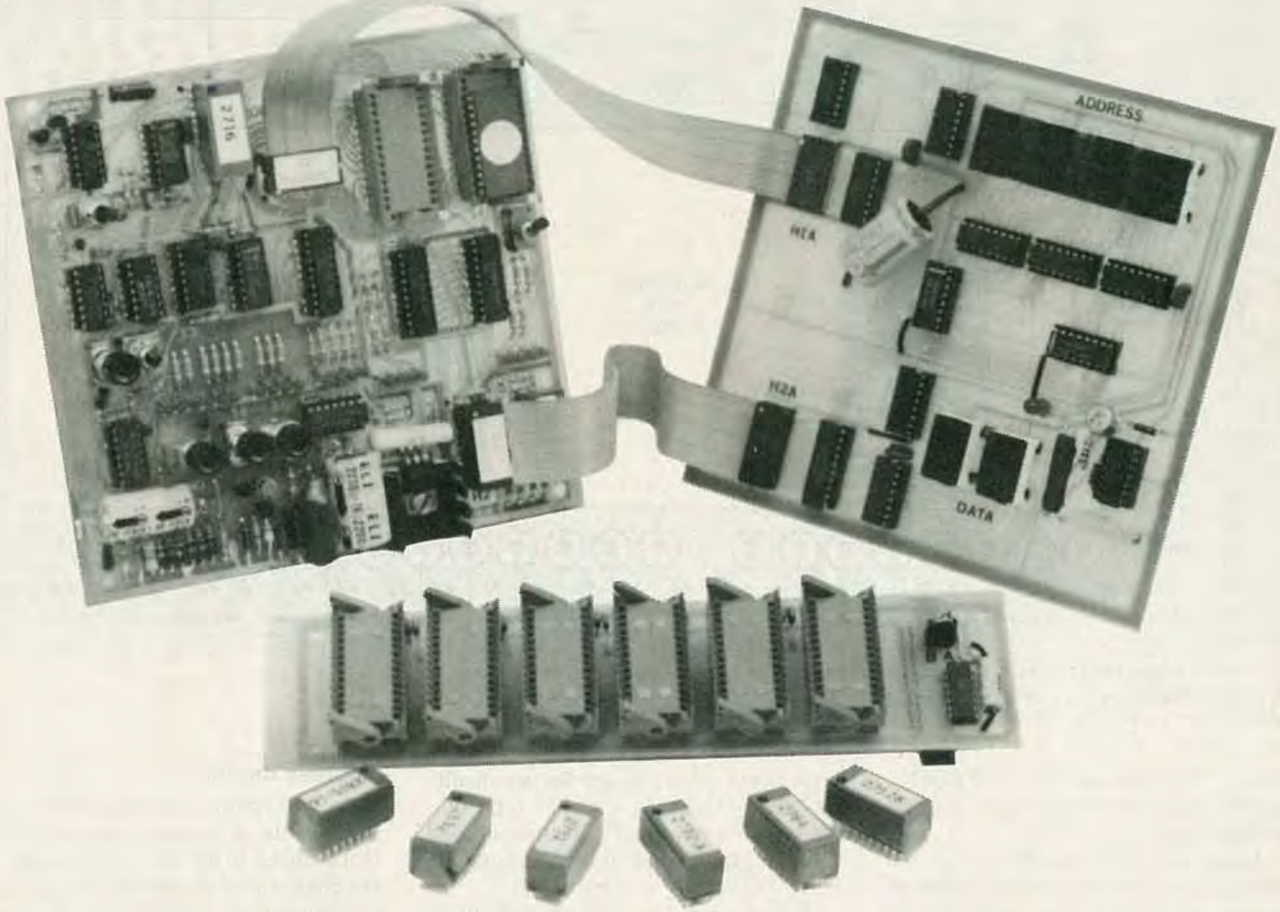

EPROM PROGRAMMER

Our low-cost EPROM programmer can burn all the popular types, including EEPROM's!

LUBOMIR B. SAWKIW

THE MICROPROCESSOR IS TURNING UP IN some very unlikely places these days. You might find one in a TV remote control, an automotive ignition and timing circuit, a video game, or even a microwave oven. But a microprocessor can't do the work all by itself: It requires permanent memory that stores the data and instructions that allows it to do its job. And that's where the EPROM comes in. It can provide a low-cost way of developing, testing, and even distributing data and programs for many types of computer systems.

EPROM's aren't used solely with computers, of course. Often a complex logic problem that would require numerous individual gates can be solved with a small EPROM.

