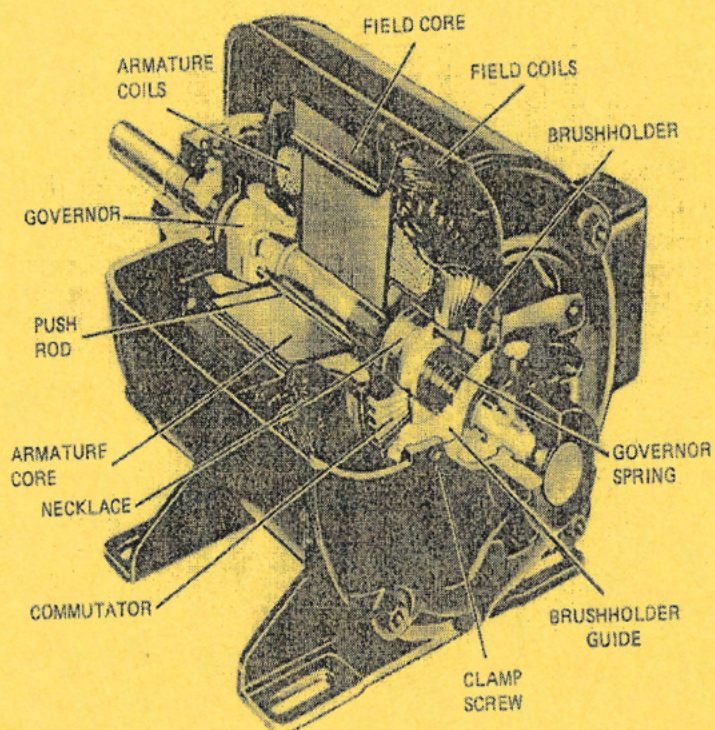
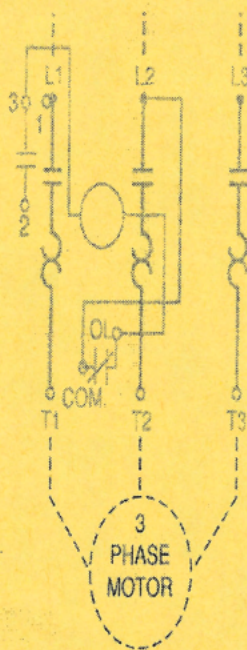
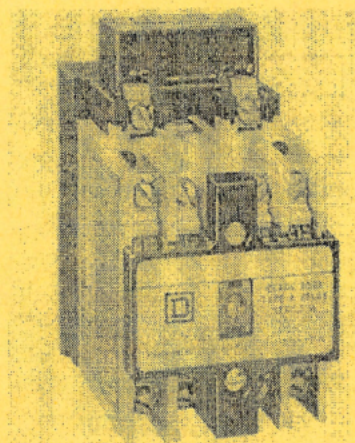
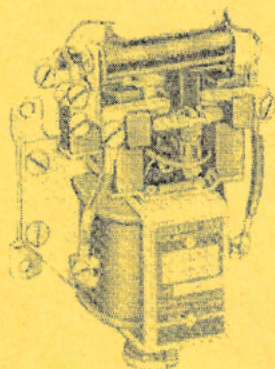


AET - 1285 DC and AC MACHINES

2 OF 4



EART – 1285 (PART TWO)

Lab Projects

NAME: _____

HAND IN COMPLETED BY DUE DATE TO THE INSTRUCTOR

The Instructor must date and initial each project upon completion!!

PROJECT NAME & NUMBER	DATE	INITIALS	BRIEF DESCRIPTION
Conduit Bending Packet (READ)			READ
Written test in packet			TAKE TEST
Practice conduit bending			SEE INSTRUCTOR
Conduit test board stub 90 degree			SEE INSTRUCTOR
Conduit test board 10" 90 degree			SEE INSTRUCTOR
Conduit test board 6" offset 45 degree			SEE INSTRUCTOR
Conduit test board 4" offset 30 degree			SEE INSTRUCTOR
Conduit test board 3-point saddle over 2" pipe			SEE INSTRUCTOR
Conduit test board 4-point saddle over 6" beam			SEE INSTRUCTOR
Conduit concentric bends 1/2" and 3/4"			SEE INSTRUCTOR
DIAGRAM #1			
STANDARD CONTROL #1			
CUTLER-HAMMER STARTER #1			
GENERAL ELECTRIC DC STARTER #1			
GENERAL ELECTRIC DC STARTER #2			
WESTINGHOUSE CONTROL #1			
MONITOR CONROLLER #1			
ALLEN BRADLEY D.C. STARTER #1			

EART – 1285 (PART TWO)

Lab Projects

NAME: _____

HAND IN COMPLETED BY DUE DATE TO THE INSTRUCTOR

The Instructor must date and initial each project upon completion!!

PROJECT NAME & NUMBER	DATE	INITIALS	BRIEF DESCRIPTION
DYNAMIC BREAKING			
GE 90 VOLT DC PM MOTOR FORWARD AND REVERSE (USE MOTORS BOOK CH. #6)			SEE INSTRUCTOR
ALLEN-BRADLEY DEFINITE TIME #1 HOOK-UP			SEE INSTRUCTOR
ALLEN-BRADLEY DEFINITE TIME #2 PART (DRAW UP & TROUBLES)			SEE INSTRUCTOR
EXTRA G.E. #1			
CRANE CONTROL (PAGES 82-96)			
D.C. REVERSING STARTER			SEE INSTRUCTOR

DIAGRAM No. 1

OBJECTIVES:

1. To use the schematic diagram in analyzing control circuit functions.
2. To use the wiring diagram for component and terminal identification.
3. To use switches for motor reversal and speed control.

DISCUSSION:

A control diagram is a drawing that shows the components of a particular circuit, their electrical relationship to each other, and the way they are connected together. It is usually detailed so that you can follow the various branches of the circuit and analyze how the circuit functions.

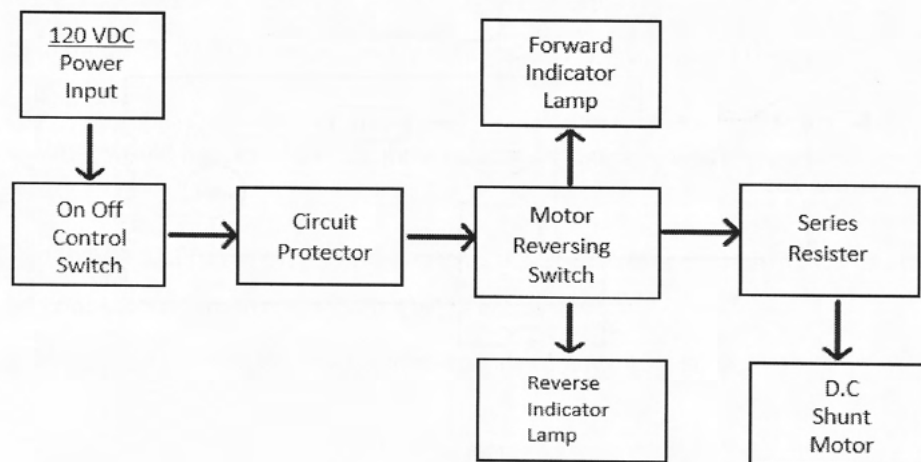
There are several different types of control diagrams, but the four most common are:

1. Block diagram
2. One-line diagram
3. Schematic (elementary) diagram
4. Connection (wiring) diagram

To illustrate, we will use a simple D.C. motor reversing control circuit that consists of

- a. A 120 VDC in coming power line
- b. A motor "on-off" control switch
- c. A branch circuit protection device
- d. A motor reversing switch
- e. Two motor direction indicating lamp
- f. A current limiting resistance
- g. A shunt connected D.C. motor

Let's see how this circuit looks using each of the four types of control diagrams.



(Figure 1)

A block diagram is a layout of the controls circuit in which the individual components are indicated by simple geometric shapes, each containing a short definition of its function. Figure 1 shows a block diagram of our simple D.C. motor controls circuit. Arrows are used to connect the blocks and show the flow of power.

ONE – LINE DIAGRAM

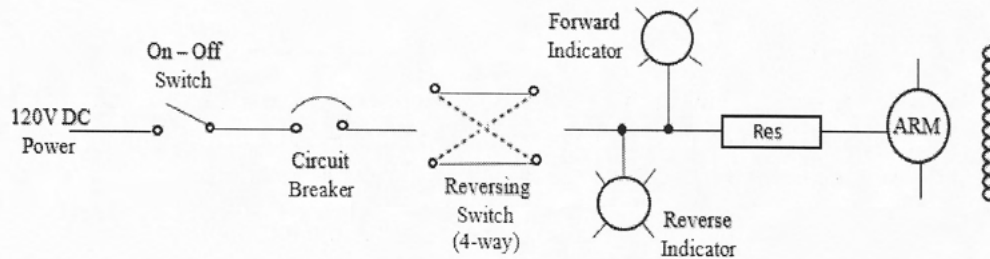


Figure 2

A one - line diagram is similar to a block diagram except that the various control components are shown by symbols instead of geometric shapes. The symbols indicate the general nature of the components, thus the one – line diagram tells a more comprehensive story than the block diagram. As shown in (Figure 2) a single line indicates the inter connections, regardless of the actual number of wires used in the circuit.

SCHEMATIC DIAGRAM

A schematic or elementary diagram shows the electrical relationship of all the various components. It disregards physical relationships and highlights each electrical element regardless of whether it is a complete device or only a portion of a device.

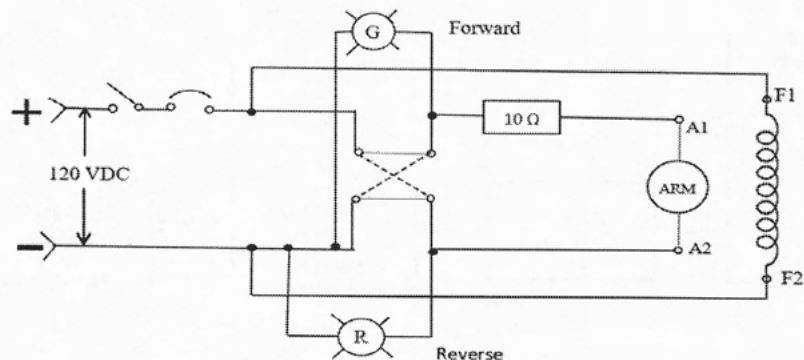


Figure 3

Symbols are used to indicate electrical elements and lines indicate connection wires. This type of diagram shows how a control system functions and it is the type we shall be using throughout this course. A schematic diagram of our D.C. motor control circuit is shown in (Figure3).

CONNECTION DIAGRAM

A connection or wiring diagram is a layout of a control circuit in which the primary emphasis is on physical relationship. Connection or wiring diagrams are used to identify components and wires during installation, wire tracing, or trouble-shooting activities. Each component is shown in its relative physical location and each wire is shown along with the terminal to which it is connected. Although it is possible to analyze the function of a circuit from this type of diagram, it is much more difficult than when a schematic diagram is used.

MATERIAL NEEDED:

3- way switch
4- way switch
Circuit breaker
10 ohms resistor
100 ohms resistor
Red pilot lamp
Green pilot lamp
Shunt motor
Three- phase motor
D.C. ammeter, 0-5 amps
Control Switch (on the Power Panel)

NOTE: Be Careful, Do Not make any connections with the power on!

PROCEDURE:

1. (a) Of the four diagrams discussed in the Discussion section, which one would you use to explain the actual operation of the circuit? Explain:
(b) Which one would you use to make the actual circuit connections? Explain:
(c) If you were using (figure 3) in making your circuit connections, would it help if the component terminals shown in the drawing were numbered? Explain:
(d) In (figure 3) if the armature and resistance is 17 ohms, what is the maximum starting current? Explain:
(e) What would happen if the 10 ohms resistor in (figure 3) was eliminated from the circuit? Explain:
(f) In (figure 3) if terminals A1 and F1 are positive with respect to terminals A2 and F2, in which directions will the motor run(CW/CCW)? Explain:
(g) In (figure 3), would the red pilot light be illuminated? Explain:

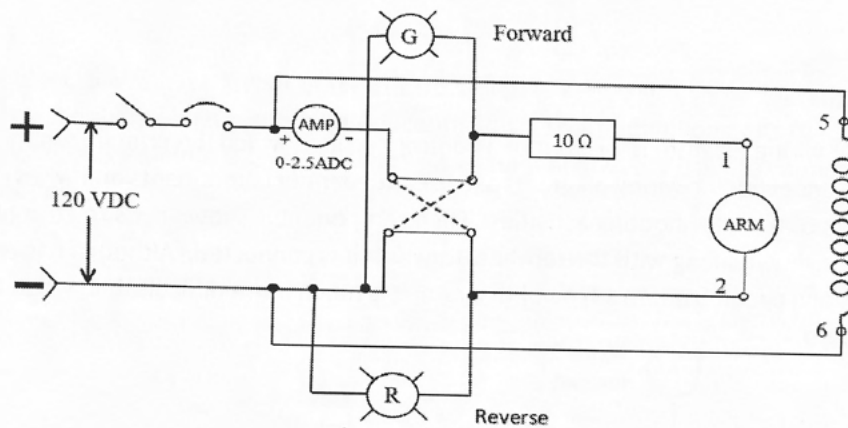


Figure 4

2. a. Examine the circuit shown in (figure 4)
- b. It is the same circuit shown in (figure 3), with the addition of component terminal identification and a current meter?
- c. Connect the circuit as shown in (figure 4).
- d. With the 4-way switch toggle to the left, apply power and note the deflection of the current meter pointer.
- e. Did the pointer deflect full scale? Yes/No
- f. Is the motor running in a CW or CCW direction? CW or CCW
- g. Which pilot lamp is illuminated?
- h. Record the no – load armature current.

$$I_A = \underline{\hspace{2cm}} \text{ A.D.C.}$$

- i. Throw the toggle of the 4-way switch to the right.
- j. Is the motor running in the opposite direction? Yes/No
- k. Did the other pilot lamp light? Yes/No
- l. Record the no – load armature current.

$$I_A = \underline{\hspace{2cm}} \text{ A.D.C.}$$

- m. Are the two currents, forward and reverse the same? Yes/No
- n. Operate the 4-way switch several times while observing the operation of the motor.
- o. Turn off the power supply to the motor.

3. a. Calculate the voltage drop across the 10ohm resistor when the power was first applied.

E (start) = _____ V.D.C.

- b. Calculate the voltage drop across the 10ohm resistor during normal no – load motor operation.

E (normal) = _____ V.D.C.

4.

- a. The speed of a D.C. shunt motor can be increased by inserting resistance in series with its field winding. In fact, the motor speed will increase very rapidly if the field is completely disconnected from the power source. You will now add resistance into the shunt field of the motor circuit of (figure 4).

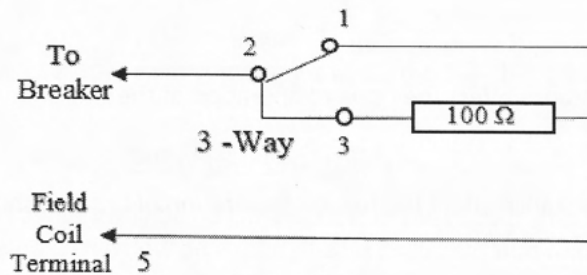
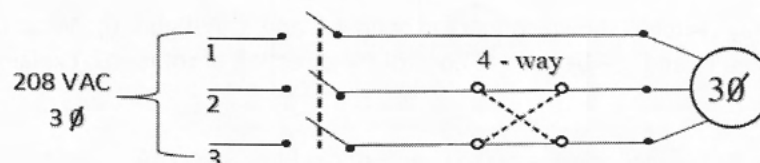


Figure 5

- b. Using the three - way switch and 100 ohms set up the circuit shown in (figure 5).
 c. Open the connection between the positive side of the power source and field terminal number 5. Insert the circuit of figure 5.
 d. Turn on the power supply and observe the operation of the motor.
 e. Does the motor speed change when the three- way switch is operated? Yes/No
 f. Does the speed increase when the 100ohm resistor is inserted into the shunt field? Yes/No
 g. Turn off the power supply.

5.

- a. A three – phase motor can be reversed by interchanging any two of its three-line terminations. A simple method for manually reversing a three – phase motor is using a four-way switch.



(Figure 6)

5.cont.

- b. Connect up the circuit shown in (figure 6). Ask your instructor for a three – phase motor.
- c. With the four-way switch toggle to the left, turn on the power.
- d. Is the motor running in the CW or CCW direction? CW/ CCW
- e. Operate the four – way switch and observe the motor operation. Does the motor change direction when the four – way switch is operated? Yes/ No
- f. Turn off the power supply and put your equipment up.

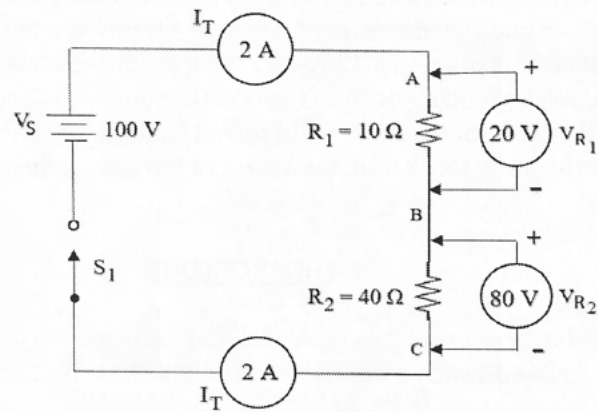
QUESTIONS:

Now answer the following questions and turn this complete project into your instructor for grading.

