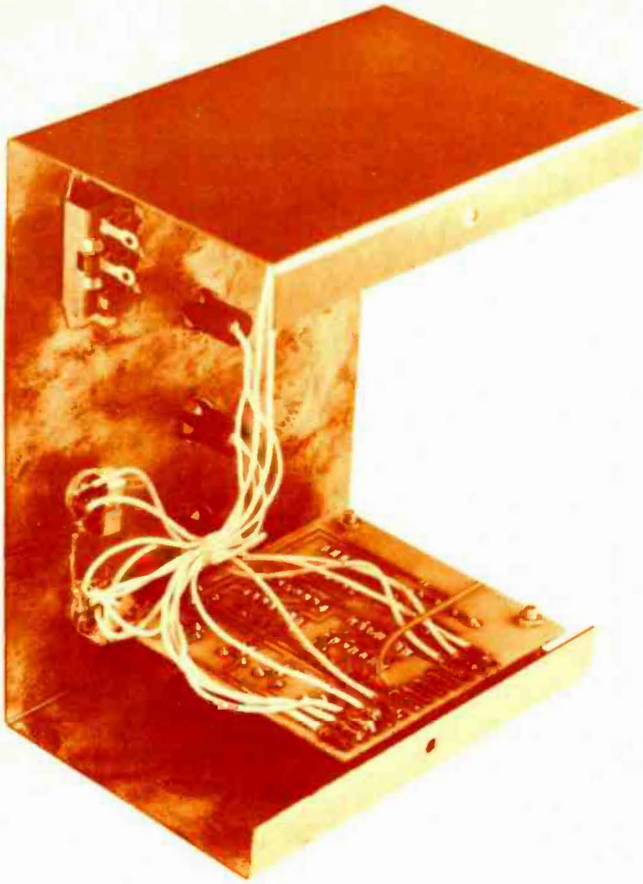
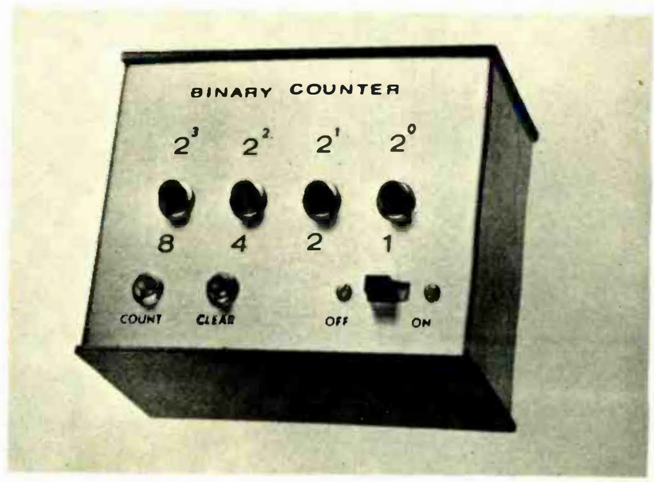




Experiment with a Binary Counting Demonstrator

It's easy to understand counting to the base two when you have a visual aid like this demonstrator to show you what's going on.

by **DON LANCASTER**

This binary counter demonstrator counts by two's instead of tens, showing the base two arithmetic and counting used by most computers. It counts up to sixteen and can be reset to zero at any time. You use it as a study or teaching aide, or as a science-fair or computer-technology entry, or for a school lab project. It uses three TTL integrated circuits and four transistors and may be built in an evening or two.

Why binary?

