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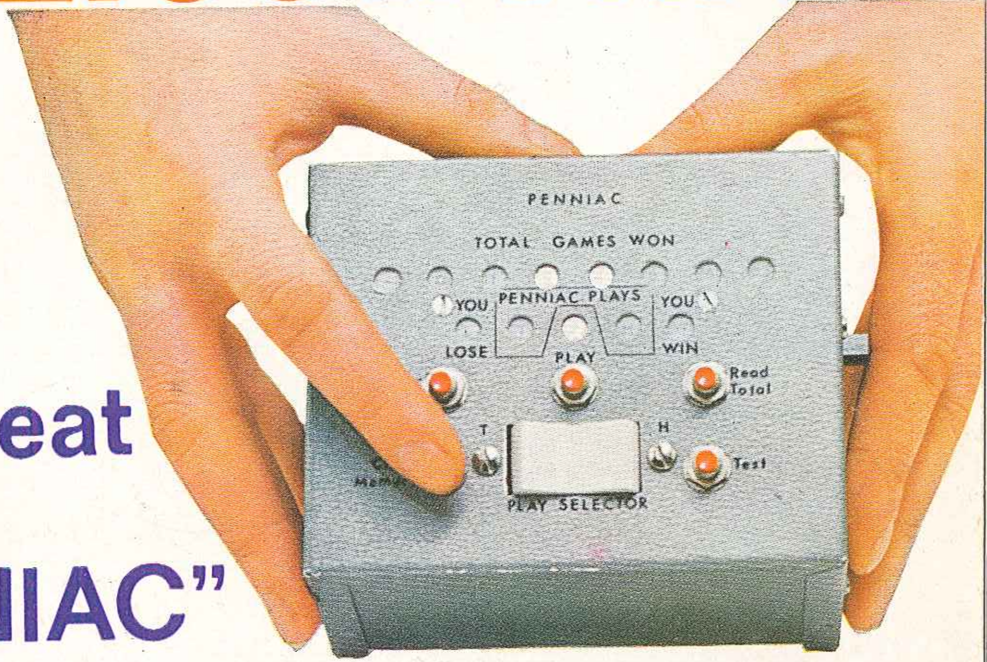

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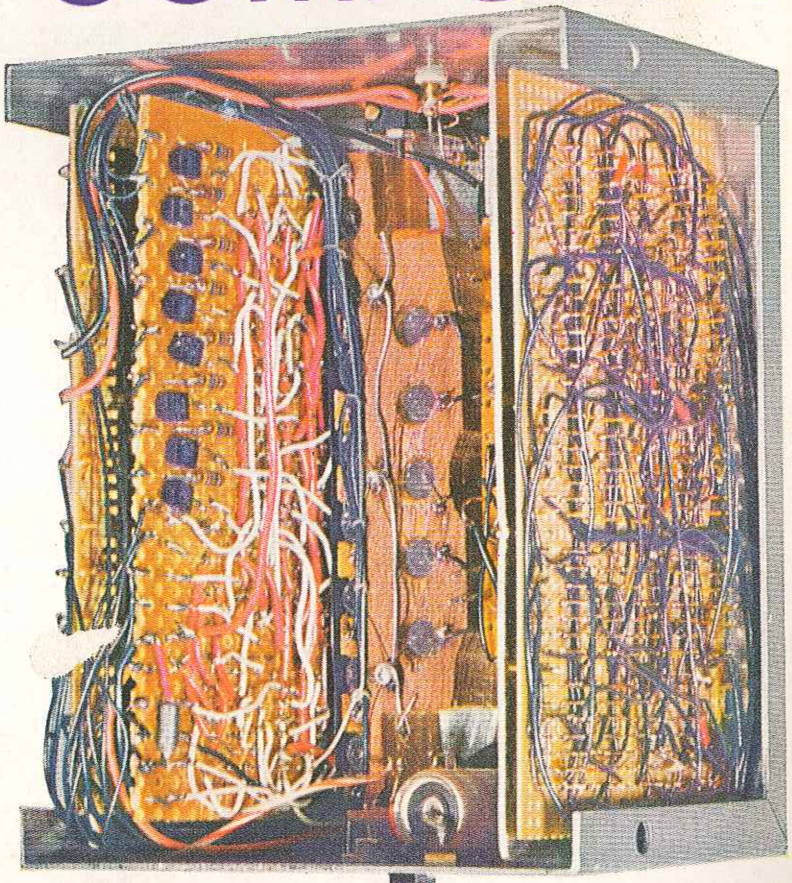

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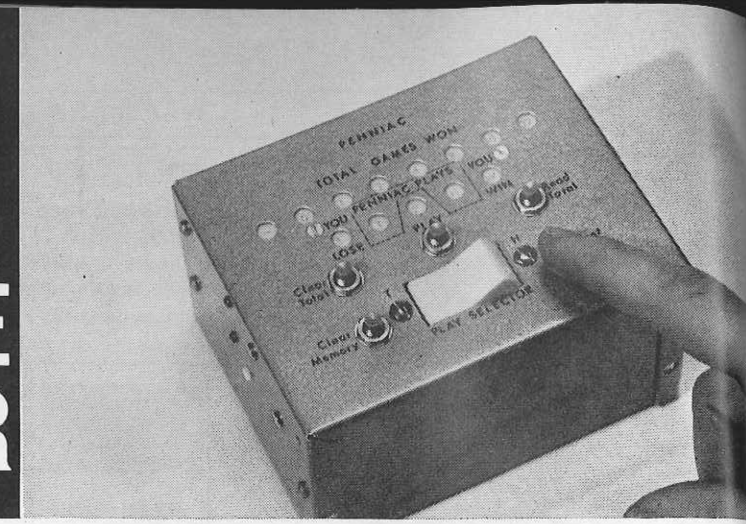


Penny-matching computer records your heads-or-tails play sequence and computes its plays accordingly. Has rechargeable power supply for its 66 IC's

by R. R. YOST

ALL WORK AND NO PLAY DESCRIBES THE LIFE OF MOST computers, but their human designers never have seen it that way. It wasn't long after computers became available that programs were written to teach them to play a good checker game and a pretty passable chess game.

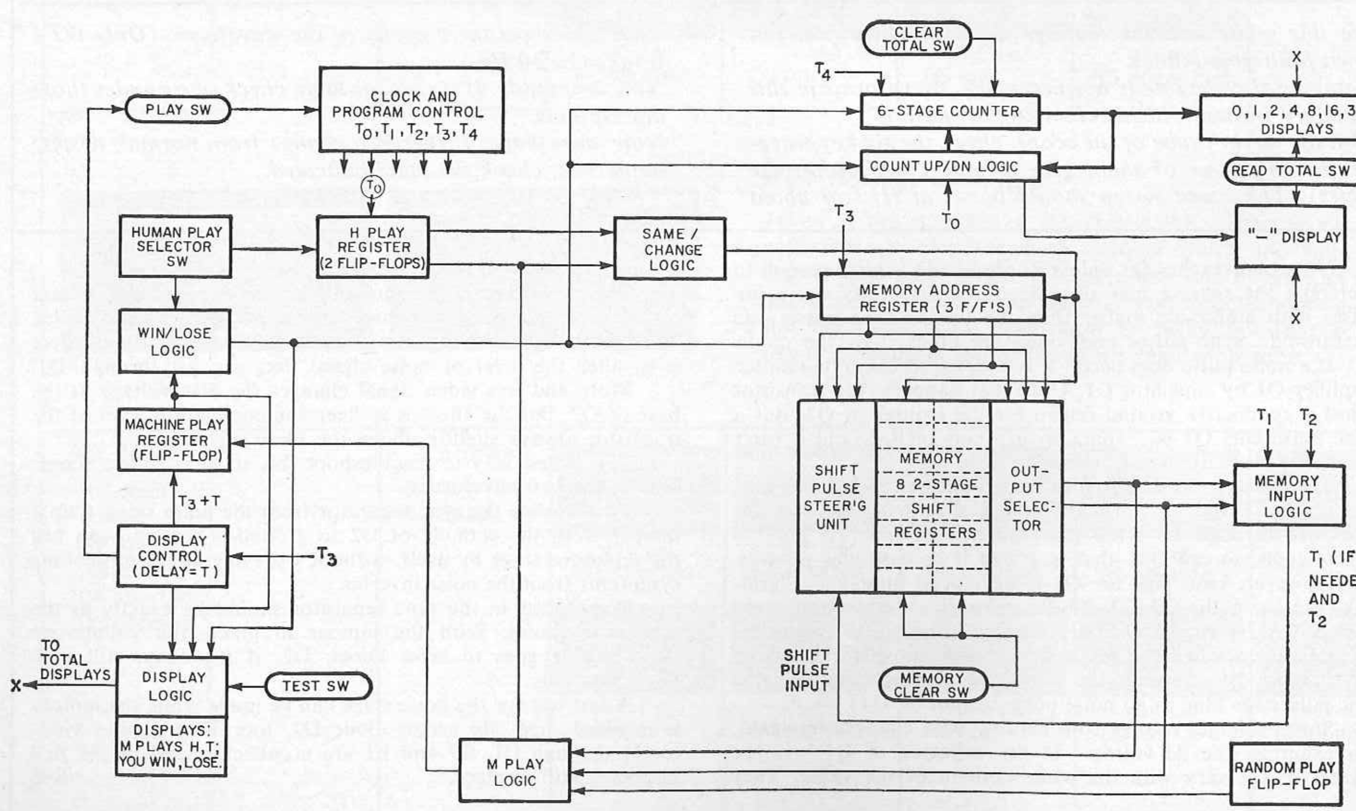
Even these accomplishments didn't satisfy us humans. We're now busy trying to teach computers to become even more human—to be able to adapt to and communicate with the world around them. Clearly, computers will someday be more than the dull work-a-day "accountants" they now are—they will be fascinating companions for our recreational and leisure hours.

