→ Programmable logic controllers

It is a computer based controller that is used to sequentially scan the inputs to determine their value and accordingly it activates the output channels depending on input state and programming software.

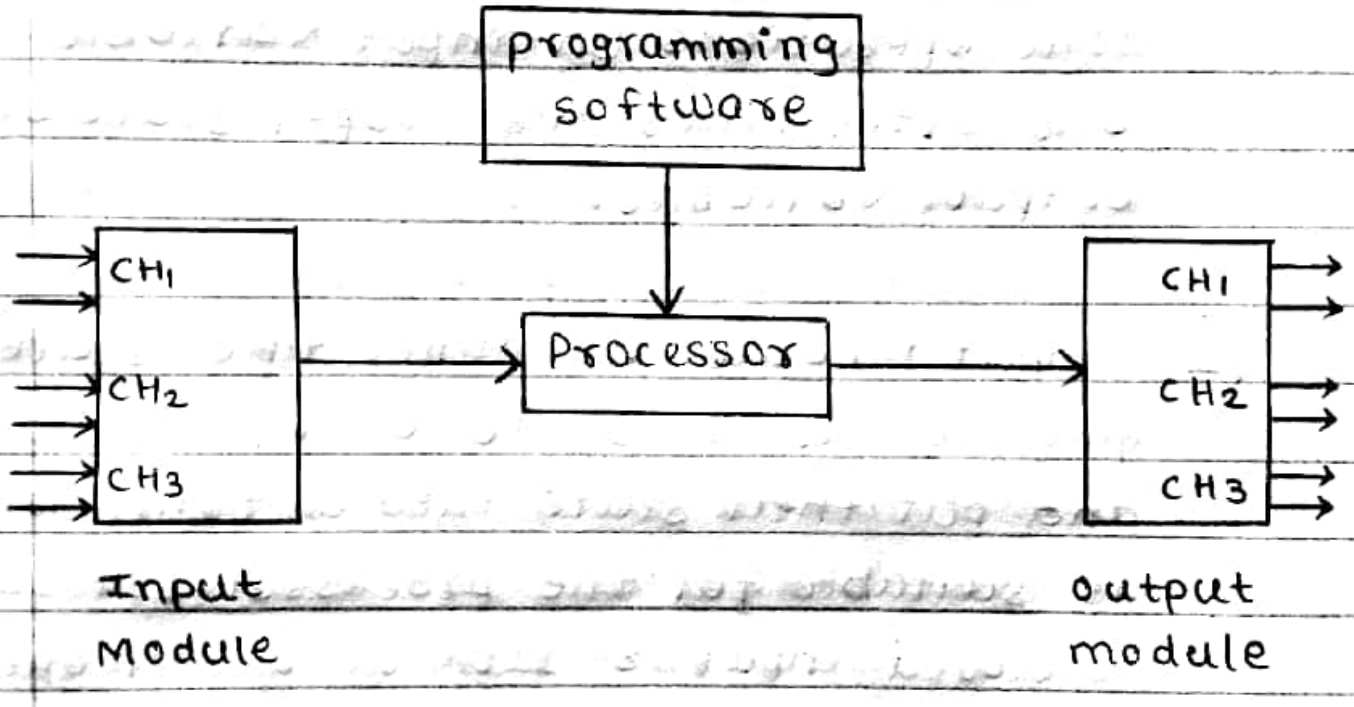


Diagram above shows the basic structure of the programmable logic controller (PLC) that consist of input modules, the output modules, programming software and the processor. Main difference between the PLC and the computer is that while computer does parallel processing of data, the PLC is a sequential device as it evaluates each rung of ladder diagram one-by-one. A

general description of the PLC can be given by describing its important constituents as shown below :-

1. Processor is a microcomputer that can excecute a program to perform the operations specified in the ladder diagram. It performs arithmetic and logic operations on input variable data and determines the proper state of the output variables.

2. Input Module examines the state of physical switches and other input devices and put their state into a form that is suitable for the processor. If switch is closed input is 110V ac and if open it is 0V ac. The input module converts this into 1 or 0 state respectively.

3. Output Modules supply ac power to external devices such as motor, lights, solenoids as required in ladder diagram. Internally the output module accepts a 0 or 1 from the processor and uses this to turn ON/OFF a power control device or a solid state relay.

→ Operation of the PLC

The operation of the programmable logic controller is s not simultaneous for the ladder diagram nor continuous as it is for the relay sequencers. Here the PLC operates in two main modes :-

1. I/O scan mode makes the processor update all the outputs and inputs one channel at a time. The time required for this depends upon the speed of the processor.

