Refrigeration, Air Conditioning,
and Heating

Refrigeration Systems and Controls

Student Manual
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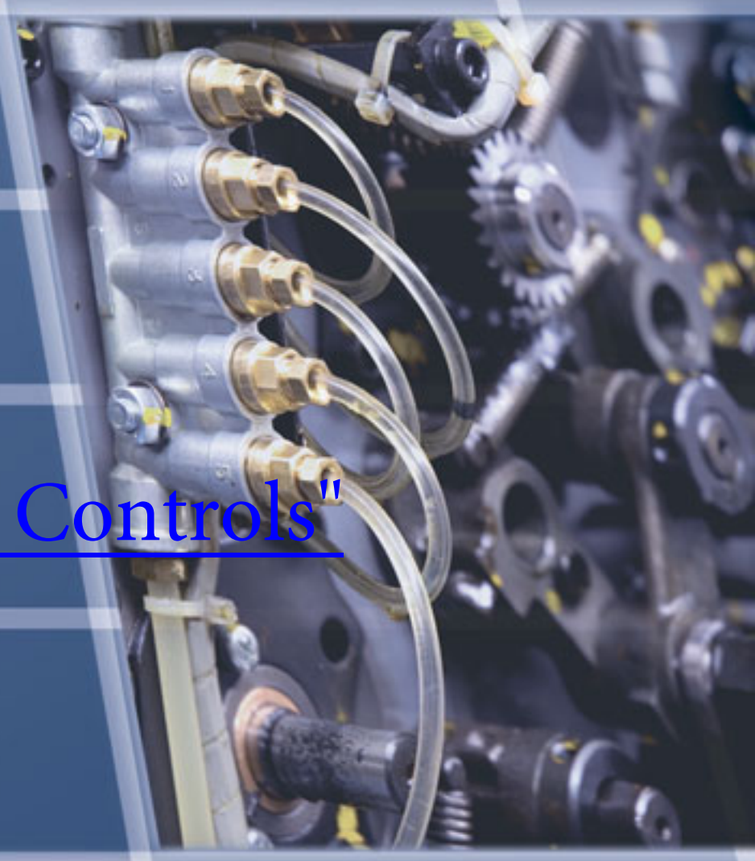

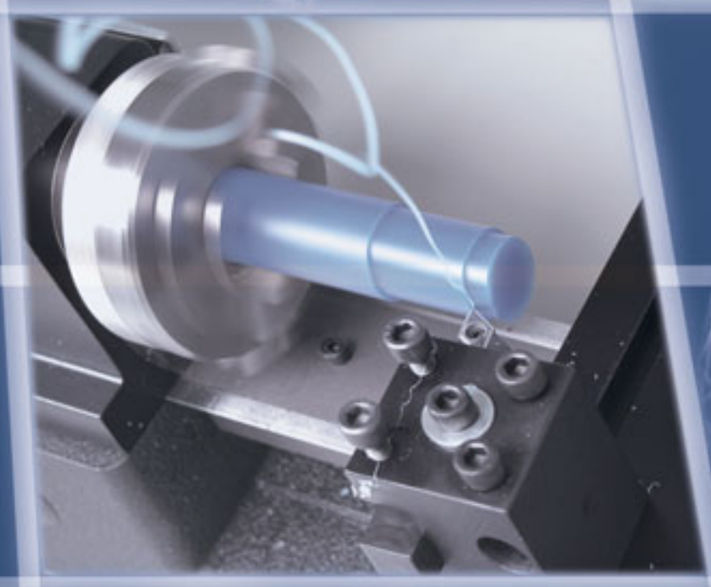

Lab-Volt®

Unit 1

Introduction to the Refrigeration System Trainer

UNIT OBJECTIVE

Upon completion of this unit, you will be familiar with, and be able to identify, the main panels on the Refrigeration System Trainer.

DISCUSSION OF FUNDAMENTALS

The Refrigeration System Trainer consists of two control panels and a refrigeration system panel.

The control panel contains the necessary control, monitoring and protective equipment to enable the trainee to investigate various refrigeration principles and perform practical exercises on many refrigeration system configurations.

The system panel contains the necessary devices, such as manual valves, liquid receiver and **suction accumulator**, required to configure many refrigeration systems.

