Relays and switches generally fall into two categories: (1) those that are of a passive nature, these devices are operated manually, and (2) those that are actuated by the application of electrical current, temperature or pressure.

In this conference the relay or the switch will be identified and then the functional purpose and the operation will be described.

In FIGURE 3 is shown a basic electromagnetic relay.

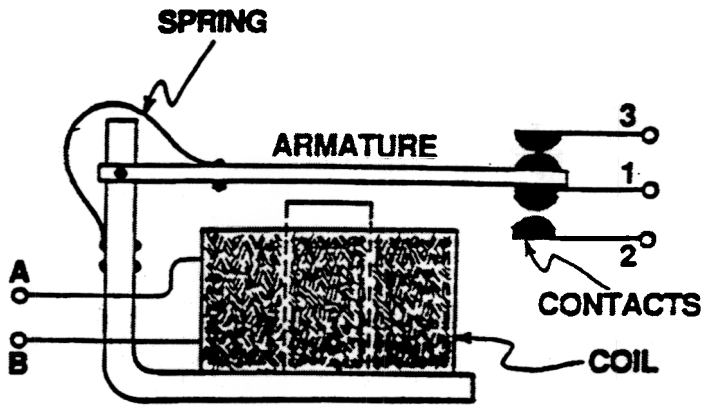


FIGURE 3

This relay is shown in the de-energized state.

The schematic diagram of the electromagnetic relay is shown in FIGURE 4.

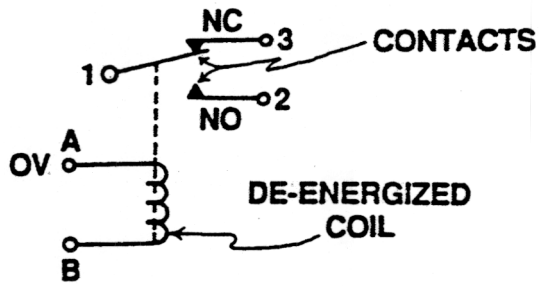


FIGURE 4

The electromagnetic relay is made up to have four basic parts.

The coil is made by winding a number of turns of wire on a plastic bobbin. The bobbin has a hole in the center into which the soft iron core is inserted to form the electromagnet.

The base of the core is fastened to the metal bracket.

The armature is attached to the bracket such that it can pivot. This completes the electromagnet path for the flux lines.

The spring serves to keep the armature pulled away from the coil's core, this opening contacts 1 and 2, and closing 1 and 3.

The contacts may be connected to some external circuit and control that circuit.

The relay serves to isolate the operator from the circuit.

The relay also acts as an amplifier. Small values of current and voltage applied to A and B may control large amounts of current and voltage on the controls.

FIGURE 5 shows the relay energized.

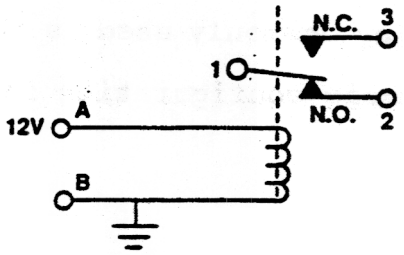


FIGURE 5

The basis cycle of operation is as follows; voltage is applied to the coil at A and B. An electromagnetic field is produced in the coil when current flows through the coil. The flux lines are concentrated (strongest) through the core. The soft iron armature is attracted to the core completing the path for the electronmagnetic circuit.

When the armature moves toward the core the contacts attached to it move to open 1 and 3 and to close 1 and 2.

It should be understood that the contacts are normally insulated from the armature.

As shown in FIGURE 6, a diode (CR1) may be used (connected) in parallel, with the coil to prevent arching due to energy generated when the voltage is removed from the coil and the magnetic field collapses.

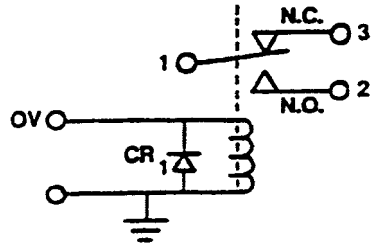


FIGURE 6

Another type of relay commonly used is the thermal time delay relay.

In FIGURE 7, the basic configuration is shown.

