

Chapter 2

Understanding Electrical Drawings

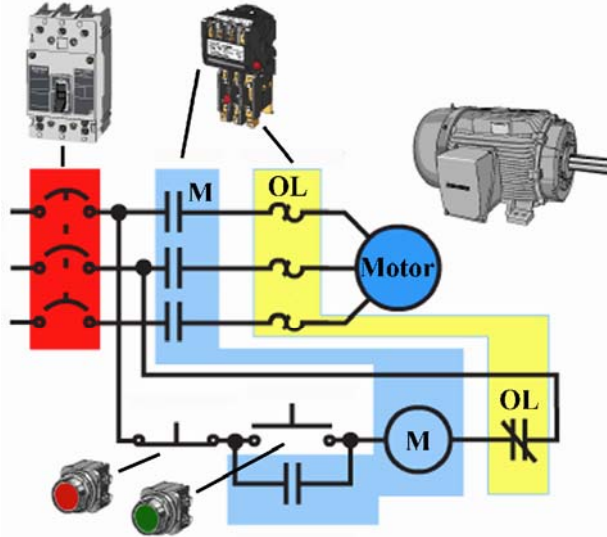
PART 1 Symbols— Abbreviations—Ladder Diagrams

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MOTOR SYMBOLS

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Symbols are used to represent the different components of a motor control system.

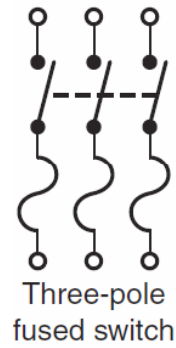
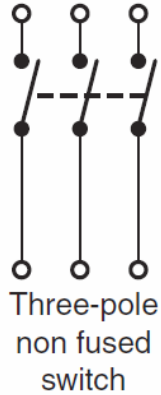
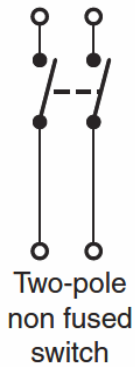


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Symbols sometimes look nothing like the real thing, so we have to learn what the symbols mean.


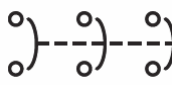


Disconnect Switches



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Three-pole circuit breaker



Overload relay





Thermal OL relay


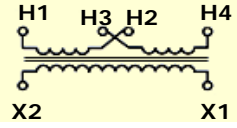
Solid-state OL relay

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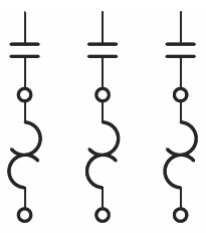
Fuse



Control transformer

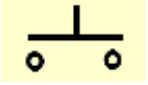


Three-phase magnetic motor starter

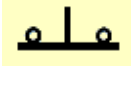


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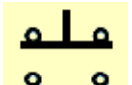
Push buttons




**Normally open
momentary
pushbutton**



**Normally closed
momentary
pushbutton**





**Combination
normally
open
and
normally
closed,
momentary
pushbutton**




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Pilot light


Electrical wires are represented by lines




Low-current
control
wiring




High-current
control
wiring



Wires
crossed but
not connected




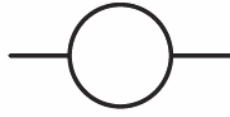


Wires
connected



Ground
connection

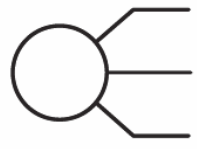
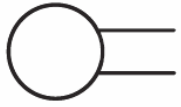

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Electromechanical relay

 Normally open contact	 Magnetic coil	 Normally closed contact	
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AC Motor

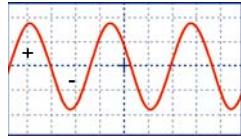
 Three-phase motor	 Single-phase motor	
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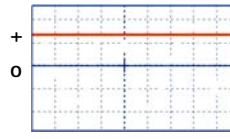
**ABBREVIATIONS
FOR MOTOR TERMS**

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An abbreviation is the shortened form of a word or phrase. Uppercase letters are used for most abbreviations.



