again for an extensive period, open control panel and turn circuit breakers CB1 through CB6 to OFF.

c. Remove and stow outlet ducts and install air outlet cap, disconnect power cable and stow on back of unit, and close all doors including top (condenser outlet) cover.

d. Remove drain hose and install cap on condensate drain.

Table 4-1. Controls and Indicators - Purpose

Fig.4-4 Index No.	Control or Indicator	Purpose	Nominal Operating Indication
1	Air Volume Control Switch S12	Sets damper to control airflow output.	---
2	Hourmeter M	Records total time unit has operated for maintenance and record purposes.	---
3	Pushbutton (STOP) Switch S15	Shuts air conditioner off.	---
4	Pushbutton (START) Switch S1	Starts system.	---
5	Panel Lights Switch S7	Switches panel lights on and off.	---
6	Indicator Lamp DS8	DS8 indicates compressor heater on.	green
7	Indicator Lamp DS7	DS7 indicates pump down in progress.	green
8	Indicator Lamp DS3	DS3 indicates compressor fault.	red
9	Indicator Lamp DS2	DS2 indicates blower fault.	red
10	Indicator Lamp DS1	DS1 indicates control power on.	green
11, 14 & 18	Panel Lamp DS4, DS5, and DS6	Night illumination for instrument panel.	---
12	Refrigerant Suction Pressure Gage	Indicates refrigerant suction pressure at the compressor.	28-45 psig
13	Refrigerant Discharge Pressure Gage	Indicates refrigerant discharge pressure at the compressor.	100-250 psig
15	Refrigeration Oil Pressure Gage	Indicates compressor oil pressure.	35-55 psig
16	Digital Air Temperature Display (DD)	Indicates air temperature at conditioned air outlet.	40-90°F (4.4-32.2°C)

Table 4-1. Controls and Indicators - Purpose (Continued)

Fig.4-4 Index No.	Control or Indicator	Purpose	Nominal Operating Indication
17	Air Volume Gage	Indicates discharge airflow rate.	26 lbs/min (40°F) 34 lbs/min (65°F) 51 lbs/min (90°F)
19	Air Discharge Pressure Gage	Indicates static pressure at airflow discharge port.	0-4 psig
20	High Pressure Cutout Switch S2	Shuts down compressor when discharge pressure exceeds 280±10 psig.	---
21	Low Pressure Cutout Switch - S3	Shuts down compressor when suction pressure drops below 2(+5,-0) psig.	---
22	Oil Safety Switch S5 (Differential Oil Pressure)	Shuts down system if compressor oil pressure is too low. A 120±15 second delay prevents action on pressure pulses.	Closes at 5 psig. diff.
23	Compressor Motor Starter K4	Contactor supplies line power to compressor motor through 0.1 sec time delay relay TD3 after K3 closes.	---
24	Compressor Motor Starter K3	Contactor supplies line power to compressor motor through 30 sec time delay relay TD2 after K2 closes.	---
25	Current Monitor K9	Contactor supplies control power to damper control S12 if air pressure is an acceptable range as indicated by Current Transformer CT1.	---
26	Blower Motor Starter K2	Contactor supplies line power to blower motor through 0.1 sec time delay relay TD1 after K1 closes.	---
27	Transformer TR	Drops ac line voltage to 24V ac for operating control circuit components.	---

Table 4-1. Controls and Indicators - Purpose (Continued)

Fig.4-4 Index No.	Control or Indicator	Purpose	Nominal Operating Indication
28	Temperature Controller TC (Suction Throttling Valve)	Provides temperature control voltages.	---
29	Blower Motor Starter K1	Contactor supplies line power to blower motor.	---
30	Push Switch S18 (Horn Disconnect)	Switch located on junction box door that shuts off Horn, by opening door, while correcting problem.	---
31	Horn HN	High ambient temperature warning.	---
32	Main Circuit Breaker CB1	CB1 switches main line power to air conditioner.	---
33	Current Transformer CT1	Detects overcurrent indicating over air pressure and opens Current Monitor K9.	---
34	Blower Motor Circuit Breaker CB4	Provides overload protection and disconnect for fan blower motor.	---
35	Circuit Breaker CB3	Transformer Circuit Breaker.	---
36	Circuit Breaker CB2	Control Circuit Breaker.	---
37	Compressor Motor Circuit Breaker CB5	Provides overload protection and disconnect for compressor motor.	---
38	Compressor Heater Relay K7	Contactor supplies control power to compressor heaters HR and HR2 when Compressor Thermostat Switch S11 senses ambient temperature below $50^{o}F\pm5$ (S11 resets at $70^{o}F\pm5$).	---
39	Discharge Air Temperature Control (Potentiometer PT1)	Controls temperature of conditioned air.	---
40	Circuit Breaker CB6	Condenser Fan Motor Circuit Breaker.	---

Table 4-1. Controls and Indicators - Purpose (Continued)

Fig.4-4 Index No.	Control or Indicator	Purpose	Nominal Operating Indication
41	Startup relay K8	Contactor through which control power is supplied to the control side.	---
42	Condenser Fan Motor Starter K5	Contactors supply line power to condenser fan motor.	---
43	Control Relay K6	Contactor supplies control power to Temperature Controller TC through 3 sec time delay relay TD4 after K4 closes.	---
44	Low Pressure Switch S4	Allows compressor head pressure to cycle condenser fan motor.	opens at 90±5 psig closes at 130±5 psig
45	Time Delay Relay TD1	Provides a 0.1 second delay between blower motor part winding starters.	0.1 sec.
46	Time Delay Relay TD2	Provides 30 second delay from blower startup to compressor startup.	30 sec.
47	Time Delay Relay TD3	Provides a 0.1 second delay between compressor motor part winding starters.	0.1 sec.
48	Time Delay Relay TD4	Provides a 3 sec delay between compressor motor relay K4 and Control Relay K6.	3 sec

SECTION V

MAINTENANCE

5-1. INSPECTION

5-2. Table 5-1 lists the inspection requirements for the air conditioner. Inspection intervals are based on normal operating conditions. Perform inspection at more frequent intervals if unusual operating or ambient conditions exist.

5-3. OPERATIONAL CHECKOUT

5-4. To verify that the air conditioner is operating normally, perform the following tests.

a. Operate air conditioner as described in paras 4-23 through 4-30.

b. Using an inspection mirror, carefully check compressor oil level sight glass. It should be 1/4 to 1/2 of the way up the sightglass when the compressor is running, and 1/2 to 7/8 of the way up the sightglass when the compressor is stopped. If oil appears to be low, the system should be allowed to operate continuously for three or four hours, with an oil level check every 30 minutes. If oil continues low, add more oil (Castrol SW68 or ICI Emkarate RL68H) to bring it up to the correct level. (Refer to para 5-19.) The total amount of oil, as recommended by compressor manufacturer, is 19 pints.

c. Check compressor oil pressure. The oil pressure gage (15, fig. 4-4) should indicate about 16 to 22 pounds higher than the suction pressure during operation. If pressure is too low, check the probable causes given in table 5-3 and perform the appropriate remedy as indicated in the table.

d. Check the discharge pressure gage (13, fig. 4-4). It should register 100 to 230 psig, depending on ambient conditions. In an ambient temperature of 110^{o}F (43.3^{o}C), the high pressure will be approximately 215 pounds. In an ambient temperature of 80^{o}F (26.7^{o}C) or below, the high pressure will be approximately 135 pounds. If pressure is too high or too low, check the probable causes given in table 5-3, and perform the appropriate remedy.

e. Check suction pressure gage (12, fig. 4-2). It should register from 26 to 40 pounds, depending on the high pressure of the system and the ambient temperature. If pressure is too high or too low, check the probable causes (see table 5-3) and perform the appropriate remedy as indicated in the table.

f. When system has been in operation continuously for at least 30 minutes, check refrigerant sightglass for bubbles or fog indicating low refrigerant charge. If bubbles or fog are present, the system cannot maintain desired conditioned air temperatures, and the suction pressure is lower than normal, test the system for leaks (refer to para 5-13) and repair any leaks found (refer to para 5-31). If necessary, add refrigerant as directed in para 5-28.

g. Stop compressor. Check compressor for leaks using the procedure in para 5-13. If a leak is indicated, replace gaskets or associated parts as necessary.

Table 5-1. Inspection Requirements

COMPONENT	PROCEDURE	OPERATING HOURS
1. Air Filters	Check condition. Clean if dirty (refer to para 5-6). Replace if damaged.	100
2. Refrigerant Sight Glass	Follow the procedure given in para 5-4 f.	50
3. Compressor Oil Level	Follow the procedure given in para 5-4 b.	50
4. Compressor Oil Pressure	Follow the procedure given in para 5-4 c.	50
5. Flexible Air Ducts	Check for wear or holes. Check flange joints.	50
6. Tire Pressure	Check pressure. It should be 100 psig. Repair or replace tire if leaks are indicated, and adjust pressure to 100 psig.	100
7. Condenser Fan	Check condenser fan for cracks, bent or missing blades. Replace if damaged. Check fan motor for signs of overheating, bent shaft, and cracked or broken mounting feet. Replace if damaged.	150
8. Electrical Connections	Check all connections for tightness, secure contact, and freedom from corrosion. Adjust, clean, repair or replace as required.	150
9. Wiring	Check condition, noting any frayed or missing insulation. Replace wires as necessary	150
10. Discharge Pressure Gage	Follow the procedure given in para 5-4 d.	200
11. Suction Pressure	Follow the procedure given in para 5-4 e.	200
12. Entire Unit	Clean completely and tighten all accessible nonadjustable bolts, nuts, and screws. Check entire unit for accessible broken welds, solidity of structure and brackets. Repair as required.	250
13. Mounting Bolts: Blower Motor, Condenser Fan Motor, Compressor (4 each)	Inspect to ensure they are secure. Tighten as necessary.	300

Table 5-1. Inspection Requirements - continued

COMPONENT	PROCEDURE	OPERATING HOURS
14. Brakes	Wheels should turn freely when brake is released. With brake on, tires should skid if towed on dry cement surface. If not adjusted properly, release brake and adjust knob on end of brake lever. If brakes can not be adjusted tight enough, brake shoes have worn and must be replaced.	300

5-5. PREVENTIVE MAINTENANCE

5-6. CLEANING AIR FILTERS. The filters are of a permanent, washable type. Do not discard unless damaged. To clean the filters, proceed as follows.

