Color Television—Its Status Today

Dr. W. R. G. BAKER'S RECENT ADDRESS to the 45th Annual Convention of the National Association of Electrical Distributors contained probably the outstanding summary of the past, present and future of compatible color television, presented to date. Dr. Baker is vice president of the General Electric Co. and Chairman of the National Television System Committee and the RTMA Television Committee. Technical information describing the operation of the NTSC compatible color-TV system has been excerpted from this address and is presented herewith.

In 1950, the FCC approved a field sequential system of color television. The principal objection to this system lay in the fact that it was not compatible to the system under which black and white television was operating, which meant that the 8,000,000 black and white receivers then in American homes could not receive color broadcasts either in color or black and white, without extensive alterations and expense to the owner.

The importance of that major shortcoming is evidenced and magnified by the fact that, today, the public has invested over $7-billion in some 25-million black and white receivers, that would not be able to receive such color broadcasts in black and white without such expensive alterations.

Obviously, the solution of the problem lay in the possibility of developing an all electronic system that would be "compatible"—that is, a system that would make it possible for any and every black and white receiver in the home to receive future color broadcasts in black and white, without any alteration or expense.

National Television System Committee

The development of this system was the task undertaken by the National Television System Committee, formed under the auspices of the Radio-Television Manufacturers Association.

It should be appreciated that in the development of the standards for a compatible color system the NTSC had the full and complete cooperation of the companies comprising our industry. The source of an idea was completely disregarded. The only question was—Is this the best idea—Is this the best way to do the job?

Ninety-one companies in the industry contributed the skill and services of over 200 of its leading scientists and engineers toward the color assignment. One of the first actions of the NTSC was the naming of a five-man Ad Hoc Committee to determine whether a compatible Color television system could be evolved within the standard 6 M.C. band. While RCA in 1950 proposed and demonstrated a compatible system which would operate within the standard band, it was thought desirable to initiate a comprehensive analysis of the entire field to review existing material and thoroughly explore new approaches to the problem.

After considering all the developments to date and the possible new solutions to the problems, the Ad Hoc Committee reported in the affirmative and laid down the framework and philosophy for the proposed system. The system was broken down into its major components and 10 Panels of the NTSC were established to undertake the solution of the many and complex problems.

Monochrome TV

The standard black and white television transmitter sends out two signals, one carrying the picture, the other the sound. The picture signal, is produced in the television camera which views the scene in full color and transforms it into a representation in shades of gray. In so doing, the camera removes the "color" aspect of the image. In the monochrome television image, it is not possible, for example, to tell whether an object is red or green, nor to tell whether the colors are deep and intense or are displayed in pastel shades. The monochrome system thus omits any reference to the spectral quality of the color itself (known to artists as "hue" or its visual depth of color known as "saturation").

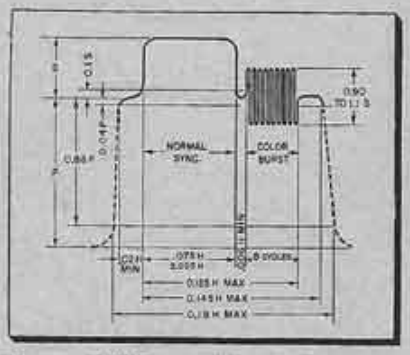


Diagram of NTSC compatible color-TV horizontal sync signal showing amplitude-time relationship. P is pedestal, S is sync and H is time for one horizontal line. Note location of color burst

In transmitting a full-color image, then, it is necessary to take into account the missing elements of hue and saturation. In the NTSC system, these are transmitted by a third signal, known as the color carrier, which is fitted into the channel between the picture signal and the sound signal.

How NTSC Color-TV Works

The NTSC color system is thus founded on the principle that a color image may be reproduced from two signals, one of which carries a monochrome version of the image in shades of gray, while the second superimposes on the monochrome image the missing hues and saturations. This principle is well suited to compatible operation of monochrome receivers. It is merely necessary so to arrange the transmissions that monochrome receivers respond only to the monochrome signal, ignoring the color signal. Color receivers, on the other hand, are designed to accept and make use of both signals.

Simple as this principle appears, it was a major task to develop a system based on it. The principal problems were two:

1) How to fit all the information of both monochrome values and hue and saturation values into the standard television channel without overcrowding, and

2) How to assure that monochrome receivers would ignore the color information for which they have no use.

The first problem was solved by the NTSC with the discovery that the monochrome aspect carries the essential pictorial detail of a full-color image. Once the monochrome portion is available in full detail, the hues and saturation can be superimposed in a relatively coarse manner, "painted with a broad brush," so to speak. Hence, the color carrier need not occupy as much channel space as the picture carrier, and overcrowding of the channel is avoided.

