# Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

## Electronic Dice

**Q** *I want to build an electronic set of dice using LEDs in the traditional arrangement. The purpose of using LEDs instead of a numeric display is to teach children how to count and add dots. I want to be able to disable one of the two dice for some games. I want to build this project as a Christmas present for my grandchildren. — C. J. G., Sebring, FL*

**A** Unfortunately, our backlog, and the fact that this column is written four months before publication, didn't allow us to get to this project in time for Christmas. But perhaps the children could enjoy it during summer vacation.

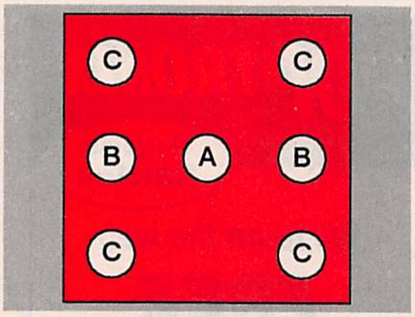



FIG. 1—THE LEDs in our electronic dice are switched in three groups: A, B, and C. Each whole group is either on or off.

As you can see from Fig. 1, the seven LEDs that serve as spots on each die can be switched in three groups, which we'll call A, B, and C. For example, to display 5, you'd turn on groups A and C. Accordingly, the LED drivers, shown in Fig. 2, only need three input signals. Each signal tells whether to illuminate each set of LEDs.

To roll the dice, use the oscillator/counter circuit in Fig. 3. When the button is pressed, the oscillator runs at 5 kHz and the 4017 decade counter activates its outputs, one at a time, too fast for the human user to see, resetting itself whenever the count reaches 7 (output

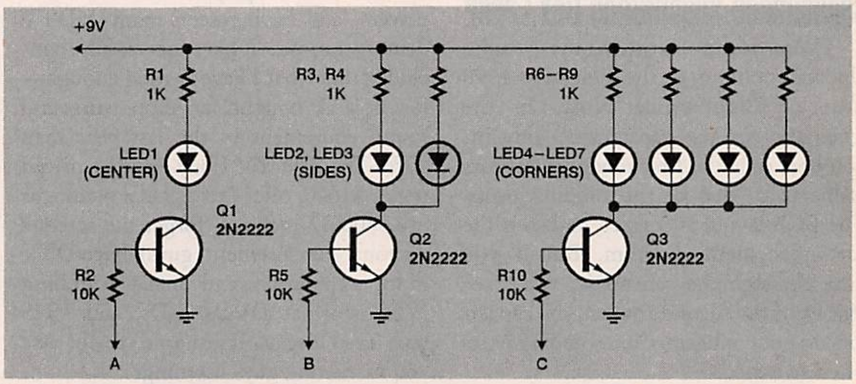



FIG. 2—BECAUSE THE LEDs are driven in three groups, this LED driver circuit needs only three inputs.

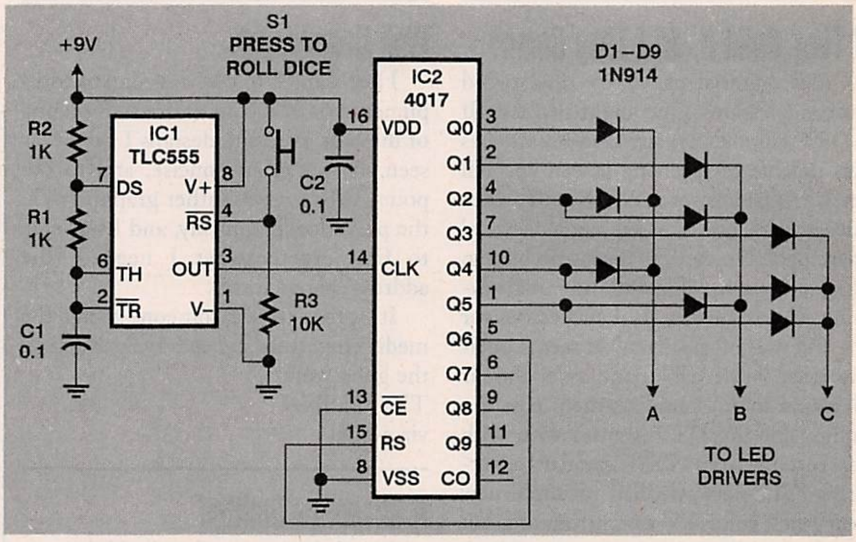



FIG. 3—TO ROLL THE DICE, press switch S1. When the oscillator stops, one of the outputs of the 4017 is left high, determining the dice display.

Q6). When the button is released, the oscillator stops, one of the outputs is held high, and the diodes direct the signal to the appropriate combination of A, B, and C outputs, which are connected to the LED drivers.

To build two dice, you can connect one oscillator to two 4017s. To deactivate one die, cut off power to its LED drivers. Leave both 4017s powered up because CMOS chips can be damaged if their inputs are driven while supply voltage is absent.

## Weather Satellites

**Q** *It just occurred to me that the PIC microcontroller chips would be perfect for collecting weather satellite data streams and converting the tone bursts into binary code. Unfortunately, I haven't been able to locate a source for what data streams are transmitted. — N., Waco, TX*

**A** A more powerful microprocessor might be even better for this—in fact, most satellite experimenters use their

# 62 An electronic die

## Introduction

Throwing a die is a venerable way of generating a ‘random’ number between 1 and 6. A die is easy to lose, so here is an electronic die-throwing circuit which brings the technique up to date and serves as another application of logic circuits. If you need a reminder of the basics of logic, refer to *Digital logic circuits*.

## Warning

**This circuit uses members of the integrated circuit family known as CMOS (complementary metal-oxide semiconductor). These use very little current and can be completed destroyed if they come into contact with the**

magnitudes of static electricity that most of us carry about when we walk on carpets and wear rubber shoes. You will never know if this wanton destruction has happened – all you will discover is that your circuit doesn't work and that you have tested *everything*. To avoid this problem do the following things:

1. Before you open the little packet in which the IC is supplied, touch something which you *know* to be earthed – the metalwork of any equipment which is mains-earthed, for example. Then open the packet.
2. Let the IC fall gently on the bench – don't pick it out with your fingers. Touch your earthed metalwork again. Pick up the IC and insert it gently into its holder.

The circuit is safe from damage while it is connected to the battery.

## Description

The circuit is shown in **Figure 1**. IC1a and IC1b form an *astable multivibrator*, similar to that used in 'An LED Flasher' also in this book. It runs constantly, and its output is fed to IC2 via a single NAND gate, IC1c. The other input of IC1c is held at 0 V by R3 and C3. Whenever one input of a NAND gate is logic 0 (or 0 V), there can be *no output* from the gate, irrespective of what is happening at other inputs. So, despite the fact that the oscillator (or *clock*) is running all the time, its square-wave output never

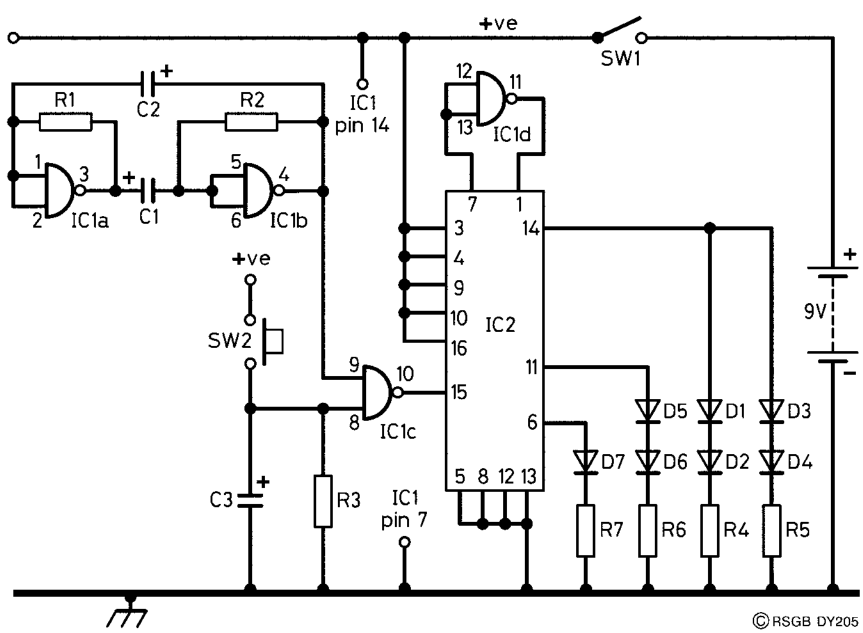



**Figure 1** Electronic dice, circuit diagram

reaches IC2 until the 'other' input of IC1c is brought away from logic 0. This happens when SW2 is pressed. Pressing SW2 momentarily, as is normally done, charges up C3 to 9 V, putting a logic 1 on the second input of IC1c and allowing the clock signal through to IC2. As the switch is released, C3 begins to discharge through R3, gradually lowering the voltage on pin 8 of IC1c. As this voltage crosses 4.5 V (half the supply voltage), IC1c then treats this input as logic 0, which cuts off the clock signal from IC2 again. Thus, when SW2 is momentarily pressed, the clock signal is fed to IC2 for a short interval of time, before being blocked again.

IC2 is a binary counter, and the outputs that concern us are from pins 14, 11 and 6. Pin 14 is the *most significant bit* and pin 6 the *least significant bit*. See the panel for an explanation of what happens here.

To understand these outputs, you should be able to count in binary, using three bits. At the start of the counting process, all the bits have zero values, i.e. 000. The left-most bit is called the *most significant bit*, and the right-most bit is called the *least significant bit*. (When we write numbers normally, a number 1 in the left-hand position represents one hundred, 1 in the middle column represents ten, while the number 1 in the right-hand position means one. One hundred is a more significant number than one, hence the nomenclature.)

The three bits of our binary number have values, from left to right, of 4 ($=2^2$), 2 ($=2^1$) and 1 ($=2^0$). This means that a number 1 in the left-hand column signifies the normal number four, in the middle column it would represent two, and in the right-hand column, it would represent one. This should help you understand the patterns of bits which emerge as the clock waveform is counted, as the next paragraph explains.

As each cycle of the clock enters IC2, it increments its internal counter and the values of that counter are shown by the states of pins 14, 11 and 6. After the first pulse, these three pins would have states corresponding to 001; after the second, 010; after the third, 011; after the fourth, 100; after the fifth, 101; after the sixth, 110. This sequence of 3-bit numbers represents a binary count from 1 to 6 in 'normal' parlance. These six states are used to illuminate the conventional pattern of dots on a die, using LEDs.

