

# Dr. Norbert Cheung's Series in Electrical Engineering

Level 4      Topic no: 01

## Control Components and Ladder Diagram

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1. Introduction
2. Control Components
3. Ladder Network
4. Application Example

### Reference:

“Industrial Control Handbook,” 2nd Edition, E.A. Parr, Butterworth Heinemann

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## **1. Introduction**

- Most control machines built in 10-20 years ago relies on control components and ladder logic.
- The method is low cost and efficient, and the technique is known by most people at that time. The method is very robust and can withstand harsh environment and EMI/EMC interference.
- However, as the control requirement gets more complicated, and the circuit needs frequent changes, the hard-wiring technique becomes inefficient and clumsy.
- Nowadays most of this control functions are replaced by Programmable Logic Controllers (PLC). However, the method of programming the PLC is still using the ladder network technique.
- Relay type ladder logic network is still used in some simple applications today.

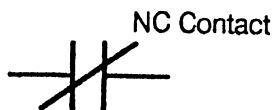
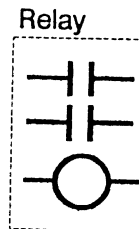
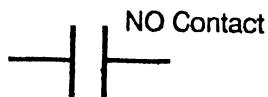
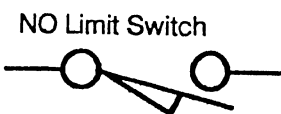
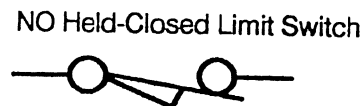
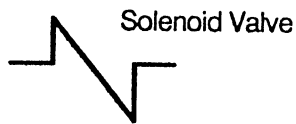
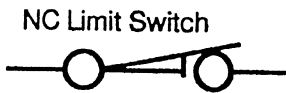
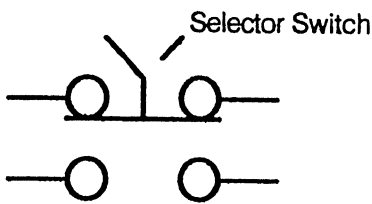
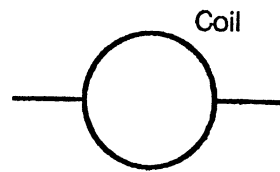
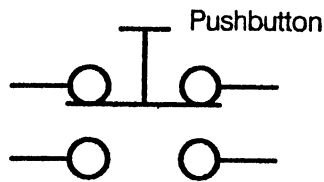


## 2. Components for Industrial Control

This includes Control Components, Input Components, and Output Components:

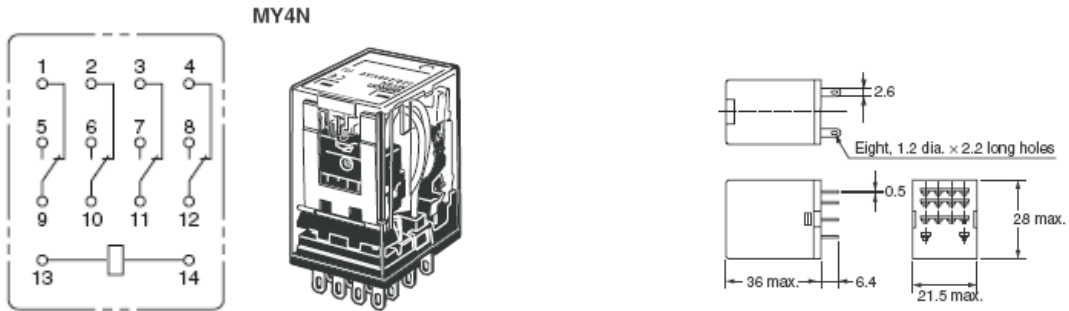
- Example of Control Components: Relay, Timer, Counter, etc.
- Example of Output Components: Contactors, Motor, Lamp, etc.
- Example of Input Components: Limit Switches, Sensors, etc.