People are used to counting by tens, and before "modern math" came along, non-computer people gave very little thought to counting in any number *base* but ten. The problem with *decimal* or *base ten* counting is that you need ten

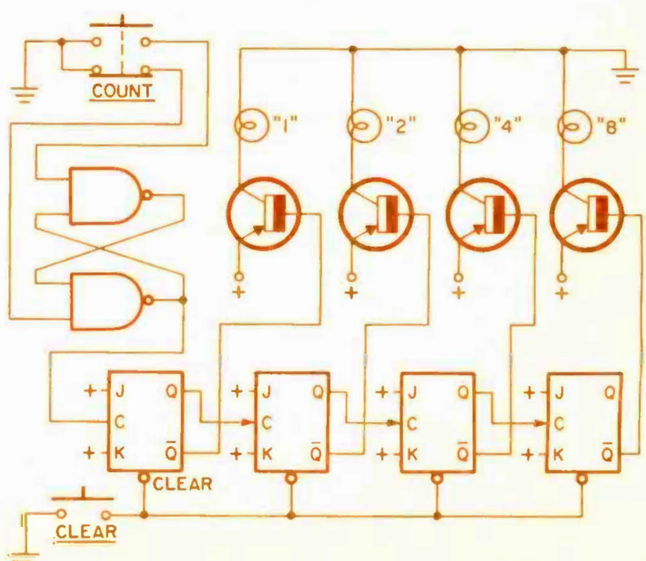


FIG. 1—BASIC LOGIC DIAGRAM of binary ripple counter

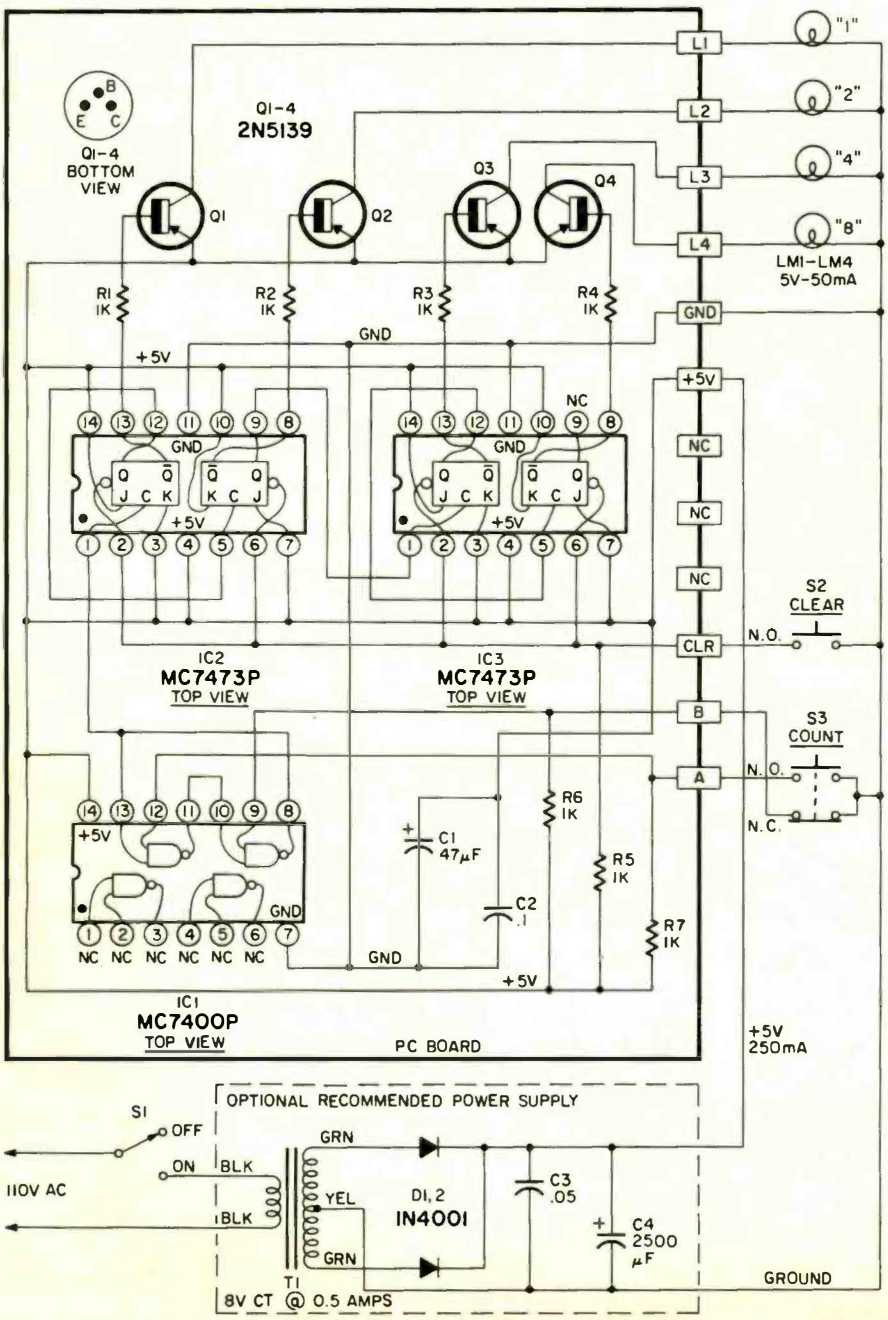
PARTS LIST

C1—47 μF, 15 volts, electrolytic
C2—0.1 μF, 10 volts, disc ceramic
*C3—0.05 μF, mylar or disc ceramic
*C4—2500 μF, 10 volts, electrolytic
*D1, D2—1 amp, 50 PIV silicon power diode, IN4001 or equal
IC1—MC7400P
IC2, IC3—MC7473P
LM1 thru LM4—5-volt 50-mA panel lamp assembly
*S1—spst slide switch
S2—spst normally open pushbutton
S3—spdt pushbutton
Q1 thru Q4—2N5139 transistor (National)
R1 thru R7—1000 ohms, ¼-watt carbon
*T1—8 Vct, 0.5-A transformer
MISC—2½" x 2⅝" PC board; PC Board standoffs and hardware (4); case; Bottom feet (4); C4 mounting clip*; line cord and strain relief*; 4 lug terminal strip*; wirenut*; power supply hardware*; case hardware; wire; solder; etc . . .

***Parts for power supply**

NOTE: The following items are available from Southwest Technical Products, Box 16297, San Antonio, Texas, 78216:
Etched and drilled PC board No. 183, $1.80
Complete kit of all parts, including prepunched and prefinished case but less power supply, No. 183-K, $8.90

