

Wiring Diagram Book

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# Standard Elementary Diagram Symbols

The diagram symbols in Table 1 are used by Square D and, where applicable, conform to NEMA (National Electrical Manufacturers Association) standards.

Table 1 Standard Elementary Diagram Symbols

SWITCHES						SELECTORS																									
Disconnect		Circuit Interrupter		Circuit Breakers w/ Thermal OL		Circuit Breakers w/ Magnetic OL		2-Position Selector Switch																							
								<table border="1" style="margin-left: auto; margin-right: auto;"> <tr><td></td><td>J</td><td>K</td><td></td></tr> <tr><td>A1</td><td>I</td><td></td><td></td></tr> <tr><td>A2</td><td></td><td>I</td><td></td></tr> </table>					J	K		A1	I			A2		I									
	J	K																													
A1	I																														
A2		I																													
Pressure & Vacuum Switches		Liquid Level Switches		Temperature Actuated Switches		3-Position Selector Switch																									
N.O.		N.C.		N.O.		N.C.		N.O.		N.C.		<table border="1" style="margin-left: auto; margin-right: auto;"> <tr><td></td><td>J</td><td>K</td><td>L</td><td></td></tr> <tr><td>A1</td><td>I</td><td></td><td></td><td></td></tr> <tr><td>A2</td><td></td><td></td><td>I</td><td></td></tr> </table>					J	K	L		A1	I				A2			I		
	J	K	L																												
A1	I																														
A2			I																												
Limit Switches		Speed (Plugging)		Anti-Plug		2-Position Selector Push Button																									
N.O.		N.C.		F		F		<table border="1" style="margin-left: auto; margin-right: auto;"> <tr><th>Selector Position</th><th>Push Button</th><th>Contacts 1-2</th><th>Contacts 3-4</th></tr> <tr><td>A</td><td>Free</td><td>I</td><td></td></tr> <tr><td>A</td><td>Depressed</td><td></td><td>I</td></tr> <tr><td>B</td><td>Free</td><td></td><td>I</td></tr> <tr><td>B</td><td>Depressed</td><td></td><td>I</td></tr> </table>				Selector Position	Push Button	Contacts 1-2	Contacts 3-4	A	Free	I		A	Depressed		I	B	Free		I	B	Depressed		I
Selector Position	Push Button	Contacts 1-2	Contacts 3-4																												
A	Free	I																													
A	Depressed		I																												
B	Free		I																												
B	Depressed		I																												
Held Closed		Held Open		R		R		<p>I = contact closed</p>																							
Flow Switches		Foot Switches																													
N.O.		N.C.		N.O.		N.C.																									
PUSH BUTTONS – MOMENTARY CONTACT						PUSH BUTTONS – MAINTAINED CONTACT																									
N.O.		N.C.		N.O. & N.C. (double circuit)		Mushroom Head		Wobble Stick		Illuminated		2 Single Circuits		1 Double Circuit																	
PILOT LIGHTS						INSTANT OPERATING CONTACTS				TIMED CONTACTS																					
Non Push-to-Test		Push-to-Test				w/ Blowout N.O.		w/ Blowout N.C.		w/o Blowout N.O.		w/o Blowout N.C.		Contact action retarded after coil is:																	
(indicate color by letter)														Energized																	
														Deenergized																	
														N.O.T.C.																	
														N.C.T.O.																	
														N.O.T.O.																	
														N.C.T.C.																	

Table 1 Standard Elementary Diagram Symbols (cont'd)

INDUCTORS		TRANSFORMERS					
Iron Core 	Air Core 	Auto 	Iron Core 	Air Core 	Current 	Dual Voltage 	
OVERLOAD RELAYS		AC MOTORS					
Thermal 	Magnetic 	Single Phase 	3-Phase Squirrel Cage 	2-Phase, 4-Wire 	Wound Rotor 		
DC MOTORS							
Armature 		Shunt Field (show 4 loops) 	Series Field (show 3 loops) 	Commutating or Compensating Field (show 2 loops) 			
WIRING							
Not Connected 	Connected 	Power 	Control 	Terminal 	Ground 	Mechanical Connection 	Mechanical Interlock Connection 
CAPACITORS		RESISTORS					
Fixed 	Adjustable 	Fixed 	Heating Element 	Adjustable, by Fixed Taps 	Rheostat, Potentiometer or Adjustable Taps 		
SEMICONDUCTORS							
Diode or Half Wave Rectifier 	Tunnel Diode 	Zener Diode 	Bidirectional Breakdown Diode 	Triac 	SCR 	PUT 	Photosensitive Cell 
Full Wave Rectifier 	NPN Transistor 	PNP Transistor 	UJT, N Base 	UJT, P Base 	Gate Turn-O Thyristor 		

Table 1 Standard Elementary Diagram Symbols (cont'd)

OTHER COMPONENTS					
Bell 	Annunciator 	Buzzer 	Horn, Alarm, Siren, etc. 	Meter (indicate type by letters) 	
Battery 	Fuse 	Thermocouple 	Meter Shunt 		
SUPPLEMENTARY CONTACT SYMBOLS					
SPST, N.O. Single Break 		SPST, N.C. Single Break 		SPDT Single Break 	
Double Break 		Double Break 		Double Break 	
DPST, 2 N.O. Single Break 		DPST, 2 N.C. Single Break 		DPDT Single Break 	
Double Break 		Double Break 		Double Break 	
IEC SYMBOLS					
Push Buttons N.O. N.C. 		Coil 	Aux. Contacts N.O. N.C. 		Contactors Breakers 
STATIC SWITCHING CONTROL					
Limit Switch, N.O., Static Control 		Static switching control is a method of switching electrical circuits without the use of contacts, primarily by solid state devices. To indicate static switching control, use the symbols shown in this table, enclosing them in a diamond as shown.			
TERMS					
SPST: Single Pole, Single Throw	N.O.: Normally Open	PUT: Programmable Unijunction Transistor			
SPDT: Single Pole, Double Throw	N.C.: Normally Closed	SCR: Silicon Controlled Rectifier			
DPST: Double Pole, Single Throw	T.O.: Timed Open	Triac: Bidirectional Triode Thyristor			
DPDT: Double Pole, Double Throw	T.C.: Timed Closed	UJT: Unijunction Transistor			

Table 2 NEMA and IEC Terminal Markings

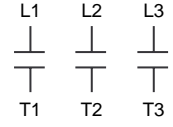


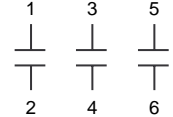

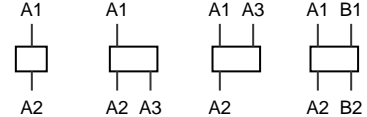
NEMA		
 <p style="font-size: small; text-align: center;">Alphanumeric, corresponding to incoming line and motor terminal designations</p> <p style="text-align: center; font-weight: bold;">Power Terminals</p>	 <p style="font-size: small; text-align: center;">No specific marking</p> <p style="text-align: center; font-weight: bold;">Control Terminals</p>	 <p style="font-size: small; text-align: center;">No standard designation</p> <p style="text-align: center; font-weight: bold;">Coil Terminals</p>
IEC		
 <p style="font-size: small; text-align: center;">Single digit numeric, odd for supply lines, even for load connections</p> <p style="text-align: center; font-weight: bold;">Power Terminals</p>	 <p style="font-size: small; text-align: center;">2-digit numeric, 1st designates sequence, 2nd designates function (1-2 for N.C., 3-4 for N.O.)</p> <p style="text-align: center; font-weight: bold;">Control Terminals</p>	 <p style="font-size: small; text-align: center;">One Winding    Tapped Winding    Tapped Winding    Two Windings</p> <p style="text-align: center; font-weight: bold;">Coil Terminals</p>

Table 3 NEMA and IEC Controller Markings and Elementary Diagrams

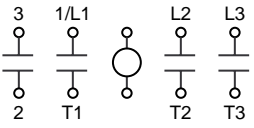
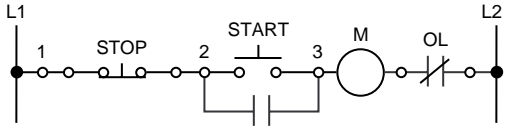
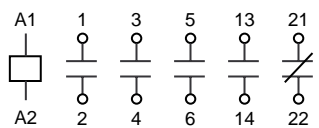
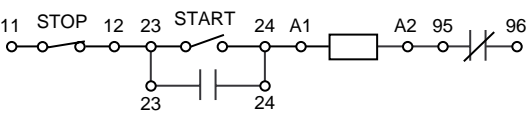
NEMA	
 <p style="text-align: center; font-weight: bold;">Typical Controller Markings</p>	 <p style="text-align: center; font-weight: bold;">Typical Elementary Diagram</p>
IEC	
 <p style="text-align: center; font-weight: bold;">Typical Controller Markings</p>	 <p style="text-align: center; font-weight: bold;">Typical Elementary Diagram</p>

Table 4 Control and Power Connections for Across-the-Line Starters, 600 V or less (From NEMA standard ICS 2-321A.60)

	1-Phase	2-Phase, 4-Wire	3-Phase
<b>Line Markings</b>	L1, L2	L1, L3: Phase 1 L2, L4: Phase 2	L1, L2, L3
<b>Ground, when used</b>	L1 is always ungrounded	—	L2
<b>Motor Running Overcurrent, units in:</b>	1 element 2 element 3 element	L1 — —	— — L1, L2, L3
<b>Control Circuit Connected to</b>	L1, L2	L1, L3	L1, L2
<b>For Reversing, Interchange Lines</b>	—	L1, L3	L1, L3

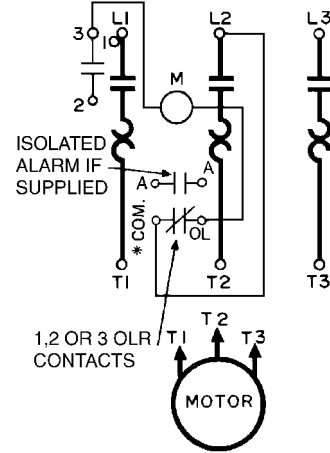


### WIRING DIAGRAM

A wiring diagram shows, as closely as possible, the actual location of all component parts of the device. The open terminals (marked by an open circle) and arrows represent connections made by the user.

Since wiring connections and terminal markings are shown, this type of diagram is helpful when wiring the device or tracing wires when troubleshooting. Bold lines denote the power circuit and thin lines are used to show the control circuit. Black wires are conventionally used in power circuits and red wire in control circuits for AC magnetic equipment.

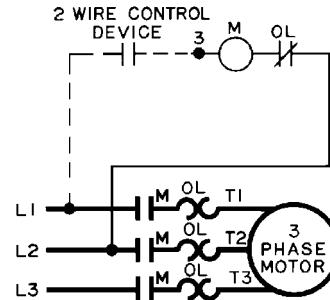
A wiring diagram is limited in its ability to completely convey the controller's sequence of operation. The elementary diagram is used where an illustration of the circuit in its simplest form is desired.



### ELEMENTARY DIAGRAM

An elementary diagram is a simplified circuit illustration. Devices and components are not shown in their actual positions. All control circuit components are shown as directly as possible, between a pair of vertical lines representing the control power supply. Components are arranged to show the sequence of operation of the devices and how the device operates. The effect of operating various auxiliary contacts and control devices can be readily seen. This helps in troubleshooting, particularly with the more complex controllers.

This form of electrical diagram is sometimes referred to as a "schematic" or "line" diagram.



# Examples of Control Circuits

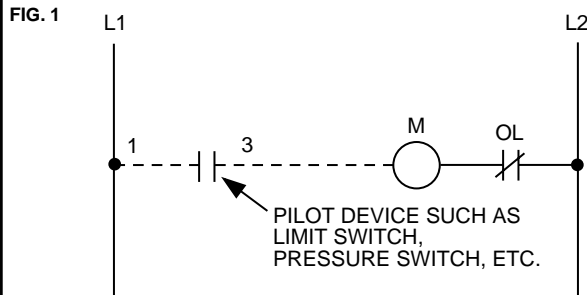
## 2- and 3-Wire Control

### Elementary Diagrams

Low Voltage Release and Low Voltage Protection are the basic control circuits encountered in motor control applications. The simplest schemes are shown below. Other variations shown in this section may appear more complicated, but can always be resolved into these two basic schemes.

Note: The control circuits shown in this section may not include overcurrent protective devices required by applicable electrical codes. See page 11 for examples of control circuit overcurrent protective devices and their use.

#### Low Voltage Release: 2-Wire Control

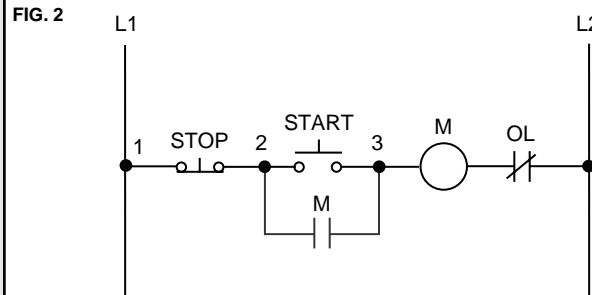


Low voltage release is a 2-wire control scheme using a maintained contact pilot device in series with the starter coil.

This scheme is used when a starter is required to function automatically without the attention of an operator. If a power failure occurs while the contacts of the pilot device are closed, the starter will drop out. When power is restored, the starter will automatically pickup through the closed contacts of the pilot device.

The term "2-wire" control is derived from the fact that in the basic circuit, only two wires are required to connect the pilot device to the starter.

#### Low Voltage Protection: 3-Wire Control

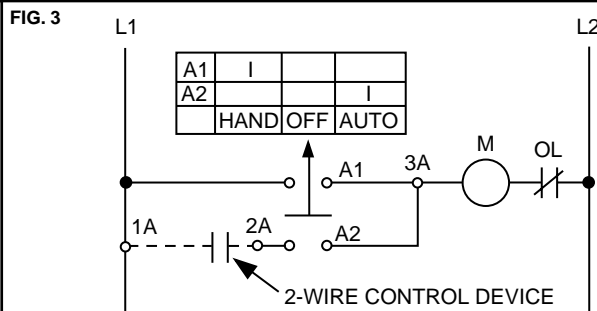


Low voltage protection is a 3-wire control scheme using momentary contact push buttons or similar pilot devices to energize the starter coil.

This scheme is designed to prevent the unexpected starting of motors, which could result in injury to machine operators or damage to the driven machinery. The starter is energized by pressing the Start button. An auxiliary holding circuit contact on the starter forms a parallel circuit around the Start button contacts, holding the starter in after the button is released. If a power failure occurs, the starter will drop out and will open the holding circuit contact. When power is restored, the Start button **must** be operated again before the motor will restart.

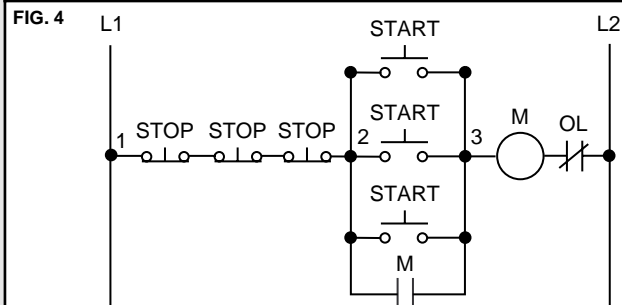
The term "3-wire" control is derived from the fact that in the basic circuit, at least three wires are required to connect the pilot devices to the starter.

#### 2-Wire Control: Maintained Contact Hand-Off-Auto Selector Switch

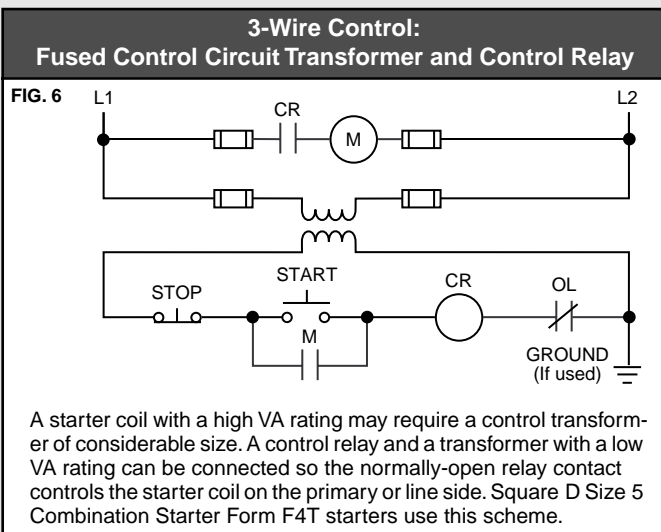
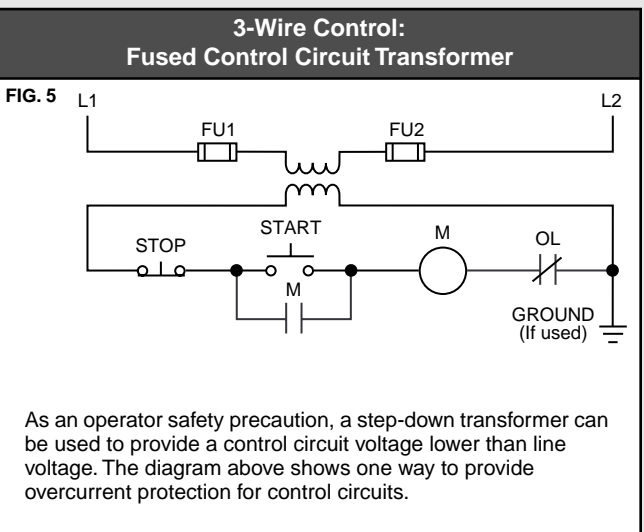
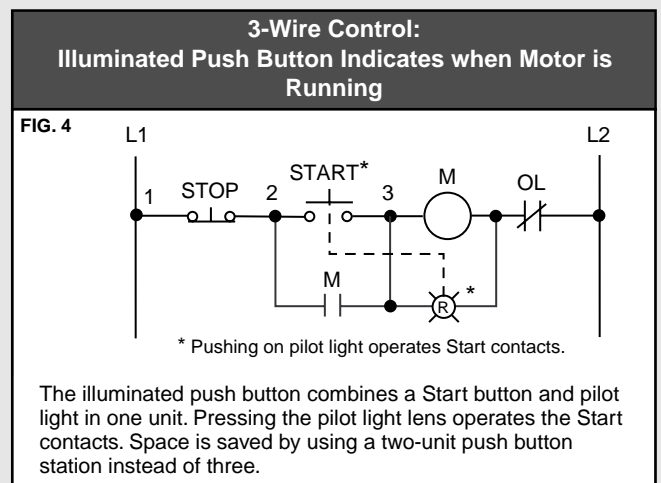
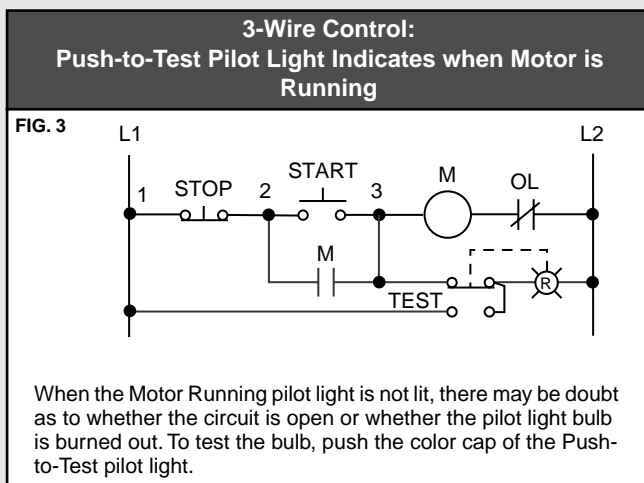
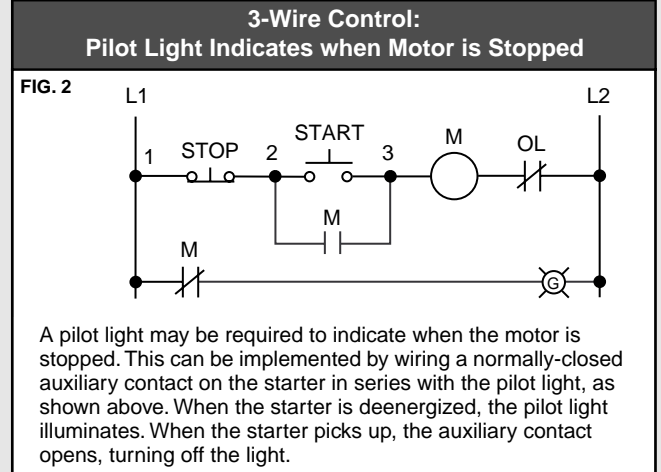
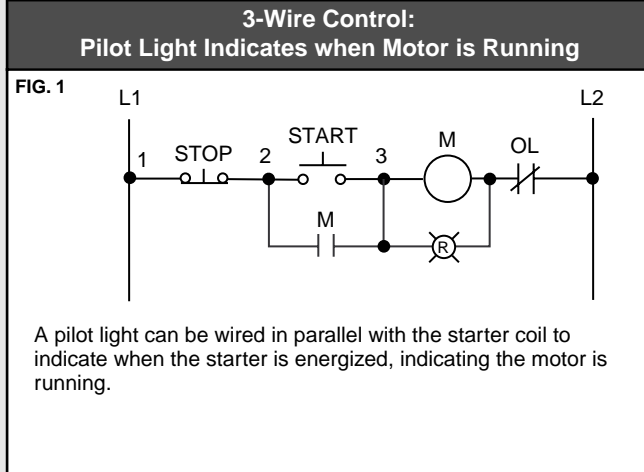


A Hand-Off-Auto selector switch is used on 2-wire control applications where it is desirable to operate the starter manually as well as automatically. The starter coil is manually energized when the switch is turned to the Hand position and is automatically energized by the pilot device when the switch is in the Auto position.

#### 3-Wire Control: Momentary Contact Multiple Push Button Station

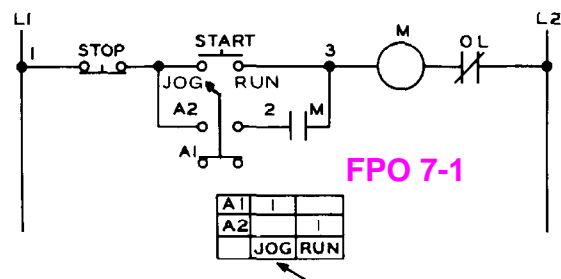


When a motor must be started and stopped from more than one location, any number of Start and Stop push buttons may be wired together. It is also possible to use only one Start-Stop station and have several Stop buttons at different locations to serve as an emergency stop.



**Jogging: Selector Switch and Start Push Button**

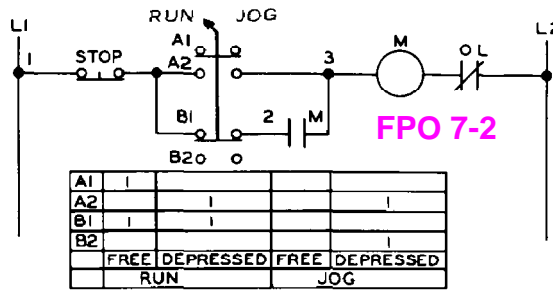
FIG. 1



Jogging, or inching, is defined by NEMA as the momentary operation of a motor from rest for the purpose of accomplishing small movements of the driven machine. One method of jogging is shown above. The selector switch disconnects the holding circuit contact and jogging may be accomplished by pressing the Start push button.

**Jogging: Selector Push Button**

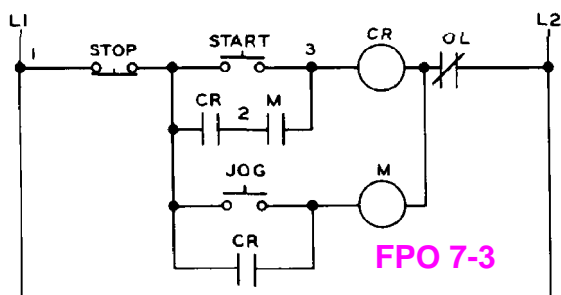
FIG. 2



A selector push button may be used to obtain jogging, as shown above. In the Run position, the selector-push button provides normal 3-wire control. In the Jog position, the holding circuit is broken and jogging is accomplished by depressing the push button.

**Jogging: Control Relay**

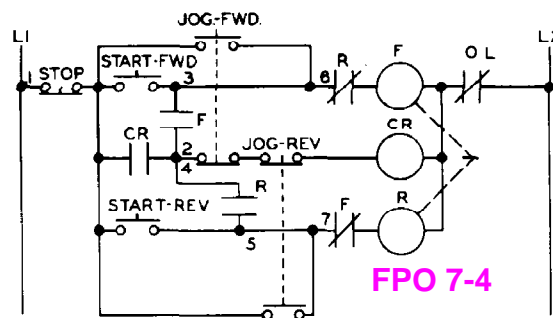
FIG. 3



When the Start push button is pressed, the control relay is energized, which in turn energizes the starter coil. The normally open starter auxiliary contact and relay contact then form a holding circuit around the Start push button. When the Jog push button is pressed, the starter coil is energized (independent of the relay) and no holding circuit forms, thus jogging can be obtained.

**Jogging: Control Relay for Reversing Starter**

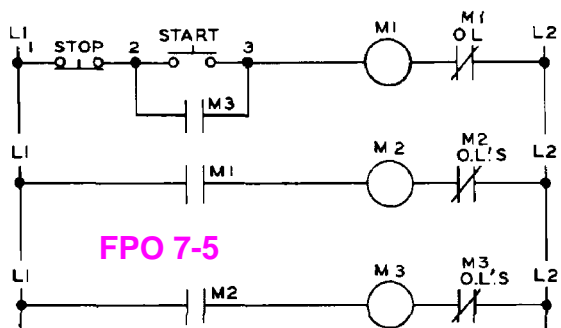
FIG. 4



This control scheme permits jogging the motor either in the forward or reverse direction, whether the motor is at standstill or rotating. Pressing the Start-Forward or Start-Reverse push button energizes the corresponding starter coil, which closes the circuit to the control relay. The relay picks up and completes the holding circuit around the Start button. As long as the relay is energized, either the forward or reverse contactor remains energized. Pressing either Jog push button will deenergize the relay, releasing the closed contactor. Further pressing of the Jog button permits jogging in the desired direction.

**3-Wire Control: More than 1 Starter, 1 Push Button Station Controls all**

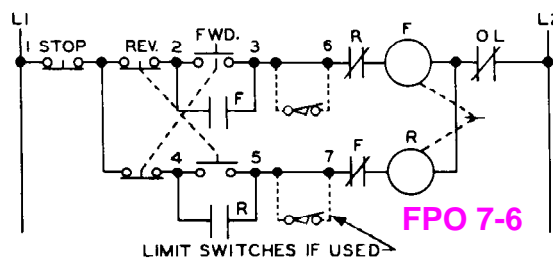
FIG. 5



When one Start-Stop station is required to control more than one starter, the scheme above can be used. A maintained overload on any one of the motors will drop out all three starters.

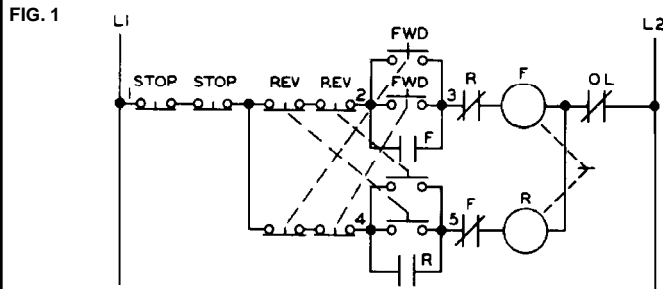
**3-Wire Control: Reversing Starter**

FIG. 6



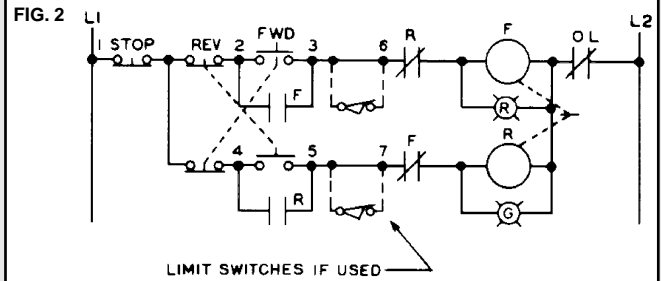
3-wire control of a reversing starter can be implemented with a Forward-Reverse-Stop push button station as shown above. Limit switches may be added to stop the motor at a certain point in either direction. Jumpers 6 to 3 and 7 to 5 must then be removed.

**3-Wire Control:  
Reversing Starter Multiple Push Button Station**



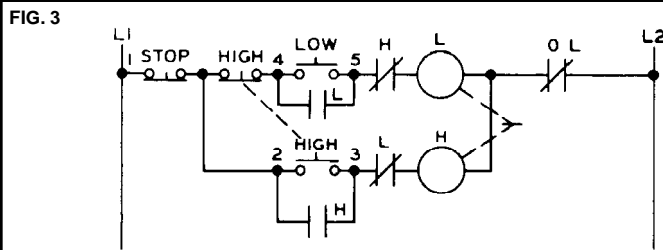
More than one Forward-Reverse-Stop push button station may be required and can be connected in the manner shown above.

**3-Wire Control: Reversing Starter w/ Pilot Lights to Indicate Motor Direction**



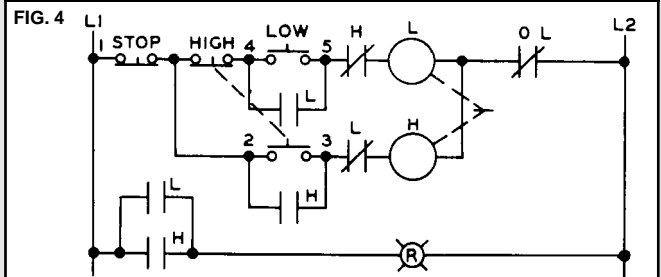
Pilot lights may be connected in parallel with the forward and reverse contactor coils, indicating which contactor is energized and thus which direction the motor is running.

**3-Wire Control:  
2-Speed Starter**



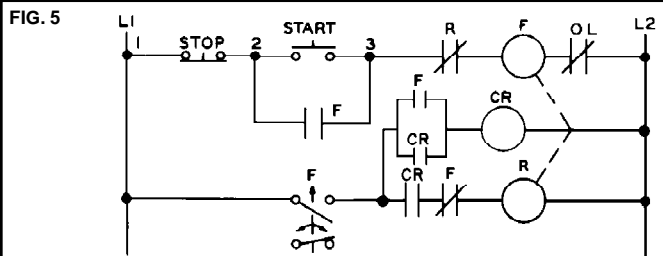
3-wire control of a 2-speed starter with a High-Low-Stop push button station is shown above. This scheme allows the operator to start the motor from rest at either speed or to change from low to high speed. The Stop button must be operated before it is possible to change from high to low speed. This arrangement is intended to prevent excessive line current and shock to motor and driven machinery, which results when motors running at high speed are reconnected for a lower speed.

**3-Wire Control: 2-Speed Starter w/ 1 Pilot Light to Indicate Motor Operation at Each Speed**



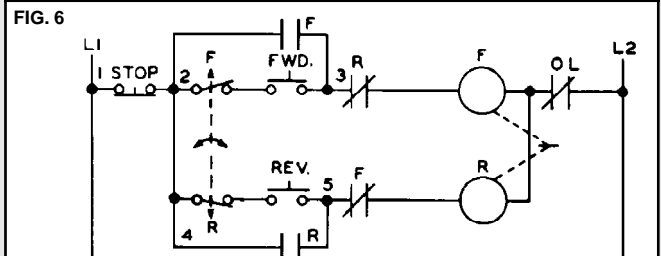
One pilot light may be used to indicate operation at both low and high speeds. One extra normally-open auxiliary contact on each contactor is required. Two pilot lights, one for each speed, may be used by connecting pilot lights in parallel with high and low coils (see reversing starter diagram above).

**Plugging:  
Plugging a Motor to a Stop from 1 Direction Only**



Plugging is defined by NEMA as a braking system in which the motor connections are reversed so the motor develops a counter torque, thus exerting a retarding force. In the above scheme, forward rotation of the motor closes the normally-open plugging switch contact and energizing control relay CR. When the Stop push button is operated, the forward contactor drops out, the reverse contactor is energized through the plugging switch, control relay contact and normally-closed forward auxiliary contact. This reverses the motor connections and the motor is braked to a stop. The plugging switch then opens and disconnects the reverse contactor. The control relay also drops out. The control relay makes it impossible for the motor to be plugged in reverse by rotating the motor rotor closing the plugging switch. This type of control is not used for running in reverse.

**Anti-Plugging:  
Motor to be Reversed but Must Not be Plugged**



Anti-plugging protection is defined by NEMA as the effect of a device that operates to prevent application of counter-torque by the motor until the motor speed has been reduced to an acceptable value. In the scheme above, with the motor operating in one direction, a contact on the anti-plugging switch opens the control circuit of the contactor used for the opposite direction. This contact will not close until the motor has slowed down, after which the other contactor can be energized.

# Examples of Control Circuits

## Shunting Thermal Units During Starting Period

### Elementary Diagrams

#### Shunting Thermal Units During Starting Period

Article 430-35 of the NEC describes circumstances under which it is acceptable to shunt thermal units during abnormally long accelerating periods.

#### 430-35. Shunting During Starting Period.

**(a) Nonautomatically Started.** For a nonautomatically started motor, the overload protection shall be permitted to be shunted or cut out of the circuit during the starting period of the motor if the device by which the overload protection is shunted or cut out cannot be left in the starting position and if fuses or inverse time circuit breakers rated or set at not over 400 percent of the full-load current of the motor are so located in the circuit as to be operative during the starting period of the motor.

**(b) Automatically Started.** The motor overload protection shall not be shunted or cut out during the starting period if the motor is automatically started.

*Exception. The motor overload protection shall be permitted to be shunted or cut out during the starting period on an automatically started motor where:*

- (1) *The motor starting period exceeds the time delay of available motor overload protective devices, and*
- (2) *Listed means are provided to:*
  - a. *Sense motor rotation and to automatically prevent the shunting or cut out in the event that the motor fails to start, and*
  - b. *Limit the time of overload protection shunting or cut out to less than the locked rotor time rating of the protected motor, and*
  - c. *Provide for shutdown and manual restart if motor running condition is not reached.*

Figures 1 and 2 show possible circuits for use in conjunction with 3-wire control schemes. Figure 1 complies with NEC requirements. Figure 2 exceeds NEC requirements, but the additional safety provided by the zero speed switch might be desirable.

Figure 3 shows a circuit for use with a 2-wire, automatically started control scheme that complies with NEC requirements. UL or other listed devices must be used in this arrangement.

FIG. 1

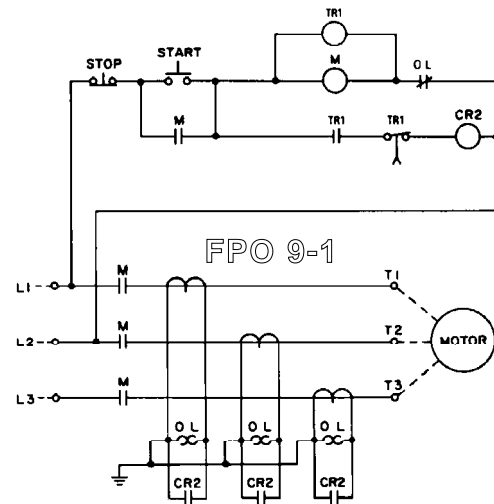


FIG. 2

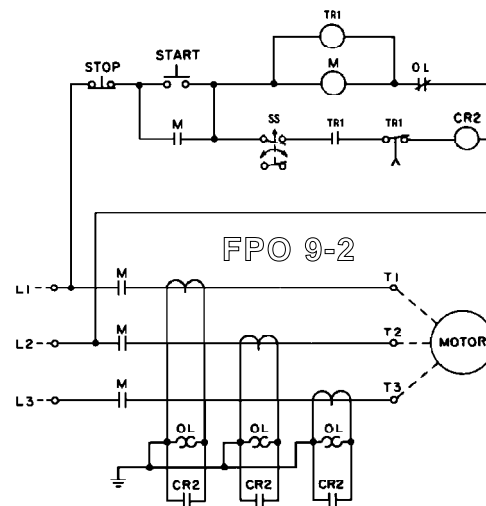
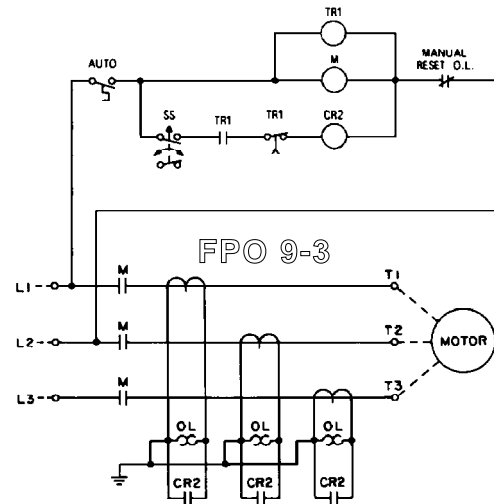
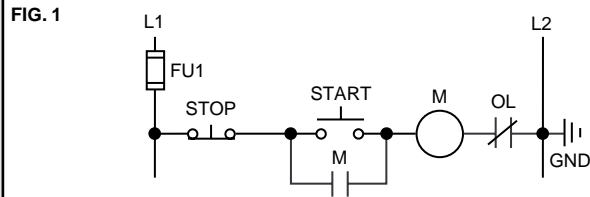


FIG. 3

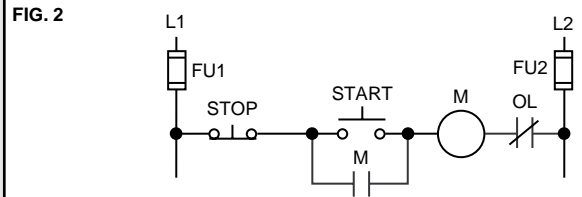


**3-Wire Control:  
Fusing in 1 Line Only**



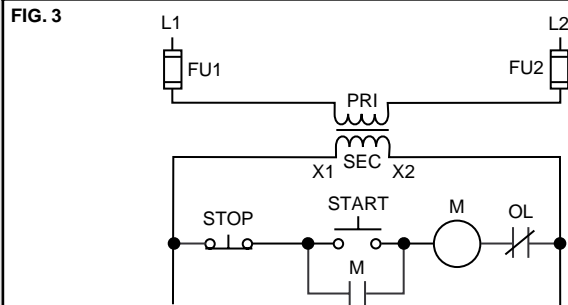
Common control with fusing in one line only and with both lines ungrounded or, if user's conditions permit, with one line grounded.

**3-Wire Control:  
Fusing in Both Lines**



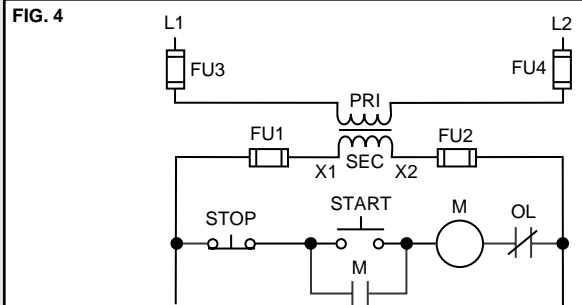
Common control with fusing in both lines and with both lines ungrounded.

**3-Wire Control:  
Fusing in Both Primary Lines**



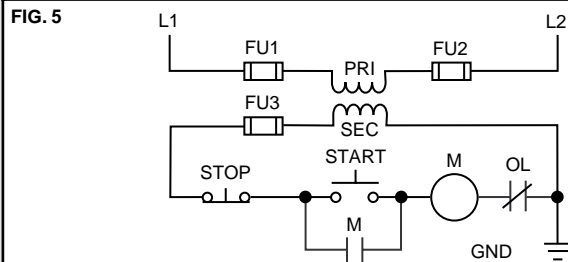
Control circuit transformer with fusing in both primary lines, no secondary fusing and all lines ungrounded.

**3-Wire Control:  
Fusing in Both Primary and Secondary Lines**



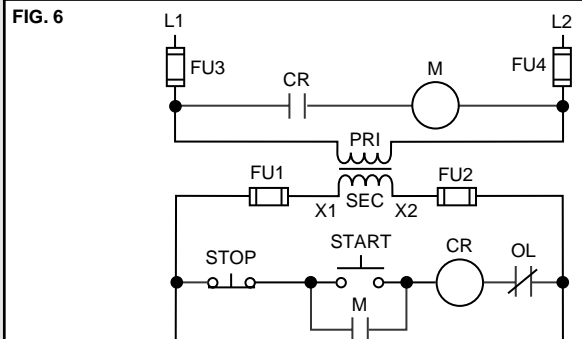
Control circuit transformer with fusing in both primary lines and both secondary lines, with all lines ungrounded.

**3-Wire Control:  
Fusing in Both Primary Lines and 1 Secondary Line**

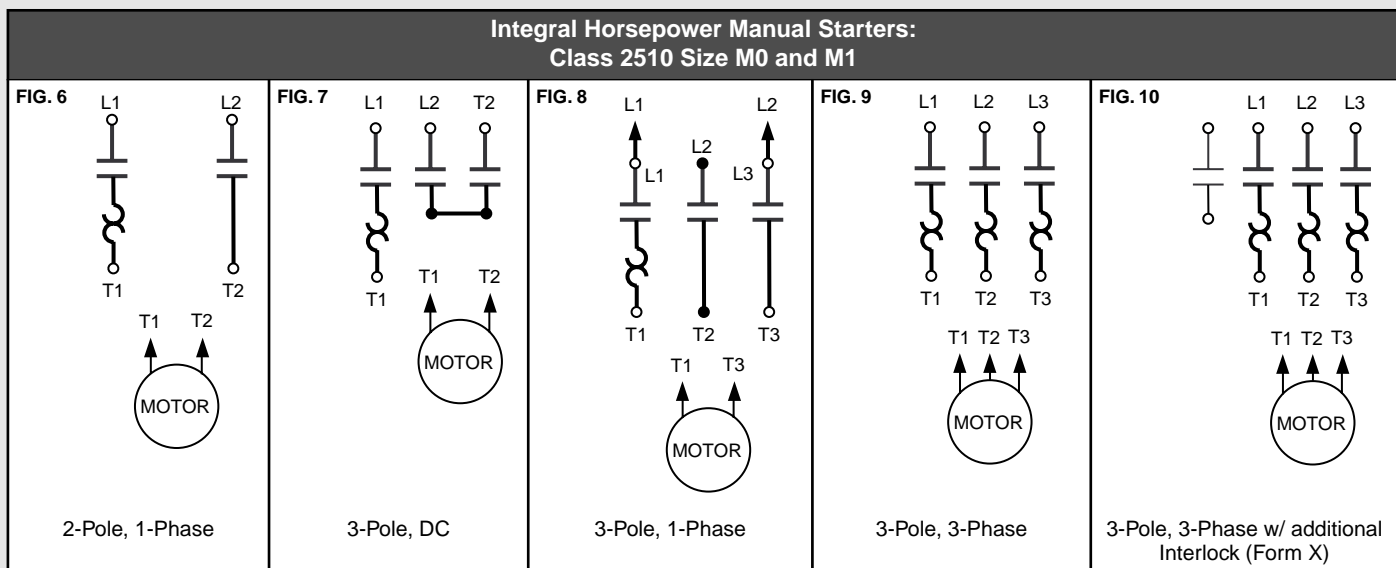
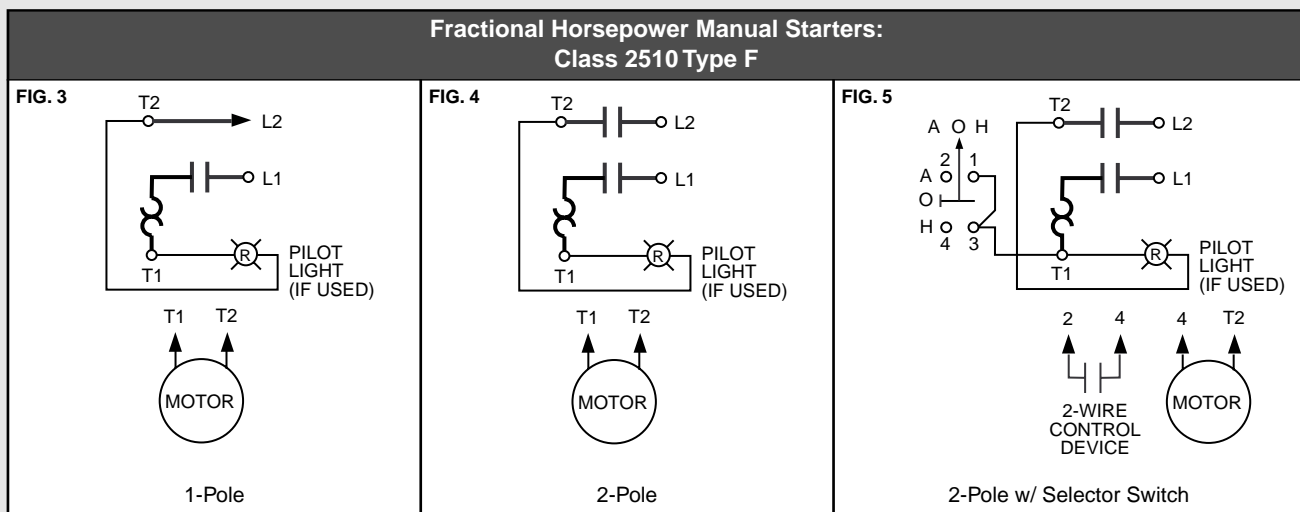
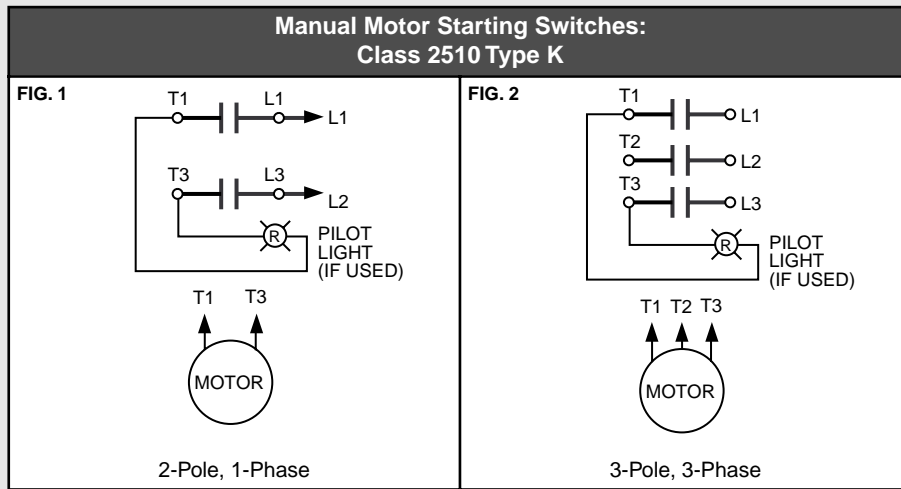


Control circuit transformer with fusing in one secondary line and both primary lines, with one line grounded.

**3-Wire Control:  
Fusing in Both Primary and Secondary Lines  
For Large Starters using Small Transformer**

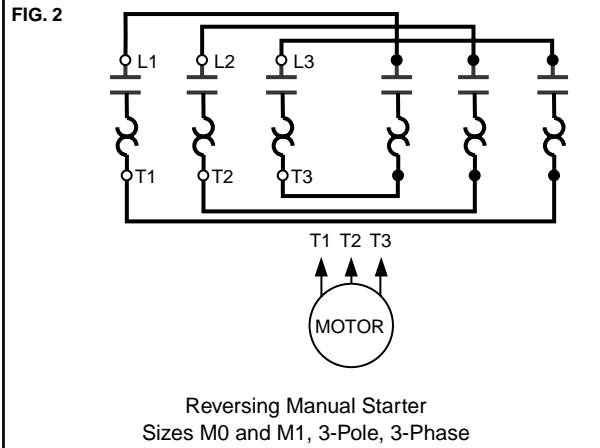
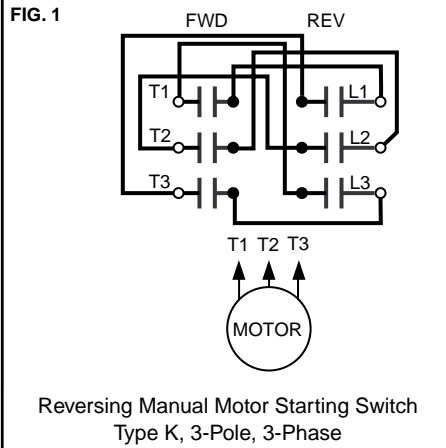


Control circuit transformer with fusing in both primary lines and both secondary lines, with all lines ungrounded. Used for large VA coils only.