CAUTION

Do not direct a high velocity stream of water against the filter.

a. Remove filter from unit, and immerse in warm water to clean. If coating remains, use a detergent followed by a rinse. If it is impossible to immerse filter, accumulation may be washed out by using a stream of water from a garden hose or equivalent washing through the filter in a direction opposite that of the airflow arrows. Direct the water flow from the clean side to the dirty side of the filter and accumulation of dirt will flow off the filter.

b. Carefully shake water out of filter and reinstall.

WARNING

Wear suitable eye and face protective equipment while using compressed air for cleaning purposes. Do not direct airstream towards self or other personnel.

5-7. CLEANING CONDENSER COILS. To clean the condenser coils, proceed as follows.

a. Remove condenser screens to allow access to coils from below.

b. Remove excess dirt with a fiber brush.

c. Use compressed air at 15 psig or water to remove any loosened residue. Direct water or airflow from top of unit down and away from fan.

5-8. LUBRICATION. Wipe all grease fittings with a clean cloth before greasing. Wipe all linkage free of excess dust and dirt before oiling. Do not over oil. Lubricate the air conditioner at the points shown in fig. 5-1, using the lubricants listed in table 5-2.

5-9. TROUBLESHOOTING

5-10. REFRIGERATION SAFETY PRECAUTIONS.

a. Wear goggles when handling refrigerants.

b. Never heat refrigerant drums with flame.

c. When repairing refrigerant pipe or tubing, always blow out refrigerant gas before applying blow torch. Flow nitrogen gas through tube while applying solder during repair.

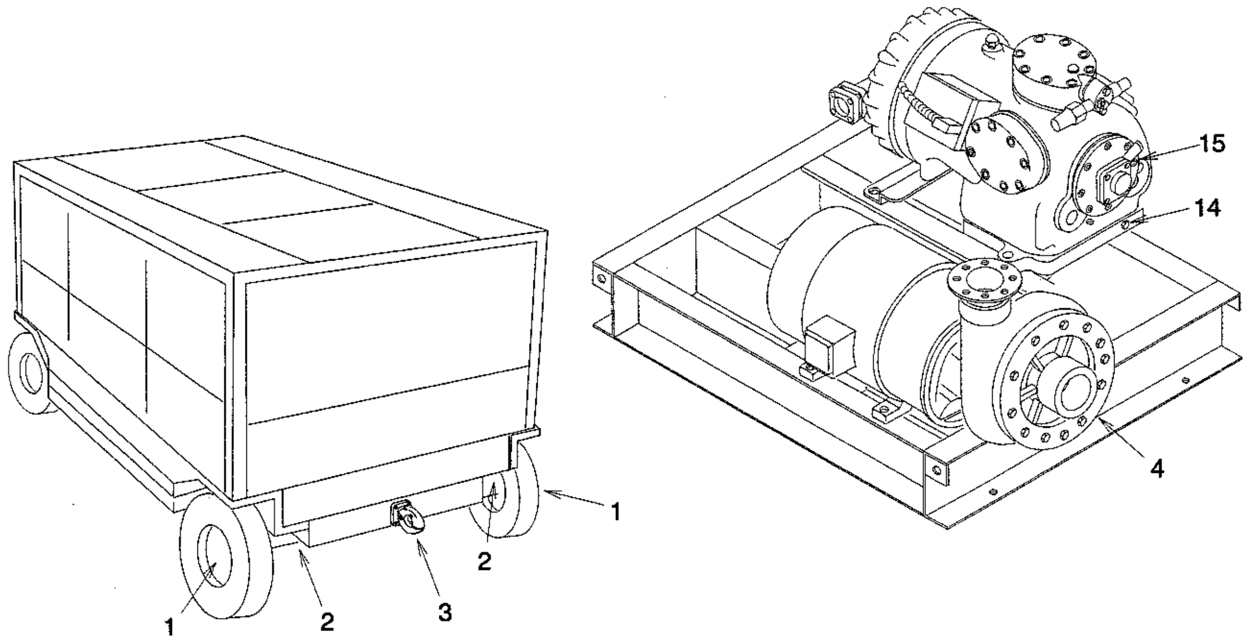
d. Never fill a refrigerant cylinder to more than 85 percent of its capacity.

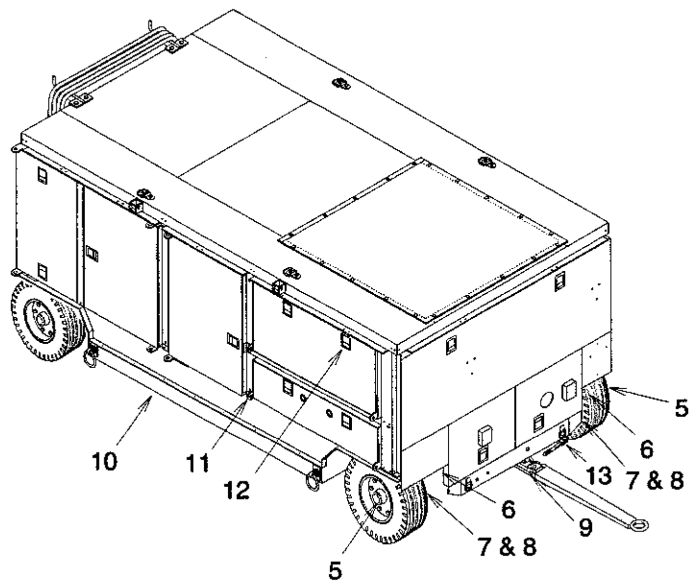
e. Never heat any part of refrigerant system if refrigerant is stored within.

f. Never introduce liquid refrigerant into a compressor suction line.

g. Before adding refrigerant, inspect charging lines used with refrigerant tank gages for brittleness. Check the condition of the flare connections.

h. Always use proper gages when transferring refrigerant.





1 REAR WHEEL BEARINGS
2 REAR SPRING PINS (2 FITTINGS)
3 PINTLE HOOK (PIN AND PAWL) (2 FITTINGS)
4 BLOWER
5 FRONT WHEEL BEARINGS
6 FRONT SPRING PINS (2 FITTINGS)
7 KING PINS (4 FITTINGS)
8 TIE ROD ENDS (4 FITTINGS)
9 DRAWBAR RETAINER (1 FITTING)
10 BRAKE LINKAGE
11 HINGES
12 LATCHES
13 BRAKE OPERATOR LEVER
14 COMPRESSOR DRAIN PLUG
15 COMPRESSOR FILL PLUG

Figure 5-1. Lubrication Diagram

Table 5-2. Lubrication Chart

Fig. 5-1 Index No.	Description (No. of lubrication points in parenthesis)	Procedures	Hours of Operation
1	Rear Wheel Bearings (2)	Clean and repack with grease, Specification MIL-G-10924.	Every two years
2 & 6	Spring Pin Fittings (4)	Apply with grease gun. Use general purpose lubricating grease.	250
3	Hook (Pin and Pawl) Fittings (2)	Apply with grease gun. Use general purpose lubricating grease.	250
4	Blower	Check oil level at sightglass. Level should be as marked on plate at side of sightglass. To replenish, add oil at top filler plug to marked level. Do not fill through vent plug. Make sure hole in vent plug is open. Use of ISO viscosity grade 32 (recommend Mobile 1 synthetic oil 5W-30) is preferred. The total amount of oil, as recommended by blower manufacturer, is 2 quarts. To change, open drain at bottom of blower and drain into container. close drain and add oil at top filler plug slowly until sight glass indicates marked level. Do not fill through vent plug. Make sure hole in vent plug is open. (Allow time for oil level to stabilize before checking.) Do not overfill.	250
5	Front Wheel Bearings (2)	Clean and repack with grease.	Every two years
7 & 9	King Pins and Drawbar (5)	Apply with grease gun. Use general purpose lubricating grease.	250
8	Tie Rod Ends (4)	Apply with grease gun. Use general purpose lubricating grease.	250
10	Brake Linkage	Apply several drops lubricating oil.	500
11	Hinges (21)	Wipe using clean cloth dampened with lubricating oil.	500
12	Latches (17)	Apply not more than two drops lubricating oil.	500

Table 5-2. Lubrication Chart (Cont)

Fig. 5-1 Index No.	Description (No. of lubrication points in parenthesis)	Procedures	Hours of Operation
13	Brake Operating Lever	Apply two drops of oil, specification MIL-L-2104, at each pivot point. With brake set, coat exposed portion of operating cable and terminating fitting with grease.	500
14	Compressor Drain Plug	Drain oil from compressor using gravity.	At overhaul or as required
15	Compressor Fill Plug	Fill compressor with Castrol SW68 or ICI Emkarate RL68H (POE) oil as required. See paragraph 5-19 for procedure.	At overhaul or as required

5-11. FIRST AID TREATMENT.

a. If liquid refrigerant comes in contact with the skin, a serious "burn" may result and should be treated as if the skin were frostbitten or frozen.

b. Particular care must be taken that refrigerant does not come in contact with the eyes by wearing goggles when working on parts in which refrigerant may be discharged. If liquid refrigerant should come in contact with the eyes, call a doctor and use the following first aid treatment.