AC - alternating current



DC - direct current



ARM - armature



FLD - field

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L1, L2, L3
line connections

M - motor starter

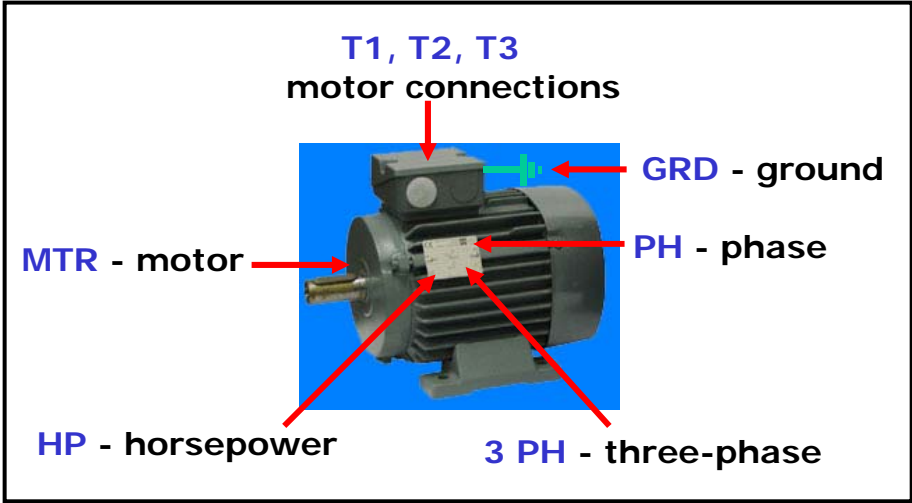
FWD -forward
contactor

REV -reverse
contactor

OL - overload relay

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T1, T2, T3
motor connections



