RCA COLOR TELEVISION

HOW IT WORKS

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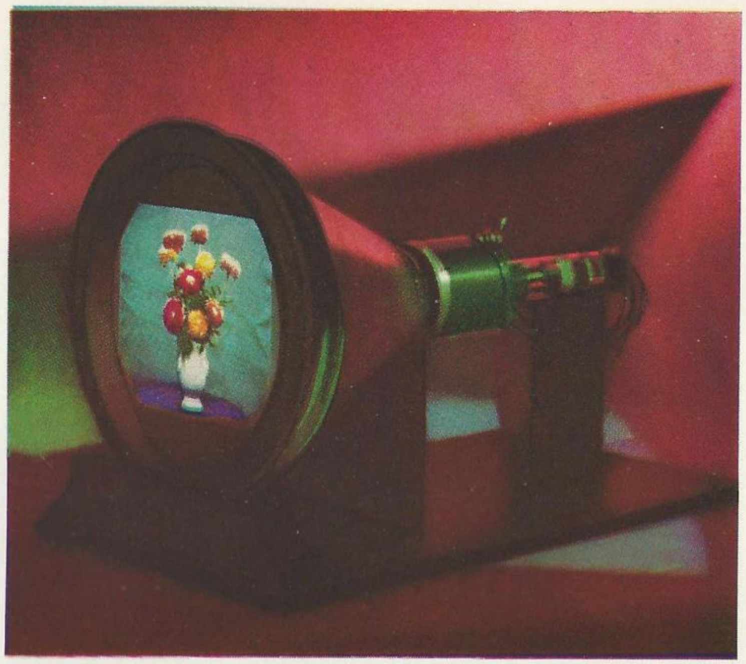


RCA COLOR TELEVISION PICTURE TUBE

". . . never before have I witnessed compressed into a single device so much ingenuity, so much brain power, so much development, and such phenomenal results, as are represented in this color tube."

BRIGADIER GENERAL DAVID SARNOFF

RCA COLOR TELEVISION

How It Works

I. THE TELEVISION PROCESS

TELEVISION, as it is known and enjoyed today, is made possible by the ability of television equipment to pick up, transmit and reproduce in varying shades of light and dark, the scene which is being televised. This original scene is, of course, in natural color. Commercial television equipment in use thus far does not reproduce these colors. Instead, the scene is reproduced in black, grays and white, as in the case of black-and-white motion pictures. However, as the result of years of intensive research, the Radio Corporation of America has developed a television system which does transmit and reproduce the original scene in its natural colors. But before explaining the RCA color television system, it is helpful to review briefly how black-and-white television works.

The standard commercial black-and-white television system produces black-and-white television pictures by an electronic scanning process in which a stream of electrons in the camera tube sweeps across, or scans, the image of the scene being viewed. In effect, the image of the scene being televised is electronically dissected into 525 horizontal lines with the entire picture being completely scanned 30 times per second. The brightness of any given part of the scene at the instant it is being televised is translated into electrical currents. These currents are transmitted through space as radio waves.

The Federal Communications Commission has assigned channels or "highways" in the radio spectrum for the transmission of television programs and has specified operating standards for television broadcasts so that all television receivers can receive

Figure 1. RCA Color Camera in Operation During a Color Broadcast from the WNBW Studios in Washington, D.C.

any station within range. The channel allotted to a television station occupies 6 megacycles or 6,000,000 cycles per second as compared with 10,000 cycles for a standard radio broadcast transmission.

As the radio waves transmitted by the television station reach the receiver an electron beam sweeping back and forth across the face of the picture tube converts the incoming waves to spots of light varying in intensity from zero (black) to maximum (white). The transmission from the camera at the station to the receiver in the home is practically instantaneous. The spots of light are reassembled into a complete picture in the same sequence and at the exact same rate at which the original scene was scanned and dissected at the camera; 525 lines per picture, 30 complete pictures per second. The entire process of picture reassembly in the television receiver is accomplished so rapidly that the viewer sees a complete black-and-white picture in motion which except for color hues is identical with the scene being viewed by the television camera.

