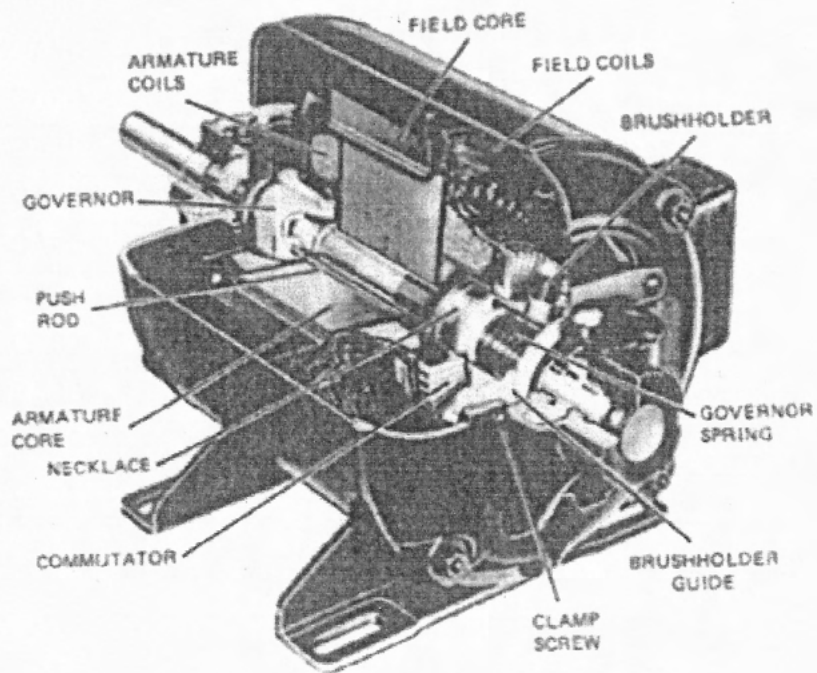
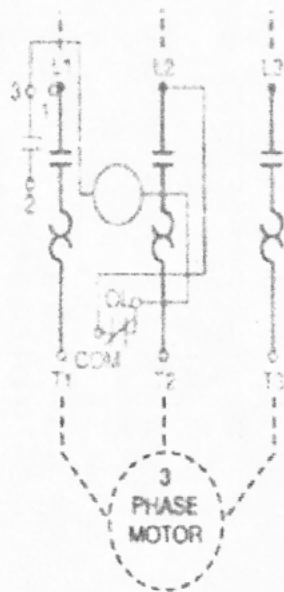
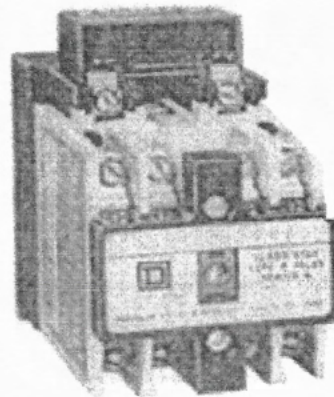
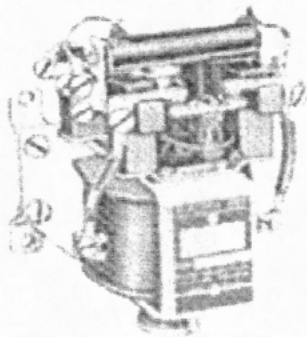


EART - 1285 DC and AC MACHINES

LAB 4 OF 4



EART – 1285 DC and AC MACHINE

LAB 4 OF 4

Name: _____

HAND IN COMPLETED BY DUE DATE TO THE INSTRUCTOR

The instructor most date and initial each project upon completion!!

PROJECT NAME & NUMBER	DATE	INITIAL	NOTES
A.C. MOTOR CONTROL No. 1			READ ONLY
MOTOR CONTROL #1 DRAWN & WIRED ON BOARD			
MOTOR CONTROL #2 DRAWN & WIRED ON BOARD			All Motor
MOTOR CONTROL #3 DRAWN & WIRED ON BOARD			Controls Must
MOTOR CONTROL #4 WIRED ON BOARD			Be Wired to a
MOTOR CONTROL #5 WIRED ON BOARD			Motor(s) and
MOTOR CONTROL #6 WIRED ON BOARD			Lights
MOTOR CONTROL #7 DRAWN & WIRED ON BOARD			
MOTOR CONTROL #8 WIRED ON BOARD			
MOTOR CONTROL #9 WIRED ON BOARD			
MOTOR CONTROL #10 WIRED ON BOARD			
MOTOR CONTROL #11 WIRED ON BOARD			
MOTOR CONTROL #12 WIRED ON BOARD			
MOTOR CONTROL #13 WIRED ON BOARD			
MOTOR CONTROL #14 WIRED ON BOARD			
MOTOR CONTROL #15 WIRED ON BOARD			
MOTOR CONTROL #16 WIRED ON BOARD			
MOTOR CONTROL #17 WIRED ON BOARD			
MOTOR CONTROL #18 WIRED ON BOARD			
MOTOR CONTROL #19 WIRED ON BOARD			
MOTOR CONTROL #20 WIRED ON BOARD			
MOTOR CONTROL #21 WIRED ON BOARD			
HOUSE CURRENT KILLS			
INDUSTRIAL CONTROLLERS #1			MCC BUCKET
INDUSTRIAL CONTROLLERS #3 ITE			INDIVIDUAL STARTERS FORWARD REV
INDUSTRIAL CONTROLLERS #3 SQUARE D			“ “ “

Name: _____

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

PROJECT NAME & NUMBER	DATE	INITIAL	NOTES
INDUSTRIAL CONTROLLERS #3 WESTINGHOUSE			INDIVIDUAL STARTERS FORWARD REV
INDUSTRIAL CONTROLLERS #3 FURNAS			" " "
INDUSTRIAL CONTROLLERS #3 SYLVANIA			" " "
INDUSTRIAL CONTROLLERS #3 ALLEN BRADLEY			" " "
INDUSTRIAL CONTROLLERS #2 (DO LAST) CULTER HAMMER			WASHER
INDUSTRIAL CONTROLLERS #2 SQUARE D			WASHER
MOTOR CONTROL PROJECT #4 DRAW & WIRE			SEE INSTRUCTOR
MOTOR CONTROL PROJECT #5 DRAW & WIRE			SEE INSTRUCTOR
MOTOR CONTROL PROJECT #6 DRAW & WIRE			SEE INSTRUCTOR
TROUBLE SHOOTING (READ & ANSWER QUESTIONS)			
TROUBLE SHOOTING TEST #1 (ON WALL BOARD)			
CONTROL CIRCUIT GROUNDING (QUESTIONS)			
TROUBLE SHOOTING #2 (ON WALL BOARD)			SEE INSTRUCTOR
SAFETY (LADDERS)			
SOLID STATE 3-PHASE MOTOR STARTER 11 C3M			PROJECT #7
SOLID STATE 3-PHASE MOTOR STARTER 11R			
SOLID STATE REVERSING MOTOR STARTER #2			SEE INSTRUCTOR
THREE PHASE POWER MONITOR			
PHASE SEQUENCE DETECTOR (NO POWER)			SEE INSTRUCTOR
MOTOR ROTATION INDICATOR (NO POWER)			SEE INSTRUCTOR
PHASE SEQUENCE 1 (QUESTIONS)			
FORWARD & REVERSE 1-PHASE DUAL VOLTAGE MOTOR (USE MOTORS BOOK FOR HELP)			SEE INSTRUCTOR
WIRE UP ALL BUCKETS TO 3 – PHASE MOTORS MCC			SEE INSTRUCTOR
CONTROL CIRCUIT TEST #1			
CONTROL CIRCUIT TEST #2			

LAB 4 of 4

NAME: _____

THE INSTRUCTOR MUST DATE AND INITIAL EACH PROJECT UPON COMPLETION!!

PROJECT NAME & NUMBER	DATE	INITIAL	NOTES
Field Test #1			
			SEE INSTRUCTOR
Program soft start in the MCC and Hook it up			SEE INSTRUCTOR
Hook up a Small PLC/PLR			SEE INSTRUCTOR
Hook up Blue Frequency Drive on Board			SEE INSTRUCTOR
Hook Up Allen Bradley Flex Drive			SEE INSTRUCTOR
Fluke 43 Power Quality Meter Hook Up to 3-phase Panel			SEE INSTRUCTOR
Amprobe Power quality meter hook up to 3 Phase Panel			SEE INSTRUCTOR
Timer and relay board projects (Robert Benson)			SEE INSTRUCTOR
Hook up the Wye-Delta starter			SEE INSTRUCTOR
Wire up the two speed Westinghouse starter			SEE INSTRUCTOR
Use the power quality meter and correct power factor			SEE INSTRUCTOR
Hook up and Run large Blue motor and Explain			SEE INSTRUCTOR
Hook up the small 120 PLC board to run a 3-phase motor			SEE INSTRUCTOR

A.C. MOTOR CONTROL No. 1

Much of the work a maintenance electrician does is involved with motors and motor control. In this project you are going to connect up many of the common motor control circuit. This will give you a better understanding of motor control and will also aid you in print reading. The object of this project is to familiarize you with the use of elementary diagrams or schematics, wiring problems in the actual wiring of circuits. The actual industrial wiring would be done in conduit an enclosed electrical equipment.

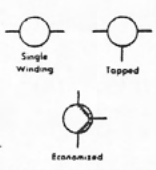
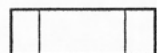
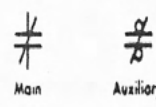
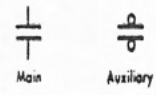
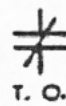
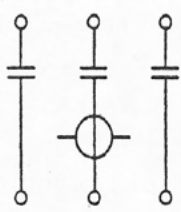
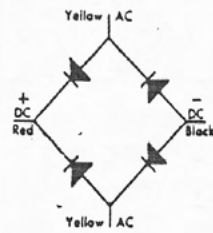
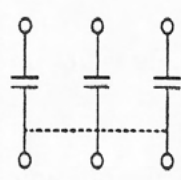
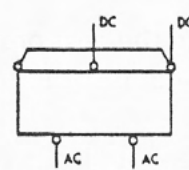
As an aid in helping you understand the wiring of the circuits, **color in each wire with a different colored pencil before you wire the first eight problems.** This will aid you in determining where each wire is to go.

Follow the following procedure in wiring these problems:

1. Wire up the problem, making sure you use only the items called for on the project.
2. Avoid short circuits in your wiring.
3. Step back from the board when you or someone else is trying a circuit.
4. **When your circuit is complete, let your instructor give your wiring of visual inspection.**
5. Turn the power on in try this circuit to see if it functions as the problem calls for.
6. If the circuit fails to function properly, **turn the power off**, and check the circuit to see if you can find the problem. After you have made a complete check and make the corrections necessary, try the circuit again. If you still cannot find the trouble, check with your instructor.
7. If the circuit functions as the problem call for, have your instructor initial your circuit sheet. Then **turn the power off** and tear down the wiring.
8. Proceed to the next problem. Progress at your own speed. Be cautious of and consider the safety of yourself and the others well working on these panel.
9. Remember your instructor is there to help you if you have any problem ask him for his help.
10. GOOD LUCK!!!

Shown here are the symbols most often used in this book. Although the explanations accompanying the diagram describes the devices used, familiarity with the various symbols will lead to a quicker understanding of each circuit.

The symbols, device designations, and abbreviations in this book, are taken from the American Standard for Graphical Symbols for Electrical Diagrams, Publication No. Y332.2 – 1954, and have been approved as NEMA Standard.

Device		Symbol	Device		Symbol
COILS	Relay and Switch Coils		FUSE	General	
	Normally Closed (NC)		INDICATING LIGHTS	General	 A - Amber B - Blue C - Clear G - Green R - Red W - White
CONTACTS	Normally Open (NO)		MOTORS	3-Phase Squirrel Cage Induction	
	Time Closing			Single Phase	
	Time Opening			2Phase 4 Wire	
CONTACTORS	AC Solenoid Type		RECTIFIER	Full Wave with Color Code	
	Manually Operated				

Wiring Diagram Symbols

Device		Symbol	Device		Symbol
RELAYS	Control Type BR		SWITCHES	Push Button Standard	
	Control Type B			Push Button Heavy Duty, Oil Tight	
	Thermal Overload			Push Button and Jog Attachment	
	Timing (Pneumatic) ON-DELAY			Standard Duty Selector Switch	
	3-Wire Thermostat Type BA			Heavy Duty Selector 2-Position	
SWITCHES	Float Switch		Transformer	Heavy Duty Selector 3-Position	
	Limit Switches			Potential	
	Pressure and Temperature			Current	

"WIRING DIAGRAMS" vs "LINE DIAGRAMS"

Most of the diagrams in this lab packet are shown in two ways. There is a wiring diagram and adjacent to it a line diagram. Line diagrams are included because their use is becoming more widespread and we believe it is to your advantage to learn to use them.

Wiring diagrams include all of the devices system and show their physical relation each other. All poles, terminals, coils, etc., are shown in their proper places on each device. These diagrams are helpful in wiring-up systems, because connections can be made exactly as they are shown on the diagram. In following the electrical sequence of any circuit, however, the wiring diagram does not show the connections in a manner that can be easily followed. For this reason, a rearrangement this circuit elements to form a line diagram is desirable.

The line diagram (sometimes referred to as an elementary diagram or a schematic diagram) is a representation of this system showing everything in the simplest way. No attempt is made to show the various devices in their actual relative positions. All control devices are shown between vertical lines which represents the source of control power, and circuits are shown connected as directly as possible from one of these lines to the other. All connections are made in such a way not the functioning of the various devices can be easily traced.

A WIRING DIAGRAM gives the necessary information for actually wiring-up a group of control devices for physically tracing wires when troubleshooting is necessary. A LINE DIAGRAM gives the necessary information for easily following the operation of the various devices in the circuit. It is a great aid in trouble shooting as it shows, in a simple way, effect that opening or closing various contacts has other devices in the circuit.

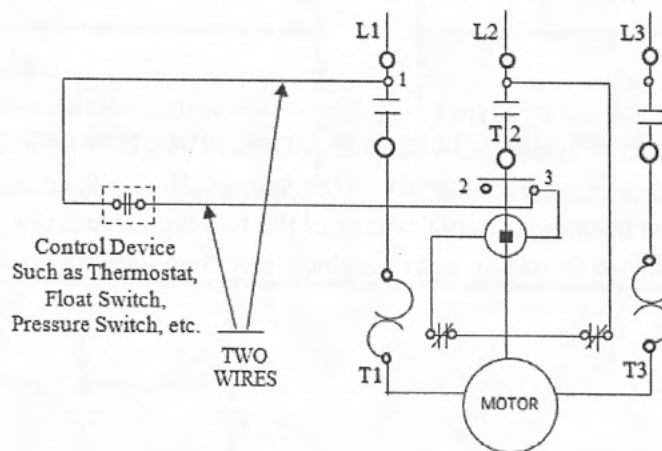
SOME COMMON AND IMPORTANT TERMS

In this booklet, and where motor control is discussed, there are terms which are used heatedly but who's meanings are often not completely understood by the reader. These terms represent things which are actually quite simple, and everyone should become familiar with them as standard "motor control jargon."

NO-VOLTAGE RELEASE:

Also Called: Low-voltage release Two-wire control

These terms mean that the starter will drop out when there is a voltage failure and will pick up again as soon as voltage returns. Reference to the diagram below will show how this occurs. The pilot device is unaffected by the loss voltage and its contact remains closed, ready to carry current as soon as line voltage returns to normal.

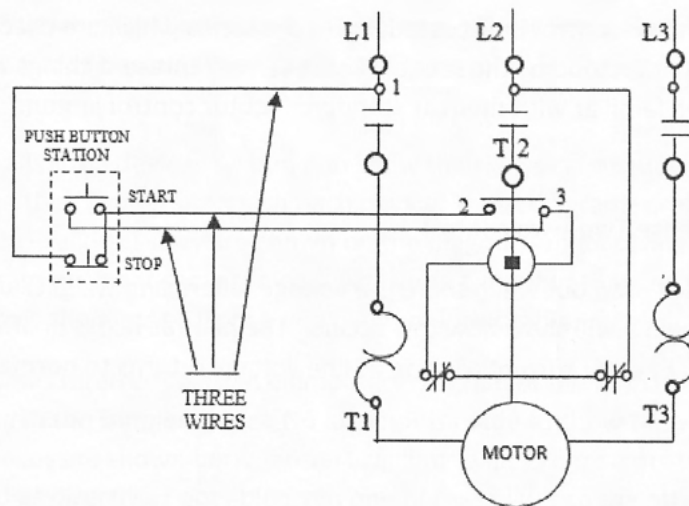


Two wire lead from the pilot device to the starter. "No-voltage release" and "two-wire control" should bring to mind an automatic pilot device such as a limit switch or float switch whose function is opening and closing the control circuit by means of a single contact.

NO - VOLTAGE PROTECTION:

Also Called: Low-Voltage Protection Three-wire Control

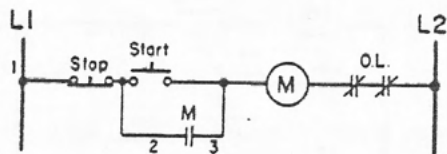
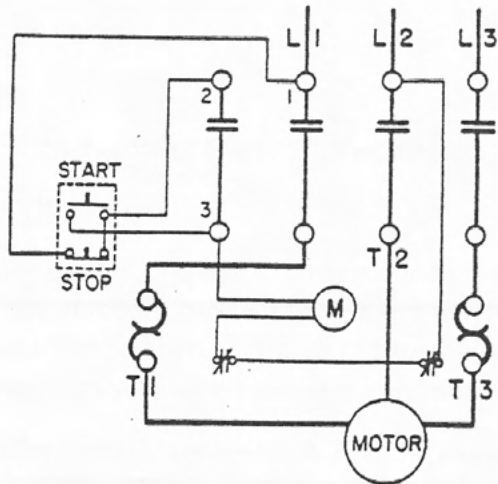
These terms mean that the starter will drop out when there is a voltage failure and will not pick up automatically when voltage returns. The control circuit is completed through the "Stop" button and also through a "Holding" contact (2-3) on the starter. When the starter drops out, this contact opens, breaking the control circuit until the "Start" button is pressed once again.



Three wires lead from the pilot device to the stator. "No-voltage protection". A "Three-wire" control should bring to mind "start-stop" push button station, which is the most common means of providing this type of control.

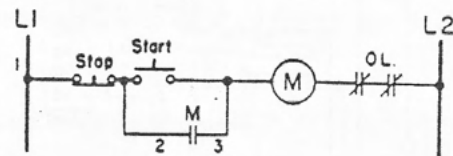
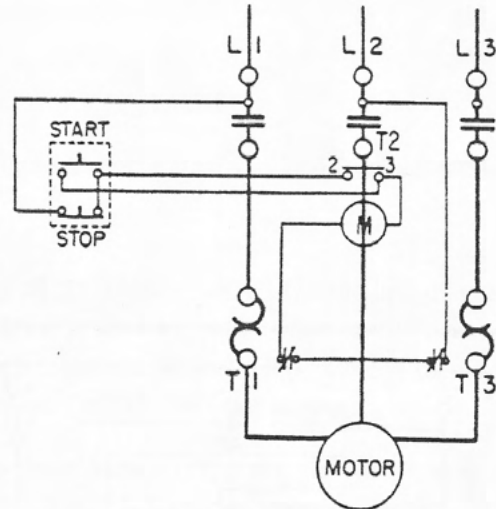
The main distinction between the above two types of control is that with NO-Voltage RELEASE, the coil circuit is maintained through the pilot switch contact, and with NO-VOLTAGE PROTECTION it is maintained through a "STOP" contact on the push button starter and also an auxiliary contact on the starter. The designations "two-wire" and "three-wire" are used only because they describe the simplest applications of the two types. Actually, in other systems, there might be more wires leading from pilot device to starter, but the principle of "two-wire" or "three-wire" control would still be present.

3 Phase Starters



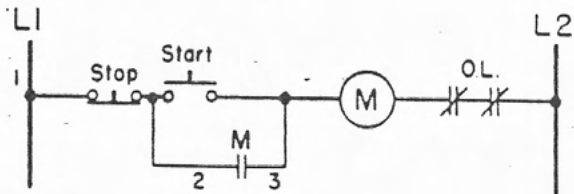
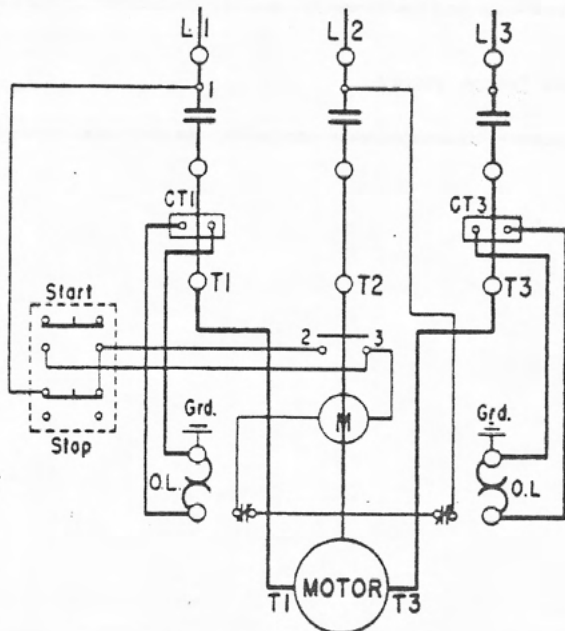
Size 00

Standard wiring with start-stop push button station



Sizes 0, 1, 2, 3 & 4

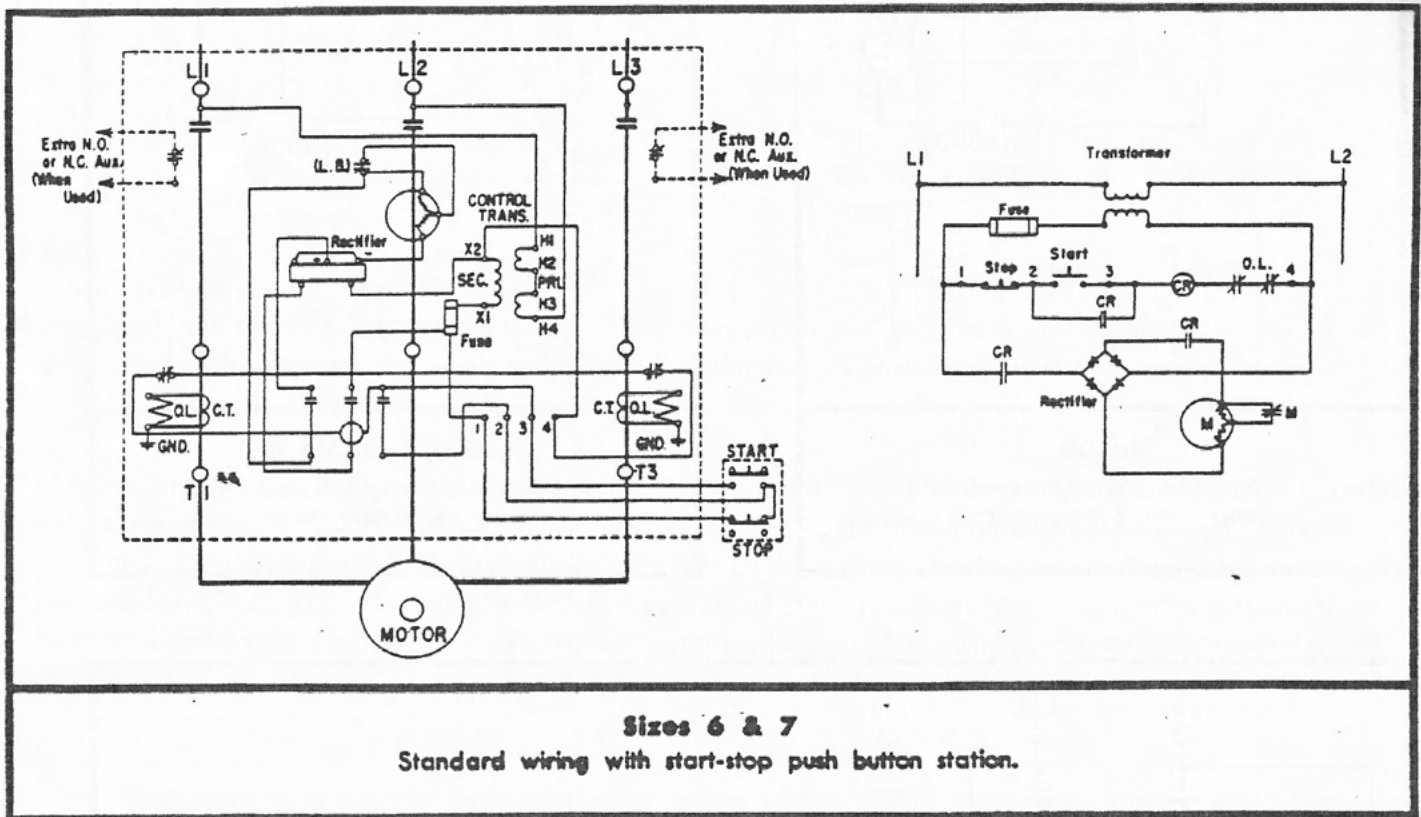
Standard wiring with start-stop push button station



Size 5

Standard wiring with start-stop push button station. Current transformers are utilized thereby allowing the use of Size 1 overload relays.

3 Phase Starter



MOTOR CONTROL 1

OBJECTIVE:

To learn the use of line and wiring diagrams in the actual wiring of a motor starter controlling a 3-phase motor.

INSTRUCTIONS:

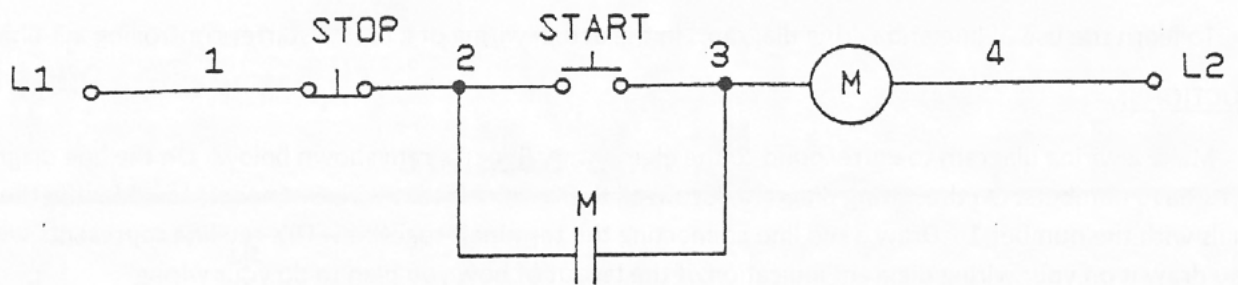
Make a wiring diagram to correspond to the elementary line diagram shown below. On the line diagram notice the wires have numbers. On the wiring diagram, locate all the terminals that wire 1 connects to. Identify these terminals with the number 1. Draw a red line connecting the terminals together. This red line represents wire 1 in the way you draw it on your wiring diagram indication of the layout of how you plan to do your wiring.

Do the same thing for wire 2, 3, and 4. Draw a blue line to represent wire 2, green for wire 3, and orange for wire 4. When the wiring diagram is complete, wire this circuit on the board assigned to you in the shop. Use the same color in your wiring that you used on your wiring diagram. Use masking tape to identify the terminals before you connect the wires to them.

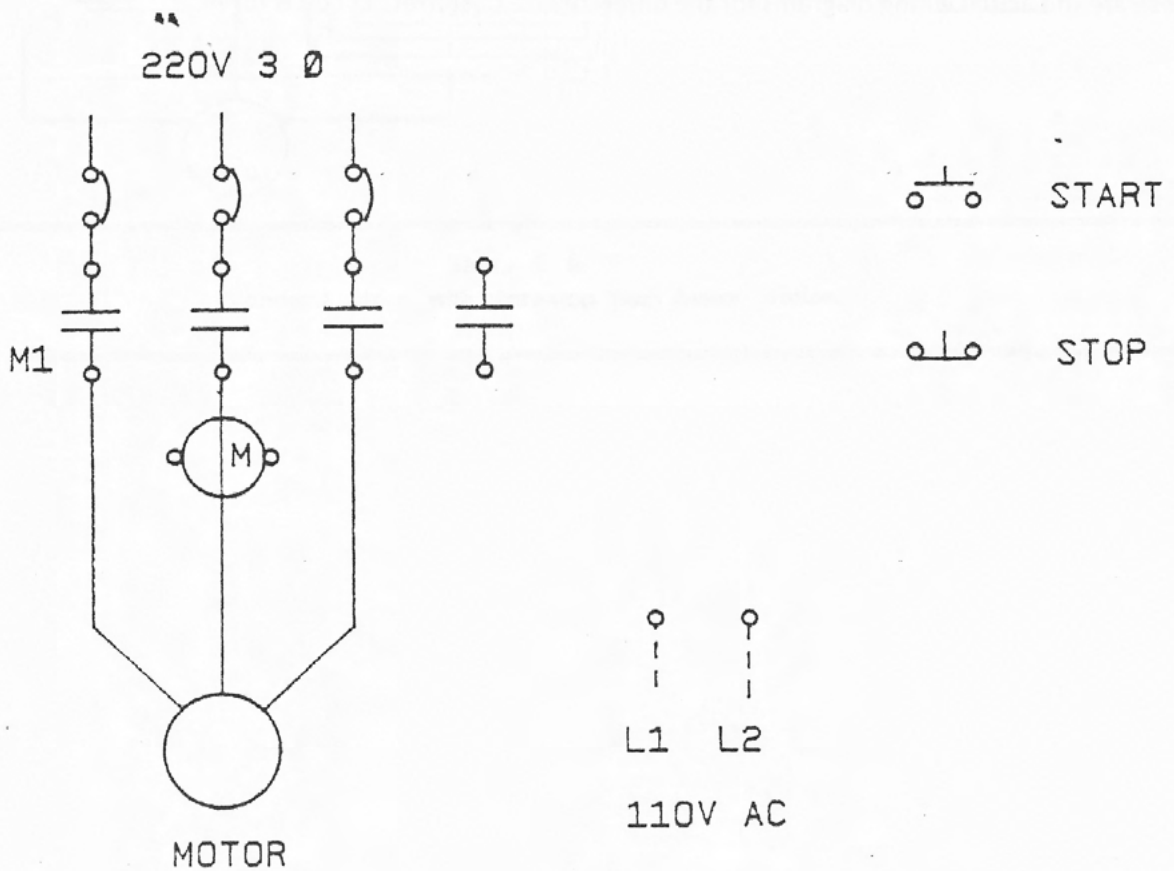
This is only a practice board. You will be wiring most of these projects up using actual motor controllers, later in the lab. Make sure that you know how these controllers work in their functions. If you can wire these up, you will have less trouble on the real thing.

These are the actual wiring diagrams for the different size of starters circuit is for AC 1.

AC MOTOR CONTROL 1

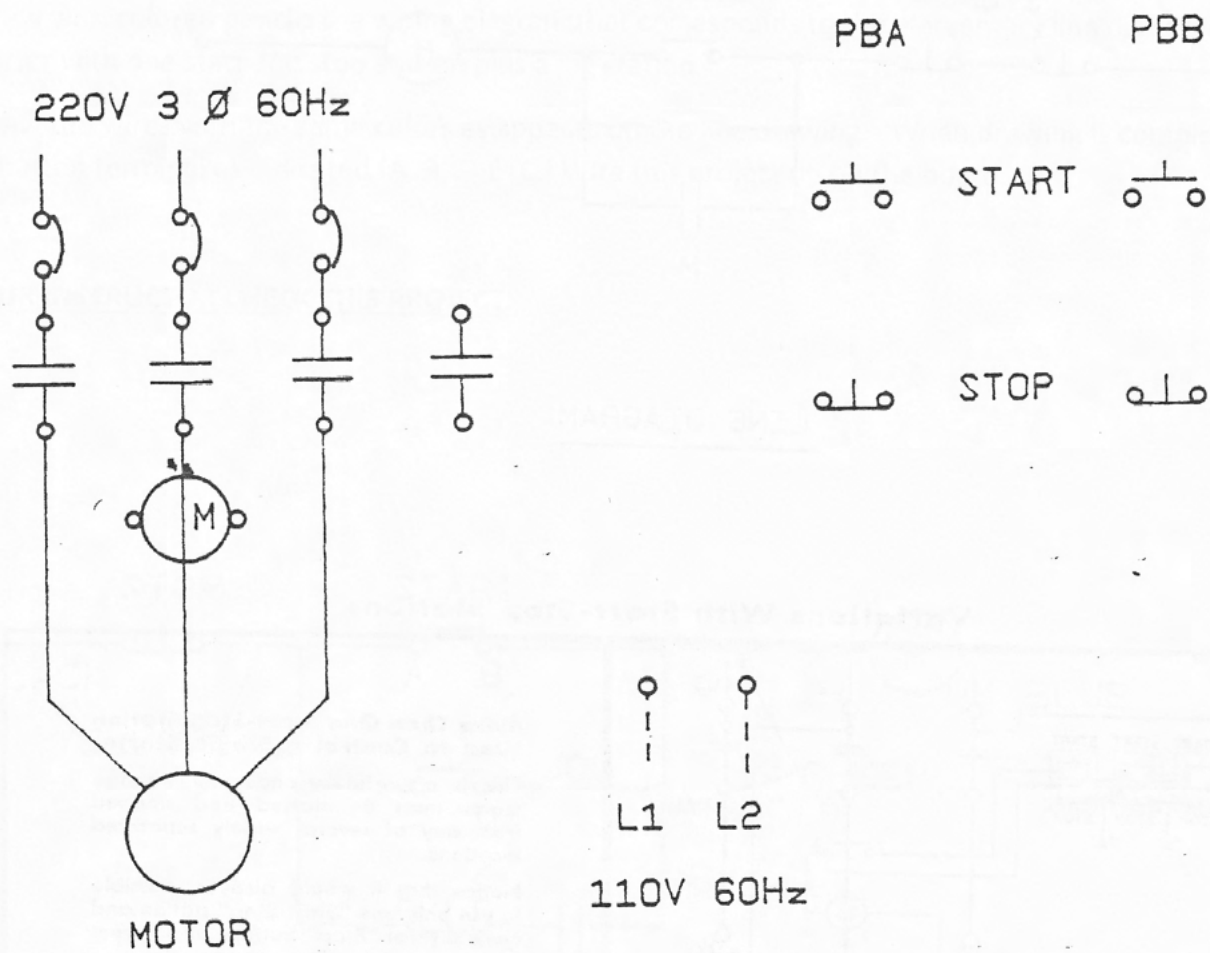


ELEMENTARY DIAGRAM



WIRING DIAGRAM

AC MOTOR CONTROL 2

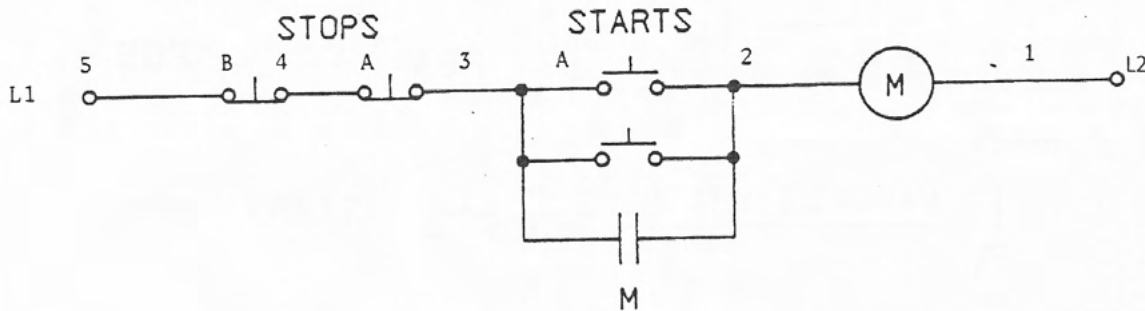


WIRING DIAGRAM

AC MOTOR CONTROL 2

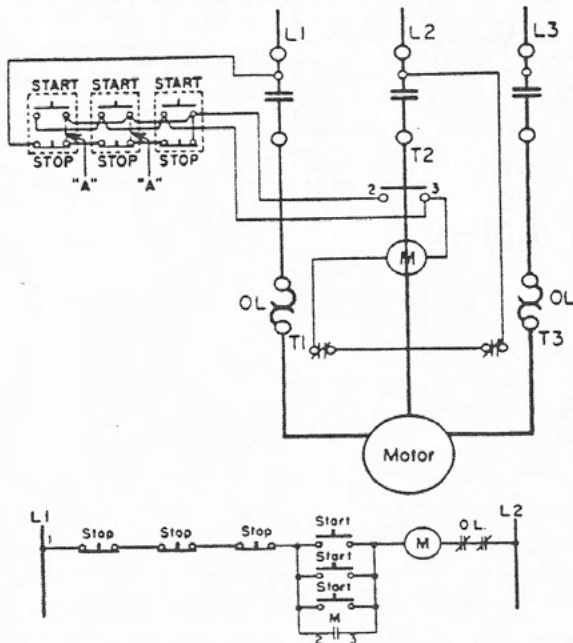
INSTRUCTIONS:

Make a wiring diagram corresponding to the line diagram of the motor starter using multiple controls stations. Make this drawing the same way you did in problem 1. Identify terminals with masking tape. Wire the circuit on the board with the same color wires that you have drawn on the line and wire diagrams. Use red for wire 1, Black for wire 2, Green for wire 3, Blue for wire 4, and yellow for wire 5.