So, sooner or later, whatever your involvement with digital electronics, you'll find it necessary to burn (program) an EPROM. And we've got an inexpensive way of doing so. Our EPROM programmer can be built for about $60 (less PC board) in its basic form, and it can burn all of the popular five-volt EPROM's in both 24- and 28-pin packages, as well as several popular types of EEPROM's. The unit allows you to burn single locations one by one, burn one value into a number of consecutive locations, or copy one entire EPROM to another. An optional multi-EPROM board allows you to program up to six EPROM's simultaneously.

Features

The programmer is a stand-alone unit; no computer or ASCII display terminal is required to operate it. But it has input/output lines (labeled A–G in Fig. 1) that you can use to automate control of all functions.

In the basic programmer, data input is provided by an eight-position DIP switch (S8), and addresses are selected by means of FAST (S5) and STEP (S6) switches. Address and data lines are displayed in binary by 22 discrete LED's (LED1–LED22). An optional display board allows you to view the address and data lines in hexadecimal.

The programmer has a verification feature that allows you to view the contents of each EPROM location after that location has been programmed.

Personality modules are used to accommodate a variety of EPROM's. The personality module matches the operating requirements and pin assignments of each EPROM to the address, data, programming and timing signals developed on the programmer board. By using the appropriate personality module, you can program the 2716, 2732, 2732A, 2764,

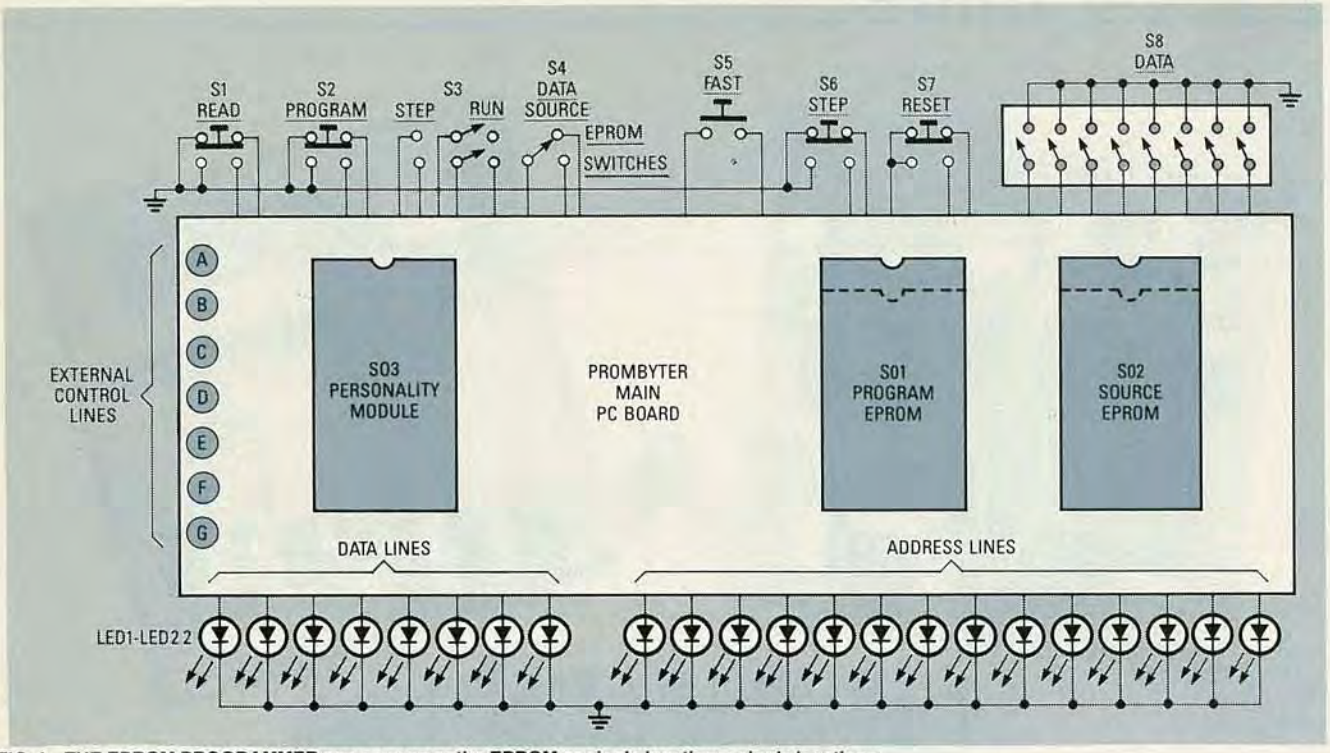

FIG. 1—THE EPROM PROGRAMMER can copy an entire EPROM or single locations; single locations can also be programmed manually. Separate sockets are provided for source and program EPROM's, and for plug-in personality modules that feed each type of EPROM the proper signals.

