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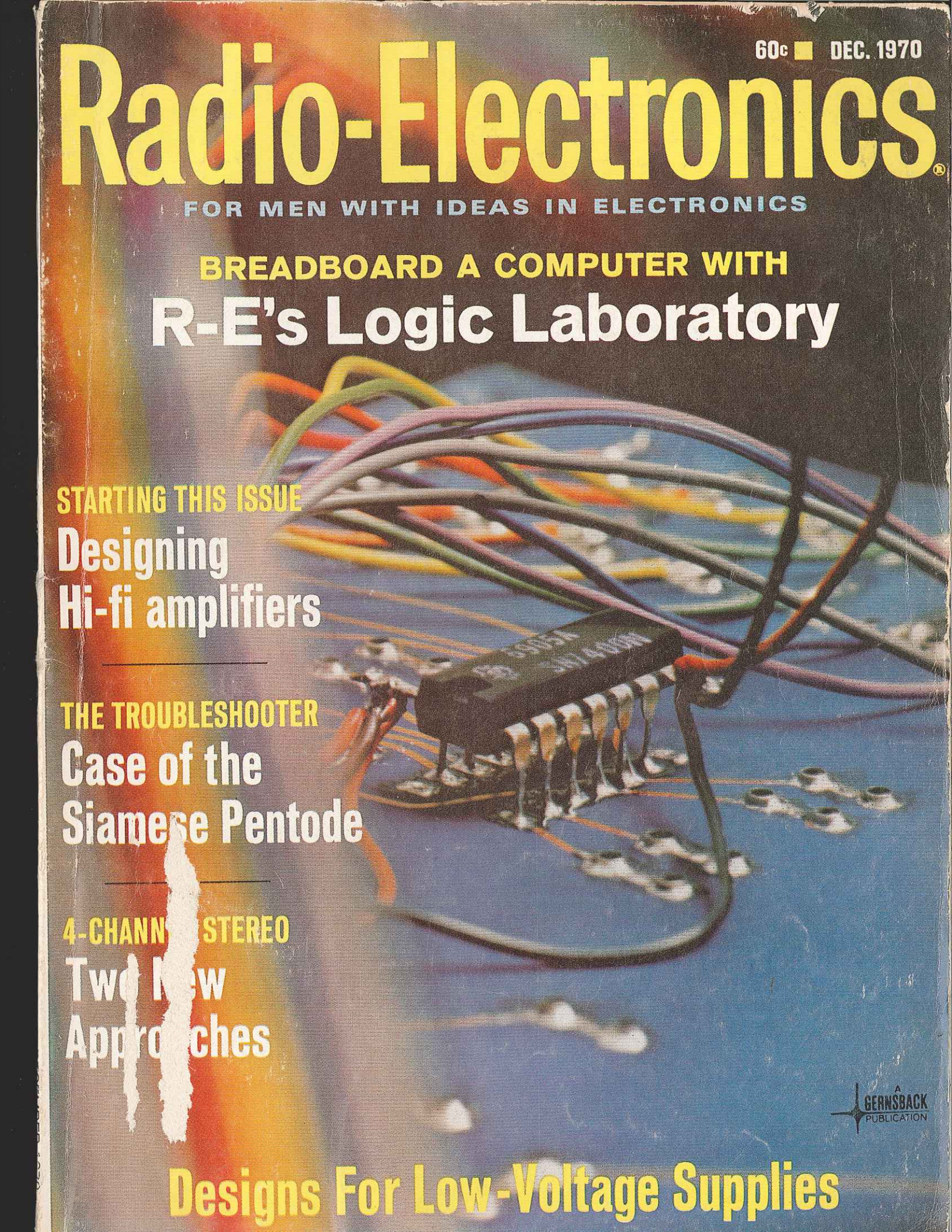
BREADBOARD A COMPUTER WITH R-E's Logic Laboratory