The complete system trainer is represented on a **schematic** panel. This panel shows the electrical and tubing schematics for the trainer. The schematics are complete with indicator lamps and testing points.

NEW TERMS AND WORDS

Celsius – the scale of changes of temperature which uses 0°C (32°F) as the freezing point and 100°C (212°F) as the boiling point for water at standard pressure.

Condenser – the device in a refrigeration system where refrigerant gives off the heat which was absorbed at the evaporator.

Evaporator – the refrigerant filled device in the low pressure side of a refrigeration system which absorbs the unwanted heat from the area to be cooled.

Pressure – force on a unit area exerted by the molecules of refrigerant (varies directly with absolute temperature).

Refrigeration – the process of removing heat under controlled conditions.

Schematic – a diagram showing the layout of a system, using symbols to represent the various components.

Solenoid valve – electromagnet with a moving core which serves as a stem to operate a valve.

Suction accumulator – storage tank which receives liquid refrigerant from the evaporator and prevents it from flowing into the suction line of the compressor before vaporizing.

Introduction to the Refrigeration System Trainer

EQUIPMENT REQUIRED

Lab-Volt Refrigeration System Trainer, Model 3401

Exercise 1-1

System Control Panels

EXERCISE OBJECTIVE

When you have completed this exercise, you will be familiar with the operation of the system panel by configuring a typical refrigeration system following schematic and pictorial diagrams.

DISCUSSION

The Refrigeration System Trainer is equipped with two control panels and a schematic panel. These panels are used to monitor and control the operations required for refrigeration training. The main control panel, mounted on the left side of the system trainer, is shown in Figure 1-1. This panel contains three meters: an AC voltmeter (M1); an AC ammeter (M2); and a wattmeter (M3). These meters are used to monitor the electrical system of the trainer. The meters are wired into the system as shown on the schematic panel, Figure 1-3.

The AC voltmeter (M1) is used to monitor the system voltage, or as a test meter for troubleshooting. Selecting "TEST", using the selector switch, removes the meter from the line. The meter can then be used to measure specific voltages, for troubleshooting purposes, at test points (TP) located on the schematic panel.

A digital thermometer is also included on this panel. It permits temperature measurements at four different locations, in either Celsius or Fahrenheit degrees.

The temperature readings can be stored to a memory with battery back-up. The temperature differential between two points can be measured at the press of one button. The meter comes with a set of sensing probes:

- General purpose probes can be used to measure temperature within the evaporator's cabinet, or at various points of the system tubing, in which case they must be secured firmly against the tubing with the supplied "velcro" strips to ensure a good thermal contact between their sensing element and the tubing.

- If your set of probes includes clamp-on probes, these probes can be used to measure temperature all along the system tubing. It is particularly recommended that you use these probes for temperature measurements at the evaporator's inlet and outlet to ensure a good accuracy of measurement.

- Finally, if your set of probes includes an air (coiled) probe, this probe can be used to measure temperature within the evaporator's cabinet.

Indicator lamps are mounted on the panel to show the condition of the pressure controllers. When a pressure controller, either high or low, is in normal operation, a green indicator lamp is illuminated. If either controller experiences an abnormal condition, a yellow lamp is illuminated. These lamps are also found on the electrical schematic panel. The pressure controllers are located in the system, as shown on the tubing schematic.

This panel also includes two illuminated breaker switches. The mains input breaker switch energizes the control circuit. The compressor breaker switch starts the compressor after the main breaker switch is turned on. See electrical schematic panel, Figure 1-3, for breaker switch location.