LINE DIAGRAM

Variations With Start-Stop Stations



More Than One Start-Stop Station Used to Control a Single Starter

This is a useful arrangement when a motor must be started and stopped from any of several widely separated locations.

Notice that it would also be possible to use only one "Start-Stop" station and have several "Stop" buttons at different locations to serve as emergency stops.

Standard duty "Start-Stop" stations are provided with the connections "A" shown in the adjacent diagram. This connection must be removed from all but one of the "Start-Stop" stations used.

Heavy duty and oiltight push button stations can also be used but they do not have the wiring connection "A", so it must be added to one of the stations.

AC MOTOR CONTROL 3

INFORMATION:

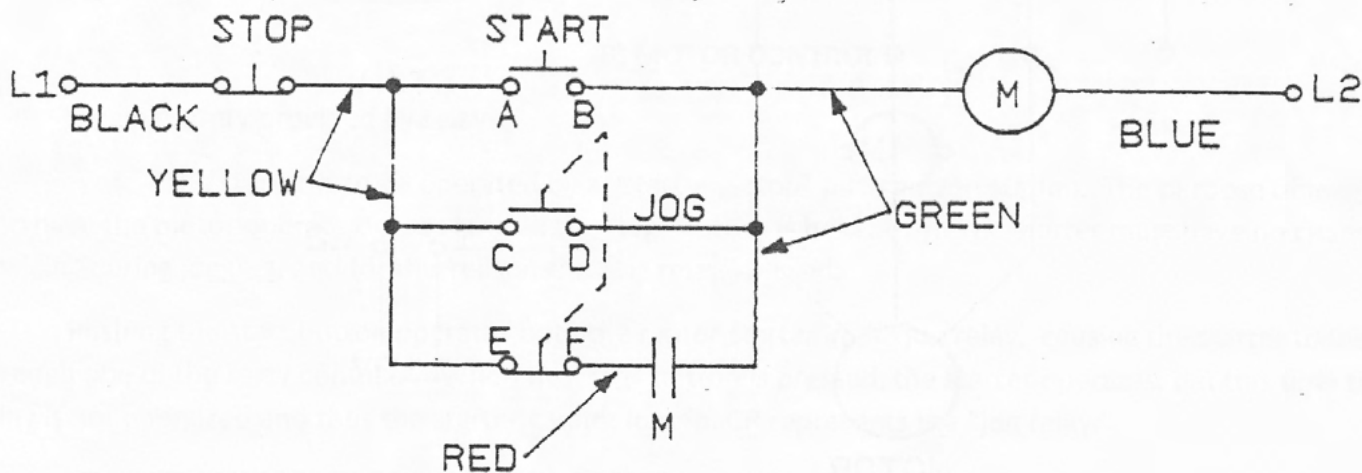
To jog a motor preferences the motor running as long as the jog button is held closed. The motor stops as soon as the button is released. The motor starts and stops normal at the start and stop button.

INSTRUCTIONS:

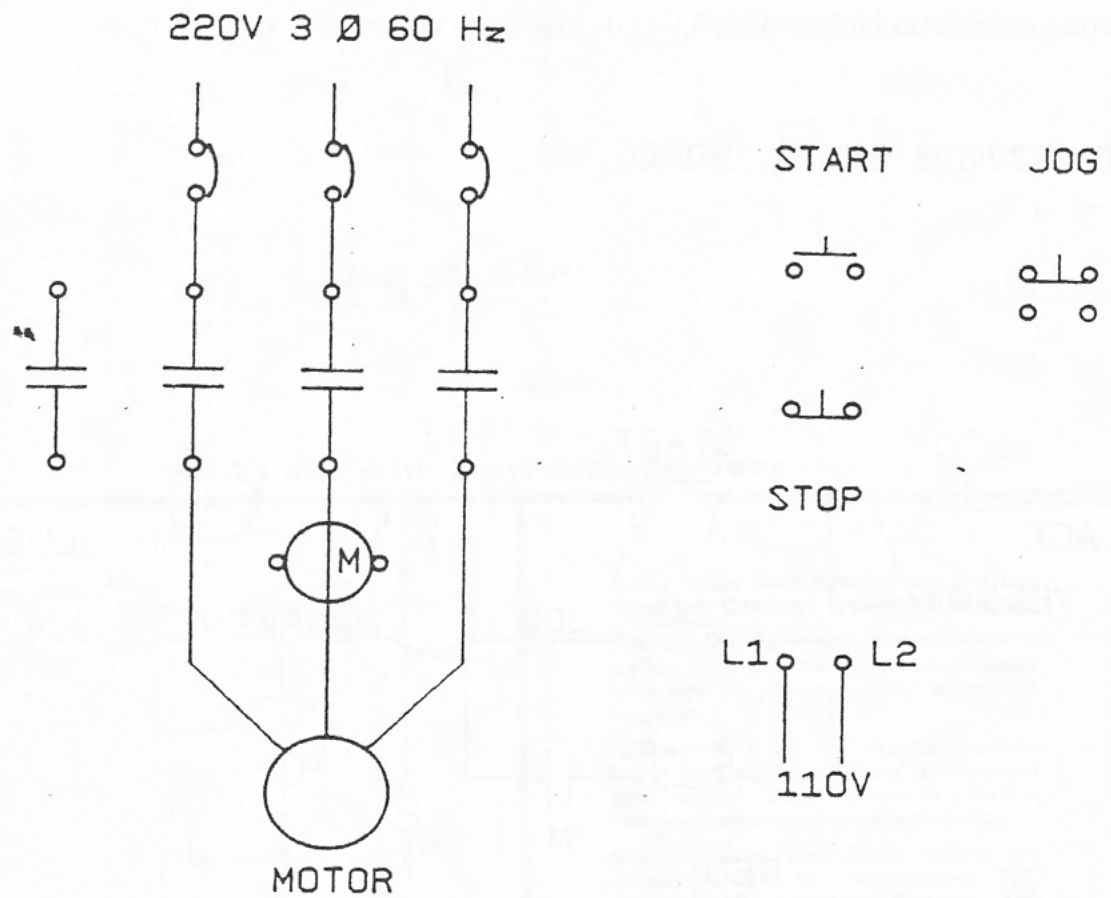
Draw with colored pencils the wiring diagram that corresponds to the elementary line diagram of a motor starter with one start and stop station plus a jog station.

Draw the wires with the same colors as appears on the line drawing. When drawing is complete, mark the push button terminal as indicated (A, B, C, ETC.) Wire this project up on the board.

HAVE YOUR INSTRUCTOR CHECK THIS PROJECT.



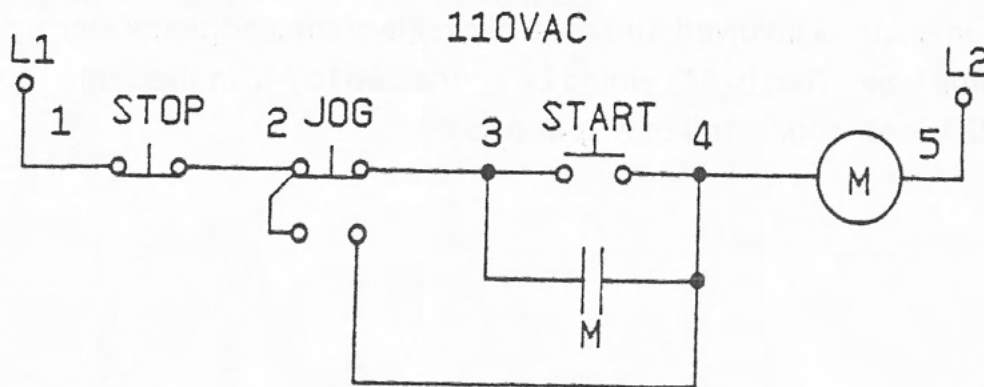
AC MOTOR CONTROL 3



AC MOTOR CONTROL 4

A.C. MOTOR CONTROL 4

Jogging with push buttons. This is like project #3 in that you have a job station. This starter can "lock in" during the jog function. It should only jog for as long as the job button is held down. This is a cheap and economical way to wire a jog-start-stop button even though it is not the safest.



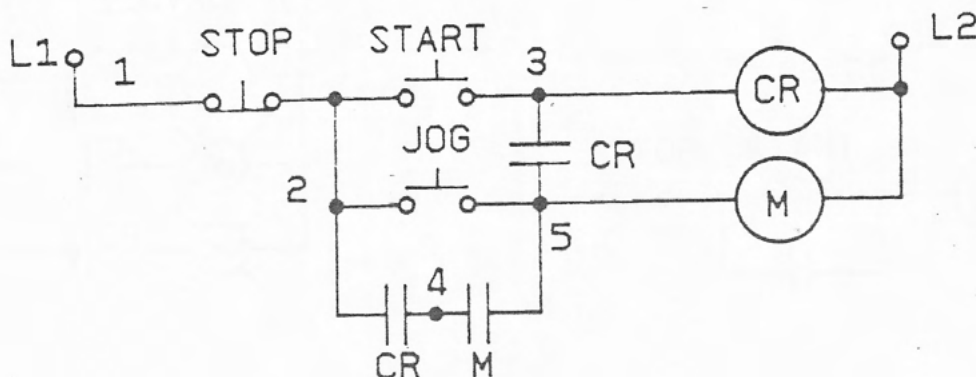
AC MOTOR CONTROL 5

Jogging safety provided by relay.

The starter is to be operated by a "start-jog-stop" push button station. The purpose of jogging is to have the motor operate only as long as the "jog" button is held down. The starter must have no chance to "lock in" during jogging, and for this reason the "jog relay" is used.

Pushing the start button operates both the motor starter in the jog relay, causing the starter to lock in through one of the relay contacts. When the "jog" button is pressed, the starter operates, but this time the relay is not energized and thus the starter cannot lock in. CR represents the "jog relay."

HAVE YOUR INSTRUCTOR CHECK THIS PROJECT.

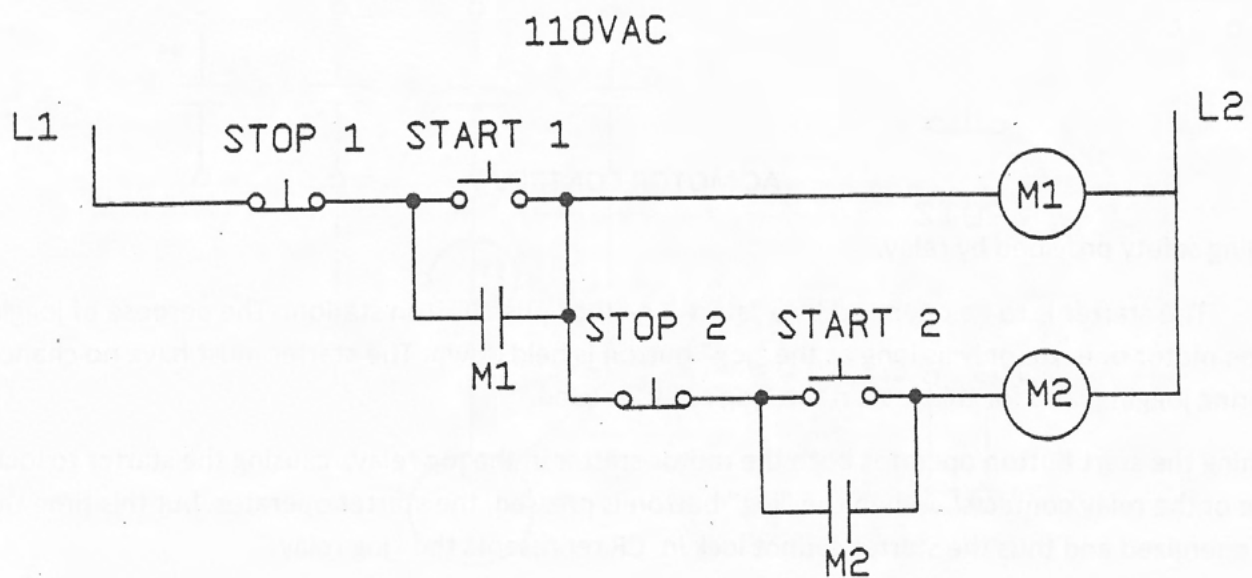


AC MOTOR CONTROL 6

Starters arranged for Sequence Control of a Conveyor System.

The two starters are wired so that M2 cannot be started until M1 is running. In one is driving conveyor fed by another conveyor driven by M2. Material from the M2 conveyor would pile up if the M1 conveyor could not move and carry it away.

If a series of conveyors is involved, the control circuit of the additional starters can be interlocked in the same way. That is, M3 would be connected to M2 in the same "Step" arrangement that M2 is now connected to M1, and so on.



AC MOTOR CONTROL 7

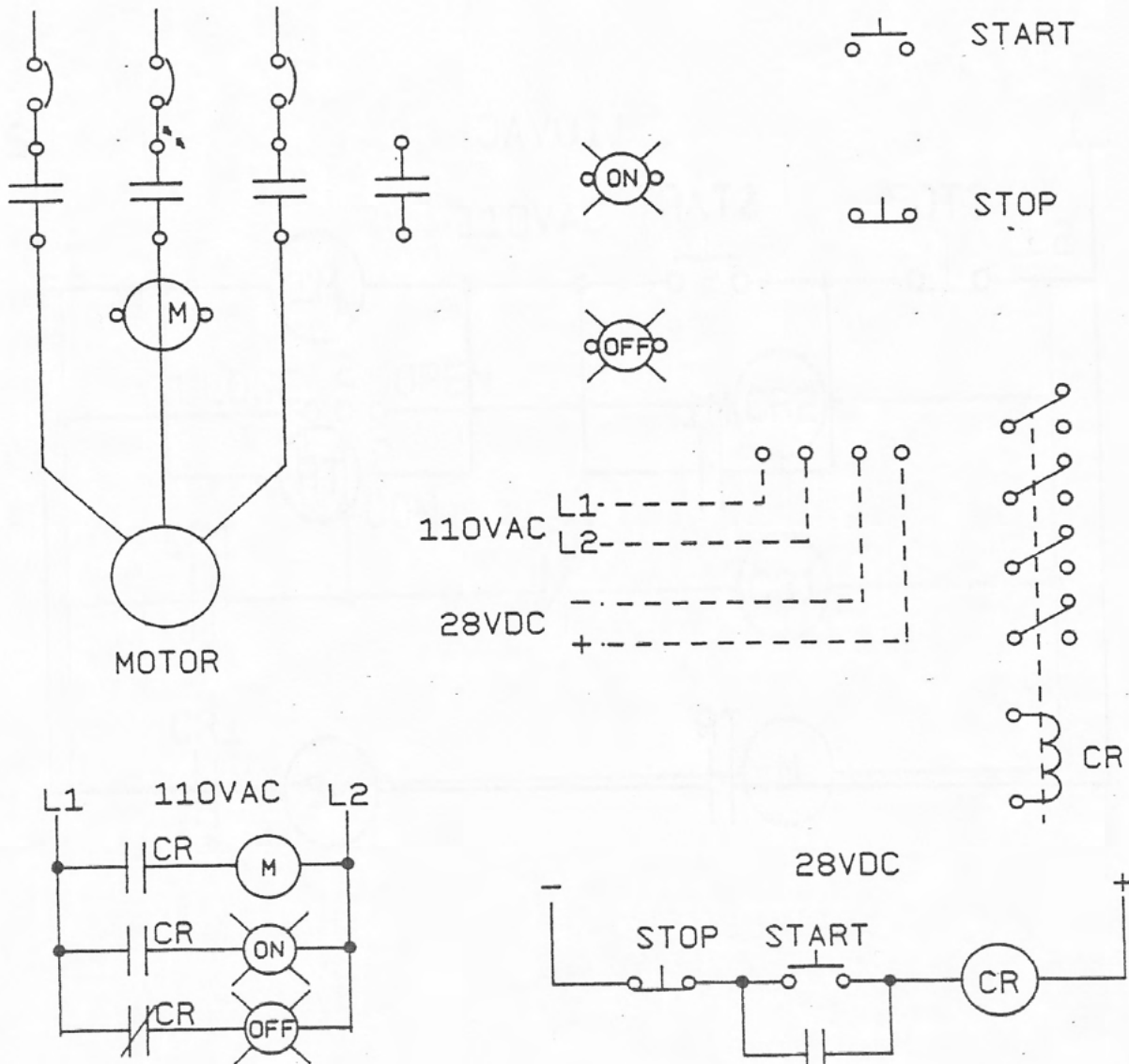
The control circuit for motor starters is often a lower voltage than the closing coil of the line starter. To give satisfactory operation, relays are used to energize the higher voltage circuits. Lights are used at the start and stop station to indicate if the motor is running or if it is off.

PROBLEM: Draw a wiring diagram to correspond to the elementary diagram of a motor.

Connect up this circuit to operate as indicated.

BE VERY CAREFUL NOT TO MIX THE TWO VOLTAGES.

110 volts A.C. does not mix with 28 volts D.C.

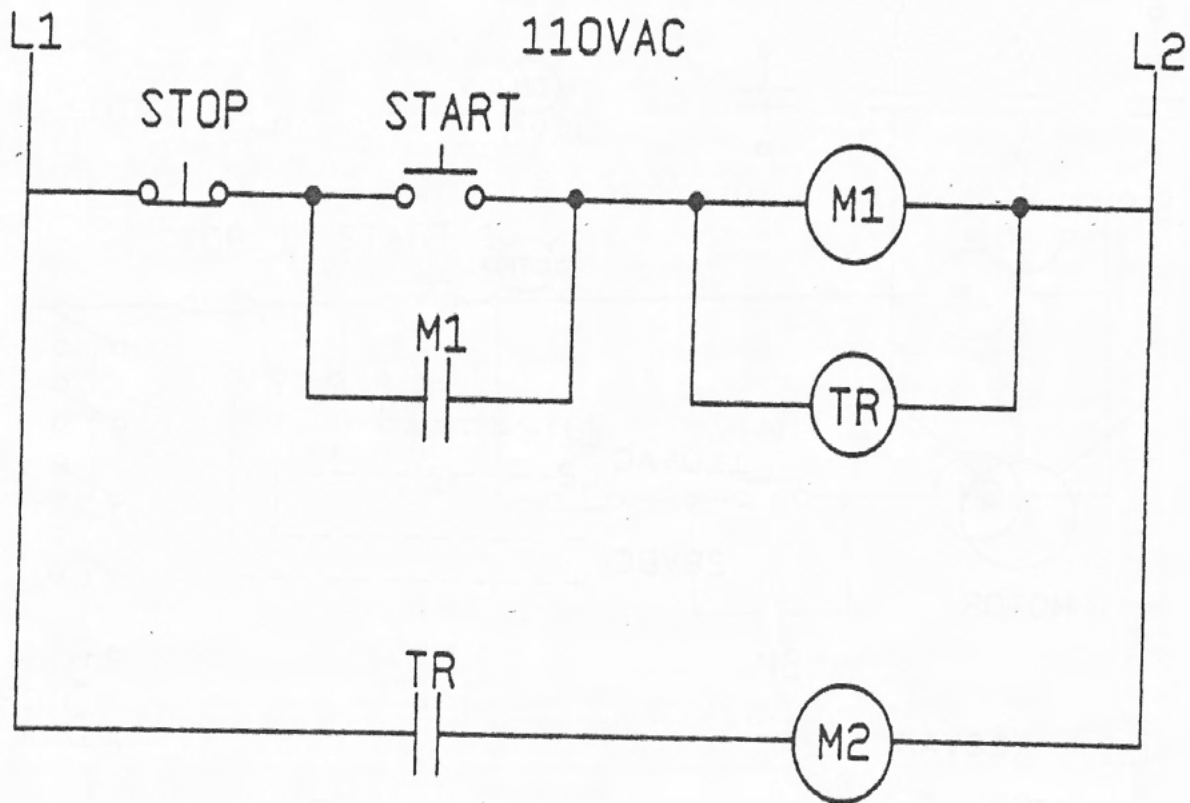


AC MOTOR CONTROL 8

Two starters are to be operated from a Single Station, but a short delay must prevent them from being energized together.

In some cases, distribution system does not have sufficient capacity to start several motors simultaneously. If several motors are to be started from the same push button station under these conditions as a time delay can be provided between operation of the motor starters.

When the start button is pushed, the first starter is energized along with a timing relay. When the timing relay times out, it operates a contact which closes the control circuit of the second starter. If more than two starters are to be used, additional timers will have to be added in the same way as the one shown connected to M1 here.

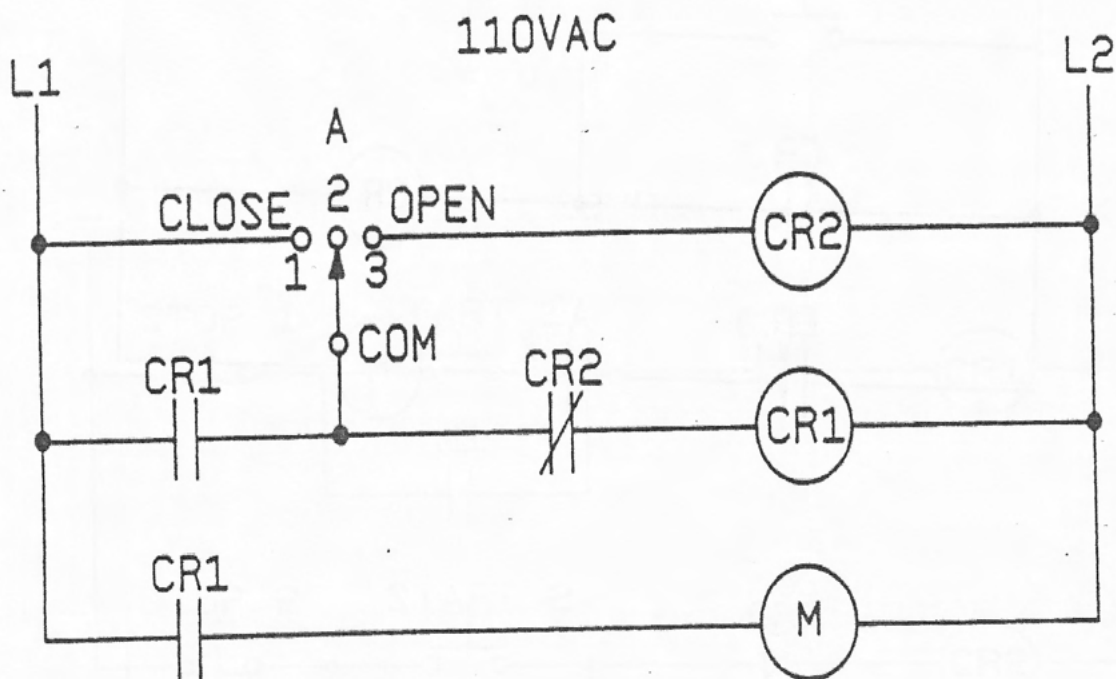


AC MOTOR CONTROL 9

Starter is controlled a gauge-type thermostat contacts can switch only a small amount of current.

Here is another method protecting thermostat from high current. This scheme, however, is for use with a thermostat whose contacts can handle even less current than the ones in the previous example.

In a case like this, it is advisable to use relays having coils which operate at a very small value of volt-amperes. This will reduce the burden on the thermostat out contacts and is especially advisable where frequent operation is required. "A" represents the three-wire sensitive gauge type control. You can use a selector switch for switch "A".



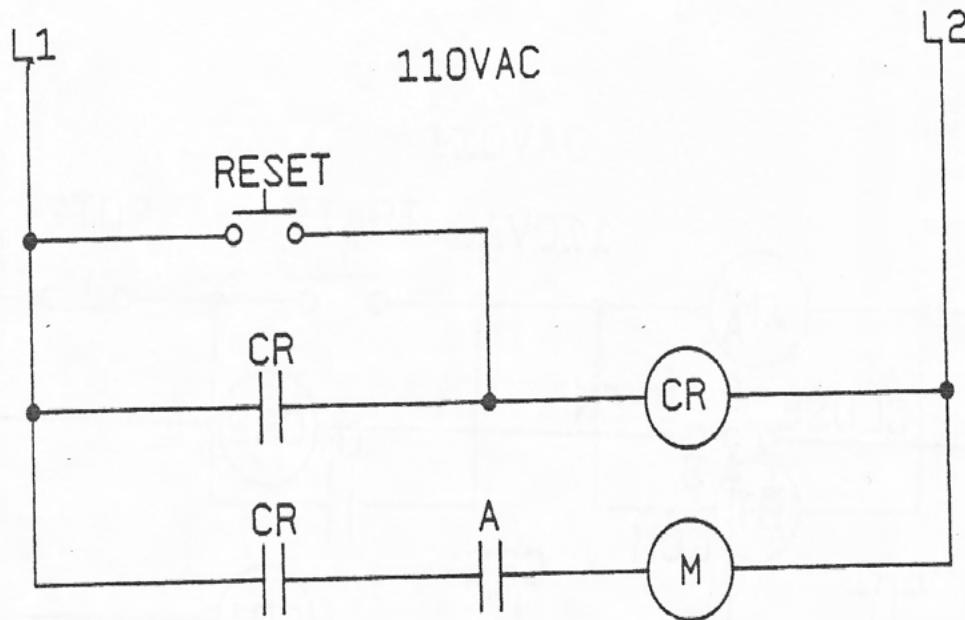
AC MOTOR CONTROL 10

Two-wire control with control relay added to provide no-voltage protection.

No-voltage protection is often necessary when two-wire control is used in a location where line disturbances are frequent. Since the two-wire pilot device is not affected by loss of voltage, its contact will remain closed even though there is no power on the line. This means that without the feature of no-voltage protection, repeated voltage dips would cause the starter to "chatter" and welding of contacts might result.

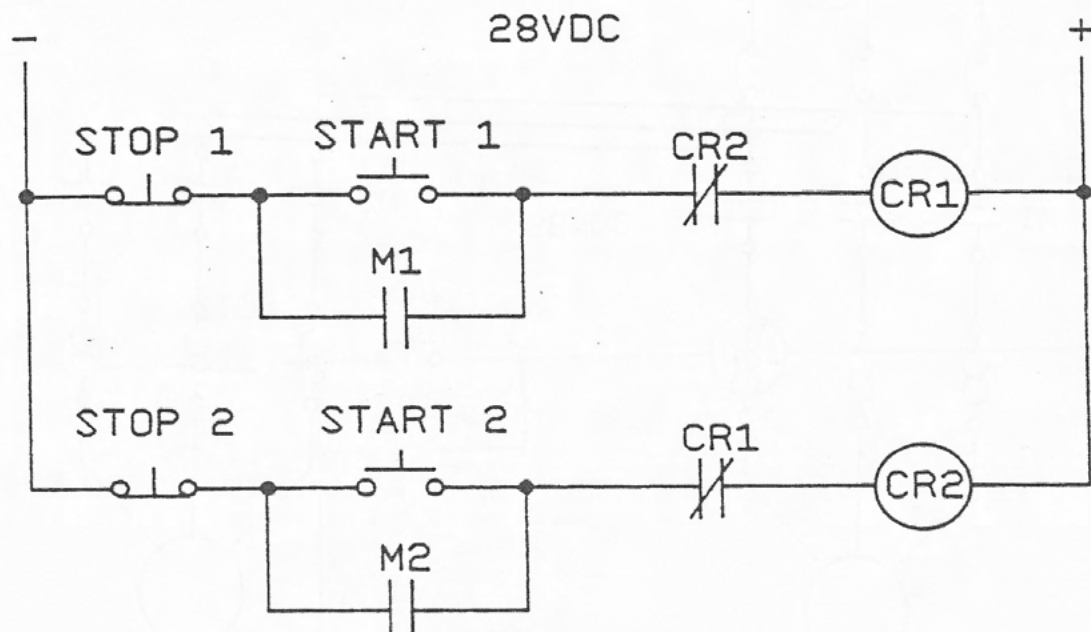
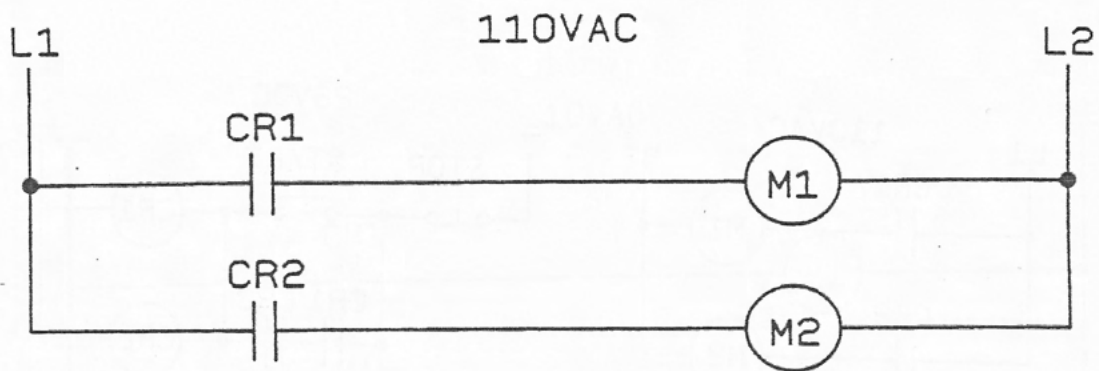
If a voltage failure is added, it will open the pilot circuit at a bad voltage dip and will not permit the starter to close again until the relay has been reset.

"A" represents the two-wire pilot device. It can be a single pole switch.



AC MOTOR CONTROL 11

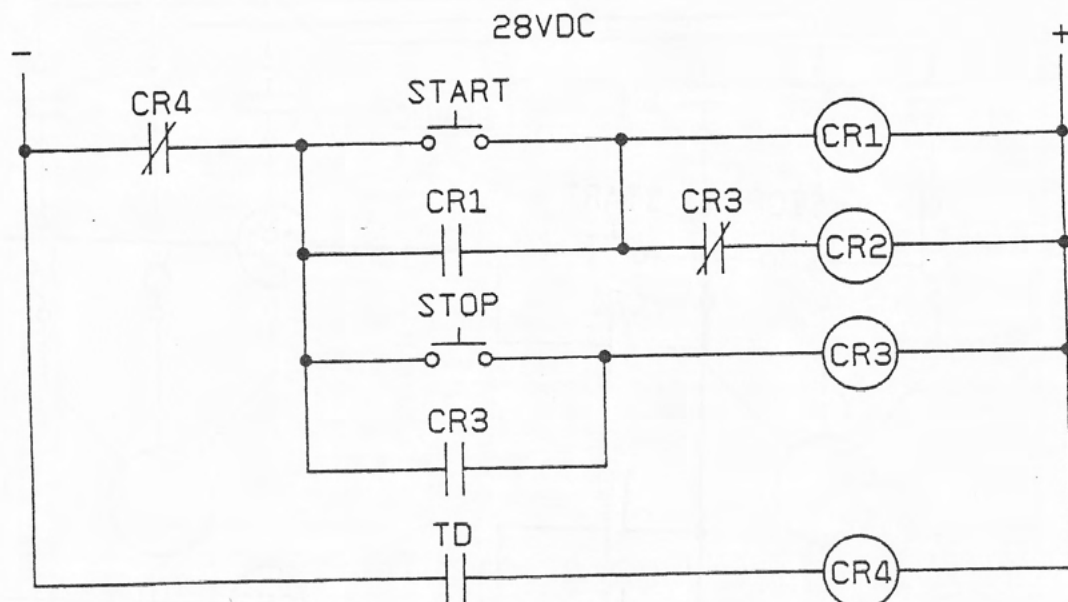
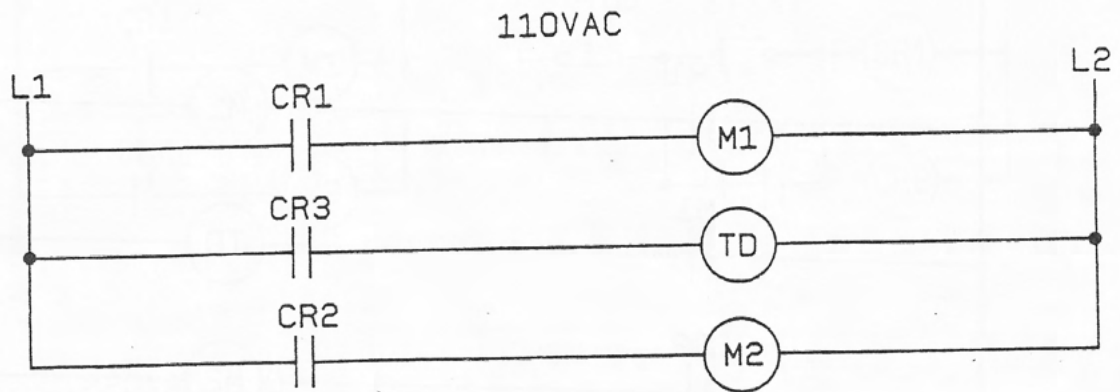
Connect the motor starters to operate the motor as follows: When motor 1 is running, motor 2 cannot run. When motor 2 is running, motor 1 cannot run. The interlocking is accomplished by the normally closed CR contacts. "Electrical Interlock".



AC MOTOR CONTROL 14

Some industrial applications require that a group of machines or mechanical devices start together when a start button is pressed. When the stop button is pressed some of the machines stop immediately and others continue to run until a definite time delay has elapsed and then the other machine stop.

Wire starters so they both energize and start motors when the start button is pressed. Connect so that when the stop button is pressed, line starter 2 will de-energize stopping motor 2, but line starter 1 will continue to remain energized until a definite time delay has elapsed, then it will de-energize and stop motor 1.



AC MOTOR CONTROL 15

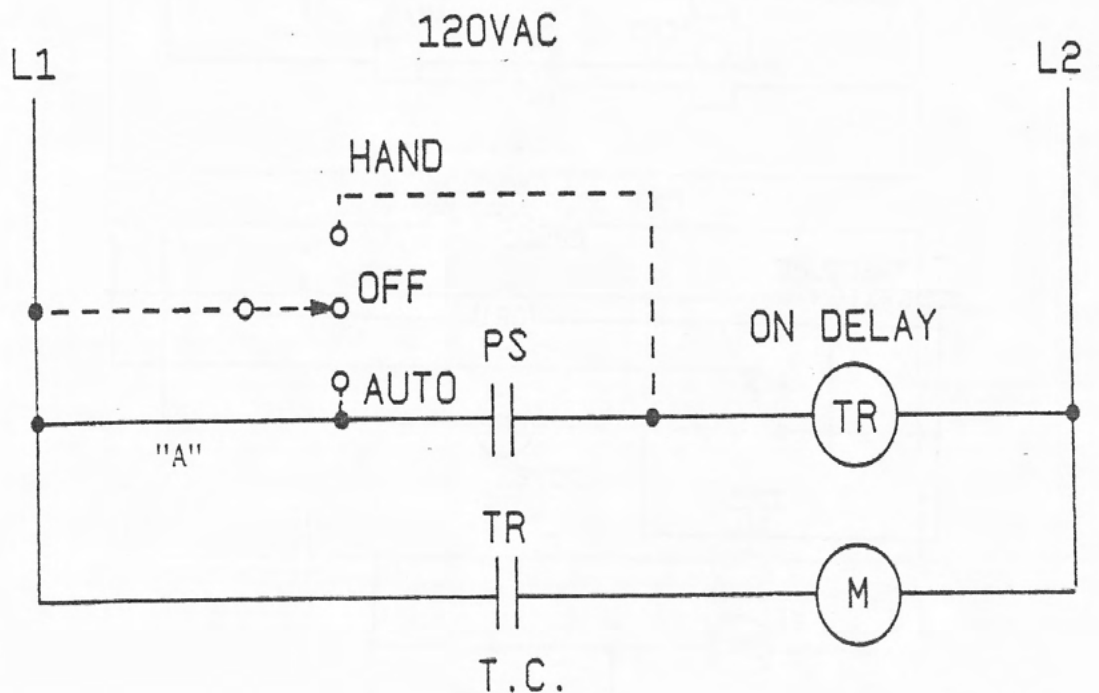
Surge Protection is often necessary when the pump is turned off and the long column of water is stopped by a check valve. The force of the sudden stop may cause surges which operate the pressure switch contacts, thus subjecting the starter to "chattering".