The pint-size game computer described here is a step toward the day when adaptive game-playing computers will be in every home. It plays a very simple game by adapting itself to its human opponent. Its $150 construction cost puts it within reach of hobby groups, clubs and many individuals.

What Penniac does

Penniac plays a penny-matching game. The human chooses heads or tails and the computer tries to guess which it will be. If it correctly predicts the human's choice, the computer wins; if not, it loses and the human wins. Simple computers to play this game are not new. Dr. Shannon, of information-theory fame, described two such computers built at Bell Labs back in 1953, but not until inexpensive IC's became available did the construction of such a computer become feasible for a hobbyist.

Fig. 1—Complex interactions in Penniac are shown in this simplified block diagram. Three major sections are shown in Figs. 2–4, which should be studied with text and Fig. 1.



The adaptive feature of Penniac is its strategy for winning. It records the human's play sequence and memorizes his responses to each of a number of game situations. For example, if the human plays heads, wins, plays heads again, and wins again (a game situation), he may tend to change to tails (his response is to change his play).

To decide what the human is going to play next, the computer consults its situation memory to see what the human did the last time he was in the present situation. For each situation, it has stored an S, a C, or an R, based on the previous play history. An S means that previously, in that situation, the human played the same as before; C that he changed; R that the last *two* times this situation came up the human responded in different ways.

When the computer finds an R in the cell of its memory corresponding to the present situation, it makes a random choice of heads or tails.

Penniac, being pretty simple compared to its human opponent, can be beaten if you carefully remember what it has stored in each of its memory cells. (You probably will need pencil and paper for this.) Under this mode of play, it will lose three out of four games on the average. If you play completely random, so does Penniac and the result of a large number of games is a tie. Casual impulsive playing permits Penniac to draw ahead slowly, winning more games than it loses. Of course, luck plays a part!

Penniac is packaged in a 3 x 4 x 5-inch box, complete with its nickle cadmium (NiCd) batteries and their charging circuit. A counter is provided to keep track of wins and losses. To play with Penniac, you first turn the power on, using the switch on the right side. Then the won-games counter and the memory must be "cleared" by pressing the two buttons marked CLEAR TOTAL and CLEAR MEMORY.

Clearing the counter resets it to zero from the random count it assumes at turn-on, and clearing the memory sets

FIG. 2—PROGRAM CONTROL BOARD

I. Clock and Program Control
IC1: clock oscillator.
IC's 2, 3, 4: counter whose output states are used to steer control pulses to proper output terminals.
IC5a: Clock Control logic (stops clock after t_4).
IC5b, IC6a, b:
clock pulse shaper & drivers for steering logic.
IC6c: inverter and driver to reduce loading on IC3.
IC's 7, 8, 9: Clock Pulse steering logic input:
Y9: from H-Play pushbutton.
Outputs:
Y3: t_4 pulse.
Y5: t_0 pulse.
IC10a:T_0 pulse driver.
IC10b: T_1 pulse driver and inverter.
IC10c: T_8 pulse driver and inverter.

II. Win-Lose Logic
IC21: a, b, c, d; IC20 a, b.
Inputs: 24, 25 from H Play selector switch.
Outputs: X6, X7 to count Up/Down Logic.

III. Change-Same Logic
IC15 a, b
IC5a, IC16a, IC17a
Output 42: to memory.

IV. H Play Register
IC12a, IC13a.

V. Address Register
IC13b, IC14a, b.
Outputs: X1, X2, X3 to memory.

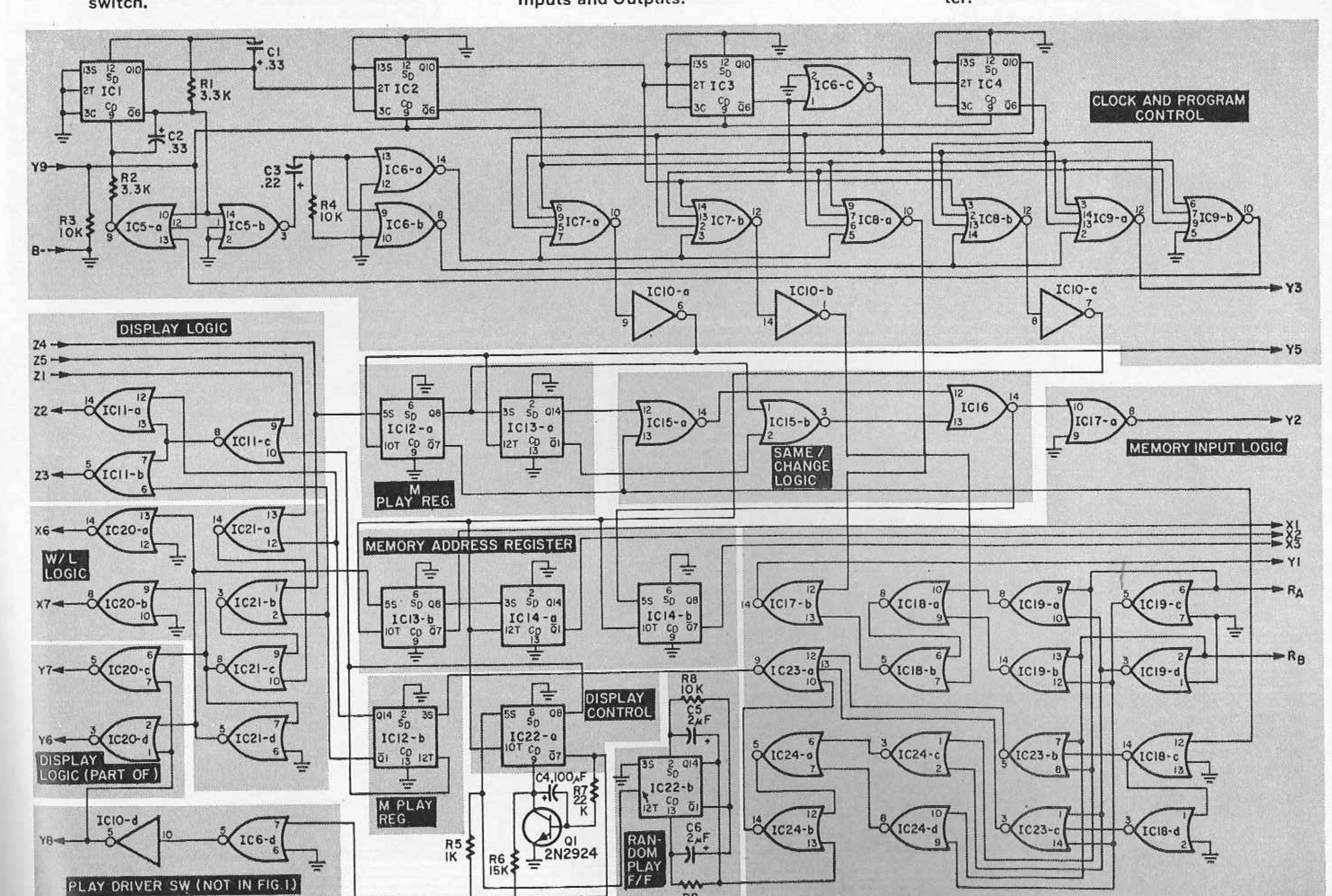
VI. Display Control Monostable F/F
IC22 a, IC6 d, IC10 d (inverter and driver).
Output 48: to Ready display and Play pushbutton

VII. M Play Register
IC12b

VIII. Display Logic
IC11a, b, c; IC20 c, d; plus elements on won-games counter board.
Inputs and Outputs:
Z1: from Test switch.
Z2, Z3: to M Play T, M display.
Y6, Y7: to display drivers, You Lose, You Win.
Z4, Z5: from H Play selector switch.
(Z4 to positive if heads; Z5 to positive if tails).

