Part 6

ALTERNATING CURRENT

MOTOR CONTROL

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Alternating Current Motor Control

If an AC motor is started on full voltage, it will draw from two to six time of its normal running current. Because the motor is constructed to withstand the shock of starting, no harm will be causes; it is generally desirable to take some measure to reduce the starting current;

For the small motor, or where the load can stand the shock of starting and no objectionable line disturbance are created, a hand operated or an automatic starting switch can be used for control of the motor. This type of switch connects the motor directly across the line is called an across the line starter or full voltage starter.

In the case of large motor, where the starting torque must develop gradually, or where the high initial current will affect the line voltage, it is necessary to insert in the line some device which will reduce the starting current. This device may be a resistance unit or autotransformer. Controllers which use this method of starting a motor is called reduce voltage starters. Controllers are also to protect the motor from overheat and overloading, to provide speed control, to provide for reversing the motor, and to provide under voltage protection.

The following popular types of conductors will be described: push-button switch starter for small motors, magnetic across the line Star, Wye-delta starters, drum starters, part-winding starters, two speed controllers, plugging and controllers.

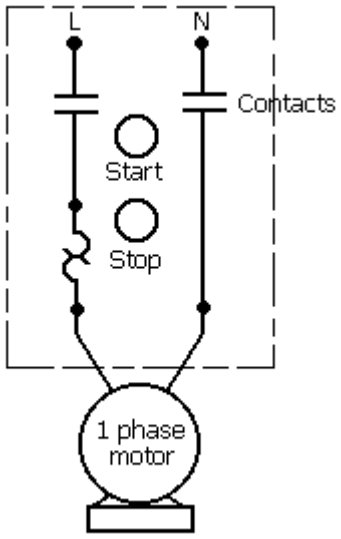


Fig. 1 Pushbutton switch starter connected to a single-phase motor.

Push-button Switch Starter for Fractional Horsepower Motors

This is a simple type of switch connects the motor directly to the line. Two push-button are located on the switch, one for starting and the other for stopping the motors. Pressing the start button case the contacts inside the switch to make and connect the motor across the line. Pressing the stop button cause the contacts to break apart and open the circuit to the motor. This type is show in Fig. 1

The usual type of push-button switch starter is equipped with a thermal overload device connect in series with the line. It opens the circuit to the motor an overload current persists for a short period of time.

Most of switch starters can be used for single, two or three-phase motors. Fig. 1 shows a diagram of a push-button starter connected to a single-phase motor and Fig. 2 shows such a starter connected to three-phase motors. In Fig. 1- 1, when the start button is pressed it close the contacts of L1 and L2 and connect the motor across the line. If an overload occurs, the thermal relay will trip the releasing mechanism and cause the contacts to open, thereby stopping the motors. To reset the tripping mechanism, it is usually to press the stop button. If the motor is running normally and it is necessary to stop it, the contacts are released by pressing the stop button. Fig. 3 is an illustration of a manual starter.

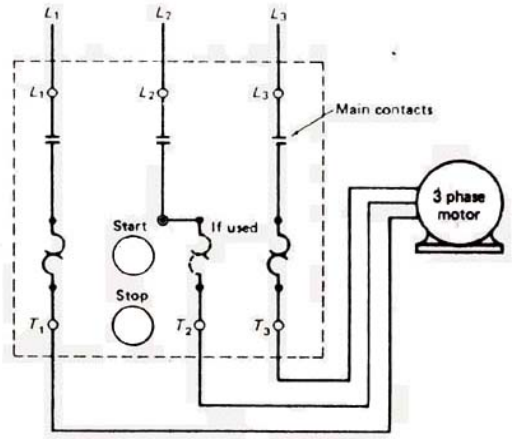


Fig. 2 Pushbutton switch starter connected to a three-phase motor.

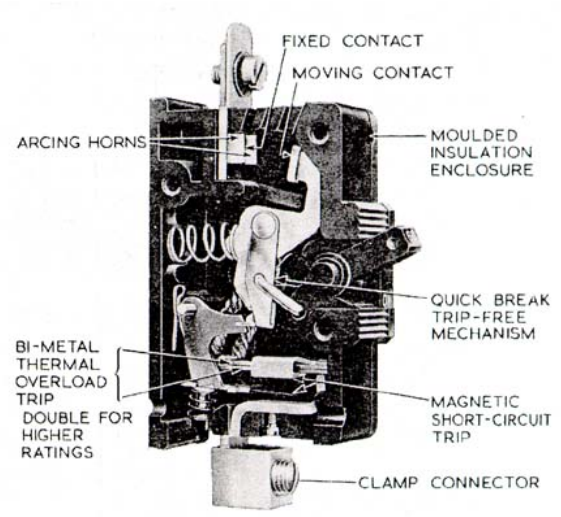


Fig.3 Type of a protection switch or manual starter

Magnetic Full-wave Starter

A starter, which connects a motor directly across the line, is called a full- wave starter. If this starter is operated magnetically, it is called a magnetic full-wave starter. A magnetic starter designed to operate a three-phase motor is shown in Fig. 4 Some of the wiring symbols in this and other diagrams are shown in Fig. 5 Fig.4 has three normally open main contacts which closed connect the motor directly to the line. It also has a magnetic holding coil, which closes the main contacts upon being energized, and also closes a normally open auxiliary and departure the contact of the normally closed auxiliary. The normally open auxiliary used to maintaining contact to the line through the holding coil. The main and auxiliary contacts are generally joined by insulating connecting bar so that all contacts will close or open when the holding coil becomes energized. It is obvious that just sending a small current through the coil can operate any size of magnetic switch. Starters are often equipping with single or dual-voltage coil for operating on either high or low voltage. Coil is made in two section in-series for high voltage, parallel for low voltage.