As the clock cycles are counted, the LEDs flicker as the die is 'rolled'. Resistors R4 to R7 are used to limit the current through the LEDs. When the counter stops, it can be in any of the positions shown in **Table 1**. Because of

**Table 1** Dice number relative to counter output

| Step | Pins | | | Dice number |
|---|---|---|---|---|
| | 14 | 11 | 6 | |
| 1 | 0 | 0 | 1 | 4 |
| 2 | 0 | 1 | 0 | 2 |
| 3 | 0 | 1 | 1 | 6 |
| 4 | 1 | 0 | 0 | 1 |
| 5 | 1 | 0 | 1 | 5 |
| 6 | 1 | 1 | 0 | 3 |

the way in which the dots are grouped on the faces of a die, the wiring of the LEDs is simpler than it might otherwise be. You can see from Figure 1 that there are really only three sets of connections to the LEDs – one from each bit of the counter output. When pin 14 is at logic 1, four LEDs are lit, corresponding to the number four. For the number five, pins 14 and 6 will be at logic 1. For the number one, only pin 6 is at logic 1. For three, pins 11 and 6 are at logic 1, for six, pins 14 and 11 are at logic 1, and for two, only pin 11 is at logic 1. These conditions are summarised in Table 1.

## Construction

Two pieces of Veroboard (of the strip type) are needed – one for the main circuit (**Figure 2**) and the other for the display LEDs (**Figure 3**). The display board is easier to build, so we will do that first. It measures 20 holes by 18 strips.

Cut the tracks as shown in Figure 3, using a 3 mm (⅟inch) twist drill rotated between thumb and forefinger. Insert and solder the Veropins, resistors and the wire links. Then solder the LEDs in place, making sure their polarities are correct. The LEDs are mounted proud of the board (**Figure 4**, which will help when you come to fix the board into a case.

The main board measures 32 holes by 18 strips. As before, remove the tracks in the places shown in Figure 2. Note that track 'L' is *not* broken under the position for IC2. Solder in the IC holders and the links. Solder in R1 and R2 vertically, and R3 horizontally. Then solder in C1, C2 and C3; these all being electrolytics, check their polarities. Solder in the Veropins and prepare the connections to those components not on the main board, using stranded, insulated wire. Check the circuit carefully, and read the handling precautions given earlier before carefully inserting the two ICs.

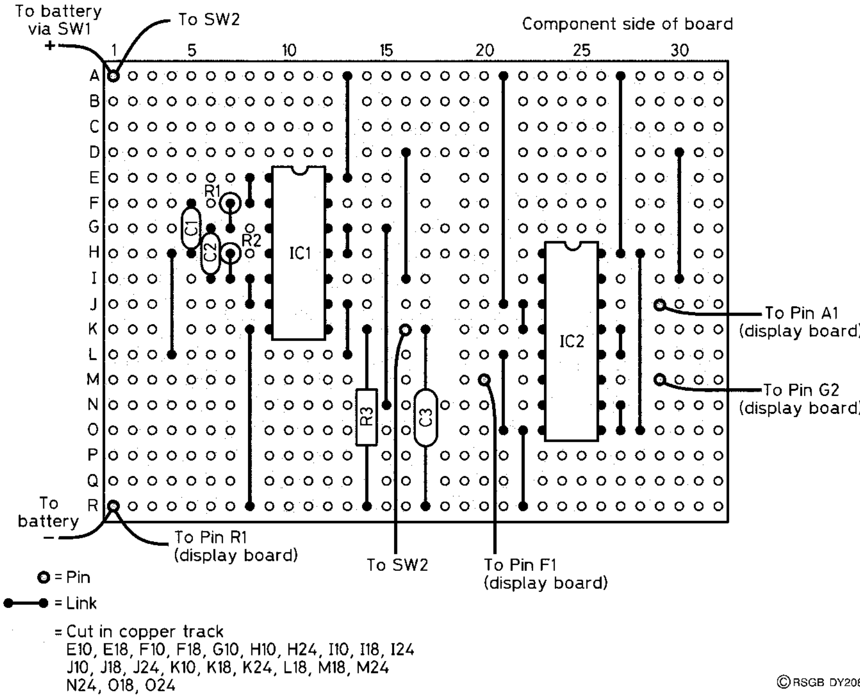



**Figure 2** Main board, component layout

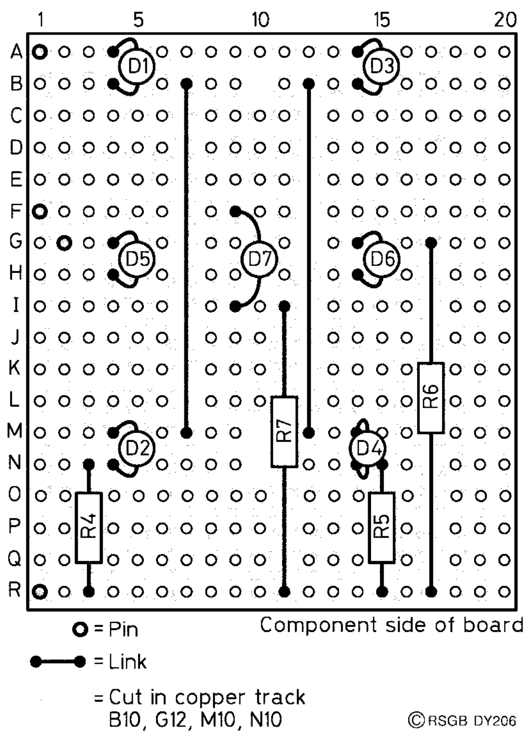



**Figure 3** Board for the six LEDs

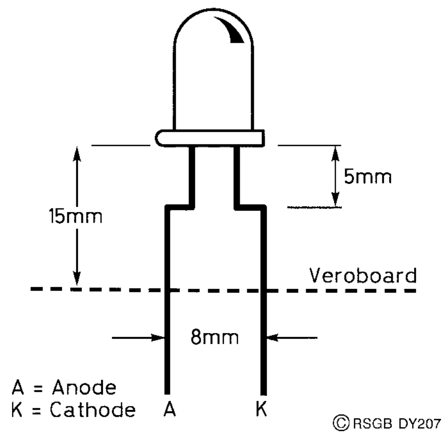



**Figure 4** D7 lead bending

## Testing and use

When the circuit is switched on, it is likely that the centre LED only will be lit. Press SW2, the ‘throw’ switch. All the LEDs should flicker, even after the switch is released, but only for a second or so. Then a standard pattern should show, signifying numbers between one and six. If this does not happen, switch off and check your circuit again. Are there any missing links? Are there any obvious dry joints (usually dull instead of shiny)? Can you see any solder bridges between tracks? Did you choose to ignore the handling precautions? If none of these results in a working circuit, try some fault-finding.

- Disconnect the lead to D7 on the main board (marked ‘to pin F1’ on Figure 2). Touch the lead on to the positive supply rail. D7 should light. Now transfer this lead on to pin 4 of IC1. If it flickers, then the oscillator is running (which it should).
- Transfer this lead to pin 10 of IC2. D7 should flicker when SW2 is pressed, but should be on permanently when it is released. This means that the correct signals are reaching IC2 from IC1.
- If one of the chains of LEDs (i.e. D1 and D2, D3 and D4, D5 and D6) does not light, you may have one *or both* LEDs the wrong way round.

When the die is working, you may care to experiment with the values of R1 and R2, but you should keep their values the same, i.e. R1 = R2. The larger the values of these, the more slowly the die will appear to ‘roll’.

## Finishing touches

On completion of the project, you will want to mount it in a smart case; any plastic box is suitable for this, with the display board mounted so that the

LEDs protrude through the top and are fixed to it using LED clips. The way in which you mount both boards to the case is entirely up to you.

## Parts list

Resistors: all 0.25 watt, 10% tolerance, or better

| | |
|---|---|
| R1, R2 | 5600 ohms (Ω) |
| R3 | 15 kilohms (kΩ) |
| R4–R7 | 470 ohms (Ω) |

Capacitors

| | |
|---|---|
| C1, C2 | 1 microfarad (μF) electrolytic, 16 V WKG |
| C3 | 68 microfarads (μF) electrolytic, 16 V WKG |

Semiconductors

| | |
|---|---|
| IC1 | 4011 |
| IC2 | 4029 |
| D1–D7 | LEDs, any size and colour |

Additional items

| | |
|---|---|
| SW1 | On-off switch SPST toggle |
| SW1 | Push-to-make, non-latching |
| | Veroboard, 2 pieces, see text for sizes |
| | Veropins, 10 |
| | Stranded insulated wire for general wiring |
| | Single-core insulated wire for links |
| | PP3 battery clip |
| | PP3 battery |
| | Plastic box to suit |
| | LED mounting clips (7) |
| | Means of mounting boards to box |

## Source

Components are available from Maplin.

# PUSH BUTTON DICE

**We think this project will be a winner . . .**

GENERATORS OF RANDOM NUMBERS in the range one to six (dice to most of us), are essential items in games ranging from Ludo to Backgammon. This is fortunate for those of us who count electronics amongst our hobbies. Why? you ask, well the answer's simple. When asked what your hobby is, if in reply you answer electronics, as often as not this will be greeted with a yawn, pictures of boring theory and mountains of test gear being conjured up by the questioner. Bring out an electronic game, however, and all this changes. Electronics can be fun.

**Never Say Die**

Unfortunately, most games, in order to be interesting, involve a lot of different factors that our electronics must keep track of. This, in terms of 'hardware' means lots of lamps, switches, and wire — complications. Happily, to build a dice, if our plans are followed, is an easy task, and will impress your friends as it is a distinct improvement over the traditional spotty blocks of wood.

**Straight As A Die**

Our photographs show that our die is built into a small box that has a line of Light Emitting Diodes (LEDs) to represent the six numbers plus a push button. Operating the button will activate the circuit and when the button is released one of the six LEDs will be lit, the particular one being impossible to predict. The LED will stay on for about five to ten seconds before going out. The dice is now ready to be "rolled" again.

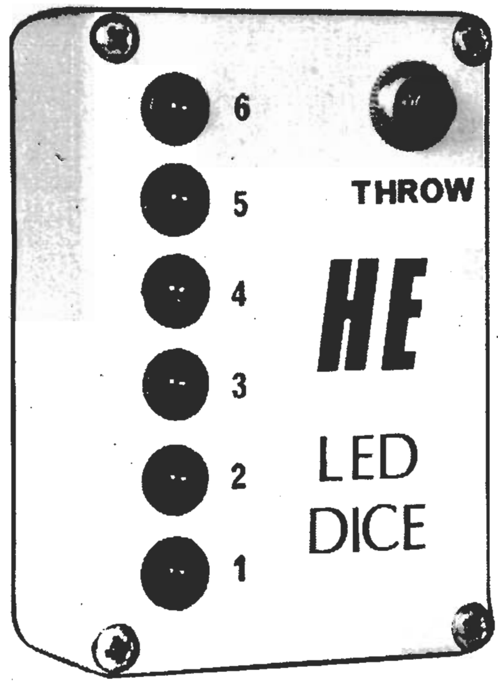
The dice does not have an on/off swich, as with the LEDs off the circuit draws such a small amount of current from the battery that such a switch is not necessary.

**Construction**

As with any project, the exact method of construction is largely a matter of personal choice. The photographs clearly show how our dice went together, but there is no reason why you should not put your project in a different type of case. At any rate the first thing to do is to assemble the PCB according to our overlay.

