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LOW-COST EPROM PROGRAMMER

BY DAN VINCENT

Now, you can program 1702A, 4702A, and 8702A EPROM's inexpensively.

PART 1

PROGRAMMING erasable read-only memories (EPROM's) has generally been beyond the reach of most electronics experimenters owing to the high cost of the machine required to do the job. Thus experimenters have been virtually limited to PROM's, in which fuse links are burned out and which, therefore, can never be reprogrammed. Now, with the low-cost EPROM Programmer presented here ($40 without power supply, $80 complete), it's anticipated that more and more electronics enthusiasts will use erasable (and reprogrammable) ROM's, where mistakes can be corrected as well as an entire program changed should this become necessary.

The EPROM Programmer is designed to operate with the highly popular 256-word-by-8-bit 1702A, and associated family (4702A, 8702A), EPROM's. Note that it is not compatible with other similar devices such as a 1701 or 1702. Also,

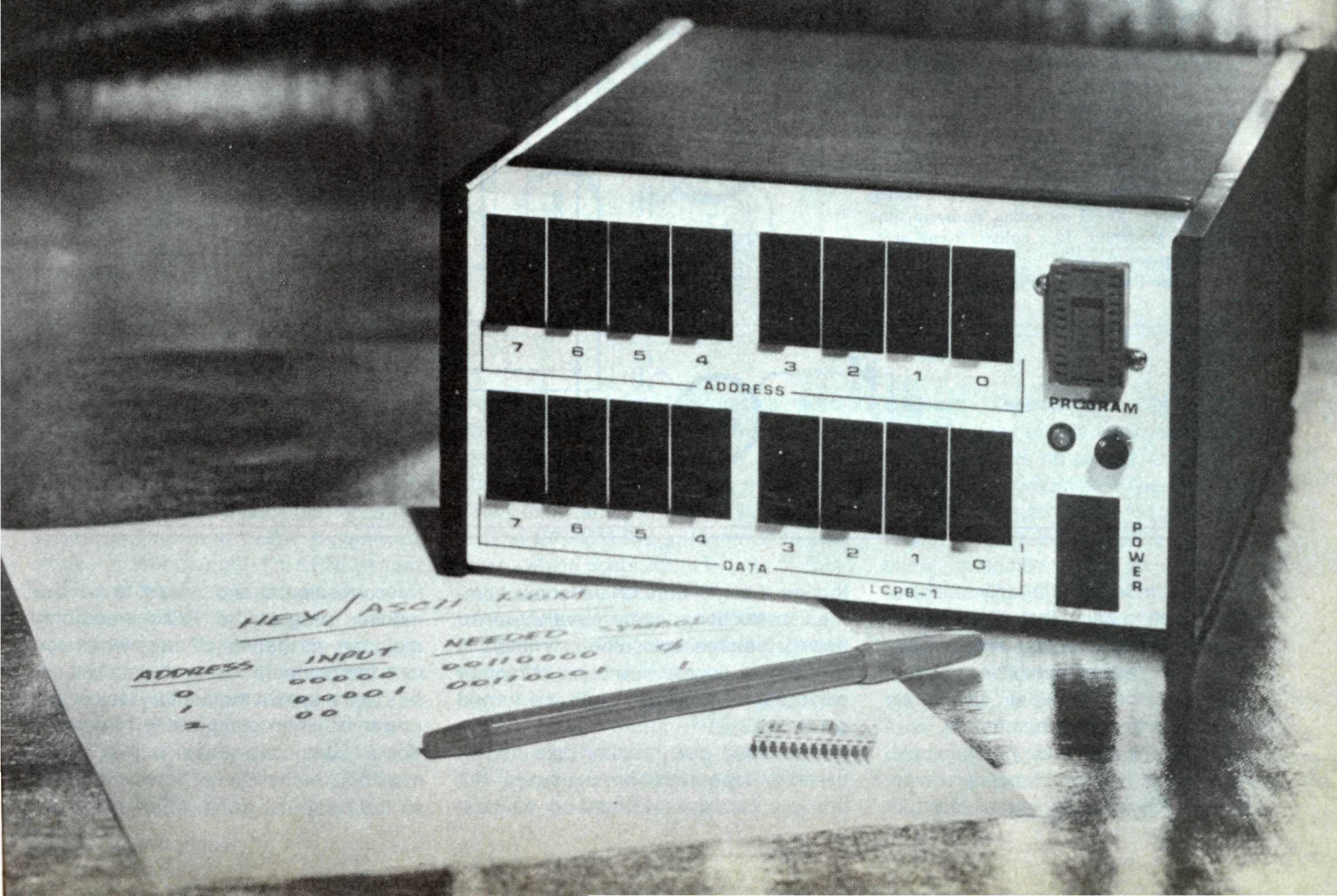
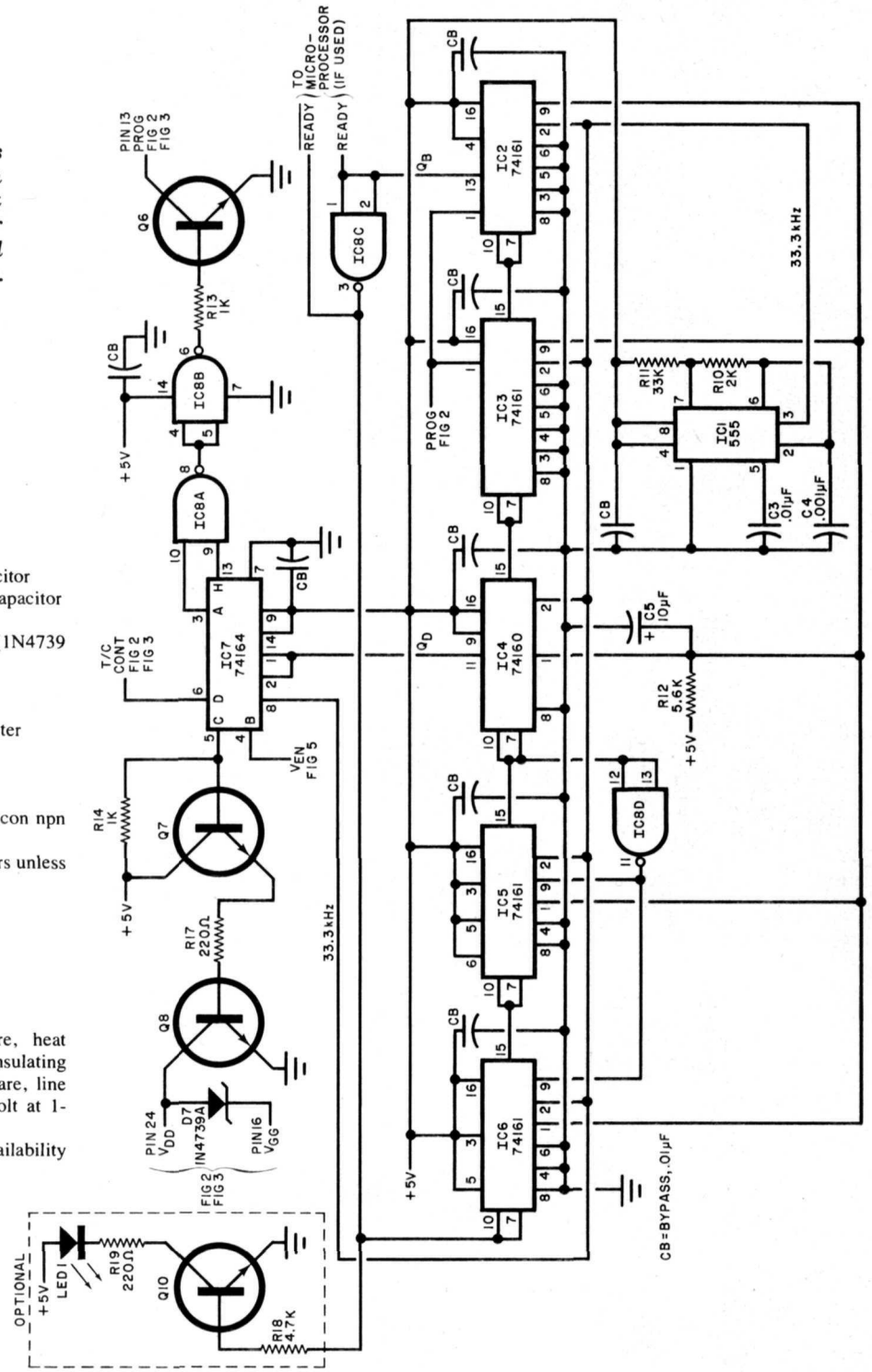


