BUILD THIS NEW HIGH-POWER COLORGAN

Author's Colorgan is housed in walnut cabinet. Light display is reflected from crumpled aluminum foil.

Had your fill of TV? Then build this modulated-light display and enjoy flowing color with your music

By DONALD LANCASTER

HERE'S A FRESH APPROACH TO A LOW-cost, high-power light-with-music display. The total semiconductor cost of this new circuit is under $16. Overall cost comes to less than 2¢ per watt of display power. Sensitivity of this 1.2-kilowatt unit is good to well below normal listening levels, and even whisper-level audio will excite the control. Unlike some smaller, lower-power designs, there is no audio threshold or dead space that must be overcome with high drive levels.

Because of a novel filter circuit, only low-cost ceramic disc capacitors are required for audio channel separation. Both the filter characteristics and the time constants (lamp attack and decay time) are easily adjusted to suit individual tastes simply by altering capacitor values.

You'll have full control of background level, to compensate for ambient lighting and the strength of the dyes or filters used with the display bulbs. Because of this full background control range, you can also use the Colorgan, with no audio input, as a conventional three-channel dimmer for advertising displays or as a light balance or shadow control with small photofloods in photographic work. If you used the Colorgan to drive three primary-colored spotlights aimed at a single display, the display could be made any color or brightness simply by adding various amounts of the three light sources.

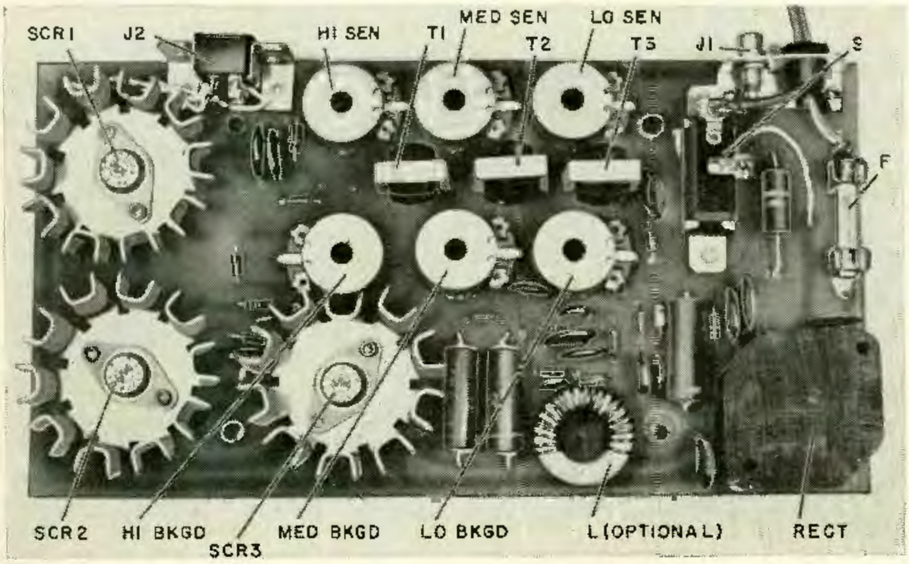
Colorgan vs color organ

Briefly, a Colorgan is an electronic device that relates music to color so that musical pitch becomes color (hue), and volume becomes intensity. This allows the viewer to watch as well as listen to music, adding a new dimension to musical enjoyment.

Although the concept of color music can be traced to 1725 and a rather unusual musical instrument, the *Clavécin Oculaire*, or "viewing harpsichord," the serious treatment of this art form did not develop until the very early 1900's. At that time the Russian composer Alexander Scriabin created a device he called a *Clavier à Lumière*, "light keyboard," or color organ. This was a keyboard instrument that would cause various colored lights to project themselves on a series of gauze veils suspended above a stage. When used in conjunction with a symphony orchestra, "rainbow symphonies" resulted. Quite a bit of interest was aroused in this art form, as a search of the 1910-20 literature will reveal.

A 1935 article in a popular magazine saw the first electronic audio-to-light converter. This device was powered by audio from a radio receiver and used vacuum tubes to separate the audio into three frequency channels—high, medium and low—and then modulate a group of colored pilot lights in a small display. For want of a better name, the author called his device a "color organ."

This misnomer has stuck with these



Bottom view of control circuit board.

electronic devices through three decades and a considerable number of "color-organ" designs. To overcome this misnomer, the term *Colorgan* was recently introduced to describe any electronic device that converts music into proportional light variations.

