Neon Lamp Logic Gates

Elementary computer acts as silent adversary to a human opponent in an ancient pastime. Neon lamps perform the function of diode gates and also indicate moves and positions occupied on the board. A thyratron-relay combination comprises the memory and another series of relays referees the sequence to prevent two successive moves by either participant. Experience suggests the neon-lamp circuit may have many other computer applications

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THE NEON LAMP has a great number of potential uses as a logical gate. Typical of these is a device which performs all logic and control functions needed to play the game tick-tack-toe.

The system is comprised of the elements of a large-scale computer, as shown in Fig. 1. The input-output control panel permits the operator to enter his desired moves on the board by push-buttons. Nine neon lamps indicate positions selected by the operator or board during the game.

The memory function is performed by a thyratron-relay combination, which stores positions occupied by the operator or board and makes this information available to the logic section for decision regarding successive plays. The sequencer unit referees the game, permitting the operator to make a move, followed by a board move and so forth to a win, lose or draw decision.

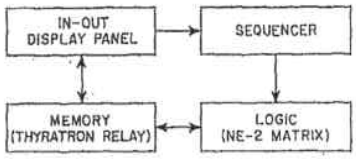


FIG. 1—Block diagram of complete system

Sequencer

A series of relays acts as a stepping switch in the sequencer and a thyratron switches control from board to operator as soon as the board completes a move. Conversely, control is switched from operator to board after the operator makes a play.

When the operator releases the pushbutton the sequencer sends an offense signal to the logic section. If the board has previously filled two positions in a line and the third position is vacant, the board will make an offensive move and win the game. If no such opportunity exists, the sequencer signals the logic section for a defensive move, which is required if the operator has filled two positions in a line and the third is vacant. If no defensive move is made, the sequence continues, filling the first vacant position in the order 5, 1, 6, 7, 2, 9, 4, 3, 8. A schematic of this circuit is shown in Fig. 2.

The order of independent play would make it possible to trap the board so that two defense moves are required simultaneously. A special-defense mode has been included in the sequencer and logic to prevent this situation from occurring. The

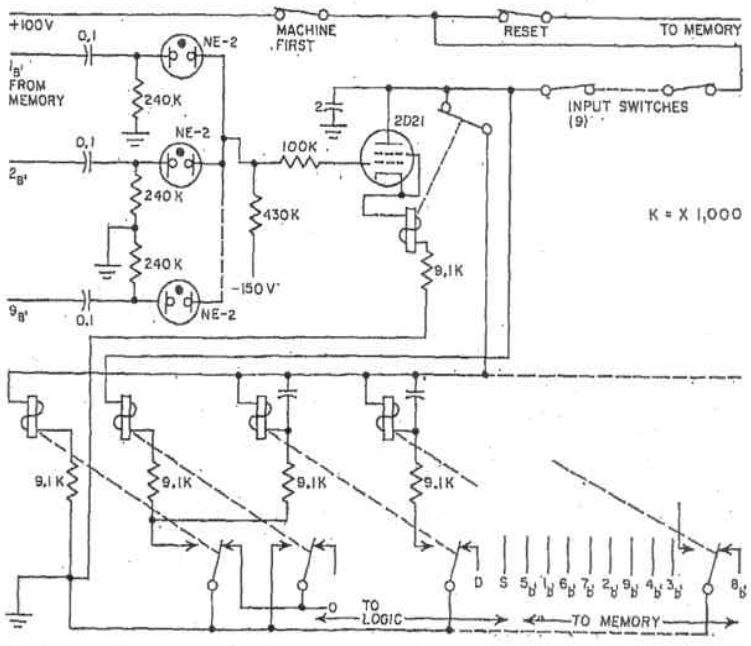
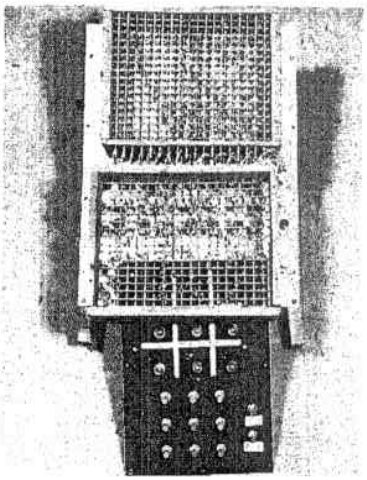