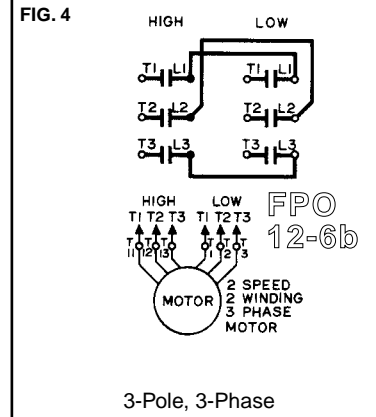
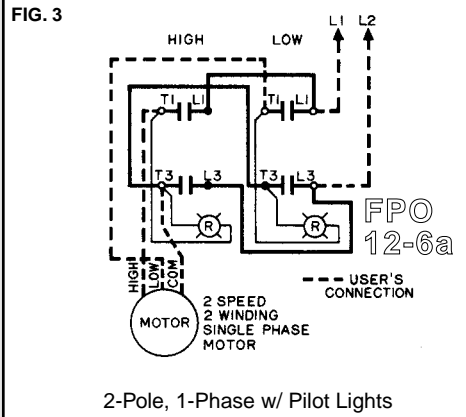




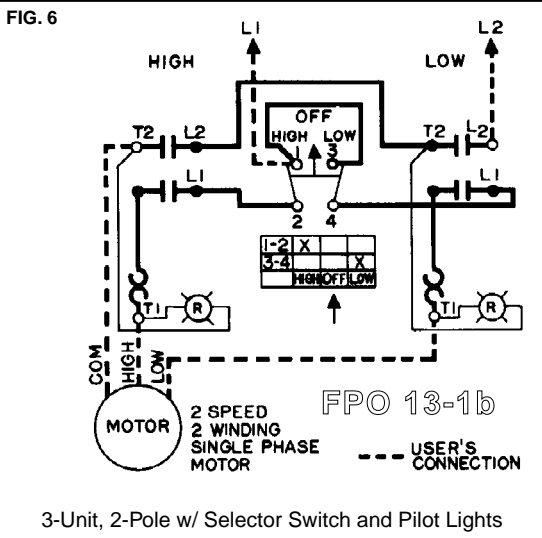
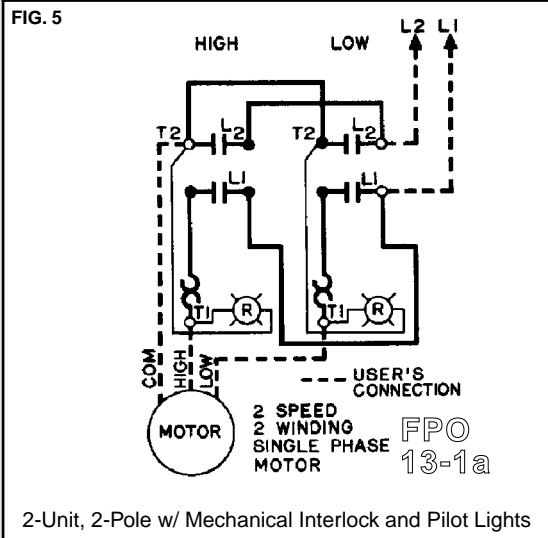
AC Reversing Manual Starters and Manual Motor Starting Switches:  
Class 2511

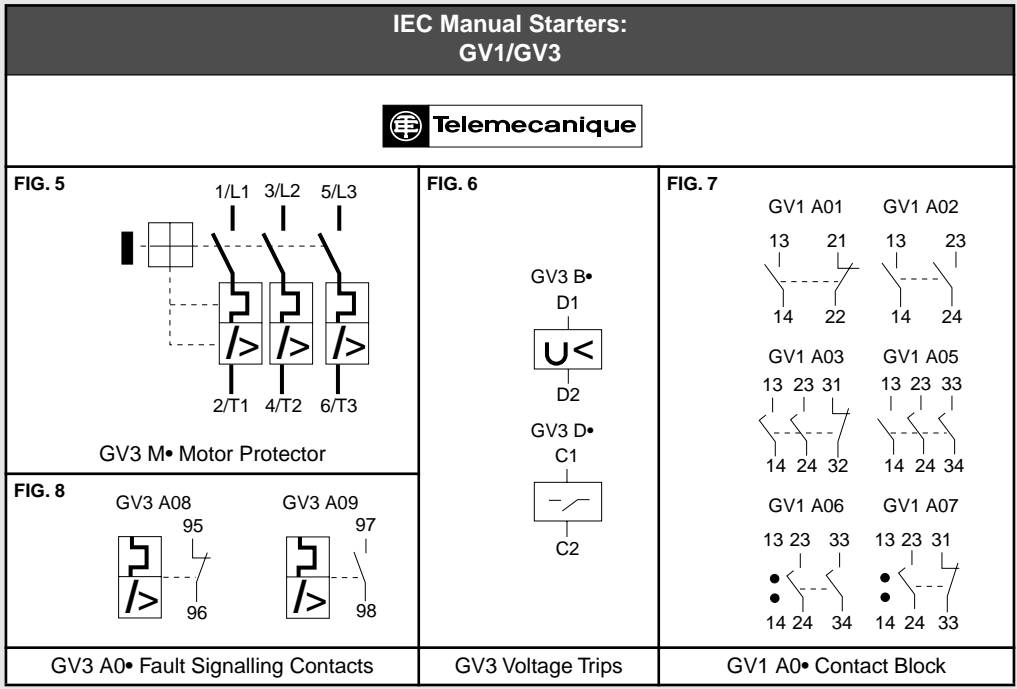
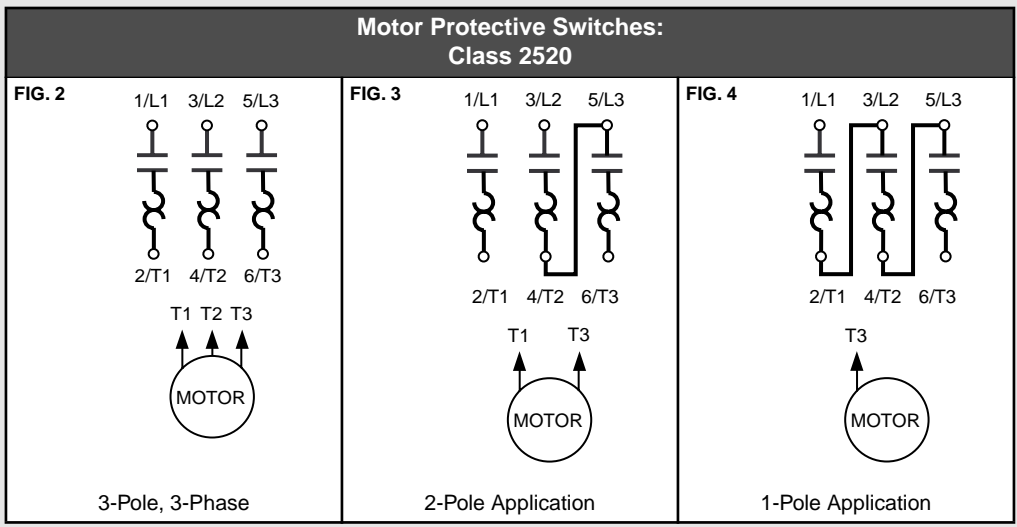
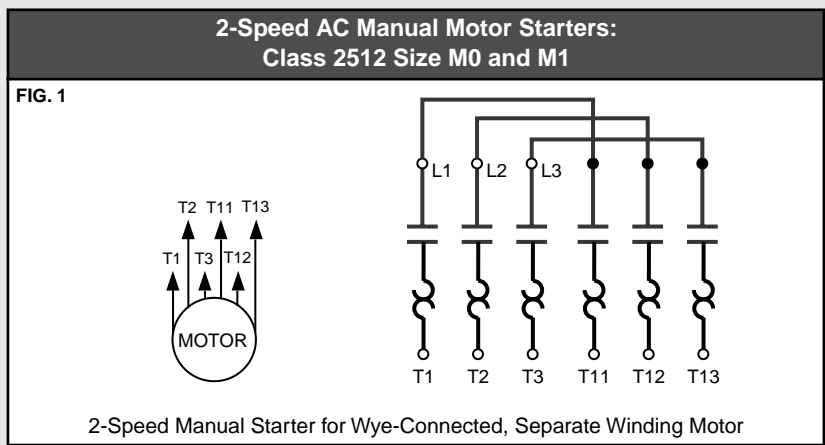


AC 2-Speed Manual Motor Starting Switches:  
Class 2512 Type K



AC 2-Speed Manual Motor Starters:  
Class 2512 Type F



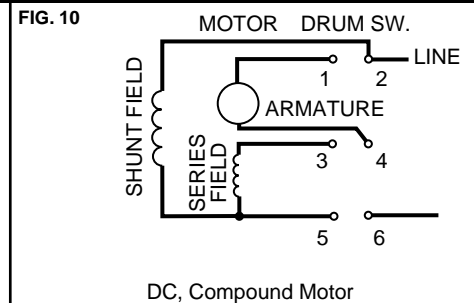
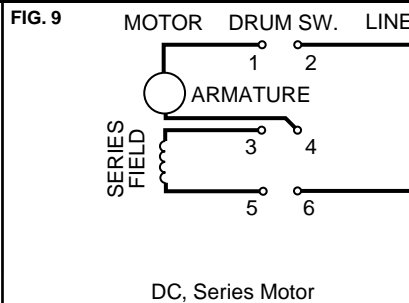
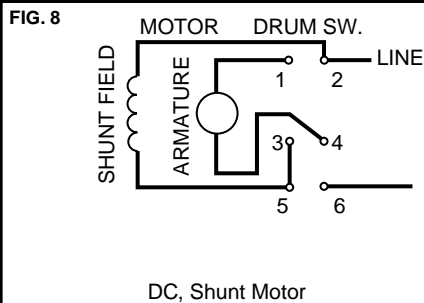
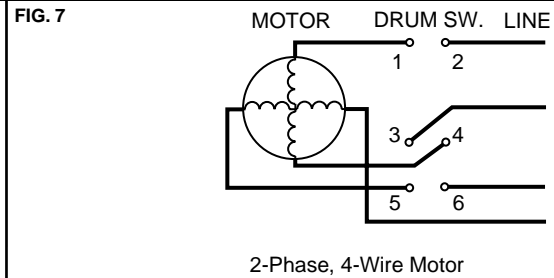
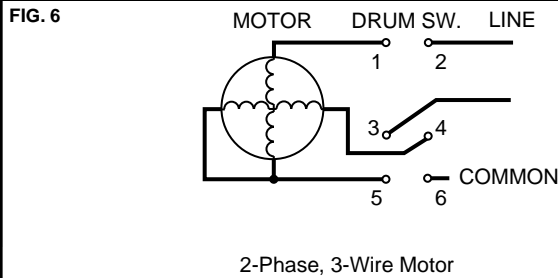
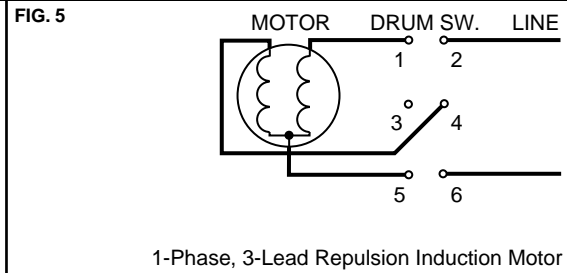
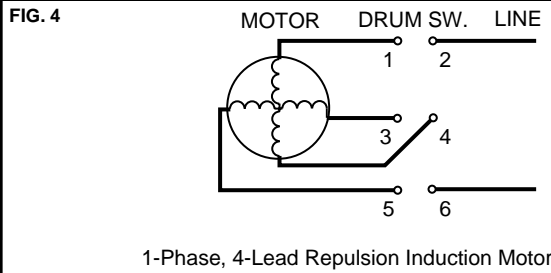
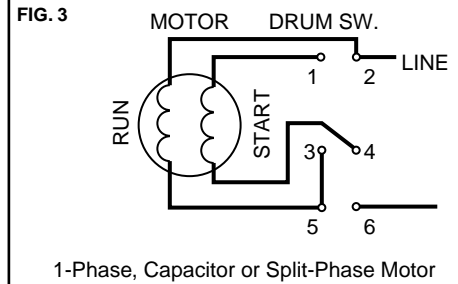
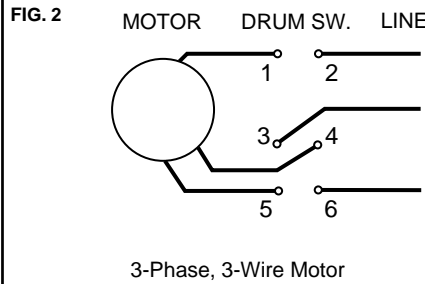


Drum Switches:  
Class 2601

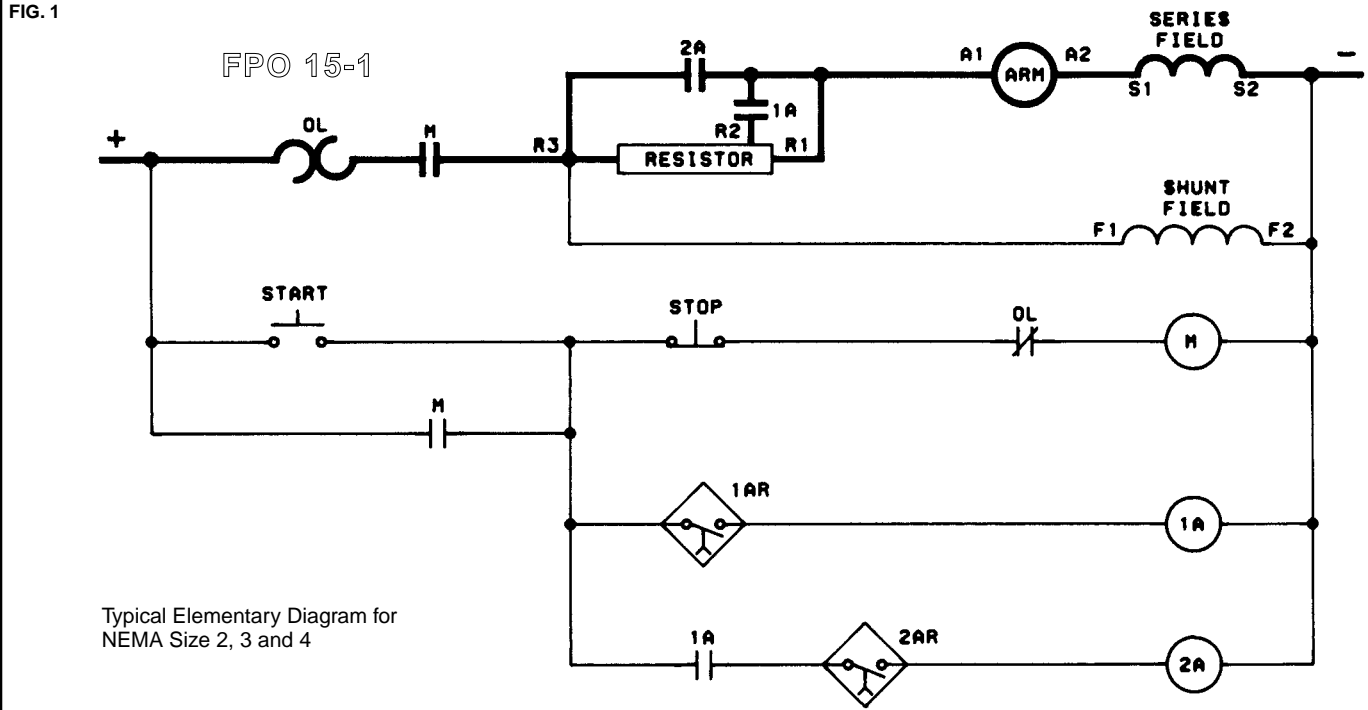
**FIG. 1**

HANDLE END		
REVERSE	OFF	FORWARD
1 — 2	1 ○ ○ 2	1 — 2
3 — 4	3 ○ ○ 4	3 — 4
5 — 6	5 ○ ○ 6	5 — 6

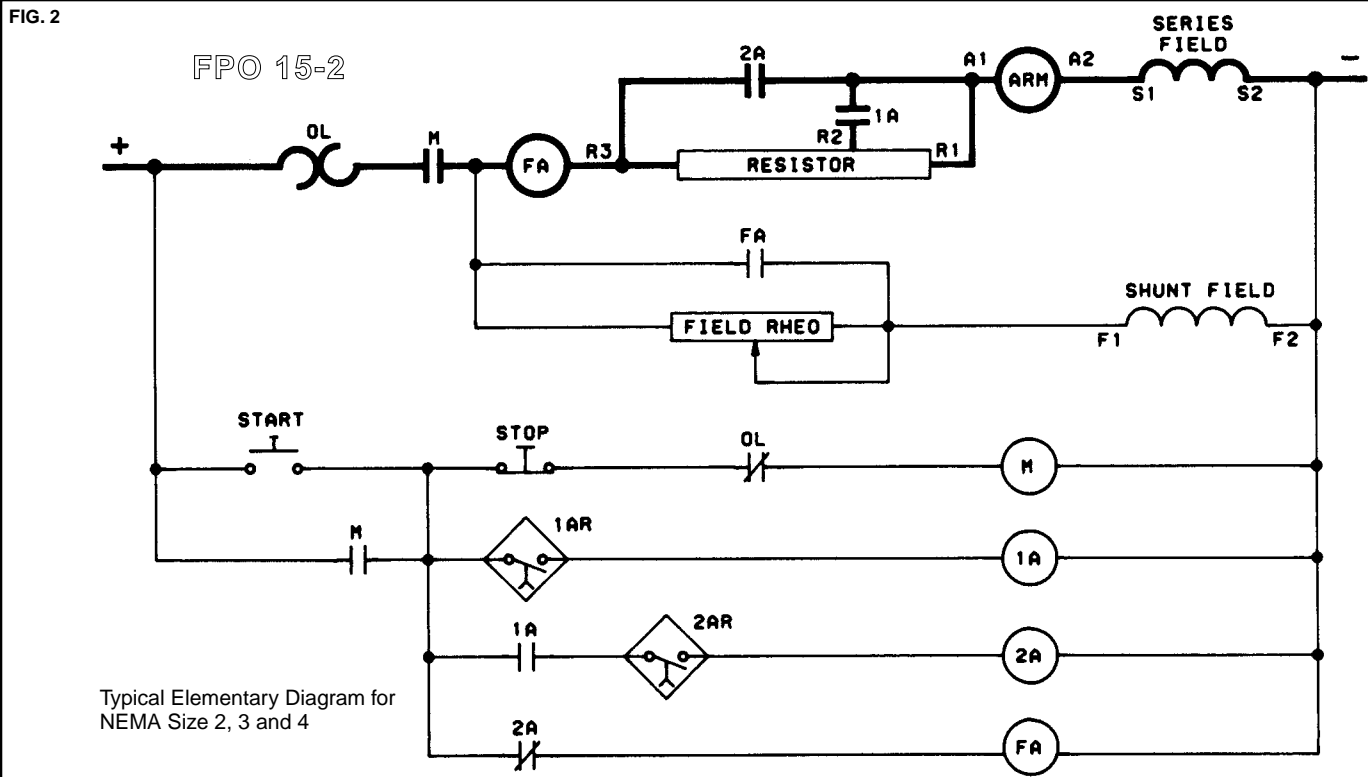
Internal Switching



Constant Speed DC Starter: Class 7135

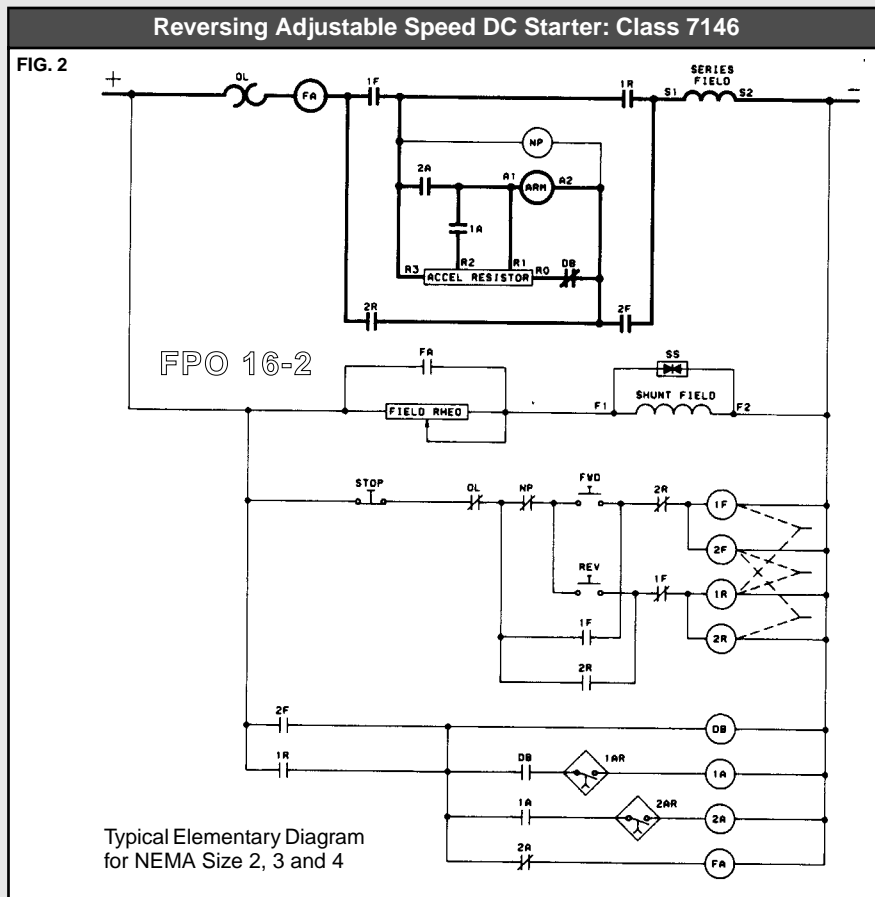
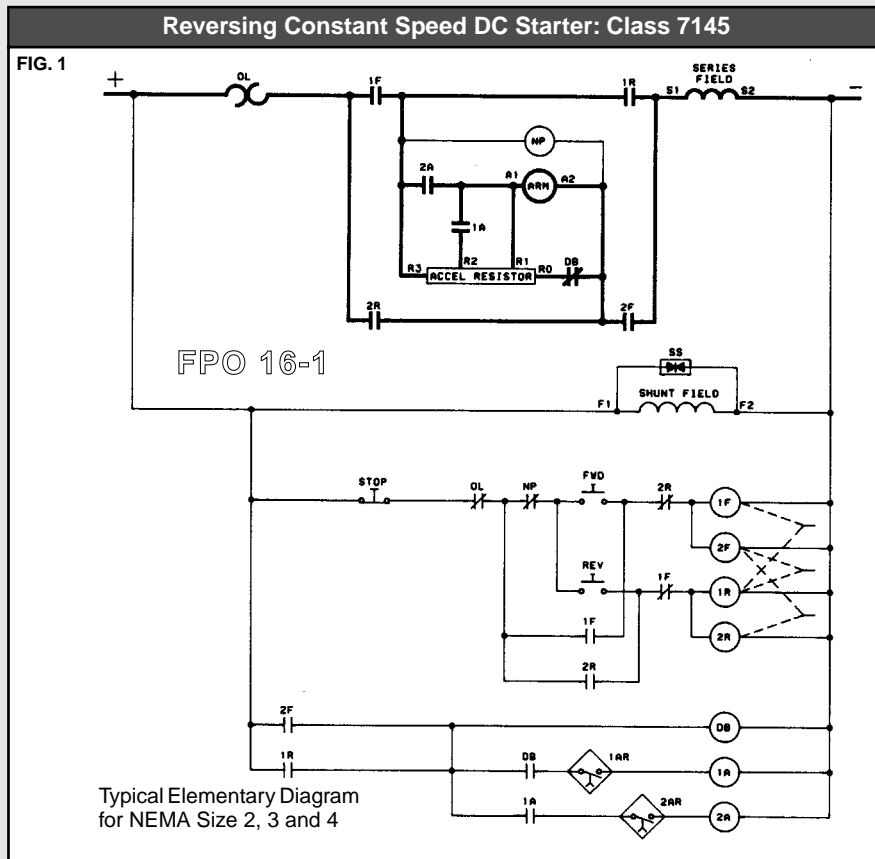


Adjustable Speed DC Starter: Class 7136



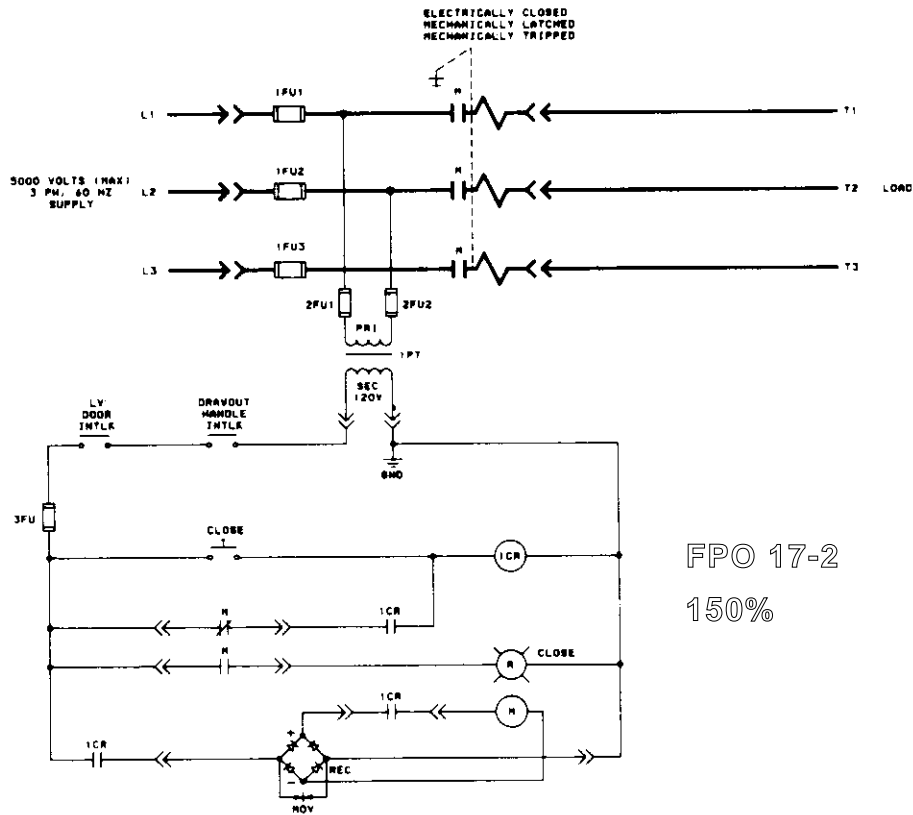
Acceleration Contactors: Class 7135, 7136, 7145 and 7146

NEMA Size	1	2	3	4	5
No. of Acceleration Contactors	1	2	2	2	3



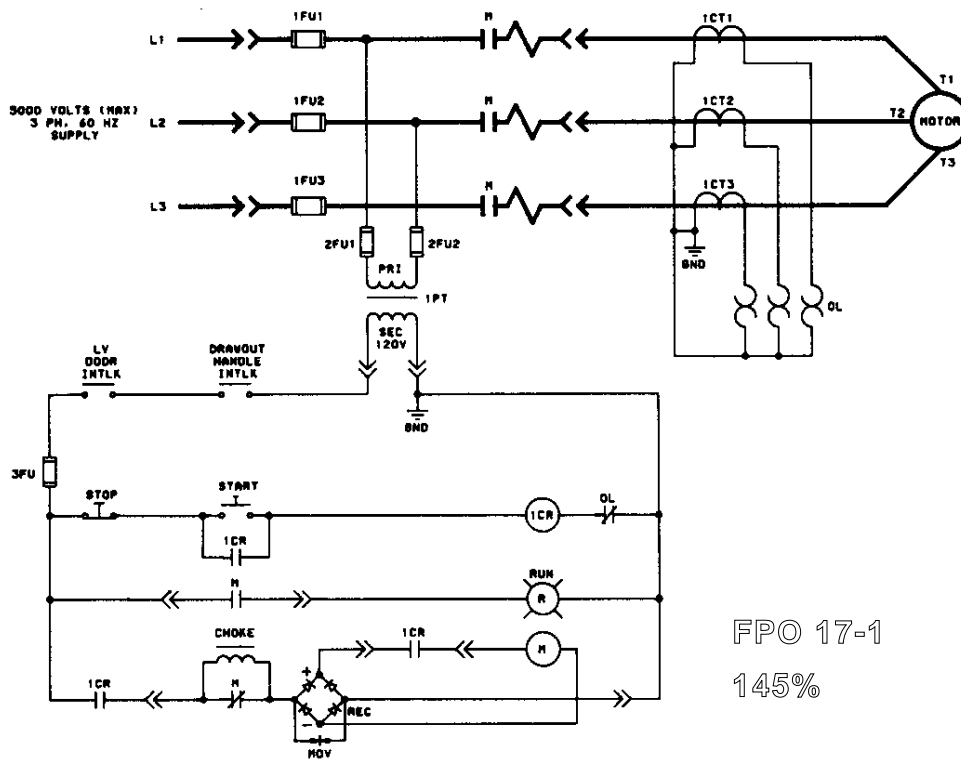
Mechanically Latched Contactor:  
 Class 8196 Type FL13, FL23, FL12 and FL22

FIG. 1



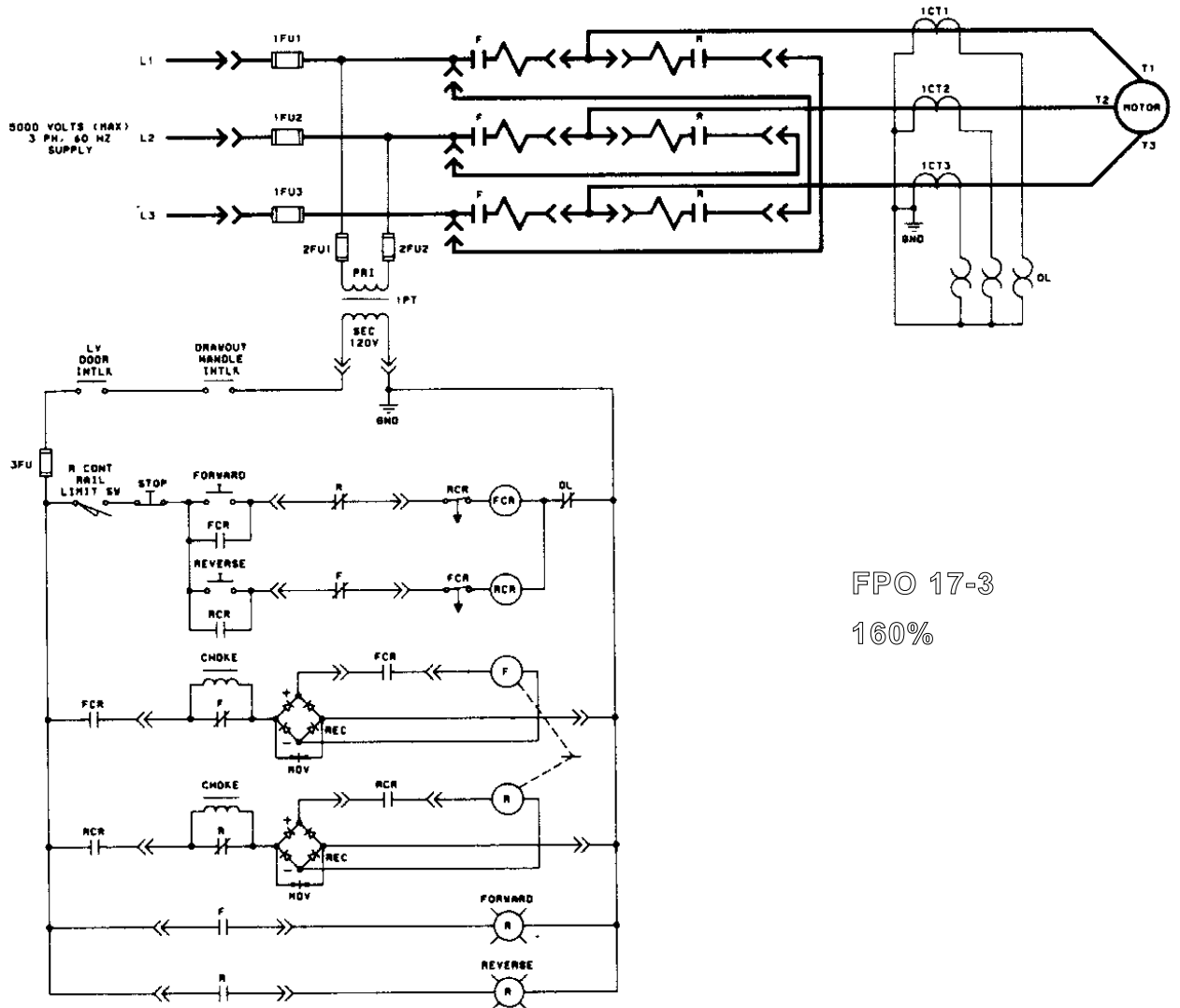
Full-Voltage, Non-Reversing Squirrel Cage Motor Controller:  
 Class 8198 Type FC11, FC21, FC13, FC23, FC12 and FC22

FIG. 2



Full-Voltage Squirrel Cage Motor Controller:  
Class 8198 Type FCR1 and FCR2

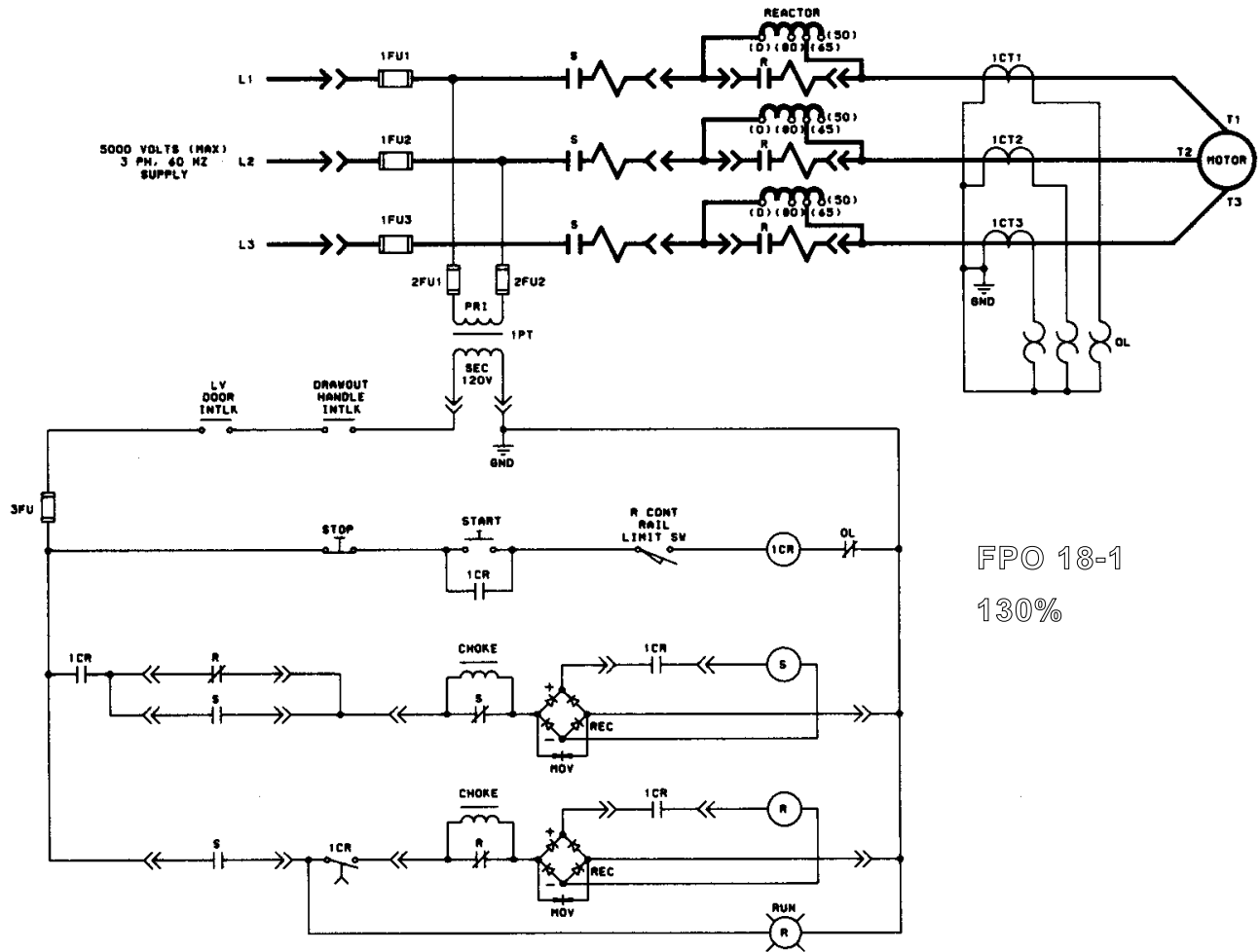
FIG. 1



FPO 17-3  
160%

Reduced-Voltage, Primary Reactor, Non-Reversing Squirrel Cage Motor Controller:  
 Class 8198 Type RCR1 and RCR2

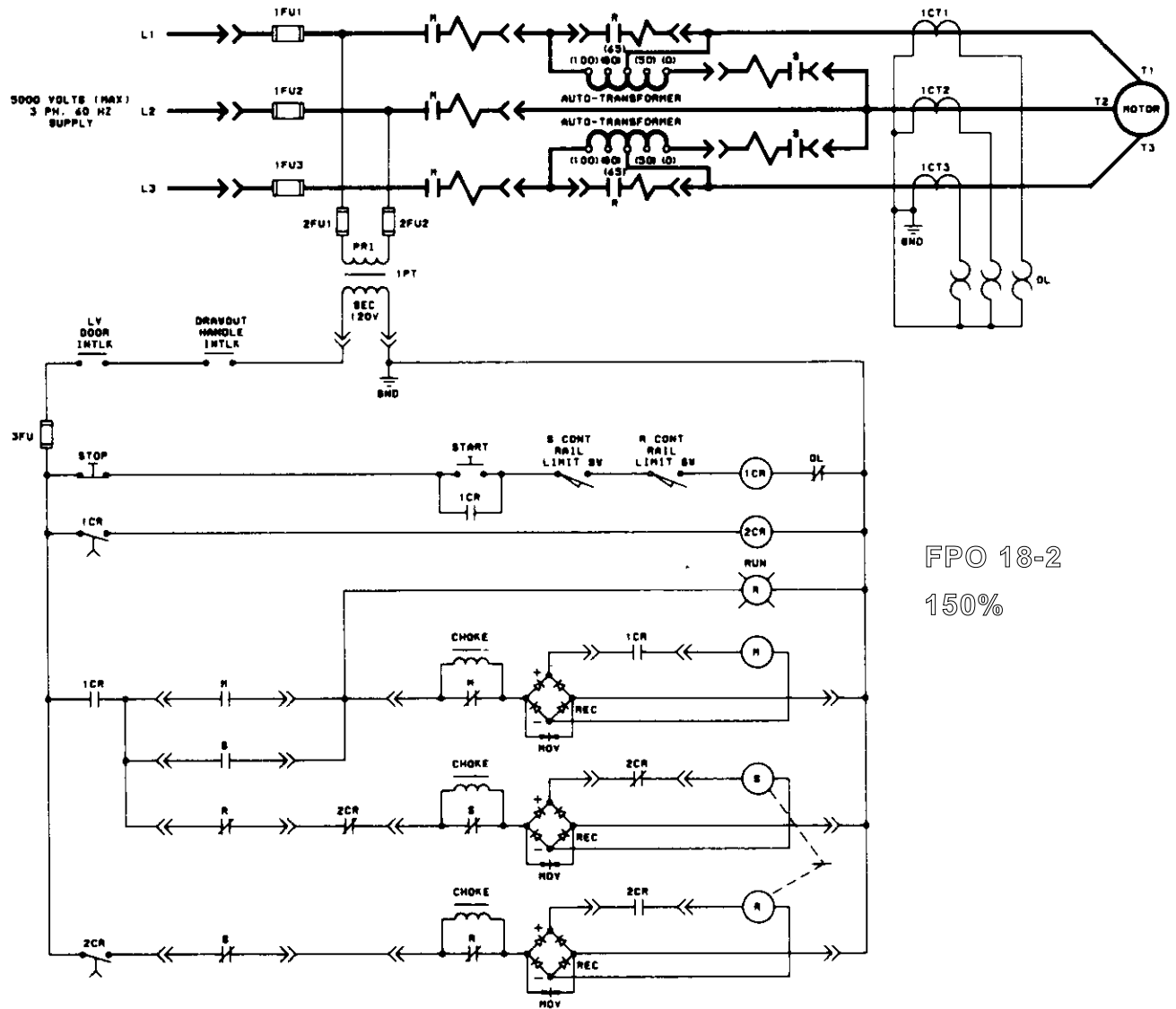
FIG. 1





Reduced-Voltage, Primary Reactor, Autotransformer, Non-Reversing Squirrel Cage Motor Controller:  
Class 8198 Type RCA1 and RCA2

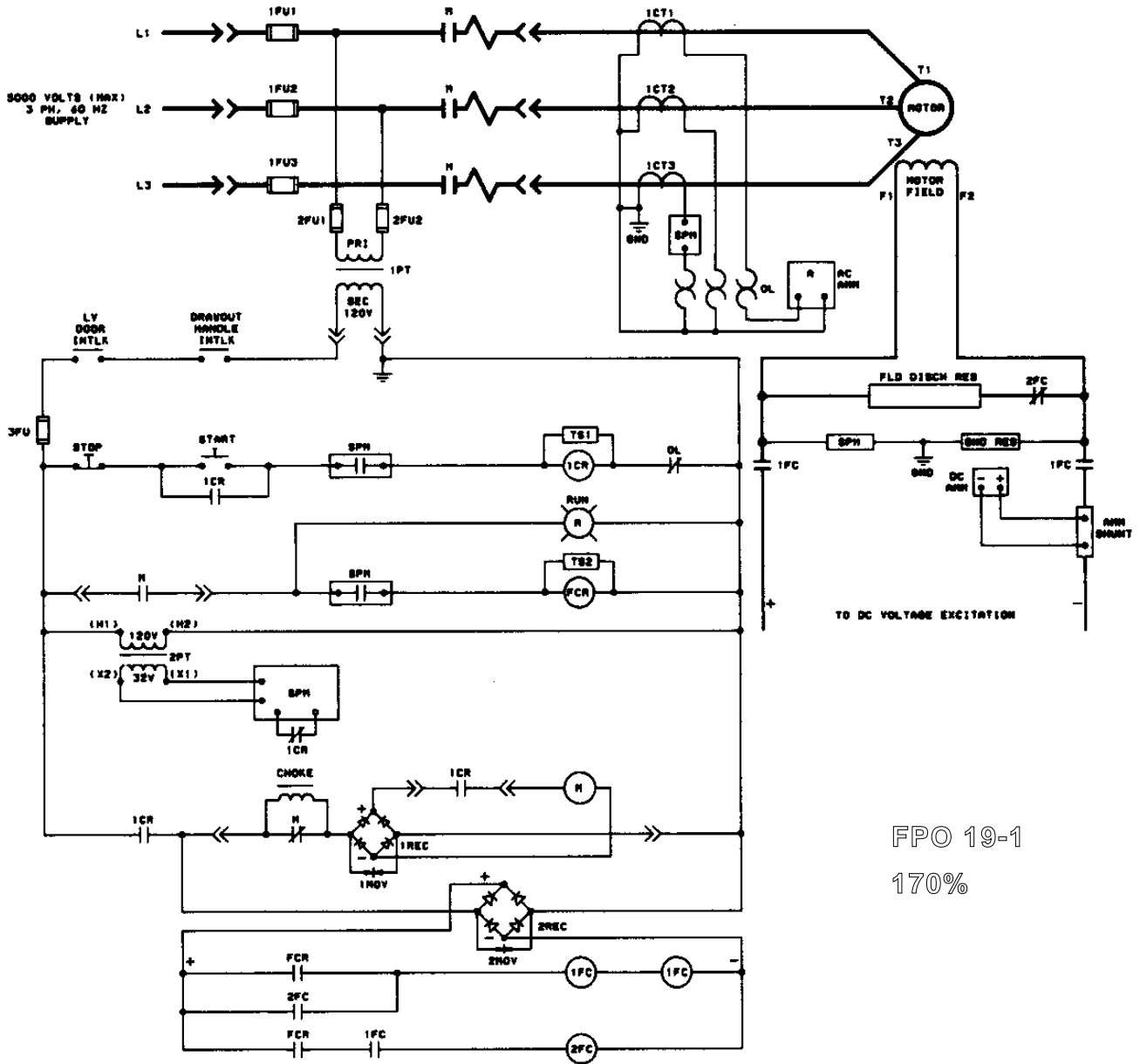
FIG. 1



FPO 18-2  
150%

Full Voltage, Non-Reversing Synchronous Motor Controller:  
 Class 8198 Type FS1 and FS2

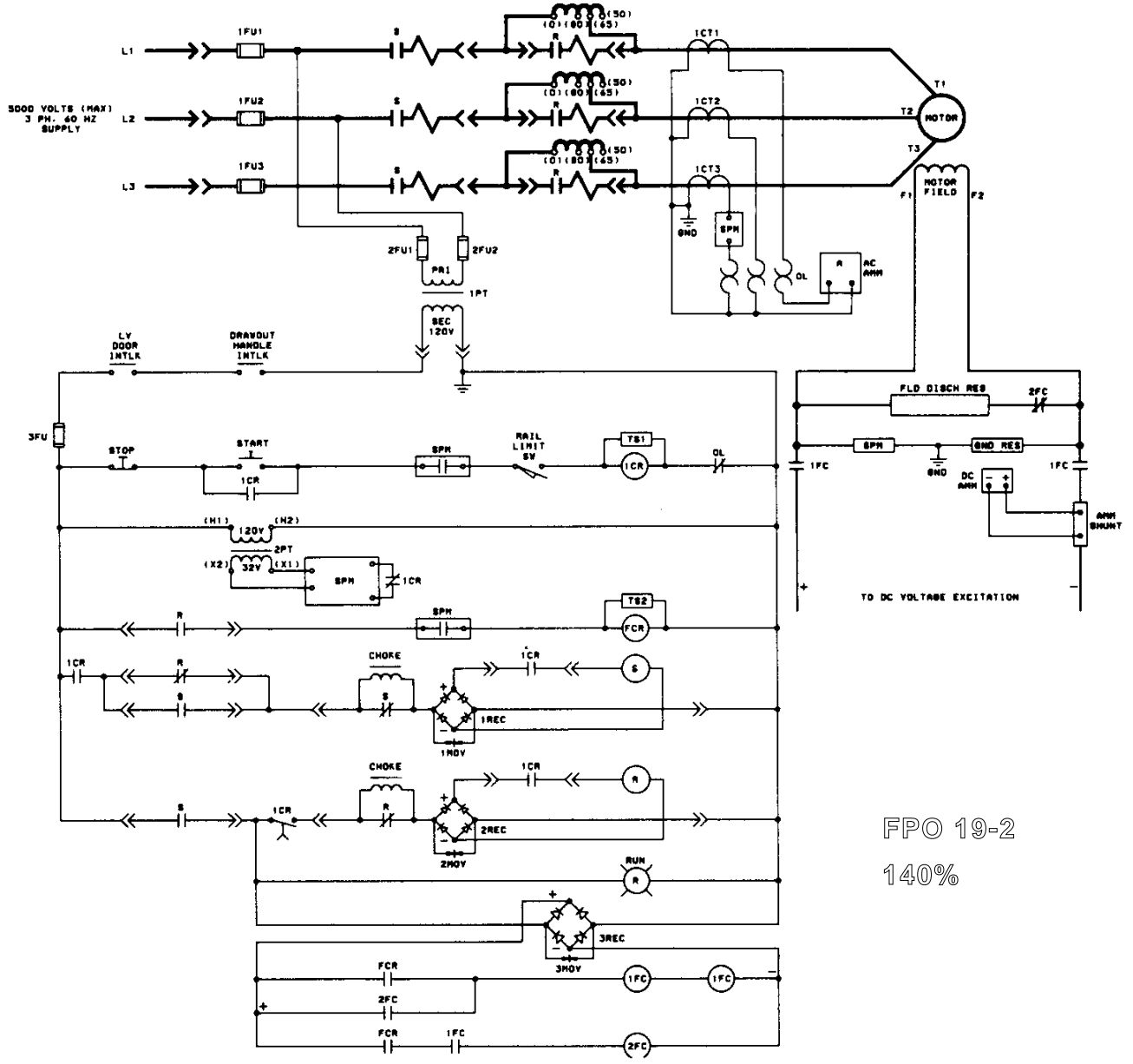
FIG. 1



FPO 19-1  
 170%

Reduced-Voltage, Primary Reactor, Non-Reversing Synchronous Motor Controller:  
Class 8198 Type RS1 and RS2

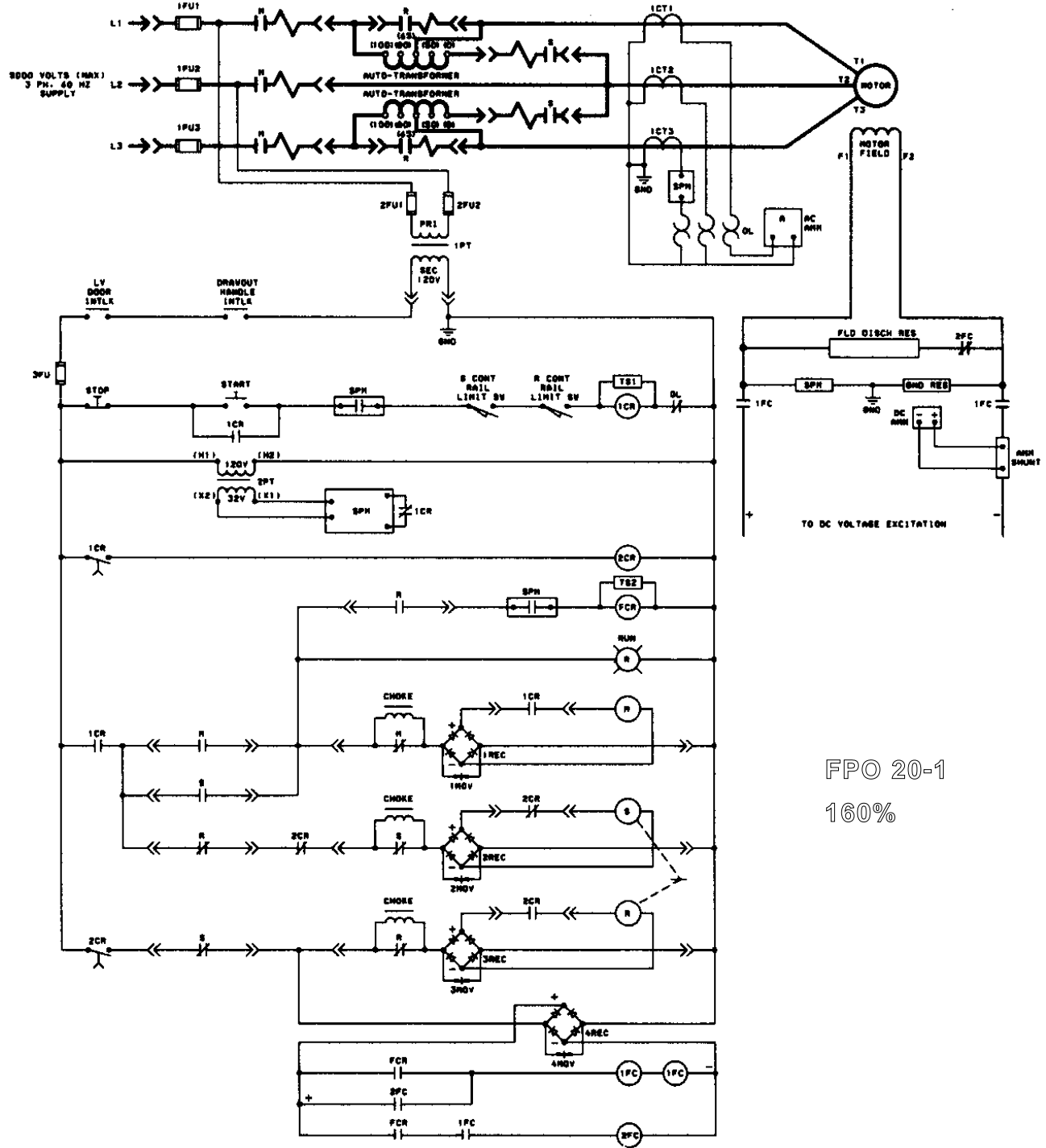
FIG. 1



FPO 19-2  
140%

Reduced-Voltage, Autotransformer, Non-Reversing Synchronous Motor Controller:  
Class 8198 Type RSA1 and RSA2

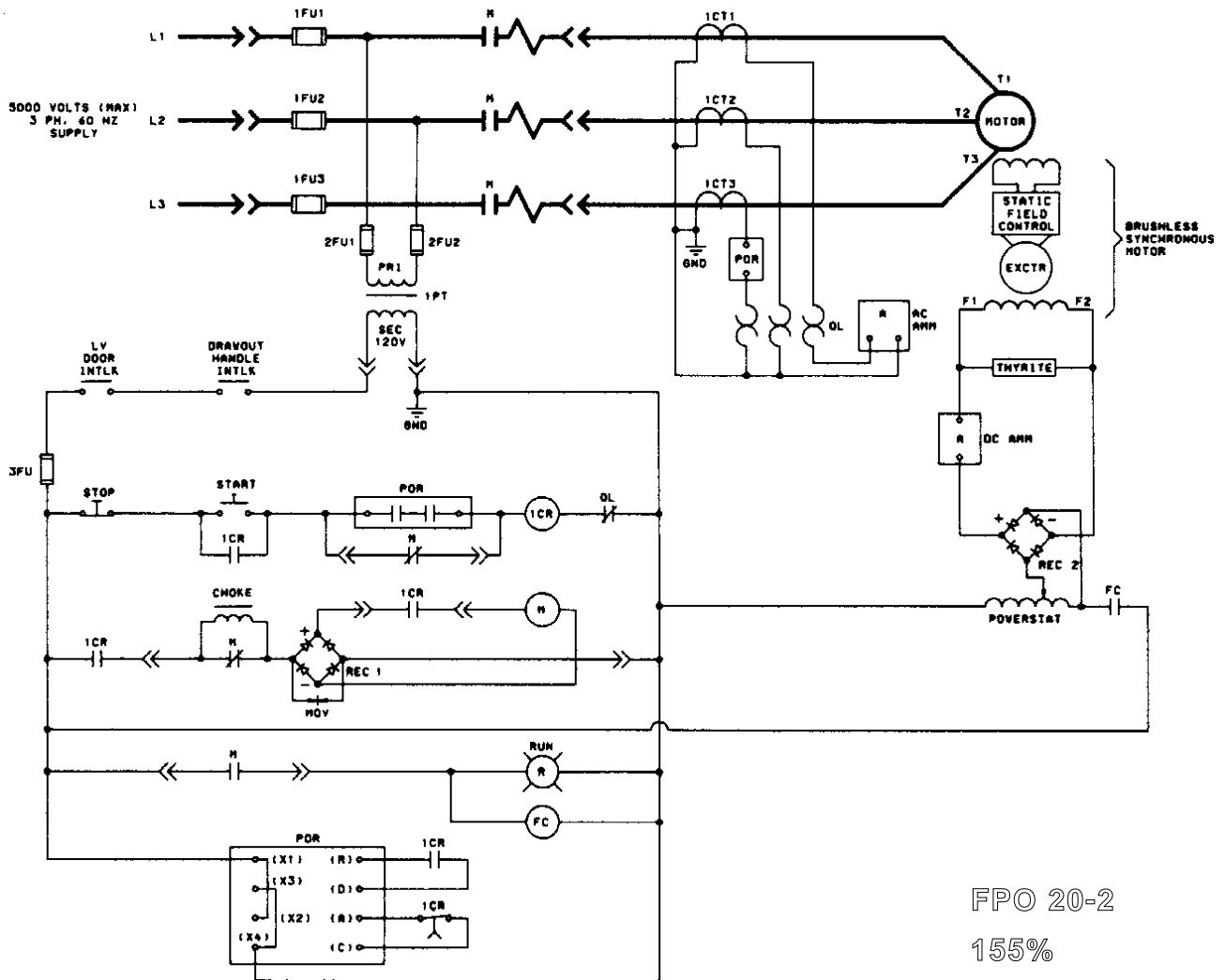
FIG. 1



FPO 20-1  
160%

Full-Voltage, Non-Reversing, Brushless Synchronous Motor Controller:  
Class 8198 Type FSB1 and FSB2

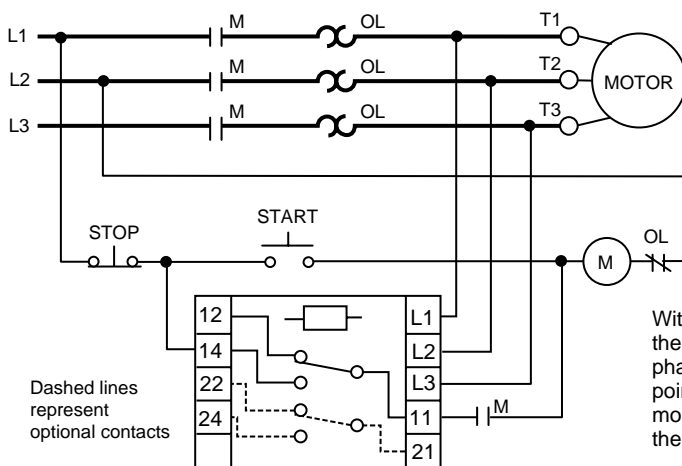
FIG. 1



FPO 20-2  
155%

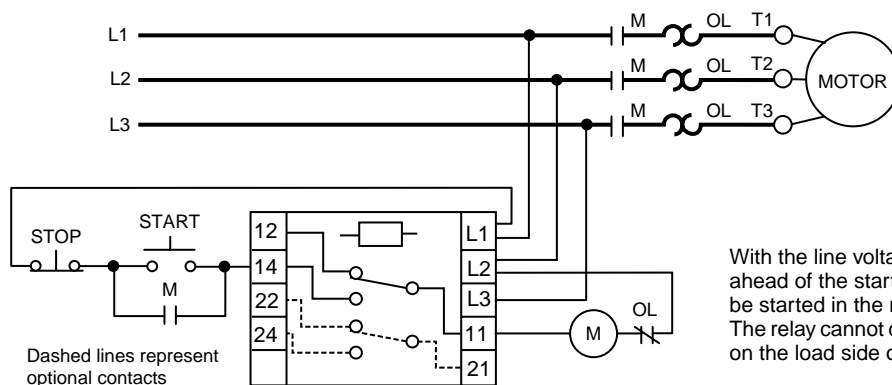
Solid State Protective Relays:  
Class 8430 Type DAS, DASW, DASV and DASVW

FIG. 1



With the line voltage connections directly at the motor terminals, the relay will detect all phase loss conditions ahead of the connection points. However, the motor may sustain a momentary "bump" in the reverse condition if the proper phase sequence is not present.

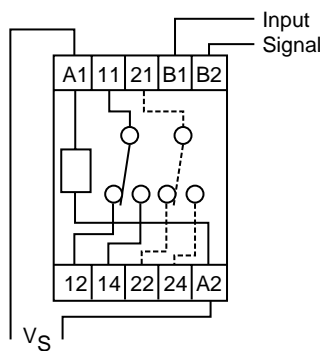
FIG. 2



With the line voltage connections ahead of the starter, the motor can be started in the reverse direction. The relay cannot detect a phase loss on the load side of the starter.