### Common Electrical Symbols



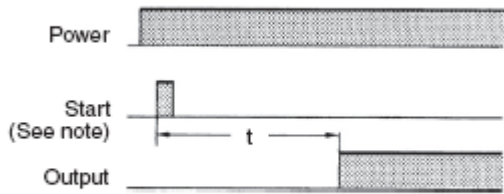
## Control Relays

### 4-Pole Models



## Delay Timer

### Basic operation



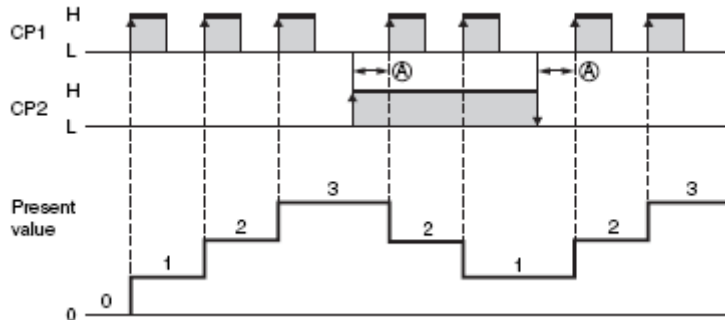
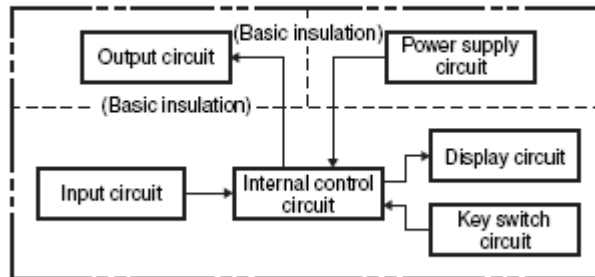
**Note:** Start input is invalid while the Timer is in operation.



## Counter



### Block Diagram

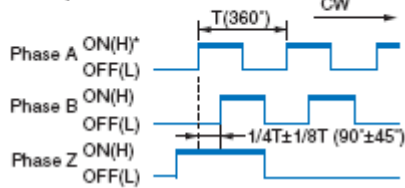


## Incremental Encoders



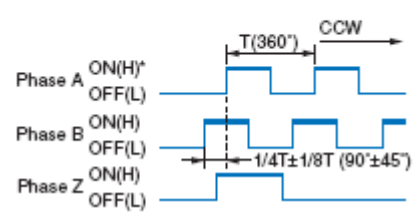
Direction of rotation: CW  
(as viewed from end of shaft)

Output transistor



Direction of rotation: CCW  
(as viewed from end of shaft)

Output transistor

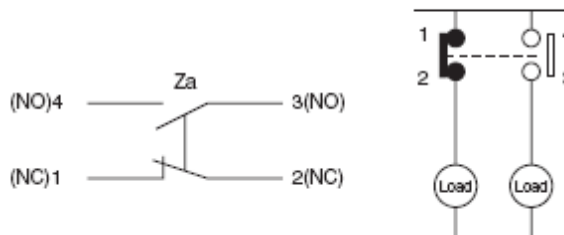


## Limit Switches



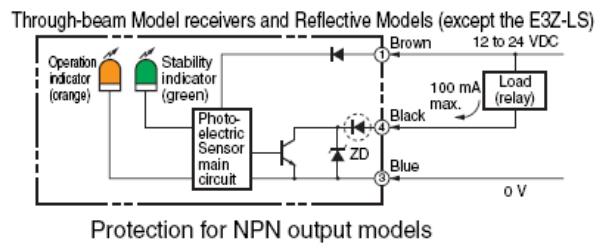
### **DPDB Operation**

The double-pole, double-break structure ensures circuit braking.