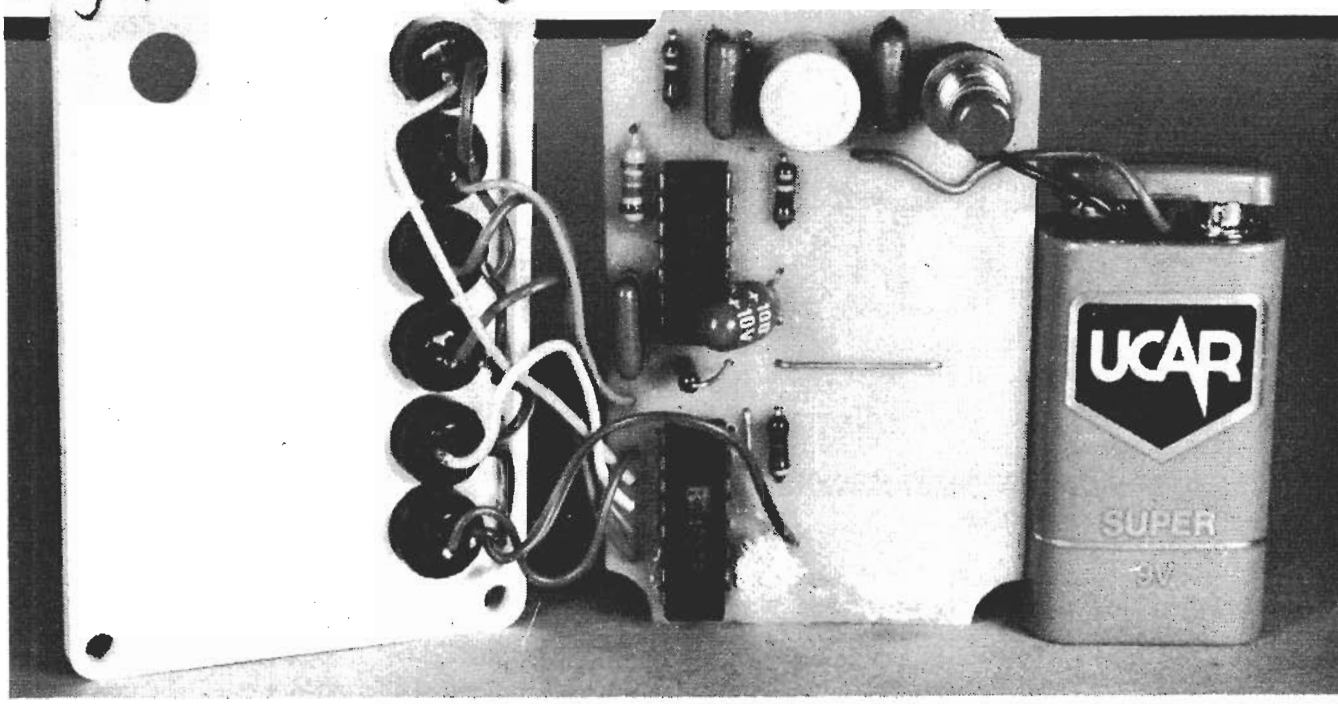
The dice uses a type of IC known as CMOS and for this reason we suggest that you use IC sockets when building the project as CMOS ICs are more electrically 'fragile' than other types of IC.

When mounting the components, make sure that the ICs and the electrolytic and tantalum capacitors are fitted

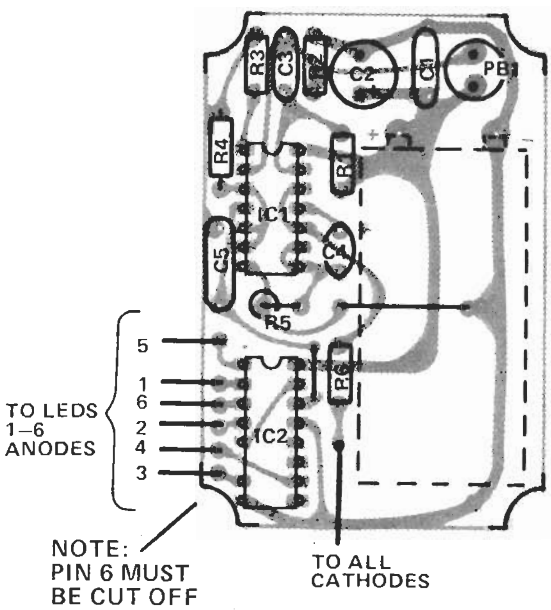


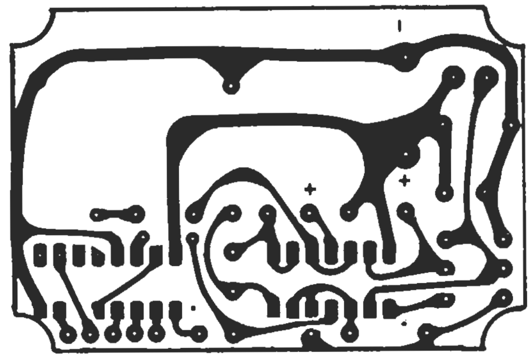

## PARTS LIST

| | | |
|---|---|---|
| RESISTORS | (all ¼w 5%) | |
| R1, 3, 5 | 100k | |
| R2 | 10k | |
| R4 | 56k | |
| R6 | 470R | |
| CAPACITORS | | |
| C1 | 100n | polyester |
| C2 | 100u | 16V electrolytic |
| C3, 5 | 10n | polyester |
| C4 | 100u | 10V tantalum |
| SEMICONDUCTORS | | |
| IC1 | CD4011B | |
| IC2 | CD4017B | |
| LEDS 1-6 | TIL209 | |
| SWITCH | | |
| PB1 | Miniature push to make | |
| MISCELLANEOUS | | |
| PCB as pattern, 9V battery plus clip, Vero box, wire, etc. | | |




ABOVE: the case opened to show what makes the dice tick. LEFT: the 'component overlay' which links the circuit diagram with the above photo. BELOW: the pattern for the copper foil side of the printed circuit board.



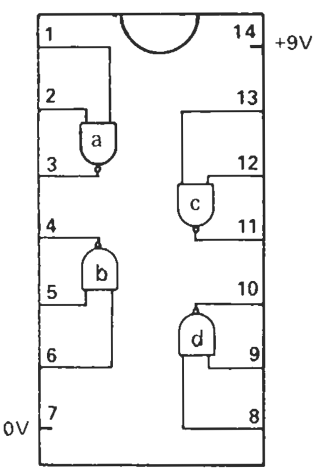
the right way round. Failure to do so will result in a dead LED dice.

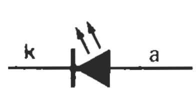
When marking out the front panel take care that the LEDs are in a straight line. The LEDs are mounted with special mounting clips that should be available from the people who supply the LEDs themselves.

There is a fair bit of wiring to do so take care when doing this job. It's easy to make a mistake here, and any error can take a long time to find.

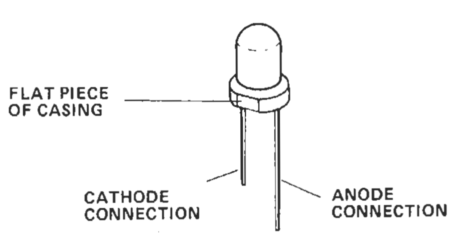
When all construction is complete, fit the battery and get ready to roll your first electronic die.●

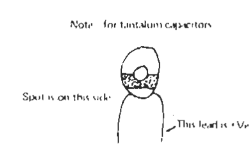
Below: Pin out data for IC1 and LEDs 1-6.



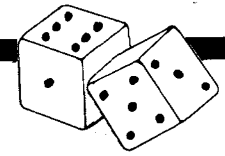



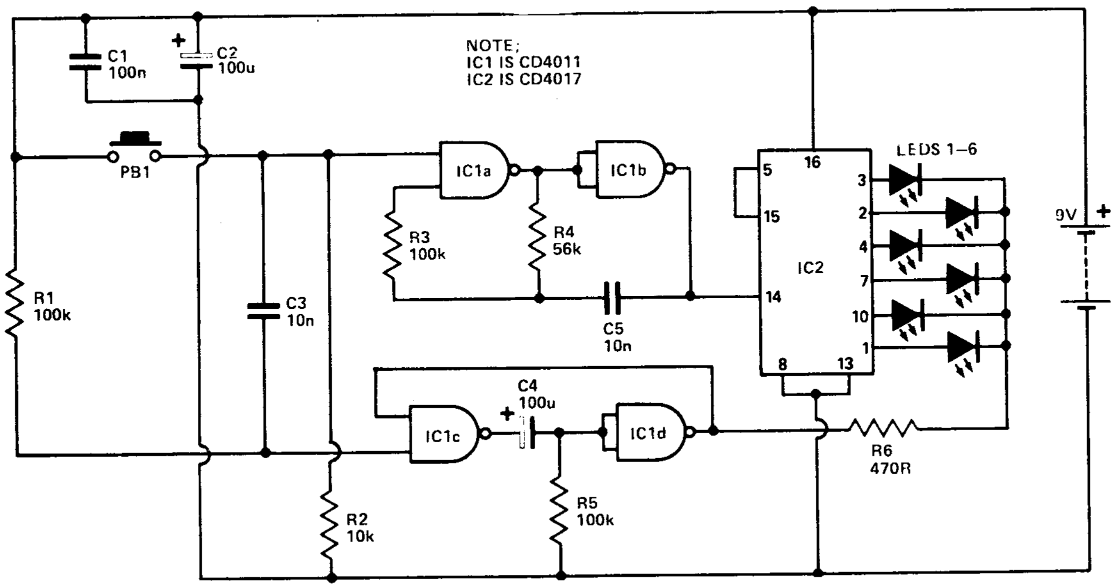

a = ANODE
k = CATHODE



ABOVE: some tantalum capacitors are not marked with a "+" as in the photo. They instead have a dot on one side only.






The circuit diagram

## HOW IT WORKS

THE digital dice, in order to simulate the action of a real die, is required to "stop" with one of the circuit's six light-emitting diodes (LEDs) lit, each LED corresponding to one of the six numbers on the faces of the real die. To do this, it quickly turns each LED on in sequence when the start button is pressed, stopping with one LED on when the button is released. Because the circuit cycles through the sequence very quickly it is not possible to cheat by waiting for a particular LED to light and release the button at this point!

The circuit can be broken down into two sections, one dealing with the display and the other with timing and control signals. The latter are provided by two 'classic' circuit building blocks, namely the 'astable' formed by IC1a and IC1b and the 'monostable' configuration of IC1c and IC1d.

**Each circuit is formed from two out of the four logic gates of IC1. The inputs of the logic gate can be in one of two conditions. They can either be 'low' (that is, near O V), or 'high'(near** to the supply voltage, 9V in this case). The output of the gate can also adopt only these two values, the choice being determined by the state of the inputs. In this case as the gates are 'NAND' gates the output will be high at all times except when both the inputs are high at which point the output will go low. 'NAND' stands for 'not-and', the output being low whenever both one input 'and' the other are high.