Before answering these questions read article (8-22) on page (85) of Electrical Principles and Practices.

1. Would you consider the 10ohm resistor in (figure 4) a control circuit element? Yes/No? Explain:
2. Does this resistance affect the no-load operation of the D.C. shunt motor? Explain:
3. Would this resistance affect the full-load operation of the D.C. shunt motor, if the full-load armature current is 2 ADC?
Explain:
4. Could you correct for the condition mentioned in Question No. 3 and yet retain the primary function of the 10ohm resistor?
Explain:
5. Would this also be considered a control circuit function?
6. What is the reason for the connection between terminals 2 and 3 of the three-way switch in (figure 5). Explain:
7. In the space provided, show how you would add another three-way switch to the circuit shown in (figure 5) to enable the motor speed to be controlled from two locations.
8. The four-way switch is shown connected in lines 2 and 3, in (figure 6). What other lines could it be connected to and still be used to control the direction of rotation? Explain:

FAULT-FINDING No. 1



(Figure 1)

Voltages across each component when the switch is closed

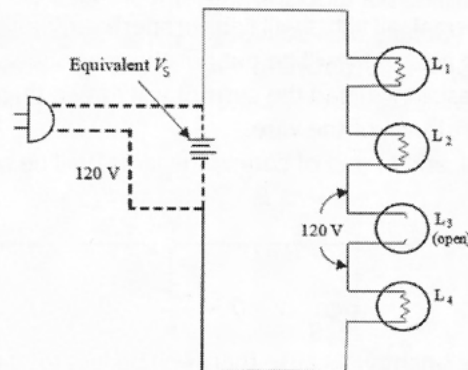
OPEN COMPONENTS

If switch S_1 in (figure 1) is opened, there will be no current flow in the circuit. This is analogous to automobile traffic: There will be no traffic flow on a road of a lift bridge on that road is open(lifted). There can be no current flow if a component in a series circuit is open. No current flow means that zero voltage drops across the components in that series circuit.

$$V_R = I \times R \quad \text{If } I = 0$$

$$\text{then } V_R = 0 \times R = 0 \text{ V}$$

Because the pressure of the voltage is still present, the total value is the voltage source will be produced across the open switch or component



(Figure 2) An open light bulb (burned out) in a series light-string

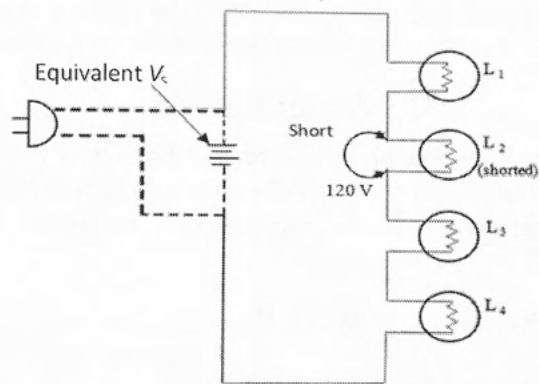
The best practical example of this type of fault and its consequences is a string of Christmas tree lights (figure 2). All the tree lights go out when one bulb socket is left open, because no current can flow. However, 120V would be measured with a voltmeter across the terminals of the open socket.

The nasty shock which one would receive of one foolishly poked one's finger in the socket of the burned-out light bulb would be full proof that 120V was being produced across the socket terminals.

The fact that 120V will be produced across the open component is also proof that there can be voltage without current. The fact that the other bulbs do not light means that there is no current flow through them, yet the nasty shock from the socket of the open bulb proves that the full 120V supply of voltage is present.

SHORT CIRCUITS

A component is said to be shorted if its resistance has decreased to 0 ohms, or if its value is much less than its stated value. A closed switch is equivalent to a total short, because the resistance of it is 0 ohms.



(Figure 3) -A shorted lamp in series light-string

The string of Christmas tree lights can also be used as an example to demonstrate the effect of a short (figure 3). When the circuit is normal, all lights will light properly. If, however, a wire is connected across the terminals of lamp 2 (L₂), the light in L₂ will go out but the other bulbs will light more brightly. The wire across lamp 2 shorts out its resistance, and the current will not go through the resistance of the lamp but will flow through the zero resistance of the wire.

The voltage developed across the wire, and of of of course the lamp, will be zero.

$$V = I \times R$$

$$\text{IF } R = 0$$

$$\text{Then } V = 0$$

The other lamps will light more brightly because there will be less total resistance in the series circuit. More current will flow and more will be produced.

FAULT: 1

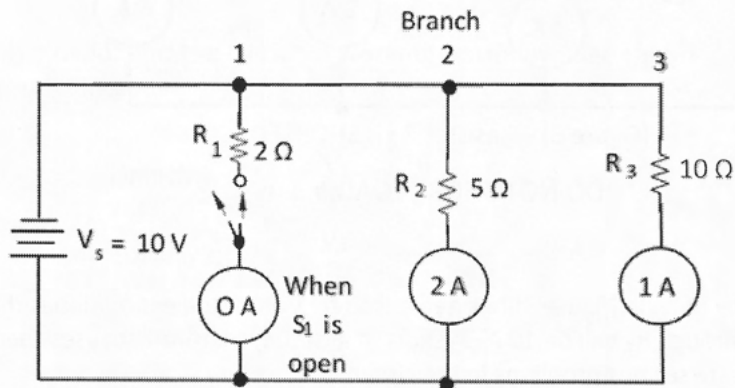
The following current would flow in the circuit of (figure 1) when S_1 is closed:

$$I_{R_1} = \frac{V_s}{R_1} = \frac{10}{2} = 5 \text{ A}$$

$$I_{R_2} = \frac{V_s}{R_2} = \frac{10}{5} = 2 \text{ A}$$

$$I_{R_3} = \frac{V_s}{R_3} = \frac{10}{10} = 1 \text{ A}$$

The total current would be **8 A**



(Figure 1) – Switch S_1 is Open

FAULT: 2

If S_1 were opened in figure 1 and all the other branches were the same as in Fault 1, there would be no current flow through R_1 , and the total current from the source would be reduced to 3A (i.e. $I_{R_2} + I_{R_3}$). The voltage across R_1 (V_{R_1}) would be zero, and the full V_s voltage would be across S_1 . In other words, there is no current flow in an open branch circuit. The full supply voltage will be across the open switch because no voltage drop is developed across the resistive load.

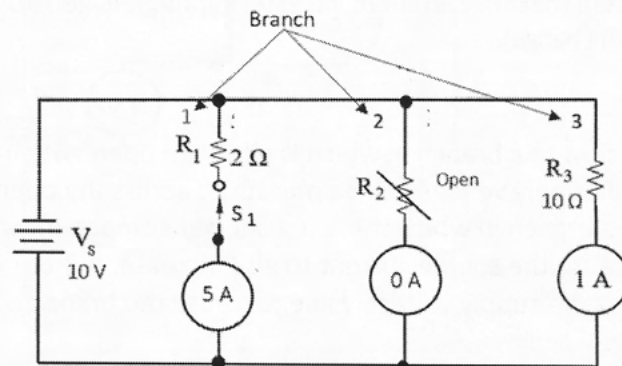
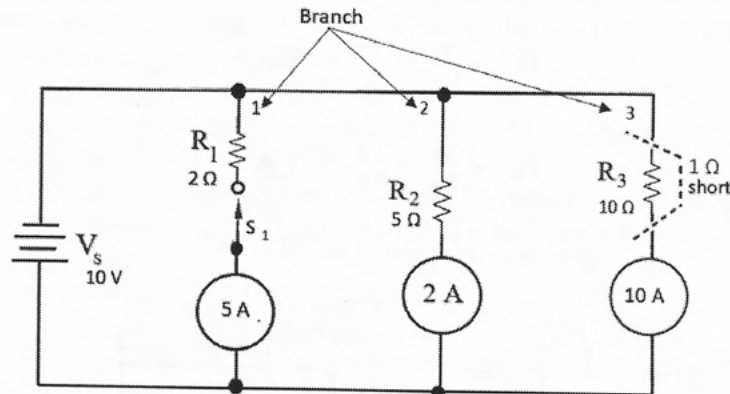


Figure 2 – Resistor R_2 is OPEN

FAULT: 3

If R_2 in (figure 2, is opened, and branch 1 and branch 3 are the same as in Fault 1, there will be no current flow in branch 2, and the total current from the source will be reduced to $(I_{R1} + I_{R3})$ or 6A. The full supply voltage (V_s) will still be measured across R_2 even though there is no current flow through it.



(Figure 3) – Resistor R_3 is SHORTED

DO NOT SHORT LOAD # 3

FAULT: 4

If the resistance of R_3 in (figure 3) has decreased to 1 ohm (the expression is that it is shorted), the resulting current through R_3 will be 10 A. A short in a circuit, therefore, causes the current to increase which can create serious problems in the circuit.

$$I_{R_3} = \frac{V_s}{R_3} = \frac{10}{1} = 10 \text{ A}$$

$$I_{R_1} = 5 \text{ A}$$

$$I_{R_2} = 2 \text{ A}$$

$$I_T = 17 \text{ A}$$

A short in R_3 has caused the total current to increase, but the voltage across R_3 will remain at the supply voltage value (it will not change).

SUMMARY:

1. There is no current flow in a branch in which is either an open switch or an open component. The full supply voltage will be measured across the open component.
2. The current flow in a branch in which there is a shorter component will increase. This will increase. This will cause the source current to also increase, but the voltage across the branch will remain at the supply voltage value, because the branch is connected directly to the supply voltage.

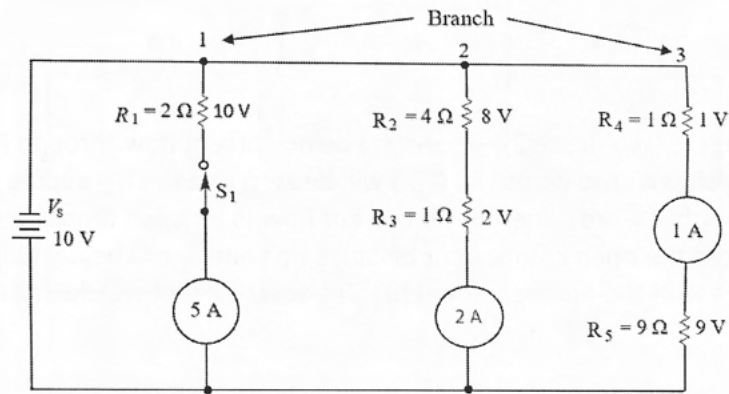


Figure 1 – Fault 1: The circuit is normal

The circuit in (figure 1) will be used as a sample circuit in which faults may be assumed. The following fault studies will give you some insight into the effect that certain faults can produce in a circuit.

FAULT: 1

Switch S_1 is closed, and the circuit is working normally. See (figure 1). If S_1 is closed, the following currents will flow:

$$\text{Branch 1. } I_1 = \frac{V_s}{R} = \frac{10}{2} = 5 \text{ A}$$

$$\text{Branch 2. } I_2 = \frac{V_s}{R} = \frac{10}{(1+4)} = 2 \text{ A}$$

$$\text{Branch 3. } I_3 = \frac{V_s}{R} = \frac{10}{(1+9)} = 1 \text{ A}$$

$$\text{Total current} = 8 \text{ A}$$

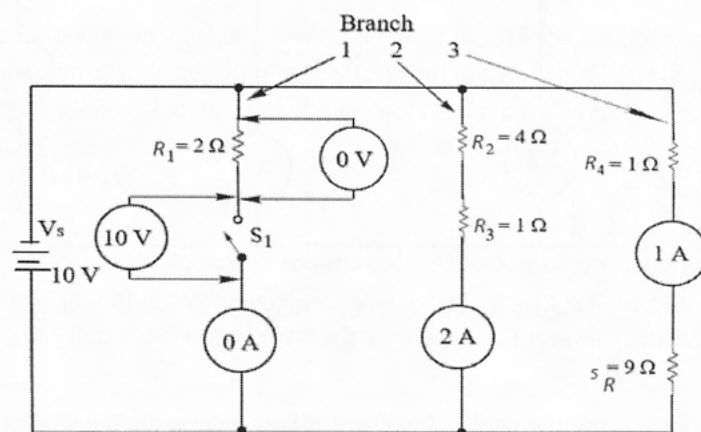
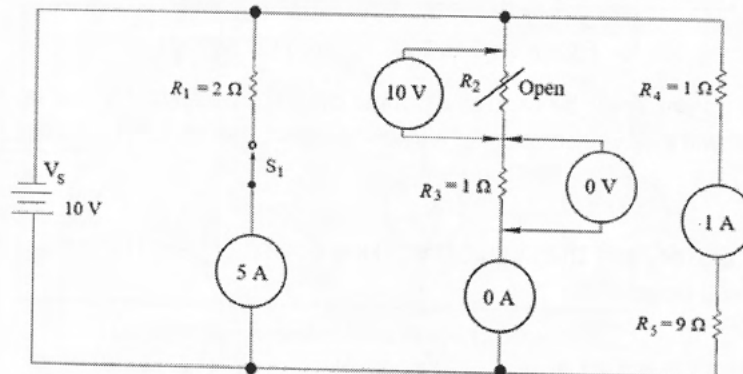


Figure 2 – The Switch, S_1 in branch 1 is open.

FAULT: 2

Switch S_1 is open, (see figure 2). There will be no current flow through R_1 when the switch is open. The voltage drop across R_1 (V_{R1}) will be zero and the full supply voltage will be across the switch. In other words, there is no current flow in an open branch circuit and the full supply voltage is across the open component because no voltage will be developed across the resistive load in series with the open component. The total current will decrease to 3A.



(Figure 3) – Fault 3: A Resistor in Branch 2 is OPEN

FAULT: 3

Resistor R_2 is open, see (figure 3). If R_2 is open, there will be no current flow in (branch 2), and the total current from the power source will be reduced to 6A. The full supply voltage will be across R_2 because there is no current in (Branch 2), and there will be zero volts across R_3 .

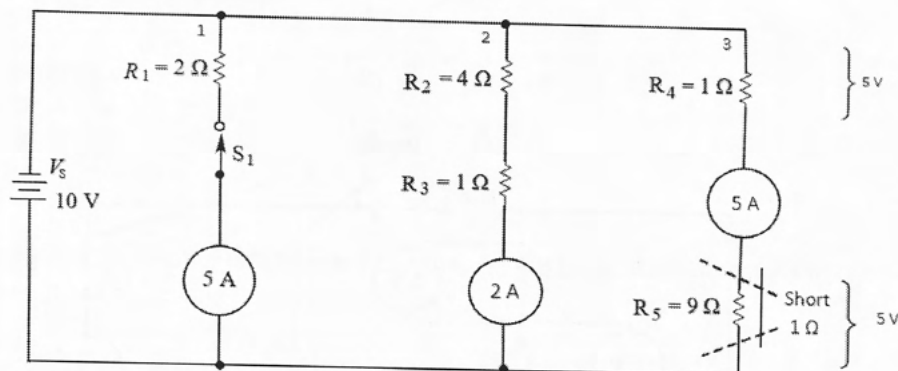
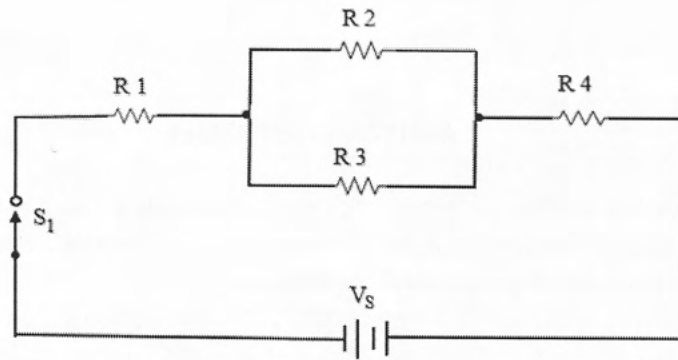


Figure 4 – Fault 4: R_5 SHORTED

FAULT: 4

Resistor R_5 is shorted, see (figure 4). The current flow in (Branch 3) will increase if the 9-ohm resistor R_5 develops, for example, a 1 ohm short. The total circuit current will also increase in that event from 8 to 12A. The voltage drops developed across R_5 will decrease to 5V but the voltage across resistor R_4 in series with R_5 will increase to 5V.



(FIGURE 1) – Series – Parallel Circuit

The circuit shown in (figure 1) is a series-parallel circuit of a different type than discussed in Fault-Finding No. 3. The knowledge gained from the discussion in Fault-Finding No.3 will be applied to the circuit in (figure 1) to determine the effects created in the circuit under various faulty conditions.

FAULT: 1

Resistor R_1 becomes shorted. If R_1 becomes shorted in (figure 1) the total circuit resistance decreases and the total circuit current increases. The voltage drops across R_2 , R_3 , R_4 will increase, but the voltage drop across R_1 will decrease.

FAULT: 2

Resistor R_4 becomes shorted. This fault produces symptoms similar to those produced by R_1 . The total resistance decreases and total current increases. If R_4 becomes shorted, the voltage drops across R_1 , R_2 , and R_3 will increase but the voltage drop across R_4 will decrease.

FAULT: 3

Resistors R_1 or R_4 become open. The power supply voltage will be measured across the open component, but zero voltage will be measured across the open component, but zero voltage will be measured across all the other resistors if R_1 or R_4 open.

