Color Is Catalyst in Battle of the Tubes

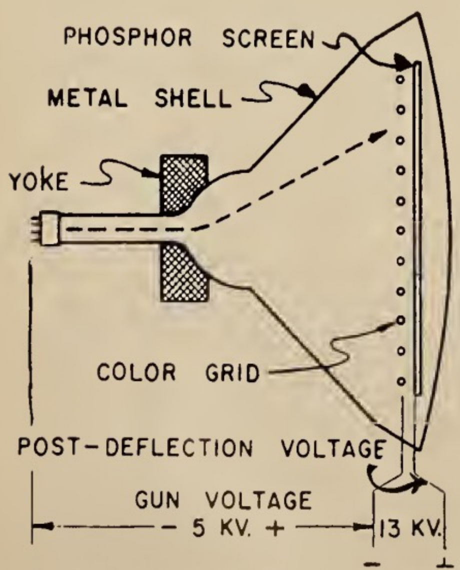
24-inch color television tube is already here. So claim the engineers who developed the unpublicized Chromatron. RCA and CBS vie in race for public favor as new medium gets FCC blessing

By FREDERICK HODGSON

COLOR TELEVISION has arrived officially — and with it comes the start of one of the most exciting races for preferred position since land-hungry settlers in the Old West careened across the plains in the sprint for the Cherokee Strip. The fun began on December 17 when word was flashed from Washington that the Federal Communications Commission had formally approved colorcasting under standards proposed by the National Television System Committee, an all industry group now well known by its initials, NTSC.

The new colorcast standards, replacing a previous set approved back in 1950 at the behest of the Columbia Broadcasting System with its now outlawed (except for closed circuit colorcasts) field-sequential system, permits reception of color programs on standard black-and-white sets.

In this article we are concerned principally with the "Battle of the Tubes," with the receiving end of color television rather than with the now satisfactorily settled issue of how to put the show on the air. This latter matter, of great importance to projectionists because of the increasing use of film both for broadcast and for rear projection in live shows, will be dealt with briefly later on in this piece and will be the subject of future IP attention.



This is a cross section of the Lawrence, single-gun Chromatron tube. Note how the electron stream inside the shell is deflected by the coil magnetic yoke. Note, too, the placing of the wires of the color grid in relation to the phosphor face plate. The 13 KV post deflection voltage varies.

The NTSC standards, now a part of the law of the land via FCC regulations, demand that any color television system be compatible, in other words that the 27,000,000 black-and-white sets now in use should not be rendered obsolete. The three types of tubes to be discussed here can receive in either black-and-white or color, a simple clockwise turn of the chroma dial on the receiving set changing a program broadcast in color from the familiar blacks, whites and grays to all the hues of the rainbow.

Three picture cathode tubes, or kinescopes, are major entries in the color television sweepstakes. They are RCA's tri-dot, three-gun kinescope, the one-gun Lawrence tube, also known as the Chromatron, and the three-gun CBS-Hytron, or Colortron. Engineers of the three developing companies quite naturally claim very special advantages for their respective brain children.

Let's look at this trio of entries in the contest of the cathodes, starting with a brief description of the RCA receiving tube. This kinescope was discussed in some detail by James Morris in an article on "Color TV . . . and How it Works!" in IP for September, 1953.

Basically the Same

Basically, the three kinescopes are the same. The differences, however, are of extreme importance because they will determine the winner, if any, in the race for public favor — and because the differences will largely determine how much you'll pay for a color TV set and how big a picture you will see.

Each of the tubes is of the vacuum type employing one or more cathodes, or "guns," to fire one or more electron

Dr. Paul K. Weimer, RCA engineer, is shown holding an experimental single tube unit for the taking camera in the RCA tri-color television broadcasting system. Called an iconoscope, or orthicon, the tube is expected to do the work of the three tubes now used. The CBS system uses a single tube for broadcasting color, separating the three colors by means of a color wheel. Circuitry for the single tube is simpler than for three guns, according to both CBS and RCA engineers.

beams at a phosphor plate. In the black-and-white phosphor plates the electrons, hitting the phosphor dots at high speed, cause these dots to glow with varying brilliancy. Hence you are able to see a picture. In color television the chemical composition of the dots has been changed so that they glow in color, also with varying brilliancy. In the case of the Lawrence tube, or Chromatron, there are no dots, phosphor strips are used instead of the dots.

