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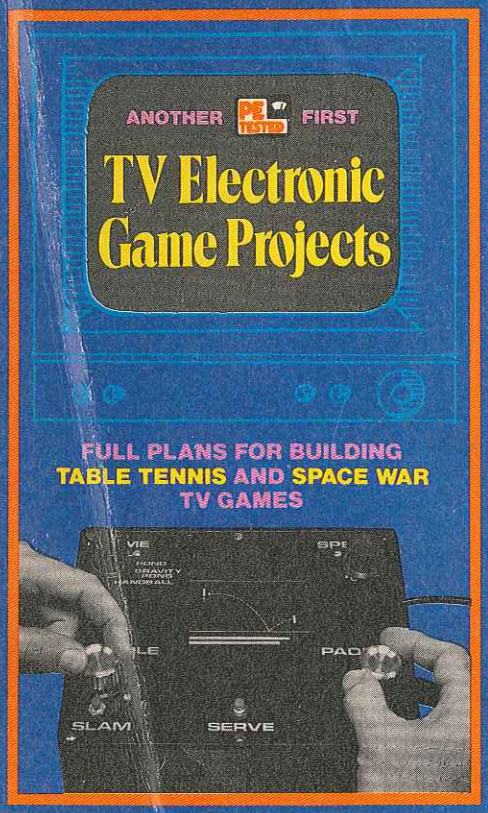

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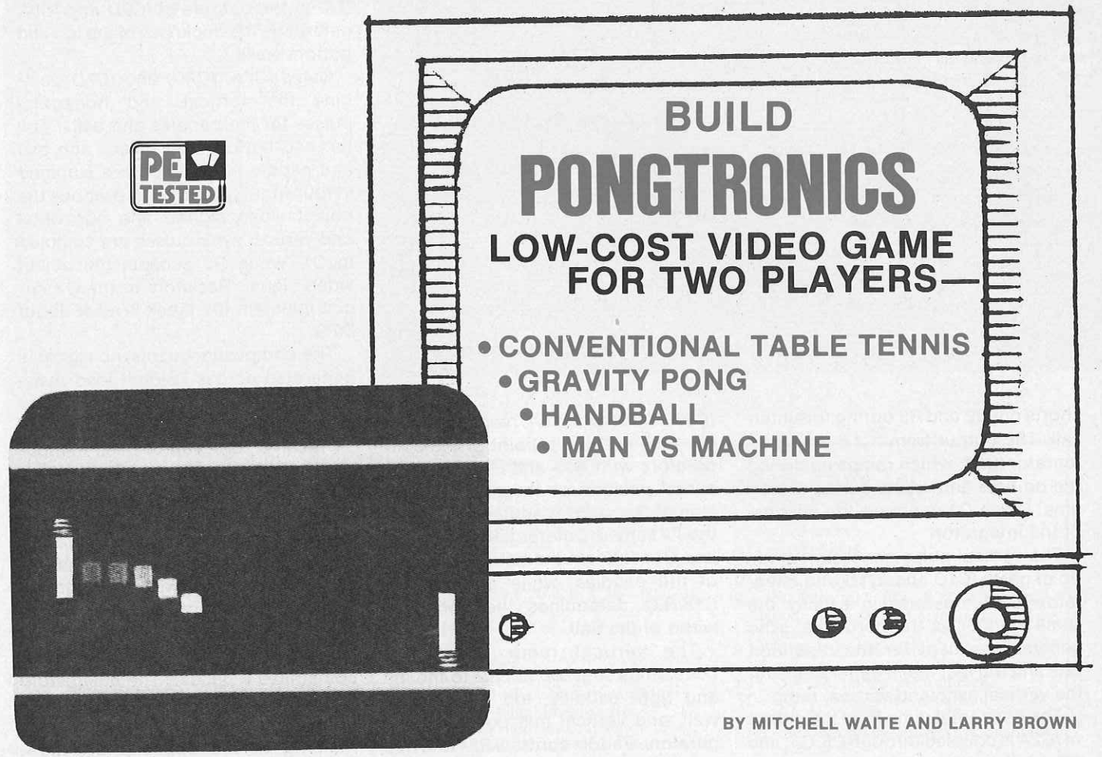
TV ELECTRONIC GAME PROJECTS



BY MITCHELL WAITE AND LARRY BROWN

EVER since Magnavox introduced its "Odyssey" TV game for home use, the popularity of such items has been increasing. Coin-operated games simulating tennis and hockey now appear in shopping centers, airports, etc., and are challenging conventional electro-mechanical pinball machines in popularity.