(1) Drop sterile mineral oil into the eye as an irrigator.

(2) Wash the eyes with a boric acid solution if the irritation continues.

(3) Do not rub or irritate the eyes.

5-12. GENERAL TROUBLESHOOTING INSTRUCTIONS. Table 5-3 indicates the troubles and probable causes most likely to be encountered in the air conditioner, and gives the appropriate remedy for each cause. Table 5-4 presents troubleshooting procedures for the compressor only.

5-13. TESTING FOR LEAKS. The air conditioner can be tested for refrigerant leaks by the use of an electronic leak detector, by the halide leak test or by the soap bubble method.

a. If sufficient pressure is not present in the system to accomplish an adequate leak test, isolate the compressor by front seating (clockwise) the two service valves (18 and 23, fig. 5-3) and add dry nitrogen at the receiver charging valve to increase the system pressure to 30 psig, then conduct the leak test.

NOTE

If nitrogen is used, the nitrogen must be evacuated before charging (see para 5-27).

b. If the system is totally discharged to conserve leak test refrigerant, pressurize the system with R-134a to approximately 40 to 50 lbs. Isolate the compressor by front seating (clockwise) the service valves and at the receiver charging valve pressurize the system with dry nitrogen to 300 psig. Then conduct the leak test.

5-14. Electronic Leak Detector. Using a G.E. Type H-2 Detector, or equivalent, proceed as follows.

a. Turn on and calibrate the leak detector to 0.5 oz. per year as described in the instructions supplied with the instrument.

b. Slowly pass the detector probe tip over the sweat fittings, mechanical couplings and valves in the refrigerant circuit. If refrigerant is leaking, detector will provide a visible or audible signal.

c. Use the soap bubble method (para 5-16) to localize the leak of a defective component or connection.

5-15. Halide Leak Test. Using a propane flame halide leak detector, proceed as follows.

a. Slowly pass the exploring tube of the torch over the sweat fittings, mechanical couplings and valves. If refrigerant is leaking, the flame will be affected as follows:

Small leak - flame changes from blue to green;

Large leak - flame changes from blue to dense blue with reddish tip;

Massive leak - may extinguish flame.

b. Use the soap bubble method (para 5-16) to localize the leak to a defective component or connection.

5-16. Soap Solution Method. Using either a prepared bubble type leak detector compound or a solution of hand soap in water, proceed as follows.

a. Apply the solution to all points of possible leakage, and watch for bubble formation indicating a refrigerant leak.

NOTE

Allow solution to remain on joints long enough for small leaks to form noticeable bubbles.

b. Wipe solution from joints and mark spots where leakage is observed.

c. For repairs, refer to para 5-31.

5-17. SERVICING THE REFRIGERANT SYSTEM

WARNING

Avoid bodily contact with liquid refrigerant and avoid inhaling refrigerant gas. Be especially cautious that refrigerant does not come in contact with the eyes. Provide adequate ventilation to fully carry away discharged refrigerant gas.

5-18. Refrigerant system servicing includes adding oil to compressor, pumping down, evacuating, adding refrigerant, and discharging refrigerant. Normally, even if there has been some loss of refrigerant, the refrigerant in the system is to be pumped down into the receiver and held there while repairs are performed. Discharging refrigerant is normally required only if it is severely contaminated.

5-19. ADDING OIL TO COMPRESSOR

5-20. COMPRESSOR LUBRICATION. The compressor must be properly lubricated to ensure trouble free operation and a long compressor life. Failure to stabilize oil levels can cause the compressor to fail. While it is apparent that very low oil levels can cause compressor damage, excess oil charges can shorten the life of the compressor by elevating crankcase and oil temperatures, increasing power consumption, and causing valve plate gasket and equipment failures.

5-21. Some oil is normally lost when the system is placed in operation. Oil loss results from coatings left inside piping, oil lodged in low velocity areas, and other causes. Oil loss must be made up by adding oil after initial startup, as indicated by the oil levels in the compressor sightglass (see fig. 5-2). Flooded starts (refrigerant migrating to the oil during off periods, and pulling oil out of its sump during startup) can cause oil loss due to sudden pressure drops.

5-22. OIL LEVELS. The compressor oil level should be checked by observing the sightglass while the compressor is in operation. Observing the oil level with the compressor not in operation gives an inaccurate reading because it reflects a mixture of oil and refrigerant. Oil levels above the center of the sightglass indicate potential compressor failure, as indicated in para 5-20. If no oil level is observed, and vertical or circular lines are not seen, the oil level is above the top of the sightglass. If the level is less than 1/8 up from the bottom, the oil level is low. If the level is more than 1/2, a high oil level exists. The acceptable oil level is from 1/8 to 3/8 full (in the sightglass) with the compressor in operation.

5-23. ADDING OIL. Oil may be added by charging it into the compressor crankcase using an oil pump (table 2-1) through a suitable dehydrator. Follow the instructions provided with the compressor and/or oil pump.

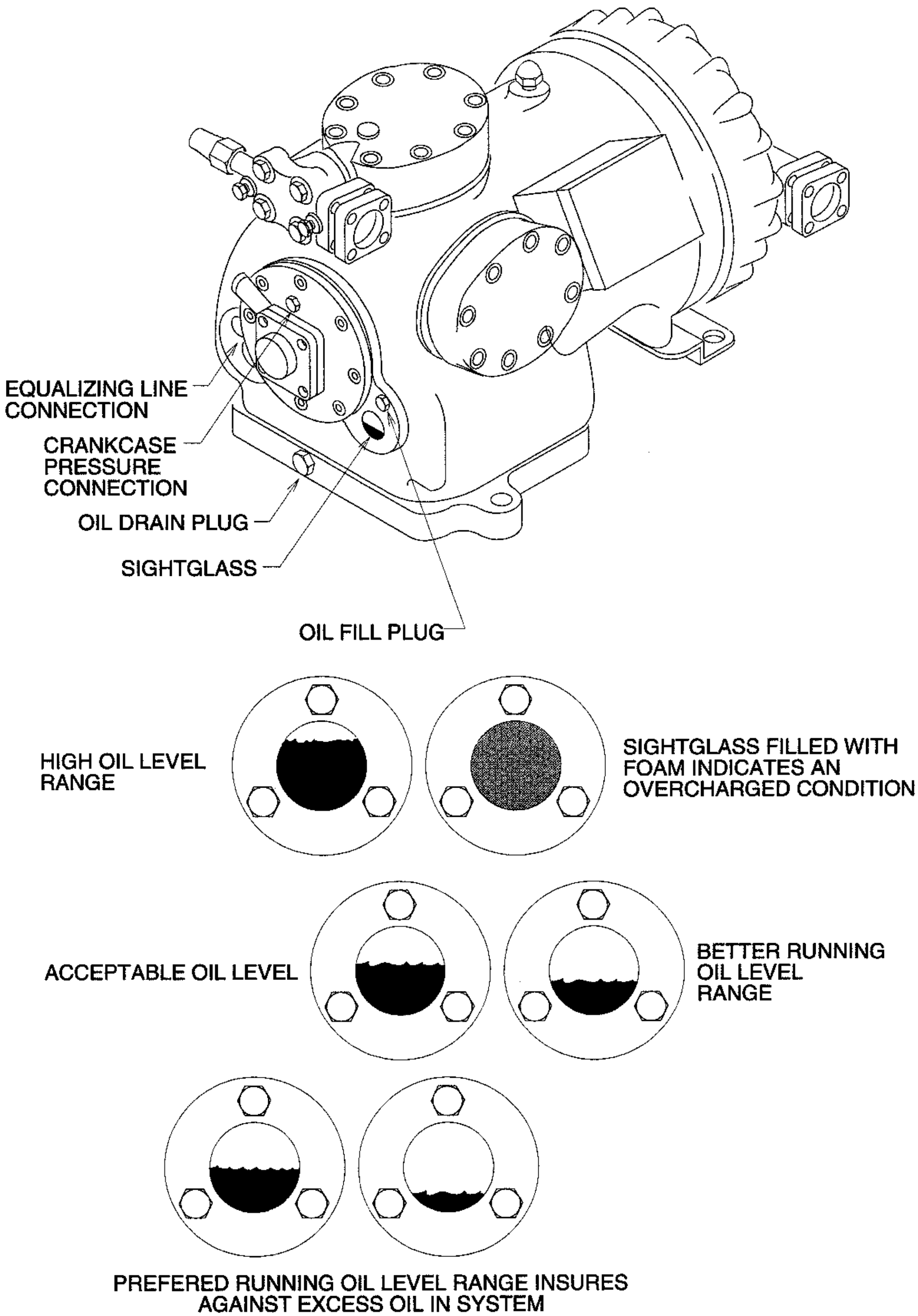


Figure 5-2. Compressor Oil Levels

5-24. MAINTAINING CORRECT OIL LEVEL. The system should be checked regularly to prevent excess oil charges. To check the system, the oil in the compressor must be brought down to approximately 1/4 level in the sightglass. If the system is overcharged, the oil level in the sightglass rises to 1/2 level within a short time (usually within one hour) after the compressor is placed in operation. To correct this condition, oil must be removed until the oil level does not rise. The oil level should be kept at the correct level to eliminate potential gasket and equipment problems, allow cooler system operation, and to provide better gas equalization.