"Backspin" is the name given to the backward turning of a centrifugal pump when a head of water runs back through the pump just after it has been turned off. Obviously starting the pump during backspin might damage the pump or motor.

System provides backspin protection and surge protection on stopping. Time delay between pressure switch causing a motor to start.

The pressure switch energizes the timer (TR), but the motor cannot start until the time delay contact has closed. The timer can thus be set for a time long enough to allow all surges and backspin to stop.

The dotted lines show how a selector switch can be added to by-pass the pressure switch if necessary. This is often used for motor testing purposes. It does not eliminate the time delay however, if the selector switch is added, the wire "A" must be removed. (Use selector and remove wire "A").

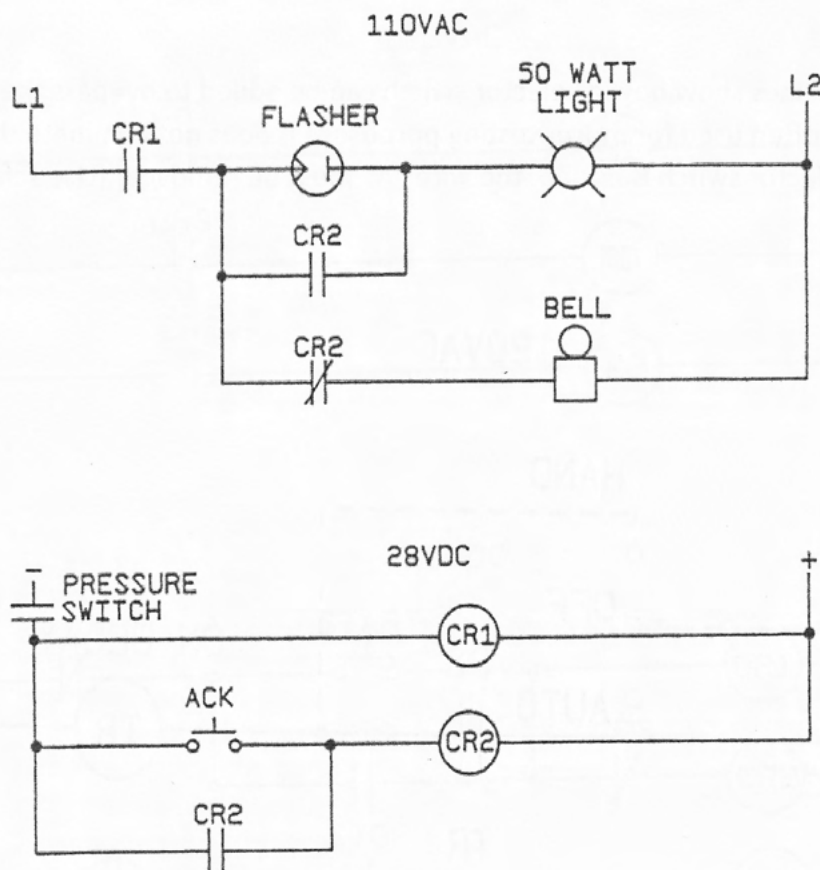


AC MOTOR CONTROL 16

Some industrial processes require that when trouble occurs, a contact from a sensing device closes and gives an alarm. This alarm consists of a flashing light and bell. When the operator acknowledges the trouble, by pressing the acknowledge button, the bell stops ringing and the light stops flashing but remains on steady. When the trouble clears up, the light goes off.

Now wire up the circuit below on the motor control board.

HAVE YOUR INSTRUCTOR CHECK YOUR CIRCUIT.



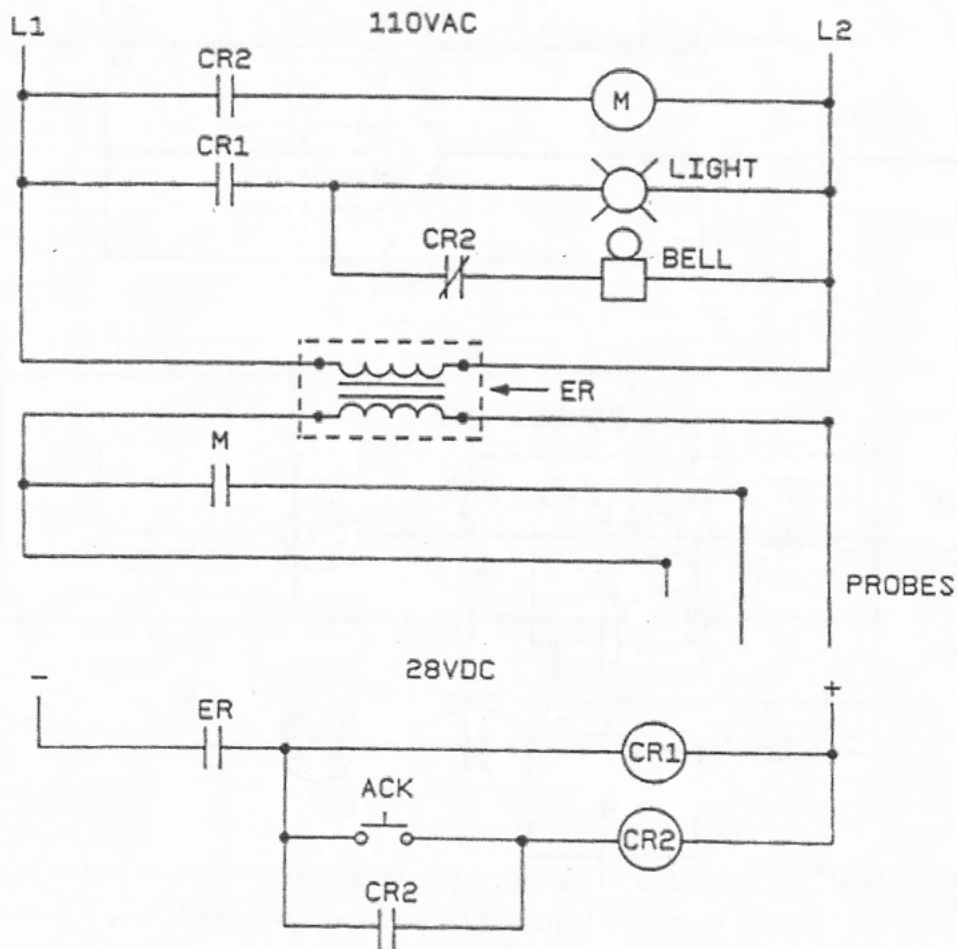
Now modify the above circuit by adding a motor to come on when acknowledge button is pressed and off when trouble is cleared.

AC MOTOR CONTROL 17

Annunciator for high liquid level.

When the water level of a tank, boiler, etc., becomes too high, it is desirable to have an alarm to warn the operator. When the liquid level becomes too high, shorting out between probes 1 and 3, the level relay energizes. This closes the ER contact, which energizes CR1 and turns the bell and light on. When the operator acknowledges the trouble by pushing the acknowledge button (ACK), CR2 energizes; this turns the bell off, starts the pump (M) and the light stays on, letting the operator know it still has a high liquid level. When the liquid is pumped down to a point where probes 1 and 2 are no longer shorted, the level relay de-energizes, turns off the light, and the pump automatically letting the operator know the trouble has been corrected.

NOW WIRE UP THE CIRCUIT BELOW ON THE MOTOR CONTROL BOARD.

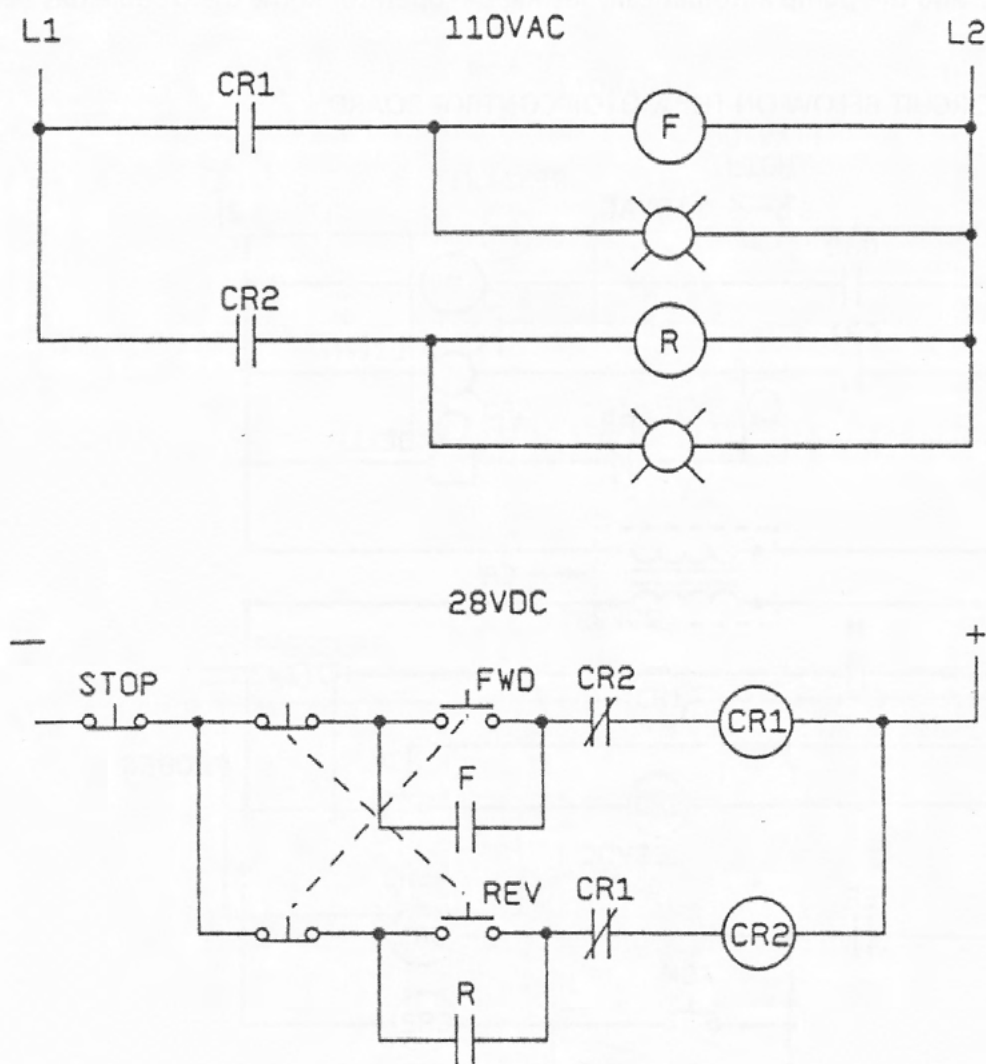


AC MOTOR CONTROL 18

This circuit performs the control kitchen of forward reverse control, start, stop, interlock overload protection, and plugging. For Motors that must be stopped very quickly and accurately but which do not need to hold a load, probably the most widely used method is known as plugging. This is accomplished by the use of an automatic plugging switch or unplugging push button in conjunction with a reversing starter.

With either of these units, the motor starter is dropped out and then energized in the reverse direction. The monetary reversal plugs motor too and abrupt stop.

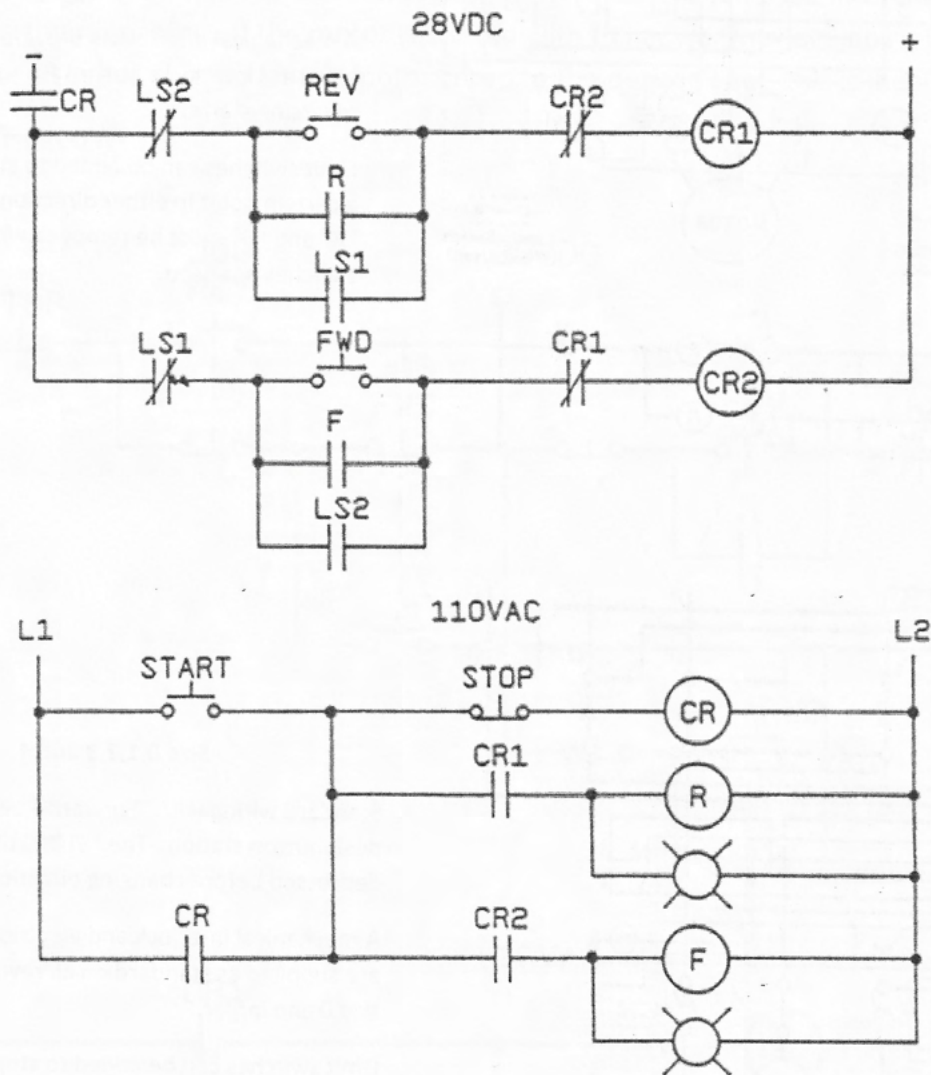
WIRE THE BELOW CIRCUIT.



MOTOR CONTROL 19

Forward and reversing control can be manual or automatic. Limit switches are used for automatic reversing.

HAVE YOUR INSTRUCTOR CHECK THIS CIRCUIT.



Now add to the above circuit so that either manual or automatic will reverse the motor. Automatic by way of the limit switches and manual by way of the pushbutton.

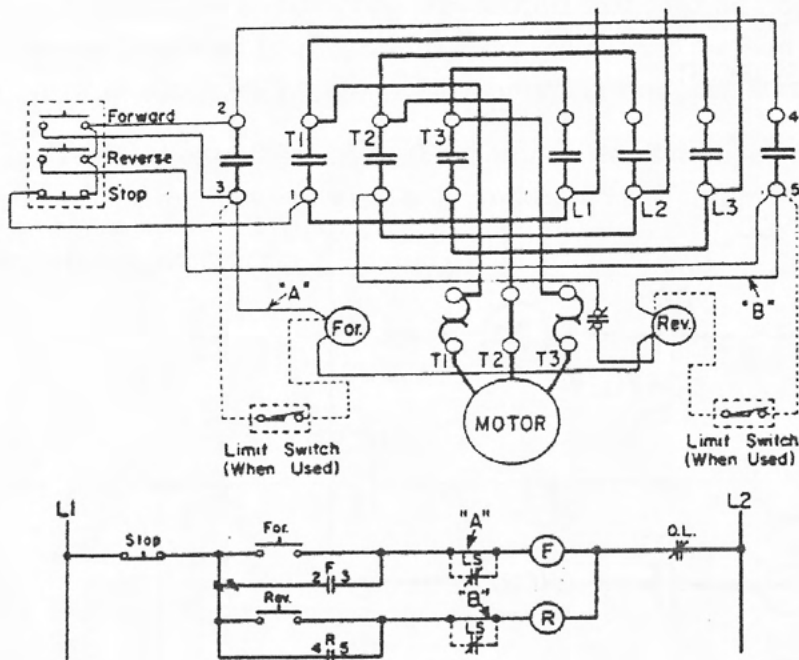
This is similar to A.C. 19

Size 00

Standard wiring with "Forward-Reverse-Stop" pushbutton station. The "Stop" button must be depressed before changing directions.

A mechanical interlock is provided, however electrical interlocks are not furnished on Size 00 reversing starters.

Limit switches can be added to stop the motor at a certain point in either direction. Connections "A" and "B" must be removed when limit switches are used.

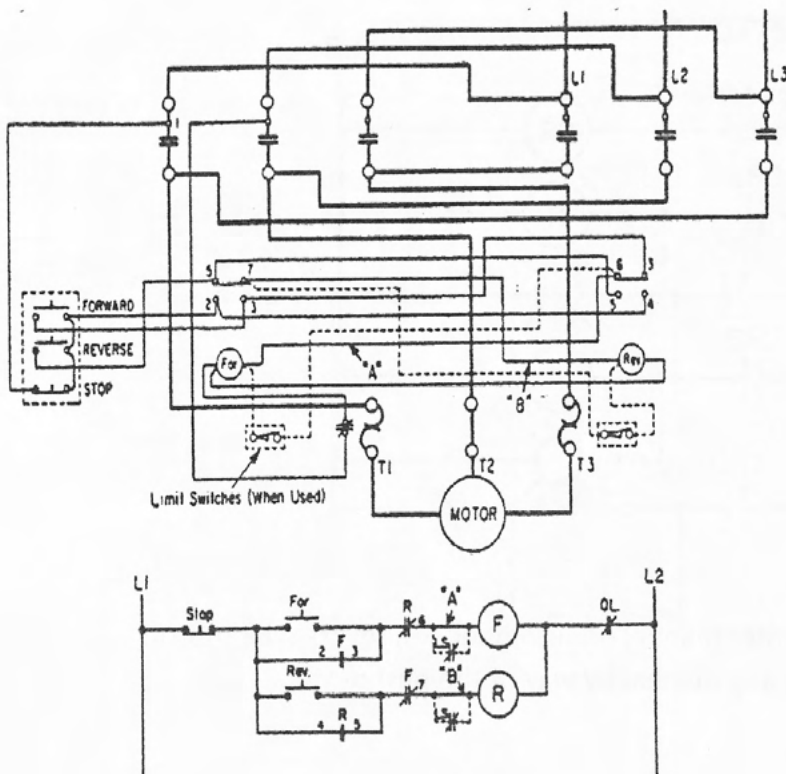


Size 0,1,2,3 and 4

Standard wiring with "Forward-Reversing-Stop" push button station. The "STOP" button must be depressed before changing directions.

A mechanical interlock and electrical interlocks are supplied as standard on all reversing starters size 0 and larger.

Limit switches can be added to stop the motor at a certain point in either direction. Connections "A" and "B" must be removed when limit switches are used.

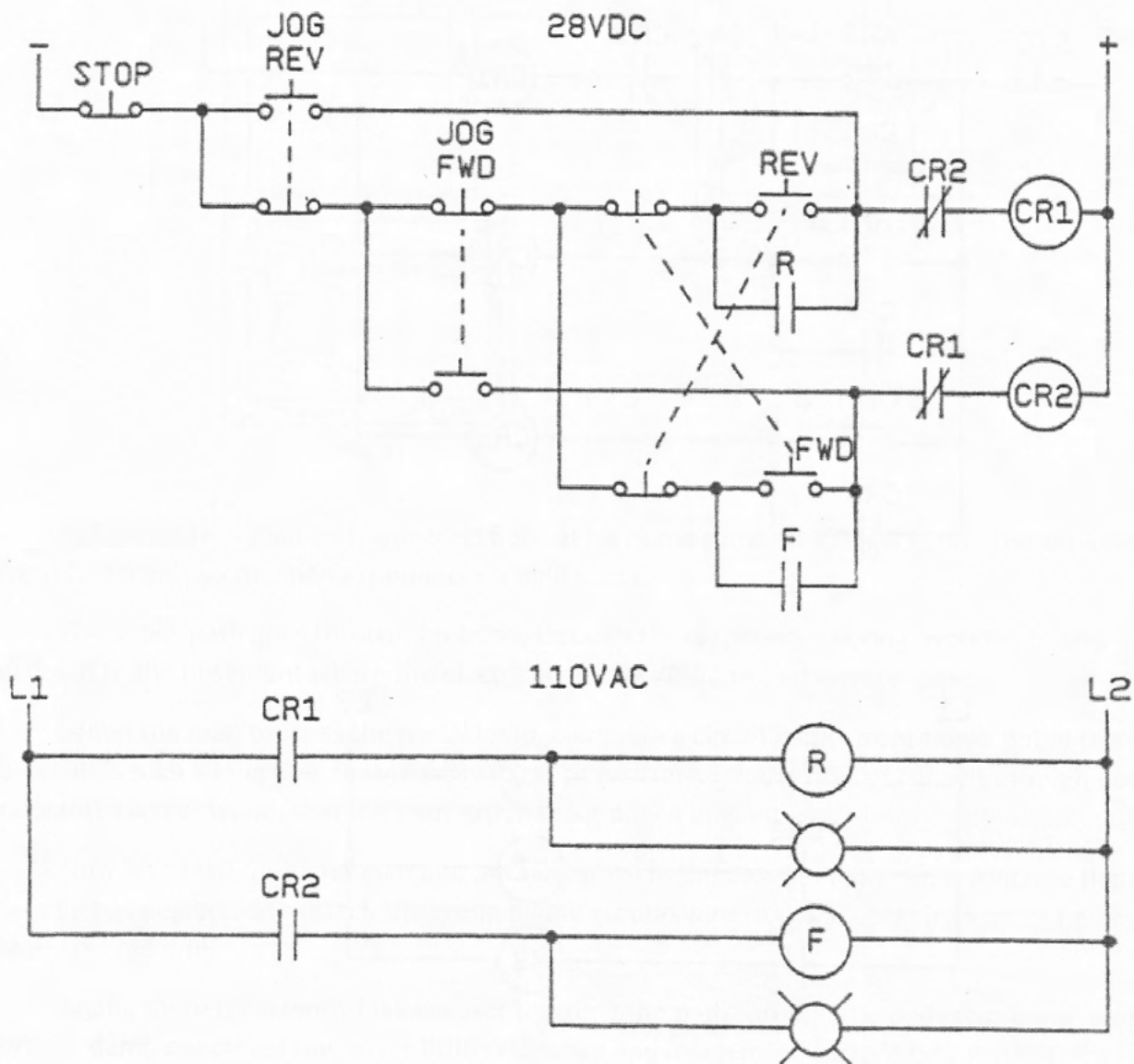


AC MOTOR CONTROL 20

This circuit incorporates many of the functions of control. It has start and stop in both forward and reverse, manual plugging duty, jogging service in forward and reverse, electrical interlock, and overload protection.

Printing presses, cranes, hoists and similar equipment require that the motor be started repeatedly for short periods of time in order to bring some part of the machine into a given position. This process is known as jogging or inching. Even though these terms are often used interchangeably, there is a slight difference in their meaning. If the motor is started with full power in short jabs it is jogging. If the motor is started at reduced speeds so as to let the motor creep to the desired spot, this is inching.

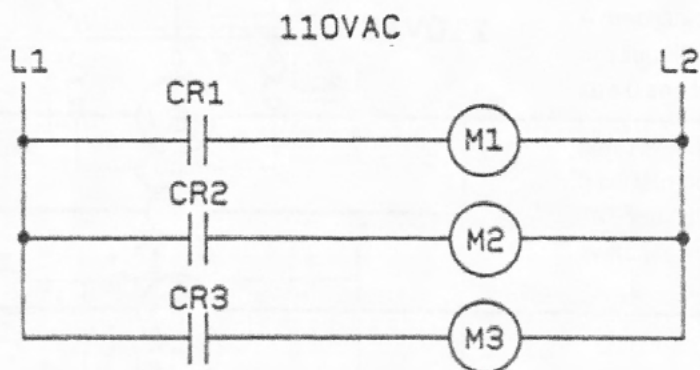
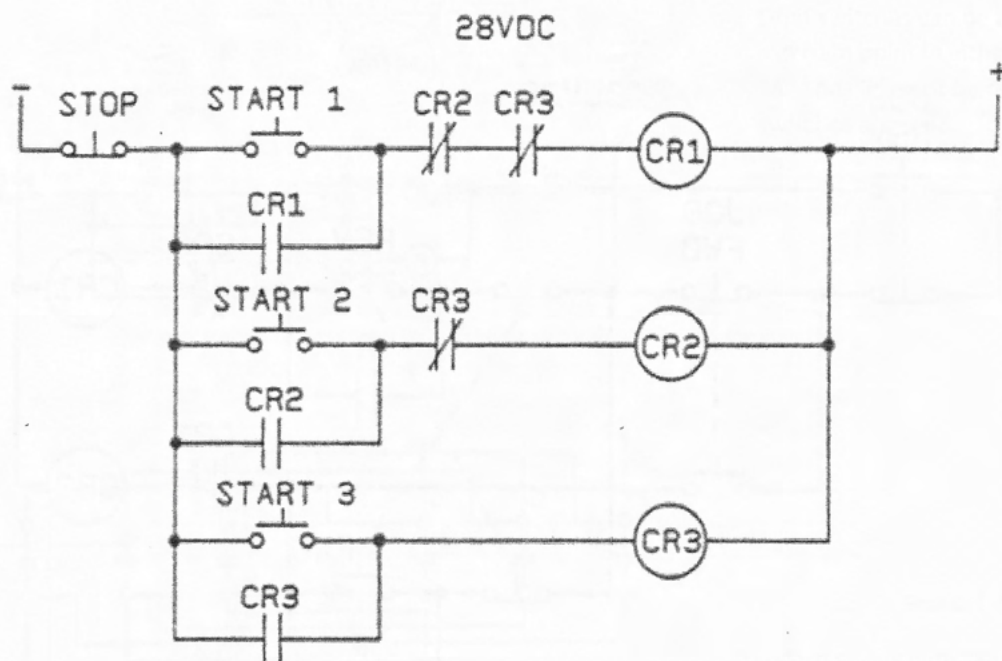
WIRE THE CIRCUIT BELOW.



AC MOTOR CONTROL 21

This circuit will give selective sequence control to three motors. This means that an operator could start any motor he desired and could progress upward in the sequence of motors at will. To go backwards in the sequence, he must first stop whatever motor is running and then select the motor. This control could be expanded to any number of motors desired.

NOW WIRE THE CIRCUIT BELOW.



HOW HOUSE CURRENT KILLS

Many people think fuses and circuit breakers are all the electrical protection that is necessary in the home. They are quick to related causes where household voltage did nothing more than produce an unpleasant muscle flex. But up closer look at a hypothetical home situation will show how a little voltage can be dangerous.

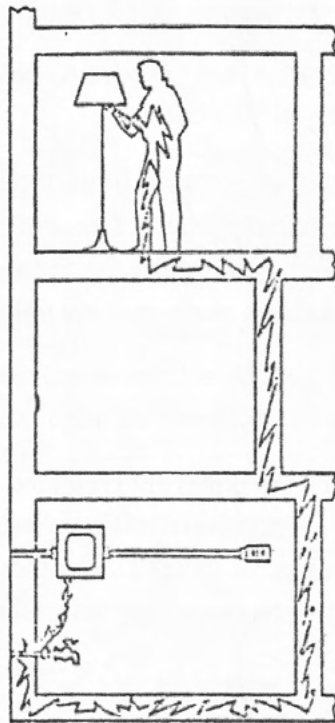


Fig. 1

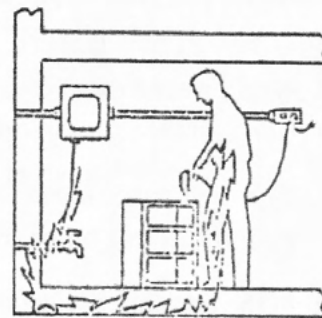


Fig. 2

In figure one, a man on the second floor of his home turns on a faulty lamp. There's a little current "leakage", so the man experiences a mild shock.

The shock path goes through his body, through the carpeting, flooring, wooden beams in all the way down to the basement where the electrical service is bound to the water pipes.

When the man touches the metal lamp, complete a circuit and current flows. But in this case, this circuit is such a long one, that there is so much resistance to the flow of current through poor conductors such as wood, that the man experiences only a tingling sensation.

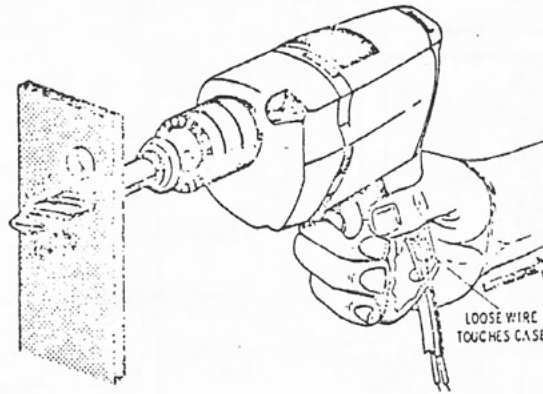
Now let's take the same man and put him down in the basement on damp concrete (figure 2) where he has neglected to attach the green pigtail ground wire to the adapter into which he has plugged his old drill.

Again, there is currently leakage, but this time the path through the body to ground is very short the damp concrete floor offers little resistance and much more current flow instead of a tingling sensation same voltage produce an electric shock.

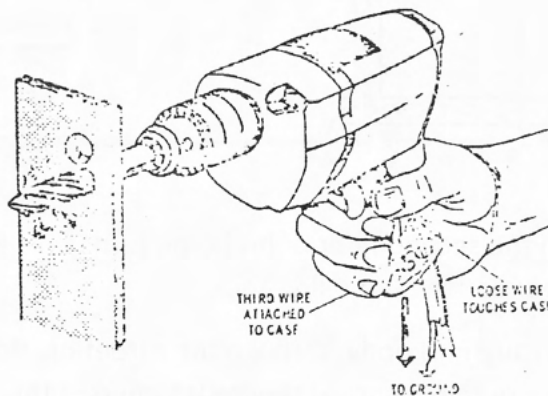
The following steps are important in working with electricity. These should be observed by electrical workers and in working with appliances and power tools.

1. Never cut off the third prong of a grounded plug. The grounded plug can make the appliance and powered tools much safer.
2. Never touch any wire without mean sure that it is not a live wire.
3. Since the resistance of dry skin is more than 1,000,000 ohms and the resistance of wet skin is only about 1000 ohms, never turn an electrical device on or off while the skin is wet.

Figure A



A) Electricity travels from the housing through the human body if the drill is not grounded properly.



B) If the drill is grounded with a third wire, the electricity passes from the housing through the third wire to ground because it's resistance is less than the resistance of the human body.

4. Remember that only 0.1 amperes of alternating current flowing through a vital part of the body fatal.

EFFECTS OF ELECTRIC SHOCK

Electric shock may cause instant death, or may cause unconsciousness, cessation of breathing, and burns of all degrees. If a 60-cycle alternating current is passed through a person from hand to hand or from hand to foot, the effects when current is gradually increased from zero are as follows;

1. At about 1 milliamperes (0.001 ampere) the shock can be felt.
2. At about 10 milliamperes (0.010 ampere) the shock is severe enough to paralyze muscles so that a person is unable to release the conductor.
3. At about 100 milliamperes (0.100 amperes) the shock is fatal if it lasts for one second or more.

IT IS IMPORTANT TO REMEMBER THAT CURRENT IS THE SHOCK FACTOR RATHER THAN THE AMOUNT OF VOLTAGE.

You should clearly understand that the resistance of the human body is not great enough to prevent fatal shock from a voltage as low as 115 volt. In many cases, voltage less than 115 volt are fatal. When the skin is dry, it has a high resistance. The resistance may be high enough to protect a person from a fatal shock even if one hand touches a high voltage while another part of the body touches the chassis or another ground.

Contact resistance decreases when the skin is moist and body resistance may drop as low as 300 ohms. With this low body resistance, it can be seen that a very low voltage could supply enough current to cause death.

A current of 0.10 amperes is the maximum flow that a muscle can carry and still turn loose from the conductor. Be careful; but if you must touch a conductor, do so with the back of your hand. Therefore, a muscle spasm will cause the hand to jerk away from the conductor.

Never work on an electrical line or circuit, until you have located and disconnected the master switch.

Never work on an electrical appliance and tell you have unplugged it. Merely turning it off may not make it safe.

Always replace worn appliance cords.

Always unplug chords by pulling on the plug - not on the cord.

Never turn on appliance on or off while standing on or touching a wet area.

Always tin a stranded wire when it is necessary to make a screw-type connection. Loose strands can cause a short or electrical shock.

If you find broken electrical wiring that is touching the ground, find someone to guard it and notified the proper authority. Never attempt to touch the wires with any.

Soldering tools are the same color when they are hot and cold. Never touch the tip of a soldering tool.

Never work with capacitors until you are sure they are discharged. Discharge any capacitor that you are not sure.

Keep one hand in your pocket while adjusting electrical equipment that must be operating during adjustment.

Tools with plastic or rubber handles are preferred for electrical work. The insulated handles reduce the possibility of electrical shock.

Always check your work carefully before connecting a circuit to the power source. It is always good practice to have someone double-check your work.

1. How much resistance does your skin have? Measure it with your ohmmeter from one hand to be other. _____
2. How much current would you draw from a line of 120 volts with the resistance that you measured from hand to hand? _____
3. Would you be alive or dead? _____
4. Would you feel a shock from a current with a GFI on it that trips at 5 amp?
Explain: _____
5. Would you get a hard are shot from 220 volts then 120 volts? _____
6. What color is a hot soldering iron? _____
7. How can you tell if a capacitor is charged? _____
8. Why use just one hand on electrical work?
Explain: _____
9. Why should electrical cords be in good condition?
Explain: _____
10. Are dry hands better to work with electricity than moist ones?
Explain: _____

INDUSTRIAL CONTROLLER PROJECT 1

After you have received an industrial control unit from your instructor, make a close study of the unit, noting how the unit and selector switch are connected to the terminal board. Now that you are sure you know how the universe operates, make an elementary drawing circuit only.

Now make the following connection listed below.

HAVE YOUR INSTRUCTOR CHECK YOUR CIRCUIT.

1. With the selector switch in the automatic position, operate the starter with a single pole switch.
2. With the selector switch in the hand position, operate the starter with start-stop push button system.

Your unit should now operate either in the automatic or hand position as listed above.

3. Now in Step 2, above, add a second start-stop push button system.

Now with the selector switch in the hand position, you should be able to start and stop the starter unit from two locations.