Fig. 1. System clock is IC1. Countdown chain and IC1 develop correct system timing for 1702A. LED1 is optional pulse timing monitor.



PARTS LIST

C3,C8—0.01-μF, 25-V ceramic capacitor
C4—0.001- μF, 10%, 25-V ceramic capacitor
C5—10- μF, 15-V electrolytic
D7—9.1-V, 10%, 1-W zener diode (1N4739 or similar)
D8—Red LED (optional)
IC1—555 timer
IC2,IC3,IC5,IC6—74161 binary counter
IC4—74160 decade counter
IC7—74164 8-bit shift register
IC8—7400 quad 2-input NAND gate
Q6,Q7,Q8,Q10—MPS-A05 60-V silicon npn transistor
The following are ¼-W, 10% resistors unless otherwise noted:
R10—2000 ohms, 5%
R11—33,000 ohms, 5%
R12—5600 ohms
R13,R14—1000 ohms
R17,R19—220 ohms
R18—4700 ohms
Misc.—Suitable chasis or enclosure, heat sink, thermal grease, transistor insulating hardware, #6-32 mounting hardware, line cord, grommets, fuse holder, 5-volt at 1-ampere power supply.
Note—See Parts List for Fig. 5 for availability of kits.

the programmer is a write-only machine, the assumption being that, if you're programming the device, you already have some type of reading provision.

Perhaps the greatest utility for EPROM's among experimenters is in the microcomputer field. For example, there is a host of different monitors available for every microprocessor chip. Although the monitors share some common instructions, some have more (or better) features than others. Without a monitor, of course, the basic computer can't "do something" when it's turned on.

One could load monitor data from a cassette tape machine, naturally, but this is a cumbersome method. It's best for convenience and speed to have a monitor program in ROM (read-only memory) so that it's all there when you turn the computer on, and data will not be lost if there's a momentary loss of line power or when computer is turned off. Some computers have built-in ROM monitors; many do not have monitors, so the computer owner must either buy

PARTS LIST

C6—0.01- μF, 25-V ceramic capacitor
Q11,Q12,Q13—MPS-A05 silicon npn transistor
R21,R22,R23,R24,R25,R31—1000-ohm, ¼-watt, 10% resistor
R26,R27—10,000-ohm, ¼-W, 10% resistor
R28,R29,R30—47,000-ohm, ¼-W, 10% resistor
S2 through S17—Spdt toggle switch
S18—Spdt momentary (break-before-make) toggle switch

S01—25-pin IC socket (preferably zero-insertion-force)
Note—See Parts List for Fig. 5 for availability of kits.