It should be note that two overload relays are shown in Fig.4. Most three-phase starters are made with provision for two overload elements as standard equipment, as illustrated.

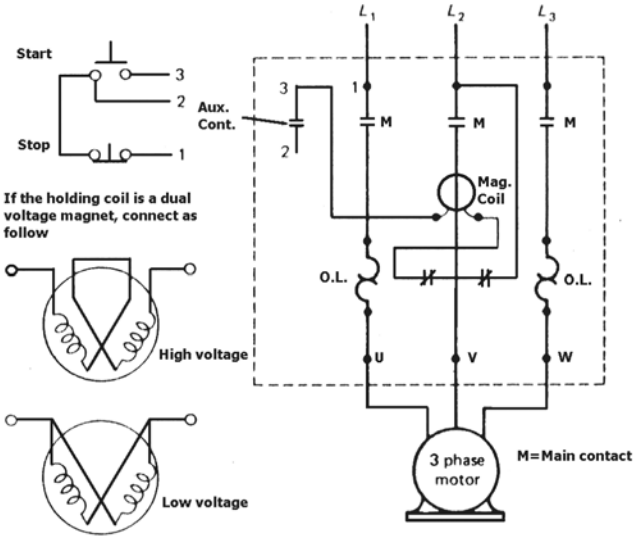


Fig.4 A magnetic across the line starter connected to a three-phase motor with two overload elements

Relay and Auxiliary Contacts	Contactor Contacts	Push Bttons	Motors and Indicating lights
Nomally Open	Nomally Open	Single Circuit Nomally Open	Indicating Light Indicate Colour By Letter Symbole
Normally Close	Normally Close	Single Circuit Normally Close	U V W 3 Phase Motor
Timed Open	Overload Relay	Double Circuits Normally Close	X Y Single Phase Non-Reversing

Fig. 5 wiring diagram symbols

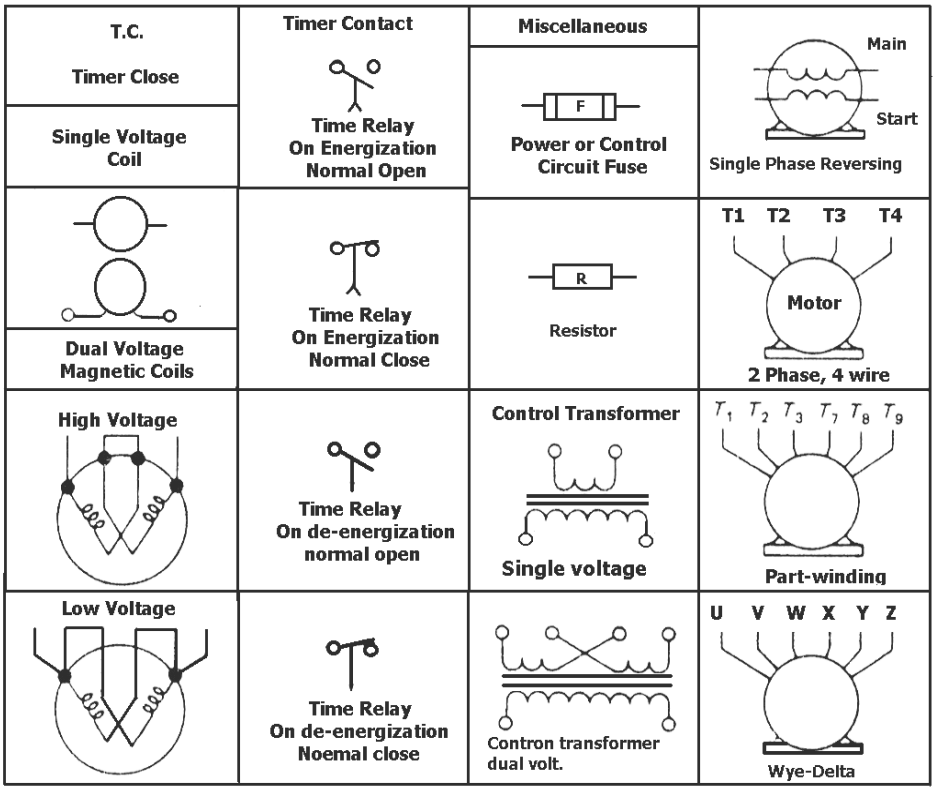
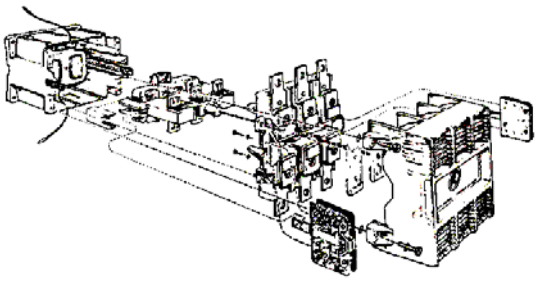


Fig. 6 wiring diagram symbols



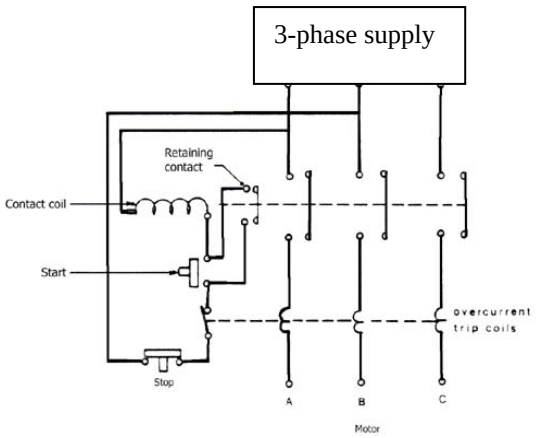


Fig. 7 A magnetic starter for a three-phase motor

An advantage of the magnetic starter over a manual starter is that merely pressing a pushbutton, which may be located some distance from both the starter and the motor, may operate it. This tends to convenience and safety in starting and stopping a motor, especially if it is high voltage or if it must be controlled from one or more remote points.