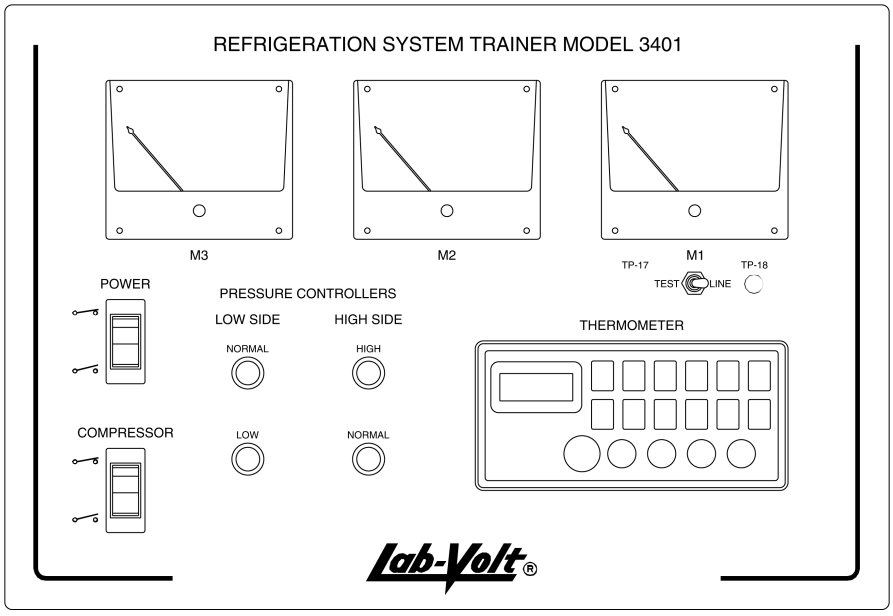

Figure 1-1. The main control panel.

The second control panel, located on the right side of the system trainer, is shown in Figure 1-2. This panel controls the fan speed for the **condenser** and both **evaporators**. Indicating lamps are used to indicate when each fan is running. The illumination of each lamp is proportional to the speed of the fan. When the fan knob is set for a high speed (turned counterclockwise near "OFF"), the lamp is bright. Setting the fan knob for a lower speed (knob turned clockwise) reduces the brightness. The fans and controls are shown on the electrical schematic panel, Figure 1-3.

This panel also controls the operation of two thermostatic controllers, TIC1 and TIC2. Illuminated breaker switches are used to energize two solenoid valves through the thermostatic controllers. These are connected as shown on the electrical schematic panel in Figure 1-3. The devices are placed in the system as shown on the tubing schematic panel in Figure 1-3. Illuminated lamps are used to indicate when the solenoid valves are open (solenoid energized) or closed (solenoid deenergized). When the thermostatic controllers are not in use, the "BYPASS" switch on the electrical schematic panel must be set to "I" (ON) and the manual bypass valves over the solenoids must be open.

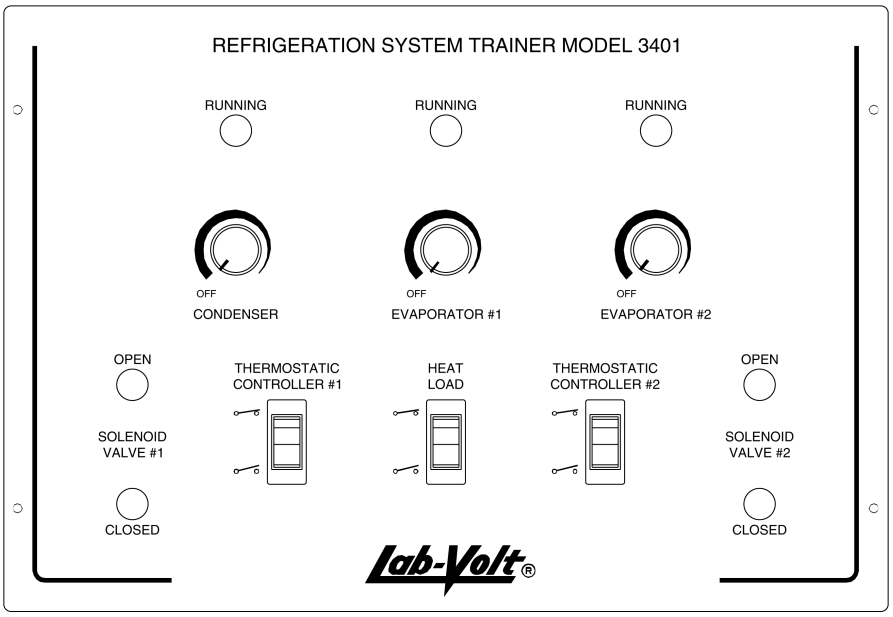

Figure 1-2. The second control panel.

The schematic panel, as shown in Figure 1-3, is located on the left hand side of the system trainer, directly above the main control panel. This panel shows the electrical and tubing schematics of the system trainer.

The electrical schematic identifies the monitoring and control devices found on the system and control panels. Test points are located on this panel for troubleshooting using the schematic panel.

