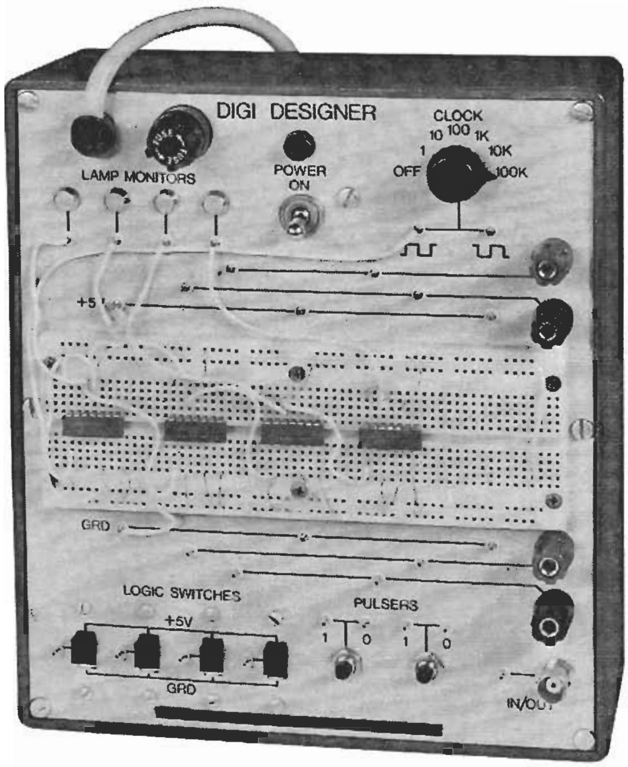
DIGITAL IC BREADBOARD
Build It Yourself

For fast breadboarding of digital IC circuits you need more than just a breadboard. You also need a power supply; a clock generator; and some logic switches. Here's a single unit that has it all

by JACK CAZES



HOW OFTEN HAVE YOU BREADBOARDED AN IDEA AND WISHED you had a fast, solderless way to do it so you could spend more time testing your circuit than wiring it? Have you ever ruined heat-sensitive components such as transistors and IC's because of repeated soldering and unsoldering? Do your breadboarding attempts sometimes end up as a cumbersome maze of boxes—experimental circuit in one box, power supply in another, logic indicators in still another?

The DIGI-DESIGNER incorporates many circuits that the serious digital hobbyist uses to design relatively complex digital circuits, all in a single, compact unit, and . . . it uses two unique new breadboarding components that enable you to make solderless connections by simply pushing wires into holes. Connections to and from circuits *within* the Digi-Designer are made by inserting the stripped ends of pieces of No. 22 solid wire into small holes in the tops of *breading pins*; these are miniature, feedthrough, Teflon-insulated terminals that serve as low-resistance solderless connecting points.

Integrated circuits, transistors, capacitors, resistors, etc., plug into solderless terminals of a unique breadboarding socket. It has 128 sets of five electrically connected terminals each, at the center; and 8 sets of 25 electrically connected terminals each along each edge. The terminals in the center are spaced 0.1-inch apart to accommodate the pins of a DIP (Dual Inline Package) integrated circuit. When an IC is plugged into the breading socket, four connections can be made to each of its pins without soldering or additional jumpers. The groups of terminals at the edges of the socket are handy where numerous connections must be made to common circuit points, such as ground, V_{cc}, and reset bus.

Circuits that are built into the DIGI-DESIGNER include

- A transistor-regulated 5-volt power supply, that can deliver up to several hundred milliamperes,
- A six-decade 1 Hz to 100 kHz digital clock generator, with complementary outputs,
- Two manual bounceless (digitally conditioned) pulsing buttons, also with complementary outputs,
- Four logic-level lamp monitors, each with its own Darlington transistor driver circuit, and,
- Four logic switches.