4. **Keep this paper work for third and fourth semester**

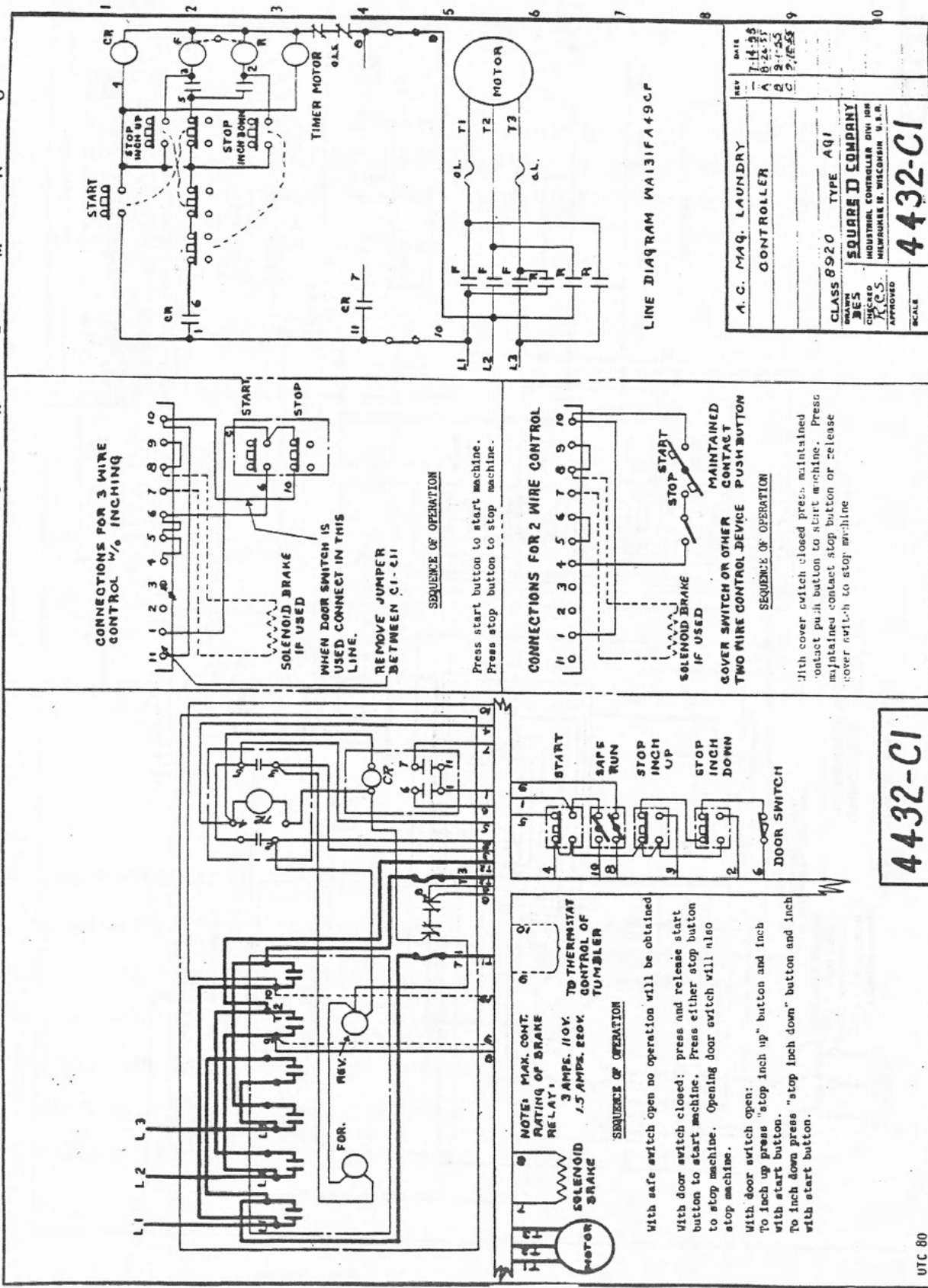
INDUSTRIAL CONTROLLER PROJECT 2

Included with the information sheet, there are two industrial prints in your lab manual: Square D controller in the other is a Cutler-Hammer controller. On these prints you will find a panel diagram and a line or elementary diagram. Study these diagrams, until you know how these controllers operate, and the location of the component parts. When you are ready, your instructor will give you one of these controllers. You are to wire it up so it will operate as indicated in the line diagram.

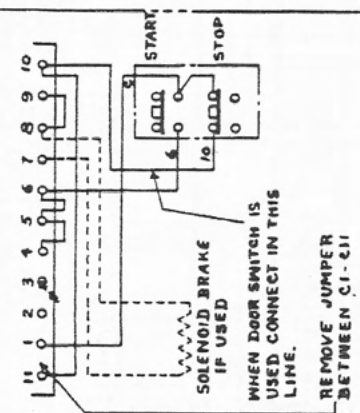
CHECK WITH YOUR INSTRUCTOR FOR ANY CHANGES YOU MIGHT NEED TO MAKE.

When you have finished one controller go to the next one and wire it up.

A B C D E F G H I J K L M N O



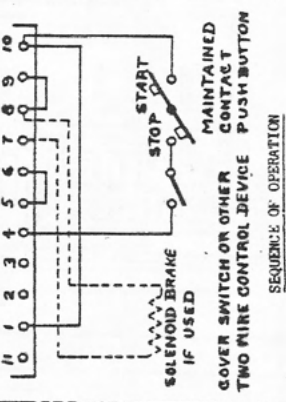
CONNECTIONS FOR 3 WIRE CONTROL W/ 1/2 INCHING



SEQUENCE OF OPERATION

Press start button to start machine.
Press stop button to stop machine.

CONNECTIONS FOR 2 WIRE CONTROL



SEQUENCE OF OPERATION

With cover switch closed press maintained contact push button to start machine. Press maintained contact stop button or release cover switch to stop machine.

LINE DIAGRAM WA131FA49CF

DATE	7-14-55
REV	A
DES	A
CONTROLLER	C
CLASS	8920
TYPE	AGI
MANUFACTURER	SQUARE D COMPANY
INDUSTRIAL CONTROLLER DIV. 100	
MILWAUKEE, WISCONSIN, U.S.A.	
APPROVED	
SCALE	

4432-C1

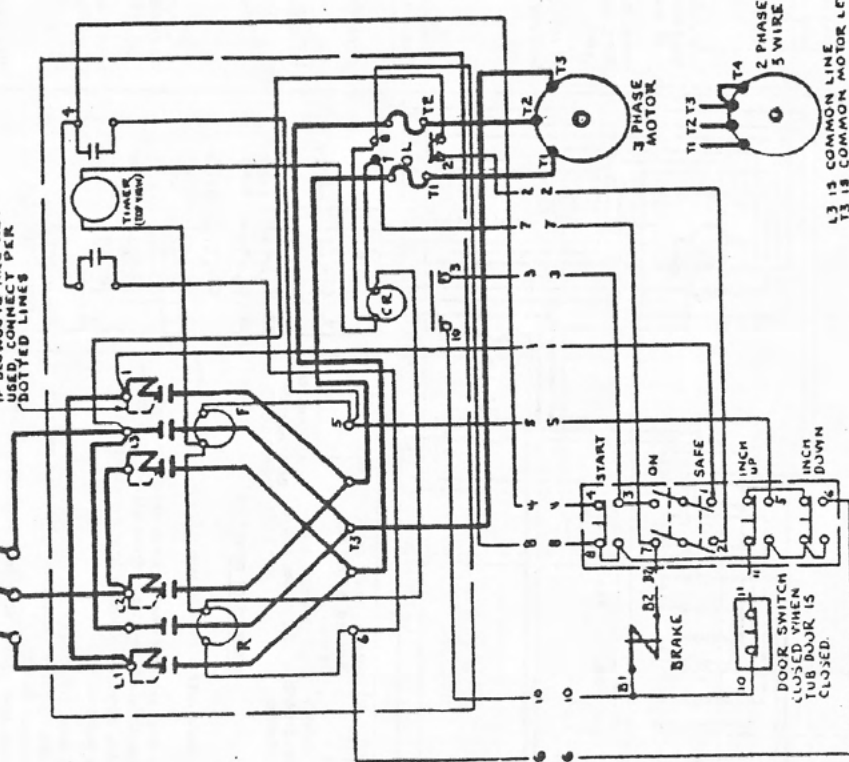
112581 D2

FRONT VIEW DIAGRAM

L1 L2 L3
USE A CUTLER-HAMMER
SAFETY SWITCH WITH
THIS CONTROLLER.
GET IT FROM YOUR
ELECTRICAL SUPPLIER.
IF BLOWOUTS ARE NOT
USED, CONNECT PER
DOTTED LINES

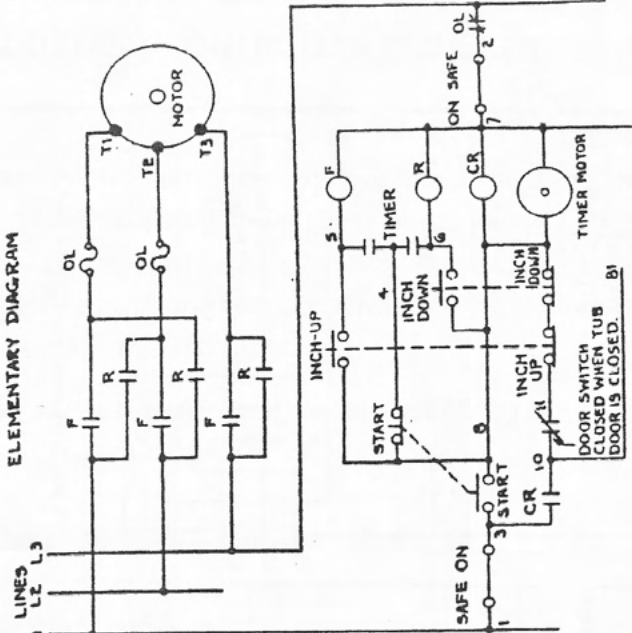
CONTACTORS "F" AND "R" ARE
MECHANICALLY INTERLOCKED

CONNECTION IS WIRE
BUT 102.50 PLSA
BUT TO 102.50 PLSA



L3 IS COMMON LINE
T3 IS COMMON MOTOR LEAD.

ELEMENTARY DIAGRAM



CONNECTIONS FOR REVERSING WASHER CONTROLLER - 3 WIRE CONTROL - 2 WAY INCH

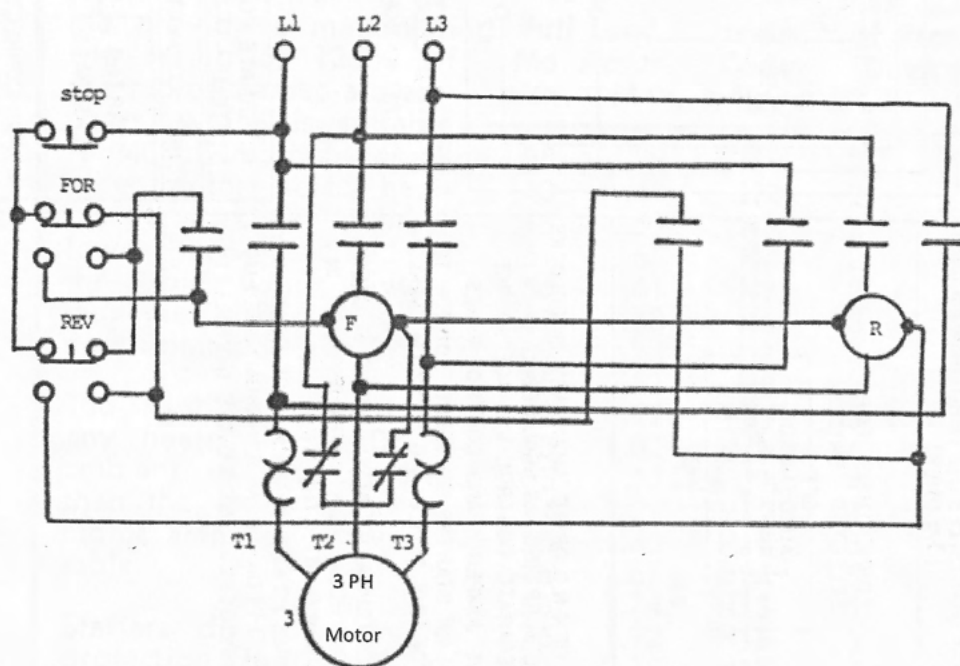
A	MC 100	DESIGNED BY E.A. SCHUBERT	12-19-44	ORDER NO. C481754A
B	MC 100	DESIGNED BY E.A. SCHUBERT	1-22-45	REV. NO. 9597 SILENCE
C	MC 100	DESIGNED BY E.A. SCHUBERT	12-18-44	REV. NO.
D	MC 100	DESIGNED BY E.A. SCHUBERT	12-18-44	REV. NO.
E	MC 100	DESIGNED BY E.A. SCHUBERT	12-18-44	REV. NO.
F	MC 100	DESIGNED BY E.A. SCHUBERT	12-18-44	REV. NO.

CUTLER-HAMMER, INC.

INDUSTRIAL CONTROLLER #3

Wire the two motor starters given to you by your instructor in such a way as to give forward and reverse control for a three-phase motor. In this project you will connect a motor to the starters. Modify wiring of the two starters in such a way that the wiring will match that in the diagram below.

This is an example of a basic element diagram.



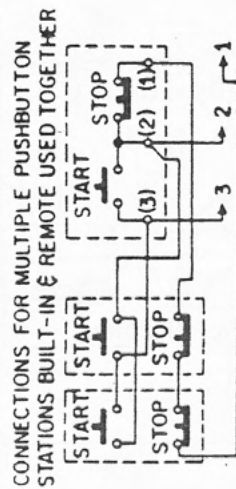
HAVE YOUR INSTRUCTOR CHECK EACH CIRCUIT!!

- Connect up the Forward Reversing Motor Controller – (ITE)
- Connect up the Forward Reversing Motor Controller – (Square D)
- Connect up the Forward Reversing – (Westinghouse)
- Connect up the Forward Reversing– (Furnass)
- Connect up the Forward Reversing– (Sylvania)
- Connect up the Forward Reversing Motor Controller – (Allen Bradley)

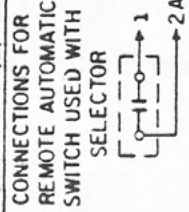
THREE PHASE MAGNETIC STARTER

USE COPPER WIRE ONLY. FOR AL. WIRE SEE NOTE 4.

MODIFICATIONS KITS		PART NO.	MODIFICATIONS KITS		PART NO.
AUXILIARY CONTACT	N.O.	49D54682NO	START-STOP	PUSHBUTTON	50D54688
	N.C.	49D54682NC	HAND OFF AUTO.	SELECTOR SWITCH	50D54773
TANDEM MOUNTING FOR ABOVE		49L106889	PILOT LIGHT	(120,240,480&600V)	50D24999
TIMER		55AA14	POWER P.O.E	N.O. (SIZES 00 THRU 1 3/4 ONLY)	49B25132NO
ALUM. WIRE LUGS SIZES 00,0.1		49L106726ABC			



REMOTE STATIONS BUILT-IN STATION
SEE NOTE (3) WHEN REMOTE



CONNECTIONS FOR
REMOTE 2 WIRE
CONTROL

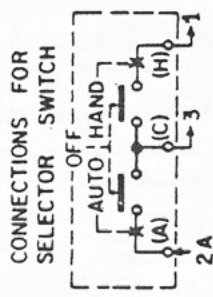


FURNAS FLECTRIC COMPANY



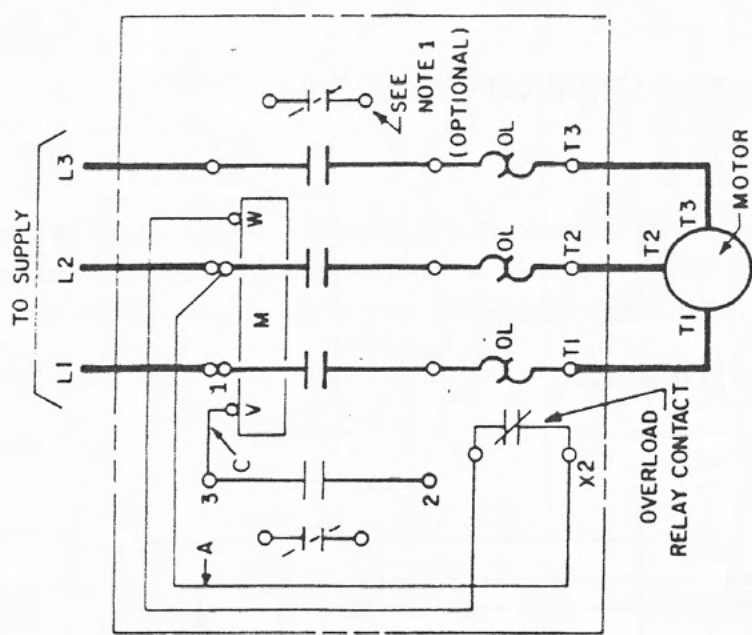
11/11/11 11:11:11

D24863



NOTES

- 1-A MAX. OF 4 N.O. OR N.C. AUXILIARY INTERLOCKS MAY BE SUPPLIED AS REQUIRED.
- 2-FOR SEPARATE CONTROL VOLTAGE SOURCE REMOVE JUMPER 'A' AND CONTROL WIRES FROM '1' ON STARTER. CONNECT SOURCE TO '1' ON CONTROL DEVICE AND TO 'X2' ON OVERLOAD RELAY.
- 3-WHEN EXTERNAL CONTROL WIRING IS USED THE CONTROL CIRCUIT MUST BE FUSED IN ACCORDANCE WITH THE N.E.C.
- 4-ALUMINUM POWER WIRES MAY BE USED ONLY ON SIZE 1³/₄ OR WHEN ALUMINUM WIRE LUG KITS 49L106726A, B OR C ARE INSTALLED.



ALTERNATE POWER SYSTEM 		SINGLE PHASE		TWO PHASE FOUR WIRE				
LINE CONNECTIONS		L1	L2		L1	L2	L3	L4
STARTER TERMINALS	LINE	L1	L2	L3	L1	L2	L3	                        

**NOTE: TWO PHASE 4 WIRE SYSTEMS REQ JIRE ADDITION
OF POWER POLE KIT 49HD25132 FOR BREAKING
ALL LINES (SIZES 00 THRU 1³/₄ ONLY)**

FURNAS ELECTRIC COMPANY, BATAVIA, ILLINOIS

CATALOG NUMBER

14BF32AC

MAGNET COIL RATING

240/480

60

VOLTS

HERTZ

INSPECTED

**H "Standard Trip" HEATER ELEMENTS
FOR MELTING ALLOY RELAYS**

Heaters shown in the table provide a maximum trip rating of 125% of the motor nameplate amperes, which is suitable for 40° C motors. For all other motors select heaters one code number lower than specified in the table, which give a maximum trip rating of approximately 115%.

The tripping current of any heater in a 40° C ambient is 25% greater than the lower value of motor amperes shown in table.

Starters do not provide protection from short circuits. A protective device should be provided in accordance with the N.E.C. (C.E.C. in Canada) and not exceed the values shown in the table.

PROTECTIVE DEVICE:

*Fuse or inverse time circuit breaker. Fuses above 600 amps are Class "L".

†Instantaneous trip circuit breaker.

Full Load Mo. Amps.		Heater Code No.	Max. Rat. of Prot. Device * †
Min.	Max.		
.35	.39	H1	2
.40	.44	H2	2
.45	.50	H3	2
.51	.55	H4	2
.56	.61	H5	2
.62	.68	H6	3
.69	.74	H7	3
.75	.82	H8	3
.83	.92	H9	3
.93	1.02	H10	4
1.03	1.13	H11	4
1.14	1.29	H12	4
1.30	1.45	H13	5
1.46	1.57	H14	5
1.58	1.74	H15	6
1.75	1.92	H16	6
1.93	2.18	H17	8
2.19	2.34	H18	8
2.35	2.62	H20	10
2.63	2.97	H21	10
2.98	3.25	H22	12
3.26	3.60	H23	12
3.61	4.00	H24	15
4.01	4.50	H25	15
4.51	5.10	H26	20
5.11	6.32	H28	25
6.33	6.81	H29	25
6.82	7.69	H30	30
7.70	8.54	H31	30

ALLEN - BRADLEY

FORWARD-REVERSE MOTOR CONTROLL

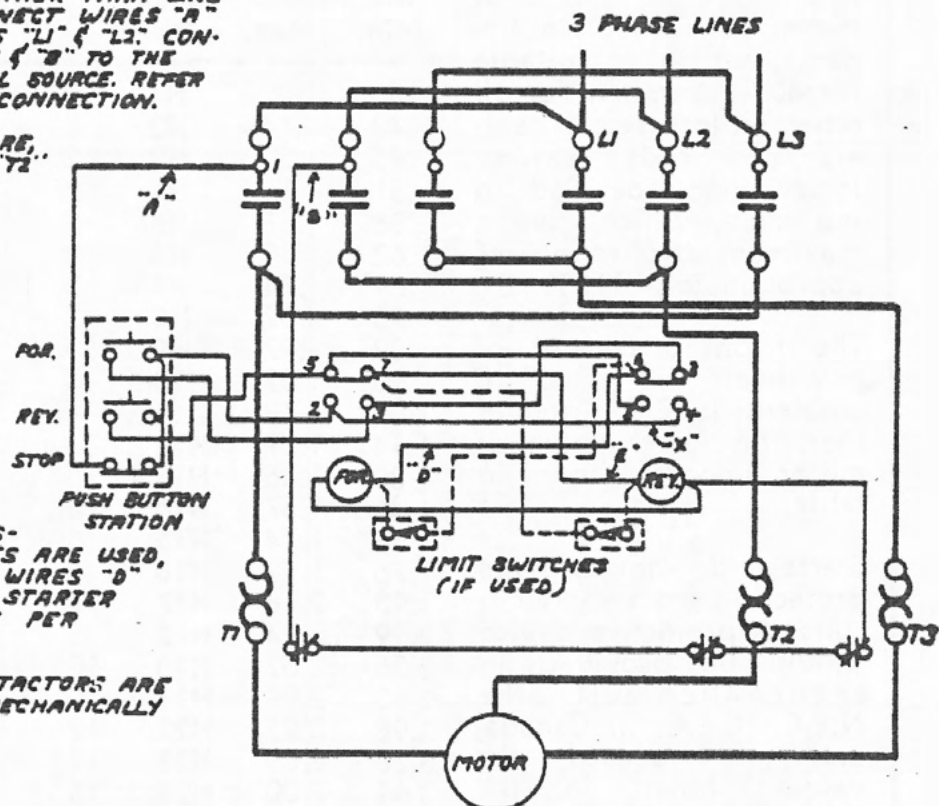
Connect up this controller and make it function properly. Connect up two sets of push buttons.
Connect up two limit switches forward and reverse operations.

- SEP. CONTROL NOTE -
IF THE SWITCH COIL IS TO OPERATE
ON A VOLTAGE OTHER THAN LINE
VOLTAGE, DISCONNECT WIRES "A"
& "B" FROM LINES "L1" & "L2". CON-
NECT WIRES "A" & "B" TO THE
SEPARATE CONTROL SOURCE. REFER
TO N.E.C. FOR DISCONNECTION.

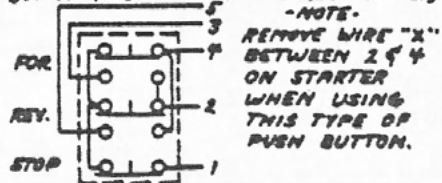
- NOTE -
FOR 2 PHASE, 3-WIRE,
TERMINALS "L2" & "T2"
ARE THE COMMON.

- NOTES -
IF LIMIT SWITCHES ARE USED,
REMOVE CONTROL WIRES "D"
& "E" FROM THE STARTER
AND CONNECT AS PER
DOTTED LINES.

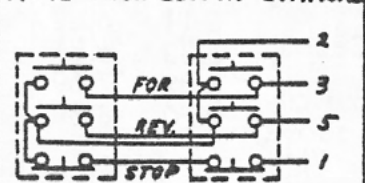
"FOR." & "REV." CONTACTORS ARE
ELECTRICALLY & MECHANICALLY
INTERLOCKED.



CONNECTIONS FOR N.D. TYPE PUSH
BUTTON (ELECTRICAL INTERLOCK AT A.B.)



CONNECTIONS FOR 2 OR
MORE PUSH BUTTON STATIONS



X-80586

BULLETIN 705, SIZE —, STYLE RT, TYPE —, A.C. REVER. SWITCH

ALLEN-BRADLEY CO.

MILWAUKEE

WISCONSIN

MADE IN U.S.A.

MOTOR CONTROL PROJECT #4

Wire two motor starters and two motors to start one after the other. Use one start stop station and a 24-volt solid-state timer.

Push start button and a #1 motor starts, after a time motor #2 starts. Stop button will stop all Motors. Use the voltage and components you need to make this circuit operate. Draw a schematic diagram first **and have your instructor check it before you wire it up.**

MOTOR CONTROL PROJECT #5

2 Motors on conveyor belt. Motor #1 starts first then motor #2 starts. On stopping motor #2 stops first, then motor #1 stops. Each motor will be on a timer. Motor #2 is starting and motor #1 is stopping.

Draw the schematic diagram of the circuit and **have your instructor check it before wiring it up.**

Use any relays or motor starters you want or that your instructor including the solid-state timers. The timer should be 110 VAC.

MOTOR CONTROL PROJECT #6

Use a solid-state relay to start and stop a single-phase motor. "Turn on a light."

Use a Prusser switch for the control. The relay should be a 24-volt DC really to control the 120-volt AC motor.

Draw the circuit.

Have your instructor check it.

TROUBLE SHOOTING

Polyphase Stator Troubles

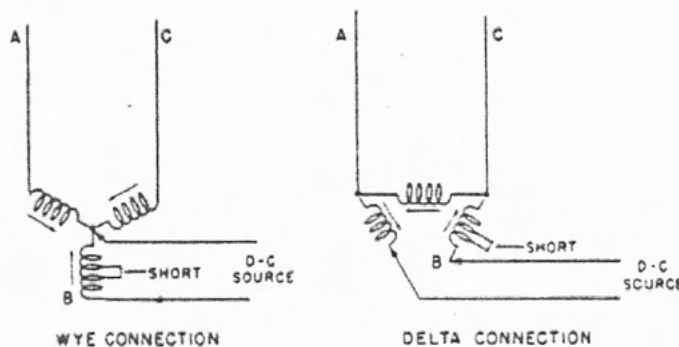
The method of locating and correcting the common troubles encountered in rewound and reconnected polyphase stator windings are included for convenience.

SHORTED POLE-PHASE GROUP

An entire pole-phase group maybe shorted in a polyphase stator. Such a defect is usually indicated by excessive in the defective part. The trouble can be readily located by a compass test. To conduct a compass test, excite the stator windings with a low-voltage, direct current that will set up the poles in the stator (figure 1). When the windings are excited, a compass is moved around the inside circumference of the stator core. As each pole group is approached, the polarity is indicated by the compass. There should be the same number of alternate north and south poles in a 3-phase winding.

In testing a 3-phase, wye-connected winding (Figure 1A), test each phase separately by impressing the D.C. voltage successively on each of the phase leads and the midpoint of the wye connection. If there no trouble in the winding, the compass will indicate alternately north and south for each pole-phase group around the stator. If a complete pole-phase group is shorted, the compass needle will not be deflected at this point.

In testing a 3-phase delta-connected winding (Figure 1B), open one of the delta connections and apply the direct current to the winding. The current will flow through the three-phase in series. If the pole-phase groups are connected properly, the compass will indicate alternate north and south poles around the stator frame. As in the wye-connected winding a shorted pole-phase group is indicated by no deflection of the compass needle.



A B
Compass test for shorted pole-phase groups.

Figure 1

SHORTED PHASE

When an entire phase of a phase 3 winding is shorted, the defect is most readily located by balance-current test made with an industrial analyzer. This test can also be made with an ammeter in a low voltage a.c. source (figure 2).

In testing a 3-phase wye-connected winding (figure 2A), test each phase separately by impressing the a.c. voltage successfully on each of the phase leads and the midpoint of the wye connection. If there is no trouble in the windings, and if the impedance of the winding of each phase is the same, the ammeter will indicate approximately the same value of current for each of the 3 phases. If one phase is shorted, the ammeter will indicate a higher current reading for this phase than those of the other two phases because the impedance is less.

In testing of 3 phase Delta connected winding (figure 2B), open each Delta connection and test each phase separately. As in the wye-connected winding, the short phase will be indicated by a much higher current reading on the ammeter.

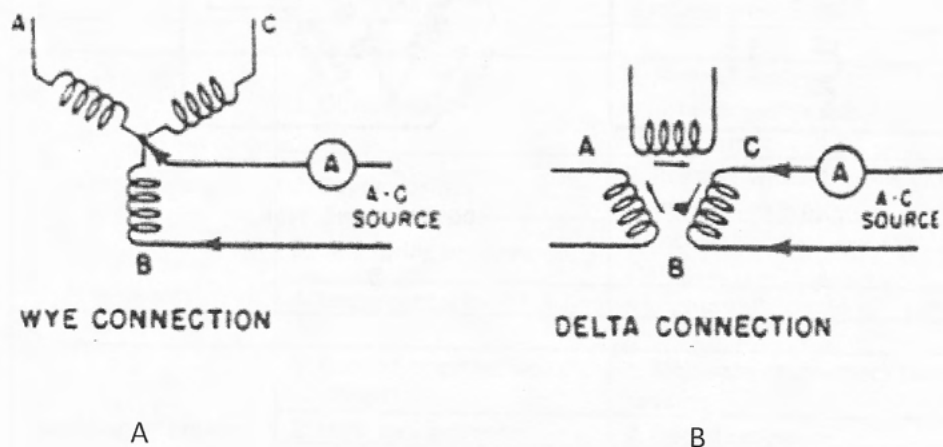


Figure 2

OPEN CIRCUITS:

An open circuit in a 3-phase winding can be readily located by means of ohmmeter (figure 3).

In testing a 3-phase wye connected wiring (figure 3A), connect the ohmmeter leads across each of the phases to locate the defective phase. When the ohmmeter leads are placed on terminals A and C, no open circuit (a low reading) is indicated. However, when the leads are placed on terminals C and B, then on terminals B and A, an open circuit (a high reading) is indicated in both positions, thus denoting an open in phase B. After the defective phase has been located, test each stub connection of the pole-phase groups with the ohmmeter until the open coil is located. In testing a 3-phase, Delta-connected winding (figure 3B), it is necessary to open one Delta connection to avoid shunting the phase being test. Test each phase separately until the open is located. After the faulty phase is located, test each stub connection of the pole-phase groups, as in the wye-connection, until the open coil is located.

If the windings are parallel, it is necessary to open each parallel group and test each group separately.

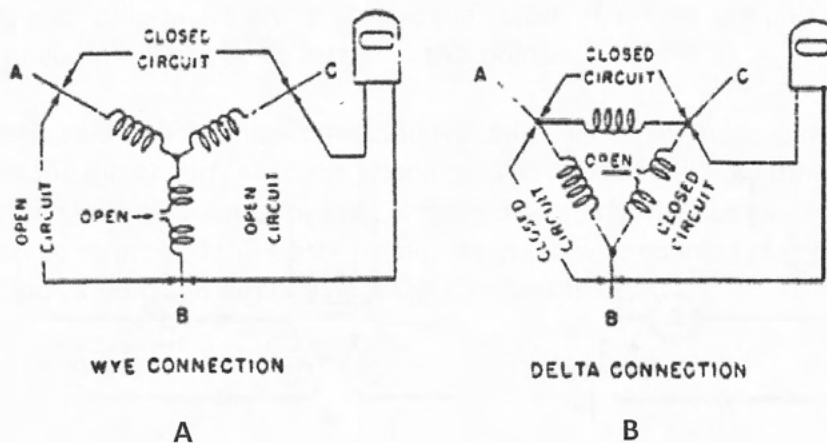


Figure 3

CONTROL TROUBLESHOOTING

Although the companies maintain a policy of preventing trouble, sometimes trouble is unavoidable. General, when a controller fails to operate, or signs of trouble (heat, smoke, smell of burning insulation, etc.) occur, the cause of the trouble can be found by conducting an examination that consists of nothing more than using the sense of feel, sight, and sound. On other occasions, however, locating the cause of the problem will involve more detailed actions.

Troubles tend to gather around mechanical moving parts and where electrical systems are interrupted by the making and breaking of contact. Center your attention in these areas. see (Table 1) for a list of common trouble, their causes, and corrective action.

TROUBLE	CAUSE	CORRECTION
Burnouts	1. Short circuits or grounds*	1. Remove grounds or shorted conditions
	2. Overheating	2. Increase low contact pressure, remove dirt, oil or grease, remove oxides or sulfides
	3. Slow "breaking"	3. Eliminates bind
	4. Low lead dimension	4. Renew contacts
	5. Excessive lead dimension	5. Reduce lead dimension
Excessive Wear	1. Excessive jogging or inching	1. Do not jog or inch controllers unnecessarily
	2. Faulty blowout assembly or arc shield	2. Replace or repair blowout coil, eliminate shorted turns
	3. Excessive overloads*	3. Eliminate cause-check current readings
	4. Slow "breaking"	4. Remove bind of parts
	5. Excessive filing	5. Do not dress or file the contacts unnecessarily
Overheating	1. Oil or grease	1. Remove with a cloth moistened with methyl chloroform
	2. Copper oxides	2. Remove with a fine file or 00 grade sandpaper
	3. Low spring pressure	3. Increase pressure or replace spring
	4. Loose contacts	4. Tighten
Welding or Sticking	1. Ground or excessive overload*	1. Eliminate cause-check current reading
	2. High spring pressure	2. Reduce pressure
	3. Low voltage	3. Increase
	4. Slow "making" or bind	4. Remove bind
Excessive Arching or Sputtering	1. Short circuit or ground	1. Remove grounded or shorted circuit
	2. Binding parts	2. Eliminate bind of parts
	3. Faulty blow out assembly	3. Replace or repair blowout coil, eliminate shorted turns
	4. Excessive lead dimension	4. Reduce to increase contact gap
* WARNING: Short circuits or grounds in the associated equipment necessitates a thorough inspections of the controller, as the contacts may be damaged by these conditions.		

TROUBLE-SHOOTING MALFUNCTIONS IN MOTOR STARTERS

PROBLEMS	POSSIBLE CAUSE	SOLUTION
MAGNETIC AND MECHANICAL PARTS		
Noisy magnet (humming)	Misalignment or mis-mating of magnet pole faces	Realign replace magnet assembly.
	Foreign matter on pole face (dirt, lint, rust, etc.)	Clean (but do not file) pole faces and realign if necessary.
	Low voltage applied to coil	Check system and coil voltage. Observe voltage variations during startup time.
Loud Buzz	Broken shading coil	Replace shading coil and/or magnet assembly.
Fail to pick up or seal in	Low voltage	Check system voltage, coil voltage, and watch for voltage variations during start.
	Wrong magnet coil or wrong connection	Check wiring coil nomenclature, etc.
	Coil open or shorted	Check with an ohmmeter and when in doubt replace.
	Mechanical obstruction	Disconnect power and check for free movement of magnet and contact assembly.
Failure to drop out	"Gummy" substance of pole faces or magnet slides	Clean with nonvolatile solvent, degreasing fluid, possibly gasoline (with caution).
	Voltage to coil not remove	Shorted seal-in contact (exact cause found by checking coil circuit).
	Worn or rusted parts causing binding	Clean or replace worn parts
	Residual magnetism due to lack of air gap in magnet path	Replace any worn magnet parts or accessories.
CONTACTS		
Contact Chatter (source probably from magnetic assembly)	Broken shading coil	Replace assembly
	Poor contact continuity in control circuit	Improve contact continuity or use holding-circuit interlock (3-wire control).
	Low voltage	Correct voltage condition. Check momentary voltage dip during start.
Welding	Abnormal inrush of current	Use larger contactor or check for grounds, shorts, or excessive motor load current.

TROUBLE-SHOOTING MALFUNCTIONS IN MOTOR STARTERS

PROBLEMS	POSSIBLE CAUSE	SOLUTION
<u>PUSH BUTTONS</u>		
Button inoperable. (Mechanically)	Shaft binding due to dirt or residue	Check, clean and clear.
	Contact board spring broken	Replace contact board
(Electrical)	Contaminated contacts and corrosion	Clean
	Excessive jogging	Install larger device or check rated for jogging or caution operator.
	Weak contact pressure	Replace contact springs; check contact carrier for deformation or damage.
	Dirt or foreign matter on contact surface	Clean contacts with nonvolatile solvent.
	Rapid jogging	Install larger device rated for jogging service or caution operator.
	Insufficient tip pressure	Replace contact springs; check contact carrier for deformation or damage.
	Low voltage preventing magnet from sealing	Correct voltage condition. Check momentary voltage dip during starting.
	Foreign matter preventing contacts from closing	Clean contacts with nonvolatile solvent. Contactors, starters, and control accessories used with small current or low voltage should be cleaned so well to remove the solvent residue.
	Short circuit	Remove short fault and check to be sure fuse or breaker size is correct.