For more information, please visit: <http://www.ia.omron.com>

## Light Sensor

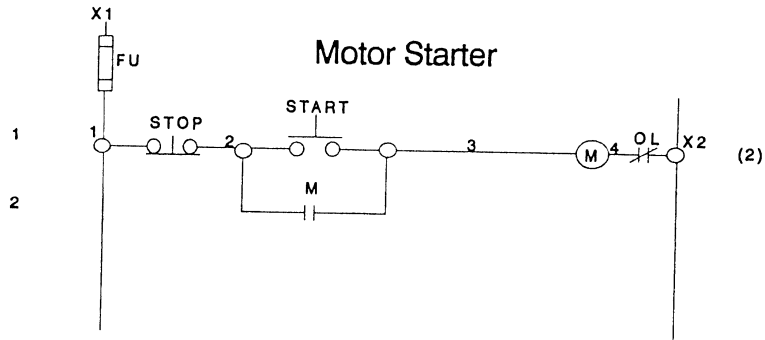


## 3. Ladder Diagrams

- Ladder diagrams are the most common method of showing electrical logic.
- They are usually referred to as schematic diagrams, because they show the sequential scheme or order of events for the process and the control components required.
- The physical locations of the control components are not primary considerations in this diagram, only the sequence of operation and the relative timing (scheduling) of events.
- Each rung of the ladder represents a separate event.
- The left side-bar is the beginning of the event, and the right one represents the completion.
- Electrically, the left side is usually the positive or high side of the control power, and the right is the negative, or low side.
- The power source will be labeled at the top of the side rails, or shown connected to a source such as a control transformer.
- Logic is read from left to right on each rung of the ladder.
- Conditions are represented by normally open (NO) or normally closed (NC) contacts.
- The resulting action, or stored information, will usually be represented by a relay, contactor coil, or solenoid.
- The conditional contacts are often referred to as inputs, and the coils as outputs.
- Inputs such as push-buttons and limit switches are usually shown using their symbolic contacts.

A motor control Ladder Diagram

After Ladder



the

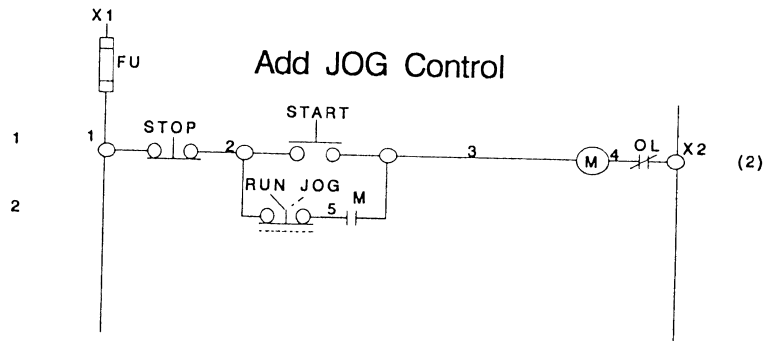
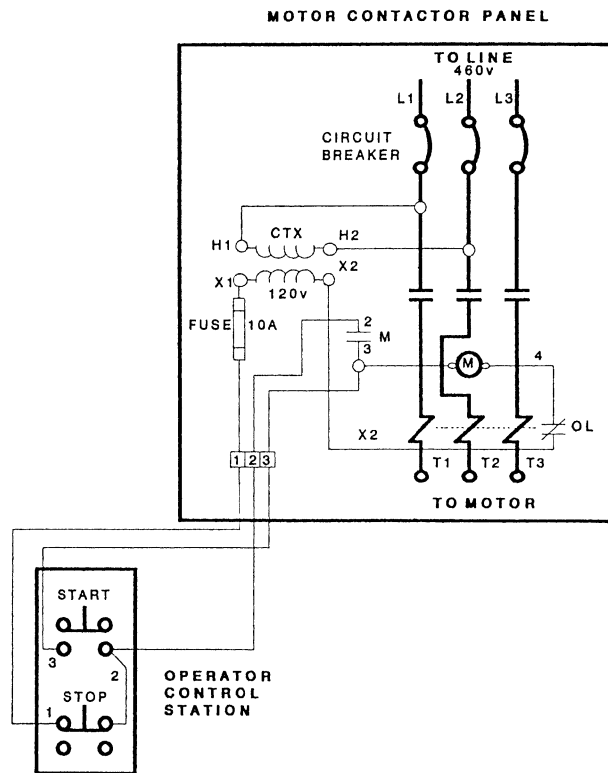
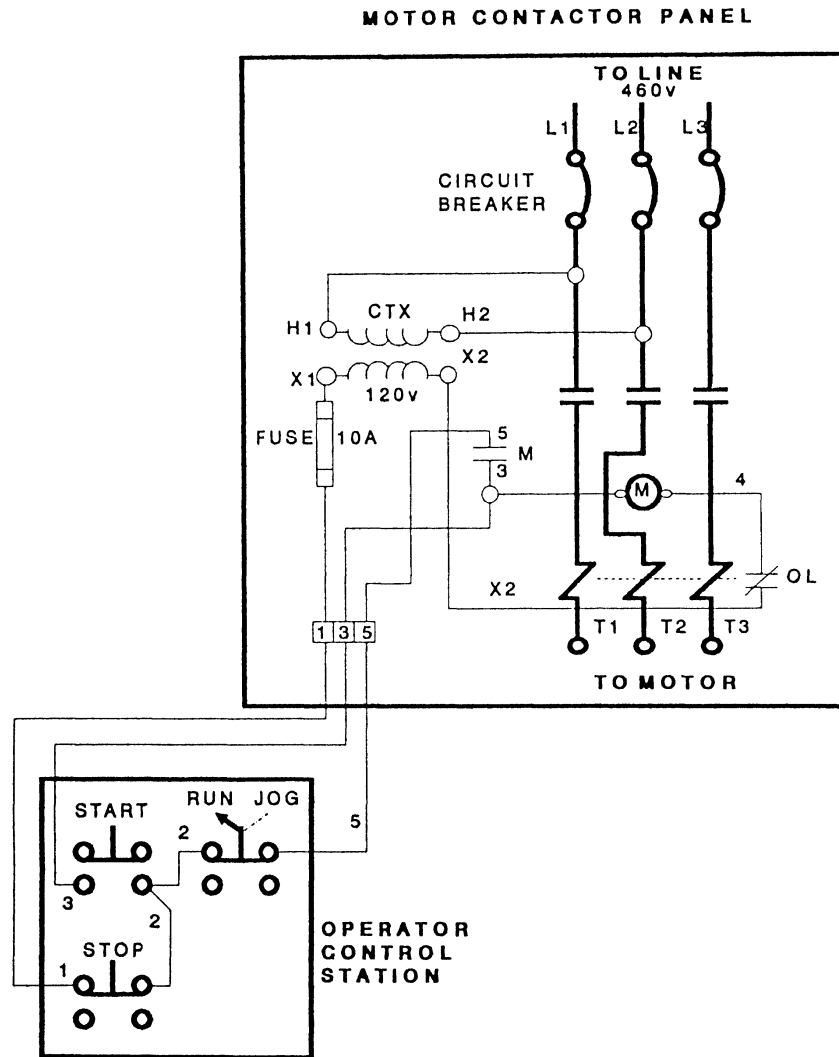


