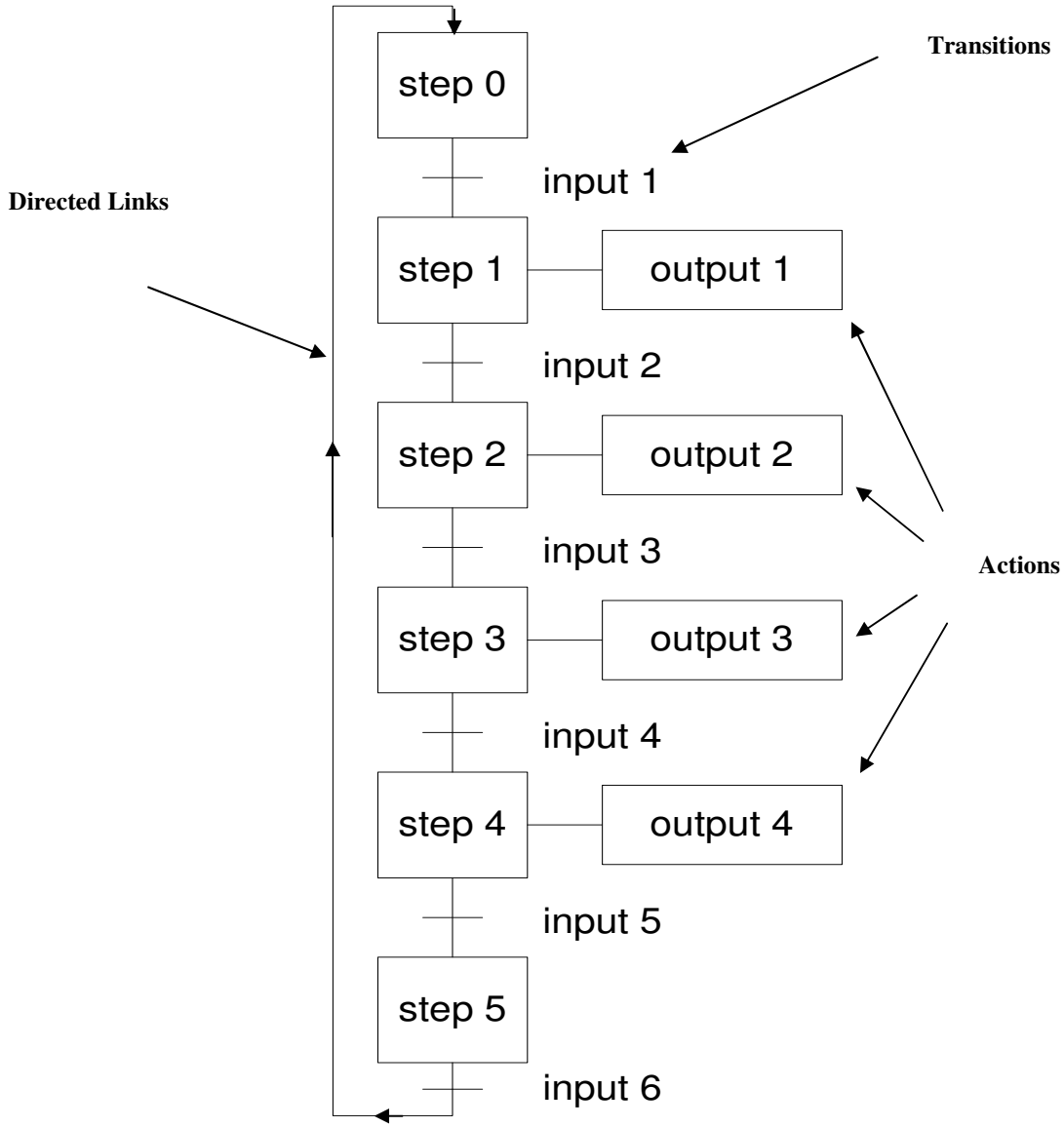
Chapter 9 : GRAFCET and Ladder Diagram

The GRAFCET is a tool for describing the specifications of the control unit of an automated system.

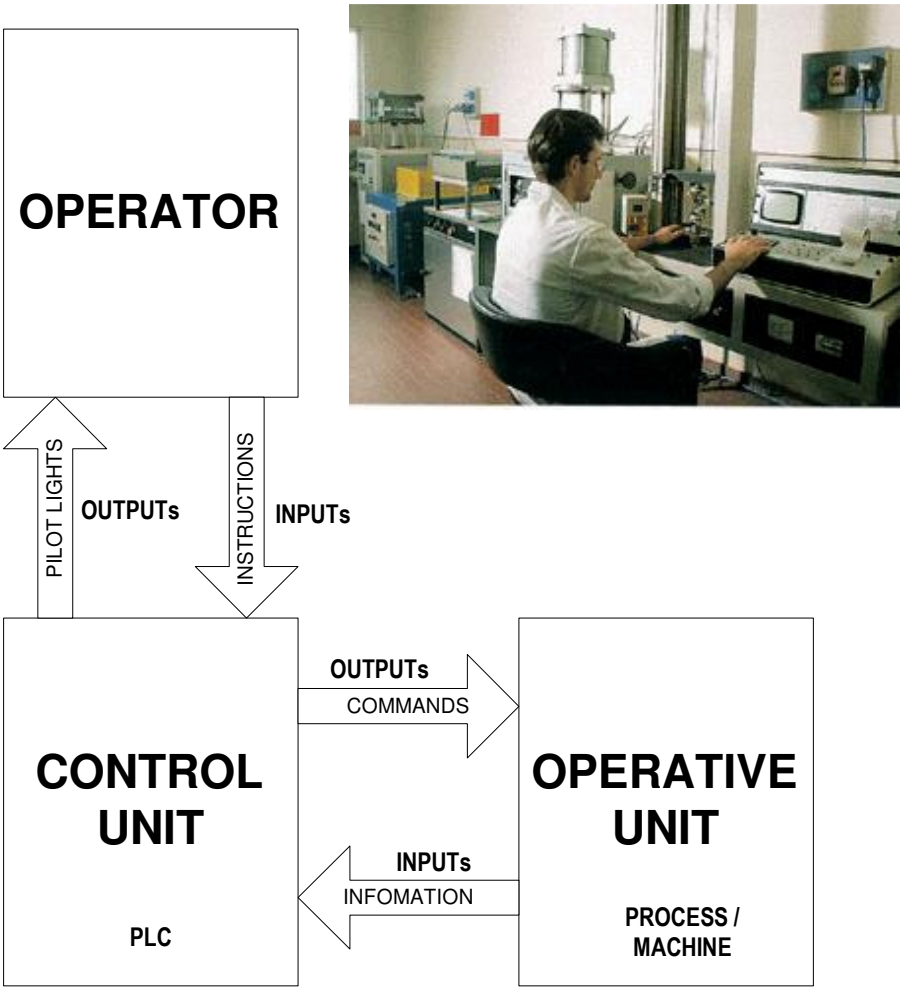
The working of an automatic equipment may be described graphically by a group of:

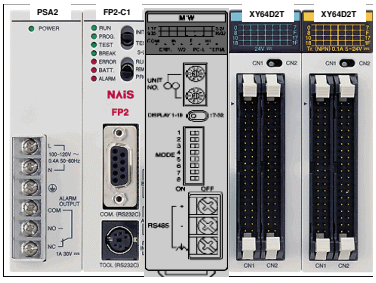
- **STEPS** to which are associated certain ACTIONS
- **TRANSITIONS** which are conditions to be fulfilled
- **DIRECTED LINKS** linking steps and transitions

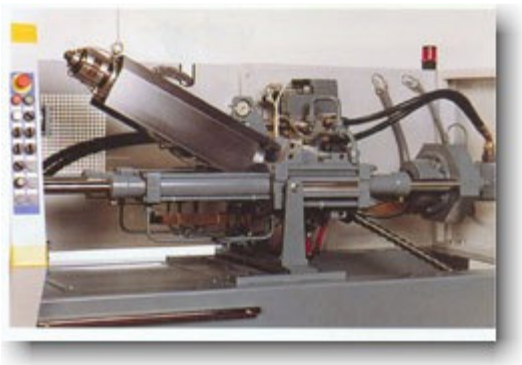


The GRAFCET (cont'd)

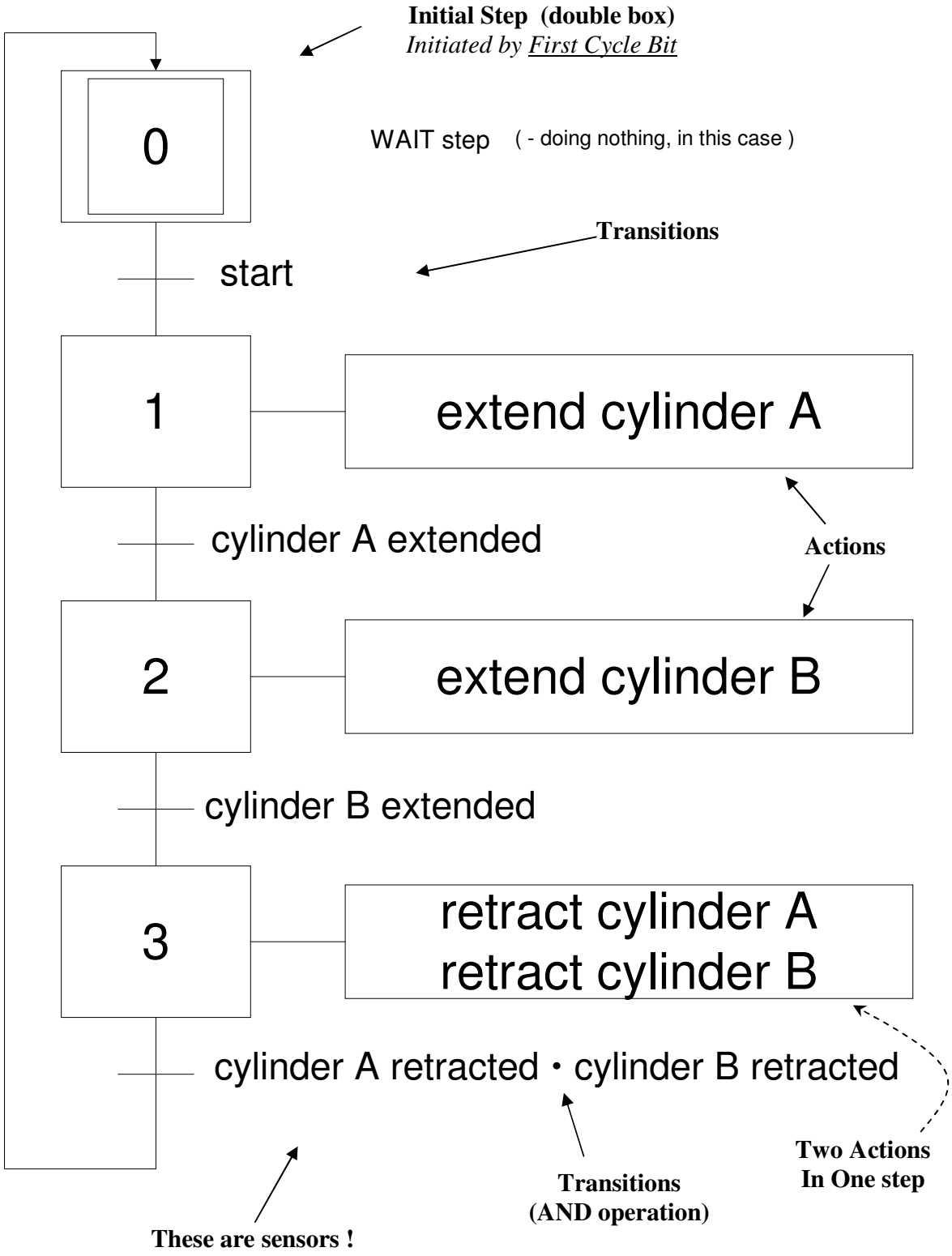
Block Diagram of a PLC-controlled automatic system :