TROUBLE-SHOOTING MALFUNCTIONS IN MOTOR STARTERS

PROBLEMS	POSSIBLE CAUSE	SOLUTION
OVERLOAD RELAYS		
Nuisance Tripping	Sustained overload	Check for motor or electrical equipment grounds and shorts, as well as excessive motor currents due to overload. Check motor resistance to ground.
	Loose connections	Clean connections and tighten. This includes load wires and heater element mounting screws.
	Incorrect heater	Check heater sizing and ambient temperature.
Failure to trip out, (Causing motor burnout)	Mechanical binding, dirt, corrosion, etc.	Clean or replace.
	Incorrect heater or heaters omitted, and jumper wires used instead	Recheck ratings and heater size. Correct if necessary.
	Wrong calibration adjustment	Consult factory, calibration adjustment is not normally recommended unless factory supervised. It is customary to return units to factory for check and calibration.
MANUAL STARTERS		
Failure to operate, (Mechanically)	Mechanical parts, including springs, worn or broken.	Replace parts as needed
	Welded contacts due to misapplication or other cause.	Replace contacts and recheck operation.
Trips out prematurely	Motor overload, incorrect heaters or misapplications	Check conditions and replace or adjust as needed.

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	Welded contacts due to misapplication or other cause.	Replace contacts and recheck operation.
Trips out prematurely	Motor overload, incorrect heaters or misapplications	Check conditions and replace or adjust as needed.
Short contact life or overheating	Filing or dressing	Do not file silver contacts. Rough spots or discoloration will Not harm them or impair their efficiency.
	Interrupting excessively high currents.	Install larger device or check for grounds, shorts, or excessive motor currents.
NOTE: Any contact replacement should include a complete set, replacement includes support springs, screws, etc.		

TROUBLE-SHOOTING MALFUNCTIONS IN MOTOR STARTERS

PROBLEMS	POSSIBLE CAUSE	SOLUTION
<u>COILS</u>		
Open circuit	Mechanical damage	Handle and store coils careful
Cooked coils (overheated)	Overvoltage of high ambient temperature	Check application and circuit. Coils will operate over a range of 85% to 110% rated voltage.
	Incorrect coil	Check rating and if incorrect replace with proper coil.
	Shorted turned caused by mechanical damage or corrosion.	Replace coil.
	Undervoltage, failure to magnetize and to seal.	Correct system voltage.
	Dirt or rust on pole faces, increasing air gap.	Clean pole faces.
	Sustained low voltage	Remedy according to local code requirements, low voltage system protection, etc.
	Short circuits	Remove short, fault and checks be sure fuse or breaker size is correct.
	Loose connection	Clean and tighten
	Sustained overload	Install larger device or check for excessive motor load current
	Excessive wear	Higher than normal voltage Cause unnecessary force that may result in mechanical wear.
Contacts, supports, discoloring	Loose connections	Tighten hardware or replace.

TROUBLE-SHOOTING QUESTIONS:

1. What are the most common troubles you would find in a motor starter contacts?

Explain: _____

2. What are the most common troubles you would find in a motor starters Magnetic & Mechanical circuit?

Explain _____

3. What are the most common troubles you would find in a motor starter Push circuit?

Explain: _____

4. What are the most common troubles you would find in a motor starters Overload Relays?

Explain: _____

5. What are the most common troubles you would find in a motor starters coils?

Explain: _____

6. What are the most common troubles you would find in a motor Manual Starter?

Explain: _____

ELECTRICAL SYSTEM ANALYSIS

When a motor controller system has failed and pressing the START button will not start the system, then press the overload relay reset push buttons and again attempt to start the motor. Observe what happens. The system may start, and operation is restored, or you hear the controller power contacts close, but the motor will not start, or the system may be dead. If you hear the power contacts close, then the power circuit needs to be checked. If the system remains dead, then the CONTROL circuit will have to be checked. An example of troubleshooting a motor control electrical system is given in the sequence of steps may be used in locating a fault figure one. first, we will start by analyzing the power circuit.

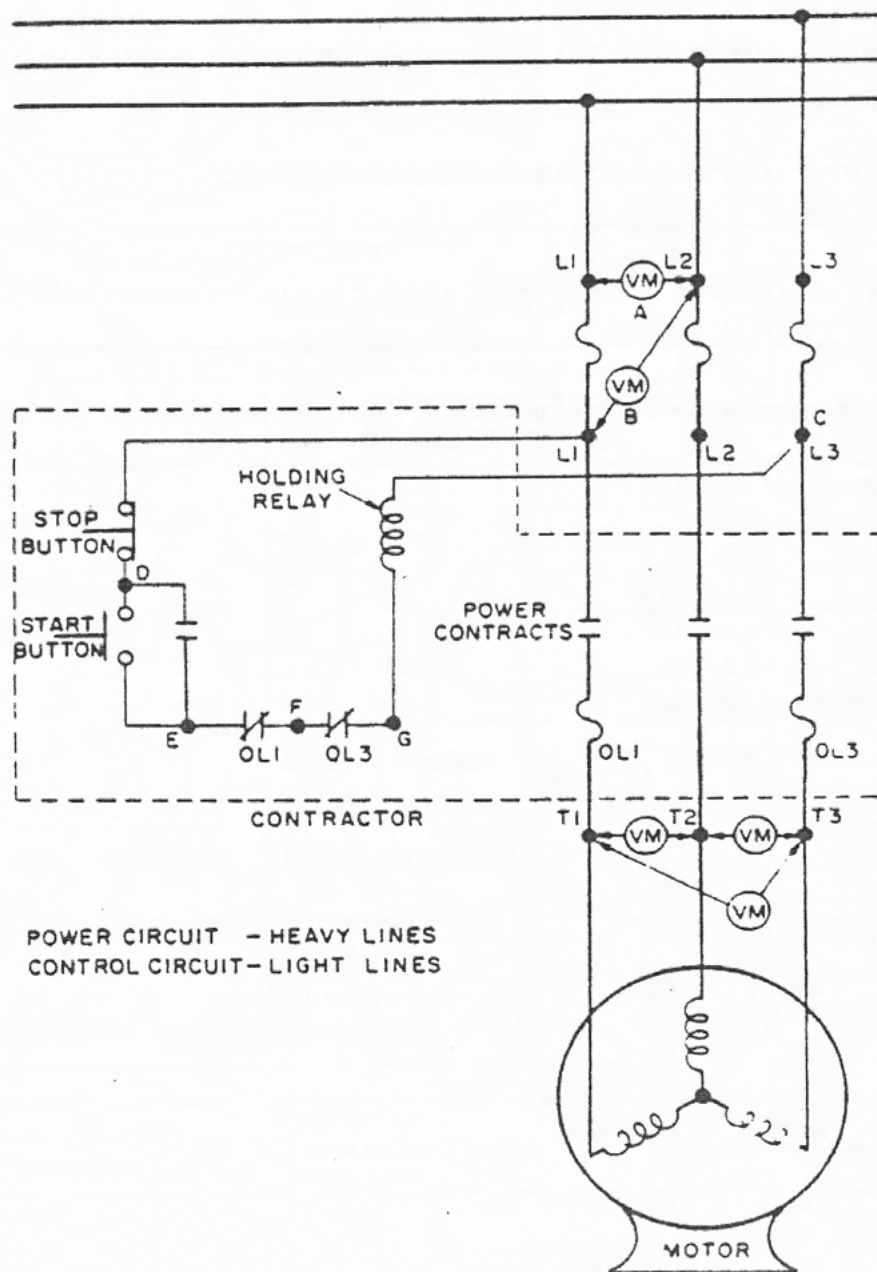


Figure 1

POWER CIRCUIT ANALYSIS

When no visual signs of failure can be located, and an electrical failure is indicated in the power circuit, you must first check the line voltage and fuses as shown in (figure 1). Place the voltmeter prods on the hot side of the line fuses as shown in position "A". A line voltage reading tells you that your voltmeter is operational and that you have voltage to the source side of the line fuses L1 - L 2.

You may also check between L1 - L3 and L2 - L3. To check the fuse in line one, place the Voltmeter across the line fuse as shown in position "B" between L1 - L 2. Voltage reading shows a good fuse in L1. Likewise, check the other two fuses between L1 - L3 and L2 - L3. A no voltage reading would show a faulty fuse.

If the line fuse checks good, then check the voltage between terminals T1 -T2, T2 - T3 and T1-T3. The controller is faulty if there aren't voltmeter readings on all three of the terminal pairs and you would then proceed to check the power contacts, overloads and lead connections within the controller. However, if voltage is indicated at all 3 terminals, then the trouble is either in the motor or lines leading to the motor.

CONTROL CIRCUIT ANALYSIS

Suppose the overload reset buttons have been reset in the start switch closed. If the power contacts do not close, then the control circuit must be checked. A testing procedure follows.

1. Check for voltage at the controller at lines L1, L2 and L3.
2. Place the voltmeter probe at point C and D (figure 1). You should have a voltage reading when the STOP switch is closed and have a non-voltage reading when the STOP switch is open. The conditions would indicate a good STOP switch.
3. Next, check the voltage between points C and E. If you get a no-voltage reading when the START switch is open any voltage reading when the START switch is closed, then the START switch is good.
4. Place the voltmeter probe at C and F. A voltage reading with the START button closed would indicate a good OL1, but would also indicate an open OL3, an open relay coil, or an open connection to line-3.
5. Please the Voltmeter probe at point C and G and close the START switch. A no-voltage reading locates the trouble in the control circuit; the OL3 is faulty.

A faulty holding relay contact will be indicated when the system operates only as long as the START push-button switch is held in the ON position, but will shut down the system when the switch is released.

When a 3-phase system shuts down and you here a.c. hum in the motor, you should secure the system immediately by pushing the STOP switch. This means that one of the phases in the motor is not being energized. It can be assumed that the control circuit is good since it is holding the power contacts closed and that the trouble is in the power circuitry.

In summary, troubleshooting is nothing more than a series of steps that lead to the isolation of a faulty component, a loose connection, broken lead, ETC. With each step you eliminate a section of the circuit as being good or bad.

Now that you understand troubleshooting – **TROUBLESHOOT MOTOR CONTROL PANEL #1**

TROUBLE SHOOTING TEST #1

Wall Board

Now that you have connected up mini motor controllers and understand their operations, you are to do some troubleshooting.

On the troubleshooting panel there are 6 switches, by turning on one switch at a time, it will put different types of trouble on the motor N motor controller. Use only a "Wiggie" voltage tester.

List what you think the trouble is for each switch, in what you would do to solve the problem, or to fix the trouble. Give details and Explain:

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

CONTROL CIRCUITS GROUNDING

Article 430-F paragraph 430-73 of the NEC states "When one side of the control circuit is grounded, the control circuit shall be so arranged that an accidental grounding in the remote-control devices will not start the motor."

QUESTION: What would be the interpretation of the above statement in regard to the line voltage control circuit on 480/277 Volt grounded WYE power system?

Explain: _____

Are there special precautions on this type of power system? Explain: _____

Possible violation of section 430/73 of the NEC would really late only 2 a grounded control circuit. When a controller is connected to a 480/277-volt system, the control circuit would have to be a on 277 volts in order to come with in the intent of this section.

The starting of a motor or the pulling in of a magnet contactor controlling a motor as the result of an accidental ground in a remote-control device of a control circuit using a grounded leg is foolish. It is certainly not commonplace. Accomplish this kind of hazardous condition would require unusual and unlikely circuitry. There may be some special circuitry for control to which I have not been exposed; discounting this, the only way a grounded control circuit could get into trouble where an accidental ground would cause the control to pull in, would be with a circuit as shown in (figure 1).

The holding in of contact are as the result of an accidental ground is also an unsafe condition. This holding of the coil with an accidental ground on an ungrounded control circuit is possible on "normal" or "standard" type circuitry. The "holding-in-voltage" could be about 58% of regular "pull-in-voltage". This of course, would occur with the Wye systems such as 120/208 volts and 277/480 volts where the coil is connected line to line and becomes accidental line to neutral. Because of the impedance in the control circuit and the large size overcurrent devices so commonly used and Code permitted in the control circuit, the overcurrent device may not function to clear the circuit as the result of an accidental ground. See (figure 2).

There is another accidental ground concern on these control circuits. This is a condition ignored by most design and installation people where an accidental ground could bridge out and void the thermal devices in this circuit. This is shown in (figure 3). A revise circuitry and easy change would prevent this problem see (figure 4).

L1

L2

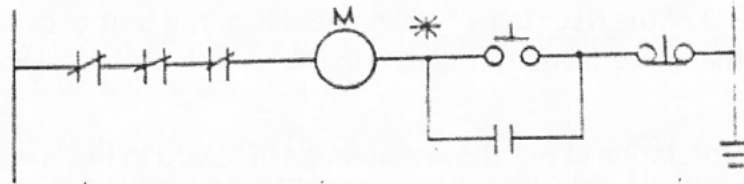


FIGURE 1

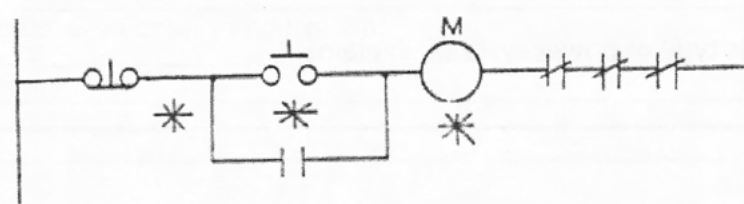


FIGURE 2

• GROUND AREA PROBLEM

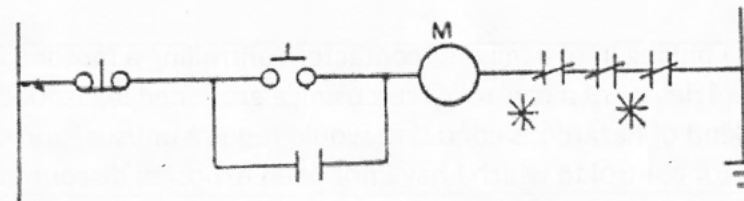


FIGURE 3

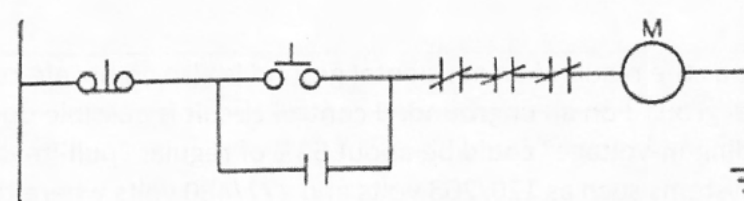


FIGURE 4

1. Should the control circuit be grounded? _____
2. What side of the control circuit, (L1 – L2), should be grounded? _____
3. Will an accidental ground cause the controller to pull in?
(in Figure 1) (ground at star). _____
4. Is a ground more likely to occur in the push buttons (control circuit) or in the starter?
Explain: _____

TROUBLE SHOOTING #2

On the panel we have a motor starter, a heater, and a start-stop station.

Check out the circuit and see how it is wired. If it is O.K., then apply power and check the circuit.

WHAT IS THE TROUBLE?

Explain: _____

OVERLOAD RELAY HEATERS FOR ENCLOSED SWITCH

For use with standard of high reactance squirrel cage motors. When necessary to change heaters, select from table below. For short circuit protection, provide fuses in motor branch circuit in accordance with N. E. Code, but in no case should the fuse rating exceed 3.5 times motor full load current.

For standard continuous rated 40° C rise motors, select heater corresponding to motor ampere rating. This provides approximately 125%. For continuous rated 50° C and 55° C rise in 40° C rise high resistance motors, multiply full load current of motor by .90 and use this value to select a heater. This provides approximately 112% protection. If protection is wanted at approximately 140% of rated motor current, use one size larger heater.

Heater No.	Motor Amps.		Heater No.	Motor Amps.	
	Minimum	Maximum		Minimum	Maximum
42001	.77	.86	42011	4.1	4.5
42002	.89	.98	42012	4.7	5.2
42003	1.10	1.21	42013	5.6	6.3
42004	1.22	1.34	42014	6.7	7.3
42005	1.35	1.48	42015	7.4	8.1
42006	1.50	1.78	42016	8.3	9.1
42007	1.95	2.18	42017	9.2	9.9
42008	2.19	2.44	42018	10.0	10.6
42009	2.57	2.86	42019	10.7	11.5
42010	3.25	3.64	42020	11.6	12.7

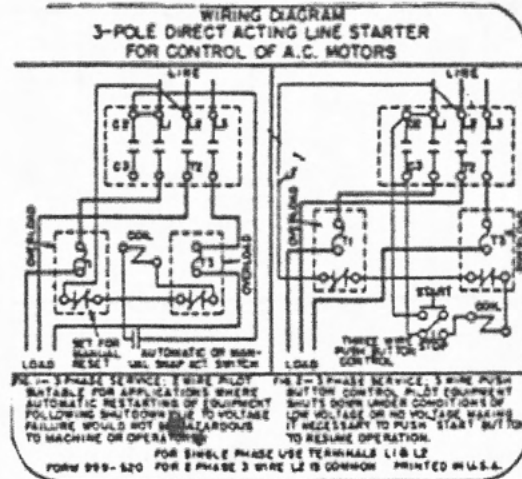
Relay tripping current for 40° C. ambient is minimum value of current listed under "motor amp." multiplied by 1.25.

When the control circuit is operated by a device which remains closed after the thermal overload relay has opened, it is recommended that the overload relay be hand reset. To change type of setting lift and turn lever to setting desired as marked on overload relay adjacent to lever.

Form 999-731

SIZE O ENCLOSED

Printed in U.S.A.



NEMA SIZE O CONTROLLER (GENERAL PURPOSE ENCLOSURE)

TYPE R493B1L1 Notes

COIL CIRCUIT 230 VOLTS 60 CYC.

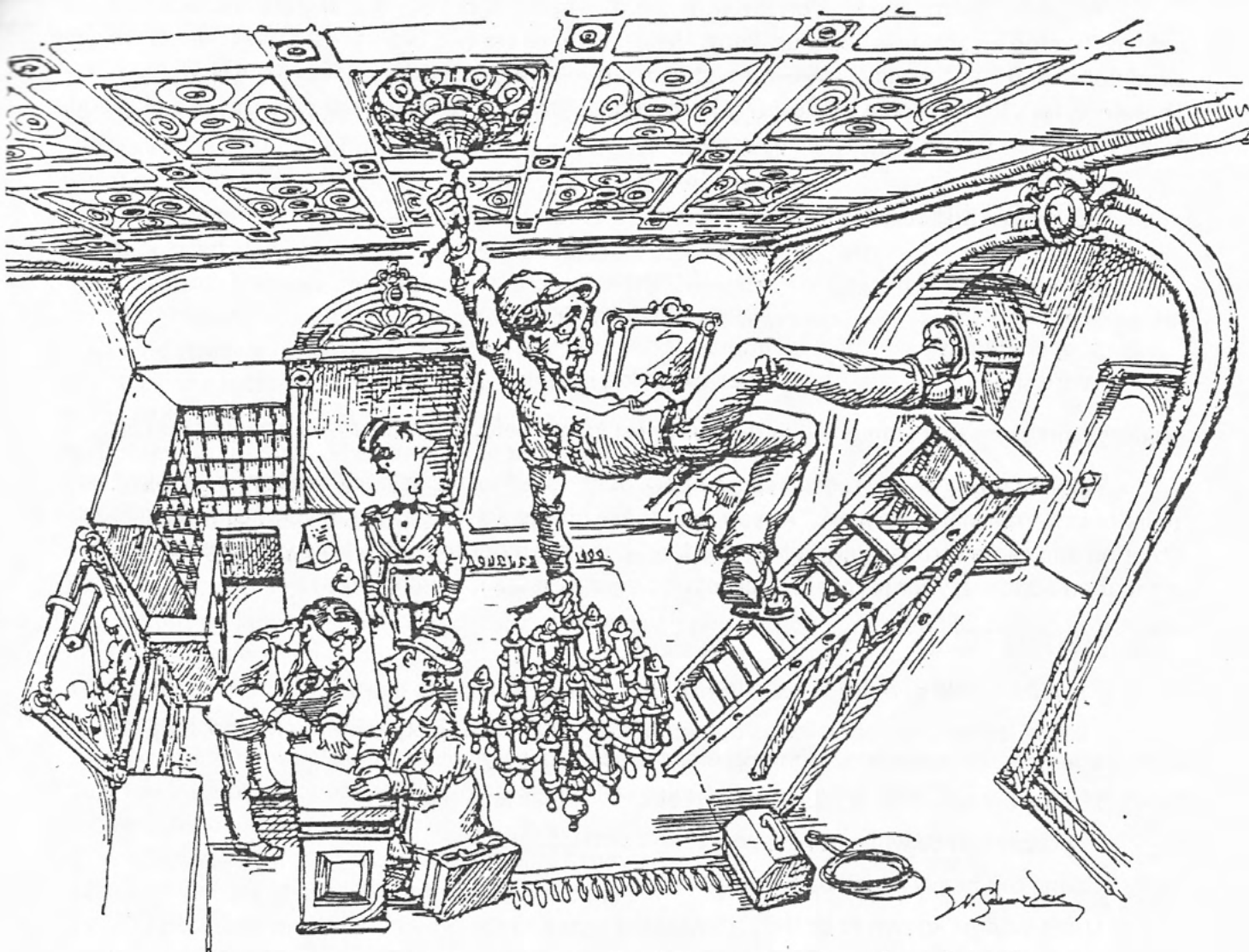
LOAD CIRCUIT ELECTRICAL RATINGS

12.5 AMPERES

1 H. P. 115 V., A.C. SINGLE PHASE
1½ H. P. 230 V., A.C. SINGLE PHASE, 110 V. A.C. POLYPHASE
2 H. P. 220-550 V., A.C. POLYPHASE
Fluct Duty Rating Each Pole Standard Duty 800V. A.C. or Less

MINNEAPOLIS-HONEYWELL REGULATOR CO.

MADE IN U. S. A. WABASH, INDIANA 46786



*Some days in the electrical contracting business,
it's hard to stay on top of things.*

SAFETY WITH LADDERS

Accidents do too are high on the work list. The cause of fall but one of the basic factors is the ladder. To stop an accident, we must know the causes. There are two basic causes of accidents "unsafe conditions" and "unsafe acts". Are interested in stopping these accidental falls from ladders. Therefore, let's look at some of the "unsafe conditions" that can crop up in the normal use of a ladder by an electrician that might cause an accident.

UNSAFE CONDITIONS

Broken Rungs	Metal Ladders
Cracked Rails	Improper ladder for the job
Slippery Rungs	Improper material
Worn shoes	Over-extended ladders

Predominant point that stands out in the above list is that defective ladders are accident makers.

Now let's look at this second cause of accident - the "unsafe acts" of an electrician might be guilty of in his normal days' work. As you read these unsafe acts, recall when you were last in the same situation and came through without an accident, but remember that each time you come through without an accident, your percentage drops and your next fall is coming closer.

"UNSAFE ACTS"

Failure to secure ladder at top or bottom.

Placing ladder unsafely, such as on equipment, near moving equipment on planking over openings, on an incline or on irregular surface.

Placing an extension ladder at too great or too small an angle.

Improper stance while using leverage tools on ladders.

Caring too heavy a load up a ladder.

Using ladders known to be defective.

Straddling a space between a ladder and an object.

Going up or down a ladder with your back to a ladder.

Not opening a step ladder fully.

Working off the top rung or step of the ladder.

And the list could be much longer. To combat these "unsafe conditions" in the electrical industry and "unsafe acts" by the electricians, many people have set it up SAFETY standards to work by. Many states have state SAFETY standards enforced by state laws and inspectors. The National Safety Council has set up SAFETY standards. Standard set up by organizations are minimal. Should local, state or employers SAFETY rules pertaining to any given condition more stringent, the rule that most nearly affects the highest standard of SAFETY should prevail.

The following is a collection of SAFETY rules, practices or standards pertaining to the safe use and care of ladders. Many of which are incorporated in the affirmation SAFETY standards. Make room for as many of them as possible in your work habits.

1. Ladders should be patiently strong for the use intended.
2. Select ladders of the proper length for the work to be done.
3. Examine ladders before use if defective, remove from service for repair.
4. Keep the hands free for use in climbing up and down ladders.
5. Care should be taken to provide the proper devices to meet the conditions in which the ladder is to be used. Such as suction shoes, steel toe, carborundum grips, etc.
6. Barricade the area or position a Workman in front of the ladder when it is necessary to place a ladder in an aisle, driveway, street, sidewalk, or any location where there is possible danger of it being struck by a person or other object.
7. Face the ladder when going up and down.
8. Ladders should always be placed on a secure footing.
9. Heavy loads should not be carried up ladders.
10. Keep ladders clean and free from dirt or paint which may conceal defects, ladders may be protected by clear varnish but not paint.
11. No more than one man should work off any one ladder at any time.
12. Single ladders of over 30 feet in length should not be used.
13. Extension ladders should not consist of more than two sections or exceed 55 feet in length when fully extended.
14. Ladder top should extend at least 32 inches above roof edge, scaffold or beam when it is necessary for electricians to step from the ladder.
15. Extension ladders should have at least three feet overlap between sections when they are extended.
16. The base of a ladder should be placed not less than 1/4 nor greater than 1/3 of its length from the vertical to obtain a safe working angle.
17. When working on a ladder, it should, whenever possible, be secured at the top.
18. Step ladders of over 20 feet should not be used.
19. Do not stand on the top two steps of a step ladder.
20. Step ladders should be fully opened out and locked in position before ascending.
21. A step ladder should not be used as a straight ladder.
22. Before moving a ladder, make sure that there is no person, tools, or material on or beneath it.
23. Portable metal ladders should not be used where electrical hazards are involved.
24. Rolling ladders should be ascended or descended only when they are standing still.
25. Avoid using ladders in a strong wind except in emergency, and then only when they are securely lashed or tied into position.
26. Carry the ladder by placing the upper side rail on the shoulder and the bottom rail resting against the body. Heavy ladders should be carried horizontally in a like manner by two men.

Many electricians have suffered not only fatal falls from ladders, but many have been crippled because some simple SAFETY practice was not followed. Experience has proven that most effective way to reduce accidents is to concentrate on one phase of the accident problem at a time. Therefore, this lesson is devoted to one cause of falls; namely ladder.

QUESTIONS

1. The two basic causes of accidents are:
 - a. _____
 - b. _____
 2. What is the maximum required link of the following ladders?
 - a. Single ladder _____ ft.
 - b. Step Ladder _____ ft.
 - c. Extended extension ladder _____ ft.
 3. How should a ladder be carried by an individual? _____
 4. What is the proper way to ascend and descend a ladder? _____
 5. What precautions are necessary when placing a ladder against a building on the busy sidewalk? _____
 6. What precautions should be taken before moving a ladder question?

 7. Extension ladders should have at least _____ ft overlap between section when extended.
 8. A ladder top should extend at least _____ inches above the roof's edge of a building, when used as access to the roof of the building.
 9. When working on a ladder, it should, whenever possible be _____ at the top.
 10. Keep the _____ free for use in climbing up and down a ladder.
 11. When over-reaching from a ladder, you are heading for a _____.
 12. Do not stand on the top _____ steps of a step ladder.
 13. What is the minimum distance of the base of a 40-foot extension ladder should be set from the wall it is leaning against?
 - a. Minimum _____
 - B. Maximum _____
 14. What is the minimum and maximum distance from a vertical 20 ft. ladder should be placed?
 - a. Minimum _____
 - b. Maximum _____
 15. A step ladder should be fully _____ before climbing.
- ### True and False Statements
16. _____ Ladders should be painted to preserve them.
 17. _____ A ladder is not long enough for the job to be done safely, if the base of the ladder cannot be placed at least $\frac{1}{4}$ the length of the ladder from the vertical surface against which it is leaning.
 18. _____ Straddling a space between a ladder and an object makes for comfortable working.
 19. _____ Step ladders and extension ladders are interchangeable for use.

PERILOUS PASSAGEWAYS

A journeyman electrician and an apprentice were installing emergency lighting unit at a small fabrication plant. They spent most of the day putting up the units in the main part of the plant and then moved into the materials warehouse area. The lighting unit at the far end of the storage room went up fairly quickly, and then the men moved back towards the door of the warehouse to affix the final unit.

The unit was to be mounted approximately 12 feet above the floor, immediately above the double doors into the warehouse area. Noting that the passageway was used as a means of access by the plants forklift operator, the journeyman electricians recognized that there would be a possible hazard when his ladder was placed in the doorway. He made sure that the open doors were blocked so they could not accidentally swing back into the ladder. He also told the apprentice to stand just outside the door in the main plant area and warn any arriving forklift operators that a man was working on a ladder in the doorway.

After they put the ladder in place, the journeyman inclined it and began drilling the mounting holes for the unit. The apprentice stood outside the doorway. Soon thereafter, the journeyman broke his bit. He called down to his helper and asked him to get another one from the toolbox sitting in the warehouse area and throw it up to him.

The apprentice did as he was instructed. But just as he straightened up with the new bit in his hand, he heard the journeyman shout: "I hear a forklift." He raced back toward the doorway to warn the driver. Before he could reach the passageway, the forklift turned the corner and hit the ladder. The journeyman electrician came crashing down breaking a leg and a wrist as he hit the floor.

COMMENTARY: For reasons very clearly illustrated in this unfortunate case, the Occupational Safety and Health Standards include the following ladder safety rules:

"Ladders should not be placed in passageways, doorways, driveways, or any location where they may be displaced by activities being conducted on any other work unless they are protected by barricades or guards."

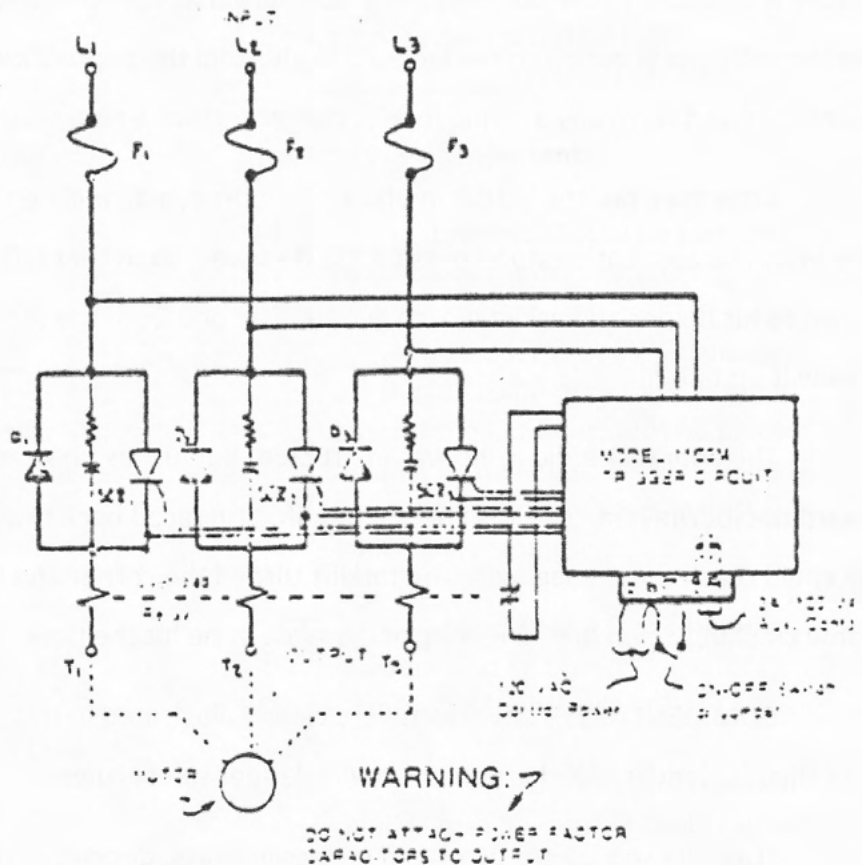
Remember that this important rule is for your safe..... Please observe!

MOTOR CONTROL PROJECT #7
SOLID STATE 3-PHASE MOTOR STARTER
By PAYNE ENGINEERING
MODEL # 11C3M

1. MOUNTING - The 11C3M motor starter is designed to be mounted in and up right, vertical manner to allow for free natural convection cooling. Do not obstruct top and bottom openings. *
2. Connect proper size motor to load terminals only: T1, T2, T3.
3. Connect proper 3-phase power 208 volts to terminals marked L1, L2 and L3. With power on, light marked LINE should be ON. if not check the fuses.
4. CONTROL WIRING:

- a. 120 VAC control power (less than 10 watts) must be applied to terminals 5 and 6. With a jumper on terminal 6 and 7, starter will switch ON in with application of 120 VAC.
- b. TWO WIRE CONTROL – Can be used by wiring an isolated switch across terminals 6 and 7 but only if 120 VAC control power is on terminals 5 and 6.

5. Voltage to motor will be applied within one-half cycle since this control utilizes a zero fired trigger signal to minimize all switching transients. On de-energization of the trigger circuit, the voltage to the motor will be removed within one-half cycle at current zero for each phase.



3. If a fuse blows in this unit, the motor size and/or the connected load is too large. Select a smaller motor or a larger starter. **DO NOT SUBSTITUTE INCORRECT FUSES.**

7. If overload relay trip, check your heater size vs. motor load. The standard NEMA type overload relay uses standard heaters. The overload relay is not a solid-state device.

MAXIMUM Amb. Temp. = 50°

NOTE: This device is fully warranted for 12 months from the date of purchase. Occasional load faults will not harm semiconductors providing are recommended fuses are used. Any do's substitution or unauthorized modification voids all warranties.

8. **AUXILIARY CONTACT:** Dry contact normally open (NO) rated 2A @ 120 VAC. 11C3M 3Ø Motor Starter wire to control terminals 8 and 9.

PLEASE NOTE: The Auxiliary contact will operate as soon as the control circuit is closed.

9. STARTING VOLTAGE ADJUST

Also called pedal/ ramp initial voltage, this feature establishes an adjustable (0- 60%) initial voltage on the motor windings which will appear instantly an operation of the control circuit. The reduced voltage timed to ramp will then begin from this present voltage level.

10. LOW-VOLYAGE LOCKOUT ADJUST

This feature is designed to protect motors from operating at low voltage. When using the 3-wire control circuit, it will lock out the motor starter if the 3Ø means voltage drops below an adjustable 0 to minus 15 % range from full line voltage. When using the 2-wire control, it will de-energize the motor with low voltage and then automatically restart the motor when the 3Ø mains voltage increases above the trip point.

Please note that the factory setting will always be the lowest voltage trip point

11. Connect up this motor starter to a 3 phase 208 Volt motor. Used 2 wire control. Now connect up the motor control using 3 wire control.

MOTOR CONTROL PROJECT #8
SOLID STATE 3-PHASE REDUCED
Voltage Motor Starter
#18 EM3HP2
By Payne Engineering

1. MOUNTING- The 18 EM 3 soft starter is designed to be mounted in an upright vertical manner to allow for free natural convection cooling in a ventilated enclosure. Do not obstruct top and bottom openings. *

2. Connect proper size motor to load terminals only: T1, T2, T3.

3. Connect proper 3-phase power two terminals marked L1, L2 and L3. With power on, light marked LINE should be on. If not, disconnect the line in reverse any two of the leads.

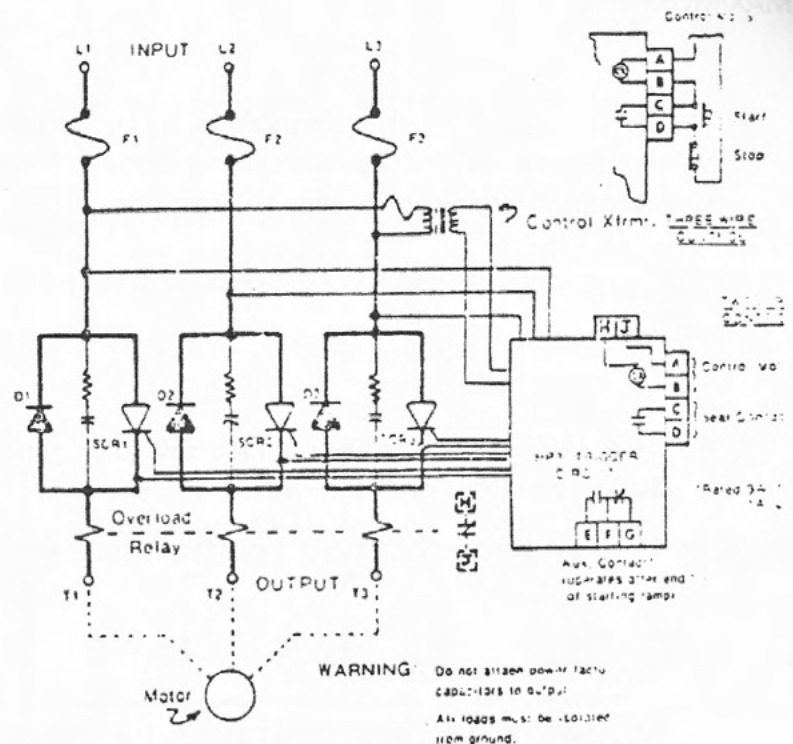
4. CONTROL WIRING:

- a. TWO WIRE CONTROL- Can be used by applying 120 VAC to terminal A and B.
- b. THREE WIRE CONTROL – See drawing:
- c. AUXILIARY CONTACTS - At terminal E, F, and G are actuated at the end of the ACCEL starting ramp for customer use.

