Programming Methods

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Instruction List

An instruction list :

- Gives programs as a series of instructions, with each instruction on a new line.
- Each instruction consists of an operator followed by one or more operands, that is, the subjects of the operator.

LD A

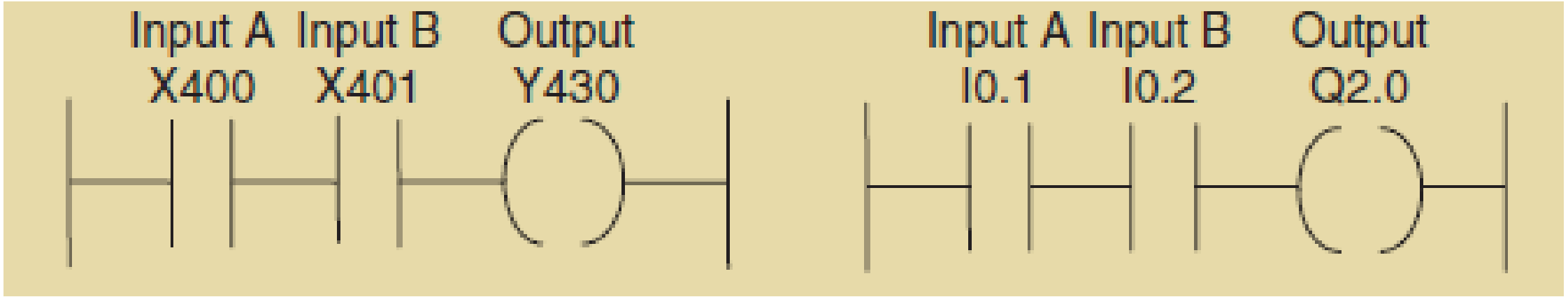
- To indicate that the operand A is to be loaded, LD being the operator used to indicate loading.

In terms of ladder diagrams, an operator may be regarded as a ladder element, and LD is equivalent to starting a rung with open contacts for input A.

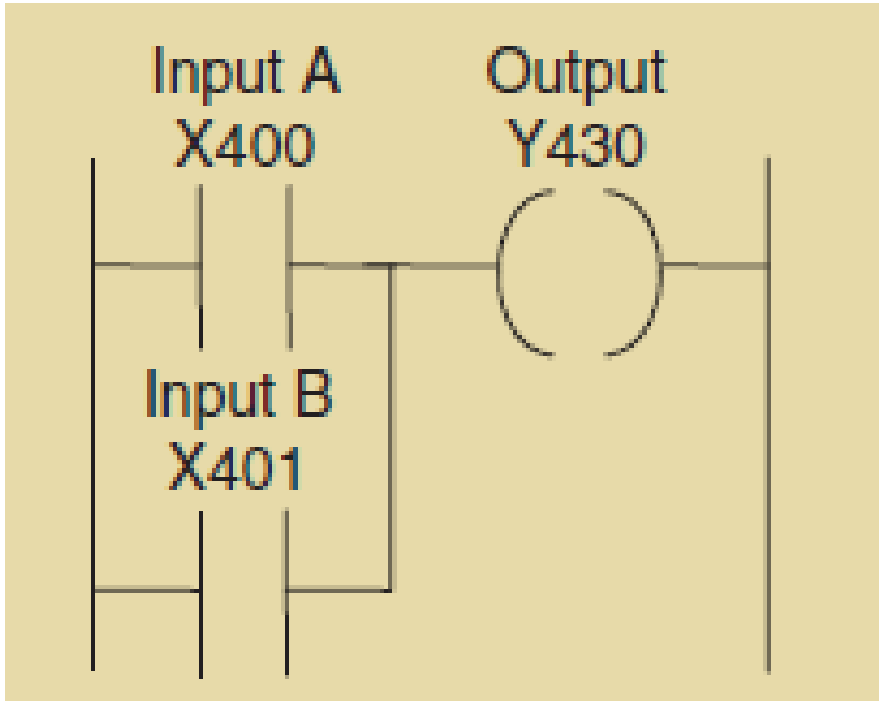
Another instruction might be:

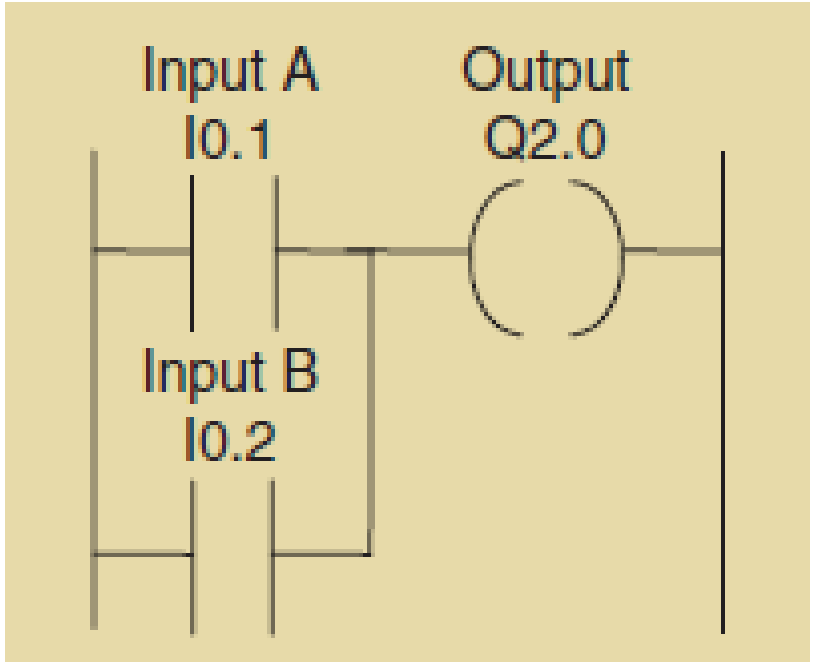
OUT Q

IEC 1131-3	Mitsubishi	OMRON	Siemens	Operation	Ladder Diagram
LD	LD	LD	A	Load operand into result register.	Start a rung with open contacts.
LDN	LDI	LD NOT	AN	Load negative operand into result register.	Start a rung with closed contacts.
AND	AND	AND	A	Boolean AND.	Series element with open contacts.
ANDN	ANI	AND NOT	AN	Boolean AND with negative operand.	Series element with closed contacts.
OR	OR	OR	O	Boolean OR.	Parallel element with open contacts.
ORN	ORI	OR NOT	ON	Boolean OR with negative operand.	Parallel element with closed contacts.
ST	OUT	OUT	=	Store result register into operand.	An output.

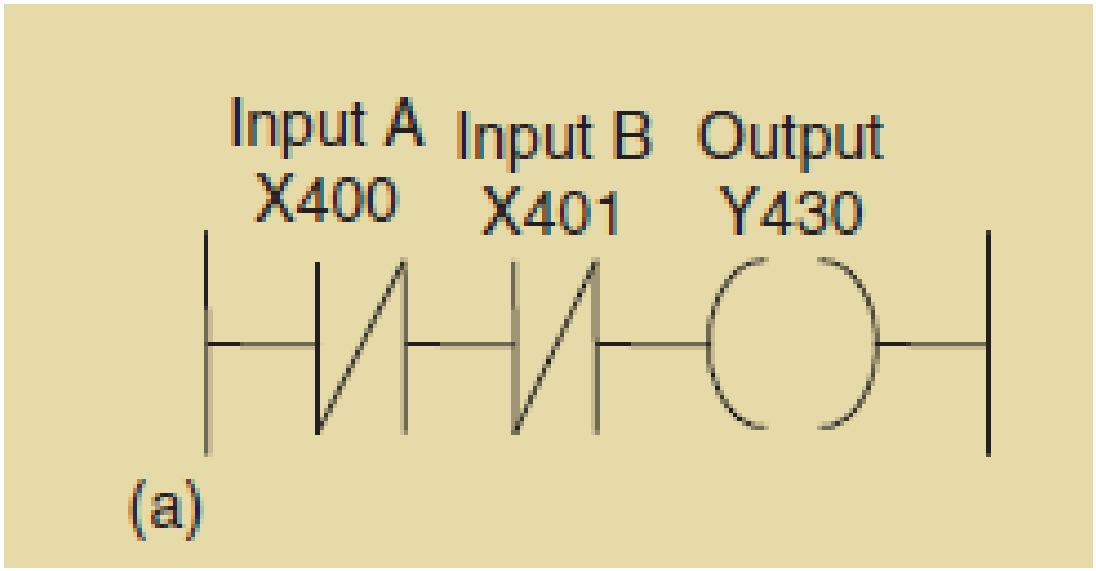

Input A
X400
Input B
X401
Output
Y430
Input A
I0.1
Input B
I0.2
Output
Q2.0

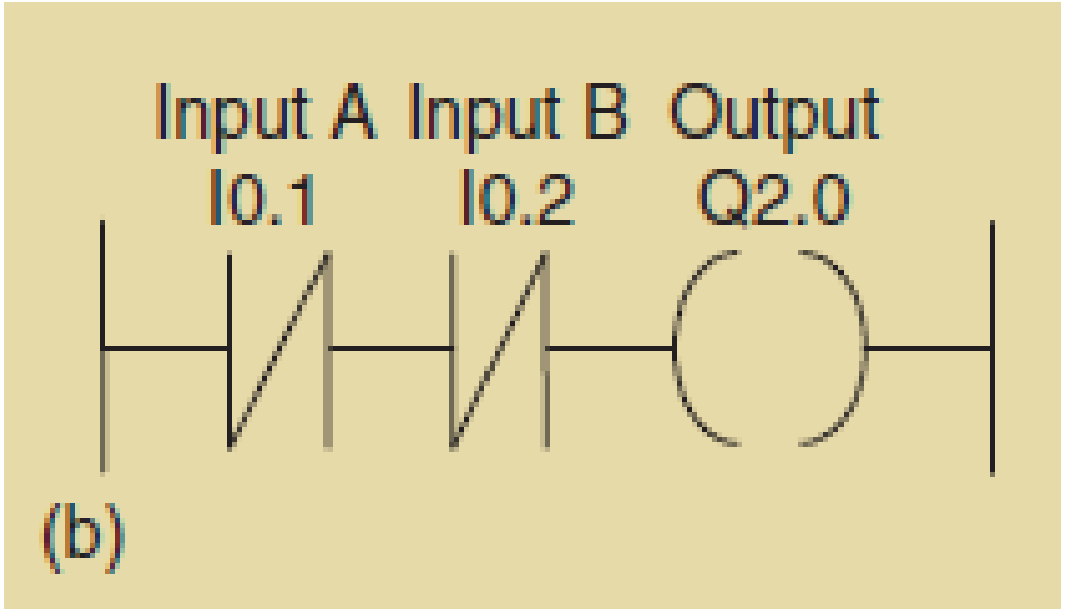
LD X400	A I0.1
AND X401	A I0.2
OUT Y430	=Q2.0


Input A
X400
Output
Y430
Input B
X401

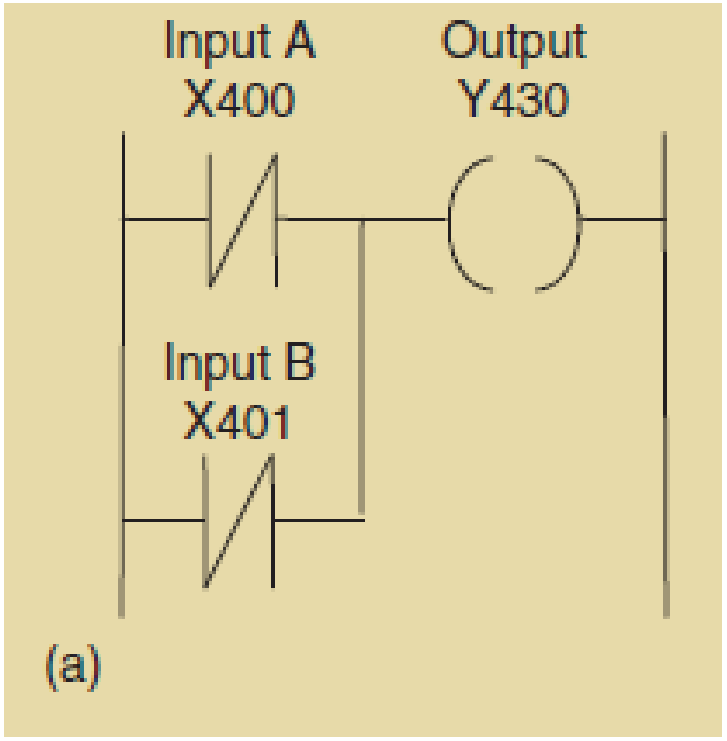

Input A
I0.1
Output
Q2.0
Input B
I0.2

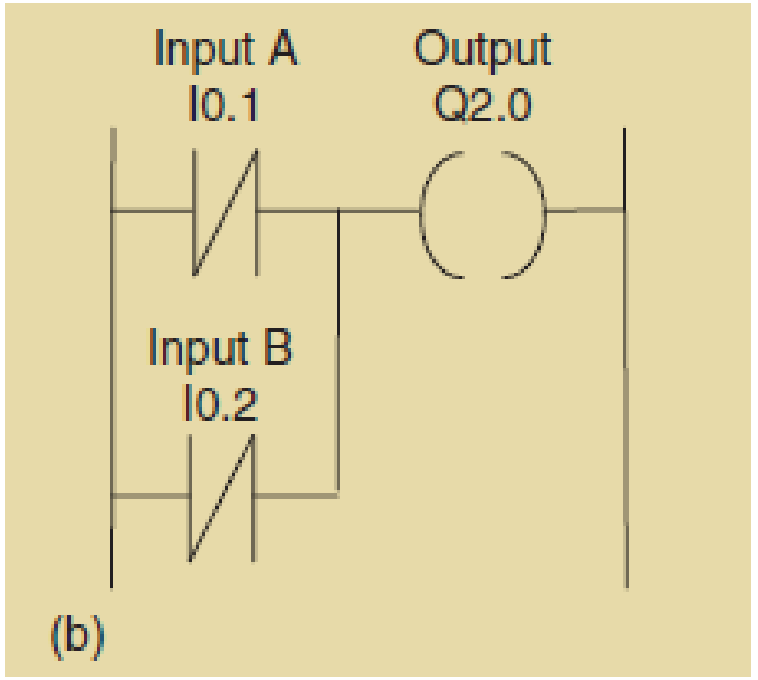
LD X400	A I0.1
OR X401	O I0.2
OUT Y430	=Q2.0