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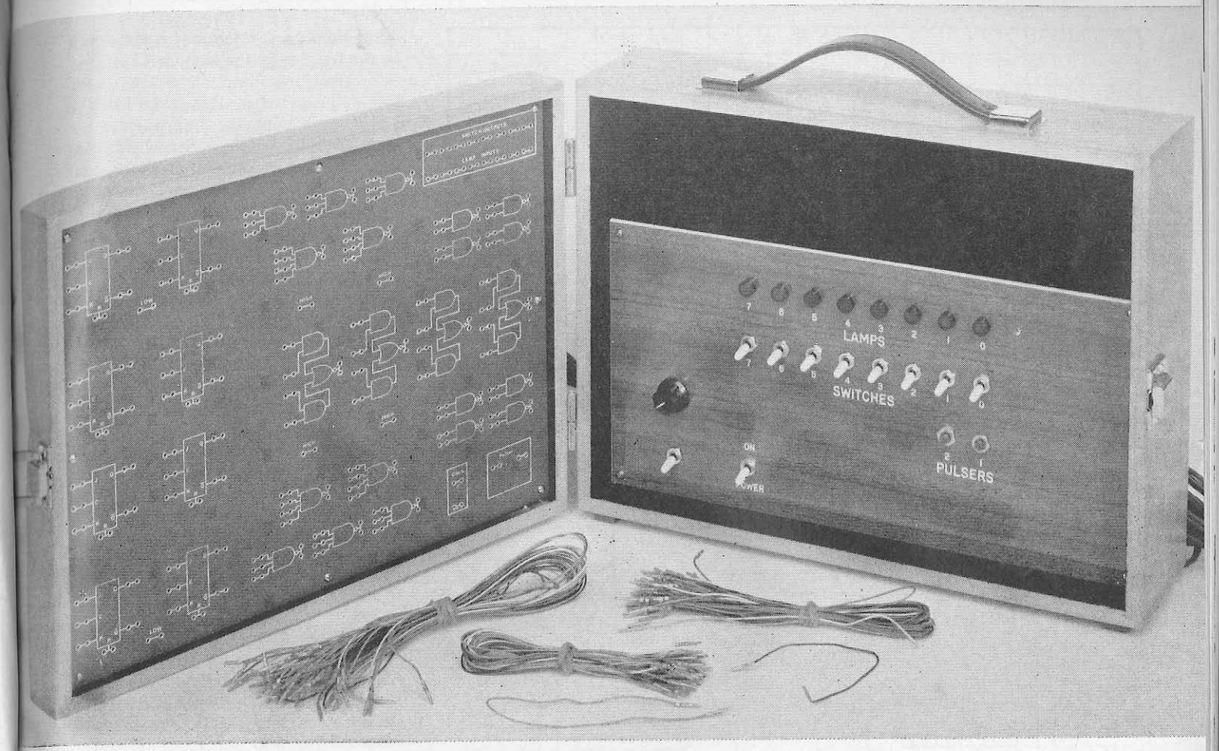


BREADBOARD A COMPUTER WITH

R-E's Logic Laboratory

by DAVID KORMAN

A number of educational systems have been designed over the last ten years or so that allow a beginner to learn digital logic. Each of these has been expensive, running as much as a thousand dollars or more for a very small system. The system described here costs only a little over $100 yet it is patterned after a system that currently sells for $450.

A computer logic laboratory is a device that can be used to learn about, test and design computer circuits. The unit described here can be used as a home study unit to learn digital logic. It can be used in a classroom to teach digital logic. Having learned logic, the system can be used to construct and test encoders, decoders, gating circuits, counters, shift registers, storage registers, adders, and many other logic circuits.

More than one unit can be "ganged" to build a complete computer. The lab has eight lamps, eight switches, two pulsers, clock circuitry, power supplies and a complete logic system all packed in a 9″ x 12″ x 4″ package for easy portability.

To keep cost low, the entire logic section has been layed out on the reverse side of a printed circuit logic panel. The reverse side contains all interconnect wiring, integrated circuits (Transistor-Transistor Logic), and power distribution.

The front of the card contains MIL806B logic symbols with eyelets used for interconnection. The interconnection is made from gate to gate using wires with taper pins. These make ideal low-cost connectors.

The logic panel is in the 9″ x 12″ by 1″ deep lid of the laboratory. There are provisions for connecting the logic to lamps, switches, pulsers and clock outputs.

The balance of the circuitry, including lamps and switches is in the body of the case. The entire assembly weighs less than 5 pounds making it easily portable. Power for most of the circuitry is obtained from a standard 117-volt outlet. The low drain clock oscillator is operated from a 9-volt battery that should last for a year in normal operation. The battery isolates the clock oscillator from the rest of the circuitry.

