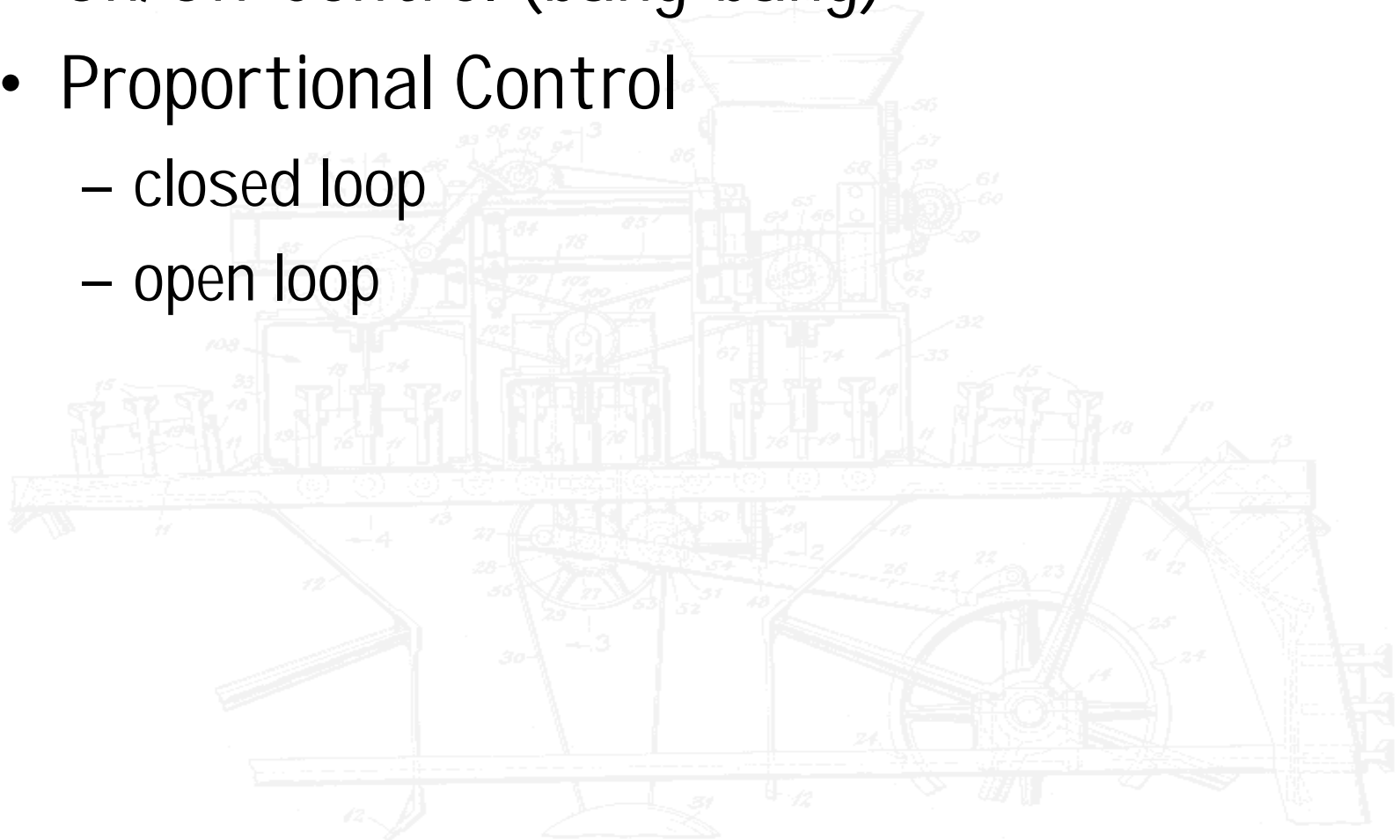


# Control of Motion

---

- On/Off Control (bang-bang)
- Proportional Control
  - closed loop
  - open loop



# Digital Logic Expressions

---

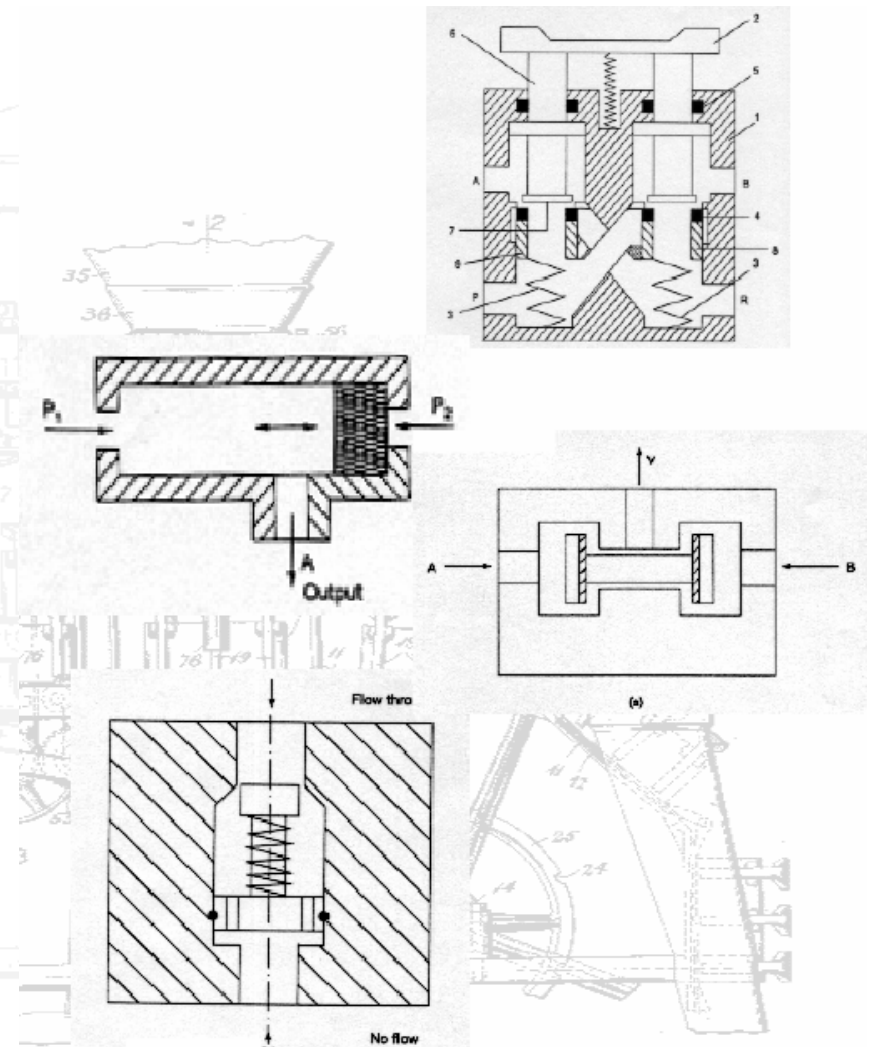
$$oCUT = (iPARTRDY \cdot iCYLRETRACT + oCUT \cdot /iCYLEXTEND) \cdot /iESTOP$$