Pongtronics, described here, lets you play conventional table tennis on TV, with the ball bouncing back and forth between two paddles and off either the top or bottom walls of the "court." You can also play "gravity pong," where the ball bounces in an arc simulating the influence of gravity, except that in this case it may even reverse gravity. Finally, you can play handball, which converts one paddle into a full court wall on one side.

The Pongtronics is also designed to let one player pit himself against the machine or even have the machine play against itself. In the latter case, you can set the system up so that one paddle has the advantage over the other. The machine-play feature requires the addition of a single switch and a couple of resistors.

Automatic "English" can be put on the ball. How much English depends on which portion of the paddle strikes the ball. If the ball strikes the upper portion of the paddle, it rebounds upward, and vice versa. Hit the ball with the center of the paddle, and it rebounds off in a direction perpendicular to the paddle's plane.

The speed of the ball can be controlled over a relatively wide range from rather slow to quite fast. You can even try to catch your opponent off guard by operating a SLAM pushbutton, to speed up the ball.

In a future issue, we will describe how to add an optional scoring and sound-effects board to the basic Pongtronics game. Provisions are already on the board for this added assembly. (A kit of parts for the addition will be $33.00.)

About the Circuit. The entire schematic diagram of the Pongtronics is shown in Figs. 1 through 4.

Gates *IC1A* and *IC1B* form the horizontal sync generator whose on time is controlled by *C1*, *R2*, and *R3* and off time is controlled by *C1* and *R4* (*D1*

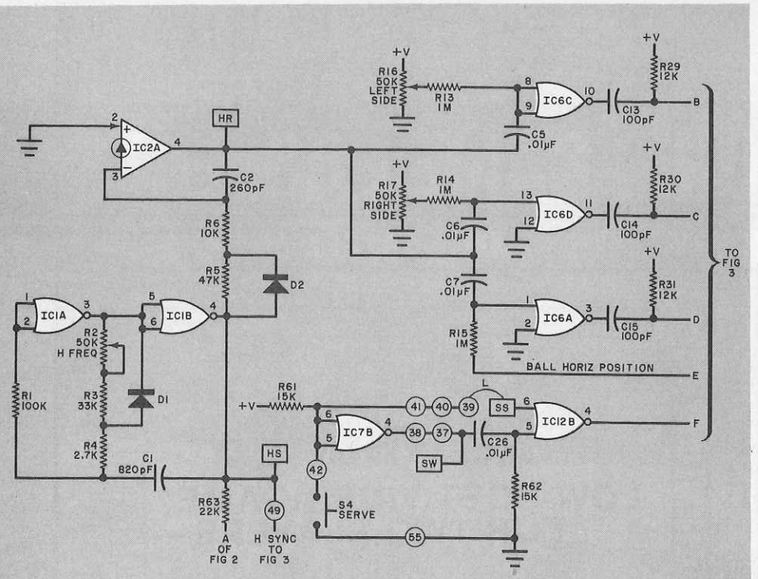


Fig. 1. Horizontal sync and ramp generator and associated comparators.

shorts out *R2* and *R3* during this interval). The output from *IC1B* drives integrator *IC2A*, which ramps up during the on time and resets during the off time. Diode *D2* improves the fall time of the integrator.

The vertical pulse generator, made up of gates *IC1C* and *IC1D* and integrator *IC2D*, operates in exactly the same manner as the horizontal sync generator, except for the repetition rate and the fact that it generates both the vertical sync and vertical ramp.

The horizontal ramp from the output of *IC2A* is coupled through *C5, C6,* and *C7* to left paddle, right paddle, and ball horizontal position comparators *IC6C, IC6D,* and *IC6A*, respectively. By controlling the trip point of the comparators with *R16* and *R17*, the horizontal position of the right and left side of the court (paddles) are set on the TV screen. Differentiators *C13/R29* and *C14/R30* set the horizontal width of the paddles, while differentiator *C15/R31* determines the horizontal width of the ball.

The vertical ramp from *IC2D* couples through *C8* to *C12* to the left and right paddles, top and bottom wall, and vertical ball position comparators. Paddle controls *R24* and *R25* set the trip points of the comparators to position the paddles vertically on the screen. Trimmer control *R26* sets the vertical center reference position of the ball, *R27* the vertical position of the top wall of the court, and *R28* the vertical position of the bottom wall.

Differentiator *R32/C16* at the output of *IC9A* determines the vertical height of the left paddle; *R33/C17* at the output of *IC9B* the vertical height of the right paddle; and *R35/C19* and *R36/C20* at the outputs of *IC9D* and *IC9C* determine the thickness of the top and bottom walls.