Fig. 1 shows a block diagram of a typical Colorgan. Input audio, from the speaker system of a hi-fi amplifier, is split three ways into high, medium and low frequencies. The audio is then used to control or modulate three primary-colored lamps or lamp banks in a suitable display. The various colors combine to produce an entire rainbow spectrum in tune to the audio input.

Controlling large amounts of 117-volt ac power for the display lamps (usually 25-watt colored bulbs, Christmas-tree light strings or large outdoor spotlights) is easy with silicon controlled rectifiers. Low-cost ($1.60) SCR's can handle 400 watts easily. This three-channel design uses three such SCR's for a total display capability of 1.2 kw.

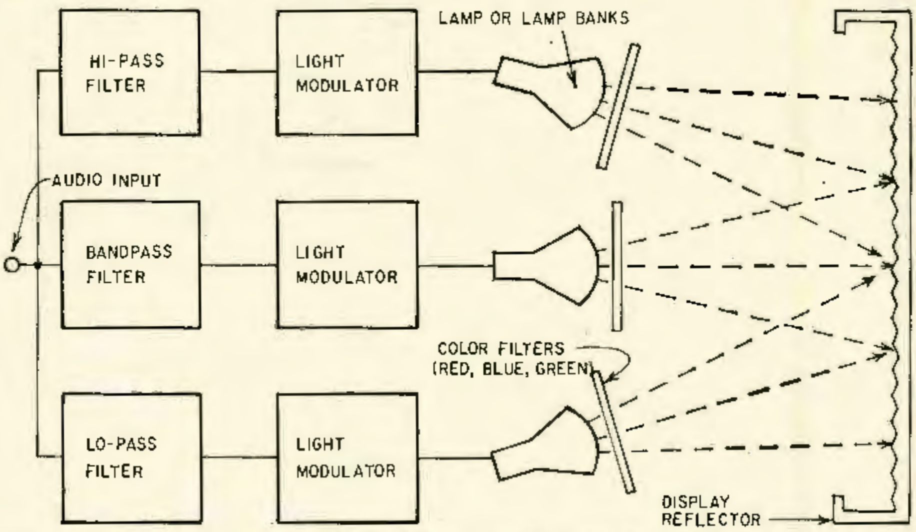


Fig. 1—Scheme of Colorgan is simple. Audio spectrum is divided and used to control wide reflected-light display.

How it works

Fig. 2 shows the basic control scheme used, and some of the waveforms. Since the SCR's are unilateral, a full-wave bridge rectifier is required to invert the alternate half cycles for the required unidirectional current. One 10-ampere molded bridge assembly ($4.85) serves all three channels.

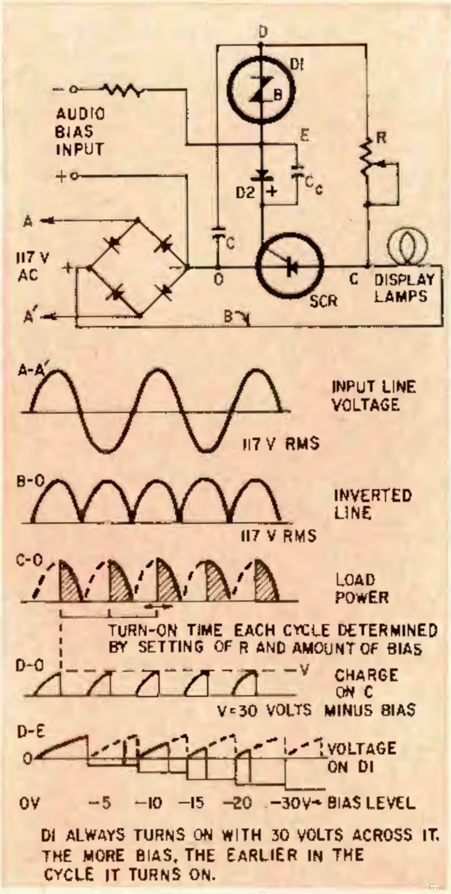


Fig. 2—Basics of one control circuit. Audio back-biases only a diode; hence, input impedance and sensitivity are high.

The SCR is nothing but a switch in series with the full-wave-rectified ac and the display bulbs. A pulse at the SCR gate turns the device on. It stays on until the first zero-volt point of the ac waveform, then turns off. This happens every half-cycle.

