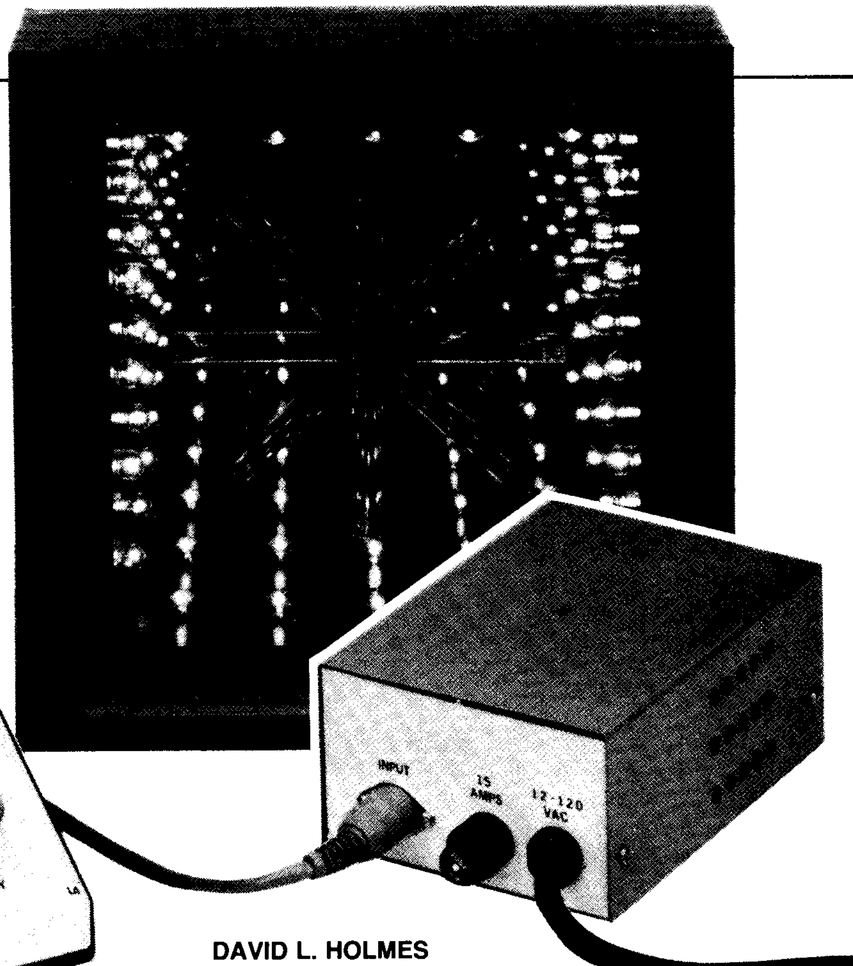
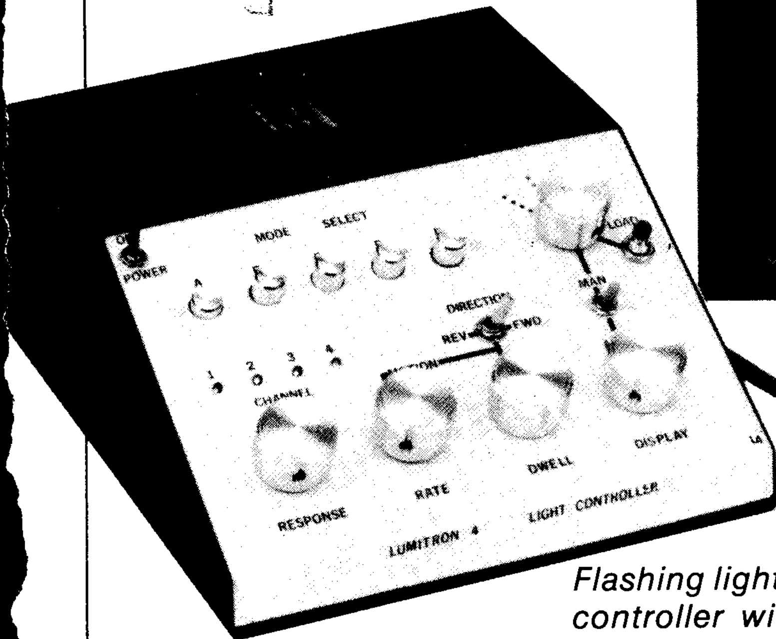
BUILD THIS VERSATILE LIGHT SEQUENCER





DAVID L. HOLMES

Flashing lights do not a disco make. This four-channel light controller will sequence automatically or in time to the music, and will dazzle your eyes in other ways as well.

HAVE YOU EVER HOSTED OR ATTENDED A party and discovered that even though you were having a good time and enjoying the music and dancing, you felt that something was missing? Perhaps something *was* missing—a lighting system capable of translating the disco beat into a tantalizing light display. One factor probably responsible for the absence of such a system was its high price. The systems that are available—and these are for commercial use—cost hundreds of dollars. Now, however, you can build a multi-function lighting-display control system that will rival many commercial units, but for a fraction of their cost.

The system is called the Lumitron-4 and it has the following features:

- Four-channel control capability
- Separate function-control and opto-isolated power-switching units
- Manual and automatic bidirectional "light-chaser" action
- Manual and automatic "light-chaser" pattern selection
- Variable dwell-time for automatic change of "light-chaser" direction and light pattern
- Audio-response control
- Five pushbutton MODE controls that select the following:

1. All display lights on continuously
2. Sound-sync-controlled intensity of all display lights simultaneously
3. Sound-sync-controlled rate of light chasing
4. Constant "light-chasing" rate
5. Combination of modes 2 and 4

The power-switching system described in this article uses opto-isolated triac drivers having the capability to trigger any triac requiring less than a 100-mA gate trigger-current. The power-switching unit was designed to be located remote from the master-control unit and the two are interconnected by a five-conductor cable. Originally, a six-foot cable with five-pin DIN plugs was used, but the prototype has been operated with the two units separated by as much as twenty-five feet.

Channel-control signals output from the control unit have a nominal +5-volt level when they are inactive and a +.7-volt level when active. Each channel is designed to have a 25-mA current-sinking capability.

Figure 1 shows a block diagram of the system.

How it works

The heart of the Lumitron-4 (see Figs. 2 and 3) is IC1, a 74194 presettable 4-bit bidirectional shift register with modes (LOAD, SHIFT FORWARD, SHIFT REVERSE) and timing that are controlled by IC2 and IC3 respectively. Integrated-circuit IC2 is a 7472 JK flip-flop with AND-gated inputs, and IC3 is a 556 dual timer with each timer configured as an astable multivibrator. The shift rate of IC1 is controlled by IC3-b, with R14 serving as a RATE control, and IC3-a clocking IC2. Switch S2 (FORWARD/REVERSE/AUTO) and IC3-a control the shift-forward and shift-reverse signals generated by IC2. (The output of IC3-b is AND-ed with the JK inputs to IC2 so the shift-forward/reverse signals generated by IC2 do not change while the output of IC3-b is low; that is an operational constraint for IC1.) In its center AUTO position, S2 allows the Q and $\overline{Q}$ outputs of IC2 to change states alternately with each IC3-a clock pulse; this causes IC1 to alternate its shifting direction. Setting S2 to its other positions keeps the output of IC2 constant after one clock pulse and causes IC1 to continue shifting in one direction. For example, if