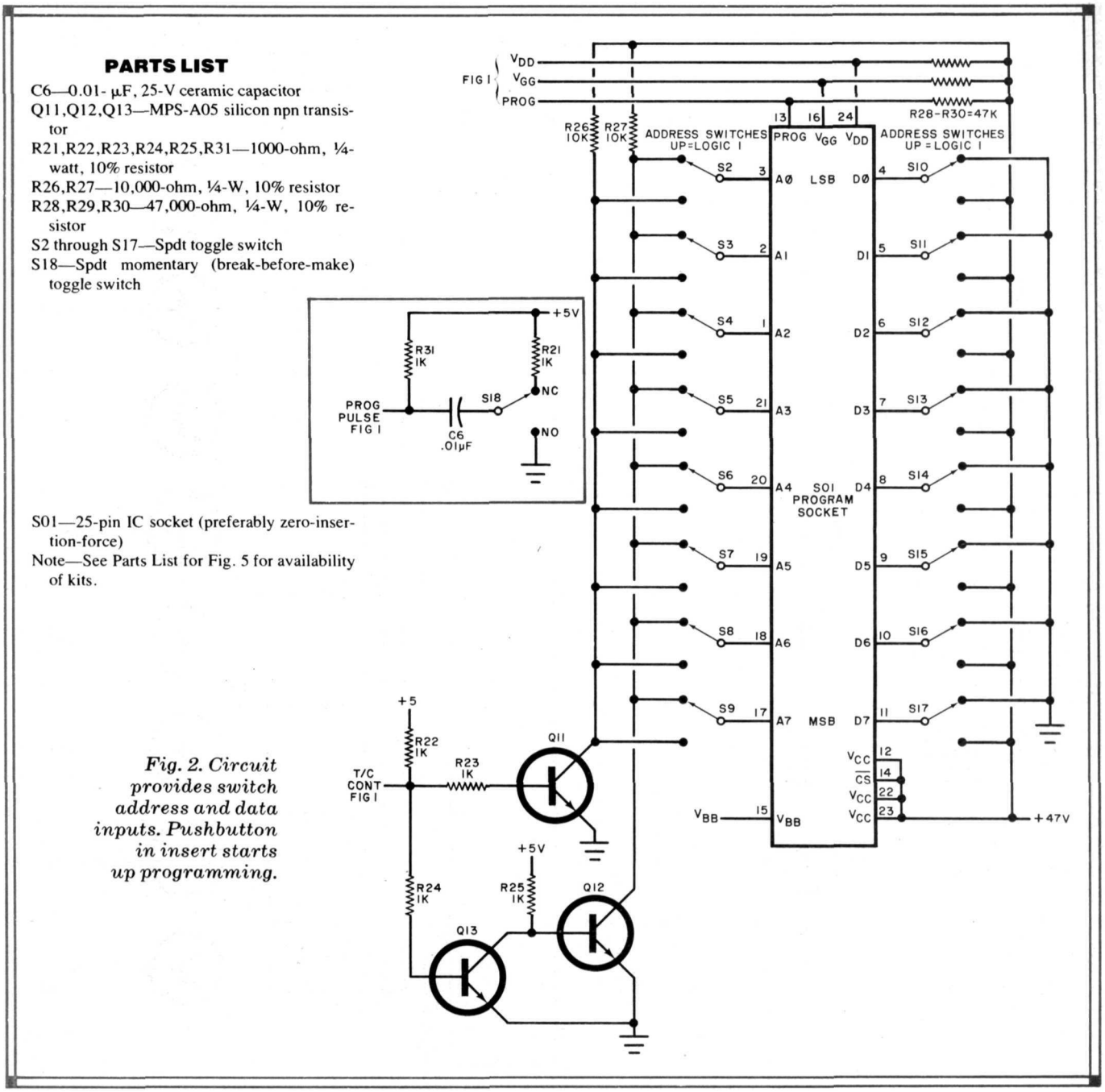


Fig. 2. Circuit provides switch address and data inputs. Pushbutton in insert starts up programming.

a ROM monitor, have a supplier prepare ROM's or program his own.

The latter route, using EPROM's could be the least expensive in the long run if a person continually upgrades his system whenever a better program or monitor comes along. An EPROM can be erased and reprogrammed very easily. The device's bit pattern can be erased (all set to "zero") by exposing the chip's transparent quartz window to ultraviolet light. In essence, the UV light's photons displace electrons that were induced in the silicon gate to form the equivalent of "1's" in the bit pattern. Then, using the EPROM Programmer, the memory can be electronically reprogrammed. Once programmed, it will maintain data when power is removed, but unlike a fuse-link ROM, it can lose data if exposed to strong UV light.

The EPROM Programmer described here—which costs about $^1/_3$ to $^1/_4$ of commercial models—complements the appealing economic picture of the popular 1702A. The device's original tag was about $100, where today its cost ranges from $3 to $12, depending on quantity purchased and source. In addition, since commercial houses charge as much as $40 to program an EPROM, doing it yourself can represent a substantial saving.

Circuit Operation. The 1702A EPROM itself is fully static, easily interfaced, requires no clocks, and is input/output TTL compatible. The three-state output buffers are rated for one full TTL load. However, it does require a -9-volt supply in addition to the conventional 5-volt operating supply.

The Programmer can be built as a stand-alone device using switches for address and data selection, or as a TTL-compatible peripheral for use with either switches or microprocessor ports. The circuit shown in Fig. 1 provides all the timing necessary for the Programmer. The 33.3-kHz clock, generated by *IC1* ,