The astable will not function until the start button takes one of IC1a's inputs high. At this point the output of IC1b will oscillate between 0V and 9V. The circuit is referred to as an astable (meaning 'not stable') because the output can assume these two conditions but is stable in neither.

A detailed description of the circuit would take up too much room but briefly the oscillator works like this: Suppose the output of IC1a is low and that as one of this gates' inputs is 'tied' high the other, connected to R3, must also be high. The junction of R3, R4 and C5 is thus high, but as R4 goes to the output of IC1a, which is low, the charge on C5 will leak away. At some point the voltage at this junction, having fallen to near the 0V rail, will cause the output of IC1a to go high and that of IC1/b to go low. C5 will now charge up via R4 which will in turn cause the circuit to assume its original state.

The series of pulses generated by the astable is fed to IC2. This is a counter IC, having ten outputs. As the pulses are fed to its input, each of the ten outputs will be turned on in sequence. For this circuit, however, we only want the IC to count up to six. To achieve this we connect the seventh output of IC2 to another of the IC's inputs called the 'reset' pin. When this pin is taken high it resets the counter back to the start. We now have our count of six.

The outputs of IC2 are taken to LEDs 1-6. LEDs are like ordinary diodes in that they will only pass current in one direction, but in addition when they are passing current will emit light. When an output of IC2 is high the associated LED will emit light if the common point to which the LEDs are taken, R6, is low.

R6 is taken to the output of IC1d. This point is normally high and thus the LEDs are all off. When the start button is released, however, the input of IC1c, junction of C3 and R1, goes low for a brief period of time and causes the output of this gate to go high. C4 'couples' this change to the input of IC1d and causes the output this gate to go low, activating the display and, by virtue of the fact that the output is also connected to IC1c, maintaining the high on the output of this gate. The charge on C4 will leak away, however, via R5 – and cause the circuit to assume the previous state after several seconds. This circuit is termed a monostable because it has two possible states, only one of which is stable (mono = one). It is necessary to include R6 in the circuit because the current passed by the LEDs must be limited to a safe value.

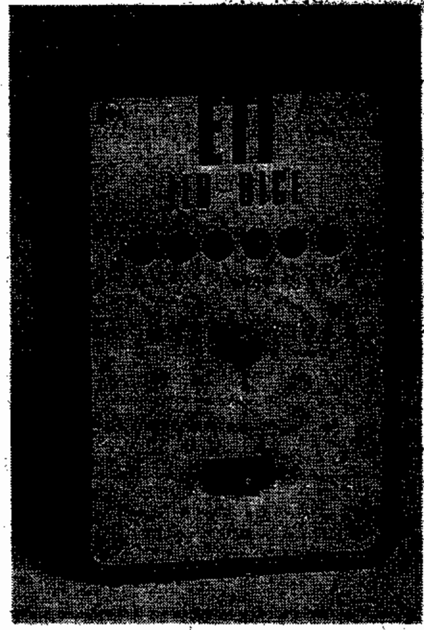
C2 and C1 are included to 'decouple' the supply that is, remove any fluctuations in the supply voltage that might upset circuit action.

# SHORT CIRCUITS

NEW SERIES

**This new series will describe straightforward projects but they are not necessarily simple in their operation or aimed at the beginner. We plan to carry between two and four such projects each month.**

# LED DICE



THIS SIMPLE DICE PROJECT IS based on a CMOS (Complementary Metal-Oxide Semiconductor) integrated circuit counter which is stepped by the output of a 555 timer integrated circuit connected to run as an oscillator at approximately 6500 Hz.

When the button on the unit is pressed the 555 oscillates and the kHz 6.51 pulses which it generates at pin 3 are fed to the input of IC2 (pin 14). The integrated circuit, IC2 is a decade counter in which each of the count states (0 to 9) are brought out to separate pins. By connecting the seventh count output (pin 5) back to the reset input (pin 15) the counter is made to reset after every sixth count. The six count states of the IC which are used are each connected to a light-emitting diode (LED). As the IC counts it will switch on each of the six light emitting diodes in turn. Whilst the button is pressed the LEDs will be switched at a rate of 6.5 kHz and thus all LEDs will appear to be on due to the limited frequency response of the human eye.

When the button is released the oscillator stops counting leaving one only of the LEDs alight. As the IC cycles through its six states the LEDs will each be on for the same interval. Thus the probability of being on when the button in released is the same for each LED. The LEDs may therfore be numbered from one to six and the device can then be used as a dice.

## CONSTRUCTION

Whilst CMOS devices are fairly rugged in-circuit they are liable to be damaged by static discharges when handled out of circuit. For this reason they are supplied in either conducive foam, aluminium foil or specially-coated plastic containers which short all the pins together for protection. The CMOS should only be removed from its protective packing when you are ready to insert the device into the board. All other components should be mounted to the board first and the CMOS inserted last of all. Handle the pins of the device as little as possible and solder in place quickly and cleanly with a light-weight soldering iron.

The integrated circuits are marked by a small notch or dot at one end of the body. When inserting the IC make sure that this mark is aligned with the orientation mark provided on the component overlay. Make sure also that the electrolytic capacitor C2 in inserted with the correct polarity.

The light-emitting diodes will have their cathode terminals (k) marked in some way. Usually this is

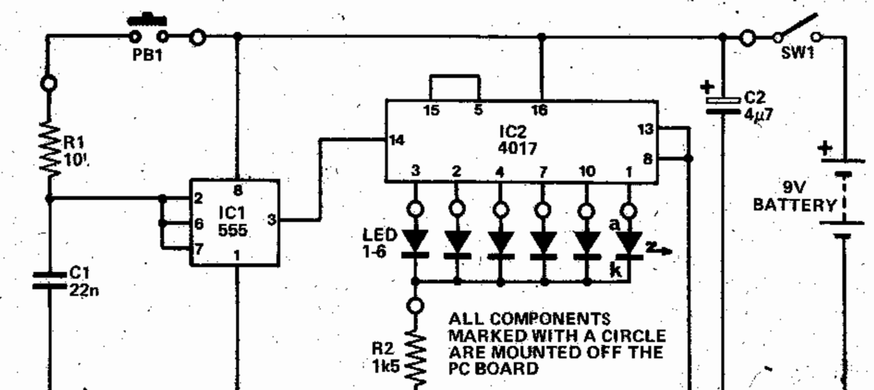
## How it works

The output of IC1 is connected to the clock input of IC2 and every time there is a pulse from IC1 the output of IC2 which was high, will go low and the next output will go high (providing that the reset input is low). Thus the "high" shifts through the ten outputs of IC2 in sequence at the same rate as the input pulses from IC1. The sequence of ten outputs recycles whilst there are input pulses.

However a dice has only six surfaces so we require IC2 to count to six, rather than to ten. This is easily performed by connecting the seventh output of the IC back to the reset input. Now when the counter is clocked from output six to output seven, seven goes high and resets the counter. Once the counter resets the high is removed from output seven and the counter, back at output one, is free to count again. The time taken to do this is only about 100 nanoseconds (0.000 000 1 sec).

The outputs one to six of IC2 are each connected to the anode of an LED. The cathodes of the LEDs are all connected in parallel, via a common current-limiting resistor, to 0 volts.

For checking purposes the action may be slowed down by putting a high value resistor across the terminals of the push button (even just the finger across the terminals will do). This will cause the oscillator to run at a low speed so that the changing of the LEDs can be seen.



by means of a small flat on the plastic body of the component adjacent to the cathode lead or the cathode lead many be shorter than the other. Make sure that the leds are inserted the correct polarity — if any LED fails to light when the button is pressed it is most likely that it is the wrong way round.

The dice project may be assembled using the Veroboard layout as given or using the printed-circuit board alternative. If Veroboard is used the tracks must be cut in the positions indicated with a small drill bit. The components are then assembled to the respective board with the appropriate overlay. ●

