PSYCHEDELIA 1

Color Organ Designed for the 70's Opens New Vistas in Display of Sound

BY DON LANCASTER

THIS IS the day of the color organ. By combining the visual stimuli of multi-color lighting with the aural stimuli of hi-fi sound you can make your living room or den into a psychedelic showcase. Of course, you can now buy a color organ (some even physically looking pretty much like the one described here) but for a modest investment you can build a more versatile color organ with greater sensitivity and power handling capacity.

By employing new design techniques, the latest semiconductors, and computer-derived audio filtering—the ultimate in color organs has been designed. It's called Psychedelia 1 and can control up to 600 watts of vari-colored light per channel. The input signal to the Psychedelia 1 can be a hi-fi system loudspeaker output, a contact microphone, tape recorder output, or just about any audio source. The Psychedelia 1 will add no distortion. The visual display of Psychedelia 1 is distinctive and eye-catching—(see cover photo).

The basic 600-watt Psychedelia 1 described in this issue consists of three

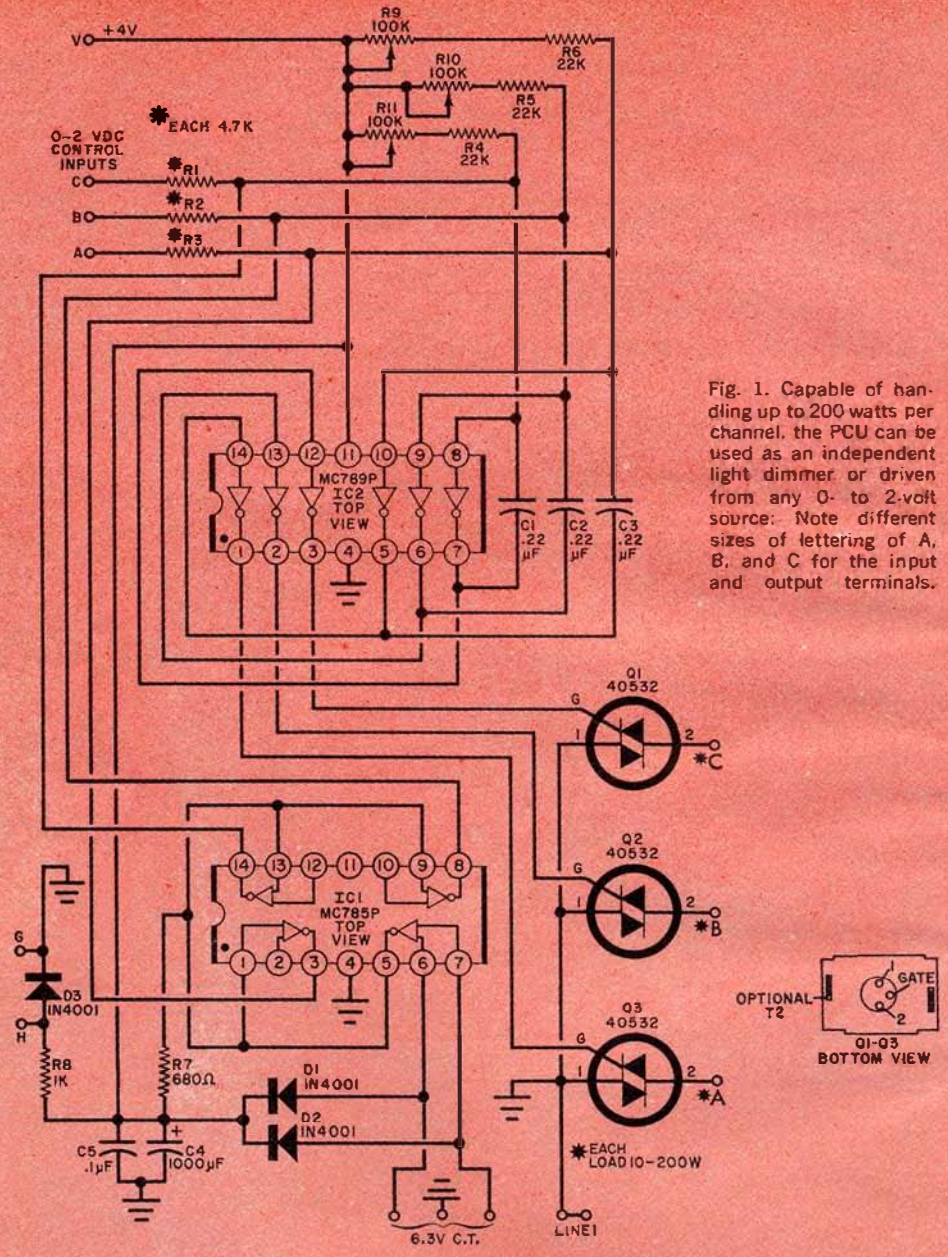


Fig. 1. Capable of handling up to 200 watts per channel, the PCU can be used as an independent light dimmer or driven from any 0- to 2-volt source. Note different sizes of lettering of A, B, and C for the input and output terminals.

PARTS LIST
POWER CONTROL UNIT

C1-C3—0.22-µF, 50-volt Mylar capacitor (see text)
C4—1000-µF, 5-volt electrolytic capacitor
C5—0.1-µF, disc ceramic capacitor
D1-D3—30-volt, 500-mA silicon power diode (1N4001 or similar)
IC1—MRTL quad two-input expander (Motorola MC785P)
IC2—MRTL hex inverter (Motorola MC789P)
Q1-Q3—Triac (RCA 40532, no substitute)
R1-R3—4700-ohm, ¼-watt resistor
R4-R6—22,000-ohm, ¼-watt resistor
R7—680-ohm, ¼-watt resistor
R8—1000-ohm, ¼-watt resistor
R9-R11—100,000-ohm trimmer potentiometer (CTS U-201 or similar)
Misc.—Male quick-disconnect PC terminals (Keystone #1256 or #1257 or similar, 3 required); mounting hardware: solder; etc.

Note—The following are available from Southwest Technical Products, Box 16297, San Antonio, Texas, 78216: etched and drilled PC board, #501, $2.80; complete kit of all parts, #501-K, $13.90; postpaid in U.S.A. Individual parts and assembled and tested units are also available.