$$oCUT = iPARTRDY \cdot iCYLRETRACT \cdot /iESTOP + oCUT \cdot /iCYLEXTEND \cdot /iESTOP$$

- Cut when part is ready, **and** cylinder is retracted, **and** emergency stop is **not** on, **or** while cylinder is not fully extended **and** emergency stop is **not** on.

# Pneumatic Logic Elements

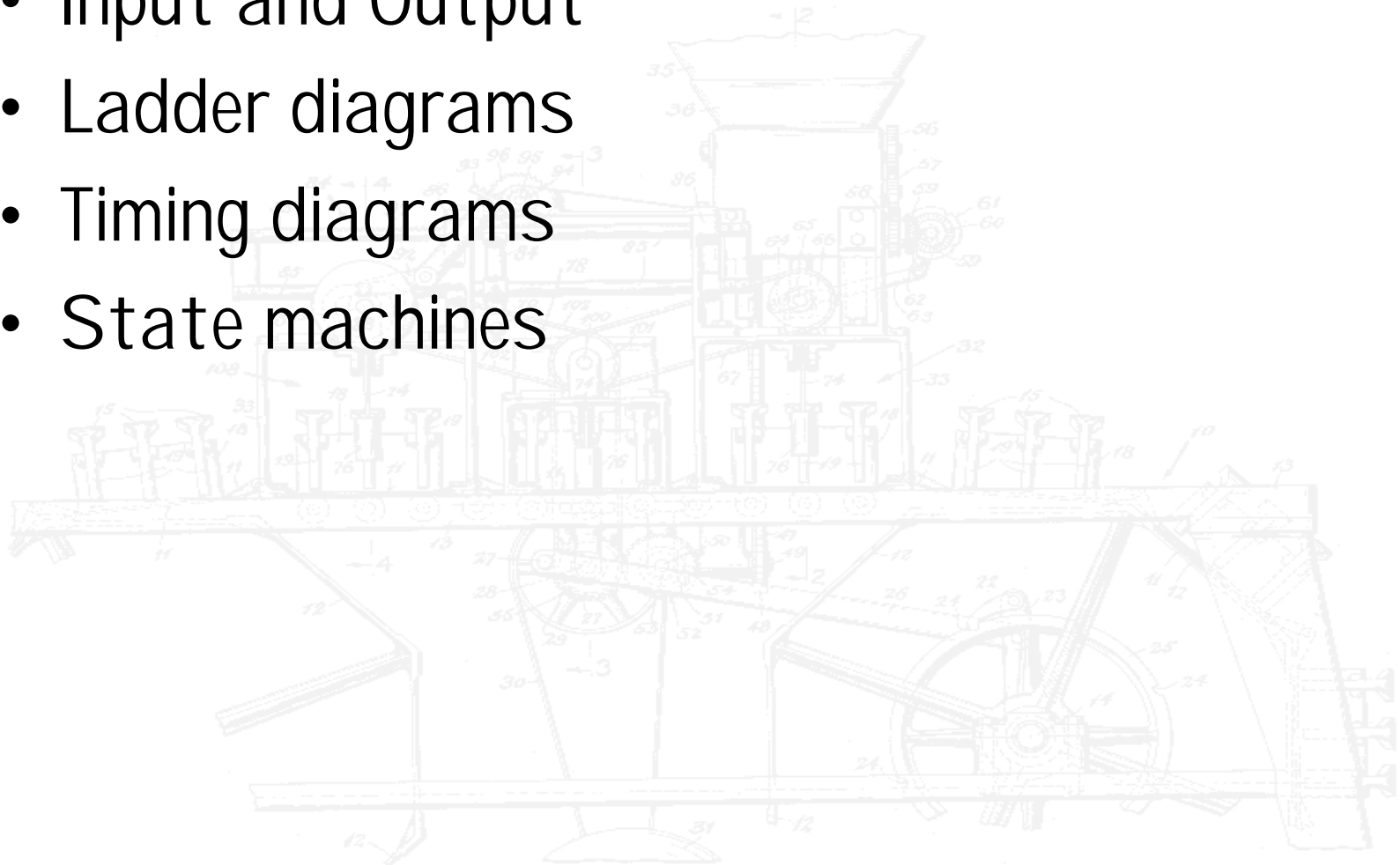
- Directional control valve
- Shuttle valve - OR function
- Twin pressure valve - AND function
- Other functions
  - Check valve
  - Speed control valve
  - Time delay valve