## Parts List

**RESISTORS**
R1 10K
R2 1K5
All ½W 5%

**SEMICONDUCTORS**
IC1 555 resistors
IC2 4017 CMOS
LED 1,2,3,4,5,6 TIL 209 or similar

**MISCELLANEOUS**
PP3 battery
PP3 battery clip
Board spacers
Nuts, bolts, etc.

**CAPACITORS**
C1 22n ceramic or similar
C2 4u7 16V electrolytic

**SWITCH**
P.B.1 = push to make type
SW1 = single pole / Off-On rocker

**CASE**
ABS M2 Doram

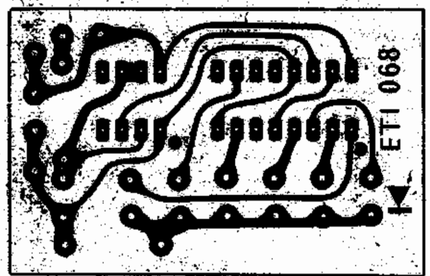



*Fig. 2. Printed-circuit board layout for the LED dice. Full size 55mm x 35mm.*

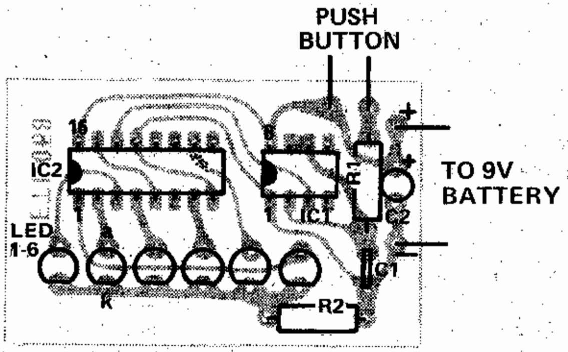
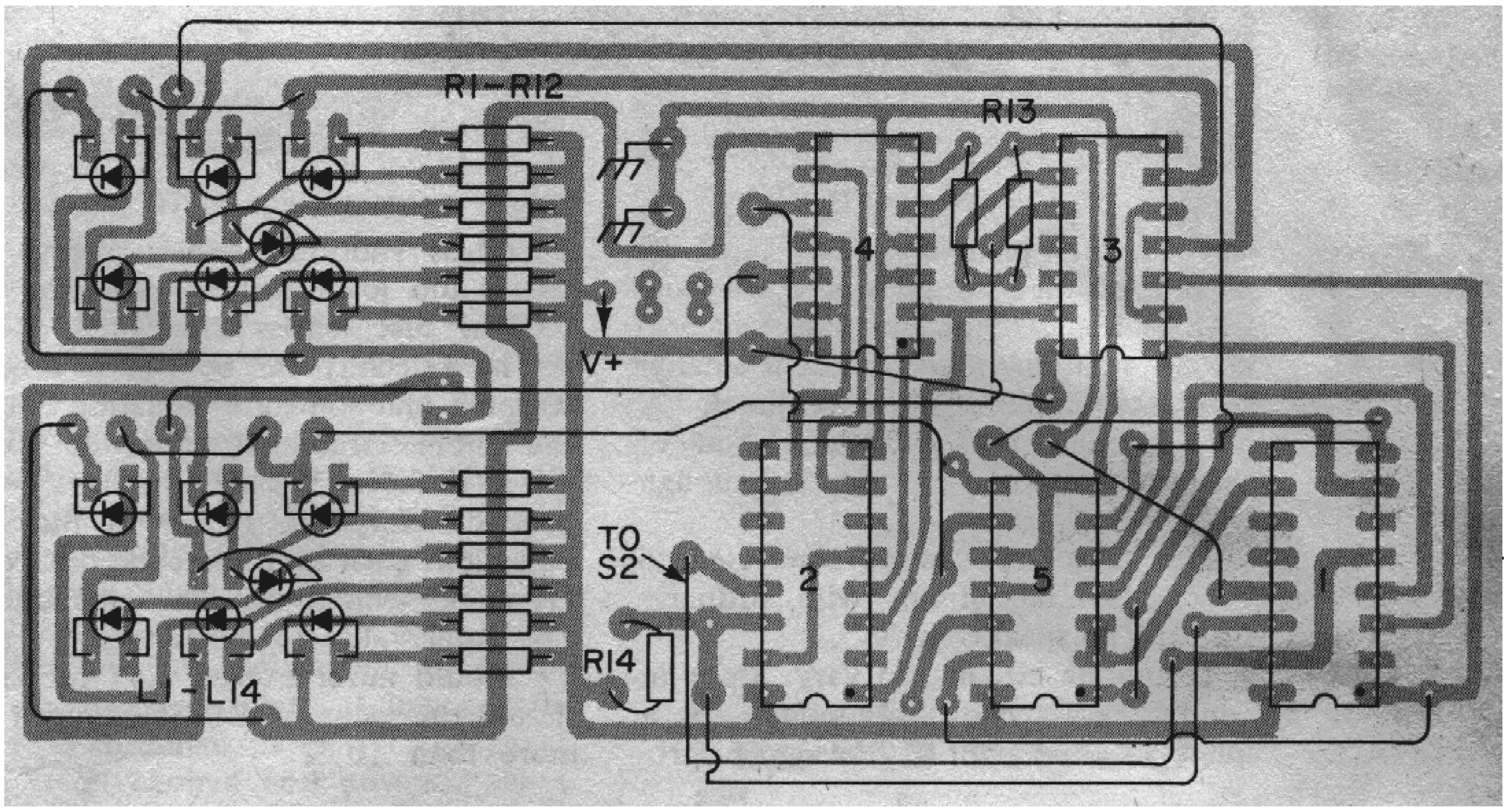



*Fig. 3. How the components are mounted to the printed-circuit board.*

that the theoretical 16⅔ frequency for each level is closely approached—the small variations are just random fluctuations in this relatively few number of trials. *Digi Dice* draws about 20 to 60 mA from the supply, depending on how many LEDs are lit. Alkaline cells are best for long life, but regular carbon-zinc batteries will provide several hours of "rolling." Be sure to try this circuit in a game of backgammon. It runs much more quickly and a third person can get into the game as a dice roller.

***Conclusion.*** We'll add the usual caution at this point about getting involved with "money" games. While *Digi Dice* has been designed to be as "random" as is possible for a project of this nature, we certainly do not wish to become referees in arguments between you and your friends (or your victims). *Digi Dice* is intended for entertainment only, and any other use of this project (either with a modified circuit or not), especially for gambling, is done against our strongest recommendation. If you're all that hot to *really* gamble, the Chamber of Commerce of Atlantic City would no doubt like you to visit the town's casinos instead! ■

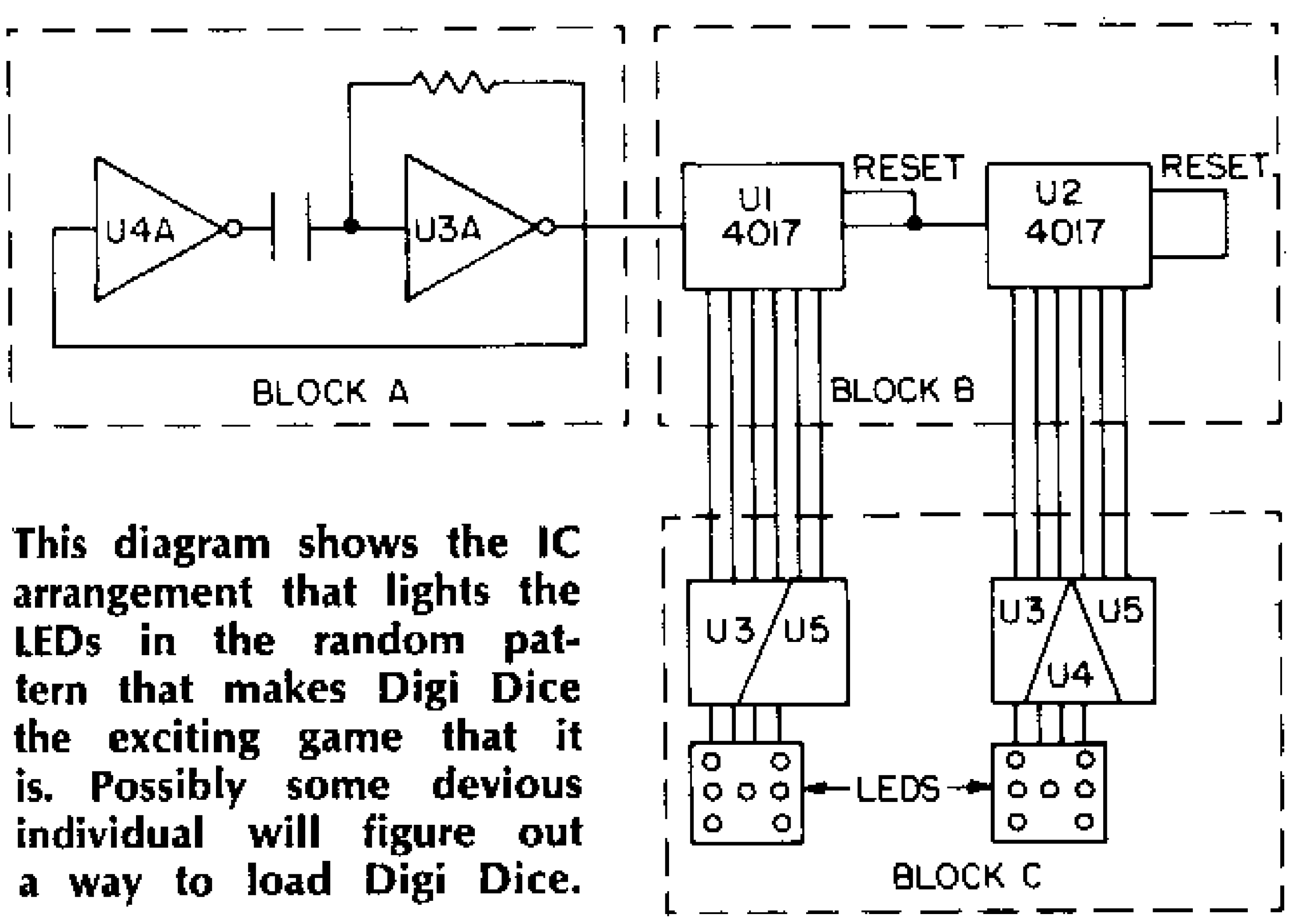



**The parts overlay diagram shows the placement of components on the PC board. As in all projects using a number of delicate ICs care must be taken with the pins and with the use of soldering irons too near to the chips. Digi Dice is a project to gladden a gambler.**

### STATISTICAL BREAKDOWN OF 100 ROLLS

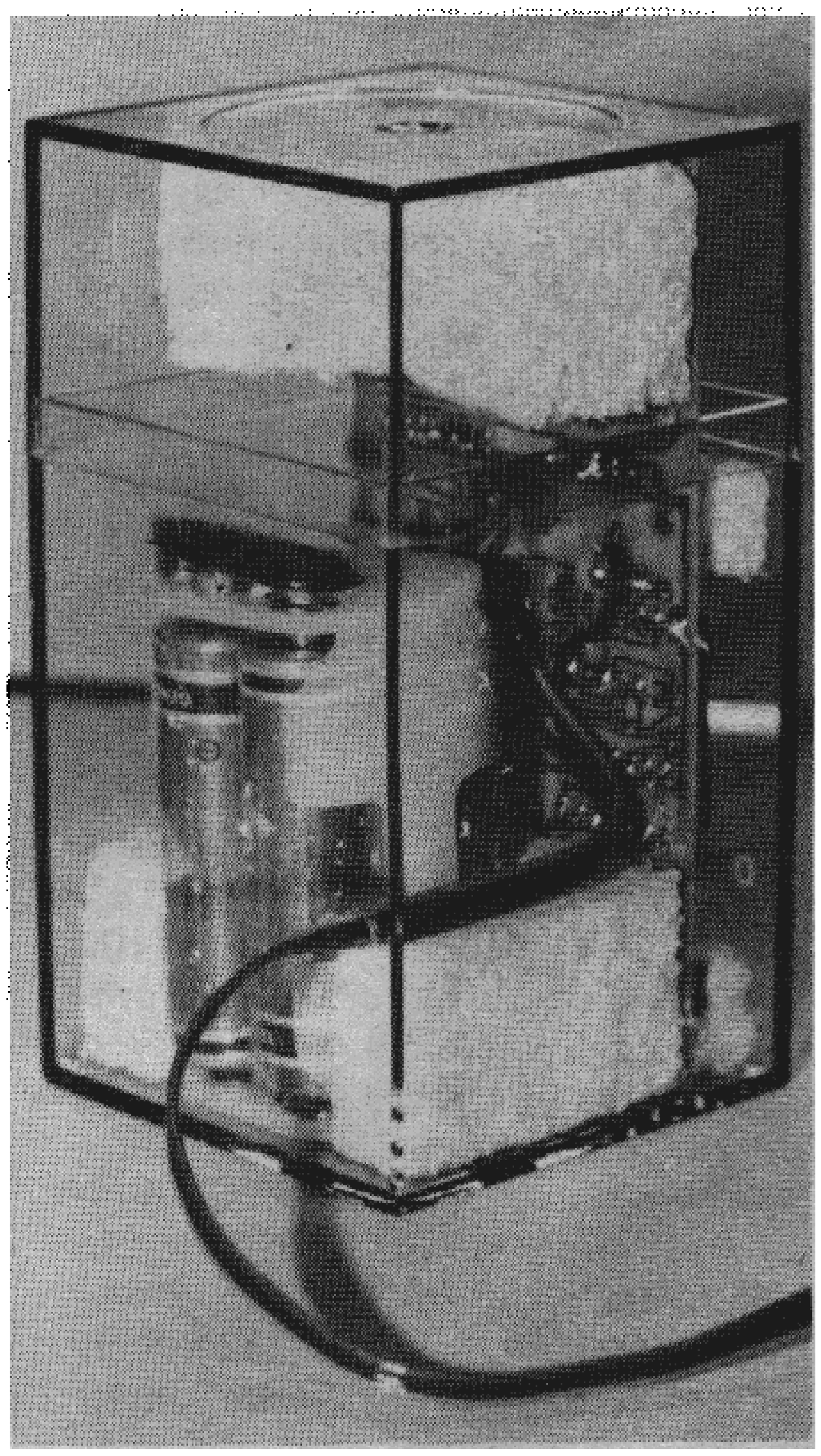
| Face Value | Die #1/100 Rolls | Die #2/100 Rolls |
|---|---|---|
| 1 | 18 | 16 |
| 2 | 14 | 18 |
| 3 | 18 | 14 |
| 4 | 15 | 17 |
| 5 | 18 | 16 |
| 6 | 17 | 19 |
| Total | 100 | 100 |

**This chart shows how truly random Digi Dice is, much more so than old-fashioned "bones." While it may be possible, we know of no way to rig Digi Dice.**




**This diagram shows the IC arrangement that lights the LEDs in the random pattern that makes Digi Dice the exciting game that it is. Possibly some devious individual will figure out a way to load Digi Dice.**

**The battery pack holding the four 1.5 volt cells that power Digi Dice fits neatly into one of the common rectangular plastic boxes which can be found in a variety of shops. Styrofoam or a similar material can be used to take up room in the box, since the PC board and battery pack aren't likely to fill the entire box.**



# DIGI DICE

counting in both U1 and U2 by holding pin 14 at ground. Opening (pushing) S2 allows R14 to pull pin 14 to a high level, thereby allowing the counters to run. When this happens, the decoder/drivers will be displaying the contents of the U1 and U2 using the LEDs, but so quickly that the eye cannot follow. Releasing the pushbutton switch (closing S2) will freeze the count in each 4017, which can now be seen displayed by the LEDs.