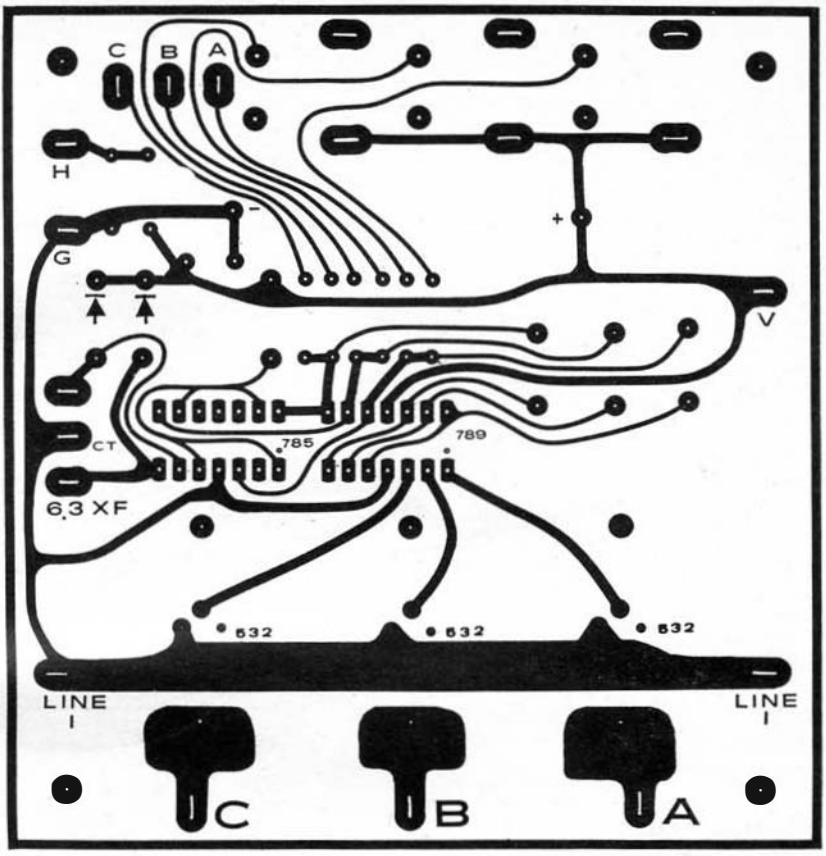
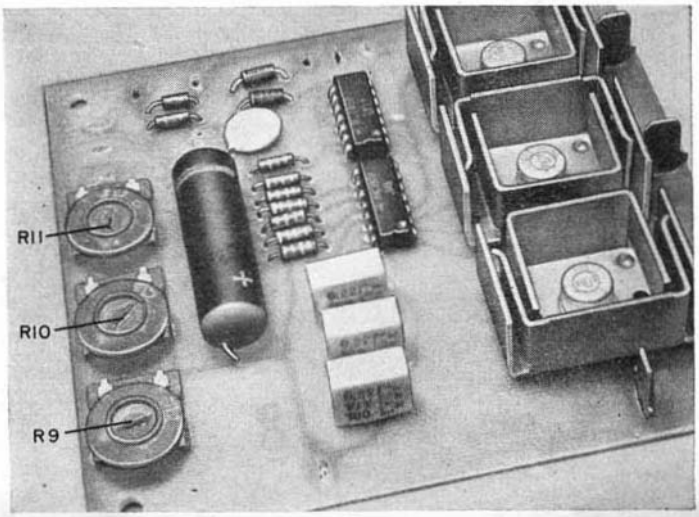


Fig. 2. This foil pattern for the PCU PC board is actual-size and can be reproduced.

elements: a power control unit (PCU), a quality filter unit (QFU), and a holographic bookshelf display. This is all you need for a "starter" system.

Power Control Unit. This is a three-channel (200 watt per channel) full-wave proportional (or strobe) a.c. power controller. It uses three triacs and two IC's in a unique (patent pending) circuit. It has continuous gate drive for the triacs, eliminating channel-to-channel interaction; it is very sensitive and requires only 0-2 volts d.c. for operation; and it is mechanically simple. The triacs have their own built-in heat sinks and require no insulation or mounting hardware. Three background control po-



The three background controls can either be finger or screwdriver adjusted. They are physically isolated from the power line for maximum safety in adjustments. The three triac heat sinks may be "hot" to ground, depending on polarity of line.

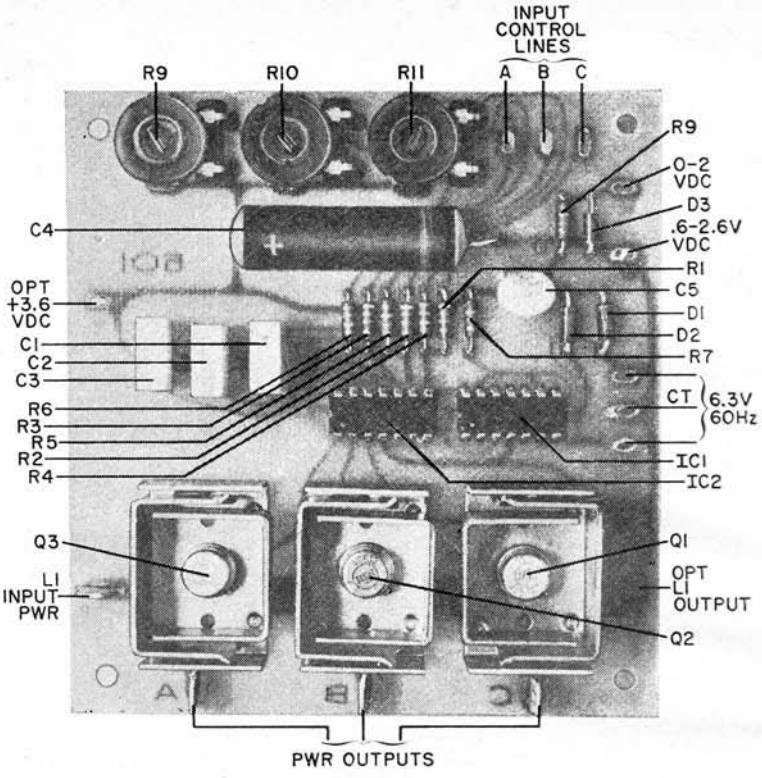


Fig. 3. To install the components, follow the arrangement shown here. Soldered-in, slip-on power terminals are to be used for the output.

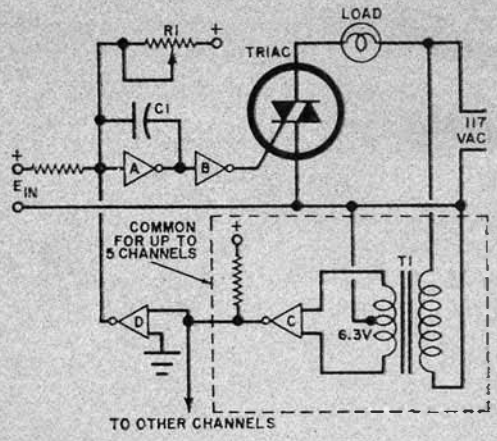
HOW IT WORKS
POWER CONTROL UNIT

As shown in the simplified schematic, in the Power Control Unit, Inverter A is a single *npn* gain stage which, with capacitor *C1* forms a ramp generator. The amplitude of the ramp is at a maximum each time the reference or a.c. line voltage passes through zero. The build-up and decay of the ramp are determined, as we shall see, by other elements in the circuit.