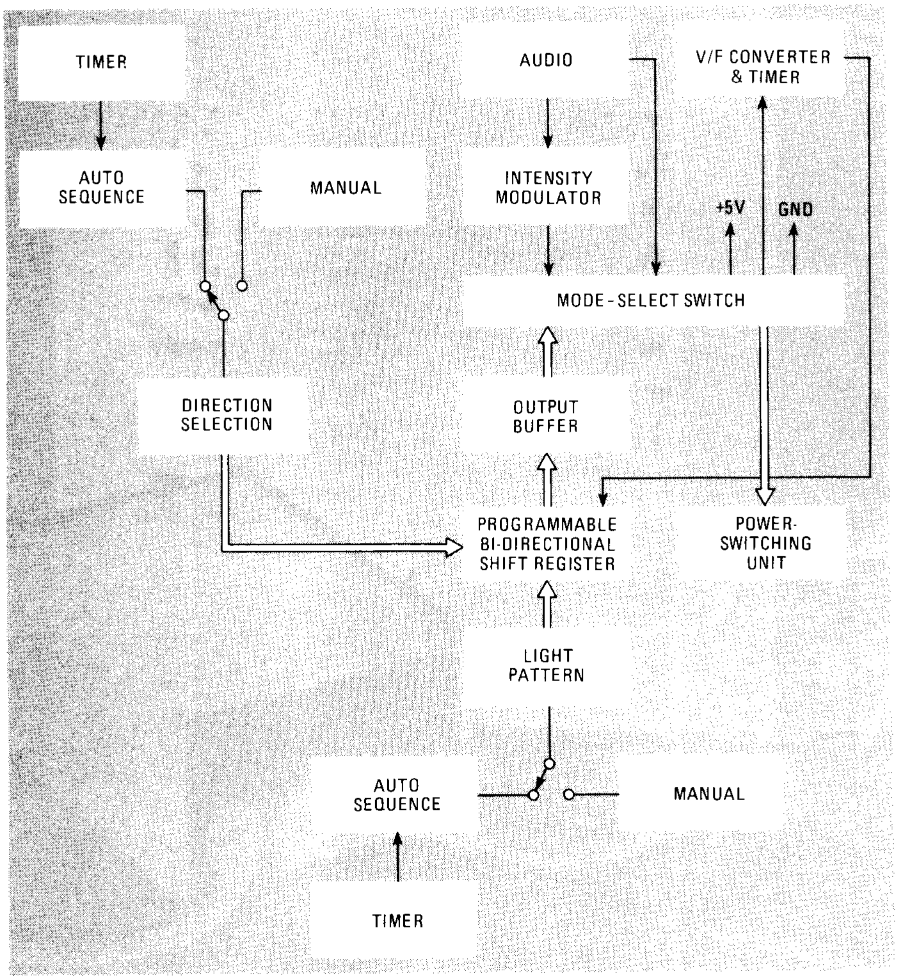


FIG. 1—BLOCK DIAGRAM of the Lumitron-4 shows the many effects available and how they are created.

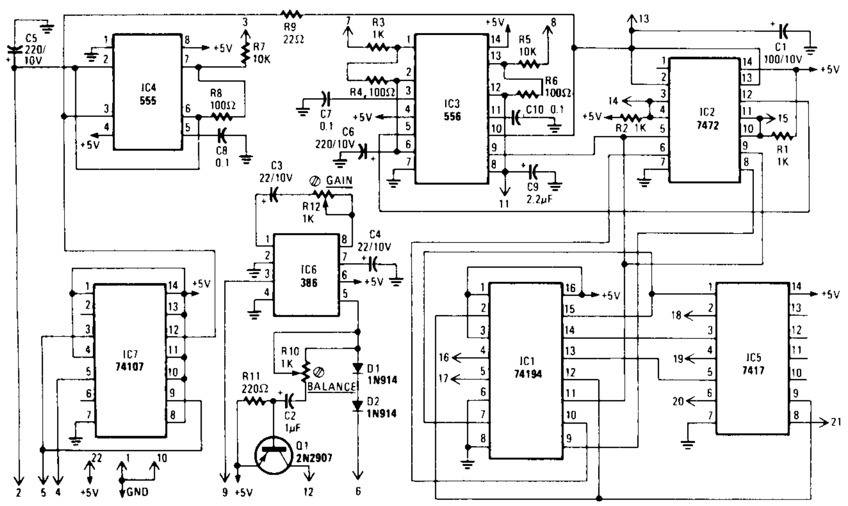


FIG. 2—GOOD DESIGN PRACTICE dictates that all unused IC pins be tied either to five-volts or ground. Numbers next to "<" symbols refer to PC-board finger numbers and to S6.

IC1 is shifting "forward" and S2 is switched to the REVERSE position, IC1 will continue to shift "forward" until the next clock pulse from IC3-a causes the IC2 outputs to change states. This state change will cause IC1 to start and to continue shifting in "reverse" until S2 is switched to a new position. The time interval between pulses from IC3-a is adjusted by the DWELL control, R15.

The desired display pattern is loaded into IC1 by applying four bits of data to IC1's parallel inputs and forcing both of its MODE-CONTROL inputs high. The new display pattern will appear at IC1's outputs after the positive transition of the clock pulse from IC3-b. Inputs A and D are permanently wired to high and low states respectively, with the states of inputs B and C being selectable. The "high" mode-control signals to IC1 are supplied by IC2 and are loaded by simultaneously taking IC2's PRESET and CLEAR inputs low. Those inputs are connected together and are taken low one of two ways, depending on the position of S3 (MANUAL/AUTO). When S3 is set to the MANUAL position, S4 (PATTERN-SELECT) selects the desired IC1-b and IC1-c iput levels and when S5 (LOAD) is momentarily depressed, PRESET and CLEAR inputs go low.

Switching S3 to the AUTO position connects the B and C inputs of IC1 to the Q outputs of IC7, a dual JK flip-flop configured as a modulo-4 counter, and ungrounds C5, the timing capacitor for IC4. The output of IC4 is connected to the PRESET and CLEAR inputs of IC2 and the ENABLE input of IC3-b. As long as C5 is grounded, the output of IC4 remains high, and IC2, and IC3-b function as described above. With IC5 ungrounded, IC4 functions as an astable multivibrator with its rate controlled by R16 (DISPLAY). When the output of IC4 goes low, that causes the PRESET and CLEAR inputs of IC2 to go low as well, forcing the Q and $\overline{Q}$ outputs of IC2 high; this places IC1 in the LOAD mode. Additionally, the enable pin of IC3-b goes low, disabling IC3-b and causing its output to go low, and IC7 is clocked causing it to increment its count.

When the output of IC4 again goes high, IC3-b is enabled and its output goes high providing the positive-transition clock signal required by IC1 to transfer the data on its input pins to its output pins. The Q and $\overline{Q}$ outputs of IC2 remain high momentarily after the "low" is removed from the PRESET and CLEAR inputs because of internal propagation delay and the time constant determined by R9-C1. Resistor R9 also serves as a current limiter for the output current of IC4, should S5 be depressed while IC4's output is high.

Sound activation of the Lumitron-4 is controlled by IC6, a 386 high-impedance, variable-gain audio amplifier. The setting of R12 together with the value of C3 determines the overall gain while the input-signal level to IC6 is controlled by R13 (RESPONSE). The output of IC6 is fed to Q1 and D1/D2. The manner in which Q1 and D1/D2 affect the operation of the circuit is controlled by S6 (see Fig. 4).

A description of the modes of operation of the Lumitron-4 follows:

With S6-a depressed, 5-volts is connected to the "common" output line and each output channel is connected to ground. The console LED's and light display will remain on continuously.

Depressing S6-b switches the collector of Q1 to the "common" output line and grounds each output channel. The intensity of the lights and console LED's will vary according to the audio input.

Switch S6-c causes 5-volts to be connected to the "common" output line,

PARTS LIST

All resistors ¼ watt, 5% unless otherwise specified
R1-R3, R17, R30-R33—1000 ohms
R4, R6, R8—100 ohms
R5, R7—10,000 ohms
R9—22 ohms
R10, R12—1000 ohms, trimmer potentiometer
R11—220 ohms
R13—5000 ohms, potentiometer, audio taper
R14-R16—1 megohm, potentiometer, linear taper
R18-R29—330 ohms
R34-R37—100 ohms, 1-watt
Capacitors
C1—100 µF, 10 volts, electrolytic
C2—1 µF, 10 volts, electrolytic or tantalum
C3, C4—22 µF, 10 volts, electroytic
C5, C6—220 µF, 10 volts, electrolytic
C7, C8, C10, C12-C14—0.1 µF, ceramic disc or Mylar
C9—2.2 µF, 10 volts, electrolytic (3.3 µF acceptable)
C11—1000 µF, 25 volts, electrolytic, axial leads
C15-C18—0.1 µF, 250 volts, Mylar
Semiconductors
IC1—74194 4-bit bidirectional shift register
IC2—7472 JK flip-flop
IC3—556 dual timer
IC4—555 timer
IC5—7417 hex buffer/driver
IC6—386 low-voltage audio amp
IC7—74107—dual JK flip-flop
IC8—IC11—MOC3031 optoisolated, zero voltage crossing, triac driver (Motorola)
IC12—7805 5-volt regulator
IC13-IC16—2N6342 8-amp, 200-volt, triac
Q1—2N2907 or equivalent
LED1-LED4—.125-inch red LED
BR1—one-amp, 50 PIV, bridge rectifier
D1, D2—1N914 or 1N4148
S1—SPST miniature toggle
S2—DPDT miniature toggle
S3—3PDT miniature toggle
S4—2P4T rotary
S5—SPST N.O. momentary push-button
S6—5 (or 6) PDT interlocking push-button bank
T1—8-12-volt, 500 mA, wall-plug transformer
J1, J2—5-pin DIN socket
J3—22-pin soldertail edge connector, .156-inch spacing
J4—miniature phone jack
SO1-SO4—chassis-mount AC receptacle
F1—fuse (see text)
Miscellaneous: PC boards, IC sockets, enclosures, 5-connector cable with DIN plugs, ribbon cable, hardware, terminal strips, materials for infinity mirror, etc.