Building the Digi-Designer

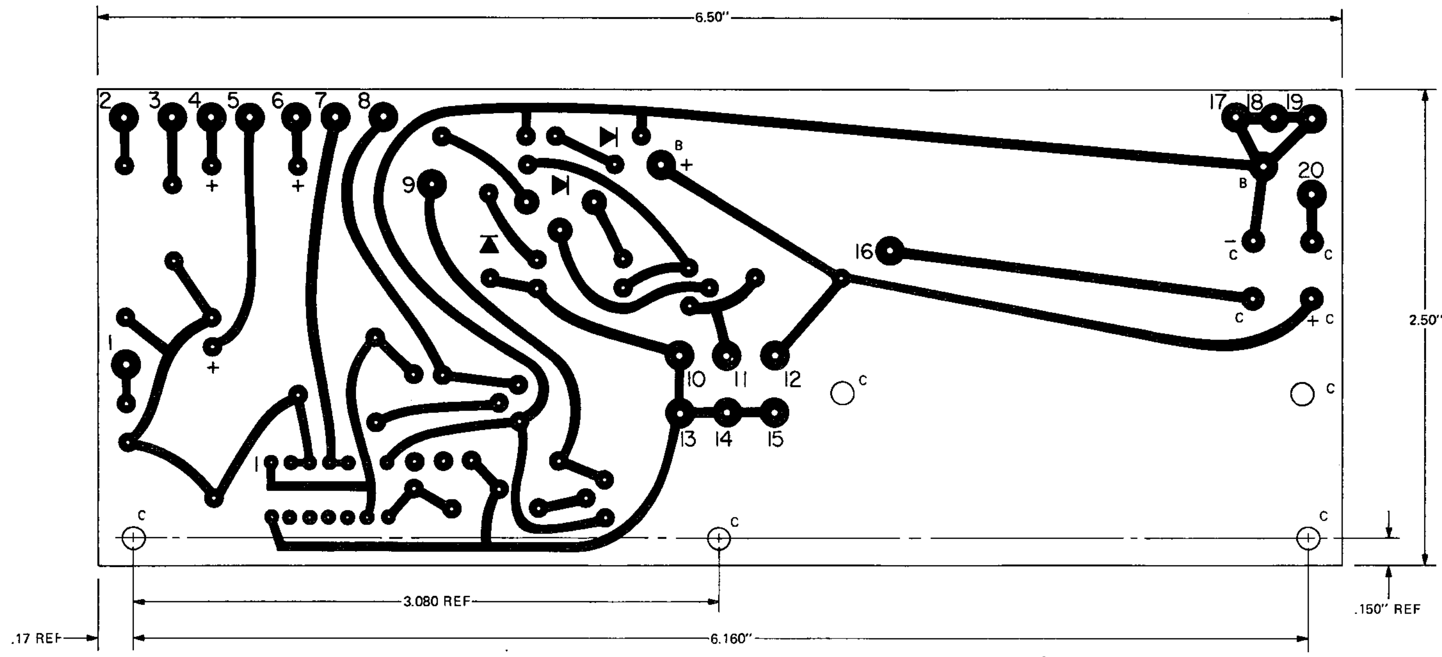
Wiring and component layout are not critical, but should be kept neat to make debugging (if necessary) easy. The front-panel layout shown is a convenient arrangement that minimizes the number of crossed and tangled leads. Make the front panel first. This includes drilling, painting, and marking. Dry-transfer lettering is handy here. Next, install all front-panel mounted components; lamps, switches, breading pins and socket. Also install four insulated 5-way binding posts and a BNC connector along the right edge of the case. These were selected to mate with a variety of commonly used pieces of test equipment. It might be a good idea to check your own test gear and select connectors that match them.

Install breading pins by first slipping their insulators into No. 29 holes drilled in the front panel, and then pushing the metal posts through the insulators with the flat side of a heavy pair of pliers. Be sure to push the metal post straight in, with little or no lateral wobbling. Careful insertion results in even expansion of the insulator at the rear of the panel, with a solid fit.