27128, 2758, 2516, and 2532 EPROM's; the CMOS versions of those devices; and the 2815/2816 EEPROM's.

Manual operation is simple. You set the DIP switches to the desired data, then set the FAST and STEP switches to the desired address, and last press the PROGRAM switch (S2). When that location has been programmed, the programmer automatically moves to the next location.

Circuit description

Except for the AC transformer, the entire power supply is contained on the main PC board. As you can see in Fig. 2, the regulated five-volt supply is derived from an eight-volt AC input. That AC is rectified by bridge BR1, filtered by capacitor C7, and then regulated by IC14, a 7805 regulator. Output capacitor C6 and bypass capacitors C10 through C17 further filter the +5-volt line. Optional resistor R57 provides extra power for the optional display board.

The 25-volt AC input is rectified and filtered for two purposes: to provide the +35-volt programming voltage (V_{PP}), and to provide the 120-Hz clock signal that is the core of the circuit's timing chain. Diodes D4 and D9 isolate the clock circuit from the V_{PP} output. Zener diode D10 clips the positive half-cycles of the unfiltered output at about 9 volts. Then IC7-b and IC7-c square up those pulses.

The programming voltage, V_{PP}, is what "burns" each bit into an erased EPROM. Digital control of V_{PP} is provided by IC7-f and IC7-a. When a high level signal is fed through the personality module (SO3) to pin 13 of IC7-f, the output of IC7-a goes high, Q1 turns on, Q2 turns off, and that allows D2 to bring the base of Q3 up to +25 volts.

At that point Q4 turns on and allows approximately +25 volts to appear at its emitter. That voltage is fed back to pin 8 of SO3. Capacitors C2 and C3 prevent a transient overshoot of the +25-volt line during switching. An overshoot of more than one volt could ruin the EPROM you are programming. Components in some personality modules reduce the +25- to +21-volts, for EPROM's that need +21 volts.

Transistor Q5 is used to prevent V_{PP} pulses from damaging an EPROM when power is removed from or applied to the circuit. As stated previously, Q2 normally conducts and shorts out Zener diode D2. However, Q2 is biased from the +5-volt supply line. If for any reason during power up the +35-volt line receives power an instant before the +5-volt line, Q3's base would shoot up to about +26-volts, and a +25-volt program pulse would appear on the V_{PP} line.

To prevent that surge, Q5's emitter is connected to the +5-volt supply, and its base is biased at +4.7 volts from the voltage at Q3's base by means of Zener diode D3. So, if the base of Q3 were trying to go up to +26-volts, and the +5-volt supply were not quite up yet, Q5 would be forward biased, so it would conduct through R52, and thereby reduce the voltage at the base of Q3.

Address circuit

Overall operation of the circuit is governed by the FUNCTION switch, S3. When that switch is in the RUN position, the 120-Hz clock signal causes operations to occur sequentially every 1/120th of a second. When S3 is in the STEP position, addresses must be set manually, and PROGRAM switch S2 must be pressed for each location that is to be programmed by the EPROM programmer.

Addresses are selected by pressing switches S5 and S6. When switch S6 is pressed, it is debounced by IC5-a, which delivers one pulse through IC6-b and IC6-d to IC8, a 4040 12-stage binary counter. That pulse increments the address held in IC8 by one. On the other hand, when switch S5 is pressed, it connects the 120-Hz clock signal to IC6-b and IC6-d, and then to IC8, which then increments at a rate of 120 Hz.

Since larger EPROM's have as many as 14 address lines, and the 4040 has only 12 outputs, IC3-b is also used as an address counter. When pin 1 of IC8 goes low, IC3-b increments. Its A, B, and C outputs provide the A12, A13, and A14 address lines. Two IC's buffer the current address for display on LED1–LED14: IC9 and IC10.

Reset

Switch S7 forces the system to reset. When that switch is pressed, a reset pulse is fed to all counters and flip-flops. Also, a reset pulse occurs at power up by means of C1's charging up through R8.