The following are available from Design Specialty, 15802 Springfield St., Suite 80, Huntington Beach, CA 92649: Etched & drilled control unit PC board (879-2A), $18.00; etched & drilled S6 PC board (22280-1), $8.50; etched & drilled power-switching PC board (22280), $8.50; all three PC boards (580), $30.00; switch S6 (SW6), $16.00; all three PC boards plus S6 (580-SW6), $42.00; four 10-amp, 20-140 VAC zero-switching solid-state relays on aluminum base plate (PWR-4), $75.00. In U.S., Canada and Mexico add 5% shipping & handling; all others add 10%. CA residents add 6% sales tax. Please allow three weeks to process orders accompanied by personal checks.

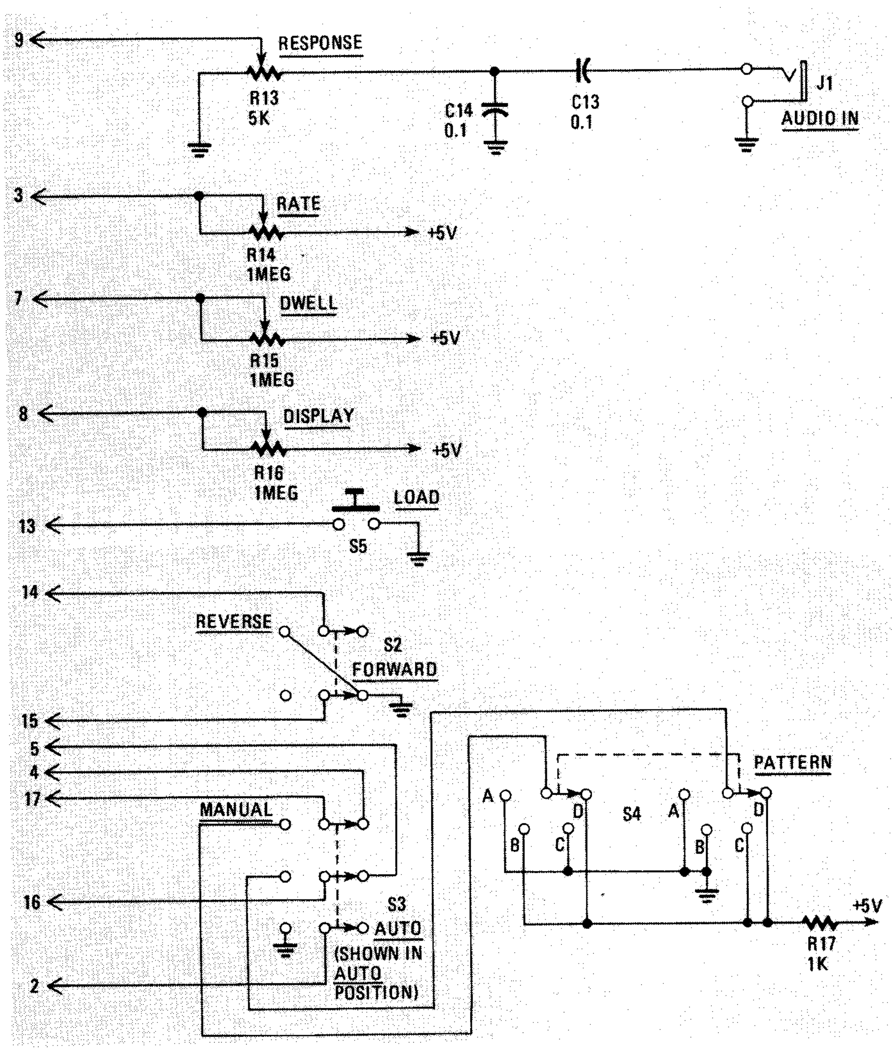
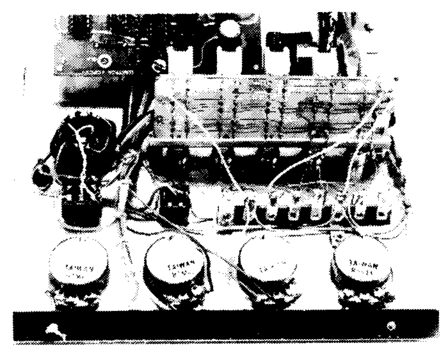


FIG. 3—MAIN FRONT-PANEL switches and potentiometers. Swich S2 is of the "center-off" type.



REAR VIEW OF CONTROL PANEL shows how controls are wired. Leads from LED's are visible behind terminal strip.

connects diodes D1/D2 to timer IC3-b and connects each output channel to a corresponding output of IC5. The displays will sequence at a rate that varies with the audio input. In the absence of any audio, the displays will sequence at a rate determined by the setting of R14 (RATE).

Depressing S6-d connects the collector of Q1 to the "common" output line and connects each output channel to a corresponding output of IC5. The lights will now sequence at a constant rate as determined by the setting of R14 but their intensity will vary in synchronization with the audio input.

With S6-e depressed, 5-volts is connected to the "common" output line and each output channel is connected to a corresponding output of IC5. The displays will sequence at a constant rate as determined by the setting of R14.

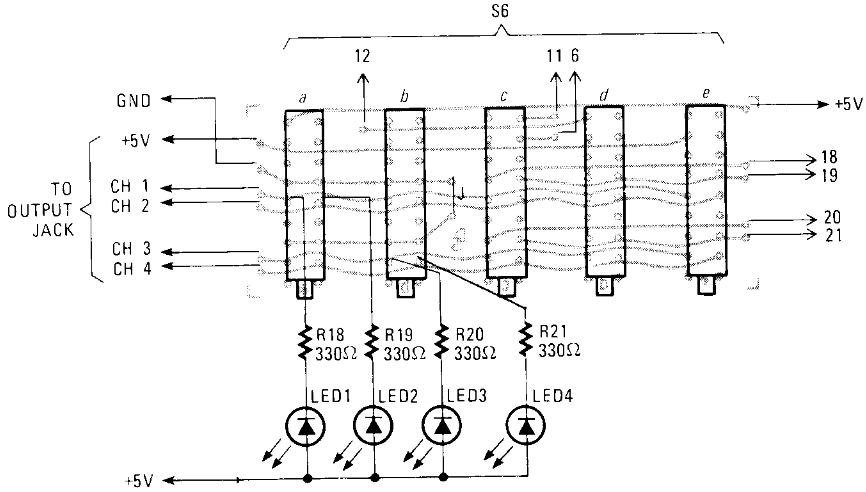


FIG. 4—SWITCH S6 is used to select one of five possible modes of operation. LED's indicate channel activity.