Inverter B operates whenever the ramp voltage drops below 0.6 volt. Above 0.6 volt, the inverter holds the triac in the nonconducting state and below 0.6 volt, the triac is conducting. In this way, the triac gate is either clamped to ground or to a positive voltage so that the possibility of gate interactions is eliminated. Inverter B also isolates the loading effect of the triac from the ramp generator.

The triac acts as a series switch between the supply and the load, automatically turning off when the a.c. line passes through zero. Once it is off, the triac stays off until the ramp voltage drops below 0.6 and the inverter supplies a gate signal. The decay time of the ramp voltage is determined by the size of the input control voltage E_{IN} and the resultant input current. The higher the input, the faster the ramp decays and the sooner the triac turns on during each cycle. Thus more power is supplied to the load and the light is brighter.

The ramp generator is reset each time the supply goes through zero by a synchronizing signal provided by transformer *T1* and gate expander *C*. Each time the supply passes through



zero, a 0.5-millisecond positive pulse drives expander D to recharge capacitor *C1* and return the ramp to its initial positive value. Only one synchronizer circuit is required for 5 or less channels.

Background control is obtained by applying a constant d.c. level in parallel with the input through potentiometer *R1*.

Strobe or on-off operation of the Psychedelia I can be obtained by decreasing the background control to a minimum. This produces an abrupt switching action. The switching action can be made even faster by eliminating capacitor *C1*.

tentiometers permit the user to preset the "off" level of the display lamps.

The schematic of the PCU is shown in Fig. 1. The unit is assembled on a fiberglass PC board using the foil pattern shown actual-size in Fig. 2. Once the board has been made or purchased, mount the components as shown in Fig. 3. Observe the notch, dot, and lead code on the semiconductors and polarity markings on the electrolytic capacitors. The case lead (*T2*) on each triac may be cut short since the *T2* connection is made when the heat sink is soldered in place on the board. The triacs come with an integral heat sink and require no insulation from the board. Install quick-disconnect male terminals at the triac outputs, which are marked **A**, **B**, and **C** beside each heat sink.

Quality Filter Unit (QFU). This circuit takes a relatively low-level audio input, divides it into three isolated frequency bands, and provides three proportional control voltages for the PCU. The QFU is considerably more complex than most color organ filters, but it gives the finest filtering ever offered for a lighting display. Usual filter problems involving display washout, multiple-channel tracking, input loading, distortion, requirements for high input levels, nonlinearity and limited dynamic range have been eliminated.

Among the unique features of the QFU are active filters with very steep slopes and narrow guard bands between channels, and the use of an averaging detector.

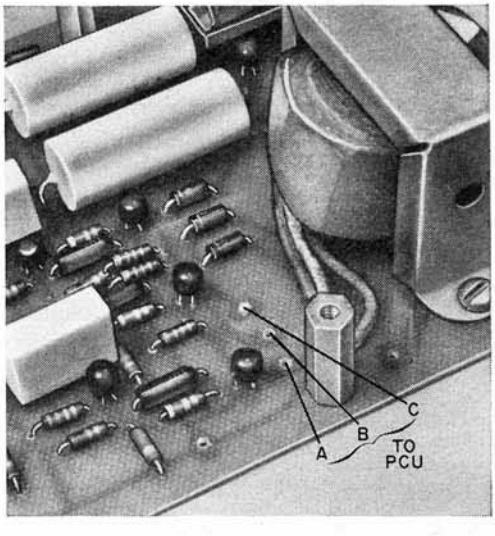
An averaging detector responds to the average value of a signal for a few milliseconds instead of instantaneous peak values. This makes the display less susceptible to radical input variations and eliminates threshold nonlinearity.

The filters are a combination of transistors and passive components called a "two-pole Tschebyscheff." They would require two high-Q, load-isolated inductors per channel if conventional parts were used.

Guard bands are "holes" between the filter responses. These no-response areas between the channels eliminate multiple-channel tracking on a single loud passage or a dominant instrument. Because of the high harmonic content of most music, the guard bands lose very little of the music. Usually there is *too much* "information" in most music for a psychedelic light display to handle. If a little of the music information is thrown away, the display action is much livelier and is without washout or multiple tracking.

Since transistors are used for the filters in the QFU, they also provide gain. The result is excellent sensitivity, no noticeable loading of the input circuit, and no noticeable distortion since the input impedance is resistive at all frequencies of interest.

Resistor *R44* (see Fig. 4) provides input protection and also serves as a sensitivity adjustment. For normal audio listening levels with a 5- to 20-watt amplifier, use the 47-ohm resistor specified. For lower power levels, *R44* can be reduced to 12 ohms, 1 watt. For high-power systems, increase *R44* to at least 100 ohms, 10 watts. The resistor should be the largest ohmic value that still gives acceptable sensitivity to minimum-volume passages.



Holes marked A, B, and C on QFU provide outputs to PCU. The single spacer shown here is one of four used to attach PCU and QFU boards together.