II. COLOR TELEVISION

The desirability of television in natural color is universally recognized. Television engineers have been working on the problem for many years. But, as happens so often in the world of scientific progress, advances must await invention and development of the necessary "tools". For example, camera tubes (image orthicons) and suitable viewing tubes (tri-color kinescopes) were many years in the laboratory before satisfactory models could be developed.

In color television it is not only necessary to reproduce accurately the varying intensities of light and shade in a scene (comparable to the black-and-white process), but also to reproduce accurately the various colors themselves. This means that in transmitting a program in color, the television engineer must provide means for sending much more picture information than would be required for transmitting the same program in black-and-white.

Fortunately for television, the human eye has a storage characteristic known as persistence of vision. If this were not so, the 30 pictures transmitted each second would result in a jumpy, flickery picture somewhat like the earliest movies. But the retina, or "screen", of the eye cannot function fast enough to distinguish separate pictures when they are transmitted in rapid sequence as in television. Consequently, the separate pictures blend together to create the sensation of a complete and continuous presentation.

Both black-and-white and color television are based upon this principle. When color is involved an additional characteristic of the human eye is used—the ability of the eye to reproduce practically all colors with remarkable accuracy by combining only three components or primary colors in correct proportions.

Various combinations of primary colors may be chosen, depending upon the color reproduction process involved. The primary colors generally used in television are red, green and blue. When all three of these primary colors are produced in the proper proportions, the eye has the impression of white. When they are all absent, the impression is black. If green and red appear together, the eye receives the impression of yellow;

with red and blue both present, the result is purple; and by other combinations of these three primaries, other colors are reproduced.

The various colors and shades of natural color can be created on the television screen by the RCA color television system. This is accomplished in a manner quite similar to that used in black-and-white television—by the use of materials called phosphors. In black-and-white television, the scanning beam recreates the picture by directing a fine beam of electrons against a phosphor surface on the inside face of the picture tube, which glows only in white. In color television, electron beams are directed to small phosphor dots each of which, when hit by an electron beam, glows in one of the three primary colors. Thus, when all three color-sensitive phosphors are exposed to electron beams at the same time, it is possible to reproduce the original scene in its natural color hues.

The ability of the eye to give faithful color reproduction using only three primary colors simplifies the problem of the television engineer. But it might still seem that if a transmitting station utilizes a certain channel width for black-and-white, it would require a channel three times as wide for color.

This requirement would be of no great concern to the television engineer if it were not for the fact that the ether spectrum used for the transmission of radio waves is crowded and channel space must be rigidly conserved. There are many radio services such as marine, police and government communications, which must be accommodated in addition to television broadcasting. Furthermore, the spectrum space which can be assigned to television is needed for an expanding television service. Color television service must be accomplished in the same channels as are available to black-and-white television. The color television service should also be compatible so that color broadcasts in a television channel can give service to both black-and-white and color receivers at the same time.

There are several ways of providing color television service in a channel of the same width as now used for black-and-white television. One way involves the acceptance of inferior picture quality in order to add color to the black-and-white rendition. This is the old way to get color television since no new methods or techniques are involved. However, a color television system provided by such an approach has distinct disadvantages. Two of the principal ones are:

1—It produces a picture with poor detail.

2—It must use scanning rates which are not the same as those used in black-and-white television and are incompatible with black-and-white.

Consequently, transmissions in color using an incompatible system give no picture at all on standard receivers unless extensive and costly alterations are made in those sets, and even then the picture has less than half the detail or sharpness of present black-and-white.

The other approach to color television takes advantage of new techniques and methods. This is the modern, electronic way to provide a color television system and it is the best way.

1—It provides a picture of the same detail quality as the standard black-and-white television picture.