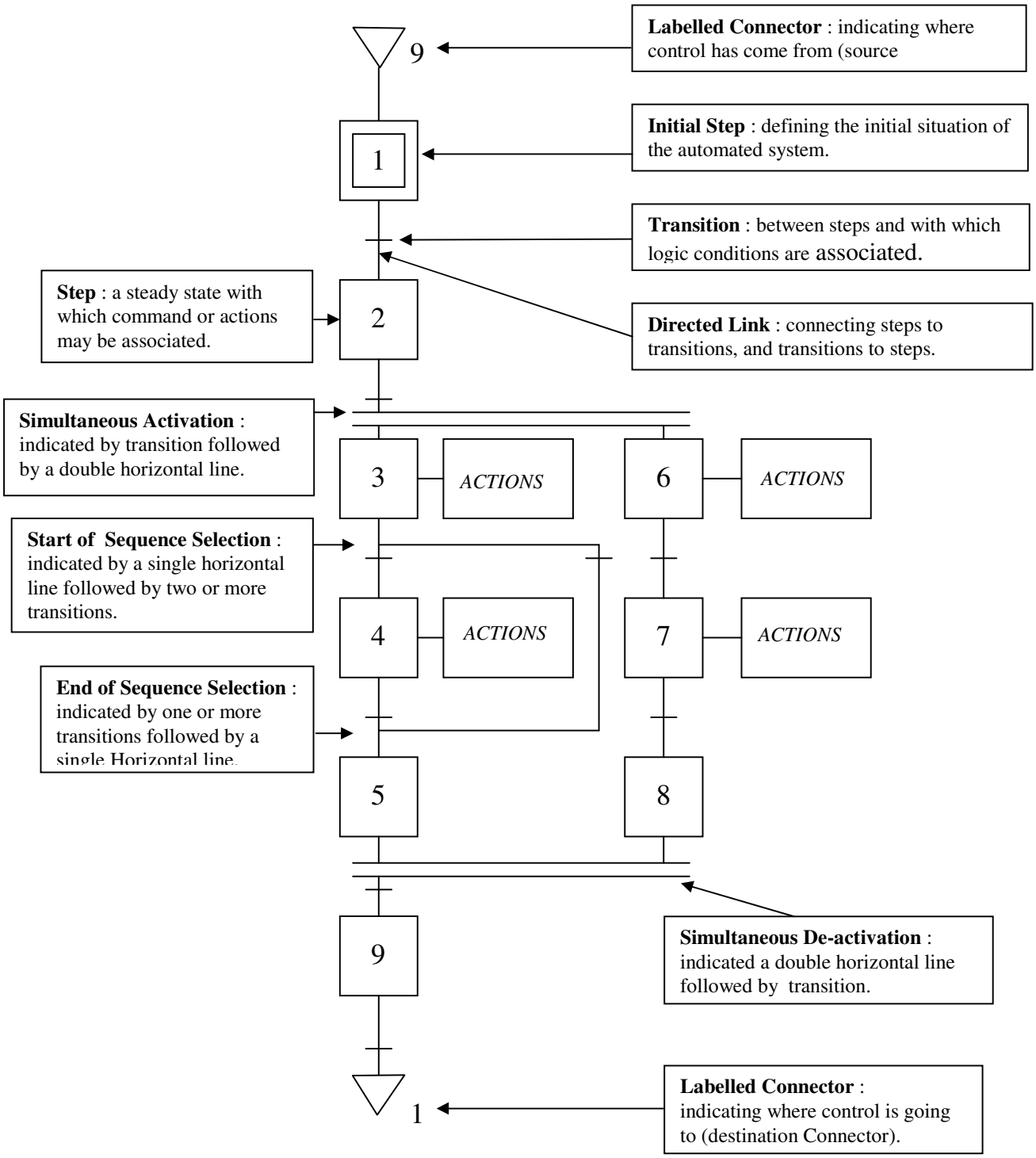




The GRAFCET (cont'd)



Different parts of a GRAFCET



Grafcet Design – Sequence

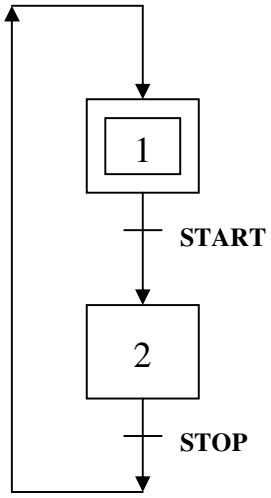
How to do the sequence.

1. Represent the steps (step_1 and step_2) by internal Relay bits R1 and R2.
   R1 and R2 will either be "1" (active) or "0" (inactive).

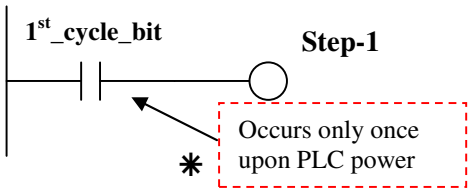
2. Only 1 step should be active at any one time.

3. Do not worry about outputs at the moment.

4. The initial step should be activated by the PLC internal scan cycle (the very first cycle). After which it will be activated by step_2 and stop_PB (during the return loop).

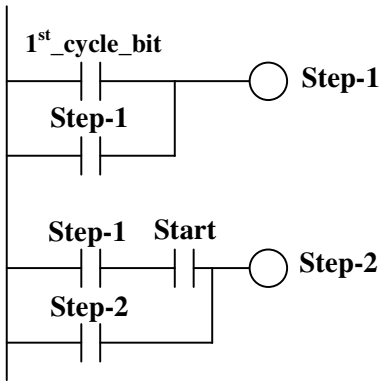


Step_1 activated by 1st cycle bit, but it will turn off during the 2nd cycle onwards. Hence, the need to on to the avtive state (therefore latch It) using step_1.



Step_1 latched.

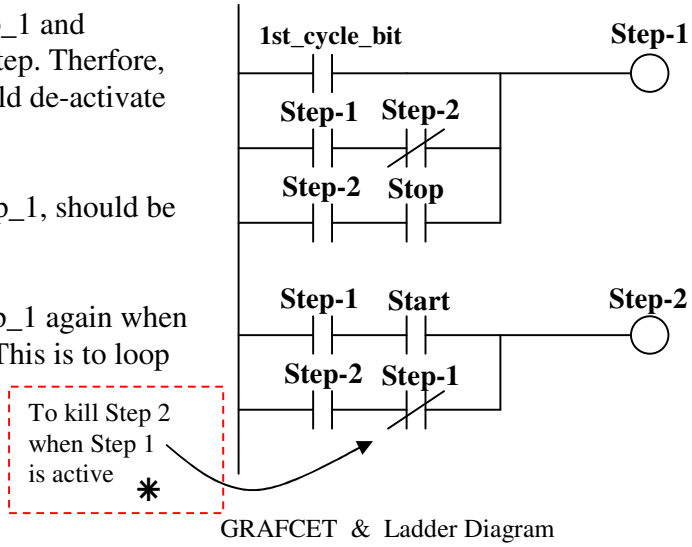
When step_1 is active and start_PB is pressed, step_2 will be active and need to be latched (because start_PB will eventually be released!)



(But then there will be 2 active steps: step_1 and step_2.We want to have only one active step. Therfore, when step_2 becomes active, step_2 should de-activate (kill-off) step_1.

Similarly, the step after step_2, that is step_1, should be used to de-activate (kill-off) step-2.

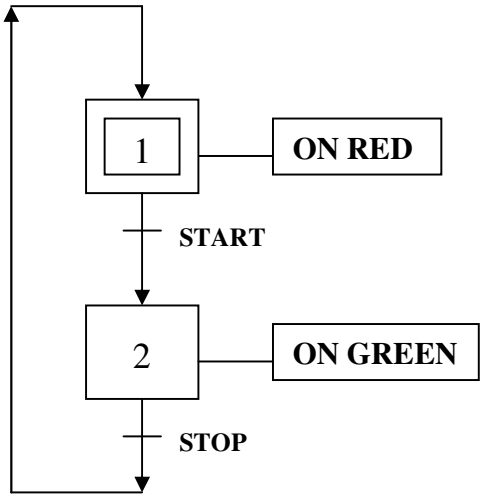
Provision must be made to go back to step_1 again when Step_2 is active and stop_PB is pressed.(This is to loop back).



Grafcet Design – Output

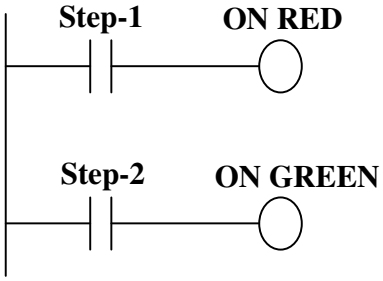
How to do the output:

1. Now that we have got the sequence, (sequence Ensures that step_1 and start_PB goes to step_2, And step_2 and stop_PB goes back to step_1, And so on) we can determine the outputs (i.e. What happens at each step).