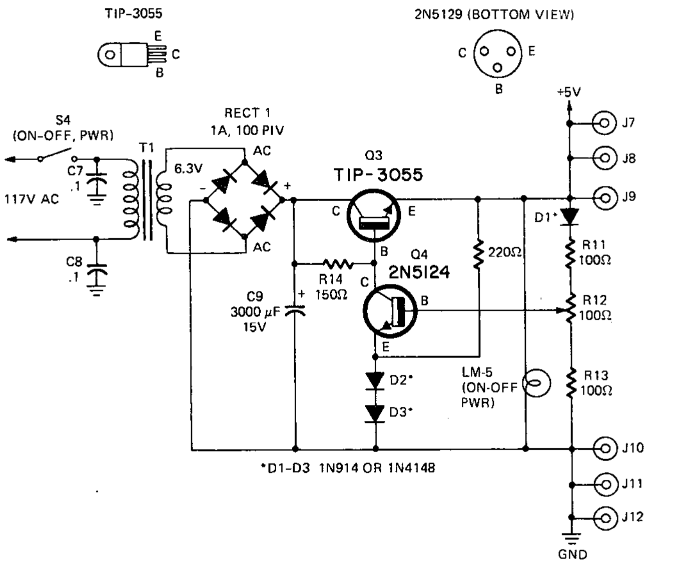
Fasten the breading socket to the case with the six countersunk screws provided. No permanent electrical connections are made between the socket and the rest of the Digi-Designer. Be sure, when fastening the socket, that the self-stick insulating backing is between the socket and the case to prevent any of its metal terminals from shorting to the case.

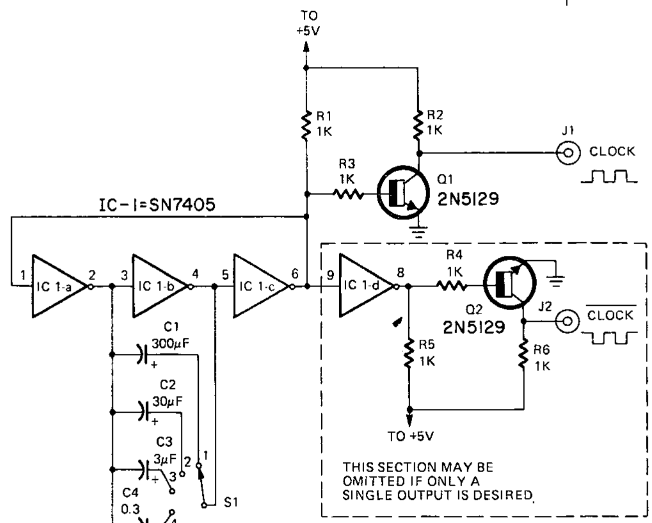
The power supply, pulser button conditioning circuits, clock circuits, and the lamp drivers are all on printed circuit boards. The power supply and clock circuit are on one board, the pulser circuits are on another board, and the lamp driver circuits are on a third. Insert components in their respective locations on the boards according to the drawings. Be sure to use a temporary heat sink, such as a pair of long-nose pliers, when soldering transistor and IC leads to the copper foils on the boards, since they can be easily damaged by overheating. DIP sockets are not required, but are convenient for mounting the IC's.

Now connect all panel-mounted ground points together with a piece of bare wire. These include J10, J11, J12, one side of S5 thru S8, J26, J30, the outside of J28, and the com-



MAIN PRINTED CIRCUIT BOARD (above) is used for both the clock generator and power supply. CLOCK-GENERATOR CIRCUIT (right) is simple and easy to build. POWER-SUPPLY CIRCUIT (below) uses Zener-diode regulation.