2—It can use the same scanning rates as in black-and-white television and is compatible with black-and-white.

Consequently, in a compatible system, transmissions in color give a high-quality color picture on color receivers and also give a high-quality black-and-white picture on standard television receivers without any modification at all.

III. THE RCA COLOR TELEVISION SYSTEM

RCA thoroughly investigated the incompatible method starting years ago and is convinced that the second and modern approach now provides the correct and lasting solution. Considerable research and development have been necessary to devise and make use of advanced techniques and methods. The basic and simplified discussion which follows describes the RCA color television system, a system which is based upon the second approach. The RCA system produces a high-quality color television picture which is at the same time completely compatible with standard black-and-white television.

A combination of several new techniques and methods is used in the RCA color television system to enable it to send the information necessary for a high-detail color picture in the

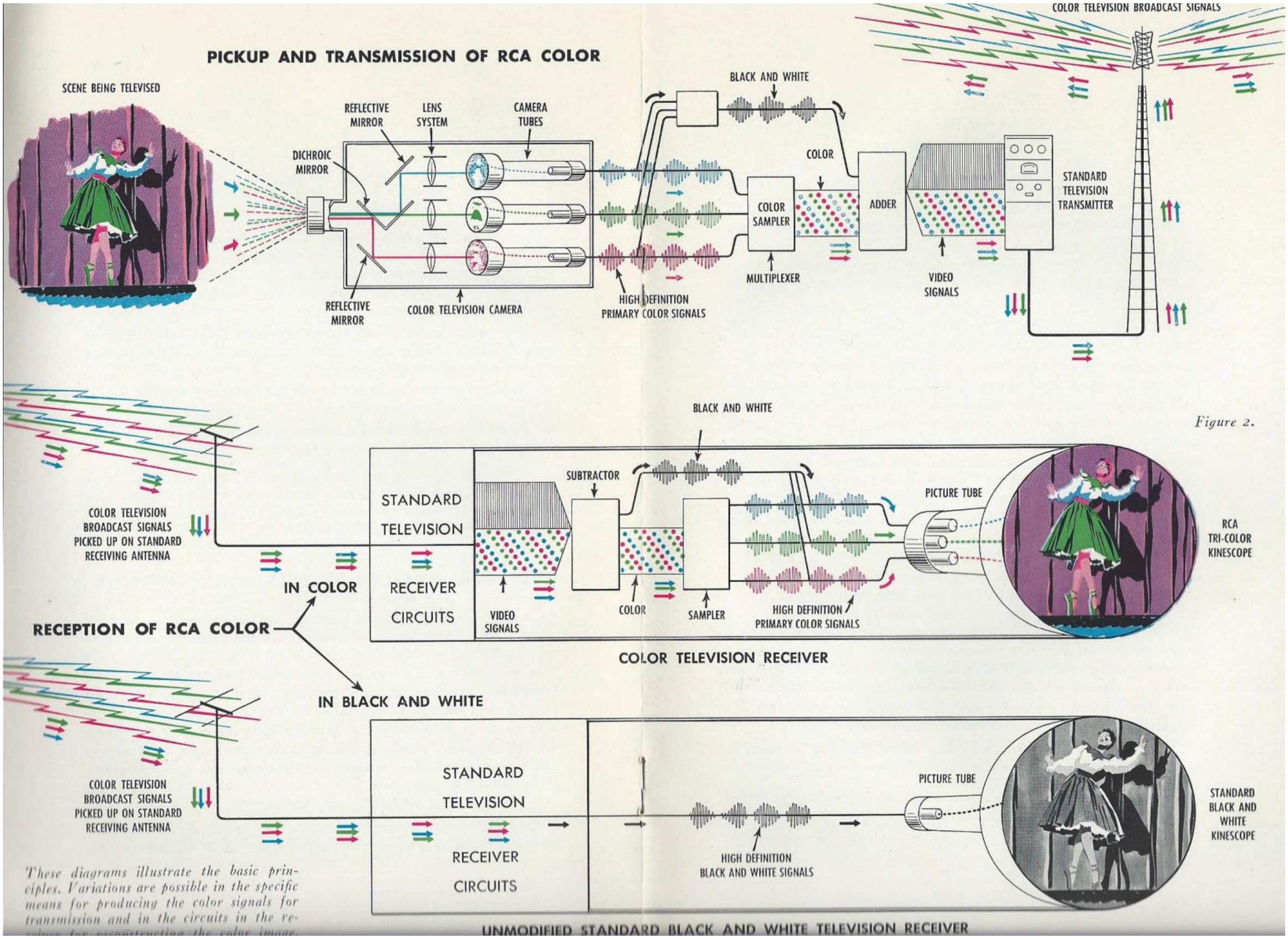


Figure 2.

These diagrams illustrate the basic principles. Variations are possible in the specific means for producing the color signals for transmission and in the circuits in the receiver for reconstructing the color image.

same channel width now used for black-and-white television. An explanation of two of these techniques, "mixed highs" and "color sampling" (or "time multiplexing") follows.

The "mixed-highs"* principle is based on the fact that the eye cannot distinguish color in fine detail. For example, a housewife will seldom try to match thread to material by using only a single strand of thread. She will generally use the whole spool since experience has taught her that it is very difficult for the eye to detect a slight difference in color when laying only one strand of fine thread against the material. Another example: a person can see the slats in a picket fence at a much greater distance than he can distinguish the color of the slats. The RCA color television system takes advantage of this principle.

It takes much less space in the radio spectrum to send fine detail in black-and-white and, as has been shown, the eye can only see fine detail in black-and-white. Therefore, in the RCA system the fine details in all three primary colors are mixed, giving fine detail black-and-white instead. The eye is unaware of this mixing and a major saving in bandwidth is thus accomplished. Larger detail is, of course, sent in color and this is done by a process called "color sampling".