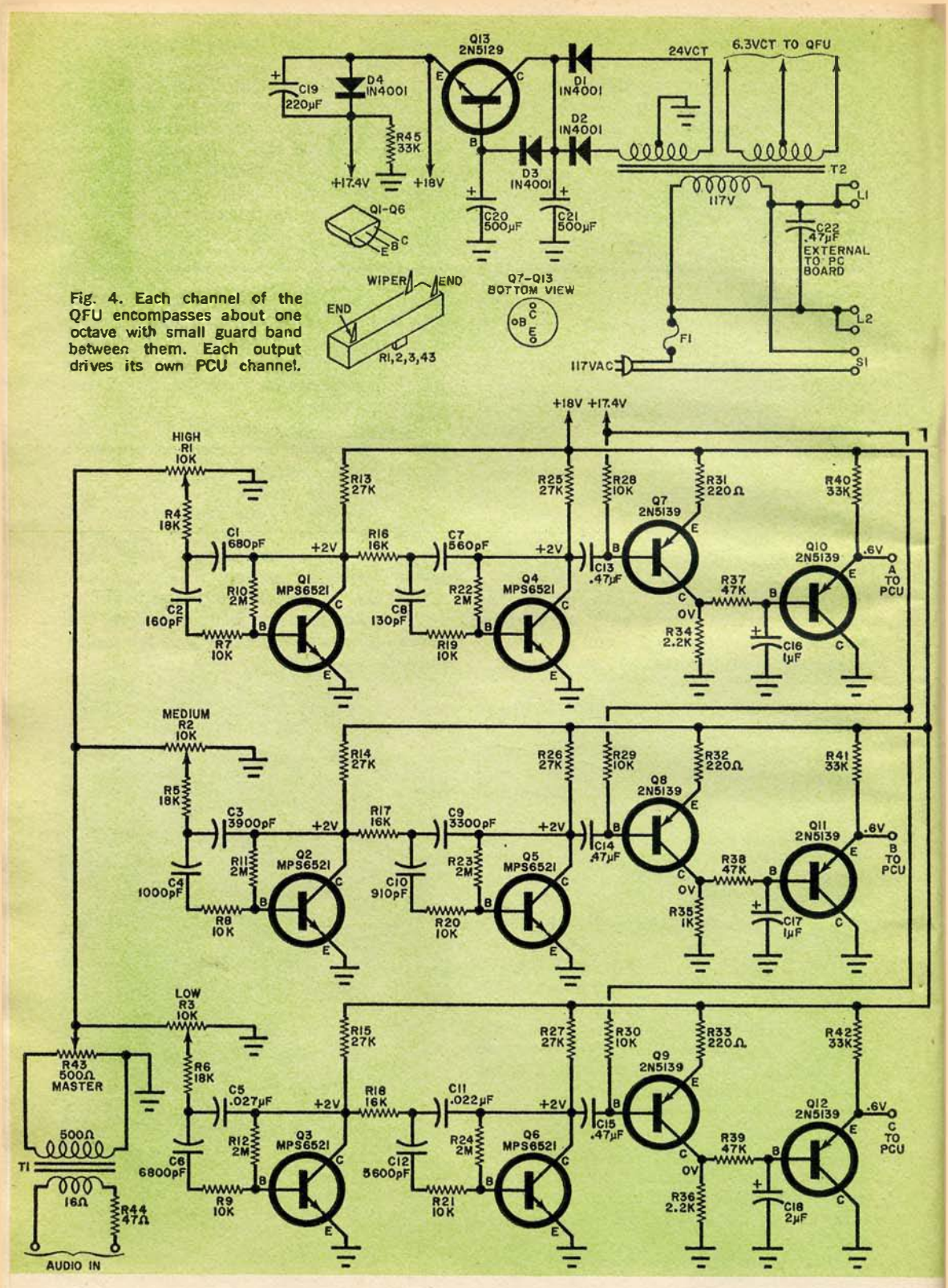
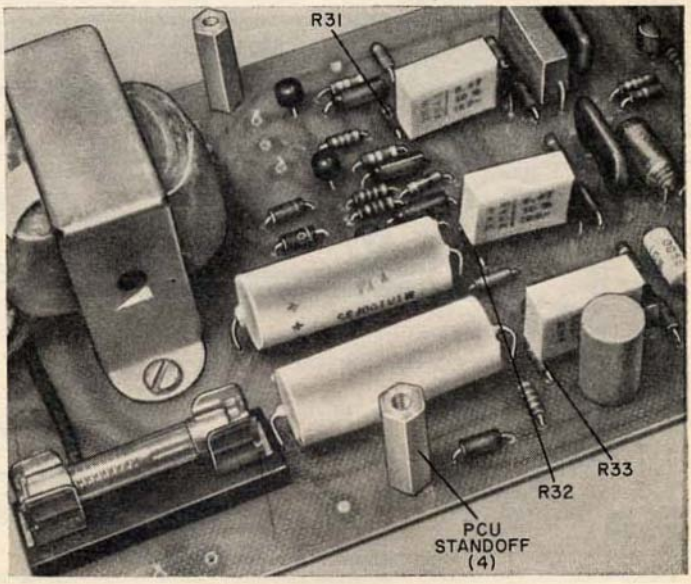


Fig. 4. Each channel of the QFU encompasses about one octave with small guard band between them. Each output drives its own PCU channel.

PARTS LIST
QUALITY FILTER UNIT (QFU)

C1—680-pF, 5% mica or polystyrene capacitor
C2—160-pF, 5% mica or Mylar capacitor
C3—3900-pF, 5% Mylar or polystyrene capacitor
C4—1000-pF, 5% Mylar or polystyrene capacitor
C5—0.027-μF, 5% Mylar or polystyrene capacitor
C6—6800-pF, 5% Mylar or polystyrene capacitor
C7—560-pF, 5% Mylar or polystyrene capacitor
C8—130-pF, 5% Mylar or polystyrene capacitor
C9—3300-pF, 5% Mylar or polystyrene capacitor
C10—910-pF, 5% mica or polystyrene capacitor
C11—0.022-μF, 5% Mylar or polystyrene capacitor
C12—5600-pF, 5% Mylar or polystyrene capacitor
C13-C15—0.47-μF Mylar capacitor (do not substitute an electrolytic)
C16,C17—1-μF, 6-volt tantalum or electrolytic capacitor
C18—2-μF, 6-volt tantalum or electrolytic capacitor
C19—220-μF, 6-volt electrolytic capacitor
C20,C21—500-μF, 20-volt electrolytic capacitor
C22—.47-μF, 600-volt high-quality Mylar capacitor
D1-D4—1-ampere, 50-PIV silicon power diode (1N4001 or similar)
F1—Fuse to suit load, clip mounted to board
Q1-Q6—Transistor (Motorola MPS6521, no substitute)
Q7-Q12—Transistor (National 2N5139)
Q13—Transistor (National 2N5129)

R1-R3—10,000-ohm, color-coded slide potentiometer, one each red, blue, and green (Southwest Technical #S-10K-R, S-10K-B and S-10K-G or similar rotary equivalent or stack pole slide-trol)
R4-R6—18,000-ohm, 5%
R7-R9,R19-R21—10,000-ohm, 5%
R10-R12,R22-R24—2-megohm
R13-R15,R25-R27—27,000-ohm
R16-R18—16,000-ohm
R28-R30—10,000-ohm
R31-R33—220-ohm
R34,R36—2200-ohm
R35—1000-ohm
R37-R39—47,000-ohm
R40-R42,R45—33,000-ohm
All resistors ¼-watt
R43—500-ohm, white-coded slide potentiometer (Southwest Technical S-500-W or similar rotary equivalent or stackpole slide-trol)
R44—47-ohm, 2-watt resistor
S1—S.p.s.t. switch
T1—Input transformer: 8- or 16-ohm primary, 500-ohm secondary, 5 watts, 500-volt winding-to-winding insulation. (Knight 54F1423, Southwest Technical PSV-T1 or similar)
T2—Power transformer: secondaries, 24 VCT at 100 mA and 6.3 VCT at 100 mA (Southwest Technical PSV-T2 or two separate filament transformers such as Knight 54F1416 (6.3 VCT) and 54F210 (24 VCT) or similar)
Misc.—Fuse mount; male quick-disconnect terminals (15); transformer rivets or hardware; mounting hardware; spacers for PCU; clamp for C22; solder; etc.
Note—The following are available from Southwest Technical Products, Box 16297, San Antonio, Texas 78216: etched and drilled PC board, #502, $5.50; complete kit of all parts, #502-K, $29.50; postpaid in U.S.A. Individual parts and assembled and tested units are also available.



The three resistors called out here cannot be seen in the top view as they are hidden by the three capacitors. Also shown are two of the four spacers that join the PCU to the QFU.