FIG. 2—COMPLETE WORKS of the binary counter. Note that the correct position of the IC's is indicated by the notch in one end.



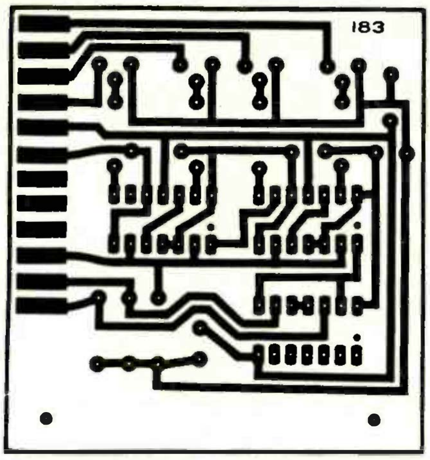
different symbols (0,1,2,3,4,5,6,7,8, and 9) to represent any number. To do this electronically in the decimal system, we'd have to recognize either ten different voltage levels, or, to get by with loose-tolerance circuits, a signal on one of ten different lines.

In the *binary* or *base two* system, we only need remember two states "1" and "0", or simply "yes" and "no". Just as we move over one decimal point when we get to ten, we move over one *binary point* when we get to two, with the "heavier" numbers always tacked on the left. The binary equivalents for the first sixteen numbers (0-15) are:

DECIMAL		BINARY			
tens	units	8	4	2	1
0	0	0	0	0	0
0	1	0	0	0	1
0	2	0	0	1	0
0	3	0	0	1	1
0	4	0	1	0	0
0	5	0	1	0	1
0	6	0	1	1	0
0	7	0	1	1	1
0	8	1	0	0	0
0	9	1	0	0	1
1	0	1	0	1	0
1	1	1	0	1	1
1	2	1	1	0	0
1	3	1	1	0	1
1	4	1	1	1	0
1	5	1	1	1	1

While binary numbers may appear longer than decimal ones, the looks are deceiving, because ten different states go into a decimal number, while only two are used in binary. To represent a "15" in true decimal form, at least eleven leads would be needed. In binary, it takes only four.

