5. Study the ladder logic program in Figure 7-34 on page 198, and answer the questions that follow:

a. What is the purpose of interconnecting the two timers?

b. How much time must elapse before output PL is energized?

c. What two conditions must be satisfied for timer T4:2 to start timing?

d. Assume that output PL is on and power to the system is lost. When power is restored, what will the status of this output be?

e. When input PB2 is on, what will happen?

f. When input PB1 is on, how much accumulated time must elapse before rung 3 will be true?

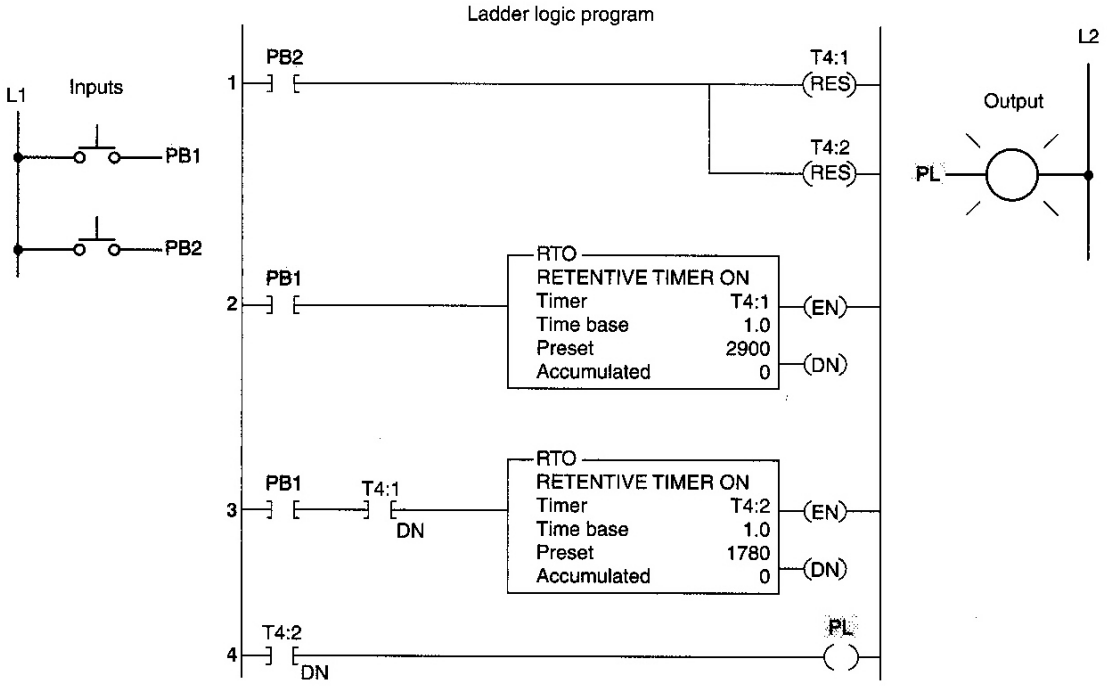

FIGURE 7-34

6. You have a machine that cycles on and off during its operation. You need to keep a record of its total run time for maintenance purposes. Which timer would accomplish this?

7. Write a ladder logic program that will turn on a light, PL, 15 s after switch S1 has been turned on.

8. Study the on-delay timer ladder logic program in Figure 7-35, and from each of the conditions stated, determine whether the timer is reset, timing, or timed out or if the conditions stated are not possible.

a. The input is true, and EN is 1, TT is 1, and DN is 0.

b. The input is true, and EN is 1, TT is 1, and DN is 1.

c. The input is false, and EN is 0, TT is 0, and DN is 0.

d. The input is true, and EN is 1, TT is 0, and DN is 1.

