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OCTOBER, 1957
VOL. 58 • NO. 4

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RADIO & TV NEWS
Medium Power Color Organ

By GLEN SOUTHWORTH

Small audio signals easily drive three 100-watt light bulbs producing sound-synchronized colors.

In its most popular form, the color organ consists of three amplifiers, each coupled to a light producing one of the primary colors: red, green, and blue. An audio signal is applied to the inputs of these amplifiers through three bandpass filters which select the low, medium, and high parts of the audio range. When music is played through the system, one color will be produced when bass notes are present, another color with the midrange frequencies, and the third color when treble passages occur.

The idea of synchronizing colored light with sound has intrigued many persons over a period of several decades and dozens of variations of this technique have been tried out, including some unusual and elaborate public displays. Probably the main reason that the color organ did not find wide acceptance in the home is the fact that most of the early versions used small audio amplifiers capable of generating only about four to ten watts each and, in turn, used this energy to excite pilot lamps or other low wattage bulbs. Of course, the quality of the amplifiers used need not be too good, but still this is an expensive arrangement that tends to be ultimately disappointing simply because not enough light output is available to match the corresponding volume issuing from the loudspeakers. This is true even with 20-30 watt amplifiers.

The objections of low power and high expense are easily overcome by using triacs to control the flow of 60-cycle current through conventional 117-volt tungsten lights. The inherent simplicity of this technique is shown in Fig. 1, which diagrams a method of controlling up to one-hundred watts of a.c. power from the output of any conventional, small or medium power, audio amplifier. The triac tube used in the circuit can be either an FG-17 (5557) mercury vapor type, or a 3C23, mixed gas tube which has slightly higher ratings. Both tubes are interchangeable in this circuit, and may be purchased in many areas for approximately four dollars each as surplus.

In operation, the triac is biased to cut-off, or slightly under, by applying a nearly out-of-phase a.c. voltage to the grid. A one-megohm potentiometer acts as a bias setting control, while a one-megohm fixed resistor and a .01 µfd. capacitor in the grid circuit act to provide a moderate amount of phase shift at 60 cycles. This is necessary in order to provide smooth, continuously variable control of the plate current of the triac. Now if this phase shift is not present the tube will tend to act like a relay, firing at a predetermined point. It will be noticed that the out-of-phase grid bias voltage is obtained in a rather unconventional, though economical, manner by using only one half of the winding of a 6.3 volt filament transformer to heat the triac cathode, and employing the other half to produce the bias voltage. With the filament transformer used as a result of the heavy load provided by the triac filament, the voltage across the filament came very close to the required two-and-one-half volt value, and the current consumed is well within the rating of the transformer. It is important that the grid bias be in the proper phase relationship with the triac plate supply, and it may be necessary to reverse the primary leads of the filament transformer if the bias pot does not control the tube plate current smoothly.

Preceding the grid of the triac is a crystal diode which generates a positive d.c. voltage from the output of a simple audio bandpass filter, reducing the effective grid bias and causing the triac to conduct in accordance with program content. A small output transformer, connected backwards, acts to isolate the color organ from the audio power amplifier and to step up the relatively small

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Footnote: If it is intended to operate over an extended period, a heavy duty, 6.3 volt filament transformer should be used. The 6.3 volt transformer is then used only for bias.
voltage appearing across the loudspeaker voice coil. The isolation is especially important in reducing the possibility of shock or short circuits inasmuch as the color organ is connected directly to the a.c. line.

The "load" of the thyratron is simply a standard 117 volt light bulb of between 25- and 100-watt rating. The static brilliance of the lamp may be set by means of the bias potentiometer and the full range between extinction and nearly maximum brilliance should be maintainable by this means. It should be noted, however, that the same intensity as when the bulb is placed directly in an a.c. socket is not obtainable for two reasons. First is the fact that a small voltage drop exists in the thyratron tube itself even under conditions of maximum conductivity. Second, and more important, is the fact that the thyratron is actually a grid-controlled rectifier, and consequently only applies alternate half cycles of a.c. energy to the load. These difficulties can be overcome by using higher plate and bias voltages, but as it was the intent of the author to develop as simple, inexpensive, and compact a circuit as possible, these possibilities were not explored, since they would normally involve the use of heavy, high-wattage, plate transformers.

The choice of light bulbs for a load is influenced by several factors. Clear glass, with the addition of a color filter, is most desirable, and at the standpoint of maximum light output, and the baby spot or floodlight type of lamp is very convenient to use. The small, 75-watt, G-E reflector spots are the writer's current choice and provide adequate light output for a medium sized room, good directivity of light pattern, and a relatively small area over which the color filter need be applied. These spots are also available with colored face plates so that external filters may be dispensed with.

Whether several small bulbs are used or one large one, will affect not only the spatial distribution of the light, but the dynamic characteristics of the system as well. This is due to the fact that the filaments of the larger bulbs possess more thermal inertia and, as a consequence, are slower to heat up and take longer to cool down than the smaller wattages. In one sense, this is an advantage in that the bigger bulbs produce a smoother changing pattern of light, relatively free from annoying flicker. On the other hand, the transient response of the color organ will be poorer and the instantaneous load on the thyratrons may be appreciably heavier due to the fact that filament resistance is usually much lower when the bulb is cold and higher wattages will cause slower heating.