If the SCR is always pulsed very early in each half-cycle, almost all the available power reaches the load, and the lamps light to practically full brilliance. If the SCR's are pulsed on in the middle of each half-cycle, only about half the available power reaches the load, and the lights run at half brilliance. If the SCR's are pulsed on very late each half-cycle, very little of the available power gets to the load, and the lamps light dimly. Thus, by controlling the time in each half-cycle that the SCR turns on, lamp brilliance can be controlled smoothly from full off to full on is possible. Note that this is a full-wave circuit, so the maximum brilliance is the same as if each lamp were simply plugged into the line.

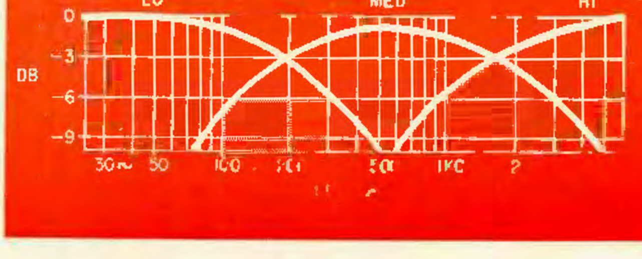
The necessary gate turn-on pulses are produced by a 30-volt avalanche breakdown diode D1. The setting of background potentiometer R determines the rate at which timing capacitor C will charge. When C reaches 30 volts, D1 abruptly conducts and turns on the SCR. The SCR turn-on eliminates the source of charging current for R, and the charge on the capacitor rapidly drops to zero. The SCR then turns off at the first line zero, and the operation repeats every half-cycle. Since there is zero capacitor charge at the beginning of each half-cycle, the R-C charging is locked (synchronized) to the ac line.

This circuit establishes the background level for the display lamps. If a negative bias of 0 to −30 volts is introduced at the lower end of D1, this 30-volt avalanche diode will always break down progressively earlier in each half-cyle in direct proportion to the bias voltage present. D2, an ordinary diode, and commutating capacitor C_c prevent the SCR gate from loading the bias source, but still allow the turn-on pulse to control the SCR. Input audio is stepped up, filtered, rectified, integrated and used as this bias source.

The important thing in this biasing arrangement is that the turn-on energy for the SCR is provided by the 117-volt ac line through R and C, and *not* from the bias source. This means that the bias voltage works into a very high impedance (actually an open circuit most of the time), and that *very little bias power is needed,* far less than is required for the SCR turn-on pulses. This is how the Colorgan achieves its high sensitivity without input amplifiers.

Background control R is set to the minimum desired display brightness.

Fig. 3—Response of the three Colorgan channels



The audio bias then increases the brightness in proportion to the music amplitude.

The very high impedance of the bias circuits allows R-C filtering, since R-C filters will function properly only when unloaded. Further, the high impedance means large values of R and small values of C may be used. These may be in the range of ordinary small mica or ceramic disc capacitors. The R-C filter characteristics are shown in Fig. 3; they are as good as the bulkier L-C designs in an earlier version.

Fig. 4 shows the actual circuit. The high-current portions of the circuit are shown as heavy lines in the schematic. The 117 volts ac goes directly to the full-wave bridge-rectifier assembly RECT after passing through the 10-ampere fuse and the rocker type slide switch. RECT is soldered directly to the printed board; no heat sink is necessary. C1, C2 and L form a noise filter for the line. L consists of 22 turns of heavy wire hand-wound on a powdered-iron core (see parts list).

The SCR's must be mounted on heat sinks. Flower-shaped heat sinks are riveted directly to the printed circuit. Silicone thermal grease must be used between the SCR and the heat sink. The SCR used is the RCA 2N3228, a low-cost distributor item rated at 5 amperes, 200 volts. Connection to the display is made through a high-current four-prong plug and socket, and a four-wire cable.

The SCR turn-on and background circuitry includes R10, R11 and R12, the background level potentiometers. These pots, along with the input sensitivity pots, are the low-cost Centralab type TT. They solder direct to the circuit board. Diodes D4, D5 and D6 are bypass diodes needed for stable operation at very low brightness levels. Capacitors C3, C4 and C5 are the timing capacitors. C6, C7 and C8 are the SCR turn-on (commutating) capacitors. D10, D11 and D12 are the 30-volt trigger diodes, and D7, D8 and D9 are the bias-blocking diodes. Negative dc bias derived from the audio input is applied to each firing circuit via R2, R3 or R4.