IX. Memory Input Logic
IC19a, b, cd; IC18a, b; IC 23a, b, c; IC 22b (Random Play FF).
Input:
R_A, R_B from memory output Selector
Output:
Y_1: t_1 and t_2 shift pulse to memory shift pulse steering unit.

X. Machine Play Logic
IC24a, b, c, d; IC 18c, d;
IC23a, b, c; IC 22b (Random Play F/F).
Inputs:
R_A, R_B: inputs from Memory Output selector.
Output:
Internally, to IC12b, Machine Play register.



MC717P - IC'S 6, 11, 15, 16, 18, 19, 20, 21, 24
MC719P - IC'S 7, 8, 9
MC722P - IC'S 1, 2, 3, 4
MC724P - IC17
MC789P - IC10
MC793P - IC5, 23

PARTS LIST

C1, C2, C7, C9—0.33μF electrolytic
C3—0.22-μF electrolytic
C4—100-μF, electrolytic (Kemet K100 or equiv.)
C4—100-μF, electrolytic (Kemet K100 or equiv.)
C5, C6—2-μF, electrolytic (Kemet 2R 2μF or equiv.)
C8—4.7-μF, electrolytic
C10—100-μF electrolytic
C11—600-μF electrolytic
All capacitors 6 volts or more. All tantalum except C10 and C11 to conserve space.
R1, R2—3300 ohms. 1/8W
R3, R4, R8, R11—10,000 ohms
R5, R27, R28, R35, R36—1000 ohms
R6—15,000 ohms
R7—22,000 ohms
R9—6800 ohms, ½W
R10, R12–R19, R29, R30–R34—470 ohms
R20, R21—56 ohms, 1W
R22—5000-ohm trimmer potentiometer
R23—47 ohms
R24—4.7 ohms, 1W
R25, R26, R37—2200 ohms
All resistors ¼W unless noted
Semiconductors (integrated circuits (IC1–IC66, Motorola)
IC1–IC4, IC50, IC52–IC56, IC65—MC722P
IC5, IC23, IC63—MC793P
IC6, IC11, IC15, IC16, IC18–IC21, IC27, IC39, IC57–IC62, IC64, IC66—MC717P
IC7–IC9, IC26, IC30, IC32, IC33, IC36–IC38, IC42–IC44, IC47, IC49—MC719P
IC10, IC25—MC789P
IC12–IC14, IC22, IC28, IC29, IC34, IC35, IC40, IC41, IC45, IC46—MC778P
IC17, IC51—MC724P
IC31—MC725P
IC48—MC786P
Q1–Q10, Q12–Q16—2N2924 (Motorola)
Q11—2N2925 (Motorola)
D1—1N4154 diode
D2—1N4371A Zener diode (Motorola)
RECT 1—bridge rectifier MDA 920A-1 (Motorola)
Other parts
T1—6.3V, 0.6A transformer
RY1—250-ohm, 14-mA, spdt dc relay (Sigma 11F-250-G/SIL)
B1—3 1.25-volt nickel cadmium cells (G.E.)
LM1–LM13—4-volt, 40-mA lamps (4ES), base-less
S1—dpst slide switch
S2-S5—spdt, NC momentary pushbutton switch (subminiature)
S7—2-position dpdt rocker switch
MISC—perf board (0.1-inch centers), 6-lug terminal strip, standoff terminals, 3 x 4 x 5-inch metal case, No. 32 stranded wire, Vector type K24A pins

all cells to "R" (random). The human makes his first choice of heads or tails by setting the PLAY SELECTOR rocker switch to the right or left, and then enters his play by pressing the centrally located PLAY pushbutton. Lights come on for about 1 second to indicate what Penniac's play was and whether the human won or lost. The TOTAL WON GAMES lights also illuminate momentarily, indicating the net games won by the human.

For example, if the human selected heads and the computer also selected heads, the human would lose and the TOTAL WON GAMES would indicate −1, meaning the human is now one game behind. The counter is a binary counter and the total is obtained by mentally adding together all the illuminated numbers. If the human is seven games behind, for example, this would be indicated by −1 2 4. The counter has a range of ±63; on the count of 64 it resets to 0. After the 1-sec interval, all indicators go out and the central play indicator (P) comes on, signifying that the computer is ready for the next play by the human operating it.

The button marked TEST is provided to assure the human that the computer is not cheating. Pressing this button at any time tells you what the computer is going to play next. You can verify that changing the play selector switch will not affect the computer's choice. Also, you can verify, by holding this button down continuously, that the computer always makes its choice just at the end of the 1-sec display ON period, *before* you have made your next selection.

The READ TOTAL button is provided so that you can check the won-games counter to find out how you stand.

Table I shows the results of playing a sequence of games. The second, third and fourth columns tell which of its memory cells Penniac "read" from, what it read therein, and which play number those contents were based on. The fifth column lists Penniac's prediction for the human's play. Column 6 contains the human's actual play. These plays were chosen to illustrate how Penniac adapts to the human's strategy; they also illustrate what happens when the human tries to vary his strategy so as to "fool" Penniac. Column 7 records whether the human won or lost and column 8 lists what Penniac wrote into the memory cell it had consulted for prediction. Column 9 contains a "+" when Penniac correctly predicted the human's play, a "−" when it was fooled, and an R when it played at random. Column 10 records games won by the human.

Of course, each game starts with the human's play and ends with Penniac predicting the human's next play. For example, after the human makes his third play, Penniac writes S in cell WSL, and then consults cell LSL to predict the human's 4th play.

Note that in this sequence of 50 games, Penniac predicted correctly 21 times, incorrectly 11 times, and played at random 18 times, in spite of the human's attempts to mislead it. At the end of the 50-game sequence the human is down 6 games, so he was actually somewhat lucky. If he had won only half the time that Penniac played at random, he would have been down 10 games.

How it works

For understanding anything as complex as Penniac, detailed schematic diagrams are not a good starting place. Fig. 1 is a block diagram that shows how the major elements of Penniac interact.

Clock and Program Control: This unit is controlled by the PLAY pushbutton; upon its release, a series of five output pulses is generated. Each pulse comes out on a different output lead. The pulses last about 0.2 msec and are spaced at 2.5-msec intervals. Each pulse is a command to a block-diagram element to perform its function at the time the pulse arrives.

Counter and Count Up/Down Logic: The usual flip-flop (F/F) counter counts up only; that is, it increases its stored total by one for each input pulse until all stages are holding binary 1's. Then the next input pulse results in all stages holding binary 0's. However, for the net games won, the counter must be able to count both up and down. If it is holding a positive total, a game lost by the human must reduce the stored count by one. On the other hand, if it is holding a minus total, meaning the human has lost more games than he has won, a lost game must increase the count. The Count Up/Down logic sets a "sign" flip-flop to the "−" or "+" state when the total is 0 and the human loses or wins, respectively. This happens *only* if the total is 0; for other values of the total the sign F/F does not change. When the sign F/F is in its "−" state,

FIG. 3—MEMORY BOARD

I. Shift Pulse Steering Unit
IC25 (driver), IC's 26, 33, 38, 44, 27, 39.
II. Memory
IC's 28, 29, 34, 35, 40, 41, 45, 46.
III. Output Selector
IC's 30, 36, 42, 47, 32, 37, 43, 49, 31, 48.
Inputs:
X1, X2, X3: from Address register.
Y1: from Machine Play logic.
Y2: input from Change-same logic.
P: from memory clear pushbutton.
Output:
RA, RB: to Memory Input logic and Machine Play logic.