Time-multiplexing or sampling is used extensively in communications work to enable a large number of telephone or telegraph messages to be sent simultaneously over a single wire or radio circuit. Color sampling in television uses these techniques. It is used in the RCA color television system as the method of combining the red, blue and green primary color signals, without mixing them. In this way the three color signals may be transmitted in less spectrum space that would be required to send them separately. Color sampling is accomplished by an electronic device which takes the necessary color picture information in order from the red, blue and green primary color signals and sends along this information to the receiver.

The use of "mixed-highs" and "color sampling", together with certain other special techniques and methods, save valuable

* *TECHNICAL NOTE: "Mixed highs" as described in this booklet illustrate the basic principles. Variations are possible in the specific means for producing the color signals for transmission and in the circuits in the receiver for reconstructing the color image.*

spectrum space that otherwise would be required for high-definition color television. By using these modern electronic techniques, the RCA system provides color television with the same high picture quality as present black-and-white television and in the same space or bandwidth.

Pick-up and Transmission of RCA Color Television Signals

In the RCA color television system, the equipment throughout is all-electronic—at studio, transmitter and receiver. Figure 1 shows an RCA color camera in operation during a color television broadcast from the WNBW studios in the Wardman Park Hotel, Washington, D. C. The color television cameras currently in use contain three camera tubes.

As shown in the top diagram of Figure 2, light coming from the scene being televised passes into the RCA color camera and then through a series of mirrors to the tubes. Two of the mirrors are called dichroics and have the property of splitting the light from the scene into the three primary components—blue, green and red. Each dichroic mirror reflects one of the primary components of the light while passing the other components, thus "splitting" the light into the three primary colors. The other mirrors, which are similar to ordinary mirrors, act simply to guide the light beams along their paths through the dichroic mirrors, the lenses and on to the camera tubes.