Overload Relays.

Nearly all-magnetic starters are equipped with an overload device to protect the motor from excessive current. Two types of overload relays are used on magnetic starters, and these are either magnetic or thermal in operation. The thermal overload relay may be either the bimetallic or solder-pot type.

A thermal relay is illustrated in Fig. 8 (a) and (b). This bimetallic type of relay consists of a small heater coil or strip which is connected in series with the line and which generates heat by viture of the current flowing through it; the amount of the heat generated deepens on the current flow in the line. Mounted adjacent to or directly inside, the coil is a strip formed of two metals. This is fixed at one end. The others end being free to move. The two metals have different degree of expansion, and the strip will bend when heated. The free end normally keeps the contacts of the control circuit opened. When an overload occurs, the heater heats the thermostatic so that it will bend separate the two contacts, thereby opening the holding-coil circuit and stopping the motor. The bimetallic type of overload relay is usually designed with a feature which permits automatic resetting, although it is also design for manual resetting. Some overload relays are ambient-compensated to provide maximum protection where the temperature surrounding the relay differs from the temperature surrounding the motor.

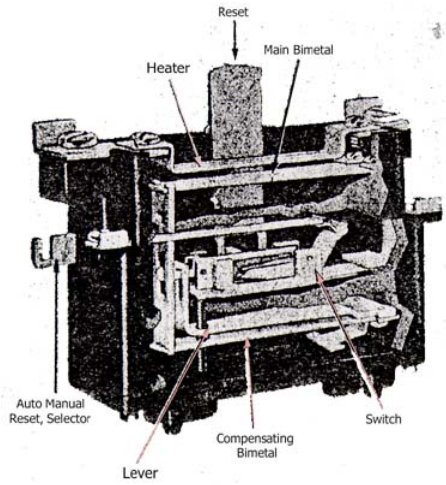


Fig. 8a bimetallic overload relay

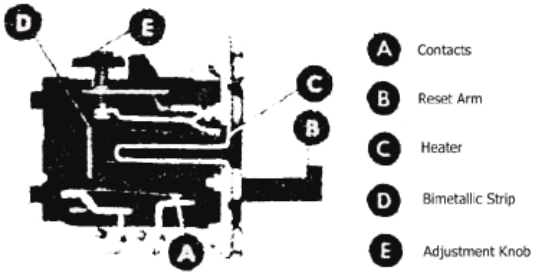


Fig. 8b. Bimetallic overload relay

Pushbutton Stations

Magnetic starters are controlled by means of pushbutton stations. The most common station has start and stop, as shown in fig. 9 when the start button is pressed, two normally open contacts are closed and when the stop button is pressed, two normally close contacts are opened. Spring action returns the button to their original position when finger pressure is removed. To operate a magnetic switch by a start-stop station, it necessary to connect the holding coil to the station contacts so that when the start button is press, the coil will become energized; and when the stop button is pressed the holding coil circuit is opened.

Fig. 9 Start Stop stations

A diagram of a typical full-voltage magnetic equipped with two thermal overload relays and connected to a start-stop station is shown in Fig. 10 In the diagram to follow, heavy lines indicate the motor circuits, and light lines show control circuits. The operation of this starter is as follow:

When the start button of Fig.10 is pressed it completes. The circuit from L1 to the normally closed contacts of the stop button through coil M and close contacts of the overload relays to L2. Thus the coil is energized and it closes contacts M and connects the motor across the line. A maintaining circuit is completed at point 3 to keep the holding coil energized after the finger is removed from the start button. Pressing the stop button opens the coil circuit and causes all contacts to open. If prolonged overload should occur during the operation of the motor, the motor relay contacts will open and de- energized the holding coil. If an overload condition has caused the relay to trip it will be necessary to reset the relay contact by hand before the motor can be restarted.

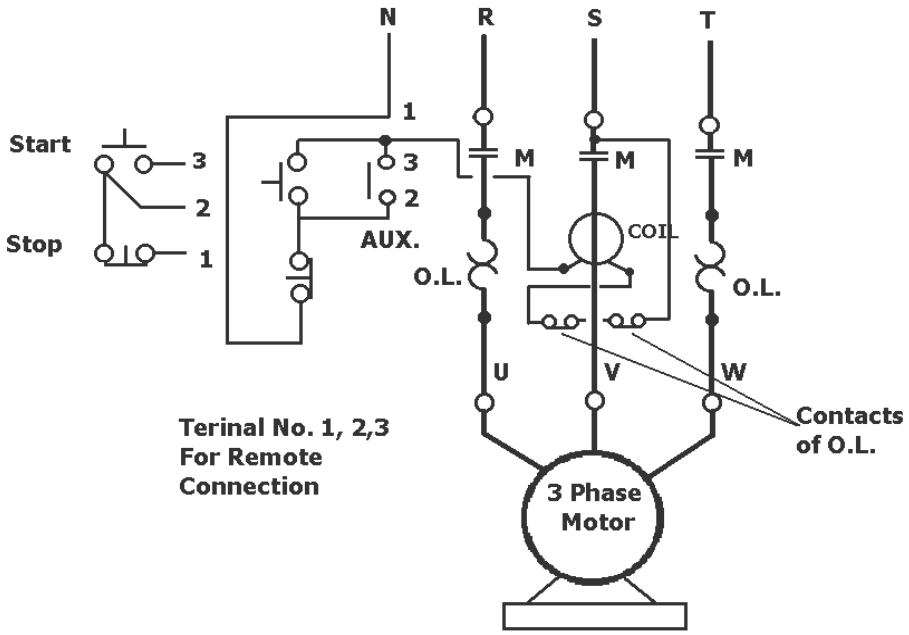


Fig. 10 A simplified diagram of magnetic across the line starter.