5. Voltage to motor will now increase on the linear adjust full time ramp from 02 full voltage. If motor is running in reverse direction, reverse any to output wire T1, T2 or T3). **DO NOT** reverse input wiring. This and mains voltage less than 90° of nameplate automatically locks out the control circuit.

- a. ACCEL, ADJ, TRIMMER – Accessible with a small screwdriver through a hole marked “ACCEL”. This is a 270° turning trimmer. Full CCW will give the shortest starting time. By adjusting CW, can be adjusted over a range of 1-10 seconds minimum.
- b. DECEL, ADJ, TRIMMER – Accessible with a small Screwdriver through hole marked “DECAL”. This is a 270° turning trimmer. Full CCW will give the shortest starting time. By adjusting CW, the acceleration time can be adjusted over a range of 1 – 10 seconds.
- c. START VOLTAGE - Accessible with a small screwdriver. This is a 270° trimmer, turn clockwise (CW) for increasing initial voltage on motor windings on operation of control circuit, adjustable from 0 - 60% of mains voltage.
- d. VOLTAGE LIMIT - See attached instruction sheet.

6. If a fuse blows in this unit, your ACCEL time may be too short or the motor size and war wick connected load is too large. Select motor larger starter. **DO NOT SUBSTITUE INCORRECT FUSES.**



7. If overload relay trips, check your heater size vs. motor load. The standard NEMA type overload relay uses standard heaters. The overload relay is not solid-state device.

MAXIMUM Amb. Temp. = 50°

NOTE: This device is fully warranted for twelve months from date of purchase. Occasional load faults will not harm semiconductors providing our recommended fuses are used. Any fuse substitution or unauthorized modification voids all warranties.

DESCRIPTION:

8. The adjustment supplied on the main control board of the model 18EM3 RVS can be used to REDUCE the RUN VOLTAGE being applied to a motor by the starter. The minimum setting is approximately 75% of maximum output voltage.

CAUTION:

This should only be done to a motor that is operating under lightly loaded conditions in order to improve its energy efficiency. A motor running at Full Load condition normally requires maximum voltage. There are motors that will operate at Full Load and still required less than the maximum voltage from the start, such as a 440 VAC motor being run from 480 VAC mains.

OBJECTIVES:

1. To measure the time required to start a motor and bring it up to full speed using a solid-state reduced voltage motor starter.
2. To measure the power saved under no load and full load.

EQUIPMENT NEEDED:

1. ¼ HP motor 3-phase unit
2. Solid State motor starter 18EM3
3. Electrodynamometer
4. Wattmeter 0 - 600 watts
5. Voltmeter 0 – 250 volts
6. Ammeter 0 – 10 amperes
7. Connecting leads
8. Timing belt

PROCEDURE:

Connect up the circuit as shown in (figure 1).

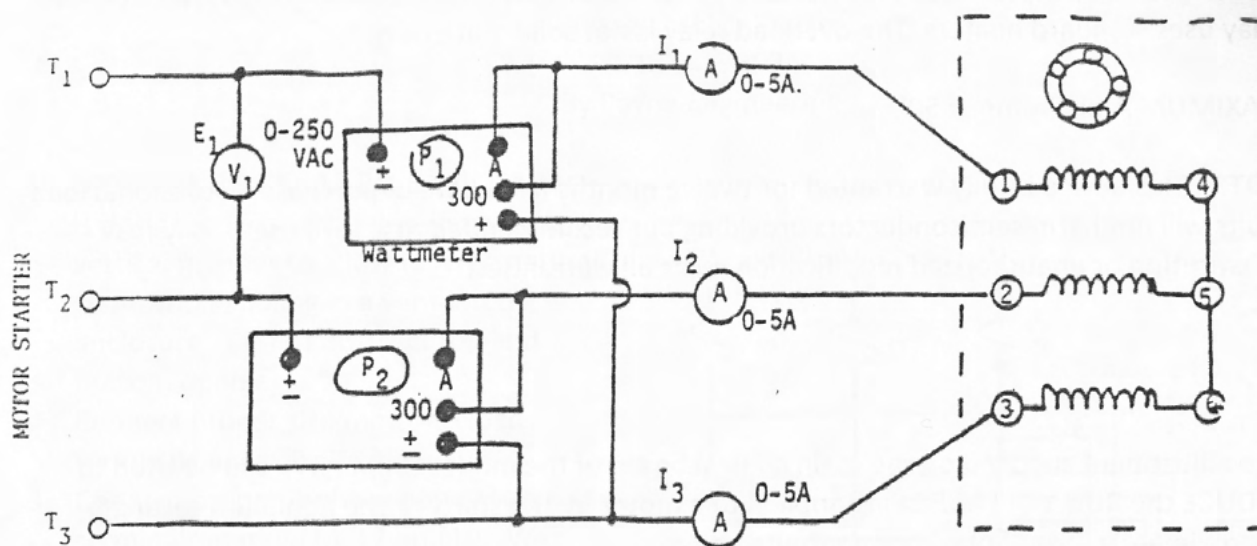


Figure 1

1. Connect up this motor controller using 2 wire control.
2. Connect up a 1/4 HP 3 ϕ motor and note how long it takes to come up to full speed _____ sec. on no load.
3. Now connect a load to the motor and adjust to full load com note how long it takes to come up to full speed _____ sec.
4. Was it faster on no load or full load or the same time? _____
5. Now connect up this motor using 3-wire control, use 2 sets of push buttons; two stop and two starts.
6. Now connect up a wattmeter and determine the amount of power used _____.
W _____, PF _____, phase angle, VA _____ under no load.
7. Repeat #6 under full load. W _____, PF _____, phase angle, VA _____.
8. Which is the most effective no load or full load? _____
Explain: _____
9. What is the amount of power saved? _____ (No load to full load).

OPERATING INSTRUCTIONS FOR MODEL 11R

Solid state 3 Ø Reversing Motor Starter #1

CONNECT proper size motor to load terminals

only; T1, T2, and T3.

Connect proper here phase power to resistor terminals marked L1, L2 and L3. Resistor block must be mounted at least six inches (150 mm) above 11R chassis.

CONTROL WIRING:

120 VAC control power (less than 10 Watts) must be applied to terminals 1 and 2. Closing a (10 VA or greater) contact between terminals 3 and 4 will switch the starter FORWARD and FORWARD pilot lamp will be ON. Closing a (10 V or greater) contact between terminals 4 and 5 will switch the starter too REVERSE and the REVERSE pilot lamp will be ON.

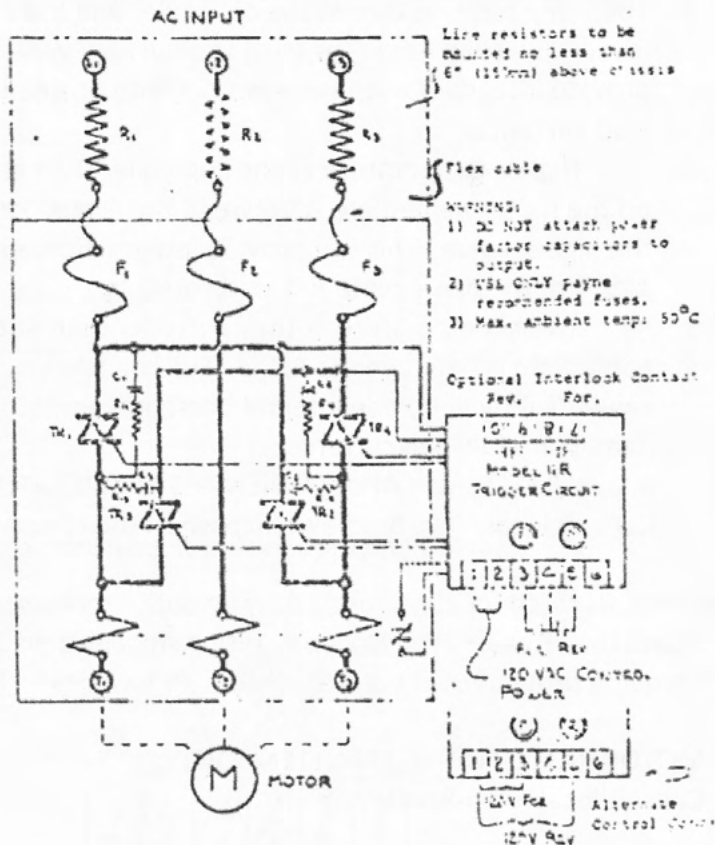
Voltage to motor will be applied within one-half cycle of closing control contacts. On de-energization of the trigger circuit, the voltage to the momager will be removed with one-half cycle at current zero for each phase. A 3-phase load must be connected to operate this control! The time between FORWARD and REVERSE energization must be greater than 10 milliseconds.

If a fuse blows in this unit, the motor size and or connected load is too large. Select a smaller motor or a larger starter. **DO NOT SUBSTITUTE INCORRECT FUSES.**

If overload relay trips, check your heater size vs. motor load. The overload relay is not a solid-state device.

WARNING: This starter is designed in electronically interlocked only for normal plugging duty up to 5 reversal per minute. It may be necessary to provide higher wattage line resistors for severe high ambient plugging service. Heavy duty line resistors are available as an extra cost option.

WARNING: To provide continued protection against fire or shock hazard, the complete overload really must be replaced if burned out of heater element occurs.



IMPORTANT: When ordering heater elements for this controller always specify the desired "Heater Type NO." MOTORS rated for continuous duty:

MOTORS with marked service factor of not less than 1.15. or motors with a marked temperature rise not over 40°C.

1. The same temperature at the controller and the motor - Select the "Heater Type No...." with the listed "Full Load Amps" nearest the full load values shown on the motor nameplate. This will provide integral horsepower motors with protection between 110 and 120 % of the nameplate full load currents.
2. A. Higher temperature at the controller than at the motor - If the full load current value shown on the motor nameplate is between the listed "Full Load Amps", Select the "Heater Type No." with the higher value. This will provide integral horsepower motors with protection between 115 and 125 % of the name plate full load currents.
3. A. Lower temperature at the controller than at the motor - If the full load of the motor nameplate is between the listed "Full Load Amps.", Select the "Heater Type No." with the lower value. This will provide integral horsepower motors with protection between 105 and 115% of the nameplate full load currents.
4. A. RULES 2 and 3 APPLY WHEN THE TEMPERATURE DIFFERENCE DOES NOT EXCEED 10° C (18°F). Consult local Allen-Bradley office when the temperature difference is greater.

All other motors rated for continuous duty (includes motors with marked service factors of 1,0)

Select the "Heater Type No." one rating smaller than determined by the rules in paragraphs 1,2 and 3. This will provide protection at current levels 10% lower than indicated above.

MOTOR RATED FOR INTERMITTENT DUTY:

Consult local Allen-Bradley office.

TABLE 22							
Heater Type No.	Full Load Amps	Heater Type No.	Full Load Amps	Heater Type No.	Full Load Amps	Heater Type No.	Full Load Amps
N2	0.51	N13	1.86	N24	5.14	N35	14.7
N3	0.62	N14	2.04	N25	5.65	N36	16.4
N4	0.78	N15	2.24	N26	6.20	N37	17.7
N5	0.84	N16	2.45	N27	6.80	N38	19.8
N6	0.95	N17	2.69	N28	7.48	N39	22.0
N7	1.03	N18	2.95	N29	8.20	N40	24.2
N8	1.15	N19	3.24	N30	9.01	N41	26.1
N9	1.26	N20	3.56	N31	9.92	N42	28.7
N10	1.37	N21	3.90	N32	11.0		
N11	1.53	N22	4.28	N33	12.2		
N12	1.68	N23	4.68	N34	13.6		

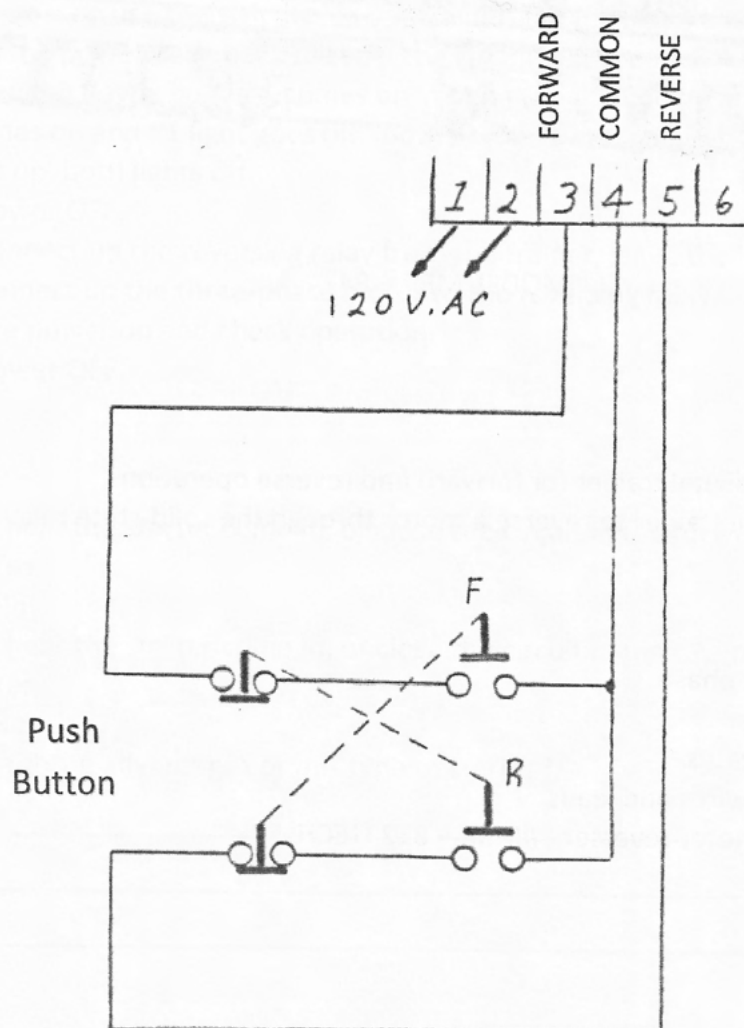
The rating of the relay at 40° is 115% of the "Full Load Amps" for the "Motor Nameplate"

Select the Motor Branch Circuit Overcurrent Protection in accordance with the National Electrical Code for motors with full load currents of 3.0 amperes or more. For motors with full load currents less than 3.0 amperes, the rating of the fuse selected must not exceed the values listed.

NOTE: For inverse-time circuit breaker application select the Motor Branch Circuit Overcurrent Protection in accordance with the National Electrical Code.

Full Load Current Amperes	Maximum Fuse Rating Amperes
0.45 - 0.89	3
0.90 - 1.79	6
1.80 - 2.99	10

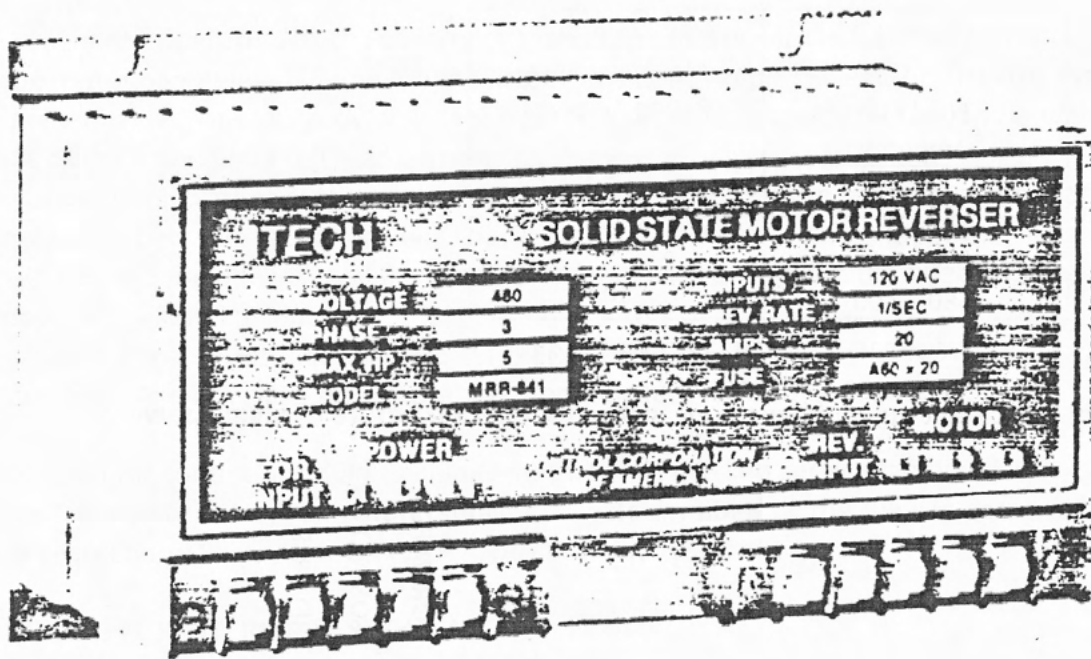
1. Connect this circuit up, and **have your instructor check it before applying power.**



SOLID STATE REVERSING MOTOR CONTROLLER #2

General Information:

The controller is a solid state my 3-phase motor reversing really that contains no moving parts. The advantage of this relay Over the Electro mechanical reversing relay: No contacts to spark and burn, completely silent operation, an extremely long life.



MODEL MRR – 841

Objective:

1. To connect the digital trainer for forward and reverse operations.
2. To use the digital trainer to reverse a motor through the solid-state relay.

Equipment Needed

1. Motor three phase
2. Digital trainer
3. Package of gates
4. Connecting wires and leads
5. Solid state motor reverser - #MRR – 812 ITECH

Operating Voltage	240 Volt Models 200 - 250 Volts 480 Volts Models 400 - 500 Volts	Input Current Drain	40 MA Maximum Resistive Load
Motor HP	Up to 10 HP	Rev. Rate	1/Sec. Maximum
Fusing Requirement	Install in Power Lines L1 and L2	Overall Size	8" wide, 5 1/4" high, 5" deep
		Mounting Centers	6" horizontal 4 7/8" vertical

PROCEDURE:

1. Draw the logic circuit on paper. This circuit is to turn on one (1) light and only one light out of time.
2. Connect up the digital trainer using the gates in your package.
3. This circuit is to use the switches in the trainer and the lights that are on the trainer.
4. Turn on the power and check to see if the circuit works correctly. Then #1 switch up and #2 switch down, light # 1 comes on. Then #1 switch down and #2 switch up, #2 light comes on and #1 light goes off. Both switches down, and both lights go off. Both switches up, both lights off.
- 4a. Turn power OFF.
5. Now connect up the reversing relay from the trainer, leave the lights connected.
6. Also connect up the three-phase motor to the reversing relay.
7. Turn the power on and check operation.
- 7a. Turn power OFF.

Conclusion:

1. Can you hear the starter come in, or close the circuit in the forward direction?
 - a. Yes
 - b. No
2. Can you hear the starter come in, or close the circuit in the reverse direction?
 - a. Yes
 - b. No
3. What are three advantages of this type of starter?
 - a. _____
 - b. _____
 - c. _____

THREE-PHASE POWER MONITOR
MODEL 258
Installation Instructions

CAUTION!

Potentially hazardous voltages are present at the base and socket area. **All electrical power should be removed when connecting or disconnecting wiring.** The unit should be installed and serviced by qualified personnel.

INSTALLATION:

Using the Model 258 base diagram pictured on the unit, contacts shown in failed position, connect the wiring to the socket as required. If the contacts do not transfer when power is applied (indicator off), check that all three phases are present and are the correct voltage. If all phases are correct, rotate the failure level adjustment counter-clockwise to the low position. If the contacts still do not transfer, remove power from the unit. Reverse two of the three-phase wires at the socket then reapply the power. Contacts should then transfer to provide a signal path between pins 1 and 8 (indicator off).

ADJUSTMENT:

Allow a 15-minute warm-up before adjustment. Rotate the failure level adjustment in the clockwise direction until the contact transfer to the field conditions (indicator on). Then slowly turn the adjustment counter-clockwise until the contacts again transfer to the normal condition (indicator off). This setting will be correct for most installations. If nuisance trips occur, turn the adjustment slightly further counterclockwise.

NOTE:

When installing the Model 258 in areas of high humidity or contamination, it is recommended that the base area and all exposed metal parts of the socket be coated liberally with a good quality silicone grease such as Dow Corning DC-4 or DC-4X. Insert the unit into the socket and wipe off the excess grease from around the base. This will prevent the entrance of moisture and other contaminations into the base and socket area.

GENERAL:

This application guide was written for use by equipment designers, maintenance personnel, electrical contractors, etc., to aid them in the installation of phase-loss or phase-unbalance protection for sensitive equipment. The application notes, charts, and schematic are all centered around several models of 3-phase power monitors manufactured by TIME MARK CORPORATION. A simplified schematic diagram of the basic circuit and sensing method is shown in (figure 1).

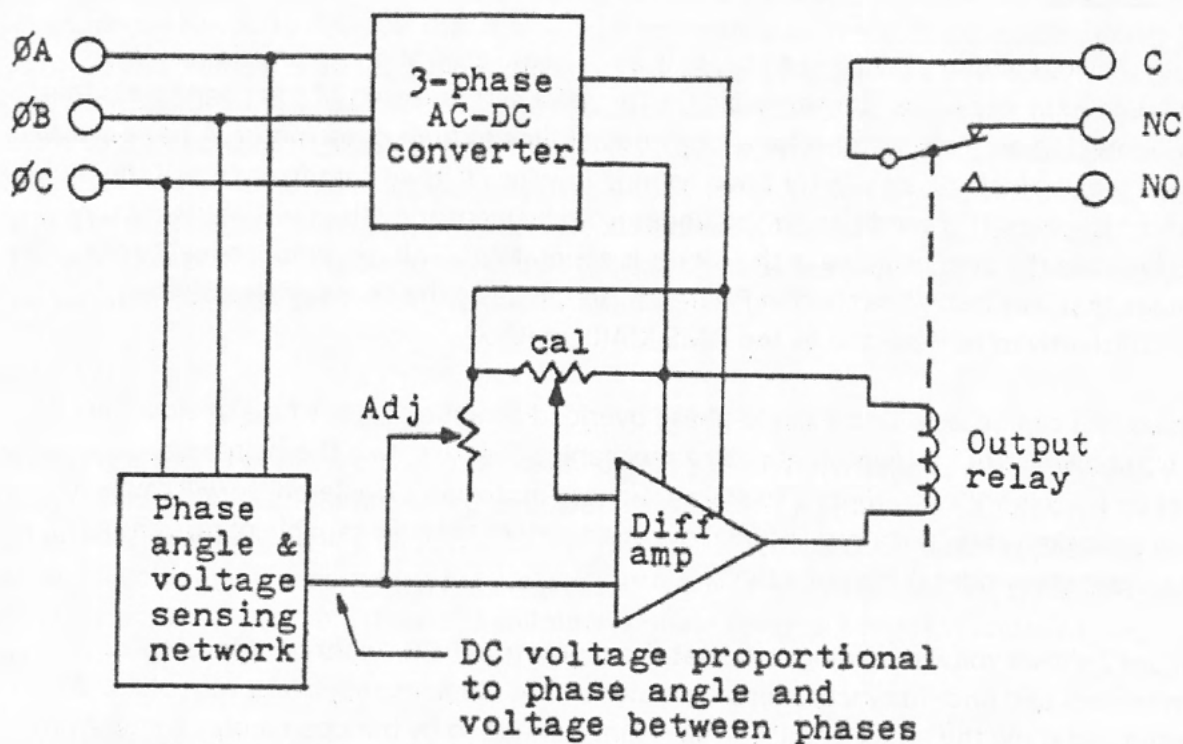


Figure #1 Schematic Diagram (Simplified)

The schematic shown in (figure one), shows the basic circuit configuration used in all the 3-phase power monitors discussed in this application guide. The heart of this device is the exclusive "phase angle and voltage sensing network" developed by TIM MARK which allows last phases to be detected even when regenerative loads cause very little voltage decrease to be measured between phases.

PHASE UNBALANCE:

Unbalance of a 3-phase power system will occur when single phase loads are applied causing one or two of the lines to carry more or less of the load. On new installation of 3 phase power systems, normally careful attention is given to balancing of loads. However, as more and more single-phase loads are added to the system, and unbalanced begins to occur.

This phase voltage unbalance causes 3-phase motors to run at temperatures beyond their published ratings. These high temperatures soon result in insulation breakdown and shortened motor life. Thermal overload's, magnetic breakers, and other such device usually will not detect this gradual unbalanced and therefore do not afford proper protection.

PHASE LOSS:

The total loss of one of the three phases is an extreme case of phase unbalance. This condition is generally known as "single phasing". The most serious result of this condition is that it can be undetected on most systems for a long enough time to burn out a motor. A three-phase motor running on a single phase will continue to run, drawing all its current from two of the lines. In most all cases, this condition will be undetected by measuring the voltage at the motor terminals, because the open winding in the motor is generating a voltage almost equal to the phase voltage that was lost. (See chart in Figure 2). In this case, the phase angles will be displaced sufficiently to be detected by the TIME MARK method.

Phase loss can occur within a single-phase overload condition causes fuse to blow; but a 3-phase circuit been struck by lightning; or by a mechanical failure within the switching equipment on machinery. Attempting to start a 3-phase motor on a single-phase will cause the motor to draw locked-rotor current. Thermal overloads are not always capable of preventing damage to the motor under these conditions.

Figure 2 shows voltage readings taken at the motor terminals on three different size inductions motors and once in synchronous type motor. The readings shown are with phase-3 disconnected and show the effect of the voltage being generated by the open motor winding under different load conditions.

% LOAD	1 HP			10 HP			100 HP			2 HP (sync)		
	1-2	2-3	3-1	1-2	2-3	3-1	1-2	2-3	3-1	1-2	2-3	3-1
0	480	402	434	480	432	443	480	446	451	480	405	431
25	480	401	422	480	439	438	480	454	438	480	404	420
50	480	399	405	480	430	437	480	459	429	480	401	404
75	480	394	376	480	426	430	480	453	410	480	397	382
100	480	391	364	480	410	416	480	440	325	480	392	371

Voltage Readings at Motor Terminals with 03 Disconnected
Figure 2

It can be seen from the charts in (figure 2) that if a phase is lost and the normal line voltage varies from 420 volt to 480 volt that it would be impossible to detect the condition under all loads by sensing only voltage is on the three lines. For this reason, phase angle detection In addition to voltage detection has been incorporated into the design of these power monitors this method allows an additional 5% to 8% decrease in phase to phase voltage set-point. That is, to detect a lost phase to phase voltage set-point. This is, to detect a lost phase on 100 HP induction motor with no load, the line voltage would have to remain constant, and the detection point would have to be set at 95% of the line voltage. The addition of phase angle sensing allows the set-point to be made at 85% to 90% so that normal line variations are not sensed as a failure or unbalanced.

PHASE REVERSAL:

Reversing any two of the 3-phases may cause damage to driven machinery or injury to personnel. This can occur when modifications are made to power distribution systems, or when maintenance is performed on cabling and switching equipment. The National Electrical Code requires phase reversal protection on all equipment transporting people, such as elevator and escalator. All types of 3-phase power monitors shown in the table (figure 3) will sense a phase reversal condition under all load conditions.

MODELS AVAILABLE:

The table shown on the following page gives some general information for use in selecting the device that best suits the application. The sensing method on all models shown are for all practical purposes the same. Variations in the models are in the type of enclosure, the wiring method, output relay contact rating, failure delays and adjustment ranges. More detailed information and specification may be obtained by referring to the data sheets which are available for each model.

APPLICATION:

Figure 4 shows a typical application with a single motor load. Connecting the power monitor in this manner will protect against any of the following:

1. Loss of primary fuse.
2. Loss of phase in secondary protection circuits.
3. Failure in primary or secondary windings of transformation.
4. Phase reversal throughout the distribution system.
5. Low voltage on feeder lines.



QUICK REFERENCE - 3-PHASE POWER MONITORS

PHASE TO PHASE

MODEL SERIES	NOMINAL VOLTAGES AVAILABLE	ADJUSTMENT RANGE	CASE TYPE	OUTPUT CONTACTS	TERMINATION METHOD	FAILURE DELAY	DEAD BAND	FAILURE INDICATOR
258	120 240 480	85-125VAC 160-240VAC 340-480VAC	OCTAL PLUG-IN	SPDT 3A-115V 1A-240V	OCTAL SOCKET	NO	2%	YES
259	120 240 480 575	85-125VAC 160-240VAC 340-480VAC 420-575VAC	OPEN CHASSIS	DPDT 10A-115V 6A-240V	TERM STRIP	ADJUSTABLE 1-5 SECONDS	.2%	YES
263	120 240 480 575	85-125VAC 160-240VAC 340-480VAC 420-575VAC	FLANGE MOUNT CHASSIS	SPDT 4A-115V 2A-240V	TERM STRIP	NO	2%	YES
264	120 240 480 575	85-125VAC 160-240VAC 340-480VAC 420-575VAC	FLANGE MOUNT CHASSIS	ISOLATED NO & NC 3A-115V 1A-240V	TERM STRIP	FIXED 4-5 SEC 8-10SEC	.2%	YES

The power monitor may be connected as shown in (figure 4). This will allow installation without disturbing existing protection devices. Output contacts may be wired into a control circuit to trip the monitor contactor should failure occur.

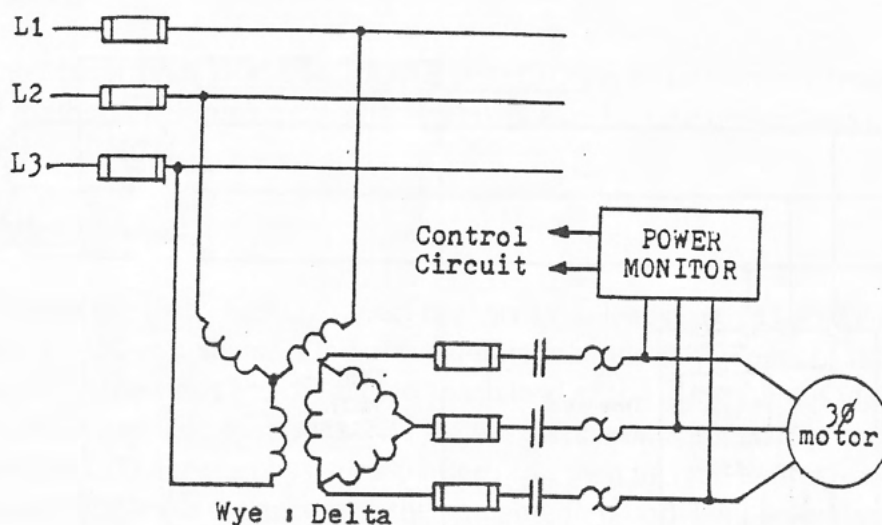


Figure 4. Typical 3-Phase Motor Protection

The following figures 5 and 6 show examples of how to install the phase-loss/low voltage protection using the Model 258 where line transients might cause accidental or nuisance tripping. The use of low-cost solid-state time delay relays to delay that actual tripping of the main breaker motor starter contacts are used. The amount of time delay may be adjusted to suit that application. The settings will vary with different installations but only in rare cases will the amount of delay exceed 10 seconds.

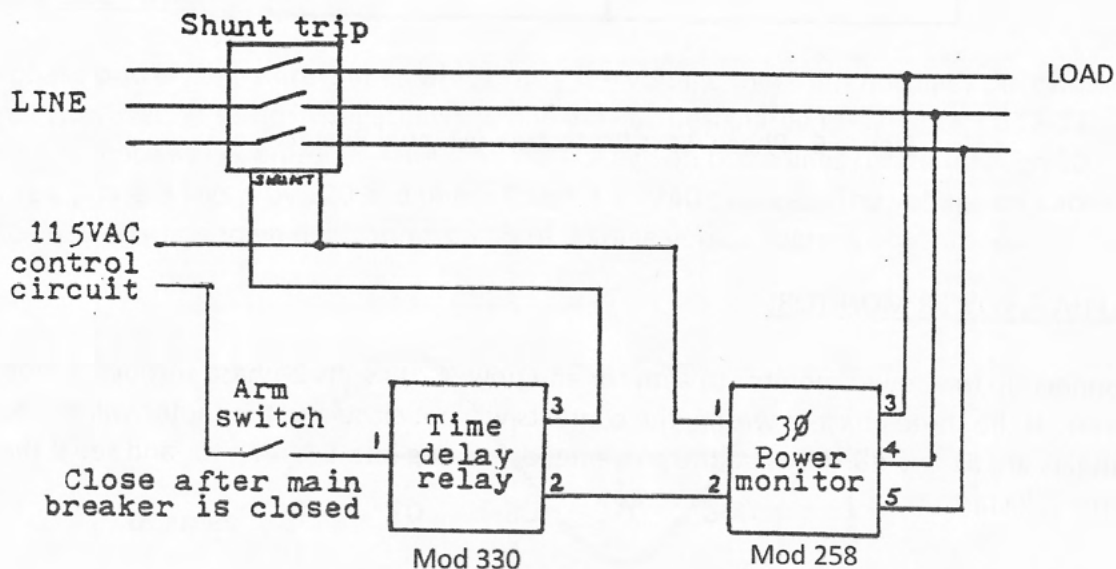


Figure 5. Phase Loss Protection (Manual Restart)

Figure 6 below shows how to install Phase-Loss protection when a typical motor starter is being used. The model 258 just with the model 330-time delay relay will prevent nuisance tripping from transients which last for 3 cycles of the line or more.

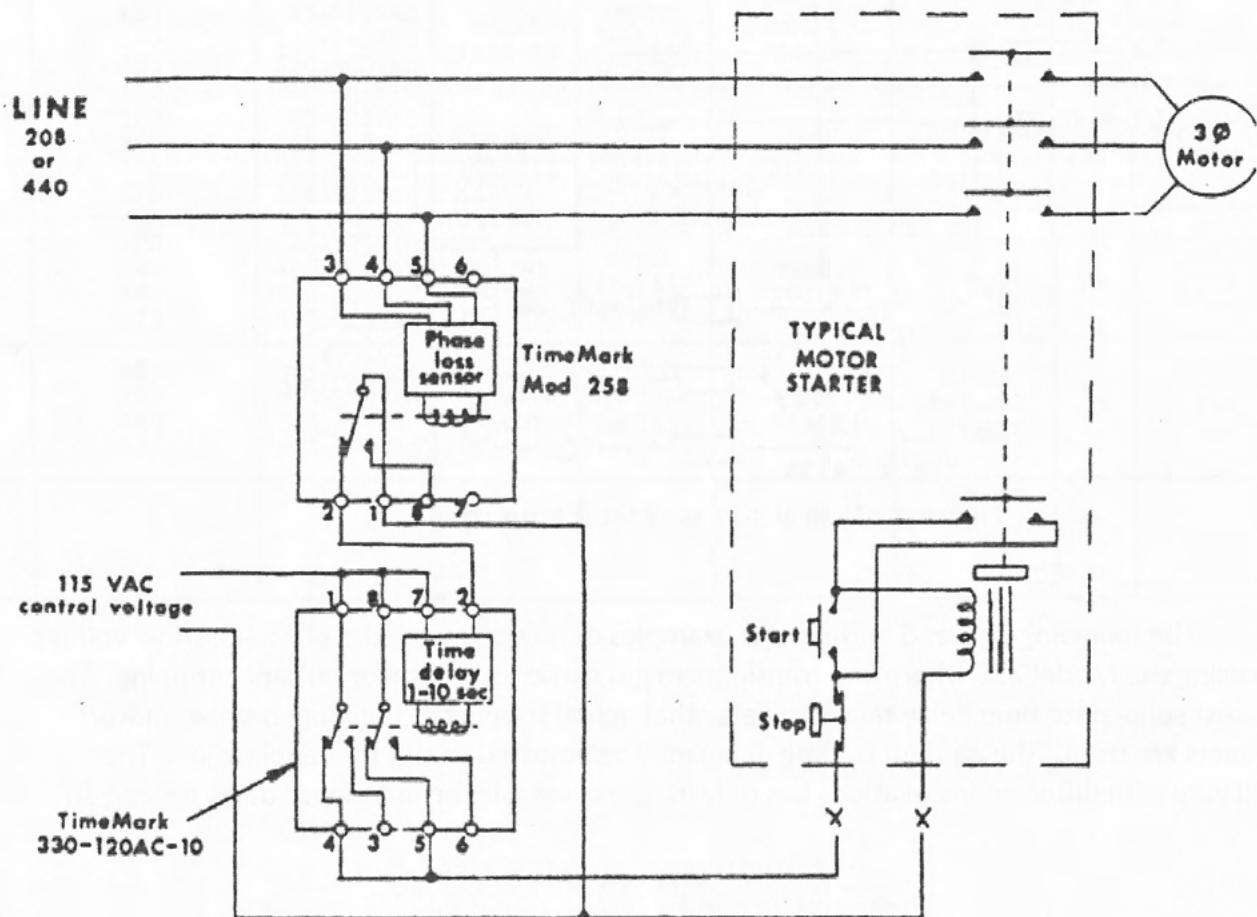


Figure 6 Phase- Loss Protection (Manual Restart)

THREE-PHASE POWER MONITOR:

1. Connect up the power monitor to a motor and power 208 volts 2-phase through a motor starter. If the three phase is wrong, the contacts will not close and the motor will not run. Contacts are #1 and #8. Reverse the power leads coming into the monitor and see if the motor will start.