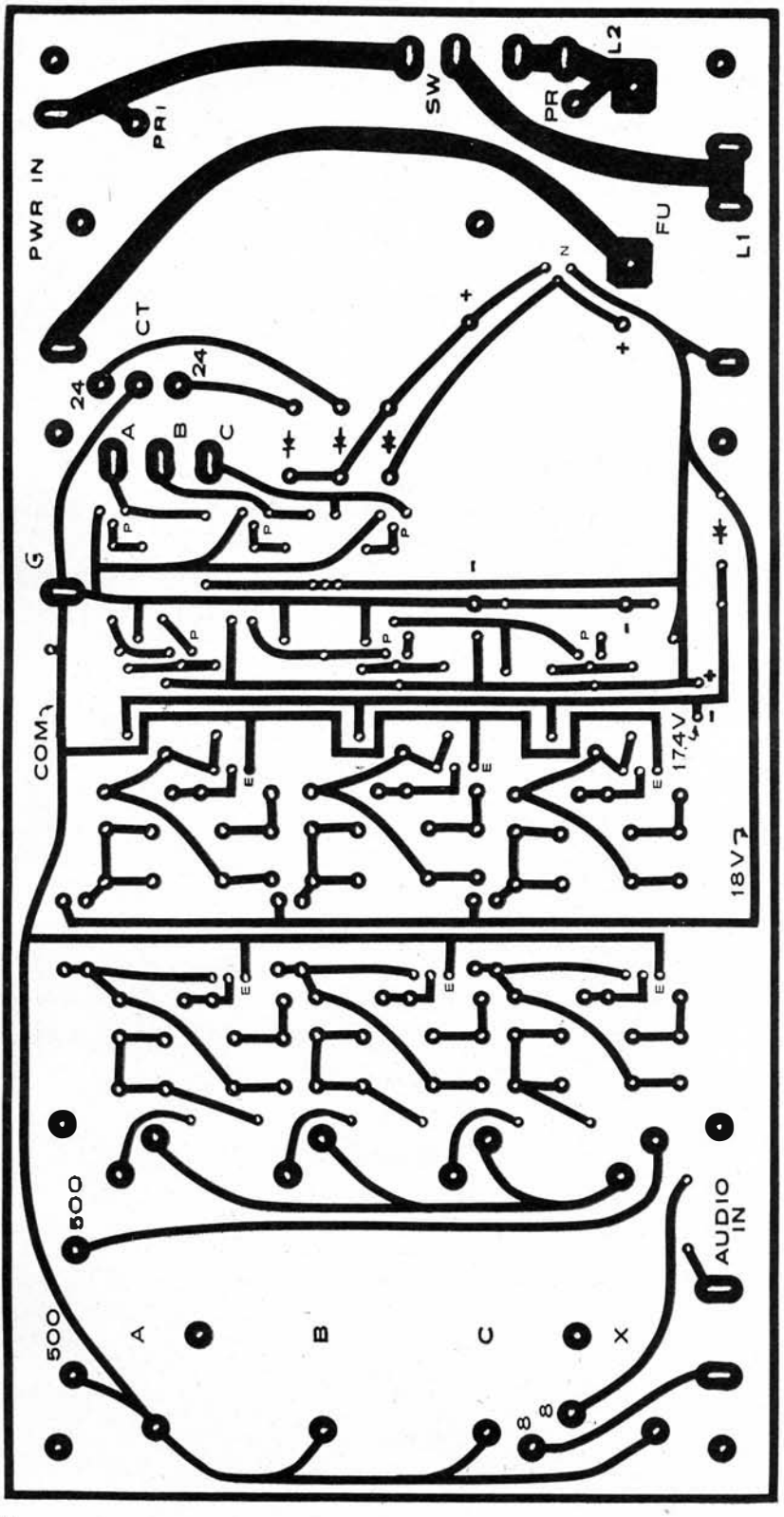


Fig. 5. You can copy this actual-size foil pattern for the QFU PC board or buy the board readymade.

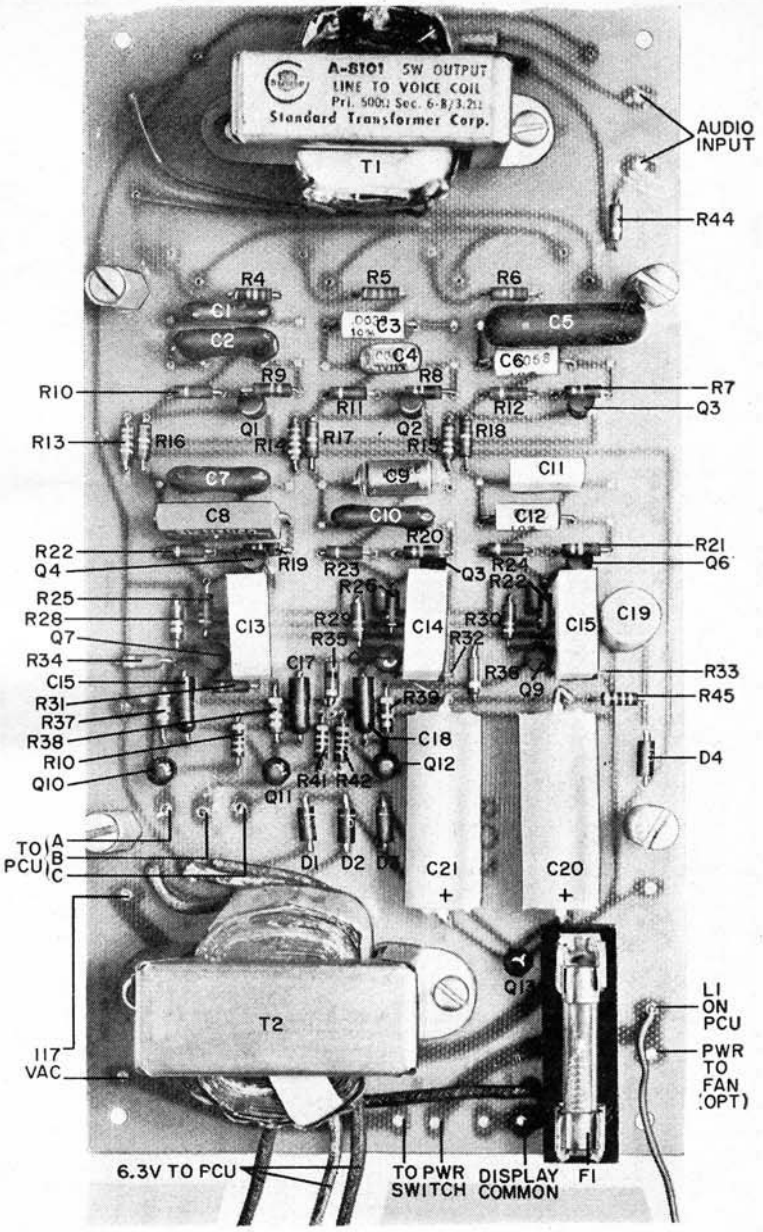


Fig. 6. Component installation on QFU PC board. Also shown are connections made to the board.