The tubing schematic identifies the control valves, monitoring devices and control devices found on the system panel. All devices on the tubing schematic are labeled as shown in the legend of symbols. Temperature sensor points are also included on this panel to indicate the most practical point for temperature measurement.

A legend of symbols and abbreviations is provided for both electrical and tubing schematics.

System Control Panels

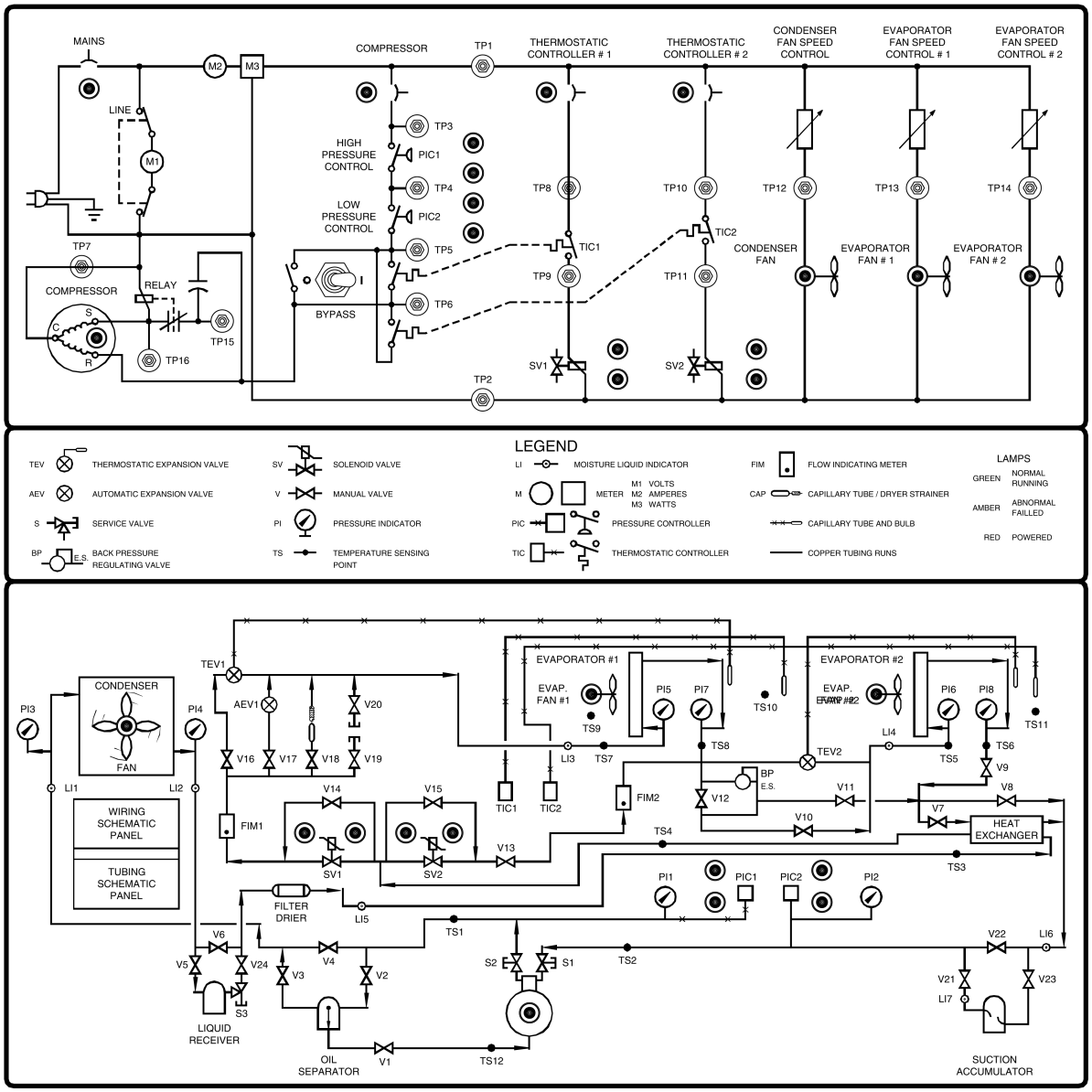

Figure 1-3. The schematic (electrical and tubing) panel.