MTR - motor

HP - horsepower

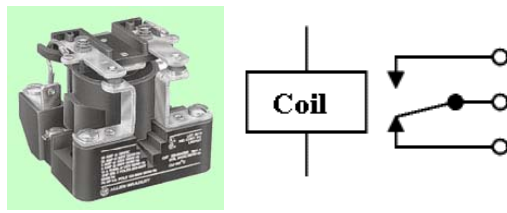
GRD - ground

PH - phase

3 PH - three-phase

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CR - control relay




Coil

NO - normally open

COM - common

NC - normally closed


AUTO - automatic




MAN - manual

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BKR - breaker



DB Resistor




DB - dynamic braking



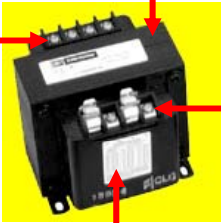
CT - current transformer

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LS -limit switch



TRANS -transformer







PRI - primary

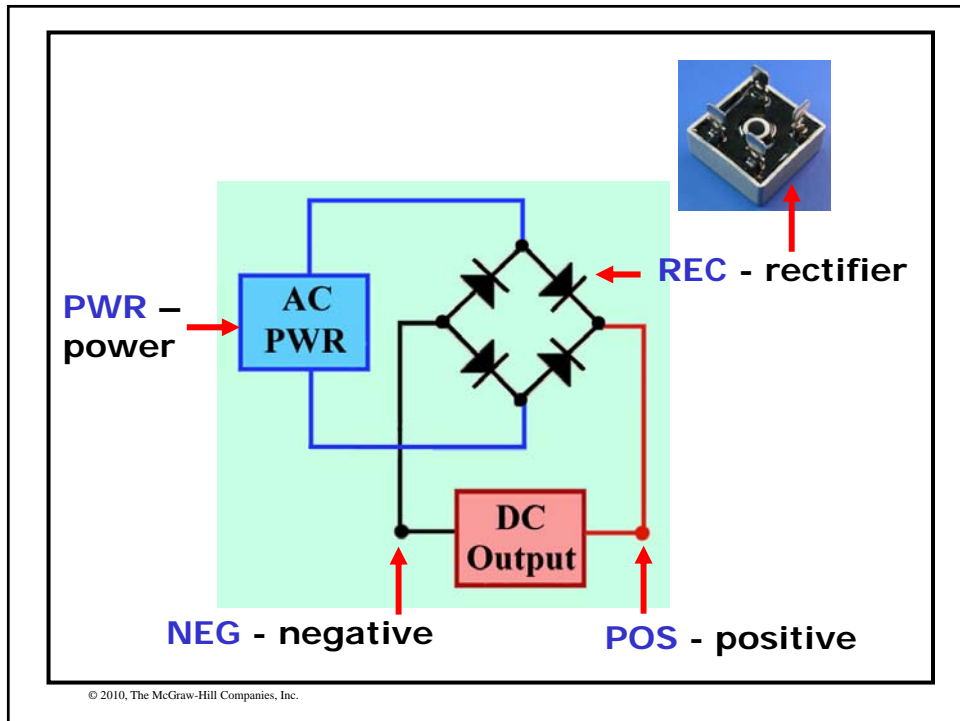
SEC - secondary

1 PH - single-phase

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<p>SOL - solenoid</p> 	<p>RH - rheostat</p> 
 <p>TD - time delay (relay)</p>	 <p>SW - switch</p>

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SSW - safety switch



PB - pushbutton



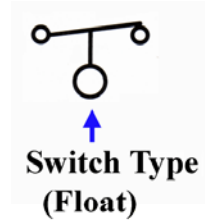
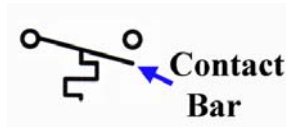
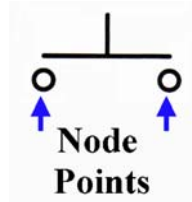
PL - pilot light

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MOTOR LADDER DIAGRAMS

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Motor control drawings provide information on circuit operation, device and equipment location, and wiring instructions.

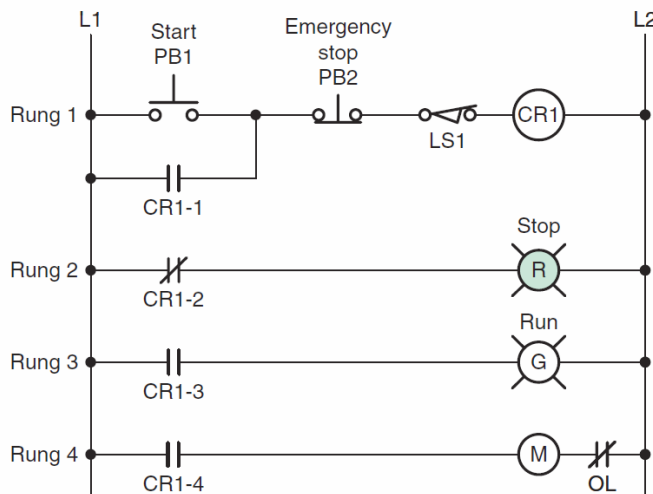


Symbols used to represent switches consist of node points (places where circuit devices attach to each other), contact bars, and the specific symbol that identifies that particular type of switch

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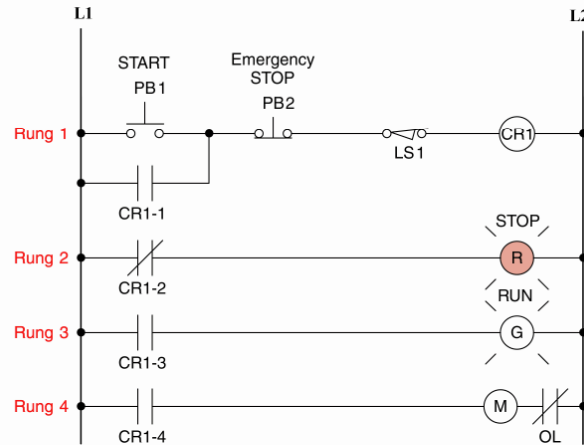
The *ladder diagram* focuses on the electrical operation of a circuit, not the physical location of a device.

