



TELEVISION





Lee de Forest

RADIO and television technicians, scientists, the general public, are today focusing attention on the absorbing topic of color television. When can we see it; place it in our homes; how good and reliable will "color" be; at what price, or range of prices?

Today's color television is the outcome of many years of careful thought, persistent ingenuity, and thousands of experimental hours. That sterling British TV pioneer inventor, John Logie Baird, made interesting experiments and gave the art some highly valuable suggestions as to how his crude television images could be combined with natural colors. There has been scarcely a television inventor since Baird who has not conceived some method or apparatus for mingling natural colors with the present monochrome image.

To actually accomplish this, one must begin with the television pickup device or camera. The simplest way to do so is—quite obviously—to employ three cameras, exactly like the present black-and-white type, typified by the RCA orthicon camera. Most researchers have been content to use the amazingly faithful and instantaneous qualities of the orthicon—three of these focused upon the color image to be transmitted: live object, wide scene, or Technicolor film. Each camera is synchronized with the TV transmitter; each views the scene through one of three primary color filters—red, green, and blue—of the exact shade found by practice to produce the most nearly correct color or tint on the final projected image tube, or screen. The three colored images are separated by a dichroic mirror into three images, each in its own color, and directed upon the lens of its own orthicon. Thus each color image is translated into a electron image. The three-electron images are scanned simulta-

neously by the cathode beam in each pickup camera. The combined electron output, now in the form of electric, high-frequency images, is caused to modulate—at a subcarrier frequency—the common television carrier as it is delivered to the transmitter antenna.

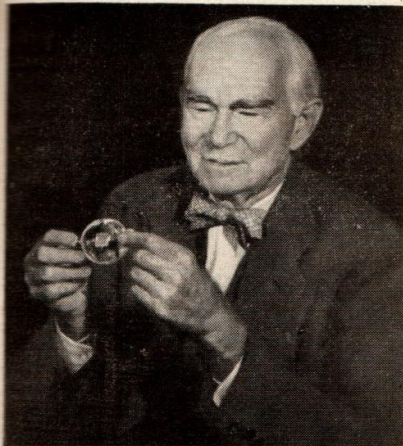
If the color filters were removed from the front end of each orthicon, these would see and translate the same all-color image, and the resultant would be that from three identical camera images—black and white or monochrome, all in perfect synchronism.

The old CBS field sequential color television system employed only one camera, located behind a rapidly rotating tricolor disc. The color segments transmitted only those picture elements from the scene which were of the same color as that of the segment then in the line of sight. A similar arrangement of a tricolor segmented disc rotating before the kinescope of the receiver and synchronized with the disc at the transmitter camera caused the picture to be seen in a semblance of its true colors. The practical limitations of the sizes of the disc in front of the kinescope so limited the size of the latter as to be disappointing to the viewer who had become accustomed to kinescopes of 15 or more inches in diameter. Moreover, the large, rapidly whirling disc in the room constituted a serious disadvantage to this method, quite aside from the fact that the CBS color system was incompatible and required special frequency standards.

With the casting into limbo of the rotating disc type of television, and the rapid development of large cathode-beam viewing tubes, (10 or 12 inches at first, then rapidly expanding after the war to our present 21-inch and 27- to 30-inch tubes), the combined active zeal of a hundred inventors and technicians in a half-dozen laboratories gradually

resulted in an intelligent aggregation of ideas from which developed our present official National Television Systems Committee (NTSC) color TV standards, covering first the optimum use of the 6-megacycle band which the Federal Communications Commission had allotted for monochrome picture transmission, the prescribed synchronizing signal wave form, the number of horizontal lines permitted in the picture, the aspect ratio, the intensity and duration of the blanking signal, the burst frequency, etc. Such co-operative spirit had never before been witnessed, though it had been foreshadowed by the work of that earlier committee which—before the monochrome dawn of television—made to the FCC the recommendations which integrated finally to today's highly practical, well-proven national black-and-white standards, now universally adopted in the United States. The results of their foresight are evidenced today by more than 27 million television receivers in use; the highly profitable employment of thousands of so-styled, "artists," mostly unknown otherwise; a systematic process of implanting terror, fright, and rough manners into the impressive generation of younger ones; the frantic resurrection of millions of feet for opportune gain, of long-forgotten "Western" murder and mayhem films—plus the most gigantic travesty—advertisement conspiracy—in the history of modern civilization.