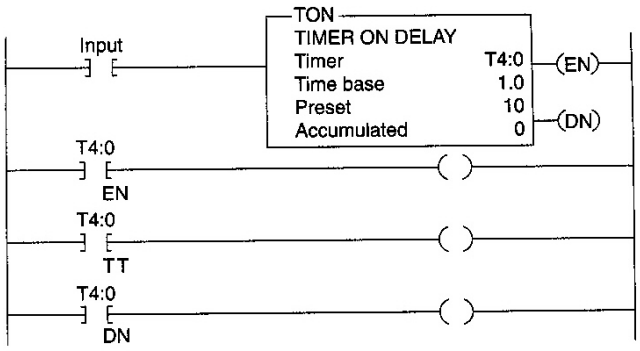

FIGURE 7-35

9. Study the off-delay timer ladder logic program in Figure 7-36, and from each of the conditions stated, determine whether the timer is reset, timing, or timed out or if the conditions stated are not possible.

- **a.** The input is true, and EN is 0, TT is 0, and DN is 1.
- **b.** The input is true, and EN is 1, TT is 1, and DN is 1.
- **c.** The input is true, and EN is 1, TT is 0, and DN is 1.
- **d.** The input is false, and EN is 0, TT is 1, and DN is 1.
- **e.** The input is false, and EN is 0, TT is 0, and DN is 0.

10. Write a program for an "anti–tie down circuit" that will disallow a punch press solenoid from operating unless both hands are on the two palm start buttons. Both buttons must be pressed at the same time within 0.5 s. The circuit also will not allow the operator to tie down one of the buttons and operate the press with just one button. (Hint: Once either of the buttons is pressed, begin timing 0.5 s. Then, if both buttons are not pressed, prevent the press solenoid from operating.)

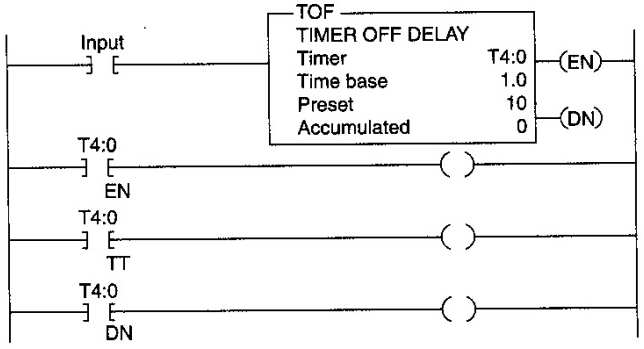

FIGURE 7-36

11. Modify the traffic control program of Figure 7-29 (on page 193) so that there is a 3-s period when both directions will have their red lights illuminated.

12. Write a program to implement the process illustrated in Figure 7-37. The sequence of operation is to be as follows:

- Normally open start and normally closed stop pushbuttons are used to start and stop the process.
- When the start button is pressed, solenoid A energizes to start filling the tank.
- As the tank fills, the empty level sensor switch closes.
- When the tank is full, the full level sensor switch closes.
- Solenoid *A* is de-energized.
- The agitate motor starts automatically and runs for 3 min to mix the liquid.
- When the agitate motor stops, solenoid B is energized to empty the tank.
- When the tank is completely empty, the empty sensor switch opens to de-energize solenoid *B*.
- The start button is pressed to repeat the sequence.

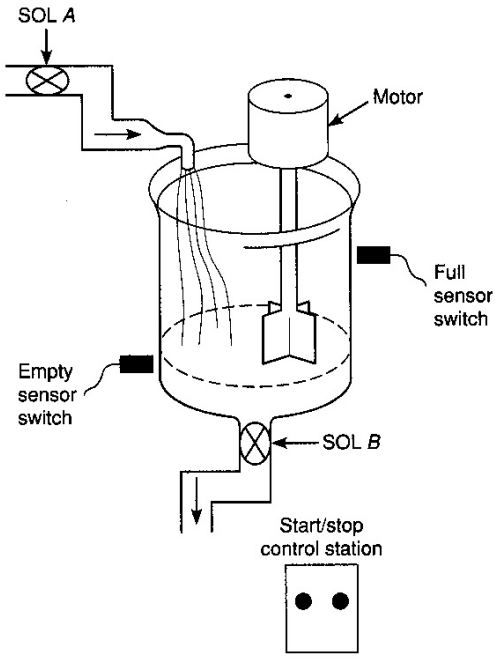

FIGURE 7-37

13. When the lights are turned off in a building, an exit door light is to remain on for an additional 2 min, and the parking lot lights are to remain on for an additional 3 min after the door light goes out. Write a program to implement this process.