The vertical lines (called rails) connect to the power source and are identified as line 1 (L1) and line 2 (L2).



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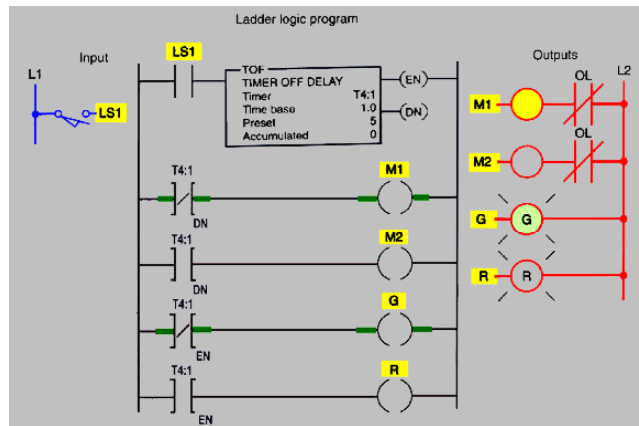
The horizontal lines (called rungs) are connected across L1 and L2 and contain the control circuitry.



Ladder diagrams are designed to be read like a book, starting at the top left and reading from left to right and top to bottom.

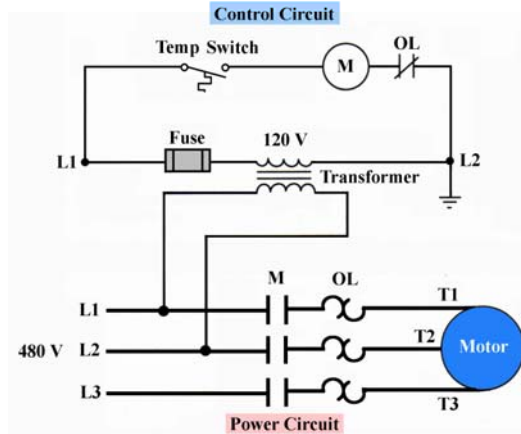
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Most programmable logic controllers (PLCs) use the ladder-diagramming concept as a programming language.



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On diagrams that include power and control circuit wiring, you may see both heavy and light conductor lines. The heavy lines are used for the higher-current power circuit and the lighter lines for the lower-current control circuit.

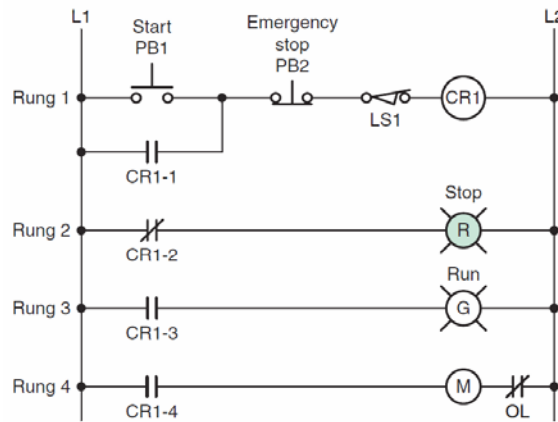


Using a transformer allows a lower voltage for the control circuit while supplying the three-phase motor power circuit with a higher voltage.