Input A
X400
Input B
X401
Output
Y430
(a)

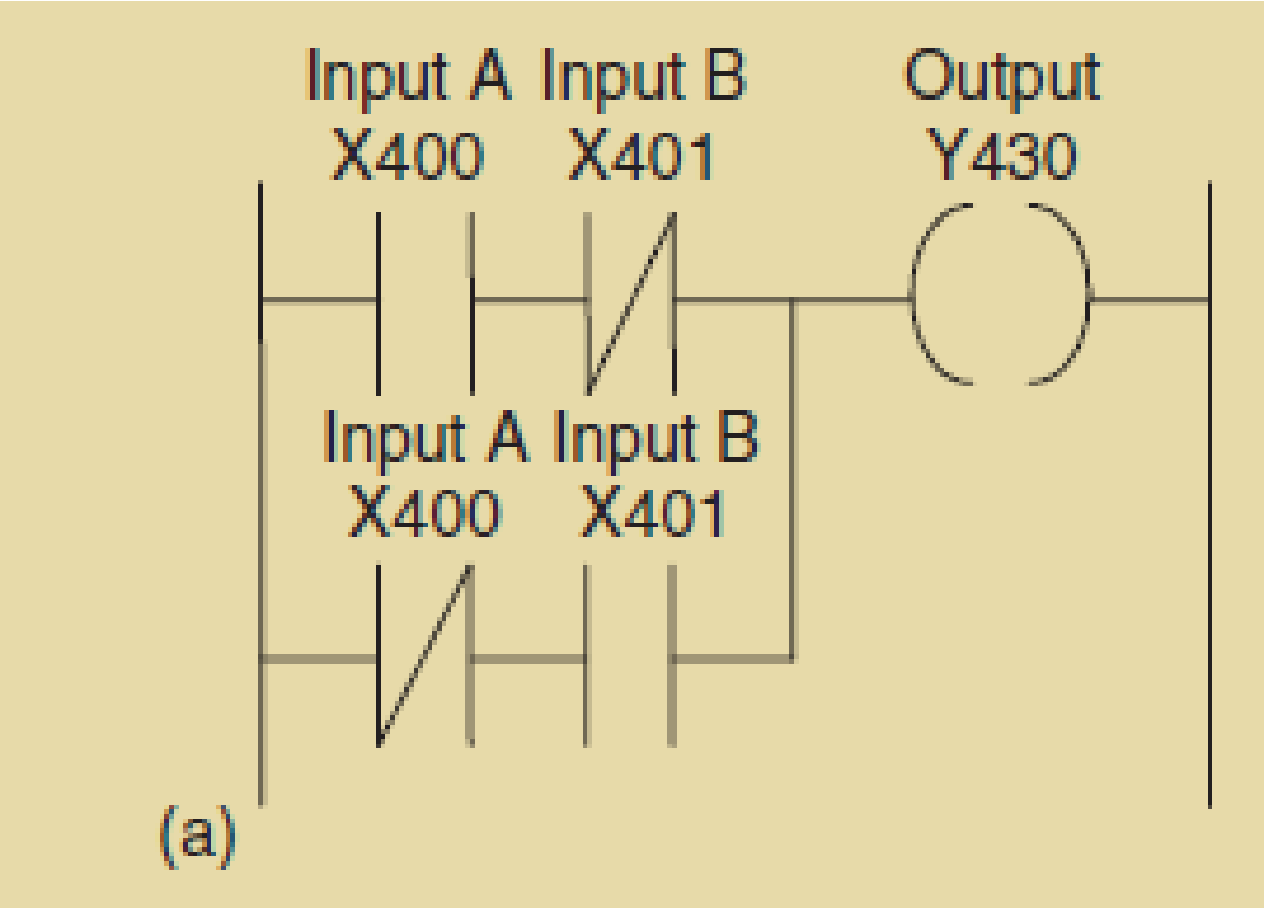

Input A
I0.1
Input B
I0.2
Output
Q2.0
(b)

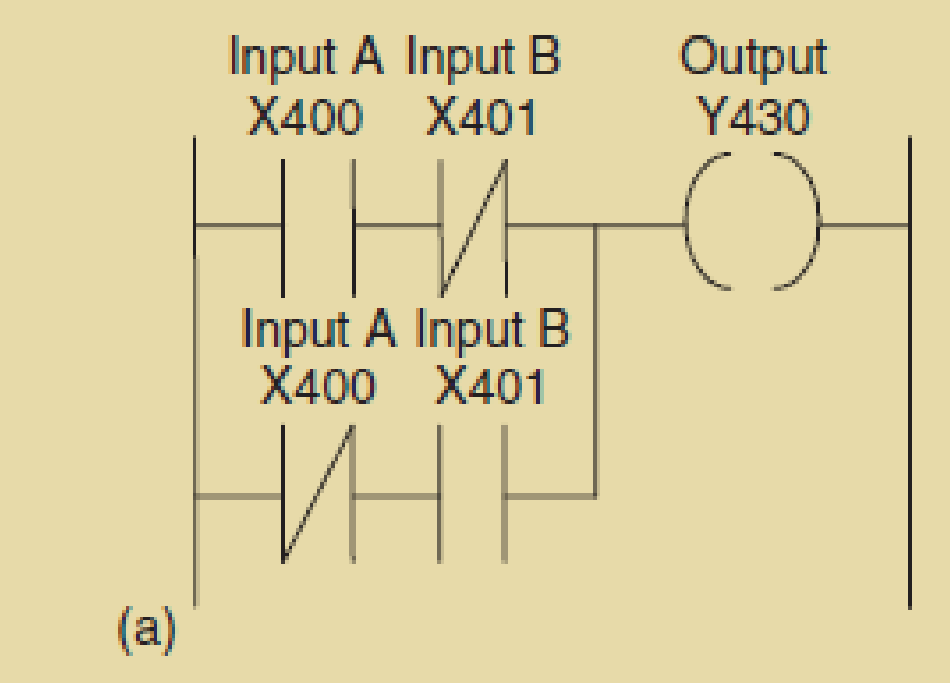
LDI X400	LN I0.1
ANI X401	AN I0.2
OUT Y430	= Q2.0


Input A
X400
Output
Y430
Input B
X401
(a)


Input A
I0.1
Output
Q2.0
Input B
I0.2
(b)

LDI X400	AN I0.1
ORI X401	ON I0.2
OUT Y430	=Q2.0


Input A
X400
Input B
X401
Output
Y430
Input A
X400
Input B
X401
(a)



LD X400

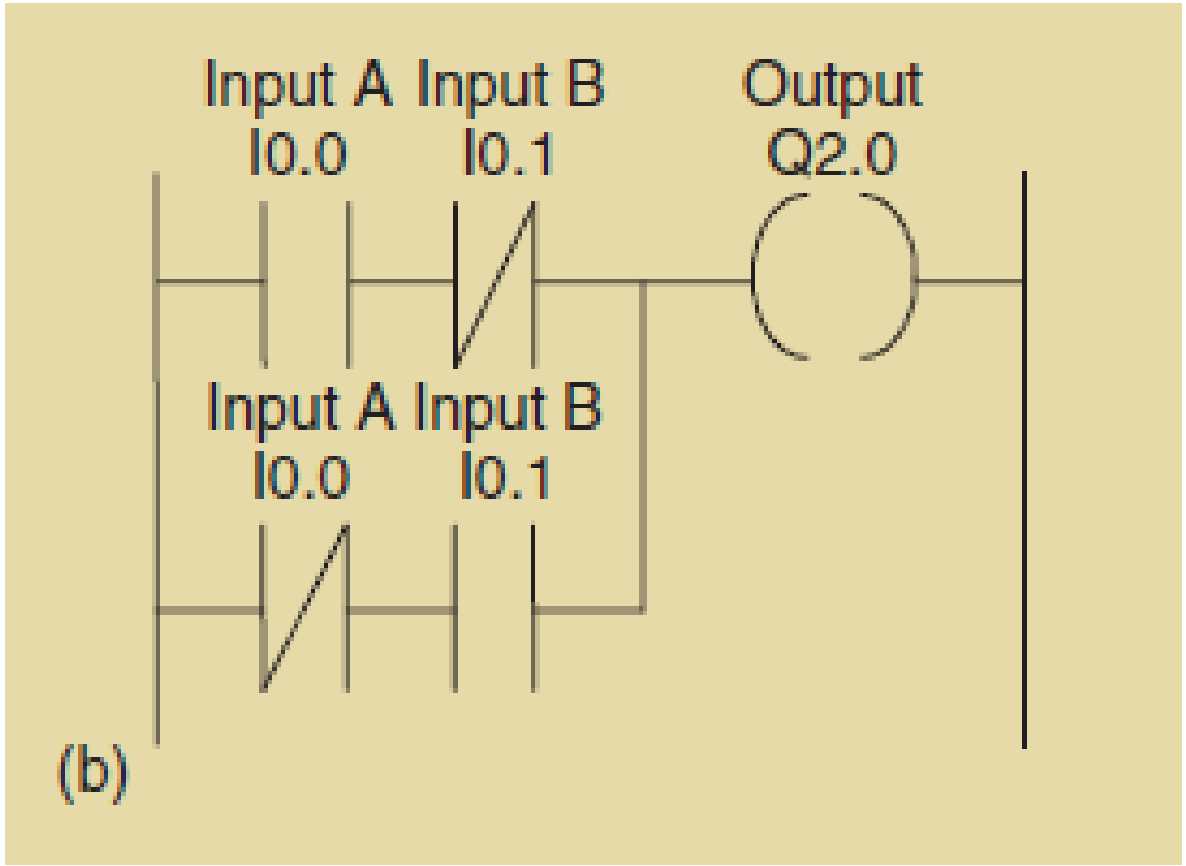
ANI X401

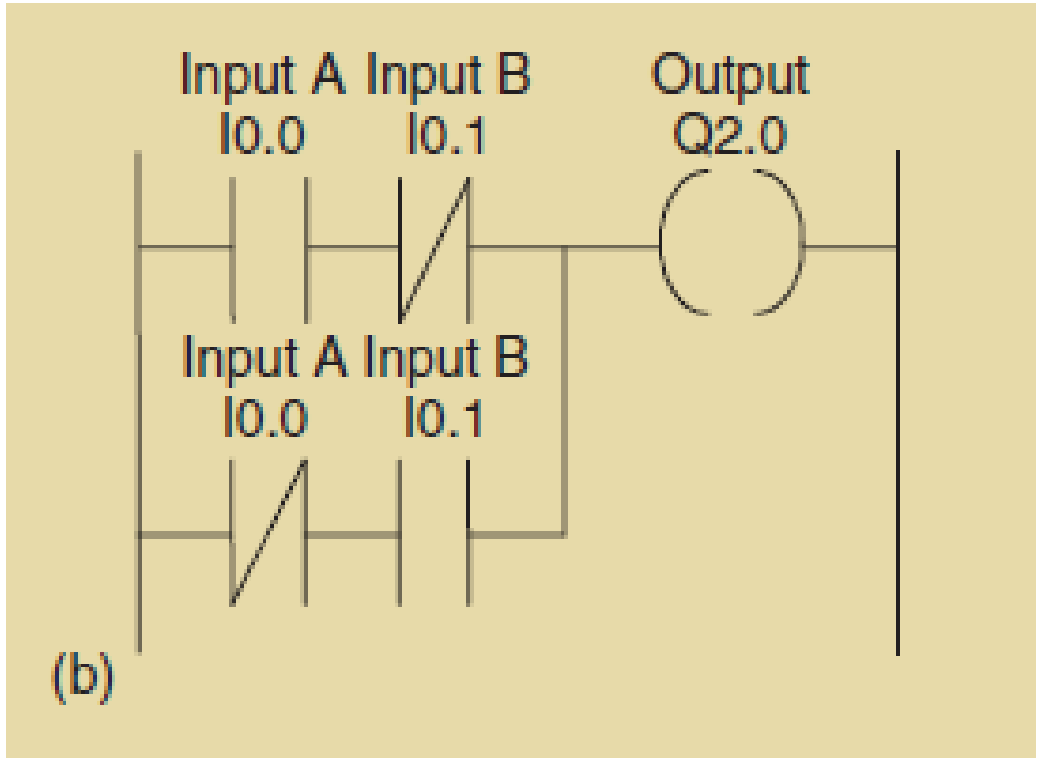
LDI X400

AND X401

ORB

OUT Y430


Input A
I0.0
Input B
I0.1
Output
Q2.0
Input A
I0.0
Input B
I0.1
(b)



Step Instruction

0 A(

1 A I0.0

2 AN I0.1

3)