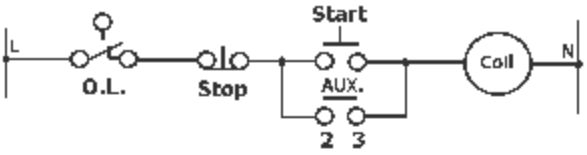


Fig. 11 showed a line diagram of the control circuit.

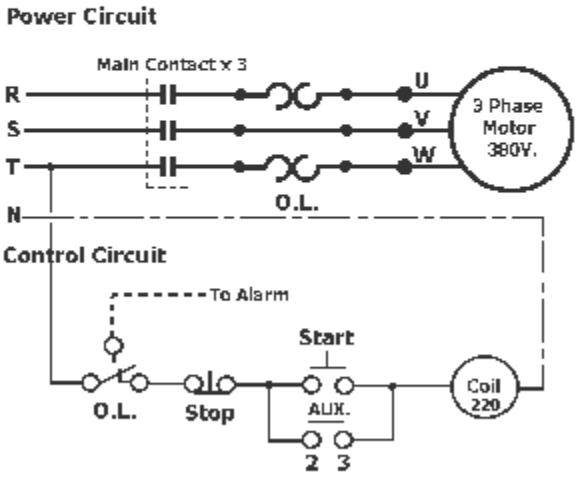


Fig. 12 line diagram of a magnetic across the line starter

The manufacturers make magnetic full-voltage starters. A typical controller is shown in Fig. 13, Fig.14, and Fig.15 shown controllers with a step-down transformer in the control circuit. This permits operating the control circuit at a lower voltage than the line voltage, and usually done for safety reasons.

If a control circuit transformer is used, the primary should be connected to the line terminals of the starter. These diagrams one end of the secondary is grounded, and also one side of control coil M is connected to the grounded.

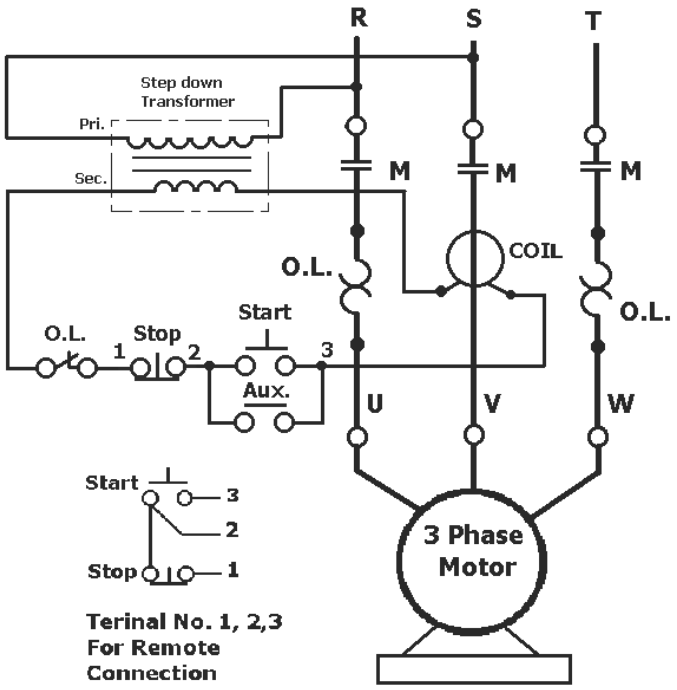


Fig.13 Three-phase starter with step down transformer in control circuit

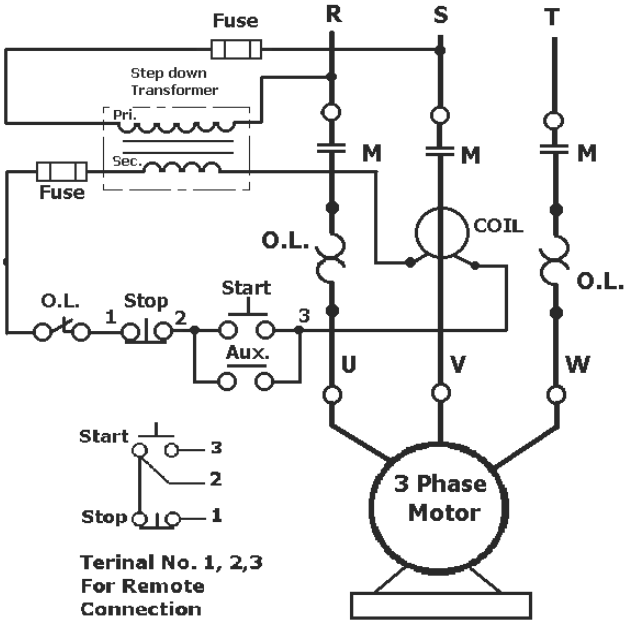


Fig.14 Three-phase starter with control circuit transformer and secondary fuse.