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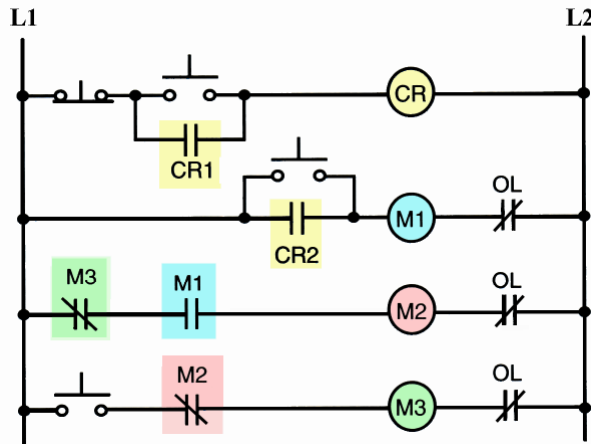
A ladder diagram gives the necessary information for easily following the sequence of operation of the circuit.

All switches and relay contacts are classified as normally open (NO) or normally closed (NC). They are drawn in the “off the shelf” or deenergized or state.



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One method used to identify the relay coil and the contacts operated by it is to place a letter or letters in the circle that represents the coil.

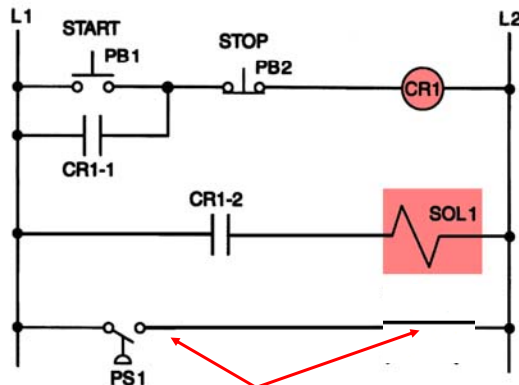


Each contact that is operated by this coil will have the coil letter or letters written next to the symbol for the contact.

- CR - Control relay
- M1 - Starter #1
- M2 - Starter #2
- M3 - Starter #3

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A load is a circuit component that has resistance and consumes electric power supplied from L1 to L2. Control coils, solenoids, and pilot lights are examples of loads.

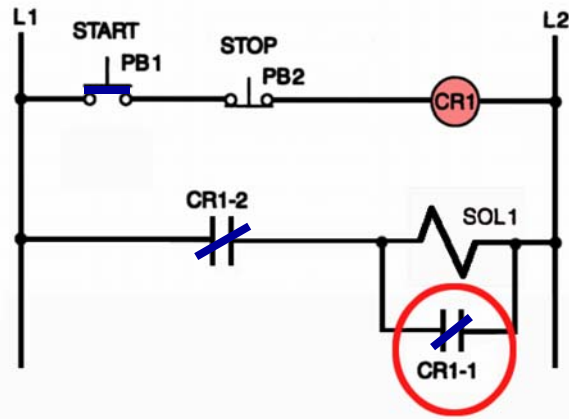


At least one load device must be included in each rung (individual circuit) of the diagram.

Without a load device, the control devices would be switching an open circuit to a short circuit between L₁ and L₂.

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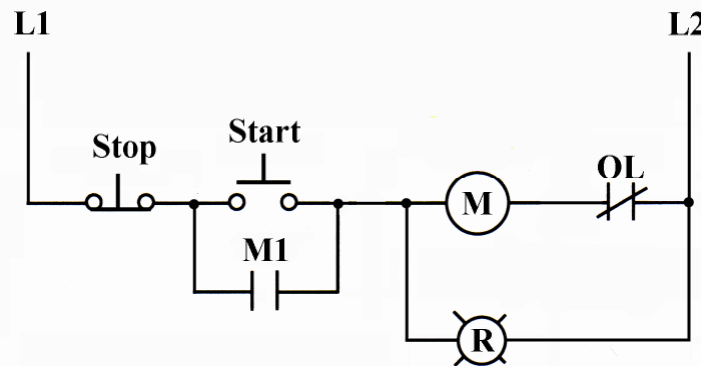
Contacts from control devices such as switches, push buttons, and relays are considered to have little or no resistance in the closed state.



Incorrect connection of contacts in parallel with a load will result in a short circuit when the contact closes.