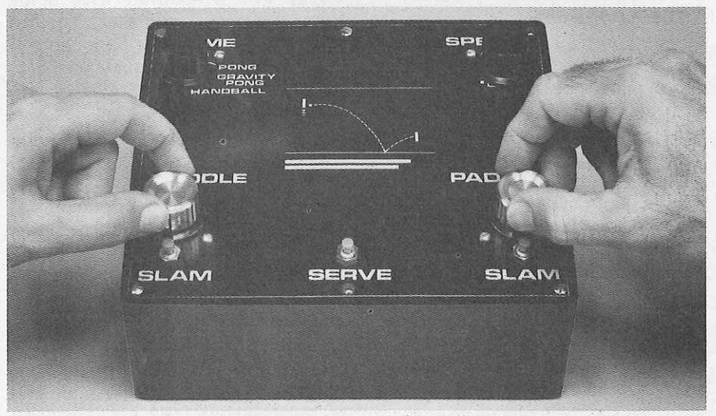
Gates *IC7A, IC7C,* and *IC7D* combine the vertical, and horizontal pulses for the paddles and balls. The top and bottom wall pulses and ball and paddle information are summed in four-input gate *IC8B* to produce the object video signal. The horizontal and vertical sync pulses are summed in *Q1*, while *Q2* accepts the object video signal. Resistors in the *Q2* circuit maintain the black level at about 30%.

The composite video/sync signal is generated across 75-ohm load resistor *R55*. The signal can then be ac coupled into the video amplifier of a TV receiver, or it can be used to modulate an FCC-certified class-1 device for r-f operation into the antenna input of the receiver, on an unused channel.

The left-to-right and right-to-left horizontal movement of the ball is controlled by position integrator *IC2B*, which in turn is driven by horizontal ball control flip-flop *IC4B*. This flip-flop sets and resets each time the ball strikes a paddle. The ball/paddle coincidence signal causes the Q output to change states and *IC2B* to start ramping in the opposite direction. Since the output of *IC2B* connects to ball horizontal position comparator *IC6A*, the horizontal motion of the ball reverses. The horizontal speed of the ball is controlled by *R37, R38,* and *R39*. SLAM pushbuttons *S2* and *S3* can momentarily short out *R38* and *R39* to increase the ball's speed.

The vertical angle and position of the ball are controlled by differential integrator *IC2C*, analog sample-and-hold circuit *IC12A*, the transmission gates in analog switch *IC5*, and bounce flip-flop *IC4A*. The rebound angle can be controlled by varying the rate at which the vertical integrator charges. With the horizontal rate of the ball a constant, any change in the vertical rate will change the angle of the ball.

Operation begins when the circuit produces a pulse at the exact moment



One way to assemble the controls and switches is in single chassis.

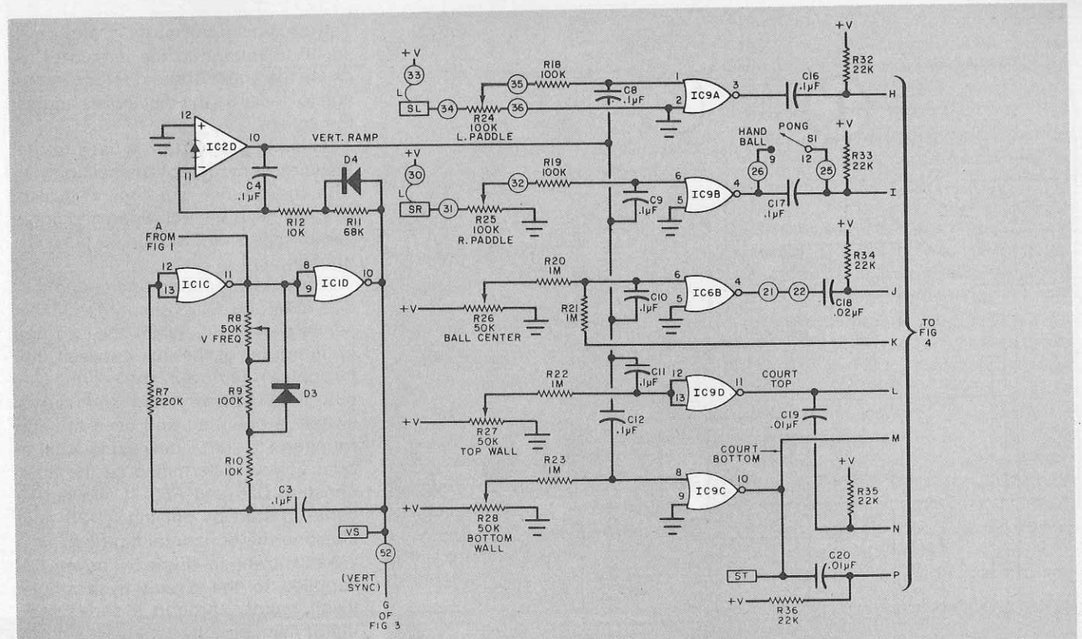


Fig. 2. Vertical sync and ramp generator and related circuits.

the ball hits the paddle (*IC10C*). The hit pulse sets change-angle RS flip-flop *IC12C* and *IC12D*, causing electronic switch *IC5D* to close. At the same instant, *IC5A* is momentarily closed by differentiator *C21/R45* to zero the charge on integrator *IC12A*, which then begins to charge.