FAULT: 4

Resistor R_2 or R_3 decrease in value. The total circuit resistance will decrease in value if R_2 or R_3 is reduced in value or becomes shorted, but the total current will increase. The result is that the voltage across R_1 and R_4 will increase in value, but the voltage across the parallel network (R_2 and R_3) will decrease in value.

FAULT: 5

Resistors R_2 or R_3 increase in value. The parallel network resistance will increase in value if either R_2 or R_3 becomes open or increase in value. The circuit current will decrease, and the voltage drops across R_1 and R_4 will decrease, but the voltage across the parallel network will increase in value.

SUMMARY:

1. The voltage measured across an open switch or component in a series circuit is always the supply voltage. Zero volts will be measured across any component connected in series with an open switch or component.
2. The voltage decreases across a component which becomes shorted in a series circuit, but the voltage across the other components will increase.

ANALYZING THE PROBLEM

There are two methods or approaches in troubleshooting that are affected by the condition of the circuit. Can the circuit be energized (hot) for checking? If not, then the circuit must be checked in its deenergized (dead) condition.

There are limitations to checking a circuit in the deenergized condition. These consist mainly of checking continuity of the circuit, including grounds. Disconnecting some of the conductors in the area that is being checked may be required to prevent measuring alternate paths.

An electrical resistance measuring instrument (ohmmeter) can be used. The test light can also be used to check continuity. While this method does have some limitations, it should not be passed up completely. There are situations where this can be valued as a quick and easy check.

The more complete and probably more widely used method is the circuit energized. A simple test unit is the common incandescent light used with a pigtail socket. Using a light bulb of a given voltage rating, and indication can be obtained of the presence of electrical energy. To a degree it will indicate the level of the potential. This, of course, can only be approximate.

The second piece of equipment used is the indication voltmeter. This instrument is available in many forms. It may vary from a very inexpensive and not too accurate voltage indicator to a precision laboratory voltmeter. A compromise between the two extremes is available in a good, general purpose voltmeter at a moderate cost. This usually works out to be the best all-around solution.

Most control circuits are energized at a maximum of 120V. This is a relatively low voltage, but safety is an important consideration in troubleshooting.

Only skilled personnel familiar with electrical equipment should be permitted to do the work. There may be hazards present not only from electrical energy but also from mechanical, fluid power, or pneumatic equipment.

A thorough knowledge of the machine and its operation is essential. It is important to know the condition of all sections of the machine before starting troubleshooting work. Accidents usually are a result of ignorance or carelessness.

STANDARD CONTROL No. 1
(Two & Three Wire Control)

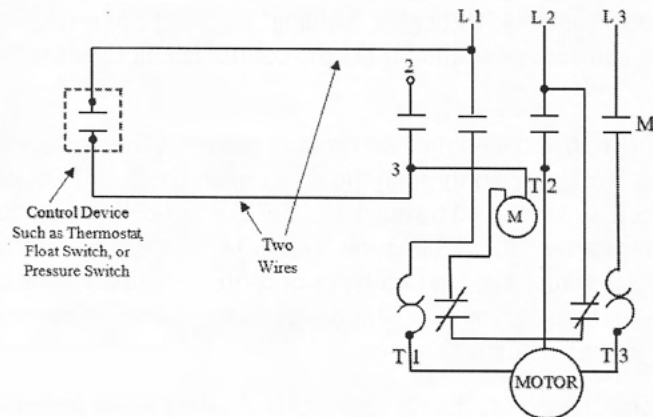


Figure 1- Two- wire control

Two-wire control is also known as No-voltage release or Low-voltage release. Two-wire control of a magnetic starter means that the starter drops out when there is a voltage failure and picks up as soon as the voltage returns. In (figure 1) the pilot device is unaffected by the loss of voltage and its contact

remains closed, ready to carry current as soon as line voltage returns to normal. This form of control is used frequently to operate supply and exhaust blowers, fans, pumps, and etc.

While two-wire control means that an operator does not have to be present to restart a machine following a voltage failure, this type of restart can be a safety hazard to personnel and

machinery. For example, materials in process may be damaged due to the sudden restart of machines upon restoration of power. (remember power may return without warning).

Three-wire control, known as No-voltage protection or Low-voltage protection, is also a basic and commonly used control circuit.

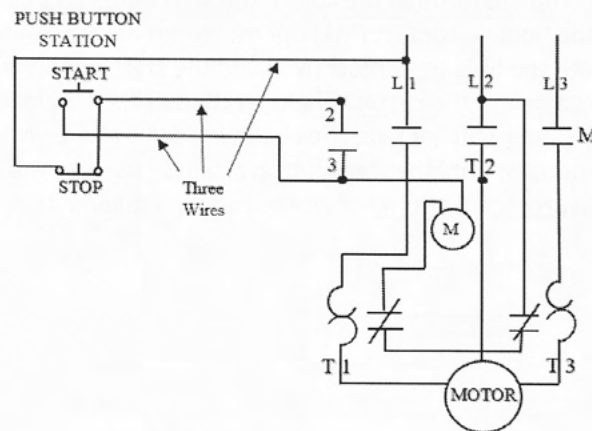


FIGURE 2 – Three- wire Control

Three-wire control of a starter means that the starter will drop out when there is a voltage failure but will not pick up automatically when voltage returns. The control circuit in (figure 2) is completed through the "stop" button and also through a "holding" contact (2-3) on the starter. When the starter drops out, the holding contact opens and breaks the control circuit until the "start" button is pressed to restart the motor.

The main distinction between the two types of control is that in no-voltage release (two-wire control) the coil circuit is maintained through the pilot switch contacts; in no-voltage protection (three-wire control). The circuit is maintained through a "stop" contact on the pushbutton station and an auxiliary contact on the starter. The designation "two-wire" and "three-wire" are used only because they describe the simplest applications of the two-types of control. Actually, for more complicated circuits, there may be more wires leading from the pilot device to the starter. However, the principle of two-wire control will still apply in these situations.

Three-wire control prevents the restarting of machinery when power is restored. It will be necessary for an operator to press the "start" button to resume production when it is safe to do so.

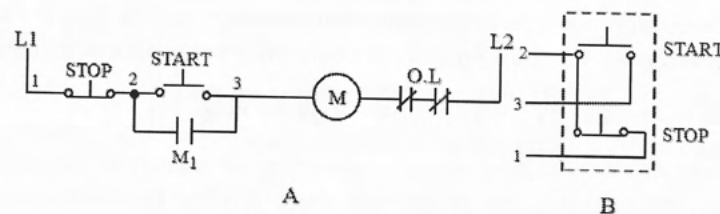


Figure 3 – Three-wire schematic

The sequence of operation for the circuit is (figure 3) is as follows: when the start button is pushed, the circuit is completed through the stop button and coil (M) and the contacts of M close. When the start button is released, the hold contact (M1) keeps the coil energized. With the holding contact closed, the circuit is still complete through the coil. If the stop button is pushed, the circuit is broken, the coil loses its energy and the holding contact (M1) opens. When the stop button is released, the circuit remains open because both the holding contact (M1) and the start button are open. The start button must be pushed again to complete the circuit. The operation of the overload protection will have the same effect, that is, if the supply voltage fails, the circuit is deenergized. When the supply voltage returns, the circuit remains open until the start button again is pushed. This arrangement is called no-voltage protection and protects both the operator and the equipment.

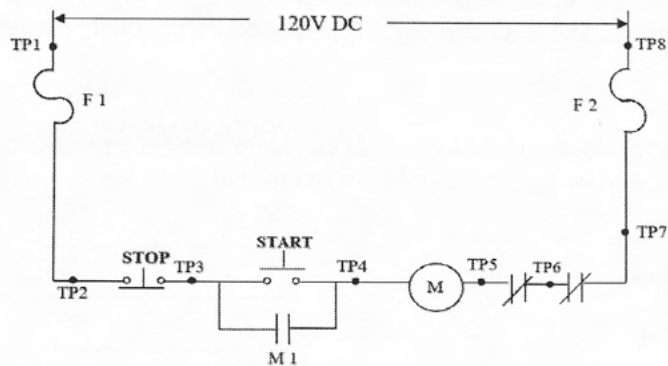


Figure 4 – Project Board

Figure 4 shows the layout of the board you will be using for this project. The points marked TP are test points, so that you can make voltage measurements. When you obtain the board from your instructor, you will notice seven (7) fault switches. With these switches all in the up position, the circuit will function like a normal three-wire control circuit. When the switch is put in the down position, one at a time, there will be faults in the circuit for you to find.

PROCEDURE:

1. Obtain the three-wire control board No. 1 from your instructor.
2. Connect the board up to 120V DC and measure the voltage between the following test points (TP) with the circuit deenergized. Make sure the fault switch are in the UP position.

<u>POINTS</u>		<u>VOLTAGE MEASURED</u>
TP1 to TP8	=	_____
TP1 to TP7	=	_____
TP1 to TP6	=	_____
TP1 to TP5	=	_____
TP1 to TP4	=	_____
TP1 to TP3	=	_____
TP1 to TP2	=	_____
TP2 to TP3	=	_____
TP3 to TP4	=	_____
TP4 to TP5	=	_____
TP5 to TP6	=	_____
TP6 to TP7	=	_____
TP7 to TP8	=	_____

3. Now push the start button and energize the circuit. With the circuit energized, measure the voltage between the following test points(TP). Make sure the fault switches are in the UP position.

<u>POINTS</u>		<u>VOLTAGE MEASURED</u>
TP1 to TP8	=	_____
TP1 to TP7	=	_____
TP1 to TP6	=	_____
TP1 to TP5	=	_____
TP1 to TP4	=	_____
TP1 to TP3	=	_____
TP1 to TP2	=	_____
TP2 to TP3	=	_____
TP3 to TP4	=	_____
TP4 to TP5	=	_____
TP5 to TP6	=	_____
TP6 to TP7	=	_____
TP7 to TP8	=	_____

4. Turn the power off. With the power, off put fault switch No. 1 in the down position. Now make the voltage measures with the circuit energized or deenergized. What is Fault No. 1?
5. Now repeat the procedure given in step 4 and determine the remaining faults. Only put one fault in at a time and make sure the power is **off** when you change positions of the fault switches.

Fault No. 2 is _____

Fault No. 3 is _____

Fault No. 4 is _____

Fault No. 5 is _____

Fault No. 6 is _____

Fault No. 7 is _____

6. Now turn this completed project into your instructor for grading.

CUTTER-HAMMER D.C. STARTER No. 1

INTRODUCTION:

Small D.C. motors, up to 1 ½ horse power at 115 volts and 2 horsepower at 230 volts, have sufficiently high internal resistance to allow them to start on full voltage without burning up the armature.

DISCUSSION:

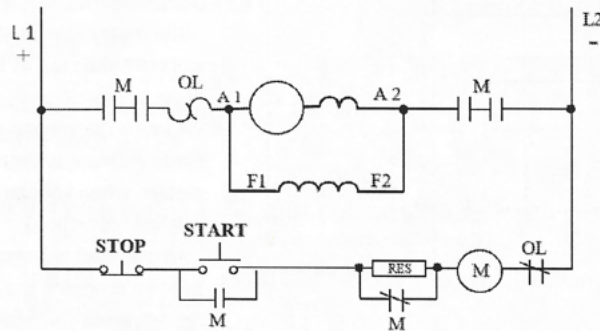
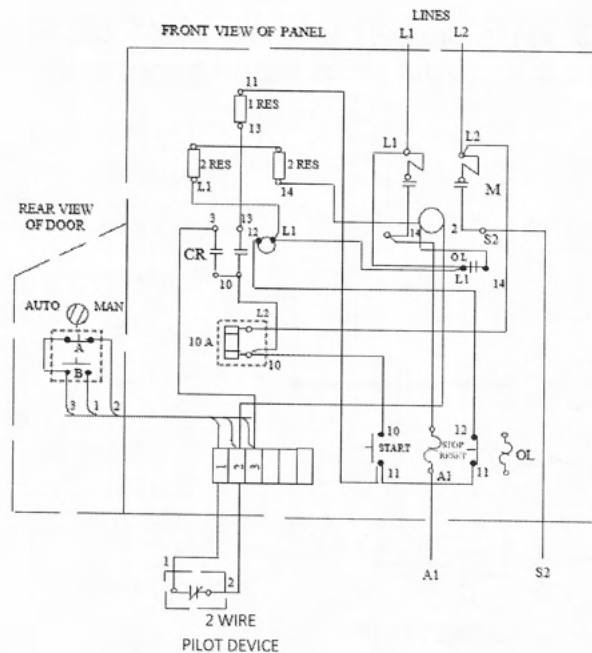


Figure 1 – Full Voltage Starter

A typical full-voltage starter circuit is shown in (figure 1). Small motors are not started and stopped frequently; therefore, the shunt field winding is connected permanently in parallel with the motor armature. No shunt field discharge resistor is needed; the shunt field discharges through the motor armature. A resistor is connected in series with the line contactor coil (M). The resistor is short-circuited by a normally closed interlock on the line contactor, so that a high inrush current is obtained for closing the contactor. After the contactor has picked up, the normally closed interlock on (M) opens and the resistance is inserted in series with the line contactor coil (M). Coil current is reduced to a magnitude sufficient to keep the contactor closed without overheating the coil.

PROCEDURE:



CONT.	POSITION	
	MAN	AUTO
A	X	
B		X

X-CONTACT CLOSED

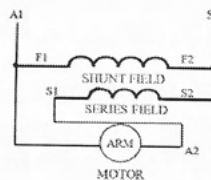


Figure 2 – Cutler-Hammer Starter

DESCRIPTION ON OPERATION

To start the motor, press the start button. This energizes relay (CR) which maintains itself thru its own contacts. Another set of contactson (CR) close to establish a circuit to main contactor (M). With the selection switch in the (MAN) position.

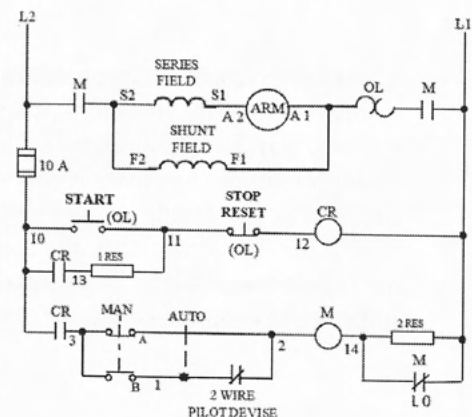
The motor will run as long as the selection switch is in this position. With the selection switch in the auto position.

The motor is under the control of the 2 wire pilot device and will start and stop as the contacts of this device close and open.

A low voltage condition will cause (CR) to open dropping the control circuit, disconnecting the motor from the line. To restart, when voltage is restored, press the start button (low-voltage protection)

An overload will cause the (OL) contacts to open causing (CR) to open dropping the control circuit stopping the motor. To restart, press the reset button, then press the start button.

ELEMENTARY DIAGRAM



1. Obtain the Cutler-Hammer starter from your instructor.
Compare this starter with the panel diagram shown in Figure 2.
2. Read over the description of the diagram (figure 2). Make sure you understand the operation of this circuit before you go any further.
3. You will notice in the panel diagram (Figure 2), that the external devices you will need to make the circuit function properly are a pilot device, and a selection switch, and a compound motor. Obtain these devices from your instructor.
4. Now connect the circuit shown in (figure 2). When you have it working correctly, have your instructor check it.

QUESTIONS:

Now answer the following questions and then turn this completed project into your instructor for grading. Use the schematic in (figure 2) in answering these questions.

1. What is the purpose of 1 RES and 2 RES? Explain:
2. What would be the indications if the CR relay coil was open? Explain:
If it was shorted? Explain:
3. What would be the indications if the M coil was open? Explain:
If it was shorted? Explain:
4. What would be the indications if the start button stayed closed all the time? Explain:
5. What would be the indications if the shunt field was open? Explain:
If it was shorted? Explain:
6. What would be the indications if the series field was open? Explain:
If it was shorted? Explain:
7. Why didn't they put a fuse in line L1 too? Explain:
8. What is the direction of rotation of the motor shown in (figure 2)?

GENERAL ELECTRIC D.C. STARTER NO. 1

INTRODUCTION: Mechanical timer can be used to accelerate a D.C. motor

DISCUSSION:

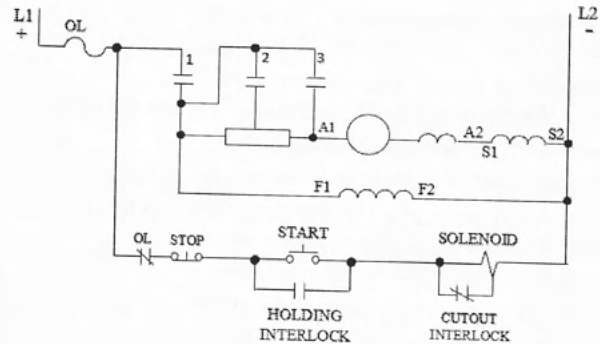
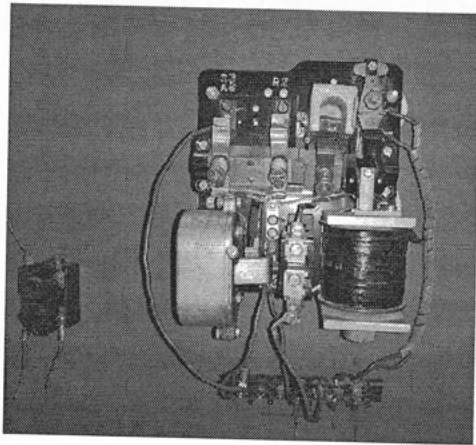


Figure 1 – D.C. Shunt Motor Starter

A simple starter obtaining definite-time acceleration, suitable for use with motors up to 5 horsepower at 115V D.C. or 10 horsepower at 230 V D.C., is illustrated in (figure 1). It consists of a system of contacts, mounted on a shaft and operated by a solenoid. When the starter push-button is pressed, the solenoid coil is energized with part of its winding short-circuited. Line contact 1, which is equipped with blowout coil and arc chute, closes immediately and connects the motor to the line. A holding contacts seals around the start button, and a cut-out interlock inserts the remainder of the solenoid coil in the circuit. This connection obtains a high inrush current to close the solenoid; but this current is later reduced to a value which keeps the heating of the solenoid coil within the permissible limit, while still producing sufficient holding pull. A mechanical – escapement type time-delay mechanism is connected to the shaft carrying accelerating contacts 2 and 3 permitting these contacts to close in time sequence as the energy stored in a spring by the solenoid closing action is gradually released. The total time of the acceleration sequence adjustable.