Each primary color is directed to one of the three camera tubes. The pictures on the three tubes are then scanned by electron beams simultaneously and each image is thereby dissected into 525 lines, the entire process being repeated 30 times per second. The outputs of the three-camera tubes consist of three simultaneous high-definition television picture signals — each representing one of the three primary colors.

After the signals leave the camera tubes they are combined to form a black-and-white picture which contains the "mixed highs". At the same time the three primary color signals pass through the color sampler and are "multiplexed" to permit their transmission in the standard television channel. The black-and-white signal containing the "mixed-highs" is added to the sampled or multiplexed color signals in an electronic unit called an adder, and the result is the combined high-detail video signal.

The video signal is sent to a standard television transmitter which is the same transmitter used for standard black-and-white television broadcasts. The signal is then broadcast for reception in the regular manner. The channel width—six megacycles—is the same as the standard black-and-white television channel. Hence, the standard television channel may be used to transmit either black-and-white television or RCA color television.

Reception of RCA Color Television Signals

RCA color television signals can be received in one of three ways:

1—They can be received in color on color television receivers;

2—They can be received in color on converted black-and-white receivers; or

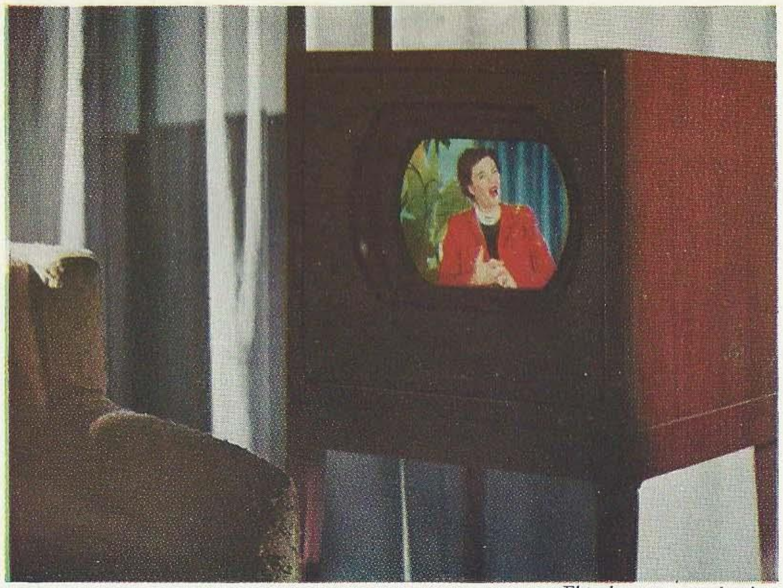
3—They can be received as standard high-quality black-and-white pictures on an ordinary black-and-white television receiver without any modification at all.

In each case, all-electronic equipment is used throughout.

The bottom diagram in Figure 2 shows how RCA color television signals are reproduced in black-and-white on a standard unmodified black-and-white television receiver. This is known as compatibility, which has previously been referred to, and which will be discussed again later.

The middle diagram in Figure 2 illustrates how RCA color television signals are reproduced in color. This applies to both a color television receiver and a black-and-white receiver converted for color. As shown in the diagram, the incoming television signal passes through standard television receiver circuits which again reproduce the combined video signal. The black-and-white signal containing the "mixed highs" is separated or "subtracted" and, at the same time, the color signals pass to an electronic unit known as the color receiver sampler where the original three primary color signals are simultaneously produced. The black-and-white signal containing the "mixed highs" is then added to each of the primary color signals.

Each high-definition primary color signal thus produced is then directed continuously to one of the electron guns in the



Ektachrome reproduction

Figure 3a. Development Model Color Television Receiver with an RCA 16-inch Color Television Tube

direct-view tri-color kinescope as shown. Each gun produces a complete high-definition color picture in its own primary color. In this way three primary color pictures are produced simultaneously on the face of the color television tube and appear as a single full-color reproduction. As in black-and-white television the size of the picture is determined by the size of the tube. The RCA color system can use any size picture tube.