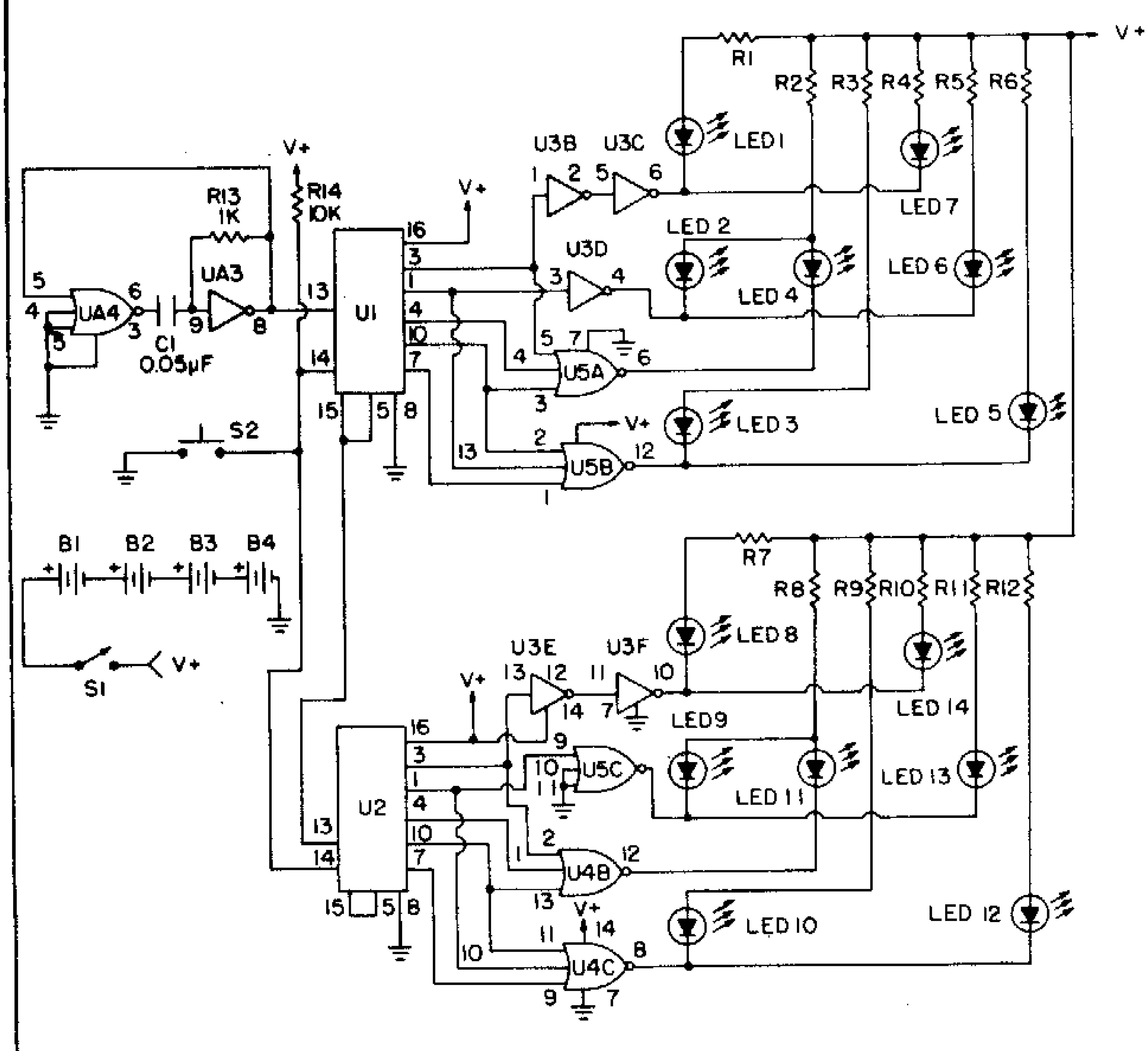
***Construction.*** A full size PC board layout is shown for your use. As the pattern is very tight, we recommend that only advanced hobbyists attempt a reproduction. Wire wrapping is a bit more tedious and time consuming, but easier to correct. Anyway, if you do choose the PC route, carefully check for breaks and shorts in the foil with an ohmmeter, since they are easy to miss by visual inspection.

Follow the parts layout guide when assembling the PC board, and be sure you have the correct orientation of the chips; a small notch is preesnt at pin #1 of each chip. Also, don't arrange the LEDs backwards. The anode lead (+), which is usually longer than the cathode lead is always nearest to the ICs on the board. Reversing this won't hurt the LED but it won't light either.

The entire project fits neatly into a 2¼-inch by 2¼-inch by 4⅙-inch plastic box available in art supply stores. We ran four wires out of the main box to a smaller matching unit in which we mounted switches S1 and S2. Ribbon cable is perfect for this. The battery and circuit board are stabilized by styrofoam strips and blocks cut to the necessary shapes and either glued or press-fit into the large box. When the time comes to change batteries, the holder is easily unclipped and slid out of the case. Incidently, any 5-volt to 6-volt source can be used in place of the dry cells. The absolute maximum voltage the 74LS chips will tolerate is 7 VDC, so be careful.

***Operation.*** Closing switch S1 activates the circuit. Don't be surprised if an unusual combination of lights appears when the unit is first turned on. Now press pushbutton switch S2. All of the LEDs will illuminate, some more brightly than others. Releasing the pushbutton will force *Digi Dice* to display two random values. Repeat the sequence for further play.

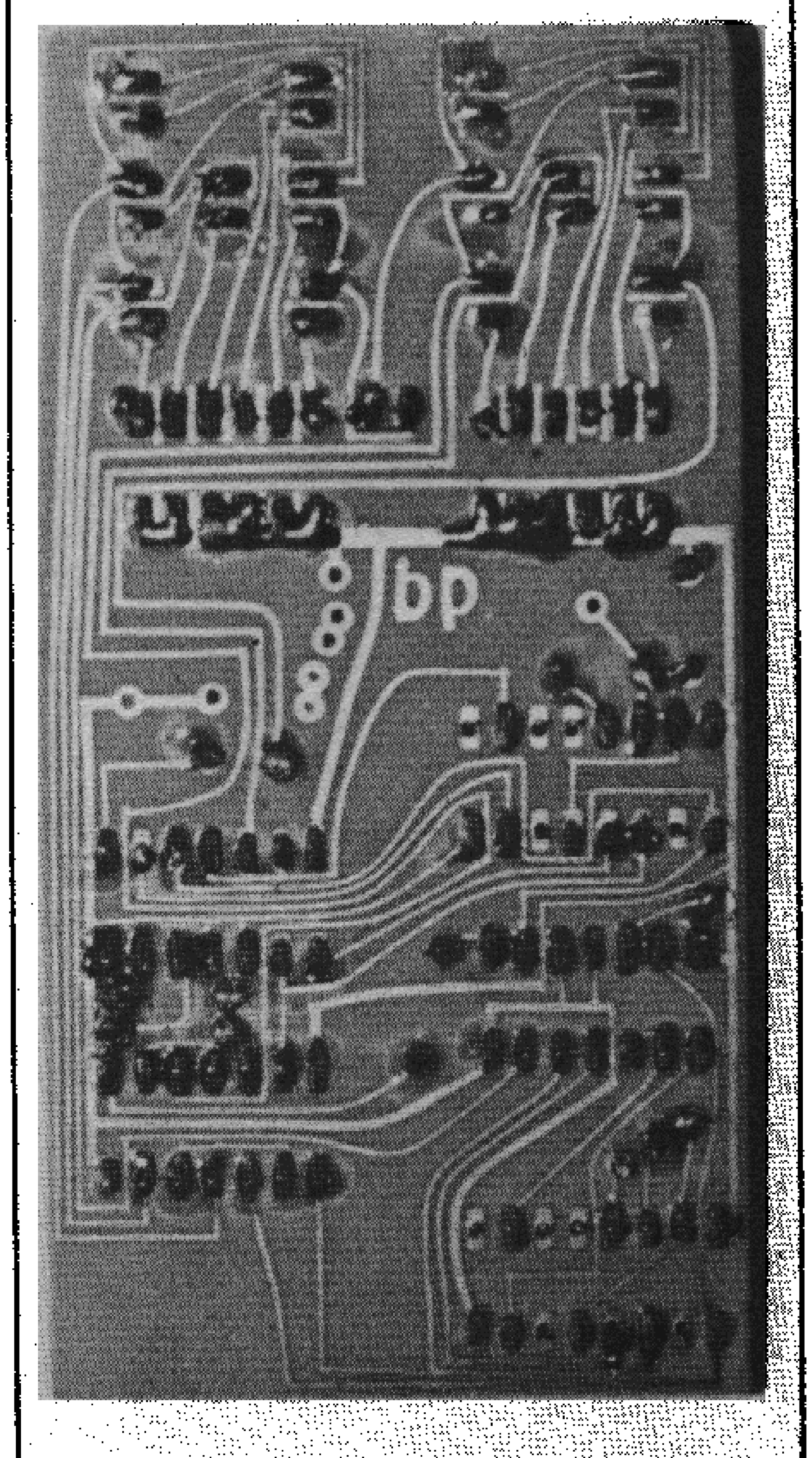
To test the theory of randomness, we "rolled" Digi Dice one hundred times. A summary of the results is shown. Although the tabulation was not checked using statistical analysis, you can see