The second problem was solved by the NTSC when the color signal carrier frequency was assigned a precise numerical value relative to the picture signal carrier frequency.

and a Look into the Future

When this exact frequency relationship is maintained, the monochrome receiver retains its full sensitivity for the picture signal, but finds itself virtually blind to the color signal. Mutual interference between the signals is thereby avoided.

In summary, the NTSC system achieves compatible color transmissions by building on the existing monochrome system. No basic changes are required in the existing FCC regulations governing black and white broadcasting beyond tightening of tolerances which has the effect of improving the performance of receivers now in the hands of the public and making a minor addition to the synchronizing pulse. To these regulations must be added a group of supplementary standards, which set up the color signal, specify its frequency, and outline the techniques by which the hue and saturation values are transmitted.

On April 14, 1953, this NTSC system was formally demonstrated by RCA to the Wolverton Committee and to the Industry on April 16, 1953. It was acclaimed as highly successful. It is now undergoing final and extensive field tests, preparatory to formal submission to FCC for consideration.

A television transmitter broadcasting a monochrome signal will accommodate the color signal without change. Precautions necessary to insure satisfactory monochrome transmission are, in general, the only precautions necessary to insure proper color transmission, although misadjustment will be more objectionable in the picture when transmitting color.

Transmitters which will take color signals from the network will probably be required to utilize an additional piece of equipment known as a "synchlock" to insure the adequacy of the received synchronizing pulse. This, fortunately, is a rather simple and inexpensive piece of equipment and could be supplied quickly to any station then on the air with black and white.

The Networks

Signals have been satisfactorily transmitted over the telephone company's networks. The telephone company's engineers have taken a very active part in the affairs of the NTSC, and are thoroughly familiar with the NTSC proposal. The development of the telephone company's facilities has kept pace with the development of the system generally.

These two factors mean that a color program originated at a network key station and put on the network, could, for a minor capital investment and at practically no extra operating expense, be taken off the network and rebroadcast by any local station.

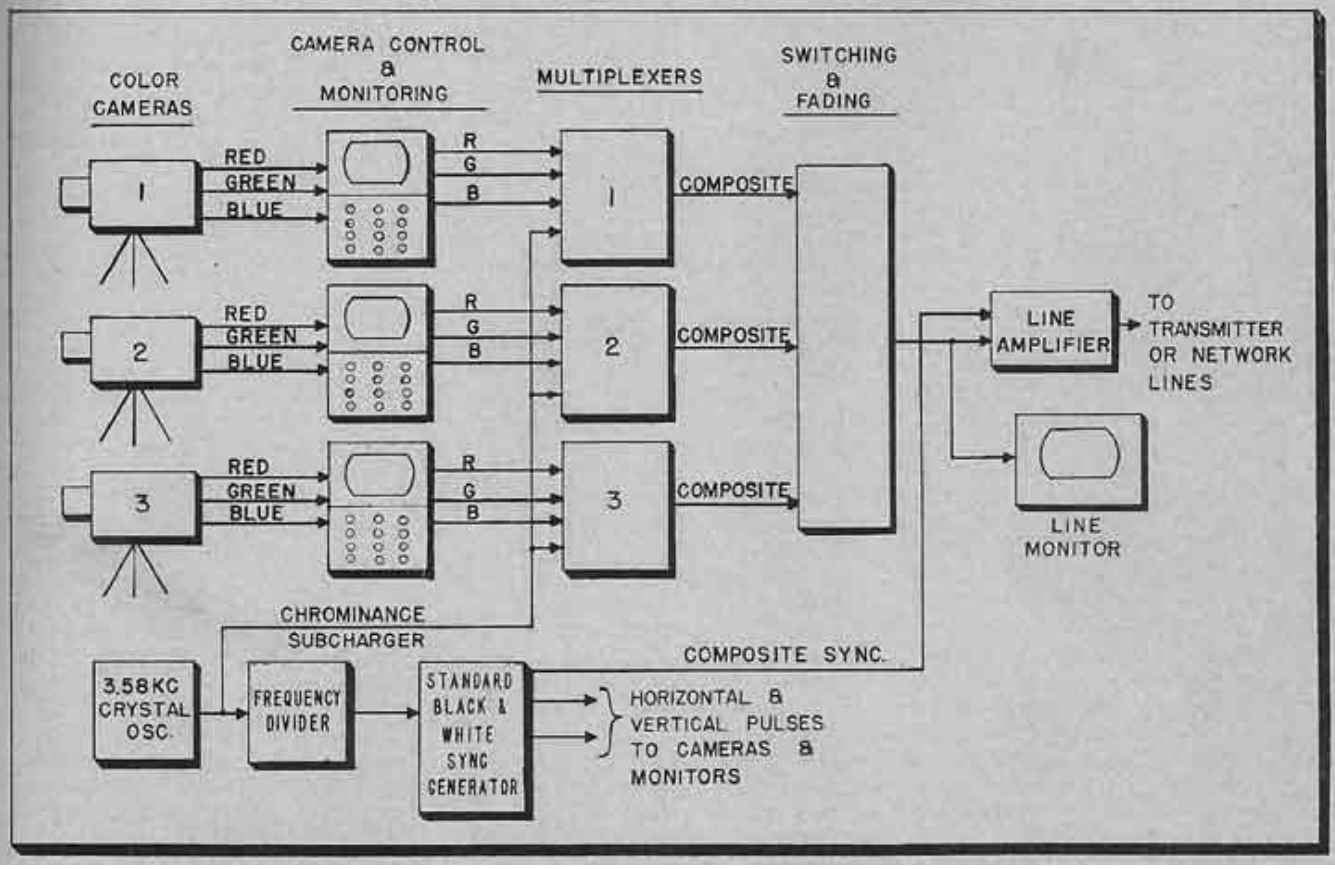
Thus, color programs on a national basis could be available a few months after the system is approved.