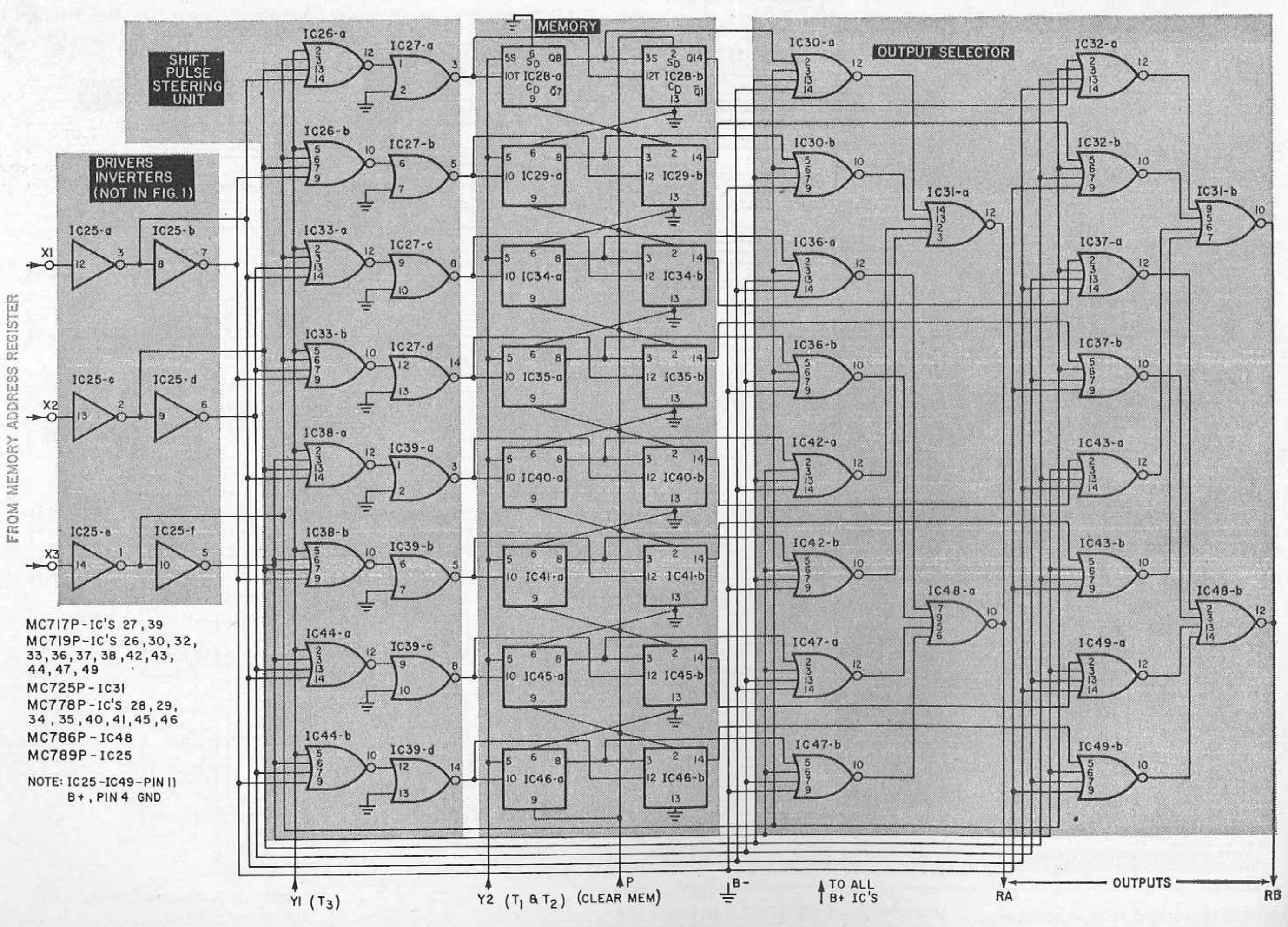
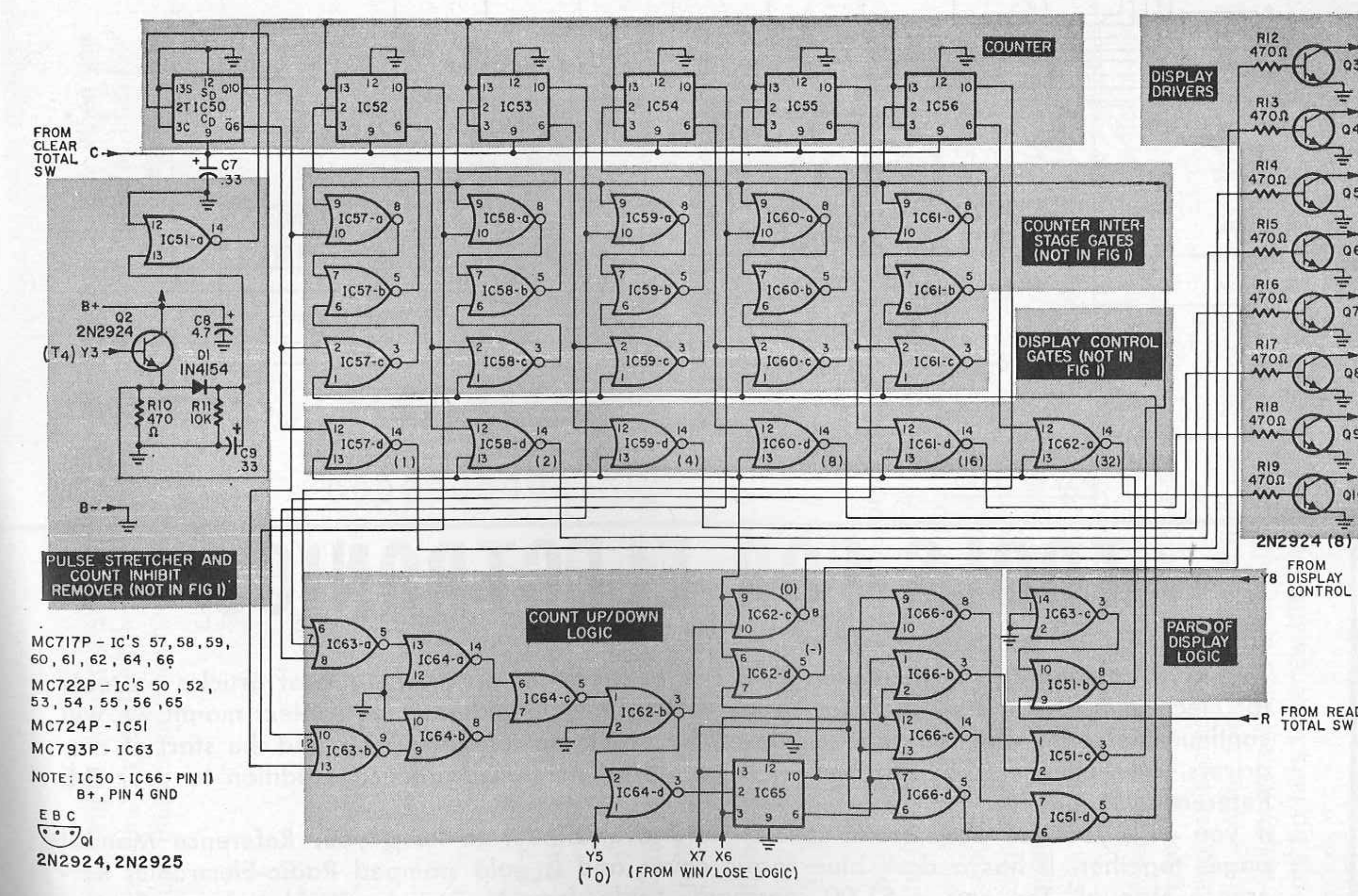


FIG. 4—TOTAL GAMES WON COUNTER

I. Counter
IC's 50. 52, 53, 54, 55, 56.
II. Count Up/Down Logic
IC's 57 a, b, c; 58 a, b, c; 59 a, b, c; 60 a, b, c; 61 a, b, c; IC66 a, b, c, d; IC51 c, d.
IC65 is Sign flip-flop. IC63 a, b; IC64 a, b, c, d; IC62 b are logic for driving sign flip-flop.
Display Logic: IC63c; IC's 57d, 58d, 59d, 60d, 61d; IC62 a, c, d.
Inputs pulse shaping and count-inhibit voltage generator: Q2 and IC51a.
Inputs:
C: Total-Clear pushbutton.
Y3: t_4 pulse to advance counter.
Y8: from display monostable F/F.
R: from Read-Total pushbutton.
Y5: t_0 pulse to Count Up/Down Logic.
X6, X7: from Win/Lose logic.
Outputs:
To lamps as indicated.
Y4: t_4 pulse to other circuits.



the count up/down logic sets the counter interstage connections so that a game lost by the human increases the count and a game won decreases the count. When the sign F/F is "+" it controls the counter so it counts up for games won by the human and vice versa. The sign F/F also controls the "−" display lamp.

H Play Shift Register: This comprises two cascaded F/F's. Upon pulsing the S terminal, the left one stores whatever is at its input terminal—in this case, the setting of the H PLAY SELECTOR switch—and the right-hand F/F stores what the left one held before the pulse. Thus this register stores the human's last two plays.