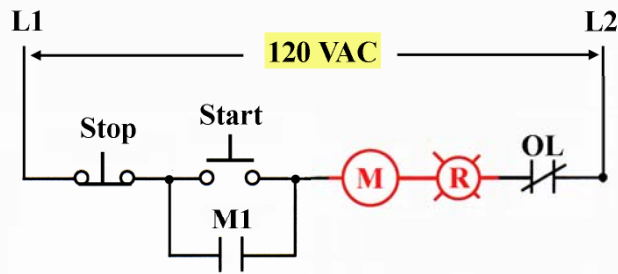
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Normally loads are placed on the right side of the ladder diagram next to L2 and contacts on the left side next to L1. One exception to this rule is the placement of the normally closed contacts controlled by the motor overload protection device. These contacts are drawn on the right side of the motor starter coil



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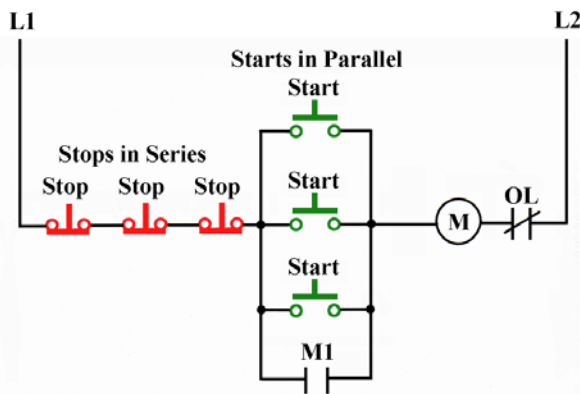
When two or more loads are required to be energized simultaneously, they must be connected in parallel. This will ensure that the full line voltage from L1 and L2 will appear across each load.



If the loads are connected in series, neither will receive the entire line voltage necessary for proper operation.

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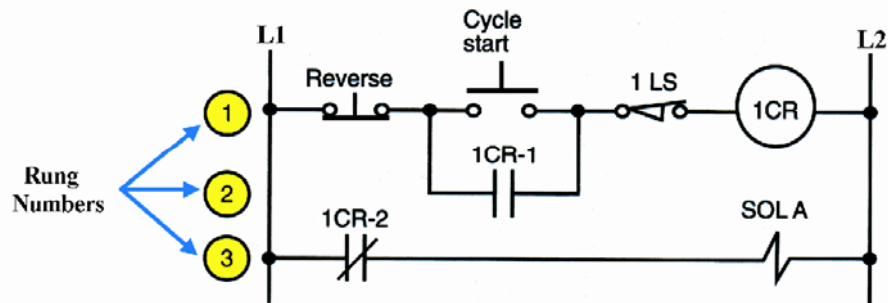
Control devices operate loads. Devices that start a load are usually connected in parallel, while devices that stop a load are connected in series.



All control devices are identified with the appropriate nomenclature for the device (e.g., stop, start). Similarly, all loads are required to have abbreviations to indicate the type of load (e.g., M for starter coil).

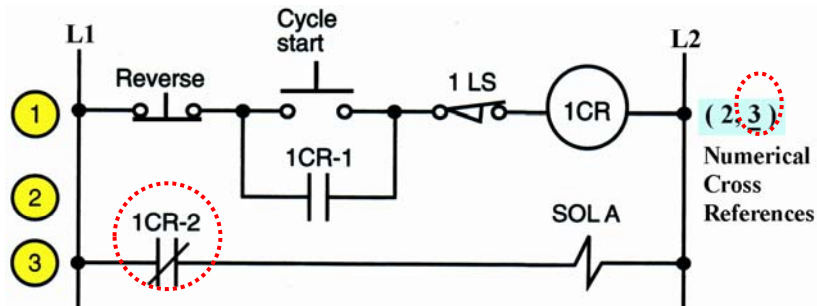
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"Rung numbering" is used to assist in reading and understanding larger ladder diagrams. Each rung of the ladder diagram is marked (rung 1, 2, 3, etc.), starting with the top rung and reading down. A rung can be defined as a complete path from L1 to L2 that contains a load.