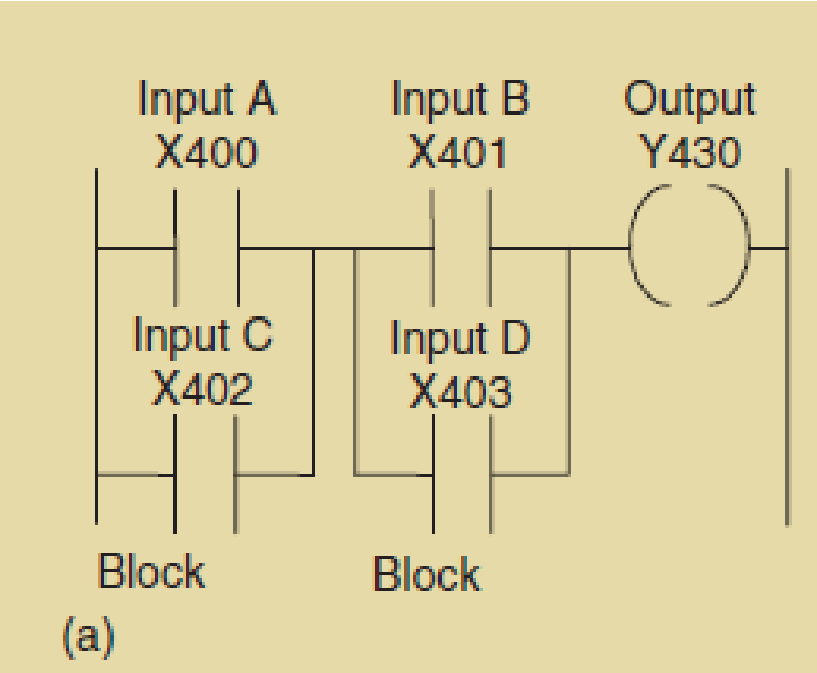
4 O(

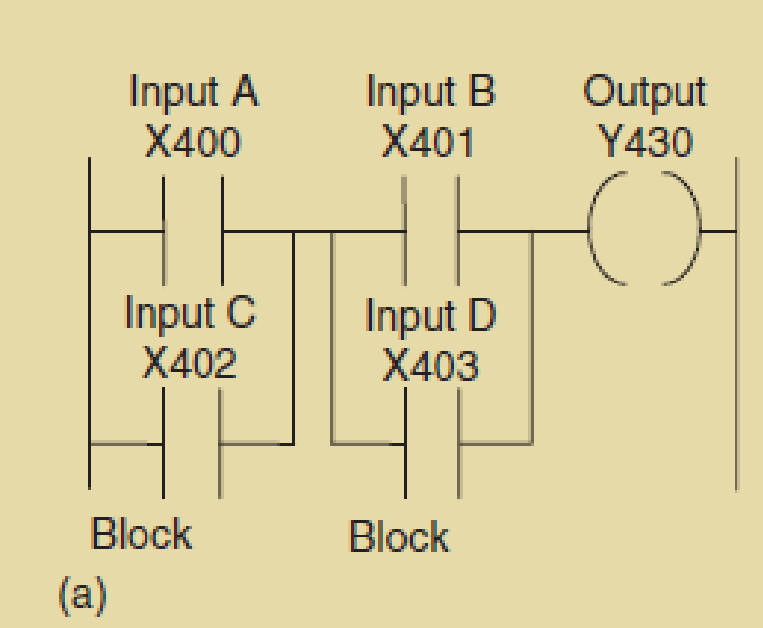
5 AN I0.0

6 A I0.1

7)

8 = Q2.0


Input A
X400
Input B
X401
Output
Y430
Input C
X402
Input D
X403
Block
Block
(a)



0 LD X400

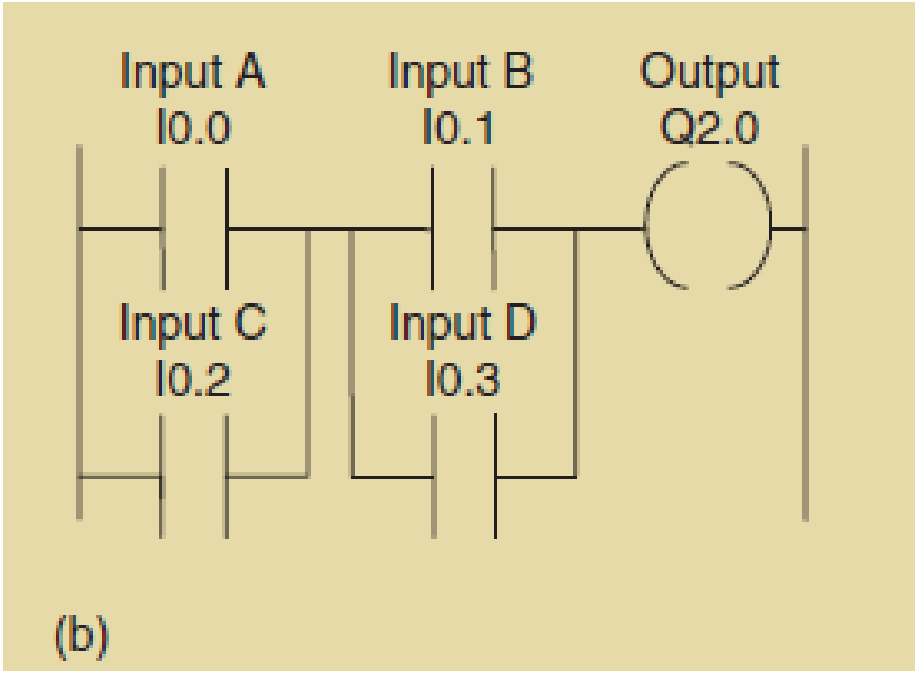
1 OR X402

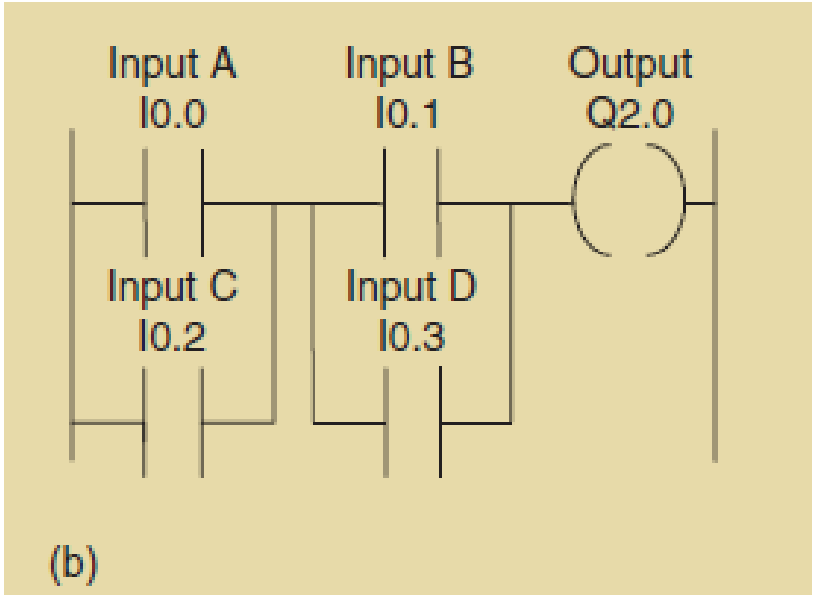
2 LD X401

3 OR X403

4 ANB

5 OUT Y430


Input A
I0.0
Input B
I0.1
Output
Q2.0
Input C
I0.2
Input D
I0.3
(b)



0 A(

1 A I0.0

2 O I0.2

3)

4 A(

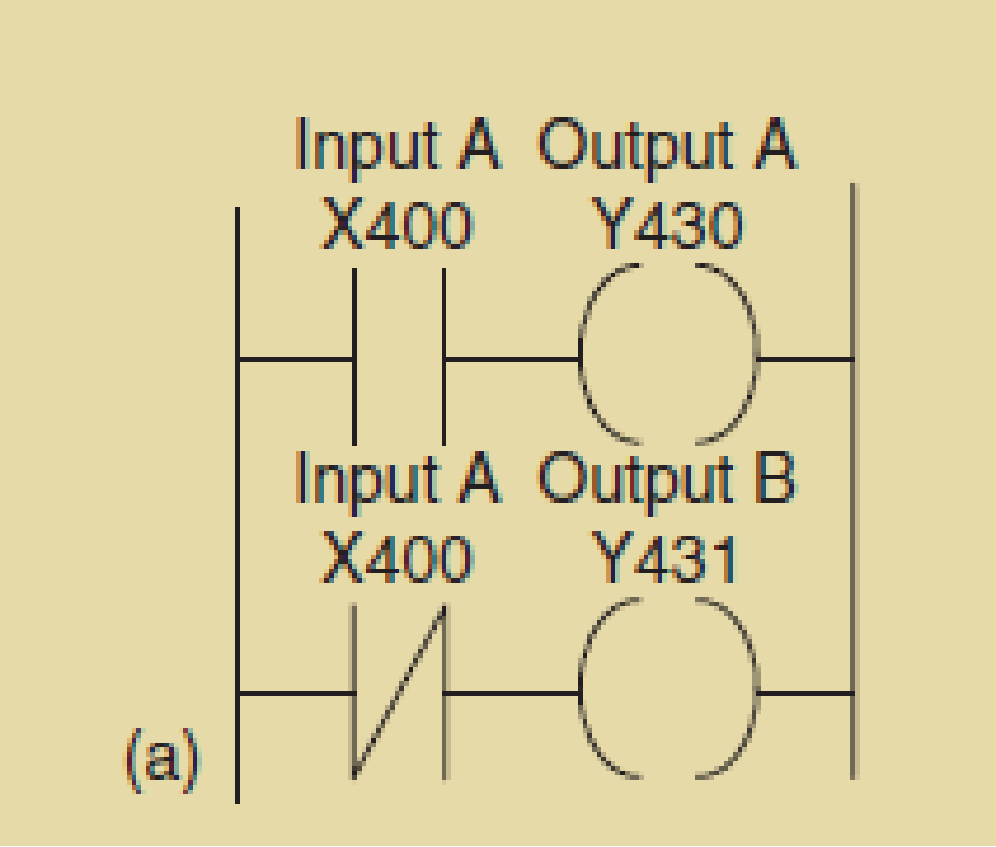
5 A I0.1

6 O I0.3

7)