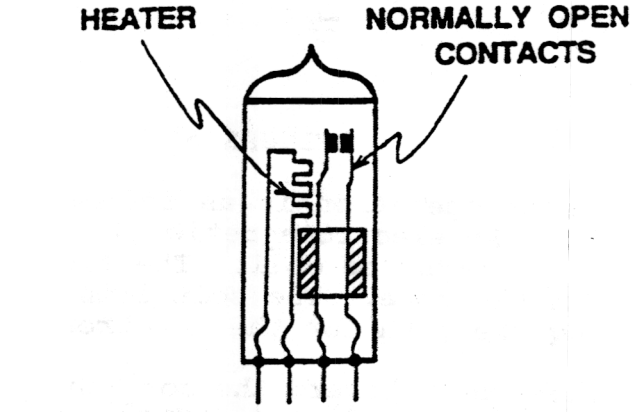


FIGURE 7

The thermal relay is used in circuits that require a delay or warmup before power is turned on.

An example would be in a circuit using vacuum tubes, where the heaters (filaments) in the tube must become hot before plate voltage is applied.

The time delay relay shown in FIGURE 7, is contained in a glass envelope that has been evacuated.

The relay has a heater and a set of normally open (NO) contacts. When proper voltage is applied to the heater connections, the heater heats the metal arm holding the contact near it. The heat causes the metal to expand forcing the contacts to close.

The amount of time can be determined by the metal to which contacts are attached.

FIGURE 8 shows the schematic diagram of the relay opened and closed or de-energized and energized.

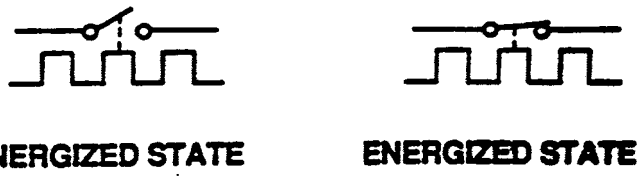


FIGURE 8

FIGURE 9 shows some graphic symbols for the solenoid (coil) of electromagnetic relay.

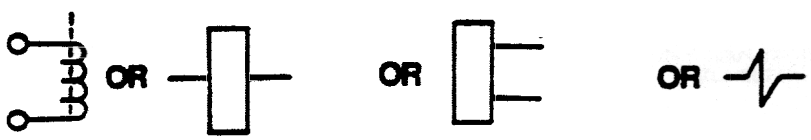


FIGURE 9

FIGURE 10 shows some schematic symbols of contacts for relays, both opened and closed.

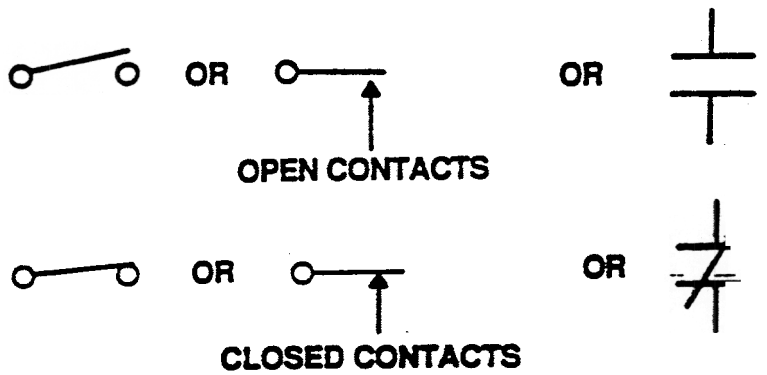


FIGURE 10

In the following discussion several types of switches will be presented symbolically. These switches will be shown in FIGURES 11, 12, and 13.

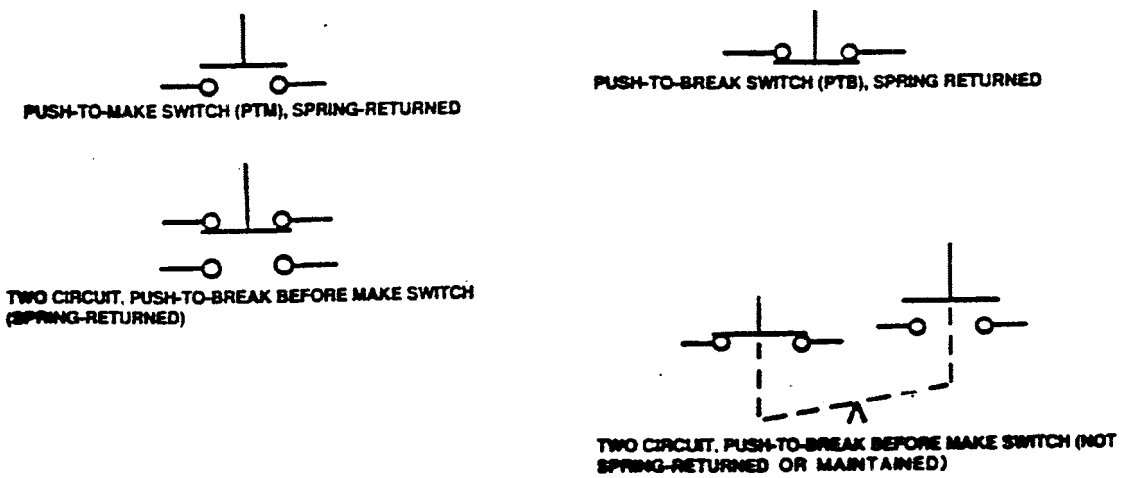
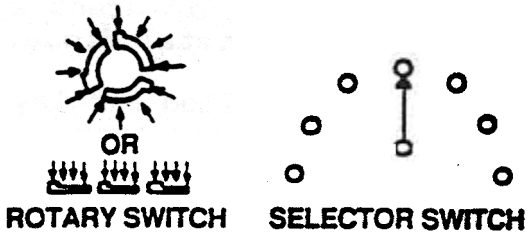
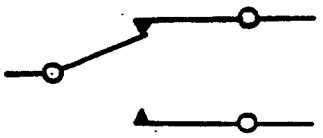