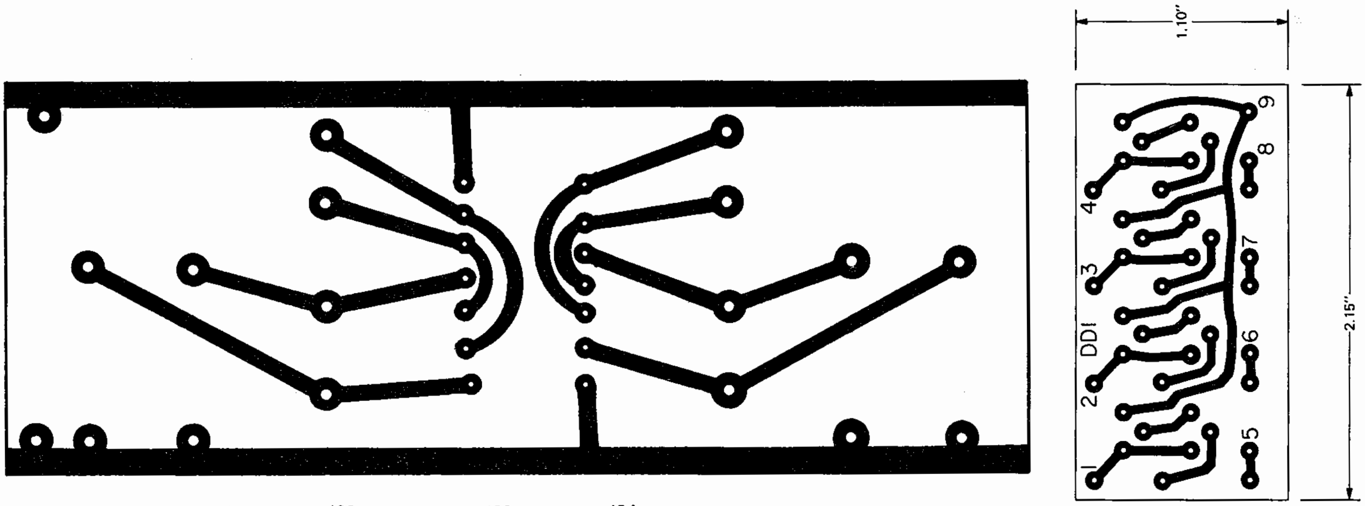
S1 POS'N	FREQ. NOMINAL
1	1 Hz.
2	10 Hz.
3	100 Hz.
4	1 kHz
5	10 kHz
6	100 kHz
7	OFF

All resistors ¼ watt 10% unless noted
R1 thru R10—1000 ohms
R11, R13—100 ohms
R12—100 ohms, trimmer
R14—150 ohms
R15—220 ohms
R16 thru R19—22,000 ohms
All capacitors 15V ceramic unless noted
C1—300-μF electrolytic
C2—30-μF electrolytic
C3—3-μF electrolytic
C4—0.3 μF
C5—0.03 μF
C6—0.003 μF
C7, C8—0.1-μF 400V
C9—3000-μF electrolytic
Q1, Q2, Q4 thru Q12—2N5129
Q3—TIP3055 or 2N3055
IC1—SN7405
IC2—SN7400
D1, D2, D3—1N914 or 1N4148
RECT—Full-wave bridge rectifier, 1 amp, 100 piv
T1—117 Vac primary, 6.3V secondary, 1.2A (Stancor No. P6134 or equal)
S1—single pole, 7-position, non-shorting selector switch
S2, S3—spdt monetary pushbutton
S4—spst toggle
S5 thru S8—spdt toggle
LM1 thru LM5—5V, 50mA lamps
SOCKET—EL breadboarding socket SK-10
J1 thru J29—EL breading pins
J30, J31, J33, J34—Five-way binding posts
J32—BNC panel connector
Misc:—PC boards, DIP sockets, case. etc.
A complete kit of all parts needed to build the Digi-Designer, including a case, is available for $49.95 including postage. An SK-10 socket and 29 breading pins are available for $24.95, postpaid. E. L. Instruments, Inc., 61 First Street, Derby, Conn. 06418.
Kit DES-1, consisting of the IC's needed to perform the experiments described in this article (3-SN7400, 4-SN7490, and 1-SN74181 selected for the computer circuit described is available for $17.95, postpaid, from Electronetics Co., Inc., P.O. Box 278, Cranbury, N.J. 08512.