Solid State Protective Relays:  
Class 8430

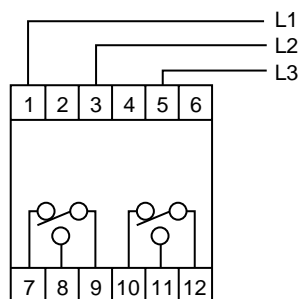
FIG. 3



Dashed lines represent optional contacts (DIAW and DUAW devices only)

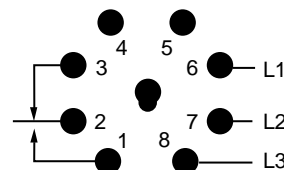
Type DIA, DIAW, DUA and DUAW

FIG. 4



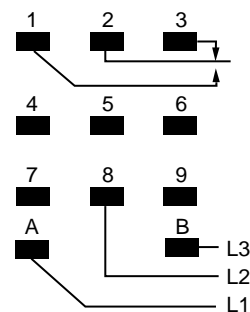
Type MPD

FIG. 5

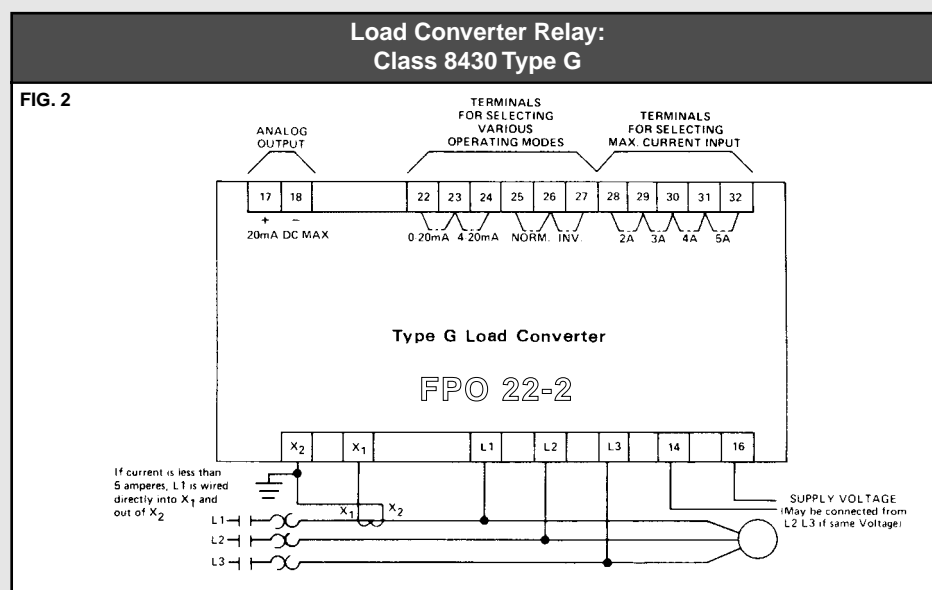
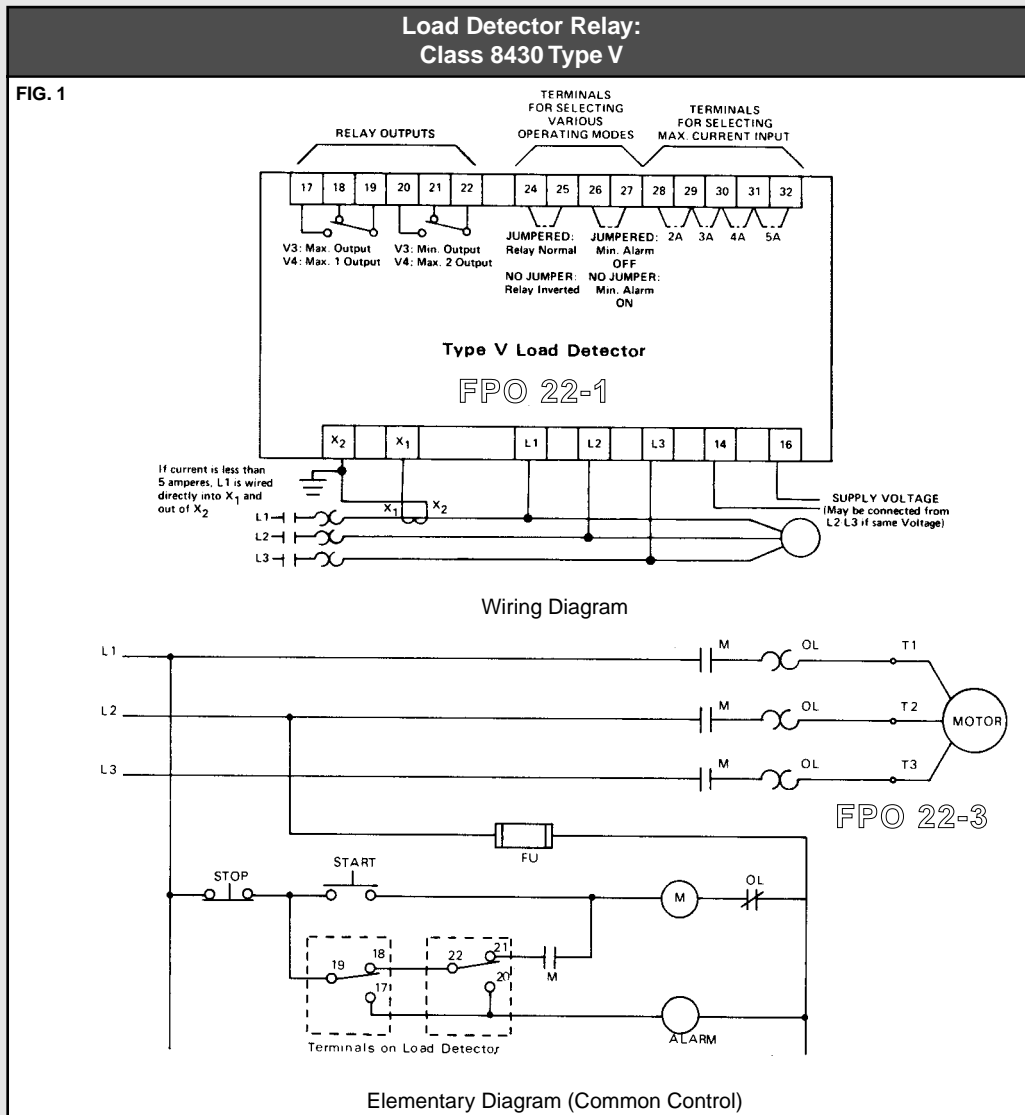


Type MPS 240V

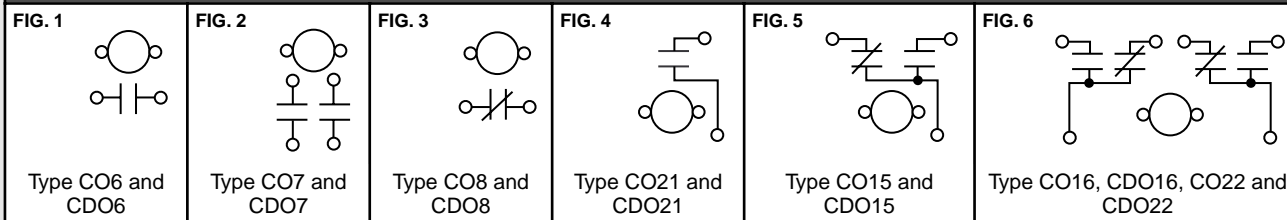
FIG. 6



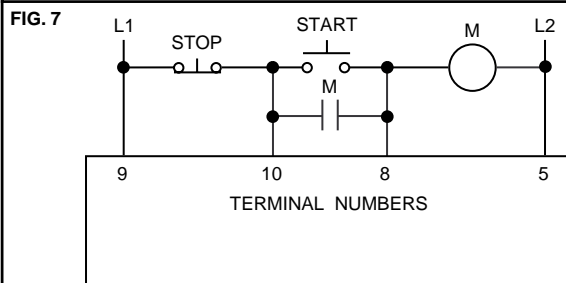
Type MPS 480V



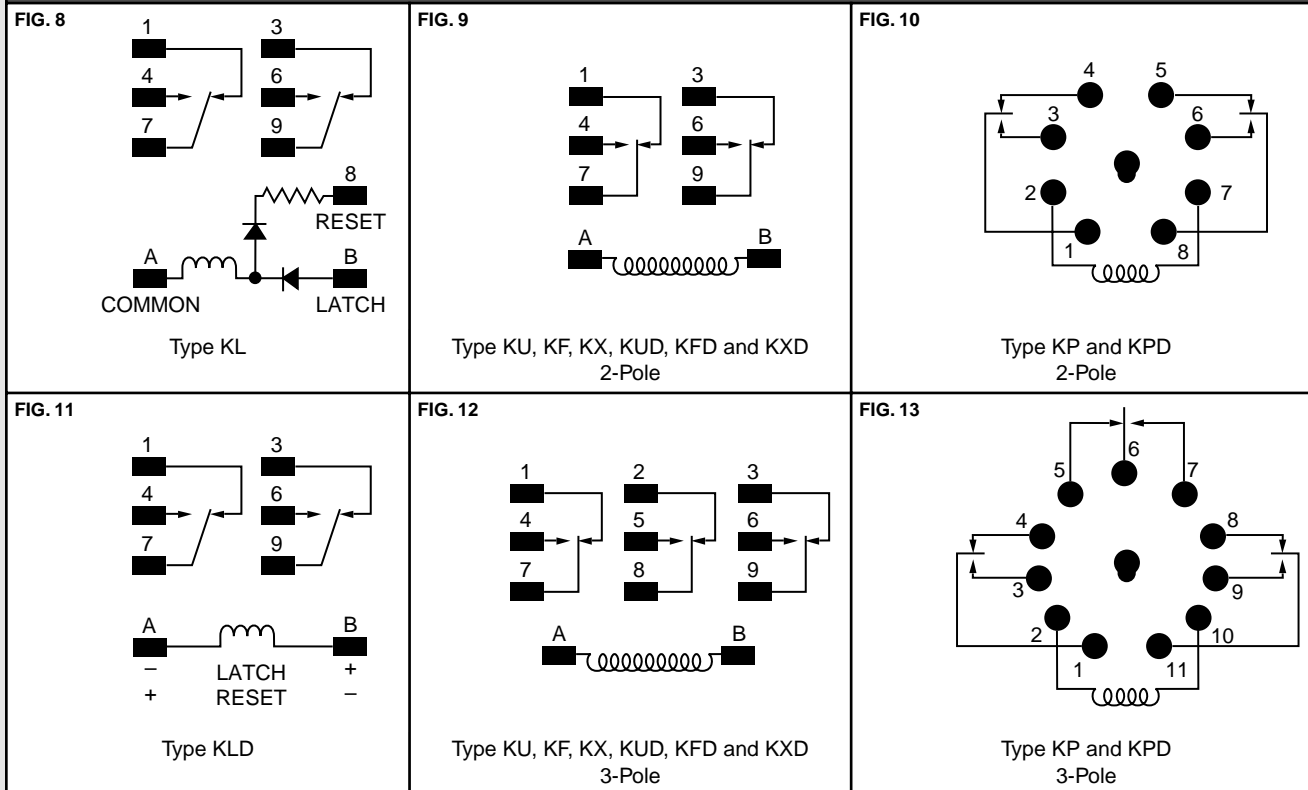
**Control Relays:  
Class 8501 Type CO and CDO**



**Control Relays:  
Class 8501 Type UBS**



**Control Relays:  
Class 8501 Type K**





10 A Control Relay w/ Convertible Contacts:  
Class 8501 Type X

FIG. 1

**2, 3 and 4 Pole Relay  
All Contacts Convertible**

No. of Poles	Type	Pole Number#			
		1	2	3	4
2	XO-20	S	O	O	S
	XO-11	S	O	1	S
	XO-02	S	1	1	S
3	XO-30	O	O	O	S
	XO-21	O	1	O	S
	XO-12	O	1	1	S
4	XO-03	1	1	1	S
	XO-40	O	O	O	O
	XO-31	O	1	O	O
	XO-22	O	1	1	O
	XO-13	O	1	1	1
	XO-04	1	1	1	1

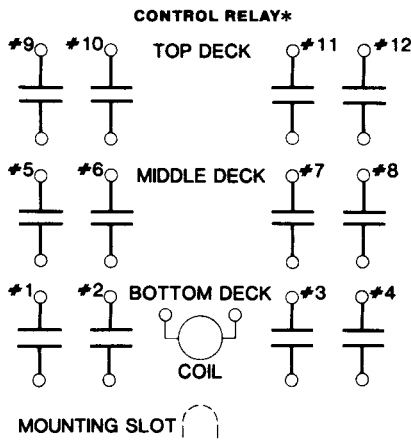
#O — Normally Open Contact  
1 — Normally Closed Contact  
S — Space for Future Contact

**6 and 8 Pole Relay  
All Contacts Convertible**

No. of Poles	Type	Pole Number#			
		5	6	7	8
6	XO-60	S	O	O	S
		O	O	O	O
	XO-51	S	O	O	S
		O	1	O	O
	XO-42	S	O	O	S
		O	1	1	O
	XO-33	S	1	1	S
		O	1	O	O
	XO-24	S	1	1	S
		O	1	1	O
XO-15	S	1	1	S	
	O	1	1	1	
XO-06	S	1	1	S	
	1	1	1	1	
8	XO-80	O	O	O	O
		O	O	O	O
	XO-71	O	1	O	O
		O	O	O	O
	XO-62	O	1	1	O
		O	O	O	O
	XO-53	O	1	O	O
		O	1	1	O
	XO-44	O	1	1	O
		O	1	1	O
XO-35	O	1	1	1	
	O	1	1	O	
XO-26	1	1	1	1	
	O	1	1	1	
XO-17	1	1	1	1	
	1	1	1	1	
XO-08	1	1	1	1	
	1	1	1	1	

**10 and 12 Pole Relay  
All Contacts Convertible**

No. of Poles	Type	Pole Number#			
		9	10	11	12
10	XO-1000	S	O	O	S
		O	O	O	O
	XO-0901	S	O	O	S
		O	1	O	O
	XO-0802	S	O	O	S
		O	1	1	O
	XO-0703	S	O	O	S
		O	1	1	O
	XO-0604	S	O	O	S
		O	1	1	O
XO-0505	S	O	O	S	
	O	1	1	1	
XO-0406	S	1	1	S	
	O	1	1	O	
12	XO-0307	S	1	1	S
		O	1	1	1
	XO-0208	S	1	1	S
		O	1	1	O
	Maximum of 8 N.C. Poles				
	XO-1200	O	O	O	O
		O	O	O	O
	XO-1101	O	1	O	O
		O	O	O	O
	XO-1002	O	1	1	O
O		O	O	O	
XO-0903	O	1	1	O	
	O	O	O	O	
XO-0804	O	1	1	O	
	O	O	O	O	
XO-0705	O	1	1	O	
	O	1	1	O	
XO-0606	O	1	1	O	
	O	1	1	O	
XO-0507	O	1	1	O	
	O	1	1	1	
XO-0408	O	1	1	O	
	O	1	1	1	
Maximum of 8 N.C. Poles					

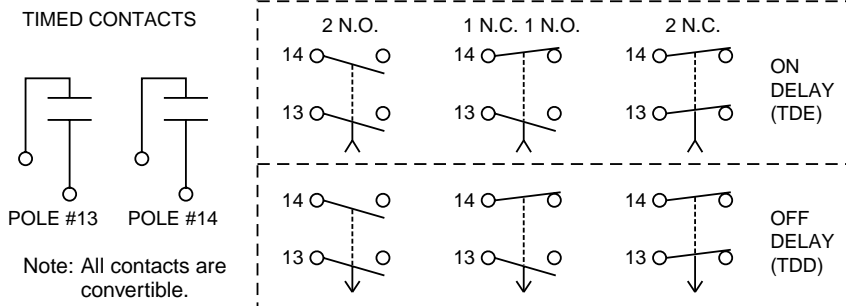


FPO 27-1

\* Note: Class 8501 Type XO\*\*\*XL, XDO\*\*\*XL, XDO\*\*\*XDL and XO\*\*\*XDL latch relays use the same diagram except for the addition of an unlatch coil (8 poles maximum).

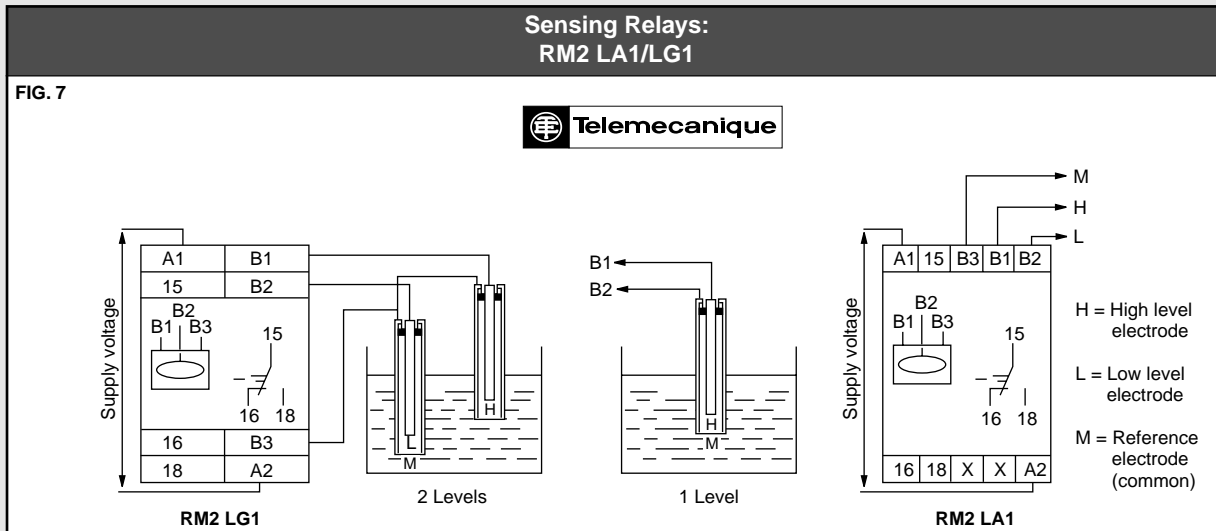
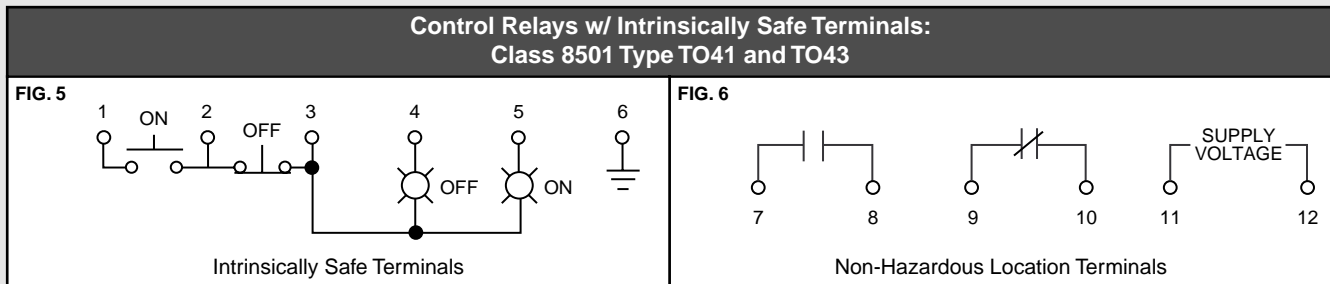
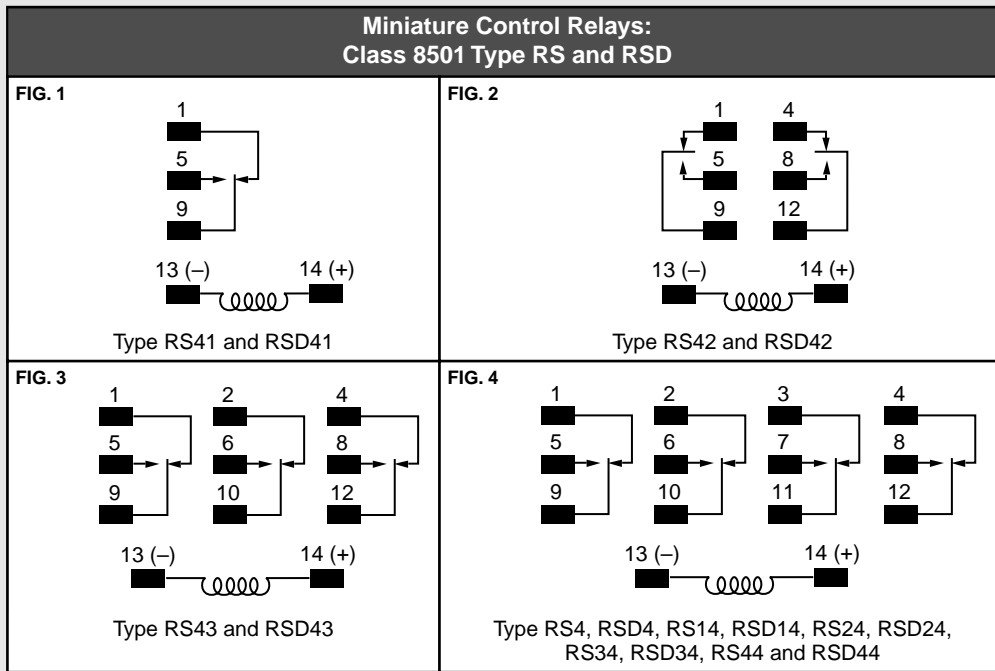
Timer Attachment:  
Class 9999 Type XTD and XTE

FIG. 2

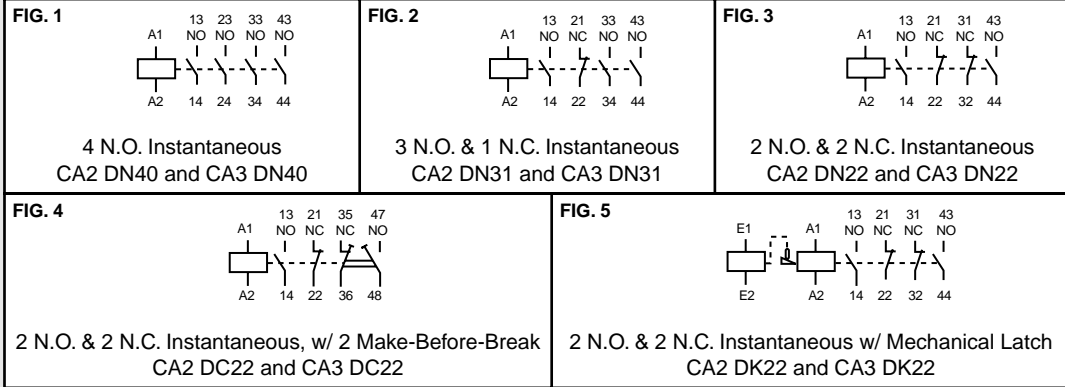


No. of Timed Contacts	Class 9999 Type	Pole No.*	
		13	14
2	XTD XTE	O	1

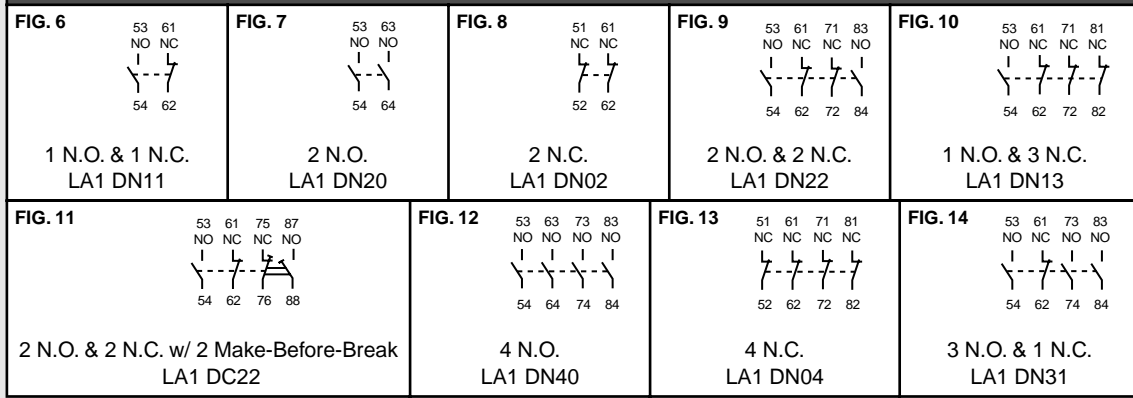
\* O = N.O. Contact  
1 = N.C. Contact



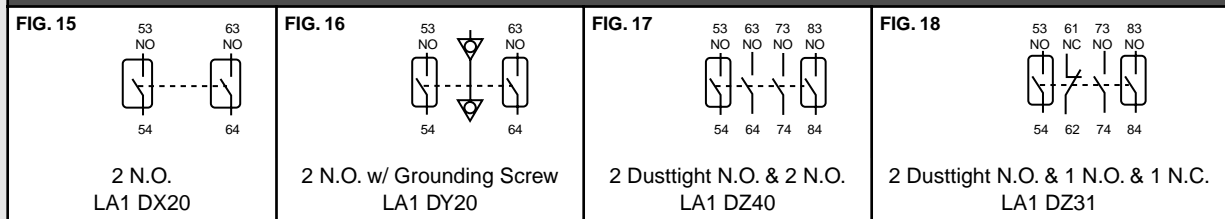
**Control Relays: CA2 and CA3**



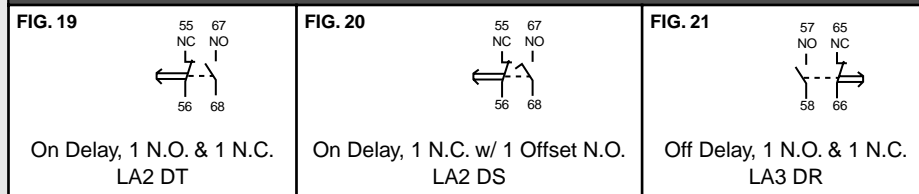
**Front-Mounted Standard Instantaneous Auxiliary Contact Blocks: LA1**



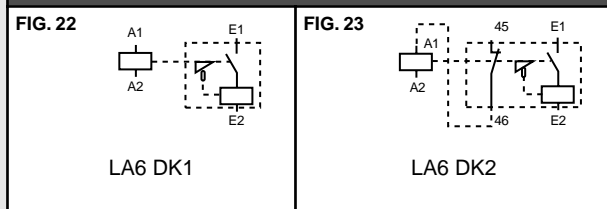
**Front-Mounted Damp- and Dust-Protected Instantaneous Auxiliary Contact Blocks: LA1**



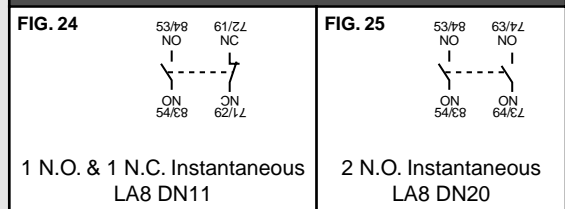
**Front-Mounted Time Delay Auxiliary Contacts: LA2 and LA3**

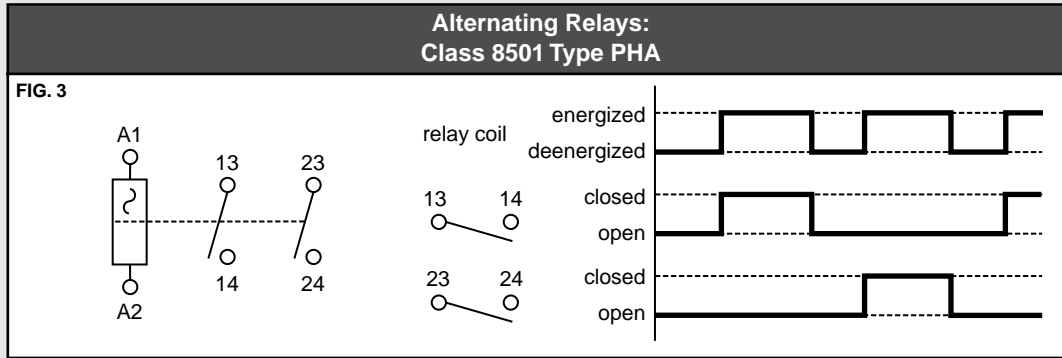
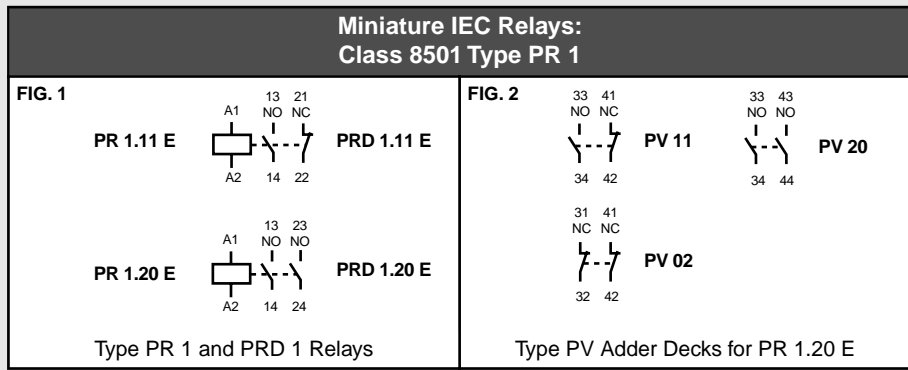


**Front-Mounted Mechanical Latch Adder Blocks: LA6**



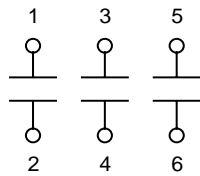
**Side-Mounted Auxiliary Contact Blocks: LA8**





**Power Terminals**

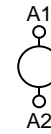
FIG. 1



Power terminals on contactors, overloads and switches are single digits – odd for line side terminals and even for load side terminals.

**Coil Terminals**

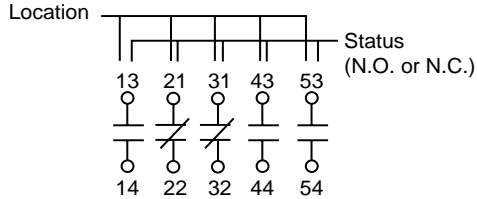
FIG. 2



Coil terminals are designated by a letter and a number. Terminals for a single winding coil are designated "A1" and "A2".

**Auxiliary Contact Terminals**

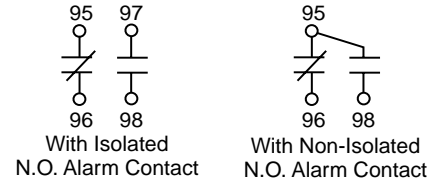
FIG. 3



Auxiliary contacts on contactors, relays and push button contacts use 2-digit terminal designations, as shown in the diagram above. The first digit indicates the location of the contact on the device. The second digit indicates the status of the contacts, N.O. or N.C. "1" and "2" indicate N.C. contacts. "3" and "4" indicate N.O. contacts.

**Overload Relay Contact Terminals**

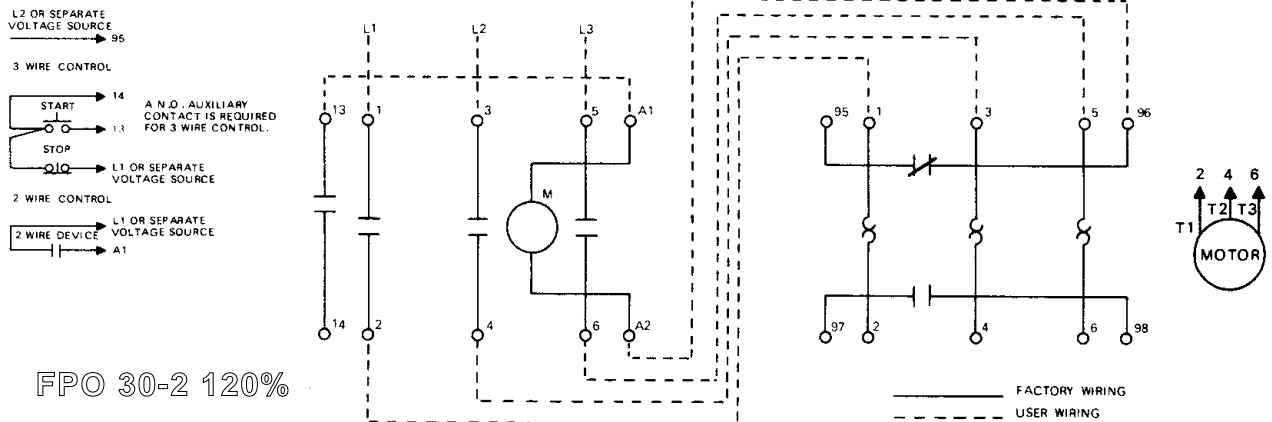
FIG. 4



Overload contact terminals are marked with two digits. The first digit is "9". The second digits are "5" and "6" for a N.C. and "7" and "8" for a N.O. isolated contact. If the device has a non-isolated alarm contact (single pole), the second digits of the N.O. terminals are "5" and "8".

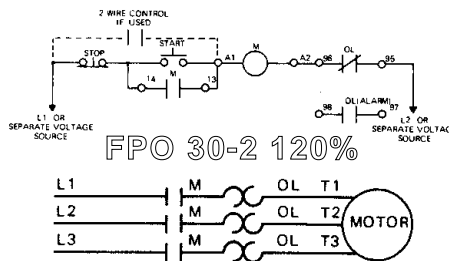
**Class 8502 Type PD or PE Contactor  
w/ Class 9065 Type TR Overload Relay**

FIG. 5



FPO 30-2 120%

Wiring Diagram

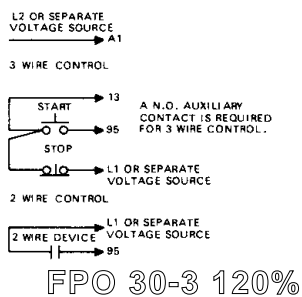


FPO 30-2 120%

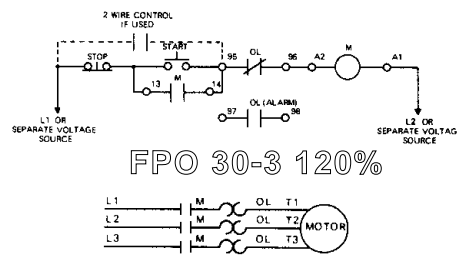
Elementary Diagram

Class 8502 Type PG or PD Contactor  
w/ Class 9065 Type TD Overload Relay

FIG. 1



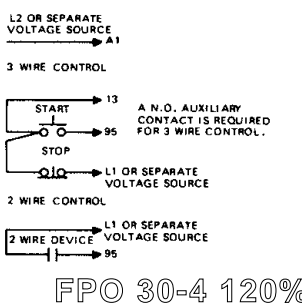
Wiring Diagram



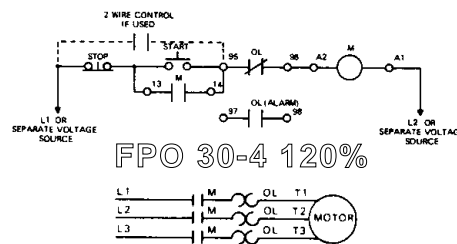
Elementary Diagram

Class 8502 Type PE Contactor  
w/ Class 9065 Type TE Overload Relay

FIG. 2



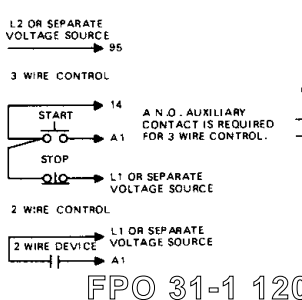
Wiring Diagram



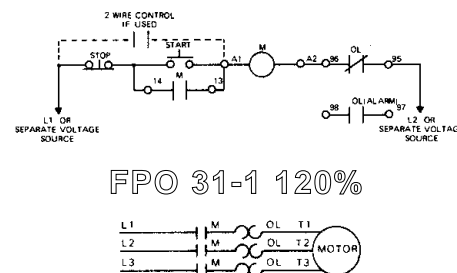
Elementary Diagram

Class 8502 Type PF, PG or PJ Contactor  
w/ Class 9065 Type TF, TG or TJ Overload Relay

FIG. 3



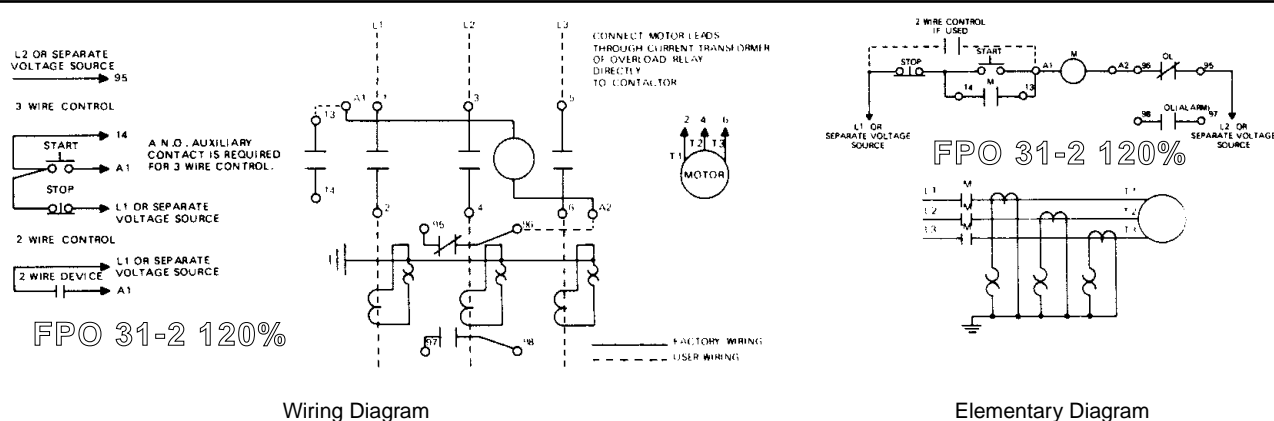
Wiring Diagram



Elementary Diagram

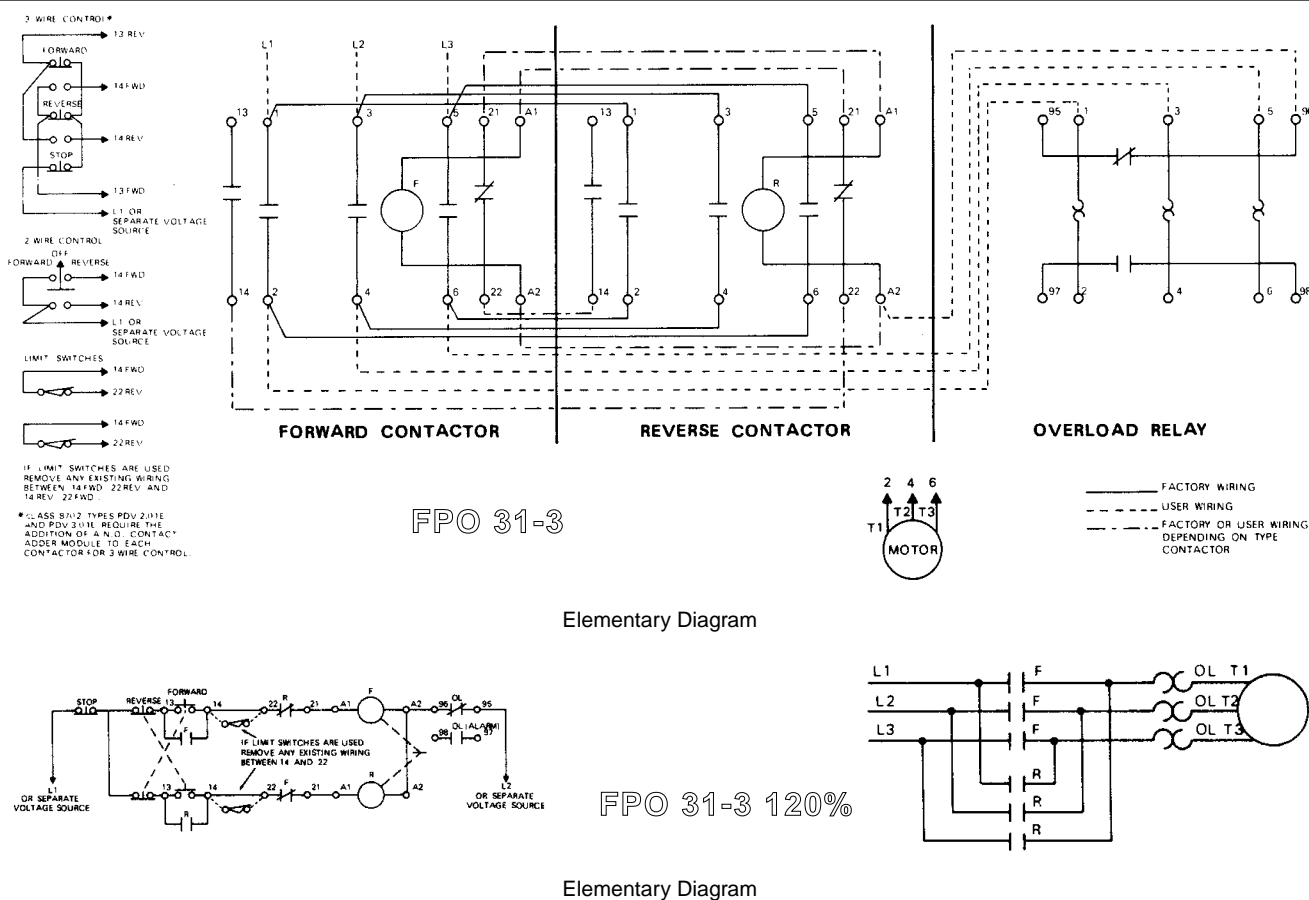
Class 8502 Type PJ or PK Contactor  
w/ Class 9065 Type TJE Overload Relay

FIG. 4



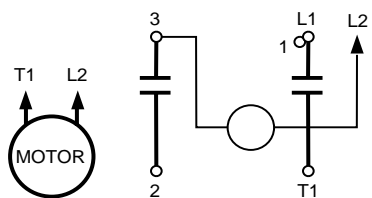
Class 8702 Type PDV or PEV Reversing Contactor  
w/ Class 9065 Type TR Overload Relay

FIG. 1



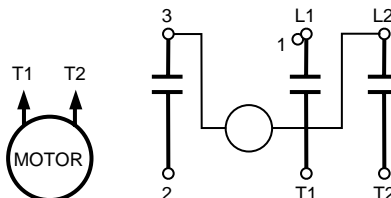
AC Magnetic Contactors:  
Class 8502 Type S

FIG. 1



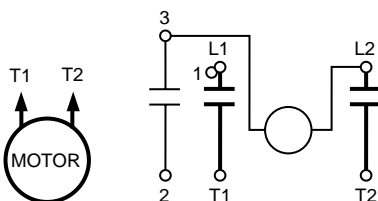
1-Pole, Size 0 and 1

FIG. 2



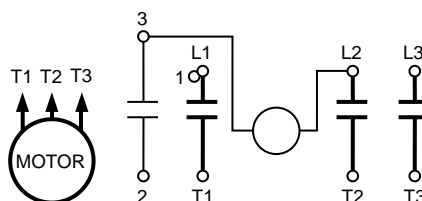
2-Pole, Size 00, 0 and 1

FIG. 3



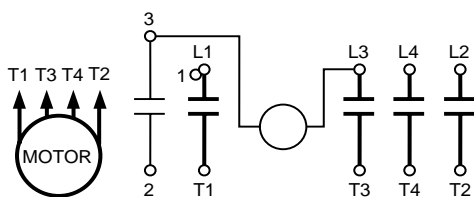
2-Pole, Size 2 to 5

FIG. 4



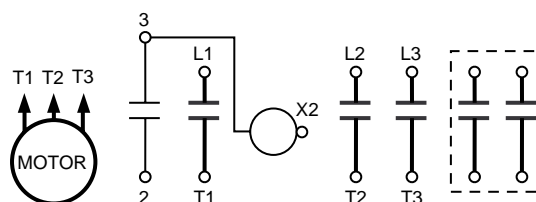
3-Pole, Size 00 to 5

FIG. 5



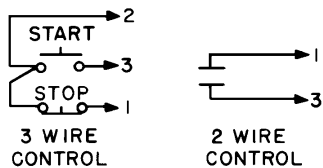
4-Pole, Size 0, 1 and 2

FIG. 6



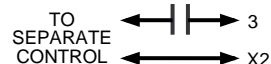
5-Pole, Size 0, 1 and 2

FIG. 7



2- and 3-Wire Control for Figure 1 to 5

FIG. 8

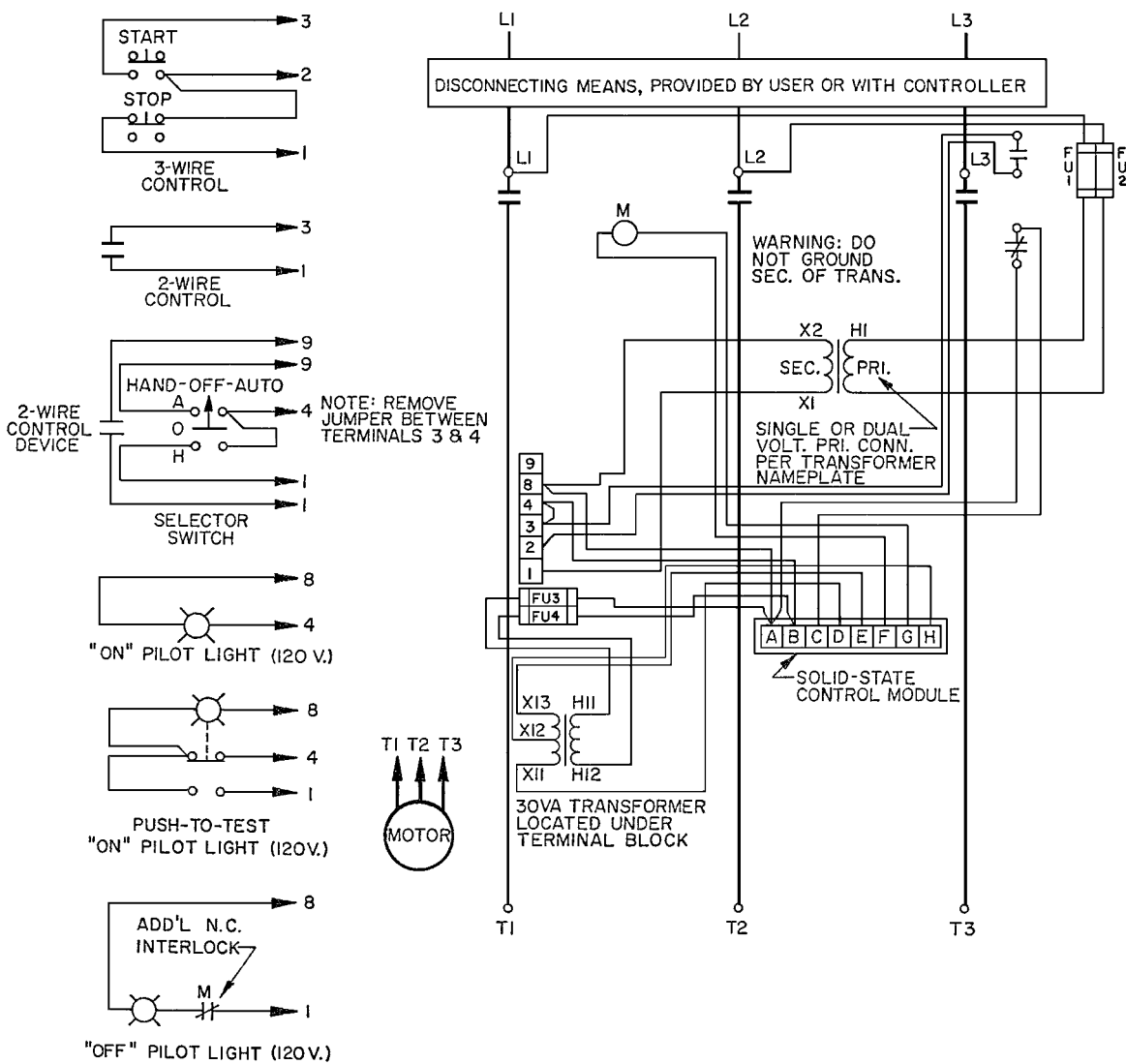


Separate Control for Figure 6

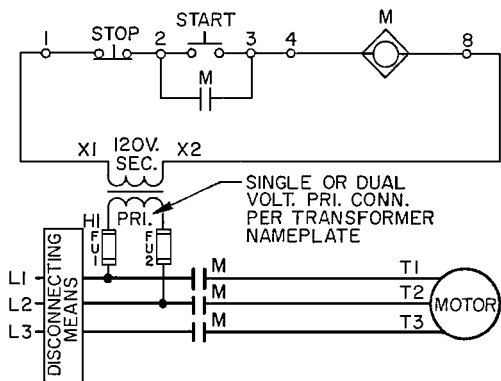


Size 6, 3-Pole Contactor – Common Control  
Class 8502 Type SH Series B

FIG. 1



Wiring Diagram



Elementary Diagram

This symbol denotes the coil function, provided by a solid-state control module, 30 VA transformer, two fuses in the secondary of the transformer, N.C. electrical interlock and DC magnet coil.

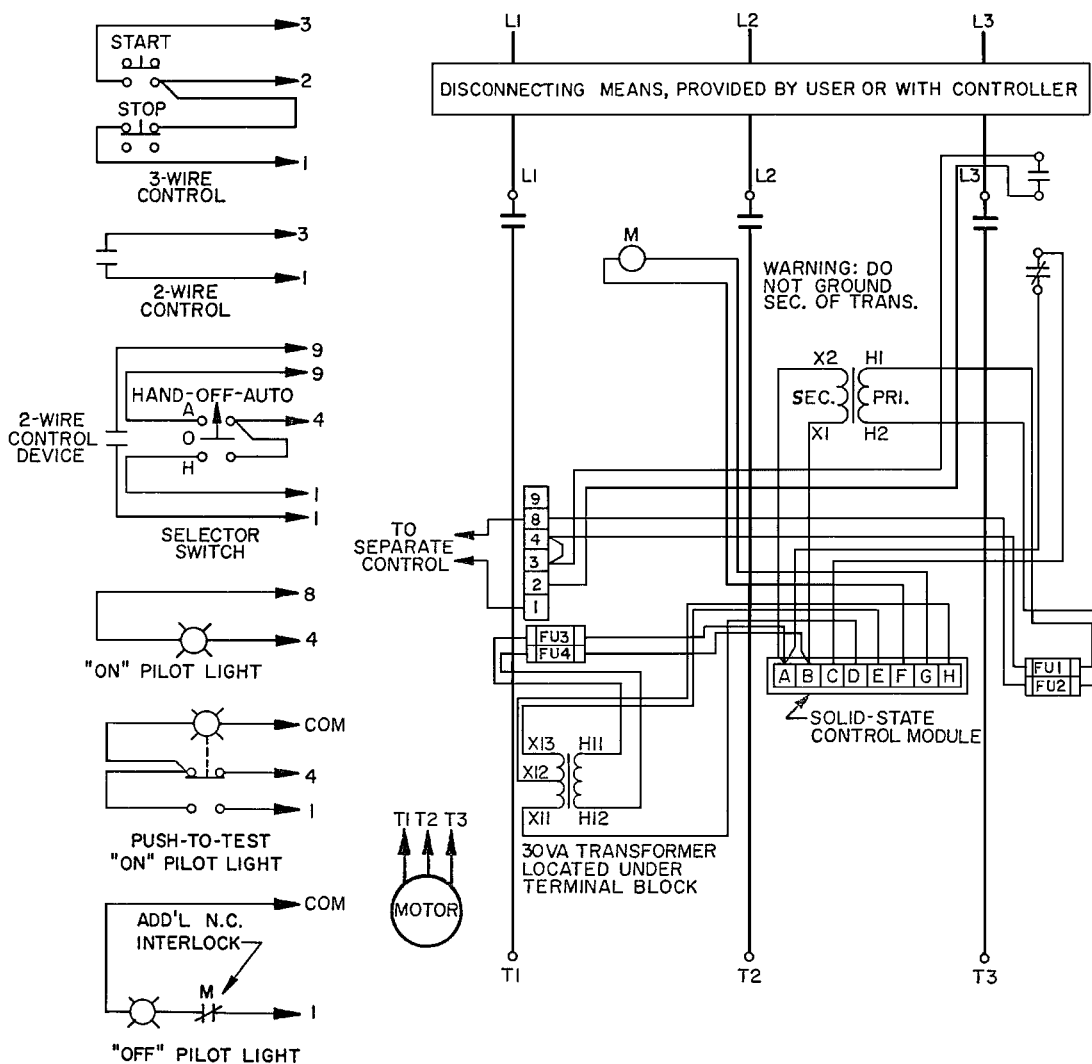
Short-Circuit Protection

Rating of branch circuit protective device must comply with applicable electrical codes and the following limitations:

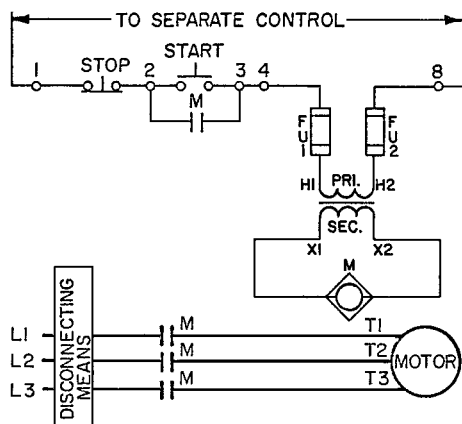
Type of Device	Max. Rating
Class K5 or RK5 time-delay fuse	600 A
Class J, T or L fuse	1200 A
Inverse-time circuit breaker	800 A

Size 6, 3-Pole Contactor – Separate Control  
Class 8502 Type SH Form S Series B

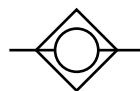
FIG. 1



Wiring Diagram



Elementary Diagram



This symbol denotes the coil function, provided by a solid-state control module, 30 VA transformer, two fuses in the secondary of the transformer, N.C. electrical interlock and DC magnet coil.

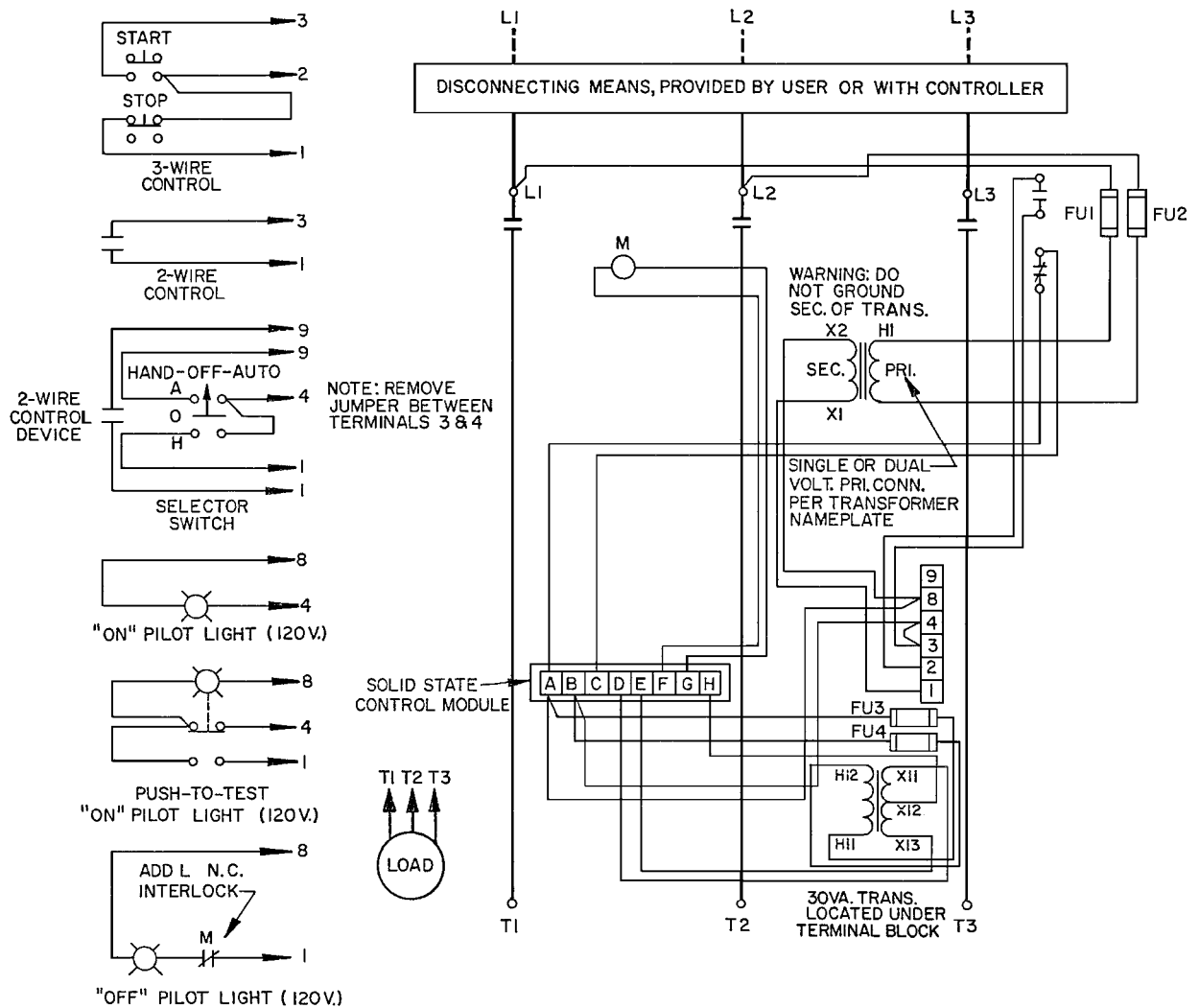
Short-Circuit Protection

Rating of branch circuit protective device must comply with applicable electrical codes and the following limitations:

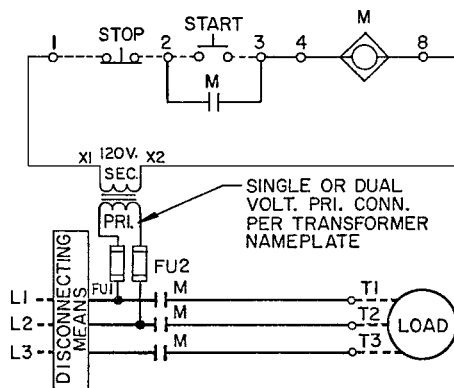
Type of Device	Max. Rating
Class K5 or RK5 time-delay fuse	600 A
Class J, T or L fuse	1200 A
Inverse-time circuit breaker	800 A

Size 7, 3-Pole Contactor – Common Control  
Class 8502 Type SJ Series A

FIG. 1



Wiring Diagram



Elementary Diagram



This symbol denotes the coil function, provided by a solid-state control module, 30 VA transformer, two fuses in the secondary of the transformer, N.C. electrical interlock and DC magnet coil.