Figures 3a and 3b show two development models of RCA color television receivers. These receivers use the 16-inch RCA direct-view tri-color kinescope shown in the Frontispiece. The screen in this color picture tube is composed of a total of approximately 600,000 dots of red, green and blue phosphors. These dots are arranged in groups of three and so positioned that the electrons from each of the three electron guns always hit the dots of their own color. The phosphor dot groups are so small and so close together that when illuminated by the electron streams they present a continuous, smooth full-color picture.

The reception in color on a converted black-and-white receiver is identical with the above. In this case the color television tube is used instead of a black-and-white kinescope. The necessary color sampler and other circuits are added to the black-and-white receiver. Black-and-white television pictures can still be received from those stations transmitting in black-and-white and viewed on the tri-color tube as a high-quality black-and-white picture.

IV. ADVANTAGES OF THE RCA COLOR TELEVISION SYSTEM

The question might well arise at this point: the RCA system is one way to produce color television pictures, but why is it the *best* way?

First, the RCA color television system is a fully compatible system.

Compatibility is directly in the public interest. When stations broadcast, using a compatible color system such as the RCA color television system, nothing whatever must be done by the owner of a black-and-white television receiver to continue to receive high-quality black-and-white from the compatible color transmissions. His program service is undiminished, either in quality or quantity; the usefulness of his receiver is unimpaired; his pocketbook is untouched. If he wishes color, he can either buy a new color television receiver or he can convert his present set, using the RCA tri-color picture tube.

If an incompatible color system is used, not one of the many millions of television receivers now used by the public can receive any picture at all from the station broadcasting in color. If the owner of a black-and-white receiver wishes to continue to receive black-and-white pictures of all broadcasts from the station, he must spend approximately \$50 for an adapter, plus installation cost, to enable his set to receive both black-and-white and color broadcasts. Purchasers of new black-and-white sets will have to spend about \$20 more than they ordinarily would if they wish an adapter built-in at the factory. This will not give color — just a poor quality black-and-white picture from the color station, with less than half the picture detail of present black-and-white pictures. To get color, a further estimated \$100 must be

Ektachrome reproduction

Figure 3b. Development Model Color Television Receiver with an RCA 16-inch Color Television Tube

spent for a converter, plus installation cost. This will give a color picture from the color transmissions.

Compatibility is of first importance to the successful introduction of color television. Not a single receiver in the hands of the public can receive any picture from an incompatible color broadcast. Consequently, the broadcaster would have no incentive to put on good color television programs or use favorite viewing hours for color broadcasts, and television viewers would have no incentive to purchase color television receivers or converters.

Quite the reverse is true in a case of a compatible color television system. A color television broadcast using the RCA compatible color television system will reach every member of the regular viewing audience since all present receivers would receive a standard black-and-white picture from these color broadcasts and color receivers will receive the picture in color. Consequently, the television broadcaster and the advertiser would have every incentive to put on their best programs in color in the best viewing hours.

A compatible color television system is one which keeps faith with the many millions of owners of standard television receivers. A noncompatible color system breaks faith with these owners and therefore is directly contrary to the public interest.

A second major advantage of the RCA color television system lies in the fact that it produces, both in black-and-white and in color, the same high-quality television picture produced today by the standard black-and-white television system. RCA has permitted no degradation in the quality of the television picture in order to add color. Instead high-quality color has been added as a plus factor while maintaining the high quality of the present black-and-white system. In a non-compatible system picture detail is less than half of that in present black-and-white.

A third major advantage of the RCA color television system lies in the fact that it is a completely all-electronic system, possesses high standards of color fidelity and is capable of taking advantage of future refinements and improvements. It employs advanced electronic techniques and not outmoded mechanical methods.

The RCA color television system provides the means by which a color television broadcast service of the highest quality, can be furnished to the public.

RCA