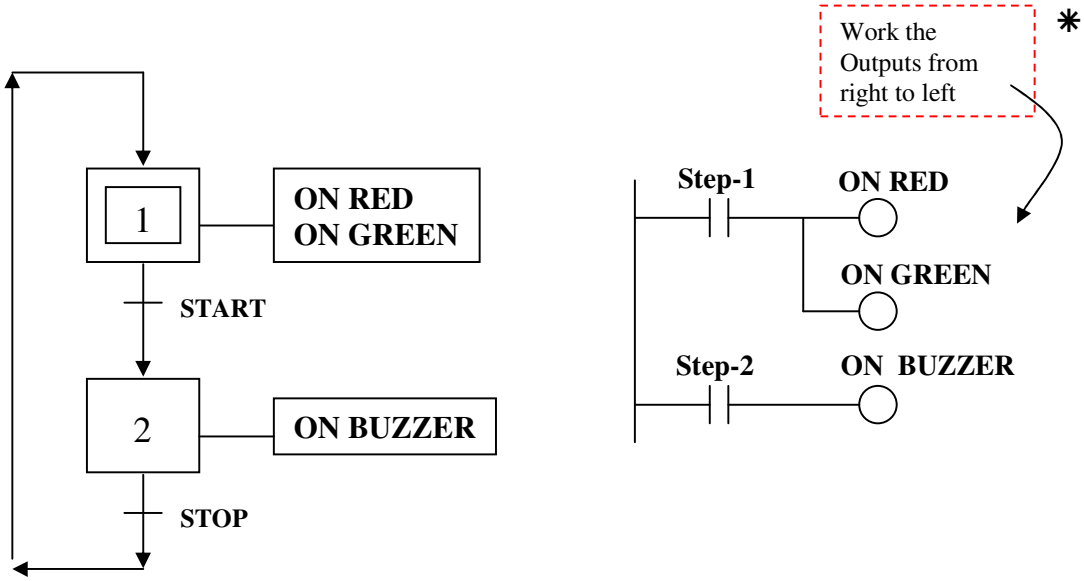
2. We can decide to turn on red_light in step_1 And turn on green_light in step_2 (if that is What is required).

3. That means upon powering up of PLC (remember 1st_ cycle_ bit → hence the initial step : step_1), the red light turns. When start_PB is pressed, green_light turns on. When stop_PB is pressed, red light turns on, and so on.
(Remember : no change in sequence, only the output).



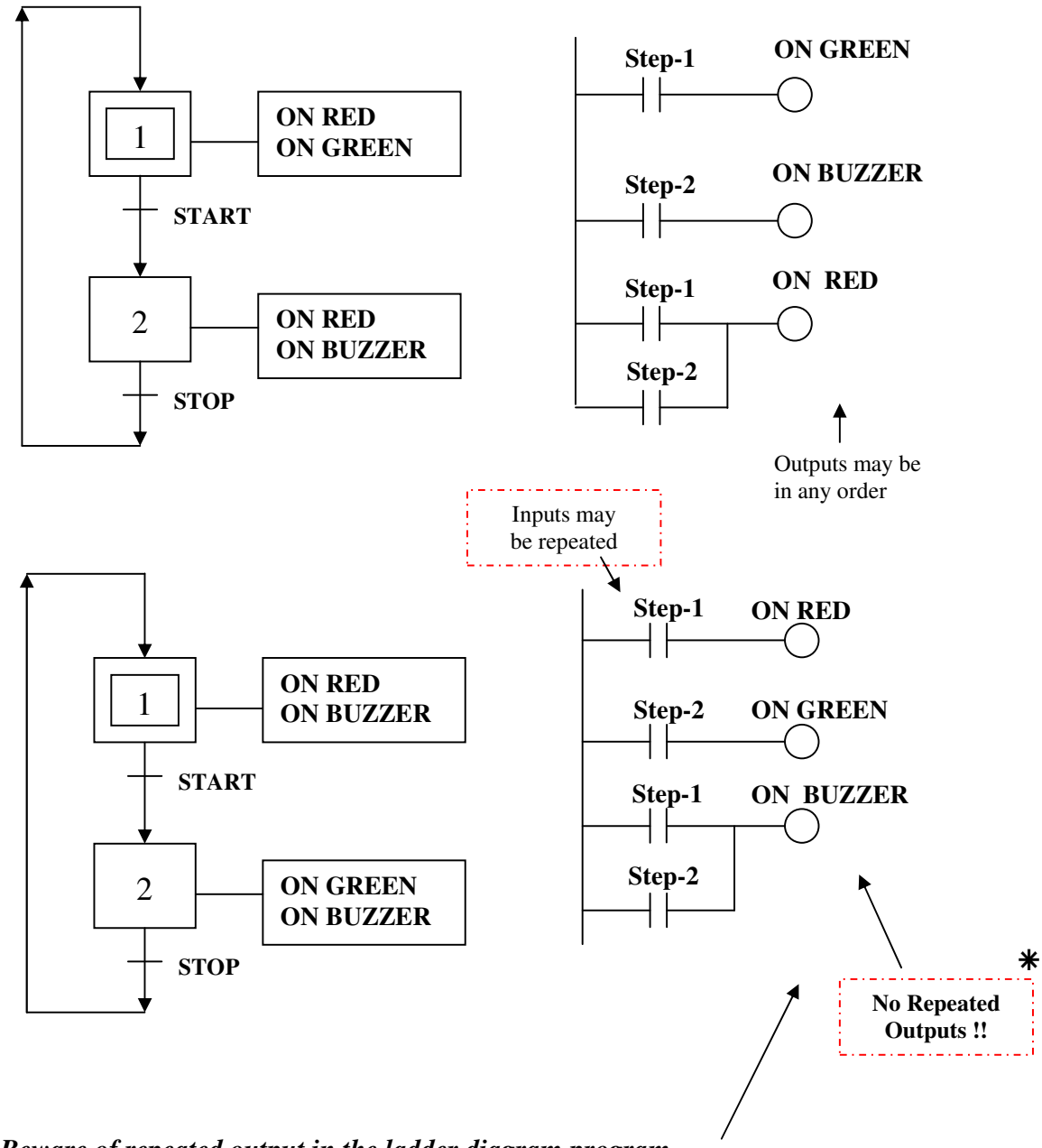
OR

We can decide to turn on the buzzer in step_2 and turn on both the lights in step_1. So that when start_PB is pressed, the red_light and green_light will turn on. (Remember : still no change in sequence, only the output).



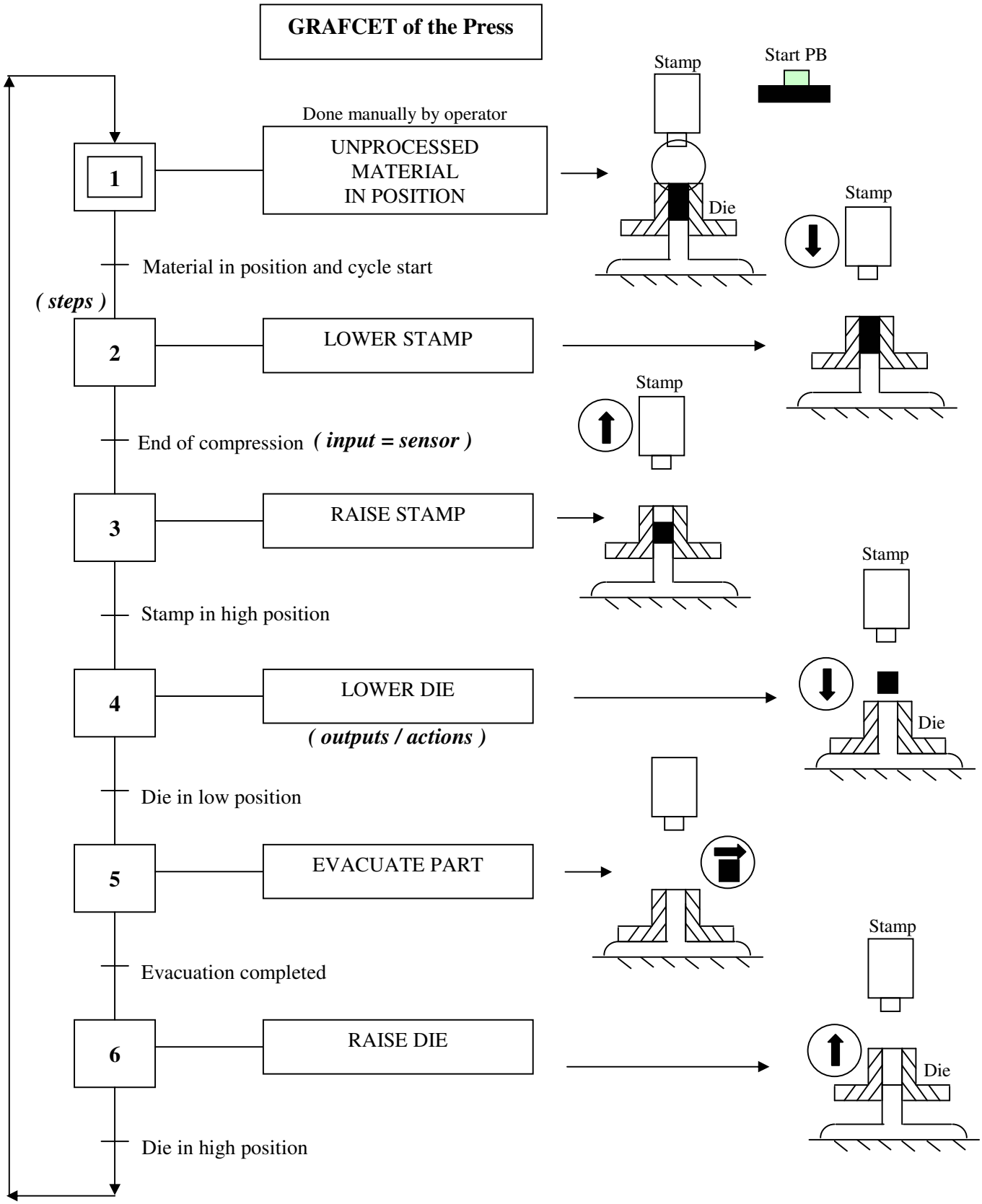
OR

Other examples.