It turns out that binary is the most efficient possible way of storing information and performing arithmetic. It uses the simplest possible storage devices and requires the fewest interconnections. Practically all computers *internally* deal with binary and then make a *binary to decimal conversion* only when they interface with people. When computers (particularly small



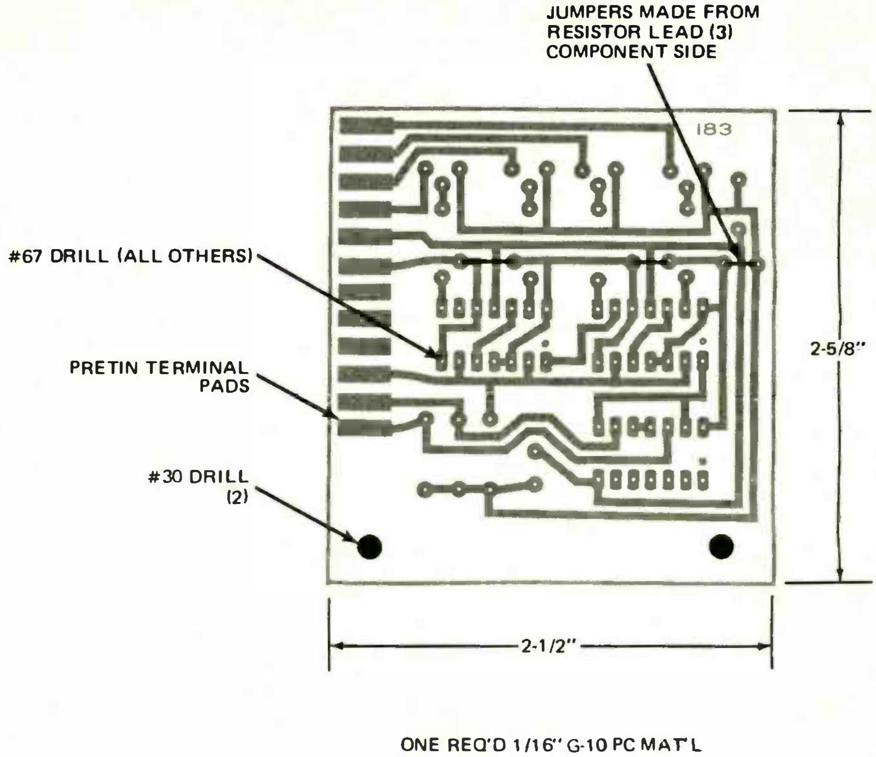
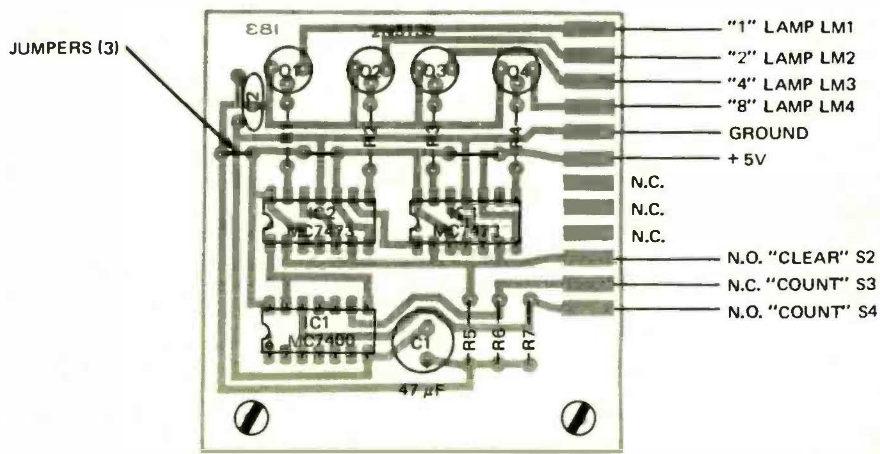


FIG. 3—FULL SIZE diagram of the printed-circuit board as seen from the foil side.