FIGURE 11





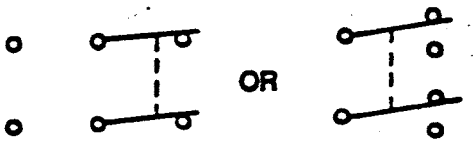


FIGURE 12

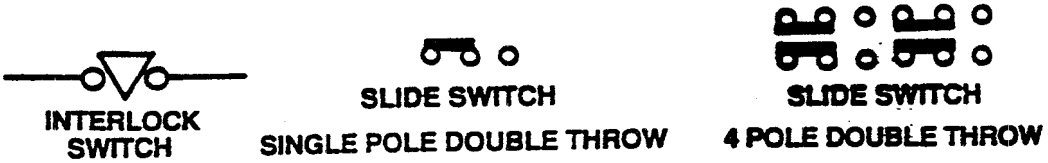


FIGURE 13

The following are some of the different symbols that may be used: LED, I for Indicator or CR for Crystal diode.

The circuit in FIGURE 14 is called a relay tree. The relay tree is a good example to use to learn signal tracing using a maze of switches and relay contacts.

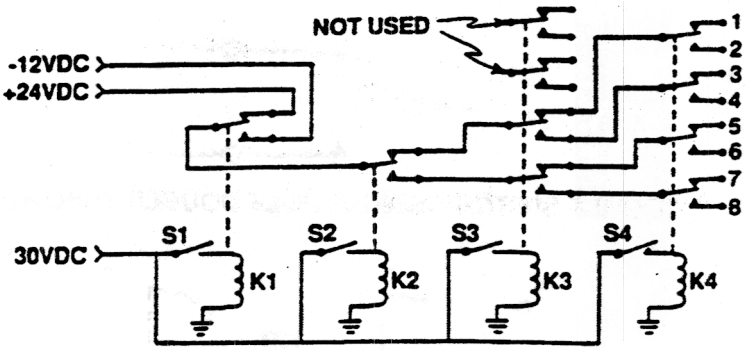


FIGURE 14

There are three sources of voltage available to the relay tree, 30VDC to operate each relay, -12VDC and +24VDC that can be routed to pins 1-8.

Study the programs outlined below in a-h.

a. +24 volts at pin 1.

   1. All switches open.

   2. All relays de-energized.

b. +24 volts at pin 2.

   1. S4 closed.

   2. K4 energized.

c. -12 volts at pin 3.

   1. S1 and S3 closed.

   2. K1 and K3 energized.

d. -12 volts at pin 4.

   1. S1, S3 and S4 closed.

   2. K1, K3, and K4 energized.

e. +24 volts at pin 5

1. S2 closed.

2. K2 energized.

f. +24 volts at pin 6.

1. S2 and S4 closed.

2. K2 and K4 energized.

g. -12 volts at pin 7

1. S1, S2 and S3 closed.

2. K1, K2 and K3 energized.

h. -12 volts at pin 8.

1. All switches closed.

2. All relays energized.

In FIGURE 15, a number of the relays and switches have been incorporated to form a control circuit card.

This circuit is PC-130-71, and must be operated on the Solid State Electronic Trainer.