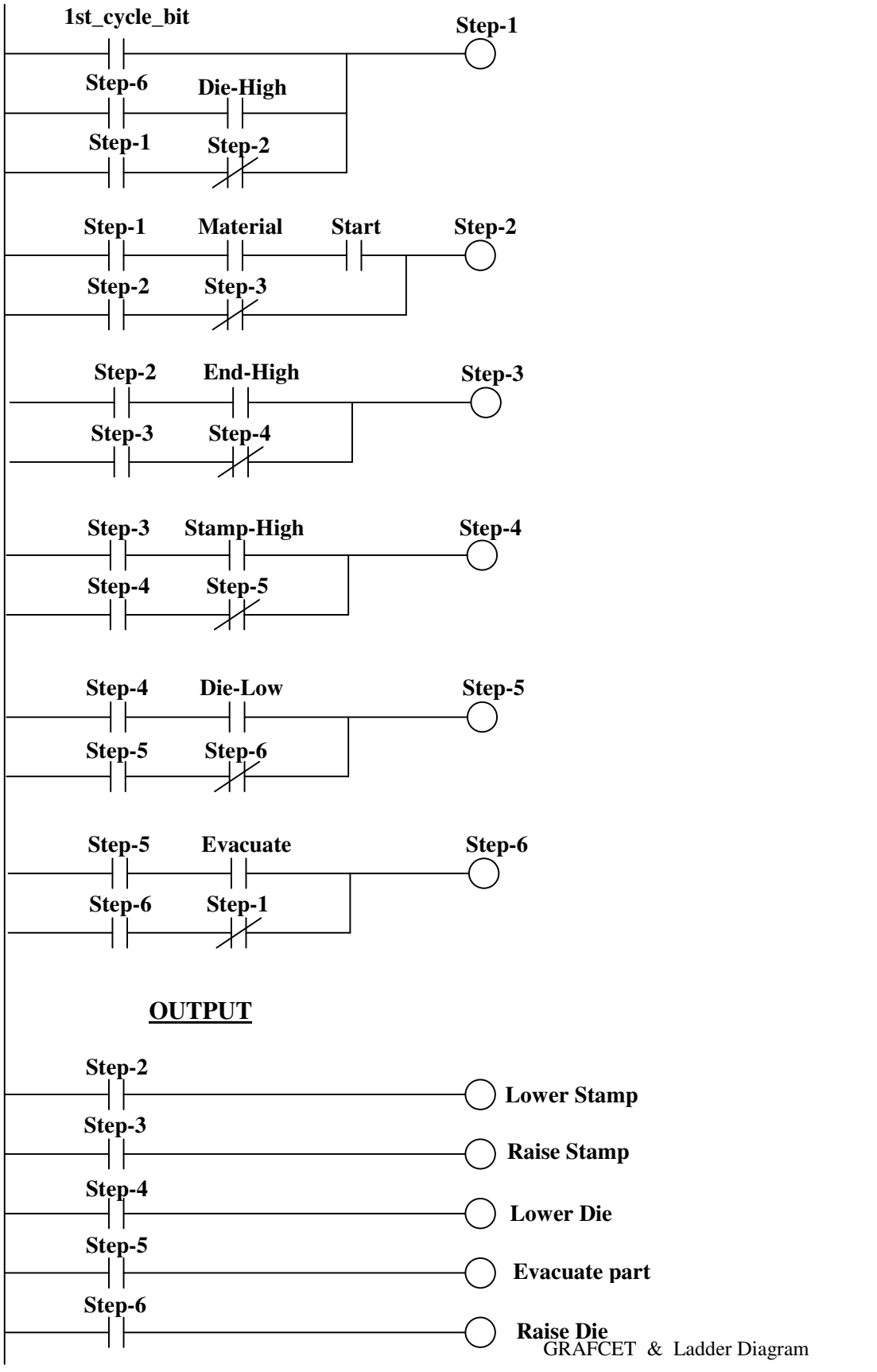


Note : ***Beware of repeated output in the ladder diagram program.***

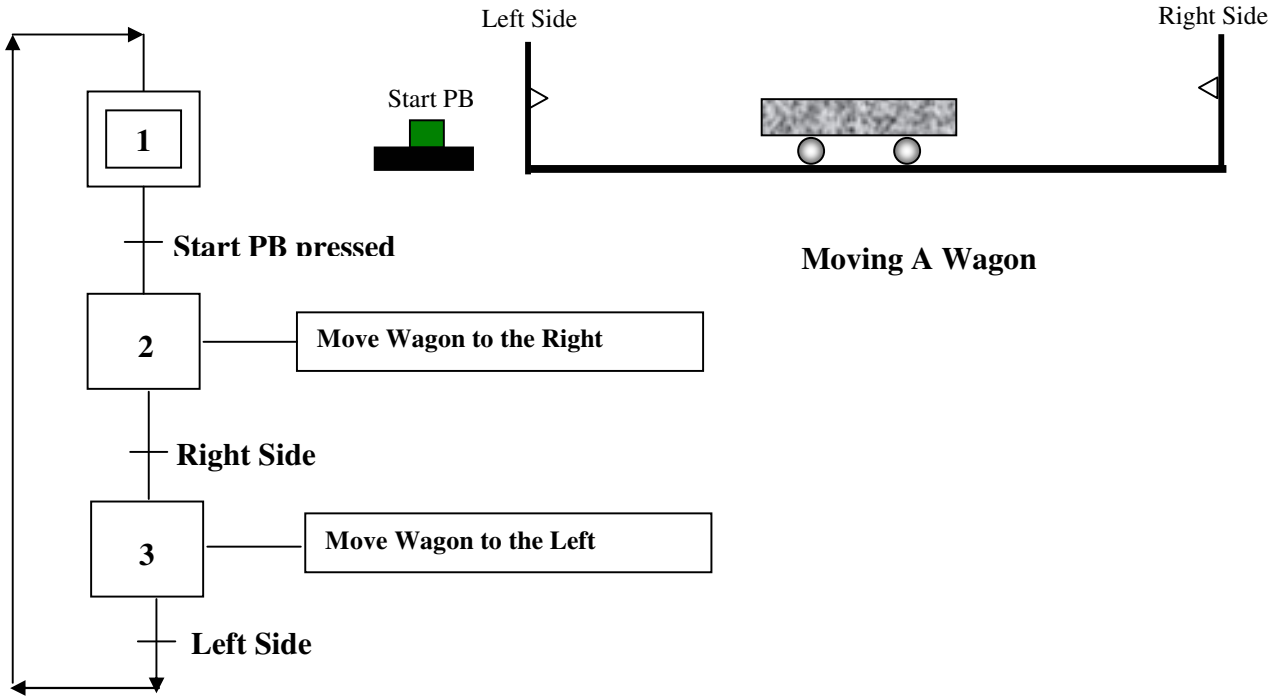
Even though the GRAFCET contains two instances of ON BUZZER
The OUTPUT ladder diagram should contain only one instance of ON BUZZER.
It is wise therefore to state the output first and see which steps need this output.
That is work the output part of the ladder diagram from right to left.


GRAFCET of the Press
Stamp
Start PB
Done manually by operator
1
UNPROCESSED MATERIAL IN POSITION
Die
Stamp
Material in position and cycle start
(steps)
2
LOWER STAMP
Stamp
End of compression (input = sensor)
3
RAISE STAMP
Stamp
Stamp in high position
4
LOWER DIE
(outputs / actions)
Die
Die in low position
5
EVACUATE PART
Stamp
Evacuation completed
6
RAISE DIE
Die
Die in high position

