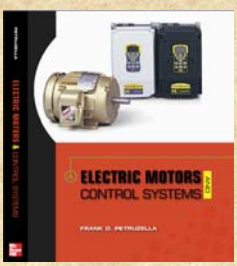


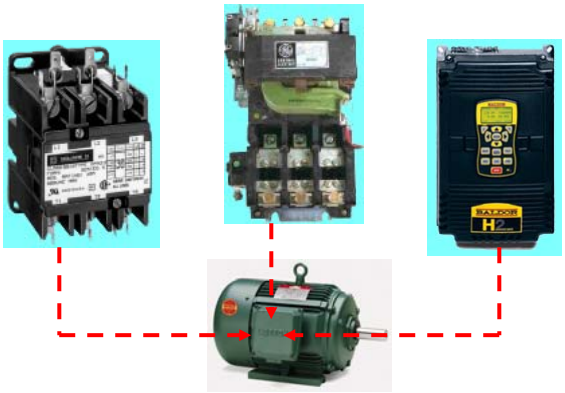
Chapter 4

Motor Control Devices

PART 1 Manually Operated Switches

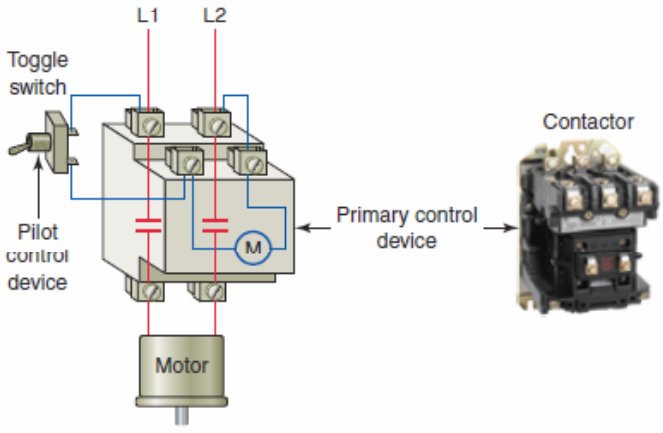
PRIMARY AND PILOT CONTROL DEVICES

All components used in motor control circuits may be classed as either *primary* control devices or *pilot* control devices.



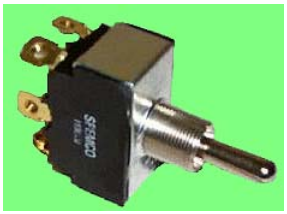
A *primary control device,* such as a motor contactor, starter, or controller, connects the load to the line.

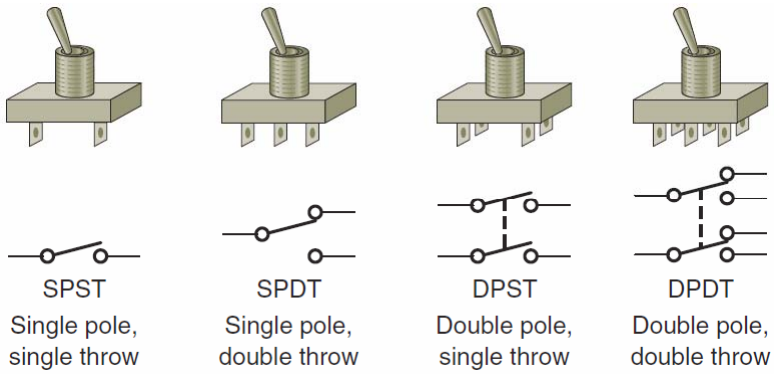
A *pilot control device*, such as a relay or sensor contact which activates a power circuit, directs the operation of another device.



TOGGLE SWITCHES

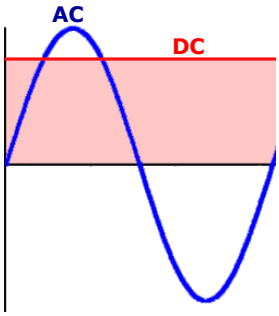
A manually operated switch is one that is controlled by hand. The *toggle switch* is an example of a manually operated switch.