8 =Q2.0

More Than One Rung

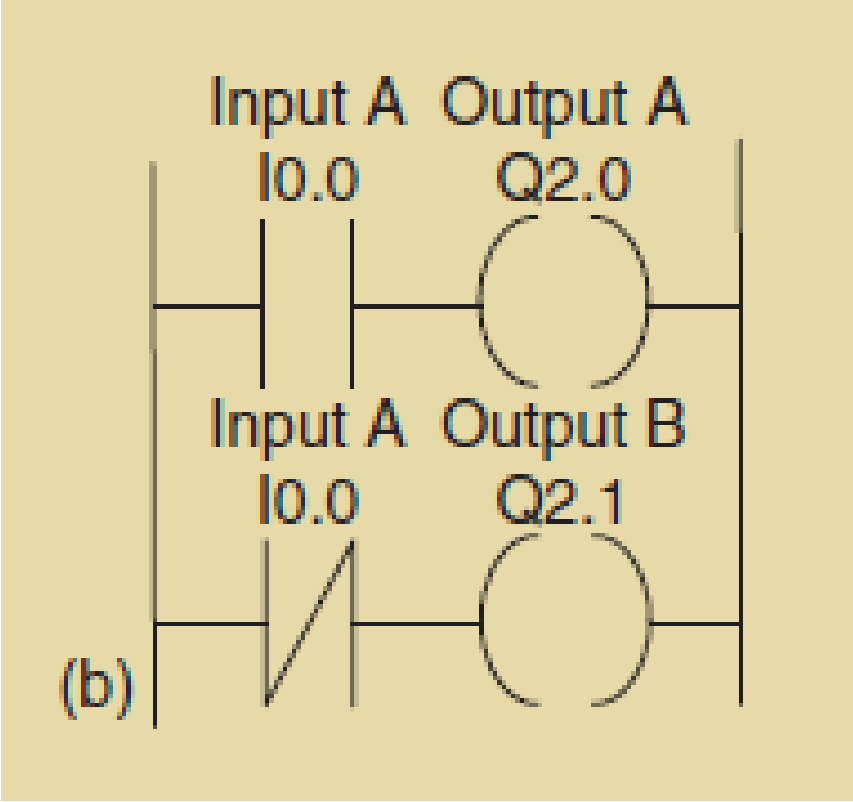


LD X400

OUT Y430

LDI X400

OUT Y431



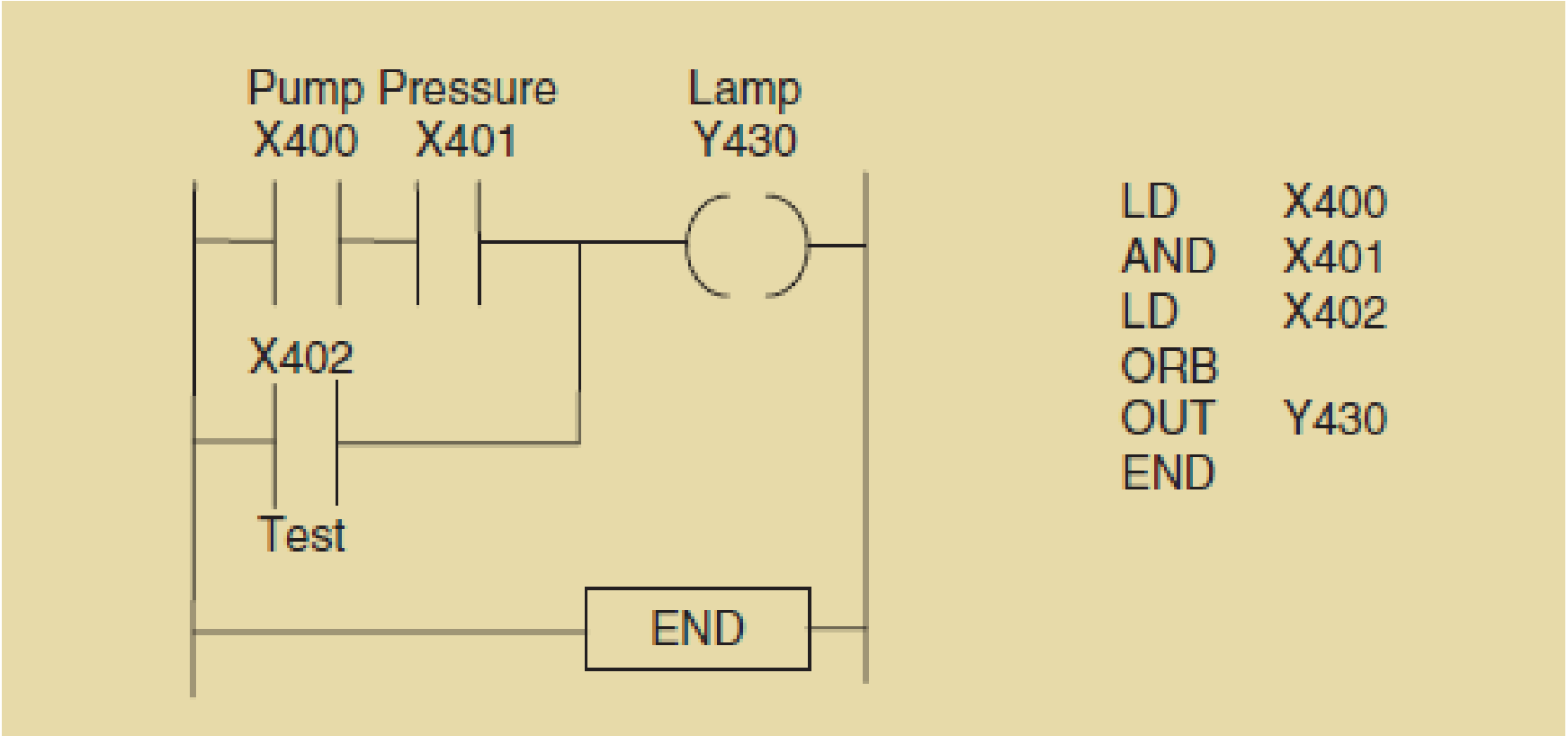
A I0.0

=Q2.0

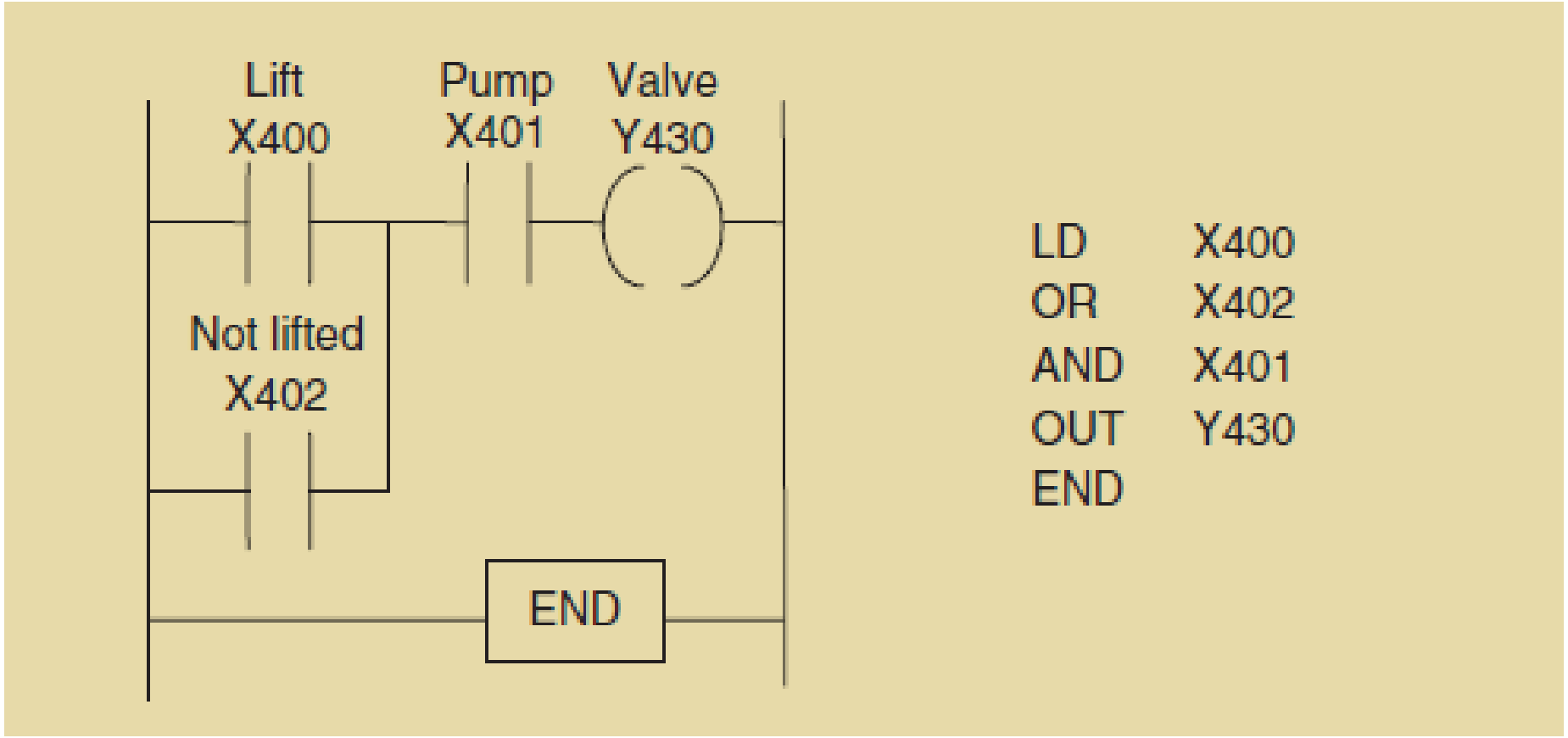
AN I0.0

=Q2.1

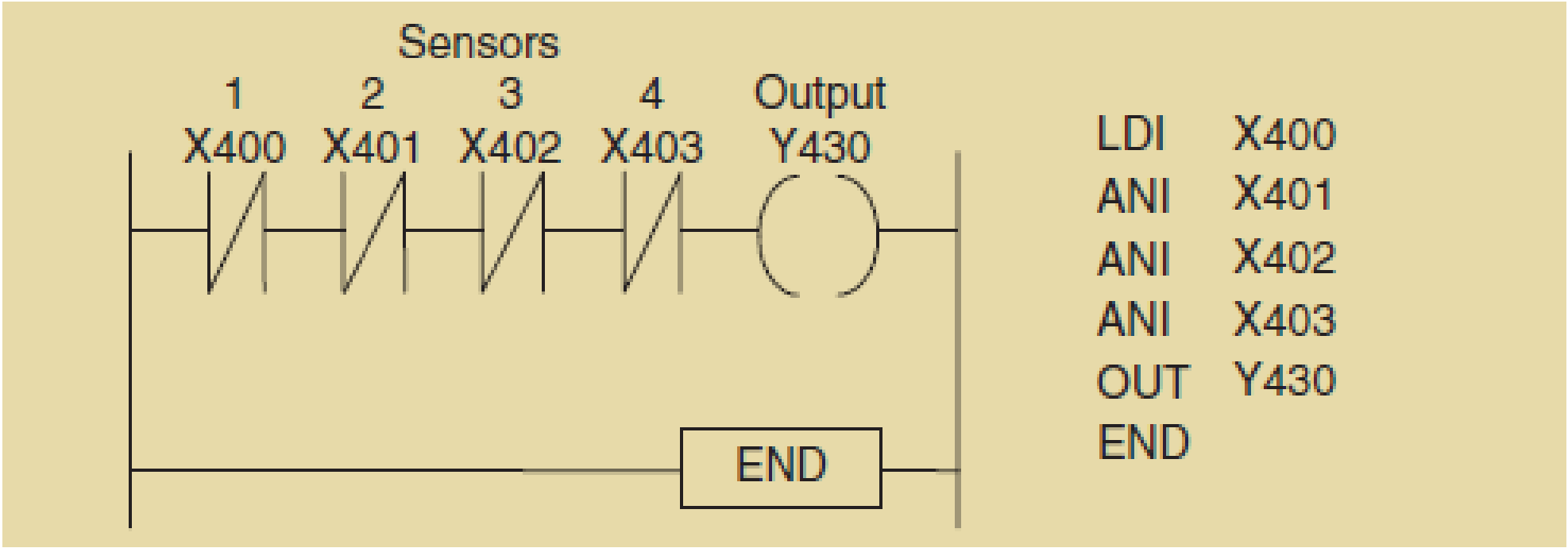
A signal lamp is required to be switched on if a pump is running and the pressure is satisfactory or if the lamp test switch is closed.


Pump Pressure
X400 X401
Lamp
Y430
X402
Test
END
LD X400
AND X401
LD X402
ORB
OUT Y430
END

a valve that is to be operated to lift a load when a pump is running and either the lift switch operated or a switch operated indicating that the load has not already been lifted and is at the bottom of its lift channel,


Lift
X400
Pump
X401
Valve
Y430
Not lifted
X402
END
LD X400
OR X402
AND X401
OUT Y430
END

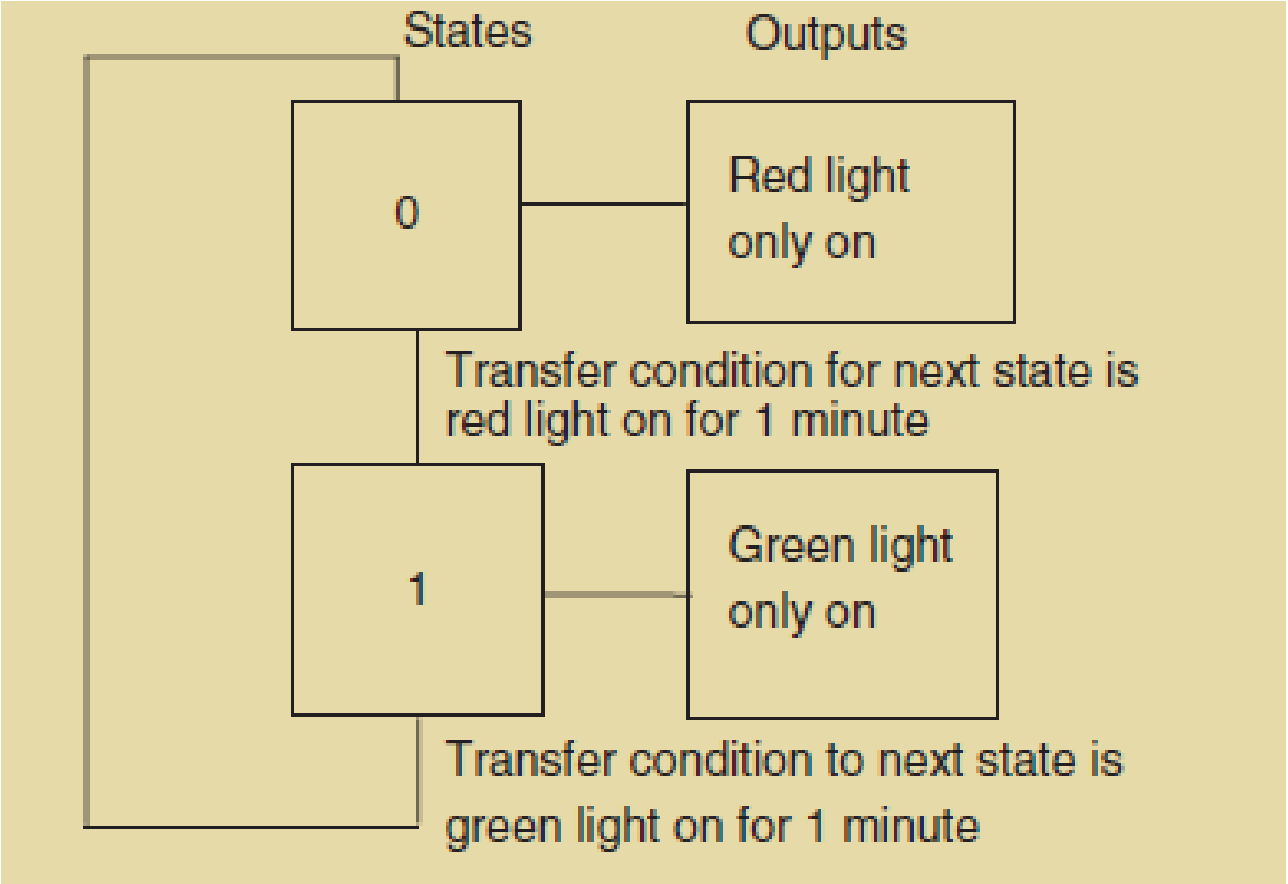
A system in which there has to be no output when any one of four sensors gives an output and otherwise there is to be an output,