A thermal overload relay protects the motor. When the motor is stopped by dropping out the solenoid and opening the contacts, the motor armature circuit provides a discharge path for the shunt field. No dynamic braking circuit is provided, and the motor coasts to a stop.

This simple and inexpensive starter is suited only for non-reversing starting service for non-Reversing starting service for constant-speed motors. It has the advantage of being small and compact. However, because of its moving parts, this device has an inherently low mechanical life and should not be used for frequent starting and jogging service.

PROCEDURE:

1. Obtain G.E. D.C. starter No. 1 from your instructor. Study this starter over carefully and compare it with the schematic diagram shown in (figure 1).
2. Before you connect up this starter, read page 136 -143 (Electrical Principles and Practices), this will give you the reason for using reduced voltage starting on D.C. motors of 2H.P. or larger.

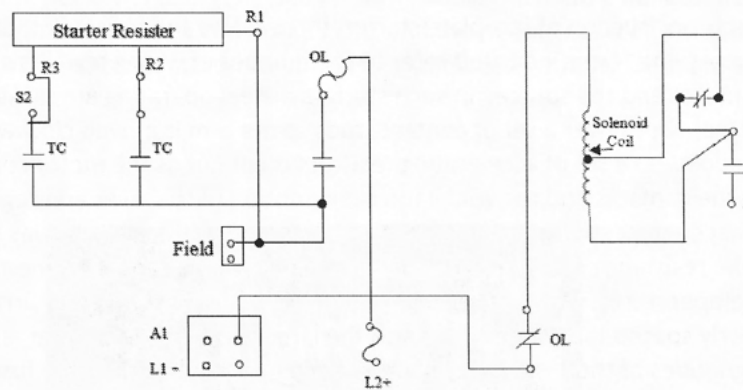


Figure 2

3. Figure 2 is a panel diagram for the starter given to you by your instructor. Now compare the schematic diagram in (figure 1) with the panel diagram of figure 2.
4. On (figure 2) show how you would connect a start and stop pushbutton into this circuit also on (figure 2). Show on (figure 2) how you would connect a compound D.C. motor into this circuit.
5. Have the connections of step 4 Approved by your instructor.
6. After you have obtained approval from your instructor, connect a start-stop pushbutton and compound D.C. motor to the starter given you by your instructor.
7. When you have the pushbutton, motor, and starter connected, apply 120V DC to your circuit. Then have it checked by your instructor for proper operation.
8. Write down the sequence of operation of this starter and turn it into your instructor for grading.

GENERAL ELECTRIC D.C. STATER No. 2

OBJECTIVES: After studying this project, you will be able to:

1. Identify the terminal marking for a three and four-point starter
2. Describe the operation of a three-point starter
3. Describe the operation of a four-point starter
4. Describe the difference between a three and four-point starter

DISCUSSION:

Two general construction of faceplate starter, three-point and four-point, are employed for shunt and compound motors: the terms indicated refer to the number of wiring terminals that are provided for connection to the motor and the source. In such starters a steel operating arm is fitted with a spring-loaded brass shoe that wipes over a set of contact studs as the arm is moved clockwise from the OFF to the ON position; in doing so a set of accelerating resistors is cut out as the motor comes up to speed. To minimize arcing at the contacts and to avoid a too rapid motion of the lever and regulated automatic devices; also, the last contact stud is made larger than the others because it carries current continuously. For smaller sizes, the resistance material is usually iron wire or some ferro-chrome-nickel alloy that resists oxidation at high temperatures, while heavy cast-iron or special alloy stampings, arranged in built-up sections with properly spaced taps, are common to the larger starters. Moreover, as previously explained, the magnitudes of the various acceleration value—and the size of the fuses that must protect the motor.

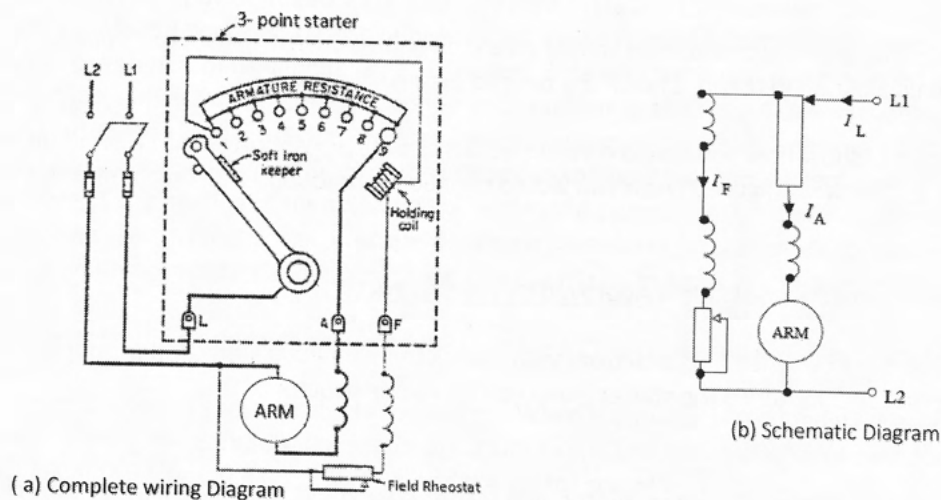


Figure 1- Diagram showing a three-point manual starter connected to a compound motor.

Figure 1- shows a wiring diagram of a three-point starter connected to a compound motor, with (figure 1b) illustrating schematically how the line current divides into two parallel paths, the low-current shunt-field circuit and the armature or load circuit. Note particularly that full voltage is applied to the shunt field on the first point – this is, therefore, a full-field point as well as an armature – current limiting point – and that the very resistance that is cut out of the armature circuit (comparatively low) is cut into the shunt-field circuit. This is because maximum field strength is desired, for highest developed torque, at the instant the motor is started. Since the resistors are used only during the accelerating period, they are designed for short-duty service and usually for inrush or maximum currents of about 150 per cent of full-load value. For normal starting service such resistors would be NEMA class 115, and for heavy-starting service NEMA class 135. (The last figure in the class designation, i.e., number 5, implies that the inrush current would be 150 per cent F.L.C. (full-load current), while the middle number indicates the duty cycle; the middle number 1 means 5 sec ON out of 80 sec, and the middle number 3 stands for 10 sec ON out of 80 sec.) A three-point starter mounted in a steel case with the front protecting cover removed is depicted in (figure 2).

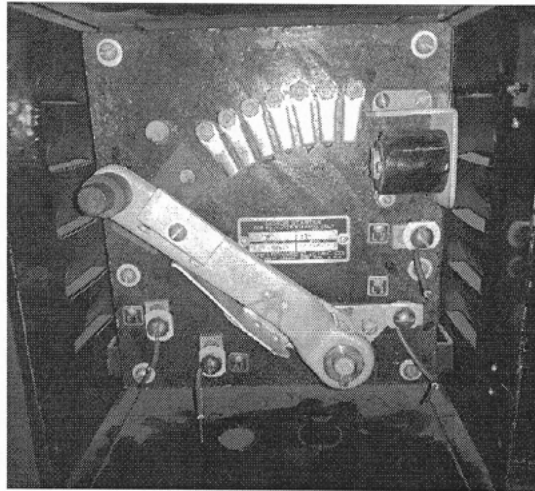
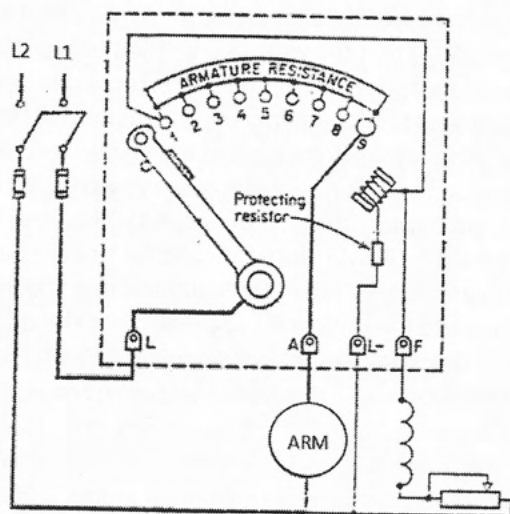
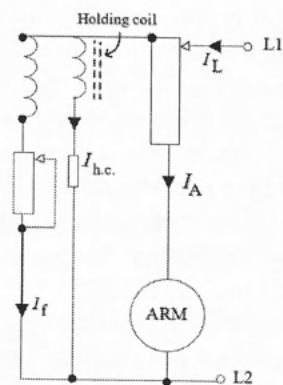


Figure 2 – Enclosed three-point manual D.C. motor starter with front cover removed

Referring to (figure 1) it will be noted that the current in the holding coil (the holding coil is an electromagnet that keeps the spring-loaded arm in the FULL-ON position until the voltage drops considerably or there is a power failure, in which case the force of the spring returns the arm to the OFF position) is in series with the shunt field and the current in the two are the same. This means that, if a field-rheostat resistance of sufficient ohmic value is cut into the field to raise the speed (this will be discussed later under the subject of speed adjustment), the magnetomotive force of the holding coil may be reduced to a value too low to hold the arm in the FULL-ON position; the arm would then return to the OFF position automatically and the motor would stop. To avoid such faulty operation for high-speed shunt-field-controlled motors, the holding coil is removed from the shunt-field circuit and is energized directly, through a limiting resistor, by the main power source; this change results in a four-point starter.



(a) Complete wiring Diagram



(b) Schematic Diagram

Figure 3 – Diagram showing four-point manual starter connected to a shunt motor.

A wiring diagram of a four-point starter connected to a shunt motor is shown in (figure 3) with (figure 3b) illustrating schematically how the line current divides into three parallel paths. As mentioned above, the holding coil and shunt-field currents are independent of each other, so that speed changes by field rheostat adjustment will not affect the electromagnetic pull exerted by the holding coil.

One of the objections to the use of the simple three-point and four-point starters (figures 1 and 3) is that a motor may be started inadvertently with considerable field-rheostat resistance in the shunt-field circuit; this may occur when the motor is stopped after having been operated at high speed and the operator neglects to set the rheostat in the all-out position before a new start is made. When this happens the inrush armature current may rise well above its intended value because starting torque is proportional to both armature current and flux, and any deficit in the latter must be made up by an increase in the former if the load is to be accelerated. In fact, the armature current may rise to an abnormally high value and cause fuses to blow or the circuit breaker to open if the motor is started with a weak field.

The object indicated can be avoided if a compound faceplate starter is employed, a construction that combines both acceleration resistors for starting and field rheostat for speed adjustment

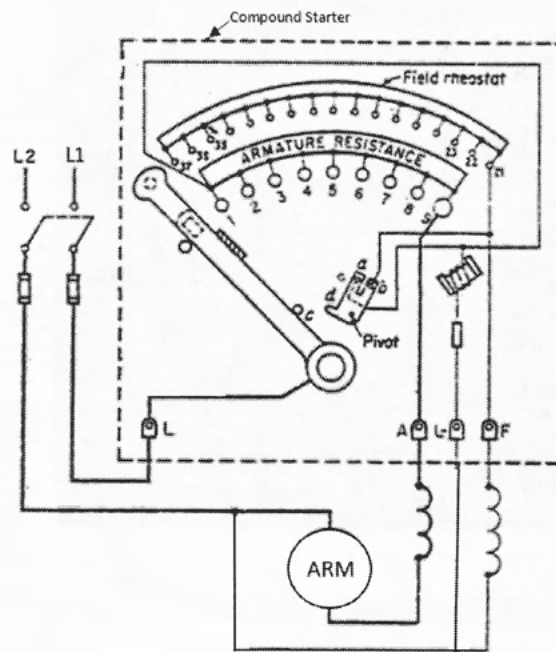


Figure 4 – Diagram showing a compound starter connected to a compound motor

Figure 4 – shows a wiring diagram of a compound motor connected to a compound starter, an arrangement that not only makes certain that the motor starts with full field but provides a neat unit construction of armature and field-rheostat resistors. The arrangement requires a double arm, one longer than the other, and mounted and pivoted at the same hub post. An operating handle, fixed to the end of the free brush-carrying long arm, is moved over a set of field-rheostat studs in a clockwise direction and pushes the shorter spring-loaded arm whose brush wipes over the armature-resistance studs. During the accelerating period, i.e., as the armature resistors are being cut out, field current passes directly from stud 1 to contacts (a) and (b), through a pivoted U-shaped brass piece, and thence directly to field terminal (F). Note particularly that the motor starts on full field but, as in the plain starters, the armature resistors are inserted in the field circuit as they are removed from the armature circuit. When the short arm reaches its final position, it is held there by the low-voltage release (holding coil). At the same time, a small insulated piece (C) that is fastened to the short arm engages the pivoted U-shaped brass segment at (d) to rotate it counterclockwise; this motion disconnects the brass segment from the armature resistor at point 1 and connects the line terminal directly to stud 21 and field terminal F. The motor will thus be running on full field with all acceleration resistors cut out. Now then, if the long arm, which is free, is moving counterclockwise, it can be made to rest by friction at any higher numbered stud and cause speedup; this motion is equivalent to cutting in resistance with a field rheostat.

A typical four-point compound motor starter is shown in (figure 5).

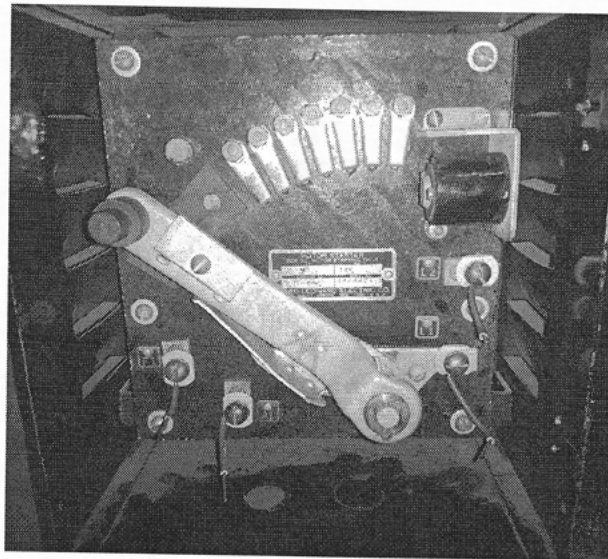


Figure 5 – Enclosed four-point compound manual D.C. motor starter with front cover

PROCECEDURE:

1. Obtain from your instructor a G.E. four-point starter.
2. Look this starter over very carefully and make sure you understand its operation. You will notice that this starter is like the one shown in (figure 3).
3. Now connect this starter up to a lab volt motor. Before you apply 110V D.C. to your starter and motor, have your instructor check your connections.
4. If your circuit operates alright and is approved by your instructor, disconnect the starter and put the starter and motor away.

QUESTIONS:

Now answer the following questions and then hand this completed project into your instructor for grading.

1. Complete the connections in (figure 6) so that the shunt motor is properly connected to the indicated device. Have the motor rotate CW.

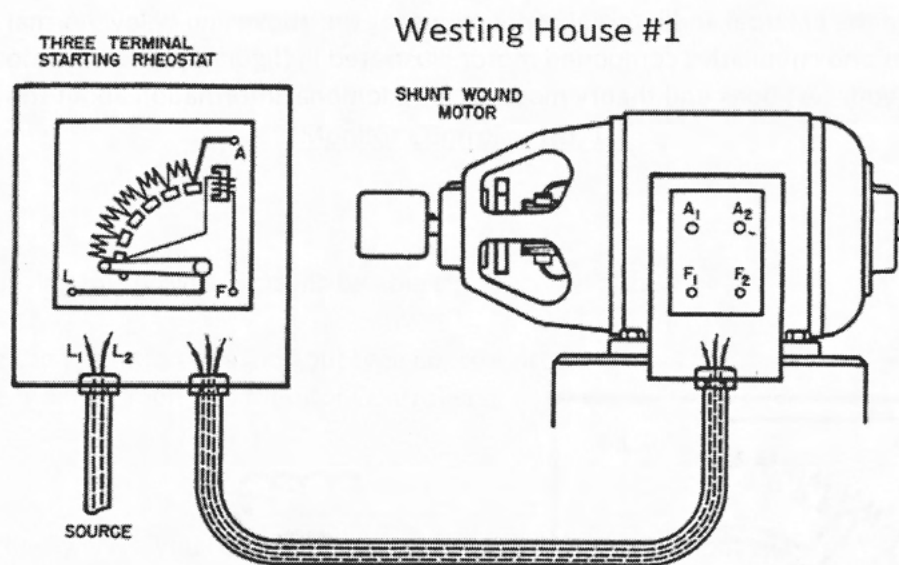


Figure 6

2. Complete the connection in (figure 7), so that the compound motor is properly connected to the device indicated. Have the motor rotate CCW.