The audio input is stepped up by transformers T1, T2 and T3 to the level required for the bias circuits. These transformers also isolate the circuit common from the amplifier ground. These are relatively inexpensive transformers, also available as surplus microphone or transistor transformers.

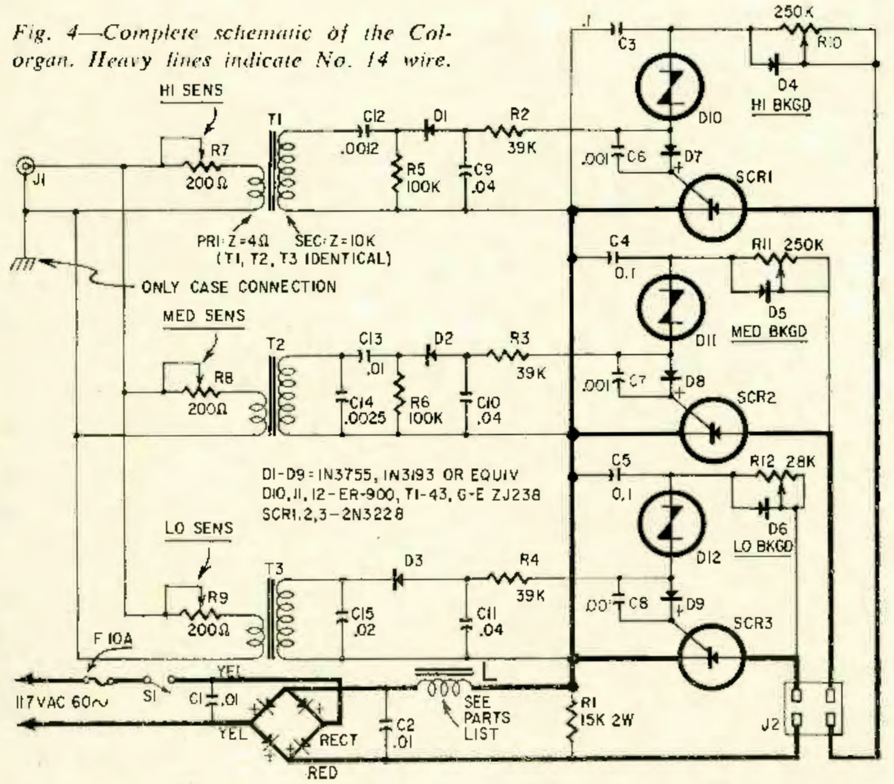
The high-voltage audio is then filtered. The low-pass filter consists of C15 and the transformer impedance. The larger C15, the lower will be the rolloff frequency. The high-pass filter consists of C12 and R5. Increasing C12 lowers the rolloff frequency. The bandpass filter is actually an overlapping high-pass (C13 and R6) and low-pass (C14 and T2 internal impedance) filter. Since the impedance level keeps increasing through the filter circuitry, the filters do not load one another, and the ideal 6-db-per-octave filter slopes are actually achieved in this circuit.

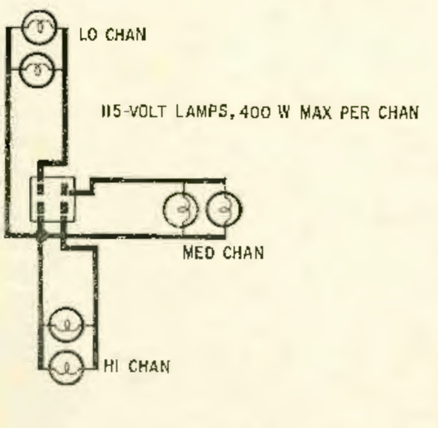
The filter response is easily changed simply by altering C12 through C15. Experiment for best results. Changing T1, T2 and T3 from those recommended in the parts list can drastically affect the values required for the capacitors. Removing C15 from the low channel makes this channel a broadband (all-frequency) one, useful for special effects and initial setup.

The filter outputs are rectified by D1, D2 and D3 to obtain the dc bias required to proportionately control the SCR's. Capacitors C9, C10 and C11 determine the time constant (attack and decay time) of each channel. The values used give a time constant of about 0.2 second. This is easily altered to suit your taste by increasing or decreasing C9, C10 and C11.