Diagram is done, the Wiring Diagram can proceed...



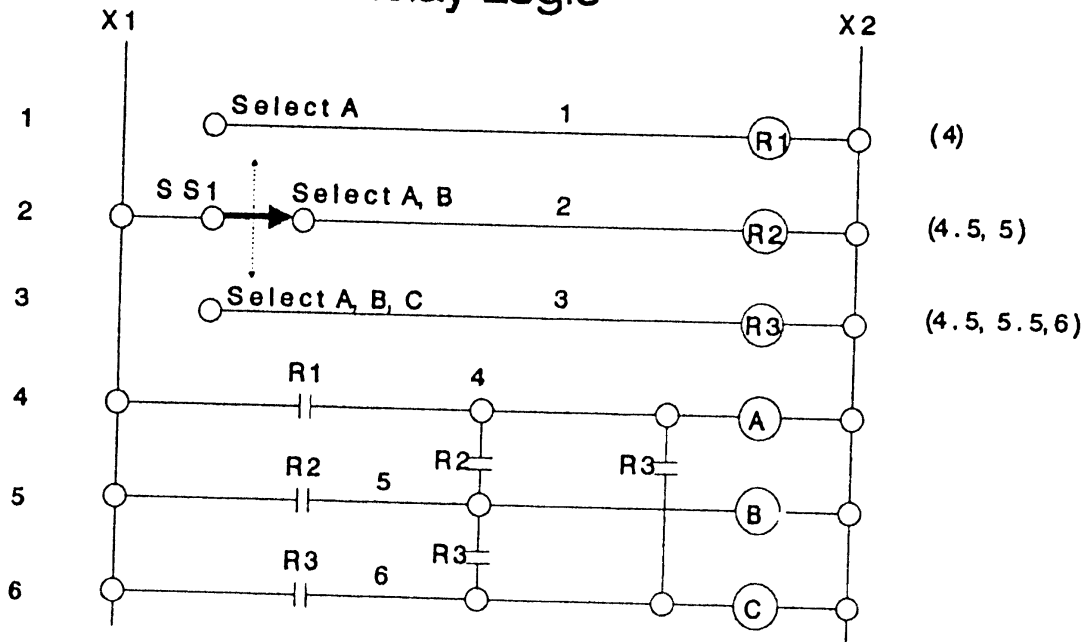
Another version of the wiring diagram (with the jog function)