5-25. VALVE PLATE GASKET AND EQUIPMENT DAMAGE. The probability of damage to compressor components is increased when excess oil is allowed to accumulate in motor compartments of a non operating compressor. A grossly overcharged system causes cylinders to be "slugged" on startup and can lead to gasket and equipment failures. Overcharged oil levels are reflected as 1/2 to 3/4 levels in the sightglass. To minimize this potential problem, oil levels should be kept at 1/8 to 3/8 levels in the sightglass.

5-26. REFRIGERANT PUMP DOWN. The receiver can hold the entire refrigerant charge. To pump refrigerant into the receiver before making repairs or for other purposes, proceed as follows. (See fig. 5-3.)

a. Close the receiver outlet service valve (26) to retain the liquid in the receiver.

b. Jumper the contacts for the low pressure cutout switch (21, fig. 4-4), as the suction pressure must be pumped well below the normal cutoff setting to approximately two pounds suction pressure.

CAUTION

Do not allow the suction pressure to go below 2 psig. 2 to 4 psig pressure must be on the system before any part is opened to prevent air and moisture from entering the system.

c. Start unit (compressor) and allow it to run. Remove jumper as soon as two pounds suction pressure is attained.

d. Check suction pressure gage after a few minutes wait. If the pressure has risen to 5 psig or more, rejump the contacts and repeat step b. If the pressure rise is to less than 5 psig, pump down is satisfactory. Stop the compressor and quickly close the compressor discharge service valve (18, fig. 5-3). Then close the suction service valve (23) and the receiver inlet service valve (24). This will trap practically all of the refrigerant in the receiver. Allow slight pressure in the lines to remain while the system is opened to prevent air and moisture from being drawn in. Turn off main circuit breaker and tag with warning; Compressor service valves have been closed, open prior to operation.

5-27. EVACUATING THE SYSTEM

CAUTION

Never, under any circumstances should the compressor be used for evacuation. If used for this purpose, serious damage to equipment will result.

a. If receiver is to be included in the evacuation, first remove refrigerant as directed in para 5-30.

b. Use an auxiliary vacuum pump (table 2-1) capable of pulling a 50-micron vacuum. Connect the vacuum pump and a vacuum dehydration indicator (table 2-1) to the appropriate service valve(s) depending upon what portion(s) of the system is to be evacuated.

1 ACCUMULATOR, SUCTION (A)
2 COMPRESSOR, REFRIGERATION (B2)
3 COIL, CONDENSER (C1)
4 COIL, CONDENSER (C2)
5 COIL, PRECOOLER (C3)
6 COIL, AFTERCOOLER (3 CIRCUIT) (C4)
7 DRIER STRAINER (D)
8 VALVE, SOLENOID, PRECOOLER (L1)
9 VALVE, SOLENOID, AFTERCOOLER (L2)
10 VALVE, SOLENOID, AFTERCOOLER (L3)
11 VALVE, SOLENOID, HOT GAS BYPASS (L4)
12 VALVE, SOLENOID, QUENCH (L5)
13 VALVE, SOLENOID, PUMP DOWN (L6)
14 RECEIVER (R)
15 INDICATOR, SIGHT LIQUID (SG)
16 VALVE, SUCTION LINE THROTTLING (TV)
17 SWITCH, THERMOSTAT (S8)
18 VALVE, COMPRESSOR DISCHARGE SERVICE (V1)
19 VALVE, QUENCH (V2)
20 VALVE, REGULATOR, HOT GAS BYPASS (V3)
21 VALVE, CHECK (V4)
22 VALVE, HEAD PRESSURE CONTROL (V6)
23 VALVE, COMPRESSOR SUCTION SERVICE (V7)
24 VALVE, RECEIVER INLET SERVICE (V8)
25 VALVE, PRESSURE RELIEF (V9)
26 VALVE, RECEIVER OUTLET SERVICE (V10)
27 VIBRATION ABSORBER (VA1)
28 VIBRATION ABSORBER (VA2)
29 VALVE, EXPANSION, PRECOOLER (X1)
30 VALVE, EXPANSION, AFTERCOOLER (X2)
31 VALVE, EXPANSION, AFTERCOOLER (X3)
32 VALVE, EXPANSION, AFTERCOOLER (X4)
33 VALVE, ANGLE
34 VALVE, PRESSURE RELIEF (V14)

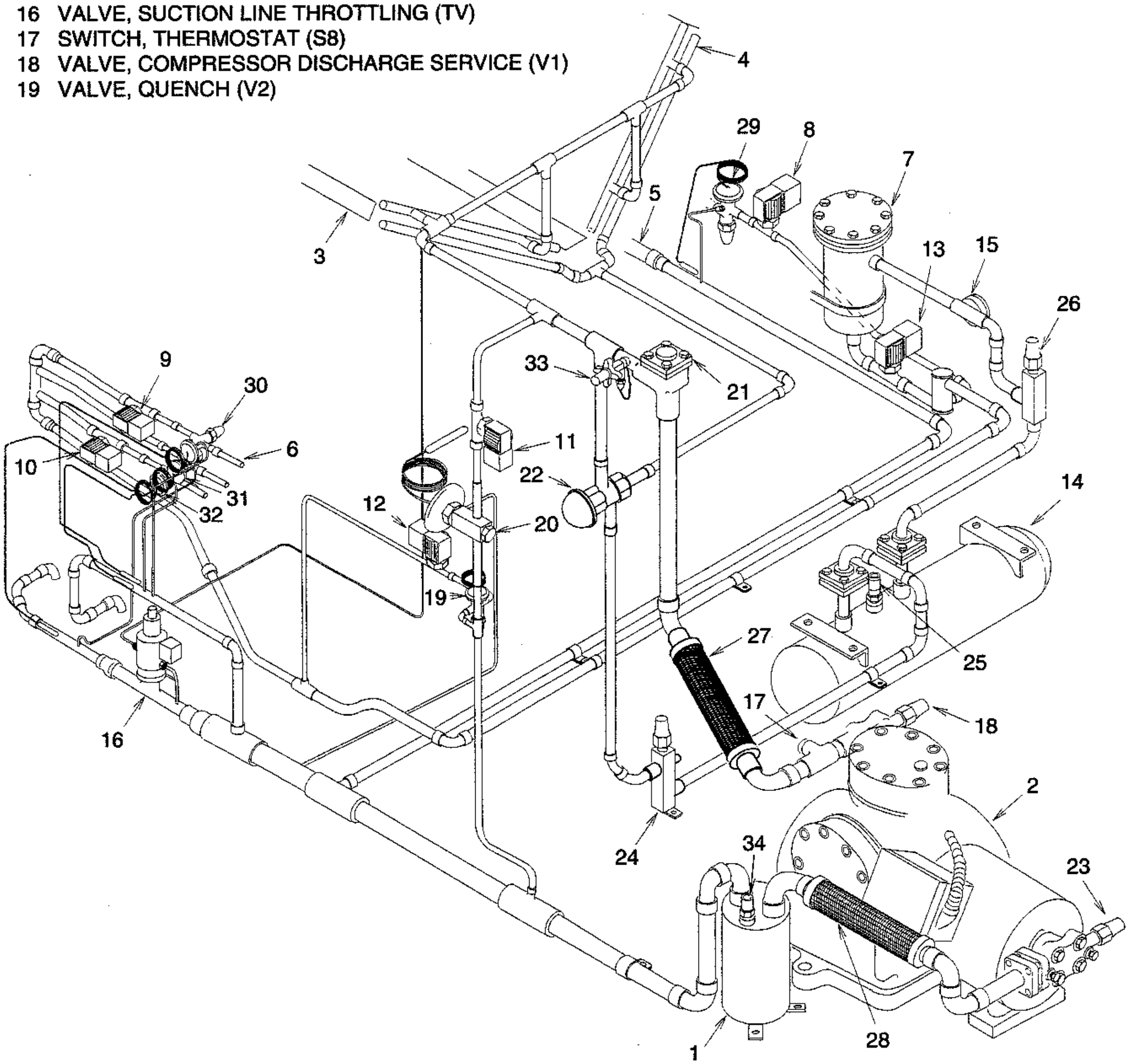


Figure 5-3. Refrigeration System

(1) Low Side Only: Front seat (clockwise) compressor suction service valve, disconnect pressure gage and attach vacuum pump line.

(2) High Side Only: Front seat (clockwise) receiver outlet service valve, disconnect pressure gage and attach vacuum pump line.

(3) Both Sides: Attach pump line to two of the following (or all three for more rapid evacuation):

- Receiver Outlet Service Valve (partially open),
- Receiver Inlet Service Valve (partially open),
- Compressor Discharge Service Valve (front seated) (clockwise) (disconnect pressure gage) always use this port if receiver is to be evacuated.

c. Operate the pump until a vacuum low enough to evaporate moisture is shown on the vacuum indicator. This evacuated pressure should be 0.5 mm Hg absolute (500 microns Hg) or less. The length of time required will vary with the amount of moisture in the system. Failure to reach a sufficiently low vacuum may be due to the following.