Construction details

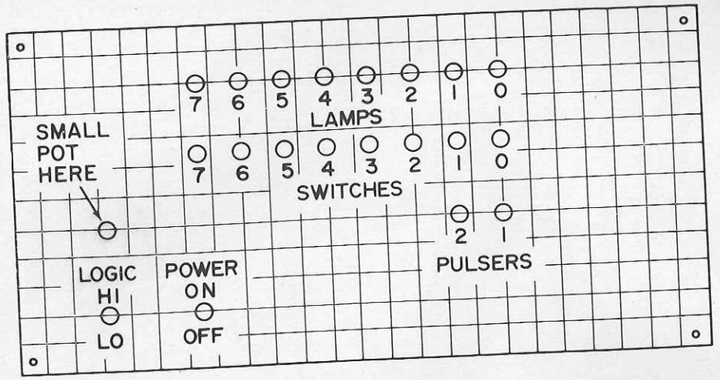
Building the unit is broken down into several individual steps:

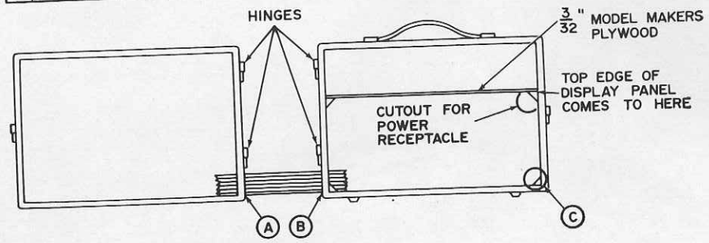
1. Display panel
2. Hardwood case
3. Logic panel
4. Rectifier-regulator card
5. Clock-lamp driver card
6. Final testing and assembly.

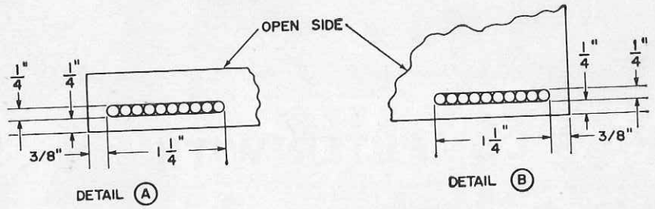
After construction is completed, you will be presented with a complete set of operating instructions and experiments for the laboratory.

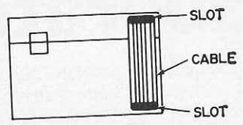
Display panel

If you are building your own panel (Fig. 1), make sure all drilling is completed and all legends are in place before starting construction, then ream the lamp holes carefully. **These holes must be just large enough to allow the lens cap to slip in with a fair amount of pressure. The only**









HINGE END VIEW OF SLOT LOCATIONS

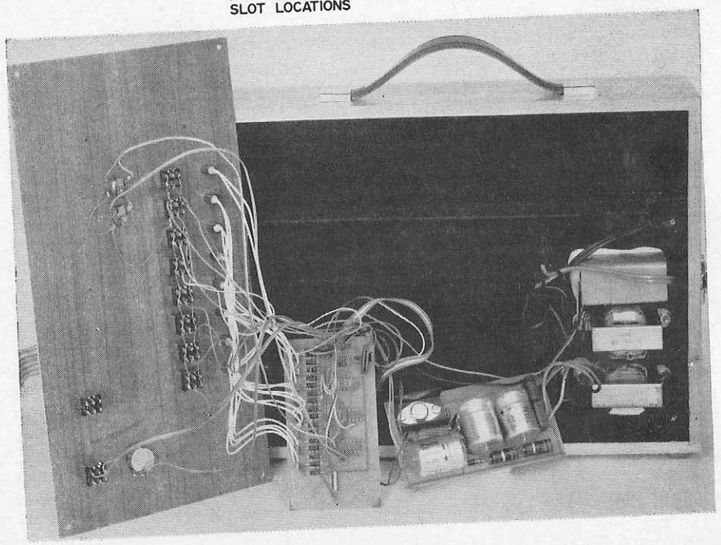


FIG 1 (top)—DISPLAY PANEL is 1/8-in. wood-grained hardboard. Squares are 1/2 in. (Center)—HOW CASE IS ARRANGED. (Bottom)—INSIDE THE CASE shows rear of display panel, the power supply and the voltage-regulator and clock/lamp-driver boards. Note transistor on the heat-sink.

thing holding the lamps in place will be the tension on the lens caps.