# Electric Logic Control

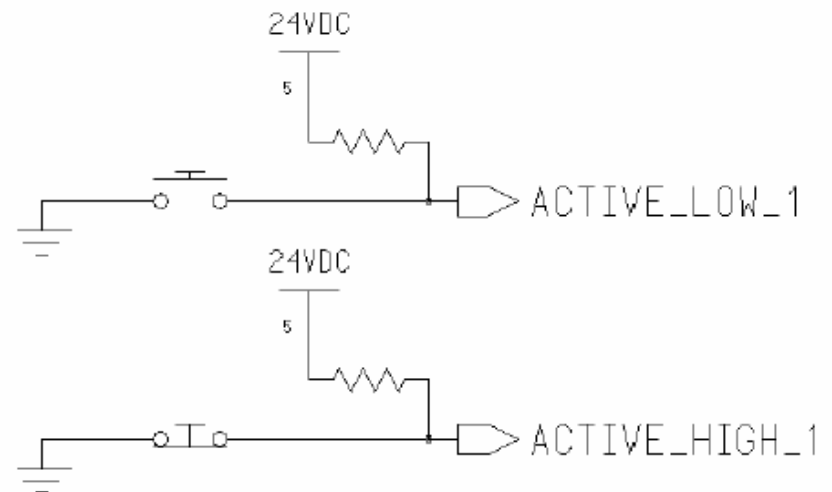
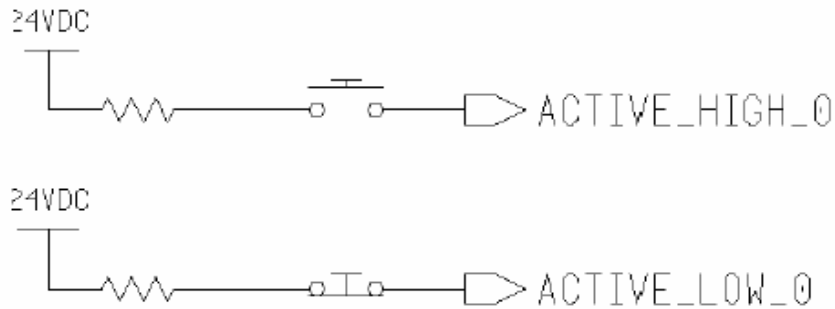
---

- Input and Output
- Ladder diagrams
- Timing diagrams
- State machines

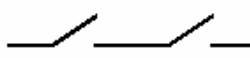


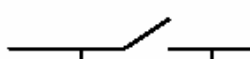

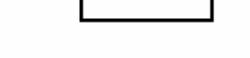



# I/O Activity Levels

- Active = TRUE Inactive = FALSE
- Active High - **active** level is +24 volts
- Active Low - **active** level is 0 volts (GND)



# Boolean Arithmetic

- 0 and 0 = 0 ( $0 \cdot 0 = 0$ ) 
- 0 and 1 = 0 ( $0 \cdot 1 = 0$ ) 
- 1 and 1 = 1 ( $1 \cdot 1 = 1$ ) 
- 0 or 0 = 0 ( $0 + 0 = 0$ ) 
- 0 or 1 = 1 ( $0 + 1 = 1$ ) 
- 1 or 1 = 1 ( $1 + 1 = 1$ ) 
- not 0 = 1 ( $/0 = 1$ ) 