14. Write a program to simulate the operation of a sequential taillight system. The light system consists of three separate lights on each side of the car. Each set of lights will be activated separately, by either the left or right turn signal switch. There is to be a 1-s delay between the activation of each light, and a 1-s period when all the lights are off. Ensure that when both switches are on, the system will not operate. Use the least number of timers possible. The sequence of operation should be as follows:

- The switch is operated.
- Light 1 is illuminated.
- Light 2 is illuminated 1 s later.
- Light 3 is illuminated 1 s later.
- Light 3 is illuminated for 1 s.
- All lights are off for 1 s.
- The system repeats while the switch is on.

COUNTER PROBLEMS

6. Design a PLC program and prepare a typical I/O connection diagram and ladder logic program that will correctly execute the industrial control process in Figure 8-38. The sequence of operation is as follows:

- Product in position (limit switch LS1 contacts close).
- The start button is pressed and the conveyor motor starts to move the product forward toward position *A* (limit switch LS1 contacts open when the actuating arm returns to its normal position).
- The conveyor moves the product forward to position *A* and stops (position detected by 8 off-to-on output pulses from the encoder, which are counted by an up-counter).
- A time delay of 10 s occurs, after which the conveyor starts to move the product to limit switch LS2 and stops (LS2 contacts close when the actuating arm is hit by the product).
- An emergency stop button is used to stop the process at any time.
- If the sequence is interrupted by an emergency stop, counter and timer are reset automatically.

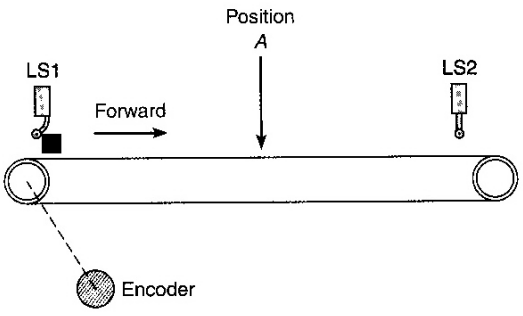

FIGURE 8-38

8. Write a program to implement the process illustrated in Figure 8-39. An up-counter must be programmed as part of a batch-counting operation to sort parts automatically for quality control. The counter is installed to divert 1 part out of every 1000 for quality control or inspection purposes. The circuit operates as follows:

- A start/stop pushbutton station is used to turn the conveyor motor on and off.
- A proximity sensor counts the parts as they pass by on the conveyor.
- When a count of 1000 is reached, the counter's output activates the gate solenoid, diverting the part to the inspection line.
- The gate solenoid is energized for 2 s, which allows enough time for the part to continue to the quality control line.
- The gate returns to its normal position when the 2-s time period ends.
- The counter resets to 0 and continues to accumulate counts.
- A reset pushbutton is provided to reset the counter manually.

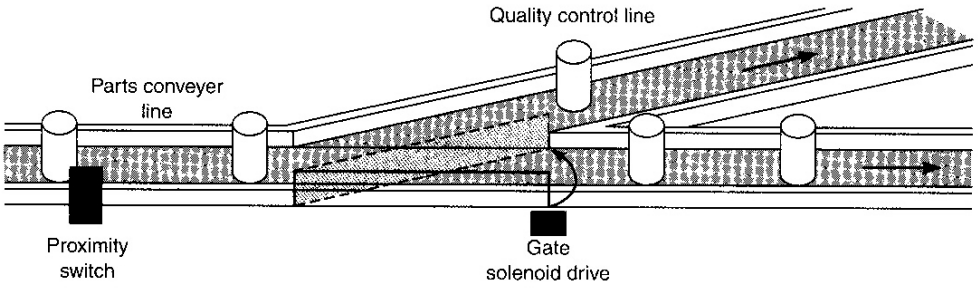

FIGURE 8-39

9. Write a program that will increment a counter's accumulated value 1 count every 60 s. A second counter's accumulated value will increment 1 count every time the first counter's accumulated value reaches 60. The first counter will reset when its accumulated value reaches 60, and the second counter will reset when its accumulated value reaches 12.