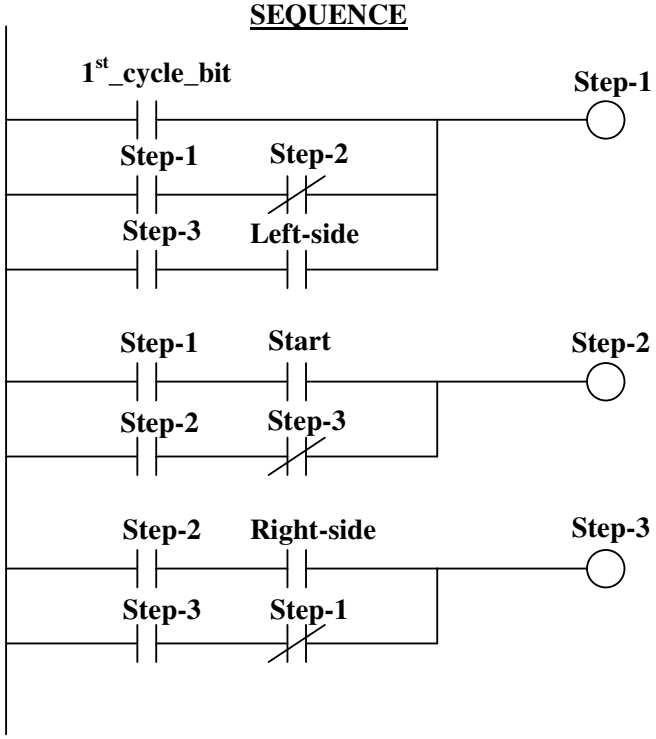
Ladder Diagram of the Press



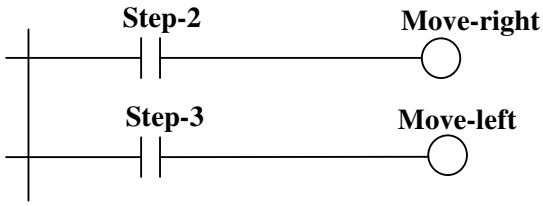
Project 1 - Moving a Wagon



SEQUENCE

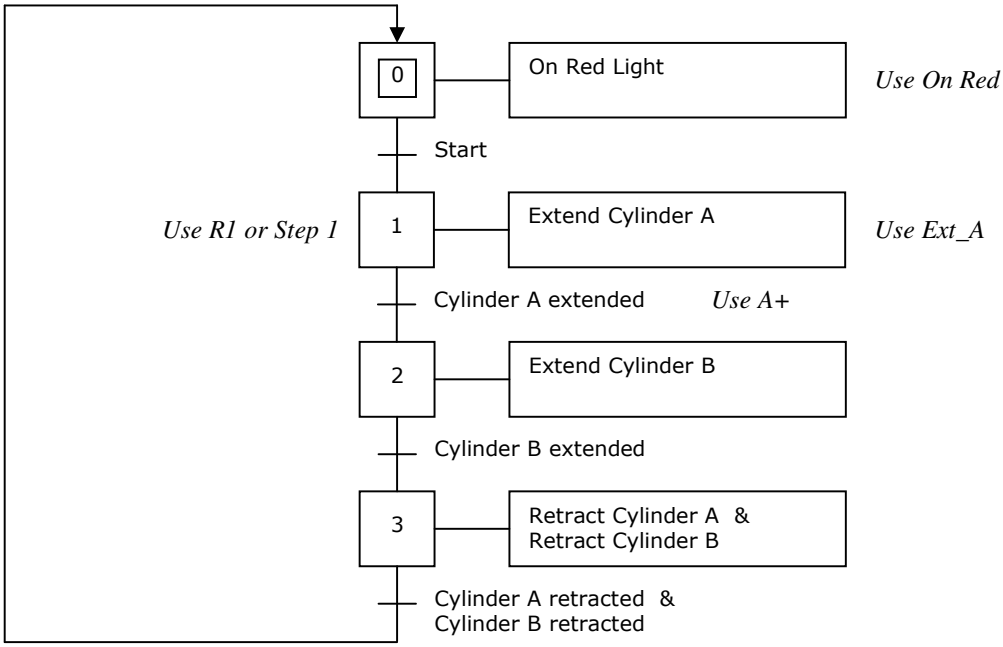


OUTPUT



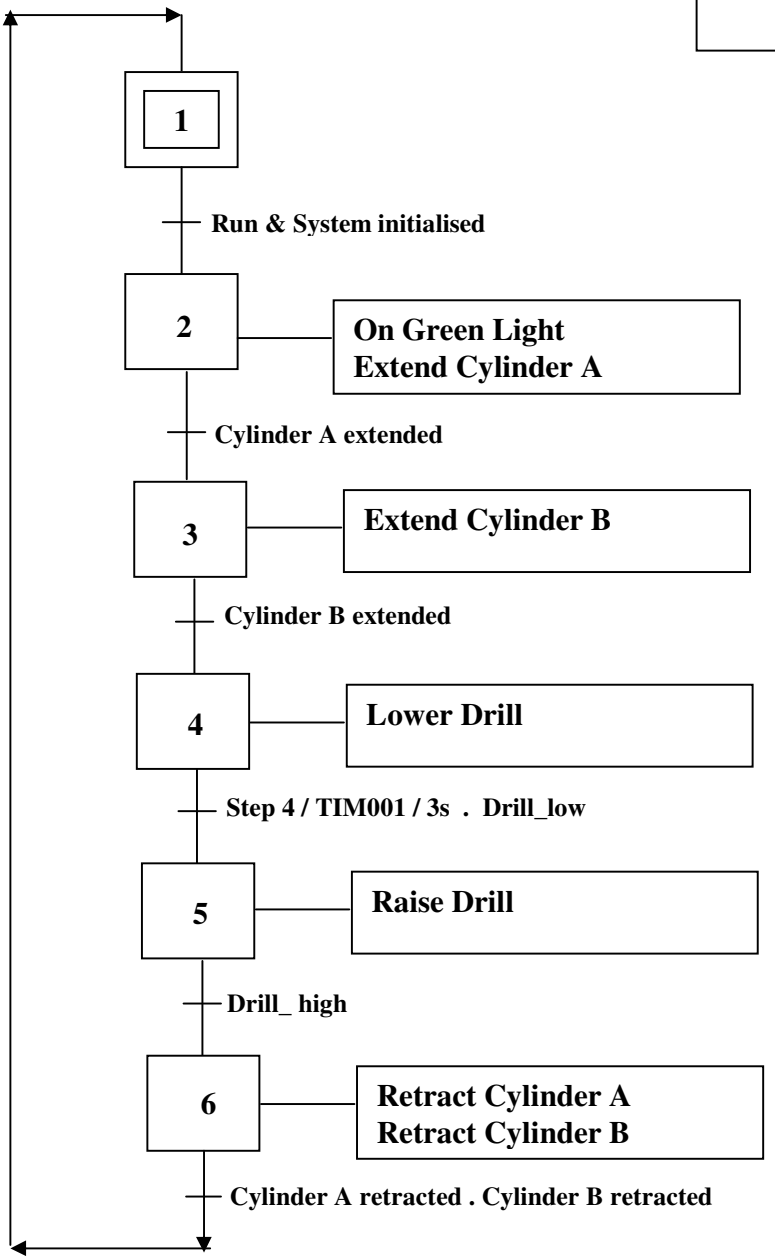
You try !

Convert GRAFCET → Ladder Diagram



Sequence *Output*

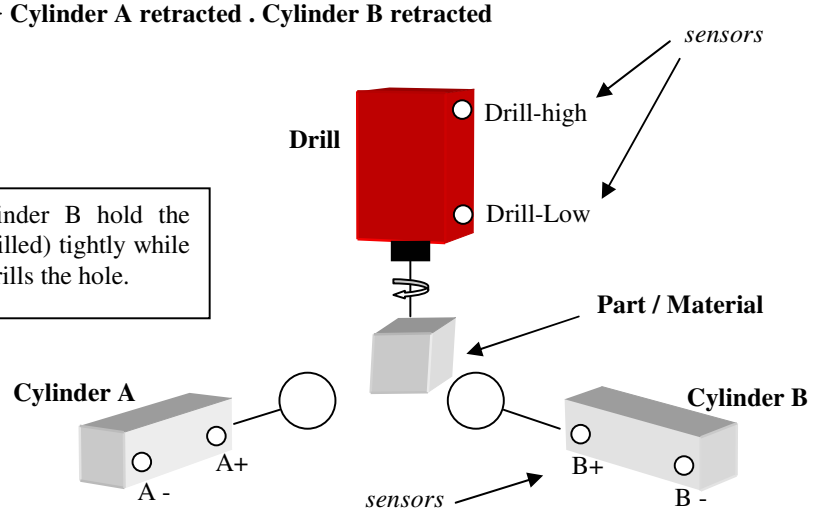
GRAFCET of the Drill



System initialization :

Retract Cylinder A
Retract Cylinder B
Off Green Light

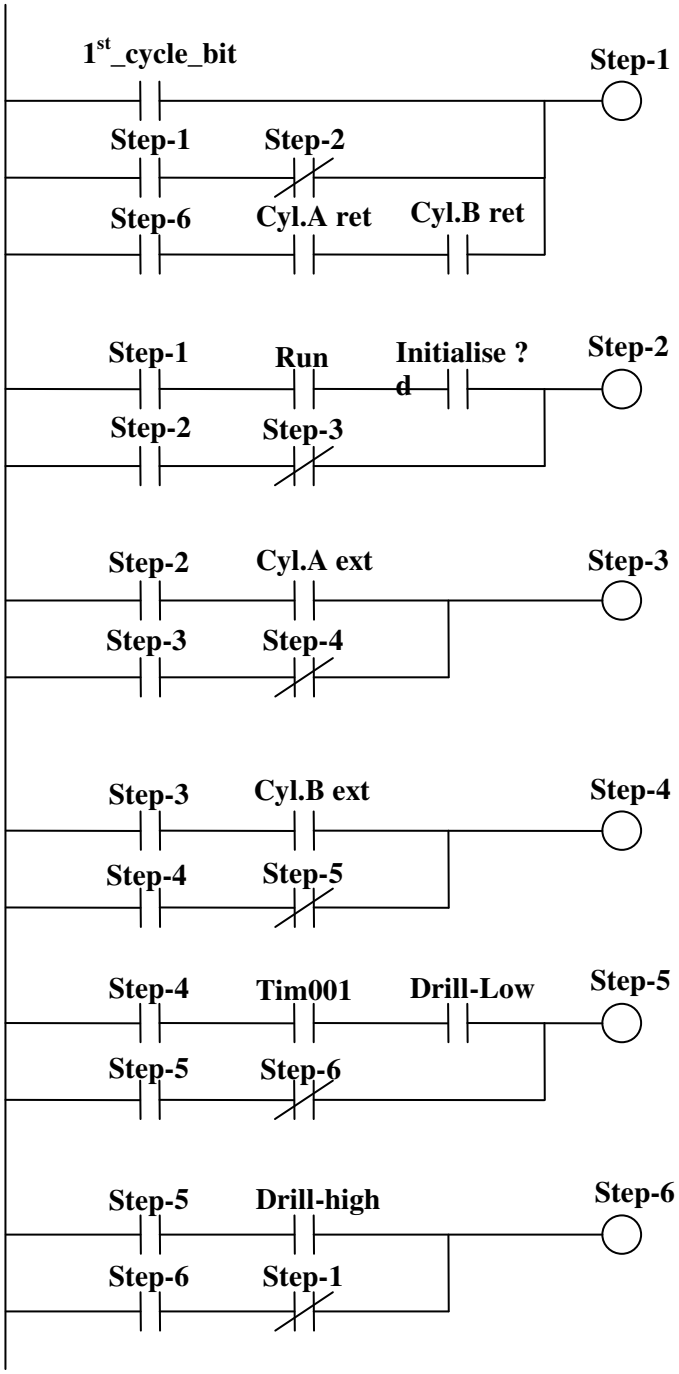
Cylinder A and Cylinder B hold the material (part to be drilled) tightly while the drilling machine drills the hole.



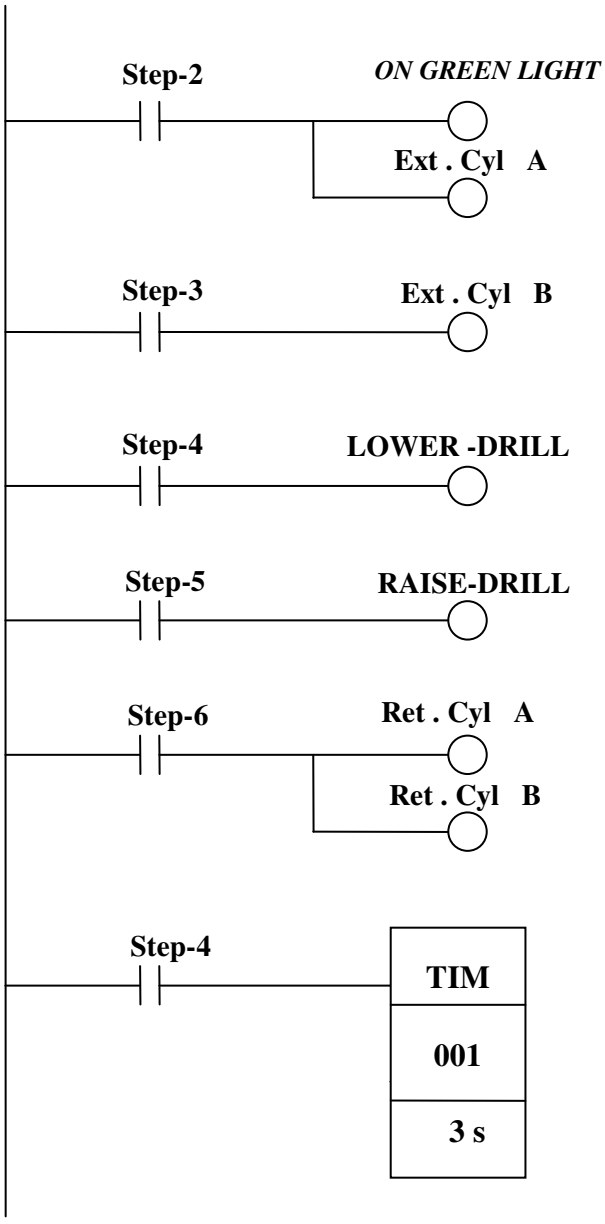
Project 2

Ladder Diagram of the Drill

SEQUENCE



OUTPUT

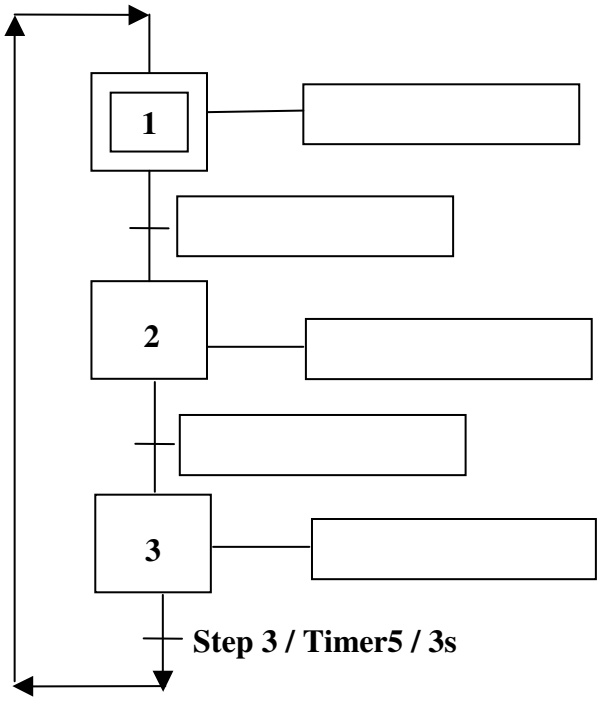


Grafcet Design

Automatic Hand Dryer

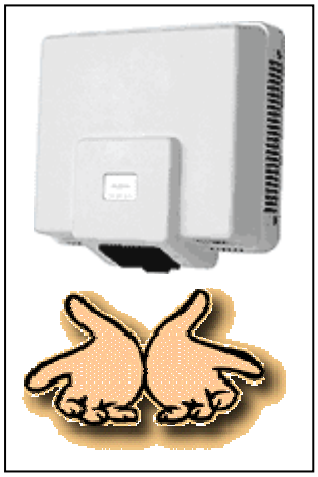
The system incorporates a diffuse sensor to detect the the presence of a pair of hands. When a pair of hands are placed just below the the Automatic Hand Dryer, heated air flow is turned on. When the person has completed drying his hands, the removal or absence of hands will be detected. The heated air will continue to flow for a further 3 seconds before the heated air flow is turned off.