CONTROL DEVICES PC-130-71

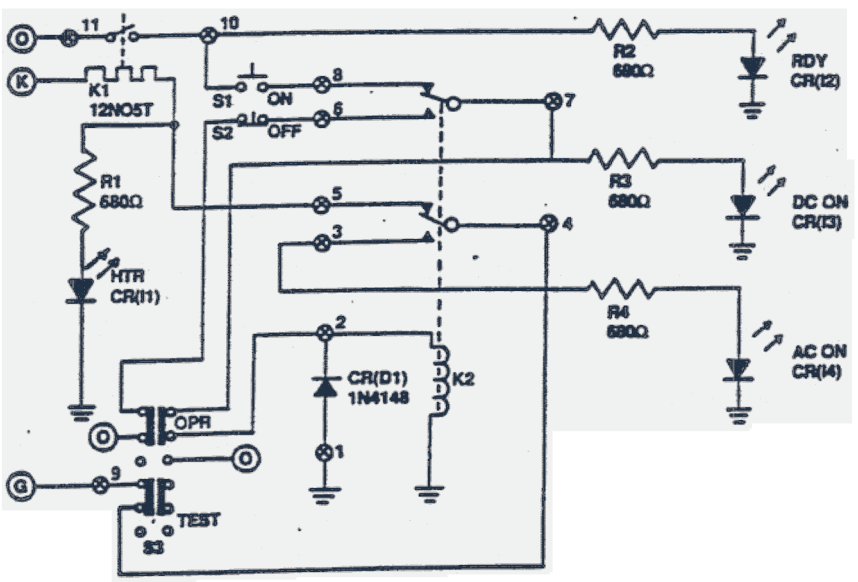


FIGURE 15

The cycle of operation for FIGURE 15 is as follows:

Jack G supplies approximately 13.5VAC to the circuit and can be measured at Tp 9.

Jack K is the grounded end of K1 heater coil. There should be zero resistance between Pin K and TP1.

Jack O supplies approximatley 12.0VDC to the circuit and may be measured at TP11.

To begin the sequence of operation, S3 must be operated to the test position. Relay K2 will energize opening the path for AC current to the heater coil of K1. FIGURE 15 shows S3 drawn in the operate position. This (with S3 in the test position) supplies DC power only to K2.

When K2 is energized, TP7 is no longer connected to TP8 but is connected to TP6. TP4 is not connected to TP5, but is connected to TP3. Thus I1, I2, I3 and I4 will be extinguished.

It would be good at this time to establish why the LED's are out by tracing the path of current flow from ground through the LED to its source of power to find the open.

I1) The "Heater" LED is connected in parallel with K1 coil. K1 receives its power through the relay contacts of K2 connected to TP4 and TP5. This path is open because K2 is energized.

I2) The "Ready (RDY)" LED receives its power from TP11 through the contacts of K1. K1 is open thus the LED is off.

I3) The "DC ON" LED receives DC power from jack 0 and S3, when S3 is in the OPR position. S3 is in the TEST position, thus the path is open.

I4) The "AC ON" LED receives its AC power from jack G, through S3 in the OPR position, but S3 is int he TEST position this current cannot flow.

Next the sequential operation will be discussed.

S3 is moved forward to the OPR position. I3 and I4 illuminate.

I3 is connected to DC power through S3 to Jack O.

I4 is connected to AC power through S3 to Jack G.

Relay K1 remains de-energized and K2 remains energized.

Operating S2, a push to break switch, will de-energize K2 and energize K1. I1 will illuminate immediately and I2 will illuminate after 5 seconds. I3 and I4 will extinguish.

The opening of S2 opened the path for current from jack O through the left side of S3, to S2, through K1 contacts 6 and 7, back through the right side of S3 to TP2, and through K1 to ground.

Relay K1 coil beginning at jack K (ground), will have a path for current flow through K2 contacts 3 and 4, and the left side of S3 to TP9 and Jack G, suppling AC power.

Please note, there are 3 jacks in FIGURE 15 that are labeled O. On the circuit card, there is only one jack labeled O. This means that 12VDC will appear at each jack labeled O. Just as all grounds are common, all jacks labeled O, are common.

At this point I1 and I2 are illuminated. This indicates that K1 coil is on, and K1 contact is closed.

The next step is to operate S1, which is a push to make switch. This applies DC voltage momentarily from TP11 through K1 closed contacts, through K2 contacts 7 and 8, and through the right side of S3 to TP2. K2 is energized latching itself to 12VDC on the left side of S3. When K2 energizes, it opens K1 coil and turns off I1. After 5 seconds K1 contact 1 opens, turning I2 off. I3 is illuminated through the closed contacts.

I3 is illuminated through the closed contacts 6 and 7 of K2, through S2 and through the left side of S3 to jack O.

I4 is illuminated through contacts 3 and 4 of K2, through the left side of S3 to TP9 and receives AC power from jack G.

To summarize, during this lesson you have studied the theory concerning relays and switches, indicator, and some protective type switches. You have been taught, relays and switches and how they are used to transfer (control) voltages or AC signals from one point to another. You have also learned how to theoretically analyze the circuit in FIGURE 15.