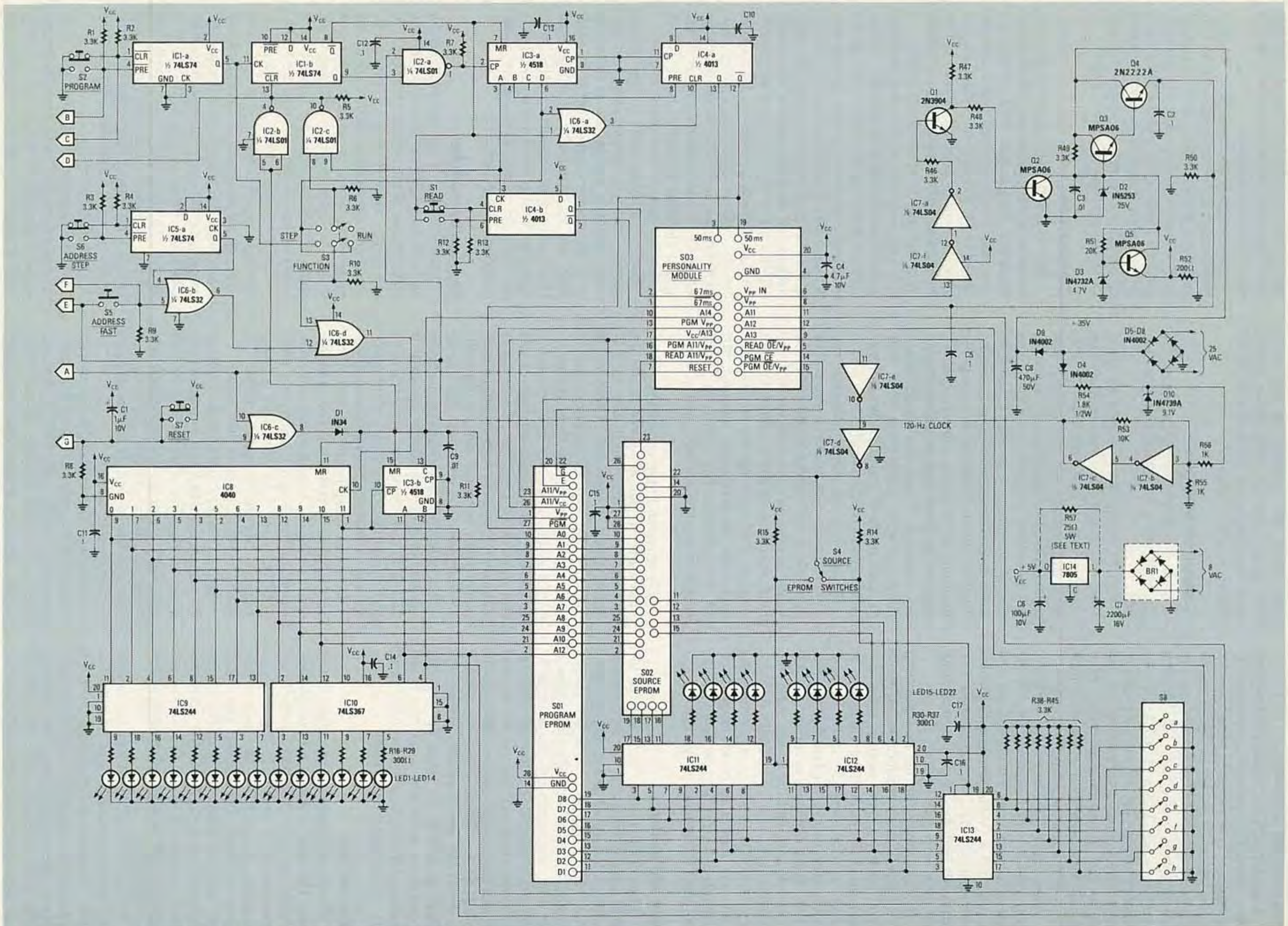

FIG. 2—THE EPROM PROGRAMMER IS DRIVEN BY A 120-Hz clock circuit that is generated by IC7-c and IC7-d; LED's indicate addresses and data in binary.

Programming circuitry

Assume that S3 is in the STEP position. Then, when S2 is pressed, a program cycle begins. That switch is debounced by IC1-a, which clocks IC1-b. The Q output of of IC1-b allows the 120-Hz clock (at pin 2 of IC2-a) to be fed to IC3-a. The first count to reach IC3-a is fed to IC4-b, which provides the 67-ms data gating pulse. The second pulse presets IC4-a and begins the 50-ms program pulse. Both signals stay high until count 8, which clears IC4-a and ends the 50-ms pulse.

When count 9 arrives NAND gate IC2-c clears IC1-b, which prevents the 120-Hz signal from passing through IC2-a and counter IC3-a. At that time $\overline{Q}$ of IC1-b also goes high, resets IC3-a, and clears IC4-b. That ends both the 50-ms program-pulse and the 67-ms gating pulse.