(1) Presence of moisture in the system. This will be removed by continued operation of the vacuum pump.

(2) Inefficiency of the vacuum pump. This may be due to leaks within the pump proper or contaminated oil in the vacuum pump. The pump may be checked by valving off the system and operating the pump against the vacuum indicator only.

d. After the system has reached a sufficiently low vacuum, allow the evacuating pump to operate for at least four hours.

e. When the system has been evacuated, record the wet bulb reading on the vacuum dehydration indicator. Close the valves being used for evacuation and close the liquid line charging valve. Close the valve to the vacuum dehydration indicator. Stop the vacuum pump but do not disconnect the pump or the vacuum dehydration indicator. Allow the system to stand a minimum of ten hours.

f. Again, crack the valves being used for evacuation off the back seat (counterclockwise) position and open the liquid line charging valve. Start the vacuum pump. Allow the vacuum pump to operate for approximately two minutes and then open the valve to the dehydration indicator. Never open the vacuum dehydration indicator to the system unless the vacuum pump is operating. If there is no noticeable rise in wet bulb temperature or loss of vacuum, the system is evacuated and ready for charging. Back seat (counterclockwise) the service valves, close the liquid line valve, stop the vacuum pump and disconnect the pump and indicator from the system.

5-28. ADDING SMALL QUANTITIES OF REFRIGERANT. To fully recharge the system, refer to para 5-29. However, if the system has previously been charged and is free of leaks but the refrigerant sightglass shows bubbles or is only partially filled with liquid, there is insufficient cooling, and suction pressure is low, proceed as follows. Check that bypass valve (V3) and head pressure regulator (V6) are not bypassing, and that temperature set point is below ambient temperature by more that one degree fahrenheit. (Refer to fig. 5-4. See WARNING under para 5-17. See para 5-10 for safety precautions.)

a. Remove service valve cap and ensure that the compressor suction service valve is fully back seated (counterclockwise). Remove the back seat port plug from the service valve and install appropriate flare fitting.

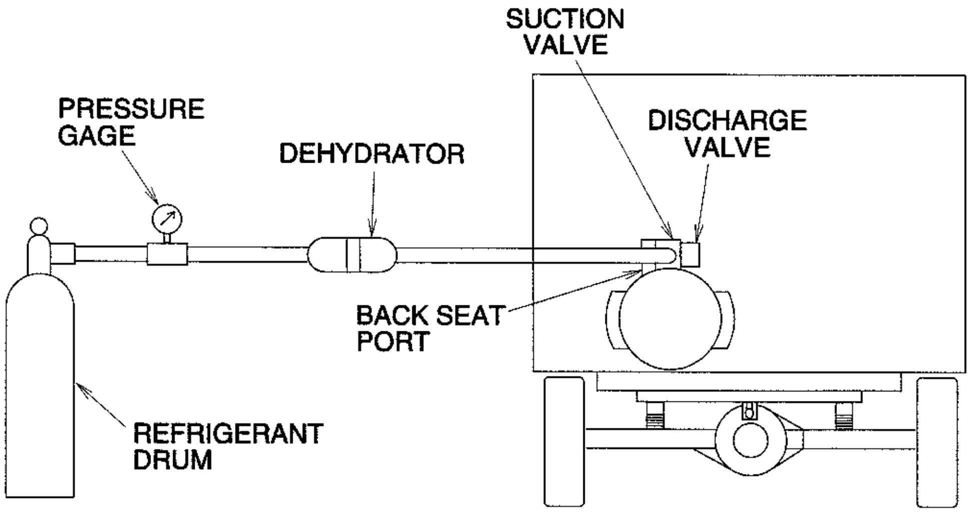


Figure 5-4. Charging Refrigerant System with Gas

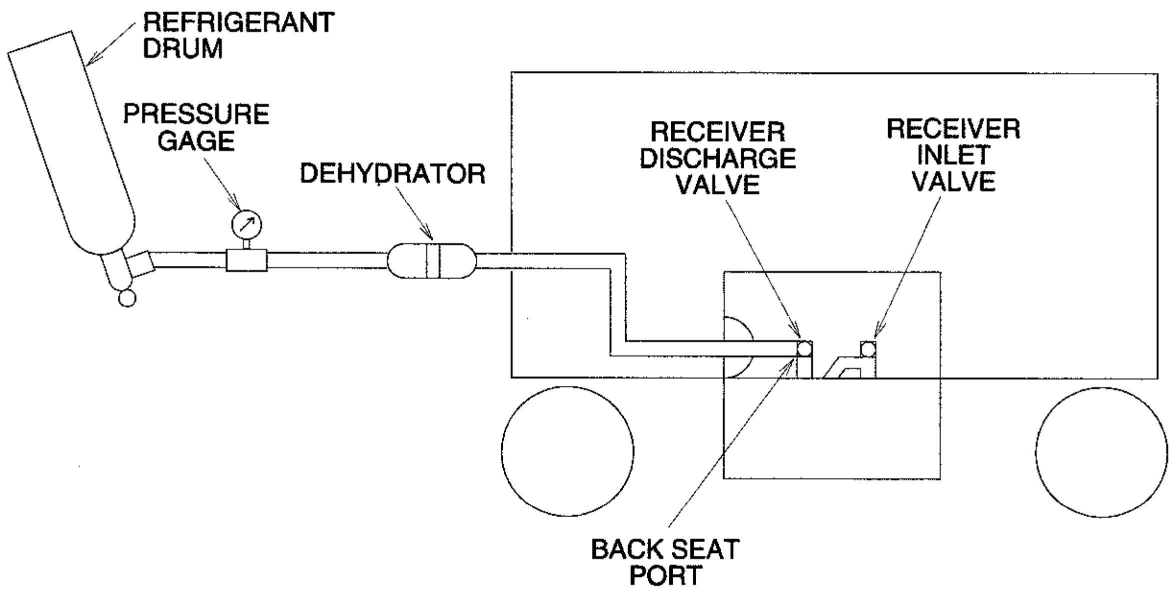


Figure 5-5. Charging Refrigerant System with Liquid

b. Support the refrigerant drum in the vertical position and install a suitable dehydrator (Sporlan C-052, or equal) as shown.

c. Connect the charging line from the top of the refrigerant drum to the suction valve back seat (counterclockwise) port fitting as shown in fig. 5-4. As the refrigerant is to be charged into the system as a gas, do not use drum liquid charging line. Connect the charging line to the port loosely and open valve on drum to purge air from the charging line. Tighten charging line connection and close the drum valve. Open the compressor suction service approximately two turns.

d. Start the unit and allow the compressor to operate in a normal manner until system is stabilized.

NOTE

During operation when the ambient temperature is below 80°F, (26.7°C), the head pressure regulator valve (22, fig. 5-3) will back up refrigerant in the condenser to hold the discharge pressure at approximately 110 psig.

e. Slowly open the drum valve and add refrigerant until the sightglass just begins to clear or only a few bubbles of gas are visible. Close the valve on the refrigerant drum when the sightglass first begins to clear. Do not overcharge at this point.

f. Observe the sightglass for approximately 10 to 15 minutes. If it remains filled and free of bubbles, the system is properly charged for this ambient temperature.

g. Close the drum valve. Back seat (counterclockwise) the compressor suction valve and shut off the unit. Disconnect the charging line from the back seat port, install the port plug, leak check the service valve (see para 5-13) and replace the valve cap.

h. Check the oil level in the compressor. Add oil to compressor if necessary. Refer to para 5-19 for procedures required to add oil to the compressor.

5-29. RECHARGING SYSTEM. These instructions apply when the system has been completely evacuated (see para 5-27). While the system is still holding a vacuum, recharge as follows. (Refer to fig. 5-5. See WARNING in paras 5-10 and 5-17.)

a. Weigh the drum of refrigerant. The system is to be charged with a total of 85 pounds of R-134a. Most refrigerant may be charged directly into the receiver prior to startup of the unit, as described in steps b through d.

b. Connect the charging line from the refrigerant drum to the receiver discharge valve back seat port as shown. As the refrigerant is to be charged into the receiver as liquid, use the drum liquid charging line, or invert the drum if it has only one charging line. Connect the charging line to the port loosely and open valve on drum to purge air from the charging line. Tighten charging line connection and close the valve. The charging line should contain a suitable dehydrator as shown (Sporlan C-052 or equal).

c. Open receiver discharge valve and drum valve slightly. Using a portable air heater, warm refrigerant drum to provide a pressure difference, thus allowing liquid to enter the receiver.

d. Weigh refrigerant drum from time to time to determine how much refrigerant has been charged. When most refrigerant has been charged into the receiver, close the drum valve. Back seat (counterclockwise) the receiver discharge valve. Disconnect the charging line and install the port plug and valve cap.

e. Complete the charging by adding refrigerant as gas at the compressor suction valve, following the procedure described in para 5-28.