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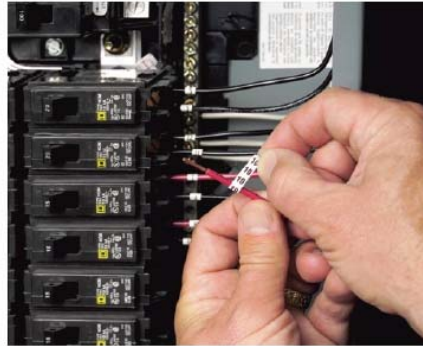
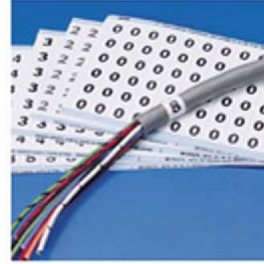
"Numerical cross-referencing" is used in conjunction with the rung numbering to locate auxiliary contacts controlled by coils in the control circuit. To locate these contacts, rung numbers are listed to the right of L2 in parentheses on the rung of the coil controlling their operation.



Numbers used for normally closed contacts are identified by underlining or over scoring the number to distinguish them from normally open contacts.

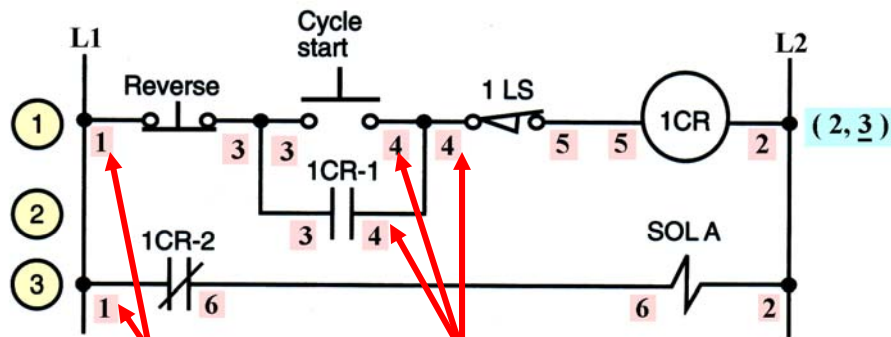
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Some type of “wire identification” is required to correctly connect the control circuit conductors to their components in the circuit.



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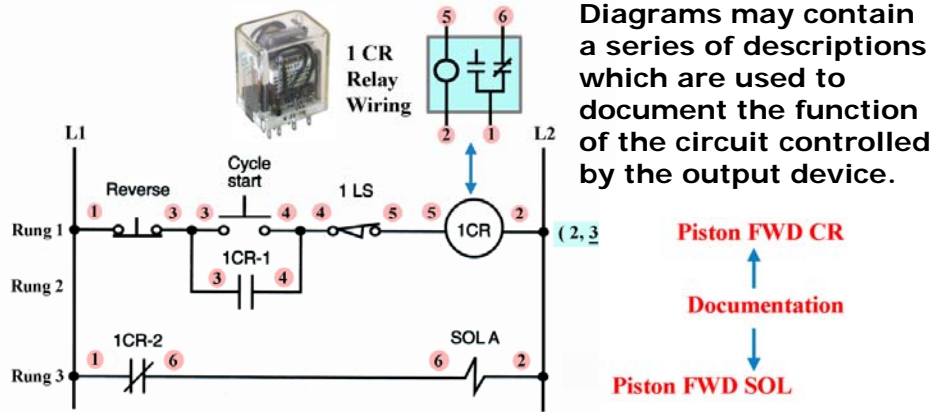
The method used for wire identification varies for each manufacturer. One method where each common point in the circuit is assigned a reference number is illustrated below.



