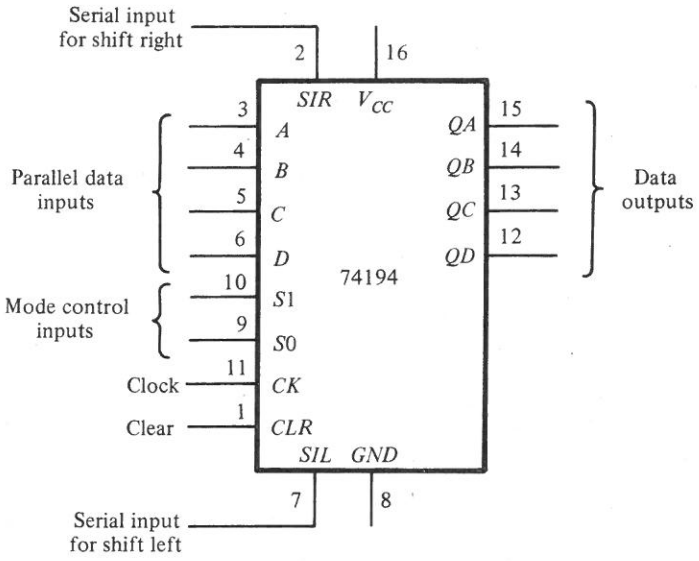
IC Type 74194: This is a 4-bit bidirectional shift register with parallel load. The internal logic is similar to Fig. 7-9. The pin assignment to the inputs and outputs is shown in Fig. 11-19. The two mode-control inputs determine the type of operation as specified in the function table. The operation of the circuit is described in detail in Section 7-3 in conjunction with Fig. 7-9.

Logic Diagram: The logic diagram of the electronic lamp handball is shown in Fig. 11-20. It consists of two 74194 ICs, a dual *D* flip-flop 7474 IC, and three gate ICs: 7400, 7404, and 7408. The ball is simulated by a moving light that is shifted left or right through the bidirectional shift register. The rate at which the light moves is



Function table

Clear	Clock	Mode S1	Mode S0	Function
0	*X*	*X*	*X*	Clear outputs to 0
1	↑	0	0	No change in output
1	↑	0	1	Shift right in the direction from *QA* to *QD*. *SIR* to *QA*
1	↑	1	0	Shift left in the direction from *QD* to *QA*. *SIL* to *QD*
1	↑	1	1	Parallel load input data