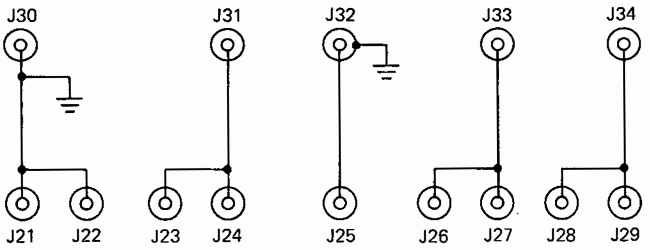
mon terminals of S2 and S3. Similarly, use a length of insulated wire to connect all panel-mounted 5-volt points together, including J7, J8, J9, and the other side of S5 thru S8. Also install the jumpers between the output connectors and their respective breading pins.

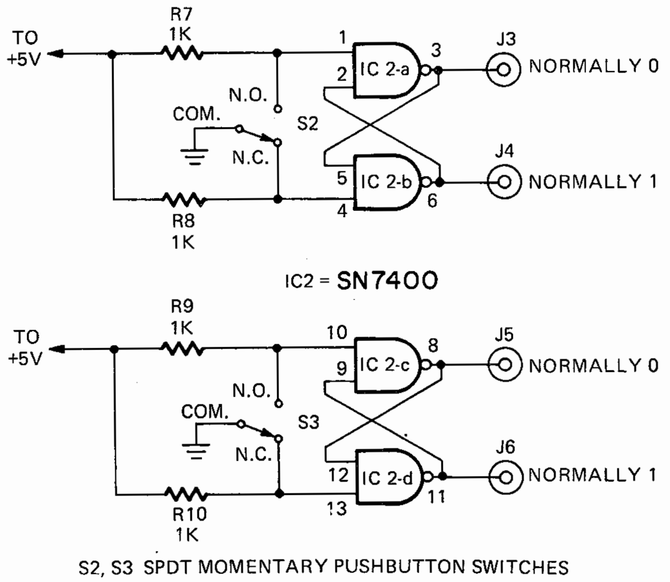
The power supply/clock board is mounted on the rear of the panel after making connections between it and other panel-mounted components. Mount the lamp driver board directly onto the lamp terminals with stiff connecting leads that are sturdy enough to support it. Similarly, mount the pulser board onto the pulser switches. Next, tie all ground points together and all 5-volt points together on boards and other components. Finally, wire the transformer primary circuit and connect a line cord to it.

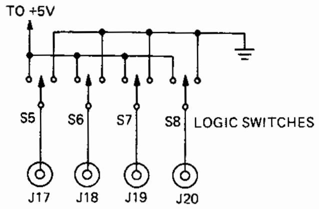
Set R12 for an output voltage of less than 5 volts at any convenient tie point (at J7, for instance). Plug IC1 and IC2 into their respective sockets, making certain that pin 1 of each IC is in socket position 1. Adjust R12 so that the output volt-

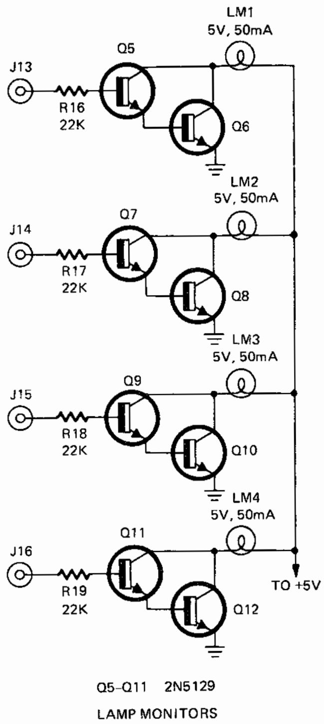


TWO CIRCUIT BOARDS used in the digital breadboard. The one at the top left is for the pulsers. The one at the top right is for the lamp-driver circuit.