If S3 is toggled to the RUN position, NAND gate IC2-c never receives the ninth count, so IC1-b is not cleared, and IC3-a continues to count until the tenth pulse, at which time it internally resets to zero. Since there is no reset signal from $\overline{Q}$ of IC1-b, IC3-a continues to count, so IC4-b is not cleared, and the 67-ms pulse line remains high. Also, count eight (available at pin 6 of IC3-a) is used to increment the address counter (IC8) in this mode. If S3 is toggled to STEP, the next count of nine will reset the programming cycle.

Data verification

When S3 is in the STEP position, the 4040 address counter is not incremented until S2 is released and Q of IC1-a goes low. That low-going transition passes through S3 and IC6-d to the clock input of the 4040 and increments the address by one. So, if you hold S2 down after a location is programmed, you can see whether that location has the correct data by examining LED15–LED22. When you're ready to go to the next location, release S2. There is no way to "back up" by one location (or more than one). You'll just have to reset the prom burner, or cycle all the way around through ØØØØ.

Data section

The programmer has an eight-bit data bus. The logic levels of all bits are displayed by LED15–LED22, which are driven by IC11 and IC12. The data displayed by those LED's (and used to program an EPROM) is chosen via switch S4, SOURCE. When S4 is in the EPROM position, the EPROM in SO2 provides data; when S4 is in the SWITCHES position, DIP switches S8-a through S8-h provide data.

Pushbutton switch S1 can be used to view the contents of the source EPROM in SO2. When that switch is pressed, IC4-b is preset, and that activates the 67-ms data gating line, which places the program EPROM in a standby mode. In addition, that signal places the source EPROM in a read mode, and connects its data input pins to the data bus. That allows you to view the contents of the source EPROM before programming.

Component selection

With that basic understanding of the circuit in mind, let's build a programmer now.

Our PC board was designed for miniature, PC-mountable switches like those sold by Alco, C & K, and other companies. But you can use any switches that are functionally equivalent. If you use the PC-mountable switches, you can, with careful planning, secure the PC board directly to the front panel of your enclosure. To do so, just drill holes in the appropriate locations on the panel, and secure the PC board to the panel with the switch-mounting hardware. If you don't want direct-panel mounting, simply run wires from the pads on the PC board to the appropriate terminals on the switches.

In addition, for panel mounting, two 28-pin wirewrap sockets should be mounted at the correct height above the board in the holes provided for SO1 and SO2; then plug the ZIF sockets into those sockets. The same applies to SO3, the socket for the personality modules, and S8, the data input DIP switch. A 20-pin socket is required for SO3, and a 16-pin socket for S8.

Pay attention to the circuit's power requirements. If you are going to use the two option boards, you'll will need 8-volts AC at 1.2 amps and 25-volts AC at 280 mA. The two AC supplies must be separate; they cannot be taps on one winding or in any other way be connected to each other. Two separate windings on one transformer will suffice. Don't apply more than 10 volts to the 8-volt input pads on the board, nor more than 30 volts to the 25-volt pads. In addition, the circuit works only with a power-line frequency of 60 Hz, because the timing circuitry is locked to that frequency. Also, it's not a bad idea to fuse the primary of the transformer. A ¼-amp, 250-volt fuse will do.

Don't use bargain transistors; they can be destroyed at power up. For example, Q4 is a 2N2222A. Make sure your transistor has the A suffix, because a plain 2N2222 is rated for operation at lower voltages. Nor should you use a PN2222, which has limited power dissipation.

The personality modules are built on 20-pin headers which may be hard to find. If you have trouble locating them, you can substitute 20-pin machined-contact, solder-tail IC sockets instead. Those sockets have pins that are sturdy but thin enough to fit into an IC socket.

Although 74LS series IC's were used in our prototype, you may want to experiment with 74HC and 74HCT devices. They are CMOS versions of the 74LS series, and they feature speed and drive capacity comparable to those of the 74LS series, but with the advantage of CMOS's low power consumption.

Last, use good quality LED's. We have found that LED's vary greatly in quality and light output. Some hobbyist-grade LED's require a great deal of current to produce much light, and the 7805 can't provide a great deal of current and drive all the other circuitry. So stay with prime LED's or get high-brightness LED's.

Construction

Due to the complexity of the project, we recommend that you use a PC board to build the programmer. Foil patterns for one side of double-sided board are presented in PC Service; the other side will appear in next month's issue. A pre-etched and drilled board is also available from the source in the Parts List.

If you etch your own board, it likely will not have plated-through holes. In that case use wirewrap IC sockets mounted a little above the board so that you can solder each pin to both sides of the board. Make sure that you also solder all other components on both sides of the board.