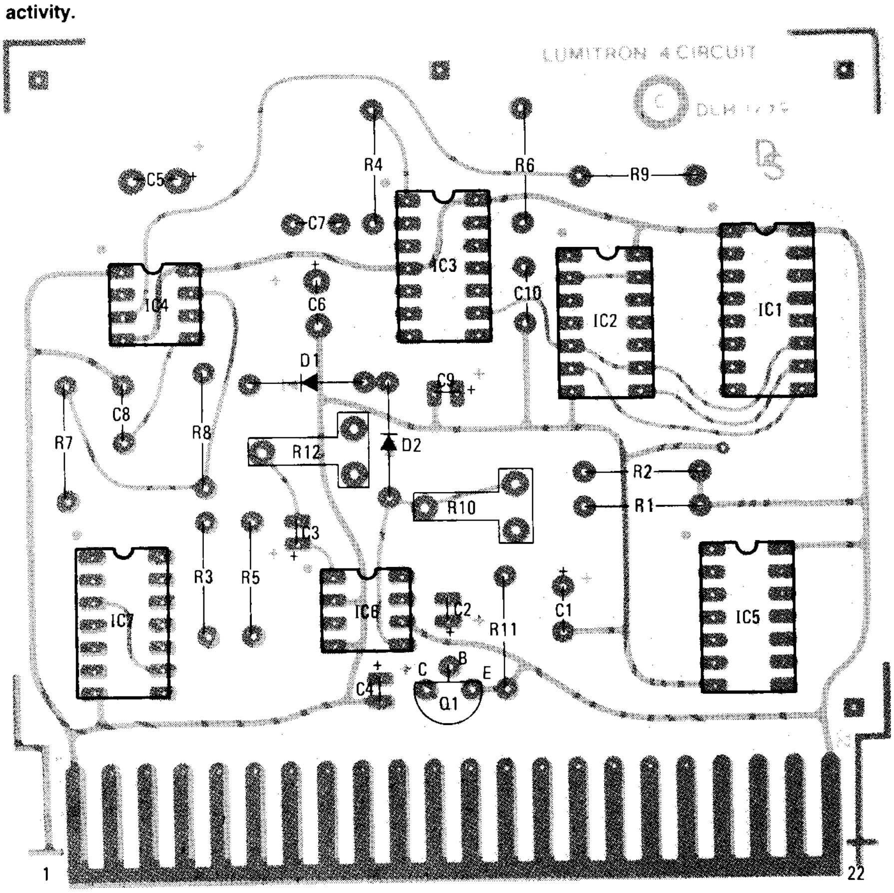


FIG. 7—CONTROL-UNIT PC BOARD plugs into 22-pin socket with .156-inch spacing.

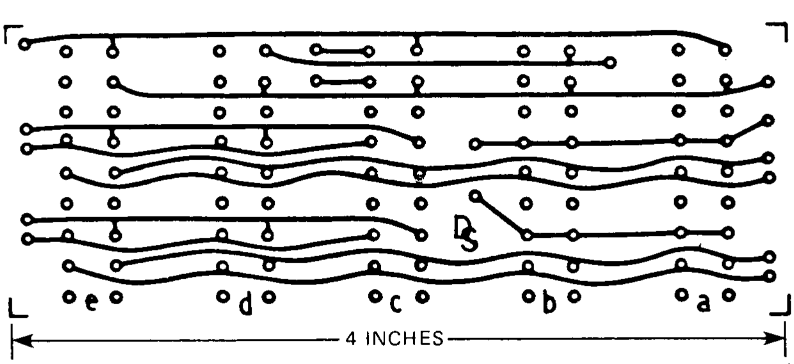


FIG. 8—SINGLE-SIDED BOARD is used to mount switch S6 (see Fig. 4 for connection details).

Construction

Construction of the Lumitron-4 is straightforward and parts placement is not critical. A 22-finger double-sided, plated-through, PC board (Figs. 5, 6, and 7) is used for the control unit.

The mode-select switch, S6, is mounted on a single-sided PC board (Fig. 8). Parts placement and connections for this board were shown in Fig. 4.

Figure 9 shows suggested case dimensions and provides a drilling-guide for holes for the switches, pots, and LED's.

The LED's, used to monitor output-channel activity, are press-fit into their mounting holes and their leads connected to a terminal strip. The 330-ohm current-limiting resistor for each LED is connected directly between the cathode lead and the appropriate location on S6 (refer to Fig. 4).

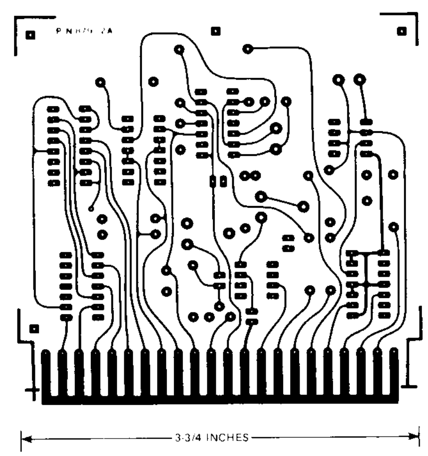


FIG. 5—FOIL SIDE of double-sided control-unit PC board. Connector finger 22 is at left.

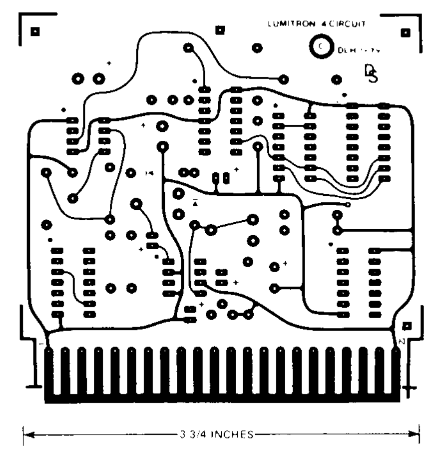


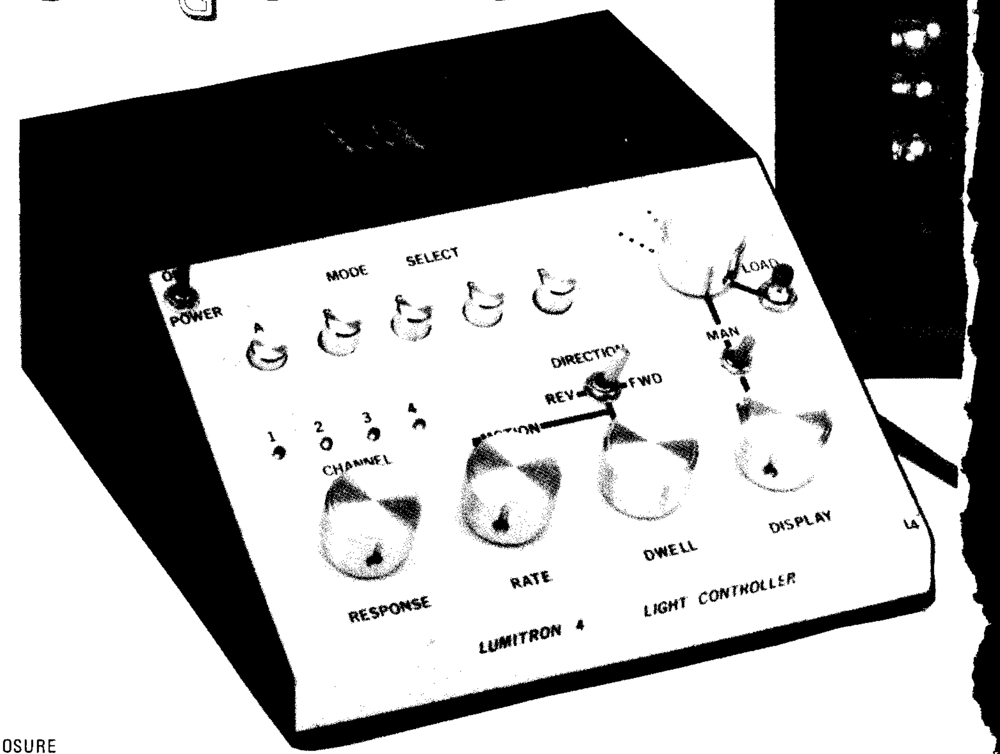
FIG. 6—COMPONENT SIDE of control-unit board. If you etch this board yourself, all holes that coincide on both sides will have to be jumpered through. Take special care at IC sockets.

The last board to be mounted should be the one holding S6. It should be positioned so that switch S6-a is at the left when the switch assembly is viewed from the front of the cabinet. Use spacers at least 3/8-inch long when mounting the switch board in the cabinet.