After installing all 8 lens caps, install the switches. Remove all of the hardware except the nut nearest the body on all switches. Screw the nut remaining up a couple of turns, put the lock washer in place and fit it into the hole. If the bushing clears far enough to allow the outside nut to screw all the way down without showing any threads, the setting is about right. Mount all switches this way using the two nuts and the lock washer.

Install the two push-button PULSER switches and the small potentiometer. The potentiometer fits in the top left hole in the panel. If necessary, cut the shaft shorter to allow the knob to slide down nearly to the face of the display panel. Install and tighten the knob.

Install the eight lamps by pushing them into the lens caps from the back. Check your work and lay the panel aside for mounting it in the case.

Hardwood case

Check the display panel fit in the deeper part of the case. Mark the point on the case where the top edge of the panel stops. Do this on both sides of the case and using a square, draw a perpendicular line down the inside of the case using the top edge of the case and a tri-square.

Now, at these two points and at the two lower corners, measure 1" and mark the case. Using these marks as guide lines, carefully glue the display panel mounting blocks into place. Check them with the display panel to insure that the display panel touches all four blocks.

Glue in a piece of 3/32" model makers plywood 2 inches wide and 12 inches long to form a box.

Using a 1/4" drill, drill holes as closely spaced as possible as shown in details A, B and the hinge end view of these slot locations. Once drilled, shape the holes neatly with an X-Acto knife.

The next step, though not absolutely essential, will make a far neater job. Remove the hardware and lay it out so that it can be replaced exactly as it was. Sand the exposed edges of the case as smoothly as desired and dope them with ordinary or "hot fuel-proof" model airplane dope. When dry, sand lightly and put on one more coat.

Mask these edges very carefully and spray the interior of both the lid and the case with the color of your choice. I used Krylon flat-black spray lacquer on my unit. Let the glue and paint dry overnight and replace the hardware to complete the case finish.

Mark out the power receptacle cutout from inside the case. Rough it out with a 1/4" drill and smooth out the cutout. Drill the holes for the mounting screws and mount the receptacle. This completes the majority of the work on the case.

Lay out the transformers and 9-volt power supply to insure that they will fit properly into the case. Drill holes for mounting all parts that require drilled holes. Use flat washers under the heads of binder head screws on the outside of the case and tighten nuts on the inside to secure all parts in place.

Logic panel

If you do not purchase the card for this section of the logic lab, obtain a piece of 1/16" circuit card material with, preferably, 2-ounce copper on one side. The raw stock should be large enough to accommodate a 9" x 12" card with working room.

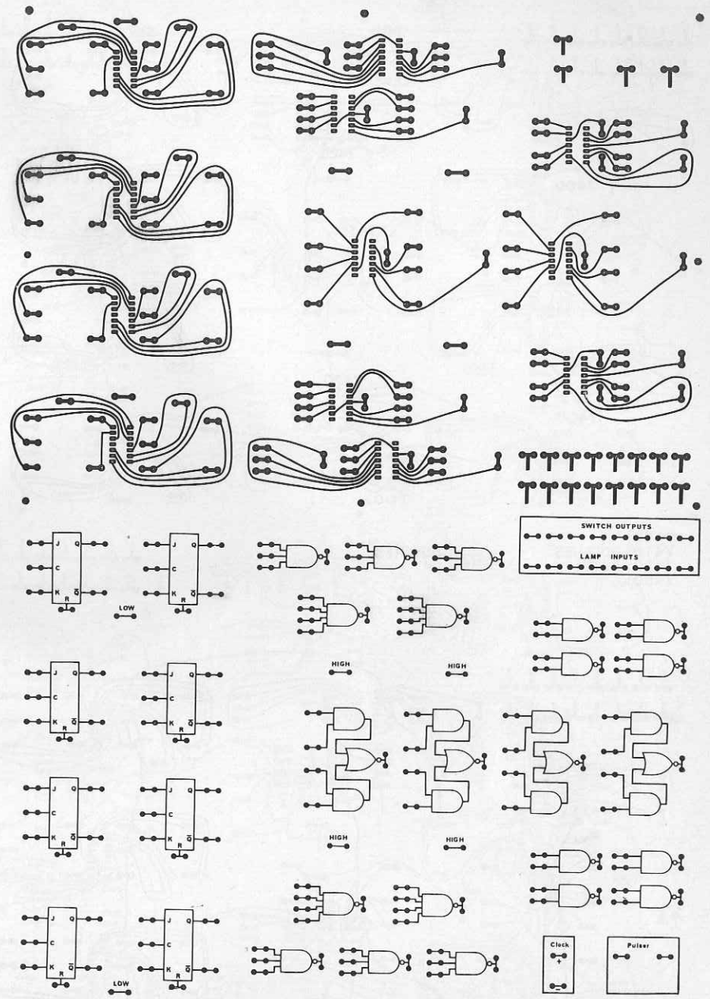
Set up and etch the copper side with the pattern in Fig. 2. Drill the large pad positions with a No. 47 drill. This allows a snug fit for the Mark Eyelet and Stamping eyelets used for terminals. **The small pad positions should not be drilled since the IC's are surface mounted on the pads.**