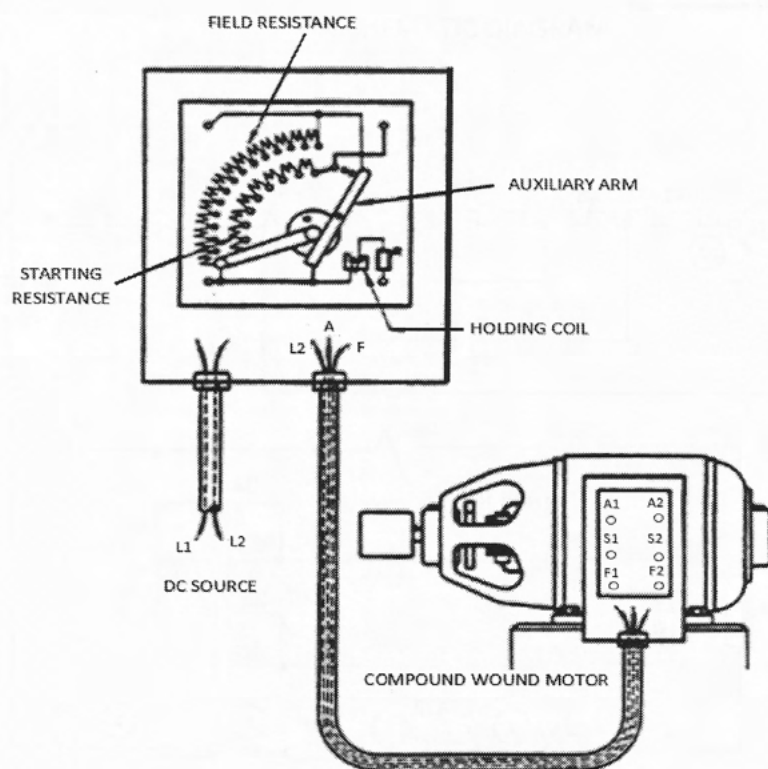


Figure 7

3. Complete the external and internal connections for the above and below normal speed controller and cumulative compound motor illustrated in (figure 8). Have the motor rotate CCW. Refer to your test book and theory modules for additional information about this connection.

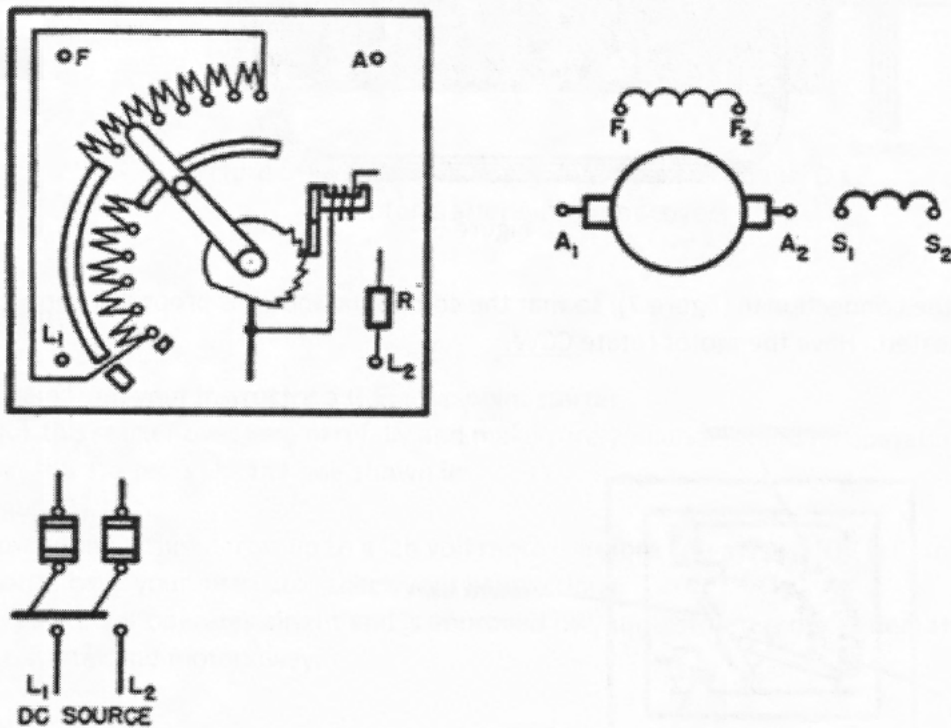


Figure 8

Monitor Controller No. 1

OBJECTIVE:

After studying this project, you will be able to:

1. Describe the operation of a lock-out type control circuit.
2. Describe the operation of a Monitor Controller.

DISCUSSION:

In your theory class, you have been given some modules on lock-out type relays. Read these over before you start this project.

Figure 1 below is a Schematic Diagram for the monitor controller and figure 2 is the wiring diagram for this controller.

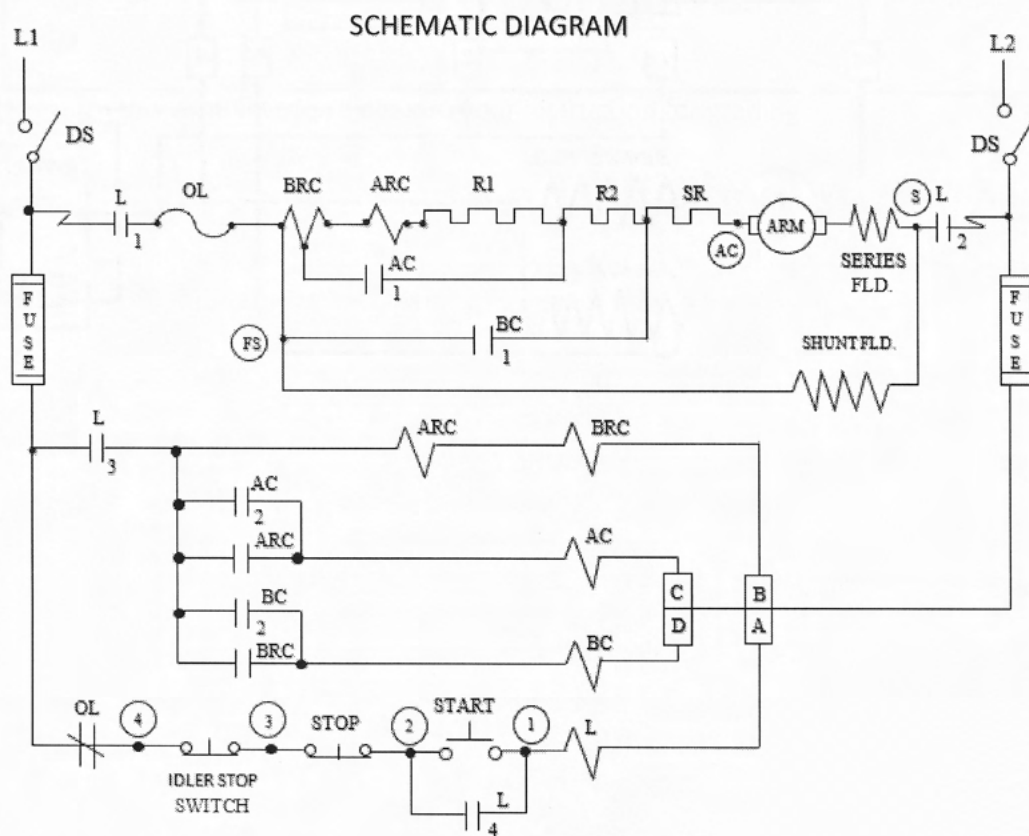


FIGURE 1

FRONT VIEW OF PANEL

SOLID LINES- CONTROLLER WIRING

DASH LINES - EXTERNAL WIRING

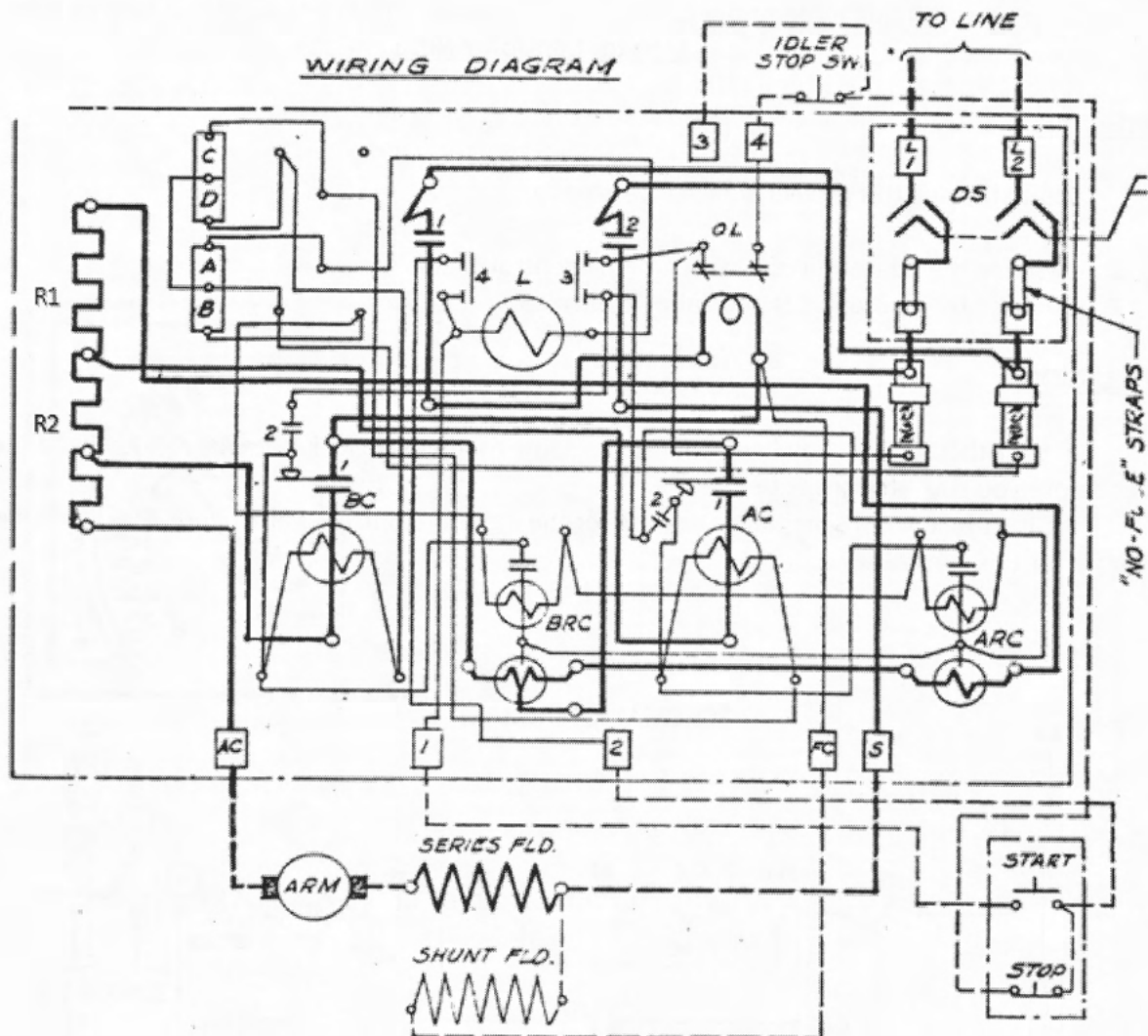


FIGURE 2

PROCEDURE:

1. Obtain the Monitor controller from your instructor. Compare it with the schematic and wiring diagram.
2. From the schematic diagram write down the sequence of operation for this controller and have it approved by your instructor.
3. Now in connecting up this controller to a Lab Volt motor, you will need a start and stop pushbutton station and a single pole switch. The single pole switch will be used as the idler stop switch. Obtain these parts from your instructor.
4. Now connect this controller up to a motor and apply 110V DC to it. Have your instructor approve your connection before you apply power to the circuit.
5. After you have the circuit working correctly, have your instructor check it.
6. Turn the power off. Disconnect your circuit and return all parts to their proper place.
7. Now turn this completed project into your instructor for grading.

ALLEN BRADLEY D.C. STARTER No. 1

OBJECTIVES: After studying this project, you will be able to:

1. Connect up an Allen Bradley starter
2. Troubleshoot an Allen Bradley starter

Discussion:

Different companies draw their wiring diagrams different ways. As an electrician you should be able to understand any type of wiring diagram.

This skill is necessary in order for you to be able to connect in the starter, troubleshoot the starter, understand how the starter operates and be able to draw a schematic diagram.

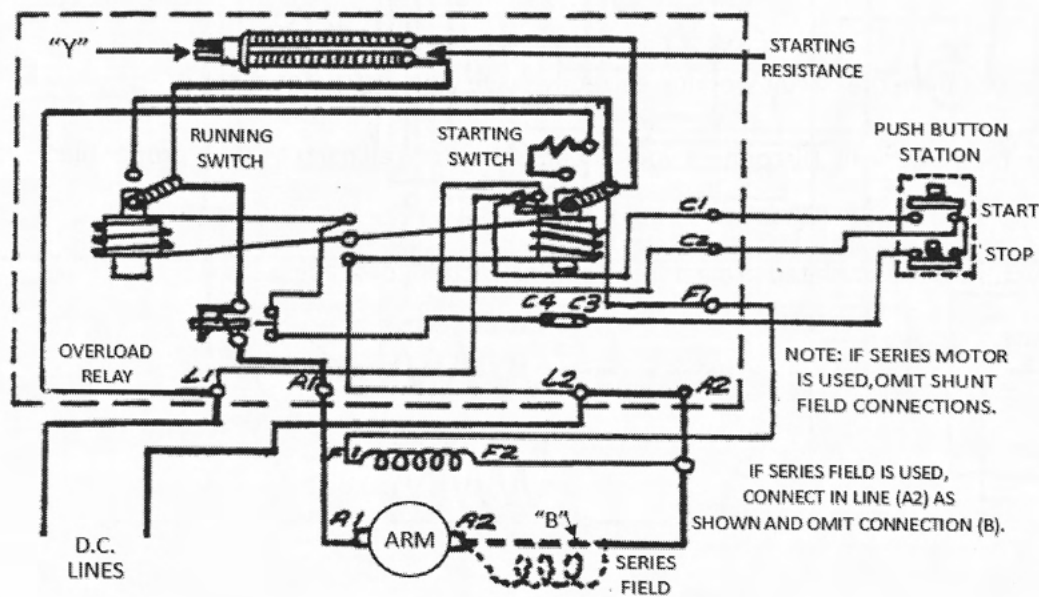


Figure 1

Figure 1- is a wiring diagram for the starter you will be using during this project.

PROCEDURE:

1. Obtain this starter from your instructor. Study it over and compare it with the wiring diagram above (Figure 1).
2. Draw a schematic diagram for the circuit shown in (Figure 1). Have the schematic approved by your instructor.
3. Write the sequence of operation for this starter.
4. Connect a shunt motor (Lab volt motor) and start – stop pushbutton to this starter. Have your connections approved by your instructor.
5. Apply 110V DC to your circuit. Does it operate as your schematic diagram indicated it would? YES/NO If it doesn't reconnect it so it will. Turn power off.
6. Now connect a series motor (Lab volt motor) and start-stop pushbutton to this starter. Have your connections approved by your instructor.
7. Apply 110V D.C. to your circuit. Does it operate as your schematic diagram indicated it would? YES/NO If it doesn't reconnect it so it will. Turn power off. Return your parts to their proper places.
8. Turn this completed project into your instructor for grading.

DYNAMIC BRAKING No. 1

OBJECTIVE: After studying this project, you will be able to:

1. Describe what is meant by the process of dynamic braking.
2. Connect and troubleshoot motors with dynamic braking.

DISCUSSION:

Dynamic braking may be compared to the use of an auto engine to slow a car going downhill. As you may know, pressure is generated by the compression, which acts as a brake. This compression is possible because a D.C. motor, if its field remains excited while it is being driven by a load, will act as a generator and returns power to the line. The generator action holds the load.

However, in an actual system that uses dynamic braking with a series D.C. motor, the motor is disconnected from the line, and its armature and field are connected in series with a resistor to form a loop. The field connections to the armature are reversed so that the armature counter-voltage will maintain the field with its original polarity.

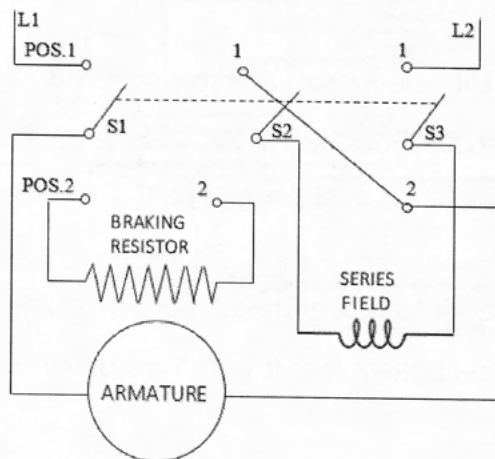


Figure 1 – Connections for dynamic braking of a series D.C. motor.

Figure 1 shows the connections used for dynamic braking of a series-wound D.C. motor. The field switching is done by switches S1, S2, and S3. The three switches are part of a 3PDT assembly and are magnetically operated from a controller.