Next month we'll finish construction of the Lumitron-4 and show you how to operate the device. We'll also give you a few ideas on how to create an eye-catching display. **R-E**

BUILD THIS

VERSATILE LIGHT SEQUENCER

Part 2 THIS MONTH WE'LL conclude our look at the Lumitron-4 light sequencer, test the unit, and finish up by giving you some ideas for a lighting display.

Figure 9 shows suggested case dimensions and provides a drilling-guide for holes for the switches, pots, and LED's.

The LED's, used to monitor output-channel activity, are press-fit into their mounting holes and their leads connected to a terminal strip. The 330-ohm current-limiting resistor for each LED is connected directly between the cathode lead and the appropriate location on S6 (refer to Fig. 4).

The last board to be mounted should be the one holding S6. It should be positioned so that switch S6-a is at the left when the switch assembly is viewed from the front of the cabinet. Use spacers at least 3/8-inch long when mounting the switch board in the cabinet.

The power supply (Fig. 10) uses a wall-plug transformer for safety and space-saving reasons. The full-wave bridge rectifier (BR1), filter capacitors, and voltage regulator are all wired to one terminal strip inside the control-unit cabinet. On the same terminal strip is the audio-input coupling capacitor. All audio-circuit connections should be made using shielded cable.

The wiring connections to S6, the panel-mounted components, and the card socket are best made using ribbon cable. For ease of wiring, it is recommended that the socket for the control-

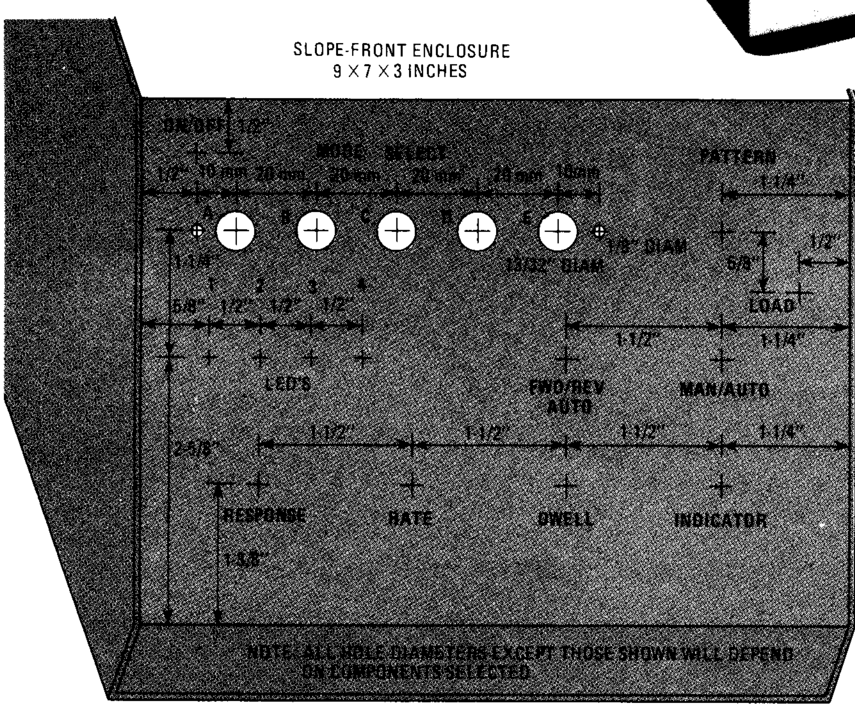


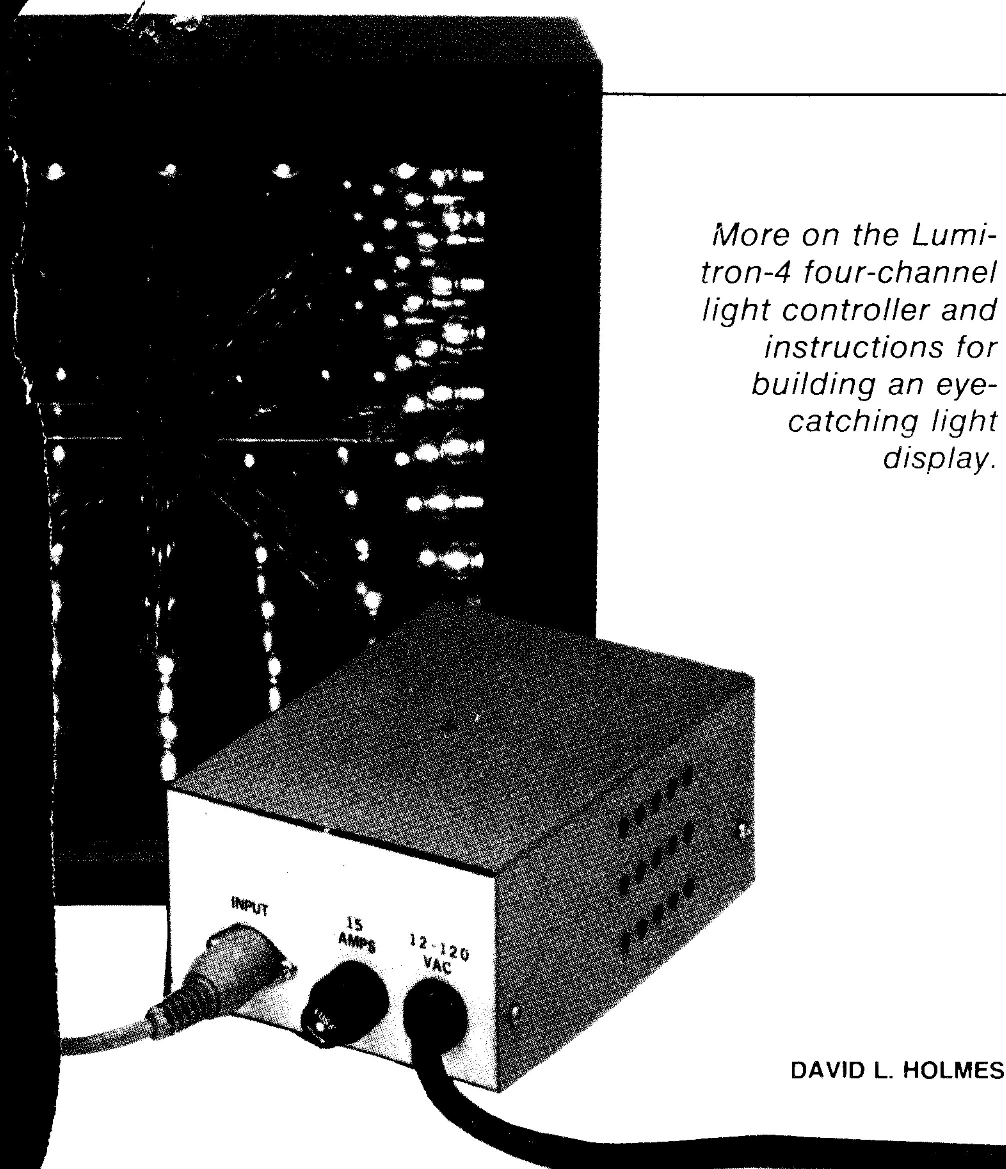
FIG. 9—USE THIS as a drilling guide for the control unit's front-panel components.

unit board not be mounted until all wiring to it has been completed. In the prototype, the card socket was mounted horizontally using 5/8-inch threaded spacers placed at a height of 5/8-inch from the enclosure bottom. This height was chosen to allow the use of another 5/8-inch threaded spacer to support the center of the circuit card. Figure 11 shows the completed control unit.

The schematic in Fig. 12 shows one of the four power-switching unit sections. A foil pattern for the complete unit is provided in Fig. 13, and a parts-placement diagram in Fig. 14.

The assembled power-switching unit is shown in Fig. 15.

(It is also possible to use solid-state zero-crossing relays in place of the triacs and triac-drivers. In that case, wire all the relays' "+" terminals together and connect them to the +5-volt control-signal lead from the control unit. Connect the "−" terminal of each relay



More on the Lumitron-4 four-channel light controller and instructions for building an eye-catching light display.