5-30. DISCHARGING REFRIGERANT. The entire refrigerant charge should be discarded only if it is contaminated. A small amount of refrigerant may be removed if the system has been overcharged, which would happen only in case of an error in charging or if unit was charged in an area of low ambient and movedto a high ambient temperature. If it is necessary to discharge refrigerant, proceed as follows.

a. Back seat (counterclockwise) both compressor service valves and attach a suitable hose with pressure gage to each charging port of the service valves.

b. Route hoses to an area where refrigerant gas can be safely released in accordance with local environmental requirements.

c. Carefully turn both service valves approximately two turns towards the front seat (clockwise) position.

d. After all refrigerant is discharged (i.e. when gage readings are stabilized), or after only a small amount is removed if the problem is an overcharge, back seat (counterclockwise) the service valves and remove hoses.

5-31. <u>REFRIGERANT SYSTEM REPAIRS</u>

CAUTION

If the refrigerant lines to be opened to atmosphere are colder than the ambient air temperature, a considerable amount of sweating will take place on the inside of the opened piping. Always allow refrigerant piping to warm up to the ambient air temperature before opening the system to the atmosphere.

5-32. To open the refrigerant system for components, fitting or piping repair or replacement, proceed as follows.

a. Locate leaks by leak testing as directed in para 5-13.

b. Pump down as described in para 5-26, unless refrigerant charge is severely contaminated. In that case, discharge refrigerant as described in para 5-30.

c. Evacuate system as described in para 5-27.

WARNING

Ensure that adequate ventilation is present and avoid breathing fumes generated by soldering for prolonged periods. Use extreme caution to avoid being burned and use eye protection to prevent injury.

d. Using a propane flame or welding torch, heat tubing until metal reaches a dull red color, melting the solder. Separate the soldered joints.

e. Plug openings to portion of system not undergoing repair.

NOTE

When soldering during system repairs, pass an inert gas, such as nitrogen, continuously through the connection being soldered to prevent formation of harmful oxides. Shut off gas and remove all plugs before soldering the final connection.

f. Solder replacement components into system using sil-phos, phos-copper or silver brazing alloy.

g. Install a new filter-drier core and evacuate again as described in para 5-27.

h. Leak test as described in para 5-13.

i. If system was pumped down in step b, open the receiver service valves to release the refrigerant into the system.

j. Add refrigerant as directed in para 5-29.

5-33. For repairing specific parts of the system, observe the following special instructions.

a. Compressor. Before opening the compressor for servicing, front seat (clockwise) both service valves. Then remove the compressor and refer to the Overhaul manual for repair instructions.

b. Low side and Liquid Lines. To service any part of the low side of the system or the liquid lines, it is not necessary to close the compressor discharge service valve or the receiver inlet service valve.

CAUTION

If the system has been pumped down when the ambient temperature is below 80°F or the compressor discharge pressure is below 130 psig, the condenser or high side should not be opened. If it is necessary to open the condenser or high side under these circumstances, follow the procedure given in step d.

c. Condenser and High Side Piping. Before opening any part of the high side of the system, close the receiver outlet service valve, and the compressor discharge service valve, and follow the procedure given in step d.

d. Condenser and High Side Piping, When Condenser Contains Excess Refrigerant. To move refrigerant from the condenser into the receiver, proceed as follows.

(1) Front seat (clockwise) the compressor discharge service valve. Attach a pressure gage to the receiver inlet service valve.

(2) Heat the condenser with a portable air heater until the condenser pressure is over 150 psig, forcing the liquid from the condenser into the receiver. Do not allow the receiver pressure to exceed 300 psig while heating the condenser.

(3) When the condenser pressure has reached 150 psig, close the receiver inlet service valve and discontinue heating the condenser.

(4) Allow the condenser to cool to ambient temperature, discharge remaining refrigerant from high side as described in para 5-30, and then open the high side of the refrigerant system.

5-34. STARTING UP AFTER REPAIRS. (Refer to fig. 5-3.)

a. When the system has been properly repaired, all joints have been leak tested and found tight, and the lines have been properly purged or evacuated, the system is ready to start.

WARNING

Compressor suction and discharge service valves MUST be opened before compressor operation.

b. Back seat (counterclockwise), then turn back in about two turns, the compressor discharge service valve (18, fig. 5-3), the suction service valve (23), and the receiver inlet valve (24), in that order. Then slowly open the receiver outlet service valve (26) and allow liquid to enter the system. Start unit. Pressure in the system should now cause the low pressure switch to reset enabling the compressor to start. Reinstall all valve caps.

c. Check the oil level in the crankcase and the sightglass (15) in the liquid line to see that the system has sufficient oil and refrigerant.

5-35. CLOGGED FILTER-DRIER. Occasionally the filter-drier in the liquid line may become clogged with dirt or other foreign material left in the system following assembly or repair. When this happens, the liquid line leaving the filter-drier will feel cooler than the liquid entering. If it is badly clogged, some sweat or frost may appear at the filter drier outlet. In case of clogging, replace the filter-drier core as follows.

a. Pump down as described in para 5-26. If the ambient temperature is below 80°F (26.7°C) or the compressor discharge pressure is below 130 psig, follow the procedure given in para 5-27 b.

b. Shut down air conditioner by pushing the STOP button.

c. Unbolt head of filter-drier housing and remove.

d. Remove filter-drier core and install new core.

e. Bolt down head.

f. Evacuate the refrigerant lines (see para 5-27).

g. Open receiver service valves (2 and 4, fig. 5-3) to release the refrigerant into the system.

h. Check for refrigerant leaks at head of filter-drier (refer to para 5-13).

5-36. THERMOSTATIC EXPANSION VALVE HAS LOST CHARGE. The power element of an expansion valve consists of the control bulb, the capillary tube, and the bellows or diaphragm which actuates the valve. If this power element is inoperative or has lost its charge, the valve will either maintain an almost closed position or else close completely. To test for an inoperative power element, proceed as follows.

a. Stop compressor.

b. Loosen metal straps and remove remote bulb from suction line, taking care not to kink the capillary.

c. Place bulb in ice water.

d. Start compressor.

WARNING

Do not allow floodthrough for too long a period because excessive floodthrough can cause severe damage to the compressor and possible injury to operating personnel.

e. Remove bulb from ice water and warm in hand. At the same time check suction line for rapid temperature change which indicates floodthrough of liquid refrigerant. If refrigerant floods through valve, power assembly operates properly.

5-37. Replace a defective thermostatic expansion valve as follows.

a. Detach sensing bulb from piping.

b. Coil up capillary tubing.

c. Using a suitable size wrench, unscrew power assembly from top of valve.

d. Apply pipe dope (LOCKTITE No. 92-31) to new power assembly and install.

e. Carefully route capillary tube and attach sensing bulb.

5-38. THERMOSTATIC EXPANSION VALVE STUCK IN OPEN POSITION. If one of the thermostatic expansion valves is stuck in an open position, there will be an excessive amount of sweating on the compressor crankcase due to the large amount of liquid being passed into the suction line. In this case, it is necessary to send the unit to Overhaul for superheat readjustment or replacement of the expansion valve.

5-39. THERMOSTATIC EXPANSION VALVE IMPROPERLY ADJUSTED. If the expansion valve is adjusted for too low a superheat, too much liquid will be passed to the evaporator. The suction line will be abnormally cold, and liquid may slug back to the compressor. If the expansion valve is adjusted for too high a superheat, too little liquid will be passed to the evaporator and the suction line will be abnormally warm. To readjust the superheat, send the unit to Overhaul.

5-40. SHORTAGE OF REFRIGERANT. There should always be sufficient liquid in the receiver to completely submerge the inlet to the liquid line pipe. If there is a shortage of refrigerant, the liquid level will fall below the inlet to the liquid line, and a mixture of gas and liquid will pass into the liquid line. Bubbles will appear in the sightglass and the larger the bubbles the more severe the refrigerant shortage. Frequently there will be a hissing or whistling sound at the expansion valves. If the shortage is severe, the coil and suction line will be relatively warm and the suction pressure will be low, due to little or no liquid being supplied to the evaporator. Add refrigerant as described in para 5-28.

5-41. OVERCHARGE OF REFRIGERANT. An overcharge of refrigerant should occur only in case of an error in charging. Such overcharge will cause liquid refrigerant to back up in the condenser and decrease the amount of surface available for condensing, and as a result the head pressure will rise. In extreme cases, it may rise to a point where the high pressure cutout will stop the compressor. Adjust the refrigerant charge by discharging a small quantity of refrigerant (see para 5-30). Observe the effect of discharge pressure on the sightglass. If no drop in discharge pressure is noted, refer to table 5-3, and perform the appropriate remedy.

5-42. AIR IN SYSTEM. If air or other non-condensible gases are present in the system, they will tend to move toward, and collect in, the condenser. The head pressure will rise to a point above the pressure corresponding to the temperature at which the refrigerant vapor is condensing. In extreme cases, the pressure may rise to a point where the high pressure cutout may stop the compressor. To determine if there is air in the system, allow the compressor to stand idle, usually overnight, until the entire system cools down to the temperature of the surrounding air. After the entire system has attained the same temperature as the surrounding air, the head pressure gage should indicate not more than 10 pounds above the saturation pressure corresponding to the surrounding air temperature.

5-43. If the indication is higher, it is necessary to discharge the refrigerant as directed in para 5-30, and then evacuate and recharge the system as directed in paras 5-27 and 5-29.

5-44. BROKEN VALVES IN COMPRESSOR. Broken suction valves or broken or leaky discharge valves in the compressor are generally indicated by a rapid rise in the suction pressure as soon as the machine has stopped. If the suction pressure rises faster than five pounds per minute, it is an indication that the compressor discharge valves are not holding. Before the compressor is removed for repairs, however, it should be determined that the pressure rise is not due to other causes, such as a leaky solenoid valve or the equalization of suction and oil pressures. Repair compressor if defective.