Mask versue Grid

The electron beams, or cathode rays, carry the color and picture information and, in accordance with NTSC demands, utilize black-and-white scanning standards, 520 lines at 30 cycles per second. Two of the kinescopes, the RCA tube and the CBS-Hytron, use aperature masks, each perforation positioned directly behind a phosphor dot. Electrons stream through the tiny holes of the plate, strike the proper dots and so produce the color picture. The Lawrence tube, using but one gun, actually bends the beams by means of an electrostatic "lens," a charged wire grid placed just back of the phosphor face plate. This "lens" system eliminates the perforated shadow mask.

The Lawrence tube differs from the RCA and CBS-Hytron in other ways as well. For example, the distance from the cathode to the phosphor plate is much shorter thus permiting a much larger picture. First of these new tubes, now completely unknown to the general public, to go on the market will be as big as those now popular in black-and-white sets, 21 inches and 24 inches. The top picture size so far announced for the RCA tube is 16 inches, with the 12½ inch tube being widely publicized. A 21-inch tube has been announced by CBS.

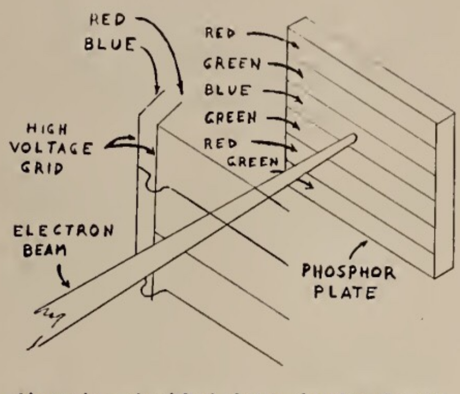
In the RCA tube the three guns are positioned inside a metal cylinder and converge at a narrow angle so as to aim three narrow electron streams at the perforated masking plate. The beams sweep across the plate, electrons streaming through the tiny holes to strike the phosphor dots and make each glow in its proper color. The magnetic deflection system in the tube, as in the other tubes under consideration here, is somewhat similar to that used in the black-and-white tubes.

An idea of the complexity of a cathode color tube may be gleaned from the fact that for the RCA 12½-inch picture size, the phosphor plate contains some 600,000 phosphor dots, 1,000,000 for the 16-inch. These are placed so closely together that the resultant picture is smooth. An analogy might be the photographs reproduced in IP as halftone engravings using a 120 screen. Examine one of these pictures under a magnifying glass and you'll see a myriad of tiny dots. Because IP is printed on an exceptionally fine grade of paper these dots can be smaller and closer together than is possible for a daily paper printed on newsprint. Newspapers usually use a screen as coarse as 60-line, or even 55-line. Use the glass to examine a photo in your favorite daily and you'll see what we mean. Another analogy might be the grain in film.

Midget Pictures

Some criticism has been leveled at RCA tubes, notably by Lee DeForest, and others, who say that the necessary metal shield adds unduly to the weight and also restricts picture size. RCA engineers, on the other hand, insist that there actually is no restriction on the ultimate picture size. However, the proof is in the eating, and any color TV we've seen on RCA sets has been of the midget variety, even in situations where the company was putting its best foot forward and would be expected to use the biggest screen possible and still have a good color picture. Too, RCA is known to be experimenting with one-gun tubes, even with the wire grid type of electrostatic lens as in the Lawrence tube.

In IP's humble opinion, subject to change as the inventive genius of



Above is a simplified sketch showing the passage of the high-velocity electron stream from the cathode of the Lawrence tube to the phosphor plate through the high-voltage grid, or electrostatic lens. Note that the two sets of grid wires (marked red and blue) are connected to two separate electrodes. In practice the grid is set but a fraction of an inch behind the phosphor plate.

engineers continues to perform electronic miracles, the most promising of the three tubes under discussion, for mass production and other reasons, is the Chromatron, or Lawrence tube. The public has been conditioned to big TV screens and may be expected to balk when asked to shell out anywhere from $500 to $1,000 or more for a TV set, color or not, with a picture size reminiscent of the early days of black-and-white.