DAVID L. HOLMES

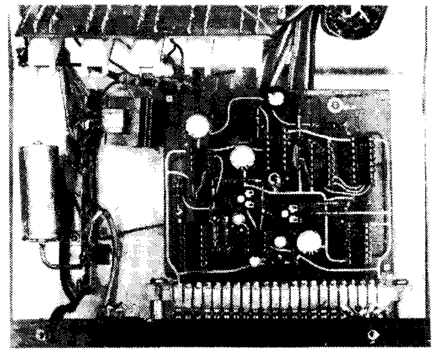


FIG. 11—COLOR-CODED RIBBON CABLE makes connections neater and easier and simplifies signal tracing.

to the appropriate-channel signal-lead.)

As with any construction project, steps should be taken to insure that the Lumitron-4 is safe to operate when completed. Be sure that adequate heat sinking is provided for the triacs. Also be sure that the power source is adequate to power all four channels operating all lights simultaneously. For a 15-ampere, 117-volt circuit, a maximum wattage of 450 watts per channel should be allowed. The permissible wattage increases to 600 watts per channel for a 20-amp circuit. The rating of fuse F1 should be chosen in accordance with the total load.

Under certain conditions, you may wish to operate the light display at less than full intensity. Two circuits that will permit that are shown in Fig. 16. The one in Fig. 16-a changes the brightness of the entire display while the circuit in Fig. 16-b allows independent control of each channel.

Standard household-type dimmers may be used but be absolutely certain—especially in the first case—that they can safely handle the power.

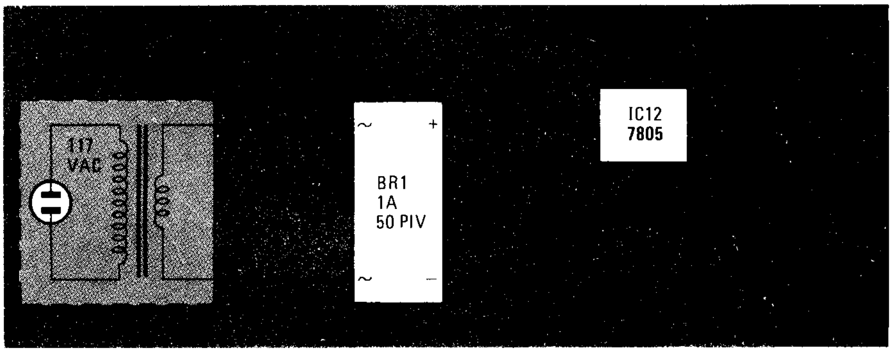


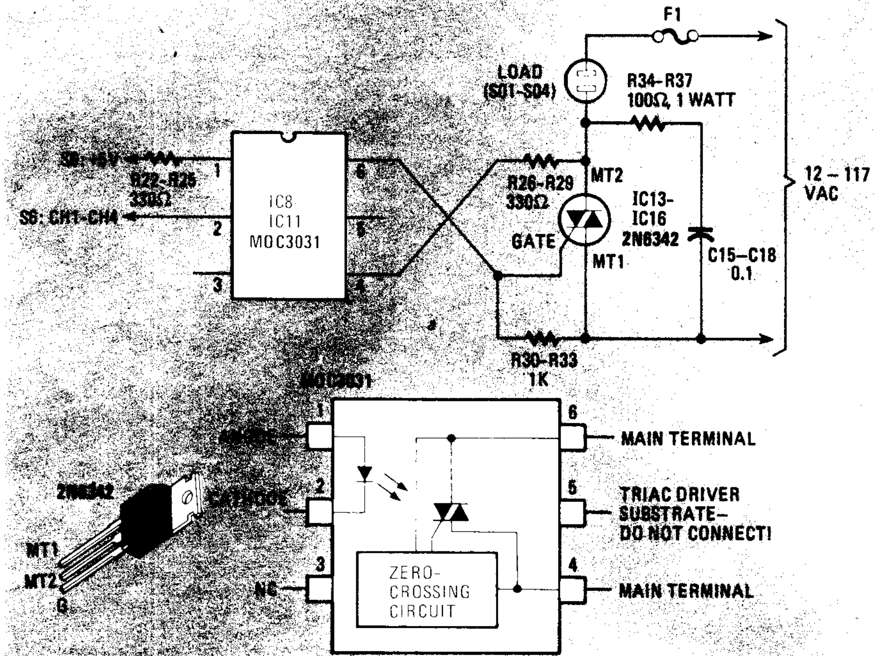
FIG. 10—FIVE-VOLT POWER SUPPLY for control unit uses wall-plug-type transformer. Supply is built on terminal strip using point-to-point wiring.

Operation

The control unit may be operated and tested with the aid of the console LED's and does not require connection of the power-switching unit. Before turning on the control unit, rotate all variable controls to their full counterclockwise position, place the FORWARD/REVERSE switch in the FORWARD position, set the indicator switch to the MANUAL position, set the PATTERN-SELECT switch to pattern "D" and depress MODE-SELECT switch A. Turn the unit on and verify that all console LED's light steadily.

Next, depress MODE-SELECT control switch E and verify that one LED at a time is lit and that the LED's light sequentially in one direction. The rate of movement should vary as the RATE control is rotated clockwise. Moving the PATTERN-SELECT switch to a new position and depressing and releasing the LOAD button should cause a new light pattern to be displayed. The light patterns available include: one light, two adjacent lights, every other light, and three lights. Setting the MANUAL/AUTO switch to the AUTO position should cause the light pattern to change automatically, with the time between changes increasing as the DISPLAY control is rotated clockwise.

The modes controlled by MODE-SELECT switches B, C, and D require an audio signal of at least 50 millivolts for proper operation. With the RESPONSE control still in the full counterclockwise position, depressing switch C should not affect the light movement. Rotating the RESPONSE control clockwise should eventually cause the light pattern to move in sync with the audio signal. Depressing switch B should cause the intensity of all the LED's to change in sync with the audio signal. When switch D is depressed, the light pattern should move at a constant rate, but the intensity of the display should


F1
LOAD
(S01-S04)
R34-R37
100Ω, 1 WATT
R22-R25
330Ω
S6: CH1-CH4
1
2
3
IC8
IC11
MOC3031
6
5
4
R26-R29
330Ω
MT2
IC13-
IC16
2N6342
GATE
MT1
C15-C18
0.1
12 – 117
VAC
R30-R33
1K
2N6342
MT1
MT2
G
CATHODE
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ZERO-
CROSSING
CIRCUIT

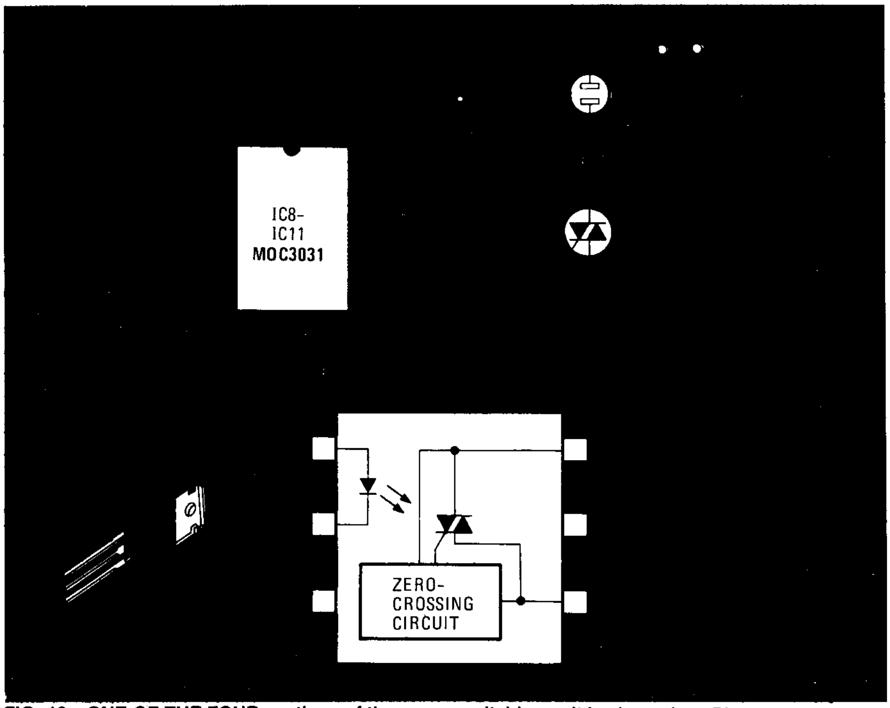

FIG. 12—ONE OF THE FOUR sections of the power-switching unit is shown in *a*. Pinouts of triac and optoisolated zero-crossing triac driver are shown in *b*.