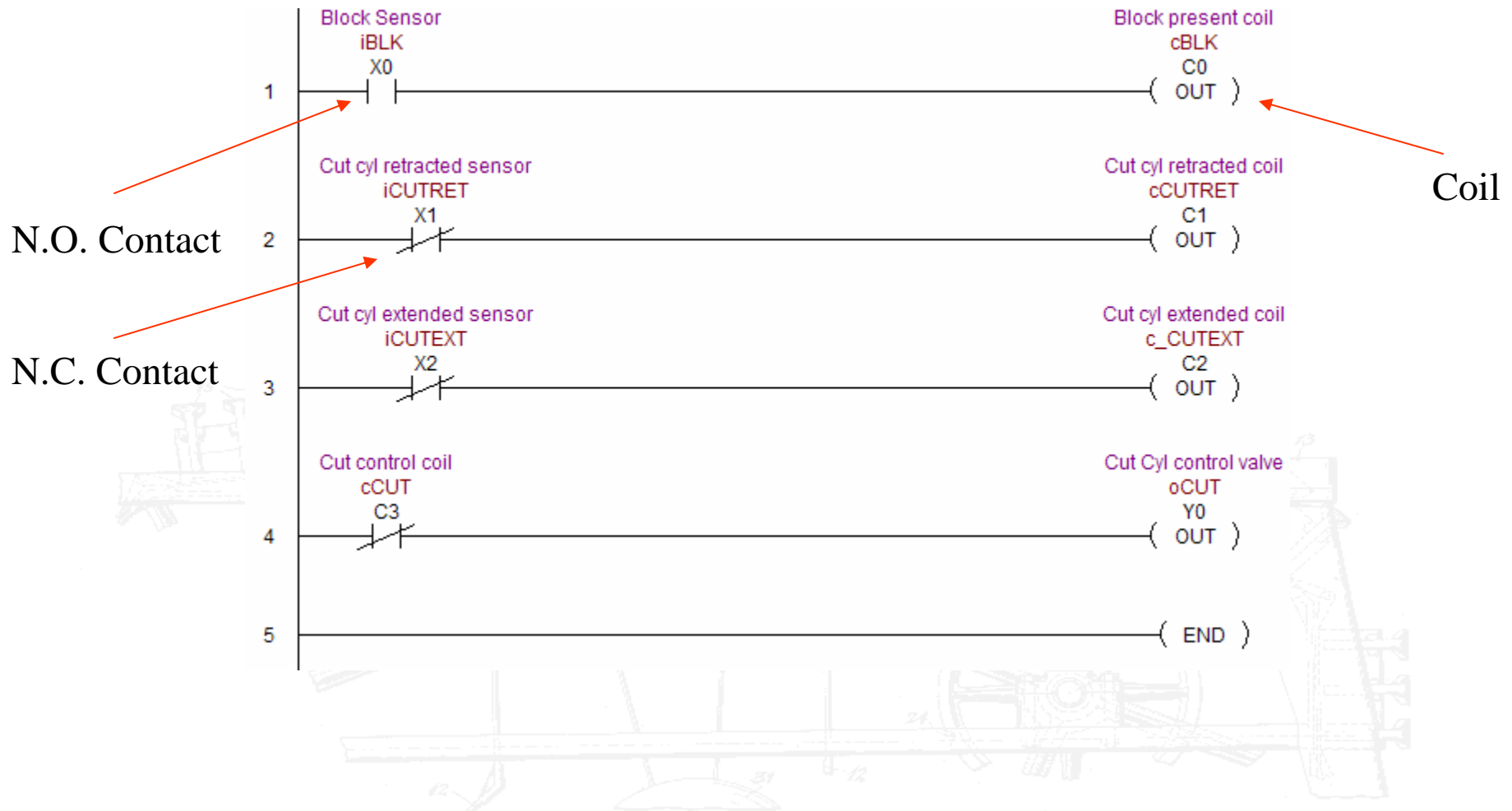
---

$$A + /A = 1$$

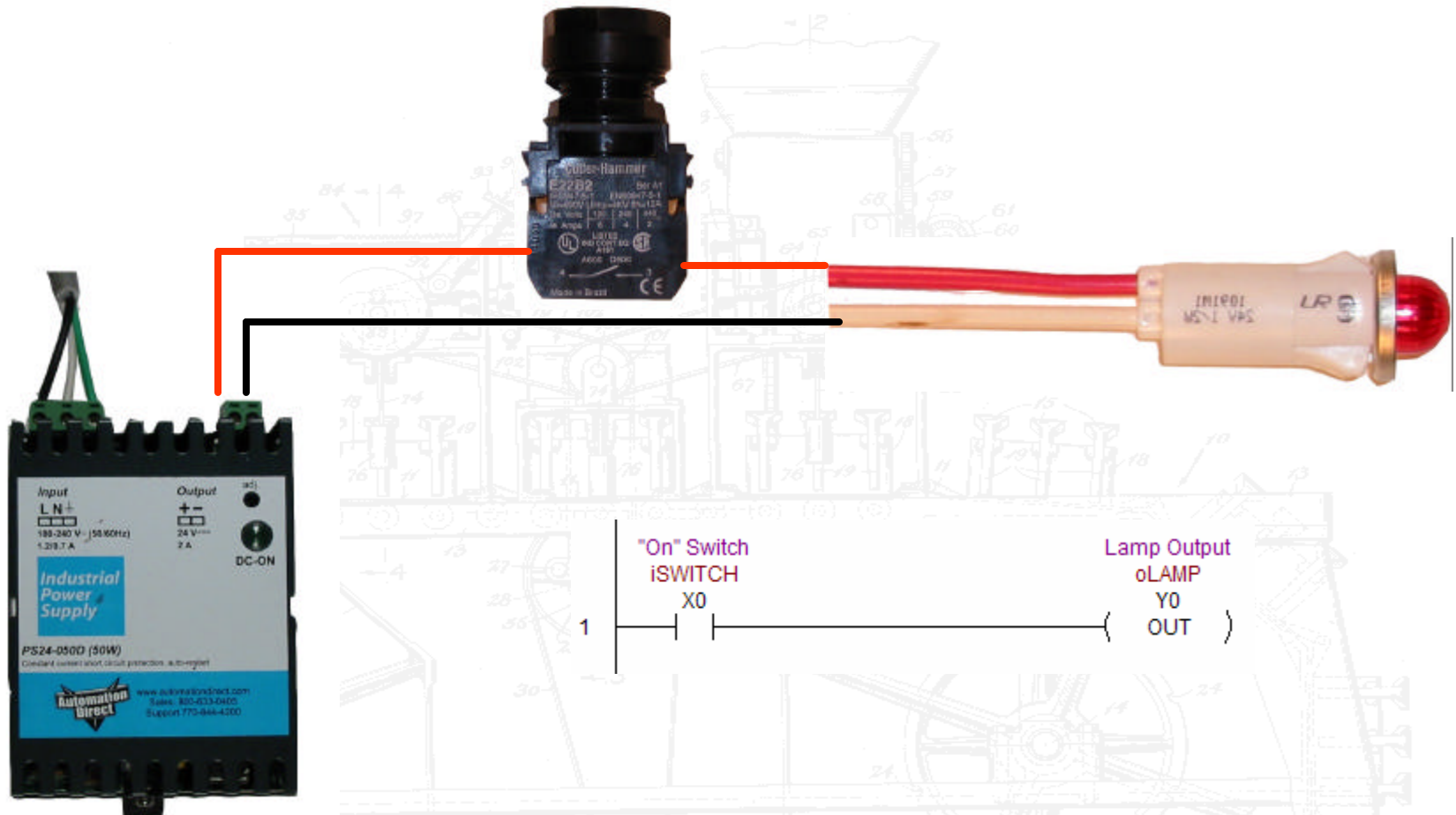
$$A \cdot B = B \cdot A$$