The Chromatron was invented by a world-famous physicist, Dr. Ernest O. Lawrence, winner of the Nobel Prize for his invention of the cyclotron and other types of atom smashers. He is now director of the Radiation Laboratory at the University of California and consultant to Chromatic Television Laboratories, Inc. Dr. Lawrence was one of the top ranking scientists called upon for work on the atomic bomb. He is responsible for the development of the Calutron, the electromagnetic method for isotrope separation.

3-D on TV

The Chromatron, based on Dr. Lawrence's ideas, was brought to its present development by Chromatic Laboratories, a Paramount Pictures subsidiary headed by Richard Hodgson (no relation to the writer), a Stanford University engineer and war-time radar expert. We first saw the new tube at Chromatic's closely-guarded New York laboratory on the ninth floor of the Paramount Building. There we examined the electrostatic lens grid assembly and phosphor plate, heart of the tube. We mentioned to Albert Chesnes, a Chromatic engineer, that the assembly, with its grid of many hundreds of fine wires mounted just behind the phosphor screen, looked for all the world as if the lab were developing a motion picture screen for parallax barrier 3-D. Chesnes grinned, and let a secret slip. Just for the heck of it, Chromatic engineers had "broadcast" 3-D over the closed laboratory circuit. This, however, had nothing to do with the wire grid. Any color tube, RCA, CBS or Lawrence, can pick up perfectly good stereoscopic pictures of the anaglyph variety. Viewers, of course, must wear traditional red-and-green anaglyph glasses.

Later, still over the closed circuit, Chromatic engineers, for the benefit of IP and Henry Kogel, staff engineer for SMPTE, "broadcast" an analyph still picture. As in theatre 3-D projection using the anaglyph system, the original color picture reached the eyes through the "glasses" as a black-and-white picture. Without the red-and-green viewers the picture was nothing but a dark blur with red streaks.

3-D Importance

This completely unexpected blessing, or curse if one doesn't happen to like the third dimension in movies and shudders at the idea of its invasion of the home, is of real interest and may be of great importance. With 3-D projection of training films in industry and for military training purposes, rapidly gaining in use, along with in-plant television, the possibilities for development are obviously very great.

Up to this writing telecasting of 3-D has been impossible except under harrowing conditions. Several months ago we saw true 3-D on our home black-and-white television set in a broadcast from the University of Pennsylvania. The viewer stood with his back to the screen and watched the screen in a mirror held at arm's length. A piece of cardboard was then held vertically on a level with the nose, permitting the eye to get just one of twin pictures on the screen. We saw 3-D alright but wouldn't want to spend an evening with such dubious entertainment.

[TO BE CONTINUED]

Atom-Smasher Principle Aids Color TV

Projectionists very much in the picture as color TV gets off to a hesitant start with the Cyclotron idea of electron acceleration spurring new controversies

By FREDERICK HODGSON

PROJECTIONISTS who have watched technological advances turn the motion picture industry topsy-turvy within the past twelve months may spend a profitable and enlightening moment considering the effect of progress in other fields, color television as the top example. If any there be who think that Tv in rainbow hues has nothing to do with the film business, let them read this month's "Spotlight" in IP and ponder some of the data recounted there.

This brings us back to the subject under discussion in this series of articles, color television at the receiving end — the cathode tubes, or kinescopes, that bring the show into the living room and will eventually bring Tv into the theatre. Either way, the projectionist is very much in the picture.

Last month we discussed very briefly the three kinescopes so far entered in the color television sweepstakes, the three-gun RCA and CBS tubes and the simpler one-gun Chromatron developed by Paramount-owned Chromatic Laboratories.

Atom-Smasher Principle

The Chromatron, devised by Dr. Ernest O. Lawrence, inventor of the atom-smashing Cyclotron, makes use of the Cyclotron principle of high acceleration voltage to fire the picture-carrying electrons from the cathode at ultra high speeds into the phosphor strips of the face, or picture, plate of tube. Let's pick up where last month's article left off and examine a few of the differences between the three top kinescopes so far announced.