Fill in the blanks :



Inputs

Presence of Hands
Absence of Hands



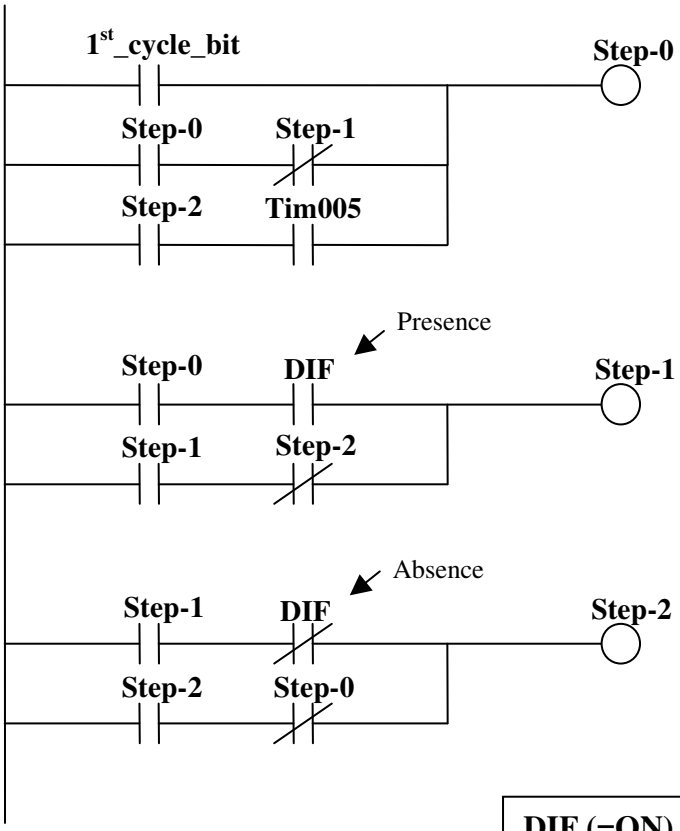
Automatic Hand Dryer

Outputs

Off Hand Dryer
On Hand Dryer

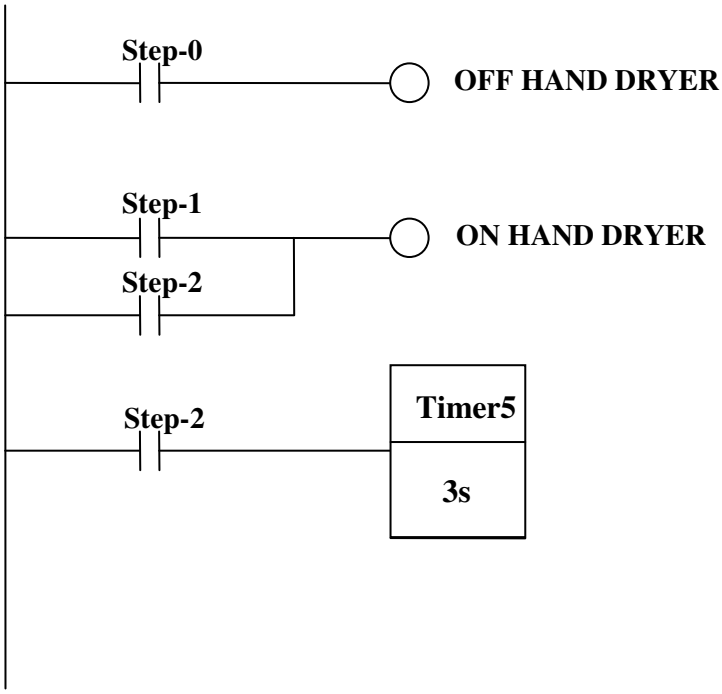
Automatic Hand Dryer

SEQUENCE



DIF (=ON) = Presence of hands

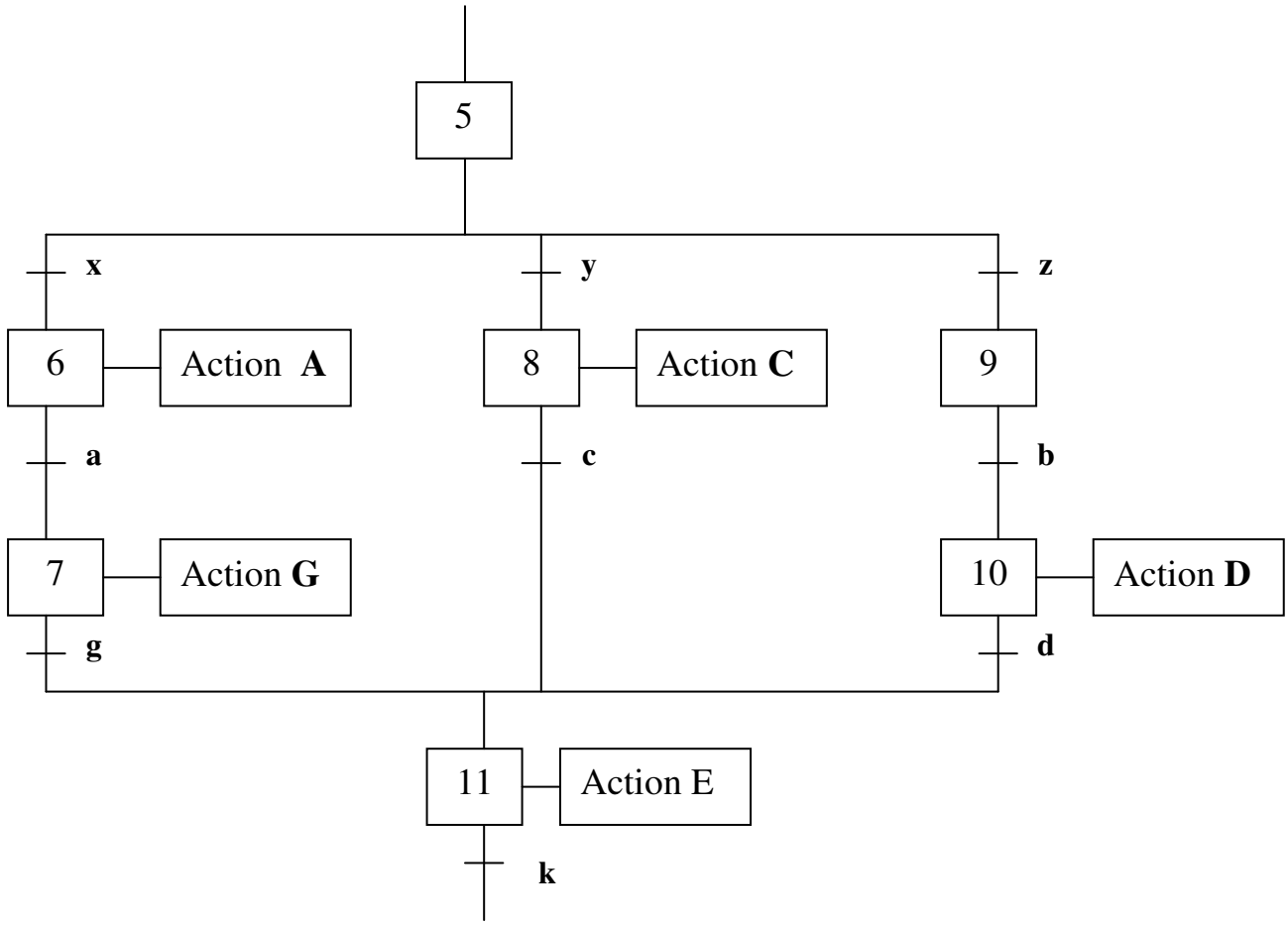
OUTPUT



GRAFCET with multiple selections

A Grafcet is generally made up of several sequences (several series of steps that execute one after the other) and it is often necessary to exclusively select one of these sequences.

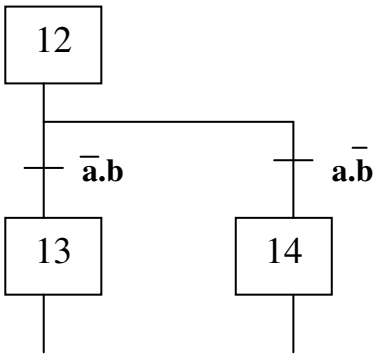
Example:



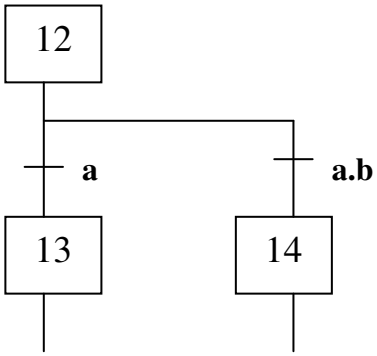
The above GRAFCET consists of a switch which allow to select one out of three possible sequences depend on the transition conditions x, y and z. The different transitions corresponding with their conditions x, y and z may be enable simultaneously and they could be cleared simultaneously if the transition conditions x, y and z were true at the same time. In order to avoid this from happening, the transition conditions must be mutually exclusive. It is also possible to introduce the priorities among the different sequences.

