How to Grow Your Own Crystal Radio!

RADIO-TV EXPERIMENTER

DECEMBER-JANUARY 75c

WHITE'S RADIO LOG

AM-FM-TV STATIONS
NEW EXPANDED
WORLD-WIDE
SHORT-WAVE LISTINGS!

CHROMATRON—The New Color TV Tube!

How Electronics Predicts Weather!

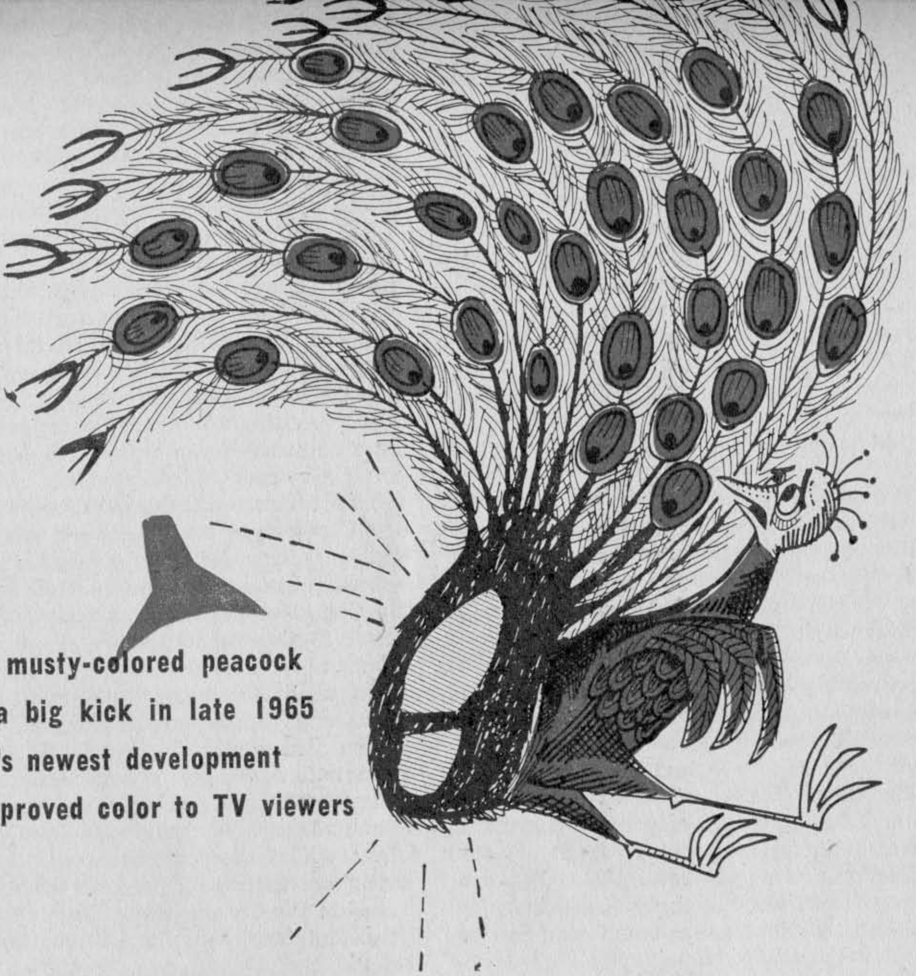
PROJECTS TO BUILD:

- $4 Telephone Beeper!
- $22 Door Answerer!
- $4.50 5-Way Power Tap!
- $23 R/C Mailbox Alarm!

TEST REPORTS:

- Knight-Kit KG-870 Stereo Amplifier
- H. H. Scott LT-110B Stereo-MX Tuner
- Channel Master Lodestar Pocket Tape Recorder

Build This Xenon Strobe! ⇦



That old musty-colored peacock will get a big kick in late 1965 when TV's newest development brings improved color to TV viewers

CHROMATRON COMES TO COLOR TV

That living-color picture—a peacock fanning a color-splashed tail—is in for a big change. After a decade of home color reception built around the "shadow mask" picture tube, a new breed of color tube is bowing in. It is the Lawrence tube, conceived by a university professor 14 years ago, cheered as an engineering marvel—and once rejected as impractical. Today it is a reality. Far from a laboratory curiosity (like most other stabs at a new-type color tube) the Lawrence version has followed a tortuous path of development until refined to the point of practicality. The first commercial TV sets containing Dr. Lawrence's radically different technique will soon be here. You'll

CHROMATRON

be seeing the tube under a new name, too; it's now the "Chromatron."