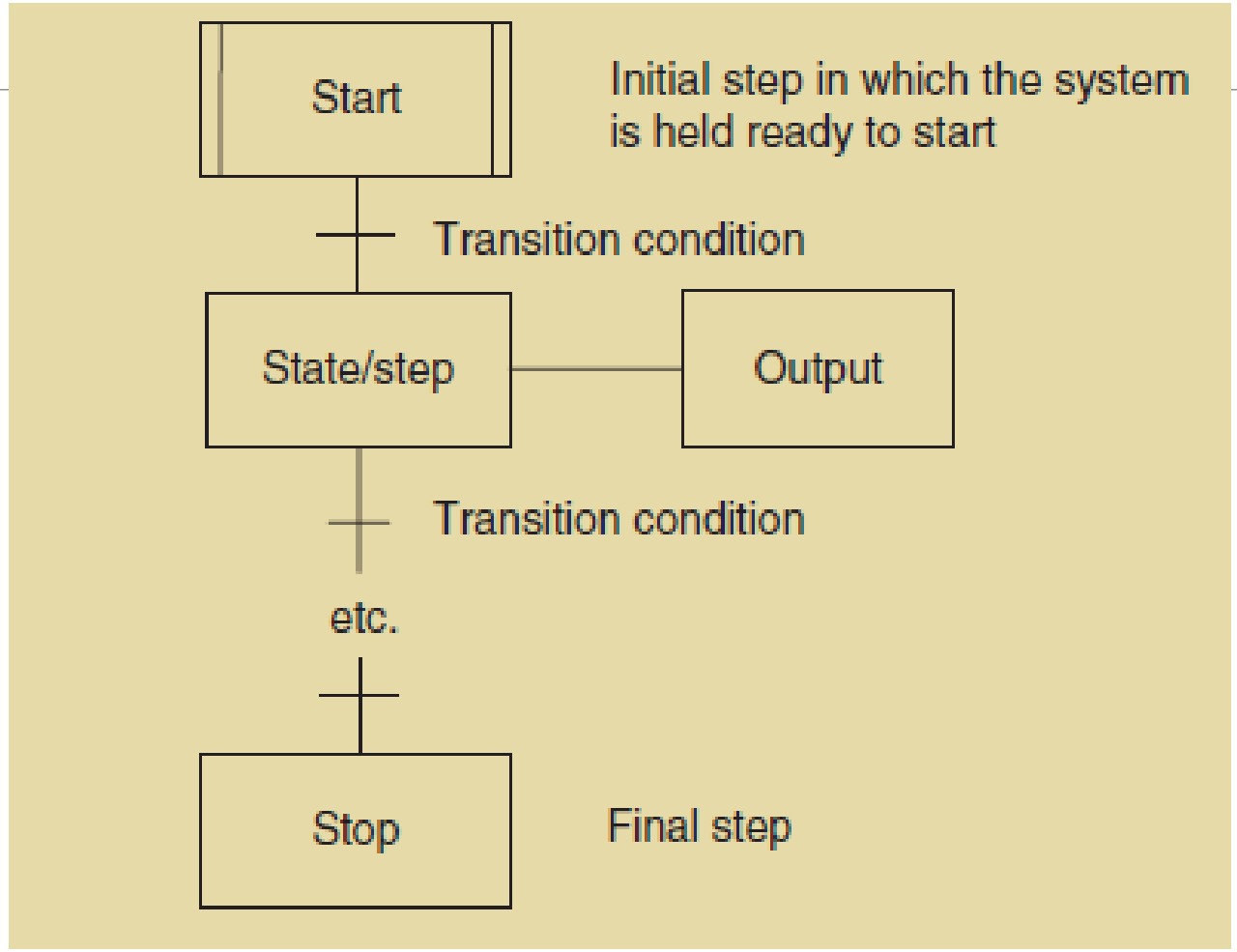

Sensors
1
X400
2
X401
3
X402
4
X403
Output
Y430
END
LDI X400
ANI X401
ANI X402
ANI X403
OUT Y430
END

Sequential Function Charts

The term sequential function chart (SFC) is used for a pictorial representation of a system’s operation to show the sequence of events involved in its operation.

Traffic Light Control




Start
Initial step in which the system is held ready to start
Transition condition
State/step
Output
Transition condition
etc.
Stop
Final step

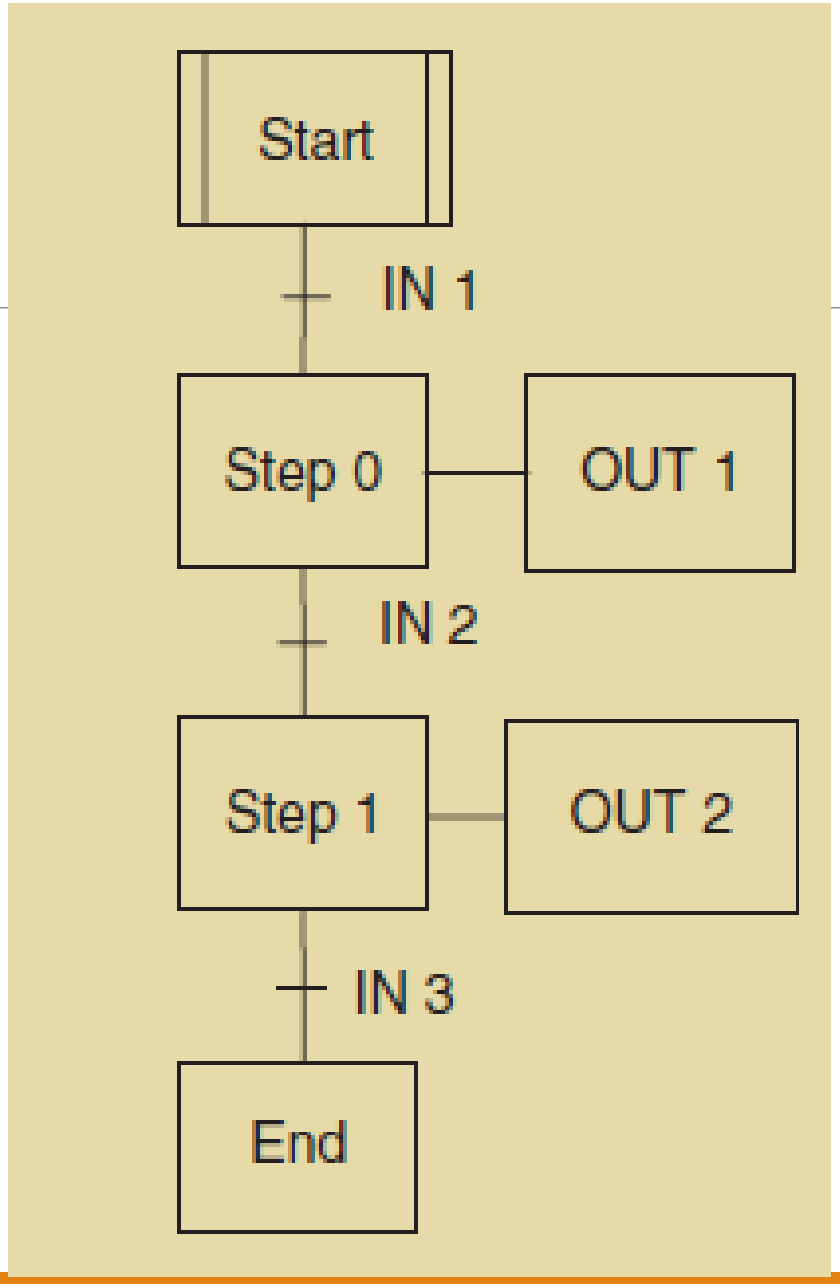
- The operation is described by a number of separate sequentially connected states or steps that are represented by rectangular boxes, each representing a particular state of the system being controlled.
- Each connecting line between states has a horizontal bar representing the transition
- condition that has to be realized before the system can move from one state to the next.

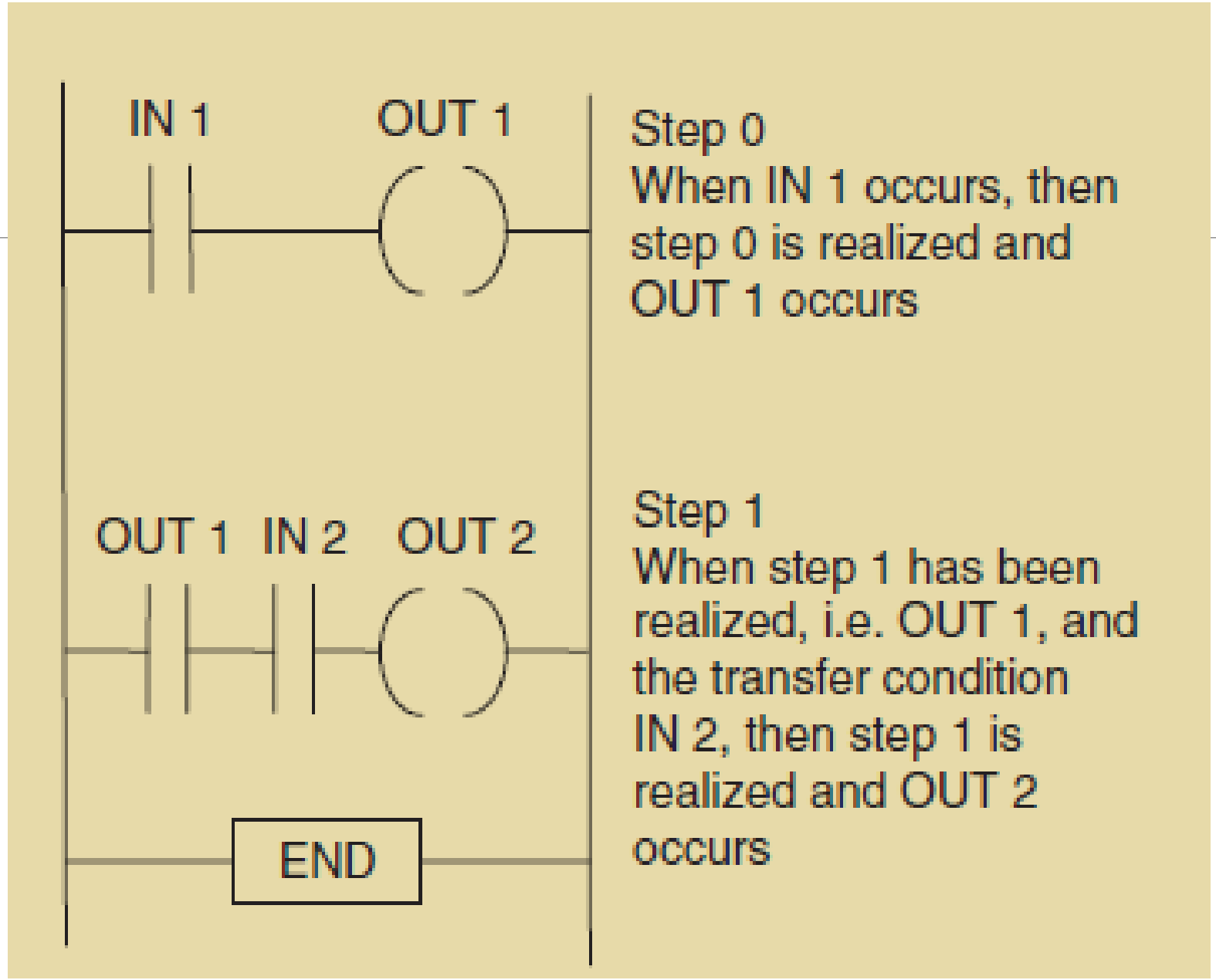
- Two steps can never be directly connected; they must always be separated by a transition.
- Two transitions can never directly follow from one to another; they must always be separated by a step.
- When the transfer conditions to the next state are realized, the next state or step in the program occurs.

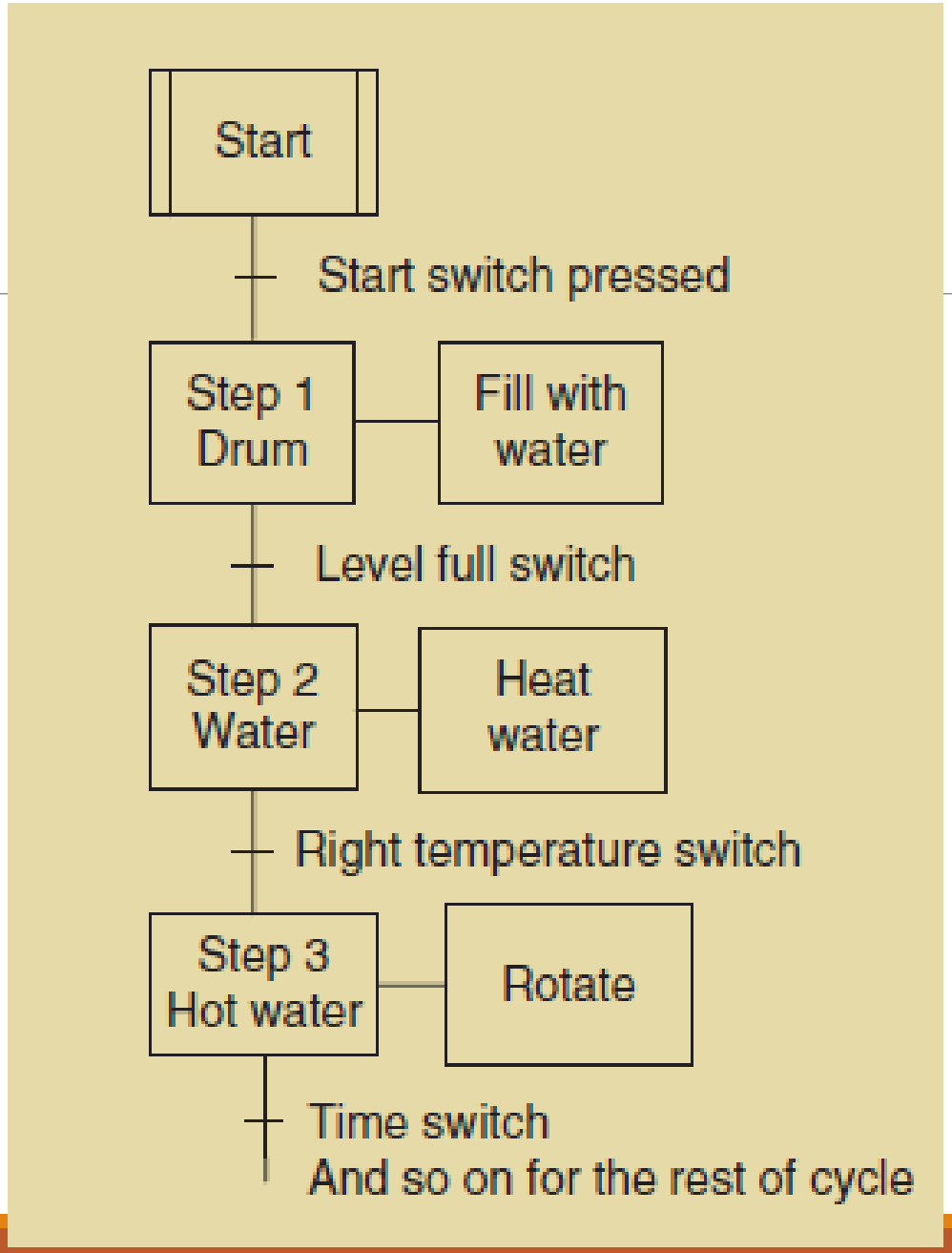
- The process thus continues from one state to the next until the complete machine cycle is completed.
- Outputs/actions at any state are represented by horizontally linked boxes and occur when that state has been realized.