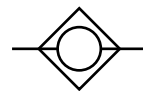
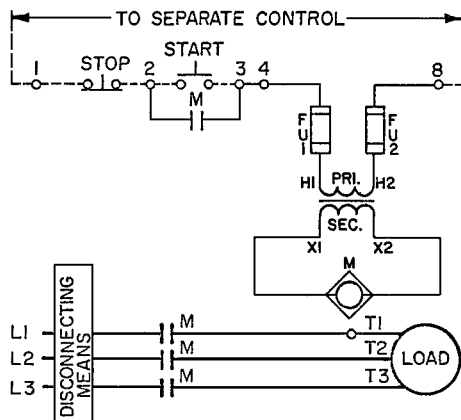
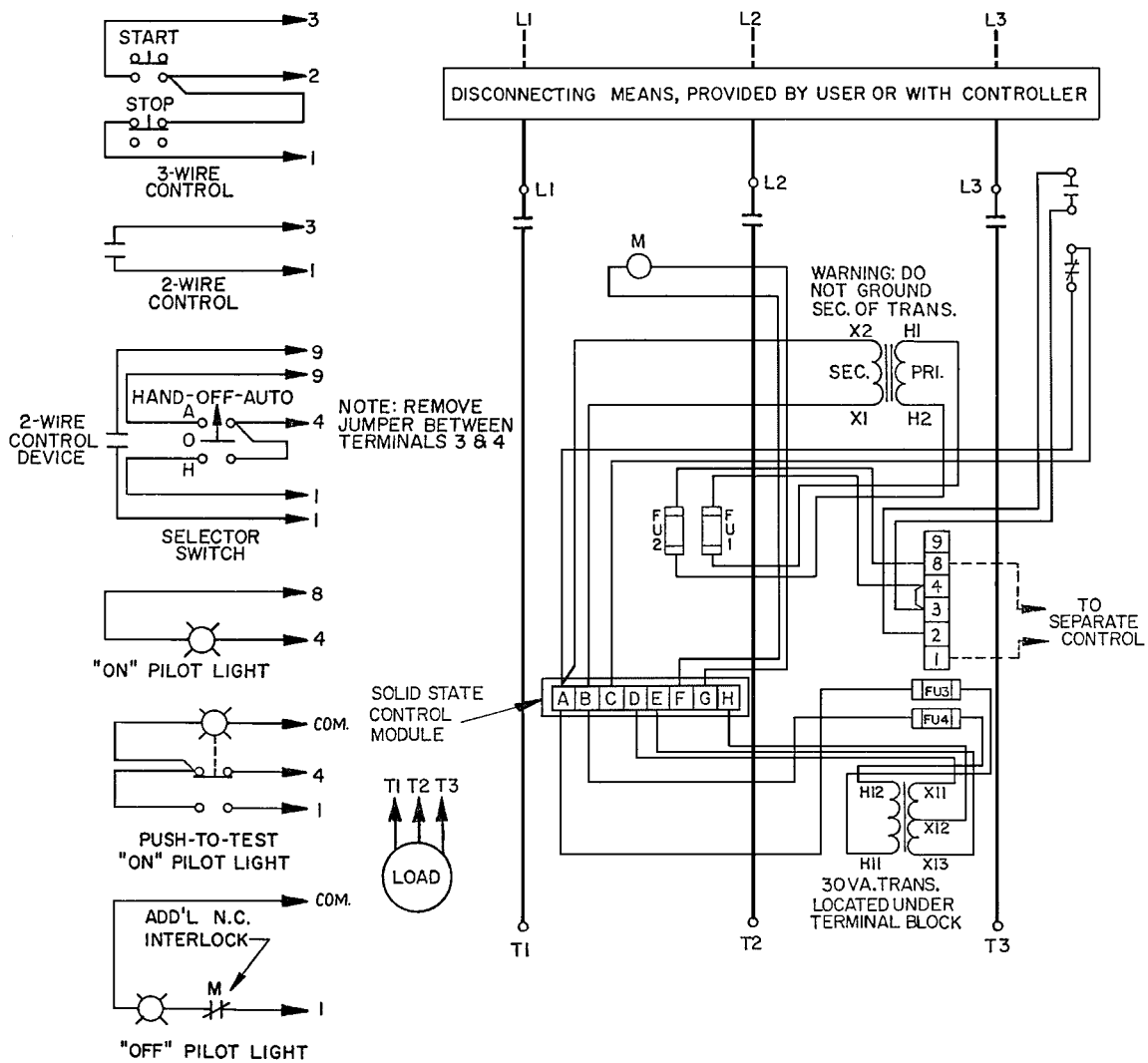
Short-Circuit Protection

Rating of branch circuit protective device must comply with applicable electrical codes and the following limitations:

Type of Device	Max. Rating
Class K5 or RK5 time-delay fuse	600 A
Class J, T or L fuse	1600 A
Inverse-time circuit breaker	2000 A

Size 7, 3-Pole Contactor – Separate Control  
Class 8502 Type SJ Form S Series A

FIG. 1

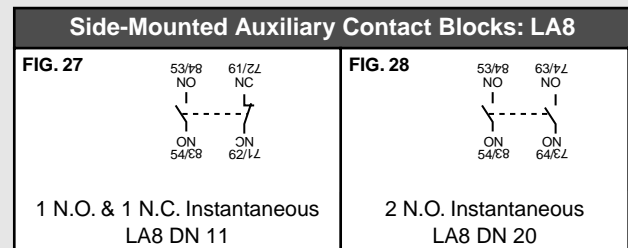
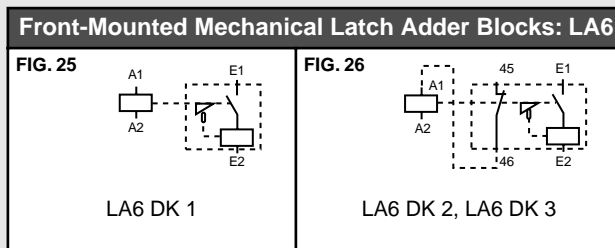
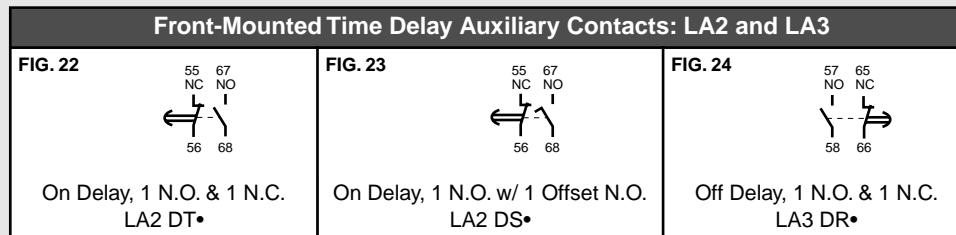
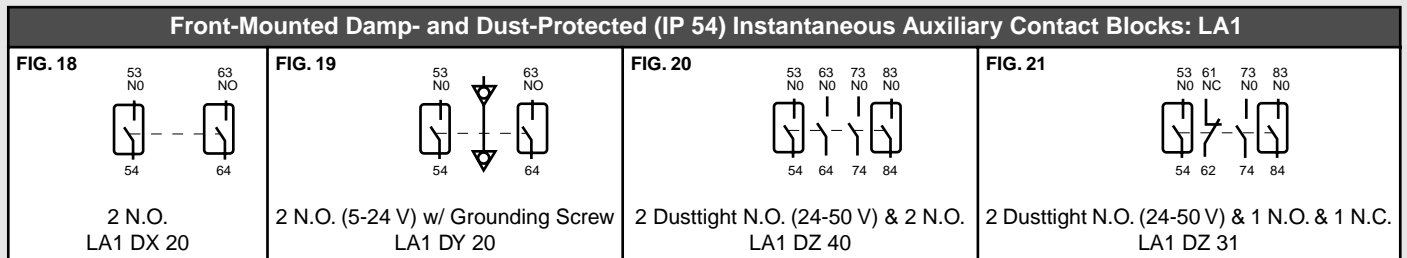
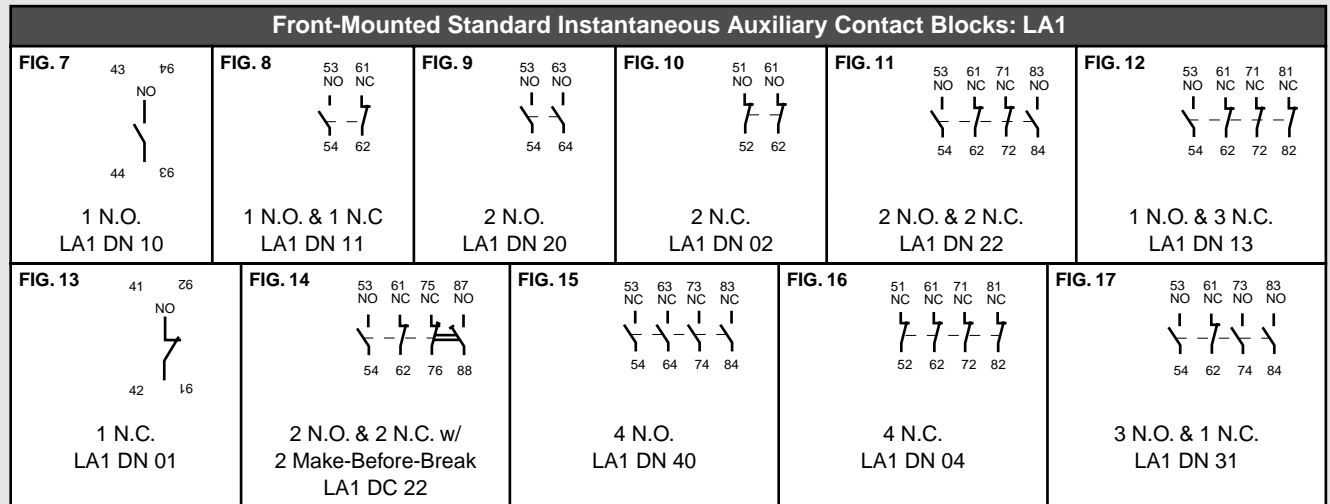
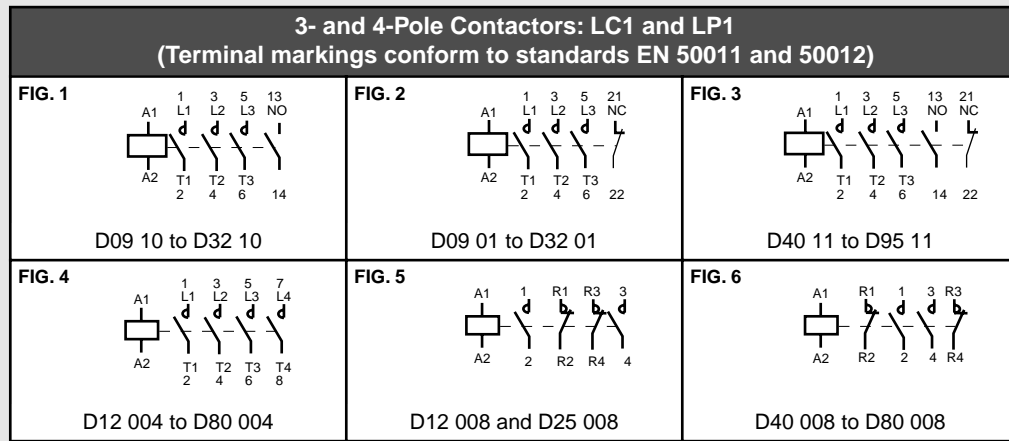


This symbol denotes the coil function, provided by a solid-state control module, 30 VA transformer, two fuses in the secondary of the transformer, N.C. electrical interlock and DC magnet coil.

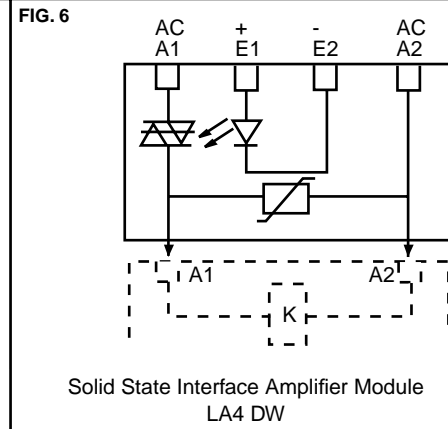
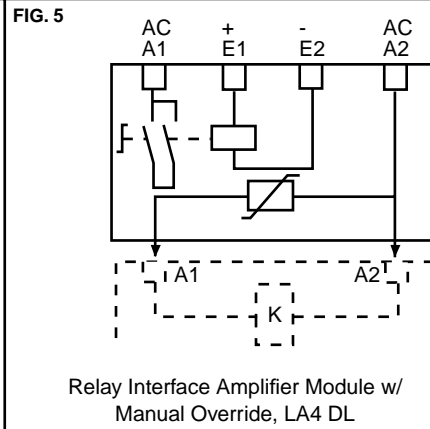
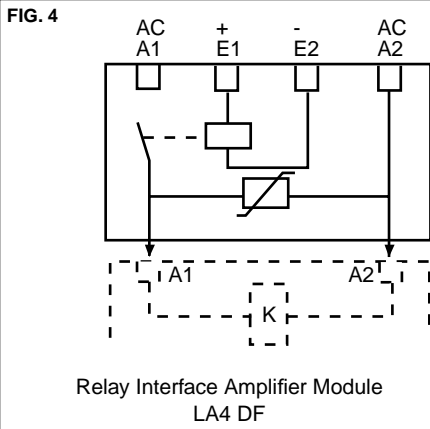
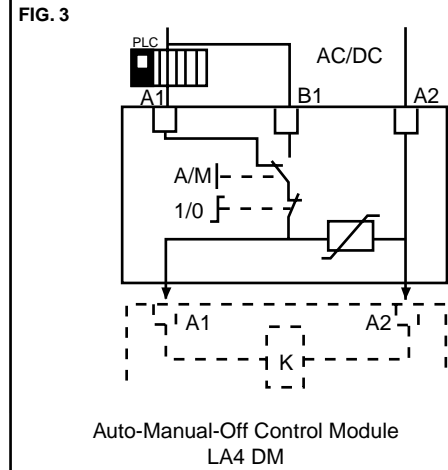
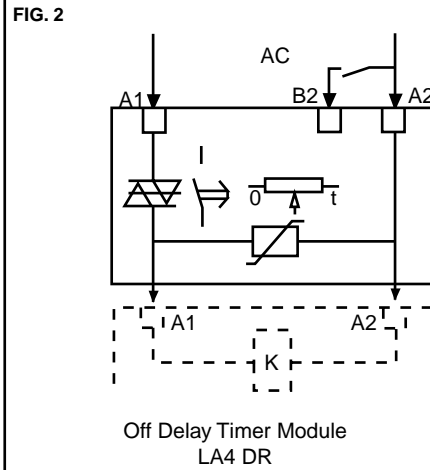
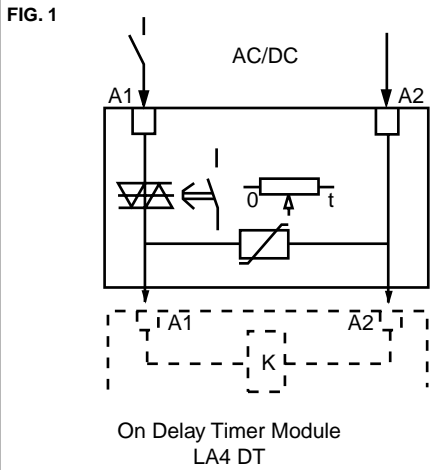
Short-Circuit Protection

Rating of branch circuit protective device must comply with applicable electrical codes and the following limitations:

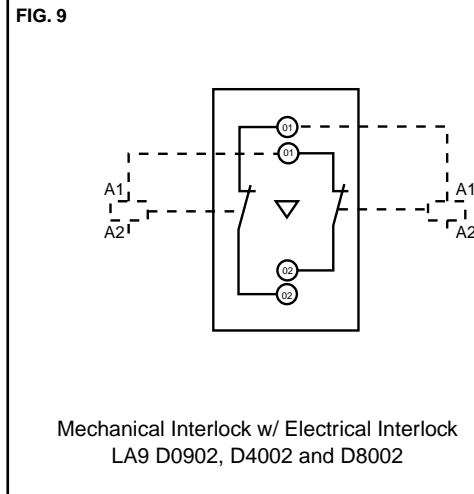
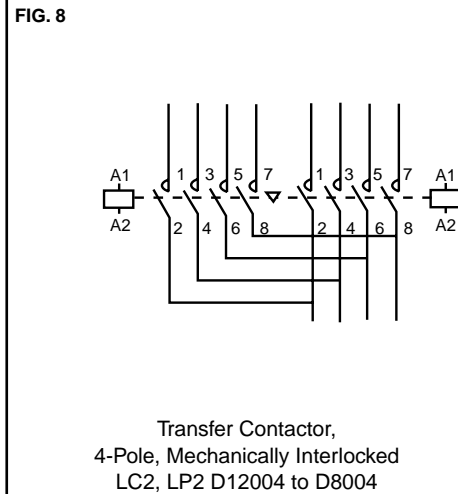
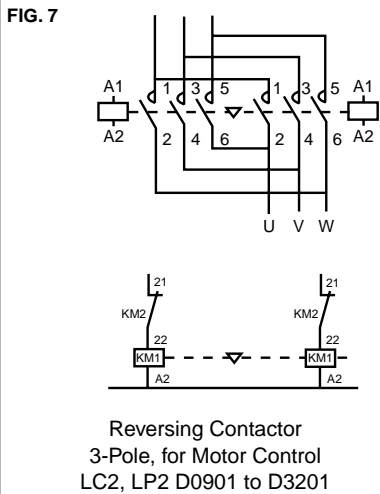
Type of Device	Max. Rating
Class K5 or RK5 time-delay fuse	600 A
Class J, T or L fuse	1600 A
Inverse-time circuit breaker	2000 A



**Input Modules:  
LA4**

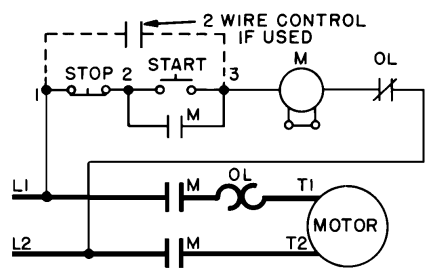
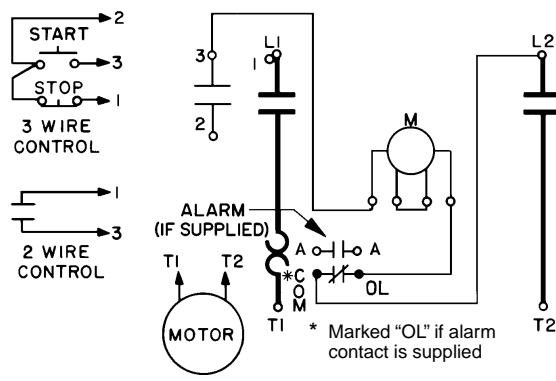


**Contactors:  
LC2, LP2 and LA9**



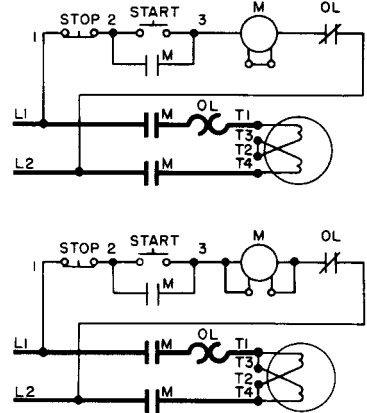
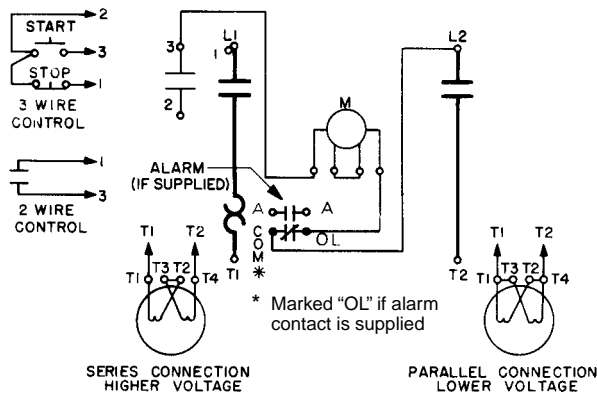
1-Pole, 1-Phase Magnetic Starters, Size 00 to 3:  
Class 8536 Type S

FIG. 1



Single Phase Starter w/ Single Voltage Motor

FIG. 2

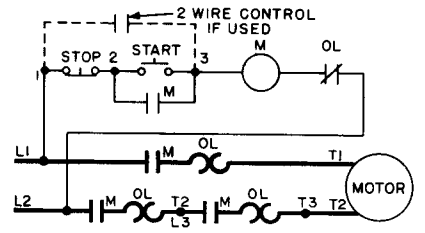
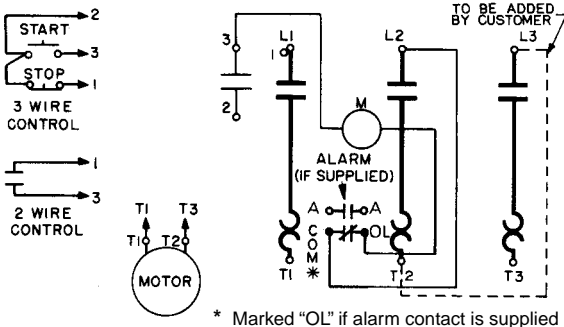


Note: Starters are factory-wired with coil connected for the higher voltage. If starter is used on lower voltage, connect per coil diagram.

Single Phase Starter w/ Dual Voltage Motor

3-Pole, 3-Phase Magnetic Starters, Size 00 to 3, Connected for Single Phase:  
Class 8536 Type S

FIG. 3



3-Phase Starter Connected for Single Phase, Single Voltage Motor

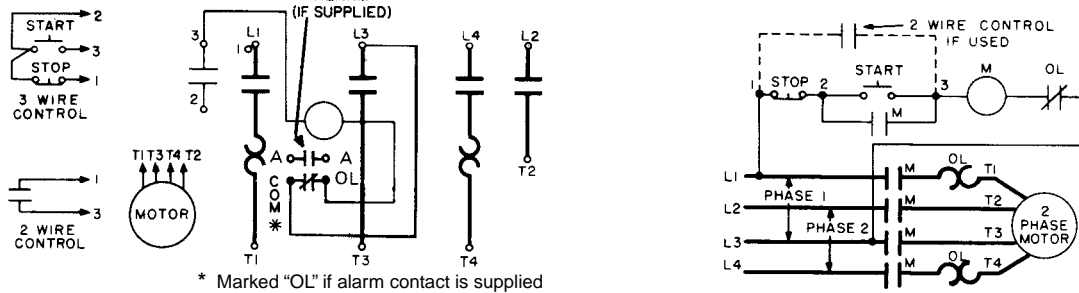
# Type S AC Magnetic Starters

## Class 8536

### 2-Phase and 3-Phase, Size 00 to 5

#### 4-Pole, 2-Phase Magnetic Starters: Class 8536 Type S

FIG. 1

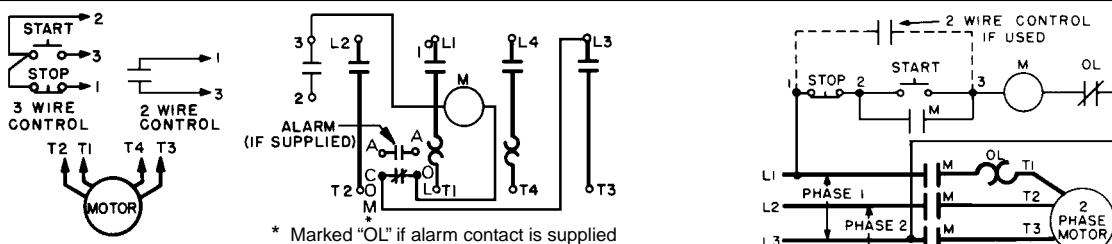


Wiring Diagram

Elementary Diagram

Size 0, 1 and 2

FIG. 2



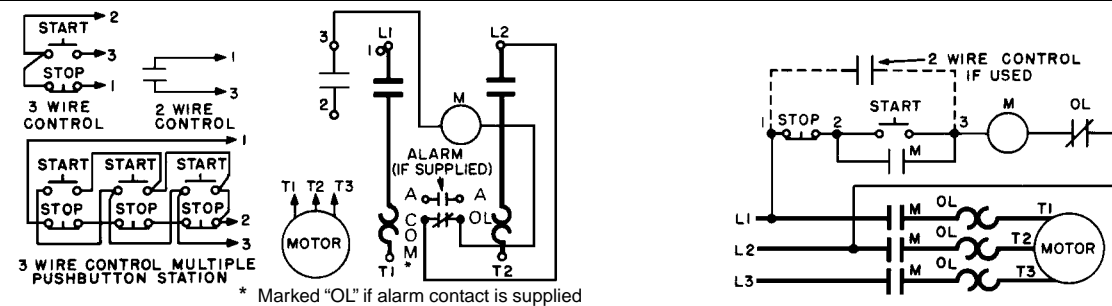
Wiring Diagram

Elementary Diagram

Size 3 and 4

#### 3-Pole, 3-Phase Magnetic Starters: Class 8536 Type S

FIG. 3

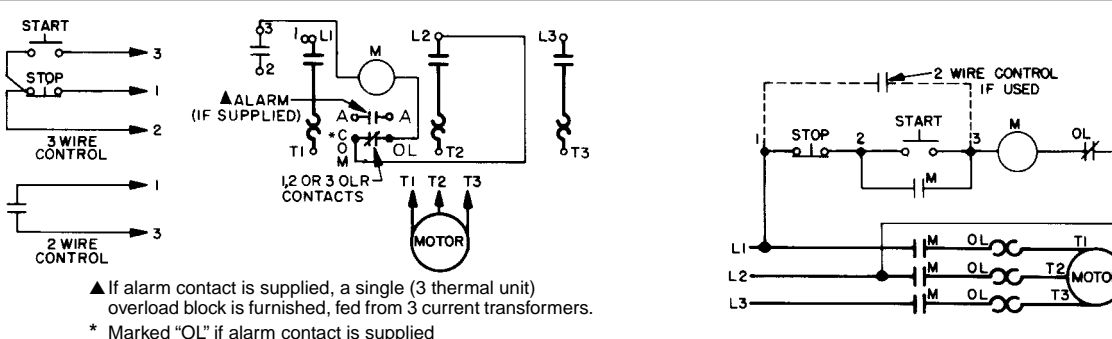


Wiring Diagram

Elementary Diagram

Size 00 to 4

FIG. 4



▲ If alarm contact is supplied, a single (3 thermal unit) overload block is furnished, fed from 3 current transformers.  
\* Marked "OL" if alarm contact is supplied

Wiring Diagram

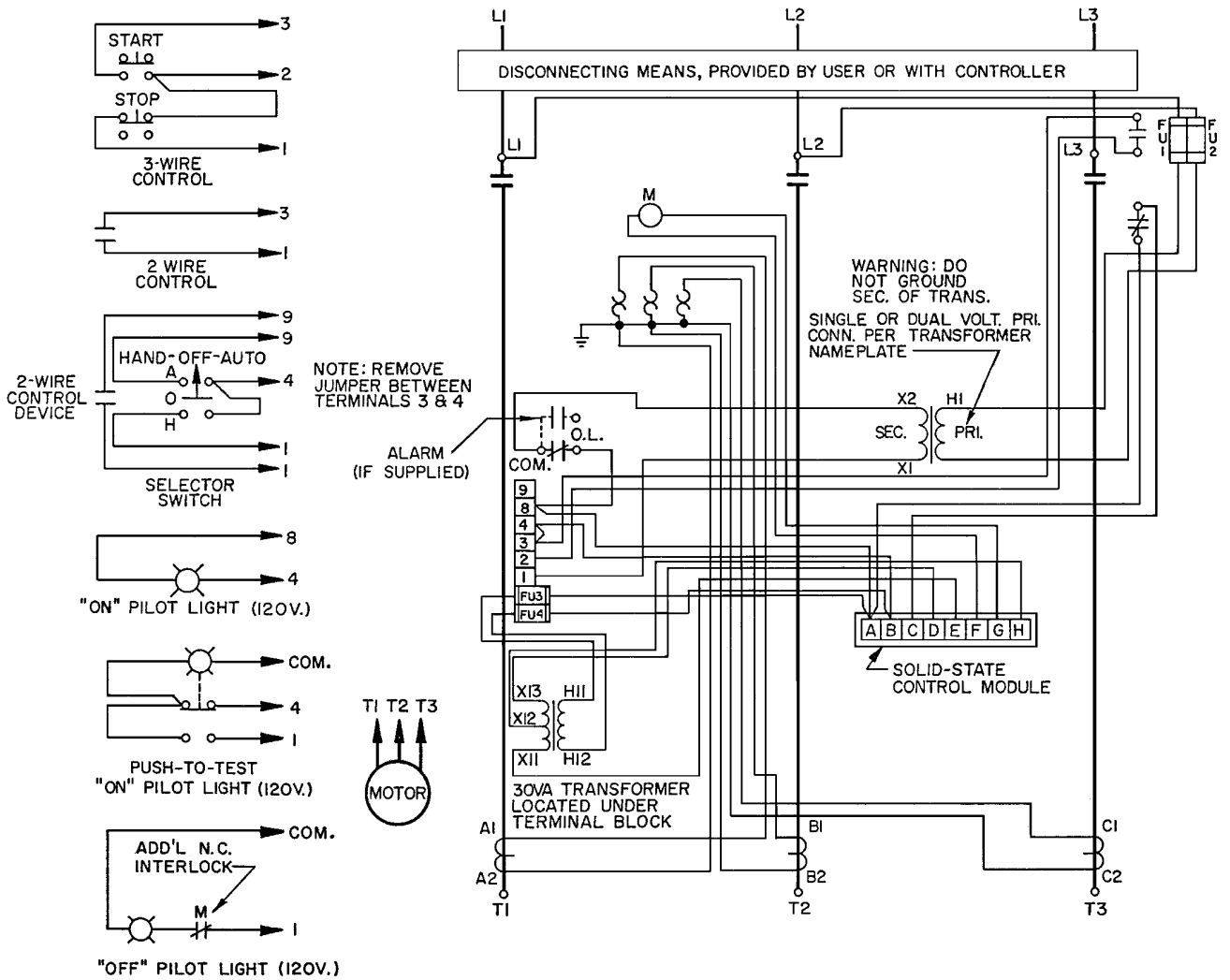
Elementary Diagram

Size 5

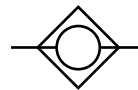
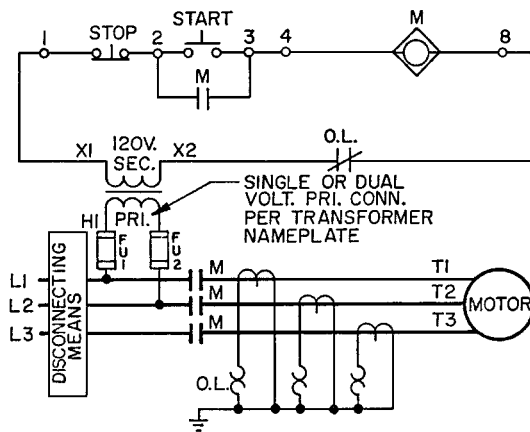


3-Pole, 3-Phase Magnetic Starters, Size 6 – Common Control  
 Class 8536/8538/8539 Type SH Series B

FIG. 1



Wiring Diagram



This symbol denotes the coil function, provided by a solid-state control module, 30 VA transformer, two fuses in the secondary of the transformer, N.C. electrical interlock and DC magnet coil.

Elementary Diagram

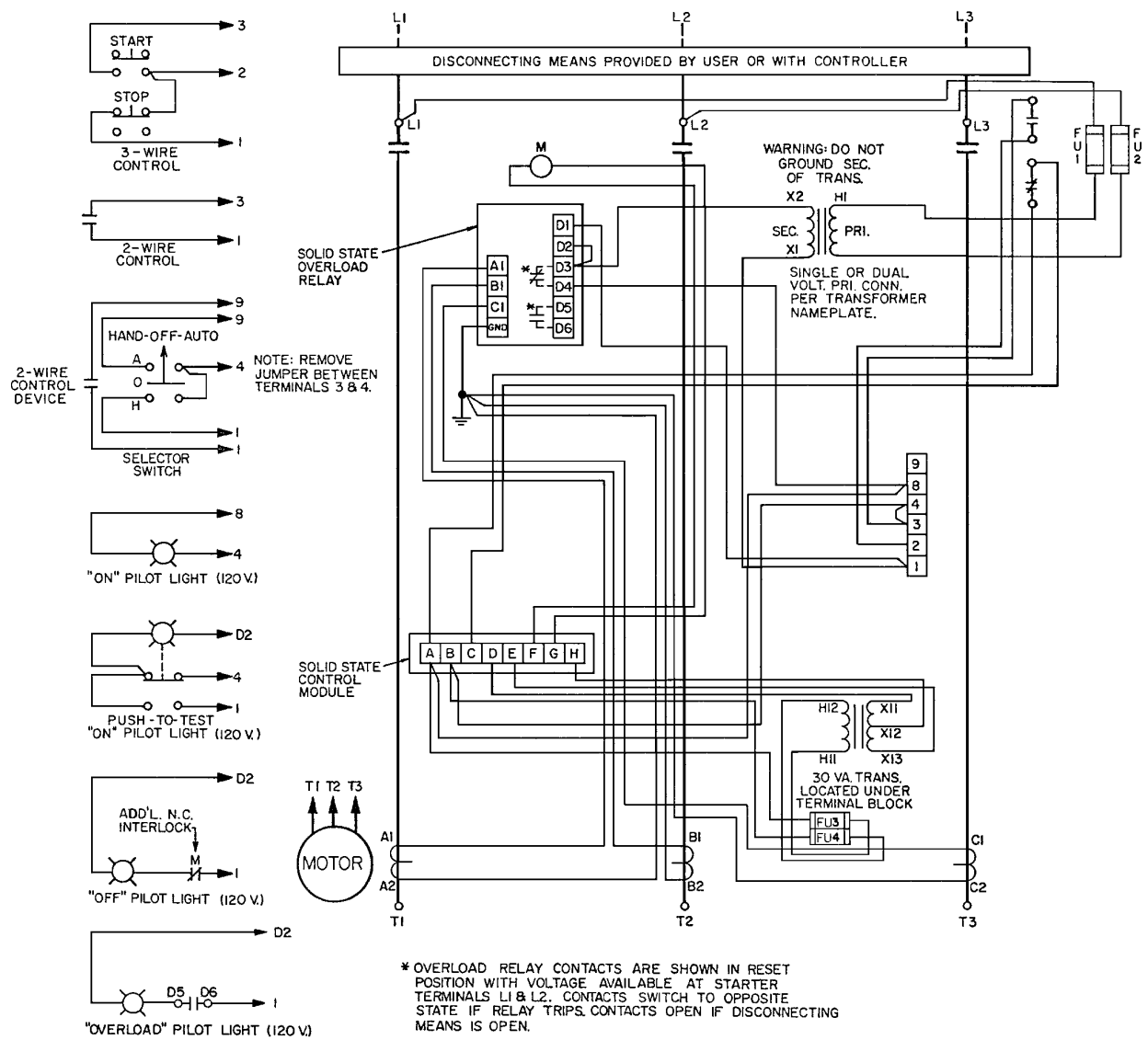
# Type S AC Magnetic Starters

Class 8536

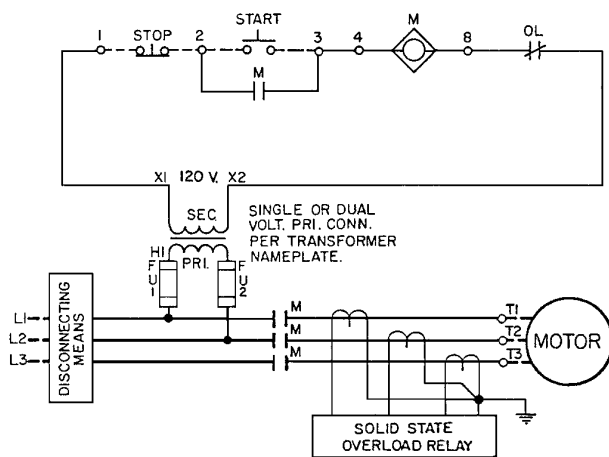
3-Phase, Size 7

## 3-Pole, 3-Phase Magnetic Starters, Size 7 – Common Control Class 8536 Type SJ Series A

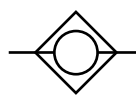
FIG. 1



Wiring Diagram



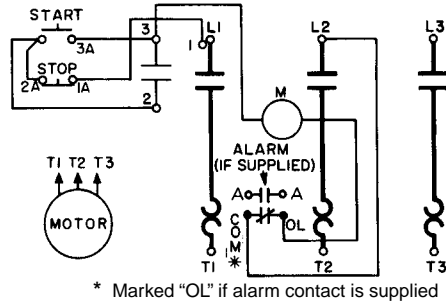
Elementary Diagram



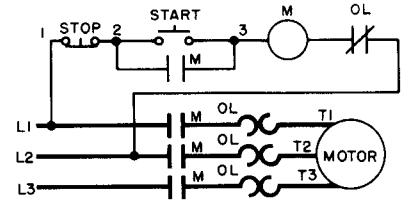
This symbol denotes the coil function, provided by a solid-state control module, 30 VA transformer, two fuses in the secondary of the transformer, N.C. electrical interlock and DC magnet coil.

3-Pole, 3-Phase Magnetic Starters, Size 00 to 4:  
 Class 8536 Type S

FIG. 1



Wiring Diagram

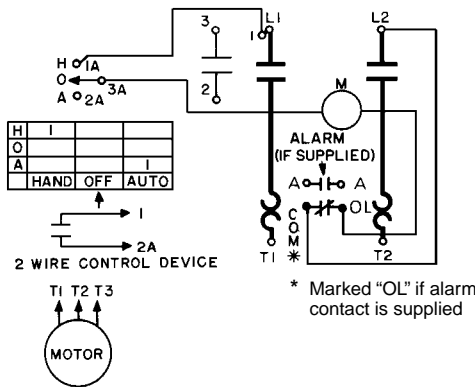


Elementary Diagram

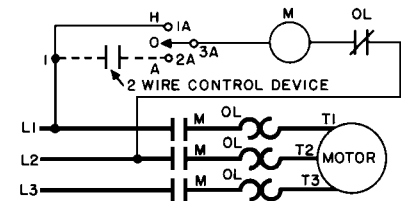
\* Marked "OL" if alarm contact is supplied

Form A – Start-Stop Push Button Mounted in Cover

FIG. 2



Wiring Diagram

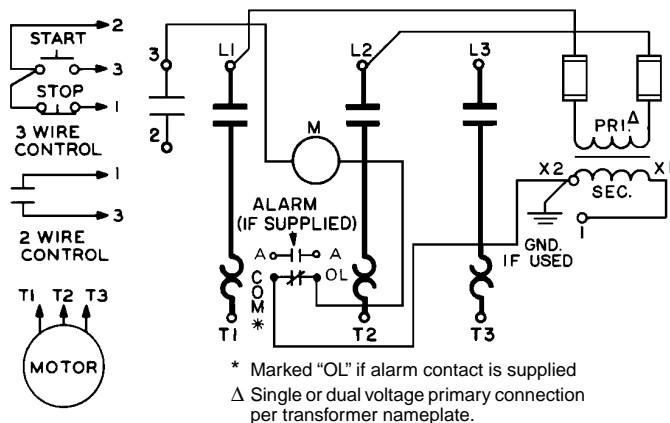


Elementary Diagram

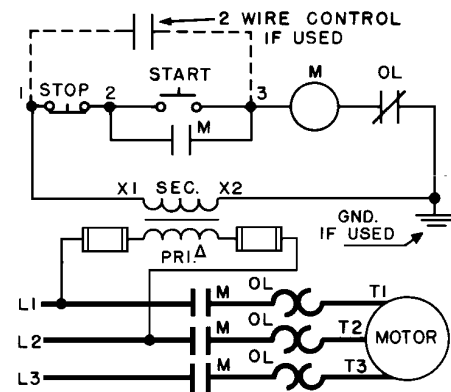
\* Marked "OL" if alarm contact is supplied

Form C – Hand-Off-Auto Selector Switch Mounted in Cover

FIG. 3



Wiring Diagram



Elementary Diagram

\* Marked "OL" if alarm contact is supplied  
 Δ Single or dual voltage primary connection per transformer nameplate.

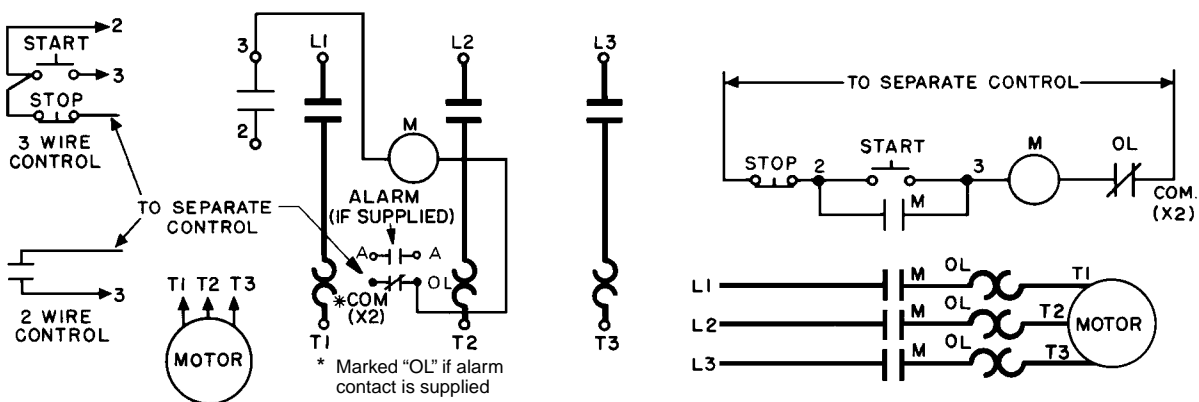
Δ Single or dual voltage primary connection per transformer nameplate.

Form F4T – Control Circuit Transformer and Primary Fuses

Type S AC Magnetic Starters  
 Class 8536  
 3-Phase Additions and Special Features

3-Pole, 3-Phase Magnetic Starters, Size 00 to 4:  
 Class 8536 Type S

FIG. 1

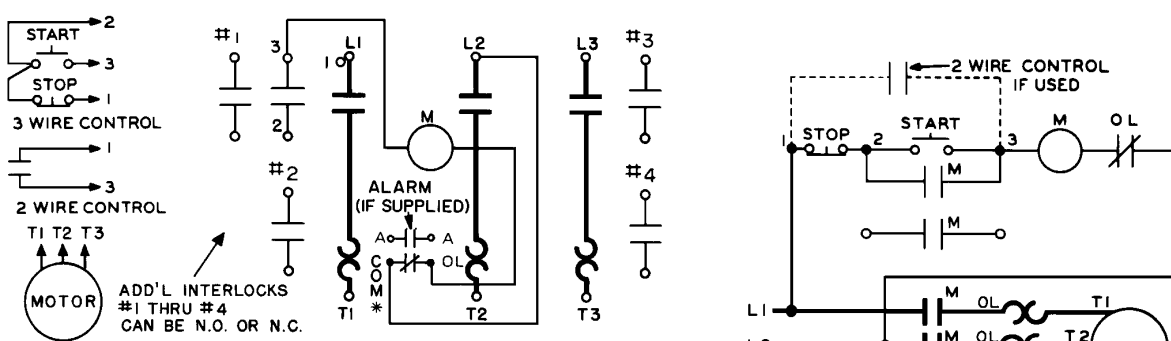


Wiring Diagram

Elementary Diagram

Form S - Separate Control

FIG. 2



ADD'L INTERLOCKS #1 THRU #4 CAN BE N.O. OR N.C.  
 \* Marked "OL" if alarm contact is supplied  
 On NEMA Size 3 and 4 starters, holding circuit contact is in position #1. Max. of 3 external auxiliary contacts on NEMA Size 00.

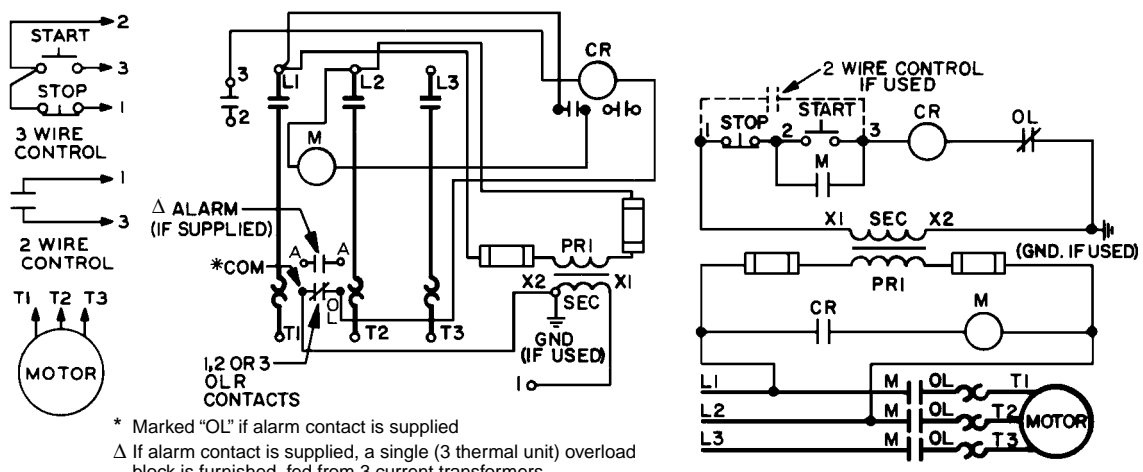
Wiring Diagram

Elementary Diagram

Form X - Additional Auxiliary Contacts

3-Pole, 3-Phase Magnetic Starters, Size 5:  
 Class 8536 Type S

FIG. 3



\* Marked "OL" if alarm contact is supplied  
 Δ If alarm contact is supplied, a single (3 thermal unit) overload block is furnished, fed from 3 current transformers

Wiring Diagram

Elementary Diagram

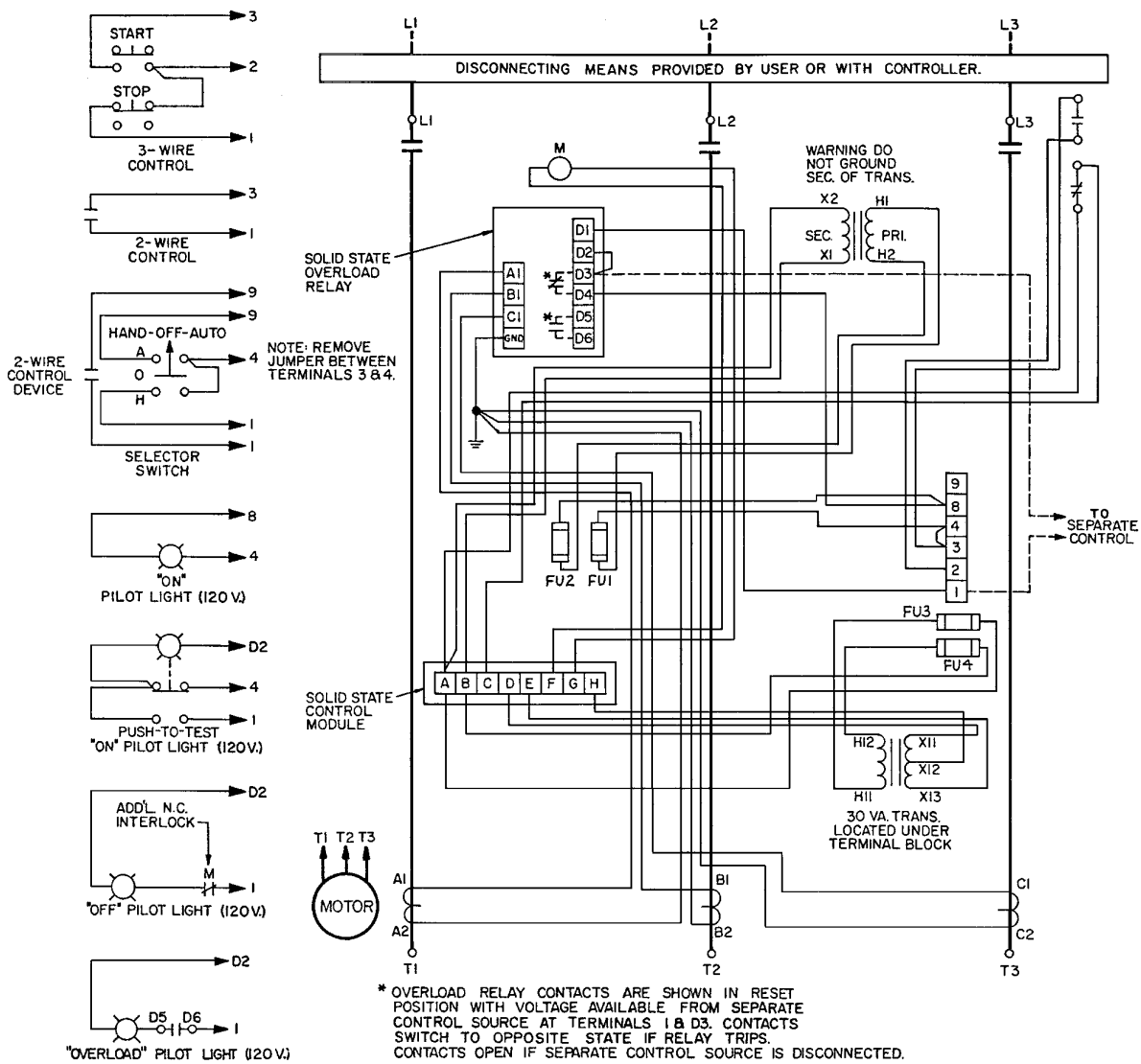
Form F4T - Control Circuit Transformer and Primary Fuses



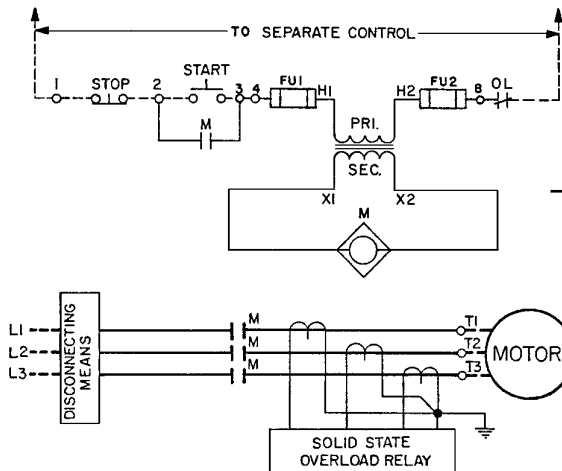
Type S AC Magnetic Starters  
 Class 8536  
 3-Phase Additions and Special Features

3-Pole, 3-Phase Magnetic Starters, Size 7 – Separate Control  
 Class 8536 Type SJ Form S Series A

FIG. 1



Wiring Diagram



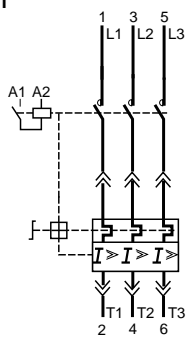
This symbol denotes the coil function, provided by a solid-state control module, 30 VA transformer, two fuses in the secondary of the transformer, N.C. electrical interlock and DC magnet coil.