5-45. STARTER DELAY ADJUSTMENT

a. General. Blower motor starters K1 (29, fig. 4-4) and K2 (26) and compressor starters K3 (23) and K4 (24) are energized upon application of control power to their respective starter coils. Starters K2, K3, K4, and K6 are delayed in contact closure by time delay relays TD1 (45), TD2 (46), TD3 (47), and TD4 (48) respectively.

b. Timing. To make the following adjustment refer to fig. 4-4. The nominal delay for relays TD1 and TD3 is 0.1 seconds, for TD2 is 30 seconds, and for TD4 is 3 seconds. Too long a delay causes the starter overloads to kick out. Too short a time delay defeats the purpose of the part winding starter to limit current demand by the air conditioner at startup. If time delay adjustment is needed, perform the procedure in step c as applicable.

c. Adjustment. Perform the following steps.

(1) Make sure dial knobs on time delay relays are set as follows:

TD1 - 0.1 seconds,
TD2 - 30 seconds,
TD3 - 0.1 seconds, and
TD4 - 3 seconds.

(2) Using a stopwatch, fine tune if necessary.

Table 5-3. General Troubleshooting Chart

TROUBLE	PROBABLE CAUSE	REMEDY
1. Unit will not start up.	No power at unit.	Verify unit is wired for facility voltage, verify all circuit breakers are on, ensure that cord is plugged in and not defective.
2. Unit starts up but shuts down immediately.	Incorrect motor starter time delay relay.	Make starter time delay adjustment as described in para 5-45.
	Defective main circuit breaker CB1.	Replace faulty circuit breaker.
3. Unit starts up but condenser fan draws air from outlet and blower motor rotation is opposite arrow.	Motors rotating in wrong direction due to incorrect phase sequence of facility ac power.	Interchange any two phase wires at air conditioner power cable attachment to facility power. See para 3-8.
4. Blower motor will not turn on.	Defective motor starter, K1 or K2.	Repair or replace starter as applicable.
	Defective starter overload OL1 or OL2.	Replace faulty overload.
	Defective time delay relay TD1.	Replace faulty time delay relay.
	Defective circuit breaker CB4.	Replace faulty circuit breaker.
	Defect in control circuit.	See Trouble 7 and 8.
	Faulty motor B1.	Repair or replace as applicable.
	Door has closed.	Open door.
	Defective (open) switches S6, S9, S10, S16, and/or S17. See Wiring Schematic, fig. 4-3.	Check continuity with multimeter. Replace faulty switch.

Table 5-3. General Troubleshooting Chart - continued

TROUBLE	PROBABLE CAUSE	REMEDY
5. Condenser fan motor will not turn on (blower operable).	Defective motor starter K5.	Repair or replace as applicable.
	Defective starter overload OL5.	Replace faulty overload.
	Defective low pressure switch S4. Be sure head pressure is 100 psig or more.	Check closed contact continuity with multimeter. Replace switch if defective.
	Defect in control circuit.	See Trouble 7 and 8.
	Faulty motor, B3.	Repair or replace as applicable.
6. Compressor motor will not turn on (blower operable).	Faulty time delay relay TD2 (46, fig. 4-4).	Check closed contact continuity 30 seconds after blower motor starts. Replace relay if defective.
	Suction pressure below 20 psig.	Check charge.
	Defective motor starter K3 or K4.	Repair or replace as applicable.
	Defective starter overload OL3 and OL4	Replace faulty overload.
	Defective time delay relay TD3.	Replace faulty time delay relay.
	Defective circuit breaker CB5.	Replace circuit breaker.
	Defective solenoid valve L6.	Replace solenoid.
	Defect in control circuit.	See Trouble 7 and 8.
	Faulty motor B2.	Repair or replace as applicable.
	Defective Discharge Line Thermostat Switch S8. See Wiring Schematic, fig. 4-3.	Check continuity with multimeter. Replace faulty switch.

Table 5-3. General Troubleshooting Chart - continued

TROUBLE	PROBABLE CAUSE	REMEDY
7. Unit power lamp DS1 on control panel (10, figure 4-4) remains dark.	Open circuited transformer TR (27, fig. 4-4).	Check continuity of primary and secondary with multimeter. Replace faulty transformer.
	Circuit breaker CB1, CB2, or CB3 open.	Reset/replace as needed.
8. Blower turns on but compressor and condenser fan will not start up.	Faulty time delay relay TD2 (46, fig. 4-4).	Check relay operation. Replace faulty relay.
	Faulty oil safety switch S5 (22, fig. 4-4)).	Depress reset button. Refer to fig. 4-3 and check normally closed contact continuity with multimeter. Replace faulty oil safety switch.
	Faulty low pressure cutout S3 (21, fig. 4-4) or high pressure cutout S2 (20, fig. 4-4).	Refer to fig. 4-3 and check closed contact continuity with multimeter. Depress the high pressure cutout switch reset button. Replace faulty cutout switch.
9. Compressor fails to start	Compressor locked up or blocked, preventing rotation.	Repair or replace compressor. Refer to Field Maintenance and Depot Overhaul Instructions.
	Suction pressure below cut in setting of low pressure switch or discharge pressure above cut out setting of high pressure switch.	Check refrigerant charge, solenoid valves, expansion valves, and settings of high pressure and low pressure switches. Make indicated repairs and/or reset switches as directed in field Maintenance and Depot Overhaul Instructions.
	Defecitve low oil pressure cut out.	Depress reset button. Replace if defective. Follow procedure given in para 5-4 c.

Table 5-3. General Troubleshooting Chart - continued

TROUBLE	PROBABLE CAUSE	REMEDY
10. Compressor "short cycles" or stops after a short run time.	Intermittent contact, electrical control circuit (See Trouble 7 and 8).	Repair or replace faulty electrical control.
	Discharge pressure above cut out setting of high pressure switch.	If necessary, reset high pressure control as directed in Field Maintenance and Depot Overhaul Instructions. Open condenser fan doors if shut. Clean condenser filters if dirty. Remove any obstructions in air pathways. If condenser fan still is not operating, see Trouble 5.
	Iced evaporator.	Allow evaporator to defrost. Clean filters if dirty. Remove any obstructions in air pathways. Check operation of hot gas bypass valve and solenoid valves. Repair or replace as required (see para 5-32).
	Overloads on condenser fan motor starter defective or tripped.	Reset overloads or replace.
	Pump down solenoid valve L6 defective.	Replace solenoid valve.
	Filter drier D clogged.	Replace drier.
	Low pressure switch S3 misadjusted or defective.	Adjust or replace pressure switch.
10. Compressor "short cycles". - cont.	Lack of refrigerant. (Bubbles in refrigerant sight glass.)	Repair refrigerant leak and recharge (para 5-31).
	Restricted liquid line strainer.	Replace filter-drier core (para 5-35).

Table 5-3. General Troubleshooting Chart - continued

TROUBLE	PROBABLE CAUSE	REMEDY
11. Compressor loses oil.	Loose expansion valve sensing bulb.	Provide good contact between sensing bulb and suction line.
	Liquid "floodback" to compressor.	If sensing bulb of thermostatic expansion valve is loose on suction line, tighten bulb clamp. Otherwise, send unit to overhaul for superheat adjustment or replacement of valve.
	Short cycling.	See items in this table under "compressor short cycles".
	Crankcase fittings leak oil.	Tighten fittings.
12. Compressor is noisy.	Lack of oil.	Add oil (para 5-19).
	Internal parts of compressor.	Rebuild or replace compressor.
	Liquid "floodback".	If sensing bulb of thermostatic expansion valve is loose on suction line, tighten bulb clamp. Otherwise, send unit to overhaul for superheat adjustment or replacement of valve.
	Expansion valve stuck in open position.	Replace valve (para 5-31).
	Compressor assembly loose on base.	Tighten compressor assembly hold down bolts.
13. System does not deliver the proper quantity or temperature of cooled air.	Flash gas in liquid line.	Add refrigerant (see para 5-28).
	Insufficient airflow.	Set airflow to 85 PPM. Check ducts for leaks and blower for proper rotation.
	Improper setpoint adjustment.	Set temperature setpoint to 50°F.