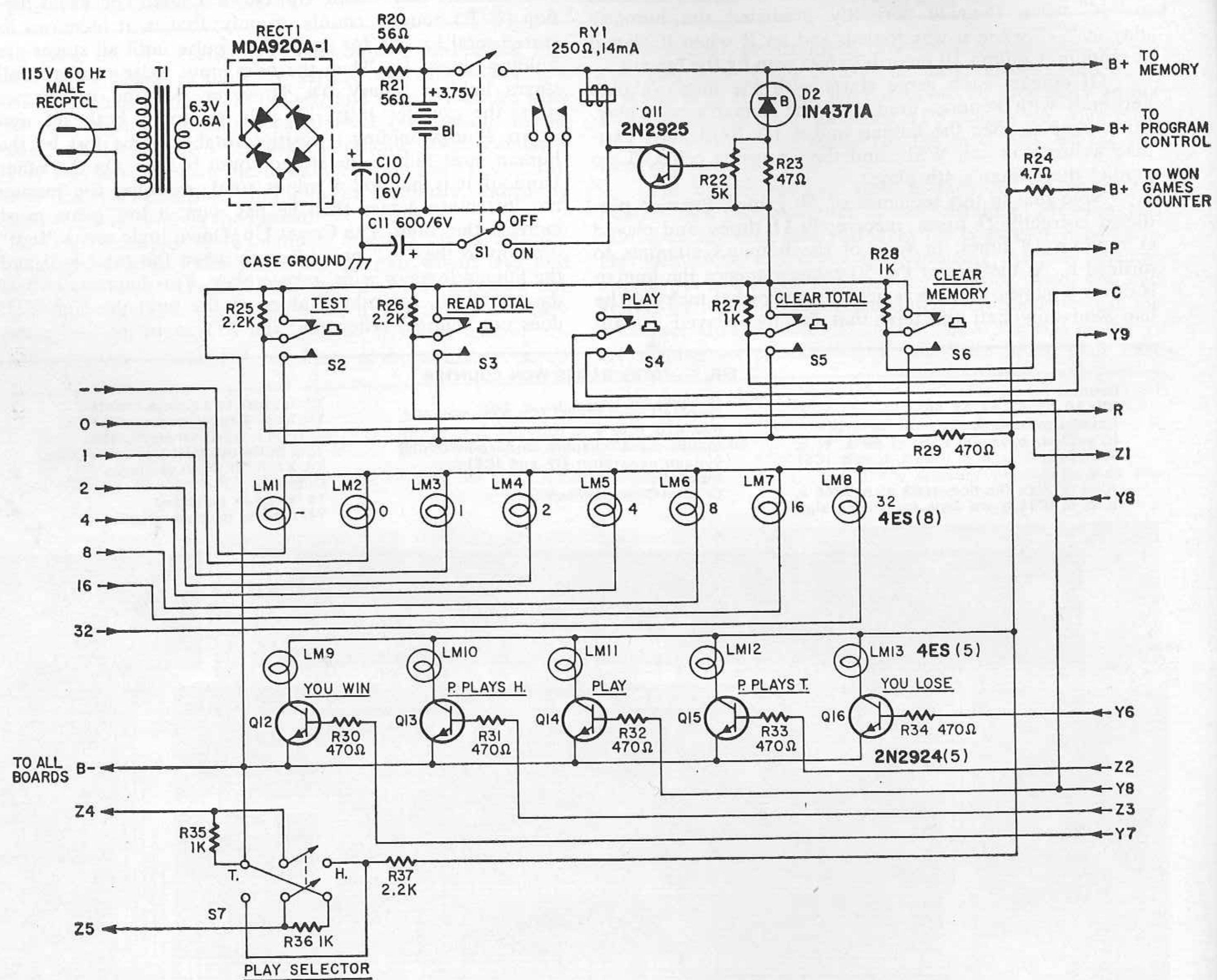
Same/Change Logic: The Same/Change logic network compares the last two human plays stored in the H-Play register to determine whether he played the same or changed. Its output is fed to the Memory-Address register and to the memory itself.

Win/Lose Logic: The Win/Lose (W/L) logic network compares the setting of the H PLAY SELECTOR switch with the machine's play, which is stored in the machine-play register F/F. Its output is a binary 1 if the human wins, a 0 if he loses.

Memory Address Register: This unit stores the last two outputs of the Win/Lose logic and the previous output of the Same/Change (S/C) logic. Its three binary

(continued on page 72)

Fig. 5—Depending on component values, it may be necessary to connect R22 across Zener diode D2 to get the 3.3-volt drop-out point within the adjustment range of the potentiometer.



TOOLS FOR ELECTRONICS

by TOM HASKETT

This issue, starting on the facing page, is the next part of our new series of articles on tools for electronics. It is the second part of our description of soldering tools. Next month we will continue the series with the final section of the article on soldering tools and the start of nutdrivers. We believe you will find all of this material a handy, practical addition to your R-E Reference Manual.

If you wish you can purchase a special hardcover binder to keep your Reference Manual pages together. It has a dark blue fabric cover and is gold stamped Radio-Electronics Reference Manual. The cost is $1.00, postpaid. Order from N. Estrada, 17 Slate Lane, Central Islip, L.I., N.Y. 11722.

Fig. 3 shows the schematic of the transformer-type gun. When you pull the trigger, the transformer primary is connected to the ac line. Notice that the primary has many turns while the secondary has only one.

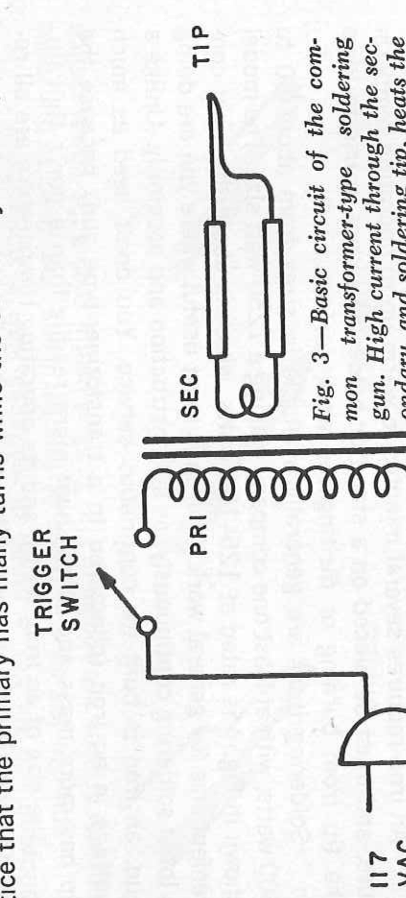


Fig. 3—Basic circuit of the common transformer-type soldering gun. High current through the secondary, and soldering tip, heats the tip.

Thus secondary voltage is low and current is high. This secondary current heats the tip.

Guns are available from 100 to 325 watts. Some have a dual-position trigger switch which connects the ac line to more or less of the primary, providing more or less secondary current. The model shown in Fig. 2 has a two-position trigger which produces 100 or 140 watts at the tip.

A transformer-type gun is most useful in installation and servicing, where you might solder connections only now and then. It's most useful for intermittent work; the one shown in Fig. 2 has a duty cycle of 1 minute on and 4 minutes off. A gun heats rapidly (it can melt solder about 5 seconds after you pull the trigger), requires no stand and is therefore convenient for occasional soldering. Also, the spotlight (some models have two) is useful because it lights your way into dark corners. But you cannot use a gun constantly, as in construction and assembly.

Gun tips are usually bare copper and several types are available. Most common is the chisel tip, for routine work. There is also a flat blade type, for cutting soft plastic and similar material. Tips are inexpensive and replacement is simple.

After some use, you'll find that the tip doesn't get hot easily or rapidly. When this happens, let the gun cool. Then loosen and retighten the tip nuts to renew the solid heat-transfer connection at those points.

idle for a half hour or so, the tip stabilizes at what's called **idling temperature.** This must be well above the melting point of the solder you're using. It must also be high enough so that rapid and frequent applications to the cold work won't immediately drop tip temperature below the solder-melting point. If you use an iron intermittently this is a less important consideration than if you use the iron continuously, as in production and assembly. In general, a small tip, which loses heat rapidly when applied to the work, should idle at a proportionally higher temperature than a large tip, which has more mass and therefore greater heat-storage capacity.

Continuous vs intermittent soldering

On a factory production line, a technician performs the same soldering operations over and over again throughout a work shift. A production soldering tool must therefore be durable and capable of constant and reliable performance to assure uniformity of soldered joints. It must be as light and maneuverable as possible to permit rapid production with maximum operator comfort. Except for special applications with low-temperature limitations (such as printed-circuit work, which may require operations as low as 400°F), most production irons operate above 800°F to allow the soldering of as many as 50 joints per minute while still maintaining suitable working temperatures.