OUTPUT JACK connections (top left) for the Digi-Designer. PULSER SWITCH circuits are shown at the left.

age is exactly 5.0 volts.

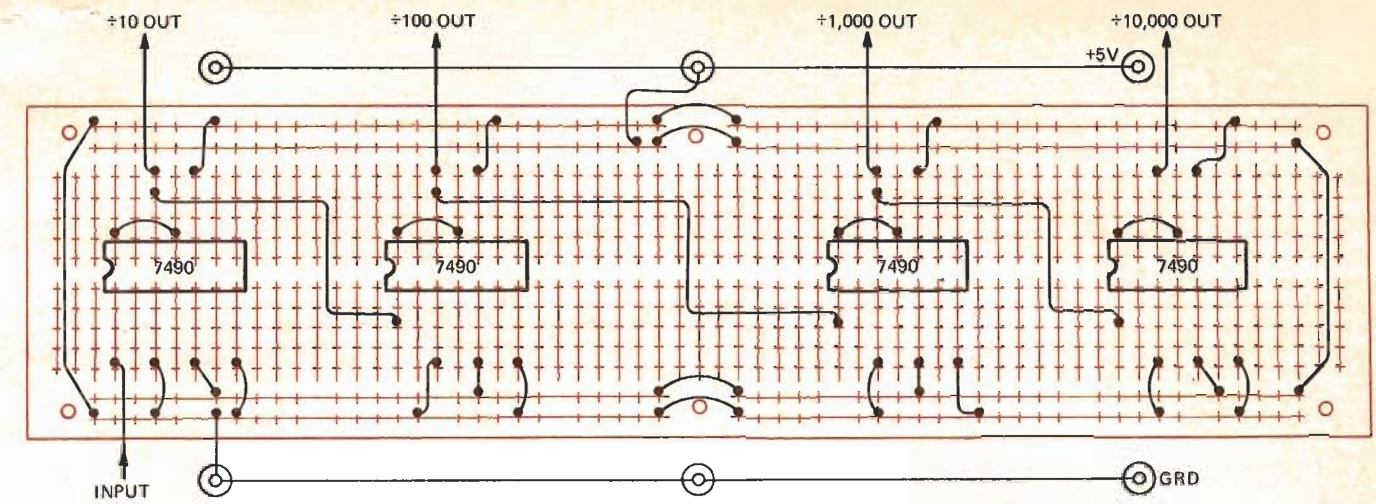
Measure the voltage between each of the 5-volt pins (J7-J9) and ground (J10-J12) to see that 5-volts is present at each of these locations. Connect jumpers from each of the lamp-monitor pins to 5 volts. They should light. If they do not, and you're sure that all your wiring is correct, then check the lamps with an ohmmeter. Also, check or replace the driver transistors in those circuits that are inoperative, since it is easy to damage these by careless soldering. If all lamps are operating properly (off when grounded, and on when connected to 5 volts), they can now be used to check other circuits in the Digi-Designer. Connect jumpers from each of the logic switch common pins (J17 thru J20) to lamp monitors. With the switches in their grounded positions, all lamps should be off; in the 5-volt positions, lamps should be on.