When the vertical scan detects the bottom of the paddle, NAND gates *IC11A, IC11B,* and *IC11C* reset change-angle flip-flop *IC12C/IC12D* to open the *IC5D* electronic switch. Integrator *IC12A* stops charging and holds its output voltage. (Only a CMOS device could be used as a gate element and sample-and-hold integrator.) The voltage now at the output of the sampling integrator represents where the ball hit vertically on the paddle. This voltage is then used to set the charge rate of vertical ball position integrator *IC2C*.

Differential integrator *IC2C* and analog switches *IC5B* and *IC5C* apply the angle-reference voltage held at the output of *IC12A* to the integrator inputs. The states of *IC5B* and *IC5C* are, in turn, controlled by bounce flip-flop *IC4A*, which keeps track of the ball's direction. Exclusive-OR gate *IC10B* applies the correct information to the *IC4A* D input so that, when a bounce from a wall occurs, the integrator changes its direction of charging in

PARTS LIST

B1—9-volt battery
C1—820-pF, 5% silver mica capacitor
C2—260-pF, 5% silver mica capacitor
C3,C4,C8 through C12,C16,C17,C29 through C35,C37—0.1-μF, 10% Mylar capacitor
C5,C6,C7,C19,C20,C26,C36—0.01-μF, 10% Mylar capacitor
C13,C14,C15—100-pF, 5% silver mica capacitor
C18,C22—0.02-μF, 10% Mylar capacitor
C21—0.002-μF, 10% Mylar capacitor
C23,C38—3.3-μF, tantalum capacitor
C24—1.5-μF tantalum capacitor
C25—0.68-μF tantalum capacitor
C27,C28—100-μF, 16-volt electrolytic capacitor
D1 through D6—1N4148 diode
D7—6.2-volt, 400-mW zener diode
IC1,IC6,IC9—34001 quad two-input NOR gate (Fairchild). Do not substitute.
IC2—LM3900 quad op amp (National)
IC3—4081 quad two-input AND gate
IC4—4013 dual JK flip-flop
IC5—4016 quad bilateral switch
IC7,IC12—4001 quad two-input NOR gate
IC8—4002 dual four-input NOR gate
IC10—4030 quad two-input XOR gate
IC11—4011 quad two-input NAND gate
Q1,Q3—2N4401 transistor
Q2—2N3638A transistor
The following resistors are ¼-watt, 5%:
R1,R9,R18,R19,R38—100,000 ohms
R3—33,000 ohms
R4,R41—2700 ohms
R5,R47—47,000 ohms
R6,R10,R12,R58—10,000 ohms
R7—220,000 ohms
R11—68,000 ohms
R13,R14,R15,R20,R21,R22,R23,R42—1 megohm
R29,R30,R31—12,000 ohms
R32 through R36,R40,R43,R45,R63—22,000 ohms
R37—270,000 ohms
R46—10 megohms
R48,R53,R54,R59,R61,R62—15,000 ohms
R49,R50—470,000 ohms
R51,R52—390,000 ohms
R55—75 ohms
R56—270 ohms
R57—1000 ohms
R60—100 ohms
R64,R65—30,000 ohms
R2, R8, R16, R17, R26, R27, R28, R44—50,000-ohm, ⅛-watt trimmer potentiometer
R24,R25—100,000-ohm linear-taper potentiometer
R39—500,000-ohm potentiometer
S1—Three-pole, three-position rotary switch
S2,S3,S4—Normally open spst pushbutton switch
S5—Dpdt, center-off miniature toggle switch
S6—Spst switch (part of R39)
Misc.—Printed circuit board; IC sockets (12) or Molex Soldercons; control knobs (4); suitable case; coaxial cable; battery holder; machine hardware; hookup wire; solder; etc.

Note: The following items are available from Cal Kit, P.O. Box 877, Sebastopol, CA 95472:

No. TV-1 plated epoxy-type pc board for $12.00
No. TV-3 complete kit of game parts less battery, sound/score option, and case for $55.00
No. TV-6 set of IC's for game for $15.50
No. TV-8 set of sockets for game for $6.00
No. TV-10 FCC type-approved r-f modulator; write for details
No. TV-11 drilled and silk-screened case for $12.50

All items postpaid and insured. Add $2.00 for handling. No COD's. California residents, please add sales tax.