PROCEDURE

☐ 1. Turn on the mains input breaker switch. Switch voltmeter to "LINE" and turn off the thermostatic controllers. Observe and record the following:

Voltmeter reading = _____ V ac

Ammeter reading = _____ A

Wattmeter reading = _____ W

Low side pressure = _____ kPa or _____ psi

High side pressure = _____ kPa or _____ psi

☐ 2. Turn on the condenser fan and evaporator-1 fan. Vary the speed of these fans. Record observations of the fan's behavior.

_____

_____

☐ 3. Adjust the following manual valves as indicated below (refer to Figure 1-4):

VALVES OPENED			VALVES CLOSED		
V1	V8	V14	V4	V13	V19
V2	V9	V18	V5	V15	V20
V3	V11	V21	V7	V16	V22
V6	V12	V23	V10	V17	V24

☐ 4. Have valves checked by instructor.

Set the condenser fan speed to **medium**, and the evaporator-1 fan speed to **medium**.

> **Note:** *The condenser and evaporator fan speed settings are given here as guidelines only, and could require readjustments if the pressures and temperatures measured in this exercise seem erroneous. For a room temperature of 21 °C (70 °F), and with no load applied on the system, a low-side pressure of around 100-140 kPa (15-20 psi) and a high-side pressure of around 860-1035 kPa (125-150 psi) indicate normal system operation.*

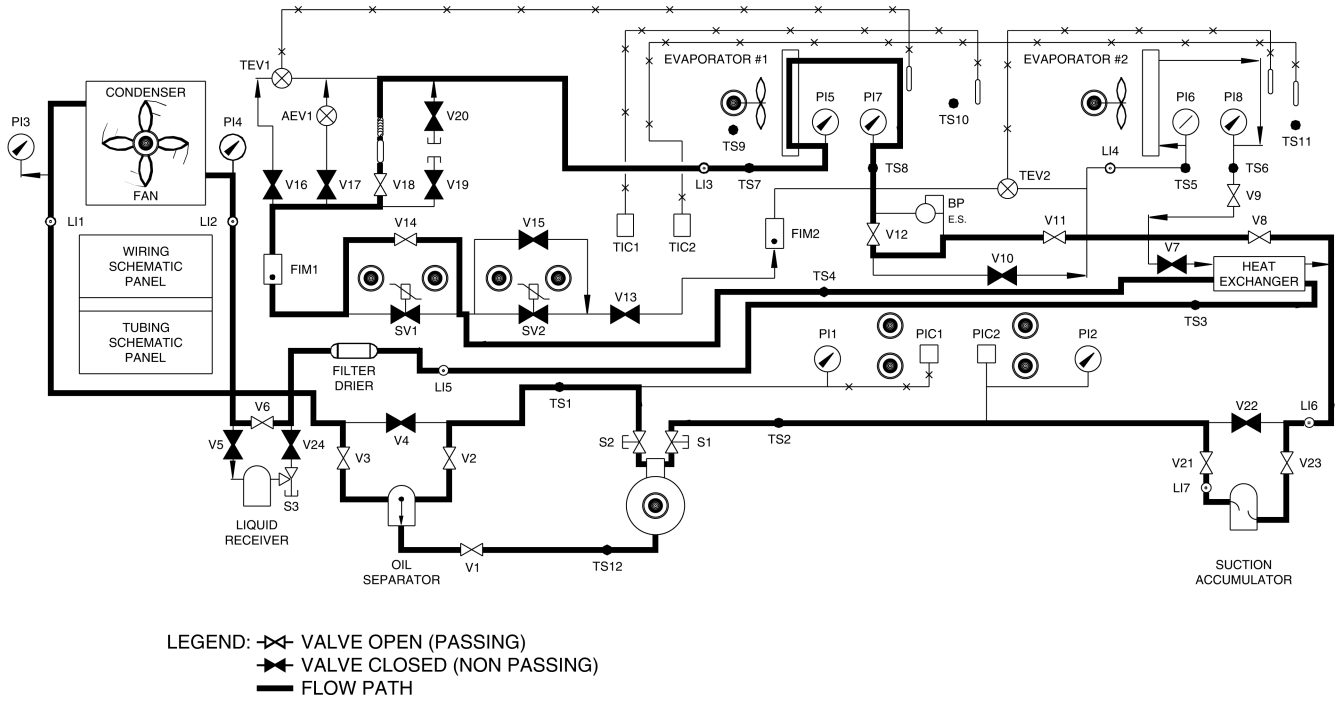

Figure 1-4. Valve configuration.