According to its present developers, Paramount Pictures Corp., the Chromatron promises several advantages. First is increased color brightness. More vivid color gives the illusion of depth in the picture and permits viewing under more room light. It's simpler, too. The number of tubes required over a black and white set is reduced by four or five. Circuits, are fewer; adjustments, less. The Chromatron could also open up the big, untapped field of small-screen color TV. The tube lends itself exceptionally well to under 21-inch screen sizes.

Seeing Is Believing. By what technical wizardry does the Chromatron hope to capture a sizeable segment of the growing color TV market? To find the answer, I traveled to New York's big Paramount theater—to an office situated a few floors above the huge movie screen. The attraction in that office proved far more exciting than the current movie attraction floors below. There were three side-by-side TV receivers, each displaying the identical program in black and white. The time: 10:27 a.m. I was instructed to watch and carefully compare the screens. In three minutes the local TV station would start transmitting in color. As 10:30 came up, the peacock obligingly fanned its polychromatic tail. The eye could not resist being drawn to the center screen; the bird appeared in brilliant and vivid color, nearly eclipsing the images on the two sets alongside it. (One was black and white, the other a conventional color receiver.) After some minutes, an engineer flicked on two white fluorescent lamps, aiming their beams directly at the two color screens. Again the results were startling. The center screen continued to display strong, clear color, suffering little "wash out" from the bright lamplight. I moved in close to the center screen, placing my eye about two inches from it. Instead of the usual fine dots I'd been accustomed to seeing on the usual color screen, there were numerous thin lines similar to what you see on a black-and-white screen when viewed up close. On this TV picture tube, however, those lines ran up and down, and glowed in different colors.

That center screen was the business end of a Chromatron. Paul Raibourn, vice-president of Paramount, then conducted an interesting demonstration to illustrate how increasing color brightness sharpens and suggests a 3-dimensional quality in the image; a bowl of fruit appeared to pop out from its background. An identical picture, of less illumination, appeared flattened. This, of course, dramatized the big advantages in Chromatron's ability to deliver high-intensity color. But to probe the inner workings, operation and theory of the tube, I toured the lab where actual developments had occurred; Paramount Picture's Chromatic Division.

Inside the Chromatron. Easily the most significant feature of the Chromatron is a unique grid structure of fine stainless steel wires positioned just behind the viewing screen. Here lies the secret of the tube's "transparency"—the characteristic which determines how brightly the screen can light up. In a regular black-and-white tube, transparency presents little problem; an electron beam issuing from the neck of the tube strikes the viewing screen and causes it to glow with light. There is little to block its path.

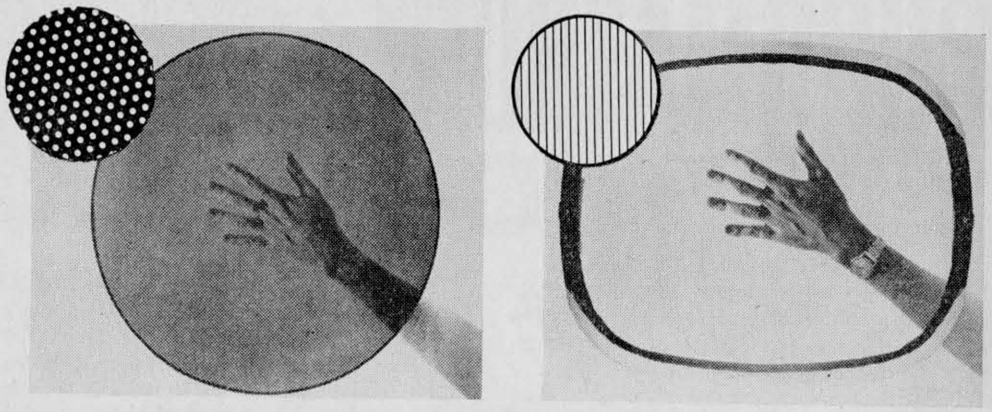


Fig. 1. Conventional color tubes uses a dot-pattern shadow mask (left) that consists of many fine holes; Chromatron uses fine, evenly spaced grid wires (right). Note the difference in transparency of the masks.