Construction of the QFU. The schematic of the QFU is shown in Fig. 4 and an actual-size foil pattern for the PC board is in Fig. 5. Components are installed on both sides of the PC board. The units on the foil side are shown in Fig. 6. Install the four slide potentiometers with the blue at *R1*, green at *R2*, red at *R3*, and white at *R43*. The components on the other side of the board are shown in Fig. 7. Transformers *T1* and *T2* are pop-riveted or bolted in place on the component side of the board. Except for the three leads to the 6.3-volt winding of *T2*, all transformer leads terminate on the *PC* board.

Do not be disturbed by what appear to be extra holes near the active filter capacitors. These holes permit the use of capacitors of different physical sizes at each stage. Use the holes that fit the capacitors you have. If you alter the PC

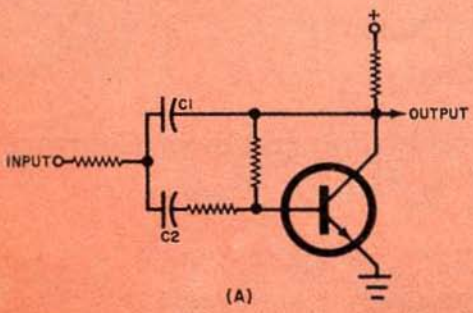
HOW IT WORKS
QUALITY FILTER UNIT

The heart of the QFU is an active filter with the basic configuration shown in the schematic. The transistor must have a very high gain for best operation. This circuit produces a single resonant peak such as that shown at B. Two of the filter stages are cascaded for each channel and the responses are slightly staggered to produce a steep-skirted, flat-topped, octave-wide response such as that at C.

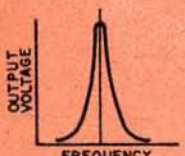
The values of capacitors *C1* and *C2* determine both the Q of the circuit and the center frequency. The capacitors used in the Psychedelia 1 were selected to produce the response shown at D. To experiment or add more channels, divide each capacitor value by the ratio of old to new center frequencies. For example, the low channel shown covers 50 to 100 Hz. To change it to cover 100 to 200 Hz, each capacitor value would be divided by 2. Do not change the ratios between capacitor values or the Q and bandpass values will be changed.

The output of each cascaded filter is applied to a detector transistor biased so that it is almost, but not quite, conducting. A negative-going audio signal turns the detector on, and vice versa. This type of detector produces some gain with a very low threshold offset. The detected signal is smoothed by an RC filter and coupled to the PCU through an emitter follower. The medium-frequency channel detector has half the gain of the others (*R35* is lower in value than either *R34* or *R36*). This compensates for the greater amount of medium frequencies than either high or low in most music.

D.c. supply is obtained from a regulated supply powered by transformer *T2*. Dynamic regulator *Q13* insures excellent low-frequency bypassing. Transformer *T2* also provides 6.3 volts, center-tapped for the PCU. To prevent coupling hum in the low channel, *T1* and *T2* must be located at least 5½" apart.



(A)



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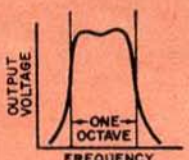

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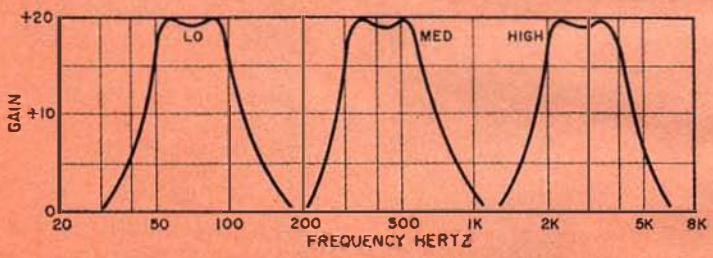


(D)

board layout, be sure that *T1* and *T2* are at least 5½" apart and that *T1* is at least 10" away from any other source of a.c. hum (motors, power transformers, etc.). Do not substitute for transistors *Q1* through *Q6* and use only polystyrene, Mylar, or mica capacitors for the filter elements. Above all, do not delete *T1* since it provides power-line isolation as well as impedance matching for the audio input.

Capacitor *C22* is a noise reducing filter and can be mounted wherever convenient off the PC board. It must be a high-quality, 600-volt Mylar type.

Assembly. The PCU board can be mounted directly above the QFU board to form a control console. Use 1" spacers at each of the four corners of the PCU and mount the PCU on the four holes of the larger QFU board as shown in Fig. 8. Note how the two boards are aligned—component side of the QFU facing the foil side of the PCU with the triacs adjacent to *T1*. Short spacers can be used to mount the combined board on the front panel of the console you select. Only the four level potentiometers are exposed.

Make the board-to-board connections as shown in Fig. 9. For testing, connect three 25- to 40-watt lamps to the system as shown in Fig. 9. These are not the lamps used in the final display. They are for testing only.

Caution is advised from here on since portions of the PCU are referenced to ground and severe shock can be experienced if you touch certain leads.

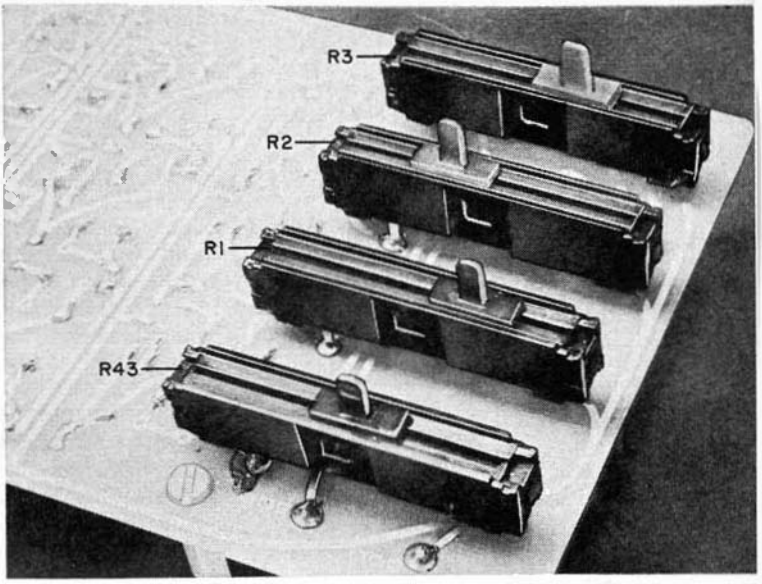


Fig. 7. The three color-level and the master-level slide potentiometers are mounted on the foil side of the QFU PC board.

With the primary a.c. power turned on but no audio applied, the three lamps may or may not glow. Adjustment of the three background controls on the bottom of the PCU (*R9*, *R10*, and *R11*) should cause the respective lamps to vary in brightness from out to almost fully lit. Set the three controls so that the lamps barely glow.

With the audio input coupled to the speaker leads of a radio or other power amplifier, turn up the volume to the source. Slide control *R43* is the master gain control and can be set at about ¾ of the way up. Adjustment of each of the channel slide potentiometers will cause the respective lights to glow in proportion to the amount of power in that frequency range. Each control must be checked for smooth operation.