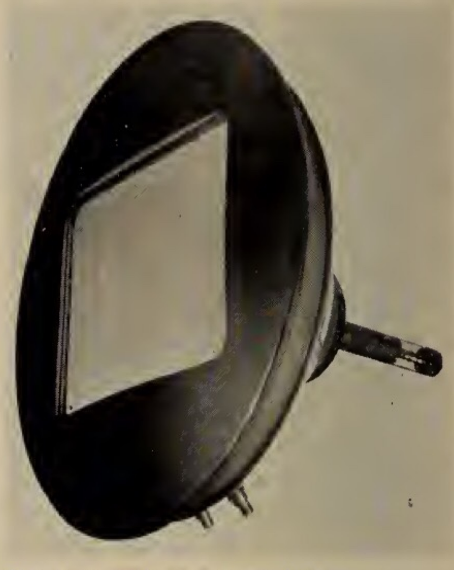
Some Chromotron Details

The basic differences between the Chromatron and the CBS-Hytron and the RCA tube have been recounted previously. It remains now to cover details of the Chromatron, some of them shared with the other kinescopes.

The Chromatron uses a flat viewing plate with more than 1,000 phosphor strips placed horizontally across the back for the 21-inch picture size. The color scheme used is red, green, blue, green, red, green, and so on, every second strip being green. Other combinations might be used for the strips, provided every other strip were of the same color phosphor. Back of each red and blue strip (none for the green) is a fine wire carrying the voltage which switches the electron beam to the proper color.

There has been some criticism of the Lawrence tube on the score that the voltages necessary for its operation are too high. In truth, the Chromatron anode voltage is 18,000, which is the same or less than, with either the RCA or the CBS tubes. Voltages must correspond for the high velocity electron beam and for the control grid wires.

Too, it has been asserted that there is a loss of electrons caused by the grid wires and that this results in a loss of picture brilliance. IP fails to see how this loss of 15% or less in electrons can be a greater disadvantage than is the obviously much greater loss of electrons caused by the perforated metal masks of the RCA and CBS tubes. Some electronic engineers place this loss as high as 85%, a figure vehemently denied by RCA spokesmen.



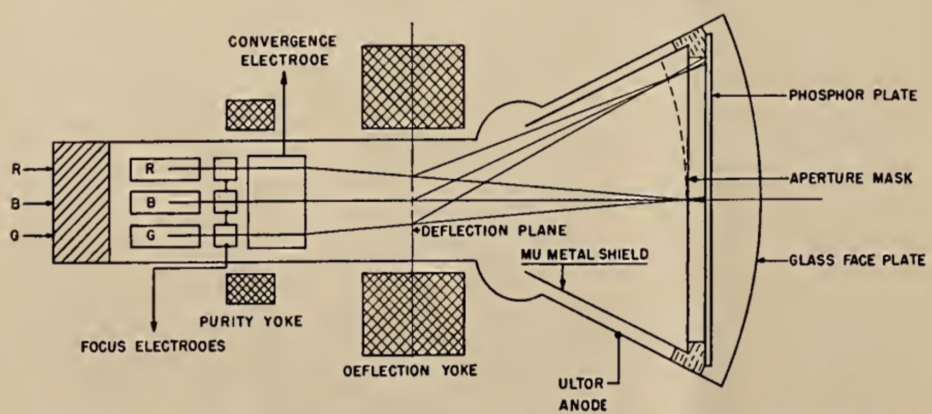
This is an early experimental Chromatron, or Lawrence tube. Production models for 21" and 24" color pictures will be rectangular at the face plate instead of round. Note the short distance between the cathode in the neck of the tube and the phosphor face plate.

Aperture vs Grid

In the Lawrence tube the electron stream from the single gun is bent around the grid wires to hit the proper phosphor strip. In the aperture or perforated masking plate type of tube there is no bending effect, part of the electron stream being stopped dead by the metal plate. Only that part of the beam passing through the perforations is of any use in bringing the color picture to the screen. Even a casual study of the illustrations accompanying this article will make the point clear.

Stated as briefly as possible, and closely quoting Chromatic engineers, claims for the Lawrence Chromatron are:

1. Wide deflection angle. This is 72 degrees, making it a short tube. The overall length for a 22½-inch picture is 22 inches, comparing very favorably with the length (from the



Above is a simplified cross section of the present RCA three-cathode (or gun), tri-dot kinescope, or receiving tube. Note the length of the tube in contrast to the other tubes illustrated.

face plate to the back of the cathode in the neck of the tube) of your 21-inch black-and-white set at home.