Fig. 2 shows the input stages for a three-channel color organ. When driven from the voice-coil winding of a conventional audio amplifier the isolation transformer provides adequate response to the inputs of the three audio bandpass filters which cover the range of frequencies shown to the right in Fig. 3. The circuits are of very simple design, and use resistance-capacitance elements for the high-pass and low-pass filters. The mid-frequency range is selected by means of a parallel resonant element, a rather broad peak being obtained in the 1000 cycle region due to the loading effect of the associated resistances.

Fig. 3 is the response curves of the three filters shown, but it should be noted that these ranges were selected somewhat arbitrarily and do not necessarily represent the scheme of operating practice. The fairly gentle slopes of the filters are rationalized, to some extent, in that they provide less abrupt transitions when instrumental ranges span the area from one filter to another and, although various arguments might be presented regarding steepness of cut-off and other factors, it is a good starting point for the constructor. In fact, if a three- or four-way speaker system were used in conjunction with the color organ, it is quite possible that the bandpass filters shown could be dispensed with altogether, and the various color channels driven directly from the crossover network through small isolation transformers.

The colored filters for the light sources represent another variable in which personal tastes play an important part. Colored cellophane, obtained from a variety store, provides a very inexpensive method of achieving assorted hues, although care must be taken that the cellophane does not come in contact with the bulb, due to the heat produced. You are not bound to use the three primary colors, unless you wish to, and, in fact, you might desire to add more thyratron channels for exotic effects.

Intensity balance between channels seems desirable, however, and some color filters will have appreciably more light loss than others. Similarly, when not glowing at maximum brilliance, a tungsten lamp will produce a distinct yellowish light which will contaminate the color values of some filters during soft passages.

As the color organ is a device intended to elicit subjective moods and sensations by synchronizing light to music, its success or failure will depend upon a number of semi-intangibles. Sufficient variety is an important factor, and if you have light colored living room walls an interesting technique is to place the light sources (Continued on page 177)
near the baseboard, shining upwards along the wall. By doing this the light reflected not only varies in intensity, but will appear to change in size, a small area resulting from weak suction, a taller column or fan light occurring during loud passages. This additional element of spaciousness is appreciably more dramatic, as well as being easier on the eyes, than looking directly at the light sources.

Certain musical compositions and recordings appear to reproduce much more effectively over the color organ than others. This is due to a complex of factors and for most effective synchronization a program should not only have adequate energy distribution in all parts of the audio spectrum, but should be orchestrated in such a manner that the various frequency ranges are well separated from time to time. In many instances instruments which may be heard clearly will simply not have sufficient energy to accentuate the particular channel of the color organ satisfactorily but, on the other hand, sometimes surprising things are discovered about a particular piece of music because the color organ will call attention to the fact that appreciable sound intensity exists in a region that the mind had previously ignored.

The color organ appears to provide a good indication of musical balance, both in regard to the instrumental pickup in the initial recording session, and in the matter of over-all frequency response. This is due to the fact that the three channels, if matched to each other, are the equivalent of three separate volume indicators, providing an indication of the amount of audio energy instantaneously present in each frequency band. As a consequence, the setting of the audio amplifier bass and treble controls will affect the performance of the color organ as well as the content of a particular recording. In addition, the dynamic characteristics of the color organ may be altered to an appreciable degree by adjustment of the thyratron bias controls. Adjusting the bias to the point where the filament of the bulb just glows will provide the maximum sensitivity and most linear operation, while overbiasing the tube will decrease the sensitivity of the particular channel and cause the thyratron to be actuated only on musical peaks.

A wide number of variations are possible in the design and operation of color organs, but the utility of the thyratron is limited to biasing control, and may easily be applied to many other situations requiring the use of modest amounts of power. One final precaution, however, is to keep the thyratron circuits well isolated from high gain amplifier input stages, as the high pressure of the gas in the thyratron tube may cause a disturbing noise in the audio system.

October, 1957

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Fig. 1. Schematic diagram and parts list for one of the three channels of organ.

- $R_1$: 500,000 ohm, ½ w. res.
- $R_2$: 1 megohm, ½ w. res.
- $R_3$: 1 megohm pot
- $C_1$: 1 μfd., 200 v. capacitor
- $C_2$: 0.005-0.01 μfd., 200 v. capacitor (value depends on individual thyratron)
- Bulb: 25- to 100-watt baby spot or floodlight (see text)
- $T_1$: Output trans., push-pull plates to r.c.; 50,000 ohm pri., 3-6 ohm sec. (Chicago RO-113 or equiv.)
- $T_2$: Fil. trans., 6.3 v. c.t. @ 3 amps. (Chicago FO-63 or equiv.)
- $C_{R_1}$: CK705 or 1N66 crystal diode
- $V_1$: FG-17 or 3C23 thyratron (see text)

Fig. 2. Input circuits for the three channels showing the values of components needed for the three filter circuits employed. For values of the unidentified components refer to Fig. 1 which shows one of the three channels that are identical except for filter circuits.

Fig. 3. The approximate response curves of the three filter circuits shown above.