Editor's Note: New 22" video monitor, with audio, available from GBC Closed Circuit TV Corp., 74 Fifth Ave., NY, NY 10011 for $119.50. NY residents, add sales tax.

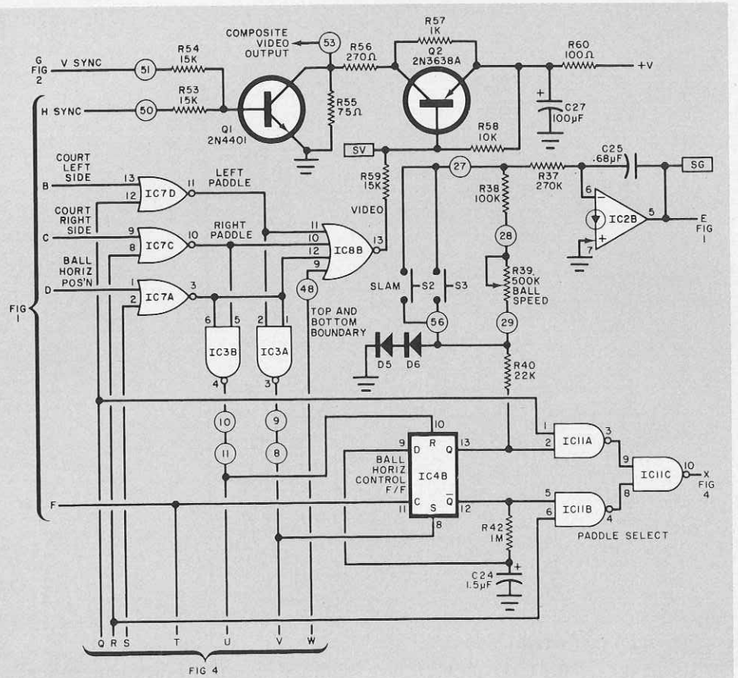


Fig. 3. Six gates operate on ball-paddle contact to reverse motion.

step. The current angle voltage is compared with the instantaneous vertical position voltage by *IC10B*.

Bounce flip-flop *IC4A* is also controlled by the paddle and ball coincidence circuits. A paddle/ball coincidence generates a hit pulse that resets *IC4A*, deflecting the ball upward when it hits the upper half of the paddle and downward when it hits the lower half. The GRAVITY portion of *S1* applies a small dc voltage to the integrator to cause the angle of the reference voltage to decay as the ball moves across the screen.

Initiating gate *IC10A* is used to get the vertical motion of the ball in sync with the bounce flip-flop. It is also used to invert the ball video and put a vertical line on the screen for purpose of alignment.

Without the scoring and sound circuit, *IC7B* and *IC12B* simply debounce SERVE switch *S4*. When the scoring option is used, the link between the two gates is removed. The scoring circuit then senses when the SERVE switch is operated and uses this information to start a new game. After a brief period, determined by the time constant *C26* and *R62*, it allows the game to start by pulsing *IC12B* and clocking the horizontal flip-flop.

As shown in Fig. 5, power is supplied to the circuit by a single 9-volt battery through a series regulator made up of *Q3* and *D7* and decoupled by *C28*. Capacitors *C29* through *C33* decouple the CMOS IC's connected to the 5.5-volt line.

Also shown in Fig. 5 is CYBERNETIC switch, *S5*, an option that might prove of interest to you. This is the switch that allows you to play against the machine or have the machine play against itself.