☐ 5. Turn on the compressor breaker switch. Observe and record the following:

Voltmeter reading = _____ V ac

Ammeter reading = _____ A

Wattmeter reading = _____ W

Low side pressure = _____ kPa or _____ psi

High side pressure = _____ kPa or _____ psi

> **Note:** *In this exercise and for the rest of the manual, immediately turn off the compressor if the ammeter needle goes beyond the maximum of the meter scale, then advise your instructor. Excessive current drawn upon compressor start-up will occur when, for example, an excessive pressure differential is present across the suction and discharge sides of the compressor, or if liquid refrigerant has entered the compressor.*

Did the compressor data change? Explain.

_____

_____

_____

_____

_____

☐ 6. Switch the AC voltmeter to "TEST".

☐ 7. Connect leads to the voltmeter (TP-17, 18) on the main control panel.

☐ 8. Measure and record the voltage between test points TP1 and TP2 on the schematic panel (electrical section).

$V_{TP1,\ TP2}$ = _____ V ac

CAUTION!

Do not short test leads or touch metal tips of test leads as high voltages are being measured.

☐ 9. Connect one of the thermometer probes to input A of this meter. Turn on the thermometer. Press button A of this meter.

☐ 10. With the probe, measure and record the temperatures at TS1 and TS2. The temperature test point locations are shown on the schematic panel (tubing section) in Figure 1-3.

Note: *If you are using a general purpose probe to measure the temperatures, make sure to secure it firmly against the tubing with the supplied "velcro" strips to ensure a good thermal contact between its sensing element and the tubing.*

TS1 = _____ °C or _____ °F

TS2 = _____ °C or _____ °F

Turn off the meter.

Compare temperatures TS1 and TS2 to the ambient (room) temperature and record your observations.

_____

_____

☐ 11. Have your results checked by the instructor.

☐ 12. Turn off the compressor breaker switch and then the mains input breaker switch.

CONCLUSION

The refrigeration system trainer has two control panels to monitor and control the system. The voltmeter on the main control panel is used to monitor the system voltage, or as a test meter. Indicator lamps are used to indicate pressure controller and fan speed conditions. An analog temperature meter monitors specific temperatures in the system.

The schematic panel shows the electrical and tubing schematics of the system trainer. The schematics are complete with indicator lamps, test points, temperature sensor points and appropriate schematic symbols.

REVIEW QUESTIONS

1. What is the voltmeter used for and where is it located?

2. What is the digital thermometer used for and where is it located?

3. List some of the thermometer functions.

4. How can you approximately determine the evaporator fan speed?

5. Explain the function of the schematic panel.

Exercise 1-2

System Configuration

EXERCISE OBJECTIVE

When you have completed this exercise, you will be able to configure a typical refrigeration system following schematic and pictorial diagrams.

DISCUSSION

The Refrigeration System Trainer is shown in Figure 1-5. All necessary devices required to learn the principles of different refrigeration systems are mounted on this panel. Each device can be added to, or removed from, the basic refrigeration system by opening or closing the appropriate manual valve. These devices are all identified on the schematic panel (tubing section), using symbols shown in the legend. This panel also has test points (TP) and temperature sensor points (TS) indicating the location of the voltage and temperature measurement points throughout the system.