FIG. 2—Simplified schematic of the sequencer shows some of the stepping switches

Play Tick-Tack-Toe



Lamp matrices, play area and control switches of tick-tack-toe game

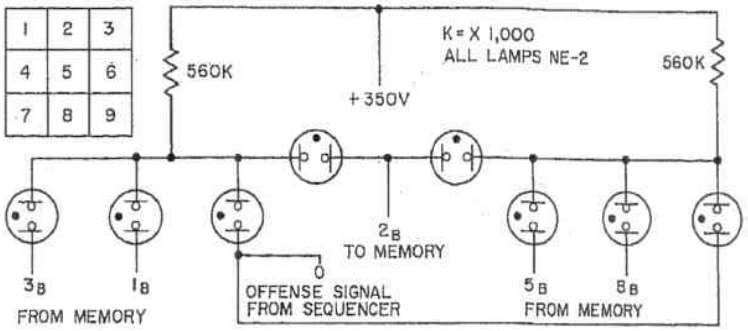


FIG. 3—Logic circuit for offensive move to position 2 of board in upper left

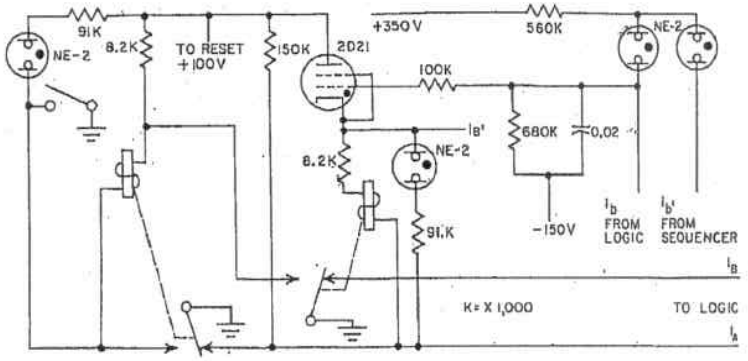


FIG. 4—Nine memory cells are used, one for each board position. Above is No. 1

board makes one move and stops until the operator completes the next play, and so forth until the game is completed. The rate at which the sequencer operates has been intentionally made slower than necessary, to give the effect of a thought process in the board.

The most important part of the game communicates with the memory, makes decisions as needed and matches wits with the operator. Although the decisions are simple, the use of neon lamps as logical gates is unique. A typical gate network, this one used to make an offensive move into position 2, is shown in Fig. 3.

The gate function is identical to the more familiar diode gate. When inputs 3_B, 1_B and 0 are all in a high voltage state, output 2_B becomes high, resulting in a board move into position 2. An output-signal change from low-state to high-state is also obtained when 5_B, 8_B and 0 are high. The B-subscripts refer to board-occupied positions. The 0-signal is received from the sequencer calling for an offensive move if such an opportunity exists.

This logic network is a combination of AND and OR gates satisfying the equation $2_B = (3_B \times 1_B \times 0) + (5_B \times 8_B \times 0)$. Similar logic networks, covering all nine positions, are used to make all the decisions of offense and defense as required during the progress of the game.

The neon-lamp matrix is constructed of three layers placed one atop the other in honeycomb fashion. Two layers, offense and defense, are identical. The third includes the special-defense matrix and provisions for future addition of win, lose, tie and game-end decisions.

Memory

The circuit diagram of one of the nine memory cells is shown in Fig. 4. Operator moves are entered into the board by push-buttons on the display panel energizing self-latching relays of the memory. Board moves are determined by the logic section triggering the thyratron of the memory and energizing the relay. Signals from memory to logic are in the form of grounded or open relay contacts, an open contact indicating an occupied position. The latching arrangement prevents an operator move into a position already occupied by the board or the player. Neon lamps on the display panel indicate the condition of each of the nine memory cells, whether the position is filled, and by whom.

Some modifications or additions to the game would be desirable for commercial use, aside from improving the appearance. The independent play program may be modified to add variety to the board's tactics. The machine may also be made vincible in some subtle ways. Logic and indicators for win, lose, draw and the like may be added.

Experience with this use of the neon lamp as a logical element has demonstrated some valuable properties of the component. Large deviations in electrical characteristics are tolerable and extremely long life may be expected. The lamps here were not pretested or selected in any way. None of the 187 lamps has required replacement after an estimated 1,000 hours of use.