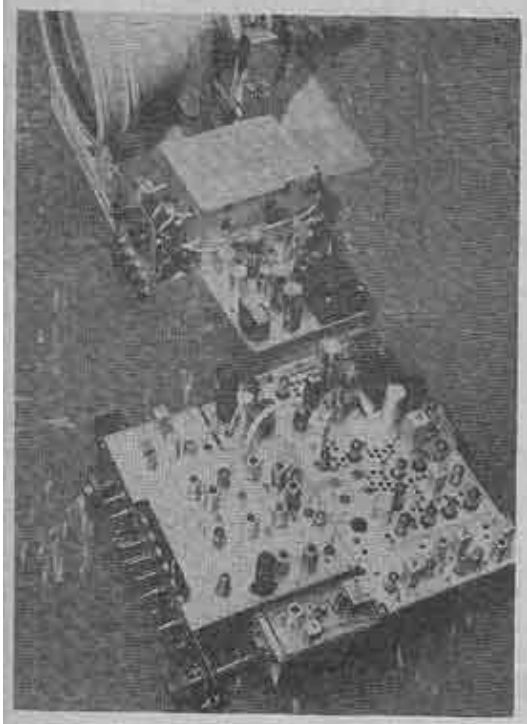
Studio Equipment

It is in the color television studio that the most extensive changes will be required. A three-tube camera initially will be used, although development now intensively underway, may result in a single camera tube which, if successful, will materially reduce the bulk and complexity of the color camera.

The signal from the camera is directed to a system of rack mounted equipment, where the signal is dis-

Simplified block diagram illustrating equipment interconnections within typical color-TV studio.





Close-up showing present day experimental General Electric NTSC color-TV receiver.

sected and each of the signal components is then optimized and dealt with individually. At this point, also, the special synchronizing pulse is generated. From this equipment then, there is delivered a complete signal which is ready to modulate a standard transmitter or to be fed to the networks.

Providing the necessary studio equipment for hundreds of stations across the country is a very substantial technical and production job. But, this need not necessarily preclude the possibility of originating a national color television signal quickly, as above. Enough studio gear, much of it now only in prototype stages, is available to equip at least several key network stations. This equipment, however, could be used to put small percentage of color programs through the networks in parallel with the standard black and white programs.

Color Television Receivers

One of the three important elements of the NTSC color television signal is that it employs the same monochrome signal as used for present day black and white television. This, of course, is the feature of the system which makes it fully compatible. This feature in the NTSC system does simplify to some degree the design of color television receivers. The fact remains, however, that to incorporate in one chassis and in one picture tube, the ability to receive either color programs or black and white, at the turn of a switch, is a complex problem in engineering and costly in production.

The first sets must be "good" if color is to be given its proper chance to prove its desirability and win the approval of the public. Nothing could retard color quicker than the advent of "compromise" color receivers that would offer less than the maximum performance. Cost reduction can come later as a logical development, but the first units must be "tops" and that means that they will be expensive in comparison to present black and white receivers. Industry estimates indicate they will be at least double the price and may run three times the cost of comparable picture-size monochrome sets.

It has been estimated that somewhere in the neighborhood of 100 color receivers have been built to date. These have been kept "up to date" with the latest NTSC developments and, by and large, have been successful after the expected "prototype" bugs have been eliminated.