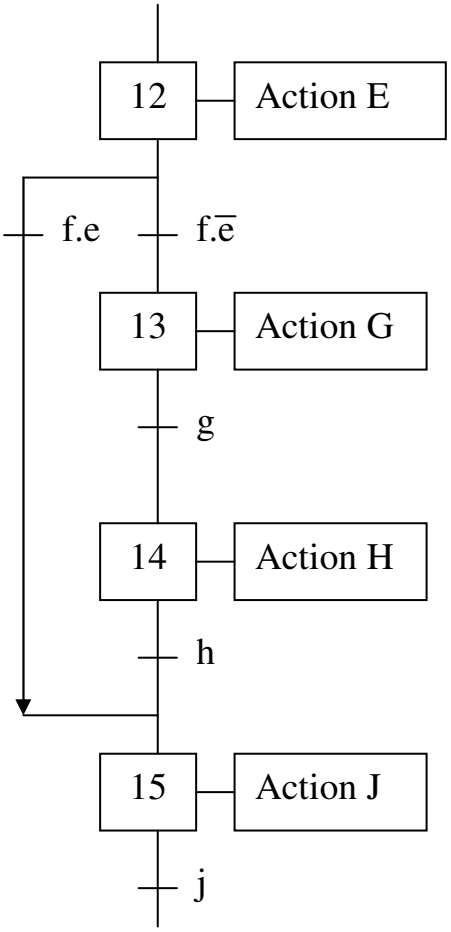
GRAFCET with multiple selections

The transition conditions $\bar{a}.b$ and $a.\bar{b}$ are mutually exclusive. If a and b are both present, the transition from step 12 will not be cleared.

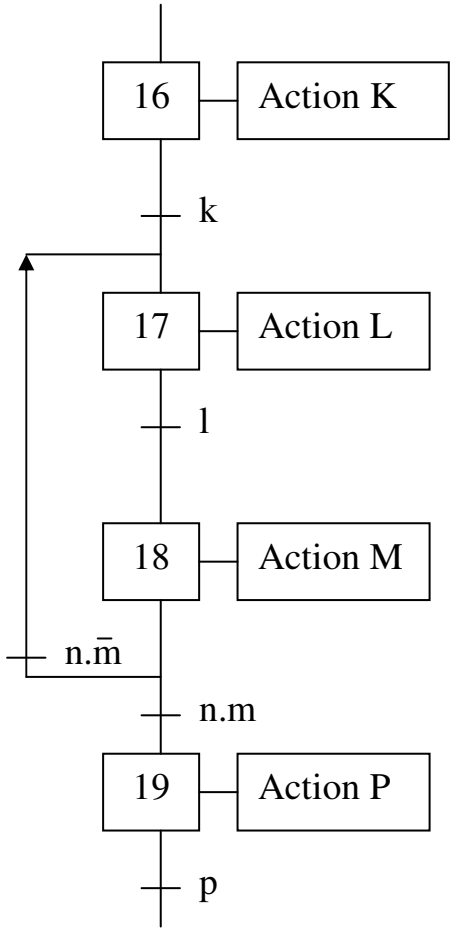


The transition 12-13 has higher priority than 12-14: the transition 12-13 will be cleared if both a and b are true at the same time.



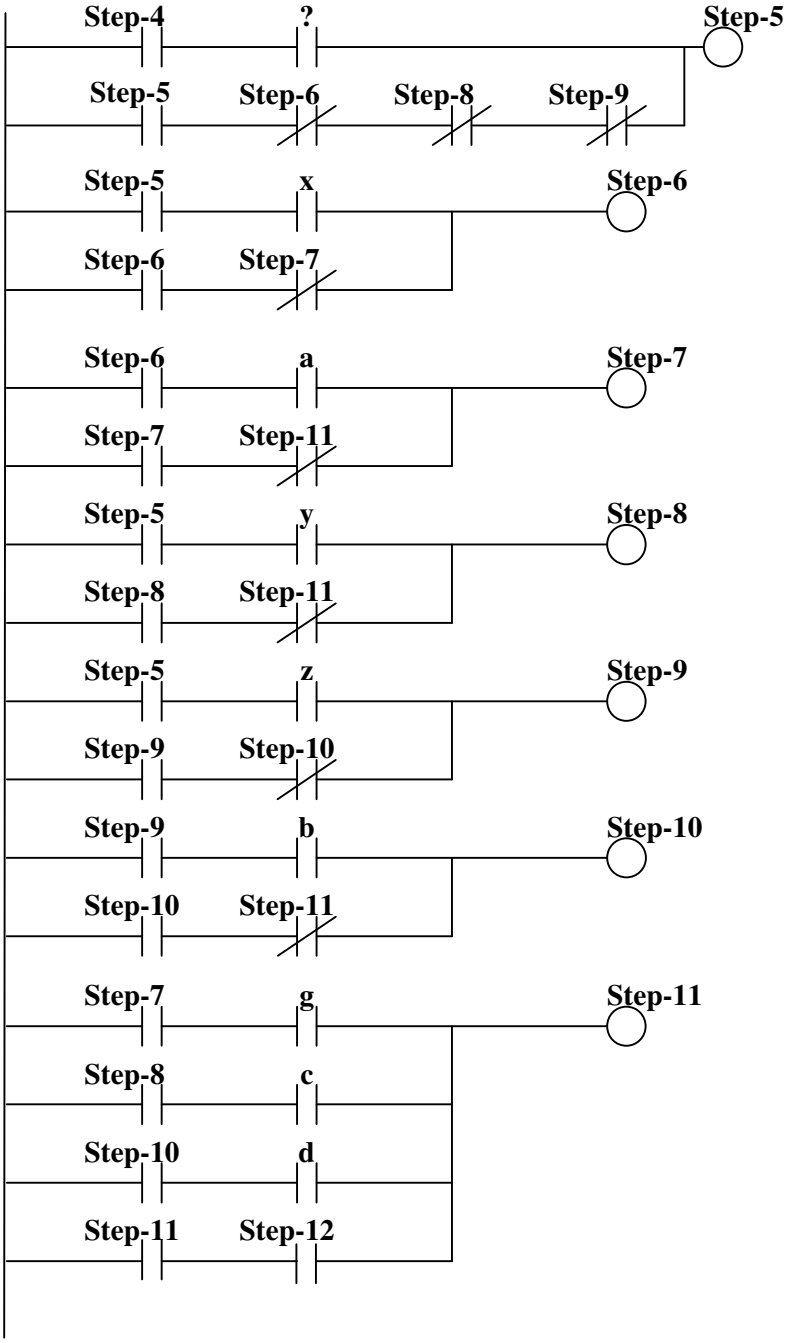


Jump from step 12 to step 15 if condition f.e is true.

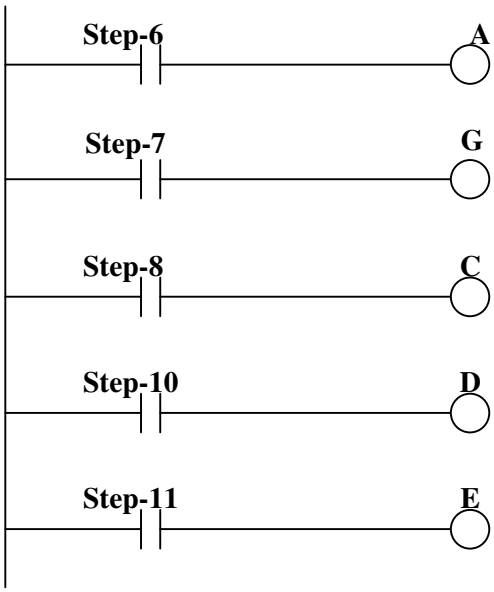


Repeat 17-18 if condition n.m is not obtained and $n.\bar{m}$ is true.

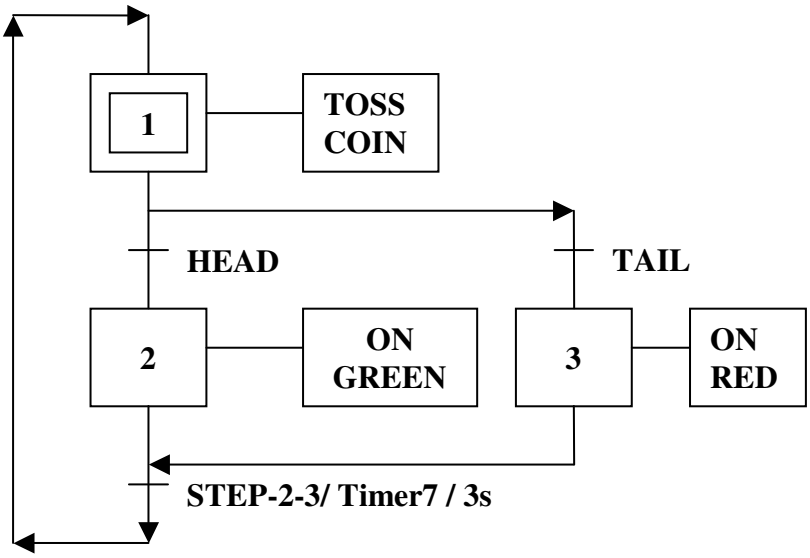
SEQUENCE



OUTPUT



GRAFCET : COIN TOSSER

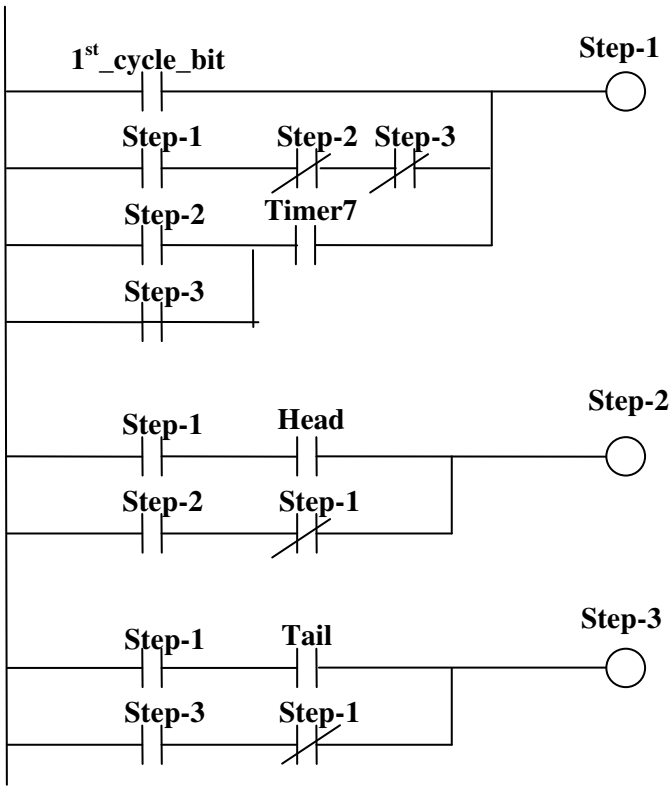


Input **Output**

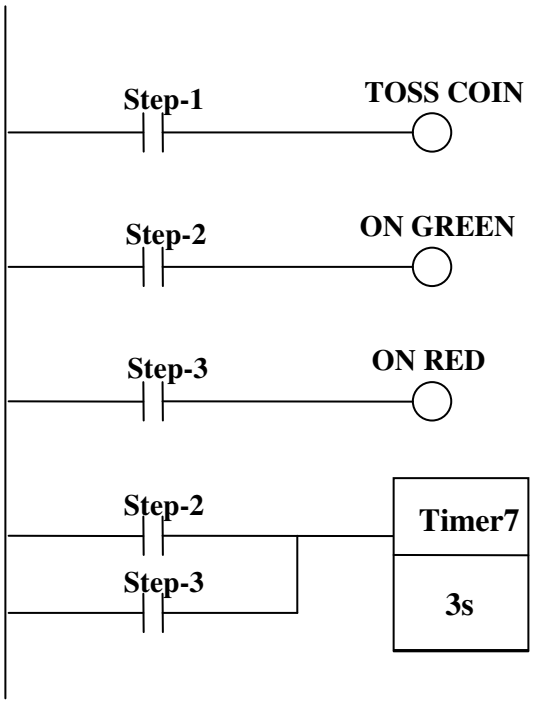
Label	Addr	Label	Addr
Head	X1	TOSS COIN	Y1
Tail	X2	GREEN	Y2
		RED	Y3