GAME switch *S1* allows you to select

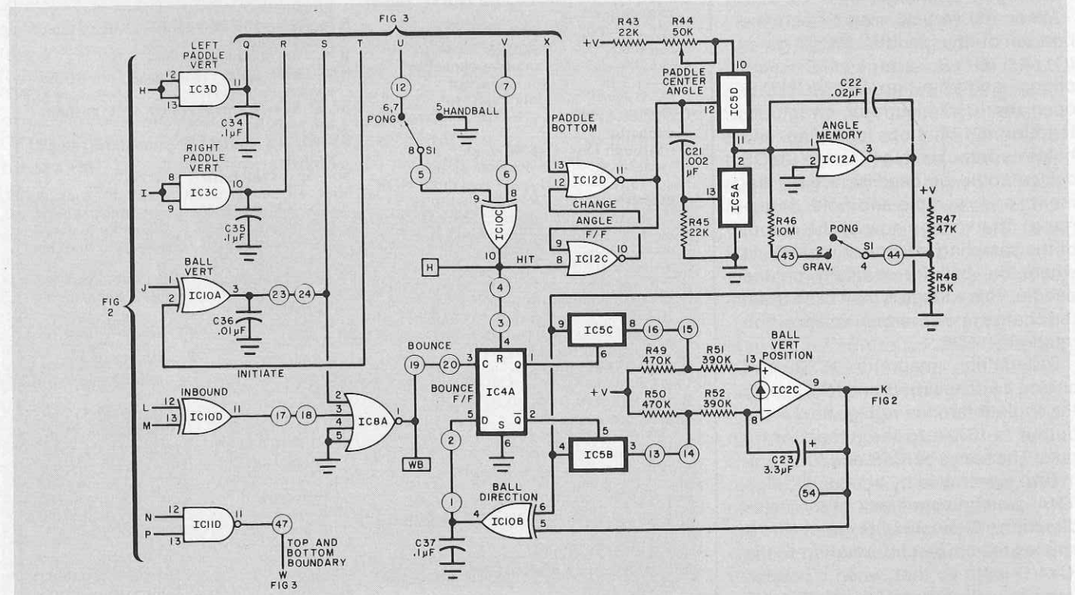


Fig. 4. Circuit to determine "English" and change type of game.

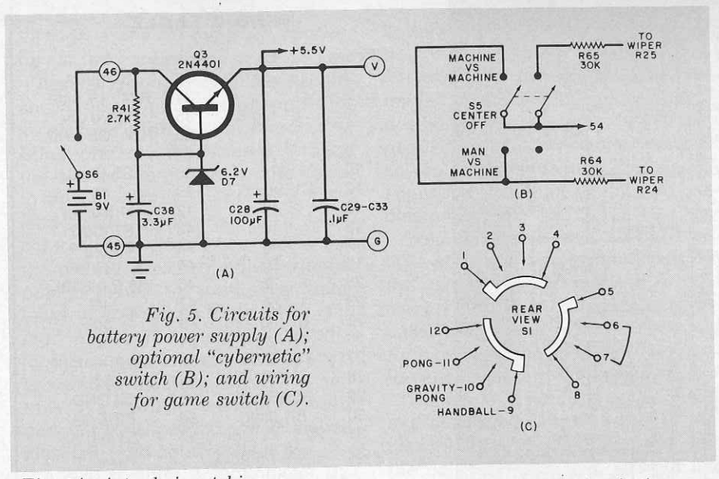
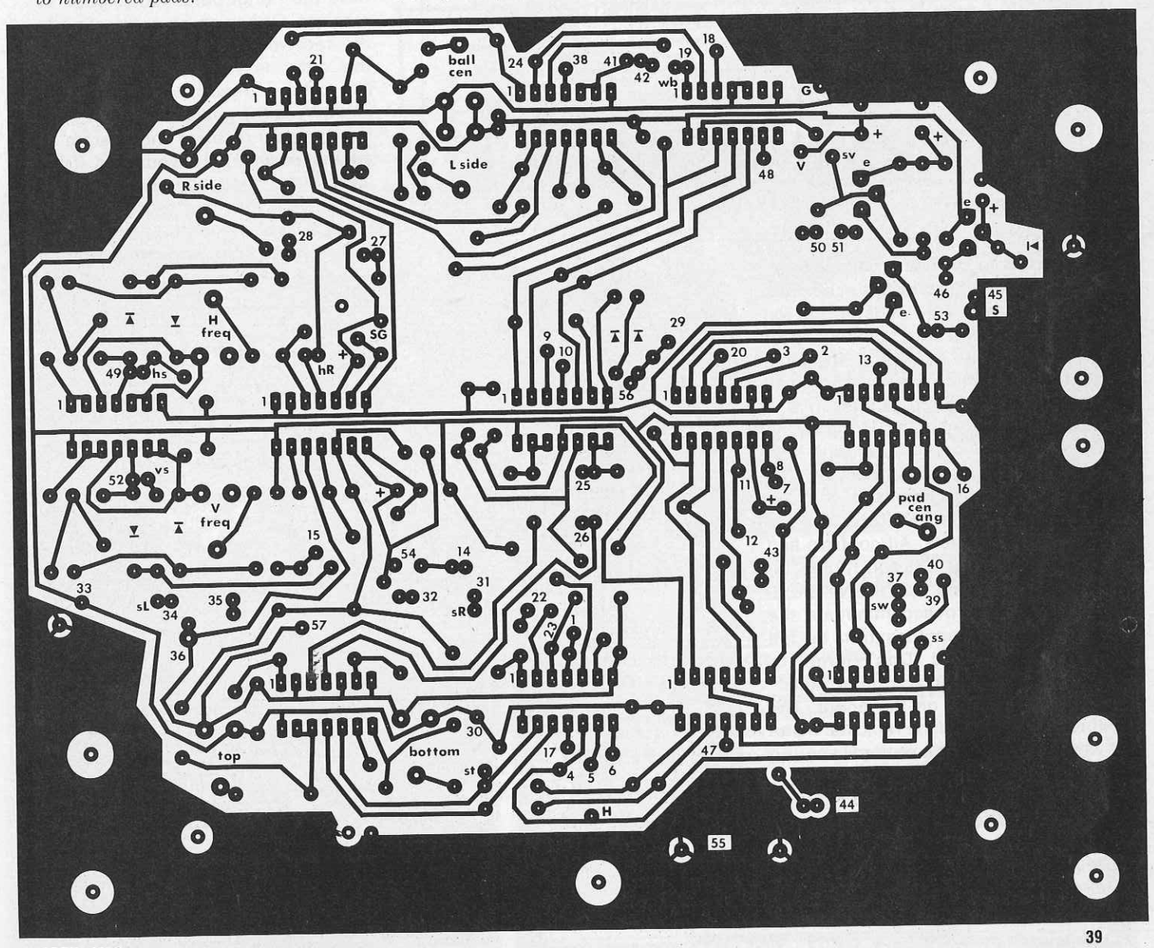