Receiver Availability

Actual commercial designs, however, cannot be completely frozen until final specifications have been determined and the system receives final approval by FCC. Much design work, however, can be anticipated, which will materially reduce the time cycle required for final designing, tooling and getting color receivers into production. In spite of this, it may well develop that the receivers will be the bottleneck and that color programs will be on the air months before any reasonable supply of receivers is available.

The major remaining problem in color television lies in the picture tube. One industry leader has made the statement "We do not have a picture tube." This is not actually true, but the severity of this problem should not be minimized.

All tri-color tubes have in common the requirements that the phosphor surface utilize not a homogeneous deposit, as is the case in monochrome, but three separate phosphors for red, green and blue, deposited as hundreds of thousands of dots, or, as fine vertical or horizontal stripes. Here the similarity ends and development is progressing in two general directions:

1) Using a single electron beam with a change in beam direction at the front of the tube to provide color selection. Such approaches are exemplified by the Lawrence tube of Chromatic Laboratories, and by the Lafferty tube of General Electric. Such tubes, in general, are simpler and cheaper than the ones next to be described, but depend upon complicated chassis and require greater circuit precision in order to insure color fidelity. Furthermore, the beam bending operation requires an appreciable amount of power at high frequency, which raises the problem of interference radiation.

2) The second general category of tubes comprises those utilizing three separate electron beams whose possible paths are restricted physically so that the green gun, for instance, can only reproduce green, etc. These tubes are exemplified most familiarly by the one introduced by RCA. The use of these tubes permits a reduction in chassis and circuit precision and complication, but the tube complexity and cost is increased. The radiation problem, of course, does not exist. Several laboratories are known to be working in this direction.

In summary, then, as regards the picture tube, the Industry seems to have two choices:

a) Build the precision in the tube, thus permitting simpler chassis circuits with the assurance that when a given color is called for, only that color can be reproduced. The radiation problem does not exist.

b) Build the precision into the chassis. This alternative possibly will result in lower cost tubes. It involves the hazard of radiation and probably puts more of the responsibility for reliable operation into the hands of the customer.

Color Receiver Costs

The picture tube holds, not only the key as to how the chassis is to be designed, but also in a great measure, the cost of the finished end product—the complete color television receiver.

If the three-gun type, such as this RCA tube is used, and if current price estimates of $150 to $200 prevail, it is obvious that the picture tube component alone in the receiver might add $325 to $350 to the list price. Just adding this difference in picture tube price to the price of an average good quality 21" console would bring the total cost to $750 or more. Further, a color receiver will probably use 45 to 50 receiving tubes, more than twice that of a black and white set. Add the

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Color TV

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cost of these tubes and necessary circuitry and it becomes evident that a color receiver will have to be priced at $800 or more. There is no doubt that they will be expensive.

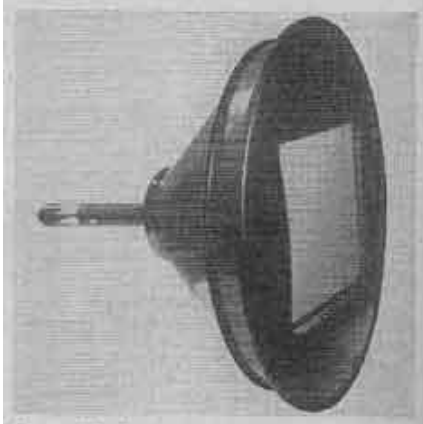
I am presuming in this projection that the color picture size will be equivalent to the 21" black and white picture. Most demonstrations to date have shown smaller size pictures. This problem still lies ahead of the tube industry, but must be resolved if color is to compete successfully with black and white.

Looking forward to picture sizes for color television, it is obvious that sizes must be equal to black and white, probably starting with a 21-in. picture and later including 24 and 27-in. pictures, if and when these sizes are available in monochrome receivers.

Target Dates for Color-TV

It now appears possible that the NTSC can conclude its technical work by September. We might then allow 45 to 60 days for the complete organization of all data to be presented to the FCC.

If such a schedule is met we can assume that the NTSC would petition the FCC for a hearing in October or early November. This could mean that the hearing could be scheduled early in 1954 and the



Chromatic's Lawrence tube, now in pilot production, is 22 in. in diameter, 21.5 in. long, and has rectangular color screen 11 by 15 in.

NTSC system could be approved by March 1, 1954.

If this should happen, I think I can safely predict that some color programs would be available in key city markets shortly thereafter and that color programs, put on the networks might actually be available in many local markets certainly by the middle of 1954.