10. Write a program to implement the process illustrated in Figure 8-40. A company that makes electronic assembly kits needs a counter to count and control the number of resistors placed into each kit. The controller must stop the take-up spool at a predetermined amount of resistors (100). A worker on the floor will then cut the resistor strip and place it in the kit. The circuit operates as follows:

    - A start/stop pushbutton station is used to turn the spool motor drive on and off manually.
    - A through-beam sensor counts the resistors as they pass by.
    - A counter preset for 100 (the amount of resistors in each kit) will automatically stop the take-up spool when the accumulated count reaches 100.
    - A second counter is provided to count the grand total used.
    - Manual reset buttons are provided for each counter.

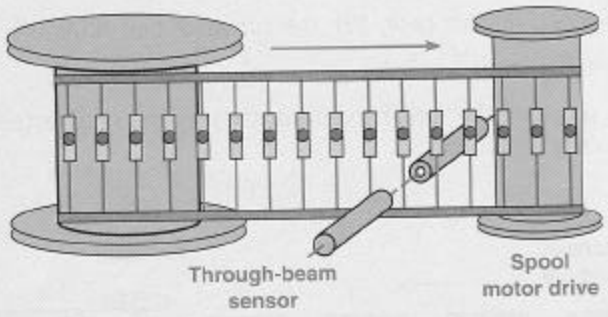

FIGURE 8-40

11. Write a program that will latch on a light 20 s after an input switch has been turned on. The timer will continue to cycle up to 20 s and reset itself until the input switch has been turned off. After the third time the timer has timed to 20 s, the light will be unlatched.

12. Write a program that will turn a light on when a count reaches 20. The light is then to go off when a count of 30 is reached.

13. Write a program to implement the box-stacking process illustrated in Figure 8-41. This application requires the control of a conveyor belt that feeds a mechanical stacker. The stacker can stack various numbers of cartons of ceiling tile onto each pallet (depending on the pallet size and the preset value of the counter). When the required number of cartons has been stacked, the conveyor is stopped until the loaded pallet is removed and an empty pallet is placed onto the loading area. A photoelectric sensor will be used to provide count pulses to the counter after each carton passes by. In addition to a conveyor motor start/stop station, a remote reset button is provided to allow the operator to reset the system from the forklift after an empty pallet is placed onto the loading area. The operation of this system can be summarized as follows:
    - The conveyor is started by pressing the start button.
    - As each box passes the photoelectric sensor, a count is registered.
    - When the preset value is reached (in this case, 12), the conveyor belt turns off.
    - The forklift operator removes the loaded pallet.
    - After the empty pallet is in position, the forklift operator presses the remote reset button, which then starts the whole cycle over again.

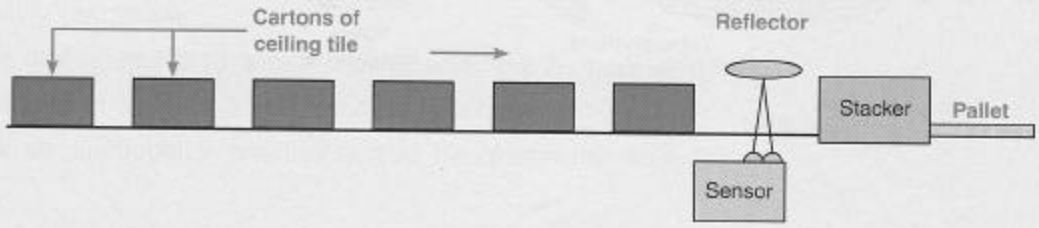

FIGURE 8-41