Fig. 5. Circuits for battery power supply (A); optional "cybernetic" switch (B); and wiring for game switch (C).

Fig. 6A. Actual-size etching and drilling guide for pc board. Component layout guide is on next page, with wiring table for connections to numbered pads.

the game you want to play. In the PONG position, the Pongtronics operates as a conventional TV table tennis game. In the GRAVITY position, *IC12A* is reconfigured, while in the HANDBALL position, *C17* is shorted out to extend the right paddle's vertical height to the top and bottom of the screen. Also, the "hit" information is overridden by grounding one input to *IC10C*. The right paddle becomes a wall that deflects the ball according to where the ball strikes it.

Construction. Because of the number of IC's used and the complexity of the associated wiring, a printed-circuit board is highly recommended for assembling the Pongtronics. If you plan to make your own pc board, you can use the actual-size etching and drilling guide shown in Fig. 6. Once the board is prepared, you can mount the components on it as shown. Note that all components, including PADDLE potentiometers, SERVE pushbuttons, GAME select switch, and BALL SPEED control can be mounted directly on the board. Alternatively, these controls can be mounted separately and



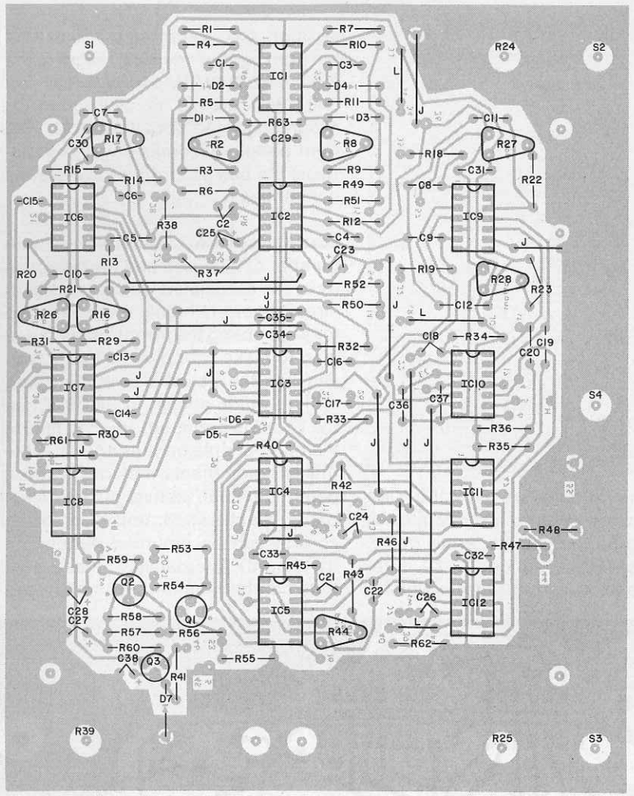


Fig. 6B. Component layout and wiring table.

WIRING TABLE

From	To	From	To
1	2	33	SL (link)
3	4	34	R24, +V side
5	S1 lug 8	35	R24 wiper
6	7	36	R24,R25 GND
8	9	37	38
10	11	39	SS (link)
12	S1 lugs 6,7	40	41
13	14	42	S4 (serve)
15	16	43	S1 lug 2
17	18	44	S1 lug 4
19	20	45	B1-
21	22	46	S6 (on R39)
23	24	47	48
25	S1 lug 12	49	50
26	S1 lug 9	51	52
27	S2 & S3	53	Video output
28	R39	54	S5
29	R39,S2,S3	55	S4 GND
30	SR (link)	56	S2 & S3
31	R25, +V side	57	S1 lug 5
32	R25 wiper		

Note: Pads on the board with letter legends are for optional scoring/sound board.

connected to the board with cables.