Elementary Diagram



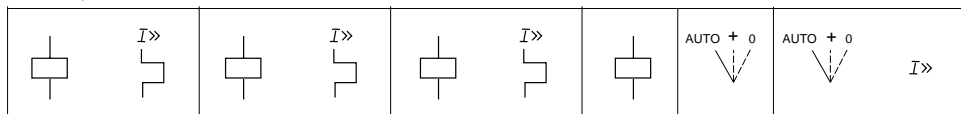
State of Auxiliary Contacts for LD1

FIG. 1 LD1



□ Contact open  
■ Contact closed

Auxiliary contact actuators

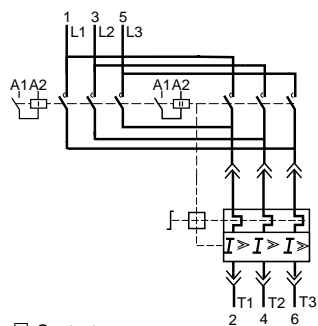


Auxiliary contacts

		LA1-LB015		LA1-LB017		LA1-LB019		LA1-LB001	LA1-LB031	LA1-LB034	
		13 23 31 14 24 32	95 97 96 98	13 31 14 32	97 98	13 31 14 32	95 96	41 42	16 18 15 17	16 18 15 17	6 8 5 7
Off		13 23 31 14 24 32	95 97 96 98	13 31 14 32	97 98	13 31 14 32	95 96	41 42	16 18 15 17	16 18 15 17	6 8 5 7
On, contactor open		13 23 31 14 24 32	95 97 96 98	13 31 14 32	97 98	13 31 14 32	95 96	41 42	16 18 15 17	16 18 15 17	6 8 5 7
On, contactor closed		13 23 31 14 24 32	95 97 96 98	13 31 14 32	97 98	13 31 14 32	95 96	41 42	16 18 15 17	16 18 15 17	6 8 5 7
Tripped on overload		13 23 31 14 24 32	95 97 96 98	13 31 14 32	97 98	13 31 14 32	95 96	41 42	16 18 15 17	16 18 15 17	6 8 5 7
Tripped on short circuit		13 23 31 14 24 32	95 97 96 98	13 31 14 32	97 98	13 31 14 32	95 96	41 42	16 18 15 17	16 18 15 17	6 8 5 7
Off after short circuit		13 23 31 14 24 32	95 97 96 98	13 31 14 32	97 98	13 31 14 32	95 96	41 42	16 18 15 17	16 18 15 17	6 8 5 7
Manual reset		13 23 31 14 24 32	95 97 96 98	13 31 14 32	97 98	13 31 14 32	95 96	41 42	16 18 15 17	16 18 15 17	6 8 5 7

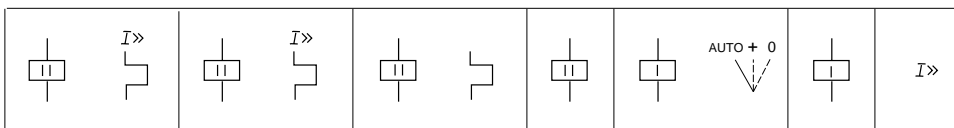
State of Auxiliary Contacts for LD5

FIG. 1 LD5



□ Contact open  
■ Contact closed

Auxiliary contact actuators



Auxiliary contacts

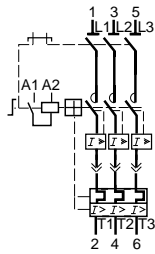
	LA1-LB015	LA1-LB017	LA1-LB019	LA1-LB001	LA1-LB021	LA1-LB001	On Integral				
	 13 23 31 14 24 32	 95 97 96 98	 13 31 14 32	 97 98	 13 31 14 32	 95 96	 41 42	 13 23 31 14 24 32	 16 18 15 17	 41 42	 6 8 5 7
Off	 13 23 31 14 24 32	 95 97 96 98	 13 31 14 32	 97 98	 13 31 14 32	 95 96	 41 42	 13 23 31 14 24 32	 16 18 15 17	 41 42	 6 8 5 7
On, contactor open	 13 23 31 14 24 32	 95 97 96 98	 13 31 14 32	 97 98	 13 31 14 32	 95 96	 41 42	 13 23 31 14 24 32	 16 18 15 17	 41 42	 6 8 5 7
On, contactor II closed	 13 23 31 14 24 32	 95 97 96 98	 13 31 14 32	 97 98	 13 31 14 32	 95 96	 41 42	 13 23 31 14 24 32	 16 18 15 17	 41 42	 6 8 5 7
On, contactor I closed	 13 23 31 14 24 32	 95 97 96 98	 13 31 14 32	 97 98	 13 31 14 32	 95 96	 41 42	 13 23 31 14 24 32	 16 18 15 17	 41 42	 6 8 5 7
Tripped on overload	 13 23 31 14 24 32	 95 97 96 98	 13 31 14 32	 97 98	 13 31 14 32	 95 96	 41 42	 13 23 31 14 24 32	 16 18 15 17	 41 42	 6 8 5 7
Tripped on short circuit	 13 23 31 14 24 32	 95 97 96 98	 13 31 14 32	 97 98	 13 31 14 32	 95 96	 41 42	 13 23 31 14 24 32	 16 18 15 17	 41 42	 6 8 5 7
Off after short circuit	 13 23 31 14 24 32	 95 97 96 98	 13 31 14 32	 97 98	 13 31 14 32	 95 96	 41 42	 13 23 31 14 24 32	 16 18 15 17	 41 42	 6 8 5 7
Manual reset	 13 23 31 14 24 32	 95 97 96 98	 13 31 14 32	 97 98	 13 31 14 32	 95 96	 41 42	 13 23 31 14 24 32	 16 18 15 17	 41 42	 6 8 5 7



State of Auxiliary Contacts for LD4

FIG. 1

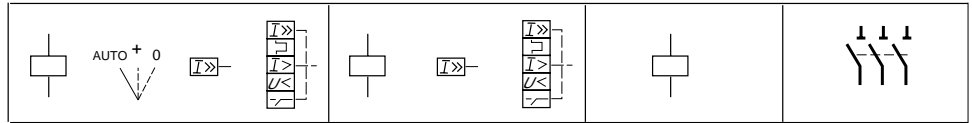
LD4



□ Contact open  
■ Contact closed

LD4

Auxiliary contact actuators

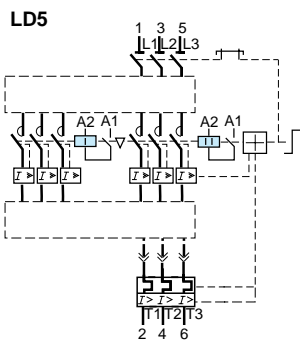


Auxiliary contacts

	LA1-LC010			LA1-LC012			LA1-LC020	LA1-LC030
	13 23 31 14 24 32	16 18 15	06 08 05	96 98 95	13 23 31 14 24 32	08 05	98 95	(63) 53 54 (64)
Off + isolation	□ □ □ □ □ □	□ ■ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □	□ □ □ □ □ □	□ □ □ □ □ □	□ □ □ □ □ □	□ □ □ □ □ □
Off	□ □ □ □ □ □	□ ■ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □	□ □ □ □ □ □	□ □ □ □ □ □	□ □ □ □ □ □	■ □ □ □ □ □
On, contactor open	□ □ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □	□ □ □ □ □ □	□ □ □ □ □ □	□ □ □ □ □ □	■ □ □ □ □ □
On, contactor closed	■ □ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □	□ □ □ □ □ □	□ □ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □
Tripped, on overload	□ □ □ □ □ □	□ ■ □ □ □ □	■ □ □ □ □ □	□ ■ □ □ □ □	□ □ □ □ □ □	□ □ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □
Off, after overload	□ □ □ □ □ □	□ ■ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □	□ □ □ □ □ □	□ □ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □
Tripped, on short circuit	□ □ □ □ □ □	□ ■ □ □ □ □	■ □ □ □ □ □	□ ■ □ □ □ □	□ □ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □
Off, after short circuit	□ □ □ □ □ □	□ ■ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □	□ □ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □
Manual reset	□ □ □ □ □ □	□ ■ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □	□ □ □ □ □ □	□ □ □ □ □ □	■ □ □ □ □ □	■ □ □ □ □ □

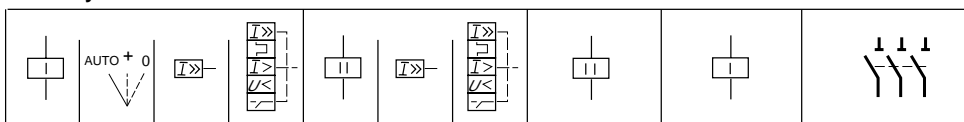
State of Auxiliary Contacts for LD5

FIG. 1



□ Contact open  
■ Contact closed

Auxiliary contact actuators

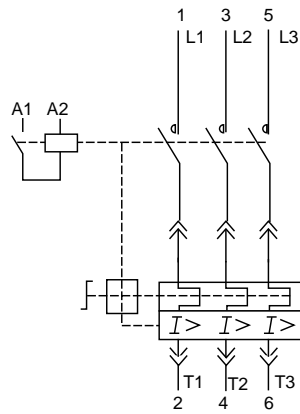


Auxiliary contacts

	LA1-LC010				LA1-LC012			LA1-LC020	LA1-LC021	LA1-LC031
	13 23 31 14 24 32	16 18 15	06 08 05	96 98 95	13 23 31 14 24 32	08 05	98 95	13 23 31 14 24 32	13 23 31 14 24 32	53 63 54 64
Off + isolation	□ □ □	□ □	□ □	□ □	□ □ □	□	□	□ □ □	□ □ □	□ □
Off	□ □ □	□ □	□ □	□ □	□ □ □	□	□	□ □ □	□ □ □	□ □
On, both contactors open	□ □ □	□ □	□ □	□ □	□ □ □	□	□	□ □ □	□ □ □	□ □
On, contactor □ open	□ □ □	□ □	□ □	□ □	□ □ □	□	□	□ □ □	□ □ □	□ □
On, contactor ■ closed	□ □ □	□ □	□ □	□ □	□ □ □	□	□	□ □ □	□ □ □	□ □
Tripped on overload	□ □ □	□ □	□ □	□ □	□ □ □	□	■	□ □ □	□ □ □	□ □
Off, after overload	□ □ □	□ □	□ □	□ □	□ □ □	□	□	□ □ □	□ □ □	□ □
Tripped on short circuit	□ □ □	□ □	□ □	□ □	□ □ □	□	■	□ □ □	□ □ □	□ □
Off after short circuit	□ □ □	□ □	□ □	□ □	□ □ □	□	□	□ □ □	□ □ □	□ □
Manual reset	□ □ □	□ □	□ □	□ □	□ □ □	□	□	□ □ □	□ □ □	□ □

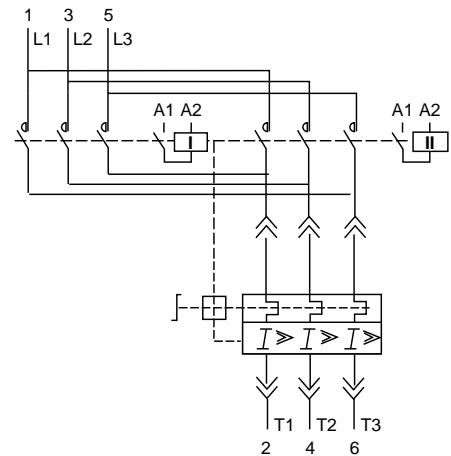
Integral 18

FIG. 1



Self-Protected Starter w/ Protection Module LB•  
Integral 18 LD1 L80

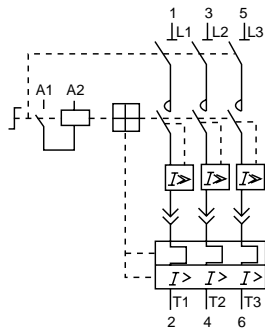
FIG. 2



Self-Protected Reversing Starter w/ Protection Module LB•  
Integral 18 LD5 LB130 + LB1 LB03P

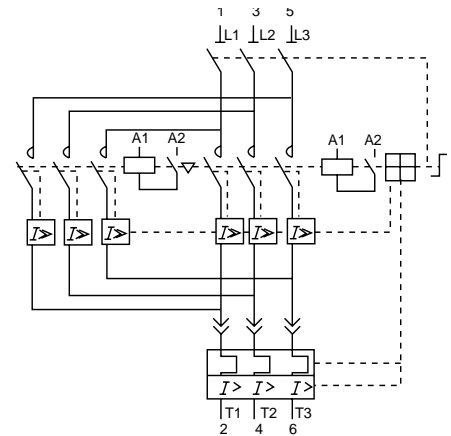
Integral 32

FIG. 3



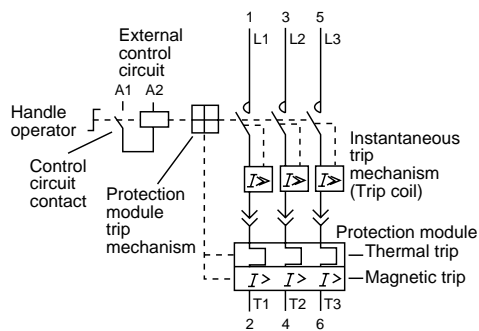
Starter w/ Isolator  
Integral 32 LD4

FIG. 5



Reversing Starter w/ Isolator  
Integral 32 LD5

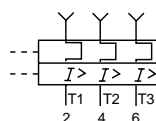
FIG. 4



Starter w/o Isolator  
Integral 32 LD1

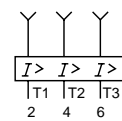
Protection Modules: LB•

FIG. 6

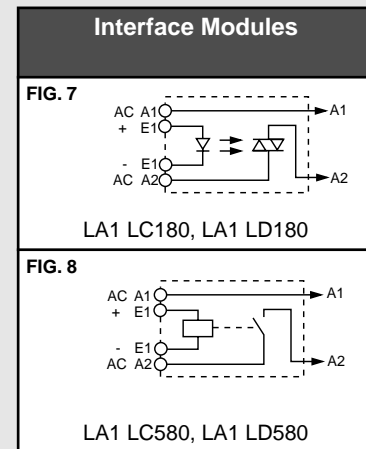
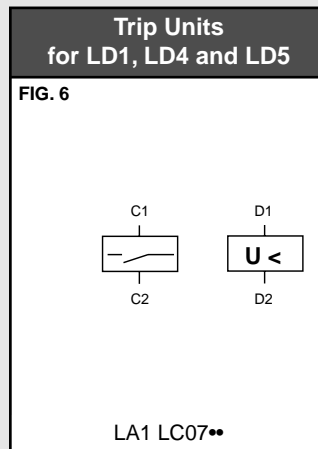
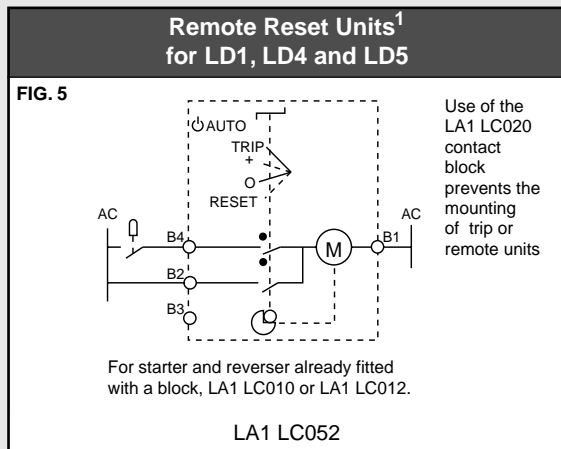
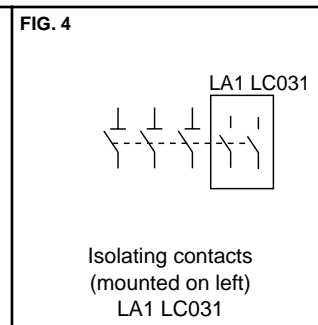
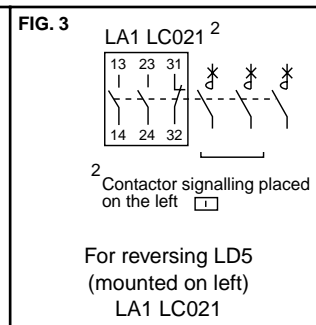
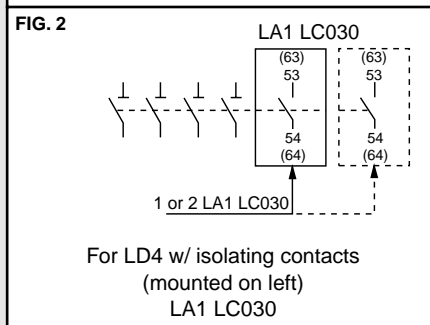
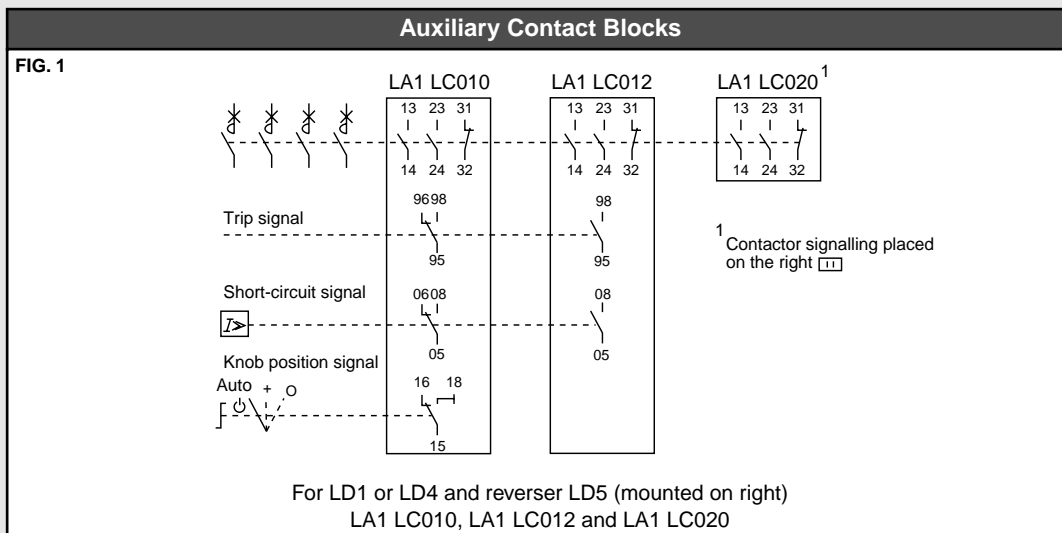


Thermal and Magnetic Trip  
LB1

FIG. 7

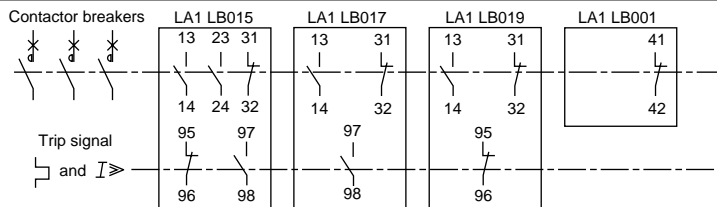


Magnetic Trip Only  
LB6



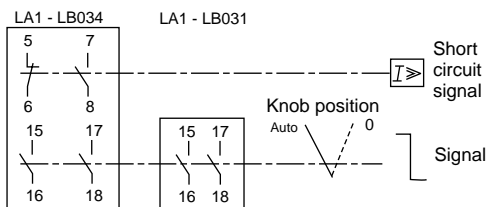
**Add-on Blocks: LA1 LB0\*\***

**FIG. 1**



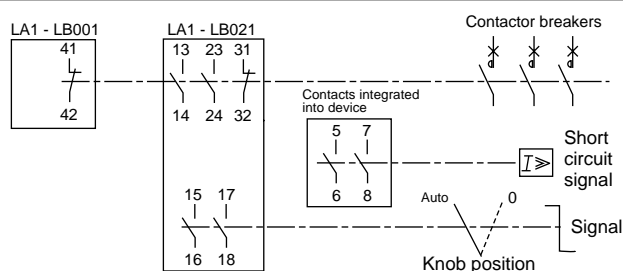
For LD1 (mounted on right)

**FIG. 2**



For LD1 (mounted on left)

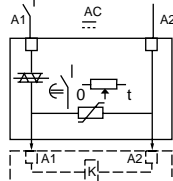
**FIG. 3**



For LD5 (mounted on left)

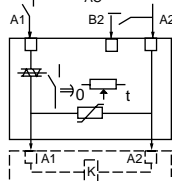
**Time Delay Modules**

**FIG. 4**



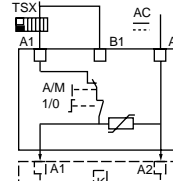
On Module  
LA4 DT

**FIG. 5**



Off Module  
LA4 DR

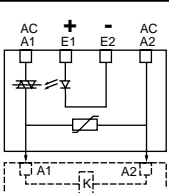
**FIG. 6**



Auto-Man-Stop Module  
LA4 DM

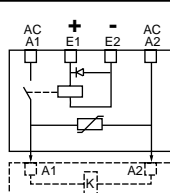
**Interface Modules**

**FIG. 7**



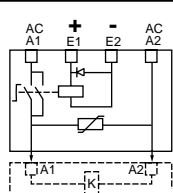
Solid State Module  
LA4 DW

**FIG. 8**



Relay Module  
LA4 DF

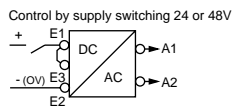
**FIG. 9**



Relay Module w/ Manual Override  
LA4 DL

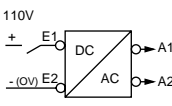
**Voltage Converters: LA1 LC080 and LA1 LD080**

**FIG. 10**



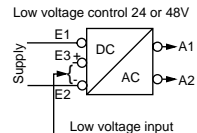
For 24 or 48 V Supply

**FIG. 11**



For 110 V Supply

**FIG. 12**

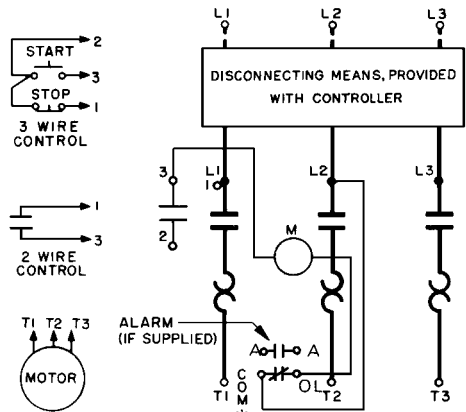


For 24 or 48 V Supply w/ Low Voltage Input

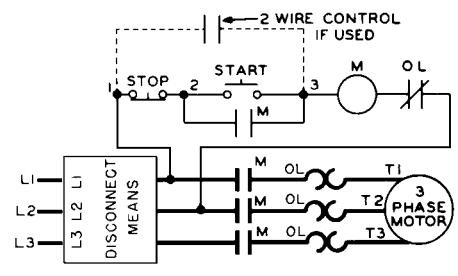
Type S AC Combination Magnetic Starters  
 Class 8538 and 8539  
 3-Phase, Size 0-5 (see pages 45 and 49 for Size 6)

3-Pole, 3-Phase Combination Starters:  
 Class 8538 and 8539 Type S

FIG. 1



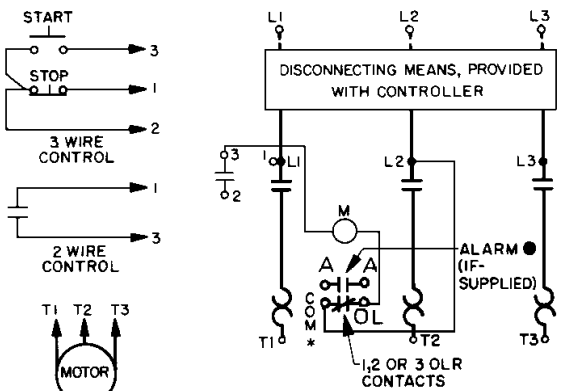
Wiring Diagram



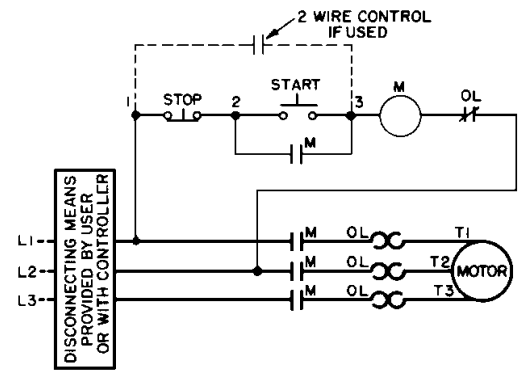
Elementary Diagram

Size 0-4

FIG. 2



Wiring Diagram

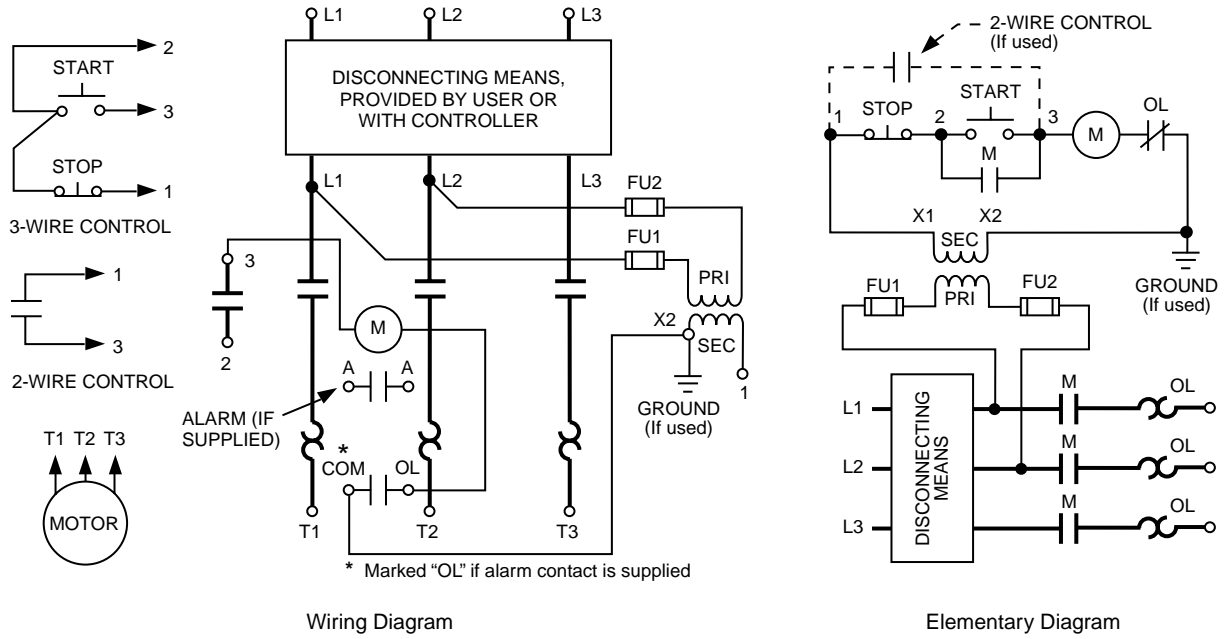


Elementary Diagram

Size 5

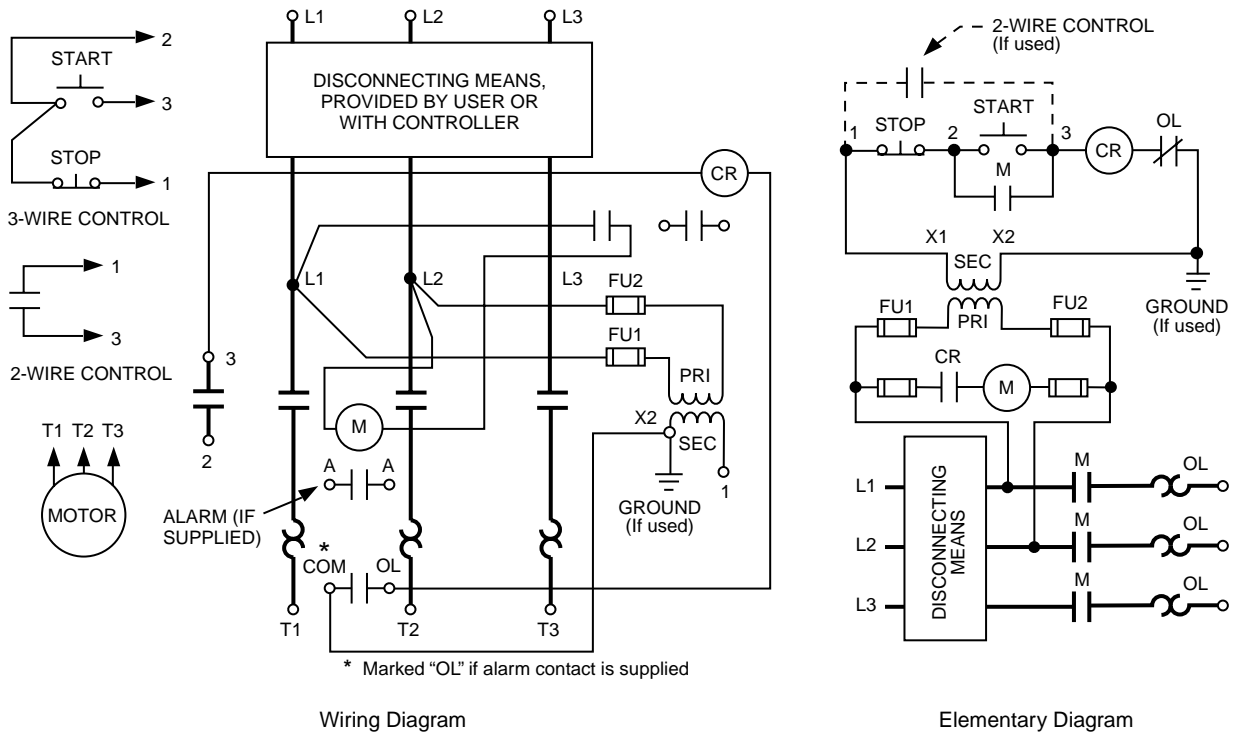
3-Pole, 3-Phase Combination Starters w/ Control Circuit Transformer and Primary Fuses:  
 Class 8538 and 8539 Type S Form F4T

FIG. 1



Size 0-4

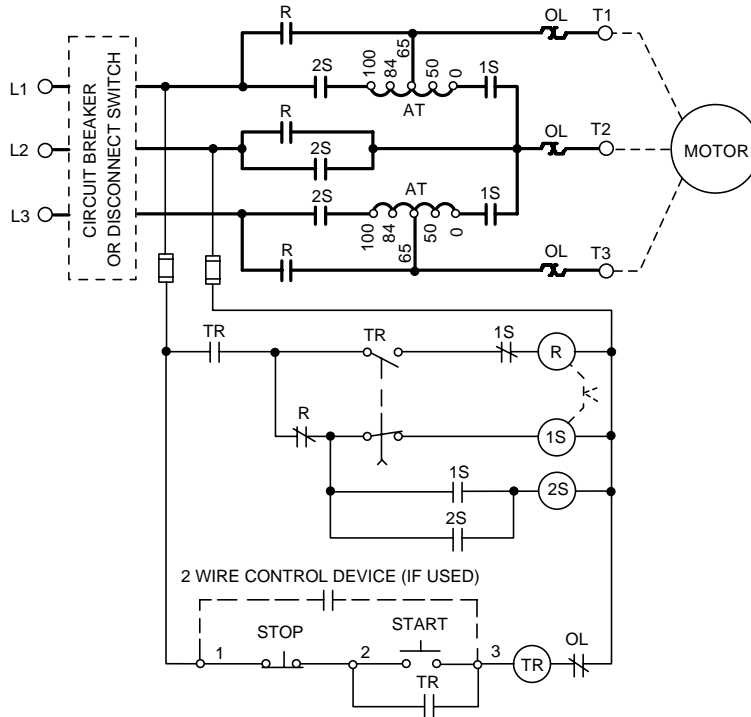
FIG. 2



Size 5

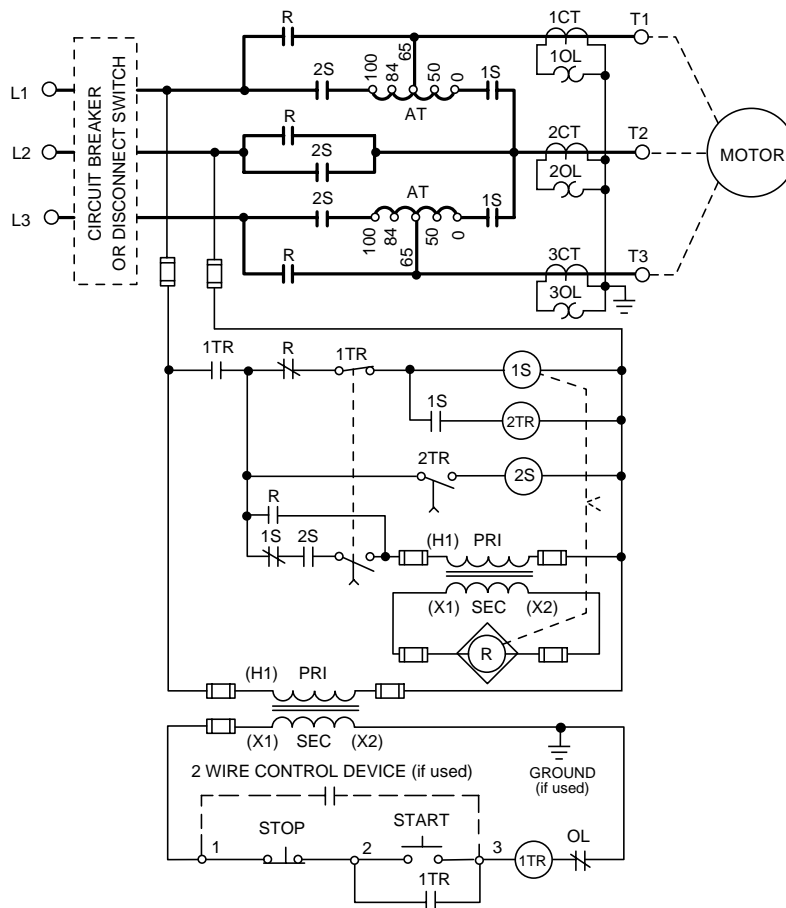
Reduced Voltage Autotransformer Controllers w/ Closed Transition Starting: Class 8606 Size 2-5

FIG. 1



Reduced Voltage Autotransformer Controller w/ Closed Transition Starting: Class 8606 Size 6

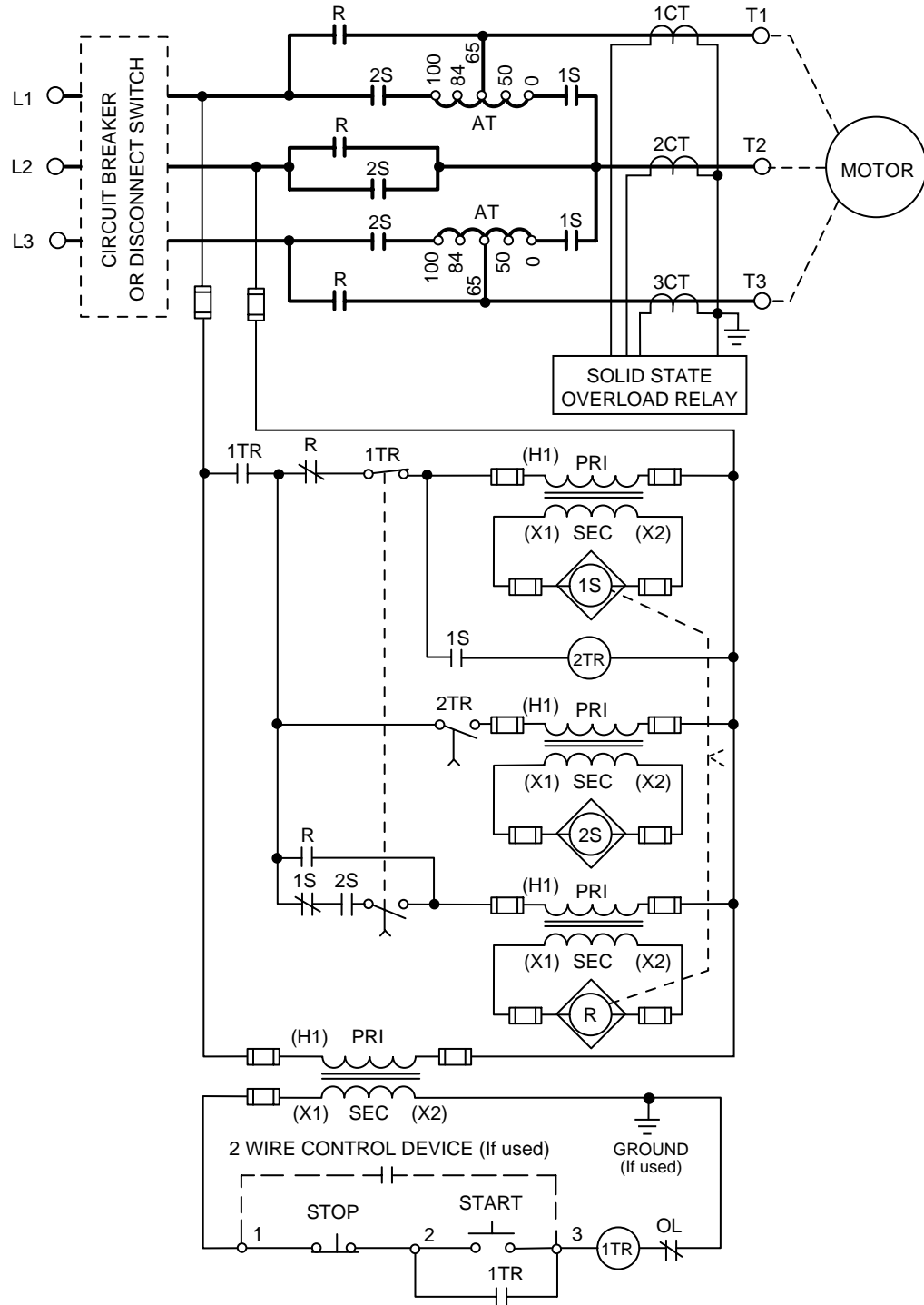
FIG. 2





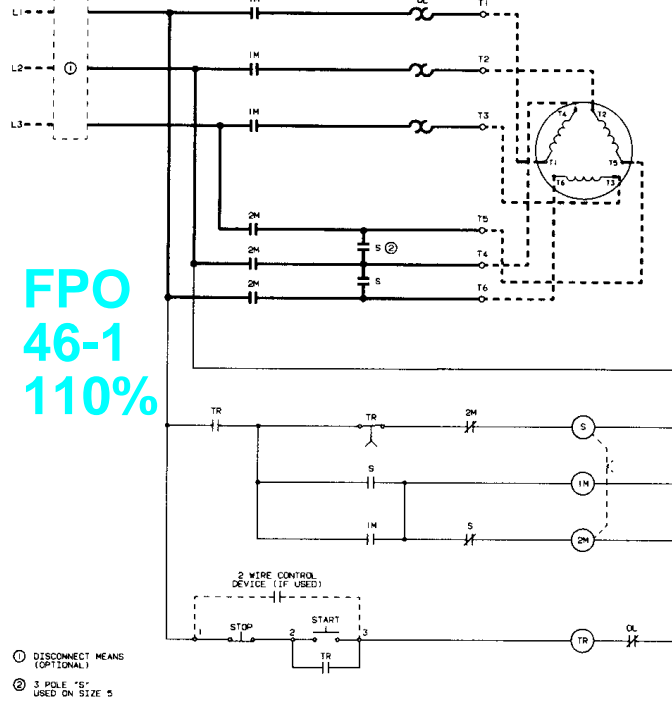
Reduced Voltage Autotransformer Controllers w/ Closed Transition Starting:  
 Class 8606 Size 7

FIG. 1



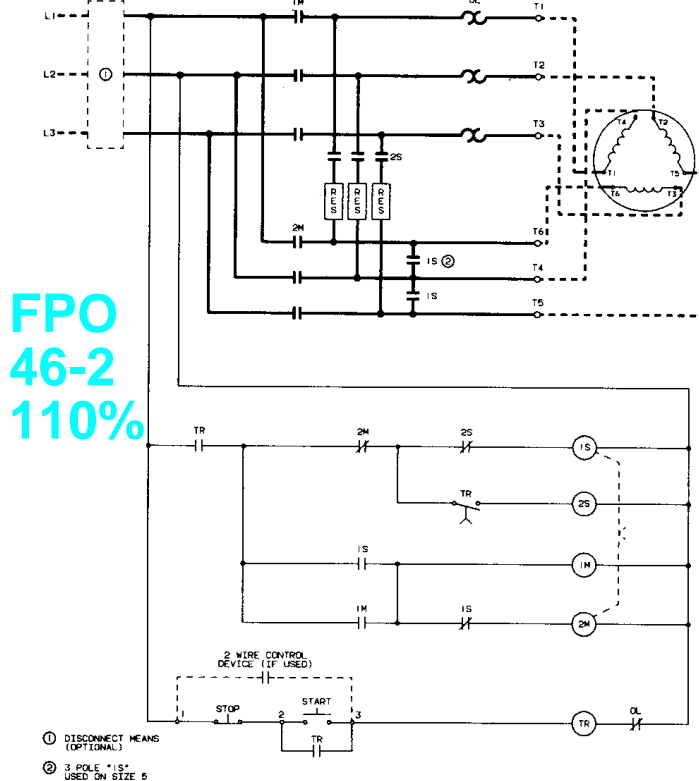
Wye-Delta Type Reduced Voltage Controllers, Size 1YΔ-5YΔ:  
 Class 8630

FIG. 1



Size 1YΔ-5YΔ Controllers with Open-Transition Starting

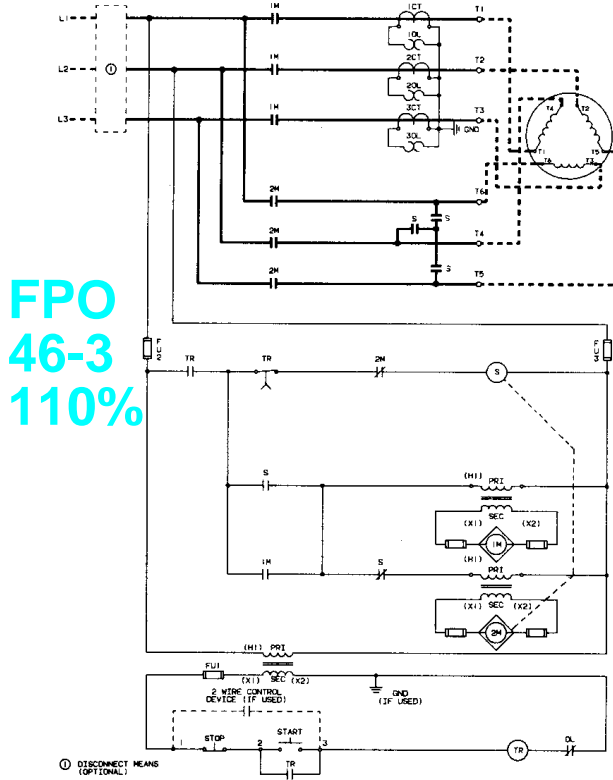
FIG. 2



Size 1YΔ-5YΔ Controllers with Closed-Transition Starting

Wye-Delta Type Reduced Voltage Controllers, Size 6YΔ:  
 Class 8630

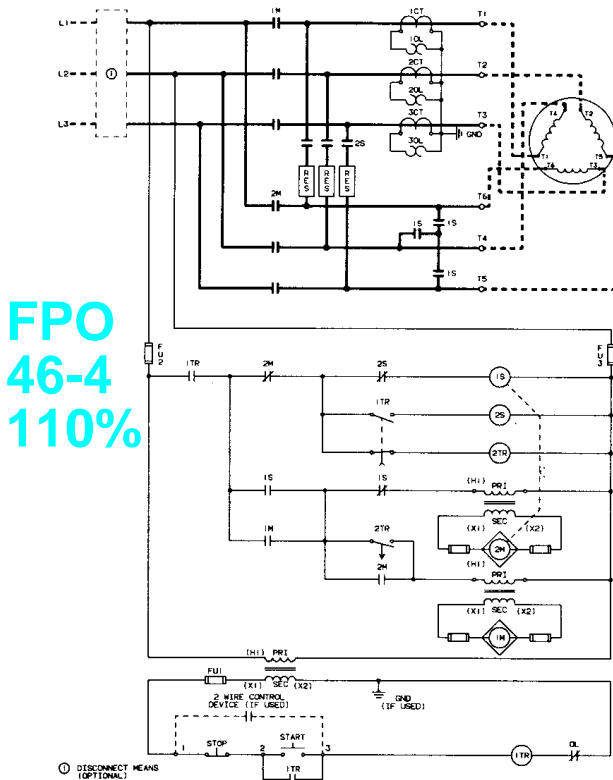
FIG. 1



FPO  
 46-3  
 110%

Size 6YΔ Controller with Open-Transition Starting

FIG. 2



FPO  
 46-4  
 110%

Size 6YΔ Controller with Closed-Transition Starting

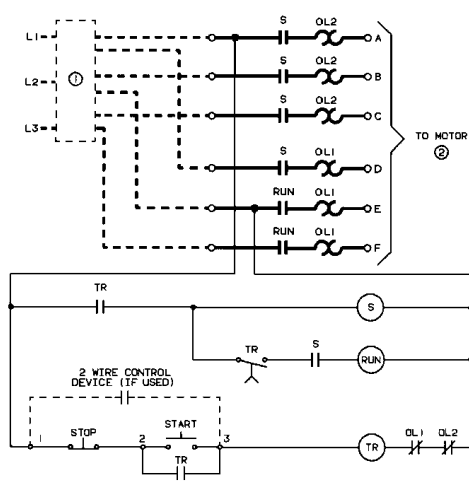
Table 5 Motor Lead Connections

Part Winding Schemes	Lettered Terminals in Panel						Part Winding Schemes	Lettered Terminals in Panel					
	A	B	C	D	E	F		A	B	C	D	E	F
1/2 Wye or Delta 6 Leads	T1	T2	T3	T7	T8	T9	2/3 Wye or Delta 6 Leads	T1	T2	T9	T7	T8	T3
1/2 Wye 9 Leads [1]	T1	T2	T3	T7	T8	T9	2/3 Wye 9 Leads [1]	T1	T2	T9	T7	T8	T3
1/2 Delta 9 Leads [2]	T1	T8	T3	T6	T2	T9	2/3 Delta 9 Leads [2]	T1	T4	T9	T6	T2	T3

[1] Connect terminals T4, T5 and T6 together at terminal box. [2] Connect terminals T4 and T8, T5 and T9, T6 and T7 together in 3 separate pairs at terminal box.

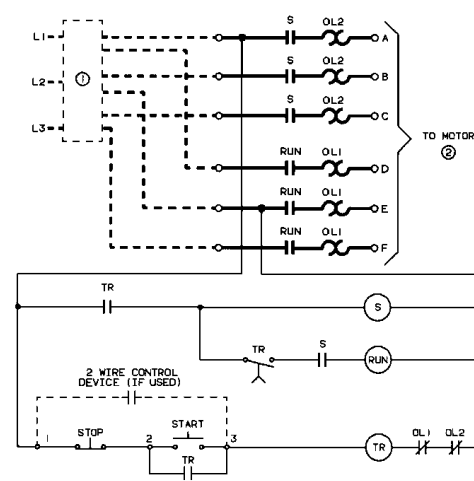
#### Part-Winding Reduced Voltage Controllers: Class 8640, Size 1PW-7PW

FIG. 1



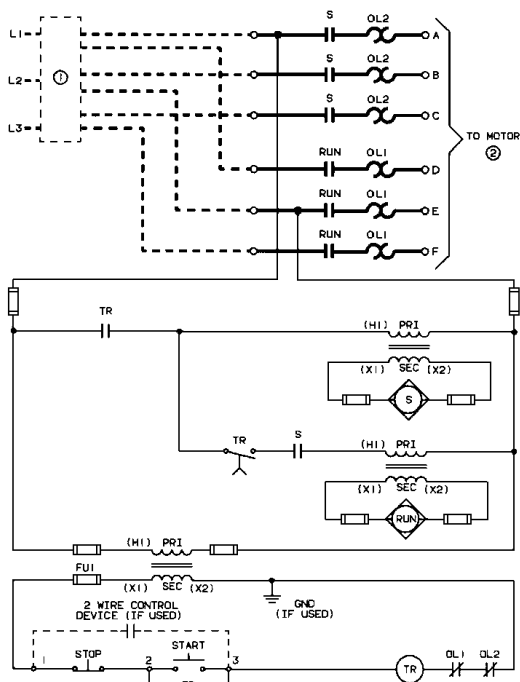
Size 1PW-4PW, 2-Step Part-Winding Controllers

FIG. 2



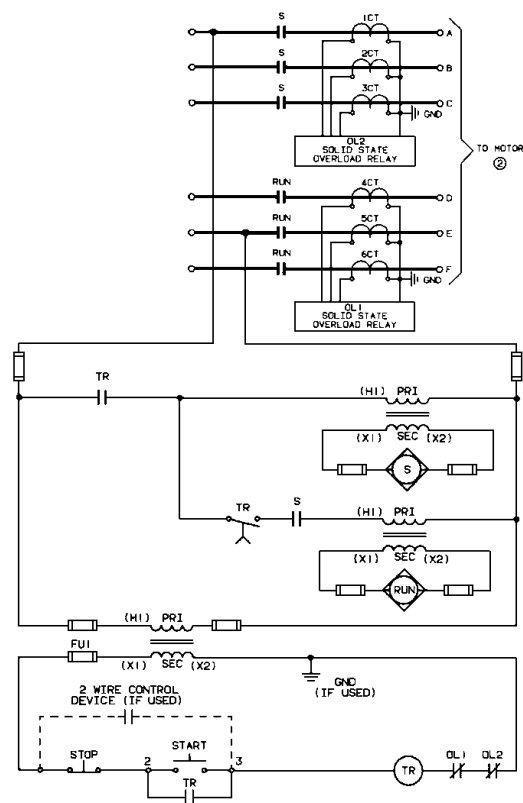
Size 5PW, 2-Step Part-Winding Controller

FIG. 3



Size 6PW, 2-Step Part-Winding Controller

FIG. 4



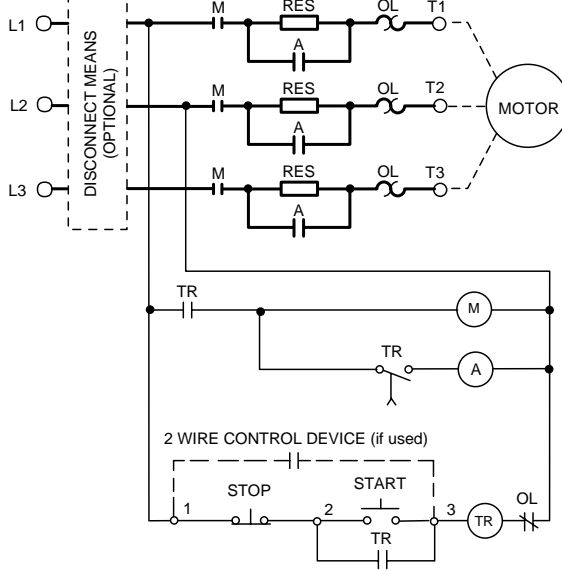
Size 7PW, 2-Step Part-Winding Controller

① Disconnect means (optional): 2 required, 1 for each motor winding.

② See Table 5 for motor lead connections.

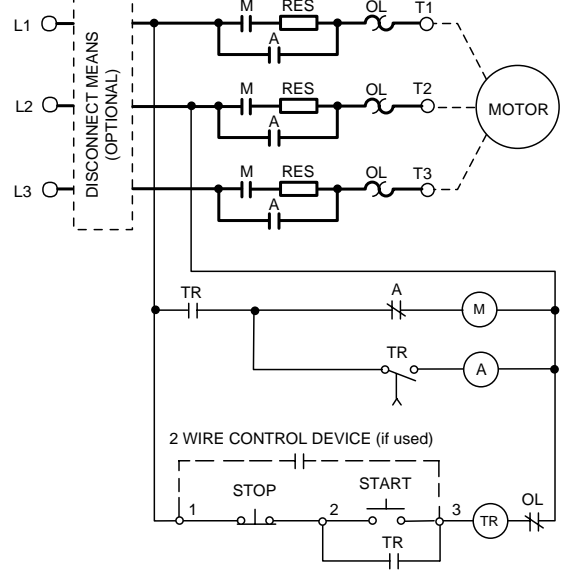
3-Phase Primary-Resistor Reduced Voltage Controllers:  
 Class 8647, Size 1-7

FIG. 1



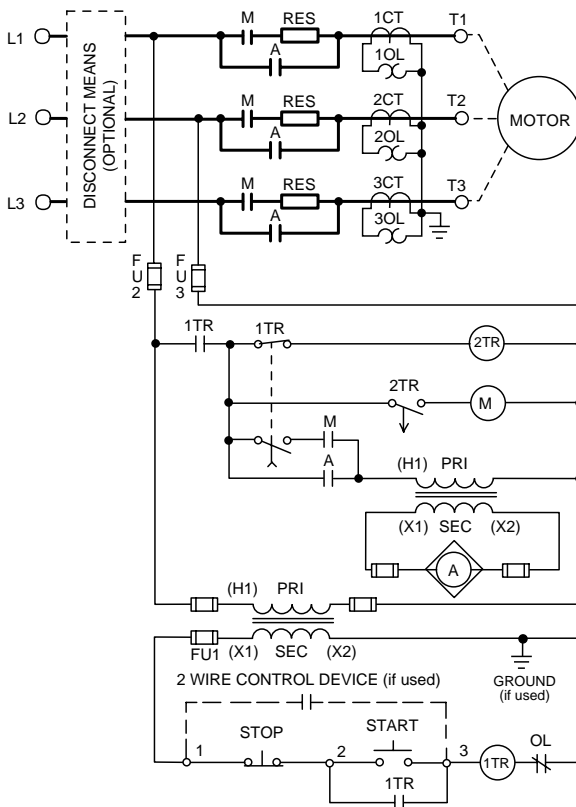
Size 1-4

FIG. 2



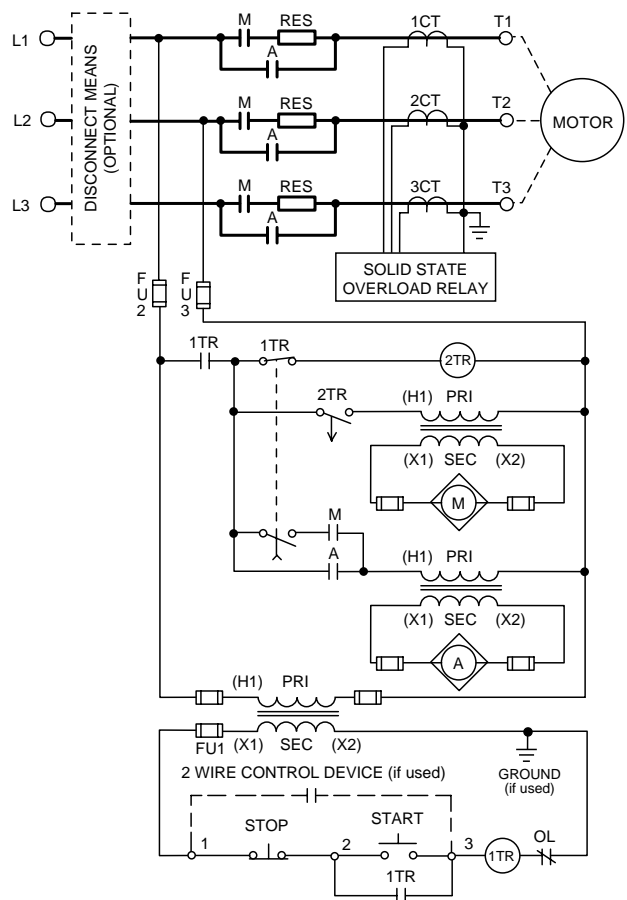
Size 5

FIG. 3



Size 6

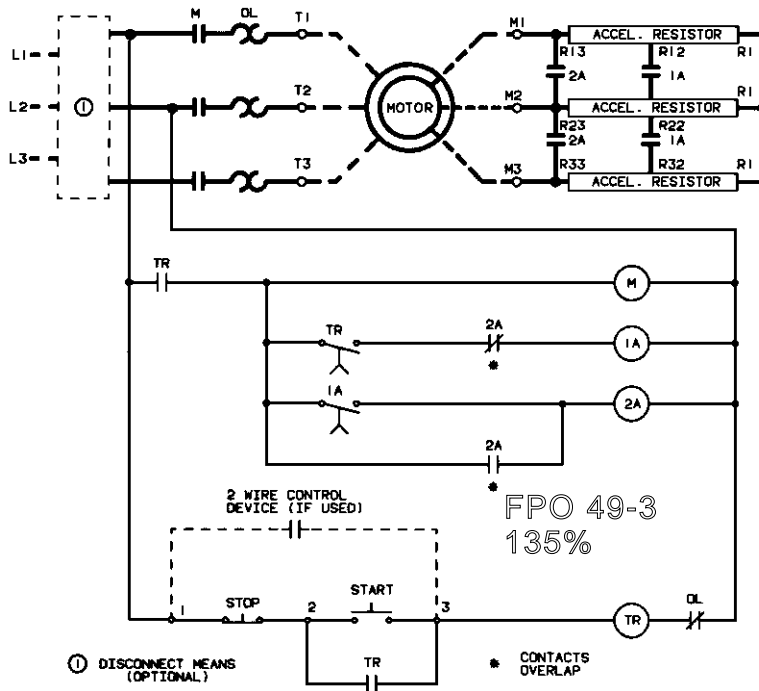
FIG. 4



Size 7

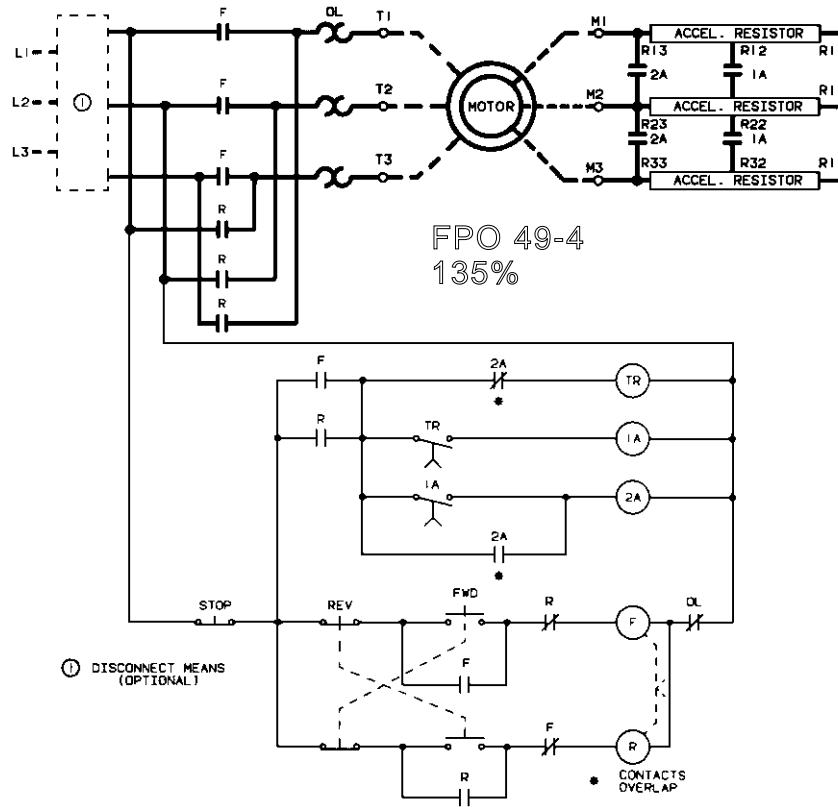
Wound-Rotor Reduced Voltage Controllers:  
 Class 8650 and 8651

FIG. 1



Non-Reversing Wound-Rotor Motor Controller w/ 3 Points of Acceleration  
 Class 8650

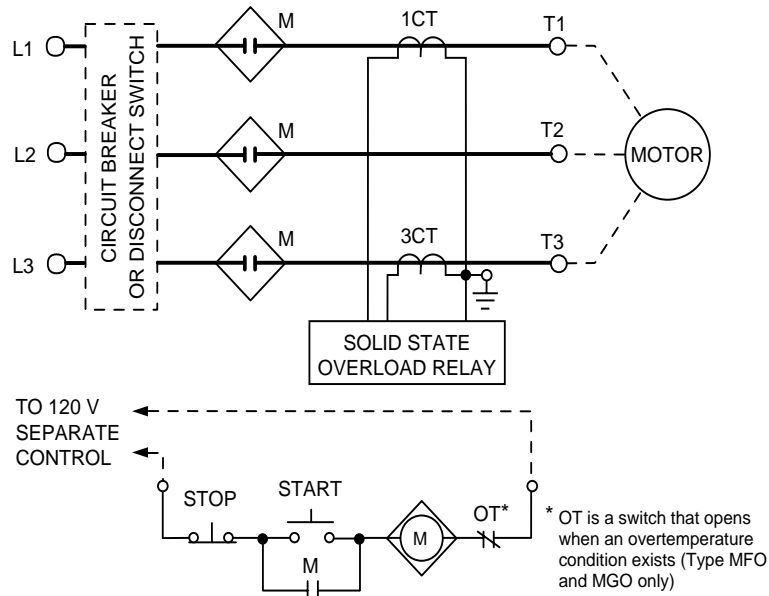
FIG. 2



Reversing Wound-Rotor Motor Controller w/ 3 Points of Acceleration  
 Class 8651

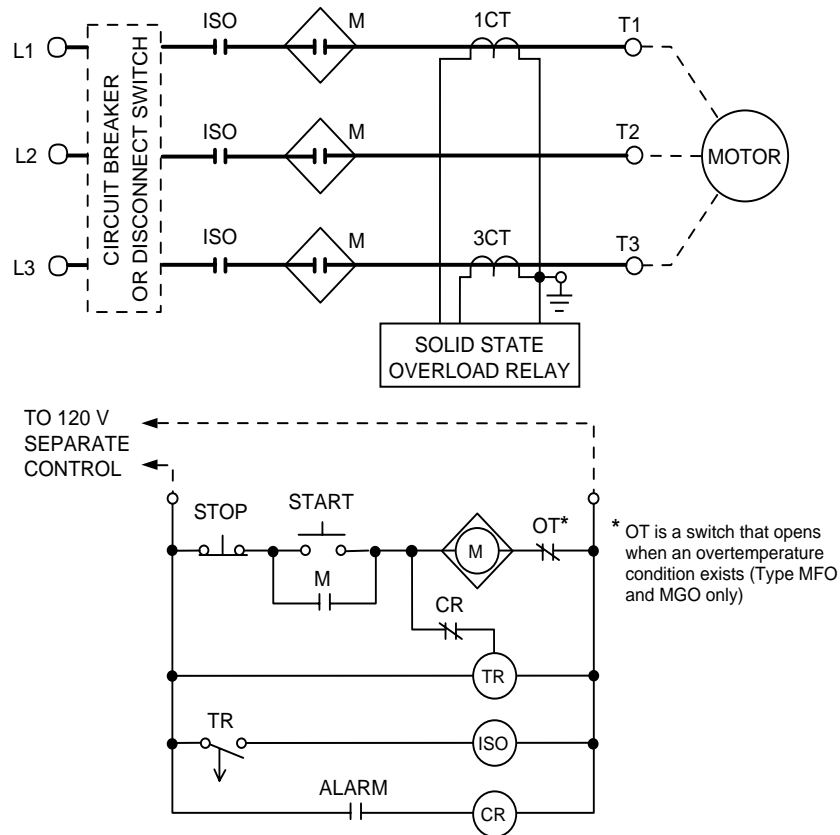
ALPHA PAK<sup>®</sup> Solid State Reduced Voltage Starters:  
Class 8660 Type MD-MG