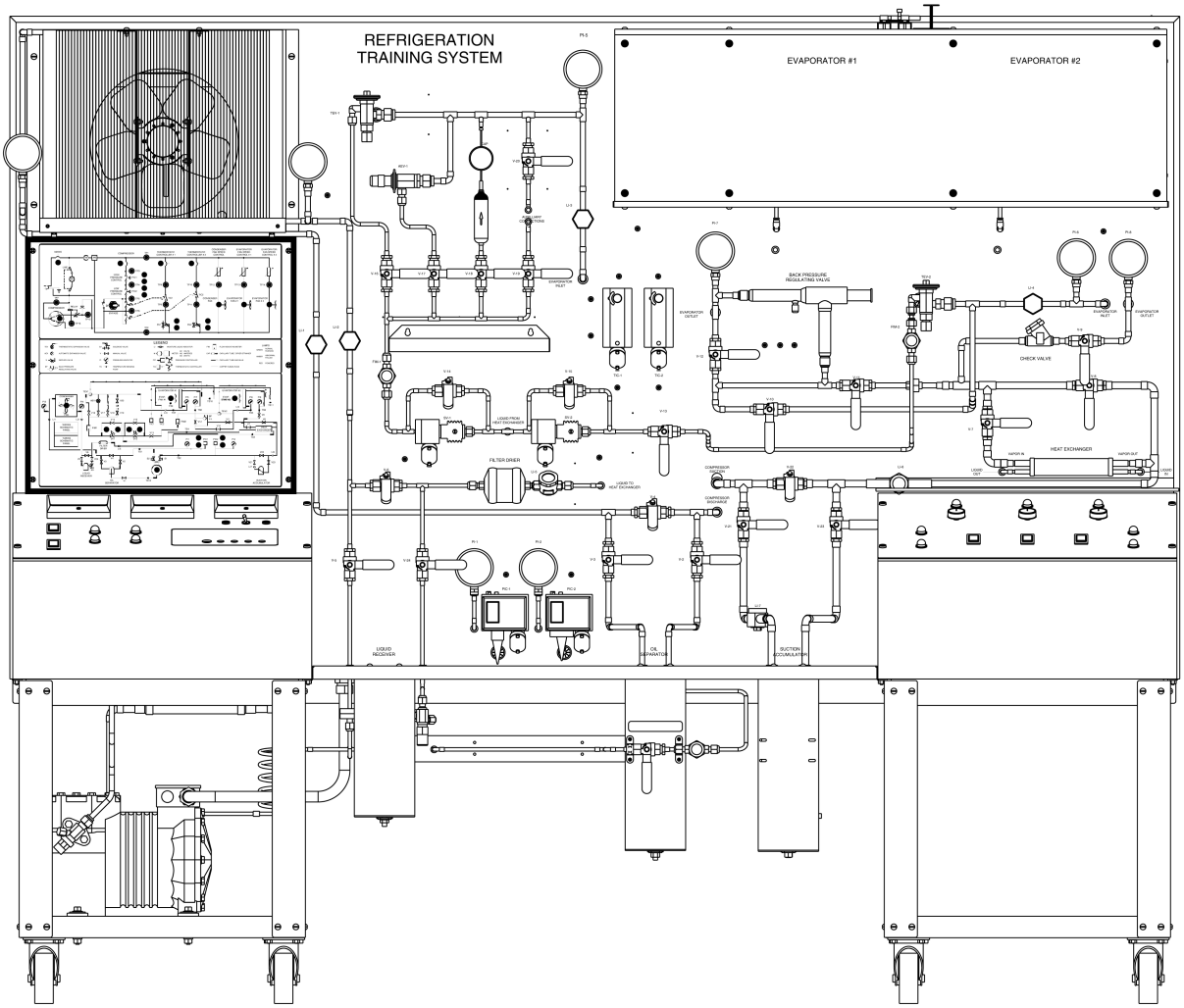

Figure 1-5. Refrigeration System Trainer.

To connect a refrigeration system, a tubing schematic diagram, as shown in Figure 1-6, is required. This diagram shows the devices required to connect the system and their locations within the system. This diagram does not show which manual valves should be opened or closed. It is therefore necessary for you to understand how to follow this diagram.

The schematic panel (tubing section) on the trainer (Figure 1-7) identifies the valves which must be closed to set up the refrigeration system shown in Figure 1-6. The valves that are darkened in Figure 1-7 must be closed and the valves that are white must be open. Follow through the schematic panel in Figure 1-7 with the schematic diagram in Figure 1-6.

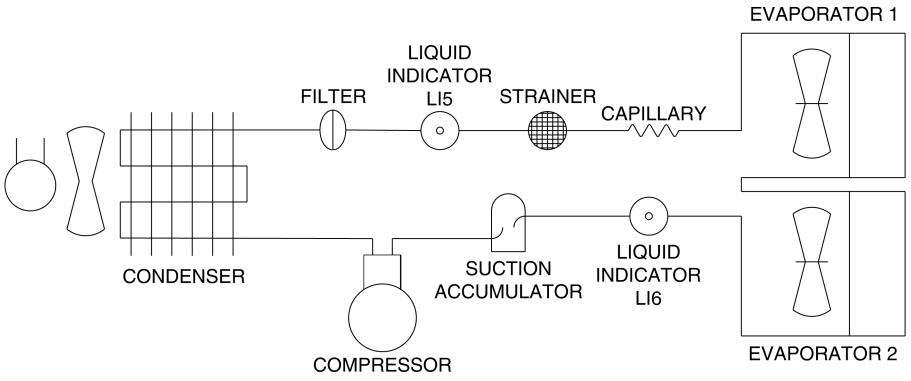

Figure 1-6. Tubing schematic panel.