$$A \cdot B + A \cdot C = A \cdot (B + C)$$

# Ladder Diagrams

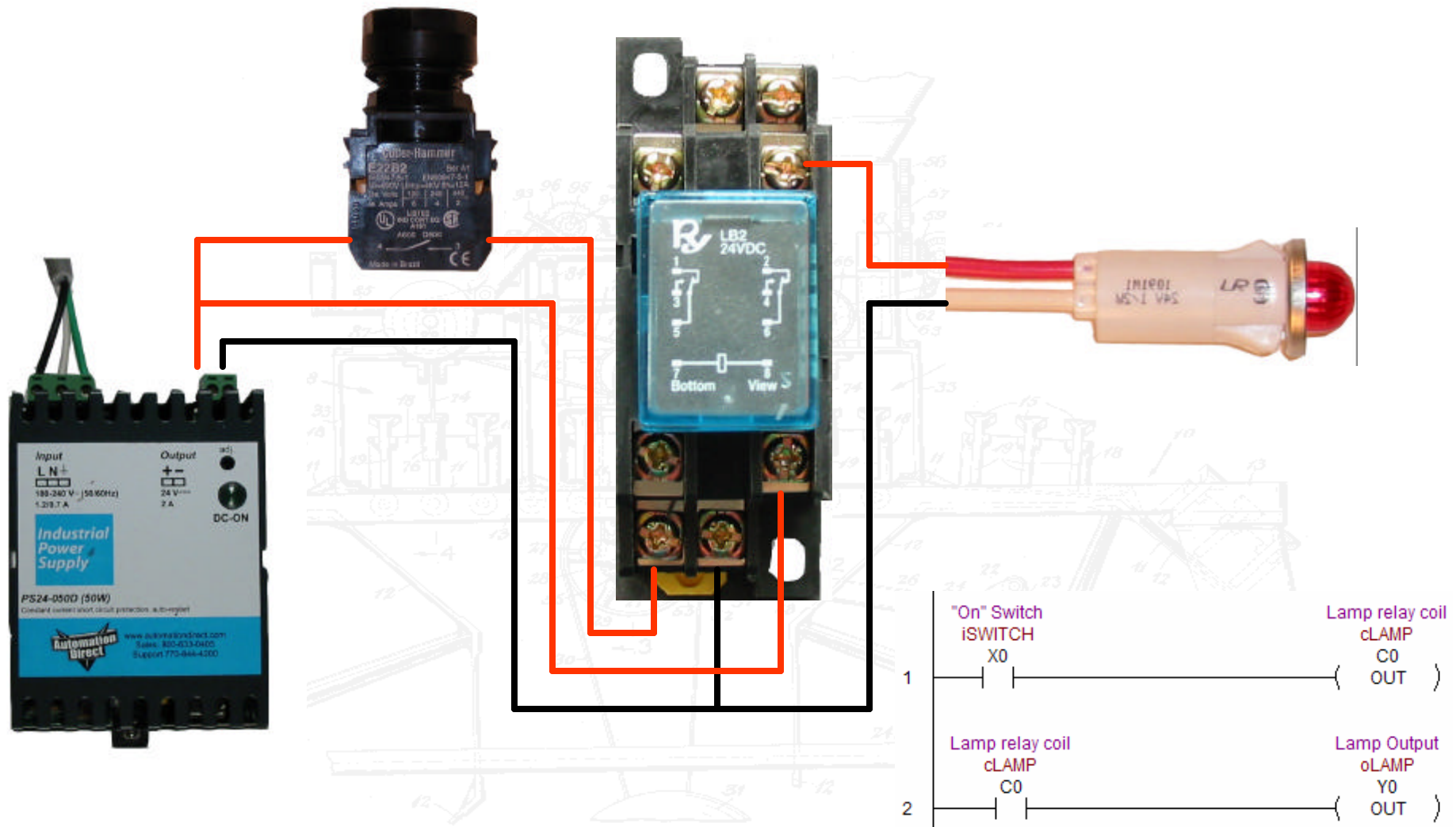