FIG. 1



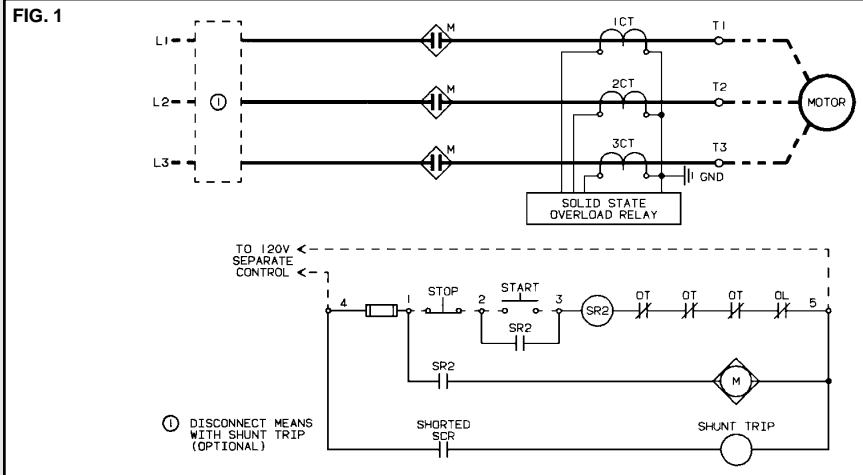
Type MD (16 A), ME (32 A), MF (64 A) and MG (128 A)

FIG. 2

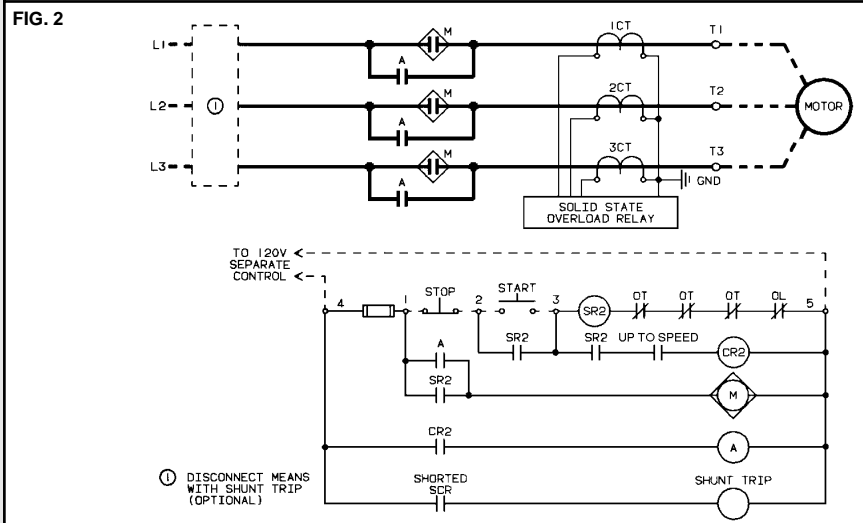


Type MD (16 A), ME (32 A), MF (64 A) and MG (128 A) w/ Isolation Contactor

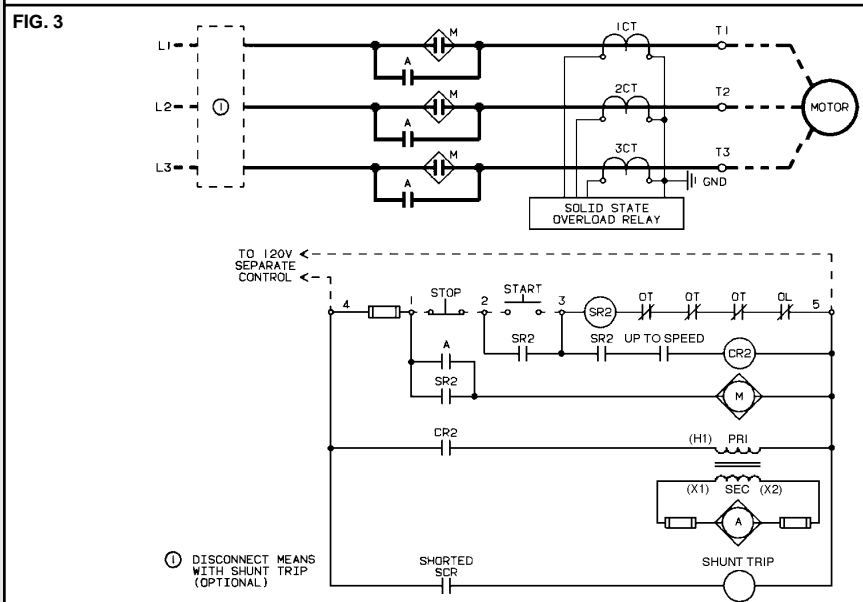
#### Solid State Reduced Voltage Controllers: Class 8660 Type MH, MJ, MK and MM



Type MH (200 A), MJ (320 A), MK (500 A) and MM (750 A)



Type MH (200 A) w/ Shorting Contactor

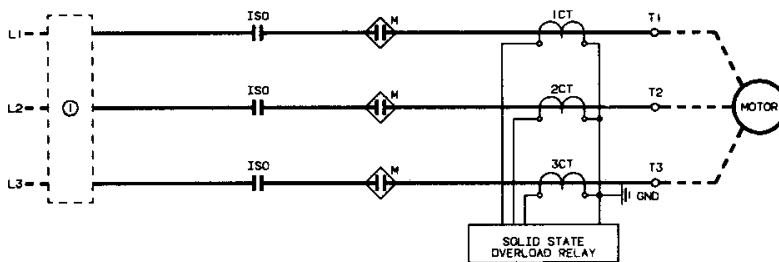


Type MJ (320 A), MK (500 A) and MM (750 A) w/ Shorting Contactor

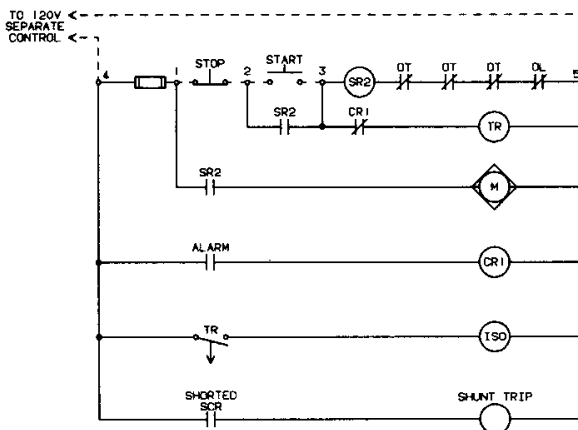


Solid State Reduced Voltage Controllers: Class 8660 Type MH, MJ, MK and MM

FIG. 1



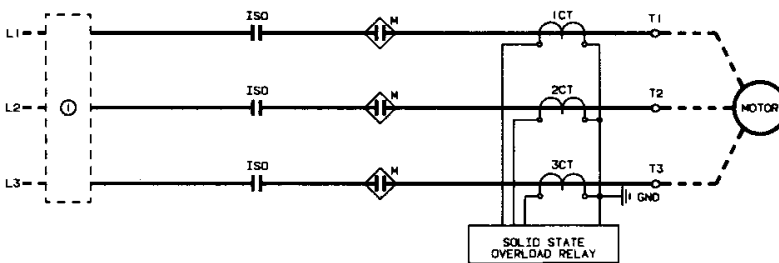
FPO  
51-1  
130%



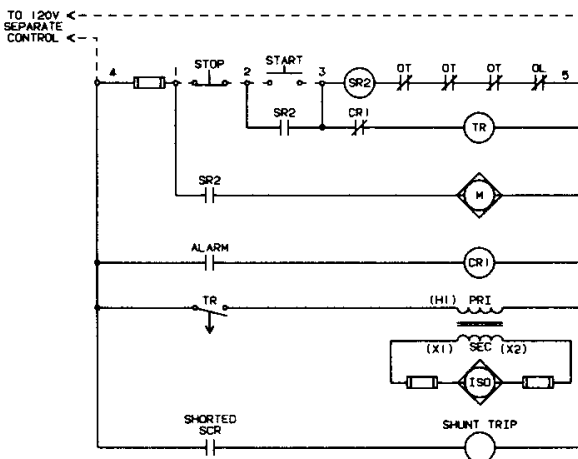
① DISCONNECT MEANS WITH SHUNT TRIP (OPTIONAL)

Type MH (200 A) w/ Isolation Contactor

FIG. 2



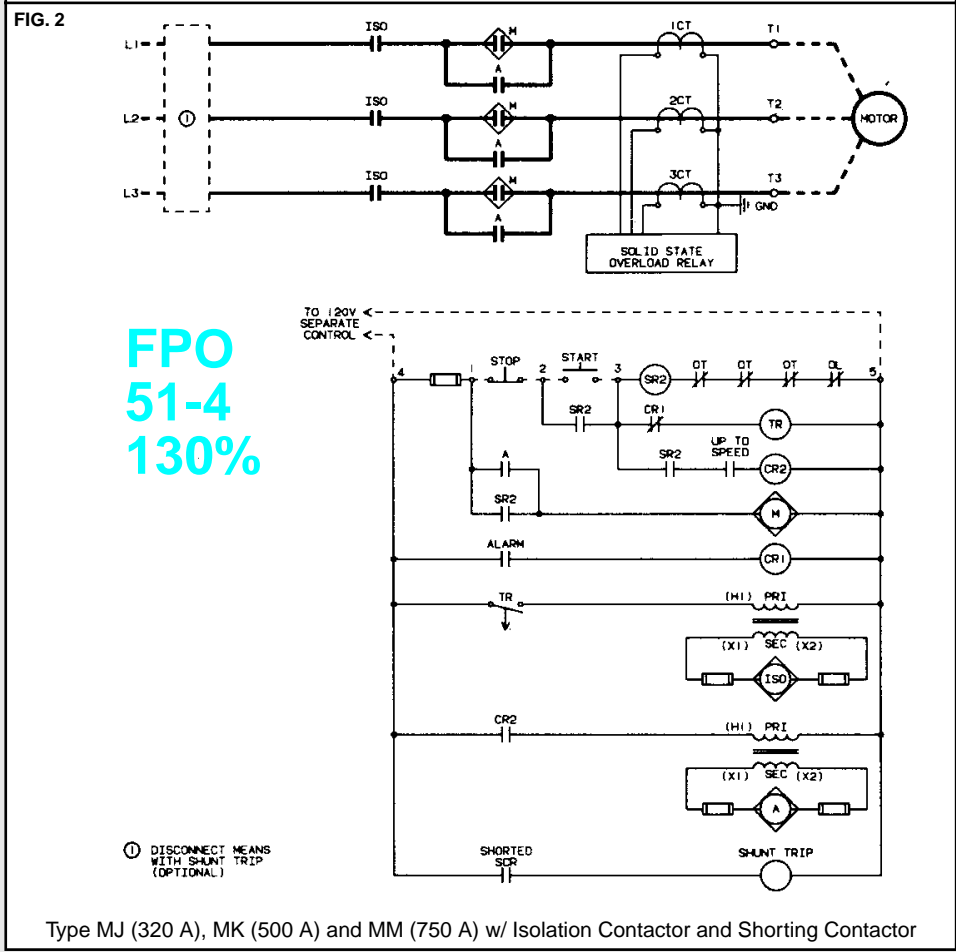
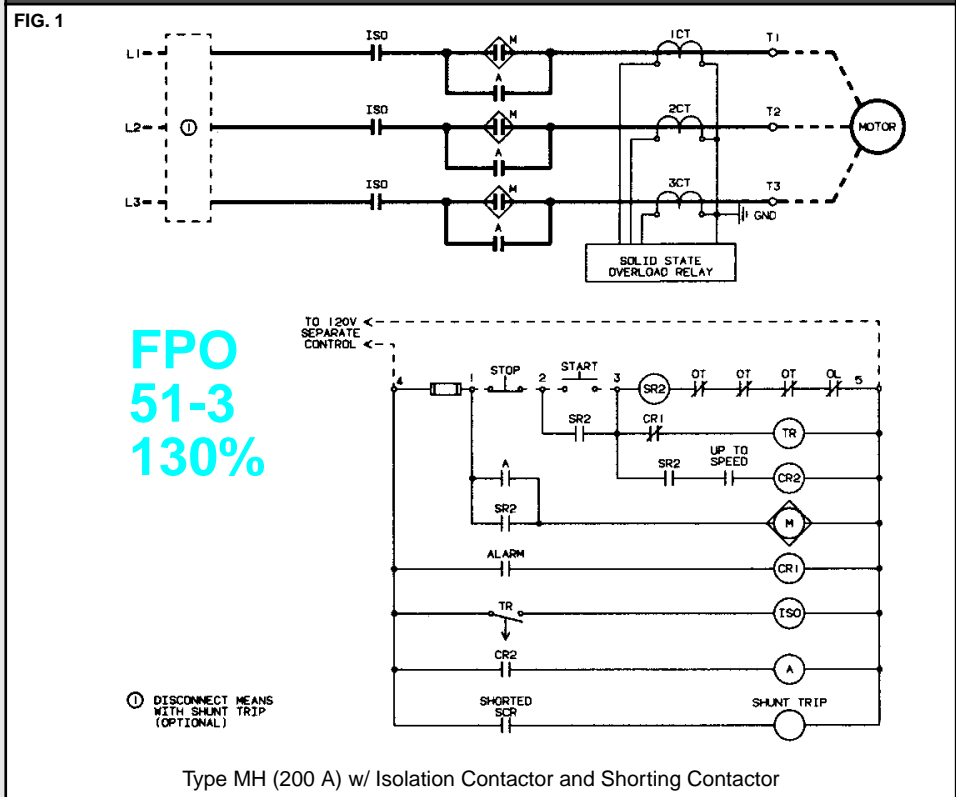
FPO  
51-2  
130%



① DISCONNECT MEANS WITH SHUNT TRIP (OPTIONAL)

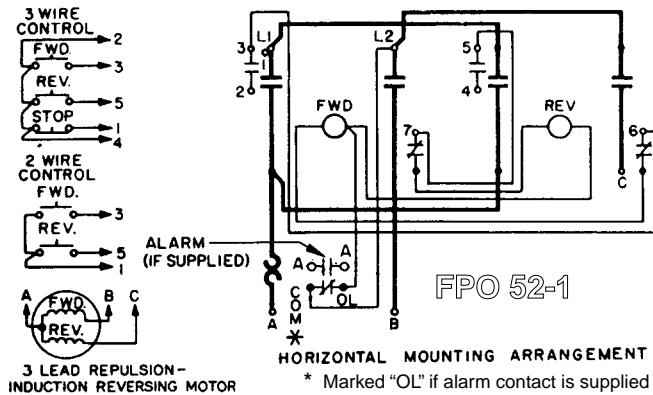
Type MJ (320 A), MK (500 A) and MM (750 A) w/ Isolation Contactor

Solid State Reduced Voltage Controllers: Class 8660 Type MH, MJ, MK and MM



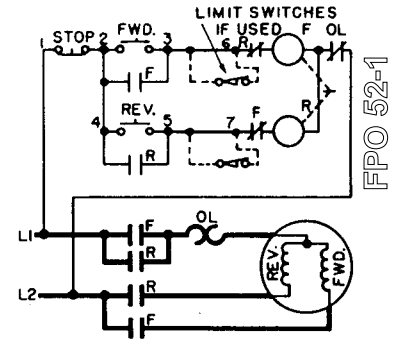
Reversing Starters, 2- and 3-Pole, Size 00-1:  
 Class 8736 Type S

FIG. 1



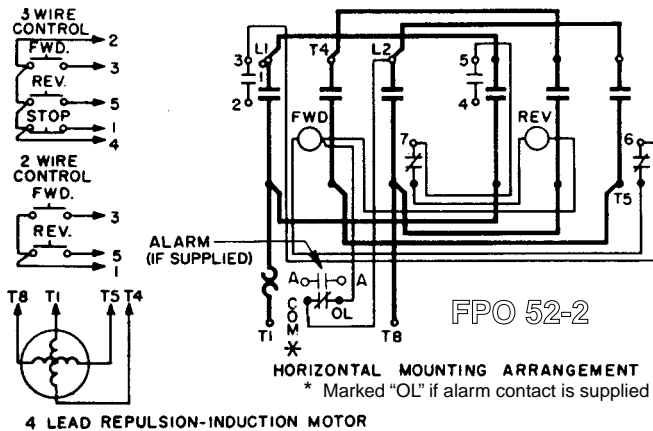
Wiring Diagram

2-Pole, w/ Single Phase, 3-Lead Motor



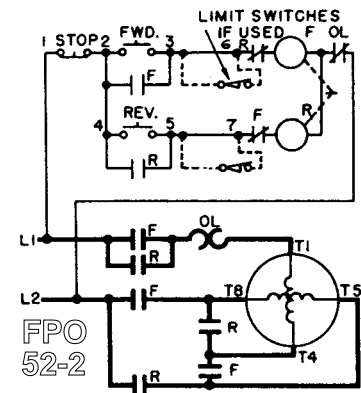
Elementary Diagram

FIG. 2



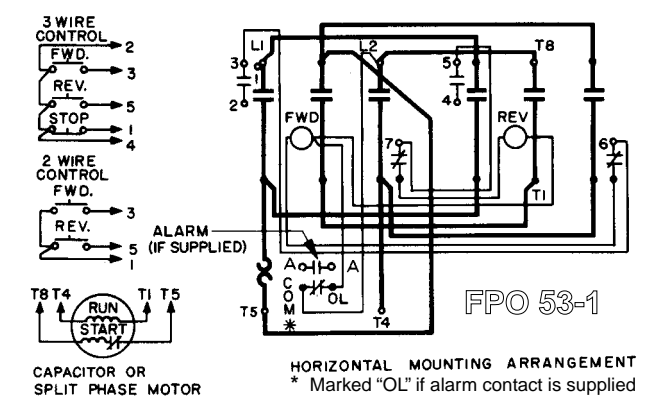
Wiring Diagram

3-Pole, w/ Single Phase, 4-Lead Repulsion-Induction Motor



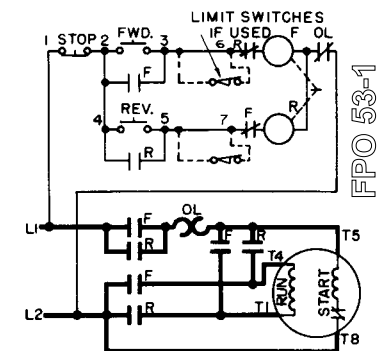
Elementary Diagram

FIG. 3



Wiring Diagram

3-Pole, w/ Single Phase, 4-Lead Capacitor or Split-Phase Motor



Elementary Diagram

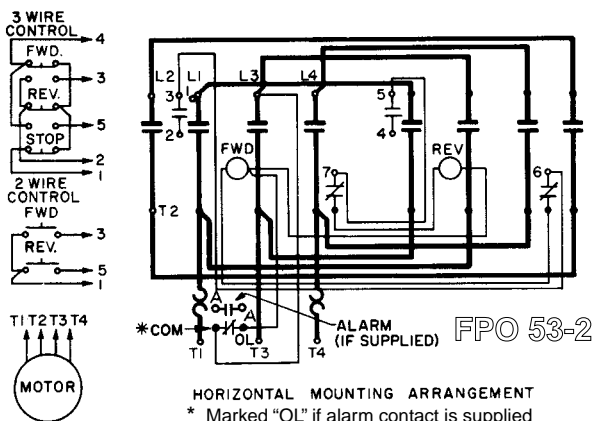
# Type S AC Reversing Magnetic Starters

Class 8736

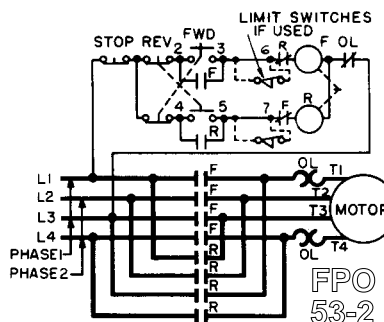
3- and 4-Pole

## Reversing Starters, 3- and 4-Pole: Class 8736 Type S

FIG. 1



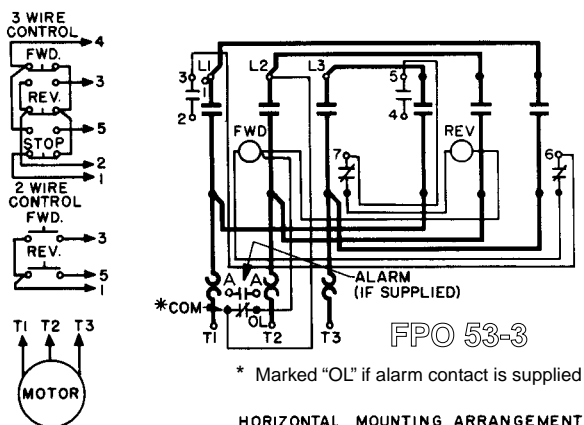
Wiring Diagram



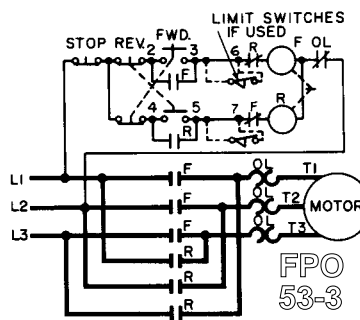
Elementary Diagram

Size 00-2, 4-Pole, 2-Phase

FIG. 2



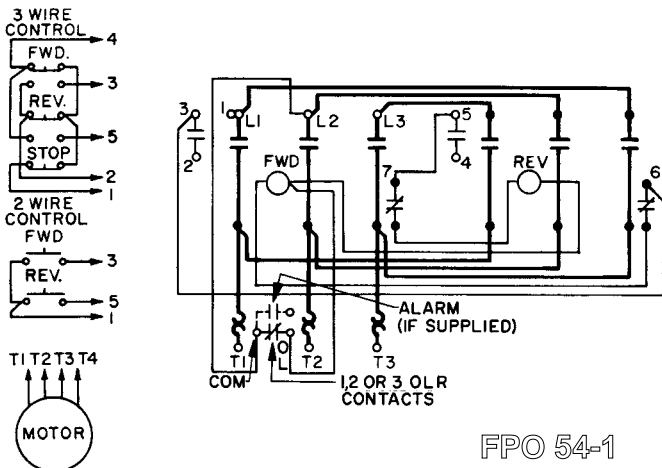
Wiring Diagram



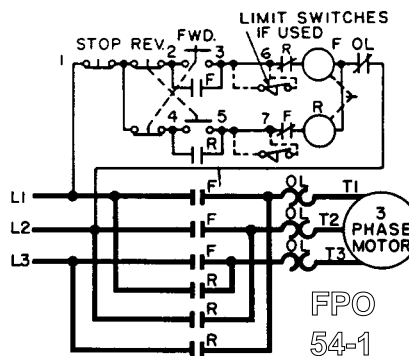
Elementary Diagram

Size 00-4, 3-Pole, 3-Phase

FIG. 3



Wiring Diagram

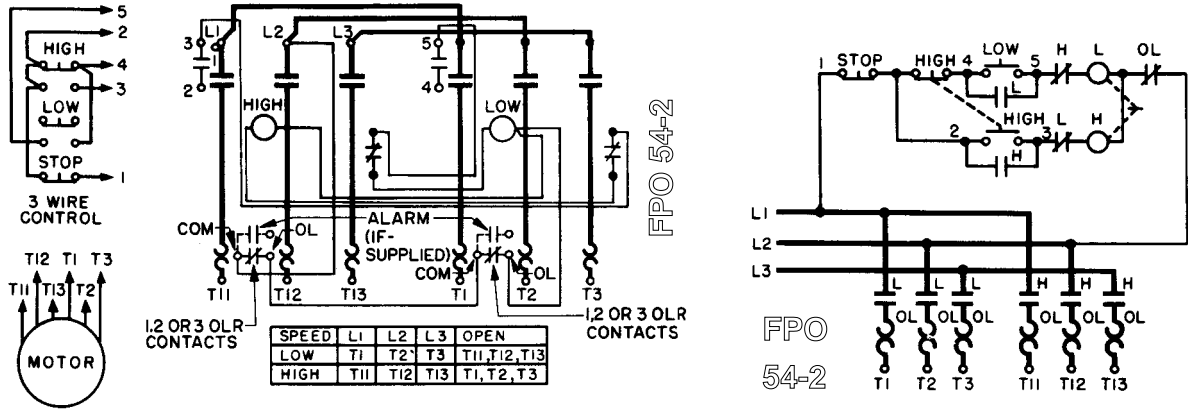


Elementary Diagram

Size 5, 3-Pole, 3-Phase

Starters for 2-Speed, 2-Winding (Separate Winding), 3-Phase Motors:  
Class 8810 Type S

FIG. 1

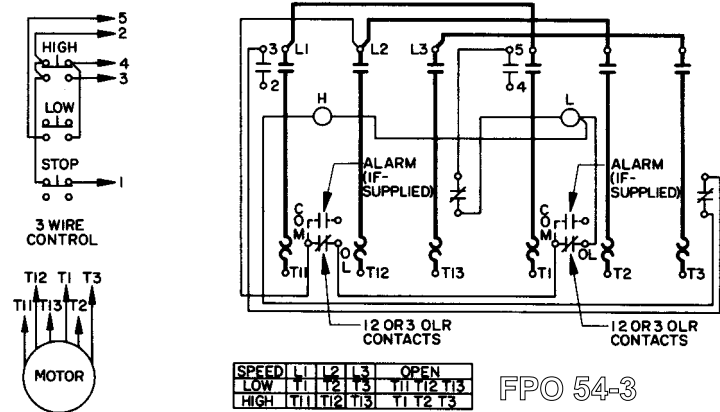


Wiring Diagram

Elementary Diagram

Size 0-4

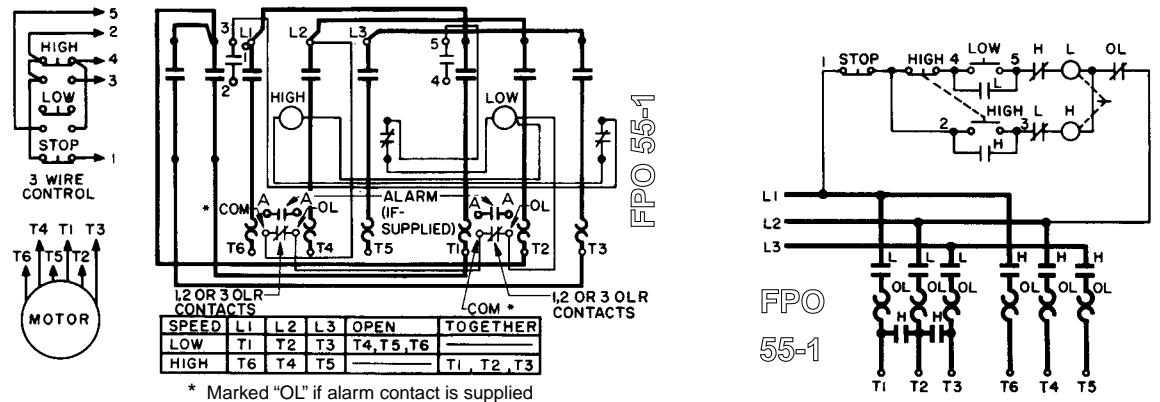
FIG. 2



Size 5 Wiring Diagram

Starters for 2-Speed, 1-Winding (Consequent Pole), Constant or Variable Torque, 3-Phase Motors:  
Class 8810 Type S

FIG. 3



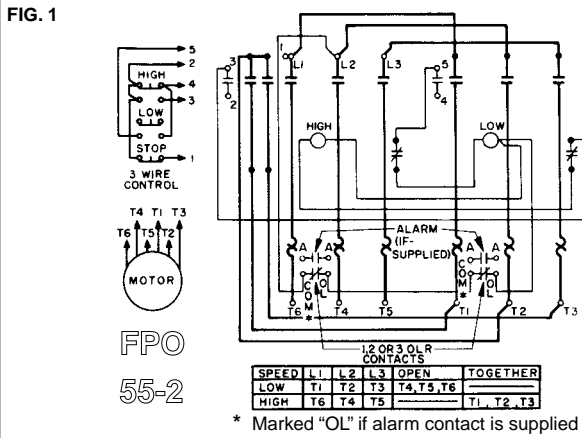
Wiring Diagram

Elementary Diagram

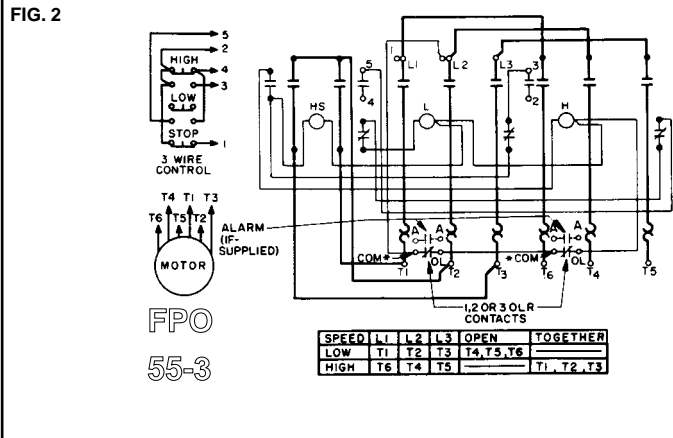
Size 0-2

\* Marked "OL" if alarm contact is supplied

Starters for 2-Speed, 1-Winding (Consequent Pole), Constant or Variable Torque, 3-Phase Motors:  
Class 8810 Type S

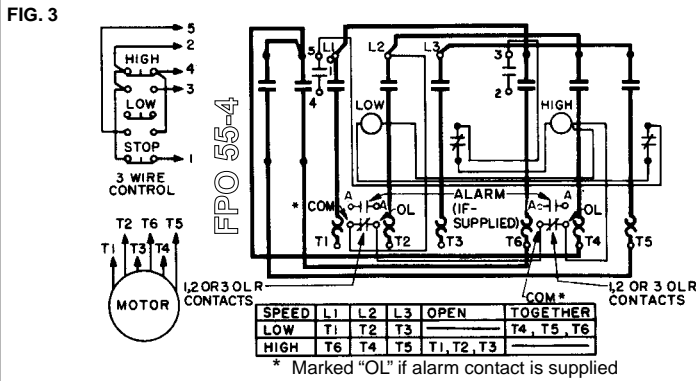


Size 3 and 4 Wiring Diagram



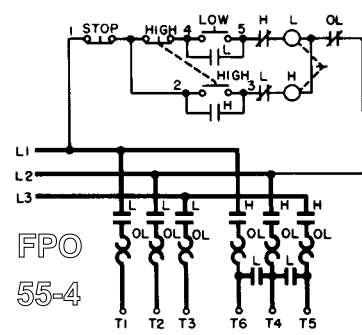
Size 5 Wiring Diagram

Starters for 2-Speed, 1-Winding (Consequent Pole), Constant Horsepower, 3-Phase Motors:  
Class 8810 Type S

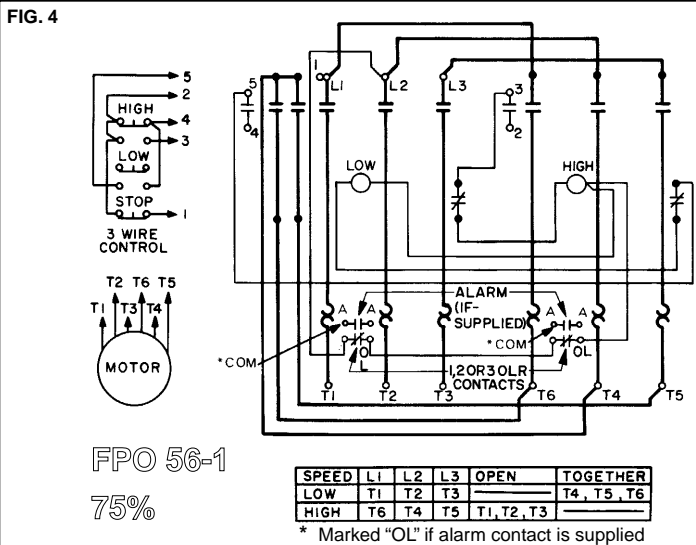


Wiring Diagram

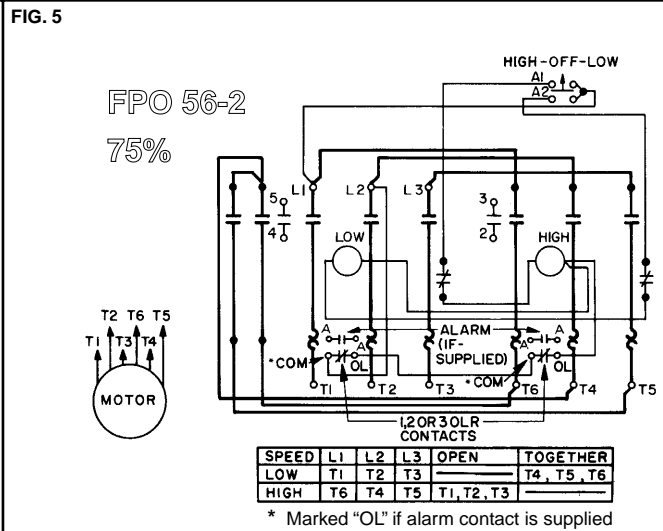
Size 0-2



Elementary Diagram



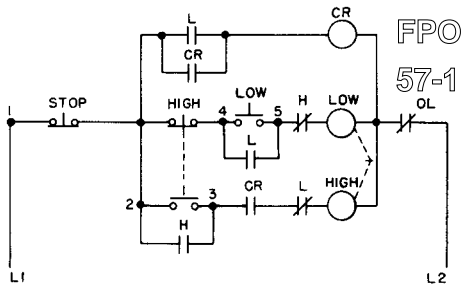
Size 3 and 4 Wiring Diagram



Size 0, w/ High-Off-Low Selector Switch (Form C7) Wiring Diagram

Form R1

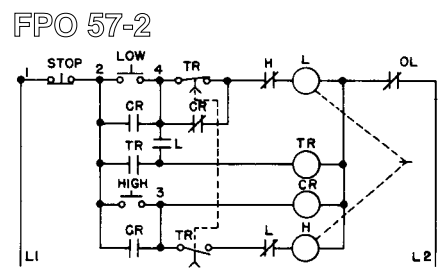
FIG. 1



Compelling Relay, Requiring Motor Starting in Low Speed

Form R2

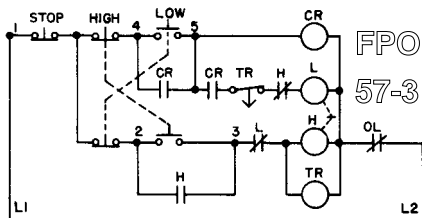
FIG. 2



Accelerating Relay, Providing Timed Acceleration to Selected Speed

Form R3

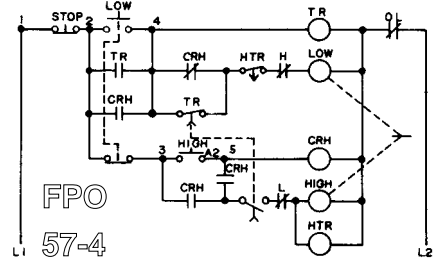
FIG. 3



Decelerating Relay, w/ Time Delay During Transfer from Higher to Lower Speed

Form R2R3

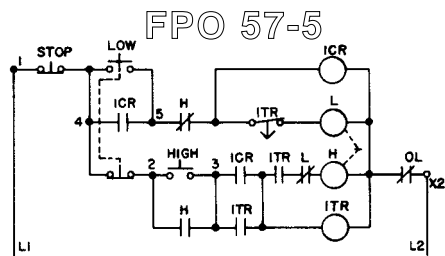
FIG. 4



Accelerating Relay and Decelerating Relay

Form R1R3

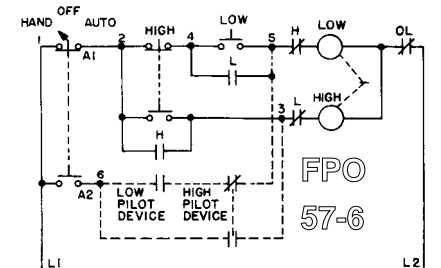
FIG. 5



Compelling Relay and Decelerating Relay

Form A10C

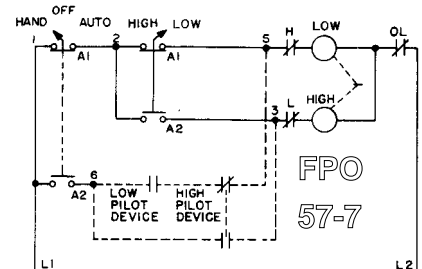
FIG. 6



Hand-Off-Auto Selector Switch and High-Low Push Button

Form CC17

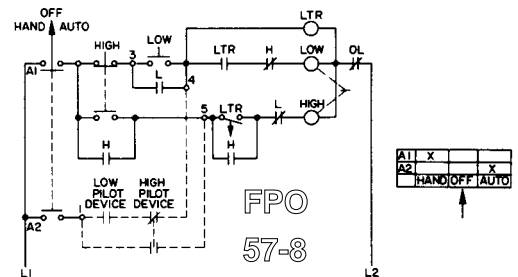
FIG. 7



Hand-Off-Auto Selector Switch and High-Low Selector Switch

Form A10CR1

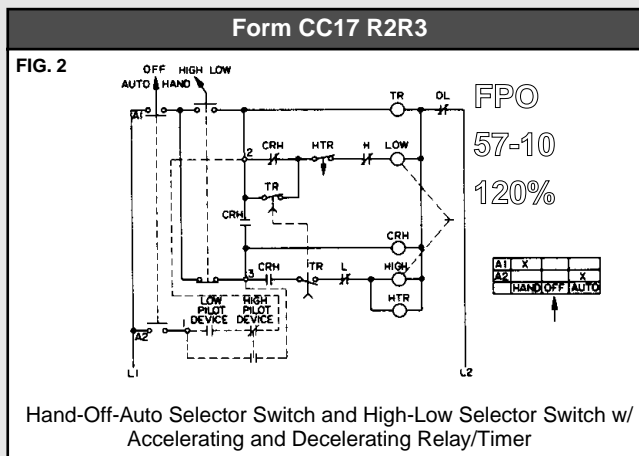
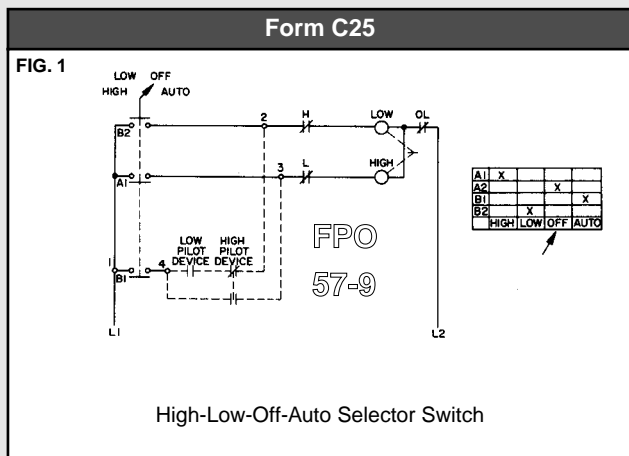
FIG. 8



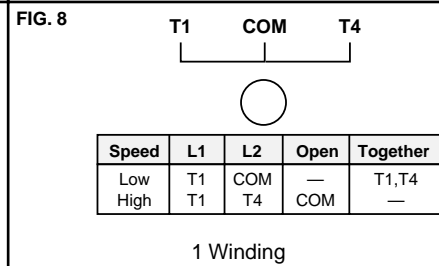
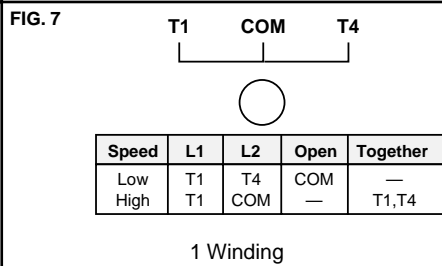
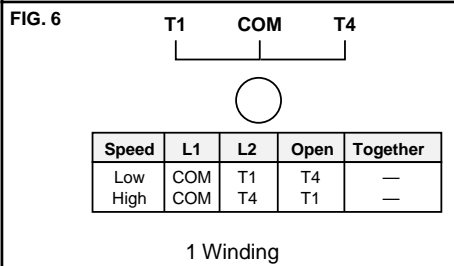
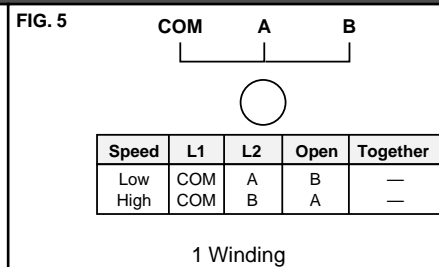
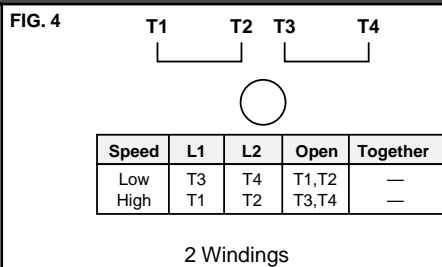
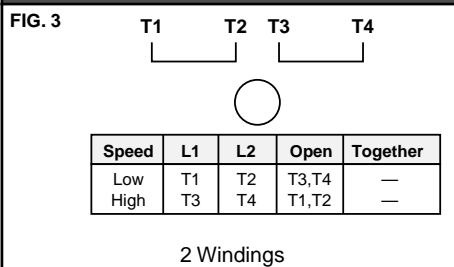
Hand-Off-Auto Selector Switch and High-Low Push Button w/ Compelling Relay/Timer

A1	X	X	X
A2			

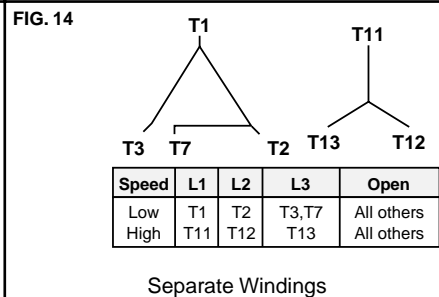
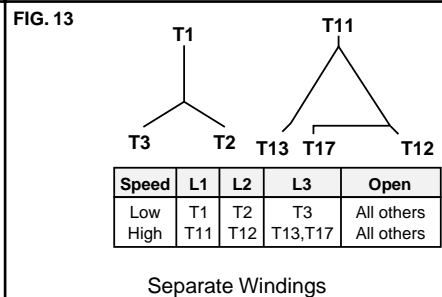
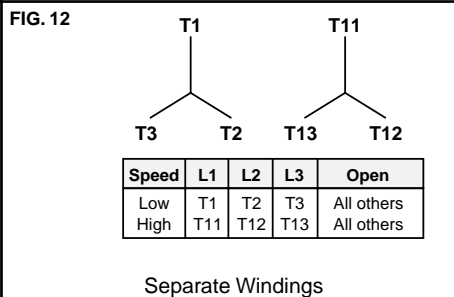
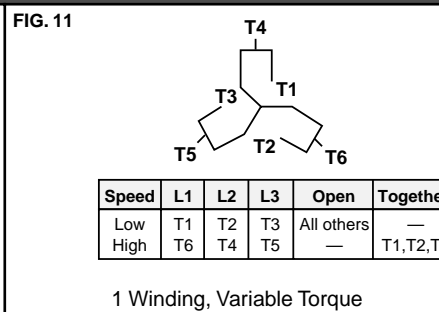
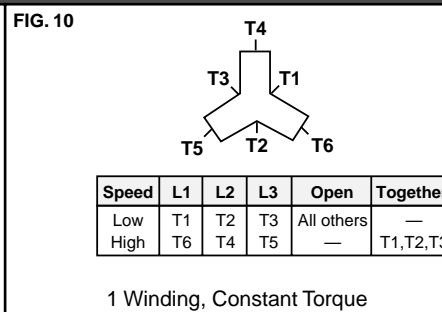
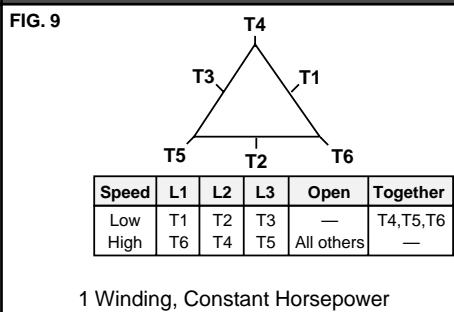
HAND/OFF/AUTO



### Multispeed Motor Connections: 1-Phase, 2-Speed Motors



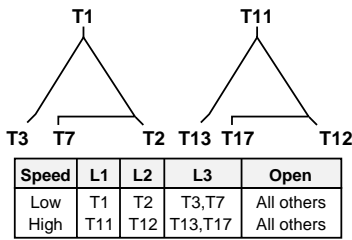
### Multispeed Motor Connections: 3-Phase, 2-Speed Motors





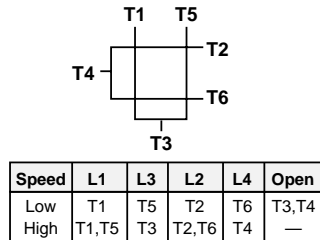
Multispeed Motor Connections:  
3-Phase, 2-Speed Motors

FIG. 1



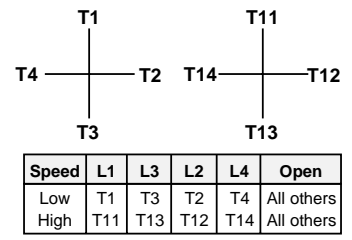
Separate Windings

FIG. 2



2-Phase, 1 Winding, Variable Torque

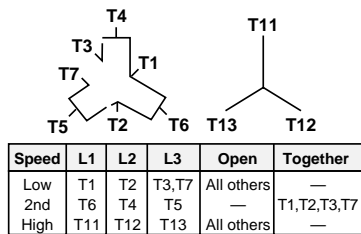
FIG. 3



2-Phase, Separate Windings

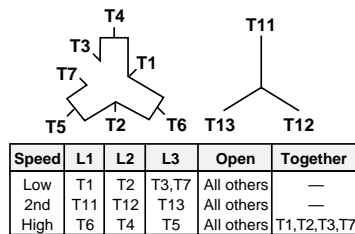
Multispeed Motor Connections:  
3-Phase, 3-Speed Motors

FIG. 4



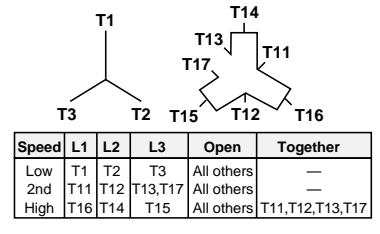
2 Windings, Constant Torque

FIG. 5



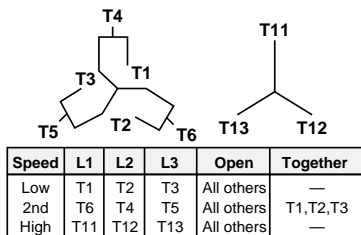
2 Windings, Constant Torque

FIG. 6



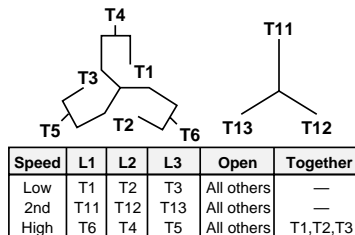
2 Windings, Constant Torque

FIG. 7



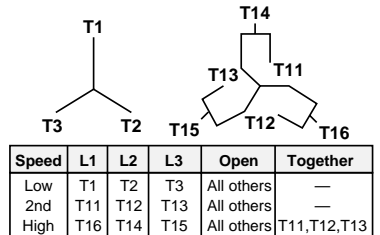
2 Windings, Variable Torque

FIG. 8



2 Windings, Variable Torque

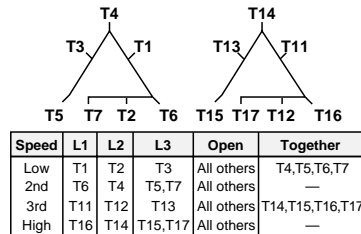
FIG. 9



2 Windings, Variable Torque

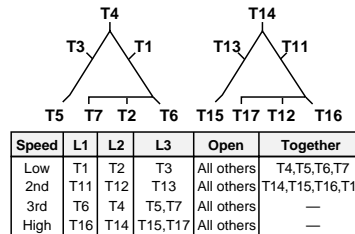
Multispeed Motor Connections:  
3-Phase, 4-Speed Motors

FIG. 10



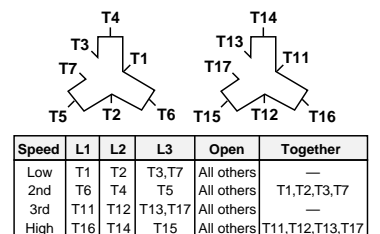
2 Windings, Constant Horsepower

FIG. 11



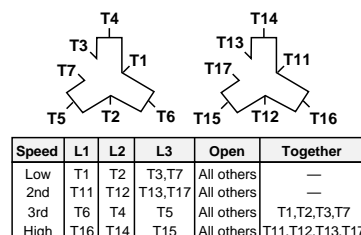
2 Windings, Constant Horsepower

FIG. 12



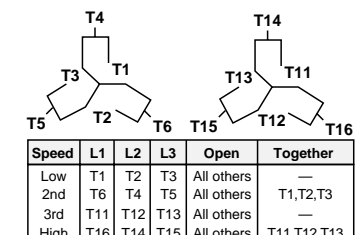
2 Windings, Constant Torque

FIG. 13



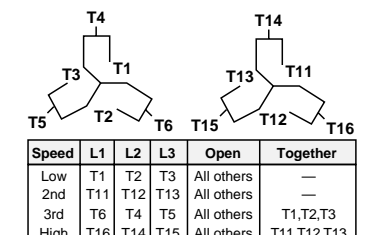
2 Windings, Constant Torque

FIG. 14



2 Windings, Variable Torque

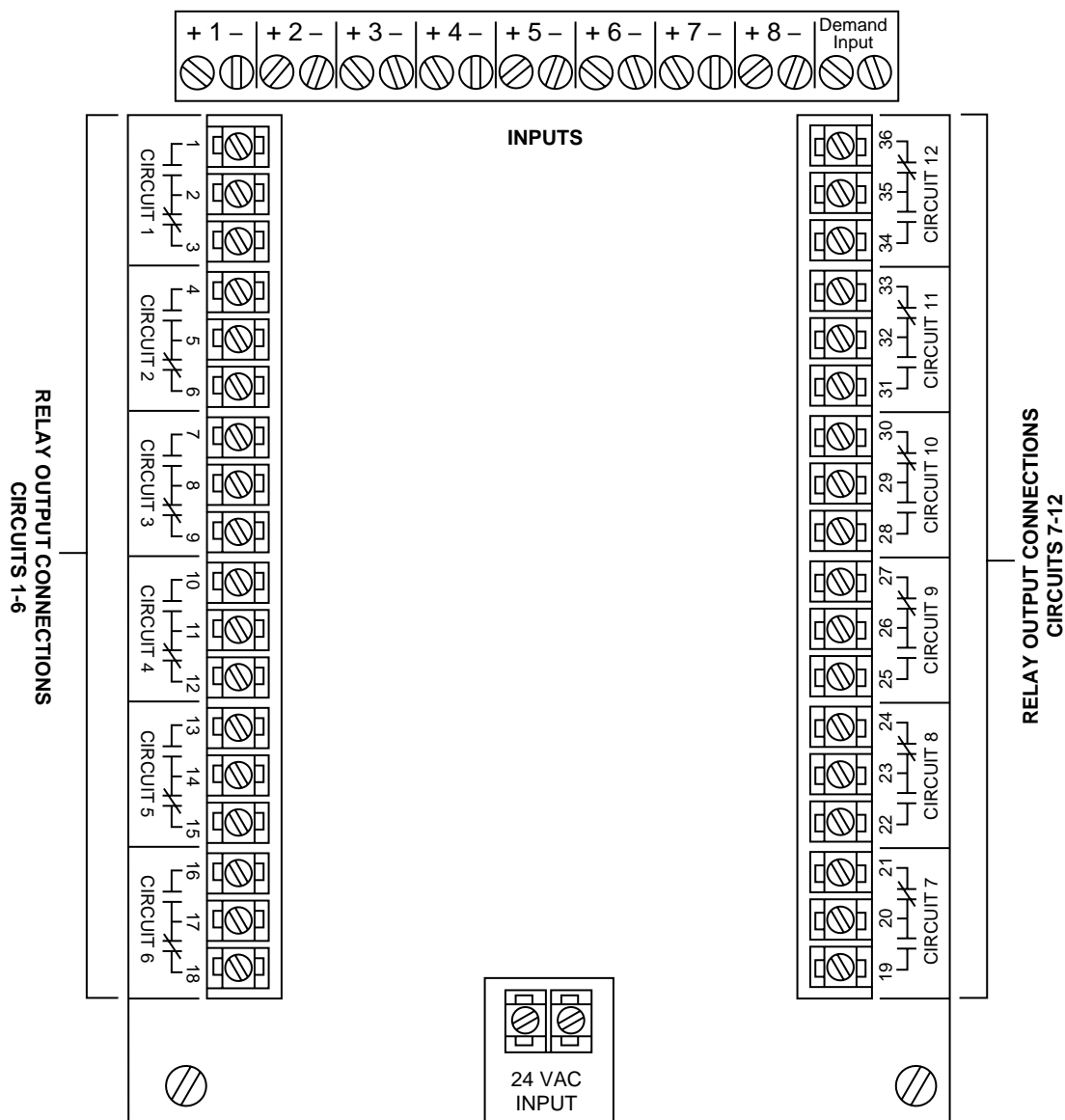
FIG. 15

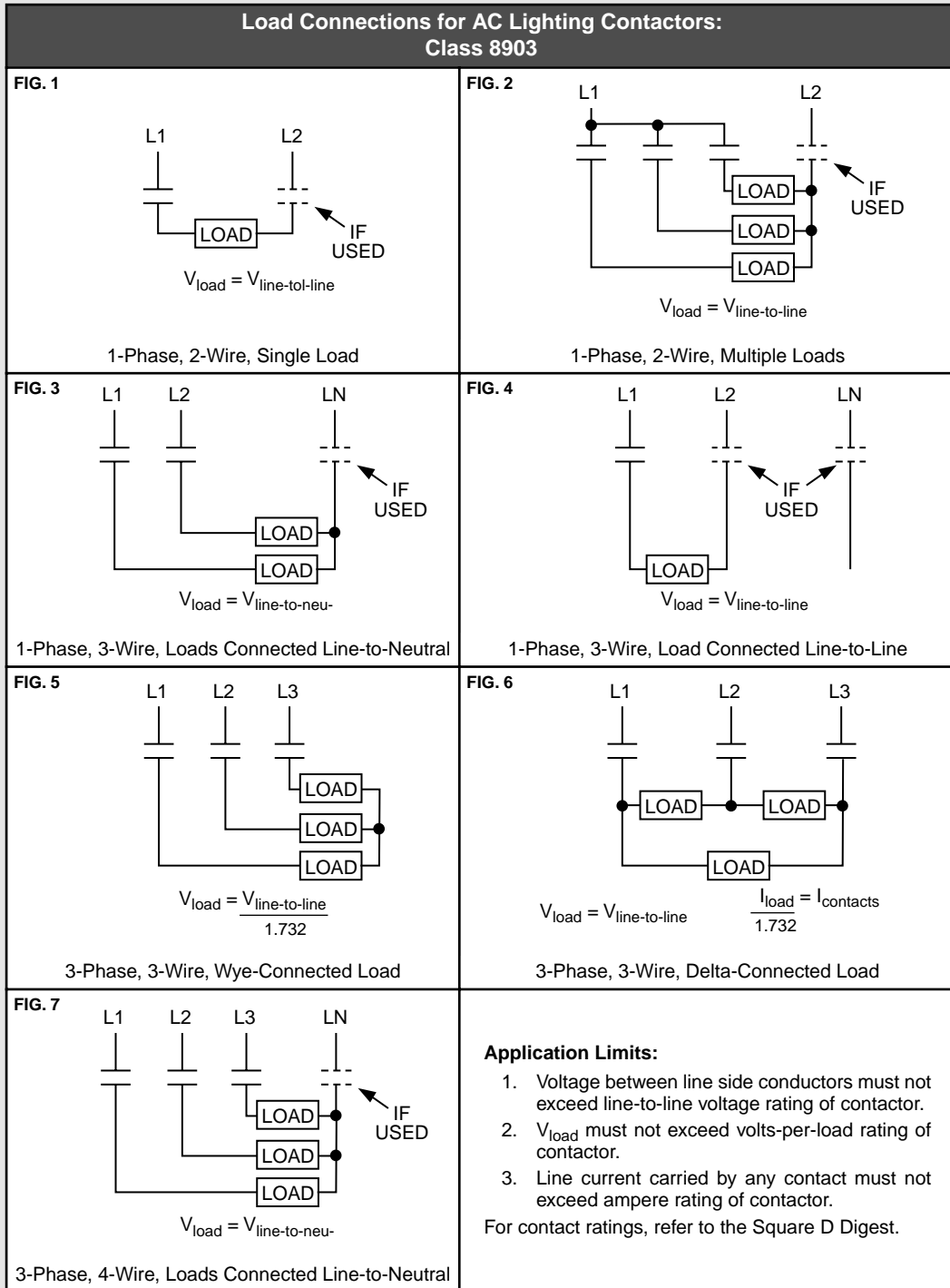


2 Windings, Variable Torque

Programmable Lighting Controller:  
Class 8865 Type TC12

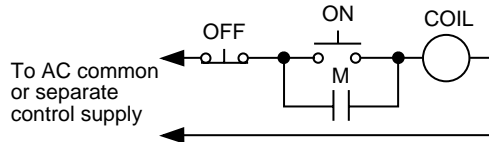
FIG. 1





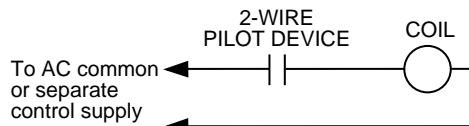
#### Control Circuit Connections for Electrically-Held Contactors: Class 8903 Type L and S