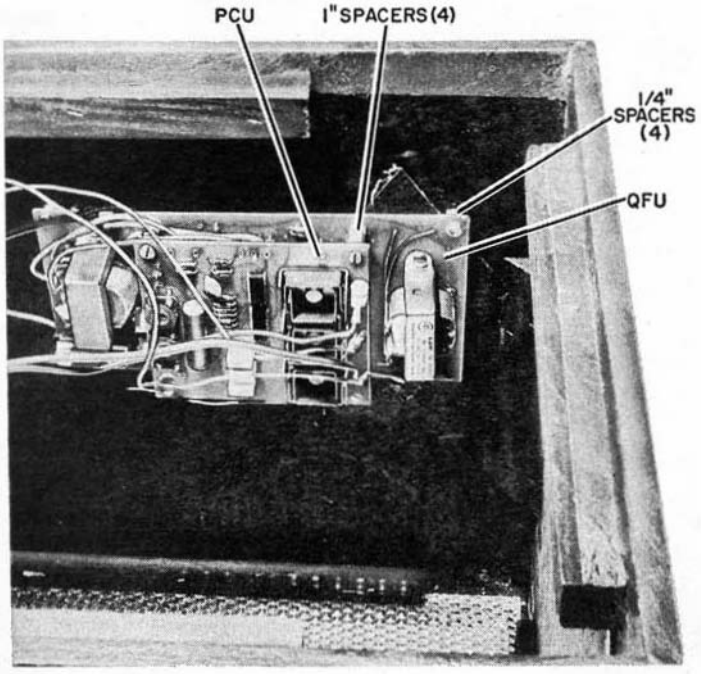


Fig. 8. Four 1" spacers are used to assemble the PCU and QFU boards together. Then use smaller spacers to mount the two of them on the top of the cabinet with the four sliders accessible through a cut slot.

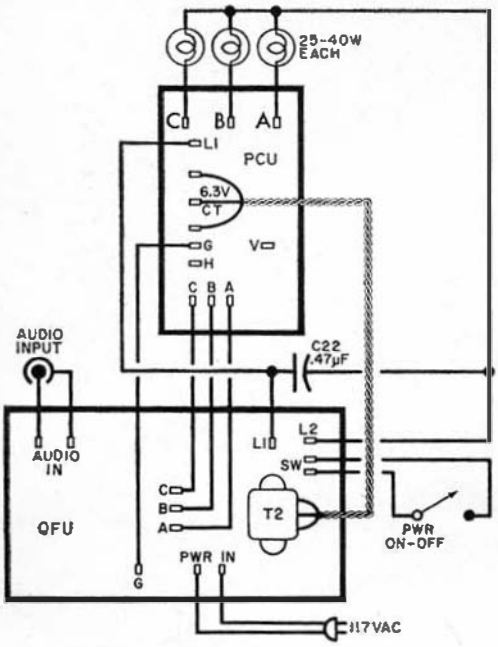


Fig. 9. Interconnection of the complete system. Capacitor C22 is added to reduce switching noise in a radio if that is the source of the signal.

If noise is created in the audio system, install capacitor *C22* as shown in Fig. 9. Some localized interference may be heard on the AM broadcast band, particularly if long display cables are used.

Holographic Bookshelf Display (HBD). A suggested display unit for the Psychedelia 1 is shown in the photos. It is 15" × 16" × 24" with a durable vinyl covering and an attractive holographic imaging system. The HBD can be built as an integral unit with internal QFU and PCU units or it can be built separately for remote control. A maximum of four HBD's can be powered by one QFU/PCU combination.

Keys to successful display in the HBD are the holographic imaging panel and the lamp placement. The imaging panel is a rigid transparent plastic sheet with hexagonal lenses made up of individual wedge-shaped elements. If you look at a single colored lamp through the panel you see a six-petaled flower. The bulb diameter and the spacing of the bulb from the plastic sheet govern the size, shape, and petal details of the flowers.

Constructing the Display. The imaging panel is a light diffuser for fluorescent lighting usually suspended from the ceiling ("T-Bar" or "Grid Lume"). You can buy it at your local hardware or building supplier in an 18" × 24" sheet.

The HBD case is a box made of 4 particle board panels ½" thick. You can buy the panels already prepared as mentioned in the Parts List or you can buy the material and have it cut (or cut it yourself) according to the details given in Fig. 10. Cleats are added to the panels to strengthen the corners and provide a means of attaching the rear panel. The panels are assembled around the imaging panel using nails and glue.

The interior of the cabinet may be painted all flat black, black on the sides and white on the rear panel, or all gloss white. A solid black background accentuates the flower pattern produced by the lamps; while a completely white interior increases the overall brightness and mutes the flower pattern. Painting the rear panel gloss white increases the light output slightly but does not mute or blend the patterns. The cover photo was taken with a white interior.

SIX- OR TWELVE-CHANNEL OPERATION. You can operate the six lamps in the Psychedelia 1 individually by using two PCU units and two QFU's. However, the capacitors in the QFU must be changed to the values given below.

	QFU #1	QFU #2
C1	1200 pF	470 pF
C2	270 pF	110 pF
C3	5600 pF	2200 pF
C4	1500 pF	620 pF
C5	0.047 μF	0.015 μF
C6	0.012 μF	4200 pF
C7	910 pF	390 pF
C8	220 pF	62 pF
C9	4700 pF	2000 pF
C10	1300 pF	560 pF
C11	0.039μF	0.012 μF
C12	0.01 μF	3300 pF

All capacitors are 5% mica, Mylar or polystyrene types.

You can use only one bulb per channel in one display unit or you can use two units side-by-side with three channels in each. For a super-duper 12-channel stereo display, use 4 PCU's and 4 QFU's.

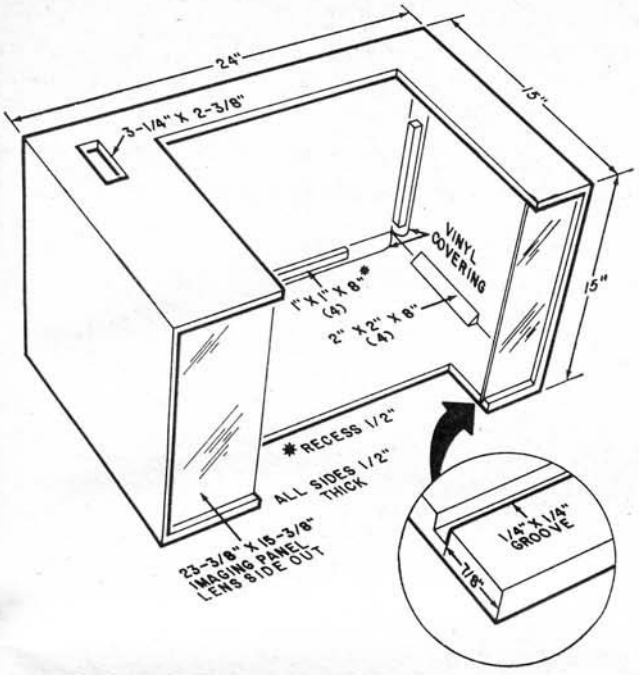


Fig. 10. General construction details of a display cabinet. Any other dimensions can be used. The controls are accessible through a small cutout in the top of the cabinet. Display can be viewed either horizontally or vertically.