**PARTS LIST FOR DIGI DICE**

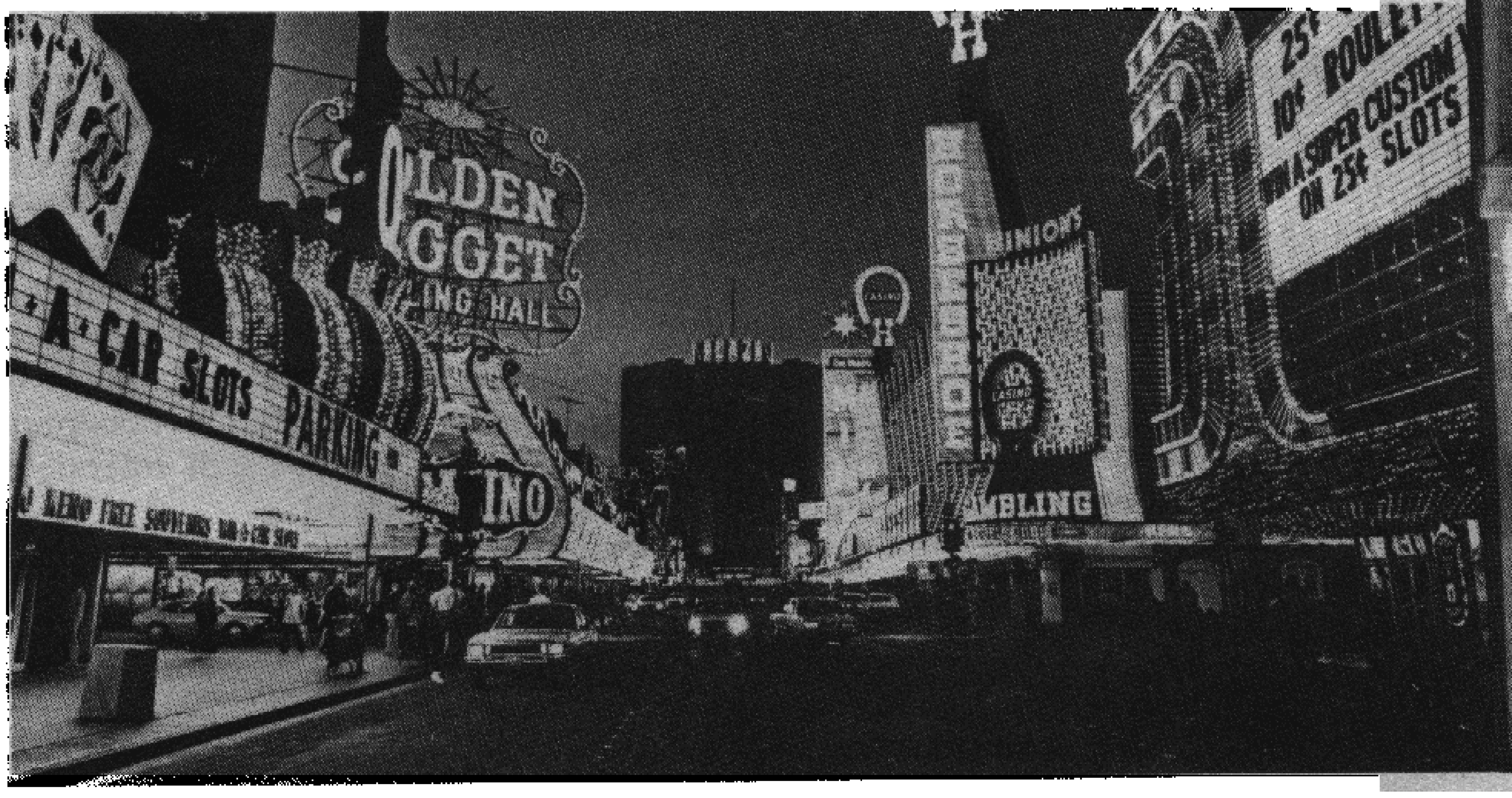
**B1 thru B4**—1.5 VDC battery
**C1**—0.05-uF, 50 VDC ceramic disc capacitor
**LED1 thru LED 14**—light emitting diode rated 20 mA @ 1.7 VDC
**R1 thru R12**—470-ohm, ¼-watt resistor, 10%
**R13**—1,000-ohm, ¼-watt resistor, 10%
**R14**—10,000-ohm, ¼-watt resistor, 10%
**S1**—SPST subminiature slide switch
**S2**—SPST normally closed pushbutton switch
**U1, U2**—CD4017 decade counter integrated circuit
**U3**—74LS04 hex inverter integrated circuit
**U4, U5**—74LS27 three section, triple input NOR gate integrated circuit
**Misc.**—battery holder/clip, suitable enclosure, IC sockets, hookup wire, solder etc.

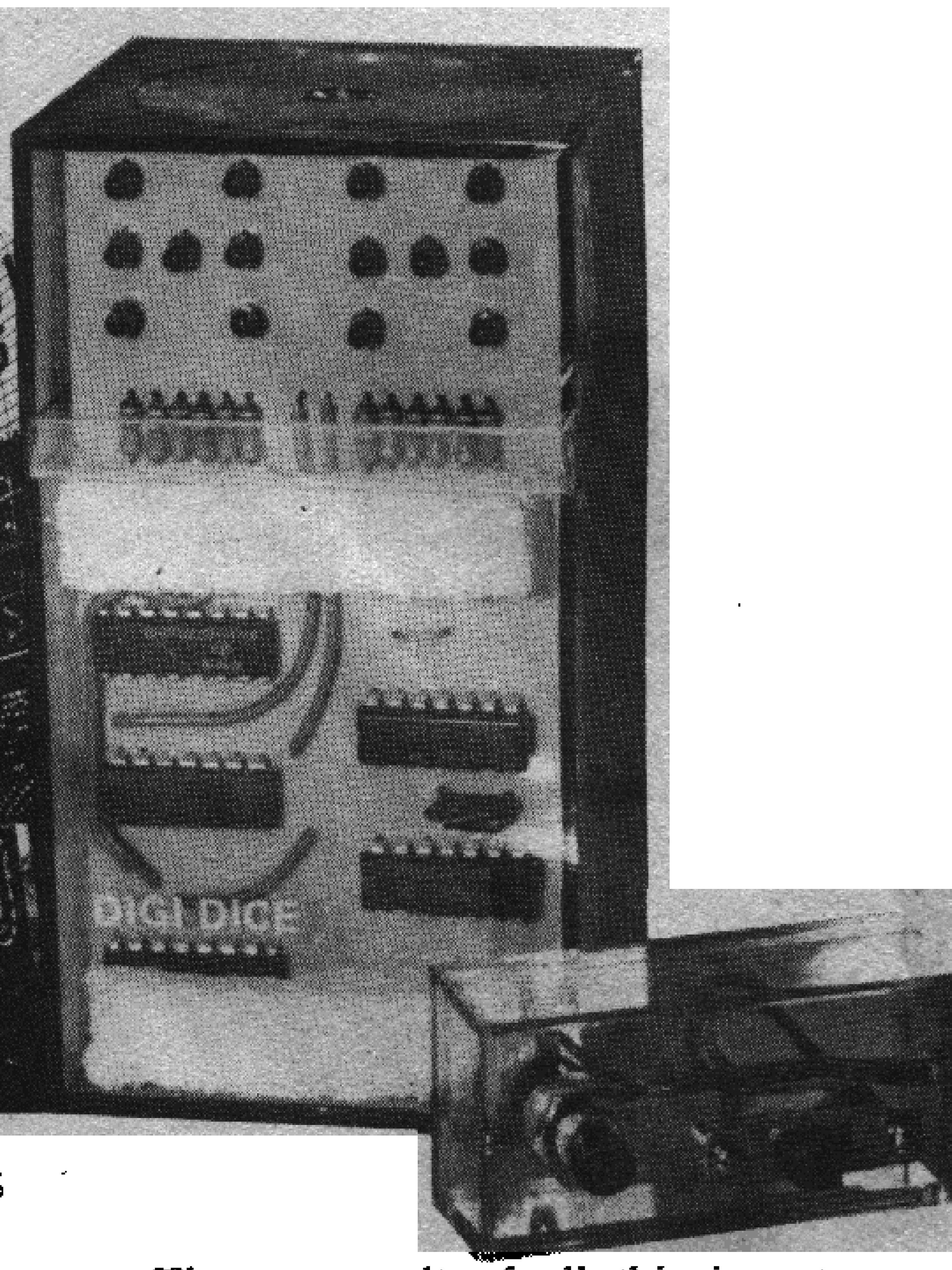
A complete parts kit including PC board and all components is available from Niccum Electronics, Rte. 3, Box 271B, Stroud, OK 74079. Price for the complete kit is $24.50; a pre-etched and labeled PC board only is $5.50. No CODs, please.



**The foil side of the completed PC board is a gem of neat solder connections. The unit fits into a variety of handy plastic cases.**

# DIGI DICE






An electronic dice game with infinite possibilities

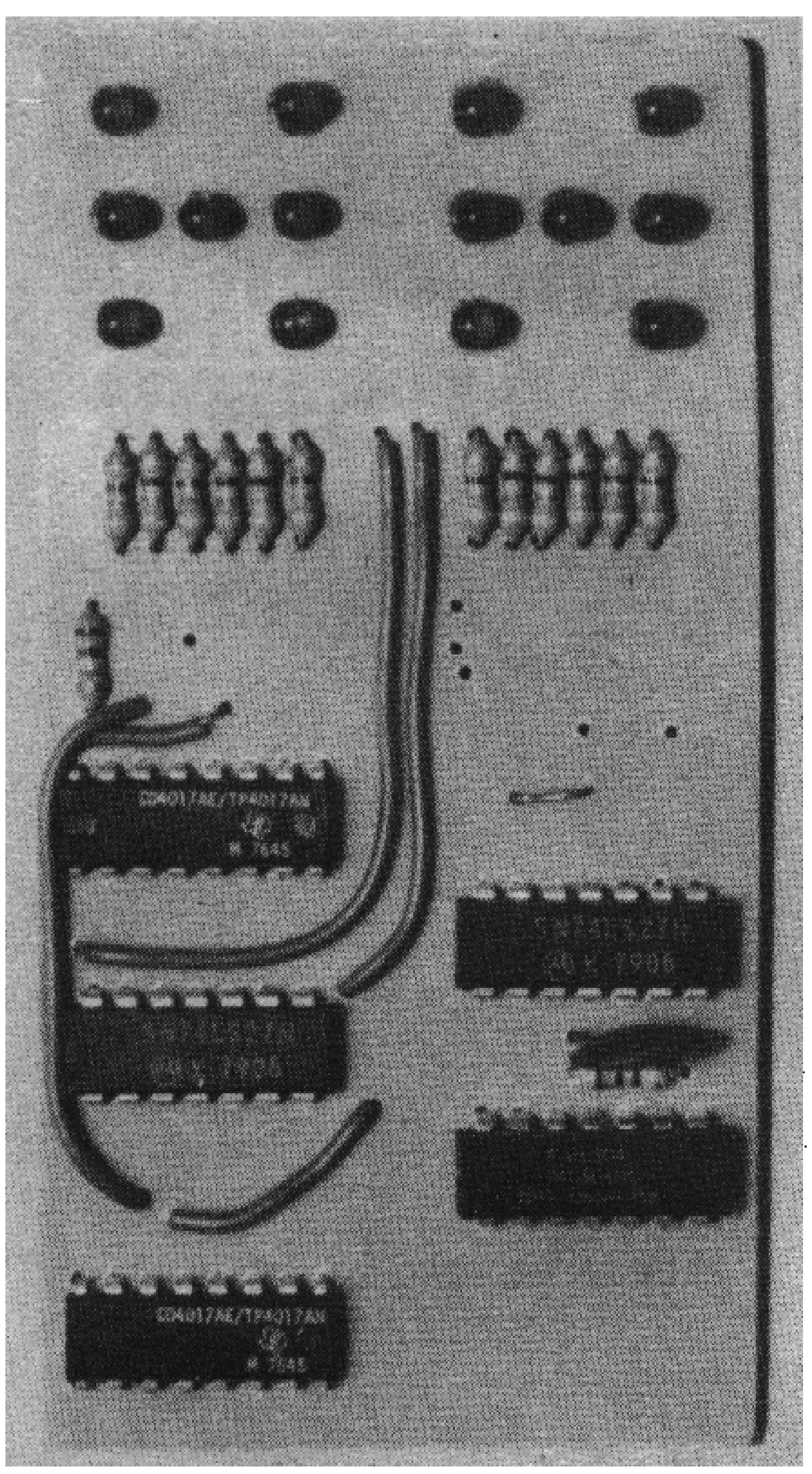
HERE IS A PROJECT for those of you tired of rolling old fashioned mechanical dice. *Digi Dice* can be used anywhere normal dice are used, and has been designed to be cheap, portable, and fun. And, since it is an electronic device, it is probably more random than any regular dice with their inherent mechanical imperfections. Construction time will vary, of course, but we built our dice in an afternoon and by evening were "rolling" in a game of craps. Total cost should run about $12 to $15, depending on how much spare junk you have lying about and where you buy the needed parts.