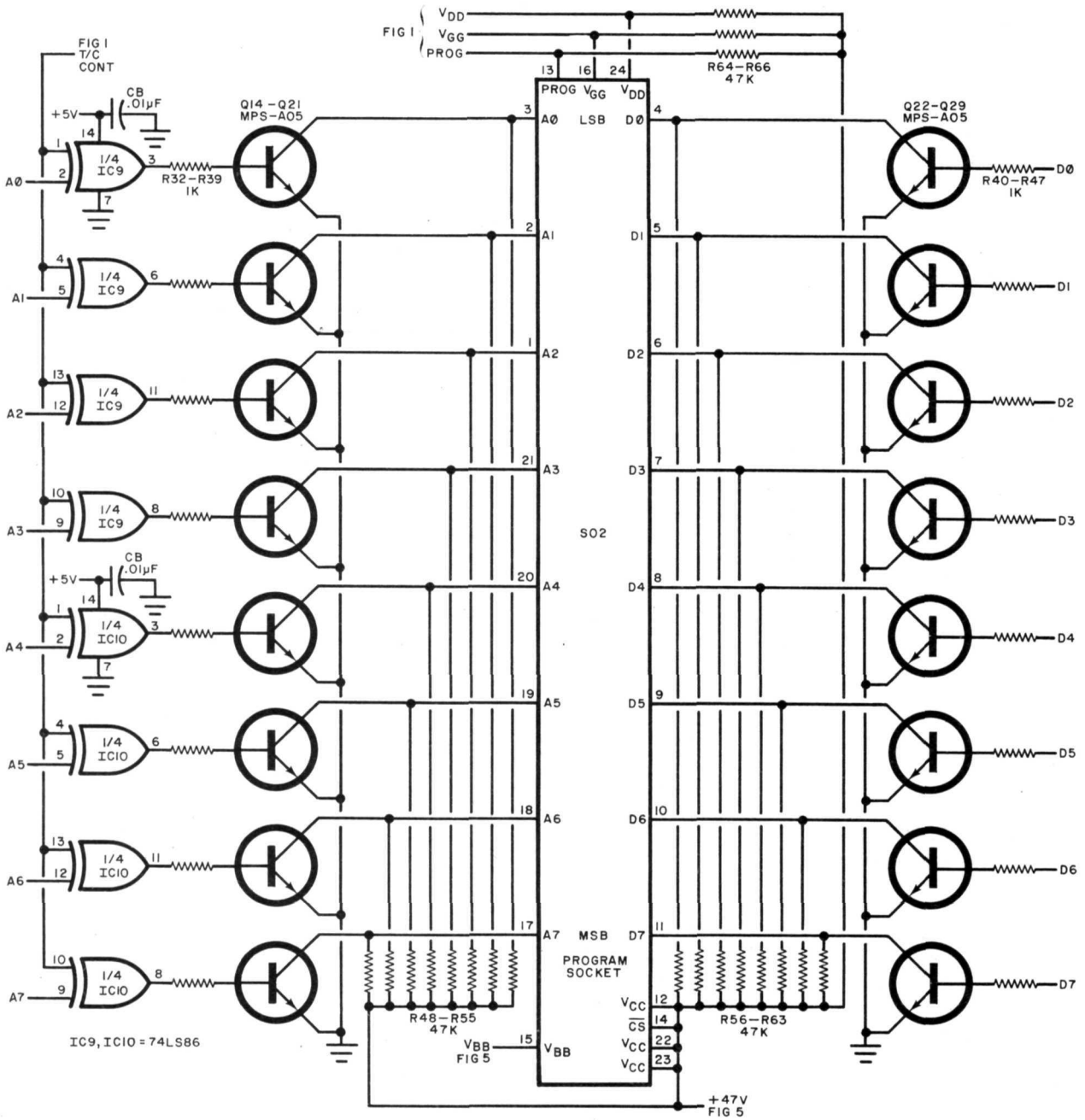


Fig. 3. TTL option is used with switch address and data inputs or accept data from microcomputer.

PARTS LIST

IC9,IC10—74LS86 quad 2-input exclusive-OR gate
Q14 through Q29—MPS-A05 60-V silicon npn transistor
R32 through R47—1000-ohm, ¼-W, 10% resistor
R48 through R66—47,000-ohm, ¼-W, 10% resistor
SO2—24-pin IC socket (preferably zero-insertion-force)
Note—See Parts List for Fig. 5 for availability of kits.

is routed to 8-bit shift register *IC7* and to a synchronous counter chain consisting of *IC2* through *IC6.* Integrated circuits *IC4, IC5* and *IC6,* in conjunction with *IC8D,* form a divide-by-430 counter whose carry output enables a divide-by-32 counter formed by *IC2* and *IC3.* Capacitor *C5* and resistor *R12* provide the power-up initialization for the chain.

Circuit action begins with the programming command (PROG), a negative-going pulse used to asynchronously clear *IC2* and *IC3.* The pulse width should be limited to less than five milliseconds. The *Qb* output of *IC2* (pin 13) is inverted by *IC8C* to control the operation of the divide-by-430 counter. The output of this divider is taken from pin 11 of *IC4* and is a 77.52-Hz (33.3 kHz/430) signal having a 20% duty cycle with 2.58 ms on and 10.32 ms off. This waveform meets the V_{DD} /V_{GG} Programming duty cycle restrictions of the 1702A EPROM. Also, the 2.58-ms pulse falls

under the 3-ms maximum specified for the 1702A programming pulse.

This signal is applied to the serial input of *IC7* and causes its eight outputs to sequence high in 30-us intervals, the period of the clock. Output B of *IC7* begins the programming cycle by turning on the +47-volt supply through *Q2* of the power supply. This action sets the address and data lines to their proper levels. The address is complemented at this time. Thirty microseconds later, V_{DD} and V_{GG} move to their negative levels controlled by output C of *IC4* driving transistors *Q7* and *Q8.* Output D (T/C or true/complement) of *IC7* follows on the next clock pulse and inverts the address lines to their true state. Outputs E, F, and G of *IC7* are not used. When output H goes high, it is AND'ed with output A by *IC8A.* This output is inverted by *IC8B* to drive *Q6* and provide the program pulse to *SO1* (Fig. 2 or 3).

These conditions are stable until the termination of the 2.58-ms pulse. At this point, output A of *IC7* goes low, thus ending the program pulse. Then output B disables the +47-volt supply. The shift register (*IC7)* is completely cleared in six more clock pulses.

During the last 30 microseconds of the 2.58-ms pulse, a carry is generated by *IC4,* causing the divide-by-32 counter (*IC2, IC3)* to advance. This sequence repeats until the end of the 32nd iteration, when pin 13 of *IC2* goes true and shuts down the counter through *IC8C.* The total elapsed time for programming one 8-bit word is therefore about 413 ms. This period can be monitored by the optional status indicator (formed by *Q10, R18* , *R19* and *LED1*) shown in Fig. 1.

Switch Option. Address and data selection during programming are provided by the 16 spdt switches shown in Fig. 2. A logic 0 on the address lines is accomplished by switching the line to the collector of *Q11.* Using the Vcc as a reference, this will result in a level of -47 volts during the program pulse when the address true/complement (T/C) signal from *IC7* is high, thus selecting the true address. Placing the address switch in the 1 position ties that line to the complement of the signal present at the collector of *Q12* , resulting in a logic 1.

For data input, connecting an output line to ground through the data switch results in a 47-volt level during the program cycle. This programs a logic 1 on the selected address output. Connection to the Vcc line will leave the bit unchanged—a logic 0 during read.