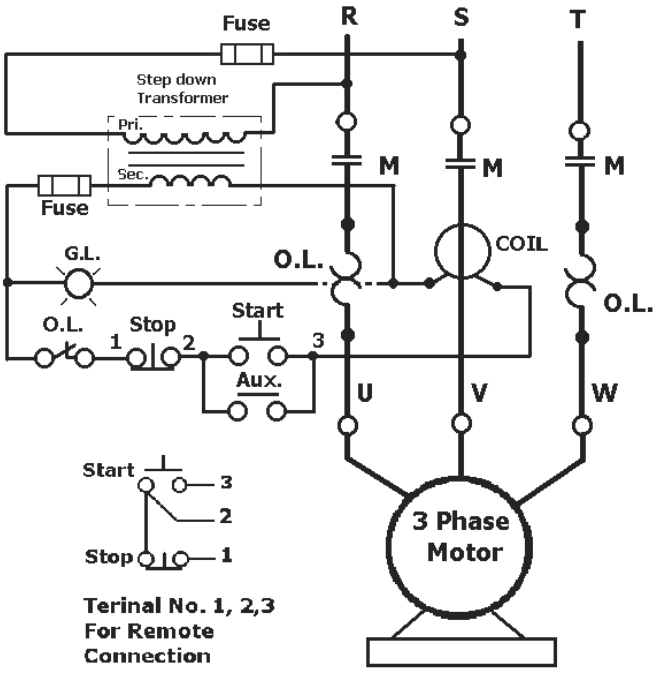


Fig.15 Three phase starter with control circuit transformer and pilot light

Combination Starters

A combination starter consists of a magnetic starter and disconnects switch mounted in the same enclosure. These starters are supplied with either a fused disconnect switch or circuit breaker. The fuse or circuit breaker provides short-circuit protection by disconnecting the line. A combination starter with circuit breaker will prevent a phasing by simultaneously opening all lines when a fault occurs in any phase. This type of starter can be quickly reset, when the fault has been cleared.

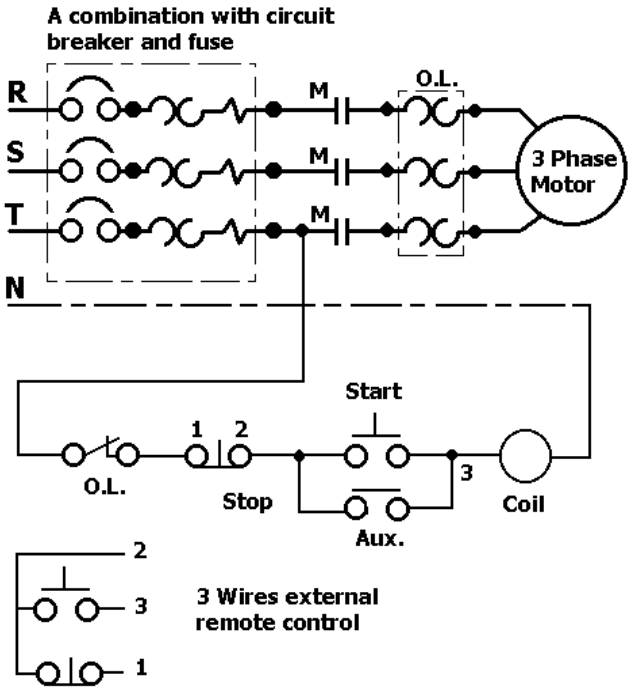


Fig.16 illustrates a circuit breaker and fused combination starter.

Pushbutton Station Connections

A number of control circuits will be illustrated involving various combinations of pushbutton stations. All of these diagrams employs one type of magnetic switch butt others can be used. Fig.17 illustrates a magnetic switch, which is operated from either of two stations. The pushbuttons are shown in two positions. Fig.18 shows a straight-line diagram of the control circuit of two start-stop stations. Fig.19 gives the control circuit of three start-stop stations. In these diagrams the start buttons are connected in parallel and the stop buttons are connected in series. This must be done, regardless of the number of stations.

The maintaining contact is always connected across the start button. All stop buttons are connected in series with the holding coil to earth, therefore the motor can be stopped any position in case of emergency.