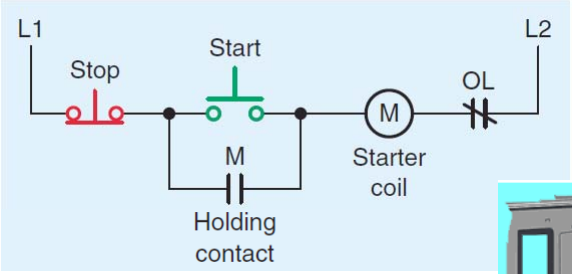
Electrical ratings for all switches are expressed in terms of the *maximum interrupting voltage and current* they can safely handle.

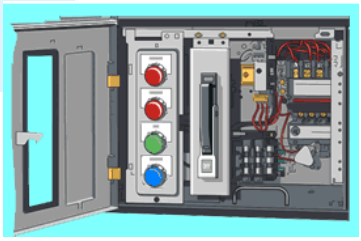
The AC current rating will be higher than its DC rating for an equivalent amount of voltage. One reason for this is that AC has current zeros twice a cycle reduces the likelihood of an electric arc forming across the contacts.



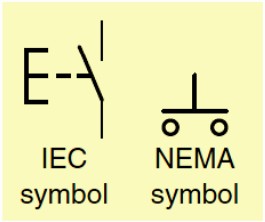
PUSHBUTTON SWITCHES

Pushbutton switches **are commonly used in motor control applications to start and stop motors, as well as to control and override process functions.**



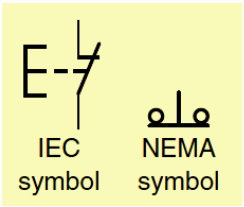


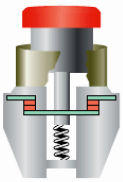
A pushbutton operates by pressing a button that opens or closes contacts.



N.O. (normally open) pushbutton

The N.O. pushbutton makes a circuit when it is pressed and returns to its open position when the button is released.

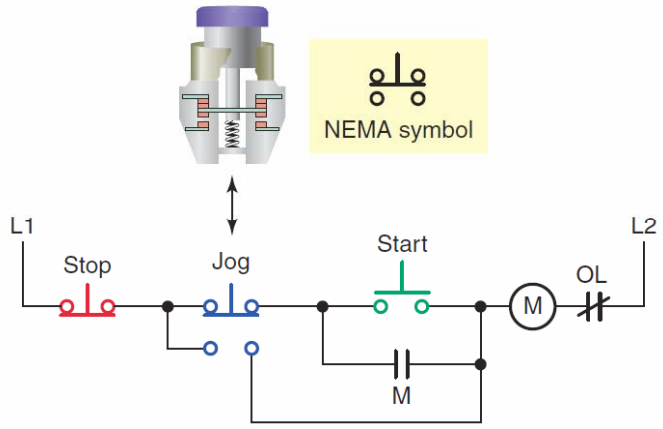




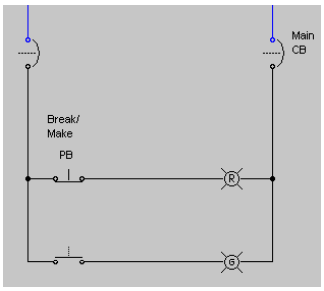
N.C. (normally closed) pushbutton

The N.C. pushbutton opens the circuit when it is pressed and returns to the closed position when the button is released.

With a *break-make pushbutton* the top section contacts are N.C. the bottom section contacts are N.O. When the button is pressed, the bottom contacts are closed after the top contacts open.



Simulated Break-Make Pushbutton Operation



Most motor control devices are mounted in *enclosures* designed to protect their contents from operating environmental conditions.

When you have one or more pushbuttons in a common enclosure, it is referred to as a *pushbutton station.*

NEMA Type 1 Enclosure

The types of enclosures are standardized by the National Electrical Manufacturers Association (NEMA).