2. Execution mode makes the processor to evaluate each rung of the ladder diagram in a sequential manner. As a rung is evaluated the last known state of each switch is considered. At the end of the ladder diagram the I/O mode is entered again and all the output devices provided with the ON/OFF state determined from execution of the ladder diagram. All the inputs are sampled and the execution mode will start again.

→ Programming the PLC

Methods of programming the PLC can be discussed using the scan time, programming unit, PLC networks and RAM/ROM:-

* Scan time is the time required for one complete cycle of I/O scan and execution and depends on the processor speed. The length of scan time contains the input time, output time and execution time.

* Programming unit is an external electronic package that is connected to the programmable controller when programming occurs. It allows input of a program in ladder diagram symbols.

* Modern plants employ computer networks to link PLC's and other controlling hardware via communication networks. They normally use LAN or Profibus.

* RAM is used as temporary memory for ladder diagram program testing and evaluation, while ROM is used to store the program once it has been debugged.

→ Addressing and interpretation

* The address designation depends upon the type of programmable controller. Some of controllers may reserve certain addresses for physical I/O devices, other addresses for software control relays.

* In a physical diagram the symbol for a NO contact indicates a normally open contact through which current can't flow unless the contact has been closed. In the case of relay, the coil must be energised and for a switch the contacts are pushed.

* In a programmed diagram the symbol for a NO contact indicates that the device should be interpreted as FALSE if contact is tested and found to be open and TRUE if it is found to be closed.

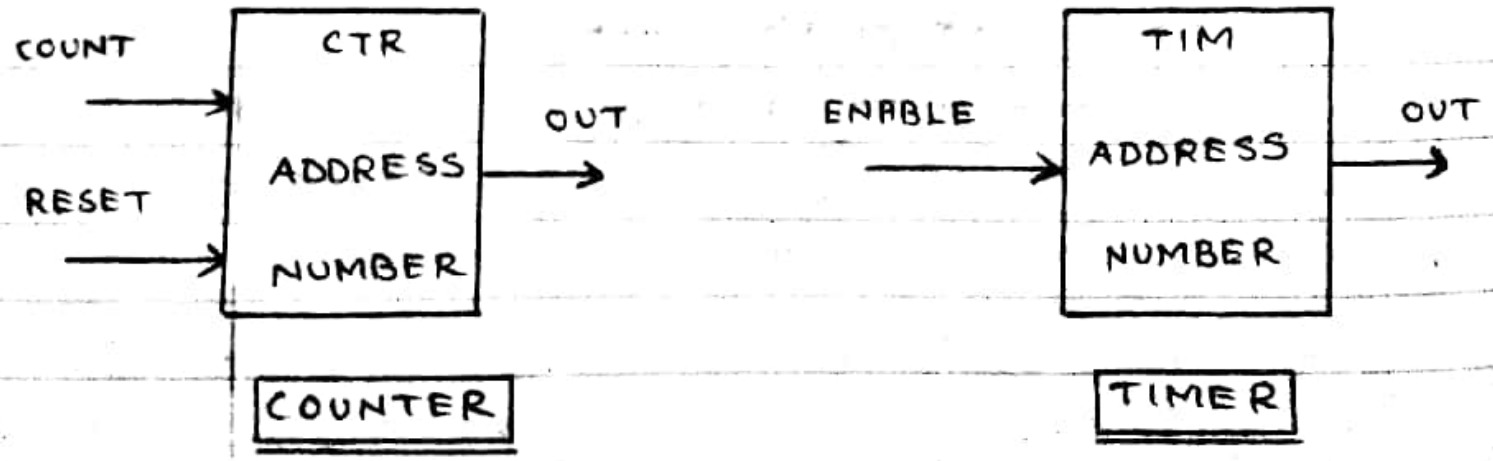
* For the programmed diagram rung the ON or OFF state of the output of the rung is determined by testing the elements of the rung for TRUE/FALSE condition.

→ PLC software functions

Modern programmable logic controllers have many functions implemented in the software associated with processor, with most common ones being :-

1. Counters are programmed function that count or increment every time input changes from false to true. They have two input lines for count and reset and have address and preset no. of counts.