Usually production soldering doesn't require great tip versatility for a single work station. An integral tip-and-heater unit with iron-clad tip and heater rating to handle the size of the job may be selected and used continuously, without requiring a great deal of maintenance. The tip should have a high idling temperature and the tip mass and heater output should be designed so the tip will rapidly recover heat which is lost during each soldering operation.

Maintenance and service technicians, and others who troubleshoot and repair equipment, perform soldering intermittently or occasionally, as much of their time is taken up with reading voltages, removing screws and covers, etc. During these periods, the soldering tool lies idle. If an iron is used, it must not overheat during long idling times. Conversely, it must be able to successively solder several joints. An iron with interchangeable tips (or heaters and tips) is preferred for this type of service, so that a variety of jobs may be performed. Irons should operate in the range of 750–900°F.

outputs determine which memory situation cell shall have new information written into it.

PLAY NO.	ADDRESS OF MEMORY CELL USED	MEMORY READ	BASED ON PLAY NO.	P's PREDICTION	H's PLAY	H's W/L RESULT	MEMORY WRITE	SUCCESS	NET GAMES WON BY H.	REMARKS
1	?	R	0	T	H	W	?	R	1	
2	?	R	0	H	H	L	S	R	0	
3	WSL	R	0	H	H	L	S	R	−1	
4	LSL	R	0	T	H	W	S	R	0	
5	LSW	R	0	H	H	L	S	R	−1	
6	WSL	S	3	H	H	L	S	+	−2	
7	LSL	S	4	H	H	L	S	+	−3	
8	LSL	S	7	H	T	W	R	−	−2	H changes strategy
9	LCW	R	0	H	T	W	S	R	−1	to play tails.
10	WSW	R	0	H	T	W	S	R	0	
11	WSW	S	10	T	T	L	S	+	−1	
12	WSL	S	6	T	T	L	S	+	−2	
13	LSL	R	8	H	T	W	S	R	−1	
14	LSW	S	5	T	T	L	S	+	−2	
15	WSL	S	12	T	T	L	S	+	−3	
16	LSL	S	13	T	H	W	R	−	−2	H changes strategy
17	LCW	S	9	H	H	L	S	+	−3	to all Heads.
18	WSL	S	15	H	H	L	S	+	−4	
19	LSL	S	13	H	H	L	S	+	−5	
20	LSL	S	19	H	T	W	R	−	−4	H begins strategy
21	LCW	S	17	T	H	W	R	−	−3	of alternate H & T.
22	WCW	R	0	H	T	W	C	R	−2	
23	WCW	C	22	H	H	L	C	+	−3	
24	WCL	R	0	H	T	W	C	R	−2	
25	LCW	R	21	H	H	L	C	R	−3	
26	WCL	C	24	T	T	L	C	+	−4	
27	LCL	R	0	H	T	W	S	R	−3	H decides
28	LSW	S	14	T	T	L	S	+	−4	to play all T's.
29	WSL	S	18	T	T	L	S	+	−5	
30	LSL	R	20	T	H	W	C	R	−4	H switches
31	LCW	C	25	T	H	W	R	−	−3	to all H's.
32	WSW	S	11	H	H	L	S	+	−4	
33	WSL	S	29	H	H	L	S	+	−5	
34	LSL	C	30	T	T	L	C	+	−6	H switches to
35	LCL	S	27	T	H	W	R	−	−5	a strategy of changing
36	LCW	R	31	T	H	W	S	R	−4	if he loses, playing
37	WSW	S	32	H	H	L	S	+	−5	same if he wins.
38	WSL	S	33	H	T	W	R	−	−4	
39	LCW	S	36	T	T	L	S	+	−5	
40	WSL	R	38	H	H	L	C	R	−6	
41	LCL	R	35	T	T	L	C	R	−7	
42	LCL	C	41	H	T	W	R	−	−6	H switches to strategy
43	LSW	S	28	T	H	W	R	−	−5	of changing if he wins,
44	WCW	C	23	T	T	L	C	+	−6	playing same if he
45	WCL	C	26	H	T	W	R	−	−5	loses.
46	LSW	R	43	T	H	W	C	R	−4	
47	WCW	C	44	T	T	L	C	+	−5	
48	WCL	R	45	T	T	L	S	R	−6	
49	LSL	C	34	H	T	W	R	−	−5	
50	LSW	C	46	H	H	L	C	+	−6	

C—Change, H—Heads, T—Tails
L—(Lose), S—(Play Same), W—Win, R—Random,
21 +, 11 −, 18 Random

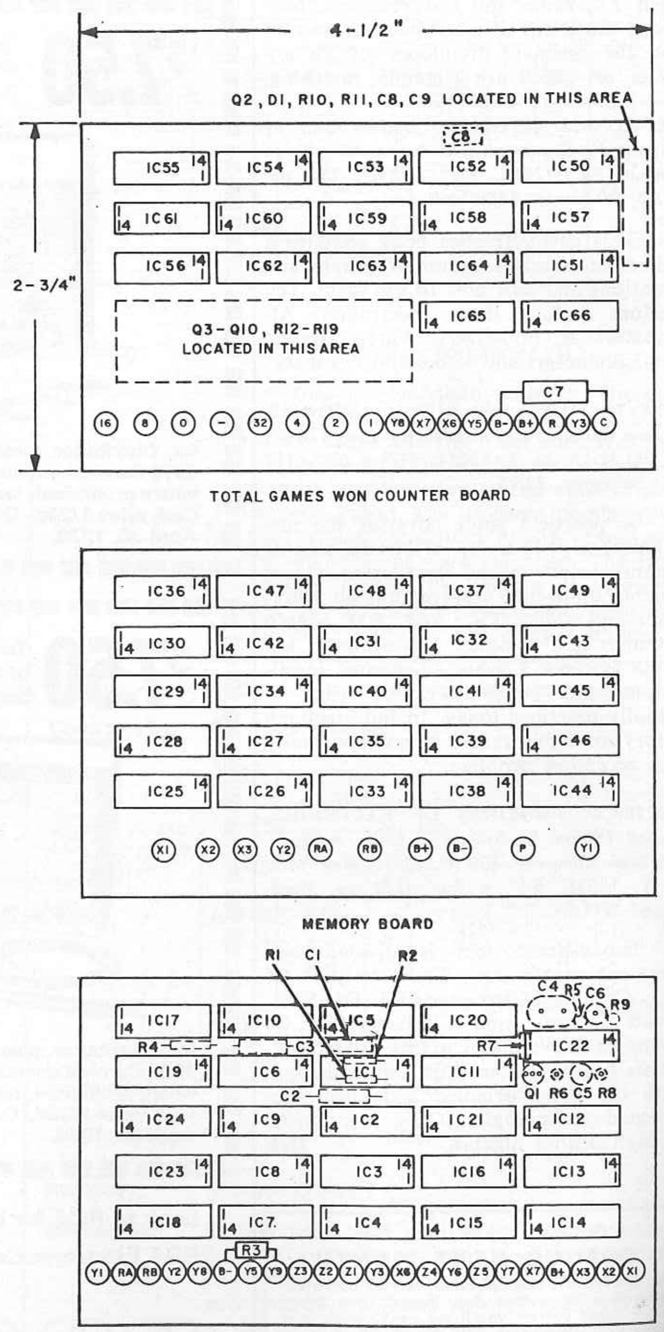
Memory: The memory consists of eight two-stage shift registers. If the two F/F's in a cell are storing 0–0, this corresponds to storing an S; if 1–1, a C; and if 0–1 or 1–0, an R. All the left-hand stages are continuously sampling the output of the Same/Change logic, but which cell receives the shift pulses that cause the cell contents to change is determined by the Shift-Pulse steering unit. Similarly, both stages of a cell corresponding to the address in the Memory Address go through the output selector to the Memory Input and Machine Play logics.

Memory Input Logic: This unit assures that a single game will change the contents of a cell holding on R to an S or a C. If a shift register holds 0–1 (R), shifting in a single 1 would result in the register holding 1–0 (still R), as the 0 would shift from the left to the right stage. Thus *two* shift pulses are applied in this case, as well as in the case where it is desired to change 1–0 to 0–0.

Machine Play Logic: This unit uses outputs from the memory, from the first stage of the H Play register, and from a Random Play flip-flop, to compute the machine's next play. If the memory holds an R, the Random Play F/F, which is continually changing state at over 100 times per second, is connected to this unit's output. The state that happens to be present at the end of the display illumi-

(continued on page 75)

Fig. 6—Arrangement of the 66 IC's and other components on three perf boards. This permits most compact circuit layout.