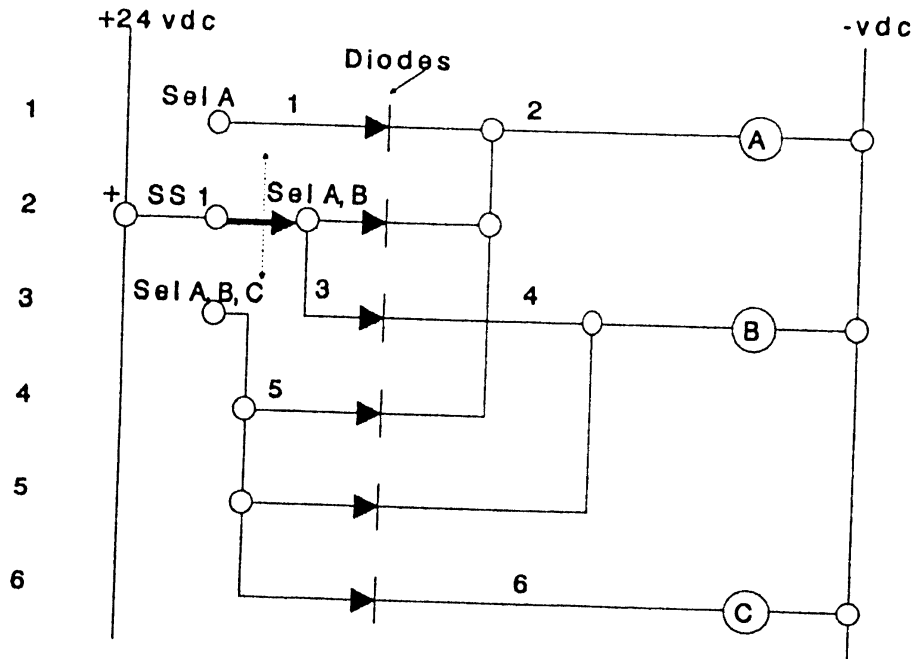


There are some cases in which Relay Logic is preferred to simple relay switch logic, as shown below....