PHASE SEQUENCE DETECTOR Model 108B

General

The Model 108B PHASE SEQUENCE DETECTOR is an Instrument designed to provide a fool proof method of obtaining the phase sequence of 3-phase power lines in the range of 208 to 480 volts, 50/60 HZ.

Operation

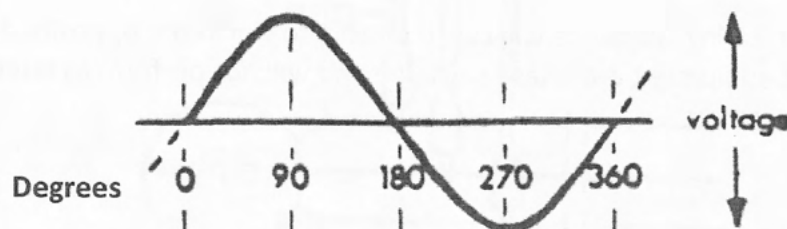
In using this instrument, connect the three clip leads to the 3-phase power source. Apply the 208 to 480-volt power. One of the detector lamps will illuminate showing the phase sequence as the leads are connected. Each lead of the instrument is identified on the front panel. If the desired phase sequence lamp is not illuminated, change any two of the three connections. The three phase designations can then be read on the front panel and the corresponding leads connected to the equipment. If both lamps illuminate check for a loss of voltage on one of the 3-phase. If neither lamp illuminates, check for a loss of voltage on at least two of the three phases.

Caution

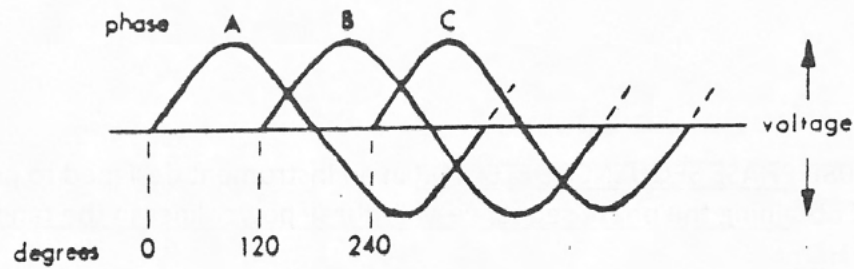
Do not connect this instrument power line voltage is in excess of 480 volts. Personnel working with electrical power line voltage should take all necessary precautions as potentially dangerous voltages are used. Remove power before connecting and disconnecting the unit.

Three Phase Power

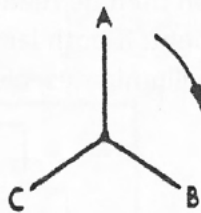
In 3-phase power, there are 3 lines which carry the voltage these are normally designated A-B-C. However, in some installations the line may be designated L1-L2-L3 or T1-T2-T3. The phase sequence as generated is A-B-C. As the voltage on these lines rotate through 360 degrees, phase B lags A by 120 and phase C lags A by 240 degrees. The voltage on each of these lines vary as shown below on a graph of voltage versus degrees of rotation.



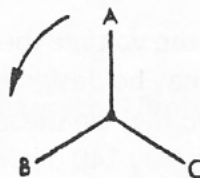
If all phases were shown on the same graph it would appear as below.



Pictured on a rotating phasor diagram, the angle between each phase is fixed at 120 degrees as they rotate in unison at the line frequency.



From the diagram below it can be seen that if any two phases are reversed, the direction of rotation will be in the opposite direction.



This reversal of the rotating sequence will cause motors to run in the opposite direction. Also many other types of equipment are phase sensitive and will not perform as intended if the phase sequence is incorrect.

MOTOR ROTATION INDICATOR
Model 108C
INSTALLATION INSTRUCTIONS

CAUTION – DO NOT CONNECT THE 108 C TO A MOTOR WHEN POWER IS APPLIED.

HOOK UP:

Step 1: Connect Leads

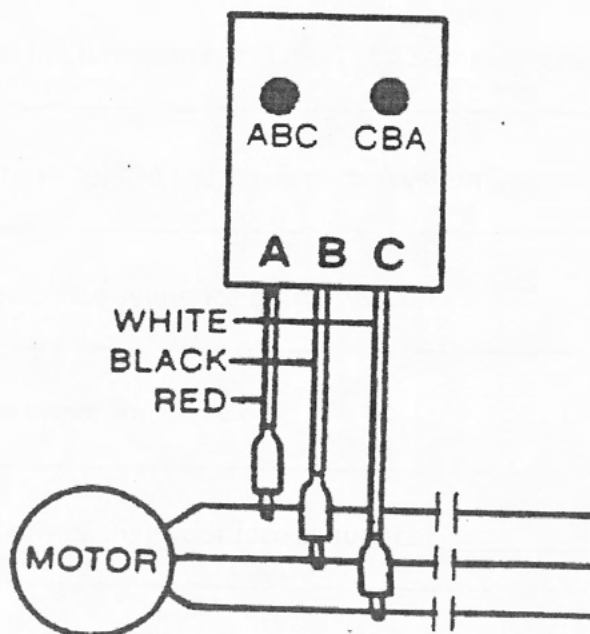
Disconnect motor from line, connect 3 indicator leads to 3 motor leads. Color coded leads are provided for your convenience. (See diagram below).

Step 2: Push Buttons

Press the button marked "first", holding for approximately five (5) seconds, and release. Then press the button marked "second", after approximately five (5) seconds, rotate the motor shaft SWIFTLY 1-4 turn or more. Either the ABC or the CBA lamp will light, indicating the motor connection sequence. This sequence will cause your motor to run in either a forward or reverse direction. Release the second push button.

Step 3: Set Rotation

If the ABC light illuminates, connect the ABC your 3-phase line* to the motor leads, identified as ABC by the 108C leads. The motor will turn as desired. If CBA light illuminates, reverse leads A and C, and repeat steps 2 and 3.



****If NOT** sure of 3-phase line sequence, use time Mark's Model 108B Phase Sequence Indicator to eliminate errors.

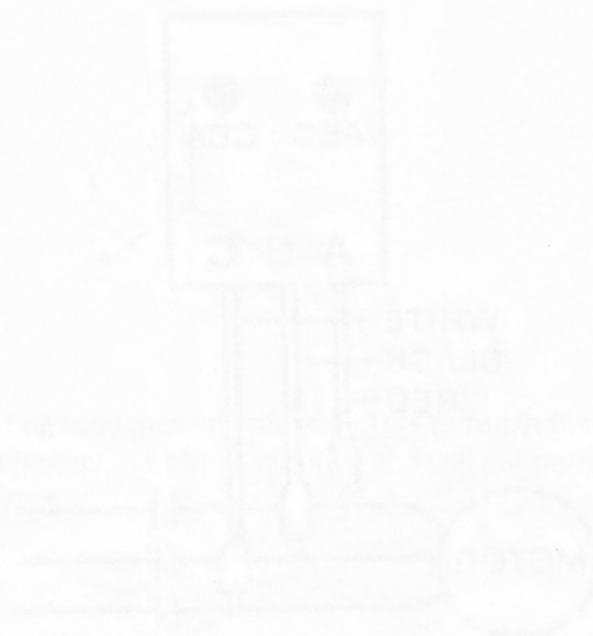
Battery Replacement

The Model 108C uses any standard 9-volt transistor battery. If doubtful of the unit working properly:

1. Check the battery and or lead connections.
2. Replace the battery. (See battery removal)

Battery Removal

Remove the four screws on the front panel. Gently pull the panel forward. Replace the battery with the appropriate type as described above. Remount the front panel.



PHASE SEQUENCE 1

1. In doing repair or replacement work on a 3-phase system, it is possible to inadvertently reverse the phase sequence of the system; and it is often necessary to maintain the same phase sequence on the lines. Phase sequence is the order in which the face voltages come on the system. If two lines are transposed from their original position, the phase sequences will be reversed, in all 3-phase motors on the system will be reversed. Now read pages 188 - 190 in your textbook, INDUSTRIAL ELECTRICAL PRINCIPLES and PRACTISES.
2. From the reading in your text, you should understand the operation of a phase sequence tester. Your instructor will now show you how to get a 3-phase power to your work bench, and you will measure and write down the phase sequence of this power as measured with a phase sequence tester.
3. Now with the motor rotation in Decatur given to you by your instructor, Read the instructions on the back of the indicator. **CAUTION: NEVER** apply power to a motor rotation indicator and **NEVER** use a motor rotation indicator in a circuit which has power applied to it.
4. You are now going to connect up a 3-phase system and make a 3-phase motor rotate in a given direction. Your instructor will now give you a 3-phase, 208-volt motor. Now connect up the 3-phase motor to rotate in a CW direction when you first applied power to it. You should be able to do this with the aid of a phase sequence tester and a motor rotation indicator. Remember the motor rotation in Decatur has its own source of power so **DO NOT** connected it to a hot circuit.
5. Now connect up the 3-phase motor to rotate CCW direction the first time you apply power to it. Use the low voltage connections of about 100-120 volts. Use the transformer to get this low voltage.
6. How did do you change the direction of rotation of a 3-phase motor?
Explain: _____
7. What is meant by the term "phase sequence of the system"?
Explain: _____
8. How do you change the phase sequence of the system?
Explain: _____
9. Why is phase sequence important?
Explain: _____
10. Could the power company change your face sequence? _____
How? _____

Check it over making sure you know how it operates. When are you are sure you understand the rotary stepping switch you have just been given, connect up the below listed circuits with the aid of your rotary switch.

1. Connect up two pumps, so that they are turned on alternately.
2. Connect up two pumps, so that pump A will start pumping on the high-level indication, and after a given length of time, if pump A has not pumped the level down far enough, pump B will be turned on.
3. Write your name in lights.

You will find it easier to connect of these circuit problems, if you will draw yourself schematic first!

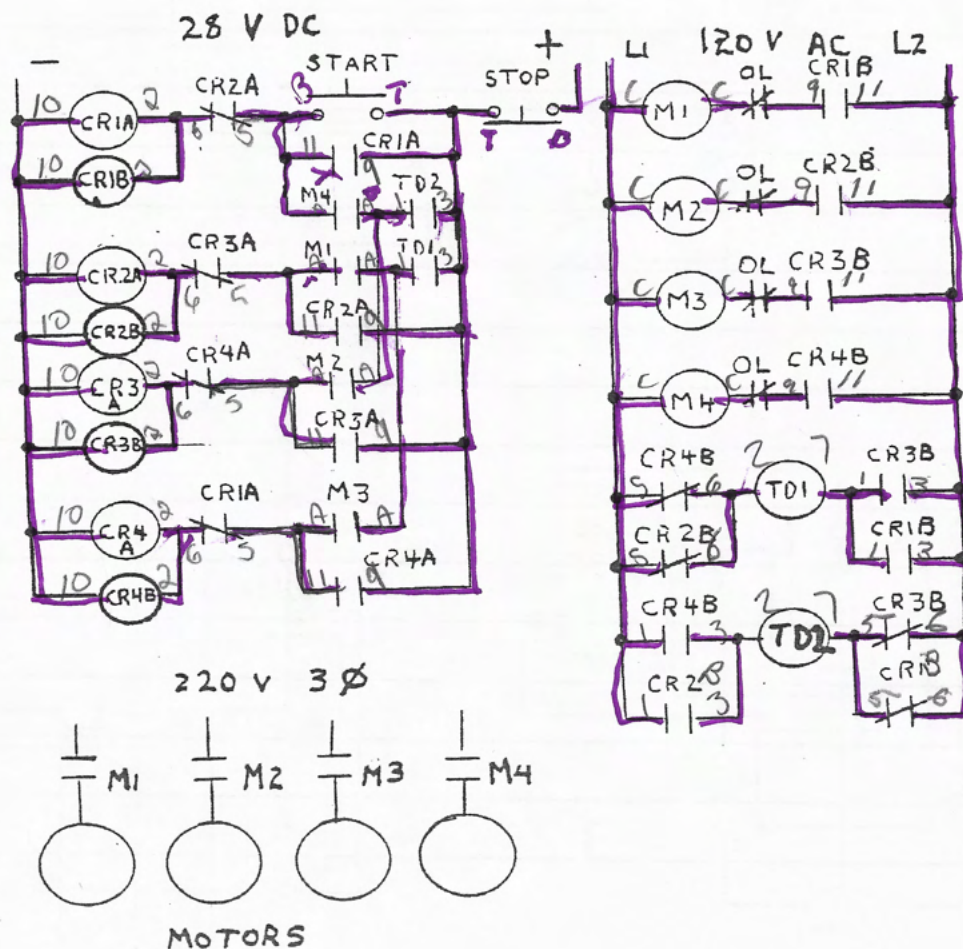
CONTROL CIRCUIT TEST #1

Now that you understand motor control circuits, connect it up on the circuit board that your instructor will give you. You can use the large motor control panel in the center of the lab. You will need to use test boards in order to get for motor starters and 2 timers. The control panel will be a separate unit. You do not need to connect up the 4 motors on this project

When this project is completed, have your instructor check it off for you. He would like to see the project work. **THIS IS A TEST**

INSTRUCTIONS:

In the conversion of an elementary diagram into a wiring diagram, the first requirement is to determine which circuitry is common to the relay control panel and which circuitry is external from the control panel. On the circuit below identify the external wiring by drawing over it with a red pencil. Next, identify the places in the circuit requiring terminal strip connection points for connecting the relay circuits in the external circuits together. Do this by drawing a circle with a number in it. Six terminal strip connections are required for the 28volt DC circuit and 10 are required for the 120volt AC circuit.

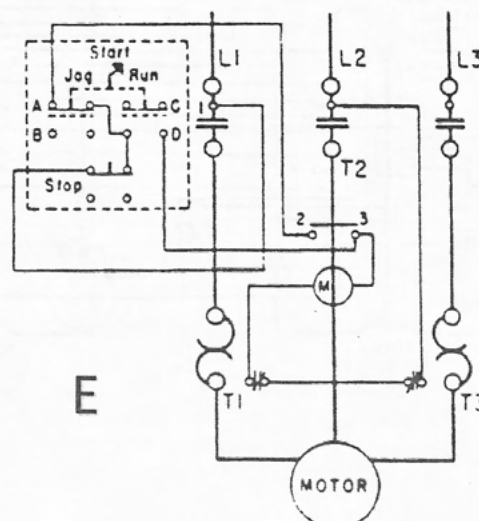
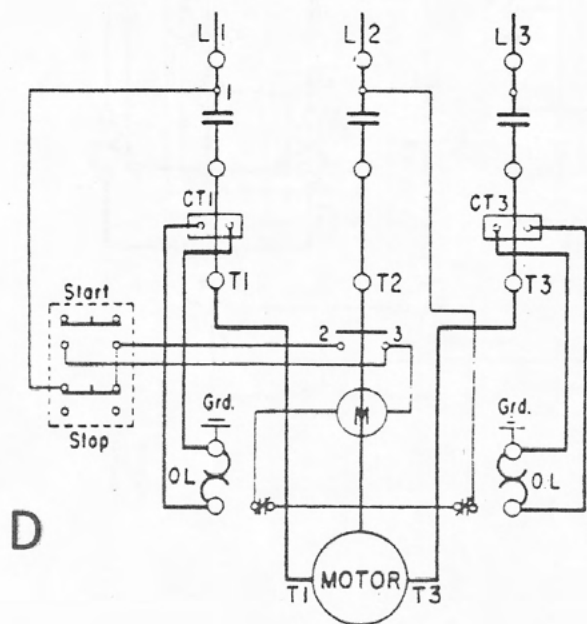
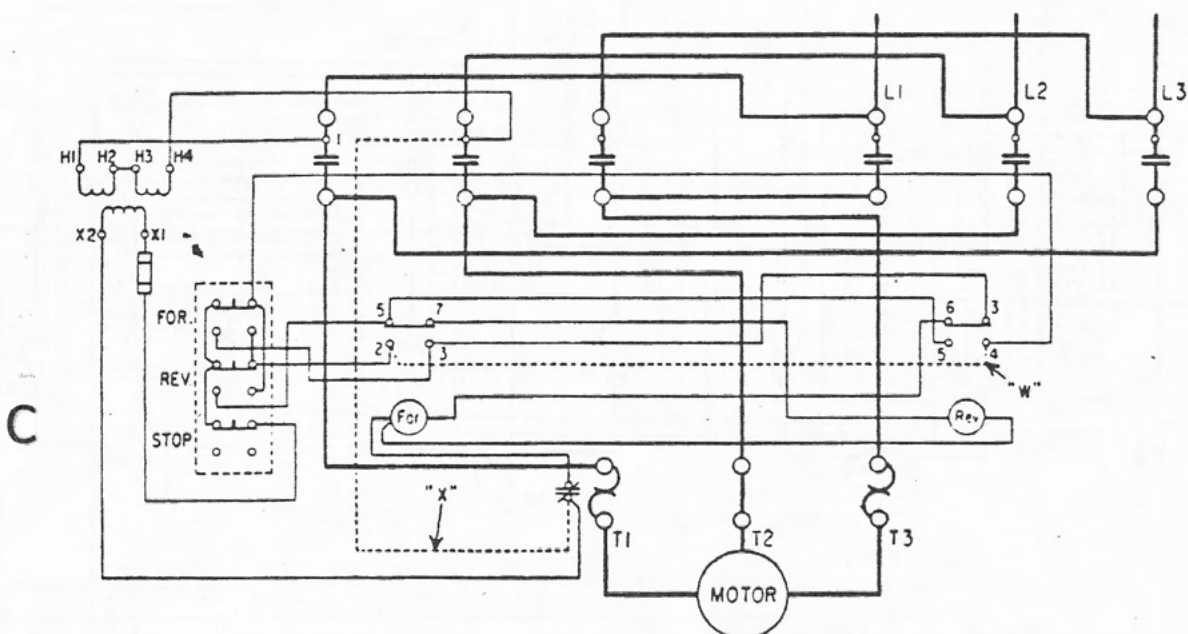
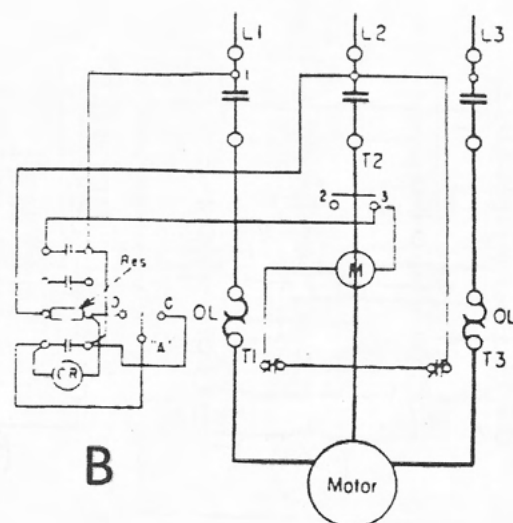
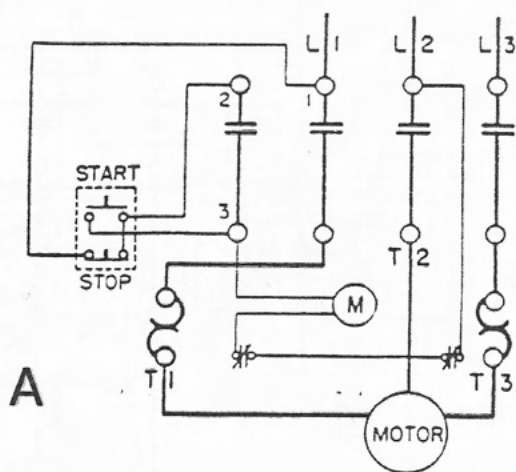


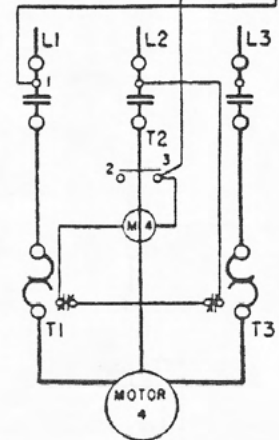
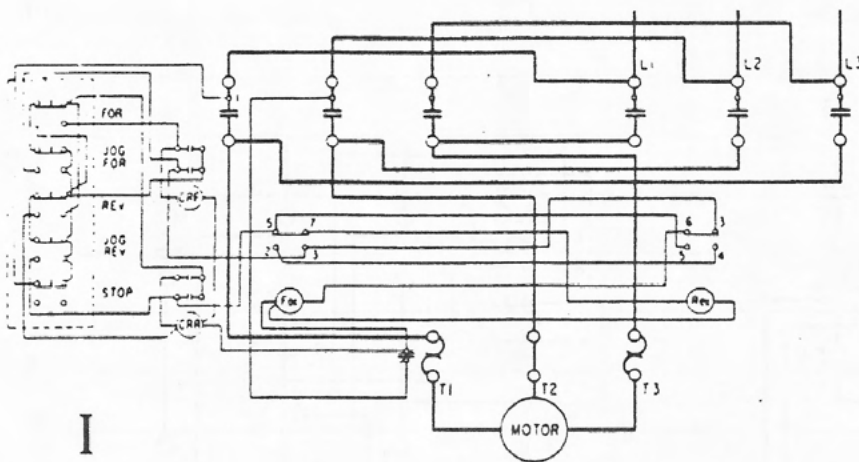
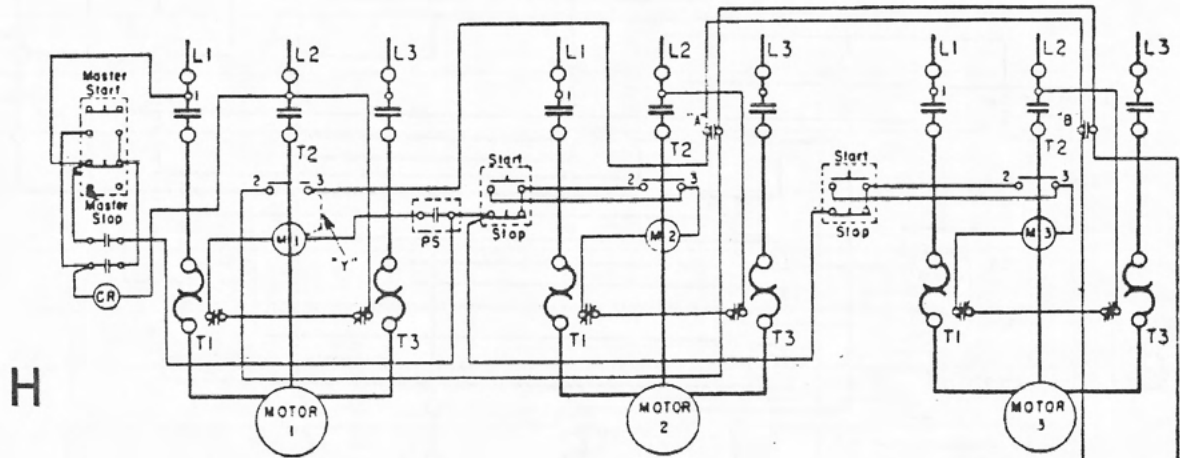
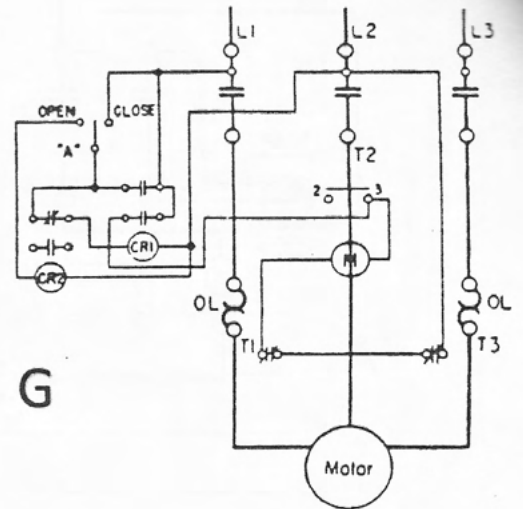
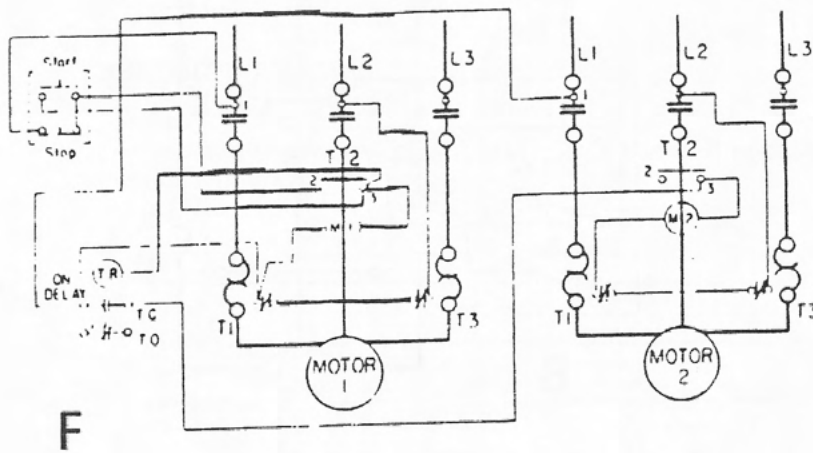
TEST #2

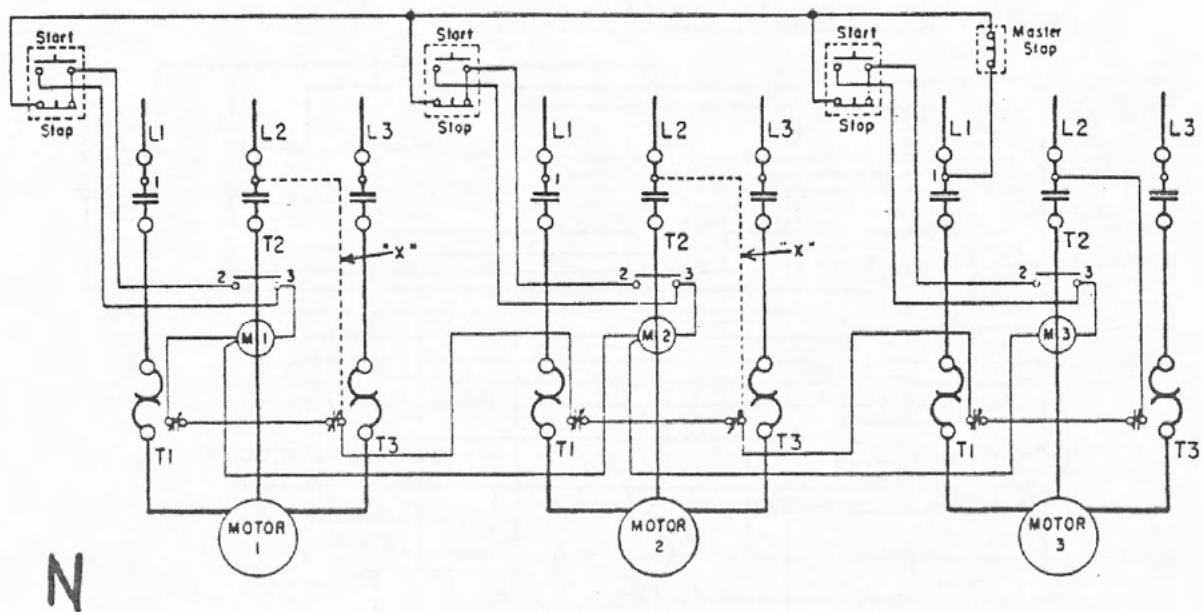
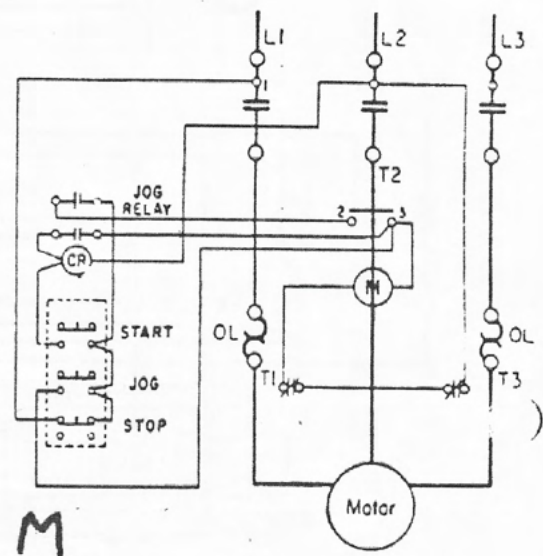
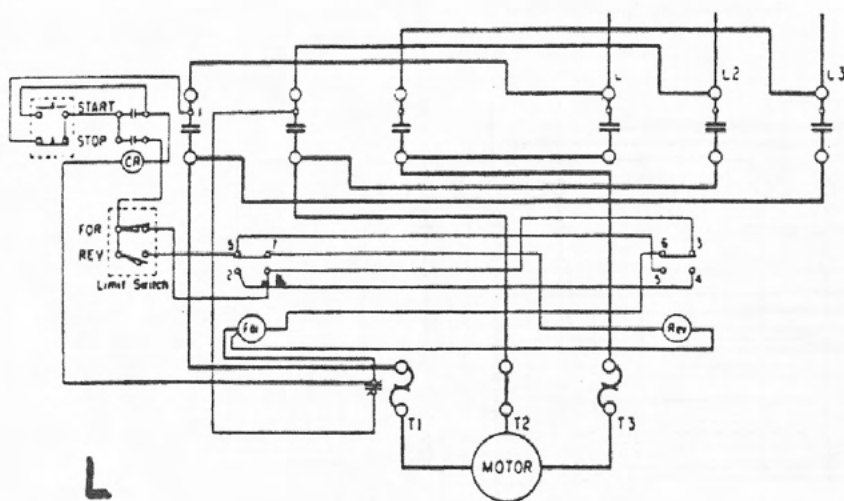
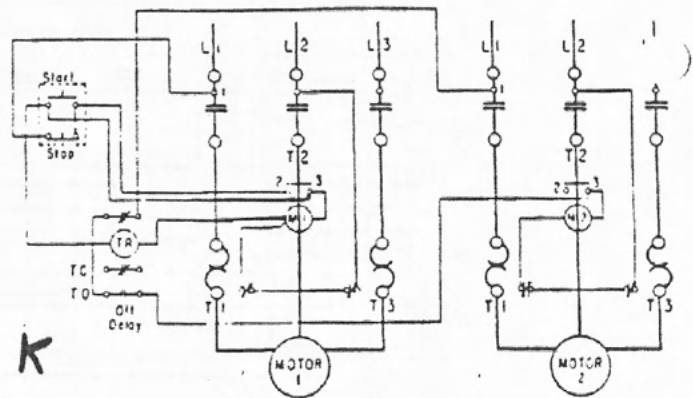
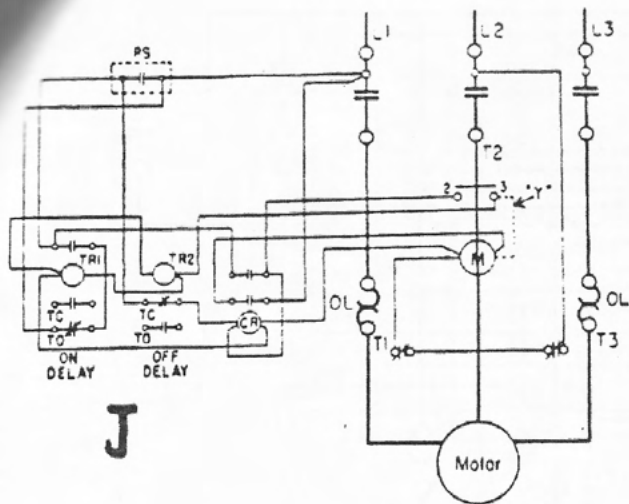
CIRCUIT DIAGRAMS

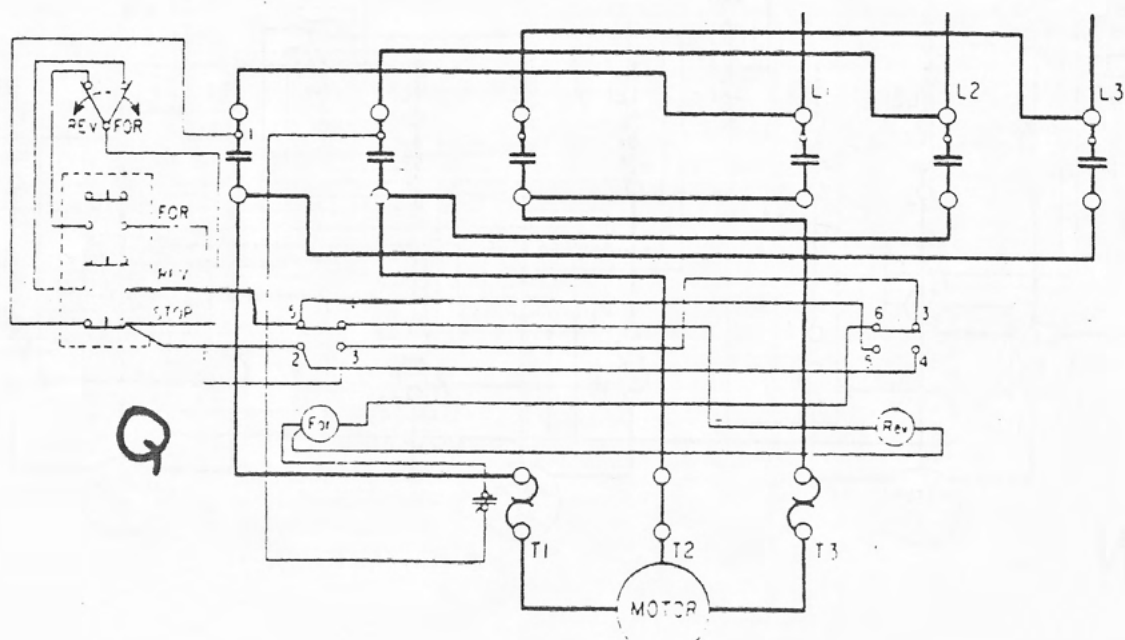
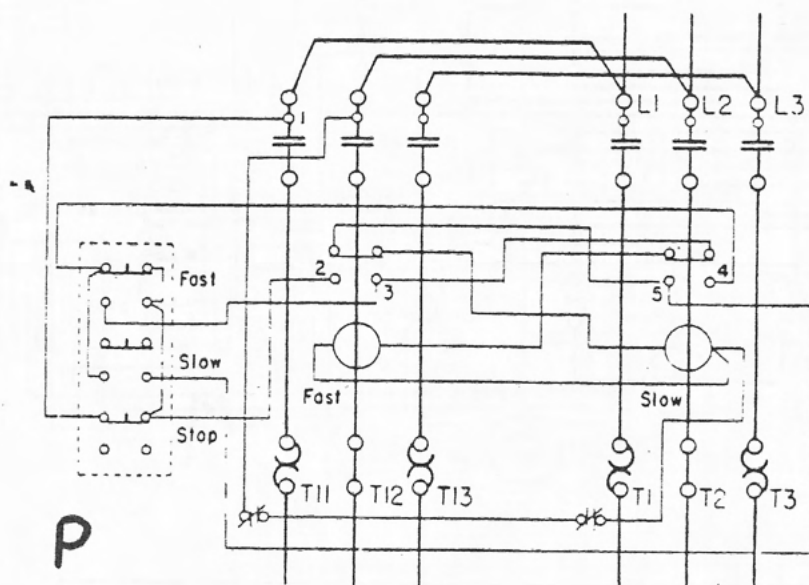
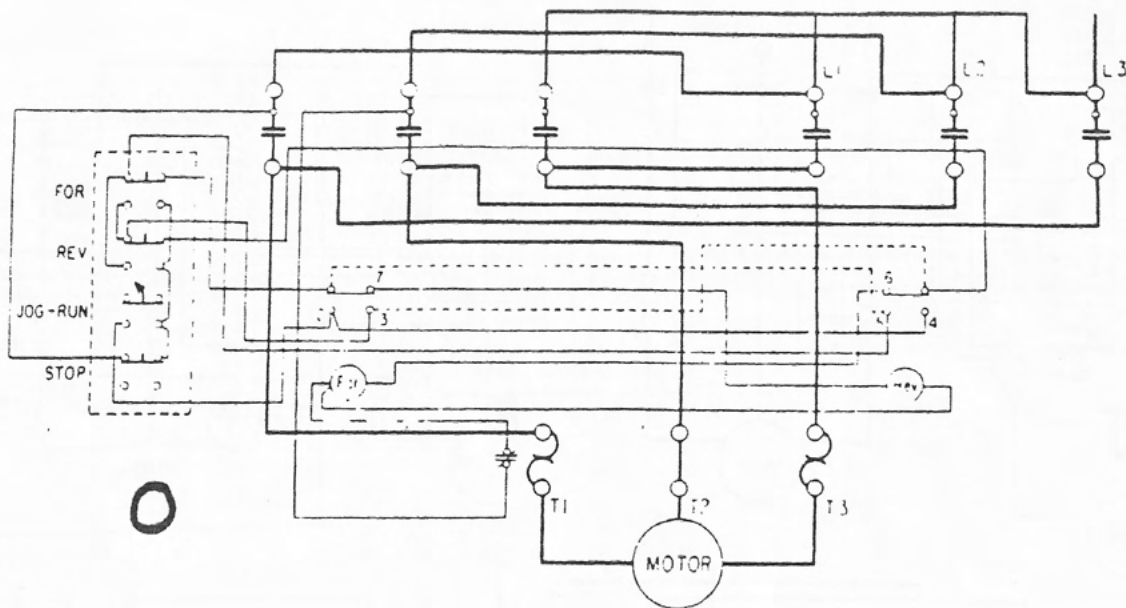
On the following sheets, match the wiring diagrams up to the elementary diagrams.