FIG. 4—DRILL AND JUMPER guide for the binary counter circuit board.

FIG. 5—OVERLAY DIAGRAM shows parts mounting positions on the circuit board.



ones) *must* deal with decimal, they re-encode it into a near-binary form, called *Binary Coded Decimal.* (BCD) Even in this form, the numbers can only be handled in 16/10 the space that would be needed for binary, a storage penalty of 60% in the size of a machine. Arithmetic operations in BCD are also proportionately more complex than in straight binary.

How it works

The logic diagram of the demonstrator is shown in Fig. 1. The circuit consists of a four-stage binary ripple counter formed by cascading two dual JK flip-flop TTL integrated circuits. The input COUNT commands from a pushbutton are made noiseless and bounceless by a set-reset contact conditioning flip-flop made of half of a quad two-input gate TTL integrated circuit. Contact conditioning on the CLEAR line is not needed, for resetting a counter to 0000 a dozen times has the same effect as only doing it once. The states of the counters are indicated by connecting the $\bar{Q}$ terminal on each flip-flop to a lamp through an inverting pnp driver transistor.

Construction hints

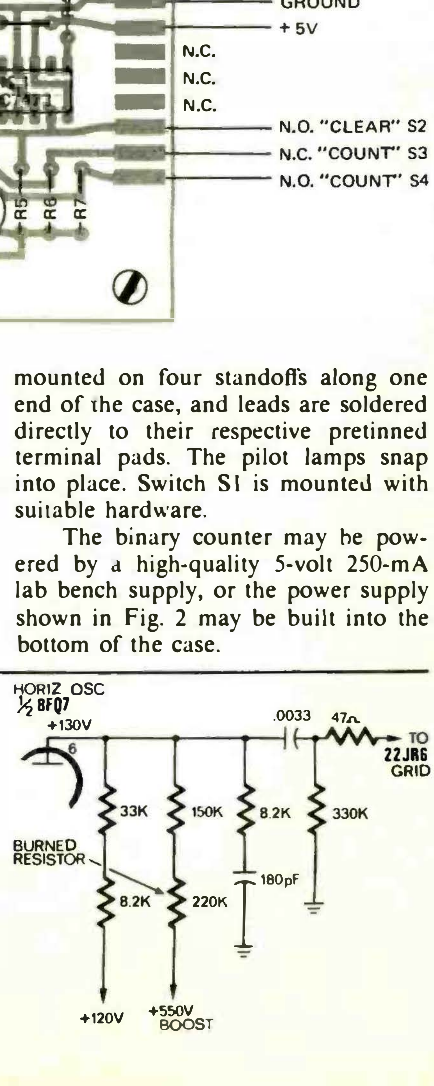
The schematic is in Fig. 2. A printed circuit board is recommended for component mounting. Figs. 3 and 4 show how the board is set up. Three jumpers are needed. These may be made out of cutoff resistor leads and are positioned as shown.

Component locations are shown in Fig. 5. Note the polarity on C1 and the three IC's. The code notch and dot is between pins 1 and 14.

The photos show the internal assembly details. The circuit board is mounted on four standoffs along one end of the case, and leads are soldered directly to their respective pretinned terminal pads. The pilot lamps snap into place. Switch S1 is mounted with suitable hardware.

The binary counter may be powered by a high-quality 5-volt 250-mA lab bench supply, or the power supply shown in Fig. 2 may be built into the bottom of the case.

ROLLING PICTURE IN RCA KCS132A



The picture would roll constantly and would not lock-in vertically. When the vertical hold control was rotated the picture would roll up but never downward. The picture would roll slowly upward with the vertical hold control at top end of rotation. Undoubtedly, poor vertical sync. The vertical oscillator tube was changed. All voltages were quite close to what they were supposed to be, yet the picture continued to roll.

A check showed the feedback .0068-μF capacitor at the grid (pin 4) of the 6EM7 was leaky. A replacement restored normal performance. After a few years this capacitor becomes leaky and the picture has a tendency to roll.—*Homer Davidson*