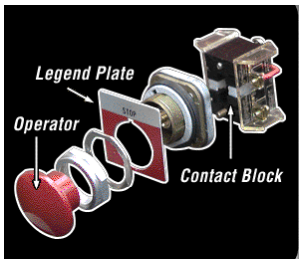
Nema Enclosure Types

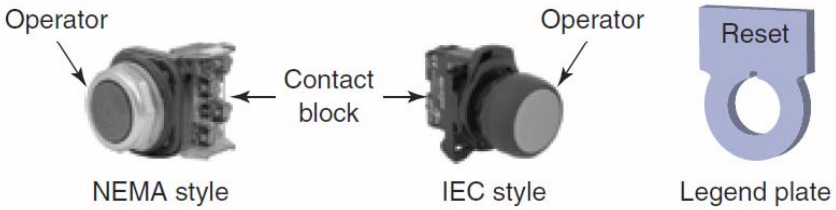
Type	Use	Service Conditions
1	Indoor	No unusual
3	Outdoor	Windblown dust, rain, sleet, and ice on enclosure
3R	Outdoor	Falling rain and ice on enclosure
4	Indoor/outdoor	Windblown dust and rain, splashing water, hose-directed water, and ice on enclosure
4X	Indoor/outdoor	Corrosion, windblown dust and rain, splashing water, hose-directed water, and ice on enclosure
6	Indoor/outdoor	Occasional temporary submersion at a limited depth
6P	Indoor/outdoor	Prolonged submersion at a limited depth
7	Indoor locations classified as Class I, Groups A, B, C, or D, as defined in the NEC	Withstand and contain an internal explosion sufficiently so an explosive gas-air mixture in the atmosphere is not ignited
9	Indoor locations classified as Class II, Groups E or G, as defined in the NEC	Dust
12	Indoor	Dust, falling dirt, and dripping noncorrosive liquids
13	Indoor	Dust, spraying water, oil, and noncorrosive coolant

NEMA Type 7

NEMA Type 9

Pushbuttons assemblies **basically consist of an operator legend plate and contact block.**



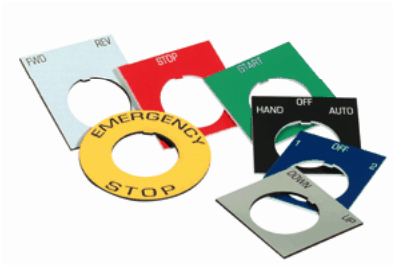


The *operator* is the part of the pushbutton assembly that is pressed, pulled, or rotated to activate the pushbutton's contacts.

Operators are come in many different colors, shapes, and sizes designed for specific control applications.

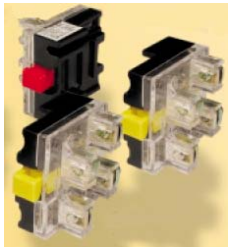
Legend plates **are the labels that are installed around a push button and identify its purpose. They come in many sizes, colors, and languages.**

Examples of label text include START, STOP, FWD, REV, JOG, UP, DOWN, ON, OFF, RESET, and RUN.

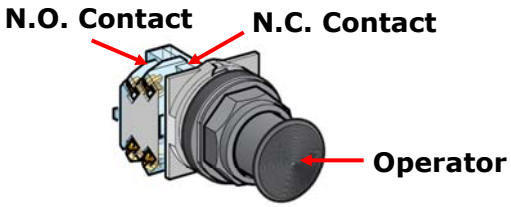


The *contact block* is the part of the pushbutton assembly that is activated when the button is pressed.

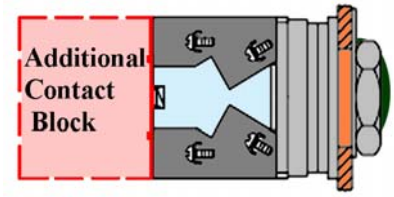
The contact block may house many sets of contacts that open and close when you operate the pushbutton.



The standard contact configuration allows for one *normally open* and one *normally closed* set of contacts within a contact block.

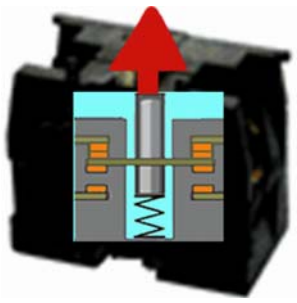


A pushbutton may contain *stacked contacts* that change state with a single push of a single button.