"SYNCRO SLIDE" Adds Sound To Your Slide Show

Low-cost silicon controlled switch advances slide projector from taped sync pulses on a stereo channel

By PHILIP BLAIRE

MUCH THAT'S GOOD IN A GOOD SLIDE show is in the showing. Use a little showmanship and your friends will greet your slide shows with real enthusiasm rather than dutiful politeness.

The Syncro-Slide will help you with the showmanship. For less than $10 this handy little solid-state device lets your stereo tape recorder control your solenoid-actuated slide projector.

The Syncro-Slide is designed around a very sensitive but inexpensive silicon controlled switch (General Electric 3N84) and a dc relay. The SCS, when used in an ac circuit like this one, conducts only when the anode and cathode are forward-biased and a positive voltage is applied to the cathode gate.* The high gate-firing sensitivity of the 3N84 eliminates the need for amplifying control signal. The rectifying characteristic of the SCS eliminates the need for a dc power supply. With those two circuits gone, the Syncro-Slide is about as simple and cheap to build as anyone could wish.

Fig. 1 is a diagram of the Syncro-Slide circuit. An ac signal of 0.6 volt applied to input jack J1 is rectified by D1, filtered by C1 and applied through R1 to the cathode gate of the SCS. This positive voltage turns the SCS on. Once on, the SCS rectifies the ac voltage supplied by T1. The resulting direct current actuates the relay, which in turn triggers

(turn page)

the slide projector. When the positive voltage is removed from the cathode gate, the SCS will turn off as the supply voltage from T swings through zero.

C2 smooths the pulsating dc flowing through the relay and prevents chatter. D2 surpresses inductive transients that could damage the SCS. These transients occur when the magnetic field around the relay coil collapses.

Resistors R2 and R3 forms a voltage-dividing network which is interrupted by switch S. When S is closed, a 1-volt 60-Hz signal appears at J1 and D1. This signal is used for recording sync tones on the tape recorder. It also triggers the SCS into conduction.

A double-pole relay may be substituted for the single pole unit shown. A neon light connected via the extra contacts to the 117-volt line will flash each time the relay closes.

A 3-volt Zener diode can be placed in the gate circuit. It will protect the SCS gate from overloads caused by excessive signal levels or leaking B+ from the tape recorder. The maximum allowable gate signal is 5 volts.

One more addition you may want to consider for your Syncro-Slide: a low-power lamp dimmer for controlling room illumination.

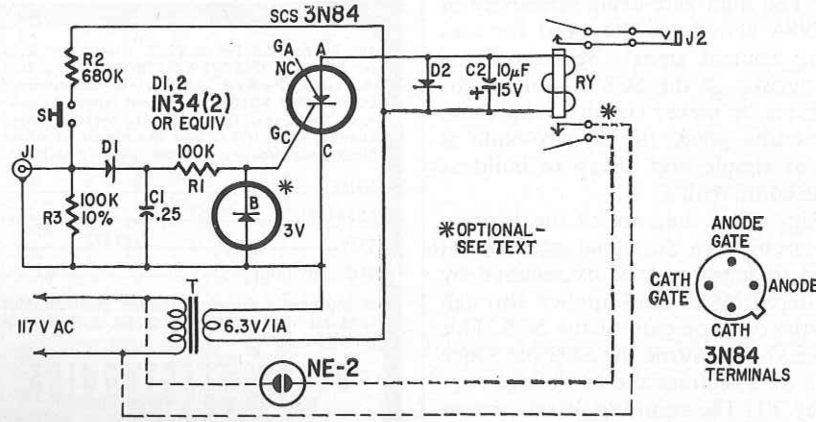


Fig. 1—Highly sensitive 3N84 silicon controlled switch is triggered by 60-Hz signal programmed on tape and applied through J1. Relay RY advances projector.

The circuit shown was laid out on Veroboard. The Veroboard and transformer were mounted in the bottom of a plastic meter case. J1, J2 and the ac line cord are on the back of the case.

You can get the parts for your Syncro-Slide either at a local supply house or through the larger mail-order houses. A 6-volt relay and transformer are used for the unit described here, but 12- or 24-volt devices can also be used. Simply change the value of R2 to obtain the proper relay voltage.

Assemble the circuit except for J1, J2 and the SCS. With S closed you should obtain 1 volt ac ±0.25 volt across R3, and 1 volt dc ± 0.25 volt across C1. This positive voltage should drop immediately to zero when S is opened. If it drops slowly or not at all, shunt C1 with a 1-meg resistor.

Now install the SCS. The anode-gate lead is not used and can be cut off. The SCS is extremely sensitive to heat. Solder it in carefully using a heat sink, or use a transistor socket instead and avoid soldering.

Measure the circuit resistance from the anode to the cathode of the SCS. Reverse the ohmmeter leads and measure again. The resistance in one direction should approximate the relay coil resistance; in the other direction the resistance should approximate the resistance of D2 when it is forward-biased. The SCS will have little effect on resistance readings unless it is shorted inside the unit.

With S closed, measure the dc voltage across the relay. If this voltage exceeds the rating of the relay, insert a series of dropping resistor. If there is no voltage, check the polarity of D2.

Install the Veroboard circuit and T in the plastic meter case. Install J1 and J2. Insert S in the top plate and install the top plate. Your Syncro-Slide is now ready to go to work for you.

To prepare a control tape, record a commentary about your slides on channel 1 of your tape recorder. Use the Syncro-Slide to record sync tones on channel 2 at points where you want the slides to change.

Once your control tape is made, you are ready for completely automatic showing. Connect J2 to your automatic slide projector; connect J1 to the channel-2 output of your tape recorder. As the tape plays, you will hear your commentary from channel 1. Slides change on each tone from channel 2.

With your best slides (*only* your best, please!) arranged in an interesting sequence and accompanied by a tape of fast-moving commentary, appropriate background music and subtle sound effects, your audience will sit up and take notice! **R-E**

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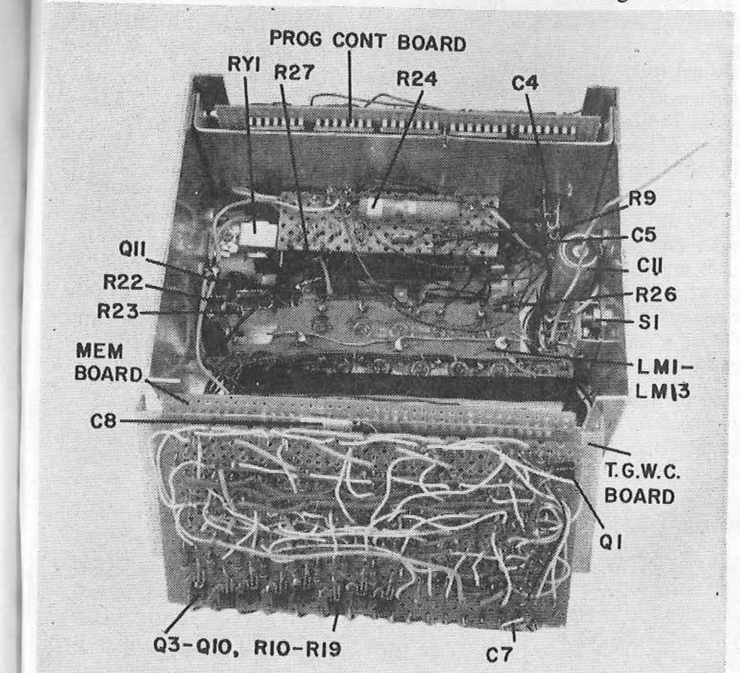
nation period is stored in the Machine Play register F/F as the machine's next play.

Display Control: This unit illuminates the displays upon receipt of a trigger pulse, and turns them off after an interval of about 1 sec. The purpose is to minimize battery drain. It deactivates the PLAY PUSHBUTTON during the interval, and sends a trigger pulse to the Machine Play register F/F at the end of the interval.



Follow this wiring procedure: Cut and tin wires, forming hooks at both ends. Tin IC pin; crimp wire to pin. Touch with iron to flow solder; inspect joint. Jumper all IC commons with No. 32 bare wire; run B+ and B— leads to all IC's. Interconnect boards.

With the functions of the individual blocks in mind, the sequence of events that occur when the play button is released can be described. The initial conditions are:

(1) The H PLAY selector switch holds the human's current choice of play.
(2) The M Play register holds the computer's play.
(3) The W/L logic output is the result of the game that is about to be played.
(4) The Memory Address register holds the previous two W/L results and the S/C results of the human's two *previous* plays. This is the cell "address" corresponding to the game situation for which the human has just selected a play.
(5) The Random Play F/F is running.