If a built-in PCU and QFU are used, a suitable access hole should be added to one side. The rear panel supports the lamps and optional fan, and is shown in photos. The five 2" × 3" posts on the inside of the rear panel range in height from ¾" to 8½". They support the sockets for the lamps and should be spaced in a random manner to give the most pleasing pattern.

The Edison lamp sockets are mounted with wood screws on the posts with a sixth socket attached to the rear panel itself. The higher wattage bulbs go to the rear. The prototype uses 7½- and 25-watt red bulbs for the low frequencies, two 25-watt green bulbs for the medium frequencies, and 7½- and 40-watt blue bulbs for the highs. You can experiment to obtain what you think are the most dramatic effects.

Wiring. Using 16- or 18-gauge wire, parallel the two similarly colored lamps for each channel. Connect one side of each pair to each other and then to ter-

CABINET BILL OF MATERIALS

Lumber
2—24" x 15" pieces of ½" particle board
2—15" x 15" pieces of ½" particle board
1—22⅞" x 14⅞" piece of ½" particle board
4—2" x 2" x 8" triangular pine molding
4—1" x 1" x 8" pine
1—4" x 3" x ¾" pine
1—¾"
1—3½"
1—4½" } *3" x 2" pine*
1—7½"
1—8½"

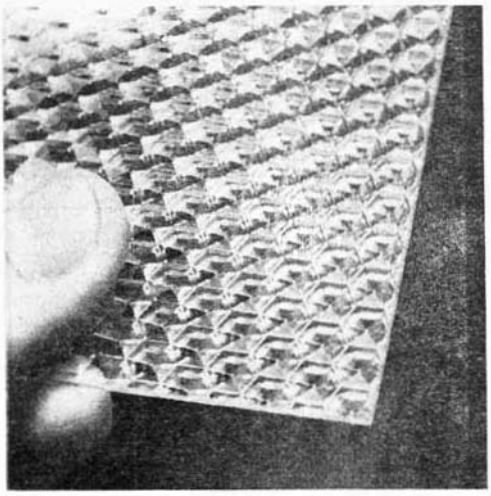
Electrical
6—Edison cleat sockets for 117-volt lamps
2—40-watt, 117-volt lamps, one red, one blue
2—25-watt, 117-volt lamps, both green
2—7½-watt, 117-volt lamps, one red, one blue
1—Cooling fan, whisper type, 55 CFM (optional)
1—6-pin female chassis mounting socket, polarized (Cinch-Jones S-306-AB or similar)
1—6-pin male plug, polarized (Cinch-Jones P-306-AB or similar)
3—Quick disconnect female terminals

Integral Master Unit
1—Line cord and strain relief
1—Phono jack
1—Rocker switch (6 amperes, 117-volts)

Slave Unit
1—6-pin female chassis mounting socket, polarized (Cinch-Jones S-306-AB or similar)

Misc.—23⅜" x 15⅜" panel of "T-Bar" or "Grid Lume" (for imaging panel); cloth-back upholstery vinyl 21" x 84"; vinyl glue; wood glue; nails; no-skid feet (4); paint; wood screws.

Note—An assembled cabinet, less lamps and not wired, is available from Southwest Technical Products, Box 16297, San Antonio, Texas 78216 for $26.50. Item is shipped express or truck, collect only. Specify type of shipment desired.

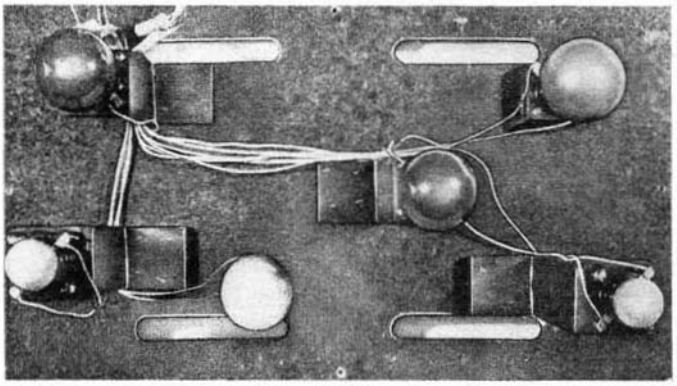


The imaging panel is made up of hexagonal lenses that make each lamp appear as a flower.

minate *L2* on the QFU board. Connect the other sides of the pairs to female quick-disconnect terminals to mate with the male terminals at **A**, **B**, and **C** on the PCU board.

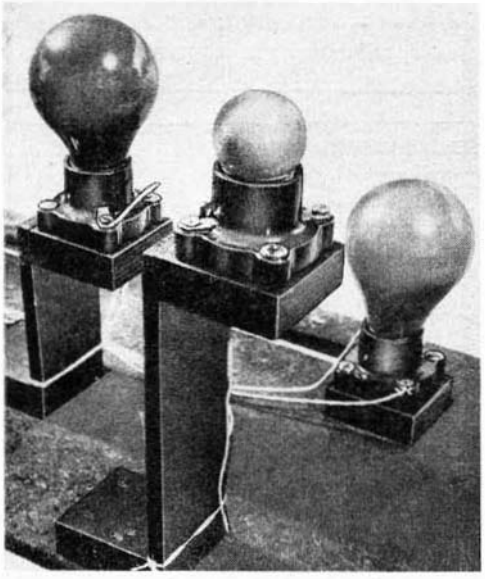
The colors that you put on the respective channels is up to you. Once the system is operating, you can change the colors by switching the quick-disconnect terminals around. Be sure that primary power is turned off before touching these terminals. The system doesn't require any warm-up time, so there is no need to rush.

Connect a suitable length of shielded audio cable between the input bracket audio jack and the QFU board. Connect capacitor *C22* (Fig. 9) between the *L1* and *L2* terminals of the QFU boards to reduce switching noise.



The lamps are arranged in any random pattern around the rear panel. Secure wiring to hold it in place and avoid shorts.

Three different lamp heights are used as shown here. The stands are made from wood.



Final Assembly. When the wiring is completed and checked, mount the electronics assembly to the cutout on the inside of the display cabinet so that the slide potentiometers are accessible from the outside. Use spacers at the four holes on the corners of the QFU board to support the assembly. The power on-off switch can be mounted anywhere that is convenient.

Connect the audio input cable and turn on the power. Set the amplifier to a reasonable listening level. (Make sure that *R44* has been selected to match the audio system as explained previously.) The white slide potentiometer controls the master level, while the three colored slide potentiometers can be adjusted to obtain the desired interplay of colors. The display is best viewed directly from the front. The cabinet can be mounted either horizontally or vertically. -30-