Figure 11-19 IC type 74194 bidirectional shift register with parallel load

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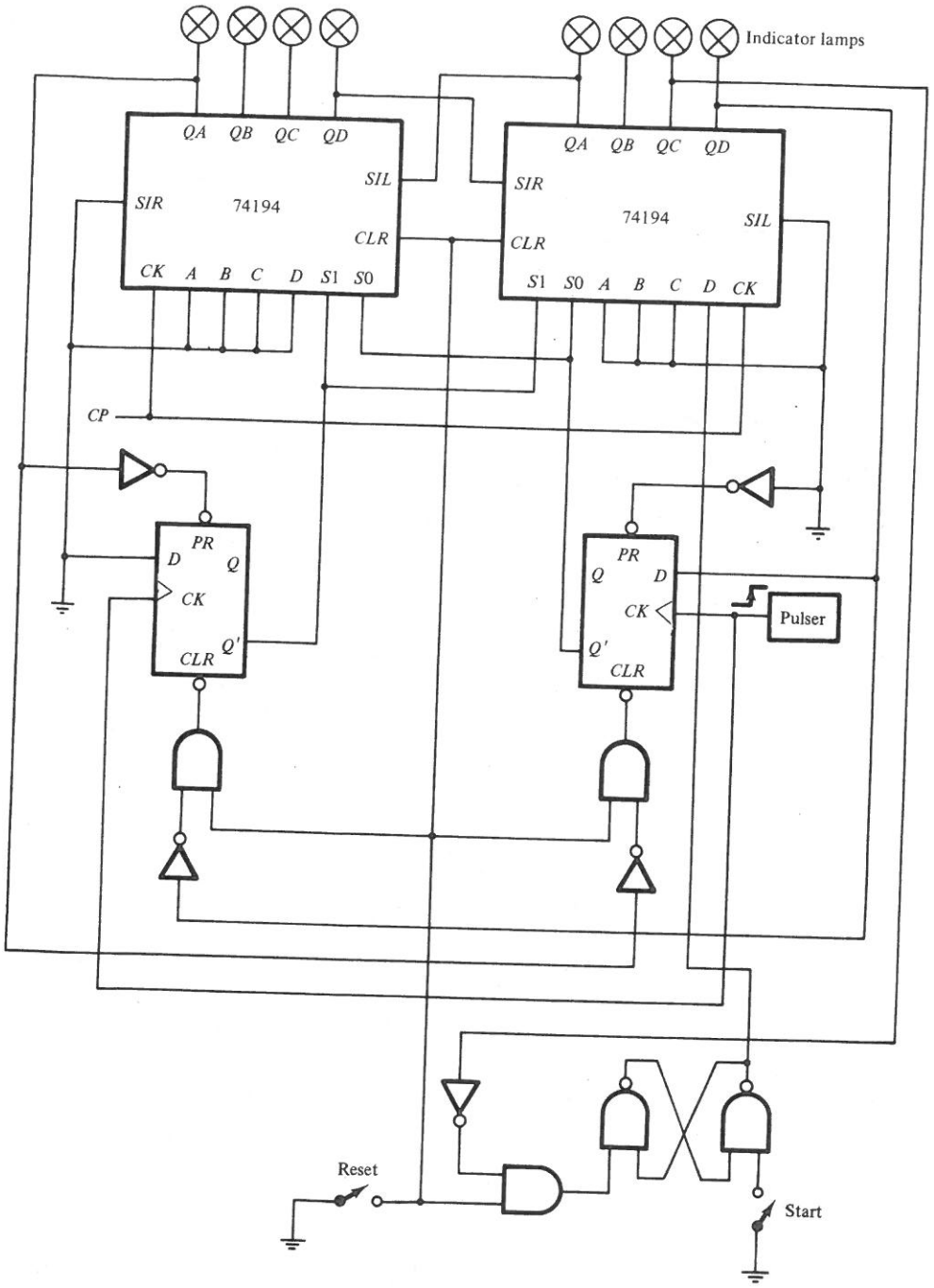

Figure 11-20 Lamp handball logic diagram

determined by the frequency of the clock. The circuit is first initialized with the *reset* switch. The *start* switch starts the game by placing the ball (an indicator lamp) at the extreme right. The player must press the pulser pushbutton to start the ball moving to the left. The single light shifts to the left until it reaches the leftmost position (the wall), at which time the ball returns to the player by reversing the direction of shift of the moving light. When the light is again at the rightmost position, the player must press the pulser again to reverse the direction of shift. If the player presses the pulser too soon or too late, the ball disappears and the light goes off. The game can be restarted by turning the start switch on and then off. The start switch must be open (logic 1) during the game.

Circuit Analysis: Prior to connecting the circuit, analyze the logic diagram to ensure that you understand how the circuit operates. In particular try to answer the following questions:

1. What is the function of the reset switch?
2. Explain how the light in the rightmost position comes on when the start switch is grounded. Why is it necessary to place the start switch in the logic 1 position before the game starts?
3. What happens to the two mode-control inputs $S1$ and $S0$ once the ball is set in motion?
4. What happens to the mode-control inputs and to the ball if the pulser is pressed while the ball is moving to the left? What happens if it is moving to the right but has not reached the rightmost position yet?
5. Suppose that the ball returned to the rightmost position but the pulser has not been pressed yet; what is the state of the mode control inputs if the pulser is pressed? What happens if it is not pressed?

Playing the Game: Wire the circuit of Fig. 11-20. Test the circuit for proper operation by playing the game. Note that the pulser must provide a positive edge transition and that both the reset and start switches must be open (be in the logic 1 state) during the game. Start with a low clock rate and increase the clock frequency to make the handball game more challenging.

Lamp Ping-Pong: Modify the circuit of Fig. 11-20 so as to obtain a lamp ping-pong game. Two players can participate in this game with each player having his own pulser. The player with the right pulser returns the ball when in the extreme right position, and the player with the left pulser returns the ball when in the extreme left position. The only modification required for the ping-pong game is a second pulser and a change of few wires.

With a second start circuit, the game can be made to start (serve) by either one of the two players. This addition is optional.