The small insert schematic in Fig. 2 is used to manually generate the programming command through pushbutton switch *S18.*

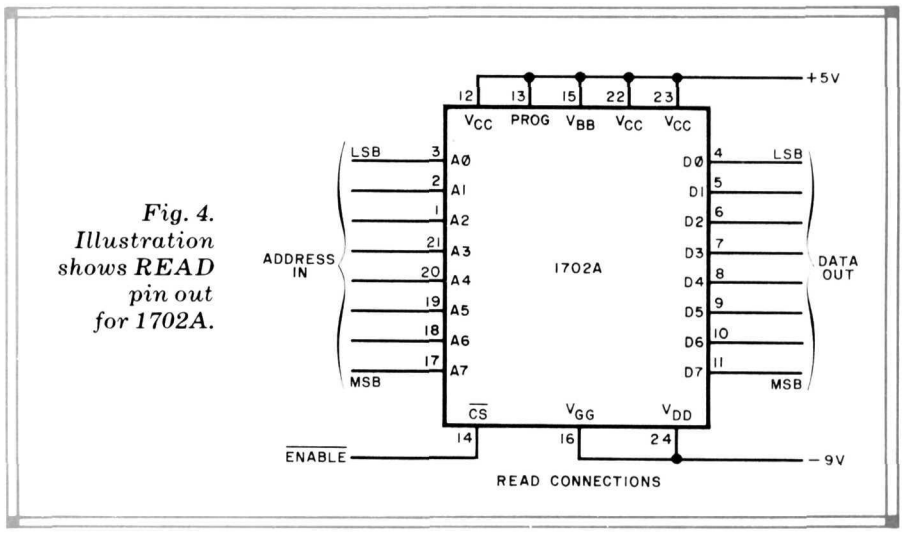


Fig. 4. Illustration shows READ pin out for 1702A.

HOW AN EPROM WORKS

The 1702A belongs to a family of electrically programmable, ultraviolet-light-erasable, read-only memories. Each memory cell in the ROM has the appearance of a flip-flop with a new element—a "floating gate," that is isolated from the silicon substrate by a narrow band of silicon dioxide (glass). This element is not connected to anything electrically. The output signal from each flip-flop, a 1 or a 0, depends on the charge (or lack of it) on the gate.

The application of a train of electrical pulses to a cell "charges" the floating gate, and causes the associated flip-flop to produce a 1 at its output. This charge on the floating gate leaks off after many ten's of years. Since there is no electrical connection between the floating gate and the remainder of the ROM internal circuit, the charge is not affected by the removal of the chip's operating power.

The upper surface of the chip has a quartz window that is transparent to ultraviolet (UV) light. If strong UV light is allowed to pass through the window, it will displace the electrons from their shallow energy levels on the floating gate and cause them to migrate to the silicon substrate where their charge is neutralized. Typically, it takes several minutes of strong UV exposure to erase a device, and conventional room lighting will not do the job—though exposure to direct sunshine may. After the UV exposure, all the cells go to a 0 output.

TTL Input Option. The circuit shown in Fig. 3 is similar to the switch option circuit shown in Fig. 2, except that the switches are replaced by 16 transistors and 8 exclusive-OR gates. Programming voltage levels are the same as those described in the switch option. The transistors provide logic inversion as well as high-voltage isolation so that conventional TTL logic levels can define address and data selection.

The gates in *IC9* and *IC10* are turned on by the T/C signal to invert the address at the proper time. Resistors *R48* through *R66* provide leakage-current paths and insure good dynamic response.

The address lines present one "LS"-load to the driving circuit and should be no problem to interface to a microcomputer. The data lines must be driven by circuits capable of sourcing at least 1 mA at 1.7 V. Standard TTL devices will handle this, as well as many of the LSI I/O chips designed for microprocessors. Switches, connecting the inputs to the +5-volt line or ground, may be used.

1702A Data. The read connections for the 1702A (and family) are shown in Fig. 4. The EPROM may be erased by exposure to high-intensity short-wave ultraviolet radiation of 2537 angstroms. The recommended integrated dosage is 6W-sec/cm_2. Depending on the ultraviolet light source, the erasure may take from 10 to 20 minutes. O

Note: Part 2 of this article, next month, will describe the power supply, pc board, and construction.

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PART 2 *Power supply, construction and checkout.*

Power Supply. The supply (Fig. 5) delivers approximately +75 volts to a transistor switch/current limiter consisting of *Q1, Q2, Q3, R1,* R2 and *R3.* Transistors *Q4* and *Q5,* in conjunction with *D5, R6, R7,* and *R8* regulate the +75-volt output down to +47 volts. Diode *D6* and resistor *R5* provide the V_{BB} bias supply. Resistor *R9* insures a minimum load on the regulator and provides a path for the *D6* zener current. Capacitor *C2* and resistor *R20* prevent the high-gain circuit of *Q5* from oscillating.