After drilling, insert the eyelets through a film positive or similar artwork of the front of the panel (Fig. 3) cut to match the drilling pattern. Solder the eyelets from the copper side; be very careful not to get solder in the eyelets as these are just large enough to accept the taper pins used as plugs. The eyelets forced through the artwork will hold the artwork in place.

In one instance the pattern for the front panel was etched (using 2-sided copper board) and the resulting conductors cut to avoid causing shorts.

From this point the procedures apply to either a home-brew or purchased circuit-card:

Insert eyelets in each hole press-



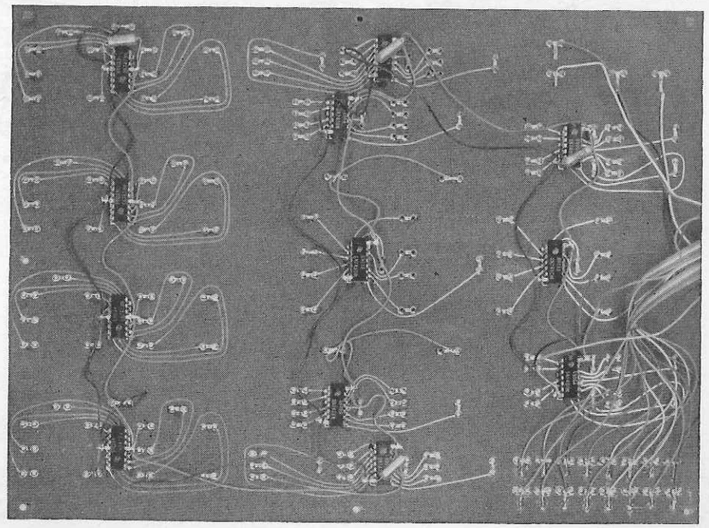


FIG. 2 (top)—LOGIC PANEL WIRING is smaller than half-size. Enlarge so pattern is 11 1/2 x 8 1/2 in. between corner mounting holes. FIG. 3 (center)—FRONT OF LOGIC PANEL. Enlarge to same size as Fig. 2. (Bottom)—LOGIC PANEL PHOTO shows the IC's, all jumpers and leads.