***The Circuit.*** Refering to the block diagram, you can see that *Digi Dice* is composed of three main blocks. Block A, the oscillator, is made of two 74LS inverters connected as an oscillator, using a resistor and capacitor to regulate the frequency. The output of this oscillator is sent to block B, the counter. This consists of two CD 4017 decimal decoded counters, each wired to reset at a count of six, such that its sequence is 0, 1, 2, 3, 4, 5, 0, 1, etc. The first IC (U1) gets its input directly from the block A oscillator, while the second (U2) receives its pulses every time its partner resets itself to zero. Obviously, the second 4017 only counts one sixth as fast as the first.

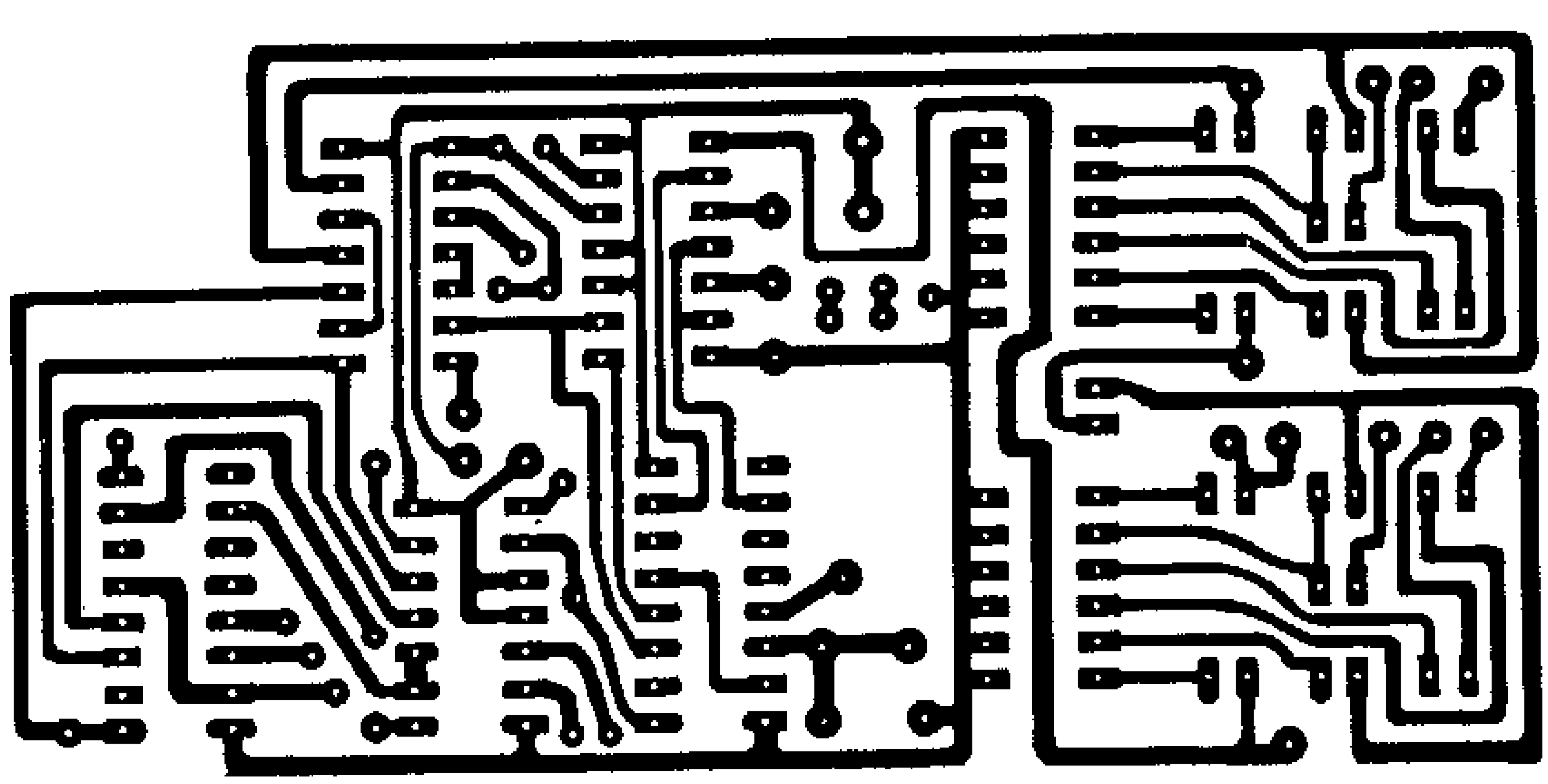
The net result of all this is a two-place base six (modulo six) counter. If we now interrupt the count at some point, each 4017 will contain a value of 0 through 5. If then, and this is the heart of the circuit, we run the counters so fast that we don't know where they are when we halt them, we have devised two independent and "random" six counters. But that is exactly what mechanical dice are, so now all that must be done is to display our results in some suitable way.

Block C, decoding and driving, does this by interpreting the values present in the CD 4017s and displaying them using red LEDs arranged to give the appearance of a pair of dice.

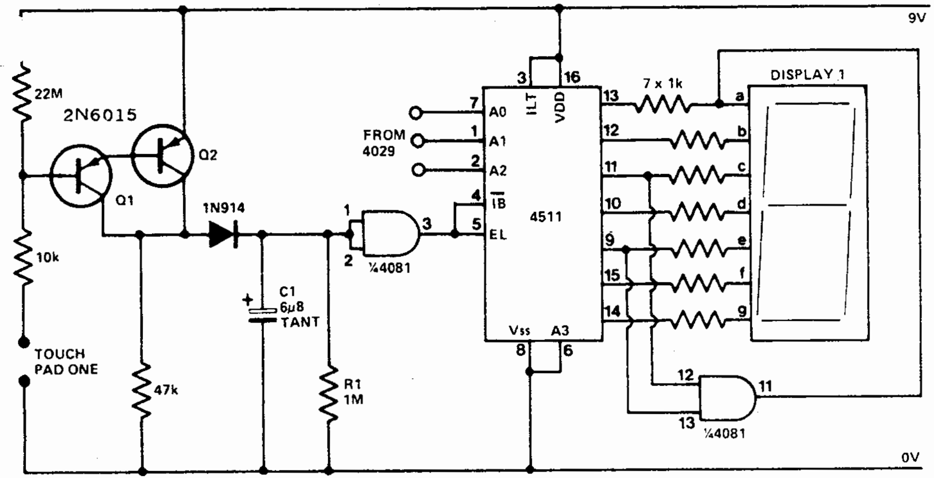
Now, look at the schematic diagram for a more complete idea of how the circuit operates. Switch S1 is power on-off. S2 is a normally closed momentary-contact pushbutton which inhibits



This front view of the PC board shows the arrangement of ICs and the LEDs that read out the score. "Snake eyes" lights up first.

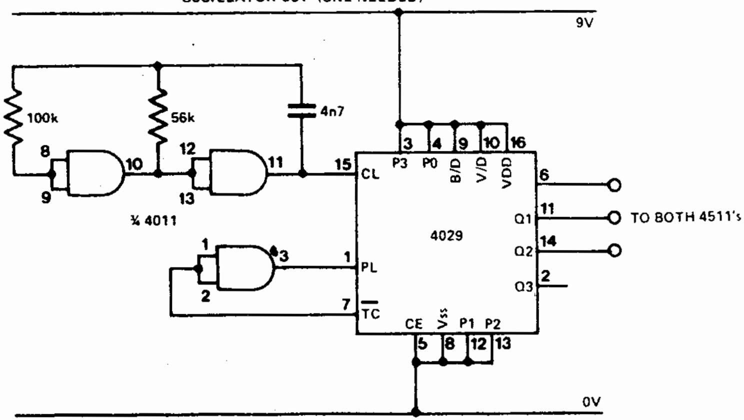


This is the exact size of the PC board for Digi Dice, shown here with foil side up. If you do not care to etch the board yourself, order a pre-etched and labeled Niccum kit.




CIRCUIT 1 (2 NEEDED)

OSCILLATOR CCT (ONE NEEDED)




## Dual Digital Dice

Russel Sharp

Two identical seven-segment display driver circuits, driven from a common counter circuit, provide the numerals for this dice.

The counter is driven from a 2 kHz oscillator, the 4011, and generates a count sequence from 1001 to 1110. The terminal count (low on output 1111) is inverted to load 1001 into the parallel input of the 4029. When your finger is pressed on the touch pad the collectors of Q1 and Q2 go high and pins 4 and 5 on the 4511 are held high for about three seconds after your finger is removed from the touch pad. The delay is provided by C1 and R1, together with the 4081 gate. The high on pin 5 of the 4511 loads the last data present on the address inputs (A0 to A2) into the latch of the 4511, whilst a high on pin 4 releases the display from the 'blank' mode to display the contents of the latch. The number is then displayed. When pin 4 goes low again after three seconds, the display is blanked to conserve battery power.

The high clock frequency ensures that the dice has a random result. Even if you attempt to touch both pads simultaneously, each die shows a different throw.