Characteristics of trigger diodes vary fairly widely especially from manufacturer to manufacturer. Because of this, C3 through C8 may need some trimming. The value of timing capaci-

Fig. 4—Complete schematic of the Color-organ. Heavy lines indicate No. 14 wire.





C1, C2, C13—.01-μf 600-volt disc ceramic
C3, C4, C5—0.1-μf 400-volt paper or Mylar
C6, C7, C8—.001-μf 600-volt disc ceramic
C9, C10, C11—.04-μf 600-volts (two .02 μf disc ceramic in parallel)
C12—.0012-μf disc ceramic
C14—.0025-μf disc ceramic
C15—.02-μf disc ceramic
D1 through D9—silicon diode, at least 100 ma, 200 volts (RCA 1N3755, 1N3193 or equivalent)
D10, D11, D12—30-volt avalanche trigger diode (Transitron ER-900, Texas Instruments TI-43, G-E ZJ238 or ST2 or equivalent)
F—10-ampere fuse
J1—phono jack
J2—4-prong socket (Jones S304 AB)
L—22 turns No. 20 enameled wire on Arnold core No. A 930157-2; 60 μh approximate inductance (optional interference filter—see text). Core is available for $1 postpaid from Clare M. Dahl, Dept. Q, 2237 West Glenerosa Ave., Phoenix, Ariz. 85015.
P—4-prong plug (Jones P304 CCT)
R1—15,000 ohms, 2 watts
R2, R3, R4—39,000 ohms, ½ watt
R5, R6—100,000 ohms, ½ watt
R7, R8, R9—pot, 200 ohms (Centralab TT-2)
R10, R11, R12,—pot, 250,000 ohms (Centralab TT-50)
RECT—10-amp 200-volt full-wave bridge rectifier (Motorola MDA962-3 or equivalent)
S—10-amp, 250-volt spst rocker switch
SCR1, 2, 3—2N3228 silicon controlled rectifier (RCA)
T1, T2, T3—transistor output transformer: 4-ohm primary, 10,000-ohm secondary (Stancor TA-33, Knight 62 G 363, Argonne AR-133 or equivalent)
Heat sinks for SCR's (3)—Daedalus type 600 blank heat sink; Daedalus Co., 129½ Rosencrans Ave., Manhattan Beach, Calif. ($0.29 each plus postage.)
Case, panel, knobs, hardware—see text, drawings and photos

tors C3, C4 and C5 is correct when the display lamps just extinguish completely at the minimum background control setting. Commutating capacitors C6, C7 and C8 should be the smallest value that allows reliable bias voltage control of the display brightness.

The circuit will operate only on 117-volt, 50- or 60-cycle alternating current, and will control only 117-volt incandescent bulbs (or series combinations of lower-voltage bulbs) or other resistive loads. The *minimum* load for any channel is 10 watts.

No portion of the control circuitry or the display (with the sole exception of a case connection at J1) may be grounded or connected to any other piece of equipment. To do so introduces a severe shock hazard and can immediately destroy the rectifier.

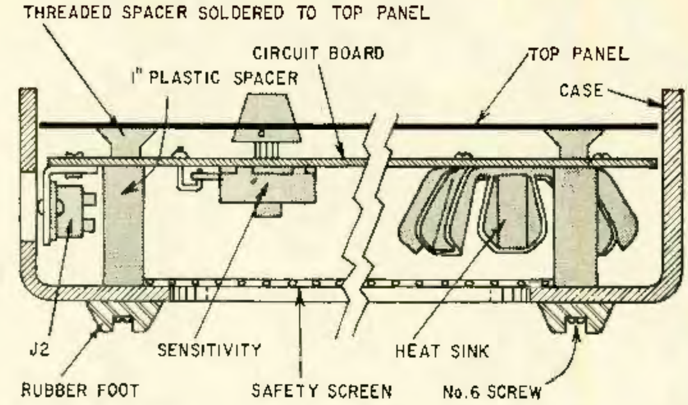
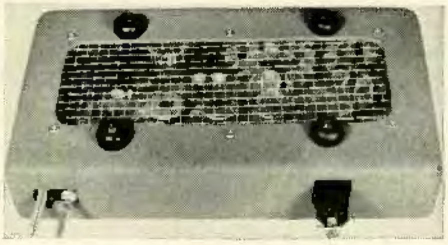
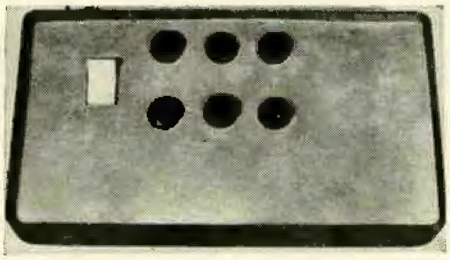


Fig. 5—Cross-section of Colorgan control box shows assembly.