Also, by March 1, 1954, the color tube output could possiby attain a monthly rate of 2,000 to 4,000 tubes. Assuming that this is accomplished, it may be anticipated that a model or two of color receivers will be included in the Fall line of many manufacturers. Available quantities will be limited, but there should be enough receivers available to permit the public generally to see color television in comparison to black and white in the Fall of 1954.

Conclusions

I mentioned previously that I was convinced that this would be a good thing for the industry. This is an important point of my talk, so let me set forth my reasoning and conclusions in orderly fashion:

1) I believe that color television will come as an evolution and not a revolution.

2) Color will prove to be a supplementary service and will not quickly, or perhaps ever, completely replace the monochrome service.

3) I am confident that the standard black and white receiver will continue to be the back-bone of television sales for at least five years into the future.

4) But, there will be a very critical period in sales while the public appraises the value of color against black and white—becomes educated to the true facts of the actual advantages of color television—the programs that will be available—just how much color adds to the programs and what they would have to pay over and above the cost of a good black and white receiver.

The quicker we can give the public the opportunity to make this side by side comparison and appraisal, the shorter will be the period of indecision and hesitancy to buy a black and white receiver.

5) If dealers in all areas are in a position to demonstrate color side by side with monochrome and actually show by direct comparison what each service offers, I am sure that a very high percentage of such prospects would reach the conclusion that a black and white receiver at its lower cost still represents a good sound investment for the future. This would be particularly true if it is shown that such a receiver will, without adjustment or additional cost, receive the color signal in black and white—complete compatibility.

Such a conclusion might be still more obvious by a price comparison, let us say, between well-performing 21-in. monochrome receivers in the price bracket between $250 and $450, as against 17 in. color picture receivers, listing between $750 and $900.

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6) Therefore, actual demonstration of the relative value and price of monochrome versus color, would give the dealer a definitely better chance to sell monochrome, than if he attempted to compete with rumor, misunderstanding and public imagination, which would tend to run toward the anticipation of perfection; a general idea that the difference in price would soon be negligible and that it might be smart to withhold purchase of a monochrome set and wait for color.

Acceptance of Color

After this initial period and the rapidity with which color will be accepted by the public will depend on two major factors:

1) The matter of programs.—After all, the "show is the thing." People buy good entertainment. Color alone cannot make a good program out of a poor one. This has been proven in the motion picture industry. It has been 31 years since full color movies have been available, yet today monochrome movies are still the backbone of the business. Many black and white pictures continue to be the box office hits, while many "color" films are among the "flops."

Likewise, I believe that black and white programs will prove to be the "bread and butter" of the television industry for many years to come.

There is a serious matter of economics involved. The cost of programming has already reached staggering proportions that represent a real economic problem to television as an advertising medium. Color will add to these costs—of this, there can be little doubt. How many advertisers will consider that color will add enough "sell" to their programs to justify these extra costs?

Color will add little to the entertainment value of most of the highly popular shows on television today—the situation comedies; the prize fights and wrestling matches; the newscasts and most of the popular plays. True, some programs, like the variety shows, will be greatly enhanced, but will the public pay a big premium in the price of the receiver for this advantage, particularly, when he can get all such programs in excellent black and white on his present set?

2) Another factor also is undeniable—that the cost of the complete color receiver will always be higher than a standard monochrome set. It will always require, not only a more expensive picture tube, but also more receiving tubes and circuitry. I have heard optimistic indications that this difference in price may be

as low as 25%. I am inclined to believe that it may be nearer 50%. In any event, even 25% will prove an important economic factor in the mass markets, which leads me to predict that good standard black and white receivers will represent a comparative value that will attract the major portion of the market for many years to come, perhaps, for all time.

These are the two main reasons that convince me that color television will not be revolutionary but, rather, go through an evolutionary

Tricolor kinescope tubes in pilot production are checked at RCA plant in Lancaster, Penna.

process until it finds its proper level as a supplementary service.

During 1955, the number of hours of color programs will gradually increase. At the same time, perhaps by the Fall of 1955, the price of color receivers will come down somewhat in price as the volume of production increases. We will then be entering the real period of evolution, with color gradually bettering its service and lowering its cost to the consumer. The ratio of color sales to black and white will increase, but I predict that standard sets will still outsell color receivers four to one in 1955.

By that time the industry will be oriented into a pattern where they will be offering the public both types of receivers as a matter of course, and the public will be making their individual choice purely on the basis of what each service offers to them at the price they have to pay. And, I am convinced that under such circumstances and realistic comparison, a high percentage of purchasers will continue to favor the standard black and white receiver. Plain economics will dictate this choice for millions of families, particularly when they know that such a receiver will bring them all the programs on the air in excellent black and white.