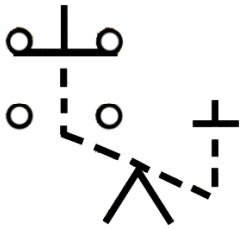
The contacts of the contact block itself are spring loaded and return to their normal "ON" or "OFF" state when the operator is released. However, when contact blocks are attached to a pushbutton operator their switching action is determined in part by that of the operator.

Momentary type pushbutton operators return to their normal "ON" or "OFF" state as soon as the operator is released.



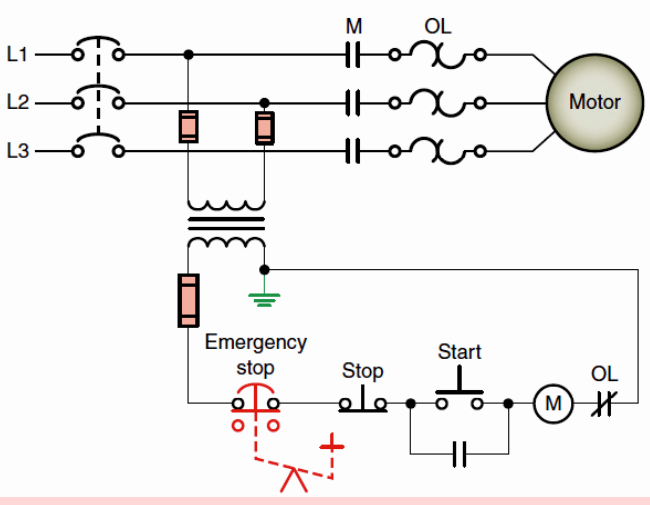
Maintained **type pushbutton operators require you to press and release the operator to switch the contacts to their "ON" state and to press and release the operator a second time to return the contacts to their "OFF" state.**

Maintained type
Emergency Stop
switch



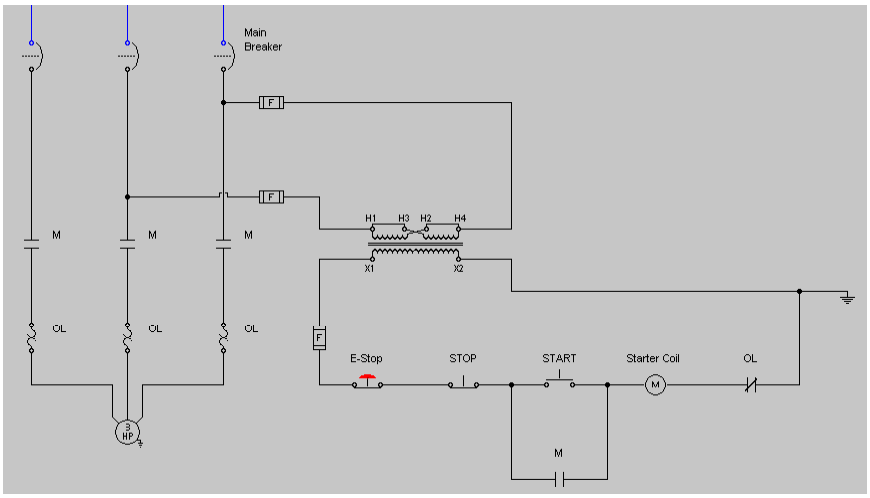
Maintained Contact Double Circuit Pushbutton Symbol

Typical Emergency Stop Circuit



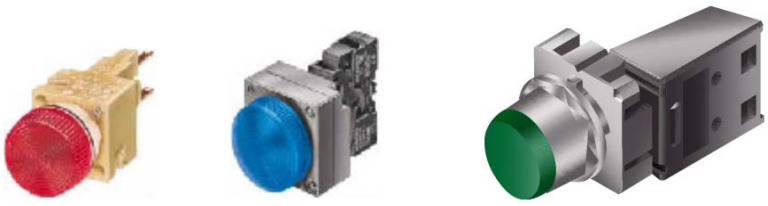
In order to restart the motor after the emergency stop pushbutton has been activated you must first reset the emergency stop pushbutton and then press the start button.