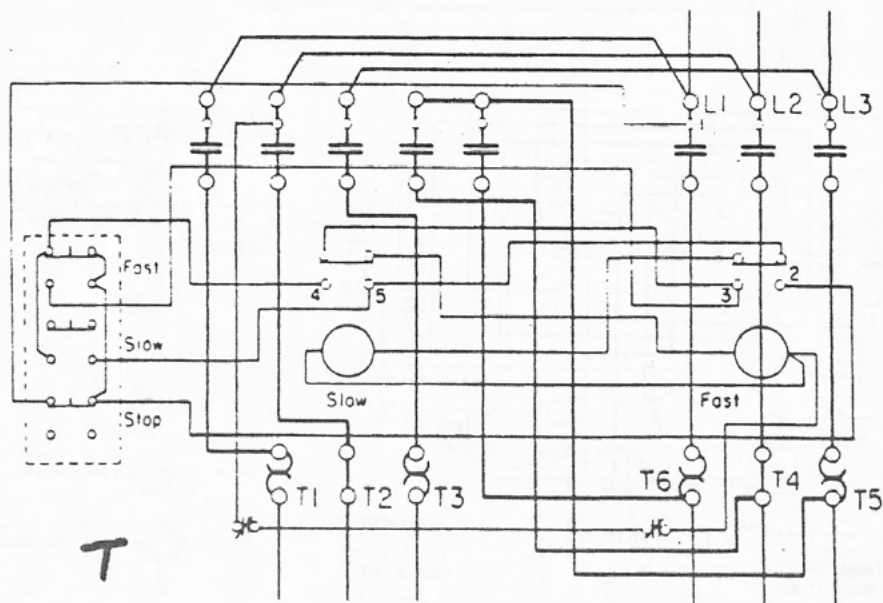
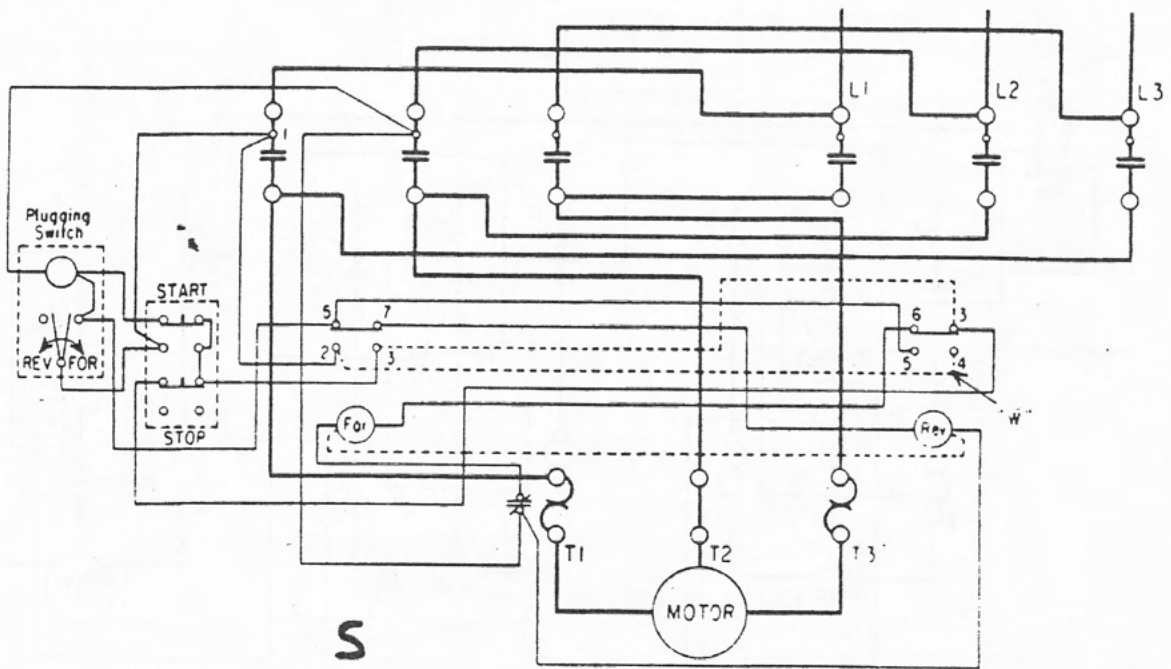
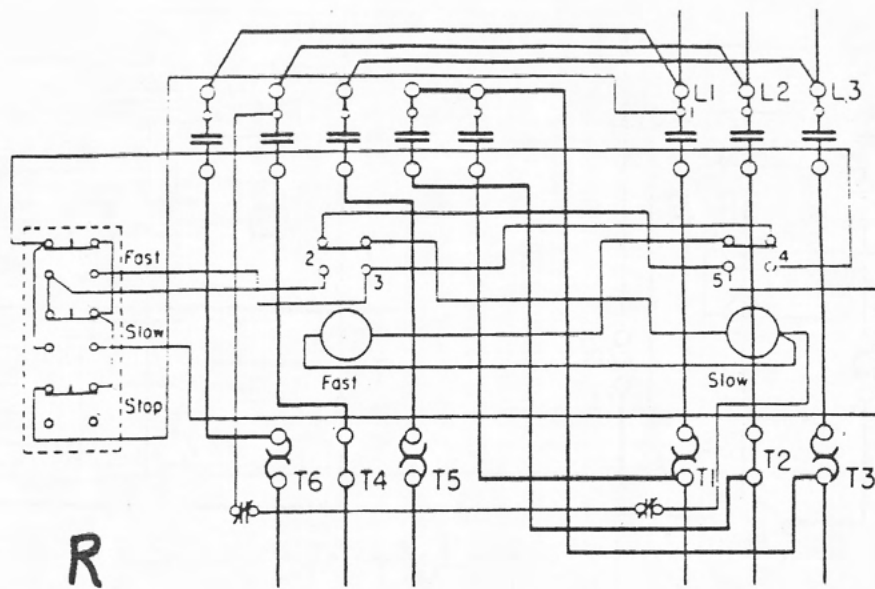
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- b. _____
- c. _____
- d. _____
- e. _____
- f. _____
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- h. _____
- i. _____
- j. _____
- k. _____
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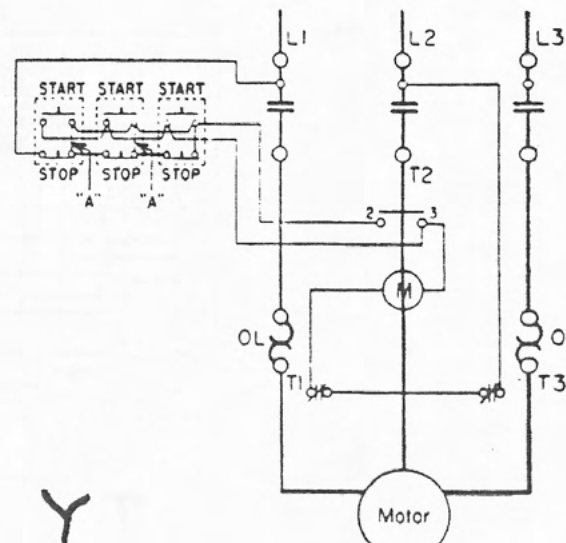
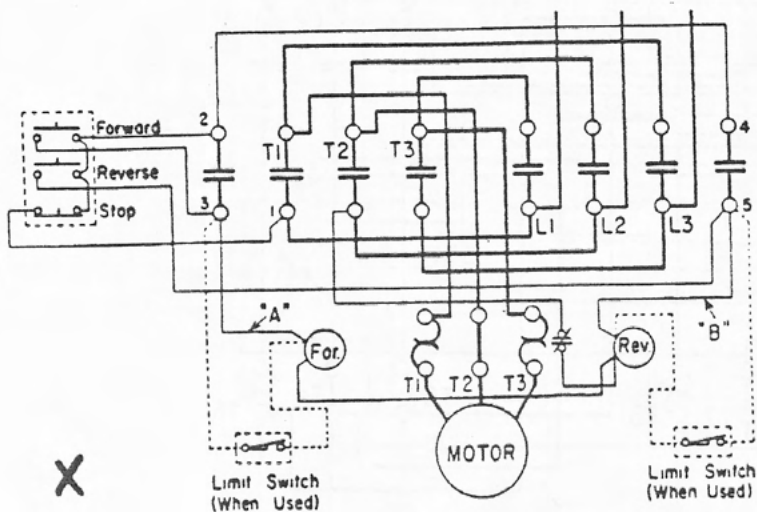
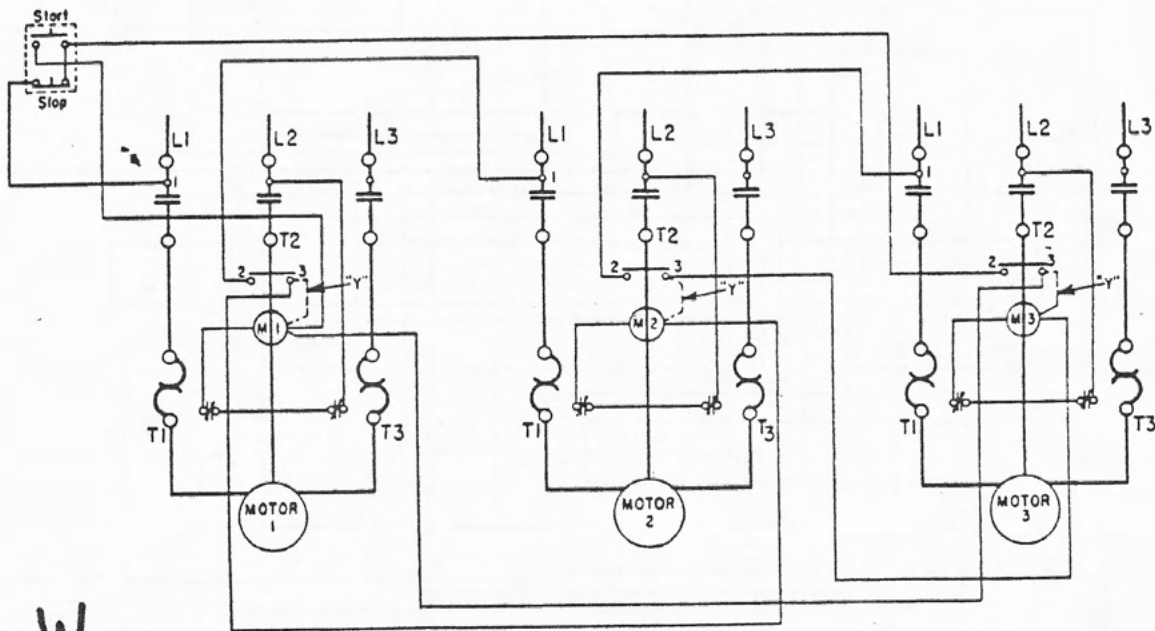
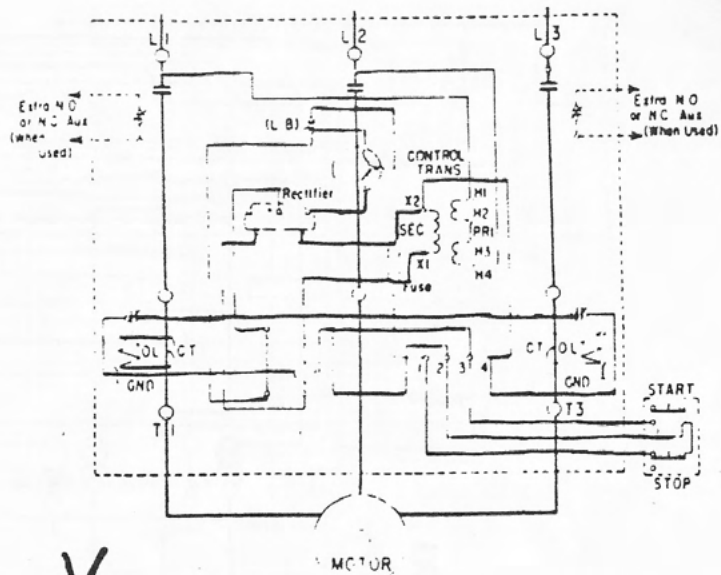
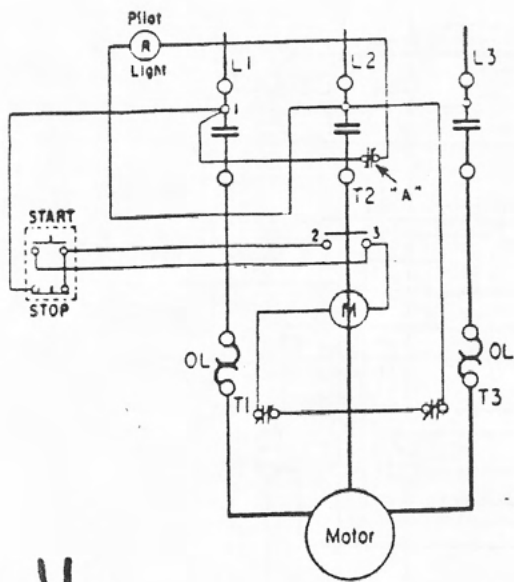


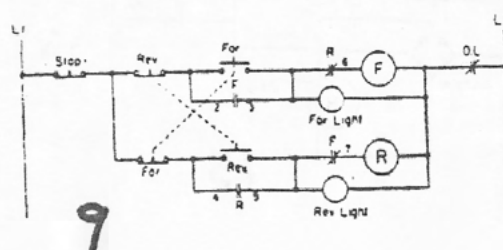
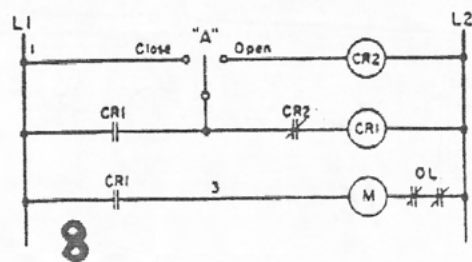
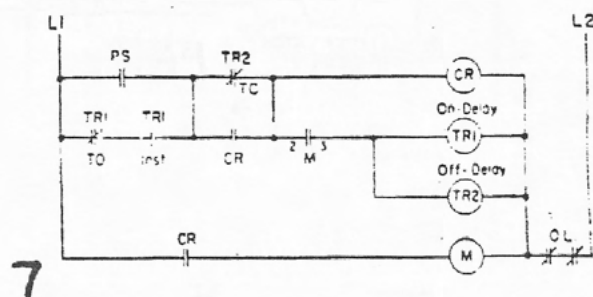
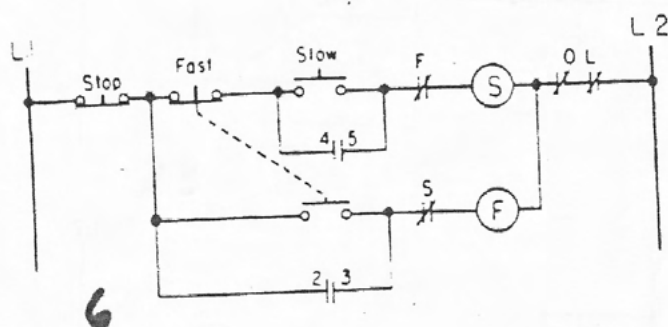
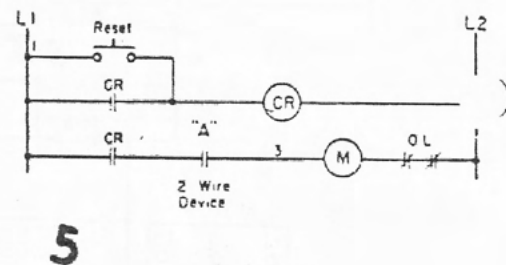
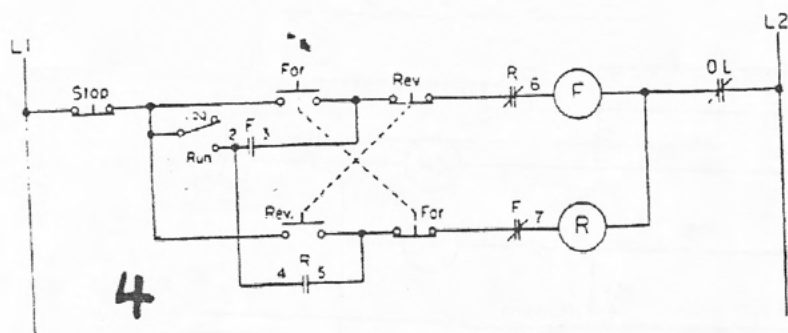
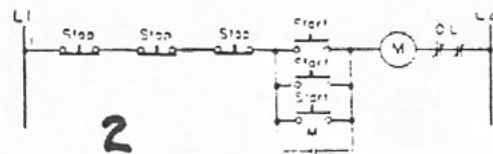


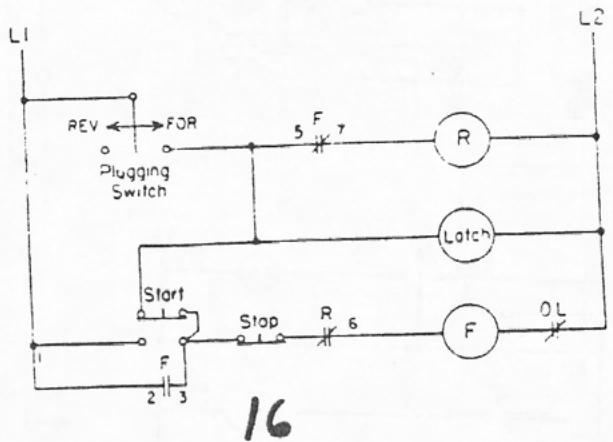
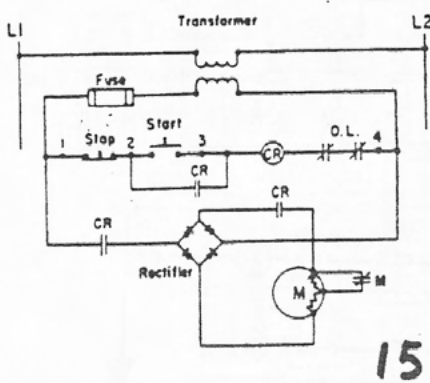
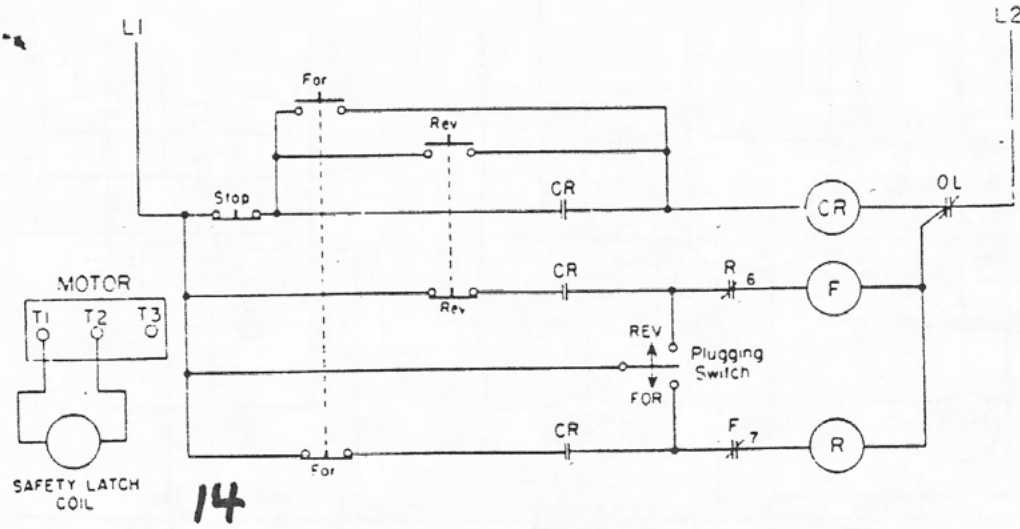
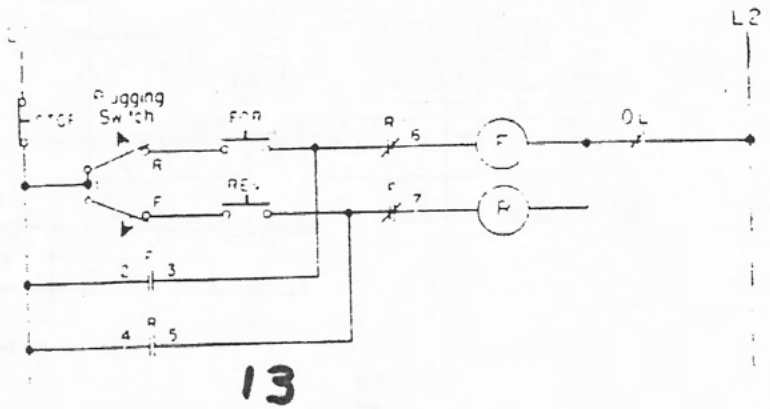
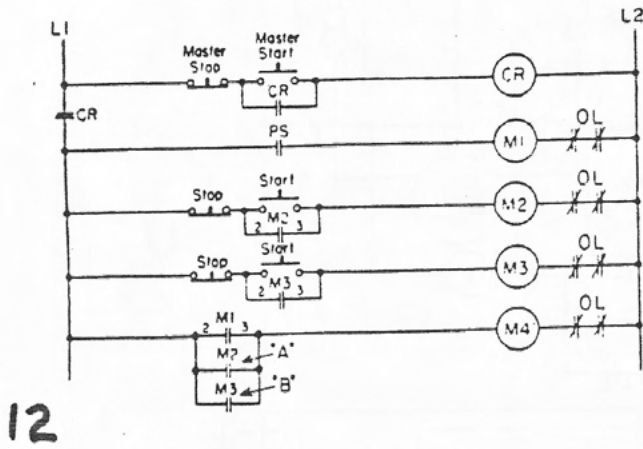
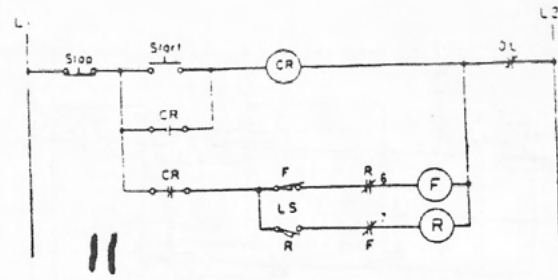
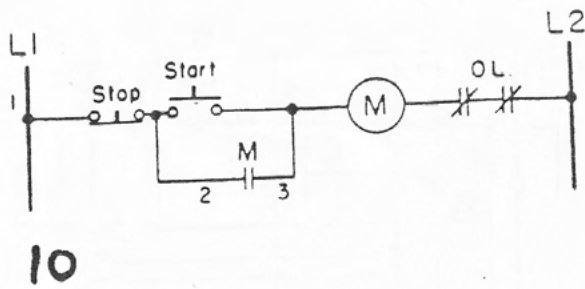




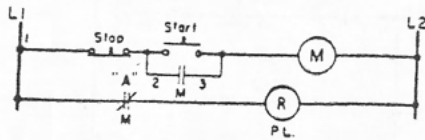




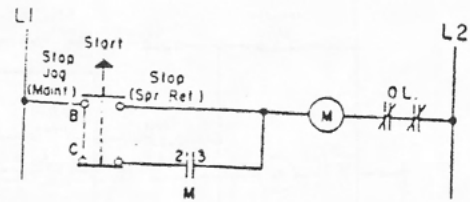




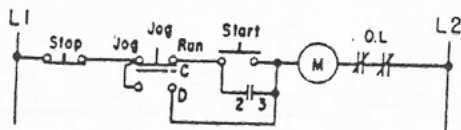
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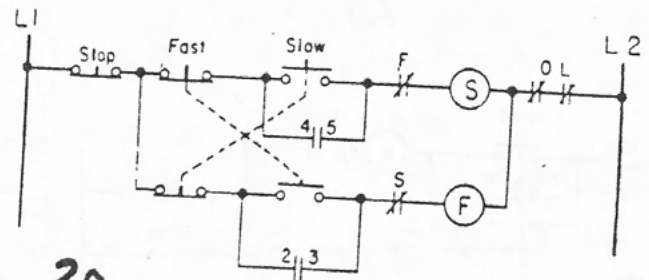
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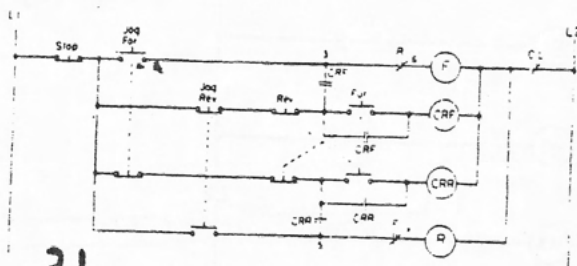
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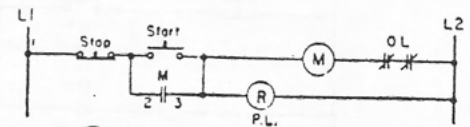
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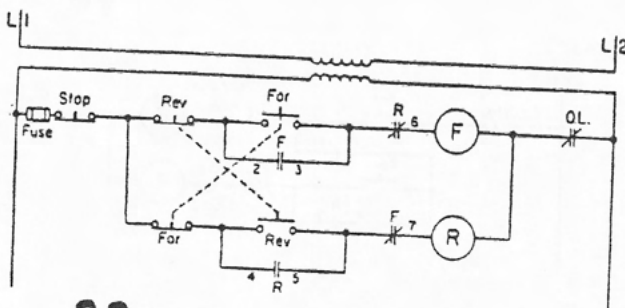
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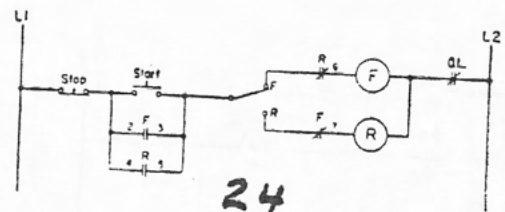
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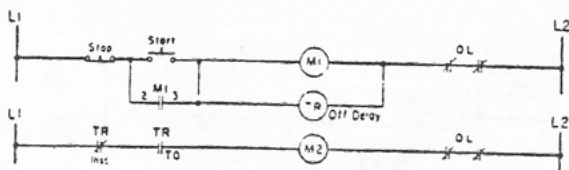
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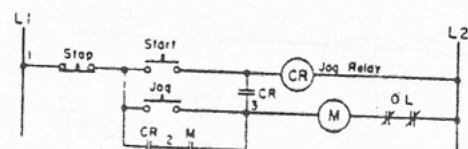
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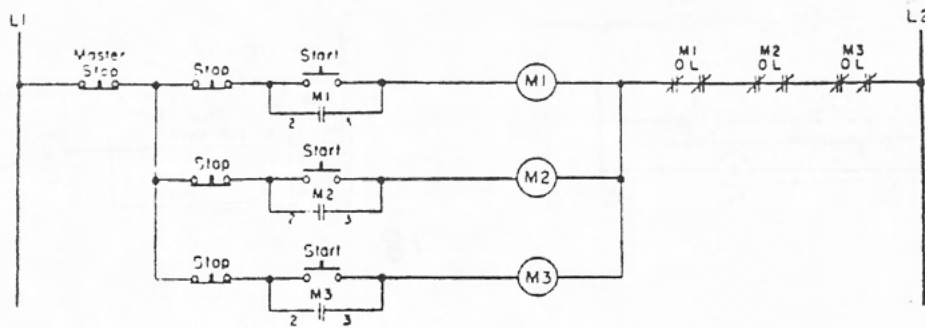


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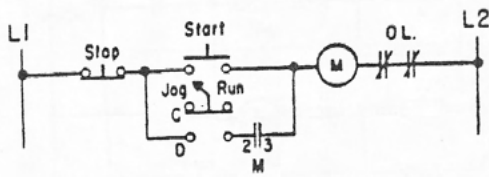


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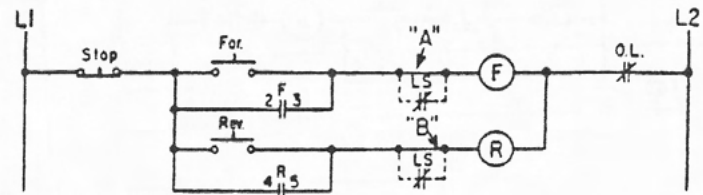




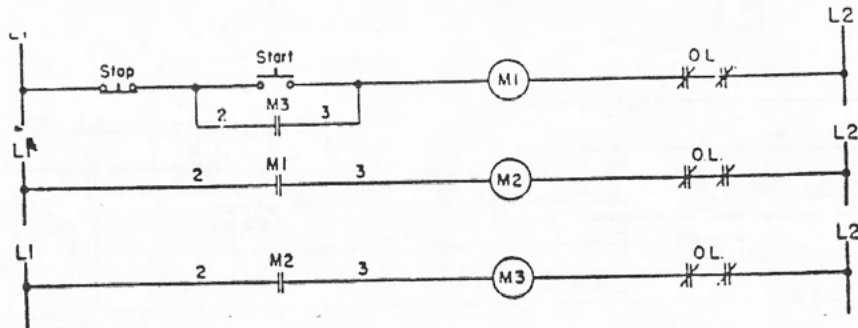
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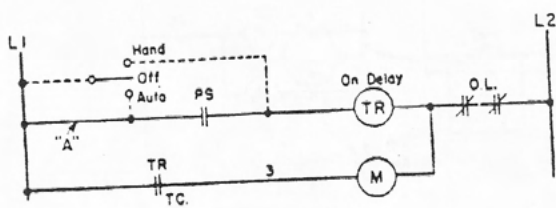
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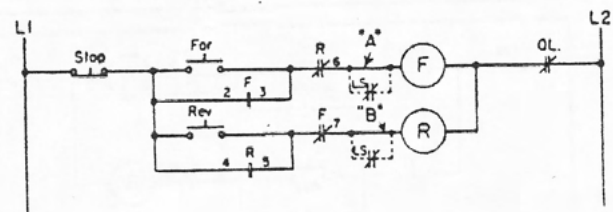
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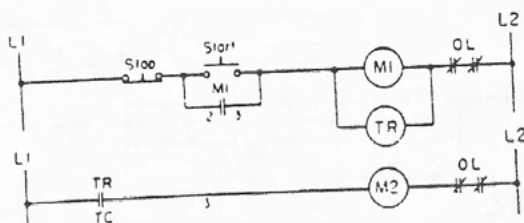
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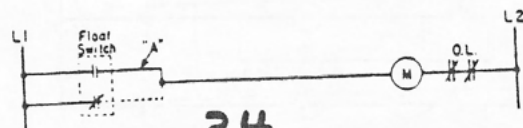
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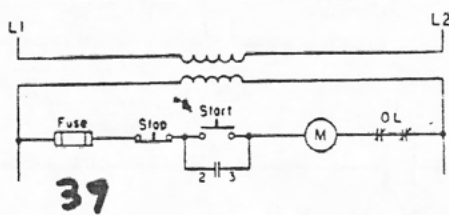
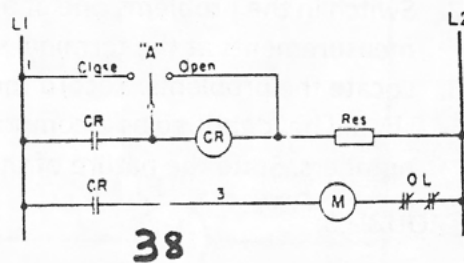
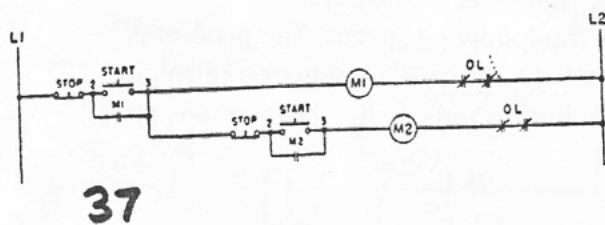
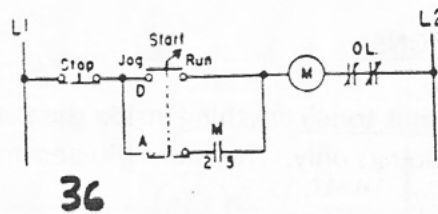
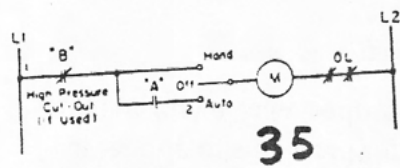
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FIELD TEST 1

INSTRUCTIONS:

Do not touch anything inside the panel except the terminal's stripes, where you will take voltage readings only. The four switches on the right side will cause for problems to appear in the circuitry.

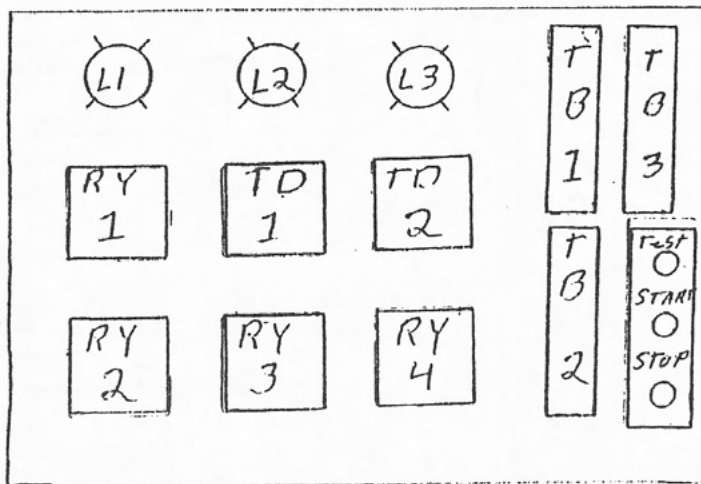
1. With no problem switch is activated identify the proper operation of the circuit (NOTE the sequence of operation listed below).
2. Switch in the problems one at a time. Troubleshoot the circuitry by making voltage measurements at the terminal stripes on the right side of the panel.
3. Locate the problems. Record the troubles in the following spaces. The problems should be identified as 2 component number or as to the wire between terminal numbers. State the nature of the problem such as (open circuit, short circuit, etc.)

TROUBLES:

1. _____
2. _____
3. _____
4. _____

4. Hand the information to your instructor for grading.

SEQUENCE OF OPERATION:



COMPONENT LOCATION