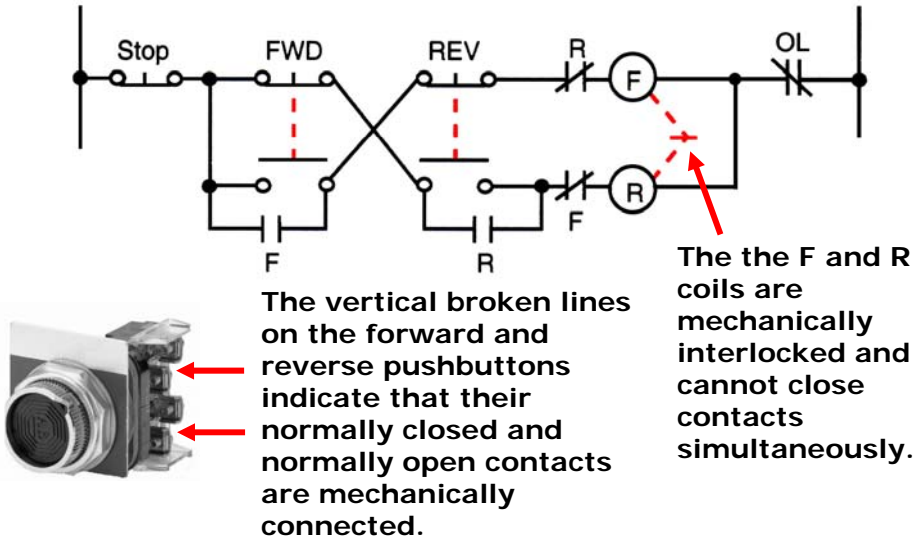
All wires that connect to one of these common points are assigned the same number.

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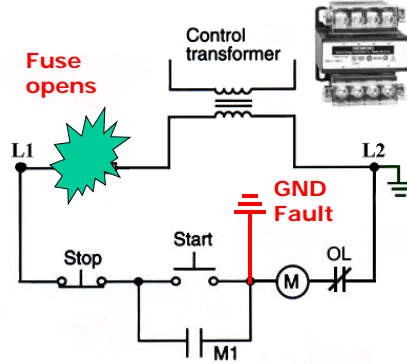
With this alternative method all wires directly connected to L1 are designated 1 while all those connected to L2 as 2. After all the wires with 1 and 2 are marked, the remaining numbers are assigned in a sequential order starting at the top left of the diagram.



A broken line indicates a mechanical function. *It is not an electrical conductor.*



When a control transformer is required to have one of its secondary lines grounded, the ground connection must be made so that an accidental ground in the control circuit will not start the motor or make the stop button or control inoperative.

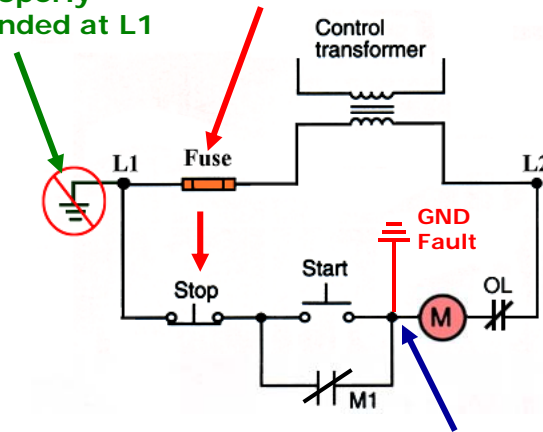


The secondary of the control transformer is properly grounded to the L2 side of the circuit. When the circuit is operational, the entire circuit to the left of coil M is the ungrounded circuit (it is the "hot" leg). A fault path to ground in the ungrounded circuit will create a short circuit condition causing the control transformer fuse to open.

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The same circuit improperly grounded at L1

The fuse would not operate to open the circuit and pressing the stop button would not de-energize the M coil.



A short to ground fault to the left of coil M would energize the coil, starting the motor unexpectedly.

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Reading Ladder Diagrams