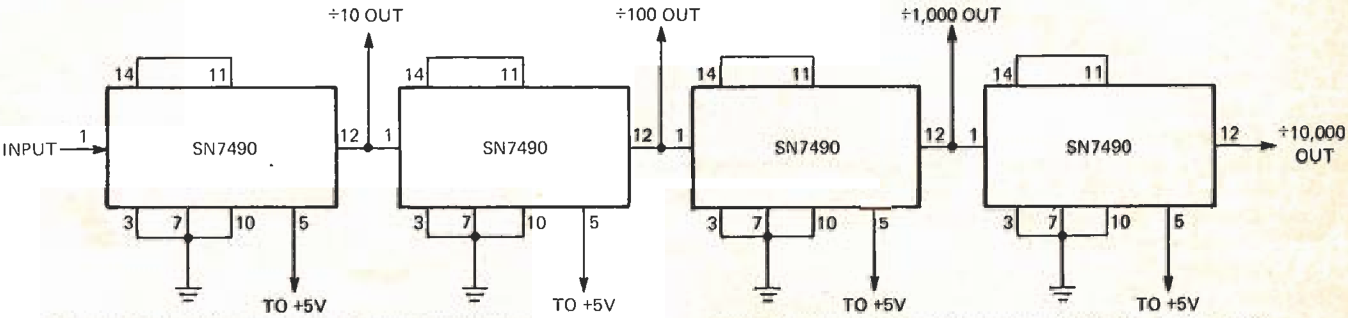
Move the jumpers to connect the pulser button output pins (J3 thru J6) to the lamp monitors. A logic "1" output should turn on a lamp, whereas a logic "0" output should turn a lamp off. Now connect the complementary clock generator outputs (J1 and J2) to two of the lamp monitors. Set the clock selector switch (S1) to the 1 Hz position. The lamps should turn alternately on and off at a rate of about once per second. With the selector switch in the 10 Hz position, the on-off flashing should be barely discernible. Higher frequency settings should cause both lamps to appear to be on continuously, at about half-normal brilliance. If a scope or frequency counter is available, measure the actual frequencies and record them for future reference. The capacitor tolerances are generally so broad that actual frequencies obtained will probably be quite different from the nominal values. In my prototype, the following frequencies were measured:

NOMINAL SETTING	ACTUALLY MEASURED
1 Hz	1 Hz
10 Hz	12.5 Hz
100 Hz	122 Hz
1 kHz	1.4 kHz
10 kHz	13.6 kHz
100 kHz	143 kHz

Using the Digi-Designer

Let's look at a few examples of how to use the Digi-Designer to breadboard and operate digital circuits. Remember, all you have to do to make a connection is to push the stripped ends of wires, or the bare ends of component leads into the holes in the breading socket and breading pins. External pieces of equipment (scope, meter, power supplies, etc.,) are plugged into a mating *external connector,* with breading pins serving as breadboarding tie points.





Four-Decade Scaler—Plug four SN7490 integrated circuits into the breading socket as shown above. Here, as in most cases, several 5-volt and ground connections are involved. It's convenient to set up long strips of tie points for this. It should take only a few minutes to hook up the scaler circuit shown in the schematic; one possible physical arrangement is shown. Connections to the input and the four outputs are determined by the end use to which the scaler will be applied. You might try connecting the input to the CLOCK or to the PULSER button, and the outputs to lamp monitors or to a scope to observe the various input/output relationships for the four scaler stages. Thus, we have built, in a few minutes, an extremely accurate frequency scaler for use in digital division applications, such as digital clocks, calculators, digital measuring instruments, etc. Additional decade stages can be included by moving the IC's closer together.

Digital Binary Adder Circuit—In many computers, addition and subtraction are the only functions performed. Multiplication, division, exponentiation; are carried out by multiple additions and/or subtractions. The binary adder described here represents the basic arithmetic building block of such a computer. In actual use, numbers consisting of more than a single bit (as is generally the case) are handled in either of two ways:

1. Have a *full adder* to handle each bit simultaneously,
2. Feed the bits, one at a time, to a single, high-speed full-adder.

Wire the half-adder as shown below and note the states of the SUM and CARRY outputs that result from various combinations of A and B inputs. Now, build two half-adders and connect them together as shown in the schematic, to form a single-bit full-adder. Again compare input/output relationships. This time, a CARRY INPUT is provided. This input accepts the CARRY OUTPUT from a previous stage.

I think that these examples have shown you how you can make use of your Digi-Designer to conveniently design, assemble, and test relatively complex digital circuits, even a small computer, without soldering . . . and in only a few minutes. **R-E**