# Example – Light Switch

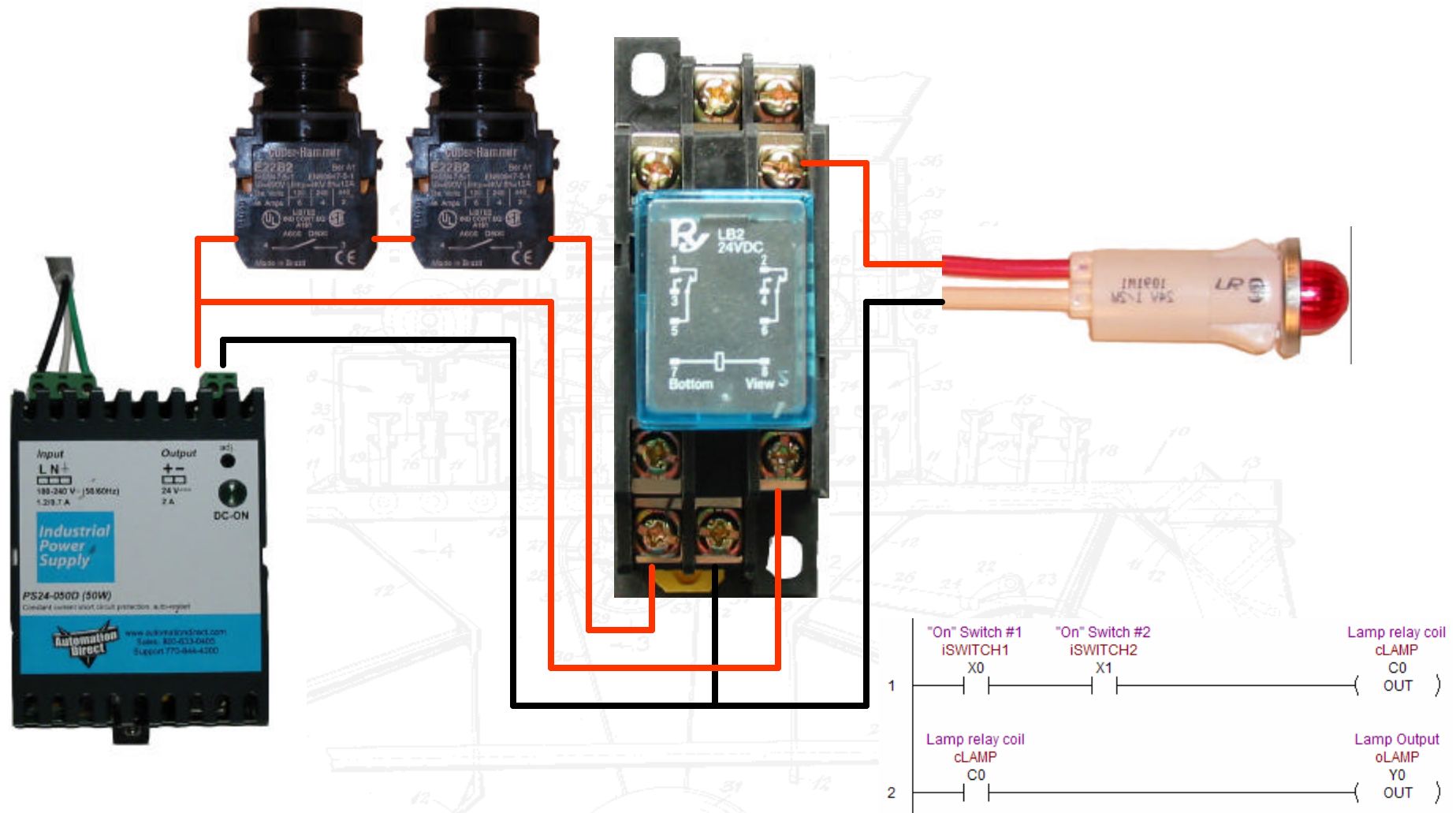




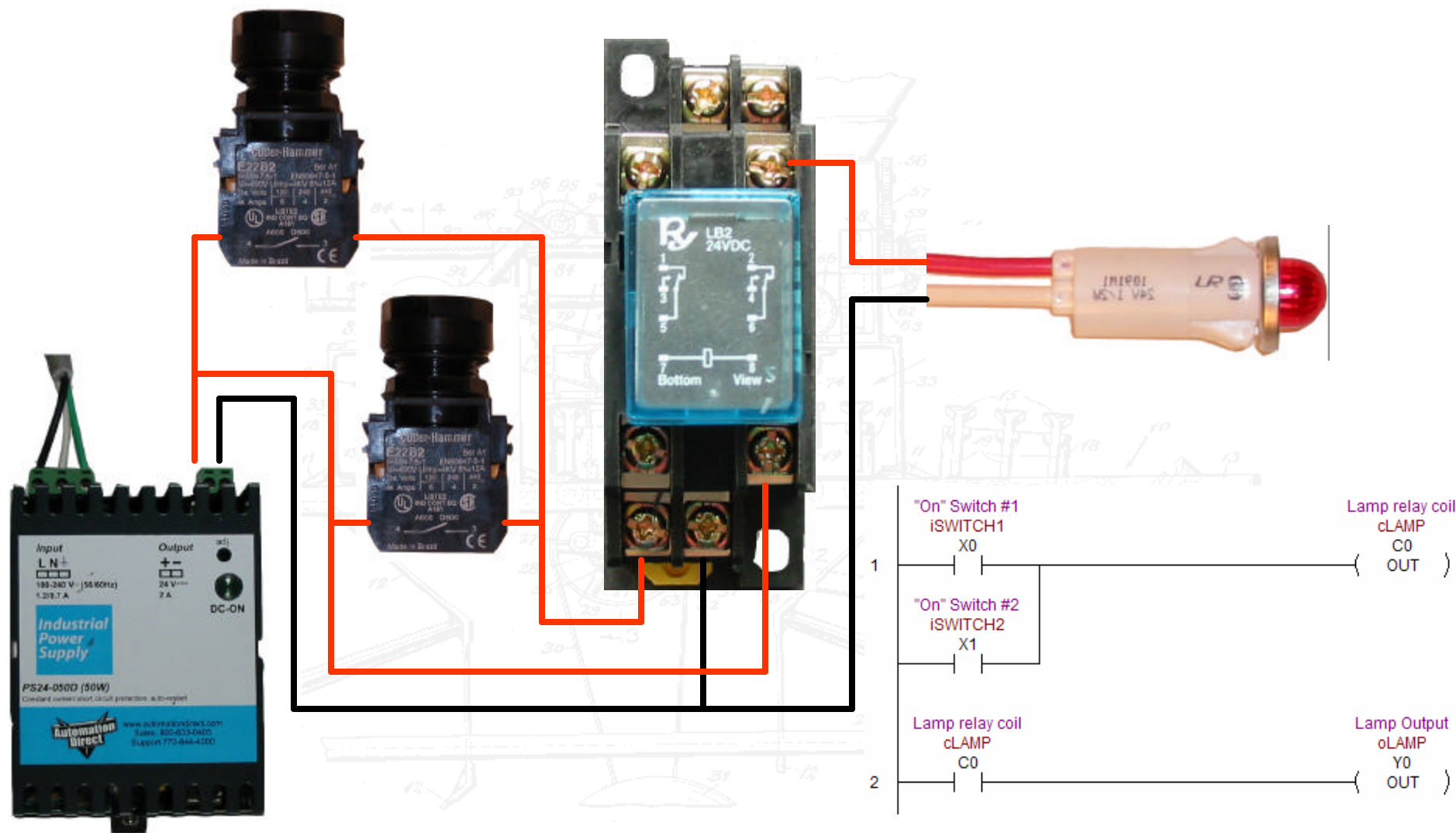
# Example – Light Relay