2. Large picture. Over 60% larger than pictures produced by three-gun shadow mask tubes of the same dimensions.

3. Bright picture. At an anode voltage of 18,000, the brightness measured through 66% efficient filter face plate is above 50 foot lamberts in the highlights.

4. Low raster (image) scanning power. The deflected beam is one quarter the potential of the final acceleration.

5. Resolution. In the horizontal direction definition is equivalent to black-and-white. In the vertical it is limited only by the number of color strips.

6. Standard deflection components. The tube uses standard low-cost black-and-white magnetic deflection yoke and standard magnetic focal coils.

7. Quick set up. This is done in a matter of minutes since there are no problems of raster registry or dynamic convergence. This is in contrast to other tubes.

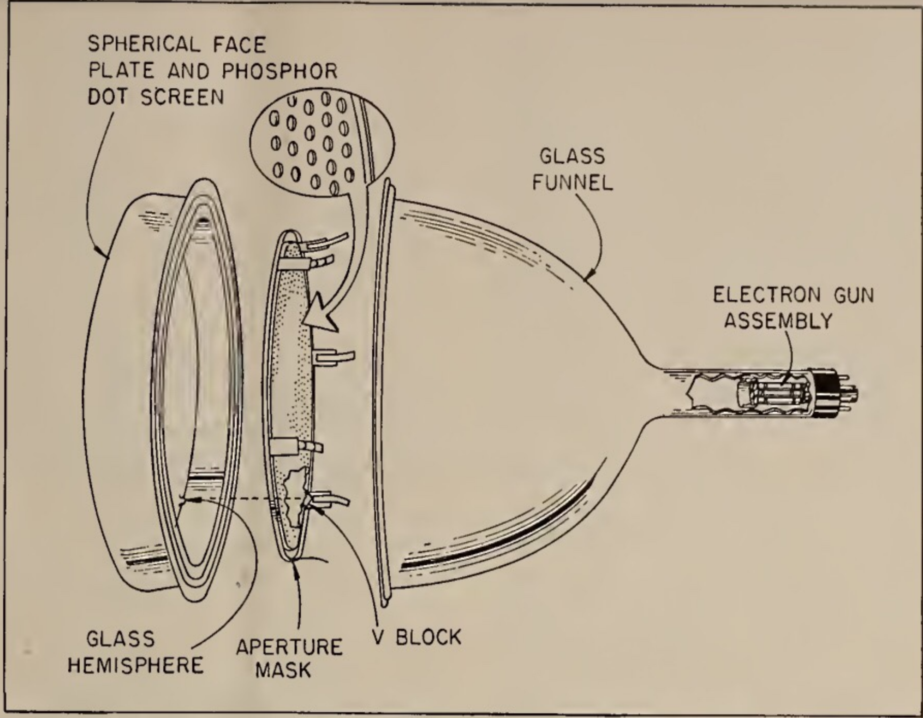
8. Simplified circuitry. This is because the Chromatron is a one-gun tube, not three.

Other Advantages Claimed

In addition to the above, Chromatics engineers boast of fringe-free color pictures and fringe-free reception of black-and-white. They claim that the tube is relatively inexpensive to produce because of several factors, notably because of the single gun, the standard magnetic yokes and the fact that only reasonable production tolerances are required. Alignment of the Chromatron is extremely simple.

The Lawrence tube illustrated with this article is an early experimental type, no pictures of the new tubes being available as IP goes to press. The new tubes are rectangular at the face, rather than round. It is pointed out by practically all concerned in the development of color television that the present production bottleneck is the shortage of envelopes, the glass bottle of the tube.

An indication of the expected demand for Chromatron tubes is found in Chromatic Laboratories' action last month in setting up new facilities for grid production at the company's plant in Emeryville, Calif. This new plant, scheduled to employ some 200 people at the start, will be in production by



Above is an "exploded" diagram of the CBS-Hytron tube showing the three-gun assembly inside the neck of the envelope. Note that the phosphor screen is on the face of the tube itself.

the end of March with an initial capacity of 25,000 grids per year. CTL has been making grids for licensees and potential licensees in a pilot plant connected with the company's Oakland laboratories.