Scientific and engineering brains and their standards apparently are no match against the impropriety and lack of moral obligation of the group comprising program producers and advertising business managers, whose wholesale profanations of God's and mankind's ether in the name of beer, cigarettes, laxatives and cosmetics may mean millions of dollars to a few hundred private interests, but only impatient dis-



The Father of Radio and the Audion. From a painting by George Camarero.

gust to millions of other persons.

Television is a great and marvelous institution toward which science has been steadily working through decades. The dignity of its future will not be limited by commercial exploiters.

There are today, over three hundred television transmitters in operation. The number is increasing at an average of nearly three dozen per month. Within two years, scarcely a household in the United States will be out of range of at least one TV station, v.h.f. or u.h.f. This great increase in station erection, following the prolonged "freeze" by the FCC, exceeds the forecasts of its most enthusiastic proponents.

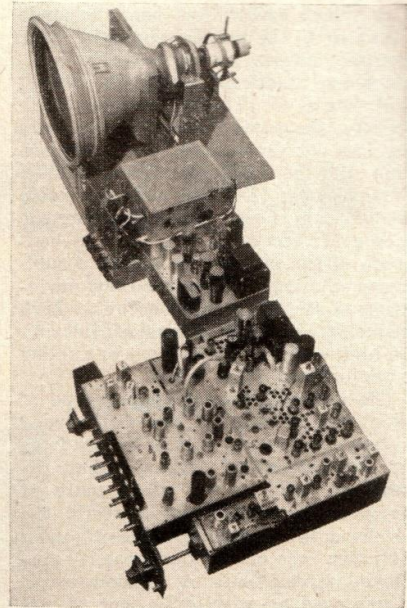
Unquestionably, the present state of compatible color television is chiefly due to the determined, long pursued, and ingenious labors of the research engineers of the Radio Corporation of America in its laboratories in Camden and Princeton, N. J. Spurred on by the zeal of RCA chairman, General David Sarnoff, the advent of compatible color TV has been advanced by years, so that today daily demonstrations of live and color-film pictures may be seen in New York, and will be available soon in Hollywood, Washington, and elsewhere.

To make this rapid progress possible it was necessary that the technical leaders of the TV industry should

jointly and harmoniously agree upon a national set of standards, to avoid prolonged and manifold working at cross purposes throughout the industry. Last March the previously agreed upon standards were somewhat altered and improved. Patent licences were generously exchanged so that the various technical leaders can now work harmoniously in the common aim to bring to the public, as quickly as possible, (following FCC formal approval of the NTSC standards), color television receivers at the lowest possible prices.

Today there are at least three types of color kinescopes in "laboratory" production, the tridot perforated masking screen kinescope of RCA, using at present three guns; the horizontal tricolor narrow horizontal strip (or wire), so-called Lawrence tube; and the new CBS-Hytron tube to be described later.

The three guns of the RCA tube are located within a nickel cylinder converging at a narrow angle which brings the three narrow cathode beams together in the plane of the perforated plate. Magnetic deflection means similar to those used with the conventional black-and-white single gun cause the three beams to be swept across the perforated masking plate, horizontally and vertically, exactly as in the monochrome kinescope. The three beams are controlled in time and intensity by the arriving "red," "green," and "blue" signals from the distant transmitter, so that any one, two, or all three beams pass through a single hole in the masking plate simultaneously. Upon passing through any aperture in the masking plate, the three beams diverge, each beam falling upon a tiny red, green, or blue fluorescent spot on the parallel flat glass plate which is mounted approximately one inch in front of the perforated masking plate. By this arrangement the viewer in front of the tube sees true color reproduction, because the intensity of the three primary color dots varies in accordance with the three colors picked up by the three closely grouped cameras at the distant transmitter, and are commingled so as to reproduce all color tints and shades with their proper intensities.