2. Timers is a programmed function that provides delay in ladder diagram and it specifies period of time some operation has to last. When activated it begin to accumulate time in form of ticks. They have two input lines for reset and enable and contain address and preset number. Diagrams of both are shown below :-

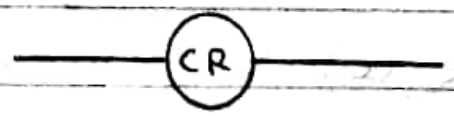


→ Ladder diagram representation

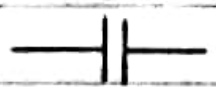
Ladder diagram is a schematic type of a representation of the hardware and its connection that describes the sequential events of that process. It is called so because the various circuit elements are connected in parallel across the power supply line, with each parallel connection called as a rung on the ladder. Following are the elements of the ladder diagram :-

* Relays :-

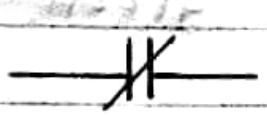
It is represented by circle and identified as the CR. contacts for that relay will be either normally open or else normally closed (NC).



Control Relay



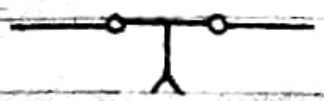
NO



NC

Timer Relay

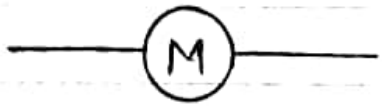
NO



NC

* Motor and solenoid :-

Here the motor is represented by a circle with the symbol M inside while the solenoid uses the symbol SOL. It could be a solenoid to open a flow valve or move material off a conveyor belt or others.

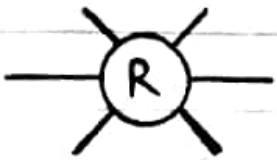


Motor

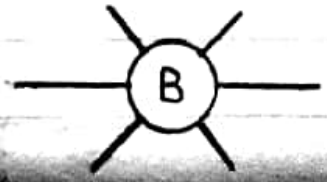
Solenoid

* Lights :-

They are used as indicators to give information to the operators about the state of the system. colour of light is indicated by capital letter in the circle where R denotes red, G is for green, A denotes amber and B for blue.



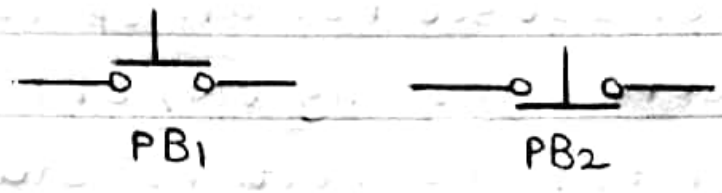
Red Light



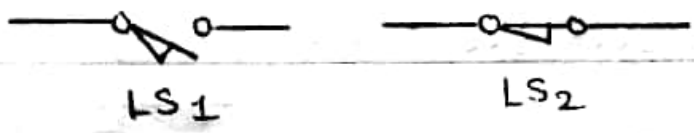
Blue light

* Switches :-

Diagram below shows the different types of push button switches i.e. momentary action switch, physical limit switch, pressure limit switch, temperature limit switch or Level limit switch. They may be either NO/NC type.