FIG. 1



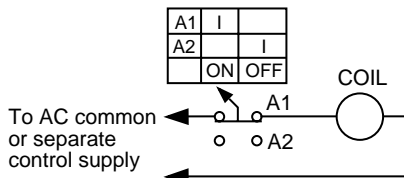
On-Off Push Button (Form A12)

FIG. 2



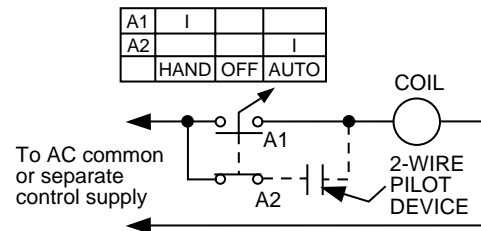
Direct Control from Pilot Device

FIG. 3



On-Off Selector Switch (Form C6)

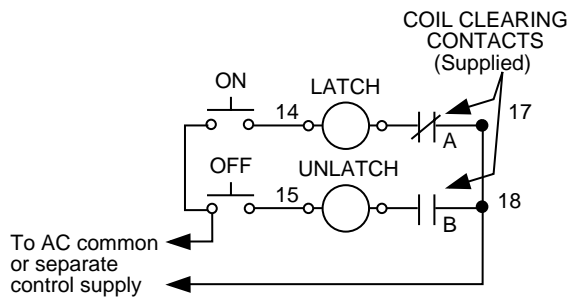
FIG. 4



Hand-Off-Auto Selector Switch (Form C)

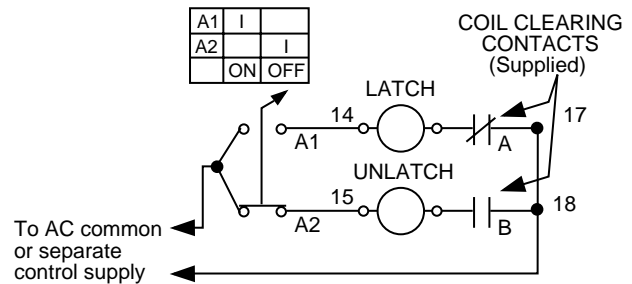
#### Control Circuit Connections for Mechanically-Held Contactors: Class 8903 Type LX and S

FIG. 5



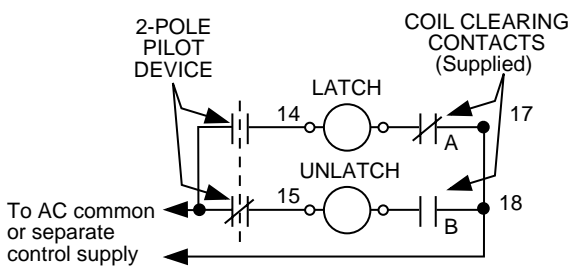
On-Off Push Button (Form A3)

FIG. 6



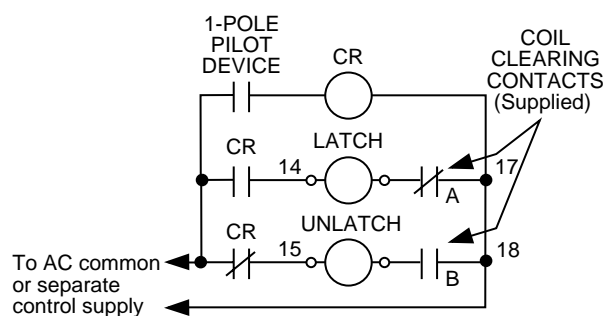
On-Off Selector Switch (Form C6)

FIG. 7



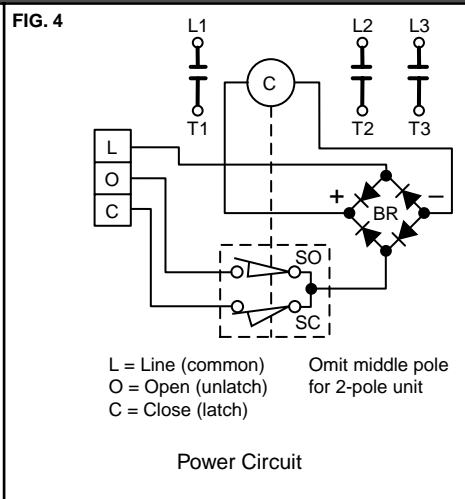
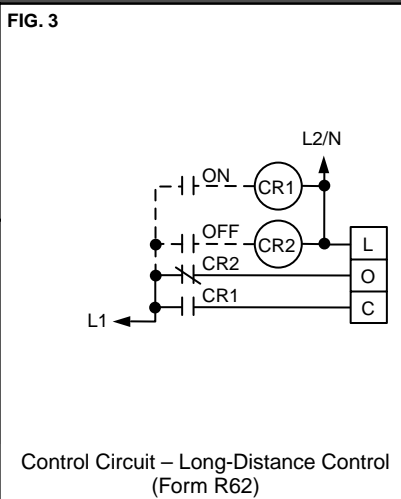
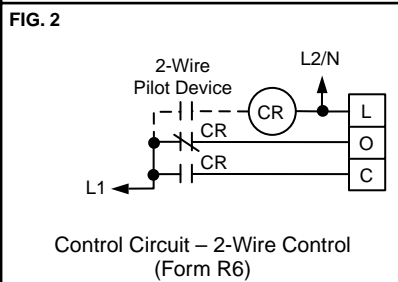
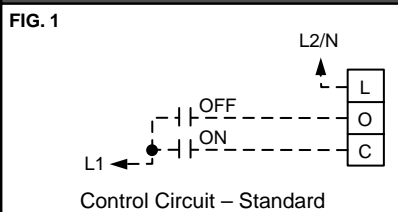
Control from 2-Pole Pilot Device

FIG. 8

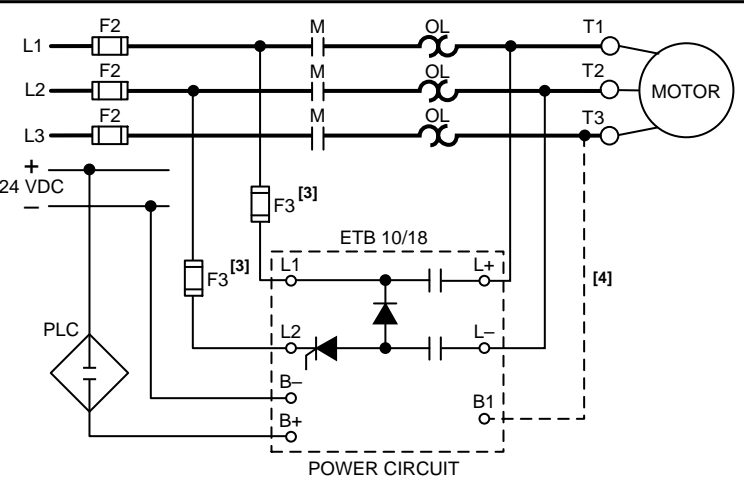
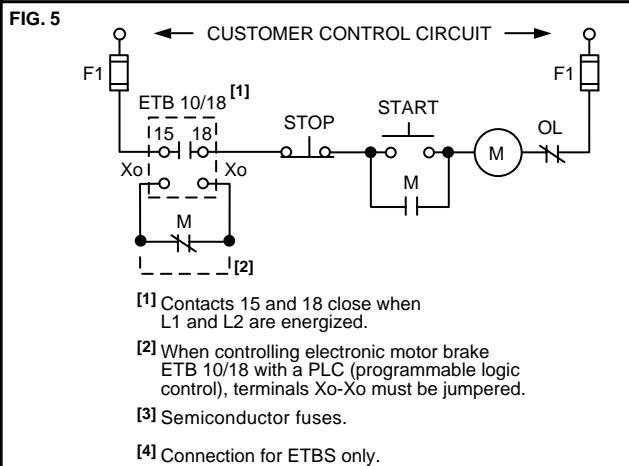


1-Pole Pilot Device w/ CR relay (Form R6)

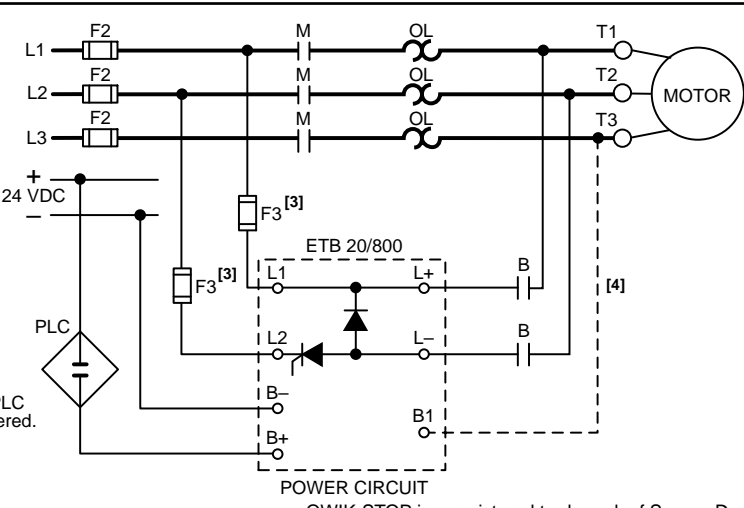
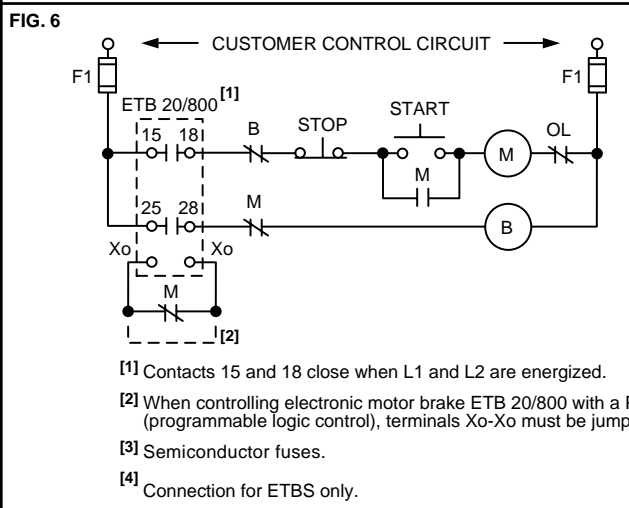
Panelboard Type Wiring:  
Class 8903 Type PB, 30-225 A



QWIK-STOP<sup>®</sup> Electronic Motor Brake:  
Class 8922



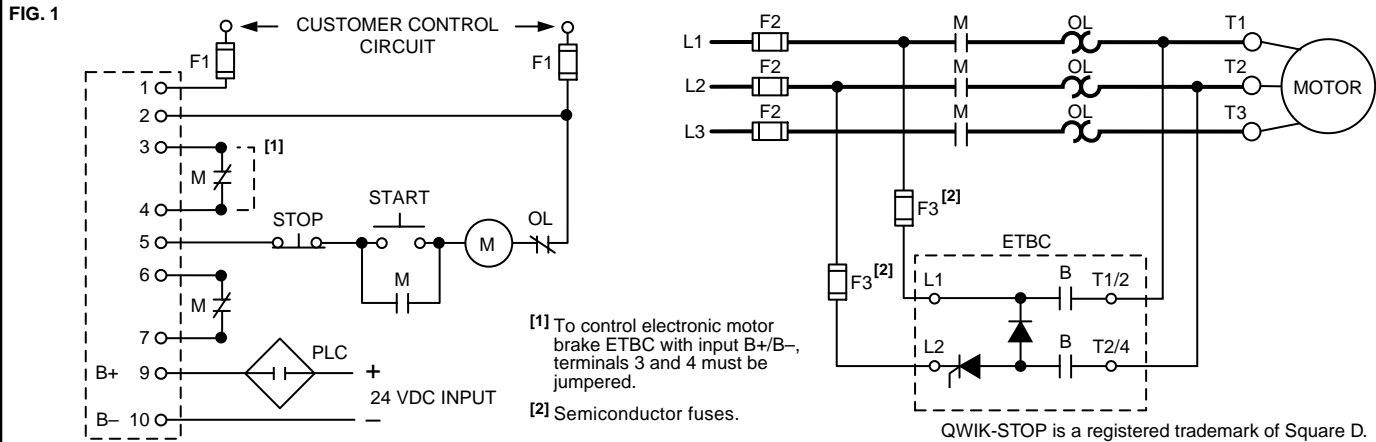
Type ETB10, ETB18 and ETBS18 w/ Internal Braking Contactor



Type ETB20-ETB800 and ETBS20-ETBS800

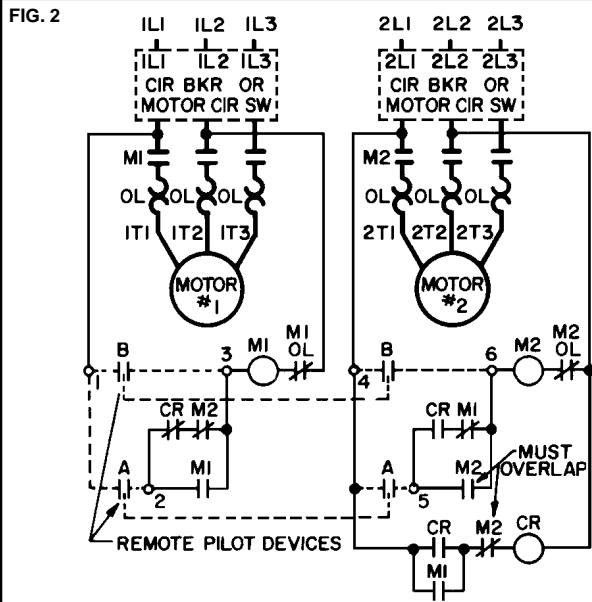
QWIK-STOP is a registered trademark of Square D.

**QWIK-STOP® Electronic Motor Brake: Class 8922 Type ETBC**



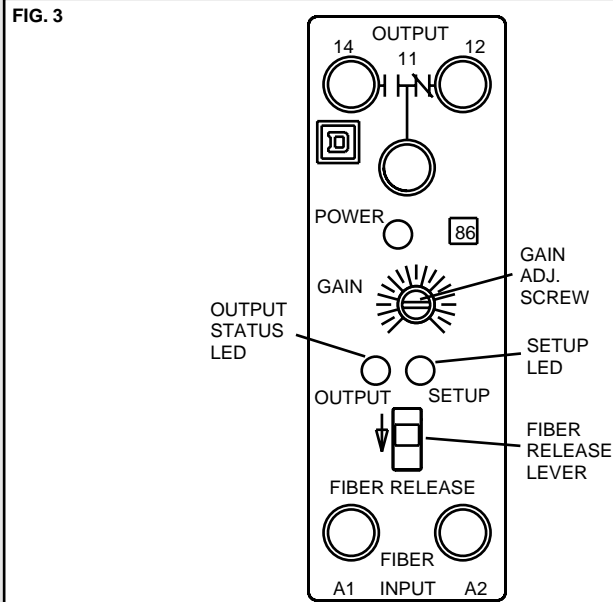
Type ETBC

**AC Duplex Motor Controller: Class 8941**



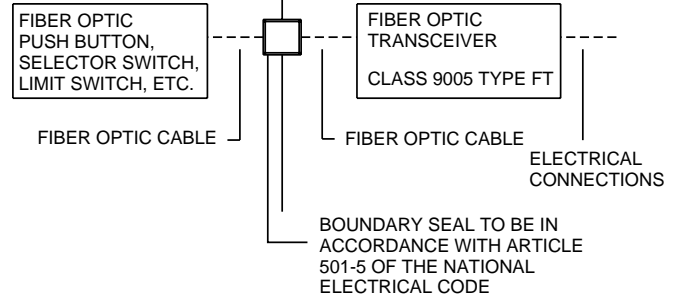
Elementary Diagram for Duplex Motor Controller w/  
 Electric Alternator

**Fiber Optic Transceiver: Class 9005**



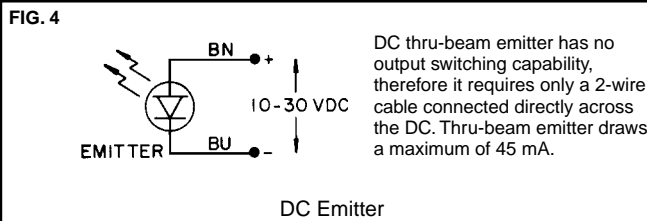
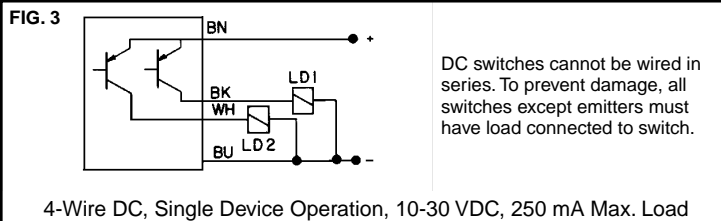
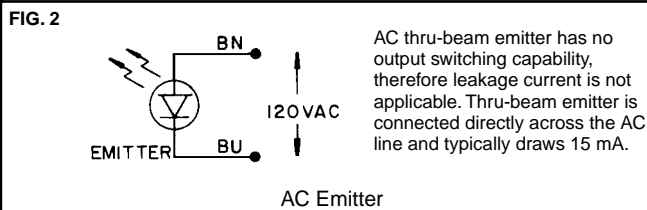
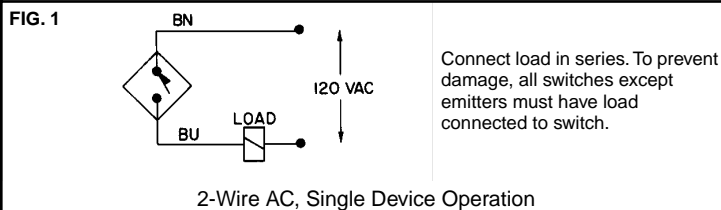
Transceiver, Front View

**FIG. 4 HAZARDOUS LOCATIONS**  
 CLASS I GROUPS A, B, C & D  
 CLASS II GROUPS E, F & G  
 CLASS III

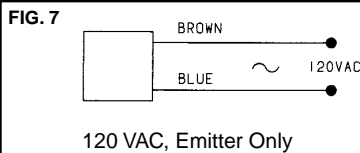
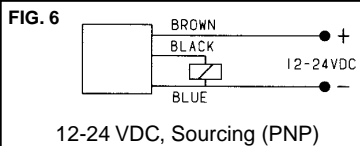
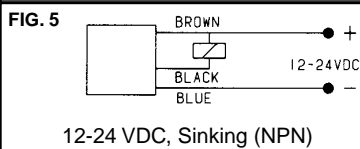


Location

**Photoelectric Switches:  
Class 9006 Type PE1 (Obsolete)**

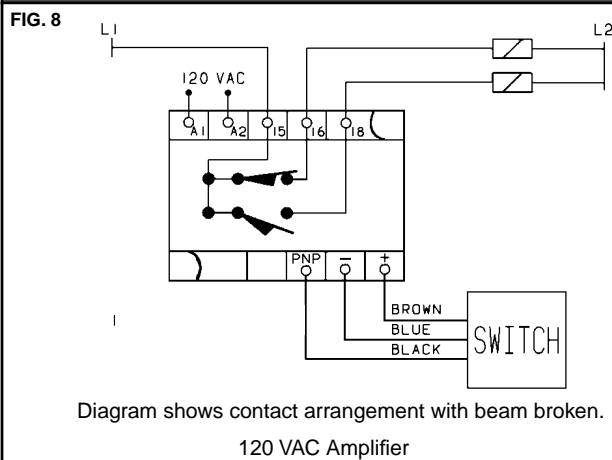


**Photoelectric Switches:  
Class 9006 Type PE6 and PE7 (Obsolete)**

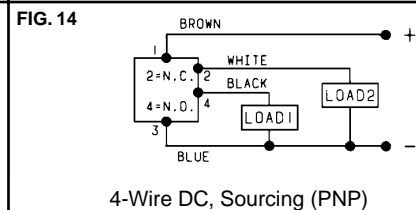
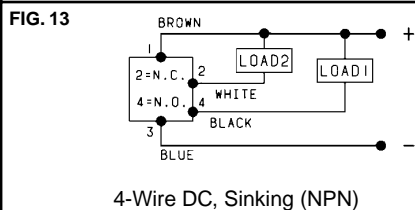
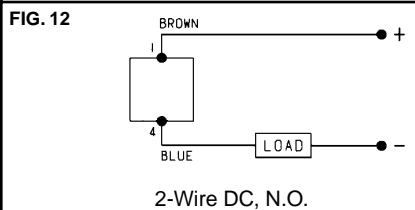
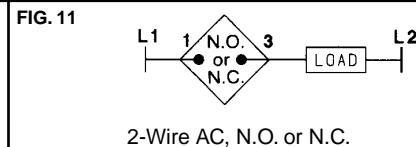
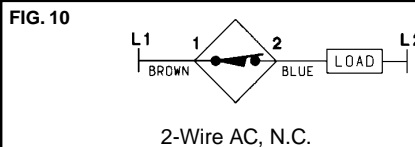
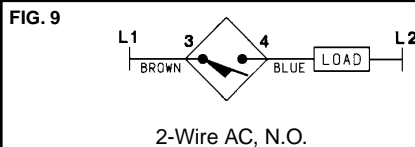


These switches are light operated only.  
Beam broken = load deenergized  
Beam unbroken = load energized

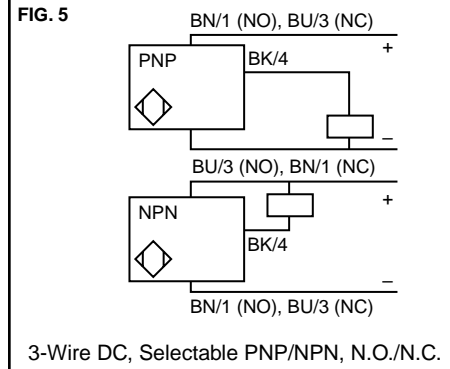
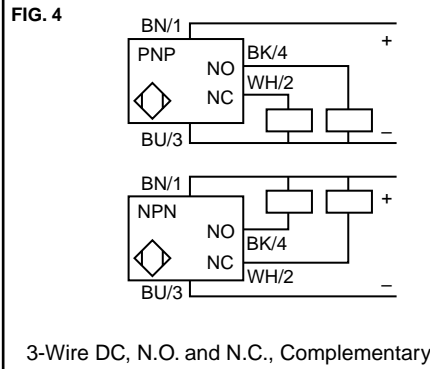
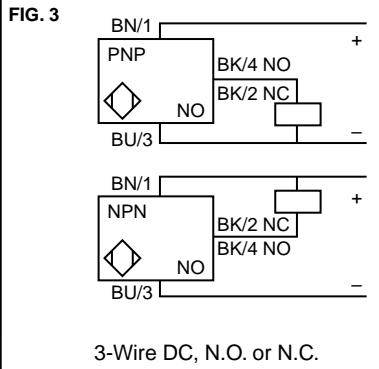
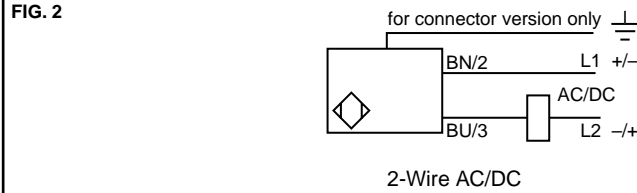
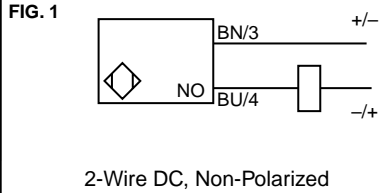
**Photoelectric Switches:  
Class 9006 Type PEA120 (Obsolete)**



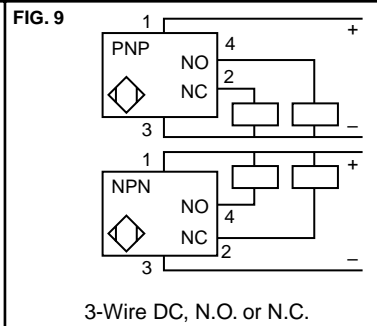
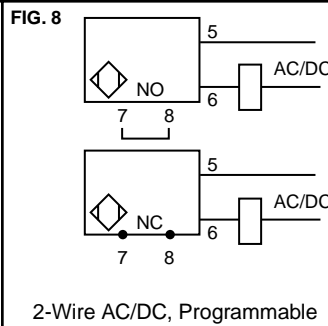
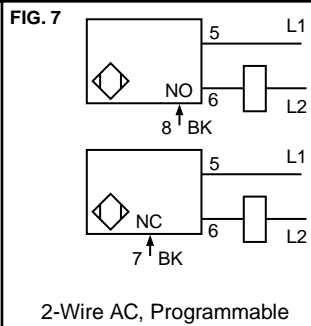
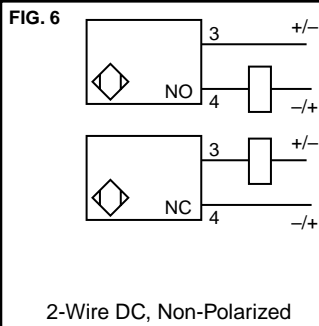
**Inductive Proximity Switches:  
Class 9006 Type PS (Obsolete)**



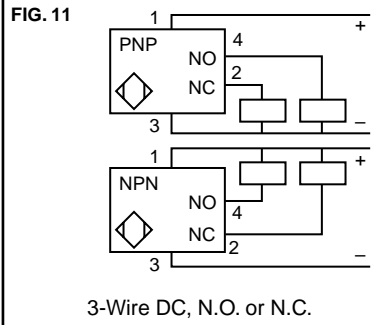
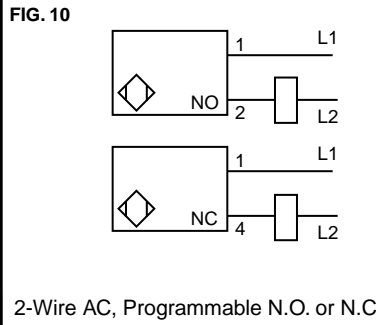
**XS Tubular Inductive Proximity Sensors**



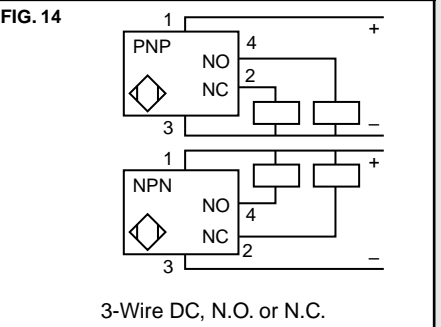
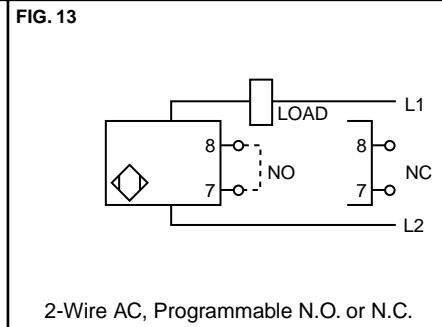
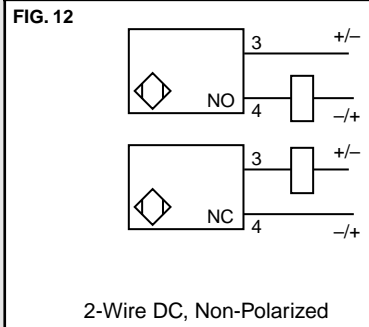
**XSC Rectangular Inductive Proximity Sensors**



**XSF Rectangular Inductive Proximity Sensors**



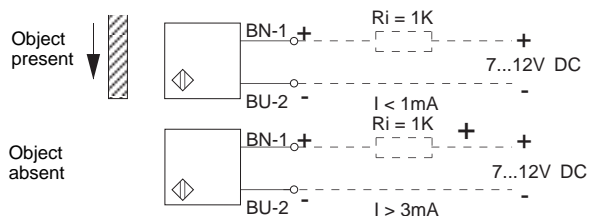
**XSD Rectangular Inductive Proximity Sensors**





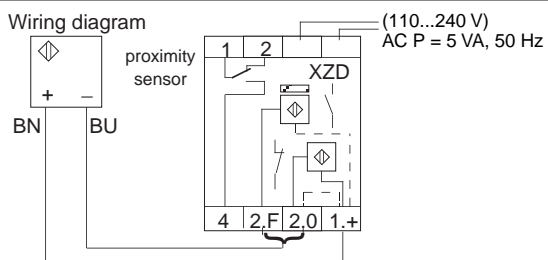
### XS Tubular Inductive Proximity NAMUR Sensors

FIG. 1



Non-Intrinsically Safe Applications (Normal Safe Zone),  
Connected to a Solid State Input

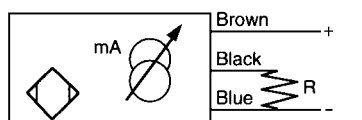
FIG. 2



With XZD Power Supply/Relay Amplifier Unit

### XS Inductive Proximity Sensors w/ Analog Output

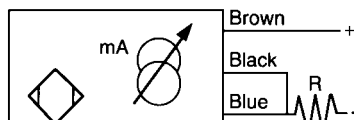
FIG. 3



Output current	Value of Load R (max.)
@ 24 V:	
0-10 mA	1800 Ω
0-16 mA	1125 Ω
@ 48 V:	
0-10 mA	4200 Ω

2-Wire DC

FIG. 4



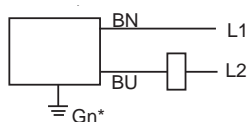
Output current	Value of Load R (max.)
@ 24 V:	
4-14 mA	640 Ω
4-20 mA	450 Ω
@ 48 V:	
4-14 mA	2350 Ω

3-Wire DC

These sensors may be wired in the 2- or 3-wire mode, depending on the current output characteristics required.

### XTA Tubular Capacitive Proximity Sensors

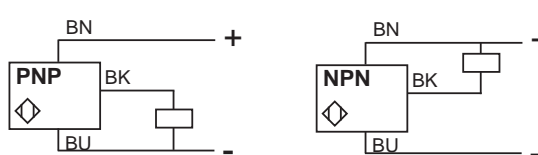
FIG. 5



\* Ground for XTA A115 only

2-Wire AC

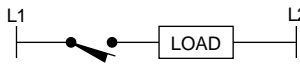
FIG. 6



3-Wire DC

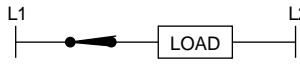
**SG Magnet Actuated Proximity Sensors, Surface Mount Style**

FIG. 1



SGA 8016, SGA 8031, SGA 8182, SGA 8053, SGA 8176, SGA 8177, SGO 8168 and SG08239

FIG. 2



SGB 8175

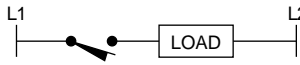
FIG. 3



SG2 8195

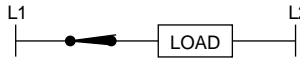
**SG Magnet Actuated Proximity Sensors, Limit Switch Style**

FIG. 4



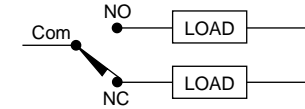
SG0 8003, SG1 8004, SGA 8005 and SGA 8040

FIG. 5



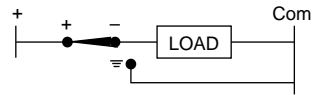
SG0 L8003 and SG1 L8004

FIG. 6



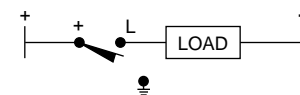
SGC 8027 and SGC 8025

FIG. 7



SG0 B8114, SG1 B8147, SGO BL8114, SGO BL8147 and SGC 8142-T-P

FIG. 8

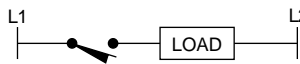


SG0 8079 and SG1 8056

SG1 8056 is normally closed. Connect red terminal (+) to power source. Connect minus (-) terminal to load. Housing must be connected to minus.

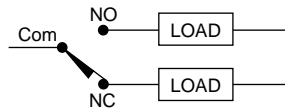
**SG Magnet Actuated Proximity Sensors, Tubular Style**

FIG. 9



SGA 8057, SGA 8189, SGA 8072, SGA 8179, SGA 8180 and SGA 8038

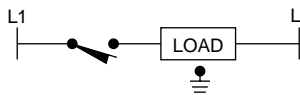
FIG. 10



SGC 8058 and SGC 8181

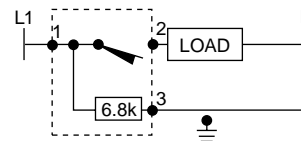
**SG Magnet Actuated Proximity Sensors, Maintained Contact**

FIG. 11



SGA 8018, SGO 8026

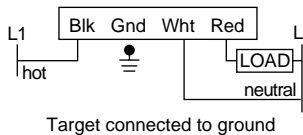
FIG. 12



SGO 8110

**ST Grounded Probe Switch**

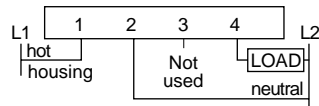
FIG. 13



Target connected to ground

Cable Wiring

FIG. 14



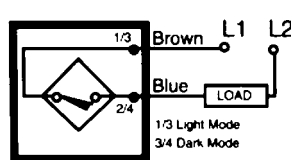
Target connected to ground. Housing must be grounded for proper operation.

Terminal strip Wiring

ST switches may be wired in series or parallel. For series operation, connect red lead (terminal 4) to black lead (terminal 1) of other switch. The voltage drop across each switch (in the closed state) does not exceed 2 VAC.

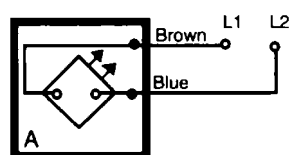
**XUB Short Range Tubular Photoelectric Sensors**

FIG. 15



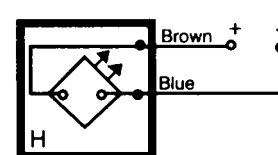
2-Wire AC

FIG. 16



AC Emitter

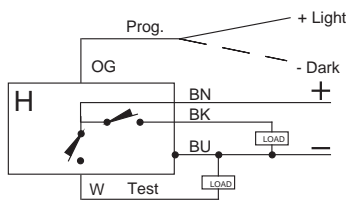
FIG. 17



DC Emitter

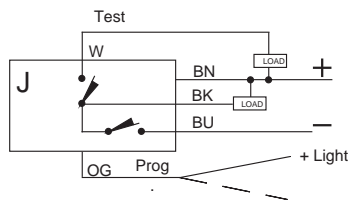
**XUM Miniature High Performance Photoelectric Sensors**

**FIG. 1**



PNP Output

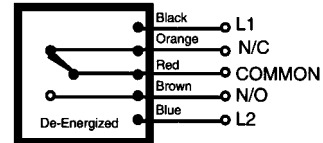
**FIG. 2**



NPN Output

**XUH and XUG Medium Range Photoelectric Sensors**

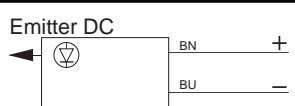
**FIG. 3**



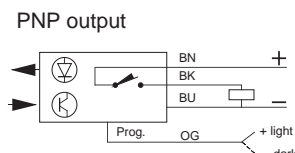
5-Wire AC

**XUL Subcompact Photoelectric Sensors**

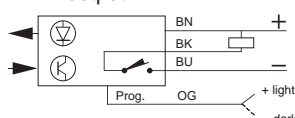
**FIG. 4**



DC 3 wire

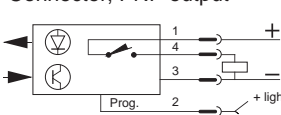


NPN output

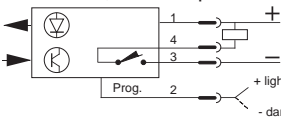


DC

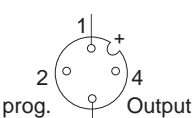
Connector, PNP output



Connector, NPN output

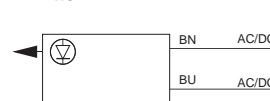


DC connector



**FIG. 5**

Emitter



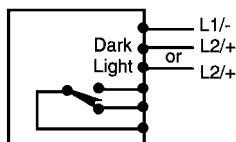
Relay output  
AC/DC versions



AC/DC

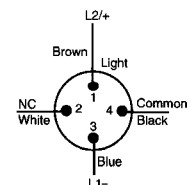
**XUJ Compact High Performance Photoelectric Sensors**

**FIG. 6**



5-Wire Relay, AC/DC

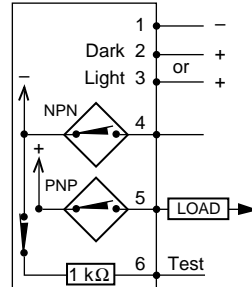
**FIG. 7**



For dark mode connect  
Brown wire to terminal 2  
For NO contact connect  
White wire to terminal 4

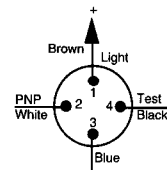
AC/DC Microchange  
DC Connector

**FIG. 8**



DC Output

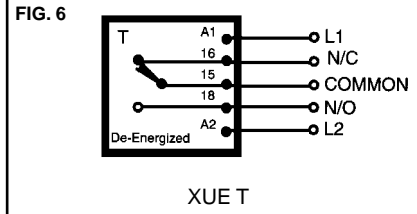
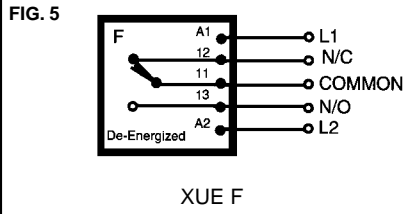
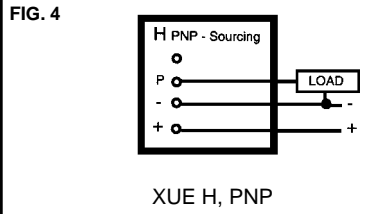
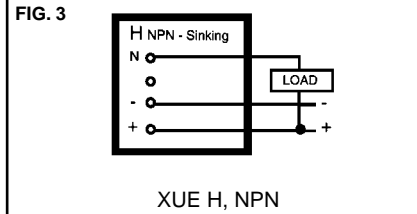
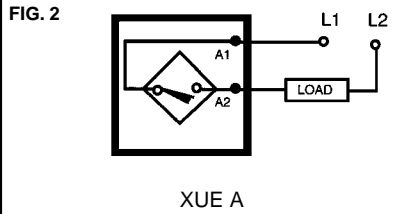
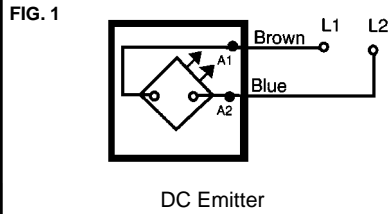
**FIG. 9**



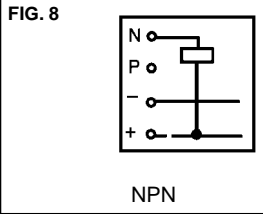
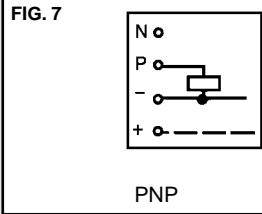
For dark mode connect  
Brown wire to terminal 2  
For NPN output connect  
White wire to terminal 4

DC Output Microchange  
DC Connector

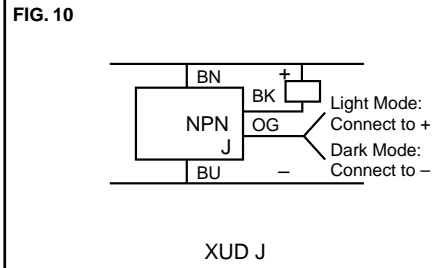
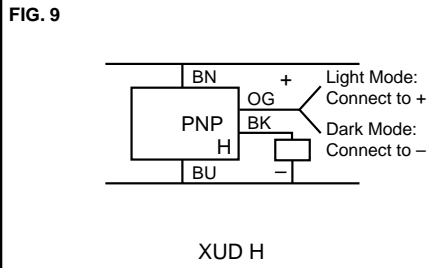
**XUE Long Range Plug-In Photoelectric Sensors**



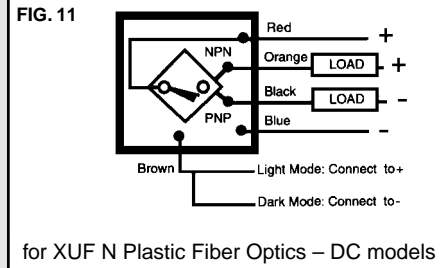
**XUR Color Registration Photoelectric Sensors**



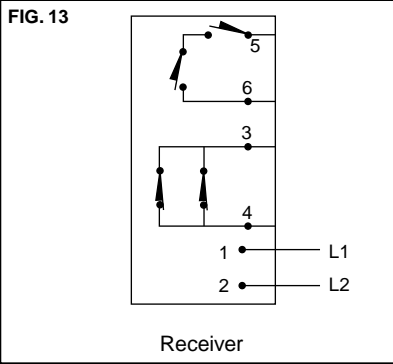
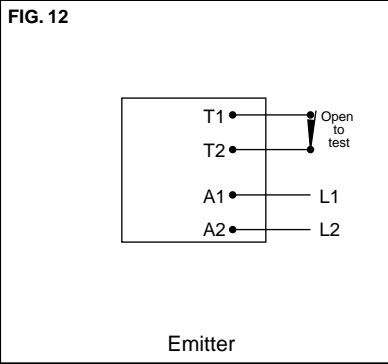
**XUD Amplifiers**



**XUG Amplifiers**



**XUE S Security Light Barriers**



XUV Photoelectric Sensors w/ Separate Optical Heads

FIG. 1

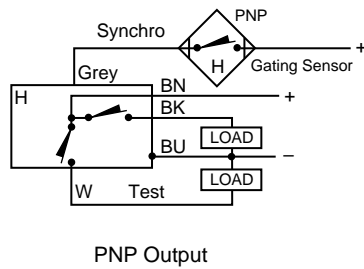


FIG. 2

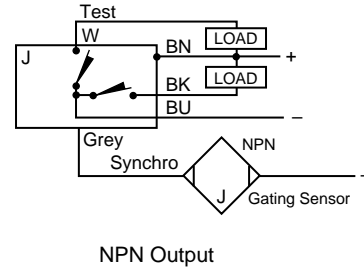
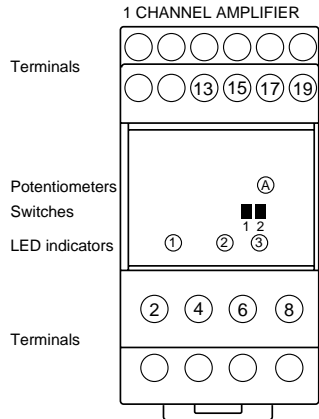


FIG. 3

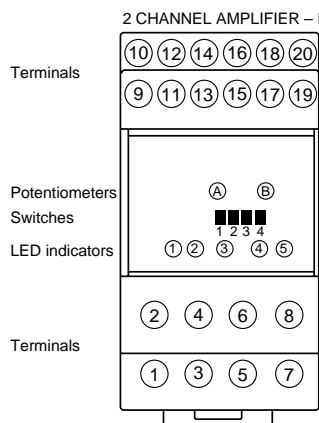


TERMINALS
2 L1 Supply
4 L2 Supply
6-8 Relay output (1 contact)
13 Receiver (white wire)
15 Receiver shielded cable
17 Emitter shield
19 Emitter (red wire)

SWITCHES
1 Light/Dark
2 Monostable timer (pulse stretcher)

POTENTIOMETERS
A Sensitivity adjustment

LED INDICATORS
1 Green: power supply
2 Red: unstable
3 Yellow: output

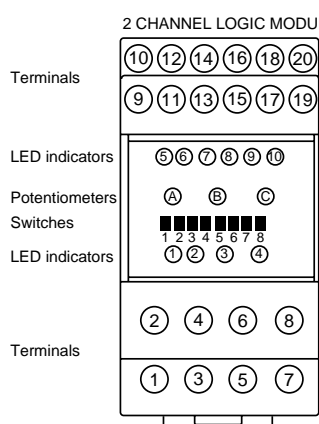


TERMINALS
1 L1 Supply
2 L2 Supply
3 NC output, Channel 2
4 NC output, Channel 1
5 Common, Channel 2
6 Common, Channel 1
7 NO output, Channel 2
8 NO output, Channel 1
9 12 VDC output ⊖ for synchro sensors
10 12 VDC output ⊕ for synchro sensors
11 Synchronization, Channel 2, NPN
12 Synchronization, Channel 1, NPN
13 Emitter shield, Channel 1
14 Receiver, Channel 1 (white wire)
15 Emitter, Channel 1 (red wire)
16 Receiver shield, Channel 1
17 Emitter shield, Channel 2
18 Receiver, Channel 2 (white wire)
19 Emitter, Channel 2 (red wire)
20 Receiver shield, Channel 2

SWITCHES
1 Monostable timer (pulse stretcher), Channel 1
2 Light/Dark, Channel 1
3 Monostable timer (pulse stretcher), Channel 2
4 Light/Dark, Channel 2

POTENTIOMETERS
A Sensitivity adjustment, Channel 1
B Sensitivity adjustment, Channel 2

LED INDICATORS
1 Green: power supply
2 Red: unstable, Channel 1
3 Yellow: output, Channel 1
4 Red: unstable, Channel 2
5 Yellow: output, Channel 2



TERMINALS
1 L1 Supply
2 L2 Supply
3 Output test (1 contact relay)
4 Output test (1 contact relay)
5 Channel 1 output (1 contact relay)
6 Channel 1 output (1 contact relay)
7 Channel 2 output (1 contact relay)
8 Channel 2 output (1 contact relay)
9 12 VDC output ⊖ for synchro sensors
10 12 VDC output ⊕ for synchro sensors
11 Synchronization, Channel 2, NPN
12 Synchronization, Channel 1, NPN
13 Emitter shield, Channel 1
14 Receiver, Channel 1 (white wire)
15 Emitter, Channel 1 (red wire)
16 Receiver shield, Channel 1
17 Emitter shield, Channel 2
18 Receiver, Channel 2 (white wire)
19 Emitter, Channel 2 (red wire)
20 Receiver shield, Channel 2

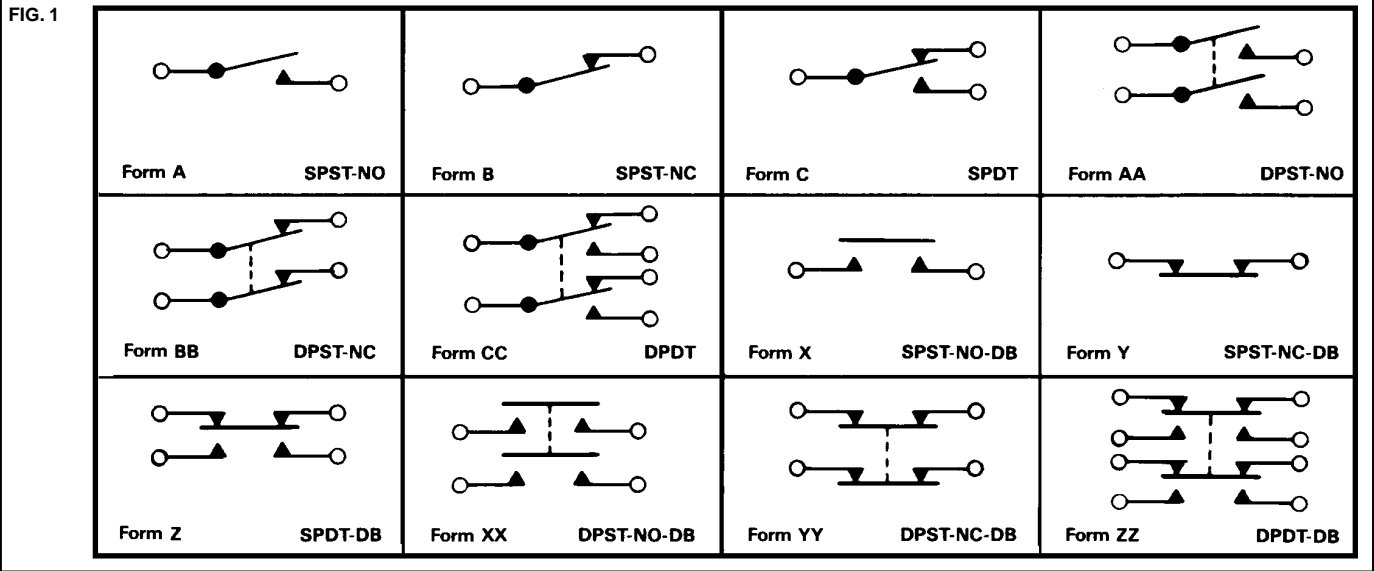
SWITCHES
1 Time delay, Channel 1 (0.05 to 3 s or 1 to 60 s)
2 Time delay, Channel 1 (On/Off)
3 Time delay mode (mono. or adjustable time delay)
4 Leading/Trailing edge selection
5 Logic function (And/Or)
6 Logic function (On/Off)
7 Light/Dark, Channel 1
8 Light/Dark, Channel 2

POTENTIOMETERS
A Time delay, Channel 1
B Sensitivity adjustment, Channel 1
C Sensitivity adjustment, Channel 2

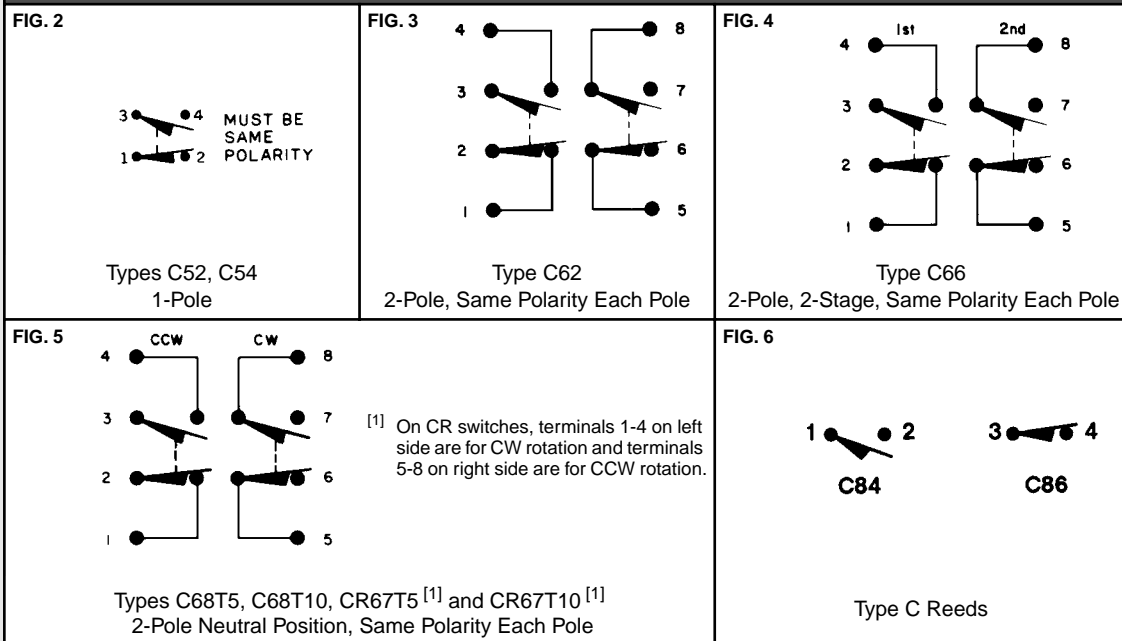
LED INDICATORS
1 Green: power supply
2 Red: output test
3 Yellow: output, Channel 1
4 Yellow: output, Channel 2
5 Green: synchronization, Channel 1
6 Yellow: detection, Channel 1
7 Red: unstable, Channel 1
8 Green: synchronization, Channel 2
9 Yellow: detection, Channel 2
10 Red: unstable, Channel 2

AC Wiring Diagrams

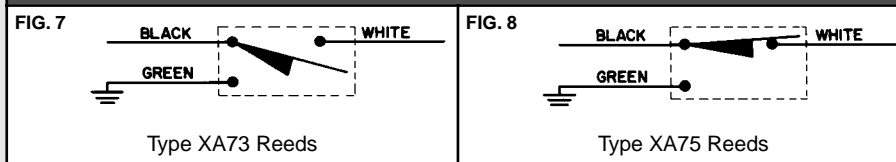
Contact Forms for  
Class 9007 Limit Switches