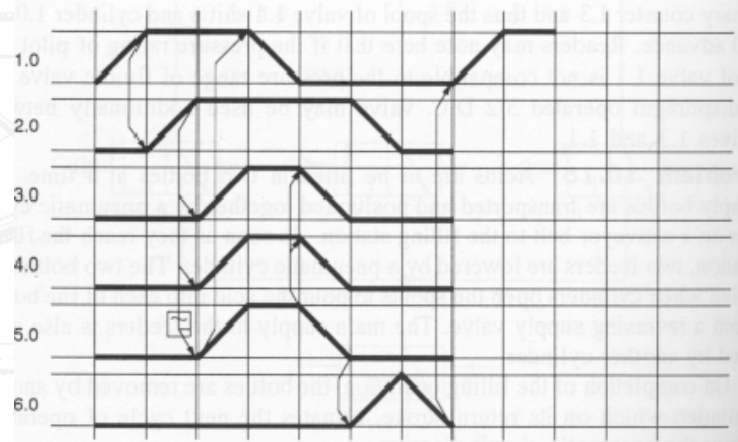
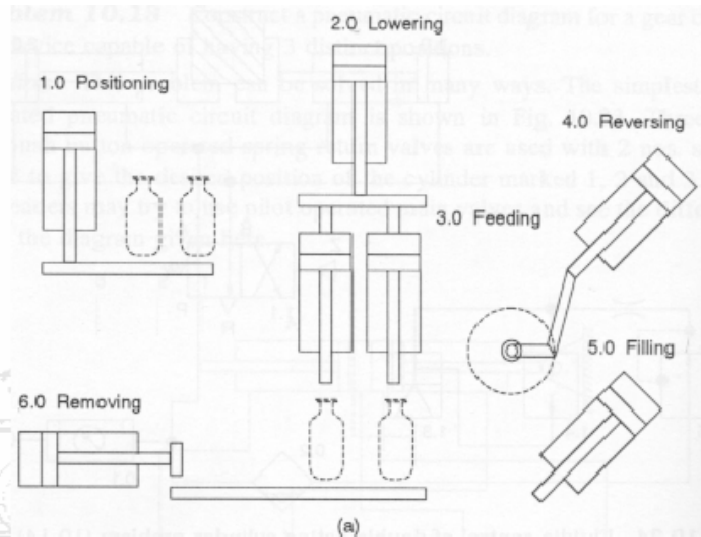
# Example – Light Relay, “And” Logic