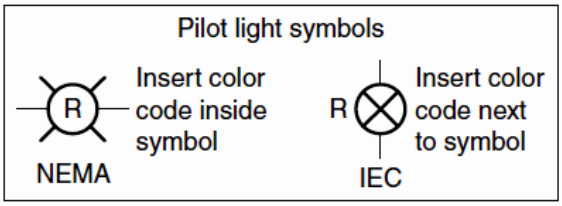
Simulated Emergency Stop Operation



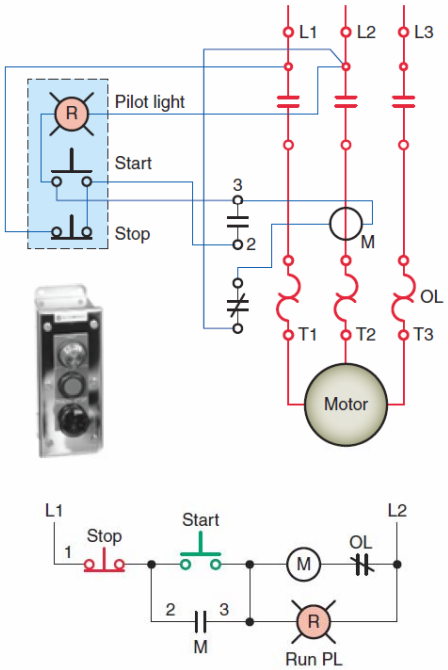
PILOT LIGHTS

Pilot lights **provide visual indication of the status for many motor controlled processes permitting personal at remote locations to observe the current state of the operation.**

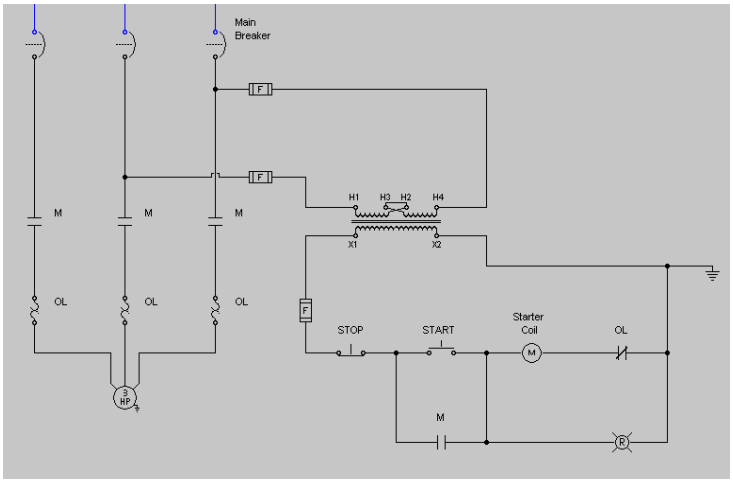




Circuit for a start/stop pushbutton station with a pilot light connected to indicate when the starter is energized.

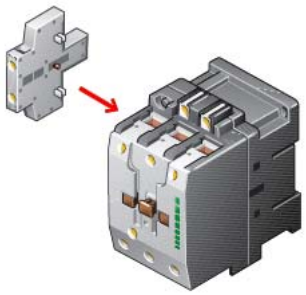


Simulated RUN Pilot Light Operation



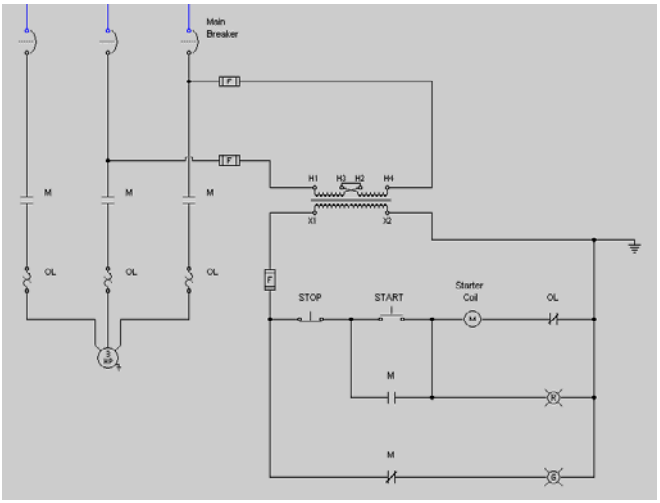
If it is necessary for a pilot light to show when the starter is de-energized, a normally closed auxiliary contact may be attached to the starter.