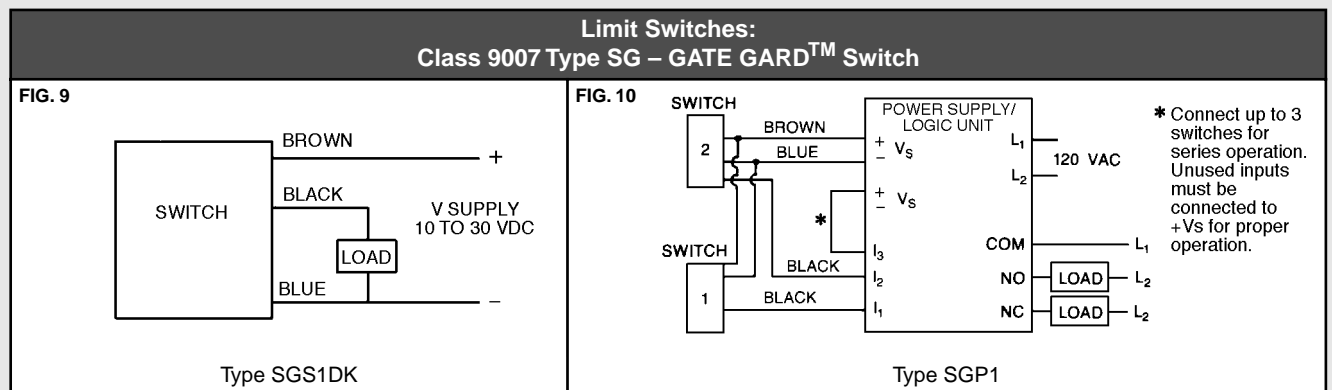
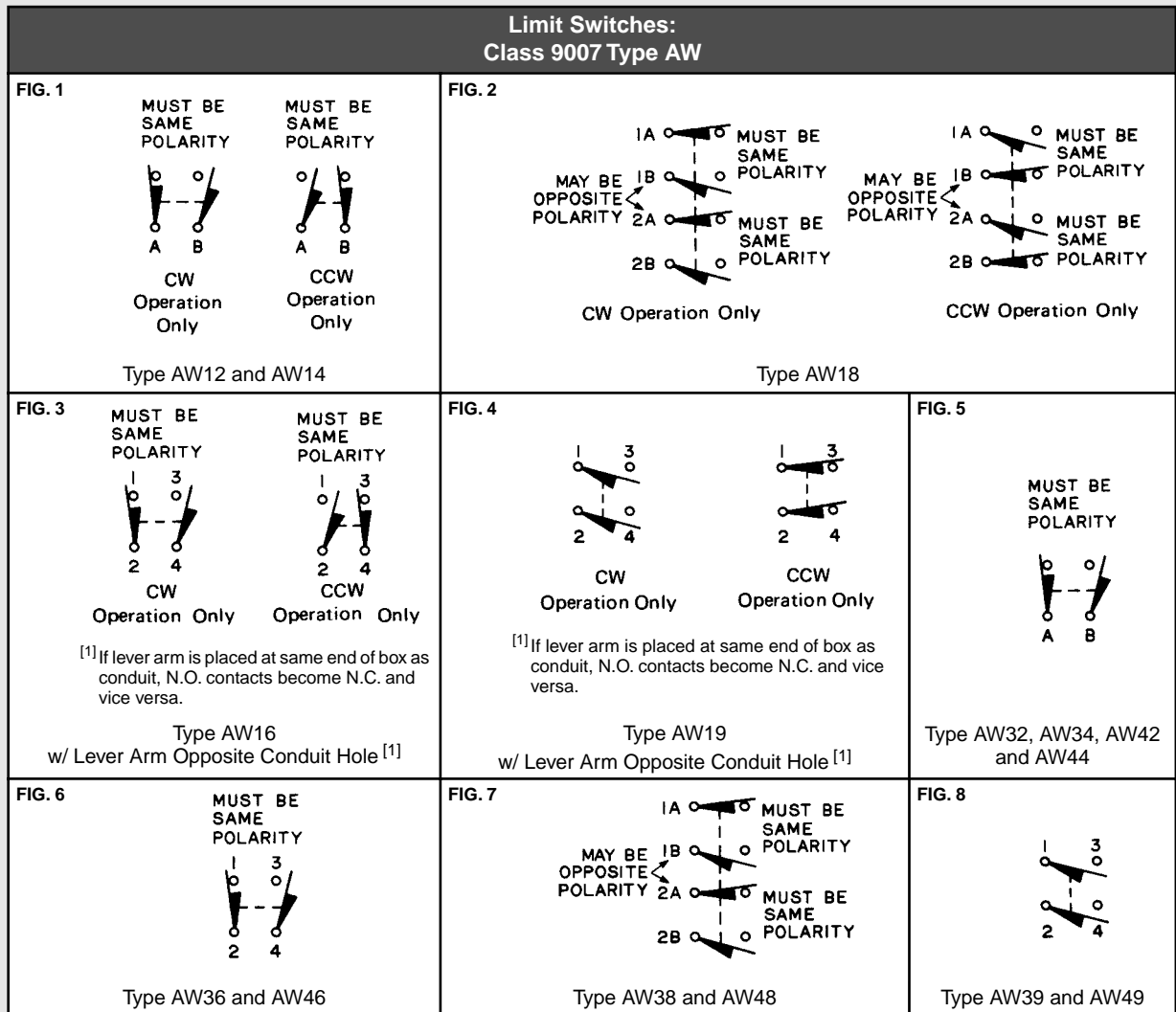


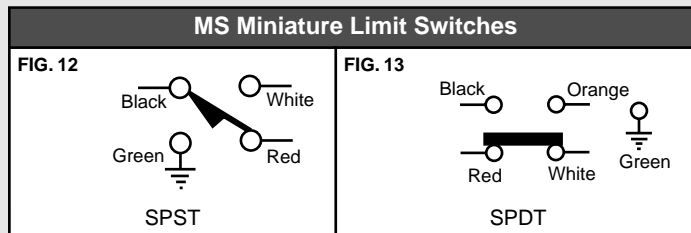
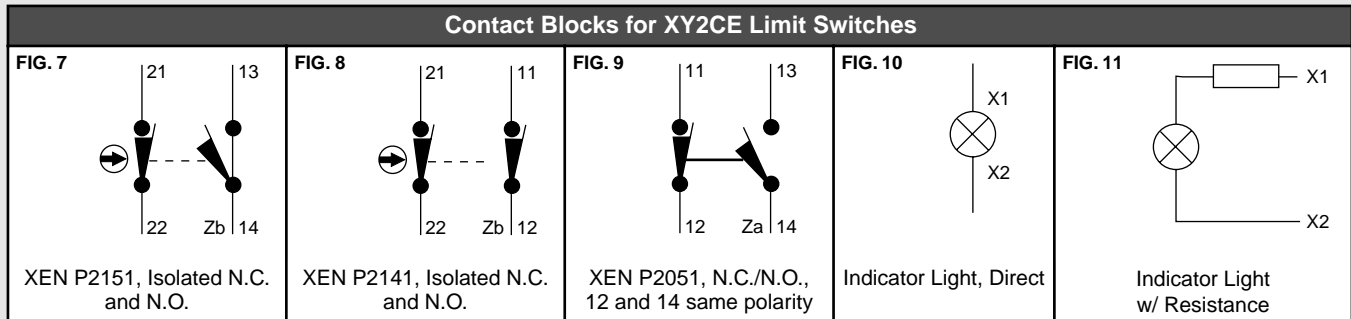
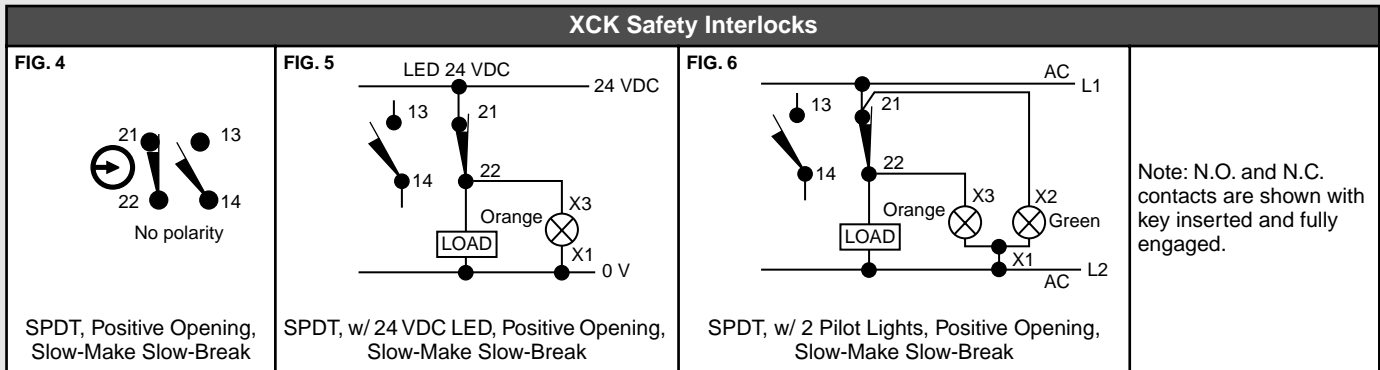
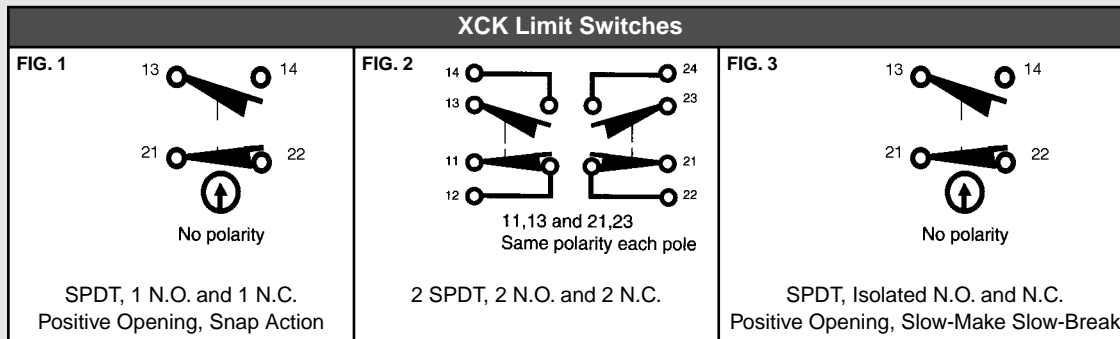
Limit Switches:  
Class 9007 Type C



Limit Switches:  
Class 9007 Type XA

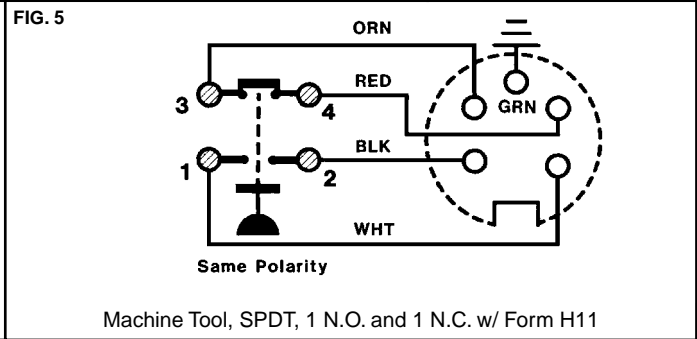
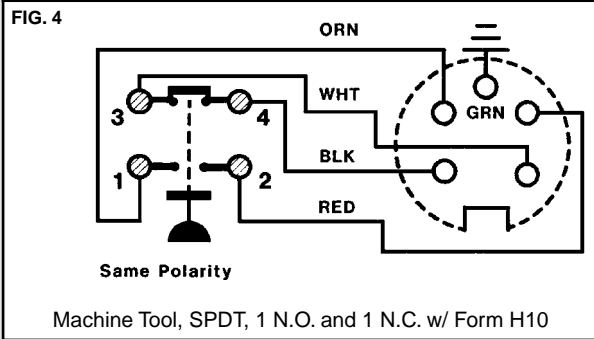
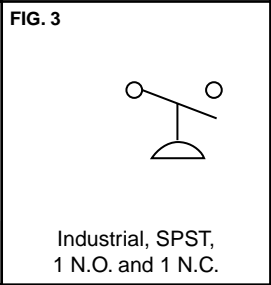
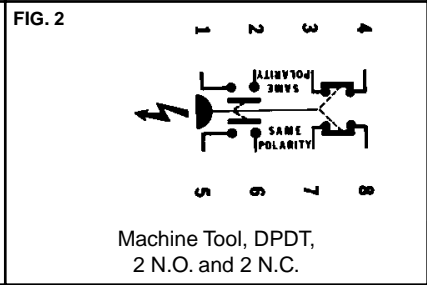
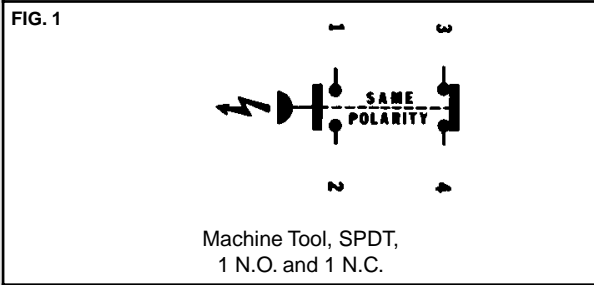




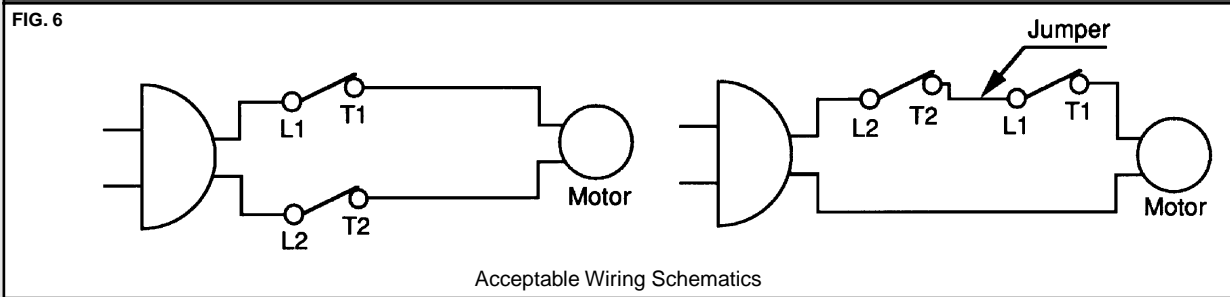




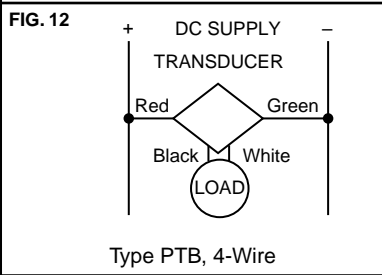
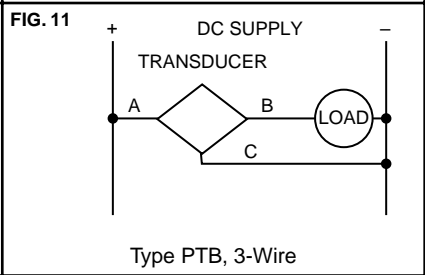
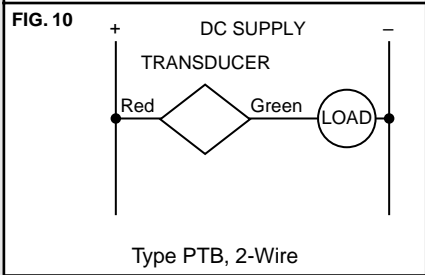
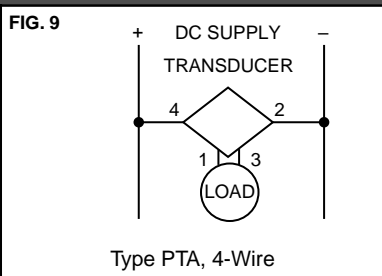
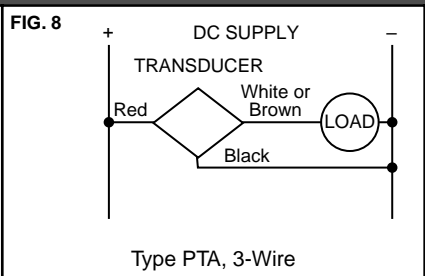
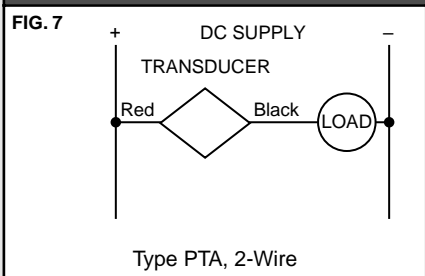
**Pressure and Temperature Switches:  
Class 9012 and 9025 Type G**



**Commercial Pressure Switches:  
Class 9013 Type CS**



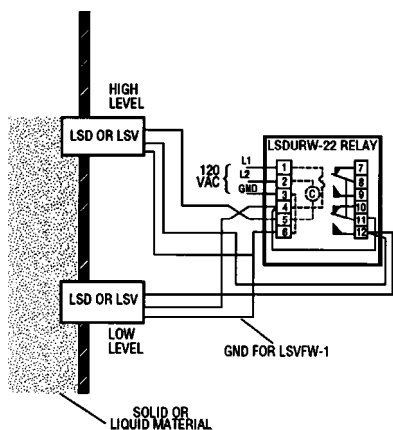
**Pressure Transducers:  
Class 9022 Type PTA and PTB**



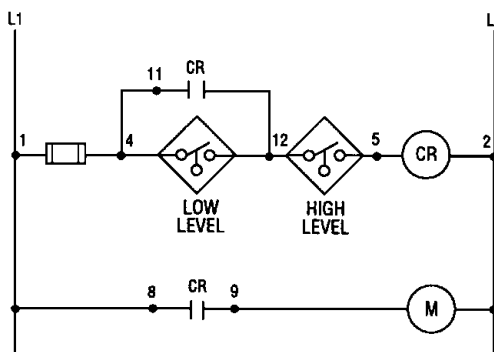
Level Sensors:  
Class 9034 Types LSD and LSV

FIG. 1

Wiring Diagram



Elementary Diagram

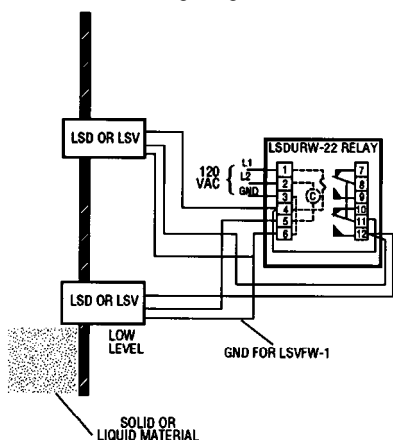


Output selection of both sensors in maximum (N.C. when absent). Both devices at max. setting.

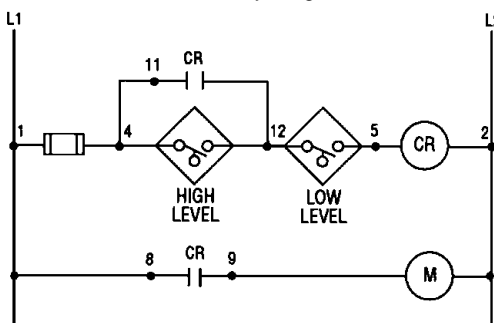
Fill Cycle, Tank Full

FIG. 2

Wiring Diagram



Elementary Diagram

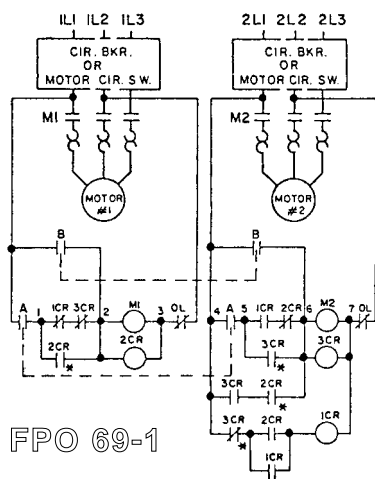


Output selection of both sensors in minimum (N.O. when absent). Both devices at min. setting.

Drain Cycle, Tank Empty

Electric Alternators:  
Class 9039 Type X

FIG. 3



FPO 69-1

Set pilot device A contacts to close before pilot device B contacts.

Connections shown are for common control. If motor line voltage is different from voltage rating stamped on alternator coil terminals, alternator must be connected to motor lines thru control transformers.

Control circuit conductors require overcurrent protection in accordance with applicable electrical codes.

\* Overlapping contact.

Pneumatic Timing Relays:  
Class 9050: Type AO

<p>FIG. 1</p> <p>Type AO10E</p>	<p>FIG. 2</p> <p>Type AO10D</p>	<p>FIG. 3</p> <p>Type AO20E</p>	<p>FIG. 4</p> <p>Type AO20D</p>	<p>FIG. 5</p> <p>Type AO110DE</p>	<p>FIG. 6</p> <p>Type AO120DE</p>
<p>FIG. 7</p> <p>Type AO11E</p>	<p>FIG. 8</p> <p>Type AO11D</p>	<p>FIG. 9</p> <p>Type AO21E</p>	<p>FIG. 10</p> <p>Type AO21D</p>	<p>FIG. 11</p> <p>Type AO111DE</p>	<p>FIG. 12</p> <p>Type AO121DE</p>
<p>FIG. 13</p> <p>Type AO12E</p>	<p>FIG. 14</p> <p>Type AO12D</p>	<p>FIG. 15</p> <p>Type AO22E</p>	<p>FIG. 16</p> <p>Type AO22D</p>	<p>FIG. 17</p> <p>Type AO112DE</p>	<p>FIG. 18</p> <p>Type AO122DE</p>
<p>FIG. 19</p> <p>Type AO210DE</p>	<p>FIG. 20</p> <p>Type AO211DE</p>	<p>FIG. 21</p> <p>Type AO212DE</p>	<p>FIG. 22</p> <p>Type AO220DE</p>	<p>FIG. 23</p> <p>Type AO221DE</p>	<p>FIG. 24</p> <p>Type AO222DE</p>

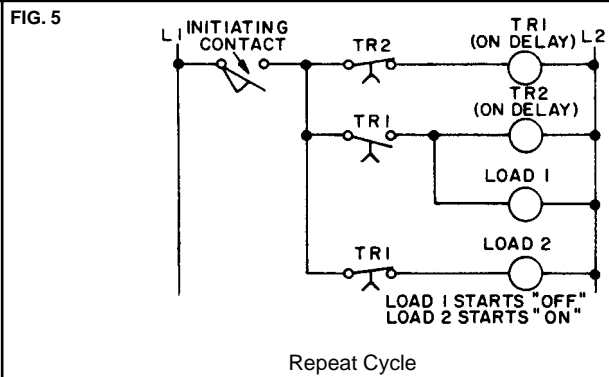
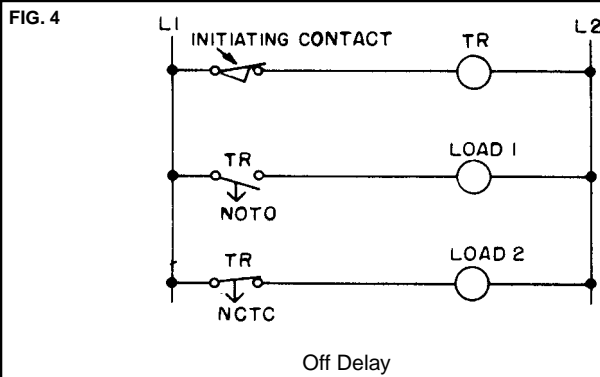
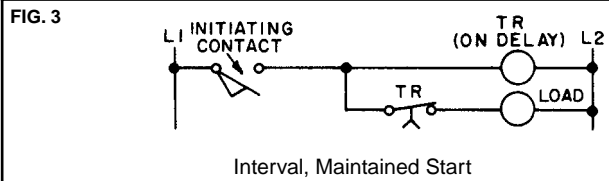
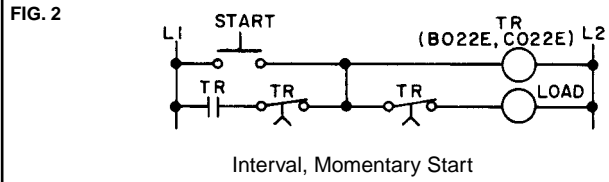
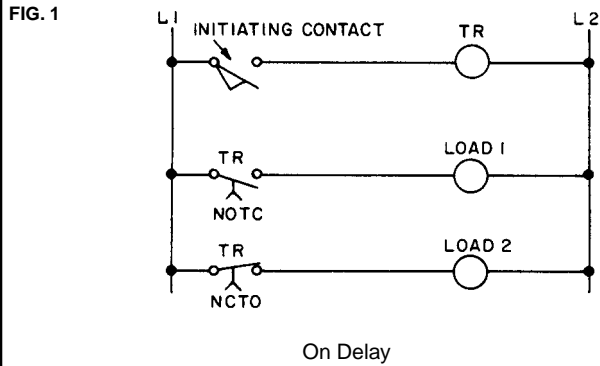
Pneumatic Timing Relays:  
Class 9050: Type HO

<p>FIG. 25</p> <p>Type HO10E, On Delay</p>	<p>FIG. 26</p> <p>Type HO10D, Off Delay</p>
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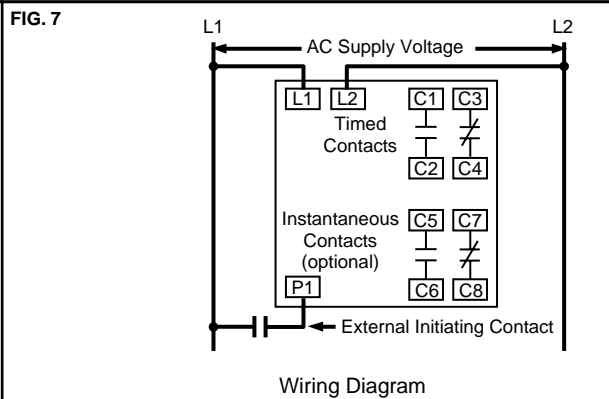
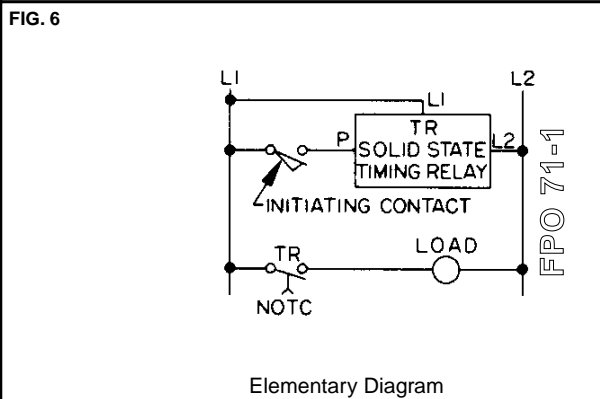
Pneumatic Timing Relays:  
Class 9050: Types B and C

<p>FIG. 27</p> <p>Off Delay</p> <p>Type B</p>	<p>FIG. 28</p> <p>On Delay</p> <p>Type C</p>
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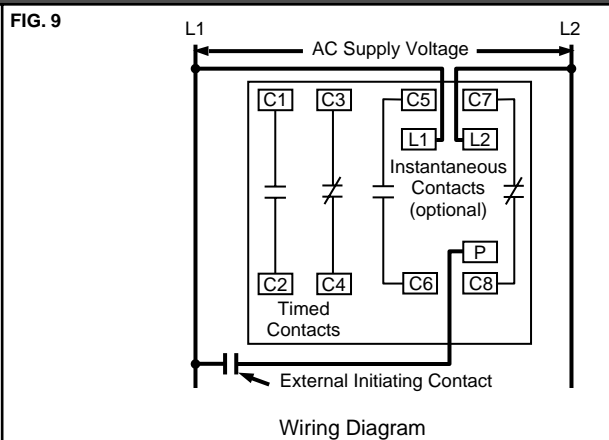
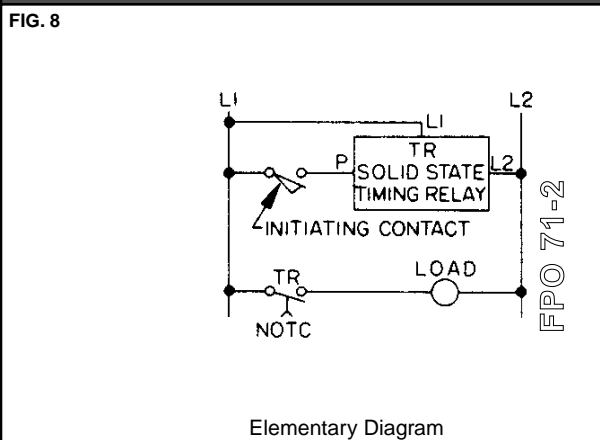
Class 9050 Pneumatic Timing Relays: Typical Elementary Diagrams



Solid State Industrial Timing Relays: Class 9050 Types FS and FSR

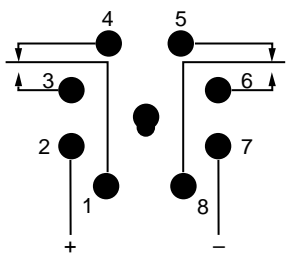


Solid State Industrial Timing Relays: Class 9050 Type FT



**Solid State Industrial Timing Relays:  
Class 9050 Type JCK**

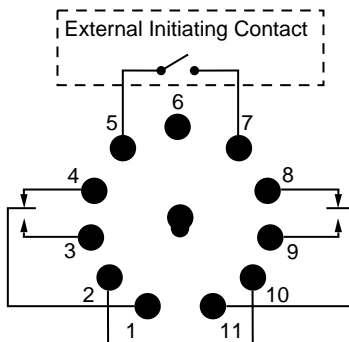
FIG. 1



Control Power  
Polarity markings are for DC units only. JCK 60 is AC only.

Type JCK 11-19, 31-39 and 51-60

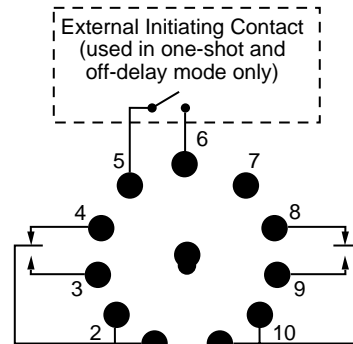
FIG. 2



Control Power  
Polarity markings are for DC units only.  
Terminals 5 and 10 are internally jumpered. Applying power to terminal 7 or jumpering from terminal 5 to 7 through an external contact initiates the timer.

Type JCK 21-29 and 41-49

FIG. 3

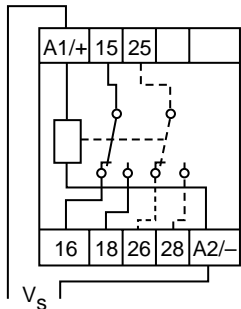


Control Power

Type JCK 70

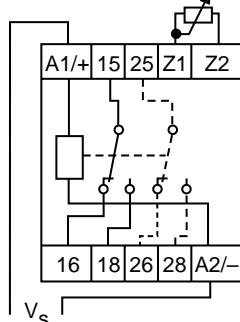
**Solid State Timers:  
Class 9050 Type D**

FIG. 4



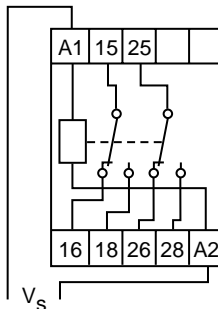
Type DER, DZM, DTR, DWE, DEW and DBR

FIG. 5



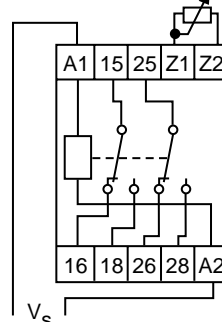
Type DERP, DERLP, DWEP and DZMP

FIG. 6



Type DAR

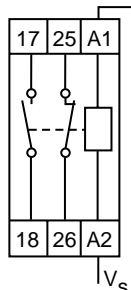
FIG. 7



Type DARP

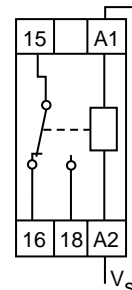
**Solid State Timers:  
Class 9050 Type M**

FIG. 8



Type MAN, MBR, MER, MEW, MTG, MWE and MZM

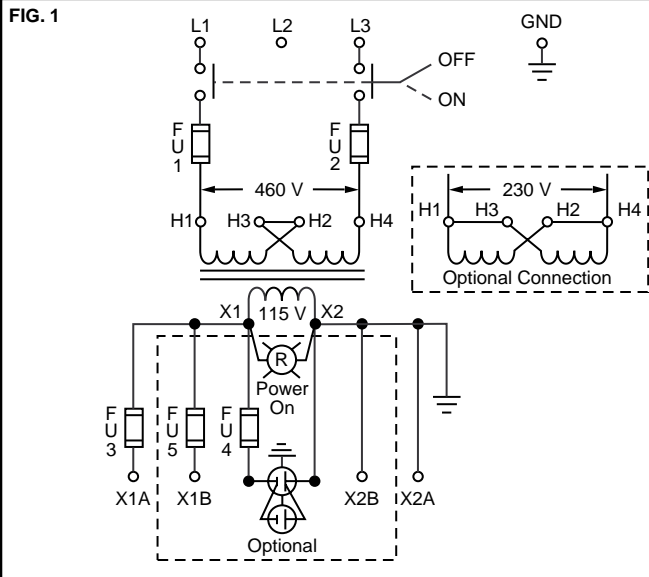
FIG. 9



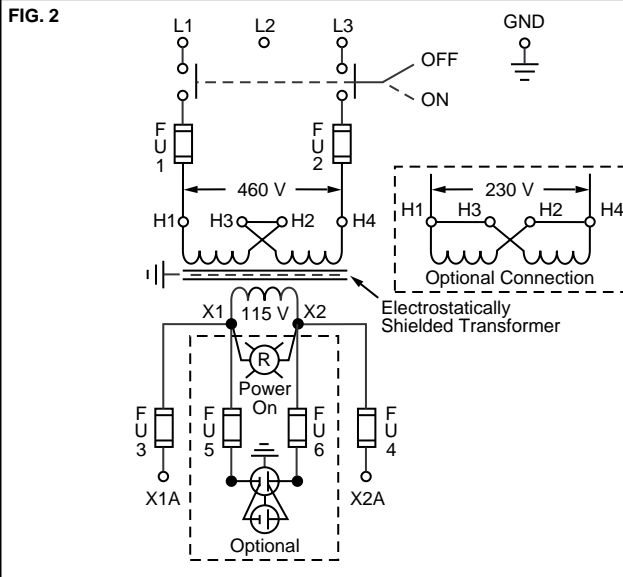
Type MAR

**Transformer Disconnects:  
Class 9070**

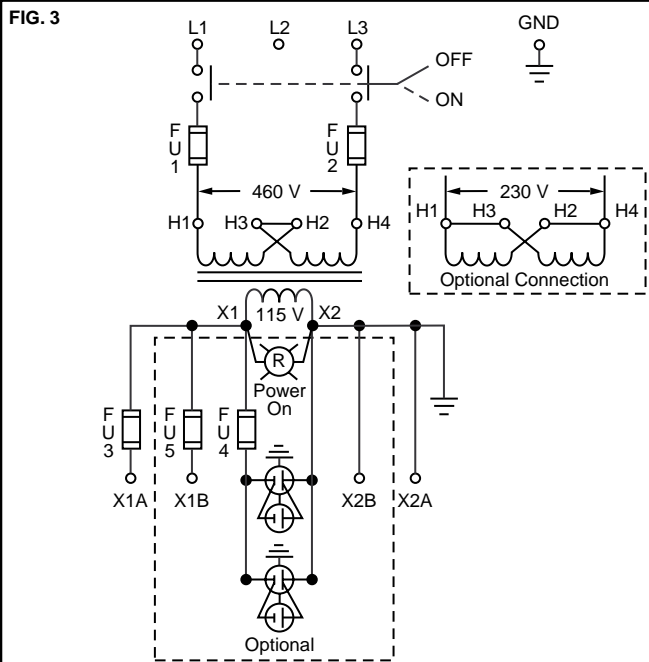
Note: Some factory modifications, depending on enclosure and transformer VA size selected, are not available. Consult factory modification chart.



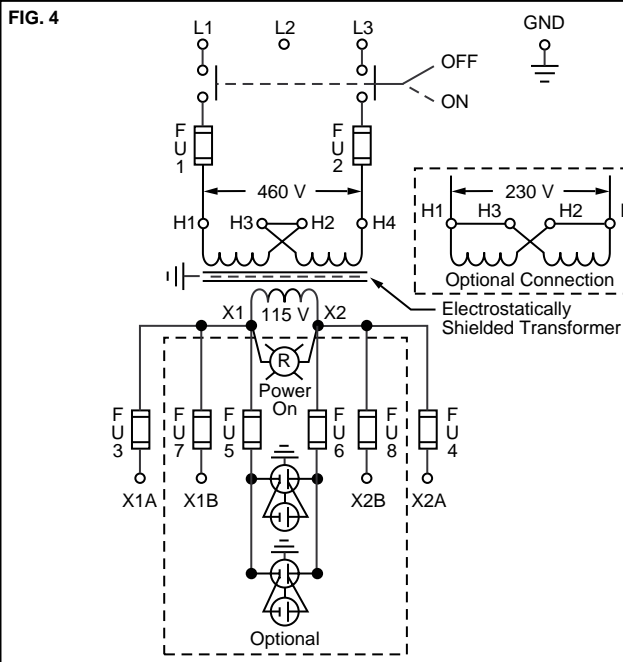
For Size 1 Enclosures except w/ Form E23



For Size 1 Enclosures w/ Form E23



For Size 2 Enclosures except w/ Form E23



For Size 2 Enclosures w/ Form E23

Table 6 Enclosures for Non-Hazardous Locations

Provides Protection Against	NEMA Type 1	NEMA Type 3 <sup>[1]</sup>	NEMA Type 3R <sup>[1]</sup>	NEMA Type 4 <sup>[2]</sup>	NEMA Type 4X <sup>[2]</sup>	Type 5	NEMA Type 12 <sup>[3]</sup>	Type 12K	NEMA Type 13
Accidental contact w/ enclosed equipment	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Falling dirt	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Falling liquids and light splashing	...	Yes	Yes	Yes	Yes	...	Yes	Yes	Yes
Dust, lint, fibers and flyings	...	...	...	Yes	Yes	Yes	Yes	Yes	Yes
Hosedown and splashing water	...	...	...	Yes	Yes	...	...	...	...
Oil and coolant seepage	...	...	...	...	...	...	Yes	Yes	Yes
Oil and coolant spraying and splashing	...	...	...	...	...	...	...	...	Yes
Corrosive agents	...	...	...	...	Yes	...	...	...	...
Rain, snow and sleet <sup>[4]</sup>	...	Yes	Yes	[5]	Yes	...	...	...	...
Windblown dust	...	Yes	...	[5]	Yes	Yes	...	...	...

[1] Intended for outdoor use.

[2] Intended for indoor and outdoor use.

[3] Square D Industrial Control design NEMA Type 12 enclosures may be field modified for outdoor applications.

[4] External operating mechanisms are not required to be operable when the enclosure is ice covered.

[5] Square D Industrial Control design NEMA Type 4 enclosures provide protection against these environments.

Table 7 Enclosures for Hazardous Locations

Provides Protection Against	Class <sup>[1]</sup>	Group <sup>[1]</sup>	Enclosure					
			NEMA Type 7			NEMA Type 9		
			7B	7C	7D	9E	9F	9G
Hydrogen, manufactured gas	I	B	Yes	...	...	...	...	...
Ethyl ether, ethylene, cyclopropane	I	C	Yes	Yes	...	...	...	...
Gasoline, hexane, naphtha, benzine, butane, propane, alcohol, acetone, benzol, natural gas, lacquer solvent	I	D	Yes	Yes	Yes	...	...	...
Metal dust	II	E	...	...	...	Yes	...	...
Carbon black, coal dust, coke dust	II	F	...	...	...	...	Yes	...
Flour, starch, grain dust	II	G	...	...	...	...	Yes	Yes

[1] As described in Article 500 of the National Electrical Code.

# Conductor Ampacity and Conduit Tables

## Based on 1993 National Electrical Code

Ampacity Based on NEC® Table 310-16 — Allowable Ampacities of Insulated Conductors Rated 0-2000 Volts, Not More Than Three Conductors in Raceway or Cable. Based on 30 °C Ambient Temperature. Trade Size of Conduit or Tubing Based on NEC Chapter 9, Table 1 and Tables 3A, 3B, 3C, 4 and 5B. Refer to Chapter 9 for Maximum Number of Conductors in Trade Sizes of Conduit or Tubing. Dimensions of Insulated Conductors for Conduit Fill Determined from NEC Chapter 9 Tables 5 and 5A.

**For information on temperature ratings of terminations to equipment, see NEC Section 110-14c. Underlined conductor insulation types indicates ampacity is for WET locations. See NEC Table 310-13.**

Table 8 Conductor Ampacity based on NEC Table 310-16

Wire Size AWG kcmil	COPPER CONDUCTORS									ALUMINUM CONDUCTORS								
	75 °C (167 °F) Conductor Insulation [1]						90 °C (194 °F) Conductor Insulation [1]			75 °C (167 °F) Conductor Insulation [1]						90 °C (194 °F) Conductor Insulation [1]		
	Table 310-16 Ampacity Insulated Copper	THHW, THW, RW, USE		THWN, XHHW		Table 310-16 Ampacity Insulated Copper	THHN, XHHW		Wire Size AWG kcmil	Table 310-16 Ampacity Insulated Copper	THHW, THW, USE		XHHW		Table 310-16 Ampacity Insulated Copper	THHN, XHHW		
		Conduit 3W	Conduit 4W [2]	Conduit 3W	Conduit 4W [2]		Conduit 3W	Conduit 4W [2]			Conduit 3W	Conduit 4W [2]	Conduit 3W	Conduit 4W [2]		Conduit 3W	Conduit 4W [2]	
†14	20	...	...	1/2	1/2	25	1/2	1/2	...	...	...	...	...	...	...	...	...	
†12	25	...	...	1/2	1/2	30	1/2	1/2	†12	20	...	...	1/2	1/2	25	1/2	1/2	
†10	35	...	...	1/2	1/2	40	1/2	1/2	†10	30	...	...	1/2	1/2	35	1/2	1/2	
8	50	3/4	1	1/2 [3]	3/4	55	1/2 [3]	3/4	8	40	3/4	3/4	1/2	3/4	45	1/2	3/4	
6	65	1	1	3/4	3/4 [4]	75	3/4	3/4 [4]	6	50	3/4	1	3/4	3/4	60	3/4	3/4	
4	85	1	1-1/4	1	1	95	1	1	4	65	1	1	3/4	1	75	3/4	1	
3	100	1-1/4	1-1/4	1	1-1/4	110	1	1-1/4	3	75	...	...	...	...	85	...	...	
2	115	1-1/4	1-1/4	1	1-1/4	130	1	1-1/4	2	90	1	1-1/4	1	1-1/4	100	1	1-1/4	
1	130	1-1/4	1-1/2	1-1/4	1-1/2	150	1-1/4	1-1/2	1	100	1-1/4	1-1/2	1-1/4	1-1/2	115	1-1/4	1-1/2	
1/0	150	1-1/2	2	1-1/4	1-1/2	170	1-1/4	1-1/2	1/0	120	1-1/4	1-1/2	1-1/4	1-1/2	135	1-1/4	1-1/2	
2/0	175	1-1/2	2	1-1/2	2	195	1-1/2	2	2/0	135	1-1/2	2	1-1/4	1-1/2	150	1-1/4	1-1/2	
3/0	200	2	2	1-1/2	2	225	1-1/2	2	3/0	155	1-1/2	2	1-1/2	2	175	1-1/2	2	
4/0	230	2	2-1/2	2	2	260	2	2	4/0	180	2	2	1-1/2	2	205	1-1/2	2	
250	255	2-1/2	2-1/2	2	2-1/2	290	2	2-1/2	250	205	2	2-1/2	2	2	230	2	2	
300	285	2-1/2	3	2	2-1/2	320	2	2-1/2	300	230	2	2-1/2	2	2-1/2	255	2	2-1/2	
350	310	2-1/2	3	2-1/2	3	350	2-1/2	3	350	250	2-1/2	3	2-1/2	3	280	2-1/2	3	
400	335	3	3	2-1/2	3	380	2-1/2	3	400	270	2-1/2	3	2-1/2	2-1/2 [5]	305	2-1/2	2-1/2 [5]	
500	380	3	3-1/2	3	3	430	3	3	500	310	3	3	2-1/2	3	350	2-1/2	3	
600	420	3	3-1/2	3	3-1/2	475	3	3-1/2	600	340	3	3-1/2	3	3	385	3	3	
700	460	3-1/2	4	3	3-1/2	520	3	3-1/2	700	375	3	3-1/2	3	3-1/2	420	3	3-1/2	
750	475	3-1/2	4	3-1/2	4	535	3-1/2	4	750	385	3	3-1/2	3	3-1/2	435	3	3-1/2	
800	490	3-1/2	4	3-1/2	4	555	3-1/2	4	800	395	...	...	...	...	450	...	...	
900	520	4	5	3-1/2	4	585	3-1/2	4	900	425	...	...	...	...	480	...	...	
1000	545	4	5	3-1/2	5	615	3-1/2	5	1000	445	3-1/2	4	3-1/2	4	500	3-1/2	4	

[1] Unless otherwise permitted in the Code, the overcurrent protection for conductor types marked with an with an obelisk (†) shall not exceed 15 A for No. 14, 20 A for No. 12 and 30 A for No. 10 copper, or 15 A for No. 12 and 25 A for No. 10 aluminum after any correction factors for ambient temperature and number of conductors have been applied.

[2] On a 4-wire, 3-phase wye circuit where the major portion of the load consists of nonlinear loads such as electric discharge lighting, electronic computer/data processing, or similar equipment there are harmonic currents present in the neutral conductor and the neutral shall be considered to be a current-carrying conductor.

[3] #8 XHHW copper wire requires 3/4" conduit for 3W.

[4] #6 XHHW copper wire requires 1" conduit for 3Ø4W.

[5] 400 kcmil aluminum wire requires 3" conduit for 3Ø4W.

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**Ampacity Correction Factors:**

For ambient temperatures other than 30 °C (86 °F), multiply the ampacities listed in Table 8 by the appropriate factor listed in Table 9.

**Adjustment Factors:**

Where the number of current-carrying conductors in a raceway or cable exceeds three, reduce the allowable ampacities as shown in Table 9.

Table 9 Ampacity Correction Factors

Ambient Temperature (°C)	75 °C (167 °F) Conductors	90 °C (194 °F) Conductors	Ambient Temperature (°F)
21-25	1.05	1.04	70-77
26-30	1.00	1.00	78-86
31-35	.94	.96	87-95
36-40	.88	.91	96-104
41-45	.82	.87	105-113
46-50	.75	.82	114-122
51-55	.67	.76	123-131
56-60	.58	.71	132-140
61-70	.33	.58	141-158
71-80	...	.41	159-176

Table 10 Adjustment Factors

No. of Current-Carrying Inductors	Values in Tables as Adjusted for Ambient Temperature
4-6	80%
7-9	70%
10-20	50%
21-30	45%
31-40	40%
41 and above	35%

For exceptions, see exceptions to Note 8 of NEC<sup>®</sup> Table 310-16.

**Ratings for 120/240 V, 3-Wire, Single-Phase Dwelling Services:**

The ratings in Table 11 are permitted ratings for dwelling unit service and feeder conductors which carry the total load of the dwelling. The grounded conductor (neutral) shall be permitted to be not more than 2 AWG sizes smaller than the ungrounded conductors, provided the requirements of 215-2, 220-22 and 230-42 are met.

Table 11 Ratings for 120/240 V, 3-Wire, Single-Phase Dwelling Services – see NEC 310-16 Note 3

Rating (A)	100	110	125	150	175	200	225	250	300	350	400
<b>Copper</b>	4 AWG	3 AWG	2 AWG	1 AWG	1/0 AWG	2/0 AWG	3/0 AWG	4/0 AWG	250 kcmil	350 kcmil	400 kcmil
<b>Aluminum</b>	2 AWG	1 AWG	1/0 AWG	2/0 AWG	3/0 AWG	4/0 AWG	250 kcmil	300 kcmil	350 kcmil	500 kcmil	600 kcmil

**NEC 240-3 Protection of Conductors:**

Conductors, other than flexible cords and fixture wires, shall be protected against overcurrent in accordance with their ampacities as specified in NEC Section 310-15, unless otherwise permitted in parts (a) through (m).

**NEC 220-3 (a) Continuous and Noncontinuous Loads:**

The branch circuit rating shall not be less than the noncontinuous load plus 125% of the continuous load (see exception for 100% rated devices).

**NEC 220-10 (b) Continuous and Noncontinuous Loads:**

Where a feeder supplies continuous loads or any combination of continuous and noncontinuous loads, the rating of the overcurrent device shall not be less than the noncontinuous load plus 125% of the continuous load (see exception for 100% rated devices).

**NEC 430-22 (a) Single Motor Circuit Conductors:**

Branch circuit conductors supplying a single motor shall have an ampacity not less than 125% of the motor full-load current rating (see exceptions).

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Table 12 AWG and Metric Wire Data

AWG Size	Conductor dia. (mm)	Conductor dia. (in)	Resistance @ 20 °C (68 °F)		AWG Size	Conductor dia. (mm)	Conductor dia. (in)	Resistance @ 20 °C (68 °F)	
			Ohm per ft	Ohm per m				Ohm per ft	Ohm per m
29		.01126	.08180	.2684	13	1.900	.07480	.001853	.006081
	.315	.01240	.06743	.2212		2.000	.07874	.001673	.005488
28		.01264	.06491	.2130	12		.08081	.001588	.005210
	.355	.01398	.05309	.1742		2.120	.08346	.001489	.004884
27		.01420	.05143	.1687		2.240	.08819	.001333	.004375
	.400	.01575	.04182	.1372	11		.09074	.001260	.004132
26		.01594	.04082	.1339		2.360	.09291	.001201	.003941
	.450	.01772	.03304	.1084		2.500	.09843	.001071	.003512
25		.01790	.03237	.1062	10		.1019	.0009988	.003277
	.500	.01969	.02676	.08781		2.650	.1043	.0009528	.003126
24		.02010	.02567	.08781		2.800	.1102	.0008534	.002800
	.560	.02205	.02134	.07000	9		.1144	.0007924	.002500
23		.02257	.02036	.06679		3.000	.1181	.0007434	.002439
	.630	.02480	.01686	.05531		3.150	.1240	.0006743	.002212
22		.02535	.01614	.05531	8		.1285	.0006281	.002061
	.710	.02795	.01280	.04201		3.350	.1319	.0005662	.001956
21		.02846	.01280	.04201		3.550	.1398	.0005309	.001742
	.750	.02953	.01190	.03903	7		.1443	.0004981	.001634
	.800	.03150	.01045	.03430		3.750	.1476	.0004758	.001561
20		.03196	.01015	.03331		4.000	.1575	.0004182	.001372
	.850	.03346	.009261	.05038	6		.1620	.0003952	.001296
	.900	.03543	.008260	.02642		4.250	.1673	.0003704	.001215
19		.03589	.008051	.02642		4.500	.1772	.0003304	.001084
	.950	.03740	.007414	.02432	5		.1819	.0003134	.001028
	1.000	.03937	.006991	.02195		4.750	.1870	.0002966	.0009729
18		.04030	.006386	.02095		5.000	.1968	.0002676	.0008781
	1.060	.04173	.005955	.01954	4		.2043	.0002485	.0008152
	1.120	.04409	.005334	.01750		5.600	.2205	.0002134	.0007000
17		.04526	.005063	.01661	3		.2294	.0001971	.0006466
	1.180	.04646	.004805	.01577		6.300	.2480	.0001686	.0005531
	1.250	.04921	.004282	.01405	2		.2576	.0001563	.0005128
16		.05082	.004016	.01317		7.100	.2795	.0001327	.0004355
	1.320	.05197	.003840	.01260	1		.2893	.0001239	.0004065
	1.400	.05512	.004016	.01317		8.000	.3150	.0001045	.0003430
15		.05707	.003414	.01045	0		.3249	.00009825	.0003223
	1.500	.05906	.002974	.009756		9.000	.3543	.00008260	.0002710
	1.600	.06299	.002526	.008286	2/0		.3648	.00007793	.0002557
14		.06408	.002315	.007596		10.000	.3937	.00006691	.0002195
	1.700	.06693	.002315	.007596	3/0		.4096	.00006182	.0002195
	1.800	.07087	.002065	.006775	4/0		.4600	.00004901	.0001608
13		.07196	.002003	.006571		11.800	.4646	.00004805	.0001577

Table 13 Electrical formulas for Amperes, Horsepower, Kilowatts and KVA

To find	Single phase	3-phase	Direct current
Kilowatts	$\frac{I \times E \times PF}{1000}$	$\frac{I \times E \times 1.73 \times PF}{1000}$	$\frac{I \times F}{1000}$
KVA	$\frac{I \times E}{1000}$	$\frac{I \times E \times 1.73}{1000}$	—
Horsepower (output)	$\frac{I \times E \times \% \text{ Eff} \times PF}{746}$	$\frac{I \times E \times 1.73 \times \% \text{ Eff} \times PF}{746}$	$\frac{I \times E \times \% \text{ Eff}}{746}$
Amperes when Horsepower is known	$\frac{HP \times 746}{E \times \% \text{ Eff} \times PF}$	$\frac{HP \times 746}{1.73 \times E \times \% \text{ Eff} \times PF}$	$\frac{HP \times 746}{E \times \% \text{ Eff}}$
Amperes when Kilowatts is known	$\frac{KW \times 1000}{E \times PF}$	$\frac{KW \times 1000}{1.73 \times E \times PF}$	$\frac{KW \times 1000}{E}$
Amperes	$\frac{KVA \times 1000}{E}$	$\frac{KVA \times 1000}{1.73 \times E}$	—

E=Volts I = Amperes %Eff = Percent efficiency PF = Power factor HP = Horsepower KVA = Kilovolt-Amps

**Average Efficiency and Power Factor Values of Motors:**

When actual efficiencies and power factors of the motors to be controlled are not known, the following approximations may be used:

**Efficiencies:**

DC motors, 35 hp and less:	80% to 85%
DC motors, above 35 hp:	85% to 90%
Synchronous motors (at 100% PF):	92% to 95%

**“Apparent” efficiencies (Efficiency x PF):**

3-phase induction motors, 25 hp and less:	70%
3-phase induction motors above 25 hp:	80%

Decrease these figures slightly for single phase induction motors.

Table 14 Ratings for 3-Phase, Single-Speed, Full-Voltage Magnetic Controllers for Nonplugging and Nonjogging Duty

Size of Controller	Continous Current Rating (A)	Horsepower at <sup>[1]</sup>				Service-Limit Current Rating (A)
		60 Hz 200 V	60 Hz 230 V	50 Hz 380 V	60 Hz 460 or 575 V	
00	9	1-1/2	1-1/2	1-1/2	2	11
0	18	3	3	5	5	21
1	27	7-1/2	7-1/2	10	10	32
2	45	10	15	25	25	52
3	90	25	30	50	50	104
4	135	40	50	75	100	156
5	270	75	100	150	200	311
6	540	150	200	300	400	621
7	810	—	300	—	600	932

<sup>[1]</sup> These horsepower ratings are based on typical locked-rotor current ratings. For motors having higher locked-rotor currents, use a larger controller to ensure its locked-rotor current rating is not exceeded.

Table 15 Ratings for 3-Phase, Single-Speed, Full-Voltage Magnetic Controllers for Plug-Stop, Plug-Reverse or Jogging Duty

Size of Controller	Continuous Current Rating (A)	Horsepower at <sup>[1]</sup>				Service-Limit Current Rating (A)
		60 Hz 200 V	60 Hz 230 V	50 Hz 380 V	60 Hz 460 or 575 V	
0	18	1-1/2	1-1/2	1-1/2	2	21
1	27	3	3	5	5	32
2	45	7-1/2	10	15	15	52
3	90	15	20	30	30	104
4	135	25	30	50	60	156
5	270	60	75	125	150	311
6	540	125	150	250	300	621

<sup>[1]</sup> These horsepower ratings are based on typical locked-rotor current ratings. For motors having higher locked-rotor currents, use a larger controller to ensure its locked-rotor current rating is not exceeded.

Table 16 Power Conversions

From	to kW	to PS	to hp	to ft-lb/s
1 kW (kilowatt) = $10^{10}$ erg/s	1	1.360	1.341	737.6
1 PS (metric horsepower)	0.7355	1	0.9863	542.5
1 hp (horsepower)	0.7457	1.014	1	550.0
1 ft-lb/s (foot-pound per sec)	$1.356 \times 10^{-3}$	$1.843 \times 10^{-3}$	$1.818 \times 10^{-3}$	1

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