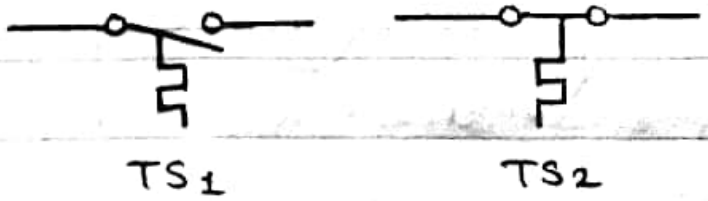


Push Button

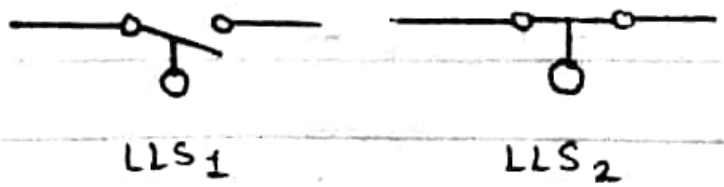


Physical Limit

Pressure Limit



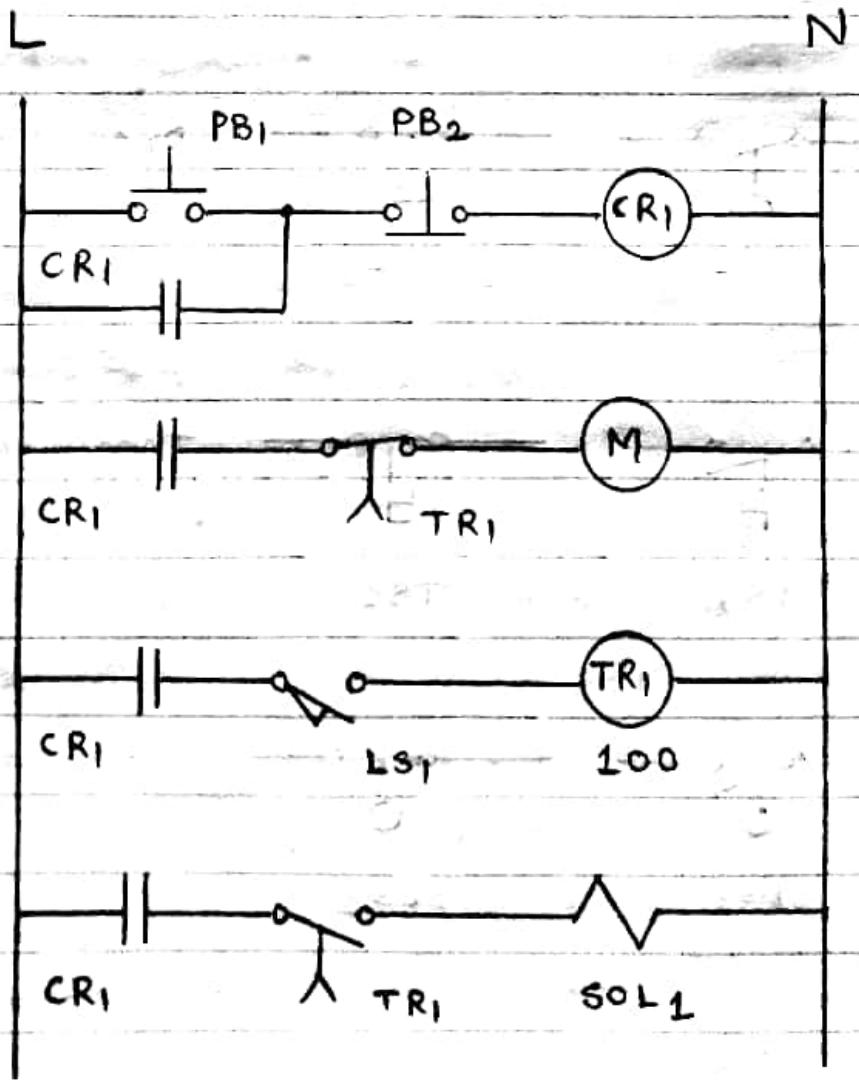
Temperature Limit



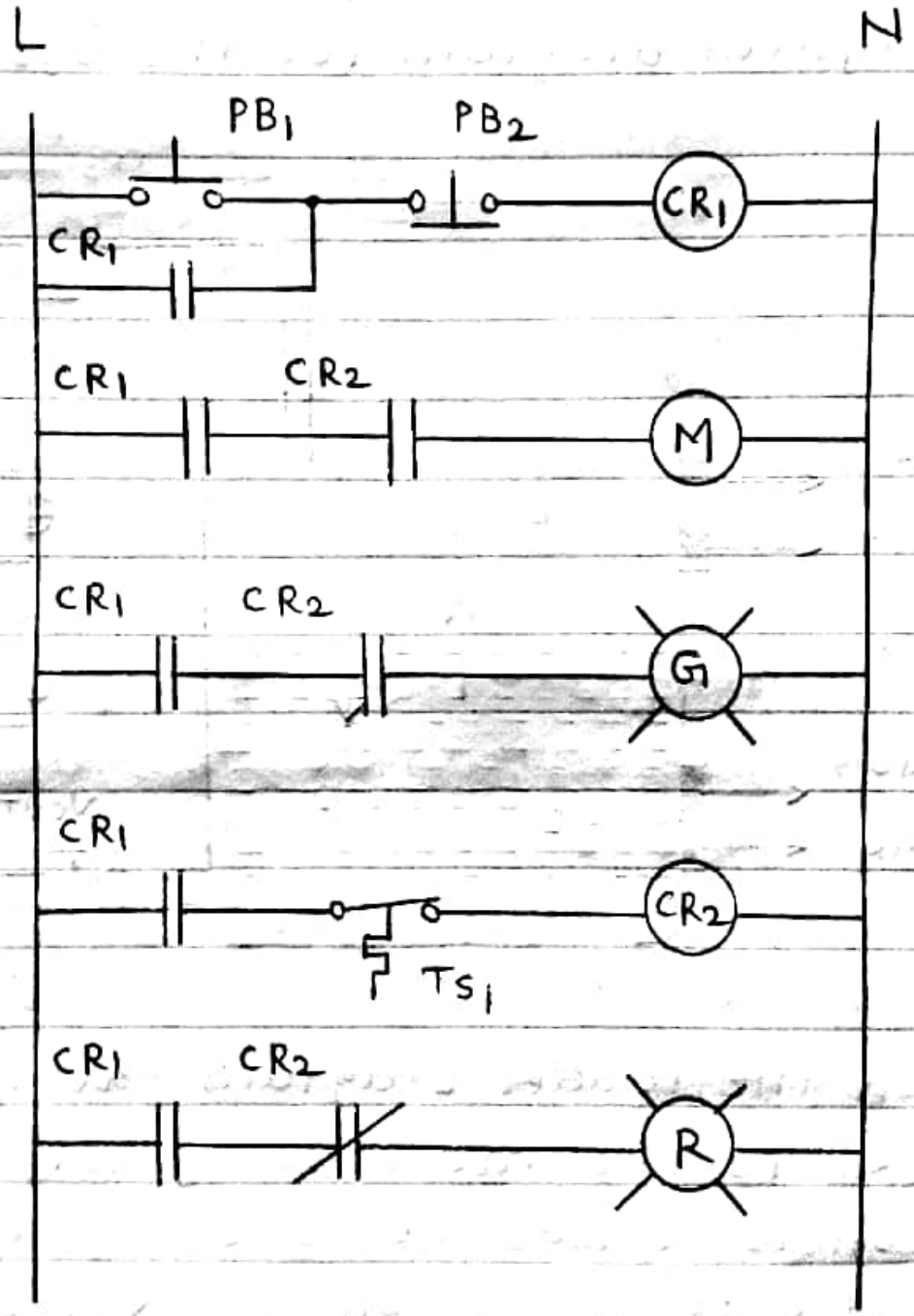
Level Limit

→ Ladder diagram examples

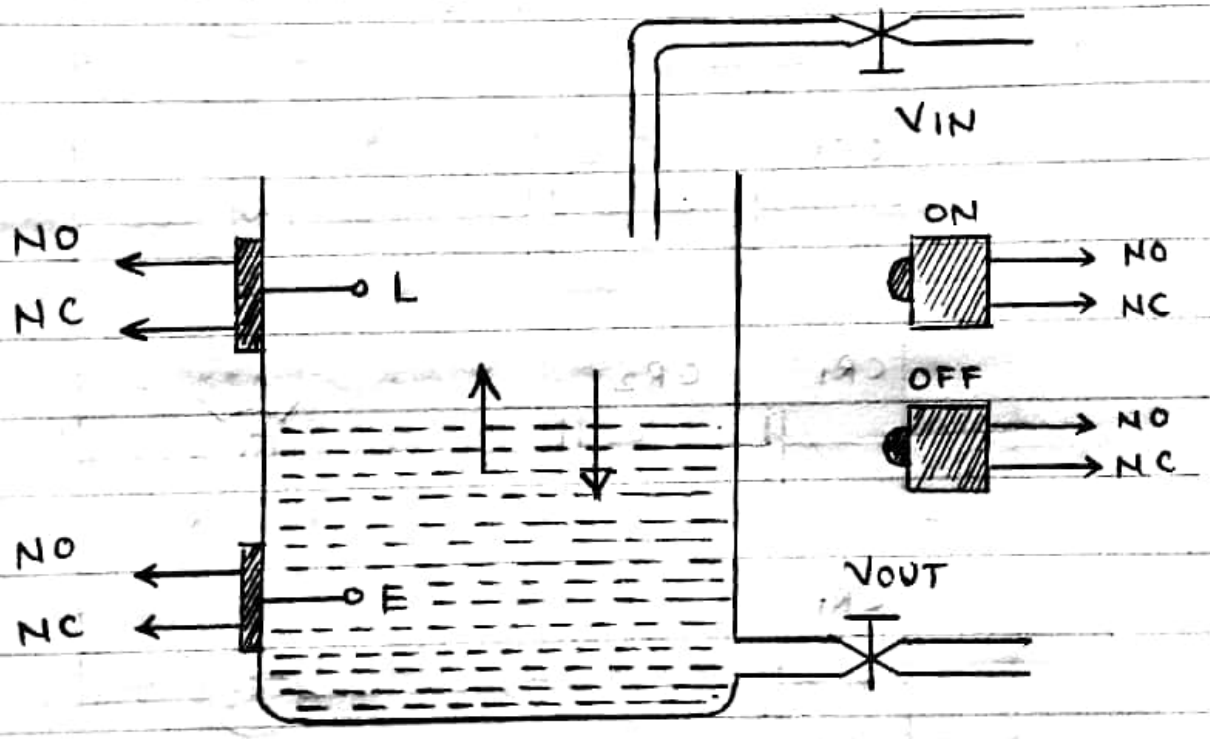
* Draw ladder diagram that could be used with conveyor belt which is used to move items to workstation. Presence of the item of the workstation is detected by breaking contact activated by beam of light to photosensor. There it stops for 100 sec for an operation to be performed before moving ON/OFF the conveyor. Motor for the belt is started by normally open start switch and stopped by normally closed switch.