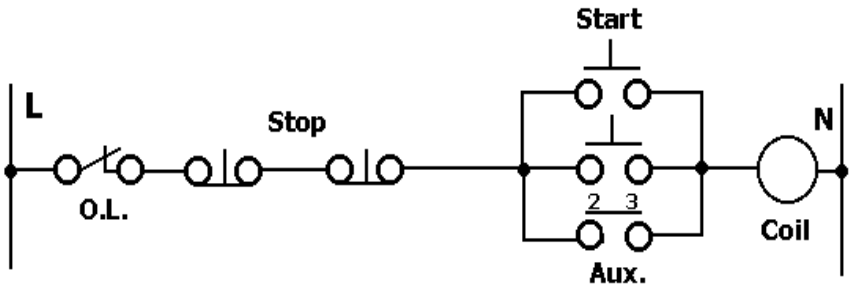


Fig.17 the magnetic switch controlled by two stop-start stations

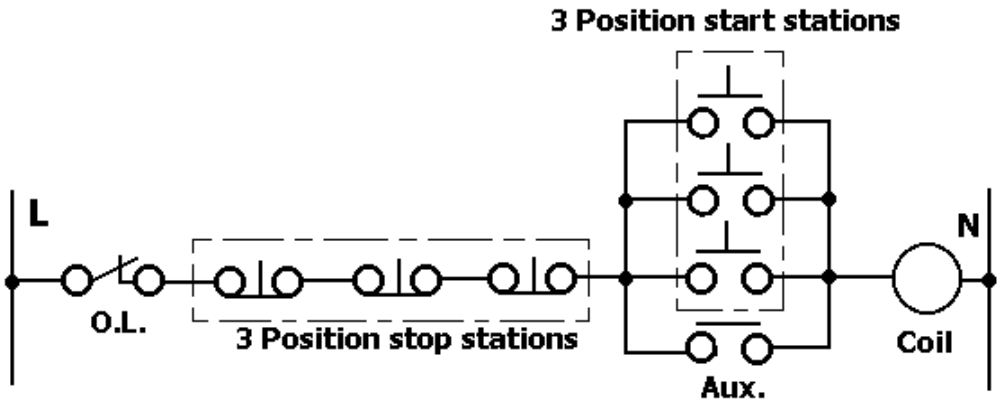


Fig.18 the control circuits for three start-stop stations

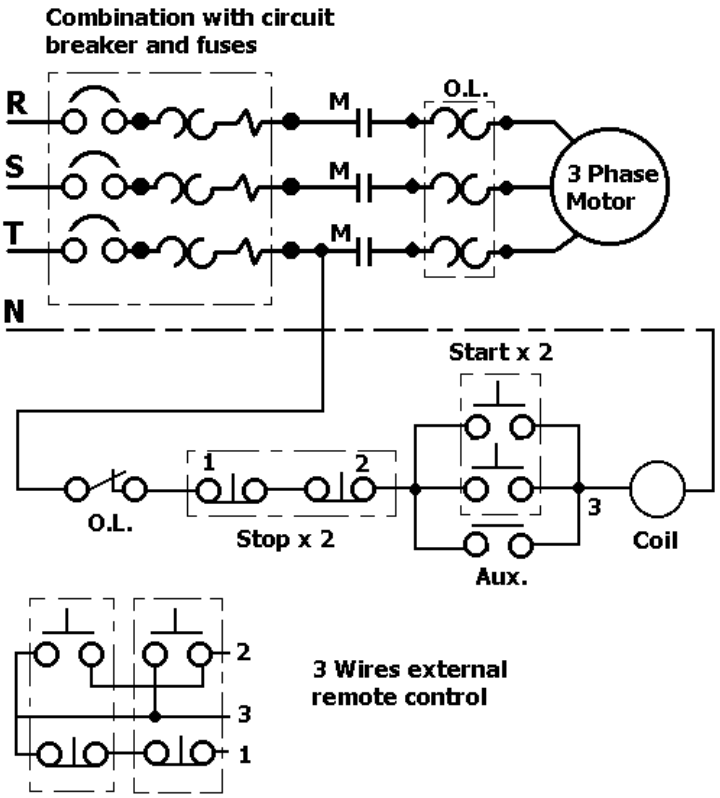


Fig.19 illustrates a circuit breaker, fuse and two start-stop push button combination starter.

Jogging

Magnetic switches can be jogged or inched by this method the motor is made to run only while the finger is pressing the jog button. As soon as pressure is removed, the motor stops.

Jogging may be accomplished by using:

1. A station with a selector pushbutton
2. A station with a selector switch.
3. A station with standard pushbutton and a jog relay.

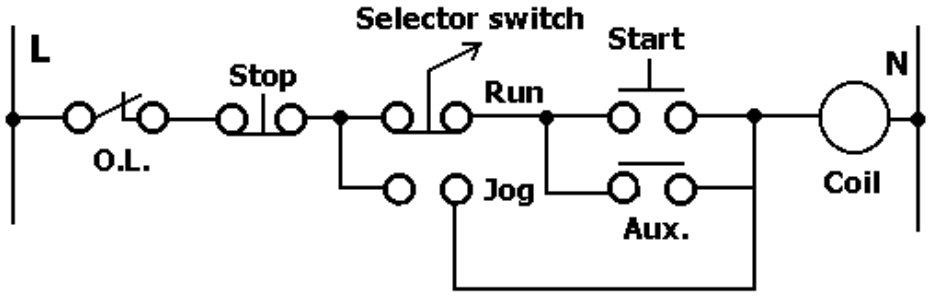


Fig.20 illustrates a start-jog-stop station by selector switch

Fig.20 shows a control circuit of full-voltage magnetic starter concerned to a start-jog-stop station having a selector pushbutton. This button is constructed with a sleeve that may be turned to either a jog or run position. With the sleeve turned to the run position, the start and stop buttons functions as in ordinary start-stop station. With the sleeve in the jog position the circuit to the holding contacts is broken and the motor will run only when the jog button is held down.

The operation of the control circuit of Fig.20 is as follow. With the selector sleeve on run, pressing the start button completed a circuit from L1 through the contact of overload relay, stop button and the close contacts of the jogging selector button, the start contacts, the holding coil to L2. This energizes the holding coil, causing contacts M to make and connect the motor across the line. The maintaining auxiliary contact keeps the holding coil in the circuit after the finger is removed from the start button. Pressing the stop button opens the coil circuit. With the selector sleeve on jog, the current cannot flow to the start button because the front contacts are in open position. Depressing the jog selector button completes a circuit through the overload relay, stop button, the jog contacts of the selector button, the holding coil, to L2. The holding coil will energize only when the button is pressed.

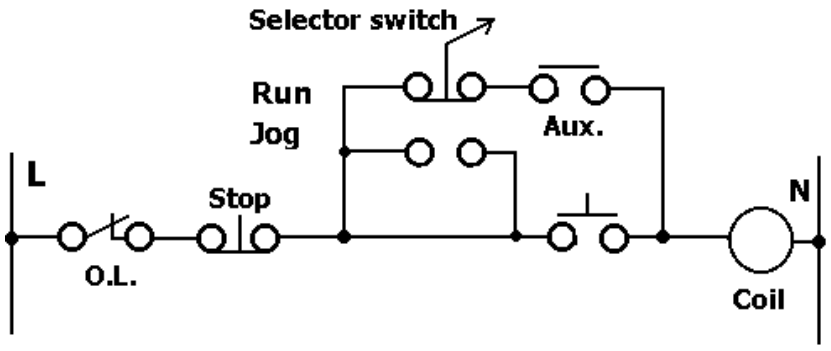


Fig 21 illustrate a jog or run is start by pushbutton

Fig.21 is show jog stations, which use a selector switch. The start button is used to jog or run the motor, depending on the position of the switch in each case with the button. In the jog position the holding auxiliary contact is broken.