But in color tubes, some additional element must be introduced between the tube neck and screen. Although its function varies, as shown later, this element generally serves to keep colors on their correct screen position. But in performing its job, this element also cuts down the number of electrons which may reach the screen. Brightness suffers. We can compare this effect in Fig. 1. In the conventional color tube, electrons must enter small holes in a "shadow mask"—only a certain number can get through to the screen. The grid wires of the Chromatron, however, present rather wide spaces to the beam so electrons in greater numbers may continue on to the screen. As explained by Emil Sanford, engineering manager of the division, the grid is 90 percent transparent vs. 16 percent for the conventional color tube. It results in approximately seven times more brightness.

The second key feature of the new tube is in its electron gun; the structure contained in the tube neck which supplies electrons, and aims them toward the screen where they generate visible light. The conventional tube utilizes a *3-gun* arrangement. The Chromatron, however, achieves color with a *single gun.*

To draw further comparisons, and venture more deeply into Chromatron operation, it's necessary to consider certain features of the transmitted color signal. They can be considered more simply at the studio end, where the televised scene is broken down into basic colors, then into corresponding electrical signals by the camera. As we will see, any color tube at the receiving end principally acts to reverse the order of what occurred in the camera.

The Color TV Camera. The drawing in Fig. 2 reveals a color-separating action of the studio camera. Based on a system of primary colors, the camera is seen in three distinct sections. Each responds to a different color; red, green or blue. There are, of course, many more than three hues in a scene. The human eye, in fact, can discern up to about 40,000 different ones. But just as the artist mixes primary colors to gain countless combinations so does color TV rely on a tri-color system to handle a huge number of hues. The color camera, however, achieves a neat trick that would befuddle the artist. It begins with a *complete* picture (the scene to be televised), then breaks it down into three primary colors. You demonstrate the principle everytime you look through a piece of colored glass or cellophane. If it's tinted red, for example, only the red content of the scene filters through. Thus, the camera in Fig. 2 has red, blue and green filters—equivalent to primary colors—for dividing many colors in the scene into their simplest form.

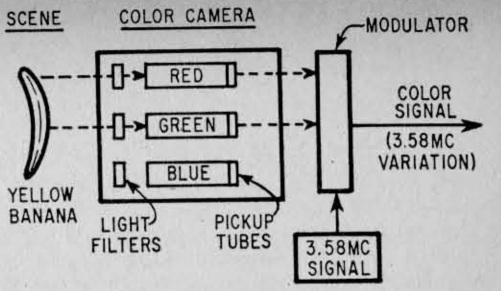


Fig. 2. TV camera breaks scene into primary colors—converts them to electrical signals.

We've shown a yellow banana in front of the camera to illustrate the point. Yellow, it's been discovered, is actually a mixture of two primaries—red and green. This might sound disturbing to an artist who, upon mixing red and green, would get some muddy-looking combination. Color TV however, mixes *light,* not paint pigments. Light mixtures follow a different set of principles. Another example is that the artist cannot mix red, blue and green to get white. But in working with these colors as *light,* the following percentages will form white: 30 percent red, 59 percent green and 11 percent blue. So our yellow banana shows up in the color camera as red and green, after its light is split by filters. The pickup tubes, operating like photocells, convert the colored shafts of light into corresponding electrical signals. In this fashion, thousands of colors are decoded into three separate signals ready for transmission over the air.

There remains another important step—modulation. Since the color TV system must satisfy the needs of both monochrome and color receivers to be compatible, color signals must not interfere with black and white. This is done by side-pocketing color information on its own carrier. This is the 3.58 mc in Fig. 2. In the modulation process, color signals are encoded on 3.58 mc, which is subsequently rejected by black and white sets. The Chromatron, however, utilizes it in a unique image-producing system.

The Color Picture. Let's see how signals are converted back into light of the correct color at the receiving end. In Fig. 3 is an overall view of a Chromatron tube. Housed in the narrow neck of the tube is an electron gun. Its hot cathode boils off electrons which travel as a beam in the direction of the yoke. Purpose of the yoke is to deflect the beam over the entire surface of the screen. Based on magnetic push-pull action, the yoke moves the beam over a familiar path: the same one your eyes now traces over the printed page; from left to right and top to bottom. The screen, therefore, is completely scanned. Occurring 60 times per second, the eye sees the screen uniformly filled with light. (Identical scanning action is also occurring at the studio camera. Camera and receiver beams are locked together by synchronizing signals transmitted by the station.) As the beam travels away from the yoke, it passes through the grid of fine wires mentioned earlier, then strikes the screen. Chemical phosphors deposited over the screen surface glow with light under the impact of the electron beam. The Chromatron, up to this point, has provided two important effects: a scanning electron beam in step with that of the camera, and a screen illuminated with light. There remains now the task of applying color and positioning it in the correct place on the phosphor screen.