Circled numbers in the schematic represent numbered pads on the foil side of the board. Interconnections for these points are detailed in the table that accompanies Fig. 6. (The small squares containing letters in the schematic are the points in the circuit to which the optional scoring and sound-effects board connect.)

To make insertion and removal easier, you can mount the IC's in the circuit with sockets. All controls and switches (except *S5*) can mount directly on the board. You'll have to drill suitable holes to accommodate the controls and mount them from the foil side of the board. Don't forget to mount the jumpers and three "links" (marked L) wires on the board. The three link wires will be removed if and when you install the optional scoring and sound-effects subassembly.

Use the Wiring Table and Fig. 7 to install the various interconnects. Then install the 9-volt battery in a holder secured to the foil side of the printed circuit board.

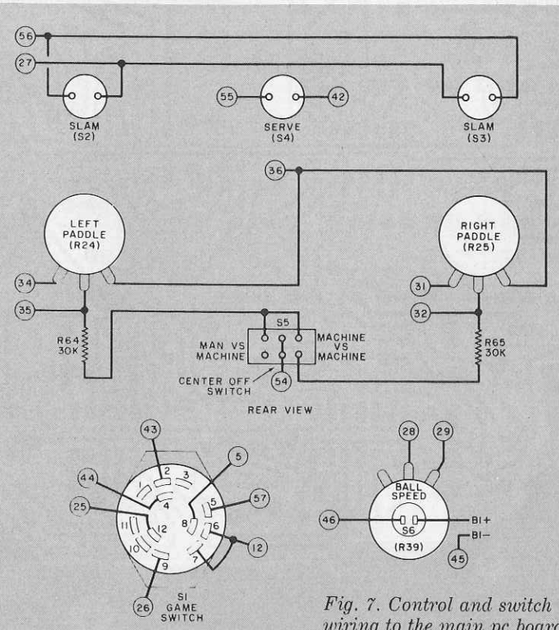


Fig. 7. Control and switch wiring to the main pc board.

Adjustments. There are two ways to have the Pongtronics fed to your TV receiver. One is an ac connection to the receiver's video amplifier input, the other is to use an FCC type-approved r-f modulator that permits you to feed the game into the antenna input of your receiver and operate on an unused channel in your area. If you elect video feed, you can install a switch that lets you select between normal TV operation from the receiver's video detector or game operation through a chassis-mounted connector for the Pongtronics' output.

Assuming your receiver's horizontal and vertical controls have been set for a stable picture, connect the Pongtronics to the receiver through the desired input. Turn on the power to the receiver and Pongtronics, in the latter case rotating the BALL SPEED control clockwise. If you notice that the picture is rolling, adjust trimmer potentiometer *R8* until the frame locks. If you notice horizontal "tearing," adjust *R2* for stable horizontal lock. You can now adjust the receiver's BRIGHTNESS and CONTRAST controls for a sharp picture with a black or dark gray background and white paddles, ball, and court walls.

Adjust trimmer potentiometer *R27* until the upper wall of the court is about 1" (2.54 cm) from the top of the screen. Then adjust *R28* so that the bottom wall is the same distance away from the bottom of the screen. Adjust *R16* to set the left paddle about 1" from the left side of the screen and *R17* to position the right paddle. One or both paddles may initially be off the screen, so you may have to start your paddle adjustments by first getting the paddles onscreen.

Hold down the SERVE button. A vertical white line with a small "hole" in the middle should appear on the screen. This hole corresponds to the ball. The line will rebound back and forth between the paddles. Adjust *R26* to center the hole on the screen.

The angle of rebound between ball and paddle is controlled by *R44*. Adjust this trimmer potentiometer until the ball rebounds in a straight line across the screen when the ball hits the center of the paddle. A simple way to do this is to temporarily bring the two paddles close together and narrowing the court to form a small rectangle with the paddles. When the ball is trapped inside the rectangle, *R44* is properly adjusted. Return the paddles and walls to their proper positions.

The Pongtronics is now ready to use. Bear in mind that each time you turn on the game it may be necessary to touch up your receiver's horizontal and vertical controls as the agc circuit locks up in the wrong direction. Momentarily changing channels may also break the sync lock. You can also hold down the SERVE button to initiate the game and allow the Pongtronics' flip-flops to get into synchronization.

After operating the SERVE button, you may have to wait for up to five seconds, depending on the setting of the BALL SPEED control, for the ball to appear on the screen. ◈

BY JOSEPH A. WEISBECKER

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