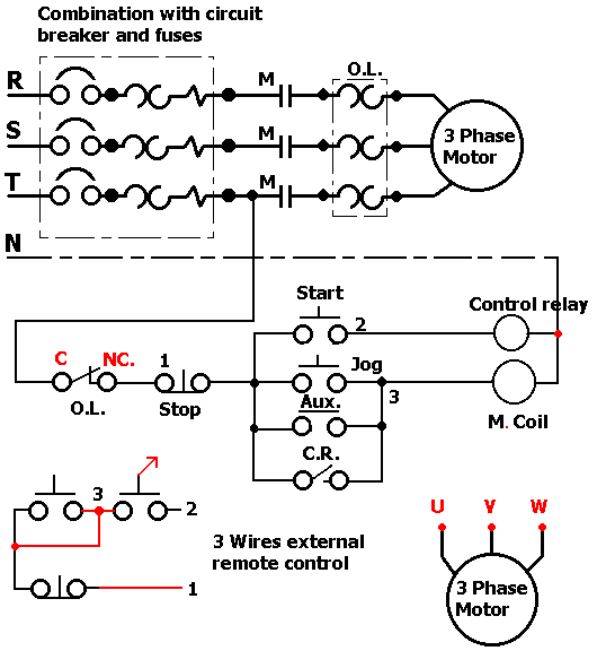


Fig. 1 - 22 Illustrate a jog or run is start by pushbutton.

When the start button is pressed, the relay coil is energized, thus the closing the relay contacts, CR; CR close the circuit for the holding coil, causing auxiliary contacts M to close. This completes the maintaining circuit for the holding coil M, when the start button is released. In the meantime all the main contacts are made, closing the circuit for the motor. If the jog button is pressed while the motor is at the stand still, a circuit is formed through the holding coils only as long as the button is pressed

Start-Stop Station with a Pilot Light

Sometimes it is advisable to have a pilot light on the pushbutton station to indicate if the motor is running. The lamp usually is mounted on the station and is connected across the holding coil. Such as connection is shown in Fig. 1- 23 and 1- 24 Fig 1-25 shows a control circuit with pilot light on when motor is stopped. Normally closed contacts are needed on this starter. With the motor running these contacts are open. Contacts are closed when the motor is stopped and pilot light goes on. A start-stop station with a pilot light is pictured in Fig.1- 23

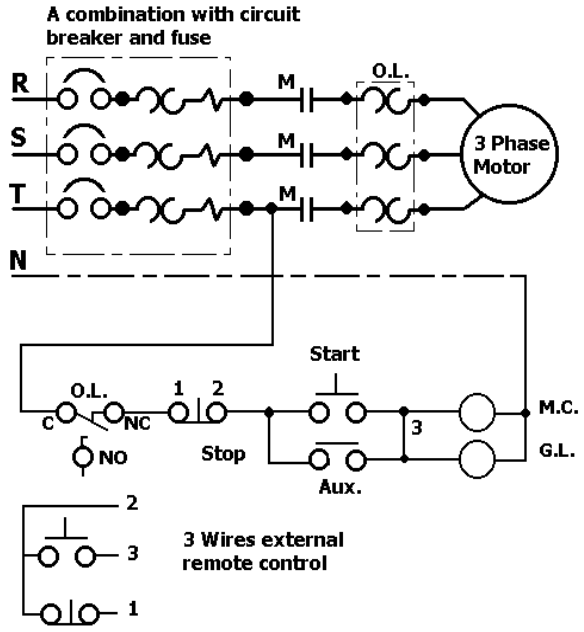


Fig. 1 - 23 Push Button Station with Pilot light connected to a 3 Phase starter.

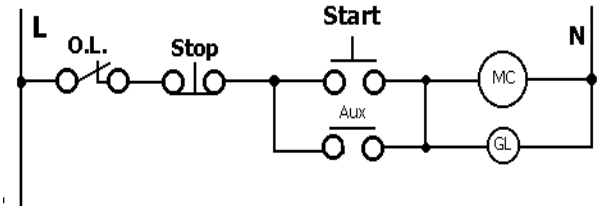


Fig. 1 - 24 A Simple control circuit of a Start-Stop Station with a Pilot light

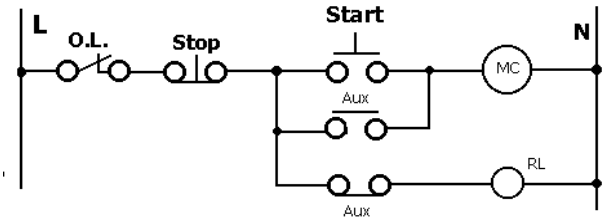


Fig. 1 - 25 Pilot light indicates when motor is not running.

Full-voltage Reversing Starter

The magnetic starters shown thus far are designed to operate the motor in one direction, either clockwise or counter clockwise. If it is necessary to reverse the motors, its connections must be changed.

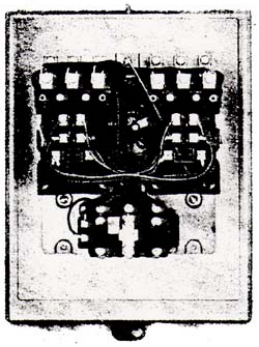
Some applications, such as conveyors, hoists, machine tools, elevators, and other require a motor starter that can reverse the motor when a button is pressed. Thus two of the line leads can be interchanged to reverse a three-phase motor by means of a magnetic reversing switch. A reversing starter of this type is shown in the Fig.1 - 26. The circuit is giving in Fig. 1 -27 and 1 - 28.

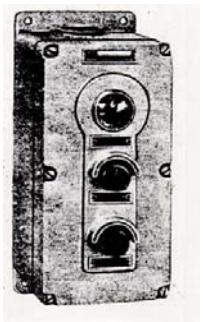
Note that it is necessary to use a Forward-Reverse-Stop station with three buttons and that two operating coils are used, one for forward rotation and the other for reverse rotation.