Referring to Fig. 3, mount all components on the board as follows. First solder the two jumpers to the board using insulated wire for each. One is located to the left of Q3 in the lower left corner of the board; the other is located to the left of IC8 in the upper center of the board.

Begin soldering parts to the board, starting with the lower-profile components (resistors and diodes) and working up to the larger components (C8, SO1, SO2, and all switches). All the discrete LED's should be mounted so that their cathodes (usually the flat side) face IC14, the 7805. Be careful to mount all polarized components correctly.

Personality modules

Shown in Fig. 4 are the modules for each of the EPROM types mentioned above. Some of the modules are very simple; others require several components. We'll give construction hints only for the more complicated modules. After you verify that each module works correctly, pot it with epoxy, mark pin 1, and label it with the type of EPROM it is used with.

The 2532, 2732, and 2372A modules, shown in Fig. 4-*c*–Fig. 4-*e*, are the only ones that are hard to build. When building them, wire the jumpers and the discrete components first, and then install the 4001 CMOS IC. Break off pins 4, 10, and 11 of the IC. Then bend pin 3 under the IC and solder an insulated jumper to it; that jumper will connect later to pin 15 (for the 2532) or pin 14 (for the 2732 and the 2732A) of the module.

Short the unused input pins (5, 6, 8, 9, 12, and 13) to pin 7, and connect that pin to pin 4 (ground) of the module. Finally, bend IC pins 1, 2, and 14 so that they can