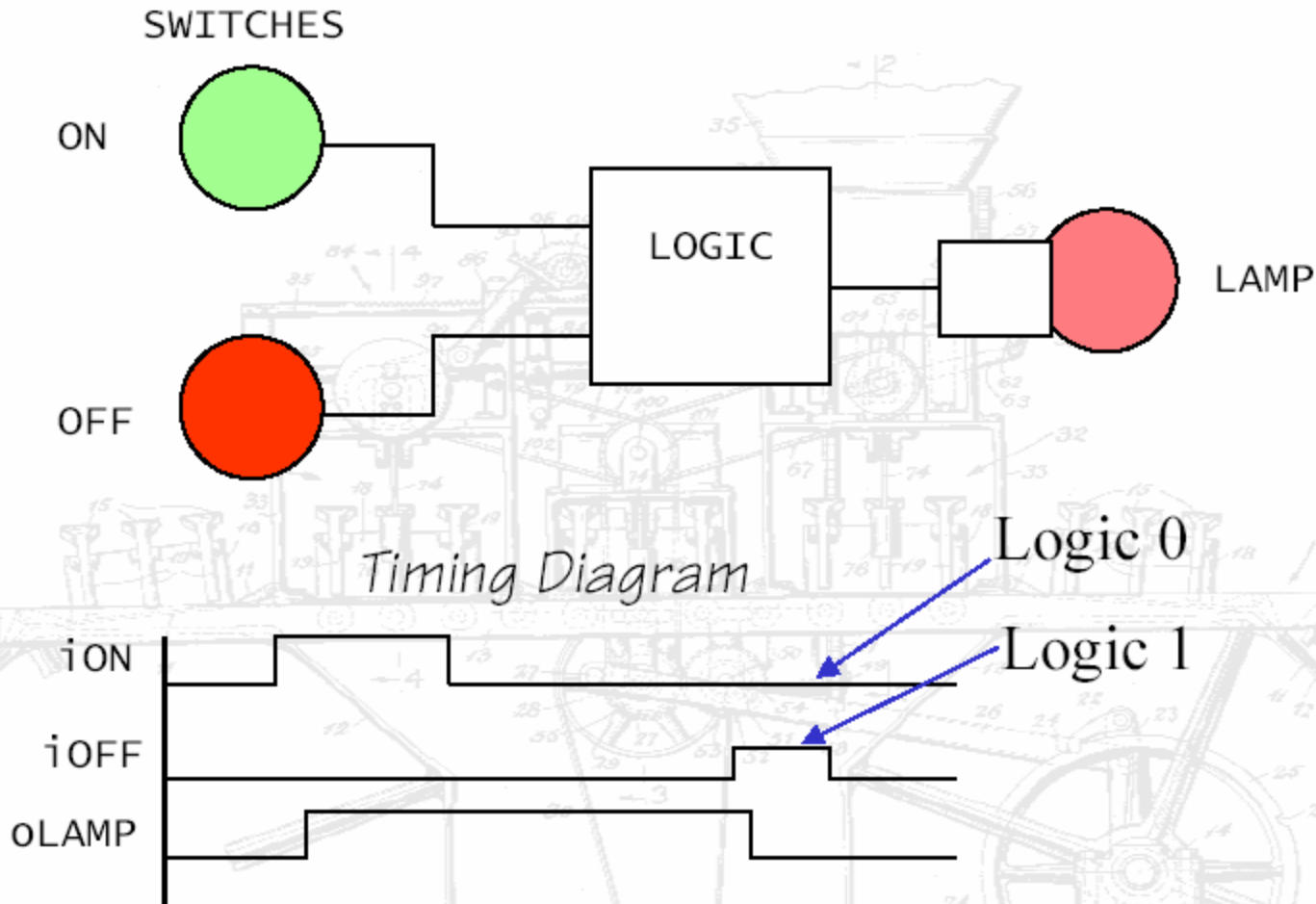
# Example – Light Relay – “OR” Logic



# Timing Diagrams

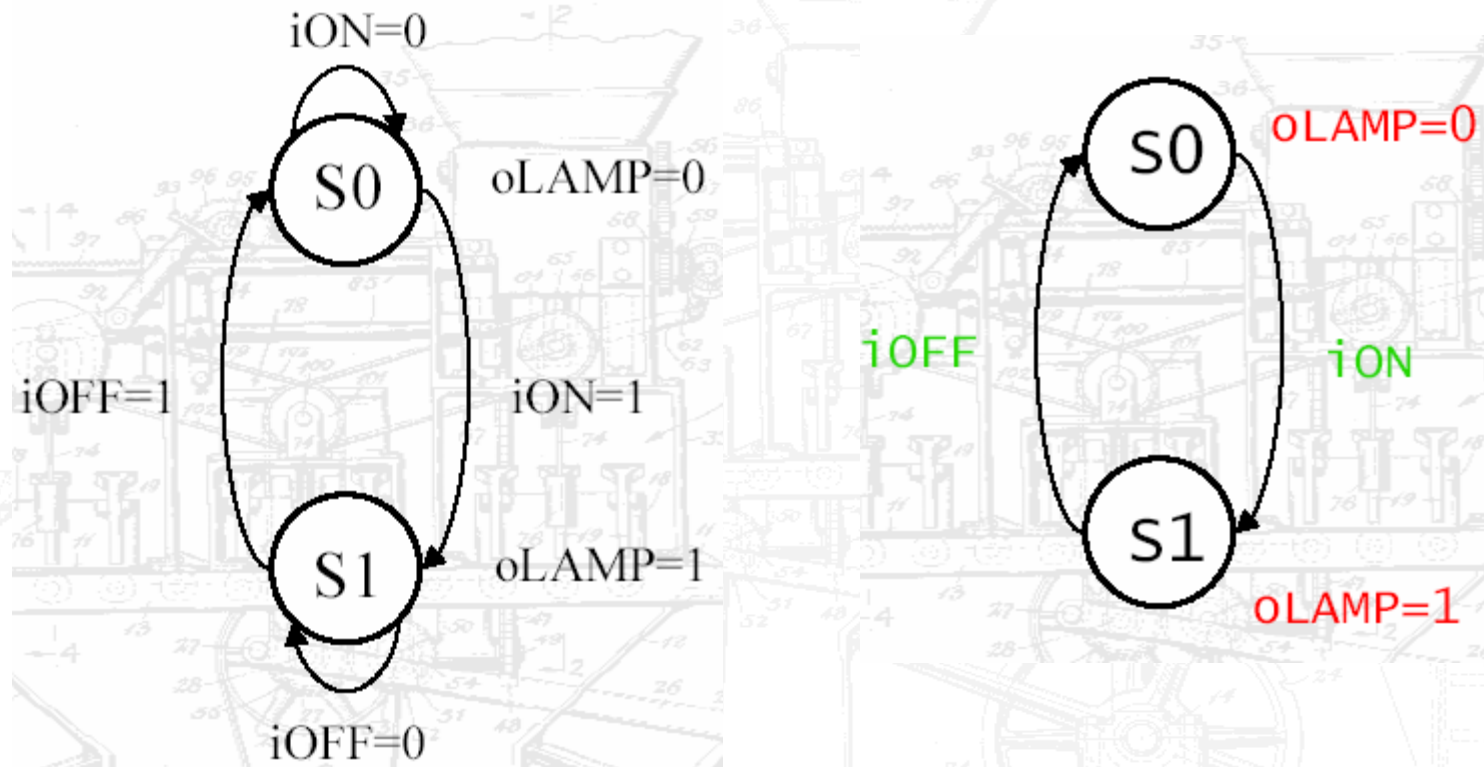


# State Machines



# State Diagram

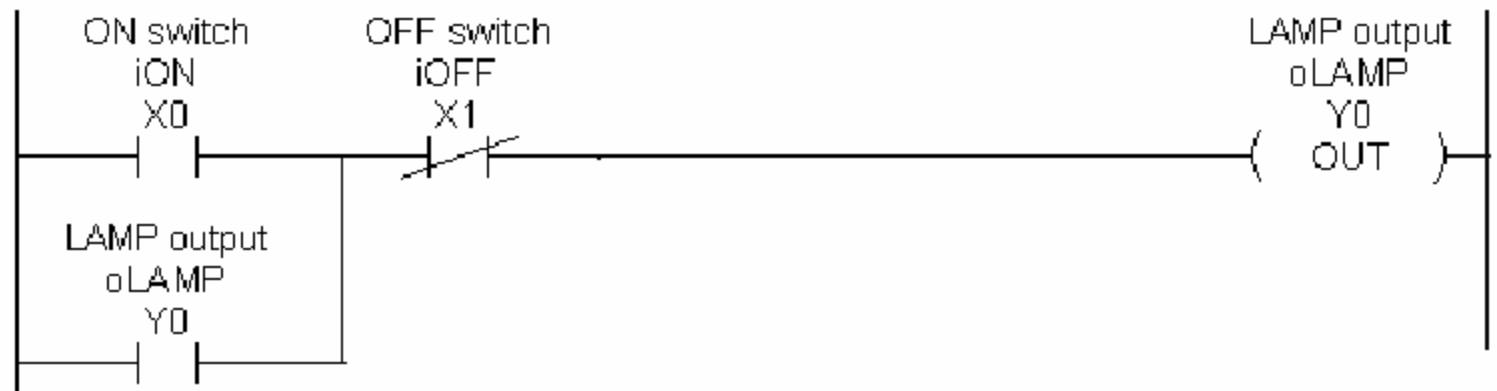
---



# Logic Equation and Ladder Diagram

$$oLAMP = /iOFF \cdot (iON + oLAMP)$$

24VDC





# Example – Latching Relay Logic