Example: part of the washing cycle of a domestic washing machine

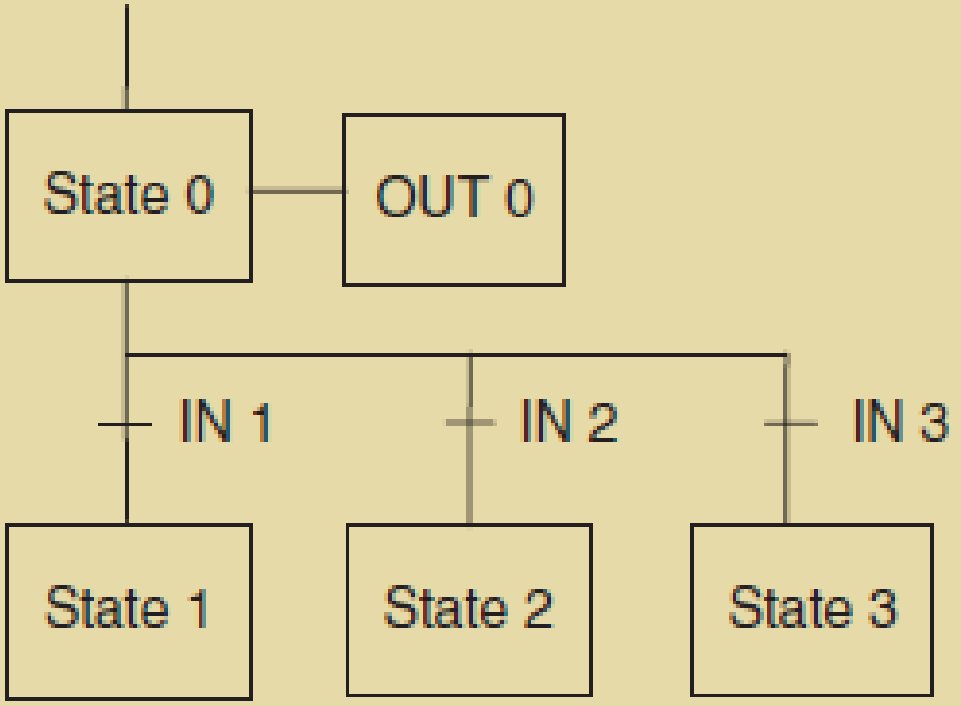
where the drum is to be filled with water, and then when the drum is full, a heater has to be switched on and remain on until the temperature reaches the required level. Then the drum is to be rotated for a specified time.


Start
IN 1
Step 0
OUT 1
IN 2
Step 1
OUT 2
IN 3
End

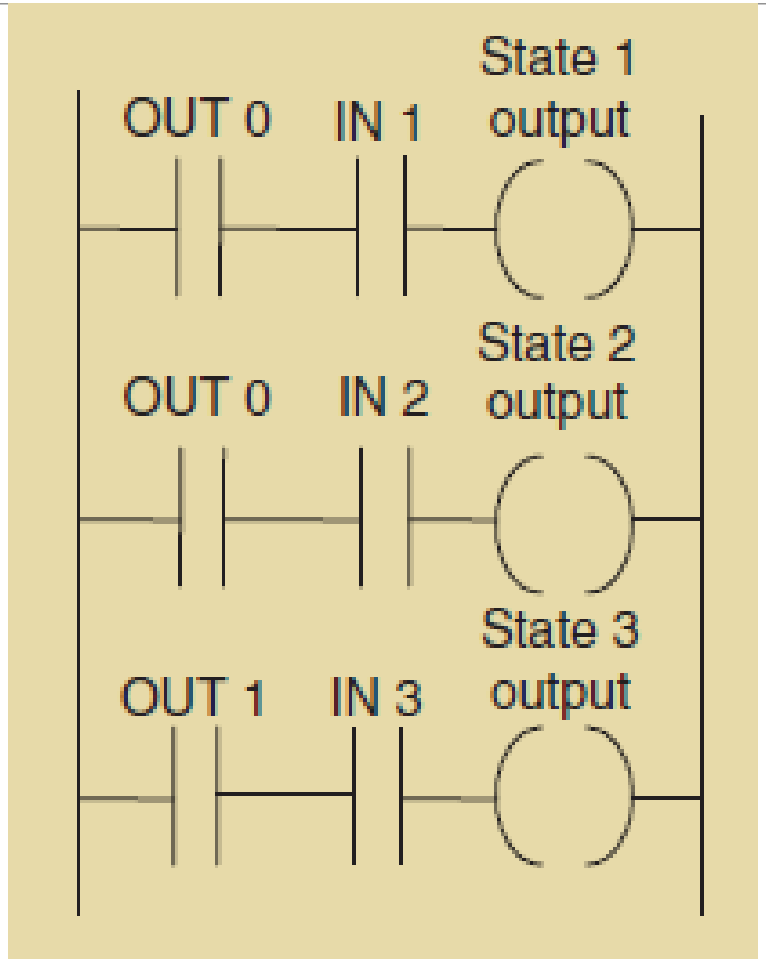

IN 1
OUT 1
Step 0
When IN 1 occurs, then step 0 is realized and OUT 1 occurs
OUT 1
IN 2
OUT 2
Step 1
When step 1 has been realized, i.e. OUT 1, and the transfer condition IN 2, then step 1 is realized and OUT 2 occurs
END


Start
Start switch pressed
Step 1
Drum
Fill with
water
Level full switch
Step 2
Water
Heat
water
Right temperature switch
Step 3
Hot water
Rotate
Time switch
And so on for the rest of cycle

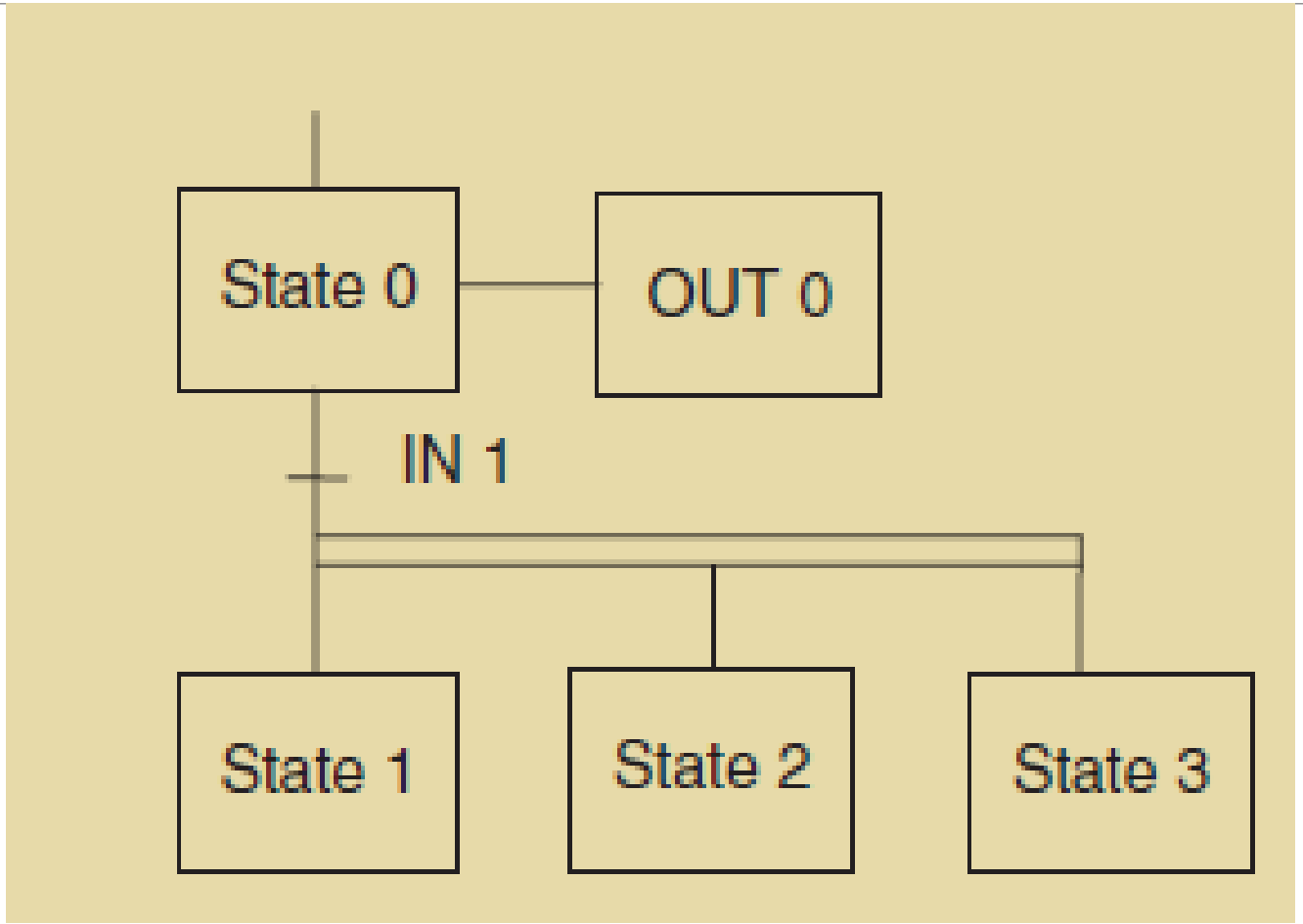
Selective Branching

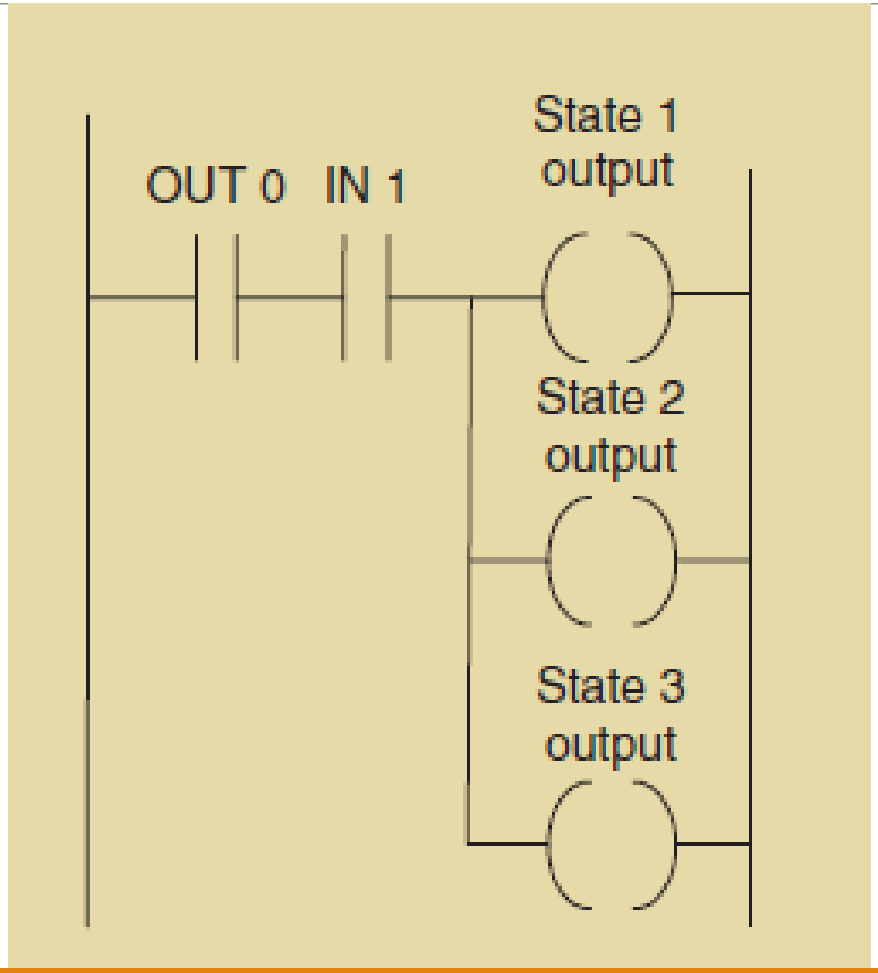


State 1 occurs if the transfer condition IN 1 occurs, but if IN 2 then state 2 or if IN 3 then state 3