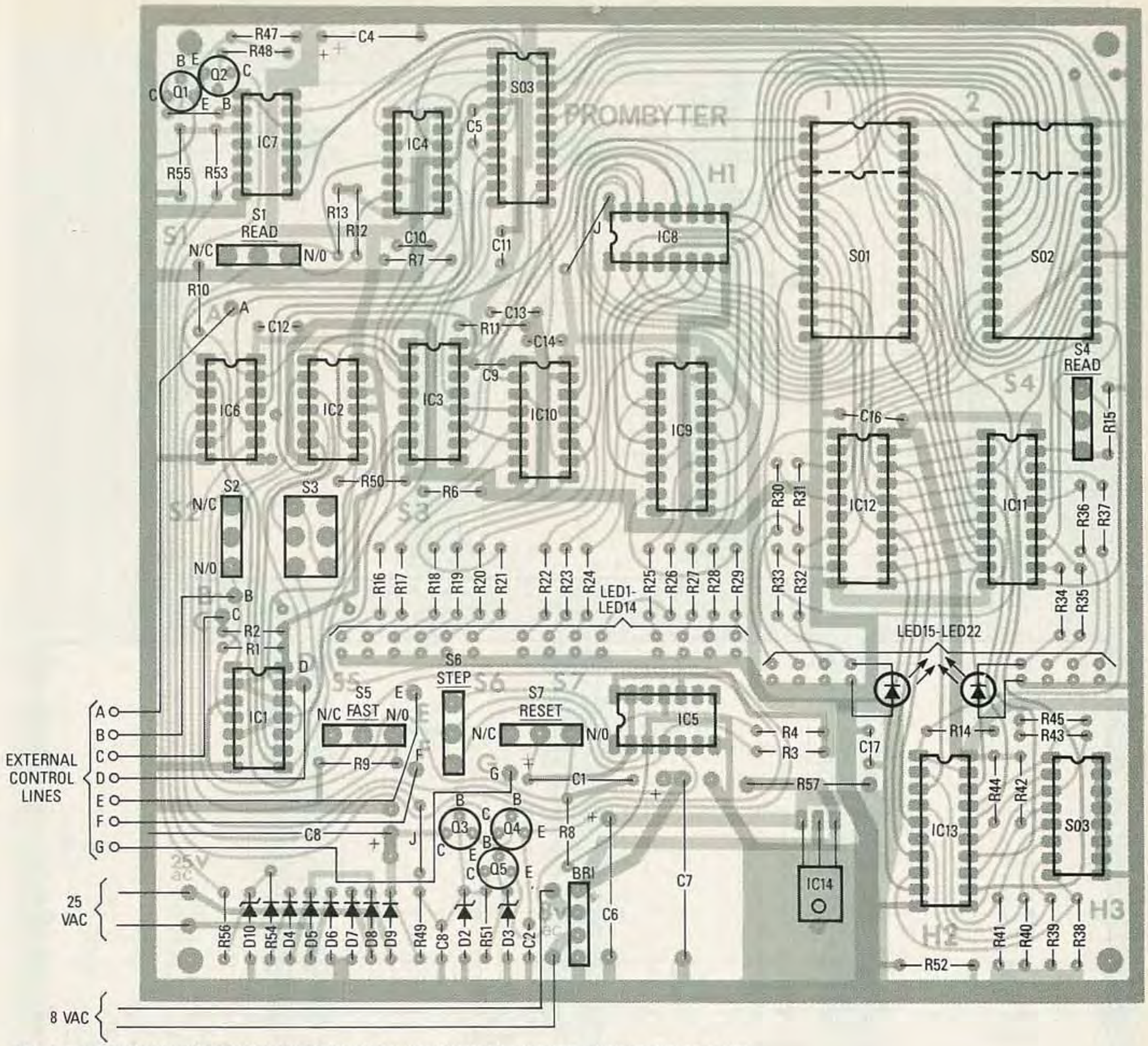

FIG. 3—THE EPROM PROGRAMMER'S PC BOARD is double-sided; all components mount as shown here. Since a home-made board's holes are not plated through, the IC sockets must be mounted slightly above the board so that the socket pins can be soldered to the top side of the board.

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.

R1–R15, R38–R50—3300 ohms
R16–R37—300 ohms
R51—20,000 ohms
R52—200 ohms
R53—10,000 ohms
R54—1800 ohms, ½ watt
R55, R56—1000 ohms
R57—25 ohms, 5 watts (see text)

Capacitors

C1—1 µF, 10 volts, electrolytic
C2, C5, C10–C17—0.1 µF, disk
C3, C9—0.01 µF, disk
C4—4.7 µF, 10 volts, electrolytic
C6—100 µF, 10 volts, electrolytic
C7—2200 µF, 16 volts, electrolytic
C8—470 µF, 50 volts, electrolytic

Semiconductors

IC1, IC5—74LS74 dual flip-flop
IC2—74LS01 quad 2-input NAND gate
IC3—4518 CMOS dual BCD counter
IC4—4013 CMOS dual flip-flop
IC6—74LS32 quad 2-input OR gate
IC7—74LS04 hex inverter
IC8—4040 12-stage binary counter
IC9, IC11–IC13—74LS244 octal 3-state buffer
IC10—74LS367 hex 3-state buffer
IC15—7805 5-volt regulator
BR1—1-amp 50-PIV bridge rectifier
D1—1N34A germanium signal diode
D2—1N5253 25 volts, 1 watt, Zener diode
D3—1N4732A 4.7 volts, 1 watt, Zener
D4–D9—1N4002 rectifier
D10—1N4739A 9.1 volts, 1 watt, Zener diode
LED1–LED22—miniature, high-brightness LED
Q1—2N3904 NPN transistor
Q2, Q3, Q5—MPSA06 NPN transistor
Q4—2N2222A NPN transistor

Other components

S1—SPDT, toggle, momentary
S2, S6—SPDT, pushbutton, momentary
S3—DPDT, toggle
S4—SPDT, toggle
S5, S7—SPST, pushbutton, momentary
S8—8-position DIP switch

Miscellaneous: Dual-secondary transformer: 8-volts at 1.2 amps, and 25-volts at 280 mA; heatsink for IC14; two 28-pin ZIF sockets; IC sockets, wire solder, case, etc.

Note: The following are available from Lubomir Sawkiw, P.O. Box 555, Rensselaer, NY 12144: A transformer with 25 and 10 volt AC secondaries, $8.00 plus $3.00 shipping and handling; 9368 Fairchild IC's, $4.25 each postpaid. New York residents must add 7% sales tax.

The following are available from E²VSI, P.O. Box 72100, Roselle, IL 60172: main circuit board, $25.00; hex display board: $15.00; gang board, $10.00; set of three boards, $45.00.