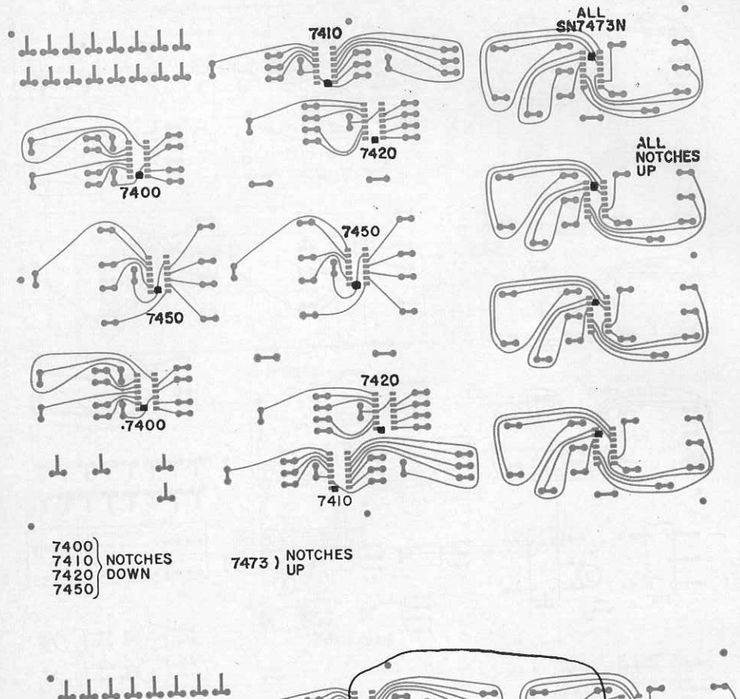


FIG. 4—TYPE AND LOCATION. The 7473's have their notches pointing up; all others point down. FIG. 5—THE NEXT STEP is to add the ground leads as shown.

(Bottom)—HOW CASE IS MADE. The top is 1 1/4 in. deep overall and the bottom is 3 1/4 in. Sectional drawing at right shows how the logic panel is mounted on angles.

ing them as near flush with the card as possible. Turn the card over and using a small iron and plenty of care, solder around the outside edge of the eyelet-pad interface. Don't get solder on the inside walls of the eyelet. Should this happen, use a small drill to clean out the inside of the eyelet. Pre-tinning all pads and then using a sweat soldering technique might be the best all-around approach to the problem.

After inspecting the board to insure that all eyelets are mounted and properly soldered, the integrated circuits are mounted as shown in Fig. 4. Their legs can be slightly compressed to make them fit the pattern of small etched holes. Very carefully solder two legs at diagonally opposite corners to the copper pattern. Use as little soldering iron dwell time as possible to avoid lifting the pads. The iron should be as small as possible and as hot as possible. Get on, make sure the solder liquifies and flows and then get off! Inspect the soldering and the positions of the remaining legs to be sure that everything is properly positioned and matched. Solder the remaining legs, excluding the power and ground legs to their pads. Since solder bridges between pads can occur quite easily with the close proximity of these circuit runs and pads, inspect every connection for solder bridges.

Bend the power and ground legs out very carefully to make them parallel to the surface of the card. Use insulated wire to run power and ground connections as in Figs. 5 and 6.

Install five 15-μF, 20-volt tantalum capacitors in the locations shown in Fig. 7.

Attach 8 "L" brackets to the board using 4-40 hardware. File two sides of each nut to remove the plating before tightening it on the screw. One or two of the brackets may have to be shortened to avoid circuitry. After the brackets are installed, fit the assembly into the lid and be sure that the brackets are all properly positioned and fit snugly against the side of the lid. Remove the assembly and solder each nut to its "L" bracket on at least two sides.

Mark the points where the "L" brackets contact the inside surfaces of the lid and apply a generous amount of epoxy cement to each of these locations. Insure that the cement comes no further up the side than the top of the "L" bracket. **Do not apply cement to the "L" brackets as this will smear the case.**

Slide the entire logic panel and bracket assembly back into the lid and allow the epoxy cement to set completely for at least 8 hours at room temperature.

Now, by removing the 8 4-40 screws, the panel can be removed to complete the wiring! The brackets should remain firmly anchored to the walls of the lid with the nuts soldered on the bottom of the brackets.

Rectifier-regulator card

All of the layout and parts placement information required to construct the rectifier-regulator card is on the card artwork or on the card (see Fig. 8).

Mount or install all components except the power transistor as indicated on the card and parts list. Solder and clip all leads close to the board. Inspect all solder connections and insure that all parts are properly placed.

In assembling the power transistor and heat sink, it will be necessary to file the tabs of the top part of the heat sink on both top and bottom to insure good contact between the transistor case and the bottom of the transistor cover and the top of the transistor cover and the screw. Mount and tighten the transistor and transistor cooler assembly.

Be sure to observe polarity of all diodes, rectifiers and electrolytic capacitors. On Zener diode D9 the banded or cathode end should be up (toward the transistor). On Zener diode D10, the band should be toward the MDA rectifiers.