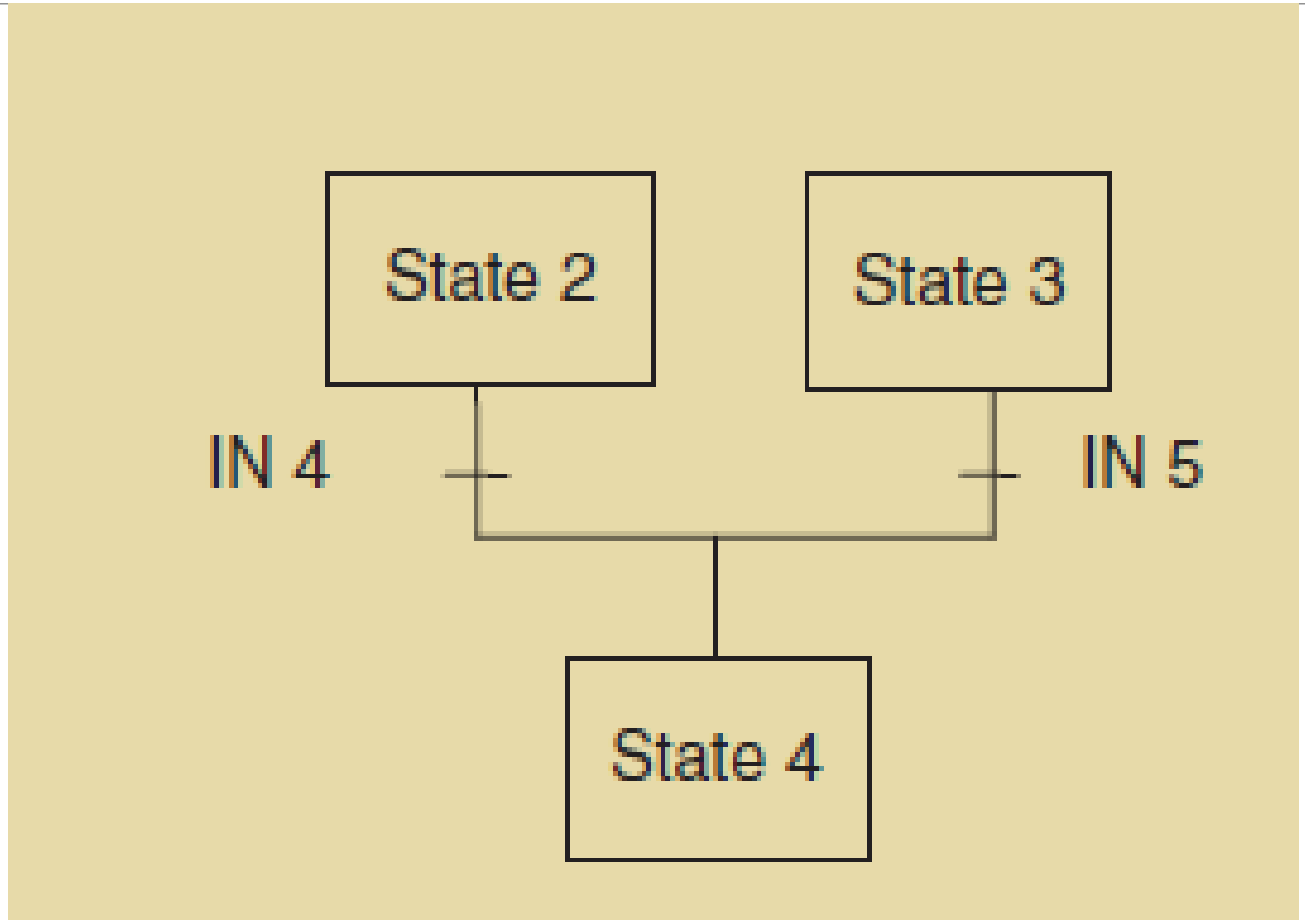

State 1
output
OUT 0
IN 1
State 2
output
OUT 0
IN 2
State 3
output
OUT 1
IN 3

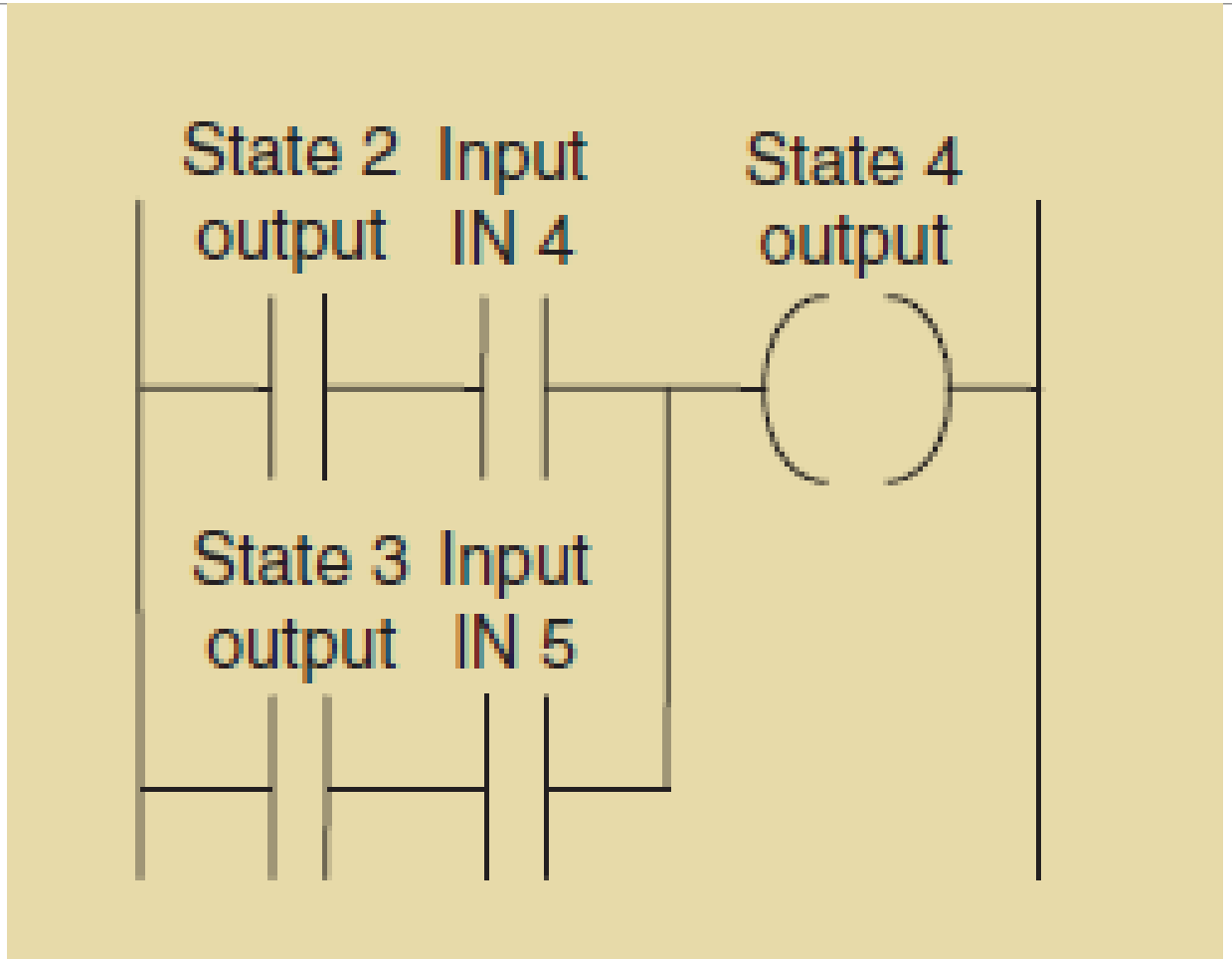
Parallel Branching



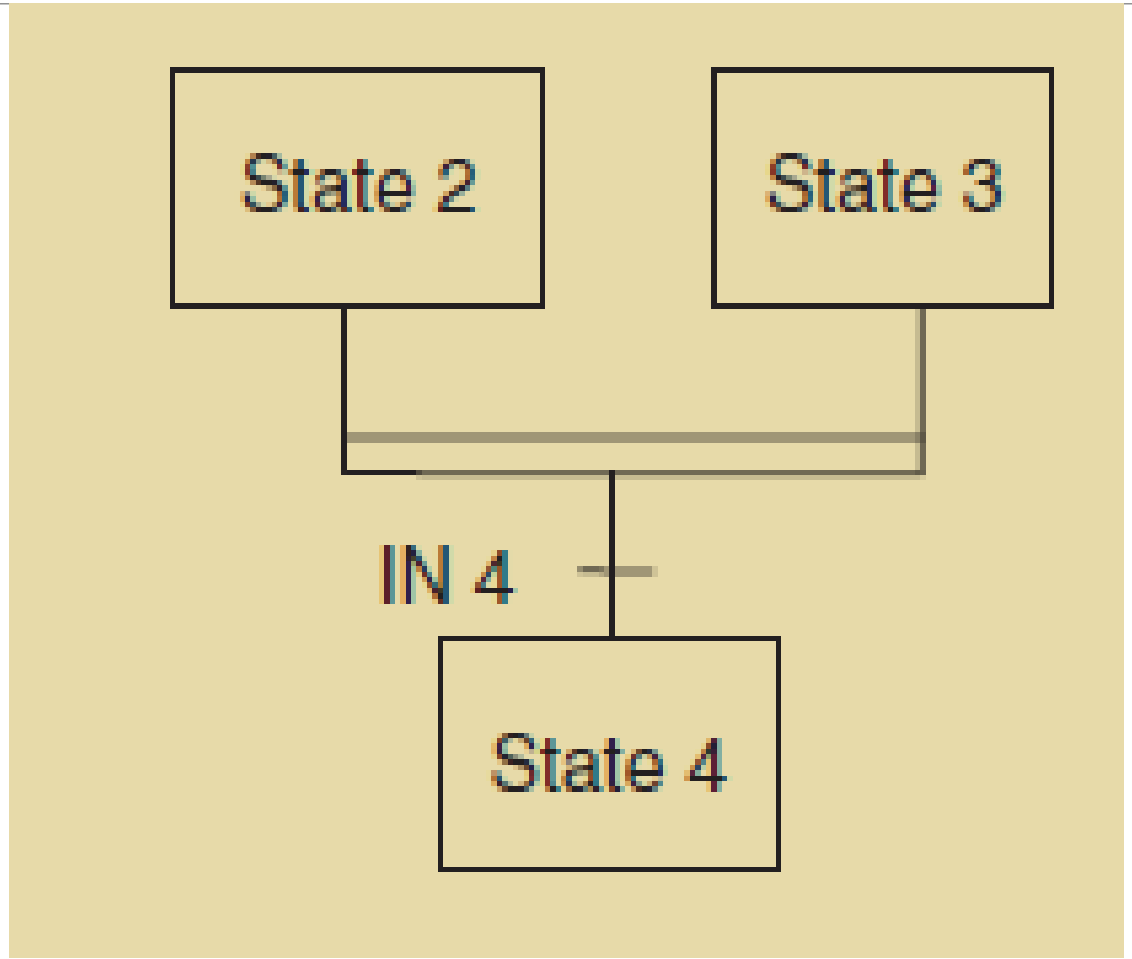

OUT 0
IN 1
State 1
output
State 2
output
State 3
output

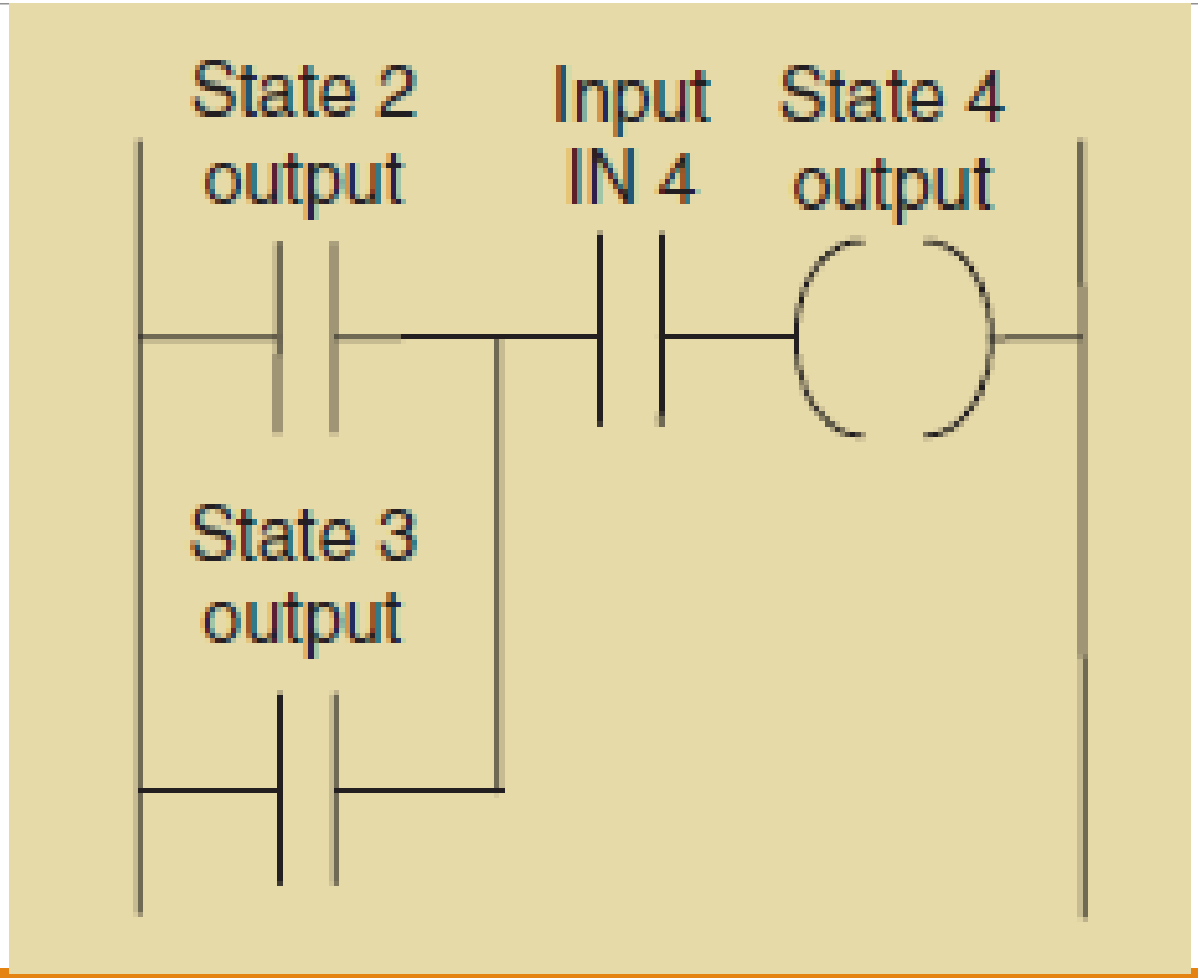
Convergence State

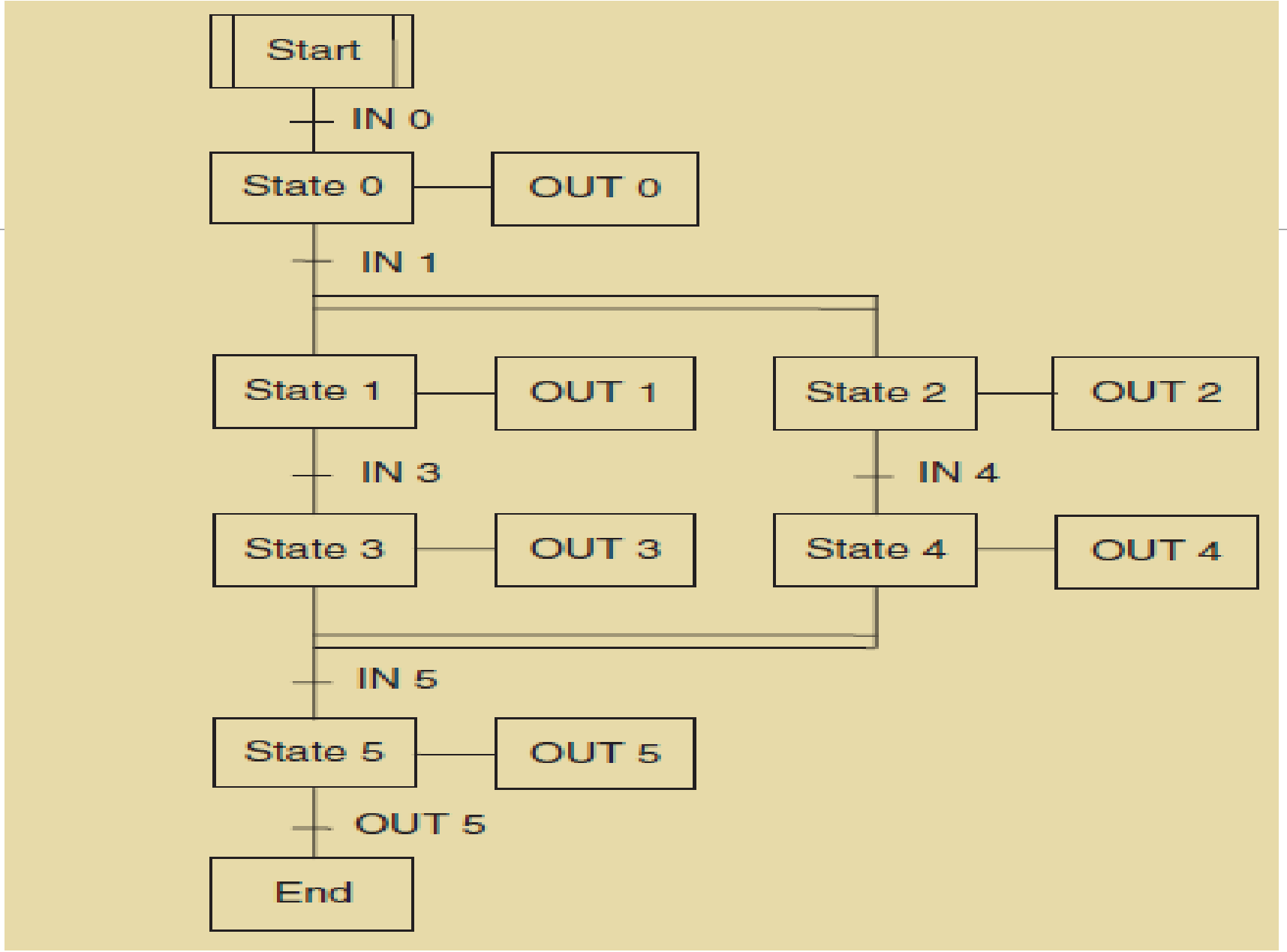


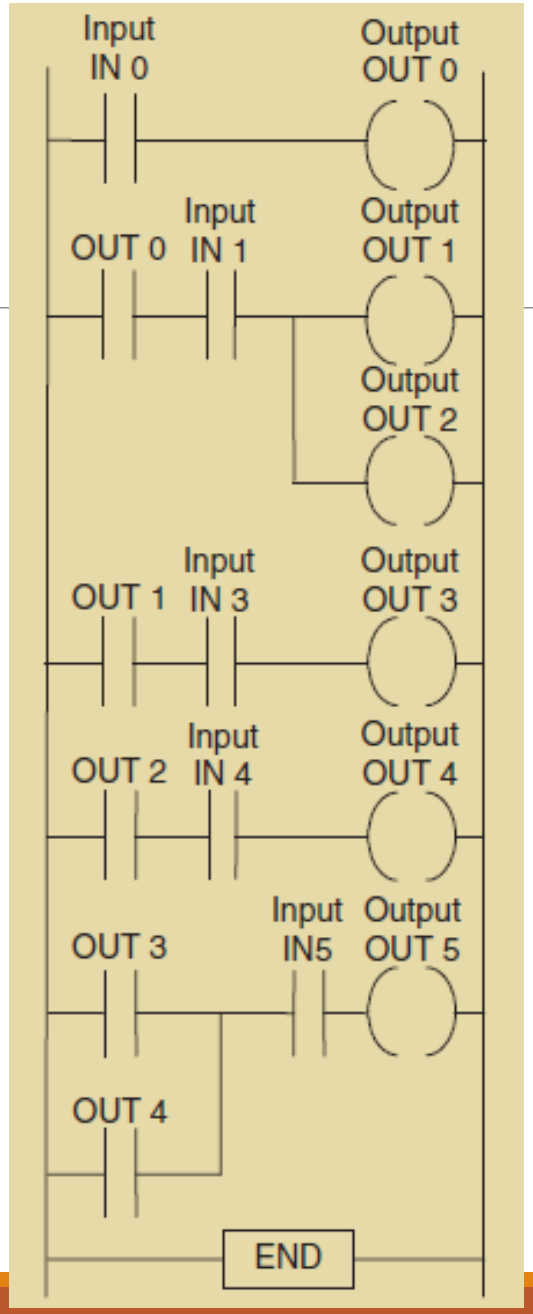

State 2
output
Input
IN 4
State 4
output
State 3
output
Input
IN 5

Simultaneous Convergence




State 2
output
Input
IN 4
State 4
output
State 3
output


Start
IN 0
State 0
OUT 0
IN 1
State 1
OUT 1
State 2
OUT 2
IN 3
IN 4
State 3
OUT 3
State 4
OUT 4
IN 5
State 5
OUT 5
OUT 5
End

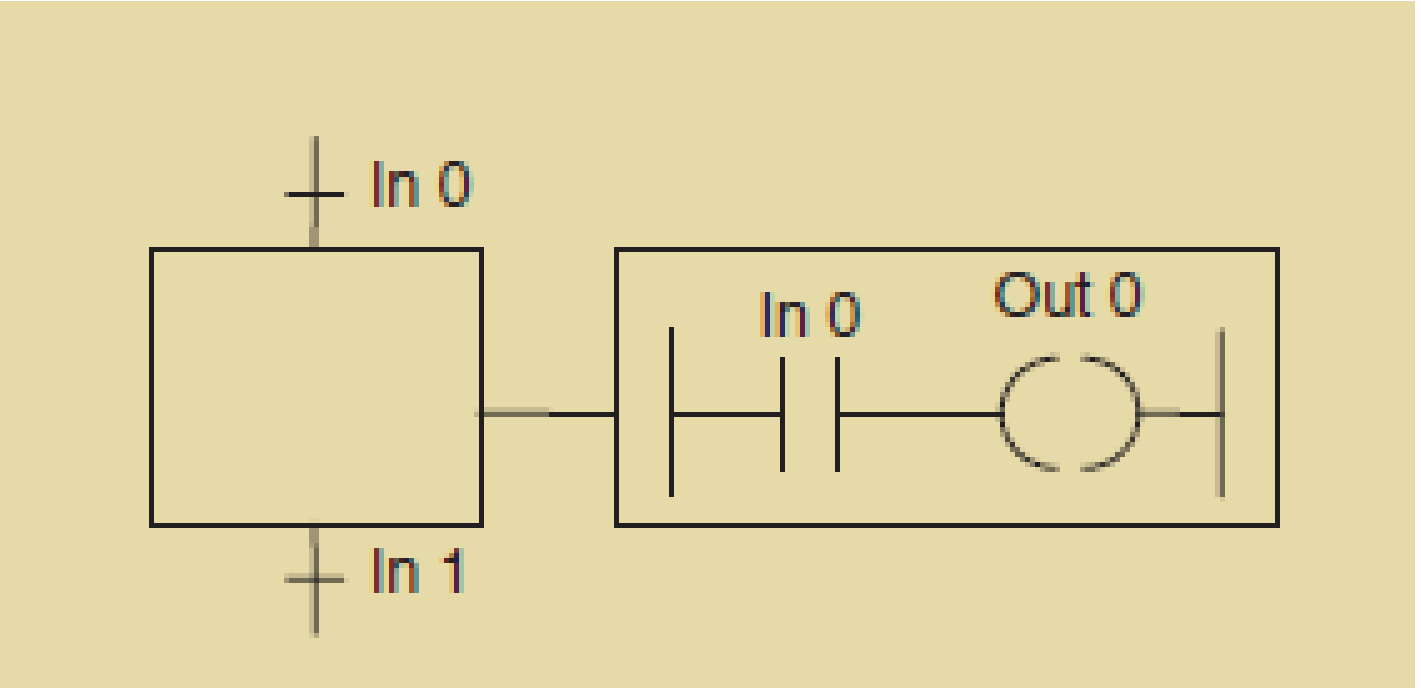

Input
IN 0
Output
OUT 0
OUT 0
Input
IN 1
Output
OUT 1
Output
OUT 2
OUT 1
Input
IN 3
Output
OUT 3
OUT 2
Input
IN 4
Output
OUT 4