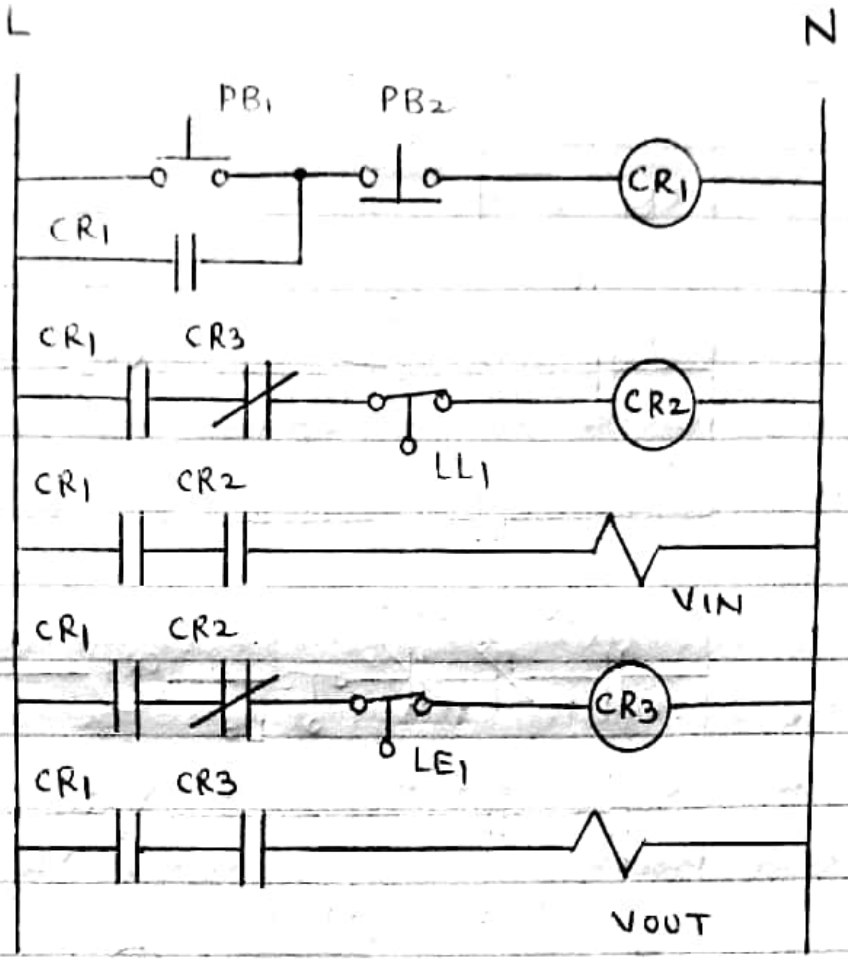
* Develop the physical ladder diagram for a motor with the following :- NO start button NC stop button, thermal overload limit switch opens on high temperature, green light when running, red for overload.



* When turned ON the tank of diagram alternately fills to level L and then will empty to level E. The switches activated on rising level. Both NO and NC type of connections are available for the level switches and ON/OFF push buttons. Develop physical diagram for the system.



In the ladder diagram the control relay CR_1 is the main relay while other control relays CR_2 and CR_3 are used to activate the solenoids V_{IN} and V_{OUT} respectively that control inlet and outlet valves. Here we assume that only one valve is on at a time.



* Develop the physical ladder diagram for the following process shown in the figure below, to fill tank till level A by valve A, fill tank to level B by valve B, start a timer, heat and stir for 5 min and open output valve C until the empty switch engages.