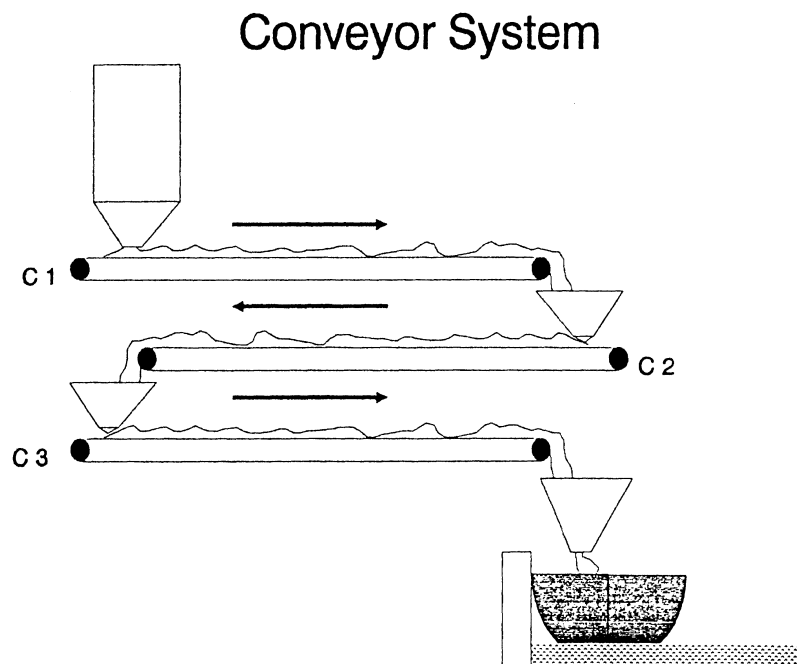
### Relay Logic



### Diode Logic



## 4. Application Example



### Automatic Mode

- Start in a timed sequence of C3, C2, C1 to prevent dropping grain on a stopped or loaded conveyor.
- Stop in a timed sequence of C1, C2, C3 to allow the system to totally empty.

### Manual Mode

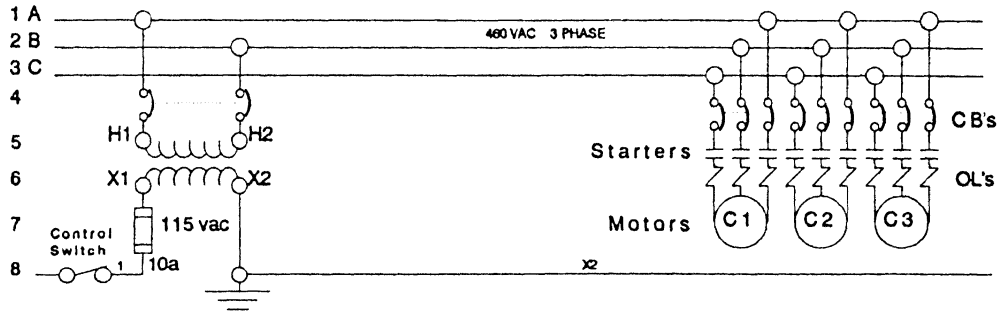
- C3 must start first.
- C2 cannot start if C3 is stopped.
- C1 cannot start if C2 is stopped.
- If any conveyor is stopped, the in-feeding conveyor(s) ahead of it must stop to prevent piling grain on a stopped conveyor.

### Manual Jog Mode

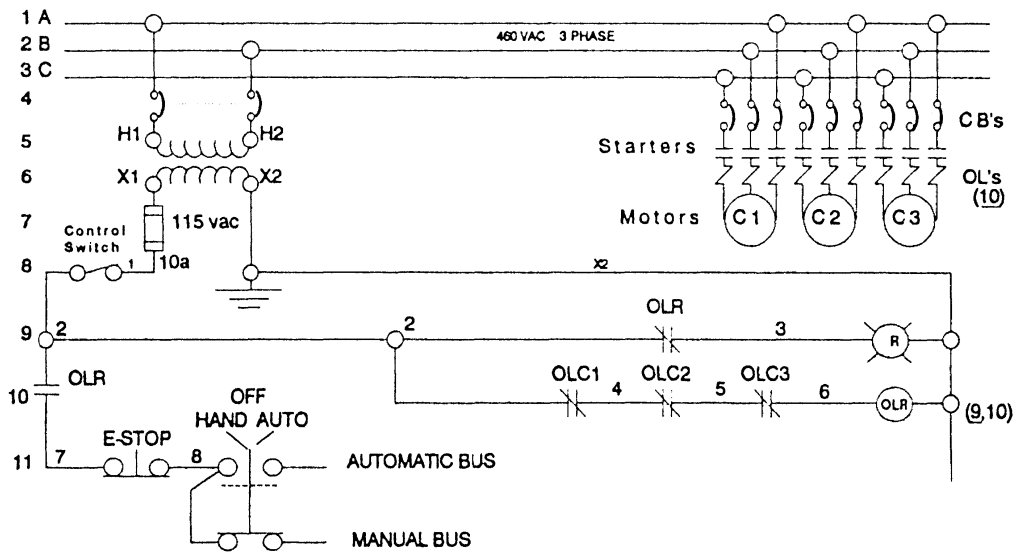
- A conveyor will only run while the start button is held down, and stop when released.
- This mode is for emergency, clean up, or belt alignment.