With the switch arms in position 1, the motor operates from the line. When the switch arms are in position 2, the resistor is connected in series with the field, and at the same time, the field connection to the armature is reversed. Thus, as long as the armature turns, it will generate a counter-voltage, which will force current through the resistor and the series field. Although the direction of current flow through the armature is reversed (because of the counter-voltage), the direction through the series field coil is the same as it was when operating as a motor. When operating in this manner, the machine is essentially a generator that is being driven by the momentum of the armature and mechanical load. This energy is quickly consumed in forcing current through the resistor, and the armature stops turning.

The time required to stop the motor may be varied by using different resistor values. The lower the resistance, the faster the braking action. If two or more resistors are connected by switches, the braking action can be varied by switching in different load resistors. Usually the same braking resistors that are used to stop the motor are also used to reduce the line voltage during acceleration. This feature has been omitted on the drawing for simplification.

When dynamic braking is used with a D.C. shunt-type motor, resistance is connected across the armature.

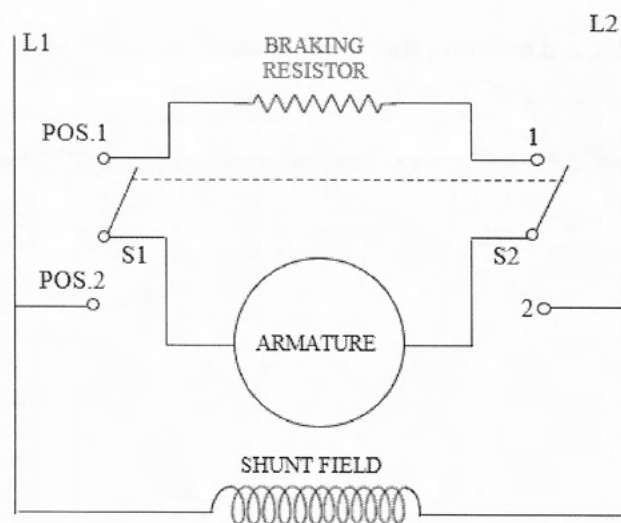


Figure 2 –
Braking of a

Connection for Dynamic
Shunt D.C. motor

Switches S1 and S2 are part of a DPDT circuit breaker assembly. When the switch arms are connected to position 2, the armature is across the line, and motor operation is obtained. When the switch arms are in position 1, the armature is disconnected from the line and connected to the resistor. The shunt field remains connected to the line. As the armature turns, it generates a counter-voltage, which forces current through the resistor. The remainder of the action is the same as described for the circuit in (figure 1).

Although dynamic braking provides an effective means of slowing motors, it is not effective when the field excitation fails or when an attempt is made to haul heavy loads; without rotation, the counter voltage is zero, and no braking reaction can exist between the armature and the field.

Braking currents is usually set at 150% of normal armature current, but where very quick stopping is desired, the current maybe allowed to go as high as 300% of normal. As the motor slows down, the generated voltage falls, consequently the braking current and braking torque are reduced. At zero speed there is no braking effect at all.

PROCEDURE:

1. Obtain the dynamic braking motor from your instructor. Also obtain from the instructor, three 15-ohm resistors, a three-pole double throw knife switch and a double pole throw knife switch.
2. Connect up the circuit shown in (figure 1) using the motor, the three-pole double throw knife switch and the three resistors in series. These three resistors are your dynamic braking resistance. Have your instructor check your connections.
3. Apply 110V DC to the circuit and measure the braking time.
Braking time (series) _____ sec.
4. Turn power off. Now connect the resistors in parallel. Apply 110V DC to the circuit and measure the braking time.
Braking time (parallel) _____ sec.

5. Turn power off. Now with the motor, the double pole double throw knife switch connects up the circuit shown in (figure 2). Connect the three resistors in series for your dynamic braking resistance. Have your instructor check your connections.
6. Apply 110V DC to the circuit and measure the braking time.
Braking time (series) _____sec.
7. Turn power Off. Now connect the resistors in parallel. Apply 110V DC to circuit and measure the braking time.
Braking time (parallel) _____sec.
8. Turn the power off. Disconnect your circuit and return the parts to their proper place.

QUESTIONS:

Now answer the following questions and then hand this completed project into your instructor for grading.

1. Will dynamic braking hold a load? Explain:
2. After dynamic braking occurs, why is mechanical braking generally necessary? Explain:
3. The smaller the resistance, the (faster or slower) the degree of braking? Explain:
4. The larger the resistance, the (faster or slower) the degree of braking? Explain:

ALLEN-BRADLEY DEFINITE-TIME STARTER No. 1

OBJECTIVES:

After studying this project, you will be able to:

1. Describe the sequence of operation of a definite-time starter.
2. Connect and troubleshoot D.C. compound motors and controllers for definite – time acceleration.

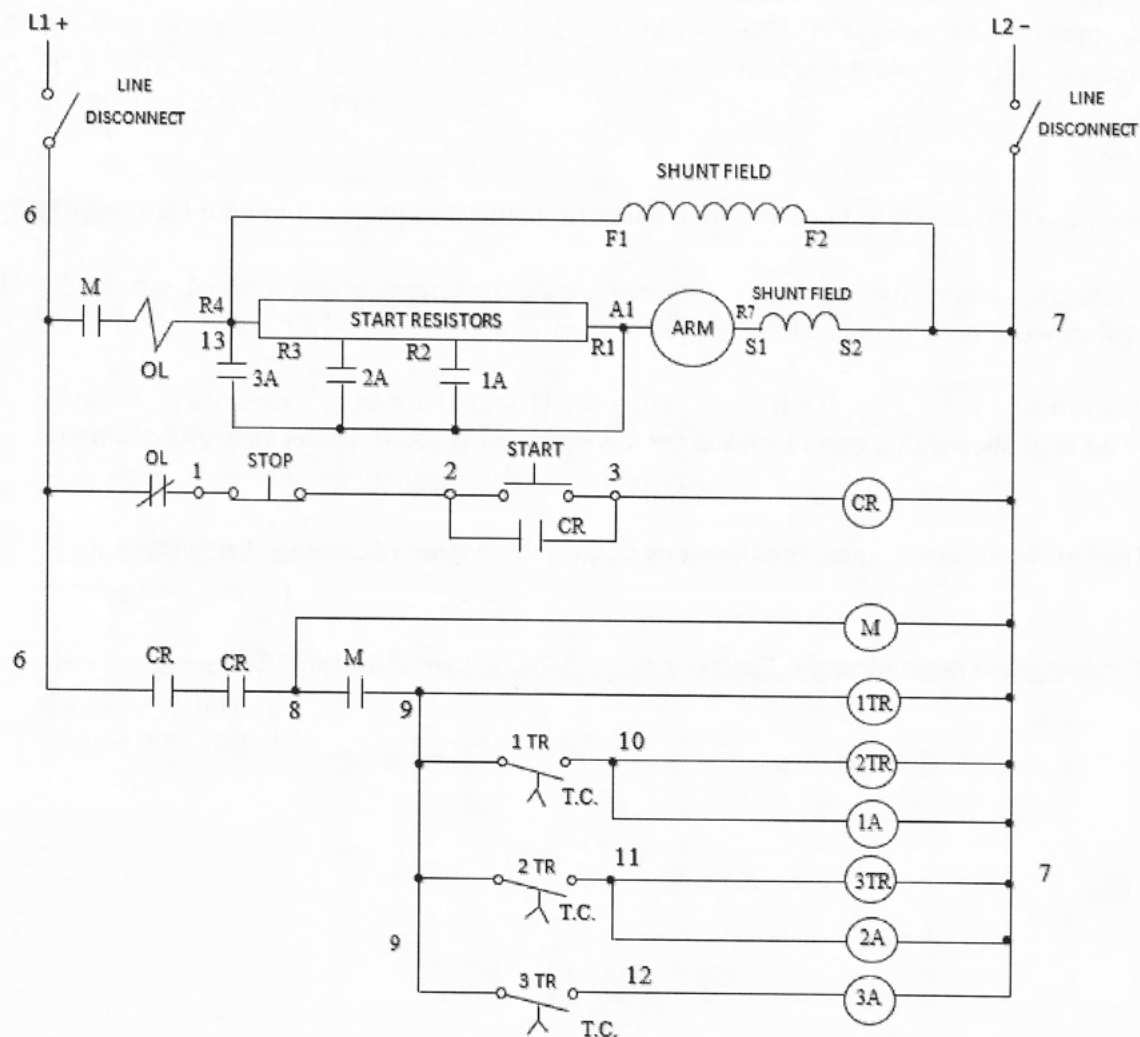
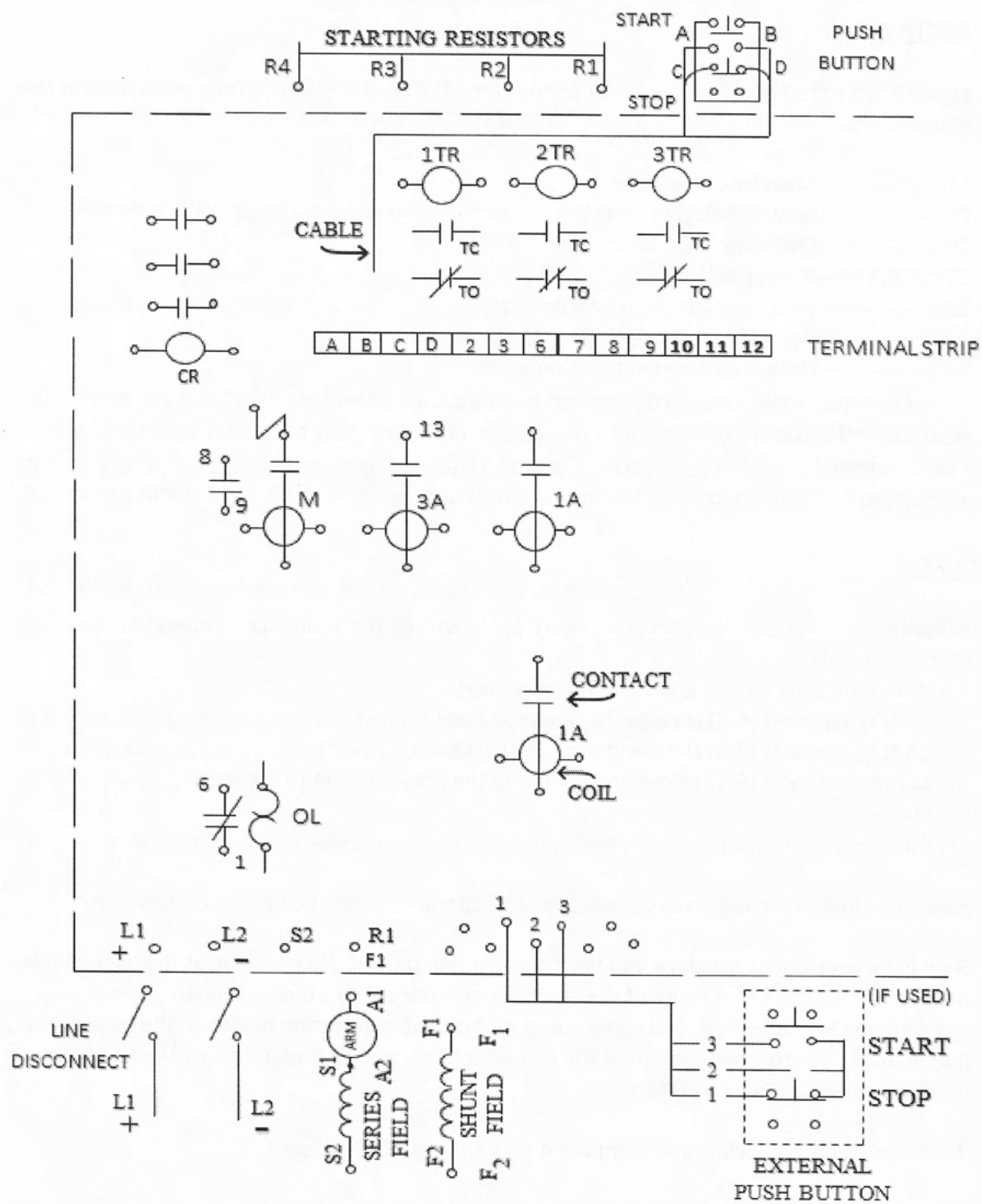


Figure 1



DISCUSSION:

Figure 1 is a schematic diagram for a definite- time D.C. motor starter. The device used in this starter is as follows.

M ----- Main Line Contactor
CR ----- Control Relay
OL ----- Overload Relay
1TR,2TR,3TR ---Timing Relay
1A -----First Step Acceleration Contactor
2A----- Second Step Acceleration Contactor
3A-----Third Step Acceleration Contactor

Read over the theory of operation of this circuit in your test book and your theory module for Chapter 11. Make sure you understand the operation of this circuit before you start connection it up.

PROCEDURE:

1. Write the sequence of operation for (figure 1). In writing this sequence of operation use the following format.
 - a. When the start button is pressed, CR energizes.
 - b. CR N.O. contacts (6-8) close and energizes M coil.
 - c. CR N.O. contacts (2-3) close and provide seal circuit.
 - d. M main contacts (6-13) close and complete the power circuit to the motor.
 - e. Etc.
 - f. Etc.

Have your instructor approve your sequence of operation when you have completed it.

2. Now have your instructor show you the panel for this starter. Now looking at the back of this panel you will notice that some of the components connect to a terminal board, some components are pre-wired, and some components have connection points on the back of the panel. Look over this panel and find the component parts indicated in (figure 1) and determine how they are presently connected.
3. Look over (figure 2) below and compare it with the panel of this starter.
4. Now on (figure 2), show how the timers and their contacts connect to the terminal board. How the start and stop buttons connect to the terminal board.
5. Draw how the accelerating resistors are connected.

6. Draw how the motor is connected to the circuit.
7. Now draw in the connections on (figure 2) so it will operate like (figure 1).
8. After your drawing is complete, have it approved by your instructor.
9. Now wire up the panel so it will operate as shown in (Figure 1).
10. When you have the panel wired and operating correctly, have your instructor check it.
11. Now connect in another start and stop station so you can control the motor from two locations.
12. When you have done this, have it checked by your instructor.
13. Your instructor will now put troubles into your circuit and you are to find them. List each of these troubles as you find them.
14. Now remove your test leads and hand this completed project into your instructor for grading.

CRANE CONTROL No. 1

INTRODUCTION:

In order for you to gain experience in D.C. print reading your next few projects will deal with print reading and sequence of operation of D.C. crane control.

DISCUSSION:

In order for an industrial electrician to troubleshoot equipment, the electrician must understand the theory of operation of the equipment. And in order to understand the theory of operation, the electrician must be able to read the blue prints on the equipment. This project will give you experience in print reading.

PROCEDURE:

1. Read over Motor Control No. 18. The first part of the project will give you a basic understanding of how a G.E. crane control operates. This control system is used to drive the crane bridge or the trolley of the crane.
2. The first part of Motor Control No. 18 goes through what happens in the following point.
 - a. OFF Point
 - b. First Point Forward
 - c. Second Point Forward
 - d. Third Point Forward, First Automatic
 - e. Third Point Forward, Second Automatic
 - f. Third Point Forward, Third Automatic

*Automatic means the controller goes through these steps automatically with no input from the operator.

3. In the latter part of this project, you will indicate what happens in each point of operation in the reverse direction.
4. In Motor Control No. 19, you are to indicate what happens in each point of the G.E. crane control operation.
5. In Motor Control No. 20, you are to show how you would wire up the control circuit (dash lines) of the G.E. crane control.
6. In Motor Control No. 21, you are to show how you would wire up the power circuit (heavy dark lines) of the G.E. crane control.
7. In Motor Control No. 22, you are to show how you would wire up both the control and power circuit of the G.E. crane control.
8. Now turn this completed project into your instructor for grading.

G.E. Crane control

In order for an industrial electrician to trouble shoot equipment, he must understand the theory of operation of the equipment. And in order to understand the theory of operation, he must be able to read the blueprint on the equipment. This project will give you experience in print reading.