Construction. Although the Program-

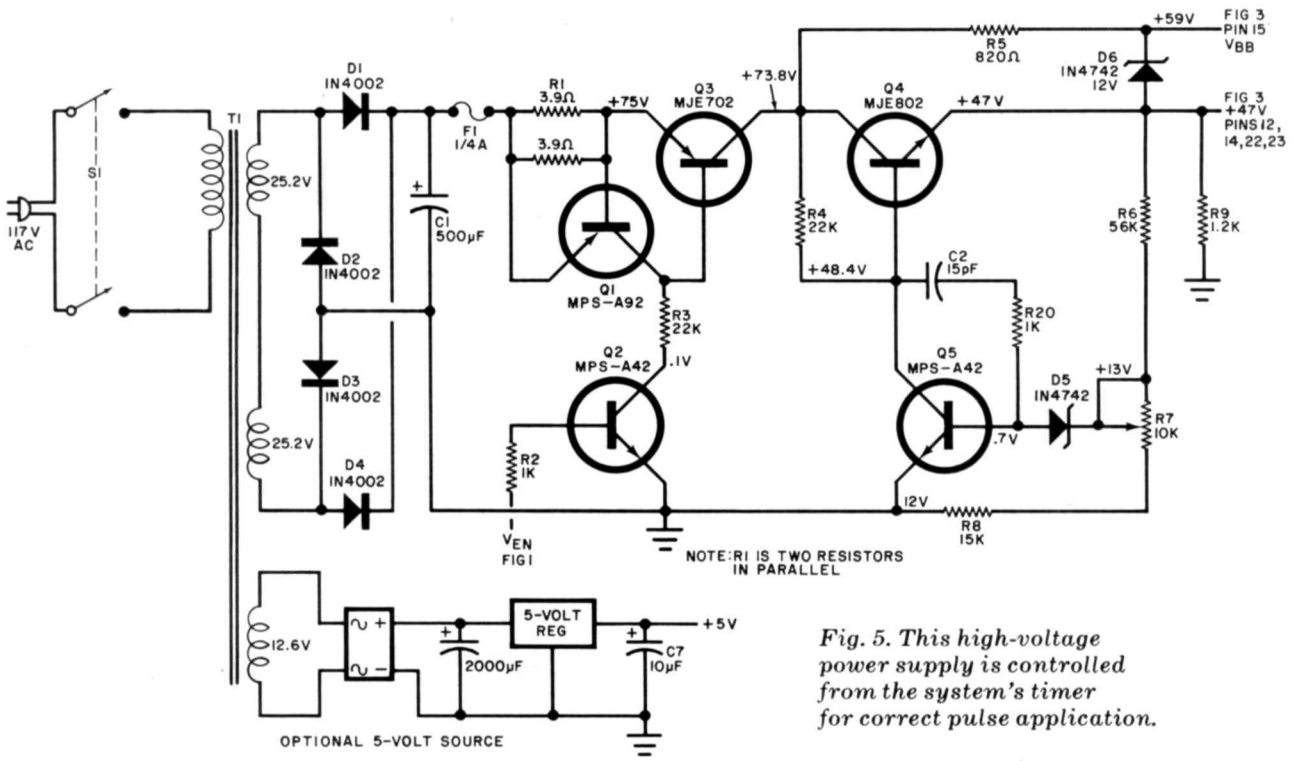


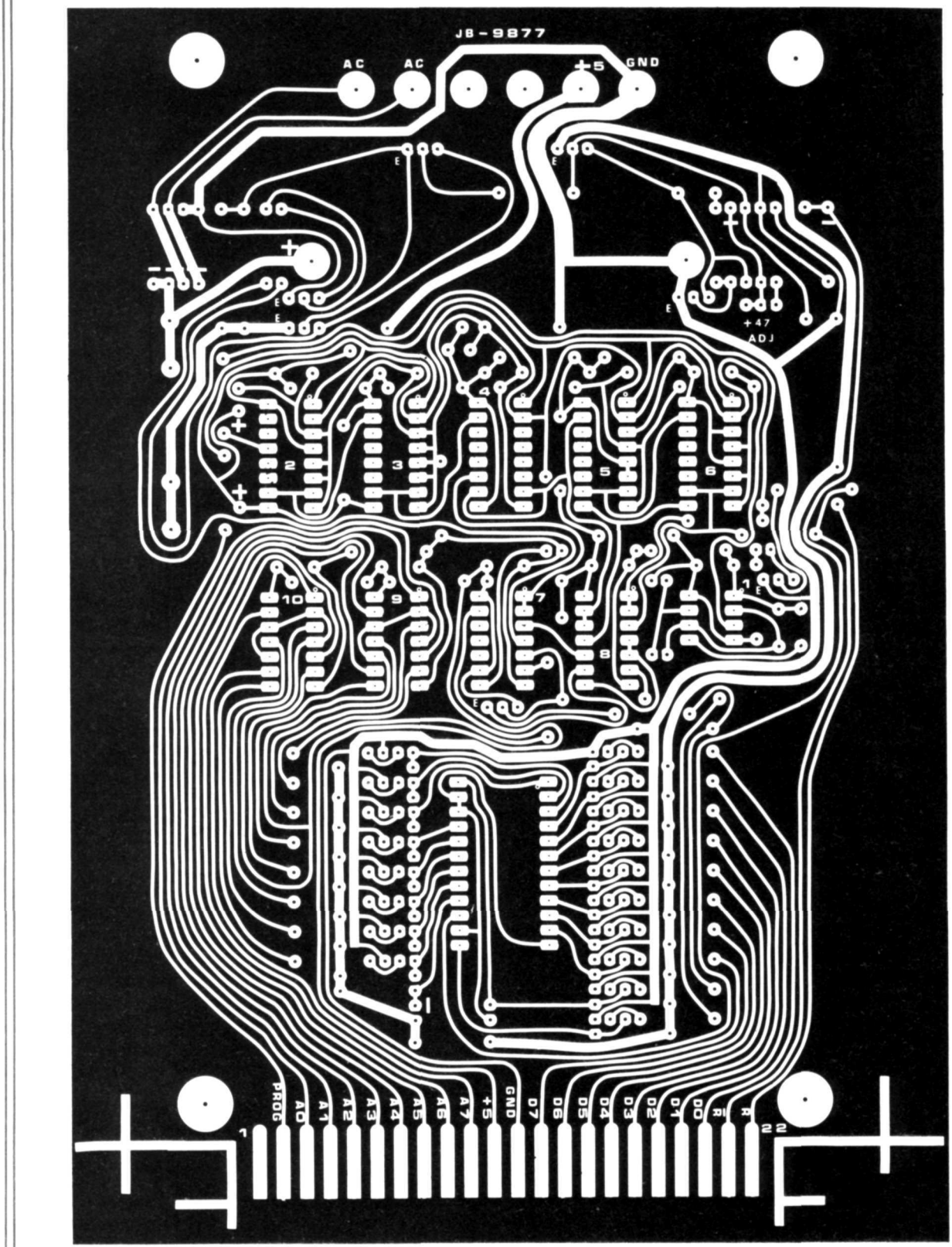
Fig. 5. This high-voltage power supply is controlled from the system's timer for correct pulse application.