When the PLAY BUTTON is pressed and released, the programer resets and then generates five pulses in sequence, applying each to different units. The pulse times are labeled t_0 through t_4. What happens at each pulse time is detailed next.

(t_0): The human's current play is shifted into the H-Play register and the Same/Change logic output now tells whether he played the same as the last time or changed. Also, if the total is zero, the sign F/F in the Count Up/Down logic is set according to the output of the W/L logic. After t_0, this unit has set the counter interconnections to count in the proper direction. No other registers have changed.

(t_1), (t_2): At this time, the human's current "same/change" response is to be written into the cell corresponding to the game situation prevailing when he selected his play. If the cell already holds an R, the t_1 pulse is applied as a shift pulse to the cell selected by the Shift-Pulse steering unit. Regardless of what happens at t_1, the same/change response is shifted into the cell (again, perhaps) at t_2.

(t_3): A shift pulse is applied to all stages of the Memory-Address register. This causes it to update to correspond to the situation when the human will select his *next* play. As a result the Machine Play logic output is determined by the human's current play and the contents of the memory cell corresponding to the *next* situation. The output is applied to the Machine-Play register, but is not set into that register till later.

The Display control is triggered to the ON state and the displays are illuminated for about 1 sec, starting from t_3.

(t_4): The leading edge of the t_4 pulse removes a count-inhibit voltage from the counter and the trailing edge causes the counter to count up or down as selected at t_0. The reason for normally inhibiting the counter is to prevent it from erroneously "counting" when the Count Up/Down interconnections are being shifted at t_0. Shortly after the end of the t_4 pulse, the count-inhibit voltage is restored.

(t_3 + 1 second): At this time the Display Control returns automatically to its OFF state, causing the Machine Play F/F to assume the instantaneous state of the output of the Machine Play logic and reactivating the PLAY pushbutton.

Three NiCd cells provide energy for about 2 hours of operation. A transformer, bridge rectifier, smoothing capacitor and current-control resistor supply charging current at a low rate that can be continued indefinitely with-
(continued on page 83)

plement consists of four 15" woofers, four 8" mid-base, four 6" mid-range and two 5" horn-type tweeters. Frequency response: 20–20,000 Hz ±3 dB with crossovers at 150 Hz 1,000 Hz and 4,000 Hz. Impedance: 4 ohms. Capacity: 200 watts rms with 100 watts rms

per channel minimal power requirement. Electronic network generates negative-feedback error voltages when speaker does not follow amplifier output and controls speaker cone to eliminate low-frequency distortion. Network tends to cancel effect of frequency-sensitive network at high frequencies. Control panel carries high-frequency high and low mid-frequency controls, phase switch, aux amplifier jack, main input connector for stereo, and room gain control. 51½ x 36¾ x 20". 250 lb. *Instant kit*, unfinished cabinet, without grille, $725. *LWE IV*, walnut cabinet with wood fret grille, $950. Marketing Dept., **LWE Div., Acoustron Corp.**, 2418 Bartlett St., Houston, Tex. 77006

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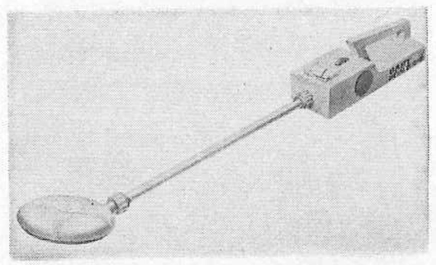

tery. 2 lb. *Model XL*, $29.95. *Model XXL*, including view meter, $39.95. Super power-coil to double penetration depth of both models, $12.95. Enclose $5 for C.O.D. **Dart Electronics**, PO Box 361, Huntsville, Tex. 77340 **R-E**

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R-E ON FILM

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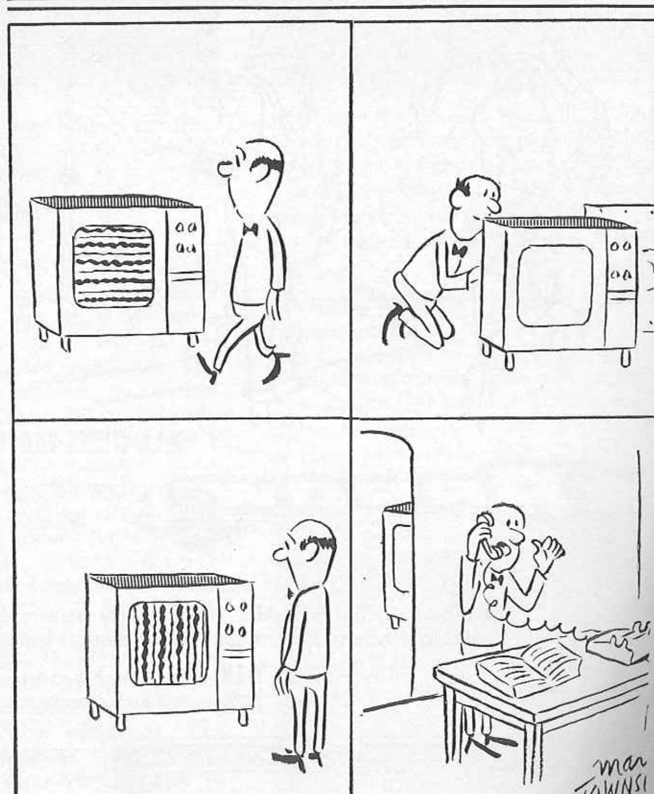

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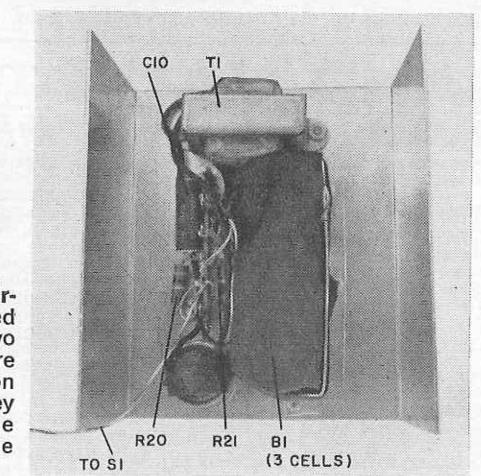
out harm to the cells (see Fig. 5). Attaching the ac line cord starts charging automatically. About 24 hours of charging is required to charge fully.

When NiCd cells are series-connected, they are subject to irreversible damage should any one cell voltage go to zero so that the other two cells tend to reverse-charge it. To prevent this, a circuit is included to turn off the unit automatically if the total battery voltage drops below about 3.3. When the power switch is turned on, relay RY1 is pulled in by a transient pulse of current flowing into C11. As soon as the relay closes, voltage is applied through Zener diode D2, and the collector current of Q11 holds the relay closed. However, should the battery voltage drop too low, Q11 will turn off, removing the load from the battery except for the leakage current through C11. The circuit has been arranged to permit the use of a compact, inexpensive, yet sensitive, relay that is constructed with a grounded armature. To obtain operation at close to 3.3 volts, it may be necessary to select the resistor in series with the Zener diode (R23), and to decrease the normally open armature spacing to increase relay sensitivity.

Unbased lamps were mounted in a wood block with thermoplastic cement to avoid the cost and space of sockets. The lamps are rated at 4.5 volts, so should last indefinitely. The logic elements are dual in-line plastic IC's. They are mounted by inserting their leads through paper-base Bakelite circuit boards perforated on 0.1-inch centers. The circuit boards are clamped at several places to aluminum mounting plates. Clamping is by wire loops passed through plates and boards, drawn snug and soldered. The aluminum plate carries away the heat generated by the IC's and conveys it to the case. Cabling permits the boards to be slid out of the case for troubleshooting.



Notice battery circuit is completed only when two case halves are joined. Position batteries so they will fit into the second half of the case.

Board wiring was done with about 100 feet of No. 32 stranded vinyl-covered wire. Each of the more than 1000 joints was carefully inspected for proper solder flow, absense of strain, etc. Careful and accurate wiring is a must on this type of project because of the difficulty of finding wiring errors and the danger of damaging the IC's.

Logic wiring diagrams of the three circuit boards are shown in Fig. 2-4. The remainder of the circuitry installed in the case was included in Fig. 5. Positioning of IC's 1-66 is shown in Fig. 6.

The total parts cost in early 1968 was $150, about half of which was for the integrated circuits. This includes everything except miscellaneous mounting hardware.

All gates are NOR gates. The logic elements are Motorola MC700P series RTL dual in-line plastic units. Harness connections to other boards and to the box-mounted circuitry are denoted by circled symbols. Like symbols on the various diagrams are connected together. B+ and B− connections to the IC's are not shown. **R-E**