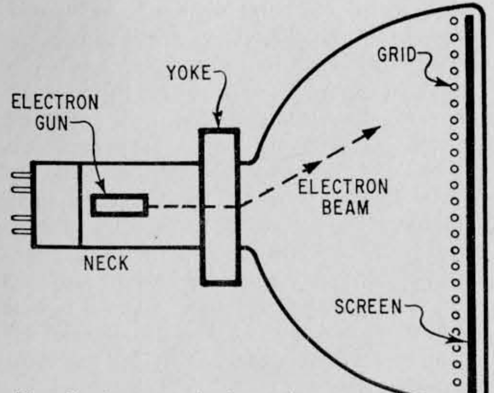


Fig. 3. As seen in top view, Chromatron has grid wires just behind viewing screen. Grid is shown greatly magnified.

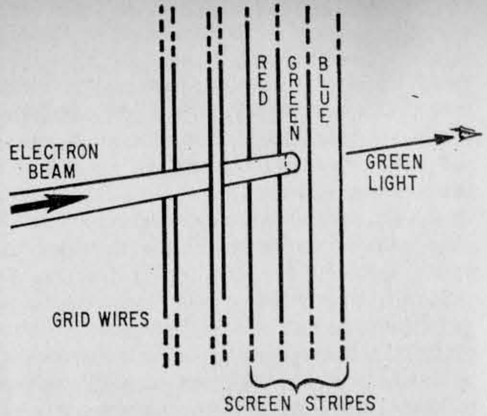


Fig. 4. Electron beam passes between grid wires undeflected—shown striking green phosphor stripe between red and blue ones.

Grid Wires. Let's examine a small section of the screen and the grid which lies just behind it, as illustrated in Fig. 4. The screen consists of thin stripes of phosphor material which emit red, green or blue light when struck by electrons. (Only three are shown for clarity, but they are repeated over the whole screen width. Note the position of the two grid wires shown. Since the electron beam is passing between them, striking only the middle phosphor stripe, the color green would be produced at this instant.

To understand the action of the grid, try this simple demonstration. Hold your arm up and point your index finger toward the wall. Now start to wiggle your index finger from side to side while, *at the same time,* sweeping your whole arm across the wall. This is a good illustration of the grid's function: it "wiggles" the *tip* of the electron beam so it moves over red, green and blue phosphor stripes. (Your sweeping arm movement represented the overall scan of the beam caused by the yoke in the tube's neck.) Now to look more closely at how the grid achieves this effect—and the role it plays in selecting correct colors.

In Fig. 5 is a portion of the screen viewed from the top. Shown are three possible beam positions for producing primary colors. Consider, first, Fig. 5 (A). Green is being produced, as just described; the beam passes through the grid wires and strikes the green phosphor. Now let's apply an electrical charge to the pair of grid wires. If the upper wire, shown in Fig. 5 (B) is impressed with a *positive* charge, it will attract the electron beam (which is negative) in the direction shown. A *negative* charge placed on the lower wire aids this direction by repelling electrons. Thus, the overall effect is to deflect the beam toward the red phosphor. The final example, Fig. 5 (C), simply reverses the charge on the grid wires and the beam now strikes the blue phosphor stripe. It should be apparent that by placing the proper electrical charges on the grid, the beam can be angled to select any of the three primary colors.

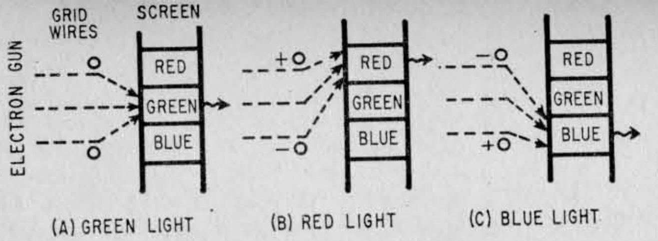


Fig. 5. Applying voltages to pairs of grid wires focuses the electron beam on one of the three phosphor screen stripes.