PROCEDURE

☐ 1. Compare the tubing schematic diagram of Figure 1-6 with the schematic panel (tubing section) on the trainer.

☐ 2. Observe all devices, test points, and temperature sensor points. Which test points are used to check the condenser fan?

_____

_____

☐ 3. The following is a list of the trainer's manual valves which must be opened and closed to form the system shown in Figure 1-6.

VALVES OPENED			VALVES CLOSED			
V4	V10	V21	V1	V7	V16	V22
V6	V12	V23	V2	V11	V17	V24
V8	V14		V3	V13	V19	
V9	V18		V5	V15	V20	

Follow through the schematics in Figures 1-6 and 1-7 as you open and close the valves.

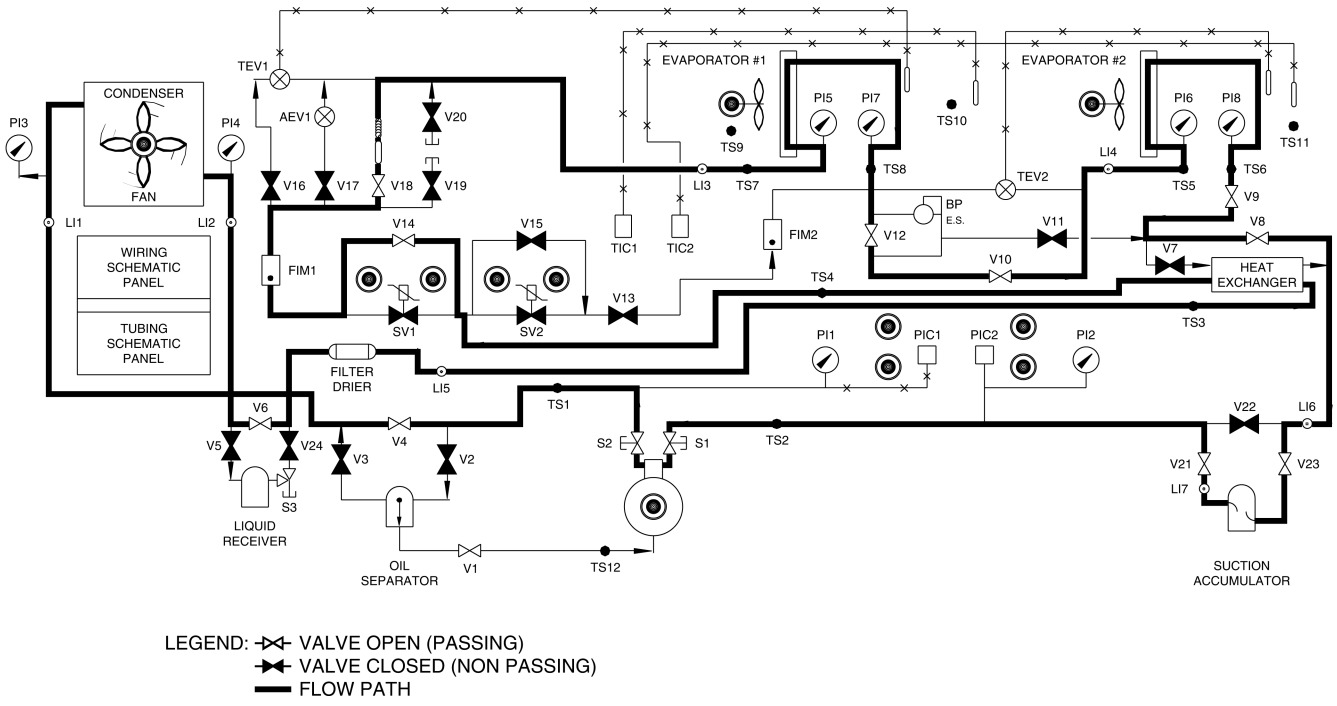

Figure 1-7. Valve configuration.