PARTS LIST

C1—400-µF, 75-V electrolytic capacitor
C2—15-pF ceramic capacitor
C7—10-µF, 15-V electrolytic capacitor
D1 through D4—1-A, 200-V silicon diode (1N4002 or similar)
D5, D6—12-V, 1-W, 10% zener diode (IN4742 or similar)
F1—¼-A fast-blow fuse and holder
Q1—MPS-A92, 300-V silicon pnp transistor
Q2,Q5—MPSA42, 300-V silicon npn transistor
Q3—MJE702, 80-V silicon Darlington pnp transistor
Q4—MJE802, 80-V silicon Darlington npn transistor

The following are ¼-W, 10% resistors unless otherwise noted:
R1—1.9-ohm, 5%, 1-W resistor (two 3.9-ohm, ½-W, 5% in parallel)
R2, R20—1000 ohms
R3,R4—22,000 ohms
R5—820 ohms, ½-W
R6—56,000 ohms
R7—10,000-ohm, 10%, ½-W trimmer potentiometer (Bourns 3389 series)
R8—15,000 ohms
R9—1200 ohms, 2 W
S1—Dpdt, 1-A toggle switch
T1—2 each 25.2-V, 300-mA transformer with 5-V power-supply winding

Note—The following are available from DIA, Inc., Box 343, Dayton OH 45459: etched and drilled pc board at $8.95; basic 1702A EPROM Programmer kit (TTL option), including pc board and all components except power supply and connector, at $39.95; special transformer that also includes 5-volt power supply winding at $9.98; complete kit, including pc board and all components for stand-alone Programmer with switches, power supply, zero-insertion-force socket and case, at $79.95; complete stand-alone Programmer, assembled and tested, at $99.95. All prices postpaid. Check, money order, Visa, or Master Charge accepted. Ohio residents, please add 4½% sales tax.



mer can be built using any desired construction technique, a printed circuit board such as that shown in Fig. 6 is suggested. Observe the correct polarities when installing capacitors, diodes, transistors and IC's (using sockets, if desired). Do not install transistors *Q8* and *Q14* through Q29 until after reading the checkout section of this article. Mount 1-inch by $^1/_2$-inch thin metal heat sinks on transistors *Q3* and *Q4* . Using the fuse as a guide, install a fuseholder or fuse clips at the *F1* position. Do not install a socket at position *S02* or the LED for *LED1* if you are going to mount the board in an enclosure.

The component installation shown in Fig. 6 uses the TTL option so that the

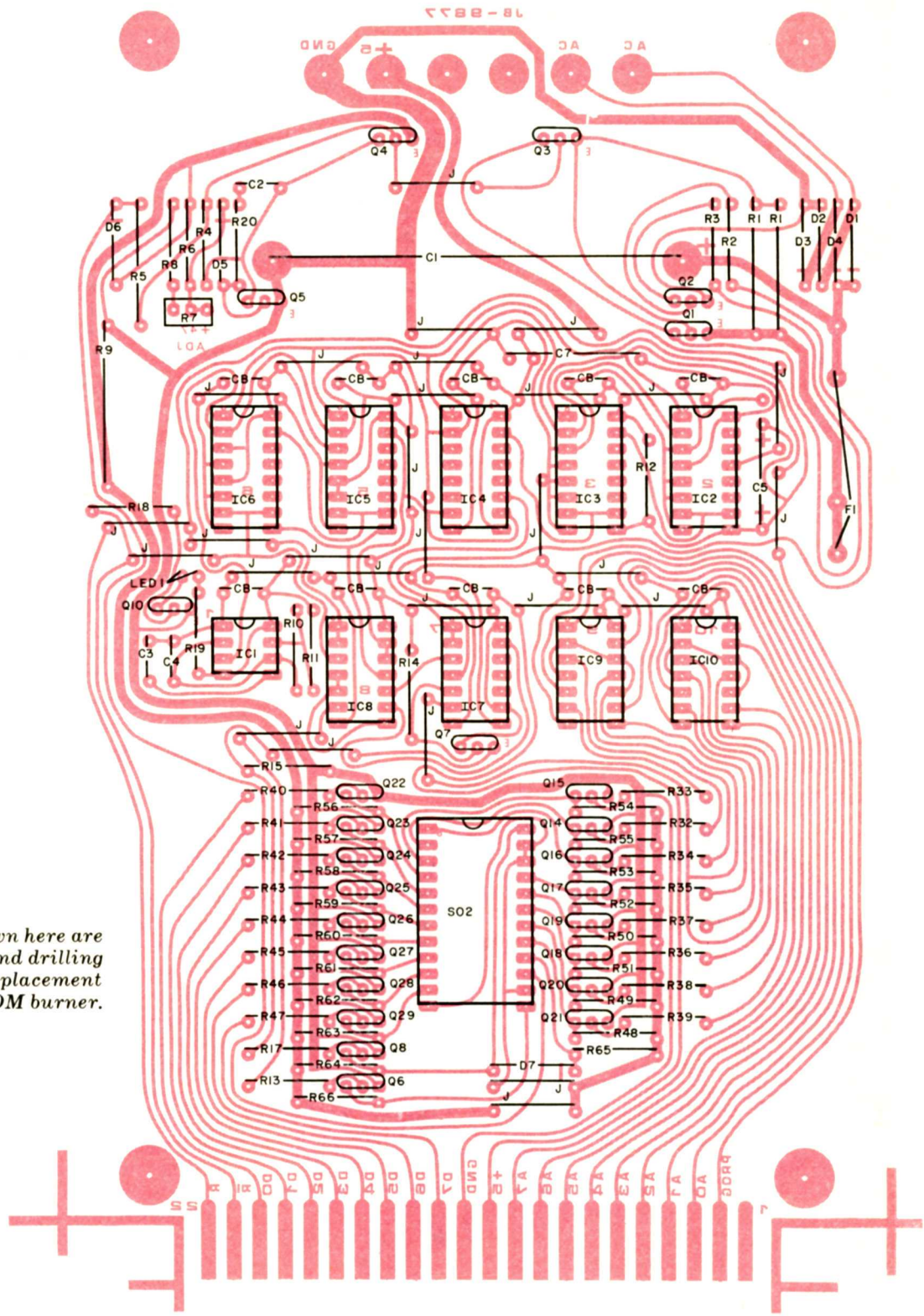


Fig. 6. Shown here are etching and drilling and component placement guides for PROM burner.

Programmer can be used with a computer at some later date.

Select a suitable enclosure whose front panel can support the eight address and write data switches in two rows (see photo). Also on the front panel are the on/off switch, the program push-button switch, *LED1,* and a zero-insertion-force 24-pin PROM socket. Identify the switches and controls properly.