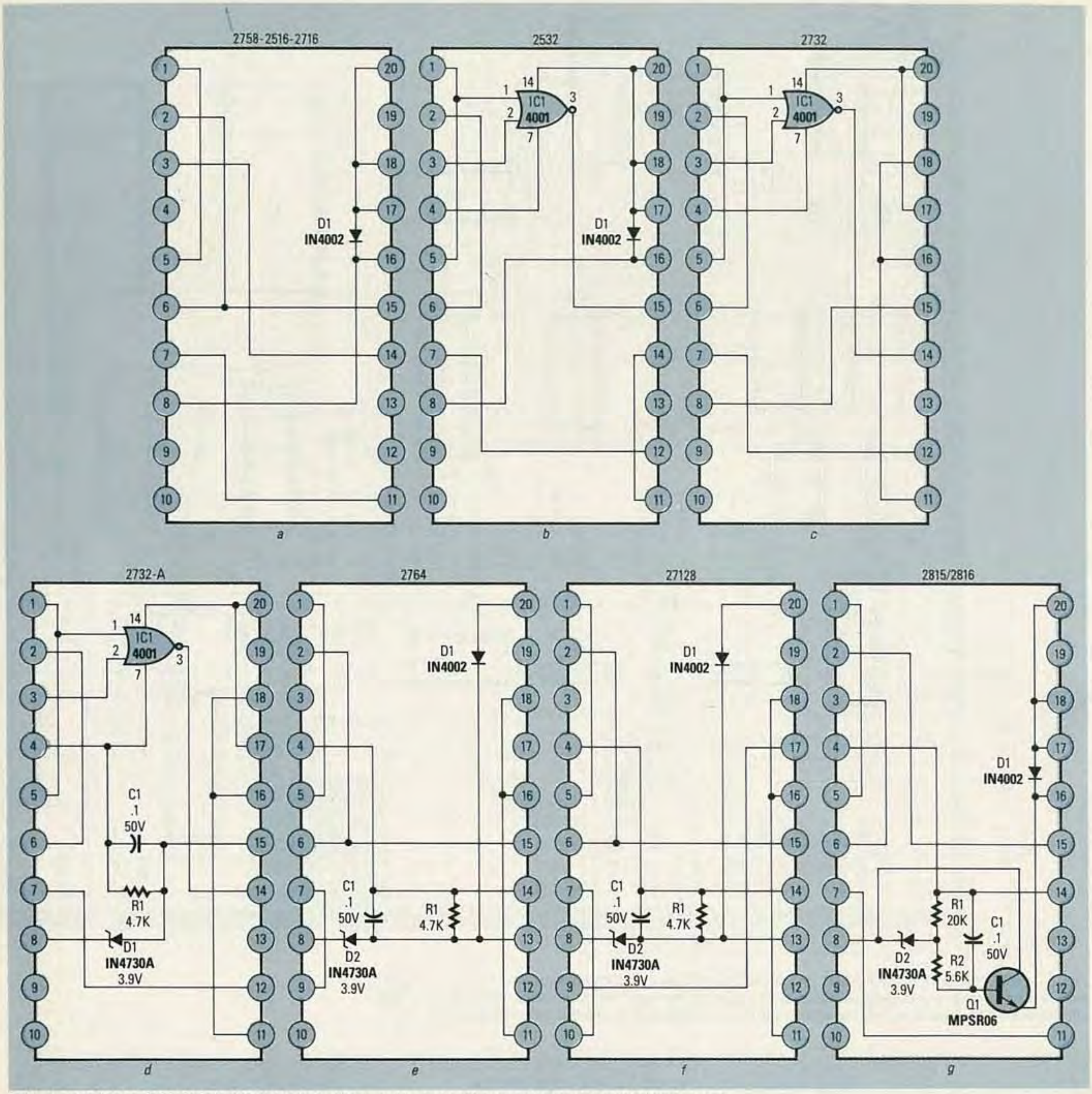

FIG. 4—EACH PERSONALITY MODULE is built on a 20-pin header; see the text for information on building the 2532, 2732, and 2732A modules.

attach directly to module pins 1, 3, and 20, respectively. When soldered in place correctly, the IC should sit firmly above the carrier wiring and components.

Initial check-out

Install all IC's and a personality module in the proper sockets, but don't install an EPROM yet. Measure the +5-volt DC output of the regulator IC as you power the board. To measure that (or any other) voltage on the board, do not clip the negative lead of your meter to the edge of the board; you would short out the power supply. Rather, connect your negative test lead to the negative side of C6, C7, or C8. After checking the +5-volt supply, measure V_{PP} across C8. The voltage there shouldn't exceed 40 volts. You need only about 27 volts to do the job; a higher voltage could destroy one of the transistors.

Now remove power and install an erased EPROM into SO1. Whether you use a 24-pin device (such as a 2716) or a 28-pin device (such as a 2764), the EPROM should be "bottom justified." In other words, pin 12 of a 24-pin device, or pin 14 of a 28-pin device should be plugged into pin 14 of the socket. After the EPROM is oriented properly, move the socket's locking lever to the closed position.

With power still off, insert the eight-position DIP switch in its socket. Mount it so that switch 1 is closest to the EPROM sockets. That places data bit Ø, on switch one and data bit 7 on switch 8. A closed DIP switch puts a low (logic Ø) on that line. An open switch puts a high (logic 1) on that line. At this point you should have an erased EPROM, the corresponding personality module, and the DIP switch inserted in the correct sockets. Place S3 in the STEP position, apply power, and press RESET (S7).

Next time we'll present more testing details, as well as plans for the optional display and gang-programming boards. **R-E**