For this exercise will implement the first condition of the automatic start mode only. For full circuit, please refer to the reference material.

First we design the power logic...



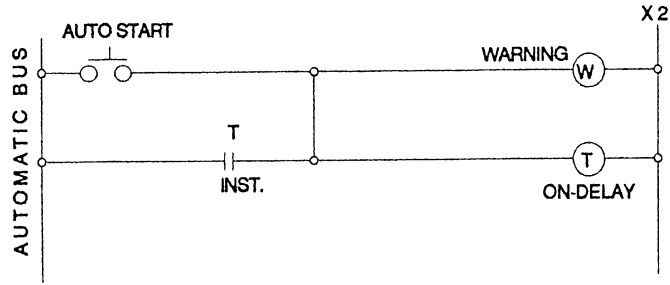
Then, we add safety features onto the power logic...



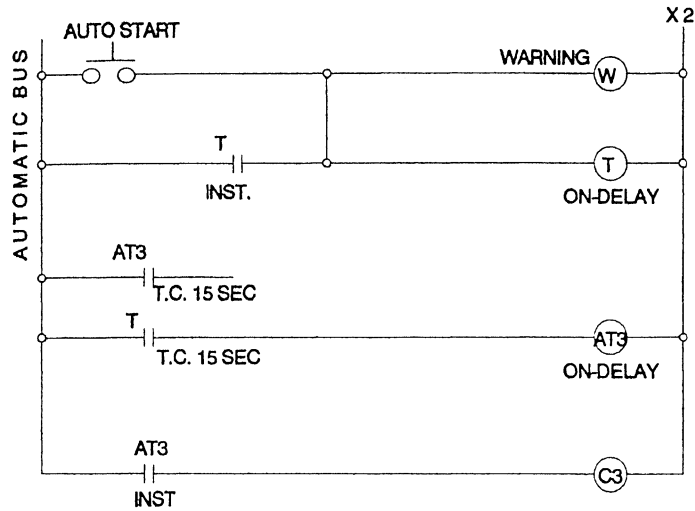
- Machine is operation when OLR relay is on
- R is the emergency warning light

Another safety feature is to provide a warning sound/light before machine starts...

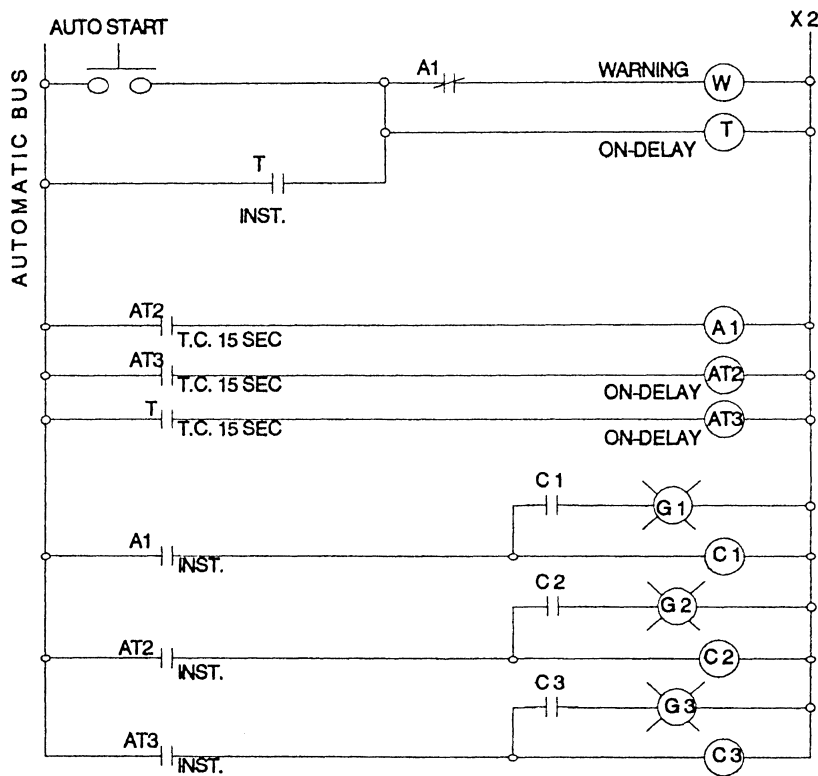
4.01 – Control Components and Ladder Diagram (last updated: Jan 2009)