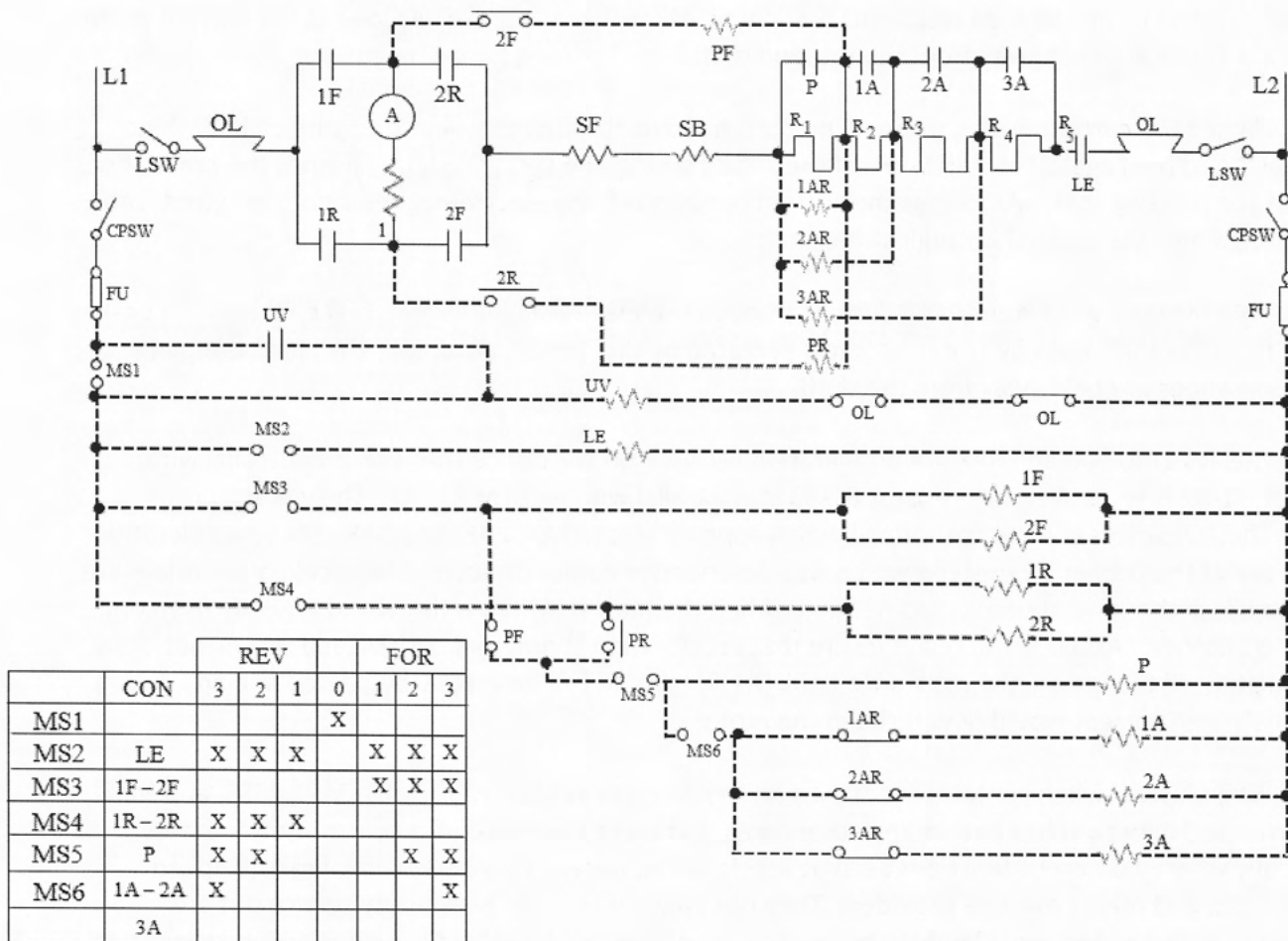


Figure 1

In order to read a print, you must understand what all components in the circuit do. Now we will look at the print for General Electric Plugging-Reversing Drive (figure 1) you will notice that the symbol for relays and contactors (1AR,2AR,1F,2F and etc.) are drawn like the symbol used for resistors. The power circuit is shown with heavy dark lines and the control circuit is shown with light dotted lines.

The knife switch (LSW) is a line switch, which controls the power to the power circuit. Knife switch (CPSW) is a control power switch, which controls the power to the control circuit. You will notice that there is an overload relay (OL) on each side of the power circuit and that the overload relay contacts are in the control circuit in series with the undervoltage relay (UV). By this arrangement, if the motor is overloaded, it will open the control circuit which will in turn remove power from the motor and power circuit.

The armature for the series motor is designed by a circle with an A in it and its series field is marked SF. The device SB is an electromagnetic type of mechanical brake. As long as the current is on, the brake shoes are kept away from the rotating shaft.

When the current flow is stopped, no current flows through the electromagnet coil. With no magnetism to hold against the pressure of the strong spring, the spring instantly pushes the brake shoes against the rotating shaft. As long as the current remains off, the electromagnet is not energized, and the spring holds the brake shoe against the shaft.

When starting the motor, the current through the electromagnet of the brake, is pulls the brake shoes from the shaft thereby releasing it to be rotated by the motor. As long as the current remains on, the brake shoes are held away from the shaft.

Relays 1AR, 2AR, and 3AR are acceleration relays. You will notice that 1AR is in parallel with resistor R1-R2 is in parallel with resistor R1-R3 is in parallel with resistor R1- R4. The voltage drops across these resistors control the voltage which appears across 1AR, 2AR, and 3AR. These acceleration relays are of the copper sleeve type which was described in earlier projects. The acceleration relays are used to break the control circuits momentarily when the master switch is thrown too quickly from one point to another. Acceleration relays insure that acceleration contactors, 1A, 2A, and 3A will not close immediately. If they close, the resistance bank (R1-R5) would be completely by-passed and an extremely high current would flow through the motor.

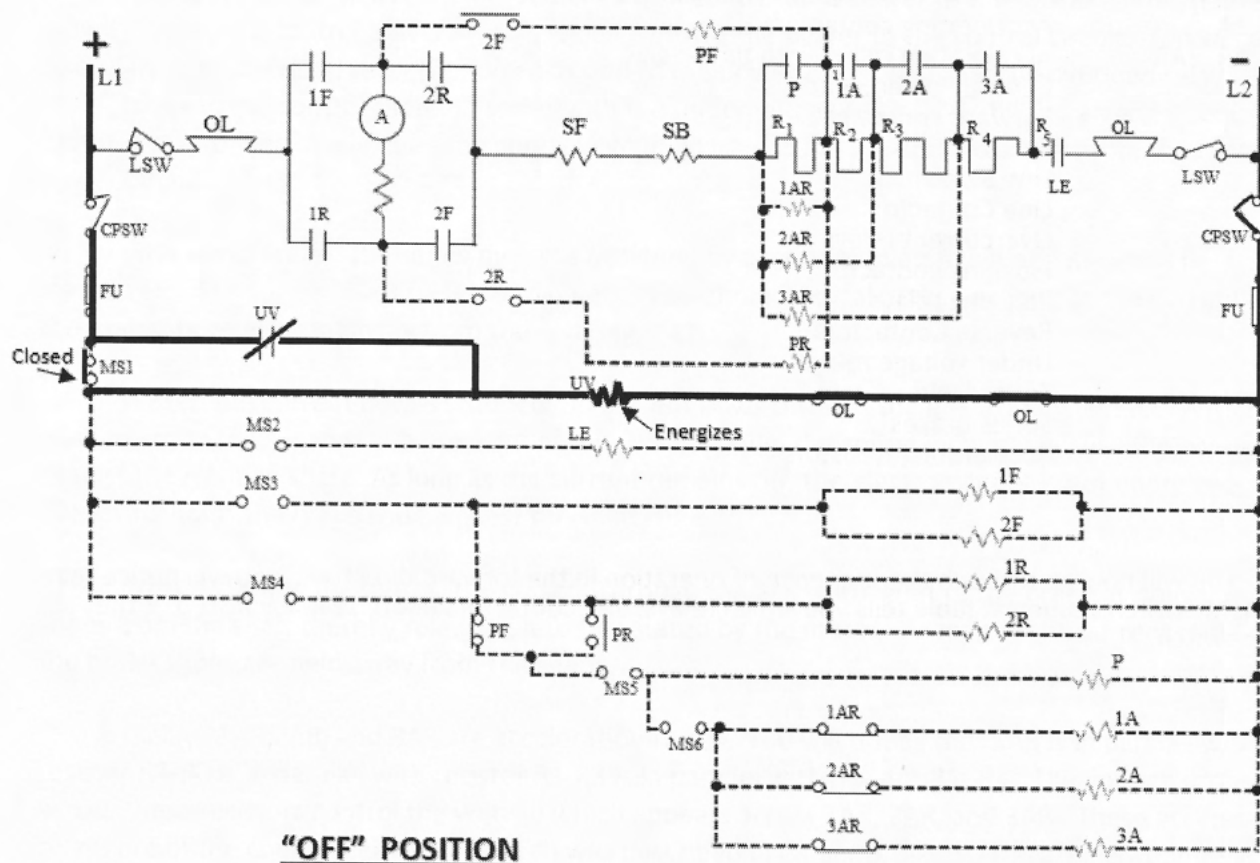
The master switch contacts are shown on the diagram as MS1, MS2, MS3, MS4, MS5, and MS6. The drum and cam switches have many advantages that make them useful in control systems, and especially where numerous functions such as acceleration, deceleration, reversing, braking, speed adjustment, and others must be provided. They not only are built for heavy-duty service but are capable of withstanding considerable abuse. This is because arc blowout protection and excellent heat-resisting insulation are incorporated; moreover, heavy contact pressure can be maintained to prevent contact burning and poor electrical continuity. An extremely important aspect of these devices is that they can be arranged with a multiplicity of contact which can be opened and closed to perform almost any desired sequencing and timing operations. This means, of course that they can be readily adapted to the most complicated circuit and often with a minimum of wiring connections.

You will notice in the master switch sequence table it shows that in the OFF position MS1 contact is closed. In the first point forward MS1 contact opens, MS2 and MS3 contacts close. In the second point forward MS1 contact is still open, MS2, MS3 and MS5 contacts are still closed, and that MS6 contact now closes. The only difference between the forward direction and the reverse direction is that in the reverse direction MS4 closes in place of MS3.

The nomenclature of all parts of this diagram are listed below:

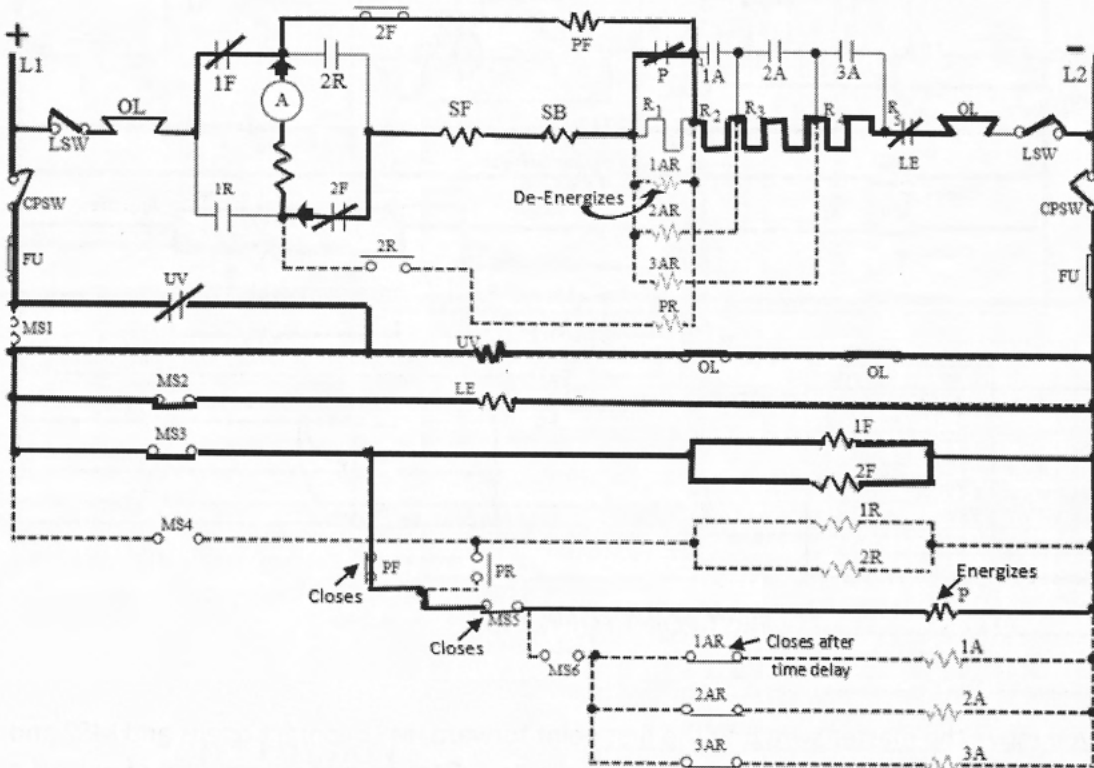
A1,2A,3A	Accelerating contactors
1AR, 2AR, 3AR	Accelerating relays with time-delay
CPSW	Central Power Switch
1F, 2F	Forward contactors
FU	Fuses
LSW	Line Switch
LE	Line Contactors
OL	Overcurrent relays
P	Plugging contactor
PF, PR	Plugging relays
1R, 2R	Reverse Contactors
UV	Under voltage relay
SF	Series Field
SB	Series Brakes
R1 – R5	Accelerating Resistors

You will now go through the sequence of operation in the forward direction. You will notice that the master switch sequence table tells you which relays, and contactors energize in each step of the master switch.



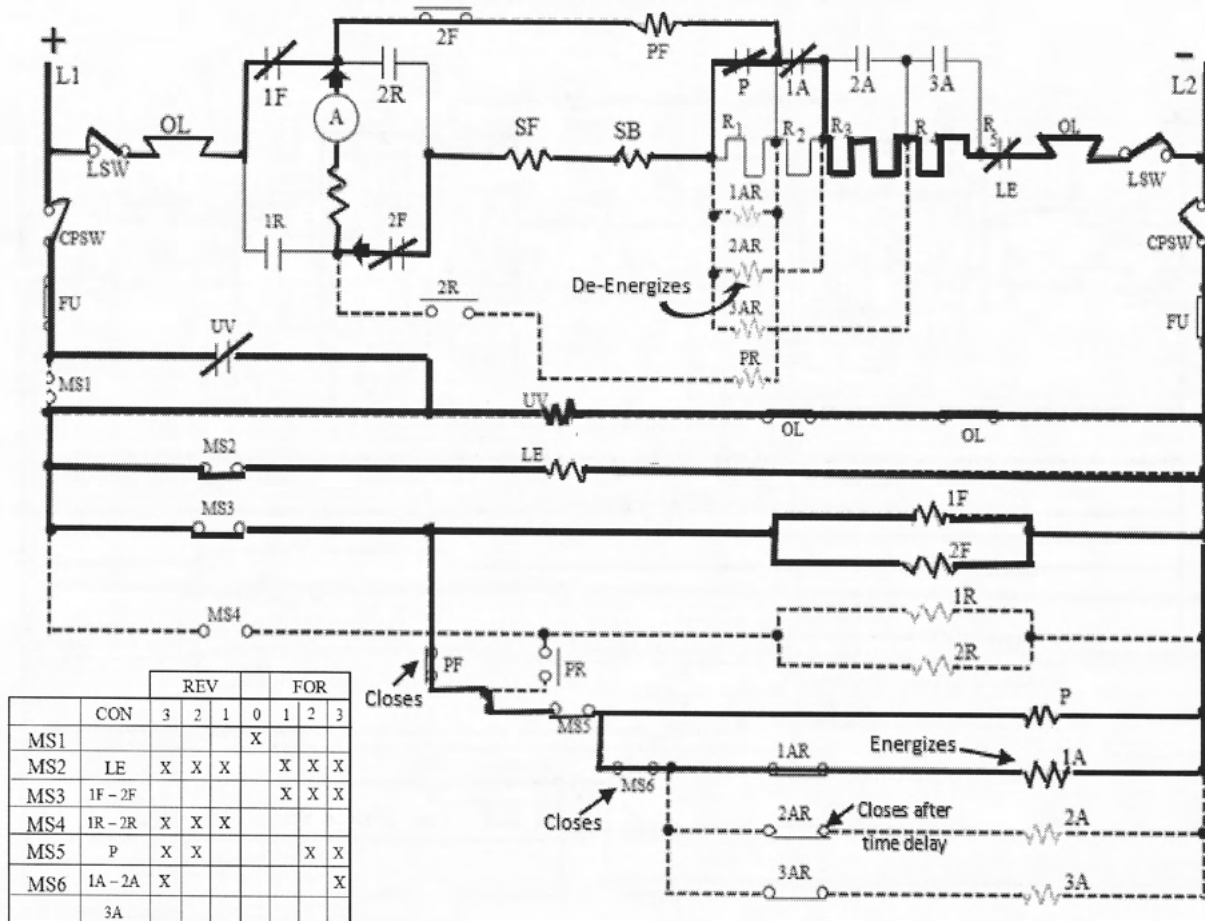
First you would close knife switch LSW and CPSW, this would supply power to the control circuit and to the power circuit. Now with master switch in the OFF position its contact, MS1 is closed, this would energize UV relay. When UV relay energizes, its normal open contact (mark UV) closes and provides a seal path for the UV relay. When you move the master switch OFF the OFF position, MS1 contact opens, but UV relay remains energized through its normal open contact.