Two sets of main and auxiliary contacts are used. One set closes when forward operation is desired, the other set close for reverse rotation. These contacts are connects in such a manner that two line wires feeding the motor is interchanged when the reverse contacts close.

In operation pressing the forward button completes a circuit from L1 the stop button, the forward button, the forward coil, and the overload contacts to L2. This energizes the coil, which closes the contacts for forward operation of the motor. Auxiliary contacts F also close, maintaining the current through coil F when the button is released. Pressing the stop button opens the circuit through the forward coil that releases all contacts. Pressure on the reverse button energizes the reverse coil that closes the reverse contacts. Terminals T1 and T3 are now interchanged and the motor reverses.

Fig. 1 - 26 an AC. Full- Voltage magnetic reversing controller





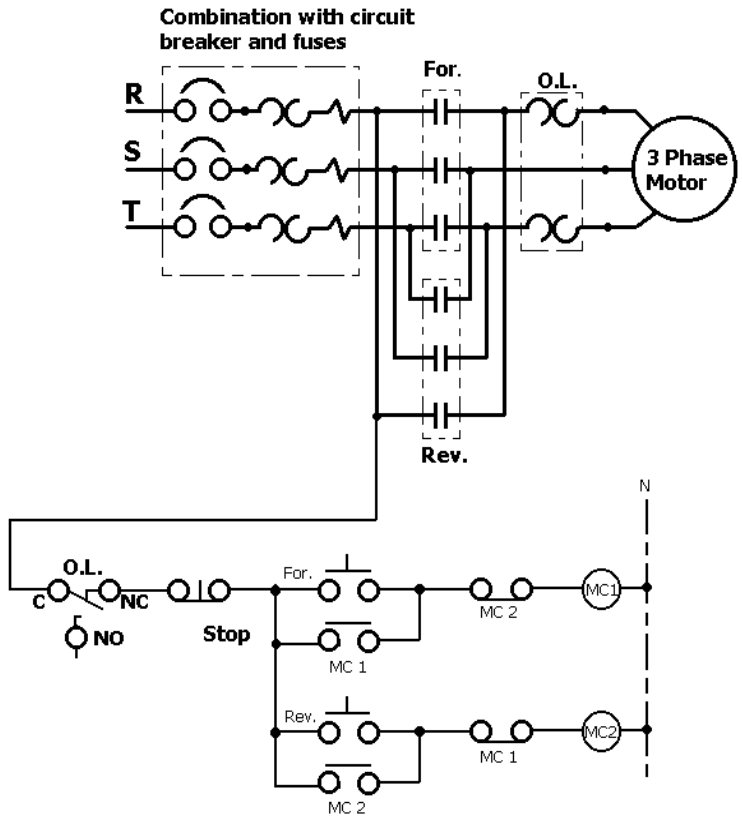


Fig. 1 - 27 A reversing magnetic starter operated by a Forward-Reverse- Stop Station

Usually, reversing starter are equipped with a mechanical interlock in the form of a bar will prevent the reverse contacts from making while the forward contacts are closed. This bar is pivoted in the center, and when the forward contractor goes in it move the bar into a position where it is impossible for the reverse contacts to make. This starter does not have electrical interlock to prevent the forward and reverse coils from being energized simultaneously. All of these starters are equipped with overload relays generally of the thermal-relay type. Remember, however that many starters use three relays for three-phase motors.

Sometime more than one forward-reverse-stop station is used to control a magnetic reversing switch. Fig. 1 - 28 shows connection diagrams of two such stations in difference positions

Besides having mechanical interlock, most reversing starter is electrically interlock. In this system, additional normally closed auxiliary contacts are used to prevent the forward and reverse contractors from being energized at the same time. The holding circuit of each main contractor coil is wired through the normally closed auxiliary contacts of the opposing contractors, thus providing the electrical interlock.

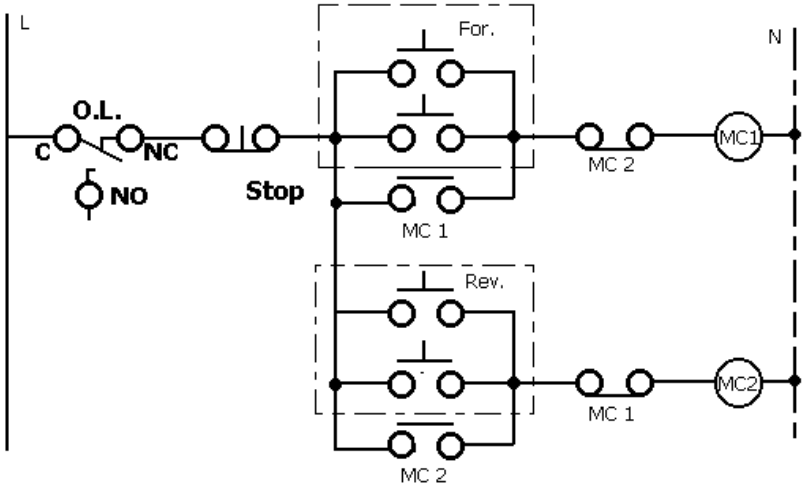


Fig.1 - 28 Connection For two Forward-Reverse and Stop stations reversing magnetic switch.

In operation, pressing the forward button closes a circuit from L1 through the stop button, the forward button, the reverse normally closed auxiliary contacts, the forward limit switch (if used), the forward coil and the overload contacts to L2. The maintaining contacts for the forward coil keep it energized when pressure is removed from the button. At the same time, the normally closed forward auxiliary contacts are opened, preventing a complete circuit through the reverse coil.