The entire circuit is built on a single 5-inch by 9-inch printed-circuit board. All parts are soldered or "pop"-riveted to this board, including the heat sinks, the input and output connectors and the fuse clips. A small aluminum bracket supports the input phono jack and the line-cord strain relief. The decorative case consists of a 1¾-inch deep-drawn thick aluminum box (Zero Manufacturing Com., Monson, Mass. #Z89-158-28, $5.10). A large hole is cut in the bottom for ventilation. A piece of hardware cloth is riveted to the inside as a safety screen. Holes in the back are for the audio, display and power connections. The case is finished in heavy gray wrinkle.



Underside of case.



Panel of Colorgan control. Colored knobs eliminate need for markings.

Downward view into front of Colorgan shows how lamps are placed near foil reflector.

The top plate is a piece of thin aluminum with four threaded spacers soldered to its underside. Holes are drilled for the six knobs and the rocker switch. A lacquered matte finish completes the plate. The knobs are translucent plastic in colors corresponding to each control's function. I couldn't find a reasonably priced commercial source, so I cast them out of acrylic resins of the required colors.

Four long 6-32 screws hold the entire Colorgan together (Fig. 5). One-inch plastic spacers support the circuit board at the proper height.

Except for the knobs and fancy case, all parts are readily available and cheap. Although this circuit lends itself very nicely to a printed-board construction, you might prefer to use a wired assembly, perhaps with tie points or terminal boards. A slightly larger package might be needed. No. 6 hardware could be used instead of the rivets.

If you do use a printed board, be sure to use at least ⅛-inch conductors of 2-oz. copper, or ¼-inch conductors of 1-oz. copper in all high-current circuits.

For stereo operation, the mono output of most stereo amplifiers may be used. Another possibility is to use a "phantom" transformer connection. Two identical Colorgan circuits of three channels each could both drive a common display.

The number of channels can be increased indefinitely, but one 10-ampere rectifier must be used for every 1,200 watts of load, regardless of the number of channels. The maximum power capability of the SCR's used is 600 watts.

END

This control has been used to power everything from small bookshelf displays to lights for the entire side of a house, illuminated as part of a Christmas outdoor lighting display, in tune to Christmas carols.

It is generally better to view reflected light, perhaps off a crumpled aluminum foil surface, than to view the bulbs directly. For maximum color saturation, high-density filters must be used on the light sources with no pinholes to let white light through. The entire rainbow of color may be produced if the colors are rich enough.

One form of display is shown in the photos and is intended as an addition to the typical home hi-fi center. It consists of a 41 x 36 x 10-inch display built of solid ¾-inch walnut. The entire inside of the case is lined with heavy aluminum foil lightly crumpled to aid diffusion and allow the lights to dance. The ornamental G-clef in the middle is cut out of 1/16-inch copper and is highly polished. The 8-32 studs supporting it are essentially invisible, allowing the clef to apparently float on a sea of dancing color.

I used ordinary 25-watt colored bulbs in the display. The dyes on these bulbs are rather poor, being unsaturated and full of pinholes, but the overall effect is quite acceptable and inexpensive. There are six bulbs per channel, giving 18 bulbs total equally divided between top and bottom. The photo shows how the bottom bulbs are situated. The low-channel bulbs (red) are predominatly at the left. The high-channel bulbs (blue) are predominantly at the right, leaving the mid-channel (green) illuminating mainly the center. If all the bulbs of one color are bunched together, the display is just three stripes with no color blending.

For larger displays, a new line of 150-watt bulbs is now available. These have an optical interference filter on the inside of the glass, resulting in a deep, saturated color, with no pinholes and no light leakage. The color-mixing possibilities are dramatic. One source of these bulbs is the General Electric line of 150 PAR/SP Dichro-Color spot lamps. These allow larger and richer displays.

It is the display that gives uniqueness and character to any Colorgan. It should be custom-designed for each application. There are no real ground rules, no limits to the bulbs or materials you use, or to the designs a display can lead to. Just be sure to follow sound electrical wiring practice, and keep your workmanship neat.