Use a length of heavy bare wire to interconnect all of the upper lugs of the top row of address switches. Interconnect the bottom row of address switch lugs similarly. Use the same technique on the data switches. Using insulated wire, connect the upper lugs of the address switches to the upper lugs of the data

switches. Do the same with the lower lugs—lower lugs to lower lugs.

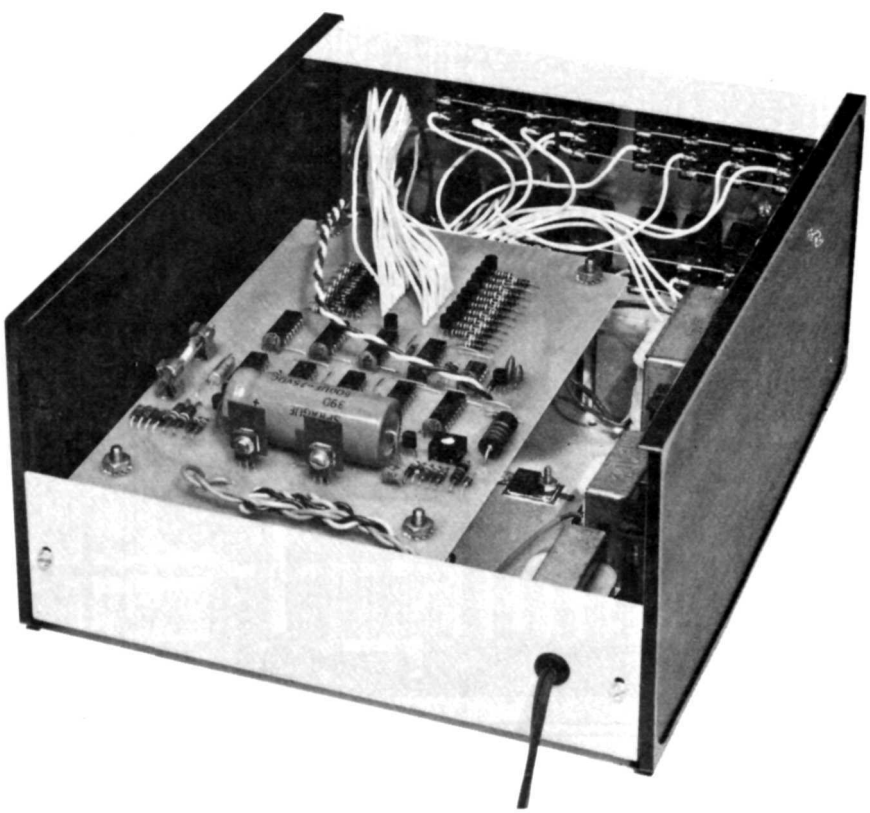
Using the small insert schematic of the *S18* circuit shown in Fig. 2, connect the normally closed contact of this switch to the top bare wire (gnd) of the address or data switches. Connect the two resistors and capacitor to the switch as shown, using the bottom lugs of either the address or data switches for the 5-volt connection.

Mount transformer T1 on one side of the chassis bottom plate. The rectifier, filter capacitor, and 5-volt regulator for this supply can also be mounted on the bottom plate of the chassis. The pc board will be mounted on spacers so that it will not contact the components mounted within the chassis. Using the four large corner holes in the pc board as a guide, and with the edge connector toward the front panel, mark and drill the four spacer mounting holes.

With the pc board held in its final mounting position (edge connector facing the front panel), cut lengths of insulated wire long enough to fit easily between the *S02* board position and the 24-pin front-panel socket. Do the same for the program switch and *LED1* . Make similar connections from the edge connector to the center lug of each of the address and data switches. A pair of wires will also be needed from the edge-connector 5-volt pad to the bottom lugs of the switches. You will also need insulated leads from the two ac-pads and the 5-volt ground pads (on the pc board edge opposite the connector) to interconnect to the power supply circuits.

Drill a hole in the rear apron of the chassis and put a grommet in it for the ac line cord. Make sure all ac connections are well insulated.

After all the wiring is installed, the board can be mounted on spacers. Do not tighten the mounting hardware, however, because the missing transistors will have to be installed after performing the following Checkout procedure.



The 5-volt supply is mounted under the pc board. With a little care, as shown *here,* a *very professional look can be attained.*

Checkout. Be sure transistors *Q8* and *Q14* through *Q29* and the +47-volt line connection are not installed until after the regulator checkout is complete.

After double checking the wiring (and pc board), adjust potentiometer *R7* to its maximum series resistance, then temporarily jumper the collector of *Q2* (Fig. 5) to ground to enable the regulator. Apply ac power to the high-voltage and 5-volt power supplies and check for the presence of +75-volt dc across filter capacitor *C1.* If necessary, reverse the secondary connections.

Using a dc voltmeter of known accuracy, monitor the voltage across *R9* (Fig. 5) and adjust *R7* to obtain +47 ±1 volts. Leave the voltmeter connected across the 47-volt line.

The current limiter is checked by *momentarily* shunting *R9* with a 68-ohm, 2-watt resistor. The voltage should drop to approximately 25 volts. If not, check *Q1* , *Q3* and *R1.*

Remove the temporary jumper from the collector of *Q2* and note that the output voltage drops to zero. If not, *Q2* is faulty or is being prematurely enabled by *IC7* . Between programming cycles, *IC7* should be completely cleared.

Using pushbutton switch *S1B* (Fig. 2), apply a pulse to the program command line and verify that the +47 volts occurs for about half a second. If it does, it is a good indication that the counters and clock are functioning normally.

The 47-volt line and the transistors can now be installed.

If you do not have a zero insertion-force socket, before installing the first PROM, loosen up the holes in the PROM socket using the leads of a $^{1}/_{4}$-watt resistor. This should be done since the pins of many 1702A PROM's are fragile and may be bent trying to force them into a tight socket.

With power applied, insert an erased EPROM in the socket, set the address and data switches in accordance with the first location of your truth table, and apply the programming command *(S18).* That location will be programmed within half a second. The optional LED programming indicator may be used to watch this timing.

You now have 255 more locations to go. If you use the microprocessor option (Fig. 3) and a suitable program, the EPROM can be programmed in just a few minutes. O