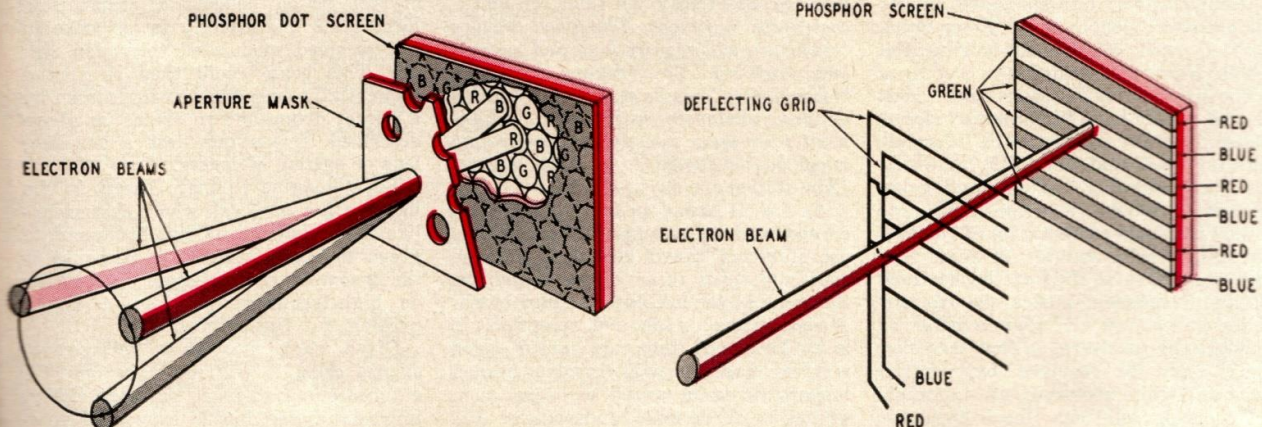


Courtesy General Electric Review
Experimental G-E color TV receiver.

The basic idea of a perforated masking plate, located before a transparent plate carrying on its face a vast number of tricolor phosphor dots, symmetrically located, is attributed jointly to TV engineer Levering, and Dr. Alfred Goldsmith. To date this arrangement, using three guns, or only one, is generally accepted as the most practical and promising of a multiplicity of more or less practical suggestions.*

The so-called Lawrence color tube employs a flat viewing plate carrying a series of fine tricolor stripes, preferably horizontal. Behind this plate is a parallel array of fine wires. Every third wire is connected to a common terminal. These three terminals are connected—each to a high-voltage source controlled by the incoming color signal, so that one set of wires divert the horizontally swept beam so that it falls upon the desired color stripe—red, green or blue—as it travels along. Thus the other-

* Included is a patent application recently filed by the writer.



Section of two types of color screens. Left is the RCA shadow-mask; right the Lawrence tube with its deflecting grid.

wise "black and white" beam is made to appear in the proper sequential color picture elements. Inasmuch as the cathode beam at the plane of the control grid wires is at high voltage, high velocity, the rapid control of the beam requires correspondingly high voltages. This may be a distinct disadvantage. Furthermore, there is a considerable loss of beam energy in transversing the wire grid, resulting in a loss in brilliance of the picture. To obtain a sufficiency of picture detail, the color modulation of the beam must occur at high frequency, a disadvantage considering the high voltages which must be applied to the beam-shifting wires.

The most recently developed type of color tube is that of the CBS-owned Hytron engineering staff. It differs from the above-described RCA in that, instead of using a flat glass plate to carry the three-color dot pattern, the tricolor dots are implanted directly upon the inner face of the kinescope. A perforated screen plate, or shadow mask, is employed as with RCA, but this is curved as is the tube face, the shadow mask plate being rigidly fastened at the correct distance behind the tube face. The tube carries three guns, as does RCA's.

This arrangement weighs much less than do the two flat plates, and the necessary heavy metal frame and screen—stretching means in the RCA tube. The exhaustion problem is thereby simplified and the tube cost is claimed to be substantially less. Further, the curved surfaces of the *Colortron* tube should avoid the size limitations presently inherent in the use of the two flat parallel plates of RCA. The anode voltage in both tubes is the same, 20 kv. Both screens are aluminized. The CBS receiver employs 40 tubes, including 2 rectifier tubes.

CBS uses the NTSC signal standards. Its newly demonstrated color system employs at the transmitter a single orthicon camera (instead of three with dichroic mirror color separators of RCA), with the familiar color-segment wheel, quite like what was used in the original CBS color system. Recent public demonstrations of this system show future promise, but as yet it is comparatively unimpressive in its performance. Doubtless Dr. Peter Goldmark is well capable of solving the problems yet remaining.

The present NTSC color signal consists of a wide-band "luminance" signal transmitted according to FCC standards for black-and-white TV, to which has been added a narrow-band color subcarrier having a video frequency of 3.58 mc. This combination of the two carriers, a color carrier of high frequency relative to that of the horizontal line frequency, makes the pattern of the subcarrier virtually invisible in monochrome receivers, so that the color signal may be received by present black-and-white receivers, an outstandingly clever solution. Hence the new color standards result in complete compatibility, an absolute essential for

successful color television today. The color subcarrier sidebands extend to 1 mc below and 0.4 mc above the color subcarrier frequency, as measured to the 6 db down point.