N.C. Auxiliary Contact Operated By Coil "M"

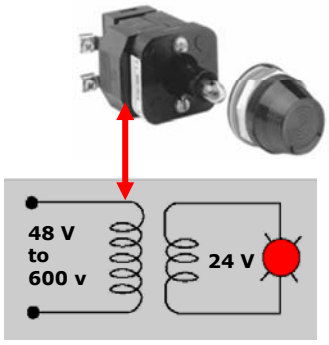


Magnetic Starter

Simulated OFF and RUN Pilot Lights Operation

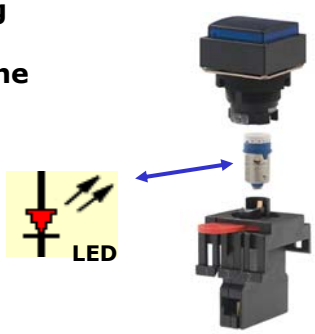


Pilot lights are available in both full voltage and *low voltage* types.

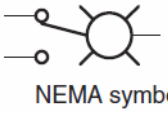


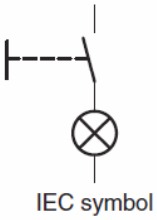
Connecting a step-down transformer to a standard pilot light reduces the operating voltage supplied to the lamp.

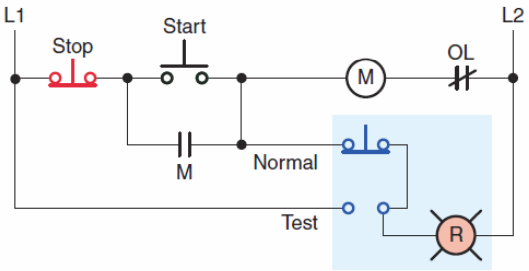
Also available are illuminated units utilizing integrated LED's (Light Emitting Diodes), which operate at 6 to 24-volt, AC or DC.



Dual input *push-to-test* pilot lights are designed to reduce the time required to troubleshoot a suspected faulty lamp.

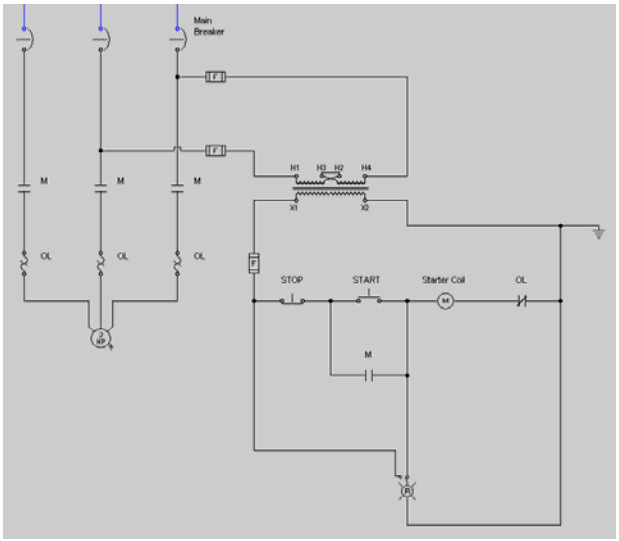






Push-to-test pilot light pilot light circuit.