General Electric Plugging Reversing Drive



SECOND POINT FORWARD

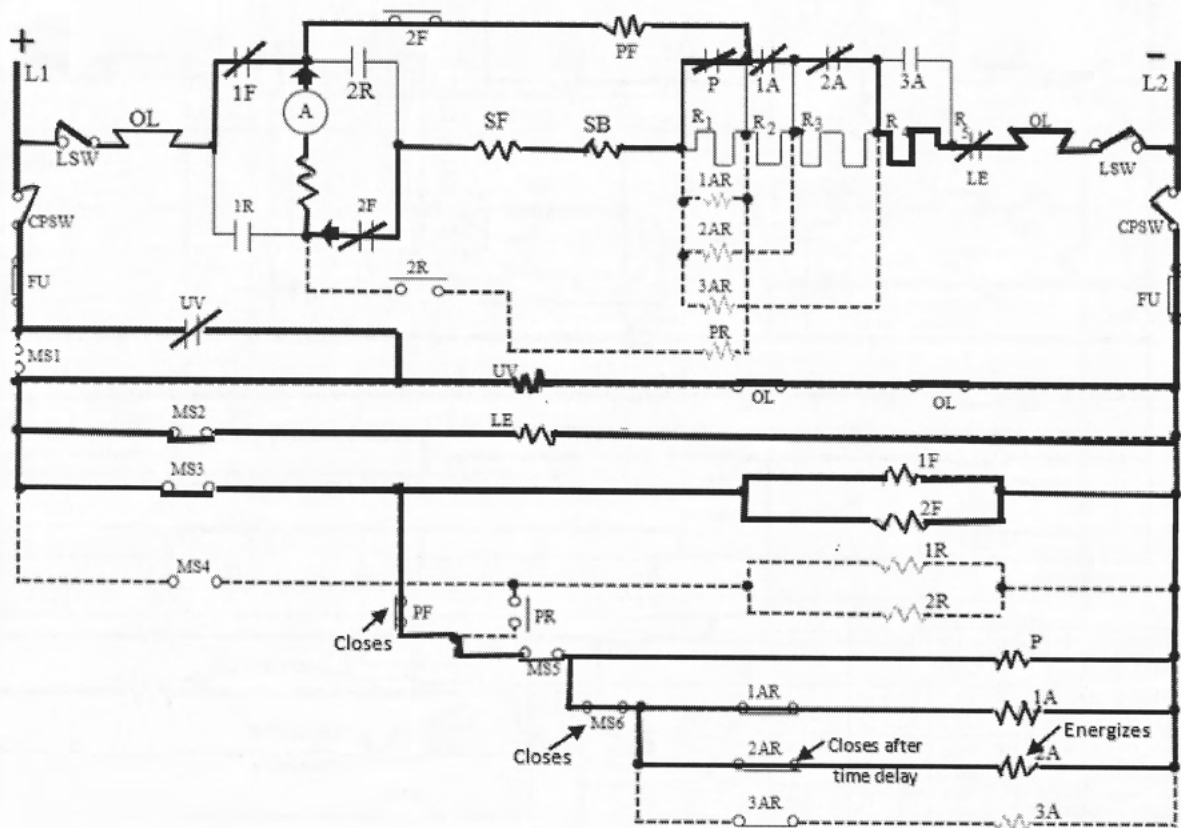
When you move the master switch to the second point forward, MS5 closes and energizes the P contactor, if the PF contact has closed. The P contactor normal open contact, in parallel with R1 – R2 and 1AR now closes. This shorts out R1-R2 and allows the motor to speed up. This also shorts out 1AR but remember that 1AR is a copper sleeve time delay, so at a given time after 1AR is shorted out, its normal contact will go back to the de-energized or closed position. You are now ready for the third point forward, first automatic.



THIRD POINT FORWARD, FIRST AUTOMATIC

When you move the master switch to the third point forward, first automatic, MS6 closes and energizes 1A contactor, if 1AR normal closed contact has closed. When 1A contactor energizes, its normal open contact closes and shorts out R2 - R3 and 2AR relay. When R2- R3 resistor shorts out, it reduces the resistance in the motor circuit and the motor speed increases. This contact also shorts out 2AR but remember that 2AR is a copper sleeve time delay relay. So, at a given time after 2AR its shorted out, its normal closed contact will go back to the de-energized or closed position. You are now ready for the third point forward, second automatic.

General Electric Plugging Reversing Drive



THIRD POINT FORWARD, SECOND AUTOMATIC

In the third point forward, second automatic when 2AR times out. Its normal closed contact will close again and energizes 2A contactor. When 2A contactor energizes, its normal open contact is parallel with R3 – R4 and 3AR relay will close and short them out. When R3 – R4 shorts out, it will reduce the resistance in the motor circuit and the motor speed will increase. This contact also shorts out 3AR but remember that 3AR is a copper sleeve time delay relay. So, at a given time after 3AR is shorted out, its normal closed contact will go back to the de-energized or closed position. You are now ready for the third point forward, third automatic.

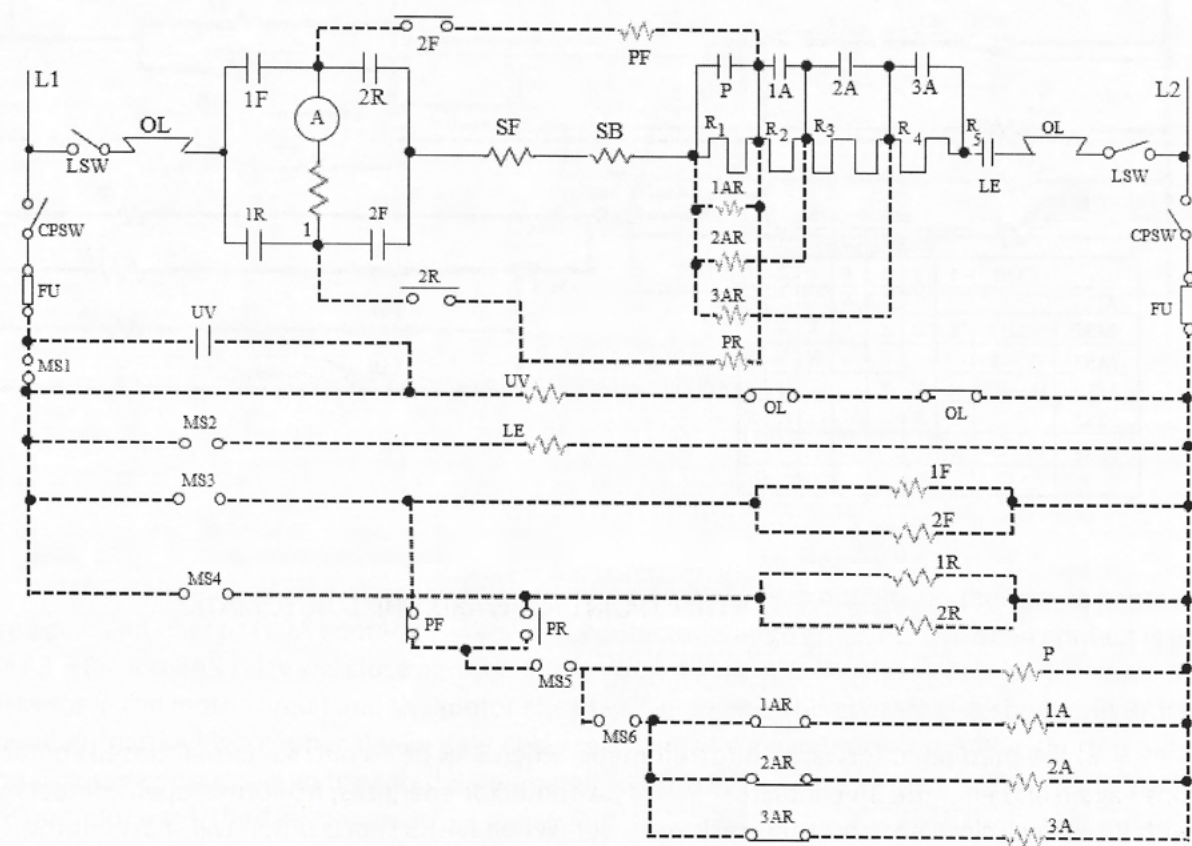


QUESTIONS

Now answer the following questions and then hand them into your instructor for grading.

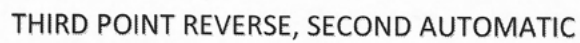
1. On the following control diagram, indicate the path of current flow for each position of the reverse sequence.

General Electric Plugging Reversing Drive



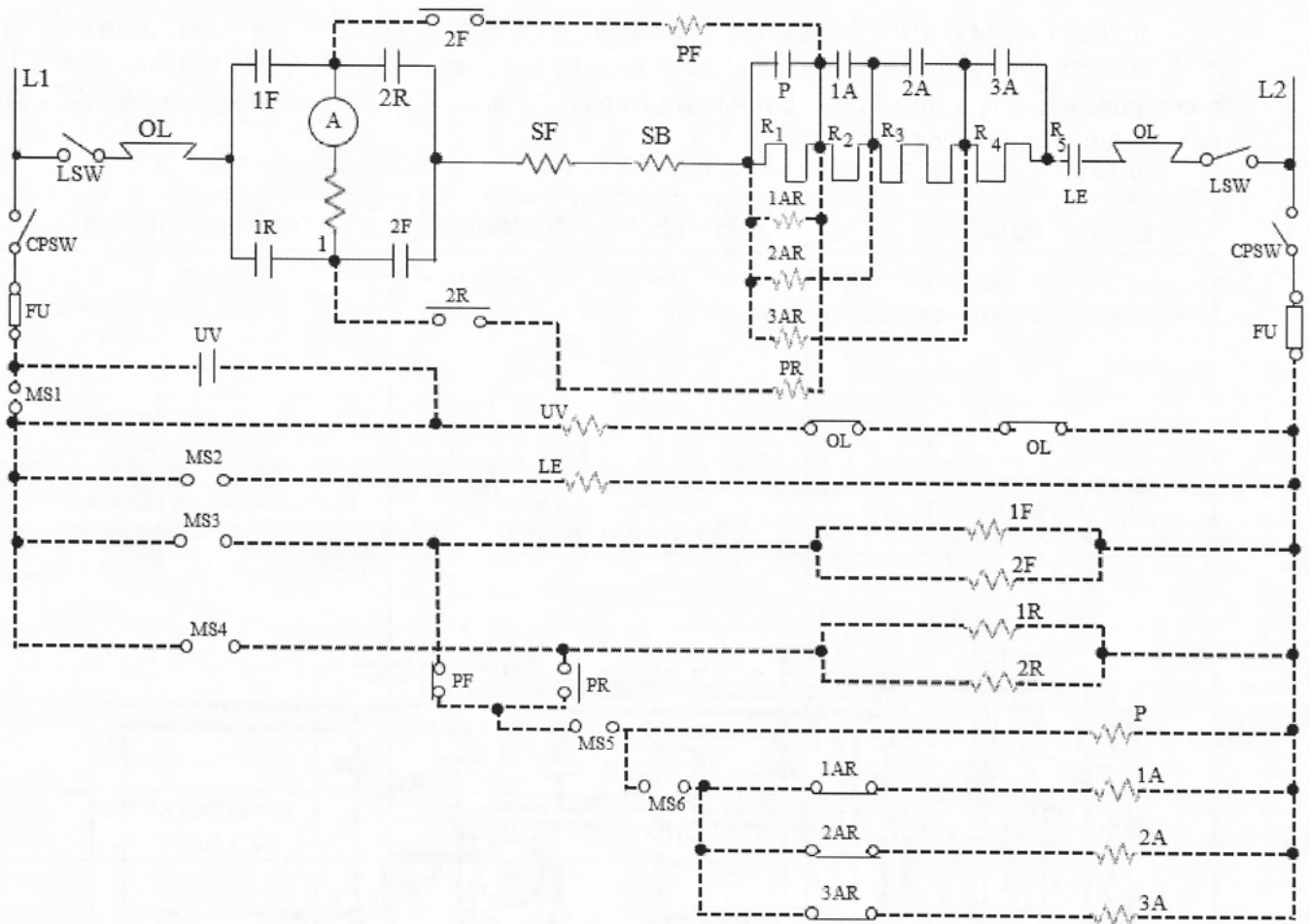
FIRST POINT REVERSE





THIRD POINT REVERSE, SECOND AUTOMATIC

General Electric Plugging Reversing Drive



THIRD POINT REVERSE, THIRD AUTOMATIC

MOTOR CONTROL No. 19

G.E. Crane Control 11

GENERAL ELECTRIC PLUGGING REVERSING DRIVE

In the boxes below, indicates which relays energize and de-energizes in each step. Also indicate which contacts open and which contacts close in each step. For example, say relay 2F energized and 2R de-energizes in the first step, in that box you would put 2F-E and 2R-D. For indicating relay contacts that open, put 2R-O and closing put 2R-C.

OFF POINT	FIRST POINT FORWARD	SECOND POINT FORWARD
THIRD POINT FORWARD FIRST AUTOMATIC	THIRD POINT FORWARD SECOND AUTOMATIC	THIRD POINT FORWARD THIRD AUTOMATIC
FIRST POINT REVERSE	SECOND POINT REVERSE	THIRD POINT REVERSE FIRST AUTOMATIC
THIRD POINT REVERSE SECOND AUTOMATIC	THIRD POINT REVERSE THIRD AUTOMATIC	

D.C. REVERSING STARTER

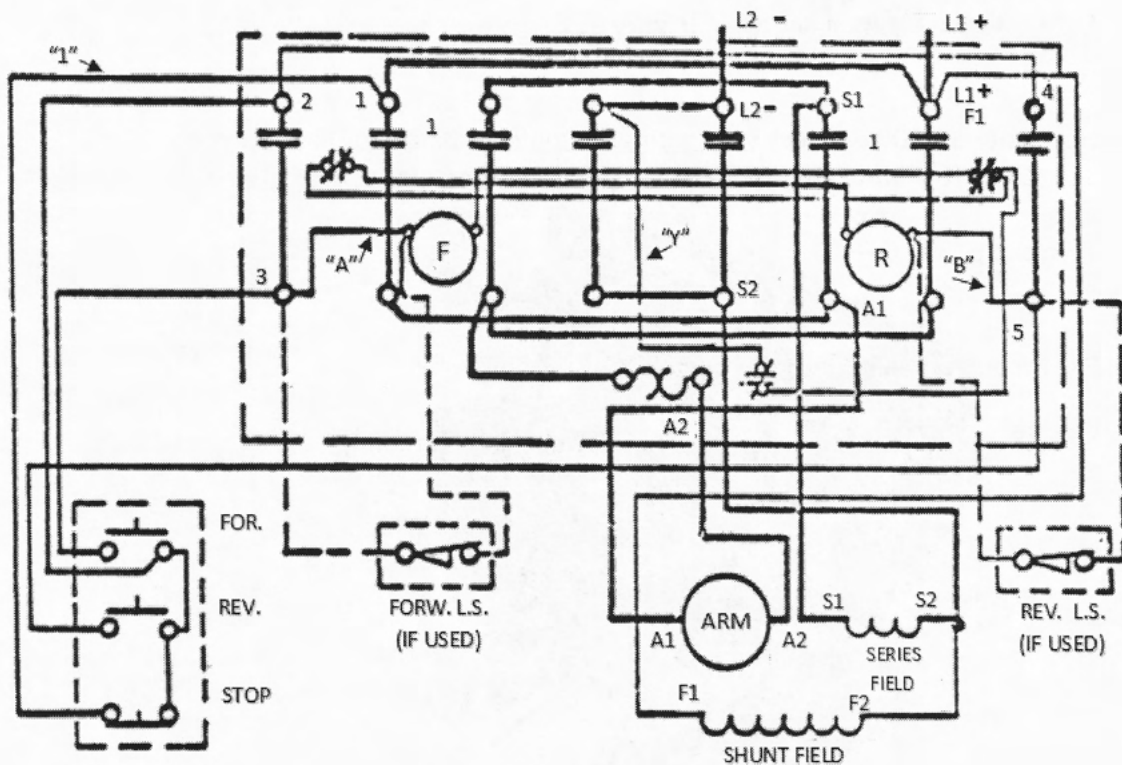
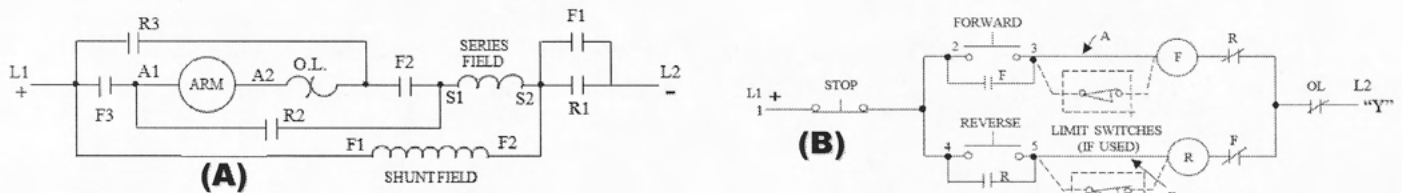
INTRODUCTION:

A reverse starter is used to reverse the direction of rotation of a D.C. motor.

DISCUSSION:

The direction of rotation of a D.C. motor can be reversed by reversing the field or armature leads. But by reversing the armature leads will cause less problems.

The starter you will be using in this project has both mechanical interlocking and contact interlocking. Read Motor Control Project No. 5 if you do not understand these methods of interlocking.



(C)

D.C AUTO REVERSING STARTER

PROCEDURE:

1. Figure 1 is a copy of the information provided by the manufacture pf this starter.
2. On (figure 1A) color each wire a different color and then color the same wires in (Figure 1C) the same color.
3. Label the contacts in (figure 1C). Use (Figure 1A to help you determine which contacts are which.
4. Now obtain from your instructor a D.C. reversing starter board, a start-stop push-button, and a D.C. compound motor.
5. Connect up the circuit shown in (figure 1C) but do not use the limit switch connections at this time. Put a jumper between terminals D1 and E1. This jumper is wire "A" on (figure 1C). Put a jumper between D1 and E1. This jumper is wire "B" on (figure 1C).
6. Now have your instructor check your wiring. After your instructor has approved your wiring, apply 115 VD.C. to your circuit. Make sure the circuit functions is indicated in (figure 1C).
7. Now turn the power OFF.
8. Connect up the circuit shown in (Figure 1B).
9. Have your instructor check your wiring. After your instructor has approved your wiring, apply 115 V.D.C. to your circuit. Make sure the circuit functions as indicated in (Figure 1B).
10. Turn the power OFF.
11. Return equipment to your instructor.
12. Turn this completed project in to your instructor. For grading.