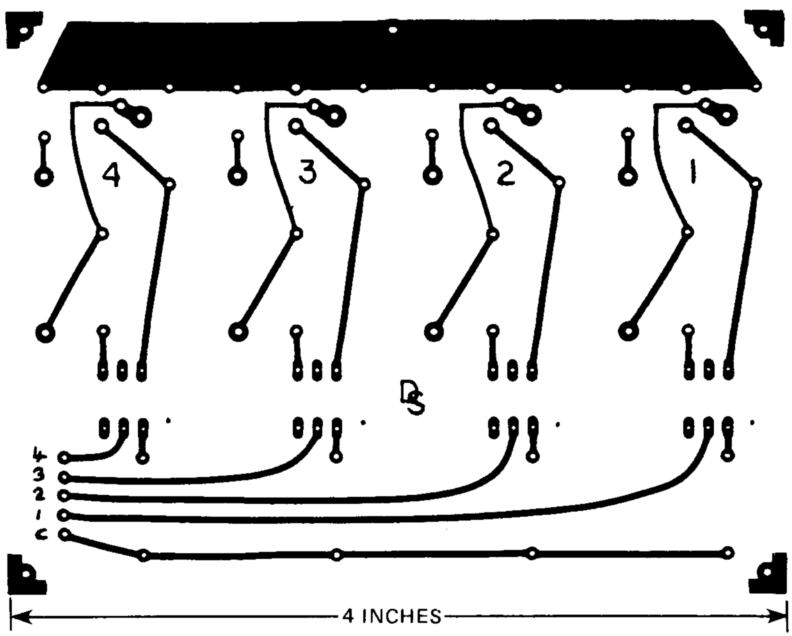

FIG. 13—POWER-SWITCHING UNIT is constructed on single-sided PC board.

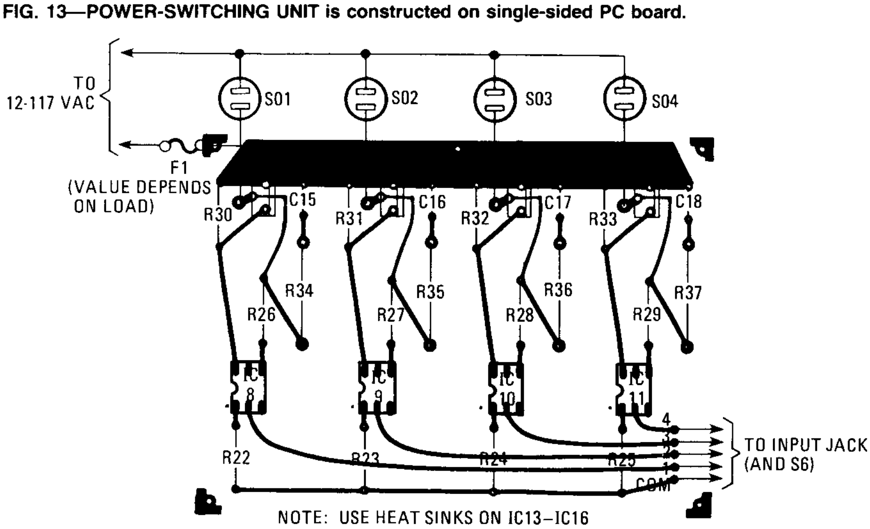

FIG. 14—SIX-PIN TRIAC DRIVERS are inserted into eight-pin IC sockets with pins 4 and 5 removed.

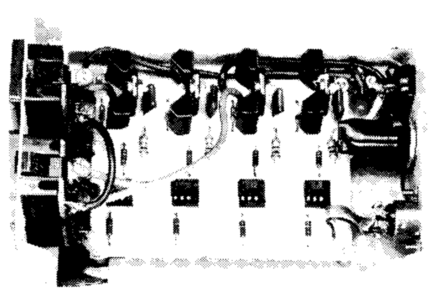
FIG. 15—IT IS IMPORTANT that triacs be heat-sinked, especially if heavy loads are to be driven.

fluctuate with the audio signal. For any mode where the light pattern is moving, positioning the FORWARD/REVERSE/AUTO switch in the AUTO position will cause the pattern to change directions periodically. The DWELL control determines the time interval between changes.

Releasing all MODE-SELECT switches will cause the light display to go off but it will reappear as soon as a mode is selected.

The lowest signal level that the audio section will respond to may be set by adjusting R12. This is useful for normally high-level signals that would otherwise limit the sensitivity control to a very small movement before saturation of the audio section occurred. Potentiometer R10 may be adjusted to obtain the desired balance between sound-sync chase, and intensity of fluctuation, for the same RESPONSE control setting.

After completing the functional check of the control unit, connect the power-switching unit to a light display consisting of at least one light per channel. The power-switching unit should be connected to a voltage source meeting the requirements of the lamps (i.e., 12 volts for 12-volt lamps, 117 volts for ordinary household lamps, etc.). Repeat all previous functional checks and verify that the light display connected to the power switching unit corresponds to the LED display of the console. One thing to keep in mind here is that the LED's may barely be visible when the light display is bright.

Lighting display

Now that you've completed the Lumitron-4 and verified that the unit is operating properly, you need to devise an appropriate light display. The lighting display used with the device requires four separate lighting circuits. The fastest way to create a four-channel display is to obtain four strings of Christmas tree lights and tape them together in a bundle. The strings should be placed, one on top of the other, so that the first bulb of three of the strings fits between the first and second bulbs of the fourth string. The idea is to have every fifth bulb in the composite string on the same circuit.

In creating your own unique display,

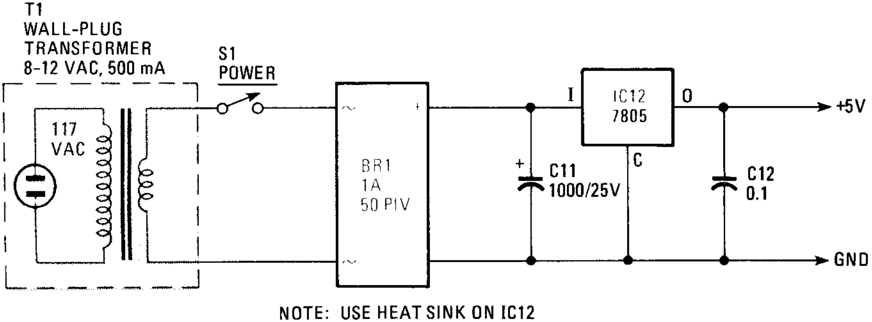

FIG 10—**FIVE-VOLT POWER SUPPLY** for control unit uses wall-plug-type transformer. Supply is built on terminal strip using point-to-point wiring.

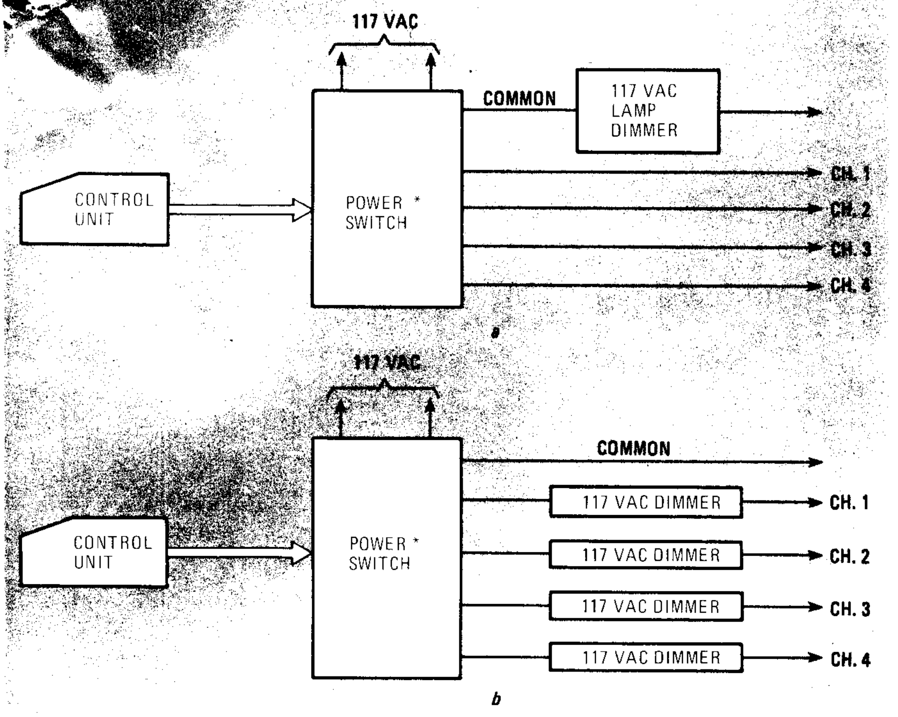

FIG. 16—OPTIONS FOR DIMMING Lumitron-4 display. All-channel dimmer is shown in *a*; individual-channel unit in *b*.