This system can not only produce white, but all the mixtures needed for rendering a color program. To generate white light, it is necessary to wiggle the beam among the three stripes—red, blue and green. It's done by placing an alternating voltage on the grid wires, as illustrated in Fig. 6. Although movement is extremely rapid, the beam remains just the right amount of time on each primary color for producing the white mixture. The viewer's eye blends the primary colors, since the glowing stripes are narrow and close together, and the complete screen appears white. And a complete scale from black to gray to white can be produced by varying the strength of the electron beam. This function—beam strength—will be provided by control voltages applied to the electron gun.

3.58-mc Carrier. Now to create a full-color image on the screen. Recall, for a moment, what happened back at the TV studio. Electrical signals corresponding to primary colors were modulated onto a 3.58-mc carrier. When these signals arrive at the receiver, a detector circuit reverses the modulation process to recover the original information. Signals are now restored to the same form as when they emerged from the camera. The 3.58-mc carrier, however, is not discarded; it serves to synchronize the Chromatron, as shown in the block diagram of Fig. 7. Note that 3.58 mc is applied directly to the switching grid of the tube. Here it fulfills the same function ascribed earlier to the "alternating voltage;" that is, to wobble the beam among the three phosphor stripes. But note the same 3.58-mc energy is also being fed to red, blue and green "gates" which feed the electron gun. As the name implies, the gate opens or closes to permit the color signal to reach the Chromatron's electron gun. Let's assume that we want the color red only to appear on the screen. *As the 3.58-mc grid switching voltage focuses the beam on a red stripe,* it also unlocks the *"red gate."* This permits the red color signal to pass through the gate. It turns on the electron gun and red appears. At the same time, green and blue color signals are unable to turn on the beam; their gates are locked. As 3.58-mc energy switches the beam to green, it simultaneously opens the green gate—and shuts red and blue gates. Thus the Chromatron's circuits continuously sort out the incoming color signals and place them on their correct stripes. This would be equivalent to the filtering, or color separating, action in the studio camera.

A Yellow Banana. Now that we can position colors properly, there remains the

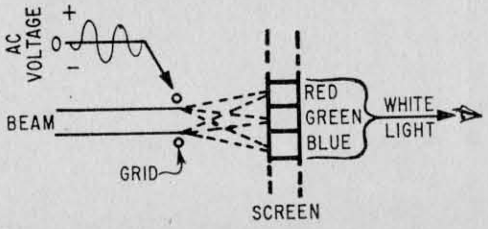


Fig. 6. An alternating voltage on grid wires shifts the beam among screen stripes.

problem of their mixtures. Creating the pure yellow banana televised earlier is not too difficult to visualize; as the beam swings over the screen area of the banana, red and green stripes illuminate (the blue gate shuts). The viewer sees a yellow mixture. A whole range of other colors is possible by varying the strength of the electron beam for each primary hue. Incoming color signals provide this information. As the strength of a given color increases, the signal raises the strength of the electron beam. Countless juggling of proportions presents all necessary screen hues for reproducing the color signal.

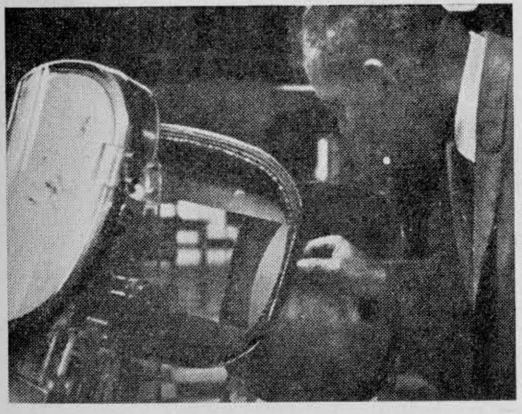
This, in simplified form, is the Chromatron's operation. Bringing it to its present state of development was no mean feat. That color switching grid, for example, presented engineering problems in early models. The fast switching voltages applied to the thin stainless steel wires set up a type of oscillation, or ringing, not unlike a microphonic tube in an audio amplifier. As the wires vibrated mechanically, they affected color reproduction. Today the problem is cured by stringing a very fine glass fiber thread through the wires to damp out movement. Perfect alignment of the grid wire with phosphor stripes on the screen was also difficult. Now, an electron printing system is used; during manufacture, electron beams are swept across the raw screen to "print" the positions where the phosphor stripes are to be deposited. The resulting match is perfect.