LOGIC LAB PARTS

Parts for the logic laboratory are available from Southwest Technical Products Corp., 219 Rhapsody, San Antonio, Texas, 78216. The following items are available:

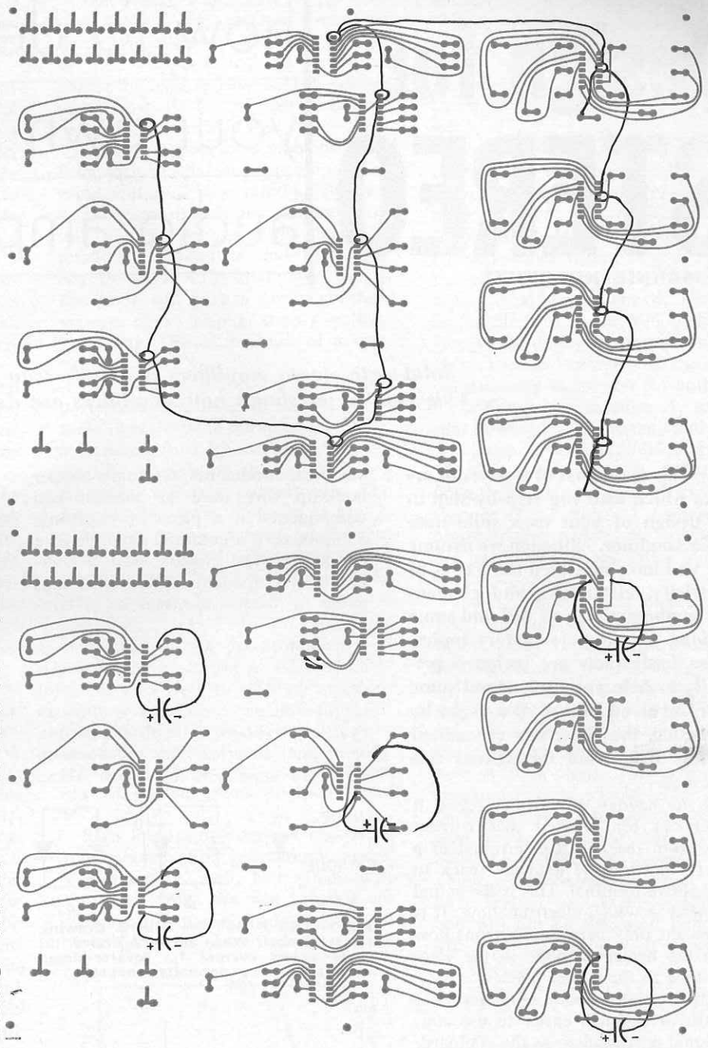
Rectifier-Regulator Board.....$2.20
Kit of parts plus board.....$17.50
Lamp-clock Driver Board.....$2.10
Kit of parts plus board.....$20.75
Lamp and Switch Panel with associated parts.....$20.00
Main Logic Panel Board.....$8.50
Kit of parts plus board.....$36.40

The only parts not listed here are the wood case and the power transformers and filters that go into the case. The pattern for the Clock-Lamp driver board will be printed next month.

The complexity of this article has made it impossible for us to present in a single issue of Radio-Electronics. Next month we will publish the remaining construction details, including full parts lists and sources of circuit boards and parts kits. (Southwest Technical Products).

In February we will start a regular column containing a series of experiments you can conduct with the lab.

(TO BE CONTINUED)



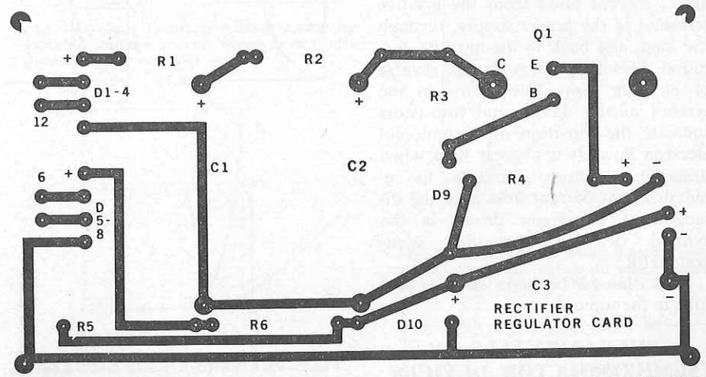


FIG. 6—(top) POWER WIRING on logic panel. Black overlay shows points to be connected with jumper wires. FIG. 7—(center) TANTALUM CAPACITORS are wired into position as shown in the black overprint. FIG. 8—(bottom) RECTIFIER-REGULATOR CIRCUIT BOARD is shown full size. No reduction is needed when using this artwork.