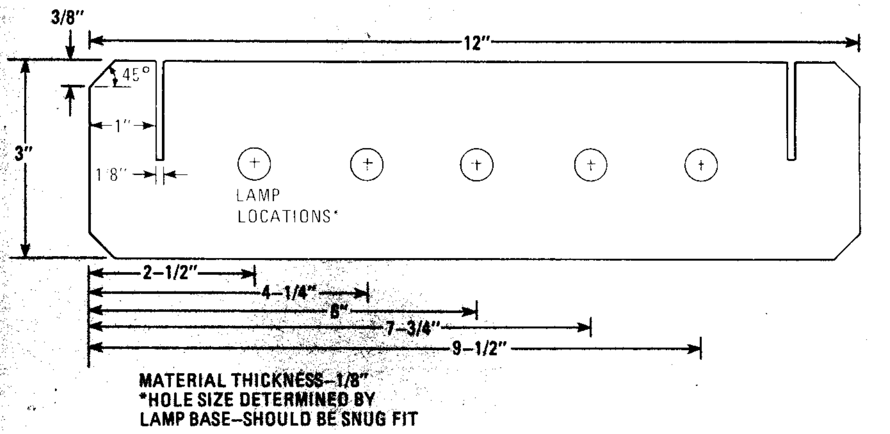

FIG. 17—FOUR OF THESE PIECES should be prepared to make square frame to hold infinity mirror's 12-volt lamps. Masonite is a good material to use.

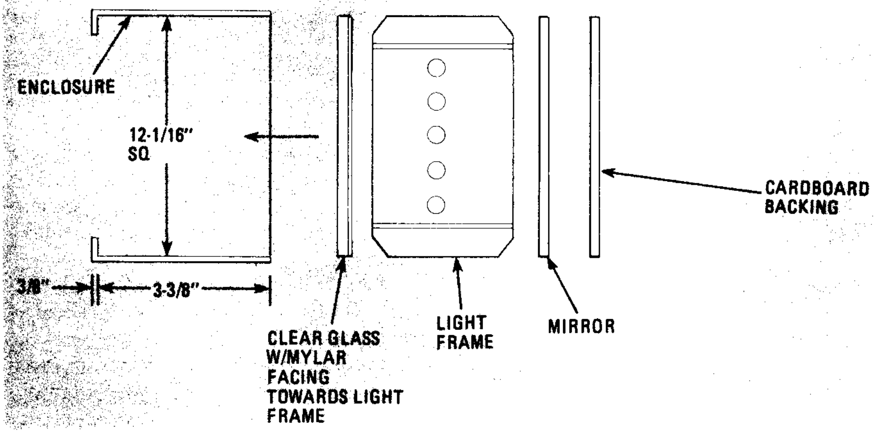

FIG. 18—EXPLODED VIEW of infinity mirror. A small notch will have to be cut or filed in the case to pass lines for lamps.

just remember to have every fifth bulb on the same circuit, and a common wire to all bulbs. Another very important point is that *the common wire must be able to carry enough current for all four circuits, operating all of the*

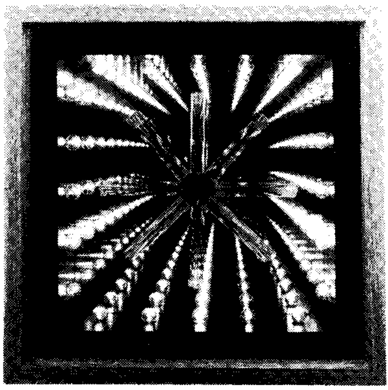

FIG. 19—INFINITY-MIRROR DISPLAY. Lamps may be clear or colored, according to taste.

bulbs simultaneously, when required.

A real eye-catching display that is rather easy to build involves the use of the "infinity-mirror" illusion that can be created with the aid of readily available Mylar sun-reflecting film. To construct the infinity-mirror you'll need a clear piece of glass (double-strength is recommended), a mirror the same size as the glass, a sheet of the Mylar reflecting-film, lights, and a frame to hold them, and a case. A convenient case size has inside dimensions of 12 1/16 × 12 1/16 inches, which allows the use of precut mirror squares and simplifies the construction of the display.

The Mylar film is applied to the glass and is trimmed flush, creating a "one-way" mirror that is placed in the display front with the Mylar film on the inside of the display. The light frame is inserted next, followed by the mirror square. It will be necessary to cut a notch in the case to allow passage of the light-display control leads around the mirror. Place a small piece of electrical tape on the edge of the mirror where it comes in contact with the control leads. Cut a piece of cardboard to fit over the back of the mirror and secure the entire assembly so that all pieces of the display fit snugly together within the case. Refer to Figs. 17 and 18 for construction details. Figure 19 shows the completed infinity mirror light display.

With the display activated, multiple reflections of the lights within the display will create an infinite-tunnel-of-lights illusion. The secret of this illusion is the Mylar film, because it partially transmits light to the outside of the display while reflecting a portion of it to the back mirror for re-reflection. Only the first row of lights seen in the display is real; the rest of the lights are reflections.

A lighting display comprised of multiple infinity mirrors is very effective and will add to your enjoyment of the Lumitron-4. **R-E** mended that the socket for the control-

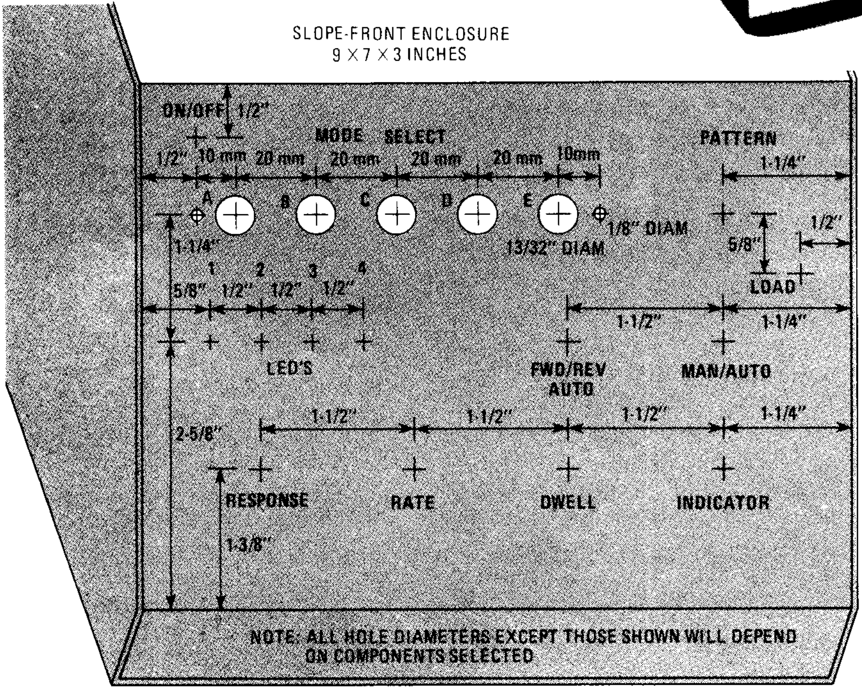

FIG. 9—USE THIS as a drilling guide for the control unit's front-panel components.