Unmasked. Other features of the Chromatron are apparent when the tube is compared to the conventional "shadow" mask color tube, shown in Fig. 8. The standard tube utilizes three electron guns aimed at a screen covered with tiny phosphor dots. Each gun is driven by color signals from the station—red, blue and green—and the corresponding dots glow in color. The purpose of the shadow mask, is to prevent the triple beam from sweeping over the wrong dots. This is how color separation is achieved. The elimination of the shadow mask in the Chromatron is the basis that tube's claim to much higher color brightness. But another major factor occurs; convergence. The three beams of the conventional tube must focus precisely as they pass through holes in the shadow mask. Only in this fashion will they strike correct color dots. To provide the focusing action, there are special adjustable coils and magnets on the neck of the tube which compress, or converge, the beams together. Since the Chromatron has only one electron gun, the convergence problem is eliminated; the switching grid focuses the beam onto the proper stripe. The effects of the earth's magnetic field, too, are less in the Chromatron. This would ease the problem of moving a color portable from one room to another, or from a picnic area to seashore, for example. Variations in the earth's field are less disturbing to color purity.

Want to Buy One. When will you see Chromatron-equipped sets on dealer's shelves? It is expected that production models will make their initial entry into this country via Japan. Under license from Paramount, Japan's big Sony Corporation is concentrating on an 18-inch color portable. Among American companies, Raytheon appears to be closest to producing the tube for U. S. manufacturers. Size might be anywhere from 8 to 16 inches. The only problem now confronting U. S. producers is setting up the tube on a production line, have it spew out in large quantities, and retain close tolerances. When this kind of momentum is achieved, the uncomplicated, low-cost color receiver should come on strong. In any case, Sony considers the Chromatron just about ready for production and possibly could bring sets into the U. S. in the very near future. Price at this time has not been announced, but Peter Ramella, Chromatic's general manager, believes that ultimately the Chromatron approach could lop a sizeable chunk off the price of small-screen color. His estimate is an approximate $250 price tag.

Research has not ceased on the Chromatron. Even now there is an effort to further simplify the circuits outside the tube. Also under development are techniques which would enable the picture tube to accomplish functions now handled by small chassis tubes. New techniques, which promise even greater brightness, are in the offing.

With engineering now in a highly refined state, there remains only the mass-production details to work out. There is no question about the high interest being demonstrated by Sony and other Japanese firms. Combine this with interest already expressed by American producers and you can say that the Chromatron has come to color TV. ■



Mockup of basic Chromatron structure (upper left) shows glass phosphor screen, left, wire grid, center, then bellshape section leading to neck of tube. Layout of small Chromatron (above) that will be seen late next year. Note dark frame held by hand. It permits one-piece assembly of fine grid-wire suspension; an important breakthrough for mass-producing the Chromatron. At lower left, Engineer John Petro looks at 8" and 23" Chromatron.

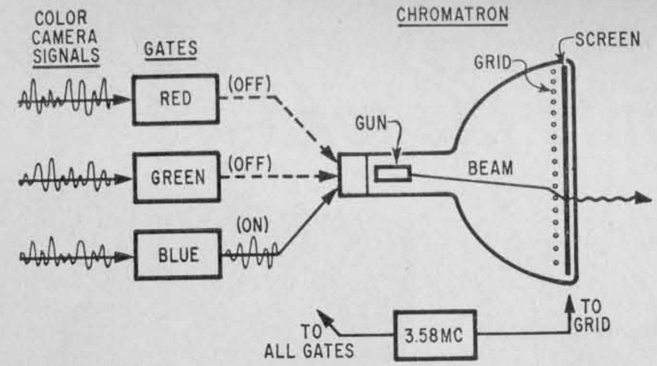


Fig. 7. Action necessary for producing blue image on phosphor screen—the 3.58-mc signal simultaneously positions beam on blue screen stripe and opens blue gate. Blue signal (originally from TV camera) may now control gun's beam strength at this short instant.

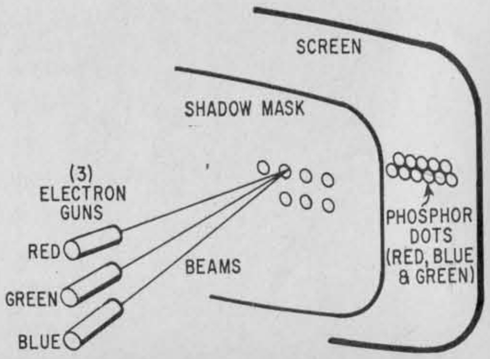


Fig. 8. Conventional color tube uses three guns, shadow mask, and phosphor-dot screen.