Start of mass production of the Lawrence tube and delivery to set manufacturers for enclosure in cabinets with the necessary electronic units for its operation should come quickly, according to Chromatic Laboratory's president, Richard Hodgson. At this writing two manufacturers, Crosley and Thomas Electronics, Inc., of Passaic, N. J., have been licensed to produce the tube. The Thomas firm, said to be the largest manufacturer of cathode tubes in the country, is picture tube supplier to most of the major producers of Tv sets.

Some further, and a bit more technical, information on the Lawrence tube might be of interest. An examination of the diagrams will show that the wires behind the red phosphor dots are electrically tied together and are brought to a single terminal at the side of the tube. In the same manner the wires behind the red phosphors are tied together and brought to a second terminal. There is a third electrode for the aluminized backing of the phosphor plate.

As stated previously, a focusing and acceleration potential is applied between the electrical center of the wire grid and the aluminum coating. This creates the electrostatic lens, or rather series of lenses, in the front section of the tube. As electrons stream down the length of the tube from the single cathode gun perpendicular to the image plate, they are focused sharply by this series of lenses to the green strips between each red and blue strip, when there is a zero potential between the red and blue termini of the wire grid. Thus a green raster appears on the image plate.

At this point, to quote Robert Dressler,* director of research and development at Chromatic's New York Laboratory, "a potential difference may be applied between the sets of wires to deflect the focused beam in the direction of the positive wires. This voltage can be made of such a magnitude that the beam will strike a phosphor strip adjacent to the green, thus rendering a red or blue raster on the image plate, depending on which set of wires was positive. Separate colors, therefore, can be displayed by simply changing the potential of these wires. With a color switching device of this type, the color displayed depends only on the potential of the wires, so that no color distortion or contamination can result from nonlinear sweeps or minor inaccuracies in gun position. In addition, the cylindrical lenses up front focus the beam of electrons into a spot so fine as compared with phosphor strip width, that the placement of wires

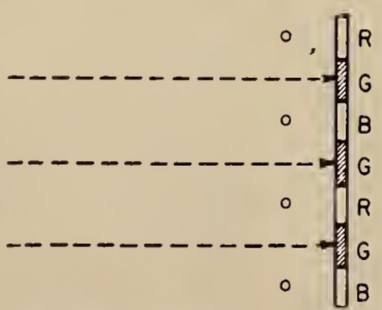
* In a paper read at the July, 1953, meeting of the Institute of Radio Engineers.

behind the phosphors need not be extremely critical."

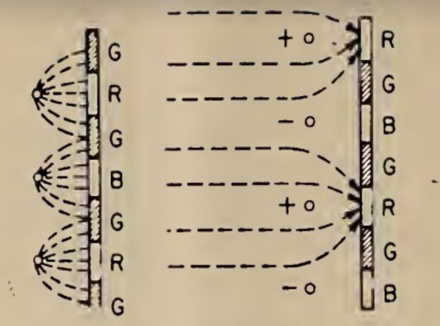
The CBS-Hytron tube, known as the Colortron, was unveiled to a waiting world last October and turned out to be a shadow mask, tri-dot three-gun tube. Thus it is similar to the RCA tube in some of its important aspects, but quite unlike the Chromatron. Its main point of distinction is a curved rather than a flat type mask designed to minimize or completely eliminate color convergence. This latter simply means color registration. Production differences are also announced for this tube, which is shown in "exploded" form in the diagram (Page 15), the main one being the method of applying the phosphor dots. This is accomplished for the Colortron by a photographic technique. In the case of both the RCA tubes and Lawrence tube, the Chromatron, application of the phosphors is by silk screen, although individual manufacturers of these tubes may elect to use other methods.

Too, the Lawrence tube has been criticized to the effect that the phosphor strips are visible to the viewer and do not give the smoothness of either the RCA or the CBS-Hytron. It is argued that the 1,000 or so phosphor lines, each 15 mils wide, cannot compete with the million phosphor dots. The reader can judge for himself by simply watching color television on the three tubes and contrasting the performance of each.