Table 5-3. General Troubleshooting Chart - continued

TROUBLE	PROBABLE CAUSE	REMEDY
13. System does not deliver the proper quantity or temperature of cooled air. - cont.	Clogged filter-drier or malfunctioning solenoid valve.	Replace filter-drier cores (para 5-35) or valves (para 5-31).
	Dirt or ice on evaporator.	Clean coil or defrost.
	Expansion valve stuck or obstructed.	Replace valve. (See paras 5-38 and 5-31.)
	Precooler off; L1 defective.	Replace L1.
	Aftercooler off; TS1 and/or TS2 defective.	Replace TS1 and/or TS2.
	Aftercooler off; TC defective.	Replace TC.
	Aftercooler off; L2 and/or L3 defective.	Replace L2 and/or L3.
	Aftercooler off; TV defective.	Replace TV if defective. Valve coil should measure 50-55 ohms resistance. Valve should be open when de-energized and closed when energized.
14. Refrigerant discharge pressure is too high.	Improper operation of condenser.	Remove obstructions to airflow. Clean coil surface.
	Air or non-condensible gas in system.	Purge (para 5-43).
	Overcharge of refrigerant.	Remove excess (para 5-41).
	Insufficient condenser airflow.	Check condenser air filters, and inlet screens. Clean filters and screens as necessary. Check fan for operation. Repair or replace fan or motor as necessary

Table 5-3. General Troubleshooting Chart - continued

TROUBLE	PROBABLE CAUSE	REMEDY
14. Refrigerant discharge pressure is too high. - cont.	Condenser fan not operating.	Check fan cycle switch and motor starter overloads. Reset or repair switch, overloads, and high pressure switch as necessary.
15. Refrigerant discharge pressure is too low, suction pressure too high.	Broken or leaky compressor discharge valves.	Repair or replace compressor.
	Overfeeding of expansion valve.	See that expansion valve sensing bulb is properly attached to suction line.
	Expansion valve stuck in open position.	Repair or replace valve (para 5-31).
	Broken suction valves in compressor.	Repair or replace compressor.
16. Refrigerant suction pressure is too low.	Loss of refrigerant.	Leak test (para 5-13). Repair leak (para 5-31), add refrigerant (para 5-28).
	Light load on evaporator; precooler on; defective TS1 and/or TS2.	Replace TS1 and/or TS2.
	Light load on evaporator; defective temperature control component.	See Temperature Control (TC) manual for troubleshooting and repair or replace as required.
	Clogged liquid line strainer.	Replace filter-drier core (para 5-35).
	Expansion valve power assembly has lost charge.	Replace expansion valve power assembly (para 5-38).
	Obstructed expansion valve.	Replace valve (para 5-31).
	Reduced airflow through evaporator coils.	Check inlet screen, air filter, air intake silencer, discharge and sound attenuator, and coils for blockage. Remove any obstructions found.

Table 5-3. General Troubleshooting Chart - continued

TROUBLE	PROBABLE CAUSE	REMEDY
16. Refrigerant suction pressure is too low. - cont.	(If discharge pressure also too low, and ambient temperature below 80°F.) Unit is low on charge or has malfunctioning head pressure regulator valve.	Turn off condenser fan until discharge pressure exceeds 120 . Then turn condenser on. Clean or replace valve.
17. Knocking in blower.	Blower mounting loose.	Tighten bolts.
	Worn or broken gears caused by improper lubrication or overloading.	Replace gears and re-lubricate.
	Worn bearings.	Install new bearings.
	Worn bearing cartridges.	Replace cartridges.
	Worn seals.	Replace seals.
	Loose impeller wheel.	Inspect impeller, impeller bolt, and high speed shaft assembly for damage. Repair and/or tighten as necessary (30-35 ft. lb.).
	Dirty or clogged air inlet filter.	Clean air filter (para 5-6).
18. Excessive heating of blower.	Gear case not properly vented or lack of lubrication.	Clean vent and correct oil level.
19. Seizing of blower rotary mechanism.	Lack of lubrication.	Repair or replace damaged components.
	Failure of bearing.	Repair or replace damaged components.
20. Excess bearing or gear wear in blower	Improper lubrication of blower.	Correct oil level. Replace oil if dirty.
21. Loss of oil in blower.	Blower vent plugged.	Clean vent. Correct oil level.
	Drain plug leak.	Tighten drain plug. Correct oil level.
	Damaged gear box gasket.	Replace gasket.

Table 5-4. Compressor Troubleshooting Chart

TROUBLE	PROBABLE CAUSE	REMEDY
1. Compressor will not start.	Power Off.	Check START switch and wiring.
	Circuit Breaker CB5 open.	Reset manually.
	Starter overload OL3 or OL4 open.	Reset or replace as needed.
	Oil safety switch S5 or high pressure switch S2 open.	Reset manually.
	Loose electrical connections or faulty wiring.	Tighten connections. Check wiring and rewire if necessary.
	Compressor motor burned out.	Check and replace compressor if defective.
	Defective switches S2, S3, S5, and/or S8. See Wiring Schematic, fig. 4-3.	Check continuity with multimeter. Replace faulty switch.
2. Low compressor capacity or inability to pump down system.	Blown valve plate or cylinder head gasket.	See Trouble No. 3.
	Leaky valve plates or worn valve seats.	Replace valve plate assembly.
	Leaky suction valves.	Pump down, remove cylinder head, examine valves and valve seats. Replace if necessary.
	Broken connecting rods or pistons.	Replace compressor.
3. Blown valve plate or cylinder head gaskets.	Cylinder head bolts not properly torqued.	Replace gaskets. Retorque cylinder head bolts to: 06E 90-100 lb-ft.
	Excessive oil in compressor system causes hydraulic cylinder pressures.	Remove excessive oil until oil level is maintained between 1/8-3/8 up the sight glass. For further details see Carlyle Product Bulletin OEM-55.
	Liquid refrigerant floodback or flooded start.	See Trouble No. 7.

Table 5-4. Compressor Troubleshooting Chart - continued

TROUBLE	PROBABLE CAUSE	REMEDY
4. Compressor cycles intermittently.	Low pressure switch erratic in operation.	Check tubing to switch to see if clogged or crimped. Check setting of switch.
	Insufficient refrigerant in system.	Add refrigerant.
	Suction service valve closed.	Open valve.
	Discharge service valve not fully open.	Open valve.
	Air in system.	Purge.
5. Compressor continually cycles.	Faulty pressurestats.	Repair or replace.
	Dirt or restriction in tubing to pressurestat.	Check and clean tubing.
	Condenser capacity reduced by refrigerant over-charge accompanied by high discharge pressure.	Remove excess refrigerant.
	Plugged filter-drier.	Replace filter.
6. Low discharge pressure.	Suction service valve partially closed.	Open the valve.
	Leaky compressor suction valves.	Pump down, remove the cylinder head, examine valves and valve seats. Replace if necessary.
	Worn piston rings.	Replace compressor.
7. Flooding.	Improper system piping allows liquid to compressor.	Correct piping.
	Defective or improperly set expansion valve.	Increase superheat or replace valve.
	Evaporator fan failure.	Correct problem or replace fan.

Table 5-4. Compressor Troubleshooting Chart - continued

TROUBLE	PROBABLE CAUSE	REMEDY
8. Low suction pressure.	Insufficient refrigerant in system.	Add refrigerant.
	Evaporator fan failure.	Correct problem or replace fan.
	Plugged filter-drier.	Replace filter.
9. Compressor noisy.	Slugging due to floodback of refrigerant.	See Trouble No. 7.
	Hydraulic knock due to excess oil in circulation.	Remove excess oil. Recheck oil return system.
	Bearings damaged because of loss of oil.	Check oil return system. See Trouble No. 15 and Trouble No. 11. Check for defective oil failure control.
	Improper support or isolation of piping.	Provide sufficient right angle bends in piping to absorb vibration and support firmly with suitable hangers.
	Compressor not firmly mounted.	Check for loose mounts.
	Unit not properly isolated or vibration pad defective.	Add vibration isolation or check for defective isolation pads.
	Broken connecting rods, valves or other running gear.	Replace compressor.
10. Pipe rattle.	Inadequately supported piping or loose pipe connections.	Support pipes or check pipe connections.
11. Oil pressure lower than normal or no oil pressure.	Low oil charge.	Check oil level and correct as necessary.
	Faulty oil pump drive segment.	Replace segment.
	Worn oil pump.	Replace bearing head assembly.

Table 5-4. Compressor Troubleshooting Chart - continued

TROUBLE	PROBABLE CAUSE	REMEDY
12. Compressor motor protectors tripping or cycling.	High suction pressure on low temperature compressor causes excessive amp draw.	If system does not have EPR valve, throttle suction service valve until system pumps down.
	High discharge pressure.	Check for loss of condenser water or blocked condenser fan or coil.
	Incorrect overload or must trip amp setting too low.	Replace with correct overload relay.
	Defective overload relay.	Replace.
	High suction temperature.	Reduce suction temperature by TCV adjustment or provide desuperheating.
	Loose power or control circuit wiring connection.	Check all power and control circuit connections.
	Defective motor.	Check for motor ground or short, replace compressor if found.
	Faulty motor protection device.	On compressors check the thermal sensor in the cylinder head. Replace sensor if necessary.
13. Compressor cycles on locked rotor.	Improper line voltage (±10% of rating).	Check line voltage and determine location of voltage problem.
	Seized compressor (remove bearing head assembly and attempt to rotate crankshaft).	Replace compressor.
	Compressor motor defective.	Check for motor winding short on ground.
	Single phasing.	Check voltage across all three legs at . Correct source of problem.
	Liquid refrigerant condensing in cylinder.	Check and replace valve plates.

Table 5-4. Compressor Troubleshooting Chart - continued

TROUBLE	PROBABLE CAUSE	REMEDY
13. Compressor cycles on locked rotor. - cont.	On part winding start compressors, the second set of windings may not be energized.	Faulty - replace. Faulty time-delay relay - replace.
14. Motor burnout.	Check control box for welded starter contacts, welded overload contacts, or burned out heater elements.	Replace defective components.
15. Compressor running hot.	Blown valve plate or cylinder head gasket.	See Trouble No. 3.
	Broken suction or discharge valve.	Replace valves and valve plate if necessary.
	Compression rate too high.	Check setting of high and low pressure switches.
		Check condenser to see if it is plugged.
		Check that all evaporator and condenser fans are operating properly.
	High suction temperature.	Reduce suction temperature by TCV adjustment or provide desuperheating.