← **IO Listing** or
IO Address Assignment Table

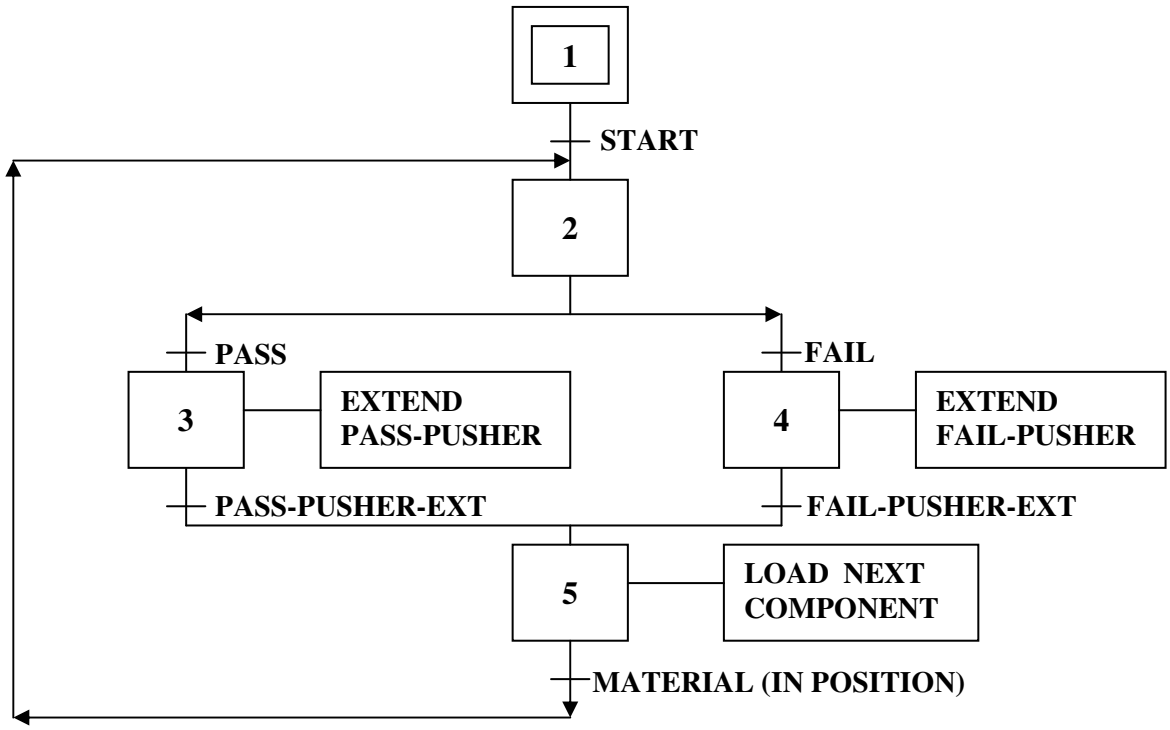
SEQUENCE



OUTPUT



GRAFCET: COMPONENT INSPECTION



SOLUTION : *Sequence & Output*

You try !

(c) **Design a GRAFCET** for the following system in Fig 1 (initial step = step 1):

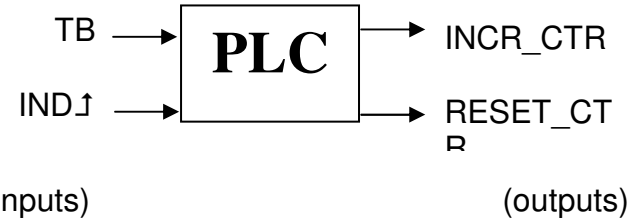
Detection of clasps on cardboard box:

The system incorporates a **through-beam** (TB) **optical sensor**, an **inductive sensor** (IND↥) and a **counter**.

The presence of a new clasp increments the counter (INCR_CTR).

The counter serves only to show the number of clasps on each box that passes by. No other action need to be taken by the system based on the number of clasps detected.

The counter is reset (RESET_CTR) for every new box that arrives.



PLC input-output diagram

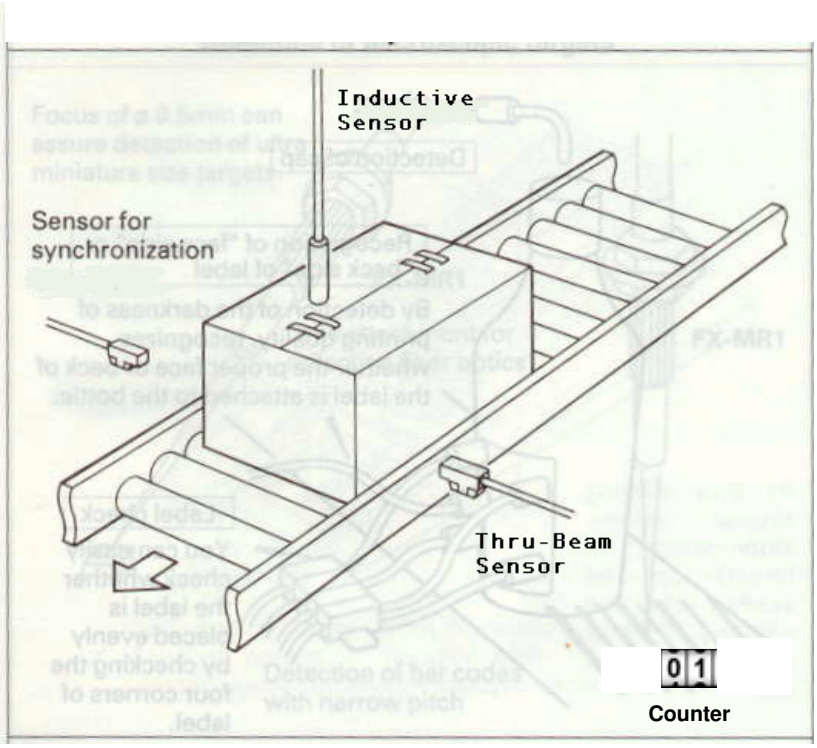


Fig. 1 : Detection of clasps on cardboard box

You try !

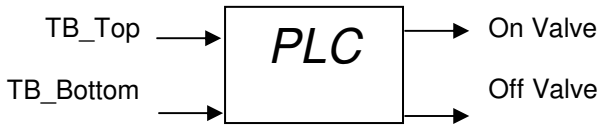
Solution :

You try !

(d) **Design a GRAFCET** for the following system in Fig Q3d (initial step = step 1):

Automatic gauge level monitoring: The system incorporates two through-beam (TB) optical sensors to monitor the level of the fluid in the stationary glass gauge as shown in Fig Q3d. When the level falls below the lower limit, a valve situated on top of the gauge is turned on automatically to add more fluid. When the fluid level reaches above the upper limit, the valve is turned on for a further 10 seconds before it is turned off.

Note : The control of filling level through glass gauge makes use of the laws of refraction. The fluid, being the optically denser medium, breaks the light beam. Without the fluid the sensor is activated.



(inputs) (outputs)

PLC input-output diagram

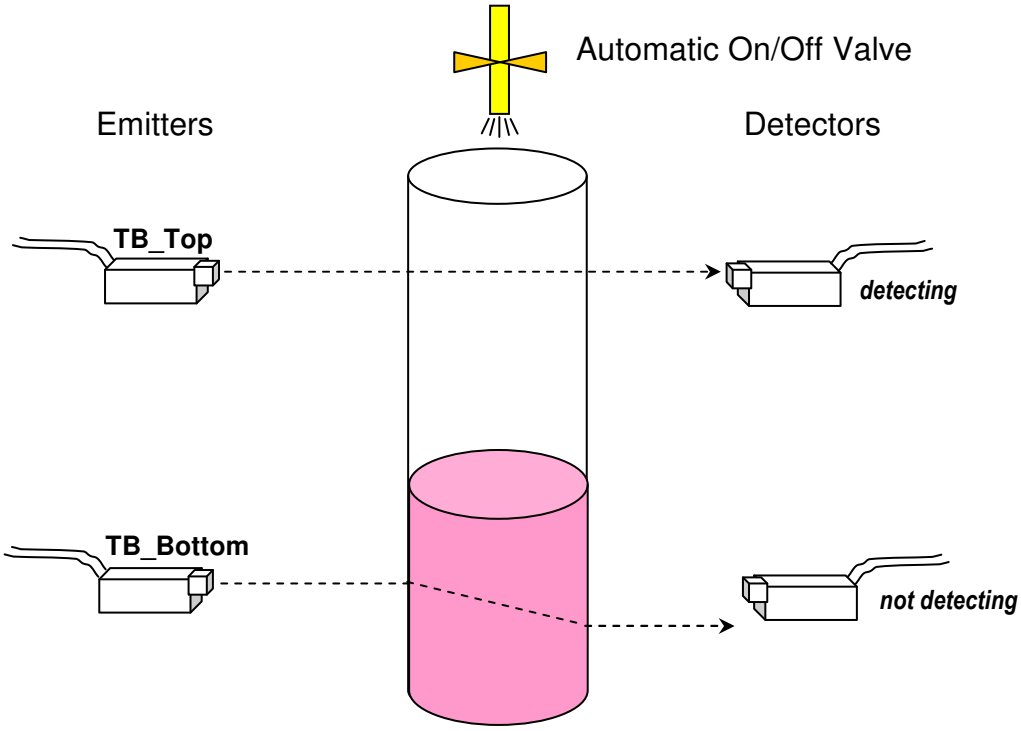


Fig. Q3d : Automatic Gauge Level Monitoring

You try !

Solution :