OUT 3
Input
IN5
Output
OUT 5
OUT 4
END

Actions

Actions: are depicted as rectangular boxes attached to the state.

The behavior of the action can be given using a ladder diagram, a function block diagram, an

instruction list, or structured text.


In 0
In 1
In 0
Out 0

Action boxes are generally preceded by qualifiers to specify the conditions to exist for the action.

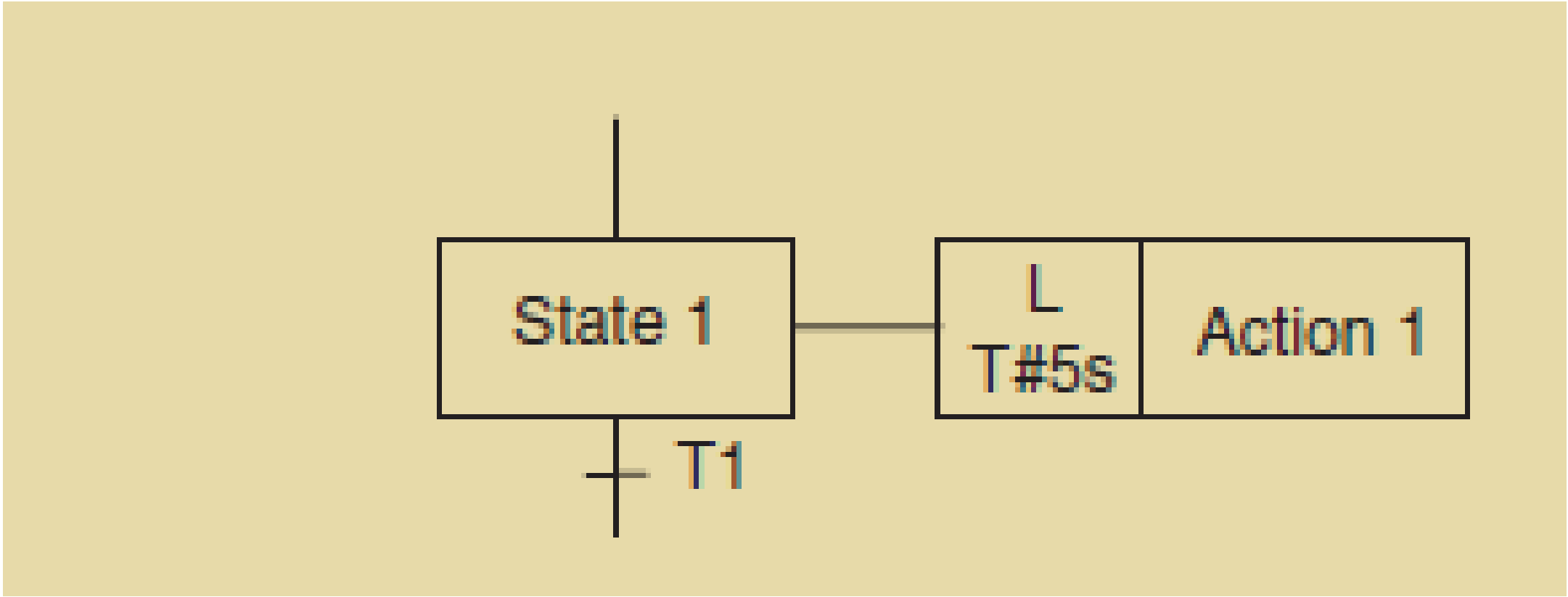
In the absence of a qualifier or with the use of qualifier N, the action is not stored and

is executed continually while the associate state is active.

The qualifier P is used for a pulse action that executes only once when a step is activated.

The qualifier D is used for a time-delayed action that only starts after a specified period.

The qualifier L is used for a time-limited action that terminates after a specified period


State 1
L
T#5s
Action 1
T1