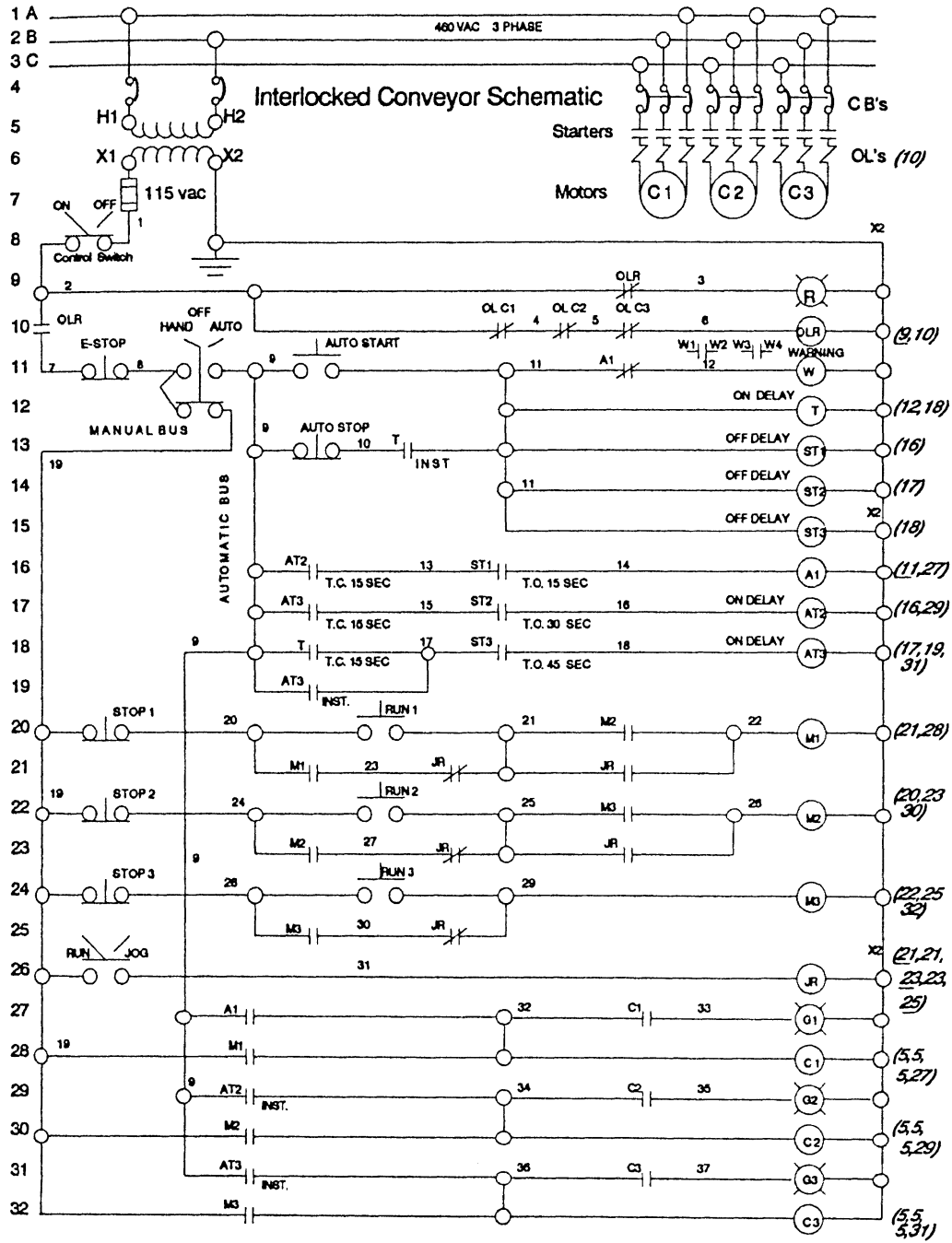
The start logic for the first conveyor...



Auto-cycle complete conveyor start logic...



The complete conveyor schematic



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