The well-known standard horizontal synchronizing pulse is followed by a burst of 3.58 mc frequency which is delivered during the "backporch" of the horizontal blanking period. This burst, of exceedingly brief duration, is used in the standard color system to lock the oscillating system of the receiver. For black-and-white reception the burst signal is omitted. For a burst of eight cycles, the pulse duration would be 2.2 microseconds. The color subcarrier frequency is chosen to be an odd multiple of one-half the horizontal deflection frequency. Therefore the unit generating the 3.58-mc signal and the synchronizing generator must be locked together.

The various types of compatible color TV systems must all conform to the present NTSC standards, but as regards the receiver, a wide variety of design of the picture tube, including the color screen (dot or linear type), is permissible and a number of inventors are still very active in efforts to obtain better results and to permit use of much larger viewing tubes than the present RCA type (approximately 15-inch) screen.

A vast amount of research to determine the most efficient types of red, green, and blue phosphors has resulted in the following: Red (zinc phosphate; manganese), green (zinc silicate; manganese), blue (zinc sulfide; silver and calcium-magnesium silicate; titanium). The relative luminosity of these three phosphors is 25.3, 100 and 26.6 respectively, that of the green being taken as 100 or standard. Doubtless, further research may result in yet greater color efficiencies. The chemists continue their researches.

Disturbance of the color picture due to outside interference is found to be no greater than with the monochrome receiver; although the present color receiver employs from 30 to 50 electron tubes, of a large variety of types. Servicing of commercial color TV receiver is certain to be a far more complicated and tricky job than for black-and-white receivers. *The good service technician will require long and meticulous training. No ordinary slap-dash "tube shifter" can be expected to qualify or give customer satisfaction. Alignment techniques and general know-how must be developed to a high degree.* (The italics are ours.—Editor)

As far as sound in color TV is concerned, nothing novel is introduced. The old standard sound circuitry and the spectrum space reserved for sound are the same as for present standard monochrome transmission and reception. It is to be hoped that the larger color receiver cabinets will involve needed improvements in sound emitters, such as two or three good loudspeakers distributed in the cabinet, with selective circuits and controls. *Improved video*

should demand correspondingly better acoustic reproduction facilities.

The estimated initial cost of color receivers varies from \$800 to \$1,400. These costs are certain to come down as quantity production proceeds, but it is clear that color will always be relatively costly, even for screen sizes small compared with our present 21- to 27-, or 30-inch kinescopes. Furthermore, much will depend on the quality of color programs. Color commercials will, of course, be much more attractive than are today's dull displays of beer-bottles and cigarette packages; but to justify the high cost of receivers, and their proper maintenance, the viewer must be given a superior quality of program along with a minimum of commercial commands.

Color television will not be all beer and skittles—we hope. The new program director will have many new problems, but also he will have a magnificent new medium for the public's delectation—not dejection.

What does the future of color TV present? A most enticing and challenging question that will stimulate ingenuity and imagination unlimited. Why, for example, must color TV be necessarily confined to a vacuum chamber? Why not use a dazzling needle of light instead of the cathode ray? Assume a brilliant gas tube which can be modulated millions of times per second, focused with tiny concave mirrors mounted in spiraled formation upon a small, light, rapidly revolving cylinder, or disc, which throws the beam across the face of a large screen, from left to right, and from top to bottom of the screen. The mechanism may be small, cabinet enclosed, and noiseless. This is a flareback to the old neon-light television ideas of C. Francis Jenkins, John Baird, and Mihaly. But it can be resurrected and refined, provided only that we can find the gas tube combining sufficient brilliancy with no inertia lag or hangover, one whose light output can be quantitatively modulated at 6,000,000 times per second!

Or, let our synthetic chemists provide a new type of light-modulating liquid cell, (resembling the Kerr cell); or, better yet, a new type of refracting crystal which deflects a transmitted light beam quantitatively in response to the received modulated television signal. This beam could then be spread sequentially over the viewing screen by a mirror drum, or two drums, as above described, traversing first a focusing lens or system of lenses.

Let's imagine further: Insert in the light path a *color cell* whose chameleon-like fluid changes its hue from red to green to blue instantly, in response to the incoming color signals, by voltage or high-frequency changes—a tricky problem for future chemists!

Given such inertialess voltage response cells, it will not take our TV engineers long to chuck the huge, bulky, implosion-labile, highly evacuated kinescopes into the trash can—an outcome devoutly to be wished. END