Feel this page of IP for thickness and you'll have an idea of the width of the phosphor strips. This page is approximately 2½ mils thick. Therefore, roughly, the phosphor strip of the Chromatron is six times as wide as the page thickness. Chromatic engineers are working on methods which they hope will reduce the strip width to 10 mils or even less. Ten mils, of course, is one one-hundredth of an inch.



The sketch shows how electrons from the cathode of the Lawrence tube, travelling thousands of miles per second, strike the green phosphors without hindrance from the grid.



Shown here is how the electron stream from the cathode of the Lawrence tube to the aluminized phosphor face plate is acted upon by an electrostatic "lens" (the grid) and is deflected at the grid (indicated by plus and minus signs) to the appropriate phosphor strips. Note that the polarity alternates.

Pilot production of the CBS-Hytron tube is set to start this month at the Hytron plant in Newburyport, Mass. At the Kalamazoo, Michigan, plant, production is scheduled to begin in September.

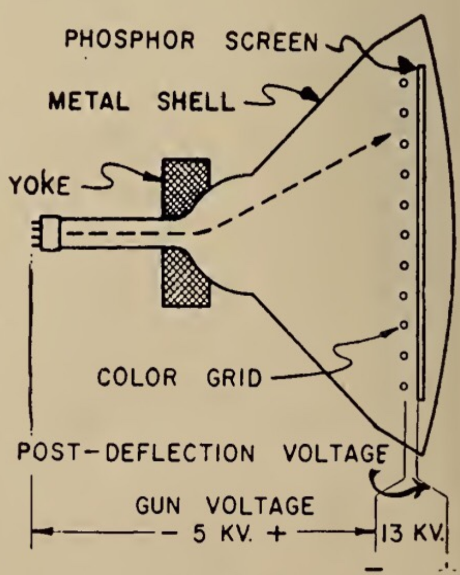
Bruce A. Coffin, president of the CBS-Hytron division of the Columbia Broadcasting System states that emphasis will be placed on production of 21-inch rectangular models. Hytron tubes seen by IP have been round, very likely due to the same bottleneck in the glass envelopes that is plaguing other manufacturers.

The Hytron tube has a metal face mask held from the flat glass phosphor plate by a spacer frame. This is to maintain a rigid relation between the perforations of the mask and the related phosphor dots which are planted directly on the inner face of the tube. This latter trick has the advantage of keeping down the weight of the tube. The tube, so CBS claims, does not require the high vacuum of the RCA tube, an important cost factor in manufacturing.

An interesting point of difference between RCA and CBS is the fact that the latter clings tenaciously to its field-sequential system in transmission. RCA uses a three-tube, or three orthicon, taking camera. Dichroic mirrors split the color image into its red, blue and green components, then reflects the beams through color-selective filters to the trio of orthicons, whence they are fed to the adder, then encoder and the transmitter. CBS, on the other hand, uses but one taking tube but splits the image into its component colors by means of a spinning color wheel. The alternating red, blue and green impulses are then carried to an ordinary black-and-white tube, a system of mirrors picking up the color and picture information from there and reflecting this information triad into three color tubes, one for red, one for green, and one for blue. Each of these tubes has a shutter synchronized with the color wheel (doubtless by selsyn interlocks). The information is then carried through the rest of the broadcast circuit and out onto the air as a compatible picture.

Incidentally, the field-sequential system, now passe with the adoption of the NTSC standards, simply fired the pictures at the receiving tube in a rapid succession of color messages. These could be separated at the receiving tube by means of a color wheel. Such a system was incompatible because color television could not have been picked up by the present black-and-white sets. Nor could color sets built for field sequential reception pick up the present black-and-white telecasts.

An interesting sidelight to the sudden furor over the advent of commercial color television is RCA's interest in projection color television. The reason is easy to figure out. The three-tube projection system of the RCA laboratories projects images through a special optical system onto an 18 by 24 inch translucent screen. For a picture of similar size on the RCA color tube described earlier in this article, the tube would have to be nearly three feet in diameter. This experimental projection of color television has been demonstrated by RCA on full-size theatre screens.



This is a cross section of the Lawrence, single-gun Chromatron tube. Note how the electron stream inside the shell is deflected by the coil magnetic yoke. Note, too, the placing of the wires of the color grid in relation to the phosphor face plate. The 13 KV post deflection voltage from the grid "lens" varies.