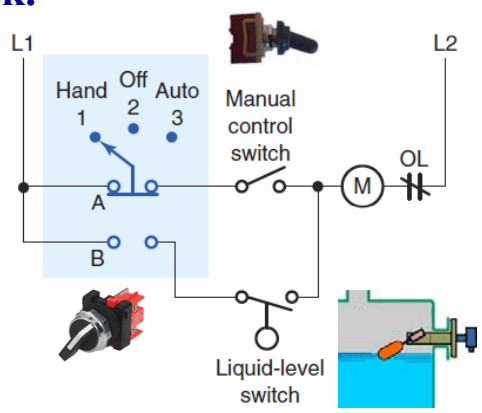
Simulated Push-to-Test Pilot Light Circuit



SELECTOR SWITCH

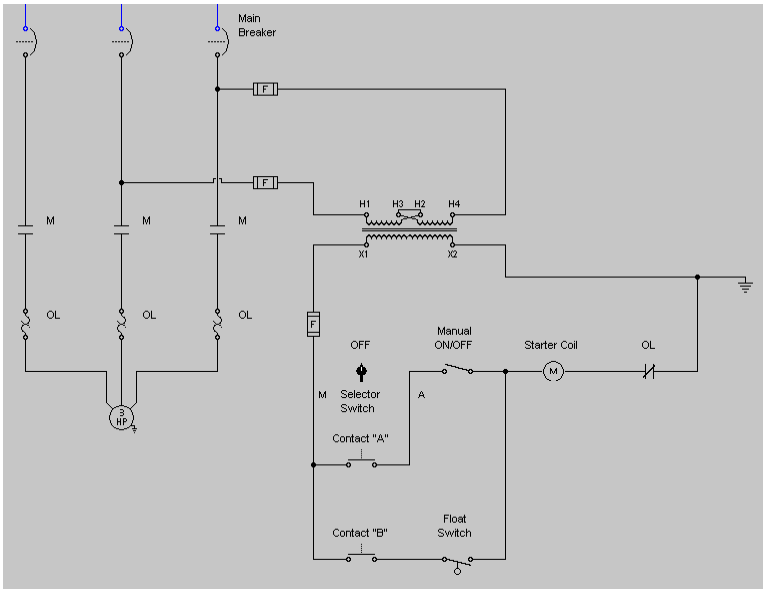
Selector switches **are manually operated switches in which the operator handle is rotated (instead of pushed) to actuate the attached contact block.**

Three-position selector switch pump circuit



Position	Contacts	
	A	B
1	X	
2		
3		X

Simulated Selector Switch Operation

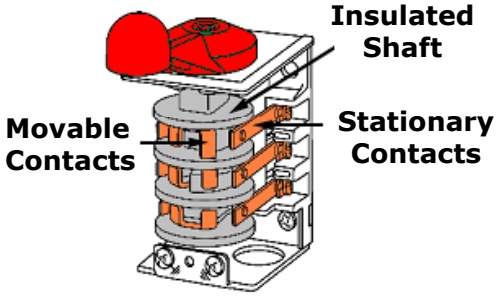


Keyed **selector switches require a special key for their operation. This allows only authorized personal actuate the switch and can serve as additional safety lockout for motors.**

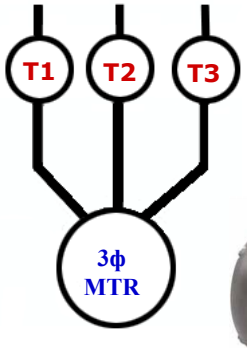
Although keyed switches may be used in addition to standard lock out tag out procedures, under no circumstance should they be used *in place of them*.

DRUM SWITCH

A *drum switch* consists of a set of moving contacts mounted on and insulated from a rotating shaft.

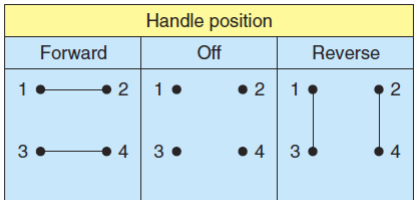


Drum switches are used for starting and reversing 3ϕ squirrel-cage motors, 1ϕ motors that are designed for reversing service, and DC shunt and compound -wound motors.



Reversing the direction of rotation of 3ϕ squirrel-cage motors is accomplished by interchanging any two of the three main power lines to the motor (T1-T2-T3).

Three-phase motor reversing drum switch connections



Motor connections	
Forward	Reverse
L1-to-T1	L1-to-T3
L3-to-T3	L3-to-T1
L2-to-T2	L2-to-T2